Yellowknife Background Soil Arsenic Review

FINAL

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Prepared by:

Stantec Architecture Ltd.
Yellowknife, NT

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Prepared by ____
(signature)

Melissa Whitfield Aslund, PhD
Environmental Scientist

Bryan Leece, Ph.D. Digitally signed by Bryan Leece, Ph.D.
Date: 2020.12.04 15:10:49 -05'00'

Reviewed by ____
(signature)

Bryan Leece, PhD
Principal, Senior Toxicologist

Loren D. Knopper
2020.12.04 15:23:30 -05'00'

Approved by ____
(signature)

Loren Knopper, PhD
Principal, Technical Lead (Canada) – Risk Assessment and Toxicology

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1.0 INTRODUCTION

The Government of the Northwest Territories (GNWT) retained Stantec Architecture Ltd. (Stantec) to compile and review a dataset of soil arsenic concentrations that may be used to characterize soil arsenic concentrations in the Yellowknife area.

The tasks to be completed as part of this report include:

- Compile soil arsenic concentration data collected within 25 km of the City of Yellowknife from sources identified by GNWT into a table with relevant sample information (e.g., sample year, sample ID, sample coordinates, underlying geology, and soil arsenic concentration);
- Screen dataset to confirm all samples are at depth (≥10 cm below surface) and appropriately collected with similar methods to confirm data integrity;
- Complete an evaluation to determine the appropriateness of using a 5 km exclusion zone around Con and Giant Mines for the determination of background soil arsenic conditions;
- Calculate key summary statistics (e.g., mean and 95% upper confidence limit of the mean (UCLM)) of the soil arsenic concentration data excluding any samples on the Con and Giant Mine properties (with any determined outliers removed) and excluding any samples located within 5 km of Con or Giant Mine (with any determined outliers removed).

2.0 DATA COMPILATION AND REVIEW

2.1 DATA COMPILATION

Based on discussion with GNWT on May 20, 2020, data collected within 25 km of Yellowknife from two key sources were compiled for evaluation in this report:

- **Geological Survey of Canada (GSC).** The Geological Survey of Canada has reported soil arsenic concentrations for samples collected in and around Yellowknife in 1999, 2000, and 2001 (Kerr et al., 2001; Kerr and Knight, 2002). Of the available reported samples, 77 were collected within 25 km of Yellowknife. The samples considered for evaluation in this report were collected at depths of 10 to 70 cm below grade. This was done to reduce potential influence of aerial deposition of arsenic from the Con and Giant Mines. The analytical package description provided by GSC for these samples indicates that the samples were dry sieved using an 8-inch sieve shaker and the <63 µm fraction (i.e., the silt + clay fraction) was analyzed for 35 trace elements (including arsenic) using enhanced instrumental neutron activation analysis (INAA).
- **Jamieson et al. 2017 (Jamieson).** Jamieson et al. (2017) reported the concentration of arsenic and other elements in soil samples collected in 2015, 2016, and 2017 within a 25 km radius of Yellowknife. Although Jamieson et al. (2017) reported soil arsenic concentrations for a large number of samples collected from surface soils (i.e., <5 cm depth), only those reported for samples collected at depth (approximately 10 to 40 cm below surface) were considered for evaluation in this report. As noted above, this was done to reduce potential influence of aerial deposition of arsenic from the Con and Giant Mines. The analytical methods described by Jamieson et al. (2017) indicate that these samples were not sieved or ground before analysis and that arsenic was analyzed by inductively coupled plasma – optical emissions spectrometry (ICP-OES). The dataset contains 39 soil arsenic concentrations (excluding laboratory duplicates, field duplicates, and split samples).

The soil arsenic concentration data from the two sources described above are compiled together in **Appendix A**. For each sample, supporting information such as the year of sample collection, sample ID, sample location coordinates, underlying bedrock lithology (as reported in the original data sources), the distance between each sample location and the Con and Giant Mines (as calculated based on sample coordinates[1]), and identification of samples collected directly on Con and Giant Mine properties (as provided to Stantec by GNWT) are also provided in **Appendix A**.

In addition, information about the sample location and underlying bedrock lithology was applied to categorize each available sample as collected from within or outside of the Yellowknife Greenstone Belt

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[1] Calculated assuming a linear straight line distance between the sample coordinates provided in **Appendix A** and the decimal coordinates for Con Mine (62.438889, -114.371667) and Giant Mine (62.499722, -114.358611) as indicated on **Figure 2 (Appendix B).**

(YGB) formation. The Yellowknife Greenstone Belt (YGB), also known as the Yellowknife Volcanic Belt, is a geologic formation largely made up of volcanic rocks and mafic sills (MacLachlan and Helmstaedt, 1995) that is known to be rich in mineral deposits, including arsenic. Samples for which the bedrock lithology was recorded as volcanic were classified as YGB. Samples for which an alternate bedrock lithology was reported were classified as Non-YGB. For samples for which the underlying bedrock lithology was not reported in the original source, sample locations were plotted on a map showing underlying bedrock lithology and a visual analysis was applied to ascertain whether the samples were collected in an area represented by volcanic bedrock lithology (classified as YGB) or an alternate bedrock lithology (classified as Non-YGB). This visual classification approach was required for only 12 GSC samples. The locations and resulting classifications for these samples are summarized in **Figure 1 (Appendix B)**. The locations of all samples identified in **Appendix A,** grouped by source and underlying geology (YGB and Non-YGB) are shown in **Figure 2 (Appendix B)**.

2.2 PRELIMINARY REVIEW OF DATA DISTRIBUTION

A preliminary evaluation of the underlying data distribution was performed by plotting histograms for the reported available data, as grouped by data source and underlying geology (YGB and Non-YGB). For each dataset, normality was improved when data were log-transformed (**Figure 3, Appendix B**), suggesting that the underlying data may be lognormally distributed. As such, the exploratory analyses presented in **Section 2.3** through **Section 2.4**, below, were performed assuming an underlying lognormal distribution. Additional review of the underlying data distribution will be completed prior to the calculation of summary statistics in **Section 3.0**, below.

2.3 EVALUATION OF SAMPLING DEPTH

As described above, only data collected at depths of 10 cm or greater below grade were considered for evaluation in this report. As noted before, this was done to reduce potential influence of aerial deposition of arsenic from the Con and Giant Mines. To investigate whether this sample depth was sufficient to reduce the potential effects of aerial deposition, soil arsenic concentrations were plotted against distance from the closer of the Con or Giant Mines (**Figure 4, Appendix B**). If aerial deposition was a significant contributor to these soil arsenic concentrations, soil arsenic concentrations would be expected to be highest closest to the mines and drop off to background concentrations as distance from the mines increased. Jamieson et al. (2017) reported this type of pattern for surface soils (i.e., 5 cm or less below ground surface) and suggested that soil arsenic concentrations in these shallow soils were not representative of background concentrations until approximately 25 km from the Giant Mine roaster.

When all samples were grouped together, regardless of underlying geology and data source, a statistically significant correlation ($p<0.05$) was observed between $\log_e$-transformed soil arsenic concentrations[2] and distance from the closest mine. This suggests that aerial deposition may have contributed to the distribution of soil arsenic concentrations for these samples. To further investigate this trend, samples were replotted with samples grouped by both underlying geology and data source (**Figure 5, Appendix B**). This additional analysis also provided evidence that aerial deposition may have contributed significantly to soil arsenic concentrations for some samples. This evidence is summarized below:

- there was a significant decreasing correlation ($p<0.05$) between $\log_e$-transformed soil arsenic concentrations and distance from the closest mine for Non-YGB samples from the Jamieson dataset and the correlation between $\log_e$-transformed soil arsenic concentrations and distance from the closest mine for Non-YGB samples from the GSC dataset approached significance ($p=0.06$); and
- although there was no significant correlation ($p>0.05$) between $\log_e$-transformed soil arsenic concentrations[2] and distance from the closest mine for soil samples classified as YGB when grouped by source (GSC or Jamieson), the minimum soil arsenic concentrations reported for YGB soil samples less than 5 km from the closest mine were generally higher than the minimum soil arsenic concentrations for samples collected more than 5 km away from the closest mine.

These findings suggest that aerial deposition may have contributed to soil arsenic concentrations in the Yellowknife area. Whereas Jamieson et al. (2017) suggested that the effects of aerial deposition were apparent at distances of up to 25 km from the Giant Mine roaster, the data presented in **Figure 5 (Appendix B**) suggest that the effects of aerial deposition were most prevalent for soil samples collected within 5 km of the closest mine.

As shown in **Figure 6** and **Figure 7** (**Appendix B)**, when samples located within 5 km of the closest mine are excluded from the analysis, no significant correlations between $\log_e$-transformed soil arsenic concentration and distance to the closest mine were observed, regardless of whether samples were grouped together or separated based on underlying geology and data source. This suggests that for soil samples collected at depths of greater than 10 cm, excluding samples collected within 5 km of either Con or Giant Mine, significantly reduces the effects of aerial deposition.

Therefore, it can be concluded that an evaluation of soil arsenic concentrations in the Yellowknife area that includes samples collected within 5 km of either mine would result in an estimated arsenic background soil concentration that is influenced by past industrial activity in the area. In contrast, excluding samples collected within 5 km of either mine would minimize the contribution of historical aerial deposition to the determination of a regional background concentration of arsenic in soil. For reference, the areas with a 5 km radius from each of the Con and Giant Mines are indicated by black circles on **Figure 2 (Appendix B).**

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[2] Based on an observed statistically significant ($p<0.05$) exponential decay relationship between distance from the closest mine and soil arsenic concentration, which is equivalent to a linear relationship between distance from the closest mine and $\log_e$-transformed soil arsenic concentrations.

2.4 EVALUATION OF ANALYTICAL METHODS AND UNDERLYING GEOLOGY

To evaluate the possible effects of different analytical methods used by GSC and Jamieson et al. (2017) and the effects of underlying geology on soil arsenic concentrations, boxplots of soil arsenic concentrations were generated based on two potential options for data analysis:

- Option A: Including samples collected <5 km from the closest mine; and
- Option B: Excluding samples collected <5 km from the closest mine.

These boxplots (**Figure 8, Appendix B**) provide a visual representation of the distribution of each dataset, where:

- the centre horizontal line of the box marks the median of the data;
- the lower edge of the box indicates the 25th percentile of the data;
- the upper edge of the box indicates the 75th percentile of the data;
- the whiskers represent the range of observed values that are less than 1.5 x the interquartile range (IQR=75th percentile – 25th percentile) from the upper or lower edges of the box; and
- values that fall more than 1.5 x IQR from the box are labelled as potential outliers, with values between 1.5 IQR and 3 IQR from the box labelled as mild outliers (asterisks) and more than 3 IQR from the box labelled as extreme outliers (open circles).

