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SUMMARY OF ENVIRONMENTAL  
INFORMATION FOR THE  
EQUITY SILVER MINE

by

V. Osborne  
B. Hallam

April, 1982

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The Equity Silver Mine lies 37 km south-east of Houston in central BC in an area formerly known as the Sam Goosly deposits. Ore deposits of copper-silver-gold-antimony were first discovered there by Kennco Explorations (Western) Ltd. following six years of geo-chemical exploration, subsequent leads, soil sampling, geological interpretation, and target drilling in the Goosly Lake area. Further investigation revealed unique problems of metallurgy and mineral continuity of the ore. Kennco, retaining 30% interest, optioned the properties in 1973 to Equity Mining Capital Ltd. who carried on further research in order to establish profitability. A name change to Equity Mining Corporation followed amalgamation in 1976 with S.G. Mining Inc. The present title; Equity Silver Mines Ltd., was the result of amalgamation in 1979 with the same - a new company formed in December 1978 by Placer Development Ltd. with the specific intent to buy out residual Kennco interests and retain 70% control in return for certain technical inputs. The various transactions are noted because separate proposals for mining, milling, and waste disposal were submitted with each new ownership and can be easily confused when reviewing environmental impact statements prepared for earlier plans. (Canadian Mines Handbook, 1979; Beak Consultants Ltd., 1976; Northern Miner, 1980, 1981.)

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Discovery in 1976 of the Sam Goosly ore body was followed by several years of geological research and metallurgical testing in order to confirm distribution and profitability of the deposits and to solve some problems of metallurgy - primarily the presence of about 0.1% antimony and a similar amount of arsenic. The chemical linkage of these within the tetrahedrite is economically and environmentally disadvantageous and requires proper leaching and disposal before the concentrate is acceptable for treatment.

While details for leach plant design and location were finalized, preliminary construction work was carried on. Groundwork for infrastructural features, leases, and permit applications was established in early baseline studies by EPS (1974, 1975) and Beak Consultants Ltd. (1976, 1976), the latter on behalf of Equity Mining Capital Ltd. and Equity Mining Operation. Road improvement operations were begun during November 1978. Mill site construction was started in April 1979 and largely completed by the third quarter of that year. Advanced stages of foundations, buildings, and plant equipment were reached by early 1980 although design aspects of the leach process were still under refinement.

Both deposits are to be mined by open pit methods but future underground potential has been discussed (Beak, 1976). Production of unleached concentrate began August 27, 1980 from the Southern Tail; ore and waste rock are currently being removed at an approximate rate of  $4.2 \times 10^6$  tonnes per year (tpy). The removal rate will peak at  $7.2 \times 10^6$  tonnes when mining in the Main Zone begins in 1983, and eventually stabilize at about  $3.0 \times 10^6$  tonnes.

Delays in leach plant construction were to design changes necessitated by the particular nature of the ore. Based on information gathered from other silver operations - the US Sunshine Mine in Idaho and Dowa Mining Co. of Japan - decisions concerning plant design and location resulted in an on-site operation that commenced production in October

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1981. European and Japanese customers have accepted initial unleached concentrate on a capacity basis. This should continue until full operational activity is attained at which time sales will continue to Dow Mining. Secondary biproducts such as salt cake (sodium sulphate) and sodium antimonate have North American markets that include several BC pulp mills (Canadian Mining Journal, August 1981).

The Sam Goosly property lies in an area of dissected plateau with broad open valleys and regional elevations of 610 to 1525 metres. The copper-silver-gold-antimony deposits are in an area of gentle relief at 1310 metres. Silver-copper (Ag-Cu) mineralization is generally restricted to a west dipping tabular zone between igneous intrusions in volcanic rock which outcrops through a window in younger rocks (Wetherell and Sinclair, 1979), in two principal deposits designated as the Main Zone and Southern Tail Pit.

Differences in aspects of size, mineralization, and ore grade exist between the two deposits. The Main Zone and Southern Tail Pit are 200-400 feet and approximately 100 feet respectively, in thickness. Main Zone ores are more pervasive and consistent in grade trends, being fine-grained and occurring generally as disseminations and only occasionally as veins. Massive sulphides are present in local patches. Southern Tail ores are softer, contain higher grades in all metals, and are more erratic in grade and distribution patterns - consisting of coarse deposits contained as large fracture fillings, veins, or blebs; and as disseminations, only locally. Therefore these are more easily accessed, removed, and concentrated. (Beak, 1976; Western Miner, Aug. 1981).

The larger Main Zone deposits total  $21.2 \times 10^6$  tonnes (t), averaging 98.4 grams per tonne (gpt) Ag, 0.825 gpt Au, 0.353% Cu, and 0.084% Sb; these are expected to provide reserves for another sixteen years once production commences in 1983. Southern Tail ores approximate  $6.8 \times 10^6$  t, grading 131 gpt Ag, 1.38 gpt Au, 0.48% Cu, and 0.087% Sb. Currently under production, they should provide mill feed for the first four years. Total combined mineable reserves are estimated at  $27.9 \times 10^6$  metric tonnes, grading 106.3 gpt Ag, 0.96 gpt Au, 0.384% Cu, and 0.085% Sb (see Table 1). Overall total mine life is predicted at twenty to twenty-four years.

In general the ore is a complex and fine-grained (particularly within the Main Zone) combination of different sulphide minerals. Silver,

gold, copper, and antimony are the major constituents of economic importance, however there are also values of lead, zinc, arsenic, bismuth, cadmium, and mercury. The metals usually exist in association with each other and within more than one mineral.

Pyrite ( $\text{FeS}_2$ ) is the most abundant component regionally and to an even greater extent within the zone of Cu-Ag mineralization. Also present and of major importance are the metallic minerals tetrahedrite ( $\text{Cu}_3\text{SbS}_3$ , 0.2%), chalcopyrite ( $\text{CuFeS}_2$ , 0.1%), sphalerite ( $\text{ZnS}$  0.4%), pyrrhotite ( $\text{Fe}_{11}\text{S}_{12}$ ), magnetite ( $\text{Fe}_3\text{O}_4$ ), hematite ( $\text{Fe}_2\text{O}_3$ ), arsenopyrite ( $\text{FeS}_2 \cdot \text{FeAs}$ ), and galena ( $\text{PbS}$ ). Chalcopyrite and tetrahedrite carry the bulk of the copper; the latter is also the major silver source.

Silica host rock has also been reported to contain marcasite, argentite, pyrargyrite, bonlangerite, pearceite, berthierite, bournonite, jamesonite, and schalite. Sulphur content averages 4.4%; tests of acid-generation potential have been carried out on samples of ore, overburden, and waste-rock, the results are discussed under the summary of Pre-production Environmental Assessments (section 8). Further details of Sam Goosly geology can be found in Wetherell and Sinclair (1979); details of minerology are given by Beak for Equity Mining Capital Ltd., February 1976, and Equity Mining Corporation, September 1976.

Both the Southern Tail and Main Zone deposits are to be mined by the open pit method, the latter will not be stripped for production until 1983. Currently ore and waste rock are being removed from the former at a rate of  $4.2 \times 10^6$  tonnes per year and an overall strip ratio of 2.3:1 (see Table 1) using conventional equipment. Due to smaller size, softer ore, and higher metal grades, these deposits require less grinding and can most profitably be exploited prior to the costlier expansion activity required for mining of the Main Zone.

Within the open pit low 5-metre bench heights permit even greater separation of ore and waste, therefore reduction of mill tonnage by about 18% with a silver sacrifice of only 4%. Regular 10-metre bench heights will be used for the more evenly disseminated Main Zone ores.

Preliminary production stages involve primary, secondary, and tertiary crushing, appropriate conveyor systems, a coarse ore stockpile, and a covered fine ore storage area. The primary screen has a larger aperture size of 19 mm which permits bypass of a large proportion of moisture-bearing fines, thus minimizing winter freezing in the coarse ore stockpile.

Milling capacity was designed at 4500 tpd and was surpassed to about 5100 tpd soon after production commenced on 01 October 1980. Fine ore is drawn at a controlled rate through two parallel tunnels which run beneath the fine ore storage pile, discharged via the mill feed conveyor to a 15.8 rpm rod mill, then directed to hydrocyclones for sizing. Oversize cyclone underflow is resubmitted via a primary 16.6 rpm rod mill. The undersize cyclone overflow, a pulp consisting of approximately 35% solids (80% minus 200 microns, or 75 mesh) reports to rougher flotation, is re-ground, and finally cleaned in a cleaner flotation circuit.

A single bank of eighteen cells produces a rougher concentrate at the first twelve cells and a scavenger concentrate from the final six. The latter can be recirculated to the head of the cells or mixed directly with the rougher concentrate. All material not reporting to the concentrate is discharged as waste to the tailing sump.

The rougher-scavenger concentrate is joined by first cleaner tails and pumped to a ball mill which is in closed circuit with a hydroclone for regrinding, sizing, and subsequent feeding at 15-20% solids to the bank of first cleaner flotation cells. The concentrate passes to the second cleaners, from which concentrate is directed to the third cleaners. Cleaner tailings follow a counter-current course; second and third tailings are recycled to the head of the first cleaners, first cleaner tails at this point join the rougher-floated concentrate, as above.

Prior to cleaning stages, all waste is discharged via the tailing sump at 20-35% solids, depending on initial feed volumes. Depressed arsenopyrite (0.56 to 0.073% As) is accomplished by addition of  $\text{SO}_2$  (g) during rougher flotation. To this stage milling reagents include lime, MIBC, Dow 250 and/or Aerofroth 650, and  $\text{Na}_2\text{S}$  - the latter necessary for differential flotation removal of pyrite from the bulk concentrate. No  $\text{NaCN}$  is used in the process.

Copper concentrate (at 80% minus 80 microns, or 200 mesh) emerges from the final cleaning and proceeds to a thickener from which surplus clear water returns to process supply while underflow at 55% solids in successively pumped to a stock tank, disc filter; and 2000 tonne capacity covered storage facility. The latter provides the large surge capacity necessary between the continuous operation of the mill and the batch requirements of the leach plant. Because of the temporary need for shipping unleached concentrates, a drying kiln was installed after the filter in order to bring moisture content to 7.5%. The entire concentration process from initial rod-milling through final drying is housed within the single mill building. Front end loaders are used to transport the unleached product to both haulage trucks and further treatment in the leach plant.

Raw concentrate produced from the mill flotation processes consists of approximately 17% Cu,  $7 \times 10^4$  gpt Ag, 15 gpt Au, 7% Sb, and 4% As. Antimony and arsenic inclusions normally are vapourized during smelting; conventional copper smelters can process only small quantities of unleached concentrate and charge a penalty for the unwanted



constituents which are best reduced to levels of 0.6% and 1.6%, respectively. Thus, the leach plant was fundamental in order to recover Sb and As in marketable form and to produce a concentrate acceptable for smelting without restriction (Western Miner, 1981). The technique involved has been tested and employed some time at the Sunshine Mine in Idaho. Various reagents including  $H_2SO_4$ ,  $O_2$ , S, CaO, NaOH, and NaHS are utilized. Non-recycled portions are converted also to saleable chemical byproducts. Process water requirements are estimated at  $4.2 \times 10^6$  IGPD with slurry densities varying between 20-25% solids (Clark, 1980; Klassen, 1980). The product is a dried concentrate grading 20-22% Cu, several thousand gpt Ag, and 10-20 gpt Au.

Initially antimony and arsenic are converted to leachable form via autoclaving. Combustion gases are discharged to the atmosphere; product gases are cooled in a quench chamber, scrubbed in a Venturi scrubber, cooked in a packed tower, further cleaned in a  $SO_2$  scrubber and finally returned to the roaster. Barren liquor storage tanks receive the scrubber water. Holding tanks separate each substage of the leach process, as it is a batch operation and is conducted in short substages spread over a 16-24 hour period.

Roaster solids are directed in 30 tonne batches to primary and secondary leaching units at a 2:1 ration which permits optimum reagent usage. The primary new-concentrate-batch and secondary, previously partly leached-batch are mixed and agitated in the presence of sodium sulphide ( $Na_2S$ ) and sodium hydroxide (NaOH) solutions as well as later-process return solutions. From the mixing tank the mixture proceeds to one of three operational leaching tanks - a fourth serves as a spare, for 16 hours agitation. All tanks are steam-heated and maintained at a temperature of  $110^\circ C$ .

Primary leaching is followed by pressure filtration separation of the solid concentrate from the leach solutions, which at this point contain the Sb and As. The solids go to a cleaning stage, the solutions

to the secondary leach circuit. The former produces a clean leached concentrate discharged to shipment storage and  $\text{H}_2\text{SO}_4$  - containing solutions returned to the process.

The 10-tonne batches for secondary leaching go to a separate mixing tank and again to steam-heated leach tanks. Solids are pressure filtered, separated, and mixed into the next batch for primary leaching. Residual fines are moved from the filtered solution by a polishing filter; the solution then passes to holding tanks at the start of the antimony-recovery section.

Two holding tanks are maintained at  $85^\circ\text{C}$ . The 53 g/l Sb solution is batch-fed to one of three operational autoclaves and held for two hours at  $150^\circ\text{C}$ , 550 kPa pressure while  $\text{O}_2$  is blown in. Thus all antimony is converted to sodium antimonate,  $\text{NaSb}(\text{OH})_6$ . A flash tank enables evaporation of a major portion of water rendering the product in suspended solid form which is washed and stored in a surge bin.

At this stage the liquid contains arsenic at about 13 grams per litre. It is pumped via a holding tank to an agitation tank to be mixed with bulk lime then delivered to a second series of autoclaves operating at  $150^\circ\text{C}$  and 1600 kPa pressure. Injected  $\text{O}_2$  completes conditions required for formation of virtually insoluble calcium arsenate:  $\text{Ca}_3(\text{AsO}_4)_2$ . A flash tank evaporates excess water and centrifugation separates the solid and liquid fractions. The calcium arsenate residue still contains undesirable reagents which are removed by repulping in an attritioner followed by pressure filtration and subsequent storage in three holding tanks prior to packing for disposal.

Liquid fractions remaining from centrifugation and filtration are pumped to storage tanks prior to removal of salt cake. The latter is formed by the oxidation of  $\text{Na}_2\text{S}$  to  $\text{Na}_2\text{SO}_4$  during oxygen autoclaving and must be removed before recycle of process solutions back to the head of the circuit. Extraction is achieved in triple-effect evaporators operating under vacuum and steam heat at  $61.5^\circ\text{C}$ ,  $91^\circ\text{C}$ , and  $113^\circ\text{C}$ ; the

sodium sulphate is concentrated and recovered in crystal form. Residual liquids are recycled.

Arsenic recovery is incomplete and some remains with the crude sodium sulphate. Therefore the crystalized product is redissolved in two steam-heated reaction tanks with addition of lime and sulphuric acid;  $\text{Ca}_3(\text{AsO}_4)_2$  is precipitated out, separated by centrifugation, and recycled to the As section. Liquid supernatant passes through a polishing filter to a holding tank from which the purified  $\text{Na}_2\text{SO}_4$  is pumped to a crystal-lizer consisting of two evaporators (at 96°C and 123°C) and a crystallization tank. The crystals are thickened in a hydro-cyclone, separated in two centrifuges, then dried and collected. (Clark, 1977; Can. Min. J., Aug. 1981; N. Miner, Mar. 1981; W. Miner, Aug. 1981). Figure 4 presents a summary flow diagram of the Equity mill and leach processes described above.

Production rates vary with amount of concentrate and component grades of antimony and arsenic - the overall biproducts average approximately 500 tonnes sodium antimonate, 600 t calcium arsenate, and 1200 t sodium sulphate per month. All products are sold in sealed containers and are transported from the mine site by haulage trucks. Sodium antimonate has a large market in the glass industry where it is used in the manufacture of television tubes. Saltcake (sodium sulphate) is in demand at BC pulpmills which in the past have been supplied primarily through mines in southeastern Alberta and southern Saskatchewan. The calcium arsenate, currently of no significant economic value, is disposed of outside of BC.

European and Japanese smelters were able to utilize only 40-50% of the initially-produced unleached concentrate. The excess was stockpiled until the leach plant was brought on-line in October 1981. The first shipment consisted of both leached and unleached concentrate grading:

Cu:	22 - 24%	Pb	2-6 %
Sb:	0.4 - 6%	Au	25 ppm
As:	1 - 5%	Ag	4000 ppm
Fe:	15 - 17%	Hg	25-100 ppm
S :	25 - 28%	solubles	9 %
Zn:	3 - 5%	moisture	10-20 %,

was made through the Port of Prince Rupert's Fairview Terminal in January 1981 (Nassichuk, 1980). Equity has contracted exclusively with Dowa Mining Co., the main previous buyer, for all concentrate produced until 1983. The same firm is expected to handle all future production. Over the first five years of mining activity leached concentrate production is expected to average  $177 \times 10^6$  g Ag,  $6.4 \times 10^3$  t Cu, and  $340 \times 10^3$  g Au, making Equity a major BC producer of silver second only to Cominco Ltd's Sullivan mine.

The Equity Mine site straddles the upland at elevations of 1300-1400 metres and the drainage divide separating the Foxy Creek and Buck Creek systems. Figure 1 shows a general map of the Equity watershed area and its geographical relationship to the municipality of Houston. The location of the drainage divide in relation to Foxy and Buck Creeks is indicated on Figure 2.

Foxy Creek flows northward for approximately 19 km where it joins Maxan Creek at the outlet to Maxan Lake and from there continues north a further 9 km to discharge at Bulkley Lake to the Bulkley river system. Lu Creek naturally flows eastward from Lu Lake and then north to flow into Foxy Creek near the present mill site. However, much of the original Lu valley corresponds to the tailings pond area so that by necessity the western end and eastern tributary of Lu Creek are now directed by diversion canals (see Figure 3) around the impoundment.

Bessemer Creek, fed by several unnamed tributaries, flows southward from the mine area to join Buck Creek which continues southwest to Goosly Lake where it is joined by several other small streams. A few of these have been given unofficial nicknames such as "Eagle" and "Burnt" Creek, referred to in some environmental impact reports. Lower Buck Creek emerges from Goosly Lake, flows north, and is joined along its source by Klo Creek, Bob Creek, and Dungate Creek before it eventually enters the Bulkley River system at the District Municipality of Houston.

Goosly Lake itself covers an area of 597 acres with a mean depth of 11 metres, a maximum depth of 22 metres, and a volume of 20,160 acre-feet, and was originally the anticipated source of process make-up water. However, DFO Smithers reported that the only recorded flows in Buck Creek during August of each year were from the tributaries described above and that the outlet to Goosly Lake was sometimes a dry creek bed (Hallam, 1975). In part because of that potential limitation, Lu Lake was chosen instead as the future water source and appropriate dams were constructed to ensure adequate levels during periods of low flow.

Water Survey of Canada commenced monitoring of the Buck Creek mouth flow (site 08EE013) in 1973. From an estimated drainage area of 224 square miles, yearly mean flows were found to be 180 cfs. The mean low of 15.3 cfs occurred in March, the mean high of 984 cfs in May (Beak, for Equity Capital Ltd., 1976). Flows of Lu Creek (08EE016) and Foxy Creek (08EE015) at their confluence were recorded between May 1974 and September 1975. Minimums occurred from December through April, maximums were obtained in May and June. From a drainage area of roughly 2.8 square miles, Lu demonstrated a mean low of  $0.017 \times 10^6$  USGPD during February 1975. The mean highs were  $1952 \times 10^6$  USGPD and  $253 \times 10^6$ , obtained in June 1974 and May 1975, respectively. The Foxy Creek drainage area approximates 6.2 square miles. Its mean low flow for the period was  $17 \times 10^6$  USGPD, in January 1976; mean high flows were  $4526 \times 10^6$  USGPD and  $314 \times 10^6$  USGPD, again during June 1974 and May 1975.

Over the covered period of eighteen months, the records provide an early indication that significant variation can be expected at these sites. Yearly as well as seasonal fluctuations are evident. Hallam (1974) gives some instantaneous flow data for Lu and Foxy at their confluence in readings taken in July 1973 and October 1973, but comparison with the more extensive Water Survey data indicates that the former may be in error by a factor of 100 ( $10^6$  USGPD = 1.55 cfs) or greater.

The Water Survey data includes one year's (1976) flow rates for Maxan Creek at the outlet to Maxan Lake (08EE019). The drainage area, not specified but estimated at 130 square miles in size, produced a yearly mean flow of 100 cfs, corresponding to a mean low of 11 cfs recorded during March and a mean high of 634 cfs during May.

Buck Creek and its tributaries comprise one of two major water systems associated with the Equity development. Falls situated about 10 km upstream from Houston hinder movement of fish during periods of low flow but are traverseable during high flow. Federal Fisheries and Marine Service records of anadromous species entering Buck date back to 1928 and indicate as many as 600 coho, 100 pink, and 50 chinook (Beak, 1976). The BC Fish and Wildlife Branch has also recorded steelhead trout and kokanee (Hallam, 1975).

Dungate Creek, Klo Creek and the Goosly Lake waters all drain to Buck Creek. Dungate is the first major tributary, and includes falls situated approximately 1.5-2.5 km upstream of the confluence with Buck which prevent further passage of fish. The area downstream however is suitable and apparently used for trout and possibly salmon spawning. Klo Creek, the major tributary, supports populations of largescale suckers, prickly sculpins, largenose dace, and rainbow trout. Goosly Lake, generally possessing higher numbers of all species surveyed, was found to contain reidside shiners, peamouth chub, longnose suckers, largescale suckers, rainbow trout, mountain whitefish, and kokanee (Beak, 1976; Bird, 1976; Hallam, 1975). The inlet areas of Goosly are seasonal and do not provide favourable, reliable habitat conditions for spawning. However, the outlet is apparently suitable enough to be utilized at least to some extent by kokanee salmon.

Maxan Creek and its associated tributaries form the second major system of concern. The creek supports several resident species: reidside shiners, peamouth chub, longnose suckers, largescale suckers, prickly sculpin, rainbow trout, mountain whitefish, squawfish, and dolly varden char. Anadromous species have also been recorded; escapement records indicate up to 300 sockeye and 500 coho spawners. The system has been known to dry up occasionally (Beak, 1976; Bird, 1976).

Lu Lake, Foxy Creek, and Maxan Lake have each been sampled. The former was found to be barren of resident species (Beak, 1976). Foxy creek was sampled 2.8 km upstream of the confluence with Maxan by gill net in September 1973 and found to contain rainbow trout and dolly varden, both of which apparently utilize it for a spawning and rearing habitat. A log jam and falls situated at 8 km and 24 km respectively, to the west apparently prevent further migration, as no fish have been observed upstream. Maxan Lake was sampled by gill net in September 1973. The findings included reidside shiners, peamouth chub, longnose suckers, largescale suckers, prickly sculpin, mountain whitefish, and squawfish. Although not collected at the time, rainbow trout and dolly varden also probably inhabit the lake.

To date there is little available information on relative species abundance, habitat availability versus use, or long-term flow patterns. There are some spontaneous on-site species counts contained in Beak (1976) and some short-term records of receiving water flows in the WMB Equis printout. This paucity of background data is perhaps due to the relatively "minor resource value" of the Buck and Foxy Creek systems (Beak, September 1976). Tabulations of species and sites listed above can be found in Beak (September, 1976) and Hallam et al (1975).



Prior to the Equity proposal the area surrounding Goosly lake was used primarily for recreational purposes with some logging activity occurring at lower elevations. Little concern was attached to physical, biological, or chemical aspects of the Buck Creek or Foxy Creek drainage systems because of their perceived, relatively low priority in terms of resource value and utilization (Beak, September 1976). Certain background data was needed in order to establish a basis for impact predictions and assessments which became necessary subsequent to the early 1970's. As a result various environmental investigations were undertaken in areas of geology, water quality, water physical and biological status, etc; the relevant findings are discussed in this report.

