MN-005

PWGSC

Quality in Environmental Services

Phase III Environmental Assessment

Big Thing Mine Site

Interim 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 1998

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 Big Thing abandoned mine site (60° 05' 01 " N, 134° 41 '01" 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 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.

Based on interim results the following conclusions have been drawn:

Conclusion 1. There is no decrease in water quality in Big Thing Creek downstream of the mine site.

Conclusion 2. Acid rock generation is occurring in the waste rock but is not impacting significant receptors.

Conclusion 3. Due to the age of the site, it is not expected that impacts due to waste rock ARD are likely.

Final recommendations will be based on a spring freshet sampling event proposed for April 1998.

Recommendation 1. The Big Thing Creek should be sampled during the spring freshet to complete the one year water quality monitoring program.

Recommendation 2. If no downstream effects are shown, no further action is required at this time.

Phase III Environmental Assessment Big Thing Mine Site

Interim 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 Big Thing abandoned mine site (60° 05' 01 " N, 134° 41 '01" 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 the waste rock and ore currently on site are generating acid. Analytical data received to date indicate that the rock piles are not impacting the local environment. However, future impacts cannot be anticipated without an understanding of the local hydrology. At this time, it is unknown whether the environmental quality of the site, as observed during the site visit in August 1996, would remain unchanged with time. The borrow source material and the gravel sampled are not potentially acid generating and would be suitable for use in remedial work.

The recommendations of the Phase II assessment were:

1. A more detailed site assessment is required to assess the potential impacts of the waste rock and to develop an effective remediation plan. There is currently insufficient information to determine whether leaving the piles as is will be environmentally acceptable. It is recommended that to determine metals in WR available for transport, a leachate extraction test should be performed.

2. A monitoring program be undertaken to obtain water quality data during spring freshet, middle summer and late fall conditions. Samples should be collected at BTWQ/STR-101, BTWQ/STR-102, BTWQ/STR-104 and BTWQ/A-103. Any additional seeps observed at the base of the waste rock and ore stockpiles should also be sampled and analyzed. The method detection limits should be CCME for freshwater aquatic life.

3. A preliminary hydrology assessment be completed to estimate the surface run off from the mine site. The results can then be used to determine appropriate remediation measures and future monitoring requirements.

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 Big Thing abandoned mine 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 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 Big Thing 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 upstream and downstream of the waste rock disposal areas, and from seeps emanating from the slope. Field pH and conductivity measurements were recorded during the summer sampling period. Samples were collected on 19 August and 18 October 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

Approximately 20 polymetallic, gold-bearing quartz veins are hosted in rocks of the mid-Cretaceous Montana Mountain volcanic complex and Montana pluton along an eight kilometre, northwest-trending belt between Windy Arm and Brute Mountain.

The gold and silver ores occur in a series of northeast striking quartz veins that cut medium to coarse grained, locally porphyritic granodiorite. Sulphide mineralization consists chiefly of pyrite (FeS_2), arsenopyrite (FeAsS), sphalerite ((Zn,Fe)S), galena (PbS) and minor chalcopyrite ($CuFeS_2$) occurring in irregular lenses and shoots within quartz vein material. The vein structures are commonly bordered by a selvage zone of altered granodiorite, consisting of bleaching and pyritization, extending up to 9.1 m (30 ft) either side of the vein. Weakly disseminated molybdenite (MoS_2) is sometimes present in the alteration envelope.

The major commodities identified at this site are gold and silver. Minor commodities include lead, zinc, copper, and molybdenum.

4.2 Surface Hydrology

Both the site and regional drainage are to the east draining into Big Thing Creek, less than 300 m south of the lower adit, and subsequently into Windy Arm of Tagish Lake, approximately 6 km east of the site.

Hydrological and water quality data are not available for Big Thing Creek.

Low seepage volumes were evident from the lower adit and drain towards the stream. Seepage was also detected from below the ore stockpile at the shaft and the site topography lends itself to seepage through the waste rock piles as a result of site drainage and surface infiltration from precipitation

4.3 Climate

The closest climatological information is from the town of Carcross, 60° 11' N, 134° 41' W; 663 m above sea level (Environment Canada, 1980). Total annual precipitation is 211.4 mm. This consists of 118.7 mm of rainfall and 101.3 mm of snowfall. Highest levels of rainfall occur in August and highest levels of snowfall occur in January. Temperatures range from -19.4° C in January to 12.7° C in July. The mean annual temperature is -1.4° C. Due to its higher elevation, Big Thing mine site is assumed to experience colder temperatures.

4.4 Vegetation

Big Thing minesite occurs within the Stikine Highlands ecoregion. Alpine tundra dominates at higher elevations including the area of the mine site, with vegetation including scrub heather, dwarf birch, willow species, grass and lichen. At lower elevations, on the access road to the site, the subalpine ecosystem is dominated by white spruce, alpine fir and white birch. Much of the area surrounding the access road consists of second growth birch and alder that appears to have been cleared in the past.

4.5 Fish and Wildlife Resources

Typical carnivores in the area include grizzly and black bear and wolf. Arctic ground squirrel, pika and yellow-bellied marmots are common rodents in the area. A small colony of hoary marmots was noted at the site. Bird species representative of this alpine habitat include several ptarmigan species and rosy finch. A number of raptors hunt and nest in the area, and waterfowl such as mergansers and harlequin ducks are found in the rivers at lower elevations. It is not currently known whether Big Thing Creek supports a fish population.

4.6 Site Topography and Soils

The soils within the Yukon Stikine Highlands ecoregion are predominantly brunisolic and regosolic. Occasionally, cryosolic soils, dystric brunisols and eutric brunisols are also found.

The site is located on the south east side of the lower-middle slope of an unnamed peak, approximately 2 km south west of Sugarloaf Mountain. The mine site is situated within a wide valley running approximately east-west with Montana Mountain forming the south side of the valley. Big Thing Creek runs along the valley floor. The north side of the valley is vegetated and gradually sloped with few rock outcroppings.

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 was flowing from the lower adit only in August 1997 (BTWQ-A-103). A seep sample was collected from below the low grade ore stockpile approximately 50m southwest of the upper adit along the roadcut in August 1996 and 1997 (BTWQ-S-101 and 97-BTWQ-SE1-1). This seep was not flowing in October 1997. Three samples were collected on Big Thing Creek: 500m upstream (97-BTWQ-STR104) and 500m downstream (97-BTWQ-STR102) of the dam, and 100m below the dam (97-BTWQ-STR208).

The seep water quality was similar at both sampling events, with near neutral pH and low conductivity (40 μS/cm to 44 μS/cm). Concentrations of aluminum, arsenic, cadmium, and iron were above the CCME guidelines during at least one sampling event. The seep disappears into the ground approximately 10 m from where it surfaces.

