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[1] https://csapsociety.bc.ca/wp-content/uploads/ATT-3_-CSAP-Professional-Judgement-May2nd.pdf

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REVIEW OF REGIONAL SOIL BACKGROUND CONCENTRATIONS

AE PROJECT NUMBER

3935
April 2025
Version 1.0

PREPARED FOR

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REVIEW OF REGIONAL BACKGROUND CONCENTRATIONS

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1 INTRODUCTION

Active Earth has conducted an informative study to identify if there is sufficient information available to support making changes and additions to the BC Ministry of Environment and Parks (ENV) Protocol 4 for Contaminated Sites – Establishing Local Background Conditions in Soil.

Feedback from CSAP membership, practitioners in the industry and the regulator suggests that the current list of regional soil background concentrations within Protocol 4 may not accurately reflect the range of parameter concentrations commonly observed during investigations and soil relocation (e.g., arsenic concentrations encountered in the Lower Mainland) and is leading to soils with naturally elevated concentrations to be considered for disposal at permitted facilities as well as adding more local background determinations to be sought from ENV.

1.1 Objectives

The project objectives were as follows:

- Identify metal parameters in each region that are posing challenges (i.e., naturally occurring concentrations commonly exceeding the CSR numerical standards and the regional background concentrations currently listed in Protocol 4 -Table 1).
- Review the current regulatory methods for determining regional soil background concentrations and identify areas where potential changes could be considered (i.e., methods for defining regions and methods of data analysis or collection) if updating of the Protocols by ENV is undertaken in the future.
- Review practices used in other jurisdictions to determine background soil concentrations.
- Based on the outcome of the above, identify data needed to scientifically support possible changes to the list of regional background concentrations.

In addition to the objectives noted above, there are several other good reasons to revisit Protocol 4, including:

- Updated, accurate and accountable local background substance concentrations improves the reliability of the dataset for site investigation and remediation professionals.
- Ensuring that the relocation of soils with naturally occurring substance concentrations above CSR standards is managed appropriately, thereby minimizing the creation of new contaminated sites.
- Accurate background concentrations can prevent unnecessary remediation costs and reduce the financial burden on businesses and taxpayers.
- Revisiting the protocol can allow for the incorporation of additional recent data and information to support improved representative sample data evaluation and statistical approaches.

- Revisiting Protocol 4 is essential to ensure that environmental management practices in BC remain effective, scientifically sound, and aligned with current conditions and regulations.

2 DATA REVIEW FROM OTHER JURISDICTIONS/AGENCIES

As part of the scope, Active Earth identified various sources of background information from other jurisdictions and agencies that was reviewed to 1) evaluate other approaches being used to determine/establish background concentrations; and 2) potentially augment or supplement current data sets to refine/revise reasonable background estimates for various regions.

Documents reviewed included the following as outlined in Table A below. A summary is provided in Section 2.11.

TABLE A – DOCUMENT REVIEW LIST

Section	Report Name	Author	Date
2.1	Federal Contaminated Sites Action Plan (FCSAP) - Ecological Risk Assessment Guidance - Module 5: Defining Background Conditions and Using Background Concentrations	Environment and Climate Change Canada (ECCC, 2019)	October 2019
2.2	Evaluation of Background Metal Concentrations in Alberta Soils	Millennium EMS Solutions Ltd., (Millenium, 2016)	August 2016
2.3	Background Data – How to get more "Bang for your Buck"?	Remediation Technologies Symposium, Banff (Advisian, 2015)	October 2015
2.4	Naturally Occurring Background Levels of Arsenic in the Soils of Southwestern Oregon	Heather Hurtado (Hurtado, 2015)	July 2015
2.5	Development of Oregon Background Metals Concentrations in Soil	Oregan Department of Environmental Quality (DEQ, 2013)	March 2013
2.6	The Dutch Soil Type Correction – An Alternative Approach	National Institute for Public Health and the Environment, Ministry of Health, Welfare and Sport – The Netherlands (RIVM, 2012)	2012
2.7	Determination of a Southern California Regional Background Arsenic Concentrations in Soil	California Department of Toxic Substances Control (DTSC, 2009)	2009
2.8	Using Soil Geochemical Data to Estimate the Range of Background Element Concentrations for Ecological and Human-Health Risk Assessments	Rencz, A.N., Garrett, R.G., Kettles, I.M., Grunsky, E.C. and McNeil, R.J., Geological Survey of Canada (GSC, 2011)	2011

TABLE A – DOCUMENT REVIEW LIST

Section	Report Name	Author	Date
2.9	Background Concentrations at California Air Force Bases	Philip Hunter, Brian Davis and Frank Roach (2005)	March 2005
2.10	Natural Background Soil Metals Concentrations in Washington State	Toxic Cleanup Program, Department of Ecology (DoE, 1994)	October 1994

2.1 Federal Contaminated Sites Action Plan – Ecological Risk Assessment – Module 5: Defining Background Conditions and Using Background Concentrations (ECCC, 2019)

The Federal Contaminated Sites Action Plan (FCSAP) was developed to assist federal departments and agencies reduce risks to human health and the environment and reduce financial liabilities from contaminated sites. ECCC prepared a series of guidance documents to support the federal Canadian Council of Ministers of the Environment (CCME) guidance (1997) and the application of ecological risk assessment (ERA) in the management of contaminated sites. Module 5 focuses on how background conditions can be used in management of contaminated sites, with an emphasis on identifying when and how to sample for background concentrations.

The document defines background conditions as the concentrations of contaminants that are naturally present or result from regional anthropogenic activities not related to the site in question. An understanding of these conditions can help with setting realistic remediation goals and aiding in the identification of contaminants of concern (COCs).

The document outlines approaches for differentiating between site-related contamination and background levels, including the importance of selecting appropriate reference areas; understanding the soil type, land use, hydrology when choosing sample locations and depths; the use of proper field sampling procedures; quality assurance/quality control; standardized methods for sample analyses; and statistical methods for reviewing data and estimating background concentrations.

Module 5 does not provide any specific data or information on appropriate regional or local background concentrations but rather provides the framework for site-specific estimates of background concentrations to meet federal requirements.

2.2 Evaluation of Background Metal Concentrations in Alberta Soils (Millenium 2016)

The Petroleum Technology Alliance of Canada commissioned development of a database of background soil concentrations for metals in Alberta. This study was undertaken by Millenium EMS Solutions Ltd. (Millenium) in 2016, and the purpose was to support industry and consultants in determining typical ranges of background metals in shallow soils.

In Alberta, Tier 1 soil guidelines are generic and conservative to protect sensitive sites and are available for 20 metal parameters. Similar to BC, the report noted that it is not uncommon for background metal concentrations to the exceed Tier 1 guidelines. Accordingly, site-specific background data collection and evaluation is becoming more routine. The study included:

- Identify analytical data sources for shallow soil and incorporate into a database.
- Review current practices for sample preparation and analysis for metals in soil samples at various analytical laboratories to determine if any differing practices could affect the data.
- Develop approach for screening out non background data (i.e., suspected to be impacted by anthropogenic sources).
- Generate statistical analyses of the collected data.
- Assess correlations between trace metals and chloride related to process water at oil and gas facilities.

Data was compiled from environmental impact assessments, environmental site assessments, remediation and reclamation programs in Alberta, British Columbia and Saskatchewan dating from 2008 to 2015. The data originated mainly from five labs, and overall, a review of differing analytical methods was deemed not likely to significantly impact variations in results.

The assembled data sets were screened to remove data potentially influenced by anthropogenic sources (i.e., based on location, depth and concentration levels of other parameters). This was followed by a site-specific screening to identify and remove outliers such that maximum values in the background distribution for each metal could be identified as a genuine background concentration with a high degree of confidence.

Statistical evaluation included determining mean, median, 25th, 75th and 95th percentiles, and minimum and maximum concentrations (noting substitution of non-detect data with a concentration equal to half the reportable detection limit). Following the screening methods a total of 793 unique samples (of an original 5677 samples) remained for the statistical analyses.

The statistical analysis using the 95th percentile as the background concentration for Alberta showed that the maximum background metal concentrations retained were below their respective Tier 1 guideline for antimony, beryllium, total chromium, hexavalent chromium, copper, lead, mercury, molybdenum, silver, thallium, tin, uranium, vanadium and zinc. The maximum background concentrations retained for arsenic, cadmium, cobalt, nickel and selenium exceeded the respective Tier 1 guideline.

The report concluded that natural background metal concentrations can vary substantially between sites and are dependent upon the parent material from which the soil formed. Caution was noted when extrapolating the results of this report to other sites, suggesting professional judgement is required when determining if elevated metal concentrations are anthropogenic or representative of elevated natural background. The report concluded that elevated background metal concentrations outside of the reported maximum values may require additional site-specific data and greater scrutiny to support identification of a natural occurrence versus the result of anthropogenic activities.

2.3 Background Data – How to get more "Bang for Your Buck?" (Advisian, 2015)

This presentation was given by Advisian at the Remediation Technologies Symposium in Banff in October 2015. Only the presentation slides were available for review.

The focus of the presentation was on obtaining soil background concentrations for the Province of Alberta. At the time of the presentation, there was no defined methodology from the Government of Alberta for obtaining sufficient, scientifically sound background concentrations.

The common approach adopted for background assessments was noted as having limitations arising from the number of available background samples (time and money constraints), site conditions (accessibility), and limited or missing site information conforming location of historical activities.

The presenters proposed a new methodology for estimating representative background estimates as follows:

Step 1 – Determine Background values for Potential Contaminants of Concern

- Anthropogenic contaminant concentrations (such as BTEX, hexavalent chromium etc.) should be below the detection limit.
- For non-anthropogenic contaminants, concentrations *(such as F3 PHC, barium and chloride) background values should be* based on the distribution in all samples.

Step 2 – Background Samples Selection

- Samples with no sign of impact are considered as representing natural conditions. Samples are determined to have no sign of impact if both anthropogenic and non-anthropogenic meet the conditions set in Step 1.

Step 3 – Background Samples Review

- Unimpacted samples are further assessed for outliers. Samples are classified as outliers when the concentrations exceed the 75th percentile, plus three times the Interquartile range.
- Outliers are further assessed against borehole logs, location etc.
- False outliers are kept for background values.

Step 4 – Representative Statistic

- Background values are calculated as the 95% upper confidence limit of the 95th percentile which incorporates some statistical uncertainty by providing an upper bound for the 95th percentile) as compared to just considering the 95th percentile value.

2.4 Naturally Occurring Background Levels of Arsenic in the Soils of Southwestern Oregan (Hurtado, 2015)

A thesis study in 2015 looked at natural background concentrations of arsenic in southwestern Oregan by examining more recent samples to potentially add to existing data collected by the Oregan Department of Environmental Quality in 2013. This study looked a re-analyzing both previous samples and the newer identified samples using ICP-MS methods with lower detection limits (previous analyses had used ICPAES methods) in order to better evaluate natural arsenic levels (determined using the 95% upper prediction limit as the default regional value). The study also looked at differing soil horizons at one specific site to evaluate the distribution and variance within the individual soil horizons. Finally, the study looked at six potential environmental factors indicative of naturally occurring arsenic including site elevation, geomorphic province, mapped rock type and age and sample soil order and colour.

The evaluation concluded that soil order, elevation and rock type were significant indicators of arsenic concentrations in natural environments. Arsenic concentrations were noted to be higher in Alfisols, Alfisols/Ultisols and Vertisol soil orders [i.e., highly fertile clay enriched soils; strongly leached, acidic forest soils with significant clay accumulation (red clay soils); and clay rich soils. As negatively charged arsenic ions adsorb to positively charged minerals (typically iron, aluminum and magnesium oxides) and clay, soils with mineral accumulation (i.e., Alfisol, Ultisol and Vertisol soils) were deemed to likely to attract, retain and concentrate arsenic concentrations in the soil.

2.5 Development of Oregan Background Metals Concentrations in Soil (DEQ, 2013)

The Oregan Department of Environmental Quality (DEQ) completed a re-evaluation of background metals concentrations that replaced previous values contained in a draft 2002 memorandum prepared by DEQ. This previous draft memorandum was reportedly based on information from the State of Washington's Department of Ecology, the US Geological Survey (USGS) and British Columbia's (BC) Ministry of Water, Land and Air Protection (now ENV). In this study, the DEQ noted limitations with the previous 2002 memorandum that included:

- Newer datasets since the 2002 memorandum were now available for consideration.
- Some data sources were not specific to Oregon and areas of the state were under-represented.
- Background estimates did not consider mineralized areas (e.g., mining areas).
- Background estimates were not available for some metals.
- All default values were based on BC 95th percentile or Washington State 90th percentile values.

The initial phase of work was completed in 2010 and involved compiling all data sets and summary statistics for 16 metals into a GIS database [i.e., data included min/max values, mean, median, 25th, 75th, 90th and 95th percentile values, 90 percent upper confidence limits on the mean (90% UCL) and box plots for each metals parameter]. This study indicated that the soils in Oregan differed enough from Washington State and BC to warrant calculation of state specific regional background concentrations.

The second phase of work in 2011 focused on outliers, non detects, duplicate samples, identifying areas requiring more analyses and de-clustering some areas with higher frequency of samples. The goal of this phase was to compile a representative data set that could be used to calculate background values.

The database that was compiled as part of the first two phases considered the following:

- All samples required consistent georeferenced coordinates.
- All samples required metals concentrations in consistent units (i.e., mg/kg).
- Each sample was assigned to a physiographic province. In total nine regions (i.e., Coast Range, Basin and Range, Cascades, Willamette Valley, High Lava Plains, Owyhee Uplands, Blue Mountains, Klamath Mountains and Deschutes Columbia Plateau) were considered with one area (i.e., Willamette Valley) further divided into sub regions. These regions were previously characterized and defined based on a combination of geological, ecological, and climatic characteristics and have evolved over time initially developed in the late 1990s with the purpose of understanding the diverse landscape of Oregan and aiding land management efforts.
- Data sources were evaluated to identify overlapping samples.
- Clear identification of samples that were not used in the statistical analyses.
- Selection of samples only within the upper 1 m of soil.
- Identification of non detect samples that exceeded maximum detected concentrations in order to remove from the statistical analyses.

Once the data set was considered complete, statistical analyses using ProUCL was carried out. A state-wide summary was created for the 16 metals that included the number of samples with detectable concentrations, number of non-detect samples, detection frequency, minimum and maximum concentrations, mean, and standard deviation. A similar summary was created by region for each of the 16 metals. Further to the regional summary, additional statistical analyses including 90th and 95th percentile values, 90% UCL and 95th upper prediction limit (UPL) were determined for each of the metals by region.

The default background concentration selected was the 95th UPL. Use of the 95th UPL has been recommended by the EPA for default background values to ensure a conservative and protective approach in environmental assessments. The 95th UPL represents a statistical threshold that accounts for variability in background data and provides a high level of confidence that the true background concentration is not underestimated. The definition of 95^{th} UPL is a statistical value that is expected to be exceeded only rarely by individual samples (DEQ, 2013).

Based on a review of the tables and figures appended to this report the following was noted:

- The sample locations in the nine areas appeared evenly distributed across the state.
- The number of samples with detectable concentrations across the state varied by metal parameters, ranging from 83 to 1,325.
- Limited data or no data was identified for only one metal parameter (i.e., thallium) in two of the regions (i.e.., where then number of samples with detects was 1 or none).

2.6 The Dutch Soil Type Correction – An Alternative Approach (RIVM, 2012)

This study was conducted by the National Institute for Public Health and the Environment (RIVM) and sponsored by the Ministry of Health, Welfare and Sport of the Federal Government of the Netherlands.

The study proposed an alternative method – referred to as 'soil type correction' (STC) for metals in soil – to determine background concentrations. It was argued that background concentrations should be dependent on soil type in addition to parameter concentration ranges. The STC consists of a series of mathematical equations between the concentrations of the metal parameters of interest (e.g. lead, zinc, chromium, etc.) with the weight percentage of clay (<2µm) and the organic matter content (also in weight percentage).

The Dutch Soil Quality Decree is the Netherlands equivalent to the BC Contaminated Sites Regulation. It should be noted that in the Netherlands, soil quality is assessed only at the Federal level and not at the Provincial level.

The current implementation of the STC in the Dutch Soil Quality Decree has four individual parts:

1. Statistical model, correlating the concentrations of metal in soil to the clay fraction and organic matter content.
2. Formulas, outlining this statistical correlation per metal.
3. Natural (non-anthropogenic) background concentration.
4. Added risk level due to anthropogenic impacts.

A significant difference in numeric soil standards between the Netherlands and BC is the Netherland standards are dependent on background concentrations, plus the evaluation of an added risk level (part 4) due to anthropogenic impacts. This reasoning is illustrated in Figure A. The principle states that the total concentration of metals in soil is derived from a Natural Background Fraction (C_b) and an Anthropogenic Addition Fraction (C_a). A portion of the "Anthropogenic Addition Fraction" is considered 'inactive' due to weathering and ecosystem adaptation, and does not necessarily add to the risk level and/or potential environmental or human health effects. Only the active Anthropogenic Addition Fraction would add to the risk level.

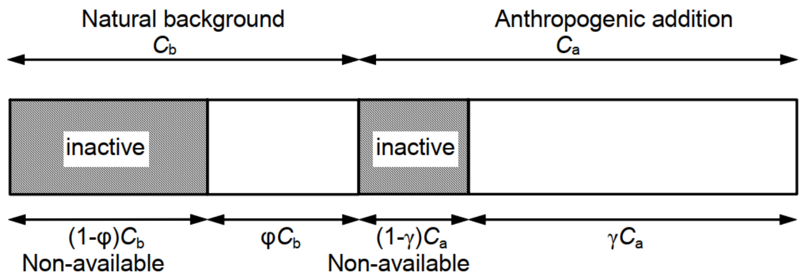

FIGURE A: ILLUSTRATION OF ADDED RISK LEVEL TO SOIL TYPE CORRECTION METHODOLOGY FOR ESTABLISHING SOIL BACKGROUND CONCENTRATIONS IN THE NETHERLANDS.

The natural background concentrations for metals vary for the four major lithologies present in the Netherlands, i.e., sand, peat, marine and fluvial clays. The lithologies differ both in mineralogical content and structural dynamics and for the Netherlands specifically, the variability is primarily a result of the variability in clay content (expressed as the weight percentage of Al_2O_3).

In order for measured metal concentrations in soil samples from different lithological classes to be compared to a single standard, the concentrations are normalized to a "standard soil" with a clay fraction of 25 wt% and 10 wt% organic matter. This 'standard soil' is used as the default standard for comparing soils of different clay and organic matter content.

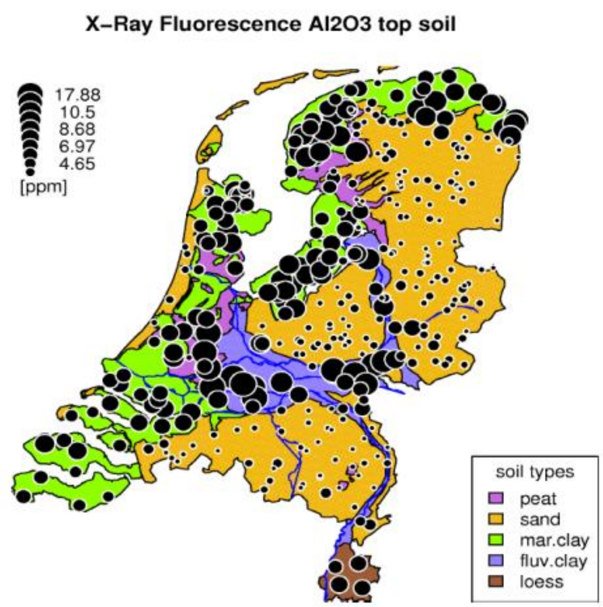

FIGURE B: CONCENTRATIONS OF AL2O3 IN TOPSOIL SAMPLES. LARGER CIRCLES INDICATE HIGHER CONCENTRATIONS. LITHOLOGICAL SOIL TYPES ARE DETERMINED BASED ON AL2O3 CONTENT.

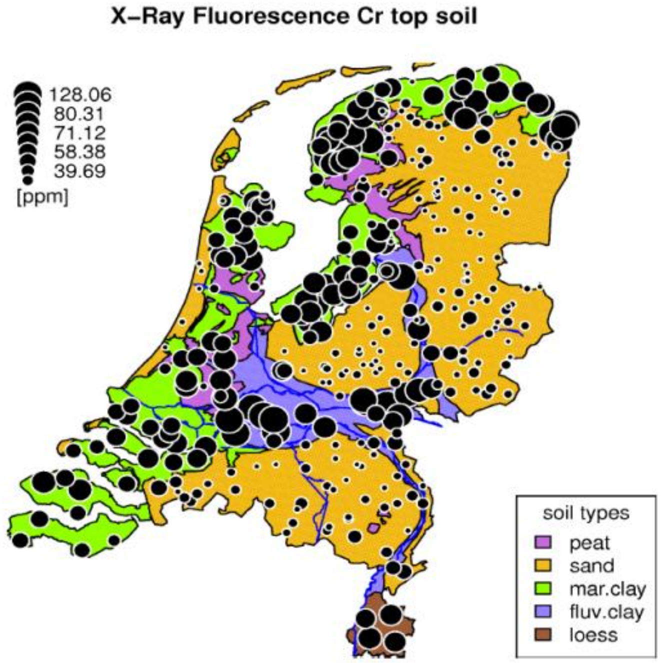

FIGURE C: CONCENTRATION OF CHROMIUM (PPM) IN TOPSOIL SAMPLES IN THE NETHERLANDS. LARGER CIRCLES INDICATE HIGHER CONCENTRATIONS.

