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PWGSC

Quality in Environmental Services

Phase III Environmental Assessment

Stump Abandoned Mine Site

Final Report

Prepared for:

Waste Program
Indian and Northern Affairs Canada
Whitehorse, Yukon

Prepared by:

Environmental Services
Public Works and Government Services Canada
Pacific & Western Regions

March 1999

Public Works and Government Services Canada
Travaux publics et Services gouvernementaux Canada

Canada

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Executive Summary

A phase II environmental assessment was conducted at the Stump abandoned mine site (61° 33' 26" N, 132° 09 '08" W) in July, 1996 by Environmental Services, Public Works and Government Services Canada for the Action on Waste Program, Indian and Northern Affairs Canada. Based on the findings of the Phase I investigation performed in 1993 by DIAND Technical Services, a phase II assessment was conducted to a) identify potential environmental and human health risks associated with the present condition of the mine site, and b) provide recommendations and preliminary cost estimates for remediation of those risks.

In 1997 a phase III follow-up assessment was performed based on the recommendations of the phase II assessment. The follow-up work included waste rock sampling where additional data was required, and water quality monitoring of adit water, seeps, and receiving water bodies and to identify seasonal variations in contaminant loadings in Ketza River upstream and downstream of the main site and waste rock piles. Laboratory leachate extraction tests were completed to characterize the soluble constituents of the waste rock.

The conclusions of the Phase III program are as follows:

Conclusion 1. *The site is not impacting the water quality of the Ketza River.* Results of the water sampling performed both upstream and downstream show elevated levels of copper and selenium.

Conclusion 2. *Vegetation is not being impacted by site runoff.* This is likely due to low precipitation as well as low soluble metals concentrations in the waste rock piles.

Conclusion 3. *Waste Rock is oxidizing but acid is being buffered.* Also, the long exposure of the site indicates that oxidation is occurring slowly.

The following recommendation regards the specific objectives outlined in this report and is to be used in conjunction with recommendations outlined in the March 1997, Phase II report where appropriate:

Recommendation. No further action regarding water quality is recommended at this time.

Phase III Environmental Assessment Stump Mine Site

Final Report

Table of Contents

1.0 INTRODUCTION AND BACKGROUND

In 1993, initial assessments (Phase I) of 49 abandoned Yukon mine exploration and development sites were completed under the Arctic Environmental Strategy - Action on Waste program by DIAND Technical Services. These assessments provided a) a general overview of historical activities, b) described site infrastructure, workings and wastes, c) summarized existing environmental or safety concerns on each site, and d) provided general recommendations for remediation or mitigation work. No rock, soil or water samples were collected for these assessments.

A phase II environmental assessment was conducted at the Stump abandoned mine site (61° 33' 26 " N, 132° 09 '08" W) in July, 1996 by Environmental Services, Public Works and Government Services Canada for the Action on Waste Program, Indian and Northern Affairs Canada. Based on the findings of the Phase I investigation performed in 1993 by DIAND Technical Services, a phase II assessment was conducted to a) identify potential environmental and human health risks associated with the present condition of the mine site, and b) provide recommendations and preliminary cost estimates for remediation of those risks.

Conclusions of the Phase II assessment were that approximately one half of the 3100 tons of waste rock may be potentially generating acid. Moderate to high conductivity measurements indicate that oxidation is already occurring in some waste however is currently being buffered by available NPs. The fact that high concentrations of metals in the waste is not being reflected in the adjacent Ketza River may be a result of sampling one day in the dry season. Soluble metals stored in exposed waste rock may reach water receptors during high precipitation or runoff conditions.

Results of paste pH testing of waste rock at the Stump Mine site conducted in 1996 indicated that the waste is not currently acidic (SRK 1997). ABA testing indicated that some of the material has the potential to generate acid, and moderate to high conductivity measurements indicated that some of the waste is oxidizing. However, the acidity produced is being buffered by the neutralizing capacity within the waste rock. Considering that the waste has been exposed since at least 1980, the sulphides in the waste are apparently slow to react.

The recommendations of the Phase II assessment were to:

1. Perform detailed assessment of receiving water quality.
2. Water quality monitoring program 3 or 4 times annually.
3. Determine metals in WR available for transport - leach extraction test.

2.0 PURPOSE AND SCOPE OF WORK

This Phase III assessment was carried out by Environmental Services for Indian and Northern Affairs Canada to conduct a follow-up assessment of the environmental impact, or potential environmental impact, of mining and exploration activities conducted at Stump abandoned site in the Yukon Territory. The follow-up work included waste rock sampling where additional data was required, and water quality monitoring of adit water, seeps, and receiving water bodies and to identify seasonal variations in contaminant loadings in Ketza River upstream and downstream of the main site and waste rock piles. Laboratory leachate extraction tests were completed to characterize the soluble constituents of the waste rock.

Accordingly, the following assessment activities were completed:

- Photo documentation of relevant site features;
- Sampling of waste rock disposal areas, including leachate extraction tests, and surface water (including waste rock seeps and receiving waters);
- Identification of environmental pathways and receptors for site contaminants if required; and
- Assessment of contaminant loadings caused by acid rock drainage at the waste rock disposal area.

Recommendations and preliminary cost estimates were then generated to meet the following remediation/mitigation requirements:

- Physical stabilization of waste rock disposal areas;
- Chemical stabilization of waste rock disposal areas, taking into account onsite resources and accessibility.

3.0 SITE ASSESSMENT METHODOLOGY

3.1 Assumptions

At the Stump mine site, the assessment was limited to the area specifically developed or occupied for mine exploration or mining purposes and off-site environmental resources potentially affected by mine exploration or development activities.

3.2 Assessment Criteria

<u>CCME Criteria</u>

The Canadian Council of Ministers of the Environment (CCME) Interim Canadian Environmental Quality Criteria for Contaminated Sites are numerical limits for contaminants in soil and water intended to protect, maintain or improve environmental quality and human health at contaminated sites in general. For this Phase III mine assessment, Freshwater Aquatic Life criteria were used to assess surface water quality.

Mine Reclamation in Northwest Territories and Yukon (INAC, 1992)

This report defines factors which are to be considered in reclamation of abandoned mine sites operating in northern climates. Factors include:

- open pit and underground mines
- waste rock and tailings disposal
- acid generation and leaching, and
- estimating cleanup costs.

3.3 Methods

3.3.1 Site Assessment Components

A professional geochemist assessed the acid rock drainage and metal leaching potential of the lower/eastern waste rock disposal area by:

- Confirming variations in rock type, mineralization and alteration noted in the Phase II assessment;
- Laboratory leachate testing of selected archived waste rock samples (originally collected during the 1996 site visit).

3.3.2 Sampling Methods and Quality Assurance

Water Sampling

Samples were collected from Ketza River upstream and downstream of the middle and lower/eastern waste rock disposal areas, and from seeps emanating from the lower/eastern waste rock slope. Field pH and conductivity measurements were recorded during the summer sampling period. Samples were collected on 19 August, 18 October, and 23 of April 1997 to measure contaminant concentrations during the summer, fall and spring seasons respectively.

250 ml water samples were collected by hand, facing upstream, ensuring that the sample was not contaminated by disturbed sediment, debris and other floating materials. Sample bottles were rinsed three times with water from the sample stream prior to collecting the sample. 2 ml of HNO_3 were immediately added to water samples intended for metals analyses. For analyses of non-metallic parameters, water samples were brim-filled to minimise head space, placed in a cooler, and maintained at 4° C until delivery to the laboratory.

