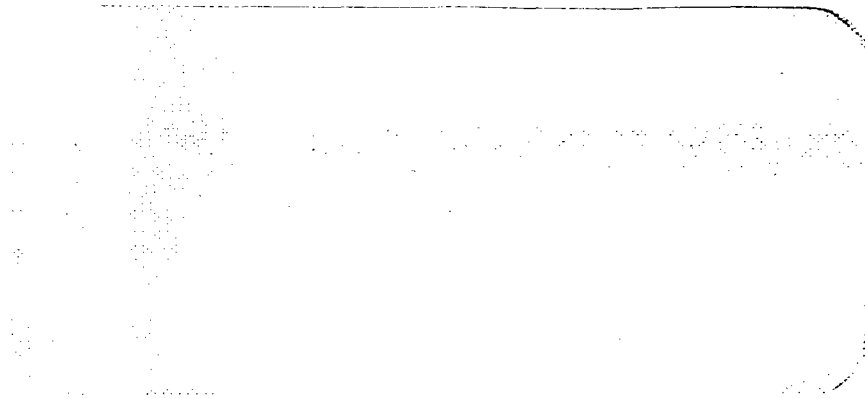


Mr. T. Cook was responsible for the organization and coordination of the field activities, compiling the analytical data and preparing the draft report.



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ENVIRONMENTAL PROTECTION SERVICE  
ENVIRONMENTAL PROTECTION BRANCH  
TECHNICAL SERVICES GROUP

COMPLIANCE EVALUATION  
OF THE COMINCO-SULLIVAN MINE,  
KIMBERLEY, B.C.

78-6.

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ABSTRACT

During the period from June 7-10, 1977 the Environmental Protection Service carried out a monitoring study of the effluent discharges from the Cominco, Sullivan Mine. The purpose of this study was to determine the state of compliance of the mine effluent discharges with the requirements of the Federal Metal Mining Liquid Effluent Guidelines.

The activities involved in this study included the following:

- 1) collecting composite and grab samples of the effluent discharges over a period of three consecutive days.
- 2) analyzing the effluent samples for a number of chemical parameters.
- 3) carrying out bioassay analyses on the collected samples.
- 4) collecting other information as necessary to assist in evaluating the state of compliance of this mine.

TABLE OF CONTENTS

	<u>Page</u>
ABSTRACT	i
TABLE OF CONTENTS	ii
List of Figures	iii
List of Tables	iii
List of Abbreviations and Definitions	iv
CONCLUSIONS	v
1    INTRODUCTION	1
2    MINE DESCRIPTION	3
2.1    General Information	3
2.2    Concentrator Operation	3
3    WASTEWATER SOURCES	6
4    SAMPLING AND ANALYTICAL METHODS	8
4.1    Sampling Program	8
4.2    Analytical Methods	8
4.2.1    Bioassay Determination	10
4.2.2    Total Metals (Cd, Cu, Ni, Pb, Zn)	10
4.2.3    Dissolved Metals (Cd, Cu, Ni, Pb, Zn)	10
4.2.4    Total Arsenic	11
4.2.5    Total Mercury	11
4.2.6    Non-Filterable Residue	11
4.2.7    pH Determination	12
5    RESULTS	13
5.1    Composite Sampling	13
5.2    Grab Samples	17
6    DISCUSSION	21
REFERENCES	26

LIST OF FIGURES

<u>Figure</u>		<u>Page</u>
1	LOCATION OF SAMPLING SITES AT COMINCO-SULLIVAN MINE AND CONCENTRATOR COMPLEX	7

LIST OF TABLES

<u>Table</u>		<u>Page</u>
1	SAMPLE CONTAINERS AND PRESERVATION METHODS	9
2	3900 LEVEL ACID MINE DRAINAGE - COMPOSITE SAMPLING RESULTS	13
3	3700 LEVEL MINE DRAINAGE - COMPOSITE SAMPLING RESULTS	14
4	SILICEOUS TAILINGS POND SUPERNATANT - COMPOSITE SAMPLING RESULTS	15
5	IRON TAILINGS POND SUPERNATANT - COMPOSITE SAMPLING RESULTS	16
6	3900 LEVEL ACID MINE DRAINAGE - GRAB SAMPLING RESULTS	17
7	3700 LEVEL MINE DRAINAGE - GRAB SAMPLING RESULTS	18
8	SILICEOUS TAILINGS POND SUPERNATANT - GRAB SAMPLING RESULTS	19
9	IRON TAILINGS POND SUPERNATANT - GRAB SAMPLING RESULTS	20
10	COMPARISON OF COMPOSITE SAMPLING RESULTS WITH FEDERAL GUIDELINES - 3900 LEVEL ACID MINE DRAINAGE	22
11	COMPARISON OF COMPOSITE SAMPLING RESULTS WITH FEDERAL GUIDELINES - 3700 LEVEL MINE DRAINAGE	23
12	COMPARISON OF COMPOSITE SAMPLING RESULTS WITH FEDERAL GUIDELINES - SILICEOUS TAILINGS POND SUPERNATANT	24
13	COMPARISON OF COMPOSITE SAMPLING RESULTS WITH FEDERAL GUIDELINES - IRON TAILINGS POND SUPERNATANT	25