2.7 Determination of a Southern California Regional Background Arsenic Concentration in Soil (DTSC, 2009)

This report establishes a regional background arsenic concentration as a screening tool for sites in Southern California by the Department of Toxic Substances Control (DTSC). The DTSC manages environmental assessments at proposed new and existing schools, and arsenic has proven to be challenging as concentrations are typically identified above the risk concentration (i.e., threshold concentration level) requiring an arsenic background assessment at each site.

To determine if a regional arsenic concentration could be established, data collected from 19 schools in the Los Angeles area was evaluated by graphical and statistical evaluations. The graphical evaluations using histograms and box plots were used to identify outliers. The statistical analyses then looked at mean, median, max and min values and 95% confidence limits using a lognormal distribution. Similar analyses were completed in 5 other areas in Southern California all with similar findings that the upper bound of background concentrations was approximately 12 mg/kg. The study concluded that the value of 12 mg/kg of arsenic may be a useful screening tool to evaluate arsenic as a potential contaminant of concern.

2.8 Using Soil Geochemical Data to Estimate Range of Background Element Concentrations for Ecological and Human-Health Risk Assessments (GSC, 2011)

This research was conducted in preparation for a workshop on the role of geochemical data in ecological and human-health risk assessments. The workshop was sponsored by Health Canada and Environment Canada in 2010.

In summary, the authors provide recommendations on following these practices in acquiring and analyzing soil geochemical data in support of risk assessment and estimating background concentrations:

1. Rather than collecting background samples from fixed depths, reference samples should be collected from similar pedological horizons (the C-horizon in particular). Since the thicknesses of soil horizons differ from location to location, sampling at a fixed depth introduces more variation into the overall data. Different soil horizons are chemically distinct from each other based on metal and organic matter content; hence reference data should be collected from similar horizons.
2. Spatially random sample design should be used to ensure the background range of element concentrations in soil are statistically defensible.
3. For sample analysis, the less than 2mm fraction of soil data is recommended as the standard for geochemical analysis. Additionally, the less than 0.0063mm fraction (silt and finer) provides more information on the mineral phases and residence sites of elements in soils.
4. Use of Aqua Regia variant USEPA 3050B for dissolution in chemical analysis of soil samples.
5. Include field duplicates in order to determine the analytical precision of the data.
6. Evaluation of chemical data through analyzing QA/QC samples.

2.9 Background Concentrations at California Air Force Bases (2005)

This 2005 report looked at evaluating background concentrations of soil and groundwater at 14 California Air Force Bases to support identification of concentrations attributable to anthropogenic sources vs naturally occurring concentrations to support risk assessment. This assessment was conducted to update a previous report in 2001 with the availability of additional datasets. Computer algorithms were used to identify the background locations based on absence of organic contamination, with outliers removed based on further graphical analyses. Specific to the soil assessment, it was noted that overall 4,230 boreholes were used in the study (specific numbers varied by metal parameter). The findings showed that metal concentration distributions did not fit either normal or lognormal distributions, and the 95th percentile for arsenic (12.7 mg/kg), iron

(36,100 mg/kg), Thallium (25 mg/kg) and Vanadium (88.3 mg/kg) exceeded their respective USEPA Region 9 Preliminary Remediation Goal concentrations for residential use.

Variability by sample depths was evaluated for horizon specific concentrations with no consistent pattern identified. Lead was noted to decrease substantially with depth, iron increased with depth, and chromium was consistent regardless of depth.

The study concluded the following:

- The 95th percentile was a good representation of background concentrations.
- Concentrations of some inorganic parameters vary substantially by depth.
- For some parameters the 95th percentile exceeded health-based criteria.
- Concentrations and statistics for the inorganic parameters did not change substantially since a referenced previous report in 2001.
- The assessment demonstrated variability across different environments, but was noted to not necessarily represent all of California.
- The results were noted to provide useful context, but did not recommend site specific background concentrations for any parameters.

2.10 Natural Background Soil Metals Concentrations in Washington State (DOE, 1994)

This study was completed in 1994 by the Department of Ecology, Toxic Cleanup Program with the objective to define a range of natural concentrations of metals in surficial soils in Washington State.

Following initial evaluation in a small test area, the State was divided into 24 regions based on geology, soils and climate, of which 12 regions were the focus of further statewide assessment. Sample collection targeted areas of undisturbed or undeveloped areas to depths of up 1 m below grade for total metals analyses.

The results underwent statistical analyses to identify the 90th percentile values which the Department of Ecology used as the default for background calculations. The data evaluation identified that the 90th percentile on average was 1.5 times higher on the west side of the state versus the east side for all parameters with the exception of arsenic. The extremities in climate, vegetation and geology between the west and east areas were thought to be the primary cause of the west to east variation. Comparisons of the 90th percentile statistical analysis results to other states were noted to be very similar. Factors such as climate (soil weathering) and vegetation in addition to soil type and geologic diversity were noted to influence background concentrations.

2.11 Summary

In summary, key information obtained from this jurisdictional review identified the following:

- Several different statistical metrics have been used by various jurisdictions to calculate background values. These have included:
  - The 90th and 95th percentile values.
  - The 95th Upper Prediction Limit which provides a range within which “future” observations are expected to fall, with a specified level of confidence (i.e., 95%).
  - 95% upper confidence limit of the 95th percentile provides a range within which a parameter will lie with a specified level of confidence.
- Background values tended to be variable, and in some cases these background values exceeded referenced standards and in other cases were less than referenced standards.
- In Oregon and Washington regional background numbers were determined similar to British Columbia. The regions in Oregan and Washington were primarily based on geology, soils and climatic characteristics.

3 SOIL BACKGROUND DATA REVIEW IN BRITISH COLUMBIA

3.1 Overview

A review of the current approach being used to evaluate background metals concentrations in BC was carried out. This included a review of the existing Protocol 4 and Protocol 28 process, as well as a review of the ENV approval letters[1] of background concentrations at specific sites.

The review focussed on the following key areas:

- Recapping the process for establishing regional background concentrations as outlined in Protocol 4 with the goal of identifying components that could be updated or enhanced to minimize the volume of background concentration applications to the ENV.
- Identification of metals parameters that are commonly found to exceed the CSR standards and deemed likely naturally occurring.
- Identification of the background concentration ranges for each parameter.
- Distribution of elevated background parameters with respect to regions, geology, and stratigraphy to help identify an updated or alternate prescriptive approach for practitioners to identify background concentrations without requiring ENV approval.
- Identification of any limitations of the collected data and recommendations for further data collection/review.

[1] Generally, information in the ENV background concentration approval letters was limited to identifying site location, parameters evaluated and concentrations. Occasionally, soil type information was also provided.

3.2 Current Protocol 4 Process

Protocol 4 of the BC Contaminated Site Regulation (CSR) describes the options for establishing a local background concentration in soil for use in the investigation and remediation of contaminated sites and/or to carry out soil relocation, where naturally occurring parameter concentrations exceed one or more of the applicable numerical soil standards outlined in the CSR.

A local background can be established through two methods:

1. Directly applying the derived regional background concentration estimates provided by the ENV for specific inorganic substances; or
2. Using the procedures outlined in this protocol for determining site-specific background concentrations in soil.

The following summarizes the process for establishing background concentrations as outlined in Protocol 4.

3.2.1 Protocol 4 Option 1 – Establishing Local Background Concentrations in Soil Based on Ministry Data

Table 1 in Protocol 4 presents the derived regional background concentrations for each of the regions: 1) Vancouver Island, 2) Lower Mainland, 3/8) Thompson/Nicola/Okanagan, 4) Kootenay, 5) Cariboo, 6) Skeena and 7) Omineca/Peace. Separate regional background estimates were derived for the Metro Vancouver area[2]. Sites located within the Lower Mainland (excluding the defined Metro Vancouver area), use the background concentrations identified for region 2.

Regional background concentrations were developed for naturally occurring inorganic parameters (metals). Parameters that were not assessed include geochemical indicators (e.g., phosphorus) and other inorganic parameters (e.g., chloride). For substances not listed in Protocol 4 - Table 1, site-specific local background concentrations in soil must be established using Option 2 as outlined in Protocol 4.

The use of Option 1 to determine local background concentrations in soil based on the regional estimates does not require an approval from the Director.

3.2.2 Protocol 28 – Section 9 Review – Regional Background sampling

Section 9 of Protocol 28 describes the methodology for establishing soil background concentrations for its eight administrative regions. Additional samples were collected for the Metro Vancouver area within the Lower Mainland region, in recognition of the intensive development in the area.

[2] The Metro Vancouver Area includes the University of British Columbia, Stanley Park, Queen Elizabeth Park, Richmond West, Richmond Central, Burnaby Lake Regional Park, Burnaby North, North Vancouver, New Westminster, and Coquitlam.

Samples were collected at 8 locales for each region, 8 samples were collected for metals assay, 16 sub-samples for organics assay and another 8 samples for archival purposes. The final database was a total of 487 samples, collected over 63 locales within the 8 administrative regions. The data from locales in Trail and Castlegar were not included in the derivation, as it was determined that these locations were impacted by anthropogenic activities (Trail smelter). All samples were analyzed using the SALM[3] method.

The regional background concentrations for each region were established by calculating the 95th percentile from all the soil data from locales within the region. The values were rounded based on the Ministry's "rounding-off" rule, which states that standards/background concentrations should be expressed as one significant digit, followed by an additional significant digit, 0 or 5, whichever is closest.

3.2.3 Protocol 28 – Regional Background Concentration Database

The locations of the sample sites and the number of samples at each site are summarized in the following table.

TABLE B - SUMMARY OF REGIONAL BACKGROUND SAMPLE LOCATIONS

Region	Number of samples	Sample Sites (8 samples collected per Sample Site)
1 – Vancouver Island	72	Cassidy, Saanich, Saltspring Island, Cumberland, Campbell River, Victoria, Malahat, Port Alberni, Port Hardy
2 – Lower Mainland	160	Squamish (2x), Port Moody (2x), Maple Ridge, Delta, Burns Bog, Surrey, Abbotsford, Chilliwack, UBC, Stanley Park, Queen Elizabeth Park, Richmond West, Richmond Central, Burnaby Lake, Burnaby North, North Vancouver, New Westminster, Coquitlam
Metro Vancouver	80	UBC, Stanley Park, Queen Elizabeth Park, Richmond West, Richmond Central, Burnaby Lake, Burnaby North, North Vancouver, New Westminster, Coquitlam
3/8 – Thompson/Nicola/ Okanagan	72	Kamloops (2x), Kelowna, Oliver, Merrit, Vernon, Princeton, Salmon Arm, Ashcroft
4 – Kootenay	56	Kimberly, Nelson, Revelstoke, Creston, Castlegar4, Trail2, Invermere, Sparwood, Golden
5 – Cariboo	24	Williams Lake, 100 Mile House, Quesnel/Barkerville
6 – Skeena	48	Kitimat, Smithers, Terrace, Burns Lake, Prince Rupert, Houston

3 British Columbia Environmental Laboratory Manual, Section C, Strong Acid Leachable Metals (SALM) in soil.
4 The samples at these locations were discarded.

TABLE B - SUMMARY OF REGIONAL BACKGROUND SAMPLE LOCATIONS

Region	Number of samples	Sample Sites (8 samples collected per Sample Site)
7 – Omenica/Peace	56	Prince George (2x), Dawson Creek, Mackenzie, Fort St. James, Tumbler, Fort St. John

A total of 8 samples were collected at each sample site. The samples were collected at 4 locations at each sample site, with one sample taken at 0-10cm below grade and one sample taken at 50-60cm below grade. The ENV reference sites are illustrated on the appended Figure 1.

The values for the regional estimates of background concentrations for each metal were calculated as the 95th percentile of all data collected within each region as is outlined in Section 9 of BC CSR Protocol 28. It is noted that the values in brackets in Table 1 of Protocol 4 indicate that more than 50% of the analyzed samples were below the laboratory detection concentration limit. Hence, the regional estimate was assumed to be half the detection limit for metals in these regions. This is the case for the following metals:

- **Antimony, Boron, Selenium, Silver** and **Tin** in all Regions.
- **Arsenic** in Region 1 – Vancouver Island and Region 4 – Kootenay.
- **Cadmium** in all Regions, except for Region 1.
- **Molybdenum** in Regions 1, 4 and 5 – Cariboo.

The data was further analyzed based on quality and whether the lab methods used at the time met current practices and standards. For example, some individual parameters had a relatively high detection limit compared to current day detection limits. Specifically, the mean detection limit at the time for concentrations of arsenic, antimony, selenium and tin was 8 mg/kg, and the detection limit for concentrations of boron and molybdenum was 2 mg/kg. In comparison, current mean detection limits vary between 0.1 and 2 mg/kg for these parameters.

To further illustrate this, the following table shows the number of sample results below the detection limit. Percentages shown in red identifies regions where more than half of the data points were below the detection limit at the time.

TABLE C - PERCENTAGE OF SAMPLES WITHIN THE REGIONAL BACKGROUND DATABASE WITH CONCENTRATIONS BELOW THE DETECTION LIMIT

Parameter	Region 1	Region 2	Metro Van	Region 3/8	Region 4	Region 5	Region 6	Region 7
Aluminum	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
Antimony	100.0	93.8	87.5	100.0	98.2	100.0	89.6	100.0
Arsenic	100.0	88.1	81.3	91.7	85.7	83.3	77.1	60.7
Barium	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
Beryllium	10.1	26.3	23.8	16.7	25.0	62.5	45.8	28.6
Boron	100.0	92.5	87.5	100.0	94.6	100.0	85.4	100.0
Cadmium	92.8	93.1	88.8	98.6	76.8	100.0	87.5	100.0
Calcium	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
Chromium	0.0	0.6	0.0	0.0	0.0	0.0	8.3	0.0
Cobalt	0.0	5.6	2.5	0.0	0.0	0.0	16.7	1.8
Copper	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
Iron	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
Lead	47.8	35.0	21.3	66.7	17.9	25.0	22.9	17.9
Magnesium	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
Manganese	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
Mercury	0.0	0.0	0.0	13.9	0.0	0.0	0.0	3.6
Molybdenum	98.6	71.3	67.5	81.9	85.7	95.8	68.8	64.3
Nickel	2.9	5.0	3.8	0.0	0.0	0.0	16.7	0.0
Selenium	100.0	95.0	90.0	100.0	98.2	100.0	89.6	100.0
Silver	100.0	95.0	90.0	100.0	98.2	100.0	89.6	100.0
Sodium	4.4	0.0	0.0	1.4	3.6	0.0	0.0	26.8
Strontium	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
Sulfur	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
Thallium	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
Tin	100.0	94.4	88.8	100.0	96.4	100.0	89.6	98.2
Vanadium	0.0	1.9	1.3	0.0	0.0	0.0	10.4	0.0
Zinc	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
Zirconium	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0

Based on this evaluation, discrepancies were found between the method described in Protocol 4 Footnote 1, Table 1 and the resulting regional background concentration presented. For the following metals, the number of samples with concentrations below the detection limit was higher than 50%, but the assumed regional background concentration was set higher than the detection limit:

- **Arsenic** in Regions 2, Metro Vancouver, 3/8, 5, 6 and 7.
- **Beryllium** in Region 5.
- **Cadmium** in Region 1.
- **Lead** in Region 3/8.
- **Molybdenum** in Regions 2, Metro Vancouver, 3/8, 6 and 7.

For these parameters, the methodology outlined in Protocol 4 suggests that the regional background concentration should have been one-half of the detection limit.

3.2.4 Protocol 4 Option 2 – Establishing Local Background Concentrations in Soil Based on Supplemental Data and Reference Sites

Option 2 outlined in Protocol 4 allows for estimating site-specific local background concentrations in soil using supplemental data, other than the Regional Background concentrations, by either:

- *Option 2a.* Augmenting Ministry background soil data relevant to the Site with additional data obtained from either literature or from in-situ background sampling at the site of interest.
- *Option 2b.* In-situ background soil sampling conducted at an appropriate (different) reference site, and relevant to the target Site.

Using either Option 2a or 2b requires the submission of a full report detailing the rationale and methodology used to determine the local background concentration.

For Option 2b, the reference site must be comparable to the target Site in terms of:

- Geographical setting (e.g. location, topography, etc.).
- Hydrological and hydrogeological setting.
- Soil physical/chemical characteristics (similar surficial geology class).
- Soil sampling depth within the geological unit.

Unaffected areas of the Site in question can also be considered as a reference site and are evaluated on a case-by-case basis.

3.2.5 Reporting Requirements

When using a reference site (i.e., Option 2), the following (minimum) information is required to be collected, documented and reported:

- Name and address of reference site owner.

- Current and historical land use of reference site and surrounding land uses.
- Potential sources of contamination (both natural and anthropogenic).
- Coordinates (latitude and longitude).
- A figure outlining the sample locations and the property boundary of the reference site.

The reporting requirements for a director's approval of local background concentrations in soils developed under Option 2 must include the submission of a Contaminated Sites Services Application From and a report with the following minimum requirements:

- Geographical location of the site that includes a description of the region in which it is located, or in the case of proposed soil relocation, additional information on the proposed soil receiving site.
- Selection of reference site(s), including the minimum reference site information (as outlined above).
- Sampling procedures, locations and soil sample depths.
- Analytical results.
- Demonstration that background data fall within a single statistical population and statistical analysis of the dataset using the 95th percentile.

3.3 ENV Applications for Background Metal Concentrations

To help determine which metals are frequently encountered during the site assessment and remediation process in BC that tend to require submission to ENV for pre-approval of elevated background concentrations (i.e., using Option 2a or 2b described above), a review of these submissions was completed.

3.3.1 Applications by Region

Records retained by CSAP Society and ENV were compiled and tallied to determine which metals parameters were most frequently being identified as elevated background and requiring ENV rulings to support pursuit of certifications. The applications were broken out by region and Metals parameter and are summarized in the Table and Figures below. Refer to appended Figures (Figure 1 through 10) for presentation of geographic locations.

TABLE D - ENV APPROVED BACKGROUND CONCENTRATIONS BY AREA AND PARAMETER

Parameter	Van Island	Lower Mainland	Metro Van	Thompson	Kootenay	Cariboo	Skeena	Omenica	Peace	Okanagan	Total
Arsenic	10	5	21	3	4	1	10	2	11	1	**68**
Aluminum	-	1	2	1	-	-	1	-	-	-	**5**
Barium	1	-	-	2	-	-	-	-	2	-	**5**
Cadmium	-	-	-	-	-	-	2	-	-	-	**2**
Chromium	4	-	1	4	-	-	-	-	-	-	**9**
Chloride	1	-	2	-	-	-	-	-	-	-	**3**
Cobalt	1	1	1	3	-	-	-	1	-	2	**9**
Copper	1	1	-	-	-	-	-	-	-	-	**2**
Iron	-	-	5	2	-	1	5	-	-	2	**15**
Lithium	2	-	-	1	1	-	-	-	-	-	**4**
Molybdenum	-	-	1	1	-	-	-	-	-	-	**2**
Nickel	1	-	-	3	-	-	-	-	-	-	**4**
Selenium	-	-	-	1	-	-	-	-	-	-	**1**
Sodium	-	-	1	-	-	-	-	-	-	-	**1**
Vanadium	1	1	2	3	-	-	2	-	-	-	**9**
Zinc	-	-	1	-	-	-	2	-	-	-	**3**
Total	**22**	**9**	**37**	**24**	**5**	**2**	**22**	**3**	**13**	**5**	**142**

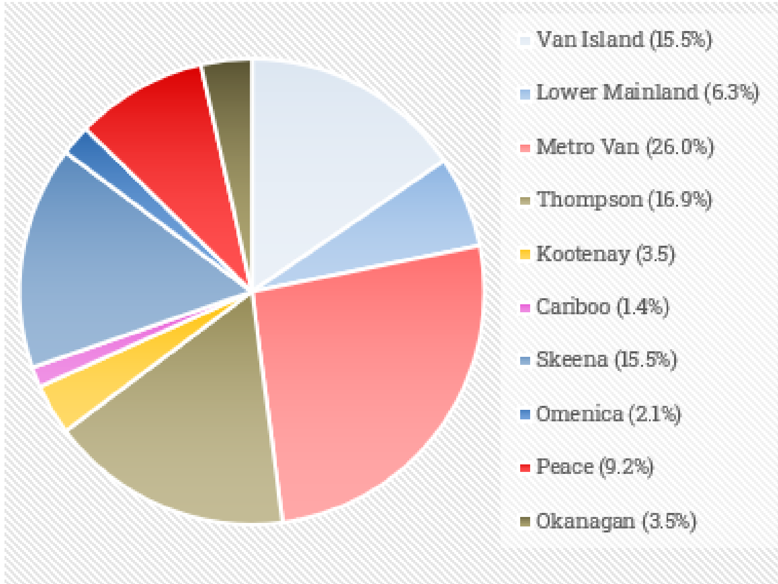

FIGURE D: SOIL BACKGROUND CONCENTRATION APPLICATIONS BY REGION.

The largest number of submissions by individual metal parameter were observed in the Metro Vancouver Region (with over 25% of the submissions noted in this area) followed by Thompson, Vancouver Island and the Skeena Region (each with over 15% of the submissions).