Beak Consultants Ltd. were retained in June 1973 by Equity Mining Capital Ltd. to act as their environmental consultants. The resulting preproduction work is contained in a baseline survey (Beak, 1973, 1973), a preliminary impact report (Beak, Feb. 1976), and a second detailed assessment report (Beak, Sept. 1976). The Environmental Protection Service carried out preoperational studies in 1973 and 1974, the findings of which are summarized in Hallam and Kussat (1974) and Hallam et al (1975). The EPS data was incorporated into the later Beak study. BC Research was retained by Equity to conduct acid generation - potential tests on various mine products. In addition to three reports (1973, 1975, 1976) on behalf of the mining company, a fourth was prepared for EPS (1977). The UBC Department of Geological Sciences, retained through Equity Mining Corporation and the BC Ministry of Mines and Resources to define the nature and relationships of the ore deposits, published a preliminary report in 1978. Technical aspects of the operation's feasibility and design were investigated by qualified consultants such as Wright Engineering Ltd. on behalf of Equity or Placer Development Ltd. The resulting environmentally-related information is summarized in the works listed below. Publications are preceded by relevant subject headings.

A.     Water Quality

Preproduction investigations involving parameters of water quality in the Foxy Creek and Buck Creek systems were actually rather broad in scope but produced a limited amount of data. EPS and Beak reports list a maximum of three sampling dates spread over periods of thirty-six and twelve months, respectively. Regardless, they do present a general indication of the near-pristine conditions which existed at most sampling locations prior to the commencement of mining operations.

- 14 July 1973 and 13 October 1973

Hallam and Kussat (1974). Eleven sites.

Parameters - Total Metals:     Cu, Pb, Zn, Fe, Ni, Mo, Cd,  
  Ca, Mg, Mn, Cr, Ag, Sb, Hg

pH

Temperature (T)

Dissolved Oxygen (DO)

Water Clarity

Stream Flow

- 25 July 1973 and 10 October 1973

Beak Consultants Ltd. (1973). Eight sites.

Parameters - Dissolved Metals: Cu, Pb, Zn, Fe, Ag, Sb, As,  
  Hg, F

pH

Temperature

Dissolved Oxygen

Turbidity

Total Solids/Total Residue (TR)

Suspended Solids/Non-filterable Residue (NFR)

Dissolved Solids/Filterable Residue (FR)

Flow

compared well overall for such patterns. Total metals, with the few exceptions noted, reported at relatively consistent levels over the respective sampling periods, and were usually equivalent to dissolved. However, Beak consistently reported total values for Cu, Pb, Fe, Zn, and Hg at significantly lower levels (usually \_ a degree of magnitude) than indicated in EPS results. Discrepancies observed for total metals and TR (total residue) at upper Bessemer sites can be expected because of differences between the periods of time and conditions of disturbance. Otherwise there were few significant fluctuations of concentrations observed over either sampling program and it would be expected that the similar locations would report similar values. Dissolved species were in general at very similar concentration levels.

B        Phytoplankton

- Hallam and Kussat. 1974.

Phytoplankton samples were obtained by EPS for all eleven sites during July 1973 and October 1973. The report gives species identification for Bacillariophyceae, Chlorophyceae, Cyanophyceae, Crysophyceae, some Rhodophyceae, and in one case, a protozoa. In all cases the majority of species were diatoms with only occasional inclusions from other categories. There was too little algae for quantification to be practical. The greatest diversity was found at the outlet of Goosly Lake and was attributed to the warmer water temperature and higher nutrient concentrations occurring at that location.

C        Benthic Invertebrates

- Beak Consultants Ltd. 1973.  
- Hallam and Kussat. 1974.

Both studies identified and quantified several groups. Although Hallam and Kussat is a more detailed treatment, both interpreted the data using sensitivity groupings and arrived at essentially the same conclusion: the majority and distribution pattern of organisms were typical of undisturbed, high altitude, fresh water streams of pristine water quality. The EPS report also provides diversity indices and total counts on collected samples. Average diversity values were 2.36 for July and 1.93 for October; average abundance was 320 per foot<sup>2</sup> in July, 191 per ft<sup>2</sup> in October, as expected in areas of such seasonal temperature extremes.

D        Vertebrates

- Beak Consultants Ltd. September 1976.
- Hallam and Kussat. 1974
- Hallam et al. 1975

Beak (1976) and Hallam et al (1975) were major sources of information concerning species identification and location. The results are discussed above under "Fisheries Resource". EPS sampling was with the objectives of establishing presence as well as uptake patterns for metals and pesticides. Fish were obtained only at sites 10 and 11 at Buck Creek and identified as peamouth chub and rainbow trout. They were small; averaging 10 cm length and 50 grams weight so that insufficient sample prohibited comprehensive heavy metal analysis. However, it was concluded that average tissue zinc levels of 21.0 ppm wet and 92 ppm dry were higher than would be expected in clean, unmineralized waters. Pesticide levels were nondetectable.

## E        Acid Generation

BC Research has produced four reports on acid generation potential.

- Duncan, D.W. and C.C. Walden. August 1973. Report on Acid Production Tests on Three Samples of Drill Core. Project 1576.
- July 1975. A Report on the Acid Production Potential Tailings Sample, in Beak (1976).
- January, 1976. A Report on the Acid Production Potential of Sam Goosly Mine (Southern Tail), in Beak (1976).
- Duncan, D.W. and C.C. Walden. August 1977. Prediction of Acid Generating Potential. EPS Report.

The 1973 study involved samples which were to be representative of 1) low grade stockpile, 2) reserve grade material for direction to the concentrator - originally stockpile itself until the reserve grade cutoff was lowered to 2% Ag thus including such samples in direct mill feed reserves, and 3) waste rock from the planned open pit. The results were based on a BC Research-developed procedure which quantitates sulphuric acid generation versus sulphuric acid consumption. The samples tested gave indication that 1) sulphuric acid production exceeded  $H_2SO_4$  consumption, 2) Thiobacillus ferrooxidans presence was associated with greater acid generation, and 3) the potential existed for acid drainage in the event of any mining activity and stockpiling of the material. Subsequent reports produced similar results of the potential for acid mine drainage.

## F        EFFLUENT TESTING

- Hallam et al 1975.

In addition to the water quality studies undertaken, chemical and bioassay analyses were run on simulated thickener overflow effluent from bench scale metallurgical tests. Flocculated and unflocculated samples contained potentially toxic levels of lead and zinc associated with nonfilterable residue but both were found to be non-toxic to coho fry in a 96-hour LC<sub>50</sub> static bioassay at 100% concentration. It is not known how representative of the actual effluent the samples were as the milling process has subsequently been substantially altered. However, it was concluded that flocculent use was environmentally advantageous due to significant reduction of deleterious levels of lead and zinc.

Considering the overall scope of the above studies, the environmental status of the two adjacent watersheds was reasonably well-documented prior to the start of production. Early recommendations resulted in Permit PE-4475 requirements and specifications discussed below.

Drainage from the current Southern Tail pit is directed to a small settling pond (WMB 0400761) and discharged to a Bessemer Creek tributary which feeds Buck Creek. Waste dumps, overburden stockpiles, and low grade stockpiles lie adjacent to the pit at its western edge. Drainage ditches have been constructed above the mine site in order to direct runoff away from immediate entrance into upper Bessemer Creek and instead to the same settling pond or back toward the mine area. No extensive measures are specified for runoff from overburden or waste-rock dumps, although some waste rock runoff does go through a silt check dam for treatment.

Plant site drainage is directed to a separate settling pond (WMB 0400762) lying adjacent to upper Bessemer Creek and southwest of the plant site. A maximum of 1360 and 6800 cubic metres per day (cmd), respectively, are to be treated by the facilities with overflow decanted to Bessemer.

Permit PE-4475 was granted June 14, 1977 and amended June 20, 1980. It specifically allows the discharge of the plant surface drainage to the settling pond with overflow to Bessemer Creek (4475-02) and the open pit drainage to the settling pond with overflow to a tributary of Bessemer (4475-03). These two effluents must meet the provincial requirements set out in the WMB permit as well as the federal specifications of the Metal Mining Liquid Effluents Regulations and Guidelines (Table 4).

As a result of early recommendations by EPS, Goosly Lake neither receives mine or mine-related discharges directly, nor supplies make-up water. Instead, Lu Creek was selected to provide supplemental fresh water. Three dams ensure sufficient levels during periods of low flow. The volume involved is less than  $6 \times 10^5$  IGPD or 500 USGPM and is restricted to usage as domestic, cooling, steam plant, and equipment seal supply.

Appendix 01 to PE-4478 allows the discharge of mill tailings to a tailings impoundment with recycle. The pond lies in the

- 26 July 1974

Hallam et al (1975). Eleven sites.

Parameters - Total Metals: Cu, Pb, Zn, Fe, Cd  
Dissolved Metals: Cu, Pb, Zn, Fe, Cd, Mo, Cr  
Turbidity  
Conductance  
Total Residue  
Non-filterable Residue  
Filterable Residue  
Bionutrients: Total Phosphates (TPO<sub>4</sub>), Nitrates  
(NO<sub>3</sub>), Nitrites (NO<sub>2</sub>), Sulphates (SO<sub>4</sub>)

- May, June 1975

Beak Consultants Ltd. (1976). Unknown sites.

Parameters - Turbidity  
Non-filterable Residue

- 12 May 1976

Beak Consultants Ltd. (1976). Eight sites.

Parameters - Total Metals: Cu, Pb, Zn, Fe, Ag, Sb, As  
Total Residue  
Non-filterable Residue  
Filterable Residue

Data from EPS and Beak is listed in Tables 5 and 6, respectively. Sampling locations are listed in Table 2 and illustrated by Figure 2. Each agency covered a variety of sites within the two watersheds.

Hallam and Kussat found both watersheds to be high in dissolved oxygen content ( 90% at most stations) and of normal pH (6.0-8.0). Summer pH values were consistently lower than fall readings by a full unit. However, the former are not considered reliable since they were taken using pH paper whereas the latter were recorded with the use of a "pH Hach kit".



Temperature ranged between 0°C in fall and 14°C in summer. Warmer conditions existed at lower elevation sites such as Goosly Lake. In general, visual clarity was good with the exception of samples from sites associated with camp or logging activities through which melting snow had carried silt to the water. Correspondingly, total metals with the exception of copper, zinc, and iron at site 4 and iron at site 5 of upper Bessemer near the camp, were usually present at levels below the detection limit. Further, concentrations overall compared with the 1974 EPS results which also indicated similar levels for most dissolved species. Sites 4 and 5 were characterized by samples containing significant amounts of suspended solids, probably contributed by camp activity, which were exposed to possible leaching by the HNO<sub>3</sub> preservative. Further contamination was possible through excess ground rock discarded from a portable core sample grinder located less than 100 feet away. Stream flow as expected peaked in early summer and reached a minimum in mid to late-winter. Wide variations in magnitude occurred between different creeks - the largest flows were observed in Foxy Creek and in Buck Creek at either end of Goosly Lake.

Hallam et al (1975) notes similarly clean conditions. Turbidity and solids were generally low, although at upper Bessemer Creek (site 4) total residues, which corresponded primarily to filterable portions throughout, were somewhat elevated at  $481 \pm 2.5$  mg/l. This was again attributed to camp-related activity and reflected in a higher turbidity reading of 15.0 FTU. Conductance, however, which is generally related directly to the level of filterable, or dissolved species was somewhat low at 55  $\mu$ m/cm for this site. This may be an error of decimal-point placement since the magnitude and direction of the solids-conductance relationship for all other samples suggests that a value of 550  $\mu$ m/cm would be more likely.

As mentioned above, both total and dissolved metal concentrations were in general low and below the detection limit, and were apparently equivalent to each other and to the 1973 total metal results. Iron

was the exception - total values in all cases significantly exceeded dissolved, and were somewhat elevated at: upper Bessemer Creek (site 5, 1.6 mg/l), a lower tributary of Bessemer (site 7, 1.3 mg/l), the main channel of Bessemer (site 8, 0.76 mg/l), lower Bessemer (site 9, 0.80 mg/l), and upper Buck Creek (site 10, 10.87 mg/l). Dissolved levels were also higher at these locations. Unlike the indications of the previous 1973 study, copper and zinc were not found to be elevated at such sites.

Nutrients ( $\text{PO}_4$ ,  $\text{NO}_3$ ,  $\text{NO}_2$ ,  $\text{SO}_4$ ) were measured in order to assess future contributions from process reagents or sewage. Most exhibited background levels which were below the effluent - provincial "A"-level objectives of 2.0 mg/l specified for "The Mining, Mine-Milling, and Smelting Industries of British Columbia" (1973). Sulphate, however, varied from undetectable to 91 mg/l, which is itself above the A-level objective of 50 mg/l for incoming effluent. No explanation was suggested for the fluctuations or magnitudes observed. Exposure of the high sulphide-content rock through weathering or other types of disturbance may have been a contributory source.

Beak reported similar findings: DO levels close to saturation, pH close to neutrality, nutrients at low levels, and trace elements generally in quantities near or below detection limits. Similar exceptions were noted: "Eagle" Creek (site 7) entering Goosly Lake and lower Buck Creek at the Kloo Creek confluence (site 8) both exhibited high total solid readings compared to Goosly Lake (site 5) findings. Other chemical dissimilarities of lower Buck Creek versus other watershed locations were not observed in the fall 1973 samples which were taken at a point upstream of Kloo Creek. Two artesian wells (numbers "53" and "128") - one in each watershed - were discussed; however, their respective locations were not specified. They recorded the lowest pH (6.3) and elevated total residue levels (1000 mg/l and 1666 mg/l, respectively) which, for all Beak sites and like the EPS findings, corresponded to filterable residue levels.

Conductance was not measured for any Beak site but was directly related to FR for the EPS results above. Data from the two agencies

broad open valley of Lu Creek immediately north of the plant site. The main tailings dam, situated a short distance upstream of Foxy Creek, will eventually reach a height of 27 metres and storage capacity of  $33 \times 10^6$  tonnes. The impervious starter dam is to be enlarged as the operation progresses; a small recovery dam and pumping station located immediately downstream collect and recycle any seepage. Uncontaminated surface drainage is directed to Foxy Creek, but in general, supernatant is collected by a floating pumphouse and recycled to the plant. Recycle from the main pond approximates 73% - the remaining 27% is accounted for as evaporation, void retention, and excess water retention.

Discharge is at a maximum 19,500 cubic metres per day (cmd) or 4.4 imperial gallons per day (IGPD). The tailings from the rougher cells are delivered at about 30% solids along a 46 mm diameter 1 km pipe to the pond for permanent impoundment behind the dam. As the tailings settle to a terminal density of about 75% solids, surplus water forms a pool from where it is reclaimed by the floating pump station at an average rate of 900 cubic metres per day.

There is no discharge per se from the leach plant. All products and reagents report to either the copper-gold-silver concentrate, anti-mony, or arsenic end products. The leach plant bleed liquor treatment produces a final product that is settled in a drying pond.

The June 1980 Letter of Transmittal specifies eight sampling locations, listed in Table 3. The first four are effluent sites which are to be monitored at least quarterly by grab sample: 1) Tailings Pond Supernatant (WMB site 0400759), 2) Tailings Seepage Pond Supernatant (0400760), 3) Mine Water Settling Pond Supernatant (0400761), and 4) Plant Drainage Pond Supernatant (0400762). The latter four are receiving water sites which must be monitored at least monthly by grab sample: 5) Foxy Creek upstream of Tailings Impoundment (0400763), 6) Foxy Creek downstream of Tailings Impoundment (0400764), 7) Buck Creek upstream of the confluence with Bessemer, ie - discharge of mine and plant drainage (0400765), and 8) Buck Creek downstream of the confluence with Bessemer (0400766).

Major monitoring parameters include Total Suspended Solids (TSS), pH, Oil and Grease, Dissolved Sulphates, and Total and Dissolved arsenic, copper, iron, lead, antimony, zinc and mercury. Further directives are for representative, monthly quantification of the discharge to and the recycle of the tailings and drainage ponds as well as the usage of mill reagents. The Letter of Transmittal also specifies the use of additional treatments if and when such are warranted, maximum usage return, surface tailing runoff diversion from the receiving waters by suitable ditching, notification of modifications; procedures for emergency and maintenance, and restriction of discharge of non-approved/untreated effluents. Finally, Equity must arrange through a qualified consultant an annual review of the tailing impoundment's performance and annual assessment of the operation's effect concerning all relevant aspects of the receiving environment.

Equity Silver commenced mining activity by August 1980. The mill began commercial production in October 1980; the leach plant, in October 1981. All post-operational data that is immediately evident and obtainable pertains to the effluent and receiving water-quality sampling program specified in WMB Permit No. PE-4475; monitoring commenced by 10 September 1980 for all locations although the starting dates and number of submissions vary.

Tables 7 through 14 present the results for sites 1(0400759) through 8(0400767) consecutively. The major portion of the data has been compiled from a recent Equis print out which lists all recorded values to 15 December 1981. An exception is the total mercury (T Hg) values discussed below. These were obtained from the original raw data sheets of the former Pollution Control Branch (now WMB) - the figures on the former are of questionable reliability; they were below the values of original records by up to five orders of magnitude ( $10^5$ ) and were recorded as existing in the nanogram range - a degree of experimental sensitivity which is not likely attainable. The values used indicate low concentrations falling consistently in the  $10^{-4}$ - $10^{-5}$  range. Other raw data that corresponds to dates not listed on the Equis printout is included also in Tables 7 through 14.

Although data is available back to mid-1980 only, certain trends are evident and are discussed below. Figures 5,6,7 and 8 graph the patterns of sulphate ( $SO_4$ ), hydrogen ion ( $H^+$ ), total and dissolved copper (Cu), and total and dissolved iron (Fe) for the four effluents. Federal Metal Mining Liquid Effluent Regulation and Waste Management Branch compliance maxima are listed in Table 4 and are referred to below.

#### 10.1 Impoundment - Tailings Pond Supernatant: 0400759

The tailing supernatant has been sampled on only eight occasions

from 10 September 1980 through 15 December 1981. This particular site doesn't suggest the presence of certain trends as strongly as other effluent sites - perhaps at least partly because of its nature; this is a supernatant which tends to flow over top of the tailings, not necessarily undergoing any significant amount of contact or interaction with the tailing material.

Regardless, sulphate has increased gradually over the sixteen month period, in two increments of about half an order of magnitude each (Table 7, Figure 5). The overall change has been from the initial low of 66.5 mg/l (10 Sept. 1980) to 850.0 mg/l (15 Dec. 1981). Very marked increases occurred over the three latest readings, with 286.0 mg/l observed on 23 June 1981; 530.0 mg/l, 10 Sept. 1981. The subsequent increase of 320 mg/l during the period to 15 Dec. 1981 coincided with a major on-site spill of sulphuric acid from corroded reagent tanks. However, it is unlikely that this was a source of contamination or therefore, a contributory factor. Generation of sulphate is more likely a result of natural processes involving either the tailings or waste-rock contained within dam structures.

Hydrogen ion concentration has remained relatively stable in relation to sulphate levels and at final reading was still within compliance maximum of  $3.16 \times 10^{-7}$  mg/l (minimum pH of 6.5). For these results the pH does not appear to be associated with the latter, although there was an observable increase of  $H^+$  coinciding with the early increases of sulphate. The lowest pH value of 6.6 (28 Apr. 1981) did coincide with the first peak for sulphate. However,  $H^+$  was decreasing steadily over the latter six months - highest and latest record of pH was 8.4, on 15 Dec. 1980.

Total and dissolved metals were in general low during the period. Some, such as total and dissolved copper demonstrated a pattern which was very similar to  $H^+$  charges; peak metal levels corresponded to peaks of  $H^+$  and lows of pH. Total iron readings also showed such patterns, but dissolved Fe essentially remained stable at  $<0.03$  mg/l. Although both Cu and Fe varied over an order of magnitude, neither had violated compliance maxima as of 15 Dec. 1981 with the exception of a

single value for dissolved Cu: 0.073 mg/l, obtained 28 Apr. 1981. Arsenic, zinc, and antimony also fluctuated and As and Sb both have exceeded compliance levels for dissolved species. As was elevated most recently - reporting at 0.62 mg/l on 15 Dec. 1981. Dissolved Sb was consistently out of compliance (0.05 mg/l) with the exception of the 03 Mar. 1981 reading of 0.028 mg/l. Other measurements varied from 0.34 mg/l to the latest 2.25 mg/l. Finally, lead and mercury remained within the  $10^{-4}$  to  $10^{-3}$  concentration range throughout. Nickel was not measured.

Non-filterable residues (NFR) were relatively low but ranged from 3.5 to one excessive level of 72.0 mg/l (08 Oct. 1980). Significant differences between total and dissolved metal fractions did not correlate with NFR changes. Instead, a higher overall content in the suspended fraction was suggested by the limited data available. No other marked changes or trends that could be related to NFR were noted, with the 1.26 exception of a jump of total Sb from the initial level of 0.37 mg/l to mg/l. Dissolved Sb doubled over the same period, from 0.34 to 0.74 mg/l, but no obvious cause was discernable. Oil and grease varied little over the period; levels ranged from undetectable to a maximum of 5.0 mg/l.

#### 10.2 Tailings Pond Supernatant: 0.400760

WMB monitoring begins at 10 Sept. 1980 and extends over fifteen sampling dates to 15 Dec. 1981. This effluent is a seepage water which has percolated through the tailings particulate and subsequently escaped the starter-dam. Thus, if either structure contains acid-generating matter, this could be considered as a potential for acid or metal compliance problems.

Sulphate has increased in total through two to three orders of magnitude. The most dramatic rise with one exception occurred between 28 May 1981 and 15 Dec. 1981, from 303.0 mg/l to 8850 mg/l; a greater jump from <5.0 mg/l to 600 mg/l followed a precipitous decrease from 243 mg/l during Mar. 1981 (Table 8, Figure 6).

Hydrogen fluctuations have been more numerous and dramatic, but  $H^+$  concentrations have shown an overall pattern similar to that of sulphate. Peaks, troughs, and levels coincide roughly, with  $H^+$  changes perhaps lagging slightly behind. The first major  $SO_4$  increases were followed in April 1981 by a sharp rise in  $H^+$  from  $1.99 \times 10^{-8}$  mg/l to  $7.94 \times 10^{-4}$  mg/l and a corresponding fall in pH from 7.7 to 3.1. Both  $H^+$  and  $SO_4$  were apparently on the second upward swing of an overall rapid and large increase as of 15 Dec. 1981, when the highest-yet values of  $1.5 \times 10^{-3}$  mg/l (pH 2.8) and 8850 mg/l, respectively, were recorded.

Metal concentration behaviour was similar to that of sulphate and hydrogen. Many species have shown elevations well above compliance levels since late 1980 - early 1981; both total and dissolved portions as of 15 Dec. 1981 were continuing to show dramatic increases. Figure 6 indicates the changes in copper and iron. As with other species, increases of three to four orders of magnitude have occurred. Total and dissolved Cu have consistently exceeded regulatory limits for at least twelve months. Final values were 99.8 mg/l and 96.0 mg/l, respectively. Fe levels were well in excess of dissolved compliance - final readings were 410.0 mg/l (19 Nov. 1981) and 370.0 mg/l (15 Dec. 1981). The corresponding total values were 611.0 mg/l and 534.0 mg/l, respectively. Both Cu and Fe demonstrated significant elevations before the large drops in pH were recorded. Zinc has shown similar elevations. Total Zn was out of compliance consistently since 31 Mar. 1981, when 1.36 mg/l was recorded. Dissolved Zn was out of compliance for the same period and previously, on 14 Jan. 1981, with a level of 0.74 mg/l. Final total and dissolved readings were 63.7 mg/l and 60.3 mg/l. Total lead has not exceeded the limit of 0.40 mg/l. Dissolved Pb has been at the compliance limit of 0.05 mg/l, on 19 Oct. 1981; and was at excess with the final reading of 0.07 mg/l. Arsenic exceeded regulations at all three final readings for both species; final total was 24.0 mg/l, final dissolved: 5.0 mg/l. Antimony behaved differently. Lowest concentration values were obtained during periods of peak  $H^+$  and other metal levels. The final



total for Sb however, was 0.20 mg/l - a rise of a degree of magnitude over the previous value. Dissolved Sb remained low at 0.009 mg/l. Thus, with exceptions for Sb and Hg, over the sixteen month period metals have increased over three to four orders of magnitude. Two major interruptions of observable trends may be related to mine activity or weather conditions. Differences of magnitude between total and dissolved fractions appear to be significant for arsenic and iron. High amounts of non-dissolved As and Fe may be associated with overall quantity of NFR and/or overall metal content per volume NFR. Other metals consistently presented significant dissolved fractions which suggested that relatively little was associated with suspended material.

