Geochemical Characterization
Kitsault Molybdenum Project

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Executive Summary

A geochemical characterization study has been completed to assist in project planning and baseline evaluations for the Kitsault project. The program has focused on developing a better understanding of existing conditions and a detailed characterization of drill core representing the proposed mine plan to predict future conditions. The results of that program are reported here.

Waste, Pit Walls and Low Grade Ore

Existing weathered waste and pit wall rock and the associated water monitoring record a resulting from past mining activities at Kitsault has greatly assisted in the understanding of the geochemical behaviour of rocks associated with the deposit. The minerals that affect the weathering behaviour of mined materials, namely sulphides and carbonates, are generally present at a few percent each. At these values and relative proportions, the processes of sulphide oxidation (acid generation) and subsequent dissolution of associated carbonates (acid neutralization) can, and have balanced one another for a number of decades. This period of time where these processes are in balance is referred to as the lag period and is clearly demonstrated in the seepage monitoring for the site. This lag period can somewhat complicate characterization of the fully oxidized scenario and quantification the timing of that anticipated outcome. The kinetic behaviour of rock that will be exposed in the proposed mine plan has therefore been a primary focus of the current study.

The predominant lithologies at Kitsault are a hornfels host rock package of the Bowser Lake Group and diorite and granodiorite/monzonite intrusives of the Lime Creek Intrusive Complex. Post-mineralization dikes comprised of aplite, lamprophyre and a quartz monzonite porphyry unit are also present but form inconsequential proportions of the proposed pit.

Mineralogy is dominated by quartz, feldspars, aluminosilicates (muscovite, biotite and chlorite), carbonates, sulphides and in certain areas of the diorite unit also gypsum. The sulphides and carbonates are associated with the mineralizing events. Molybdenum-bearing mineralization consists of a stockwork of quartz veins containing appreciable molybdenite and pyrite with minor scheelite, galena, sphalerite, chalcopyrite, Pb-Be sulphosalts, tetrahedrite and carbonate minerals; specifically calcite and dolomite with lesser ankerite and siderite. Northeast-trending polymetallic quartz veining, subsequent to molybdenum-bearing mineralization events may contain chalcopyrite, tetrahedrite, pyrite, sphalerite, galena, Pb-Bi sulphosalts, molybdenite, fluorite and carbonate.

Alteration associated with the deposit includes high temperature hydrothermal alteration in the form of an inner silicified zone and surrounding potassic zone (with plagioclase and biotite) and peripheral phyllic alteration (with quartz-pyrite-scheelite veins). Lower temperature hydrothermal alteration includes propylitic (with sericite and carbonate in the intrusive; and chlorite, calcite, epidote and sericite in the sedimentary rocks) and argillic alteration (with sericite and kaolin minerals and occasionally montmorillonite associated with faulting) throughout and peripheral to the ore body and into the sedimentary rocks overprinting the hornfels facies.

The waste rock and exposed pit walls associated with the proposed project will be dominated by the hornfels unit, with lesser though still significant amounts of granodiorite/monzonite and diorite. The median sulphur content is generally similar within these three units and on the order of 1.2% for the hornfels and 1.5 to 2% in the intrusives. Carbonate values, as mentioned, are generally similar (a few percent). Nearly all the carbonate (on the order of 90%) present at Kitsault will be in the form of Ca and Mg bearing carbonates generally considered effective at neutralization.
The majority of the waste anticipated from the proposed plan (93%) will have neutralization potential to acid potential ratios (NP/AP) less than 2, and half of that will have ratios less than 1. There is no clear sulphur cut-off below which the acid rock drainage (ARD) classification would clearly be non-potentially acid generating (non-PAG) and there is also no particular rock type that is consistently non-PAG, other than the lamprophyre dikes. Therefore waste segregation for the management of potentially acid generating (PAG) rock has not been proposed and all waste will be placed in a facility from which water management is considered relatively simple and secure.

Metals of interest with respect to potential geochemical impacts associated with the deposit include antimony, arsenic, bismuth, cadmium, fluoride, lead, molybdenum, selenium, silver, sulphur, tungsten and zinc. This suite is generally typical of that associated with molybdenum porphyry deposits. Not all of the above however are mobile at the conditions anticipated. The metal leaching potential or mobility of metals associated with the project was evaluated in a humidity cell program consisting of samples representing the median and 95th percentile sulphur values for each of the lithologies present in the pit has been conducted (and is on-going).

Leachate from all materials tested was consistently buffered throughout the test program. Results produced a relatively wide range of sulphate release rates, attributed to two dominant processes: 1) oxidation of sulphides and subsequent release of sulphate (generally <25 mg/kg./wk), and 2) dissolution of gypsum (up to 200 mg/kg/wk). The latter of these processes is anticipated to be a much lesser contributor to the overall sulphate loading from the system as the gypsum distribution in the deposit is limited. Other parameters that show a correlation of release rates with bulk composition include arsenic, antimony, cadmium, lead, molybdenum, selenium and zinc. There was a general tendency for increased release rates with increased solids metal content. Ranges over approximately two orders of magnitude were seen in the release rates for these key parameters.

Calculated lag times for the depletion of neutralization potential due to sulphide oxidation and associated carbonate dissolution ranged from approximately 1 to 11 decades, with an average of 46 years represented by the samples tested. Because the sample set tested represented median and the upper range of sulphide content in the deposit, and because sulphate release due to oxidation showed some correlation to total sulphur content, it is likely that this estimate of lag time is conservative (i.e. that a longer period of time may be experienced before the majority of waste becomes acidic).

The results of the humidity cell program were used to estimate source term concentrations for the waste rock storage facility, the low grade ore stockpile and the pit walls (before and after flooding). Time steps considered the operational phase of the project as well as the very long term post closure once the lag phase is exhausted. Predictions for this long term phase were estimated using results of calculated release rates from sequential meteoric water mobility procedure results conducted on currently acidic samples. The source term predictions were incorporated into a site-wide water and load balance completed by KP and reported elsewhere.

**Tailings**

Ore at Kitsault is largely dominated by diorite, though granodiorite/monzonite and hornfels will comprise part of the feed as well. Tailings will be produced by conventional flotation followed by de-pyritization. There will be two main waste streams from the mill; the first will consist of a de-pyritized rougher tailings that for a portion of the year will be cycloned and the remaining time will be discharged to form beaches as a de-pyritized whole rougher tailings. When cycloned, the
underflow will be used in construction of the northern dam and the overflow will be disposed of on the beach. The second waste stream from the mill will be the combined cleaner scavenger tailings and the pyrite concentrate from the de-pyritization float. This stream will be disposed of sub-aqueously within the facility.

The de-pyritized rougher tailings are strongly non-PAG with total sulphur contents anticipated being less than 0.10% and carbonate contents approximately five times that, with resulting NP/AP ratios above 15. The cleaner scavenger tailings and the sulphide concentrates that will be stored below water are anticipated to have sulphide concentrations above 30% and be clearly PAG.

Metals of note associated with the tailings solids include antimony, arsenic, bismuth, cadmium, lead, molybdenum, sulphur, selenium, and tungsten, as well as fluoride. Many of these parameters are associated with the sulphides and will partition more strongly with the de-pyritization concentrate and cleaner scavenger tails. Humidity cell results indicate the potential for leaching of many of these metals, most notably fluoride, arsenic, antimony, cadmium and molybdenum.

As with the other facilities, source term concentrations of the exposed tailings beach (on closure) and the cyclone sand dam were predicted using the results of the humidity cell program. These concentrations were incorporated into a site-wide water and load balance completed by KP and reported elsewhere.
# Table of Contents

Executive Summary ..................................................................................................................... ii
Disclaimer........................................................................................................................................ xiii
Copyright .......................................................................................................................................... xiii
List of Abbreviations ....................................................................................................................... xiv

1 **Introduction and Scope of Report** ................................................................................................. 1
   1.1 Background .................................................................................................................................. 1
   1.2 Existing Facilities .......................................................................................................................... 1
   1.3 Regulatory Context ...................................................................................................................... 2
   1.4 Regulatory Consultation .............................................................................................................. 2
   1.5 Chronology of Investigations Relevant to ML/ARD ................................................................. 3
      1.5.1 Exploration ............................................................................................................................ 3
      1.5.2 Historical ML/ARD ............................................................................................................... 3
      1.5.3 Current .................................................................................................................................. 4
   1.6 Geology ........................................................................................................................................ 4
      1.6.1 Setting .................................................................................................................................... 4
      1.6.2 Rock Types ............................................................................................................................ 4
      1.6.3 Alteration Assemblages ......................................................................................................... 5
   1.7 Mine Plan Assumptions ............................................................................................................... 5
   1.8 Organization of Report ............................................................................................................... 11
   1.9 Acknowledgements .................................................................................................................... 11
   1.10 Ongoing Studies ....................................................................................................................... 11

2 **Design of ML/ARD Characterization Program** .............................................................................. 12
   2.1 Overall Design ............................................................................................................................ 12
   2.2 Design Details ............................................................................................................................... 12
      2.2.1 Overview ............................................................................................................................... 12
      2.2.2 Waste Rock .......................................................................................................................... 13
      2.2.3 Run-of-Mine Ore Stockpile and Low Grade Ore Stockpile .................................................. 17
      2.2.4 Pit Walls .............................................................................................................................. 18
      2.2.5 Tailings ............................................................................................................................... 19
   2.3 Sample Set Summary .................................................................................................................... 20
   2.4 Quality Control Measures and Results ....................................................................................... 21

3 **Mineralogical Characterization** .................................................................................................... 22
   3.1 Methods ...................................................................................................................................... 22
   3.2 Bulk Mineralogy .......................................................................................................................... 22
   3.3 Occurrence and Form of Sulphur ............................................................................................... 22
   3.4 Occurrence and Form of Neutralization Potential ....................................................................... 26
3.5 Occurrence and Form of Weathering Products ........................................................................ 30

4 Existing Facilities Characterization ..................................................................................... 31
  4.1 Historical Assessments ........................................................................................................ 31
    4.1.1 Sample Selection and Sampling Methods ................................................................. 32
    4.1.2 Analytical Methods ..................................................................................................... 32
    4.1.3 Historical Results ......................................................................................................... 33
  4.2 Current Assessment .............................................................................................................. 41
    4.2.1 Sample Selection and Sampling Methods ................................................................. 41
    4.2.2 Waste Rock Thermal Monitoring Method ................................................................. 41
    4.2.3 Analytical Methods ..................................................................................................... 41
    4.2.4 Existing Waste Rock Dump Results ............................................................................ 42

5 Future Waste Rock and Pit Wall Characterization .......................................................... 63
  5.1 Sample Selection and Sampling Methods ........................................................................ 63
  5.2 Analytical Methods .......................................................................................................... 63
    5.2.1 Mineralogy .................................................................................................................. 63
    5.2.2 Static Testing ............................................................................................................. 63
    5.2.3 Kinetic Testing ............................................................................................................ 63
  5.3 Results ................................................................................................................................ 65
    5.3.1 Mineralogy .................................................................................................................. 65
    5.3.2 Static Testing ............................................................................................................. 65
    5.3.3 Kinetic Geochemical Characteristics ......................................................................... 77
    5.3.4 Kinetic Relationships to Bulk Characteristics ............................................................ 85

6 Tailings Characterization ...................................................................................................... 91
  6.1 Sample Selection and Sampling Methods ........................................................................ 91
  6.2 Analytical Methods .......................................................................................................... 94
    6.2.1 Mineralogy .................................................................................................................. 94
    6.2.2 Static Testing ............................................................................................................. 94
    6.2.3 Kinetic Testing ............................................................................................................ 94
    6.2.4 Water Testing ............................................................................................................. 94
  6.3 Results ................................................................................................................................ 94
    6.3.1 Mineralogy .................................................................................................................. 94
    6.3.2 Static Geochemical Characteristics .......................................................................... 95
    6.3.3 Supernatant Water Chemistry .................................................................................... 100
    6.3.4 Kinetic Geochemical Characteristics ......................................................................... 102
    6.3.5 Kinetic Relationships to Bulk Characteristics ............................................................ 108

7 Quarry Material .................................................................................................................... 108
  7.1 Sample Selection and Sampling Methods ........................................................................ 108
7.2 Analytical Methods .................................................................................................................. 108
  7.2.1 Static Testing ................................................................................................................... 108
7.3 Results ........................................................................................................................................ 109
  7.3.1 Acid Base Accounting .................................................................................................... 109
8 Source Term Water Quality Predictions ...................................................................................... 111
  8.1 Introduction .......................................................................................................................... 111
  8.2 Source Contact Water Quality Database ............................................................................. 111
  8.3 Source Term Predictions ...................................................................................................... 116
    8.3.1 Methods ...................................................................................................................... 116
    8.3.2 Existing Patsy Waste Rock Dump .............................................................................. 117
    8.3.3 East Waste Rock Management Facility ................................................................. 119
    8.3.4 Low Grade Ore Stockpile ......................................................................................... 123
    8.3.5 Pit Wall Run-Off ....................................................................................................... 124
    8.3.6 Tailings Beach ........................................................................................................... 127
    8.3.7 Tailings Sand Dam ..................................................................................................... 128
9 Conclusions .................................................................................................................................. 129
  9.1 Waste Rock ......................................................................................................................... 130
  9.2 Low Grade Ore .................................................................................................................. 130
  9.3 Pit Walls ............................................................................................................................. 131
  9.4 Tailings ............................................................................................................................... 131
10 References .................................................................................................................................. 133
List of Tables

Table 1: Overview of Testwork Conducted on Waste Rock ................................................................. 14
Table 2: Overview of Testwork Conducted on Low Grade Ore and Ore ............................................... 17
Table 3: Overview of Testwork Conducted on Pit Wall Rock ................................................................. 18
Table 4: Overview of Testwork Conducted on Metallurgical Tailings .................................................... 20
Table 5: Summary of Sample Numbers by Test Type and Facility ......................................................... 21
Table 6: Summary of Quantitative X-Ray Diffractometry Results (%) .................................................... 24
Table 7: Average Composition of Carbonate Minerals by Rock Type ..................................................... 27
Table 8: Summary of Selected Sample Locations from the Long Term Water Quality Monitoring Database Utilized in this Characterization Study ........................................................................... 35
Table 9: Summary of Acid Base Accounting Results for Existing Weathered Samples ....................... 45
Table 10: Summary of Solids Metals Content (in mg/kg) ....................................................................... 51
Table 11: Summary of Shake Flask Leach Extraction Tests on Weathered Waste Rock (n=30) ............. 56
Table 12: Maximum Concentrations for Parameters of Interest from Leach Extraction and NAG tests Performed on Weathered Waste Rock Samples .................................................. 61
Table 13: 2008 Drillcore and Intervals Located Within the Anticipated Pit Limits .................................... 64
Table 14: Summary of Acid Base Accounting Results for Fresh Drillcore Samples ............................... 75
Table 15: Summary of Samples in Kinetic Testing Program Representing Waste Rock, Low Grade Ore and Pit Wall Rock .................................................................................................................. 79
Table 16: Summary of Average Stable Release Rates (mg/kg/wk) for Selected Parameters from Drill Core Samples ..................................................................................................................................... 82
Table 17: Comparison of Maximum Concentrations for Parameters of Interest from Extraction Tests, Kinetic Tests and Seepage Monitoring (in mg/L unless otherwise noted) .................................... 84
Table 18: Calculated Depletion Rates for Drill Core Samples as of Cycle 44 ........................................... 92
Table 19: Quantitative X-Ray Diffraction Results for Metallurgical Tailings Samples (in %) ................. 95
Table 20: Summary of Acid Base Accounting Results for Ore and Tailings Samples ............................. 96
Table 21: Summary of NAG Test Results on Selected Tailings Samples .............................................. 100
Table 22: Analytical Results of Supernatant Water Produced in Metallurgical Testing ......................... 101
Table 23: Summary of Samples in Kinetic Testing Program for Metallurgical Tailings Samples ............ 103
Table 24: Summary of Stable Release Rates (mg/kg/wk) for Selected Parameters for Metallurgical Tailings Samples ................................................................................................................................... 104
Table 25: Calculated Depletion Rates for Metallurgical Samples as of Cycle 44 ..................................... 110
Table 26: Summary of Acid Base Accounting Results for Quarry Material Samples ............................ 111
Table 27: Summary of Applicable Solubility Limits ............................................................................. 115
Table 28: Empirical Scalar Values for Selected Parameters .................................................................. 117
Table 29: Summary of Typical Bulk Correction Factors for Scale-up Calculations ............................... 118
Table 30: Estimates of Infiltration Rates to Waste Rock (provided by Knight Piesold) ......................... 118
Table 31: Predicted and Monitored Concentrations for the Existing Pasty Dump ................................. 119
Table 32: Predicted Maximum Average Annual Dissolved Concentrations of Selected Parameters for Seepage from the EWRMF During Operations at Full Extent of the Facility ......................................... 121
Table 33. Comparison of pH Near Neutral Humidity Cell Release Rates to Acidic Release Rates (mg/kg/week) Calculated from the Sequential MWMP Results ............................................. 122

