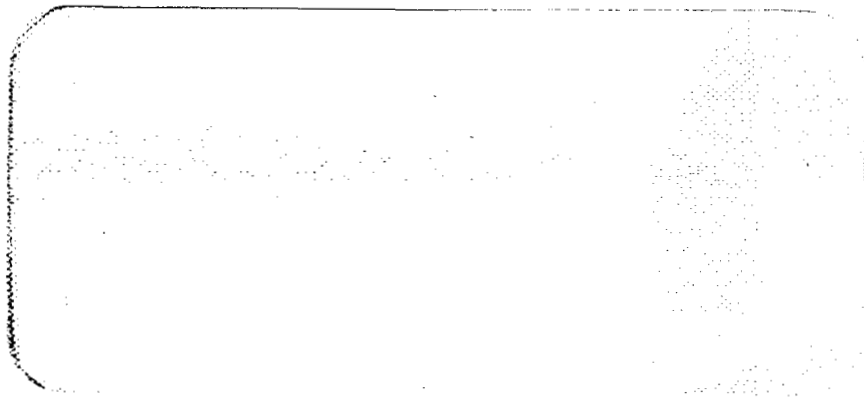


Mr. Wile was responsible for coordinating and performing the field activities, compiling the analytical data and preparing the draft report.



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FISHERIES AND ENVIRONMENT CANADA
ENVIRONMENTAL PROTECTION BRANCH
TECHNICAL SERVICES GROUP
PACIFIC REGION

COMPLIANCE EVALUATION
OF THE SILVANA MINE
NEW DENVER, BRITISH COLUMBIA

78 - 10.

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ABSTRACT

During the period from June 21-24, 1977 the Environmental Protection Service carried out a monitoring study of the effluent discharge from the Silvana Mine. The purpose of this study was to determine the state of compliance of the mine effluent discharge with respect to 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 discharge over a period of three consecutive days;
- 2) analyzing the effluent samples for a number of chemical parameters;
- 3) carrying out bioassay testing on the effluent samples;
- 4) collecting other information as necessary to assist in evaluating the state of compliance of this mine.

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LIST OF ABBREVIATIONS AND DEFINITIONS

D	Dissolved
I.G.P.D.	Imperial Gallons per Day
L	Less Than
ml	Millilitres
mg/l	Milligrams per Litre
T	Total
t.p.d	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 Silvana Mine during June 21 to 23, 1977 the following conclusions are presented:

1. The tailings pond supernatant composite samples were out of compliance with the federal guideline limits for lead, zinc, and suspended solids on all sampling days.
2. The tailings pond supernatant grab samples were out of compliance with guideline limits for lead and suspended solids on all days.
3. The tailings pond supernatant was not acutely toxic on either day 1 or day 3.

1 INTRODUCTION

On February 25, 1977 the Federal Metal Mining Liquid Effluent Regulations and Guidelines (1) 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, 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, provincial and federal government regulatory agencies. The Environmental Protection Service (E.P.S.) was responsible for the overall coordination 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 mines 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 therefore are in compliance with the 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 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 status 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 discharged tailings pond supernatant to a receiving body of water. This report is an account of the effluent surveillance study conducted on June 21, 22, and 23, 1977 at the Silvana Mine in the Kootenay area of B.C.

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

2 MINE DESCRIPTION

2.1 General Information

The Silvana Mine is situated approximately nine miles east of New Denver (see Figure 1). The plant, which has been in operation since 1959, consists of a 100 t.p.d. capacity mill fed by an underground mine producing lead, zinc, and silver. The reference mine production rate based on the 1971 operating year was established at 135 tons per day.

2.2 Concentrator Operation

The crushed ore is transported to a grinding circuit where both rod and ball mills grind the ore to a minus 200 mesh. The ground ore is classified and mixed with water to form a slurry referred to as "pulp". The pulp is separated into specific minerals in the flotation circuit. In this circuit frothing agents and chemicals specific to the desired mineral are added to the pulp. This mixture is agitated and aerated. The resulting froth which is composed of air bubbles with adhering mineral particles is skimmed off, thickened, filtered and dried. The first concentrate skimmed is the lead. The remaining pulp mixture is conditioned and refloated in the zinc circuit where the zinc concentrate is collected. The following chemicals are used in the flotation process: M.I.B.C., xanthate, sodium cyanide, and copper sulphate.