Non-filterable residues have demonstrated a similarly marked trend. Initial levels of about 13.0 mg/l were well within compliance requirements (50.0 mg/l) and were stable until the period showing jumps in hydrogen ion, sulphate, and metal concentrations. A slightly elevated second reading of 70.0 mg/l (08 Oct. 1980), occurring simultaneously with a drop in pH from 7.8 to 7.4, was followed by two successive decreases to 17.5 and 1.5 mg/l and a rise in pH to 8.0. As for other water quality parameters, direction and magnitude of NFR change was directly proportional to hydrogen concentration (e.g., 28 Apr. 1981: pH 3.1, NFR 111.0 mg/l; and 19 Nov. 1981: pH 3.0, NFR 420 mg/l). Oil and grease had been very consistent at <2.0 mg/l with the exception again of 28 Apr. 1981, when a level of 4.0 mg/l was observed. The latest (15 Dec. 1981) value was <2.0 mg/l. Metal relationships have been discussed.

In summary and with reference to Table 4, this effluent has exceeded compliance limits for most criteria on several occasions and has been deteriorating overall since at least early 1981. Indications are that pH is continuing to decrease and is currently in the 2-3 range. Only a few parameters - oil and grease, mercury, lead, and antimony - are not showing consistently non-compliant levels. Arsenic, copper, iron, zinc, and sulphate are showing elevations of at least two to three orders of magnitude.

Permit PE-4475 amendment 'C' requires recycle of all seepage back to the tailings impoundment. Excessive ion content could potentially

intiate increased oxidation or leaching activity within the tailings pile, particularly with repeated percolations and recycles. This is of concern since in general, acid mine water has definitely been in a state of progressive development at this site and excessive levels of acidity, residue, sulphates and metals appear to be related.

#### 10.3 Mine Water/Settling Pond Supernatant: 0400761

The effluent drains from the Southern Tail Pit; it is covered by PE-4475-02 and has been monitored fifteen times from 30 May 1980 through 15 Dec. 1981. Several species show striking increases of concentration and similarities of pattern (Table 9, Figure 7).

Sulphate has fluctuated but increased overall by one and one half orders of magnitude. The 10 Sept. 1981 and 15 Dec. 1981 readings revealed a marked rise from 94.0 mg/l to 540 mg/l. Peaks and troughs of hydrogen concentrations have followed a somewhat similar route. Since 23 June 1981,  $H^+$  increased dramatically from  $2.51 \times 10^{-7}$  mg/l (pH 6.6) to  $1.99 \times 10^{-4}$  mg/l (pH 3.7) and was approaching the actual magnitude of  $SO_4$  concentration. Compliance for pH was exceeded on several occasions: 03 Mar. 1981 (pH 6.3), 28 Apr. 1981 (6.4), 28 May 1981 (6.1), 01 Sept. 1981 (6.1), 10 Sept. 1981 (5.9), and 15 Dec. 1981 (3.7). No record for 14 Nov. 1981 was obtained; however, pH was probably low since  $SO_4$  on this date was elevated to a similar level as that on 01 Sept 1981, ie; levels were 135.0 mg/l and 141.0 mg/l, respectively.

Metals show increases to levels above compliance, although not to the extent observed for the seepage effluent; more parameters remained at low levels in the mine water which also had not shown as drastic an increase in sulphate as had the seepage by 15 Dec. 1981. Copper and iron show large increases and all metals show similar fluctuation patterns (Figure 7, Table 9). For example, most species showed a distinct drop in concentration around May 1981, with the exception of dissolved Fe which experienced a slight peaking. Compliance was exceeded by total and

dissolved Cu on several occasions. Final, excessive readings of both were reported at 2.40 mg/l and 2.26 mg/l, respectively. Total Fe levels were high throughout the period with only one exception: 0.05 mg/l on 02 June 1980. The final value was 6.50 mg/l. Dissolved Fe was out of compliance on 08 Aug. 1980 and 10 Oct. 1980 with levels of 0.62 mg/l and 0.81; after this date the dissolved component remained small until the final report of 1.85 mg/l (15 Dec. 1981). Total zinc fluctuated through an order of magnitude but remained within compliance overall. Similarly, dissolved Zn remained low until the final 0.76 mg/l, which was the first excessive reading. Both total and dissolved lead measured repeatedly in the  $10^{-2}$  to  $10^{-3}$  concentration range and thus well below compliance limits. Arsenic was consistently within regulation levels for both species. The later series of readings for both reported in the  $10^{-3}$  range. Total antimony levels were consistently in the  $10^{-3}$  range with the exception of some slightly higher earlier readings; dissolved Sb followed the same pattern. Overall the metals reported at low levels until the later readings. Cu, Fe, and Zn showed the most significant increases. As with other effluents Cu and Fe showed significant discrepancies between the magnitude of total and dissolved values. Later increases paralleled increases in non-filterable residues.

Non-filterable residues fluctuated with a minimum of <0.5 mg/l on 23 June 1981 and a maximum of 110 mg/l on 28 April 1981. The latter was the one date on which NFR demonstrated excessive levels. Later readings demonstrated increases which paralleled increases in both total and dissolved metal species but no conclusions can be made since earlier, lower values of NFR coincided with similarly high levels of some metals, in particular, Fe. The observed magnitude of NFR fluctuations may not be significant, particularly in relation to Fe levels. Variation in overall metal concentration may be more important.

Conductivity was measured twice: 02 June 1981 and 01 Oct. 1981 - the findings were 525.0 us/cm and 597.0 us/cm. Dissolved species were not measured, and suspended solids did not differ markedly for the two

dates; NFR's were 16.0 mg/l and 9.0 mg/l. The specific conductivities were relatively high for inland BC waters but not excessive. Oil and grease was low and reported at levels similar to those obtained at the other sites. The usual level was  $\leq 3.0$  mg/l. One higher reading of 11.0 mg/l was taken on 10 Oct. 1981.

Later readings for this effluent indicate a definite trend toward higher acidity and metal content. The effluent has the potential for continued development of acid mine water and environmentally-hazardous continued leaching activity, due to the presence of waste rock and the existing discharge of runoff to Bessemer Creek. The same waste rock material has been used in road construction and is currently producing acid runoff that necessitates transfer to the tailings impoundment via tanker truck.

#### 10.4 Storm Water/Plant Drainage Pond Supernatant: 0400762

The plant drainage pond has also been monitored on fourteen occasions from 13 June 1980 through 15 Dec. 1981. Table 10 and Figure 8 indicate overall increases and strong trends which had developed from around December 1980.

Sulphate rose over a full order of magnitude with a few, relatively small interruptions. As for other parameters, a sharp rise from May 1981 had reversed slightly during the period between the final two readings of 27 Nov. 1981 and 15 Dec. 1981, which reported respectively 830 mg/ and 750 mg/l. Hydrogen ion followed a similar course; decreasing after a rapid rise to  $1.99 \times 10^{-4}$  mg/l by 27 Nov. 1981 to  $1.26 \times 10^{-4}$  mg/l. Regardless, the effluent pH was out of compliance on 28 May 1981 (6.3), 10 Sept. 1981 (5.2), 27 Nov. 1981 (3.7,) and again on 15 Dec. 1981 (3.9). The changes appear to lag slightly behind the sulphate pattern. The pH drop that occurred during November 1981 may have corresponded to the period of the plant-area sulphuric acid spill.

Metal concentrations varied according to species. Copper, iron, and zinc were showing elevations as of 15 Dec. 1981 and were showing a

general pattern similar to that of sulphate and hydrogen. Total Cu was out of compliance for the final three readings; the latest value, on 15 Dec. 1981, was 3.05 mg/l. Dissolved Cu was in violation repeatedly from the 10 Sept. 1980 reading of 0.12 mg/l to the final reading of 2.85 mg/l. Total Fe fluctuated but was high overall. The two final values were 30.2 mg/l and 12.4 mg/l. Dissolved Fe fluctuated but exceeded compliance only at the final reading, which reported at 0.30 mg/l. An early rise did not correspond to sulphate or  $H^+$ , while the later peak, although slightly behind  $H^+$ , may have been related to the pH changes. Zn increased markedly from the early readings. The later three measurements of total Zn were all above compliance limits; a level of 3.40 mg/l was observed on 15 Dec. 1981.

Dissolved Zn showed the most marked change between 10 Sept. 1981 and 15 Dec. 1981; values for these dates were 0.01 mg/l and 3.20 mg/l, respectively. Only the latest level was above compliance. Lead, arsenic, and antimony were consistently at low levels and not demonstrating significant elevations as of 15 Dec. 1981. As for other sites, mercury was consistently in the  $10^{-4}$  to  $10^{-5}$  range and nickel was seldom measured although available figures were always well below regulation level (1.0 mg/l), at the  $10^{-2}$  concentration range. For the metals overall, total and dissolved quantities differed relatively slightly except for Fe, which showed significantly higher levels of total. Differences between total and dissolved and overall increases in total quantity did not appear to correspond to the amount or patterns of suspended matter.

Solids have varied and have exceeded compliance once on 28 Apr. 1981 with a level of 61.5 mg/l for NFR. Lower values were obtained subsequently, but the final reading of 48.5 mg/l was approximating the previous maximum. As above, increases in NFR were not distinctly related to changes and patterns for other parameters. The large rise between 10 Sept. 1981 and 15 Dec. 1981 coincided with the drop in pH, while the earlier peak was not accompanied by excess levels of any parameter except Fe. No consistent patterns were discernable.

Conductance was measured once on 27 Nov. 1981 and was extremely high at 1550 us/cm. The other sites and BC inland waters in general rarely exceed the region of approximately 500 us/cm. Dissolved metals were not determined on that date. However, total levels for Cu and Zn were excessive: 3.8 mg/l and 3.98 mg/l; and, the overall results indicate that dissolved species are present at high proportions. Further, the elevated Fe level of 30.2 mg/l was likely associated with a significant overall if not proportionate, dissolved component. Oil and grease levels were low; variations from undetectable to 6.0 mg/l were observed.

Later results for this effluent indicate an acidic; generally non-compliant situation. Discharge to Bessemer Creek occurs in the event of overflow conditions or plant area spills. No particular treatment has yet been specified although Clause F (Additional Treatment) in the Letter of Transmittal is "designed to require the permittee to provide additional treatment such as recycling of open pit and plant area drainage, if the usefulness of downstream waters are substantially impaired" (Klassen, 1980.)

#### 10.5 Foxy Creek Upstream of Tailings Impoundment: 0400763

Foxy Creek was sampled twenty times since 13 June 1980. Like other receiving water sites, changes as of 15 Dec. 1981 were not as marked as those observed at effluent monitoring sites. For example, sulphate reported at low levels; varying from the usual <5.0 mg/l to a maximum of only 20.5 mg/l, on 14 Nov. 1980. Acidity increases did not coincide with sulphate peaks; pH generally fell within the 7.2-7.8 range, the maximum was 8.1 on 12 Dec. 1980, and the minimum was 6.4 on 19 Nov. 1981. Further, this as an upstream site, should not be and was probably not affected by conditions of seepage effluent. It can be concluded however that the final two pH readings of 6.4 and 6.5, respectively, indicate that  $H^+$  levels increased significantly over the previous conditions which had existed for several months and which were reflected by readings that fell consistently in the upper 7-8 range.

In general metals have remained at relatively low levels although copper, iron, and zinc have shown occasional fluctuations over an order of magnitude. Fluctuations occur for both total and dissolved components. In several cases total values are not represented completely by dissolved species, as indicated in Table 11. Total Cu significantly exceeded dissolved Cu on 08 Aug. 1980 and 08 Oct. 1980, but was not significantly elevated overall. Total Fe reached a maximum of 0.68 mg/l on 19 Nov. 1981, this coincided with the dissolved maximum of 0.29 mg/l and the low pH of 6.4. However, subsequent Fe readings were significantly lower at 0.24 mg/l and 0.17 mg/l, respectively. Overall Zn values were low. The maximum total of 0.14 mg/l was obtained 08 Aug. 1980 and coincided with a very low dissolved of 0.004 mg/l. Later readings for both species fell in the  $10^{-3}$  concentration range. Similarly, antimony, mercury, lead, and as above, usually Cu, values remained in the  $10^{-3}$  to  $10^{-4}$  concentration range.

Residues were consistently low, especially versus the effluent results; values ranged between <0.5 mg/l to 3.0 mg/l until the final observation of 20.0 mg/l. NFR was not related to increases of total metals or to other parameters, although the two measurements of conductivity taken 02 June 1980 and 01 Sept 1981 reported 35.0 and 60.0 us/cm and coincided with NFR values of 3.0 and <1.0 mg/l, respectively. However, the number of measurements and magnitude of differences are too small to be significant. The conductivity levels are at the low end of the spectrum observed for normal unmineralized inland BC waters. No dissolved metal analyses were carried out on these dates and no significant total values were noted. The slightly acidic  $H^+$  conditions were already established at least as of 19 Nov. 1981. Oil and grease was continuously low, never exceeding 3.0 mg/l. Overall, no exceptional developments were noted.

#### 10.6 Foxy Creek Downstream of Tailings Impoundment: 0400764

Concentration patterns of the downstream site are largely similar to those observed for site 5. Sulphate remained very low, measuring <5.0

mg/l on all but three occasions. Elevations to 25.5 mg/l and <10.0 mg/l were observed on 14 Nov. 1980 and 03 March 1981. A larger increase to 249.0 mg/l was obtained on 31 March 1981 - this is either an anomalous or incorrect value as no more significant results were observed either at that time or subsequently. Following March 1981, H<sup>+</sup> concentration increased slightly, but the highest H<sup>+</sup> and correspondingly lowest pH (6.8) values were obtained when sulphate reported at <5.0 mg/l on 28 May 1981, indicating if anything, the absence of a cause-effect relationship. As with the upstream site, the final pH readings of 6.5 and 6.3 hovered at a slightly acidic level. No other strong trends were as yet observed.

Metal results were similar to those of the upstream site. Copper, iron, and zinc varied over an order of magnitude but nevertheless reported consistently at relatively low levels. Maximum total values for Cu, Fe, and Zn were 0.16 (14 July 1981), 0.51 (19 Nov. 1981), and 0.077 (10 Nov. 1981), mg/l, respectively. On these and other occasions when total amounts were at the higher levels, the dissolved values represented only a small portion of the totals, indicating that a large complement of the metals was associated with suspended matter. Arsenic, lead, antimony, and mercury did not exceed the 10<sup>-3</sup>-10<sup>-4</sup> concentration range. No continued patterns or trends were observed for the metal results. Further, while concentration ranges of several species were equivalent between the two Foxy Creek sites, individual maximum and minimum values were not consistently observed at similar points in time.

Solids measured between <0.5 and 17.0 mg/l - the final reading. the previous maximum of 6.0 was observed on 14 Jan. 1981. The data indicates that NFR was not directly related to increases of total metals. High metal values may have been reflective of higher concentrations associated with NFR, but not higher residues per se. Conductance was low on both 02 June 1981 and 01 Sept. 1981, measuring 34.0 us/cm and 73.0 us/cm. Again, a small and probably insignificant inverse COND-NFR pattern was evident; suspended levels of 3.0 and 1.0 mg/l, respectively, occurred on those



dates. Oil and grease virtually remained at  $\leq 2.0$  mg/l with the exception of one reading of 5.0 mg/l taken 19 Nov. 1981.

Later measurements of pH, NFR, and Fe were showing slight changes and perhaps trends which were not yet quantitatively significant but may have been associated with the acid conditions existing and developing simultaneously in the seepage effluent. Further monitoring of upstream and downstream parameters should indicate if overflow from the seepage pond is occurring and if so, what degree if any, of impact is evident and can be expected.

10.7 Buck Creek Upstream of Plant Drainage (Bessemer Creek): 0400765

The upstream Buck Creek station was monitored on twenty-two occasions from 30 May 1980 through 15 Dec. 1981, by which no particularly strong trends had been observed. However, fluctuations for the period were more marked than those evident at Foxy Creek.

Sulphate generally reported at  $\leq 5.0$  mg/l. Higher values of 31.8 mg/l on 21 Nov. 1980, 17.5 mg/l on 14 Jan. 1981, and 7.2 mg/l on 15 Dec. 1981, did not appear to correspond or relate to other parameter changes. Although pH readings of 7.3 and 7.4 coincided with sulphate peaks while a higher pH of 8.0 was observed simultaneous to the intervening sulphate low of  $<5.0$  mg/l, other lower pH readings also coincided with low sulphate values. The final measurements gave a pH of 6.2 and a sulphate of  $<5.0$  mg/l.

Overall metal levels were similar to results obtained at Foxy Creek stations: arsenic, antimony, lead, mercury, and copper reported to the  $10^{-3}$  to  $10^{-4}$  concentration range for both dissolved and total measurements. A few exceptions are noted for Cu, which reported a maximum total of 0.04 mg/l on 28 May 1981. Iron and zinc fluctuated. Total Fe ranged from 0.32 mg/l (08 Oct. 1980) to 2.05 mg/l (14 Aug. 1981); dissolved Fe, from 0.17 mg/l (30 May 1980) to 1.17 mg/l (14 Aug. 1981). Total Fe has exceeded 1.0 mg/l almost continuously since August 1981.

Dissolved Fe has been in excess of 0.30 mg/l since October 1980. Final readings were 1.52 mg/l and 0.99 mg/l, respectively. Zinc values have fluctuated through an order of magnitude for both species and were reporting consistently in the  $10^{-2}$  region over the final months. No other significant increases were observed for other metals. However, total values for Cu, Fe, and Zn were significantly greater than dissolved levels on several occasions.

As observed at the Foxy Creek stations; non-filterable residue levels were not excessive. Small increases from 0.5 mg/l to 2.0 mg/l (02 June 1981) and 6.0 (14 Jan. 1981), and a maximum of 20.0 mg/l (15 Dec. 1981) were observed, but the direction or presence of changes in NFR was not coincidental with any other patterns. Again, total metal maxima are possibly reflective of higher overall metal content within the relatively consistent suspended solid fraction. Conductance was measured on three occasions and found to be 69.0 us/cm (02 June 1981), 118.0 us/cm (23 Nov. 1981), and 127.0 us/cm (27 Nov. 1981). No NFR or dissolved metal readings were obtained on the latter two dates. The former value is relatively low but within the normal range expected.

10.8      Buck Creek Downstream of Plant Drainage (Bessemer Creek):  
0400766

The downstream site was monitored on nineteen occasions from 08 Aug. 1980 through 15 Dec. 1981. Few trends within the site or in comparison to the upstream location have been observed.

Sulphate, for example, has remained at similarly low levels, reporting generally at  $\leq 5.0$  mg/l. Peak values were 36.5 mg/l (21 Nov. 1980) and 49.3 mg/l (27 Nov. 1981) and the final reading was 11.0 mg/l. Hydrogen ion concentration has not fluctuated markedly, most readings of pH fell well above 7.0 although 6.8 and 6.9 were obtained on 28 Apr. 1981 and 28 May 1981, and pH dropped to 6.1 on 15 Dec. 1981. The most acidic values of  $H^+$  and pH do not correspond to the higher sulphate levels and

there does not appear to be a relationship between  $H^+$ /pH and the latter. Neither shows a consistent relationship with any parameters.

Again, metal results are similar to those of other receiving water stations. Arsenic, lead, antimony, mercury and copper existed at similar, low levels. Iron and zinc results show fluctuations. Total Fe values vary from 0.05 mg/l (10 Sept. 1980) to 0.51 mg/l (02 June 1981) but are generally in the  $10^{-1}$  range. Dissolved levels range from

0.03 mg/l (28 Apr. 1981) to 0.22 mg/l (14 Jan. 1981) and are significantly lower than total levels for several dates. However, the total dissolved fraction discrepancy is not as marked as observed at other receiving station locations. Zinc totals ranged from 0.003 mg/l (14 Jan. 1981) to 0.079 mg/l (08 Aug. 1980), dissolved values from 0.003 mg/l (14 Jan. 1981) to 0.018 mg/l (10 Sept. 1981). Significant differences between dissolved and total fractions were observed for a few dates: 08 Aug. 1980, 21 Nov. 1980, and 10 Sept. 1981. No metals were showing excessive levels as of 15 Dec. 1981.

Residues reported at  $\leq 6.0$  mg/l until the 15 Dec. 1981 reading of 18.5 mg/l. No other marked, isolated change was evident for the date with the exception of the pH drop to 6.1. NFR did not show or indicate a consistent relationship with any of the other parameters.

Conductance was measured three times and was found to be approximately equivalent to the upstream conditions; 83.0 us/cm (02 June 1981), 110.0 us/cm (23 Nov. 1981), and 208.0 us/cm (27 Nov. 1981). NFR and dissolved metal data was not available for the latter dates. Finally, oil and grease was usually present at  $\leq 2.0$  mg/l. Levels of 3.0 mg/l and 6.0 mg/l were present on 28 Apr. 1981 and 19 Nov. 1981.

Comparison of water quality data from this location with that from the upstream site indicates that similar and for many parameters (eg: iron), more marked, fluctuations were occurring at the latter. This suggests that mine and plant discharge to Bessemer Creek and subsequent flow to and impact on Buck Creek were not as yet of significant magnitude or concern.

Available information indicates that a problem situation has existed and had been developing for some months with the Equity effluents. Excessive antimony levels in the tailings pond supernatant suggest non-compliance at the mill concentration stage. Acid conditions are not expected for this effluent at least in the short run because tailings settle out quickly once discharged. However, the seepage has become strongly acid and as of 15 Dec. 1981 was not showing signs of abatement. The source of  $H^+$  activity is not confirmed. Possibly, percolation through the tailing matter has provided a large degree of surface contact with sulphide - containing particulates and resultant production of acid-generating sulphates. Further, if the above is an actual active source, it must be assumed that all  $H^+$ -containing effluent remains at depth to subsequently escape the seepage dam in significant quantities.

An additional possibility is the waste rock contained within the tailing dam itself, similar sulphide - containing rock has been associated with acid runoff elsewhere on the operation site, for example, the rock used in road bed construction is producing a runoff which is definitely acid downstream. Further credence is added to the above theory with the recognition of acid conditions in both the mine and mill discharges. Both reported pH below 4.0 and showed increasing trends for  $H^+$ ,  $SO_4$ , and several metals - primarily Cu, Fe, and Zn - as of 15 Dec. 1981. Recent reports indicate that current (March 1982) pH readings of the waste rock "pool" are at 2.6 to 2.8 (K. Ferguson).

Both biological and chemical processes have been cited as the major factors governing the initiating and/or rate-determining steps of acid mine generation. The former involves oxidation by Thiobacillus ferrooxidans of S-containing compounds, the latter,  $Fe^{+3}$  attack of  $Fe^{2+}$  once a specific  $Fe^{3+}$ :  $Fe^{2+}$  ratio is achieved. Regardless, once a pH of about 5.5 has been reached, certain iron-oxidizing bacteria (Metallogenium and some Thiobacilli) can establish; Thiobacillus establishes readily at

pH <4.0, and in all cases the presence of microbes leads to a catalytic increase in  $H^+$  generation and acid formation. The presence of Thiobacilli in each of the seepage, mine, and mill effluents is highly probable, as is the continuance of acid discharge unless comprehensively applied, acceptable measures are undertaken. Suggestions and practices such as the recycle of acid seepage back to the tailings pond may exacerbate conditions in this previously less acid effluent.

