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NORANDA MINES LTD.

GOLDSTREAM DIVISION

PRELIMINARY ASSESSMENT OF THE

COPPER-ZINC DEPOSIT

GOLDSTREAM RIVER AREA

REVELSTOKE MINING DISTRICT

June 1979

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- by B. C. Research

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SUMMARY

Noranda Mines Ltd. have confirmed the existence of a copper - zinc deposit in the Big Bend area, approximately 58 road miles north of Revelstoke, British Columbia. The deposit has been estimated to contain 3,940,600 diluted metric tons of ore grading 3.69% copper, 2.67% zinc, and 0.56 ounces per ton of silver.

A two year program of development and construction would be required to place the property in operation. The known ore reserves will maintain a production rate of 1360 metric tons per day for 8 years following production start up. Manpower requirements will peak at roughly 250 during the preproduction period and stabilize at 185 employees during operations.

Ore will be mined by a combination of a small open pit and a highly mechanized underground method. The open pit will remove approximately 10% of the known reserves with a stripping ratio of 3.47:1. A concentrator will be built on site to treat the copper zinc ores and produce two separate concentrates which will be trucked to Revelstoke for transshipment on the C. P. R. to smelters.

After all concentrates have been extracted from the ore, 45% of the fine material will be removed by cyclones to produce a backfill. This material can then be placed hydraulically in mined out openings to prevent subsidence and permit more complete

recovery of the ore. The remaining 55% of the fine tailings material will be pumped 3 miles to a tailings disposal area west of Brewster Creek.

The following summary illustrates where material from one days mine production of 1360 metric tons eventually ends up:

Copper Concentrate	- 187 metric tons
Zinc Concentrate	- 29 metric tons
Backfill	- 544 metric tons to mine openings
Tailings	- 600 metric tons to tailings pond

Support facilities required for the project include access roads, hydro power development, tailings disposal and water reclamation system, water supply, and accommodation which will consist of a single status campsite within two miles of the plant, and 6 to 10 houses in Revelstoke for senior staff.

Additional employees might settle on their own in Revelstoke, particularly as the Revelstoke dam construction program begins to slacken. A major service building will be constructed on site while administration facilities will be established in Revelstoke. Power would be supplied by the development of a hydro generating dam and station on the Goldstream River, near the mine site.

The project faces relatively minor environmental and social problems. Our main concern will be associated with the water quality of the tailings effluent. The extent of area that will be disturbed by mining activities will consist of roughly 195 acres. Once the mine closes, reclamation will comprise clearing and seeding of the disturbed land including the vegetation of the tailings disposal area. All indications suggest that the disturbed land can be returned to its present land use capability.

In addition, the proposed hydro reservoir on the Goldstream will flood approximately 265 acres. Provision has been made in the dam design to permit removal on completion of the project. It is expected that the area could be returned to a natural environment in 5 to 10 years.

The area is presently being harvested by Canadian Cellulose Ltd., under Tree Farm Licence 23. Harvesting operations are conducted under a Resource Folio developed by Cancel and Forestry Service.

1.0 INTRODUCTION

A resource development such as the Goldstream Project affects and alters certain environmental, social, and economic conditions in the region. Thoughtful planning is therefore necessary in order to ensure that a reasonable approach is taken to the managing of land use, environmental, and social impacts. Noranda Mines commit to follow this approach at Goldstream.

This Stage 1 report presents an outline of the proposed development program including sections identifying major economic, environmental, and social impacts on the region. It should be emphasized that much of the information contained in this report is of a tentative nature as it is based on preliminary studies. Future investigations may alter some of the proposed program.

B. C. Research and International Environmental Consultants were retained by Noranda Exploration Company, Limited in 1976. B. C. Research conducted tests on ore and waste rock samples to determine their acid generation potential. I. E. C. were responsible for preparing an environmental baseline study for the Goldstream Valley, and for conducting a fish inventory and wildlife survey of the valley.

2.0 DESCRIPTION OF PROJECT

2.1 Property Location

The property is situated in the Columbia Valley of east central British Columbia, between Mica Dam and the northern end of Upper Arrow Lake, The City of Revelstoke lies to the south and the Village of Mica Creek to the north. (See Dwg. 1)

The base metal deposit is located approximately 58 road miles north of Revelstoke, on the Goldstream River, a tributary of the Columbia River. Dwg. 2 shows the proposed lease boundary on the north slope and near the base of a mountain immediately to the south of the Goldstream River.

The Goldstream River generally flows from east to west, with its headwaters forming in the centre of the Selkirk Mountain Range. Placer mining activities were carried out on the river and its tributaries as early as the 1860's, forming the centre of the Columbia River Gold Rush. Intermittent mining is carried on to this date.

With the exception of a thin strip of land along the Columbia River, the entire Goldstream area is held under Tree Farm Licence 23 by Canadian Cellulose, who are conducting harvesting operations in various locations along the Goldstream. Major portions of the valley over the deposit and proposed plant site have already been cleared.

2.2 PROJECT ACTIVITIES

2.2.1 1976 Program

A camp was established on the Goldstream River in April and May of 1976. Crews and equipment were mobilized, an adit collared and an underground program of drifting and diamond drilling was completed by early November. The results of this program have been compiled and analyzed, and a proposed mining method developed.

Metallurgical testwork was carried out on material derived from the underground workings and while additional testwork is required, most problems have been satisfactorily resolved. A flow sheet and general arrangement for a concentrator have been developed.

Various studies and investigations have been completed in the areas of accommodation, power supply, environmental considerations and general plant layout. The following list summarizes the extent of work carried out during 1976.

1. A temporary plant and camp were established.

2. A total of 1106 metres of drift, including 339 metres in ore, was completed. (see Dwg. 3)

3. Dip continuity was tested by diamond drilling and approximately 70 metres x 5 metres of hanging wall were exposed.

4. Drill drift and approximately 2252 metres of diamond drilling in 44 holes were completed. The general area tested was roughly 350 metres x 100 metres.

5. A proposed development and mining program was postulated.

6. A flow sheet was designed, preliminary layouts completed, and suitable equipment located, for the concentrator.

7. Extensive studies have been carried out by M. A. Thomas and Associates to evaluate the most economical power source from: B. C. Hydro, diesel generators, and adjacent private hydro.

8. International Environmental Consultants of Vancouver were retained in order to conduct an environmental baseline study; a copy of their report is contained in Appendix I.

9. B. C. Research evaluated the acid generating potential of ore and waste rock samples; their findings are included in Appendix II.

10. The preliminary design of a tailings disposal area has been completed.

11. A weather station was established on October 1st, 1976.

12. The plant area was testholed for overburden depths and rock competence.

13. A concentrate loadout site was tentatively located in the C. P. R. yards in Revelstoke.

14. A legal survey was conducted by a B. C. Land Surveyor in order to resolve some claim fraction problems and apply for a mining lease.

2.2.2 Activities 1977 - Present

Economic conditions in 1977 and 1978 forced Noranda to hold the Project in abeyance. All camp and plant facilities were removed.

B. C. Hydro Authority were commissioned to conduct a detailed study as to the feasibility and cost of providing electrical power to the Project.

Additional cost estimates were provided for generation of power on the Goldstream River. Soil sampling and other site engineering was done in 1977 to determine the feasibility of constructing a dam on the river. During 1978, accurate estimates were prepared by consultants for the local hydro option.

Environmental field work was conducted by I. E. C. of Vancouver. A fish inventory of the project area, and a wildlife study (still in progress) were commissioned.

Some additional surface drilling was carried out on strike of the deposit to test geophysical anomalies, without success.

2.3 GEOLOGY

2.3.1 Geometry

The Goldstream deposit lies within a sequence of metamorphosed and deformed sedimentary and volcanic rocks. The shape of the deposit is that of a "flattened rod" or "ruler" and although it occurs concordantly with the surrounding rock units and as a particular stratigraphic horizon, it rakes across the dip of other units.