The average feed to the mill contains 16.0 ounces of silver per ton, 5 to 6 percent zinc and 7 to 8 percent lead. (Silver is extrated from both the zinc and lead concentrates at the smelter.) In 1976 the mine produced 1556 tons of lead concentrate, 1367 tons of zinc concentrate containing 238 198 ounces of silver.

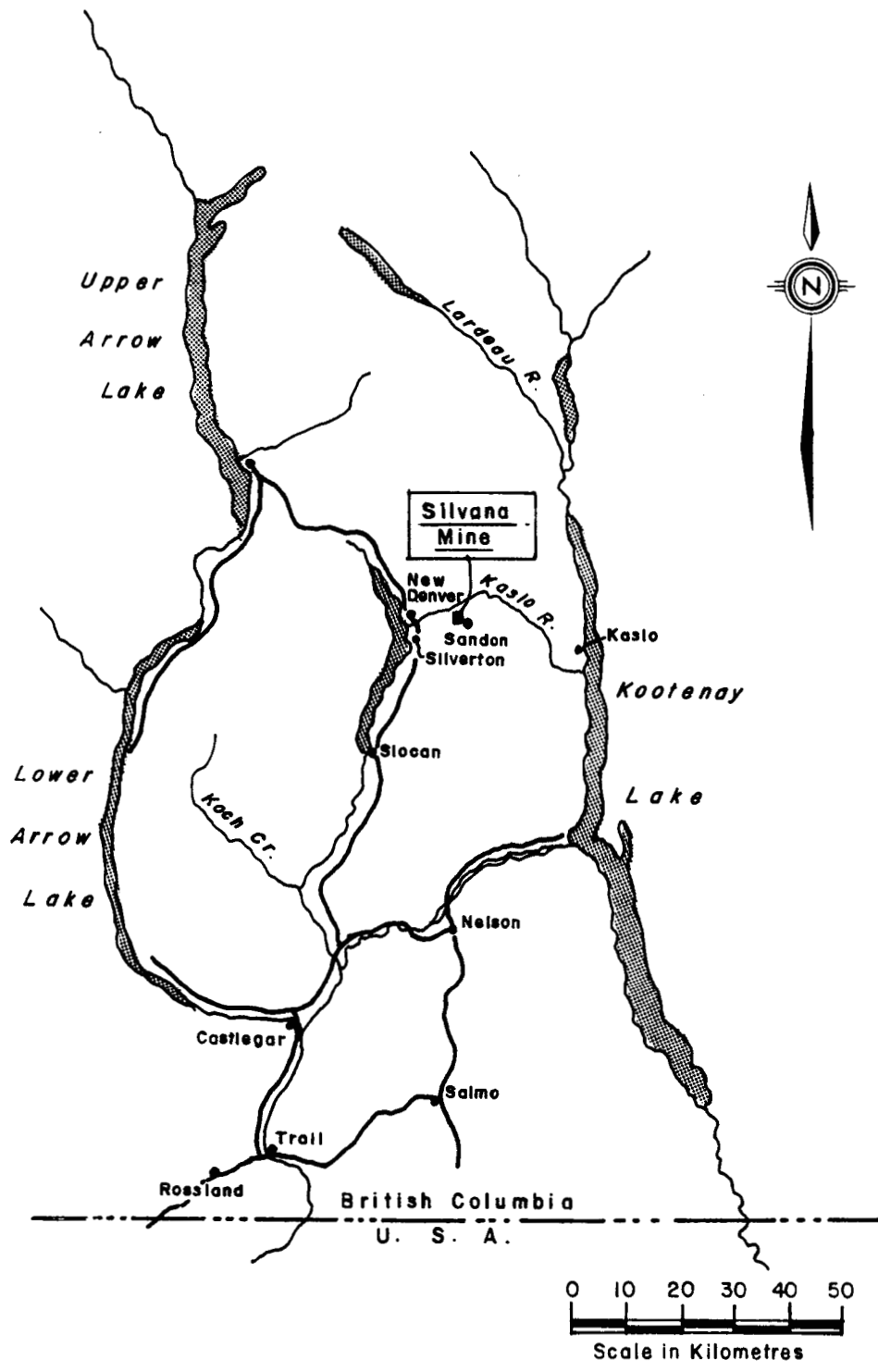


FIGURE 1 LOCATION OF SILVANA MINE SITE

3 WASTEWATER SOURCES

The mill process effluent is the principal source of wastewater. The mill utilizes an average of 45 000 I.G.P.D. of fresh water. The primary consumption of water is in the flotation and grinding circuits which can use as much as 600 gallons per ton of ore. In the grinding circuit the water is used to facilitate grinding and classification. In the flotation circuit water is used for adjustment of the solids level in the flotation feed, froth destroying spray, pump gland water, floor washing and reagent solution addition. There is a mine water stream which drains into a tributary of Carpenter Creek, however, flow estimates are not available.

The mill effluent discharges into a six acre dual tailings pond system which discharges into Carpenter Creek (see Figure 2). The Provincial Pollution Control Branch permit specifies a maximum supernatant discharge rate of 90 000 I.G.P.D.