The flow in Big Thing Creek in August 1997 was 0.137 m^3/s. All samples from the creek had near-neutral pH values and low conductivities. Metals concentrations were below the CCME guidelines for all metals except selenium and aluminum. The selenium concentration was above the guideline in all August 1997 samples (range = 0.004 mg/L to 0.007 mg/L). Selenium is commonly associated with granitoid intrusions, and the elevated concentrations are likely attributable to a high stream load resulting from recent high rainfall. The aluminum concentration in the upstream sample in August 1996 was 1.6 mg/L, significantly higher than other measurements of aluminum in the creek. This high value is probably a result of analytical error. No significant change in water quality was seen between the upstream and downstream samples.

Table 5.1 Significant Results - Big Thing Surface Water Samples

Sample ID	Sample Location	Sample Date	pH	Cond. (μS/cm)	Parameters > CCME FAL Criteria
BTWQ-SE-1	seep 50m SW of adit	Aug 1997	7.02	40.2	Al, As, Cd, Fe
		Aug 1996	6.62	44.2	As
BTWQ-ST1-104	500m upstream	Aug 1997	7.0	18.7	Se
		Aug 1996	6.8	15.1	Al
BTWQ-A1-1	lower adit seepage	Aug 1996	5.13	56.1	Al, Cd, Fe, Zn
BTWQ-STR-208	100m upstream	Oct 1997	7.04	49.0	
		Aug 1997	6.98	29.3	Se
		Aug 1996	7.08	21.7	
BTWQ-STR-102	500m downstream	Oct 1997	7.11	35.0	
		Aug 1997	7.23	31.3	Se
		Aug 1996	6.68	22.6	

Notes: FAL = Freshwater Aquatic Life corrected for hardness.

5.2 Soluble Metals Concentrations

Samples BT-WR-P302 and BT-WR-P305-1 were analyzed using bottle roll tests. Sample P302 was collected from near the base of the rock pile below the upper inclined shaft. Sample P305-1 was located on the surface of the rock pile beneath the rail car tracks outside the lower adit.

Sample P302 had a laboratory paste pH value of 3 and a field paste conductivity of 750 µS/cm. The NP/AP ratio was <0.1 indicating that the sample is potentially acid generating. Sample P305-1 had a laboratory paste pH of 8 and field paste conductivity of 140 µS/cm. The NP/AP ratio was 1.

After nine days of testing, the slurry of sample P302 had a pH of 3.7 and a conductivity of 4300 µS/cm. The sulphate concentration in the filtered leachate of this sample contained over 4000 mg/L sulphate and had no measurable alkalinity. The slurry of sample P305-1 was alkaline with a pH of 9.2. Over the course of testing, the conductivity of this sample increased from 750 µS/cm to 1580 µS/cm. The sulphate concentration of the filtered leachate was 785 mg/L and the sample had 57 mg/L $CaCO_3$ eq. alkalinity. The high sulphate concentration in both samples indicates that they contain sulphides that are oxidizing and producing acid. The high pH of sample P305-1 indicates that this samples contains some buffering capacity.

The filtered leachate from sample P302 contained high concentrations of aluminum (54 mg/L), arsenic (38 mg/L), cadmium (0.45 mg/L), iron (352 mg/L), and zinc (6.8 mg/L). Metals concentrations in the leachate from sample P305-1 were also elevated but were much lower. For example, arsenic and iron concentrations were 2.9 mg/L and <0.03 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
BT-WR-P302	Potentially Acid Generating (NP/AP=<0.1); paste pH = 2.63; $S0_4$ = 31%;high As, Cd, Cr, Cu, Fe, Pb, Ag, Zn	Conductivity increased from 750 uS/cm to 4,300 uS/cm; low alkalinity, sulphate, and Al, As, Cd, Fe, Zn
BT-WR-P305-1	Potentially Acid Generating; paste pH = 6.35; (NP/AP=1); high As, Cd, Cr, Cu, Fe, Pb	Conductivity increased from 140 uS/cm to 1,580 uS/cm; high alkalinity, sulphate, and lower metals (though elevated)

6.0 CONCLUSIONS

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

Conclusion 1. There is no decrease in water quality in Big Thing Creek downstream of the mine site.

Conclusion 2. Acid rock generation is occurring in the waste rock but is not impacting significant receptors.

Conclusion 3. Due to the age of the site, it is not expected that impacts due to waste rock ARD are likely.

7.0 RECOMMENDATIONS

Recommended remediation and management actions are compliant with applicable federal or territorial regulations and criteria, rely upon available technology, and intended to be appropriate for local conditions and sensitivities. Recommendations made in this report are preliminary. Final recommendations will be based on a spring freshet sampling event proposed for April 1998.

Recommendation 1. The Big Thing Creek should be sampled during the spring freshet to complete the one year water quality monitoring program.

Recommendation 2. If no downstream effects are shown, no further action is required at this time.

8.0 COST ESTIMATES TO IMPLEMENT RECOMMENDATIONS

As required, an estimated breakdown of expected remediation/mitigation/monitoring costs to an accuracy of 25% will be provided under separate cover to this report. The cost estimate includes project management costs and contingency.

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APPENDIX A

Detailed Geochemical Assessment of Waste Rock and Surface Water

Big Thing Mine Site

Public Works and
Government
Services
Canada

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YUKON ABANDONED MINE SITES ASSESSMENT
REPORT ON 1997 FOLLOW-UP

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.

8.0 BIG THING

8.1 Background

Much of the waste rock at the Big Thing site is acidic and is oxidizing. Monitoring is being conducted to determine the impact of the site on Big Thing Creek.

Gold and silver ores of the Big Thing deposit comprise a series of northeast striking quartz veins that cut a porphyritic granodiorite intrusion. Mineralization consists of pyrite (FeS2), arsenopyrite (FeAsS), sphalerite ((Zn,Fe)S), galena (PbS), and minor chalcopyrite (CuFeS2).

8.2 Observations

Unlike in 1996, water was flowing from the lower adit during the 1997 site visits. The seep from the low grade ore stockpile was flowing in August 1997, but not in October of that year.

8.3 Water Quality

Water was flowing from the lower adit only in August 1997 (BTWQ-A-103). A seep sample was collected from below the low grade ore stockpile approximately 50m southwest of the upper adit along the roadcut in August 1996 and 1997 (BTWQ-S-101 and 97-BTWQ-SE1-1). This seep was not flowing in October 1997. Three samples were collected on Big Thing Creek: 500m upstream (97-BTWQ-STR104) and 500m downstream (97-BTWQ-STR102) of the dam, and 100m below the dam (97-BTWQ-STR208).