LIST OF ABBREVIATIONS AND DEFINITIONS

(D)	dissolved
L	Less than
mg/l	milligrams per litre
MIGPD	million imperial gallons per day
ml	millilitres
(T)	total
tpd	tons per day
µg/l	micrograms per litre
Reference Mine Production Rate	- The greater of the design rated capacity and the maximum average annual production rate ever achieved during the operating life of a mine prior to February 25, 1977.

## CONCLUSIONS

Based on the data collected at the Cominco, Sullivan Mine from June 7 to 10, 1977, the following conclusions can be made:

- 1) The iron tailings pond supernatant and the 3900 level acid mine water were out of compliance with federal guideline limits for Pb, Zn, pH and the acute lethality requirements on all three days (toxicity analysis carried out only on day 1 and day 3).
- 2) The siliceous tailing pond supernatant was out of compliance with federal guideline limits for Ni on day 3. It was also out of compliance with the acute lethality requirements on both day 1 and day 3.
- 3) The 3700 level mine water was out of compliance with federal guideline limits for Zn on day 1 and day 3.
- 4) Dissolved lead and dissolved zinc are the most probable causes of toxicity.
- 5) The Environmental Protection Service in co-operation with the Pollution Control Branch should continue joint negotiation with Cominco Ltd. in order to facilitate the construction of appropriate pollution abatement facilities in an attempt to bring the Sullivan mining operation into compliance with Federal Guidelines.

1 INTRODUCTION

On February 25, 1977 the Federal Metal Mining Liquid Effluent Regulations and Guidelines were promulgated. These documents were developed pursuant to Section 33 and 34 of the Fisheries Act. The requirements defined in these documents are based on best practicable technology and apply uniformly as national baseline requirements. The Regulations apply to every new, expanded and reopened base metal, uranium and iron ore mine (1), while the Guidelines apply to existing base metal, uranium and iron ore mines. These control requirements were developed by a Task Force consisting of representatives of the mining industry, and provincial and federal government regulatory agencies. The Environmental Protection Service (E.P.S.) was responsible for the overall co-ordination of all the necessary inputs required to develop the national effluent controls.

Following promulgation of these guidelines, the EPS Pacific Region undertook a review of all operating metal mining operations in the Region (B.C. and Yukon), to determine the state of compliance of each operation. The review indicated that 14 mines operated tailings impoundment systems such that there was no positive discharge of effluent to a receiving body of water and were therefore in compliance with federal guidelines. Four mines discharged unconfined tailings and were obviously out of compliance with federal requirements. The remaining seven mines operated a tailings impoundment system and discharged the supernatant into a receiving body of water, and could thus be in or out of compliance depending upon the quality of the effluent being discharged.

In order to complete the assessment of the state of compliance for all mining operations in the Pacific Region, EPS carried out effluent surveillance studies for compliance verification at all seven mines (five in B.C., and two in the Yukon), which discharge tailings pond supernatant to a receiving body of water.



This report is an account of the effluent surveillance study conducted on June 7, 8, 9 and 10, 1977 at the Cominco, Sullivan Mine in Kimberley, B.C.

The following report includes a description of the mine, the procedures and methods used in this study, the results obtained and determination of the state of compliance of this mine with the Federal Guidelines.

2 MINE DESCRIPTION

2.1 General Information

The Cominco, Sullivan Mine is located in Kimberley, B.C. Mining operations began at this site around the turn of the century. The mine-mill complex has been in full scale operation since 1923. Ore reserves will ensure production for another 50 years of operation.

The Sullivan operation is an underground lead-zinc-iron mine. The mill processes approximately 8,300 tons per day of ore. The ore is present in the sulphide form as galena (lead), marmatite (zinc) and pyrrhotite (iron), in a quartzite host material. The concentrates produced at this mine are lead, zinc, iron and tin, however, quantities of silver, gold, copper and other trace metals are also recovered.

The reference mine production rate for this mine was established at 2,836,577 tons ore/year based on the 1955 operating year.

2.2 Concentrator Operation

The milling process begins in the mine, where the ore is crushed by jaw and cone crushers to pieces ranged from 1/4 inch to 1-1/2 inches in size. The crushed ore is transported by rail to the concentrator where it is first processed by a "sink-float" separator. This process removes the heavy lead-zinc-iron ore from the lighter quartzite gangue material by floating the ore in a slurry of finely divided, high grade galena and water.