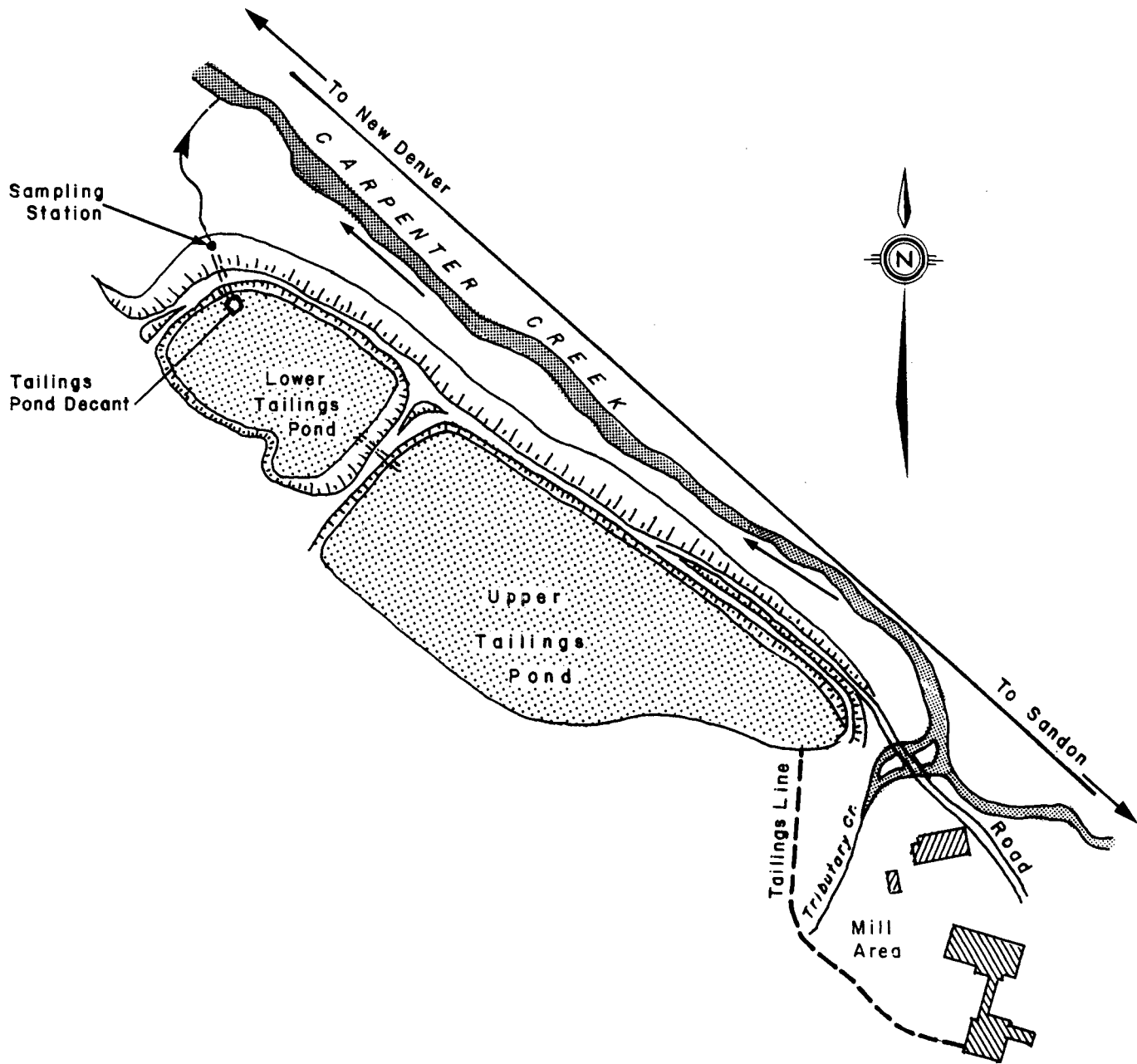


FIGURE 2 SILVANA MINE SITE LAYOUT AND SAMPLING STATION LOCATION

4 SAMPLING AND ANALYTICAL METHODS

4.1 Sampling Program

Time proportional eight hour composite samples and grab samples of the tailings pond supernatant were collected at the point of discharge as illustrated in Figure 2. Samples of the mine water were not collected because the stream was not readily accessible.

Twenty-four hour composite samples were collected on three consecutive days. Aliquots were collected on a continuous basis using a siphon system and were stored in 30 gallon polyethylene containers. Also, one set of grab samples was collected for each sampling day.

The effluent stored in the polyethylene container was well mixed prior to sample division. Composite samples for chemical analysis were collected on all three days whereas composite samples for bioassay were collected on the first and third days only. The samples for chemical analysis were preserved according to the Environmental Protection Service, Pacific Region; Sampling Handbook 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.

4.2.1 Bioassay Determination (96 hour LC₅₀). 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.

TABLE 1 SAMPLE CONTAINERS AND PRESERVATION METHODS

Parameter	Type of Container	Preservation
LC ₅₀ (96 hour)	5 gallon Polyethylene jerry cans	none
Total Arsenic	500 ml wide mouth Polyethylene bottle	none
Total Metals (Cu, Cd, Fe, Ni, Pb, and Zn)	100 ml wide mouth Polyethylene bottle	acidified with HNO ₃ to pH 1.5
Total Mercury	100 ml wide mouth Polyethylene bottle	acidified with HNO ₃ to pH 1.5
Dissolved Metals (Cu, Cd, Fe, Ni, Pb, and Zn)	100 ml wide mouth Polyethylene bottle	filtered and acidified with HNO ₃ to pH 1.5
Residues (NFR, TR)	1000 ml wide mouth Polyethylene bottle	none

The static bioassay test consisted of a series of 30 litre, all-glass test vessels containing different sample dilutions. The test vessels were placed into 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 LC₅₀ was established.