Development of acid discharge conditions was neither unpredictable nor unforeseeable. Potential for the specific waste rock to generate acid was initially recognized and discussed in the Beak report of 1974. However, the study stated that appropriate mitigative measures such as diversion of overburden and waste dump runoff from natural watercourses would prevent sulphide-related problems or hazards, that regardless of the above, risk of such an occurrence was small due to the quantity of sulphide minerals involved; that a winter climatic features of cold temperature and low precipitation "do not assist the acid-producing bacteria"; and that the anticipated environmental impact after considering relevant prerequisites, proper implementation of monitoring programs, and the availability of appropriate mitigation procedures if warranted, was negligible. A subsequent statement which originated at BC Research specified that any conceivable acid formation would be observed within two years.

This was perhaps too light a treatment. Several aspects may not have been considered thoroughly. First, the surrounding rock was known to be of high sulphur content, and anomalously high sulphate levels were on three occasions observed in the receiving environment prior to commencement of mine-related activities. Also, numerous studies have proven that sulphur-oxidizing bacteria can establish under a wide range of conditions and survive adverse circumstances for extended periods of time to propagate once favorable conditions are reestablished.

Architectural components of original mine area plans included construction of diversions to direct waste rock/dump runoff away from the immediately interceptable receiving waters while simultaneously allowing

overflow of both mine and mill discharges to be directed to Bessemer and hence Buck Creek. In addition, the event of flood conditions negates the former and the majority of runoff is permitted to reach the water systems.

EPS expressed concerns about the discharge of plant site drainage and mine water. However, WMB Permit 4475 allowed the discharges and specified neither treatment recommendations for the sites nor control or monitoring regimens for waste rock runoff.

Although many unfavourable conclusions can be made about the state of effluent quality and regulatory measures, the receiving environment is of primary concern and had as of 15 December 1981 not shown any significant developments. Regardless, it should be recognized that it is subject and susceptible to discharge of effluents and that minor effects may already be present. Slightly acidic levels approximating pH 6.5 in Buck Creek may have resulted from the November 1981 sulphuric acid spill. Elevated iron concentrations at some sites, including upstream locations; may be associated with turbid stream flow or plant-camp site activities. The potential for damage to the fisheries resource is always present and potentially great if current trends of effluent quality continue unabated and manage to impact on either drainage system. Further and extensive monitoring data should provide a better indication of whether any discharges are likely to be of major concern presently, or in the extended future. Additional insights should be gained once the first annual environmental impact report is available.

Current proposals and work are focussed on immediate remedial action, reclamation plans, appropriate status reports, and test plot programs. Existing road bed runoff is being pumped to the tailings pond for instance, but a more important consideration is the fate, subsequent to future mine abandonment, of all sources of waste rock. Preliminary studies are being conducted through private consultants.

The Department of the Environment should ensure appropriate and thorough characterization, collection, and treatment of all seepages and discharges. Site inspections, comprehensive water monitoring, and effluent audits are recommended. Any annual reports should be obtained for review and comment. From all aspects it must be recognized that: "The actual production of acid pit water in waste rock runoff without adequate controls could pose a significant threat to the fishery resources of the area and also would place the mine out of compliance with the Metal Mining Liquid Effluent Regulations". A conscientious approach to investigations of background factors and developments and possible mitigative and preventive measures should benefit future activities of similar nature and contribute valuable technical knowledge to the field.

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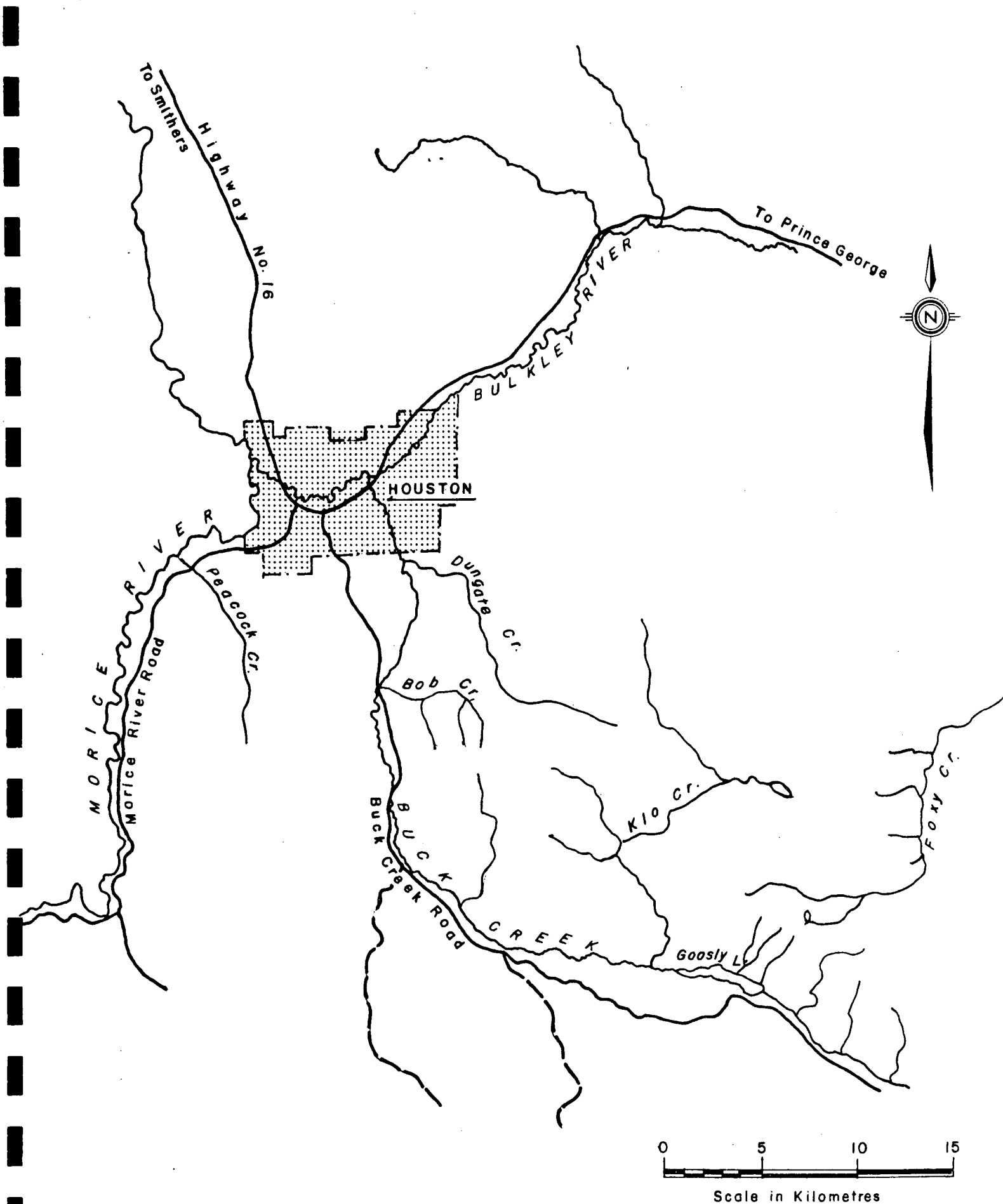
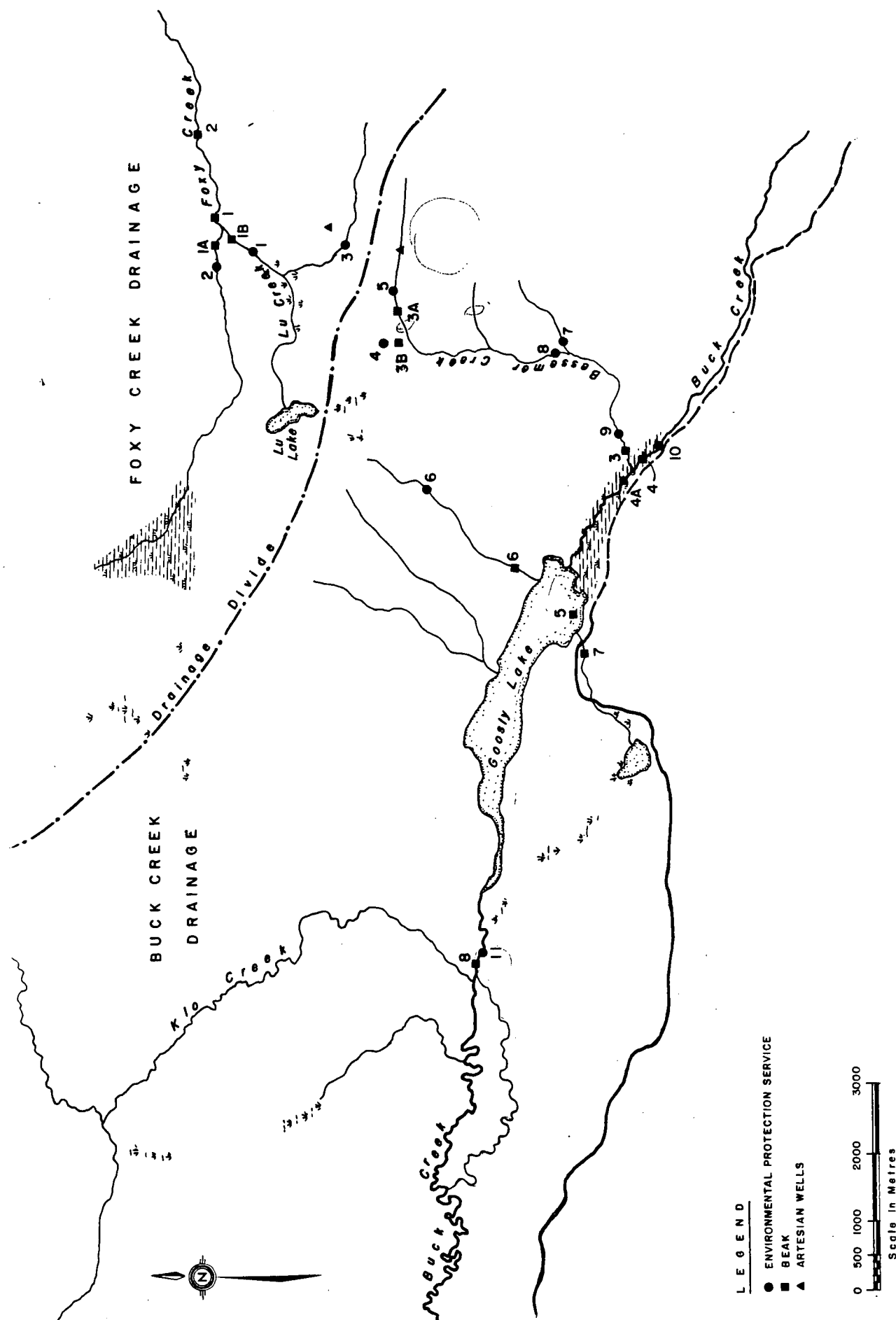