In the area of the deposit the rocks strike N65^o - 75^{o}W and dip 35^o - 45^o NE while the long, or plunge, axis of the deposit strikes N60^o E and dips 20^o - 25^o in the same direction. The down plunge length has been followed for some 1500 metres by drilling, indicating that the thickness of the deposit varies from 2 - 8 metres and the strike width from 150 - 350 metres.

2.3.2 Rock Sequence

The general sequence of rocks encountered from hangingwall to footwall are as follows:

1. Dark Banded Phyllite
2. Garnet Zone
3. Grey Green Phyllite
4. Massive Sulphides
5. Grey Green Phyllite
6. Limestone

The "Dark Banded Phyllite" presents itself as a thick layer with the base of the formation occurring 15 to 20 metres above the ore zone. This rock is generally competent and calcareous with occasional narrow graphitic fractured zones dipping with the formation.

The "Garnet Zone" occurs as a bed conforming with the base of the bed above. It is usually sheared on the hangingwall contact, contains graphite & garnets, and has a mean thickness of 12 metres.

The "Grey Green Phyllite" is an altered (sericitic) phyllite, occurring immediately in the hangingwall of the ore zone, with varying degrees of calcareous or siliceous alterations. This bed averages 5½ - 6 metres in thickness being occasionally mineralized.

The "Massive Sulphide" bed occurs as a continuous and consistent sheet of mineralization ranging from ½ - 8 metres in thickness, averaging about 3 metres. A few minor crossfaults cut the ore zone with offsets of about one metre.

The "Grey Green Phyllite" which is present in the footwall of the massive bed is similar to the hangingwall sequence, however, it does contain an additional graphite band within one metre of the footwall of the ore. Its thickness varies between 4 and 8 metres.

A "Limestone" bed is the final layer associated with the footwall. The 16 metre thickness of this bed appears to be regular and competent.

2.3.3 Mineralization

The core of the ore zone is a massive sulphide lens consisting of chalcopyrite, pyrrhotite, sphalerite and lesser amounts of pyrite. Adjoining the massive sulphide zones, on some occasions, are narrow bands of disseminated mineralization containing chalcopyrite and pyrrhotite, usually occurring in siliceous sericite schist.

2.3.4 Reserves

The final calculation of the mineral inventory, based on the surface drilling program results, indicates a total of 3,177,903 metric tons present, grading 4.49% copper, 3.24% zinc, and 0.68 opt silver.

An assessment of the proposed mining system suggests the use of a 24% dilution. This figure represents the weighted average of a hangingwall dilution of 15% and a footwall dilution of 8% in the underground, together with an open pit dilution estimated at 28%.

Grade of this dilution has been estimated at 0.36% copper, 0.28% zinc, and 0.08 opt silver as shown in the table below.

Mineral Inventory

	Metric Tons	% Cu	% Zn	opt Ag
Drill Indicated Ore	3,177,903	4.49	3.24	0.68
Dilution (24%)	762,697	0.36	0.28	0.08
Total Inventory	3,940,600	3.69	2.67	0.56

2.3.5 Further Ore Potential

The east and west limits of the ore have been reasonably well defined by the 1975 surface exploration drilling which was done on a 100 metre grid. The downdip extent of the ore has yet to be determined however, and has excellent potential of adding substantial tonnage.

The claims held by Noranda on the Goldstream property cover approximately 9 Km of favourable stratigraphy along strike from the ore body. While this has been traced by geophysics, no indication of another mineralized zone has been determined by geochemistry. It is very likely that geochemical response could be masked by an increase in overburden depth, particularly as occurs between the deposit and Brewster Creek.

2.4 MINING

2.4.1 Rock Conditions

One of the most significant findings of the 1976 development program was the highly competent rock conditions which occur through the hangingwall series to the ore zone. Several graphite shears requiring extra attention were penetrated. Occasionally jointing and fractures normal to the strike required extra scaling. The ore zone itself was drifted on for 325 metres exposing the hangingwall over an area of 70 x 5 metres, all without bolting.

However, a strike fault containing graphite and garnet is located continuously and parallel to the hangingwall of the deposit. This zone is 12 metres in true thickness and is separated from the ore zone by 5½ - 6 metres of competent rock. This area will probably require the most attention and study as it will undoubtedly control the size of openings in the stoping area.

2.4.2 Open Pit Mining Method

A small open pit will be developed to mine the top 50 metres of the orebody. The pit ensures recovery of this ore (not totally recoverable otherwise), reduces preproduction expenditures, and guarantees first throughput for the concentrator.

From the 930 metre contour on bedrock, the ore dips down slope towards the Goldstream River at angles varying from 35° - 46° to the horizontal. Assuming that the ore would be removed to the footwall contact, the slope of the resulting pit wall would correspond with the above range of dips. These would be safe, especially in a relatively shallow pit, which in this case would be approximately 70 metres in depth.

The ore body is in the form of a thin lense with a mean width of 300 metres and a thickness which varies from 3 - 6 metres. The length that would be contained within the proposed pit is approximately 100 metres.

It is proposed that the ore be mined in 10 horizontal benches, each 7.5 metres in height. A total of 360,000 metric tons (undiluted) of ore will be trucked to the concentrator, while 1,242,510 metric tons of waste (stripping ratio = 3.47:1) will be disposed of either in the tailings disposal area, plant roads, or disposal dumps.* Dwg. 4 shows a plan view of the pit and adjacent waste dumps while Dwg. 5 presents a typical section through the pit.

In order to minimize dilution of the ore by footwall waste, the ideal plan would be to mine up to the contact leaving a smooth wall with no berms on the footwall. The next best plan would be to leave 4 berms per 7.5 metre bench at widths of 1.83 metres - this could be achieved by using a conventional air track and a 6 foot burden.

The major equipment to be used in the open pit operation is as follows:

1 - 3-3/4" air track

1 - 5" air track

1 - D8 bulldozer with ripper and U blade

1 - D7 bulldozer with winch

2 - 6 cubic yard loaders

3 - 35 ton capacity haulage trucks

1 - 14 caterpillar road grader with wing

* Since there are no natural valleys near the pit, it is necessary to establish waste dumps on the hillside within a short haulage distance from the pit. Some of this waste rock material may be used for access roads and/or tailings dam construction.

Other auxiliary equipment such as pickups will be provided to service the operation. In the event that pit waste rock is also required for tailings dam construction, two additional haulage trucks and a D7 dozer would be needed. The entire life of the open pit operation would be in the neighbourhood of 15 operating months, plus an 8 month preparation program.

2.4.3 Underground Mining Method

The bulk of the ore reserves (roughly 90%) will be mined by underground methods. That part of the deposit which lies above the Goldstream River Valley will be developed by adits at the 845, 770 and 659 metre elevations.

The ore reserves below the valley bottom will be serviced by a combination of decline for men and material and a vertical shaft for muck removal.

The underground operation will employ a modified version of the Step - Room Mining Method. This particular method permits total mechanization of the stoping cycle, flood filling of the stope panels, and ultimate recovery exceeding 95%. Sections or panels are mined by open benching, followed by panel filling using deslimed tailings and underground waste rock. This method can best be demonstrated by referring to Dwg. 6.

Major underground equipment will consist of the following:

11 - 2 yard scoops

2 - 13 ton trucks

3 - 20 ton trucks

6 - 2 boom jumbos

The total material to be removed will consist of 3,350,000 metric tons (undiluted) of ore and 600,000 metric tons of waste. Muck from both the underground stopes and open pit will be dumped into ore passes and hauled by truck to the crusher bin.

2.4.4 Production Schedule

Equipment, ore storage, and crews are scheduled to meet the mill throughput of 1360 metric tons per calendar day, mining 2 shifts per day, 5 days per week. The small open pit will produce some 1,000 metric tons per calendar day for the first 15 months of production. This will permit a gradual run in of the underground section.

