

DATE March 24, 2016**REFERENCE No.** 1114220046-537-TM-Rev1-4600**TO** Derek Holmes, Operations Manager
BURNCO Rock Products Ltd.**CC** Alan Calder, Don Chorley**FROM** Paul Beddoes, Kristin Salzsauler**EMAIL** pbeddoes@golder.com;
ksalzsauler@golder.com**GEOCHEMICAL CHARACTERIZATION AT BURNCO AGGREGATE PROJECT, BC****1.0 INTRODUCTION**

BURNCO Rock Products Ltd. (BURNCO) and 0819042 BC Ltd. are proposing to construct and operate the BURNCO Aggregate Project (Project) in the McNab Valley, British Columbia. The Project is located approximately 20 km northeast of Gibsons, British Columbia. A sand and gravel pit will be developed within a gently sloping valley floor terrain.

Golder Associates Ltd. (Golder) was retained by BURNCO to collect samples of the fine aggregate (≤ 0.075 mm) that will be placed in the temporary fine stockpiles at the Project. Fine aggregate samples were submitted for geochemical testing to understand the acid rock drainage (ARD) and metal leaching (ML) potential of the material that will be stored in the waste stockpiles. The results of geochemical testing have been used to develop inputs to the water quality model for the Project.

This technical memorandum discusses the geochemical sampling and analysis program. The results of the geochemical tests are discussed in the context of the ARD/ML potential of fine aggregate material.

2.0 PROJECT DESCRIPTION

The Project is located in the McNab Valley, British Columbia. The Project will be bound to the west by a north-south aligned forest service road, to the south by a BC Hydro transmission corridor, and to the east and north by McNab Creek (Figure 1-1). A deep, steep-sided, man-made channel bisects the property at an approximately north-south alignment through the central portion of the valley floor. The channel bed is approximately 7 to 10 m below the adjacent valley floor. The watercourse was originally intended to function as a groundwater interceptor and is commonly referred to as Watercourse 2 (WC 2) (Figure 1-1).

A sand and gravel pit will be developed within a 70 ha clear-cut area (Figure 1-1). Sand and gravel will be extracted from the pit using a floating dredge. The dredged aggregate will be processed on site; fines will be screened from the gravel, and then further screened to segregate aggregate by size. Oversize gravel will be crushed, and sand will be sized and dewatered to remove the fine (≤ 0.075 mm) fractions. The separated fines and organics will be placed in berms that surround the quarry. Groundwater will fill the excavation during pit development, forming a pit lake.



3.0 METHODS

3.1 Sample Collection

Samples of fine fraction material were collected from two test pit locations on June 10, 2013 and June 25, 2013 (Figure 1-1). The aggregate material was accessed from along WC 2, which bisects the target material at depth. The test pits were dug by hand using a shovel. Samples of test pit material were collected in large pails. The following sections describe the observations made at each test pit location.

3.1.1 Test Pit 1

Three samples were collected from Test Pit 1 on June 10, 2013, which was accessed from the forestry service road that borders the southern perimeter of the BURNCO property. The test pit was hand dug to 0.9 m below the surface of the west bank of WC 2. Samples from this pit are indicated with sample names beginning with MN-TP-01.

The samples, MN-TP-01-S1, MN-TP-01-S2, and MN-TP-01-S3, consisted of approximately 70 to 80 percent (%) "fines" (i.e., coarse sand and smaller) and 20 to 30% coarse material (i.e., larger than coarse sand to cobbles). Sample material was moist, and organic material was noted in the sample (e.g., insects, plant debris). Reddish brown iron-staining was observed on sediments collected from the surface of the test pit and at depth.

For the purposes of geochemical testing, samples MN-TP-01-S1, MN-TP-01-S2, and MN-TP-01-S3 were combined; the combined sample is referred to in subsequent sections as MN-TP-01 S1-S3.

An additional six samples were collected from a second test pit at the same location as Test Pit 1 on June 25, 2013. This pit was hand dug to 1.1 m below the surface of the west bank of WC 2, immediately adjacent to the above described test pit.

The six samples collected from this second test pit were MN-TP-01-S4, MN-TP-01-S5, MN-TP-01-S6, MN-TP-01-S7, MN-TP-01-S8, and MN-TP-01-S9. These samples consisted of approximately 70 to 80% fines and 20 to 30% coarse material. Sample material was moist, and organic material was noted in the sample (e.g., insects, plant debris). Reddish brown iron-staining was observed on sediments collected from the surface of the test pit and at depth. For the purposes of geochemical testing, these samples were combined; the combined sample is referred to in subsequent sections as MN-TP-01 S4-S9.

3.1.2 Test Pit 6

Six samples were collected from Test Pit 6 on June 25, 2013. Test Pit 6 was accessed from the northern entrance to WC 2. The test pit was hand dug to approximately 1.2 m below the surface of the west bank of the watercourse.

The six samples collected from Test Pit 3, MN-TP-06-S1, MN-TP-06-S2, MN-TP-06-S3, MN-TP-06-S4, MN-TP-06-S5, and MN-TP-06-S6, consisted of approximately 55 to 65% fines and 35 to 45% coarse material. Sample material was moist, and organic material was noted in the sample (e.g., insects, plant debris). Reddish brown iron-staining was observed on sediments collected from the surface of the test pit and at depth. The six sub-samples from Test Pit 6 were combined for the purpose of geochemical testing; the combined sample is referred to in subsequent sections as MN-TP-06 S1-S6.

3.2 Geochemical Testing

Samples MN-TP-01 S1-S3, MN-TP-01 S4-S9, and MN-TP-06 S1-S6 were submitted to SGS Canada Inc. (SGS) in Burnaby, British Columbia. SGS screened to ≤ 0.075 mm at the geochemical laboratory prior to geochemical analysis. After the samples were screened for size, the following geochemical tests were performed:

- Acid Base Accounting (ABA), including: paste pH, sulfur species (including total sulfur, sulfate-sulfur, sulphide-sulfur and insoluble sulfur), acid potential (AP), neutralization potential (NP) and total inorganic carbon (TIC).
- Whole rock and trace metal analysis, including: aluminum, antimony, arsenic, boron, barium, beryllium, bismuth, cadmium, calcium, cerium, cesium, chromium, cobalt, copper, gallium, germanium, hafnium, indium, iron, lanthanum, lead, lithium, lutetium, magnesium, manganese, mercury, molybdenum, nickel, niobium, phosphorus, potassium, rubidium, scandium, selenium, sodium, silicon, silver, strontium, sulphur, tantalum, terbium, thallium, tellurium, tin, titanium, tungsten, uranium, vanadium yttrium, ytterbium, zinc, zirconium.
- Sequential leach testing, consisting of five 24 hour shake flask extraction (SFE) tests carried out in sequence. Each of the five SFE tests was completed using 3:1 water to solid ratio and agitated for 24 hours. Following each SFE test, the leachate from each test was separated from the solid sample and analysed for soluble parameters. The solid sample was then used to carry out the next SFE test. Each SFE leachate was submitted for the following analysis: pH, oxidation-reduction potential (redox), conductivity, total acidity (to pH 8.3), alkalinity, hardness, chloride, fluoride, sulphate, aluminum, antimony, arsenic, barium, beryllium, bismuth, boron, cadmium, calcium, chromium, cobalt, copper, iron, lead, lithium, magnesium, manganese, mercury, molybdenum, nickel, phosphorus, potassium, selenium, silicon, silver, sodium, strontium, sulphur, thallium, tin, titanium, uranium, vanadium, zinc, zirconium.