Bottle Roll Tests

To estimate the soluble metal load in the waste rock, large-scale leach extraction tests were conducted on selected samples. These tests involved sieving a waste rock sample to obtain 1 kg of material passing through a 5-mm screen. This material was combined with

1 litre of distilled water and agitated on a rolling device. Every 24 hours the bottle was removed from the roller and allowed to settle. The solution was sampled, and the pH and conductivity measured. Once the pH and conductivity of the solution stabilized, the solution was filtered and analyzed for immediate parameters (e.g. pH, conductivity, acidity, alkalinity, etc.), sulphate, and total metals concentrations. The resulting concentrations represent a measure of the soluble contaminants stored in the waste. A detailed protocol is provided in Appendix A.

Quality Assurance

Quality Assurance (QA) is a set of procedures for ensuring that the results of chemical analyses are (and can be shown to be) accurately representative of field conditions. A complete QA program includes both a field component and a laboratory component.

In addition to the standard sample collection methods outlined above, the field QA measures that were implemented for this assessment study include:

- chain of custody procedures and forms;
- a sample labelling and sample location identification scheme;
- laboratory preparation of all sampling containers;
- laboratory defined sample preservation and shipping procedures; and
- regular maintenance (including re-calibration) and cleaning of field equipment.

4.0 ENVIRONMENTAL SETTING

4.1 Mineralization

Rhyolite dykes and stocks , and andesite dykes, have intruded granitoid rocks. The dyke rocks are often propylitically to argillically altered and are associated with the mineralized shear zones. The mineralization consists of both massive and disseminated stibnite with lesser amounts of pyrite and sphalerite and traces of realgar, orpiment galena and tetrahedrite in a gangue of quartz and minor barite.

The major commodity identified at this site is antimony. Minor commodities include lead, silver and gold.

4.2 Surface Hydrology

Both the site and regional drainage are to the northeast draining into the Ketza River. The Ketza River falls within the Yukon River drainage system.

Mine water seepage flows from the main adit and through stockpiled waste rock drain indirectly to Ketza River. A seasonal stream flows northeast into the Ketza River and is adjacent to the south side of the mine site.

No changes in flow were noted in both the 1996 and 1997 seasons. Flow from the adit was approximately 0.03 L/sec at the time of the site visit. The Ketza River was flowing approximately 500 L/sec and the small tributary stream was flowing at approximately 50 L/sec.

4.3 Climate

The closest climatological information is from the town of Ross River, 61° 59' N, 132° 27' W; 698m above sea level (Environment Canada, 1980). Total annual precipitation is 263.5 mm. This consists of 152.1mm of rainfall and 105.8mm of snowfall. Highest levels of rainfall occur in July and highest levels of snowfall occur in January. Temperatures range from -28.6° C in January to 12.8° C in July. The mean annual temperature is -5.7° C.

4.4 Vegetation

Stump mine site is situated within the Pelly Mountains ecoregion. Much of the ecoregion lies above the treeline, and is dominated by treeless tundra vegetation including lichens, dwarf ericaceous shrubs, birch and willows. Wetter sites are occupied by grasses, sedges, cottongrass and mosses. Subalpine regions are characterized by open stands of black and white spruce and alpine fir. Valleys and lower elevation slopes are occupied by aspen and scrub birch. Disturbed areas at the mine opening and along the access road are dominated by fireweed.

4.5 Fish and Wildlife Resources

Alpine habitats are typically low in both species number and diversity. Bird species noted at the site include bald eagle, ptarmigan and rosy finches. Arctic ground squirrels and pika are the dominant rodent species and support a number of carnivorous species including wolf, coyote, and bear. Ungulates include caribou, moose and mountain sheep. This area is only able to support these species during the short summer period and most animals hibernate or move to lower elevations during the long cold winters.

Arctic Grayling and Slimy Sculpin have been observed and netted in the Ketza River. Though they do not spawn there, Chinook Salmon may overwinter in the river. Other species may include: Broad Whitefish, Rainbow Trout, Cutthroat Trout, Rainbow Trout, and Longnose.

4.6 Site Topography and Soils

The regional and site topography are mountainous, with a relief of about 1,200 metres at the Ketza River to 2,000 metres at some of the higher peaks. The mountains, though steep, are rounded with few cliffs and rock outcrops and can be easily traversed. The level of the main adit, site workings, and waste rock stockpiles is at 1212 metres lying 8 metres above the Ketza River to the northeast. Towards the southwest lies the upper adit and main shaft on steep slopes.

Topography above the mine site exhibits typical upper-alpine features such as stone nets and felsenmeer interspersed with hummocky tundra. Steep upper slopes are covered with talus or scree material contributed by freeze-thaw fracturing of sedimentary rock. The slope is uniformly covered with talus; at lower elevations, fractured shale outcrops are interspersed with hummocky flats and gentle slopes.

The Pelly Mountains ecoregion is dominated by two soil types - dystric brunisols and eutric brunisols. Turbic cryosolic soil occurs sporadically.

5.0 SITE ASSESSMENT RESULTS

5.1 Surface Water Quality

Results of analysis of water quality samples are summarized in Table 5.1. Complete analytical methods and results are provided in Appendix A.

Water quality samples were collected in the Ketza River upstream (STU-WQ-ST1-1) and downstream (STU-WQ-ST1-2) of the Stump Mine. Sample STU-WQ-STR2-1 was collected from a tributary to the Ketza River that borders the site on the west, and enters the river upstream of the site. Sample STU-WQ-AT1-1 (also STU-WQ-A1-1) was collected from the adit flow. Samples were collected from all locations at all four monitoring times, except for the tributary that was not flowing in October 1997 and April 1998.

Metals concentrations in the adit seepage had concentrations of arsenic, copper, iron, lead, selenium, and silver above the CCME guidelines during the 1997 sampling events but below MMLE criteria. These metals reflect the presence of arsenopyrite, tetrahedrite (Cu12Sb-4S13), pyrite, galena, and sphalerite in the deposit. The source of the selenium is unknown.

Metals concentrations in the Ketza River were below CCME guidelines except for copper and selenium. During the August 1997 sampling event, the copper concentration, both upstream of the site (0.0095 mg/L) and downstream (0.0174 mg/L), was above the CCME guideline of 0.004 mg/L. Both of these measurements were higher than the copper concentration in the adit water (0.0078 mg/L), indicating that the source of the copper is not the adit water. During the August 1997 sampling event, total selenium concentrations both upstream and downstream of the site ranged from 0.005 mg/L to 0.006 mg/L, above the CCME guideline of 0.001 mg/L. The analytical detection limit for selenium was above the CCME guideline for the samples collected in August 1996 and October 1997. Lead concentrations in the river were near or below the 0.0003 mg/L detection limit, despite a concentration of 0.046 mg/L lead in the adit water. The source of these metals is unknown, but is likely due to background concentrations or mine workings upstream of the Stump site.

Iron concentrations increased downstream of the site during the August 1996 and 1997 sampling events, but decreased slightly in October 1997. The higher concentrations of iron on the stream compared to copper and selenium concentrations may reflect its greater solubility and, therefore, ease of transport. Aluminum concentration sampled in spring 1998 exceeded CCME - FAL criteria, but marginally so by 0.004 ppm for a total concentration of 0.104 ppm. The spring sampling program indicated a higher concentration of metals than the winter and fall programs but were all less than the MMLE criteria.

The quality of the water in the tributary was similar to that in the Ketza River except that the copper (0.00209 mg/L), iron (< 0.003 mg/L), and selenium (< 0.003 mg/L) concentrations were lower. The tributary does not contribute a significant amount of metals to the river.