Results of water quality analyses are presented in Table 8. The seep water quality was similar at both sampling events, with near neutral pH and low conductivity (40 µS/cm to 44 µS/cm). Concentrations of aluminum, arsenic, cadmium, and iron were above the CCME guidelines during at least one sampling event. The seep disappears into the ground approximately 10 m from where it surfaces.

The flow in Big Thing Creek in August 1997 was 0.137 m3/s (Photograph 7). All samples from the creek had near-neutral pH values and low conductivities. Metals concentrations were below the CCME guidelines for all metals except selenium and aluminum. The selenium concentration was above the guideline in all August 1997 samples (range = 0.004 mg/L to 0.007 mg/L). Selenium is commonly associated with granitoid intrusions, and the elevated concentrations are likely attributable to a high stream load resulting from recent high rainfall. The aluminum concentration in the upstream sample in August 1996 was 1.6 mg/L, significantly higher than other measurements of aluminum in the creek. This high value is probably a result of analytical error. No significant change in water quality was seen between the upstream and downstream samples.

8.4 Soluble Metals Concentrations

Samples BT-WR-P302 and BT-WR-P305-1 were analyzed using bottle roll tests. Sample P302 was collected from near the base of the rock pile below the upper inclined shaft. Sample P305-1 was located on the surface of the rock pile beneath the rail car tracks outside the lower adit. Sample locations are shown on Figure 5.

Sample P302 had a laboratory paste pH value of 3 and a field paste conductivity of 750 µS/cm. The NP/AP ratio was <0.1 indicating that the sample is potentially acid generating. Sample P305-1 had a laboratory paste pH of 8 and field paste conductivity of 140 µS/cm. The NP/AP ratio was 1.

Bottle roll test results are listed in Tables 1 and 2. After nine days of testing, the slurry of sample P302 had a pH of 3.7 and a conductivity of 4300 µS/cm. The sulphate concentration in the filtered leachate of this sample contained over 4000 mg/L sulphate and had no measurable alkalinity. The slurry of sample P305-1 was alkaline with a pH of 9.2. Over the course of testing, the conductivity of this sample increased from 750 µS/cm to 1580 µS/cm. The sulphate concentration of the filtered leachate was 785 mg/L and the sample had 57 mg/L CaCO3 eq. alkalinity. The high sulphate concentration in both samples indicates that they contain sulphides that are oxidizing and producing acid. The high pH of sample P305-1 indicates that this samples contains some buffering capacity.

The filtered leachate from sample P302 contained high concentrations of aluminum (54 mg/L), arsenic (38 mg/L), cadmium (0.45 mg/L), iron (352 mg/L), and zinc (6.8 mg/L). Metals concentrations in the leachate from sample P305-1 were also elevated but were much lower. For example, arsenic and iron concentrations were 2.9 mg/L and <0.03 mg/L, respectively.

8.5 Discussion

There appears to be no decrease in the quality of water in Big Thing Creek downstream of the mine site. Selenium concentrations are above the CCME guideline both upstream and downstream of the site.

8.6 Recommendations

The water quality of Big Thing Creek should sampled during the spring freshet. No other action is recommended.

Table 1
Results of Physical Parameters in Bottle Roll Test Leachates

SAMPLE	SOLID			SLURRY										FILTERED LEACHATE									
	pH	Conductivity (µS/cm)	NP/AP	pH (Hours)					CONDUCTIVITY (uS/cm) (Hours)					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
				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	7.97	4450	280	0.0	10.5	289.0	3160	303	<1	5.5
STU-WR-P4-1	6.6	840	<0.1	--	6.2	6.4	6.1	--	--	2650	4000	4200	--	7.10	5350	290	0.0	7.5	21.0	4070	1	<1	96.8
PAD-WR-1-1	7.7	81	5	--	8.0	7.7	7.5	7.3	--	780	1490	1880	2400	8.31	3260	285	0.0	0.0	304.5	1930	320	<1	4.5
PAD-WR-2-1	7.6	77	5.3	--	8.3	8.1	8.0	8.1	--	670	1290	1590	1900	8.28	2760	288	0.0	0.5	104.0	1470	110	<1	4.2
FO-WR-P302	7.8	180	0.49	--	7.8	8.0	8.1	--	--	2300	2800	3000	--	7.52	4180	282	0.0	5.0	32.0	2140	<1	<1	754
FOR-WR-P307/	4.6	--	<0.1	--	4.0	4.3	4.3	--	--	4500	3900	3800	--	4.60	5280	365	0.0	1300.5	1.0	4570	<1	<1	5.9
GV206PAD1-3*	4	--	<0.1	4.5	4.7	--	--	--	375	420	--	--	--	5.02	623	387	0.0	31.0	10.0	208	51	<1	388
GV206PAD1-16	3	--	<0.1	2.9	2.9	--	--	--	1520	1560	--	--	--	3.10	2400	375	315.0	1500.0	0.0	1710	<1	<1	9.2
BT-WR-P302	3	750	<0.1	--	3.1	3.4	3.4	3.7	--	3900	4600	5000	4300	3.85	5750	352	58.0	1266.0	0.0	4070	123	<1	3.1
BT-WR-P305-1	8	140	1	--	8.9	9.1	9.2	9.2	--	750	1065	1240	1580	9.03	2250	242	0.0	0.0	56.5	785	129	<1	104
VE-WR-P305	6.7	>1990	0.25	--	6.6	6.7	7.0	--	--	5000	5400	5800	--	7.93	5820	252	0.0	13.0	133.5	3860	<1	<1	1.2
VE-WR-P311	8	>1990	1	--	8.5	8.6	8.7	--	--	2500	3200	3500	--	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.