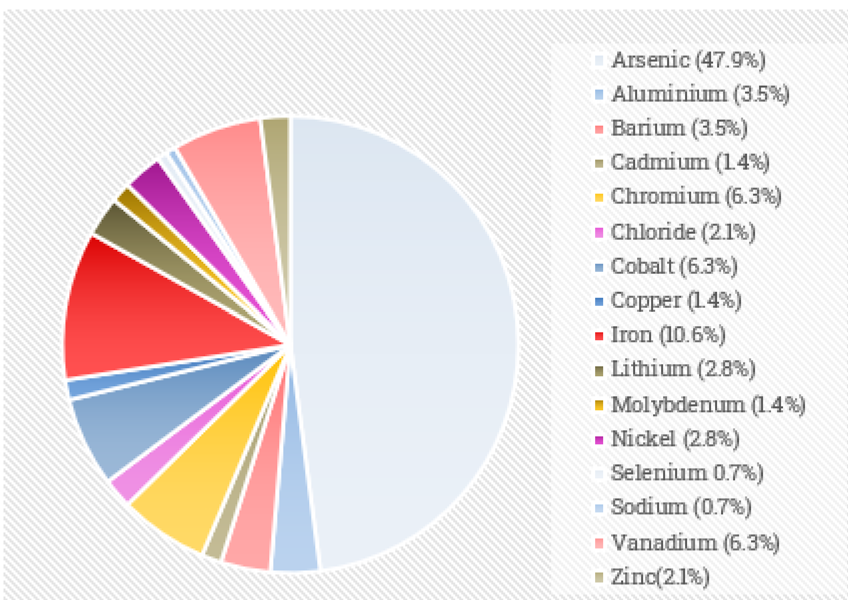

FIGURE E: SOIL BACKGROUND CONCENTRATION APPLICATIONS BY PARAMETER.

The most frequent metal parameter subject of background release was arsenic by a substantial margin. Specifically, 68 of a total 142 individual metal parameters was for arsenic representing just under 50% of the release requests. This was followed Iron (15 submissions or approximately 10% of total release requests) and chromium, cobalt and vanadium (each with 9 submissions or approximately 6%). Accordingly, arsenic, iron, chromium, cobalt and vanadium were identified as the most frequent metals warranting further review of their concentration ranges versus the established regional background values reported in Protocol 4.

3.3.2 Concentration Ranges by Region

For arsenic, iron, chromium, cobalt and vanadium, a further review was completed on the range of approved background concentrations by region. The following graphs illustrate the range of concentrations observed by region that were subject of ENV submissions related to establishing background concentrations under Option 2 of Protocol 4.

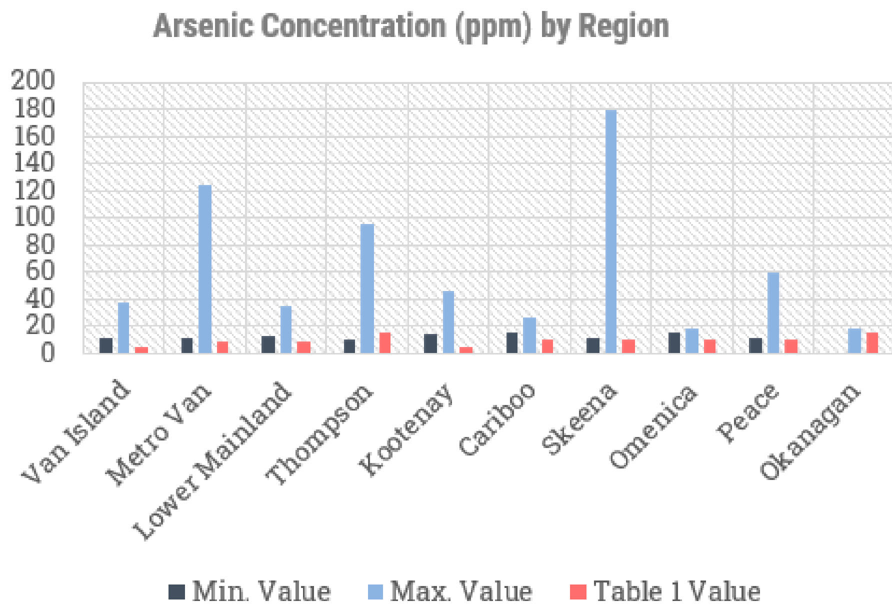

FIGURE F: BACKGROUND ARSENIC CONCENTRATIONS (PPM) BASED ON APPROVED ENV SUBMISSIONS BY REGION.

The highest approved background concentration was noted in the Skeena Region. Most approved background concentrations were less than 10 times the Protocol 4 - Table 1 value. Arsenic background approvals were issued for every region in BC.

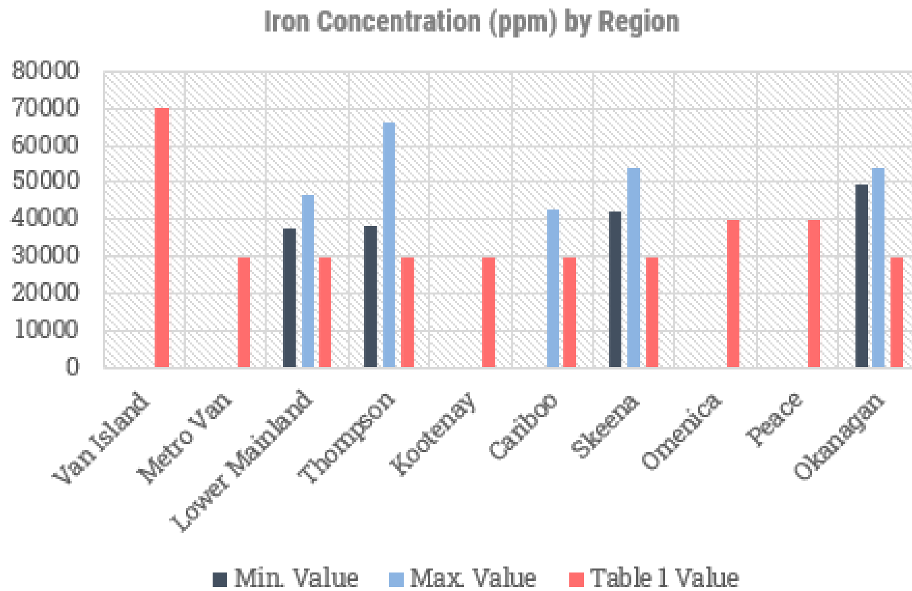

FIGURE G: BACKGROUND IRON CONCENTRATIONS (PPM) BASED ON APPROVED ENV SUBMISSIONS BY REGION.

The highest approved background concentration for iron was noted in the Thompson Region. The approved background concentrations were less than 2.5 times the Protocol 4 - Table 1 value. Iron background approvals were issued in 5 of the regions.

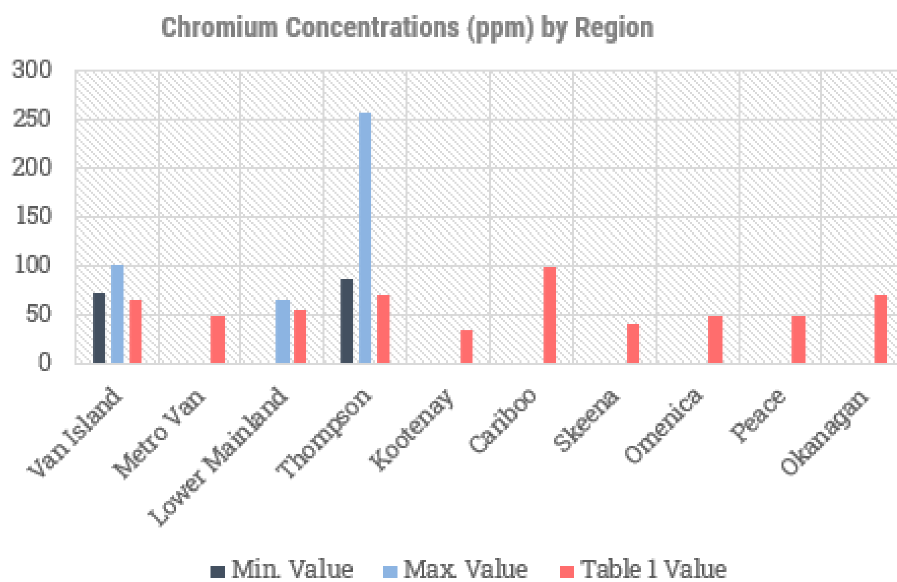

FIGURE H: BACKGROUND CHROMIUM CONCENTRATIONS (PPM) BASED ON APPROVED ENV SUBMISSIONS BY REGION.

The highest approved background concentration for chromium was noted in the Thompson Region. The majority of approved background concentrations were less than 5 times the Protocol 4 - Table 1 value. Chromium background approvals were noted in 3 of the regions.

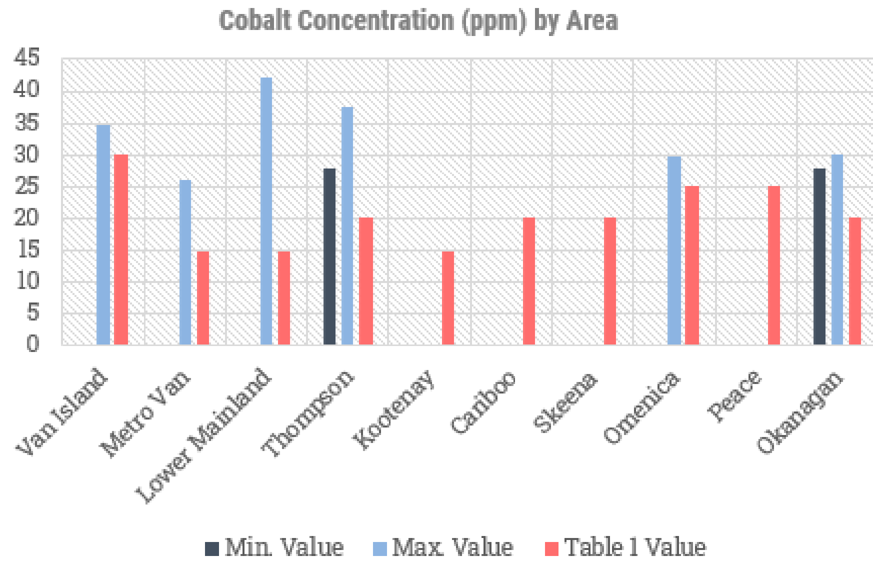

FIGURE I: BACKGROUND COBALT CONCENTRATIONS (PPM) BASED ON APPROVED ENV SUBMISSIONS BY REGION.

The highest approved background concentration for cobalt was noted in the Lower Mainland Region. The approved background concentrations were less than two (2) times the Table 1 value presented in Table 1. Cobalt background approvals were noted in 6 regions.

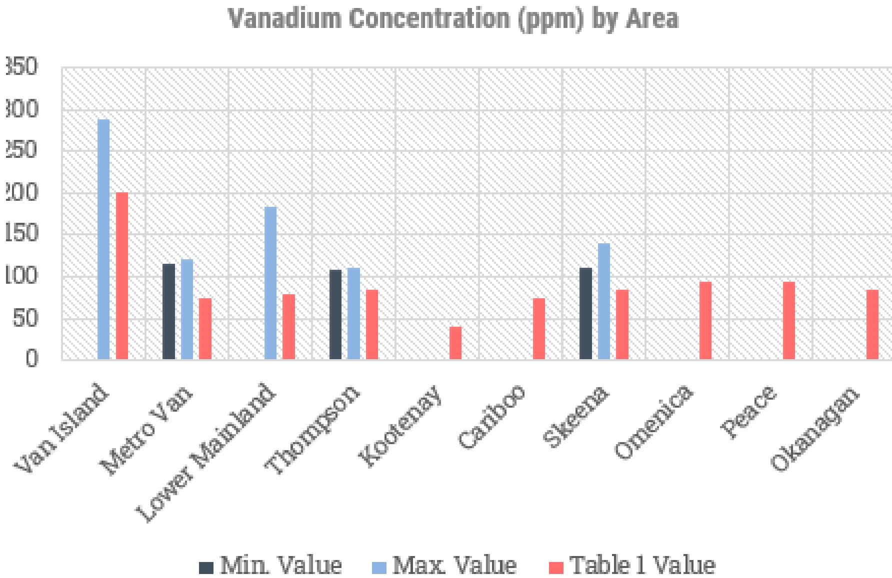

FIGURE J: BACKGROUND VANADIUM CONCENTRATIONS (PPM) BASED ON APPROVED ENV SUBMISSIONS BY REGION.

The highest approved background concentration of vanadium was noted in the Vancouver Island Region. The approved background concentrations were all less than 2 times the Protocol 4 - Table 1 value. Vanadium background approvals were issued in 5 of the regions.

There was limited information available from the ENV background approval documents to provide details on the soil stratigraphy and surficial geology present at the specific sites where the background releases were issued. This information is most likely available in the documents provided to ENV in support of establishing the site-specific background concentrations, however it was not provided for this review.

4 DISPOSAL AT SEA DATABASE

4.1 Advantages and limitations

A comprehensive database of metals parameter concentrations collected from Disposal at Sea (DAS) applications was made available for review. The data was collected and compiled by Active Earth in the Lower Mainland and Metro Vancouver regions and was used to conduct an in-depth study of parameter concentrations correlated to soil type and geology.

The DAS database provides a good proxy dataset for establishing natural background concentrations, as it is a reliable representation of natural and undisturbed soil in the region:

- DAS soil permits require material to be chemically inert, inorganic and undisturbed – no topsoil, peat, fill or previously excavated material is eligible.

- The database is a substantial size (over 1,400 samples).
- The suitability of soil for Disposal at Sea is determined through a sequential process. The first step in this process is to determine whether the soil is truly undisturbed (or for this purpose naturally occurring) through a desktop study. If the site makes it past this initial step, field investigations would be required to determine whether the site is suitable for DAS. Note that the DAS database includes sites which made it through the initial step, even if it was later determined after field investigations the soil did not meet the stringent Disposal at Sea screening criteria concentrations (Section 4.2).
- The DAS database also includes data from a variety of regions with different surficial geology classes.

Overall, DAS database is representative of chemically inert, inorganic and undisturbed soil in the Region 2 – Lower Mainland and Metro Vancouver regions.

Arguably one of the biggest limitations of the DAS database is that it does not contain any data from certain regions of Metro Vancouver and the Lower Mainland (i.e., Richmond, Delta, Tsawwassen, Coquitlam, etc.). Any elevated concentrations of select metals in these regions would therefore not be captured in the database. Soil from these regions typically doesn't meet DAS requirements, and accordingly very few attempts at applying DAS for soil management is carried out.

4.2 Disposal at Sea Screening Criteria

Soil samples are compared against Disposal at Sea screening criteria for certain metals and PAH parameters. For information purposes, the following Table E summarizes the DAS screening criteria for certain metals and compares them to the CSR standards for Residential Land Use (Low-density and High-Density), assuming both Drinking Water and Aquatic Life (Freshwater and Marine) standards apply.

Given the DAS screening criteria are typically more stringent than the CSR standards, this would likely have an influence on any regional background concentrations for arsenic, cadmium, chromium, copper, lead, mercury and zinc derived from the DAS database. Note however that the DAS database did include some higher concentration metals that exceeded DAS screening criteria concentrations, as the suitability for DAS is determined through a sequential process and the database includes data from sites that both met and did-not-meet the DAS requirements.

TABLE E - DAS SCREENING CRITERIA COMPARED TO CSR STANDARDS

Parameter	Disposal at Sea Screening Criteria (mg/kg)			CSR Standards (mg/kg)	
	CCME Marine ISQG Guidelines	CEPA			
		Disposal at Sea Screening Concentrations	Point Grey Background	Residential Low-Density	Residential High-Density
Arsenic (As)	7.24	-	-	10	10
Cadmium (Cd)[1)]	-	0.6	-	1 3 20 30	1 3 20 40
Chromium (Cr)	52.3	-	-	60	60
Copper (Cu)[1]	-	-	31.7	75 100 150	75 100 300
Lead (Pb)	30.2	-	-	120	120
Mercury (Hg)	-	0.75	-	10	25
Zinc (Zn)[1]	124	-	-	150 200	150 200

1. BC CSR standards that are dependent on soil pH – all potential CSR standards are provided.

4.3 DAS Database Compilation

The DAS database was compiled and updated to be current as of September 2024. The database consisted of over 1,400 samples, taken over approximately 140 distinct Site locations across the Lower Mainland Region. The Site locations are presented on the appended Figure 11.

Standard practice for submission of a DAS application involves the compilation of a standardized data package of the sample data and field measurements. The following parameters are included in the standard data package that were extracted for further use in the underlying study.

TABLE F - SUMMARY OF DAS DATA PACKAGE PARAMETERS

Parameter	Description
Site_Name	Site name or address
Field_Sample_ID	Sample ID from the sampling plan
Sample_Depth_To_m	Depth (m) from surface where the sample was collected, typically between 0.3 and 0.6m.

TABLE F - SUMMARY OF DAS DATA PACKAGE PARAMETERS

Parameter	Description
Latitude, Longitude	Latitude/Longitude in decimal degrees up to 5 decimal places
Datum	Geodetic datum (NAD83)
Gravel_Percent, Sand_Percent, Silt_Percent, Clay_Percent	Percentage of gravel, sand, silt and clay within the sample. Express as 0 to 100.
TOC_percent	Percentage of Total Organic Carbon
Metals concentrations	Metals concentrations for each CSR regulated metal in mg/kg

The information was extracted, compiled and stored in a single database in MS Excel. A thorough quality assessment was conducted to remove any locations without stored coordinates and/or missing metal parameter concentrations. The final table was imported into ArcGIS as a Points layer file.

The Surficial Geology Maps for Vancouver and the Lower Mailand (i.e., Maps 1486A and 1484A) were also imported into ArcGIS as a Shapefile and overlain by the DAS Points layer file. The surficial geology class was extracted for each sample location and added to the database as an additional column.

Based on the results of this analysis, the following surficial geology classes were determined to be represented within the DAS database:

TABLE G - SURFICIAL GEOLOGY CLASSES IN DAS DATABASE

Surficial Geology Classes		Surficial Geology Class Description	Number of Samples and Percentage of Total Sample Count
C	**Cb**	**Capilano Sediments** – Raised marine, deltaic and fluvial deposits; raised beach medium to coarse sand 1 to 5m thick.	181 (12.5%)
	Cd	**Capilano Sediments** – Raised marine, deltaic and fluvial deposits; marine and glaciomarine stony (including till-like deposits) to stoneless silt loam to clay loam with minor sand or silt, normally less than 3m thick but up to 10m thick in upland areas.	56 (3.9%)
PVa,c		**Pre-Vashon Deposits** – Pre-Vashon glacial, nonglacial and glaciomarine sediments; PVa – Quadra fluvial channel fill and floodplain deposits, crossbedded sand containing minor silt and gravel lenses and interbeds; PVc – Quadra marine interbedded fine sand to clayey silt believed to be offshore equivalents of PVa	34 (2.4%)
SA-C		**Postglacial and Pleistocene** – Maine shore and fluvial sand up to 8m thick.	116 (8.1%)
(P)T		**(Pre-) Tertiary Bedrock** – including sandstone, siltstone, shale, conglomerate, and minor volcanic rocks. Note that although the sample locations are positioned on top of mapped tertiary bedrock, the DAS soil likely consists of unconsolidated topsoil, potentially mixed in with weathered bedrock.	62 (4.3%)
VC	**VC**	**Vashon Drift and Capilano Sediments** – Glacial drift including lodgment and minor flow till, lenses and interbeds of substratified glaciofluvial sand to gravel, and lenses and interbeds of glaciolacustrine laminated stony silt. Up to 25m thick but in most places less than 8m thick; overlain by glaciomarine and marine deposits similar to Cd normally less than 3m but locally up to 10m thick.	229 (15.9%)
	VCa	**Vashon Drift and Capilano Sediments –** same as VC, but with bedrock less than 10m below surface.	110 (7.7%)
	VCb	**Vashon Drift and Capilano Sediments –** same as VC, but with bedrock more than 10m below surface.	651 (45.2%)

4.4 Statistical Review

Once the database was compiled and supplemented with the surficial geology information, a statistical review was undertaken. The first comparison involved deriving the regional background concentrations for soil parameters based on the DAS database and using the same methodology as for the background concentrations derived from the ENV database (i.e., as defined in Protocol 28), by calculating the 95th percentile of all samples within the region. Sample concentrations with values below the detection limit, were set equal to the detection limit for these calculations. As all DAS sample locations were situated within the extent of Region 2 – Lower Mainland and Metro Vancouver, these derived background concentrations can be compared to those concentrations presented in Table 1 of Protocol 4 for these regions.

The following table outlines the results of this analysis. The values in **bold** represent the derived Background Concentration based on the data in the DAS database and are compared to the Background concentrations of Region 2 – Lower Mainland and Metro Vancouver.

