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REVISED FINAL REPORT ON

Assessment of Regional Soil Quality, Giant Mine, Yellowknife, NT

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REPORT

Executive Summary

Public Works and Government Services Canada (PWGSC) retained AECOM Canada Ltd. (AECOM) and, as a sub-consultant, Golder Associates Ltd. (Golder) to provide environmental support services associated with the remediation of Giant Mine, located approximately 5 km north of Yellowknife, Northwest Territories (hereafter referred to as the Site).

The overall purpose of the regional soil sampling program was to characterize the concentration and distribution of metals in shallow soils across the undeveloped areas of the Site. Arsenic has been historically identified in the shallow soil at the Site and is therefore the primary contaminant of concern for this assessment. For a specific subset of soil samples, the mineralogical composition of arsenic bearing particles was assessed using advanced mineralogical techniques. The results of this analysis provide insight into the origin, mineralogical composition, particle size and texture of arsenic in soil. It is anticipated that this information will provide valuable insight into site closure decisions with respect to soil remediation, future land use management and risk assessment.

The results of this soil quality assessment provide key environmental data which facilitate the development of closure strategies for the Giant Mine lands. By understanding the speciation of arsenic, the owner can make specific conclusions with respect to the likely wide area distribution of elevated arsenic in shallow soil, and develop predictive tools. We can also develop expanded research into the potential degradation of these materials.

The field strategy involved the collection of large number (354) of shallow soil samples across undisturbed areas, and analysing all samples for bulk chemistry. The results of the bulk chemistry analysis were used to select a subset of 50 samples for arsenic speciation testing. Sample stations were established at 103 locations across the Site.

Researchers with the Jamieson Research Group (JRG) at Queen's University were retained to complete the soil quality testing based on both the specialized analytical tools available at the Queen's University and their experience and knowledge of Giant Mine soils.

Multiple discrete samples were collected at each station for the purposes of assessing vertical distribution of arsenic. The soil quality data was also reviewed with respect to lateral distance from the former Roaster Stack.

The following points summarize our conclusions.

The bulk chemistry results confirm the presence of elevated concentrations of total arsenic in shallow soil within the undisturbed areas of the Site. These elevated concentrations are particularly pronounced in the outcrop terrain. The highest concentrations were recorded in the outcrop terrain less than 1 km from the former Roaster Stack. The majority of soil samples submitted for bulk chemistry analysis recorded concentrations of total arsenic below the current soil quality criteria (Section 5.1.1.4).



- Soil samples selected for arsenic speciation were based on the bulk chemistry data. Samples containing total arsenic concentrations greater than 500 µg/g were identified as potential candidates for arsenic speciation testing (as discussed in Section 4.2.3.1). Consequently, the arsenic speciation results should be interpreted based on this sample selection criteria. The arsenic speciation results indicate that the former Roaster Stack is the primary source of the anthropogenic arsenic in the shallow soils on the Site. Arsenic trioxide derived from stack emissions is present as either the most or second-most abundant form of arsenic in over 85% (i.e., 70% primary and 15% secondary) of the 50 soil samples assessed using arsenic speciation techniques. Arsenopyrite derived from waste rock and tailings was present as the most or second-most abundant form of arsenic in over 30% (i.e., 15% primary and 15% secondary) of the 50 soil samples examined for arsenic speciation.
- The present results provide irrefutable mineralogical evidence of the presence of three primary miningrelated constituents in shallow soil at the Site: (i) arsenic trioxide; (ii) arsenopyrite; and (iii) roaster oxides. The presence of these constituents at elevated concentrations confirms anthropogenic influence on regional shallow soil quality. The quantity of arsenic trioxide/arsenopyrite/roaster oxide grains typically decreased with depth.
- The dominant abundance of arsenic trioxide grains, with minimal evidence of either arsenopyrite or arsenic sulphide suggests Roaster Stack deposition. It is acknowledged that the selection of samples for arsenic speciation testing was biased with samples containing higher total arsenic concentrations (above 500 µg/g).
- The primary or secondary abundance of arsenic trioxide is evident in outcrop samples across the entire Site. Elevated concentrations of arsenic trioxide are particularly pronounced in the outcrop terrain less than 1 km from the former Roaster Stack. Conversely, a significant decline in the number of arsenic trioxide grains present in shallow soil was recorded beyond 1 km from the Roaster Stack. With one exception, no samples contained greater than 100 grains of arsenic trioxide when located greater than 1 km from the Roaster Stack.
- Elevated concentrations of arsenic trioxide in the shallow soil will require a remediation or risk management strategy to avoid potential exposure in the future should areas of the Site become accessible to the public. Any active remediation program should consider what actions may be required to protect workers from potential exposure during the execution of the program.
- Future application of automated mineralogy techniques will be dependent upon ongoing land use planning and risk assessment studies. Automated mineralogy testing will likely continue to be required during the pre-remediation stages of the project. The method is important for informing land use decisions and providing input to risk assessment. Should future remedial works be considered in undisturbed areas, it is considered unlikely that the collection of extensive additional automated mineralogy data will be necessary.

The following points summarize our recommendations.

- The existing data should be reviewed in the context of human health and ecological risk. The application of the current soil quality guideline for total arsenic should be reviewed in the context of the bulk chemistry and arsenic speciation data presented herein.
- The potential presence of arsenic trioxide within the developed areas of the Site should be assessed. The appropriate level of PPE for workers should be established based on the results of this assessment.





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Queen's University Final Report

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1.0 INTRODUCTION

Public Works and Government Services Canada (PWGSC) retained AECOM Canada Ltd. (AECOM) and, as a sub-consultant, Golder Associates Ltd. (Golder) to provide environmental support services associated with the remediation of Giant Mine, located approximately 5 km north of Yellowknife, Northwest Territories (hereafter referred to as the Site).

As part of this environmental support services contract, the Golder/AECOM team was requested by PWGSC to assess regional soil quality across undeveloped areas of the Site. Authorization to proceed was provided by PWGSC on September 10, 2014.

Golder has retained the Jamieson Research Group (JRG) at Queen's University in Kingston, Ontario to provide analytical and technical support to this project. This group is led by Dr. Heather Jamieson, an international expert on the environmental effects of mining activities specializing in arsenic mineralogy and speciation. Dr. Jamieson and her team have carried out extensive research on arsenic mineralogy at various mine sites around the world and are currently engaged in academic research relating to mining activities throughout northern Canada, including the Giant Mine area. Golder has retained the JRG to complete both bulk chemistry analyses of 354 shallow soil samples, as well as arsenic speciation testing on a subset of 50 samples. The JRG report entitled "Characterization of Soil Samples at Giant Mine, NWT", dated February 6, 2015, is provided in Appendix A.

The purpose of the regional soil sampling program was to characterize the distribution of arsenic in shallow soils across the undeveloped areas of the Site. The results of this program will provide key data for a future risk assessment which will inform future discussion and decisions regarding end land use.

2.0 BACKGROUND

2.1 Forms of Arsenic

The presence of arsenic in shallow soils at the Site may be broadly grouped into either natural or anthropogenic categories. Natural concentrations of arsenic are elevated in the Giant Mine and surrounding Yellowknife area. Naturally occurring arsenic in shallow soils is supplemented by anthropogenic arsenic compounds released during historical mining activities in the area.

The elevated naturally occurring concentrations of arsenic in the area are a result of local geology, with the presence of massive sulphide deposits close to surface. As a result, the natural soil and rock in the area have arsenic concentrations in the range of 3 micrograms (μ g) per (/) gram (g) to 150 μ g/g¹.

The national guideline for inorganic arsenic in industrial soil of 50 μ g/g² has been superseded to reflect local conditions in the Northwest Territories; a remediation objective of 340 μ g/g³ applies to Yellowknife area soils. The current soil quality criteria for arsenic is based on total arsenic concentration and no criteria currently exist for the various speciated forms of arsenic discussed herein. It is anticipated that the relative concentrations of the various forms of arsenic in shallow soil will be a relevant consideration with respect to assessing human health and ecological risk as redevelopment of the Site proceeds.

³ Government of Northwest Territories, Department of Environment and Natural Resources. November 2003. Environmental Guideline for Contaminated Site Remediation.



¹ Environmental Sciences Group, Royal Military College of Canada. February 2001. Arsenic Levels in the Yellowknife Area: Distinguishing Between Natural and Anthropogenic Inputs.

² Canadian Council of Ministers for the Environment. 2001. Canadian Soil Quality Guidelines for the Protection of Environmental and Human Health: Arsenic (Inorganic) (1997). Updated in Canadian Environmental Quality Guidelines, 1999, Canadian Council of Ministers of the Environment, Winnipeg.



The Giant Mine Roaster Complex operated at the Site from 1949 to 1999. Airborne releases from the historical operation of the Roaster Complex represent the primary source of anthropogenic contaminant input across the undeveloped areas of the Site. Secondary sources of anthropogenic contaminants include aerially dispersed dust from tailings and waste rock impacted areas, roadways, and the mill area.

These two sources of anthropogenic arsenic have contributed to increased arsenic concentrations, above regional normal, within undisturbed areas surrounding the Site. Each source (i.e., Roaster-derived arsenic dust and tailings-derived arsenic) can be identified due to their unique mineralogy. The following paragraphs briefly describe the arsenic mineralogy of these forms.

2.1.1 Roaster Particles

Regional anthropogenic effects on soil quality have partly resulted from the historical aerial dispersion of Roaster dust (Section 2.4). The soil quality studies (referenced in Section 2.3) have shown that these anthropogenic materials consist of two primary components:

- Arsenic trioxide [As (III)] is the primary component of Roaster dust (typically 80%) and occurs in two typical mineral habits (arsenolite and clauderite). Antimony (Sb) bearing arsenic trioxide ([As,Sb]₂O₃) is also present and partly explains the persistent nature of this mineral.
- Roaster-derived iron-oxides (ROs) may contain up to 7% arsenic mixed as arsenic (III) and arsenic (V). These nanocrystalline iron oxide structures are comprised of maghemite, hematite and magnetite.

The presence of other arsenic related materials in Roaster particles is secondary in terms of occurrence and concentration in the environment. Other arsenic related materials include the following:

- Arsenates (As [V]) are the stable secondary arsenic phase and occur in many forms. This weathering mineral is present in surface soils but has not been recorded in significant amounts regionally.
- Arsenic is present as an adsorbed phase onto a variety of iron and manganese oxides, organic matter and clay minerals.

2.1.2 Mine Waste Particles

Secondary sources of arsenic include aerially dispersed dust from tailings impoundments and waste rock areas. These secondary sources are likely dominated by arsenopyrite and are potentially prevalent in the undisturbed areas.

Previous investigations (Section 2.3) have confirmed the presence of arsenic in soil within localized undeveloped areas of the Site. These investigations have been of limited scope, but provided sufficient information to confirm the need for further investigation. The primary concern involves the potential presence of elevated concentrations of arsenic trioxide in the shallow soil which may be accessible to the public following remediation. For the purposes of this study, shallow soil is defined as native materials typically from 0 to 1 meters (m) below grade. It should be noted that some soil samples were collected at depths below 1 m for the purposes of vertical delineation.



2.2 Terrain Conditions

The terrain conditions at the Site consist of a combination of the following:

- Disturbed lands as a result of mining activities, including tailings ponds, mining pits and developed areas such as roads and buildings.
- Undisturbed lands consisting of scrub forest areas, wetlands and bedrock outcrops. These lands have not been physically disturbed by historical mining operations.

Historically, the investigation of elevated concentrations of arsenic across the Site has been restricted to the disturbed lands.

The terrain conditions in the undisturbed lands consist of approximately 60% bedrock outcrops, with organic sediments comprised of peaty organic soils, scrub forest and wetlands constituting the remainder of the terrain. These lands are typically poorly drained. Many of the outcrop areas have vegetation in depressions. The native soil consists of till and gravel deposits, overlain by glaciolacustrine clays and silts. Areas with peaty organic soils can be up to 1.0 m thick in some areas.

Bedrock outcrops are predominant at higher elevations. The main portions of the outcrop typically consist of bare, smooth rock surfaces with crevices, or hollows, which collect soil. Vegetation within the outcrop areas is limited to the outcrop crevice areas, or hollows (typically less than 10% of the outcrop area); and the lower lying areas between outcrops. These bedrock outcrop crevices have been the focus of research by Wrye⁴, Bromstad⁵, and Bromstad and Jamieson⁶ in recent years. Bedrock outcrop soils were investigated as these areas were deemed to have the potential to accumulate aerially dispersed contaminants (i.e., both arsenic trioxide and ROs), primarily from the historical operation of the Roaster Complex.

Vegetated or forested areas occur in lower lying areas between the outcrops. The forested areas typically consist of small, stunted spruce and birch, with small bushes frequently intermixed. The short growing season and dry climate result in generally small and stunted vegetation. The subsurface soil conditions in the vegetated areas are likely to consist of organic deposits that are typically less than 0.50 m thick, underlain by glaciolacustrine clays and silts. These materials overlay glacial till, which is discontinuous and typically less than 2.0 m thick. Wrye found that arsenic concentrations are typically low (<100 μ g/g) on the surface (within the organic layer), and increase to a maximum concentration (approximately 300 μ g/g) at the transition zone from the base of the organics to the top of the glaciolacustrine materials⁷. Arsenic concentrations in the underlying glacial till are likely typical of natural background concentrations.

Wetlands occur in poorly drained areas between the outcrops. The wetlands are small, marshy areas situated on the edges of ponds and within hollows. Vegetation in these areas typically consists of small bushes and grasses. The subsurface soil conditions in the wetlands likely consist of organic deposits that are typically over 1.0 m thick, underlain by glaciolacustrine clays and silts.

⁷ Wrye, L.A., 2008. Distinguishing between Natural and Anthropogenic Sources of Arsenic in Soils from the Giant Mine, Northwest Territories and the North Brookfield Mine, Nova Scotia.



⁴ Wrye, L.A., 2008. Distinguishing between Natural and Anthropogenic Sources of Arsenic in Soils from the Giant Mine, Northwest Territories and the North Brookfield Mine, Nova Scotia.

⁵ Bromstad, M.J., 2011. The Characterization, Persistence and Bioaccessibility of Roaster-Derived Arsenic in Surface Soils at Giant Mine, Yellowknife, NT.

⁶ Bromstad, M.J., and Jamieson, H.E., 2011. The Persistence and Mobility of Roaster-Derived Arsenic in Surface Soils at Giant Mine, NT.

2.3 Historical Investigations

As part of the development of the scope of work for the current regional soil quality assessment, Golder reviewed and summarizes herein the following documents:

- "Arsenic Levels in the Yellowknife Area: Distinguishing Between Natural and Anthropogenic Inputs".
 Environmental Sciences Group, Royal Military College of Canada, Kingston, Ontario. February 2001.
- "Distinguishing between Natural and Anthropogenic Sources of Arsenic in Soils from the Giant Mine, Northwest Territories and the North Brookfield Mine, Nova Scotia", Wrye, L.A., 2008.
- "The Characterization, Persistence and Bioaccessibility of Roaster-Derived Arsenic in Surface Soils at Giant Mine, Yellowknife, NT", Bromstad, M.J., 2011.
- "The Persistence and Mobility of Roaster-Derived Arsenic in Surface Soils at Giant Mine, NT", Bromstad, M.J., and Jamieson, H.E., 2011.
- "Letter Report on Shallow Soil Sampling Programs Giant Mine, Yellowknife, Northwest Territories", Fiddler, S., and Cole, A. 2014.

The majority of research at the Site has focused on outcrop soils within the undisturbed lands. The outcrop soils were defined as soils found in bedrock depressions that were suitable for "trapping" arsenic-rich dust from the historical Roaster Stack emissions via washing down dust from the bedrock surface into the outcrops, a process termed the "wash down effect"⁶, which results in accumulation of arsenic-containing particles over time in the outcrop soils. These depressions represent a natural system of contaminant concentration from historical Roaster Stack emissions.

Research into the potential impacts of the Roaster Complex historical emissions within the undisturbed lands was initiated by $Wrye^8$. This research focussed on three areas to assess potential shallow soil and bedrock outcrop soil concentrations of arsenic: an area near the Town Site and southeast of the Roaster Complex, a location adjacent to the Roaster Complex, and an area east of Pocket Lake, west of the Roaster Complex. Both shallow soil and bedrock outcrops were sampled in these areas. It was concluded following initial sampling of outcrop areas that elevated concentrations of arsenic were present in the soil in these bedrock depressions. These arsenic concentrations were significantly higher than those which could be explained through natural processes; arsenic was frequently recorded at concentrations greater than (>) 1,000 μ g/g. Wrye⁸ concluded these studies as follows:

- Aerial emissions from the Roaster Complex have persisted in the shallow soil environment.
- It is possible to distinguish between natural and anthropogenic sources of arsenic using advanced laboratory techniques.
- Arsenic bearing Roaster Oxides were identified in shallow soils.
- The "wash down effect" impacted the concentrations of arsenic in shallow soil adjacent to the bedrock outcrops.

⁸ Wrye, L.A., 2008. Distinguishing between Natural and Anthropogenic Sources of Arsenic in Soils from the Giant Mine, Northwest Territories and the North Brookfield Mine, Nova Scotia.



Subsequent research focussed on characterizing the lateral extent of the elevated concentrations of arsenic within outcrop depressions across the Site, and developing a theory to explain the presence of these elevated arsenic concentrations. Bromstad⁹ sampled 40 outcrop locations and concluded that Roaster derived arsenic is widely present within bedrock outcrop soils. The arsenic concentrations in these samples frequently exceeded the industrial land use soil quality criteria of 340 μ g/g¹⁰. The persistence of arsenic in shallow soils was explained by several factors:

- the influence of antimony which lowers the solubility of arsenic trioxide;
- the cold, dry climate which affects dissolution; and
- the "trapping" of sediment in depressions with no drainage points.

Arsenic in its various forms can be examined analytically as grains, where texture and size are documented. Textural evidence suggests that at the grain scale, arsenic trioxide is changing slowly over time. The slow reaction kinetics supports the preceding factors explaining the persistence of arsenic in shallow soils, in particular, that the cold, dry climate limits arsenic trioxide dissolution and weathering, and antimony content within arsenic trioxide limits its solubility.

Arsenic trioxide is present in the greatest proportion in soils in these bedrock outcrops, but ROs represent the second-most abundant form of arsenic. In the upper organic rich soils, the higher porosity allows for precipitation to channel through the soil. Consequently, contact between the arsenic trioxide grains and precipitation is of very short duration and dissolution reactions and weathering are likely slowed.

Golder and AECOM completed a regional soil sampling program in 2013 (summarized in document number 310-As Soil Samp-8-LET-0001-Rev2_20140303 dated March 3, 2014). Results of the regional soil sampling program identified 14 undisturbed locations at the Site where the concentrations of total arsenic were greater than the industrial soil quality criteria of 340 μ g/g. Eleven soil samples, collected from the upper 0.10 m, contained detectable concentrations of arsenite, which ranged from 0.15 μ g/g to 3.95 μ g/g, and 20 soil samples, collected from the upper 0.10 m, contained detectable concentrations of arsenic concentrations of arsenate ranging from 13.5 μ g/g to 1,063 μ g/g. Both of these forms of arsenic confirm the presence of Roaster-derived emissions within the upper 0.10 m of undisturbed soils across the Site.

2.4 Roaster Stack – Historical Emissions

Throughout the 50 year mining history at the Site, operations included a roasting process to liberate gold from arsenopyrite. This process produced arsenic rich gas as a by-product, which was released as an aerial emission from the Roaster Complex. The primary form of arsenic released to the environment from the stack was arsenic trioxide, which is soluble and should not persist in the environment over the long term. During the initial two years of operation, this gas was emitted directly to the atmosphere.

⁹ Bromstad, M.J., 2011. The Characterization, Persistence and Bioaccessibility of Roaster-Derived Arsenic in Surface Soils at Giant Mine, Yellowknife, NT.

¹⁰ Government of Northwest Territories, Department of Environment and Natural Resources. November 2003. Environmental Guideline for Contaminated Site Remediation.

In 1951, the owners of the mine implemented a process to control stack emissions. From 1951 to 1999, stack emissions were captured, and arsenic trioxide dust was stored on-Site. A reported 237,000 tonnes of arsenic trioxide dust was transferred to underground storage caverns on the Site. The initial stack release of arsenic trioxide dust, combined with historical re-distribution of the dust, has resulted in arsenic contamination of the shallow soil materials across the Site.

2.5 Mineralogical Characterization

Automated laboratory techniques used for mineralogical characterization of soil and sediment are an emerging geoscience field. The recent rapid advances in computing and data processing have resulted in the development of analytical tools that allow for the rapid and comprehensive mineralogical characterization of geological samples. These automated mineralogy techniques have been adopted from mining applications to assess soil quality.

Although these techniques have been successfully applied for university research purposes with respect to the assessment of soil quality, there is limited current commercial capability for the analysis of soil or sediment quality using automated mineralogy. As a result, the commercial "track record" of case histories where the successful application of automated mineralogy to assess former mine sites is not extensive. The lack of relevant case studies necessitates the requirement to provide additional background and justification for the application of these methods for this project.

The field of automated mineralogy and specifically the application of Mineral Liberation Analyser/Scanning Electron Microscope (MLA/SEM) has grown significantly in the past 10 years. The MLA/SEM became commercially available in 2000, and is marketed by the FEI Company. Other SEM systems are now also commercially available for mineral analysis. The use of these systems was initially focussed on metallurgical processing, with particular application for optimizing ore processing in the mining industry. The application of the MLA/SEM has expanded into a wide variety of geoscience research fields, where it is advantageous to definitively verify the mineralogical composition or is necessary to assess geological processes or characteristics of sedimentary rock.

This application of automated mineralogy within the environmental field is currently led by university researchers, with the development of methods to characterize a range of geologic materials (including soil and sediment) for a variety of environmental applications. The use of the MLA/SEM for environmental research at mine sites has been led the JRG at Queen's University.

Manual mineralogy studies have been carried out for environmental projects but were extremely tedious, and were highly reliant on operator experience. Due to the time required and expense, the mineralogical characterization of soil was not a common practice with respect to environmental applications. In addition, the information offered limited practical benefit, given that the vast majority of regulatory guidelines and risk calculations relied primarily on total element concentrations.

With the gradual overall advancement of automated mineralogy within the field of soil quality assessment, the information provided by the MLA/SEM is technically reliable (much less prone to operator error) and is statistically representative. In addition, the results of this analysis provide insight into the origin, particle size, and texture of soil particles. The application of the MLA/SEM in the field of "forensic" soil science is currently evolving, as the technique enables the identification of the source of environmental impairment.





The MLA/SEM automated mineralogy method was used in this assessment for the purposes of mineral characterization. The method has been calibrated to focus on speciation of arsenic bearing particles, including the assessment of anthropogenic arsenic. This method of arsenic speciation testing is further described in Section 4.

3.0 SCOPE OF WORK

The scope of work for this Project was developed by Golder in collaboration with AECOM, PWGSC and the JRG. The scope of work was developed to assess the potential presence of anthropogenic arsenic in shallow soil across the Site. The work plan incorporated the requirement for depth control during sample collection, a direct result of the conclusions drawn from previous shallow soil sampling programs completed at Giant Mine (Section 2.3). The scope of work for this project was developed to provide wide spread geographic coverage of undeveloped areas of the Site (Figure 1) and to collect shallow soil samples within several distinct terrain types (Figure 2).

The primary objective of this project was to assess the presence or absence of anthropogenic arsenic within the undeveloped areas across the Site. A secondary objective involved the interpretation of the variation of arsenic concentration laterally and with depth, as well as with terrain type. An additional project objective included confirmation of the "source" of anthropogenic arsenic. If the primary source of anthropogenic arsenic involved aerial deposition of particles from the former Roaster Stack, it is likely that the elevated concentrations of arsenic are present in the upper soil horizon, and that concentrations decrease with depth.

To meet these objectives, the field methods involved the collection of shallow soil samples across undisturbed areas which were analysed for bulk chemistry (Section 5). Multiple discrete samples were collected at each station to assess vertical distribution of arsenic. The results of the bulk chemistry analysis were then used to select a subset of samples for arsenic speciation testing (Figure 3, Section 5).

The following sections of this report describe the field methods (Section 4.1), laboratory methods (Section 4.2), and results (Section 5.0) of the present study. Section 5.1 of this report discusses soil quality variation with depth, Section 5.2 describes soil quality variation with distance from the Roaster Stack, and Section 5.3 presents a summary of the findings. A discussion of the current and potential future use of mineralogical characterization methods is presented in Section 6. Conclusions and recommendations are provided in Section 7. Limitations of the study are presented in Section 8.

4.0 METHODS

The present study was designed based on a two-staged approach. The initial stage involved collection and interpretation of soil quality data based on both terrain type and sample depth, and the second stage involved collection and interpretation of soil quality data based on both terrain type and distance from the former Roaster Stack. The two-staged approach proceeded as follows:

- Soil Quality Variation with Depth: The undeveloped lands were broadly grouped into three terrain types: outcrop, forest and wetland. The sampling strategy provided representative coverage of the three main terrain types across the entire lease land area. Samples were collected and assessed based on depth (Figure 4).
- 2) **Soil Quality Variation with Distance from the former Roaster Stack:** Given the Roaster Stack was likely the primary source of historical air-borne emissions which had the potential to impair regional soil quality across the Site (Section 2.4), the sampling strategy provided representative coverage by terrain type and geographic distance from the former Roaster Stack.



4.1 Field Methods

4.1.1 Sample Collection

This sampling program involved the collection of shallow soil samples by both trowel and hand auger and various depths and distances from the former Roaster Stack. Care was taken to clean sample equipment between sample stations to prevent cross contamination. A total of 354 discrete soil samples were collected from 103 stations across the Site. Up to five discrete samples of 250 mL each were collected from each station, as local ground conditions allowed, to provide data for vertical delineation. For the purposes of this report, shallow soil samples were considered as ranging from 0 to 0.10 m, intermediate depth soil samples ranged from a depth of 0.10 to 0.25 m, and deep samples were considered to be greater than 0.25 m in depth. Lateral distribution was achieved by defining distance ranges from the former Roaster Stack, as follows:

- "near-source stations": Samples located 0 1 km from the former Roaster Stack;
- "mid-range stations": Samples located 1 2 km from the former Roaster Stack; and
- "distant stations": Samples located greater than 2 km from the former Roaster Stack.

Samples were placed in heavy duty plastic sample bags, labelled and secured with packing tape.

Soil samples were logged in the field and shipped to the JRG at Queen's University for bulk chemical analysis and arsenic speciation testing. The results of this bulk chemical testing were used to identify a subset of samples for arsenic speciation testing.

4.1.2 Sample Locations

Each sample station was plotted on a map and GPS coordinates were recorded to confirm locations (Figure 1). A photograph was taken of each sample station and observations were recorded, including: bedrock shape and drainage, presence and type of vegetation, soil type, thickness of the overburden, and organic content and moisture content of the soil sample (Appendix B).

Sample stations were established to provide adequate geographic coverage, and aimed to provide the following sampling distribution: (i) bedrock outcrops (70%); (ii) forested areas (15%) and (iii) wetlands (15%). The achieved sample distribution had a greater proportion of forested areas and less bedrock outcrops (Table 1).

Terrain Type	No. of Samples (% of total)	No. of Stations (% of total)
Outcrop	124 (35)	56 (55)
Wetland	90 (25)	19 (18)
Forest	140 (40)	28 (27)
Totals	354	103

Table 1: Achieved Station and Sample Distributions



4.1.3 Key Challenges to Consistent Soil Sampling

Consistent sampling methods and strategies were employed throughout the program. Previous soil sampling programs were completed by researchers at Queen's University, as detailed in Section 2.3, which focused on specific outcrop locations. Based on previous work by Bromstad (2011), two main challenges associated with soil sampling in the area have been identified which were incorporated into the sampling program as follows:

1) Variability of Depth, Soil Maturity, Organic Matter and Heterogeneity. The concentration of arsenic in outcrop soil varies with depth, soil type and the presence of organic matter. The collection of soil cores was not possible in most areas due to the thin overburden thickness; therefore, when thin overburden soils were encountered, samples were collected from 0.0 to 0.05 m and 0.05 to 0.10 m.

With respect to organic matter, it was critical that all green organics and large masses of organics were removed from the sample. However, it was also recognized that arsenic readily adsorbs to organics, consequently organic matter was retained as part of the sample. Pieces of organics larger than 15 mm were removed. The remaining organic fragments remained in place. The samples did not have greater than 50% organics.

2) Variability in Arsenic Concentrations within a Given Outcrop Hollow. The "wash down" effect traps arsenic in topographic lows or pockets within outcrops. Before sampling an outcrop, the area was assessed and likely "pockets" identified. Pockets of soil which existed as small "bowls" with few drainage exits for runoff were identified as potential sample stations. Historical stack emissions included the deposition of sulphur dioxide. As a result, bedrock locations where lichen was healthy and vegetation seems to have been unaffected by aerial deposition were interpreted likely not to have significant roaster derived arsenic.

Wind direction plays a role in arsenic distribution. Based on the Yellowknife Airport wind rose, the predominant wind directions are from the east (and northeast and southeast); as well as from the northwest. The wind rarely blows from the southwest. Wind direction was a good predictor of elevated arsenic in shallow soil.

4.1.4 Health and Safety Protocols

A health and safety plan was developed prior to commencing field activities. The primary exposure route to arsenic during the execution of the field program was dermal exposure; therefore, nitrile gloves and coveralls were used at all times during the soil sampling program.

In addition, field personnel completed a safety orientation prior to commencing the field investigation, which detailed Site-specific health and safety requirements (e.g., vehicle operation on the Site required adherence to specific speed limits, Site-specific vehicle safety equipment and protocols.). As part of the mine safety plan, field staff was required to check-in daily with mine staff. Golder field personnel were required to identify planned sampling locations daily, and the two-person field crew remained together at all times for health and safety purposes.

4.2 Laboratory Methods

Researchers from JRG developed an analytical program for interpretation of arsenic speciation. A detailed discussion of the laboratory analytical methods is presented in the JRG Queen's University Final Report (Appendix A), and is summarized below.



The analytical program was completed in two stages: (i) bulk chemical analysis was initially completed on all 354 samples; and (ii) the results of the bulk chemical analysis was used to select 50 soil samples for arsenic speciation testing that contained elevated arsenic concentrations.

4.2.1 Sample Preparation

Soil samples were shipped to the JRG and Analytical Services Unit (ASU) at Queen's University. Upon receipt samples were inventoried. Samples were homogenized by drying and grinding, after which a sub-sample was collected. Each sample was spread on paper and air dried at room temperature for one to six days. Samples were photographed and described. The description included grain size, moisture, colour and organic content.

Following drying, visible rock and organic material was discarded and a portion of the sample was further processed using a ceramic mortar and pestle. The fine material from this process was then analyzed. Possible sources of bias with respect to the sample composition are discussed in Appendix A.

4.2.2 Bulk Chemistry Analysis

Samples were digested with hydrochloric and nitric acid for five hours and filtered prior to analysis. Thirty elements (including arsenic) were analysed by inductively coupled plasma optical emission spectroscopy (ICP-OES). Gold was analyzed by inductively coupled plasma mass spectroscopy (ICP-MS). Total carbon was analysed by combustion (i.e., as CO_2) in a LECO Truspec CN analyser. The results of the bulk chemistry analysis are reported as total micrograms per gram (μ g/g).

4.2.3 Arsenic Speciation Testing

4.2.3.1 Sample Selection

Samples were selected for arsenic speciation testing based on the following criteria:

- Arsenic concentrations from bulk chemistry testing. The results of the bulk chemistry testing allowed identification of soil samples with high total arsenic concentrations (i.e., for arsenic speciation testing a high arsenic concentration was considered >500 µg/g), which increased the likelihood of identifying a variety of forms of arsenic.
- Potential for vertical delineation of arsenic. The potential for decreasing arsenic concentrations with increasing depth has been previously recognized; therefore, samples for arsenic speciation testing were identified as those where higher bulk concentrations were recorded throughout the soil profile.
- Variation in terrain type. Although the majority of soil samples were collected from outcrop locations (i.e., the dominant terrain across the Site), samples for arsenic speciation were also chosen from forest and wetland areas.
- Geographical distribution. Samples for arsenic speciation were selected to ensure adequate geographical coverage.

Based on the above criteria, 50 samples were selected for arsenic speciation testing (Table 2).



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Terrain No. of No. of Type Samples Stations		No. of Stations	Samples Selected for Arsenic Speciation Testing	Stations Selected for Arsenic Speciation Testing
Outcrop	124	56	31	15
Wetland	90	19	13	5
Forest	140	28	6	3
Totals	354	103	50	23

Table 2: Terrain Type versus Soil Analytical Testing Program

4.2.3.2 Mineral Liberation Analysis/Scanning Electron Microscope

Arsenic speciation was performed using a Mineral Liberation Analyser (MLA) and scanning electron microscope (SEM). The unit is equipped with high-resolution back scatter electron (BSE) image analysis, advanced X-ray identification techniques, and computer software to automate the microscope operation. The MLA SEM technique allows for comprehensive compilation of porosity, grain size and shape data for soil samples, in conjunction with documenting key mineralogical properties through the classification of X-ray spectra.

4.2.3.3 Grain Mount Methodology

A representative sample selected for MLA SEM testing was obtained from the prepared soil sample. Grain mount technology produces a thin section of soil by blending the soil with graphite and an epoxy, such that separation and mapping of the individual soil particles may be achieved. The method for preparing soil sample for MLA SEM analysis is described in detail in Appendix A.

In brief, arsenic speciation results were principally based on the classification of individual soil grains. Grains were classified in terms of composition/mineralogy, number and size for the various particles. Evidence for the presence of anthropogenic arsenic in shallow soil was, therefore, based on the definitive identification of both arsenic trioxide and arsenopyrite grains.

Differentiating between the potential sources of anthropogenic arsenic is challenging, and subject to interpretation. Two main sources are present: (i) Roaster Stack emissions and (ii) dust from tailings and waste rock associated with mining activities. In most locations, one source is dominant over the other, and in some locations both are evident.

4.2.3.4 MLA Mineral Reference Library

JRG and Queen's University have developed an extensive library of reference minerals which was used to identify soil particles. Samples were compared to the profiles in the library via a best-fit matching process. Each particle profile is unique, and when unknown particles were identified by the MLA (i.e., there was no matching profile in the reference library), the particle was examined by an experienced mineralogist and classified based on conventional optical microscopic methods and added to the reference library.

The MLA reporting focussed on two particle details, including: (i) particle counts (i.e., the number of particles of a specific mineral), and (ii) the approximate area of all similar particles (as a percent of the total). When both the number of mineral particles and particle size was confirmed, the approximate concentrations of the various total metals were estimated.



4.2.4 Comparison of Bulk Chemistry and Arsenic Speciation Data

Arsenic in shallow soil was characterized by both ICP bulk chemistry and MLA SEM arsenic speciation. The ICP bulk analysis measured the concentrations of total metals (including arsenic) for all soil samples. The MLA SEM provided a grain scale assessment of a subset of samples, mapping all grains and thereby allowing further assessment of arsenic minerals and arsenic-containing particles.

The two laboratory methods operate independently, and there were challenges with respect to correlating results for the two methods from the same soil sample. The heterogeneous nature of soil samples plays a significant factor in correlating results. This "nugget effect" (as described in the JRG Report) may result in significant differences in concentration of arsenic within the same sample based on the presence or absence of one or two significant "nuggets".

Furthermore, the characterization of arsenic within "nano-scale" particles (i.e., particles at dimensions of roughly 1 to 100 nanometres) including various iron oxides represents a challenge. The actual concentration of arsenic within these small-scale particles cannot be measured and must be estimated. Manual techniques were used to confirm the shape and potential composition of these particles.

Although the difficulty in correlation of results represents a challenge, the strategy of using both methods was successful and effective. The screening of samples using ICP bulk analysis allowed the identification of samples with elevated arsenic concentrations, thereby optimizing the number of samples processed by MLA SEM analysis.

5.0 RESULTS

This section first describes soil quality variation with depth (Section 5.1) and then presents the results of soil quality variation with lateral distribution from the former Roaster Stack (Section 5.2). Each section is subdivided into two sections which review the results of (i) bulk chemistry and (ii) arsenic speciation data. The soil quality data is further discussed based on the three primary terrain types, including (i) outcrops; (ii) forest; and (iii) wetland. The lateral distribution of arsenic is also considered and discussed in the context of proximity to the former Roaster Stack. A discussion of the comparison of the bulk chemistry data to current criteria is also provided.

5.1 Soil Quality Variation with Depth

5.1.1 Bulk Chemistry Results

The distribution of bulk chemistry sampling stations was spread between terrain types and depth (Table 3). A total of 354 soil samples were collected from 103 sample stations. The bulk chemistry data was used to select samples for arsenic speciation testing. Total arsenic concentrations for all 354 soil samples are presented on Figures 5 through 7.

Table of Achieved Distribution of Dank enterned y stations											
Depth	Outcrop	Wetland	Forest	Grand Total							
Shallow	107	35	52	194							
Mid-Range	16	18	28	62							
Deep	1	37	60	98							
Grand Total	124	90	140	354							

Table 3: Achieved Distribution	n of Bulk Chemistry	Sampling Stations
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Discussions of bulk chemistry results, based on soil depth and terrain type are provided in the sections below. Refer to Tables 4, 5 and 6 for maximum, minimum and average total arsenic, antimony and gold concentrations based on depth distribution.

5.1.1.1 Outcrop

A total of 124 samples representing approximately 35% of the samples collected were submitted for bulk chemistry analysis from the outcrop terrain. Due to the typical shallow soil within the outcrops, the vast majority of soil samples collected (i.e., 86%) were obtained from 0.0 to 0.10 m depth and were considered shallow samples. Only one soil sample was collected at a depth greater than 0.25 m in outcrop terrain.

Vertical delineation (i.e., two or more samples) was achieved at a total of 15 outcrop stations across the Site. Vertical delineation was not possible at 41 of the 56 outcrop stations. Arsenic concentration versus sample depth for outcrop soils was considered, and arsenic concentrations decrease with depth in outcrop soils (Graph 1).

5.1.1.1.1 Shallow Depth Samples

The shallow soil depth within the outcrop terrain represents the stratum where the vast majority of the historical anthropogenic arsenic had been identified. The documented concentrations of the three key indicator parameters were as follows:

- The total arsenic concentration identified in shallow soil samples from outcrop sample stations ranged from 17,000 µg/g (Station II-OC-5) to 20 µg/g (Station VIII-OC-1). The average arsenic concentration in shallow soil samples from outcrop sample stations was 1804 µg/g.
- The total antimony concentration identified in shallow soil samples from outcrop sample stations ranged from 900 μg/g (Station II-OC-5) to less than 1.0 μg/g (Station V-OC-2). The average antimony concentration in shallow soils from outcrop sample stations was 57 μg/g.
- The total gold concentration identified in shallow soil samples from outcrop sample stations ranged from 3.1 µg/g (Station II-OC-5) to less than 0.01 µg/g (Stations V-OC-2, VI-OC-2, VI-OC-3, VI-OC-5, VII-OC-2, VII-OC-4, VII-OC-7, VII-OC-8, VII-OC-9, VIII-OC-1, VIII-OC-2). The average gold concentration in shallow soil samples from outcrop sample stations was 0.22 µg/g.

Based on the review of this bulk chemistry data, a total of 53 (49%) soil samples collected from the shallow zone exceed the 340 μ g/g applicable arsenic criteria. The highest concentrations of arsenic, antimony, and gold in shallow soil samples were identified from the outcrops situated close to the former Roaster Stack.

5.1.1.1.2 Intermediate Depth and Deep Samples

Soil quality data was collected from a total of seventeen intermediate depth outcrop stations across the Site. A deep soil sample (>0.25 m) was collected at one station.

A total of sixteen intermediate depth soil samples were collected from outcrop stations. The soil samples were collected and submitted for analysis of arsenic, antimony and gold. The documented concentrations of the three key indicator parameters were as follows:

The total arsenic concentration identified in intermediate depth soil samples from outcrops ranged from 3,400 μg/g (Station II-OC-6) to 14 μg/g (Station VII-OC-8). The average arsenic concentration in intermediate depth soil samples from outcrops was 595 μg/g.



- The total antimony concentration identified in intermediate depth soil samples from outcrop sample stations ranged from 45 μg/g (Station II-OC-6) to 3.2 μg/g (Station VII-OC-9). The average antimony concentration in intermediate depth soils from outcrop sample stations was 11.48 μg/g.
- The total gold concentration identified in intermediate depth soil samples from outcrop sample stations ranged from 0.073 µg/g (Station II-OC-6) to less than 0.01 µg/g (Stations II-OC-5, II-OC-6, IX-OC-4, IX-OC-6). The average gold concentration in intermediate depth soil samples from outcrop sample stations was 0.02 µg/g.

One deep soil sample was collected from an outcrop location (Station V-OC-2). The arsenic concentration recorded for this sample was 44 μ g/g and antimony and gold concentrations were 2.2 μ g/g and <0.01 μ g/g, respectively.

The assessment of the vertical distribution of arsenic, antimony and gold was possible in 27% of the outcrop stations. A pattern of decreasing concentration with depth was recorded for total arsenic, antimony and gold across these outcrop stations.

In summary, a total of 81 of the 124 samples submitted for bulk chemical analysis within the outcrop terrain contain arsenic concentrations which exceed applicable criteria. Seventy-four of these samples were collected from the shallow soil, and seven of these samples were collected from intermediate depth.



Graph 1: Concentration of Total As (µg/g) in Outcrops vs Depth



5.1.1.2 Forest

A total of 140 samples (approximately 40% of the samples collected) were submitted for bulk chemistry analysis from the forest terrain (Table 3). Four to five samples were collected from each of the 28 forest stations across the Site. Vertical delineation was possible all 28 forest stations. These stations represent complete vertical profiles, with soil samples collected from all three depth strata. A graph illustrating the arsenic concentration versus sample depth for forest soils is presented in Graph 2.

The average arsenic concentration in the shallow forest soils exceeded the applicable soil quality criteria of $340 \mu g/g$. The total arsenic concentrations were generally lower compared to those recorded in the outcrop terrain. The average antimony and gold concentrations in the forest shallow soils were comparable to the outcrop soils. The intermediate depth results for the total arsenic concentrations in forest stations were significantly lower compared to the intermediate depth outcrop samples. The total antimony and total gold concentrations within the intermediate depth zone were comparable with the outcrop soils. The deep soil results for the total arsenic, antimony and gold concentrations in forest stations were comparable to the deep outcrop sample. The following sections discuss the bulk chemistry analytical results based on shallow, intermediate depth, and deep soil profiles in forest sample stations.

5.1.1.2.1 Shallow Depth Samples

Fifty-two shallow soil samples were collected from forest sample stations. At the majority of the 28 forest stations, two shallow soil samples were collected. The following points summarize the total arsenic, antimony and gold concentrations recorded within the shallow forest stations.

- The total arsenic concentration identified in shallow soil samples from forest sample stations ranged from 3,600 µg/g (Station IX-F-4) to 28 µg/g (Station VII-F-2). The average arsenic concentration in shallow soil samples from forest sample stations was 463 µg/g.
- The total antimony concentration identified in shallow soil samples from forest sample stations ranged from 570 μg/g (Station IX-F-4) to 1.3 μg/g (Station VII-F-2). The average antimony concentration in shallow soil samples from forest sample stations was 58 μg/g.
- The total gold concentration identified in shallow soil samples from forest sample stations ranged from 48 μg/g (Station IX-F-4) to less than 0.01 μg/g (Stations II-F-3, V-F-1, VI-F-3, VII-F-2). The average gold concentration in shallow soil samples from forest sample stations was 1.16 μg/g.

The average total arsenic concentration in the shallow forest soils exceeded applicable soil quality criteria (340 μ g/g). The total arsenic concentrations within the shallow soils were lower compared to those recorded in the outcrop terrain, while the average antimony and gold concentrations in the forest shallow soils were comparable to the outcrop soils.

5.1.1.2.2 Intermediate Depth Samples

Twenty-eight intermediate depth soil samples were collected from forest stations. The following points summarize the chemical analytical results for total arsenic, antimony and gold.

The total arsenic concentration identified in intermediate depth soil samples from forest stations ranged from 1,300 μg/g (Station IV-F-2) to 13 μg/g (Station VIII-F-5). The average arsenic concentration in intermediate depth soil samples from forest sample stations was 162 μg/g.



- The total antimony concentration identified in intermediate depth soil samples from forest stations ranged from 93 µg/g (Station IV-F-2) to less than 1.0 µg/g (Stations VI-F-2, VI-F-3, VI-F-4, VIII-F-3, VIII-F-5). The average antimony concentration in intermediate depth soil samples from forest sample stations was 11.75 µg/g.
- The total gold concentration identified in intermediate depth soil samples from forest stations ranged from 0.86 µg/g (Station IX-F-4) to less than 0.01 µg/g (Stations I-F-1, II-F-1, II-F-3, IV-F-1, IX-F-3, VI-F-1, VI-F-4, VII-F-1, VII-F-2, VIII-F-2, VIII-F-3, VIII-F-5). The average gold concentration in intermediate depth soil samples from forest stations was 0.08 µg/g.

The intermediate depth results for the total arsenic concentrations in forest stations were significantly lower compared to the intermediate depth outcrop samples, while total antimony and total gold concentrations within were comparable with the outcrop soils at intermediate depth.

5.1.1.2.3 Deep Samples

Sixty (60) deep soil samples were collected from forest stations. The following points summarize the chemical analytical results for total arsenic, antimony, and gold.

- The total arsenic concentration identified in deep soil samples from forest sample stations ranged from 290 μg/g (Station IX-F-1) to 5 μg/g (Station IX-F-1). The average arsenic concentration in deep soil samples from forest sample stations was 38 μg/g.
- The total antimony concentration identified in deep soil samples from forest sample stations ranged from 26 μg/g (Station IX-F-4) to less than 1.0 μg/g (Stations II-F-1, II-F-3, IV-F-1, V-F-1, V-F-2, VI-F-1, VI-F-3, VI-F-3, VI-F-4, VII-F-1, VII-F-2, VIII-F-5, IX-F-1, IX-F-3). The average antimony concentration in deep soil samples from forest sample stations was 2.11 μg/g.
- The total gold concentration identified in deep soil samples from forest sample stations ranged from 0.2 µg/g (Station IX-F-4) to less than 0.01 µg/g (Station I-F-1, I-F-2, II-F-2, III-F-2, IV-F-2, V-F-2, VI-F-1, VI-F-2, VI-F-3, VI-F-3, VI-F-4, VII-F-1, VII-F-2, VIII-F-2, VIII-F-3, VIII-F-4, VIII-F-5, IX-F-1, IX-F-3). The average gold concentration in deep soil samples from forest sample stations was 0.02 µg/g.

The deep soil results for the total arsenic, antimony and gold concentrations in forest stations were comparable to the deep outcrop sample.

In summary, a total of 18 of the 140 samples submitted for bulk chemical analysis within the forest terrain contain arsenic concentrations which exceed applicable criteria. Sixteen of these samples were collected from the shallow soil, and two of these samples were collected from intermediate depth.





Graph 2: Concentration of Total As $(\mu g/g)$ in Forest Stations vs Depth

5.1.1.3 Wetland

A total of 90 samples (approximately 25% of the samples collected) were submitted for bulk chemistry analysis from the wetland terrain (Table 3). Up to five samples were collected from each of the 19 wetlands stations across the Site, compromising 18% of all stations. Vertical delineation was possible at all 19 wetland stations. These stations also represent complete vertical profiles, with soil samples collected from all three depth strata. A graph illustrating the arsenic concentration versus sample depth for wetland soils is presented in Graph 3.

The following discusses the bulk chemistry analytical results based on shallow, mid-range, and deep soil profiles in wetland sample stations.

5.1.1.3.1 Shallow Depth Samples

Thirty-five shallow soil samples were collected from wetland sample stations. At the majority of the 19 wetland stations, two shallow soil samples were collected. The following points summarize the total arsenic, antimony, and gold concentrations recorded within the shallow wetland stations.

- The total arsenic concentration identified in shallow soil samples from wetlands ranged from 1,500 μg/g (Station VI-WL-1A) to 18 μg/g (Station VIII-WL-2). The average arsenic concentration in shallow soil samples from wetlands was 488 μg/g.
- The total antimony concentration identified in shallow soil samples from wetland sample stations ranged from 270 μg/g (Station IV-WL-2) to less than 1.0 μg/g (Station IV-WL-3). The average antimony concentration in shallow soil samples from wetland sample stations was 53 μg/g.



The total gold concentration identified in shallow soil samples from wetland sample stations ranged from 4.4 μg/g (Station III-WL-1) to less than 0.01 μg/g (Stations VIII-WL-1, VIII-WL-2). The average gold concentration in shallow soil samples from wetland sample stations was 0.38 μg/g.

The average arsenic concentration in the shallow wetland soils exceeded applicable soil quality criteria (340 μ g/g). The total arsenic concentrations were generally lower compared to those recorded in the outcrop and forest terrain. In the shallow wetland stations, the maximum arsenic and antimony concentrations were the lowest concentrations reported. The average antimony and gold concentrations in the wetland shallow soils were comparable to both the shallow forest and outcrop soils.

5.1.1.3.2 Intermediate Depth Samples

Eighteen intermediate depth soil samples were collected from wetland sample stations. The following points summarize the total arsenic antimony and gold concentrations recorded within the intermediate depth wetland stations.

- The total arsenic concentration identified in intermediate depth soil samples from wetland sample stations ranged from 2,800 μg/g (Station IV-WL-2) to 11 μg/g (Station VIII-WL-2). The average arsenic concentration in intermediate depth soil samples from wetland sample stations was 491 μg/g.
- The total antimony concentration identified in intermediate depth soil samples from wetland sample stations ranged from 800 μg/g (Station IV-WL-2) to less than 1.0 μg/g (Station VIII-WL-2). The average antimony concentration in in intermediate depth soil samples from wetland sample stations was 79 μg/g.
- The total gold concentration identified in intermediate depth soil samples from wetland sample stations ranged from 4 µg/g (Station III-WL-1) to less than 0.01 µg/g (Stations II-WL-2, VIII-WL-1, VIII-WL-2, IX-WL-2). The average gold concentration in intermediate depth soil samples from wetland sample stations was 0.38 µg/g.

The average total arsenic concentration in the intermediate depth wetland soils exceeded applicable soil quality criteria ($340 \mu g/g$). For similar depth, the total arsenic concentrations were generally lower than those recorded in the outcrop terrain, and higher compared to the forest stations. The average antimony concentrations in the wetland intermediate depth soils were significantly higher compared to the mid-range samples collected in the forest and outcrop soils.

5.1.1.3.3 Deep Samples

Thirty-seven deep soil samples were collected from wetland sample stations (Table 3). The following points summarize the total arsenic, antimony and gold concentrations recorded within the deep wetland samples.

- The total arsenic concentration identified in deep soil samples from wetland sample stations ranged from 3,400 µg/g (Station IV-WL-2) to 4.9 µg/g (Station V-WL-3). The average arsenic concentration in deep soil samples from wetland stations was 198 µg/g.
- The total antimony concentration identified in deep soil samples from wetland sample stations ranged from 1,100 µg/g (Station IV-WL-2) to less than 1.0 µg/g (Stations I-WL-2, II-WL-2, V-WL-2, V-WL-3, VIII-WL-2). The average antimony concentration in deep soil samples from wetland stations was 63.40 µg/g.



The total gold concentration identified in deep soil samples from wetland sample stations ranged from 2 μg/g (Station IV-WL-2) to less than 0.01 μg/g (Stations IV-WL-3, IV-WL-5, V-WL-1, VII-WL-1, VIII-WL-1, VIII-WL-2). The average gold concentration in deep soil samples from wetland stations was 0.09 μg/g.

The maximum total arsenic concentrations in the deep wetland soils were the highest recorded from all terrain types and were greater than the applicable arsenic criteria (340 μ g/g). Antimony concentrations were similarly elevated.

In summary, a total of 21 of the 89 samples submitted for bulk chemical analysis within the wetland terrain contain arsenic concentrations which exceed the applicable soil quality criteria of 340 μ g/g. The average arsenic concentration exceeds the soil quality criteria in shallow wetland soil. Fifteen samples were collected from the shallow soil, four of these samples were collected mid-range depth, and two samples were collected from deep wetland stations. Although elevated, the maximum arsenic and antimony concentrations were low compared to the outcrop and forest terrain samples. The average antimony and gold concentrations in the wetland shallow soils were comparable to both the shallow forest and outcrop soils.



Graph 3: Concentration of Total As (µg/g) in Wetland Stations vs Depth





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Table 4: Bulk Chemistry Maximums based on Depth Ranges

	Outcrop (n=124)			Depth	Forest (n=90)			Depth	Wetland (n=140)		
Depth Ranges	As (µg/g)	Sb (µg/g)	Au (µg/g)	Ranges	As (µg/g)	Sb (µg/g)	Au (µg/g)	Ranges	As (µg/g)	Sb (µg/g)	Au (µg/g)
Shallow (n=107)	17,000	900	3	Shallow (n=35)	1,500	270	4	Shallow (n=52)	3,600	570	48
Mid-Range (n=16)	3,400	45	0	Mid-Range (n=18)	2,800	800	4	Mid-Range (n=28)	1,300	93	1
Deep (n=1)	44	2	0	Deep (n=37)	3,400	1,100	2	Deep (n=60)	290	26	0

Table 5: Bulk Chemistry Minimums based on Depth Ranges

	Outcrop (n=124)			Depth	Forest (n=16)			Depth	Wetland (n=1)			
Depth Ranges	As (µg/g)	Sb (µg/g)	Au (µg/g)	Ranges	As (µg/g)	Sb (µg/g)	Au (µg/g)	Ranges	As (µg/g)	Sb (µg/g)	Au (µg/g)	
Shallow (n=107)	20	1	0	Shallow (n=35)	28	1.0	<0.01	Shallow (n=52)	18	<1	<0.01	
Mid-Range (n=16)	14	3	0	Mid-Range (n=18)	13	<1	<0.01	Mid-Range (n=28)	11	<1	<0.01	
Deep (n=1)	44	2	0	Deep (n=37)	5	<1	<0.01	Deep (n=60)	5	<1	<0.01	

Table 6: Bulk Chemistry Averages based on Depth Ranges

	Outcrop (n=124)			Depth	Forest (n=16)			Depth	Wetland (n=1)		
Depth Ranges	As (µg/g)	Sb (µg/g)	As (µg/g)	Ranges	Sb (µg/g)	Au (µg/g)	Au (µg/g)	Ranges	As (µg/g)	Sb (µg/g)	Au (µg/g)
Shallow (n=107)	1,804.29	57.91	0.22	Shallow (n=35)	463.27	58.24	1.16	Shallow (n=52)	488.29	52.93	0.51
Mid-Range (n=16)	595.25	11.48	0.02	Mid-Range (n=18)	162.54	11.75	0.08	Mid-Range (n=28)	491.61	79.04	0.38
Deep (n=1)	44.00	2.20	0.01	Deep (n=37)	38.89	2.11	0.02	Deep (n=60)	198.53	63.40	0.09



5.1.1.4 Comparison with Current Soil Quality Criteria

The results of the bulk chemistry data has been compared to the current arsenic soil quality criteria. A total of 120 soil samples exceeded the Government of Northwest Territories Remediation Criteria for total arsenic in the Yellowknife Area Soils and Sediment (GNWT 2003) concentration of 340 µg/g for industrial land use purposes (Table 7).

The highest concentrations of total arsenic were recorded in the outcrop soils, with typically lower concentrations recorded in wetland and forest areas. The shallow soil samples typically contained the highest concentrations of total arsenic.

Soil Depth Range	Outcrop	Wetland	Forest	Grand Total	
Shallow	74	15	16	105	
Intermediate Depth	7	4	2	13	
Deep	-	2	-	2	
Grand Total	81	21	18	120	

Table 7: Arsenic Soil Quality Criteria Exceedances

5.1.2 Arsenic Speciation Results

Arsenic speciation testing was completed on a total of 50 samples from 23 sample stations across the Site (Table 8).

Depth Interval	Outcrops	Wetlands	Forest	Grand Total
Shallow	28	8	4	40
Intermediate Depth	3	3	2	8
Deep	-	2	-	2
Total Samples	31	13	6	50
Total Stations	15	5	3	23

Table 8: Classification of Terrain and Sample Depth for Arsenic Speciation Samples

Approximately 70% of the 23 sample stations were dominated by arsenic trioxide, which is particularly prevalent in outcrop terrain and is attributed to Roaster Stack emissions as the source. When arsenopyrite and roaster oxides particles dominated the sample, the source of elevated arsenic was attributed to dust from waste rock and tailings. Approximately 15% of the samples stations were predominantly influenced by waste rock and tailings. The remaining 15% of the stations were influenced by both sources.

Vertical delineation supported by arsenic speciation data was completed at 8 of the 23 sample stations, and 80% of the samples submitted for arsenic speciation testing were collected from the shallow soil zone. The majority of samples (62%) were submitted for arsenic speciation from the outcrop terrain.

A discussion of the arsenic speciation analytical results based on terrain type and depth is provided below. Refer to Tables 9, 10 and 11 for maximum, minimum, and average values of arsenic trioxide grains and arsenopyrite grains based on depth distribution.



5.1.2.1 Outcrop

The majority (90%) of outcrop soil samples were collected from the shallow soil within the outcrop terrain (Table 7). The following discusses the arsenic speciation analytical results based on shallow, intermediate depth, and deep soil profiles in outcrop sample stations. No deep soil samples were collected from the outcrop stations due to local soil conditions, and only three intermediate depth soil samples were collected. Consequently, vertical delineation of arsenic speciation within the outcrop terrain was limited to three stations.

5.1.2.1.1 Shallow Depth Samples

Twenty-eight shallow soil samples collected from outcrop stations were selected for arsenic speciation. The vast majority (90%) of outcrop soil samples submitted for arsenic speciation testing were collected from the shallow soil zone.

Of the 28 samples submitted for arsenic speciation testing, 23 samples (82%) were dominated by grains of arsenic trioxide. The number of arsenic trioxide grains in shallow soil samples from outcrop sample stations ranged from to 1 (Station III-OC-5) to 2,259 (Station II-OC-5). The average number of grains of arsenic trioxide in shallow soil samples from outcrop stations was 211.

No samples collected from the shallow outcrop soil zone were dominated by grains of arsenopyrite.

Three shallow outcrop soil samples contained grains of both arsenic trioxide and arsenopyrite. The number of arsenic trioxide grains in these samples ranged from 437 (Station IX-OC-2) to 1 (Station III-OC-5). The number of arsenopyrite grains in these samples ranged from 256 (Station IX-OC-2) to 0 (Station IX-OC-2).

Two shallow outcrop soil samples contained no grains of arsenic trioxide or arsenopyrite.

5.1.2.1.2 Intermediate Depth Samples

Three intermediate depth soil samples collected from outcrop stations were selected for arsenic speciation. These samples represent 9% of the total number of outcrop soil samples submitted for arsenic speciation testing.

The number of arsenic trioxide grains in intermediate depth soil samples from outcrop stations ranged from 5 (Station IX-OC-4) to 3 (Station VIII-OC-4). The average number of arsenic trioxide grains in shallow soil samples from outcrop stations was 4. One sample (Station II-OC-5) consisted of grains of both arsenic trioxide and arsenopyrite.

A reduction in grain counts was recorded from the shallow to intermediate depth soil zone in the outcrop samples, indicative of the shallow nature of anthropogenic arsenic in the outcrops.

No samples from deep soil profiles from outcrops were submitted for arsenic speciation.

In summary, within the 31 outcrop soil samples submitted for arsenic speciation testing, arsenic trioxide was dominant in 25 samples (80%), with 23 of these samples situated in the shallow soil stratum. Arsenopyrite was measured in low concentrations in the shallow soils, and typically decreased with depth. The number of arsenic trioxide grains in shallow soil samples frequently exceeded 1,000.



5.1.2.2 Forest

Six soil samples collected from forest stations were selected for arsenic speciation (Table 7). Four of these samples were collected from the shallow soil zone. The following discusses the arsenic speciation analytical results based on shallow and intermediate depth soil profiles in forest sample stations. No arsenic speciation testing was completed on the deep soil samples collected from the forest terrain.

5.1.2.2.1 Shallow Depth Samples

Four shallow soil samples collected from forest stations were selected for arsenic speciation. Three of the four samples were dominated by grains of arsenic trioxide. The number of arsenic trioxide grains in shallow soil samples from forest stations ranged from 23 (Station III-F-2) to 947 (Station IV-F-2). The average number of arsenic trioxide grains in shallow soil samples from outcrop stations was 354.

A single soil sample was dominated by grains of arsenopyrite (Station IX-F-4), with 1,647 grains recorded. No samples were dominated by both grains of arsenic trioxide and arsenopyrite.

5.1.2.2.2 Intermediate Depth Samples

Two intermediate depth soil samples collected from forest stations were selected for arsenic speciation. One sample (Station IV-F-2) was dominated by arsenic trioxide grains (260 grains recorded), and the second sample (Station IX-F-4) was dominated by arsenopyrite grains (392 grains recorded).

A reduction in grain counts was recorded from the shallow to mid-range soil zone in the forest samples. This suggests a shallow nature of anthropogenic arsenic in the forest terrain.

No samples from deep soil profiles from forest stations were submitted for arsenic speciation

In summary, arsenic trioxide grains were in moderate abundance (typically 270 grains) in shallow forest soils, and decreased with depth. The number of arsenic trioxide grains in shallow soil samples was less than the outcrop soils. Similar to the outcrop soils, a reduction in arsenic trioxide grain counts was recorded from the shallow to intermediate depth soil zone, which suggests anthropogenic arsenic source in the forest terrain. Three of the four forest soil samples were dominated by grains of arsenic trioxide, and a single soil sample was dominated by grains of arsenopyrite.

5.1.2.3 Wetland

The following discusses arsenic speciation based on shallow, intermediate depth, and deep soil profiles in the wetland stations. Approximately 12% of soil samples were collected from wetland terrain (Table 7). Arsenic speciation testing was completed on soil samples collected from all three soil depth profiles in the wetland terrain.

5.1.2.3.1 Shallow Depth Samples

Eight shallow soil samples collected from wetland stations were selected for arsenic speciation (Table 7). No shallow wetland soil samples were dominated by arsenic trioxide grains. Five samples were dominated by grains of arsenopyrite. The arsenopyrite grain counts ranged from 343 (Station VI-WL-1A) to 60 (Station VI-WL-1B). The average number of grains of arsenopyrite in shallow soil samples from wetland stations was 150. Three samples (obtained from Station III-WL-1) were dominated by both grains of arsenic trioxide (grain counts ranging from 61 to 7) and arsenopyrite (grains counts ranging from 74 to 27).





The lack of abundant arsenic trioxide in the shallow wetland terrain soil is a distinguishing characteristic, and differentiates this terrain from both outcrops and forest areas.

5.1.2.3.2 Intermediate Depth Samples

Three intermediate depth soil samples collected from wetland stations were selected for arsenic speciation testing. No samples were dominated by arsenic trioxide grains. Of the three samples submitted, two samples were dominated by grains of arsenopyrite. The number of arsenopyrite grains in intermediate depth soil samples from wetland stations ranged from 369 (Station IV-WL-2) to 58 (Station V-WL-2). The average number of grains of arsenopyrite in intermediate depth soil samples from wetland stations was 213. One sample (Station V-WL-2) was dominated by 90 grains of arsenopyrite.

5.1.2.3.3 Deep Samples

Two deep soil samples collected from one wetland station (Station IV-WL-2) were selected for arsenic speciation. Both soil samples were dominated by grains of arsenopyrite, indicative of tailing ponds as the arsenic source. The number of arsenopyrite grains in deep soil samples from wetland stations ranged from 1529 to 883.

In summary, within the 13 wetland soil samples submitted for arsenic speciation, arsenic trioxide grains were either not present or were present in very low abundance (i.e., maximum grain count 61). Conversely, arsenopyrite was present in high concentration, and typically increased with depth. The lack of abundant arsenic trioxide in the shallow wetland terrain soil is a distinguishing characteristic, and differentiates wetlands from both outcrops and forest areas.





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Table 9: Arsenic Speciation Maximums based on Depth

Soil Sample Depth	Outcrop (n=31)		Soil	Fores	st (n=6)	Soil	Wetland (n=13)	
	Arsenic Trioxide (Number of grains)	Arsenopyrite (Number of grains)	Sample Depth	Arsenic Trioxide (Number of grains)	Arsenopyrite (Number of grains)	Sample Depth	Arsenic Trioxide (Number of grains)	Arsenopyrite (Number of grains)
Shallow (n=28)	2,259	256	Shallow (n=4)	947	1,647	Shallow (n=8)	61	343
Mid-Range (n=3)	5	1	Mid-Range (n=2)	260	392	Mid-Range (n=3)	6	369
Deep (n=0)	-	-	Deep (n=0)	-	-	Deep (n=2)	48	1,529

Table 10: Arsenic Speciation Minimums Based on Depth

Soil Sample Depth	Outcrop (n=31)		Soil	Fores	st (n=6)	Soil	Wetland (n=13)	
	Arsenic Trioxide (Number of grains)	Arsenopyrite (Number of grains)	Sample Depth	Arsenic Trioxide (Number of grains)	Arsenopyrite (Number of grains)	Sample Depth	Arsenic Trioxide (Number of grains)	Arsenopyrite (Number of grains)
Shallow (n=28)	0	0	Shallow (n=4)	17	0	Shallow (n=8)	0	27
Mid-Range (n=3)	2	0	Mid-Range (n=2)	6	1	Mid-Range (n=3)	0	58
Deep (n=0)	-	-	Deep (n=0)	-	-	Deep (n=2)	7	883

Table 11: Arsenic Speciation Averages Based on Depth

Soil Sample Depth	Outcrop (n=31)		Soil	Fores	t (n=6)	Soil	Wetland (n=13)	
	Arsenic Trioxide (Number of grains)	Arsenopyrite (Number of grains)	Sample Depth	Arsenic Trioxide (Number of grains)	Arsenopyrite (Number of grains)	Sample Depth	Arsenic Trioxide (Number of grains)	Arsenopyrite (Number of grains)
Shallow (n=28)	211.96	12	Shallow (n=4)	270.25	414.5	Shallow (n=8)	11.625	111.75
Mid-Range (n=3)	3.33	0.3333	Mid-Range (n=2)	133	196.5	Mid-Range (n=3)	2	172.33
Deep (n=0)	-	-	Deep (n=0)	-	-	Deep (n=2)	27.5	1,206

5.2 Soil Quality Variation with Lateral Distribution

The correlation between the lateral dispersion of arsenic from the former Roaster Stack source and the results of bulk chemistry/speciation testing is considered presently. The results are considered based on the following distance ranges from the former Roaster Stack:

- 1) "near-source stations": located 0 1 km from the former Roaster Stack;
- 2) "mid-range stations": located 1 2 km from the former Roaster Stack; and
- 3) "distant stations": located greater than 2 km from the former Roaster Stack.

The distribution of bulk chemistry soil quality data based on distance from the former Roaster Stack and terrain type is presented in Table 12.

Distance from Roaster Stack (km)	Outcrop		Wetland		Foi	rest	Total	Total
	Stations	Samples	Stations	Samples	Stations	Samples	Stations	Samples
0 - 1	13	31	8	40	10	48	31	119
1 - 2	21	41	4	20	9	43	34	104
>2	22	53	7	29	9	49	38	131
Total Stations	56	-	19	-	28	-	103	-
Total Samples	-	125	-	89	-	140	-	354

Table 12: Achieved Sample Sizes for Bulk Chemistry by Distance from Roaster Stack and Terrain Type

The distribution of arsenic speciation soil quality data based on both distance from the former Roaster Stack and terrain is presented in Table 13.

Distance To	Outcrop		Wetland		For	est	Total	Total
Roaster Stack (km)	Stations	Samples	Stations	Samples	Stations	Samples	Stations	Samples
0 - 1	8	18	1	4	3	6	12	28
1 - 2	3	7	1	3	-	-	4	10
>2	4	6	3	6	-	-	7	12
Total Stations	15	-	5	-	3	-	23	-
Total Samples	-	31	-	13	-	6	-	50

Samples selected for arsenic speciation were more heavily weighted to the area within 1 km of the Roaster Stack, with 56% of the samples and 52% of the stations selected for arsenic speciation testing situated within this area (Table 8). The majority of samples (62%) were selected from outcrop terrain. No samples were selected for arsenic speciation within the forest areas beyond 1 kilometer (km) from the Roaster Stack.



5.2.1 Near Source Stations (0 to 1 km)

5.2.1.1 Bulk Chemistry Results

A total of 31 sample stations were located within 1 km of the Roaster Stack, and 119 samples (33% of the total) were collected from these stations. A discussion of the bulk chemistry analytical results based on terrain type is provided below. Refer to Tables 14, 15 and 16 for maximum, minimum, and average total arsenic, antimony and gold concentrations based on distance from the Roaster Stack.

5.2.1.1.1 Outcrop

A total of 31 soil samples were collected from 13 sample stations situated within outcrop terrain located within 1 km of the roaster stack. The following points summarize analytical results of total arsenic, antimony, and gold.

- The total arsenic concentration measured within 1 km of the roaster stack ranged from 17,000 µg/g (Station II-OC-5) to 150 µg/g (Station IX-OC-1). The average arsenic concentration on outcrops within 1 km of the Roaster Stack was 4,600 µg/g.
- The total antimony concentration measured on outcrops within 1 km of the roaster stack ranged from 900 μg/g (Station II-OC-5) to 6 μg/g (Station IX-OC-1). The average antimony concentration on outcrops within 1 km of the Roaster Stack was 124 μg/g.
- The total gold concentration measured on outcrops within 1 km of the roaster stack ranged from 3.1 μg/g (Station II-OC-5) to 0.015 μg/g (Station IX-OC-1). The average gold concentration on outcrops within 1 km of the Roaster Stack was 0.50 μg/g.

The highest concentrations of arsenic, antimony and gold in outcrop soil within 1 km of the Roaster Stack were measured south of the Roaster Stack.

5.2.1.1.2 Forest

A total of 48 soil samples were collected from 10 stations situated within forest terrain located within 1 km of the Roaster Stack. The following points summarize analytical results of total arsenic, antimony, and gold.

- The total arsenic concentration measured in forest stations ranged from 3,600 μg/g (Station IX-F-4) to 7.3 μg/g (Station IV-F-1). The average arsenic concentration in forest stations was 474 μg/g.
- The total antimony concentration measured in forest sample stations within 1 km of the Roaster Stack ranged from 570 μg/g (Station IX-F-4) to less than 1 μg/g (Stations II-F-3, IV-F-1, II-F-3, and IV-F-1). The average antimony concentration in forest stations within 1 km of the Roaster Stack was 57.78 μg/g.
- The total gold concentration measured in forest stations within 1 km of the Roaster Stack ranged from 48 μg/g (Station IX-F-4) to less than 0.01 μg/g (Stations II-F-3, III-F-2, IV-F-1, IV-F-2, IX-F-1). The average gold concentration in forest stations was 1.52 μg/g.

The maximum arsenic, antimony, and gold concentrations in forest stations were identified east of the Roaster Stack.



5.2.1.1.3 Wetland

A total of 40 soil samples were collected from eight (8) stations situated within wetland terrain. The following points summarize analytical results of total arsenic, antimony, and gold.

- The total arsenic concentration measured within wetland sample stations within 1 km of the Roaster Stack ranged from 3,400 μg/g (Station IV-WL-2) to 13 μg/g (Station I-WL-2). The average arsenic concentration in wetland sample stations within 1 km of the Roaster Stack was 461 μg/g.
- The total antimony concentration measured within wetland sample stations within 1 km of the Roaster Stack ranged from 1,100 µg/g (Station IV-WL-2) to less than 1 µg/g (Stations IV-WL-5, IV-WL-5, II-WL-2, IX-WL-2, I-WL-2, IV-WL-3). The average antimony concentration in wetland sample stations within 1 km of the Roaster Stack was 123 µg/g.
- The total gold concentration measured within wetland sample stations within 1 km of the Roaster Stack ranged from 2.1 μg/g (Station IV-WL-1) to less than 0.01 μg/g (Stations II-WL-2, IV-WL-3, IV-WL-5, IX-WL-2). The average gold concentration in wetland sample stations within 1 km of the Roaster Stack was 0.42 μg/g.

The maximum arsenic, antimony and gold concentrations in wetlands were located west to northwest of the Site.

5.2.1.1.4 Summary of Bulk Chemistry Results

In summary, bulk chemistry results indicate the following:

- highest concentrations of total arsenic were identified in outcrops;
- lowest concentrations of total arsenic were identified in wetlands; and
- elevated antimony and gold was widespread throughout terrain types within 1 km of the Roaster Stack.

These results suggest Roaster Stack emissions are the dominant anthropogenic influence of soil quality within 1 km of the Roaster Stack.

5.2.1.2 Arsenic Speciation Results

Arsenic speciation testing was completed on a total of 12 stations within 1 km of the Roaster Stack. Arsenic speciation testing was completed on a total of 28 samples within this area. A discussion of the arsenic speciation analytical results based on terrain type is provided below. Refer to Tables 17, 18 and 19 for maximum, minimum, and average values of arsenic trioxide grains and arsenopyrite grains based on distance from the Roaster Stack.

5.2.1.2.1 Outcrop

Eighteen (18) soil samples collected from outcrop stations within 1 km of the Roaster Stack were selected for arsenic speciation analysis. Fourteen (14) samples were dominated by grains of arsenic trioxide. The number of arsenic trioxide grains in outcrop sample stations ranged from 2,259 (Station II-OC-5) to 1 (Station III-OC-5). The average number of grains of arsenic trioxide samples from outcrop stations was 253.

No samples collected from outcrop stations were dominated by grains of arsenopyrite.



Four outcrop soil samples contained grains of both arsenic trioxide and arsenopyrite. The number of arsenic trioxide grains in these samples ranged from 437 (Station IX-OC-2) to 1 (Station III-OC-5). The number of arsenopyrite grains in these samples ranged from 256 (Station IX-OC-2) to 0 (Station IX-OC-2).

5.2.1.2.2 Forest

Six soil samples collected from forest stations were selected for arsenic speciation. Four forest samples were dominated by grains of arsenic trioxide. The number of arsenic trioxide grains ranged from 947 (Station IV-F-2) to 6 (Station III-F-2). The average number of grains of arsenic trioxide from forest stations was 224.

Two soil samples were dominated by grains of arsenopyrite. The arsenopyrite grain counts ranged from 1,647 (Station IX-F-4) to 0 (Station IX-F-4). The average number of grains of arsenopyrite in soil samples from forest stations was 341.

5.2.1.2.3 Wetland

Four soil samples collected from wetland stations were selected for arsenic speciation. No samples were dominated by arsenic trioxide grains; all four samples were dominated by grains of arsenopyrite. The arsenopyrite grain counts ranged from 1,529 (Station IV-WL-2) to 113 (Station IV-WL-2). The average number of grains of arsenopyrite from wetland stations was 723.

5.2.1.2.4 Summary of Arsenic Speciation Results

In summary, the arsenic speciation results indicate the following:

- arsenic trioxide dominates the arsenic composition of outcrop soils, and arsenopyrite was present in several outcrop soil samples;
- the arsenic composition within four of the six forest soil samples was dominated by arsenic trioxide, and the other two samples were dominated by arsenopyrite; and
- arsenopyrite dominates the total arsenic composition of wetland soils.

5.2.2 Mid-Range Stations (1 to 2 km)

5.2.2.1 Bulk Chemistry

A total of 33 stations were located 1 to 2 km from the Roaster Stack. A total of 105 samples (30%) were taken from these locations. A discussion of the analytical results based on terrain type is provided below.

5.2.2.1.1 Outcrop

A total of 42 soil samples were collected form 21 sample stations situated within outcrop terrain. The following points summarize analytical results of total arsenic, antimony, and gold.

- The total arsenic concentration measured within outcrops ranged from 3200 μg/g (Station III-OC-2) to 51 μg/g (Station VIII-OC-2). The average arsenic concentration in outcrop samples was 927 μg/g.
- The total antimony concentration measured within outcrops ranged from 170 µg/g (Station III-OC-2) to 3.5 µg/g (Station VIII-OC-2). The average antimony concentration in outcrop samples was 39 µg/g.
- The total gold concentration measured within outcrops ranged from 0.73 μg/g (Station III-OC-2) to less than 0.01 μg/g (Station VIII-OC-2). The average gold concentration in outcrop samples was 0.15 μg/g.


The maximum arsenic, antimony, and gold concentrations in outcrops were south to southwest of the Roaster Stack. The minimum concentrations were identified northeast of the Roaster Stack.

5.2.2.1.2 Forest

A total of 43 soil samples were collected from 9 sample stations situated within forest terrain. The following points summarize analytical results of total arsenic, antimony, and gold.

- The total arsenic concentration measured within forest sample stations ranged from 510 μg/g (Station IX-F-3) to 5 μg/g (Station II-F-1). The average arsenic concentration in forest samples was 112 μg/g.
- The total antimony concentration measured within forest sample stations ranged from 78 μg/g (Station I-F-2) to less than 1 μg/g (Stations II-F-1, VIII-F-2, VIII-F-3, VIII-F-5, and IX-F-3). The average antimony concentration in forest samples was 16 μg/g.
- The total gold concentration measured within forest sample stations ranged from 0.32 μg/g (Station I-F-2) to less than 0.1 μg/g (Stations I-F-1, I-F-2, II-F-1, VIII-F-1, VIII-F-2, VIII-F-3, VIII-F-4, VIII-F-5, and IX-F-3). The average gold concentration in forest samples was 0.09 μg/g.

The maximum arsenic concentration in forest samples was measured east of the former Roaster Stack. Maximum antimony and gold concentrations were measured southeast of the Roaster Stack.

5.2.2.1.3 Wetland

A total of 20 soil samples were collected from three sample stations situated within wetland terrain. The following points summarize analytical results of total arsenic, antimony, and gold.

- The total arsenic concentration measured within wetland samples ranged from 2700 μg/g (Station III-WL-1) to 6.2 μg/g (Station VIII-WL-2). The average arsenic concentration in wetland samples was 302 μg/g.
- The total antimony concentration measured within wetland sample stations ranged from 470 μg/g (Station III-WL-1) to less than 1 μg/g (Station VIII-WL-2). The average antimony concentration in wetland samples was 55 μg/g.
- The total gold concentration measured within wetland sample stations ranged from 4.4 μg/g (Station III-WL-1) to 0.014 μg/g (Station I-WL-1). The average gold concentration in wetland samples from the Roaster Stack was 0.75 μg/g.

The maximum arsenic, antimony, and gold concentrations for wetlands were located south to southwest of the former Roaster Stack.

5.2.2.1.4 Summary of Bulk Chemistry Results

In summary, bulk chemistry results indicate the following:

- highest concentrations of total arsenic were identified in outcrops;
- lower concentrations of total arsenic were identified in both the forest and wetland terrains; and
- elevated antimony and gold was widespread throughput terrain types between 1 and 2 km from the Roaster Stack.



5.2.2.2 Arsenic Speciation Results

Arsenic speciation testing was completed on a total of four stations within 1 to 2 km from the Roaster Stack. Speciation testing was completed on a total of 10 samples within this area. A discussion of the analytical results based on terrain type is provided below.

5.2.2.2.1 Outcrop

Seven soil samples collected from outcrops stations were selected for arsenic speciation. Six of the samples were dominated by grains of arsenic trioxide. The number of arsenic trioxide grains ranged from 1041 (Station II-OC-9) to 0 (Station II-OC-9). The average number of grains of arsenic trioxide from outcrop stations was 181. One sample (Station II-OC-9) had no grains of either arsenic trioxide or arsenopyrite.

5.2.2.2.2 Forest

No forest sample stations were selected for detailed speciation 1 to 2 km from the Roaster Stack.

5.2.2.2.3 Wetland

Three soil samples collected from wetland station (Station III-WL-1) were selected for arsenic speciation. No samples were dominated by arsenic trioxide grains. All three samples were composed of both grains of arsenic trioxide and arsenopyrite. The number of arsenic trioxide grains ranged from 61 to 7. The number of arsenopyrite grains ranged from 74 to 27.

5.2.2.2.4 Summary of Arsenic Speciation Results

In summary, the arsenic speciation results indicate the following:

- a decrease in the number of arsenic trioxide grains was recorded in the outcrop soils located 1 to 2 km from the former Roaster Stack as compared to the near source stations 0 to 1 km; and
- the arsenic composition of wetland samples was dominated by both arsenic trioxide and arsenopyrite, but the number of grains recorded for both of these minerals was significantly lower as compared to the near Roaster Stack zone.

5.2.3 Distant Stations (>2 km from Roaster Stack)

5.2.3.1 Bulk Chemistry

A total of 130 soil samples (37%) were collected from 39 stations located >2 km from the Roaster Stack. A discussion of the analytical results based on terrain type is provided below.

5.2.3.1.1 Outcrop

A total of 51 soil samples were collected from 22 stations situated within outcrop terrain. The following points summarize analytical results of total arsenic, antimony and gold.

- The total arsenic concentration measured within outcrops ranged from 3600 μg/g (Station V-OC-2) to 14 μg/g (Station VII-OC-8). The average arsenic concentration in outcrops was 413 μg/g.
- The total antimony concentration measured within outcrops ranged from 120 μg/g (Station VI-OC-1) to less than 1.0 μg/g (Station V-OC-2). The average antimony concentration in outcrops was 16.93 μg/g.





The total gold concentration measured within outcrops ranged from 0.39 μg/g (Station VI-OC-5) to less than 0.01 μg/g (Stations V-OC-2, V-OC-4, V-OC-6, VI-OC-2, VI-OC-5, VII-OC-2, VII-OC-3, VII-OC-6, VII-OC-7, VII-OC-9, VIII-OC-1). The average gold concentration in outcrops was 0.06 μg/g.

The maximum arsenic, antimony and gold concentrations were measured northwest of the Roaster Stack.