FIGURE 1 EQUITY MINE WATERSHED AREA



**FIGURE 2 PRE-OPERATIONAL WATER QUALITY MONITORING STATIONS**

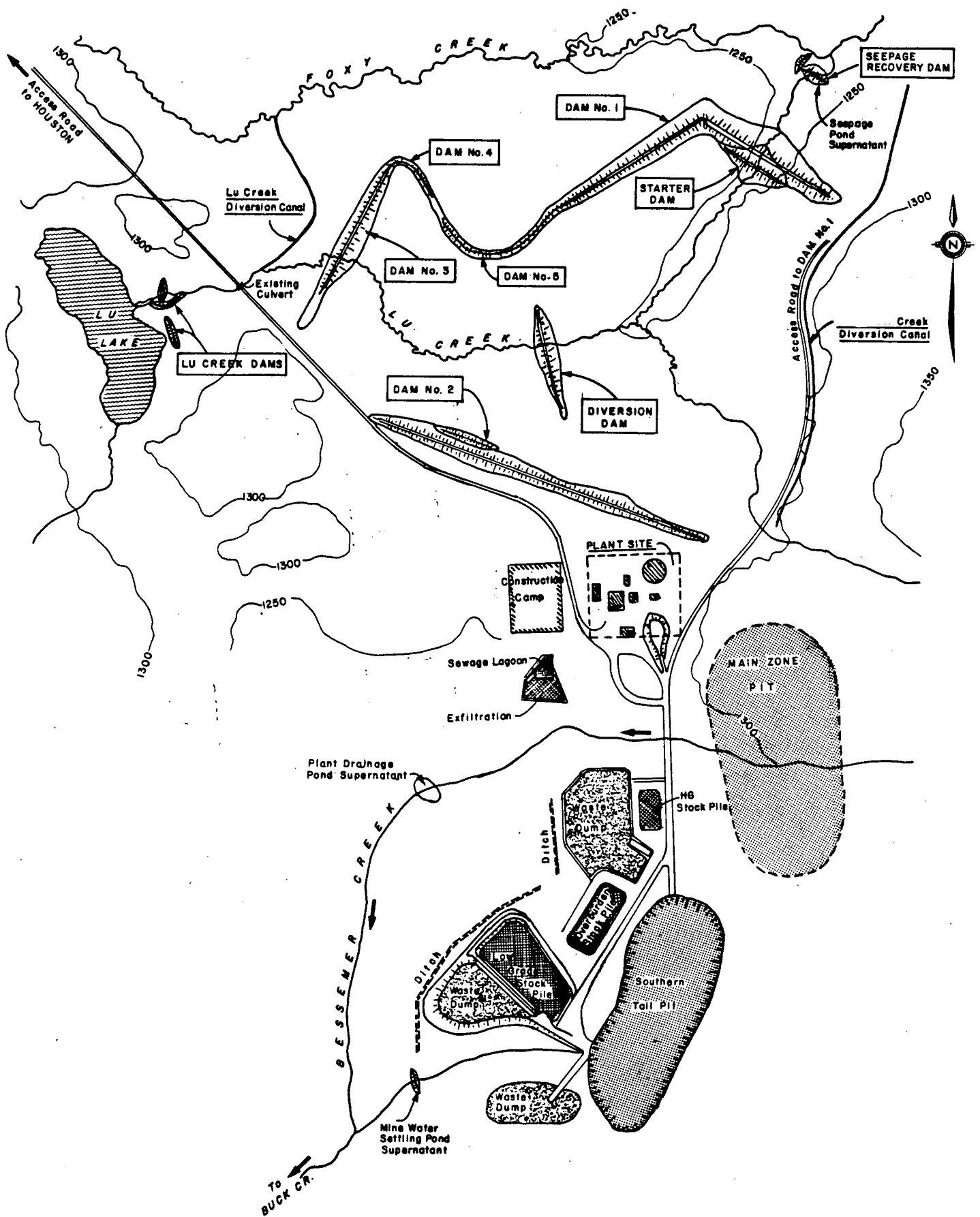


FIGURE 3 EQUITY MINE AND MILL DEVELOPMENT SITE

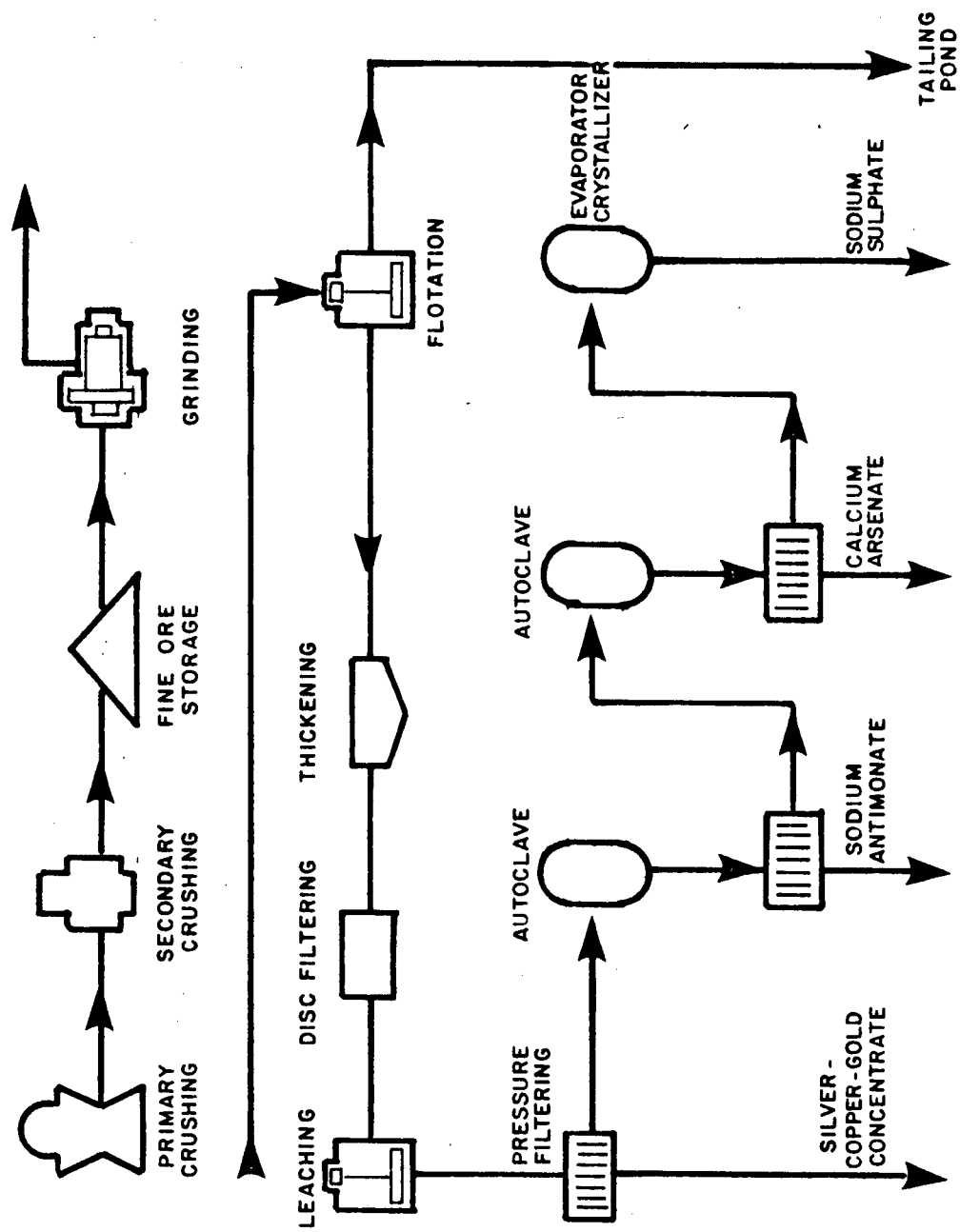


FIGURE 4 PROCESS FLOW SHEET FOR EQUITY SILVER MINE

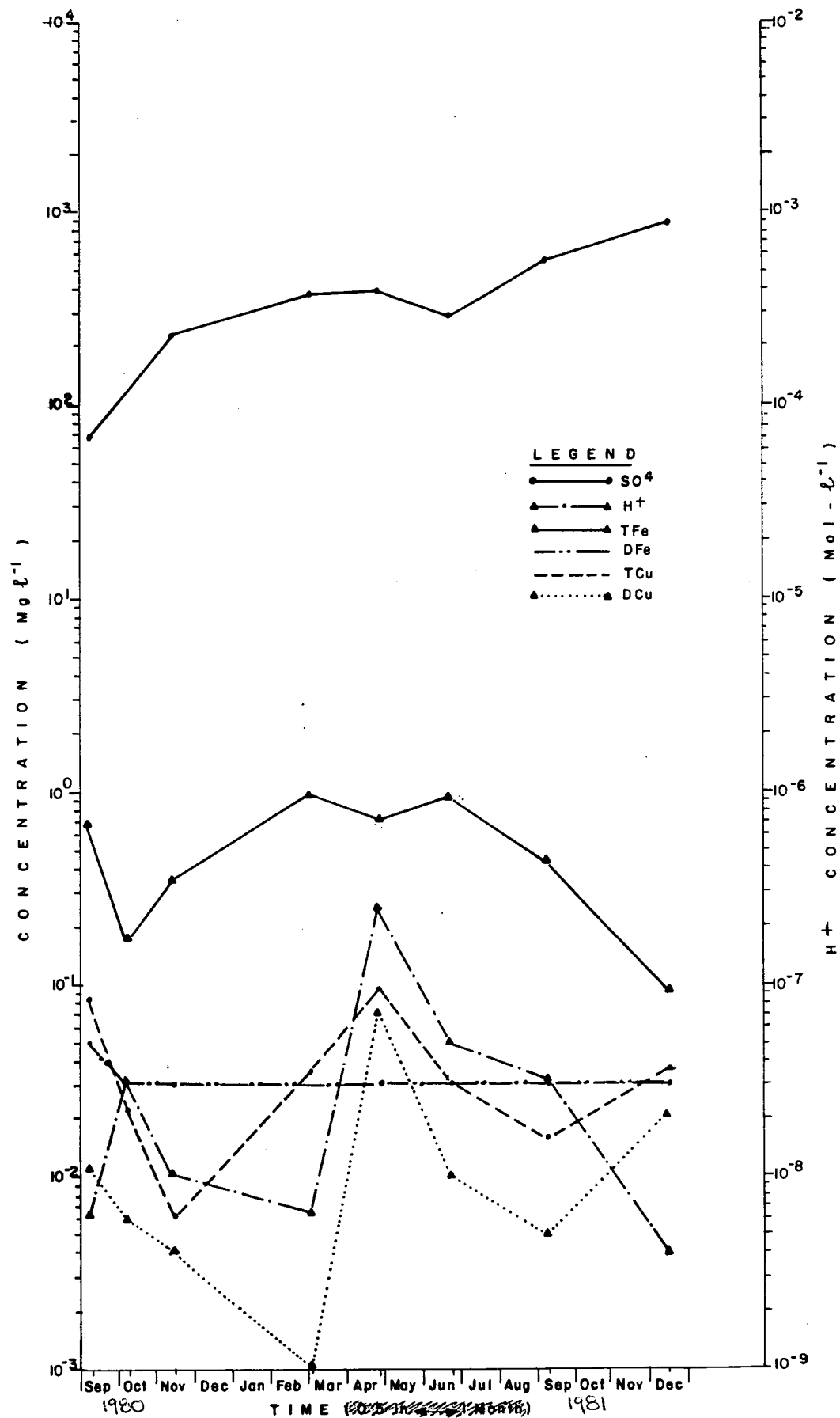


FIGURE 5 SITE I - IMPOUNDMENT-TAILINGS POND  
SUPERNATANT WMB 0400759

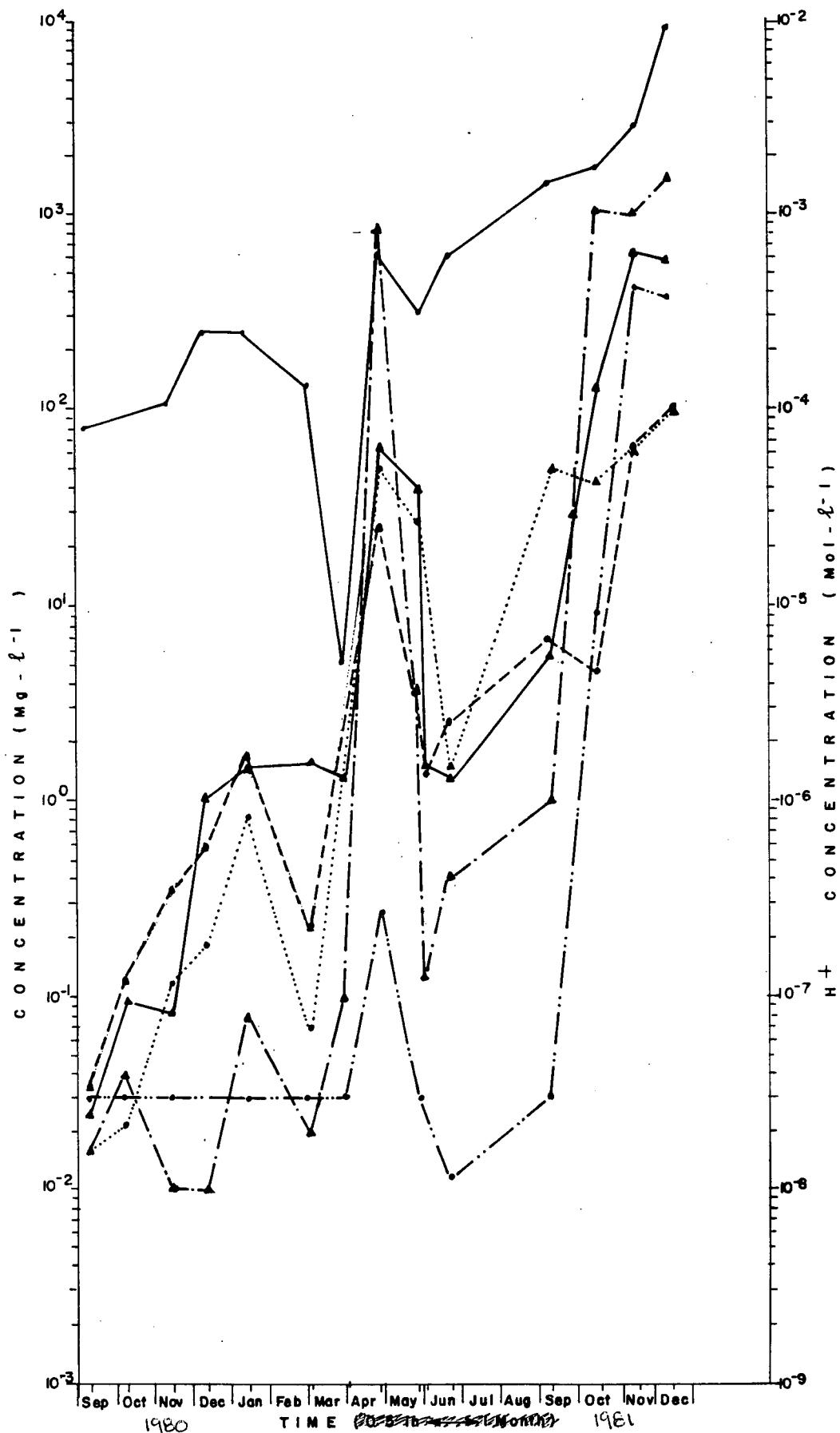


FIGURE 6 SITE 2 - TAILINGS SEEPAGE POND  
SUPERNATANT WMB 0400760



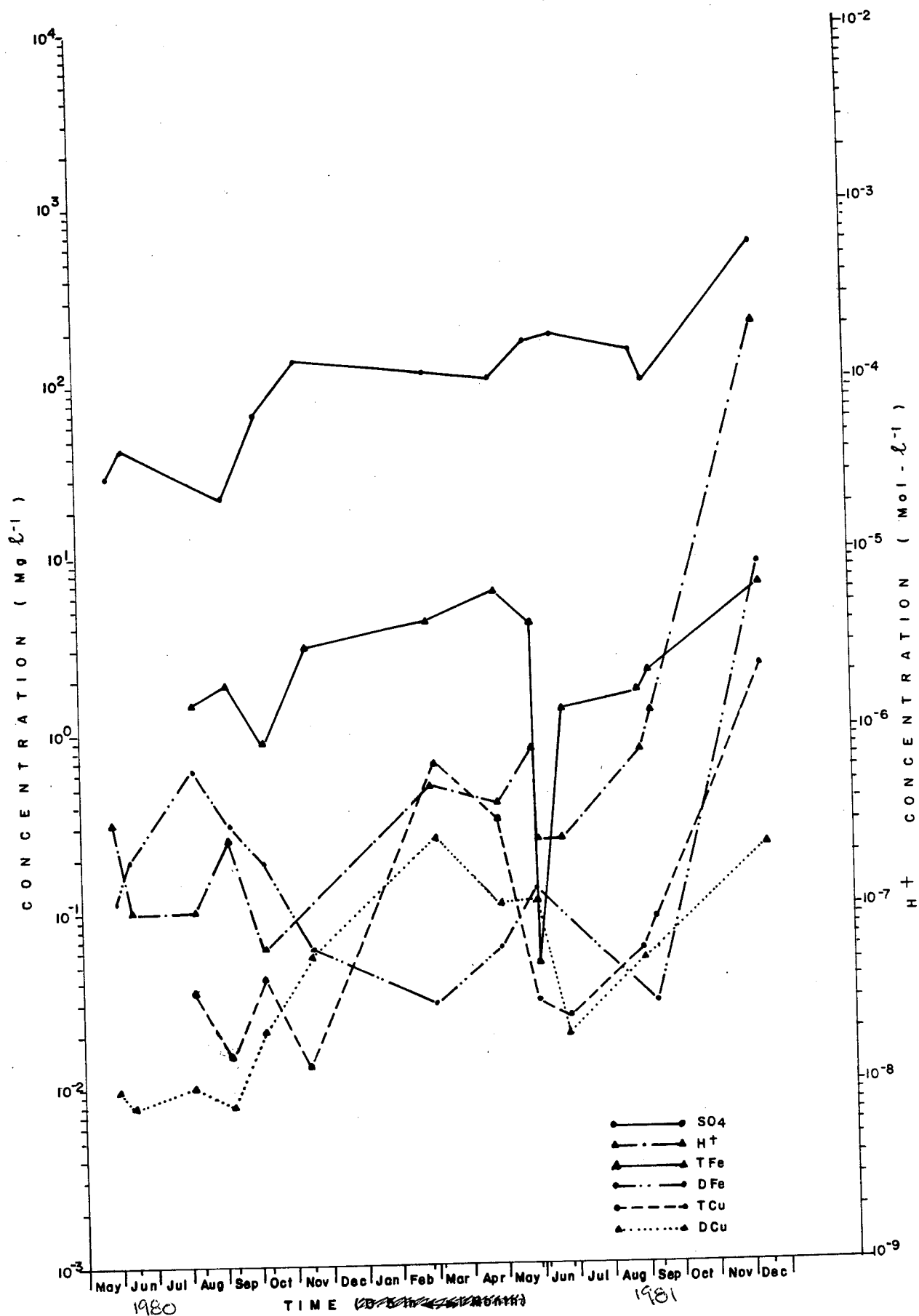
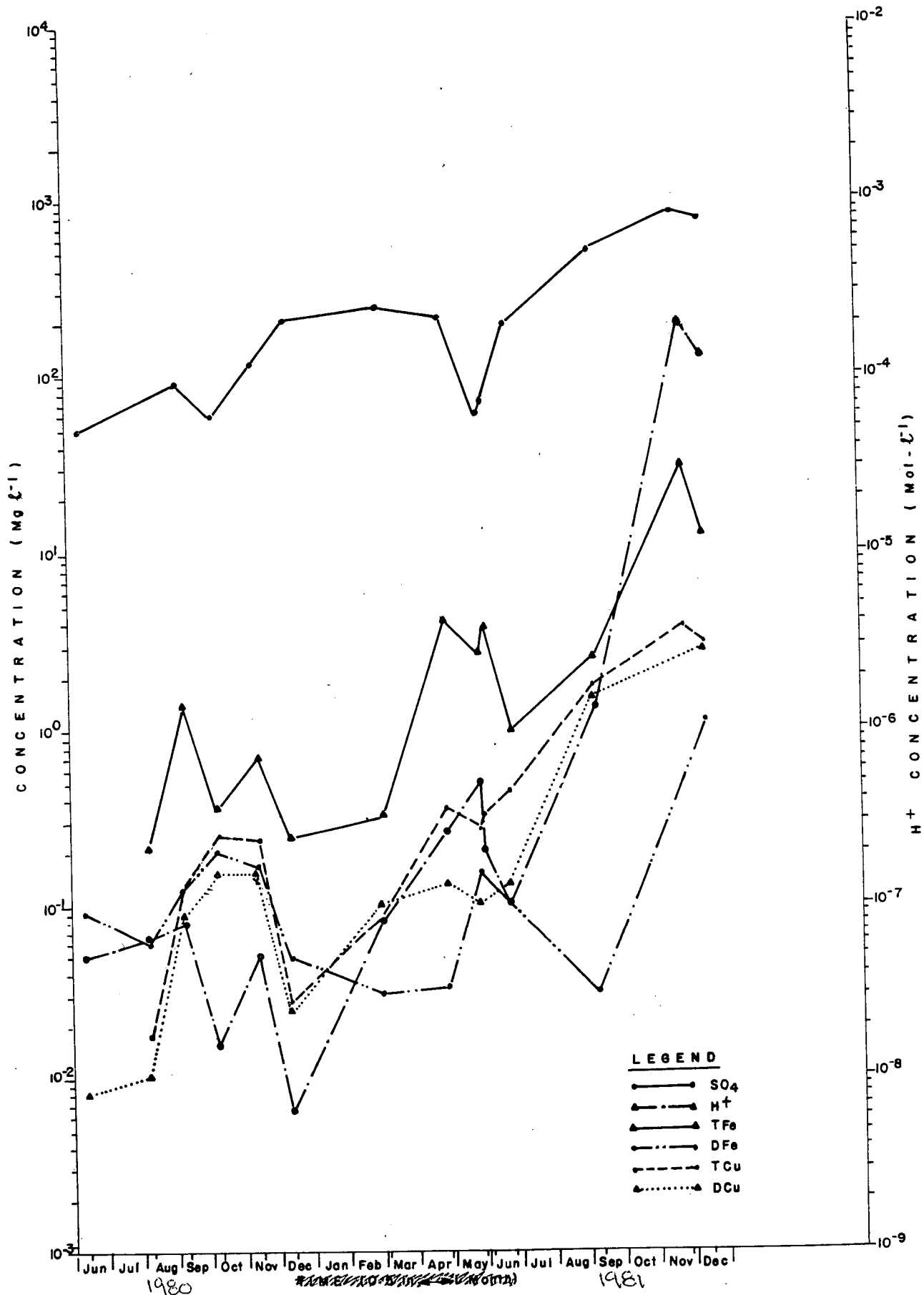


FIGURE 7 SITE 3 MINE WATER SETTLING POND  
SUPERNATANT WMB 0400761



**FIGURE 8 SITE 4 - STORMWATER PLANT DRAINAGE AND SUPERNATANT WMB 0400762**

TABLE 1: EQUITY SILVERMINE RESERVE COMPOSITION

ORE DEPOSIT	TOTAL (tonnes)	Ag (oz/t)	Au (oz/t)	Cu (%)	Sb (%)	STRIP RATIO	MINE LIFE (Yrs)
Main Zone	21.12 x 10 <sup>6</sup>	98.4	0.825	0.353	0.084	2.1:1	19 - 20
Southern Tail	6.8 x 10 <sup>6</sup>	131.0	1.38	0.48	0.087	2.3:1	4 - 5
Total	27.9 x 10 <sup>6</sup>	106.3	0.96	0.384	0.085	2.1:1	24

TABLE 2: PREOPERATIONAL WATER QUALITY SITES

AGENCY	SITE/REF. NO.	LOCATION
Beak	1	Foxy Creek at confluence with Lu Creek
"	1A/8966	Foxy Creek above confluence
"	1B/8965	Lu Creek upstream of confluence
"	2	Foxy Creek downstream of confluence
"	3/8963	Bessemer Creek near confluence with Buck Creek
"	3A/8967	Bessemer Creek upstream near pit site
"	3B/8968	Bessemer Creek upstream tributary
"	4	Buck Creek upstream of confluence with Bessemer Creek
"	4A/8964	Buck Creek downstream of confluence
"	5	Goosly Lake southeast
"	6	Goosly Lake tributary: "Burnt" Creek
"	7	Goosly Lake tributary: "Eagle" Creek
"	8	Buck Creek upstream of confluence with Klo Creek
"	53/8961 & 128/8962	Artesian wells, 1 each in Foxy and Buck systems
EPS	1	Lu Creek upstream of confluence with Foxy Creek
"	2	Foxy Creek upstream of confluence
"	3	Lu Creek: upstream easter tributary
"	4	Bessemer Creek: upstream tributary
"	5	Bessemer Creek: upstream
"	6	Goosly Lake tributary: "Burnt" Creek
"	7	Bessemer Creek: lower tributary
"	8	Bessemer Creek upstream of lower tributary
"	9	Bessemer Creek upstream of confluence with Buck Creek
"	10	Buck Creek upstream of confluence with Bessemer Creek
"	11	Buck Creek upstream of confluence with Klo Creek

TABLE 3: WMB PE4475 MONITERING SITES

SITE NO.	PERMIT SITE NO.	LOCATION
1	0400759	Impoundment - Tailings Pond Supernatant
2	0400760	Seepage Pond - Supernatant
3	0400761	Mine Water - Settling Pond Supernatant
4	0400762	Storm Water - Plant Drainage Pond Supernatant
5	0400763	Foxy Creek u/s Tailing Impoundment
6	0400764	Foxy Creek d/s Tailing Impoundment
7	0400765	Buck Creek u/s Drainage/Bessemer Creek
8	0400766	Buck Creek d/s Drainage/Bessemer Creek

TABLE 4: FEDERAL AND PROVINCIAL STANDARDS FOR EFFLUENT GRAB SAMPLES

PARAMETER		PROVINCIAL	FEDERAL STANDARDS
TSS	(mg/l)	50.0	50.0
Oil & Grease	(mg/l)	15.0	-
pH	(Rel U)	6.5-8.5	-
As	(mg/l)	0.05 D	1.0 T
Cu	(mg/l)	0.05 D	0.6 T
Fe	(mg/l)	0.30 D	-
Pb	(mg/l)	0.05 D	0.4 T
Ni	(mg/l)	-	1.0 T
Sb	(mg/l)	0.05 D	-
Zn	(mg/l)	0.05 D	1.0 T
Ra <sub>226</sub>	(pCi/l)	-	30.0

D: dissolved

T: total

(EPS, 1977; MOE, 1980)

TABLE 5: EPS PRE-OPERATIONAL MONITERING DATA

LOCATION:		LU CREEK			FOXY CREEK UPPER		
STN. NO:		1			2		
DATE:		14 Jul 73	13 Oct 73	26 Jul 74	14 Jul 73	13 Oct 73	26 Jul 74
TR	(mg/l $\pm$ 2.5)			109.0			42.0
FR	(mg/l $\pm$ 2.5)			109.0			42.0
NFR	(mg/l $\pm$ 2.5)			$\leq$ 2.5			< 2.5
Turb.	(FTU)			2.6			2.5
S.Cond	(um/cm)			160.0			73.0
T PO <sub>4</sub>	(mg/l $\pm$ .005)			0.023			0.019
T SO <sub>4</sub>	(mg/l $\pm$ .005)			--			< 5.0
NO <sub>2</sub>	(mg/l $\pm$ .005)			< 0.005			< 0.005
NO <sub>3</sub>	(mg/l $\pm$ .005)			< 0.01			< 0.01
T Cu	(mg/l)	0.01	< 0.03	0.01	< 0.01	< 0.03	0.02
T Pb	(mg/l)	$\leq$ 0.3	< 0.3	0.02	< 0.3	< 0.3	0.02
T Zn	(mg/l)	< 0.01	< 0.06	0.05	< 0.01	< 0.06	0.03
T Fe	(mg/l)	0.76	0.21	0.34	0.24	0.14	0.20
T Ni	(mg/l)	< 0.06	< 0.06		< 0.06	< 0.06	
T Mo	(mg/l)	$\leq$ 0.3	--		< 0.3	--	
T Cd	(mg/l)	0.03	--	$\leq$ 0.01	< 0.03	--	< 0.01
T Ca	(mg/l)	38.0	18.0		19.0	3.9	
T Mg	(mg/l)	5.1	3.50		6.0	1.50	
T Mn	(mg/l)	< 0.06	--		< 0.6	--	
T Cr	(mg/l)	< 0.01	--		< 0.01	--	
T Ag	(mg/l)	< 0.03	< 0.03		< 0.03	< 0.03	
T Sb	(mg/l)	< 0.3	< 0.3		< 0.3	< 0.3	
T Hg	(mg/l)	< 0.8	< 0.8		< 0.8	< 0.8	
T As	(mg/l)						
D Cu	(mg/l)			$\leq$ 0.01			< 0.01
D Pb	(mg/l)			< 0.02			< 0.02
D Zn	(mg/l)			< 0.01			< 0.01
D Fe	(mg/l)			0.15			0.09
D Mo	(mg/l)			< 0.3			< 0.3
D Cd	(mg/l)			< 0.01			< 0.01
D Cr	(mg/l)			< 0.02			< 0.02

Continued...

TABLE 5: EPS PRE-OPERATIONAL MONITERING DATA  
(Continued)

LOCATION:		LU CREEK TRIBUTARY			BESSEMER CREEK UPPER		
STN. NO:		3			4		
DATE:		14 Jul 73	13 Oct 73	26 Jul 74	14 Jul 73	13 Oct 73	26 Jul 74
TR	(mg/l $\pm$ 2.5)			168.0			481.0
FR	(mg/l $\pm$ 2.5)			168.0			481.0
NFR	(mg/l $\pm$ 2.5)			< 2.5			< 2.5
Turb.	(FTU)			4.4			15.0
S.Cond	(um/cm)			280.0			55.0
T PO <sub>4</sub>	(mg/l $\pm$ .005)			0.013			0.015
T SO <sub>4</sub>	(mg/l $\pm$ .005)			91.0			< 5.0
NO <sub>2</sub>	(mg/l $\pm$ .005)			< 0.005			< 0.005
NO <sub>3</sub>	(mg/l $\pm$ .005)			< 0.01			< 0.01
T Cu	(mg/l)	< 0.01	< 0.03	0.05	0.01	0.55	0.08
T Pb	(mg/l)	< 0.3	< 0.03	< 0.02	< 0.3	< 0.3	0.02
T Zn	(mg/l)	0.03	0.07	0.04	< 0.01	0.77	0.07
T Fe	(mg/l)	0.92	2.50	0.18	0.52	57.0	0.31
T Ni	(mg/l)	< 0.06	< 0.06		< 0.06	< 0.01	
T Mo	(mg/l)	< 0.3	--		< 0.3	--	
T Cd	(mg/l)	< 0.03	--	< 0.01	< 0.3	--	< 0.01
T Ca	(mg/l)	3.8	51.0		3.2	10.0	
T Mg	(mg/l)	3.1	4.8		2.3	4.40	
T Mn	(mg/l)	< 0.06	--		< 0.06	--	
T Cr	(mg/l)	< 0.01	--		< 0.01	--	
T Ag	(mg/l)	< 0.03	< 0.03		< 0.03	< 0.03	
T Sb	(mg/l)	< 0.3	< 0.3		< 0.3	< 0.3	
T Hg	(mg/l)	< 0.8	< 0.8		< 0.8	< 0.8	
T As	(mg/l)						
D Cu	(mg/l)			0.01			< 0.01
D Pb	(mg/l)			< 0.02			< 0.02
D Zn	(mg/l)			< 0.01			< 0.01
D Fe	(mg/l)			< 0.03			0.14
D Mo	(mg/l)			< 0.3			< 0.3
D Cd	(mg/l)			< 0.01			< 0.01
D Cr	(mg/l)			< 0.02			< 0.02

Continued...



TABLE 5: EPS PRE-OPERATIONAL MONITERING DATA  
(Continued)

LOCATION: STN. NO: DATE:	BESSEMER CREEK UPPER			"BURNT" CREEK		
	5			6		
	14 Jul 73	13 Oct 73	26 Jul 74	14 Jul 73	13 oct 73	26 Jul 74
TR (mg/l $\pm$ 2.5)			188.0			66.0
FR (mg/l $\pm$ 2.5)			183.0			66.0
NFR (mg/l $\pm$ 2.5)			5.0			< 2.5
Turb. (FTU)			2.2			3.4
S.Cond (um/cm)			280.0			88.0
T PO <sub>4</sub> (mg/l $\pm$ .005)			0.52			0.015
T SO <sub>4</sub> (mg/l $\pm$ .005)			10.0			< 5.0
NO <sub>2</sub> (mg/l $\pm$ .005)			< 0.005			< 0.005
NO <sub>3</sub> (mg/l $\pm$ .005)			< 0.01			< 0.01
T Cu (mg/l)	0.01	0.04	0.04	< 0.01	< 0.03	0.03
T Pb (mg/l)	< 0.3	< 0.3	0.02	< 0.3	< 0.3	0.02
T Zn (mg/l)	< 0.01	0.07	0.08	< 0.01	< 0.06	0.02
T Fe (mg/l)	0.40	2.90	1.6	0.62	0.11	0.23
T Ni (mg/l)	< 0.06	< 0.06		< 0.06	< 0.06	
T Mo (mg/l)	< 0.3	—		< 0.3	—	
T Cd (mg/l)	< 0.03	—	< 0.01	< 0.03	—	< 0.01
T Ca (mg/l)	28.0	31.0		9.8	10.0	
T Mg (mg/l)	7.9	6.50		6.0	3.20	
T Mn (mg/l)	< 0.06	—		< 0.06	—	
T Cr (mg/l)	< 0.02	—		< 0.01	—	
T Ag (mg/l)	< 0.03	< 0.03		< 0.03	< 0.03	
T Sb (mg/l)	< 0.3	< 0.3		< 0.3	< 0.3	
T Hg (mg/l)	< 0.8	< 0.8		< 0.8	< 0.8	
T As (mg/l)						
D Cu (mg/l)			0.01			< 0.01
D Pb (mg/l)			< 0.02			< 0.02
D Zn (mg/l)			0.03			< 0.01
D Fe (mg/l)			0.43			< 0.03
D Mo (mg/l)			< 0.3			< 0.3
D Cd (mg/l)			< 0.01			< 0.01
D Cr (mg/l)			< 0.02			< 0.02

Continued...

TABLE 5: EPS PRE-OPERATIONAL MONITORING DATA  
(Continued)

LOCATION:	BESSEMER CREEK LOWER TRIBUTARY			BESSEMER CREEK		
STN. NO:	7			8		
DATE:	14 Jul 73	13 Oct 73	26 Jul 74	14 Jul 73	13 Oct 73	26 Jul 74
TR (mg/l $\pm$ 2.5)			63.0			135.0
FR (mg/l $\pm$ 2.5)			63.0			135.0
NFR (mg/l $\pm$ 2.5)			< 2.5			< 2.5
Turb. (FTU)			1.8			9.1
S.Cond (um/cm)			110.0			200.0
T PO <sub>4</sub> (mg/l $\pm$ .005)			0.029			0.020
T SO <sub>4</sub> (mg/l $\pm$ .005)			13.0			52.0
NO <sub>2</sub> (mg/l $\pm$ .005)			< 0.005			< 0.005
NO <sub>3</sub> (mg/l $\pm$ .005)			< 0.01			< 0.01
T Cu (mg/l)	0.01	< 0.03	0.03	0.02	< 0.03	0.07
T Pb (mg/l)	< 0.3	< 0.3	0.04	< 0.3	< 0.3	< 0.02
T Zn (mg/l)	< 0.01	0.05	0.01	0.02	< 0.06	0.05
T Fe (mg/l)	0.36	0.11	1.3	—	1.30	0.76
T Ni (mg/l)	< 0.06	< 0.06		< 0.06	< 0.06	
T Mo (mg/l)	< 0.3	—		< 0.3	—	
T Cd (mg/l)	< 0.03	—	< 0.01	< 0.03	—	< 0.01
T Ca (mg/l)	17.0	24.0		8.1	12.0	
T Mg (mg/l)	7.7	6.30		3.6	3.8	
T Mn (mg/l)	< 0.06	—		< 0.06	—	
T Cr (mg/l)	< 0.01	—		< 0.01	—	
T Ag (mg/l)	< 0.03	< 0.03		< 0.03	< 0.03	
T Sb (mg/l)	< 0.3	< 0.3		< 0.3	< 0.3	
T Hg (mg/l)	< 0.8	< 0.8		< 0.8	< 0.8	
T As (mg/l)						
D Cu (mg/l)			0.02			0.02
D Pb (mg/l)			< 0.02			< 0.02
D Zn (mg/l)			< 0.01			< 0.01
D Fe (mg/l)			0.37			0.05
D Mo (mg/l)			< 0.3			< 0.3
D Cd (mg/l)			< 0.01			0.02
D Cr (mg/l)			< 0.02			< 0.02

Continued...