TABLE H - COMPARISON OF BACKGROUND CONCENTRATIONS DERIVED FROM THE DAS DATABASE TO CURRENT REGIONAL BACKGROUND CONCENTRATIONS

Parameter	Region 2 – Lower Mainland Background concentration (mg/kg)	Metro Vancouver Background concentration (mg/kg)	Number of samples in DAS Database	DAS Derived Background Concentration (95th percentile, in mg/kg)*
Aluminum (Al)	35,000	35,000	18	**15,400**
Antimony (Sb)	4	4	1347	**1**
Arsenic (As)	8.5	8.5	1388	**5**
Barium (Ba)	150	90	1347	**133**
Beryllium (Be)	0.7	0.7	1338	**1**
Boron (B)	1	1	38	**0.6**
Cadmium (Cd)	0.4	0.4	1365	**0.5**
Chromium (Cr)	55	50	1376	**30**
Cobalt (Co)	15	15	1347	**12**
Copper (Cu)	75	150	1415	**35**
Iron (Fe)	30,000	30,000	0	-
Lead (Pb)	200	300	1375	**6.1**
Manganese (Mn)	900	1,000	24	**419**
Mercury (Hg)	0.3	0.35	1348	**0.5**
Molybdenum (Mo)	4	6	1347	**0.6**
Nickel (Ni)	75	40	1347	**54**
Selenium (Se)	4	4	1347	**0.5**
Silver (Ag)	1	1	1347	**0.5**
Strontium (Sr)	60	55	544	**67**

TABLE H - COMPARISON OF BACKGROUND CONCENTRATIONS DERIVED FROM THE DAS DATABASE TO CURRENT REGIONAL BACKGROUND CONCENTRATIONS

Parameter	Region 2 – Lower Mainland Background concentration (mg/kg)	Metro Vancouver Background concentration (mg/kg)	Number of samples in DAS Database	DAS Derived Background Concentration (95th percentile, in mg/kg)*
Thallium (Tl)	-	-	1346	**0.5**
Tin (Sn)	4	4	1335	**0.5**
Vanadium (V)	80	75	1349	**71**
Zinc (Zn)	100	90	1373	**63**

* Values in red indicate the metals where the derived DAS Background Concentration is higher than the Background concentration for Region 2 and/or Metro Vancouver.

Based on these results the following observations were made:

- The DAS derived regional background concentrations are typically lower than those derived for Metro Vancouver and the Lower Mainland, with the exception of beryllium, cadmium, mercury, nickel and strontium.
- ENV did not derive regional background concentrations for thallium as no data was available. The derived background concentration for thallium based on the DAS database was determined to be 0.5 mg/kg.
- Iron is not a regulated parameter for Disposal at Sea, hence there is no DAS derived regional background concentration.
- The most frequent metals requiring approvals from ENV as noted earlier (i.e., arsenic, chromium, cobalt, iron and vanadium) have DAS derived screening criteria that are lower than the current standard.

4.5 Advantages and Limitations of the DAS Database

The DAS database is larger than the currently used regional background dataset for Region 2 – Lower Mainland, Metro Vancouver, and other regions. When using this database to support background evaluations there are few considerations and limitations to highlight:

- The database contains up to 1,415 analyses for metals – however aluminum has only 18 samples in the database and accordingly the DAS database may not be sufficient to derive aluminum background concentrations.
- Iron is not a regulated parameter for DAS permits, and accordingly no analyses were conducted for this parameter.
- The database contains data for sites that were approved for DAS, and sites which had metals exceeding one of more DAS screening criteria and were therefore not considered

suitable. The DAS screening criteria are generally more restrictive than the CSR standards for Residential Land Use (Low-density or High-Density).

- For metals where the regional background concentrations were largely based on values below the mean detection limit (arsenic, boron, beryllium, molybdenum, selenium, silver and tin), the DAS provides a more realistic background concentration based on the number of samples evaluated (>1,000 in most cases), the small percentage of samples below the laboratory detection limit, and the recentness of DAS collected samples.
- Although soil located at DAS sites should represent naturally undisturbed native soil, this does not mean that the sites are inherently undisturbed or undeveloped. Many DAS sites were historically used for residential or commercial purposes. When sites are being considered for DAS, the volume and extent of the soil that is suitable for DAS is determined.
- The locations for all DAS sites within the database are shown in Figure 11. Most Sites are located within the Metro Vancouver area, North Vancouver and Surrey. No DAS Sites are located in Richmond, Delta, Tsawwassen or Coquitlam. Sites that are located further away from the Vancouver Harbour are less likely be included in the DAS database as the transport costs of moving the soil will become too high. Furthermore, as part of the pre-screening process for suitability for DAS, soils from high clay content regions such as Richmond and Delta are likely to fail the DAS screening criteria, and clients are often dissuaded from pursuing a DAS option.
- The current DAS database is underrepresented for certain common surficial geology classes, predominantly Fraser Sediments (Fc) and SAb (bog, swamp and lake deposits) which are the dominant surficial geology classes in Richmond, Delta and Tsawwassen. This is another indication that some metals such as arsenic in Richmond, are likely underrepresented in the database. If these types of sediments are naturally enriched in arsenic, this would not be captured in the DAS database or the original dataset used to derive the regional background concentrations. More data collection from these regions would be required, and/or determination whether this area should be considered as a separate region based on an assessed arsenic regional background footprint.

4.6 Surficial Geology Class and Grain Size Considerations

Further assessment of the DAS database was done to determine whether the metals concentrations were elevated among different surficial geology classes and whether the grain size has an influence on metals concentrations in the soil.

The following figures shows the concentration of chromium in soil samples taken from the DAS database and plotted based on their weight percentage of clay (top-left), silt (top-right), sand (lower-left) and gravel content (lower-right). The linear correlation lines across the plots show that chromium concentrations are elevated in samples with relatively high clay and silt content and lower gravel and sand content (i.e., finer grained soils). The same plots for the other frequent metals of concern (i.e., arsenic, cobalt and vanadium) are attached in Appendix A and show similar correlations.

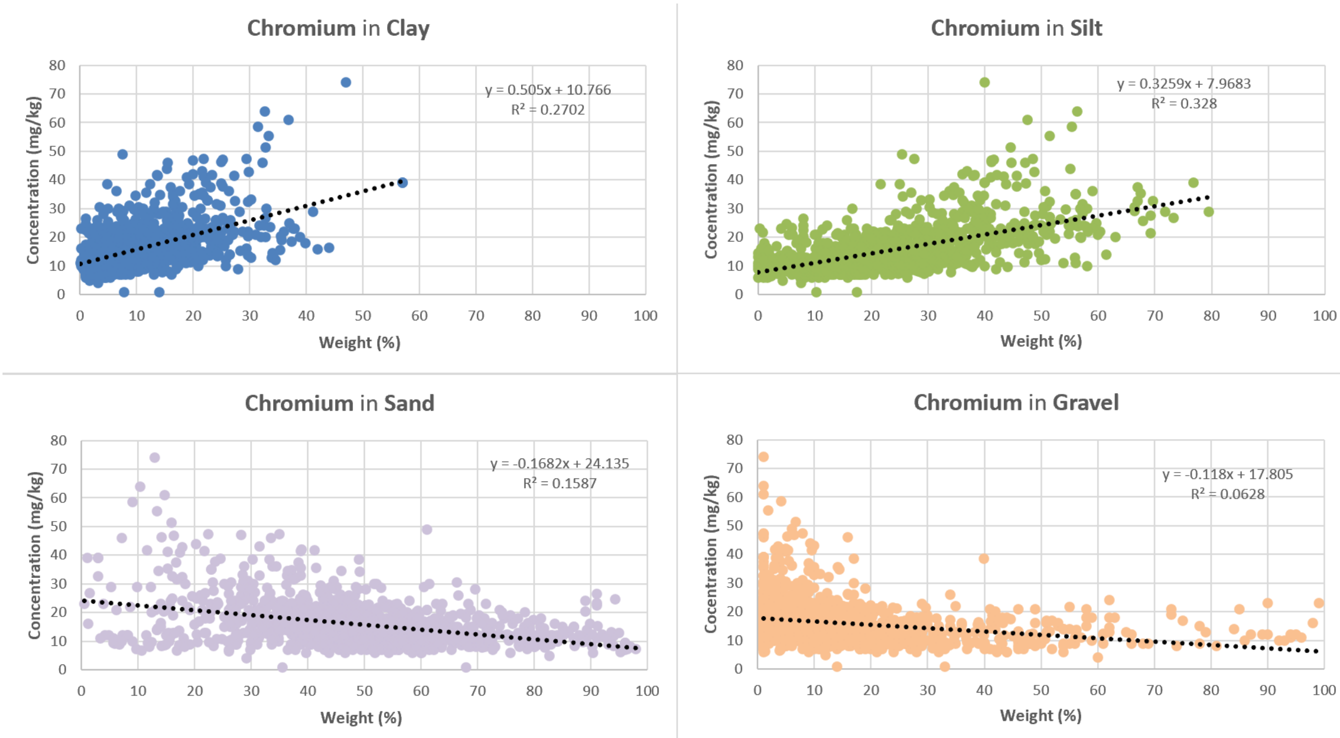

FIGURE K: CHROMIUM CONCENTRATIONS (MG/KG) BASED ON THE SAMPLE GRAINSIZE (WEIGHT PERCENTAGE CLAY, SILT, SAND AND GRAVEL).

The figure below presents box plots of the distribution of gravel, sand, silt and clay content for the various surficial geology classes (marked by colour). The following correlations were noted:

- Capilano Sediments (Cb and Cd) show the overall highest clay content of all surficial geology classes. Pre-Vashon deposits (PVa,c) show the lowest clay content of all classes. The inverse would be true for the Vashon Drift and Capilano Sediment classes (VC, VCa and VCb), which show the lowest weight percentages for gravel. This is attributed mostly to the Capilano Sediments as class Cb also shows low gravel content.
- Samples collected from regions with mapped Tertiary bedrock (T) were found to be the most coarse overall, with the highest gravel and sand content and the lowest silt content of all classes.
- Class VCa is the most well sorted and uniform surficial geology class as the average weight percentage of sand is the highest among all classes and all other grain size groups show relatively low content.

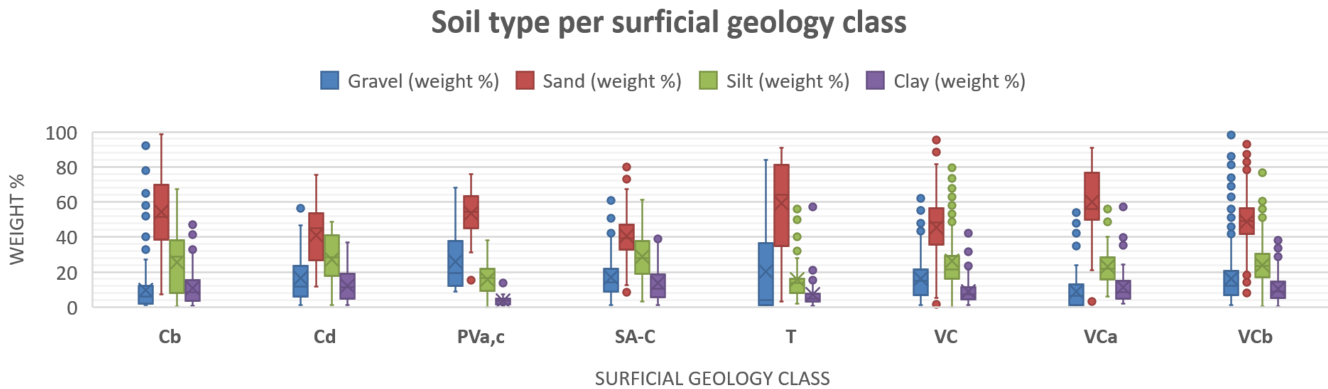

FIGURE L: BOX PLOTS OF DISTRIBUTIONS OF WEIGHT PERCENTAGES OF GRAIN SIZE CONTENT PER SURFICIAL GEOLOGY CLASS AMONG ALL SAMPLES IN THE DAS DATABASE. THE DOTS REPRESENT OUTLIERS WHICH REPRESENT VALUES HIGHER THAN THE QUARTILE 3 + 1.5X INTERQUARTILE RANGE AND LOWER THAN THE QUARTILE – 1.5X INTERQUARTILE RANGE.

The final comparison conducted for this assessment was to determine the distribution of each metal within each of the surficial geology classes. The following figure shows the distribution of four of the metals that were flagged by ENV in all off the surficial geology classes. The boxplots for all metals are attached in Appendix B. The horizontal dashed line is the current Metro Vancouver background concentration for each metal. The background concentrations for these metals are almost the same as for Region 2. The following observations were made:

- Capilano Sediments are found to be enriched in arsenic, chromium and vanadium, relative to other classes. Based on the results approximately 12% of the samples exceed the current Background concentration for arsenic, 10% exceed the current standard for chromium and 25% exceed the current standard for vanadium.
- A significant number of samples from Tertiary bedrock (T) and Vashon Drift and CapilanoSediments (VC) also exceed the current standard for vanadium (both around 12%).
- Tertiary bedrock (T) and Capilano Sediments (Cb) seem to be enriched in cobalt, while Vashon Drift (VC) sediments seem to have lower cobalt concentrations. The regions where these surficial geology classes are mapped are predominantly Surrey (Cb) and the largerMetro Vancouver areas (VC and T).

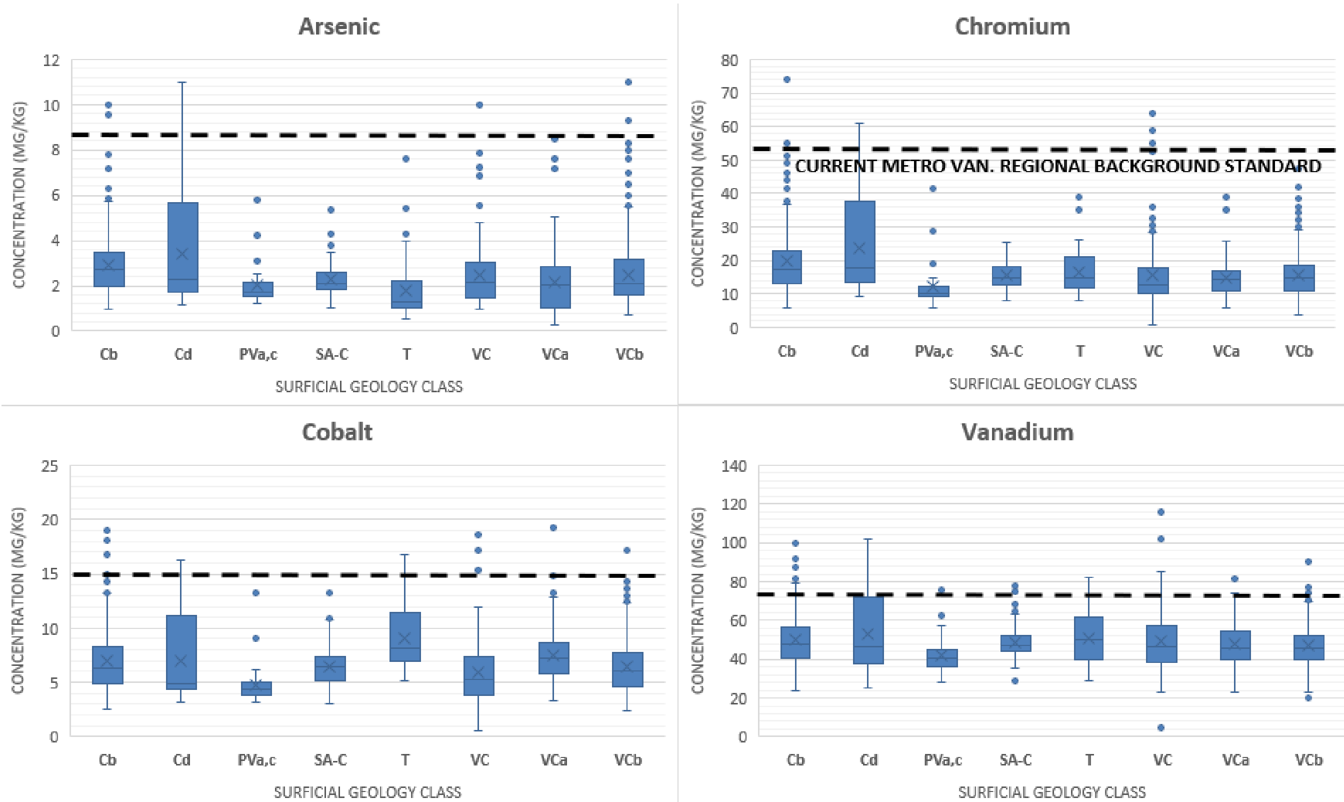

FIGURE M: BOX PLOTS OF DISTRIBUTIONS OF CONCENTRATIONS OF ARSENIC, CHROMIUM, COBALT AND VANADIUM FROM ALL SAMPLES IN THE DAS DATABASE, SEPARATED BY SURFICIAL GEOLOGY CLASS. DOTS ON THE FIGURES INDICATE OUTLIERS. THE HORIZONTAL DASHED LINES INDICATE THE CURRENTLY APPLICABLE BACKGROUND CONCENTRATION FOR THE PARAMETER IN METRO VANCOUVER AND REGION 2.

4.7 Derived Background Concentrations per Surficial Geology Class

As the DAS database covers an area with a variety of surficial geology classes within Region 2 – Lower Mainland and Metro Vancouver, current Protocol 4 methodology (see Section 3.2) can be applied to the DAS database for each surficial geology class to estimate regional background concentrations for each class ("Surficial Geological Background Concentrations"). For this purpose, we excluded some metals which had very few analytical test results in general (e.g., aluminum, boron etc) or from specific surficial geology classes (PT and PVa,c). In addition, in order to obtain sufficient data to make a statistically robust estimate, surficial geology sub-classes were aggregated to their dominant class. This resulted in four major surficial geology classes that cover the large areas of the Lower-Mainland:

- Vashon Drift and Capilano Sediments – **VC**: contains data from (sub-)classes VC, VCa and VCb.
- Capilano Sediments – **C**: contains data from (sub-)classes Ca, Cb and Cd.

- Salish Sediments – **SA**: contains data from (sub-)classes SAa, SA-C, SAh and Sai.
- Tertiary Bedrock – **T.**

The surficial geology classes were considered to have sufficient sample sizes for establishing robust regional background concentrations based on the Protocol 4 methodology. The results are outlined in Table I and compared to the Region 2 – Lower Mainland and Metro Vancouver background concentrations. Based on the results, the following observations were made:

- Surficial Geology Background Concentrations for barium, cadmium, mercury, strontium and vanadium are higher than the Region 2 and/or Metro Vancouver Regional Background concentrations for those metals.
- Background concentrations for arsenic in Capilano Sediments are 68% higher than the background concentration for arsenic in Salish sediments and 48% higher than background concentration for arsenic in Tertiary bedrock.
- Background concentrations for chromium in Capilano Sediments are up to 100% higher than the background concentration for chromium in Salish sediments, Vashon Drift and Capilano sediments and tertiary bedrock.
- Background concentrations for molybdenum are highest in Salish sediments and Tertiary bedrock.

Overall, the results show that there are significant variations in individual metal 95th Percentile concentrations per surficial geology class.

TABLE I – SURFICIAL GEOLOGICAL 95TH PERCENTILE BACKGROUND CONCENTRATIONS

Parameter	Region 2 – Lower Mainland Background Concentration (mg/kg)	Metro Vancouver Background Concentration (mg/kg)	Vashon Drift and Capilano Sediments – VC (VC, VCa and VCb)	Capilano Sediments – C (Ca, Cb and Cd)	Salish Sediments –SA (SAa, SA-C, SAh, SAi)	Tertiary Bedrock - T
			942 samples	225 samples	152 samples	62 samples
Antimony (Sb)	4	4	0.5	0.5	0.5	0.5
Arsenic (As)	8.5	8.5	4.7	6.4	3.8	4.3
Barium (Ba)	150	90	137.2	128.7	114.2	115.8
Beryllium (Be)	0.7	0.7	0.5	0.5	0.5	0.5
Cadmium (Cd)	0.4	0.4	0.5	0.2	0.5	0.2
Chromium (Cr)	55	50	28.2	46.1	23	26.1
Cobalt (Co)	15	15	11.1	13.1	10.7	14.7
Copper (Cu)	75	150	34.1	37.4	28.4	34.9

TABLE I – SURFICIAL GEOLOGICAL BACKGROUND CONCENTRATIONS

Parameter	Region 2 – Lower Mainland Background concentration (mg/kg)	Metro Vancouver Background concentration (mg/kg)	Vashon Drift and Capilano Sediments – VC (VC, VCa and VCb)	Capilano Sediments – C (Ca, Cb and Cd)	Salish sediments – SA (SAa, SA-C, SAh, SAi)	Tertiary Bedrock - T
			942 samples	225 samples	152 samples	62 samples
Lead (Pb)	200	300	6.1	5.3	6.1	8.8
Mercury (Hg)	0.3	0.35	0.5	0.04	0.5	0.03
Molybdenum (Mo)	4	6	0.5	0.6	1.1	2
Nickel (Ni)	75	40	20.7	32.3	16.9	20.8
Selenium (Se)	4	4	0.5	0.5	0.5	0.5
Silver (Ag)	1	1	0.5	0.5	0.5	0.5
Strontium (Sr)	60	55	69.7	68.5	55.6	44.1
Thallium (Tl)	-	-	0.5	0.5	0.5	0.5
Tin (Sn)	4	4	0.5	0.04	0.5	0.03
Vanadium (V)	80	75	70	79.7	66.6	71.2
Zinc (Zn)	100	90	60	60	71	79.2

* Values in red indicate the metals with derived DAS background concentrations higher than the regional background concentrations for Region 2 – Lower Mainland and/or Metro Vancouver.