A review of these boxplots identified different potential outliers for Option A and Option B (**Figure 8, Appendix B**). These outliers were investigated further using Dixon's outlier test (for $n<25$) or Rosner's outlier test (for $n\geq25$). Sample points that were confirmed as outliers were removed from the datasets and identification of additional possible outliers based on distance from the updated interquartile range was repeated using the same approach until no further potential outliers were identified. On completion, the following outliers were identified and flagged in **Appendix A**:

- **Option A (i.e., including samples collected less than 5 km from Con or Giant Mine)**: 1560 mg/kg, 1500 mg/kg, 1190 mg/kg, and 813 mg/kg for GSC (YGB) and 1200 mg/kg for Jamieson (Non-YGB).
- **Option B (i.e., excluding samples collected less than 5 km from Con or Giant Mine):** 43 mg/kg for Jamieson (Non-YGB), 320 mg/kg for Jamieson (YGB), and 1190 and 1500 mg/kg for GSC (YGB).

In addition to identifying outliers, a review of the boxplots also suggested some possible differences in soil arsenic concentrations between the GSC and Jamieson datasets and between YGB and Non-YGB samples. Particularly, soil arsenic concentrations appear to be higher in the GSC dataset compared to the

Jamieson dataset and soil arsenic concentrations appear to be higher in the YGB samples than in Non-YGB samples (**Figure 8, Appendix B**). These differences were investigated statistically using separate two-way ANOVAs of $\log_e$-transformed soil arsenic concentrations (with the identified outliers excluded) for both Option A (i.e., including samples collected less than 5 km from Con or Giant Mine) and Option B (i.e., excluding samples collected less than 5 km from Con or Giant Mine). The results of these analyses are summarized in
Table 1.

For Option A (i.e., including samples less than 5 km from Con or Giant Mine), this analysis indicated significant effects of both data source (p=0.039) and underlying geology (p=0.011), with no significant interaction effect (p=0.144) (**Table 1**). Likewise, both data source (p<0.001) and underlying geology (p=0.001) had significant effects on soil arsenic concentrations for Option B (i.e., excluding samples less than 5 km from Con or Giant Mine), with no significant interaction effect (p=0.633) (**Table 1**). These statistical results indicate that soil arsenic concentrations were significantly higher in YGB soils than non-YGB soils for both data sources and significantly higher in GSC samples than Jamieson samples for both YGB and non-YGB soils, regardless of the inclusion of samples located less than 5 km from the Con and Giant Mines.

The increased soil arsenic concentrations observed in the YGB soils support the hypothesis that soil arsenic concentrations are naturally elevated within the Yellowknife Greenstone Belt. The source of the apparent difference in soil arsenic concentrations between the GSC and Jamieson datasets is uncertain. A number of variables may have affected soil arsenic concentrations such as sample collection techniques by different teams) and random variability due to differences in sampling location. However, it is possible that some of this variability may also be related to the differences in analytical methods used to quantify soil arsenic concentrations. Specifically, GSC reported results for the silt + clay fraction (<63 µm) of sieved soil samples quantified using INAA, while Jamieson et al. (2017) reported results for unsieved, unground soil samples quantified using ICP-OES. While the actual analytical techniques (INAA vs ICP-OES) are expected to provide similar results, there is some evidence in the literature to suggest that sieving soil samples to certain fine fractions may result in higher soil arsenic concentrations (Meunier et al. 2011; Ljung et al. 2006).

Jamieson et al. (2017) did report soil arsenic concentrations for a subset of samples that were split and analyzed as both unsieved and sieved to <2 mm. This included 18 of the samples collected at depth that have been included for evaluation in this report. As shown in **Figure 9 (Appendix B)**, the soil arsenic concentration results were generally very similar for sieved vs. unsieved samples, suggesting that sieving to <2 mm would not have substantially altered the results presented by Jamieson et al. (2017). However, the fraction analyzed by GSC (<63 µm) is considerably finer than <2 mm. For soil fractions of a similar size range, Ljung et al. (2006) reported little difference in arsenic concentrations for soils sieved to <4 mm vs a 50-100 µm fraction, but reported that arsenic concentrations were an average of 1.5 times higher in soils sieved to <50 µm compared to the <4 mm fraction. Therefore, it is possible that sieving may have resulted in higher soil arsenic concentrations in the GSC dataset compared to the Jamieson dataset, but the extent to which the noted variation in analytical methods may have contributed to the observed differences in soil arsenic concentrations between the two datasets is uncertain.

Table 1 Two-way ANOVAs of $\log_e$-transformed soil arsenic concentrations, with identified outliers excluded.

Option A (i.e., Including samples <5 km from Con or Giant Mine)					
Source	**Type III SS**	**df**	**Mean Squares**	**F-Ratio**	**p-Value**
Data Source (GSC or Jamieson)	5.240	1	5.240	4.361	0.039
Underlying Geology (YGB or Non-YGB)	8.116	1	8.116	6.755	0.011
Interaction (Data Source*Underlying Geology)	2.607	1	2.607	2.169	0.144
Error	127.357	106	1.201		
Option B (i.e., Excluding samples <5 km from Con or Giant Mine)					
Source	**Type III SS**	**df**	**Mean Squares**	**F-Ratio**	**p-Value**
Data Source (GSC or Jamieson)	13.463	1	13.463	15.778	<0.001
Underlying Geology (YGB or Non-YGB)	10.515	1	10.515	12.322	0.001
Interaction (Data Source*Underlying Geology)	0.196	1	0.196	0.230	0.633
Error	52.905	62	0.853		

2.5 EVALUATION OF POSSIBLE INFLUENCE OF WIND DIRECTION ON SOIL ARSENIC CONCENTRATIONS

As noted previously, Jamieson et al. (2017) reported an apparent decreasing trend in soil arsenic concentrations with increasing distance from the Giant Mine roaster for surface soils (i.e., <5 cm depth) and interpreted this as evidence that aerial deposition from the Giant Mine roaster was a major contributor to soil arsenic for surface soils. In support of this hypothesis, Jamieson et al. (2017) also provided an analysis that suggested that arsenic concentrations in surface soils were influenced by dominant wind directions in the area, with higher surface soil arsenic concentrations observed west and south of the Giant Mine roaster (i.e., predominantly downwind) than north and east of the roaster (i.e., predominantly upwind).

In the present report, analysis has focused on soil samples collected at depths of >10 cm to reduce potential effects of aerial deposition. In **Section 2.3** above, analysis suggested that aerial deposition may have contributed to arsenic concentrations for soils collected at depths of >10 cm; however, this effect was largely limited to samples collected within 5 km of the closest mine. Therefore, it was concluded that aerial deposition had a minimal effect (if any) on arsenic concentrations for soils collected at depths of >10 cm and distances of >5 km from the closest mine.

To further investigate this conclusion, an analysis of the potential effects of wind direction on arsenic concentration in soils collected at depths of >10 cm was undertaken. For this analysis, the soil samples reported in **Appendix A** were categorized based on direction from the former Giant Mine roaster using a 360° coordinate system and direction classifications as previously defined by Jamieson et al. (2017), i.e.:

- North (315° to 45°),
- East (45° to 135°),
- South (135° to 225°), and
- West (225° to 315°).

As can be seen in **Figure 10** (**Appendix B**), under this directional classification, the north and south quadrants are dominated by YGB samples and the east and west quadrants are largely composed of non-YGB samples. Given the findings presented in **Section 2.4** that demonstrated that soil arsenic concentrations were significantly higher in YGB soils than non-YGB soils, this suggests that soil arsenic concentrations are likely to be higher in the north and south quadrants than in the east and west and quadrants based solely on underlying geology. If prominent wind direction also had a significant effect on soil arsenic concentrations, as suggested by Jamieson et al. (2017) for surface soils, higher soil arsenic concentrations would be expected in the south quadrant relative to the north quadrant and in the west quadrant relative to the east quadrant due to prevailing winds .

To investigate these patterns visually, soil arsenic concentrations measured in each quadrant were plotted against distance from the closest mine, with samples grouped based on underlying geology (**Figure 11, Appendix B**). In general, this figure supports the expectations related to underlying geology (i.e., similarity in soil arsenic concentrations between the quadrants dominated by YGB samples (i.e., north vs. south) and similarity between the quadrants dominated by non-YGB samples (i.e., east vs west)). In contrast, this figure does not appear to suggest the presence of elevated soil arsenic concentrations related to prominent wind directions as described by Jamieson et al. (2017). Specifically, concentrations do not appear to be elevated in the south quadrant relative to the north or in the west quadrant relative to the east once differences in geology are accounted for, especially at distances greater than 5 km from the closest mine.

The conclusions described above based on a visual review of **Figure 11 (Appendix B)** are further supported by the results of separate one-way ANOVAs followed by Tukey multiple comparison tests investigating the effect of sample quadrant on $\log_e$-transformed soil arsenic concentrations for both Option A (i.e., including samples collected <5 km from the closest mine) and Option B (i.e., excluding samples collected <5 km from the closest mine), with the outliers identified in **Section 2.4** excluded. For both data options, the ANOVAs indicated that sample quadrant did have a significant effect on soil arsenic concentration ($p<0.05$, **Table 2**). However, the Tukey multiple comparison tests revealed no significant differences in soil arsenic concentrations between north vs south quadrant samples or between west vs east quadrant samples ($p>0.05$, **Table 3**). Rather, the significant differences that were observed reflected elevated concentrations in the north and/or south quadrants compared to the east and/or west quadrant ($p<0.05$, **Table 3**), which are consistent with differences driven by underlying geology (mainly YGB in the north and south and mainly non-YGB in the east and west). Specifically, for Option A, soil arsenic concentrations were significantly higher in the south quadrant compared to both the east (p=0.028) and west (p=0.024) quadrants (**Table 3**) and for Option B, soil arsenic concentrations were significantly higher in the north (p=0.007) and south (p=0.003) quadrants than in the west quadrant (**Table 3**). Therefore, it can be concluded that wind direction did not have a statistically significant influence on soil arsenic concentration for the soil samples collected at depths >10 cm that are under evaluation in this report.