4.2.2 Total Metals (Cd, Cu, Fe, Ni, Pb, and Zn). The total volume of the sample (approximately 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 were 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 Cd - 0.01 mg/l, Cu - 0.01 mg/l, Fe - 0.03 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, Fe, 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, Cd, and Fe. Pb was extracted into methylisobutylketone (MIBK) using ammonium pyrrolidinedithiocarbamate (APDC) and sodium dithiodiethylcarbamate (DDC) complexing agents buffered with sodium acetate. The MIBK extract was analyzed by aspiration on a Jarrell - Ash 810 Atomic Absorption Spectrophotometer. The detection limits are Cd - 0.01 mg/l, Cu - 0.01 mg/l, Fe - 0.03 mg/l, Ni - 0.05 mg/l, Pb - 0.1 mg/l, and Zn - 0.01 mg/l.

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 aqua regia leached sample was digested with a 1:2 nitric: sulfuric acid mixture. The mercury was then reduced to elemental mercury with a solution of hyrazine sulfate and stannous chloride. The volatilized mercury vapor was passed through an absorption cell measured on a Jarrell Ash 810 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 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, and brought to constant weight, then re-weighed. The increased weight was used to calculate the NFR and the results are reported as mg/l. The minimum amount detectable is 10 mg in a 1 litre sample.

4.2.7 Total Residue (T.R.). Total residue refers to material left in an evaporating dish after the evaporation of the sample.

One hundred cubic centimetres of the sample was placed in a dried pre-weighed evaporating dish and evaporated at 90°C. The residue was then heated to 103°C for one hour. The dish was cooled, brought to constant weight then re-weighed. The increase in weight was used to calculate the TR concentration in the sample and reported as mg/l. The minimum amount detectable is 10 mg in a 1 litre sample.