Table 34. Predicted Concentrations (mg/L) of Selected Parameters for Seepage from the EWRMF With Increasing Proportion of Acidic Waste ............................................................ 123

Table 35. Predicted Concentrations (mg/L) of Selected Parameters for Seepage from the Low Grade Ore Stockpile During Operations ............................................................................ 124

Table 36. Predicted Average Annual Concentrations (mg/L) of Selected Parameters for Pit Wall Run-off from the Pit at Full Extent During Operations .......................................................... 125

Table 37. Predicted Average Annual Concentrations (mg/L) of Selected Parameters for the Pit High Wall Run-off Under Fully Flooded Conditions on Closure ................................................................ 127

Table 38. Predicted Concentrations (mg/L) of Selected Parameters for the Run-off from the Unsaturated Tailings Beach on Closure .................................................................................................. 128

Table 39. Predicted Concentrations of Selected Parameters for the Unsaturated Northern Cycloned Sand Dam on Closure ........................................................................................................ 129

List of Figures

Figure 1: Overview of Kitsault Site Conditions in 1998. Source: SRK .............................................................................................................................. 2

Figure 2: Location and Regional Geology (from Avanti, 2009) .............................................................................................................................. 7

Figure 3: Property Geology Map ........................................................................................................................................................................................... 8

Figure 4: Property Geology Map Typical Cross-Section ........................................................................................................................................ 9

Figure 5: Site Plan and Facility Layout ........................................................................................................................................................................ 10

Figure 6: Typical oxidation of sulphides noted in petrographic evaluation (A) altered pyrrhotite grains enclosed by very fine-grained pyrite/marcasite aggregate. RL. FOV=1.3mm; (B) liberated pyrite and sphalerite grains without alteration rims. RL. FOV=2.6mm, (extracted from Appendix C) .............................................................................................................................. 25

Figure 7: Sulphate Sulphur versus Total Sulphur (by ICP-MS) ........................................................................................................................................ 25

Figure 8: Ternary Diagram Showing Molar Proportions of Ca, Mg and Mn+Fe in Carbonate Grains for Various Rock Units ........................................................................................................................................ 27

Figure 9: Comparison of Neutralization Potentials Calculated from Total Inorganic Carbon Analysis and from QXRD/EPMA Mineralogical Analyses ........................................................................................................................................ 28

Figure 10: Comparison of Total Inorganic Carbon and Ca and Mg Inorganic Carbon ........................................................................................................................................ 29

Figure 11: Comparison of Neutralization Potentials Calculated from an Adjusted Total Inorganic Carbon (NP IC_{Ca,Mg}) and Modified NP ........................................................................................................................................ 29

Figure 12: Comparison of Measured Modified NP and Rinse pH of Weathered Samples ........................................................................................................................................ 30

Figure 13: Photograph of localized area of Patsy Dump in which iron staining from pyrite oxidation was evident (marker pen for scale) ........................................................................................................................................ 31

Figure 14: (A) Sample Locations Included in Annual Monitoring Program prior to 2006 ........................................................................................................................................ 36

Figure 15: Water Quality Monitoring Results for Selected Locations Associated with the Existing Pit: (A) pH, (B) sulphate, (C) alkalinity, (D) molybdenum [note reclamation activities were completed in 2006] ........................................................................................................................................ 38

Figure 16: Water Quality Monitoring Results for Selected Locations Associated with the Existing Patsy Dump: (A) pH, (B) sulphate, (C) alkalinity, and (D) molybdenum [note reclamation activities were completed in 1999] ........................................................................................................................................ 39
Figure 17: Water Quality Monitoring Results for Selected Locations Associated with the Existing Clary Dump: (A) pH, (B) sulphate, (C) alkalinity, (D) molybdenum [note reclamation activities were completed in 1999]..........................................................40

Figure 18: Waste Rock Drillhole Location Map ..................................................................................................................43

Figure 19: Photographs of Typical Weathered Waste Rock/Pit Wall Rock as of 2009: (A) gray-ish coloured intrusives, (B) yellowish-coloured argillically altered intrusives, (C) un-stained hornfels and (D) iron-stained hornfels..................................................................................................................44

Figure 20: Box and Whisker Graphs for Rinse pH, Sulphide Sulphur, Adjusted Neutralization Potential and Adjusted NP/AP Ratios for Weathered Pit Wall, Low Grade Ore and Waste Rock Samples ....46

Figure 21: Results of (A) Total Sulphur, (B) Total Inorganic Carbon and (C) NP_{adj}/AP in Various Grain Size Fractions from Weathered Waste Rock Samples..........................................................................................47

Figure 22: Results of (A) Molybdenum and (B) Zinc in Various Grain Size Fractions from Weathered Waste Rock Samples ............................................................................................................................48

Figure 23: Rinse pH versus Adjusted NP/AP Ratio for Weathered Samples........................................................................49

Figure 24: Variability of Paste pH, Total S, Sulphate S and Adjusted NP with Depth .........................................................50

Figure 25: Box and Whisker Graphs for Selected Parameters by Material Type................................................................52

Figure 26: NAGpH versus Adjusted NP/AP Ratio ................................................................................................................54

Figure 27: Metals Leached in Weathered Waste Rock Samples During the NAG Test. Results shown are for average values with error bars representing the maximum and minimum concentrations reported ..........................................................54

Figure 28: Leach Extraction pH versus Concentration of (A) sulphate, (B) fluoride, (C) aluminum, (D) cadmium, (E) copper, (F) lead, (G) molybdenum and (H) zinc..............................................................57

Figure 29: Sequential MWMP Results (A) pH, (B) sulphate, (C) calcium, (D) cadmium, (E) arsenic, (F) iron, (G) molybdenum and (H) zinc ....................................................................................................59

Figure 30: Ground Temperature Profile, Patsy Dump and Underlying Bedrock .................................................................62

Figure 31: Histograms of Molybdenum Content by Rock Type .............................................................................................66

Figure 32: Histograms of Sulphur Content by Rock Type .......................................................................................................67

Figure 33: Molybdenum versus Total Sulphur Content by Rock Type from the Exploration Database ..........68

Figure 34: Sulphur Content with Depth in Selected Drillholes............................................................................................68

Figure 35: Total Sulphur by ICP versus Sulphate Sulphur in Diorite Drillcore ................................................................69

Figure 36: Surrogate Acid Potential versus Adjusted Neutralization Potential for Drillcore Samples ....................70

Figure 37: Surrogate NP/AP versus Total Sulphur for Drillcore Samples ...........................................................................71

Figure 38: NP/AP Ratio versus Material Tonnage Produced from the Block Model (provided by AMEC) .......72

Figure 39: Neutralization Potential to Acid Potential Ratio (NP/AP) in final exposed pit walls. .................................72

Figure 40: Adjusted NP/AP Ratio versus Sulphide Sulphur ..............................................................................................74

Figure 41: Box and Whisker Graphs for Paste pH, Sulphide Sulphur, Adjusted Neutralization Potential and Adjusted NP/AP Ratios for Fresh Drill Core Samples ..........................................................76

Figure 42: Humidity Cell Test Results Showing pH, Sulphate, Arsenic and Copper Trends for Drill Core Samples .................................................................................................................................80

Figure 43: Humidity Cell Test Results Showing Iron, Manganese, Molybdenum and Zinc Trends for Drill Core Samples ..........................................................................................................................81

Figure 44: Sub-aqueous Column Results Showing pH, Sulphate, Iron and Molybdenum Trends for Weathered Waste Rock Samples .............................................................................................83
Figure 45: Comparison of Average Sulphate Release Rates and Sulphide Content........................................86
Figure 46: Comparison of Average Sulphate Release Rates and Sulphide Content for Those Samples with Sulphate Sulphur Values less than 0.1%.................................................................86
Figure 47: Comparison of Average Arsenic Release Rates and Arsenic Content .......................................87
Figure 48: Comparison of Average Antimony Release Rates and Antimony Content.................................88
Figure 49: Comparison of Average Cadmium Release Rates and Cadmium Content .....................................88
Figure 50: Comparison of Average Lead Release Rates and Lead Content..................................................89
Figure 51: Comparison of Average Molybdenum Release Rates and Molybdenum Content ....................89
Figure 52: Comparison of Average Selenium Release Rates and Selenium Content ..................................90
Figure 53: Comparison of Average Zinc Release Rates and Zinc Content ..................................................90
Figure 54: Simplified Flow Sheet (provided by Avanti). ................................................................................93
Figure 55: Acid Potential versus Adjusted Neutralization Potential for Tailings and Ore Feed Samples .......97
Figure 56: Adjusted NP/AP versus Total Sulphur for Metallurgical Tailings and Ore Samples ..................97
Figure 57: Box and Whisker Graphs for Arsenic, Cadmium, Molybdenum and Selenium Metallurgical Samples ..............................................................................................................................99
Figure 58: Humidity Cell Results Showing pH, Sulphate, Arsenic and Cadmium Trends for Metallurgical Tailings Samples ................................................................................................................105
Figure 59: Humidity Cell Results Showing Iron, Manganese, Molybdenum and Zinc Trends for Metallurgical Tailings Samples ........................................................................................................106
Figure 60: Sub-aqueous Column Results Showing pH, Sulphate, Iron and Molybdenum Trends for Metallurgical Tailings ........................................................................................................107
Figure 61: Concentrations of Al, Cd, Cu and Mn versus pH. Solubility curves for selected minerals are also shown ...................................................................................................................................113
Figure 62: Concentrations of Fe, Pb, Mo, Zn versus pH. Solubility curves for selected minerals are also shown ...................................................................................................................................114
Figure 63: Estimates of Waste Rock Tonnage by Rock Type ........................................................................120
Figure 64: Pyrite Reaction Rate as a Function of Temperature for pyrite activation energies of 50 and 60 KJ/mol (source MEND, 2005) ........................................................................................................120
Figure 65: Rock Type Distribution in Final Pit Walls ....................................................................................125
Figure 66: Area of Exposed Pit Wall Above the Final Flooded Level (515 m). Provided by AMEC ............126
Appendices

Appendix A: Sample List and Descriptions ................................................................. 1
Appendix B: Drill Logs for Patsy Dump Drillholes (from Knight Piesold) ...................... 1
Appendix C: Descriptions and Drill Log for Borrow/Quarry Materials (from Knight Piesold) .................. 1
Appendix D: Procedures of Testing Methodologies Utilized in the Program .................. 1
Appendix E: Static Characterization Results for Rock Samples .................................... 1
Appendix F: Kinetic Characterization Results for Rock Samples .................................. 1
Appendix G: Static Characterization Results for Tailings ............................................. 1
Appendix H: Kinetic Characterization Results for Tailings ........................................... 1
Appendix I: Quality Control Results ...................................................................... 1
Appendix J: Source Term Water Quality Prediction Results ........................................ 1
Appendix K: Source Term Water Quality Prediction Results for Increasing Proportions of Acidic Waste Rock ................................................................. 1
Disclaimer

The opinions expressed in this Report have been based on the information supplied to SRK Consulting (Canada) Inc. (SRK) by Avanti Mining Inc. (Avanti). These opinions are provided in response to a specific request from Avanti to do so, and are subject to the contractual terms between SRK and Avanti. SRK has exercised all due care in reviewing the supplied information. Whilst SRK has compared key supplied data with expected values, the accuracy of the results and conclusions from the review are entirely reliant on the accuracy and completeness of the supplied data. SRK does not accept responsibility for any errors or omissions in the supplied information and does not accept any consequential liability arising from commercial decisions or actions resulting from them. Opinions presented in this report apply to the site conditions and features as they existed at the time of SRK’s investigations, and those reasonably foreseeable. These opinions do not necessarily apply to conditions and features that may arise after the date of this Report.

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## List of Abbreviations

<table>
<thead>
<tr>
<th>Abbreviation</th>
<th>Description</th>
</tr>
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<tbody>
<tr>
<td>ARD</td>
<td>Acid Rock Drainage</td>
</tr>
<tr>
<td>ML</td>
<td>Metal Leaching</td>
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<td>PAG</td>
<td>Potentially acid generating</td>
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<td>Non-PAG</td>
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<tr>
<td>XRD</td>
<td>X-ray Diffractometry</td>
</tr>
<tr>
<td>ABA</td>
<td>Acid Base Accounting</td>
</tr>
<tr>
<td>ICP-MS</td>
<td>Inductively coupled plasma – mass spectroscopy</td>
</tr>
<tr>
<td>SFE</td>
<td>Shake flask extraction</td>
</tr>
<tr>
<td>MWMP</td>
<td>Meteoric water mobility procedure</td>
</tr>
<tr>
<td>HC</td>
<td>Humidity cell</td>
</tr>
</tbody>
</table>
1 Introduction and Scope of Report

1.1 Background

The Kitsault Molybdenum Project, a former producing mine, near Alice Arm in the Skeena Mining Division of BC, is currently undergoing various studies to support feasibility studies and Environmental Assessment (EA). SRK was retained by Avanti Mining Inc. (Avanti) to conduct evaluations related to metal leaching and acid rock drainage (ML/ARD) to support the EA application. This report provides methods and results of the characterization program for this site.

1.2 Existing Facilities

The existing open pit is a side hill excavation approximately 40 hectares in area and ranging from 550 to 700 m in elevation, with a northern high wall and a 12 m high central barren core that rises above the central part of the pit (Figure 1). Both intrusive and hornfels lithologies are exposed within the pit area. Reclamation of the pit area was completed in 2006 and consisted of placing covers over pit benches, including an impermeable cover over the barren core and substantial re-grading and ditching to improve water management (SRK 2003b; SRK 2006).

Low grade ore was stockpiled near the old Pit Shop as well as near Patsy Dump containing approximately 1 million tonnes and 1.2 million tonnes, respectively. The stockpile near the old Pit Shop was revegetated and regraded in 1999. The stockpile near Patsy Dump is not known to have been reclaimed. The low grade ore was comprised of both hornfels and intrusive.

Two waste rock dump facilities currently exist at site; the Clary Dump and the Patsy Dump (see Figure 1). The Clary Dump was constructed in one lift and is estimated to consist of approximately 2 million tonnes of rock. Clary Dump was re-sloped and re-vegetated in 1997. The Patsy Dump is larger, containing an estimated 29 million tonnes of rock and was constructed by free dumping and single lift methods. It was partly re-graded and re-vegetated in 1997. Both dumps contained a mixture of hornfels and intrusives.
1.3 Regulatory Context

The program has been designed following the guidelines as provided in Price (1997) and Price and Errington (1998) issued by the B.C. Ministry of Energy, Mines and Petroleum Resources (MEMPR) and recent experience gained from other British Columbia porphyry projects including Red Chris Project (RCDC 2004), Galore Creek Project (Novagold 2008) and Prosperity Project (Taseko Mines 2009).