Primary access will be provided to 3 underground sections as of the first day of production. By the end of the first production year, all muck will be provided by these three full production sections plus development of the next section.

But before production can begin, a preproduction period of two years duration will be necessary. The activities associated with the construction phase are outlined in Figure 7.

2.4.5 Access and Service

Access to the ore above 700 metres will be via two additional portals at 770 and 845 metres. A decline developed off of the 700 crosscut would provide access to the 645 metre elevation. The portal locations are shown in Dwg. 8.

Haulage crosscuts will be driven in the footwall at 700 and 645 metres. This will enable ore from the stoping blocks to be dropped through ore passes to these levels where they would be loaded and hauled to the crusher bin dump.

Internal access between working elevations would initially be provided by declines in ore. However, during the second year of operation, backfilling would cut off this access. In order to permit final recovery of the ore, a decline would be driven in the footwall limestone to replace this access.

2.4.6 Mine Ventilation, Heating, Escape

Fresh air will be introduced at the 700 metre elevation. From here it will be distributed throughout the working stopes returning to the surface via the decline system at the 845 metre elevation.

Propane space heaters will supply mine air heating requirements. Portable units would be ideal as they could be split up or combined as development and mining moves down dip. In addition, the main ventilation raise is located near the compressor room in order to utilize waste heat from the compressors.

The escape route will be through the decline system.

2.4.7 Backfill System, Mine Dewatering

A backfill plant is located in the concentrator at the end of the flotation section. A backfill recovery of 45% is assumed yielding 550 metric tons per day of backfill which will be pumped from the concentrator to underground storage bins excavated above the 770 adit elevation. Distribution to the stoping areas will be by gravity through a drill hole system, and if necessary, pumped to the mining block above 770 metres.

Backfill water will drain to sill drifts on each stoping block where it will be collected and pumped to settling sumps at 770 metres for recycle through the backfill system. Excess water will be directed to the tailings line.

2.4.8 Future Development, Deep Ore

Access to the deep ore will be accomplished by combining a decline for men and material with a bored hoisting shaft for muck removal. The development program will comprise driving down dip in ore, drifting out to the shaft location, and boring the shaft by raise machine. A loading pocket, ore pass system, and footwall haulage drifts will move muck to ore bins which have been excavated in the rock at the surface. An inexpensive underground headframe will be excavated and muck flow will be incorporated into the existing crushing and conveying system to the concentrator.

2.5 PROCESSING

2.5.1 Crushing and Fine Ore Storage

Once the ore has been mined by either underground or open pit methods it will be hauled to a coarse ore bin which has been excavated in rock below the 700 portal. The coarse ore will then be crushed to minus 6" in a jaw crusher, also situated in rock below the coarse ore bin.

In order to minimize the peak power load, underground and surface crushing plants would operate on alternate 8 or 12 hour periods for 6 days per week. This type of scheduling will require a minimum storage capacity of 1750 metric tons of jaw crushed ore.

From the coarse ore bin, the ore will proceed by conveyor out of the mine to the secondary crushing and screening plant on surface where it will be reduced to minus 5/8". The surface crushing plant is of fairly standard design consisting of a 50" x 8' rod grizzly, 4¼' x 16' screen, plus conveyors and ancillary equipment. Both the underground and surface crushing plants are rated at 200 metric tons per hour.

The ore is then transferred by conveyor to a covered fine ore stockpile before grinding. Although the capacity of this stockpile need not exceed 2,500 metric tons, it has been designed to contain 3,600 metric tons in order to provide for more operating flexibility. Either an A-frame or circular dome could be used to cover the stockpile. Ore is withdrawn from the stockpile via a slot feeder. Dwg. 9 illustrates the various crushing stages of the process in a process flow sheet form.

2.5.2 Concentrating

The concentrator consists of three adjoining buildings: a 45' x 100' grinding bay, a 94' x 100' flotation area, backfill, pumping, office and dry facilities, and a 111' x 100' thickening, filtering, drying, and concentrate storage building. (see Dwg.10)

In the grinding operation two Hardinge Ball mills plus rod mill, which can deliver 1400 horsepower, are used to produce a grind of 85% minus 200 mesh. This system is capable of handling 1360 metric tons per day with an average operating time of 95%. Copper and zinc circuit regrind ball mills have been included in the flow sheet, (see Dwg. 9) subject to more detailed metallurgical testwork to determine their necessity.

A total volume of 6,750 cubic feet of conditioning and flotation capacity will be provided; this corresponds to 4.5 cubic feet per ton of ore treated. This total volume will be comprised of 4,650 cubic feet of conventional flotation cells and 2,100 cubic feet of Maxwell flotation cells. The requirement for conditioning time is not yet known but if little is required, the Maxwell flotation cells will perform well in their task of making high grade, intermediate, or even final concentrate from the most floatable material as well as stabilizing feed grades to the conventional cells. The quantity and type of conventional flotation cells is subject to change as metallurgical testwork continues. Allowance for extra cells has been provided in the flotation circuit layout which is shown in Dwg. 9.

In the next stage of the operation, concentrate flows by gravity to the thickeners, from where it is pumped into surge tanks. Copper concentrate filtering and drying is a continuous operation, while zinc concentrate is filtered and dried for about 8 hours per day. Copper concentrate can be dried to 6 - 7% moisture content if required, whereas zinc could be dried to a lower moisture limit if necessary.*

Concentrates are then stored on covered concentrate pads from where they are loaded by front end loader into trucks and hauled to Revelstoke for transshipping into rail cars, or in the case of zinc concentrate, probably trucked directly to Trail, B.C.

Metal recoveries have been estimated at 93% for copper and 40% for zinc. Continuing testwork should improve these results, particularly zinc recoveries.

2.6 INFRASTRUCTURE

2.6.1 Road Access

Highway 23, a paved highway, runs north from Revelstoke along the east bank of the Columbia River, a distance of 88 miles

* Dwg. 10 illustrates the general arrangement plan for grinding and concentrating while Figure 11 presents a water balance for the processing operation.

to Mica Creek. Mica Creek is the location of the latest B. C. Hydro dam to come on stream as part of the Columbia River development.

From mileage 50 on Highway 23, access to the mine is via Forestry road. This roadway consists of 3 miles of off site access road from Highway 23 to the plant property and 4.6 miles of on site access road along the existing "middle road" to the plant site.

The road is presently in good condition from the highway to the plant property although a half to three quarter mile section would require only minimal work to restore it to very good condition. Considerable work will be required to upgrade and stabilize the road where it traverses the Old Goldstream River (Goldstream Creek). From here to the plant site the road is narrow and the grade steep. There is also a sharp drop off from the outer edge of the road which may not remain stable under continuous heavy haulage.

The "middle road" at the present time is only suitable for truck travel and is washed out by creeks at several locations. Apart from sizing culverts or constructing small timber structures over streams, construction of the "middle road" up to Brewster Creek should present no problems.

A bridge across Brewster Creek is required as there is evidence that the flow is quite substantial at times. Stream flow records are not available. Further studies are required to determine the most suitable location of the bridge.

From Brewster Creek to the camp site and on to the plant site, no problems are anticipated. The road would follow the contours and grades would be within acceptable limits, some culverts over small creeks would be required.

The sandy boulder overburden will generally be suitable to use for constructing the road. Hauling and rock cuts will be quite small. With the exception of one location all grades will be less than 6%.

2.6.2 Energy Options

General

Energy requirements for the Goldstream mining and concentrating plant, have been initially estimated at 30,000,000 kwh per year, rising to 34,000,000 kwh per year later in production life.

The various energy options investigated by Project Consultants, used the above requirements as a basis for comparison purposes. These options were: 1) Diesel generation 2) B. C. Hydro supply from Mica Creek 3) Local hydro generation with diesel supplement.