The galena slurry, having a higher specific gravity than waste rock, will cause the lightweight gangue material to float on the surface, where it is removed and stockpiled. The heavy ore, which sinks to the bottom, is dredged up and transported to the grinding circuit.

The grinding process reduces the heavy ore, from the sink - float process, to a fine state, first in a rod mill then a series of ball mills. Large amounts of water are mixed with the ore to produce "pulp", which is then processed through a series of floatation cells.

The process involves four separate circuits, one for each concentrate produced, starting with lead, then zinc, iron and tin. Basically, this process involves:

- a) addition of carefully controlled amounts of chemicals and frothing agents, specific to each concentrate produced. These reagents alter the ore particle surfaces to allow better separation;
- b) agitation of the pulp;
- c) blowing air into the pulp.

The result is a froth composed of air bubbles with adhering mineral particles. First, the lead concentrate is separated from the ore and floated to the surface, then skimmed off, thickened and filtered. The remaining ore, which sinks to the bottom of the cell, is removed to the next circuit to separate out the zinc concentrate in the same manner. The residual pulp is removed to the last circuit to separate out the iron concentrate in the same manner. Tin concentrate is separated out from the remaining pulp by shaking tables, leaving siliceous tailings as final waste.

The lead and zinc concentrates are shipped by rail to the Trail smelter for further processing, whereas the tin concentrate goes to a custom tin smelter. However, the iron concentrate is handled in the following ways:

- a) used as backfill in mined-out areas, in conjunction with float (barren rock);
- b) used as a sulphur source for sulphuric acid needed in their fertilizer plants;
- c) the remainder is discharged to the iron tailings pond.

The siliceous tailings (mostly barren rock) as previously mentioned, are discharged to the siliceous tailings pond.

The concentrator produces (1973 figures) approximately:

- a) 500 tpd lead concentrate containing 65% lead as a sulphide.
- b) 900 tpd zinc concentrate containing 48% zinc as a sulphide.  
(The rest is iron sulphide and impurities).
- c) 1400 tpd iron concentrate containing 55% iron and 33% sulphur as iron sulphide.
- d) 1 tpd tin concentrate.

In the floation processes, the following chemicals and frothing agents are used (1973 figures):

Copper	1.40	lb/ton ore
MIBC	0.02	lb/ton ore
Lime	2.3	lb/ton ore
Sodium isopropyl xanthate	0.2	lb/ton ore
Sodium cyanide	0.08	lb/ton ore
Pine oil	0.01	lb/ton ore
Sulphuric acid	3.0	lb/ton ore
Aeroflow 25	0.08	lb/ton ore
Dyco #7	0.004	lb/ton ore

3 WASTEWATER

The mine-mill complex has four principle sources of wastewater (see Figure 1):

- a) 3900 level acid mine water<sup>1</sup>
- b) 3700 level mine water
- c) siliceous tailings pond
- d) iron tailings pond

The 3900 level acid mine water is composed of mine seepage water, water used in the underground primary crushing operation and domestic sewage. This effluent is discharged untreated to Mark Creek at an average flow rate of 1.5 MIGPD. The maximum daily flow rate is approximately 3 MIGPD.

The 3700 level mine water is composed of mine seepage water and water used in the underground primary crushing operation. This effluent is discharged untreated to Kimberley Creek at an average flow rate of 0.3 MIGPD.

The siliceous and iron tailings ponds have been installed to treat tailings from the mill complex. The iron tailings<sup>2</sup> are discharged to the iron tailings pond. Supernatant is discharged from this pond to James Creek at a rate of 0.6 MIGPD. The maximum daily discharge rate recorded was 3 MIGPD. The siliceous tailings result from the tin separation and are discharged to the siliceous tailings pond. The supernatant from this pond is discharged into James Creek at an average rate of 1.2 MIGPD. The maximum daily discharge rate recorded was 6 MIGPD.

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<sup>1</sup> The acid water results from the interaction of water, sulphide ore and air.

<sup>2</sup> The iron concentrate is partly used in the fertilizer operation to generate sulphuric acid. Unused iron concentrate is stored as a slurry in the iron tailings pond (iron sulphide pond).