5.2.3.1.2 Forest

A total of 49 soil samples were collected from 9 sample stations within forest terrain. The following points summarize analytical results of total arsenic, antimony, and gold.

- The total arsenic concentration measured within forest sample stations ranged from 580 μg/g (Station VI-F-3) to 6.3 μg/g (Station VI-F-2). The average arsenic concentration in forest sample stations was 69 μg/g.
- The total antimony concentration measured within forest sample stations ranged from 85 μg/g (Station VI-F-4) to was less than 1.0 μg/g (Stations V-F-1, V-F-2, VI-F-1, VI-F-2, VI-F-3, VI-F-4, VII-F-1, VII-F-2). The average antimony concentration in forest sample stations > 2 km from the Roaster Stack was 14 μg/g.
- The total gold concentration measured within forest sample stations ranged from 0.33 μg/g (Station VII-F-1) to was less than 0.01 μg/g (Stations III-F-1, V-F-1, V-F-2, VI-F-1, VI-F-2, VI-F-3, VI-F-4, VII-F-1, VII-F-2). The average gold concentration in forest sample stations was 0.07 μg/g.

The maximum arsenic, gold and antimony concentrations in forest stations were measured northwest of the Site.

5.2.3.1.3 Wetland

A total of 30 soil samples were collected from three sample stations situated within wetland The following points summarize analytical results of total arsenic, antimony, and gold.

- The total arsenic concentration measured within wetland stations ranged from 1500 μg/g (Station VI-WL 1A) to 4.9 μg/g (Station V-WL-3). The average arsenic concentration in wetland stations was 292 μg/g.
- The total antimony concentration measured within wetland stations ranged from 160 μg/g (Station V-WL-1) to less than 1 μg/g (Stations V-WL-2, V-WL-3, and VIII-WL-1). The average antimony concentration in wetland stations was 18 μg/g.
- The total gold concentration measured within wetland stations ranged from 0.54 μg/g (Station V-WL-1) to less than 0.01 μg/g (Stations V-WL-1, V-WL-3, VI-WL-1B). The average gold concentration in wetland stations was 0.13 μg/g.

The maximum arsenic, antimony, and gold concentration in wetland stations were located northwest of the former Roaster Stack.

5.2.3.1.4 Summary of Bulk Chemistry Results

The bulk chemistry results within the distant zone are lower compared to those recorded within the mid-range zone. Overall, the highest concentrations of total arsenic were identified in outcrops and lower concentrations of total arsenic were identified in both the forest and wetland terrains.



5.2.3.2 Arsenic Speciation Results

Arsenic speciation testing was completed on a total of seven stations greater than 2 km from the Roaster Stack. Speciation testing was completed on a total of 12 samples within this area. A discussion of the analytical results based on terrain type is provided below.

5.2.3.2.1 Outcrop

Six soil samples collected from outcrop stations were selected for arsenic speciation, and five of the samples were dominated by grains of arsenic trioxide. The number of arsenic trioxide grains ranged from 70 (Station II-OC-9) to 0 (Station II-OC-9). The average number of grains of arsenic trioxide from outcrop stations was 20. One sample (Station II-OC-9) had no grains of either arsenic trioxide or arsenopyrite.

5.2.3.2.2 Forest

No forest sample stations were selected for arsenic speciation from sample stations beyond 2 km from the former Roaster Stack.

5.2.3.2.3 Wetland

Six soil samples collected from wetland stations were selected for arsenic speciation. Five soil samples were dominated by grains of arsenopyrite. The number of arsenopyrite grains ranged from 343 (Station VI-WL-1A) to 58 (Station VI-WL-1B). The average number of grains of arsenopyrite from wetland stations was 130.

One sample contained both grains of arsenic trioxide and arsenopyrite. The number of arsenic trioxide grains was six. The number of arsenopyrite grains was 90.

5.2.3.2.4 Summary of Arsenic Speciation Results

In summary, the arsenic speciation results from distant stations indicated the following:

- a decrease in the number of arsenic trioxide grains was recorded in the outcrop soils beyond 2 km from the Roaster Stack, but outcrop samples were still dominated by arsenic trioxide grains; and
- the arsenic in the wetland samples was dominated by arsenopyrite; however, the number of grains recorded was less as compared to the Mid-Range and Near Source Stations.

5.2.4 Summary of Lateral Distribution

There was a pronounced decline in the number of arsenic trioxide grains measured in the shallow soil within the outcrop terrain beyond 1 km from the Roaster Stack. Similar decreases in both arsenic trioxide and arsenopyrite were observed in forest and wetland terrains.





ASSESSMENT OF REGIONAL SOIL QUALITY - GIANT MINE

Distance	Out	crop (n=1	25)	Distance	Fo	rest (n=14	40)	Distance	We	tland (n=	(n=89)	
From Roaster Stack (km)	As (µg/g)	Sb (µg/g)	Au (µg/g)	u From Roaster As /g) Stack (km) (µg/g) (µ		Sb (µg/g)	Au (µg/g)	From Roaster Stack (km)	As (µg/g)	Sb (µg/g)	Au (µg/g)	
0 - 1 (n=31)	17,000	900	3.1	0 - 1 (n=48)	3,600	570	48	0 - 1 (n=40)	3,400	1,100	2.1	
1 - 2 (n=41)	3,200	170	0.73	1 - 2 (n=43)	510	78	0.32	1 - 2 (n=20)	2,700	470	4.4	
>2 (n=53)	3,600	120	0.39	>2 (n=49)	580	85	0.33	>2 (n=29)	120	160	0.54	

Table 14: Bulk Chemistry Maximum Analytical Results Based on Distance from the Stack

Table 15: Bulk Chemistry Minimum Analytical Results Based on Distance from the Stack

Distance	Outo	crop (n=1	25)	Distance	Fo	rest (n=14	10)	Distance From	We	tland (n=	(n=89)	
From Roaster Stack (km)	As (µg/g)	Sb (µg/g)	Au (µg/g)	From Roaster Stack (km)	As (µg/g)	Sb (µg/g)	Au (µg/g)	Roaster Stack (km)	As (µg/g)	Sb (µg/g)	Au (µg/g)	
0 - 1 (n=31)	150	6	0.015	0 - 1 (n=48)	7.3	<1	<0.01	0 - 1 (n=40)	13	<1	0.017	
1 -2 (n=41)	51	3.5	<0.01	1 - 2 (n=43)	5	<1	<0.01	1 -2 (n=20)	6.2	<1	0.014	
>2 (n=53)	14	<1	<0.01	>2 (n=49)	6.3	<1	<0.01	>2 (n=29)	4.9	<1	<1	

Table 16: Bulk Chemistry Average Analytical Results Based on Distance from the Stack

Distance	Outo	rop (n=12	5)	Distance	Foi	rest (n=14	ł0)	Distance From	We	tland (n=8	n=89)	
From Roaster Stack (km)	As (µg/g)	Sb (µg/g)	Au (µg/g)	Roaster Stack (km)	As (µg/g)	Sb (µg/g)	Au (µg/g)	Roaster Stack (km)	As (µg/g)	Sb (µg/g)	Au (µg/g)	
0 - 1 (n=31)	4,600.32	124.58	0.50	0 - 1 (n=48)	474.13	57.78	1.52	0 - 1 (n=40)	461.30	123.68	0.42	
1 - 2 (n=41)	927.38	39.84	0.15	1 - 2 (n=43)	112.78	16.79	0.09	1 - 2 (n=20)	302.88	55.49	0.75	
>2 (n=53)	413.08	16.93	0.06	>2 (n=49)	68.71	13.89	0.07	>2 (n=29)	292.51	17.67	0.13	





	Outcr	op (n=31)		Fore	est (n=6)		١	Wetland (13)
Distance to Roaster Stack (km)	Arsenic Trioxide (Number of grains)	Arsenopyrite (Number of grains)	Distance to Roaster Stack (km)	Arsenic Trioxide (Number of grains)	Arsenopyrite (Number of grains)	Distance to Roaster Stack (km)	Arsenic Trioxide (Number of grains)	Arsenopyrite (Number of grains)
0 - 1 (n=18)	2,259	256	0 - 1 (n=6)	947	1,647	0 - 1 (n=4)	48	1,529
1 - 2 (n=7)	1,041	2	1 - 2 (n=0)	-	-	1 - 2 (n=3)	61	74
>2 (n=6)	70	1	>2 (n=0)	-	-	>2 (n=6)	6	343

Table 17: Arsenic Speciation Maximum Values Based on Distance to Roaster Stack

Table 18: Arsenic Speciation Minimum Values Based on Distance to Roaster Stack

	Outcr	Outcrop (n=31)		Fore	est (n=6)		١	Wetland (13)
Distance to Roaster Stack (km)	Arsenic Trioxide (Number of grains)	Arsenopyrite (Number of grains)	Distance to Roaster Stack (km)	Arsenic Trioxide (Number of grains)	Arsenopyrite (Number of grains)	Distance to Roaster Stack (km)	Arsenic Trioxide (Number of grains)	Arsenopyrite (Number of grains)
0 - 1 (n=18)	1	0	0 - 1 (n=6)	6	0	0 - 1 (n=4)	0	113
1 - 2 (n=7)	0	0	1 - 2 (n=0)	-	-	1 - 2 (n=3)	7	27
>2 (n=6)	0	0	>2 (n=0)	-	-	>2 (n=6)	0	58

Table 19: Arsenic Speciation Averages Based on Distance to Roaster Stack

	Outcr	Outcrop (n=31)		Fore	est (n=6)		١	Wetland (13)
Distance to Roaster Stack (km)	Arsenic Trioxide (Number of grains)	Arsenopyrite (Number of grains)	Distance to Roaster Stack (km)	Arsenic Trioxide (Number of grains)	Arsenopyrite (Number of grains)	Distance to Roaster Stack (km)	Arsenic Trioxide (Number of grains)	Arsenopyrite (Number of grains)
0 - 1 (n=18)	253.11	18.50	0 - 1 (n=6)	224.5	0	0 - 1 (n=4)	14	723.50
1 - 2 (n=7)	181.42	0.42	1 - 2 (n=0)	-	-	1 - 2 (n=3)	27	48.33
>2 (n=6)	19.83	0.16	>2 (n=0)	-	-	>2 (n=6)	2.83	130.66

5.3 Summary of Findings

The vertical and lateral distribution of arsenic in shallow soil across undeveloped areas of the Site has been characterized in the context of three primary terrain types. This assessment confirms that the shallow soil across the entire Site has been impaired by two primary mining-related anthropogenic sources: former Roaster Stack emissions and dust from mine rock and tailings. Arsenic trioxide is associated with Roaster Stack emissions, while arsenopyrite is associated with dust from mine rock and tailings.

Aerial dispersion and transport of both sources has occurred, likely throughout the operating mining period. The results of this assessment confirm the critical importance of depth control during soil sample collection. The highest concentrations of arsenic were recorded in shallow soil, and these concentrations decreased with depth. The overall decrease in concentrations of arsenic with increasing distance from the former Roaster Stack was also confirmed. This vertical and lateral distribution pattern is a <u>primary line of evidence</u> to suggest the presence of anthropogenic arsenic in shallow soil across undisturbed areas of the Site.

The results of arsenic speciation analysis serve as the <u>secondary line of evidence</u> with respect to anthropogenic arsenic. These results provide "forensic" mineralogical evidence of the presence of three primary mining-related constituents in shallow soil: (i) arsenic trioxide; (ii) arsenopyrite; and (iii) roaster oxides. The presence of these minerals/particles at elevated concentrations confirms anthropogenic influence on shallow soil quality.

Differentiating between the potential sources of anthropogenic arsenic is challenging, and subject to interpretation. In most locations, one source (i.e., emissions versus dust) is dominant over the other, and in some locations both are evident.

The abundance of arsenic trioxide grains, with minimal evidence of either arsenopyrite or arsenic sulphide, suggests Roaster Stack deposition. This distribution is common in approximately 70% of the sample stations, and is particularly prevalent in outcrop terrain. Conversely, when arsenopyrite and roaster oxides (typical of tailings) dominate the sample, the source of elevated arsenic is likely attributed to dust from waste rock and tailings. About 15% of the sample stations were predominantly influenced by waste rock and tailings. The remaining 15% of the stations were influenced by both sources.

Vertical delineation of arsenic in soil was assessed based on both bulk chemistry and arsenic speciation data and indicated the following:

- 1) High concentrations of arsenic (primarily consisting of arsenic trioxide) were present in the shallow outcrop soils. The results suggest that these arsenic impaired soils are both wide spread and shallow (typically less than 200 mm in depth).
- 2) High concentrations of arsenic (consisting of both arsenic trioxide and arsenopyrite) were present in the forest areas. Arsenic trioxide was measured at lower concentrations in forest soils compared to the outcrop soils.
- 3) Elevated arsenic (either arsenic trioxide or arsenopyrite) was found in the shallow wetland soil. However, the concentrations of arsenic were significantly lower in the wetland areas and arsenic trioxide was not dominant in the shallow soils.



Lateral delineation of arsenic in soil was assessed based on the potential influence of emissions from the former Roaster Stack. Soil quality data was considered based on geographic distance from the former Roaster Stack (i.e., 0 to 1 km, 1 to 2 km, or greater than 2 km from the stack). Although the majority of the data is from the near source stations, this segregation of data provided evidence to suggest that arsenic concentrations in shallow soil (particularly arsenic trioxide) were decreasing with distance from the former Roaster Stack.

6.0 MINERALOGICAL CHARACTERIZATION

The section summarizes the role of mineralogical characterization, and specifically arsenic speciation using MLA/SEM automated mineralogy methods with respect the overall interpretation of shallow soil quality, and provides recommendations with respect to the future application of this technique.

6.1 Current Assessment

Although arsenic had been historically identified in the shallow soil at the Site, minimal environmental investigation work had been previously completed with respect to shallow soil in the undisturbed areas of the Site. The two staged approach to the current assessment has been previously described in Sections 3 and 4. This assessment was therefore developed to address several key questions (see below). The results of the bulk chemistry testing were used as the primary source of information to respond to Questions 1, 2 and 3. The results of arsenic speciation testing were principally used to respond to Question 4.

1) Are elevated arsenic concentrations present in undistributed areas?

The results of bulk chemistry results confirm that elevated concentrations of total arsenic are present in shallow soil across the entire lease lands. Although the total arsenic concentrations in shallow soil vary significantly, the concentrations are significantly elevated compared to natural background for the Yellowknife area.

2) Do arsenic concentrations in soil vary laterally and vertically?

The bulk chemistry results (total arsenic concentrations) were also used to confirm that that elevated concentrations of arsenic are frequently present in the upper 20 mm of soil. In addition, it was concluded that the elevated concentrations of arsenic are present in within 1 kilometer of the former Roaster Stack, and decrease in concentration with greater distance from the former stack.

3) Do arsenic concentrations in soil vary with terrain type?

The bulk chemistry results were the primary line of evidence to support the conclusion that the elevated concentrations of arsenic (significantly exceeding regional background concentrations) are present within all terrain types, with the total arsenic concentrations concentrated in bedrock crevasses.

4) What is the potential source of arsenic impairment in shallow soil?

MLA/SEM arsenic speciation techniques were successfully used to verify that former Roaster Stack emissions were the primary anthropogenic source of arsenic impairment in shallow soil. The results of the automated mineralogy testing definitively confirmed the presence of arsenic trioxide in shallow soil samples within the undisturbed areas.



The "staged" testing program proved successful in meeting the objectives of the assessment. The bulk chemistry test results provided the primary line of evidence to suggest the presence of anthropogenic arsenic in shallow soil. These results were then reviewed to identify a subset of samples for automated mineralogy testing. This strategy ensured that the selected samples likely had a significant number of arsenic grains available for identification. In addition, the total arsenic concentration from the bulk chemistry testing was used in conjunction with the mineralogical grain counts to "back calculate" the speciated proportions of arsenic in the sample. Automated mineralogy testing was therefore used to supplement the bulk chemistry data, and identify the likely source of arsenic impairment in shallow soil.

6.2 Future Applications

The project is moving into land use planning, risk assessment and remediation phases. Each phase of the project will likely require additional field assessment of soil quality in the undisturbed lands. Future soil quality testing may be considered either "routine" or "specialized".

- "Routine" testing typically involves using conventional commercial methods to obtain chemical and physical soil data. This routine testing is typically economical, and may be completed in short time frames. Routine testing will typically include bulk chemistry testing (ICP/MS) and particle grain size testing.
- "Specialized" testing typically uses university research resources/techniques to address specific scientific issues. This testing is often costly and not completed rapidly (in comparison with commercial labs). Specialized testing will typically include arsenic speciation testing and bioaccessibility testing.

It is anticipated that both categories of soil quality testing may play a role in future assessment work. The following paragraphs discuss future phases of the project and how arsenic speciation testing of soil may potentially be used to support information needs of the project.

6.2.1 Land Use and Risk Management Planning

Future land use alternatives for the undisturbed areas of Giant Mine lease are currently under consideration. It is understood that land use alternatives may include potential residential or recreational activities. Alternatively, significant portions of the undisturbed lands may be isolated from the public.

Although future land use decisions will be made primarily based on consultation with First Nations and the public, decisions will also be informed by both current soil quality data and the outcome of future ecological and human health risk assessment (refer to Section 6.2.2). The level of effort assigned to future assessment of soil quality (including arsenic speciation testing) across the Giant Mine lease will therefore depend on the future land use requirements. For example, land identified for sensitive land use (including future remediation or risk management) will likely require a greater degree of assessment compared to those areas where access may be permanently restricted.

Land use planning decisions within the undisturbed areas will take into account both the bulk chemistry data and arsenic speciation data presented herein. Arsenic speciation data allows the owner to provide important "forensic evidence" which describes not only the presence of total arsenic in shallow soil (determined through bulk chemistry), but confirms the origin, method of transport and potential distribution of arsenic in shallow soil. Arsenic speciation data therefore significantly reduces uncertainty with respect to the interpretation of the soil quality data, and provides a rational explanation of the current soil quality conditions.



Additional soil quality data will likely be needed to inform/assess the economic viability of various land use options. It is anticipated that the future assessment of shallow soil quality will include both bulk chemistry data collection to assess total concentrations of metals, and targeted arsenic speciation testing to confirm the source of arsenic and potentially inform risk assessment or remediation alternatives.

6.2.2 Human Health and Ecological Risk Assessment

It is understood that a regional ecological and human health risk assessment may proceed for the purposes of evaluating the current and future ecological and human health risks within the undisturbed areas on the Giant Mine lease lands. This risk assessment will be supported by a wide range of existing environmental site data.

It is likely that the risk assessment will rely predominantly on the existing bulk chemistry soil quality data, supplemented with existing bioaccessibility testing (Physiologically-based Extraction Testing - PBET) data. Arsenic speciation information will be used to confirm/correlate with the results of the bioaccessibility testing. These two sets of analysis will likely be interpreted in parallel to support the risk assessment.

It is known that mineralogical characterization testing provides insight into particle origin, mineralogical composition, size and texture, and this information may be used to assess human health and ecological risk from both the ingestion and inhalation pathways. The potential requirement for additional arsenic speciation data will be determined by the risk assessment team. The existing arsenic speciation data (described herein) may not likely be sufficient to allow interpretation/prediction of risk.

6.2.3 Site Remediation

It is unknown whether soil remedial work will be undertaken within undisturbed areas of the Giant Mine lease lands. Remedial soil sampling programs intended to support wide-area remediation or management programs must be tailored to provide confidence in soil quality over large areas. Sampling programs must therefore be designed to both provide statistical confidence in the soil quality data, while providing an economical strategy for site characterization.

The collection of soil samples for analysis of total arsenic is the primary tool associated required to complete site characterization. It is possible that field screening methods may be developed to characterize total arsenic concentrations in shallow soil as the remedial program proceeds. It is envisioned that both arsenic speciation testing the bioaccessibility testing will have limited application during the remedial phase of the project.

6.2.4 Risk Communication

The presence of arsenic trioxide in the shallow soil as a result of historical mining and processing activities is well known to local First Nations and the public. It is possible that arsenic speciation testing of soil or dust samples will be required throughout the project for the purposes of communicating the effectiveness of management controls implemented during the remedial program.



6.3 Summary

Automated mineralogy techniques have a specialized role in the characterization of soil at Giant Mine. With respect to the current assessment, automated mineralogy methods have been used in conjunction with the bulk chemistry analytical data to provide the "forensic evidence" necessary to identify the source of environmental impairment in soil. The technique is specialized and should be used in conjunction bulk chemistry data and other specialized analytical methods (e.g. PBET/bioaccessibility testing) to characterize soil.

Future applications of automated mineralogy techniques will be dependent upon ongoing land use planning and risk assessment studies. Automated mineralogy testing requirements will likely continue to be required during these pre-remediation stages of the project. The method is critical for informing land use decisions and providing input to risk assessment. Should confirmation of the source of arsenic impairment be necessary, arsenic speciation testing may be used (in conjunction with other methods) to resolve the issue. Should remedial works be considered in undisturbed areas, it is considered unlikely that the collection of extensive additional automated mineralogy data will be necessary.

7.0 CONCLUSIONS

The following points summarize our conclusions.

- The bulk chemistry results confirm the presence of elevated concentrations of total arsenic in shallow soil within the undisturbed areas of the Site. These elevated concentrations are particularly pronounced in the outcrop terrain. The highest concentrations were recorded in the outcrop terrain less than 1 km from the former Roaster Stack. The majority of soil samples submitted for bulk chemistry analysis recorded concentrations of total arsenic below the current soil quality criteria (Section 5.1.1.4).
- Soil samples selected for arsenic speciation were based on the bulk chemistry data. Samples containing total arsenic concentrations greater than 500 µg/g were identified as potential candidates for arsenic speciation testing (Section 4.2.3.1). Consequently, the arsenic speciation results should be interpreted based on this sample selection criteria. The arsenic speciation results indicate that the former Roaster Stack is the primary source of the anthropogenic arsenic in the shallow soils on the Site. Arsenic trioxide derived from stack emissions is present as either the most or second-most abundant form of arsenic in over 85% (i.e., 70% primary and 15% secondary) of the 50 soil samples assessed using arsenic speciation techniques. Arsenopyrite derived from waste rock and tailings was present as the most or second-most abundant form of arsenic in over 30% (i.e., 15% primary and 15% secondary) of the 50 soil samples examined for arsenic speciation.
- The present results provide irrefutable mineralogical evidence of the presence of three primary mining-related constituents in shallow soil at the Site: (i) arsenic trioxide; (ii) arsenopyrite; and (iii) roaster oxides. The presence of these constituents at elevated concentrations confirms anthropogenic influence on regional shallow soil quality. The quantity of arsenic trioxide/arsenopyrite/roaster oxide grains typically decreased with depth.
- The dominant abundance of arsenic trioxide grains, with minimal evidence of either arsenopyrite or arsenic sulphide suggests Roaster Stack deposition. It is acknowledged that the selection of samples for arsenic speciation testing was biased with samples containing higher total arsenic concentrations (above 500 μg/g).



- The primary or secondary abundance of arsenic trioxide is evident in outcrop samples across the entire Site. Elevated concentrations of arsenic trioxide are particularly pronounced in the outcrop terrain less than 1 km from the former Roaster Stack. Conversely, a significant decline in the number of arsenic trioxide grains present in shallow soil was recorded beyond 1 km from the former Roaster Stack. With one exception, no samples contained greater than 100 grains of arsenic trioxide when located greater than 1 km from the Roaster Stack.
- Elevated concentrations of arsenic trioxide in the shallow soil will require a remediation or risk management strategy to avoid potential exposure in the future should areas of the Site become accessible to the public. Any active remediation program should consider what actions may be required to protect workers from potential exposure during the execution of the program.
- Future application of automated mineralogy techniques will be dependent upon ongoing land use planning and risk assessment studies. Automated mineralogy testing will likely continue to be required during the pre-remediation stages of the project. The method is important for informing land use decisions and providing input to risk assessment. Should remedial works be considered in undisturbed areas, it is considered unlikely that the collection of extensive additional automated mineralogy data will be necessary.

The following points summarize our recommendations.

- The existing data should be reviewed in the context of both land use planning and human health/ ecological risk. The application of the current soil quality guideline for total arsenic should be reviewed in the context of the bulk chemistry and arsenic speciation data presented herein.
- The potential presence of arsenic trioxide within the developed areas of the Site should be assessed. The appropriate level of PPE for workers should be established based on the results of this assessment.



8.0 LIMITATIONS

This report was prepared for the exclusive use of AECOM Canada Ltd. and Public Works and Government Services Canada. The report, which specifically includes all tables, figures, and appendices, is based on data and information collected during the Site activities conducted by Golder Associates Ltd. and is based solely on the conditions of the property at the time of the Site field program and data obtained by Golder Associates Ltd. as described in this report.

The services performed as described in this report were conducted in a manner consistent with that level of care and skill normally exercised by other members of the engineering and science professions currently practicing under similar conditions.

Any use which a third party makes of this report, or any reliance on, or decisions to be made based on it, are the responsibilities of such third parties. Golder Associates Ltd. accepts no responsibility for damages, if any, suffered by any third party as a result of decisions made or actions based on this report.

The content of this report is based on information collected during our assessment, our present understanding of the Site conditions, and our professional judgement in light of such information at the time of this report. This report provides a professional opinion and therefore no warranty is either expressed, implied, or made as to the conclusions, advice and recommendations offered in this report. This report does not provide a legal opinion regarding compliance with applicable laws. With respect to regulatory compliance issues, it should be noted that regulatory statutes and the interpretation of regulatory statues are subject to change. The findings and conclusions of this report are valid only as of the date of this report. If new information is discovered in future work, including excavations, borings, or other studies, Golder Associates Ltd. should be requested to re-evaluate the conclusions of this report, and to provide amendments as required.





9.0 CLOSURE

We trust the above meets your present requirements. If you have any questions or require additional details, please contact the undersigned.

Sincerely,

GOLDER ASSOCIATES LTD.

Diana Yo

Diana Young, B.Sc., A.I.T. Environmental Scientist

Arthur Cole, P.Eng. Principal, Senior Environmental Engineer



DY/AC/sb

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FIGURES

Figure 1: Regional Soil Sample Locations
Figure 2: Regional Soil Sample Locations by Terrain Type
Figure 3: Regional Soil Samples Submitted for Speciation
Figure 4: Regional Soil Samples Vertically Deliniated
Figure 5: Regional Soil Sample Locations with Arsenic Lab Results (1 of 3)
Figure 6: Regional Soil Sample Locations with Arsenic Lab Results (2 of 3)
Figure 7: Regional Soil Sample Locations with Arsenic Lab

Figure 7: Regional Soil Sample Locations with Arsenic Lab Results (3 of 3)







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	PWGSC Project Manager/Administrateur de Projets TPSGC CHRIS DOUPE PWGSC, Architectural and Engineering Resources Manager/
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	REGIONAL SOIL SAMPLE LOCATIONS BY TERRAIN TYPE
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	PWGSC Project Manager/Administrateur de Projets TPSGC CHRIS DOUPE
	PWGSC, Architectural and Engineering Resources Manager/ Ressources Architectural et de Directeur d'Ingénierie, TPSGC
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LEGEND

- REGIONAL SOIL SAMPLE LOCATION
 LEASE BOUNDARY
 ROASTER STACK
- NOTES
- 1. ALL UNITS ARE IN METRES UNLESS OTHERWISE GMRP COORDINATE SYSTEM.

REFERENCES

1. AERIAL PHOTO DATED 2009, PROVIDED BY PUB CANADA

GOLDER SITE		10 (cm) 5
	5	15
I-F-1	15	30
	60	100
	0	5
I-F-2	5	<u>15</u> 30
112	30	60
	60	100
	5	<u> </u>
II-F-1	15	30
	30	60
	0	5
	5	15
11-F-2	30	<u> </u>
	60	100
	0	<u> </u>
II-F-3	15	30
	30	60
	0	<u> </u>
III-F-1	5	15
	<u> </u>	30
	0	5
וו_ב ס	5 1 E	15
111-F-2	30	55
	55	100
I-0C-1	<u> </u>	5 15
I-0C-2	2	7
I-OC-3	2	5
II-OC-1	5	10
II-OC-10	0	5
	0	<u> </u>
11-0C-11	5	10
II-OC-2	<u> </u>	10
II-OC-3	0	5
	5	<u> </u>
II-OC-4	5	15
	15	20
II-OC-5	3	10
	10	20
II-OC-6		<u> </u>
	15	20
II-OC-7	<u> </u>	<u> 10</u> 16
II_OC_8	0	12
n=0€*0	12	15
II-OC-9	3	10
	10	15
III-OC-1	5	5 15
III-0C-2	0	8
	8 0	<u>15</u> 5
III-OC-3	5	9
III-OC-5	0	5
	0	5
	5	9
III-OC-7	5	10
III-OC-8	0	5
	5	3
IX-OC-2	3	10
	10	25 5
IX-OC-3	5	10
	0 E	5
I-WL-1	15	30
	30	60
	0	<u> </u>
	5	15
I-WL-2	15 30	<u>30</u>
	60	100
	0	5
II-WL-2	15	30
	30	60
	60 0	<u>100</u>
	5	15
III-WL-1	15 २०	<u>30</u>
	60	100

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1. ALL UNITS ARE IN METRES UNLESS OTHERWISE NOTED. COORDINATE SYSTEM IS THE GMRP COORDINATE SYSTEM.

REFERENCES

1. AERIAL PHOTO DATED 2009, PROVIDED BY PUB CANADA

GOLDER SITE	FROM (cm)	TO (cm)	As (ug/g)
	0	5	540
	5	15	140
IV-F-1	15	30	51
	30	60	25
	60	100	/.3
-	<u> </u>	5	1700
11/52	<u> </u>	20	1300
IV-F-Z	20	<u> </u>	17
-	<u> </u>	100	1/
	0	5	770
IV-E-30	5	15	2500
10-1-54	15	35	300
	0	5	1300
-	5	15	130
IV-F-3B	15	30	170
	30	60	36
ľ	60	100	21
	0	5	250
	5	15	66
V-F-1	15	30	23
	30	50	9.1
	50	100	7.7
	0	5	94
	5	20	43
VII-F-1	20	30	32
[30	60	13
	60	100	8.7
	0	5	80
	5	15	100
VIII-F-1	15	30	55
ļ	30	60	
	60		10
ŀ	<u> </u>	5 15	540
VIII-F-2	<u> </u>	20	
ŀ	20	<u> </u>	
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ł	<u></u>	15	220
VIII-F-3	15	30	10
ŀ	<u></u>	60	1/
	<u> </u>	5	80
	<u> </u>	15	76
VIII-F-4	15	30	71
•••••	30	60	40
ł	60	90	23
	0	5	110
	5	15	64
VIII-F-5	15	30	13
	30	60	8.3
	60	100	7.3
	0	5	2400
ľ	5	15	300
IX-F-1	15	30	180
	30	55	290
	55	100	21
	0	5	930
IX-F-7	5	15	730
I/T I [−] Z	15	30	220
	30	45	53
	0	5	510
	5	15	/3
IX-F-3	15	30	59
ļ	30	60	28
	60	100	
-	<u> </u>	5 15	240
ŀ	<u>5</u> 15	20	5000
IX-F-4	20	<u> </u>	190
ŀ	<u> </u>		100
ł		100	40
	<u></u>	100	7000
IV-OC-1	<u> </u>	10	5400
	0	5	840
IV-OC-2	<u> </u>	10	810
	<u> </u>	5	1100
IV-OC-3	<u> </u>	15	580
	<u> </u>	5	4800
IV-OC-4	5	12	5100
	5		3100



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GOLDER SITE	FROM (cm)	TO (cm)	As (µg/g)
V-0C-1	0	5	1400
	5	15	570
V-OC-5	5	10	310
VII-OC-5	0	5	230
VII-OC-6	0	5	160
	5	10	150
VII-OC-7	5		120
	0	5	170
VIII-0C-1	5	10	20
	0	5	190
VIII-OC-2	5	$\frac{10}{20}$	51
		<u> </u>	940
VIII-OC-3	5	10	190
VIII-OC-4	0	5	840
	5	20	370
VIII-OC-5	10	10	330
	0	5	380
VIII-OC-6	5	10	280
IX-OC-1	0	5	2500
	5		150
	6	<u> </u>	1100
	15	20	1200
	0	7	920
11-00-5	7	15	1100
	<u> </u>	<u> </u>	1100
IV-WI-1	15	30	94
	30	60	120
	60	100	57
	0	5	210
	5	20	1000
	30	<u> </u>	3400
	60	100	1800
	0	5	67
	5	15	130
IV-VVL-3	30	<u> </u>	70
	60	100	38
	0	5	260
	5	15	210
IV-WL-4	15	30	140
	<u> </u>	100	160
	0	5	330
	5	15	210
IV-WL-5	15	30	200
	<u> </u>	6U 100	30
	0	5	810
	5	15	190
V-WL-1	15	30	120
	30	60	50
	00	5	<u> </u>
	5	15	32
VIII-WL-1	15	30	40
	30	60	23
	60	100	6.4 11
	5	15	18
VIII-WL-2	15	30	11
	30	60	7.3
	60	100	6.2
		5	1500
IX-WL-1	15	30	220
	30	60	150
	60	100	120
	0	5	700
Y_\\/I_2	5 15	30	110
	30	60	19
	60	100	29

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NOTES

1. ALL UNITS ARE IN METRES UNLESS OTHERWIS GMRP COORDINATE SYSTEM.

REFERENCES

1. AERIAL PHOTO DATED 2009, PROVIDED BY PU CANADA AND BASE IMAGE © 2015 OBTAINED F LICENSE. IMAGERY DATE 7-28-2013. GOOGLE E

GOLDER SITE	FROM (cm)	TO (cm)
	0 10	<u>10</u> 20
V-F-2	20	50
V-F-2	50	80
	80	90
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	5	20
VI-F-1	20	<u> </u>
	60	90
	0	5
	<u> </u>	30
VI-F-2	30	50
	50	60
	80	80
	0	5
	5	15
VI-F-3	25	45
	45	55
	55	80
	5	10
VI-F-4	10	30
	<u> </u>	<u> </u>
	0	5
	5	15
VII-F-2	30	<u> </u>
	60	70
	70	100
	5	<u> </u>
V-0C-2	15	25
	25	35
V-OC-3	5	15
	15	25
V-0C-4	0	<u> </u>
V-0C-4	15	30
V-OC-6	0	5
	<u> </u>	<u> </u>
VI-OC-1	5	15
VI-OC-2	0	5
<u> </u>	0	5
VI-UC-3	5	10
VI-OC-4	<u> </u>	<u> </u>
	Ő	5
VI-OC-5	5	10
	0	5
VII-OC-1	5	10
	10	35
VII-OC-2	5	15
VII-OC-3	0	5
	5 0	<u>15</u> 5
VII-OC-4	5	10
	0	5
VII-UC-8	5 15	25
	0	5
VII-OC-9	5	15
	0	5
V/ V/ / •	5	20
V-WL-2	20 40	40
	70	100
	0	10
V-WL-3	10 50	50 80
	80	100
VI-WL-1A	0	5
	<u>5</u>	10
	5	<u>1</u> 0
VI-WL-1B	10	30
	<u> </u>	60 80
	0	10
VII-WL-1	10	30
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APPENDIX A

Queen's University Final Report





Queen's University Kingston, Ontario, Canada K7L 3N6 (T) 613-533-2597 (F) 613-533-6592

FINAL REPORT:

CHARACTERIZATION OF SOIL SAMPLES AT GIANT MINE, NWT

Submitted to:

Giant Mine Soils Group, Golder Associates 16820 - 107 Avenue Edmonton, Alberta Canada T5P 4C3

Written and compiled by:

Mackenzie Bromstad

Tyler Nash

Agatha Dobosz

Heather E. Jamieson

February 6, 2015

Executive Summary

A suite of 359 soil samples was collected on the Giant mine property at a total of 104 outcrop, forest, and wetland soil sample sites by Golder Associates in September and October 2014. The samples were sent to the Jamieson Research Group at Queen's University for 30-element, carbon, and gold analysis, and arsenic (As) speciation using scanning electron microscope with Mineral Liberation Analyser software (SEM-MLA). Total elemental analysis by ICP-OES and ICP-MS following *aqua regia* digestion indicate that the total As concentrations range from 4.9 μ g/g to 17,000 μ g/g, 120 samples have As concentrations greater than 340 μ g/g, and 3 samples have As concentrations greater than 10,000 μ g/g As (1 % As). All samples with As greater than 3600 μ g/g come from outcrop soil sites. At most sites where depth stratified samples were taken, As concentrations decrease sharply with depth. Most As concentrations greater than 1000 μ g/g came from samples located <20 cm from the surface, and all samples with As concentrations greater than 3600 μ g/g came from samples located <10 cm from the surface.

A subset of 50 samples from 23 sites were selected for As speciation. Selection criteria favored samples with high As concentrations, samples from adjacent depth strata at selected sites, representatives of all soil site types, and samples that covered most of the area of the Giant mine lease. Arsenic trioxide was observed at all sites in this subset. The As-hosting species identified included As₂O₃, arsenopyrite, arsenic sulfide (likely realgar), roaster-generated iron oxides, iron-arsenic-bearing rims on pyrite and other sulfides, and Fe oxides with As, organics with As, Fe-As-Mn/Ca oxides, and Al-Mn-Fe-As oxide phases. A further subset of 24 samples, which contained more than 100 grains of either As₂O₃, arsenopyrite, or As-sulfide, and/or high total As concentrations (usually above $3000 \ \mu g/g$), were used to calculate the distribution of As between the various As-hosting species. For this calculation, three different values (0.1, 1 and 5%) were assumed for the As concentration in the weathering products (the organics and the Fe oxides with As and \pm Ca, Mn and Al) since these phases remain incompletely characterized.

A detailed discussion of QA/QC for all analytical methods is included in the report. Sample heterogeneity with respect to total As concentration and distribution of As species is clear at the macro and micro scale. Accordingly, some of the quantitative results in this report, including the distribution of As species, need to be used cautiously.

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1.Introduction

1.1 Purpose

Decades of processing gold ore containing arsenic (As) at Giant Mine, located near Yellowknife, NT, has resulted in significant anthropogenic arsenic contamination around the mine site, much of it in the form of arsenic trioxide (As₂O₃). The Giant Mine Remediation Plan dictates the removal and disposal of arsenic contaminated soils (INAC 2007); however, the geographic extent of anthropogenic arsenic contamination on the Giant lease must be more fully understood for remediation of soils to take place. The Giant Mine Soils team from the Golder Associates Edmonton office contracted researchers at Queen's University (Kingston) to characterize and quantify anthropogenic arsenic contamination in soil samples from across the Giant Mine property.

To help clarify the extent (both surface area and depth) of As-effected soils and to separate anthropogenic As from naturally occurring As, bulk chemical analysis and detailed quantifiable analysis of As hosts via Scanning Electron Microscope (SEM) and Mineral Liberation Analysis (MLA) software were carried out on a set of depth-stratified soil samples from across the Giant Mine lease.

1.2 Background

1.2.1 The As legacy at Giant Mine

Giant Mine operated from 1948 to 2004. The most common As-bearing mineral on earth, arsenopyrite (FeAsS), was also the most common host of refractory gold (Au) at Giant Mine. Most of the gold mined at Giant was incorporated submicroscopically within the structure of arsenopyrite and to a lesser extent pyrite (FeS2), with only a small proportion occurring as free gold. Cyanide leaching is usually used to extract gold from ore, but due to the refractory nature of the gold at Giant an additional step, roasting, was necessary for gold liberation. Roasting oxidizes the gold-bearing arsenopyrite, converting it into a porous iron (Fe) oxide that can then undergo traditional gold extraction processes. Roasting oxidized the As(-I) in arsenopyrite to As(III) as shown in Equation 1.1:

$$2\text{FeAsS} + 5\text{O}_2 \rightarrow \text{Fe}_2\text{O}_3 + \text{As}_2\text{O}_3 + 2\text{SO}_2 \quad \textbf{(1.1)}$$

This resulted in As precipitating from roasting vapors as arsenic trioxide (As₂O₃), which is both highly soluble and one of the most toxic forms of As to humans. Ore was roasted at Giant from 1949 to 1999 (Walker *et. al.* 2015, Bromstad and Jamieson 2012).

Arsenic vapors from roasting were originally allowed to vent freely into the atmosphere. However, various environmental concerns and the 1950s deaths of between two and four children from ingesting As₂O₃ contaminated snow (Hutchinson *et al.* 1982, Leffler and Fionda 2014, Sinclair 1951) spurred the implementation and subsequent improvements in roaster dust capture technology. In 1951, the first generation of As-capturing technology was implemented, a Cottrell electrostatic precipitator (ESP). The ESP captured a portion of the As-rich dusts emitted by the roaster; ESP dusts contained approximately 60% As,

of which approximately 80% was As₂O₃. Arsenic in roaster dust was also present as a mixed As(III) and As(V) form in roaster-generated porous iron oxides (mostly maghemite) (Bromstad and Jamieson 2012).

Altogether 237,000 tonnes of captured ESP dust were stored underground at Giant in a combination of purpose-built chambers and old stopes. Permafrost was originally meant to keep the ESP dust from interacting with mine and ground waters and possibly dissolving, though clear evidence of its retreat was present by the 1970s. Some ineffectual efforts to pump cold air through the chambers and reinstate the permafrost happened in the 1980s. The bulk of the Giant Mine Remediation Plan deals with the problem of the underground As₂O₃-rich dust and the specifics of the current plan to freeze it *in situ* and monitor it in perpetuity (Bromstad and Jamieson 2012).

However, approximately 20,000 tonnes of As-rich roaster dusts were emitted from the roaster at Giant from 1949-1999, despite ESP capture technology (Wrye 2008). While As-rich roaster dusts were emitted throughout the entire lifetime of roasting (1949-1999), due to changes in dust capture technology over time, 84% of total roaster As emissions occurred before 1964. Sulfur dioxide (SO₂) emissions were never controlled (Bromstad 2008).

1.2.2 Physiographic and geologic setting

Giant Mine is located approximately 5km north of Yellowknife, NT (see Figure 1.1). The gold deposit at Giant Mine occurs in schist and shear zones with quartz-carbonate veining within an Archaean-age greenstone belt. Gold within the deposit occurs primarily as a refractory phase in arsenopyrite, and to a lesser extent in pyrite. Free gold did not make up the bulk of the deposit (Canam 2006).

Giant Mine lies within a zone of discontinuous permafrost and the most prevalent sediment in the area is glacial till. Organic deposits often overlie glacio-lacustrine till, remnants of the approximately 80m of water in glacial Lake McConnell overlying the Yellowknife area 10,000 years ago. Wetlands often occur in low-lying areas and outcropping rock is very common in the Yellowknife area, with up to 75% of some areas consisting of outcrop (Bromstad and Jamieson 2012). It has been estimated that approximately 30% of the Giant Mine lease is covered in outcrop (Wrye 2008).

Prevailing wind direction in the Yellowknife area is from the east and south, secondarily from the north. Historic SO₂ emissions have left much of the outcrop at Giant within the dominant wind directions of the roaster denuded of lichen and some vegetation. Existing vegetation on outcrops is confined to outcrop crevices. Areas with more soil maintain scrub forest, and/or wetlands. Most soils have near-neutral pH. The climate is cool and dry, with an average temperature range of -50°C to 32°C, an average yearly temperature of -4.5°C, and more annual evaporation than precipitation (Bromstad and Jamieson 2012).

1.2.3 History of mining, processing, and waste management at Giant

Floatation-produced sulfide concentrate was roasted from 1949-1999 at a relatively low temperature (500°C), in air-deficient conditions. From 1951 to 1999, a portion of As₂O₃ in roaster emissions was captured via ESP and baghouse and stored underground. Tailings, consisting of a mixture of floatation waste and calcine, were discharged directly into Yellowknife Bay for the first two years of operations. Thereafter, tailings were deposited in several former lakes; later on tailings dams and impoundments were built, and tailings were also used as backfill in mine workings between the 1950s and 1970s. Before implementation of sedimentation controls, fine tailings in significant amounts, including calcine and ESP dust, often flowed over

tailings dams during freshet. These tailings were deposited at the upper end of Baker Pond. Water treatment to remove As started in 1957. A pond for calcine waste was built on a clay deposit and used for 3 months in the early 1950s before plans to re-process the calcine for gold were abandoned and the calcine pond covered in clay, composted manure, and later soil from a surface pit on the mine site (Bromstad and Jamieson 2012).

Following the original Giant Mine claims staking in 1935, several different owners operated Giant Mine between 1949 and 1999, when it went into receivership. Property control was then transferred from Royal Oak Mines, Inc., to the Canadian government. Miramar Giant Mines Ltd. purchased Giant Mine from the Department of Indian Affairs and Northern Development (DIAND) under an agreement "indemnifying Miramar for existing environmental liabilities at Giant Mine" (p. 28, Bromstad and Jamieson 2012). Miramar operated Giant at a reduced scale, trucking ore to nearby Con Mine for processing, until 2004. When Miramar was declared bankrupt in 2006 DIAND took over management of the site (Bromstad and Jamieson 2012).

1.2.4 Anthropogenic As in Giant Mine soils

Regardless of the presence of anthropogenic As contamination, arsenopyrite and its weathering products can host naturally occurring As in soils around Giant Mine. This is due to locally heightened levels of arsenopyrite in some of the underlying bedrocks hosting the gold deposit at Giant Mine (Kerr 2001). Average As content in soils worldwide is approximately 5.5 mg/kg, and 6.6 mg/ kg in Canada (Reimann et al. 2009). A background As level of 10 mg/kg was used to determine the Canadian Council for the Ministers of the Environment (CCME)'s industrial soils guideline of 12 mg/kg As (CCME 2007). In the Yellowknife area, naturally high levels of total arsenic in selected samples, and the observation that exposure would be limited by harsh winters led to a local background level of 150 mg/kg being declared. The sitespecific Government of the Northwest Territories (GNWT) remediation guideline of 340 mg/kg at Giant Mine is based on



Figure 1.1: Giant Mine location. Topographic data from Government of Canada (2009).

this number (Risklogic 2002; GNWT 2003). It is not known whether the samples used to establish a background value were influenced by roaster emissions since the sampling and these guidelines were published before the pervasive and persistent presence of As₂O₃ in the soils had been recognized.

At the time of the writing of the Giant Mine Remediation Plan, certain soils located near mining operations at Giant Mine were known to be contaminated from a multitude of anthropogenic sources, including waste rock, tailings, calcine residue, ESP dust, and aerial roaster emissions (Bromstad and Jamieson 2012). The effect of aerial roaster emissions on soils more removed from day-to-day mining operations was largely thought to have been negated by time; with most aerial emissions occurring prior to 1964 and knowing how soluble reagent grade As₂O₃ is, anthropogenic As was not expected to be present in soils more physically removed from mining operations (Bromstad 2011).

However, the work of Wrye (2008) and Bromstad (2011) unequivocally shows that roastergenerated As_2O_3 is still present in significant amounts in Giant Mine soils. Studies from other locations show As_2O_3 used in the 1950s and 1960s as a pesticide and herbicide in soils oxidizes from As(III) to As(V) and adsorbs to organic matter and Fe/Al oxyhydroxides in the long term. Additional soil column studies have shown that initial perseverance of As_2O_3 due to reaction kinetics does not affect the long term dissolution and oxidation of As_2O_3 to As(V) (Yue and Donahoe 2009, Qi and Donahoe 2008). There is evidence from Wrye (2008) and Meunier *et al.* (2011) showing that some As in Giant Mine soils is hosted as a weakly adsorbed phase on organic matter and other phases as As(V); this suggests that the dissolution and oxidation of As_2O_3 at Giant is happening, but at a slower than anticipated rate (Bromstad 2011).

1.2.4.1 Arsenic trioxide residence time

Possible dissolution textures on As₂O₃ grains observed by Wrye (2008) and Bromstad (2011), as well as elevated As concentrations in co-existing soil waters, indicate that As₂O₃ in Giant soils has changed somewhat over time. Experimental data showing As₂O₃ at Giant to be slightly less soluble than reagent grade As₂O₃, possibly due to antimony (Sb) content, in concert with the extended cold climate of Yellowknife likely play a role in explaining this phenomenon. The sub-arctic climate of Yellowknife leaves only a limited window of time each year when surface temperatures are above freezing (Bromstad 2011).

Due to the soluble nature of As₂O₃, and the decades of time elapsed since the bulk of roaster emissions, it was not initially clear from what era the bulk of the As₂O₃ found in soils by Wrye (2008) hailed from. ESP dust before and after 1964 shows clear differences in relative concentrations of As, Sb, and Au in roaster emissions. Qualitatively speaking, emissions pre-1964 contained less As, slightly less Sb, and more Au than later emissions. These changes were due to updates in efficiency technology and a change in ore chemistry. Bromstad (2011) showed that correlations amongst these elements in outcrop soils indicate that a clear signature of pre-1964 ESP dust still exists in soils at Giant Mine, regardless of the total proportion still present as As₂O₃.

1.2.4.2 The effects of geography, topography, and soil depth on As concentration

Roaster-generated As remaining in soils at Giant Mine appears to correlate with dominant wind directions relative to the roaster. In addition, high anthropogenic As concentrations have been documented in soil pockets occurring in small rock outcrop hollows. Arsenic likely accumulates in outcrop soils due to a combination of the "wash-down effect" sweeping As deposited aerially on rock outcrop surfaces into outcrop

hollows filled with soil, and the often restrictive topography of the outcrop soil hollows permitting very little material from leaving the hollow during rainfall or freshet (Bromstad 2011, Wrye 2008). The increased likelihood of outcrop soils within dominant wind directions of the roaster to have high As concentrations does not mean that soil samples from lower-lying areas are less likely to have high As concentrations. It merely means that non-outcrop soils do not necessarily have the extra input from wash-down and the concentrative effect of restrictive topography. Outcrop soils are often very shallow in depth, meaning there is less potential for As concentration dilution by spreading throughout the soil than there is for very deep soils. Additionally, outcrop soils effected by roaster emissions are often denuded due to SO2 emissions, and have less tree cover in general than lower-lying areas, which could affect the amount and uniformity of roaster-derived As that reaches soils (Bromstad 2011).

Information from soil cores at Giant taken by Wrye (2008) and Bromstad (2011) targeting roasteremitted As indicate that the top, usually organic-rich soil horizons are most likely to have As concentrations elevated above those in deeper samples. This could indicate that most trowel, non-depth stratified outcrop soil samples collected by Wrye (2008) and Bromstad (2011) are potentially diluting As concentrations by incorporating deeper, low-As soil with the very near-surface material.

1.2.4.3 Arsenic hosts in Giant Mine soils and distinguishing their provenance

The following As hosts have been identified in soils at Giant Mine (Wrye 2008, Bromstad 2011, Meunier *et al.* 2011):

- Arsenic trioxide
- Roaster-derived iron oxides (ROs) (in Giant tailings, As in ROs was measured as <1wt% to 8 wt% As (Walker *et al.* 2005))
- Arsenian Fe oxide/oxyhydroxide rims on pyrite grains
- Arsenopyrite
- Arsenic-bearing iron oxides or oxyhydroxides of unclear provenance
- Organics and potentially iron or aluminum oxides/oxyhydroxides with As adsorbed to them

Both arsenopyrite and As_2O_3 are referred to as primary As hosts in this report, while other As hosts likely related to weathering of As_2O_3 and arsenopyrite are referred to as secondary As hosts.

Distinguishing anthropogenic and natural As is possible to a certain degree, based on mineral form, texture, and knowledge of overall As concentrations. Arsenic occurring as As₂O₃ or in roaster iron oxides is anthropogenic. The main criteria separating roaster-generated iron oxides from other weathering generated iron oxides is their characteristic spongy or concentrically zoned textures. Weathering products containing As could potentially contain both natural and anthropogenic As, but it is worth noting that the large number of soil sites with As concentrations well above accepted background level, even accounting for potential arsenopyrite mineralized bedrock, make it likely that some of the weathered As is originally anthropogenic. Clearly unroasted arsenopyrite grains are likely naturally occurring in samples that have only been exposed to anthropogenic contaminants could potentially contain arsenopyrite introduced anthropogenically (Bromstad 2011).

1.3 Objectives

The following objectives are meant to help clarify the extent (both in surface area and depth) of As-effected soils, and help quantify the degree of anthropogenic As as opposed to naturally occurring As:

1. Prepare 359 depth-stratified soil samples, collected by Golder Associates, for analytical work.

2. Perform bulk chemical analysis on all soil samples and examine the relationships among depth horizon, As content, and ratios of selected elements of interest.

3. Select a subset of 50 samples and perform detailed quantifiable analysis of As hosts via Scanning Electron Microscope (SEM) and Mineral Liberation Analysis (MLA) software. Attempt to quantify to degree of anthropogenic As contamination in soils sampled.

2. Methodology

2.1 Field methods

Field sampling of soils and sediments at Giant Mine took place during September and October of 2014. All field sampling was administered and carried out by Golder Associates. The following information about the field sampling was obtained during discussions with Diana Young and Arthur Cole.

Most soil samples came from either outcrop soil pockets, wetland environments, or low-lying forest environments. Five samples were taken from the stockpile of blasted material near the new bypass road. See Figure 2.1 for sample locations.

All samples, except for the stockpile, were collected in a depth-stratified manner. The general intention was to separate samples at 5cm, 15cm, 30cm, 60cm, and 100cm depth intervals; however, this often varied somewhat in practice due to visual differences between soil horizons and other concerns arising in the field.

For forest and wetland samples, soil cores were collected. A slide-hammer core apparatus was used to collect soil cores. Core samples, once separated by depth, were placed in individual zipper-seal plastic bags with no orientation markings or other means to maintain the integrity of the core shape.

Outcrop soils are usually, by nature, shallower than forest or wetland samples and as such smalldiameter core sampling was not used. For outcrop soils a trowel was used to collect a wider diameter sample, up to 30cm diameter, at specific depths. Samples were placed in zipper-seal plastic bags.

2.2 Analytical methods

2.2.1 Sample preparation

All sample preparation for chemical analysis was conducted at the Analytical Services Unit (ASU) at Queen's University, and all methods are standard for soil samples handled by ASU. Upon receipt from Golder Associates, sample coolers were inventoried and stored in a cold room.

2.2.1.1 Drying

Sub-samples of each sample were air-dried at ambient temperature. A modest amount of each sample (approximately fist-sized or less) was spread on tables covered in multiple layers of brown butcher's paper. Samples were spread to uniform thickness for ease of drying and periodically broken up for the same purpose. Each sample had a clear margin of approximately 20 cm blank paper on all sides. To help produce a representative sample from large, heterogeneous soil volumes, samples were massaged through the bag to help mix them up before extracting a thin, uniform cross-sectional wedge from the top to the bottom of the bag. Samples of sufficient wetness as to threaten to contaminate those around them, or that were completely liquid, were contained in large weigh boats. Samples were left to dry for one to six days, periodically being broken up and redistributed to promote drying.

Photographs of laid-out samples were taken to preserve information about the physical characteristics of the samples within 12 hours of laying them out to dry (Appendix VIII). Detailed soil descriptions were recorded throughout the drying process, documenting color, grain size, root content, estimated organic matter, soil type, and other attributes (Appendix VII).

2.2.1.2 Grinding

After samples were completely dried a subsection of the dried sample (usually from one-quarter to one-half) was ground by hand with ceramic mortars and pestles (Figure 2.2). Fine material from the bottom of the dried soil sample was often selected preferentially. Rock and vegetation fragments that could not be ground to smaller than a large sand size were discarded. The unground portion of the dried sample was then bagged and saved in case of later need.

Between samples, the mortar and pestle were wiped out with clean, dry paper towels. Water was not used to clean the mortar and pestle between soil samples because the many fine pits and grooves in the ceramic interior would inhibit timely drying.





Instead, when starting to grind a new sample a soil rinse was performed. Soil rinses were conducted by first grinding a small amount of sample (~1gram), then by dipping the mortar at a slight angle and moving it in a circular motion. The small amount of ground sample would coat the interior of the mortar and the initial ground sample was then discarded. The bulk of the actual sample was then ground.
2.2.1.3 Biases and other issues with initial sample preparation

The lack of orientation and shape information of core samples has very likely resulted in patchy representativeness of core samples. The most problematic example of this is the latter half of most sites' core samples: samples below 50cm depth tend to be quite long, and due to the soil properties of the area, often consist of very hard clay. This can make obtaining a representative sub-sample problematic. In addition, long core samples often contained more than one distinct soil color or type.



Figure 2.2: A sample ready to be ground with mortar and pestle

The variety of zipper-seal bags used were not robust enough to prevent sample spillage within coolers. One of the coolers was especially messy, with multiple inches of muddy watery sludge in the bottom and coating sample bags. It was not uncommon for the exterior of sample bags have partial coatings of other leaked samples on them. In the cases of extremely liquid samples this co-mingling in the bottom of the coolers should be kept in mind when interpreting chemistry results. The worst-affected samples were ASU numbers 32 through 60 (sites IXWL1, IXWL2, IWL2, IXF2, IIF2, and IIF3). An attempt was made to neaten up coolers with muddy and wet insides with clean, dry paper towels.

There is an inherent bias towards the finer fraction of soils in the grinding methodology at ASU. This most becomes an issue when addressing the extremely immature soils, especially outcrop soils (often extremely heterogenous and rocky) and partially decomposed organic layers (the top horizon of many samples across location types). This bias is not quantifiable the way selecting for a fine fraction through sieving would be.

The grinding process was performed in close proximity to the laid-out, drying/dried samples. The dust generated from this process could have possibly contaminated other samples nearby. In addition the grinding process used mortars and pestles with many fine chips in their interior surfaces. The soil rinse was meant to negate this factor.

2.2.2 Bulk chemistry analysis (soils)

All analytical chemistry procedures were performed by ASU. Bulk 30-element analysis and Au analysis were performed in the ASU labs; the carbon analysis was performed by ASU technicians on a machine in a nearby university laboratory.

2.2.2.1 Bulk 30-element and Au analysis

2.2.2.1.1 Digestion procedure

All samples analyzed at ASU were digested by the same procedure. Only one digestion was used for both the 30-element and Au analysis. Approximately 0.5g of sample was digested with 6ml concentrated trace grade HCl and 2mL trace grade nitric acid at 90°C. To ensure the samples would stay hydrated and to

prevent loss of potentially volatile elements (i.e., Sb), 7mL of water was added to the mixture. The digestion time was 300 minutes (5 hours), for which the samples were placed on a pre-heated Digiprep MS hotblock with a vented/covered extraction system. Samples were filtered before analysis, and analysis was coordinated so samples would typically be analyzed within an hour of preparation.

2.2.2.1.2 Gold analysis

Gold was analyzed by inductively coupled plasma mass spectroscopy (ICP-MS) immediately after sample digestion, by a different method than other major elements, due to concerns about its stability postdigestion, and having sufficiently low detection limits. Much of the ASU methodology specific to these analyses was adapted from Wang and Brindle (2014).

Calibration verification solutions and standards for gold, obtained from Fluka and SCP Science, were prepared in a 1% cysteine/1% HCl matrix to aid in keeping gold in solution. The DS-1 gold ore reference material was chosen to be digested with the samples.

Approximately 80 mg of digested sample was typically used for analysis; weights were sometimes adjusted to make Au values fall on the linear range of the instrument calibration curve. To mimic conditions of possible low Au samples, low-weight digests of DS-1 (10 mg) were also ran to check stability for low ppb levels of Au.

The analyses were run at maximum high matrix introduction - gas dilution (HMI) mode. HMI mode is typically used to reduce the amount of total dissolved solids to acceptable levels; for these analyses it was used to avoid further sample dilution before analysis. This enabled a reporting limit of 10ppb (solid sample), which could possibly be expanded lower with some tweaking.

One Au sample well above the calibration curve linear range, with very high (comparatively) Au, was analyzed by flame atomic absorption spectroscopy (FAAS).

Between sample and standard runs, the probe was rinsed at a main wash station. The station contained three rinse containers, each with 1% HCl/1% cysteine to ensure optimal rinse in and rinse out times. Each sample uptake used 130 seconds, with 95 seconds of rinsing (5 second probe rinse and 30 seconds in each of the three subsequent rinse containers). This amount of time allowed for the removal of memory effects and for the gold signal to reach a steady state.

2.2.2.1.3 30-element analysis

Inductively coupled plasma optical emission spectroscopy (ICP-OES) was used for the 30-element analysis, on the same digestion of samples from the Au analysis. Since many samples returned Sb values below the $10 \mu g/g$ detection limit, all samples were then later run on ICP-MS for Sb only.

To conform to the standard ICP-OES reporting limits, no further dilution of the digested sample was necessary for most of the ICP-OES analyses. However, for As the standard limit of 250 μ g/g was too low so extended wavelength standards were used to expand the typical calibration range to a working range of 10,000 μ g/g for As. For samples above the 10,000 μ g/g range, 10x dilutions were used on samples as required. Other over-range elements were covered in a similar manner.

For the Sb ICP-MS, sample extracts were diluted at 10x and run on the ICP-MS low HMI mode. While high HMI mode is typical on ICP-MS, low HMI is sufficient for Sb sensitivity and a 1 μ g/g Sb reporting limit.

2.2.2.2 Carbon analysis

Total carbon was analyzed by combustion to form CO₂, then by infrared detection of the CO₂ in a LECO® Truspec CN analyzer. Total carbon was used as a proxy for organic carbon where appropriate, due to a presumably low carbonate mineral content in some Giant Mine soils.

2.2.2.3 Quality Assurance / Quality Control (QA/QC)

ASU ran both 30-element ICP-OES and Au/Sb ICP-MS in groups of 28 samples. For each grouping of samples for 30-element analysis, two blanks, three standard reference MESS-3 standards, and two duplicates were run for QA/QC purposes. For Au analysis, a calibration blank and 1ppb, 10 ppb, 50 ppb and 100 ppb Au standards were prepared for each run of 28 samples. Low-weight digests of DS-1 (10 mg) were also run for Au to check stability for low ppb levels of Au. These returned good numbers for stability and recovery. Carbon analysis QA/QC includes duplicates, blanks, orchard leaves standards, and mineral soil standards.

2.2.3 Grain mount methodology development and construction

Soils were prepared for Scanning Electron Microscope (SEM) analysis by mixing the samples with graphite, impregnating the mixture in epoxy, and polishing the epoxy mount down to a 1 micron finish. The details of the methodology were finalized through a series of optimization tests carried out on 34 test mounts. The optimization process led to the following conclusions:

- Graphite particle sizes below -325 mesh had no noticeable effect on sample agglomeration in the final polished mount.
- 1:3 ratio of graphite to sample provided efficient particle separation and did not compromise mount hardness.
- Sonication of the sample with an ultrasonic bath or ultrasonic probe did not noticeably reduce sample agglomeration.
- Vaseline could be used without negatively effecting mount hardness.
- Polishing the mounts with ethanol instead of water did not prohibitively decrease mount hardness or ESEM beam resilience and addressed concerns of dissolving/smearing water soluble arsenic trioxide grains.
- Density separation along the vertical axis was not significantly impacting modal results.
- Room temperature was sufficient for curing of the epoxy.
- Applying a >95% vacuum to the epoxy in three cycles resulted in significantly better wetting and agglomeration of sample particles than one cycle, or no vacuum at all.

After optimization tests were completed, the following finalized methodology was applied to all mounts analyzed by MLA:

<u>Step 1:</u> 0.75 g of dry, ground sample and 0.25 g of graphite (Alfa Aesar® Graphite Powder, crystalline, -325 mesh, 99%) were manually mixed together with a scupula in a dish. The sample/graphite mixture was then placed in a two-part 1" diameter mounting cup (Allied High Tech Products®) thinly coated with petroleum lubricant (Vaseline®) (Figure 2.3).

Figure 2.3: (left) Coating of mounting cups with vaseline, done without gloves as a final check for debris and dirt. (right) The 1:3 ratio graphite and sample mixture after mixing.



• <u>Step 2</u>: The EpoxiCure 2® hardener and resin were mixed at 23:100 weight ratio for at least 3 minutes, or until visible eddies, currents, and diffraction were gone. Epoxy was stirred in random directions while scraping the sides of the container, and then poured into the mounting cups from Step 1. After pouring epoxy into mounting cups, the epoxy and sample underwent further stirring to help eliminate clumping of fine grains (see section 2.2.2.1). Mount thickness was approximately 1-2 cm. Epoxy mounts were cast in batches of 4 to 8 (Figure 2.4).



- <u>Step 3</u>: The mounting cups were quickly placed in a vacuum chamber and a >95% vacuum applied (Figure 2.5). After waiting for bubbling to subside (approximately 2 minutes) the vacuum was removed. The vacuum cycle was then applied two additional times to ensure proper grain wetting occurred. The mounts were then removed and set aside. Two days were allowed for epoxy to fully set at ambient temperature and pressure.
- <u>Step 4:</u> Hardened grain mounts were removed from mounting cups and the petroleum lubricant was washed off with soap and ethanol.
- <u>Step 5</u>: Grain mounts were ground and polished is three steps (Figure 2.6). (1) The mounts were ground with 400 mesh silicon carbide on a glass plate. Polishing motion was random with firm pressure. (2) The

Figure 2.5: (left) Samples in the vacuum chamber (right) The vacuum chamber apparatus



second polish was done with 1000 mesh silicon carbide on glass plate lubricated with ethanol for five minutes. Polishing motion was random with firm pressure. (3) The final polish was done on a polishing wheel with 1 micron diamond compound (Beta Diamond Products®) for twenty minutes. Polishing was repeated until inspection under microscope revealed no evidence of striations or scratches on grains.



Figure 2.6: (left) Grain mount on the first polish plate with 400 mesh silicon carbide and ethanol. (center) Grain mount on the first polish plate with 1000 mesh silicon carbide and ethanol. (right) Grain mount on a polishing wheel with 1 micron diamond compound and oil.

• <u>Step 6 (density mounts only)</u>: Several duplicate mounts were constructed to be further processed into a density check mount. These mounts were cut into quarters on a lapidary saw and re-cast in epoxy with two sections rotated to reveal the vertical distribution of sample grains and one quarter left in its original position (Figure 2.7). The fourth quarter was discarded. The mounts were then polished as per steps 4-5.



Figure 2.7: (left) Small lapidary saw used to cut a grain mount into quarters.

(right) TA density mount after re-casting in epoxy and polishing. The lower two rectangular sections are rotated quarters which reveal the vertical profile of grains within the mount. The upper quarter piece is unmoved from the original casting. • <u>Step 7:</u> As a final step all mounts were carbon-coated with a high-voltage sputtering carbon source under vacuum (<1.0x10-4 torr) to increase conductivity of the sample surface to allow for a higher intensity beam and resolution during analysis. Carbon coating was conducted in a Denton Vacuum Desk V© (Figure 2.8).



Figure 2.8: The Denton Vacuum Desk V© carbon coater.

2.2.4 Scanning Election Microscope (SEM) and Mineral Liberation Analysis (MLA)

2.2.4.1 General technique

Grain mounts are first carbon-coated before examination under high vacuum mode with the backscatter electron (BSE) detector on the FEI Quanta 650 FEG ESEM at Queen's University.

An image generated using the BSE detector displays the polished surface of the grain mount in a greyscale color scheme with color (from 0-255) determined by the atomic number of the substance in view. This means that generally, higher density materials appear brighter. This mode of imaging makes textures and compositional differences easy to image, highlights phases of interest (particularly As-rich phases in Giant Mine soils), is very fast, and can be used at any magnification of the SEM. The essential mechanics of the BSE detector are as follows:

• The SEM field emission electron gun generates an accelerated electron beam that scans the sample. The beam hitting the sample surface produces both inelastic and elastic collisions of electrons interacting with the atoms of the sample surface; electrons in elastic collisions change trajectory but do not significantly change in kinetic energy. In the case of backscattered electrons, high energy electrons from the beam travel through the sample and change in trajectory relative to the atomic number. Atoms with a higher atomic number have a larger cross-sectional area for the electron beam to interact with, generally meaning a higher chance of creating elastic collisions. Thus phases whose component elements average a higher atomic number record more elastic collisions, backscattering more strongly. The reverse is true for phases with lower atomic numbers. Greater numbers of collisions correspond to brighter color in the BSE image (Goodge 2012).

- Practically speaking, arsenic is the heaviest element of any significant abundance present in the As₂O₃-bearing soils at Giant. Thus, As₂O₃ (with approximately 76 wt.% As) is often visually distinct as a very bright phase. However, other As hosts such as roaster iron oxides, other weathering iron oxides (including those forming sulfide rims), As sorbed to organics, and sulfides have smaller weight percentages of As. These have similar average atomic number to many non-As bearing phases present in the sample, and as such are not visually distinct (Bromstad 2011, Wrye 2008).
- Furthermore, the system uses energy-dispersive spectrometry (EDS) extensively for mineral identification. As the electron beam interacts with the sample surface, energy is added to the atoms composing the sample. This causes electrons in the inner shells to get ejected. Outer shell electrons cannot stay at a high-energy state and drop to a lower level, causing a characteristic x-ray photon to be released, with an energy equivalent to the difference between the two energy levels. The two x-ray detectors detect the entire expected range of energies, and count the amount of x-rays incoming at each energy thus separating the spectrum based on energy, giving the system its name. Each element has a series of characteristic spectral lines and this can be used to identify minerals.

The Mineral Liberation Analysis (MLA) software works in concert with the SEM to isolate and identify individual particles and inclusions on the polished surface of the grain mount. The MLA operator selects the area to be scanned across the surface of a given grain mount. After optimizing various parameters within the MLA software to account for the type and composition of the sample being analyzed, the MLA software can be left to complete the scan without human assistance. There are several different modes that the MLA can be run under (Buckwalter-Davis 2013, FEI 2012). Different MLA modes were used during different stages of the project; the following list details those employed:

• XBSE: The MLA software captures a BSE image of each frame and uses a series of image processing algorithms to subtract low-weight (carbon-rich phases such as epoxy and graphite) background, and record the number and shape of individual particles and the phases within. The image processing determines the shape of each discrete area of similar color in the image (assuming this is a single phase), and selects a spot in the center of each to collect an x-ray EDS spectrum. Optimization of contrast, brightness, and resolution settings on the SEM are very important to make it more likely that phases of interest, including very small particles, will be detected by the MLA software. Two high-speed energy dispersive X-ray spectrometers (EDS) in the SEM collect one EDS spectra from each phase it identifies. This mode was primarily used early in the MLA optimization process to begin building the MLA library for Giant Mine soils. Complex textural associations, agglomeration, and low-BSE regions of interest are not handled well by the image processing algorithm built into the mode, making it insufficient for much of the work on the Giant soils.

- <u>Grain X-Ray Mapping (GXMAP)</u>: GXMAP is useful for identifying and quantifying mineral phases that have similar greyscale colors under BSE, including inter-grown minerals. The process operates very similarly to XBSE mode, except that upon encountering a user-selected trigger in the EDS spectra, a grid of EDS spectra will be collected over the entire phase of interest, allowing for subtle chemical differences to be seen (FEI 2012, Buckwalter-Davis 2013). This is a very useful tool for differentiating As-bearing and non-As-bearing iron oxides in soils at Giant; upon encountering phases with an iron-oxygen EDS signature, grains can be EDS mapped in detail. Even in As-bearing roaster oxides, As content across the grain is often variable. The GXMAP mode turned out to be very useful for Giant Mine soils for iron oxide signatures. This mode, in conjunction with others, was used for almost all samples.
- <u>Sparse Phase (SPL)</u>: SPL mode essentially searches the BSE image for grains that fall within a userdefined range of brightness, and then performs an XBSE scan on those grains. Due to this selectiveness it does not provide very accurate modal mineralogy information (FEI 2012), however, it proved to be useful in documenting many As hosts in Giant Mine soil samples. For As hosts that are bright in BSE images, comparing SPL and GXMAP scans can provide valuable quality control to ensure similar quantities of bright As phases were analyzed. SPL scans were performed for almost all samples.
 - <u>SPL_XBSE:</u> This mode measures grains of interest with a single x-ray for each grain.
 - <u>SPL_GXMAP</u>: This mode behaves like SPL_XBSE, with the exception of grains encountered matching a user-set trigger in the EDS spectra, whereupon it behaves like GXMAP mode.
 - <u>SPL_Lt</u>: This mode measures mineral associations around grains selected in an SPL scan. A box is drawn around each grain selected for SPL analysis, and all surrounding grains falling within the box are also analyzed (FEI 2012).

Either SPL_GXMAP or SPL_Lt scans were performed on all Giant Mine soil samples.

• <u>XMOD</u>: This mode produces modal mineralogy information via a point counting method. One EDS spectra is collected for each counting point of an evenly spaced grid across each particle (FEI 2012). This mode was often run for Giant Mine soils to check the gross modal mineralogy; however, it was not useful for As phases, as they are often small and sparsely distributed in comparison to the bulk of the silicate and carbonate gangue mineralogy. After determining that GXMAP and SPL scans worked well for general modal mineralogy interpretation, the frequency of the time-consuming XMOD scans was decreased.

2.2.4.2 MLA settings

Table 2.1: SEM Settings

High Voltage	25kV
Beam Current	10-13nA
Spot Size	5.0-5.7 (to achieve beam current)
Working Distance	13mm

Table 2.2: General MLA Settings

Number of Frames	500
Resolution of Frame	600 x 600 pixels
Scan Speed	16 us
Image Acquisition Minimum Size	2 pixels
Retain Boundary Particles	True

Table 2.2: General MLA Settings

Background Removal	0-20
Separation	No
X-ray Acquisition Time	12ms
X-ray Minimum Size	2 pixels

Table 2.3: GXMAP Settings

Trigger Name	Fe oxides
Spectrum 1	Fe oxide displaying As peak at 10.5kV
Spectrum 2	Fe oxide without an As peak
Acquisition Time	45ms
Step Size	4 pixels
Threshold	60

Table 2.4: SPL_GXMAP/SPL_Lt_MAP Settings

Store all BSE Frames	True
Frame Guide Size	10 pixels
BSE Grayscale Search Region	150-255
Search Grain Size	2 pixels

2.2.4.3 Important MLA Caveats

The MLA processing script is optimized for accurate analysis of As-bearing phases. While the MLA analysis software can identify other minerals, such as silicates or sulfides, the script is not written to differentiate subtle elemental variation. Minerals commonly display natural variation, and require additional script entries to differentiate. This was not within the scope of the initial project and would represent a significant amount of work for the mineralogist. Basic quality control measures were used to ensure minimal instrumental error when calculating total modal mineralogy, such as comparing the GXMAP mode - which uses an image algorithm to determine phases - to the XMOD mode, which ignores all textural information. These agreed within reason.

The mechanics of the MLA image processing algorithms mean that grain mounts without significant clumping perform better under analysis. Often, the algorithm will fail to determine accurate grain boundaries when many grains are beside each other with minimal separation. It will consider this whole area as a single particle, then x-ray only the centre of this "particle". It is impossible to know how representative that phase is of the whole area. For the As-bearing phases of interest, bright phases are still well differentiated from the matrix, but this will cause inaccuracies in the silicate modal mineralogy.

In addition, the presence of organic matter in Giant Mine soils complicates MLA analysis because it can be relatively close in color to the carbon and epoxy background of the BSE image. Carbon-rich material is difficult to image under BSE conditions due to instrumental limitations of the system - low energy elements are challenging to image manually, let alone using an automated system. Organic material is challenging to polish, so will inherently have more texture than minerals - this, and the low-energy nature of the carbon-rich

organics - causes less x-rays to go into the x-ray detectors. Low counts make it very difficult to differentiate peaks from the background noise.

2.2.4.4 MLA mineral reference library and script

For all MLA measurements, the data set is processed and each EDS spectrum collected is compared to a user-generated library of minerals. Every particle is classified using a best-fit scheme and, if it is above a 70% match, assigned a mineral phase. Every particle is given a unique ID and can be manipulated and sorted within the software. The dataset is composed of a backscatter image, the raw x-ray spectral data, and the identified particles. These datasets can each be searched for phases of interest. Extensive quality control is required in the first series of samples to "train" the MLA software to accurately determine subtle differences in phases.

A robust mineral reference library is essential to MLA work. The development of the mineral reference library for Giant Mine soils started with an XBSE_STD mode MLA run. The XBSE_STD mode works very similarly to the XBSE mode described in section 2.2.3.1, except that spectra collected for all unknown phases present are binned into generic categories. These generic categories require an experienced mineralogist to classify. After this step the library is further refined by collecting EDS spectra from specific unknown phases, and manipulating EDS spectra and mineral bins to make a more thorough and accurate library (Buckwalter-Davis 2013). Table 2.5 includes a detailed listing of the mineral bins included in the Giant Mine library. Seven As-bearing species were defined.

Important caveats to note about mineral reference library

As discussed in section 2.2.4.3, many minerals exhibit natural variations in elemental concentrations. While the Giant mineral reference library includes chemical formulae and density values for all mineral bins, they are not included here. Due to the way MLA behaves, one must be cautious in using data such as these.

Density and chemical formulae are used by the MLA software to calculate statistics such as weight percent values. While it is possible to do calculations such as weight percent on the Giant Mine data, it inherently has an excessive level of uncertainty due to the optimization of the library for As phases, the high agglomeration in grain mounts, the potential for large amounts of organic matter to be present, and the difficulties these factors force on the SEM apparatus and MLA software. These issues make MLA statistics such as area percent of higher relative valuable to the project.

Mineral names listed in the mineral reference library are not always the most accurate descriptors for phases binned therein. This is a three-fold issue: (1) for phases that were not the focus of quality control, there is a level of uncertainty as to what the MLA has decided to bin within them; (2) due to the nature of SEM technology it is not possible to differentiate between polymorphs, discern crystallinity, or otherwise account for distinct phases with very similar EDS spectral chemistry; and (3) consistent but inconclusive or ambiguous EDS spectra, mineral intergrowths, uneven mount surface, small particle size, agglomeration, and other factors, may result in mixed spectra or otherwise inconclusive categories.