Table 5.1 Significant Results - Stump Surface Water Samples

Sample ID	Sample Location	Sample Date	pH	Cond. (μS/cm)	Parameters > CCME FAL Criteria (stream) or MMLE (adit)
STUWQ-ST1-1	Ketza River - upstream	23 April 1998	8.17	470	
		18 Oct 1997	8.20	462	
		19 Aug 1997	8.35	437	Cu, Se
		13 Aug 1996	8.10	452	
STUWQ-ST1-2	Ketza River -downstream	23 April 1998	8.25	475	Al
		18 Oct 1997	8.19	466	
		19 Aug 1997	8.33	438	Cu, Se
		13 Aug 1996	8.17	441	
STUWQ-A1-1	adit seepage	23 April	8.04	833	
		18 Oct 1997	7.76	807	
		19 Aug 1997	7.91	762	
		13 Aug 1996	7.86	800	
STUWQ-ST2-1	tributary creek	19 Aug 1997	8.27	498	
		13 Aug 1996	8.16	554	

Notes: FAL = Freshwater Aquatic Life corrected for hardness; MMLE = Metal Mine Liquid Effluent criteria attributed to mine water only.

5.2 Soluble Metals Concentrations

To estimate soluble metal loads in the waste rock, leach extraction tests, using the bottle-roll method, were conducted on two samples from waste rock piles. Table 5.2 provides a summary of the 1996 acid-base-accounting and 1997 bottle-roll tests conducted on two samples.

Bottle roll tests were conducted on samples STU-P3-1 and STU-P4-1. The first sample was collected in the surface of the staging area and the second was collected from one of the rock piles deposited on the staging area. These waste piles were selected for testing because they are closest to the river and would, therefore, be expected to have the highest impact on the receiving water in a high precipitation event. P3-1 is representative of the material that covers the staging area surface and is, therefore, exposed to weathering. Sample P4-1 appeared to be representative of the small pile from which it was taken.

The pH of both samples decreased during testing but remained above 6. The conductivity increased from 1410 μS/cm to 2900 μS/cm in the sample from P3-1, and from 2650 μS/cm to 4200 μS/cm in the sample from P4-1. The filtered leachates from both samples had excess alkalinity when titrated to a pH of 4.5, and sulphate concentrations were above 3000 mg/L.

Metals concentrations were generally low in the solutions from these samples. The only exception is zinc, which was present in concentrations of 0.18 mg/L and 1 mg/L, respectively.

Table 5.2 Summarized Waste Rock ABA and Bottle Roll Test Sample Results

Sample ID	Summary of 1996 ABA Test Results	Summary of 1997 Bottle Roll Test Results
STU-P3-1	Potentially Acid Generating (NP/AP=0.6); high As, Sb, Cu, Fe, Pb, Mn, Ag, Zn	Conductivity increased from 1,400 uS/cm to 2,900 uS/cm; high alkalinity, sulphate, and zinc
STU-P4-1	Potentially Acid Generating (NP/AP=< 0.1); high As, Sb, Cu, Fe, Pb, Mn, Ag, Zn	Conductivity increased from 2,650 uS/cm to 4,200 uS/cm; high alkalinity, sulphate, and zinc

6.0 CONCLUSIONS

Based on results of phase III work conducted at the Stump abandoned mine site the following conclusions have been drawn:

Conclusion1. *The site is not impacting the water quality of the Ketza River.* Results of the water sampling performed both upstream and downstream show elevated levels of copper and selenium.

Conclusion 2. *Vegetation is not being impacted by site runoff.* This is likely due to low precipitation as well as low soluble metals concentrations in the waste rock piles.

Conclusion 3. *Waste Rock is oxidizing but acid is being buffered.* Also, the long exposure of the site indicates that oxidation is occurring slowly.

7.0 RECOMMENDATIONS

Recommended remediation and management actions are compliant with applicable federal or territorial regulations and criteria, rely upon available technology, and are intended to be appropriate for local conditions and sensitivities.

The following recommendation regards the specific objectives outlined in this report and is to be used in conjunction with recommendations outlined in the March 1997, Phase II report where appropriate:

Recommendation. No further action regarding water quality is recommended at this time.

8.0 COST ESTIMATES TO IMPLEMENT RECOMMENDATIONS

There are no costs associated with implementing the above recommendation in accordance with the specific objectives outlined in this report.

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APPENDIX A

Detailed Geochemical Assessment of Waste Rock and Surface Water

Stump Mine Site

Public Works and
Government
Services
Canada

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YUKON ABANDONED MINE SITES ASSESSMENT
REPORT ON 1997 FOLLOW-UP

1CP001.00

YUKON ABANDONED MINE SITES ASSESSMENT
REPORT ON 1997 FOLLOW-UP

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YUKON ABANDONED MINE SITES ASSESSMENT
REPORT ON 1997 FOLLOW-UP

1.0 INTRODUCTION

1.1 Background

In 1993, DIAND Technical Services completed Phase I environmental assessments of 49 abandoned exploration and mine sites in the Yukon Territory as part of the Arctic Environmental Strategy Action on Waste. These initial assessments included a literature review of the historical activities at each site, described the mine infrastructure, workings and waste, summarized environmental and/or safety concerns, and made general recommendations for remediation. No waste rock or water quality samples were collected. The results of this work indicated that an assessment of the environmental impacts of the sites was required before decisions could be made regarding remediation.

In 1996, environmental assessments were conducted by Environmental Services, Public Works and Government Services Canada (PWGSC). These assessments included investigations of the current impacts of mining activities on receiving water, as well as the potential for future impacts on receiving water from waste rock and tailings disposed of on site. Current impacts were assessed by water quality sampling whereas future impacts were estimated by determining the acid generating potential and metal content of the waste. Waste at the site was mapped, described, and representative samples collected. Samples were then analzyed for acid generating potential using Acid Base Accounting (ABA), and for metals concentrations using Inductively Coupled Plasma (ICP). Professional geologists conducted the geochemical investigations. The assessment results were presented in SRK (1997), Norecol Dames and Moore (1997), and Geoviro (1997).

Based on the 1996 work, the PWGSC identified six abandoned mined sites for which additional geochemical or geotechnical information were required in order for decisions to be made regarding reclamation. In 1997, PWGSC retained Steffen, Robertson and Kirsten (Canada) Inc. (SRK) to conduct a follow-up geochemical assessment of the six sites. SRK had conducted evaluations of 15 abandoned sites during the 1996 program and, thus, were familiar with several of the mines requiring additional work (SRK, 1997).

The waste at all of the sites was deposited prior to 1985 and, therefore, has been exposed for more than 10 years. Much of the waste rock at the six sites was already generating acid or, if neutral, had been exposed for sufficient time that acidic conditions would be unlikely to develop in the future. The impact of the waste on receiving waters appeared to be small. However, sampling was conducted in August and September, generally a dry season in the Yukon Territory, when flow in local seeps and streams was low. It was, therefore, recommended that a year of water quality monitoring be conducted in order to measure seasonal variability in metal concentrations. In order to estimate the impact of the waste on receiving waters under high flow conditions, it was also recommended that the soluble metal concentrations associated with the waste rock be measured.

1.2 Objectives

The objectives of the 1997 field program were to conduct a follow-up assessment of the environmental impact, or potential environmental impact, of mining or exploration activities conducted at six abandoned sites in the Yukon Territory. The follow-up work included waste rock sampling where additional data was required, and water quality monitoring of adit water, seeps, and receiving water bodies. Laboratory leachate extraction tests were completed to characterize the soluble constituents of the waste rock.

2.0 FIELD/LABORATORY TECHNIQUES

2.1 Sample Collection

In the 1996 Assessment Reports, water quality monitoring was recommended for the six abandoned mine sites that were revisited. Samples were collected from adits, seeps, and receiving water upstream and downstream of the mine in August and in October of 1997. The sampling protocol used was provided in SRK (1997).

Waste samples were only collected during the August 1996 and 1997 visits. Waste rock sampling protocols were provided in the SRK (1997).