ABA was performed to evaluate the ARD potential of the fine aggregate material. ABA results were interpreted according to the guidance in MEND (2009). The purpose of the total metal analysis was to determine the solid-phase of the fine aggregate, for the purpose of identifying parameters of potential concern that occur at elevated concentrations in the samples. Sequential leach testing was conducted to identify the long-term metal leaching potential of the fine aggregate material.

The testing program is consistent with the recommendations in the "Policy for Metal Leaching and Acid Rock Drainage at Minesites in British Columbia, Ministry of Energy and Mines and Ministry of Environment, Lands and Parks, July 1998" (Price and Errington 1998), and "Guidelines for Metal Leaching and Acid Rock Drainage at Minesites in British Columbia, Ministry of Energy and Mines, August 1998" (MEM 1998). The program is also consistent with the recommendations of the more recent guidance document "Prediction Manual for Drainage Chemistry from Sulphidic Geologic Materials, MEND Report 1.20.1, December 2009" (MEND 2009). It should be noted that the references listed above were developed for sulphide-bearing mine wastes for metal mining projects. The methods of interpretation of test results outlined in the references above are not necessarily applicable to low sulphide, aggregate wastes. Namely, the interpretation of the results of ABA are not necessarily applicable to low sulphide wastes with a high organic content. As such, the interpretation of the ABA results should be conducted with caution.

4.0 RESULTS

4.1 Acid-Base Accounting

Table 4-1 presents the results of ABA. Key ABA results included:

- The paste pH for all samples ranged from 5.34 to 5.61. The weakly acidic pH could indicate the contribution of readily soluble acidity in the samples, resulting from the dissolution of sulphate minerals or organic matter.
- Total sulphur (S(T)) concentration ranged from 0.09 to 0.17%.
 - Sulphate-sulphur (S(SO₄)) concentration was determined using a hydrochloric acid digestion and ICP analysis. Sulphate-sulphur concentration in all samples ranged from 0.04 to 0.08%. The concentration of sulphate-sulphur in MN-TP-06 S1-S6 was 0.04%, and in both MN-TP-01 samples was 0.08%.
 - Sulphide-sulphur (S(S⁻²)) concentration was measured following the sulphate analysis using a nitric acid digestion and ICP analysis. Sulphide-sulphur concentration in all samples was below detection, <0.01%.
 - Insoluble sulphur concentration was calculated by the difference between total sulphur and the sum of sulphate-sulphur and sulphide-sulphur. Insoluble sulphur concentration ranged from 0.05 to 0.09%. The insoluble sulphur content can be attributed to the presence of organic sulphur in the sample in the form of plant debris, insects, and other organic material (MEND 2009). Consistent with the guidance in MEND (2009), sulphide-sulphur concentrations were used to calculate the AP of the samples. All samples had an AP less than <0.3 kg CaCO₃/t, because the sulphide-sulphur concentrations were less than the detection limit.
- Bulk NP in all samples ranged from -26.7 to -13.7 kg CaCO₃/t.
 - Negative bulk NP values are indicative of the presence of stored acidity in a sample. In soil systems, acidity can be released from the dissolution of acidic sulphate minerals. Additional sources of acidity can include exchangeable ions such as hydrogen and aluminium ions adsorbed on organic or mineral solids (MEND 2009).
- TIC ranged from 0.02 to 0.05%. The concentration of TIC in MN-TP-06 S1-S6 is 0.02%, and in both MN-TP-01 samples is 0.05%.
 - TIC was used to calculate the CaNP. CaNP ranged from 1.7 to 4.2 kg CaCO₃/t. The CaNP was greater than Bulk NP in all samples. Typically, CaNP exceeds NP when iron and manganese carbonate minerals not capable of providing neutralization capacity are present. However, the dissolution of iron and manganese carbonates does not provide neutralization capacity, as the oxidation of iron and manganese consumes the net alkalinity released during mineral dissolution.

The directives in MEND (2009) recommend a screening-level evaluation of ABA results using the NP/AP ratio. Owing to the negative NP of the samples, the NP/AP ratio ranged from -26.7 to -13.7 kg CaCO₃/t (Table 4-1). Using the MEND criteria, all samples would be classified as Potentially Acid Generating (PAG). The CaNP/AP ratio of all samples is greater than 2, and the materials would be classified as non-potentially acid generating (non-PAG). It is considered unlikely that this material would have a long-term acid generation potential for several reasons:

- The main sulphur species present in the samples were sulphate-sulphur and insoluble sulphur, which are most likely a component of the organic residue that was present in the samples. Oxidation of sulphide minerals is the primary source of long-term acid generation potential. Sulphide-sulphur concentrations were less than the analytical detection limit in all fine aggregate samples.
- The results of ABA (namely paste pH and NP) indicated the presence of stored acidity in the samples, which may contribute to the short-term acid generation potential of the materials. It is likely that the presence of organic matter in the samples affected the measurement of paste pH and NP.
- The directives in MEND (2009) were developed for sulphide bearing mine wastes, and the test methods are not necessarily appropriate for low-sulphide materials with a high organic content.

Table 4-1: Summary of Acid-Base Accounting (ABA) Results.

| Sample ID | | MN-TP-01 S1-S3 | MN-TP-01 S4-S9 | MN-TP-06 S1-S6 |
|--|--------------------------|-------------------|-------------------|-------------------|
| Parameter | Units | | | |
| Paste pH | pH | 5.34 | 5.39 | 5.61 |
| Total Sulfur, S(T) | % | 0.17 | 0.15 | 0.090 |
| Sulfate Sulphur, S(SO ₄) | % | 0.080 | 0.080 | 0.040 |
| Sulphide Sulphur, S(S-2) | % | <0.01 | <0.01 | <0.01 |
| Insoluble Sulphur | % | 0.090 | 0.070 | 0.050 |
| Acid Generation Potential, AP | kg CaCO ₃ / t | <0.3 | <0.3 | <0.3 |
| Acid Neutralization Potential, NP | kg CaCO ₃ / t | -26.7 | -21.9 | -13.7 |
| NP/AP Ratio | - | -26.7 | -21.9 | -13.7 |
| Total Inorganic Carbon, TIC | % | 0.050 | 0.050 | 0.020 |
| Carbonate Neutralization Potential, CaNP | kg CaCO ₃ / t | 4.17 | 4.17 | 1.67 |
| CaNP/NP Ratio | - | 14 | 14 | 5.6 |

4.2 Whole-Rock Major Element Analysis

The results of WRA are summarised below and presented in Table 4-2.