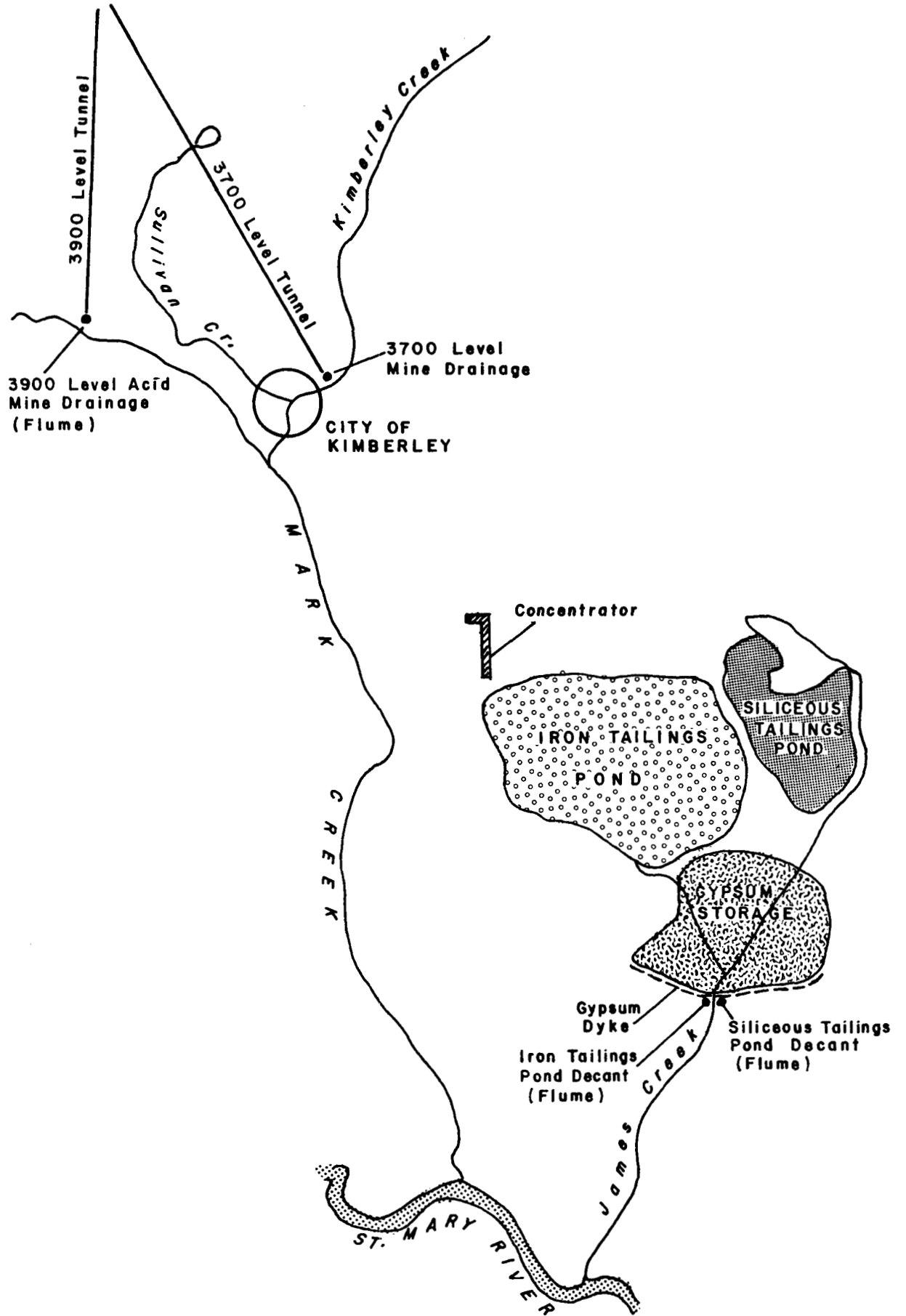


FIGURE 1 LOCATION OF SAMPLING SITES AT COMINCO-SULLIVAN MINE AND CONCENTRATOR COMPLEX

#### 4 SAMPLING AND ANALYTICAL METHODS

##### 4.1 Sampling Program

Time proportional 24 hour composite samples and grab samples were collected from the following discharges:

- 1) 3900 level acid mine water
- 2) 3700 level mine water
- 3) siliceous tailings pond supernatant
- 4) iron tailings pond supernatant

Sampling points are illustrated in Figure 1.

Twenty-four hour composite samples were collected for three consecutive days using automatic samplers. The sampler was set to collect aliquots at a rate of 1.1 litres/15 minutes. The samples were stored in 30 gallon polyethylene containers. In addition, grab samples were collected at each sampling site at a frequency of once per day.

The effluent stored in the polyethylene container was well mixed prior to sample division. Composite samples for chemical analyses were collected on all three days. Samples for bioassay determinations were collected on the 1st and 3rd days only.

The samples collected for chemical analyses were preserved according to the Environmental Protection Service, Pacific Region, Sampling Handbook (1976) as illustrated in Table 1. All samples were received by the Environmental Protection Service Laboratory facilities in North and West Vancouver within 48 hours of collection.

##### 4.2 Analytical Methods

Further to the methods outlined in the Environment Canada Laboratory Manual (2), the following notes are added.