1.4 Regulatory Consultation

Regulatory consultation for the ML/ARD characterization work for the project has consisted of:

- Two full-day presentations, one at the Ministry of Energy and Mines (MEM) in Victoria, BC and the other to the Ministry of Environment (MoE) in Smithers, BC both in June, 2010. These presentations included a one to two hour presentation on the ML/ARD program and initial results with question and answer periods.
- A one-day EA Working Group session on the Environmental Baseline Work Program for the project in Terrace, BC in October, 2010. This too included a one-hour section on the ML/ARD work plan.

In addition to presentations, comments from the MEM and MoE have been received on the draft Application Information Requirements (dAIR) document for the Kitsault Mine Project, with responses currently being compiled.
1.5 Chronology of Investigations Relevant to ML/ARD

1.5.1 Exploration

According to Wardrop (2009), molybdenum was first reported in the Alice Arm region during World War I, when a limited quantity of molybdenite was produced from the Tidewater property. At approximately the same time, molybdenite was reported in the Kitsault and Roundy Creek areas. Serious interest in the Kitsault area began in 1956 when Kennco Explorations (Western) Ltd. (Kennco) examined the property and optioned it the next year.

Kennco began mining the property in 1968, based on their reserve of 36 Mt with an average grade of 0.138% Mo (0.23% MoS2). Mining was terminated in 1972 due to low metal prices. Climax Molybdenum Company of British Columbia (CMC) purchased the property in 1973 and returned it to production in 1981 based on an expanded reserve of 142 Mt with an average grade of 0.109% Mo (0.182% MoS2). Production was again terminated because of low metal prices in 1982. During these two periods of production approximately 30 Mtbs of molybdenum was produced (BC MINFILE Report number 103P 120).

Bell Moly was recognized as a molybdenum property in 1965 by Mastedon Highland Bell Mines and Leitch Gold Mines who later formed Bell Molybdenum Mines that was subsequently purchased by CMC in 1975. Drilling by both companies identified a resource of 96.4 Mt with an average grade of 0.054% Mo (0.09% MoS2). Drilling by Silurian Chieftain Minerals at Roundy Creek during the late 1960s resulted in a resource of about 7 Mt with an average grade of 0.066% Mo (0.11% MoS2). Subsequent work by Amax of Canada Ltd. (Amax) resulted in a 1983 resource estimate of 4.24 Mt at an average grade of 0.129% Mo (0.215% MoS2), found in three separate zones.

CMC purchased the property in 1975. CMC transferred the Kitsault property (including Bell Moly and Roundy Creek) to Amax who eventually moved the property to its Alumax division. Alumax was eventually spun-off to Amax shareholders and later purchased by Alcoa, which was renamed ALI. Avanti had previously signed a Definitive Purchase and Sales Agreement with ALI, to acquire an undivided, 100% direct interest in the Kitsault mine and surrounding mineral tenures, located in northern British Columbia (BC), subject to a 120-day confirmatory due diligence period and regulatory approval (June 20, 2008 Press Release). The agreement structure required Avanti to pay US $20 M to ALI for a 100% interest in the KM property. ALI has a 1% Net Smelter Royalty (NSR) on future production subject to the right, within 90 days from the presentation of a Feasibility Study suitable for submission to international financial institutions, to elect to surrender the NSR in exchange for an additional US$10 M payment payable at Commercial Production or in Avanti shares at ALI's election. On October 20, 2008, Avanti announced that they had completed the purchase (on October 17, 2008) of the KM property. The KM property is held by Avanti’s wholly owned subsidiary, Avanti Kitsault Mine Ltd.

Avanti Kitsault Mine Ltd. has been conducted exploration, engineering and environmental evaluations on the project since this time to support feasibility level engineering and environmental permitting.

1.5.2 Historical ML/ARD

ML/ARD characterization data is documented for the project as early as 1982 and was initiated by Amax and is limited to pit samples in specific benches representing hornfels and intrusive. Testing
at this stage was limited to acid base accounting. The details of the test methods are not known, though the data are available.

The second phase of testwork occurred to support closure and reclamation work and was conducted through the mid to late 1990s. The data available during this period represents pit samples primarily of intrusives with lesser samples representing hornfels rock. Samples during this period were also collected from both the Clary and Patsy waste rock dumps. Sampling was noted to be done by the Ministry of Energy Mines and Petroleum Resources (MEMPR), now the MEM and by SRK and in 1994 and 1996 respectively. Data available includes acid base accounting, some net acid generation (NAG) tests, shake flask extraction tests and humidity cell testwork. Results from this program are described in SRK (2003).

In addition to characterization of solids samples, site wide water monitoring is conducted twice a year in the spring (high flow conditions) and fall (base flow conditions). Included in this monitoring program are a number of locations that represent waste rock seepage and pit wall run-off. Results of this monitoring are provided to agencies in Annual Reclamation Reports for Reclamation Permit M-10 (MEM 2008), with the most recent report provided in SRK (2010).

1.5.3 Current

In July, 2009 SRK submitted a gap analysis and proposed geochemical program to Avanti that was developed to support feasibility engineering design and Environmental Assessment for the project. It is this program that forms the basis of the current work.

The sample set representing the current characterization efforts includes drill core and surface grab samples from the existing waste facilities that were collected in September, 2009 as well as additional samples provided as collected by Knight Piesold through their drilling program, and metallurgical tailings samples provided as they became available.

Static testwork was initiated in the fall of 2009 with kinetic testing beginning in January, 2010.

1.6 Geology

1.6.1 Setting

The Kitsault property contains three known Molybdenum deposits: Kitsault, Bell Moly and Roundy Creek, all located within the western margin of the Bowser Basin of the Intermontane tectonic belt a few kilometres east of the Coast Plutonic Complex (Figure 2). They are quartz monzonite batholithic-type intrusions where molybdenum mineralization has a lenticular shape and is generally hosted by the youngest phases of the batholiths. The Kitsault deposit (BC MINFILE 103P 120) is the focus of this study. It is a calc-alkalic, low-fluoride molybdenum deposit, similar to the Endako (BC MINFILE 093K 006) and Glacier Gulch (BC MINFILE 093L 107) deposits.

1.6.2 Rock Types

The host rocks are thermally-metamorphosed interbedded argillite and greywacke of the Upper Jurassic to Lower Cretaceous Bowser Lake Group (Hodgson 1995). The Bowser Lake greywackes typically consist of angular fragments of grey chert and rock fragments in a fine-grained matrix consisting of quartz and chert, plagioclase, chlorite, sercite and epidote. The less abundant argillite is dark grey to black and mineralogically similar to the greywacke matrix.
These sedimentary units have been regionally metamorphosed to biotite hornfels as a result of the intrusive events. Thermal metamorphism of these rock types near the intrusive contacts has produced a biotite hornfels aureole adjacent to the intrusive, and an outer, weak, albite-epidote hornfels zone extending up to 750 m away from the intrusive contact.

The intrusive lithologies are of the Lime Creek Intrusive Complex, Clary Creek Stock, and Roundy Creek intrusive complex. Intrusives associated specifically with molybdenum mineralization are multiphase diorite, quartz monzonite, and younger felsic units. The current block model identifies the intrusive as diorite and granodiorite. The geology of the Lime Creek property is shown on Figure 3. Cross-cutting relationships within the intrusive indicate that multiple mineralizing events took place, as well as post-mineralization intrusions. Molybdenum-bearing mineralization consists of a stockwork of quartz veins containing appreciable molybdenite and pyrite with minor scheelite, galena, sphalerite, chalcopyrite, Pb-Be sulphosalts, tetrahedrite and carbonate minerals.

Northeast-trending polymetallic quartz veining, subsequent to molybdenum-bearing mineralization events may contain chalcopyrite, tetrahedrite, pyrite, sphalerite, galena, Pb-Bi sulphosalts, molybdenite, fluorite and carbonate. Post mineralization lamprophyre and basalt dikes are also common within the deposit. Geological section through the pit, looking north is shown on Figure 4.

Alteration Assemblages

Alteration includes high temperature hydrothermal alteration in the form of an inner silicified zone and surrounding potassic zone (with plagioclase and biotite), and peripheral phyllic alteration (with quartz-pyrite-scheelite veins). Lower temperature hydrothermal alteration includes propylitic (with sericite and carbonate in the intrusive; and chlorite, calcite, epidote and sericite in the sedimentary rocks) and argillic alteration (with sericite and kaolin minerals and occasionally montmorillonite associated with faulting) throughout and peripheral to the ore body and into the sedimentary rocks overprinting the hornfels facies.

Average pyrite content in the deposit is estimated at 1%. Pyrrhotite, while rare, is present as disseminations in parts of the contact aureole. The foot-wall has less sulphide, as does the silicified core zone.

Primary gypsum is present in the deposit, mainly within the diorite unit. Based on logging and observation of the existing pit walls the gypsum distribution is believed to be quite local and clustered along fault/argillized zones. There is no evidence that there was ever a pervasive gypsum boundary (a "gypsum" line) as observed at other sites in the region (R. Blair (pers. comm. (Avanti)).

1.7 Mine Plan Assumptions

The mine plan assumptions for this study are largely those as presented in Wardrop (2009) and include an open pit mining method with a 40,000 tpd (14,600,000 tpa) conventional flotation circuit for processing of the molybdenum-bearing resource at Kitsault. The average head grade is anticipated to be 0.093% Mo, and the ore will consist of 3 rock types: monzonite (55%), diorite (25%), and hornfels (20%).

Included in the flotation circuit to recovery molybdenite is a separate de-sulphidation float which will produce a saleable sulphide (mainly pyrite) concentrate for recovery of silver. The final tailings for disposal will have low sulphide content and is designed to be non-PAG. The tailings will be discharged as a slurry to the tailings storage facility located in the Patsy Lake drainage (Figure 5). A cyclone system will be used to produce a coarse tailings product for upstream raise construction of
the southern dam. When not being cycloned, all the tailings will be slurried into the impoundment as a combined stream.

The anticipated mine life is 15 years, with one year of pre-stripping. During this time, it is anticipated that the operation will produce approximately 190 Mt of ore, 25 Mt of low grade ore and 162 Mt of waste rock. Waste rock is defined as having Mo grade less than 0.036%. Low grade ore is anticipated to have molybdenum grades between this value and 0.06%.

Low grade ore will be stockpiled in an area west of the open pit (Figure 5) and the waste rock will be placed into one facility immediately south of the tailings storage facility and upgradient of the open pit creating a buttress to the tailings dam.
Figure 2: Location and Regional Geology (from Avanti, 2009)
Figure 3: Property Geology Map

from Avanti Mining Inc. NO 43-101 Pre-feasibility Study – Avanti Mining Inc., Kitsault Molybdenum Property, British Columbia Canada Document No. 0954780100-REP-R0007-02, DECEMBER 15, 2009
Figure 4: Property Geology Map Typical Cross-Section

from Avanti Mining Inc. NO 43-101 Pre-feasibility Study – Avanti Mining Inc., Kitsault Molybdenum Property, British Columbia Canada Document No. 0954780100-REP-R0007-02, DECEMBER 15, 2009
Figure 5: Site Plan and Facility Layout
1.8 Organization of Report

This document is organized by section headings as follows:

- **Section 2**: Design of ML/ARD Characterization Program. This section provides the rationale for the program design including methods used and description of the sample sets.
- **Section 3**: Mineralogical Characterization. This section describes the mineralogy of the litho-alteration units associated with the deposit including the form of the key minerals of interest with respect to ML/ARD (namely sulphides and carbonates) and the observed effects of weathering from the existing waste rock.
- **Section 4**: Existing Facilities Characterization. This section describes all aspects of rock characterization, including site monitoring as well as the results and interpretations for static and kinetic testing for the existing facilities (waste rock and pit wall rock).
- **Section 5**: Future Waste Rock Characterization. This section describes all aspects of rock characterization, results and interpretations for static and kinetic testing of in-situ rock (drill core) representing future waste rock and pit wall rock.
- **Section 6**: Tailings Characterization. This section describes all aspects of tailings characterization for material produced from bench scale metallurgical tests.
- **Section 7**: Borrow Source Characterization. This section describes all aspects of characterization for potential quarry or borrow material currently anticipated for construction use.
- **Section 8**: Source Term Water Quality Predictions. This section provides the results of the predicted water quality from various facilities.
- **Section 9**: Conclusions.

1.9 Acknowledgements

This report was prepared by Shannon Shaw, P.Geo. (SRK Associate) and Stephen Day, P.Geo.(SRK), with input from other SRK personnel including Peter Healey, P.Eng., Michel Noel, P.Eng., Kirsty Ketchum, Ph.D. and Christina James, M.A.Sc.

The following organizations and individuals also contributed to the study:

- Avanti Mining Inc. – project geology, input to design of program, core sample selection assistance, field support.
- AMEC Engineering Inc. – block modeling and mine design.
- Knight Piesold Inc. – sampling assistance for quarry rock materials and existing waste rock drill cuttings.
- SGS Canada Inc. – chemical testing (static and kinetic).
- Department of Earth and Ocean Sciences, UBC – X-ray diffractometry and microprobe analyses of mineral grains; and
- Kathryne Dunne, P.Geo. – petrographic analysis.

1.10 Ongoing Studies

This report was prepared in December 2010 and January 2011 using data up to and including October 4, 2010. This cut-off date was selected to provide a point of reference and continuity with work presented in other reports used in the FS and EA documents. A number of tests, specifically the kinetic testing program and the field monitoring are ongoing. Results from the ongoing tests will be provided in subsequent addendums to this report.
2 Design of ML/ARD Characterization Program

2.1 Overall Design

The program objectives and design for the Kitsault ML/ARD characterization program were described in AMEC (2010) and summarized below.

The program objectives were to provide an assessment of the geochemical behaviour of the future waste rock piles, pit walls, and tailings associated with the Kitsault project and support engineering decisions and impact assessment evaluations for the proposed project. Specifically, for each of these site components, the program focussed on the quantification, description and assessment of:

- mineralogy,
- acid generation and neutralization potential,
- solids metal chemistry,
- metal leaching potential,
- rate of sulphide mineral oxidation,
- rate of depletion of neutralization potential,
- relative rate of depletion of neutralization potential compared to acid potential; and,
- release rates of elements for input into water quality predictions.

The overall components of the characterization included:

- Bulk characterization: this component involves collection of bulk chemical information, for instance acid generating potential, elemental content, mineralogy etc. for anticipated waste rock, tailings, pit wall exposures etc. This is correlated to geological features and mine plans.
- Weathering characterization: this component evaluates the relationships between bulk characteristics and release rates of major and minor rock components of interest for all planned facilities and exposures. The results are used to define waste management criteria and development of input data for water quality predictions.
- Water quality predictions: this component integrates results for the prediction of water chemistry for individual sources, such as the tailings, waste rock, construction rock, pit walls etc. These predictions are cast such that they can be integrated into site-wide water and mass balances and water management planning.

2.2 Design Details

2.2.1 Overview

The program for geochemical characterization to support the proposed project draws on previous evaluations and monitoring at the site as well as detailed characterization of drill core representing rock that will be excavated in the proposed mine plan and metallurgical tailings. The program was designed using experience on similar projects SRK has performed in recent years in B.C. including Red Chris Project, Galore Creek Project and Prosperity Project. All three are porphyry deposits with comparable geological, mine and waste management features in the same regulatory environment as Kitsault Project. These projects received provincial regulatory approvals and are therefore considered a good indication of the level of effort needed to support EA and permitting.

The approach used was to design a program with reference to each mine facility then compare the identified data needs with existing dataset collected as part of closure planning for the project in the 1990s. The program was then defined to bridge any gaps between the project design and the
available data. The resulting program is summarized in the sections below for each of the main facilities/material sources.