- The main major element in the samples was Al₂O₃, which ranged from 19 to 20%.
 - The samples also contained minor amounts of the following elements: Fe₂O₃, (6.3% in all samples); K₂O (1.1 to 1.3%); MgO (1.6 to 1.9%); and Na₂O (1.5 to 2.0%).

Table 4-2: Summary of Whole-Rock Major Element Analysis (WRA)

| Sample | Al ₂ O ₃ | Ba | CaO | Cr ₂ O ₃ | Fe ₂ O ₃ | K ₂ O | MgO | MnO | Na ₂ O | Nb | P ₂ O ₅ | SiO ₂ | Sr | TiO ₂ | Y | Zn | Zr |
|-------------------|--------------------------------|-----|-----|--------------------------------|--------------------------------|------------------|-----|------|-------------------|-----|-------------------------------|------------------|-----|------------------|-----|-----|-----|
| Name | % | ppm | % | % | % | % | % | % | % | ppm | % | % | ppm | % | ppm | ppm | ppm |
| MN-TP-01 S1-S3 | 20 | 420 | 2.4 | <0.01 | 6.3 | 1.1 | 1.6 | 0.1 | 1.5 | <10 | 0.36 | 38 | 150 | 0.46 | 20 | 170 | 170 |
| MN-TP-01 S4-S9 | 19 | 410 | 2.4 | <0.01 | 6.3 | 1.1 | 1.6 | 0.11 | 1.6 | <10 | 0.36 | 38 | 160 | 0.45 | 20 | 148 | 210 |
| MN-TP-06 S1-S6 | 20 | 460 | 3.1 | <0.01 | 6.3 | 1.3 | 1.9 | 0.1 | 2.0 | <10 | 0.27 | 47 | 180 | 0.54 | 20 | 136 | 270 |

4.3 Multi-Elemental Trace Analysis

The results of the multi-elemental trace analysis are presented in Table 4-3. For screening purposes, solid-phase metal concentrations were compared to the average crustal abundances of elements in Price (1997). Trace metal concentrations greater than 5 times the average crustal abundances were considered to be “elevated” in a sample. An elevated solid phase concentration of a particular element does not necessarily imply that this element will be mobilized; rather that additional follow-up work is required to evaluate the potential for chemical mobility.

The results of trace metal analysis indicated the following:

- Copper, silver, uranium concentrations were greater than 5 times the average crustal abundance in all samples. In addition, arsenic, bismuth, phosphorus, selenium concentrations were greater than 10 times the average crustal abundance in all samples. The concentration of silver was greater than 10 times the average crustal abundance in samples MN-TP-01 S1-S3, and MN-TP-01 S4-S6.
- The concentration of tungsten was greater than 5 times the average crustal abundance in samples MN-TP-01 S1-S3, and MN-TP-06 S1-S6.
- The concentration of tin was greater than 5 times the average crustal abundance in sample MN-TP-01 S1-S3.

Table 4-3: Summary of Multi-Element Trace Analysis

| Sample ID | Al | B | Ba | Ca | Cr | Cu | Fe | K | Li | Mg | Mn | Na | Ni | P | S | Sr | Ti | V | Zn | Zr | Ag | As | Be | Bi | Cd | Ce | |
|---|--|-----|-----|------|-------|-------|------|------|------|------|-----|------|-----|------|-------|------|------|-------|------|------|-------|------|-----|--------|------|-----|--|
| | % | ppm | ppm | % | ppm | ppm | % | % | ppm | % | ppm | % | ppm | % | % | ppm | % | ppm | ppm | ppm | ppm | ppm | ppm | ppm | ppm | ppm | |
| Continental Crust | 8.2 | 10 | 425 | 4.2 | 102 | 60 | 5.6 | 2.1 | 20 | 2.3 | 950 | 2.4 | 84 | 0.11 | 0.035 | 370 | 0.57 | 120 | 70 | 165 | 0.075 | 1.8 | 3.0 | 0.0085 | 3.0 | 67 | |
| MN-TP-01 S1-S3 | 6.5 | 30 | 125 | 0.44 | 42 | 484 | 3.5 | 0.18 | 16 | 0.55 | 485 | 0.08 | 27 | 1550 | 0.09 | 36 | 0.09 | 74 | 156 | 1.6 | 1.4 | 66 | 1.0 | 0.44 | 0.35 | 36 | |
| MN-TP-01 S4-S9 | 6.5 | 40 | 131 | 0.43 | 43 | 421 | 3.5 | 0.19 | 18 | 0.55 | 496 | 0.09 | 27 | 1720 | 0.09 | 36 | 0.09 | 79 | 146 | 1.7 | 1.6 | 66 | 1.0 | 0.42 | 0.38 | 36 | |
| MN-TP-06 S1-S6 | 6.3 | 40 | 128 | 0.45 | 43 | 318 | 3.3 | 0.22 | 21 | 0.61 | 364 | 0.08 | 32 | 1440 | 0.04 | 36 | 0.11 | 91 | 128 | 2.4 | 0.48 | 82 | 0.9 | 0.39 | 0.22 | 44 | |
| Sample ID | Co | Cs | Ga | Ge | Hf | Hg | In | La | Lu | Mo | Nb | Pb | Rb | Sb | Sc | Se | Sn | Ta | Tb | Te | Th | Tl | U | W | Y | Yb | |
| | ppm | ppm | ppm | ppm | ppm | ppm | ppm | ppm | ppm | ppm | ppm | ppm | ppm | ppm | ppm | ppm | ppm | ppm | ppm | ppm | ppm | ppm | ppm | ppm | ppm | ppm | |
| Continental Crust | 25 | - | 19 | 1.5 | 3.0 | 0.085 | 0.25 | 39 | - | 1.2 | 20 | 14 | 90 | 0.2 | 22 | 0.05 | 2.3 | 2.0 | - | - | 9.6 | 0.85 | 2.7 | 1.3 | 33 | 3.2 | |
| MN-TP-01 S1-S3 | 18 | 3.5 | 11 | <0.1 | <0.05 | 0.19 | 0.03 | 13 | 0.18 | 2.7 | 1.2 | 21 | 15 | 0.81 | 4.5 | 2.0 | 14 | <0.05 | 0.49 | 0.12 | 5.1 | 0.27 | 25 | 6.5 | 14 | 1.2 | |
| MN-TP-01 S4-S9 | 20 | 3.6 | 12 | <0.1 | <0.05 | 0.17 | 0.03 | 13 | 0.19 | 3.0 | 1.2 | 32 | 16 | 0.84 | 4.6 | 2.0 | 7.5 | <0.05 | 0.52 | 0.08 | 5.4 | 0.27 | 26 | 4.9 | 15 | 1.3 | |
| MN-TP-06 S1-S6 | 14 | 4.1 | 10 | <0.1 | <0.05 | 0.09 | 0.02 | 14 | 0.18 | 3.1 | 1.2 | 22 | 19 | 0.57 | 4.8 | 1.0 | 7.2 | <0.05 | 0.5 | 0.06 | 8.3 | 0.22 | 22 | 6.4 | 15 | 1.2 | |
| Notes: | | | | | | | | | | | | | | | | | | | | | | | | | | | |
| a) Average crustal abundance (Price, 1997). | | | | | | | | | | | | | | | | | | | | | | | | | | | |
| 123 | Indicates concentration exceeds five times the average crustal abundance (Price, 1997) | | | | | | | | | | | | | | | | | | | | | | | | | | |
| 123 | Indicates concentration exceeds ten times the average crustal abundance (Price, 1997) | | | | | | | | | | | | | | | | | | | | | | | | | | |