TABLE 1            SAMPLE CONTAINERS AND PRESERVATION METHODS  
AS OUTLINED IN THE E.P.S. SAMPLING HANDBOOK (1976)

Parameter	Type of Container	Preservation
LC <sub>50</sub> (96 hour)	23 litre polyethylene jerry can	none
Total Arsenic	500 ml wide mouth polyethylene bottle	none
Total Metals (Cd, Cu, Hg, Ni, Pb, Zn)	100 ml wide mouth polyethylene bottle	acidified with HNO <sub>3</sub> to pH 1.5
Dissolved Metals (Cd, Cu, Ni, Pb, Zn)	100 ml wide mouth polyethylene bottle	filtered and acidified with HNO <sub>3</sub> to pH 1.5
Residues (NFR)	1 litre wide mouth polyethylene bottle	none



4.2.1 Bioassay Determination (96 hour LC<sub>50</sub>). The static fish bioassay gives an approximate value of the biological toxicity of an effluent. It is defined as the concentration or level of a measurable lethal agent required to kill the 50th percentile in a group of test organisms over a period of 96 hours.

The static bioassay test consisted of a series of 30 litre, all-glass test vessels containing different sample dilutions. The test vessels were placed in a controlled environment room where the temperature was maintained at 13 degrees  $\pm$  1°C and the photo period was limited to 16 hours for each 24 hour day. The samples were continuously aerated throughout the 96 hour test period with oil-free compressed air. Eight to 10 underyearling Rainbow Trout (Salmo gairdneri) were placed in each test vessel. The fish - loading density in each test vessel did not exceed 0.60 grams of fish per litre of test water. The fish mortality versus sample dilution for each test vessel was plotted on a graph and a 96 hour LC<sub>50</sub> was established.

4.2.2 Total Metals (Cd, Cu, Ni, Pb and Zn). The total volume of the sample (approx. 100 ml) was transferred to a beaker. The sample bottle was rinsed with 6 ml hydrochloric acid and 2 ml concentrated nitric acid, (aqua regia). This rinse, plus deionized water rinses, was added to the sample in the beaker. This solution was evaporated to 50 ml on a hot plate, then made up to the original volume with deionized water in the original sample bottle. The samples were then analyzed by direct aspiration on the Jarrell - Ash 810 Atomic Absorption Spectrophotometer with background correction used for Pb, Ni, Cd and Zn. The detection limits are as follows: Cd - 0.01 mg/l, Cu - 0.01 mg/l, Ni - 0.05 mg/l, Pb - 0.1 mg/l and Zn - 0.01 mg/l.

4.2.3 Dissolved Metals (Cd, Cu, Ni, Pb and Zn). The samples were filtered through a 45 micron filter and the pH was adjusted in the field to 1.5 with concentrated nitric acid. The samples were analyzed by direct aspiration on the Jarrell - Ash 810 Atomic Absorption

Spectrophotometer for Ni, Cu, Zn and Cd. Pb was extracted into methylisobutylketone (MIBK) using ammonium pyrrolidinedithiocarbamate (APDC) and sodium dithiodiethylcarbamate (DDC) complexing agents buffered with sodium acetate. The MIBK extraction was analyzed by aspiration on the Jarrell - Ash 810 Atomic Absorption Spectrophotometer. The detection limits are the same as for total metals.

4.2.4 Total Arsenic (As). A 100 ml aliquot was removed from the sample, 2 ml of concentrated nitric acid was added and the acidified aliquot was then boiled for 10 minutes. Distilled water was added to bring the volume back to the original 100 ml and nickel nitrate was added to fix the arsenic. The arsenic concentration was determined using the Graphite Furnace technique employing a Perkin Elmer Model 306 Atomic Absorption Spectrophotometer equipped with an HGA graphite furnace. The detection limit is 0.001 mg/l.

4.2.5 Total Mercury (Hg). A 60 ml portion of the above aqua regia leached sample was digested with a 1:2 nitric: sulphuric acid mixture. The mercury was then reduced to elemental mercury with a solution of hydrazine sulphate and stannous chloride. The volatilized mercury vapour was passed through an absorption cell and measured by Atomic Absorption Spectrophotometer. The detection limit is 0.2 µg/l.

4.2.6 Non-Filterable Residue (N.F.R). Non-filterable residue is that portion of the total residue retained by a GF/C filter. NFR is also referred to as suspended matter or suspended solids.

The sample was filtered through a pre-weighed Gooch crucible containing GF/C filter paper. The crucible was dried at 103°C, cooled, brought to constant weight, then re-weighed. The increased weight was used to calculate the NFR and the results were reported as mg/l. The minimum amount detectable is 10 mg in a 1 litre sample.

4.2.7 pH Determination. pH is a measure of the  $H^+$  ion concentration.

Numbers above seven indicate increasing basic condition with increasing numerical value. Numbers below seven indicate increasing acidic conditions with decreasing numerical value (pH 7 is neutral). All pH values quoted in this report are the results of on-site measurements using a Fisher Accumet 107 with a precision of  $\pm 0.03$  pH units.

5 RESULTS

5.1 Composite Samples

The chemical analyses and bioassay test results for the composite samples are presented in Tables 2 to 5.