4.2.8 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. The Accumet 107 has a precision of ± 0.03 pH units.

5 RESULTS

5.1 Composite Samples

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

5.2 Grab Samples

The chemical analyses and bioassay test results for the grab samples are presented in Table 3.

TABLE 2 SILVANA TAILINGS POND SUPERNATANT - COMPOSITE
SAMPLE RESULTS

A. Chemical Analyses

Parameter	Day 1	Day 2	Day 3
As (T) mg/l	0.018	0.033	0.023
Cd (T) mg/l	L0.01	L0.01	L0.01
Cd (D) mg/l	L0.01	L0.01	L0.01
Cu (T) mg/l	0.10	0.10	0.11
Cu (D) mg/l	L0.01	L0.01	L0.01
Hg (T) µg/l	L0.20	L0.20	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	0.50	0.70	0.78
Pb (D) mg/l	L0.02	L0.02	L0.02
Zn (T) mg/l	0.81	0.82	0.81
Zn (D) mg/l	0.08	0.14	0.21
N.F.R. mg/l	190	250	280
T.R. mg/l	430	490	510
pH	6.70	6.95	7.05

B. Toxicity Determination

	<u>Day 1</u>	<u>Day 3</u>
LC ₅₀ (96 hour)	non-toxic	3 test species died after 96 hours

TABLE 3 SILVANA TAILINGS POND SUPERNATANT - GRAB SAMPLE RESULTS

Chemical Analyses

Parameter	Day 1	Day 2	Day 3
As (T) mg/l	0.026	0.021	0.024
Cd (T) mg/l	L0.01	L0.01	L0.01
Cd (D) mg/l	L0.01	L0.01	L0.01
Cu (T) mg/l	0.13	0.11	0.11
Cu (D) mg/l	L0.01	L0.01	L0.01
Hg (T) µg/l	0.30	L0.20	0.36
Ni (T) mg/l	L0.05	L0.05	L0.05
Ni (D) mg/l	L0.05	L0.05	L0.05
Pb (T) mg/l	0.75	0.64	0.72
Pb (D) mg/l	L0.02	L0.02	L0.02
Zn (T) mg/l	1.00	0.85	0.75
Zn (D) mg/l	0.12	0.24	0.13
N.F.R. mg/l	300	240	270
T.R. mg/l	560	470	500
pH	7.10	7.15	7.10

6 DISCUSSION

A comparison between the effluent monitoring results and the federal guidelines is presented in Table 4.

The compliance summary in Table 4 shows that the composite sample results were out of compliance with the lead, zinc and suspended solids requirements on all sampling days. Further, the grab sample results were out of compliance with the lead and suspended solids requirements and in compliance with the zinc requirement on all days. The results for both the composite and the grab samples were in compliance with the nickel, copper, arsenic and pH requirements on all three days. The data also shows that the tailings pond supernatant was not acutely toxic on either day 1 or day 3.

TABLE 4 COMPARISON OF THE TAILINGS POND SUPERNATANT WITH FEDERAL GUIDELINES

Parameter	Guideline Requirement	Day 1	Day 2	Day 3
<u>A. Composite Samples</u>				
As (T) mg/l	0.75	0.018	0.033	0.023
Cu (T) mg/l	0.45	0.10	0.10	0.11
Pb (T) mg/l	0.30	0.50	0.70	0.78
Ni (T) mg/l	0.75	10.05	10.05	10.05
Zn (T) mg/l	0.75	0.81	0.82	0.81
N.F.R. mg/l	37.50	190	250	280
pH	5.5 minimum	6.70	6.95	7.05
LC ₅₀ (%)	100	non-toxic	-	non-toxic
<u>B. Grab Samples</u>				
As (T) mg/l	1.00	0.026	0.021	0.024
Cu (T) mg/l	0.60	0.13	0.11	0.11
Pb (T) mg/l	0.40	0.75	0.64	0.72
Ni (T) mg/l	1.00	10.05	10.05	10.05
Zn (T) mg/l	1.00	1.00	0.85	0.75
N.F.R. mg/l	50.0	300	240	270
pH	5.0 minimum	7.10	7.15	7.10

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).