2.2.2 Waste Rock

The geochemical program for waste rock was developed to assess a number of questions as summarized in Table 1. These pertain to:

- The bulk characteristics of the waste rock and the site-specific application of ML/ARD potential predictive methods,
- The variability of bulk characteristics in the waste rock and within specific units of waste rock,
- The potential effects of blasting on these bulk characteristics,
- The distribution and scheduling of specific units of waste rock,
- The ability to effectively and accurately segregate waste rock with varying bulk characteristics and the development of specific ARD and ML segregation criteria,
- The anticipated lag time, or timing to the onset of acidic drainage,
- The chemistry of run-off and seepage associated with the stored waste rock, both in the buffered and acidic pH conditions, and
- The potential effect of placement of weathered rock below water.

The sampling conducted and analytical program developed drew upon samples of weathered waste rock from the existing waste dumps, the existing drill core assay database and on drill core samples selectively targeted to assess the median and upper range of anticipated future waste production with respect to sulphide content. Methods utilized included detailed mineralogical work (quantitative XRD, petrography and electron probe micro analysis), expanded acid base accounting, element scans, net acid generation (NAG) testing, leach extraction testwork (single and sequential), reductive dissolution tests and kinetic testing in standard humidity cells and sub-aqueous columns. Sampling and analytical methods are described in more detail as related to existing weathered waste rock and future waste rock represented by drill core in the following sub-sections.
<table>
<thead>
<tr>
<th>Geochemical Questions</th>
<th>Data Needed</th>
<th>Methods</th>
</tr>
</thead>
<tbody>
<tr>
<td>Site-specific application of ML/ARD potential methods</td>
<td>Lithological &amp; alteration composition of waste rock tonnages, correlation with ABA &amp; metals</td>
<td>Core sampling, ABA and metals analysis, block model, waste scheduling</td>
</tr>
<tr>
<td></td>
<td>Occurrences of minerals (types, crystal form, occurrence)</td>
<td>Review of drillcore logs, existing mineralogical information, petrography</td>
</tr>
<tr>
<td></td>
<td>Mineralogical occurrence of critical contaminants</td>
<td>SEM-EDX</td>
</tr>
<tr>
<td></td>
<td>Mineralogy of carbonates as well as Ca, Mg and Fe content needs to be determined to allow interpretation of TIC content and refinement of block model NP</td>
<td>Petrography, XRD (with Rietveld refinement), SEM-EDX/microprobe for composition</td>
</tr>
<tr>
<td></td>
<td>Mineralogy of sulphate minerals and proportion of total sulphur to allow interpretation of total S content and refinement of block model NP</td>
<td>Petrography, XRD (with Rietveld refinement), ABA</td>
</tr>
<tr>
<td>Effect of blasting on ARD potential (particle size effects)</td>
<td>ABA in particles sizes</td>
<td>Existing waste rock dump sampling, ABA, metals on size fractions</td>
</tr>
<tr>
<td>Waste Distribution, release schedules</td>
<td>Spatial variation of ML/ARD measures on project scale</td>
<td>Core sampling, ABA and metals analysis</td>
</tr>
<tr>
<td>Ability to accurately segregate wastes</td>
<td>Spatial variation of ML/ARD measures on bench scale</td>
<td>Continuous core sampling of selected holes, ABA and metals analysis.</td>
</tr>
<tr>
<td>Development of ARD Criteria</td>
<td>Rate of depletion of sulphides and acid neutralizing minerals and correlation with bulk characteristics</td>
<td>Humidity cells, field weathering observations of analogues</td>
</tr>
<tr>
<td>Development of ML Segregation Criteria</td>
<td>Rate of release of contaminants and correlation with bulk characteristics</td>
<td>Humidity cells, field weathering observations of analogues</td>
</tr>
<tr>
<td>Variability in characteristics of wastes</td>
<td>Lithological composition of waste rock as pile changes with time</td>
<td>Core sampling, ABA and metals analysis, block model, waste scheduling</td>
</tr>
<tr>
<td></td>
<td>Chemical composition of waste rock</td>
<td></td>
</tr>
<tr>
<td>Timing of acidic drainage</td>
<td>Rate of depletion of sulphides and acid neutralizing minerals</td>
<td>Humidity cells, field weathering observations of analogues</td>
</tr>
<tr>
<td>Chemistry of seepage and runoff (non-acidic, acidic)</td>
<td>Rate of release under non-acidic and acidic conditions</td>
<td>Humidity cells, field weathering observations of analogues</td>
</tr>
<tr>
<td></td>
<td>Site water quality database to calibrate water chemistry estimated from laboratory tests.</td>
<td>Existing maps and water quality monitoring database</td>
</tr>
<tr>
<td></td>
<td>Water balance for waste rock</td>
<td>Hydrological evaluations</td>
</tr>
<tr>
<td></td>
<td>Water Chemistry Prediction</td>
<td>Modeling</td>
</tr>
<tr>
<td>Effect of submergence on pit water quality</td>
<td>Lithological composition of waste rock as pile changes with time</td>
<td>Core sampling, ABA and metals analysis, block model, waste scheduling</td>
</tr>
<tr>
<td></td>
<td>Chemical composition of waste rock</td>
<td></td>
</tr>
<tr>
<td></td>
<td>Quantities and types of secondary minerals formed during weathering</td>
<td>Humidity cells, leach tests on existing waste rock</td>
</tr>
<tr>
<td></td>
<td>Rate of dissolution upon submergence</td>
<td>Leach tests on existing waste rock</td>
</tr>
<tr>
<td></td>
<td>Rate of dissolution after submergence (reductive dissolution)</td>
<td>Leach tests, sequential extractions on existing waste rock, column tests</td>
</tr>
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</table>
Existing Dumps

The existing waste rock dumps are relatively small in comparison to those proposed for the new mine plan and have been reclaimed now for approximately a decade. The Clary Dump will not be disturbed and the Patsy Dump will effectively be over-dumped completely with the new waste rock. Therefore they are in large part fairly distinct from the proposed project. The SRK report completed in 2003 provides maps of the Clary and Patsy Dump delineating the exposure of rock types on the surface (Figures 5-14 and 5-15 of SRK 2003). Based on these maps, and assuming that the surface is generally an accurate representation of the volume of waste within each dump, it would be expected that most of the rock in the existing dumps is comprised of intrusives, at least three-quarters of the rock exposed. The remainder quarter (or less) is comprised of hornfels, both mineralized and unmineralized. Given that the proposed mine plan will produce rock types that are generally similar to previous mining, these materials provide good analogs of anticipated waste rock. The most marked difference between the existing and anticipated waste rock is possibly that the cut-off grades have changed since previous mining operations such that the existing waste rock likely has a higher average Mo grade than that which will be produced. In this manner, the existing waste rock is also an analog for the anticipated low grade ore production.

A significant component of the current program therefore has focussed on characterization of the existing weathered waste rock. While the historical sampling for ML/ARD characterization included sampling of the existing dumps (Section 1.5.2), the bulk of the work in this program has focussed on samples collected since 2009 to ensure consistency in methodologies and data quality. For the current study, nine large samples were selectively collected from the surface of the existing waste rock piles that were visually noted to consist predominantly of one rock type and/or show signs of weathering. Also, 89 drill cutting samples collected by Knight Piesold from the Patsy Dump were submitted for geochemical characterization as part of the current program. Descriptions of these samples are provided in Section 4.2.4 and the drill logs for the samples collected from drilling in Patsy Dump are provided in Appendix B.

Weathered waste rock samples were particularly relevant to some of the key questions with respect to the waste rock geochemistry. Specifically, the large grab samples from the existing waste dumps were used to assess the partitioning of various minerals into specific particle size fractions to assess the effects of blasting on ARD potential (Section 4.1.3). Further, mineralogical evaluations of the weathered waste rock provide an assessment of the effects of weathering on individual mineral phases as well as the rocks as a whole to assist in the longer term predictions that need to account for mineralogical changes (Section 3.5). Due to the robust seepage monitoring data in particular, the existing waste dumps serve as large scale field tests and provide an assessment of kinetics that cannot be evaluated in a laboratory program at the same scale or duration (Section 4.1.3). The seepage dataset will also provide a basis for calibrating scaling calculations for source term predictions (Section 8.2).

The weathered waste rock also provided a medium on which assessments of reductive dissolution could be conducted. This allowed for an evaluation of the potential for re-distribution of elements in weathered waste rock in a reducing environment such as submergence below water in the open pit etc. (Section 4.2.4).
Proposed Dump

The proposed mine plan includes the production of approximately 162 Mt of waste rock that will be placed north of the pit between the open pit and the tailings storage facility in the Patsy drainage. It will consist of a mixture of intrusives and hornfels rock with a Mo grade less than 0.036%.

Bulk characterization of the waste rock that will be produced under the proposed mine plan has focussed on the characterization of various ARD and ML parameters. This has included detailed assessment of the form of sulphur minerals (Section 3.3) as well as buffering mineralogy (Section 3.4).

Most of the waste rock associated with the project has relatively simple sulphide mineralogy, though the diorite unit contains sulphate, as gypsum (Section 3.3). Since these minerals are highly soluble, they mask the release of sulphate from oxidation of sulphide minerals. This was considered in the interpretation of kinetic release rates of sulphate (Section 5.3.3).

The assessment of neutralization potential included use of different methods to measure neutralization potential, measurement of total carbonate content, determination of mineralogical forms of carbonate and analyses of carbonate mineral grains to estimate the composition of different types of carbonate minerals (Section 3.4). The different methods were compared and used to estimate the various components of neutralization potential (Section 5.3.2).

Consistently, geochemical characterization work for the project has indicated that the vast majority of waste rock currently has and will continue to have a low ratio of neutralization potential to acid potential (NP/AP), i.e. less than 2. Most guidelines would classify the waste rock as having the potential to generate acid (Section 5.3.2). A significant lag time, however, prior to the onset of acidic conditions has been demonstrated by the existing facilities; with expectations to date being that the lag time would last for a few to possibly many decades. Predicting and subsequent planning for eventualities extended so far into the future is difficult. The current program has focussed substantially on quantifying, describing and defining site specific parameters for the potential for ARD and for the kinetics associated with that, i.e. the lag time (Section 5.3.3). This has taken the form of very specific drill core sampling of the main lithological and alteration units (48 samples) with detailed ABA, metals and mineralogical characterization. The current program also includes kinetic testing on a robust suite of 20 waste rock samples (and three low grade ore samples) covering each of these main litho-alteration units with sulphur contents representing the median and 95th percentile for each unit.

The extensive exploration drill core assay dataset has also been relied upon to assess and correlate ARD and ML parameters with lithological and alteration controls on a wider scale (Section 5.3.2). Integration of surrogate acid potential (AP) and neutralization potential (NP) values into the block model allowed for an assessment of the spatial variation in ML/ARD characteristics on a deposit scale and on a bench scale.

The proposed mine plan does not include segregation of waste rock into more than one storage facility, though correlations of bulk characteristics to potential for ARD in order to classify rock into potentially ARD generating (PAG) and non-potentially ARD generating (non-PAG) rock categories were completed (Section 5.3.2). Estimates of the delay to onset of acid generation were also required to provide guidance of acceptable exposure times for management of PAG rock. These questions relate primarily to the kinetics of weathering. Therefore, the kinetic test program (Section 5.3.3) was designed to allow correlation of sulphide content to sulphide oxidation rates.
using a range of rock samples representing different levels of sulphide content (the primary variable controlling ARD generation) and rock type (representing different types of minerals).

Contaminant release rates that will be required for water quality predictions were estimated through a kinetic testing program (Section 5.3.3). This included both humidity cells and sub-aqueous columns. The kinetic test program was designed to characterize release rates for a wide range of metal, metalloid and non-metal concentrations and to correlate these with lithology, alteration, other bulk characteristics and mineralogy.

### 2.2.3 Run-of-Mine Ore Stockpile and Low Grade Ore Stockpile

Both the run-of-mine (ROM) ore and low grade ore will be stockpiled for varying degrees of time. Table 2 provides a summary of the geochemical questions that were focussed on to develop the characterization program to assess the ML/ARD potential associated with the ore stockpiles. In a general sense, the program to assess ore is an extension of the program described above for the evaluation of the geochemical characteristics of waste rock and associated implications. The key questions that were assessed focussed on:

- The bulk characteristics and variability of the ore and the site-specific application of ML/ARD potential predictive methods,
- The anticipated lag time, or timing to the onset of acidic drainage, and
- The chemistry of run-off and seepage associated with the ore stockpiles, both buffered and acidic pH conditions.

#### Table 2: Overview of Testwork Conducted on Low Grade Ore and Ore

<table>
<thead>
<tr>
<th>Geochemical Questions</th>
<th>Data Needed</th>
<th>Methods</th>
</tr>
</thead>
<tbody>
<tr>
<td>Variability in characteristics of LGO</td>
<td>Lithological composition of LGO as pile changes with time</td>
<td>Update of block model (if required), mine plan</td>
</tr>
<tr>
<td></td>
<td>Chemical composition of LGO</td>
<td></td>
</tr>
<tr>
<td>Timing of acidic drainage</td>
<td>Rate of depletion of sulphides and acid neutralizing minerals</td>
<td>Humidity cells, field weathering observations of analogues</td>
</tr>
<tr>
<td>Chemistry of seepage and runoff (non-acidic, acidic)</td>
<td>Rate of release under non-acidic and acidic conditions</td>
<td>Humidity cells, field weathering observations of analogues</td>
</tr>
<tr>
<td></td>
<td>Site water quality database to calibrate water chemistry estimated from laboratory tests.</td>
<td>Existing maps and water quality monitoring database</td>
</tr>
<tr>
<td></td>
<td>Water balance for waste rock</td>
<td>Hydrological evaluations</td>
</tr>
<tr>
<td></td>
<td>Water Chemistry Prediction</td>
<td>Modeling</td>
</tr>
<tr>
<td>Variability in characteristics of Ore</td>
<td>Lithological composition of ore as mining proceeds</td>
<td>Update of block model (if required), mine plan</td>
</tr>
<tr>
<td></td>
<td>Chemical composition of Ore</td>
<td></td>
</tr>
<tr>
<td>Timing of acidic drainage</td>
<td>Rate of depletion of sulphides and acid neutralizing minerals</td>
<td>Humidity cells, field weathering observations of analogues</td>
</tr>
<tr>
<td>Chemistry of seepage and runoff (non-acidic, acidic)</td>
<td>Rate of release under non-acidic and acidic conditions</td>
<td>Humidity cells, field weathering observations of analogues</td>
</tr>
<tr>
<td></td>
<td>Site water quality database to calibrate water chemistry estimated from laboratory tests.</td>
<td>Existing maps and water quality monitoring database</td>
</tr>
<tr>
<td></td>
<td>Water balance for ore stockpile</td>
<td>Hydrological evaluations</td>
</tr>
<tr>
<td></td>
<td>Water Chemistry Prediction</td>
<td>Modeling</td>
</tr>
</tbody>
</table>
The geochemical characterization program for low grade ore therefore draws upon the characterization of existing weathered waste rock which was mined at a higher cut-off grade than that in the current proposed mine plan (Section 4) as well as from drill core sampled from the 2008 drilling program and the assay database (Section 5). The program itself is generally an extension of the waste rock program described above.

Historical sampling of the low grade ore stockpile produced in previous operations included 18 samples which have been characterized (Section 4.1.3). Further, the exploration drillcore database has been used to extrapolate the bulk chemistry of future produced ROM and low grade ore by litho-alteration type (Section 5.3) and the variability of key parameters in these units.

Seepage monitoring around the low grade ore stockpile has provided a key component of information necessary to assess anticipated contact water chemistry associated with low grade ore in particular (Section 4.1.3).