NOTE	Name	Color
	Chlorite	Color [A=255, R=126, G=150, B=101]
	Albite	Color [A=255, R=141, G=222, B=155]
	Orthoclase	Color [A=255, R=73, G=197, B=159]
	Quartz	Color [A=255, R=141, G=222, B=155]
	Hornblende/Augite?	Color [A=255, R=30, G=98, B=58]
	Epidote	Color [A=255, R=71, G=112, B=16]
	Plagioclase	Color [A=255, R=73, G=197, B=159]
	Muscovite	Color [A=255, R=165, G=226, B=202]
Refers to organic material, NOT the graphite mixed in with sample during mounting process	Carbon	Color [A=255, R=70, G=74, B=64]
	Pyrrhotite	Color [A=255, R=255, G=128, B=0]
	Pyrite	Color [A=255, R=255, G=62, B=34]
	Ilmenorutile	Color [A=255, R=112, G=227, B=91]
	Silica	Color [A=255, R=187, G=253, B=138]
Al-silicate	Al2SiO5 (Andalusite)	Color [A=255, R=27, G=190, B=157]
Sb sulfide	Stibnite	Color [A=255, R=34, G=0, B=223]
	Ti-Muscovite	Color [A=255, R=130, G=187, B=119]
	Enstatite	Color [A=255, R=126, G=216, B=124]
	Titanite	Color [A=255, R=177, G=145, B=223]
	Rutile	Color [A=255, R=142, G=107, B=214]
Fe oxides, oxyhydroxides, or hy- droxides. Due to the variation in As concentrations, parts (or less often, all) of roaster oxides are included in this category. Some weathering rims on sulfides (non- As bearing) occur in this cate- gory.	Fe Oxides - No As	Color [A=255, R=177, G=52, B=71]
	Apatite	Color [A=255, R=204, G=129, B=254]
	Calcite	Color [A=255, R=128, G=70, B=13]

Table 2.5: Mineral reference library (the 7 As-bearing phases are highlighted)

Table 2.5: Mineral reference library (the 7 As-bearing phases are highlighted)

NOTE	Name	Color
	Ankerite	Color [A=255, R=140, G=104, B=51]
As ₂ O ₃ . Other researchers have identified As ₂ O ₃ at Giant as arseno- lite through micro X-Ray Diffraction (μ XRD). QA/QC for this phase was excellent.	Arsenolite	Color (A=255, R=0, G=181, B=249)
	Zircon	Color [A=255, R=105, G=0, B=151]
	Fe Ti Silicate	Color [A=255, R=52, G=49, B=79]
	Monazite	Color [A=255, R=132, G=108, B=200]
	Mn - Chlorite?	Color [A=255, R=122, G=167, B=95]
QA/QC for this phase was excel- lent.	Arsenopyrite	Color [A=255, R=255, G=0, B=0]
	Chromite	Color [A=255, R=94, G=166, B=83]
Fe oxides, oxyhydroxides, or hy- droxides containing As. Roaster oxides fall within this category, as do unrelated Fe weathering prod- ucts (including rims on sulfides)	Fe Oxides - with As	Color [A=255, R=249, G=98, B=169]
More accurately termed As-sulfide	Realgar	Color [A=255, R=255, G=0, B=255]
	Ilmenite	Color [A=255, R=0, G=128, B=0]
	Unknown	Color [A=255, R=211, G=211, B=211]
	Low_Counts	Color [A=255, R=128, G=128, B=128]
	No_XRay	Color [A=255, R=169, G=169, B=169]
Built for As-bearing coatings on or- ganic matter, dominated by Fe (also sometimes includes Ca and Mn). Could be oxide, oxyhydroxide, or hydroxides. In organic-rich samples this phase performs very well; oth- erwise in low organic samples the MLA sometimes uses this phase for small outlying parts of As-bearing phases next to epoxy or graphite.	Organics w/As,Fe,CaOx	Color [A=255, R=189, G=102, B=148]

	Table 2.5: Mineral re	eference library	(the 7 As-b	earing phases a	are highlighted)
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NOTE	Name	Color
Coatings on organic matter, dominantly Fe oxides/ oxyhydroxides/hydroxides, with other elements sometimes pre- sent (Mn, Ca, Al)	Organics w/FeOx, no As	Color [A=255, R=119, G=64, B=68]
Sphalerite	Sphalerite with IoFe	Color [A=255, R=255, G=114, B=53]
	Dolomite	Color [A=255, R=188, G=115, B=41]
Could be oxides, oxyhydroxides, or hydroxides. Arsenic-bearing, Fe is always present, but either (1) at least one other element is also present (Mn, Ca, Al), OR (2) the EDS spectra for an As- bearing Fe -oxygen phase is poor quality. As-bearing rims on sul- fides often fit in this bin. Can also be coatings on organic matter.	Fe-As-Ca/Mn oxide	Color [A=255, R=255, G=155, B=200]
	Chalcopyrite	Color [A=255, R=255, G=223, B=40]
	Cu Sulfide	Color [A=255, R=192, G=0, B=0]
Cu Oxide	Cuprite	Color [A=255, R=223, G=56, B=0]
	Pentlandite	Color [A=255, R=255, G=157, B=60]
Could be oxides, oxyhydroxides, or hydroxides. Arsenic-bearing. Aluminum is the dominant chemi- cal species, often (but not al- ways) followed by a significant amount of Mn. Sometimes Mn is less dominant and Fe is the next- most. Calcium can be present in small quantities. Often associated with organic matter coatings and weathering products. Specifically common only in some selected MLA samples.	Al-Mn-Fe-As oxide	Color [A=255, R=255, G=187, B=221]
Non-arsenian version of above.	Al-Mn-Ca(Fe)Ox	Color [A=255, R=122, G=37, B=46]

2.2.4.5 MLA processing script

Extensive tailoring of the MLA processing process was necessary to optimize MLA for the unique problems presented by Giant Mine soils. This took the form of a detailed script that was gradually added on to as problems were found during extensive QA/QC. The main functions of the script were as follows:

- <u>To force grains classified as As-bearing phases to actually contain As</u>: This would not always be an issue with As hosts such as As₂O₃, arsenopyrite, and realgar, where As makes up a significant weight percent of the phase. However, in phases that contain As in smaller quantities, it was necessary to force the MLA software to only classify grains as As-bearing minerals if they actually had As present for a small, defined window of energies in their EDS spectra. Phases that require this sort of action also usually had a counterpart phase that would be very similar, but lacking in As. For example, the Giant Mine library has an As-bearing Fe-oxide/oxyhydroxide phase, as well as a non-As-bearing Fe-oxide/oxyhydroxide phase. To be classified as the As-bearing phase, the script forced As to be present. To be classified as the non-As phase, As could not be present in the spectra.
- <u>To force grains classified as As-bearing phases to have appropriate BSE brightness levels:</u> Often around very bright As phases, such as As₂O₃ and arsenopyrite, false positives for As phases can occur around the edges of bright grains (including on epoxy). This is due to the way the electron beam hits the surface of the grain mount at the edges of grains; this is exacerbated by unevenness of surface, which is not uncommon in samples with agglomeration issues. Unevenness artificially causes some peak intensities to be skewed incorrectly and must be accounted for. In this case, EDS spectra may match a certain As-bearing mineral, but a manual QA/QC check of the grain's BSE image will be far too dark to be correct. To correct this problem, an appropriate BSE brightness window was defined for many As hosts in the script.
- <u>To force grains classified in organic phases to have carbon present</u>: This is an almost identical issue to the As issue mentioned above. It is harder to correct, since in the course of normal classification the area of the EDS spectra indicating carbon is excluded from classification for all grains; however, forcing certain minerals to have carbon spectra present despite the fact that a contradictory part of the script prohibits including this area of the spectra actually appears to have a positive effect.
- <u>To remove low-quality spectra</u>: This is mostly an issue in samples with larger amounts of organic matter present, and sometimes results in spectra of very dubious quality. In this case, the "low counts" threshold (beneath which spectra are binned as "low counts" rather than a specific mineral) EDS spectra threshold was raised to 1000, rather than the default 800.
- <u>Any other QA/QC issues:</u> Throughout the course of QA/QC analysis across many sample types, various miscellaneous issues arose as the working library and script were applied to a wider variety of samples. Due to the nature of this project, issues corrected for in QA/QC are targeted mostly to As hosts, Fe,AI,Mn, and Ca oxides (or oxyhydroxides), and organic matter.

2.2.4.6 Sample sub-set selection

A subset of 50 samples (of 359) to be characterized in detail via MLA was selected in consideration of the following criteria:

• High As concentrations: Characterization by MLA was observed during the mount development process to work best on samples with total As concentrations above 500 mg/kg. Selecting high As samples to characterize increases the likelihood of capturing a larger variety of As hosts and

textures. These high As samples are also extremely important to understand from a human health and remediation standpoint.

- Sample site depth continuity: Depth stratified sampling has the potential to greatly inform the current level of knowledge about As-contaminated soils at Giant Mine. Not analyzing all samples from a given sample site results in incomplete information for analysis. For each sample targeted for MLA analysis, all samples from the site were analyzed if they had sufficient As.
- Representation of forest, wetland, and outcrop sample site: The samples selected based on As content were adjusted to ensure that samples from forest, wetland, and outcrop locations are all characterized.
- Balance amongst geographical areas: The very highest As concentration sample sites are not necessarily distributed evenly across the Giant property; an attempt was made to even out geographic coverage of MLA characterization sample locations, with consideration for the previously listed factors.

Table 2.2 briefly summarizes the samples selected for MLA. A full summary table with contextual information can be found in Appendix VI.

Site	ASU sample	Golder horizon	Queen' s	from (cm)	to (cm)	Au µg∕g	As µg/g	S µg/g	Sb µg/g
III-F-2	Sample 27	IIIF2-a	F-64a	0	5	0.53	1500	510	93
	Sample 28	IIIF2-b	F-64b	5	15	0.065	840	370	17
IV-F-2	Sample 344	IVF2-a	F-66a	0	5	0.96	1700	1200	270
	Sample 345	IVF2-b	F-66b	5	20	0.25	1300	1700	93
IX-F-4	Sample 2	IXF4-b	F-72b	5	15	48	3600	3900	570
	Sample 3	IXF4-c	F-72c	15	30	0.86	600	1100	86
II-OC-9	Sample 80	llOC9-a	O-14a	0	3	0.35	1400	1100	120
	Sample 81	llOC9-b	O-14b	3	10	0.019	2400	420	35
	Sample 82	IIOC9-c	O-14c	10	15	0.016	2400	600	33
II-OC-5	Sample 70	llOC5-a	O-10a	0	3	3.1	17000	1200	900
	Sample 71	llOC5-b	O-10b	3	10	0.15	1300	210	47
	Sample 72	IIOC5-c	O-10c	10	20	0.036	2000	220	25
II-OC-10	Sample 83	llOC10-a	O-5a	0	5	1.0	16000	2000	260
	Sample 84	llOC10-b	O-5b	5	8	0.081	7200	820	52
II-OC-11	Sample 85	llOC11-a	O-6a	0	5	0.90	11000	920	220
	Sample 86	IIOC11-b	O-6b	5	10	0.37	7800	920	120
III-OC-5	Sample 124	IIIOC5-a	O-18a	0	5	0.11	3200	350	45
	Sample 125	IIIOC5-b	O-18b	5	10	0.059	4100	610	74
III-OC-2	Sample 122	IIIOC2-a	O-16a	0	8	0.73	3200	570	170
	Sample 123	IIIOC2-b	O-16b	8	15	0.049	1300	210	23
III-OC-8	Sample 354	IIIOC8-a	O-21a	0	5	0.12	630	500	19

Table 2.6: MLA sample selection

Site	ASU sample	Golder horizon	Queen' s	from (cm)	to (cm)	Au µg/g	As µg/g	S µg/g	Sb µg/g
IV-OC-1	Sample 17	IVOC1-a	O-22a	0	5	0.76	7000	400	160
	Sample 18	IVOC1-b	O-22b	5	10	0.14	5400	620	73
IV-OC-4	Sample 147	IVOC4-a	O-25a	0	5	0.56	4800	1300	130
	Sample 148	IVOC4-b	O-25b	5	12	0.046	5100	580	24
V-OC-1	Sample 179	VOC1-a	O-31a	0	5	0.036	1400	<200	25
	Sample 180	VOC1-b	O-31b	5	15	0.024	570	<200	<10
V-OC-2	Sample 181	VOC2-a	O-32a	0	5	0.15	3600	450	110
VI-OC-4	Sample 202	VIOC4-a	O-40a	0	5	0.15	1200	1300	36
	Sample 203	VIOC4-b	O-40b	5	10	0.034	1300	840	20
VIII-OC-4	Sample 295	VIIIOC4-a	O-54a	0	5	0.20	840	1000	59
	Sample 296	VIIIOC4-b	O-54b	5	20	0.016	370	280	12
IX-OC-2	Sample 319	IXOC2-a	0-27a	0	3	1.8	5500	2100	0 330
	Sample 320	IXOC2-b	O-27b	3	10	0.061	910	140	18
IX-OC-4	Sample 324	IXOC4-a	O-29a	0	6	0.61	5200	1500	190
	Sample 325	IXOC4-b	O-29b	6	15	0.051	1100	460	15
	Sample 326	IXOC4-c	O-29c	15	20	0.029	1200	200	14
III-WL-1	Sample 118	IIIWL1-a	W-89a	0	5	2.4	1000	1500	160
	Sample 119	IIIWL1-b	W-89b	5	15	4.4	920	1300	200
	Sample 93	IIIWL1-c	W-89c	15	30	4.0	2700	3900	470
IV-WL-2	Sample 8	IVWL2-b	W-91b	5	15	0.98	1000	560	270
	Sample 9	IVWL2-c	W-91c	15	30	1.6	2800	2100	800
	Sample 10	IVWL2-d	W-91d	30	60	2.0	3400	4000	1100
	Sample 11	IVWL2-e	W-91e	60	100	0.22	1800	<200	1100
V-WL-2	Sample 169	VWL2-b	W-98b	5	20	0.28	1100	1300	33
VI-WL-1A	Sample 195	VIWL1A-a	W-100a	0	5	0.31	1500	4300	23
	Sample 196	VIWL1A-b	W- 100b	5	10	0.16	420	2600	26
VI-WL-1B	Sample 197	VIWL1B-a	W-101a	0	5	0.21	870	6000	25
	Sample 198	VIWL1B-b	W- 101b	5	10	0.23	1200	6200	27
	Sample 199	VIWL1B-c	W-101c	10	30	0.33	790	4500	24

3. Results and Discussion

3.1 Bulk chemistry

Bulk ICP-OES results, ICP-MS Au and Sb results, and carbon results were received for all 359 soil samples. Table 3.1 contains all As, Au, C, S, and Sb results; Appendix II includes a complete table of all chemistry results.

Arsenic results ranged from 4.9 μ g/g to 17,000 μ g/g, had a median value of 160 μ g/g, and averaged 740 μ g/g with a standard deviation of 1790 μ g/g. Of the 359 samples analyzed, 120 contain \geq 340 μ g/g As. Of the 120 samples, 65 have As concentrations greater than 1000 μ g/g. Three samples have As concentrations greater than 10,000 μ g/g As (1 % As). All samples with As greater than 3600 μ g/g come from outcrop soil sites.



Figure 3.1: Histogram showing relative frequency of As concentrations for all 359 samples. The first bin includes As concentrations up to 340 μ g/g, the site-specific cleanup guideline for Giant Mine (INAC 2007). The lower horizons of wetland and forest soil sites dominate the <340 μ g/g bin.

TYPE	Golder site	rom (cm)	to (cm)	Sample (Golder)	Sample (ASU)	Sample (Queen's)	Carbon (%)	Au (µg/ g)	As (μg/ g)	S (µg/g)	Sb (μg/ g)
F	I-F-1	0	5	IF1-a	126	F-58a	35.7	0.26	500	2000	55
F		5	15	IF1-b	127	F-58b	35.0	0.037	100	1800	20
F		15	30	IF1-c	128	F-58c	10.8	<0.01	140	450	3.3
F		30	60	IF1-d	129	F-58d	<1.0	<0.01	74	<200	1.8
F		60	100	IF1-e	130	F-58e	<1.0	<0.01	19	<200	2.0
F	I-F-2	0	5	IF2-a	102	F-59a	37.2	0.32	250	3500	74
F		5	15	IF2-b	103	F-59b	41.2	0.23	250	2600	78
F		15	30	IF2-c	104	F-59c	24.0	0.022	250	1400	12
F		30	60	IF2-d	105	F-59d	2.0	<0.01	180	<200	2.2
F		60	100	IF2-e	106	F-59e	<1.0	<0.01	120	<200	2.1
F	II-F-1	0	5	llF1-a	334	F-60a	6.3	0.076	270	860	11
F		5	15	llF1-b	335	F-60b	3.4	0.013	250	480	5.3
F		15	30	llF1-c	336	F-60c	1.4	<0.01	110	280	1.5
F		30	60	llF1-d	337	F-60d	<1.0	0.015	5.2	<200	<1.0
F		60	100	llF1-e	338	F-60e	<1.0	<0.01	5.0	<200	<1.0
F	II-F-2	0	5	llF2-a	56	F-61a	6.5	0.099	120	600	25
F		5	15	llF2-b	57	F-61b	1.3	0.10	180	440	20
F		15	30	IIF2-c	58	F-61c	<1.0	0.23	170	300	12
F		30	60	llF2-d	59	F-61d	<1.0	0.033	45	<200	5.5
F		60	100	llF2-e	60	F-61e	<1.0	0.012	21	260	2.8
F	II-F-3	0	5	IIF3-a	51	F-62a	1.2	0.061	240	<200	11.0
F		5	15	llF3-b	52	F-62b	<1.0	<0.01	63	<200	1.3
F		15	30	IIF3-c	53	F-62c	<1.0	<0.01	52	<200	1.2
F		30	60	llF3-d	54	F-62d	<1.0	<0.01	26	<200	<1.0
F		60	90	IIF3-e	55	F-62e	<1.0	<0.01	16	<200	<1.0
F	III-F-1	0	5	IIIF1-a	356	F-63a	8.2	0.018	83	810	2.2
F		5	15	IIIF1-b	357	F-63b	<1.0	0.037	90	<200	1.8
F		15	30	IIIF1-c	358	F-63c	<1.0	0.014	57	<200	1.2
F		30	70	IIIF1-d	359	F-63d	<1.0	0.030	76	<200	1.1
F	III-F-2	0	5	IIIF2-a	27	F-64a	6.7	0.53	1500	510	93
F		5	15	IIIF2-b	28	F-64b	4.85	0.065	840	370	17
F		15	30	IIIF2-c	29	F-64c	2.55	0.013	280	260	4.4
F		30	55	IIIF2-d	30	F-64d	1.3	<0.01	250	<200	3.0
F		55	100	IIIF2-e	31	F-64e	<1.0	<0.01	40	<200	1.2
F	IV-F-1	0	5	IVF1-a	101	F-65a	40.5	0.24	540	1800	100
F		5	15	IVF1-b	87	F-65b	2.7	0.018	140	<200	6.8
F		15	30	IVF1-c	88	F-65c	<1.0	<0.01	51	<200	1.3
F		30	60	IVF1-d	89	F-65d	<1.0	0.039	25	<200	<1.0
F		60	100	IVF1-e	90	F-65e	<1.0	0.012	7.3	<200	<1.0

Table 3.1: Arsenic, C, Au, S, and Sb results for all samples

ТҮРЕ	Golder site	rom (cm)	to (cm)	Sample (Golder)	Sample (ASU)	Sample (Queen's)	Carbon (%)	Au (µg/ g)	As (µg/ g)	S (µg/g)	Sb (µg/ g)
F	IV-F-2	0	5	IVF2-a	344	F-66a	32.9	0.96	1700	1200	270
F		5	20	IVF2-b	345	F-66b	41.6	0.25	1300	1700	93
F		20	30	IVF2-c	346	F-66c	4.6	0.010	80	1000	2.4
F		30	60	IVF2-d	347	F-66d	1.1	<0.01	17	560	1.2
F		60	100	IVF2-e	348	F-66e	<1.0	0.012	14	480	1.5
F	IV-F-3A	0	5	IVF3A-a	19	F-67a	31.5	1.0	770	3100	210
F		5	15	IVF3A-b	20	F-67b	32.0	0.92	2500	2200	230
F		15	35	IVF3A-c	21	F-67c	16.7	0.070	300	960	26
F	IV-F-3B	0	5	IVF3B-a	22	F-68a	20.5	0.58	1300	1300	93
F		5	15	IVF3B-b	23	F-68b	26.45	0.044	130	1600	22
F		15	30	IVF3B-c	24	F-68c	21.9	0.070	170	1600	14
F		30	60	IVF3B-d	25	F-68d	1.75	0.025	36	200	2.1
F		60	100	IVF3B-e	26	F-68e	<1.0	0.014	21	<200	1.3
F	V-F-1	0	5	VF1-a	170	F-73a	32.3	0.17	250	2700	39
F		5	15	VF1-b	171	F-73b	7.1	<0.01	66	550	4.8
F		15	30	VF1-c	172	F-73c	5.9	0.12	23	460	1.2
F		30	50	VF1-d	173	F-73d	1.8	0.055	9.1	<200	<1.0
F		50	100	VF1-e	174	F-73e	<1.0	0.039	7.7	<200	<1.0
F	V-F-2	0	10	VF2-a	175	F-74a	26.1	0.090	78	1500	14
F		10	20	VF2-b	176	F-74b	1.0	0.016	48	<200	1.4
F		20	50	VF2-c	177	F-74c	<1.0	0.013	17	<200	<1.0
F		50	80	VF2-d	178	F-74d	<1.0	0.014	22	<200	<1.0
F		80	90	VF2-e	161	F-74e	<1.0	<0.01	21	<200	<1.0
F		100	110	VF2-f	162	F-74f	<1.0	0.011	20	<200	<1.0
F	VI-F-1	0	5	VIF1-a	222	F-75a	41.3	0.11	220	2400	15
F		5	20	VIF1-b	223	F-75b	16.3	<0.01	120	840	4.9
F		20	30	VIF1-c	224	F-75c	1.1	<0.01	38	<200	<1.0
F		30	60	VIF1-d	225	F-75d	<1.0	0.015	13	<200	<1.0
F		60	90	VIF1-e	226	F-75e	<1.0	<0.01	6.8	<200	<1.0
F	VI-F-2	0	5	VIF2-a	227	F-76a	40.2	0.20	150	1500	78
F		5	10	VIF2-b	228	F-76b	32.5	0.014	370	1100	7.4
F		10	30	VIF2-c	229	F-76c	<1.0	<0.01	52	<200	<1.0
F		30	50	VIF2-d	230	F-76d	1.9	<0.01	16	<200	<1.0
F		50	60	VIF2-e	213	F-76e	9.3	<0.01	12	1000	<1.0
F		60	80	VIF2-f	214	F-76f	<1.0	<0.01	6.3	<200	<1.0
F		80	85	VIF2-g	215	F-76g	<1.0	<0.01	11	<200	<1.0
F	VI-F-3	0	5	VIF3-a	216	F-77a	12.0	0.061	580	400	14
F		5	15	VIF3-b	217	F-77b	1.5	<0.01	110	<200	2.4
F		15	25	VIF3-c	218	F-77c	<1.0	0.33	41	<200	<1.0
F		25	45	VIF3-d	219	F-77d	<1.0	<0.01	33	<200	1.1

TYPE	Golder site	rom (cm)	to (cm)	Sample (Golder)	Sample (ASU)	Sample (Queen's)	Carbon (%)	Au (µg/ g)	As (µg/ g)	S (µg/g)	Sb (µg/ g)
F		45	55	VIF3-e	220	F-77e	<1.0	<0.01	25	<200	<1.0
F		55	80	VIF3-f	221	F-77f	<1.0	<0.01	30	<200	<1.0
F	VI-F-4	0	5	VIF4-a	204	F-78a	41.3	0.27	68	2300	85
F		5	10	VIF4-b	205	F-78b	34.4	0.016	46	1700	35
F		10	30	VIF4-c	206	F-78c	<1.0	<0.01	50	<200	<1.0
F		30	60	VIF4-d	207	F-78d	<1.0	<0.01	39	<200	<1.0
F		60	100	VIF4-e	208	F-78e	<1.0	0.022	32	<200	<1.0
F	VII-F-1	0	5	VIIF1-a	245	F-79a	18.6	0.063	94	2300	11
F		5	20	VIIF1-b	246	F-79b	18.0	<0.01	43	1500	2.9
F		20	30	VIIF1-c	247	F-79c	3.6	<0.01	32	440	1.3
F		30	60	VIIF1-d	248	F-79d	1.3	<0.01	13	<200	<1.0
F		60	100	VIIF1-e	249	F-79e	<1.0	<0.01	8.7	400	<1.0
F	VII-F-2	0	5	VIIF2-a	250	F-80a	10.3	0.018	120	1000	5.8
F		5	15	VIIF2-b	251	F-80b	1.4	<0.01	28	280	1.3
F		15	30	VIIF2-c	252	F-80c	<1.0	<0.01	26	220	1.5
F		30	60	VIIF2-d	253	F-80d	<1.0	<0.01	19	<200	<1.0
F		60	70	VIIF2-e	236	F-80e	<1.0	<0.01	24	<200	<1.0
F		70	100	VIIF2-f	237	F-80f	<1.0	<0.01	22	<200	<1.0
F	VIII-F-1	0	5	VIIIF1-a	283	F-81a	30.4	0.075	80	2000	17
F		5	15	VIIIF1-b	284	F-81b	28.8	0.043	100	4200	10
F		15	30	VIIIF1-c	285	F-81c	19.9	0.019	55	2500	6.2
F		30	60	VIIIF1-d	286	F-81d	13.2	<0.01	11	1900	3.2
F		60	70	VIIIF1-e	287	F-81e	14.2	<0.01	10	2600	4.0
F	VIII-F-2	0	5	VIIIF2-a	271	F-82a	31.3	0.25	340	1300	76
F		5	15	VIIIF2-b	272	F-82b	37.1	0.017	81	1400	12
F		15	30	VIIIF2-c	273	F-82c	19.9	<0.01	51	1100	5.1
F		30	60	VIIIF2-d	274	F-82d	3.15	<0.01	8.8	300	<1.0
F	VIII-F-3	0	5	VIIIF3-a	275	F-83a	3.4	0.14	160	560	31
F		5	15	VIIIF3-b	276	F-83b	1.4	0.059	220	240	16
F		15	30	VIIIF3-c	277	F-83c	<1.0	<0.01	19	<200	<1.0
F		30	60	VIIIF3-d	278	F-83d	<1.0	<0.01	14	<200	<1.0
F	VIII-F-4	0	5	VIIIF4-a	297	F-84a	30.2	0.11	80	2100	20
F		5	15	VIIIF4-b	298	F-84b	24.5	0.019	76	2800	16
F		15	30	VIIIF4-c	299	F-84c	10.2	0.010	71	1200	7.4
F		30	60	VIIIF4-d	300	F-84d	3.7	<0.01	40	360	2.0
F		60	90	VIIIF4-e	301	F-84e	3.1	<0.01	23	760	1.5
F	VIII-F-5	0	5	VIIIF5-a	302	F-85a	2.0	0.020	110	280	5.2
F		5	15	VIIIF5-b	303	F-85b	<1.0	0.013	64	<200	2.3
F		15	30	VIIIF5-c	304	F-85c	<1.0	<0.01	13	<200	<1.0
F		30	60	VIIIF5-d	305	F-85d	<1.0	<0.01	<mark>8.3</mark>	<200	<1.0

TYPE	Golder site	rom (cm)	to (cm)	Sample (Golder)	Sample (ASU)	Sample (Queen's)	Carbon (%)	Au (µg/ g)	As (μg/ g)	S (µg/g)	Sb (µg/ g)
F		60	100	VIIIF5-e	308	F-85e	<1.0	<0.01	7.3	<200	<1.0
F	IX-F-1	0	5	IXF1-a	113	F-69a	32.7	0.56	2400	2000	190
F		5	15	IXF1-b	114	F-69b	34.6	0.066	300	1600	32
F		15	30	IXF1-c	115	F-69c	32.65	0.021	180	1800	9.4
F		30	55	IXF1-d	116	F-69d	34.3	0.010	290	2400	4.4
F		55	100	IXF1-e	117	F-69e	7.6	<0.01	21	670	1.6
F	IX-F-2	0	5	IXF2-a	37	F-70a	15.8	3.1	930	2200	120
F		5	15	IXF2-b	38	F-70b	30.6	0.66	730	1500	140
F		15	30	IXF2-c	39	F-70c	32.1	0.10	220	1600	25
F		30	45	IXF2-d	40	F-70d	8.0	0.019	53	410	5.0
F	IX-F-3	0	5	IXF3-a	329	F-71a	19.5	0.26	510	2200	60
F		5	15	IXF3-b	330	F-71b	<1.0	0.025	73	<200	3.1
F		15	30	IXF3-c	331	F-71c	<1.0	<0.01	59	<200	3.2
F		30	60	IXF3-d	332	F-71d	<1.0	<0.01	28	400	1.3
F		60	100	IXF3-e	333	F-71e	<1.0	<0.01	14	220	<1.0
F	IX-F-4	0	5	IXF4-a	1	F-72a	39.8	0.22	240	1900	49
F		5	15	IXF4-b	2	F-72b	4.4	48	3600	3900	570
F		15	30	IXF4-c	3	F-72c	5.1	0.86	600	1100	86
F		30	60	IXF4-d	4	F-72d	1.4	0.20	180	700	26
F		60	85	IXF4-e	5	F-72e	<1.0	0.17	48	<200	9.3
F		85	100	IXF4-f	6	F-72f	<1.0	0.027	22	<200	2.6
0	I-OC-1	0	5	IOC1-a	141	O-1a	11.9	0.19	1200	760	48
0		5	15	IOC1-b	142	O-1b	7.6	0.019	230	560	14
0	I-OC-2	2	7	IOC2-a	91	O-2a	15.8	0.20	2000	1100	70
0	I-OC-3	2	5	IOC3-a	92	O-3a	18.9	0.18	1700	1100	57
0	II-OC-1	0	5	llOC1-a	61	O-4a	29.7	0.56	710	1300	120
0		5	10	IIOC1-b	62	O-4b	7.2	0.021	490	510	12
0	II-OC-10	0	5	llOC10-a	83	O-5a	19.6	1.0	16000	2000	260
0		5	8	llOC10-b	84	O-5b	5.0	0.081	7200	820	52
0	II-OC-11	0	5	llOC11-a	85	O-6a	15.4	0.90	11000	920	220
0		5	10	IIOC11-b	86	O-6b	11.3	0.37	7800	920	120
0	II-OC-2	0	3	IIOC2-a	63	O-7a	20.4	0.46	1500	1300	60
0		3	10	IIOC2-b	64	O-7b	6.8	0.028	1400	440	18
0	II-OC-3	0	5	IIOC3-a	65	O-8a	22.3	0.37	1400	810	76
0	4 1 1	5	10	IIOC3-b	66	O-8b	5.8	0.030	1400	250	17
0	II-OC-4	0	5	llOC4-a	67	O-9a	14.4	0.32	2400	510	73
0		5	15	IIOC4-b	68	O-9b	2.2	0.027	460	<200	11
0		15	20	IIOC4-c	69	O-9c	2.8	0.015	410	<200	9.0
0	II-OC-5	0	3	IIOC5-a	70	O-10a	24.3	3.1	17000	1200	900
0		3	10	IIOC5-b	71	O-10b	2.9	0.15	1300	210	47

ТҮРЕ	Golder site	rom (cm)	to (cm)	Sample (Golder)	Sample (ASU)	Sample (Queen's)	Carbon (%)	Au (µg/ g)	As (µg/ g)	S (µg/g)	Sb (μg/ g)
0		10	20	IIOC5-c	72	O-10c	2.2	0.036	2000	220	25
0	II-OC-6	0	5	IIOC6-a	73	O-11a	13.3	1.7	9200	920	320
0		5	15	IIOC6-b	74	O-11b	4.4	0.060	3600	180	35
0		15	20	IIOC6-c	75	O-11c	4.2	0.073	3400	180	45
0	II-OC-7	0	10	IIOC7-a	76	O-12a	27.9	0.17	500	2900	33
0		10	16	IIOC7-b	77	O-12b	4.4	0.017	72	720	6.0
0	II-OC-8	0	12	llOC8-a	78	O-13a	20.6	0.033	480	1300	16
0		12	15	IIOC8-b	79	O-13b	14.0	0.023	320	820	8.4
0	II-OC-9	0	3	llOC9-a	80	O-14a	29.7	0.35	1400	1100	120
0		3	10	IIOC9-b	81	O-14b	7.6	0.019	2400	420	35
0		10	15	IIOC9-c	82	O-14c	8.3	0.016	2400	600	33
0	III-OC-1	0	5	IIIOC1-a	120	O-15a	15.9	0.62	3100	810	90
0		5	15	IIIOC1-b	121	O-15b	14.1	0.056	1400	1000	31
0	III-OC-2	0	8	IIIOC2-a	122	O-16a	15.2	0.73	3200	570	170
0		8	15	IIIOC2-b	123	O-16b	2.0	0.049	1300	210	23
0	III-OC-3	0	5	IIIOC3-a	107	O-17a	14.7	0.20	1400	760	34
0		5	9	IIIOC3-b	108	O-17b	10.2	0.046	1500	560	23
0	III-OC-5	0	5	IIIOC5-a	124	O-18a	10.0	0.11	3200	350	45
0		5	10	IIIOC5-b	125	O-18b	8.4	0.059	4100	610	74
0	III-OC-6	0	5	IIIOC6-a	109	O-19a	36.4	0.034	270	14000	19
0		5	9	IIIOC6-b	110	O-19b	4.1	0.14	1500	220	41
0	III-OC-7	0	5	IIIOC7-a	111	O-20a	10.4	0.049	690	560	21
0		5	10	IIIOC7-b	112	O-20b	8.4	0.032	91	1600	5.1
0	III-OC-8	0	5	IIIOC8-a	354	O-21a	10.5	0.12	630	500	19
0		5	15	IIIOC8-b	355	O-21b	11.6	0.030	260	600	12
0	IV-OC-1	0	5	IVOC1-a	17	O-22a	8.6	0.76	7000	400	160
0		5	10	IVOC1-b	18	O-22b	9.8	0.14	5400	620	73
0	IV-OC-2	0	5	IVOC2-a	143	O-23a	15.5	0.23	840	1400	42
0		5	10	IVOC2-b	144	O-23b	10.6	0.030	810	870	13
0	IV-OC-3	0	5	IVOC3-a	145	O-24a	24.4	0.39	1100	970	150
0		5	15	IVOC3-b	146	O-24b	3.5	0.036	580	210	21
0	IV-OC-4	0	5	IVOC4-a	147	O-25a	28.0	0.56	4800	1300	130
0		5	12	IVOC4-b	148	O-25b	9.4	0.046	5100	580	24
0	V-OC-1	0	5	VOC1-a	179	O-31a	3.0	0.036	1400	<200	25
0		5	15	VOC1-b	180	O-31b	1.1	0.024	570	<200	13
0	V-0C-2	0	5	VOC2-a	181	O-32a	7.8	0.15	3600	450	110
0		5	15	VOC2-b	182	O-32b	<1.0	<0.01	27	220	<1.0
0		15	25	VOC2-c	183	O-32c	1.4	0.011	400	<200	8.4
0		25	35	VOC2-d	184	O-32d	<1.0	<0.01	44	<200	2.2
0	V-OC-3	0	5	VOC3-a	185	O-33a	13.5	0.030	740	800	16

ТҮРЕ	Golder site	rom (cm)	to (cm)	Sample (Golder)	Sample (ASU)	Sample (Queen's)	Carbon (%)	Au (µg/ g)	As (µg/ g)	S (µg/g)	Sb (µg/ g)
0		5	15	VOC3-b	186	O-33b	9.5	0.016	72	530	11
0		15	25	VOC3-c	187	O-33c	9.8	0.021	260	570	10
0	V-OC-4	0	5	VOC4-a	188	O-34a	9.4	0.067	230	520	17
0		5	15	VOC4-b	189	O-34b	8.2	0.015	320	600	11
0		15	30	VOC4-c	190	O-34c	8.3	0.013	140	1200	7.5
0	V-OC-5	0	5	VOC5-a	191	O-35a	5.9	0.10	560	240	20
0		5	10	VOC5-b	192	O-35b	2.4	0.021	310	<200	11
0	V-OC-6	0	5	VOC6-a	193	O-36a	15.4	0.078	330	1000	8.2
0		5	15	VOC6-b	194	O-36b	12.1	0.23	130	800	3.9
0	VI-OC-1	0	5	VIOC1-a	209	O-37a	32.4	0.39	700	1700	120
0		5	15	VIOC1-b	210	O-37b	10.1	0.023	640	540	16
0	VI-OC-2	0	5	VIOC2-a	211	O-38a	12.7	0.028	370	740	14
0		5	10	VIOC2-b	212	O-38b	9.6	<0.01	120	840	7.4
0	VI-OC-3	0	5	VIOC3-a	231	O-39a	29.0	0.20	550	1300	54
0		5	10	VIOC3-b	232	O-39b	9.3	<0.01	450	380	8.8
0	VI-OC-4	0	5	VIOC4-a	202	O-40a	20.9	0.15	1200	1300	36
0		5	10	VIOC4-b	203	O-40b	13.2	0.034	1300	840	20
0	VI-OC-5	0	5	VIOC5-a	233	O-41a	12.6	0.055	750	660	30
0		5	10	VIOC5-b	234	O-41b	12.2	<0.01	230	540	13
0		10	20	VIOC5-c	235	O-41c	9.6	<0.01	100	620	6.4
0	VII-OC-1	0	5	VIIOC1-a	242	O-42a	26.3	0.11	530	860	34
0		5	10	VIIOC1-b	243	O-42b	7.3	0.012	450	280	11
0		10	35	VIIOC1-c	244	O-42c	5.7	0.011	230	220	7.7
0	VII-OC-2	0	5	VIIOC2-a	254	O-43a	27.65	0.014	530	1600	10
0		5	15	VIIOC2-b	255	O-43b	10.9	<0.01	64	1000	3.4
0	VII-OC-3	0	5	VIIOC3-a	256	O-44a	37.9	0.11	170	2400	18
0		5	15	VIIOC3-b	257	O-44b	12.7	0.019	530	1500	15
0	VII-OC-4	0	5	VIIOC4-a	258	O-45a	15.9	0.044	530	600	19
0		5	10	VIIOC4-b	259	O-45b	9.2	<0.01	120	500	10
0	VII-OC-5	0	5	VIIOC5-a	260	O-46a	26.1	0.029	230	1300	13
0	VII-OC-6	0	5	VIIOC6-a	261	O-47a	26.4	0.020	160	1500	9.9
0		5	10	VIIOC6-b	262	O-47b	17.2	0.013	150	1000	7.1
0	VII-OC-7	0	5	VIIOC7-a	263	O-48a	15.6	0.029	290	1400	10
0		5	10	VIIOC7-b	264	O-48b	7.3	<0.01	120	700	2.9
0	VII-OC-8	0	5	VIIOC8-a	265	O-49a	38.6	0.044	51	2100	17
0		5	15	VIIOC8-b	266	O-49b	11.8	<0.01	99	1000	3.3
o		15	25	VIIOC8-c	267	O-49c	10.2	<0.01	14	<u>1</u> 100	5.1
0	VII-OC-9	0	5	VIIOC9-a	268	O-50a	22.6	<0.01	52	2600	5.6
0		5	15	VIIOC9-b	269	O-50b	14.6	<0.01	72	1900	3.1
0		15	30	VIIOC9-c	270	O-50c	9.3	0.010	52	1600	3.2

ТҮРЕ	Golder site	rom (cm)	to (cm)	Sample (Golder)	Sample (ASU)	Sample (Queen's)	Carbon (%)	Au (µg/ g)	As (µg/ g)	S (µg/g)	Sb (µg/ g)
0	VIII-OC-1	0	5	VIIIOC1-a	288	O-51a	8.9	0.018	170	400	5.3
0		5	10	VIIIOC1-b	289	O-51b	4.5	<0.01	20	300	1.9
0	VIII-OC-2	0	5	VIIIOC2-a	290	O-52a	10.0	0.029	190	600	7.6
0		5	10	VIIIOC2-b	291	O-52b	11.8	<0.01	51	940	3.5
0		10	20	VIIIOC2-c	292	O-52c	11.1	<0.01	76	1200	3.9
0	VIII-OC-3	0	5	VIIIOC3-a	293	O-53a	24.5	0.18	940	1500	33
0		5	10	VIIIOC3-b	294	O-53b	9.9	0.011	190	640	7.3
0	VIII-OC-4	0	5	VIIIOC4-a	295	O-54a	27.9	0.20	840	1000	59
0		5	20	VIIIOC4-b	296	O-54b	8.0	0.016	370	280	12
0	VIII-OC-5	0	10	VIIIOC5-a	279	O-55a	15.9	0.22	400	1000	49
0		10	15	VIIIOC5-b	280	O-55b	15.1	0.034	330	1000	14
0	VIII-OC-6	0	5	VIIIOC6-a	281	O-56a	21.1	0.051	380	740	16
0		5	10	VIIIOC6-b	282	O-56b	13.2	0.014	280	500	6.5
0	IX-OC-1	0	5	IXOC1-a	317	O-26a	5.0	0.64	2500	1000	73
0		5	15	IXOC1-b	318	O-26b	<1.0	0.015	150	85	6.0
0	IX-OC-2	0	3	IXOC2-a	319	O-27a	18.1	1.8	5500	2100	330
0		3	10	IXOC2-b	320	O-27b	1.9	0.061	910	140	18
0		10	25	IXOC2-c	321	O-27c	1.7	0.037	480	160	12
0	IX-OC-3	0	5	IXOC3-a	322	O-28a	20.2	1.3	4800	1700	280
0		5	10	IXOC3-b	323	O-28b	15.9	0.84	4900	1000	180
0	IX-OC-4	0	6	IXOC4-a	324	O-29a	30.6	0.61	5200	1500	190
0		6	15	IXOC4-b	325	O-29b	4.5	0.051	1100	460	15
0		15	20	IXOC4-c	326	O-29c	3.0	0.029	1200	200	14
0	IX-OC-5	0	7	IXOC5-a	327	O-30a	26.7	0.69	920	1600	140
0		7	15	IXOC5-b	328	O-30b	8.8	0.037	1100	560	16
S	Stockpile 1			Stockpile	349	S-57a	<1.0	<0.01	33	6900	1.4
S	Stockpile 2			Stockpile	350	S-57b	<1.0	0.011	63	9900	4.2
S	Stockpile 3			Stockpile	351	S-57c	<1.0	0.17	27	9800	1.0
S	Stockpile 4			Stockpile	352	S-57d	<1.0	0.011	26	9000	1.3
S	Stockpile 5			Stockpile	353	S-57e	<1.0	0.015	66	2400	2.9
w	I-WL-1	0	5	IWL1-a	136	W-86a	3.5	0.25	130	1400	16.0
w		5	15	IWL1-b	137	W-86b	<1.0	0.48	93	470	8.9
w		15	30	IWL1-c	138	W-86c	<1.0	0.018	25	330	1.6
w		30	60	IWL1-d	139	W-86d	<1.0	0.014	14	<200	1.0
w		60	100	IWL1-e	140	W-86e	<1.0	0.016	15	200	1.2
w	I-WL-2	0	5	IWL2-a	46	W-87a	14.6	1.5	780	1700	16
w		5	15	IWL2-b	47	W-87b	2.3	0.97	500	1100	39
w		15	30	IWL2-c	48	W-87c	<1.0	0.16	80	260	5.0
w		30	60	IWL2-d	49	W-87d	<1.0	0.028	24	<200	1.3
w		60	100	IWL2-e	50	W-87e	<1.0	0.018	13	<200	<1.0

ТҮРЕ	Golder site	rom (cm)	to (cm)	Sample (Golder)	Sample (ASU)	Sample (Queen's)	Carbon (%)	Au (µg/ g)	As (μg/ g)	S (µg/g)	Sb (μg/ g)
w	II-WL-2	0	5	IIWL2-a	131	W-88a	37.6	0.68	900	6200	210
w		5	15	IIWL2-b	132	W-88b	37.8	0.12	240	3500	56
w		15	30	IIWL2-c	133	W-88c	3.2	<0.01	110	260	1.6
W		30	60	IIWL2-d	134	W-88d	1.5	<0.01	39	<200	1.0
W		60	100	IIWL2-e	135	W-88e	<1.0	<0.01	21	<200	<1.0
w	III-WL-1	0	5	lllWL1-a	118	W-89a	5.4	2.4	1000	1500	160
w		5	15	IIIWL1-b	119	W-89b	3.55	4.4	920	1300	200
w		15	30	IIIWL1-c	93	W-89c	4.2	4.0	2700	3900	470
w		30	60	IIIWL1-d	94	W-89d	<1.0	0.086	65	260	11.0
W		60	100	IIIWL1-e	95	W-89e	<1.0	0.058	62	200	9.0
w	IV-WL-1	0	5	IVWL1-a	12	W-90a	5.0	2.1	1100	420	150
w		5	15	IVWL1-b	13	W-90b	1.3	0.54	250	<200	38
W		15	30	IVWL1-c	14	W-90c	1.1	0.13	94	<200	8.3
W		30	60	IVWL1-d	15	W-90d	<1.0	0.17	120	<200	10.0
W		60	100	IVWL1-e	16	W-90e	<1.0	0.11	57	<200	4.4
W	IV-WL-2	0	5	IVWL2-a	7	W-91a	<1.0	0.15	210	<200	84
W		5	15	IVWL2-b	8	W-91b	<1.0	0.98	1000	560	270
W		15	30	IVWL2-c	9	W-91c	1.3	1.6	2800	2100	800
w		30	60	IVWL2-d	10	W-91d	1.8	2.0	3400	4000	1100
W		60	100	IVWL2-e	11	W-91e	2.3	0.22	1800	<200	1100
w	IV-WL-3	0	5	IVWL3-a	96	W-92a	7.8	0.019	67	1300	4.8
w		5	15	IVWL3-b	97	W-92b	5.3	0.056	130	760	<1.0
w		15	30	IVWL3-c	98	W-92c	3.5	0.028	110	660	8.3
w		30	60	IVWL3-d	99	W-92d	<1.0	<0.01	79	<200	2.0
w		60	100	IVWL3-e	100	W-92e	<1.0	<0.01	38	<200	1.0
w	IV-WL-4	0	5	IVWL4-a	149	W-93a	5.45	0.034	260	1400	14.0
w		5	15	IVWL4-b	150	W-93b	5.0	0.040	210	870	10
w		15	30	IVWL4-c	151	W-93c	4.0	0.031	140	490	10.0
w		30	60	IVWL4-d	152	W-93d	6.6	0.074	180	670	13
w		60	100	IVWL4-e	153	W-93e	3.2	0.031	160	340	5.7
w	IV-WL-5	0	5	IVWL5-a	339	W-94a	4.0	0.023	330	420	4.3
w		5	15	IVWL5-b	340	W-94b	4.3	0.030	210	470	4.6
w		15	30	IVWL5-c	341	W-94c	3.2	0.029	200	380	4.8
w		30	60	IVWL5-d	342	W-94d	1.2	<0.01	30	300	<1.0
w		60	100	IVWL5-e	343	W-94e	1.4	<0.01	22	380	<1.0
w	V-WL-1	0	5	VWL1-a	163	W-97a	41.7	0.54	810	2600	160
w		5	15	VWL1-b	164	W-97b	43.3	0.099	190	4200	26
w		15	30	VWL1-c	165	W-97c	35.4	0.040	120	5200	7.7
w		30	60	VWL1-d	166	W-97d	39.4	<0.01	50	5400	2.9
W		60	80	VWL1-e	167	W-97e	29.0	0.012	34	4400	2.7

ТҮРЕ	Golder site	rom (cm)	to (cm)	Sample (Golder)	Sample (ASU)	Sample (Queen's)	Carbon (%)	Au (<i>µ</i> g/ g)	As (μg/ g)	S (µg/g)	Sb (μg/ g)
w	V-WL-2	0	5	VWL2-a	168	W-98a	34.8	0.045	240	12000	15
w		5	20	VWL2-b	169	W-98b	7.1	0.28	1100	1300	33
w		20	40	VWL2-c	154	W-98c	35.3	0.052	220	11000	14
[w		40	70	VWL2-d	155	W-98d	35.2	0.029	190	9000	10.0
W		70	100	VWL2-e	156	W-98e	<1.0	0.036	8.2	220	<1.0
w	V-WL-3	0	10	VWL3-a	157	W-99a	4.9	0.11	35	1100	9.1
w		10	50	VWL3-b	158	W-99b	4.7	0.056	29	1100	3.8
w		50	80	VWL3-c	159	W-99c	<1.0	<0.01	4.9	<200	<1.0
W		80	100	VWL3-d	160	W-99d	<1.0	<0.01	5.7	<200	<1.0
w	VI-WL-1A	0	5	VIWL1A-a	195	W-100a	9.3	0.31	1500	4300	23
W		5	10	VIWL1A-b	196	W-100b	2.5	0.16	420	2600	26
w	VI-WL-1B	0	5	VIWL1B-a	197	W-101a	12.0	0.21	870	6000	25
w		5	10	VIWL1B-b	198	W-101b	10.9	0.23	1200	6200	27
W		10	30	VIWL1B-c	199	W-101c	14.0	0.33	790	4500	24
[w		30	60	VIWL1B-d	200	W-101d	9.7	0.039	170	2000	8.4
W		60	80	VIWL1B-e	201	W-101e	4.9	0.014	88	1400	3.2
w	VII-WL-1	0	10	VIIWL1-a	238	W-102a	34.1	0.056	260	9700	11
W		10	30	VIIWL1-b	239	W-102b	40.1	0.013	170	11000	6.4
[w		30	55	VIIWL1-c	240	W-102c	35.7	<0.01	45	9700	2.9
w		55	100	VIIWL1-d	241	W-102d	26.8	<0.01	30	16000	2.0
w	VIII-WL-1	0	5	VIIIWL1-a	309	W-103a	29.4	0.11	94	2000	11
w		5	15	VIIIWL1-b	310	W-103b	35.2	<0.01	32	3200	3.2
W		15	30	VIIIWL1-c	311	W-103c	32.4	<0.01	40	3600	1.2
w		30	60	VIIIWL1-d	312	W-103d	34.1	<0.01	23	5600	1.0
W		60	100	VIIIWL1-e	313	W-103e	<1.0	<0.01	6.4	200	<1.0
w	VIII-WL-2	0	5	VIIIWL2-a	314	W-104a	19.9	0.024	41	2500	10
w		5	15	VIIIWL2-b	315	W-104b	9.4	<0.01	18	760	2.0
w		15	30	VIIIWL2-c	316	W-104c	4.5	<0.01	11	400	<1.0
w		30	60	VIIIWL2-d	306	W-104d	1.2	<0.01	7.3	<200	<1.0
w		60	100	VIIIWL2-e	307	W-104e	<1.0	<0.01	6.2	<200	<1.0
w	IX-WL-1	0	5	IXWL1-a	32	W-95a	2.0	0.74	1500	4100	120
w		5	15	IXWL1-b	33	W-95b	<1.0	0.31	690	1700	64
w		15	30	IXWL1-c	34	W-95c	<1.0	0.16	220	480	33
w		30	60	IXWL1-d	35	W-95d	<1.0	0.040	150	<200	14
w		60	100	IXWL1-e	36	W-95e	<1.0	0.055	120	<200	12
w	IX-WL-2	0	5	IXWL2-a	41	W-96a	5.1	0.13	700	1300	27
w		5	15	IXWL2-b	42	W-96b	<1.0	0.017	160	250	6.5
w		15	30	IXWL2-c	43	W-96c	<1.0	<0.01	110	<200	3.0
w		30	60	IXWL2-d	44	W-96d	<1.0	<0.01	19	<200	<1.0
W		60	100	IXWL2-e	45	W-96e	<1.0	0.028	29	<200	1.1

3.1.1 QA/QC

Complete chemical QA/QC results, including all duplicate analyses, standards, and blanks, can be found in Appendices III, IV, and V (for 30-element, Au, and C, respectively).

3.1.1.1 30-element ICP-OES and ICP-MS

ICP-OES and ICP-MS (Sb only) QA/QC results were generally favorable. Twenty-eight blanks were taken alongside the soil analyses. Two blanks had results above detection limit. One had 19 μ g/g As and another had 2.5 μ g/g Mg and 58 μ g/g Fe. The detection limits for ICP-OES are listed below:

Element	Ag	Al	As	В	Ba	Be	Ca	Cd	Со	Cr	Cu	Fe	K	Mg	Mn
Detection Limit	2.0	50	1.0	20	5.0	4.0	100	1.0	5.0	20	5.0	50	20	20	1.0
(µg/g)															
Element	Мо	Na	Ni	Р	Pb	S	Sb	Se	Sn	Sr	Ti	ΤI	U	V	Zn
Detection															
Limit	2.0	75	5.0	20	10	200	1.0	10	2.0	5.0	10	1.0	10	10	15
(µg/g)															

Table 3.2: Detection limits for ICP-OES and ICP-MS analyses

MESS-3 was the standard reference material for this QA/QC. MESS-3 is a marine sediment from the Beaufort Sea produced and certified by the National Research Council of Canada and is appropriate for use when analyzing trace elements. Several elements in MESS-3 have concentrations below the detection limit of the ICP-OES method used. Ag, Cd, Sb, Se, Sn, Tl and U were not observed in MESS-3.

Twenty-eight ICP-OES analyses of MESS-3 were spread out among the test samples for quality control purposes. A close look at arsenic measurements revealed that the measured values deviated from the expected value (18 μ g/g) by an average of 7.4% with a standard deviation of 7.4%.

Thirty-one sample duplicate analyses were run to check for reproducibility. For As the replicates had an average percent variance of 4.5%. Detailed statistics on variance for each set of sample As duplicates are contained in Table 3.3. Two samples produced percent variance values >10%; one of these samples had extremely low As (<20 µg/g). Given the low sample volume used in analyses (<0.5g) and known heterogeneity of Giant Mine soils, duplicates generally performed well.

ASU Sample	Golder e Name	Queen's Name	As μg/g (1)	As μg/g (2)	Standard Deviation	Duplicate Mean	% Variance
4	IXF4-d	F-72d	190	180	7.07	185	3.82
20	IVF3A-b	F-67b	2500	2400	70.71	2450	2.89
30	IIIF2-d	F-64d	260	240	14.14	250	5.66
32	IXWL1-a	W-95a	1500	1600	70.71	1550	4.56

Table 3.3: Sample duplicate variance for As

ASU Sample	Golder Name	Queen's Name	As μg/g (1)	As μg/g (2)	Standard Deviation	Duplicate Mean	% Variance
55	IIF3-e	F-62e	16	15	0.71	15.5	4.56
64	IIOC2-b	O-7b	1400	1400	0	1400	0
71	IIOC5-b	O-10b	1400	1300	70.71	1350	5.24
92	IOC3-a	O-3a	1600	1700	70.71	1650	4.29
105	IF2-d	F-59d	180	180	0	180	0
118	IIIWL1-a	W-89a	1000	990	7.07	995	0.71
135	IIWL2-e	W-88e	23	20	2.12	21.5	9.87
148	IVOC4-b	O-25b	4600	5600	707.11	5100	13.86
152	IVWL4-d	W-93d	180	180	0	180	0
165	VWL1-c	W-97c	120	120	0	120	0
178	VF2-d	F-74d	22	21	0.71	21.5	3.29
191	VOC5-a	O-35a	530	600	49.5	565	8.76
204	VIF4-a	F-78a	67	68	0.71	67.5	1.05
209	VIOC1-a	O-37a	730	680	35.36	705	5.01
216	VIF3-a	F-77a	610	540	49.5	575	8.61
222	VIF1-a	F-75a	220	220	0	220	0
228	VIF2-b	F-76b	390	350	28.28	370	7.64
233	VIOC5-a	O-41a	730	760	21.21	745	2.85
240	VIIWL1-c	W-102c	47	43	2.83	45	6.29
246	VIIF1-b	F-79b	41	46	3.54	43.5	8.13
252	VIIF2-c	F-80c	26	27	0.71	26.5	2.67
265	VIIOC8-a	O-49a	50	52	1.41	51	2.77
278	VIIIF3-d	F-83d	14	14	0	14	0
291	VIIIOC2-b	O-52b	51	52	0.71	51.5	1.37
304	VIIIF5-c	F-85c	11	16	3.54	13.5	26.19
327	IXOC5-a	O-30a	940	910	21.21	925	2.29
340	IVWL5-b	W-94b	210	210	0	210	0
359	IIIF1-d	F-63d	76	76	0	76	0

Percent variance was calculated by dividing the standard deviation by the sample mean, and multiplying by 100. It is a measure of how much duplicate samples differ from one another.

While samples with very high As concentrations had to be diluted for analysis (see section 2) and as a result only have two significant figures, QA/QC results suggest that data accuracy quality for As is generally good. See Appendix III for complete results.

3.1.1.2 ICP-MS gold

ICP-MS Gold measurement was done by ICP-MS. 28 blanks were alongside the soil analyses. All blanks were below detection limit of 0.01 μ g/g.

DS-1 was the standard reference material for gold analyses QA/QC. DS-1 is a gold ore from the Deep Star mine in Nevada, USA, certified by the National Research Council of Canada, and is appropriate for

use when analyzing gold. Thirty-four measurements of DS-1 were taken. The average for the measurements was 29 μ g/g with a standard deviation of 2.9 μ g/g. The accepted value for the reference material was 28 μ g/g. Thirty-one duplicates sets of samples were run to check for reproducibility. Nine sets were below detection limit. The remaining 22 duplicate sets above detection had an average percent difference of 18.9%.

The ASU staff communicated that they observed excellent stability for Au over the course of the project, even with sub ppb standards. Sensitivity and stability were also excellent even when running the instrument in maximum HMI (high matrix introduction - gas dilution mode). There was likely one instance of a gold sample going over the linear calibration range (ASU sample 002 at site IXF4). However, checks of low-weight digests of DS-1 for low ppb level stability and recovery indicate that these should not have ben problematic. The high Au sample was analyzed via FAAS instead of being diluted and re-run on ICP-MS, however, the FAAS result was within a few percentage points of the over range estimate of the ICP-MS.

See Appendix IV for complete QA/QC results.

3.1.1.3 Carbon

Carbon analysis QA/QC included 12 blanks, 13 soil controls, and 13 orchard leaves controls. All blanks reported C% values below detection (1%), Soil controls (target 12.3% C) returned a mean value of 12.5%, with a standard deviation of 0.4 and a %CV of 3.5%. The orchard leaves control (target 51.4% C) returned a mean value of 53.98%, with a standard deviation of 2.75 and a %CV of 5.09%.

Duplicate analyses were completed for 49 samples; of these samples, one was analyzed in triplicate, and one in quadruplicate. Percent co-variance results ranged widely. While range of %CV values present is very wide (0-111%), most values fell below 12%. This is slightly higher than the control %CV measurements and is likely an artifact of sometimes heterogenous soils. The quadruplicate sample provides a good illustration of sample heterogeneity: it yielded a %CV of 28%, with carbon results from 5%-9%. The two outlier duplicates (%CV of 109% and 111% for samples with carbon % 3-24% and 4-33%, respectively) were both the top horizons their sample sites, and were described during the drying process as being very organic-rich and heterogenous. These descriptions are supported by sample photos. Results for duplicate carbon analysis, including statistical calculations, are reported in Appendix V.

3.1.2 Arsenic concentration variation with depth

For most samples, As concentration decreases with depth. Arsenic concentrations below 30cm depth typically decrease dramatically compared to the more surface-proximal soils (see Figure 3.2). Outcrop samples in particular dominate the high As samples (Figure 3.2, 3.3).



ARSENIC CONCENTRATION vs. SAMPLE MID-POINT DEPTH, ALL SAMPLES

Figure 3.2: Arsenic concentration variation with sample depth and location type for all samples

When viewing a breakdown of As concentrations in each soil horizon for individual samples, several exceptions to the general trend of decreasing As concentration with depth emerge (Figure 3.3). These sample locations (viewed in Figure 2.1) are all located near known areas of disturbed soil or in suspicious proximity to roads (IIML1, IVWL2, VWL2, IXF4, VIF2).

Figure 3.3 (next page): Soil horizons labeled A through F correspond to the relative depth of samples to one another at each sample site, not necessarily to a defined depth. In general samplers chose to sample at 0-5cm, 5-15cm, 15-30cm, 30-60cm, and 60-100cm, however there is variation amongst sample sites. For example, often the A horizon corresponds to the 0-5cm depth but for some samples it is actually 0-3cm, 2-7cm, or 0-10cm. See Table 3.1 and Appendix I for exact information on sample interval width.

Panel (A) shows all forest sites, panel (B) shows wetland sites, and panel (C)shows outcrop soil sites.



3.2 Mineral Liberation Analysis (MLA) and Scanning Electron Microscopy (SEM)

3.2.1 MLA QA/QC

The final MLA analysis protocol proved to be excellent at finding As₂O₃. Confidence in the accuracy of the As results for each sample was assured by manually checking a portion of all the different As hosts in all runs. Grains that fell across MLA frame boundaries present an issue for the accuracy of the grain count measurement, as it was impractical for this project to join them together (see example in Figure 3.4). A slight beam shift issue with the SEM has also resulted in slight inaccuracies of a few pixels for grains across frame boundaries. This is not expected to affect the accuracy of the data.

All As phases apart from As₂O₃, As sulfide, and arsenopyrite, which all have defined chemical compositions, had As levels in EDS spectra that varied qualitatively. Electron microprobe analysis would be necessary to more firmly delineate the range of As concentrations present in the phases without defined chemical compositions. The maximum As concentration in these phases is expected to be less than 10%. Please note that accuracy for the identification of individual silicate minerals and other gangue minerals is not as high as for As minerals, since the MLA was not optimized for this application in this project. Arsenic-bearing phases were the only phases checked in detail for all samples during QA/QC.

3.2.1.1 Duplicate analysis

In terms of the representativity of MLA results, duplicate analysis has quantitatively proven the macroscale heterogeneity observed in the sample preparation process, as well as earlier observations on Giant soils (i.e., Bromstad 2011, Wrye 2008), extends to the micron scale. Heterogeneity is not surprising given agglomeration, irregularly shaped organic matter, and the fact that most MLA maps only covered an area of roughly 12,000 x 15,000 pixels (approximately 10,240 x 12,800 μ m), or roughly ½ to ½ of the surface of the grain mount (barring those from density checks). See Table 3.4 and further tables in Appendix X for covariance statistics on duplicate grain mounts. Values over 50% are highlighted.

Gold		As	As ₂ O ₃				Arsenopyrite				As sulfide			
Gold er_ho rizon	Sam- ple	μg/g (mea s- ured)	area (µm²)	grai ns	As; Varia	₂O₃ nce%	area (µm²)	grain s	As Varia	py nce%	area (µm²)	grain s	As Sı Variai	ulfide nce%
IVWL	010 dup	3400	200.6	7	area	66.1	10359	883	area	2.6	22.5	6	area	7.1
2-0	10	3400	72.8	3	grains	56.6	9983	697	grains	16.6	20.3	4	grains	28.3
IIIF2-	028 dup	840	3497.9	23	area	23.8	244.6	1	area	141.4	0.0	0	area	0.0
D	28	840	4915.5	38	grains	34.8	0.0	0	grains	141.4	0.0	0	grains	0.0
IIOC5	070_1	17000	110298	2259	area	5.6	265.0	4	area	32.7	0.0	0	area	0.0
-а	70	17000	119404	1765	grains	17.4	424.5	8	grains	47.1	0.0	0	grains	0.0
IIOC5	071 redo	1300	1306.2	32	area	86.8	135.4	1	area	141.4	0.0	0	area	0.0

Table 3.4: Percent variance statistics for As₂O₃, arsenopyrite, and arsenic sulfide in GXMAP runs

Gold er_ho rizon	Sam- ple	As μg/g (mea s- ured)	As ₂ O ₃				Arsenopyrite				As sulfide			
			area (µm²)	grai ns	As; Varia	₂O₃ nce%	area grain Aspy (μm²) s Variance%		py nce%	area (µm²)	grain s	As Sulfide Variance%		
-0	071_1	1300	5452.9	94	grains	69.6	0.0	0	grains	141.4	0.0	0	grains	0.0
IIOC1 1-b	086 dup	7800	7975.8	121	area	35.9	0.0	0	area	0.0	0.0	0	area	0.0
	86	7800	13408	235	grains	45.3	0.0	0	grains	0.0	0.0	0	grains	0.0
IIIOC 2-b	123 dup	1300	1876.4	45	area	99.9	63.3	1	area	141.4	0.0	0	area	0.0
	123	1300	322.6	11	grains	85.9	0.0	0	grains	141.4	0.0	0	grains	0.0
IVOC 4-b	148 dup	5100	2191.6	16	area	133.2	52.4	3	area	141.4	0.0	0	area	0.0
	148	5100	65.5	8	grains	47.1	0.0	0	grains	141.4	0.0	0	grains	0.0
VWL2 -b	169 dup	1100	40.0	7	area	62.5	109.2	2	area	137.8	0.0	0	area	0.0
	169	1100	103.4	6	grains	10.9	8534	90	grains	135.3	0.0	0	grains	0.0
VIWL 1A-b	196 dup	420	0.0	0	area	0.0	11337	70	area	43.0	166.7	31	area	30.5
	196	420	0.0	0	grains	0.0	6047	106	grains	28.9	258.5	32	grains	2.2
VIOC 4-b	203	1300	2.9	1	area	134.7	2.9	1	area	130.5	0.0	0	area	0.0
	203 dup **XB SEST D	1300	120.1	2	grains	47.1	72.8	1	grains	0.0	0.0	0	grains	0.0
The largest percent variance statistics usually correspond to samples with the smallest surface areas and amounts of grains. Middling to poor variance percents throughout much of the data set (when values are greater than 0-1) is indicative of sample heterogeneity and the nugget effect in As hosts.														

Table 3.4 and Appendix X clearly demonstrate the at times extreme differences in presence of As phases for the same sample. Samples with less than 100 grains of either As₂O₃ or arsenopyrite had notably worse repeatability and increased nugget effect. Gangue mineral covariance tended to fare better for the most part, likely because gangue minerals usually make up larger proportions of each sample than As hosts, meaning any differences between duplicates are usually smaller relative to the total amount of the gangue mineral. Gangue minerals only produced large covariance statistics for samples with low area percent measurements, with the exception of organics, which tended to have poorer repeatability between duplicates.

Sample 148 (IV-OC-4b) has exhibited extreme variation in As for both its MLA and ASU chemical analysis duplicates. Table 3.3 details the 1000 μ g/g spread between the chemical analysis duplicates. Upon examination with the SEM, this sample appears to be a good example of the extreme nugget effect for As₂O₃ (See Figure 3.4).



3.2.1.2 Density mounts

Specialized mounts were constructed for samples 10, 72, 86, and 148 to evaluate whether particle settling introduces a bias to the Giant Mine soils MLA analysis. These samples were also part of the duplicate

grain mount set so there is a wealth of data to compare. There were not enough major As hosts present in the cross-sectional density mounts to evaluate whether a trend exists for As settling. The As₂O₃ grains that were observed were in a variety of locations, suggesting that there may possibly be no significant particle settling for this phase.

Trends observed in GXMAP density data for gangue phases may be discerned from the data in Table 3.5. For carbonates, sample 10 (the only sample with over 1% area combined carbonate minerals) shows a slight over-representation of carbonate minerals in the cross-sectional mounts. The most noticeable trend for silicates is a slight under-representation in cross section for samples 10 and 72. For organics the most noticeable trend is a slight over-representation in cross-section. If these trends have any significance, they may indicate that density separation is occurring, although it appears to be a minor issue.

Site	Sample	As µg/g	Silicate gangue	carbonate gangue	oxide gangue	sulfide gangue	phosphate gangue	organic
IVWL2-d	10	3400	86.971846	7.906223	0.764651	0.283631	0.077829	1.438021
IVWL2-d	010 D	3400	86.719438	7.478307	0.772708	0.26519	0.071161	1.520857
IVWL2-d	010 DX	3400	79.155771	11.876419	0.849219	0.246313	0.08781	2.086627
IVWL2-d	010 DX	3400	81.483913	8.56509	0.914424	0.293645	0.115824	2.387084
IVWL2-d	010 dup	3400	88.716308	6.108979	0.631738	0.227272	0.073098	1.432565
IIOC5-c	72	2000	98.270564	0.009811	0.214636	0.000472	0.034472	0.209726
IIOC5-c	072 D	2000	97.05681	0.003459	0.205314	0.00004	0.03762	0.570087
IIOC5-c	072 DX	2000	90.942517	0.080054	0.235023	0.000273	0.018121	1.459504
IIOC5-c	072 DX	2000	93.314024	0.054057	0.297409	0	0.054932	0.845685
llOC11-b	86	7800	63.874237	0.008251	1.196031	0.001913	0.010241	20.287931
llOC11-b	086 D	7800	73.021399	0.006603	0.777095	0.007588	0.005513	3.439294
llOC11-b	086 DX	7800	82.083348	0.082225	0.629633	0.000146	0.000512	4.725133
llOC11-b	086 DX	7800	77.848638	0.112721	0.633768	0.00218	0.007977	5.759226
IIOC11-b	086 dup	7800	90.8051	0.002149	0.726834	0.000883	0.002951	5.566463
IVOC4-b	148	5100	74.299719	0.007713	8.424679	0.000322	0.016841	4.044177
IVOC4-b	148 D	5100	72.133062	0.002583	0.511844	0.001049	0.003233	6.093794
IVOC4-b	148 DX	5100	81.066098	0.031479	0.355611	0.000722	0.016049	7.540637
IVOC4-b	148 DX	5100	77.026299	0.073787	0.649819	0.012871	0.007481	9.562115
IVOC4-b	148 dup	5100	87.377352	0.054312	0.796251	0.001545	0.013051	3.243659

Table 3.5: Density mount statistics for gangue mineral area % modal mineralogy

Cross-sectional density mounts are highlighted in gray. Plan view density mounts are marked with a "D" and crosssectional ones with "DX." The main different between "D" mounts and the normal sample and duplicate mounts included in this table are that the "D" mounts have a much smaller surface area, and so the GXMAP scan was done over a smaller area.

Images of density cross-section samples visually indicate a slight trend in grains orienting parallel to the sample mount surface. Both this effect and the slight differences in modal mineralogy discussed above suggest that while there is some particle settling in grain mounts, it is likely minor, and it is probably kept at manageable levels by the cycles of stirring during sample preparation. In terms of As hosts and particle settling, it is possible that the association of As_2O_3 with organics could be compared somewhat to the behavior of organics in density cross-section for samples high in organics, but this is impossible to evaluate at this time. Evaluating the effect of density segregation on As_2O_3 may be possible if using the most As_2O_3 -rich samples, in order to compensate for the relative scarcity of As_2O_3 grains observed in density cross-sections so far, and obtain more statistically significant results.



Figure 3.5: Arsenopyrite liberation. All photos in this figure are from sample 197. (**A**) shows arsenopyrite grains confined within a quartz-carbonate nodule (BSE left, MLA classified right). (**B**) shows a free-floating arsenopyrite grain stuck to a clump of mixed organics and other particles that the MLA recognizes as being confined (BSE left, MLA classified right). See Table 2.5 for MLA legend.







FINAL REPORT: CHARACTERIZATION OF SOIL SAMPLES AT GIANT MINE, NWT (2014 Regional Sampling)
3.2.1.3 Mineral liberation

Various issues arising from clumping and agglomeration of particles in Giant Mine soils have been discussed elsewhere in this report. One further issue is the use of MLA software for grain liberation analysis for As mineral hosts. In this specific case, use of the mineral liberation feature is not recommended for As hosts. Arsenic trioxide is a roaster-derived product at Giant, so in its original form it is already liberated. Analysis of SEM photographs confirms that while As₂O₃ sometimes appears to cling to clusters of organics and other particles, it is not sequestered or encapsulated within another phase. MLA analysis would not recognize this because of clumping issues. Arsenopyrite is also affected by clumping in this instance: arsenopyrite in mixed phase clumps and arsenopyrite encapsulated in carbonate/silicate rock appear the same to the MLA in terms of liberation, while in reality only the clumped arsenopyrite is actually liberated (Figure 3.5).

3.2.2 Arsenic modal mineralogy

3.2.2.1 Presence of As₂O₃

While As₂O₃ was not found in all MLA samples, it was found at all MLA sample sites except one. However, the MLA site without As₂O₃ was directly adjacent (at the same GPS coordinates) to a site that did have As₂O₃ (VI-WL-1A and VI-WL-1B, respectively). Information on samples with As₂O₃ can be found in Table 3.6, as well as a scaled-up calculation for how many mm² As₂O₃ would be present on the surface of a 100cm² area section of soil for each sample. This calculation is meant to frame As₂O₃ modal mineralogy area % results in terms more relatable to practical human health and risk assessment issues. Values greater than 4mm² As₂O₃ (in 100cm² surface area of soil) are highlighted in red.

Site	As ₂ O ₃ pre- sent?	Golder sample name	Sample	MLA run type	As μg/ g (meas ured)	As₂O₃ grains	Area (µm2) per grain	As₂O₃ area %	Surface area (in mm ²) of As ₂ O ₃ pre- sent in a 100cm ² soil film
	YES	IXF4-b	2	GXMAP	3600	17	20.52	0.00071	0.07
17-1-4	YES	IXF4-c	3	GXMAP	600	6	8.65	0.00012	0.01
	YES	IVWL2-b	8	GXMAP	1000	1	1.46	3E-06	0.00
	no	IVWL2-c	9	GXMAP	2800	0	0	0	0.00
IV-WL-2	YES	IVWL2-d	10	GXMAP	3400	3	24.25	0.00024	0.02
	YES	IVWL2-d	010 dup	GXMAP	3400	7	28.66	0.0005	0.05
	YES	IVWL2-e	11	GXMAP	1800	48	7.01	0.0009	0.09
	YES	IVOC1-a	17	GXMAP	7000	111	140.51	0.04605	4.60
10-00-1	YES	IVOC1-b	18	GXMAP	5400	10	124.87	0.00307	0.31
	YES	IIIF2-a	27	GXMAP	1500	94	285.03	0.06232	6.23
IV-F-2	YES	IIIF2-b	28	GXMAP	840	38	129.36	0.0114	1.14
	YES	IIIF2-b	028 dup	GXMAP	840	23	152.08	0.00795	0.80
	YES	llOC5-a	70	GXMAP	17000	1765	67.65	0.52469	52.47
	YES	IIOC5-a	070_1	GXMAP	17000	2259	48.83	0.61587	61.59
II-OC-5	YES	IIOC5-b	071 redo	GXMAP	1300	32	40.82	0.00317	0.32
	YES	IIOC5-b	071_1	GXMAP	1300	94	58.01	0.01723	1.72
	YES	IIOC5-c	72	GXMAP	2000	2	8.01	3.2E-05	0.00
	YES	IIOC9-a	80	GXMAP	1400	92	37.12	0.01558	1.56
II-OC-9	no	IIOC9-b	81_2	GXMAP	2400	0	0	0	0
	no	IIOC9-c	82	GXMAP	2400	0	0	0	0.00

Table 3.6: Arsenic trioxide in MLA samples

Site	As ₂ O ₃ pre- sent?	Golder sample name	Sample	MLA run type	As μg/ g (meas ured)	As ₂ O ₃ grains	Area (µm2) per grain	As₂O₃ area %	Surface area (in mm²) of As ₂ O ₃ pre- sent in a 100cm² soil film
	YES	llOC10-a	83	GXMAP	16000	383	162.58	0.14695	14.70
II-OC-10	YES	IIOC10-b	84	GXMAP	7200	16	78.77	0.00268	0.27
	YES	llOC11-a	85	GXMAP	11000	484	67.43	0.16417	16.42
II-OC-11	YES	IIOC11-b	86	GXMAP	7800	235	57.06	0.03151	3.15
	YES	IIOC11-b	086 dup	GXMAP	7800	121	65.92	0.0232	2.32
	YES	IIIWL1-a	118	GXMAP	1000	7	51.38	0.00121	0.12
III-WL-1	YES	IIIWL1-b	119	GXMAP	920	13	7.84	0.0002	0.02
	YES	IIIWL1-c	93	GXMAP	2700	61	13.02	0.00249	0.25
	YES	IIIOC2-a	122	GXMAP	3200	1041	32.59	0.08945	8.94
III-OC-2	YES	IIIOC2-b	123	GXMAP	1300	11	29.32	0.00054	0.05
	YES	IIIOC2-b	123 dup	GXMAP	1300	45	41.7	0.00319	0.32
	YES	IIIOC5-a	124	GXMAP	3200	15	35.58	0.00138	0.14
III-0C-5	YES	IIIOC5-b	125	GXMAP	4100	1	47.33	0.00015	0.02
	YES	IVOC4-a	147	GXMAP	4800	132	63.17	0.04863	4.86
IV-OC-4	YES	IVOC4-b	148	GXMAP	5100	8	8.19	0.00017	0.02
	YES	IVOC4-b	148 dup	GXMAP	5100	16	136.98	0.00718	0.72
	YES	VWL2-b	169	GXMAP	1100	6	17.23	0.00029	0.03
V-VVL-2	YES	VWL2-b	169 dup	GXMAP	1100	7	5.72	0.00012	0.01
V 00 1	YES	VOC1-a	179	GXMAP	1400	12	24.88	0.0007	0.07
V-0C-1	no	VOC1-b	180	GXMAP	570	0	0	0	0.00
V-OC-2	YES	VOC2-a	181	GXMAP	3600	70	16.2	0.00539	0.54
	no	VIWL1A-a	195	GXMAP	1500	0	0	0	0.00
VI-WL-1A	no	VIWL1A-b	196	GXMAP	420	0	0	0	0.00
	no	VIWL1A-b	196 dup	GXMAP	420	0	0	0	0.00
	YES	VIWL1B-a	197	GXMAP	870	5	11.5	0.00014	0.01
VI-WL-1B	YES	VIWL1B-b	198	GXMAP	1200	6	13.59	0.00016	0.02
		VIWL1B-c	199	GXMAP	790	0	0	0	0.00
	YES	VIOC4-a	202	GXMAP	1200	33	13.42	0.00131	0.13
VI-0C-4	YES	VIOC4-b	203	GXMAP	1300	1	2.91	7E-06	0.00

Site	As ₂ O ₃ pre- sent?	Golder sample name	Sample	MLA run type	As μg/ g (meas ured)	As ₂ O ₃ grains	Area (µm2) per grain	As ₂ O ₃ area %	Surface area (in mm ²) of As ₂ O ₃ pre- sent in a 100cm ² soil film
	YES	VIOC4-b	203 dup	XBSE_ STD	1300	2		0.00031	0.03
	YES	VIIIOC4-a	295	GXMAP	840	89	26.97	0.01028	1.03
VIII-OC-4	YES	VIIIOC4-b	296	GXMAP	370	3	22.33	0.00022	0.02
	YES	IXOC2-a	319	GXMAP	5500	437	118.49	0.12977	12.98
1X-00-2	YES	IXOC2-b	320	GXMAP	910	17	188.2	0.0051	0.51
	YES	IXOC4-a	324 dup	GXMAP	5200	293	92.35	0.164	16.40
12-00-4	YES	IXOC4-a	324	GXMAP	5200	322	97.2	0.25227	25.23
17-00-4	YES	IXOC4-b	325	GXMAP	1100	17	30.15	0.00194	0.19
	YES	IXOC4-c	326	GXMAP	1200	5	3.06	4.2E-05	0.00
	YES	IVF2-a	344	GXMAP	1700	947	28.14	0.28359	28.36
10-6-5	YES	IVF2-b	345	GXMAP	1300	260	30.38	0.05397	5.40
	YES	IIIOC8-a	354 dup	GXMAP	630	2	5.46	3.2E-05	0.00
111-00-8	no	IIIOC8-a	354	GXMAP	630	0	0	0	0.00

3.2.2.2 Arsenic hosts and textures identified in Giant Mine soils

In addition to As₂O₃, arsenopyrite, iron oxides with arsenic (including roaster-generated Fe oxides (ROs)) and As sulfide, the MLA software proved adept at identifying more ill-defined and compositionally variable As hosts. These additional hosts are mostly a combination of a variety of Fe (and/or Al) oxides/ oxyhydroxides/hydroxides, +/- Mn and Ca. They often occur around or on organic material. Although it has not been quantified, the semi-quantitative information obtained by SEM-EDS suggest the total As in these hosts is conservatively less than 10 or 15%.

Table 3.7 shows an abridged version of the modal mineralogy determined via MLA for all GXMAP runs, including As and C assay results, and if any roaster oxides were found.