Table 2 One-way ANOVAs of the effect of sample quadrant (north, east, south, or west) relative to Giant Mine Roaster on $\log_e$-transformed soil arsenic concentrations

Option A (i.e., Including samples <5 km from Con or Giant Mine) with outliers identified in Section 2.4 excluded					
Source	**Type III SS**	**df**	**Mean Squares**	**F-Ratio**	**p-Value**
Direction Relative to Giant Mine (North, East, South, or West)	15.382	3	5.127	3.948	0.011
Error	125.974	97	1.299		
Option B (i.e., Excluding samples <5 km from Con or Giant Mine) with outliers identified in Section 2.4 excluded					
Source	**Type III SS**	**df**	**Mean Squares**	**F-Ratio**	**p-Value**
Direction Relative to Giant Mine (North, East, South, or West)	20.705	3	6.902	6.113	0.001
Error	70.001	62	1.129		

Table 3 Probability results (p-values) based on Tukey's Honestly-Significant-Difference Test for multiple comparison testing following the significant ANOVAs presented in Table 2

Option A				
	North	**East**	**South**	**West**
North	1			
East	0.30	1		
South	0.49	0.028	1	
West	0.29	1	0.024	1

Option B				
	North	**East**	**South**	**West**
North	1			
East	0.23	1		
South	0.54	0.06	1	
West	0.007	0.47	0.003	1

3.0 CALCULATION OF SUMMARY STATISTICS

The final task described in the scope of work for this project was to calculate key summary statistics (e.g., mean and 95% upper confidence limit of the mean (UCLM)) for subsets of the available data that may be considered appropriate to characterize soil arsenic concentrations in the Yellowknife area. This analysis was to be based on an appropriate parametric or non-parametric distribution and to exclude any identified outliers and any samples collected directly on Con Mine or Giant Mine properties.

Based on the results presented above regarding the potential effects of aerial deposition on soil arsenic concentrations in soil samples collected in proximity to the Con and Giant Mines, it was determined that an evaluation of soil arsenic concentrations in the Yellowknife area that includes samples collected within 5 km of either mine (Option A) would result in an estimated arsenic background soil concentration that is strongly influenced by past industrial activity in the area. In contrast, excluding samples collected within 5 km of either mine (Option B) would minimize the contribution of historical aerial deposition to the determination of a regional background concentration of arsenic in soil. Therefore, summary statistics were calculated both with and without the samples collected within 5 km of either Con or Giant Mine. These calculations excluded the outliers identified in **Section 2.4** as well as any samples collected directly on Con Mine or Giant Mine properties. Details regarding which samples were included in each summary statistic calculation are provided in **Appendix A**.

The underlying data distribution and summary statistics for Option A and Option B were then evaluated based on several possible scenarios, as described below:

- **Data separated by both underlying geology and data source**. In recognition of the significant differences in soil arsenic concentration related to underlying geology and data source discussed above, underlying distributions and summary statistics were first calculated for each data source and underlying geology source separately (i.e., Jamieson (YGB), Jamieson (Non-YGB), GSC (YGB), and GSC (Non-YGB)).
- **Data separated by data source only**. In addition, for the purpose of evaluating soil arsenic concentrations in the general area of Yellowknife (without distinction by underlying geology), data distributions and summary statistics were also calculated for each data source with underlying geologies combined (i.e., Jamieson (YGB + Non-YGB) and GSC (YGB + Non-YGB)).
- **Data from both data sources combined.** Finally, the combination of data from both data sources was explored, given the considerable overlap in soil concentrations between the two data sources for both types of underlying geology (**Figure 8, Appendix B**) and the uncertainty regarding the source of observed differences in soil arsenic concentrations between the two data sources (i.e., due to analytical differences or other random variability). For completeness, this included evaluations of the combined data sources both with underlying geologies kept separate and combined (i.e., Jamieson + GSC (YGB), Jamieson + GSC (Non-YGB), and Jamieson + GSC (YGB + Non-YGB)).

For each subset of analyzed data, the suitability of combining data as described was evaluated by testing the combined data for goodness of fit to a parametric data distribution in USEPA's ProUCL Version 5.1

statistical software at a significance level of 0.05. Data grouping was supported when the combined data were found to meet a parametric data distribution. Standard summary statistics (i.e., sample size (n), minimum, maximum, and the arithmetic mean) for each dataset were calculated in Systat (Version 13.2). The 95% UCLMs were calculated using ProUCL Version 5.1, which provides recommended UCLMs based upon data size, data distribution, and skewness. In addition, the 90^{th} percentile of each selected data subset was calculated in Systat (Version 13.2) to provide a direct comparison to the ‘reasonable upper limit’ 90^{th} percentile soil arsenic concentrations reported in the previous evaluation of soil arsenic concentrations in the Yellowknife area (Risklogic 2002 and GNWT 2003).

The resulting distributions and summary statistics are presented in **Table 4**.

Table 1 Summary Statistics

Option A (Including samples <5 km from Con or Giant Mine)[1]								
Data Source	**Underlying Geology**	**Distribution**	**Sample size (n)**	**Minimum**	**Maximum**	**Mean**	**95% UCLM**	**90th Percentile**
Jamieson et al. (2017)	YGB	Lognormal or Gamma	11	2.7	320	54	151	130
	Non-YGB	Lognormal	25	1.6	240	35	81	83
	Combined	Lognormal	36	1.6	320	41	76	113
GSC	YGB	Lognormal	37	7.1	482	78	120	168
	Non-YGB	Lognormal or Gamma	28	4.1	61.7	24	31	55
	Combined	Lognormal	65	4.1	482	55	68	96
Jamieson et al. (2017) and GSC combined	YGB	Lognormal	48	2.7	482	73	114	163
	Non-YGB	Lognormal	53	1.6	240	29	41	59
	Combined	Lognormal	101	1.6	482	50	64	100
Option B (Excluding samples <5 km from Con or Giant Mine)								
Data Source	**Underlying Geology**	**Distribution**	**Sample size (n)**	**Minimum**	**Maximum**	**Mean**	**95% UCLM**	**90th Percentile**
Jamieson et al. (2017)	YGB	NC[2]	6	4.6	44	18	NC	34
	Non-YGB	Lognormal, Gamma or Normal	13	1.6	19	7	10	13
	Combined	Lognormal or Gamma	19	1.6	44	11	15	20
GSC	YGB	Lognormal	27	7.1	482	80	141	168
	Non-YGB	Lognormal or Gamma	20	4.1	61.7	20	27	47
	Combined	Lognormal	47	4.1	482	54	74	95
Jamieson et al. (2017) and GSC combined	YGB	Lognormal	33	4.6	482	69	114	137
	Non-YGB	Lognormal or Gamma	33	1.6	61.7	15	19	28
	Combined	Lognormal	66	1.6	482	42	52	88

Notes
1. Excludes samples collected directly on Con and Giant Mine properties.
2. Not calculated (NC) due to small sample size (n<10).

4.0 CONCLUSION

This report presents a compilation and review of available soil arsenic concentration data that may be used to characterize soil arsenic concentrations in the Yellowknife area. The results of this data review suggest that excluding samples collected with 5 km of Con or Giant Mines will reduce the influence of anthropogenic influence (i.e., aerial deposition).

Significant differences in soil arsenic concentrations were observed based on underlying geology and data source, with YGB soils having higher soil arsenic concentrations than non-YGB soils and higher soil arsenic concentrations reported by GSC than by Jamieson et al. (2017). However, given the considerable overlap in soil arsenic concentrations between data sources and for both types of underlying geology, it is possible to create subsets of the data that maintain a parametric distribution and are suitable for calculating representative summary statistics. These factors should be taken into consideration by the GNWT when determining which data should be relied on as representative of soil arsenic concentrations in the Yellowknife area.

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Appendix A SOIL ARSENIC CONCENTRATIONS