2.2 Flow Measurement

During the August 1997 field trip, flow in streams and seeps were measured using a Price Current meter. Stream depth and velocity measurements are taken at several locations across the stream, and averaged to obtain a value for the stream.

2.3 Analytical Techniques

Water samples were analyzed for immediate parameters (pH, electrical conductivity, hardness, alkalinity, ionic balance, and total dissolved solids), and sulphate, chloride, bicarbonate, nitrate, nitrite, and metals concentrations.

To estimate the soluble metal load in the waste rock, large-scale leach extraction tests were conducted on selected samples. These tests involved sieving a waste rock sample to obtain 1 kg of material passing through a 5-mm screen. This material was combined with 1 litre of distilled water and agitated on a rolling device. Every 24 hours the bottle was removed from the roller and allowed to settle. The solution was sampled, and the pH and conductivity measured. Once the pH and conductivity of the solution stabilized, the solution was filtered and analyzed for immediate parameters (e.g. pH, conductivity, acidity, alkalinity, etc.), sulphate, and total metals concentrations. The resulting concentrations represent a measure of the soluble contaminants stored in the waste. A detailed protocol is provided in Appendix A. Results of bottle roll tests are presented in Tables 1 and 2.

3.0 ASSESSMENT CRITERIA

The freshwater aquatic criteria of the Interim Canadian Environmental Quality Criteria for Contaminated Sites (CCME, 1995) were used to assess impacts to surficial receiving waters. These criteria provide numerical limits that are designed to protect, maintain, or improve environmental quality and human health at contaminated sites.

4.0 STUMP

4.1 Background

The Stump site is a small exploration site located beside the Ketza River. Near the river is a small staging area on which three small waste rock piles (less than 10 tonnes each) are deposited. Two other areas of waste deposition are located on the hill outside the second adit. Runoff from the waste rock, and its impact on the Ketza River, poses the greatest environmental concern at the Stump site.

Results of paste pH testing of waste rock at the Stump Mine site conducted in 1996 indicated that the waste is not currently acidic (SRK 1997). ABA testing indicated that some of the material has the potential to generate acid, and moderate to high conductivity measurements indicated that some of the waste is oxidizing. However, the acidity produced is being buffered by the neutralizing capacity within the waste rock. Considering that the waste has been exposed since at least 1980, the sulphides in the waste are apparently slow to react.

The Stump deposit is hosted in a Cretaceous quartz monzonite stock that intruded into Ordovician to Lower Devonian black shales and cherts. Mineralization consisted of sphalerite (ZnS), tetrahedrite (Cu12Sb4S13), and arsenopyrite (FeAsS) in a carbonate gangue.

4.2 Observations

The Stump site is shown in Figure 1. No new seeps had developed at the Stump exploration site since the 1996 visit, and no seepage was seen below the staging area. The minimum distance between the staging area and the creek is 20 m, and this area is flat and heavily vegetated. None of the vegetation appeared to be stressed, suggesting that no metal-rich seepage is impacting this area.

4.3 Water Quality

Water quality samples were collected in the Ketza River upstream (STU-WQ-ST1-1) and downstream (STU-WQ-ST1-2) of the Stump Mine. The flow in the river was 0.5 m3/s during the August 1997 sampling period. Sample STU-WQ-STR2-1 was collected from a tributary to the Ketza River that borders the site on the west, and enters the river upstream of the site. Sample STU-WQ-AT1-1 (also STU-WQ-A1-1) was collected from the adit flow. Samples were collected from all locations at all three monitoring times, except for the tributary that was not flowing in October, 1997.

Results of analysis of water quality samples are listed in Table 3. Metals concentrations in the adit seepage had concentrations of arsenic, copper, iron, lead, selenium, and silver above the CCME guidelines during the 1997 sampling events. These metals reflect the presence of arsenopyrite, tetrahedrite (Cu12Sb-4S13), pyrite, galena, and sphalerite in the deposit. The source of the selenium is unknown.

Metals concentrations in the Ketza River were below CCME guidelines except for copper and selenium. During the August 1997 sampling event, the copper concentration, both upstream of the site (0.0095 mg/L) and downstream (0.0174 mg/L), was above the CCME guideline of 0.004 mg/L. Both of these measurements were higher than the copper concentration in the adit water (0.0078 mg/L), indicating that the source of the copper is not the adit water. During the August 1997 sampling event, total selenium concentrations both upstream and downstream of the site ranged from 0.005 mg/L to 0.006 mg/L, above the CCME guideline of 0.001 mg/L. The analytical detection limit for selenium was above the CCME guideline for the samples collected in August 1996 and October 1997. Lead concentrations in the river were near or below the 0.0003 mg/L detection limit, despite a concentration of 0.046 mg/L lead in the adit water. The source of these metals is unknown, but may be attributed to background concentrations or mine workings upstream of the Stump site.

Iron concentrations increased downstream of the site during the August 1996 and 1997 sampling events, but decreased slightly in October 1997. The higher concentrations of iron on the stream compared to copper and selenium concentrations may reflect its greater solubility and, therefore, ease of transport.

The quality of the water in the tributary was similar to that in the Ketza River except that the copper (0.00209 mg/L), iron (< 0.003 mg/L), and selenium (< 0.003 mg/L) concentrations were lower. The tributary does not contribute a significant amount of metals to the river.

4.4 Soluble Metals Concentrations

Bottle roll tests were conducted on samples STU-P3-1 and STU-P4-1. The sample locations are shown in Figure 1. The first sample was collected in the surface of the staging area and the second was collected from one of the rock piles deposited on the staging area (Photograph 1). These waste piles were selected for testing because they are closest to the river and would, therefore, be expected to have the highest impact on the receiving water in a high precipitation event. The bulk of the material in the staging area is likely composed of material with a composition similar to that of sample P3-2, collected below sample P3-1. However, sample P3-1 is representative of the material that covers the staging area surface and is, therefore, exposed to weathering. Sample P4 appeared to be representative of the small pile from which it was taken.

Results of bottle roll tests are presented in Tables 1 and 2. The pH of both samples decreased during testing but remained above 6. The conductivity increased from 1410 μS/cm to 2900 μS/cm in the sample from P3, and from 2650 μS/cm to 4200 μS/cm in the sample from P4. The filtered leachates from both samples had excess alkalinity when titrated to a pH of 4.5, and sulphate concentrations were above 3000 mg/L.

Metals concentrations were generally low in the solutions from these samples. The only exception is zinc, which was present in concentrations of 0.18 mg/L and 1 mg/L, respectively.

4.5 Discussion

Based on the late summer and fall sampling events, the river contained elevated copper and selenium levels. However, these were measured upstream as well as downstream of the site, and cannot be attributed to the Stump workings. Therefore, the site is not impacting the quality of the Ketza River.

The lack of stress in the vegetation between the workings and river indicate that this area is not being effected by runoff from the rock piles. This is likely a result of the low precipitation in the area, as well as the low soluble metals concentrations in this material. The small waste rock pile has higher soluble metals concentrations than material in the staging area, but these constituents are washed into the underlying staging area and stored in that mass of rock. In the dry climate, the rock pile that comprises the staging area likely has a net evaporation so that constituents are reprecipitated within the pile.