Diesel

The most attractive feature of a diesel generating plant is its capital cost. A plant of sufficient capacity to operate the

Goldstream Mine, could be installed for $2,000,000. It has good flexibility in that additional power requirements can be easily provided by adding units.

However, the operating costs, (at $2.2 million annually) of a diesel plant are higher than the other alternatives. In addition, the price of diesel oil is probably the commodity most sensitive to future inflation.

B. C. Hydro

Noranda commissioned a study by B. C. Hydro to determine the cost of providing power to the Goldstream site. BCHPA concluded, after investigating several options, that power could be made available to Goldstream. However, the cost of a new corridor from either Mica Creek or Revelstoke was prohibitive. They reluctantly proposed that the only viable option was the installation of a 138,000 Volt line from Mica Creek substation, contained in the same corridor as two 500,00 Volt lines feeding power to the main Provincial Power Grid.

The capital cost to bring power to our property boundary was estimated at $7.9 million dollars. Added to this would be our own cost for a High Voltage substation, plant distribution, diesel standby and initial operation.

The advantages of B. C. Hydro supply are obvious. From an operating point of view, it is the most reliable option, most flexible, and has the most capacity for plant expansion. It has less impact on the environment than would local hydro generation.

However, the extremely high capital cost, over which we would have little control, and higher operating costs which could very well inflate at a rate faster than world oil prices, have a significant detrimental impact on return on investment.

Local Hydro

Several potential hydro generation sites are available in the Project area. The proposed reservoir would be developed on the Goldstream River, by the construction of an earth filled dam at a point 11 Kilometres above its confluence with the Columbia River.

The "Sweeper Bill" dam and reservoir location was selected as the best combination of acceptable power generation capacity and least environmental impact. The high water elevation of the reservoir has been engineered so as not to flood an area of good winter range for ungulates. As a result, it will be necessary to provide about 12% of total power requirements by diesel generation.

The disadvantages of the local hydro option, are a less desirable impact on the environment, and a more troublesome operating situation for future management. In addition, should power requirements increase, additional capacity must come from higher cost diesel generation.

Capital Cost Comparison

	B.C.Hydro	Sweeper Bill	Diesel
Mica Line	7,900,000	N/A	N/A
High Voltage Substation	350,000	N/A	N/A
Camp, Tailings, Plant Dist.	220,000	220,000	220,000
Diesel Power Plant	600,000	600,000	2,000,000
Sweeper Bill Dam	N/A	1,624,000	N/A
Spillworks, Penstock	N/A	2,793,000	N/A
Generating Station	N/A	783,000	N/A
Sub-Total	9,070,000	6,020,000	2,220,000
Engineering	75,000*	390,000	200,000
Contingency	109,000*	530,000	365,000
Total Capital	9,254,000	6,940,000	2,785,000

*Exclusive of Mica Line Estimates

Operating Cost Comparison

	B.C.Hydro	Sweeper Bill	Diesel
Consumption (KWH) Year	34,000,000	34,000,000	34,000,000
Hydro Generation	34,000,000	30,000,000	Nil
Diesel Generation	Nil	4,000,000	34,000,000
Costs -			
Hydro @ $ .0117	400,000	N/A	N/A
Hydro @ .0007	N/A	20,000	N/A
Diesel @ .065	N/A	260,000	2,210,000
Heat Saving	-	80,000	160,000
Total Annual Cost	400,000	200,000	2,050,000
Escalation (5 Years)			
Annual Rate	10%	10%	10%
Total Annual Cost (Year 5)	645,000	322,000	3,300,000

Summary

Noranda has made a major effort to resolve the energy problem. The economics of mining in Canada today, dictate that every cost benefit possible be incorporated into a new investment situation.

It is therefore considered critical that the significant benefits available from the generation of power on the Goldstream River be made available to the Project.

Proposed "Sweeper Bill" Hydro Plant

Description

The dam site is located east of the confluence of Sweeper Bill Creek and the Goldstream. The dam is an earthfill dam, 32 metres high, with a crest elevation of 730 metres.

The dam design would incorporate a method of removal at the end of its useful life.

The reservoir developed by this dam extends east a distance of 4,000 metres, with a pool capacity of 9,000 acre feet at Flashboard crest.

A free crest spillway is to be located on the left abutment leading to a stilling pond with deflector and weir, with a total capacity of 12,400 cfs.

An 84" diameter penstock 3,300 metres in length leads to the generating station located downstream of the dam and within 1,000 metres of the Mine Plant area.

The generating station would have an installed capacity of 5 MW, operating at 80% efficiency for 4 MW production. On this basis and using 13 years water flow records as a check, average diesel backup required for 6 winter months is 1.18 MW.

<u>Project Consultants</u> (Reports Available)

M. A. Thomas and Associates Ltd., of Vancouver, B. C. have provided plant power requirements, and capital and operating costs for the various options.

Sir William Halcrow and Partners (B. C.) Ltd., have provided the plant design and capital cost estimates for the generating station, penstock, spillworks, etc.

Klohn Leonoff Consultants Ltd. of Vancouver, have provided the geotechnical services and design and estimates for the earth filled dam.

International Environmental Consultants Ltd., have provided environmental background surveys for the overall mine project, as well as site specific information on the reservoir area.

<u>Environmental Studies</u>

I. E. C. of Vancouver have conducted two surveys in the Goldstream project area and are presently conducting a third.

The first report, "Preoperational Monitoring and Biological Inventory of the Goldstream River", reviews fieldwork completed during 1976. The Index page and Summary of this report are included.

The second report, "Goldstream River Fish Inventory (1977)", reviews fieldwork completed during 1977. The Index page and Summary of this report are also included.

Currently, I. E. C. are conducting a Wildlife survey in the Project area, and a preliminary report has been prepared for this report. (Bib. item 7)

The project area is on land held under Tree Farm Licence #23 by Canadian Cellulose Co. Limited, and is covered by a Resource Folio which provides much additional general background.

2.6.3 Water Supply

Brewster Creek has been selected as a source of fresh water. Although there are no flow records available it has been assumed that there are year round flows in excess of the 700 US gpm maximum required.

Water samples taken by I. E. C. of Vancouver indicate the water is suitable for domestic purposes. Filtration may be necessary to remove mica flakes.

Process water will be provided by a combination of reclaim from the tailings pond, reclaim from underground drilling, backfilling and mine inflows, with necessary makeup fresh water being derived from the Sweeper Bill penstock.

2.6.4 Sewage Disposal

Separate sewage treatment facilities will be provided for the camp site and plant area. Both aerobic sewage lagoons and activated sludge package units will be considered. Effluent from either system might be discharged to the Goldstream River which would provide the necessary dilution required by the Department of Health.

An aerobic sewage lagoon would consist of two earth berm cells with retention times of 5 days and 15 days. The depth of the sewage would be approximately 12 - 14 feet. Subsurface aerators would bubble air through the sewage to provide the oxygen necessary to maintain bacteria growth and keep the sewage from turning septic. Maintenance of such a plant is minimal. Alternatively, a prefabricated activated sludge package requiring less space but slightly higher maintenance and operating costs could be constructed. In either case, the sewerage system (see Dwg. 4) will be designed and constructed in accordance with the regulations of the Health Act.

2.6.5 Tailings Disposal

After backfill removal, the tailings are pumped directly uphill to the 730 metre elevation from where they flow through a 10" high density polyethylene pipeline to the tailings disposal site. This site is located some 3 miles west of the plant in a dammed off valley directly west of Brewster Creek. (see Dwg. 2)

The tailings impoundment area is part of an open ended valley 3,300 feet long by 1,000 feet wide at the proposed main dam location. The valley bottom slopes an average of 2% downstream and has a relatively flat bottom. The area available to the 690 metre contour level in the disposal site is 55 acres. After subtracting backfill, 1.65 million metric dry tons (1,030 acre feet) of tailings require storing. (see Dwg. 18)

Having investigated several alternate disposal methods, the following approach is proposed:

1. End spill tailings at the valley head (east end) and obtain a tailings slope of about 0.25%.

2. Construct a 60' - 65' high by 1,000' long main rock dam with an impermeable core of fine tight till or clay about 3,300 feet downstream from the spill point. This dam would be constructed in stages, as required, throughout mine production.