Appendix A Soil Arsenic Concentrations

Sample ID	Sample Year	Source	Bedrock Geology Reported by Source	Underlying Geology Group	Latitude (Decimal Degrees))	Longitude (Decimal Degrees))	Distance to Con Mine (km)	Distance to Giant Mine (km)	Direction relative to Giant Mine[A]	Arsenic Concentration (mg/kg)	Outlier?		Located on Mine Property?	Included in Summary Statistic Calculations?	
											Option A (<5 km from Closest Mine Included)	Option B (<5 km from Closest Mine Excluded)		Option A (<5 km from Closest Mine Included)	Option B (<5 km from Closest Mine Excluded)
01KKA7000	2001	GSC	Not reported	Non-YGB	62.5194	-114.2006	12.4	8.3	East	15.3	N	N	N	Y	Y
01KKA7001	2001	GSC	Not reported	Non-YGB	62.5495	-114.1825	15.5	10.5	East	61.7	N	N	N	Y	Y
01KKA7002	2001	GSC	Not reported	Non-YGB	62.5144	-114.2134	11.6	7.5	East	46.1	N	N	N	Y	Y
01KKA7003	2001	GSC	Not reported	Non-YGB	62.5039	-114.2421	9.7	5.9	East	14.7	N	N	N	Y	Y
01KKA7004	2001	GSC	Not reported	Non-YGB	62.4790	-114.2976	5.8	3.8	South	55.5	N	N	N	Y	N (<5 km to mine)
01KKA7005	2001	GSC	Not reported	Non-YGB	62.4374	-114.3108	3.1	7.3	South	59.5	N	N	N	Y	N (<5 km to mine)
01KKA7006	2001	GSC	Not reported	Non-YGB	62.5075	-114.2975	8.4	3.2	East	26.8	N	N	N	Y	N (<5 km to mine)
01KKA7010	2001	GSC	Not reported	Non-YGB	62.6510	-114.2852	23.7	17.0	North	16.7	N	N	N	Y	Y
01KKA7012	2001	GSC	Not reported	Non-YGB	62.6278	-114.2511	21.6	15.1	North	16.6	N	N	N	Y	Y
99KKA6003T	1999	GSC	granite	Non-YGB	62.4985	-114.7851	22.0	21.7	West	7.6	N	N	N	Y	Y
99KKA6004T	1999	GSC	granite	Non-YGB	62.4807	-114.7081	17.7	17.9	West	5.9	N	N	N	Y	Y
99KKA6005T	1999	GSC	granite	Non-YGB	62.4609	-114.6061	12.2	13.3	West	5.5	N	N	N	Y	Y
99KKA6006T	1999	GSC	granite	Non-YGB	62.4660	-114.4999	7.2	8.1	West	27	N	N	N	Y	Y
99KKA6007T	1999	GSC	granite	Non-YGB	62.4756	-114.4491	5.6	5.3	West	18	N	N	N	Y	Y
99KKA6013T	1999	GSC	schist	Non-YGB	62.5494	-114.0363	20.9	17.2	East	55.4	N	N	N	Y	Y
99KKA6014T	1999	GSC	schist	Non-YGB	62.5384	-114.1212	16.8	12.8	East	7.9	N	N	N	Y	Y
99KKA6015T	1999	GSC	metasedimentary	Non-YGB	62.5211	-114.1978	12.6	8.5	East	18	N	N	N	Y	Y
99KKA6016T	1999	GSC	metasedimentary	Non-YGB	62.5020	-114.2324	9.9	6.4	East	4.1	N	N	N	Y	Y
99KKA6017T	1999	GSC	basalt	Non-YGB	62.5047	-114.2766	8.7	4.2	East	23	N	N	N	Y	N (<5 km to mine)
99KKA6018T	1999	GSC	metasedimentary	Non-YGB	62.4525	-114.3116	3.4	5.7	South	13	N	N	N	Y	N (<5 km to mine)
99KKA6019T	1999	GSC	metasedimentary	Non-YGB	62.4737	-114.3001	5.3	4.1	South	28	N	N	N	Y	N (<5 km to mine)
99KKA6021T	1999	GSC	granite	Non-YGB	62.4311	-114.4197	2.6	8.2	South	48	N	N	N	Y	N (<5 km to mine)
99KKA6022T	1999	GSC	granite	Non-YGB	62.4446	-114.4848	5.8	8.8	West	8.6	N	N	N	Y	Y
99KKA6023T	1999	GSC	granite	Non-YGB	62.4380	-114.4439	3.7	8.0	West	17	N	N	N	Y	N (<5 km to mine)
99KKA6064T	1999	GSC	granite	Non-YGB	62.4486	-113.9165	23.2	23.2	East	15	N	N	N	Y	Y
99KKA6065T	1999	GSC	metasedimentary	Non-YGB	62.4479	-114.0764	15.1	15.4	East	9	N	N	N	Y	Y
99KKA6066T	1999	GSC	metasedimentary	Non-YGB	62.3175	-114.1306	18.1	23.1	South	10	N	N	N	Y	Y
99KKA6056T	1999	GSC	metasedimentary	Non-YGB	62.6099	-114.2441	19.9	13.4	North	28	N	N	N	Y	Y
00KKA6516	2000	GSC	volcanic	YGB	62.4635	-114.0617	16.0	15.7	East	7.1	N	N	N	Y	Y
00KKA6517	2000	GSC	volcanic	YGB	62.4498	-114.0887	14.5	14.9	East	7.7	N	N	N	Y	Y
00KKA6500	2000	GSC	volcanic	YGB	62.4429	-114.3663	0.4	6.5	South	78.9	N	N	N	Y	N (<5 km to mine)
00KKA6503	2000	GSC	volcanic	YGB	62.5749	-114.3620	14.7	8.0	North	24.3	N	N	N	Y	Y
00KKA6504	2000	GSC	volcanic	YGB	62.5594	-114.3610	13.0	6.3	North	47.5	N	N	N	Y	Y
00KKA6505	2000	GSC	volcanic	YGB	62.5480	-114.3683	11.8	5.1	North	91.2	N	N	N	Y	Y
00KKA6506	2000	GSC	volcanic	YGB	62.5241	-114.3542	9.2	2.5	North	55.5	N	N	Y (Giant Mine)	N (On Mine Property)	N (<5 km to mine)
00KKA6507	2000	GSC	volcanic	YGB	62.4739	-114.3833	3.7	3.3	South	44.6	N	N	N	Y	N (<5 km to mine)
00KKA6508	2000	GSC	volcanic	YGB	62.4690	-114.4123	3.7	4.5	West	14.2	N	N	N	Y	N (<5 km to mine)
00KKA6509	2000	GSC	volcanic	YGB	62.4840	-114.3686	4.7	2.0	South	118	N	N	Y (Giant Mine)	N (On Mine Property)	N (<5 km to mine)
00KKA6510	2000	GSC	volcanic	YGB	62.4355	-114.3893	1.0	7.4	South	42.7	N	N	Y (Con Mine)	N (On Mine Property)	N (<5 km to mine)
00KKA6511	2000	GSC	volcanic	YGB	62.4661	-114.3649	2.8	3.9	South	40.7	N	N	N	Y	N (<5 km to mine)
00KKA6512	2000	GSC	volcanic	YGB	62.5028	-114.3707	6.8	0.6	West	320	N	N	Y (Giant Mine)	N (On Mine Property)	N (<5 km to mine)
00KKA6513	2000	GSC	volcanic	YGB	62.5368	-114.3616	10.5	3.9	North	30.8	N	N	Y (Giant Mine)	N (On Mine Property)	N (<5 km to mine)
00KKA6514	2000	GSC	volcanic	YGB	62.5229	-114.3358	9.2	2.6	North	24.7	N	N	N	Y	N (<5 km to mine)
00KKA6515	2000	GSC	volcanic	YGB	62.4390	-114.3582	0.8	6.9	South	813	Y	N	N	N (Outlier)	N (<5 km to mine)
00KKA6518	2000	GSC	volcanic	YGB	62.3851	-114.2530	8.7	13.9	South	86.6	N	N	N	Y	Y
00KKA6519	2000	GSC	volcanic	YGB	62.3889	-114.2725	7.7	13.2	South	29.3	N	N	N	Y	Y
00KKA6520	2000	GSC	volcanic	YGB	62.4262	-114.2547	6.2	9.9	South	403	N	N	N	Y	Y
00KKA6521	2000	GSC	volcanic	YGB	62.4417	-114.2778	4.8	7.8	South	8.3	N	N	N	Y	N (<5 km to mine)
00KKA6522	2000	GSC	volcanic	YGB	62.4836	-114.3963	4.8	2.7	West	27.6	N	N	N	Y	N (<5 km to mine)
00KKA6523	2000	GSC	volcanic	YGB	62.3739	-114.4846	9.3	15.4	South	39.8	N	N	N	Y	Y
00KKA6524	2000	GSC	volcanic	YGB	62.3850	-114.4319	6.8	13.3	South	46.1	N	N	N	Y	Y