5 DISCUSSION AND RECOMMENDATIONS

The current BC CSR Protocol 4 - Table 1 values used in background assessments are based on a relatively small database with a large percentage of data points for some parameters that were non detect. Arsenic, cobalt, chromium, iron and vanadium are the most frequent parameters subject to submission to ENV for background approval under Option 2 of Protocol 4 with significant ranges on concentrations.

Based on the review of comprehensive studies from other jurisdictions that have been completed over the last 20 years, the following key considerations have been identified:

- As more recent data is acquired, updating the databases used to evaluate background concentrations should be considered as these new robust datasets provide more realistic estimates of background conditions.
- Evaluating specific background values for various regions is valuable as it recognizes differences in geology, soil type, climate and vegetation that can all affect naturally occurring concentrations.

- Updating of the databases used to evaluate background concentrations should consider:
    a. Spatial coverage in each region to ensure an even distribution of datapoints, such that specific areas are not overrepresented or clustered.
    b. Surficial geology in the development of regional background concentration boundaries.
    c. Grain size, soil type and soil horizon information where available should be documented.
    d. Use of 95% UPL statistical values as potential alternatives for the representative background value to account for future predicted values based on a level of confidence.
- Finer soils such as clays, weathered soils and sediment contribute to elevated background concentrations (particularly arsenic). Accordingly, Al_2O_3 concentrations in soil can be used as a proxy of clay content and be considered and factored into developing allowable background concentrations.
- The DAS database in Region 2 – Lower Mainland and Metro Vancouver covers six distinct surficial geology classes ranging from Tertiary Bedrock to Glacio-fluvial deposits. One common factor among all the analyzed DAS samples was that the metal concentrations were higher in samples with higher weight percentages of silt and clay, and lower in samples with higher weight percentages of sand and gravel. Regional "Surficial Geological Background Concentrations" were established for four major surficial geology classes and results showed variations in concentrations per major surficial geology class.
- Not all major surficial geology classes were represented in the DAS database. For example, there are currently no samples from the Fraser Sediments (Fc) and SAb (bog, swamp and lake deposits) sediment classes. If elevated arsenic concentrations were present in these classes, it would not be identified in either the DAS database or ENV's Protocol 4 regional background database.
- More data means a more statistically robust database, with a lower probability of statistical outliers skewing results.
- For certain parameters in the ENV Protocol 4 regional background database, metals concentrations in soil are predominantly based on non-detectable values which were sampled and measured over 30 years ago. Detection limits for some parameters have significantly improved (e.g., arsenic detection limits were 8 mg/kg in the ENV Protocol 4 database, compared to 1 mg/kg currently), allowing for lower and more precise estimations.

The following changes to Protocol 4 may be considered in future revisions to improve the approach for establishing background concentrations:

- Evaluation of the current regional boundaries in terms of geology / surficial geology classes. Consider using proxy compounds for estimating clay content and linking background concentrations to these estimates.
- Compile background concentration data from current ENV submissions in problematic areas where P4 submissions are common (e.g., arsenic concentrations in Richmond).

- Augment the datasets used for regional background estimations with current ENV submissions and/or other sources (BCER, Federal Government) – and consider grain size, surficial geology subregions, etc.
- Add parameters and observations such as grain size, soil type and regional geology to the requirements for ENV Protocol 4 local background submissions to build datasets with this information.
- Consider establishing subregions within existing regional boundaries to recognize areas enriched with specific metal parameters (e.g., arsenic concentrations in Richmond).

6 PROFESSIONAL STATEMENT & QUALIFICATIONS

The key persons involved in this assessment have demonstrable experience in the field of contaminated sites implementing the requirements under EMA, CSR and associated protocols and technical guidance. The major participants in this assessment included:

- Thomas Boerman, M.Sc., M.ASC. Mr. Boerman has more than 4 years of experience conducting hydrogeological studies, environmental site investigations and advanced statistical analysis in BC and under the BC EMA and CSR regulatory regime. Thomas undertook the statistical analyses and was the primary report author.
- Meredith Guest, P.Eng., CSAP. Ms. Guest has more than 25 years of experience conducting environmental site investigations and reporting under the BC EMA and CSR regulatory regime. Meredith provided senior project management and contributed to report content and review.
- David Kettlewell, P.Geo., CSAP. Mr. Kettlewell has almost 30 years of experience conducting environmental site investigations and reporting under the BC EMA and CSR regulatory regime. David provided senior project support and report review.

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LIST OF ACRONYMS

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LIST OF ACRONYMS

AEC	Area of Environmental Concern
AiP	Approval in Principle
AL	Agricultural Land Use Standards (CSR), or Agricultural Guidelines/Standards (CCME CSQG or CWS)
APEC	Area of Potential Environmental Concern
AST	Above Ground Storage Tank
AWfw/m	Aquatic Life Standards (CSR) (fw – freshwater, m – marine)
BCWQG	British Columbia Water Quality Guidelines
BTEXS	Benzene, Toluene, Ethylbenzene, Xylenes, and Styrene
CCME	Canadian Council of Ministers of the Environment
CL	Commercial Land Use Standards (CSR), or Commercial Guidelines/Standards (CCME CSQG or CWS)
CoC	Certificate of Compliance
COC	Contaminant of Concern
CSM	Conceptual Site Model
CSQG	Canadian Soil Quality Guidelines (CCME)
CSR	Contaminated Sites Regulation
CWS	Canada Wide Standards (CCME)
DSI	Detailed Site Investigation
DW	Drinking Water Standards (CSR)
ENV	BC Ministry of Environment & Climate Change Strategy
EPHw	Extractable Petroleum Hydrocarbons (w – water)
ESA	Environmental Site Assessment
GCDWQ	Guidelines for Canadian Drinking Water Quality
HBM	Hazardous Building Materials
HDPE	High-Density Polyethylene
HEPHs	Heavy Extractable Petroleum Hydrocarbons (s – soil)
HWR	BC Hazardous Waste Regulation
IL	Industrial Land Use Standards (CSR), or Industrial Guidelines/Standards (CCME CSQG or CWS)
IW	Irrigation Water Standards (CSR)
LEPHs/w	Light Extractable Petroleum Hydrocarbons (s – soil, w – water)
LW	Livestock Watering Standards (CSR)
MDL	Method Detection Limit
MTBE	Methyl Tertiary Butyl Ether (also referred to as Methyl Tert-Butyl Ether)
NIR	Notification of Independent Remediation
PAH	Polycyclic Aromatic Hydrocarbons
PCB	Polychlorinated Biphenyl
PCOC	Potential Contaminant of Concern
PERC	Tetrachloroethylene
Phase I	Phase I Environmental Site Assessment
Phase II	Phase II Environmental Site Assessment
PL	Urban Park Land Use Standards (CSR), or Parkland Guidelines/Standards (CCME CSQG or CWS)
PSI	Preliminary Site Investigation
RL	Residential Guidelines/Standards (CCME CSQG or CWS)
RLld	Residential Low-Density Land Use Standards (CSR)
RLhd	Residential High-Density Land Use Standards (CSR)
Stage 1	Stage 1 Preliminary Site Investigation
Stage 2	Stage 2 Preliminary Site Investigation
TCE	Trichloroethylene
VOC	Volatile Organic Compounds
VHw	Volatile Hydrocarbons (w – water)
VPHs/w/v	Volatile Petroleum Hydrocarbons (s – soil, w – water, v – vapour)
UST	Underground Storage Tank
WLn	Wildlands Natural Land Use Standards (CSR)
WLr	Wildlands Reverted Land Use Standards (CSR)
WTN	Well Tag Number

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FIGURES

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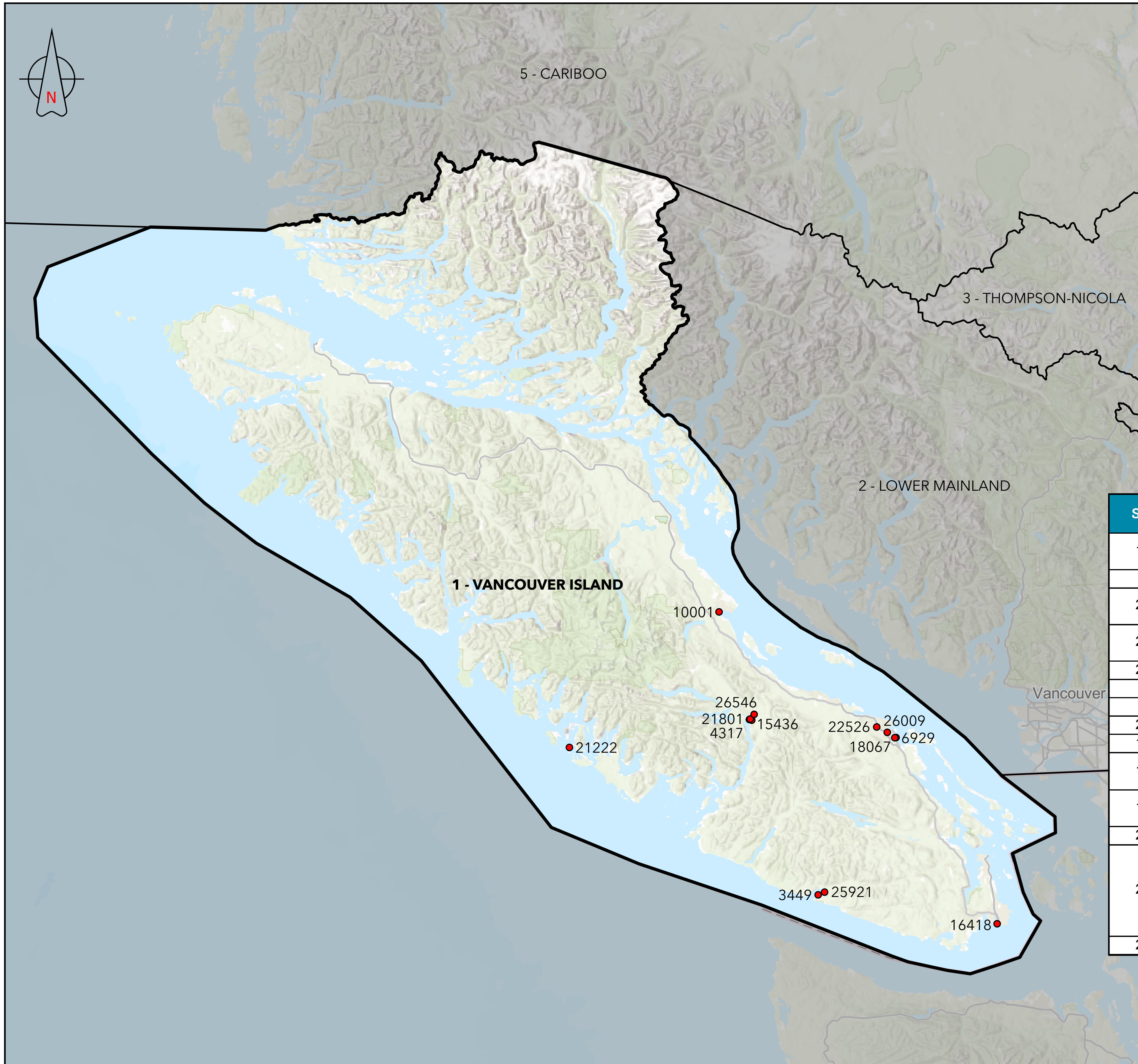
CLIENT NAME:	PROJECT LOCATION:
C.S.A.P. SOCIETY	BC

REGIONAL BACKGROUND APPROVED SITES
BC WIDE OVERVIEW

DWN BY: LT	DWG NAME: FIG1	DATE: 2024-11-28	FIGURE 1
CHK'D: MG	PLOT: 11x17	GISFILE: 3935	

REFERENCE: B.C. DATA CATALOGUE, ESRI WORLD TOPOGRAPHIC - CANADIAN STYLE



LEGEND

- REGIONAL BACKGROUND APPROVED SITE
- APPROXIMATE PROVINCIAL REGION BOUNDARY

Site ID	Location	Parameters	Background Concentration Amounts (mg/kg)
15436	4233 Redford Street, Port Alberni, BC	Arsenic	37.08
		Chromium	97.83
4317	4000 Stamp Avenue, Port Alberni, BC	Arsenic	17.9
21801	4820 Wallace Street, Port Alberni, BC	Arsenic	15.4
		Chromium	101
22526	3945 Biggs Road, Nanaimo, BC	Arsenic	22
		Lithium	51
26009	1950 Island Diesel Way, Nanaimo, BC	Arsenic	16.82
6929	477 Terminal Avenue, Nanaimo, BC	Arsenic	21.2
3449	17290 Parkinson Road, Port Renfrew, BC	Arsenic	33.7
25921	16706 Parkinson Road, Port Renfrew, BC	Lithium	38.8
16418	537 Superior Street, Victoria, BC	Chloride	289
18067	350 Prideaux Street, Nanaimo, BC	Chromium	Sandy Silt/Clay: 85.91 Sand and Gravel 71.4
10001	2751 Cliffe Avenue, Driftwood Mall, Courtenay, BC	Arsenic	18.3
		Barium	503
21222	797 & 819 Campbell Street, Tofino, BC	Arsenic	11.7
22866	2454 Powerhouse Road, Courtenay, BC	Chromium	76.1
		Cobalt	34.8
		Copper	147
		Nickel	78.5
		Vanadium	287
26546	3355 Johnston Road, Port Alberni, BC	Arsenic	16.2

0 25 50 100
1:2,000,000 Kilometers

REFERENCE: B.C. DATA CATALOGUE, ESRI WORLD TOPOGRAPHIC - CANADIAN STYLE

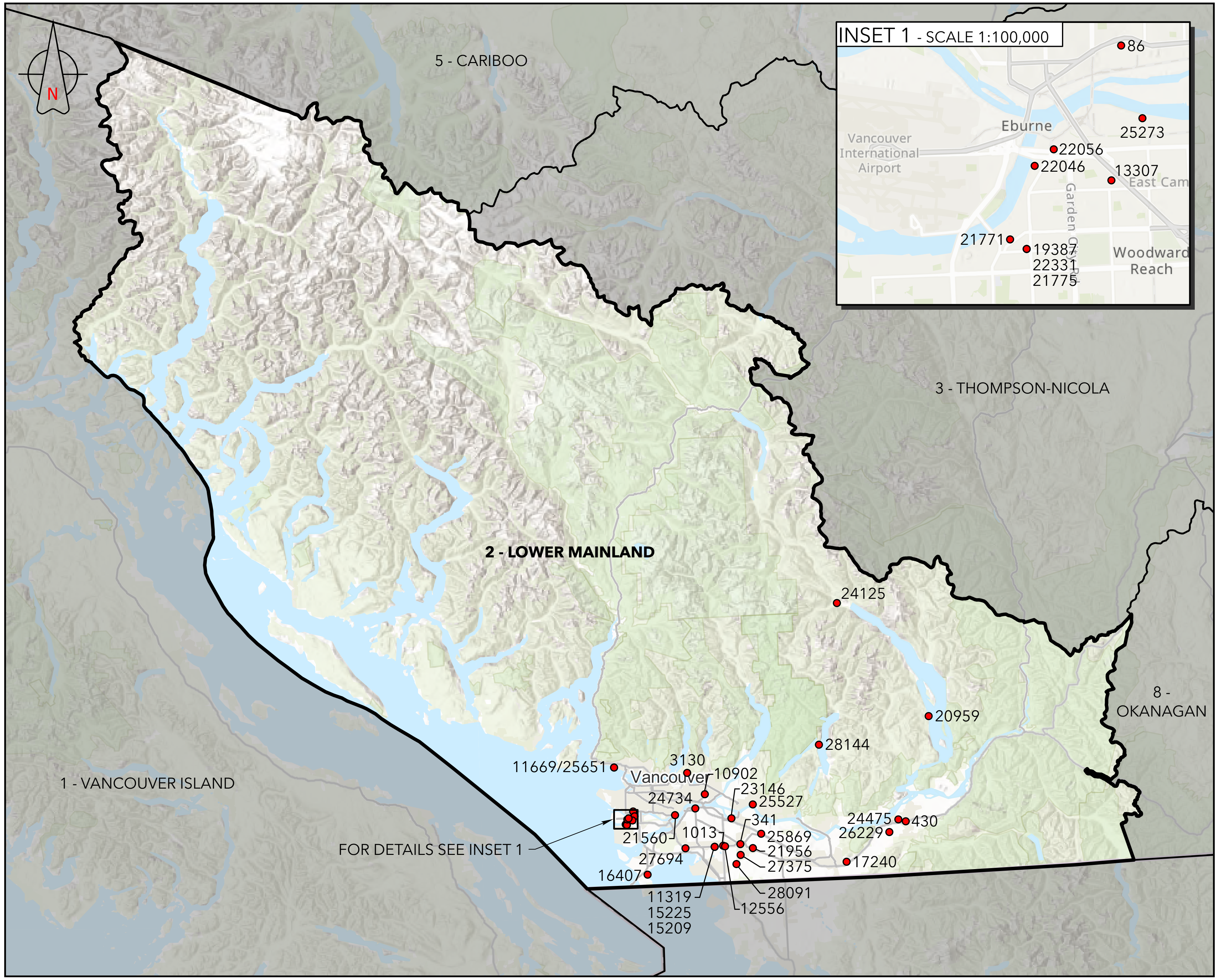
ACTIVE EARTH

CLIENT NAME: C.S.A.P. SOCIETY

PROJECT LOCATION: BC

REGIONAL BACKGROUND APPROVED SITES
VANCOUVER ISLAND

DWN BY: LT	DWG NAME: FIG2	DATE: 2024-11-28	FIGURE 2
CHK'D: MG	PLOT: 11x17	GISFILE: 3935	



Site ID	Location	Parameters	Background Concentration Amounts (mg/kg)	Surficial Geology Category
11669/25651	2452-2496 Marine Drive, West Vancouver, BC	Arsenic	21.4	T
3130	Ioco East U4 Area, Port Moody, BC	Arsenic	125	VC
86	8188 & 8232 Manitoba Street, Vancouver, BC	Arsenic	19	Fc
25273	10611 River Drive, Richmond, BC	Arsenic	15.5	SAc
13307	3640 No. 4 Road, Richmond, BC	Arsenic	13.07	SAc
21771	7811 & 7791 Alderbridge Way, Richmond, BC	Arsenic	20	Fc
19387	5651 No. 3 Road, Richmond, BC	Arsenic	11.89	Fc
22331				
21775				
16407	6005 Highway 17a, Delta, BC	Arsenic	14.8	SAf
21560	201 Duncan Street, New Westminster, BC	Arsenic	12.5	SAc
		Chromium	65.3	
24734	136 Street and 115 Avenue, Surrey, BC	Arsenic	50.8	SAb
		Molybdenum	34.1	
23146	9779 190th Street, Surrey, BC	Arsenic	14.3	Se
15225	16069, 16277, & 16327 Highway 10, Surrey, BC	Sodium (Na+)	449.8	SAb
15209		Chloride (Cl-)	512.8	
11319	16069 Highway 10, Surrey, BC	2,4-dimethylphenol	0.02	
		o-cresol	0.23	
		m-cresol	0.14	
		p-cresol	0.24	
		total cresol	0.4	
		phenol	0.1	
1013	17546 57th Avenue, Surrey, BC	Arsenic	17.7	Ce
12556	17824 56th Avenue, Surrey, BC	Arsenic	17.2	Ce
24475	44394 Progress Way, Chilliwack, BC	Arsenic	14.8	-
430	45456 Yale Road, Chilliwack, BC	Arsenic	12.89	-
20959	Ten Mile Bay, Harrison, BC	Arsenic	23	-
24125	Upper Harrison Terminal, Harrison, BC	Arsenic	14	-
17240	2310 Whatcom Road, Abbotsford, BC	Arsenic	35	Sf
21956	22051 Fraser Highway, Langley, BC	Iron	44,400	FLc
10902	2601 Lougheed Highway, Riverview Hospital, Coquitlam, BC	Arsenic	12.9	VC
		Aluminum	43,600	
		Iron	37,920	
25869	Stretch of Highway 1 from Approx 216th Street to 250m east of 256th Street, Langley, BC	Arsenic	16.2	FLd
		Vanadium	120	
26229	42952 Sumas Road, Chilliwack, BC	Arsenic	Clay unit: 15.3 Sand/silt unit: 13.3	Fg
27375	22710 201A Street, Langley, BC	Iron	46,880	Se
22046	8091 Capstan Way, Richmond, BC	Arsenic	18	Fc
341	5769 201A Street, Langley, BC	Chloride	210	Ce
25527	22311 North Avenue, Maple Ridge, BC	Aluminum	39,675	FLc
		Arsenic	11.57	
		Cobalt	26.03	
		Iron	53,225	
		Vanadium	116.5	
27694	11911 Ladner Trunk Road, Delta, BC	Arsenic in Peat	36.5	SAb
		Arsenic in Silt	26.4	
		Iron in Silt	39,300	
28144	Portion of Alouette-Stave Hydroelectric Generating Station, Stave Lake, BC	Aluminum	41,975	-
		Copper	161	-
28091	19455 28th Avenue, Surrey, BC	Arsenic	14.09	Se
22056	2840, 2880, 2920, and 2980 No 3 Road, 2811, 2831, 2851, 2891, 2951, and 2971 Sexsmith Road, Richmond, BC	Arsenic	18.6	Fc
		Zinc	173.3	