4.4 Sequential Shake Flask Extraction Leach Test

A series of five sequential SFE tests were used to determine the mass of soluble constituents that would be released from the sample material and the timing of these releases. The composition of SFE leachates was compared to the British Columbia Water Quality Guidelines (BCWQ) for Freshwater Aquatic Life (BC MoE 2015a, BC MoE 2015b) and to the Canadian Council of Ministers of the Environment (CCME) Guidelines for the protection of Freshwater Aquatic Life (CCME 1999) to identify parameters of potential concern that could leach from the fine aggregate material at concentrations requiring further consideration in the context of the Project water management plans. The results of the sequential leach tests are presented in Table 4-4. Figure 4-1 presents concentration trends for selected parameters.

- Leachate pH in all samples ranged from 6.5 to 7.6, within the range of pH of the reference criteria (6.5 – 9.0).
- The concentration of sulphate in leachate samples ranged from 13 to 19 mg/L in MN-TP-01 S1-S3, 14 to 23 mg/L in MN-TP-01 S4-S9 and 11 to 16 mg/L in MN-TP-06 S1-S6. Sulphate concentrations peaked in the third leach cycle of each sample (Figure 4-1). Sulphate concentrations were less than the BCWQ criterion in all samples.
- The concentration of aluminum in leachate samples ranged from 0.06 to 0.11 mg/L in MN-TP-01 S1-S3, 0.081 to 0.16 mg/L in MN-TP-01 S4-S9, and 0.092 to 0.15 mg/L in MN-TP-06 S1 to S6. Aluminum concentrations in MN-TP-01 S1-S3 peaked in the first leach, while concentrations in MN-TP-01 S4-S9 and MN-TP-06 S1-S6 peaked in the third leach (Figure 4-1). Aluminum concentrations exceeded the BCWQ criterion of 0.05 mg/L in all leachates from all samples. The CCME criterion of 0.1 mg/L was exceeded in the first leachate of MN-TP-01 S1-S3, MN-TP-01 S4-S9 and MN-TP-06 S1-S6, and the final 3 leachates of MN-TP-01 S4-S9 and MN-TP-06 S1-S6.
- The concentration of arsenic in leachate samples ranged from 0.0016 to 0.005 mg/L in MN-TP-01 S1-S3, 0.002 to 0.006 mg/L in MN-TP-01 S4-S9 and 0.0017 to 0.0056 mg/L in MN-TP-06 S1-S6. Concentrations in the second leach from MN-TP-01 S4-S9 and MN-TP-06 S1-S6 exceeded both the CCME and BCWQ criteria; all other concentrations were below both criteria.
- The concentration of beryllium in leachate samples ranged from <0.00002 to 0.00003 mg/L in MN-TP-01 S1-S3, <0.00002 to 0.00052 mg/L in MN-TP-01 S4-S9 and were all <0.00002 mg/L in MN-TP-06 S1-S6. Concentrations in the first leach from MN-TP-01 S4-S9 and MN-TP-06 S1-S6 exceeded the BCWQ criterion; all other concentrations were below this criterion.
- The concentration of cadmium in leachate samples ranged from 0.00007 to 0.00028 mg/L in MN-TP-01 S1-S3, 0.000045 to 0.00093 mg/L in MN-TP-01 S4-S9, and 0.00003 to 0.0001 mg/L in MN-TP-06 S1 to S6. Cadmium concentrations peaked in the first leach. Cadmium concentrations were greater than the hardness dependent CCME criterion in all samples for MN-TP-01 S4-S9 and MN-TP-01 S1-S3, and in the final leach for MN-TP-06 S1-S6.
- The concentration of chromium in leachate samples ranged from <0.0005 to 0.0007 mg/L in MN-TP-01 S1-S3, <0.0005 to 0.0019 mg/L in MN-TP-01 S4-S9 and from <0.0005 to 0.0011 mg/L in MN-TP-06 S1-S6. Concentrations in the first leach from MN-TP-01 S4-S9 and MN-TP-06 S1-S6 exceeded the BCWQ criterion; all other concentrations were below this criterion.