Table 2
Dissolved Metals Concentrations in Bottle Roll Test Leachates

Sample No.		STU-WR-P3-1	STU-WR-P4-1	PAD-WR-1-1	PAD-WR-2-1	FO-WR-P302	FOR-WR-P307/2	GV206PADI-3	V206PADI-1	BT-WR-P302	BT-WR-P305-1	VE-WR-P305	VE-WR-311
Lab. Samples No.		4062	4063	4064	4065	4067	4066	4072	4073	4069	4068	4071	4070
Aluminum	mg/L	<0.2	<1	<0.2	<0.2	<0.2	5	1.8	67.2	53.9	0.2	<0.2	<0.2
Antimony	mg/L	0.2	<1	<0.2	<0.2	<0.2	<1	0.3	0.7	<0.2	0.3	<0.2	<0.2
Arsenic	mg/L	0.309	0.593	0.0335	0.0104	0.0133	0.0124	0.129	3.4	38.1	2.9	4.3	7.4
Barium	mg/L	0.04	<0.05	0.07	0.04	0.09	<0.05	0.09	0.03	0.08	0.07	0.04	0.03
Beryllium	mg/L	<0.005	<0.03	<0.005	<0.005	<0.005	<0.03	<0.005	0.015	0.007	<0.005	<0.005	<0.005
Bismuth	mg/L	0.2	0.7	0.1	<0.1	<0.1	0.6	<0.1	0.1	0.1	<0.1	0.3	<0.1
Boron	mg/L	0.1	<0.5	<0.1	0.1	1.0	0.8	0.4	2.0	0.2	0.1	0.1	<0.1
Cadmium	mg/L	<0.01	<0.05	<0.01	<0.01	0.02	11.2	<0.01	0.421	0.346	<0.005	0.04	<0.005
Calcium	mg/L	689	513	261	130	614	488	13	33.3	296	53.1	432	200
Chromium	mg/L	<0.01	<0.05	<0.01	<0.01	<0.01	<0.05	<0.01	0.02	<0.01	<0.01	<0.01	<0.01
Cobalt	mg/L	0.04	0.27	0.01	<0.01	<0.01	0.41	0.11	0.12	0.47	<0.01	0.04	<0.01
Copper	mg/L	0.04	0.07	0.01	0.02	0.03	0.12	0.23	2.57	0.4	0.023	0.02	<0.01
Iron	mg/L	<0.03	<0.2	<0.03	<0.03	<0.03	167	1.58	431	352	<0.03	<0.03	0.007
Lead	mg/L	0.09	3.9	0.1	0.013	0.22	3.7	0.10	0.30	0.77	<0.05	<0.02	<0.02
Lithium	mg/L	0.09	0.09	0.14	0.07	0.06	0.82	0.07	0.12	0.21	<0.01	0.19	0.06
Magnesium	mg/L	221	556	131	44.7	78.4	433	7.08	17.0	19	6.35	369	49.1
Manganese	mg/L	15.5	405	0.681	0.175	1.09	97.7	7.57	19.2	3.54	0.021	22.6	0.07
Mercury	mg/L	<0.00005	0.00009	<0.00005	<0.00005	0.00008	0.00032	0.0001	<0.00005	<0.00005	<0.00005	<0.00005	<0.00005
Molybdenu	mg/L	<0.03	<0.2	<0.03	0.1	<0.03	<0.2	<0.03	<0.03	<0.03	0.87	<0.03	0.07
Nickel	mg/L	0.06	0.8	<0.02	<0.02	<0.02	1.2	0.03	0.32	0.04	<0.02	0.07	<0.02
Phosphorus	mg/L	<0.3	<2	<0.3	<0.3	<0.3	<2	<0.3	<0.3	<0.3	<0.3	<0.3	<0.3
Potassium	mg/L	66	99	36	24	93	20	28	<2	173	52	111	74
Selenium	mg/L	0.0015	0.0028	0.0046	0.0041	<0.2	<1	<0.2	<0.2	0.0015	0.0085	<0.2	<0.2
Silicon	mg/L	10.2	7	7.99	8.04	3.19	30.3	52.1	66.2	104	19.3	25.9	23.4
Silver	mg/L	<0.01	<0.05	<0.01	<0.01	0.004	0.008	<0.01	<0.01	<0.01	0.02	<0.01	<0.01
Sodium	mg/L	320	134	360	486	290	132	82	66	764	377	543	552
Strontium	mg/L	2.33	0.3	0.879	0.625	0.396	0.045	0.077	1.04	0.754	0.329	5.32	3.09
Thallium	mg/L	<0.1	<0.5	<0.1	<0.1	<0.1	<0.5	<0.1	0.3	0.2	<0.1	<0.1	<0.1
Tin	mg/L	<0.03	<0.2	<0.03	<0.03	<0.03	<0.2	<0.03	<0.03	<0.03	<0.03	<0.03	<0.03
Titanium	mg/L	<0.01	<0.05	<0.01	<0.01	<0.01	<0.05	0.02	<0.01	<0.01	<0.01	<0.01	<0.01
Uranium	mg/L	0.0031	<0.0001	0.0067	0.006	<0.0001	0.0007	0.0005	0.0062	0.0152	0.0042	0.0038	0.0065
Vanadium	mg/L	<0.03	<0.2	<0.03	<0.03	<0.03	<0.2	<0.03	<0.03	<0.03	<0.03	<0.03	<0.03
Zinc	mg/L	0.175	1.06	1.18	0.057	0.524	702	0.686	57.7	6.76	0.015	6.01	0.055

Table 8
Water Quality Data
Big Thing Mine

PARAMETER	UNITS	D.L.*	BTWQ-A-103	BTWQ-S-101	BIG-WQ-SE1-1	BTWQ-STR-104	BTWQ-STR-104	BTWQ-STR-208	97-BTWQ-STR 208	BT-WQ-STR208
Sampling Event			Aug-96	Aug-96	Aug-97	Aug-96	Aug-97	Aug-96	Aug-97	Oct-97
Location			lower adit	seep 50 m SW of adit		500 m upstream		100 m downstream		
pH		0.1	5.13	6.62	7.05	6.8	7	7.08	6.98	7.04
Electrical conductivity	uS/cm	0.1	56.1	44.2	40.2	15.1	18.7	21.7	29.3	49.0
Hardness	mg/L	0.1	--	na	13.4	--	--	--	9.5	19.0
Alkalinity	mg/L	1	<1.0	9.3	21	4.8	21	4.5	21	21
Sulphate	mg/L	0.3	20.3	6.3	4.8	1.6	1.9	3.5	5.6	12.7
Aluminum	mg/L	0.00006	[redacted]	<0.2	[redacted]	[redacted]	0.033	<0.2	0.023	0.0131
Antimony	mg/L	0.005	<0.2	<0.2	<0.005	<0.2	<0.005	<0.2	<0.005	<0.005
Arsenic	mg/L	0.01	[redacted]	[redacted]	[redacted]	<0.2	0.01	<0.2	0.02	0.03
Cadmium	mg/L	0.00006	<0.01	<0.01	[redacted]	<0.01	<0.00006	<0.01	<0.00006	<0.00006
Calcium	mg/L	0.002	6.41	5.15	4.7	5.12	2.01	2.34	3.23	5.72
Chromium	mg/L	0.00006	<0.01	<0.01	<0.00006	<0.01	<0.00006	<0.01	<0.00006	<0.00006
Cobalt	mg/L	0.00003	<0.01	<0.01	0.00012	<0.01	<0.00003	<0.01	<0.00003	<0.00003
Copper	mg/L	0.00003	0.02	<0.01	0.00127	<0.01	<0.00003	<0.03	<0.00003	<0.00003
Iron	mg/L	0.003	[redacted]	0.08	[redacted]	0.08	0.033	<0.05	0.017	0.0064
Lead	mg/L	0.0003	<0.05	0.05	0.0004	<0.05	<0.0003	<0.01	<0.0003	<0.0003
Lithium	mg/L	0.00006	<0.01	<0.01	0.00033	0.19	<0.00006	0.46	0.00017	0.00078
Magnesium	mg/L	0.005	1.85	0.71	0.638	0.34	0.323	<0.005	0.583	1.07
Manganese	mg/L	0.00002	0.506	0.005	0.00767	<0.005	0.00026	--	<0.00002	0.00022
Mercury	mg/L	0.0001	--	--	<0.0001	--	<0.0001	<0.03	<0.0001	<0.0001
Molybdenum	mg/L	0.00007	<0.03	<0.03	0.00646	<0.03	0.00091	<0.02	0.00211	0.00026
Nickel	mg/L	0.0001	<0.02	<0.02	0.0002	<0.02	<0.0001	<0.2	<0.0001	<0.0001
Selenium	mg/L	0.003	<0.2	<0.2	--	<0.2	[redacted]	<0.01	[redacted]	<0.0001
Silver	mg/L	0.00005	<0.01	<0.01	0.0001	<0.01	<0.00005	<0.005	<0.00005	<0.00005
Zinc	mg/L	0.0002	[redacted]	0.009	<0.0002	0.012	<0.0002		<0.0002	0.0013