3. Construct two small tailings retaining dams at the valley head and one dam on the north side of the disposal site. These dams are also to be constructed with impermeable cores.

4. Construct a 15' high by 300' long impermeable seepage

control dam downstream of the main dam and also provide effluent treating capability should this prove necessary.

5. Water from the main dam pool will be reclaimed by returning it to the concentrator via a 20,000 foot long 10" high density polyethylene pipeline.

6. Diversion ditches along the south edge of the disposal area will be constructed to intercept run off and divert it around the tailings disposal area. These ditches will follow the "middle access road".

7. Site investigation by Klohn Leonoff have confirmed the feasibility of the dam constructions.

About 450,000 metric tons of waste rock from the open pit operation will be available prior to production to start the main dam. Thereafter, 700,000 metric tons can be utilized during the first 3 years of production.

According to the water balance (see Fig. 11) there will be a surplus of water in the tailings pond. Depending on the circumstances, water from the seepage collection pond will be either pumped back into the main dam or released to the natural water course.

2.6.6 Accommodation

Manpower requirements will peak at about 250 during the preproduction period and stabilize at 185 employees during operations.

Temporary single status accommodation will be established at the mine site for the excess construction crews during the preproduction period.

The most acceptable type of accommodation for operating personnel would consist of family housing units located in Revelstoke. Permanent top quality single status accommodation will be provided at the mine site. In addition, 6 - 10 housing units will be purchased in Revelstoke for senior staff members. After the demand by dam employees begins to slacken it will be possible to provide assistance to any employee seeking to purchase a house in Revelstoke.

Camp accommodation will be located east of Brewster Creek utilizing an area of 25,000 square feet.

3.0 EFFECTS OF REVELSTOKE DAM CONSTRUCTION

On December 1st, 1976, Water Comptroller, Howard Debeck granted the British Columbia Hydro and Power Authority the right to construct and operate the Revelstoke 1880 Project. The project will consist of a dam located three miles north of the city of Revelstoke creating an eighty mile long, one half mile wide reservoir up to Mica Dam.

As of 1975, Revelstoke had 8,000 people with an economy that showed slow growth. The population will increase by 3,500 as dam construction proceeds, peaking in 1981; about 2,100 of these would reside in the single workers' camp. By 1983 there will be a major economic turndown; however, in 1981 at the height of construction, workers will spend some $3.4 million in the area. Most of the additional residents will probably leave Revelstoke by 1984 resulting in a long term population increase to the city of 150.

The effects of this large workforce on the well ordered life of Revelstoke could be severe. B. C. Hydro will contribute significantly to expand existing services in order to accommodate a 50 percent population increase for a short period.

Roughly half of Revelstoke's current population will receive no benefit from the project, but rather experience loss through price increases.

The Goldstream Project will be adversely affected in three main areas. First, costs of services as well as materials and housing will increase. Second, Revelstoke will probably not be available to absorb additional families until 1983. Finally, significant traffic delays may be expected due to construction near the dam site and due to the relocation of Highway 23.

4.0 DESCRIPTION OF EXISTING ENVIRONMENT

4.1 Climate

Climatic data is available for Revelstoke and for Mica Dam, at elevations of about 1,500 feet and 1,900 feet respectively, and is shown in Table 1. Temperatures vary from south to north as follows: mean annual minimum, -30^{o} to -35^{o} F; mean annual maximum, 105^{o} to 97^{o} F; mean annual temperature, 45^{o} to 40^{o} F; annual snowfalls range from 162 inches to 290 inches, with an average annual precipitation of 43 inches to 57 inches. The frost free period is estimated at 100 days. In general terms total precipitation increases northwards and with elevation above the valley bottom.

The Goldstream Valley lies in the South Interior climatic region of the province. Maritime influences are strongest in the winter while continental influences predominate in the summer, thus the climate is characterized by cold, wet winters and warm to hot summers.

In winter, freezing temperatures are the result of the southward movement of the continental Arctic air which on occasions may be forced over the Rocky Mountains. On the average, an invasion from this extremely cold air mass may be expected once a year in the South Interior region.

In summer, the eastern portion of the region receives some

TABLE 1

CLIMATIC DATA FOR REVELSTOKE AND MICA DAM

Month	MICA DAM - El. 1900 (7 years of record)					REVELSTOKE - El. 1497 (66 years of record at Revelstoke + 3 yrs. at Revelstoke Airport)				
	mean daily temp. (°C)	extreme maximum temp. (°C)	extreme minimum temp. (°C)	Precipitation		mean daily temp. (°C)	extreme maximum temp. (°C)	extreme minimum temp. (°C)	Precipitation	
				total (inches)	Snowfall (inches)				total (inches)	Snowfall (inches)
January	-10.4	5.0	-33.9	8.1	76.2	-5.9	10.6	-34.4	5.8	49.4
February	- 5.3	6.7	-23.3	6.0	47.4	-1.8	12.8	-32.2	4.1	31.1
March	- 1.3	12.8	-23.3	5.1	31.0	1.9	22.2	-22.2	2.9	10.5
April	3.5	18.3	- 8.3	3.3	3.3	7.2	28.3	-15.0	2.0	1.0
May	9.3	27.8	- 3.9	2.2	Trace	12.8	37.2	- 6.7	2.1	Trace
June	14.5	35.6	0.0	2.4	0.0	16.4	36.7	- 1.7	2.8	0.0
July	17.1	36.1	3.3	2.2	0.0	19.4	40.6	0.6	2.1	0.0
August	15.8	35.0	2.8	2.9	0.0	18.2	38.3	- 6.1	2.2	0.0
September	11.4	28.9	- 2.8	2.7	1.4	13.7	37.2	- 6.7	2.8	0.0
October	4.9	18.3	- 5.6	6.1	3.8	7.0	25.6	-12.2	4.0	1.3
November	- 2.1	9.4	-19.4	7.3	45.0	0.8	15.0	-22.8	4.8	19.2
December	- 7.2	3.3	-37.2	9.0	81.8	- 3.6	17.2	-32.8	5.7	42.5
Annual	-	-	-	57.3	289.9	-	-	-	41.3	155.0

[1] Environmental Research Consultants, "Revelstoke Project:Environmental Group II Studies"May/76

of the highest summer temperatures in western Canada as a result of warm continental air from the hot western plateau of the United States. Maximum monthly mean temperatures occur in July and August while the corresponding minima occur in December and January.

Annual precipitation is generally heavy with the majority occurring during the winter months as snow. Each of the summer months receives roughly 2 inches of rainfall. Snow may fall at Revelstoke during the months of October to April and at Mica Dam from September to May inclusive. The quantity of snowfall in the region between Revelstoke and Mica Dam increases rapidly with elevation; in general terms, land at an elevation of about 6,000 feet receives 60 to 120 inches per month more snowfall than Revelstoke. Depths of snow in the valley bottoms are small as compared with those that accumulate on the adjacent mountain ranges.

Prevailing winds in the area correspond to the alignment of the Columbia Valley and are generally southeasterly in winter and northwesterly in summer.

4.2 Geology, Landform, Soil

The Selkirk Mountains define the bedrock geology of the Goldstream region. The Selkirks are characterized by the presence of lower grade metamorphic rocks of Paleozoic age. Rock types occurring in significant amounts include: carbonaceous slate, phyllite, quartzite, crystalline schist and gneiss.