- Cobalt concentrations ranged from 0.002 to 0.013 mg/L. Cobalt concentrations exceeded the BCWQ criterion in all samples from MN-TP-01 S1-S3, in the first two leachates from MN-TP-01 S4-S9, and in the first leachate from MN-TP-06 S1 to S6.
- The concentration of copper in leachate samples ranged from 0.013 to 0.042 mg/L in MN-TP-01 S1-S3, 0.022 to 0.074 mg/L in MN-TP-01 S4-S9, and 0.017 to 0.044 mg/L in MN-TP-06 S1 to S6. Copper concentrations peaked in the first leach. Copper concentrations were greater than the hardness dependent BCWQ and CCME criteria in all samples.
- The concentration of manganese in leachate samples ranged from 0.4 to 1.0 mg/L in MN-TP-01 S1-S3, 0.3 to 1.2 mg/L in MN-TP-01 S4-S9, and 0.15 to 0.52 mg/L in MN-TP-06 S1 to S6. Manganese concentrations peaked in the first leach. The manganese concentration in the first leach of MN-TP-01 S1-S3 exceeded the hardness dependent BCWQ criterion.
- The concentration of mercury in leachate samples ranged from the detection limit (<0.00001 mg/L) to 0.00002 mg/L. Mercury concentrations in the second leach of MN-TP-01 S1-S3 and MN-TP-01 S4-S9 exceeded the BCWQ guideline criteria.
- The concentration of selenium in leachate samples ranged from 0.0004 to 0.0014 mg/L in MN-TP-01 S1-S3, <0.00004 to 0.0016 mg/L in MN-TP-01 S4-S9 and from <0.00004 – 0.00099 mg/L in MN-TP-06 S1-S6. Concentration in the first leach from MN-TP-01 S1-S3, and the second and third leach in MN-TP-01 S4-S9 exceeded the CCME criterion; all other concentrations were below both the CCME and BCWQ criteria.
- The concentration of silver in leachate samples ranged from < 0.00001 to 0.00007 mg/L in MN-TP-01 S1-S3, < 0.00001 to 0.00044 mg/L in MN-TP-01 S4-S9, and was < 0.00001 mg/L in MN-TP-06 S1 to S6. The silver concentration in MN-TP-01 S1-S3 peaked during the third leach, exceeding the BCWQ criterion. The silver concentration in the first leach of MN-TP-01 S4-S9 exceeded the BCWQ and CCME criteria.
- The concentration of thallium in leachate samples ranged from 0.00008 to 0.00029 mg/L in MN-TP-01 S1-S3, 0.00008 to 0.00081 mg/L in MN-TP-01 S4-S9 and from <0.00002 to 0.00005 mg/L in MN-TP-06 S1-S6. Concentration in the first leach from MN-TP-01 S4-S9 exceeded both the CCME and BCWQ criteria; all other concentrations were below this criteria.
- The concentration of zinc in leachate samples ranged from 0.019 to 0.067 mg/L in MN-TP-01 S1-S3, 0.009 to 0.06 mg/L in MN-TP-01 S4-S9, and 0.01 to 0.045 mg/L in MN-TP-06 S1 to S6. Zinc concentrations peaked in the first leach. Zinc concentrations in the first leach of each sample were greater than the CCME criterion of 0.033 mg/L. All zinc concentrations exceeded the hardness dependent BCWQ guideline.

Several elements exceeded the BCWQ and / or CCME Guidelines for the protection of Freshwater Aquatic Life in at least one leachate sample, including aluminum, arsenic, beryllium, cadmium, chromium, cobalt, copper, manganese, mercury, selenium, silver, thallium, and zinc. However, the leachate samples in which concentrations exceeded the guideline concentrations were not the same for each sample or parameter. Some elements, such as zinc, were released during the initial flush of the samples. Other elements, such as cadmium, were released at a steady rate with concentrations in excess of the guidelines in all samples (Figure 4-1).

Table 4-4: Summary of Sequential 24 Hour Nanopure Water Leach Extraction Test at 3:1 Liquid to Solid Ratio