### 2.2.4 Pit Walls

As with the program for the waste rock and ore, the geochemical program to evaluate the pit wall rock was derived to assess a number of key geochemical questions (Table 3). These included:

- The lithological exposure of the pit walls during mining and the bulk characteristics and variability of these units,
- The anticipated lag time, or timing to the onset of acidic drainage in exposed pit wall rock,
- The anticipated contaminant release rates associated with exposed pit wall rock in both buffered and acidic conditions,
- The chemistry of run-off and pit water during filling and overflow, and
- The potential effect of submergence of weathered rock below water in a flooded pit.

<table>
<thead>
<tr>
<th>Geochemical Questions</th>
<th>Data Needed</th>
<th>Methods</th>
</tr>
</thead>
<tbody>
<tr>
<td>Variability in characteristics of pit walls</td>
<td>Lithological composition of pit walls as mine proceeds</td>
<td>Geological model and mine plan</td>
</tr>
<tr>
<td></td>
<td>mineralogical and geochemical characteristics of waste units</td>
<td>See waste rock program</td>
</tr>
<tr>
<td>Contaminant release rates for non-acidic and acidic conditions (on a rock type basis)</td>
<td>Rate of release of contaminants</td>
<td>See waste rock program</td>
</tr>
<tr>
<td>Chemistry of runoff</td>
<td>Seepage from pit walls</td>
<td>See waste rock program</td>
</tr>
<tr>
<td></td>
<td>Chemistry of inflow waters</td>
<td>Existing water quality monitoring database</td>
</tr>
<tr>
<td></td>
<td>Water balance for the pit</td>
<td>Hydrological evaluations</td>
</tr>
<tr>
<td></td>
<td>Water Chemistry Prediction</td>
<td>Modeling</td>
</tr>
<tr>
<td>Chemistry of pit water during filling and overflow</td>
<td>Runoff chemistry predictions</td>
<td>See waste rock program</td>
</tr>
<tr>
<td></td>
<td>Loading from submerged walls</td>
<td></td>
</tr>
<tr>
<td></td>
<td>Chemistry of inflow waters</td>
<td>Existing water quality monitoring database</td>
</tr>
<tr>
<td></td>
<td>Water balance for the pit</td>
<td>Hydrological evaluations, pit water stratification assessment</td>
</tr>
<tr>
<td></td>
<td>Water Chemistry Prediction</td>
<td>Modeling</td>
</tr>
</tbody>
</table>
The program designed to characterize the pit walls was also an extension of that for the waste rock. This included 31 samples from the existing, weathered pit walls (Section 4.1.3) as well as fresh drill core that is considered representative of anticipated exposed pit walls for the proposed project (Section 5.3).

The block model has been utilized to provide an expected pit wall configuration by lithology, with the exploration drillcore database being used to extrapolate the bulk chemistry of these exposed bulk characteristics (Section 5.3).

Seepage monitoring at a number of locations within the pit both prior to and following reclamation of the existing pit provided key observations of contact water chemistry in both neutral and acidic pH conditions (Section 4.1.3). This dataset therefore provides a basis for calibration of water quality predictions for pit-run-off (SRK, in progress).

### 2.2.5 Tailings

The geochemical questions specific to the tailings for the proposed mine plan are summarized in Table 4.

- The bulk characteristics of the tailings and the site-specific application of ML/ARD potential predictive methods and classification criteria.
- The release rates of contaminants from tailings exposed on the beaches and unsaturated portions of the facility on closure.
- The release rates of contaminants from saturated tailings and the effect on water quality.
- The potential for release of contaminants and effect on run-off from the cyclone tailings used for upstream construction of the tailings dam.
- The predicted chemistry of the process pond and seepage from the tailings storage facility.

The work program for characterizing tailings was designed to include all potential tailings streams and scenarios. This included samples produced from of specific ore types and composite ore, whole tailings, rougher scavenger and cleaner tailings streams, de-sulphidized tailings and cyclone underflow and overflow streams (Section 6.1). Samples were generated in a number of metallurgical testing rounds and were tested in both subaerial and subaqueous environments.

Bulk characterization of various tailings products produced from metallurgical tests has focussed on specific mineral forms of sulphides and carbonates and metal scans. Partitioning of various components into specific tailings streams (cleaner versus rougher tails, cyclone underflow versus overflow etc.) has been evaluated. This allows for an assessment of the expected partitioning of the same variables in the discharged environment.

Contaminant release rates that will be required for water quality predictions for the facility were evaluated through a kinetic testing program (Section 6.3.4). This included both standard humidity cells and sub-aqueous columns. The kinetic test program was designed to characterize release rates for a wide range of metal, metalloid and non-metal concentrations in the different tailings streams.
Table 4: Overview of Testwork Conducted on Metallurgical Tailings

<table>
<thead>
<tr>
<th>Geochemical Questions</th>
<th>Data Needed</th>
<th>Methods</th>
</tr>
</thead>
<tbody>
<tr>
<td>Site-specific application of ML/ARD</td>
<td>ABA characteristics for various ore types</td>
<td>ABA, metals etc.</td>
</tr>
<tr>
<td>potential methods</td>
<td>Occurrences of minerals (types, crystal form, occurrence)</td>
<td>Review of drillcore logs, existing mineralogical information, petrography</td>
</tr>
<tr>
<td></td>
<td>Mineralogical occurrence of critical contaminants</td>
<td>SEM-EDX</td>
</tr>
<tr>
<td></td>
<td>Mineralogy of carbonates as well as Ca, Mg and Fe content needs to be</td>
<td>Petrography, XRD (with Rietveld refinement), SEM-EDX/microprobe for composition</td>
</tr>
<tr>
<td></td>
<td>determined to allow interpretation of TIC content and refinement of block model NP</td>
<td></td>
</tr>
<tr>
<td></td>
<td>Mineralogy of sulphate minerals and proportion of total sulphur to allow</td>
<td>Petrography, XRD (with Rietveld refinement), ABA</td>
</tr>
<tr>
<td></td>
<td>interpretation of total S content and refinement of block model</td>
<td></td>
</tr>
<tr>
<td></td>
<td>ML/ARD Criteria</td>
<td></td>
</tr>
<tr>
<td></td>
<td>Rate of depletion of sulphides and acid neutralizing minerals</td>
<td>Humidity cells</td>
</tr>
<tr>
<td></td>
<td>Rate of release of contaminants</td>
<td>Humidity cells</td>
</tr>
<tr>
<td>Effect of beaches and unsaturated</td>
<td>Rate of release of contaminants of interest</td>
<td>Humidity cells</td>
</tr>
<tr>
<td>tailings on water quality</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Effect of saturated tailings on water</td>
<td>Rate of release of contaminants of interest</td>
<td>Saturated Columns</td>
</tr>
<tr>
<td>quality</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Chemistry of Process Pond</td>
<td>Water Balance for Pond</td>
<td>Hydrological</td>
</tr>
<tr>
<td></td>
<td>Water Chemistry Prediction</td>
<td>Modelling</td>
</tr>
<tr>
<td>Chemistry of Seepage</td>
<td>Hydrogeological model</td>
<td>Hydrological evaluations</td>
</tr>
<tr>
<td></td>
<td>Water Chemistry Prediction</td>
<td>Modeling</td>
</tr>
</tbody>
</table>

2.3 Sample Set Summary

Table 5 below provides a summary of the number of samples from each of the various facilities that were evaluated by the specific test methods utilized in the program (both historic and current programs).
Table 5: Summary of Sample Numbers by Test Type and Facility

<table>
<thead>
<tr>
<th>Mineralogy</th>
<th>ABA</th>
<th>Metals</th>
<th>NAG</th>
<th>SFE</th>
<th>Sequential MWMP</th>
<th>Reductive Dissolution</th>
<th>Humidity Cell</th>
<th>Sub-aqueous Column</th>
</tr>
</thead>
<tbody>
<tr>
<td>Weathered Pit Wall Rock</td>
<td>31</td>
<td></td>
<td>7</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Weathered Low Grade Ore</td>
<td>18</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>In Situ Low Grade Ore</td>
<td>3</td>
<td>3</td>
<td>3</td>
<td></td>
<td></td>
<td></td>
<td>3</td>
<td></td>
</tr>
<tr>
<td>(drill core)</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>In Situ Ore (drill core)</td>
<td>4</td>
<td>4</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td>1</td>
<td></td>
</tr>
<tr>
<td>Weathered Waste Rock</td>
<td>9</td>
<td>140</td>
<td>85</td>
<td>9</td>
<td>21</td>
<td>9</td>
<td>6</td>
<td>2</td>
</tr>
<tr>
<td>(drill core)</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>In Situ Waste Rock</td>
<td>20</td>
<td>45</td>
<td>45</td>
<td>20</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>(drill core)</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Metallurgical Tailings</td>
<td>5</td>
<td>12</td>
<td>12</td>
<td>3</td>
<td></td>
<td></td>
<td>4 (+duplicate)</td>
<td>1 (+duplicate)</td>
</tr>
<tr>
<td>Construction Rock</td>
<td>18</td>
<td>18</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td>2</td>
</tr>
</tbody>
</table>

2.4 Quality Control Measures and Results

Quality control measures consisted of lab duplicates for static test procedures, particularly acid base accounting and metal assays. Relative percent differences were calculated comparing the original and duplicate samples and if within ±20% were considered acceptable. For ABA results, RPD values were typically within ±5% for duplicates. For metal analyses, the RPD values were more variable, though generally within the ±20% guidelines. Results outside the accepted RPD values were usually for metals present at very low levels where small variations can represent large relative differences.

Net acid generation (NAG) tests were conducted with blanks to assess potential contamination with the reagent addition. Analyses on blanks for the NAG test indicated contamination introduced with the reagent for the parameters chromium, nickel, sodium, phosphorus and tin such that the results of these parameters in NAG leachate are considered invalid.

Quality control on water samples were evaluated by assessment of ion balances. Generally if within ±20% difference, results were accepted. When outside of this range, re-analyses and/or confirmations were requested from the lab.

The kinetic program also included one duplicate cell for the tailings samples tested which represents a true split sample (T1 and T2 for reference), as well as another duplicate for waste rock that represents two samples taken from consecutive intervals (3 m each) of 6 m section of diorite with very similar values of parameters of interest (HC5 and HC6 for reference) rather than a blended and split sample. Results to date are similar and described in Sections 5.3.3 and 6.3.4 below.

Results of the quality control program are generally provided with the results for each corresponding test. Calculated RPD values for static results are however provided in Appendix I.
3 Mineralogical Characterization

3.1 Methods

Polished thin sections of selected samples for mineralogical characterization were prepared by Vancouver Petrographics Ltd. These sections and offcut mounts were evaluated by Kathryn Dunne, P.Geo. The primary objectives were to evaluate the mineralogy with particular emphasis on sulphide minerals and any carbonate minerals present.

X-Ray Diffractometry (QXRD) was conducted at the Department of Earth and Ocean Sciences at the University of British Columbia. Samples were reduced into fine powder to the optimum grain-size range for X-ray analysis (<10μm) grinding under ethanol in a vibratory McCrone Micronising Mill for 7 minutes. Step-scan X-ray powder-diffraction data were collected over a range 3-80°2θ with CoKα radiation on a standard Siemens (Bruker) D5000 Bragg-Brentano diffractometer equipped with an Fe monochromator foil, 0.6 mm (0.3°) divergence slit, incident- and diffracted-beam Soller slits and a Vantec-1 strip detector. The long fine-focus Co X-ray tube was operated at 35 kV and 40 mA, using a take-off angle of 6°.

Electron Probe Micro-Analysis (EPMA) was also conducted at the Department of Earth and Ocean Sciences at the University of British Columbia with specific objectives of evaluating the carbonate composition by electron microprobe. Carbonate grains were selected visually from polished thin sections.

3.2 Bulk Mineralogy

QXRD conducted on weathered waste rock samples obtained from Patsy and Clary Dumps was generally consistent between samples identified as predominantly hornfels and those identified as predominantly intrusives.

All samples were largely comprised of quartz (~40-50%), plagioclase (5-25%) and K-feldspar (10 40%), with minor though consistent amounts of calcite (1-3%), clinoclore (1 – 3%), muscovite (2 10%) and pyrite (0.5 to 3%). Hornfels samples typically had greater plagioclase than K-feldspar while the intrusive samples had relatively more K-feldspar. Other minerals identified included andradite garnet, ankerite, boehmite, kaolinite and in one sample sphalerite. QXRD results are summarized in Table 6 and full results are provided in Appendix A. Petrographic analyses are provided in Appendix B.

3.3 Occurrence and Form of Sulphur

In polished thin sections, sulphides noted in addition to pyrite and pyrrhotite included sphalerite, molybdenite, marcasite, chalcopyrite, galena and arsenopyrite, though for all but pyrite, these were present in only trace amounts.

Pyrite was noted to comprise 1 to 7% of the samples based on a visual estimate. Sulphide textures varied from unaltered to having fine alteration rims and were generally liberated anhedral grains <0.3 mm in diameter. Less commonly, pyrite also occurred as medium-grained patches in quartz vein chips. Pyrrhotite when noted, was most evident in hornfels samples and is also fine grained and disseminated. It was commonly rimmed and replaced by red-brown iron oxides. For rock that
has been exposed to weathering conditions for more than 20 years, the degree of oxidation noted was fairly limited (Figure 6).

Sulphate minerals were only identified by QXRD in fresh drill core samples. Drill core samples included the sulphate mineral gypsum in roughly half of the diorite samples evaluated by QXRD, with values up to 6.5%. A small amount was also identified in one of the Northeast Porphyry samples, though at much lower amounts (0.8%). None was identified in any other rock types.

A comparison of total sulphur measured on drill core via ICP-MS for the entire assay database versus sulphate sulphur on the same core show the same relationship, i.e. that it is the diorite unit predominantly that contains sulphate, with negligible amounts in the other rock units (Figure 7). Anhydrite was also identified by QXRD in one of the diorite samples. No sulphate minerals were identified in the weathered waste rock samples. This may suggest either sulphate minerals have been leached from the dump surfaces where most samples were collected, or current waste rock dumps contain only a small proportion of the diorite rock type as one of the intrusive waste rock types (note diorite is predominantly ore as described further in Section 5.3.2 below).
Table 6: Summary of Quantitative X-Ray Diffractometry Results (%)

<table>
<thead>
<tr>
<th>Mineral</th>
<th>Drill Core</th>
<th>Weathered Waste Rock</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>Units</td>
<td>Aplitie (n=1)</td>
</tr>
<tr>
<td></td>
<td></td>
<td>Min</td>
</tr>
<tr>
<td>Actinolite</td>
<td></td>
<td>-</td>
</tr>
<tr>
<td>Andradite</td>
<td></td>
<td>-</td>
</tr>
<tr>
<td>Anhydrite</td>
<td></td>
<td>-</td>
</tr>
<tr>
<td>Ankerite</td>
<td></td>
<td>-</td>
</tr>
<tr>
<td>Anatase</td>
<td></td>
<td>-</td>
</tr>
<tr>
<td>Biotite</td>
<td></td>
<td>2.1</td>
</tr>
<tr>
<td>Boehmite</td>
<td></td>
<td>-</td>
</tr>
<tr>
<td>Calcite</td>
<td></td>
<td>0.2</td>
</tr>
<tr>
<td>Clinochlore</td>
<td></td>
<td>1.2</td>
</tr>
<tr>
<td>Dolomite</td>
<td></td>
<td>-</td>
</tr>
<tr>
<td>Gypsum</td>
<td></td>
<td>-</td>
</tr>
<tr>
<td>Kaolinite</td>
<td></td>
<td>0.9</td>
</tr>
<tr>
<td>K-feldspar</td>
<td></td>
<td>24.1</td>
</tr>
<tr>
<td>Lepidocrocite</td>
<td></td>
<td>-</td>
</tr>
<tr>
<td>Magnetite</td>
<td></td>
<td>-</td>
</tr>
<tr>
<td>Molybdenite</td>
<td></td>
<td>0.1</td>
</tr>
<tr>
<td>Montmorionitite</td>
<td></td>
<td>-</td>
</tr>
<tr>
<td>Muscovite</td>
<td></td>
<td>2.0</td>
</tr>
<tr>
<td>Plagioclase</td>
<td></td>
<td>22.7</td>
</tr>
<tr>
<td>Pseudorutile</td>
<td></td>
<td>-</td>
</tr>
<tr>
<td>Pyrite</td>
<td></td>
<td>1.4</td>
</tr>
<tr>
<td>Pyrrhotite</td>
<td></td>
<td>-</td>
</tr>
<tr>
<td>Quartz</td>
<td></td>
<td>44.7</td>
</tr>
<tr>
<td>Siderite</td>
<td></td>
<td>0.7</td>
</tr>
<tr>
<td>Sphalerite</td>
<td></td>
<td>-</td>
</tr>
</tbody>
</table>

Source: Department of Earth and Ocean Sciences, University of British Columbia (2010).
Figure 6: Typical oxidation of sulphides noted in petrographic evaluation (A) altered pyrrhotite grains enclosed by very fine-grained pyrite/marcasite aggregate. RL. FOV=~1.3mm; (B) liberated pyrite and sphalerite grains without alteration rims. RL. FOV=~2.6mm, (extracted from Appendix C).