4.6 Recommendations

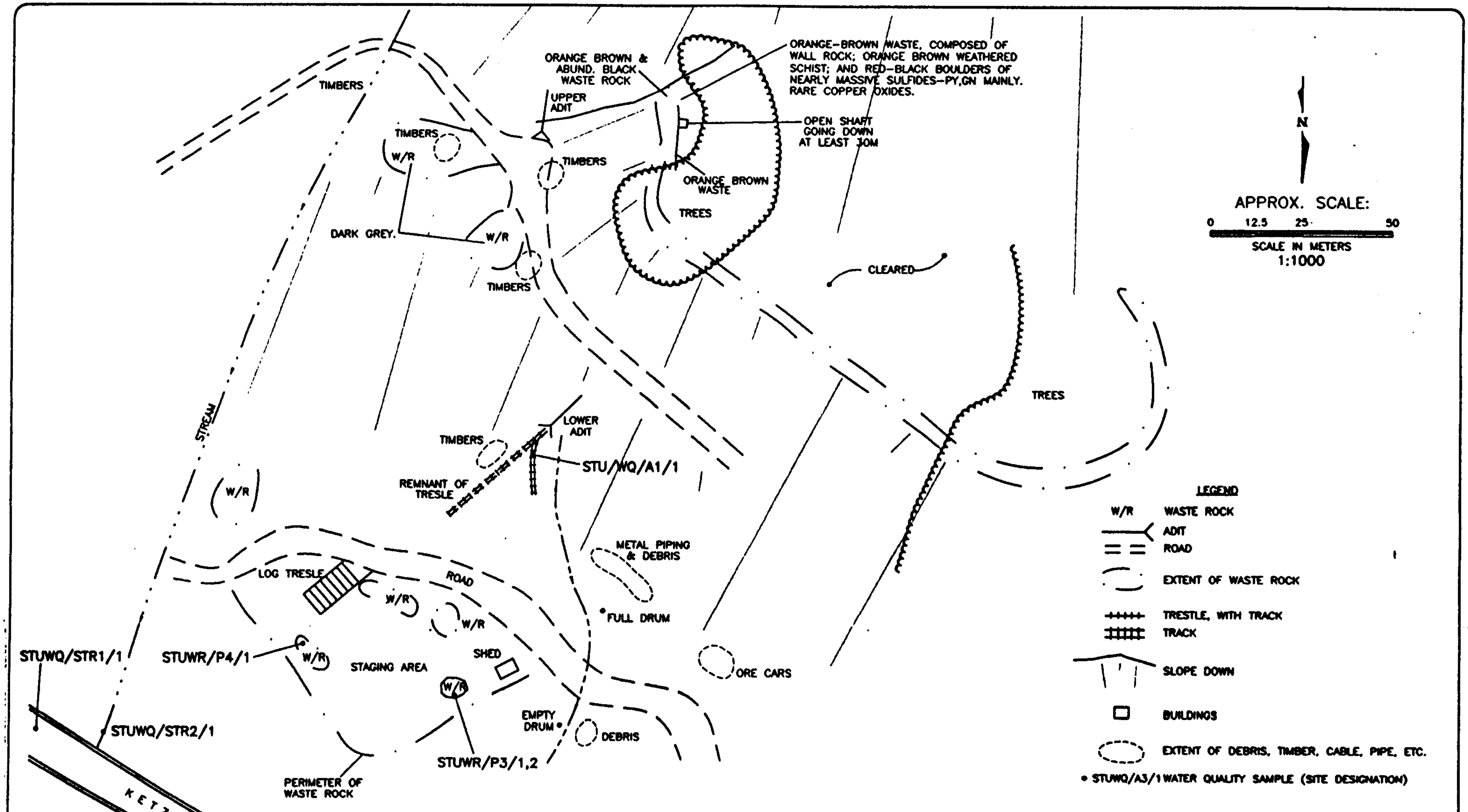
The Ketza River should be sampled during the spring freshet to complete a year of water quality monitoring. If spring samples show no additional impacts from the site, no additional action is recommended at this time with regard to assessing or alleviating environmental impacts.

Table 1
Results of Physical Parameters in Bottle Roll Test Leachates

SAMPLE	SOLID			SLURRY									
	pH	Conductivity (μS/cm)	NP/AP	pH (Hours)					CONDUCTIVITY (uS/cm) (Hours)				
				48	72	120	144	216	48	72	120	144	216
STU-WR-P3-1	7.8	270	2.5	--	7.3	6.9	6.8	6.7	--	1410	2250	2700	2900
STU-WR-P4-1	6.6	840	<0.1	--	6.2	6.4	6.1	--	--	2650	4000	4200	--
PAD-WR-1-1	7.7	81	5	--	8.0	7.7	7.5	7.3	--	780	1490	1880	2400
PAD-WR-2-1	7.6	77	5.3	--	8.3	8.1	8.0	8.1	--	670	1290	1590	1900
FO-WR-P302	7.8	180	0.49	--	7.8	8.0	8.1	--	--	2300	2800	3000	--
FOR-WR-P307/	4.6	--	<0.1	--	4.0	4.3	4.3	--	--	4500	3900	3800	--
GV206PAD1-3*	4	--	<0.1	4.5	4.7	--	--	--	375	420	--	--	--
GV206PAD1-16	3	--	<0.1	2.9	2.9	--	--	--	1520	1560	--	--	--
BT-WR-P302	3	750	<0.1	--	3.1	3.4	3.4	3.7	--	3900	4600	5000	4300
BT-WR-P305-1	8	140	1	--	8.9	9.1	9.2	9.2	--	750	1065	1240	1580
VE-WR-P305	6.7	>1990	0.25	--	6.6	6.7	7.0	--	--	5000	5400	5800	--
VE-WR-P311	8	>1990	1	--	8.5	8.6	8.7	--	--	2500	3200	3500	--

SAMPLE	FILTERED LEACHATE									
	pH	COND. (uS/cm)	REDOX POT. (mV)	ACIDITY pH 4. (mg/L CaCO3)	ACIDITY pH 8.3 (mg/L CaCO3)	ALKALINITY pH 4.5 (mg/L CaCO3)	SULPHATE (mg/L)	BICARBONATE CaCO3 (mg/L)	CARBONATE CaCO3 (mg/L)	CHLORIDE mg/L
STU-WR-P3-1	7.97	4450	280	0.0	10.5	289.0	3160	303	<1	5.5
STU-WR-P4-1	7.10	5350	290	0.0	7.5	21.0	4070	1	<1	96.8
PAD-WR-1-1	8.31	3260	285	0.0	0.0	304.5	1930	320	<1	4.5
PAD-WR-2-1	8.28	2760	288	0.0	0.5	104.0	1470	110	<1	4.2
FO-WR-P302	7.52	4180	282	0.0	5.0	32.0	2140	<1	<1	754
FOR-WR-P307/	4.60	5280	365	0.0	1300.5	1.0	4570	<1	<1	5.9
GV206PAD1-3*	5.02	623	387	0.0	31.0	10.0	208	51	<1	388
GV206PAD1-16	3.10	2400	375	315.0	1500.0	0.0	1710	<1	<1	9.2
BT-WR-P302	3.85	5750	352	58.0	1266.0	0.0	4070	123	<1	3.1
BT-WR-P305-1	9.03	2250	242	0.0	0.0	56.5	785	129	<1	104
VE-WR-P305	7.93	5820	252	0.0	13.0	133.5	3860	<1	<1	1.2
VE-WR-P311	8.40	3610	257	0.0	0.0	119.5	1840	<1	<1	4.6

*500 g sample was used with 500 ml of distilled solution.
-- = not analyzed for this element.