| Sample ID Date Sampled SFE Sequence | CCME Guideline | BCWQ Guidelines - Freshwater Aquatic Life | | Units | MN-TP-01 S1-S3 | | | | | MN-TP-01 S4-S9 | | | | | MN-TP-06 S1-S6 | | | | |
|---|----------------------|--|----------|------------|----------------|-----------------|-----------------|----------------|----------------|----------------|-----------------|-----------------|-----------------|-----------------|----------------|---------------|--------------|--------------|-----------------|
| | | 30 Day Average | Criteria | | 6-Jun-13 | | | | | 24-Jun-13 | | | | | 24-Jun-13 | | | | |
| | | | | | 1 | 2 | 3 | 4 | 5 | 1 | 2 | 3 | 4 | 5 | 1 | 2 | 3 | 4 | 5 |
| Parameter | | | | | | | | | | | | | | | | | | | |
| pH | | | A | pH | 6.8 | 6.6 | 6.9 | 6.9 | 6.6 | 6.6 | 6.7 | 7.0 | 7.0 | 6.9 | 6.5 | 7.1 | 7.0 | 7.0 | 7.6 |
| Alkalinity | - | - | - | mg CaCO3/L | 5.8 | 3.3 | 3.3 | 3.0 | 2.4 | 8.0 | 6.3 | 5.1 | 5.2 | 5.0 | 8.1 | 7.0 | 4.4 | 4.6 | 9.0 |
| Hardness CaCO3 | - | - | - | mg/L | 37 | 14 | 11 | 8.9 | 7.9 | 62 | 23 | 13 | 11 | 8.0 | 43 | 20 | 15 | 12 | 9.0 |
| Chloride | 120 | 150 | A | mg/L | 55 | 13 | 4.2 | < 2 | < 2 | 87 | 26 | 9.0 | 3.2 | < 2 | 39 | 13 | 4.9 | < 2 | < 2 |
| Fluoride | 0.12 | - | H/A | mg/L | < 0.06 | < 0.06 | < 0.06 | < 0.06 | < 0.06 | < 0.06 | < 0.06 | < 0.06 | < 0.06 | < 0.06 | < 0.06 | < 0.06 | < 0.06 | < 0.06 | < 0.06 |
| Sulphate | - | 128-429 | H/A | mg/L | 16 | 17 | 19 | 15 | 13 | 17 | 19 | 23 | 19 | 14 | 11 | 11 | 16 | 14 | 12 |
| Dissolved Metals | | | | | | | | | | | | | | | | | | | |
| Aluminum Al | 0.10 | 0.05 | pH/A | mg/L | <u>0.11</u> | <u>0.06</u> | <u>0.061</u> | <u>0.076</u> | <u>0.076</u> | <u>0.15</u> | <u>0.081</u> | <u>0.16</u> | <u>0.13</u> | <u>0.12</u> | <u>0.12</u> | <u>0.092</u> | <u>0.15</u> | <u>0.14</u> | <u>0.13</u> |
| Antimony Sb | - | 0.009 | w | mg/L | 0.0003 | 0.0003 | 0.0002 | 0.0002 | 0.0002 | 0.0008 | 0.0005 | 0.0005 | 0.0004 | 0.0004 | < 0.0002 | 0.0003 | 0.0003 | 0.0002 | 0.0002 |
| Arsenic As | 0.005 | 0.005 | A | mg/L | 0.0036 | 0.005 | 0.0031 | 0.0016 | 0.0018 | 0.0048 | <u>0.006</u> | 0.005 | 0.0021 | 0.002 | 0.0026 | <u>0.0056</u> | 0.0035 | 0.0017 | 0.0017 |
| Barium Ba | - | 1 | W | mg/L | 0.048 | 0.016 | 0.011 | 0.0093 | 0.0099 | 0.06 | 0.018 | 0.011 | 0.0072 | 0.0081 | 0.037 | 0.014 | 0.0093 | 0.0069 | 0.0065 |
| Beryllium Be | - | 0.00013 | w | mg/L | 0.00003 | < 0.00002 | < 0.00002 | < 0.00002 | < 0.00002 | <u>0.00052</u> | < 0.00002 | < 0.00002 | < 0.00002 | < 0.00002 | < 0.00002 | < 0.00002 | < 0.00002 | < 0.00002 | < 0.00002 |
| Bismuth Bi | - | - | - | mg/L | < 0.00001 | < 0.00001 | < 0.00001 | < 0.00001 | < 0.00001 | 0.00057 | < 0.00001 | < 0.00001 | < 0.00001 | < 0.00001 | 0.00002 | < 0.00001 | < 0.00001 | < 0.00001 | < 0.00001 |
| Boron B | 1.5 | 1.2 | A | mg/L | 0.033 | 0.025 | 0.021 | 0.021 | 0.022 | 0.049 | 0.035 | 0.027 | 0.026 | 0.027 | 0.029 | 0.025 | 0.019 | 0.019 | 0.019 |
| Cadmium Cd | 0.00004 ^H | 0.000033 | A, a | mg/L | <u>0.00028</u> | <u>0.000083</u> | <u>0.000076</u> | <u>0.00007</u> | <u>0.00019</u> | <u>0.00093</u> | <u>0.000079</u> | <u>0.000054</u> | <u>0.000045</u> | <u>0.000072</u> | 0.0001 | 0.000044 | 0.000038 | 0.00003 | <u>0.000043</u> |
| Calcium Ca | - | - | - | mg/L | 9.4 | 3.5 | 2.8 | 2.3 | 2.1 | 13 | 4.3 | 2.5 | 2.2 | 1.6 | 11 | 5.0 | 3.7 | 3.0 | 2.4 |
| Chromium Cr | - | 0.001 | W, b | mg/L | 0.0007 | < 0.0005 | < 0.0005 | < 0.0005 | < 0.0005 | <u>0.0019</u> | 0.0006 | 0.0005 | < 0.0005 | < 0.0005 | <u>0.0011</u> | < 0.0005 | < 0.0005 | < 0.0005 | < 0.0005 |
| Cobalt Co | - | 0.004 | A | mg/L | <u>0.011</u> | <u>0.0047</u> | <u>0.0046</u> | <u>0.0042</u> | <u>0.0046</u> | <u>0.013</u> | <u>0.0049</u> | 0.0038 | 0.0031 | 0.0032 | <u>0.0055</u> | 0.0026 | 0.0021 | 0.0017 | 0.0016 |
| Copper Cu | 0.002 ^H | 0.002 | H/A | mg/L | <u>0.042</u> | <u>0.019</u> | <u>0.017</u> | <u>0.013</u> | <u>0.015</u> | <u>0.074</u> | <u>0.038</u> | <u>0.032</u> | <u>0.023</u> | <u>0.022</u> | <u>0.044</u> | <u>0.027</u> | <u>0.024</u> | <u>0.017</u> | <u>0.02</u> |
| Iron Fe | 0.3 | - | A | mg/L | 0.076 | 0.019 | < 0.003 | 0.02 | 0.019 | 0.13 | 0.037 | 0.027 | 0.05 | 0.045 | 0.057 | 0.016 | 0.009 | 0.033 | 0.034 |
| Lead Pb | 0.001 ^H | 0.0034-0.022 | H/A | mg/L | <u>0.0016</u> | 0.00004 | 0.00022 | 0.00005 | <u>0.005</u> | 0.0011 | 0.00016 | 0.00019 | 0.00021 | 0.00075 | 0.00025 | 0.00007 | 0.00025 | 0.0011 | 0.00055 |
| Lithium Li | - | - | - | mg/L | < 0.001 | < 0.001 | < 0.001 | < 0.001 | < 0.001 | 0.001 | < 0.001 | < 0.001 | < 0.001 | < 0.001 | < 0.001 | < 0.001 | < 0.001 | < 0.001 | < 0.001 |
| Magnesium Mg | - | - | - | mg/L | 3.2 | 1.3 | 0.9 | 0.75 | 0.69 | 7.2 | 3.0 | 1.6 | 1.4 | 1.1 | 3.7 | 1.9 | 1.3 | 1.1 | 0.84 |
| Manganese Mn | - | 0.6-1.9 | H/A | mg/L | <u>1.0</u> | 0.44 | 0.41 | 0.42 | 0.4 | <u>1.2</u> | 0.48 | 0.34 | 0.35 | 0.3 | 0.52 | 0.25 | 0.2 | 0.18 | 0.15 |
| Mercury Hg | - | 0.00001 | - | mg/L | < 0.00001 | <u>0.00002</u> | < 0.00001 | < 0.00001 | < 0.00001 | < 0.00001 | <u>0.00002</u> | < 0.00001 | < 0.00001 | < 0.00001 | < 0.00001 | 0.00001 | < 0.00001 | < 0.00001 | < 0.00001 |
| Molybdenum Mo | 0.073 | 1 | A | mg/L | 0.00011 | 0.0003 | 0.00021 | 0.00018 | 0.00036 | 0.00059 | 0.00047 | 0.00051 | 0.00045 | 0.0005 | < 0.00001 | 0.00046 | 0.00043 | 0.00038 | 0.00041 |
| Nickel Ni | 0.025 ^H | 0.025-0.065 | W, c | mg/L | 0.0048 | 0.0017 | 0.0014 | 0.0012 | 0.0013 | 0.0033 | 0.0015 | 0.0011 | 0.0008 | 0.0009 | 0.0014 | 0.0014 | 0.0011 | 0.0009 | 0.001 |
| Phosphorus P | - | - | - | mg/L | 0.086 | 0.017 | 0.026 | 0.012 | 0.015 | 0.15 | 0.054 | 0.045 | 0.032 | 0.034 | 0.024 | 0.011 | 0.017 | 0.012 | 0.009 |
| Potassium K | - | - | - | mg/L | 3.6 | 2.0 | 1.4 | 1.1 | 0.93 | 5.9 | 3.9 | 2.5 | 2.2 | 1.6 | 2.1 | 1.3 | 0.95 | 0.77 | 0.6 |
| Selenium Se | 0.001 | 0.002 | A | mg/L | <u>0.0014</u> | 0.00083 | 0.00077 | 0.00044 | 0.00045 | < 0.00004 | <u>0.0017</u> | <u>0.0016</u> | 0.00085 | 0.00074 | < 0.00004 | 0.00087 | 0.00099 | 0.00058 | 0.00043 |
| Silicon Si | - | - | - | mg/L | 9.4 | 6.2 | 6.0 | 5.6 | 5.5 | 9.6 | 7.8 | 7.0 | 7.2 | 6.4 | 7.2 | 6.2 | 6.3 | 6.0 | 5.6 |
| Silver Ag | 0.0001 | 0.00005-0.0015 | H/A | mg/L | 0.00002 | < 0.00001 | <u>0.00007</u> | 0.00003 | < 0.00001 | <u>0.00044</u> | < 0.00001 | 0.00003 | 0.00002 | < 0.00001 | < 0.00001 | < 0.00001 | < 0.00001 | < 0.00001 | < 0.00001 |
| Sodium Na | - | - | - | mg/L | 29 | 10 | 5.9 | 3.7 | 3.2 | 40 | 17 | 10.0 | 7.6 | 5.2 | 21 | 9.1 | 5.6 | 4.0 | 2.9 |
| Strontium Sr | - | - | - | mg/L | 0.072 | 0.03 | 0.019 | 0.016 | 0.015 | 0.1 | 0.033 | 0.019 | 0.016 | 0.012 | 0.077 | 0.032 | 0.023 | 0.019 | 0.015 |
| Thallium Tl | 0.0008 | 0.0008 | W | mg/L | 0.00029 | 0.00014 | 0.0001 | 0.00008 | 0.00008 | <u>0.00081</u> | 0.00015 | 0.00011 | 0.00008 | 0.00008 | 0.00005 | 0.00003 | 0.00002 | < 0.00002 | < 0.00002 |
| Tin Sn | - | - | - | mg/L | 0.0002 | 0.00071 | 0.00005 | 0.00004 | 0.00008 | 0.0008 | 0.00033 | 0.00019 | 0.00003 | 0.00004 | < 0.00001 | 0.00025 | 0.00002 | 0.00002 | 0.00004 |
| Titanium Ti | - | - | - | mg/L | 0.0012 | 0.0005 | 0.0007 | 0.0007 | 0.0008 | 0.0029 | 0.0012 | 0.0023 | 0.0015 | 0.0014 | 0.0005 | 0.0004 | 0.0011 | 0.0009 | 0.0011 |
| Uranium U | 0.015 | 0.0085 | W | mg/L | 0.00052 | 0.00042 | 0.00033 | 0.00026 | 0.00032 | 0.0016 | 0.00091 | 0.00066 | 0.0005 | 0.00051 | 0.0015 | 0.0014 | 0.0011 | 0.00082 | 0.00071 |
| Vanadium V | - | - | - | mg/L | 0.00065 | 0.00039 | 0.00029 | 0.00024 | 0.00024 | 0.0015 | 0.00063 | 0.00061 | 0.00044 | 0.00042 | 0.00059 | 0.00056 | 0.00057 | 0.00041 | 0.00039 |
| Zinc Zn | 0.03 | 0.0075-0.24 | H/A | mg/L | <u>0.067</u> | <u>0.024</u> | <u>0.022</u> | <u>0.019</u> | <u>0.026</u> | <u>0.06</u> | <u>0.014</u> | <u>0.012</u> | <u>0.009</u> | <u>0.014</u> | <u>0.045</u> | <u>0.012</u> | <u>0.012</u> | <u>0.01</u> | <u>0.011</u> |
| TDS - Calculated | | | | | 128 | 55 | 42 | 31 | 27 | 184 | 84 | 58 | 45 | 34 | 99 | 51 | 41 | 32 | 30 |