LEGEND

- REGIONAL BACKGROUND APPROVED SITE
- APPROXIMATE PROVINCIAL REGION BOUNDARY

1:1,500,000 — 0 20 40 80 Kilometers

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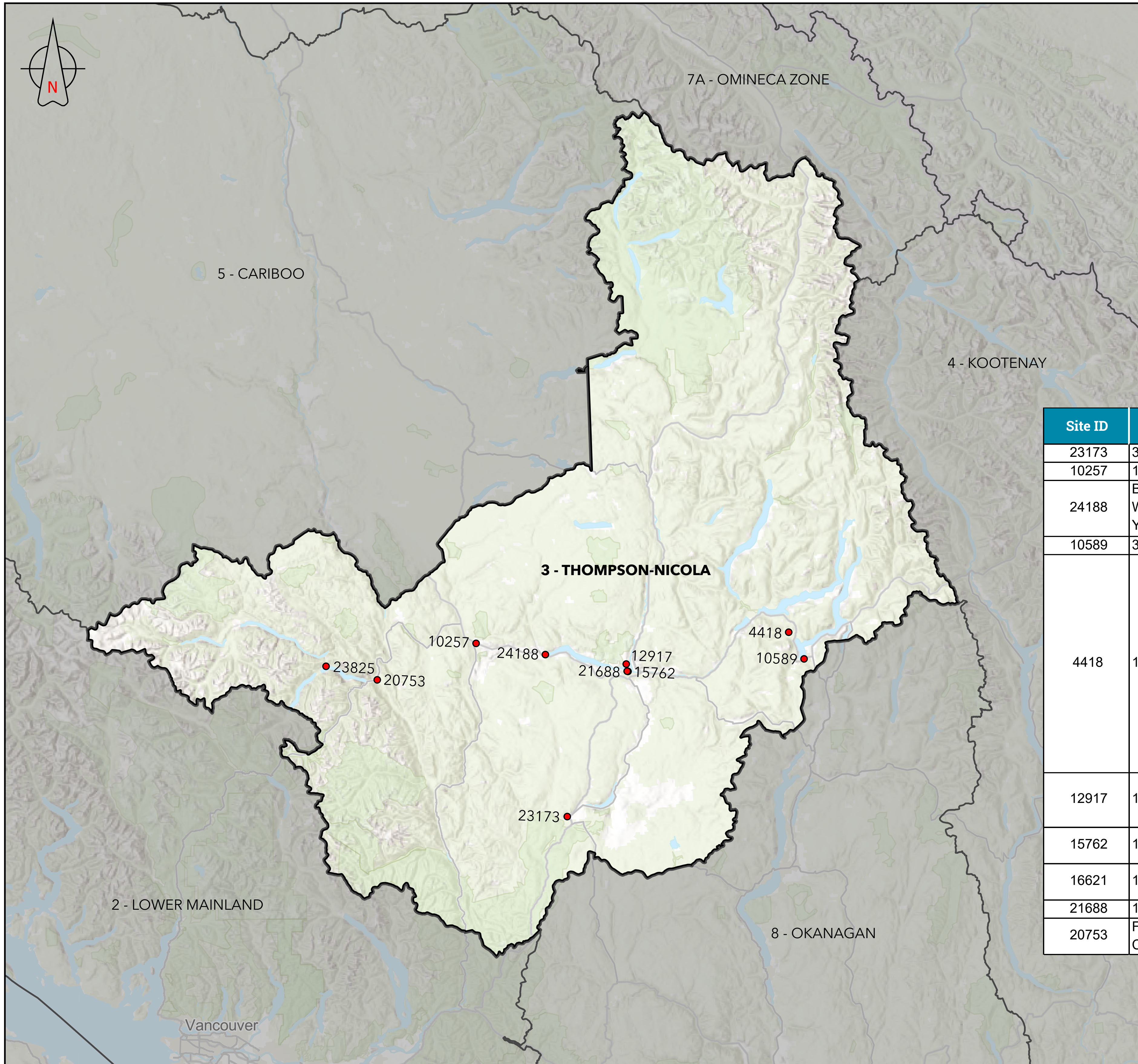
CLIENT NAME: C.S.A.P. SOCIETY

PROJECT LOCATION: BC

REGIONAL BACKGROUND APPROVED SITES
LOWER MAINLAND

DWN BY: LT	DWG NAME: FIG3	DATE: 2024-11-28	FIGURE 3
CHK'D: MG	PLOT: 11x17	GISFILE: 3935	

REFERENCE: B.C. DATA CATALOGUE, ESRI WORLD TOPOGRAPHIC - CANADIAN STYLE



LEGEND

- REGIONAL BACKGROUND APPROVED SITE
- APPROXIMATE PROVINCIAL REGION BOUNDARY

Site ID	Location	Parameters	Background Concentration Amounts (mg/kg)
23173	3420 Voght Street, Merritt, BC	Vanadium	109.6
10257	1097 South Trans-Canada Highway, Cache Creek, BC	Barium	78.9 to 463
24188	Blocks C and E, Section 5, Township 21, Range 21, West of the 6th Meridian, Kamloops Division Yale District	Iron	38,300
		Vanadium	112
10589	371 Trans-Canada Highway, Salmon Arm, BC	Cobalt	30
4418	1315 Tappen Valley Road, Tappen, BC	Aluminum	45,800
		Arsenic	9.78
		Barium	387
		Chromium	Sand: 89 Clay: 114
		Cobalt	Sand: 28 Clay: 37.6
		Iron	Sand: 54,380 Clay: 66,050
		Lithium	44
		Nickel	126
		Vanadium	112
12917	1460 and 1550 Ord Road, Kamloops, BC	Arsenic	95
		Molybdenum	80
		Selenium	8
15762	1101 Mission Flats Road, Kamloops, BC	Chromium	257
		Nickel	220
16621	1281 Mission Flats Road, Kamloops, BC	Chromium	257
		Nickel	220
21688	1325 and 1347 Mission Flats Road, Kamloops, BC	Cobalt	31.01
20753	Former Pacific Great Eastern Right-of-Way, Cayoose Creek, BC	Arsenic	36.5
		Chromium	86.6

1:2,000,000

0 25 50 100 Kilometers

REFERENCE: B.C. DATA CATALOGUE, ESRI WORLD TOPOGRAPHIC - CANADIAN STYLE

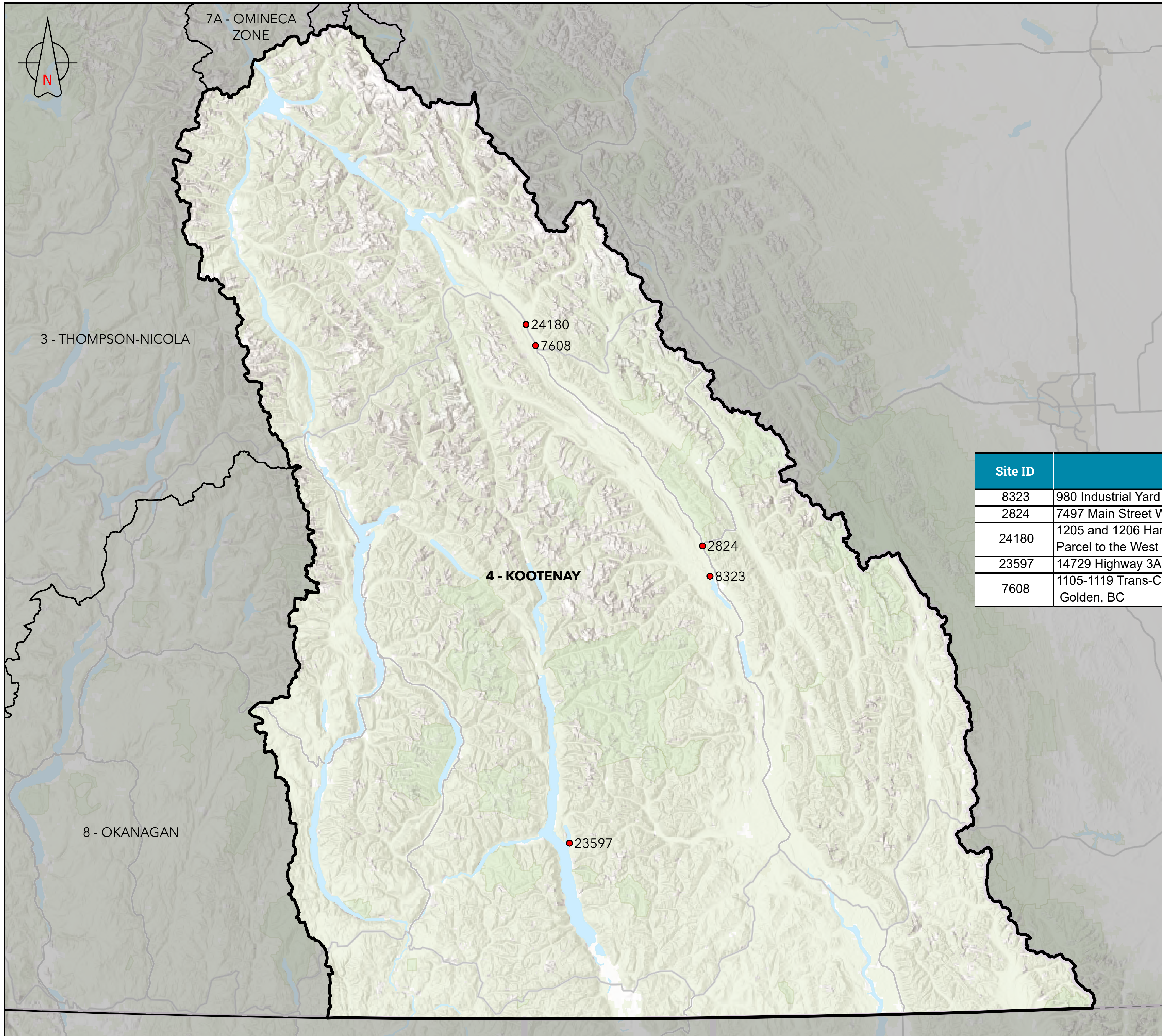
ACTIVE EARTH

CLIENT NAME: C.S.A.P. SOCIETY

PROJECT LOCATION: BC

REGIONAL BACKGROUND APPROVED SITES
THOMPSON-NICOLA

DWN BY: LT	DWG NAME: FIG4	DATE: 2024-11-28	FIGURE 4
CHK'D: MG	PLOT: 11x17	GISFILE: 3935	



LEGEND

- REGIONAL BACKGROUND APPROVED SITE
- APPROXIMATE PROVINCIAL REGION BOUNDARY

Site ID	Location	Parameters	Background Concentration Amounts (mg/kg)
8323	980 Industrial Yard 1, Invermere, BC	Arsenic	14
2824	7497 Main Street West, Radium Hot Springs, BC	Arsenic	24.9
24180	1205 and 1206 Hartley Road and Adjacent Land Parcel to the West of Highway 1, Golden, BC	Arsenic	14
23597	14729 Highway 3A, Gray Creek, BC	Lithium	39.68
7608	1105-1119 Trans-Canada Highway North, Golden, BC	Arsenic	46

1:1,600,000 — 0 20 40 80 Kilometers

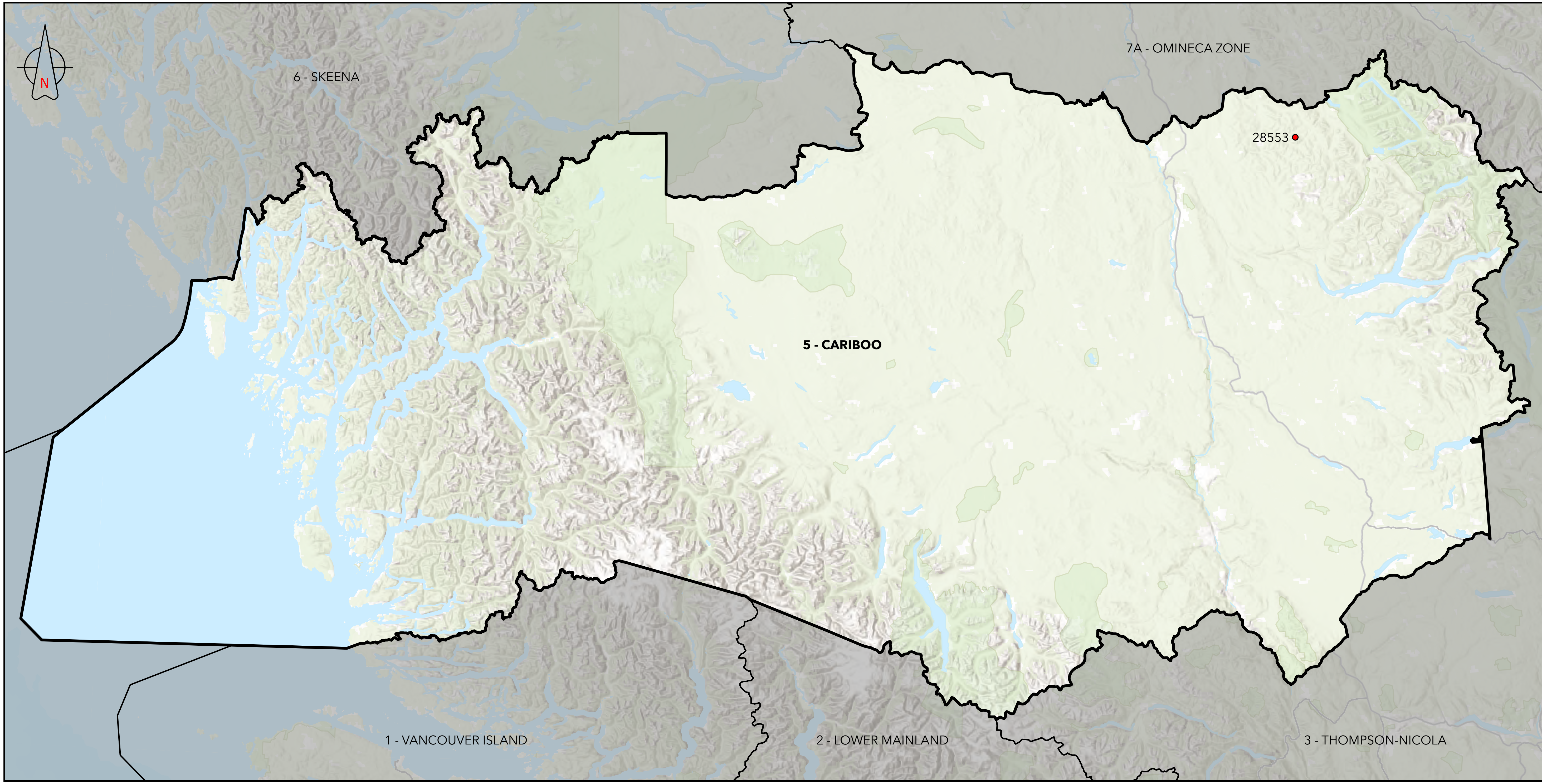
ACTIVE EARTH

CLIENT NAME: C.S.A.P. SOCIETY	PROJECT LOCATION: BC

REGIONAL BACKGROUND APPROVED SITES
KOOTENAY

DWN BY: LT	DWG NAME: FIG5	DATE: 2024-11-28	FIGURE 5
CHK'D: MG	PLOT: 11x17	GISFILE: 3935	

REFERENCE: B.C. DATA CATALOGUE, ESRI WORLD TOPOGRAPHIC - CANADIAN STYLE



LEGEND

- REGIONAL BACKGROUND APPROVED SITE
- APPROXIMATE PROVINCIAL REGION BOUNDARY

1:1,750,000 — 0 25 50 100 Kilometers

Site ID	Location	Parameters	Background Concentration Amounts (mg/kg)
28553	Island Mountain Site, Wells	Arsenic - Uplands	50.5
		Arsenic - Valley Bottom	27.3
		Iron	42,550

REFERENCE: B.C. DATA CATALOGUE, ESRI WORLD TOPOGRAPHIC - CANADIAN STYLE

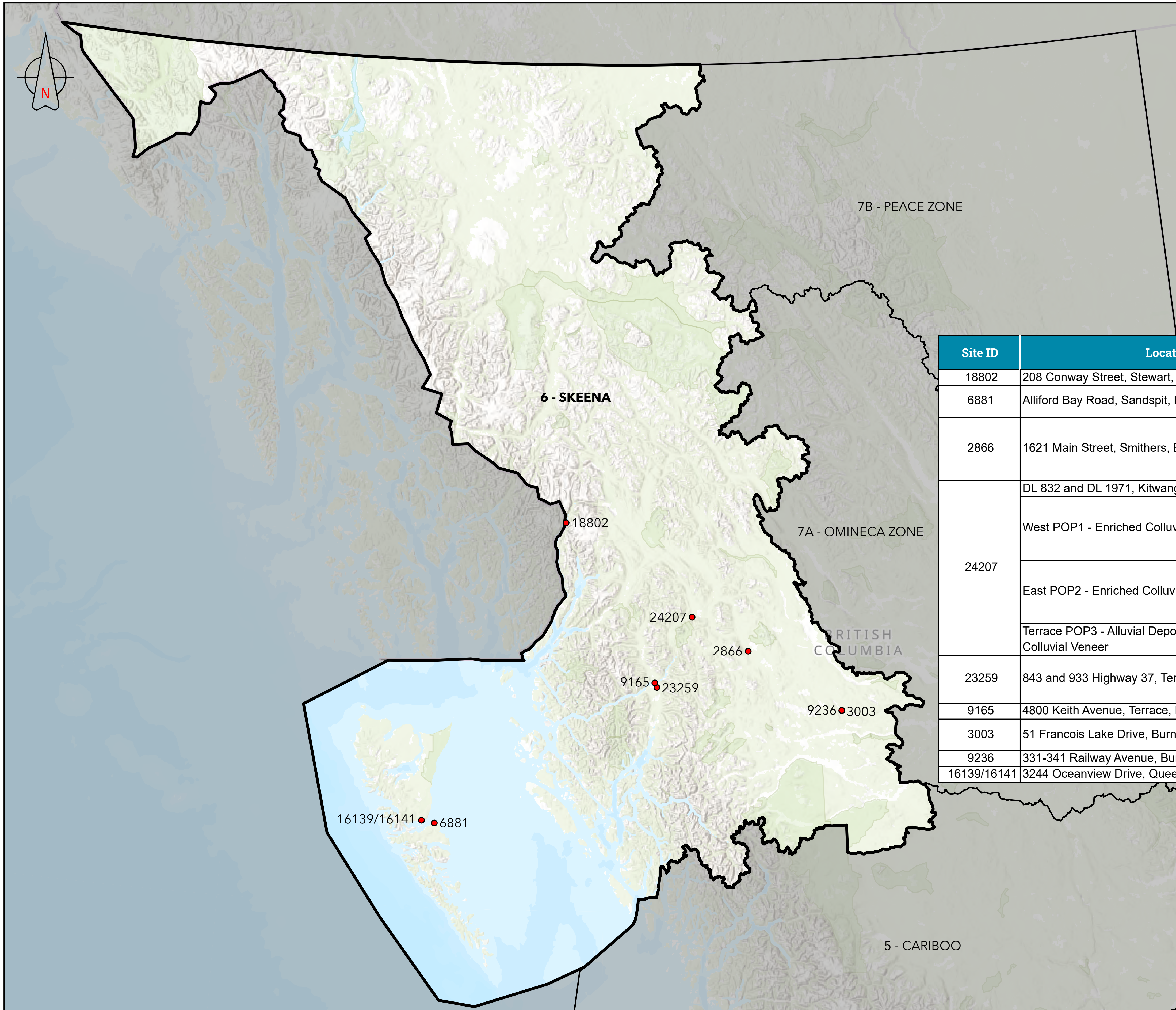
ACTIVE EARTH

CLIENT NAME: C.S.A.P. SOCIETY

PROJECT LOCATION: BC

REGIONAL BACKGROUND APPROVED SITES
CARIBOO

DWN BY: LT	DWG NAME: FIG6	DATE: 2024-11-28	FIGURE 6
CHK'D: MG	PLOT: 11x17	GISFILE: 3935	



LEGEND

- REGIONAL BACKGROUND APPROVED SITE
- APPROXIMATE PROVINCIAL REGION BOUNDARY

Site ID	Location	Parameters	Background Concentration Amounts (mg/kg)
18802	208 Conway Street, Stewart, BC	Arsenic	25
6881	Alliford Bay Road, Sandspit, BC	Arsenic	15.3
		Vanadium	139
2866	1621 Main Street, Smithers, BC	Arsenic	Native Clay: 17.32 Native Clay and Gravel Till: 17.
		Iron	Native Clay: 45,480 Native Clay and Gravel Till: 43,
24207	DL 832 and DL 1971, Kitwanga, BC		
	West POP1 - Enriched Colluvial Veneer:	Arsenic	184
		Cadmium	5.5
		Iron	51,100
		Zinc	819
	East POP2 - Enriched Colluvial Veneer	Arsenic	180
		Cadmium	31.2
		Iron	51,100
		Zinc	3,025
	Terrace POP3 - Alluvial Deposits Enriched Colluvial Veneer	Arsenic	15.9
		Iron	42,200
23259	843 and 933 Highway 37, Terrace, BC	Aluminum	53,020
		Iron	53,840
		Vanadium	111
9165	4800 Keith Avenue, Terrace, BC	Arsenic	14.7
3003	51 Francois Lake Drive, Burns Lake, BC	Arsenic	Peat: 27.4 Silt and Clay: 14.4
9236	331-341 Railway Avenue, Burns Lake, BC	Arsenic	12.1
16139/16141	3244 Oceanview Drive, Queen Charlotte, BC	Arsenic	20.75