STEFFEN ROBERTSON & KIRSTEN (CANADA) Consulting Engineers & Scientists			**FIGURE 1** STUMP MINE SITE 1997 INVESTIGATION
PROJECT NO.	DATE	REVISION	
1CP001	02/98	A	

APPENDIX B

Laboratory Reports

NORWEST LABS
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YUKON PH3

WATER ANALYSIS REPORT

SAMPLE		10 STUMP MINE STU-WQ-ST1-2	11 STUMP MINE STU-WQ-STR1-1	12 STUMP MINE STU-WQ-STR2-1
TOTAL METALS				
SELENIUM	mg/L	<0.0001	<0.0001	0.0004
ROUTINE WATER				
pH		8.33	8.35	8.27
ELECTRICAL COND	uS/cm	438	437	498
CALCIUM	mg/L	63.4	63.3	55.8
MAGNESIUM	mg/L	26.7	26.5	43.5
SODIUM	mg/L	1.0	1.4	3.3
POTASSIUM	mg/L	1.13	1.25	1.39
IRON	mg/L	<0.04	<0.04	<0.04
MANGANESE	mg/L	<0.003	<0.003	<0.003
SULPHATE	mg/L	72.5	74.0	53.4
CHLORIDE	mg/L	<0.5	<0.5	<0.5
BICARBONATE	mg/L	229	224	310
T ALKALINITY	mg/L	188	183	254
HARDNESS	mg/L	268	267	318
T DIS SOLIDS	mg/L	278	277	311
IONIC BALANCE	%	-103	-104	-105
WATER NUTRIENTS				
NO2&NO3-N	mg/L	<0.05	0.06	0.50
TOTAL, COLD VAPO				
MERCURY	mg/L	<0.0001	<0.0001	<0.0001
TRACE ICP,TOTAL				
ALUMINUM	mg/L	0.015	0.016	0.012
ANTIMONY	mg/L	<0.005	<0.005	<0.005
ARSENIC	mg/L	<0.01	<0.01	<0.01
BARIUM	mg/L	0.0813	0.0816	0.0610
BERYLLIUM	mg/L	<0.00001	<0.00001	<0.00001
BISMUTH	mg/L	<0.0004	<0.0004	<0.0004
BORON	mg/L	0.004	0.005	0.007
CADMIUM	mg/L	<0.00006	<0.00006	<0.00006
CALCIUM	mg/L	61.0	60.8	53.3
CHROMIUM	mg/L	<0.00006	<0.00006	<0.00006

Lab Manager: [signature]

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WATER ANALYSIS REPORT

SAMPLE		10 STUMP MINE STU-WQ-ST1-2	11 STUMP MINE STU-WQ-STR1-1	12 STUMP MINE STU-WQ-STR2-1
TRACE ICP,TOTAL				
COBALT	mg/L	<0.00003	<0.00003	<0.00003
COPPER	mg/L	0.0174	0.00954	0.00209
IRON	mg/L	0.034	<0.003	<0.003
LEAD	mg/L	<0.0003	<0.0003	<0.0003
LITHIUM	mg/L	0.00337	0.00299	0.00759
MANGANESE	mg/L	0.00237	0.00251	0.00016
MAGNESIUM	mg/L	24.7	24.5	40.0
MOLYBDENUM	mg/L	0.00072	0.00062	0.00070
NICKEL	mg/L	0.0009	<0.0001	<0.0001
PHOSPHORUS	mg/L	<0.006	<0.006	<0.006
POTASSIUM	mg/L	1.23	3.76	4.86
SILVER	mg/L	<0.00005	<0.00005	<0.00005
SELENIUM	mg/L	0.006	0.005	<0.003
SILICON	mg/L	2.37	2.36	2.40
STRONTIUM	mg/L	0.206	0.205	0.363
SODIUM	mg/L	1.05	1.00	2.98
THALLIUM	mg/L	<0.001	<0.001	<0.001
SULPHUR	mg/L	23.9	24.4	17.2
TITANIUM	mg/L	<0.00002	<0.00002	<0.00002
TIN	mg/L	0.0008	0.0004	<0.0002
VANADIUM	mg/L	<0.00003	<0.00003	<0.00003
ZINC	mg/L	<0.0002	<0.0002	<0.0002

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WATER ANALYSIS REPORT

SAMPLE		13 STUMP MINE STU-WQ-AT1-1	14 PESO PESO-WQ-ST1-1	15 PESO PESO-WQ-ST1-2
TOTAL METALS				
SELENIUM	mg/L	0.0002	<0.0001	0.0002
ROUTINE WATER				
pH		7.91	7.36	7.14
ELECTRICAL COND	uS/cm	762	151	149
CALCIUM	mg/L	78.8	16.0	16.1
MAGNESIUM	mg/L	72.8	7.2	6.9
SODIUM	mg/L	11.3	1.6	1.6
POTASSIUM	mg/L	5.11	1.40	1.40
IRON	mg/L	0.08	0.04	0.05
MANGANESE	mg/L	<0.003	0.041	0.072
SULPHATE	mg/L	111	49.0	49.5
CHLORIDE	mg/L	<0.5	<0.5	0.8
BICARBONATE	mg/L	468	30	28
T ALKALINITY	mg/L	384	24	23
HARDNESS	mg/L	497	69.8	68.4
T DIS SOLIDS	mg/L	510	90	90
IONIC BALANCE	%	~106	~98.7	94.7
WATER NUTRIENTS				
NO2&NO3-N	mg/L	<0.05	<0.05	0.64
TOTAL, COLD VAPO				
MERCURY	mg/L	<0.0001	<0.0001	<0.0001
TRACE ICP,TOTAL				
ALUMINUM	mg/L	0.068	0.053	0.125
ANTIMONY	mg/L	0.107	<0.005	<0.005
ARSENIC	mg/L	0.05	<0.01	<0.01
BARIUM	mg/L	0.0254	0.0307	0.0692
BERYLLIUM	mg/L	<0.00001	<0.00001	<0.00001
BISMUTH	mg/L	<0.0004	<0.0004	<0.0004
BORON	mg/L	0.075	<0.002	0.017
CADMIUM	mg/L	<0.00006	0.00011	0.00048
CALCIUM	mg/L	79.6	15.8	25.3
CHROMIUM	mg/L	<0.00006	<0.00006	0.00216

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WATER ANALYSIS REPORT

SAMPLE		13 STUMP MINE STU-WQ-AT1-1	14 PESO PESO-WQ-ST1-1	15 PESO PESO-WQ-ST1-2
TRACE ICP,TOTAL				
COBALT	mg/L	0.00044	0.00068	0.00163
COPPER	mg/L	0.00776	0.00178	0.0223
IRON	mg/L	0.413	0.125	0.205
LEAD	mg/L	0.0456	<0.0003	0.0068
LITHIUM	mg/L	0.0361	0.00718	0.0129
MANGANESE	mg/L	0.0350	0.0730	0.138
MAGNESIUM	mg/L	67.2	6.63	10.1
MOLYBDENUM	mg/L	0.00048	0.00020	0.00108
NICKEL	mg/L	0.0027	0.0056	0.0196
PHOSPHORUS	mg/L	<0.006	<0.006	<0.006
POTASSIUM	mg/L	7.79	<0.60	0.72
SILVER	mg/L	0.00039	<0.00005	<0.00005
SELENIUM	mg/L	0.005	<0.003	<0.003
SILICON	mg/L	2.71	6.50	9.98
STRONTIUM	mg/L	1.18	0.0645	0.108
SODIUM	mg/L	11.8	1.41	2.44
THALLIUM	mg/L	<0.001	<0.001	<0.001
SULPHUR	mg/L	37.8	16.0	25.0
TITANIUM	mg/L	0.00043	0.00042	0.00277
TIN	mg/L	0.0003	<0.0002	0.0010
VANADIUM	mg/L	<0.00003	<0.00003	0.00013
ZINC	mg/L	0.0131	0.0091	0.235

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WATER ANALYSIS REPORT

note	pH	pH REPORTED AT ROOM TEMP
note	ELECTRICAL COND	'ELECTRICAL COND' (EC) is in microsiemens/cm and is a measure of solids in solution E.C. CORRECTED TO 25C
note	T ALKALINITY	'ALKALINITY' is CARBONATE/BICARBONATE expressed as CALCIUM CARBONATE
note	HARDNESS	'HARDNESS' is calcium and magnesium expressed as CALCIUM CARBONATE
note	NO2&NO3-N	is expressed as nitrogen