Appendix A Soil Arsenic Concentrations

Sample ID	Sample Year	Source	Bedrock Geology Reported by Source	Underlying Geology Group	Latitude (Decimal Degrees))	Longitude (Decimal Degrees))	Distance to Con Mine (km)	Distance to Giant Mine (km)	Direction relative to Giant Mine[A]	Arsenic Concentration (mg/kg)	Outlier?		Located on Mine Property?	Included in Summary Statistic Calculations?	
											Option A (<5 km from Closest Mine Included)	Option B (<5 km from Closest Mine Excluded)		Option A (<5 km from Closest Mine Included)	Option B (<5 km from Closest Mine Excluded)
00KKA6525	2000	GSC	volcanic	YGB	62.3962	-114.3752	4.9	11.6	South	314	N	N	N	Y	N (<5 km to mine)
00KKA6526	2000	GSC	volcanic	YGB	62.4161	-114.3693	2.7	9.4	South	1560	Y	N	N	N (Outlier)	N (<5 km to mine)
00KKA6527	2000	GSC	volcanic	YGB	62.4277	-114.3595	1.6	8.1	South	134	N	N	N	Y	N (<5 km to mine)
00KKA6529	2000	GSC	volcanic	YGB	62.6743	-114.3197	25.8	19.1	North	54.7	N	N	N	Y	Y
00KKA6530	2000	GSC	volcanic	YGB	62.6579	-114.3010	24.1	17.4	North	1190	Y	Y	N	N (Outlier)	N (Outlier)
00KKA6531	2000	GSC	volcanic	YGB	62.6404	-114.2775	22.4	15.8	North	11.8	N	N	N	Y	Y
00KKA6532	2000	GSC	volcanic	YGB	62.6375	-114.3120	21.8	15.1	North	99.7	N	N	N	Y	Y
00KKA6533	2000	GSC	volcanic	YGB	62.6403	-114.3552	21.9	15.2	North	38.6	N	N	N	Y	Y
00KKA6534	2000	GSC	volcanic	YGB	62.6260	-114.4234	20.5	14.0	North	25.1	N	N	N	Y	Y
00KKA6535	2000	GSC	volcanic	YGB	62.6214	-114.3656	19.8	13.1	North	45.1	N	N	N	Y	Y
00KKA6536	2000	GSC	volcanic	YGB	62.6069	-114.3580	18.2	11.5	North	146	N	N	N	Y	Y
00KKA6537	2000	GSC	volcanic	YGB	62.6096	-114.2868	19.0	12.4	North	88.5	N	N	N	Y	Y
00KKA6538	2000	GSC	volcanic	YGB	62.5945	-114.3315	17.0	10.3	North	482	N	N	N	Y	Y
00KKA6539	2000	GSC	volcanic	YGB	62.5780	-114.3175	15.3	8.7	North	1500	Y	Y	N	N (Outlier)	N (Outlier)
00KKA6540	2000	GSC	volcanic	YGB	62.5670	-114.2801	14.6	8.2	East	23.9	N	N	N	Y	Y
00KKA6541	2000	GSC	volcanic	YGB	62.5486	-114.3225	12.1	5.5	North	11.9	N	N	N	Y	Y
00KKA6562	2000	GSC	volcanic	YGB	62.5612	-114.3872	13.2	6.7	North	58.6	N	N	N	Y	Y
01KKA7007	2001	GSC	Not reported	YGB	62.5172	-114.3675	8.6	2.0	North	71.8	N	N	Y (Giant Mine)	N (On Mine Property)	N (<5 km to mine)
01KKA7009	2001	GSC	Not reported	YGB	62.6200	-114.3419	19.9	13.2	North	10.1	N	N	N	Y	Y
01KKA7014	2001	GSC	Not reported	YGB	62.5910	-114.2807	17.3	10.8	North	202	N	N	N	Y	Y
99KKA6020T	1999	GSC	volcanic	YGB	62.5062	-114.3559	7.4	0.7	North	55.9	N	N	Y (Giant Mine)	N (On Mine Property)	N (<5 km to mine)
99KKA6024T	1999	GSC	volcanic	YGB	62.4402	-114.3645	0.4	6.5	South	43	N	N	N	Y	N (<5 km to mine)
99KKA6025T	1999	GSC	volcanic	YGB	62.5774	-114.3668	15.2	8.5	North	16	N	N	N	Y	Y
99KKA6067T	1999	GSC	volcanic	YGB	62.3860	-114.2647	8.0	13.4	South	57.3	N	N	N	Y	Y
99KKA6068T	1999	GSC	volcanic	YGB	62.3836	-114.4360	6.9	13.3	South	15	N	N	N	Y	Y
BPR-FCSC-02	2015	Jamieson	Granitoid	Non-YGB	62.4990	-114.3858	7.5	1.5	West	29	N	N	N	Y	N (<5 km to mine)
BPR-FCSC-21	2015	Jamieson	Granitoid	Non-YGB	62.5071	-114.3754	8.4	1.1	North	42	N	N	Y (Giant Mine)	N (On Mine Property)	N (<5 km to mine)
BPR-PSC-161B	2015	Jamieson	Granitoid	Non-YGB	62.4965	-114.3840	7.2	1.5	West	240	N	N	N	Y	N (<5 km to mine)
BPR-PSC-161C	2015	Jamieson	Granitoid	Non-YGB	62.4965	-114.3840	7.2	1.5	West	1200	Y	N	N	N (Outlier)	N (<5 km to mine)
BPR-PSG-08	2015	Jamieson	Granitoid	Non-YGB	62.4976	-114.3868	7.4	1.6	West	31	N	N	N	Y	N (<5 km to mine)
DETR-FCOSC-35	2015	Jamieson	Sedimentary	Non-YGB	62.4398	-114.3072	3.2	7.4	South	59	N	N	N	Y	N (<5 km to mine)
DETR-FCSC-38	2015	Jamieson	Sedimentary	Non-YGB	62.4402	-114.3097	3.1	7.3	South	5.4	N	N	N	Y	N (<5 km to mine)
HW3-FCSC-132	2015	Jamieson	Granitoid	Non-YGB	62.4602	-114.5911	11.9	12.9	West	10	N	N	N	Y	Y
HW3-FCSC-134	2015	Jamieson	Granitoid	Non-YGB	62.4616	-114.5887	11.9	12.7	West	4.8	N	N	N	Y	Y
HW3-FCSC-135	2015	Jamieson	Granitoid	Non-YGB	62.4659	-114.5032	8.0	8.5	West	10	N	N	N	Y	Y
HW3-OSC-136	2015	Jamieson	Granitoid	Non-YGB	62.4657	-114.5033	7.9	8.5	West	3.7	N	N	N	Y	Y
INGT-FCOSC-141	2015	Jamieson	Sedimentary	Non-YGB	62.5371	-114.1451	16.3	11.6	East	10	N	N	N	Y	Y
INGT-FCOSC-42	2015	Jamieson	Sedimentary	Non-YGB	62.5409	-114.0908	18.7	14.3	East	7.4	N	N	N	Y	Y
INGT-FCSC-28	2015	Jamieson	Sedimentary	Non-YGB	62.5081	-114.2901	9.4	3.5	East	38	N	N	N	Y	N (<5 km to mine)
BC20-FCSC-163	2015	Jamieson	Granitoid	Non-YGB	62.5006	-114.3909	7.7	1.7	West	10	N	N	N	Y	N (<5 km to mine)
HL-OSC-165	2015	Jamieson	Granitoid	Non-YGB	62.4947	-114.3938	7.1	2.0	West	96	N	N	N	Y	N (<5 km to mine)
ML-FCSC-102	2015	Jamieson	Granitoid	Non-YGB	62.5335	-114.4284	11.7	5.1	North	14	N	N	N	Y	Y
ML-OSC-98	2015	Jamieson	Granitoid	Non-YGB	62.5383	-114.4107	12.0	4.9	North	29	N	N	N	Y	N (<5 km to mine)
ML-OSG-104.2	2015	Jamieson	Granitoid	Non-YGB	62.5292	-114.4339	11.4	5.0	North	140	N	N	N	Y	N (<5 km to mine)
NWFAR1-FCSC-75	2015	Jamieson	Granitoid	Non-YGB	62.5707	-114.7815	26.3	23.1	West	4	N	N	N	Y	Y
SW3-PSG-89.1	2015	Jamieson	Granitoid	Non-YGB	62.4028	-114.6271	13.8	17.7	West	4.1	N	N	N	Y	Y
LL-OSC-119	2015	Jamieson	Granitoid	Non-YGB	62.5583	-114.3990	14.2	6.6	North	1.6	N	N	N	Y	Y
LL-OSC-120	2015	Jamieson	Granitoid	Non-YGB	62.5577	-114.3986	14.1	6.6	North	2.5	N	N	N	Y	Y
LL-PSG-117.1	2015	Jamieson	Granitoid	Non-YGB	62.5686	-114.4106	15.4	7.9	North	43	N	Y	N	Y	N (Outlier)
LL-PSG-117.2	2015	Jamieson	Granitoid	Non-YGB	62.5686	-114.4106	15.4	7.9	North	19	N	N	N	Y	Y
VL-FCSC-111	2015	Jamieson	Granitoid	Non-YGB	62.5875	-114.4272	17.6	10.2	North	3.8	N	N	N	Y	Y

Appendix A Soil Arsenic Concentrations

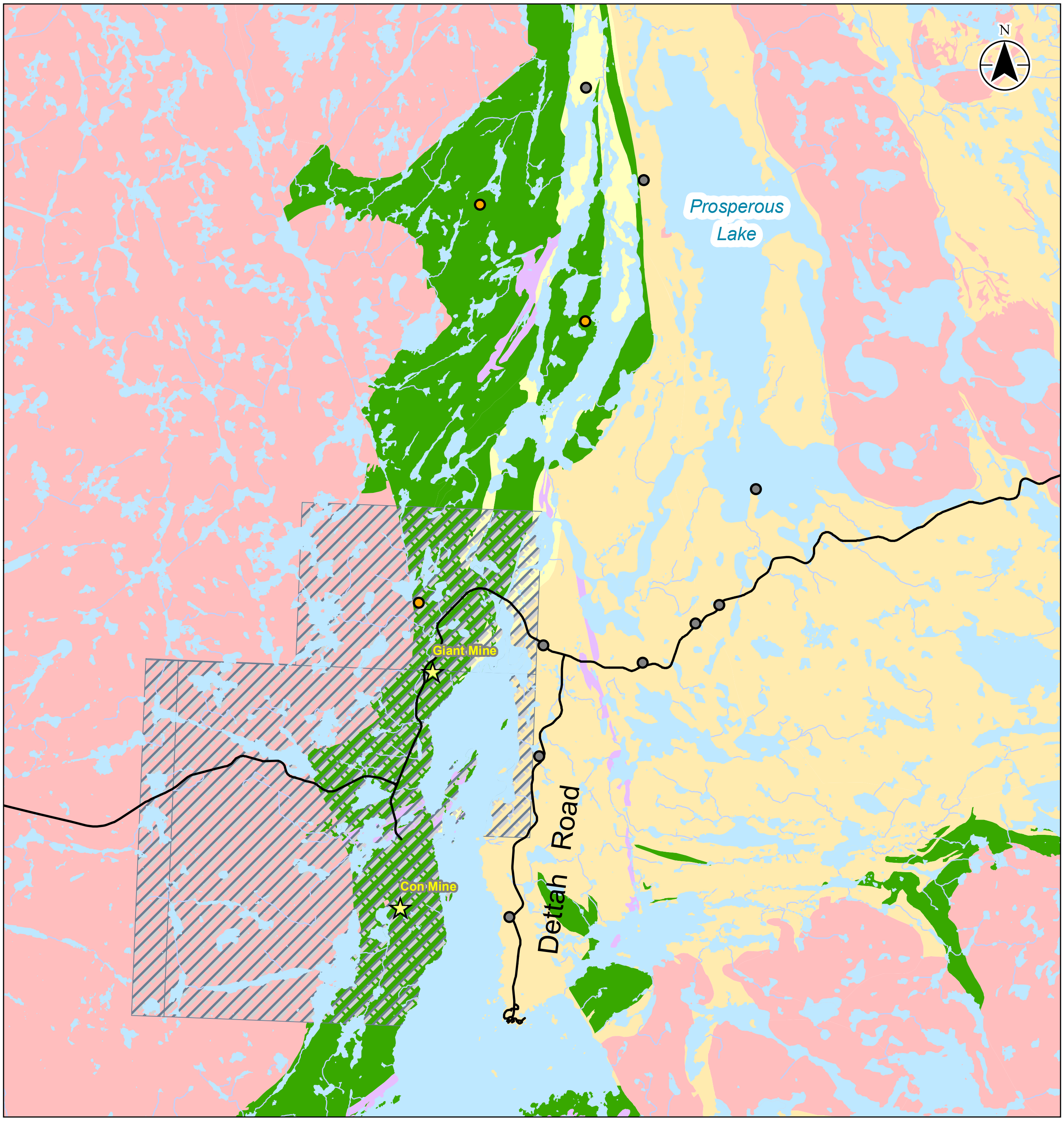
Sample ID	Sample Year	Source	Bedrock Geology Reported by Source	Underlying Geology Group	Latitude (Decimal Degrees))	Longitude (Decimal Degrees))	Distance to Con Mine (km)	Distance to Giant Mine (km)	Direction relative to Giant Mine[A]	Arsenic Concentration (mg/kg)	Outlier? Option A (<5 km from Closest Mine Included)	Outlier? Option B (<5 km from Closest Mine Excluded)	Located on Mine Property?	Included in Summary Statistic Calculations? Option A (<5 km from Closest Mine Included)	Included in Summary Statistic Calculations? Option B (<5 km from Closest Mine Excluded)
BPR-FCSC-14	2015	Jamieson	Granitoid	Non-YGB	62.4873	-114.3912	6.3	2.4	West	63	N	N	N	Y	N (<5 km to mine)
EAST2-FCSC-66	2015	Jamieson	Volcanic	YGB	62.4492	-114.0879	14.5	15.0	East	4.6	N	N	N	Y	Y
BPR-MFENC-22	2015	Jamieson	Volcanic	YGB	62.5095	-114.3673	8.6	1.0	North	29	N	N	Y (Giant Mine)	N (On Mine Property)	N (<5 km to mine)
BPR-OSC-16	2015	Jamieson	Volcanic	YGB	62.4727	-114.4130	5.1	4.3	West	12	N	N	N	Y	N (<5 km to mine)
BPR-PSG-19.2	2015	Jamieson	Volcanic	YGB	62.4734	-114.4106	5.1	4.2	West	130	N	N	N	Y	N (<5 km to mine)
INGT-FCSC-45	2015	Jamieson	Volcanic	YGB	62.5225	-114.3334	10.2	2.6	North	2.7	N	N	N	Y	N (<5 km to mine)
INGT-FCSC-50	2015	Jamieson	Volcanic	YGB	62.5219	-114.3254	10.2	2.8	East	25	N	N	N	Y	N (<5 km to mine)
HOML-FCSC-56	2015	Jamieson	Volcanic	YGB	62.6571	-114.3046	25.2	17.5	North	24	N	N	N	Y	Y
HOML-PSC-58	2015	Jamieson	Volcanic	YGB	62.6560	-114.3031	25.1	17.3	North	7.8	N	N	N	Y	Y
TX-FCOSC-150	2015	Jamieson	Volcanic	YGB	62.5733	-114.3600	15.7	7.9	North	18	N	N	N	Y	Y
TX-FCOSC-155	2015	Jamieson	Volcanic	YGB	62.5817	-114.3551	16.7	8.9	North	7.1	N	N	N	Y	Y
TX-FCSC-144	2015	Jamieson	Volcanic	YGB	62.5571	-114.3601	13.9	6.1	North	44	N	N	N	Y	Y
TX-OSC-145	2015	Jamieson	Volcanic	YGB	62.5574	-114.3596	14.0	6.2	North	320	N	Y	N	Y	N (Outlier)

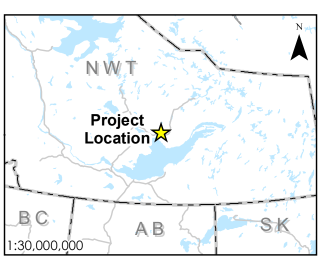
Notes

A. Categorized based on direction from the former Giant Mine roaster using a 360° coordinate system and direction classifications as previously defined by Jamieson et al. (2017), i.e.: north (315° to 45°), east (45° to 135°), south (135° to 225°), and west (225° to 315°).