Figure 7: Sulphate Sulphur versus Total Sulphur (by ICP-MS)
3.4 Occurrence and Form of Neutralization Potential

For this project, the assumption has been made that only carbonate minerals can provide useful neutralization potential at pH values above those needed to control the solubility of important metal contaminants. Although the rocks contain abundant silicate minerals, most of these are aluminous and cannot be expected to buffer pH significantly above pH 5 when reacting with sulphuric acid from sulphide mineral oxidation. The assessment of neutralization potential provided by carbonates had to consider the observation that several different carbonate minerals were expected to be present and that a component of the carbonates could be associated with iron and therefore potentially not effective as buffers above pH 7.

Carbonates were noted in thin section as typically fine, anhedral liberated grains similar in size to the sulphides (typically <0.3mm in size) but occasionally coarser (to 1.2 mm), and occasionally partly rimmed or replaced by red-brown iron oxides. Carbonates also occur as irregular patches within and fracture infill to quartz veins, and as irregular patches within the biotite hornfels. QXRD analyses identified that the dominant carbonate was calcite (undetected to up to 18.2% in a lamprophyre sample, average 2.5%), though ankerite and dolomite also occur in all rock types to variable degrees (averaging 2.0 and 1.8% respectively). In the diorite and lamprophyre samples, siderite was also identified but at lower levels (average 0.7%). Ankerite and calcite were identified in weathered samples, though no dolomite or siderite was noted in weathered material.

Because total carbonate analyses can over-estimate the effective or fast-reacting neutralization potential of a sample if significant iron and manganese carbonates are present, electron probe micro-analyses (EPMA) of 276 carbonate mineral grains from both fresh drill core and weathered waste rock representing the major rock units were conducted to assess the chemical composition of carbonate grains.

Of the 276 mineral grains analyzed in this manner, 67% were classified as calcite, and 33% were classified as dolomite. None were identified as ankerite or siderite suggesting that the ankerite identified in QXRD could be dolomite (i.e. with higher Mg than Fe) or that ankerite was too fine grained to be selected optically for XRD.

Average compositions of calcite and dolomite grains by rock type are provided in Table 7. Calcite grains contained low proportions of other cations (typically less than 5%). Dolomite grains from the hornfels unit had a slightly higher proportion of Fe than dolomite from the intrusives, though the grains still classified as dolomite rather than ankerite. Manganese was present at higher concentrations in dolomite compared to calcite.

The molar proportions of Ca, Mg and Mn+Fe are provided in Figure 8.
Table 7: Average Composition of Carbonate Minerals by Rock Type

<table>
<thead>
<tr>
<th>Rock Unit</th>
<th>Calcite [grain count]</th>
<th>Dolomite [grain count]</th>
</tr>
</thead>
<tbody>
<tr>
<td>Unweathered Diorite</td>
<td>Ca$<em>{0.96}$Mg$</em>{0.01}$Fe$<em>{0.01}$Mn$</em>{0.02}$CO$_3$ [n=51]</td>
<td>Ca$<em>{1.02}$Mg$</em>{0.77}$Fe$<em>{0.19}$Mn$</em>{0.11}$(CO$_3$)$_2$ [n=14]</td>
</tr>
<tr>
<td>Unweathered Granodiorite</td>
<td>Ca$<em>{0.96}$Mg$</em>{0.02}$Fe$<em>{0.01}$Mn$</em>{0.02}$CO$_3$ [n=29]</td>
<td>Ca$<em>{1.08}$Mg$</em>{0.71}$Fe$<em>{0.10}$Mn$</em>{0.11}$(CO$_3$)$_2$ [n=24]</td>
</tr>
<tr>
<td>Unweathered Hornfels</td>
<td>Ca$<em>{0.96}$Mg$</em>{0.01}$Fe$<em>{0.01}$Mn$</em>{0.02}$CO$_3$ [n=39]</td>
<td>Ca$<em>{1.05}$Mg$</em>{0.61}$Fe$<em>{0.29}$Mn$</em>{0.06}$(CO$_3$)$_2$ [n=36]</td>
</tr>
<tr>
<td>Unweathered Lamprophyre</td>
<td>Ca$<em>{0.96}$Mg$</em>{0.01}$Fe$<em>{0.01}$Mn$</em>{0.04}$CO$_3$ [n=23]</td>
<td>Ca$<em>{1.14}$Mg$</em>{0.66}$Fe$<em>{0.15}$Mn$</em>{0.06}$(CO$_3$)$_2$ [n=2]</td>
</tr>
<tr>
<td>Weathered Hornfels</td>
<td>Ca$<em>{0.96}$Mg$</em>{0.01}$Fe$<em>{0.01}$Mn$</em>{0.05}$CO$_3$ [n=21]</td>
<td>Ca$<em>{1.05}$Mg$</em>{0.66}$Fe$<em>{0.29}$Mn$</em>{0.09}$(CO$_3$)$_2$ [n=5]</td>
</tr>
<tr>
<td>Weathered Intrusives</td>
<td>Ca$<em>{0.96}$Mg$</em>{0.01}$Fe$<em>{0.01}$Mn$</em>{0.02}$CO$_3$ [n=18]</td>
<td>Ca$<em>{1.05}$Mg$</em>{0.79}$Fe$<em>{0.10}$Mn$</em>{0.05}$(CO$_3$)$_2$ [n=14]</td>
</tr>
</tbody>
</table>

Figure 8: Ternary Diagram Showing Molar Proportions of Ca, Mg and Mn+Fe in Carbonate Grains for Various Rock Units
Using the method of Day (2009), analysed carbonate content was compared to carbonate content calculated from the QXRD results and formula weights of calcite and dolomite derived from the compositions in Table 7 (Figure 9) (note the formula weight of ankerite was assumed to be the same as dolomite based on the EPMA results). A relatively good correlation for all but a few samples indicates that QXRD has good accounting for carbonate content.

Figure 9: Comparison of Neutralization Potentials Calculated from Total Inorganic Carbon Analysis and from QXRD/EPMA Mineralogical Analyses

The molar proportion of Ca and Mg in the carbonate grains analyzed ranged from 81% to 98%, with an average of 96% for calcite and 87% for dolomite grains. Adjusting the total inorganic carbon values by the molar proportion of Ca and Mg ($IC_{Ca,Mg}$), provides a very good agreement with measured TIC (Figure 10). A good agreement is also found between an adjusted NP based on the Ca and Mg inorganic carbon (NP $IC_{Ca,Mg}$) and the measured modified Sobek NP (Figure 11).
**Figure 10:** Comparison of Total Inorganic Carbon and Ca and Mg Inorganic Carbon

![Graph showing the comparison of Total Inorganic Carbon (TIC) and Ca and Mg Inorganic Carbon (IC Ca,Mg) with data points for different rock types.](S:/Kitsault1100_1CA020.002_Geochemistry Review 2009_100500_EA_Reporting/Geochem_Char_EA/Text/Supporting files/Compiled geochem data for waste rock 1CA020.002_20110504.xlsx)

\[ y = 1.1x + 0.005 \]
\[ R^2 = 1.0 \]

**Figure 11:** Comparison of Neutralization Potentials Calculated from an Adjusted Total Inorganic Carbon (NP IC_{Ca,Mg}) and Modified NP

![Graph showing the comparison of Modified NP (kg CaCO\(_3\)/t) and NP (IC_{Ca,Mg} kg CaCO\(_3\)/t) with data points for different rock types.](S:/Kitsault1100_1CA020.002_Geochemistry Review 2009_100500_EA_Reporting/Geochem_Char_EA/Text/Supporting files/Compiled geochem data for waste rock 1CA020.002_20110504.xlsx)

\[ y = 0.86x + 5.5 \]
\[ R^2 = 0.98 \]
The regression equation for the linear trendline in the dataset shown in Figure 11 indicates that the modified NP includes approximately 5 to 6 kg CaCO₃/t equivalent more than the NP calculated from the Ca and Mg based carbonates in the samples analyzed. This suggests that the associated aluminosilicate minerals in the samples such as quartz, feldspars, biotite etc. contribute approximately 5 kg CaCO₃/t NP in the titration. These minerals would not provide reactive buffering in the field at rates required to neutralize acidity derived from sulphide oxidation.

A separate indication of the proportion of measured NP that is ineffective at buffering is provided by an assessment of the measured NP versus the paste pH of weathered material from site. These data are shown in Figure 12 below and with the exception of one pit sample, support the value of 5 kg CaCO₃/t as being an appropriate estimate of ineffective NP as measured by the Modified NP method. For the purposes of this study, measured NP values were adjusted downwards by a value of 5 kg CaCO₃/t equivalent to provide a more accurate assessment of available NP for the Kitsault rock types.

Figure 12: Comparison of Measured Modified NP and Rinse pH of Weathered Samples

### 3.5 Occurrence and Form of Weathering Products

Boehmite, an aluminum oxide hydroxide, was the only secondary mineral or weathering product that was clearly identified by QXRD from weathered samples, however other weathering products were identified in petrographic evaluation (Appendix B), specifically red-brown, yellow-brown and orange-brown iron oxide hydroxide minerals, noted in nearly all of the samples evaluated. These
were typically described as very fine-grained aggregates, as local replacement of biotite and carbonate as well as alteration rims around pyrite and pyrrhotite. Surface staining observed in localized areas on the existing waste dumps also indicates the presence of iron oxyhydroxides (Figure 13). Typically, areas in which staining was observed were predominantly comprised of intrusive rocks.

No molybdenite weathering products have been identified.

Figure 13: Photograph of localized area of Patsy Dump in which iron staining from pyrite oxidation was evident (marker pen for scale)

4 Existing Facilities Characterization

4.1 Historical Assessments

Historical assessments of ML/ARD potential at Kitsault for which data has been found, started as early as 1982, and with closure focussed work occurring in the mid to late 1990s. Sampling was done by the Ministry of Energy Mines and Petroleum Resources (MEMPR), now the MEM and by SRK and in 1994 and 1996 respectively. Data available include acid base accounting, some selected net acid generation results, shake flask extraction tests and humidity cell testwork. Results from this program are described in SRK (2003), and incorporated into the current evaluations as appropriate.
4.1.1 Sample Selection and Sampling Methods

Waste Rock and Low Grade Ore Piles

Waste rock and low grade ore samples were collected in 1994, 1996 and 1997 by MEMPR (now MEM) and SRK. These consisted of surface grab samples and samples obtained from shallow test pits as described in SRK (2003).

Pit Walls

Pit wall samples were collected at three separate times, 1982, 1994 and 1996 and included hornfels and intrusives from specific benches as well as the central core. Again, sampling was done by MEMPR (now MEM) and SRK at different times.

Seepage Monitoring

In accordance with the requirements of the Reclamation Permit M-10 (MEM 2008) for the existing mine, monitoring of seepage from the existing waste rock dumps and within the pit is conducted as part of the overall site water and reclamation monitoring. This information is reported annually (e.g. SRK 2010) and the reader is referred to those reports for more complete site data. This information, particularly for locations proximal to the existing waste rock dumps or within the existing pit can provide additional insight into the current metal leaching associated with the existing facilities. Only the sample locations that are pertinent to this characterization are discussed.

4.1.2 Analytical Methods

Analytical methods in historical assessments as described in SRK 2003 included both static and kinetic testing as described below.

Static Geochemistry

Historical assessments of static geochemistry included acid base accounting (ABA) by the Method EPA 600 (earlier work) and the Modified Sobek Method (later work). Also conducted were carbonate analyses (method unspecified) and metals by ICP-OES following an aqua regia digestion and atomic absorption (for molybdenum). In addition to these standard procedures, a net acid potential (NAP) test was conducted which is the same as what is referred to in this report as the NAG test, but conducted in the field.

Shake flask extraction tests were conducted using a 3:1 demineralized water to solid ratio. Samples were placed in a bottle roller for 48 hours and the solutions decanted, filtered and analyzed for a full metal suite.

Kinetic Testing

Kinetic testing done historically consisted of standard humidity cell procedures following the MEND, 1991 protocol using a 1 kg sample. Analyses were conducted such that general parameters pH, conductivity, redox, acidity, alkalinity and sulphate were measured every other week and metals by ICP-OES (metals) were monitored monthly.

A recycle column test was also conducted by SRK using 1 kg of sample in a 7.5 cm diameter column filled with deionized water to cover the sample. The solution was left in contact for a day and then drained overnight. Measurements of pH and conductivity were taken and the solution
returned to the column until the pH and conductivity values stabilized at which point the solution was analyzed for metals by ICP-OES.

**Water Testing**

Water samples have typically been analyzed for pH, conductivity, hardness, total suspended solids (by gravimetric methods), alkalinity (colourimetric method), sulphate (by turbidity) and total metals (by ICP-OES). In addition, dissolved metals (by ICP-OES) are measured at certain stations. Method details and certificates of analyses are provided in the Annual Reclamation Reports (see SRK, 2010).

### 4.1.3 Historical Results

#### Waste Rock Lithological Composition

Historical evaluations of the existing waste rock dumps indicate that there are approximately 2 million tonnes of waste rock in the Clary Dump and another 29 million tonnes of waste rock in the Patsy Dump. The waste rock is comprised of hornfels and mixed intrusives. Mapping of the surface of the existing dumps conducted by SRK in 1996 and reported in SRK (2003) differentiated four waste rock types as follows:

- Intrusive rock that generally retained a grayish colouration with some iron stained surfaces. This tended to represent potassically- or silicically-altered intrusive rock.
- Intrusive rock that had weathered to a fine grain size with a yellowish or orange colouration and was identified as argillically-altered.
- Mineralized hornfels rock containing visible pyrite and molybdenite and some areas of iron-staining.
- Mixtures of un-mineralized hornfels containing only widely disseminated pyrrhotite with little or no indication of weathering.

Based on the maps produced in that report, the dumps were reported to be comprised predominantly of grayish coloured intrusives (an estimated 75% of surface area), with lesser mineralized hornfels (about 15 to 20% of surface area), minor exposure of the yellow-stained intrusives (5% of surface area) and un-mineralized hornfels (<5% of surface area).

Mapping of the existing open pit using the same rock types was also conducted. Rock units were generally well defined with the high wall (generally above Bench 606) representing mineralized hornfels, the flat area and barren core of the pit and pit floor consisting predominantly of gray-ish coloured intrusives and the zone around the barren core and in the area of the historic ‘orange pond’ comprised of the yellowish coloured argillically-altered intrusives. Minor exposures of aplite, intramineral porphyry and lamprophyre dykes were also noted.