TABLE 5: EPS PRE-OPERATIONAL MONITERING DATA  
(Continued)

LOCATION:		BESSEMER CREEK LOWER			BUCK CREEK UPPER (above Bessemer)		
STN. NO:		9			10		
DATE:		14 Jul 73	13 Oct 73	26 Jul 74	14 Jul 73	13 Oct 73	26 Jul 74
TR	(mg/l $\pm$ 2.5)			121.0			95.0
FR	(mg/l $\pm$ 2.5)			121.0			95.0
NFR	(mg/l $\pm$ 2.5)			< 2.5			< 2.5
Turb.	(FTU)			9.5			4.2
S.Cond	(um/cm)			170.0			130.0
T PO <sub>4</sub>	(mg/l $\pm$ .005)			0.017			0.027
T SO <sub>4</sub>	(mg/l $\pm$ .005)			43.0			10.0
NO <sub>2</sub>	(mg/l $\pm$ .005)			< 0.005			< 0.005
NO <sub>3</sub>	(mg/l $\pm$ .005)			< 0.01			< 0.01
T Cu	(mg/l)	0.04	< 0.03	0.02	0.01	< 0.03	0.03
T Pb	(mg/l)	< 0.3	< 0.3	< 0.02	< 0.3	< 0.3	0.03
T Zn	(mg/l)	< 0.01	< 0.06	0.02	< 0.01	< 0.06	0.04
T Fe	(mg/l)	0.33	.47	0.80	0.96	0.89	0.87
T Ni	(mg/l)	< 0.06	< 0.06		< 0.06	< 0.06	
T Mo	(mg/l)	< 0.3	--		< 0.3	--	
T Cd	(mg/l)	< 0.03	--	< 0.01	< 0.03	--	< 0.01
T Ca	(mg/l)	15.0	22.0		12.0	13.0	
T Mg	(mg/l)	7.4	6.5		8.2	5.0	
T Mn	(mg/l)	< 0.06	--		< 0.06	--	
T Cr	(mg/l)	< 0.01	--		< 0.01	--	
T Ag	(mg/l)	< 0.03	< 0.03		< 0.03	< 0.03	
T Sb	(mg/l)	< 0.3	< 0.3		< 0.3	< 0.3	
T Hg	(mg/l)	< 0.8	< 0.8		< 0.8	< 0.8	
T As	(mg/l)						
D Cu	(mg/l)			< 0.01			0.01
D Pb	(mg/l)			< 0.02			< 0.02
D Zn	(mg/l)			< 0.01			< 0.01
D Fe	(mg/l)			0.16			0.44
D Mo	(mg/l)			< 0.3			< 0.3
D Cd	(mg/l)			< 0.01			< 0.01
D Cr	(mg/l)			< 0.02			< 0.02

Continued...

TABLE 5: EPS PRE-OPERATIONAL MONITERING DATA  
(Continued)

LOCATION:		LOWER BUCK CREEK (near K1o Creek)		
STN. NO:		11		
DATE:		14 Jul 73	13 Oct 73	26 Jul 74
TR	(mg/l $\pm$ 2.5)			69.0
FR	(mg/l $\pm$ 2.5)			69.0
NFR	(mg/l $\pm$ 2.5)			< 2.5
Turb.	(FTU)			3.5
S.Cond	(um/cm)			82.0
T PO <sub>4</sub>	(mg/l $\pm$ .005)			< 0.01
T SO <sub>4</sub>	(mg/l $\pm$ .005)			< 5.0
NO <sub>2</sub>	(mg/l $\pm$ .005)			< 0.005
NO <sub>3</sub>	(mg/l $\pm$ .005)			< 0.01
T Cu	(mg/l)	< 0.01	<0.03	0.02
T Pb	(mg/l)	< 0.3	<0.3	0.02
T Zn	(mg/l)	< 0.01	<0.06	0.02
T Fe	(mg/l)	0.61	0.30	0.50
T Ni	(mg/l)	< 0.06	<0.06	
T Mo	(mg/l)	< 0.3	--	
T Cd	(mg/l)	< 0.03	--	< 0.01
T Ca	(mg/l)	8.6	8.3	
T Mg	(mg/l)	7.1	3.40	
T Mn	(mg/l)	< 0.06	--	
T Cr	(mg/l)	< 0.01	--	
T Ag	(mg/l)	< 0.03	<0.03	
T Sb	(mg/l)	< 0.3	<0.3	
T Hg	(mg/l)	< 0.8	<0.8	
T As	(mg/l)			
D Cu	(mg/l)			< 0.01
D Pb	(mg/l)			< 0.02
D Zn	(mg/l)			< 0.01
D Fe	(mg/l)			0.17
D Mo	(mg/l)			< 0.3
D Cd	(mg/l)			< 0.01
D Cr	(mg/l)			< 0.02

TABLE 6: BEAK PRE-OPERATIONAL MONITERING DATA

LOCATION: REFERENCE NO: <sup>1</sup> DATE:	FOXY CREEK CONFLUENCE		FOXY CREEK UPPER
	1		1A - 8966
	25-26 Jul 73	10-11 Oct 73	14 May 76
pH (rel U)	6.8	7.0	7.1
FR (mg/l)	56.0	106.0	59.0
NFR (mg/l)	8.0	2.0	1.0
TR (mg/l)	64.0	108.0	59.0
Temp. (°C)	7.8	0.0	
D.O. (mg/l)	10.2	11.9	
Turb. (FTU)	1.0	1.0	1.0
Flow (cfs)	13	12	
CN (mg/l)	< 0.005	< 0.005	
T Sb (mg/l)			< 0.05
T As (mg/l)			< 0.005
T Cu (mg/l)			< 0.005
T Fe (mg/l)			0.12
T Pb (mg/l)			< 0.020
T Ag (mg/l)			< 0.010
T Zn (mg/l)			0.005
D Sb (mg/l)	< 0.025	< 0.025	
D As (mg/l)	< 0.01	< 0.01	
D Cu (mg/l)	0.009	0.014	
D Fe (mg/l)	0.08	0.10	
D Pb (mg/l)	< 0.025	< 0.025	
D Ag (mg/l)	< 0.01	< 0.01	
D Zn (mg/l)	< 0.005	< 0.005	
D Hg (mg/l)	< 0.001	< 0.001	
D F (mg/l)	< 0.1	0.2	

<sup>1</sup> Beak Consultants Ltd., 1976

Continued...

TABLE 6: BEAK PRE-OPERATIONAL MONITERING DATA  
(Continued)

LOCATION: REFERENCE NO: <sup>1</sup>	LU CREEK	FOXY CREEK LOWER	
	1B - 8965	2	
DATE:	14 May 76	25-26 Jul 73	10-11 Oct 73
pH (rel U)	7.4	7.0	7.0
FR (mg/l)	97.0	57.0	92.0
NFR (mg/l)	4.0	8.0	5.0
TR (mg/l)	101.0	65.0	92.0
Temp. (°C)		13.0	3.8
D.O. (mg/l)		9.2	11.1
Turb. (FTU)	2.7	2.0	1.0
Flow (cfs)		11.0	20.0
CN (mg/l)		< 0.005	< 0.005
T Sb (mg/l)	< 0.05		
T As (mg/l)	< 0.005		
T Cu (mg/l)	< 0.005		
T Fe (mg/l)	0.21		
T Pb (mg/l)	< 0.020		
T Ag (mg/l)	< 0.010		
T Zn (mg/l)	< 0.008		
D Sb (mg/l)		< 0.025	< 0.025
D As (mg/l)		< 0.01	< 0.01
D Cu (mg/l)		0.011	< 0.005
D Fe (mg/l)		0.08	0.10
D Pb (mg/l)		< 0.025	< 0.025
D Ag (mg/l)		< 0.01	< 0.01
D Zn (mg/l)		< 0.005	< 0.005
D Hg (mg/l)		< 0.001	< 0.001
D F (mg/l)		0.1	0.2

<sup>1</sup> Beak Consultants Ltd., 1976

Continued...

TABLE 6: BEAK PRE-OPERATIONAL MONITORING DATA  
(Continued)

LOCATION:		BESSEMER CREEK LOWER			BESSEMER CR. UPPER	BESSEMER CR. UPPER
REFERENCE NO: <sup>1</sup>		3-8963			3A-8967	3B-8968
DATE:		25-26 Jul 73	10-11 Oct 73	14 May 76	14 May 1976	14 May 76
pH	(rel U)	7.0	7.0	7.1	7.1	6.7
FR	(mg/l)	104.0	189.0	82.0	96.0	77.0
NFR	(mg/l)	7.0	32.0	21.0	3.0	1.0
TR	(mg/l)	111.0	221.0	103.0	99.0	78.0
Temp.	(°C)	11.0	2.8			
D.O.	(mg/l)	10.2	12.1			
Turb.	(FTU)	14.0	3.4	22.0	3.4	1.4
Flow	(cfs)	1.0	1.0			
CN	(mg/l)	< 0.005	< 0.005			
T Sb	(mg/l)			< 0.05	< 0.05	< 0.05
T As	(mg/l)			< 0.005	< 0.005	< 0.005
T Cu	(mg/l)			0.017	0.014	< 0.005
T Fe	(mg/l)			1.8	0.41	0.32
T Pb	(mg/l)			< 0.020	< 0.020	< 0.020
T Ag	(mg/l)			< 0.010	< 0.010	< 0.010
T Zn	(mg/l)			0.017	0.019	0.005
D Sb	(mg/l)	< 0.025	< 0.025			
D As	(mg/l)	< 0.01	< 0.01			
D Cu	(mg/l)	0.009	0.014			
D Fe	(mg/l)	0.09	0.06			
D Pb	(mg/l)	< 0.025	< 0.025			
D Ag	(mg/l)	< 0.01	< 0.01			
D Zn	(mg/l)	< 0.005	< 0.005			
D Hg	(mg/l)	< 0.001	< 0.0001			
D F	(mg/l)	0.2	0.2			

<sup>1</sup> Beak Consultants Ltd., 1976

Continued...

TABLE 6: BEAK PRE-OPERATIONAL MONITERING DATA  
(Continued)

LOCATION:		BUCK CREEK UPPER		BUCK OR BELOW CONFLUENCE
REFERENCE NO: <sup>1</sup>		4		4A-8964
DATE:		25-26 Jul 73	10-11 Oct 73	14 May 76
pH	(rel U)	7.0	7.1	7.2
FR	(mg/l)	60.0	110.0	86.0
NFR	(mg/l)	6.0	6.0	14.0
TR	(mg/l)	66.0	116.0	100.0
Temp.	(°C)	10.5	2.2	
D.O.	(mg/l)	9.4	10.7	
Turb.	(FTU)	3.0	3.0	13.0
Flow	(cfs)	5.0	5.0	
CN	(mg/l)	< 0.005	< 0.005	
T Sb	(mg/l)			< 0.05
T As	(mg/l)			
T Cu	(mg/l)			0.009
T Fe	(mg/l)			1.0
T Pb	(mg/l)			< 0.020
T Ag	(mg/l)			< 0.010
T Zn	(mg/l)			0.005
D Sb	(mg/l)	< 0.025	< 0.025	
D As	(mg/l)	< 0.01	< 0.01	
D Cu	(mg/l)	< 0.005	< 0.005	
D Fe	(mg/l)	0.49	0.54	
D Pb	(mg/l)	< 0.025	< 0.025	
D Ag	(mg/l)	< 0.01	< 0.01	
D Zn	(mg/l)	< 0.005	< 0.005	
D Hg	(mg/l)	< 0.0001	< 0.0001	
D F	(mg/l)	0.2	0.2	

<sup>1</sup> Beak Consultants Ltd., 1976

Continued...



TABLE 6: BEAK PRE-OPERATIONAL MONITERING DATA  
(Continued)

LOCATION: REFERENCE NO: <sup>1</sup> DATE:	GOOSLY LAKE		"BURNT" CREEK	
	5		6	
	25-26 Jul 73	10-11 Oct 73	25-26 Jul 73	10-11 Oct 73
pH (rel U)	6.8	7.1	6.9	7.2
FR (mg/l)	48.0	90.0	92.0	98.0
NFR (mg/l)	11.0	10.0	4.0	6.0
TR (mg/l)	59.0	100.0	96.0	104.0
Temp. (°C)	16.0	7.2	9.5	3.0
D.O. (mg/l)	8.3	7.8	10.4	10.8
Turb. (FTU)	2.0	1.0	2.0	1.0
Flow (cfs)	--	--	< 0.2	< 0.2
CN (mg/l)	< 0.005	< 0.005	< 0.005	< 0.005
T Sb (mg/l)				
T As (mg/l)				
T Cu (mg/l)				
T Fe (mg/l)				
T Pb (mg/l)				
T Ag (mg/l)				
T Zn (mg/l)				
D Sb (mg/l)	< 0.025	< 0.025	< 0.025	< 0.025
D As (mg/l)	< 0.01	< 0.01	< 0.01	< 0.01
D Cu (mg/l)	< 0.005	< 0.005	< 0.005	< 0.005
D Fe (mg/l)	0.18	0.22	0.18	0.02
D Pb (mg/l)	< 0.025	< 0.025	< 0.025	< 0.025
D Ag (mg/l)	< 0.01	< 0.01	< 0.01	< 0.01
D Zn (mg/l)	< 0.005	< 0.005	< 0.005	< 0.005
D Hg (mg/l)	< 0.0001	< 0.0001	< 0.0001	< 0.0001
D F (mg/l)	0.2	0.2	0.1	0.2

<sup>1</sup> Beak Consultants Ltd., 1976

Continued...

TABLE 6: BEAK PRE-OPERATIONAL MONITERING DATA  
(Continued)

LOCATION:		"EAGLE" CREEK		BUCK CREEK LOWER (near K1o Cr	
REFERENCE NO: <sup>1</sup>		7		6	
DATE:		25-26 Jul 73	10-11 Oct 73	25-26 Jul 73	10-11 Oct 73
pH	(rel U)	6.9	7.2	6.9	7.0
FR	(mg/l)	80.0	115.0	88.0	90.0
NFR	(mg/l)	6.0	6.0	7.0	4.0
TR	(mg/l)	86.0	121.0	95.0	94.0
Temp.	(°C)	8.8	1.6	12.5	4.5
D.O.	(mg/l)	9.2	11.1	9.0	10.4
Turb.	(FTU)	3.0	4.5	1.0	1.0
Flow	(cfs)	< 0.2	< 0.2	16.2	2.5
CN	(mg/l)	< 0.005	< 0.005	< 0.005	< 0.005
T Sb	(mg/l)				
T As	(mg/l)				
T Cu	(mg/l)				
T Fe	(mg/l)				
T Pb	(mg/l)				
T Ag	(mg/l)				
T Zn	(mg/l)				
D Sb	(mg/l)	< 0.025	< 0.025	< 0.025	< 0.025
D As	(mg/l)	< 0.01	< 0.01	< 0.01	< 0.01
D Cu	(mg/l)	< 0.005	< 0.005	< 0.005	< 0.005
D Fe	(mg/l)	0.22	0.34	0.09	0.22
D Pb	(mg/l)	< 0.025	< 0.025	< 0.025	< 0.025
D Ag	(mg/l)	< 0.01	< 0.01	< 0.01	< 0.01
D Zn	(mg/l)	< 0.005	< 0.005	< 0.005	< 0.005
D Hg	(mg/l)	< 0.0001	< 0.0001	< 0.0001	< 0.0001
D F	(mg/l)	0.2	0.2	< 0.1	0.2

<sup>1</sup> Beak Consultants Ltd., 1976

<sup>2</sup> Location changed for fall sampling to upstream K1o Cr.

Continued...

TABLE 6: BEAK PRE-OPERATIONAL MONITERING DATA  
(Continued)

LOCATION:		ARTESIAN #53	ARTESIAN #128
REFERENCE NO: <sup>1</sup>		8961	8962
DATE:		14 May 76	14 May 1976
pH	(rel U)	7.4	6.3
FR	(mg/l)	1660.0	994.0
NFR	(mg/l)	6.0	6.0
TR	(mg/l)	1660.0	1000.0
Temp.	(°C)		
D.O.	(mg/l)		
Turb.	(FTU)	20.0	13.0
Flow	(cfs)		
CN	(mg/l)		
T Sb	(mg/l)	< 0.05	< 0.05
T As	(mg/l)	< 0.005	0.043
T Cu	(mg/l)	< 0.005	< 0.005
T Fe	(mg/l)	1.5	15.0
T Pb	(mg/l)	< 0.020	< 0.020
T Ag	(mg/l)	< 0.010	< 0.010
T Zn	(mg/l)	< 0.005	0.42
D Sb	(mg/l)		
D As	(mg/l)		
D Cu	(mg/l)		
D Fe	(mg/l)		
D Pb	(mg/l)		
D Ag	(mg/l)		
D Zn	(mg/l)		
D Hg	(mg/l)		
D F	(mg/l)		

<sup>1</sup> Beak Consultants Ltd., 1976

TABLE 7: WMB MONITORING PRE AND POST PRODUCTION

1) Impoundment - Tailings pond Supernatant - 0400759

PARAMETER	10 Sept. 1980	08 Oct. 1980	14 Nov. 1980	03 Mar. 1981
Oil & Grease (mg/l)	3.0	< 2.0	< 2.0	< 2.0
[H <sup>+</sup> ] (mol/l)	$6.31 \times 10^{-9}$	$3.16 \times 10^{-8}$	$1.0 \times 10^{-8}$	$6.31 \times 10^{-9}$
pH (rel U)	8.2	7.5	8.0	8.2
NFR (mg/l)	46.0	72.0	3.5	27.5
Sulphate (mg/l)	66.5	--	227.0	379.0
S.Cond. (us/cm)	--	--	--	--
T As (mg/l)	0.24	0.10	0.030	0.20
T Cu (mg/l)	0.084	0.024	0.006	0.035
T Fe (mg/l)	0.67	0.17	0.35	0.95
T Pb (mg/l)	0.038	0.008	0.002	0.006
T Zn (mg/l)	0.052	0.017	0.008	0.027
T Sb (mg/l)	0.37	1.26	0.79	0.29
T Ni (mg/l)	--	--	--	--
T Hg (mg/l)	0.0002	0.0002	0.0002	0.00005
D As (mg/l)	0.014	0.041	0.028	0.032
D Cu (mg/l)	0.011	0.006	0.004	0.001
D Fe (mg/l)	< 0.05	< 0.03	< 0.03	< 0.03
D Pb (mg/l)	< 0.001	< 0.001	< 0.001	< 0.001
D Zn (mg/l)	< 0.015	0.015	< 0.005	0.016
D Sb (mg/l)	0.34	0.74	0.78	0.028

NB x : Values for T Hg on "Equis" Printout, questionable reliability. Orders of magnitude overall (between Hg values on Equis Printout and Raw Data sheets from PCB) differ by up to  $10^5$ .

TABLE 7: WMB MONITORING PRE AND POST PRODUCTION

1) Impoundment - Tailings pond Supernatant - 0400759  
(Continued)

PARAMETER	28 Apr. 1980	23 June 1980	10 Sept. 1980	15 Dec. 1981
Oil & Grease (mg/l)	5.0	< 2.0	--	< 2.0
[H+] (mol/l)	$2.51 \times 10^{-7}$	$5.01 \times 10^{-8}$	$3.16 \times 10^{-8}$	$3.98 \times 10^{-9}$
pH (rel U)	6.6	7.3	7.5	8.4
NFR (mg/l)	25.5	14.0	28.0	21.5
Sulphate (mg/l)	378.0	286.0	530.0	850.0
S.Cond. (us/cm)	--	--	--	--
T As (mg/l)	0.028	0.012	0.039	0.62
T Cu (mg/l)	0.095	0.031	0.016	0.036
T Fe (mg/l)	0.72	0.92	0.43	0.093
T Pb (mg/l)	0.002	0.007	< 0.001	< 0.001
T Zn (mg/l)	0.040	< 0.010	0.080	0.041
T Sb (mg/l)	0.42	0.69	0.50	2.34
T Ni (mg/l)	--	--	--	--
T Hg (mg/l)	0.00005	0.0002	--	0.00005
D As (mg/l)	0.021	0.011	0.028	0.62
D Cu (mg/l)	0.073	0.010	0.005	0.021
D Fe (mg/l)	< 0.03	< 0.03	< 0.03	< 0.03
D Pb (mg/l)	< 0.001	< 0.001	< 0.001	< 0.001
D Zn (mg/l)	0.038	< 0.010	0.021	0.031
D Sb (mg/l)	0.36	0.47	0.39	2.25

NB x : Values for T Hg on "Equis" Printout, questionable reliability. Orders of magnitude overall (between Hg values on Equis Printout and Raw Data sheets from PCB) differ by up to  $10^5$ .

TABLE 8: WMB MONITORING PRE AND POST PRODUCTION  
2) Tailings Seepage Pond Supernatant - 0400760

PARAMETER	10 Sept. 1980	08 Oct. 1980	14 Nov. 1980	12 Dec. 1980
Oil & Grease (mg/l)	< 2.0	< 2.0	< 2.0	< 2.0
[H <sup>+</sup> ] (mol/l)	$1.58 \times 10^{-8}$	$3.98 \times 10^{-8}$	$1.0 \times 10^{-8}$	$1 \times 10^{-8}$
pH (rel U)	7.8	7.4	8.0	8.0
NFR (mg/l)	13.0	70.0	17.5	1.5
Sulphate (mg/l)	79.0	--	105.0	243.0
S.Cond. (us/cm)	--	--	--	--
T As (mg/l)	0.008	0.056	0.006	0.016
T Cu (mg/l)	0.033	0.18	0.35	0.57
T Fe (mg/l)	2.49	0.94	0.81	1.01
T Pb (mg/l)	0.006	0.008	0.005	0.003
T Zn (mg/l)	0.059	0.074	0.18	0.43
T Sb (mg/l)	0.055	0.42	0.068	0.14
T Ni (mg/l)	--	--	--	--
T Hg (mg/l)	< 0.0002	< 0.0002	< 0.0002	< 0.00005
D As (mg/l)	0.005	0.010	0.004	0.002
D Cu (mg/l)	0.016	0.021	0.11	0.18
D Fe (mg/l)	< 0.030	< 0.030	< 0.030	< 0.030
D Pb (mg/l)	< 0.001	< 0.001	< 0.001	< 0.001
D Zn (mg/l)	0.015	< 0.015	0.006	0.17
D Sb (mg/l)	0.046	0.23	0.065	0.13

Continued...

TABLE 8: WMB MONITORING PRE AND POST PRODUCTION

2) Tailings Seepage Pond Supernatant - 0400760

(Continued)

PARAMETER	14 Jan. 1981	03 Mar. 1981	31 Mar. 1981	28 Apr. 1981
Oil & Grease (mg/l)	--	< 2.0	--	4.0
[H+] (mol/l)	$7.94 \times 10^{-8}$	$1.99 \times 10^{-8}$	$1 \times 10^{-7}$	$7.94 \times 10^{-4}$
pH (rel U)	7.1	7.7	7.0	3.1
NFR (mg/l)	10.5	2.5	3.0	111.0
Sulphate (mg/l)	240.0	129.0	5.0	600.0
S.Cond. (us/cm)	--	--	--	--
T As (mg/l)	0.017	0.003	0.020	3.52
T Cu (mg/l)	1.69	0.22	2.80	25.0
T Fe (mg/l)	1.43	1.52	1.29	64.3
T Pb (mg/l)	0.004	0.005	0.003	0.021
T Zn (mg/l)	0.96	0.17	1.36	6.62
T Sb (mg/l)	0.11	0.062	0.059	< 0.001
T Ni (mg/l)	--	--	--	--
T Hg (mg/l)	0.00005	0.00008	--	0.00005
D As (mg/l)	< 0.001	0.002	0.003	0.041
D Cu (mg/l)	0.80	0.065	1.54	24.9
D Fe (mg/l)	< 0.30	< 0.030	< 0.030	20.7
D Pb (mg/l)	< 0.001	< 0.001	< 0.001	0.015
D Zn (mg/l)	0.74	0.008	1.11	6.60
D Sb (mg/l)	0.10	0.061	0.048	< 0.001

Continued...