S A	M	C a r	As	As	2 O 3	Arso py	eno- rite	A sul	ls- fide	Fe- Ox+ As	Org +As	Fe- As- Mn/ Ca	Al- Mn- Fe- As	sili- cat es	car bon ate s	low cou nts	car bon	RO
P L E	U N T	b o n wt%	p p m	g r a i n s	a r e a %	g r a i s	area%	g r a i s	a r e a %	a r e a %	a r e a %	a r e a %	a r e a %	a re a %	a r e a %	a r e a %	a r e a %	?
IXF4-b	2	4.4	3600	17	0	1647	0.18	0	0	0.32	0.02	0.08	0	77.8	17.1	0.03	0.82	Yes, 260 +
IXF4-c	3	5.1	600	6	0	392	0.04	0	0	0.03	0	0.01	0	94.9	1.84	0.09	2.08	Yes, 50+
IVWL2-b	8	<1.0	1000	1	0	113	0	3	0	0.01	0	0.02	0	97.7	1.29	0.06	0.23	yes
IVWL2-c	9	1.3	2800	0	0	369	0.01	0	0	0.04	0.01	0.07	0	94.2	2.97	0.63	0.67	yes
IVWL2-d	010 dup	1.8	3400	7	0	883	0.03	6	0	0.27	0.02	0.15	0	88.7	6.11	0.05	0.99	Yes, 200 +++
IVWL2-d	10	1.8	3400	3	0	697	0.03	4	0	0.32	0.03	0.2	0	87	7.91	0.04	0.89	
IVWL2-e	11	2.3	1800	48	0	1529	0.04	4	0	0.14	0.05	0.11	0	88.8	6.57	0.31	1.3	Yes, 100 +++
IVOC1-a	17	8.6	7000	111	0.05	0	0	0	0	0.01	0.33	0.18	0.25	82	0.04	9.75	5.58	yes
IVOC1-b	18	9.8	5400	10	0	0	0	0	0	0.03	0.44	0.34	0.12	79.2	0	0.56	16.4	NF
IIIF2-a	27	6.7	1500	94	0.06	10	0	0	0	0.01	0.01	0.01	0	93.4	0.3	2.7	2.61	Yes
IIIF2-b	028 dup	4.9	840	23	0.01	1	0	0	0	0	0	0.02	0	90.3	0.34	2.61	5.79	Yes
IIIF2-b	28	4.9	840	38	0.01	0	0	0	0	0	0.01	0.01	0	94.5	0.55	0.21	4.07	
IIOC5-a	070 _1	24	17000	2259	0.62	4	0	0	0	0.29	1.42	0.57	0	73.4	0.01	0.49	18.9	Yes, 87+
llOC5-a	70	24	17000	1765	0.52	8	0	0	0	0.18	0.53	0.19	0	60	0.01	33	3.58	
IIOC5-b	071 red 0	2.9	1300	32	0	1	0	0	0	0	0.02	0.01	0.01	97.4	0.01	1.92	0.15	yes
IIOC5-b	071 _1	2.9	1300	94	0.02	0	0	0	0	0.01	0.36	0.04	0.07	90.2	0.01	2.63	5.48	
IIOC5-c	72	2.2	2000	2	0	1	0	0	0	0	0.02	0.02	0.03	98.3	0.01	1.05	0.19	NF
llOC9-a	80	30	1400	92	0.02	0	0	0	0	0.03	0.08	0.2	0	68.5	0.01	0.01	26.1	NF
IIOC9-b	81_ 2	7.6	2400	0	0	2	0	0	0	0.01	0.06	0.07	0	95.2	0.04	0.13	1.27	NF
IIOC9-c	82	8.3	2400	0	0	0	0	0	0	0	0.06	0.06	0.01	85.2	0.01	2.62	8.2	NF
llOC10-a	83	20	16000	383	0.15	0	0	1	0	0.31	4.2	2.48	0.37	55.1	0.01	6.8	27.8	Yes, <50
IIOC10-b	84	5	7200	16	0	1	0	0	0	0.1	0.74	0.58	0.24	90	0.01	0	5.24	Yes
llOC11-a	85	15	11000	484	0.16	0	0	0	0	0.04	1.79	0.49	0.37	77.9	0.01	1.91	13.8	Yes, <15

Table 3.7: Abridged modal mineralogy, all GXMAP samples

S A	M	C a r	As	As	2 O 3	Ars py	eno- rite	A sul	\s- lfide	Fe- Ox+ As	Org +As	Fe- As- Mn/ Ca	Al- Mn- Fe- As	sili- cat es	car bon ate s	low cou nts	car bon	BO
M P L E	U N T	b o n wt%	p p m	g r a i s	a r e a %	g r a i n s	a r e a %	g r a i n s	a r e a %	a r e a %	a r e a %	a r e a %	a r e a %	a r e a %	a r e a %	a r e a %	a r e a %	?
llOC11-b	086 dup	11	7800	121	0.02	0	0	0	0	0.02	0.26	0.16	0.47	90.8	0	0.93	4.8	Yes
IIOC11-b	86	11	7800	235	0.03	0	0	0	0	0.03	0.32	0.36	0.73	63.9	0.01	12.2	19.5	
IIIWL1-c	93	4.2	2700	61	0	74	0.02	407	0.01	0.01	0.15	0.81	0	83.5	1.34	2.65	8.45	Yes
IIIWL1-a	118	5.4	1000	7	0	27	0.01	200	0	0.01	0.02	0.05	0	91.3	0.21	1.63	5.39	Yes
IIIWL1-b	119	3.6	920	13	0	44	0	55	0	0	0.01	0.04	0	90	0.9	4.9	2.94	Yes
IIIOC2-a	122	15	3200	1041	0.09	0	0	0	0	0.01	0.08	0.24	0.09	85.8	0.2	4.13	7.54	Yes
IIIOC2-b	123 dup	2	1300	45	0	1	0	0	0	0	0.02	0.07	0.01	96.9	0	0.72	1.08	NF
IIIOC2-b	123	2	1300	11	0	0	0	0	0	0	0.01	0.02	0.01	96.7	0.01	1.01	0.87	
IIIOC5-a	124	10	3200	15	0	0	0	0	0	0.01	0.59	0.93	0.02	84.7	0.08	7.29	2.9	NF
IIIOC5-b	125	8.4	4100	1	0	1	0	0	0	0.01	0.55	0.35	0.22	80.4	0.01	9.73	3.7	NF
IVOC4-a	147	28	4800	132	0.05	0	0	0	0	0.03	0.71	0.84	0	47.9	0.01	46.1	2.02	Yes
IVOC4-b	148 dup	9.4	5100	16	0.01	3	0	0	0	0.01	0.45	0.27	0.02	87.4	0.05	7.19	1.48	NF
IVOC4-b	148	9.4	5100	8	0	0	0	0	0	0.02	1.18	0.62	0.03	74.3	0.01	10.7	1.66	
VWL2-b	169 dup	7.1	1100	7	0	2	0	0	0	0.01	0.02	0.06	0.01	92.2	0.04	3.69	1.01	NF
VWL2-b	169	7.1	1100	6	0	90	0.02	0	0	0.01	0.02	0.04	0	93.4	0.01	3.53	0.5	
VOC1-a	179	3	1400	12	0	0	0	0	0	0	0.05	0.04	0.02	92	0	6.28	0.91	NF
VOC1-b	180	1.1	570	0	0	0	0	0	0	0	0.01	0.01	0	97.8	0.02	1.16	0.18	NF
VOC2-a	181	7.8	3600	70	0.01	0	0	0	0	0.01	0.11	0.17	0.23	83.8	0.02	13.4	1.09	Yes
VIWL1A- a	195	9.3	1500	0	0	60	0.01	88	0	0	0.05	0.31	0	54.5	32.9	0.97	7.8	Yes
VIWL1A- b	196 dup	2.5	420	0	0	70	0.02	31	0	0	0	0.01	0	82.9	13.9	0.84	0.59	NF
VIWL1A- b	196	2.5	420	0	0	106	0.01	32	0	0	0	0.01	0	83.6	13.8	0.13	0.63	
VIWL1B- a	197	12	870	5	0	127	0.03	128	0	0	0	0.02	0	57.2	23.3	2.66	13.1	NF
VIWL1B- b	198	11	1200	6	0	343	0.08	111	0	0	0	0	0	78	9.87	3.57	6.02	NF
VIWL1B- c	199	14	790	0	0	58	0.02	210	0	0	0	0	0	80.5	7.48	1.23	7.74	NF
VIOC4-a	202	21	1200	33	0	0	0	0	0	0	0.02	0.02	0.14	55.1	0.07	7.65	30.9	Yes

S A	M	C a r	As	As	2 O 3	Ars py	eno- rite	A sul	\s- lfide	Fe- Ox+ As	Org +As	Fe- As- Mn/ Ca	Al- Mn- Fe- As	sili- cat es	car bon ate s	low cou nts	car bon	BO
M P L E	U N T	b o n wt%	p p m	g r a i n s	a r e a %	g r a i s	a r e a %	g r a i n s	a r e a %	a r e a %	area%	area%	area%	area%	area%	a r e a %	a r e a %	?
VIOC4-b	203 dup	13	1300	2	0	1	0	0	0	0	0.02	0.03	0.07	82	0.01	10.9	1.69	NF
VIOC4-b	203	13	1300	1	0	1	0	0	0	0	0.02	0.02	0.11	77.5	0	15.7	2.1	
VIIIOC4- a	295	28	840	89	0.01	0	0	0	0	0.06	0.03	0.15	0.06	64.1	0.03	30.3	1.52	Yes, <30
VIIIOC4- b	296	8	370	3	0	0	0	0	0	0	0	0.01	0	88.7	0.1	8.4	0.68	NF
IXOC2-a	319	18	5500	437	0.13	256	0.03	0	0	0.32	0.05	0.1	0.01	76.2	1.76	17.2	1.9	Yes, 200 +++
IXOC2-b	320	1.9	910	17	0.01	0	0	0	0	0.01	0	0.03	0	98.6	0.01	0.09	0.32	NF
IXOC4-a	324 dup	31	5200	293	0.16	37	0.02	0	0	0.07	0.07	0.09	0.04	41.7	5.32	12.4	38.6	Yes, 50+
IXOC4-a	324	31	5200	322	0.25	65	0.02	0	0	0.13	0.07	0.16	0.08	82.7	2.18	1.22	10.8	Yes, 50+
IXOC4-b	325	4.5	1100	17	0	2	0	0	0	0	0.03	0.07	0	92.7	2.37	3	0.62	Yes
IXOC4-c	326	3	1200	5	0	0	0	0	0	0	0.02	0.05	0	96.8	0.03	1.89	0.41	Yes
IVF2-a	344	33	1700	947	0.28	0	0	0	0	0	0.03	0.01	0	42.6	0.1	54.3	1.3	Yes
IVF2-b	345	42	1300	260	0.05	1	0	0	0	0	0.01	0	0	24.5	0.08	68.6	6.2	Yes
IIIOC8-a	354 dup	11	630	2	0	0	0	0	0	0	0.02	0.03	0	83.5	0.01	10.5	2.31	yes, one
IIIOC8-a	354	11	630	0	0	0	0	0	0	0.01	0.02	0.03	0.01	83.1	0.02	10.9	2.16	

Regarding roaster oxides (ROs), NF = "Not found." In NF cases, ROs could still possibly be present (due to map size and the nature of the visual RO checks).

Many of the phases binned into the Low Counts category were actually found to be organic-rich.

This table does not account for any other phosphate, oxide, or sulfide minerals present in samples. See Appendix X for complete modal mineralogies.

Figures 3.6 through 3.12 give an overview of the variety of textures and As hosts encountered in Giant Mine soils. These hosts and textures include:

- •As₂O₃, from large grains (>100 μm) to clumps of <5 μm grains;
- •ROs, including highly weathered grains from wetland samples;
- •As-bearing Fe-dominated rims on pyrite and other sulfides (including double rim texture);

•Arsenopyrite, both as free grains and as part of quartz-carbonate nodules;

•As-sulfide particles, usually no more than specks, often clustering around organics in wetland samples. Textural relationships suggest these are likely weathering products;

• As-bearing Fe(sometimes Al)-dominated oxides or oxyhydroxides. These can be associated with organic material (very common in organic-rich high As samples) or can be free floating. They also are often associated with variable amounts of Mn, Ca, and Al.

Figure 3.6: Large As_2O_3 clumps. (**A**) One clump from sample 122 in BSE (A1), in MLA classified (A2), and in closeup BSE (A3). The red boxes indicate the approximate location of A3. (**B**) A similar large As_2O_3 clump from sample 071. Small grain size could possibly be a result of larger grain breakdown. See Table 2.5 for MLA legend.





Many of these hosts, especially the As sulfide and coatings on organics, would not have been found without MLA.





Figure 3.9: Pyrite grains with double weathering rims (mounts 002 and 003). In all three cases the inner weathering rim is Fe-dominated with no As, while the outer rim has As as well as Fe. Top: Mount 002, featuring adjacent RO pieces. Right: Both BSE photos are from mount 003, with the same double Fe-dominated rim with As exterior as the top photo.

Most As-bearing weathering rims found at Giant are not double rims like those in mounts 002 and 003. The double weathering rims depicted in this figure have not been documented before as an As host in Giant soils.



1/14/2015 HV spot det WD 1/24/29 PM 25 00 kV 5 0 BSED 12 8 mm



Figure 3.10: Arsenopyrite sequestered within a carbonate - quartz rock nodule in mount 002. Left: Part of the nodule classified by MLA. RIght: BSE image showing a large RO to the left to the nodule. See Table 2.5 for MLA legend.







Figure 3.11: Arsenic sulfide specks on organics in mount 093. Textures support the notion of As sulfide as a weathering product in Giant soils. Red boxes indicate a zoomed in area. (**A**) MLA classified GXMAP for mount 093. Note the bright fuchsia specks along the organics. (**B**) BSE photo of the As-sulfide bearing organic broken into three pieces in panel (A). (**C**) Zoomed in look at As-sulfide above organic and Fe-As-bearing material below from panel (B). (**D**) Close-up of As sulfide from panel (**C**).



3.2.3 Elemental distribution of As in Giant Mine soils

There are a number of sources of uncertainty associated with elemental distribution calculations for As in Giant Mine soil mounts based on MLA analysis. The statistical significance of various As hosts must be considered before calculating the elemental distribution of As amongst said As hosts at Giant. Results from duplicate mounts indicate that most samples exhibit a nugget effect to some degree regarding As hosts; those with the best repeatability usually had greater than 100 grains of either As₂O₃, arsenopyrite, or Assulfide, as well as total As concentrations above 3000 μ g/g. These are the general criteria chosen for including samples in calculations presented in Table 3.8. Even so, results from duplicate samples in Table 3.8 indicate that calculated As elemental distribution results as a whole should be viewed with some skepticism, and individual results should probably not be used, or at least used with extreme caution, for application to areas larger than a grain mount surface.

The main difficulty in calculating elemental distribution of As at Giant lies with the secondary As hosts with no quantitative information available about their As wt% content. Density values also need to be determined for the Fe-oxides with As, organics with As, Fe-As-Mn/Ca oxide, and Al-Mn-Fe-As oxide phases, however this is a slightly less open-ended matter given that there are defined values available for the variety of likely constituent minerals of each phase. Table 3.8 includes elemental distribution calculations for As in Giant Mine soils for a subset of MLA samples, assuming three different As concentrations for these secondary phases: 0.1%, 1%, and 5% for the Fe-oxides with As, organics with As, Fe-As-Mn/Ca oxide, and Al-Mn-Fe-As oxide phases. These values were chosen to test possible broad variation outcomes. Samples with a large proportion of As hosted in As weathering products had the most variation in relative proportions of As hosts amongst the 0.1%< 1%, and 5% calculations.

Site	Golder_ horizon	Sam ple	Total As (µg/g)	As as As ₂ O ³	As μg/g in As₂O₃	As as Aspy	As μg/g in Aspy	As as As- sulfid e	As μg/g in As sul- fide	As as Fe- oxide s w/ As	As μg/g as Fe- oxide s w/ As	As as other As hosts	As µg/g in other As hosts
0.1 wt%	As for all	but A	s₂O₃ (76	6% As),	Arsenop	oyrite (4	6% As) a	and As-s	sulfide (70% As)			
	IVWL2-c	9	2800	0%	0	98%	2733	0%	0	1%	26	1%	41
	IVWL2- d	010 dup	3400	2%	64	95%	3243	<1%	6	2%	56	1%	31
IV-WL-2	IVWL2- d	10	3400	1%	24	97%	3285	<1%	6	2%	54	1%	32
	IVWL2- e	11	1800	2%	43	96%	1730	<1%	6	1%	11	1%	10
IV-OC-1	IVOC1- a	17	7000	98%	6861	0%	0	0%	0.0	<1%	4	2%	136
	llOC5-a	070 _1	17000	99%	16885	0%	40	0%	0.0	<1%	13	<1%	62
	llOC5-a	70	17000	99%	16905	0%	59	0%	0.0	<1%	9	<1%	26
II-OC-5	IIOC5-b	071 redo	1300	89%	1162	9%	119	0%	0.0	<1%	2	1%	17

Table 3.8: Arsenic elemental distribution for selected samples, multiple variables

Site	Golder_ horizon	Sam ple	Total As (µg/g)	As as As ₂ O ₃	As µg/g in As₂O₃	As as Aspy	As μg/g in Aspy	As as As- sulfid e	As μg/g in As sul- fide	As as Fe- oxide s w/ As	As μg/g as Fe- oxide s w/ As	As as other As hosts	As µg/g in other As hosts
	IIOC5-b	071 _1	1300	97%	1262	0%	0	0%	0.0	<1%	1	3%	37
	llOC9-a	80	1400	97%	1363	0%	0	0%	0.0	<1%	5	2%	32
II-OC-9	IIOC9-b	081 _2	2400	0%	0	10%	237	0%	0	9%	207	82%	1956
	IIOC9-c	82	2400	0%	0	0%	0	0%	0	3%	71	97%	2330
II-OC-	llOC10- a	83	16000	94%	15098	0%	0	0%	1	<1%	53	5%	849
10	llOC10- b	84	7200	55%	3956	3%	246	0%	0	3%	239	38%	2760
	llOC11- a	85	11000	98%	10800	0%	0	0%	0	<1%	4	2%	196
II-OC- 11	llOC11- b	086 dup	7800	95%	7447	0%	0	0%	0	<1%	11	4%	342
	llOC11- b	86	7800	95%	7378	0%	0	0%	0	<1%	13	5%	410
III-OC-2	IIIOC2-a	122	3200	99%	3180	0%	0	0%	0	<1%	1	1%	19
	IVOC4- a	147	4800	96%	4614	0%	0	0%	0	<1%	4	4%	182
IV-OC-4	IVOC4- b	148 dup	5100	87%	4444	2%	105	0%	0	<1%	13	11%	538
	IVOC4- b	148	5100	7%	380	0%	0	0%	0	1%	68	91%	4653
V-OC-2	VOC2-a	181	3600	89%	3211	0%	0	0%	0	<1%	7	11%	382
VI-WL-	VIWL1A -b	196 dup	420	0%	0	99%	414	1%	5	0%	0	<1%	<1
1A	VIWL1A -b	196	420	0%	0	96%	404	4%	15	0%	0	<1%	1
VI-WL-	VIWL1B -a	197	870	<1%	4	91%	795	8%	70	0%	0	<1%	1
1B	VIWL1B -b	198	1200	<1%	2	97%	1168	2%	30	0%	0	<1%	1
IX-OC-2	IXOC2- a	319	5500	79%	4368	20%	1108	0%	0	<1%	18	<1%	7
12-00-4	IXOC4- a	324 dup	5200	90%	4660	10%	531	0%	0	<1%	3	<1%	7
1/-00-4	IXOC4- a	324	5200	94%	4899	6%	290	0%	0	<1%	4	<1%	8
IV-F-2	IVF2-a	344	1700	100%	1700	0%	0	0%	0	0%	0	<1%	<1
	IVF2-b	345	1300	99%	1290	1%	9	0%	0	0%	0	<1%	<1
1 wt% A	s for all b	ut As ₂ 0	D ₃ (76%	As), Ar	senopyr	rite (46%	As) an	d As-sul	fide (70	% As)			

Site	Golder_ horizon	Sam ple	Total As (µg/g)	As as As ₂ O ₃	As µg/g in As₂O₃	As as Aspy	As μg/g in Aspy	As as As- sulfid e	As μg/g in As sul- fide	As as Fe- oxide s w/ As	As μg/g as Fe- oxide s w/ As	As as other As hosts	As µg/g in other As hosts
	IVWL2-c	9	2800	0%	0	80%	2249	0%	0	8%	213	12%	338
	IVWL2- d	010 dup	3400	2%	52	78%	2636	<1%	5	13%	458	7%	249
IV-WL-2	IVWL2- d	10	3400	1%	20	79%	2681	<1%	4.9	13%	437	8%	258
	IVWL2- e	11	1800	2%	39	87%	1562	<1%	5.3	6%	102	5%	93
IV-OC-1	IVOC1- a	17	7000	83%	5820	0%	0	0%	0	<1%	30	16%	1150
	IIOC5-a	070 _1	17000	96%	16238	0%	39	0%	0	1%	128	4%	596
	llOC5-a	70	17000	98%	16593	0%	58	0%	0	1%	93	2%	257
II-OC-5	IIOC5-b	071 redo	1300	79%	1027	8%	105	0%	0	2%	20	11%	148
	IIOC5-b	071 _1	1300	77%	1002	0%	0	0%	0	<1%	5	23%	293
	llOC9-a	80	1400	79%	1100.3	0%	0	0%	0	3%	38	19%	262
II-OC-9	IIOC9-b	081 _2	2400	0%	0	1%	26	0%	0	9%	227	89%	2147
	IIOC9-c	82	2400	0%	0	0%	0	0%	0	3%	70	97%	2330
II-OC-	llOC10- a	83	16000	63%	10019	0%	0	0%	1	2%	350	35%	5631
10	llOC10- b	84	7200	12%	833.2	1%	52	0%	0	7%	502	81%	5813
	llOC11- a	85	11000	84%	9282	0%	0	0%	0	<1%	37	15%	1681
II-OC- 11	llOC11- b	086 dup	7800	68%	5289	0%	0	0%	0	1%	81	31%	2430
	llOC11- b	86	7800	64%	4962	0%	0	0%	0	1%	85	35%	2754
III-OC-2	IIIOC2-a	122	3200	94%	3013	0%	0	0%	0	<1%	6	6%	181
	IVOC4- a	147	4800	71%	3422	0%	0	0%	0	1%	29	28%	1349
IV-OC-4	IVOC4- b	148 dup	5100	44%	2254	1%	53	0%	0	1%	64	54%	2729
	IVOC4- b	148	5100	1%	41	0%	0	0%	0	1%	73	98%	4987
V-0C-2	VOC2-a	181	3600	45%	1628	0%	0	0%	0	1%	36	54%	1936
VI-WL-	VIWL1A -b	196 dup	420	0%	0	98%	411	1%	5	0%	0	1%	4

Site	Golder_ horizon	Sam ple	Total As (µg/g)	As as As ₂ O ³	As μg/g in As₂O₃	As as Aspy	As μg/g in Aspy	As as As- sulfid e	As μg/g in As sul- fide	As as Fe- oxide s w/ As	As μg/g as Fe- oxide s w/ As	As as other As hosts	As μg/g in other As hosts
1A	VIWL1A -b	196	420	0%	0	95%	399	4%	15	<1%	0	1%	5
VI-WL-	VIWL1B -a	197	870	<1%	4	91%	788	8%	69	0%	0	1%	9
1B	VIWL1B -b	198	1200	<1%	2	97%	1167	2%	29	<1%	<1	<1%	1
IX-OC-2	IXOC2- a	319	5500	76%	4198	19%	1064	0%	0	3%	168	1%	70
IX-OC-4	IXOC4- a	324 dup	5200	88%	4581	10%	522	0%	0	1%	30	1%	68
	IXOC4- a	324	5200	92%	4801	5%	284	0%	0	1%	41	1%	74
IV-F-2	IVF2-a	344	1700	100%	1697	0%	0	0%	0	<1%	<1	<1%	3
	IVF2-b	345	1300	99%	1288	1%	9	0%	0	<1%	<1	<1%	2
5 wt% A	s for all bu	ut As ₂ (O₃ (76%	As), Ar	senopyr	rite (46%	S As) an	d As-su	fide (70	% As)		•	
	IVWL2-c	9	2800	0%	0	45%	1259	0%	0.0	21%	597	34%	945
	IVWL2- d	010 dup	3400	1%	28	42%	1439	<1%	3	37%	1250	20%	680
IV-WL-2	IVWL2- d	10	3400	0%	11	43%	1476	<1%	3	35%	1202	21%	709
	IVWL2- e	11	1800	2%	27	61%	1091	<1%	4	20%	355	18%	324
IV-OC-1	IVOC1- a	17	7000	50%	3477	0%	0	0%	0	1%	90	49%	3434
	llOC5-a	070 _1	17000	82%	13877	<1%	33	0%	0	3%	545	15%	2546
	llOC5-a	70	17000	90%	15333	<1%	54	0%	0	3%	427	7%	1186
II-OC-5	llOC5-b	071 redo	1300	52%	677	5%	69	0%	0	5%	66	38%	488
	IIOC5-b	071 _1	1300	40%	522	0%	0	0%	0	1%	13	59%	765
	llOC9-a	80	1400	42%	593	0%	0	0%	0	7%	103	50%	704
II-OC-9	llOC9-b	081 _2	2400	0%	0	<1%	5.2	0%	0	10%	229	90%	2166
	IIOC9-c	82	2400	0%	0	0%	0	0%	0	3%	70	97%	2330
II-OC-	llOC10- a	83	16000	25%	4015	0%	0	0%	<1	4%	702	71%	11283
10	llOC10- b	84	7200	3%	185	<1%	12	0%	0	8%	557	90%	6447
	llOC11- a	85	11000	52%	5712	0%	0	0%	0	1%	114	47%	5174

Site	Golder_ horizon	Sam ple	Total As (µg/g)	As as As ₂ O ³	As μg/g in As₂O₃	As as Aspy	As μg/g in Aspy	As as As- sulfid e	As μg/g in As sul- fide	As as Fe- oxide s w/ As	As μg/g as Fe- oxide s w/ As	As as other As hosts	As μg/g in other As hosts
II-OC- 11	llOC11- b	086 dup	7800	30%	2312	0%	0	0%	0	2%	176	68%	5312
	llOC11- b	86	7800	26%	2020	0%	0	0%	0	2%	173	72%	5606
III-OC-2	IIIOC2-a	122	3200	76%	2442	0%	0	0%	0	1%	26	23%	732
	IVOC4- a	147	4800	33%	1593	0%	0	0%	0	1%	68	65%	3139
IV-OC-4	IVOC4- b	148 dup	5100	14%	706	<1%	17	0%	0	2%	100	84%	4277
	IVOC4- b	148	5100	<1%	8	0%	0	0%	0	1%	73	98%	5019
V-OC-2	VOC2-a	181	3600	14%	510	0%	0	0%	0	2%	56	84%	3034
VI-WL-	VIWL1A -b	196 dup	420	0%	0	94%	395	1%	5	0%	0	5%	20
1B	VIWL1A -b	196	420	0%	0	90%	380	3%	15	<1%	<1	6%	26
VI-WL-	VIWL1B -a	197	870	<1%	4	87%	757	8%	67	0%	0	5%	43
1B	VIWL1B -b	198	1200	<1%	2	97%	1163	2%	29	<1%	1	<1%	5
IX-OC-2	IXOC2- a	319	5500	65%	3579	17%	908	0%	0	13%	717	5%	297
	IXOC4- a	324 dup	5200	82%	4260	9%	485	0%	0	3%	140	6%	315
1X-00-4	IXOC4- a	324	5200	85%	4410	5%	261	0%	0	4%	190	7%	340
	IVF2-a	344	1700	99%	1684	0%	0	0%	0	<1%	2	1%	15
10-6-2	V-F-2 IVF2-b 345 130				1277	1%	9	0%	0	<1%	2	1%	11
			Den	sities us	ed in ca	lculation	s were a	s follows	s (in g/cr	n ³):		•	
As ₂ O ₃	3.74	Aspy	6.07	As sulfide	∋ 3.56	Fe oxides 4.67	with As:	Organics 2.9	with As:	Fe-As-Mn 4.0	/Ca oxide	Al-Mn-Fe- 3.5	As oxide

Notes:

Sample sites VI-WL-1A and VI-WL-1B are actually two cores from the same site location. VI-WL-1A was aborted
partway through and re-started as VI-WL-1B.

• The 0.1%, 1%, and 5% calculations were performed for all MLA samples. However, numerical data in this table represents only a subset of this data. This subset is meant to include samples with the best chance of producing the most reliable As elemental distribution data. Samples included in this table contain:

• approximately 100 or more grains of either As₂O₃, arsenopyrite, or As-sulfide, AND/OR

• greater than 3000 μ g/g As, AND/OR

• a partial match with the two above criteria, plus close physical proximity to a sample does meet the above criteria

• Criteria for inclusion in this table may under-represent samples with a dominant As host other than As₂O₃, arsenopyrite, and As sulfide.

• Figures 3.13 and 3.15 both include calculated As distributions for the 1% variation for ALL MLA samples.





4000

4000 3000 As concentration (mg/kg) 2000 1000 0 0 IIIF2-b (028*) -IXF4-a (001) IXF4-b (002) IXF4-c (003) IXF4-d (004) IXF4-e (005) IXF4-f (006) IIIF2-a (027) IIIF2-d (030) IIIF2-e (031) IVF2-a (344) IVF2-b (345) IVF2-c (346) IVF2-d (347) IVF2-e (348)

Figure 3.13: Elemental distribution for As for all MLA samples, plotted by depth horizon and with additional samples from the same sites that did not have MLA done on them for context. **TOP**: Outcrop soil samples. **MIDDLE**: Wetland soil samples. **BOT-TOM**: Forest soil samples.

Calculations were done assuming 1% As in the Fe oxide with As, Organics with As, Fe-As-Mn/Ca oxide, and Al-Mn-Fe-As oxide phases.

The dominant As hosts vary somewhat by sample site type. The only samples with significant As sulfide occur in wetlands. Several of the dominantly arsenopyrite samples may have a waste rock influence.

Important notes:

- Arsenic trioxide was found at ALL sample sites in this figure, in at least one sample. This may be difficult to discern due to local proportions of As hosts.
- This figure contains elemental distribution calculation data for ALL MLA samples, including those omitted from Table 3.8.

Figure 3.13 shows calculated elemental distribution for As for the 1 wt% variation is plotted for all MLA samples. There is a clear difference between dominant As hosts between site types, as well as between depth horizons at certain individual sites (mostly outcrop sites).

3.3 Geographic extent of arsenic at Giant Mine

3.3.1 Arsenic bulk concentrations

In Figure 3.14, high As concentrations can be seen within either rough proximity to the roaster within its dominant wind direction, or in close proximity to other areas that may invite anthropogenic As contamination, such as tailings ponds, Baker Pond, mine roads, and other historic areas of surface mine operations. See Appendix XI for additional maps.

3.3.1 Arsenic trioxide geographic extent

A map showing MLA sample locations, site type, and relative proportions of calculated As differentiation amongst As hosts can be found in Figure 3.15. All MLA sites included at least one sample with As_2O_3 .





4.0 Discussion and Conclusions

4.1 Variation of As concentration with depth and soil type

The highest concentrations of As were found mostly in outcrop soil samples rather than wetland or forest samples, and in shallower samples rather than deeper samples (at the same site). Arsenic concentrations are usually highest near the surface and diminish with depth. This trend is clear for many samples but is most starkly obvious for core samples >40cm long. There are a few notable exceptions to this trend in wetland and forest samples located in areas that have likely experienced some displacement of surface material.

4.2 Evidence for anthropogenic As

Most of the As in the samples examined by MLA is of anthropogenic origin. All sample sites included at least one sample with evidence of As₂O₃, a form of As of clear anthropogenic origin. There are several other pieces of evidence to suggest an anthropogenic origin for the majority of As in the samples examined; this includes samples with high concentrations of As dominantly hosted as secondary weathering products.

Being able to examine secondary weathering products of As has been especially helpful with regards to interpreting the significance of the presence of As₂O₃. Samples with arsenopyrite as the dominant primary As host did not tend to have as many secondary weathering products present relative to primary hosts as those samples with most primary As as As₂O₃. In the latter scenario, the ratios between As₂O₃ content for different depth horizons and the collection of As weathering products (including As associated with organic matter and Fe other oxides) is striking (Figure 3.13). The proportion of weathering-related As hosts often increases relative to primary As hosts with depth. This could be a result of As dissolved from primary As hosts re-precipitating in secondary phases. If this is a valid interpretation, it provides a not unreasonable explanation for some soils at Giant with high As concentrations only having a few grains of As₂O₃. Most samples in the subset examined by MLA tend to have larger concentrations of primary As minerals relative to weathering products in higher horizons, and more weathering products relative to primary As hosts in lower horizons

Furthermore, most sites examined in this study have their highest As concentrations in the sample horizon closest to the surface. This should not be the case if the bulk of these As concentrations were related to background geology locally high in As (Risklogic 2002). All samples with a significant arsenopyrite presence as a primary As host also showed signs of introduced waste rock in SEM and MLA textural relationships and carbonate modal mineralogies, and (with the exception of samples with disturbed As-depth profiles, Figure 4.1) this presence decreased with depth.

The highest concentrations of natural As might be expected in samples closest to the mineralized shear zones and in soil just above the outcrop surface. The first situation is complicated by the fact that the shear zones are also likely to be disturbed sites since they were the locus of exploration and mining activity.

The soil samples in this study that best represent the second most likely area to concentrate natural As are the lowermost portion of the outcrop soil cores. Most of the outcrops are granitic and do not include shear zones. In fact, the samples with the highest total As concentrations in this study overlie mafic volcanic rocks, exhibit a distinct decrease of As concentration with depth, are removed from mining, road and other activities



Figure 4.1: MLA depth disturbed sites and anthropogenic As sources. This map is an interpretation of anthropogenic As provenance by site location at Giant Mine. All sites contained at least one sample with at least one grain of As_2O_3 , and roaster-derived As has likely effected all sites tested to some degree. In the case of sites marked as having both a roaster and a waste rock component (orange cross), As hosts included As₂O₃ as well as arsenopyrite in association with quartz/carbonate rock fragments. These sites are also all located near roads (often built of waste rock at mine sites). Sites marked as having a roaster, waste rock, and tailings component shared the same characteristics as those with both roaster and waste rock As sources, with the addition of extremely large numbers of roaster oxides (Table 3.7). Previous work at Giant (Bromstad 2011, Wrye 2008) has shown that soils effected only by roaster-derived As have a more modest number of roaster oxides in proportion to As₂O₃ grains.

Sites marked as more likely disturbed show evidence disturbance of the depth profile of As concentrations in addition to the introduction of anthropogenic As. This is likely as a result of soil and other surface material being moved around after initial anthropogenic As deposition. This is supported by As concentration fluctuations with depth, as well as textural and host modal mineralogy As information collected during MLA analysis. All of these sites are located along Baker Creek, a known nexus of historic soil upheaval at Giant.

Other sites may have been anthropogenically effected by more than just roaster fallout, in the sense of being contaminated with waste rock or tailings. However, these sites do not show any disruption of the soil depth column in the manner that the Baker Creek wetland soils do (see Figure 3.13, Table 3.7). and lie within one of the downwind directions from the roaster. If we assume that the sampling done for this study is representative of near-surface soils on the Giant property, it can be concluded that most of the As is not of natural origin.

4.2.1 Anthropogenic influences other than roaster fallout

During the MLA QA/QC process it became obvious that several sample sites examined were likely effected by As inputs in addition to roaster fallout (Figure 4.1, Table 4.1). The evidence for this is based in textural relationships of arsenopyrite associated with and still encapsulated within waste rock (mixed silicate/ carbonate), as well as the presence of an unusually large number of ROs. Roaster oxides were manually counted by looking through the Fe-oxides with As phase with the MLA software and visually identifying textures typical of these roaster-generated particles. Many samples analyzed had ratios of ROs to As₂O₃ similar to those qualitatively observed in previous studies of roaster-impacted soils at Giant Mine (Wrye 2008, Bromstad 2011), however, several samples had noticeably large quantities of ROs relative to other As hosts. As a rule of thumb, most samples interpreted to be effected only by aerial As had less than 50 roaster oxides while some anomalous RO samples had well over 200 (the exception to this is sample 070, with 17,000 µg/g As and around 90 ROs identified). Samples with high RO counts likely represent soils affected by tailings, which are known to contain relatively high amounts of ROs (Walker *et al.* 2005, 2015).

Data in Table 3.7 shows supporting evidence for non-aerial anthropogenic As in the form of RO counts, and the relative proportion of carbonate gangue minerals, arsenopyrite, and As₂O₃. All samples with carbonate gangue material greater than 1% area contained silicate/carbonate nodules associated with arsenopyrite. Samples thought to be effected by waste rock are all nearby roads or other known disturbed areas. Samples thought to be effected by tailings also happen to be nearby tailings ponds. Figure 4.1 provides a summary of the various anthropogenic influences on MLA samples.

Table 4	.1: Determining	g anthrop	ogenic As s	ources of	ther than roaster emissions at Giant (supports Figure 4.1)
ASU name	Depth profile disturbed?	source	Golder Sample	As ₂ O ₃	Reasoning and justification for being anthropogenic (if no $\mbox{As}_2\mbox{O}_3$ in sample)
2	Y	RTW	IXF4-b	YES	Carbonate/arsenopyrite relationship, 260+ roaster oxides
3	Y	RTW	IXF4-c	YES	carbonate/arsenopyrite/ As_2O_3 relationship, 50+ roaster oxides with little $As_2O_3,$ proximity to sample 2
8	Y	RTW	IVWL2-b	no	carbonate/arsenopyrite/ As_2O_3 relationship, relationship with other samples at site
9	Y	RTW	IVWL2-c	YES	carbonate/arsenopyrite/ As_2O_3 relationship, relationship with other samples at site
10	Y	RTW	IVWL2-d	YES	carbonate/arsenopyrite/As $_2O_3$ relationship, well over 200 roaster oxides
11	Y	RTW	IVWL2-e	YES	carbonate/arsenopyrite/As2O3 relationship, well over 100 roaster oxides
17		R	IVOC1-a	YES	
18		R	IVOC1-b	YES	
27		R	IIIF2-a	YES	
28		R	IIIF2-b	YES	
70		R	llOC5-a	YES	
71		R	IIOC5-b	YES	
72		R	IIOC5-c	YES	

Table 4	Table 4.1: Determining anthropogenic As sources other than roaster emissions at Giant (supports Figure 4.1)										
ASU name	Depth profile disturbed?	source	Golder Sample	As ₂ O ₃	Reasoning and justification for being anthropogenic (if no $\mbox{As}_2\mbox{O}_3$ in sample)						
80		R	llOC9-a	YES							
81		R	IIOC9-b	YES							
82		R	IIOC9-c	no	As concentration and weathering product hosts relationship to $\ensuremath{As_2O_3}\xspace$ bearing horizon above						
83		R	llOC10-a	YES							
84		R	IIOC10-b	YES							
85		R	IIOC11-a	YES							
86		R	IIOC11-b	YES							
118	Y	RW	IIIWL1-a	YES	arsenopyrite/carbonate relationship; also disrupted depth horizon rela- tionship						
119	Y	RW	IIIWL1-b	YES	arsenopyrite/carbonate relationship; also disrupted depth horizon rela- tionship						
93	Y	RW	IIIWL1-c	YES	arsenopyrite/carbonate relationship; also disrupted depth horizon rela- tionship						
122		R	IIIOC2-a	YES							
123		R	IIIOC2-b	YES							
124		R	IIIOC5-a	YES							
125		R	IIIOC5-b	YES							
147		R	IVOC4-a	YES							
148		R	IVOC4-b	YES							
169		RW	VWL2-b	YES							
179		R	VOC1-a	YES							
180		R	VOC1-b	no	As concentration and weathering product hosts relationship to $\ensuremath{As_2O_3}\xspace$ bearing horizon above						
181		R	VOC2-a	YES							
195		RW	VIWL1A-a	no	Same location as VI-WL-1B, which does have As ₂ O ₃ . Also arsenopyrite/ carbonate rock relationship						
196		RW	VIWL1A-b	no	Same location as VI-WL-1B, which does have As ₂ O ₃ . Also arsenopyrite/ carbonate rock relationship						
197		RW	VIWL1B-a	YES	Little As ₂ O ₃ , arsenopyrite/carbonate rock relationship						
198		RW	VIWL1B-b	YES	Little As ₂ O ₃ , arsenopyrite/carbonate rock relationship						
199		RW	VIWL1B-c	YES	Little As ₂ O ₃ , arsenopyrite/carbonate rock relationship						
202		R	VIOC4-a	YES							
203		R	VIOC4-b	YES							
295		R	VIIIOC4-a	YES							
296		R	VIIIOC4-b	YES							
319		RTW	IXOC2-a	YES	Well over 200 ROs, plus arsenopyrite/carbonate relationship						
320		RW	IXOC2-b	YES	arsenopyrite/carbonate relationship						
324		RTW	IXOC4-a	YES	Close to 100 ROs (tailings possible), plus arsenopyrite/carbonate rela- tionship						
325		RW	IXOC4-b	YES	arsenopyrite/carbonate relationship						

Table 4	Table 4.1: Determining anthropogenic As sources other than roaster emissions at Giant (supports Figure 4.1)									
ASU name	Depth profile disturbed?	source	Golder Sample	As ₂ O ₃	Reasoning and justification for being anthropogenic (if no As_2O_3 in sample)					
326		RW	IXOC4-c	YES	arsenopyrite/carbonate relationship					
344		R	IVF2-a	YES						
345		R	IVF2-b	YES						
354		R	IIIOC8-a	YES						

4.3 Conclusions

Depth-stratified regional soil sampling across the Giant Mine lease in 2014 revealed wide-spread As concentrations above the site-specific cleanup guideline of 340 µg/g, with values as high as 17,000 µg/g. Sampling and analyzing all soil samples by depth proved extremely useful, and results indicate that the top soil horizons (usually 0-5cm depth) at a given sample site often had the most As for that site. The exceptions to this are areas with known disturbance, such as the wetland on the edge of Baker Creek. These results have important implications for interpreting results of previous soil sampling studies of the area that did not control sample depth as carefully. Results of this program indicate that a non-depth stratified approach likely underestimates the total concentration of As by diluting As concentrations. This is important with respect to risk assessment if the expectation is that humans and other organisms are most likely to interact with the top few cm of soil.

Mineral Liberation Analysis for this project has turned out to be an extremely useful tool in speciation of As in soils at Giant Mine. On multiple occasions during this project, for samples with very scarce amounts of As₂O₃, the MLA software found and catalogued As₂O₃ grains that would have been difficult to impossible to find by conventional SEM analysis alone; sometimes the largest As₂O₃ grain(s) in a sample were $<5\mu$ m in diameter. While samples with low total As₂O₃ grain counts and area per cents are not very statistically reliable for quantitative calculations, knowing that at least one grain of As₂O₃ has been found at all 23 MLA sample sites across the Giant Mine Lease is valuable information.

While optimization of MLA operating and processing settings is a very time-consuming affair, once methods have matured they can be very widely applied. While it cannot quantify As weight percentages in poorly-defined phases, the MLA's ability to provide some kind of quantification for As hosts with indistinct BSE brightness levels is very powerful technology. The major As hosts documented in this report, other than As₂O₃, arsenopyrite, ROs and As-bearing Fe oxides/oxyhydroxides, had never before been documented in Giant Mine soils. Being able to visually analyze As-bearing weathering products and coatings on organic matter in comparison to As₂O₃ provides much-needed context for the presence of As₂O₃ and arsenopyrite in soils. This, in concert with depth-stratified sampling, has resulted in a wealth of new information about the fate of anthropogenic As in Giant Mine soils that will be useful for risk assessment and remediation planning. As well, the extensive MLA analysis of Giant Mine soils has produced a massive amount of data, of which this report only explores a fraction.

Soil samples in this study as a whole are likely to have come by their elevated As concentrations from anthropogenic sources. This is supported by depth horizon chemical information, MLA/SEM exploration

of As hosts amongst soil depths at specific locations, and geographic proximity to the source of contaminants.

The results of this As speciation study can be used to suggest which soils on the Giant property contain the most bioaccessible form of As if orally ingested, and which are most likely to leach As to surrounding surface and ground water. As noted by Plumlee and Morman (2011), As₂O₃ is considered the most bioaccessible As mineral in terms of its solubility in simulated gastric fluid. Arsenopyrite is one of the least bioaccessible As minerals, and realgar is intermediate. However, the bioaccessibility of the As in the weathering products and organic material noted in this study are unknown. Similarly, the role that these weathering products and organic material play in releasing as to surface and groundwater on the Giant property is unknown. The preliminary evidence from this study is that these materials play a role in mobility of As in the near-surface horizon and require further study.

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Appendix I: Sample names, GPS coordinates, and processing information

All GPS coordinates are presented as UTM NAD 83, Zone 11N. "ASU" sample names are the simplified sample numbers used by the lab for all chemistry results.

Queen's name	Golder site + horizon	ASU nam e	Golder site name	from depth (cm)	to depth (cm)	interval width (cm)	Easting (NAD 83, Zone 11N)	Northing (NAD 83, Zone 11N)	Sampling Date	Cooler	Lo- ca- tion Type	Rela- tive Hori- zon
O-1a	IOC1-a	141	I-OC-1	0	5	5	636185.01	6931689.17	Sept 24, 2014	4	0	a
O-1b	IOC1-b	142	I-OC-1	5	15	10	636185.01	6931689.17	Sept 24, 2014	4	0	b
O-2a	IOC2-a	91	I-OC-2	2	7	5			Sept 24, 2014	III OC ½	0	а
O-3a	IOC3-a	92	I-OC-3	2	5	3			Sept 24, 2014	III OC ½	0	а
O-4a	llOC1-a	61	II-OC-1	0	5	5	635950.66	6931541.29	Sept 23, 2014	OC II	0	а
O-4b	IIOC1-b	62	II-OC-1	5	10	5	635950.66	6931541.29	Sept 23, 2014	OC II	0	b
O-5a	llOC10-a	83	II-OC-10	0	5	5	636432.2	6932428.69	Sept 23, 2014	OC II	0	а
O-5b	IIOC10-b	84	II-OC-10	5	8	3	636432.2	6932428.69	Sept 23, 2014	OC II	0	b
O-6a	IIOC11-a	85	II-OC-11	0	5	5	636325	6932364.07	Sept 23, 2014	OC II	0	а
O-6b	IIOC11-b	86	II-OC-11	5	10	5	636325	6932364.07	Sept 23, 2014	OC II	0	b
O-7a	llOC2-a	63	II-OC-2	0	3	3	635922.81	6931629.37	Sept 23, 2014	OC II	0	а
O-7b	IIOC2-b	64	II-OC-2	3	10	7	635922.81	6931629.37	Sept 23, 2014	OC II	0	b
O-8a	llOC3-a	65	II-OC-3	0	5	5	636083.31	6931640.4	Sept 23, 2014	OC II	0	а
O-8b	IIOC3-b	66	II-OC-3	5	10	5	636083.31	6931640.4	Sept 23, 2014	OC II	0	b
O-9a	llOC4-a	67	II-OC-4	0	5	5	636048.51	6931949.02	Sept 23, 2014	OC II	0	а
O-9b	IIOC4-b	68	II-OC-4	5	15	10	636048.51	6931949.02	Sept 23, 2014	OC II	0	b
O-9c	IIOC4-c	69	II-OC-4	15	20	5	636048.51	6931949.02	Sept 23, 2014	OC II	0	с
O-10a	llOC5-a	70	II-OC-5	0	3	3	636451.05	6932509.77	Sept 23, 2014	OC II	0	а
O-10b	IIOC5-b	71	II-OC-5	3	10	7	636451.05	6932509.77	Sept 23, 2014	OC II	0	b
O-10c	IIOC5-c	72	II-OC-5	10	20	10	636451.05	6932509.77	Sept 23, 2014	OC II	0	С
O-11a	llOC6-a	73	II-OC-6	0	5	5	636398.7	6932302.41	Sept 23, 2014	OC II	0	а
O-11b	IIOC6-b	74	II-OC-6	5	15	10	636398.7	6932302.41	Sept 23, 2014	OC II	0	b
O-11c	IIOC6-c	75	II-OC-6	15	20	5	636398.7	6932302.41	Sept 23, 2014	OC II	0	с
O-12a	llOC7-a	76	II-OC-7	0	10	10	636122.55	6931639.77	Sept 23, 2014	OC II	0	а
O-12b	llOC7-b	77	II-OC-7	10	16	6	636122.55	6931639.77	Sept 23, 2014	OC II	0	b
O-13a	llOC8-a	78	II-OC-8	0	12	12	635941.7	6931608.95	Sept 23, 2014	OC II	0	а
O-13b	IIOC8-b	79	II-OC-8	12	15	3	635941.7	6931608.95	Sept 23, 2014	OC II	0	b
O-14a	llOC9-a	80	II-OC-9	0	3	3	636029.02	6931857.88	Sept 23, 2014	OC II	0	а
O-14b	IIOC9-b	81	II-OC-9	3	10	7	636029.02	6931857.88	Sept 23, 2014	OC II	0	b
O-14c	IIOC9-c	82	II-OC-9	10	15	5	636029.02	6931857.88	Sept 23, 2014	OC II	0	С
O-15a	IIIOC1-a	120	III-OC-1	0	5	5	635503.8	6932278.09	Sept 18, 2014	III OC 2/2	0	a

Queen's name	Golder site + horizon	ASU nam e	Golder site name	from depth (cm)	to depth (cm)	interval width (cm)	Easting (NAD 83, Zone 11N)	Northing (NAD 83, Zone 11N)	Sampling Date	Cooler	Lo- ca- tion Type	Rela- tive Hori- zon
O-15b	IIIOC1-b	121	III-OC-1	5	15	10	635503.8	6932278.09	Sept 18, 2014	III OC 2/2	0	b
O-16a	IIIOC2-a	122	III-OC-2	0	8	8	635380.53	6931910.61	Sept 18, 2014	III OC 2/2	0	а
O-16b	IIIOC2-b	123	III-OC-2	8	15	7	635380.53	6931910.61	Sept 18, 2014	III OC 2/2	0	b
O-17a	IIIOC3-a	107	III-OC-3	0	5	5	635383.51	6931444.55	Sept 24, 2014	III OC ½	0	а
O-17b	IIIOC3-b	108	III-OC-3	5	9	4	635383.51	6931444.55	Sept 24, 2014	III OC ½	0	b
O-18a	IIIOC5-a	124	III-OC-5	0	5	5	635474.54	6932350.5	Sept 18, 2014	III OC 2/2	0	а
O-18b	IIIOC5-b	125	III-OC-5	5	10	5	635474.54	6932350.5	Sept 18, 2014	III OC 2/2	0	b
O-19a	IIIOC6-a	109	III-OC-6	0	5	5	635407.47	6931400.91	Sept 24, 2014	III OC ½	0	а
O-19b	IIIOC6-b	110	III-OC-6	5	9	4	635407.47	6931400.91	Sept 24, 2014	III OC ½	0	b
O-20a	IIIOC7-a	111	III-OC-7	0	5	5	635313.32	6931470.69	Sept 24, 2014	III OC ½	0	а
O-20b	IIIOC7-b	112	III-OC-7	5	10	5	635313.32	6931470.69	Sept 24, 2014	III OC ½	0	b
O-21a	IIIOC8-a	354	III-OC-8	0	5	5	635524.27	6930889.3	Sept 25, 2014	Unlabeled 3	0	а
O-21b	IIIOC8-b	355	III-OC-8	5	15	10	635524.27	6930889.3	Sept 25, 2014	Unlabeled 3	0	b
O-22a	IVOC1-a	17	IV-OC-1	0	5	5	635624.43	6933075.96	Sept 23, 2014	Unlabeled 1	0	а
O-22b	IVOC1-b	18	IV-OC-1	5	10	5	635624.43	6933075.96	Sept 23, 2014	Unlabeled 1	0	b
O-23a	IVOC2-a	143	IV-OC-2	0	5	5	635439.89	6934352.11	Sept 20, 2014	4	0	а
O-23b	IVOC2-b	144	IV-OC-2	5	10	5	635439.89	6934352.11	Sept 20, 2014	4	0	b
O-24a	IVOC3-a	145	IV-OC-3	0	5	5	635637.44	6934159.42	Sept 20, 2014	4	0	а
O-24b	IVOC3-b	146	IV-OC-3	5	15	10	635637.44	6934159.42	Sept 20, 2014	4	0	b
O-25a	IVOC4-a	147	IV-OC-4	0	5	5	635534.69	6933392.38	Sept 19, 2014	4	0	а
O-25b	IVOC4-b	148	IV-OC-4	5	12	7	635534.69	6933392.38	Sept 19, 2014	4	0	b
O-26a	IXOC1-a	317	IX-OC-1	0	5	5	636381.15	6933044.47	Sept 19, 2014	IX	0	а
O-26b	IXOC1-b	318	IX-OC-1	5	15	10	636381.15	6933044.47	Sept 19, 2014	IX	0	b
O-27a	IXOC2-a	319	IX-OC-2	0	3	3	636398.38	6932913.57	Sept 19, 2014	IX	0	а
O-27b	IXOC2-b	320	IX-OC-2	3	10	7	636398.38	6932913.57	Sept 19, 2014	IX	0	b
O-27c	IXOC2-c	321	IX-OC-2	10	25	15	636398.38	6932913.57	Sept 19, 2014	IX	0	С
O-28a	IXOC3-a	322	IX-OC-3	0	5	5	636623.56	6932591.58	Sept 18, 2014	IX	0	а
O-28b	IXOC3-b	323	IX-OC-3	5	10	5	636623.56	6932591.58	Sept 18, 2014	IX	0	b
O-29a	IXOC4-a	324	IX-OC-4	0	6	6	636325.05	6933004.24	Sept 18, 2014	IX	0	а
O-29b	IXOC4-b	325	IX-OC-4	6	15	9	636325.05	6933004.24	Sept 18, 2014	IX	0	b
O-29c	IXOC4-c	326	IX-OC-4	15	20	5	636325.05	6933004.24	Sept 18, 2014	IX	0	С
O-30a	IXOC5-a	327	IX-OC-5	0	7	7	636228.05	6934011.83	Sept 19, 2014	IX	0	а
O-30b	IXOC5-b	328	IX-OC-5	7	15	8	636228.05	6934011.83	Sept 19, 2014	IX	0	b
O-31a	VOC1-a	179	V-OC-1	0	5	5	635422.67	6934951.42	Sept 20, 2014	V OC	0	а
O-31b	VOC1-b	180	V-OC-1	5	15	10	635422.67	6934951.42	Sept 20, 2014	V OC	0	b
O-32a	VOC2-a	181	V-OC-2	0	5	5	635540.94	6935248.45	Sept 20, 2014	V OC	0	а
O-32b	VOC2-b	182	V-0C-2	5	15	10	635540.94	6935248.45	Sept 20, 2014	V OC	0	b
O-32c	VOC2-c	183	V-0C-2	15	25	10	635540.94	6935248.45	Sept 20, 2014	V OC	0	С
O-32d	VOC2-d	184	V-0C-2	25	35	10	635540.94	6935248.45	Sept 20, 2014	V OC	0	d
O-33a	VOC3-a	185	V-OC-3	0	5	5	635830.81	6936035.41	Sept 21, 2014	V OC	0	а
O-33b	VOC3-b	186	V-OC-3	5	15	10	635830.81	6936035.41	Sept 21, 2014	V OC	0	b
O-33c	VOC3-c	187	V-OC-3	15	25	10	635830.81	6936035.41	Sept 21, 2014	V OC	0	С
O-34a	VOC4-a	188	V-OC-4	0	5	5	636109.43	6935799.23	Sept 20, 2014	V OC	0	а
O-34b	VOC4-b	189	V-OC-4	5	15	10	636109.43	6935799.23	Sept 20, 2014	V OC	0	b

Queen's name	Golder site + horizon	ASU nam e	Golder site name	from depth (cm)	to depth (cm)	interval width (cm)	Easting (NAD 83, Zone 11N)	Northing (NAD 83, Zone 11N)	Sampling Date	Cooler	Lo- ca- tion Type	Rela- tive Hori- zon
O-34c	VOC4-c	190	V-OC-4	15	30	15	636109.43	6935799.23	Sept 20, 2014	V OC	0	с
O-35a	VOC5-a	191	V-OC-5	0	5	5	635488.15	6935064.51	Sept 20, 2014	V OC	0	а
O-35b	VOC5-b	192	V-OC-5	5	10	5	635488.15	6935064.51	Sept 20, 2014	V OC	0	b
O-36a	VOC6-a	193	V-OC-6	0	5	5	635863.32	6936172.8	Sept 21, 2014	V OC	0	а
O-36b	VOC6-b	194	V-OC-6	5	15	10	635863.32	6936172.8	Sept 21, 2014	V OC	0	b
O-37a	VIOC1-a	209	VI-OC-1	0	5	5	635739.69	6936928.37	Sept 20, 2014	6 (2)	0	а
O-37b	VIOC1-b	210	VI-OC-1	5	15	10	635739.69	6936928.37	Sept 20, 2014	6 (2)	0	b
O-38a	VIOC2-a	211	VI-OC-2	0	5	5	635376.33	6937414.29	Sept 20, 2014	6 (2)	0	а
O-38b	VIOC2-b	212	VI-OC-2	5	10	5	635376.33	6937414.29	Sept 20, 2014	6 (2)	0	b
O-39a	VIOC3-a	231	VI-OC-3	0	5	5	636016.33	6936625.18	Sept 21, 2014	6 (2)	0	а
O-39b	VIOC3-b	232	VI-OC-3	5	10	5	636016.33	6936625.18	Sept 21, 2014	6 (2)	0	b
O-40a	VIOC4-a	202	VI-OC-4	0	5	5	635412.78	6936899.4	Sept 20, 2014	VI	0	a
O-40b	VIOC4-b	203	VI-OC-4	5	10	5	635412.78	6936899.4	Sept 20, 2014	VI	0	b
O-41a	VIOC5-a	233	VI-OC-5	0	5	5	635334.11	6937401.41	Sept 20, 2014	6 (2)	0	а
O-41b	VIOC5-b	234	VI-OC-5	5	10	5	635334.11	6937401.41	Sept 20, 2014	6 (2)	0	b
O-41c	VIOC5-c	235	VI-OC-5	10	20	10	635334.11	6937401.41	Sept 20, 2014	6 (2)	0	С
O-42a	VIIOC1-a	242	VII-OC-1	0	5	5	636334.58	6935862	Sept 19, 2014	VII	0	а
O-42b	VIIOC1-b	243	VII-OC-1	5	10	5	636334.58	6935862	Sept 19, 2014	VII	0	b
O-42c	VIIOC1-c	244	VII-OC-1	10	35	25	636334.58	6935862	Sept 19, 2014	VII	0	С
O-43a	VIIOC2-a	254	VII-OC-2	0	5	5	636392.48	6935769.57	Sept 19, 2014	7 – 2	0	а
O-43b	VIIOC2-b	255	VII-OC-2	5	15	10	636392.48	6935769.57	Sept 19, 2014	7 – 2	0	b
O-44a	VIIOC3-a	256	VII-OC-3	0	5	5	636451.42	6935589.09	Sept 19, 2014	7 – 2	0	a
O-44b	VIIOC3-b	257	VII-OC-3	5	15	10	636451.42	6935589.09	Sept 19, 2014	7 – 2	0	b
O-45a	VIIOC4-a	258	VII-OC-4	0	5	5	636801.34	6935300.12	Sept 19, 2014	7 – 2	0	a
O-45b	VIIOC4-b	259	VII-OC-4	5	10	5	636801.34	6935300.12	Sept 19, 2014	7 – 2	0	b
O-46a	VIIOC5-a	260	VII-OC-5	0	5	5	636755.79	6935129.84	Sept 19, 2014	7 – 2	0	a
O-47a	VIIOC6-a	261	VII-OC-6	0	5	5	636603.53	6934997.55	Sept 19, 2014	7 – 2	0	а
O-47b	VIIOC6-b	262	VII-OC-6	5	10	5	636603.53	6934997.55	Sept 19, 2014	7 – 2	0	b
O-48a	VIIOC7-a	263	VII-OC-7	0	5	5	636697.62	6935090.64	Sept 19, 2014	7 – 2	0	а
O-48b	VIIOC7-b	264	VII-OC-7	5	10	5	636697.62	6935090.64	Sept 19, 2014	7 – 2	0	b
O-49a	VIIOC8-a	265	VII-OC-8	0	5	5	636781.22	6935225.69	Sept 19, 2014	7 – 2	0	а
O-49b	VIIOC8-b	266	VII-OC-8	5	15	10	636781.22	6935225.69	Sept 19, 2014	7 – 2	0	b
O-49c	VIIOC8-c	267	VII-OC-8	15	25	10	636781.22	6935225.69	Sept 19, 2014	7 – 2	0	С
O-50a	VIIOC9-a	268	VII-OC-9	0	5	5	636441.03	6935779.38	Sept 19, 2014	7 – 2	0	a
O-50b	VIIOC9-b	269	VII-OC-9	5	15	10	636441.03	6935779.38	Sept 19, 2014	7 – 2	0	b
O-50c	VIIOC9-c	270	VII-OC-9	15	30	15	636441.03	6935779.38	Sept 19, 2014	7 – 2	0	С
O-51a	VIIIOC1-a	288	VIII-OC-1	0	5	5	637083.34	6934785.33	Sept 19, 2014	VIII	0	a
O-51b	VIIIOC1-b	289	VIII-OC-1	5	10	5	637083.34	6934785.33	Sept 19, 2014	VIII	0	b
O-52a	VIIIOC2-a	290	VIII-OC-2	0	5	5	636768.33	6934462.29	Sept 19, 2014	VIII	0	a
O-52b	VIIIOC2-b	291	VIII-OC-2	5	10	5	636768.33	6934462.29	Sept 19, 2014	VIII	0	b
O-52c	VIIIOC2-c	292	VIII-OC-2	10	20	10	636768.33	6934462.29	Sept 19, 2014	VIII	0	С
O-53a	VIIIOC3-a	293	VIII-OC-3	0	5	5	636830.17	6934349.96	Sept 19, 2014	VIII	0	а
O-53b	VIIIOC3-b	294	VIII-OC-3	5	10	5	636830.17	6934349.96	Sept 19, 2014	VIII	0	b
O-54a	VIIIOC4-a	295	VIII-OC-4	0	5	5	636751.1	6934342.25	Sept 19, 2014	VIII	0	а

Queen's name	Golder site + horizon	ASU nam e	Golder site name	from depth (cm)	to depth (cm)	interval width (cm)	Easting (NAD 83, Zone 11N)	Northing (NAD 83, Zone 11N)	Sampling Date	Cooler	Lo- ca- tion Type	Rela- tive Hori- zon
O-54b	VIIIOC4-b	296	VIII-OC-4	5	20	15	636751.1	6934342.25	Sept 19, 2014	VIII	0	b
O-55a	VIIIOC5-a	279	VIII-OC-5	0	10	10	636385.08	6934179.99	Sept 19, 2014	VIII	0	а
O-55b	VIIIOC5-b	280	VIII-OC-5	10	15	5	636385.08	6934179.99	Sept 19, 2014	VIII	0	b
O-56a	VIIIOC6-a	281	VIII-OC-6	0	5	5	637059.27	6934681.73	Sept 19, 2014	VIII	0	а
O-56b	VIIIOC6-b	282	VIII-OC-6	5	10	5	637059.27	6934681.73	Sept 19, 2014	VIII	0	b
S-57a	Stockpile 1-a	349	Stockpile 1			0	635571.06	6933322.49	Sept 25, 2014	Unlabeled 3	S	а
S-57b	Stockpile 2-b	350	Stockpile 2			0	635571.06	6933322.49	Sept 25, 2014	Unlabeled 3	S	b
S-57c	Stockpile 3-c	351	Stockpile 3			0	635571.06	6933322.49	Sept 25, 2014	Unlabeled 3	S	С
S-57d	Stockpile 4-d	352	Stockpile 4			0	635571.06	6933322.49	Sept 25, 2014	Unlabeled 3	S	d
S-57e	Stockpile 5-e	353	Stockpile 5			0	635571.06	6933322.49	Sept 25, 2014	Unlabeled 3	S	е
F-58a	IF1-a	126	I-F-1	0	5	5	636350.79	6931873.29	Sept 24, 2014	4	F	а
F-58b	IF1-b	127	I-F-1	5	15	10	636350.79	6931873.29	Sept 24, 2014	4	F	b
F-58c	IF1-c	128	I-F-1	15	30	15	636350.79	6931873.29	Sept 24, 2014	4	F	С
F-58d	IF1-d	129	I-F-1	30	60	30	636350.79	6931873.29	Sept 24, 2014	4	F	d
F-58e	IF1-e	130	I-F-1	60	100	40	636350.79	6931873.29	Sept 24, 2014	4	F	е
F-59a	IF2-a	102	I-F-2	0	5	5	636212.25	6931855.35	Sept 24, 2014	III OC ½	F	а
F-59b	IF2-b	103	I-F-2	5	15	10	636212.25	6931855.35	Sept 24, 2014	III OC ½	F	b
F-59c	IF2-c	104	I-F-2	15	30	15	636212.25	6931855.35	Sept 24, 2014	III OC ½	F	С
F-59d	IF2-d	105	I-F-2	30	60	30	636212.25	6931855.35	Sept 24, 2014	III OC ½	F	d
F-59e	IF2-e	106	I-F-2	60	100	40	636212.25	6931855.35	Sept 24, 2014	III OC ½	F	е
F-60a	IIF1-a	334	II-F-1	0	5	5	635728.32	6931692.81	Sept 23, 2014	IX	F	а
F-60b	llF1-b	335	II-F-1	5	15	10	635728.32	6931692.81	Sept 23, 2014	IX	F	b
F-60c	IIF1-c	336	II-F-1	15	30	15	635728.32	6931692.81	Sept 23, 2014	IX	F	С
F-60d	llF1-d	337	II-F-1	30	60	30	635728.32	6931692.81	Sept 23, 2014	IX	F	d
F-60e	IIF1-e	338	II-F-1	60	100	40	635728.32	6931692.81	Sept 23, 2014	IX	F	е
F-61a	IIF2-a	56	II-F-2	0	5	5	635905.99	6931977.76	Sept 23, 2014	Unlabeled 2	F	а
F-61b	IIF2-b	57	II-F-2	5	15	10	635905.99	6931977.76	Sept 23, 2014	Unlabeled 2	F	b
F-61c	IIF2-c	58	II-F-2	15	30	15	635905.99	6931977.76	Sept 23, 2014	Unlabeled 2	F	с
F-61d	IIF2-d	59	II-F-2	30	60	30	635905.99	6931977.76	Sept 23, 2014	Unlabeled 2	F	d
F-61e	IIF2-e	60	II-F-2	60	100	40	635905.99	6931977.76	Sept 23, 2014	Unlabeled 2	F	е
F-62a	IIF3-a	51	II-F-3	0	5	5	636019.77	6932159.74	Sept 23, 2014	Unlabeled 2	F	а
F-62b	IIF3-b	52	II-F-3	5	15	10	636019.77	6932159.74	Sept 23, 2014	Unlabeled 2	F	b
F-62c	IIF3-c	53	II-F-3	15	30	15	636019.77	6932159.74	Sept 23, 2014	Unlabeled 2	F	с
F-62d	llF3-d	54	II-F-3	30	60	30	636019.77	6932159.74	Sept 23, 2014	Unlabeled 2	F	d
F-62e	IIF3-e	55	II-F-3	60	90	30	636019.77	6932159.74	Sept 23, 2014	Unlabeled 2	F	е
F-63a	IIIF1-a	356	III-F-1	0	5	5	635584.18	6930900.66	Sept 25, 2014	Unlabeled 3	F	а
F-63b	IIIOC8-b	357	III-OC-8	5	15	10	635524.27	6930889.3	Sept 25, 2014	Unlabeled 3	F	b
F-63c	IIIOC8-c	358	III-OC-8	15	30	15	635524.27	6930889.3	Sept 25, 2014	Unlabeled 3	F	с
F-63d	IIIOC8-d	359	III-OC-8	30	70	40	635524.27	6930889.3	Sept 25, 2014	Unlabeled 3	F	d
F-64a	IIIF2-a	27	III-F-2	0	5	5	635671.81	6932673.05	Sept 23, 2014	Unlabeled 1	F	а
F-64b	IIIF2-b	28	III-F-2	5	15	10	635671.81	6932673.05	Sept 23, 2014	Unlabeled 1	F	b

Queen's name	Golder site + horizon	ASU nam e	Golder site name	from depth (cm)	to depth (cm)	interval width (cm)	Easting (NAD 83, Zone 11N)	Northing (NAD 83, Zone 11N)	Sampling Date	Cooler	Lo- ca- tion Type	Rela- tive Hori- zon
F-64c	IIIF2-c	29	III-F-2	15	30	15	635671.81	6932673.05	Sept 23, 2014	Unlabeled 1	F	с
F-64d	IIIF2-d	30	III-F-2	30	55	25	635671.81	6932673.05	Sept 23, 2014	Unlabeled 1	F	d
F-64e	IIIF2-e	31	III-F-2	55	100	45	635671.81	6932673.05	Sept 23, 2014	Unlabeled 1	F	е
F-65a	IVF1-a	101	IV-F-1	0	5	5	635676.81	6933750.61	Sept 24, 2014	III OC ½	F	а
F-65b	IVF1-b	87	IV-F-1	5	15	10	635676.81	6933750.61	Sept 24, 2014	III OC ½	F	b
F-65c	IVF1-c	88	IV-F-1	15	30	15	635676.81	6933750.61	Sept 24, 2014	III OC ½	F	с
F-65d	IVF1-d	89	IV-F-1	30	60	30	635676.81	6933750.61	Sept 24, 2014	III OC ½	F	d
F-65e	IVF1-e	90	IV-F-1	60	100	40	635676.81	6933750.61	Sept 24, 2014	III OC ½	F	е
F-66a	IVF2-a	344	IV-F-2	0	5	5	635657.79	6933610.42	Sept 25, 2014	Unlabeled 3	F	а
F-66b	IVF2-b	345	IV-F-2	5	20	15	635657.79	6933610.42	Sept 25, 2014	Unlabeled 3	F	b
F-66c	IVF2-c	346	IV-F-2	20	30	10	635657.79	6933610.42	Sept 25, 2014	Unlabeled 3	F	С
F-66d	IVF2-d	347	IV-F-2	30	60	30	635657.79	6933610.42	Sept 25, 2014	Unlabeled 3	F	d
F-66e	IVF2-e	348	IV-F-2	60	100	40	635657.79	6933610.42	Sept 25, 2014	Unlabeled 3	F	е
F-67a	IVF3A-a	19	IV-F-3A	0	5	5	635642.96	6933228.39	Sept 23, 2014	Unlabeled 1	F	а
F-67b	IVF3A-b	20	IV-F-3A	5	15	10	635642.96	6933228.39	Sept 23, 2014	Unlabeled 1	F	b
F-67c	IVF3A-c	21	IV-F-3A	15	35	20	635642.96	6933228.39	Sept 23, 2014	Unlabeled 1	F	С
F-68a	IVF3B-a	22	IV-F-3B	0	5	5	635618.05	6933181.65	Sept 23, 2014	Unlabeled 1	F	а
F-68b	IVF3B-b	23	IV-F-3B	5	15	10	635618.05	6933181.65	Sept 23, 2014	Unlabeled 1	F	b
F-68c	IVF3B-c	24	IV-F-3B	15	30	15	635618.05	6933181.65	Sept 23, 2014	Unlabeled 1	F	с
F-68d	IVF3B-d	25	IV-F-3B	30	60	30	635618.05	6933181.65	Sept 23, 2014	Unlabeled 1	F	d
F-68e	IVF3B-e	26	IV-F-3B	60	100	40	635618.05	6933181.65	Sept 23, 2014	Unlabeled 1	F	е
F-69a	IXF1-a	113	IX-F-1	0	5	5	636261.41	6933286.03	Sept 24, 2014	III OC ½	F	а
F-69b	IXF1-b	114	IX-F-1	5	15	10	636261.41	6933286.03	Sept 24, 2014	III OC ½	F	b
F-69c	IXF1-c	115	IX-F-1	15	30	15	636261.41	6933286.03	Sept 24, 2014	III OC ½	F	с
F-69d	IXF1-d	116	IX-F-1	30	55	25	636261.41	6933286.03	Sept 24, 2014	III OC ½	F	d
F-69e	IXF1-e	117	IX-F-1	55	100	45	636261.41	6933286.03	Sept 24, 2014	III OC ½	F	е
F-70a	IXF2-a	37	IX-F-2	0	5	5	636275.36	6933650.19	Sept 23, 2014	Unlabeled 2	F	а
F-70b	IXF2-b	38	IX-F-2	5	15	10	636275.36	6933650.19	Sept 23, 2014	Unlabeled 2	F	b
F-70c	IXF2-c	39	IX-F-2	15	30	15	636275.36	6933650.19	Sept 23, 2014	Unlabeled 2	F	с
F-70d	IXF2-d	40	IX-F-2	30	45	15	636275.36	6933650.19	Sept 23, 2014	Unlabeled 2	F	d
F-71a	IXF3-a	329	IX-F-3	0	5	5	636126.95	6934013.26	Sept 22, 2014	IX	F	а
F-71b	IXF3-b	330	IX-F-3	5	15	10	636126.95	6934013.26	Sept 22, 2014	IX	F	b
F-71c	IXF3-c	331	IX-F-3	15	30	15	636126.95	6934013.26	Sept 22, 2014	IX	F	с
F-71d	IXF3-d	332	IX-F-3	30	60	30	636126.95	6934013.26	Sept 22, 2014	IX	F	d
F-71e	IXF3-e	333	IX-F-3	60	100	40	636126.95	6934013.26	Sept 22, 2014	IX	F	е
F-72a	IXF4-a	1	IX-F-4	0	5	5	636187.95	6933732.48	Sept 23, 2014	Unlabeled 1	F	а
F-72b	IXF4-b	2	IX-F-4	5	15	10	636187.95	6933732.48	Sept 23, 2014	Unlabeled 1	F	b
F-72c	IXF4-c	3	IX-F-4	15	30	15	636187.95	6933732.48	Sept 23, 2014	Unlabeled 1	F	С
F-72d	IXF4-d	4	IX-F-4	30	60	30	636187.95	6933732.48	Sept 23, 2014	Unlabeled 1	F	d
F-72e	IXF4-e	5	IX-F-4	60	85	25	636187.95	6933732.48	Sept 23, 2014	Unlabeled 1	F	е
F-72f	IXF4-f	6	IX-F-4	85	100	15	636187.95	6933732.48	Sept 23, 2014	Unlabeled 1	F	f
F-73a	VF1-a	170	V-F-1	0	5	5	635549.57	6934923.14	Sept 21, 2014	V	F	а
F-73b	VF1-b	171	V-F-1	5	15	10	635549.57	6934923.14	Sept 21, 2014	V	F	b
F-73c	VF1-c	172	V-F-1	15	30	15	635549.57	6934923.14	Sept 21, 2014	V	F	С
Queen's name	Golder site + horizon	ASU nam e	Golder site name	from depth (cm)	to depth (cm)	interval width (cm)	Easting (NAD 83, Zone 11N)	Northing (NAD 83, Zone 11N)	Sampling Date	Cooler	Lo- ca- tion Type	Rela- tive Hori- zon
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F-73d	VF1-d	173	V-F-1	30	50	20	635549.57	6934923.14	Sept 21, 2014	V	F	d
F-73e	VF1-e	174	V-F-1	50	100	50	635549.57	6934923.14	Sept 21, 2014	V	F	е
F-74a	VF2-a	175	V-F-2	0	10	10	635808.72	6936399.2	Sept 21, 2014	V	F	а
F-74b	VF2-b	176	V-F-2	10	20	10	635808.72	6936399.2	Sept 21, 2014	V	F	b
F-74c	VF2-c	177	V-F-2	20	50	30	635808.72	6936399.2	Sept 21, 2014	V	F	с
F-74d	VF2-d	178	V-F-2	50	80	30	635808.72	6936399.2	Sept 21, 2014	V	F	d
F-74e	VF2-e	161	V-F-2	80	90	10	635808.72	6936399.2	Sept 21, 2014	V	F	е
F-74f	VF2-f	162	V-F-2	100	110	10	635808.72	6936399.2	Sept 21, 2014	V	F	f
F-75a	VIF1-a	222	VI-F-1	0	5	5	635933.86	6936475.7	Sept 21, 2014	6 (2)	F	а
F-75b	VIF1-b	223	VI-F-1	5	20	15	635933.86	6936475.7	Sept 21, 2014	6 (2)	F	b
F-75c	VIF1-c	224	VI-F-1	20	30	10	635933.86	6936475.7	Sept 21, 2014	6 (2)	F	с
F-75d	VIF1-d	225	VI-F-1	30	60	30	635933.86	6936475.7	Sept 21, 2014	6 (2)	F	d
F-75e	VIF1-e	226	VI-F-1	60	90	30	635933.86	6936475.7	Sept 21, 2014	6 (2)	F	е
F-76a	VIF2-a	227	VI-F-2	0	5	5	635606.08	6936706.54	Sept 20, 2014	6 (2)	F	а
F-76b	VIF2-b	228	VI-F-2	5	10	5	635606.08	6936706.54	Sept 20, 2014	6 (2)	F	b
F-76c	VIF2-c	229	VI-F-2	10	30	20	635606.08	6936706.54	Sept 20, 2014	6 (2)	F	С
F-76d	VIF2-d	230	VI-F-2	30	50	20	635606.08	6936706.54	Sept 20, 2014	6 (2)	F	d
F-76e	VIF2-e	213	VI-F-2	50	60	10	635606.08	6936706.54	Sept 20, 2014	6 (2)	F	е
F-76f	VIF2-f	214	VI-F-2	60	80	20	635606.08	6936706.54	Sept 20, 2014	6 (2)	F	f
F-76g	VIF2-g	215	VI-F-2	80	85	5	635606.08	6936706.54	Sept 20, 2014	6 (2)	F	g
F-77a	VIF3-a	216	VI-F-3	0	5	5	635353.5	6937279.52	Sept 20, 2014	6 (2)	F	а
F-77b	VIF3-b	217	VI-F-3	5	15	10	635353.5	6937279.52	Sept 20, 2014	6 (2)	F	b
F-77c	VIF3-c	218	VI-F-3	15	25	10	635353.5	6937279.52	Sept 20, 2014	6 (2)	F	С
F-77d	VIF3-d	219	VI-F-3	25	45	20	635353.5	6937279.52	Sept 20, 2014	6 (2)	F	d
F-77e	VIF3-e	220	VI-F-3	45	55	10	635353.5	6937279.52	Sept 20, 2014	6 (2)	F	е
F-77f	VIF3-f	221	VI-F-3	55	80	25	635353.5	6937279.52	Sept 20, 2014	6 (2)	F	f
F-78a	VIF4-a	204	VI-F-4	0	5	5	635401.46	6936772.91	Sept 20, 2014	6 (2)	F	a
F-78b	VIF4-b	205	VI-F-4	5	10	5	635401.46	6936772.91	Sept 20, 2014	6 (2)	F	b
F-78c	VIF4-c	206	VI-F-4	10	30	20	635401.46	6936772.91	Sept 20, 2014	6 (2)	F	С
F-78d	VIF4-d	207	VI-F-4	30	60	30	635401.46	6936772.91	Sept 20, 2014	6 (2)	F	d
F-78e	VIF4-e	208	VI-F-4	60	100	40	635401.46	6936772.91	Sept 20, 2014	6 (2)	F	е
F-79a	VIIF1-a	245	VII-F-1	0	5	5	636693.6	6934875.22	Sept 21, 2014	VII	F	а
F-79b	VIIF1-b	246	VII-F-1	5	20	15	636693.6	6934875.22	Sept 21, 2014	VII	F	b
F-79c	VIIF1-c	247	VII-F-1	20	30	10	636693.6	6934875.22	Sept 21, 2014	VII	F	С
F-79d	VIIF1-d	248	VII-F-1	30	60	30	636693.6	6934875.22	Sept 21, 2014	VII	F	d
F-79e	VIIF1-e	249	VII-F-1	60	100	40	636693.6	6934875.22	Sept 21, 2014	VII	F	е
F-80a	VIIF2-a	250	VII-F-2	0	5	5	636167.83	6935606.44	Sept 21, 2014	VII	F	a
F-80b	VIIF2-b	251	VII-F-2	5	15	10	636167.83	6935606.44	Sept 21, 2014	VII	F	b
F-80c	VIIF2-c	252	VII-F-2	15	30	15	636167.83	6935606.44	Sept 21, 2014	VII	F	С
F-80d	VIIF2-d	253	VII-F-2	30	60	30	636167.83	6935606.44	Sept 21, 2014	VII	F	d
F-80e	VIIF2-e	236	VII-F-2	60	70	10	636167.83	6935606.44	Sept 21, 2014	VII	F	е
F-80f	VIIF2-f	237	VII-F-2	70	100	30	636167.83	6935606.44	Sept 21, 2014	VII	F	f
F-81a	VIIIF1-a	283	VIII-F-1	0	5	5	636844.61	6934675.11	Sept 22, 2014	VIII	F	а
F-81b	VIIIF1-b	284	VIII-F-1	5	15	10	636844.61	6934675.11	Sept 22, 2014	VIII	F	b

Queen's name	Golder site + horizon	ASU nam e	Golder site name	from depth (cm)	to depth (cm)	interval width (cm)	Easting (NAD 83, Zone 11N)	Northing (NAD 83, Zone 11N)	Sampling Date	Cooler	Lo- ca- tion Type	Rela- tive Hori- zon
F-81c	VIIIF1-c	285	VIII-F-1	15	30	15	636844.61	6934675.11	Sept 22, 2014	VIII	F	С
F-81d	VIIIF1-d	286	VIII-F-1	30	60	30	636844.61	6934675.11	Sept 22, 2014	VIII	F	d
F-81e	VIIIF1-e	287	VIII-F-1	60	70	10	636844.61	6934675.11	Sept 22, 2014	VIII	F	е
F-82a	VIIIF2-a	271	VIII-F-2	0	5	5	636616.26	6934575.37	Sept 22, 2014	VIII	F	а
F-82b	VIIIF2-b	272	VIII-F-2	5	15	10	636616.26	6934575.37	Sept 22, 2014	VIII	F	b
F-82c	VIIIF2-c	273	VIII-F-2	15	30	15	636616.26	6934575.37	Sept 22, 2014	VIII	F	С
F-82d	VIIIF2-d	274	VIII-F-2	30	60	30	636616.26	6934575.37	Sept 22, 2014	VIII	F	d
F-83a	VIIIF3-a	275	VIII-F-3	0	5	5	636459.66	6934384.91	Sept 22, 2014	VIII	F	а
F-83b	VIIIF3-b	276	VIII-F-3	5	15	10	636459.66	6934384.91	Sept 22, 2014	VIII	F	b
F-83c	VIIIF3-c	277	VIII-F-3	15	30	15	636459.66	6934384.91	Sept 22, 2014	VIII	F	С
F-83d	VIIIF3-d	278	VIII-F-3	30	60	30	636459.66	6934384.91	Sept 22, 2014	VIII	F	d
F-84a	VIIIF4-a	297	VIII-F-4	0	5	5	637024.46	6934550.92	Sept 22, 2014	8 – 2	F	а
F-84b	VIIIF4-b	298	VIII-F-4	5	15	10	637024.46	6934550.92	Sept 22, 2014	8 – 2	F	b
F-84c	VIIIF4-c	299	VIII-F-4	15	30	15	637024.46	6934550.92	Sept 22, 2014	8 – 2	F	С
F-84d	VIIIF4-d	300	VIII-F-4	30	60	30	637024.46	6934550.92	Sept 22, 2014	8 – 2	F	d
F-84e	VIIIF4-e	301	VIII-F-4	60	90	30	637024.46	6934550.92	Sept 22, 2014	8 – 2	F	е
F-85a	VIIIF5-a	302	VIII-F-5	0	5	5	637029.16	6934336.98	Sept 22, 2014	8 – 2	F	а
F-85b	VIIIF5-b	303	VIII-F-5	5	15	10	637029.16	6934336.98	Sept 22, 2014	8 – 2	F	b
F-85c	VIIIF5-c	304	VIII-F-5	15	30	15	637029.16	6934336.98	Sept 22, 2014	8 – 2	F	с
F-85d	VIIIF5-d	305	VIII-F-5	30	60	30	637029.16	6934336.98	Sept 22, 2014	8 – 2	F	d
F-85e	VIIIF5-e	308	VIII-F-5	60	100	40	637029.16	6934336.98	Sept 22, 2014	8 – 2	F	е
W-86a	IWL1-a	136	I-WL-1	0	5	5	636471.88	6931851.49	Sept 24, 2014	4	W	а
W-86b	IWL1-b	137	I-WL-1	5	15	10	636471.88	6931851.49	Sept 24, 2014	4	W	b
W-86c	IWL1-c	138	I-WL-1	15	30	15	636471.88	6931851.49	Sept 24, 2014	4	W	С
W-86d	IWL1-d	139	I-WL-1	30	60	30	636471.88	6931851.49	Sept 24, 2014	4	W	d
W-86e	IWL1-e	140	I-WL-1	60	100	40	636471.88	6931851.49	Sept 24, 2014	4	W	е
W-87a	IWL2-a	46	I-WL-2	0	5	5	636672.24	6932247.84	Sept 23, 2014	Unlabeled 2	W	а
W-87b	IWL2-b	47	I-WL-2	5	15	10	636672.24	6932247.84	Sept 23, 2014	Unlabeled 2	W	b
W-87c	IWL2-c	48	I-WL-2	15	30	15	636672.24	6932247.84	Sept 23, 2014	Unlabeled 2	W	С
W-87d	IWL2-d	49	I-WL-2	30	60	30	636672.24	6932247.84	Sept 23, 2014	Unlabeled 2	W	d
W-87e	IWL2-e	50	I-WL-2	60	100	40	636672.24	6932247.84	Sept 23, 2014	Unlabeled 2	W	е
W-88a	IIWL2-a	131	II-WL-2	0	5	5	636316.02	6932016.85	Sept 24, 2014	4	W	а
W-88b	IIWL2-b	132	II-WL-2	5	15	10	636316.02	6932016.85	Sept 24, 2014	4	W	b
W-88c	IIWL2-c	133	II-WL-2	15	30	15	636316.02	6932016.85	Sept 24, 2014	4	W	С
W-88d	IIWL2-d	134	II-WL-2	30	60	30	636316.02	6932016.85	Sept 24, 2014	4	W	d
W-88e	IIWL2-e	135	II-WL-2	60	100	40	636316.02	6932016.85	Sept 24, 2014	4	W	е
W-89a	IIIWL1-a	118	III-WL-1	0	5	5	635640.33	6931459.47	Sept 24, 2014	III OC ½	W	а
W-89b	IIIWL1-b	119	III-WL-1	5	15	10	635640.33	6931459.47	Sept 24, 2014	III OC ½	W	b
W-89c	IIIWL1-c	93	III-WL-1	15	30	15	635640.33	6931459.47	Sept 24, 2014	III OC ½	W	С
W-89d	IIIWL1-d	94	III-WL-1	30	60	30	635640.33	6931459.47	Sept 24, 2014	III OC ½	W	d
W-89e	IIIWL1-e	95	III-WL-1	60	100	40	635640.33	6931459.47	Sept 24, 2014	III OC ½	W	е
W-90a	IVWL1-a	12	IV-WL-1	0	5	5	636018.58	6933436.69	Sept 23, 2014	Unlabeled 1	W	а
W-90b	IVWL1-b	13	IV-WL-1	5	15	10	636018.58	6933436.69	Sept 23, 2014	Unlabeled 1	W	b
W-90c	IVWL1-c	14	IV-WL-1	15	30	15	636018.58	6933436.69	Sept 23, 2014	Unlabeled 1	W	С

Queen's name	Golder site + horizon	ASU nam e	Golder site name	from depth (cm)	to depth (cm)	interval width (cm)	Easting (NAD 83, Zone 11N)	Northing (NAD 83, Zone 11N)	Sampling Date	Cooler	Lo- ca- tion Type	Rela- tive Hori- zon
W-90d	IVWL1-d	15	IV-WL-1	30	60	30	636018.58	6933436.69	Sept 23, 2014	Unlabeled 1	W	d
W-90e	IVWL1-e	16	IV-WL-1	60	100	40	636018.58	6933436.69	Sept 23, 2014	Unlabeled 1	w	е
W-91a	IVWL2-a	7	IV-WL-2	0	5	5	636010.78	6933702.92	Sept 23, 2014	Unlabeled 1	W	a
W-91b	IVWL2-b	8	IV-WL-2	5	15	10	636010.78	6933702.92	Sept 23, 2014	Unlabeled 1	w	b
W-91c	IVWL2-c	9	IV-WL-2	15	30	15	636010.78	6933702.92	Sept 23, 2014	Unlabeled 1	W	с
W-91d	IVWL2-d	10	IV-WL-2	30	60	30	636010.78	6933702.92	Sept 23, 2014	Unlabeled 1	W	d
W-91e	IVWL2-e	11	IV-WL-2	60	100	40	636010.78	6933702.92	Sept 23, 2014	Unlabeled 1	W	е
W-92a	IVWL3-a	96	IV-WL-3	0	5	5	635716.76	6933820.27	Sept 24, 2014	III OC ½	W	а
W-92b	IVWL3-b	97	IV-WL-3	5	15	10	635716.76	6933820.27	Sept 24, 2014	III OC ½	W	b
W-92c	IVWL3-c	98	IV-WL-3	15	30	15	635716.76	6933820.27	Sept 24, 2014	III OC ½	W	с
W-92d	IVWL3-d	99	IV-WL-3	30	60	30	635716.76	6933820.27	Sept 24, 2014	III OC ½	W	d
W-92e	IVWL3-e	100	IV-WL-3	60	100	40	635716.76	6933820.27	Sept 24, 2014	III OC ½	W	е
W-93a	IVWL4-a	149	IV-WL-4	0	5	5	635845.61	6934148.96	Sept 21, 2014	4	W	а
W-93b	IVWL4-b	150	IV-WL-4	5	15	10	635845.61	6934148.96	Sept 21, 2014	4	W	b
W-93c	IVWL4-c	151	IV-WL-4	15	30	15	635845.61	6934148.96	Sept 21, 2014	4	W	с
W-93d	IVWL4-d	152	IV-WL-4	30	60	30	635845.61	6934148.96	Sept 21, 2014	4	W	d
W-93e	IVWL4-e	153	IV-WL-4	60	100	40	635845.61	6934148.96	Sept 21, 2014	4	W	е
W-94a	IVWL5-a	339	IV-WL-5	0	5	5	635737.09	6933688.38	Sept 25, 2014	Unlabeled 3	W	а
W-94b	IVWL5-b	340	IV-WL-5	5	15	10	635737.09	6933688.38	Sept 25, 2014	Unlabeled 3	W	b
W-94c	IVWL5-c	341	IV-WL-5	15	30	15	635737.09	6933688.38	Sept 25, 2014	Unlabeled 3	W	с
W-94d	IVWL5-d	342	IV-WL-5	30	60	30	635737.09	6933688.38	Sept 25, 2014	Unlabeled 3	W	d
W-94e	IVWL5-e	343	IV-WL-5	60	100	40	635737.09	6933688.38	Sept 25, 2014	Unlabeled 3	W	е
W-95a	IXWL1-a	32	IX-WL-1	0	5	5	636338.6	6933491.06	Sept 23, 2014	Unlabeled 2	W	а
W-95b	IXWL1-b	33	IX-WL-1	5	15	10	636338.6	6933491.06	Sept 23, 2014	Unlabeled 2	W	b
W-95c	IXWL1-c	34	IX-WL-1	15	30	15	636338.6	6933491.06	Sept 23, 2014	Unlabeled 2	W	с
W-95d	IXWL1-d	35	IX-WL-1	30	60	30	636338.6	6933491.06	Sept 23, 2014	Unlabeled 2	W	d
W-95e	IXWL1-e	36	IX-WL-1	60	100	40	636338.6	6933491.06	Sept 23, 2014	Unlabeled 2	W	е
W-96a	IXWL2-a	41	IX-WL-2	0	5	5	636228.76	6933290.27	Sept 23, 2014	Unlabeled 2	w	a
W-96b	IXWL2-b	42	IX-WL-2	5	15	10	636228.76	6933290.27	Sept 23, 2014	Unlabeled 2	w	b
W-96c	IXWL2-c	43	IX-WL-2	15	30	15	636228.76	6933290.27	Sept 23, 2014	Unlabeled 2	w	с
W-96d	IXWL2-d	44	IX-WL-2	30	60	30	636228.76	6933290.27	Sept 23, 2014	Unlabeled 2	w	d
W-96e	IXWL2-e	45	IX-WL-2	60	100	40	636228.76	6933290.27	Sept 23, 2014	Unlabeled 2	W	е
W-97a	VWL1-a	163	V-WL-1	0	5	5	635651.65	6934985.3	Sept 21, 2014	V	W	а
W-97b	VWL1-b	164	V-WL-1	5	15	10	635651.65	6934985.3	Sept 21, 2014	V	W	b
W-97c	VWL1-c	165	V-WL-1	15	30	15	635651.65	6934985.3	Sept 21, 2014	V	W	С
W-97d	VWL1-d	166	V-WL-1	30	60	30	635651.65	6934985.3	Sept 21, 2014	V	W	d
W-97e	VWL1-e	167	V-WL-1	60	80	20	635651.65	6934985.3	Sept 21, 2014	V	W	е
W-98a	VWL2-a	168	V-WL-2	0	5	5	635958.07	6936337.28	Sept 21, 2014	V	W	а
W-98b	VWL2-b	169	V-WL-2	5	20	15	635958.07	6936337.28	Sept 21, 2014	V	W	b
W-98c	VWL2-c	154	V-WL-2	20	40	20	635958.07	6936337.28	Sept 21, 2014	V	W	С
W-98d	VWL2-d	155	V-WL-2	40	70	30	635958.07	6936337.28	Sept 21, 2014	V	W	d
W-98e	VWL2-e	156	V-WL-2	70	100	30	635958.07	6936337.28	Sept 21, 2014	V	W	е
W-99a	VWL3-a	157	V-WL-3	0	10	10	635634.5	6936288.36	Sept 21, 2014	V	w	а
W-99b	VWL3-b	158	V-WL-3	10	50	40	635634.5	6936288.36	Sept 21, 2014	V	W	b

Queen's name	Golder site + horizon	ASU nam e	Golder site name	from depth (cm)	to depth (cm)	interval width (cm)	Easting (NAD 83, Zone 11N)	Northing (NAD 83, Zone 11N)	Sampling Date	Cooler	Lo- ca- tion Type	Rela- tive Hori- zon
W-99c	VWL3-c	159	V-WL-3	50	80	30	635634.5	6936288.36	Sept 21, 2014	V	W	с
W-99d	VWL3-d	160	V-WL-3	80	100	20	635634.5	6936288.36	Sept 21, 2014	V	W	d
W-100a	VIWL1A-a	195	VI-WL-1A	0	5	5	635564.03	6936966.91	Sept 20, 2014	VI	W	а
W-100b	VIWL1A-b	196	VI-WL-1A	5	10	5	635564.03	6936966.91	Sept 20, 2014	VI	W	b
W-101a	VIWL1B-a	197	VI-WL-1B	0	5	5	635564.03	6936966.91	Sept 20, 2014	VI	W	а
W-101b	VIWL1B-b	198	VI-WL-1B	5	10	5	635564.03	6936966.91	Sept 20, 2014	VI	W	b
W-101c	VIWL1B-c	199	VI-WL-1B	10	30	20	635564.03	6936966.91	Sept 20, 2014	VI	W	с
W-101d	VIWL1B-d	200	VI-WL-1B	30	60	30	635564.03	6936966.91	Sept 20, 2014	VI	W	d
W-101e	VIWL1B-e	201	VI-WL-1B	60	80	20	635564.03	6936966.91	Sept 20, 2014	VI	W	е
W-102a	VIIWL1-a	238	VII-WL-1	0	10	10	636211.16	6936120.14	Sept 21, 2014	VII	W	а
W-102b	VIIWL1-b	239	VII-WL-1	10	30	20	636211.16	6936120.14	Sept 21, 2014	VII	W	b
W-102c	VIIWL1-c	240	VII-WL-1	30	55	25	636211.16	6936120.14	Sept 21, 2014	VII	W	с
W-102d	VIIWL1-d	241	VII-WL-1	55	100	45	636211.16	6936120.14	Sept 21, 2014	VII	W	d
W-103a	VIIIWL1-a	309	VIII-WL-1	0	5	5	636893.67	6934897.96	Sept 22, 2014	8 – 2	W	а
W-103b	VIIIWL1-b	310	VIII-WL-1	5	15	10	636893.67	6934897.96	Sept 22, 2014	8 – 2	W	b
W-103c	VIIIWL1-c	311	VIII-WL-1	15	30	15	636893.67	6934897.96	Sept 22, 2014	8 – 2	W	с
W-103d	VIIIWL1-d	312	VIII-WL-1	30	60	30	636893.67	6934897.96	Sept 22, 2014	8 – 2	W	d
W-103e	VIIIWL1-e	313	VIII-WL-1	60	100	40	636893.67	6934897.96	Sept 22, 2014	8 – 2	W	е
W-104a	VIIIWL2-a	314	VIII-WL-2	0	5	5	636889.76	6934292.19	Sept 22, 2014	8 – 2	W	а
W-104b	VIIIWL2-b	315	VIII-WL-2	5	15	10	636889.76	6934292.19	Sept 22, 2014	8 – 2	W	b
W-104c	VIIIWL2-c	316	VIII-WL-2	15	30	15	636889.76	6934292.19	Sept 22, 2014	8 – 2	W	с
W-104d	VIIIWL2-d	306	VIII-WL-2	30	60	30	636889.76	6934292.19	Sept 22, 2014	8 – 2	W	d
W-104e	VIIIWL2-e	307	VIII-WL-2	60	100	40	636889.76	6934292.19	Sept 22, 2014	8 – 2	W	е

Appendix II: All Chemistry Results (30-Element ICP-OES, Au and Sb ICP-MS, and Carbon Analyses)

All results are reported in μ g/g, except for carbon (%).