#### Static Geochemical Characteristics

Results of static testwork conducted historically and reported in SRK (2003) indicated that most of the waste rock, pit wall and low grade ore samples collected had sulphur values typically ranging between 0.5% and 1.5% as total sulphur and NP values most typically between approximately 10 and 40 kg CaCO₃/t and carbonate NP values were similar to the modified Sobek NP values. NP/AP ratios below 1 and were classified as potential acid producing samples. Most samples fell within that classification, though most were not acidic at the time of sampling. A proportion of the
sample set also had NP/AP ratios between 1 and 3 and were classified at the time as uncertain with respect to acid generating potential.

The distribution of metals in the samples collected was variable, with elevated Mo, Pb and Zn noted as ‘pockets of mineralized material’ that could be found anywhere on site, but particularly in the low grade ore stockpile and the open pit.

**Leach Tests**

Results of shake flask extraction tests were generally buffered, though a few selected samples reported acidic leachate. With lower pH, concentrations of Al, Cu, Pb, Mn and Zn tended to be higher. Concentrations of Mo were variable, but higher in buffered leachate solutions. It was noted that shake flask leachate concentrations were generally lower than concentrations observed in the field (for example, at the historic Orange Pond).

**Kinetic Geochemical Characteristics**

The kinetic tests reported in SRK (2003) were conducted for a 32-week period, on samples that had been exposed for approximately 18 years prior to collection. With the exception of one sample, all samples tested remained buffered and metal concentrations were low. The exception consisted of a mildly acidic sample from the Clary Dump that reported leachate pH of ~4.5, with higher sulphate and copper concentrations than the other cells. Conclusions presented in the report based on the humidity cell testwork indicated that waste rock with NP/AP ratios greater than 1 was unlikely to become acidic.

Results of the recycle columns were interpreted to indicate that at alkaline pH conditions, molybdenum could become elevated (~1.58 mg/L) though most other parameters were low or below detection limits. At pH values less than 5.5, increased concentrations of SO4 (about 366 mg/L), Al (about 17 mg/L), Cu (about 0.25 mg/L) and Zn (about 1.85 mg/L) were seen and below a pH of 4, iron concentrations were higher (about 1.59 mg/L).

**Seepage Chemistry**

Seepage monitoring at selected sites summarized in Table 8 and shown on Figure 14 (A) and (B) also tended to reflect the conclusions described above; i.e. that seepage while buffered has low levels of most parameters other than in certain cases Mo and where evidenced, acidity is associated with increased concentrations of parameters such as Al, Cu and Zn.
Table 8: Summary of Selected Sample Locations from the Long Term Water Quality Monitoring Database Utilized in this Characterization Study

<table>
<thead>
<tr>
<th>Station ID</th>
<th>Description</th>
</tr>
</thead>
<tbody>
<tr>
<td>W-11</td>
<td>Orange Pond on Bench 594</td>
</tr>
<tr>
<td>M-04</td>
<td>East Pit Channel diversion ditch (W-11 after reclamation)</td>
</tr>
<tr>
<td>W-12</td>
<td>Waterfall from Bench 594 to Bench 582</td>
</tr>
<tr>
<td>W-13</td>
<td>Flow from Bench 582 to Settling Pond on Bench 558</td>
</tr>
<tr>
<td>W-14</td>
<td>Collection ditch on Bench 582 (below Orange Pond)</td>
</tr>
<tr>
<td>W-Pit-1</td>
<td>Bench 642</td>
</tr>
<tr>
<td>W-Pit-2</td>
<td>Settling Pond</td>
</tr>
<tr>
<td>W-Pit-3</td>
<td>Clear Pond</td>
</tr>
<tr>
<td>W-CD-1</td>
<td>Clary Dump</td>
</tr>
<tr>
<td>W-CD-2</td>
<td>Clary Dump</td>
</tr>
<tr>
<td>W-CD-3</td>
<td>Clary Dump</td>
</tr>
<tr>
<td>W-CD-4</td>
<td>Clary Dump</td>
</tr>
<tr>
<td>W-CD-5</td>
<td>Clary Dump</td>
</tr>
<tr>
<td>W-CD-6</td>
<td>Clary Dump</td>
</tr>
<tr>
<td>W-CD-7</td>
<td>Clary Dump</td>
</tr>
<tr>
<td>W-CD-8</td>
<td>Clary Dump</td>
</tr>
<tr>
<td>W-PD-1</td>
<td>Patsy Dump</td>
</tr>
<tr>
<td>W-PD-2</td>
<td>Patsy Dump</td>
</tr>
<tr>
<td>W-PD-3</td>
<td>Patsy Dump</td>
</tr>
<tr>
<td>W-PD-4</td>
<td>Patsy Dump</td>
</tr>
<tr>
<td>W-PD-5</td>
<td>Patsy Dump</td>
</tr>
</tbody>
</table>

Results of pH, sulphate, alkalinity and total molybdenum over the period of record for the water monitoring locations associated with the pit and waste rock dumps are shown in Figure 15, Figure 16 and Figure 17.

Facility seepage associated with the existing weathered rock tends to show buffered pH, reflecting dissolution of carbonates, moderate sulphate concentrations (about 300 to 500 mg/L), alkalinity levels above background (about 80 to 150 mg/L) and molybdenum concentrations up to approximately 2 mg/L.

The only sampling location that has reported acidic seepage is station W11, that prior to pit reclamation was called the ‘orange pond’ (see Figure 1). It is speculated that this was a very localized area of ponded water adjacent to the barren core that was affected by higher sulphide content in rock surrounding the barren core. Seasonally acidic pH values were reported to levels of around 3. Associated with the lower pH were elevated concentrations of sulphate (up to 900 mg/L) and metals such as copper (about 0.3 mg/L), cadmium (up to about 0.2 mg/L), iron (up to about 60 mg/L) and zinc (up to about 5 mg/L). Monitoring indicated lower molybdenum concentrations at low pH, on the order of 0.03 mg/L.
Figure 14: (A) Sample Locations Included in Annual Monitoring Program prior to 2006
Figure 14 (continued): (B) Sample Locations Included in Annual Monitoring Program Since 2006
Figure 15: Water Quality Monitoring Results for Selected Locations Associated with the Existing Pit: (A) pH, (B) sulphate, (C) alkalinity, (D) molybdenum [note reclamation activities were completed in 2006]
Figure 16: Water Quality Monitoring Results for Selected Locations Associated with the Existing Patsy Dump: (A) pH, (B) sulphate, (C) alkalinity, and (D) molybdenum [note reclamation activities were completed in 1999]
Figure 17: Water Quality Monitoring Results for Selected Locations Associated with the Existing Clary Dump: (A) pH, (B) sulphate, (C) alkalinity, (D) molybdenum [note reclamation activities were completed in 1999].
4.2 Current Assessment

The current assessment also includes samples of the historic waste rock collected in 2009 to provide another assessment of the weathering effects on the Kitsault rock types.

4.2.1 Sample Selection and Sampling Methods

Weathered waste rock samples for the current assessment include samples collected from depth (via drilling) as well as targeted surface grab samples.

Waste Rock Dump Drilling

Drill cutting samples recovered from drilling conducted by Knight Piesold for hydrogeological and geotechnical evaluations were also included providing an indication of variability with depth in the waste rock facilities. Drillhole locations are shown in Figure 18 and logs are provided in Appendix B.

Waste Rock Dump Surface Grab Sampling

Surface grab samples collected during a field reconnaissance were selected targeting the two predominant rock types (intrusive and hornfels) based on what was considered visually typical of each type with consideration of spatial coverage of both waste rock facilities. Sample descriptions are provided in Appendix A.

As described in SRK (2003) and summarized in Section 4.1.3 above, weathered waste rock was typically of two primary lithological types (intrusives and hornfels) and two alteration/weathering types. The intrusive waste rock was either grayish in colour (potassic and silicic alteration) or fine grained and yellowish in colour (argillic alteration). The hornfels waste rock was present both as relatively unweathered and as having some degree of iron staining from the effects of weathering. Photographs of these typical descriptions are provided in Figure 19.

4.2.2 Waste Rock Thermal Monitoring Method

The Patsy Dump drillhole labelled K09-15GT was instrumented with thermistor cables for monitoring dump temperature over time. The thermistor type was a 10 kOhm RST TH2016 thermistor cable with 15 nodal points at varying depths through approximately 13 metres of waste rock and into the underlying greywacke bedrock. The drill log and instrumentation details are provided in Appendix B.

4.2.3 Analytical Methods

Analytical methods used are summarized below with greater detail provided in Appendix D.

Mineralogy

Detailed mineralogical analyses of the reactive components of the rocks were conducted via x-ray diffractometry (XRD), petrography and electron micro-probe analysis (EPMA).

Static Testing

Static testing included modified acid base accounting (ABA) as per MEND (1991), metal scans by ICP-MS following aqua-regia digestion, and net acid generation tests (NAG) with analyses of the NAG liquor using ICP-MS.
Leach Testing
Shake flask extraction testwork was conducted using a 3:1 de-ionized water to solids ratio on the as received fines fraction of weathered samples as suggested by Price (1997).

In addition to shake flask tests, a sequential meteoric water mobility procedure was conducted on weathered samples whereby sequential leaches (using the samples leachate for subsequent cycles) were conducted on the same sample at a preserved water to solid ratio of 1:1 (see Appendix D).

4.2.4 Existing Waste Rock Dump Results

Mineralogy
Mineralogy of the existing waste rock was described in Section 3.

ABA Testing
Weathered waste rock from the Clary and Patsy Dumps has predominantly maintained weakly basic buffered conditions. With rinse pH values typically between 7 and 8, though some localized acidic values were reported, in samples dominantly comprised of hornfels as well as samples dominantly comprised of intrusives. Sulphur values ranged from 0.01 to 2.09% with median values somewhere between 0.55 and 1.00% depending on lithology (hornfels tended to have higher median values). NP values ranged from negligible to up to 300 kg CaCO₃/t, though were typically between 15 and 25 kg CaCO₃/t, very similar to samples from the pit and low grade ore sample sets. The majority of weathered waste rock samples classified as likely to produce acid (NP/AP<1) regardless of lithology (Table 9 and Figure 20).

Various grain size fractions of surface grab samples from the waste rock dumps were evaluated to assess whether specific parameters partition into any size fraction preferentially. Figure 21 provides the results for total sulphur, total inorganic carbon, adjusted NP/AP and Figure 22 molybdenum and zinc in different grain size fractions. In general, most samples report slightly higher amounts of total sulphur and total inorganic carbon in the -2 mm size fraction. The exceptions to this trend are samples that were predominantly comprised of hornfels. Variability across size fractions however was not great.

A plot of the rinse pH of weathered samples against the adjusted NP/AP (Figure 23) indicates that over the period of time for which most of these samples have been exposed (a few decades) that a current adjusted NP/AP of greater than 1 has been sufficient to maintain the pH conditions within the near neutral range.

An evaluation of variability with depth in the existing waste dumps shows no clear trend related to depth within the dump. Results may indicate a marginal decrease in paste pH with depth as well as possible decrease in adjusted NP with depth. While the trend is not strongly marked, and given the depth from surface, it is likely that a lower carbonate content and therefore slightly lower paste pH are likely related to mineralogical factors rather than weathering effects.
Figure 18: Waste Rock Drillhole Location Map

provided by Knight Piésold, in B11 Progress Print 2011-05-24.pdf
Figure 19: Photographs of Typical Weathered Waste Rock/Pit Wall Rock as of 2009: (A) gray-ish coloured intrusives, (B) yellowish-coloured argillically altered intrusives, (C) un-stained hornfels and (D) iron-stained hornfels
### Table 9: Summary of Acid Base Accounting Results for Existing Weathered Samples

<table>
<thead>
<tr>
<th></th>
<th>Pit Wall Samples (n=31)</th>
<th>Low Grade Ore Samples (n=18)</th>
<th>Weathered Intrusives (n=42)</th>
<th>Weathered Hornfels (n=26)</th>
<th>Weathered Mixed Samples (n=99)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Rinse pH</td>
<td>2.83</td>
<td>3.40</td>
<td>6.83</td>
<td>6.19</td>
<td>8.15</td>
</tr>
<tr>
<td>Rinse EC</td>
<td>-</td>
<td>-</td>
<td>-</td>
<td>-</td>
<td>-</td>
</tr>
<tr>
<td>Paste pH</td>
<td>-</td>
<td>-</td>
<td>-</td>
<td>-</td>
<td>-</td>
</tr>
<tr>
<td>Total S (%)</td>
<td>0.77</td>
<td>1.20</td>
<td>1.46</td>
<td>0.30</td>
<td>0.66</td>
</tr>
<tr>
<td>Sulphate S (%)</td>
<td>-</td>
<td>-</td>
<td>-</td>
<td>-</td>
<td>-</td>
</tr>
<tr>
<td>Sulphide S (%)</td>
<td>-</td>
<td>-</td>
<td>-</td>
<td>-</td>
<td>-</td>
</tr>
<tr>
<td>AP (kg CaCO₃/t)</td>
<td>24</td>
<td>37</td>
<td>45</td>
<td>9</td>
<td>21</td>
</tr>
<tr>
<td>NPadj (kg CaCO₃/t)</td>
<td>13</td>
<td>21</td>
<td>32</td>
<td>4</td>
<td>17</td>
</tr>
<tr>
<td>TIC (kg CaCO₃/t)</td>
<td>5</td>
<td>18</td>
<td>29</td>
<td>4</td>
<td>18</td>
</tr>
<tr>
<td>NPadj/AP</td>
<td>0.4</td>
<td>0.5</td>
<td>0.9</td>
<td>0.02</td>
<td>0.7</td>
</tr>
</tbody>
</table>
Figure 20: Box and Whisker Graphs for Rinse pH, Sulphide Sulphur, Adjusted Neutralization Potential and Adjusted NP/AP Ratios for Weathered Pit Wall, Low Grade Ore and Waste Rock Samples

(This plot is a conventional box and whisker graph, with the upper and lower extremes showing the minimum and maximum values, tick marks outside the box showing the 10th and 90th percentiles, outer margins of the box showing the 25th and 75th percentiles, central dash in the box showing the median value, and dot showing the arithmetic mean).
Figure 21: Results of (A) Total Sulphur, (B) Total Inorganic Carbon and (C) NP_{adj}/AP in Various Grain Size Fractions from Weathered Waste Rock Samples
Figure 22: Results of (A) Molybdenum and (B) Zinc in Various Grain Size Fractions from Weathered Waste Rock Samples
Trace Elements

Trace element analyses for all samples are provided in Appendix E. Results are summarized by material type in Table 10 and selected parameters are shown graphically in Figure 25.

To assess which elements are anomalously elevated in the Kitsault samples, the results were compared to ten times the average crustal abundance as taken from Price (1997). Elements which were consistently above this basis for comparison include silver (Ag), bismuth (Bi), cadmium (Cd), molybdenum (Mo) and sulphur (S). Less consistently elevated levels of antimony (Sb), arsenic (As), gold (Au), lead (Pb), selenium (Se), tungsten (W) and zinc (Zn) were also noted. Most of these elements are typically elevated in molybdenum porphyry environments (Levinson 1980).

Comparing the rock types with respect to the metals of particular interest, the hornfels unit appears to have slightly higher arsenic than the intrusive units. No clear differentiation can be seen when comparing the weathered mixed rock with the fresh drill core samples.