Three phases of surficial material, exclusive of consolidated bedrock occur in the Goldstream River Valley. The first phase consists of colluvial and alluvial fan materials. The Columbia River has been subjected to glacial scour. As a result the Goldstream's U - shaped valley has become a "hanging valley", dropping sharply towards the Columbia in its lowest reaches. The extreme steepness of the valley sides has encouraged avalanches, rock slides, and mass - wasting, thus areas of colluvial accumulation and alluvial fans have developed.

Alluvium, (sorted material deposited by flowing water) is usually moderately well to well sorted and moderately well to well stratified. The texture varies but few boulders or coarse fragments are found. Alluvial fans consist of unconsolidated materials of varying textures and soils - mainly sands and gravels on 0 - 50% slopes. Fans are the deposition of alluvium made by a stream where it runs out onto a level plain or meets a slower stream. Alluvial terraces are found in the lower reaches of the Goldstream River and Old Goldstream River. They consist of a platform of bedrock mantled with a sheet of gravel and sand passing upwards into finer alluvium (silt and clays). These terraces are relatively flat (0 - 5%) and are terminated by an abrupt change in slope.

Colluvium (loose material accumulated on and at the foot of slopes by various processes of mass movement) is usually unsorted to crudely stratified and of highly variable texture depending on the source material. Slopes are usually greater than 60%. Colluvial soils generally provide a good source of road surfacing materials if they are shaly or gravelly. Most of the colluvial material in the valley occurs as a veneer, that is less than one metre deep with very steep slopes. Traces of colluvial fans and aprons may also be found.

The second phase is comprised of morainal materials (i.e. of glacial origin). During the recession of the valley glaciers, a mantle of glacial till was left over portions of the valley slopes. About half of this material occurs as a veneer while the other half takes the form of a blanket on the steep slopes, a terrace on a series of ridges all with a depth of at least one metre. Generally these tills are an unstratified, unconsolidated mixture of clay, silt, sand and gravel and sometimes boulders. Finer textured tills are usually quite productive; however, slumping is common on steep slopes and roads located through them are usually subject to frost boils in the spring. On slopes greater than 50%, road construction should be minimized. The limits to regeneration include frost heaving on fine textured soil, moisture deficiency on coarse textured soil, and unstable soil surfaces on steeper slopes.

The third phase consists of alluvial and organic deposits. Since the end of glaciation, the Goldstream River has transported sediments and deposited them on top of outwash and lacustine material, forming a complex stratigraphy in some areas. Organic deposits develop in the flatter poorly drained areas on recent alluvium. The Goldstream Valley contains some extensive areas of organic terrain.

Soil resources are not well documented for the Goldstream Valley; however, the following general comments can be made. Orthic humo - ferric podzols predominate on colluvial and morainal deposits. These coarse textured soils have pH of about five and generally become less acid with depth. Regosols and organic soils are situated on alluvial deposits. These soils however, are not as acidic as the upland soils, thus providing higher intrinsic productivity.

Dwg. 12 employs Fulton's Landform Scheme to present the soil and landform capability of the Goldstream River Valley.

4.3 Vegetation

Three broad vegetation patterns occur in the Goldstream drainage and surrounding area. Coniferous forest vegetation, characteristic of the Interior Western Hemlock Zone, occupies the valley bottoms and lower slopes of the steep sided mountains to elevations of roughly 4500 feet. On higher slopes, mountain shoulders, and ridge crests, subalpine vegetation (Engelmann Spruce - Subalpine Fir Zone) is dominant. Beyond the tree line (7000 - 7500 feet), the subalpine vegetation gives way to alpine vegetation (Alpine Tundra Zone) characterized by low shrub and herbaceous cover. These three main vegetation patterns are shown in Dwg. 13.

Several tree species occur in the Interior Western Hemlock Zone including: western hemlock, western red cedar, douglas fir, subalpine fir, cottonwood, spruce, alders and willows. Characteristic climax forest cover of this zone is dominated by western hemlock and western red cedar. Peatland habitat occupy poorly drained areas along French Creek and Goldstream River in comparatively large areas. Some of the common shrubs associated with the cedar and hemlock dominated forests include: blueberry, devils club, false azalea, elderberry, red twinberry, alders and willows.

Engelmann spruce, subalpine fir, and to a lesser extent mountain hemlock characterize the mature forest cover of the Engelmann Spruce - Subalpine Fir Zone. At lower elevations in this zone and up to approximately 6000 feet, the forest cover is largely continuous. With increasing elevation, snow depth and duration, the forest cover thins and trees occur in clusters. Conifers in this region support lichens, thus providing an important winter browse for caribou. Some of the shrubs associated with this zone include: huckleberry, rhododendron, false azalea, mountain ash, alder, elderberry and willows.

Tree species are absent from the alpine zone. Habitats of the zone support only low shrub cover or crowberry patches, dwarf willow, sedge, grass or herbaceous cover. Many of the alpine

TABLE 2

GOLDSTREAM RIVER BELOW OLD CAMP CREEK

MONTHLY AND ANNUAL MEAN DISCHARGES IN CFS

YEAR	JAN.	FEB.	MAR.	APR.	MAY	JUNE	JULY	AUG.	SEPT.	OCT.	NOV.	DEC.	MEAN
1964	213	167	153	330	1630	4830	4340	2030	1380	1290	672	371	1450
1965	266	196	181	609	1950	3870	3020	2100	741	775	672	353	1230
1966	337	273	226	545	2590	4290	4100	2190	1220	821	511	316	1460
1967	276	279	204	318	2190	6590	4460	2180	1350	780	554	282	1630
1968	248	245	300	404	2380	5080	4950	2230	1650	990	691	-	-
1969	215	215	262	836	3050	4750	2450	1520	1060	838	551	376	1350
1970	269	273	213	276	1650	4680	2790	1620	825	553	306	229	1140
1971	203	252	194	424	3120	4350	3190	2120	929	666	358	199	1340
1972	180	189	246	337	3040	6440	4400	2420	867	590	364	238	1610
1973	181	188	213	410	2310	3840	3070	1690	794	625	387	258	1170
MEAN	239	228	219	449	2391	4872	3677	2010	1082	793	507	291	1376

TABLE 2A

STITT CREEK AT THE MOUTH

MONTHLY AND ANNUAL MEAN DISCHARGES IN CFS

YEAR	JAN.	FEB.	MAR.	APR.	MAY	JUNE	JULY	AUG.	SEPT.	OCT.	NOV.	DEC.	MEAN
1974	15.8	16.3	17.2	65.0	606	634	974	882	500	143	60.2	35.7	329
1975	39.5	22.4	15.7	22.0	242	704	825	375	191	109	99.5	20.5	222
1976	36.7	25.6	23.2	73.0	209	978	1130	684	301	117	58.5	36.0	306
MEAN	30.7	21.4	18.7	53.3	352	772	976	647	331	123	72.7	30.7	286

communities lack a closed plant cover because of unstable ground conditions and short growing season so that productivity is low. Ground surface lichens as well as bryophytes may dominate the vegetation cover in particular communities.

4.4 Hydrology

The Goldstream River originates in the Selkirk Mountains and flows in a westerly direction to its confluence with the Columbia River. Rapids characterize the upper reaches of the Goldstream River where Stitt Creek and Norman Wood Creek are the main tributaries. Once the river reaches the mine site, sorting and deposition of material begins as the river exhibits irregular meanders and sand bars. The principal tributaries in this section of the river include French Creek, Brewster Creek, McCulloch Creek, and Old Camp Creek. Below Old Camp Creek, Goldstream River transforms from its tranquile state to one which includes rapids and a set of waterfalls before it empties into the Columbia River.

A large portion of the basin's annual precipitation falls on high, mountainous terrain where it accumulates through the winter in extensive snowfields and glaciers. In its natural state, therefore, the Goldstream is a typical snowmelt river. Its regime is characterized by high flows from May until August and flows below the annual mean during the other eight months of the year. The natural mean monthly flows are highly variable; the magnitude and relative position of the annual peak in the hydrograph is dependent upon the rate of melting of the snow pack as well as its extent.