Appendix B FIGURES

\Revised: 2020-06-10 By: ipodrug





Mine
Highway / Major Road
Watercourse
Waterbody
City of Yellowknife
GSC, Non-YGB
GSC, YGB

Bedrock Geology

Granite
Mafic
Volcanic
Metasedimentary
Sedimentary

0 1 2 3 4 5 km
1:170,000 (at original document size of 8.5x11)

Stantec

Project Location
Yellowknife, NWT

Project Numbers 144902990, 144903036
Prepared by IPODRUG on 20200610

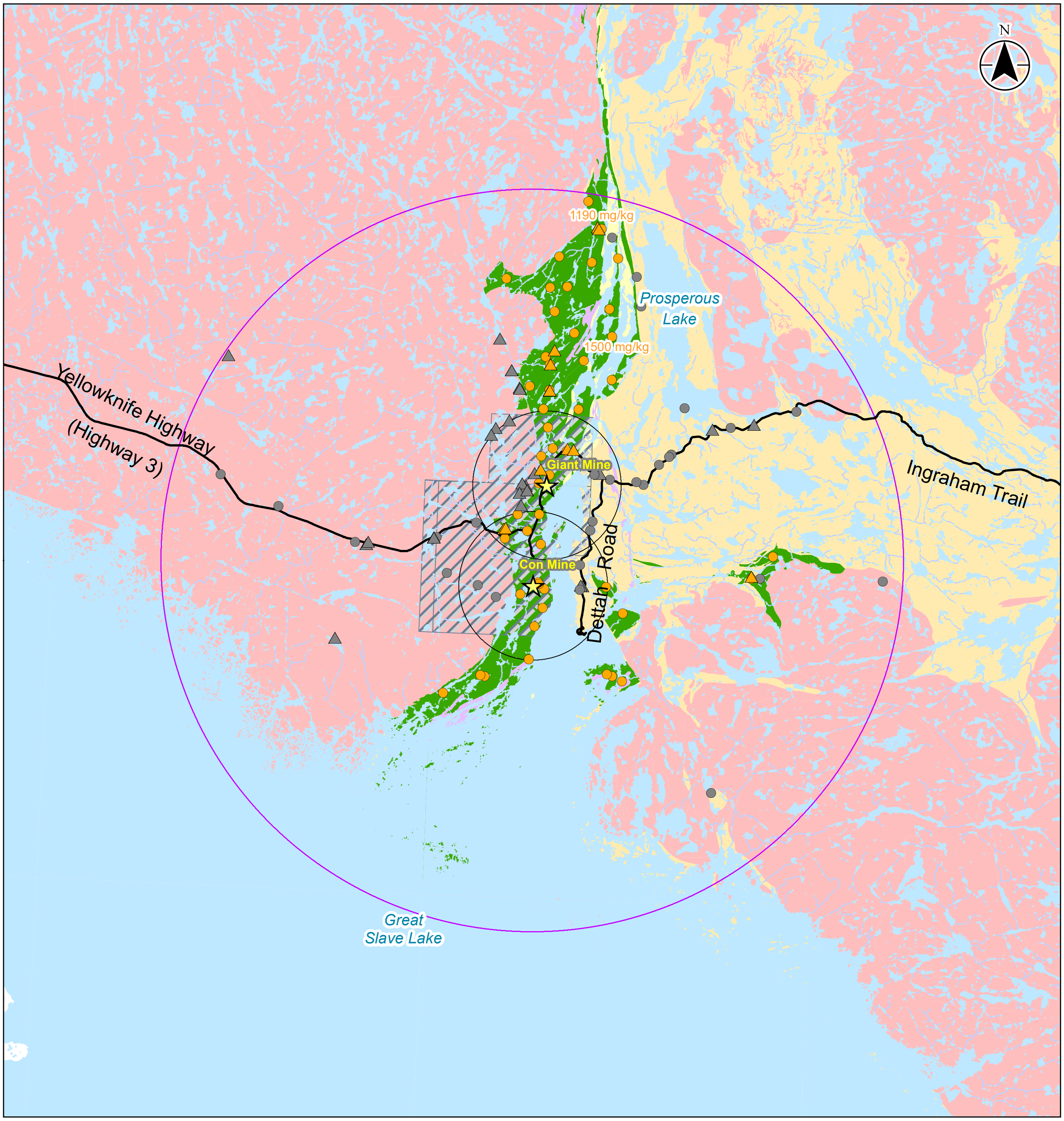
Client/Project/Report
Government of Northwest Territories
Yellowknife Background Soil Arsenic
Data Review

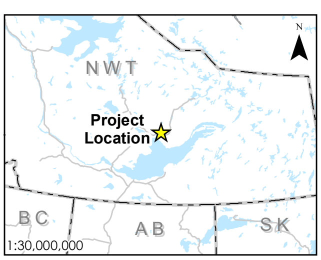
Figure No.
1

Title
Sample locations and inferred sample classifications (YGB or non-YGB) for 12 GSC samples with no reported bedrock lithology

Notes
1. Coordinate System: NAD 1983 CSRS Northwest Territories Lambert
2. Data Sources: Government of Northwest Territories, Natural Resources Canada

Revised: 2020-07-16 By: ipodrug





Mine
Highway / Major Road
Watercourse
Waterbody
City of Yellowknife
Radius (5 km) around Con and Giant Mines
Radius (25 km) around City of Yellowknife

Sample Locations
- GSC, Non YGB
- GSC, YGB
- Jamieson, Non YGB
- Jamieson, YGB

Bedrock Geology
- Granite
- Mafic
- Volcanic
- Metasedimentary
- Sedimentary

0 2 4 6 8 10 km
1:400,000 (at original document size of 8.5x11)

Notes
1. Coordinate System: NAD 1983 CSRS Northwest Territories Lambert
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Stantec

Project Location
Yellowknife, NWT

Project Numbers 144902990,144903036
Prepared by IPODRUG on 20200610

Client/Project/Report
Government of Northwest Territories
Yellowknife Background Soil Arsenic
Data Review

Figure No.
2

Title
Sample locations and underlying bedrock geology for samples collected within 25 km of Yellowknife

Figure 3 **Histograms for untransformed log-transformed soil arsenic concentrations grouped by data source (GSC and Jamieson) and underlying geology (YGB and Non-YGB)**

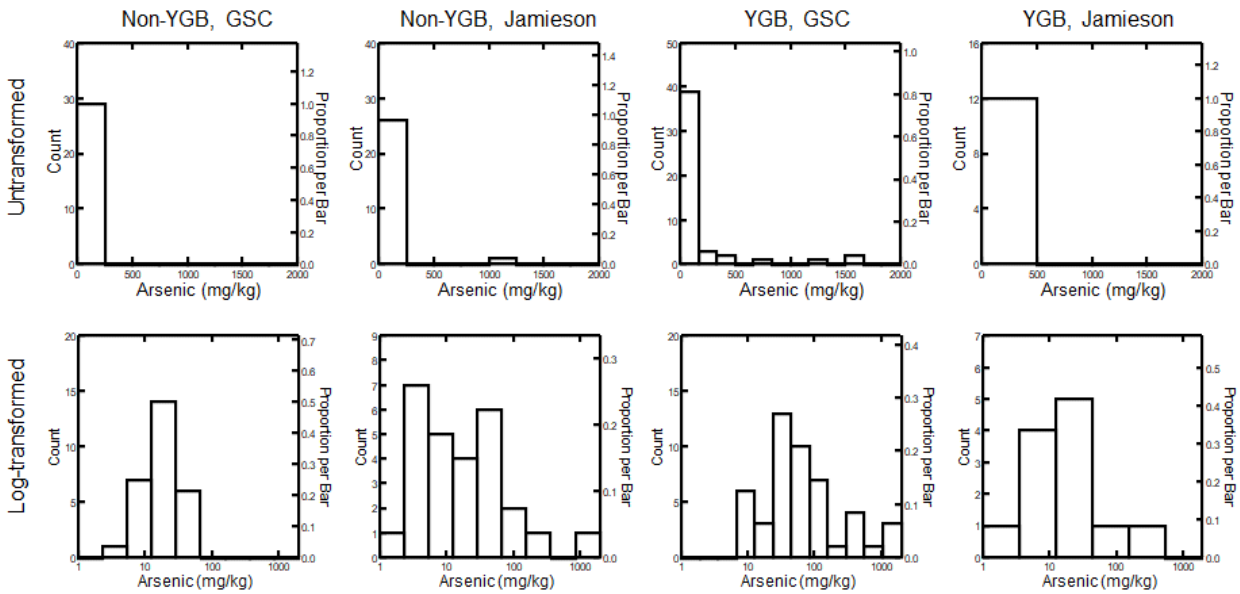


Figure 4 **Soil arsenic concentrations plotted against distance to the closest mine for all samples grouped together. Regression line and statistics provided are based on a linear regression between $\log_e$-transformed soil arsenic concentrations and distance from the closest mine**