TABLE 2 3900 LEVEL ACID MINE DRAINAGE - COMPOSITE SAMPLING RESULTS

A. Chemical and Physical Analyses

Parameter	Day 1	Day 2	Day 3
As (T) mg/l	0.172	0.061	0.067
Cd (T) mg/l	0.10	0.10	0.09
Cd (D) mg/l	0.10	0.09	0.09
Cu (T) mg/l	0.49	0.37	0.42
Cu (D) mg/l	0.31	0.29	0.32
Hg (T) µg/l	1.3	0.88	1.1
Ni (T) mg/l	0.28	0.44	0.25
Ni (D) mg/l	0.22	0.21	0.24
Pb (T) mg/l	9.5	6.5	5.8
Pb (D) mg/l	3.7	3.6	2.6
Zn (T) mg/l	65.0	97.0	83.0
Zn (D) mg/l	80.0*	87.0	86.0*
N.F.R. mg/l	460	120	360
pH	-	3.2	3.2

B. Toxicity Determination

	<u>Day 1</u>	<u>Day 2</u>	<u>Day 3</u>
LC <sub>50</sub>	0.56	-	0.56

\* dissolved results higher than total results, possibly due to contamination.

TABLE 3 3700 LEVEL MINE DRAINAGE - COMPOSITE SAMPLING RESULTS

A. Chemical and Physical Analyses

Parameter	Day 1	Day 2	Day 3
As (T) mg/l	0.001	0.003	0.002
Cd (T) mg/l	L0.01	L0.01	L0.01
Cd (D) mg/l	L0.01	L0.01	L0.01
Cu (T) mg/l	0.01	L0.01	L0.01
Cu (D) mg/l	L0.01	L0.01	L0.01
Hg (T) µg/l	0.44	0.33	0.39
Ni (T) mg/l	L0.05	L0.05	L0.05
Ni (D) mg/l	L0.05	L0.05	L0.05
Pb (T) mg/l	L0.1	L0.1	L0.1
Pb (D) mg/l	L0.1	L0.1	L0.1
Zn (T) mg/l	1.3	0.47	0.87
Zn (D) mg/l	0.73	0.82*	0.65
N.F.R. mg/l	L10	L10	L10
pH	-	8.1	8.0

B. Toxicity Determination

	<u>Day 1</u>	<u>Day 2</u>	<u>Day 3</u>
LC <sub>50</sub> (%)	non-toxic	-	non-toxic

\* dissolved results higher than total results, possibly due to contamination.

TABLE 4 SILICEOUS TAILINGS POND SUPERNATANT - COMPOSITE  
SAMPLING RESULTS

A. Chemical and Physical Analyses

Parameter	Day 1	Day 2	Day 3
As (T) mg/l	0.012	0.004	0.014
Cd (T) mg/l	L0.01	L0.01	L0.01
Cd (D) mg/l	L0.01	L0.01	L0.01
Cu (T) mg/l	0.04	0.01	0.02
Cu (D) mg/l	L0.01	L0.01	L0.01
Hg (T) µg/l	1.3	0.61	0.56
Ni (T) mg/l	L0.05	L0.05	L0.05
Ni (D) mg/l	L0.05	L0.05	L0.05
Pb (T) mg/l	L0.1	L0.1	L0.1
Pb (D) mg/l	L0.1	L0.1	L0.1
Zn (T) mg/l	0.63	0.56	1.8
Zn (D) mg/l	0.54	0.56	0.23
N.F.R. mg/l	10	10	L10
pH	-	5.8	5.5

B. Toxicity Determination

	<u>Day 1</u>	<u>Day 2</u>	<u>Day 3</u>
LC <sub>50</sub> (%)	5.6	-	6.5

TABLE 5 IRON TAILINGS POND SUPERNATANT - COMPOSITE  
SAMPLING RESULTS

A. Chemical and Physical Analyses

Parameter	Day 1	Day 2	Day 3
As (T) mg/l	0.008	0.007	0.008
Cd (T) mg/l	LO.01	LO.01	LO.01
Cd (D) mg/l	LO.01	LO.01	LO.01
Cu (T) mg/l	0.05	0.05	0.05
Cu (D) mg/l	0.04	0.04	0.03
Hg (T) µg/l	0.77	0.39	0.77
Ni (T) mg/l	LO.05	0.06	0.06
Ni (D) mg/l	LO.05	LO.05	LO.05
Pb (T) mg/l	1.2	1.2	1.0
Pb (D) mg/l	0.8	1.1	0.7
Zn (T) mg/l	2.0	5.5	3.8
Zn (D) mg/l	3.1*	4.6	3.2
N.F.R. mg/l	64	18	43
pH	-	4.9	5.0

B. Toxicity Determination

	<u>Day 1</u>	<u>Day 2</u>	<u>Day 3</u>
LC <sub>50</sub> (%)	2.7	-	5.6

\* dissolved result higher than total result, possibly due to contamination.