-- not analyzed for this parameter.
* Detection Limit for analyses of 1997 samples.
CCME = Canadian Council of Ministers of the Environment, Canadian Water Quality Guidelines
Exceeds the guidelines

Table 8
Water Quality Data
Big Thing Mine

PARAMETER	UNITS	D.L.*	BTWQ-STR-102	BTWQ-STR-102	BT-WQ-STR102	CCME *	MMLE*
Sampling Event			Aug-96	Aug-97	Oct-97		
Location			500 m downstream				
pH		0.1	6.68	7.23	7.11		<6.0
Electrical conductivity	uS/cm	0.1	22.6	31.3	35.0		
Hardness	mg/L	0.1	–	11.1	12.8		
Alkalinity	mg/L	1	6.3	21	21		
Sulphate	mg/L	0.3	3.5	4.6	6.6		
Aluminum	mg/L	0.00005	0.3	0.023	0.0284	0.1	
Antimony	mg/L	0.005	<0.2	<0.005	<0.005		
Arsenic	mg/L	0.01	<0.2	0.01	0.02	0.05	0.5
Cadmium	mg/L	0.00006	<0.01	<0.00006	<0.00006	0.0002	
Calcium	mg/L	0.002	2.49	3.42	3.62		
Chromium	mg/L	0.00006	<0.01	<0.00006	<0.00006	0.002	
Cobalt	mg/L	0.00003	<0.01	<0.00003	<0.00003		
Copper	mg/L	0.00003	<0.01	<0.00003	<0.00003	0.002	0.3
Iron	mg/L	0.003	<0.03	0.024	0.0150	0.3	
Lead	mg/L	0.0003	<0.05	<0.0003	<0.0003	0.001	0.2
Lithium	mg/L	0.00006	<0.01	<0.00006	0.00095		
Magnesium	mg/L	0.005	0.47	0.836	0.828		
Manganese	mg/L	0.00002	<0.005	0.00024	0.00034		
Mercury	mg/L	0.0001	na	<0.0001	<0.0001	0.0001	
Molybdenum	mg/L	0.00007	<0.03	0.00443	0.00030		
Nickel	mg/L	0.0001	<0.02	<0.0001	<0.0001	0.025	0.5
Selenium	mg/L	0.003	<0.2	[redacted]	<0.0001	0.001	
Silver	mg/L	0.00005	0.01	<0.00005	<0.00005	0.0001	
Zinc	mg/L	0.0002	<0.005	0.0226	0.0006	0.03	0.5