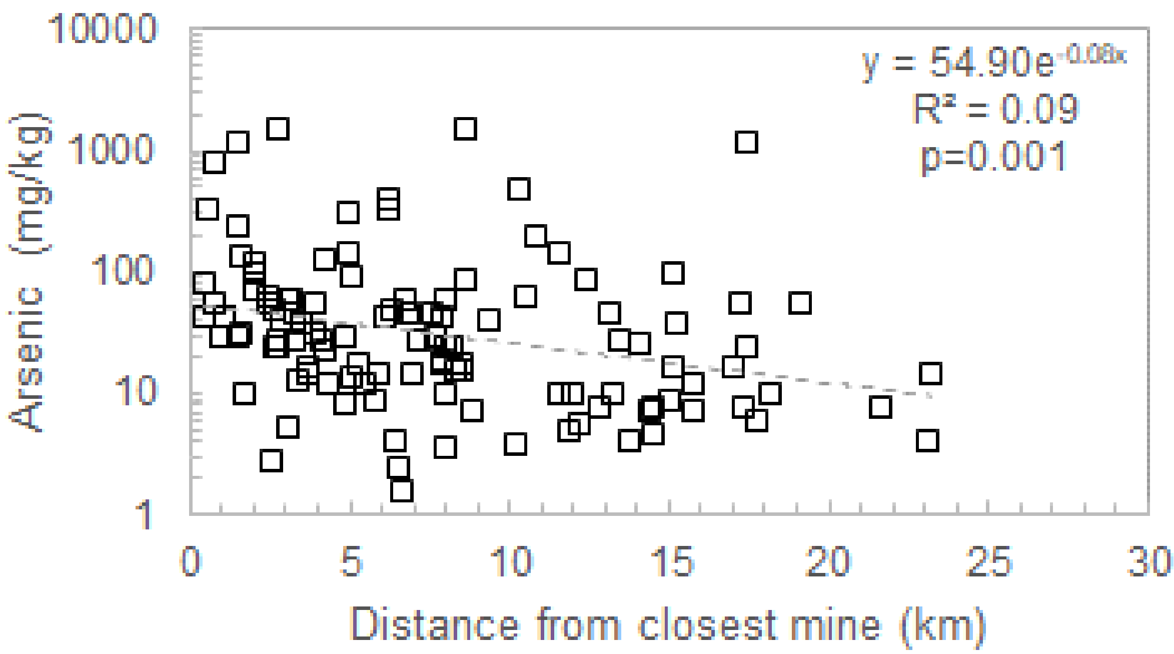


Figure 5 **Soil arsenic concentrations plotted against distance to the closest mine for samples categorized by source (GSC and Jamieson) and underlying geology (YGB and Non-YGB). Regression line and statistics provided are based on a linear regression between $\log_e$-transformed soil arsenic concentrations and distance from the closest mine**

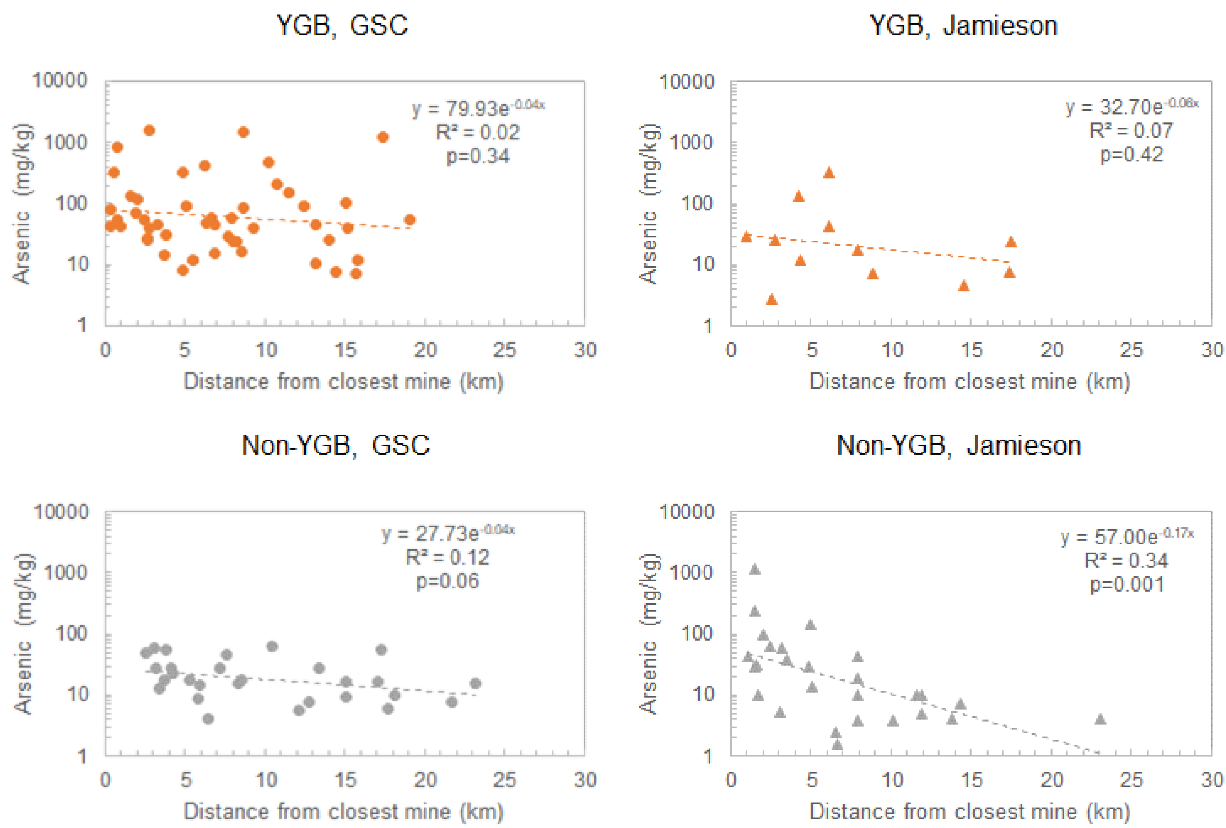


Figure 6 **Soil arsenic concentrations plotted against distance to the closest mine for all samples, excluding those collected within 5 km of the closest mine. Regression line and statistics provided are based on a linear regression between $\log_e$-transformed soil arsenic concentrations and distance from the closest mine**

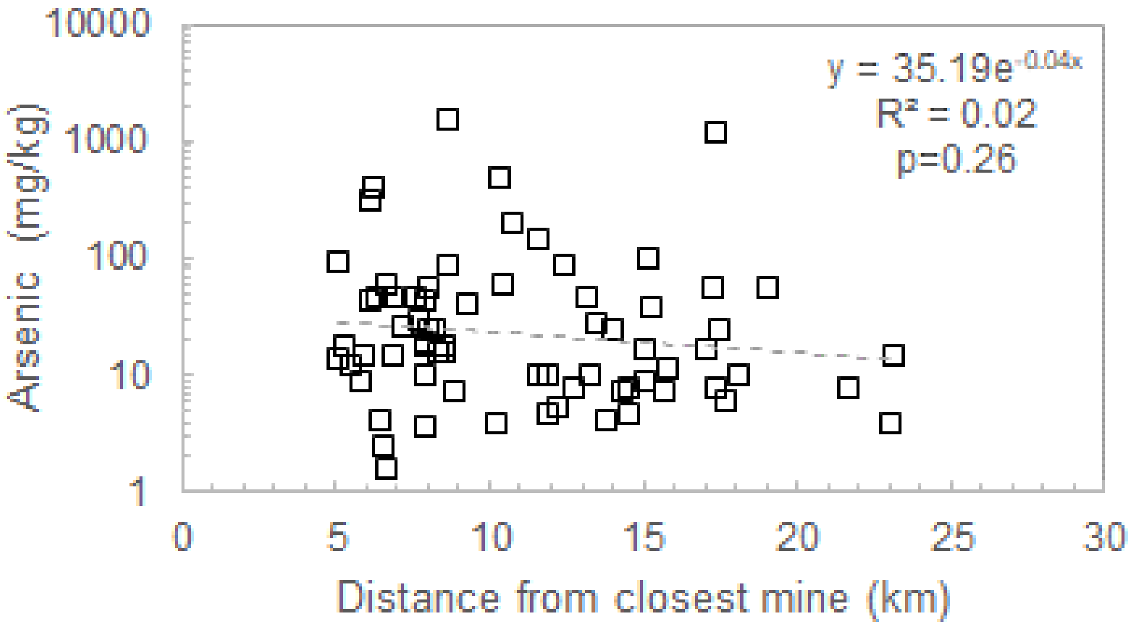


Figure 7 Soil arsenic concentrations plotted against distance to the closest mine for samples categorized by source (GSC and Jamieson) and underlying geology (YGB and Non-YGB), with samples less than 5 km from the closest mine excluded. Regression line and statistics provided are based on a linear regression between $\log_e$-transformed soil arsenic concentrations and distance from the closest mine