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WATER ANALYSIS REPORT

The following published METHODS OF ANALYSIS were used:

34011 SELENIUM
Total, perchloric acid digest, automated
hydride atomic absorption spectroscopy.
Ref. APHA 3114 C

10301L pH
Electrometric (pH meter)
Ref. APHA 4500-H+

02041L ELECTRICAL COND
Conductance meter
Ref. APHA 2510 B

20103 CALCIUM
ICP spectroscopy @ 317.9 nm
Ref. APHA 3120 B

12102L MAGNESIUM
ICP spectroscopy @ 285.2 nm
Ref. APHA 3120 B

11102L SODIUM

19111 POTASSIUM
Diss.,ICP Spectroscopy, Ref. APHA 3120 B

26304L IRON

16306L SULPHATE
ICP spectroscopy @ 180.7 nm
Ref. APHA 3120 B

17203L CHLORIDE
Automated colorimetry, Thiocyanate
Ref. APHA 4500 Cl-,E

06201L BICARBONATE
Potentiometric titration with standard
acid to pH 8.3 and pH 4.5
Ref. APHA 2320 B

10101 T ALKALINITY
Potentiometric titration with standard
acid to pH 4.5 & pH 8.3. Report as CaCO3
Ref. APHA 2320 B

10602 HARDNESS
Calculation from 2.5*Ca + 4.1*Mg
Reported as CaCO3
Ref. APHA 2340 B

00203 T DIS SOLIDS
SUM OF IONS CALCULATION
Ca + Mg + K + Na + SO4 + Cl + 0.6*T Alk
Ref. APHA 1030 F

NWL4994 IONIC BALANCE

00100 IONIC BALANCE 2
%Diff=(Sum Cations-Sum Anions)/
(Sum Cations+Sum Anions)*100
Ref. APHA 1030 F

07105L NO2&NO3-N
Automated colorimetry Cadmium reduction
Ref. APHA 4500-NO3-,F

Method References:

1. APHA Standard Methods for the Examination of Water and Wastewater, American Public Health Assoc., 17th ed.
2. EPA a. Test Methods for Evaluating Solid Waste, Physical/Chemical Methods SW-846, 3rd ed., US EPA, 1986
   b. Methods for Chemical Analysis of Water and Wastewater, US EPA, 1983
3. MSS Manual on Soil Sampling and Methods of Analysis, Cdn. Soc. of Soil Science, J. A. McKeague, 2nd ed.

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MICHEAL NAHIR
YUKON PHIII
19 10 97

WATER ANALYSIS REPORT

SAMPLE		1 STU-WQ-A1-1 10/97	2 STU-WQ-STR1-1 10/97	3 STU-WQ-STR1-2 10/97
ROUTINE WATER				
pH		7.76	8.20	8.19
ELECTRICAL COND	uS/cm	807	462	466
CALCIUM	mg/L	79.1	66.9	66.2
MAGNESIUM	mg/L	77.7	28.9	28.9
SODIUM	mg/L	14.4	1.9	1.5
POTASSIUM	mg/L	5.30	0.80	<0.60
SULPHATE	mg/L	123	75.2	73.8
CHLORIDE	mg/L	<0.5	<0.5	<0.5
BICARBONATE	mg/L	471	237	239
T ALKALINITY	mg/L	386	194	196
HARDNESS	mg/L	518	286	284
T DIS SOLIDS	mg/L	531	291	289
IONIC BALANCE	%	-108	~107	~106
WATER NUTRIENTS				
NO2&NO3-N	mg/L	0.50	0.07	<0.05
ICP METALS,EXTR				
IRON	mg/L	0.51	0.04	0.03
MANGANESE	mg/L	0.046	<0.003	<0.003
DISS, COLD VAPOR				
MERCURY	mg/L	<0.0001	<0.0001	<0.0001
METALS,DISS,AAS				
SELENIUM	mg/L	<0.0001	<0.0001	<0.0001
TRACE ICP,DISS				
IRON	mg/L	0.3834	0.0273	0.0207
ALUMINUM	mg/L	0.0545	0.00821	0.00582
ANTIMONY	mg/L	0.108	<0.005	<0.005
ARSENIC	mg/L	0.04	<0.01	<0.01
BARIUM	mg/L	0.0281	0.0781	0.0780
BERYLLIUM	mg/L	<0.00001	<0.00001	<0.00001
BISMUTH	mg/L	<0.0004	<0.0004	<0.0004
BORON	mg/L	0.131	0.011	0.006

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WATER ANALYSIS REPORT

SAMPLE		1 STU-WQ-A1-1 10/97	2 STU-WQ-STR1-1 10/97	3 STU-WQ-STR1-2 10/97
TRACE ICP,DISS				
CADMIUM	mg/L	<0.00006	<0.00006	<0.00006
CALCIUM	mg/L	80.9	61.5	61.3
CHROMIUM	mg/L	0.00040	0.00029	0.00031
COBALT	mg/L	0.00049	<0.00003	<0.00003
COPPER	mg/L	0.00539	0.00026	0.00014
LEAD	mg/L	0.0444	0.0005	<0.0003
LITHIUM	mg/L	0.0403	0.00263	0.00269
MANGANESE	mg/L	0.0390	0.00250	0.00206
MAGNESIUM	mg/L	68.7	25.7	25.9
MOLYBDENUM	mg/L	<0.00007	0.00015	0.00015
NICKEL	mg/L	0.0025	0.0003	0.0003
PHOSPHORUS	mg/L	0.062	0.012	0.007
POTASSIUM	mg/L	5.30	0.80	<0.60
SILVER	mg/L	0.00013	<0.00005	<0.00005
SELENIUM	mg/L	<0.003	<0.003	<0.003
SILICON	mg/L	2.76	2.37	2.36
STRONTIUM	mg/L	1.25	0.201	0.206
SODIUM	mg/L	12.1	1.13	1.15
THALLIUM	mg/L	<0.001	<0.001	<0.001
SULPHUR	mg/L	38.2	23.4	23.3
TITANIUM	mg/L	0.00087	<0.00002	<0.00002
TIN	mg/L	0.0072	0.0036	0.0037
URANIUM	mg/L	0.0032	0.0009	<0.0009
VANADIUM	mg/L	<0.00003	<0.00003	<0.00003
ZINC	mg/L	0.0163	0.0019	0.0018
ZIRCONIUM	mg/L	0.00029	<0.00004	<0.00004

Lab Manager: [signature]

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MICHEAL NAHIR
YUKON PHIII
19 10 97

WATER ANALYSIS REPORT

note	pH	pH REPORTED AT ROOM TEMP
note	ELECTRICAL COND	'ELECTRICAL COND' (EC) is in microsiemens/cm and is a measure of solids in solution E.C. CORRECTED TO 25C
note	T ALKALINITY	'ALKALINITY' is CARBONATE/BICARBONATE expressed as CALCIUM CARBONATE
note	HARDNESS	'HARDNESS' is calcium and magnesium expressed as CALCIUM CARBONATE
note	NO2&NO3-N	is expressed as nitrogen

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MICHEAL NAHIR
YUKON PHIII
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WATER ANALYSIS REPORT