0 50 100 200
1:4,000,000 Kilometers

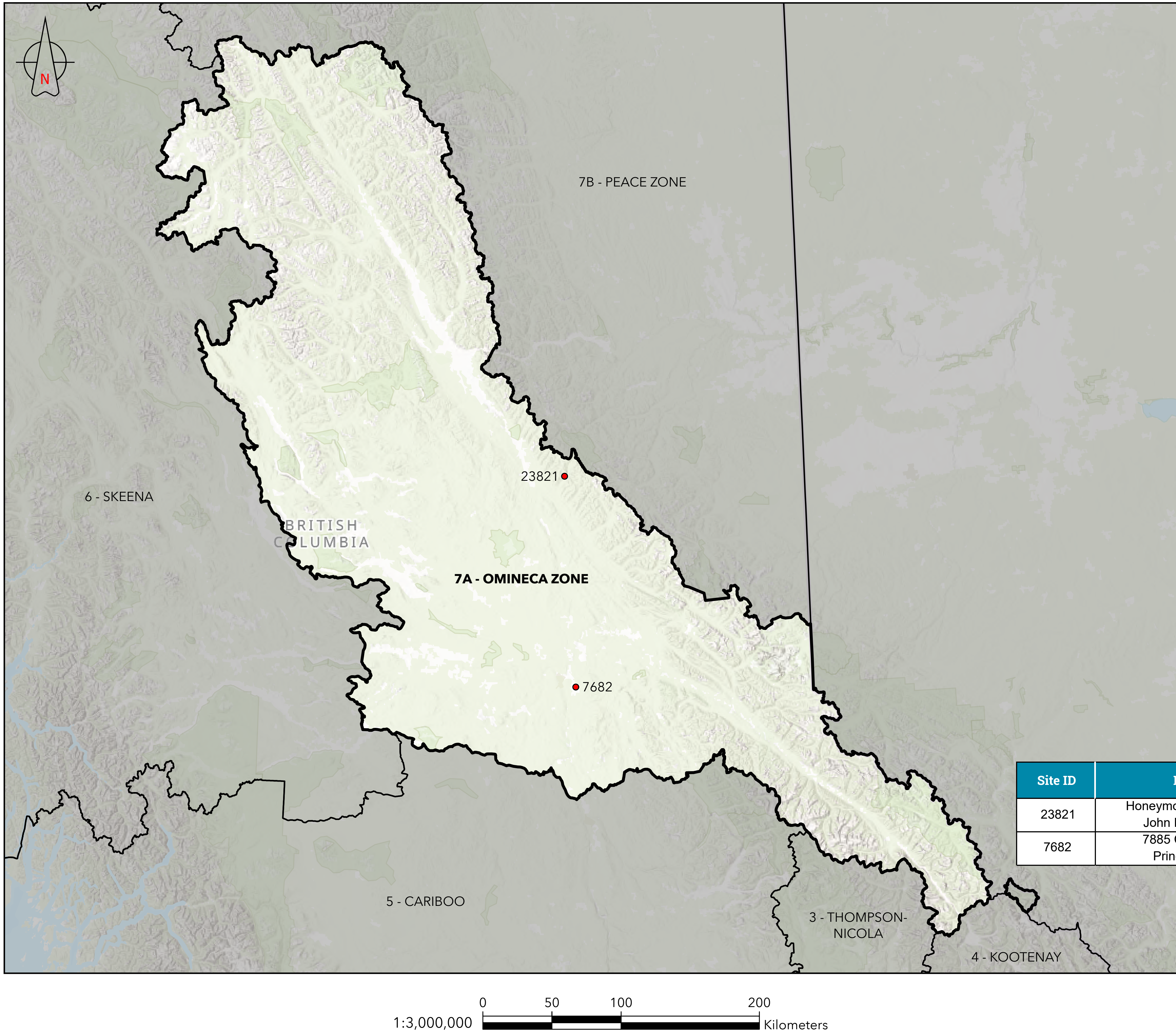
ACTIVE EARTH

CLIENT NAME:	PROJECT LOCATION:
C.S.A.P. SOCIETY	BC

REGIONAL BACKGROUND APPROVED SITES
SKEENA

DWN BY: LT	DWG NAME: FIG7	DATE: 2024-11-28	FIGURE 7
CHK'D: MG	PLOT: 11x17	GISFILE: 3935	

REFERENCE: B.C. DATA CATALOGUE, ESRI WORLD TOPOGRAPHIC - CANADIAN STYLE



LEGEND

- REGIONAL BACKGROUND APPROVED SITE
- APPROXIMATE PROVINCIAL REGION BOUNDARY

Site ID	Location	Parameters	Background Concentration Amounts (mg/kg)
23821	Honeymoon Creek Gravel Pit, John Hart Highway, BC	Arsenic	18.9
7682	7885 Cummings Road, Prince George, BC	Arsenic	15.8
		Cobalt	29.8

ACTIVE EARTH

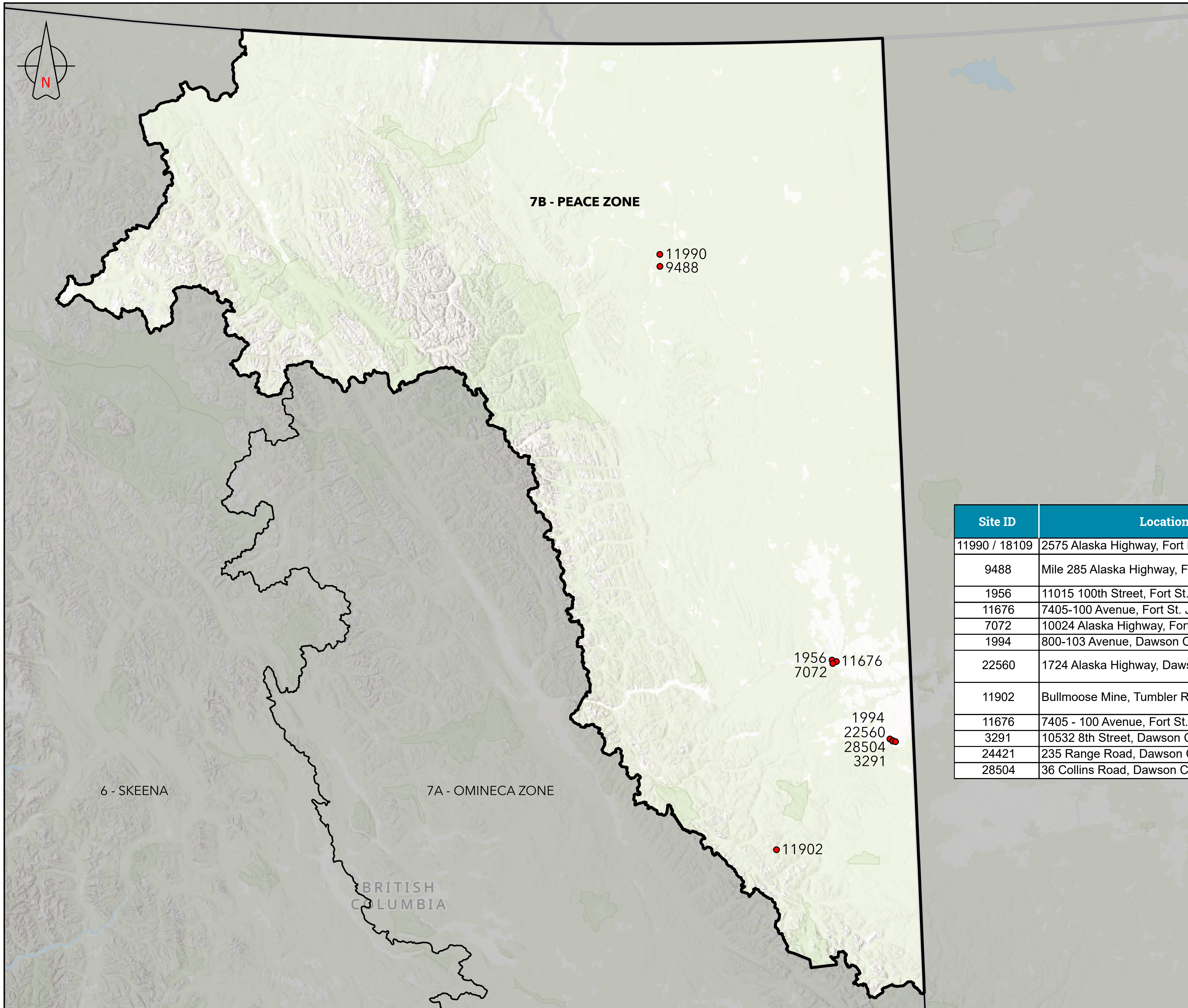
CLIENT NAME: C.S.A.P. SOCIETY

PROJECT LOCATION: BC

REGIONAL BACKGROUND APPROVED SITES
OMINECA ZONE

DWN BY: LT	DWG NAME: FIG8	DATE: 2024-11-28	FIGURE 8
CHK'D: MG	PLOT: 11x17	GISFILE: 3935	

REFERENCE: B.C. DATA CATALOGUE, ESRI WORLD TOPOGRAPHIC - CANADIAN STYLE



LEGEND

- REGIONAL BACKGROUND APPROVED SITE
- APPROXIMATE PROVINCIAL REGION BOUNDARY

Site ID	Location	Parameters	Background Concentration Amounts (mg/kg)
11990 / 18109	2575 Alaska Highway, Fort Nelson, BC	Arsenic	59.3
9488	Mile 285 Alaska Highway, Fort Nelson, BC	Arsenic	Surficial Soil: 14.8 Sand/Silt/Clay Unit: 14.7
1956	11015 100th Street, Fort St. John, BC	Arsenic	14
11676	7405-100 Avenue, Fort St. John, BC	Arsenic	13.23
7072	10024 Alaska Highway, Fort St. John, BC	Arsenic	20.15
1994	800-103 Avenue, Dawson Creek, BC	Arsenic	13
22560	1724 Alaska Highway, Dawson Creek, BC	Arsenic	15.1
		Barium	400
11902	Bullmoose Mine, Tumbler Ridge, BC	Barium	1250
		Toluene	1.7
11676	7405 - 100 Avenue, Fort St. John, BC	Arsenic	13.23
3291	10532 8th Street, Dawson Creek, BC	Arsenic	11.9
24421	235 Range Road, Dawson Creek, BC	Arsenic	18.2
28504	36 Collins Road, Dawson Creek, BC	Arsenic	13.9

1:2,750,000

0 37.5 75 150 Kilometers

ACTIVE EARTH

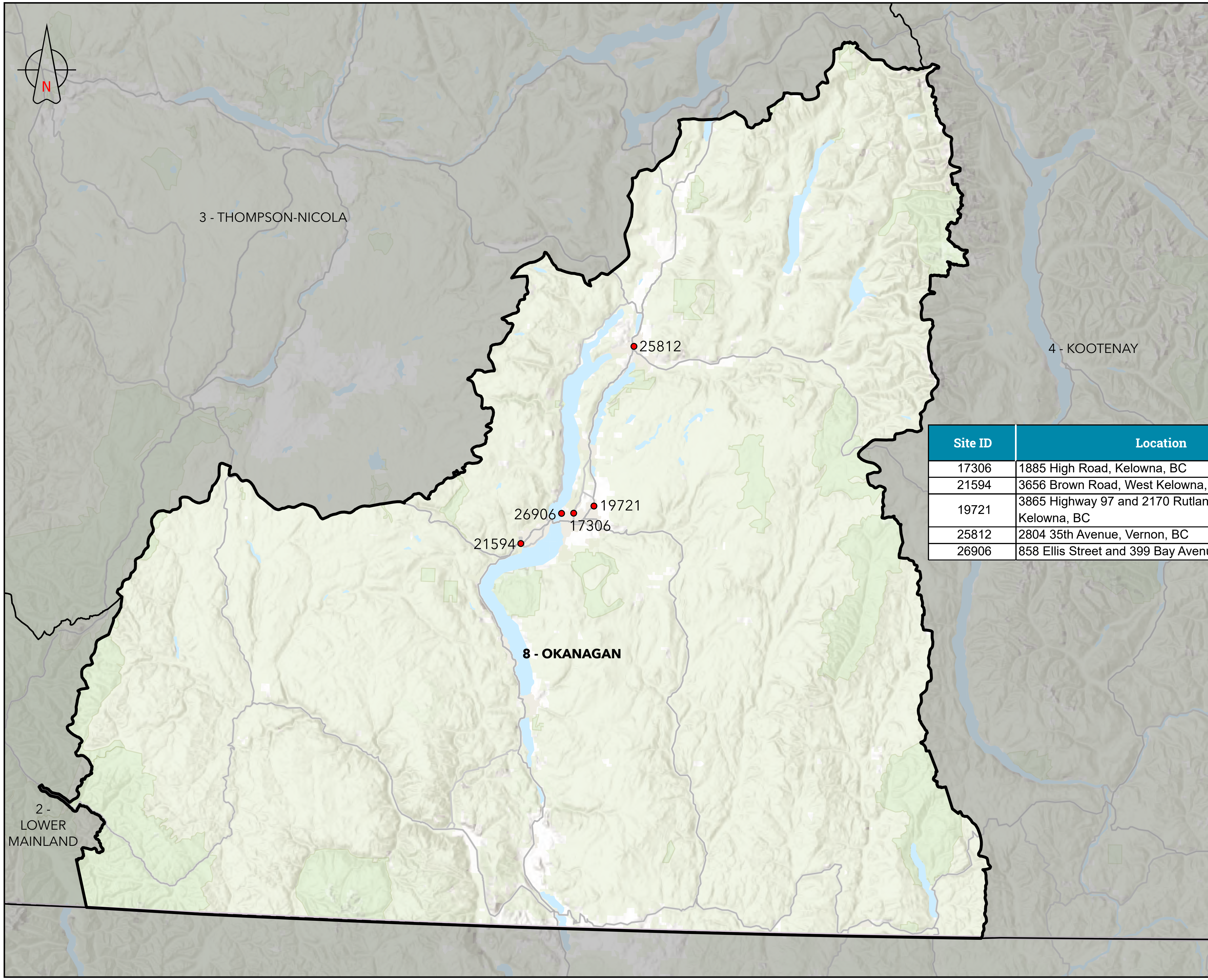
CLIENT NAME: C.S.A.P. SOCIETY

PROJECT LOCATION: BC

REGIONAL BACKGROUND APPROVED SITES
PEACE ZONE

DWN BY: LT	DWG NAME: FIG9	DATE: 2024-11-28	FIGURE 9
CHK'D: MG	PLOT: 11x17	GISFILE: 3935	

REFERENCE: B.C. DATA CATALOGUE, ESRI WORLD TOPOGRAPHIC - CANADIAN STYLE



LEGEND

- REGIONAL BACKGROUND APPROVED SITE
- APPROXIMATE PROVINCIAL REGION BOUNDARY

Site ID	Location	Parameters	Background Concentration Amounts (mg/kg)
17306	1885 High Road, Kelowna, BC	Cobalt	30.1
21594	3656 Brown Road, West Kelowna, BC	Iron	53,660
19721	3865 Highway 97 and 2170 Rutland Road, Kelowna, BC	Cobalt	27.9
25812	2804 35th Avenue, Vernon, BC	Arsenic	17.8
26906	858 Ellis Street and 399 Bay Avenue, Kelowna, BC	Iron	49,600

1:1,000,000

0 15 30 60 Kilometers

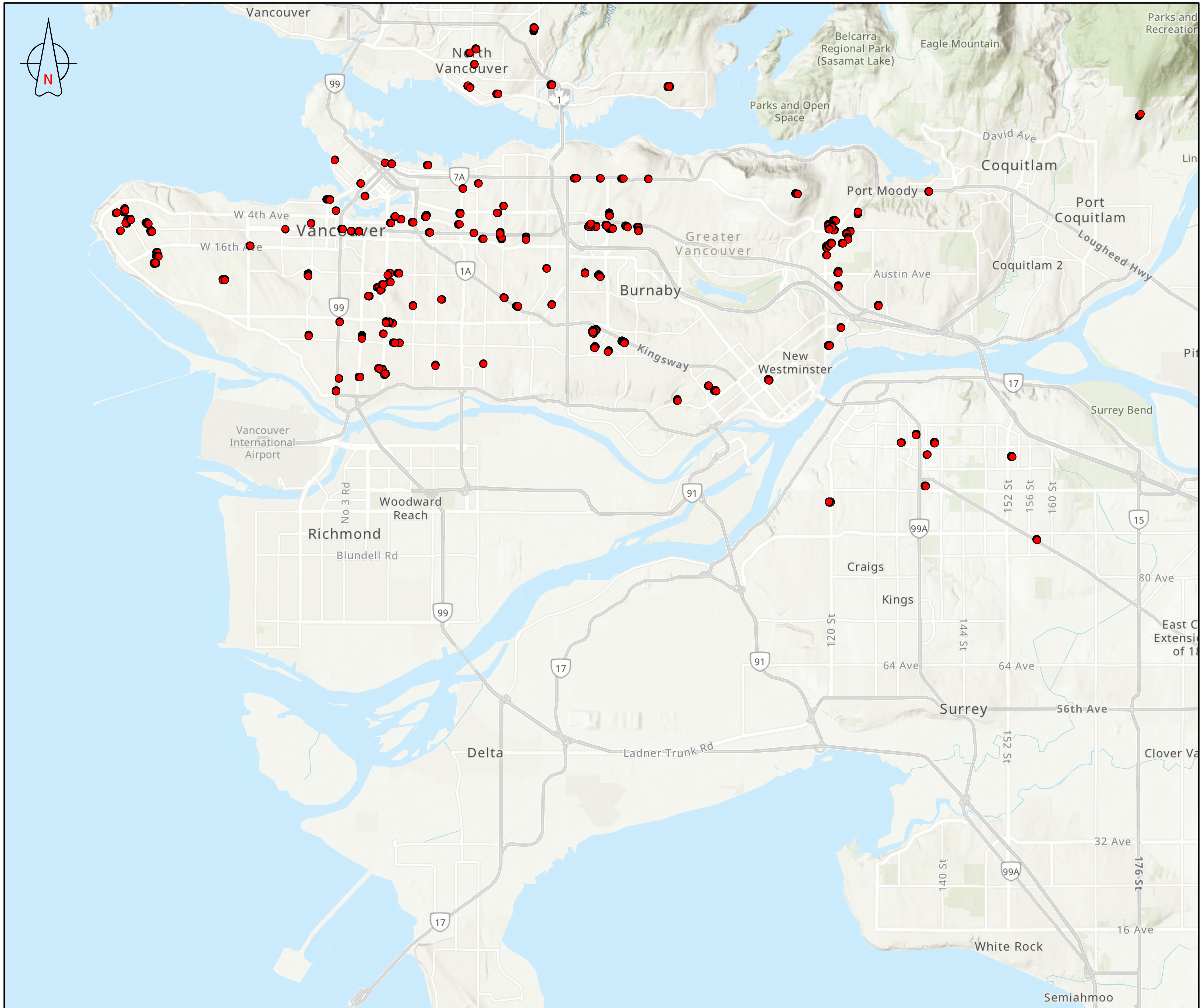
REFERENCE: B.C. DATA CATALOGUE, ESRI WORLD TOPOGRAPHIC - CANADIAN STYLE

ACTIVE EARTH

CLIENT NAME: C.S.A.P. SOCIETY	PROJECT LOCATION: BC

REGIONAL BACKGROUND APPROVED SITES
OKANAGAN

DWN BY: LT	DWG NAME: FIG10	DATE: 2024-11-28	FIGURE 10
CHK'D: MG	PLOT: 11x17	GISFILE: 3935	



REFERENCE: ESRI WORLD TOPOGRAPHIC MAP

LEGEND

● DAS SAMPLE LOCATION

1:150,000

0 2 4 8 Kilometers

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CLIENT NAME: C.S.A.P. SOCIETY	PROJECT LOCATION: GREATER VANCOUVER, BC