Notes

Half detection limit used in statistical calculations

"-" indicates absence of input data or input data not required (i.e., total concentrations in groundwater)

CCME: Canadian Council of Ministers of the Environment (CCME) Guidelines for the protection of Freshwater Aquatic Life.

BCWQ: BC Water Quality Guidelines for the protection of Freshwater Aquatic Life

H = criteria is hardness-dependent; pH:criteria is pH-dependent; V: criteria

is valence state-dependent; A = Approved Guideline; W = Working Guideline

| | |
|-----|---|
| 123 | Indicates concentration exceeding BCWQ Guidelines for the protection of Freshwater Aquatic Life (30 day - average). |
| 123 | Indicates concentration exceeding CCME Guidelines for the protection of Freshwater Aquatic Life. |

5.0 SUMMARY

A sand and gravel pit will be developed within a 70 ha clear-cut area at the proposed McNab Valley Aggregate Project. The main waste materials will include fine grain sized material that is screened from the sand and gravel aggregate resource, and organics. The separated fines and organics will be placed in berms that surround the quarry.

Samples of the fine grain sized material were collected from shallow, hand-dug test pits in WC 2 in June 2013. Samples generally consisted of a mixture of fines (i.e., coarse sand and smaller), with lesser gravel to cobble sized material. Visible organic material was observed in all samples. Samples were screened to ≤ 0.075 mm prior to geochemical analysis.

Samples were submitted for static geochemical analyses, to confirm the ML/ARD potential of the fine material. The samples were classified as PAG according to NP/AP ratio owing to the low NP of the wastes. However, samples were classified as non-PAG according to CaNP/AP ratio. It is considered unlikely that this material will generate acidity in the long term. The primary source of sulphur in the fine material was sulphate and insoluble (i.e., organic) sulphur. Sulphate sulphur and organic sulphur provide short-term, soluble acidity typical of soils. The samples have a low sulphide-sulphur content (i.e., $<0.03\%$); therefore, there is no source of sulphide minerals to generate acidity.

The results of solid phase analysis identified several elements that occur at elevated concentrations in samples of fine material relative to average crustal abundances, including iron, arsenic, bismuth, copper, phosphorus, selenium, silver, tin, uranium, and tungsten. The results of repetitive short-term leach tests were used to confirm the metal leaching potential of these samples. Concentrations several elements exceeded the BCWQ and/or CCME Guidelines for the protection of Freshwater Aquatic Life in at least one leachate sample during the sequential leach testing procedure, including aluminum, arsenic, beryllium, cadmium, chromium, cobalt, copper, manganese, mercury, selenium, silver, thallium and zinc. Leach test results will be used to develop inputs to the water quality predictions for the Project.

6.0 CLOSURE

We trust that this memorandum meets your current requirements; if you have any questions or concerns, please contact the undersigned.

GOLDER ASSOCIATES LTD.

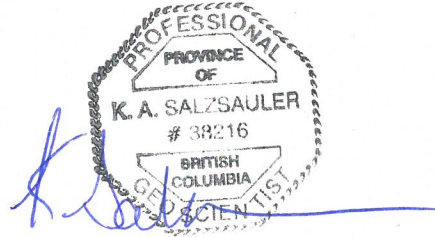


Paul Beddoes, R.P.Bio., GIT
Environmental Scientist

PAB/KAS/asd

Attachments: Figure 1-1: Test Pit Locations

Figure 4-1: Sequential Shake Flask Extraction Test Timeseries for Selected Parameters



Kristin Salzsauler, M.Sc., P.Geo. (BC, NT)
Senior Geochemist

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7.0 REFERENCES

BC MoE 2015a. British Columbia Approved Water Quality Guidelines. [online]:

<http://www2.gov.bc.ca/gov/topic.page?id=044DD64C7E24415D83D07430964113C9>.