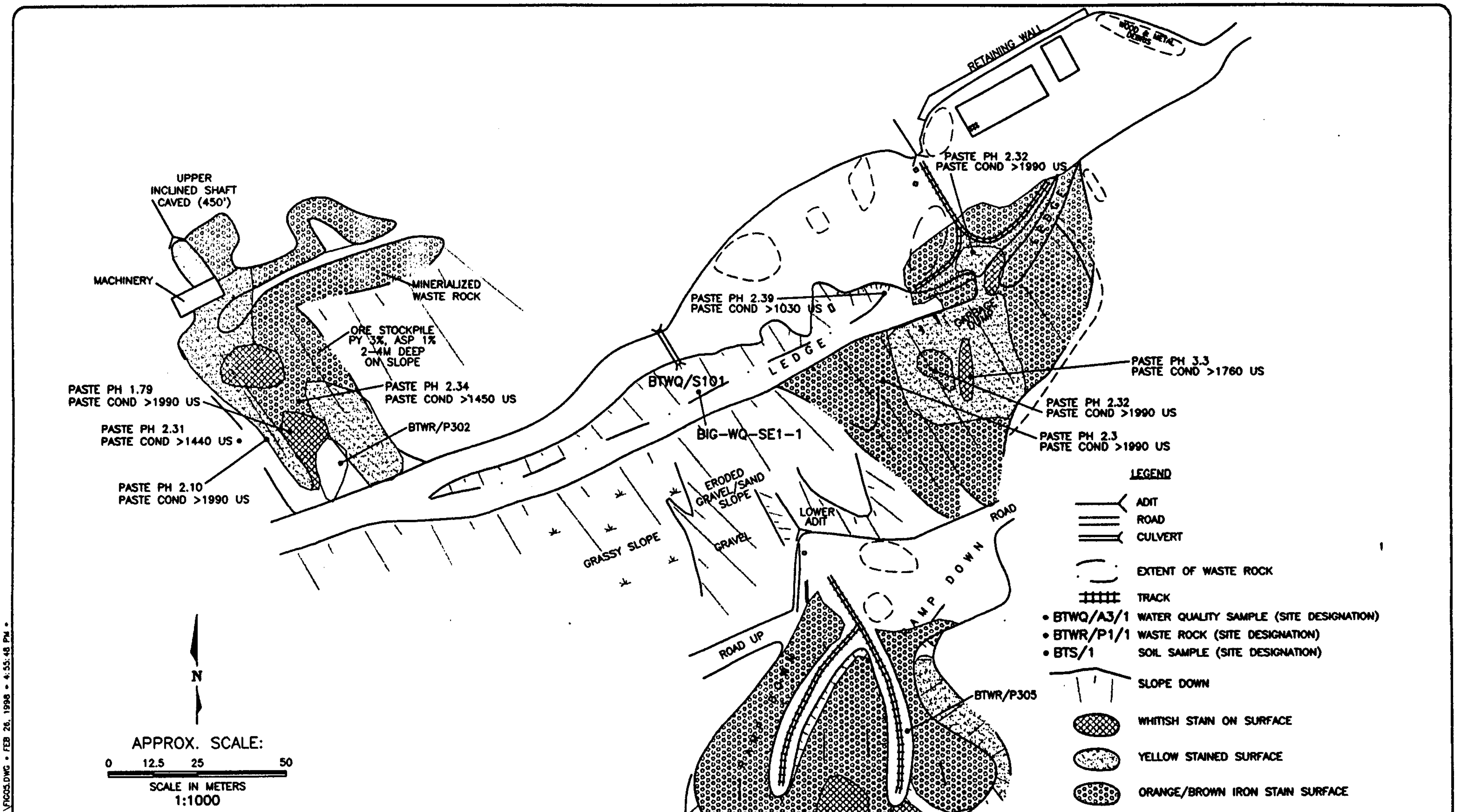

FIGURE 5

BIG THING MINE SITE
1997 INVESTIGATION

STEFFEN ROBERTSON & KIRSTEN (CANADA)
Consulting Engineers & Scientists

PROJECT NO.	DATE	REVISION
1CP001	02/98	A

• STA #2 • J:\1CP001\FIG05.DWG • FEB 26, 1998 • 4:55:48 PM •

APPENDIX B

Laboratory Reports

NORWEST LABS
EDMONTON PH. (403) 438-5522 FAX (403) 438-0396
CALGARY PH. (403) 291-2022 FAX (403) 291-2021
LANGLEY PH. (604) 530-4344 FAX (604) 534-9996
LETHBRIDGE PH. (403) 329-9266 FAX (403) 327-8527
WINNIPEG PH. (204) 982-8630 FAX (204) 275-6019

DATE 28 AUG 97 10:06
P.O. NO.
W.O. NO. 3 138316

PUBLIC WORKS CANADA
ENVIRONMENTAL SERVICES
1000, 9700 JASPER AVE
EDMONTON, AB
T5J 4E2

MIKE NAHIR
WATER/BASELINE

WATER ANALYSIS REPORT

SAMPLE		4 VEWQ-S201	5 VE-WQ-S2-1 VENUS MINE AUDT 2 WP PILE BELOW	6 BTWQ-STR-102 YUKON MINE PHIII 500M DOWSTREAM
TRACE ICP,TOTAL				
IRON	mg/L	0.044	0.029	0.024
LEAD	mg/L	<0.0003	0.0014	<0.0003
LITHIUM	mg/L	0.0149	0.0143	<0.00006
MANGANESE	mg/L	0.00048	0.00117	0.00024
MAGNESIUM	mg/L	23.6	23.1	0.836
MOLYBDENUM	mg/L	0.00888	0.0129	0.00443
NICKEL	mg/L	<0.0001	<0.0001	<0.0001
PHOSPHORUS	mg/L	<0.006	0.059	0.038
POTASSIUM	mg/L	2.04	<0.60	<0.60
SILVER	mg/L	<0.00005	<0.00005	<0.00005
SELENIUM	mg/L	0.007	0.004	0.007
SILICON	mg/L	3.36	3.66	1.76
STRONTIUM	mg/L	0.995	0.988	0.0199
SODIUM	mg/L	5.25	5.31	0.796
THALLIUM	mg/L	<0.001	<0.001	<0.001
SULPHUR	mg/L	22.7	22.4	1.67
TITANIUM	mg/L	<0.00002	<0.00002	0.00028
TIN	mg/L	<0.0002	<0.0002	<0.0002
VANADIUM	mg/L	<0.00003	<0.00003	0.00018
ZINC	mg/L	<0.0002	0.0355	0.0226

Lab Manager: [signature]

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PUBLIC WORKS CANADA
ENVIRONMENTAL SERVICES
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T5J 4E2

MIKE NAHIR
WATER/BASELINE

WATER ANALYSIS REPORT

SAMPLE		7 97-BTWQ-STR104 YUKON MINE 500M UPSTREAM	8 97-BTWQ-STR 208 YUKON MINE 100M BELOW DAM	9 BIG-WQ-SE1-1 SEPAGE 50M WEST OF UPPER AUDIT
ROUTINE WATER				
pH		7.00	6.98	7.05
ELECTRICAL COND	uS/cm	18.7	29.3	40.2
CALCIUM	mg/L	1.6	2.9	4.3
MAGNESIUM	mg/L	0.3	0.6	0.7
SODIUM	mg/L	0.7	0.8	1.2
POTASSIUM	mg/L	<0.60	<0.60	<0.60
IRON	mg/L	<0.04	<0.04	0.12
MANGANESE	mg/L	<0.003	<0.003	<0.003
SULPHATE	mg/L	1.9	5.6	4.8
CHLORIDE	mg/L	<0.5	<0.5	<0.5
BICARBONATE	mg/L	25	25	26
T ALKALINITY	mg/L	21	21	21
HARDNESS	mg/L	5.3	9.5	13.4
T DIS SOLIDS	mg/L	18	23	25
IONIC BALANCE	%	-32.2	-44.1	-58.3
WATER NUTRIENTS				
NO2&NO3-N	mg/L	<0.05	<0.05	0.60
TOTAL, COLD VAPO				
MERCURY	mg/L	<0.0001	<0.0001	<0.0001
TRACE ICP,TOTAL				
ALUMINUM	mg/L	0.033	0.023	0.119
ANTIMONY	mg/L	<0.005	<0.005	<0.005
ARSENIC	mg/L	0.01	0.02	0.43
BARIUM	mg/L	0.00087	0.00089	0.00038
BERYLLIUM	mg/L	<0.00001	<0.00001	<0.00001
BISMUTH	mg/L	<0.0004	<0.0004	<0.0004
BORON	mg/L	<0.002	<0.002	<0.002
CADMIUM	mg/L	<0.00006	<0.00006	0.00040
CALCIUM	mg/L	2.01	3.23	4.70
CHROMIUM	mg/L	<0.00006	<0.00006	<0.00006
COBALT	mg/L	<0.00003	<0.00003	0.00012
COPPER	mg/L	<0.00003	<0.00003	0.00127

Lab Manager: [signature]

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PUBLIC WORKS CANADA
ENVIRONMENTAL SERVICES
1000, 9700 JASPER AVE
EDMONTON, AB
T5J 4E2