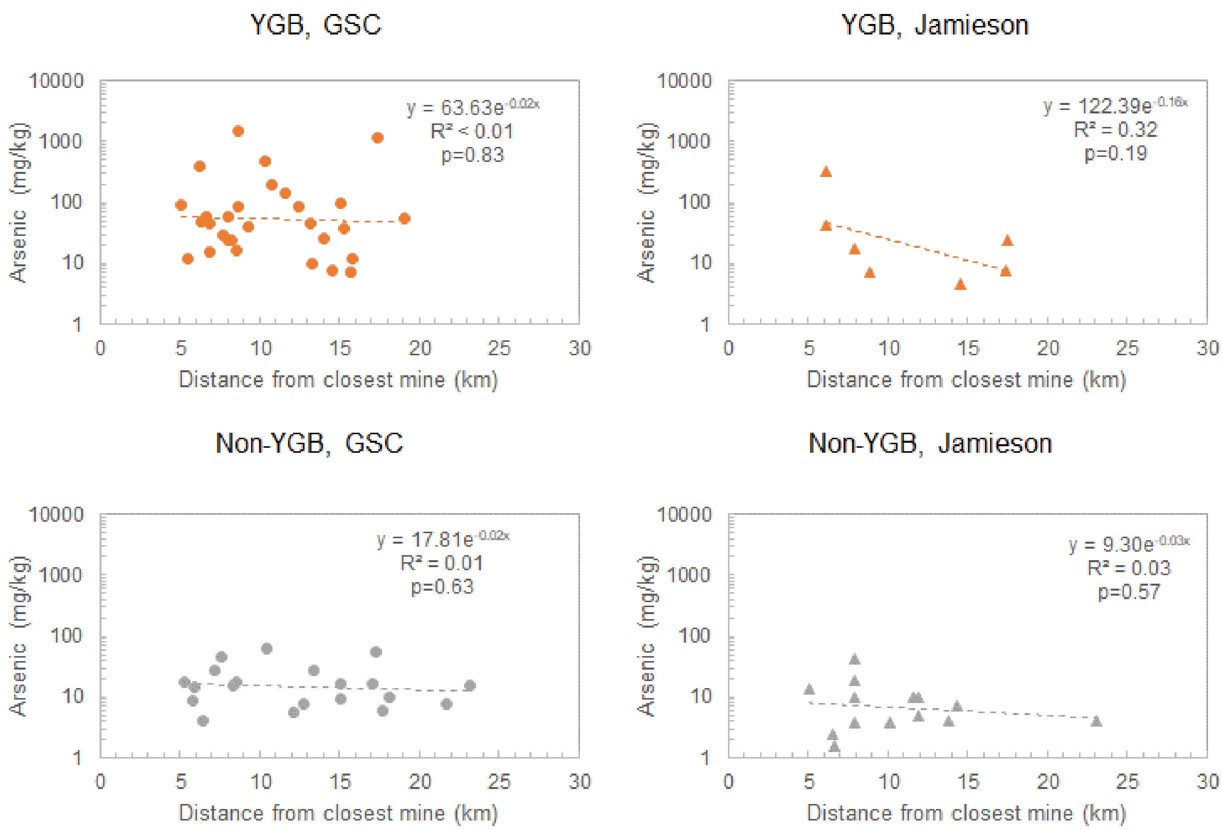


Figure 8 **Boxplots summarizing soil arsenic concentrations for available data (with and without data for samples collected within 5 km of the closest mine excluded) grouped based on source (GSC vs. Jamieson) and underlying geology (Non-YGB vs YGB)**

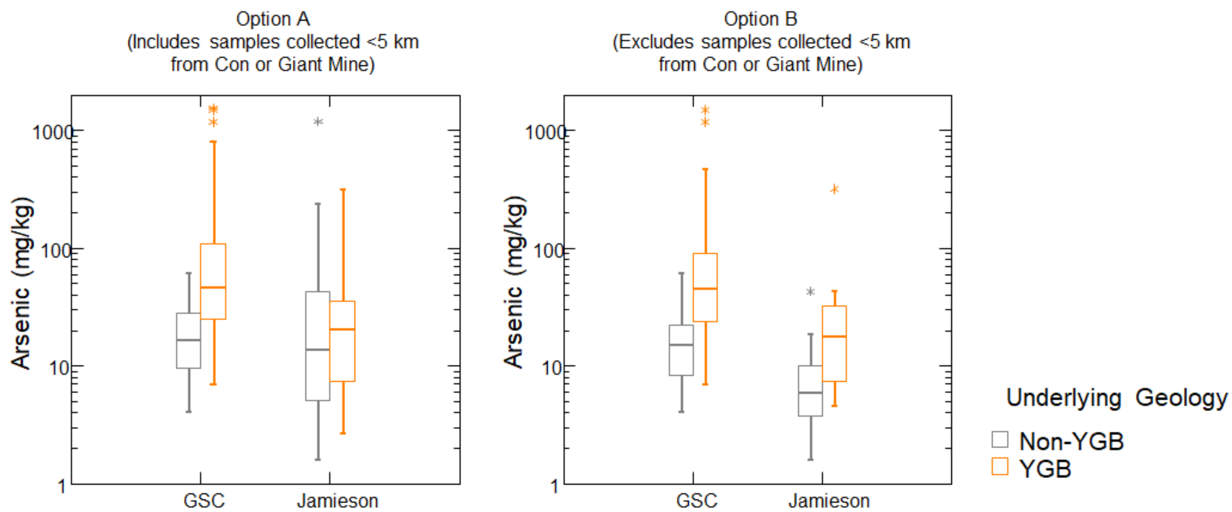
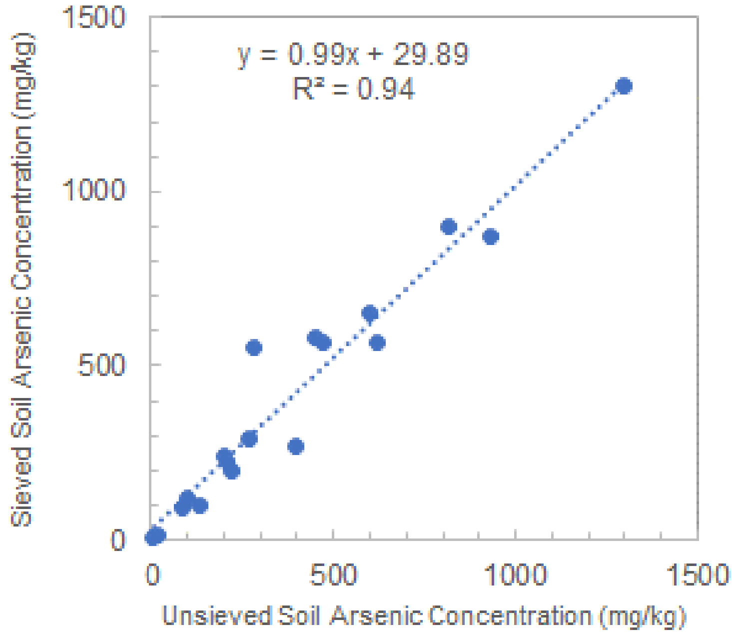
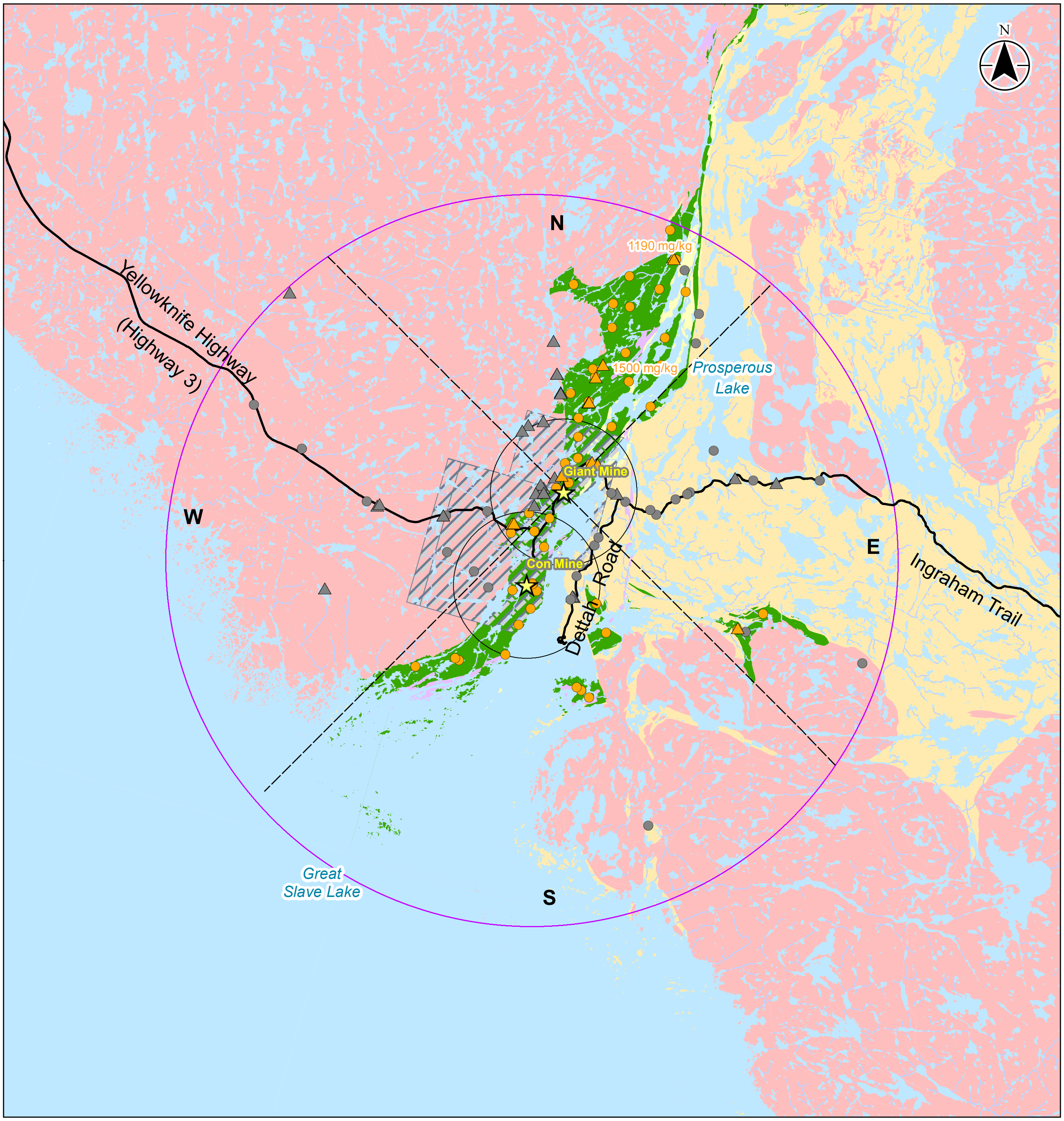
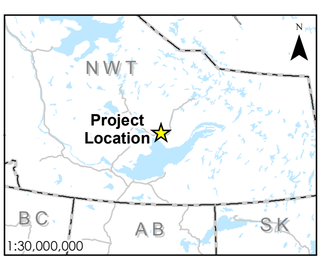


Figure 9 Comparison of results for samples collected at depth that were split and analyzed as both unsieved and sieved to <2 mm by Jamieson et al. (2017)







Mine
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City of Yellowknife
Mine Buffer (5 km)
City of Yellowknife (25 km)

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Stantec

Project Location
Yellowknife, NWT

Project Numbers 144902990, 144903036
Prepared by IPODRUG on 20200928

Client/Project/Report
Government of Northwest Territories
Yellowknife Background Soil Arsenic
Data Review

Figure No.
10

Title
Directional classification by quadrant (north, east, south or west) relative to Giant Mine for samples collected within 25 km of Yellowknife

Notes
1. Coordinate System: Canada Lambert Conformal Conic
2. Data Sources: Government of Northwest Territories, Natural Resources Canada

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Figure 11 **Soil arsenic concentrations plotted against distance to the closest mine for samples categorized by underlying geology (YGB and Non-YGB) and quadrant (north, east, south, or west) relative to Giant Mine. Regression lines indicate the line of best fit between $\log_e$-transformed soil arsenic concentrations and distance from the closest mine. The vertical dashed line indicates a 5 km distance to the closest mine.**