Sample (Golder)	Sam- ple ASU	Sample (Queen's)	from (cm)	to (cm)	Car- bon (%)	Au (µg/g)	Ag (µg/g)	Al (µg/g)	As (µg/g)	В (µg/g)	Ba (µg/g)	Be (µg/g)	Ca (µg/g)	Cd (µg/g)	Со (µg/g)
IOC1-a	141	O-1a	0	5	11.9	0.19	<2.0	33000	1200	<20	90	<4.0	3100	<1.0	24
IOC1-b	142	O-1b	5	15	7.6	0.019	<2.0	44000	230	<20	46	<4.0	1300	<1.0	35
IOC2-a	91	O-2a	2	7	15.8	0.20	<2.0	27000	2000	<20	120	<4.0	2400	3.4	38
IOC3-a	92	O-3a	2	5	18.9	0.18	<2.0	25000	1700	<20	110	<4.0	2500	2.8	41
llOC1-a	61	O-4a	0	5	29.7	0.56	<2.0	9100	710	<20	98	<4.0	21000	<1.0	12
IIOC1-b	62	O-4b	5	10	7.2	0.021	<2.0	28000	490	<20	69	<4.0	6500	<1.0	30
llOC10-a	83	O-5a	0	5	19.6	1.0	<2.0	24000	16000	<20	120	<4.0	4700	<1.0	24
IIOC10-b	84	O-5b	5	8	5.0	0.081	<2.0	45000	7200	<20	53	<4.0	4100	<1.0	39
llOC11-a	85	O-6a	0	5	15.4	0.90	<2.0	34000	11000	<20	140	<4.0	3100	<1.0	28
IIOC11-b	86	O-6b	5	10	11.3	0.37	<2.0	39000	7800	<20	120	<4.0	2600	<1.0	24
llOC2-a	63	O-7a	0	3	20.4	0.46	<2.0	15000	1500	<20	560	<4.0	25000	1.6	50
IIOC2-b	64	O-7b	3	10	6.8	0.028	<2.0	29000	1400	<20	200	<4.0	9200	<1.0	56
IIOC3-a	65	O-8a	0	5	22.3	0.37	<2.0	16000	1400	<20	560	<4.0	17000	1.6	26
IIOC3-b	66	O-8b	5	10	5.8	0.030	<2.0	27000	1400	<20	200	<4.0	7700	1.0	28
llOC4-a	67	O-9a	0	5	14.4	0.32	<2.0	16000	2400	<20	270	<4.0	3200	1.0	17
IIOC4-b	68	O-9b	5	15	2.2	0.027	<2.0	17000	460	<20	29	<4.0	1200	<1.0	8.9
IIOC4-c	69	O-9c	15	20	2.8	0.015	<2.0	22000	410	<20	40	<4.0	1300	<1.0	12
llOC5-a	70	O-10a	0	3	24.3	3.1	4.5	11000	17000	<20	210	<4.0	5000	<1.0	24
IIOC5-b	71	O-10b	3	10	2.9	0.15	<2.0	11000	1300	<20	33	<4.0	890	<1.0	5.8
IIOC5-c	72	O-10c	10	20	2.2	0.036	<2.0	21000	2000	<20	45	<4.0	1200	<1.0	16
llOC6-a	73	O-11a	0	5	13.3	1.7	<2.0	17000	9200	<20	240	<4.0	9100	1.2	37
IIOC6-b	74	O-11b	5	15	4.4	0.060	<2.0	30000	3600	<20	94	<4.0	6600	<1.0	29
IIOC6-c	75	O-11c	15	20	4.2	0.073	<2.0	29000	3400	<20	61	<4.0	6700	<1.0	26
llOC7-a	76	O-12a	0	10	27.9	0.17	<2.0	13000	500	<20	89	<4.0	26000	<1.0	12
IIOC7-b	77	O-12b	10	16	4.4	0.017	<2.0	24000	72	<20	88	<4.0	5800	<1.0	18
IIOC8-a	78	O-13a	0	12	20.6	0.033	<2.0	16000	480	<20	90	<4.0	3100	<1.0	<5.0
IIOC8-b	79	O-13b	12	15	14.0	0.023	<2.0	22000	320	<20	100	<4.0	3300	<1.0	5.0
llOC9-a	80	O-14a	0	3	29.7	0.35	<2.0	13000	1400	<20	110	<4.0	4300	1.1	10
IIOC9-b	81	O-14b	3	10	7.6	0.019	<2.0	25000	2400	<20	77	<4.0	3600	<1.0	14
IIOC9-c	82	O-14c	10	15	8.3	0.016	<2.0	29000	2400	<20	72	<4.0	3300	<1.0	14
IIIOC1-a	120	O-15a	0	5	15.9	0.62	<2.0	26000	3100	<20	240	<4.0	5400	2.7	40
IIIOC1-b	121	O-15b	5	15	14.1	0.056	<2.0	29000	1400	<20	140	<4.0	6200	2.6	36
IIIOC2-a	122	O-16a	0	8	15.2	0.73	<2.0	12000	3200	<20	380	<4.0	9900	1.2	24

Sample (Golder)	Sam- ple ASU	Sample (Queen's)	from (cm)	to (cm)	Car- bon (%)	Au (µg/g)	Ag (µg/g)	ΑΙ (µg/g)	As (µg/g)	В (µg/g)	Ba (µg/g)	Be (µg/g)	Ca (µg/g)	Cd (µg/g)	Co (µg/g)
IIIOC2-b	123	O-16b	8	15	2.0	0.049	<2.0	14000	1300	<20	120	<4.0	3600	<1.0	19
IIIOC3-a	107	O-17a	0	5	14.7	0.20	<2.0	27000	1400	<20	420	<4.0	11000	5.2	65
IIIOC3-b	108	O-17b	5	9	10.2	0.046	<2.0	32000	1500	<20	310	<4.0	7100	2.6	67
IIIOC5-a	124	O-18a	0	5	10.0	0.11	<2.0	34000	3200	<20	86	<4.0	7000	<1.0	34
IIIOC5-b	125	O-18b	5	10	8.4	0.059	<2.0	37000	4100	<20	110	<4.0	5400	<1.0	33
IIIOC6-a	109	O-19a	0	5	36.4	0.034	<2.0	6600	270	23	90	<4.0	24000	<1.0	<5.0
IIIOC6-b	110	O-19b	5	9	4.1	0.14	<2.0	19000	1500	<20	59	<4.0	5200	<1.0	20
IIIOC7-a	111	O-20a	0	5	10.4	0.049	<2.0	30000	690	<20	200	<4.0	5600	<1.0	19
IIIOC7-b	112	O-20b	5	10	8.4	0.032	<2.0	43000	91	<20	140	<4.0	3700	<1.0	22
IIIOC8-a	354	O-21a	0	5	10.5	0.12	<2.0	26000	630	<20	150	<4.0	3500	1.8	18
IIIOC8-b	355	O-21b	5	15	11.6	0.030	<2.0	26000	260	<20	100	<4.0	2400	1.6	13
IVOC1-a	17	O-22a	0	5	8.6	0.76	<2.0	19000	7000	<20	150	<4.0	2100	<1.0	10
IVOC1-b	18	O-22b	5	10	9.8	0.14	<2.0	21000	5400	<20	150	<4.0	1900	<1.0	8.7
IVOC2-a	143	O-23a	0	5	15.5	0.23	<2.0	16000	840	<20	77	<4.0	4900	1.2	9.8
IVOC2-b	144	O-23b	5	10	10.6	0.030	<2.0	14000	810	<20	42	<4.0	2600	<1.0	5.9
IVOC3-a	145	O-24a	0	5	24.4	0.39	<2.0	15000	1100	<20	95	<4.0	5100	<1.0	10
IVOC3-b	146	O-24b	5	15	3.5	0.036	<2.0	22000	580	<20	60	<4.0	2600	<1.0	11
IVOC4-a	147	O-25a	0	5	28.0	0.56	<2.0	18000	4800	<20	140	<4.0	7500	<1.0	21
IVOC4-b	148	O-25b	5	12	9.4	0.046	<2.0	33000	5100	<20	93	<4.0	4400	<1.0	35
IXOC1-a	317	O-26a	0	5	5.0	0.64	<2.0	25000	2500	<20	110	<4.0	8600	<1.0	34
IXOC1-b	318	O-26b	5	15	<1.0	0.015	<2.0	23000	150	<20	48	<4.0	2300	<1.0	15
IXOC2-a	319	O-27a	0	3	18.1	1.8	<2.0	14000	5500	<20	310	<4.0	16000	1.1	36
IXOC2-b	320	O-27b	3	10	1.9	0.061	<2.0	22000	910	<20	62	<4.0	1800	<1.0	16
IXOC2-c	321	O-27c	10	25	1.7	0.037	<2.0	23000	480	<20	69	<4.0	1700	<1.0	15
IXOC3-a	322	O-28a	0	5	20.2	1.3	<2.0	20000	4800	<20	160	<4.0	18000	1.4	43
IXOC3-b	323	O-28b	5	10	15.9	0.84	<2.0	27000	4900	<20	140	<4.0	12000	1.3	52
IXOC4-a	324	O-29a	0	6	30.6	0.61	<2.0	8100	5200	<20	210	<4.0	24000	1.7	24
IXOC4-b	325	O-29b	6	15	4.5	0.051	<2.0	22000	1100	<20	70	<4.0	9800	<1.0	14
IXOC4-c	326	O-29c	15	20	3.0	0.029	<2.0	21000	1200	<20	52	<4.0	3300	<1.0	14
IXOC5-a	327	O-30a	0	7	26.7	0.69	<2.0	9300	920	<20	190	<4.0	19000	1.3	18
IXOC5-b	328	O-30b	7	15	8.8	0.037	<2.0	23000	1100	<20	94	<4.0	5600	2.2	44
VOC1-a	179	O-31a	0	5	3.0	0.036	<2.0	26000	1400	<20	210	<4.0	1900	<1.0	34
VOC1-b	180	O-31b	5	15	1.1	0.024	<2.0	28000	570	<20	100	<4.0	1900	<1.0	25
VOC2-a	181	O-32a	0	5	7.8	0.15	<2.0	17000	3600	<20	62	<4.0	1400	<1.0	10
VOC2-b	182	O-32b	5	15	<1.0	<0.01	<2.0	11000	27	<20	27	<4.0	1500	<1.0	8.2
VOC2-c	183	O-32c	15	25	1.4	0.011	<2.0	12000	400	<20	22	<4.0	990	<1.0	7.5
VOC2-d	184	O-32d	25	35	<1.0	<0.01	<2.0	12000	44	<20	34	<4.0	1600	<1.0	9.2
VOC3-a	185	O-33a	0	5	13.5	0.030	<2.0	30000	740	<20	170	<4.0	3400	<1.0	19
VOC3-b	186	O-33b	5	15	9.5	0.016	<2.0	32000	72	<20	78	<4.0	3200	<1.0	15
VOC3-c	187	O-33c	15	25	9.8	0.021	<2.0	30000	260	<20	79	<4.0	2600	<1.0	13
VOC4-a	188	O-34a	0	5	9.4	0.067	<2.0	16000	230	<20	140	<4.0	3600	<1.0	9.5
VOC4-b	189	O-34b	5	15	8.2	0.015	<2.0	26000	320	<20	140	<4.0	3500	<1.0	13
VOC4-c	190	O-34c	15	30	8.3	0.013	<2.0	34000	140	<20	120	<4.0	3600	<1.0	17
VOC5-a	191	O-35a	0	5	5.9	0.10	<2.0	13000	560	<20	120	<4.0	2000	<1.0	9.8
VOC5-b	192	O-35b	5	10	2.4	0.021	<2.0	16000	310	<20	39	<4.0	1200	<1.0	12

Sample (Golder)	Sam- ple ASU	Sample (Queen's)	from (cm)	to (cm)	Car- bon (%)	Au (µg/g)	Ag (µg/g)	ΑΙ (µg/g)	As (µg/g)	В (µg/g)	Ba (µg/g)	Be (µg/g)	Ca (µg/g)	Cd (µg/g)	Co (µg/g)
VOC6-a	193	O-36a	0	5	15.4	0.078	<2.0	24000	330	<20	62	<4.0	2800	1.3	14
VOC6-b	194	O-36b	5	15	12.1	0.23	<2.0	30000	130	<20	47	<4.0	3500	<1.0	24
VIOC1-a	209	O-37a	0	5	32.4	0.39	<2.0	12000	700	<20	150	<4.0	7200	1.4	16
VIOC1-b	210	O-37b	5	15	10.1	0.023	<2.0	20000	640	<20	53	<4.0	4800	<1.0	17
VIOC2-a	211	O-38a	0	5	12.7	0.028	<2.0	20000	370	<20	100	<4.0	2700	<1.0	20
VIOC2-b	212	O-38b	5	10	9.6	<0.01	<2.0	21000	120	<20	58	<4.0	2300	<1.0	16
VIOC3-a	231	O-39a	0	5	29.0	0.20	<2.0	10000	550	<20	340	<4.0	12000	<1.0	15
VIOC3-b	232	O-39b	5	10	9.3	<0.01	<2.0	24000	450	<20	93	<4.0	3200	<1.0	22
VIOC4-a	202	O-40a	0	5	20.9	0.15	<2.0	23000	1200	<20	140	<4.0	12000	2.0	31
VIOC4-b	203	O-40b	5	10	13.2	0.034	<2.0	32000	1300	<20	130	<4.0	8200	1.9	49
VIOC5-a	233	O-41a	0	5	12.6	0.055	<2.0	28000	750	<20	110	<4.0	4600	2.1	32
VIOC5-b	234	O-41b	5	10	12.2	<0.01	<2.0	37000	230	<20	66	<4.0	4600	1.8	33
VIOC5-c	235	O-41c	10	20	9.6	<0.01	<2.0	40000	100	<20	55	<4.0	4800	1.4	28
VIIOC1-a	242	O-42a	0	5	26.3	0.11	<2.0	14000	530	<20	400	<4.0	11000	<1.0	22
VIIOC1-b	243	O-42b	5	10	7.3	0.012	<2.0	26000	450	<20	130	<4.0	4200	<1.0	23
VIIOC1-c	244	O-42c	10	35	5.7	0.011	<2.0	30000	230	<20	73	<4.0	3500	<1.0	21
VIIOC2-a	254	O-43a	0	5	27.65	0.014	<2.0	15000	530	<20	140	<4.0	3300	1.7	20
VIIOC2-b	255	O-43b	5	15	10.9	<0.01	<2.0	24000	64	<20	56	<4.0	3700	<1.0	16
VIIOC3-a	256	O-44a	0	5	37.9	0.11	<2.0	4600	170	<20	99	<4.0	53000	2.9	12
VIIOC3-b	257	O-44b	5	15	12.7	0.019	<2.0	30000	530	<20	260	<4.0	22000	8.6	90
VIIOC4-a	258	O-45a	0	5	15.9	0.044	<2.0	28000	530	<20	390	<4.0	12000	1.9	51
VIIOC4-b	259	O-45b	5	10	9.2	<0.01	<2.0	29000	120	<20	180	<4.0	5300	1.5	44
VIIOC5-a	260	O-46a	0	5	26.1	0.029	<2.0	27000	230	<20	69	<4.0	7800	2.0	34
VIIOC6-a	261	O-47a	0	5	26.4	0.020	<2.0	10000	160	<20	83	<4.0	5300	1.2	12
VIIOC6-b	262	O-47b	5	10	17.2	0.013	<2.0	12000	150	<20	43	<4.0	2600	<1.0	7.8
VIIOC7-a	263	O-48a	0	5	15.6	0.029	<2.0	21000	290	<20	160	<4.0	5000	2.2	14
VIIOC7-b	264	O-48b	5	10	7.3	<0.01	<2.0	38000	120	<20	180	<4.0	4000	1.8	24
VIIOC8-a	265	O-49a	0	5	38.6	0.044	<2.0	4200	51	<20	99	<4.0	14000	1.4	<5.0
VIIOC8-b	266	O-49b	5	15	11.8	<0.01	<2.0	28000	99	<20	79	<4.0	3400	1.7	14
VIIOC8-c	267	O-49c	15	25	10.2	<0.01	<2.0	36000	14	<20	130	<4.0	3200	1.7	21
VIIOC9-a	268	O-50a	0	5	22.6	<0.01	<2.0	12000	52	<20	44	<4.0	5100	1.1	7.6
VIIOC9-b	269	O-50b	5	15	14.6	<0.01	<2.0	25000	72	<20	51	<4.0	3600	1.1	16
VIIOC9-c	270	O-50c	15	30	9.3	0.010	<2.0	30000	52	<20	43	<4.0	3600	<1.0	20
VIIIOC1-a	288	O-51a	0	5	8.9	0.018	<2.0	21000	170	<20	240	<4.0	6000	1.2	25
VIIIOC1-b	289	O-51b	5	10	4.5	<0.01	<2.0	27000	20	<20	51	<4.0	2800	<1.0	21
VIIIOC2-a	290	O-52a	0	5	10.0	0.029	<2.0	32000	190	<20	63	<4.0	3200	1.1	28
VIIIOC2-b	291	O-52b	5	10	11.8	<0.01	<2.0	34000	51	<20	54	<4.0	3300	<1.0	25
VIIIOC2-c	292	O-52c	10	20	11.1	<0.01	<2.0	34000	76	<20	52	<4.0	3400	<1.0	25
VIIIOC3-a	293	O-53a	0	5	24.5	0.18	<2.0	17000	940	<20	180	<4.0	9200	2.1	20
VIIIOC3-b	294	O-53b	5	10	9.9	0.011	<2.0	32000	190	<20	67	<4.0	5200	1.1	30
VIIIOC4-a	295	O-54a	0	5	27.9	0.20	<2.0	16000	840	<20	190	<4.0	6500	1.2	58
VIIIOC4-b	296	O-54b	5	20	8.0	0.016	<2.0	29000	370	<20	85	<4.0	4100	1.0	81
VIIIOC5-a	279	O-55a	0	10	15.9	0.22	<2.0	17000	400	<20	130	<4.0	7700	1.5	13
VIIIOC5-b	280	O-55b	10	15	15.1	0.034	<2.0	24000	330	<20	64	<4.0	5400	<1.0	9.5
VIIIOC6-a	281	O-56a	0	5	21.1	0.051	<2.0	16000	380	<20	260	<4.0	6400	<1.0	16

Sample (Golder)	Sam- ple ASU	Sample (Queen's)	from (cm)	to (cm)	Car- bon (%)	Au (µg/g)	Ag (μg/g)	Al (µg/g)	As (µg/g)	В (µg/g)	Ba (µg/g)	Be (µg/g)	Ca (µg/g)	Cd (µg/g)	Co (µg/g)
VIIIOC6-b	282	O-56b	5	10	13.2	0.014	<2.0	17000	280	<20	77	<4.0	3700	<1.0	15
Stockpile 1-a	349	S-57a			<1.0	<0.01	<2.0	7900	33	<20	28	<4.0	6500	<1.0	14
Stockpile 2-b	350	S-57b			<1.0	0.011	<2.0	10000	63	<20	31	<4.0	9200	<1.0	24
Stockpile 3-c	351	S-57c			<1.0	0.17	<2.0	9500	27	<20	29	<4.0	14000	<1.0	24
Stockpile 4-d	352	S-57d			<1.0	0.011	<2.0	10000	26	<20	31	<4.0	8300	<1.0	20
Stockpile 5-e	353	S-57e			<1.0	0.015	<2.0	8100	66	<20	33	<4.0	6400	<1.0	11
IF1-a	126	F-58a	0	5	35.7	0.26	<2.0	3500	500	28	75	<4.0	35000	<1.0	<5.0
IF1-b	127	F-58b	5	15	35.0	0.037	<2.0	5200	100	27	100	<4.0	43000	<1.0	<5.0
IF1-c	128	F-58c	15	30	10.8	<0.01	<2.0	14000	140	<20	120	<4.0	15000	<1.0	9.7
IF1-d	129	F-58d	30	60	<1.0	<0.01	<2.0	20000	74	<20	180	<4.0	6300	<1.0	14
IF1-e	130	F-58e	60	100	<1.0	<0.01	<2.0	28000	19	<20	260	<4.0	7000	<1.0	17
IF2-a	102	F-59a	0	5	37.2	0.32	<2.0	4900	250	<20	68	<4.0	22000	<1.0	5.7
IF2-b	103	F-59b	5	15	41.2	0.23	<2.0	4300	250	<20	80	<4.0	24000	<1.0	<5.0
IF2-c	104	F-59c	15	30	24.0	0.022	<2.0	14000	250	<20	140	<4.0	20000	<1.0	7.9
IF2-d	105	F-59d	30	60	2.0	<0.01	<2.0	22000	180	<20	210	<4.0	6800	<1.0	15
IF2-e	106	F-59e	60	100	<1.0	<0.01	<2.0	23000	120	<20	220	<4.0	6400	<1.0	17
llF1-a	334	F-60a	0	5	6.3	0.076	<2.0	21000	270	<20	150	<4.0	9900	<1.0	15
llF1-b	335	F-60b	5	15	3.4	0.013	<2.0	22000	250	<20	170	<4.0	7500	<1.0	14
llF1-c	336	F-60c	15	30	1.4	<0.01	<2.0	24000	110	<20	220	<4.0	5900	<1.0	15
llF1-d	337	F-60d	30	60	<1.0	0.015	<2.0	18000	5.2	<20	200	<4.0	3800	<1.0	11
llF1-e	338	F-60e	60	100	<1.0	<0.01	<2.0	24000	5.0	20	260	<4.0	4600	<1.0	13
IIF2-a	56	F-61a	0	5	6.5	0.099	<2.0	20000	120	<20	180	<4.0	9400	<1.0	15
IIF2-b	57	F-61b	5	15	1.3	0.10	<2.0	24000	180	<20	220	<4.0	8200	<1.0	18
IIF2-c	58	F-61c	15	30	<1.0	0.23	<2.0	24000	170	<20	230	<4.0	6700	<1.0	17
IIF2-d	59	F-61d	30	60	<1.0	0.033	<2.0	25000	45	22	230	<4.0	6200	<1.0	16
IIF2-e	60	F-61e	60	100	<1.0	0.012	<2.0	27000	21	25	270	<4.0	7000	<1.0	16
IIF3-a	51	F-62a	0	5	1.2	0.061	<2.0	13000	240	<20	76	<4.0	2600	<1.0	12
IIF3-b	52	F-62b	5	15	<1.0	<0.01	<2.0	7700	63	<20	43	<4.0	2300	<1.0	7.4
IIF3-c	53	F-62c	15	30	<1.0	<0.01	<2.0	7300	52	<20	42	<4.0	2200	<1.0	7.7
llF3-d	54	F-62d	30	60	<1.0	<0.01	<2.0	9700	26	<20	66	<4.0	2500	<1.0	8.0
IIF3-e	55	F-62e	60	90	<1.0	<0.01	<2.0	11000	16	<20	88	<4.0	2600	<1.0	9.0
IIIF1-a	356	F-63a	0	5	8.2	0.018	<2.0	18000	83	<20	120	<4.0	14000	<1.0	15
IIIOC8-b	357	F-63b	5	15	<1.0	0.037	<2.0	22000	90	<20	130	<4.0	4900	<1.0	17
IIIOC8-c	358	F-63c	15	30	<1.0	0.014	<2.0	19000	57	<20	110	<4.0	4000	<1.0	15
IIIOC8-d	359	F-63d	30	70	<1.0	0.030	<2.0	20000	76	<20	86	<4.0	5700	<1.0	16
IIIF2-a	27	F-64a	0	5	6.7	0.53	<2.0	15000	1500	<20	130	<4.0	8600	<1.0	13
IIIF2-b	28	F-64b	5	15	4.85	0.065	<2.0	15000	840	<20	120	<4.0	7900	<1.0	11
IIIF2-c	29	F-64c	15	30	2.55	0.013	<2.0	18000	280	<20	160	<4.0	6200	<1.0	11
IIIF2-d	30	F-64d	30	55	1.3	<0.01	<2.0	20000	250	<20	180	<4.0	5300	<1.0	13
IIIF2-e	31	F-64e	55	100	<1.0	<0.01	<2.0	8400	40	<20	68	<4.0	3200	<1.0	7.2
IVF1-b	87	F-65b	5	15	2.7	0.018	<2.0	10000	140	<20	61	<4.0	2900	<1.0	6.0
IVF1-c	88	F-65c	15	30	<1.0	<0.01	<2.0	8600	51	<20	43	<4.0	2100	<1.0	6.7
IVF1-d	89	F-65d	30	60	<1.0	0.039	<2.0	16000	25	<20	140	<4.0	3400	<1.0	12
IVF1-e	90	F-65e	60	100	<1.0	0.012	<2.0	23000	7.3	<20	220	<4.0	5000	<1.0	14
IVF1-a	101	F-65a	0	5	40.5	0.24	<2.0	4500	540	<20	110	<4.0	13000	<1.0	<5.0

Sample (Golder)	Sam- ple ASU	Sample (Queen's)	from (cm)	to (cm)	Car- bon (%)	Au (µg/g)	Ag (μg/g)	Al (µg/g)	As (µg/g)	В (µg/g)	Ba (µg/g)	Be (µg/g)	Ca (µg/g)	Cd (µg/g)	Co (µg/g)
IVF2-a	344	F-66a	0	5	32.9	0.96	<2.0	4100	1700	<20	43	<4.0	8200	<1.0	6.5
IVF2-b	345	F-66b	5	20	41.6	0.25	<2.0	5600	1300	<20	39	<4.0	5900	<1.0	5.3
IVF2-c	346	F-66c	20	30	4.6	0.010	<2.0	17000	80	<20	140	<4.0	2200	<1.0	7.2
IVF2-d	347	F-66d	30	60	1.1	<0.01	<2.0	16000	17	<20	140	<4.0	2500	<1.0	8.1
IVF2-e	348	F-66e	60	100	<1.0	0.012	<2.0	16000	14	<20	170	<4.0	3300	<1.0	9.5
IVF3A-a	19	F-67a	0	5	31.5	1.0	<2.0	5600	770	27	73	<4.0	24000	<1.0	7.6
IVF3A-b	20	F-67b	5	15	32.0	0.92	<2.0	5800	2500	23	87	<4.0	29000	<1.0	5.3
IVF3A-c	21	F-67c	15	35	16.7	0.070	<2.0	15000	300	<20	130	<4.0	19000	<1.0	10
IVF3B-a	22	F-68a	0	5	20.5	0.58	<2.0	4800	1300	<20	64	<4.0	14000	<1.0	<5.0
IVF3B-b	23	F-68b	5	15	26.45	0.044	<2.0	3800	130	<20	60	<4.0	21000	<1.0	<5.0
IVF3B-c	24	F-68c	15	30	21.9	0.070	<2.0	8800	170	<20	93	<4.0	25000	<1.0	5.3
IVF3B-d	25	F-68d	30	60	1.75	0.025	<2.0	25000	36	<20	280	<4.0	9600	<1.0	18
IVF3B-e	26	F-68e	60	100	<1.0	0.014	<2.0	16000	21	<20	140	<4.0	6600	<1.0	12
IXF1-a	113	F-69a	0	5	32.7	0.56	<2.0	6600	2400	26	99	<4.0	25000	<1.0	6.7
IXF1-b	114	F-69b	5	15	34.6	0.066	<2.0	5600	300	<20	120	<4.0	28000	<1.0	<5.0
IXF1-c	115	F-69c	15	30	32.65	0.021	<2.0	8100	180	22	200	<4.0	42000	<1.0	<5.0
IXF1-d	116	F-69d	30	55	34.3	0.010	<2.0	6900	290	31	190	<4.0	43000	<1.0	<5.0
IXF1-e	117	F-69e	55	100	7.6	<0.01	<2.0	16000	21	<20	160	<4.0	12000	<1.0	9.7
IXF2-a	37	F-70a	0	5	15.8	3.1	<2.0	18000	930	<20	41	<4.0	12000	<1.0	24
IXF2-b	38	F-70b	5	15	30.6	0.66	<2.0	9500	730	<20	59	<4.0	20000	<1.0	16
IXF2-c	39	F-70c	15	30	32.1	0.10	<2.0	6800	220	<20	73	<4.0	33000	<1.0	8.7
IXF2-d	40	F-70d	30	45	8.0	0.019	<2.0	13000	53	<20	79	<4.0	12000	<1.0	13
IXF3-a	329	F-71a	0	5	19.5	0.26	<2.0	13000	510	<20	80	<4.0	16000	<1.0	20
IXF3-b	330	F-71b	5	15	<1.0	0.025	<2.0	10000	73	<20	63	<4.0	3300	<1.0	8.7
IXF3-c	331	F-71c	15	30	<1.0	<0.01	<2.0	14000	59	<20	100	<4.0	3600	<1.0	12
IXF3-d	332	F-71d	30	60	<1.0	<0.01	<2.0	19000	28	<20	150	<4.0	4400	<1.0	15
IXF3-e	333	F-71e	60	100	<1.0	<0.01	<2.0	12000	14	<20	84	<4.0	3100	<1.0	11
IXF4-a	1	F-72a	0	5	39.8	0.22	<2.0	4100	240	37	52	<4.0	27000	<1.0	23
IXF4-b	2	F-72b	5	15	4.4	48	16	20000	3600	<20	44	<4.0	40000	1.8	34
IXF4-c	3	F-72c	15	30	5.1	0.86	<2.0	20000	600	<20	140	<4.0	10000	<1.0	16
IXF4-d	4	F-72d	30	60	1.4	0.20	<2.0	23000	180	<20	210	<4.0	6700	<1.0	16
IXF4-e	5	F-72e	60	85	<1.0	0.17	<2.0	21000	48	<20	190	<4.0	4900	<1.0	15
IXF4-f	6	F-72f	85	100	<1.0	0.027	<2.0	14000	22	<20	110	<4.0	4100	<1.0	11
VF1-a	170	F-73a	0	5	32.3	0.17	<2.0	8600	250	<20	120	<4.0	22000	<1.0	<5.0
VF1-b	171	F-73b	5	15	7.1	<0.01	<2.0	14000	66	<20	140	<4.0	8800	<1.0	6.8
VF1-c	172	F-73c	15	30	5.9	0.12	<2.0	16000	23	<20	160	<4.0	8700	<1.0	7.8
VF1-d	173	F-73d	30	50	1.8	0.055	<2.0	18000	9.1	<20	170	<4.0	6000	<1.0	9.3
VF1-e	174	F-73e	50	100	<1.0	0.039	<2.0	22000	7.7	<20	240	<4.0	6600	<1.0	14
VF2-e	161	F-74e	80	90	<1.0	<0.01	<2.0	14000	21	<20	120	<4.0	3400	<1.0	11
VF2-f	162	F-74f	100	110	<1.0	0.011	<2.0	10000	20	<20	64	<4.0	2500	<1.0	9.3
VF2-a	175	F-74a	0	10	26.1	0.090	<2.0	4800	78	<20	58	<4.0	20000	<1.0	5.9
VF2-b	176	F-74b	10	20	1.0	0.016	<2.0	11000	48	<20	76	<4.0	3600	<1.0	6.8
VF2-c	177	F-74c	20	50	<1.0	0.013	<2.0	8000	17	<20	58	<4.0	2100	<1.0	6.7
VF2-d	178	F-74d	50	80	<1.0	0.014	<2.0	9700	22	<20	68	<4.0	2300	<1.0	8.0
VIF1-a	222	F-75a	0	5	41.3	0.11	<2.0	3900	220	<20	100	<4.0	25000	<1.0	7.8

Sample (Golder)	Sam- ple ASU	Sample (Queen's)	from (cm)	to (cm)	Car- bon (%)	Au (µg/g)	Ag (μg/g)	Al (µg/g)	As (µg/g)	В (µg/g)	Ba (µg/g)	Be (µg/g)	Ca (µg/g)	Cd (µg/g)	Co (µg/g)
VIF1-b	223	F-75b	5	20	16.3	<0.01	<2.0	14000	120	<20	160	<4.0	17000	<1.0	11
VIF1-c	224	F-75c	20	30	1.1	<0.01	<2.0	16000	38	<20	140	<4.0	5100	<1.0	10
VIF1-d	225	F-75d	30	60	<1.0	0.015	<2.0	16000	13	<20	140	<4.0	4800	<1.0	9.9
VIF1-e	226	F-75e	60	90	<1.0	<0.01	<2.0	18000	6.8	<20	180	<4.0	4800	<1.0	12
VIF2-e	213	F-76e	50	60	9.3	<0.01	<2.0	9000	12	<20	110	<4.0	12000	<1.0	5.1
VIF2-f	214	F-76f	60	80	<1.0	<0.01	<2.0	7600	6.3	<20	37	<4.0	1600	<1.0	6.3
VIF2-g	215	F-76g	80	85	<1.0	<0.01	<2.0	14000	11	<20	93	<4.0	2700	<1.0	9.3
VIF2-a	227	F-76a	0	5	40.2	0.20	<2.0	4800	150	<20	200	<4.0	9900	<1.0	5.6
VIF2-b	228	F-76b	5	10	32.5	0.014	<2.0	9000	370	<20	240	<4.0	14000	<1.0	13
VIF2-c	229	F-76c	10	30	<1.0	<0.01	<2.0	6200	52	<20	34	<4.0	2200	<1.0	<5.0
VIF2-d	230	F-76d	30	50	1.9	<0.01	<2.0	6900	16	<20	48	<4.0	3100	<1.0	<5.0
VIF3-a	216	F-77a	0	5	12.0	0.061	<2.0	13000	580	<20	280	<4.0	6000	<1.0	42
VIF3-b	217	F-77b	5	15	1.5	<0.01	<2.0	7800	110	<20	40	<4.0	1400	<1.0	8.7
VIF3-c	218	F-77c	15	25	<1.0	0.33	<2.0	7300	41	<20	21	<4.0	1000	<1.0	6.5
VIF3-d	219	F-77d	25	45	<1.0	<0.01	<2.0	8100	33	<20	26	<4.0	1300	<1.0	8.0
VIF3-e	220	F-77e	45	55	<1.0	<0.01	<2.0	6800	25	<20	26	<4.0	1500	<1.0	6.6
VIF3-f	221	F-77f	55	80	<1.0	<0.01	<2.0	6900	30	<20	37	<4.0	2100	<1.0	6.6
VIF4-a	204	F-78a	0	5	41.3	0.27	<2.0	1800	68	<20	74	<4.0	36000	<1.0	<5.0
VIF4-b	205	F-78b	5	10	34.4	0.016	<2.0	2700	46	<20	110	<4.0	34000	<1.0	<5.0
VIF4-c	206	F-78c	10	30	<1.0	<0.01	<2.0	5000	50	<20	23	<4.0	2100	<1.0	5.7
VIF4-d	207	F-78d	30	60	<1.0	<0.01	<2.0	6400	39	<20	29	<4.0	1800	<1.0	6.6
VIF4-e	208	F-78e	60	100	<1.0	0.022	<2.0	6400	32	<20	35	<4.0	1700	<1.0	6.9
VIIF1-a	245	F-79a	0	5	18.6	0.063	<2.0	3900	94	31	82	<4.0	54000	<1.0	<5.0
VIIF1-b	246	F-79b	5	20	18.0	<0.01	<2.0	8400	43	<20	97	<4.0	25000	<1.0	6.9
VIIF1-c	247	F-79c	20	30	3.6	<0.01	<2.0	21000	32	<20	170	<4.0	10000	<1.0	12
VIIF1-d	248	F-79d	30	60	1.3	<0.01	<2.0	23000	13	<20	200	<4.0	6700	<1.0	14
VIIF1-e	249	F-79e	60	100	<1.0	<0.01	<2.0	23000	8.7	<20	210	<4.0	5800	<1.0	16
VIIF2-e	236	F-80e	60	70	<1.0	<0.01	<2.0	15000	24	<20	97	<4.0	2800	<1.0	12
VIIF2-f	237	F-80f	70	100	<1.0	<0.01	<2.0	16000	22	<20	100	<4.0	3000	<1.0	12
VIIF2-a	250	F-80a	0	5	10.3	0.018	<2.0	13000	120	<20	96	<4.0	9600	<1.0	12
VIIF2-b	251	F-80b	5	15	1.4	<0.01	<2.0	11000	28	<20	86	<4.0	4500	<1.0	8.8
VIIF2-c	252	F-80c	15	30	<1.0	<0.01	<2.0	14000	26	<20	99	<4.0	4100	<1.0	12
VIIF2-d	253	F-80d	30	60	<1.0	<0.01	<2.0	17000	19	<20	120	<4.0	3800	<1.0	14
VIIIF1-a	283	F-81a	0	5	30.4	0.075	<2.0	2100	80	<20	32	<4.0	14000	<1.0	<5.0
VIIIF1-b	284	F-81b	5	15	28.8	0.043	<2.0	4100	100	<20	78	<4.0	23000	<1.0	<5.0
VIIIF1-c	285	F-81c	15	30	19.9	0.019	<2.0	12000	55	<20	130	<4.0	19000	<1.0	6.9
VIIIF1-d	286	F-81d	30	60	13.2	<0.01	<2.0	17000	11	<20	180	<4.0	16000	<1.0	10
VIIIF1-e	287	F-81e	60	70	14.2	<0.01	<2.0	17000	10	<20	190	<4.0	17000	<1.0	10
VIIIF2-a	271	F-82a	0	5	31.3	0.25	<2.0	6000	340	<20	31	<4.0	9800	<1.0	11
VIIIF2-b	272	F-82b	5	15	37.1	0.017	<2.0	5800	81	<20	90	<4.0	14000	<1.0	<5.0
VIIIF2-c	273	F-82c	15	30	19.9	<0.01	<2.0	17000	51	<20	230	<4.0	14000	<1.0	8.4
VIIIF2-d	274	F-82d	30	60	3.15	<0.01	<2.0	26000	8.8	<20	250	<4.0	7400	<1.0	15
VIIIF3-a	275	F-83a	0	5	3.4	0.14	<2.0	24000	160	<20	220	<4.0	5100	<1.0	18
VIIIF3-b	276	F-83b	5	15	1.4	0.059	<2.0	28000	220	20	260	<4.0	5400	<1.0	19
VIIIF3-c	277	F-83c	15	30	<1.0	<0.01	<2.0	20000	19	<20	200	<4.0	4500	<1.0	15

Sample (Golder)	Sam- ple ASU	Sample (Queen's)	from (cm)	to (cm)	Car- bon (%)	Au (µg/g)	Ag (µg/g)	ΑΙ (µg/g)	As (µg/g)	В (µg/g)	Ba (µg/g)	Be (µg/g)	Ca (µg/g)	Cd (µg/g)	Co (µg/g)
VIIIF3-d	278	F-83d	30	60	<1.0	<0.01	<2.0	17000	14	<20	150	<4.0	3900	<1.0	14
VIIIF4-a	297	F-84a	0	5	30.2	0.11	<2.0	4500	80	<20	73	<4.0	28000	<1.0	<5.0
VIIIF4-b	298	F-84b	5	15	24.5	0.019	<2.0	12000	76	<20	170	<4.0	32000	<1.0	5.6
VIIIF4-c	299	F-84c	15	30	10.2	0.010	<2.0	20000	71	<20	190	<4.0	17000	<1.0	11
VIIIF4-d	300	F-84d	30	60	3.7	<0.01	<2.0	24000	40	<20	220	<4.0	9400	<1.0	14
VIIIF4-e	301	F-84e	60	90	3.1	<0.01	<2.0	25000	23	<20	230	<4.0	9100	<1.0	15
VIIIF5-a	302	F-85a	0	5	2.0	0.020	<2.0	23000	110	<20	200	<4.0	26000	<1.0	17
VIIIF5-b	303	F-85b	5	15	<1.0	0.013	<2.0	26000	64	<20	270	<4.0	8400	<1.0	19
VIIIF5-c	304	F-85c	15	30	<1.0	<0.01	<2.0	22000	13	<20	230	<4.0	16000	<1.0	17
VIIIF5-d	305	F-85d	30	60	<1.0	<0.01	<2.0	24000	8.3	<20	250	<4.0	12000	<1.0	18
VIIIF5-e	308	F-85e	60	100	<1.0	<0.01	<2.0	18000	7.3	<20	160	<4.0	19000	<1.0	15
IWL1-a	136	W-86a	0	5	3.5	0.25	<2.0	7600	130	<20	38	<4.0	5300	<1.0	7.4
IWL1-b	137	W-86b	5	15	<1.0	0.48	<2.0	7400	93	<20	38	<4.0	4200	<1.0	7.3
IWL1-c	138	W-86c	15	30	<1.0	0.018	<2.0	8500	25	<20	52	<4.0	3500	<1.0	7.7
IWL1-d	139	W-86d	30	60	<1.0	0.014	<2.0	8000	14	<20	50	<4.0	3200	<1.0	7.2
IWL1-e	140	W-86e	60	100	<1.0	0.016	<2.0	10000	15	<20	52	<4.0	4000	<1.0	8.9
IWL2-a	46	W-87a	0	5	14.6	1.5	<2.0	8100	780	<20	41	<4.0	40000	<1.0	9.4
IWL2-b	47	W-87b	5	15	2.3	0.97	<2.0	12000	500	<20	46	<4.0	28000	<1.0	10
IWL2-c	48	W-87c	15	30	<1.0	0.16	<2.0	12000	80	<20	88	<4.0	9200	<1.0	10
IWL2-d	49	W-87d	30	60	<1.0	0.028	<2.0	12000	24	<20	89	<4.0	5300	<1.0	9.6
IWL2-e	50	W-87e	60	100	<1.0	0.018	<2.0	15000	13	<20	110	<4.0	4900	<1.0	12
IIWL2-a	131	W-88a	0	5	37.6	0.68	<2.0	3200	900	20	61	<4.0	29000	<1.0	<5.0
IIWL2-b	132	W-88b	5	15	37.8	0.12	<2.0	3200	240	<20	110	<4.0	44000	<1.0	<5.0
IIWL2-c	133	W-88c	15	30	3.2	<0.01	<2.0	17000	110	<20	150	<4.0	7700	<1.0	11.0
IIWL2-d	134	W-88d	30	60	1.5	<0.01	<2.0	21000	39	<20	190	<4.0	6300	<1.0	13
IIWL2-e	135	W-88e	60	100	<1.0	<0.01	<2.0	26000	21	22	260	<4.0	7800	<1.0	14
IIIWL1-c	93	W-89c	15	30	4.2	4.0	6.0	18000	2700	<20	99	<4.0	11000	1.9	28
IIIWL1-d	94	W-89d	30	60	<1.0	0.086	<2.0	19000	65	<20	190	<4.0	4700	<1.0	13
IIIWL1-e	95	W-89e	60	100	<1.0	0.058	<2.0	21000	62	<20	220	<4.0	5100	<1.0	14
IIIWL1-a	118	W-89a	0	5	5.4	2.4	2.5	16000	1000	<20	79	<4.0	6800	1.0	30
IIIWL1-b	119	W-89b	5	15	3.55	4.4	3.5	18000	920	<20	88	<4.0	6900	1.0	38
IVWL1-a	12	W-90a	0	5	5.0	2.1	3.4	20000	1100	<20	170	<4.0	5300	<1.0	14
IVWL1-b	13	W-90b	5	15	1.3	0.54	<2.0	19000	250	<20	140	<4.0	4300	<1.0	13
IVWL1-c	14	W-90c	15	30	1.1	0.13	<2.0	22000	94	<20	180	<4.0	4900	<1.0	13
IVWL1-d	15	W-90d	30	60	<1.0	0.17	<2.0	22000	120	<20	210	<4.0	4700	<1.0	14
IVWL1-e	16	W-90e	60	100	<1.0	0.11	<2.0	21000	57	<20	200	<4.0	4500	<1.0	14
IVWL2-a	7	W-91a	0	5	<1.0	0.15	<2.0	14000	210	<20	150	<4.0	5400	<1.0	11
IVWL2-b	8	W-91b	5	15	<1.0	0.98	2.4	18000	1000	<20	130	<4.0	13000	<1.0	17
IVWL2-c	9	W-91c	15	30	1.3	1.6	4.1	21000	2800	<20	51	<4.0	32000	2.4	23
IVWL2-d	10	W-91d	30	60	1.8	2.0	2.7	16000	3400	<20	26	<4.0	38000	2.8	32
IVWL2-e	11	W-91e	60	100	2.3	0.22	2.7	17000	1800	<20	28	<4.0	36000	2.1	19
IVWL3-a	96	W-92a	0	5	7.8	0.019	<2.0	9200	67	<20	72	<4.0	8100	<1.0	7.0
IVWL3-b	97	W-92b	5	15	5.3	0.056	<2.0	10000	130	<20	78	<4.0	6200	<1.0	7.7
IVWL3-c	98	W-92c	15	30	3.5	0.028	<2.0	13000	110	<20	100	<4.0	5400	<1.0	8.5
IVWL3-d	99	W-92d	30	60	<1.0	<0.01	<2.0	14000	79	<20	90	<4.0	3400	<1.0	11

Sample (Golder)	Sam- ple ASU	Sample (Queen's)	from (cm)	to (cm)	Car- bon (%)	Au (µg/g)	Ag (µg/g)	ΑΙ (µg/g)	As (µg/g)	В (µg/g)	Ba (µg/g)	Be (µg/g)	Ca (µg/g)	Cd (µg/g)	Co (µg/g)
IVWL3-e	100	W-92e	60	100	<1.0	<0.01	<2.0	15000	38	<20	100	<4.0	3300	<1.0	12
IVWL4-a	149	W-93a	0	5	5.45	0.034	<2.0	12000	260	<20	100	<4.0	6100	<1.0	8.6
IVWL4-b	150	W-93b	5	15	5.0	0.040	<2.0	16000	210	<20	150	<4.0	6800	<1.0	11
IVWL4-c	151	W-93c	15	30	4.0	0.031	<2.0	16000	140	<20	150	<4.0	5700	<1.0	10
IVWL4-d	152	W-93d	30	60	6.6	0.074	<2.0	16000	180	<20	160	<4.0	8200	<1.0	10
IVWL4-e	153	W-93e	60	100	3.2	0.031	<2.0	21000	160	<20	190	<4.0	6300	<1.0	12
IVWL5-a	339	W-94a	0	5	4.0	0.023	<2.0	12000	330	<20	94	<4.0	5100	<1.0	7.1
IVWL5-b	340	W-94b	5	15	4.3	0.030	<2.0	13000	210	<20	94	<4.0	5100	<1.0	7.0
IVWL5-c	341	W-94c	15	30	3.2	0.029	<2.0	14000	200	<20	100	<4.0	4900	<1.0	7.7
IVWL5-d	342	W-94d	30	60	1.2	<0.01	<2.0	19000	30	<20	190	<4.0	4200	<1.0	12
IVWL5-e	343	W-94e	60	100	1.4	<0.01	<2.0	16000	22	<20	150	<4.0	3600	<1.0	11
IXWL1-a	32	W-95a	0	5	2.0	0.74	<2.0	23000	1500	<20	200	<4.0	16000	<1.0	21
IXWL1-b	33	W-95b	5	15	<1.0	0.31	<2.0	25000	690	20	240	<4.0	9200	<1.0	17
IXWL1-c	34	W-95c	15	30	<1.0	0.16	<2.0	24000	220	<20	220	<4.0	7100	<1.0	17
IXWL1-d	35	W-95d	30	60	<1.0	0.040	<2.0	22000	150	<20	220	<4.0	5600	<1.0	15
IXWL1-e	36	W-95e	60	100	<1.0	0.055	<2.0	25000	120	<20	250	<4.0	6700	<1.0	17
IXWL2-a	41	W-96a	0	5	5.1	0.13	<2.0	25000	700	26	210	<4.0	8400	<1.0	17
IXWL2-b	42	W-96b	5	15	<1.0	0.017	<2.0	28000	160	26	250	<4.0	6100	<1.0	18
IXWL2-c	43	W-96c	15	30	<1.0	<0.01	<2.0	26000	110	24	250	<4.0	5500	<1.0	16
IXWL2-d	44	W-96d	30	60	<1.0	<0.01	<2.0	28000	19	25	270	<4.0	5400	<1.0	18
IXWL2-e	45	W-96e	60	100	<1.0	0.028	<2.0	27000	29	28	270	<4.0	5400	<1.0	17
VWL1-a	163	W-97a	0	5	41.7	0.54	<2.0	4300	810	<20	98	<4.0	15000	<1.0	5.1
VWL1-b	164	W-97b	5	15	43.3	0.099	<2.0	2400	190	<20	77	<4.0	19000	<1.0	<5.0
VWL1-c	165	W-97c	15	30	35.4	0.040	<2.0	3300	120	<20	72	<4.0	19000	<1.0	<5.0
VWL1-d	166	W-97d	30	60	39.4	<0.01	<2.0	4200	50	<20	81	<4.0	18000	<1.0	<5.0
VWL1-e	167	W-97e	60	80	29.0	0.012	<2.0	9100	34	<20	110	<4.0	15000	<1.0	<5.0
VWL2-c	154	W-98c	20	40	35.3	0.052	<2.0	5400	220	21	76	<4.0	26000	<1.0	<5.0
VWL2-d	155	W-98d	40	70	35.2	0.029	<2.0	4800	190	23	82	<4.0	28000	<1.0	<5.0
VWL2-e	156	W-98e	70	100	<1.0	0.036	<2.0	23000	8.2	<20	230	<4.0	5400	<1.0	14
VWL2-a	168	W-98a	0	5	34.8	0.045	<2.0	5100	240	22	70	<4.0	24000	<1.0	<5.0
VWL2-b	169	W-98b	5	20	7.1	0.28	<2.0	16000	1100	<20	58	<4.0	6900	<1.0	26
VWL3-a	157	W-99a	0	10	4.9	0.11	<2.0	7900	35	<20	64	<4.0	6100	<1.0	6.1
VWL3-b	158	W-99b	10	50	4.7	0.056	<2.0	8100	29	<20	75	<4.0	6500	<1.0	6.8
VWL3-c	159	W-99c	50	80	<1.0	<0.01	<2.0	8300	4.9	<20	49	<4.0	2800	<1.0	6.4
VWL3-d	160	W-99d	80	100	<1.0	<0.01	<2.0	12000	5.7	<20	98	<4.0	3200	<1.0	6.9
VIWL1A-a	195	W-100a	0	5	9.3	0.31	<2.0	25000	1500	<20	42	<4.0	75000	<1.0	33
VIWL1A-b	196	W-100b	5	10	2.5	0.16	<2.0	30000	420	<20	10	<4.0	50000	<1.0	42
VIWL1B-a	197	W-101a	0	5	12.0	0.21	<2.0	19000	870	<20	44	<4.0	81000	<1.0	26
VIWL1B-b	198	W-101b	5	10	10.9	0.23	<2.0	25000	1200	<20	32	<4.0	40000	<1.0	32
VIWL1B-c	199	W-101c	10	30	14.0	0.33	<2.0	19000	790	<20	54	<4.0	26000	1.6	25
VIWL1B-d	200	W-101d	30	60	9.7	0.039	<2.0	16000	170	<20	120	<4.0	12000	<1.0	13
VIWL1B-e	201	W-101e	60	80	4.9	0.014	<2.0	13000	88	<20	100	<4.0	6500	<1.0	10
VIIWL1-a	238	W-102a	0	10	34.1	0.056	<2.0	3700	260	24	58	<4.0	13000	<1.0	<5.0
VIIWL1-b	239	W-102b	10	30	40.1	0.013	<2.0	3100	170	<20	45	<4.0	13000	<1.0	<5.0
VIIWL1-c	240	W-102c	30	55	35.7	<0.01	<2.0	2800	45	<20	56	<4.0	11000	<1.0	<5.0

Sample (Golder)	Sam- ple ASU	Sample (Queen's)	from (cm)	to (cm)	Car- bon (%)	Au (µg/g)	Ag (µg/g)	Al (µg/g)	As (µg/g)	В (µg/g)	Ba (µg/g)	Be (µg/g)	Ca (µg/g)	Cd (µg/g)	Co (µg/g)
VIIWL1-d	241	W-102d	55	100	26.8	<0.01	<2.0	9900	30	<20	120	<4.0	10000	<1.0	7.6
VIIIWL1-a	309	W-103a	0	5	29.4	0.11	<2.0	4900	94	<20	59	<4.0	27000	<1.0	6.7
VIIIWL1-b	310	W-103b	5	15	35.2	<0.01	<2.0	2400	32	<20	87	<4.0	52000	<1.0	<5.0
VIIIWL1-c	311	W-103c	15	30	32.4	<0.01	<2.0	3200	40	<20	81	<4.0	44000	<1.0	<5.0
VIIIWL1-d	312	W-103d	30	60	34.1	<0.01	<2.0	3900	23	<20	84	<4.0	34000	<1.0	<5.0
VIIIWL1-e	313	W-103e	60	100	<1.0	<0.01	<2.0	26000	6.4	24	260	<4.0	6300	<1.0	16
VIIIWL2-d	306	W-104d	30	60	1.2	<0.01	<2.0	26000	7.3	<20	250	<4.0	6100	<1.0	18
VIIIWL2-e	307	W-104e	60	100	<1.0	<0.01	<2.0	27000	6.2	<20	270	<4.0	5900	<1.0	18
VIIIWL2-a	314	W-104a	0	5	19.9	0.024	<2.0	15000	41	<20	160	<4.0	18000	<1.0	9.5
VIIIWL2-b	315	W-104b	5	15	9.4	<0.01	<2.0	20000	18	<20	180	<4.0	11000	<1.0	12
VIIIWL2-c	316	W-104c	15	30	4.5	<0.01	<2.0	22000	11	<20	180	<4.0	7500	<1.0	14

Sample (Golder)	Sam- ple ASU	Sample (Queen's)	from (cm)	to (cm)	Cr (µg/g)	Cu (µg/g)	Fe (µg/ g)	K (µg/ g)	Mg (µg/g)	Mn (µg/g)	Mo (µg/g)	Na (µg/g)	Ni (µg/ g)	Ρ (μg/ g)	Pb (µg/g)
IOC1-a	141	O-1a	0	5	190	240	42000	390	22000	600	<2.0	88	53	1000	22
IOC1-b	142	O-1b	5	15	260	200	56000	330	33000	830	<2.0	<75	68	690	13
IOC2-a	91	O-2a	2	7	140	160	58000	350	8400	1900	<2.0	84	51	2800	40
IOC3-a	92	O-3a	2	5	130	130	48000	360	11000	2500	<2.0	78	45	1800	37
llOC1-a	61	O-4a	0	5	21	100	15000	360	4700	740	<2.0	<75	20	770	41
llOC1-b	62	O-4b	5	10	69	130	47000	350	17000	800	<2.0	99	43	580	14
llOC10-a	83	O-5a	0	5	51	100	52000	380	8300	520	<2.0	100	45	1800	89
llOC10-b	84	O-5b	5	8	75	62	110000	180	30000	1200	<2.0	<75	53	780	37
llOC11-a	85	O-6a	0	5	58	130	59000	260	13000	680	<2.0	88	40	910	60
IIOC11-b	86	O-6b	5	10	66	180	49000	250	9800	450	<2.0	88	34	840	31
IIOC2-a	63	0-7a	0	3	37	75	24000	710	6900	3600	<2.0	170	45	1300	52
IIOC2-b	64	O-7b	3	10	71	45	44000	420	11000	1600	<2.0	130	45	450	18
IIOC3-a	65	O-8a	0	5	34	56	28000	540	7300	3500	<2.0	120	31	800	46
IIOC3-b	66	O-8b	5	10	55	44	49000	340	11000	1600	<2.0	92	31	520	21
llOC4-a	67	O-9a	0	5	38	66	21000	580	4400	510	<2.0	120	39	1100	42
IIOC4-b	68	O-9b	5	15	45	12	23000	300	6800	210	<2.0	<75	21	140	<10
IIOC4-c	69	O-9c	15	20	55	23	26000	510	7900	210	<2.0	110	26	210	<10
llOC5-a	70	O-10a	0	3	38	130	41000	520	4900	270	<2.0	120	59	1400	280
IIOC5-b	71	O-10b	3	10	37	12	13000	460	3900	98	<2.0	120	12	190	16
IIOC5-c	72	O-10c	10	20	62	32	28000	800	9400	260	<2.0	120	31	310	16
llOC6-a	73	O-11a	0	5	47	120	34000	610	6500	1200	<2.0	110	57	1200	140
IIOC6-b	74	O-11b	5	15	78	82	56000	380	12000	360	<2.0	96	39	540	23
IIOC6-c	75	O-11c	15	20	85	75	62000	370	15000	520	<2.0	78	34	360	23
llOC7-a	76	O-12a	0	10	34	340	19000	470	3700	590	<2.0	100	40	1500	36
IIOC7-b	77	O-12b	10	16	73	270	36000	460	9100	310	<2.0	140	43	750	53
IIOC8-a	78	O-13a	0	12	31	93	9400	290	1400	57	<2.0	100	20	1800	<10
IIOC8-b	79	O-13b	12	15	40	120	9700	280	2000	70	<2.0	94	20	1000	10
IIOC9-a	80	O-14a	0	3	32	76	26000	280	2700	190	<2.0	89	25	980	38
IIOC9-b	81	O-14b	3	10	63	150	50000	290	4900	320	<2.0	84	24	1000	26
IIOC9-c	82	O-14c	10	15	70	200	50000	350	5300	310	<2.0	76	24	1000	28

Sample (Golder)	Sam- ple ASU	Sample (Queen's)	from (cm)	to (cm)	Cr (µg/g)	Cu (µg/g)	Fe (µg/ g)	K (μg/ g)	Mg (µg/g)	Mn (µg/g)	Mo (µg/g)	Na (µg/g)	Ni (µg/ g)	Ρ (μg/ g)	Pb (µg/g)
IIIOC1-a	120	O-15a	0	5	38	110	42000	490	7000	1100	<2.0	120	49	2400	44
IIIOC1-b	121	O-15b	5	15	44	98	49000	330	11000	1300	<2.0	91	55	2000	15
IIIOC2-a	122	O-16a	0	8	23	64	28000	390	5700	4900	<2.0	230	28	450	85
IIIOC2-b	123	O-16b	8	15	25	20	30000	240	5400	1100	<2.0	250	19	160	24
IIIOC3-a	107	O-17a	0	5	74	190	61000	510	9500	9400	<2.0	300	78	1600	96
IIIOC3-b	108	O-17b	5	9	78	190	61000	450	9400	8600	<2.0	300	67	1600	85
IIIOC5-a	124	O-18a	0	5	88	62	60000	380	20000	560	<2.0	95	75	760	22
IIIOC5-b	125	O-18b	5	10	73	140	48000	440	10000	380	<2.0	180	58	1100	19
IIIOC6-a	109	O-19a	0	5	<20	23	8900	810	3100	110	2.3	200	11	460	<10
IIIOC6-b	110	O-19b	5	9	35	59	52000	400	5700	560	<2.0	350	19	400	52
IIIOC7-a	111	O-20a	0	5	59	190	37000	590	5200	580	<2.0	300	40	1500	16
IIIOC7-b	112	O-20b	5	10	66	270	41000	640	6100	430	<2.0	240	44	2800	14
IIIOC8-a	354	O-21a	0	5	32	110	38000	530	7800	740	<2.0	140	26	1200	52
IIIOC8-b	355	O-21b	5	15	30	130	36000	460	7200	570	<2.0	110	22	1300	48
IVOC1-a	17	O-22a	0	5	38	50	29000	690	5300	270	<2.0	200	25	2400	70
IVOC1-b	18	O-22b	5	10	36	41	33000	510	3800	210	<2.0	130	20	3000	22
IVOC2-a	143	O-23a	0	5	22	130	16000	340	2100	270	<2.0	240	26	1400	39
IVOC2-b	144	O-23b	5	10	21	210	12000	260	1700	110	<2.0	230	23	1100	20
IVOC3-a	145	O-24a	0	5	28	38	24000	430	5700	180	<2.0	130	17	520	34
IVOC3-b	146	O-24b	5	15	41	24	27000	380	6100	160	<2.0	120	18	300	13
IVOC4-a	147	O-25a	0	5	<20	77	35000	500	3800	500	<2.0	170	37	1000	36
IVOC4-b	148	O-25b	5	12	27	55	57000	450	5800	500	<2.0	170	42	590	15
IXOC1-a	317	O-26a	0	5	58	53	40000	600	12000	1700	<2.0	140	52	390	50
IXOC1-b	318	O-26b	5	15	75	30	30000	430	11000	320	<2.0	150	35	150	<10
IXOC2-a	319	O-27a	0	3	35	76	40000	530	9400	1300	<2.0	110	58	550	140
IXOC2-b	320	O-27b	3	10	60	16	28000	420	8600	240	<2.0	120	30	180	12
IXOC2-c	321	O-27c	10	25	60	17	29000	510	8900	270	<2.0	160	30	140	10
IXOC3-a	322	O-28a	0	5	70	140	62000	460	13000	4600	<2.0	87	48	830	100
IXOC3-b	323	O-28b	5	10	98	120	100000	450	13000	5200	<2.0	93	43	840	74
IXOC4-a	324	O-29a	0	6	<20	90	20000	410	6100	880	<2.0	110	49	670	81
IXOC4-b	325	O-29b	6	15	41	22	27000	380	10000	270	<2.0	130	23	210	11
IXOC4-c	326	O-29c	15	20	41	19	28000	370	6800	220	<2.0	120	22	180	10
IXOC5-a	327	O-30a	0	7	33	53	21000	740	6500	1400	<2.0	120	33	810	61
IXOC5-b	328	O-30b	7	15	87	80	44000	470	10000	2300	<2.0	110	55	1000	27
VOC1-a	179	O-31a	0	5	78	24	34000	530	8500	630	<2.0	160	48	610	15
VOC1-b	180	O-31b	5	15	88	46	36000	550	10000	280	<2.0	170	56	440	13
VOC2-a	181	O-32a	0	5	51	110	22000	200	3400	91	<2.0	120	21	1200	26
VOC2-b	182	O-32b	5	15	32	36	13000	300	4200	120	<2.0	120	19	410	<10
VOC2-c	183	O-32c	15	25	32	34	13000	260	3700	90	<2.0	88	17	360	<10
VOC2-d	184	O-32d	25	35	33	38	14000	330	4600	120	<2.0	120	20	380	<10
VOC3-a	185	O-33a	0	5	67	130	32000	550	4700	370	<2.0	130	38	2200	18
VOC3-b	186	O-33b	5	15	77	160	34000	320	5300	190	<2.0	87	29	1000	15
VOC3-c	187	O-33c	15	25	72	150	31000	310	4700	160	<2.0	77	26	930	16
VOC4-a	188	O-34a	0	5	24	55	13000	310	2400	80	<2.0	190	14	360	12
VOC4-b	189	O-34b	5	15	36	67	22000	280	3500	110	<2.0	130	19	400	12

Sample (Golder)	Sam- ple ASU	Sample (Queen's)	from (cm)	to (cm)	Cr (µg/g)	Cu (µg/g)	Fe (μg/ g)	K (μg/ g)	Mg (µg/g)	Mn (µg/g)	Mo (µg/g)	Na (µg/g)	Ni (µg/ g)	Ρ (μg/ g)	Pb (µg/g)
VOC4-c	190	O-34c	15	30	47	70	39000	370	5800	190	<2.0	110	24	560	14
VOC5-a	191	O-35a	0	5	35	18	19000	450	4600	240	<2.0	100	20	630	16
VOC5-b	192	O-35b	5	10	46	16	24000	450	5700	160	<2.0	98	20	290	11
VOC6-a	193	O-36a	0	5	75	310	23000	290	6400	230	<2.0	79	39	1300	18
VOC6-b	194	O-36b	5	15	100	490	36000	280	13000	430	<2.0	<75	59	1100	18
VIOC1-a	209	O-37a	0	5	36	54	26000	360	5800	420	<2.0	<75	30	1000	46
VIOC1-b	210	O-37b	5	15	53	34	45000	290	9300	600	<2.0	<75	22	620	17
VIOC2-a	211	O-38a	0	5	87	45	31000	240	12000	880	<2.0	100	42	1200	12
VIOC2-b	212	O-38b	5	10	92	41	31000	250	11000	760	<2.0	<75	38	1400	<10
VIOC3-a	231	O-39a	0	5	24	31	16000	600	4500	1600	<2.0	120	28	700	21
VIOC3-b	232	O-39b	5	10	50	21	36000	500	9100	600	<2.0	120	39	360	10
VIOC4-a	202	O-40a	0	5	70	130	26000	400	6100	3900	<2.0	150	36	1200	19
VIOC4-b	203	O-40b	5	10	120	170	44000	360	8200	3400	<2.0	180	47	1100	16
VIOC5-a	233	O-41a	0	5	21	200	71000	300	9700	1600	<2.0	130	28	1300	27
VIOC5-b	234	O-41b	5	10	24	250	78000	330	12000	1600	<2.0	140	27	2000	16
VIOC5-c	235	O-41c	10	20	26	270	77000	460	15000	1300	<2.0	110	26	2500	16
VIIOC1-a	242	O-42a	0	5	37	30	26000	750	4900	3600	<2.0	180	21	1100	21
VIIOC1-b	243	O-42b	5	10	82	28	49000	770	10000	1200	<2.0	160	30	950	13
VIIOC1-c	244	O-42c	10	35	100	38	50000	710	12000	650	<2.0	150	35	780	12
VIIOC2-a	254	O-43a	0	5	28	90	28000	380	2100	520	<2.0	94	28	2100	13
VIIOC2-b	255	O-43b	5	15	63	190	34000	280	9000	370	<2.0	<75	28	1000	12
VIIOC3-a	256	O-44a	0	5	<20	370	6700	390	2000	1100	<2.0	<75	23	1400	14
VIIOC3-b	257	O-44b	5	15	59	1200	42000	360	6000	6900	<2.0	140	140	1600	28
VIIOC4-a	258	O-45a	0	5	70	120	51000	430	12000	2900	<2.0	150	59	1100	26
VIIOC4-b	259	O-45b	5	10	68	130	54000	370	7000	1300	<2.0	120	52	890	27
VIIOC5-a	260	O-46a	0	5	48	100	46000	240	19000	1200	<2.0	76	44	970	12
VIIOC6-a	261	O-47a	0	5	<20	82	9500	330	970	79	<2.0	140	33	1500	17
VIIOC6-b	262	O-47b	5	10	27	74	13000	290	2700	110	<2.0	150	19	970	23
VIIOC7-a	263	O-48a	0	5	42	110	30000	390	4200	330	<2.0	130	44	2000	15
VIIOC7-b	264	O-48b	5	10	77	170	48000	440	6400	280	<2.0	140	59	2300	20
VIIOC8-a	265	O-49a	0	5	<20	32	6200	340	890	120	<2.0	<75	14	1300	<10
VIIOC8-b	266	O-49b	5	15	39	200	29000	230	4300	180	<2.0	78	44	2300	13
VIIOC8-c	267	O-49c	15	25	49	460	28000	350	3900	160	<2.0	88	82	2800	16
VIIOC9-a	268	O-50a	0	5	21	92	11000	240	2000	88	<2.0	<75	28	2100	<10
VIIOC9-b	269	O-50b	5	15	46	180	19000	220	3000	130	<2.0	<75	40	1800	12
VIIOC9-c	270	O-50c	15	30	52	180	26000	170	2600	130	<2.0	<75	47	2100	13
VIIIOC1-a	288	O-51a	0	5	48	64	34000	670	8900	1900	<2.0	110	35	700	12
VIIIOC1-b	289	O-51b	5	10	82	58	45000	660	14000	750	<2.0	88	45	620	13
VIIIOC2-a	290	O-52a	0	5	140	62	49000	300	27000	630	<2.0	<75	82	670	12
VIIIOC2-b	291	O-52b	5	10	130	86	44000	310	22000	540	<2.0	75	70	1100	12
VIIIOC2-c	292	O-52c	10	20	130	77	45000	290	22000	540	<2.0	<75	68	1300	11
VIIIOC3-a	293	O-53a	0	5	<20	120	29000	510	4500	1200	<2.0	120	27	1500	32
VIIIOC3-b	294	O-53b	5	10	32	160	59000	400	12000	910	<2.0	83	28	900	20
VIIIOC4-a	295	O-54a	0	5	37	62	24000	440	4700	4800	<2.0	97	34	850	29
VIIIOC4-b	296	O-54b	5	20	93	57	50000	400	8800	2000	<2.0	110	58	320	22