5.2 Grab Samples

The chemical analyses results for the grab samples are presented in Tables 6 to 9.

TABLE 6 3900 LEVEL ACID MINE DRAINAGE - GRAB SAMPLING RESULTS

Parameter	June 8	June 9	June 10
As (T) mg/l	0.061	0.037	0.076
Cd (T) mg/l	0.11	0.07	0.10
Cd (D) mg/l	0.09	0.07	0.11*
Cu (T) mg/l	0.29	0.20	0.41
Cu (D) mg/l	0.20	0.15	0.32
Hg (T) µg/l	1.10	1.40	0.77
Ni (T) mg/l	0.24	0.17	0.36
Ni (D) mg/l	0.23	0.17	0.37*
Pb (T) mg/l	7.5	4.9	4.0
Pb (D) mg/l	3.9	2.2	2.1
Zn (T) mg/l	90.0	70.0	110.0
Zn (D) mg/l	84.0	68.0	120.0*
N.F.R. mg/l	260	76	31
pH	-	3.3	3.2

\*dissolved results higher than total results, possibly due to contamination.



TABLE 7 3700 LEVEL MINE DRAINAGE - GRAB SAMPLING RESULTS

Parameter	June 8	June 9	June 10
As (T) mg/l	0.003	0.004	L0.001
Cd (T) mg/l	L0.01	L0.01	L0.01
Cd (D) mg/l	L0.01	L0.01	L0.01
Cu (T) mg/l	0.01	L0.01	L0.01
Cu (D) mg/l	L0.01	L0.01	L0.01
Hg (T) µg/l	0.39	0.33	0.44
Ni (T) mg/l	L0.05	L0.05	L0.05
Ni (D) mg/l	L0.05	L0.05	L0.05
Pb (T) mg/l	L0.1	L0.1	L0.1
Pb (D) mg/l	L0.1	L0.1	L0.1
Zn (T) mg/l	0.85	0.40	0.24
Zn (D) mg/l	0.58	0.62*	0.48*
N.F.R. mg/l	L10	L10	L10
pH	-	8.1	8.2

\*dissolved results higher than total results, possibly due to contamination.

TABLE 8 SILICEOUS TAILINGS POND SUPERNATANT - GRAB SAMPLING RESULTS

Parameter	June 8	June 9	June 10
As (T) mg/l	0.012	0.004	0.008
Cd (T) mg/l	L0.01	L0.01	L0.01
Cd (D) mg/l	L0.01	L0.01	L0.01
Cu (T) mg/l	0.01	0.02	0.01
Cu (D) mg/l	L0.01	L0.01	L0.01
Hg (T) µg/l	0.33	0.50	0.55
Ni (T) mg/l	L0.05	L0.05	L0.05
Ni (D) mg/l	L0.05	L0.05	L0.05
Pb (T) mg/l	L0.1	L0.1	L0.1
Pb (D) mg/l	L0.1	L0.1	L0.1
Zn (T) mg/l	1.4	0.43	0.82
Zn (D) mg/l	0.71	0.54*	0.35
N.F.R. mg/l	L10	L10	L10
pH	-	6.1	6.0

\*dissolved results higher than total results, possibly due to contamination.

TABLE 9 IRON TAILINGS POND SUPERNATANT - GRAB SAMPLING RESULTS

Parameter	June 8	June 9	June 10
As (T) mg/l	0.015	0.004	0.006
Cd (T) mg/l	0.01	LO.01	LO.01
Cd (D) mg/l	0.01	LO.01	LO.01
Cu (T) mg/l	0.09	0.05	0.05
Cu (D) mg/l	0.03	0.04	0.03
Hg (T) $\mu$ g/l	0.55	0.44	0.71
Ni (T) mg/l	LO.05	LO.05	LO.05
Ni (D) mg/l	LO.05	LO.05	LO.05
Pb (T) mg/l	1.4	1.4	1.1
Pb (D) mg/l	1.2	1.0	0.5
Zn (T) mg/l	10.0	4.3	3.5
Zn (D) mg/l	5.7	3.6	3.0
N.F.R. mg/l	20	29	22
pH	-	5.2	5.6

6 DISCUSSION

A comparison between our effluent monitoring results and the federal guidelines is presented in Tables 10 to 13. The results indicate the following:

- a) The 3900 level acid mine water was out of compliance for Pb, Zn, pH and NFR on all three days, and for Cu on the 1st day. The bioassay results also show that this mine water was acutely toxic on both days sampled (1st and 3rd).
- b) The 3700 level mine water was out of compliance for Zn on the 1st and 3rd day. However, the bioassay results do not show any acute toxicity.
- c) The siliceous tailings supernatant was out of compliance for Zn on the 3rd day of sampling. In addition, the bioassay results show that this effluent was acutely toxic on both days sampled (1st and 3rd).
- d) The iron tailing supernatant was found to be out of compliance for Pb, Zn and pH for all three days, and for NFR on the 1st day. The bioassay results show that the effluent was acutely toxic on both days sampled (1st and 3rd).