MIKE NAHIR
WATER/BASELINE

WATER ANALYSIS REPORT

SAMPLE		7 97-BTWQ-STR104 YUKON MINE 500M UPSTREAM	8 97-BTWQ-STR 208 YUKON MINE 100M BELOW DAM	9 BIG-WQ-SE1-1 SEPAGE 50M WEST OF UPPER AUDIT
TRACE ICP, TOTAL				
IRON	mg/L	0.033	0.017	0.306
LEAD	mg/L	<0.0003	<0.0003	0.0004
LITHIUM	mg/L	<0.00006	0.00017	0.00033
MANGANESE	mg/L	0.00026	<0.00002	0.00767
MAGNESIUM	mg/L	0.323	0.583	0.638
MOLYBDENUM	mg/L	0.00091	0.00211	0.00648
NICKEL	mg/L	<0.0001	<0.0001	0.0002
PHOSPHORUS	mg/L	<0.006	<0.006	0.047
POTASSIUM	mg/L	<0.60	<0.60	2.89
SILVER	mg/L	<0.00005	<0.00005	0.00010
SELENIUM	mg/L	0.005	0.004	0.005
SILICON	mg/L	1.27	1.40	2.94
STRONTIUM	mg/L	0.0114	0.0168	0.0109
SODIUM	mg/L	0.573	0.655	1.03
THALLIUM	mg/L	<0.001	<0.001	<0.001
SULPHUR	mg/L	0.705	1.98	1.68
TITANIUM	mg/L	0.00030	0.00022	0.00072
TIN	mg/L	<0.0002	<0.0002	<0.0002
VANADIUM	mg/L	0.00017	0.00013	0.00022
ZINC	mg/L	<0.0002	<0.0002	<0.0002

Lab Manager: [signature]

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P.O. NO.
W.O. NO. 3 138316
PAGE 7

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MIKE NAHIR
WATER/BASELINE

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

Lab Manager: ______________________

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MIKE NAHIR
WATER/BASELINE

WATER ANALYSIS REPORT

---PARAMETER----	DATE OF-ANALYSIS	------ANALYZED BY-------	---PARAMETER----	DATE OF-ANALYSIS	------ANALYZED BY-------
pH	27Aug97	DARREN CRICHTON	ELECTRICAL COND	27Aug97	DARREN CRICHTON
CALCIUM	27Aug97	LANG QUE TRAN	MAGNESIUM	27Aug97	LANG QUE TRAN
SODIUM	27Aug97	LANG QUE TRAN	POTASSIUM	27Aug97	LANG QUE TRAN
IRON	27Aug97	LANG QUE TRAN	MANGANESE	27Aug97	LANG QUE TRAN
SULPHATE	27Aug97	LANG QUE TRAN	CHLORIDE	27Aug97	THERESA LIEU
BICARBONATE	27Aug97	DARREN CRICHTON	T ALKALINITY	27Aug97	DARREN CRICHTON
HARDNESS	28Aug97	LANG QUE TRAN	T DIS SOLIDS	28Aug97	LANG QUE TRAN
IONIC BALANCE	28Aug97	LANG QUE TRAN	NO2&NO3-N	27Aug97	THERESA LIEU
MERCURY	27Aug97	LANG QUE TRAN	ALUMINUM	27Aug97	LANG QUE TRAN
ANTIMONY	27Aug97	LANG QUE TRAN	ARSENIC	27Aug97	LANG QUE TRAN
BARIUM	27Aug97	LANG QUE TRAN	BERYLLIUM	27Aug97	LANG QUE TRAN
BISMUTH	27Aug97	LANG QUE TRAN	BORON	27Aug97	LANG QUE TRAN
CADMIUM	27Aug97	LANG QUE TRAN	CALCIUM	27Aug97	LANG QUE TRAN
CHROMIUM	27Aug97	LANG QUE TRAN	COBALT	27Aug97	LANG QUE TRAN
COPPER	27Aug97	LANG QUE TRAN	IRON	27Aug97	LANG QUE TRAN
LEAD	27Aug97	LANG QUE TRAN	LITHIUM	27Aug97	LANG QUE TRAN
MANGANESE	27Aug97	LANG QUE TRAN	MAGNESIUM	27Aug97	LANG QUE TRAN
MOLYBDENUM	27Aug97	LANG QUE TRAN	NICKEL	27Aug97	LANG QUE TRAN
PHOSPHORUS	27Aug97	LANG QUE TRAN	POTASSIUM	27Aug97	LANG QUE TRAN
SILVER	27Aug97	LANG QUE TRAN	SELENIUM	27Aug97	LANG QUE TRAN
SILICON	27Aug97	LANG QUE TRAN	STRONTIUM	27Aug97	LANG QUE TRAN
SODIUM	27Aug97	LANG QUE TRAN	THALLIUM	27Aug97	LANG QUE TRAN
SULPHUR	27Aug97	LANG QUE TRAN	TITANIUM	27Aug97	LANG QUE TRAN
TIN	27Aug97	LANG QUE TRAN	VANADIUM	27Aug97	LANG QUE TRAN
ZINC	27Aug97	LANG QUE TRAN			

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MIKE NAHIR
WATER/BASELINE

WATER ANALYSIS REPORT

The following published METHODS OF ANALYSIS were used:

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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PAGE 1

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MIKE NAHIR

WATER ANALYSIS REPORT

SAMPLE		1 BT-WQ-STR102 97/10	2 BT-WQ-STR208 97/10	3 FO-WQ-ST1-1
ROUTINE WATER				
pH		7.11	7.04	8.01
ELECTRICAL COND	uS/cm	35.0	49.0	566
CALCIUM	mg/L	3.6	5.7	113
MAGNESIUM	mg/L	0.9	1.2	23.1
SODIUM	mg/L	1.6	1.7	2.5
POTASSIUM	mg/L	1.22	1.11	<0.60
SULPHATE	mg/L	6.6	12.7	216
CHLORIDE	mg/L	<0.5	<0.5	<0.5
BICARBONATE	mg/L	26	25	174
T ALKALINITY	mg/L	21	21	142
HARDNESS	mg/L	12.8	19.0	377
T DIS SOLIDS	mg/L	27	35	441
IONIC BALANCE	%	~59.0	~67.9	~104
WATER NUTRIENTS				
NO2&NO3-N	mg/L	0.30	0.33	0.10
ICP METALS,EXTR				
IRON	mg/L	0.02	<0.02	0.05
MANGANESE	mg/L	<0.003	<0.003	0.140
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	0.0150	0.0064	0.0395
ALUMINUM	mg/L	0.0284	0.0131	0.00172
ANTIMONY	mg/L	<0.005	<0.005	<0.005
ARSENIC	mg/L	0.02	0.03	<0.01
BARIUM	mg/L	0.00099	0.00148	0.0524
BERYLLIUM	mg/L	<0.00001	<0.00001	<0.00001
BISMUTH	mg/L	<0.0004	<0.0004	<0.0004
BORON	mg/L	<0.002	<0.002	<0.002