Sample (Golder)	Sam- ple ASU	Sample (Queen's)	from (cm)	to (cm)	Cr (µg/g)	Cu (µg/g)	Fe (µg/ g)	K (μg/ g)	Mg (µg/g)	Mn (µg/g)	Mo (µg/g)	Na (µg/g)	Ni (µg/ g)	Ρ (μg/ g)	Pb (µg/g)
VIIIOC5-a	279	O-55a	0	10	30	86	26000	590	5500	320	<2.0	84	32	1900	42
VIIIOC5-b	280	O-55b	10	15	33	82	25000	550	7000	270	<2.0	<75	24	1700	14
VIIIOC6-a	281	O-56a	0	5	<20	51	24000	360	4700	550	<2.0	130	23	660	18
VIIIOC6-b	282	O-56b	5	10	24	35	28000	340	7000	380	<2.0	130	20	520	16
Stockpile 1-a	349	S-57a		1	<20	52	20000	1000	4500	310	<2.0	490	27	210	15
Stockpile 2-b	350	S-57b		1	28	97	28000	850	6000	420	2.4	720	46	270	12
Stockpile 3-c	351	S-57c		1	25	100	26000	840	5300	480	<2.0	740	48	250	11
Stockpile 4-d	352	S-57d		1	26	84	25000	940	5900	390	<2.0	620	46	270	12
Stockpile 5-e	353	S-57e		1 1 1	<20	58	17000	1100	5400	360	<2.0	500	18	250	20
IF1-a	126	F-58a	0	5	<20	36	5500	720	4700	290	<2.0	150	8.6	890	22
IF1-b	127	F-58b	5	15	<20	40	7000	740	5800	240	<2.0	200	8.4	760	<10
IF1-c	128	F-58c	15	30	33	28	21000	2000	7900	310	<2.0	330	19	520	<10
IF1-d	129	F-58d	30	60	46	25	30000	3200	10000	360	<2.0	440	26	510	12
IF1-e	130	F-58e	60	100	54	34	37000	4800	13000	520	<2.0	710	32	580	15
IF2-a	102	F-59a	0	5	<20	21	8900	820	4000	130	<2.0	140	11	1100	22
IF2-b	103	F-59b	5	15	<20	16	6500	640	3400	160	<2.0	140	8.6	740	21
IF2-c	104	F-59c	15	30	27	19	18000	2200	6200	180	<2.0	260	16	640	<10
IF2-d	105	F-59d	30	60	53	29	33000	4200	12000	430	<2.0	580	31	610	13
IF2-e	106	F-59e	60	100	57	33	36000	4400	13000	510	<2.0	620	34	580	14
IIF1-a	334	F-60a	0	5	50	23	30000	3500	10000	330	<2.0	390	30	520	18
IIF1-b	335	F-60b	5	15	50	21	29000	3600	9700	300	<2.0	400	29	430	14
IIF1-c	336	F-60c	15	30	55	28	32000	3900	10000	310	<2.0	470	32	400	15
llF1-d	337	F-60d	30	60	35	24	23000	2600	8300	350	<2.0	480	22	460	<10
IIF1-e	338	F-60e	60	100	41	27	28000	3700	11000	440	<2.0	650	25	450	11
IIF2-a	56	F-61a	0	5	45	44	29000	3600	10000	390	<20	480	31	770	18
IIF2-b	57	F-61b	5	15	53	35	34000	4000	12000	580	<2.0	560	36	620	19
IIF2-c	58	F-61c	15	30	53	32	34000	4200	12000	540	<2.0	640	34	630	17
IIF2-d	59	F-61d	30	60	48	29	32000	4400	12000	490	<20	680	32	610	15
IIF2-e	60	F-61e	60	100	51	30	35000	4700	13000	630	<20	760	33	670	15
IIF3-a	51	F-62a	0	5	41	25	20000	980	6600	250	<20	240	26	310	10
IIE3-b	52	F-62h	5	15	24	16	12000	690	4200	170	<2.0	200	16	440	<10
IIF3-c	53	F-62c	15	30	22	15	12000	680	3900	180	<2.0	200	15	440	<10
IIF3-d	54	F-62d	30	60	28	20	14000	1000	4800	190	<2.0	250	18	420	<10
IIF3-e	55	E-62e	60	90	31	24	17000	2000	5900	210	<2.0	320	21	400	<10
IIIF1-a	356	F-63a	0	5	45	36	26000	2600	11000	520	<2.0	270	35	400	<10
	357	F-63b	5	15	58	12	31000	1400	11000	430	<2.0	340	36	240	<10
	250	E 620	15	20	50	42	28000	1200	0800	200	<2.0	210	20	240	<10
	350		15	30	52	40	20000	1200	9000	500	<2.0	050	32 05	250	<10
	07	F-030	30	70	20	40	32000	0400	7900	500	<2.0	250	35	006	<10
	21	г-04a		о 15	40	30	23000	2400	7800	0.10	<2.0	270	25	510	34
IIIF2-D	28	F-64D	5	15	40	23	21000	2200	7000	310	<2.0	230	22	540	12
IIIF2-C	29	F-64C	15	30	45	21	24000	2600	8000	250	<2.0	270	23	400	10
IIIF2-0	30	r-640	30	55	43	22	20000	3400	8300	330	<2.0	320	25	420	11
IIIF2-e	31	F-64e	55	100	22	16	14000	1500	4800	200	<2.0	230	14	400	<10
IVF1-b	87	F-65b	5	15	24	14	13000	740	4000	140	<2.0	150	14	300	<10
IVF1-c	88	F-65c	15	30	24	8.3	14000	700	4400	160	<2.0	160	14	310	<10

Sample (Golder)	Sam- ple ASU	Sample (Queen's)	from (cm)	to (cm)	Cr (µg/g)	Cu (µg/g)	Fe (μg/ g)	K (μg/ g)	Mg (µg/g)	Mn (µg/g)	Mo (µg/g)	Na (µg/g)	Ni (µg/ g)	Ρ (μg/ g)	Pb (µg/g)
IVF1-d	89	F-65d	30	60	35	20	24000	2700	7600	330	<2.0	370	22	470	<10
IVF1-e	90	F-65e	60	100	46	25	31000	4300	11000	380	<2.0	630	28	580	14
IVF1-a	101	F-65a	0	5	<20	21	7800	780	2500	40	<2.0	120	9.8	860	18
IVF2-a	344	F-66a	0	5	<20	26	6800	810	1900	130	<2.0	75	20	440	51
IVF2-b	345	F-66b	5	20	<20	28	4600	680	790	34	<2.0	<75	29	820	24
IVF2-c	346	F-66c	20	30	36	27	22000	1900	5700	150	2.3	260	20	390	<10
IVF2-d	347	F-66d	30	60	38	25	20000	2300	7000	180	<2.0	340	19	380	<10
IVF2-e	348	F-66e	60	100	40	25	21000	2600	7800	220	<2.0	400	20	410	<10
IVF3A-a	19	F-67a	0	5	<20	57	13000	680	6300	440	5.7	450	19	1100	67
IVF3A-b	20	F-67b	5	15	<20	45	9600	620	5400	240	15	540	15	760	39
IVF3A-c	21	F-67c	15	35	34	40	19000	1600	8100	450	4.2	430	22	620	<10
IVF3B-a	22	F-68a	0	5	<20	21	8700	640	3600	180	<2.0	140	12	570	31
IVF3B-b	23	F-68b	5	15	<20	18	4600	470	2500	78	<2.0	120	7.8	460	<10
IVF3B-c	24	F-68c	15	30	<20	26	11000	820	4300	180	<2.0	180	15	490	<10
IVF3B-d	25	F-68d	30	60	60	44	35000	4200	14000	550	<2.0	640	39	550	13
IVF3B-e	26	F-68e	60	100	41	26	25000	3000	9600	350	<2.0	430	26	410	<10
IXF1-a	113	F-69a	0	5	<20	26	12000	1100	5800	580	<2.0	140	13	790	49
IXF1-b	114	F-69b	5	15	<20	18	6600	1200	4200	140	<2.0	190	7.8	660	<10
IXF1-c	115	F-69c	15	30	<20	27	9400	890	5200	190	<2.0	280	12	750	<10
IXF1-d	116	F-69d	30	55	<20	30	8300	630	4600	190	<2.0	240	13	800	<10
IXF1-e	117	F-69e	55	100	31	18	22000	3100	7800	240	<2.0	340	20	400	<10
IXF2-a	37	F-70a	0	5	59	51	36000	920	14000	700	<2.0	120	44	620	80
IXF2-b	38	F-70b	5	15	29	37	17000	880	6800	830	<2.0	120	25	640	90
IXF2-c	39	F-70c	15	30	<20	35	9600	670	4700	310	<2.0	110	21	650	14
IXF2-d	40	F-70d	30	45	42	62	20000	740	7200	270	<2.0	180	34	500	<10
IXF3-a	329	F-71a	0	5	46	46	29000	2400	10000	740	<2.0	270	39	840	54
IXF3-b	330	F-71b	5	15	33	16	17000	1800	5400	210	<2.0	260	19	500	<10
IXF3-c	331	F-71c	15	30	50	27	24000	2400	7900	270	<2.0	350	28	540	<10
IXF3-d	332	F-71d	30	60	66	32	32000	3700	11000	370	<2.0	610	38	550	12
IXF3-e	333	F-71e	60	100	41	23	20000	2300	6800	250	<2.0	370	26	530	<10
IXF4-a	1	F-72a	0	5	<20	42	10000	1100	5200	380	<2.0	110	24	890	34
IXF4-b	2	F-72b	5	15	53	110	56000	910	25000	1100	<2.0	140	66	490	450
IXF4-c	3	F-72c	15	30	46	37	30000	3500	12000	520	<2.0	400	33	380	70
IXF4-d	4	F-72d	30	60	58	34	31000	4200	13000	470	<2.0	690	36	490	26
IXF4-e	5	F-72e	60	85	57	30	28000	4000	12000	400	<2.0	720	34	520	15
IXF4-f	6	F-72f	85	100	41	25	21000	2700	8100	280	<2.0	530	25	580	<10
VF1-a	170	F-73a	0	5	<20	16	9200	1200	3300	69	<2.0	360	13	660	13
VF1-b	171	F-73b	5	15	27	14	18000	1900	5200	160	<2.0	370	16	520	<10
VF1-c	172	F-73c	15	30	31	16	20000	2100	5800	160	<2.0	380	18	500	<10
VF1-d	173	F-73d	30	50	36	19	23000	2800	7000	210	<2.0	450	20	420	11
VF1-e	174	F-73e	50	100	49	29	32000	4400	11000	400	<2.0	740	31	480	13
VF2-e	161	F-74e	80	90	38	28	22000	2800	6700	260	<2.0	330	26	400	<10
VF2-f	162	F-74f	100	110	35	24	18000	2000	5800	190	<2.0	220	23	460	<10
VF2-a	175	F-74a	0	10	<20	13	6700	1000	3600	160	<2.0	110	9.6	670	16
VF2-b	176	F-74b	10	20	28	13	13000	720	4200	140	<2.0	180	14	240	<10

Sample (Golder)	Sam- ple ASU	Sample (Queen's)	from (cm)	to (cm)	Cr (µg/g)	Cu (µg/g)	Fe (µg/ g)	K (μg/ g)	Mg (µg/g)	Mn (µg/g)	Mo (µg/g)	Na (µg/g)	Ni (µg/ g)	Ρ (μg/ g)	Pb (µg/g)
VF2-c	177	F-74c	20	50	24	9.6	12000	840	3800	130	<2.0	160	12	250	<10
VF2-d	178	F-74d	50	80	32	21	15000	1600	5000	170	<2.0	210	19	420	<10
VIF1-a	222	F-75a	0	5	<20	20	5400	880	3800	610	2.2	190	12	820	<10
VIF1-b	223	F-75b	5	20	33	22	18000	2000	6600	520	<2.0	330	21	540	<10
VIF1-c	224	F-75c	20	30	41	16	21000	2400	7000	270	<2.0	320	21	460	10
VIF1-d	225	F-75d	30	60	38	21	22000	2700	6800	270	<2.0	410	23	500	<10
VIF1-e	226	F-75e	60	90	40	23	26000	3400	7900	350	<2.0	550	25	580	11
VIF2-e	213	F-76e	50	60	31	53	12000	650	4500	130	<2.0	140	21	570	<10
VIF2-f	214	F-76f	60	80	29	6.3	13000	1000	5000	180	<2.0	140	16	270	<10
VIF2-g	215	F-76g	80	85	40	15	21000	2100	7400	310	<2.0	270	23	400	<10
VIF2-a	227	F-76a	0	5	<20	19	7600	810	3000	74	<2.0	110	10	640	24
VIF2-b	228	F-76b	5	10	22	31	13000	420	2500	390	<2.0	120	14	800	<10
VIF2-c	229	F-76c	10	30	<20	<5.0	11000	320	3000	110	<2.0	120	8.9	390	<10
VIF2-d	230	F-76d	30	50	21	8.9	11000	440	3200	110	<2.0	120	10	390	<10
VIF3-a	216	F-77a	0	5	40	48	22000	640	4000	6000	<2.0	120	24	1200	18
VIF3-b	217	F-77b	5	15	24	5.5	12000	280	3400	390	<2.0	85	11	120	<10
VIF3-c	218	F-77c	15	25	25	5.8	13000	310	3600	160	<2.0	120	14	76	<10
VIF3-d	219	F-77d	25	45	32	9.2	13000	320	3900	160	<2.0	150	18	150	<10
VIF3-e	220	F-77e	45	55	25	7.6	12000	350	3700	150	<2.0	160	16	190	<10
VIF3-f	221	F-77f	55	80	24	7.8	12000	440	3800	180	<2.0	240	15	300	<10
VIF4-a	204	F-78a	0	5	<20	17	2800	760	3800	1000	<2.0	120	6.2	740	13
VIF4-b	205	F-78b	5	10	<20	26	3600	320	3600	1100	<2.0	140	9.3	520	<10
VIF4-c	206	F-78c	10	30	<20	5.3	9900	350	3100	230	<2.0	110	10	310	<10
VIF4-d	207	F-78d	30	60	26	7.5	11000	570	4000	220	<2.0	120	14	340	<10
VIF4-e	208	F-78e	60	100	25	12	10000	730	3800	240	<2.0	140	18	330	<10
VIIF1-a	245	F-79a	0	5	<20	26	6500	580	4100	690	<2.0	160	12	670	<10
VIIF1-b	246	F-79b	5	20	22	26	14000	730	4900	880	<2.0	180	17	490	<10
VIIF1-c	247	F-79c	20	30	47	27	28000	3000	9000	650	<2.0	390	29	500	11
VIIF1-d	248	F-79d	30	60	47	27	30000	3700	9300	660	<2.0	460	31	490	13
VIIF1-e	249	F-79e	60	100	56	31	32000	4400	11000	470	<2.0	590	37	510	14
VIIF2-e	236	F-80e	60	70	42	29	23000	2700	7400	330	<2.0	360	29	480	<10
VIIF2-f	237	F-80f	70	100	51	33	24000	2900	8200	320	<2.0	370	33	570	<10
VIIF2-a	250	F-80a	0	5	32	42	18000	2000	5500	290	<2.0	330	25	590	10
VIIF2-b	251	F-80b	5	15	31	21	16000	1500	4900	210	<2.0	280	20	470	<10
VIIF2-c	252	F-80c	15	30	44	33	21000	2500	7000	260	<2.0	350	30	560	<10
VIIF2-d	253	F-80d	30	60	47	34	25000	3300	8200	330	<2.0	420	35	570	10
VIIIF1-a	283	F-81a	0	5	<20	11	5400	680	2200	110	<2.0	80	5.3	600	13
VIIIF1-b	284	F-81b	5	15	<20	15	4900	730	2500	76	5.5	130	8.4	490	<10
VIIIF1-c	285	F-81c	15	30	22	17	14000	2100	4700	140	2.3	250	15	470	<10
VIIIF1-d	286	F-81d	30	60	33	22	21000	3000	6900	190	<2.0	320	22	490	<10
VIIIF1-e	287	F-81e	60	70	33	24	21000	2900	6700	180	<2.0	350	23	470	<10
VIIIF2-a	271	F-82a	0	5	<20	36	16000	1100	4600	190	<2.0	100	20	680	46
VIIIF2-b	272	F-82b	5	15	<20	15	6900	1300	3000	84	<2.0	190	9.3	630	<10
VIIIF2-c	273	F-82c	15	30	27	25	18000	2700	5400	170	<2.0	450	22	490	<10
VIIIF2-d	274	F-82d	30	60	54	32	30000	4500	10000	370	<2.0	610	35	500	13

Sample (Golder)	Sam- ple ASU	Sample (Queen's)	from (cm)	to (cm)	Cr (µg/g)	Cu (µg/g)	Fe (µg/ g)	K (μg/ g)	Mg (µg/g)	Mn (µg/g)	Mo (µg/g)	Na (µg/g)	Ni (µg/ g)	P (µg/ g)	Pb (µg/g)
VIIIF3-a	275	F-83a	0	5	59	46	35000	4600	12000	390	<2.0	520	40	630	35
VIIIF3-b	276	F-83b	5	15	68	40	39000	5200	13000	450	<2.0	610	42	610	22
VIIIF3-c	277	F-83c	15	30	60	32	31000	4000	11000	380	<2.0	590	36	570	12
VIIIF3-d	278	F-83d	30	60	55	31	28000	3500	9900	340	<2.0	440	34	550	11
VIIIF4-a	297	F-84a	0	5	<20	40	8800	860	3800	170	<2.0	480	23	610	12
VIIIF4-b	298	F-84b	5	15	<20	30	12000	1800	4600	120	<2.0	690	21	740	<10
VIIIF4-c	299	F-84c	15	30	37	19	24000	3300	7600	300	<2.0	560	22	560	11
VIIIF4-d	300	F-84d	30	60	47	22	31000	4000	9600	400	<2.0	500	28	480	14
VIIIF4-e	301	F-84e	60	90	50	25	32000	4100	10000	450	<2.0	600	30	480	14
VIIIF5-a	302	F-85a	0	5	60	36	33000	4000	13000	640	<2.0	570	36	380	14
VIIIF5-b	303	F-85b	5	15	63	41	41000	4700	15000	560	<2.0	780	40	490	15
VIIIF5-c	304	F-85c	15	30	55	35	34000	4300	14000	560	<2.0	700	34	470	13
VIIIF5-d	305	F-85d	30	60	61	35	36000	4700	14000	540	<2.0	810	37	520	14
VIIIF5-e	308	F-85e	60	100	51	30	32000	3800	13000	510	<2.0	570	31	500	11
IWL1-a	136	W-86a	0	5	21	32	16000	910	5600	140	<2.0	190	16	440	16
IWL1-b	137	W-86b	5	15	21	27	16000	950	5400	160	<2.0	190	15	400	24
IWL1-c	138	W-86c	15	30	26	18	16000	1300	5200	170	<2.0	280	15	520	<10
IWL1-d	139	W-86d	30	60	24	19	15000	1400	4800	170	<2.0	260	15	500	<10
IWL1-e	140	W-86e	60	100	29	20	20000	1400	6400	220	<2.0	280	18	550	<10
IWL2-a	46	W-87a	0	5	22	43	28000	700	18000	870	<2.0	180	23	750	28
IWL2-b	47	W-87b	5	15	33	40	28000	1300	19000	690	<2.0	220	24	420	29
IWL2-c	48	W-87c	15	30	36	25	22000	2200	9100	350	<2.0	410	22	560	<10
IWL2-d	49	W-87d	30	60	37	23	20000	2300	7600	280	<2.0	440	22	590	<10
IWL2-e	50	W-87e	60	100	46	27	24000	2900	8700	340	<2.0	530	27	600	<10
IIWL2-a	131	W-88a	0	5	<20	31	6600	730	3200	190	2.3	130	10	910	49
IIWL2-b	132	W-88b	5	15	<20	19	5400	400	3000	290	2	200	6.5	610	12
IIWL2-c	133	W-88c	15	30	37	18	24000	2400	8000	250	<2.0	300	22	370	<10
IIWL2-d	134	W-88d	30	60	45	23	30000	3500	9900	370	<2.0	470	27	420	12
IIWL2-e	135	W-88e	60	100	50	29	34000	4700	12000	390	<2.0	680	29	520	15
IIIWL1-c	93	W-89c	15	30	45	340	46000	2000	13000	400	<2.0	350	61	630	360
IIIWL1-d	94	W-89d	30	60	41	27	29000	3300	8900	300	<2.0	410	25	460	17
IIIWL1-e	95	W-89e	60	100	43	29	30000	3700	9900	360	<2.0	560	27	520	17
IIIWL1-a	118	W-89a	0	5	40	160	34000	1600	9800	320	<2.0	500	55	680	110
IIIWL1-b	119	W-89b	5	15	44	280	38000	1700	12000	350	<2.0	430	80	570	130
IVWL1-a	12	W-90a	0	5	47	900	26000	3000	9000	240	<2.0	500	73	610	36
IVWL1-b	13	W-90b	5	15	47	360	26000	3100	9500	280	<2.0	490	41	500	15
IVWL1-c	14	W-90c	15	30	51	42	28000	3700	10000	320	<2.0	580	35	480	13
IVWL1-d	15	W-90d	30	60	50	45	28000	3800	11000	410	<2.0	680	34	520	13
IVWL1-e	16	W-90e	60	100	48	54	28000	3800	10000	390	<2.0	670	35	520	13
IVWL2-a	7	W-91a	0	5	39	34	21000	2600	8200	330	<2.0	450	26	570	25
IVWL2-b	8	W-91b	5	15	48	380	30000	3000	12000	440	<2.0	430	56	540	100
IVWL2-c	9	W-91c	15	30	52	380	47000	1800	22000	810	<2.0	250	65	440	370
IVWL2-d	10	W-91d	30	60	44	140	57000	920	21000	880	<2.0	180	72	350	420
IVWL2-e	11	W-91e	60	100	48	240	47000	1000	21000	840	<2.0	180	59	350	370
IVWL3-a	96	W-92a	0	5	25	18	15000	820	4700	550	<2.0	170	13	430	<10

Sample (Golder)	Sam- ple ASU	Sample (Queen's)	from (cm)	to (cm)	Cr (µg/g)	Cu (µg/g)	Fe (µg/ g)	K (μg/ g)	Mg (µg/g)	Mn (µg/g)	Mo (µg/g)	Na (µg/g)	Ni (µg/ g)	Ρ (μg/ g)	Pb (µg/g)
IVWL3-b	97	W-92b	5	15	28	17	16000	940	5000	280	<2.0	200	15	460	10
IVWL3-c	98	W-92c	15	30	31	18	18000	1400	5600	410	<2.0	230	18	490	<10
IVWL3-d	99	W-92d	30	60	40	22	23000	2100	7500	530	<2.0	280	22	410	<10
IVWL3-e	100	W-92e	60	100	39	26	23000	2500	7700	340	<2.0	350	24	550	<10
IVWL4-a	149	W-93a	0	5	26	16	17000	1900	5900	210	<2.0	290	18	440	<10
IVWL4-b	150	W-93b	5	15	36	21	22000	2500	7400	240	<2.0	370	22	480	12
IVWL4-c	151	W-93c	15	30	34	20	22000	2500	6900	220	<2.0	350	21	430	11
IVWL4-d	152	W-93d	30	60	35	22	22000	2600	7100	250	<2.0	370	22	490	12
IVWL4-e	153	W-93e	60	100	40	23	30000	3500	8600	290	<2.0	510	25	490	13
IVWL5-a	339	W-94a	0	5	26	12	15000	1500	5400	600	<2.0	210	14	410	<10
IVWL5-b	340	W-94b	5	15	28	13	15000	1600	5900	260	<2.0	230	15	400	<10
IVWL5-c	341	W-94c	15	30	31	12	18000	1800	6400	240	<2.0	240	16	440	<10
IVWL5-d	342	W-94d	30	60	42	26	23000	2900	9000	310	<2.0	470	25	410	<10
IVWL5-e	343	W-94e	60	100	35	20	20000	2300	7700	260	<2.0	360	21	350	<10
IXWL1-a	32	W-95a	0	5	53	210	31000	4500	12000	380	<2.0	630	65	570	15
IXWL1-b	33	W-95b	5	15	53	73	33000	4800	12000	380	<2.0	700	42	570	14
IXWL1-c	34	W-95c	15	30	59	48	33000	4600	13000	410	<2.0	670	39	610	13
IXWL1-d	35	W-95d	30	60	49	32	29000	5300	12000	420	<2.0	700	32	490	14
IXWL1-e	36	W-95e	60	100	56	37	33000	4900	13000	470	<2.0	760	35	530	14
IXWL2-a	41	W-96a	0	5	52	34	32000	4800	11000	430	<2.0	710	36	620	26
IXWL2-b	42	W-96b	5	15	57	30	35000	5400	12000	450	<2.0	730	36	570	16
IXWL2-c	43	W-96c	15	30	53	28	33000	5100	11000	440	<2.0	700	34	540	16
IXWL2-d	44	W-96d	30	60	55	30	36000	5400	12000	620	<2.0	730	36	610	16
IXWL2-e	45	W-96e	60	100	52	28	34000	5500	12000	530	<2.0	740	34	590	17
VWL1-a	163	W-97a	0	5	<20	39	12000	250	3200	97	<2.0	280	12	560	86
VWL1-b	164	W-97b	5	15	<20	11	7200	140	1400	53	3.2	220	<5.0	520	24
VWL1-c	165	W-97c	15	30	<20	11	4800	250	1300	50	2.9	240	<5.0	530	<10
VWL1-d	166	W-97d	30	60	<20	12	5600	430	2000	68	2.8	210	6.2	370	<10
VWL1-e	167	W-97e	60	80	<20	19	8700	1000	3500	98	2.8	260	12	400	<10
VWL2-c	154	W-98c	20	40	<20	20	7800	760	2700	110	<2.0	230	10	420	<10
VWL2-d	155	W-98d	40	70	<20	16	9900	750	2700	170	2.3	260	8.5	490	<10
VWL2-e	156	W-98e	70	100	43	25	33000	4400	10000	320	<2.0	670	28	540	14
VWL2-a	168	W-98a	0	5	<20	19	7600	770	2600	100	2.0	230	10	490	<10
VWL2-b	169	W-98b	5	20	54	56	59000	490	8200	720	<2.0	400	28	420	53
VWL3-a	157	W-99a	0	10	22	13	13000	1500	4300	190	3.4	220	13	410	<10
VWL3-b	158	W-99b	10	50	22	13	13000	1400	4400	180	3.3	230	14	420	<10
VWL3-c	159	W-99c	50	80	24	11	13000	1100	4100	130	<2.0	180	13	390	<10
VWL3-d	160	W-99d	80	100	31	19	18000	2000	5400	190	<2.0	270	16	370	<10
VIWL1A-a	195	W-100a	0	5	76	190	54000	460	23000	990	<2.0	190	57	730	51
VIWL1A-b	196	W-100b	5	10	78	140	60000	160	27000	1100	<2.0	89	69	360	420
VIWL1B-a	197	W-101a	0	5	58	57	39000	570	17000	820	<2.0	260	48	630	36
VIWL1B-b	198	W-101b	5	10	65	80	51000	430	22000	800	<2.0	140	57	490	30
VIWL1B-c	199	W-101c	10	30	62	54	35000	620	14000	520	2.4	160	47	450	25
VIWL1B-d	200	W-101d	30	60	40	43	22000	1200	7400	250	2.9	280	32	420	13
VIWL1B-e	201	W-101e	60	80	38	31	18000	1500	6400	230	2.4	290	28	430	<10

Sample (Golder)	Sam- ple ASU	Sample (Queen's)	from (cm)	to (cm)	Cr (µg/g)	Cu (µg/g)	Fe (µg/ g)	K (μg/ g)	Mg (µg/g)	Mn (µg/g)	Mo (µg/g)	Na (µg/g)	Ni (µg/ g)	Ρ (μg/ g)	Pb (µg/g)
VIIWL1-a	238	W-102a	0	10	<20	21	5000	600	2100	93	<2.0	190	11	580	<10
VIIWL1-b	239	W-102b	10	30	<20	24	3300	350	1400	78	<2.0	160	11	410	<10
VIIWL1-c	240	W-102c	30	55	<20	18	6200	350	1300	74	<2.0	130	9.8	280	<10
VIIWL1-d	241	W-102d	55	100	24	23	20000	1600	4300	180	<2.0	280	20	330	<10
VIIIWL1-a	309	W-103a	0	5	<20	17	8700	750	4500	790	<2.0	500	13	610	12
VIIIWL1-b	310	W-103b	5	15	<20	15	2500	360	2900	490	<2.0	860	7.6	610	<10
VIIIWL1-c	311	W-103c	15	30	<20	12	3700	320	2300	130	<2.0	710	5.6	390	<10
VIIIWL1-d	312	W-103d	30	60	<20	22	6000	490	2200	88	<2.0	790	8.7	330	<10
VIIIWL1-e	313	W-103e	60	100	49	28	34000	4600	11000	360	<2.0	700	32	560	16
VIIIWL2-d	306	W-104d	30	60	57	31	35000	4500	12000	570	<2.0	700	35	510	15
VIIIWL2-e	307	W-104e	60	100	64	35	38000	5400	14000	530	<2.0	870	40	540	16
VIIIWL2-a	314	W-104a	0	5	31	34	20000	2500	6300	240	<2.0	330	22	600	12
VIIIWL2-b	315	W-104b	5	15	46	28	27000	3000	8700	280	<2.0	410	26	480	12
VIIIWL2-c	316	W-104c	15	30	53	27	33000	3500	10000	300	<2.0	440	32	480	13

Sample (Golder)	Sam- ple ASU	Sample (Queen's)	from (cm)	to (cm)	S (μg/ g)	Sb (μg/ g)	Se (µg/ g)	Sn (μg/ g)	Sr (µg/ g)	Ti (μg/ g)	TI (μg/ g)	U (µg/ g)	V (µg/ g)	Zn (μg/ g)
IOC1-a	141	O-1a	0	5	760	48	<10	<2.0	7.9	620	<1.0	<10	130	76
IOC1-b	142	O-1b	5	15	560	14	<10	<2.0	<5.0	560	<1.0	<10	180	82
IOC2-a	91	O-2a	2	7	1100	70	<10	<2.0	8.1	610	<1.0	<10	110	290
IOC3-a	92	O-3a	2	5	1100	57	<10	<2.0	8.5	1000	<1.0	<10	110	230
llOC1-a	61	O-4a	0	5	1300	120	<10	<2.0	21	350	<1.0	<10	34	98
IIOC1-b	62	O-4b	5	10	510	12	<10	<2.0	9.9	1900	<1.0	<10	120	200
llOC10-a	83	O-5a	0	5	2000	260	<10	<2.0	15	830	<1.0	<10	90	120
IIOC10-b	84	O-5b	5	8	820	52	<10	<2.0	9.2	2400	<1.0	<10	130	120
llOC11-a	85	O-6a	0	5	920	220	<10	<2.0	8.8	1200	<1.0	<10	110	120
llOC11-b	86	O-6b	5	10	920	120	<10	<2.0	7.5	1500	<1.0	<10	120	100
IIOC2-a	63	0-7a	0	3	1300	60	<10	<2.0	49	450	2.7	<10	52	240
IIOC2-b	64	O-7b	3	10	440	18	<10	<2.0	23	920	<1.0	<10	110	120
IIOC3-a	65	O-8a	0	5	810	76	<10	<2.0	38	660	1.8	<10	59	410
IIOC3-b	66	O-8b	5	10	250	17	<10	<2.0	25	1200	<1.0	<10	120	360
llOC4-a	67	O-9a	0	5	510	73	<10	<2.0	17	270	<1.0	<10	44	110
IIOC4-b	68	O-9b	5	15	<200	11	<10	<2.0	5.4	560	<1.0	<10	58	34
IIOC4-c	69	O-9c	15	20	<200	9.0	<10	<2.0	7.9	770	<1.0	<10	60	38
IIOC5-a	70	O-10a	0	3	1200	900	<10	<2.0	15	180	<1.0	<10	38	180
IIOC5-b	71	O-10b	3	10	210	47	<10	<2.0	<5.0	550	<1.0	<10	34	24
IIOC5-c	72	O-10c	10	20	220	25	<10	<2.0	5.3	960	<1.0	<10	62	41
IIOC6-a	73	O-11a	0	5	920	320	<10	<2.0	24	590	<1.0	<10	62	200
IIOC6-b	74	O-11b	5	15	180	35	<10	<2.0	19	1400	<1.0	<10	130	72
IIOC6-c	75	O-11c	15	20	180	45	<10	<2.0	19	1600	<1.0	<10	160	61
llOC7-a	76	O-12a	0	10	2900	33	<10	<2.0	30	260	<1.0	<10	32	150
IIOC7-b	77	O-12b	10	16	720	6.0	<10	<2.0	11	760	<1.0	<10	65	140
IIOC8-a	78	O-13a	0	12	1300	16	<10	<2.0	12	160	<1.0	<10	37	26
IIOC8-b	79	O-13b	12	15	820	8.4	<10	<2.0	13	410	<1.0	<10	48	26

Sample (Golder)	Sam- ple ASU	Sample (Queen's)	from (cm)	to (cm)	S (μg/ g)	Sb (µg/ g)	Se (µg/ g)	Sn (μg/ g)	Sr (μg/ g)	Ti (μg/ g)	TI (μg/ g)	U (µg/ g)	V (µg/ g)	Zn (μg/ g)
IIOC9-a	80	O-14a	0	3	1100	120	<10	<2.0	13	370	<1.0	<10	52	110
IIOC9-b	81	O-14b	3	10	420	35	<10	<2.0	14	1000	<1.0	<10	99	120
IIOC9-c	82	O-14c	10	15	600	33	<10	<2.0	13	970	<1.0	<10	99	110
IIIOC1-a	120	O-15a	0	5	810	90	<10	<2.0	21	360	<1.0	<10	92	210
IIIOC1-b	121	O-15b	5	15	1000	31	<10	<2.0	24	640	<1.0	<10	110	190
IIIOC2-a	122	O-16a	0	8	570	170	<10	<2.0	16	440	2.1	<10	48	230
IIIOC2-b	123	O-16b	8	15	210	23	<10	<2.0	8.8	710	<1.0	<10	56	100
IIIOC3-a	107	O-17a	0	5	760	34	<10	<2.0	21	470	5.6	<10	100	800
IIIOC3-b	108	O-17b	5	9	560	23	<10	<2.0	11	600	2.5	<10	120	550
IIIOC5-a	124	O-18a	0	5	350	45	<10	<2.0	11	1000	<1.0	<10	170	74
IIIOC5-b	125	O-18b	5	10	610	74	<10	<2.0	10	890	<1.0	<10	120	62
IIIOC6-a	109	O-19a	0	5	14000	19	<10	<2.0	54	220	<1.0	<10	18	42
IIIOC6-b	110	O-19b	5	9	220	41	<10	<2.0	<5.0	1300	<1.0	<10	210	88
IIIOC7-a	111	O-20a	0	5	560	21	<10	<2.0	11	930	<1.0	<10	83	100
IIIOC7-b	112	O-20b	5	10	1600	5.1	<10	<2.0	6.6	980	<1.0	<10	87	170
IIIOC8-a	354	O-21a	0	5	500	19	<10	<2.0	12	720	<1.0	<10	83	180
IIIOC8-b	355	O-21b	5	15	600	12	<10	<2.0	8.9	410	<1.0	<10	79	150
IVOC1-a	17	O-22a	0	5	400	160	<10	<2.0	12	630	<1.0	<10	56	130
IVOC1-b	18	O-22b	5	10	620	73	<10	<2.0	9.9	780	<1.0	<10	63	130
IVOC2-a	143	O-23a	0	5	1400	42	<10	<2.0	12	200	<1.0	<10	30	160
IVOC2-b	144	O-23b	5	10	870	13	<10	<2.0	8.6	280	<1.0	<10	27	96
IVOC3-a	145	O-24a	0	5	970	150	<10	<2.0	12	750	<1.0	<10	42	36
IVOC3-b	146	O-24b	5	15	210	21	<10	<2.0	7.7	990	<1.0	<10	59	28
IVOC4-a	147	O-25a	0	5	1300	130	<10	<2.0	20	450	<1.0	<10	68	76
IVOC4-b	148	O-25b	5	12	580	24	<10	<2.0	17	1100	<1.0	<10	140	87
IXOC1-a	317	O-26a	0	5	1000	73	<10	<2.0	14	750	<1.0	<10	63	140
IXOC1-b	318	O-26b	5	15	85	6.0	<10	<2.0	7.1	1000	<1.0	<10	63	49
IXOC2-a	319	O-27a	0	3	2100	330	<10	<2.0	27	320	<1.0	<10	41	210
IXOC2-b	320	O-27b	3	10	140	18	<10	<2.0	6.6	910	<1.0	<10	62	58
IXOC2-c	321	O-27c	10	25	160	12	<10	<2.0	9.2	900	<1.0	<10	59	52
IXOC3-a	322	O-28a	0	5	1700	280	<10	<2.0	19	340	3.9	<10	120	180
IXOC3-b	323	O-28b	5	10	1000	180	<10	<2.0	16	550	4.1	<10	170	140
IXOC4-a	324	O-29a	0	6	1500	190	<10	<2.0	41	230	<1.0	<10	23	160
IXOC4-b	325	O-29b	6	15	460	15	<10	<2.0	13	590	<1.0	<10	58	39
IXOC4-c	326	O-29c	15	20	200	14	<10	<2.0	9.8	710	<1.0	<10	70	49
IXOC5-a	327	O-30a	0	7	1600	140	<10	<2.0	31	430	<1.0	<10	34	200
IXOC5-b	328	O-30b	7	15	560	16	<10	<2.0	15	1500	<1.0	<10	94	400
VOC1-a	179	O-31a	0	5	<200	25	<10	<2.0	9.5	1200	<1.0	<10	78	200
VOC1-b	180	O-31b	5	15	<200	13	<10	<2.0	8.4	1400	<1.0	<10	85	85
VOC2-a	181	O-32a	0	5	450	110	<10	<2.0	6.4	290	<1.0	<10	39	36
VOC2-b	182	O-32b	5	15	220	<1.0	<10	<2.0	<5.0	550	<1.0	<10	26	21
VOC2-c	183	O-32c	15	25	<200	8.4	<10	<2.0	<5.0	430	<1.0	<10	30	19
VOC2-d	184	O-32d	25	35	<200	2.2	<10	<2.0	5.1	580	<1.0	<10	30	20
VOC3-a	185	O-33a	0	5	800	16	<10	<2.0	11	1200	<1.0	<10	68	70
VOC3-b	186	O-33b	5	15	530	11	<10	<2.0	9.4	1800	<1.0	<10	78	68

Sample (Golder)	Sam- ple ASU	Sample (Queen's)	from (cm)	to (cm)	S (μg/ g)	Sb (µg/ g)	Se (µg/ g)	Sn (μg/ g)	Sr (µg/ g)	Ti (μg/ g)	TI (μg/ g)	U (µg/ g)	V (μg/ g)	Zn (µg/ g)
VOC3-c	187	O-33c	15	25	570	10	<10	<2.0	8.2	1400	<1.0	<10	74	63
VOC4-a	188	O-34a	0	5	520	17	<10	<2.0	13	1800	<1.0	<10	44	32
VOC4-b	189	O-34b	5	15	600	11	<10	<2.0	14	2400	<1.0	<10	78	35
VOC4-c	190	O-34c	15	30	1200	7.5	<10	<2.0	14	3300	<1.0	<10	100	51
VOC5-a	191	O-35a	0	5	240	20	<10	<2.0	11	600	<1.0	<10	43	56
VOC5-b	192	O-35b	5	10	<200	11	<10	<2.0	5.4	800	<1.0	<10	60	52
VOC6-a	193	O-36a	0	5	1000	8.2	<10	<2.0	7.8	950	<1.0	<10	71	82
VOC6-b	194	O-36b	5	15	800	3.9	<10	<2.0	8.2	1500	<1.0	<10	100	94
VIOC1-a	209	O-37a	0	5	1700	120	<10	<2.0	12	1100	<1.0	<10	60	140
VIOC1-b	210	O-37b	5	15	540	16	<10	<2.0	12	3600	<1.0	<10	120	150
VIOC2-a	211	O-38a	0	5	740	14	<10	<2.0	13	210	<1.0	<10	75	100
VIOC2-b	212	O-38b	5	10	840	7.4	<10	<2.0	11	260	<1.0	<10	76	91
VIOC3-a	231	O-39a	0	5	1300	54	<10	<2.0	35	540	<1.0	<10	36	120
VIOC3-b	232	O-39b	5	10	380	8.8	<10	<2.0	13	1400	<1.0	<10	81	180
VIOC4-a	202	O-40a	0	5	1300	36	<10	<2.0	17	280	3.0	<10	58	160
VIOC4-b	203	O-40b	5	10	840	20	<10	<2.0	14	740	1.7	<10	100	210
VIOC5-a	233	O-41a	0	5	660	30	<10	<2.0	29	1200	<1.0	<10	160	190
VIOC5-b	234	O-41b	5	10	540	13	<10	<2.0	28	1300	<1.0	<10	170	170
VIOC5-c	235	O-41c	10	20	620	6.4	<10	<2.0	37	1100	<1.0	<10	160	170
VIIOC1-a	242	O-42a	0	5	860	34	<10	<2.0	30	640	1.6	<10	60	250
VIIOC1-b	243	O-42b	5	10	280	11	<10	<2.0	16	2300	<1.0	<10	140	210
VIIOC1-c	244	O-42c	10	35	220	7.7	<10	<2.0	12	2600	<1.0	<10	140	110
VIIOC2-a	254	O-43a	0	5	1600	10	<10	<2.0	12	240	<1.0	<10	51	100
VIIOC2-b	255	O-43b	5	15	1000	3.4	<10	<2.0	10	1900	<1.0	<10	100	58
VIIOC3-a	256	O-44a	0	5	2400	18	<10	<2.0	29	160	<1.0	<10	15	360
VIIOC3-b	257	O-44b	5	15	1500	15	<10	<2.0	21	1300	1.9	<10	94	2300
VIIOC4-a	258	O-45a	0	5	600	19	<10	<2.0	23	1300	<1.0	<10	120	460
VIIOC4-b	259	O-45b	5	10	500	10	<10	<2.0	14	1700	<1.0	<10	120	460
VIIOC5-a	260	O-46a	0	5	1300	13	<10	<2.0	9.3	1100	<1.0	<10	120	220
VIIOC6-a	261	O-47a	0	5	1500	9.9	<10	<2.0	14	190	<1.0	<10	11	33
VIIOC6-b	262	O-47b	5	10	1000	7.1	<10	<2.0	8.9	330	<1.0	<10	29	58
VIIOC7-a	263	O-48a	0	5	1400	10	<10	<2.0	13	500	<1.0	<10	57	170
VIIOC7-b	264	O-48b	5	10	700	2.9	<10	<2.0	12	1700	<1.0	<10	100	240
VIIOC8-a	265	O-49a	0	5	2100	17	<10	<2.0	17	140	<1.0	<10	<10	43
VIIOC8-b	266	O-49b	5	15	1000	3.3	<10	<2.0	13	1100	<1.0	<10	59	110
VIIOC8-c	267	O-49c	15	25	1100	5.1	<10	<2.0	15	1200	<1.0	<10	69	160
VIIOC9-a	268	O-50a	0	5	2600	5.6	<10	<2.0	10	240	<1.0	<10	23	52
VIIOC9-b	269	O-50b	5	15	1900	3.1	<10	<2.0	9.7	1000	<1.0	<10	50	110
VIIOC9-c	270	O-50c	15	30	1600	3.2	<10	<2.0	13	1500	<1.0	<10	55	140
VIIIOC1-a	288	O-51a	0	5	400	5.3	<10	<2.0	19	1000	<1.0	<10	63	150
VIIIOC1-b	289	O-51b	5	10	300	1.9	<10	<2.0	8.3	1300	<1.0	<10	100	160
VIIIOC2-a	290	O-52a	0	5	600	7.6	<10	<2.0	8.1	1600	<1.0	<10	140	80
VIIIOC2-b	291	O-52b	5	10	940	3.5	<10	<2.0	10	1500	<1.0	<10	120	120
VIIIOC2-c	292	O-52c	10	20	1200	3.9	<10	<2.0	11	1500	<1.0	<10	120	140
VIIIOC3-a	293	O-53a	0	5	1500	33	<10	<2.0	19	490	<1.0	<10	61	130

Sample (Golder)	Sam- ple ASU	Sample (Queen's)	from (cm)	to (cm)	S (μg/ g)	Sb (µg/ g)	Se (µg/ g)	Sn (μg/ g)	Sr (μg/ g)	Ti (μg/ g)	TI (μg/ g)	U (µg/ g)	V (µg/ g)	Zn (μg/ g)
VIIIOC3-b	294	O-53b	5	10	640	7.3	<10	<2.0	13	2600	<1.0	<10	160	140
VIIIOC4-a	295	O-54a	0	5	1000	59	<10	<2.0	14	520	1.7	<10	40	100
VIIIOC4-b	296	O-54b	5	20	280	12	<10	<2.0	10	2000	<1.0	<10	100	240
VIIIOC5-a	279	O-55a	0	10	1000	49	<10	<2.0	19	470	<1.0	<10	47	120
VIIIOC5-b	280	O-55b	10	15	1000	14	<10	<2.0	19	520	<1.0	<10	57	66
VIIIOC6-a	281	O-56a	0	5	740	16	<10	<2.0	23	840	<1.0	<10	45	81
VIIIOC6-b	282	O-56b	5	10	500	6.5	<10	<2.0	13	1400	<1.0	<10	57	68
Stockpile 1-a	349	S-57a		- - - -	6900	1.4	<10	<2.0	7.7	530	<1.0	<10	25	40
Stockpile 2-b	350	S-57b		1 1 1	9900	4.2	<10	<2.0	10	840	<1.0	<10	39	39
Stockpile 3-c	351	S-57c		1	9800	1.0	<10	<2.0	13	790	<1.0	<10	35	39
Stockpile 4-d	352	S-57d		1	9000	1.3	<10	<2.0	10	810	<1.0	<10	36	51
Stockpile 5-e	353	S-57e		1	2400	2.9	<10	<2.0	7.9	530	<1.0	<10	23	88
IF1-a	126	F-58a	0	5	2000	55	<10	<2.0	60	74	<1.0	<10	16	34
IF1-b	127	F-58b	5	15	1800	20	<10	<2.0	83	140	<1.0	<10	16	29
IF1-c	128	F-58c	15	30	450	3.3	<10	<2.0	49	610	<1.0	<10	34	35
IF1-d	129	F-58d	30	60	<200	1.8	<10	<2.0	42	1200	<1.0	<10	53	51
IF1-e	130	F-58e	60	100	<200	2.0	<10	<2.0	53	1600	<1.0	<10	63	71
IF2-a	102	F-59a	0	5	3500	74	<10	<2.0	35	120	<1.0	<10	18	51
IF2-b	103	F-59b	5	15	2600	78	<10	<2.0	40	120	<1.0	<10	13	41
IF2-c	104	F-59c	15	30	1400	12	<10	<2.0	42	500	<1.0	<10	30	32
IF2-d	105	F-59d	30	60	<200	2.2	<10	<2.0	33	1100	<1.0	<10	57	66
IF2-e	106	F-59e	60	100	<200	2.1	<10	<2.0	30	1200	<1.0	<10	63	72
llF1-a	334	F-60a	0	5	860	11	<10	<2.0	54	1000	<1.0	<10	58	77
llF1-b	335	F-60b	5	15	480	5.3	<10	<2.0	52	1100	<1.0	<10	56	74
IIF1-c	336	F-60c	15	30	280	1.5	<10	<2.0	54	1200	<1.0	<10	62	79
llF1-d	337	F-60d	30	60	<200	<1.0	<10	<2.0	38	1200	<1.0	<10	46	39
IIF1-e	338	F-60e	60	100	<200	<1.0	<10	<2.0	61	1300	<1.0	<10	54	50
IIF2-a	56	F-61a	0	5	600	25	<10	<2.0	50	1000	<1.0	<10	54	82
IIF2-b	57	F-61b	5	15	440	20	<10	<2.0	51	1200	<1.0	<10	63	79
IIF2-c	58	F-61c	15	30	300	12	<10	<2.0	57	1300	<1.0	<10	62	76
IIF2-d	59	F-61d	30	60	<200	5.5	<10	<2.0	69	1300	<1.0	<10	58	73
IIF2-e	60	F-61e	60	100	260	2.8	<10	<2.0	79	1400	<1.0	<10	64	77
IIF3-a	51	F-62a	0	5	<200	11.0	<10	<2.0	12	670	<1.0	<10	35	37
IIF3-b	52	F-62b	5	15	<200	1.3	<10	<2.0	8.2	520	<1.0	<10	22	20
IIF3-c	53	F-62c	15	30	<200	1.2	<10	<2.0	7.7	470	<1.0	<10	20	19
IIF3-d	54	F-62d	30	60	<200	<1.0	<10	<2.0	12	590	<1.0	<10	26	24
IIF3-e	55	F-62e	60	90	<200	<1.0	<10	<2.0	16	660	<1.0	<10	30	31
IIIF1-a	356	F-63a	0	5	810	2.2	<10	<2.0	30	680	<1.0	<10	51	63
IIIOC8-b	357	F-63b	5	15	<200	1.8	<10	<2.0	18	1000	<1.0	<10	58	44
IIIOC8-c	358	F-63c	15	30	<200	1.2	<10	<2.0	15	1000	<1.0	<10	58	39
IIIOC8-d	359	F-63d	30	70	<200	1.1	<10	<2.0	13	790	<1.0	<10	63	43
IIIF2-a	27	F-64a	0	5	510	93	<10	<2.0	30	650	<1.0	<10	42	71
IIIF2-b	28	F-64b	5	15	370	17	<10	<2.0	28	670	<1.0	<10	40	44
IIIF2-c	29	F-64c	15	30	260	4.4	<10	<2.0	34	900	<1.0	<10	48	47
IIIF2-d	30	F-64d	30	55	<200	3.0	<10	<2.0	38	930	<1.0	<10	50	51

Sample (Golder)	Sam- ple ASU	Sample (Queen's)	from (cm)	to (cm)	S (µg/ g)	Sb (µg/ g)	Se (µg/ g)	Sn (μg/ g)	Sr (μg/ g)	Ti (μg/ g)	TI (μg/ g)	U (µg/ g)	V (µg/ g)	Zn (μg/ g)
IIIF2-e	31	F-64e	55	100	<200	1.2	<10	<2.0	15	510	<1.0	<10	26	25
IVF1-b	87	F-65b	5	15	<200	6.8	<10	<2.0	15	460	<1.0	<10	23	23
IVF1-c	88	F-65c	15	30	<200	1.3	<10	<2.0	10	510	<1.0	<10	25	22
IVF1-d	89	F-65d	30	60	<200	<1.0	<10	<2.0	32	820	<1.0	<10	40	44
IVF1-e	90	F-65e	60	100	<200	<1.0	<10	<2.0	49	1100	<1.0	<10	53	64
IVF1-a	101	F-65a	0	5	1800	100	<10	<2.0	57	120	<1.0	<10	<10	33
IVF2-a	344	F-66a	0	5	1200	270	<10	<2.0	16	120	<1.0	<10	11	41
IVF2-b	345	F-66b	5	20	1700	93	<10	<2.0	14	79	<1.0	<10	<10	34
IVF2-c	346	F-66c	20	30	1000	2.4	<10	<2.0	25	880	<1.0	<10	42	33
IVF2-d	347	F-66d	30	60	560	1.2	<10	<2.0	25	970	<1.0	<10	42	39
IVF2-e	348	F-66e	60	100	480	1.5	<10	<2.0	28	1000	<1.0	<10	46	44
IVF3A-a	19	F-67a	0	5	3100	210	<10	<2.0	45	140	<1.0	<10	22	130
IVF3A-b	20	F-67b	5	15	2200	230	<10	<2.0	54	150	<1.0	<10	18	87
IVF3A-c	21	F-67c	15	35	960	26	<10	<2.0	43	540	<1.0	<10	36	74
IVF3B-a	22	F-68a	0	5	1300	93	<10	<2.0	19	170	<1.0	<10	14	62
IVF3B-b	23	F-68b	5	15	1600	22	<10	<2.0	24	100	<1.0	<10	11	19
IVF3B-c	24	F-68c	15	30	1600	14	<10	<2.0	28	300	<1.0	<10	21	30
IVF3B-d	25	F-68d	30	60	200	2.1	<10	<2.0	31	1300	<1.0	<10	64	72
IVF3B-e	26	F-68e	60	100	<200	1.3	<10	<2.0	19	910	<1.0	<10	45	49
IXF1-a	113	F-69a	0	5	2000	190	<10	<2.0	67	180	<1.0	<10	18	56
IXF1-b	114	F-69b	5	15	1600	32	<10	<2.0	94	140	<1.0	15	12	17
IXF1-c	115	F-69c	15	30	1800	9.4	<10	<2.0	160	180	<1.0	50	18	18
IXF1-d	116	F-69d	30	55	2400	4.4	<10	<2.0	170	140	<1.0	72	17	<15
IXF1-e	117	F-69e	55	100	670	1.6	<10	<2.0	67	720	<1.0	<10	38	42
IXF2-a	37	F-70a	0	5	2200	120	<10	<2.0	22	450	<1.0	<10	62	100
IXF2-b	38	F-70b	5	15	1500	140	<10	<2.0	33	250	<1.0	<10	30	64
IXF2-c	39	F-70c	15	30	1600	25	<10	<2.0	51	180	<1.0	<10	17	25
IXF2-d	40	F-70d	30	45	410	5.0	<10	<2.0	25	560	<1.0	<10	34	34
IXF3-a	329	F-71a	0	5	2200	60	<10	<2.0	36	520	<1.0	<10	44	110
IXF3-b	330	F-71b	5	15	<200	3.1	<10	<2.0	13	700	<1.0	<10	30	34
IXF3-c	331	F-71c	15	30	<200	3.2	<10	<2.0	17	940	<1.0	<10	44	47
IXF3-d	332	F-71d	30	60	400	1.3	<10	<2.0	22	1300	<1.0	<10	58	67
IXF3-e	333	F-71e	60	100	220	<1.0	<10	<2.0	13	830	<1.0	<10	36	42
IXF4-a	1	F-72a	0	5	1900	49	<10	<2.0	69	110	<1.0	<10	19	580
IXF4-b	2	F-72b	5	15	3900	570	<10	<2.0	37	220	<1.0	<10	60	380
IXF4-c	3	F-72c	15	30	1100	86	<10	<2.0	36	860	<1.0	<10	49	110
IXF4-d	4	F-72d	30	60	700	26	<10	<2.0	36	1300	<1.0	<10	59	81
IXF4-e	5	F-72e	60	85	<200	9.3	<10	<2.0	31	1300	<1.0	<10	55	64
IXF4-f	6	F-72f	85	100	<200	2.6	<10	<2.0	19	1100	<1.0	<10	41	43
VF1-a	170	F-73a	0	5	2700	39	<10	<2.0	70	220	<1.0	<10	18	17
VF1-b	171	F-73b	5	15	550	4.8	<10	<2.0	46	590	<1.0	<10	32	30
VF1-c	172	F-73c	15	30	460	1.2	<10	<2.0	52	660	<1.0	<10	36	30
VF1-d	173	F-73d	30	50	<200	<1.0	<10	<2.0	50	870	<1.0	<10	42	38
VF1-e	174	F-73e	50	100	<200	<1.0	<10	<2.0	48	1200	<1.0	<10	57	60
VF2-e	161	F-74e	80	90	<200	<1.0	<10	<2.0	18	750	<1.0	<10	37	40

Sample (Golder)	Sam- ple ASU	Sample (Queen's)	from (cm)	to (cm)	S (μg/ g)	Sb (µg/ g)	Se (µg/ g)	Sn (µg/ g)	Sr (µg/ g)	Ti (μg/ g)	TI (μg/ g)	U (µg/ g)	V (µg/ g)	Zn (μg/ g)
VF2-f	162	F-74f	100	110	<200	<1.0	<10	<2.0	9.0	620	<1.0	<10	31	33
VF2-a	175	F-74a	0	10	1500	14	<10	<2.0	23	190	<1.0	<10	13	42
VF2-b	176	F-74b	10	20	<200	1.4	<10	<2.0	11	490	<1.0	<10	26	23
VF2-c	177	F-74c	20	50	<200	<1.0	<10	<2.0	9.5	470	<1.0	<10	22	20
VF2-d	178	F-74d	50	80	<200	<1.0	<10	<2.0	9.1	550	<1.0	<10	27	30
VIF1-a	222	F-75a	0	5	2400	15	<10	<2.0	78	140	<1.0	<10	18	22
VIF1-b	223	F-75b	5	20	840	4.9	<10	<2.0	71	680	<1.0	<10	41	35
VIF1-c	224	F-75c	20	30	<200	<1.0	<10	<2.0	38	980	<1.0	<10	45	42
VIF1-d	225	F-75d	30	60	<200	<1.0	<10	<2.0	36	960	<1.0	<10	43	46
VIF1-e	226	F-75e	60	90	<200	<1.0	<10	<2.0	40	1200	<1.0	<10	48	54
VIF2-e	213	F-76e	50	60	1000	<1.0	<10	<2.0	21	290	<1.0	<10	28	18
VIF2-f	214	F-76f	60	80	<200	<1.0	<10	<2.0	5.8	440	<1.0	<10	34	26
VIF2-g	215	F-76g	80	85	<200	<1.0	<10	<2.0	25	660	<1.0	<10	39	41
VIF2-a	227	F-76a	0	5	1500	78	<10	<2.0	36	140	<1.0	<10	12	30
VIF2-b	228	F-76b	5	10	1100	7.4	<10	<2.0	45	200	<1.0	<10	24	15
VIF2-c	229	F-76c	10	30	<200	<1.0	<10	<2.0	6.9	440	<1.0	<10	21	<15
VIF2-d	230	F-76d	30	50	<200	<1.0	<10	<2.0	8.0	390	<1.0	<10	22	<15
VIF3-a	216	F-77a	0	5	400	14	<10	<2.0	16	500	4.6	<10	54	67
VIF3-b	217	F-77b	5	15	<200	2.4	<10	<2.0	5.2	430	<1.0	<10	34	22
VIF3-c	218	F-77c	15	25	<200	<1.0	<10	<2.0	<5.0	530	<1.0	<10	29	18
VIF3-d	219	F-77d	25	45	<200	1.1	<10	<2.0	6.2	520	<1.0	<10	30	20
VIF3-e	220	F-77e	45	55	<200	<1.0	<10	<2.0	6.7	360	<1.0	<10	24	18
VIF3-f	221	F-77f	55	80	<200	<1.0	<10	<2.0	9.4	390	<1.0	<10	27	21
VIF4-a	204	F-78a	0	5	2300	85	<10	<2.0	68	32	<1.0	<10	<10	48
VIF4-b	205	F-78b	5	10	1700	35	<10	<2.0	71	64	<1.0	<10	<10	42
VIF4-c	206	F-78c	10	30	<200	<1.0	<10	<2.0	6.7	280	<1.0	<10	18	16
VIF4-d	207	F-78d	30	60	<200	<1.0	<10	<2.0	6.6	380	<1.0	<10	24	20
VIF4-e	208	F-78e	60	100	<200	<1.0	<10	<2.0	6.5	350	<1.0	<10	21	23
VIIF1-a	245	F-79a	0	5	2300	11	<10	<2.0	76	130	<1.0	<10	13	50
VIIF1-b	246	F-79b	5	20	1500	2.9	<10	<2.0	44	360	<1.0	<10	25	21
VIIF1-c	247	F-79c	20	30	440	1.3	<10	<2.0	39	980	<1.0	<10	50	52
VIIF1-d	248	F-79d	30	60	<200	<1.0	<10	<2.0	45	1100	<1.0	<10	55	61
VIIF1-e	249	F-79e	60	100	400	<1.0	<10	<2.0	35	1300	<1.0	<10	60	73
VIIF2-e	236	F-80e	60	70	<200	<1.0	<10	<2.0	21	810	<1.0	<10	43	45
VIIF2-f	237	F-80f	70	100	<200	<1.0	<10	<2.0	19	890	<1.0	<10	44	52
VIIF2-a	250	F-80a	0	5	1000	5.8	<10	<2.0	26	560	<1.0	<10	33	41
VIIF2-b	251	F-80b	5	15	280	1.3	<10	<2.0	19	660	<1.0	<10	32	30
VIIF2-c	252	F-80c	15	30	220	1.5	<10	<2.0	21	810	<1.0	<10	40	46
VIIF2-d	253	F-80d	30	60	<200	<1.0	<10	<2.0	30	960	<1.0	<10	45	55
VIIIF1-a	283	F-81a	0	5	2000	17	<10	<2.0	28	85	<1.0	<10	<10	40
VIIIF1-b	284	F-81b	5	15	4200	10	<10	<2.0	52	160	<1.0	<10	10	26
VIIIF1-c	285	F-81c	15	30	2500	6.2	<10	<2.0	60	530	<1.0	<10	27	33
VIIIF1-d	286	F-81d	30	60	1900	3.2	<10	<2.0	67	830	<1.0	<10	40	45
VIIIF1-e	287	F-81e	60	70	2600	4.0	<10	<2.0	74	830	<1.0	<10	40	44
VIIIF2-a	271	F-82a	0	5	1300	76	<10	<2.0	19	220	<1.0	<10	20	80

Sample (Golder)	Sam- ple ASU	Sample (Queen's)	from (cm)	to (cm)	S (μg/ g)	Sb (µg/ g)	Se (µg/ g)	Sn (μg/ g)	Sr (μg/ g)	Ti (μg/ g)	TI (μg/ g)	U (µg/ g)	V (µg/ g)	Zn (μg/ g)
VIIIF2-b	272	F-82b	5	15	1400	12	<10	<2.0	45	200	<1.0	<10	15	38
VIIIF2-c	273	F-82c	15	30	1100	5.1	<10	<2.0	70	550	<1.0	<10	32	35
VIIIF2-d	274	F-82d	30	60	300	<1.0	<10	<2.0	59	1200	<1.0	<10	58	66
VIIIF3-a	275	F-83a	0	5	560	31	<10	<2.0	35	1200	<1.0	<10	60	100
VIIIF3-b	276	F-83b	5	15	240	16	<10	<2.0	40	1500	<1.0	<10	69	88
VIIIF3-c	277	F-83c	15	30	<200	<1.0	<10	<2.0	26	1400	<1.0	<10	57	65
VIIIF3-d	278	F-83d	30	60	<200	<1.0	<10	<2.0	19	1100	<1.0	<10	50	58
VIIIF4-a	297	F-84a	0	5	2100	20	<10	<2.0	50	130	<1.0	<10	18	34
VIIIF4-b	298	F-84b	5	15	2800	16	<10	<2.0	73	330	<1.0	<10	22	50
VIIIF4-c	299	F-84c	15	30	1200	7.4	<10	<2.0	62	860	<1.0	<10	43	55
VIIIF4-d	300	F-84d	30	60	360	2.0	<10	<2.0	59	1200	<1.0	<10	55	63
VIIIF4-e	301	F-84e	60	90	760	1.5	<10	<2.0	61	1100	<1.0	<10	57	68
VIIIF5-a	302	F-85a	0	5	280	5.2	<10	<2.0	35	1200	<1.0	<10	61	64
VIIIF5-b	303	F-85b	5	15	<200	2.3	<10	<2.0	37	1400	<1.0	<10	68	72
VIIIF5-c	304	F-85c	15	30	<200	<1.0	<10	<2.0	32	1200	<1.0	<10	60	63
VIIIF5-d	305	F-85d	30	60	<200	<1.0	<10	<2.0	39	1400	<1.0	<10	66	71
VIIIF5-e	308	F-85e	60	100	<200	<1.0	<10	<2.0	29	1300	<1.0	<10	80	60
IWL1-a	136	W-86a	0	5	1400	16.0	<10	<2.0	14	380	<1.0	<10	26	48
IWL1-b	137	W-86b	5	15	470	8.9	<10	<2.0	9.7	460	<1.0	<10	27	42
IWL1-c	138	W-86c	15	30	330	1.6	<10	<2.0	11	680	<1.0	<10	28	31
IWL1-d	139	W-86d	30	60	<200	1.0	<10	<2.0	9.3	640	<1.0	<10	26	28
IWL1-e	140	W-86e	60	100	200	1.2	<10	<2.0	10	780	<1.0	<10	33	36
IWL2-a	46	W-87a	0	5	1700	16	<10	<2.0	43	160	<1.0	<10	28	110
IWL2-b	47	W-87b	5	15	1100	39	<10	<2.0	20	440	<1.0	<10	41	86
IWL2-c	48	W-87c	15	30	260	5.0	<10	<2.0	17	930	<1.0	<10	42	42
IWL2-d	49	W-87d	30	60	<200	1.3	<10	<2.0	17	980	<1.0	<10	38	40
IWL2-e	50	W-87e	60	100	<200	<1.0	<10	<2.0	21	1200	<1.0	<10	45	48
IIWL2-a	131	W-88a	0	5	6200	210	<10	<2.0	37	69	<1.0	<10	15	110
IIWL2-b	132	W-88b	5	15	3500	56	<10	<2.0	56	66	<1.0	<10	13	47
IIWL2-c	133	W-88c	15	30	260	1.6	<10	<2.0	32	780	<1.0	<10	43	42
IIWL2-d	134	W-88d	30	60	<200	1.0	<10	<2.0	39	990	<1.0	<10	52	53
IIWL2-e	135	W-88e	60	100	<200	<1.0	<10	<2.0	62	1200	<1.0	<10	58	66
IIIWL1-c	93	W-89c	15	30	3900	470	<10	<2.0	39	540	<1.0	<10	51	620
IIIWL1-d	94	W-89d	30	60	260	11.0	<10	<2.0	44	1000	<1.0	<10	51	65
IIIWL1-e	95	W-89e	60	100	200	9.0	<10	<2.0	50	1100	<1.0	<10	53	71
IIIWL1-a	118	W-89a	0	5	1500	160	<10	<2.0	45	580	<1.0	<10	44	240
IIIWL1-b	119	W-89b	5	15	1300	200	<10	<2.0	37	640	<1.0	<10	52	280
IVWL1-a	12	W-90a	0	5	420	150	<10	<2.0	48	970	<1.0	<10	50	280
IVWL1-b	13	W-90b	5	15	<200	38	<10	<2.0	38	1200	<1.0	<10	50	160
IVWL1-c	14	W-90c	15	30	<200	8.3	<10	<2.0	48	1300	<1.0	<10	56	94
IVWL1-d	15	W-90d	30	60	<200	10.0	<10	<2.0	46	1300	<1.0	<10	54	96
IVWL1-e	16	W-90e	60	100	<200	4.4	<10	<2.0	43	1200	<1.0	<10	53	63
IVWL2-a	7	W-91a	0	5	<200	84	<10	<2.0	24	860	<1.0	<10	39	71
IVWL2-b	8	W-91b	5	15	560	270	<10	<2.0	28	780	<1.0	<10	49	230
IVWL2-c	9	W-91c	15	30	2100	800	<10	<2.0	28	250	<1.0	<10	58	520

Sample (Golder)	Sam- ple ASU	Sample (Queen's)	from (cm)	to (cm)	S (μg/ g)	Sb (µg/ g)	Se (µg/ g)	Sn (μg/ g)	Sr (μg/ g)	Ti (μg/ g)	TI (μg/ g)	U (µg/ g)	V (μg/ g)	Zn (μg/ g)
IVWL2-d	10	W-91d	30	60	4000	1100	<10	<2.0	26	140	<1.0	<10	48	610
IVWL2-e	11	W-91e	60	100	<200	1100	<10	<2.0	26	170	<1.0	<10	51	590
IVWL3-a	96	W-92a	0	5	1300	4.8	<10	<2.0	31	400	<1.0	<10	23	27
IVWL3-b	97	W-92b	5	15	760	<1.0	<10	<2.0	25	470	<1.0	<10	27	30
IVWL3-c	98	W-92c	15	30	660	8.3	<10	<2.0	24	530	<1.0	<10	30	36
IVWL3-d	99	W-92d	30	60	<200	2.0	<10	<2.0	20	740	<1.0	<10	38	38
IVWL3-e	100	W-92e	60	100	<200	1.0	<10	<2.0	20	830	<1.0	<10	40	42
IVWL4-a	149	W-93a	0	5	1400	14.0	<10	<2.0	41	530	<1.0	<10	28	35
IVWL4-b	150	W-93b	5	15	870	10	<10	<2.0	46	760	<1.0	<10	40	44
IVWL4-c	151	W-93c	15	30	490	10.0	<10	<2.0	40	750	<1.0	<10	41	42
IVWL4-d	152	W-93d	30	60	670	13	<10	<2.0	48	720	<1.0	<10	41	45
IVWL4-e	153	W-93e	60	100	340	5.7	<10	<2.0	59	1000	<1.0	<10	49	54
IVWL5-a	339	W-94a	0	5	420	4.3	<10	<2.0	23	560	<1.0	<10	28	31
IVWL5-b	340	W-94b	5	15	470	4.6	<10	<2.0	24	620	<1.0	<10	30	33
IVWL5-c	341	W-94c	15	30	380	4.8	<10	<2.0	26	750	<1.0	<10	34	38
IVWL5-d	342	W-94d	30	60	300	<1.0	<10	<2.0	32	1100	<1.0	<10	49	46
IVWL5-e	343	W-94e	60	100	380	<1.0	<10	<2.0	28	940	<1.0	<10	44	40
IXWL1-a	32	W-95a	0	5	4100	120	<10	<2.0	49	1100	<1.0	<10	56	74
IXWL1-b	33	W-95b	5	15	1700	64	<10	<2.0	54	1200	<1.0	<10	58	74
IXWL1-c	34	W-95c	15	30	480	33	<10	<2.0	43	1300	<1.0	<10	60	73
IXWL1-d	35	W-95d	30	60	<200	14	<10	<2.0	46	1200	<1.0	<10	54	68
IXWL1-e	36	W-95e	60	100	<200	12	<10	<2.0	50	1400	<1.0	<10	60	76
IXWL2-a	41	W-96a	0	5	1300	27	<10	<2.0	59	1100	<1.0	<10	61	75
IXWL2-b	42	W-96b	5	15	250	6.5	<10	<2.0	66	1300	<1.0	<10	66	78
IXWL2-c	43	W-96c	15	30	<200	3.0	<10	<2.0	66	1200	<1.0	<10	62	71
IXWL2-d	44	W-96d	30	60	<200	<1.0	<10	<2.0	74	1300	<1.0	<10	66	77
IXWL2-e	45	W-96e	60	100	<200	1.1	<10	<2.0	80	1300	<1.0	<10	64	80
VWL1-a	163	W-97a	0	5	2600	160	<10	<2.0	63	140	<1.0	<10	15	52
VWL1-b	164	W-97b	5	15	4200	26	<10	<2.0	84	58	<1.0	<10	<10	18
VWL1-c	165	W-97c	15	30	5200	7.7	<10	<2.0	80	100	<1.0	<10	<10	<15
VWL1-d	166	W-97d	30	60	5400	2.9	<10	<2.0	71	160	<1.0	<10	12	15
VWL1-e	167	W-97e	60	80	4400	2.7	<10	<2.0	62	370	<1.0	<10	22	32
VWL2-c	154	W-98c	20	40	11000	14	<10	<2.0	57	210	<1.0	<10	16	40
VWL2-d	155	W-98d	40	70	9000	10.0	<10	<2.0	69	190	<1.0	<10	13	35
VWL2-e	156	W-98e	70	100	220	<1.0	<10	<2.0	65	1200	<1.0	<10	55	64
VWL2-a	168	W-98a	0	5	12000	15	<10	<2.0	51	200	<1.0	<10	17	53
VWL2-b	169	W-98b	5	20	1300	33	<10	<2.0	6.8	1300	<1.0	<10	160	95
VWL3-a	157	W-99a	0	10	1100	9.1	<10	<2.0	26	430	<1.0	<10	23	26
VWL3-b	158	W-99b	10	50	1100	3.8	<10	<2.0	27	450	<1.0	<10	23	24
VWL3-c	159	W-99c	50	80	<200	<1.0	<10	<2.0	14	560	<1.0	<10	24	23
VWL3-d	160	W-99d	80	100	<200	<1.0	<10	<2.0	24	730	<1.0	<10	34	31
VIWL1A-a	195	W-100a	0	5	4300	23	<10	<2.0	58	1100	<1.0	<10	110	110
VIWL1A-b	196	W-100b	5	10	2600	26	<10	<2.0	28	3000	<1.0	<10	140	100
VIWL1B-a	197	W-101a	0	5	6000	25	<10	<2.0	64	820	<1.0	<10	87	87
VIWL1B-b	198	W-101b	5	10	6200	27	<10	<2.0	33	1200	<1.0	<10	110	120

Sample (Golder)	Sam- ple ASU	Sample (Queen's)	from (cm)	to (cm)	S (μg/ g)	Sb (µg/ g)	Se (µg/ g)	Sn (μg/ g)	Sr (µg/ g)	Ti (µg/ g)	TI (μg/ g)	U (µg/ g)	V (μg/ g)	Zn (μg/ g)
VIWL1B-c	199	W-101c	10	30	4500	24	<10	<2.0	30	830	<1.0	<10	78	130
VIWL1B-d	200	W-101d	30	60	2000	8.4	<10	<2.0	32	640	<1.0	<10	48	51
VIWL1B-e	201	W-101e	60	80	1400	3.2	<10	<2.0	31	640	<1.0	<10	42	54
VIIWL1-a	238	W-102a	0	10	9700	11	<10	<2.0	32	110	<1.0	<10	<10	65
VIIWL1-b	239	W-102b	10	30	11000	6.4	<10	<2.0	30	69	<1.0	<10	<10	45
VIIWL1-c	240	W-102c	30	55	9700	2.9	<10	<2.0	26	76	<1.0	<10	<10	38
VIIWL1-d	241	W-102d	55	100	16000	2.0	<10	<2.0	35	400	<1.0	<10	24	63
VIIIWL1-a	309	W-103a	0	5	2000	11	<10	<2.0	42	230	<1.0	<10	16	34
VIIIWL1-b	310	W-103b	5	15	3200	3.2	<10	<2.0	77	58	<1.0	<10	<10	<15
VIIIWL1-c	311	W-103c	15	30	3600	1.2	<10	<2.0	71	75	<1.0	<10	<10	<15
VIIIWL1-d	312	W-103d	30	60	5600	1.0	<10	<2.0	62	120	<1.0	<10	13	<15
VIIIWL1-e	313	W-103e	60	100	200	<1.0	<10	<2.0	77	1300	<1.0	<10	61	75
VIIIWL2-d	306	W-104d	30	60	<200	<1.0	<10	<2.0	55	1300	<1.0	<10	62	72
VIIIWL2-e	307	W-104e	60	100	<200	<1.0	<10	<2.0	52	1500	<1.0	<10	68	83
VIIIWL2-a	314	W-104a	0	5	2500	10	<10	<2.0	54	670	<1.0	<10	38	52
VIIIWL2-b	315	W-104b	5	15	760	2.0	<10	<2.0	52	960	<1.0	<10	50	54
VIIIWL2-c	316	W-104c	15	30	400	<1.0	<10	<2.0	45	1000	<1.0	<10	61	59

Appendix III: 30-element analysis QA/QC

All units are μ g/g. Standards and blanks:

Sample	Blank	Blank	MESS-3 Found	MESS-3 Found	MESS-3 Ex- pected
Ag	<2.0	<2.0	<2.0	<2.0	<2.0
AI	<50	<50	19000	18000	20000
As	<1.0	1.9	23	22	18
В	<20	<20	-	-	-
Ва	<5.0	<5.0	340	320	350
Be	<4.0	<4.0	<4.0	<4.0	<4.0
Ca	<100	<100	14000	13000	14000
Cd	<1.0	<1.0	<1.0	<1.0	<1.0
Co	<5.0	<5.0	13	12	12
Cr	<20	<20	33	31	36
Cu	<5.0	<5.0	32	29	31
Fe	<50	<50	36000	34000	35000
к	<20	<20	4600	4400	4900
Mg	<20	<20	14000	14000	13000
Mn	<1.0	<1.0	340	320	300
Мо	<2.0	<2.0	2.4	2.0	2.1
Na	<75	<75	12000	12000	11000
Ni	<5.0	<5.0	39	37	37
Р	<20	<20	1000	1000	1000
Pb	<10	<10	21	20	19
S	<200	<200	1700	1700	1700
Sb	<1.0	<1.0	1.2	1.2	-
Se	<10	<10	<10	<10	<10
Sn	<2.0	<2.0	<2.0	<2.0	<2.0
Sr	<5.0	<5.0	66	62	64
Ti	<10	<10	-	-	-
TI	<1.0	<1.0	<1.0	<1.0	<1.0
U	<10	<10	<10	<10	<10
V	<10	<10	83	77	84
Zn	<15	<15	140	140	130

Sample	Blank	Blank	MESS-3 Found	MESS-3 Found	MESS-3 Ex- pected
Ag	<2.0	<2.0	<2.0	<2.0	<2.0
AI	<50	<50	17000	18000	20000

Sample	Blank	Blank	MESS-3 Found	MESS-3 Found	MESS-3 Ex- pected
Ag	<2.0	<2.0	<2.0	<2.0	<2.0
AI	<50	<50	18000	19000	20000
As	<1.0	<1.0	19	20	18
В	<20	<20	-	-	-
Ba	<5.0	<5.0	340	350	350
Be	<4.0	<4.0	<4.0	<4.0	<4.0
Ca	<100	<100	14000	14000	14000
Cd	<1.0	<1.0	<1.0	<1.0	<1.0
Co	<5.0	<5.0	14	14	12
Cr	<20	<20	32	35	36
Cu	<5.0	<5.0	32	33	31
Fe	<50	<50	35000	36000	35000
к	<20	<20	4400	4700	4900
Mg	<20	<20	13000	14000	13000
Mn	<1.0	<1.0	340	350	300
Mo	<2.0	<2.0	2.2	2.3	2.1
Na	<75	<75	12000	12000	11000
Ni	<5.0	<5.0	38	40	37
Р	<20	<20	1100	1100	1000
Pb	<10	<10	22	22	19
S	<200	<200	1700	1700	1700
Sb	<1.0	<1.0	1.2	1.1	-
Se	<10	<10	<10	<10	<10
Sn	<2.0	<2.0	<2.0	<2.0	<2.0
Sr	<5.0	<5.0	66	68	64
Ti	<10	<10	-	-	-
ТІ	<1.0	<1.0	<1.0	<1.0	<1.0
U	<10	<10	<10	<10	<10
V	<10	<10	82	86	84
Zn	<15	<15	140	140	130

Sample	Blank	Blank	MESS-3 Found	MESS-3 Found	MESS-3 Ex- pected
Ag	<2.0	<2.0	<2.0	<2.0	<2.0
AI	<50	<50	16000	18000	20000

Sample	Blank	Blank	MESS-3 Found	MESS-3 Found	MESS-3 Ex- pected
As	<1.0	<1.0	18	20	18
В	<20	<20	-	-	-
Ва	<5.0	<5.0	320	340	350
Be	<4.0	<4.0	<4.0	<4.0	<4.0
Ca	<100	<100	12000	13000	14000
Cd	<1.0	<1.0	<1.0	<1.0	<1.0
Co	<5.0	<5.0	12	13	12
Cr	<20	<20	29	31	36
Cu	<5.0	<5.0	29	32	31
Fe	<50	<50	31000	34000	35000
к	<20	<20	4200	4100	4900
Mg	<20	<20	13000	14000	13000
Mn	<1.0	<1.0	280	300	300
Мо	<2.0	<2.0	<2.0	2.1	2.1
Na	<75	<75	10000	11000	11000
Ni	<5.0	<5.0	34	36	37
Р	<20	<20	940	1000	1000
Pb	<10	<10	20	21	19
S	<200	<200	1500	1600	1700
Sb	<1.0	<1.0	1.3	1.3	-
Se	<10	<10	<10	<10	<10
Sn	<2.0	<2.0	<2.0	<2.0	<2.0
Sr	<5.0	<5.0	58	62	64
Ti	<10	<10	-	-	-
TI	<1.0	<1.0	<1.0	<1.0	<1.0
U	<10	<10	<10	<10	<10
V	<10	<10	74	78	84
Zn	<15	<15	120	130	130

Sample	Blank	Blank	MESS-3 Found	MESS-3 Found	MESS-3 Ex- pected
Ag	<2.0	<2.0	<2.0	<2.0	<2.0
AI	<50	<50	17000	19000	20000
As	<1.0	<1.0	18	16	18
В	<20	<20	-	-	-
Ba	<5.0	<5.0	330	370	350
Be	<4.0	<4.0	<4.0	<4.0	<4.0
Ca	<100	<100	14000	13000	14000
Cd	<1.0	<1.0	<1.0	<1.0	<1.0
Co	<5.0	<5.0	13	12	12
Cr	<20	<20	29	28	36
Cu	<5.0	<5.0	29	33	31
Fe	<50	<50	36000	33000	35000
К	<20	<20	4000	4100	4900

Sample	Blank	Blank	MESS-3	MESS-3	MESS-3
			Found	Found	Ex- pected
As	<1.0	<1.0	19	20	18
В	<20	<20	-	-	-
Ba	<5.0	<5.0	310	330	350
Be	<4.0	<4.0	<4.0	<4.0	<4.0
Ca	<100	<100	13000	14000	14000
Cd	<1.0	<1.0	<1.0	<1.0	<1.0
Co	<5.0	<5.0	12	13	12
Cr	<20	<20	28	31	36
Cu	<5.0	<5.0	30	33	31
Fe	<50	<50	34000	36000	35000
к	<20	<20	4000	4100	4900
Mg	<20	<20	13000	14000	13000
Mn	<1.0	<1.0	310	330	300
Мо	<2.0	<2.0	2.1	2.2	2.1
Na	<75	<75	10000	11000	11000
Ni	<5.0	<5.0	34	37	37
Р	<20	<20	1000	1100	1000
Pb	<10	<10	21	20	19
S	<200	<200	1600	1700	1700
Sb	<1.0	<1.0	1.2	1.1	-
Se	<10	<10	<10	<10	<10
Sn	<2.0	<2.0	<2.0	<2.0	<2.0
Sr	<5.0	<5.0	59	64	64
Ti	<10	<10	-	-	-
ТІ	<1.0	<1.0	<1.0	<1.0	<1.0
U	<10	<10	<10	<10	<10
V	<10	<10	71	78	84
Zn	<15	<15	130	140	130

Sample	Blank	Blank	MESS-3 Found	MESS-3 Found	MESS-3 Ex- pected
Ag	<2.0	<2.0	<2.0	<2.0	<2.0
AI	<50	<50	18000	18000	20000
As	<1.0	<1.0	18	18	18
В	<20	<20	-	-	-
Ba	<5.0	<5.0	350	350	350
Be	<4.0	<4.0	<4.0	<4.0	<4.0
Ca	<100	<100	14000	13000	14000
Cd	<1.0	<1.0	<1.0	<1.0	<1.0
Co	<5.0	<5.0	12	12	12
Cr	<20	<20	30	30	36
Cu	<5.0	<5.0	31	31	31
Fe	<50	<50	36000	35000	35000
к	<20	<20	4200	4300	4900

Sample	Blank	Blank	MESS-3 Found	MESS-3 Found	MESS-3 Ex- pected
Mg	<20	<20	14000	14000	13000
Mn	<1.0	<1.0	290	280	300
Мо	<2.0	<2.0	2.2	2.0	2.1
Na	<75	<75	11000	10000	11000
Ni	<5.0	<5.0	41	31	37
Р	<20	<20	1100	940	1000
Pb	<10	<10	22	19	19
S	<200	<200	1800	1500	1700
Sb	<1.0	<1.0	1.2	1.0	-
Se	<10	<10	<10	<10	<10
Sn	<2.0	<2.0	<2.0	<2.0	<2.0
Sr	<5.0	<5.0	60	56	64
Ti	<10	<10	-	-	-
ТІ	<1.0	<1.0	<1.0	<1.0	<1.0
U	<10	<10	<10	<10	<10
V	<10	<10	75	76	84
Zn	<15	<15	130	110	130