DAS INVESTIGATION LOCATIONS

DWN BY: LT	DWG NAME: FIG1	DATE: 2024-08-27	FIGURE 11
CHK'D: TB	PLOT: 11x17	GISFILE: 3935	

APPENDIX A
Statistics DAS Database per Surficial Geology Class

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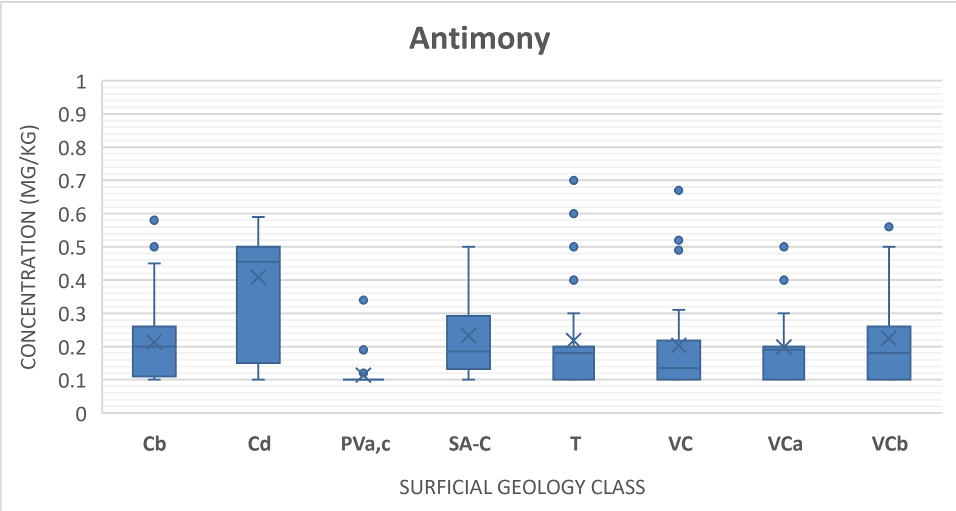
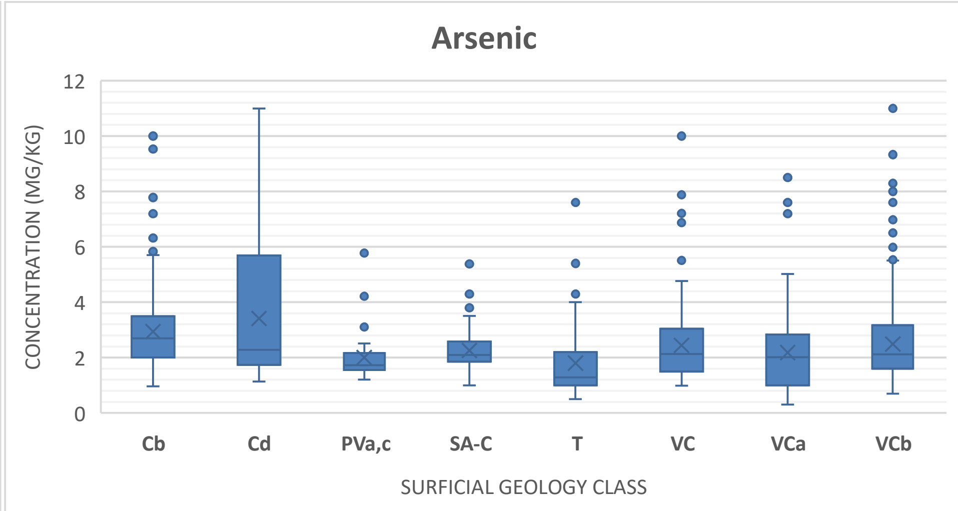
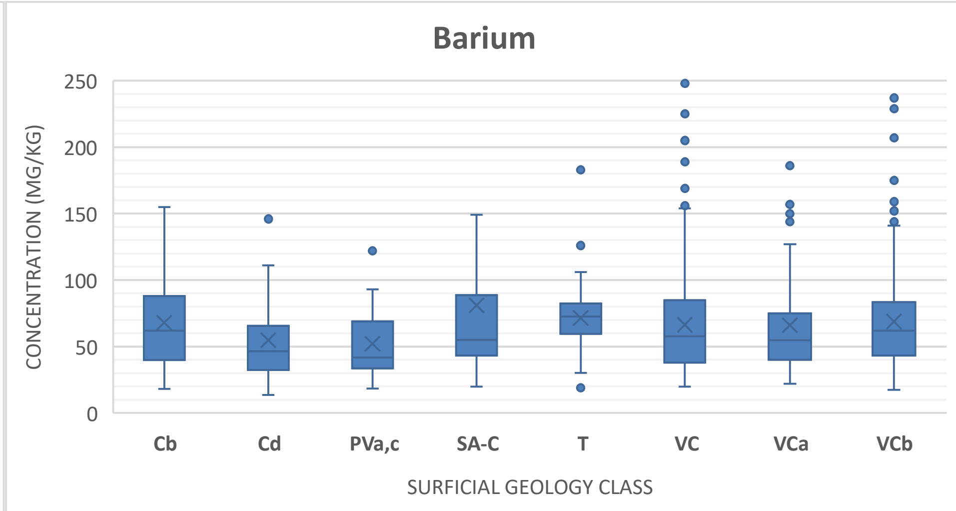
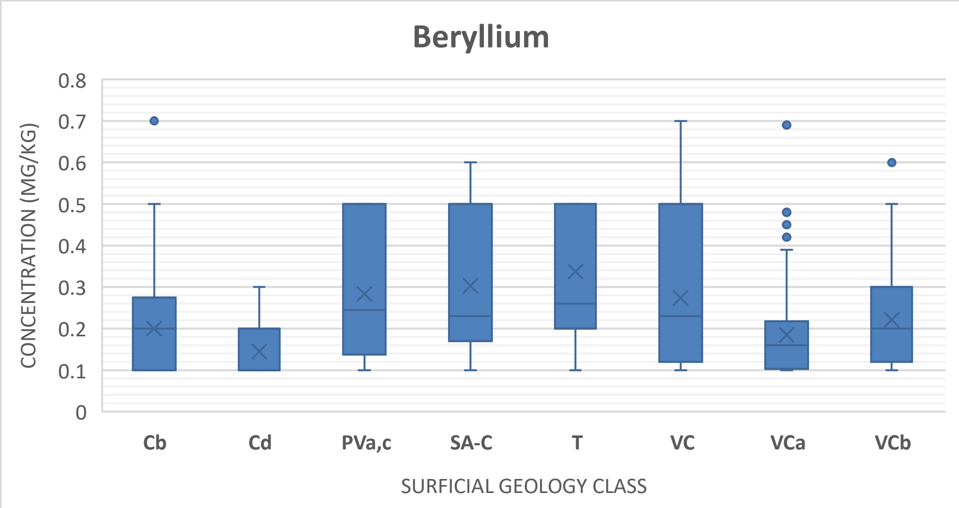
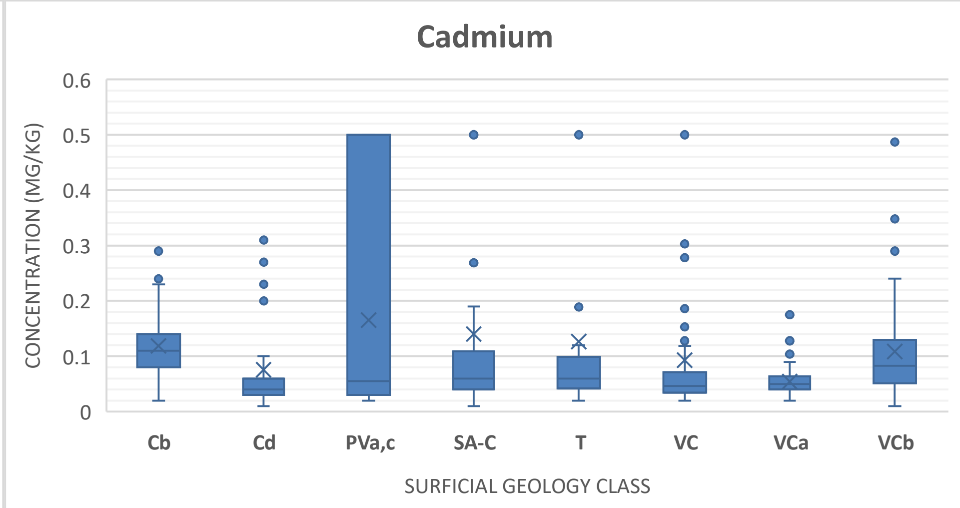
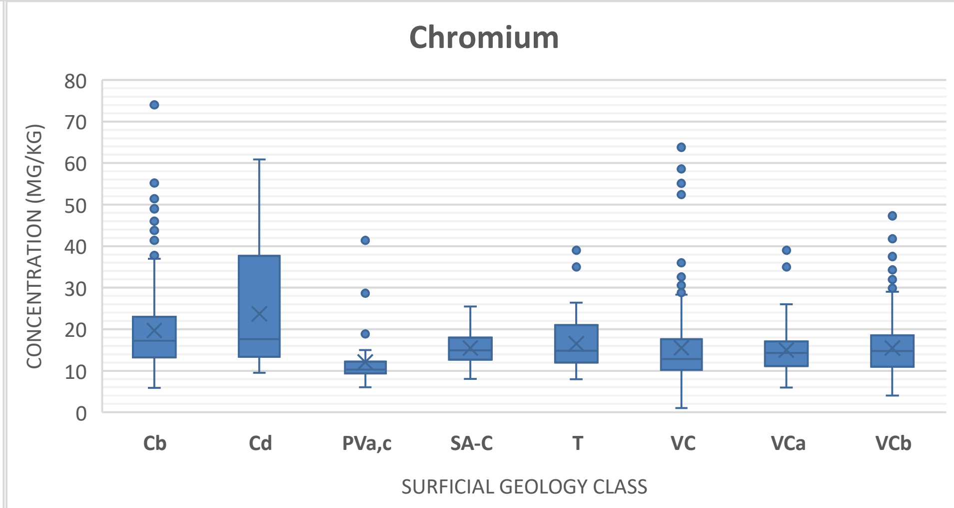

Antimony
CONCENTRATION (MG/KG)
1
0.9
0.8
0.7
0.6
0.5
0.4
0.3
0.2
0.1
0
Cb
Cd
PVa,c
SA-C
T
VC
VCa
VCb
SURFICIAL GEOLOGY CLASS

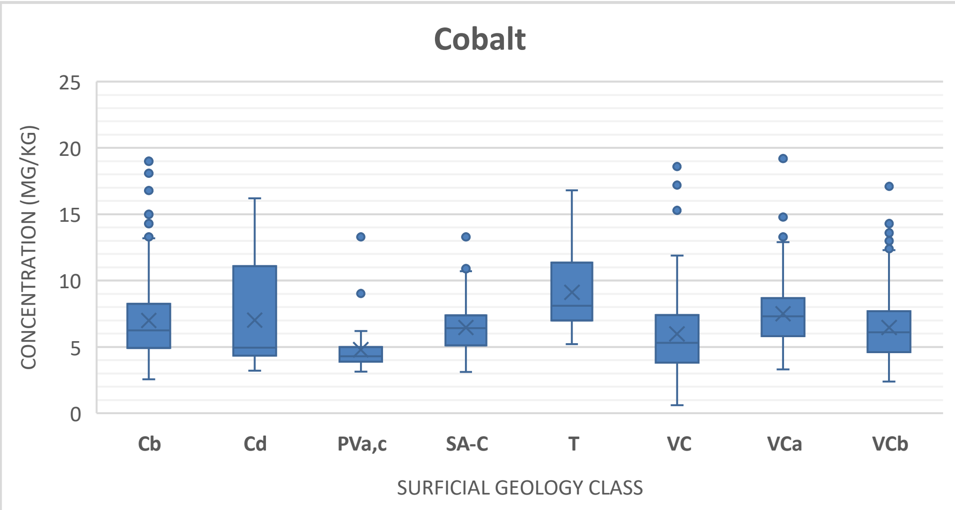

Arsenic
CONCENTRATION (MG/KG)
12
10
8
6
4
2
0
Cb
Cd
PVa,c
SA-C
T
VC
VCa
VCb
SURFICIAL GEOLOGY CLASS

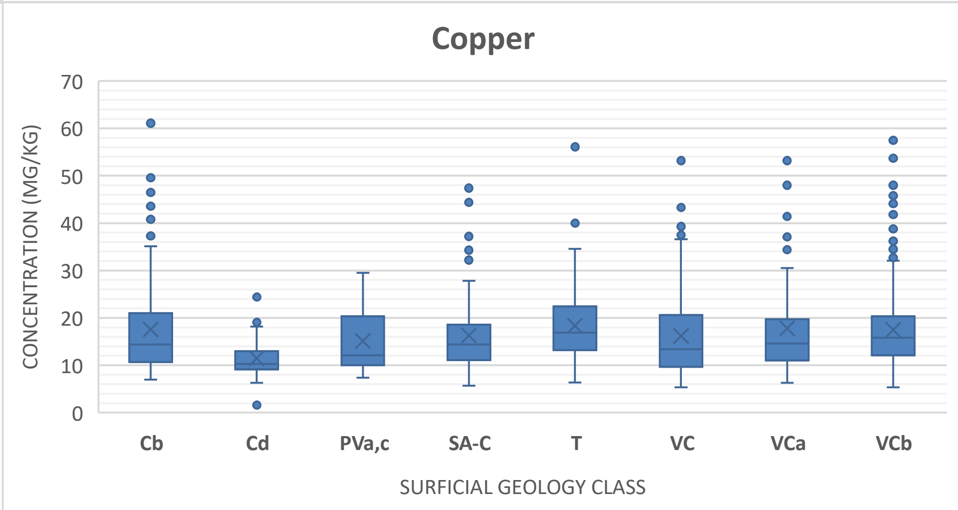

Barium
CONCENTRATION (MG/KG)
250
200
150
100
50
0
Cb
Cd
PVa,c
SA-C
T
VC
VCa
VCb
SURFICIAL GEOLOGY CLASS

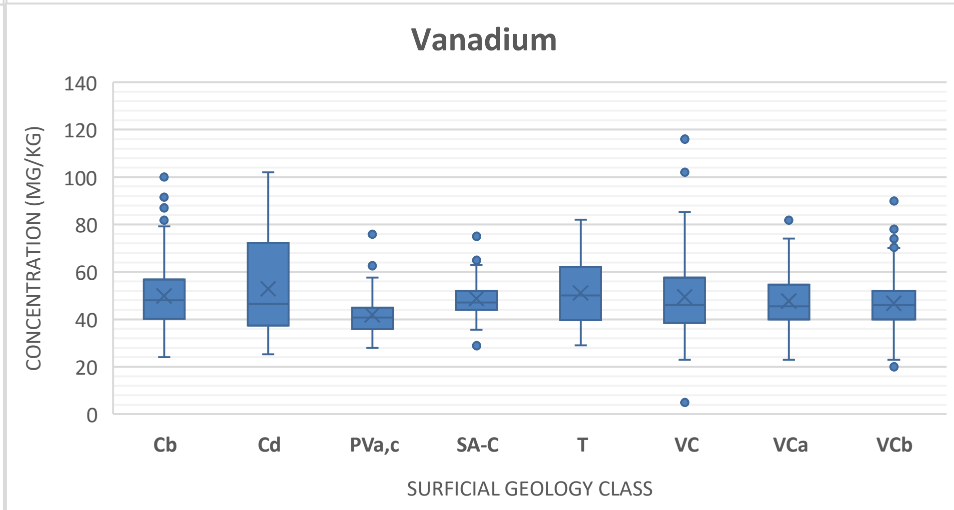

Beryllium
CONCENTRATION (MG/KG)
0.8
0.7
0.6
0.5
0.4
0.3
0.2
0.1
0
Cb
Cd
PVa,c
SA-C
T
VC
VCa
VCb
SURFICIAL GEOLOGY CLASS


Cadmium
CONCENTRATION (MG/KG)
0.6
0.5
0.4
0.3
0.2
0.1
0
Cb
Cd
PVa,c
SA-C
T
VC
VCa
VCb
SURFICIAL GEOLOGY CLASS


Chromium
CONCENTRATION (MG/KG)
80
70
60
50
40
30
20
10
0
Cb
Cd
PVa,c
SA-C
T
VC
VCa
VCb
SURFICIAL GEOLOGY CLASS


Cobalt
CONCENTRATION (MG/KG)
25
20
15
10
5
0
Cb
Cd
PVa,c
SA-C
T
VC
VCa
VCb
SURFICIAL GEOLOGY CLASS


Copper
CONCENTRATION (MG/KG)
70
60
50
40
30
20
10
0
Cb
Cd
PVa,c
SA-C
T
VC
VCa
VCb
SURFICIAL GEOLOGY CLASS


Vanadium
CONCENTRATION (MG/KG)
140
120
100
80
60
40
20
0
Cb
Cd
PVa,c
SA-C
T
VC
VCa
VCb
SURFICIAL GEOLOGY CLASS

ACTIVE EARTH
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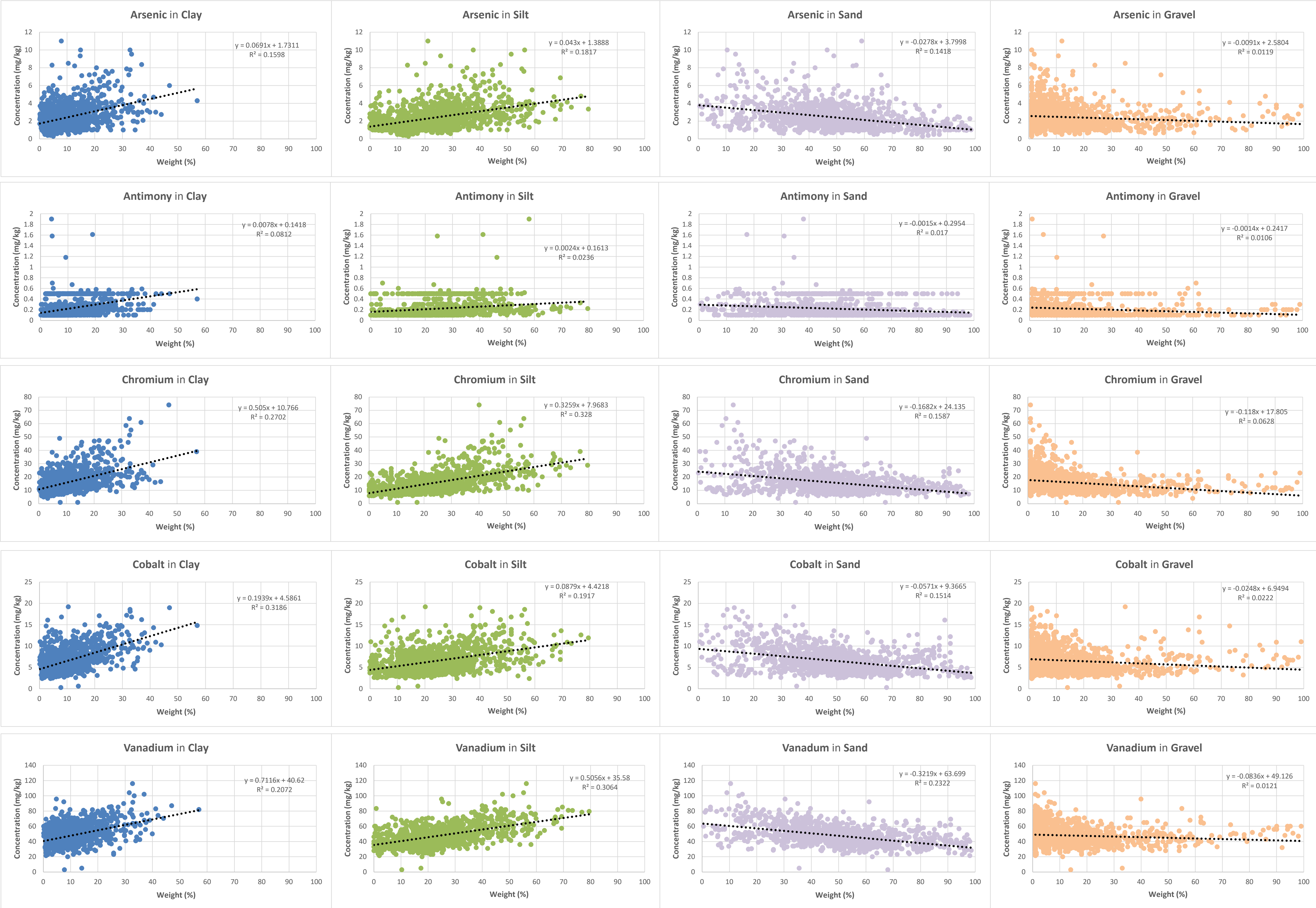
APPENDIX B
Metals Concentrations in Soil by Grain Size in DAS Database

activeearth.ca



Arsenic in Clay
y = 0.0691x + 1.7311
R² = 0.1598
Arsenic in Silt
y = 0.043x + 1.3888
R² = 0.1817
Arsenic in Sand
y = -0.0278x + 3.7998
R² = 0.1418
Arsenic in Gravel
y = -0.0091x + 2.5804
R² = 0.0119
Antimony in Clay
y = 0.0078x + 0.1418
R² = 0.0812
Antimony in Silt
y = 0.0024x + 0.1613
R² = 0.0236
Antimony in Sand
y = -0.0015x + 0.2954
R² = 0.017
Antimony in Gravel
y = -0.0014x + 0.2417
R² = 0.0106
Chromium in Clay
y = 0.505x + 10.766
R² = 0.2702
Chromium in Silt
y = 0.3259x + 7.9683
R² = 0.328
Chromium in Sand
y = -0.1682x + 24.135
R² = 0.1587
Chromium in Gravel
y = -0.118x + 17.805
R² = 0.0628
Cobalt in Clay
y = 0.1939x + 4.5861
R² = 0.3186
Cobalt in Silt
y = 0.0879x + 4.4218
R² = 0.1917
Cobalt in Sand
y = -0.0571x + 9.3665
R² = 0.1514
Cobalt in Gravel
y = -0.0248x + 6.9494
R² = 0.0222
Vanadium in Clay
y = 0.7116x + 40.62
R² = 0.2072
Vanadium in Silt
y = 0.5056x + 35.58
R² = 0.3064
Vanadum in Sand
y = -0.3219x + 63.699
R² = 0.2322
Vanadium in Gravel
y = -0.0836x + 49.126
R² = 0.0121
Concentration (mg/kg)
Weight (%)