BC MoE 2015b. British Columbia Working Water Quality Guidelines. [online]:

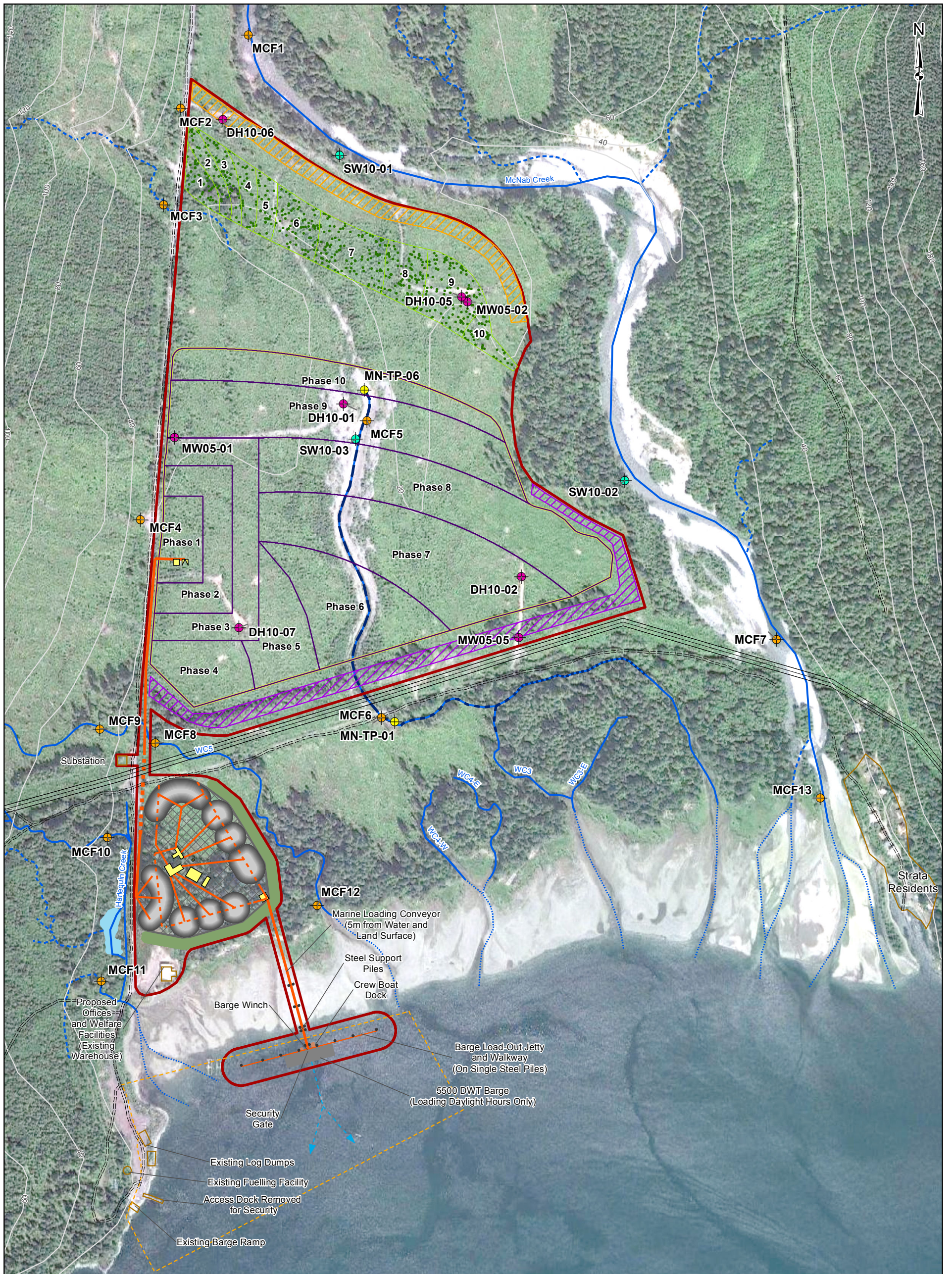
<http://www2.gov.bc.ca/gov/topic.page?id=044DD64C7E24415D83D07430964113C9>.

CCME (Canadian Council of Ministers of Environment). 1999. Canadian Water Quality Guidelines for the Protection of Aquatic Life with updates to 2015. Canadian Council of Ministers of the Environment, Winnipeg, Manitoba.

Mine Effluent Neutral Drainage Program (MEND). 2009. Prediction Manual for Drainage Chemistry from Sulphidic Geologic Materials. MEND Report 1.20.1. Version 0. December, 2009.

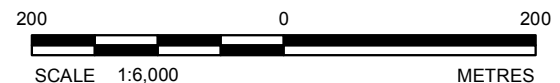
Ministry of Energy and Mines and Ministry of Environment, Lands and Parks, 1998. Policy for Metal Leaching and Acid Rock Drainage at Minesites in British Columbia.

Price, W.A. and J.C Errington, 1998. Guidelines for Metal Leaching and Acid Rock Drainage at Minesites in British Columbia, Ministry of Energy and Mines.



| LEGEND | |
|--------|--|
| | Test Pit Location (Golder 2013) |
| | Freshwater Quality Sampling Location (Golder 2012) |
| | Monitoring Well (Golder 2012) |
| | Surface Water Monitoring Station (Golder 2010) |
| | Project Area |
| | Proposed Aggregate Pit Phase |
| | Final Pit Lake Outline |
| | Product Stockpile |
| | Fines Storage Area |
| | Processing Area |
| | Existing Feature |
| | Existing Log Tenure Area |
| | Possible Processing Plant Configuration |
| | McNab Creek Flood Protection Dyke |
| | Pit Lake Containment Berm |
| | Processing Area Berm |
| | Elevated Conveyor |
| | Underground Conveyor |
| | Barge Load-out |
| | Transmission Line |
| | Road (Existing) |
| | Contour (20m) |
| | Permanent / Perennial Watercourse |
| | Intermittent Watercourse |
| | Intertidal Watercourse |
| | Constructed Watercourse |
| | Phase 1 (1985) |
| | Phase 2 (1998) |
| | Phase 3 (2001 - 2003) |
| | Barge Route |
| | Pile |

REFERENCE
 Watercourses from the Province of British Columbia and field data. Base data from the Province of British Columbia. Contours from TRIM positional data. Base Imagery from Google Maps 20100807. Projection: UTM Zone 10 Datum: NAD 83



| | | | |
|--------------------------|------------------|---|--------|
| PROJECT | | BURNCO ROCK PRODUCTS LTD. BURNCO AGGREGATE PROJECT, HOWE SOUND, B.C. | |
| TITLE | | SAMPLING LOCATIONS | |
| PROJECT NO. 11-1422-0046 | | PHASE No. | |
| DESIGN | PB 27 May. 2014 | SCALE AS SHOWN | REV. 2 |
| GIS | DL 10 Mar. 2016 | | |
| CHECK | PAB 24 Oct. 2014 | FIGURE 1-1 | |
| REVIEW | KAS 24 Oct. 2014 | | |

Path: X:\Project Data\BC\Burnco\Figures\MXD\Surface Water\Appendices\5.6-C\BURNCO_FRESHWATER_Figure_1-1_Sampling_Locations.mxd