Data published by the Water Survey of Canada include flow measurements at Stitt Creek and at Goldstream below Old Camp Creek. From 19 years of records, the latter station which comprises a 362 square mile drainage area, has a mean annual flow of 1380 cfs, a minimum daily flow of 142 cfs, and a maximum daily flow of 15,100 cfs. Further data for both these stations has been assembled in Table 2. It should be noted that the total drainage area of the Goldstream River is 365 square miles.

4.5 Aquatic Ecology

Rivers and streams, in contrast to lakes, rely to a large extent on ditrital food chains to support their invertebrate and fish populations. Some primary productivity does occur in situ from small plants, such as diatoms and algae, that live on the surface of the gravels and stones in the stream bed. As a result of unstable beds, changing currents, turbulence, turbidity and shading, flowing water systems depend primarily on leaves, twigs, branches, logs and other terrestrial material to provide food for stream invertebrates.

Secondary productivity was determined by Surber sampling of aquatic insects in stream gravels. Results of field work completed by International Environmental Consultants Ltd. during 1976 may be found in Appendix I.

Data compiled for B. C. Hydro's Revelstoke 1880 Project also included Surber sampling of the Goldstream River.[1] Two stations were established - one located near the mouth of McCulloch Creek and one between McCulloch Creek and Old Camp Creek. Three samples were taken at each site. The results of this study indicate a mean number of 157 organisms per square metre of river bottom. In all, 14 different taxa were identified. Of these, 69.4% were Ephemeroptera (mayflies). The results compiled for B. C. Hydro indicate that Goldstream River is moderately productive.[2]

B. C. Hydro also had a water quality station located at the mouth of the Goldstream River. Water chemistry parameters and corresponding concentrations are as follows:[3]

Total Dissolved Solids	102 - 120 ppm
Total Suspended Solids	13 - 15 ppm
pH	7.4 - 7.7
Colour	4 - 16
Hardness	65 - 66 ppm
Nitrates	0.2 ppm
Phosphates	0.2 ppm
Alkalinity	60 - 63 ppm
Calcium	26 ppm

[1] - Reference 4, Page 3 -54
[2] - Reference 4, pp 3 - 53 to 3 - 63; Appendix V; Fig. 3.14; Fig. 2.1
[3] - Reference 4, Appendix V

Corresponding results obtained by I. E. C. may be found in Appendix I.

I. E. C. carried out an Inventory on Fish in the Goldstream (Appendix I), and identified yellowstone cutthroat trout and mountain whitefish. E. R. C.[1], and Canadian Cellulose make mention of observations of both these fish. Due to the migration blocks only 8000 sq. metres of Goldstream River habitat is available to fish from the Columbia. Resident fish have the remaining 210,000 square metres of stream habitat above the falls.

The suitability of the Goldstream River as a fish habitat has been inventoried.[2] A plan and profile of the Goldstream River watershed is shown in Dwg. 14.

4.6 Wildlife

Due to the complex nature of habitat present in the area, the Goldstream Valley supports a good variety of mammals and resident migratory birds, none of which are considered as rare or endangered species.[3]

Wild ungulates occurring in the Goldstream Valley include moose, caribou and mountain goat (see Dwg. 15). The valley bottomlands of the Goldstream River below the confluence of Goldstream River and Stitt Creek as well as portions of Old Goldstream River have slight limitations to the production of ungulates and are an important winter range for moose; snow depth is the major limiting

1 - Reference 4, pp 3 - 56 to 3 - 57; Fig. 2.1
2 - Reference 4, pp 3 - 58 to 3 - 59
3 - This is generally true of the Columbia watershed between Revelstoke and Mica Dam. (see Reference 1, page 6 - 29)

factor. Caribou habitat is situated in the Brewster Creek, Old Camp Creek, McCulloch Creek and western French Creek drainages mainly above the 5000 foot elevation level. The northern exposures with moderate slopes serve as the most important winter range areas. Ungulate movement across the Goldstream drainage occurs mainly along the ridge between McCulloch and French Creeks, across the Goldstream River and up Brewster Creek.[1]

Large mammals in the area include grizzly and black bears. A further description of these and other mammals inhabiting the Goldstream drainage is presented in Appendix I.

Several dominant factors influence the suitability of wildlife habitat in this area. Climatically, it is situated in the Interior Wet Belt, or Columbia Rain Forest; heavy snow accumulation and abundant summer rainfall are common. The topography is rugged with U - shaped glaciated valleys originating in ice or snowfields and traversing alpine, subalpine and finally conifer forests. Repeated snow avalances on steep sided valleys clear tracts of luxuriant forest vegetation and its heavey underbrush. Such harsh conditions favour some species such as moose, caribou and grizzly bear while restricting deer, ruffled grouse and coyote.

Waterfowl use the area primarily for staging and nesting. Habitat selected for these purposes include the margins of slow moving streams, small ponds or lakes offering cover and producing

[1] - Reference 2, page 14

aquatic vegetation. The Goldstream River contains 148.0 acres of lake, 835.2 acres of swamp, and 183.2 acres of tree swamp among its total acreage of 1166.4[1]. On the area surveyed by Entech in 1975, their report concluded: "the most extensive and highly populated marshes occur above the zone of influence in the upper reaches of the Goldstream River, Old Goldstream and Downie Creek".[2]

4.7 Present Land Use

Land use in the valley is dominated by commercial forestry. Aside from mineral exploration and placer gold mining, outdoor recreation activities also occur but to a much lesser extent. Agricultural activities are non - existent.

The Goldstream valley is presently held under Tree Farm License 23 by Canadian Cellulose (see Dwg. 2). Until recently Can Cel have logged the areas adjacent to the Goldstream River; however, a government stop order has restricted the use of the "lower road" for planned forest extraction programs. Can Cel indicate they will probably not require the use of either the "lower", "middle", or even "upper" access road until 1980.

Present mining activity in the area, aside from our own takes the form of placer gold mining on French and McCulloch Creeks. Only several individuals are involved.

1 - Reference 4, page 3 - 117
2 - Reference 4, page 3 - 115

The Goldstream River is the only tributary of the Columbia between Revelstoke and Mica Creek that has a viable potential for hydro power. Downie Creek is not being considered, as possible dam sites are difficult and expensive. The Goldstream flat valley floor has an elevation of about 2,100 feet within one mile of the Columbia River where the elevation is 1,800 feet. Studies have shown that if a head of 400 feet could be attained, with a reservoir of adequate storage, then roughly 40 MW of firm (continuous) power could be produced at this site. However, there are no known plans to develop the hydro power potential of the Goldstream River [1] by BCHPA.

Hunting activities between Revelstoke and Mica Creek are primarily pursued in the side valleys of the Columbia, particularly the Goldstream drainage; local resident indicate that the Goldstream provides one of the most accessible wildlife habitat and hunting areas in the Revelstoke area.[2] Moose is the primary big game species pursued, with only small harvests of caribou and minimal hunting of waterfowl. In the last few years, the Revelstoke/ Mica Creek area moose harvest has fallen below average; this may indicate that the moose population is being over harvested.[3] A local outfitter operation hunts in the Goldstream Valley, while the status of trapping is not known at this time.

[1] - Reference 1, page 7 - 15
[2] - Reference 1, page 7 - 16
[3] - Reference 4, page 3 - 122

Non - consumptive wildlife users in Revelstoke likely devote much of their interest to the Goldstream drainage as there is relatively easy access and moderate quantities of game[1]. At present no reasonable methodology exists to estimate the social value of these non - consumptive wildlife activities. The users are likely comprised of area residents with a smaller tourist component.