Sample	Blank	Blank	MESS-3 Found	MESS-3 Found	MESS-3 Ex- pected
Ag	<2.0	<2.0	<2.0	<2.0	<2.0
AI	<50	<50	14000	17000	20000
As	<1.0	<1.0	16	16	18
В	<20	<20	-	-	-
Ba	<5.0	<5.0	300	310	350
Be	<4.0	<4.0	<4.0	<4.0	<4.0
Ca	<100	<100	13000	14000	14000
Cd	<1.0	<1.0	<1.0	<1.0	<1.0
Co	<5.0	<5.0	11	12	12
Cr	<20	<20	26	30	36
Cu	<5.0	<5.0	28	29	31
Fe	<50	<50	34000	35000	35000
К	<20	<20	3700	4000	4900
Mg	<20	<20	12000	12000	13000
Mn	<1.0	<1.0	270	270	300
Мо	<2.0	<2.0	<2.0	<2.0	2.1
Na	<75	<75	10000	11000	11000
Ni	<5.0	<5.0	32	33	37
Р	<20	<20	900	930	1000
Pb	<10	<10	20	20	19
S	<200	<200	1500	1500	1700
Sb	<1.0	<1.0	1.1	1.0	-
Se	<10	<10	<10	<10	<10
Sn	<2.0	<2.0	<2.0	<2.0	<2.0

Sample	Blank	Blank	MESS-3 Found	MESS-3 Found	MESS-3 Ex- pected
Mg	<20	<20	13000	13000	13000
Mn	<1.0	<1.0	290	280	300
Mo	<2.0	<2.0	2.1	2.0	2.1
Na	<75	<75	11000	11000	11000
Ni	<5.0	<5.0	33	33	37
Р	<20	<20	980	970	1000
Pb	<10	<10	21	21	19
S	<200	<200	1500	1400	1700
Sb	<1.0	<1.0	1.2	1.1	-
Se	<10	<10	<10	<10	<10
Sn	<2.0	<2.0	<2.0	<2.0	<2.0
Sr	<5.0	<5.0	60	60	64
Ti	<10	<10	-	-	-
ТІ	<1.0	<1.0	<1.0	<1.0	<1.0
U	<10	<10	<10	<10	<10
V	<10	<10	76	75	84
Zn	<15	<15	130	120	130

Sample	Blank	Blank	MESS-3 Found	MESS-3 Found	MESS-3 Ex- pected
Ag	<2.0	<2.0	<2.0	<2.0	<2.0
AI	<50	<50	17000	18000	20000
As	<1.0	<1.0	18	18	18
В	<20	<20	-	-	-
Ba	<5.0	<5.0	330	330	350
Be	<4.0	<4.0	<4.0	<4.0	<4.0
Ca	<100	<100	12000	13000	14000
Cd	<1.0	<1.0	<1.0	<1.0	<1.0
Co	<5.0	<5.0	12	12	12
Cr	<20	<20	30	30	36
Cu	<5.0	<5.0	30	31	31
Fe	<50	<50	31000	32000	35000
к	<20	<20	3900	3800	4900
Mg	<20	<20	12000	12000	13000
Mn	<1.0	<1.0	270	280	300
Мо	<2.0	<2.0	<2.0	<2.0	2.1
Na	<75	<75	9700	10000	11000
Ni	<5.0	<5.0	33	35	37
Р	<20	<20	910	960	1000
Pb	<10	<10	22	23	19
S	<200	<200	1500	1600	1700
Sb	<1.0	<1.0	1.1	1.2	-
Se	<10	<10	<10	<10	<10
Sn	<2.0	<2.0	<2.0	<2.0	<2.0

Sample	Blank	Blank	MESS-3 Found	MESS-3 Found	MESS-3 Ex- pected
Sr	<5.0	<5.0	56	58	64
Ti	<10	<10	-	-	-
TI	<1.0	<1.0	<1.0	<1.0	<1.0
U	<10	<10	<10	<10	<10
V	<10	<10	67	76	84
Zn	<15	<15	120	120	130

Sample	Blank	Blank	MESS-3 Found	MESS-3 Found	MESS-3 Ex- pected
Ag	<2.0	<2.0	<2.0	<2.0	<2.0
AI	<50	<50	16000	17000	20000
As	<1.0	1.2	19	20	18
В	<20	<20	-	-	-
Ва	<5.0	<5.0	320	360	350
Be	<4.0	<4.0	<4.0	<4.0	<4.0
Ca	<100	<100	12000	13000	14000
Cd	<1.0	<1.0	<1.0	<1.0	<1.0
Co	<5.0	<5.0	12	12	12
Cr	<20	<20	30	33	36
Cu	<5.0	<5.0	30	33	31
Fe	<50	<50	31000	33000	35000
к	<20	<20	3800	4000	4900
Mg	<20	<20	12000	13000	13000
Mn	<1.0	<1.0	310	330	300
Мо	<2.0	<2.0	<2.0	2.0	2.1
Na	<75	<75	10000	11000	11000
Ni	<5.0	<5.0	37	40	37
Р	<20	<20	940	990	1000
Pb	<10	<10	21	22	19
S	<200	<200	1500	1600	1700
Sb	<1.0	<1.0	1.0	1.1	-
Se	<10	<10	<10	<10	<10
Sn	<2.0	<2.0	<2.0	<2.0	<2.0
Sr	<5.0	<5.0	64	69	64
Ti	<10	<10	-	-	-
ТІ	<1.0	<1.0	<1.0	<1.0	<1.0
U	<10	<10	<10	<10	<10
V	<10	<10	74	81	84
Zn	<15	<15	130	140	130

Sample	Blank	Blank	MESS-3 Found	MESS-3 Found	MESS-3 Ex- pected
Ag	<2.0	<2.0	<2.0	<2.0	<2.0
AI	<50	<50	15000	18000	20000

Sample	Blank	Blank	MESS-3 Found	MESS-3 Found	MESS-3 Ex- pected
Sr	<5.0	<5.0	58	60	64
Ti	<10	<10	-	-	-
ТІ	<1.0	<1.0	<1.0	<1.0	<1.0
U	<10	<10	<10	<10	<10
V	<10	<10	73	75	84
Zn	<15	<15	120	130	130

Sample	Blank	Blank	MESS-3 Found	MESS-3 Found	MESS-3 Ex- pected
Ag	<2.0	<2.0	<2.0	<2.0	<2.0
AI	<50	<50	19000	18000	20000
As	<1.0	<1.0	20	18	18
В	<20	<20	-	-	-
Ba	<5.0	<5.0	340	330	350
Be	<4.0	<4.0	<4.0	<4.0	<4.0
Ca	<100	<100	14000	13000	14000
Cd	<1.0	<1.0	<1.0	<1.0	<1.0
Co	<5.0	<5.0	12	12	12
Cr	<20	<20	32	31	36
Cu	<5.0	<5.0	34	32	31
Fe	<50	<50	38000	36000	35000
к	<20	<20	4300	4100	4900
Mg	<20	<20	14000	13000	13000
Mn	<1.0	<1.0	330	320	300
Mo	<2.0	<2.0	2.2	2.1	2.1
Na	<75	<75	12000	11000	11000
Ni	<5.0	<5.0	38	35	37
Р	<20	<20	1100	1000	1000
Pb	<10	<10	22	20	19
S	<200	<200	1800	1600	1700
Sb	<1.0	<1.0	1.1	1.1	-
Se	<10	<10	<10	<10	<10
Sn	<2.0	<2.0	<2.0	<2.0	<2.0
Sr	<5.0	<5.0	65	63	64
Ti	<10	<10	-	-	-
ТІ	<1.0	<1.0	<1.0	<1.0	<1.0
U	<10	<10	<10	<10	<10
V	<10	<10	80	79	84
Zn	<15	<15	140	130	130

Sample	Blank	Blank	MESS-3 Found	MESS-3 Found	MESS-3 Ex- pected
Ag	<2.0	<2.0	<2.0	<2.0	<2.0
AI	<50	<50	19000	16000	20000

Sample	Blank	Blank	MESS-3 Found	MESS-3 Found	MESS-3 Ex- pected				
As	<1.0	<1.0	18	18	18				
В	<20	<20	-	-	-				
Ва	<5.0	<5.0	300	320	350				
Be	<4.0	<4.0	<4.0	<4.0	<4.0				
Ca	<100	<100	13000	13000	14000				
Cd	<1.0	<1.0	<1.0	<1.0	<1.0				
Co	<5.0	<5.0	13	13	12				
Cr	<20	<20	28	31	36				
Cu	<5.0	<5.0	30	30	31				
Fe	<50	<50	33000	34000	35000				
к	<20	<20	3800	4100	4900				
Mg	<20	<20	13000	13000	13000				
Mn	<1.0	<1.0	290	290	300				
Мо	<2.0	<2.0	2.1	2.1	2.1				
Na	<75	<75	11000	10000	11000				
Ni	<5.0	<5.0	36	36	37				
Р	<20	<20	1000	1000	1000				
Pb	<10	<10	21	21	19				
S	<200	<200	1700	1600	1700				
Sb	<1.0	<1.0	1.1	1.1	-				
Se	<10	<10	<10	<10	<10				
Sn	<2.0	<2.0	<2.0	<2.0	<2.0				
Sr	<5.0	<5.0	61	63	64				
Ti	<10	<10	-	-	-				
TI	<1.0	<1.0	<1.0	<1.0	<1.0				
U	<10	<10	<10	<10	<10				
V	<10	<10	71	78	84				
Zn	<15	<15	140	140	130				

Sample	Blank	Blank	MESS-3 Found	MESS-3 Found	MESS-3 Ex- pected
Ag	<2.0	<2.0	<2.0	<2.0	<2.0
AI	<50	<50	18000	17000	20000
As	<1.0	<1.0	20	20	18
В	<20	<20	-	-	-
Ba	<5.0	<5.0	330	320	350
Be	<4.0	<4.0	<4.0	<4.0	<4.0
Ca	<100	<100	14000	14000	14000
Cd	<1.0	<1.0	<1.0	<1.0	<1.0
Co	<5.0	<5.0	13	13	12
Cr	<20	<20	32	31	36
Cu	<5.0	<5.0	32	31	31
Fe	<50	<50	35000	36000	35000
К	<20	<20	4400	4200	4900

Sample	Blank	Blank	MESS-3	MESS-3	MESS-3				
			Found	Found	Ex- pected				
As	<1.0	<1.0	19	20	18				
В	<20	<20	-	-	-				
Ba	<5.0	<5.0	380	350	350				
Be	<4.0	<4.0	<4.0	<4.0	<4.0				
Ca	<100	<100	14000	14000	14000				
Cd	<1.0	<1.0	<1.0	<1.0	<1.0				
Co	<5.0	<5.0	13	13	12				
Cr	<20	<20	34	30	36				
Cu	<5.0	<5.0	33	32	31				
Fe	58	<50	36000	36000	35000				
к	<20	<20	4500	4200	4900				
Mg	<20	<20	13000	13000	13000				
Mn	2.5	<1.0	310	310	300				
Мо	<2.0	<2.0	<2.0	<2.0	2.1				
Na	<75	<75	11000	11000	11000				
Ni	<5.0	<5.0	38	37	37				
Р	<20	<20	1000	1000	1000				
Pb	<10	<10	21	22	19				
S	<200	<200	1600	1600	1700				
Sb	<1.0	<1.0	1.3	1.1	-				
Se	<10	<10	<10	<10	<10				
Sn	<2.0	<2.0	<2.0	<2.0	<2.0				
Sr	<5.0	<5.0	67	62	64				
Ti	<10	<10	-	-	-				
ТІ	<1.0	<1.0	<1.0	<1.0	<1.0				
U	<10	<10	<10	<10	<10				
V	<10	<10	84	74	84				
Zn	<15	<15	140	140	130				

Sample	Blank	Blank	MESS-3 Found	MESS-3 Found	MESS-3 Ex- pected
Ag	<2.0	<2.0	<2.0	<2.0	<2.0
AI	<50	<50	19000	18000	20000
As	1.9	<1.0	18	19	18
В	<20	<20	-	-	-
Ba	<5.0	<5.0	370	370	350
Be	<4.0	<4.0	<4.0	<4.0	<4.0
Ca	<100	<100	13000	13000	14000
Cd	<1.0	<1.0	<1.0	<1.0	<1.0
Co	<5.0	<5.0	12	13	12
Cr	<20	<20	30	30	36
Cu	<5.0	<5.0	34	34	31
Fe	<50	<50	33000	34000	35000
к	<20	<20	3900	3900	4900

Sample	Blank	Blank	MESS-3 Found	MESS-3 Found	MESS-3 Ex- pected
Mg	<20	<20	13000	13000	13000
Mn	<1.0	<1.0	300	310	300
Мо	<2.0	<2.0	<2.0	<2.0	2.1
Na	<75	<75	11000	11000	11000
Ni	<5.0	<5.0	36	37	37
Р	<20	<20	970	990	1000
Pb	<10	<10	22	22	19
S	<200	<200	1600	1600	1700
Sb	<1.0	<1.0	1.2	<1.0	-
Se	<10	<10	<10	<10	<10
Sn	<2.0	<2.0	<2.0	<2.0	<2.0
Sr	<5.0	<5.0	65	65	64
Ti	<10	<10	-	-	-
TI	<1.0	<1.0	<1.0	<1.0	<1.0
U	<10	<10	<10	<10	<10
V	<10	<10	81	79	84
Zn	<15	<15	140	140	130

Sample	Blank	Blank	MESS-3 Found	MESS-3 Found	MESS-3 Ex- pected
Mg	<20	<20	14000	14000	13000
Mn	<1.0	<1.0	310	320	300
Мо	<2.0	<2.0	2.2	2.1	2.1
Na	<75	<75	11000	11000	11000
Ni	<5.0	<5.0	36	36	37
Р	<20	<20	890	940	1000
Pb	<10	<10	17	18	19
S	<200	<200	1400	1400	1700
Sb	<1.0	<1.0	1.1	1.0	-
Se	<10	<10	<10	<10	<10
Sn	<2.0	<2.0	<2.0	<2.0	<2.0
Sr	<5.0	<5.0	61	62	64
Ti	<10	<10	-	-	-
ТІ	<1.0	<1.0	<1.0	<1.0	<1.0
U	<10	<10	<10	<10	<10
V	<10	<10	82	81	84
Zn	<15	<15	110	120	130

Duplicates:

ASU Sam ple	Ag	AI	As	As %CV	в	Ва	Ве	Ca	Cd	Co	Cr	Cu	Fe	к	Mg	Mn	Мо	Na	Ni	Р	Pb	s	Sb	Se	Sn	Sr	Ti	ті	U	v	Zn
4	<2.0	2300	190	3.8	<20	210	<4.0	7100	<1.0	16	58	34	3100	4100	1300	470	<2.0	670	36	490	26	760	27	<10	<2.0	35	1200	<1.0	<10	59	80
4	<2.0	2400	180		<20	210	<4.0	6300	<1.0	16	58	34	3100	4200	1300	470	<2.0	710	36	490	27	660	25	<10	<2.0	36	1300	<1.0	<10	59	82
20	<2.0	6000	2500	2.9	23	88	<4.0	2900	<1.0	5.4	<20	45	9700	610	5500	250	15	540	16	770	39	2200	230	<10	<2.0	54	150	<1.0	<10	18	88
20	<2.0	5700	2400		23	85	<4.0	2900	<1.0	5.2	<20	44	9500	640	5300	240	15	540	15	750	39	2200	220	<10	<2.0	53	140	<1.0	<10	18	87
30	<2.0	2000	260	5.7	<20	180	<4.0	5500	<1.0	13	44	22	2600	3400	8600	350	<2.0	330	26	430	11	<200	3.0	<10	<2.0	39	970	<1.0	<10	51	53
30	<2.0	1900	240		<20	180	<4.0	5200	<1.0	12	42	21	2500	3300	8100	320	<2.0	310	24	400	12	<200	2.9	<10	<2.0	37	900	<1.0	<10	48	50
32	<2.0	2300	1500	4.6	<20	200	<4.0	1600	<1.0	20	52	210	3100	4500	1200	370	<2.0	620	64	560	15	4000	120	<10	<2.0	48	1100	<1.0	<10	55	72
32	<2.0	2400	1600		<20	200	<4.0	1700	<1.0	21	54	210	3200	4500	1200	390	<2.0	640	67	580	15	4200	120	<10	<2.0	50	1100	<1.0	<10	56	75
55	<2.0	1200	16	4.6	<20	90	<4.0	2800	<1.0	9.3	33	24	1800	2100	6300	220	<2.0	340	22	420	<10	<200	1.0	<10	<2.0	16	700	<1.0	<10	32	32
55	<2.0	1100	15		<20	86	<4.0	2500	<1.0	8.6	30	23	1600	2000	5500	210	<2.0	300	20	370	<10	<200	<1.0	<10	<2.0	15	620	<1.0	<10	29	30
64	<2.0	2900	1400	0	<20	200	<4.0	9400	<1.0	57	72	46	4500	450	1100	1600	<2.0	140	46	480	18	370	18	<10	<2.0	24	930	<1.0	<10	110	120
64	<2.0	2800	1400		<20	200	<4.0	9100	<1.0	55	70	45	4400	390	1100	1600	<2.0	120	45	430	18	510	18	<10	<2.0	23	920	<1.0	<10	100	120
71	<2.0	1100	1400	5.2	<20	33	<4.0	870	<1.0	5.7	37	12	1300	460	3800	96	<2.0	120	12	190	16	200	46	<10	<2.0	<5.0	520	<1.0	<10	34	23
71	<2.0	1100	1300		<20	34	<4.0	910	<1.0	5.9	37	12	1300	460	3900	100	<2.0	120	12	200	16	220	47	<10	<2.0	<5.0	570	<1.0	<10	35	25
92	<2.0	2500	1600	4.3	<20	110	<4.0	2500	2.8	40	130	130	4800	350	1000	2500	<2.0	76	44	1800	37	1100	56	<10	<2.0	8.4	1000	<1.0	<10	110	220
92	<2.0	2600	1700		<20	110	<4.0	2500	2.8	41	130	130	4900	370	1100	2600	<2.0	78	45	1900	37	1200	58	<10	<2.0	8.6	1000	<1.0	<10	110	230
105	<2.0	2300	180	0	<20	210	<4.0	6800	<1.0	16	53	30	3300	4300	1200	440	<2.0	590	32	610	13	200	2.3	<10	<2.0	34	1100	<1.0	<10	58	66
105	<2.0	2200	180		<20	210	<4.0	6700	<1.0	15	53	29	3300	4200	1200	420	<2.0	570	31	600	13	<200	2.1	<10	<2.0	33	1100	<1.0	<10	57	66
118	2.6	1600	1000	0.7	<20	81	<4.0	6900	1.0	30	41	170	3500	1600	1000	330	<2.0	510	55	690	120	1600	160	<10	<2.0	46	600	<1.0	<10	45	240
118	2.4	1600	990		<20	76	<4.0	6700	1.0	30	40	160	3400	1600	9700	310	<2.0	490	55	670	110	1500	160	<10	<2.0	44	560	<1.0	<10	43	240
135	<2.0	2700	23	9.9	22	260	<4.0	7100	<1.0	15	50	29	3500	4800	1200	390	<2.0	700	30	530	15	<200	<1.0	<10	<2.0	63	1200	<1.0	<10	58	68
135	<2.0	2600	20		21	260	<4.0	8500	<1.0	14	49	28	3400	4700	1200	380	<2.0	670	29	510	14	<200	<1.0	<10	<2.0	61	1100	<1.0	<10	57	65
148	<2.0	2900	4600	14	<20	84	<4.0	3900	<1.0	32	24	49	5100	430	5400	450	<2.0	150	38	520	14	520	20	<10	<2.0	14	890	<1.0	<10	130	78
148	<2.0	3600	5600		<20	100	<4.0	5000	<1.0	39	30	61	6300	480	6300	550	<2.0	190	46	660	16	620	27	<10	<2.0	19	1200	<1.0	<10	150	96
152	<2.0	1600	180	0	<20	160	<4.0	8100	<1.0	10	35	22	2200	2600	7000	250	<2.0	360	22	480	12	670	12	<10	<2.0	48	720	<1.0	<10	40	45
152	<2.0	1600	180		<20	160	<4.0	8400	<1.0	10	35	22	2300	2600	7200	250	<2.0	370	22	490	12	670	13	<10	<2.0	49	720	<1.0	<10	41	45
165	<2.0	3300	120	0	<20	72	<4.0	1900	<1.0	<5.0	<20	11	4900	250	1300	50	2.9	240	<5.0	530	<10	5200	7.5	<10	<2.0	79	100	<1.0	<10	<10	<15

ASU Sam ple	Ag	AI	As	As %CV	в	Ва	Ве	Ca	Cd	Co	Cr	Cu	Fe	к	Mg	Mn	Мо	Na	Ni	Р	Pb	s	Sb	Se	Sn	Sr	ті	ті	U	v	Zn
165	<2.0	3300	120		<20	72	<4.0	1900	<1.0	<5.0	<20	11	4800	250	1300	50	2.9	240	<5.0	520	<10	5200	7.8	<10	<2.0	80	100	<1.0	<10	<10	<15
178	<2.0	9700	22	3.3	<20	68	<4.0	2400	<1.0	8.1	32	21	1500	1600	5100	170	<2.0	210	20	430	<10	<200	<1.0	<10	<2.0	9.0	540	<1.0	<10	27	31
178	<2.0	9600	21		<20	67	<4.0	2300	<1.0	7.9	32	20	1400	1600	4900	170	<2.0	200	19	410	<10	<200	<1.0	<10	<2.0	9.2	550	<1.0	<10	27	30
191	<2.0	1300	530	8.8	<20	110	<4.0	1900	<1.0	9.6	34	17	1900	440	4900	230	<2.0	92	20	590	15	<200	18	<10	<2.0	9.8	590	<1.0	<10	43	55
191	<2.0	1300	600		<20	130	<4.0	2200	<1.0	10	36	19	1800	460	4200	250	<2.0	110	20	680	17	300	22	<10	<2.0	12	600	<1.0	<10	42	58
204	<2.0	1800	67	1.1	<20	73	<4.0	3500	<1.0	<5.0	<20	17	2800	770	3800	1000	<2.0	120	6.1	740	13	2200	84	<10	<2.0	67	31	<1.0	<10	<10	48
204	<2.0	1900	68		<20	74	<4.0	3600	<1.0	<5.0	<20	17	2800	760	3900	1100	<2.0	120	6.3	740	13	2300	86	<10	<2.0	68	33	<1.0	<10	<10	48
209	<2.0	1100	730	5	<20	150	<4.0	7200	1.3	14	31	56	2300	360	4700	360	<2.0	<75	28	1000	48	1700	120	<10	<2.0	13	940	<1.0	<10	53	130
209	<2.0	1400	680		<20	150	<4.0	7200	1.4	17	42	52	3000	350	6800	480	<2.0	<75	31	990	45	1600	120	<10	<2.0	12	1300	<1.0	<10	67	140
216	<2.0	1300	610	8.6	<20	300	<4.0	6400	<1.0	45	40	51	2200	670	3700	6300	<2.0	130	23	1300	19	420	15	<10	<2.0	16	520	5.0	<10	56	69
216	<2.0	1300	540		<20	270	<4.0	5600	<1.0	40	41	46	2200	600	4200	5600	<2.0	120	24	1200	18	380	14	<10	<2.0	15	480	4.2	<10	53	65
222	<2.0	3800	220	0	<20	100	<4.0	2400	<1.0	7.8	<20	19	5400	860	3700	600	<2.0	180	12	780	<10	2300	14	<10	<2.0	75	130	<1.0	<10	18	22
222	<2.0	4000	220		<20	100	<4.0	2600	<1.0	7.8	<20	20	5500	900	3900	620	2.2	200	13	850	<10	2400	16	<10	<2.0	81	140	<1.0	<10	19	23
228	<2.0	9100	390	7.6	<20	250	<4.0	1400	<1.0	15	22	32	1300	420	2500	460	<2.0	130	14	820	<10	1200	8.0	<10	<2.0	47	180	<1.0	<10	20	17
228	<2.0	8800	350		<20	220	<4.0	1300	<1.0	11	22	30	1300	410	2600	320	<2.0	120	14	780	<10	1100	6.8	<10	<2.0	43	230	<1.0	<10	28	<15
233	<2.0	2800	730	2.9	<20	100	<4.0	4800	2.1	31	21	200	7000	290	9500	1600	<2.0	140	27	1300	26	660	29	<10	<2.0	30	1300	<1.0	<10	160	180
233	<2.0	2800	760		<20	110	<4.0	4400	2.1	32	21	200	7200	300	9900	1600	<2.0	120	28	1400	28	660	30	<10	<2.0	28	1100	<1.0	<10	160	190
240	<2.0	2800	47	6.3	<20	56	<4.0	1100	<1.0	<5.0	<20	18	6200	350	1300	74	<2.0	130	9.8	280	<10	9700	2.9	<10	<2.0	26	76	<1.0	<10	<10	38
240	<2.0	2800	43		<20	56	<4.0	1100	<1.0	<5.0	<20	18	6300	350	1300	74	<2.0	130	9.8	280	<10	9700	2.9	<10	<2.0	26	76	<1.0	<10	<10	38
246	<2.0	8000	41	8.1	<20	98	<4.0	2500	<1.0	6.4	21	25	1300	720	4700	850	<2.0	180	17	490	<10	1600	3.1	<10	<2.0	45	330	<1.0	<10	23	20
246	<2.0	8700	46		<20	96	<4.0	2400	<1.0	7.4	23	26	1500	740	5200	910	<2.0	180	18	490	<10	1500	2.6	<10	<2.0	43	390	<1.0	<10	26	22
252	<2.0	1400	26	2.7	<20	97	<4.0	4100	<1.0	12	43	33	2100	2500	6900	260	<2.0	350	30	560	<10	240	1.4	<10	<2.0	20	810	<1.0	<10	39	45
252	<2.0	1500	27		<20	100	<4.0	4200	<1.0	13	44	34	2100	2600	7000	270	<2.0	350	30	570	<10	220	1.5	<10	<2.0	21	820	<1.0	<10	40	46
265	<2.0	4100	50	2.8	<20	100	<4.0	1400	1.4	<5.0	<20	30	6000	330	860	120	<2.0	<75	14	1400	<10	2000	17	<10	<2.0	17	140	<1.0	<10	<10	44
265	<2.0	4300	52		<20	97	<4.0	1400	1.3	<5.0	<20	33	6400	340	910	120	<2.0	<75	15	1300	<10	2100	17	<10	<2.0	18	140	<1.0	<10	<10	43
278	<2.0	1700	14	0	<20	150	<4.0	3800	<1.0	14	55	31	2800	3500	9700	330	<2.0	420	34	550	11	<200	<1.0	<10	<2.0	19	1100	<1.0	<10	50	58
278	<2.0	1800	14		<20	150	<4.0	3900	<1.0	14	55	31	2800	3500	1000	340	<2.0	450	34	540	11	<200	<1.0	<10	<2.0	20	1100	<1.0	<10	50	59
291	<2.0	3400	51	1.4	<20	54	<4.0	3300	<1.0	24	130	86	4400	320	2200	530	<2.0	76	70	1100	11	940	3.3	<10	<2.0	10	1500	<1.0	<10	120	120
291	<2.0	3400	52		<20	54	<4.0	3300	<1.0	25	130	86	4500	310	2200	540	<2.0	<75	70	1100	12	940	3.7	<10	<2.0	10	1600	<1.0	<10	120	120
304	<2.0	2200	11	26	<20	230	<4.0	1400	<1.0	16	55	35	3400	4300	1400	510	<2.0	700	34	460	13	<200	<1.0	<10	<2.0	32	1200	<1.0	<10	60	63
304	<2.0	2200	16		<20	230	<4.0	1700	<1.0	17	55	35	3500	4300	1500	610	<2.0	690	34	480	13	<200	<1.0	<10	<2.0	32	1200	<1.0	<10	61	64
327	<2.0	9500	940	2.3	<20	200	<4.0	1900	1.3	19	34	54	2100	760	6600	1400	<2.0	130	34	830	62	1700	140	<10	<2.0	33	440	<1.0	<10	35	200
327	<2.0	9200	910		<20	180	<4.0	1800	1.3	18	32	51	2000	720	6300	1300	<2.0	120	32	780	60	1600	130	<10	<2.0	30	420	<1.0	<10	33	200
340	<2.0	1300	210	0	<20	94	<4.0	5000	<1.0	6.8	28	13	1500	1600	5800	260	<2.0	230	15	390	<10	460	4.4	<10	<2.0	24	620	<1.0	<10	30	32
340	<2.0	1300	210		<20	94	<4.0	5200	<1.0	7.1	28	13	1500	1600	5900	260	<2.0	230	15	420	<10	480	4.8	<10	<2.0	24	620	<1.0	<10	30	34
359	<2.0	2000	76	0	<20	86	<4.0	5400	<1.0	17	57	40	3200	1100	1400	510	<2.0	250	36	370	<10	<200	1.0	<10	<2.0	12	770	<1.0	<10	61	44
359	<2.0	1900	76		<20	85	<4.0	6000	<1.0	16	58	40	3200	1100	1400	500	<2.0	250	35	360	<10	<200	1.1	<10	<2.0	13	800	<1.0	<10	64	43
Appendix IV: Au ICP-MS QA/QC

All units are $\mu g/g.$

Duplicates:

Sample (ASU)	Au	Mean	Standard Deviation	%CV
Sample 4	0.28	0.2	0.11	56.57
Sample 4	0.12	-	-	-
Sample 20	0.94	0.92	0.03	3.07
Sample 20	0.90	-	-	-
Sample 32	0.74	0.74	0.01	0.96
Sample 32	0.73	-	-	-
Sample 55	<0.01	<0.01	0	0
Sample 55	<0.01	-	-	-
Sample 64	0.036	0.03	0.01	37.22
Sample 64	0.021	-	-	-
Sample 71	0.18	0.15	0.04	28.28
Sample 71	0.12	-	-	-
Sample 92	0.18	0.18	0	0
Sample 92	0.18	-	-	-
Sample 105	<0.01	<0.01	0	0
Sample 105	<0.01	-	-	-
Sample 118	2.5	2.35	0.21	9.03
Sample 118	2.2	-	-	-
Sample 135	<0.01	<0.01	0	0
Sample 135	<0.01	-	-	-
Sample 148	0.041	0.05	0.01	15.37
Sample 148	0.051	-	-	-
Sample 152	0.083	0.07	0.01	16.14
Sample 152	0.066	-	-	-
Sample 165	0.035	0.04	0.01	17.68
Sample 165	0.045	-	-	-
Sample 178	0.014	0.01	0	5.24
Sample 178	0.013	-	-	-
Sample 191	0.081	0.1	0.03	27.44
Sample 191	0.12	-	-	-
Sample 204	0.25	0.27	0.03	10.48
Sample 204	0.29	-	-	-
Sample 209	0.39	0.39	0.01	1.84
Sample 209	0.38	-	-	-
Sample 216	0.064	0.06	0	6.96
Sample 216	0.058	-	-	-
Sample 222	0.11	0.11	0.01	6.73

Sample (ASU)	Au	Mean	Standard Deviation	%CV
Sample 222	0.10	-	-	-
Sample 228	0.016	0.01	0	14.63
Sample 228	0.013	-	-	-
Sample 233	0.052	0.06	0	7.71
Sample 233	0.058	-	-	-
Sample 240	<0.01	<0.01	0	0
Sample 240	<0.01	-	-	-
Sample 246	<0.01	<0.01	0	0
Sample 246	<0.01	-	-	-
Sample 252	<0.01	<0.01	0	0
Sample 252	<0.01	-	-	-
Sample 265	0.046	0.04	0	8.13
Sample 265	0.041	-	-	-
Sample 278	<0.01	<0.01	0	0
Sample 278	<0.01	-	-	-
Sample 291	<0.01	<0.01	0	0
Sample 291	<0.01	-	-	-
Sample 304	<0.01	<0.01	0	0
Sample 304	<0.01	-	-	-
Sample 327	0.64	0.69	0.07	10.25
Sample 327	0.74	-	-	-
Sample 340	0.028	0.03	0	7.19
Sample 340	0.031	-	-	-
Sample 359	0.031	0.03	0	2.32
Sample 359	0.030	-	-	-

Standards and blanks:

Sample	Au
Blank	<0.01

Sample	Au
Control 2	0.023
Control 2	0.025
Control 2	0.025
Control 2	0.025
Control 2	0.024
Control 2	0.025
Control 2	0.026
Control 2	0.025
Control 2	0.025
Control 2	0.026
Control 2	0.025
Control 2	0.026
Control 2	0.027
Control 2	0.021
Control 2	0.027
DS-1 Target	28

Sample	Au
Blank	<0.01
Control Target 1	0
Control 1	0
Control 1	0
Control 1	0
Control 1	0
Control 1	0
Control 1	0
Control 1	0
Control 1	0
Control 1	0
Control 1	0
Control Target 2	0.03
Control 2	0.026
Control 2	0.027
Control 2	0.028
Control 2	0.027
Control 2	0.027
Control 2	0.027
Control 2	0.025
Control 2	0.024
Control 2	0.024
Control 2	0.024

Sample	Au
DS-1	32
DS-1	33
DS-1	28
DS-1	29
DS-1	26
DS-1	24
DS-1	24
DS-1	24
DS-1	31
DS-1	29
DS-1	30
DS-1	29
DS-1	31
DS-1	29
DS-1	30
DS-1	31
DS-1	20
	23
D3-1	32
DS-1	32
DS-1	32
DS-1	23
DS-1	24
DS-1	23
DS-1	29
DS-1	28
DS-1	29
DS-1	28
DS-1	33
DS-1	32
DS-1	29
DS-1	29

Appendix V: Carbon QA/QC

All units are percentages.

Duplicates:

Sample (ASU)	Carbon %	Carbon %	Carbon %	Carbon %	Standard Deviation	Mean	%CV
Sample 7*	<1.0	<1.0			0	<1.0	0
Sample 23*	26.6	26.3			0.21	26.45	0.8
Sample 24*	21.5	22.3			0.57	21.9	2.58
Sample 25*	1.6	1.9			0.21	1.75	12.12
Sample 26*	<1.0	<1.0			0	<1.0	0
Sample 27*	6.6	6.8			0.14	6.7	2.11
Sample 28*	4.7	5.0			0.21	4.85	4.37
Sample 29*	2.5	2.6			0.07	2.55	2.77
Sample 34*	<1.0	<1.0			0	<1.0	0
Sample 38*	31.6	29.6			1.41	30.6	4.62
Sample 39*	33.8	30.3			2.47	32.05	7.72
Sample 40*	7.8	8.2			0.28	8	3.54
Sample 59*	<1.0	<1.0			0	<1.0	0
Sample 61*	30.1	29.3			0.57	29.7	1.9
Sample 62*	5.3	5.7	8.8	9.0	1.97	7.2	27.38
Sample 67*	14.0	14.8			0.57	14.4	3.93
Sample 72*	2.2	2.2	2.1		0.06	2.17	2.66
Sample 73*	23.6	3.0			14.57	13.3	109.52
Sample 97*	5.3	5.3			0	5.3	0
Sample 103*	40.8	41.6			0.57	41.2	1.37
Sample 108*	9.7	10.7			0.71	10.2	6.93
Sample 115*	32.7	32.6			0.07	32.65	0.22
Sample 119*	3.5	3.6			0.07	3.55	1.99
Sample 123*	1.9	2.1			0.14	2	7.07
Sample 143*	15.8	15.1			0.49	15.45	3.2
Sample 149*	5.7	5.2			0.35	5.45	6.49
Sample 168*	34.0	35.6			1.13	34.8	3.25
Sample 169*	6.6	7.6			0.71	7.1	9.96
Sample 192*	2.2	2.6			0.28	2.4	11.79
Sample 197*	12.7	11.3			0.99	12	8.25
Sample 201*	4.7	5.1			0.28	4.9	5.77
Sample 210*	9.8	10.3			0.35	10.05	3.52
Sample 223*	15.7	16.8			0.78	16.25	4.79
Sample 239*	40.2	40.0			0.14	40.1	0.35
Sample 245*	33.2	4.0			20.65	18.6	111.01
Sample 247*	3.4	3.8			0.28	3.6	7.86
Sample 254*	27.6	27.7			0.07	27.65	0.26

Sample (ASU)	Carbon %	Carbon %	Carbon %	Carbon %	Standard Deviation	Mean	%CV
Sample 274*	3.1	3.2			0.07	3.15	2.24
Sample 280*	14.5	15.7			0.85	15.1	5.62
Sample 288*	8.7	9.1			0.28	8.9	3.18
Sample 303*	<1.0	<1.0			0	<1.0	0
Sample 308*	<1.0	<1.0			0	<1.0	0
Sample 319*	18.1	18.1			0	18.1	0
Sample 323*	15.7	16.1			0.28	15.9	1.78
Sample 330*	<1.0	<1.0			0	<1.0	0
Sample 335*	3.5	3.3			0.14	3.4	4.16
Sample 348*	<1.0	<1.0			0	<1.0	0
Sample 356*	8.4	7.9			0.35	8.15	4.34
Sample 359*	<1.0	<1.0			0	<1.0	0

Standards and blanks:

Sample	Carbon %
Blank	<1.0
Soil Control	12.9
Soil Control	12.4
Soil Control	12.7
Soil Control	12.3
Soil Control	12.4
Soil Control	12.00
Soil Control	11.6
Soil Control	13.4
Soil Control	12.7
Soil Control	12.6
Soil Control	12.5
Soil Control	12.3
Soil Control	12.3
Mean	12.5
Standard Deviation	0.4
%CV	3.5

Sample	Carbon %
Soil Control Target	12.3
Orchard Leaves Control	54.2
Orchard Leaves Control	58.1
Orchard Leaves Control	51.5
Orchard Leaves Control	52.4
Orchard Leaves Control	49.6
Orchard Leaves Control	50.6
Orchard Leaves Control	52.6
Orchard Leaves Control	52.5
Orchard Leaves Control	50.6
Orchard Leaves Control	57.9
Orchard Leaves Control	53.8
Orchard Leaves Control	52.4
Orchard Leaves Control	51.8
Mean	53.98
Standard Deviation	2.75
%CV	5.09
Orchard Leaves Control Target	51.4

Appendix VI: MLA Sample Information

Samples colored in grey were not chosen for MLA analysis. They are included here to provide context to those that were chosen.

	Site	Note	Golder_ho- rizon	Queen's name	ASU sam- ple	from_cm	to_cm	Au_µg/g	As	S
			IIIF2-a	F-64a	Sample 27	0	5	0.53	1500	510
			IIIF2-b	F-64b	Sample 28	5	15	0.065	840	370
	III-F-2		IIIF2-c	F-64c	Sample 29	15	30	0.013	280	260
			IIIF2-d	F-64d	Sample 30	30	55	<0.01	250	<200
			IIIF2-e	F-64e	Sample 31	55	100	<0.01	40	<200
F			IVF2-a	F-66a	Sample 344	0	5	0.96	1700	1200
0			IVF2-b	F-66b	Sample 345	5	20	0.25	1300	1700
R	IV-F-2	public access- road	IVF2-c	F-66c	Sample 346	20	30	0.010	80	1000
E			IVF2-d	F-66d	Sample 347	30	60	<0.01	17	560
S			IVF2-e	F-66e	Sample 348	60	100	0.012	14	480
Т			IXF4-a	F-72a	Sample 1	0	5	0.22	240	1900
	IX-F-4	Disturbed area. Anomalous Au	IXF4-b	F-72b	Sample 2	5	15	48	3600	3900
			IXF4-c	F-72c	Sample 3	15	30	0.86	600	1100
			IXF4-d	F-72d	Sample 4	30	60	0.20	180	700
			IXF4-e	F-72e	Sample 5	60	85	0.17	48	<200
			IXF4-f	F-72f	Sample 6	85	100	0.027	22	<200
		II-OC-5 Highest As sites. Best shot for statistical signifi- cance of MLA re- sults.	IIOC5-a	O-10a	Sample 70	0	3	3.1	17000	1200
			IIOC5-b	O-10b	Sample 71	3	10	0.15	1300	210
	II-OC-5		IIOC5-c	O-10c	Sample 72	10	20	0.036	2000	220
			llOC9-a	O-14a	Sample 80	0	3	0.35	1400	1100
	II-OC-9		IIOC9-b	O-14b	Sample 81	3	10	0.019	2400	420
			IIOC9-c	O-14c	Sample 82	10	15	0.016	2400	600
	II-OC-10		llOC10-a	O-5a	Sample 83	0	5	1.0	16000	2000
			IIOC10-b	O-5b	Sample 84	5	8	0.081	7200	820
	II-OC-11		llOC11-a	O-6a	Sample 85	0	5	0.90	11000	920
			IIOC11-b	O-6b	Sample 86	5	10	0.37	7800	920
	III-OC-5	Chose over	IIIOC5-a	O-18a	Sample 124	0	5	0.11	3200	350
		III-OC-1	IIIOC5-b	O-18b	Sample 125	5	10	0.059	4100	610

		Chose over	IIIOC2-a	O-16a	Sample 122	0	8	0.73	3200	570
0	III-OC-2	III-OC-3	IIIOC2-b	O-16b	Sample 123	8	15	0.049	1300	210
	III-OC-8	farthest	IIIOC8-a	O-21a	Sample 354	0	5	0.12	630	500
		south	IIIOC8-b	O-21b	Sample 355	5	15	0.030	260	600
	11/-00-1	public	IVOC1-a	O-22a	Sample 17	0	5	0.76	7000	400
U	10-00-1	road	IVOC1-b	O-22b	Sample 18	5	10	0.14	5400	620
Т	IV-0C-4	public	IVOC4-a	O-25a	Sample 147	0	5	0.56	4800	1300
С		road	IVOC4-b	O-25b	Sample 148	5	12	0.046	5100	580
R		Originally chose over	VOC1-a	O-31a	Sample 179	0	5	0.036	1400	<200
O P	V-OC-1	due to proximity to lease boundary	VOC1-b	O-31b	Sample 180	5	15	0.024	570	<200
			VOC2-a	O-32a	Sample 181	0	5	0.15	3600	450
	V-0C-2	(ended up being able to keep top	VOC2-b	O-32b	Sample 182	5	15	<0.01	27	220
_	V-00-2	sample, see above)	VOC2-c	O-32c	Sample 183	15	25	0.011	400	<200
			VOC2-d	O-32d	Sample 184	25	35	<0.01	44	<200
	VI-OC-4 VIII-OC-4	north end	VIOC4-a	O-40a	Sample 202	0	5	0.15	1200	1300
			VIOC4-b	O-40b	Sample 203	5	10	0.034	1300	840
			VIIIOC4-a	O-54a	Sample 295	0	5	0.20	840	1000
			VIIIOC4-b	O-54b	Sample 296	5	20	0.016	370	280
		might not need both IX-OC-2 and 4	IXOC2-a	O-27a	Sample 319	0	3	1.8	5500	2100
	IX-OC-2		IXOC2-b	O-27b	Sample 320	3	10	0.061	910	140
			IXOC2-c	O-27c	Sample 321	10	25	0.037	480	160
			IXOC4-a	O-29a	Sample 324	0	6	0.61	5200	1500
	IX-OC-4		IXOC4-b	O-29b	Sample 325	6	15	0.051	1100	460
			IXOC4-c	O-29c	Sample 326	15	20	0.029	1200	200
			IIIWL1-a	W-89a	Sample 118	0	5	2.4	1000	1500
	III-WL-1	disturbed	IIIWL1-b	W-89b	Sample 119	5	15	4.4	920	1300
		area	IIIWL1-c	W-89c	Sample 93	15	30	4.0	2700	3900
			IIIWL1-d	W-89d	Sample 94	30	60	0.086	65	260
			IIIWL1-e	W-89e	Sample 95	60	100	0.058	62	200
			IVWL2-a	W-91a	Sample 7	0	5	0.15	210	<200
		diature	IVWL2-b	W-91b	Sample 8	5	15	0.98	1000	560
	IV-WL-2	area	IVWL2-c	W-91c	Sample 9	15	30	1.6	2800	2100

14/			IVWL2-d	W-91d	Sample 10	30	60	2.0	3400	4000	
VV			IVWL2-e	W-91e	Sample 11	60	100	0.22	1800	<200	
Ε			VWL2-a	W-98a	Sample 168	0	5	0.045	240	12000	
Т			VWL2-b	W-98b	Sample 169	5	20	0.28	1100	1300	
L	V-WL-2	distrubed?	VWL2-c	W-98c	Sample 154	20	40	0.052	220	11000	
Α			VWL2-d	W-98d	Sample 155	40	70	0.029	190	9000	
Ν			VWL2-e	W-98e	Sample 156	70	100	0.036	8.2	220	
D	\/L-\A/I1.A	same location as below	VIWL1A-a	W-100a	Sample 195	0	5	0.31	1500	4300	
	VI-WE-IX		VIWL1A-b	W-100b	Sample 196	5	10	0.16	420	2600	
		same location as above	VIWL1B-a	W-101a	Sample 197	0	5	0.21	870	6000	
				VIWL1B-b	W-101b	Sample 198	5	10	0.23	1200	6200
	VI-WL-1B		VIWL1B-c	W-101c	Sample 199	10	30	0.33	790	4500	
			VIWL1B-d	W-101d	Sample 200	30	60	0.039	170	2000	
			VIWL1B-e	W-101e	Sample 201	60	80	0.014	88	1400	

Appendix VII: Sample Descriptions

Samples were roughly described before grinding. The Munsell Soil Color Charts (1994) were used for color descriptions. Soil colors were officially described with the Munsell chart after they had dried. Otherwise descriptions were after NRCS (2002).

ASU num ber	Site	fro m (c m)	to (c m)	ho- ri- zon type	munse	ell numl color	per and	grain size	roots	Basic description	NOTE
					hue	value	chrom a				
1	IX-F-4	0	5	Oi	7.5YR	3	/2	Silt (<<5%); leaf litter generally <1- 2cm	2,VF,T	Basically dark brown leaf litter, small pinecones, fir needles, etc. <<5% mineral soil. Incredibly immature	
2	IX-F-4	5	15	Ai	7.5YR	4	/2	silt to clay size	3,VF,T	crumbly, micro rots throughout, brownish grey with bits of poorly decomp OM (~30%); regolith bits <10%	
3	IX-F-4	15	30	Ai	7.5YR	4	/3	mix of silt and clay 40:60	2-3, VF-M, T	brown to pale grey (OM to clay basically), clay clumps, ~20% OM? Roots and leaf litter partially decomp	
4	IX-F-4	30	60	At	7.5YR	5 or 6	/3	clay with silt (30-40%), fine roots throughout	2-3, VF-M, T	pale grey with brownish mottle (OM to clay basically), clay clumps, ~20% OM? Roots and leaf litter partially decomp	
5	IX-F-4	60	85	В	10YR	7	/2	clay, minor OM (unde- comp)	1,VF,T	pale brownish grey clay with OM traces, moderately dry	
6	IX-F-4	85	100	В	10YR	8	/2	clay, v minor OM (unde- comp)	0-1, VF, T	very pale grayish white silicate clay, small <2cm pinecone part	
7	IV-WL-2	0	5	Bt	10YR	7	/3	Clay	1, VF-F, T	saturated medium tan brown clay	
8	IV-WL-2	5	15	Bt	10YR	8	/2	Clay	0, VF,T	saturated medium tan brown clay	
9	IV-WL-2	15	30	Bt	10YR	8	/2	Clay	0	saturated medium tan brown clay	
10	IV-WL-2	30	60	Bt	7.5YR	7	/1	Clay	0	Semi-saturated medium brown clay	
11	IV-WL-2	60	100	O-Bt	7.5YR	7	/1	Clay	0	very saturated medium grey brown clay	
12	IV-WL-1	0	5	Bi	7.5YR	6 & 5	/3	Clay, ~ 30% or more OM, possible silt	3,VF- M,T	dark brown to grey (mottled) clay with significant OM/roots through- out, semi-saturated. OM ~30- 40%?	
13	IV-WL-1	5	15	Bi,t	7.5YR	7	/3	Clay, ~ 15% or more OM,	3,VF- M,T	medium/light brown to grey (mot- tled) clay with significant OM/roots throughout, semi-saturated. OM ~15-20%	

14	IV-WL-1	15	30	Bt	7.5YR	7	/3	Clay, ~ 5% or more OM,	1-2, VF-M, T	tan/light brown to grey (mottled) clay with OM/roots throughout unevenly, semi-saturated. OM ~5- 10%	
15	IV-WL-1	30	60	Bt	7.5YR	7	/3	Clay, ~ 3-5% OM,	2,VF- M,T	tan/light brown to grey clay with OM/roots throughout unevenly, semi-saturated. OM ~3-5%. Mostly	
16	IV-WL-1	60	100	Bt	7.5YR	7	/3	Clay, ~ 3-5% OM,	2,VF- M,T	tan/light brown to grey clay with OM/roots throughout unevenly, semi-saturated. OM ~3-5%. Mostly	
17	IV-OC-1	0	5	O-Bi	7.5YR	5	/3	Clay, possibly silt <15%	2,VF,T	saturated (dark brown when wet, medium when dry) clay with OM, fine roots throughout, OM ${\sim}15\%$	
18	IV-OC-1	5	10	Ai-Bi	10YR	4	/4	clay size to silt size, very fine with roots	2, VF-F, T	saturated (dark brown when wet, medium when dry) crumbly silty clay with OM, fine roots thorught, OM ~15-20%	
19	IV-F-3A	0	5	Oe-i				clay to silt, OM >40%	3,F,T	extremely wet, bits of moss, etc. OM ~40-50%	
20	IV-F-3A	5	15	Oi				clay to silt, OM <40%	3,F,T	Very extremely wet, etc. OM ~40- 50%	
21	IV-F-3A	15	35	Bi				clay to silt, OM <20%	2,F,T	saturated clay with OM fine roots mostly <20%	
22	IV-F-3B	0	5	Oa	7.5YR	3	/2	fine to very fine, OM>40%	3,VF- M,T	reasonably well-decomposed OM and roots, fairly dry, very clumpy with micro root clusters. Medium dark brown	
23	IV-F-3B	5	15	Aa-e	7.5YR	3	/4	fine to very fine, OM<40%	3,VfF- F,T	like about but less clumpy, slightly redder, hints of tan clay bits	
24	IV-F-3B	15	30	Ae	7.5YR	3	/3	fine to very fine, OM 20%	3,VfF- F,T	like above but more hints of tan clay bits	
25	IV-F-3B	30	60	Bi,t	7.5YR and 10YR	3&8	/3 and /2-3	clay with <20% silt	2,VF- M,T	Pale grey-tan Clay with <30% medium brown silt	
26	IV-F-3B	60	100	СВ	5YR	6	/3	gravel with clay/silt parti- cles through- out and coat- ing. Till?	0-1, VF, T	medium reddish tan color silt and clay covering gravel, minor fine roots	
27	III-F-2	0	5	OA e	5YR	4	/2	clumps of silt/ clay w/ OM roots	3,VF- C,T	mix of medium brown silty/clay size silt particles clumped with roots and OM, some lighter clay bits	
28	III-F-2	5	15	Ae,t	5YR	6	/2	clay with silty clumps of OM, unde- comp OM	3,VF- C,T	same as above but much more clay content	
29	III-F-2	15	30	AB e,t	5YR	6	/2	clay with silty clumps of OM, unde- comp OM	3,VF- C,T	same as above but slightly more clay content	

30	III-F-2	30	55	Bt,i	10YR	7	/4	Clay	1,VF- M,T	clay clumps with roots	Cooler full of mud/ water
31	III-F-2	55	10(B,t	7.5YR	6	/4	Clay		reddish tan clay	Cooler full of mud/ water
32	IX-WL-1	0	5	AB	10YR	8	/2	Clay; minor silt/sand	2- 3,VF,T	saturated clay goop with silty sand fragments	Cooler full of mud/ water. Wet color 10YR/5/3
33	IX-WL-1	5	15	В	7.5YR	7	/3	clay, minor silt	1- 2,VF,T	saturated clay goop with less silty sand fragments	Cooler full of mud/ water
34	IX-WL-1	15	30	Bt	7.5YR	7	/3	Clay	1,VF,T	saturated clay with minor roots	Cooler full of mud/ water
35	IX-WL-1	30	60	Bt	7.5YR	7	/3	Clay	0	saturated clay	Cooler full of mud/ water
36	IX-WL-1	60	10(Bt	7.5YR	7	/3	Clay	0	saturated clay	Cooler full of mud/ water
37	IX-F-2	0	5	Oi-e	10YR	4	/3	clay to silt, OM >30%	3,VF- F,T	clumps of micro roots holding together medium brown OM silty particles and lighter tan clay to silt globs. Dominated by darker leaf litter color.	Cooler full of mud/ water. Light grey rocks
38	IX-F-2	5	15	OA	10YR	2	/2	Fine silt, OM>30%	3,F-M,T	rich organic soil, lots of small roots, OM is slightly clumpy. Well- developed	Cooler full of mud/ water
39	IX-F-2	15	30	OA	7.5YR	3	/3	Fine silt, OM>30%	2,F,T	rich organic soil, lots of micro roots, minor regolith. Well- developed	Cooler full of mud/ water. Light grey rocks
40	IX-F-2	30	45	Aa	10YR	3	/3	Fine silt, OM>30%	2,F,T	rich organic soil, lots of micro roots, slight mix of tan clay parti- cles with darker brown. Well- developed	Cooler full of mud/ water. Light grey rocks, few pink
41	IX-WL-2	0	5	OB	7.5YR	6	/3	fine silt/clay with roots	3,VF- F,T	clay with lots of roots, saturated	Cooler full of mud/ water
42	IX-WL-2	5	15	В	7.5YR	7	/3	clay with roots	2, VF-F, T	clay with roots, saturated	Cooler full of mud/ water
43	IX-WL-2	15	30	Bt	7.5YR	7	/3	Clay	1,F,T	clay, minor roots, saturated	Cooler full of mud/ water
44	IX-WL-2	30	60	Bt	7.5YR	7	/3	Clay	0	clay, semi-saturated	Cooler full of mud/ water

45	IX-WL-2	60	10(Bt	7.5YR	7	/3	Clay	0	clay, minor roots, saturated	Cooler full of mud/ water
46	I-WL-2	0	5	OB,i	5YR	8	/2	clay, half roots	3,VF- C,T	Dark brown, OM>40% with clay, saturate	Cooler full of mud/ water
47	I-WL-2	5	15	В	10YR	7	/3	clay, minor roots	2,VF- F,T	clay with lots of small roots, satu- rated	Cooler full of mud/ water
48	I-WL-2	15	30	Bt	10YR	8	/3 and /2	Clay	1,F,T	clay, saturated, minor roots	Cooler full of mud/ water
49	I-WL-2	30	60	Bt	7.5YR	8	3 and /2	Clay	1, VF-F, T	mix of pale yellow casted tan and slightly more red, darker tan. Saturated. Clay.	Cooler full of mud/ water
50	I-WL-2	60	10(Bt	2.5YR & 10YR	6 &7	/3 and /2	Clay	0	mix of pale yellow casted tan and slightly more red, darker tan. Saturated. Clay.	Cooler full of mud/ water
51	II-F-3	0	5	AB e	10YR	5	/3	clay to silt, OM ~20%	3,VF- F,T	mix of tan clay and minor med brown silty OM	Cooler full of mud/ water
52	II-F-3	5	15	AB	10YR	7	/4	silty clay	2, VF-F, T	yellow cast tan fine silt (possible clay)y, crumbly, minor hem stained regolith bits <5mm, small roots, small angular regolith	Cooler full of mud/ water
53	II-F-3	15	30	AB	10YR	7	/4	silty clay	2, VF-F, T	yellow cast tan fine silt (possible clay), crumbly, small roots, small round to angular regolith up to 2cm	Cooler full of mud/ water
54	II-F-3	30	60	AB	10YR	7	/4	silty clay	1,VF,T	yellow cast tan fine silt (possible clay), crumbly, small roots, small round to angular regolith up to 2cm	Cooler full of mud/ water
55	II-F-3	60	90	AB t	10YR	7	/4	silty clay to clay	0	yellow cast tan silt to clay (actual chunks present) crumbly, small roots, small round to angular regolith up to 2cm	Cooler full of mud/ water
56	II-F-2	0	5	OB e	10YR & 7.5YR	7&3	/1 and /2	clay mixed with OM litter ~50%	3,VF- M,T	mix of semi-decomposed leaf litter and roots (dark brown) with light grey clay. More dark than light	Cooler full of mud/ water
57	II-F-2	5	15	Be	10YR & 7.5YR	7&3	/1 and /2	clay mixed with OM litter ~10%	2,VF- M,T	mix of semi-decomposed leaf litter and roots (dark brown) with light grey clay. MORE LIGHT THAN DARK	Cooler full of mud/ water
58	II-F-2	15	30	Be	7.5YR	7	/2	clay with roots	3,VF- C,T	clay with roots	Cooler full of mud/ water
59	II-F-2	30	60	Be	7.5YR	7	/2	clay mixed with OM litter !5%	1,M- C,T	dam/wet tan clay with roots, some visible leaves, poorly decompose	Cooler full of mud/ water
60	II-F-2	60	10(Bi	10YR	7	/3	clay mixed with OM litter !5%	1,M- C,T	clay with roots, some visible leaves, poorly decompose	Cooler full of mud/ water
61	II-OC-1	0	5	0	5YR	3	/2	silt	2,VF,T	dark brown organics with common small roots. Fairly dry. No rocks	

62	II-OC-1	5	10	0	7.5YR	5	/3	silt	2,VF,T	Light brown organic soil with nu- merous roots. Fairly dry, no rocks	
63	II-OC-2	0	3	Oi – A	5YR	3	/2	Silt, <5% small gravel	2,F-C,T	organic rich (~30-40%?), roots and other small (<3cm) bits of forest floor type OM (small twigs, bits of leaves, etc). Lots of roots. Regolith <10%, rounded to angu- lar, indeterminate color. Soil color is rich chocolate brown	
64	II-OC-2	3	10	Ar	5YR	5	/4	silt with ~20% small gravel (prob regolith)	1-2, F, T	reddish brown soil with lots of small gravel size regolith, regolith ~10-15%. roots and OM more like 10% or less	
65	II-OC-3	0	5	0	7.5YR	3	/2	silt	2,VF- F,T	medium brown soil with some thicker roots. Fairly dry. No rocks	
66	II-OC-3	5	10	A	5YR	4	/6	silt, up to 10% small irregular an- gular gravel	1,F,T	medium red brown	
67	II-OC-4	0	5	OA	7.5YR	4	12	silt, some clay, up to 15% or so small gravel (irregular amt of roundedness/ angles)	2,F,T	Grayish brown. Mix of medium brown silty material (organic?) and lighter tan more clay size in aggregate clumps (small). Abun- dant small roots. Regolith ~15% at least. Small bits of OM <<1cm ~10%	
68	II-OC-4	5	15	A	7.5YR	7	/3	silt/fine sand, up to 10% large rocks, up to 3cm long	1,VF,T	light tan mineral soil with some large rocks, fairly dry.	
69	II-OC-4	15	20	AB	10YR	8	/2	clay clumps with small twigs, scat- tered gravel ~10%. Some sand?	1-2, F, T	pale off-white, small crumbled bits throughout.	
70	II-OC-5	0	3	0	5YR	4	/1	silt	2,VF,T	grey silt with some fine roots, fairly dry	
71	II-OC-5	3	10	AB	10YR	7	/2	mix of sand and clay ma- trix with ~15- 20% gravel	1-2,VF- F,T	OM ~10%. Pale off white to grey crumbled mess (sand with clay) with irregular gravel and bits of twigs and roots	
72	II-OC-5	10	20	AB	2.5YR	8	/2	mix of sand and clay ma- trix with ~15- 20% gravel	1-2,VF- F,T	OM ~10%. Pale off white to white- tan crumbled mess (sand with clay) with irregular gravel and bits of twigs and roots	grey rocks
73	II-OC-6	0	5	OA	7.5YR	3	/2	silt with <25% pebbles	3,F,T	fluffy immature soil, medium brown, regolith pebbles, twigs and roots <2cm	
74	II-OC-6	5	15	A	5YR	4	/4	Silt with 10% pebbles	2,F,T	medium red brown, regolith peb- bles, twigs and roots <2cm	
75	II-OC-6	15	20	A	7.5YR	6	/4	silt with <25% pebbles, clay 10-20%	2,F,T	medium gold- brown, regolith pebbles, twigs and roots <2cm. Slightly more clay than soil above, more small micro-clumps	pink rocks

76	II-OC-7	0	10	Ot, i	7.5YR	4	/2	silt to clay size w/leaf and twig litter <1cm	2-3,F,T	Dark brown.medium size clumps of dark clay with abundant regolith (~15%? Hard to say) and leaf and twig litter <1cm	
77	II-OC-7	10	16	AB	7.5YR	6	/4	silt to clay size w/leaf and twig litter <1cm	2-3,M- C,T	Tan version of soil stratigraphi- cally above, but with more large clay clumps and regolith	pink rocks
78	II-OC-8	0	12	0	7.5YR	4	/3	silt to sand, small pebbles <15%	3,VF,T	medium brown, heterogenous and OM rich (~30%), but decomposed and uniform size <1cm	
79	II-OC-8	12	15	OA	7.5YR	4	/3	silt to sand, small pebbles <15%	3,VF- M,T	regolith pebbles <2cm, OM, fluffy brown, slightly more clay in above stratigraphic layer. OM ~30%	
80	II-OC-9	0	3	0	7.5YR	3	/2	silt	3,VF,T	Very fluffy, more homogenous and smaller particles of OM than II_OC-8. Regolith pebbles <1cm are more rare, OM, fluffy brown	
81	II-OC-9	3	10	OA	7.5YR	4	/4	silt	3,VF- M,T	regolith pebbles <2cm, OM, fluffy brown, reddish color, more clay right than above (more clumpy)	
82	II-OC-9	10	15	A	7.5YR	5	/4	silt	3,VF- F,T	regolith pebbles <2cm, OM, fluffy brown	
83	II-OC-10	0	5	Et	5YR	3	/2	Clay	1,VF,T	dark brown clay with some small roots, fairly dry.	
84	II-OC-10	5	8	A	7.5YR	5	/4	clay with <20% silt and large sand	2,VF- F,T	wet clay with some roots, silt, and large sand/small pebbles	
85	II-OC-11	0	5	Aa	7.5YR	4	/6	clay with <20% silt	2,F,T	wet silty clay with roots	
86	II-OC-11	5	10	В	7.5YR	5	/4	Clay <10% silt	2,VF- F,T	wet clay, roots, not nodules	
87	IV-F-1	5	15	OA	7.5YR	6	/3	silt, clay, and pebbles <1.5cm <20%	3,VF- M,T	Mix of yellowish tan silt and clay clumps with roots and small peb- bles <1cm with medium brown fine OM. OM ~25%	
88	IV-F-1	15	30	A	10YR	7	/3	silt, clay, and pebbles <1.5cm <20%	2,M,T	yellowish tan silt and clay clumps with roots and small pebbles <1cm	
89	IV-F-1	30	60	В	10YR & 5YR	7 & 8	/3 and /2	Clay, <30% silt/sand coat- ing	1,VF- F,T	yellowish off-white sand and silt coating pinkish clay nodules.	
90	IV-F-1	60	10(В	10YR & 5YR	7&8	/3 and /2	Clay, <15% silt/sand coat- ing	1,F,T	same as above but much more clay content	
91	I-OC-2	2	7	OA	5YR	4	/3	silt and clay, OM <1cm particles	3,F,T	red brown soil with regolith parti- cles <1cm, a bit clumpy, OM <1cm. OM ~30%	
92	I-OC-3	2	5	A	5YR	3	/3	silty, minor/ moderate clumping (clay?), small angular peb- bles 10%	2,VF,T	medium brown clumpy silt/clay with high organic content, small particle size though. OM ~20- 25%?. Small regolith pebbles	

93	III-WL-1	15	30	В	7.5YR	5	/3	clay with <20% silt	2-3,F- C,T	brown clay with OM ~20%	
94	III-WL-1	30	60	В	7.5YR	6	/4	clay	2,F,T	tan clay, roots etc <5%	
95	III-WL-1	60	10(В	5YR	7	/3	Clay	2,F-M,T	tan clay, less roots than above	
96	IV-WL-3	0	5	0	7.5YR	5	/2	silt and clay, OM <1cm particles	3,F-C,T	OM layer with mixed tan clay. Fluffy, lots of roots, clumps. OM ~40%	
97	IV-WL-3	5	15	A	7.5YR	6	/2	silt and clay, OM <1cm particles	3,F-M,T	more silt than above layer, still lots of OM, includes some green bits moss. OM ~35%	
98	IV-WL-3	15	30	AB	7.5YR	6	/3	silt and clay with medium roots, scat- tered sand rare	2-3,F- M,T	clay with silty content, OM ~15%	
99	IV-WL-3	30	60	В	7.5YR	7	/3	Clay	1,F,T	clay clumps with roots	
100	IV-WL-3	60	10(В	10YR	7	/2	Clay	0	clay with roots	
101	IV-F-1	0	5	0	7.5YR	3	/2	silt; roots and fine leaf litter	3,F,T	fluffy brown organic material, mostly looks like partially decom- posed fine root masses with finer brown silty material, a few larger roots. OM ~40% or more	
102	I-F-2	0	5	0	7.5YR	3	/2	silt to clay, roots and fine leaf litter	3,VF- F,T	silty decomposed organics and roots coating clay nodules, OM ~35%	
103	I-F-2	5	15	OA	5YR	3	/2	silt to clay, roots and fine leaf litter	3,VF- M,T	silty decomposed organics and roots coating clay nodules, OM ~35%. More homogeneous than layer above	
104	I-F-2	15	30	A	5YR	3	/2	silt to clay, roots and fine leaf litter	3,VF- F,T	silty decomposed organics and roots coating clay nodules, OM ~30%. More homogeneous than layer above, more clay and larger nodules (up to ~3cm). Clay nod- ules are medium grey	
105	I-F-2	30	60	Ва	10YR	7	/3	clay with silt <10%	1,VF,T	large clay nodules (pale tan) with dusting of brown organic silt ma- terial	
106	I-F-2	60	10(Ва	10YR	7	/3	clay with silt <5%	0	same as above with slightly less organics.	
107	III-OC-3	0	5	OA	7.5YR	4	/3	silt and clay with angular platy gravel up to 3cm (15%)	2, VF-F, T	stony medium brown organic rich heterogenous soil . OM ~35%?	
108	III-OC-3	5	9	Oa	7.5YR	4	/4	silt and clay with angular platy gravel up to 2cm (5%)	2, VF-F, T	stony medium brown organic rich heterogenous soil . OM ~35%?	
109	III-OC-6	0	5	OA	7.5YR	5	/4	clay, sand, pebbles, gravel	2,F,T	orangey brown, rocky soil with roots, organic litter. OM ~15%	

110	III-OC-6	5	9	Ai	7.5YR	6	/6	clay, sand, pebbles, gravel	2,F,T	same as above but more clay content, slightly less obvious OM . OM ~10-15%	
111	III-OC-7	0	5	0	7.5YR	5	/4	wet sand/clay matrix with copious peb- bles, coarse sand, gravel	2,F-M,T	OM ~25%??. Dark brown, wet	
112	III-OC-7	5	10	OA	7.5YR	5	/4	wet clay/sand matrix with copious peb- bles, coarse sand, gravel	3,M,T	same as above but fine matrix is more clay-rich	
113	IX-F-1	0	5	Oi	7.5YR	3	/2	Fine silt, OM>30%	3+,F- C,T	fluffy brown web of roots and fine organic soil. Very high OM. C% >40% likely	
114	IX-F-1	5	15	Оa	7.5YR	3	/2	Fine silt, OM>30%	2-3, VF-M, T	same as above but less of a root web and more of the fluffy fine brown soil	
115	IX-F-1	15	30	Оa	5YR	3	/2	Fine silt, OM>30%	2,VF- M,T	same as above but less of a root web and more of the fluffy fine brown soil	
116	IX-F-1	30	55	OA	7.5YR	3	/3	Fine silt, OM>30%; OM <1cm pieces	1-2,VF- M,T	same as above but less of a root web and more of the fluffy fine brown soil. OM <1cm pieces	
117	IX-F-1	55	100	AB	7.5YR	7	/3	Clay-rich, with copious coarse sand to pebble- sized angular regolith	2,F-C,T	dark brown, organic rich but clay dominated. Clay has angular rock bits throughout	
118	III-WL-1	0	5	OB	10YR	7	/3	Clay with OM	3,F-C,T	clay with lots of roots and moss, saturated, OM >40%	
119	III-WL-1	5	15	Bi	10YR	7	/3	Clay with OM	3,F-C,T	clay with lots of roots and moss, saturated, OM <30% (slightly less than above)	
120	III-OC-1	0	5	OA	5YR	4	/2	clay, silt, sand, coarse sand, peb- bles, gravel	1,F,T	poorly sorted OC soil with me- dium brown color, organic content probably high (>15%?)	
121	III-OC-1	5	15	OA	5YR	4	/2	clay, silt, sand, coarse sand, peb- bles, gravel	1,F,T	poorly sorted OC soil with me- dium brown color, organic content probably high (>15%?). twigs, etc, usually <3cm long	
122	III-OC-2	0	8	Oe-i	7.5YR	5	/3	silt to peb- bles, angular gravel	3,F-C,T	partially decomp leaf and twig litter <3cm long, ~35% or 45%? mottled color. Partially decom- posed wood chunks	
123	III-OC-2	8	15	A	7.5YR	6	/4	silt to peb- bles, angular gravel	1-2,F,T	paler, less brown version of soil above it. Still poorly sorted, etc.	
124	III-OC-5	0	5	OA	7.5YR	6	/2	clay with silt, sand, peb- bles, gravel, etc	3,M- C,T	Clay-rich with OM >25%, also includes poorly sorted angular rock fragments, etc	

125	III-OC-5	5	10	OA	10YR	7	/3	clay with silt, sand, peb- bles, gravel, etc	3,M- C,T	Clay-rich with OM >25%, also includes poorly sorted angular rock fragments, etc	
126	I-F-1	0	5	0	10YR	4	/4	silt and OM, other sizes indetermin- able before grinding	3+,F- C,T	mossy root web, OM <40%	
127	I-F-1	5	15	0	10YR	4	/4	silt and OM, other sizes indetermin- able before grinding	3,F-C,T	mossy root web, OM <30%. Less comprehensive root web than sample above	
128	I-F-1	15	30	AB	7.5YR	5	/3	clay though gravel	2,M,T	more clay rich than layers above, transitioning into clay soil	
129	I-F-1	30	60	В	7.5YR	6	/4	clay, coarse sand included	1,M.T	clay with coating of brown silty OM	
130	I-F-1	60	10(В	7.5YR	6	/4	clay, coarse sand included	0	clay, includes coarse sand to pebble fragments	
131	II-WL-2	0	5	0	10YR	3	/3	silty clay sand	3,F-C,T	clayey sand with OM ~45%	
132	II-WL-2	5	15	OA	7.5YR	4	/3	clay, sand, etc	3,F-C,T	clayey sand with OM ~40%	
7	II-WL-2	15	30	AB	7.5YR	6	/3	clay, minor sand	2,C,T	dark brown sandy clay with roots	
134	II-WL-2	30	60	В	7.5YR	7	/3	clay studded with sparse small pebbles	1,M- C,T	reddish color hard clay studded with angular coarse sand to small pebbles, coating of brown OM	
135	II-WL-2	60	10(В	7.5YR	8	/4	clay studded with sparse small pebbles	0	reddish color hard clay studded with angular coarse sand to small pebbles, coating of brown OM	
136	I-WL-1	0	5	OA	7.5YR	6	/3	sand and clay	3,VF- C,T	Sand+clay+organic matter (~30%)	
137	I-WL-1	5	15	E	7.5YR	6	/3	Sand, <40% finer particles	1,VF,T	extremely sandy clay, includes bits of minor OM	
138	I-WL-1	15	30	EB	10YR	7	/2	Clay 50%, sand and silt 40\$, 10% larger	1, VF-F, T	clumpy sandy clay with small pebbles	
139	I-WL-1	30	60	Е	10YR	8	/2	Sand , some finer material	1,M,T	saturated grayish sand, minor clay and finer content. Cuts nicely	
140	I-WL-1	60	10(Е	10YR	8	/2	Sand , some finer material	1,M,T	same as above but less com- pletely saturated	
141	I-OC-1	0	5	0	10YR	4	/2	unsorted mix, clay through small angular pebbles, OM ~40%	3,VF- M,T	unsorted mix, clay through small angular pebbles, OM ~40%. Clumpy. Immature, organic rich, medium brown	
142	I-OC-1	5	15	Oa	10YR	6	/4	unsorted mix, clay through small angular pebbles, OM ~30%	2-3, VF-M, T	unsorted mix, clay through small angular pebbles, OM ~30%. Immature and poorly sorted, OM partially decomposed. Slightly less wet than layer above.brown	

143	IV-OC-2	0	5	OA	7.5YR	6	/3	silt, sand, minor clay, angular coarse sand to pebbles	3,F-M,T	OM ~30%. Sandy but just as poorly sorted . Clumpy sand. Thoroughly damp.	
144	IV-OC-2	5	10	OA	7.5YR	5	/3	silt, clay and sand, angular coarse sand to pebbles	2,F-M,T	same as above but more wet	
145	IV-OC-3	0	5	OA	7.5YR	5	/4	unsorted mix, clay through small angular pebbles, OM ~35%.	3,F-C,T	unsorted, heterogenous, organic bits <1cm large, semi- decomposed and clumpy. Wet. OM ~40%	
146	IV-OC-3	5	15	Ae	7.5YR	7	/6	unsorted mix, clay through small angular pebbles, OM ~10%.	1-2, F, T	less wet, reddish version of soil above with less OM. OM ~10%	
147	IV-OC-4	0	5	0	7.5YR	5	/3	unsorted mix, clay through small angular pebbles, OM ~35%.	3,F-C,T	unsorted, heterogenous, organic bits <1cm large, semi- decomposed and clumpy. Wet. OM ~40%	
148	IV-OC-4	5	12	A	7.5YR	6	/6	unsorted mix, clay through small angular pebbles, OM ~10%.	2,F-C,T	less wet, reddish version of soil above with less OM. OM ~15%	
149	IV-WL-4	0	5	ABE	7.5YR	7	/2	clay with silt and	2,C,T	grey, wet, OM (~20%) chunks in sandy clay	
150	IV-WL-4	5	15	ABE	7.5YR	7	/2	clay with silt and	2,F-C,T	grey, wet, OM (~10%) chunks in sandy clay	
151	IV-WL-4	15	30	В	7.5YR	7	/2	Clay	1,F,T	grey, wet, OM (~3%) chunks in clay with slight sand/silt content	
152	IV-WL-4	30	60	В	7.5YR	6	/2	clay, some larger bits (up to coarse sand)	1,F,T	grey, wet, OM (~5%) chunks in clay clumps	
153	IV-WL-4	60	100	В	7.5YR	6	/2	clay, some larger bits (up to coarse sand)	1,F,T	grey, wet, OM (~5%) chunks in clay clumps	
154	V-WL-2	20	40	0	7.5YR	4	/4	? fine-grained soup	3,F,T	dark brown organic soup	precipi- tate on protruding organic bits?
155	V-WL-2	40	70	0	7.5YR	4	/5	? fine-grained soup	2, VF-F, T	dark brown organic soup	
156	V-WL-2	70	100	В	5YR	7	/3	Clay	0	pinkish grey clay	
157	V-WL-3	0	10	AE	5YR	6	/3	organics with sand/clay	3,M,T	soupy clay with organics ~15%	
158	V-WL-3	10	50	AE	5YR	6	/3	organics with sand/clay	3,F-C,T	slightly less soupy clay with abundant organics ~25%	

159	V-WL-3	50	80	E	10YR	7	/3	Sand with some clay content	1,M,T	wet hard sand	
160	V-WL-3	80	10(EB	10YR & 5YR	7 & 6	/3 and /4	sand mixed with clay	1,M,T	wet hard sand (yellowish grey) with reddish and tan clay	
161	V-F-2	80	90	E	10YR & 5YR	7	/4	clay nodules covered in sand	1,F,T	tan sand, covering reddish clay nodules up to 5cm long, down to few mm	
162	V-F-2	10	11(E	10YR	7	/4	sand (minor clay)	1,VF,T	clumpy yellowish sand with minor clay content. Crumbly	
163	V-WL-1	0	5	0	7.5YR	7	/3	silty wet OM	3,F-C,T	dark colored organic rich wet mass. Roots and leaves. Looks like wet land stuff. OM ~45%	
164	V-WL-1	5	15	0	7.5YR	4	/4	silty wet OM	2-3,F- C,T	dark colored organic rich wet mass. Roots and leaves. Looks like wet land stuff. OM ~45%	
165	V-WL-1	15	30	0	5YR	4	/4	clay silt sand small peb- bles?	3,F-C,T	Rich-looking dark wet OM soil	
166	V-WL-1	30	60	0	5YR	4	/4	clay silt sand small peb- bles?	2,F-C,T	Rich-looking dark wet OM soil	
167	V-WL-1	60	80	0	5YR	6	/3	fine dusty silt/ clay with OM bit	2,M,T	soup OM	
168	V-WL-2	0	5	0	7.5YR	5	/4	fine dusty silt/ clay with OM bit	3,VF- M,T	soup OM, lots of moss roots. OM ~40%	precipi- tate on protruding organic bits?
169	V-WL-2	5	20	0	7.5YR	5	/4	silt and up	2,M,T	soup OM, lots of moss roots. OM ${\sim}40\%$	
170	V-F-1	0	5	0	5YR	3	/2	silt or clay, OM litter	3,VF- M,T	unsorted, heterogenous, organic bits <1cm large, semi- decomposed and clumpy. OM ~40%	
171	V-F-1	5	15	OA	5YR	4	/2	silt, clay with angular bits of rock coarse sand to small peb- ble size	2-3,F- C,T	tan clay nodules covered in me- dium silty brown OM sediment, leaf and root litter,	
172	V-F-1	15	30	AB	5YR	5	/2	clay with angular bits of rock coarse sand to small peb- ble size	2,F,T	same as above but more clay nodules	
173	V-F-1	30	50	В	5YR	6	/2	clay with angular bits of rock coarse sand to small peb- ble size	1,F,T	same as above but even more clay vs organics	

174	V-F-1	50	10(В	5YR	6	/3	clay with angular bits of rock coarse sand to small peb- ble size	1,F,T	same as above but even more clay vs organics	
175	V-F-2	0	10	0	5YR	4	/2	silt to angular pebble	3+,F- C,T	fluffy web of brown fine roots and decomposed OM, heterogenous grain size	
176	V-F-2	10	20	A	7.5YR	6	/3	Sand with some clay content	1-2,F-C	tan finely clumpy mineral soil with OM roots and twigs sparsely	
177	V-F-2	20	50	AE	7.5YR	7	/3	Sand with some clay content	1-2,F-C	tan finely clumpy mineral soil with OM roots and twigs sparsely	
178	V-F-2	50	80	AE	10YR	7	/3	Sand with some clay content	1-2,F-C	tan finely clumpy mineral soil with OM roots and twigs sparsely	
179	V-OC-1	0	5	A	7.5YR	7	/6	silt sand clay pebbles	2,M- C,T	red soil with lots of small gravel and smaller rock parts, heteroge- nous OM (~15%), etc. Clumpy.	
180	V-OC-1	5	15	A	7.5YR	6	/4	silt sand clay pebbles	2,M- C,T	slightly less OM, slightly lighter color	
181	V-OC-2	0	5	0	7.5YR	5	/3	silt to angular pebble	2-3, VF-M, T	heterogenous OM clay sand silt pebbles etc	
182	V-OC-2	5	15	Е	10YR	7	/3	sand	0	sand, wet, with some clay con- tent, tan color.	
183	V-OC-2	15	25	E	7.5YR	7	/3	Sand with some clay content	1, VF-F, T	slightly more clay than above layer, more brown/red mottle color	
184	V-OC-2	25	35	EB	10YR	7	/3	Sand with some clay content	0	sand with some clay content, scattered pebbles (angular)	
185	V-OC-3	0	5	0	7.5YR	4	/3	silt, clay, larger (het- erogenous mix)(3,F-M,T	organic rich (~30-40%?), roots and other small (<3cm) bits of OM (small twigs, bits of leaves, etc). Lots of roots. Pebbles. Wet. Soil color is rich chocolate brown	
186	V-OC-3	5	15	OA	7.5YR	4	/4	Sand with some clay content	2,F,T	reddish brown wet clay-sand, roots/OM	
187	V-OC-3	15	25	В	10YR	4	/6	Sand with some clay content	1,VF,T	reddish brown soil with minor mossy roots	
188	V-OC-4	0	5	0	7.5YR	4	/3	silt and OM, other sizes indetermin- able before grinding	3,VF- M,T	brown clumpy organic layer, semi- decomposed wood pieces and moss roots	
189	V-OC-4	5	15	AB	10YR	7	/3	Clay ~50%, otherwise silt/ sand. Less OM	2,M- C,T	Clay-rich sediment with bits of roots and twigs ~10%. dull brownish tan. Damp but not su- persaturated	

190	V-OC-4	15	30	AB	7.5YR	7	/3	Clay ~50%, otherwise silt/ sand. Less OM	1,M,T	Clay-rich sediment with bits of roots and twigs ~10%. reddish brown tan. Damp but not super- saturated	
191	V-OC-5	0	5	OA	7.5YR	4 & 7	/2 and /3	clay/silt/sand/ pebbles/small gravel	3,VF- F,T	tan clay-rich balls (<5mm, clay+silt+sand) mixed with angu- lar pebbles and small gravel and medium dull brown OM ~25%	
192	V-OC-5	5	10	A	7.5YR	6	/4	clay/silt/sand/ pebbles/small gravel	2,M- C,T	same as above but not much brown color, mostly golden tan color. Twigs and roots are very abundant though.	
193	V-OC-6	0	5	OA	7.5YR	5	/3	Clay-rich outcrop soil. Clay ~40- 50%	3,VF- M,T	OM ~25%? Wet, not supersatu- rated, medium brown color with lots of roots, some small pebbles and angular small gravel but mostly finer particles (sand/silt/ clay)	
194	V-OC-6	5	15	A	7.5YR	6	/3	gravel domi- nated with smaller parti- cles down to silt/clay	3,C,T	angular gravel dominated outcrop soil	
195	VI-WL- 1A	0	5	AE	10YR	6	/3	sand mostly	2,F,T	damp/wet sand-dominated sedi- ment with lots of roots.	
196	VI-WL- 1A	5	10	A	2.5Y	8	/3	gravel domi- nated with smaller parti- cles down to silt/clay	1,M,T	rounded gravel and smaller en- crusted with clay/silt in pale yel- lowish color	
197	VI-WL- 1B	0	5	A	2.5Y	7	/2	mostly sand/ silt	2,M,T	wet smeared sandy/silty sediment with lot of fine roots	
198	VI-WL- 1B	5	10	A	10YR	6	/1	mostly sand/ silt with more clay than above unit	3,F-M,T	wet, same as above but higher clay content	
199	VI-WL- 1B	10	30	В	7.5YR	5	/2	mostly clay, some silt/ sand	1,F-M,T	damp dark brown, more clay-rich than above layer, in nodules so less wet	
200	VI-WL- 1B	30	60	В	7.5YR	7	/2	mostly clay, less silt/sand than above	0-1,F,T	same as above but less rots	
201	VI-WL- 1B	60	80	В	10YR	8	/2	mostly clay		drier version of above	
202	VI-OC-4	0	5	OA	7.5YR	5	/3	silt with clay content	2,VF,T	dark brown, damp organic rich clumpy clay/silt	
203	VI-OC-4	5	10	OA	7.5YR	5	/3	silt with clay content	2,VF- M,T	dark brown, damp organic rich clumpy clay/silt	
204	VI-F-4	0	5	Oa	7.5YR	3	/2	silt sand etc, some pebbles possible, lots of organics (well- decomposed mostly except for extant roots	3,VF- M,T	organics, dark brown, slightly damp with lots of roots. OM ~40%	

205	VI-F-4	5	10	0	7.5YR	3	/2	silt sand etc, some pebbles possible, lots of organics (well- decomposed mostly except for extant roots	3,VF- M,T	organics, dark brown, slightly damp with lots of roots. OM ~40%	
206	VI-F-4	10	30	E	10YR	7	/3	sand	1,F,T	sand. Looked exactly like golden brown sugar when first laid out. Dry it is more of a normal tan color. Includes some fine sand that clumps nicely.	
207	VI-F-4	30	60	E	10YR	7	/3	sand	1,F,T	sand. Looked exactly like golden brown sugar when first laid out. Dry it is more of a normal tan color. Includes some fine sand that clumps nicely.	
208	VI-F-4	60	10(E	10YR	7	/3	sand,	1,F,T	sand. Looked exactly like golden brown sugar when first laid out. Dry it is more of a normal tan color. Includes some fine sand that clumps nicely.	
209	VI-OC-1	0	5	0	7.5YR	3	/2	mix of silt clay sand pebbles	3,VF- M,T	heterogenous mix of OM, clay up to small pebbles. OM ~30%,over- all finely clumped.	
210	VI-OC-1	5	15	OA	7.5YR	5	/2	rocky angular pebbles and small gravel, silt, sand, clay	3,VF- C,T	more rocky, less OM rich version of soil above, slightly lighter color. Lots of angular pebbles. OM ~15%	
211	VI-OC-2	0	5	OA	7.5YR	5	/2	silt	2,VF,T	very wet silt with fine roots	
212	VI-OC-2	5	10	0	7.5YR	5	/3	silt	1,VF,T	soup OM	
213	VI-F-2	50	60	A	7.5YR	4	/2	sand, silt, pebbles	2,VF,T	dark brown sandy material with clay clumps and roots, very differ- ent from layer above it and below, OM ~25%	
214	VI-F-2	60	80	E	7.5YR	5	/3	coarse sand, 15% pebbles	0	Mottled color. Medium tan to light brown sand, looking close quite a variation in color across coarse sand and pebble grains (some pink etc)	
215	VI-F-2	80	85	Be	7.5YR	6	/2	clay nodules 70% 30% sand coating	0	reddish clay nodules, oblong up to 7cm long, with the medium brown/ tan sand encrusted and around (looks like sand in layer above this one).	
216	VI-F-3	0	5	0	7.5YR	4	/3	silt and sand	3,VF- F,T	medium reddish brown damp OM soil with fine roots, OM ~30%	
217	VI-F-3	5	15	E	7.5YR	6	/4	Sand, ~15% gravel and pebbles (semi- rounded)		tan sand with rounded to sub- angular pebbles	

218	VI-F-3	15	25	E	10YR	7	/4	Sand, <10% rounded peb- bles		tan sand	
219	VI-F-3	25	45	E	10YR	7	/4	Sand, <10% rounded peb- bles		tan sand	
220	VI-F-3	45	55	E	10YR	7	/4	Sand, <10% rounded peb- bles		tan sand with rounded pebbles	
221	VI-F-3	55	80	Е	10YR	7	/4	sand		sand	
222	VI-F-1	0	5	0	7.5YR	3	/3	silt	3+,F- M,T	root webs supporting silty OM, well-decomposed (OM ~45% or more)	
223	VI-F-1	5	20	OB	7.5YR	3&6	/2 and /3	silt, with clay lumps	2-3,VF- F,T	small clay lumps covered in silty decomposed OM in a sea of silty OM and roots. OM ~40%	
224	VI-F-1	20	30	В	7.5YR	6	/3	clay, minor silt	1, VF-F, T	mix of medium colors of clay in nuggets covered in silty black OM layer (clumpy)	
225	VI-F-1	30	60	В	7.5YR	6	/3	Clay	1, VF-F, T	mix of 3 colors of clay, some clumps with OM coatings. Clumpy	
226	VI-F-1	60	90	В	10YR	7	/3	Clay	0-1, VF, T	reddish brown pale clay, minor fine roots. Smoosh/smoothy	
227	VI-F-2	0	5	OA	10YR	4	/2	sand/silt	3,VF- F,T	dark silty OM clumpy stuff with roots, OM ~40%	
228	VI-F-2	5	10	OA	10YR	5	/2	sand	2,VF- F,T	dark colored sand and silt mix with roots, speckles of tan sand ~2% throughout spread evenly. OM ~35%	
229	VI-F-2	10	30	E	7.5YR	6	/3	sand	0-1, VF, T	tan sand with scattered silty black OM clumpy bits with fine roots $\sim 5\%$	
230	VI-F-2	30	50	E	7.5YR	5	/2	sand	0	light brown sand (darker than above)with more dark clumpy OM bits than unit above (~7%)	
231	VI-OC-3	0	5	0	7.5YR	4	/3	Silt with 10% pebbles	3,VF- M,T	dark silty sand with fine OM, peb- bles, lots of roots. OM well- decomposed, content ~30%	
232	VI-OC-3	5	10	A	7.5YR	5	/4	Silt with 10% pebbles	3,F-M,T	more reddish version of soil above, OM ~20%	
233	VI-OC-5	0	5	OA	7.5YR	4	/4	silt with ~40% clay	3,F,T	medium reddish-brown	
234	VI-OC-5	5	10	A	7.5YR	5	/4	silty clay,	2,M,T	fully saturated, reddish brown, roots	
235	VI-OC-5	10	20	AB	7.5YR	5	/3	silty clay	1,F,T	fully saturated smeary mud, me- dium brown	
236	VII-F-2	60	70	В	7.5YR	6	/2 and /3	clay to silt		Slightly mottled soil of discrete clay nugget clumps <3cm (pale pinkish tan) covered in less pink silt/clay. Clumps go down to a few cms. 25%>1cm.	
237	VII-F-2	70	10(ΒE	7.5YR	6	/3	Clay >50%, up to fine sand	1,F,T	crumbly clay-rich sediment to fine sand.	