TABLE 8: WMB MONITORING PRE AND POST PRODUCTION  
 2) Tailings Seepage Pond Supernatant - 0400760  
 (Continued)

PARAMETER	28 May 1981	02 June 1981	23 June 1981	10 Sept. 1981
Oil & Grease (mg/l)	--	< 1.07	< 2.0	< 2.0
[H <sup>+</sup> ] (mol/l)	$3.16 \times 10^{-6}$	$1.26 \times 10^{-7}$	$3.98 \times 10^{-7}$	$1 \times 10^{-6}$
pH (rel U)	5.5	6.9	6.4	6.0
NFR (mg/l)	21.5	41.0	12.0	48.0
Sulphate (mg/l)	303.0	298.0	537.0	1400.0
S.Cond. (us/cm)	--	730.0		
T As (mg/l)	0.060	0.005	0.006	0.018
T Cu (mg/l)	3.15	1.03	2.40	6.94
T Fe (mg/l)	3.91	1.5	1.15	5.55
T Pb (mg/l)	0.002	0.003	< 0.001	0.004
T Zn (mg/l)	1.36	1.01	1.63	4.18
T Sb (mg/l)	0.018	0.035	0.040	0.002
T Ni (mg/l)	--	0.2	--	--
T Hg (mg/l)	--	--	0.0001	0.00005
D As (mg/l)	< 0.001		< 0.001	0.002
D Cu (mg/l)	2.60		1.49	4.83
D Fe (mg/l)	< 0.030		0.14	< 0.030
D Pb (mg/l)	0.001		< 0.001	0.001
D Zn (mg/l)	1.31		1.49	4.01
D Sb (mg/l)	0.003		0.030	0.001

Continued...



TABLE 8: WMB MONITORING PRE AND POST PRODUCTION

2) Tailings Seepage Pond Supernatant - 0400760

(Continued)

PARAMETER	19 Oct. 1981	19 Nov. 1981	15 Dec. 1981
Oil & Grease (mg/l)	--	--	< 2.0
[H+] (mol/l)	$1 \times 10^{-3}$	$1 \times 10^{-3}$	$1.5 \times 10^{-3}$
pH (rel U)	3.0	3.0	2.8
NFR (mg/l)	110.0	420.5	415.0
Sulphate (mg/l)	1670.0	2780.0	8850.0
S.Cond. (us/cm)			
T As (mg/l)	4.12	30.9	24.0
T Cu (mg/l)	46.0	67.7	99.8
T Fe (mg/l)	123.0	611.0	534.0
T Pb (mg/l)	0.21	0.12	0.070
T Zn (mg/l)	19.0	39.0	63.7
T Sb (mg/l)	0.003	0.055	0.20
T Ni (mg/l)	--	--	--
T Hg (mg/l)	--	--	0.00005
D As (mg/l)	0.48	9.97	5.00
D Cu (mg/l)	41.40	63.9	96.0
D Fe (mg/l)	83.6	410.0	370.0
D Pb (mg/l)	0.050	0.10	0.070
D Zn (mg/l)	17.5	37.1	60.3
D Sb (mg/l)	< 0.001	0.007	0.009

TABLE 9: WMB MONITERING PRE AND POST PRODUCTION  
3) Mine Water Settling Pond Supernatant - 0400761

PARAMETER	30 May. 1980	13 June 1980	08 Aug. 1980	10 Sept. 1980
Oil & Grease (mg/l)	--	< 2.0	< 2.0	< 2.0
[H+] (mol/l)	$3.16 \times 10^{-7}$	$1.0 \times 10^{-7}$	$1.0 \times 10^{-7}$	$2.51 \times 10^{-7}$
pH (rel U)	6.5	7.0	7.0	6.0
NFR (mg/l)	5.5	31.0	4.5	11.0
Sulphate (mg/l)	30.5	43.5	--	23.0
S.Cond. (us/cm)				
T As (mg/l)	--	--	0.001	0.003
T Cu (mg/l)	--	--	0.035	0.015
T Fe (mg/l)	--	--	1.45	1.85
T Pb (mg/l)	--	--	0.003	0.002
T Zn (mg/l)	--	--	0.13	< 0.015
T Sb (mg/l)	--	--	< 0.003	< 0.005
T Ni (mg/l)	--	--	--	--
T Hg (mg/l)	--	< 0.0002	< 0.0002	0.0003
D As (mg/l)	< 0.001	0.001	< 0.001	< 0.001
D Cu (mg/l)	0.011	0.008	0.010	0.008
D Fe (mg/l)	0.14	0.20	0.62	0.31
D Pb (mg/l)	0.001	< 0.001	< 0.001	< 0.001
D Zn (mg/l)	0.011	0.011	0.009	< 0.015
D Sb (mg/l)	0.002	0.002	< 0.003	< 0.005

Continued...

TABLE 9: WMB MONITORING PRE AND POST PRODUCTION

3) Mine Water Settling Pond Supernatant - 0400761

(Continued)

PARAMETER	08 Oct. 1980	14 Nov. 1980	03 Mar. 1981	28 Apr. 1981
Oil & Grease (mg/l)	< 2.0	3.0	< 2.0	3.0
[H+] (mol/l)	$6.31 \times 10^{-8}$	--	$5.01 \times 10^{-7}$	$3.98 \times 10^{-7}$
pH (rel U)	7.2	--	6.3	6.4
NFR (mg/l)	29.0	43.0	13.0	110.0
Sulphate (mg/l)	66.5	135.0	111.0	103.0
S.Cond. (us/cm)		--	--	--
T As (mg/l)	0.005	0.008	0.11	0.028
T Cu (mg/l)	0.042	0.13	0.67	0.34
T Fe (mg/l)	0.86	2.90	4.38	6.17
T Pb (mg/l)	0.016	0.007	0.035	0.012
T Zn (mg/l)	0.027	0.024	0.20	0.15
T Sb (mg/l)	< 0.005	0.011	0.015	0.010
T Ni (mg/l)	--	--	--	--
T Hg (mg/l)	< 0.0002	< 0.0002	0.00008	0.00005
D As (mg/l)	< 0.001	0.002	0.002	0.023
D Cu (mg/l)	0.022	0.055	0.26	0.11
D Fe (mg/l)	0.18	0.063	< 0.030	0.063
D Pb (mg/l)	0.002	< 0.001	< 0.001	< 0.001
D Zn (mg/l)	0.022	0.020	0.20	0.10
D Sb (mg/l)	< 0.005	0.010	0.013	0.009

Continued...

TABLE 9: WMB MONITORING PRE AND POST PRODUCTION  
 3) Mine Water Settling Pond Supernatant - 0400761  
 (Continued)

PARAMETER	28 May 1981	02 June 1981	23 June 1981	01 Sept. 1981
Oil & Grease (mg/l)	--	1.4	< 2.0	--
[H+] (mol/l)	$7.94 \times 10^{-7}$	$2.51 \times 10^{-7}$	$2.51 \times 10^{-7}$	$7.94 \times 10^{-7}$
pH (rel U)	6.1	6.6	6.6	6.1
NFR (mg/l)	42.5	16.0	< 0.5	9.0
Sulphate (mg/l)	163.0	165.0	177.0	141.0
S.Cond. (us/cm)	--	525.0	--	597.0
T As (mg/l)	0.015	< 0.005	0.003	< 0.005
T Cu (mg/l)	0.034	0.03	0.025	0.06
T Fe (mg/l)	4.18	0.05	1.30	1.66
T Pb (mg/l)	0.004	< 0.001	< 0.001	0.002
T Zn (mg/l)	0.10	0.1	--	0.1
T Sb (mg/l)	0.003	< 0.005	0.003	< 0.005
T Ni (mg/l)	--	0.01	--	--
T Hg (mg/l)	--	--	0.00005	--
D As (mg/l)	< 0.001		< 0.001	
D Cu (mg/l)	0.014		0.020	
D Fe (mg/l)	0.13		0.096	
D Pb (mg/l)	< 0.001		< 0.001	
D Zn (mg/l)	0.073		0.088	
D Sb (mg/l)	0.002		< 0.001	

Continued...

TABLE 9: WMB MONITORING PRE AND POST PRODUCTION

3) Mine Water Settling Pond Supernatant - 0400761

(Continued)

PARAMETER	10 Sept. 1981	15 Dec. 1981
Oil & Grease (mg/l)	11.0	< 2.0
[H <sup>+</sup> ] (mol/l)	$1.26 \times 10^{-6}$	$1.99 \times 10^{-4}$
pH (rel U)	5.9	3.7
NFR (mg/l)	11.0	30.0
Sulphate (mg/l)	94.0	540.0
S.Cond. (us/cm)	--	--
T As (mg/l)	0.002	< 0.001
T Cu (mg/l)	0.098	2.40
T Fe (mg/l)	2.07	6.50
T Pb (mg/l)	< 0.001	0.010
T Zn (mg/l)	--	--
T Sb (mg/l)	0.002	< 0.001
T Ni (mg/l)	--	--
T Hg (mg/l)	0.00005	0.00005
D As (mg/l)	0.001	< 0.001
D Cu (mg/l)	0.062	2.26
D Fe (mg/l)	0.031	1.85
D Pb (mg/l)	< 0.001	0.009
D Zn (mg/l)	0.13	0.76
D Sb (mg/l)	0.001	< 0.001

TABLE 10: WMB MONITORING PRE AND POST PRODUCTION

4) Storm Water Plant Drainage Supernatant - 0400762

PARAMETER	13 June 1980	08 Aug. 1980	10 Sept. 1980	08 Oct. 1980
Oil & Grease (mg/l)	< 2.0	< 2.0	< 2.0	< 2.0
[H <sup>+</sup> ] (mol/l)	$5.01 \times 10^{-8}$	$6.31 \times 10^{-8}$	$7.94 \times 10^{-8}$	$1.5 \times 10^{-8}$
pH (rel U)	7.3	7.2	7.1	7.8
NFR (mg/l)	36.0	< 1.0	19.0	11.0
Sulphate (mg/l)	49.5	--	91.0	58.5
S.Cond. (us/cm)	--	--	--	--
T As (mg/l)	--	0.001	0.009	0.008
T Cu (mg/l)	--	0.017	0.12	0.24
T Fe (mg/l)	--	0.21	1.37	0.35
T Pb (mg/l)	--	0.002	0.033	0.010
T Zn (mg/l)	--	0.10	0.16	0.16
T Sb (mg/l)	--	0.003	< 0.005	< 0.005
T Ni (mg/l)	--	--	--	--
T Hg (mg/l)	< 0.0002	< 0.0002	0.0002	< 0.0002
D As (mg/l)	0.002	< 0.001	0.002	0.003
D Cu (mg/l)	0.008	0.010	0.085	0.15
D Fe (mg/l)	0.092	0.060	0.12	0.20
D Pb (mg/l)	< 0.001	< 0.001	0.005	0.003
D Zn (mg/l)	0.011	0.053	0.11	0.12
D Sb (mg/l)	0.002	0.003	< 0.005	< 0.005

Continued...

TABLE 10: WMB MONITERING PRE AND POST PRODUCTION

4) Storm Water Plant Drainage Supernatant - 0400762

(Continued)

PARAMETER	14 Nov. 1980	12 Dec. 1980	23 Mar. 1981	28 Apr. 1981
Oil & Grease (mg/l)	6.0	--	< 2.0	3.0
[H+] (mol/l)	$5.01 \times 10^{-8}$	$6.31 \times 10^{-9}$	$7.94 \times 10^{-8}$	$2.51 \times 10^{-7}$
pH (rel U)	7.3	8.2	7.1	6.6
NFR (mg/l)	9.0	1.0	< 1.0	61.5
Sulphate (mg/l)	113.0	207.0	240.0	210.0
S.Cond. (us/cm)	--	--	--	--
T As (mg/l)	0.006	0.005	0.006	0.033
T Cu (mg/l)	0.23	0.027	0.085	0.36
T Fe (mg/l)	0.68	0.24	0.32	4.12
T Pb (mg/l)	0.004	0.001	0.001	0.010
T Zn (mg/l)	0.16	0.11	0.26	0.42
T Sb (mg/l)	< 0.005	0.007	0.008	0.005
T Ni (mg/l)	--	--	--	--
T Hg (mg/l)	0.0002	0.00005	0.00005	0.00005
D As (mg/l)	0.002	0.002	0.004	0.002
D Cu (mg/l)	0.15	0.024	0.10	0.13
D Fe (mg/l)	0.17	0.048	< 0.030	0.033
D Pb (mg/l)	< 0.001	< 0.001	< 0.001	< 0.001
D Zn (mg/l)	0.14	0.14	0.23	0.41
D Sb (mg/l)	< 0.005	0.005	0.008	0.004

Continued...

TABLE 10: WMB MONITORING PRE AND POST PRODUCTION

4) Storm Water Plant Drainage Supernatant - 0400762

(Continued)

PARAMETER	25 May 1981	02 June 1981	23 June 1981	10 Sept. 1981
Oil & Grease (mg/l)	--	1.2	< 2.0	< 2.0
[H+] (mol/l)	$5.01 \times 10^{-7}$	$1.99 \times 10^{-7}$	$1 \times 10^{-7}$	$6.31 \times 10^{-6}$
pH (rel U)	6.3	6.7	7.0	5.2
NFR (mg/l)	30.0	46.0	< 0.5	14.5
Sulphate (mg/l)	58.0	66.3	192.0	510.0
S.Cond. (us/cm)	--	177.0	--	--
T As (mg/l)	0.023	0.011	0.012	0.020
T Cu (mg/l)	0.27	0.33	0.44	1.74
T Fe (mg/l)	2.70	3.95	0.94	2.51
T Pb (mg/l)	0.013	0.015	0.007	< 0.001
T Zn (mg/l)	0.21	0.38	0.41	1.77
T Sb (mg/l)	0.004	< 0.005	0.005	0.003
T Ni (mg/l)	--	0.03	--	--
T Hg (mg/l)	--	--	0.00005	0.00005
D As (mg/l)	0.003		< 0.001	0.002
D Cu (mg/l)	0.10		0.13	1.49
D Fe (mg/l)	0.15		0.098	< 0.030
D Pb (mg/l)	0.001		< 0.001	< 0.001
D Zn (mg/l)	0.13		0.29	0.010
D Sb (mg/l)	0.003		< 0.001	0.002

Continued...



TABLE 10: WMB MONITERING PRE AND POST PRODUCTION

4) Storm Water Platin Drainage Supernatant - 0400762

(Continued)

PARAMETER	27 Nov. 1981	15 Dec. 1981
Oil & Grease (mg/l)	--	< 2.0
[H+] (mol/l)	$1.99 \times 10^{-4}$	$1.26 \times 10^{-4}$
pH (rel U)	3.7	3.9
NFR (mg/l)	--	48.5
Sulphate (mg/l)	830.0	750.0
S.Cond. (us/cm)	1550.0	--
T As (mg/l)	0.59	0.003
T Cu (mg/l)	3.8	3.05
T Fe (mg/l)	30.2	12.4
T Pb (mg/l)	0.38	0.004
T Zn (mg/l)	--	3.40
T Sb (mg/l)	--	< 0.001
T Ni (mg/l)	--	--
T Hg (mg/l)	--	0.00005
D As (mg/l)		< 0.001
D Cu (mg/l)		2.85
D Fe (mg/l)		1.06
D Pb (mg/l)		0.003
D Zn (mg/l)		3.20
D Sb (mg/l)		< 0.001

TABLE 11: WMB MONITERING PRE AND POST PRODUCTION  
5) Foxy Creek u/s Tailing Impoundment - 0400763

PARAMETER	13 June 1980	08 Aug. 1980	10 Sept. 1980	08 Oct. 1980
Oil & Grease (mg/l)	< 2.0	< 2.0	< 2.0	2.0
pH (rel U)	7.5	7.7	7.4	7.4
NFR (mg/l)	2.0	< 1.0	1.0	2.0
Sulphate (mg/l)	< 5.0	--	< 5.0	< 5.0
S.Cond. (us/cm)	--	--	--	--
T As (mg/l)	--	< 0.001	< 0.001	0.002
T Cu (mg/l)	--	0.026	0.005	0.014
T Fe (mg/l)	--	0.029	0.22	0.13
T Pb (mg/l)	--	0.006	0.001	0.010
T Zn (mg/l)	--	0.14	< 0.015	< 0.015
T Sb (mg/l)	--	0.003	0.005	0.005
T Ni (mg/l)	--	--	--	--
T Hg (mg/l)	< 0.0002	< 0.0002	< 0.0002	< 0.0002
D As (mg/l)	< 0.001	< 0.001	< 0.001	< 0.001
D Cu (mg/l)	< 0.001	< 0.001	0.002	0.004
D Fe (mg/l)	0.091	0.082	0.076	0.12
D Pb (mg/l)	< 0.001	< 0.001	< 0.001	0.004
D Zn (mg/l)	0.002	0.004	< 0.015	< 0.015
D Sb (mg/l)	< 0.001	< 0.003	< 0.005	< 0.005

Continued...

TABLE 11: WMB MONITORING PRE AND POST PRODUCTION  
 5) Foxy Creek u/s Tailing Impoundment - 0400763  
 (Continued)

PARAMETER	14 Nov. 1980	12 Dec. 1980	14 June 1981	03 Mar. 1981
Oil & Grease (mg/l)	2.0	< 2.0	< 2.0	< 2.0
pH (rel U)	7.8	8.1	7.3	7.6
NFR (mg/l)	3.0	< 0.5	5.0	< 1.0
Sulphate (mg/l)	20.5	< 5.0	5.0	< 10.0
S.Cond. (us/cm)	--	--	--	--
T As (mg/l)	< 0.001	< 0.001	< 0.001	< 0.001
T Cu (mg/l)	0.027	0.002	0.009	0.002
T Fe (mg/l)	0.27	0.23	0.15	0.10
T Pb (mg/l)	0.001	< 0.001	< 0.001	0.001
T Zn (mg/l)	0.005	0.011	0.004	0.010
T Sb (mg/l)	< 0.005	< 0.005	< 0.005	< 0.001
T Ni (mg/l)	--	--	--	--
T Hg (mg/l)	0.0002	0.00005	0.00005	0.00008
D As (mg/l)	< 0.001	< 0.001	< 0.001	< 0.001
D Cu (mg/l)	0.022	0.001	0.001	0.007
D Fe (mg/l)	0.13	0.10	0.061	0.037
D Pb (mg/l)	< 0.001	< 0.001	< 0.001	< 0.001
D Zn (mg/l)	< 0.005	< 0.001	< 0.002	< 0.010
D Sb (mg/l)	< 0.005	< 0.005	< 0.005	< 0.001

Continued...

TABLE 11: WMB MONITORING PRE AND POST PRODUCTION  
 5) Foxy Creek u/s Tailing Impoundment - 0400763  
 (Continued)

PARAMETER	31 Mar. 1981	28 Apr. 1981	28 May 1981	02 June 1981
Oil & Grease (mg/l)	< 2.0	5.0	< 2.0	1.2
pH (rel U)	7.3	7.2	6.9	7.4
NFR (mg/l)	< 1.0	< 0.5	3.0	3.0
Sulphate (mg/l)	< 5.0	< 5.0	< 5.0	< 5.0
S.Cond. (us/cm)	--	--	--	35.0
T As (mg/l)	< 0.001	0.002	0.001	< 0.005
T Cu (mg/l)	0.008	0.010	0.002	0.001
T Fe (mg/l)	0.12	0.27	0.41	0.33
T Pb (mg/l)	0.001	0.002	0.002	< 0.001
T Zn (mg/l)	0.010	< 0.010	< 0.010	< 0.005
T Sb (mg/l)	< 0.001	< 0.010	0.001	< 0.005
T Ni (mg/l)	--	--	--	< 0.01
T Hg (mg/l)	0.00007	0.00005	0.00005	--
D As (mg/l)	< 0.001	0.001	< 0.001	
D Cu (mg/l)	< 0.001	0.008	< 0.001	
D Fe (mg/l)	0.060	0.094	0.091	
D Pb (mg/l)	< 0.001	< 0.001	< 0.001	
D Zn (mg/l)	< 0.010	< 0.010	< 0.010	
D Sb (mg/l)	< 0.001	< 0.001	< 0.001	

Continued...

TABLE 11: WMB MONITORING PRE AND POST PRODUCTION  
 5) Foxy Creek u/s Tailing Impoundment - 0400763  
 (Continued)

PARAMETER	23 June 1981	14 July 1981	14 Aug. 1981	01 Sept. 1981
Oil & Grease (mg/l)	< 2.0	< 2.0	< 2.0	--
pH (rel U)	7.5	7.7	7.7	7.9
NFR (mg/l)	< 0.5	< 0.5	2.0	< 1.0
Sulphate (mg/l)	< 5.0	< 5.0	< 5.0	< 5.0
S.Cond. (us/cm)	--	--	--	66.0
T As (mg/l)	< 0.001	0.001	0.003	< 0.005
T Cu (mg/l)	0.003	0.003	< 0.001	< 0.001
T Fe (mg/l)	0.20	0.13	0.10	0.11
T Pb (mg/l)	< 0.001	0.009	< 0.001	0.002
T Zn (mg/l)	< 0.010	0.018	< 0.010	0.02
T Sb (mg/l)	< 0.001	0.002	< 0.001	< 0.005
T Ni (mg/l)	--	--	--	--
T Hg (mg/l)	0.00005	0.0001	0.00005	--
D As (mg/l)	< 0.001	< 0.001	< 0.001	
D Cu (mg/l)	0.005	0.001	< 0.001	
D Fe (mg/l)	0.087	0.051	0.053	
D Pb (mg/l)	< 0.001	< 0.001	< 0.001	
D Zn (mg/l)	< 0.010	< 0.010	< 0.010	
D Sb (mg/l)	< 0.001	< 0.001	< 0.001	

Continued...

TABLE 11: WMB MONITORING PRE AND POST PRODUCTION  
 5) Foxy Creek u/s Tailing Impoundment - 0400763  
 (Continued)

PARAMETER	10 Sept. 1981	19 Oct. 1981	19 Nov. 1981	15 Dec. 1981
Oil & Grease (mg/l)	< 2.0	3.0	< 2.0	< 2.0
pH (rel U)	7.7	7.5	6.4	6.5
NFR (mg/l)	2.0	< 0.5	0.5	20.0
Sulphate (mg/l)	< 5.0	9.5	9.0	6.0
S.Cond. (us/cm)	--	--	--	--
T As (mg/l)	< 0.001	0.004	0.012	< 0.001
T Cu (mg/l)	0.017	0.015	0.038	0.028
T Fe (mg/l)	0.19	0.36	0.68	0.24
T Pb (mg/l)	0.002	0.003	< 0.001	< 0.001
T Zn (mg/l)	0.085	0.016	0.039	0.094
T Sb (mg/l)	< 0.001	0.003	< 0.001	< 0.001
T Ni (mg/l)	--	--	--	--
T Hg (mg/l)	0.00005	0.0016	0.00005	0.0001
D As (mg/l)	< 0.001	0.004	0.001	< 0.001
D Cu (mg/l)	0.002	0.022	< 0.001	0.003
D Fe (mg/l)	0.042	0.11	0.29	0.17
D Pb (mg/l)	< 0.001	< 0.001	< 0.001	< 0.001
D Zn (mg/l)	0.011	0.010	0.021	< 0.010
D Sb (mg/l)	< 0.001	0.002	< 0.001	< 0.001

Continued...