Although a discussion of the causes of toxicity is beyond the scope of this report, the most likely cause of the toxicities are the dissolved heavy metals.

TABLE 10                      COMPARISON OF COMPOSITE SAMPLING RESULTS WITH FEDERAL  
GUIDELINES - 3900 LEVEL ACID MINE DRAINAGE

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Parameter	Federal Guidelines	Day 1	Day 2	Day 3
As (T) mg/l	0.75	0.172	0.061	0.067
Cu (T) mg/l	0.45	0.49	0.37	0.42
Ni (T) mg/l	0.75	0.28	0.44	0.25
Pb (T) mg/l	0.30	9.5	6.5	5.8
Zn (T) mg/l	0.75	65.0	97.0	83.0
As (D) mg/l	-	-	-	-
Cu (D) mg/l	-	0.31	0.29	0.32
Ni (D) mg/l	-	0.22	0.21	0.24
Pb (D) mg/l	-	3.7	3.6	2.6
Zn (D) mg/l	-	80.0	87.0	86.0
N.F.R. mg/l	37.5	460	120	360
pH	5.5	-	3.2	3.2
LC <sub>50</sub> (%)	50	0.56	-	0.56

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TABLE 11                      COMPARISON OF COMPOSITE SAMPLING RESULTS WITH FEDERAL  
GUIDELINES - 3700 LEVEL MINE DRAINAGE

Parameter	Federal Guidelines	Day 1	Day 2	Day 3
As (T) mg/l	0.75	0.001	0.001	0.002
Cu (T) mg/l	0.45	0.01	LO.01	LO.01
Ni (T) mg/l	0.75	LO.05	LO.05	LO.05
Pb (T) mg/l	0.30	LO.1	LO.1	LO.1
Zn (T) mg/l	0.75	1.3	0.47	0.87
As (D) mg/l	-	-	-	-
Cu (D) mg/l	-	LO.01	LO.01	LO.01
Ni (D) mg/l	-	LO.05	LO.05	LO.05
Pb (D) mg/l	-	LO.1	LO.1	LO.1
Zn (D) mg/l	-	0.73	0.82	0.65
N.F.R. mg/l	37.5	L10	L10	L10
pH	5.5	-	8.1	8.0
LC <sub>50</sub> (%)	50	non-toxic	-	non-toxic

TABLE 12                      COMPARISON OF COMPOSITE SAMPLING RESULTS WITH FEDERAL  
GUIDELINES - SILICEOUS TAILINGS POND SUPERNATANT

Parameter	Federal Guidelines	Day 1	Day 2	Day 3
As (T) mg/l	0.75	0.012	0.004	0.014
Cu (T) mg/l	0.45	0.04	0.01	0.02
Ni (T) mg/l	0.75	L0.05	L0.05	L0.05
Pb (T) mg/l	0.30	L0.1	L0.1	L0.1
Zn (T) mg/l	0.75	0.63	0.56	1.8
As (D) mg/l	-	-	-	-
Cu (D) mg/l	-	L0.01	L0.01	L0.01
Ni (D) mg/l	-	L0.05	L0.05	L0.05
Pb (D) mg/l	-	L0.1	L0.1	L0.1
Zn (D) mg/l	-	0.54	0.56	0.23
N.F.R. mg/l	37.5	10	10	L10
pH	5.5	-	5.8	5.5
LC <sub>50</sub> (%)	50	5.6	-	6.5

TABLE 13                      COMPARISON OF COMPOSITE SAMPLING RESULTS WITH FEDERAL  
GUIDELINES - IRON TAILINGS POND SUPERNATANT

Parameter	Federal Guidelines	Day 1	Day 2	Day 3
As (T) mg/l	0.75	0.008	0.007	0.008
Cu (T) mg/l	0.45	0.05	0.05	0.05
Ni (T) mg/l	0.75	L0.05	0.06	0.06
Pb (T) mg/l	0.30	1.2	1.2	1.0
Zn (T) mg/l	0.75	2.0	5.5	3.8
As (D) mg/l	-	-	-	-
Cu (D) mg/l	-	0.04	0.04	0.03
Ni (D) mg/l	-	L0.05	L0.05	L0.05
Pb (D) mg/l	-	0.8	1.1	0.7
Zn (D) mg/l	-	3.1	4.6	3.2
N.F.R. mg/l	37.5	64	18	43
pH	5.5	-	4.9	5.0
LC <sub>50</sub> (%)	50	2.7	-	5.6



REFERENCES

1. Metal Mining Liquid Effluent Regulations and Guidelines, Department of Fisheries and the Environment (1977).
2. Laboratory Procedures, Environmental Protection Service, Pacific Region (1974).