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MIKE NAHIR

WATER ANALYSIS REPORT

SAMPLE		1 BT-WQ-STR102 97/10	2 BT-WQ-STR208 97/10	3 FO-WQ-ST1-1
TRACE ICP,DISS				
CADMIUM	mg/L	<0.00006	<0.00006	0.00047
CALCIUM	mg/L	3.62	5.72	106
CHROMIUM	mg/L	<0.00006	<0.00006	<0.00006
COBALT	mg/L	<0.00003	<0.00003	<0.00003
COPPER	mg/L	<0.00003	<0.00003	<0.00003
LEAD	mg/L	<0.0003	<0.0003	<0.0003
LITHIUM	mg/L	0.00095	0.00078	0.00833
MANGANESE	mg/L	0.00034	0.00022	0.137
MAGNESIUM	mg/L	0.828	1.07	20.0
MOLYBDENUM	mg/L	0.00030	0.00025	0.00029
NICKEL	mg/L	<0.0001	<0.0001	0.0009
PHOSPHORUS	mg/L	<0.006	<0.006	<0.006
POTASSIUM	mg/L	1.22	1.11	<0.60
SILVER	mg/L	<0.00005	<0.00005	<0.00005
SELENIUM	mg/L	<0.003	<0.003	<0.003
SILICON	mg/L	2.03	2.20	3.33
STRONTIUM	mg/L	0.0170	0.0247	0.226
SODIUM	mg/L	0.765	0.885	1.41
THALLIUM	mg/L	<0.001	<0.001	<0.001
SULPHUR	mg/L	2.16	4.16	66.5
TITANIUM	mg/L	0.00037	0.00015	<0.00002
TIN	mg/L	0.0003	0.0002	0.0009
URANIUM	mg/L	0.0034	0.0018	0.0057
VANADIUM	mg/L	<0.00003	<0.00003	<0.00003
ZINC	mg/L	0.0008	0.0013	0.0507
ZIRCONIUM	mg/L	<0.00004	<0.00004	<0.00004

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PAGE 11

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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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MIKE NAHIR

WATER ANALYSIS REPORT

---PARAMETER----	DATE OF-ANALYSIS	------ANALYZED BY-------	---PARAMETER----	DATE OF-ANALYSIS	------ANALYZED BY-------
pH	21Oct97	DARREN CRICHTON	ELECTRICAL COND	21Oct97	DARREN CRICHTON
CALCIUM	22Oct97	LANG QUE TRAN	MAGNESIUM	22Oct97	LANG QUE TRAN
SODIUM	22Oct97	LANG QUE TRAN	POTASSIUM	22Oct97	LANG QUE TRAN
SULPHATE	22Oct97	LANG QUE TRAN	CHLORIDE	21Oct97	THERESA LIEU
CARBONATE	21Oct97	DARREN CRICHTON	BICARBONATE	21Oct97	DARREN CRICHTON
P ALKALINITY	21Oct97	DARREN CRICHTON	T ALKALINITY	21Oct97	DARREN CRICHTON
HARDNESS	0	LANG QUE TRAN	T DIS SOLIDS	0	LANG QUE TRAN
IONIC BALANCE	0	LANG QUE TRAN	NO2&NO3-N	21Oct97	THERESA LIEU
IRON	21Oct97	LANG QUE TRAN	MANGANESE	21Oct97	LANG QUE TRAN
MERCURY	23Oct97	LANG QUE TRAN	SELENIUM	22Oct97	LANG QUE TRAN
IRON	22Oct97	LANG QUE TRAN	ALUMINUM	22Oct97	LANG QUE TRAN
ANTIMONY	22Oct97	LANG QUE TRAN	ARSENIC	22Oct97	LANG QUE TRAN
BARIUM	22Oct97	LANG QUE TRAN	BERYLLIUM	22Oct97	LANG QUE TRAN
BISMUTH	22Oct97	LANG QUE TRAN	BORON	22Oct97	LANG QUE TRAN
CADMIUM	22Oct97	LANG QUE TRAN	CALCIUM	22Oct97	LANG QUE TRAN
CHROMIUM	22Oct97	LANG QUE TRAN	COBALT	22Oct97	LANG QUE TRAN
COPPER	22Oct97	LANG QUE TRAN	LEAD	22Oct97	LANG QUE TRAN
LITHIUM	22Oct97	LANG QUE TRAN	MANGANESE	22Oct97	LANG QUE TRAN
MAGNESIUM	22Oct97	LANG QUE TRAN	MOLYBDENUM	22Oct97	LANG QUE TRAN
NICKEL	22Oct97	LANG QUE TRAN	PHOSPHORUS	22Oct97	LANG QUE TRAN
POTASSIUM	22Oct97	LANG QUE TRAN	SILVER	22Oct97	LANG QUE TRAN
SELENIUM	22Oct97	LANG QUE TRAN	SILICON	22Oct97	LANG QUE TRAN
STRONTIUM	22Oct97	LANG QUE TRAN	SODIUM	22Oct97	LANG QUE TRAN
THALLIUM	22Oct97	LANG QUE TRAN	SULPHUR	22Oct97	LANG QUE TRAN
TITANIUM	22Oct97	LANG QUE TRAN	TIN	22Oct97	LANG QUE TRAN
URANIUM	22Oct97	LANG QUE TRAN	VANADIUM	22Oct97	LANG QUE TRAN
ZINC	22Oct97	LANG QUE TRAN	ZIRCONIUM	22Oct97	LANG QUE TRAN

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P.O. NO.
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PAGE 13

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WATER ANALYSIS REPORT

The following published METHODS OF ANALYSIS were used:

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

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

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

06301L CARBONATE
Potentiometric titration with standard
acid to pH 8.3 and pH 4.5
Ref. APHA 2320 B

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

10151 P ALKALINITY
Potentiometric titration with standard
acid to pH 8.3. Report as CaCO3
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

26321 IRON
Acid extr.,ICP Spectro. Ref. APHA 3120 B

25321 MANGANESE
Acid extr.,ICP Spectro. Ref. APHA 3120 B

80016 MERCURY
Dissolved, cold vapor atomic absorption
spectroscopy, with H2SO4/K2S2O8 digest
Ref. EPA 245.2

34102 SELENIUM
Dissolved, perchloric acid digest, auto.
hydride atomic absorption spectroscopy

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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WATER ANALYSIS REPORT

Ref. APHA 3114 C

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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