---PARAMETER----	DATE OF-ANALYSIS	------ANALYZED BY-------	---PARAMETER----	DATE OF-ANALYSIS	------ANALYZED BY-------
pH	23Oct97	DARREN CRICHTON	ELECTRICAL COND	23Oct97	DARREN CRICHTON
CALCIUM	24Oct97	LANG QUE TRAN	MAGNESIUM	24Oct97	LANG QUE TRAN
SODIUM	24Oct97	LANG QUE TRAN	POTASSIUM	24Oct97	LANG QUE TRAN
SULPHATE	24Oct97	LANG QUE TRAN	CHLORIDE	23Oct97	THERESA LIEU
BICARBONATE	23Oct97	DARREN CRICHTON	T ALKALINITY	23Oct97	DARREN CRICHTON
HARDNESS	0	LANG QUE TRAN	T DIS SOLIDS	0	LANG QUE TRAN
IONIC BALANCE	0	LANG QUE TRAN	NO2&NO3-N	23Oct97	THERESA LIEU
IRON	24Oct97	LANG QUE TRAN	MANGANESE	24Oct97	LANG QUE TRAN
MERCURY	24Oct97	LANG QUE TRAN	SELENIUM	24Oct97	LANG QUE TRAN
IRON	23Oct97	LANG QUE TRAN	ALUMINUM	23Oct97	LANG QUE TRAN
ANTIMONY	24Oct97	LANG QUE TRAN	ARSENIC	24Oct97	LANG QUE TRAN
BARIUM	23Oct97	LANG QUE TRAN	BERYLLIUM	23Oct97	LANG QUE TRAN
BISMUTH	23Oct97	LANG QUE TRAN	BORON	24Oct97	LANG QUE TRAN
CADMIUM	23Oct97	LANG QUE TRAN	CALCIUM	24Oct97	LANG QUE TRAN
CHROMIUM	23Oct97	LANG QUE TRAN	COBALT	23Oct97	LANG QUE TRAN
COPPER	23Oct97	LANG QUE TRAN	LEAD	23Oct97	LANG QUE TRAN
LITHIUM	24Oct97	LANG QUE TRAN	MANGANESE	23Oct97	LANG QUE TRAN
MAGNESIUM	24Oct97	LANG QUE TRAN	MOLYBDENUM	23Oct97	LANG QUE TRAN
NICKEL	23Oct97	LANG QUE TRAN	PHOSPHORUS	24Oct97	LANG QUE TRAN
POTASSIUM	24Oct97	LANG QUE TRAN	SILVER	23Oct97	LANG QUE TRAN
SELENIUM	24Oct97	LANG QUE TRAN	SILICON	24Oct97	LANG QUE TRAN
STRONTIUM	23Oct97	LANG QUE TRAN	SODIUM	24Oct97	LANG QUE TRAN
THALLIUM	23Oct97	LANG QUE TRAN	SULPHUR	24Oct97	LANG QUE TRAN
TITANIUM	23Oct97	LANG QUE TRAN	TIN	23Oct97	LANG QUE TRAN
URANIUM	23Oct97	LANG QUE TRAN	VANADIUM	23Oct97	LANG QUE TRAN
ZINC	23Oct97	LANG QUE TRAN	ZIRCONIUM	23Oct97	LANG QUE TRAN

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YUKON MINES III-
STUMP MINE
23 04 98

WATER ANALYSIS REPORT

SAMPLE		1 STU-WQ-ST1-1	2 STU-WQ-ST1-2	3 STU-WQ-A1-1
TOTAL METALS				
SELENIUM	mg/L	<0.0001	<0.0001	0.0002
ROUTINE WATER				
pH		8.17	8.25	8.04
ELECTRICAL COND	uS/cm	470	475	833
CALCIUM	mg/L	61.6	61.2	71.0
MAGNESIUM	mg/L	27.8	28.3	75.3
SULPHATE	mg/L	62.5	61.7	121
BICARBONATE	mg/L	251	254	467
T ALKALINITY	mg/L	206	208	383
HARDNESS	mg/L	268	269	487
LOW LEVEL HG TOT				
MERCURY	mg/L	<0.00001	<0.00001	<0.00001
TRACE ICP,TOTAL				
ALUMINUM	mg/L	0.0270	0.104	0.434
ARSENIC	mg/L	<0.01	<0.01	0.06
CADMIUM	mg/L	<0.00006	<0.00006	0.00014
CHROMIUM	mg/L	0.0008	0.0010	0.0024
COPPER	mg/L	<0.001	<0.001	0.008
IRON	mg/L	0.011	0.025	1.19
LEAD	mg/L	<0.0003	<0.0003	0.0460
NICKEL	mg/L	0.002	<0.001	0.004
SILVER	mg/L	<0.00005	<0.00005	0.00061
ZINC	mg/L	<0.0005	0.0014	0.0216

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WATER ANALYSIS REPORT

note	pH	pH REPORTED AT ROOM TEMP
note	ELECTRICAL COND	'ELECTRICAL COND' (EC) is in microsiemens/cm and is a measure of solids in solution E.C. CORRECTED TO 25C
note	T ALKALINITY	'ALKALINITY' is CARBONATE/BICARBONATE expressed as CALCIUM CARBONATE
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WATER ANALYSIS REPORT

---PARAMETER----	DATE OF-ANALYSIS	------ANALYZED BY-------	---PARAMETER----	DATE OF-ANALYSIS	------ANALYZED BY-------
SELENIUM	30Apr98	LANG QUE TRAN	pH	29May98	DARREN CRICHTON
ELECTRICAL COND	29May98	DARREN CRICHTON	CALCIUM	29May98	LANG QUE TRAN
MAGNESIUM	29May98	LANG QUE TRAN	SULPHATE	29May98	LANG QUE TRAN
BICARBONATE	01Jun98	DARREN CRICHTON	T ALKALINITY	01Jun98	DARREN CRICHTON
HARDNESS	29May98	LANG QUE TRAN	MERCURY	28Apr98	LANG QUE TRAN
ALUMINUM	02Jun98	LANG QUE TRAN	ARSENIC	28Apr98	LANG QUE TRAN
CADMIUM	29Apr98	LANG QUE TRAN	CHROMIUM	28Apr98	LANG QUE TRAN
COPPER	28Apr98	LANG QUE TRAN	IRON	28Apr98	LANG QUE TRAN
LEAD	29Apr98	LANG QUE TRAN	NICKEL	28Apr98	LANG QUE TRAN
SILVER	29Apr98	LANG QUE TRAN	ZINC	28Apr98	LANG QUE TRAN

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WATER ANALYSIS REPORT

The following published METHODS OF ANALYSIS were used:

34011 SELENIUM
Total, perchloric acid digest, automated
hydride atomic absorption spectroscopy.
Ref. APHA 3114 C

10301L pH
Electrometric (pH meter)
Ref. APHA 4500-H+

02041L ELECTRICAL COND
Conductance meter
Ref. APHA 2510 B

20103 CALCIUM
ICP spectroscopy @ 317.9 nm
Ref. APHA 3120 B

12102L MAGNESIUM
ICP spectroscopy @ 285.2 nm
Ref. APHA 3120 B

16306L SULPHATE
ICP spectroscopy @ 180.7 nm
Ref. APHA 3120 B

06201L BICARBONATE
Potentiometric titration with standard
acid to pH 8.3 and pH 4.5
Ref. APHA 2320 B

10101 T ALKALINITY
Potentiometric titration with standard
acid to pH 4.5 & pH 8.3. Report as CaCO3
Ref. APHA 2320 B

10602 HARDNESS
Calculation from 2.5*Ca + 4.1*Mg
Reported as CaCO3
Ref. APHA 2340 B

Method References:

1. APHA Standard Methods for the Examination of Water and Wastewater, American Public Health Assoc., 17th ed.
2. EPA a. Test Methods for Evaluating Solid Waste, Physical/Chemical Methods SW-846, 3rd ed., US EPA, 1986
   b. Methods for Chemical Analysis of Water and Wastewater, US EPA, 1983
3. MSS Manual on Soil Sampling and Methods of Analysis, Cdn. Soc. of Soil Science, J. A. McKeague, 2nd ed.

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