TABLE 12: WMB MONITORING PRE AND POST PRODUCTION  
6) Foxy Creek d/s Tailing Impoundment - 0400764

PARAMETER	13 June 1980	08 Aug. 1980	10 Sept. 1980	08 Oct. 1980
Oil & Grease (mg/l)	< 2.0	< 2.0	< 2.0	< 2.0
pH (rel U)	7.5	7.6	7.4	7.3
NFR (mg/l)	5.0	< 1.0	< 1.0	< 1.0
Sulphate (mg/l)	5.0	--	5.0	5.0
S.Cond. (us/cm)	--	--	--	--
T As (mg/l)	--	< 0.001	< 0.001	0.002
T Cu (mg/l)	--	0.010	0.005	0.010
T Fe (mg/l)	--	0.26	0.16	0.14
T Pb (mg/l)	--	0.001	0.001	0.010
T Zn (mg/l)	--	0.030	< 0.015	< 0.015
T Sb (mg/l)	--	< 0.003	< 0.005	< 0.005
T Ni (mg/l)	--	--	--	--
T Hg (mg/l)	< 0.0002	< 0.0002	< 0.0002	< 0.0002
D As (mg/l)	< 0.001	< 0.001	< 0.001	< 0.001
D Cu (mg/l)	< 0.001	0.001	0.002	0.002
D Fe (mg/l)	0.066	0.058	0.068	0.13
D Pb (mg/l)	< 0.001	< 0.001	< 0.001	0.002
D Zn (mg/l)	0.002	0.007	< 0.015	< 0.015
D Sb (mg/l)	< 0.001	< 0.003	< 0.005	< 0.005

Continued...

TABLE 12: WMB MONITORING PRE AND POST PRODUCTION

5) Foxy Creek d/s Tailing Impoundment - 0400764

(Continued)

PARAMETER	14 Nov. 1980	12 Dec. 1980	14 Jan. 1981	03 Mar. 1981
Oil & Grease (mg/l)	< 2.0	< 2.0	< 2.0	< 2.0
pH (rel U)	7.3	8.0	7.2	7.7
NFR (mg/l)	3.0	< 0.5	6.0	1.0
Sulphate (mg/l)	25.5	< 5.0	< 5.0	<10.0
S.Cond. (us/cm)	--	--	--	--
T As (mg/l)	< 0.001	< 0.001	< 0.001	0.001
T Cu (mg/l)	0.003	0.003	0.002	0.003
T Fe (mg/l)	0.33	0.23	0.16	0.10
T Pb (mg/l)	0.002	< 0.001	0.001	< 0.001
T Zn (mg/l)	< 0.005	0.017	0.003	0.010
T Sb (mg/l)	< 0.005	< 0.005	< 0.005	< 0.001
T Ni (mg/l)	--	--	--	--
T Hg (mg/l)	< 0.0002	0.00005	0.00005	0.00006
D As (mg/l)	< 0.001	< 0.001	< 0.001	< 0.001
D Cu (mg/l)	0.002	0.003	0.002	0.003
D Fe (mg/l)	0.14	0.19	0.074	0.041
D Pb (mg/l)	< 0.001	< 0.001	0.001	< 0.001
D Zn (mg/l)	< 0.005	0.005	0.002	0.010
D Sb (mg/l)	< 0.005	< 0.005	< 0.005	< 0.001

Continued...



TABLE 12: WMB MONITERING PRE AND POST PRODUCTION  
 6) Foxy Creek d/s Tailing Impoundment - 0400764  
 (Continued)

PARAMETER	31 Mar. 1981	28 Apr. 1981	28 May 1981	02 June 1981
Oil & Grease (mg/l)	--	< 2.0	< 2.0	1.1
pH (rel U)	7.4	7.1	6.8	7.4
NFR (mg/l)	< 1.0	< 0.5	1.0	3.0
Sulphate (mg/l)	249.0	< 5.0	< 5.0	< 5.0
S.Cond. (us/cm)	--	--	--	34.0
T As (mg/l)	< 0.001	< 0.001	< 0.001	< 0.005
T Cu (mg/l)	0.004	0.006	< 0.001	< 0.002
T Fe (mg/l)	0.12	0.31	0.40	0.33
T Pb (mg/l)	< 0.001	< 0.001	< 0.001	0.003
T Zn (mg/l)	< 0.010	< 0.010	< 0.010	0.04
T Sb (mg/l)	< 0.001	< 0.001	< 0.001	< 0.005
T Ni (mg/l)	--	--	--	< 0.01
T Hg (mg/l)	--	0.00005	0.00005	--
D As (mg/l)	< 0.001	< 0.001	< 0.001	
D Cu (mg/l)	0.002	0.005	< 0.001	
D Fe (mg/l)	0.059	0.098	0.089	
D Pb (mg/l)	< 0.001	< 0.001	< 0.001	
D Zn (mg/l)	< 0.010	< 0.010	< 0.010	
D Sb (mg/l)	< 0.001	< 0.001	< 0.001	

Continued...

TABLE 12: WMB MONITORING PRE AND POST PRODUCTION  
 6) Foxy Creek d/s Tailing Impoundment - 0400764  
 (Continued)

PARAMETER	23 June 1981	14 July 1981	14 Aug. 1981	01 Sept. 1981
Oil & Grease (mg/l)	< 2.0	< 2.0	< 2.0	--
pH (rel U)	7.4	7.7	7.7	8.0
NFR (mg/l)	< 0.5	< 0.5	0.5	1.0
Sulphate (mg/l)	< 5.0	< 5.0	< 5.0	< 5.0
S.Cond. (us/cm)	--	--	--	73.0
T As (mg/l)	< 0.001	< 0.001	0.002	< 0.005
T Cu (mg/l)	0.003	0.16	< 0.001	< 0.001
T Fe (mg/l)	0.20	0.13	0.087	0.12
T Pb (mg/l)	< 0.001	0.001	0.008	0.001
T Zn (mg/l)	< 0.010	< 0.010	< 0.010	0.005
T Sb (mg/l)	< 0.001	< 0.001	< 0.001	< 0.005
T Ni (mg/l)	--	--	--	--
T Hg (mg/l)	0.00005	0.004	0.00005	--
D As (mg/l)	< 0.001	< 0.001	< 0.001	
D Cu (mg/l)	0.003	0.002	< 0.001	
D Fe (mg/l)	0.083	0.064	0.053	
D Pb (mg/l)	< 0.001	< 0.001	< 0.001	
D Zn (mg/l)	< 0.010	< 0.010	< 0.010	
D Sb (mg/l)	< 0.001	< 0.001	< 0.001	

Continued...

TABLE 12: WMB MONITORING PRE AND POST PRODUCTION  
 6) Foxy Creek d/s Tailing Impoundment - 0400764  
 (Continued)

PARAMETER	10 Sept. 1981	19 Oct. 1981	19 Nov. 1981	15 Dec. 1981
Oil & Grease (mg/l)	—	2.0	5.0	< 2.0
pH (rel U)	7.7	7.4	6.5	6.3
NFR (mg/l)	6.0	< 0.5	0.5	17.0
Sulphate (mg/l)	< 5.0	< 5.0	< 5.0	< 5.0
S.Cond. (us/cm)	--	--	--	--
T As (mg/l)	< 0.001	< 0.001	0.007	< 0.001
T Cu (mg/l)	0.011	0.002	0.011	0.018
T Fe (mg/l)	0.15	0.38	0.51	0.22
T Pb (mg/l)	< 0.001	< 0.001	< 0.001	< 0.001
T Zn (mg/l)	0.077	< 0.010	0.030	< 0.010
T Sb (mg/l)	< 0.001	< 0.001	< 0.001	< 0.001
T Ni (mg/l)	—	--	--	--
T Hg (mg/l)	--	0.0009	0.00005	0.00005
D As (mg/l)	< 0.001	< 0.001	< 0.001	< 0.001
D Cu (mg/l)	< 0.001	0.007	< 0.001	< 0.001
D Fe (mg/l)	< 0.030	0.20	0.17	0.14
D Pb (mg/l)	< 0.001	< 0.001	< 0.001	< 0.001
D Zn (mg/l)	0.012	< 0.010	< 0.010	< 0.010
D Sb (mg/l)	< 0.001	< 0.001	< 0.001	< 0.001

Continued...

TABLE 13: WMB MONITORING PRE AND POST PRODUCTION

7) Buck Creek u/s Draining - Bessemer Creek - 0400765

PARAMETER	30 May 1980	13 June 1980	08 Aug. 1980	10 Sept. 1980
Oil & Grease (mg/l)	--	< 2.0	4.0	3.0
pH (rel U)	7.2	7.5	7.8	7.4
NFR (mg/l)	6.0	3.0	< 1.0	2.0
Sulphate (mg/l)	5.0	5.0	--	5.0
S.Cond. (us/cm)	--	--	--	--
T As (mg/l)	< 0.001	--	< 0.001	< 0.001
T Cu (mg/l)	0.013	--	0.010	0.005
T Fe (mg/l)	0.44	--	0.38	0.57
T Pb (mg/l)	0.004	--	0.002	< 0.001
T Zn (mg/l)	0.090	--	0.019	< 0.015
T Sb (mg/l)	< 0.003	--	< 0.003	< 0.005
T Ni (mg/l)	--	--	--	--
T Hg (mg/l)	--	< 0.0002	< 0.0002	0.0003
D As (mg/l)	< 0.001	< 0.001	< 0.001	< 0.001
D Cu (mg/l)	0.001	< 0.001	0.002	0.002
D Fe (mg/l)	0.17	0.19	0.19	0.29
D Pb (mg/l)	< 0.001	< 0.001	< 0.001	< 0.001
D Zn (mg/l)	< 0.001	< 0.001	0.002	< 0.015
D Sb (mg/l)	< 0.001	< 0.001	< 0.003	< 0.005

Continued...

TABLE 13: WMB MONITORING PRE AND POST PRODUCTION

7) Buck Creek u/s Draining - Bessemer Creek - 0400765

(Continued)

PARAMETER	08 Oct. 1980	21 Nov. 1980	12 Dec. 1980	14 Jan. 1981
Oil & Grease (mg/l)	< 2.0	< 2.0	< 2.0	< 2.0
pH (rel U)	7.3	7.3	8.0	7.4
NFR (mg/l)	< 1.0	< 1.0	1.0	6.0
Sulphate (mg/l)	< 5.0	31.8	< 5.0	17.5
S.Cond. (us/cm)	--	--	--	--
T As (mg/l)	< 0.001	0.002	< 0.001	< 0.001
T Cu (mg/l)	0.012	0.005	0.003	0.004
T Fe (mg/l)	0.32	0.70	0.93	0.67
T Pb (mg/l)	0.004	0.002	< 0.001	< 0.001
T Zn (mg/l)	< 0.015	0.024	0.026	0.044
T Sb (mg/l)	< 0.005	< 0.005	< 0.005	< 0.005
T Ni (mg/l)	--	--	--	--
T Hg (mg/l)	< 0.0002	0.00005	0.00005	0.00005
D As (mg/l)	< 0.001	< 0.001	< 0.001	< 0.001
D Cu (mg/l)	0.002	0.004	0.002	0.003
D Fe (mg/l)	0.33	0.36	0.62	0.46
D Pb (mg/l)	0.003	0.001	< 0.001	0.001
D Zn (mg/l)	< 0.015	0.004	0.020	0.003
D Sb (mg/l)	< 0.005	< 0.005	< 0.005	< 0.005

Continued...

TABLE 13: WMB MONITORING PRE AND POST PRODUCTION

7) Buck Creek u/s Draining - Bessemer Creek - 0400765

(Continued)

PARAMETER	03 Mar. 1981	31 Mar. 1981	28 Apr. 1981	28 May 1981
Oil & Grease (mg/l)	< 2.0	< 2.0	4.0	< 2.0
pH (rel U)	7.7	7.6	7.4	6.8
NFR (mg/l)	< 1.0	< 1.0	< 0.5	< 1.0
Sulphate (mg/l)	< 10.0	< 5.0	< 5.0	< 5.0
S.Cond. (us/cm)	--	--	--	--
T As (mg/l)	< 0.001	< 0.001	< 0.001	0.001
T Cu (mg/l)	0.002	0.003	0.011	0.040
T Fe (mg/l)	0.80	0.78	0.53	0.47
T Pb (mg/l)	0.001	< 0.001	0.001	0.001
T Zn (mg/l)	< 0.005	0.013	< 0.010	< 0.010
T Sb (mg/l)	< 0.005	0.001	< 0.001	< 0.001
T Ni (mg/l)	--	--	--	--
T Hg (mg/l)	0.00005	0.00012	0.00005	0.00005
D As (mg/l)	< 0.001	< 0.001	< 0.001	< 0.001
D Cu (mg/l)	0.003	< 0.001	0.002	< 0.001
D Fe (mg/l)	0.51	0.46	0.36	0.18
D Pb (mg/l)	< 0.001	< 0.001	< 0.001	< 0.001
D Zn (mg/l)	< 0.005	0.012	< 0.010	< 0.010
D Sb (mg/l)	< 0.001	< 0.001	< 0.001	< 0.001

Continued...

TABLE 13: WMB MONITERING PRE AND POST PRODUCTION

7) Buck Creek u/s Draining - Bessemer Creek - 0400765

(Continued)

PARAMETER	02 June 1981	23 June 1981	14 July 1981	14 Aug. 1981
Oil & Grease (mg/l)	--	< 2.0	< 2.0	2.0
pH (rel U)	7.1	7.5	7.5	7.4
NFR (mg/l)	2.0	< 0.5	< 0.5	5.5
Sulphate (mg/l)	5.0	5.0	5.0	5.0
S.Cond. (us/cm)	69.0	--	--	--
T As (mg/l)	< 0.005	< 0.001	0.001	0.005
T Cu (mg/l)	0.003	0.006	0.006	< 0.001
T Fe (mg/l)	0.63	0.36	0.69	2.05
T Pb (mg/l)	0.003	< 0.001	< 0.001	< 0.001
T Zn (mg/l)	0.011	< 0.010	< 0.010	< 0.010
T Sb (mg/l)	< 0.005	< 0.001	< 0.001	< 0.001
T Ni (mg/l)	< 0.01	--	--	--
T Hg (mg/l)	--	0.00005	0.0001	0.00005
D As (mg/l)		< 0.001	0.001	0.002
D Cu (mg/l)		0.006	0.002	0.001
D Fe (mg/l)		0.20	0.41	1.17
D Pb (mg/l)		0.001	< 0.001	< 0.001
D Zn (mg/l)		< 0.010	< 0.010	< 0.010
D Sb (mg/l)		< 0.001	< 0.001	< 0.001

Continued...

TABLE 13: WMB MONITORING PRE AND POST PRODUCTION

7) Buck Creek u/s Draining - Bessemer Creek - 0400765  
(Continued)

PARAMETER	10 Sept. 1981	19 Oct. 1981	19 Nov. 1981	23 Nov. 1981
Oil & Grease (mg/l)	--	< 2.0	5.0	--
pH (rel U)	7.4	7.3	7.1	7.4
NFR (mg/l)	5.5	< 0.5	1.0	--
Sulphate (mg/l)	< 5.0	< 5.0	< 5.0	7.2
S.Cond. (us/cm)	--	--	--	118.0
T As (mg/l)	0.001	0.003	0.002	
T Cu (mg/l)	0.003	0.006	0.004	
T Fe (mg/l)	1.06	0.91	1.37	
T Pb (mg/l)	0.001	0.001	< 0.001	
T Zn (mg/l)	0.036	< 0.010	0.013	
T Sb (mg/l)	< 0.001	0.002	< 0.001	
T Ni (mg/l)	--	--	--	
T Hg (mg/l)	--	0.0007	0.00005	
D As (mg/l)	< 0.001	0.002	< 0.001	
D Cu (mg/l)	0.005	0.003	< 0.001	
D Fe (mg/l)	0.64	0.55	0.71	
D Pb (mg/l)	< 0.001	0.001	< 0.001	
D Zn (mg/l)	0.011	< 0.010	< 0.010	
D Sb (mg/l)	< 0.001	0.001	< 0.001	

Continued...



TABLE 13: WMB MONITORING PRE AND POST PRODUCTION

7) Buck Creek u/s Draining - Bessemer Creek - 0400765

(Continued)

PARAMETER	27 Nov. 1981	15 Dec. 1981
Oil & Grease (mg/l)	--	< 2.0
pH (rel U)	7.17	6.2
NFR (mg/l)	--	20.0
Sulphate (mg/l)	6.3	< 5.0
S.Cond. (us/cm)	127.0	--
T As (mg/l)	< 0.005	< 0.001
T Cu (mg/l)	< 0.001	< 0.001
T Fe (mg/l)	1.24	1.52
T Pb (mg/l)	< 0.001	< 0.001
T Zn (mg/l)	0.008	< 0.010
T Sb (mg/l)	--	< 0.001
T Ni (mg/l)	--	
T Hg (mg/l)	--	0.00005
D As (mg/l)		< 0.001
D Cu (mg/l)		< 0.001
D Fe (mg/l)		0.99
D Pb (mg/l)		< 0.001
D Zn (mg/l)		< 0.010
D Sb (mg/l)		< 0.001

TABLE 14: WMB MONITORING PRE AND POST PRODUCTION

8) Buck Creek d/s Draining - Bessemer Creek - 0400766

PARAMETER	08 Aug. 1980	10 Sept. 1980	08 Oct. 1980	21 Nov. 1980
Oil & Grease (mg/l)	2.0	< 2.0	< 2.0	2.0
pH (rel U)	7.5	7.5	7.7	7.3
NFR (mg/l)	< 1.0	5.0	< 1.0	< 0.5
Sulphate (mg/l)	--	< 5.0	< 5.0	36.5
S.Cond. (us/cm)	--	--	--	--
T As (mg/l)	< 0.001	< 0.001	< 0.001	0.002
T Cu (mg/l)	0.015	0.005	0.014	0.007
T Fe (mg/l)	0.16	< 0.05	0.072	0.26
T Pb (mg/l)	0.003	0.001	0.010	0.002
T Zn (mg/l)	0.079	< 0.015	< 0.015	0.028
T Sb (mg/l)	< 0.003	< 0.005	< 0.005	< 0.005
T Ni (mg/l)	--	--	--	--
T Hg (mg/l)	< 0.0002	0.0003	< 0.0002	0.00005
D As (mg/l)	< 0.001	< 0.001	< 0.001	0.001
D Cu (mg/l)	0.001	0.002	0.003	0.004
D Fe (mg/l)	0.070	< 0.05	0.079	0.090
D Pb (mg/l)	< 0.001	< 0.001	0.001	< 0.001
D Zn (mg/l)	0.005	< 0.015	< 0.015	0.004
D Sb (mg/l)	< 0.003	< 0.005	< 0.005	< 0.005

Continued...

TABLE 14: WMB MONITERING PRE AND POST PRODUCTION

8) Buck Creek d/s Draining - Bessemer Creek - 0400766

(Continued)

PARAMETER	14 Jan. 1981	03 Mar. 1981	31 Mar. 1981	28 Apr. 1981
Oil & Grease (mg/l)	< 2.0	< 2.0	< 2.0	3.0
pH (rel U)	7.1	7.4	7.2	6.8
NFR (mg/l)	6.0	< 1.0	< 1.0	2.65
Sulphate (mg/l)	5.0	<10.0	< 5.0	< 5.0
S.Cond. (us/cm)	--	--	--	--
T As (mg/l)	0.015	0.001	< 0.001	0.001
T Cu (mg/l)	0.004	0.003	0.007	0.007
T Fe (mg/l)	0.38	0.34	0.31	0.36
T Pb (mg/l)	0.002	< 0.001	0.005	0.004
T Zn (mg/l)	0.003	< 0.005	0.010	0.022
T Sb (mg/l)	< 0.005	< 0.001	0.004	< 0.001
T Ni (mg/l)	--	--	--	--
T Hg (mg/l)	0.00005	0.00005	0.00013	0.00005
D As (mg/l)	< 0.001	0.001	< 0.001	0.001
D Cu (mg/l)	0.004	0.003	0.005	0.002
D Fe (mg/l)	0.22	0.21	0.16	< 0.030
D Pb (mg/l)	< 0.001	< 0.001	< 0.001	< 0.001
D Zn (mg/l)	0.003	< 0.005	< 0.010	< 0.010
D Sb (mg/l)	< 0.005	< 0.001	< 0.001	< 0.001

Continued...

TABLE 14: WMB MONITORING PRE AND POST PRODUCTION

8) Buck Creek d/s Draining - Bessemer Creek - 0400766

(Continued)

PARAMETER	28 May 1981	02 June 1981	23 June 1981	14 July 1981
Oil & Grease (mg/l)	< 2.0	--	< 2.0	< 2.0
pH (rel U)	6.9	7.5	7.4	7.7
NFR (mg/l)	< 1.0	2.0	< 0.5	< 0.5
Sulphate (mg/l)	< 5.0	7.5	< 5.0	< 5.0
S.Cond. (us/cm)	--	83.0	--	--
T As (mg/l)	0.001	< 0.005	< 0.001	0.002
T Cu (mg/l)	0.004	0.004	0.005	0.008
T Fe (mg/l)	0.41	0.51	0.23	0.20
T Pb (mg/l)	0.001	0.007	< 0.001	0.001
T Zn (mg/l)	< 0.010	0.007	< 0.010	< 0.010
T Sb (mg/l)	< 0.001	< 0.005	< 0.001	0.002
T Ni (mg/l)	--	< 0.01	--	--
T Hg (mg/l)	0.00005	--	0.00005	0.00005
D As (mg/l)	< 0.001		< 0.001	< 0.001
D Cu (mg/l)	< 0.001		0.004	0.003
D Fe (mg/l)	0.14		0.090	0.15
D Pb (mg/l)	< 0.001		< 0.001	< 0.001
D Zn (mg/l)	< 0.010		< 0.010	< 0.010
D Sb (mg/l)	< 0.001		< 0.001	< 0.001

Continued...

TABLE 14: WMB MONITORING PRE AND POST PRODUCTION

8) Buck Creek d/s Draining - Bessemer Creek - 0400766

(Continued)

PARAMETER	14 Aug. 1981	10 Sept. 1981	19 Oct. 1981	19 Nov. 1981
Oil & Grease (mg/l)	< 2.0	--	< 2.0	6.0
pH (rel U)	7.4	7.5	7.2	7.2
NFR (mg/l)	1.5	4.0	< 0.5	0.5
Sulphate (mg/l)	7.0	< 5.0	< 5.0	9.5
S.Cond. (us/cm)	--	--	--	--
T As (mg/l)	0.004	< 0.001	0.005	0.002
T Cu (mg/l)	0.008	0.017	0.020	0.009
T Fe (mg/l)	0.30	0.45	0.35	0.23
T Pb (mg/l)	0.002	< 0.001	0.008	< 0.001
T Zn (mg/l)	0.019	0.065	< 0.010	0.024
T Sb (mg/l)	0.003	0.001	--	--
T Ni (mg/l)	--	--	--	--
T Hg (mg/l)	0.00005	--	0.0004	0.00005
D As (mg/l)	< 0.001	< 0.001	0.003	< 0.001
D Cu (mg/l)	0.003	< 0.001	0.010	0.002
D Fe (mg/l)	0.088	0.045	0.079	0.071
D Pb (mg/l)	< 0.001	< 0.001	0.001	< 0.001
D Zn (mg/l)	< 0.010	0.018	< 0.010	< 0.010
D Sb (mg/l)	< 0.001	0.001	0.003	< 0.001

Continued...

TABLE 14: WMB MONITORING PRE AND POST PRODUCTION

8) Buck Creek d/s Draining - Bessemer Creek - 0400766

(Continued)

PARAMETER	23 Nov. 1981	27 Nov. 1981	15 Dec. 1981
Oil & Grease (mg/l)	--	--	< 2.0
pH (rel U)	7.3	7.17	6.1
NFR (mg/l)	--	--	18.5
Sulphate (mg/l)	14.9	49.3	11.0
S.Cond. (us/cm)	111.0	208.0	--
T As (mg/l)			0.001
T Cu (mg/l)			0.001
T Fe (mg/l)			0.26
T Pb (mg/l)			0.004
T Zn (mg/l)			0.020
T Sb (mg/l)			--
T Ni (mg/l)			--
T Hg (mg/l)			0.00005
D As (mg/l)			< 0.001
D Cu (mg/l)			< 0.001
D Fe (mg/l)			0.13
D Pb (mg/l)			< 0.001
D Zn (mg/l)			< 0.010
D Sb (mg/l)			< 0.001