An evaluation of potential partitioning of metals into different grain size fractions as shown for molybdenum and zinc in Figure 22 indicates that most samples tended to report higher zinc concentrations in the finest size fraction, as was seen with the sulphur values (Figure 21). No specific trend however was seen with respect to partitioning of molybdenum content.
Figure 24: Variability of Paste pH, Total S, Sulphate S and Adjusted NP with Depth
<table>
<thead>
<tr>
<th></th>
<th></th>
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<tbody>
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<td>0.3</td>
<td>0.4</td>
<td>0.4</td>
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<tr>
<td>Sb</td>
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<td>0.9</td>
<td>1.7</td>
<td>1.2</td>
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<td>2.7</td>
<td>0.6</td>
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<tr>
<td>As</td>
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<td>4.6</td>
<td>14</td>
<td>10</td>
<td>20</td>
<td>30</td>
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</tr>
<tr>
<td>Cd</td>
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<td>5.9</td>
<td>13</td>
<td>1.2</td>
<td>1.6</td>
<td>2.0</td>
<td>6.3</td>
</tr>
<tr>
<td>Pb</td>
<td>56</td>
<td>112</td>
<td>208</td>
<td>24</td>
<td>25</td>
<td>25</td>
<td>81</td>
</tr>
<tr>
<td>Mo</td>
<td>80</td>
<td>206</td>
<td>289</td>
<td>410</td>
<td>483</td>
<td>556</td>
<td>224</td>
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<td>Se</td>
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<td>0.7</td>
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<td>W</td>
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<td>0.5</td>
</tr>
<tr>
<td>Zn</td>
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<td>222</td>
<td>54</td>
<td>54</td>
<td>71</td>
<td>87</td>
<td>202</td>
</tr>
</tbody>
</table>
Figure 25: Box and Whisker Graphs for Selected Parameters by Material Type

(This plot is a conventional box and whisker graph, with the upper and lower extremes showing the minimum and maximum values, tick marks outside the box showing the 10th and 90th percentiles, outer margins of the box showing the 25th and 75th percentiles, central dash in the box showing the median value, and dot showing the arithmetic mean).
NAG Tests

Net acid generation tests, or NAG tests, were conducted on a set of weathered waste rock samples and pit wall samples. The test adds a strong oxidant ($H_2O_2$) to a sample to assess the balance of acid produced by oxidation and inherent buffering of the sample itself. The results are interpreted such that NAGpH results less than 4.5 are considered acid generating. The results are provided in Figure 26 compared to the results from the acid base accounting (ABA) testwork for the same sample set. For the most part, the NAG tests confirmed the classification by ABA methods as non PAG for samples with adjusted Net NP values $>10$ kg CaCO$_3$/t equivalent and adjusted NP/AP ratios above 1.4. Samples that classified as PAG by the NAGpH definition had adjusted Net NP values less than -10 kg CaCO$_3$/t equivalent and adjusted NP/AP values <1. Samples for which there were discrepancies, or differing classifications via the NAG and ABA methods suggests uncertainty when adjusted NP/AP values are between 1 and 1.4. Results of the kinetic testwork provided in Section 5.3.3 provide additional comment on these values for classification purposes.

For the weathered waste rock samples submitted for NAG testwork, the resulting NAG leachate was submitted for metal analysis by ICP-MS to assess what metals were liberated in weathered samples subjected to a strong oxidant. Results are provided in Appendix E and summarized graphically in Figure 27 for selected parameters of interest. The results indicate that upon oxidation, the samples dominated by intrusives could leach cadmium, selenium and zinc and to a lesser extent aluminum, antimony, arsenic, copper, iron, lead, manganese, molybdenum, and vanadium at levels that are at or slightly above the aquatic water quality guidelines. The hornfels samples tested indicated a similar suite of potentially leachable metals as that for the intrusives with the added parameter of nickel. For certain elements, a higher potential was indicated for the intrusive dominated samples tested (antimony, molybdenum), but most of the parameters of interest indicated higher leachable concentrations from the hornfels samples tested (Figure 27).

Chromium concentrations were also reported at values considered somewhat elevated, however this was also the case for the blank sample analyzed indicating that chromium is introduced during the NAG test itself, likely as a constituent of the reagent. It is therefore not flagged here as a constituent of interest with respect to metal leaching at Kitsault.
Figure 26: NAGpH versus Adjusted NP/AP Ratio

Figure 27: Metals Leached in Weathered Waste Rock Samples During the NAG Test. Results shown are for average values with error bars representing the maximum and minimum concentrations reported.
Extraction Tests

Leach extraction tests, using a 3:1 nanopure water to solid ratio were conducted on thirty weathered waste rock samples collected from surface and from depth. Results are provided in full in Appendix E and summarized in Table 11 and Figure 28.

Results showed consistently elevated concentrations of fluoride and cadmium. Other parameters that were elevated, but not on a consistent basis included sulphate, aluminum, copper, iron, molybdenum, manganese, nickel, lead and zinc. Some of these parameters were only elevated in samples which had reported acidic leachate pH as shown in Figure 28. This included aluminum, copper, nickel, lead, manganese and zinc. The elements molybdenum and fluoride showed greater concentrations at alkaline pH values.

For those samples with sufficient mass (i.e. the grab samples) sequential meteoric water mobility procedures (SMWMP) were also conducted such that the leachate from one test is utilized as the extraction reagent in a second sequential leach (and so on) while maintaining the same water to solid ratio. This test was conducted to further assess the cumulative effects of sequential leaching/contact. Results generally showed no clear trend with respect to pH changes with increased contact, most parameters such as sulphate, aluminum, calcium, cadmium, magnesium, manganese, and zinc and possibly copper however showed increasing concentrations with each sequential leach. This suggests that for these parameters, the concentrations being reported are not reflective of solubility limits. Concentrations of iron and arsenic were more variable. For iron, elevated concentrations were only seen in those samples with acidic leachate pH, and in those samples showed inconsistent peak concentrations. Sometimes iron was highest in the first leach, and in other samples it was higher in subsequent leach stages. Similarly, arsenic concentrations were highest in those samples with acidic leachate pH and often peak concentrations were reported in the fourth or fifth leach stage. Figure 29 shows the results of these key parameters of interest.

Resulting maximum concentrations from the shake flask extractions and SMWMP for the parameters of interest are shown as compared to maximum values from the NAG tests described in the preceding subsection in Table 12. Results are provided for two subsets, those with acidic pH values and those with near neutral pH values. In general, maximum concentrations were comparable between test methods. Samples in the near neutral pH range tended to report slightly higher concentrations from the NAG leachate (i.e. following additional oxidation), particularly for metals such as antimony, arsenic, cadmium, nickel and zinc. Samples that reported acidic pH values tended to show higher concentrations for many parameters in the sequential leach extraction testwork, i.e. with additional contact. This included parameters such as fluoride, sulphate, aluminum, calcium, lead, magnesium, manganese and nickel. Other parameters, such as arsenic, cadmium, selenium and zinc were slightly higher when subjected to additional oxidation in the NAG leachate.
### Table 11: Summary of Shake Flask Leach Extraction Tests on Weathered Waste Rock (n=30)

<table>
<thead>
<tr>
<th>Concentration (mg/L unless otherwise noted)</th>
<th>Min</th>
<th>P25</th>
<th>P50</th>
<th>P75</th>
<th>Max</th>
</tr>
</thead>
<tbody>
<tr>
<td>pH (s.u.)</td>
<td>3.9</td>
<td>6.7</td>
<td>7.6</td>
<td>7.8</td>
<td>8.1</td>
</tr>
<tr>
<td>Redox (mV)</td>
<td>185</td>
<td>299</td>
<td>346</td>
<td>364</td>
<td>491</td>
</tr>
<tr>
<td>Conductivity (µS/cm)</td>
<td>100</td>
<td>136</td>
<td>171</td>
<td>234</td>
<td>553</td>
</tr>
<tr>
<td>Chloride</td>
<td>0.50</td>
<td>0.50</td>
<td>0.70</td>
<td>1.4</td>
<td>8.0</td>
</tr>
<tr>
<td>Fluoride</td>
<td>0.14</td>
<td>0.45</td>
<td>0.86</td>
<td>1.6</td>
<td>3.7</td>
</tr>
<tr>
<td>Sulphate</td>
<td>7</td>
<td>14</td>
<td>24</td>
<td>82</td>
<td>262</td>
</tr>
<tr>
<td>Hardness CaCO₃</td>
<td>25</td>
<td>61</td>
<td>75</td>
<td>112</td>
<td>289</td>
</tr>
<tr>
<td>Aluminum</td>
<td>0.0053</td>
<td>0.013</td>
<td>0.019</td>
<td>0.041</td>
<td>2.6</td>
</tr>
<tr>
<td>Antimony</td>
<td>0.000020</td>
<td>0.00033</td>
<td>0.0010</td>
<td>0.0016</td>
<td>0.0050</td>
</tr>
<tr>
<td>Arsenic</td>
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<td>0.00010</td>
<td>0.00016</td>
<td>0.00034</td>
<td>0.0021</td>
</tr>
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<td>Barium</td>
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<td>0.050</td>
<td>0.070</td>
<td>0.14</td>
</tr>
<tr>
<td>Boron</td>
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<td>0.050</td>
<td>0.050</td>
<td>0.30</td>
<td>0.30</td>
</tr>
<tr>
<td>Cadmium</td>
<td>0.00011</td>
<td>0.00090</td>
<td>0.0014</td>
<td>0.0027</td>
<td>0.071</td>
</tr>
<tr>
<td>Calcium</td>
<td>9.0</td>
<td>19</td>
<td>24</td>
<td>32</td>
<td>91</td>
</tr>
<tr>
<td>Chromium</td>
<td>0.00010</td>
<td>0.00010</td>
<td>0.00025</td>
<td>0.00050</td>
<td>0.0041</td>
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<td>Cobalt</td>
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<td>0.000083</td>
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<td>0.0043</td>
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<td>Copper</td>
<td>0.0011</td>
<td>0.0030</td>
<td>0.010</td>
<td>0.022</td>
<td>13</td>
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<tr>
<td>Iron</td>
<td>0.0030</td>
<td>0.0060</td>
<td>0.011</td>
<td>0.050</td>
<td>4.5</td>
</tr>
<tr>
<td>Lead</td>
<td>0.000015</td>
<td>0.000063</td>
<td>0.00010</td>
<td>0.00040</td>
<td>0.14</td>
</tr>
<tr>
<td>Lithium</td>
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<td>0.0017</td>
<td>0.0030</td>
<td>0.0042</td>
<td>0.021</td>
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<td>Magnesium</td>
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</tr>
<tr>
<td>Manganese</td>
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<td>0.084</td>
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<td>0.66</td>
<td>7.0</td>
</tr>
<tr>
<td>Molybdenum</td>
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<td>0.19</td>
<td>0.58</td>
<td>1.0</td>
<td>6.0</td>
</tr>
<tr>
<td>Nickel</td>
<td>0.00031</td>
<td>0.0012</td>
<td>0.0023</td>
<td>0.0078</td>
<td>0.50</td>
</tr>
<tr>
<td>Phosphorus</td>
<td>0.0020</td>
<td>0.0040</td>
<td>0.010</td>
<td>0.010</td>
<td>0.35</td>
</tr>
<tr>
<td>Potassium</td>
<td>1.2</td>
<td>2.6</td>
<td>3.8</td>
<td>4.9</td>
<td>23</td>
</tr>
<tr>
<td>Selenium</td>
<td>0.000070</td>
<td>0.00020</td>
<td>0.00020</td>
<td>0.00033</td>
<td>0.0012</td>
</tr>
<tr>
<td>Silicon</td>
<td>0.5</td>
<td>0.78</td>
<td>0.97</td>
<td>1.5</td>
<td>5.3</td>
</tr>
<tr>
<td>Sodium</td>
<td>0.23</td>
<td>1.1</td>
<td>1.5</td>
<td>2.2</td>
<td>7.5</td>
</tr>
<tr>
<td>Strontium</td>
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<td>Thallium</td>
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<td>Zinc</td>
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<td>0.0040</td>
<td>0.0082</td>
<td>0.050</td>
<td>1.3</td>
</tr>
</tbody>
</table>

Note: Parameters that were consistently less than detection were excluded from this table. Complete results are provided in Appendix E.
Figure 28: Leach Extraction pH versus Concentration of (A) sulphate, (B) fluoride, (C) aluminum, (D) cadmium, (E) copper, (F) lead, (G) molybdenum and (H) zinc
Figure 28: (continued): Leach Extraction pH versus Concentration of (A) sulphate, (B) fluoride, (C) aluminum, (D) cadmium, (E) copper, (F) lead, (G) molybdenum and (H) zinc
Figure 29: Sequential MWMP Results (A) pH, (B) sulphate, (C) calcium, (D) cadmium, (E) arsenic, (F) iron, (G) molybdenum and (H) zinc
Figure 29: (continued): Sequential MWMP Results (A) pH, (B) sulphate, (C) calcium, (D) cadmium, (E) arsenic, (F) iron, (G) molybdenum and (H) zinc
Table 12: Maximum Concentrations for Parameters of Interest from Leach Extraction and NAG tests Performed on Weathered Waste Rock Samples

<table>
<thead>
<tr>
<th>Parameter</th>
<th>Acidity</th>
<th>Single SFE</th>
<th>SMWMP</th>
<th>NAG Tests</th>
<th>Near Neutral pH (pH&gt;5)</th>
<th>Single SFE</th>
<th>SMWMP</th>
<th>NAG Tests</th>
</tr>
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<tbody>
<tr>
<td>pH*</td>
<td></td>
<td>3.9</td>
<td>3.5</td>
<td>3.0</td>
<td>6.5</td>
<td>7.4</td>
<td>7.4</td>
<td>5.0</td>
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<tr>
<td>Redox</td>
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<td>491</td>
<td>505</td>
<td>480</td>
<td>387</td>
<td>353</td>
<td>389</td>
<td>389</td>
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<tr>
<td>Conductivity</td>
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<td>501</td>
<td>930</td>
<td>1040</td>
<td>553</td>
<td>474</td>
<td>790</td>
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<tr>
<td>Fluoride</td>
<td></td>
<td>3.7</td>
<td>10</td>
<td>--</td>
<td>2.9</td>
<td>3.2</td>
<td>--</td>
<td></td>
</tr>
<tr>
<td>Sulphate</td>
<td></td>
<td>122</td>
<td>615</td>
<td>408</td>
<td>262</td>
<td>201</td>
<td>348</td>
<td></td>
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<tr>
<td>Aluminum</td>
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<td>2.6</td>
<td>14</td>
<td>2.9</td>
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<td>0.020</td>
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<td>Antimony</td>
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<td>0.0021</td>
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<td>23</td>
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<td>13</td>
<td>7.0</td>
<td></td>
</tr>
<tr>
<td>Manganese</td>
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<td>7.0</td>
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<td>7.8</td>
<td>1.2</td>
<td>0.010</td>
<td>1.9</td>
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</tr>
<tr>
<td>Molybdenum</td>
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<td>6.0</td>
<td>3.6</td>
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<td>Nickel</td>
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<td>0.50</td>
<td>1.5</td>
<td>0.27</td>
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<td>0.010</td>
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<td>Selenium</td>
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<td>0.0012</td>
<td>0.0038</td>
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<td>0.0029</td>
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</tr>
<tr>
<td>Zinc</td>
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<td>1.3</td>
<td>5.6</td>
<td>7.6</td>
<td>0.060</td>
<td>0.010</td>
<td>0.85</td>
<td></td>
</tr>
</tbody>
</table>

Notes: * pH values are minimum values (maximum values for H\(^+\))

**Thermal Monitoring**

Thermal monitoring of the existing Patsy Dump is available for a relatively short period of record beginning though monitoring is on-going. In general, results show cool, near ambient conditions near the surface of the dump (depth of 1 m), slightly warmer temperatures at 3 m depth cooling again to temperatures generally consistent with bedrock values at depths of approximately 13 m (see Figure 30). The trend appears to indicate that in the early fall (September), the upper node and the node at 3 m were similar. As the outside temperatures cooled through October, the upper node quickly reflected the ambient cooling temperatures, but the node at 3 m showed similar temperatures to September values. More recent readings in November and December showed that values at the upper node and the node at 3 m were nearly equal. This reflects a delay in cooling with depth as a result of outside temperature variation rather than a heating within the pile itself.
Notes: Ground temperature instrumentation installed by Knight Piesold personnel. Stratigraphic details provided by Knight Piesold.

Figure 30: Ground Temperature Profile, Patsy Dump and Underlying Bedrock