238	VII-WL-1	0	10	0	10YR	4	/3	silt and clay with OM <1cm	3,VF- C,T	medium brown brown organic soupy mess. OM ~50%	
239	VII-WL-1	10	30	0	10YR	4	/2	silt and clay with OM <1cm	3,VF- F,T	dark brown organic soupy mess, OM ~50%	
240	VII-WL-1	30	55	OA	10YR	4	/2	silt and clay with OM <1cm	3,VF- F,T	dark brown organic soupy mess, OM ~50%	
241	VII-WL-1	55	10(AB	10YR	4	/2	clay to silt	2,VF,T	Clay-rich organic soupy mess. OM ~15%	
242	VII-OC-1	0	5	OA	10YR	5	/2	Pebbles to gravel ~10%, silty material ~50%, rest is in-between	3,F-M,T	rocky medium brown OC soil, rounded pebbles. OM ~20%	
243	VII-OC-1	5	10	A	7.5YR	5	/4	50% gravel and pebbles, rest is smaller with dominant sand and silt	2,F,T	OM <10%	
244	VII-OC-1	10	35	A	7.5YR	6	/4	~55% small rounded gravel, the rest is a het- erogenous mix down to silt size	2,F-C,T	tan mix of small gravel and every- thing smaller. Some rots	
245	VII-F-1	0	5	0	5YR	3	/2	silt, some larger frag- ments	3,F-C,T	Fine roots and OM ~45%	
246	VII-F-1	5	20	OA	7.5YR	3	/2	silt	3,F,T	finely crumbly silty dark brown organic rich mineral soil (OM ~20%? 35%?)	
247	VII-F-1	20	30	AB	7.5YR		/3 and /2	clay with ~40% silt	2,F-M,T	~3cm clay nuggets with dark brown silty OM coating (~10%)	
248	VII-F-1	30	60	В	7.5YR	8&3	/3 and /2	clay with ~10% silt	1,F-M,T	same as last but less OM coating $(\sim 5\%)$	
249	VII-F-1	60	10(В	7.5YR	7&3	/3 and /2	clay with ~8% silt	1,F-M,T	same as last but less OM coating $(\sim 5\%)$	
250	VII-F-2	0	5	0	10YR	4	/2	silty and clay	3+,VF- M,T	fluffy root mass with trapped silty clay size sediment	
251	VII-F-2	5	15	AB	10YR	7	/3	clay with ~40% silt	2,M,T	Tan Clay-rich discrete clumpy soil, minor OM <5%, clumps <1cm	
252	VII-F-2	15	30	В	10YR	7	/2	clay with ~30% silt	1,F-M,T	Tan Clay-rich discrete clumpy soil, minor OM <5%, clumps <1cm	
253	VII-F-2	30	60	В	10YR & 7.5YR	7	/3 and /4	clay with ~20% silt	1,F,T	Tan Clay-rich discrete clumpy soil, minor OM <5%, clumps <3cm. The insides of the large clumps gradate to pink	
254	VII-OC-2	0	5	OA	7.5YR	3	/2	silt with ~30% clay content for clumping	3,F,T	medium brown clumpy soils with silty clay and lots of fine roots, some angular rocks thrown in. OM ~20%?	

255	VII-OC-2	5	15	A	7.5YR	4	/2	silt with ~30% clay content for clumping	3,F,T	same as last but more rocks (~10-15%?), clumping is finer	
256	VII-OC-3	0	5	0	5YR	2.5	/2	silt	3,VF- F,T	dark dark brown, organic rick clumpy soil, looks like new potting soil but with more roots	
257	VII-OC-3	5	15	OA	5YR	4	/3	silt with ~25% clay content, <10% angular pebbles and small gravel		medium brown silty soil with OM <20%, clay content in soil making it clumpy, minor angular rocks	
258	VII-OC-4	0	5	OA	5YR	4	/3	silt with ~20% clay content, 25% angular pebbles and gravel	3,M,T	medium brown, very rocky, OM ~ 25-35%	
259	VII-OC-4	5	10	A	5YR	5	/4	silt with ~15% clay, small gravel and pebbles ~20%	2,M,T	reddish brown, similar texture as soil above, OM ~15% or less	
260	VII-OC-5	0	5	OA	7.5YR	4	/3	mix of silt and clay60/40	3,F-M,T	medium brown, very rocky, OM ~ 25-35%	
261	VII-OC-6	0	5	OA	7.5YR	4	/2	silt with ~15% pebbles and small gravel, 25% clay	3,F,T	medium brown, very rocky, OM ~ 25-35%	
262	VII-OC-6	5	10	A	5YR	5	/2	silt with ~20% clay nodules <1cm and dispersed paler clay, some rocks	3,F,T	medium brown mottled with specks of tan	
263	VII-OC-7	0	5	OA	7.5YR	5	/3	silt with ~20% clay contents, <10% peb- bles	3,VF,T	medium brown, very rocky, OM ~ 25-35%	
264	VII-OC-7	5	10	OA	7.5YR	6	/3	Clay 30% silt	2,F,T	silty clay, medium brown, small roots, specks of reddish dirt here and there. OM~15%	
265	VII-OC-8	0	5	0	5YR	4	/2	silt	3,VF,T	OM ~40%. relatively homogenous for an outcrop soil	
266	VII-OC-8	5	15	OA	7.5YR	6	/3	Silt-clay-sand	3,F,T	clumpy silty soil with small roots, OM~20%. Medium brown	
267	VII-OC-8	15	25	Α	7.5YR	6	/3	clay, silt/fine sand ~40%	2,M,T	more clay rich than layers above, OM ~15%. Medium brown	
268	VII-OC-9	0	5	0	7.5YR	6	/3	Silt-clay-sand	3,F,T	clumpy silty soil with small roots, OM~20%. Medium brown	
269	VII-OC-9	5	15	OA	7.5YR	6	/3	Silt-clay-sand	3,F,T	clumpy silty soil with small roots, OM~20%. Medium brown	
270	VII-OC-9	15	30	A	7.5YR	6	/4	Silt, <20% clay, some sand?	3,F,T	reddish silt/clay, medium brown red color, large lumps, fine roots. OM ~50%	
271	VIII-F-2	0	5	0	7.5YR	5	/2	silt. Mostly roots.	3+,F- M,T	root web with grayish brown OM	

272	VIII-F-2	5	15	0	7.5YR	6	/3	silt	3,F-M,T	lots of fluffy roots, semi- decomposed forest floor OM ~45%. medium brown	
273	VIII-F-2	15	30	0	7.5YR	4	/2	silt	3+,F- M,T	lots of fluffy roots, semi- decomposed forest floor OM ~45%. slightly less undecom- posed twig/leaf/pinecone litter	
274	VIII-F-2	30	60	AB	7.5YR	5	/2	Clay	1,F,T	clay clumps coated in silty black OM	
275	VIII-F-3	0	5	AB	7.5YR	6	/3	Clay, 40% sand+silt	2,F,T	clumpy clay-rich tan sediment with crumbly texture from silt sand content	
276	VIII-F-3	5	15	AB	10YR	8	/2	Clay, 30% sand+ silt	1,M,T	same as last but most clay, slightly lighter color, bit less OM cover (<5%)	
277	VIII-F-3	15	30	В	10YR	8	/2	Clay, 20% sand + silt	1,M,T	tan to reddish tan clay with slight sandy silt texture	
278	VIII-F-3	30	60	В	10YR	8	/2	Clay, 20% sand + silt	0	same as last	
279	VIII-OC-5	0	10	0	7.5YR	5	/2	silt with a few rocks	3,F,T	OM fine roots with silty dark brown material. OM ~30%	
280	VIII-OC-5	10	15	0	7.5YR	5	/2	silt with a few rocks	3,F-M,T	OM fine roots with silty dark brown material. OM ~30%	
281	VIII-OC-6	0	5	0	7.5YR	5	/2	silt with a few rocks	1,F,T	OM fine roots with silty dark brown material. OM ~30%	
282	VIII-OC-6	5	10	OA	7.5YR	5	/3	silt with a few rocks	2,F-M,T	OM fine roots with silty dark brown material. OM ~20%	
283	VIII-F-1	0	5	0	7.5YR	5	/1	silt	3+,F- M,T	immature organic soil, OM >50%, some live moss still. Tons of roots	
284	VIII-F-1	5	15	0	7.5YR	3	/3	silt	2-3,F- M,T	organic rich brown soil OM ~40%	
285	VIII-F-1	15	30	0	7.5YR	4	/3	silt	3,F-M,T	organic rich brown soil OM ~40%, lots of roots and wood. Slight mottle of grey clay	
286	VIII-F-1	30	60	AB	7.5YR	5&3	/1 and /2	Clay, 20% silt	1,M,T	grey clay nuggets covered in dark brown organic silt	
287	VIII-F-1	60	70	В	7.5YR	5	/1	Clay	0	grey saturated clay	
288	VIII-OC-1	0	5	OA	5YR	4	/3	silt with mixed sand/clay, pebbles	1,F,T	Semi-homogenous organic rich outcrop soil (includes angular pebbles <1cm), OM ~30%	
289	VIII-OC-1	5	10	A	5YR	5	/3	silt with mixed sand/clay, pebbles. Pebbles ~10%	2,M,T	same as above but lighter brown color and more pebbles	
290	VIII-OC-2	0	5	0	7.5YR	3	/3	silt with mixed sand/clay, pebbles. Pebbles ~10%	2,F-M,T	Semi-homogenous organic rich outcrop soil (includes angular pebbles <1cm), OM ~30%	

291	VIII-OC-2	5	10	0	7.5YR	4	/3	silt with mixed sand/clay, pebbles. Pebbles ~10%	3,F-M,T	Semi-homogenous organic rich outcrop soil (includes angular pebbles <1cm), OM ~30%	
292	VIII-OC-2	10	20	OA	7.5YR	4	/3	silt with mixed sand/clay, pebbles. Pebbles ~10%	3,F-M,T	Semi-homogenous organic rich outcrop soil (includes angular pebbles <1cm), OM ~30%	
293	VIII-OC-3	0	5	0	7.5YR	4	/2	silt with mixed sand/clay, pebbles	3,F-M,T	Semi-homogenous organic rich outcrop soil (includes angular pebbles <1cm), OM ~30%	
294	VIII-OC-3	5	10	0	7.5YR	5	/3	silt with mixed sand/clay, pebbles	3,F-M,T	Semi-homogenous organic rich outcrop soil (includes angular pebbles <1cm), OM ~30%	
295	VIII-OC-4	0	5	0	7.5YR	4	/2	silt with mixed sand/clay, pebbles	3,F-M,T	Semi-homogenous organic rich outcrop soil (includes angular pebbles <1cm), OM ~30%	
296	VIII-OC-4	5	20	A	7.5YR	4	/6	silt with mixed sand/clay, pebbles. An- gluar gravel 15%	1,M,T	Semi-homogenous reddish brown outcrop soil (includes angular pebbles <1cm), OM <15%	
297	VIII-F-4	0	5	0	7.5YR	3	/2	silt with mixed sand/clay, pebbles	3,F-C,T	Semi-homogenous organic rich soil OM ~35%	
298	VIII-F-4	5	15	0	7.5YR	3	/2	silt with mixed sand/clay, pebbles, clay 30%	2,F-C,T	Semi-homogenous organic rich soil OM ~25%	
299	VIII-F-4	15	30	0	7.5YR	5	/2	silty OM clay	3,M- C,T	mix of brown OM and clay. OM ~20%? has some roots etc	
300	VIII-F-4	30	60	В	7.5YR	7	/2	Clay	0	tan saturated clay	
301	VIII-F-4	60	90	В	7.5YR	7	/2	Clay	0	tan saturated clay	
302	VIII-F-5	0	5	В	7.5YR	6	/2	clay with <30% sand+silt	2,F,T	tan saturated clay, clumpy and hard	
303	VIII-F-5	5	15	В	7.5YR	7	/2	clay with <30% sand+silt	1-2, F, T	tan saturated clay, clumpy and hard	
304	VIII-F-5	15	30	В	7.5YR	7	/4 and /2	clay with <30% sand+silt	0-1, VF, T	tan saturated clay, clumpy with sand and other particle content, pink and tan	
305	VIII-F-5	30	60	В	7.5YR	7	/4 and /2	clay with <30% sand+silt	0	tan saturated clay, clumpy with sand and other particle content. Tan, pinkish, and a few specks of orangey pink (5YR 6/6)	
306	VIII-WL-2	30	60	В	7.5YR	7&4	/2	Clay	1,F,T	tan clay with blackish traces of silty OM	
307	VIII-WL-2	60	10(В	7.5YR	7&4	/2	Clay with OM	0	Tan Clay-rich discrete clumpy soil, minor OM <5%, clumps <1cm	
308	VIII-F-5	60	10(В	7.5YR	8&7	/2 and /4	clay with <30% sand+silt	0	tan clay with some pink clay, has some sand material or silt mate- rial making it easier to break up	

309	VIII-WL-1	0	5	0	7.5YR	3	/3	silty clay and OM	3+,F- C,T	brown mess of 50% om and silty clay	
310	VIII-WL-1	5	15	0	7.5YR	3	/3	silty clay and OM	3,F-C,T	brown mess of 30% om and silty clay	
311	VIII-WL-1	15	30	OA	7.5YR	3	/3	silty clay and OM	2,F-C,T	brown mess of 30% om and silty clay	
312	VIII-WL-1	30	60	OA	7.5YR	3	/3	silty clay and OM	2,F-M,T	brown mess of 30% om and silty clay	
313	VIII-WL-1	60	100	В	10YR	8	/2	Clay	0	tan saturated clay	
314	VIII-WL-2	0	5	0	7.5YR	4	/2	silty clay and OM	3+,F- C,T	brown mess of 50% om and silty clay	
315	VIII-WL-2	5	15	В	5YR	5	/2	clay and ~45% silt	3,F-C,T	mix of greyish clay and dark brown clay/silt with OM ~20%	
316	VIII-WL-2	15	30	В	5YR	5	/2	Clay	1,F-M,T	mix of tan and dark brown semi- saturated clay	
317	IX-OC-1	0	5	0	7.5YR	6	/4	assorted clay through gravel	3,F-M,T	rocky heterogenous OC soil, brown, OM ~35%	
318	IX-OC-1	5	15	A	10YR	8	/3	assorted clay through gravel	3,F-M,T	rocky heterogenous OC soil, tan, sandier, OM<20%	
319	IX-OC-2	0	3	0	7.5YR	4	/2	assorted clay through gravel	3,F-M,T	rocky heterogenous OC soil, dark brown, OM ~35%	
320	IX-OC-2	3	10	A	7.5YR	7	/3	assorted clay through gravel	3,F-M,T	rocky heterogenous OC soil, tan, sandier, OM<20%	
321	IX-OC-2	10	25	A	7.5YR	8	/3	assorted clay through gravel	3,F-M,T	rocky heterogenous OC soil, tan, sandier, OM<20%	
322	IX-OC-3	0	5	0	7.5YR	3	/3	assorted clay through gravel	3,F-M,T	rocky heterogenous OC soil, chocolate brown, OM ~35%	
323	IX-OC-3	5	10	A	5YR	4	/4	assorted clay through gravel	3,F-M,T	rocky heterogenous OC soil, rusty color, sandier, OM<20%	
324	IX-OC-4	0	6	0	7.5YR	3	/1	assorted clay through gravel	3,F-M,T	rocky heterogenous OC soil, ddark greysih brown, OM ~35%	
325	IX-OC-4	6	15	A	7.5YR	7	/3	assorted clay through gravel	3,F-M,T	rocky heterogenous OC soil, tan, sandier, OM<20%	
326	IX-OC-4	15	20	A	7.5YR	6	/4	assorted clay through gravel	3,F-M,T	rocky heterogenous OC soil, tan, sandier, OM<20%	
327	IX-OC-5	0	7	0	5YR	3	/1	assorted clay through gravel	3,F-M,T	rocky heterogenous OC soil, dark rich brown, OM ~35%	
328	IX-OC-5	7	15	A	5YR	4	/4	assorted clay through gravel	3,F-M,T	rocky heterogenous OC soil, rusty color, sandier, OM<20%	

329	IX-F-3	0	5	0	5YR	3	/1	assorted clay through gravel	3+,F- C,T	leaf and forest floor litter, un- evenly decomposed, fluffy, brown. Small pinecone. Lots of roots. OM ~50%	
330	IX-F-3	5	15	E	10YR	8	/2.5	sand/silt	2,F-M,T	dry sand/silt. Some powder, some clumps.	
331	IX-F-3	15	30	E	10YR	8	/2.5	sand/silt	1,F-M,T	very dry sand/silt. Mostly pow- dery, a bit clumpy	
332	IX-F-3	30	60	Е	10YR	8	/2	sand/silt		very dry sand/silt. Powdery.	
333	IX-F-3	60	10	E	10YR	8	/2	sand/silt	0	very dry sand/silt. Powdery.	
334	II-F-1	0	5	OAB	5YR	6	/3	silty OM, roots, clay	3,F-C,T	brown OM silty material (45%), lots of roots, minor clay	
335	II-F-1	5	15	Ва	7.5YR	6	/3	clay with silty OM coating	1-2, F, T	clay with silty OM coating (~5%)	
336	II-F-1	15	30	В	7.5YR	6	/3	clay with silty OM coating	1,F,T	clay with silty OM coating (~3%)	
337	II-F-1	30	60	В	7.5YR	7	/4	Clay	0	pinkish tan clay	
338	II-F-1	60	10	В	7.5YR	7	/4	Clay	0	pinkish tan clay	
339	IV-WL-5	0	5	OA e	7.5YR	7	/3	silt, half sand+clay	3+,VF- C,T	lots of roots. OM is somewhat well-decomposed other than roots. Clumpy. Organics ~20%	
340	IV-WL-5	5	15	A	7.5YR	7	/3	Clay <40%,silt, sand, silt	3,VF- C,T	roots, clumpy brown soil, some OM <15%	
341	IV-WL-5	15	30	A	7.5YR	6	/3	Clay <50%, sand, silt	2,VF- F,T	same, slight increase in grain compaction. Clumy	
342	IV-WL-5	30	60	AB	5YR	6	/3	Clay (~20% coarser up to coarse sand)	2, VF-F, T	same but much more clay. Hard	
343	IV-WL-5	60	10	Be	10YR	7	/1	sandy clay	1, VF-F, T	clumpy and hard, similar to above layer but LESS clay content, more sandy.	
344	IV-F-2	0	5	0	7.5YR	5	/3	fine dusty silt to wood chips 1"	3,M,T	OM ~45%. big fluffy root clumps, dusty brown soil, partially well- decomposed. Medium brown	
345	IV-F-2	5	20	OA	7.5YR	3	/3	fine dusty silt to wood chips 1"	2,F-M,T	OM ~45%. less clumps than in layer before. Like potting soil except medium brown and bits of undecomp OM	
346	IV-F-2	20	30	A	7.5YR	6	/3	coarse silt to sand up to angular small pebbles	1,C,T	brownish tan sandy silty het- erogenous grain size soil with ~10% clumps. OM ~5%	
347	IV-F-2	30	60	E	10YR	7	/3	coarse silt to sand up to angular small pebbles, clay- rich clumps	0	Yellowish tan sandy silty het- erogenous grain size soil with ~10% clumps. Looks like more clay content than above.	
348	IV-F-2	60	10	E	10YR	7	/3	coarse silt to sand up to angular small pebbles, clay- rich clumps	0	Yellowish tan sandy silty het- erogenous grain size soil with ~10% clumps.	

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	349	Stockpile 1			N/A	10YR	7	/1	dust to gravel	0	greyish dust up to copious angu- lar gravel.	
	350	Stockpile 2			N/A	10YR	7	/1	dust to gravel	0	greyish dust up to copious angu- lar gravel.	
	351	Stockpile 3			N/A	10YR	7	/1	dust to gravel	0	greyish dust up to copious angu- lar gravel.	
	352	Stockpile 4			N/A	10YR	7	/1	dust to gravel	0	greyish dust up to copious angu- lar gravel.	
	353	Stockpile 5			N/A	10YR	7	/2	dust to gravel	0	greyish dust up to copious angu- lar gravel. Slightly more yellow than other stockpile samples	
	354	III-OC-8	0	5	0	7.5YR	7	/3	Clay (<40%) to coarse angular pebbes	3,F-M,T	OM ~35%. Clay-rich clumping. Medium flat brown	
	355	III-OC-8	5	15	OA	7.5YR	7	/3	Clay (<40%) to coarse angular pebbes and small gravel	3,F-M,T	OM ~35%. Clay-rich clumping. Medium flat brown	
	356	III-F-1	0	5	0	7.5YR	4 & 6	/2 and /3	silty OM ma- terial, clay <20%, lots of roots	3,VF- C,T	mix of fluffy brown organic dust in root clumps with smaller and harder (but not super hard) clumps of tan-ish mineral soil	
	357	III-OC-8	5	15	A	7.5YR	6	/3	Clay <35%, silt, sand	1,VF,T	looks like tannish clumps from above layer with some slightly lighter clumps, still some root clusters. Lighter colors	
	358	III-OC-8	15	30	E	10YR	6	/4	Clay <30%, silt, sand, gravel	0	golden brown with clay clumping (Clay<40%), sandy, some gravel possibly	
	359	III-OC-8	30	70	E	10YR	6	/3	Clay <30%, silt, sand, gravel	0	golden brown with clay clumping (Clay<40%), sandy, some gravel possibly	

Appendix VIII: Sample Photographs

See electronic supplemental material. Sample photographs were taken after samples were laid out to dry in the ASU lab, preserving some sense of relative locations of drying samples and original sample condition.

Appendix IX: SEM Photographs

Additional SEM photographs can be shared upon request in an electronic format.

Appendix X: Additional MLA data

The following appendix includes selected additional tables of MLA data, including duplicate co-variance statistics for gangue minerals. Supplemental electronic files with more information can be supplied upon request. The following two tables show the covariance statistics for phases not included in the MLA QA/QC section in the main body of the report.

Gold	Sam	As		As s	ulfide		Fe	oxide	s with	As	Or	ganics	s with	As	F	e-As-C	Ca∕Mn	oxide	AI-	Mn-Fe	-As ox	ide
er Sam ple	pie	µg/g (mea s- ured)	area (µm²)	grain s		%CV	area (µm²)	grain s		%CV												
IVWL 2-d	010 dup	3400	22.5	6	area	7.1	1E+0	5825	area	7.2	8790	1409	area	2.4	6193	1020	area	1.3	2.1	2	area	141
IVWL 2-d	10	3400	20.3	4	grain s	28.3	9728	5460	grain s	4.6	8491	1494	grain s	4.1	6078	9697	grain s	3.6	0.0	0	grain s	141
lIIF2- b	028 dup	840	0.0	0	area	0.0	157	10	area	12.3	2160	190	area	24.2	8693	355	area	21.4	65.5	5	area	94.3
lIIF2- b	28	840	0.0	0	grain s	0.0	187	16	grain s	32.6	3052	350	grain s	41.9	6405	444	grain s	15.8	13.1	3	grain s	35.4
IIOC 5-a	070_ 1	1700	0.0	0	area	0.0	5254	1691	area	18.5	3E+0	5879	area	50.7	1E+0	3821	area	57.1	232	11	area	32.4
IIOC 5-a	70	1700	0.0	0	grain s	0.0	4037	1320	grain s	17.4	1E+0	4475	grain s	19.2	4338	3350	grain s	9.3	369	8	grain s	22.3
IIOC 5-b	071 redo	1300	0.0	0	area	0.0	1536	39	area	4.4	7342	223	area	124	4598	120	area	59.5	3889	23	area	99.7
IIOC 5-b	071_ 1	1300	0.0	0	grain s	0.0	1636	39	grain s	0.0	1E+0	657	grain s	69.7	1128	282	grain s	57.0	2248	229	grain s	116
IIOC 11-b	086 dup	7800	0.0	0	area	0.0	7371	166	area	43.6	8771	2292	area	31.5	5580	1797	area	66.6	2E+0	1254	area	45.2
IIOC 11-b	86	7800	0.0	0	grain s	0.0	1394	430	grain s	62.6	1E+0	3067	grain s	20.5	2E+0	2987	grain s	35.2	3E+0	1175	grain s	4.6
IIIOC 2-b	123 dup	1300	0.0	0	area	0.0	1083	37	area	128	9020	299	area	39.3	4017	927	area	72.8	7476	162	area	51.7
IIIOC 2-b	123	1300	0.0	0	grain s	0.0	56.1	4	grain s	114	5095	217	grain s	22.5	1286	400	grain s	56.2	3471	88	grain s	41.9
IVOC 4-b	148 dup	5100	0.0	0	area	0.0	3776	156	area	43.4	1E+0	4179	area	75.1	8278	4245	area	67.7	6416	41	area	39.5
IVOC 4-b	148	5100	0.0	0	grain s	0.0	7115	377	grain s	58.6	4E+0	8839	grain s	50.6	2E+0	1022	grain s	58.4	1139	64	grain s	31.0
VWL 2-b	169 dup	1100	0.0	0	area	0.0	4748	245	area	5.4	7125	480	area	3.7	1934	1415	area	14.1	1933	97	area	52.7
VWL 2-b	169	1100	0.0	0	grain s	0.0	5122	228	grain s	5.1	6757	383	grain s	15.9	1583	1001	grain s	24.2	883	29	grain s	76.3
VIWL 1A-b	196 dup	420	167	31	area	30.5	0.0	0	area	141	2086	74	area	37.7	6397	137	area	19.9	0.0	0	area	0.0
VIWL 1A-b	196	420	259	32	grain s	2.2	24.8	5	grain s	141	1208	39	grain s	43.8	4821	102	grain s	20.7	0.0	0	grain s	0.0
VIOC 4-b	203	1300	0.0	0	area	0.0	104	9	area	1.0	7147	217	area	2.4	9362	413	area	11.0	4314	684	area	29.2
VIOC 4-b	203 dup **XB SES TD	1300	0.0	0	grain s	0.0	106	6	grain s	28.3	7393	187	grain s	10.5	1094	278	grain s	27.6	2836	673	grain s	1.1

Gold er Sam ple	Sam ple	Silicate gangue		Carbonate gangue		oxide gangue		sulfide gangue		organic gangue		unknowns		low counts	
		Area %	%CV	Area %	%CV	Area %	%CV	Area %	%CV	Area %	%CV	Area %	%CV	Area %	%CV
IVW L2-d	010 dup	88.7	1.4	6.11	18.1	0.63	13.5	0.23	15.6	1.43	0.3	2.29	12.1	0.05	14.9
	10	87.0	-	7.91	-	0.77	-	0.28	-	1.44	-	1.93	-	0.04	-
IIIF2	028 dup	90.3	3.3	0.34	34.3	0.16	1.1	0	122	5.86	23.6	0.34	31.8	2.61	120
d-	28	94.5	-	0.55	-	0.16	-	0	-	4.18	-	0.22	-	0.21	-
IIOC	070_ 1	73.4	14.2	0.01	35.0	0.91	7.3	0.01	45.6	20	92.8	1.83	73.5	0.49	137
5-a	70	60.0	-	0.01	-	0.82	-	0.01	-	4.16	-	0.58	-	33	-
lioc	071 redo	97.4	5.4	0.01	6.6	0.33	3.0	0	25.7	0.16	133	0.12	88.3	1.92	22.1
5-b	071_ 1	90.2	-	0.01	-	0.32	-	0	-	5.58	-	0.53	-	2.63	-
lioc	086 dup	90.8	24.6	0	83.0	0.73	34.5	0	52.1	5.57	80.5	1.03	24.3	0.93	121
11-D	86	63.9	-	0.01	-	1.2	-	0	-	20.3	-	0.73	-	12.2	-
	123 dup	96.9	0.1	0	80.7	0.46	18.8	0	70.6	1.35	10.4	0.43	7.8	0.72	23.3
02-0	123	96.7	-	0.01	-	0.6	-	0	-	1.16	-	0.38	-	1.01	-
IVO	148 dup	87.4	11.4	0.05	106	0.8	117	0	92.6	3.24	15.5	0.56	5.2	7.19	27.9
04-0	148	74.3	-	0.01	-	8.43	-	0	-	4.04	-	0.52	-	10.7	-
VWL	169 dup	92.2	0.9	0.04	105	1.49	11.2	0.04	16.2	1.87	27.2	0.47	40.8	3.69	3.1
2-0	169	93.4	-	0.01	-	1.27	-	0.05	-	1.27	-	0.26	-	3.53	-
VIW L1A- b	196 dup	82.9	0.6	13.9	0.3	0.77	5.2	0.23	24.5	0.63	5.5	0.6	13.9	0.84	105
	196	83.6	-	13.8	-	0.83	-	0.33	-	0.68	-	0.49	-	0.13	-
	203	77.5	4.0	0	33.3	2.58	7.1	0	63.2	3.59	2.7	0.43	11.0	15.7	25.2
VIO C4-b	203 dup **	82.0	-	0.01	-	2.85	-	0	-	3.46	-	0.5	-	10.9	-

Table: Covariance statistics for gangue mineral categories in GXMAP runs

Gold er Sam ple	Sam ple	Silicate gangue		Carbonate gangue		oxide gangue		sulfide gangue		organic gangue		unknowns		low counts	
		Area %	%CV	Area %	%CV	Area %	%CV	Area %	%CV	Area %	%CV	Area %	%CV	Area %	%CV
Notes: Gangue mineral categories include sums of all minerals in in the library and modal mineralogy, with the exception of phosphates (monazite and apatite). Organic gangue includes carbon and the "or- ganics w/ Feox, no As" phase. Any big variations in the organics gangue duplicates come from the car- bon phase. **The duplicate for sample 203 was run as an XBSE_STD, not a GXMAP.															

Table:	Table: Area % Modal Mineralogy for all GXMAP runs (simplified, no phosphates)												
#	As ₂ O ₃	Aspy	As- sulfide	Fe Ox- ides - with As	Organics w/ As,Fe,Ca Ox	Fe-As- Ca/Mn oxide	Al-Mn- Fe-As oxide	ROs?	Silicates	carbon- ates	sulfides	organics	
2	0.0007	0.1822	0	0.317	0.0218	0.0774	0	Yes, 260+	77.837	17.148	0.289	1.0046	
3	0.0001	0.0431	0	0.0348	0.0021	0.0122	0.0001	Yes, 50+	94.877	1.8388	0.0309	2.1178	
8	3E-06	0.0033	0.0001	0.0129	0.0037	0.02	0	yes	97.697	1.2905	0.0216	0.2817	
9	0	0.0074	0	0.0419	0.0063	0.0729	0	yes	94.181	2.9724	0.0682	0.794	
10	0.0002	0.0332	0.0001	0.3237	0.0283	0.2023	0	Yes, 200++	86.972	7.9062	0.2836	1.438	
010 dup	0.0005	0.0257	0.0001	0.2674	0.0218	0.1538	5E-06	Yes, 200++	88.716	6.109	0.2273	1.4326	
11	0.0009	0.0364	0.0001	0.1414	0.051	0.1138	6E-06	Yes, 100++	88.813	6.5722	0.1905	1.6273	
17	0.046	0	0	0.0144	0.334	0.1792	0.2547	yes	82.017	0.0354	0.0006	6.5296	
18	0.0031	0	0	0.0291	0.4363	0.3431	0.1248	none found	79.229	0.0019	0.0013	18.209	
27	0.0623	0.0004	0	0.0056	0.0059	0.0144	0.0019	Yes	93.365	0.3001	0.005	2.6552	
28	0.0114	0	0	0.0004	0.0071	0.0149	3E-05	Yes	94.548	0.5504	0.0002	4.179	
028 dup	0.008	0.0006	0	0.0004	0.0049	0.0198	0.0001	Yes	90.256	0.3354	0.0027	5.8556	
70	0.5247	0.0019	0	0.1774	0.5276	0.1906	0.0016	Yes, 87+	59.969	0.013	0.0059	4.1562	
070_1	0.6159	0.0015	0	0.2934	1.4192	0.5701	0.0013	Yes	73.371	0.0079	0.0116	20.024	
71	0.0172	0	0	0.0052	0.3578	0.0356	0.0711	Yes	90.239	0.01	0.001	5.5747	
071 redo	0.0032	0.0003	0	0.0037	0.0178	0.0111	0.0094	Yes	97.404	0.0091	0.0014	0.1643	
72	0	0.0001	0	0.0036	0.0247	0.0177	0.0333	none found	98.271	0.0098	0.0005	0.2097	
80	0.0156	0	0	0.0328	0.0778	0.2039	0.0022	none found	68.518	0.0058	0.0015	28.669	
081_2	0	2E-05	0	0.0104	0.0556	0.0736	0.0009	none found	95.168	0.0438	0.0006	2.9877	
Table:	Area %	Modal	Mineralogy for all GXMAP runs (simplified, no phosphates)										
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#	As ₂ O ₃	Aspy	As- sulfide	Fe Ox- ides - with As	Organics w/ As,Fe,Ca Ox	Fe-As- Ca/Mn oxide	Al-Mn- Fe-As oxide	ROs?	Silicates	carbon- ates	sulfides	organics	
82	0	0	0	0.0029	0.0584	0.0613	0.0093	none found	85.198	0.0058	0.0012	10.706	
83	0.147	0	9E-06	0.3115	4.1952	2.4849	0.3687	Yes, <50	55.147	0.008	0.0033	29.465	
84	0.0027	0.0002	0	0.0981	0.7373	0.5841	0.2364	Yes	90.001	0.0068	0.0007	6.034	
85	0.1642	0	0	0.0397	1.7903	0.4881	0.3656	Yes, <15	77.91	0.0104	0.0004	16.286	
86	0.0315	0	0	0.0328	0.3245	0.3643	0.73	Yes	63.874	0.0083	0.0019	20.288	
086 dup	0.0232	0	0	0.0214	0.2551	0.1623	0.4659	Yes	90.805	0.0021	0.0009	5.5665	
93	0.0025	0.0176	0.0118	0.0102	0.1539	0.8098	0	Yes	83.459	1.3382	0.1704	9.6139	
118	0.0012	0.0113	0.0044	0.0055	0.0209	0.0487	0	Yes	91.285	0.2106	0.0122	5.5908	
119	0.0002	0.0049	0.0031	0.0028	0.0062	0.0419	0	Yes	89.982	0.8983	0.0255	3.1495	
122	0.0894	0	0	0.0115	0.077	0.2435	0.092	Yes	85.751	0.1983	0.0017	7.9099	
123	0.0005	0	0	0.0001	0.0085	0.0214	0.0058	none found	96.715	0.0058	0.0015	1.161	
123 dup	0.0032	0.0001	0	0.0018	0.0153	0.0683	0.0127	none found	96.864	0.0016	0.0005	1.345	
124	0.0014	0	0	0.0132	0.5912	0.9304	0.0186	none found	84.733	0.0782	0.0009	4.9131	
125	0.0002	0.0002	0	0.0055	0.5549	0.3493	0.217	none found	80.436	0.0054	0.0002	6.1691	
147	0.0486	0	0	0.0253	0.7079	0.8435	0.0004	Yes	47.905	0.0078	0.0006	3.45	
148	0.0002	0	0	0.0187	1.1802	0.6179	0.03	none found	74.3	0.0077	0.0003	4.0442	
148 dup	0.0072	0.0002	0	0.0124	0.4495	0.2711	0.021	none found	87.377	0.0543	0.0015	3.2437	
169	0.0003	0.0242	0	0.0145	0.0191	0.0448	0.0025	none found	93.41	0.0062	0.0537	1.2676	
169 dup	0.0001	0.0003	0	0.0138	0.0207	0.0562	0.0056	none found	92.225	0.0423	0.0427	1.8718	
179	0.0007	0	0	0.0031	0.0495	0.0407	0.0177	none found	92.004	0.0021	0.0004	1.0694	
180	0	0	0	0.0005	0.0051	0.0063	0.0009	none found	97.799	0.021	0.0006	0.2144	
181	0.0054	0	0	0.0072	0.1128	0.1715	0.2297	Yes	83.799	0.0183	0.0011	1.472	
195	0	0.0104	0.0016	2E-06	0.047	0.3096	0	Yes	54.51	32.886	0.059	8.3122	
196	0	0.0085	0.0004	0	0.0017	0.0068	0	none found	83.595	13.838	0.3318	0.6767	
196 dup	0	0.0161	0.0002	0	0.003	0.0091	0	none found	82.944	13.891	0.2338	0.6262	

Table:	Table: Area % Modal Mineralogy for all GXMAP runs (simplified, no phosphates)											
#	As ₂ O ₃	Aspy	As- sulfide	Fe Ox- ides - with As	Organics w/ As,Fe,Ca Ox	Fe-As- Ca/Mn oxide	Al-Mn- Fe-As oxide	ROs?	Silicates	carbon- ates	sulfides	organics
197	0.0001	0.028	0.0028	0	0.0021	0.0208	0	none found	57.168	23.349	0.1969	13.256
198	0.0002	0.0785	0.0022	0.0005	0.0004	0.0043	0	none found	78.048	9.8687	0.1978	6.1176
199	0	0.0194	0.0036	0.0001	0.0003	0.0014	0	none found	80.533	7.4798	0.5731	7.9015
202	0.0013	0	0	0.0013	0.0201	0.0162	0.1442	Yes	55.127	0.0679	0.0006	31.67
203	7E-06	7E-06	0	0.0003	0.0175	0.0229	0.1055	none found	77.48	0.0033	0.0001	3.5937
203 dup	0.0003	0.0002	0	0.0003	0.019	0.0282	0.073	none found	82.022	0.0054	0.0003	3.458
295	0.0103	0	0	0.0552	0.0302	0.1473	0.0589	Yes, <30	64.124	0.0318	0.0133	2.0982
296	0.0002	0	0	0.0012	0.0031	0.0076	0.0011	none found	88.714	0.0996	0.0007	1.8936
319	0.1298	0.0334	0	0.3153	0.0506	0.1048	0.0125	Yes, 200+++	76.187	1.758	0.1142	2.1856
320	0.0051	0	0	0.0058	0.0022	0.0252	0.0001	none found	98.576	0.0145	0.0007	0.3446
324	0.2523	0.0151	0	0.1317	0.0665	0.1558	0.0812	Yes, 50+	82.696	2.182	0.1213	11.041
324 dup	0.164	0.0189	0	0.0653	0.0654	0.0853	0.0449	Yes	41.655	5.3154	0.0762	38.86
325	0.0019	0.001	0	0.003	0.0262	0.0666	0.0002	Yes	92.698	2.3713	0.0079	0.9183
326	0	0	0	0.0009	0.0224	0.0495	0.0002	Yes	96.799	0.0271	0.0018	0.5099
344	0.2836	0	0	0.0033	0.0344	0.0103	0	Yes	42.633	0.104	0.0032	1.5701
345	0.054	0.0004	0	0.0011	0.0067	0.0018	0	Yes	24.459	0.0753	0.0011	6.2839
354	0	0	0	0.01	0.0179	0.0291	0.0061	none found	83.106	0.0234	0.001	4.1916
354 dup	0	0	0	0.0033	0.0235	0.0266	0.0042	Yes, 1	83.525	0.0076	0.0023	4.4872

Appendix XI: Additional Maps



FINAL REPORT: CHARACTERIZATION OF SOIL SAMPLES AT GIANT MINE, NWT (2014 Regional Sampling)



FINAL REPORT: CHARACTERIZATION OF SOIL SAMPLES AT GIANT MINE, NWT (2014 Regional Sampling)



The pie charts compare relative As concentrations between soil horizons for each sample site. Total As concentrations between sample sites are not represented on this map. "As_" is the top horizon, "As_b" the one below, and so on. Anomalous samples with highest As concentrations in deeper soil horizons pop out clearly this way, regardless of absolute total As concentrations across the property. Note: Lease boundary

FINAL REPORT: CHARACTERIZATION OF SOIL SAMPLES AT GIANT MINE, NWT (2014 Regional Sampling)







Arsenic elemental distribution by sample site and geographic location, calculated with 1 wt% As for Feoxides with As, Fe-As-Mn/Ca oxides, Organics with As, and Al-Mn-Fe-As oxides. Pie chart symbol size is proportional to total As concentration (µg/g) for each sample.





ASSESSMENT OF REGIONAL SOIL QUALITY - GIANT MINE

APPENDIX B

Soil Descriptions



Soil Descriptions

Cito	Depth		
Site	from (cm)	to (cm)	Basic description
I-OC-1	0	5	Unsorted mix, clay through small angular pebbles, OM ~40%. Clumpy. Immature, organic rich, medium brown
I-OC-1	5	15	Unsorted mix, clay through small angular pebbles, OM ~30%. Immature and poorly sorted, OM partially decomposed. Slightly less wet than layer above. brown
I-OC-2	2	7	Red brown soil with regolith particles <1cm, clumpy, OM <1cm. OM ~30%
I-OC-3	2	5	Medium brown clumpy silt/clay with high organic content, small particle size. OM ~20-25%. Small regolith pebbles
I-F-1	0	5	Mossy root web, OM <40%
I-F-1	5	15	Mossy root web, OM <30%. Less comprehensive root web than sample above
I-F-1	15	30	More clay rich than layers above, transitioning into clay soil
I-F-1	30	60	Clay with coating of brown silty OM
I-F-1	60	100	Clay, includes coarse sand to pebble fragments
I-F-2	0	5	Silty decomposed organics and roots coating clay nodules, OM ~35%
I-F-2	5	15	Silty decomposed organics and roots coating clay nodules, OM ~35%. More homogeneous than layer above
I-F-2	15	30	Silty decomposed organics and roots coating clay nodules, OM ~30%. More homogeneous than layer above, more clay and larger nodules (up to ~3cm). Clay nodules are medium grey
I-F-2	30	60	Large clay nodules (pale tan) with dusting of brown organic silt material
I-F-2	60	100	As above with slightly less organics.
I-WL-1	0	5	Sand, clay, organic matter (~30%)
I-WL-1	5	15	Extremely sandy clay, includes bits of minor OM
I-WL-1	15	30	Clumpy sandy clay with small pebbles
I-WL-1	30	60	Saturated greyish sand, minor clay and finer content. Cuts nicely
I-WL-1	60	100	As above, less saturated
I-WL-2	0	5	Dark brown, OM>40% with clay, saturate
I-WL-2	5	15	Clay with small roots, saturated
I-WL-2	15	30	Clay, saturated, minor roots
I-WL-2	30	60	Mix of pale yellow casted tan and slightly more red, darker tan. Saturated. Clay.
I-WL-2	60	100	Mix of pale yellow casted tan and slightly more red, darker tan. Saturated. Clay.
II-F-1	0	5	Brown OM silty material (45%), abundant roots, minor clay
II-F-1	5	15	Clay with silty OM coating (~5%)
II-F-1	15	30	Clay with silty OM coating (~3%)
II-F-1	30	60	Pinkish tan clay
II-F-1	60	100	Pinkish tan clay
II-F-2	0	5	Mix of semi-decomposed leaf litter and roots (dark brown) with light grey clay.
II-F-2	5	15	Mix of semi-decomposed leaf litter and roots (dark brown) with light grey clay.
II-F-2	15	30	Clay with roots
II-F-2	30	60	Moist clay with roots, leaves, poorly decomposed
II-F-2	60	100	Clay with roots, leaves, poorly decomposed
II-F-3	0	5	Mix of tan clay and minor brown silty OM

	Depth		
Site	from (cm)	to (cm)	Basic description
II-F-3	5	15	Yellow cast tan fine silt (possible clay)y, crumbly, <5mm, small roots
II-F-3	15	30	Yellow cast tan fine silt (possible clay), crumbly, small roots
II-F-3	30	60	Yellow cast tan, fine silt (possible clay), crumbly, small roots, small round to angular regolith up to 2cm
II-F-3	60	90	Yellow cast tan silt to clay (actual chunks present) crumbly, small roots, small round to angular regolith up to 2cm
II-OC-1	0	5	Dark brown organics with common small roots. Fairly dry, no rocks
II-OC-1	5	10	Light brown organic soil with numerous roots. Fairly dry, no rocks
II-OC-2	0	3	Organic rich (~30- 40%), roots and other small (<3cm) bits of forest floor type OM (small twigs, bits of leaves, etc.). High root concentration. Regolith <10%, rounded to angular, indeterminate color. Soil color is rich chocolate brown
II-OC-2	3	10	Reddish brown soil with small gravel size regolith, regolith ~10-15%. roots and OM more like 10% or less
II-OC-3	0	5	Medium brown soil with some thicker roots. Fairly dry. No rocks
II-OC-3	5	10	Medium red brown
II-OC-4	0	5	Greyish brown. Mix of medium brown silty material and lighter tan, clay size in aggregate clumps (small). Abundant small roots. Regolith ~15% at least. Small bits of OM <<1cm ~10%
II-OC-4	5	15	Light tan mineral soil with large rocks, fairly dry.
II-OC-4	15	20	Pale off-white, small crumbled bits throughout.
II-OC-5	0	3	Grey silt with fine roots, fairly dry
II-OC-5	3	10	OM ~10%. Pale off white to grey sand with clay with irregular gravel and bits of twigs and roots
II-OC-5	10	20	OM ~10%. Pale off white to white-tan sand with clay with irregular gravel and bits of twigs and roots
II-OC-6	0	5	Medium brown, regolith pebbles, twigs and roots <2cm
II-OC-6	5	15	Medium red brown, regolith pebbles, twigs and roots <2cm
II-OC-6	15	20	Medium gold- brown, regolith pebbles, twigs and roots <2cm. Slightly more clay than soil above
II-OC-7	0	10	Dark brown. Medium size clumps of dark clay with abundant regolith (~15%? Hard to say) and leaf and twig litter <1cm
II-OC-7	10	16	Tan version of soil stratigraphically above, more large clay clumps and regolith
II-OC-8	0	12	Medium brown, heterogeneous and OM rich (~30%), but decomposed and uniform size <1cm
II-OC-8	12	15	Regolith pebbles <2cm, OM, fluffy brown, slightly more clay in above stratigraphic layer. OM ~30%
II-OC-9	0	3	Homogenous and small particles. Regolith pebbles <1cm are more rare, OM, fluffy brown
II-OC-9	3	10	Regolith pebbles <2cm, OM, reddish color, more clay right than above (more clumpy)
II-OC-9	10	15	Regolith pebbles <2cm, OM, fluffy brown
II-OC-10	0	5	Dark brown clay with some small roots, fairly dry.
II-OC-10	5	8	Wet clay with some roots, silt, and large sand/small pebbles
II-OC-11	0	5	Wet silty clay with roots

	Depth		
Site	from (cm)	to (cm)	Basic description
II-OC-11	5	10	Wet clay, roots
II-WL-2	0	5	Clayey sand with OM ~45%
II-WL-2	5	15	Clayey sand with OM ~40%
II-WL-2	15	30	Dark brown sandy clay with roots
II-WL-2	30	60	Reddish color hard clay with angular coarse sand to small pebbles, coating of brown OM
II-WL-2	60	100	Reddish color hard clay with angular coarse sand to small pebbles, coating of brown OM
III-F-1	0	5	Organic dust in root clumps with smaller and harder clumps of tan mineral soil
III-F-2	0	5	Mix of medium brown silty/clay size silt particles clumped with roots and OM, some light clay
III-F-2	5	15	As above, higher clay content
III-F-2	15	30	As above, higher clay content
III-F-2	30	55	Clay clumps with roots
III-F-2	55	100	Reddish tan clay
III-OC-1	0	5	Poorly sorted OC soil with medium brown color, organic content probably high (>15 %?)
III-OC-1	5	15	Poorly sorted OC soil with medium brown color, organic content probably high (>15 %). twigs, usually <3cm long
III-OC-2	0	8	Partially decomposed leaf and twig litter <3cm long, ~35 -45%. Mottled color. Partially decomposed wood chunks
III-OC-2	8	15	Paler, less brown version of soil above. Still poorly sorted, etc.
III-OC-3	0	5	Stony medium brown organic rich heterogeneous soil. OM ~35%?
III-OC-3	5	9	Stony medium brown organic rich heterogeneous soil. OM ~35%?
III-OC-5	0	5	Clay-rich with OM >25%, includes poorly sorted angular rock fragments, etc.
III-OC-5	5	10	Clay-rich with OM >25%, includes poorly sorted angular rock fragments, etc.
III-OC-6	0	5	Orangey brown, rocky soil with roots, organic litter. OM ~15%
III-OC-6	5	9	As above but more clay content, slightly less obvious OM. OM ~10-15%
III-OC-7	0	5	OM ~25%. Dark brown, wet
III-OC-7	5	10	As above but fine matrix is more clay-rich
III-OC-8	0	5	OM ~35%. Clay-rich clumping. Medium flat brown
III-OC-8	5	15	OM ~35%. Clay-rich clumping. Medium flat brown
III-OC-8	5	15	Tannish clumps from above layer with some slightly lighter clumps, still some root clusters. Lighter colors
III-OC-8	15	30	Golden brown with clay clumping (Clay<40%), sandy, some gravel possibly
III-OC-8	30	70	Golden brown with clay clumping (Clay<40%), sandy, some gravel possibly
III-WL-1	15	30	Brown clay with OM ~20%
III-WL-1	30	60	Tan clay, roots etc. <5%
III-WL-1	60	100	Tan clay, less roots than above
III-WL-1	0	5	Clay with roots and moss, saturated, OM >40%
III-WL-1	5	15	Clay with roots and moss, saturated, OM <30% (slightly less than above)
IV-F-1	5	15	Mix of yellowish tan silt and clay clumps with roots and small pebbles <1cm with medium brown fine OM. OM ${\sim}25\%$

	Depth		
Site	from (cm)	to (cm)	Basic description
IV-F-1	15	30	Yellowish tan silt and clay clumps with roots and small pebbles <1cm
IV-F-1	30	60	Yellowish off-white sand and silt coating pinkish clay nodules.
IV-F-1	60	100	As above, higher clay content
IV-F-1	0	5	Brown organic material, partially decomposed fine root masses with finer brown silty material, a few larger roots. OM ~40% or more
IV-F-2	0	5	OM ~45%. Big fluffy root clumps, dusty brown soil, partially well-decomposed. Medium brown
IV-F-2	5	20	OM ~45%. Less clumps, medium brown and bits of undecomposed OM
IV-F-2	20	30	Brownish tan sandy silty heterogeneous grain size soil with ~10% clumps. OM ${\sim}5\%$
IV-F-2	30	60	Yellowish tan sandy silty heterogeneous grain size soil with ~10% clumps. Looks like more clay content than above.
IV-F-2	60	100	Yellowish tan sandy silty heterogeneous grain size soil with ~10% clumps.
IV-F-3A	0	5	Extremely wet, bits of moss, etc. OM ~40-50%
IV-F-3A	5	15	Very wet, etc. OM ~40-50%
IV-F-3A	15	35	Saturated clay with OM fine roots mostly <20%
IV-F-3B	0	5	Reasonably well-decomposed OM and roots, fairly dry, very clumpy with micro root clusters. Medium dark brown
IV-F-3B	5	15	As above but less clumpy, slightly redder, hints of tan clay
IV-F-3B	15	30	As above but more hints of tan clay
IV-F-3B	30	60	Pale grey-tan Clay with <30% medium brown silt
IV-F-3B	60	100	Medium reddish tan color silt and clay covering gravel, minor fine roots
IV-OC-1	0	5	Saturated (dark brown when wet, medium when dry) clay with OM, fine roots throughout, OM ${\sim}15\%$
IV-OC-1	5	10	Saturated (dark brown when wet, medium when dry) crumbly silty clay with OM, fine roots throughout, OM ~15-20%
IV-OC-2	0	5	OM ~30%. Sandy but poorly sorted. Clumpy sand. Thoroughly damp.
IV-OC-2	5	10	As above but more saturated
IV-OC-3	0	5	Unsorted, heterogeneous, organic bits <1cm large, semi-decomposed and clumpy. Wet. OM ~40%
IV-OC-3	5	15	Reddish version of soil above with less OM. OM ~10%
IV-OC-4	0	5	Unsorted, heterogeneous, organic bits <1cm large, semi-decomposed and clumpy. Wet. OM ~40%
IV-OC-4	5	12	Reddish version of soil above with less OM. OM ~15%
IV-WL-1	0	5	Dark brown to grey (mottled) clay with significant OM/roots throughout, semi- saturated. OM ~30-40%
IV-WL-1	5	15	Medium/light brown to grey (mottled) clay with significant OM/roots throughout, semi-saturated. OM ~15-20%
IV-WL-1	15	30	Tan/light brown to grey (mottled) clay with OM/roots throughout unevenly, semi- saturated. OM ~5-10%
IV-WL-1	30	60	Tan/light brown to grey clay with OM/roots throughout unevenly, semi-saturated. OM ~3-5%.
IV-WL-1	60	100	Tan/light brown to grey clay with OM/roots throughout unevenly, semi-saturated. OM ~3-5%.

0.4	Depth		
Site	from (cm)	to (cm)	Basic description
IV-WL-2	0	5	Saturated medium tan brown clay
IV-WL-2	5	15	Saturated medium tan brown clay
IV-WL-2	15	30	Saturated medium tan brown clay
IV-WL-2	30	60	Semi-saturated medium brown clay
IV-WL-2	60	100	Very saturated medium grey brown clay
IV-WL-3	0	5	OM layer with mixed tan clay. Abundant roots, clumps. OM ~40%
IV-WL-3	5	15	More silt than above layer, high OM, includes some green bits of moss. OM ~35%
IV-WL-3	15	30	Clay with silty content, OM ~15%
IV-WL-3	30	60	Clay clumps with roots
IV-WL-3	60	100	Clay with roots
IV-WL-4	0	5	Grey, wet, OM (~20%) chunks in sandy clay
IV-WL-4	5	15	Grey, wet, OM (~10%) chunks in sandy clay
IV-WL-4	15	30	Grey, wet, OM (~3%) chunks in clay with slight sand/silt content
IV-WL-4	30	60	Grey, wet, OM (~5%) chunks in clay clumps
IV-WL-4	60	100	Grey, wet, OM (~5%) chunks in clay clumps
IV-WL-5	0	5	Abundant roots. OM is well-decomposed. Clumpy. Organics ~20%
IV-WL-5	5	15	Roots, clumpy brown soil, some OM <15%
IV-WL-5	15	30	As above, slight increase in grain compaction. Clumpy
IV-WL-5	30	60	As above, higher clay content. Hard
IV-WL-5	60	100	Clumpy and hard, similar to above layer but LESS clay content, more sandy.
V-OC-1	0	5	Red soil with abundant small gravel and smaller rock parts, heterogeneous OM (~15%), etc. Clumpy.
V-OC-1	5	15	Slightly less OM, slightly lighter color
V-OC-2	0	5	Heterogeneous OM clay sand silt pebbles etc.
V-OC-2	5	15	Sand, wet, with some clay content, tan color.
V-OC-2	15	25	Slightly more clay than above layer, more brown/red mottle color
V-OC-2	25	35	Sand with some clay content, scattered pebbles (angular)
V-OC-3	0	5	Organic rich (~30-40 %), roots and other small (<3cm) bits of OM (small twigs, bits of leaves, etc.). Abundant roots. Pebbles. Wet. Soil color is rich chocolate brown
V-OC-3	5	15	Reddish brown wet clay-sand, roots/OM
V-OC-3	15	25	Reddish brown soil with minor mossy roots
V-OC-4	0	5	Brown clumpy organic layer, semi-decomposed wood pieces and moss roots
V-OC-4	5	15	Clay-rich sediment with roots and twigs ~10%. Dull brownish tan. Damp but not supersaturated
V-OC-4	15	30	Clay-rich sediment with roots and twigs ~10%. Reddish brown tan. Damp but not supersaturated
V-OC-5	0	5	Tan clay-rich balls (<5mm, clay+silt+sand) mixed with angular pebbles and small gravel and medium dull brown OM ~25%
V-OC-5	5	10	As above. Abundant twigs and roots
V-OC-6	0	5	OM ~25%? Wet, not supersaturated, medium brown color with abundant roots, some small pebbles and angular small gravel but mostly finer particles

Site	Depth		Basic description			
Site	from (cm)	to (cm)	Basic description			
			(sand/silt/clay)			
V-OC-6	5	15	Angular gravel dominated outcrop soil			
V-F-1	0	5	Unsorted, heterogeneous, organic bits <1cm large, semi-decomposed and clumpy. OM ~40%			
V-F-1	5	15	Tan clay nodules covered in medium silty brown OM sediment, leaf and root litter,			
V-F-1	15	30	As above but more clay nodules			
V-F-1	30	50	As above but even more clay vs organics			
V-F-1	50	100	As above but even more clay vs organics			
V-F-2	80	90	Tan sand, covering reddish clay nodules up to 5cm long, down to few mm			
V-F-2	100	110	Clumpy yellowish sand with minor clay content. Crumbly			
V-F-2	0	10	Brown fine roots and decomposed OM, heterogeneous grain size			
V-F-2	10	20	Tan finely clumpy mineral soil with OM roots and twigs sparsely			
V-F-2	20	50	Tan finely clumpy mineral soil with OM roots and twigs sparsely			
V-F-2	50	80	Tan finely clumpy mineral soil with OM roots and twigs sparsely			
V-WL-1	0	5	Dark colored organic rich wet mass. Roots and leaves. Looks like wet land stuff. OM ${\sim}45\%$			
V-WL-1	5	15	Dark colored organic rich wet mass. Roots and leaves. Looks like wet land stuff. OM ${\sim}45\%$			
V-WL-1	15	30	Rich-looking dark wet OM soil			
V-WL-1	30	60	Rich-looking dark wet OM soil			
V-WL-1	60	80	Organic matter			
V-WL-2	20	40	Dark brown organic			
V-WL-2	40	70	Dark brown organic			
V-WL-2	70	100	Pinkish grey clay			
V-WL-2	0	5	Organic matter, moss roots. OM ~40%			
V-WL-2	5	20	Organic matter, moss roots. OM ~40%			
V-WL-3	0	10	Clay with organics ~15%			
V-WL-3	10	50	Less saturated clay with abundant organics ~25%			
V-WL-3	50	80	Wet hard sand			
V-WL-3	80	100	Wet hard sand (yellowish grey) with reddish and tan clay			
VI-OC-1	0	5	Heterogeneous mix of OM, clay up to small pebbles. OM ~30%, overall finely clumped.			
VI-OC-1	5	15	Rocky, less OM rich version of soil above, slightly lighter color. Abundant angular pebbles. OM ~15%			
VI-OC-2	0	5	Very wet silt with fine roots			
VI-OC-2	5	10	Organic matter			
VI-OC-3	0	5	Dark silty sand with fine OM, pebbles, abundant roots. OM well-decomposed, content ~30%			
VI-OC-3	5	10	Reddish version of soil above, OM ~20%			
VI-OC-4	0	5	Dark brown, damp organic rich clumpy clay/silt			
VI-OC-4	5	10	Dark brown, damp organic rich clumpy clay/silt			
VI-OC-5	0	5	Medium reddish-brown			

	Depth		
Site	from (cm)	to (cm)	- Basic description
VI-OC-5	5	10	Fully saturated, reddish brown, roots
VI-OC-5	10	20	Fully saturated smeary mud, medium brown
VI-WL-1A	0	5	Damp/wet sand-dominated sediment with abundant roots.
VI-WL-1A	5	10	Rounded gravel and smaller encrusted with clay/silt in pale yellowish color
VI-WL-1B	0	5	Wet smeared sandy/silty sediment with abundant fine roots
VI-WL-1B	5	10	Wet, as above but higher clay content
VI-WL-1B	10	30	Damp dark brown, more clay-rich than above layer, in nodules so less wet
VI-WL-1B	30	60	As above but less roots
VI-WL-1B	60	80	As above, less saturated
VI-F-1	0	5	Root webs supporting silty OM, well-decomposed (OM ~45% or more)
VI-F-1	5	20	Small clay lumps covered in silty decomposed OM in a sea of silty OM and roots. OM ${\sim}40\%$
VI-F-1	20	30	Mix of medium colors of clay in nuggets covered in silty black OM layer (clumpy)
VI-F-1	30	60	Mix of 3 colors of clay, some clumps with OM coatings.
VI-F-1	60	90	Reddish brown pale clay, minor fine roots.
VI-F-2	50	60	Dark brown sandy material with clay clumps and roots, very different from layer above it and below, OM ${\sim}25\%$
VI-F-2	60	80	Mottled color. Medium tan to light brown sand
VI-F-2	80	85	Reddish clay nodules, oblong up to 7cm long, with the medium brown/tan sand encrusted
VI-F-2	0	5	Dark silty OM clumpy stuff with roots, OM ~40%
VI-F-2	5	10	Dark colored sand and silt mix with roots, speckles of tan sand ~2% throughout spread evenly. OM ~35%
VI-F-2	10	30	Tan sand with scattered silty black OM clumpy bits with fine roots ~<5%
VI-F-2	30	50	Light brown sand (darker than above) with darker clumpy OM
VI-F-3	0	5	Medium reddish brown damp OM soil with fine roots, OM ~30%
VI-F-3	5	15	Tan sand with rounded to sub angular pebbles
VI-F-3	15	25	Tan sand
VI-E-3	25	20 45	Tan sand
	25 45	43 EE	Top cond with rounded pebbles
	40	00	
	55	60 E	Sallu
	0	5	Organics, dark brown, slightly damp with abundant roots. OM ~40%
	5	10	
VI-F-4	10	30	Sand. Fine sand, clumps
VI-F-4	30	60	Sand. Fine sand clumps
VI-F-4	60	100	Sand. Looked exactly like golden brown sugar when first laid out. Includes some fine sand that clumps nicely.
VII-OC-1	0	5	Rocky medium brown OC soil, rounded pebbles. OM ~20%
VII-OC-1	5	10	OM <10%
VII-OC-1	10	35	Tan mix of small gravel and everything smaller. Some roots

	Depth		
Site	from (cm)	to (cm)	Basic description
VII-OC-2	0	5	Medium brown clumpy soils with silty clay and abundant fine roots, some angular rocks thrown in. OM ~20%?
VII-OC-2	5	15	As above, with more rocks (~10-15%?), clumping is finer
VII-OC-3	0	5	Dark brown, organic rick clumpy soil,
VII-OC-3	5	15	Medium brown silty soil with OM <20%, clay content in soil making it clumpy, minor angular rocks
VII-OC-4	0	5	Medium brown, very rocky, OM ~ 25-35%
VII-OC-4	5	10	Reddish brown, similar texture as soil above, OM ~15% or less
VII-OC-5	0	5	Medium brown, very rocky, OM ~ 25-35%
VII-OC-6	0	5	Medium brown, very rocky, OM ~ 25-35%
VII-OC-6	5	10	Medium brown mottled with specks of tan
VII-OC-7	0	5	Medium brown, very rocky, OM ~ 25-35%
VII-OC-7	5	10	Silty clay, medium brown, small roots, specks of reddish dirt here and there. OM~15%
VII-OC-8	0	5	OM ~40%. relatively homogenous for an outcrop soil
VII-OC-8	5	15	Clumpy silty soil with small roots, OM~20%. Medium brown
VII-OC-8	15	25	More clay rich than layers above, OM ~15%. Medium brown
VII-OC-9	0	5	Clumpy silty soil with small roots, OM~20%. Medium brown
VII-OC-9	5	15	Clumpy silty soil with small roots, OM~20%. Medium brown
VII-OC-9	15	30	Reddish silt/clay, medium brown red color, large lumps, fine roots. OM ~50%
VII-WL-1	0	10	Medium brown organic. OM ~50%
VII-WL-1	10	30	Dark brown organic, OM ~50%
VII-WL-1	30	55	Dark brown organic, OM ~50%
VII-WL-1	55	100	Clay-rich organic. OM ~15%
VII-F-1	0	5	Fine roots and OM ~45%
VII-F-1	5	20	Finely crumbly silty dark brown organic rich mineral soil (OM ~20%? 35 %?)
VII-F-1	20	30	~3cm clay nuggets with dark brown silty OM coating (~10%)
VII-F-1	30	60	Same as last but less OM coating (~5%)
VII-F-1	60	100	Same as last but less OM coating (~5%)
VII-F-2	60	70	Slightly mottled soil of discrete clay nugget clumps <3cm (pale pinkish tan) covered in less pink silt/clay. Clumps go down to a few cms. 25%>1cm.
VII-F-2	70	100	Crumbly clay-rich sediment to fine sand.
VII-F-2	0	5	Root mass with trapped silty clay size sediment
VII-F-2	5	15	Tan Clay-rich discrete clumpy soil, minor OM <5%, clumps <1cm
VII-F-2	15	30	Tan Clay-rich discrete clumpy soil, minor OM <5%, clumps <1cm
VII-F-2	30	60	Tan Clay-rich discrete clumpy soil, minor OM <5%, clumps <3cm.
VIII-F-1	0	5	Immature organic soil, OM >50%, some live moss still. Tons of roots
VIII-F-1	5	15	Organic rich brown soil OM ~40%
VIII-F-1	15	30	Organic rich brown soil OM ~40%, abundant roots and wood. Slight grey mottle clay
VIII-F-1	30	60	Grey clay nuggets covered in dark brown organic silt
VIII-F-1	60	70	Grey saturated clay

0:4-	Depth		Desis description
Site	from (cm)	to (cm)	Basic description
VIII-F-2	0	5	Root web with greyish brown OM
VIII-F-2	5	15	Abundant roots, semi-decomposed forest floor OM ~45%. medium brown
VIII-F-2	15	30	Abundant roots, semi-decomposed forest floor OM ~45%. slightly less undecomposed twig/leaf/pinecone litter
VIII-F-2	30	60	Clay clumps coated in silty black OM
VIII-F-3	0	5	Clay-rich tan sediment with crumbly texture from silt sand content
VIII-F-3	5	15	As above, higher clay, slightly lighter color, bit less OM cover (<5%)
VIII-F-3	15	30	Tan to reddish tan clay with slightly sandy silt texture
VIII-F-3	30	60	Tan to reddish tan clay with slightly sandy silt texture
VIII-F-4	0	5	Semi-homogenous organic rich soil OM ~35%
VIII-F-4	5	15	Semi-homogenous organic rich soil OM ~25%
VIII-F-4	15	30	Mix of brown OM and clay. OM ~20%? has some roots etc.
VIII-F-4	30	60	Tan saturated clay
VIII-F-4	60	90	Tan saturated clay
VIII-F-5	0	5	Tan saturated clay, clumpy and hard
VIII-F-5	5	15	Tan saturated clay, clumpy and hard
VIII-F-5	15	30	Tan saturated clay, clumpy with sand and other particle content, pink and tan
VIII-F-5	30	60	Tan saturated clay, clumpy with sand and other particle content. Tan, pinkish, and a few specks of orangey pink (5YR 6/6)
VIII-F-5	60	100	Tan clay with some pink clay, has some sand material or silt material making it easier to break up
VIII-OC-1	0	5	Semi-homogenous organic rich outcrop soil (includes angular pebbles <1cm), OM ~30%
VIII-OC-1	5	10	As above, lighter brown color and more pebbles
VIII-OC-2	0	5	Semi-homogenous organic rich outcrop soil (includes angular pebbles <1cm), OM ~30%
VIII-OC-2	5	10	Semi-homogenous organic rich outcrop soil (includes angular pebbles <1cm), OM ~30%
VIII-OC-2	10	20	Semi-homogenous organic rich outcrop soil (includes angular pebbles <1cm), OM ~30%
VIII-OC-3	0	5	Semi-homogenous organic rich outcrop soil (includes angular pebbles <1cm), OM ~30%
VIII-OC-3	5	10	Semi-homogenous organic rich outcrop soil (includes angular pebbles <1cm), OM ~30%
VIII-OC-4	0	5	Semi-homogenous organic rich outcrop soil (includes angular pebbles <1cm), OM ~30%
VIII-OC-4	5	20	Semi-homogenous reddish brown outcrop soil (includes angular pebbles <1cm), OM <15%
VIII-OC-5	0	10	OM fine roots with silty dark brown material. OM ~30%
VIII-OC-5	10	15	OM fine roots with silty dark brown material. OM ~30%
VIII-OC-6	0	5	OM fine roots with silty dark brown material. OM ~30%
VIII-OC-6	5	10	OM fine roots with silty dark brown material. OM ~20%
VIII-WL-1	0	5	Brown. 50% OM and silty clay

Sito	Depth		Pacia description
Sile	from (cm)	to (cm)	
VIII-WL-1	5	15	Brown. 30% OM and silty clay
VIII-WL-1	15	30	Brown. 30% OM and silty clay
VIII-WL-1	30	60	Brown. 30% OM and silty clay
VIII-WL-1	60	100	Tan saturated clay
VIII-WL-2	30	60	Tan clay with blackish traces of silty OM
VIII-WL-2	60	100	Tan Clay-rich discrete clumpy soil, minor OM <5%, clumps <1cm
VIII-WL-2	0	5	Brown 50% OM and silty clay
VIII-WL-2	5	15	Mix of greyish clay and dark brown clay/silt with OM ~20%
VIII-WL-2	15	30	Mix of tan and dark brown semi-saturated clay
IX-F-1	0	5	Brown web of roots and fine organic soil. Very high OM. C% >40% likely
IX-F-1	5	15	As above, less root web and more fine brown soil
IX-F-1	15	30	As above, less root web and more fine brown soil
IX-F-1	30	55	As above, less root web and more fine brown soil. OM <1cm pieces
IX-F-1	55	100	Dark brown, organic rich but clay dominated. Clay has angular rock bits throughout
IX-F-2	0	5	Clumps of micro-roots holding together medium brown OM silty particles and lighter tan clay to silt. Dominated by darker leaf litter color.
IX-F-2	5	15	Rich organic soil, abundant small roots. OM are slightly clumpy. Well-developed
IX-F-2	15	30	Rich organic soil, abundant micro roots, minor regolith. Well-developed
IX-F-2	30	45	Rich organic soil, abundant micro roots, slight mix of tan clay particles with darker brown. Well-developed
IX-F-3	0	5	Leaf and forest floor litter, unevenly decomposed, and brown. Small pinecone. Abundant roots. OM ~50%
IX-F-3	5	15	Dry sand/silt. Some powder, some clumps.
IX-F-3	15	30	Very dry sand/silt. Mostly powdery, a bit clumpy
IX-F-3	30	60	Very dry sand/silt. Powdery.
IX-F-3	60	100	Very dry sand/silt. Powdery.
IX-F-4	0	5	Basically dark brown leaf litter, small pinecones, fir needles, etc. <5% mineral soil.
IX-F-4	5	15	Crumbly, micro roots throughout, brownish grey with bits of poorly decomposed OM (~30%); regolith bits <10%
IX-F-4	15	30	Brown to pale grey (OM to clay basically), clay clumps, ~20% OM Roots and leaf litter partially decomposed
IX-F-4	30	60	Pale grey with brownish mottle (OM to clay basically), clay clumps, ~20% OM Roots and leaf litter partially decomposed
IX-F-4	60	85	Pale brownish grey clay with OM traces, moderately dry
IX-F-4	85	100	Very pale greyish white silicate clay, small <2cm pinecone part
IX-OC-1	0	5	Rocky heterogeneous OC soil, brown, OM ~35%
IX-OC-1	5	15	Rocky heterogeneous OC soil, tan, sandier, OM<20%
IX-OC-2	0	3	Rocky heterogeneous OC soil, dark brown, OM ~35%
IX-OC-2	3	10	Rocky heterogeneous OC soil, tan, sandier, OM<20%
IX-OC-2	10	25	Rocky heterogeneous OC soil, tan, sandier, OM<20%
IX-OC-3	0	5	Rocky heterogeneous OC soil, chocolate brown, OM ~35%

Site	Depth		Pasia description
	from (cm)	to (cm)	Basic description
IX-OC-3	5	10	Rocky heterogeneous OC soil, rusty color, sandier, OM<20%
IX-OC-4	0	6	Rocky heterogeneous OC soil, dark grayish brown, OM ~35%
IX-OC-4	6	15	Rocky heterogeneous OC soil, tan, sandier, OM<20%
IX-OC-4	15	20	Rocky heterogeneous OC soil, tan, sandier, OM<20%
IX-OC-5	0	7	Rocky heterogeneous OC soil, dark rich brown, OM ~35%
IX-OC-5	7	15	Rocky heterogeneous OC soil, rusty color, sandier, OM<20%
IX-WL-1	0	5	Saturated clay with silty sand fragments
IX-WL-1	5	15	Saturated clay with less silty sand fragments
IX-WL-1	15	30	Saturated clay with minor roots
IX-WL-1	30	60	Saturated clay
IX-WL-1	60	100	Saturated clay
IX-WL-2	0	5	Clay with roots, saturated
IX-WL-2	5	15	Clay with roots, saturated
IX-WL-2	15	30	Clay, minor roots, saturated
IX-WL-2	30	60	Clay, semi-saturated
IX-WL-2	60	100	Clay, minor roots, saturated



APPENDIX C

Site Reconnaissance Photographs



APPENDIX C Site Reconnaissance Photographs



Photograph 1:

View of various terrain types across the Giant Mine Lease.

m West: (800) 386-7247 East: (800) 563-6266 Goldad Company:_ Sample ID: 11-0C - 1 Date Sampled: 14 / 09 / 18 (yyyy/mm/dd) Project/Location: Gia

Photograph 2: Example of sample bag labeling.







Photograph 3:

View of forest sample location .



Photograph 4: View of forest sample location (II-F-3).





Photograph 5:



Photograph 6:

Example of forest soil profile (V-F-1).







Photograph 7:



Photograph 8: Example of outcrop sample location (II-OC-9).







Photograph 9:

Example of outcrop sampling location (III-OC-6).



Photograph 10: Example of outcrop sampling location (IV-OC-1).







Photograph 11: Example of outcrop sampling location (VIII-OC-5).



Photograph 12: Example of outcrop sampling location (VII-OC-8).







Photograph 13:

Example of wetland sampling location (I-WL-1).



Photograph 14: Example of wetland sampling location (II-WL-2).







Photograph 15:

Example of wetland sampling location (IV-WL-1).



Photograph 16: Example of wetland sampling location surface (IV-WL-4).



Photograph 17:

Example of wetland sampling location (VIII-WL-1).



Photograph 18: Field map with proposed sampling locations.



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