Anglers have reported a lightly utilized fishery for Yellowstone cutthroat trout in the Goldstream River system[2]. The main fishing in the Revelstoke area is done in the Arrow Reservoir where rainbow trout, Dolly Varden and Kokanee are caught.

Dwg. 16 indicates the recreational inventory and capability of the area. Stitt valley offers some potential and is an important contiguous zone to recreational designation and use of the Remillard - Adamant - Sir Sanford complex. But since the present use of upland areas is functionally related to the availability of access, the upland areas of the Goldstream drainage do not demonstrate a high potential for facility development. It should be noted that no ecological reserves are located in the Goldstream River Valley.

The final aspect of land use of significance is the fact that Highway 23 is supported by borrow pits and a maintenance establishment in the Old Goldstream channel.

1 - Reference 4, page 7 - 23
2 - Reference 1, page 7 - 25

5.0 PRESENT SOCIO - ECONOMIC STATUS

5.1 Background

The historical development of Revelstoke as a community can be divided into four major periods of growth. The first period begins with fur traders and surveyors who used the Columbia River as one of their main routes. Second Crossing was known as a trading, trapping and fishing centre during those years of exploration in the early 1800's. In 1865 - 1866 came news of placer gold fields in the Big Bend country focussing on Downie Creek and Goldstream River. Thousands of men rushed to the area but soon left.

The second period encompasses 1880 to 1890 with the coming of the Canadian Pacific Railway. During the late 1880's, the townsite of Donald, 20 miles north of Golden, was abandoned and the C. P. R. divisional headquarters moved to Revelstoke. It was at this time (1889) that Revelstoke was incorporated as a city, named after Lord Revelstoke, head of an English banking firm, that helped to finance the construction of the railway. It was the coming of the C. P. R. that ensured the establishment of Revelstoke as a viable community.

The third period, from 1890 to 1960, saw the population stabilize to a slow but steady rate of growth. Revelstoke became established as the transportation centre for C. P. R. activities in the region. By 1905, Revelstoke had a thriving lumber mill operation.

The fourth period, from 1960 to the present, has been a time of more rapid growth as a result of two major construction projects in the area; the building of the Trans Canada Highway route through Rogers Pass and the Mica Hydroelectric Project. These developments, particularly the former one, have introduced tourism as an important component of the community's economic base. From its inception, Revelstoke has become an established community which still relies heavily on the C. P. R. for its viability.

5.2 Present Day Revelstoke

Within the Columbia - Shuswap Regional District, the greatest economic activity as well as population is centered in Revelstoke and its environs which had a population of roughly 8,000 in 1975. Revelstoke is somewhat isolated, yet is a well established community with a long history of slow but steady growth. As shown in Dwg. 17, the main settlement is located on a bench on the east bank of the Columbia River, overlooking the northern end of the Upper Arrow Lake reservoir. The city encompasses a relatively small area of about 1,100 acres with the central business district occupying twelve city blocks. Residential land surrounds the business core, and extends south and southeast toward the Illecillewaet River.

Although the existing land area within the boundaries of the City of Revelstoke is nearing full development, there are two areas which have vacant land capable of accommodating future growth.

Big Eddy is located on the west bank of the Columbia River opposite Revelstoke, while Arrow Heights is situated on a plateau south of the Illecillewaet River.

Residential development in Revelstoke and surrounding areas is generally in the form of single family detached units, many of which are mobile homes. The present supply of housing in Revelstoke is almost completely utilized. Few, if any, vacant homes are available and rental accommodation is extremely scarce. The main reason for the shortage is the fact that there exists a restricted supply of serviced land. Also, Mica Project workers have attempted to secure housing in Revelstoke in anticipation of the Revelstoke 1880 Project. A possible increase in housing could come from Central Mortgage and Housing Commission's demonstration development in Revelstoke. This could provide housing for 100 - 150 families.

At present, the C. P. R. employs up to 750 people in the Revelstoke area; this amounts to 20% of the local labour force. Sawmilling is the second major employer. Four sawmills now employ 250 people. The future of sawmill activity in Revelstoke is uncertain at this time as there is no secure long term source of logs. Tourism is the final major employer. The accommodation and food service sector employs 450 people for part of the year. Community leaders look upon tourism as a likely source of long term ecomomic growth. Steps are being taken to develop this potential.

5.3 Community Services

5.3.1 Education

Revelstoke is situated in School District 19, which also includes Mica Creek. As of October 1975, the teacher/pupil ratio for School District 19 was 1:18, a ratio that compares with the 1:19 provincial average. All physical facilities are in good condition and a new elementary school has just opened. Revelstoke also has services for special children as well as specialized support staff at both elementary and secondary school levels. The community Education Services of Okanagan College offers post - secondary and other courses in Revelstoke.

Elementary and secondary school facilities are presently adequate to meet the needs of the current population. Enrollment projections over the next ten years suggest that existing school facilities and staff complements would be more than adequate to handle future student enrollment until 1986 if Revelstoke were to continue its present growth trend.

5.3.2 Social Services

In this section we are particularly concerned with those services offered by the Provincial Department of Human Resources and the Attorney Generals' Department. These include child welfare, adoption, foster care, mincome, social assistance, services to the handicapped, day care, probation, youth programs and services to seniors. The social assistance caseload in Revelstoke includes a relatively high number of unemployed employable persons, a number of which can be explained in part in the case of single men who pass through Revelstoke on the way to and from the Coast. The social services now available are stretched to their limits and are characterized by major gaps in day care and counseling services.

5.3.3 Health Care

The Queen Victoria Hospital is located two miles south of the Revelstoke city boundaries. In 1975 it had 42 acute care beds with an occupancy rate of 52% and 10 extended care beds with a 100% occupancy rate. A radiologist is shared half time with the Golden District Hospital. Consulting specialists in the fields of obstetrics, gynecology, internal medicine, and orthopedic surgery provide their services in Revelstoke as required. The service is adequate to meet existing as well as the projected population until 1986.

As far as physicians are concerned, Revelstoke has 1 surgeon, 5 general practitioners and a part time radiologist. Two additional general practitioners are based at Mica Creek. The private practitioners in Revelstoke operate a group practice. Although the doctor/population ratio is about one half the provincial average it would appear that there is no significant gap in service at the present time. In order to meet additional demands for the projected growth, the current practitioners would likely recruit either one or two additional doctors sometime between 1977 and 1985.

There are 2 dentists in group practice with a third based in Vernon who practices in Revelstoke four to six days per month. The group practice expects two additional dentists to join shortly. They plan to operate on a rotating basis so that 2 dentists are always available at any given time. The dentist/population ratio is about one half the provincial average. According to returned questionaires from Revelstoke professionals, dental care is one service that is inadequate to serve the existing population. The situation should improve somewhat with the arrival of the two additional dentists but service will continue to be a problem as only two will be available at a time.

Regarding public health, the North Okanagan Health Unit covers 8 municipalities (including Revelstoke) and other unorganized areas with a combined population of about 58,000 people. The staff in Revelstoke include 2.5 nurses and a health inspector who is available two days per week. They are responsible for inspection and maintenance of sanitation standards in public buildings, school health services, maternal and child health, epidemiology, speech therapy and preventive mental health services. The staff could easily be increased by an additional worker over the next five years to meet the needs of the population increase.

Mental Health Services are limited to four hours a month direct service by a visiting consulting team consisting of a psychiatrist, psychologist and counselor. The team makes recommendations for appropriate treatment care plans. Unfortunately their advice is most often difficult if not impossible to implement due to a lack of appropriate referral services and resources in the community. They have planned to hire a mental health worker but this will still not be sufficient to meet the populations' present needs.

5.3.4 Law Enforcement

There is a 17 man Royal Canadian Mounted Police detachment in Revelstoke. They are responsible for an area that covers Revelstoke and the 30 miles south, 45 miles north, 40 miles west and 45 miles east of the City. There are also 10 auxiliary officers available to augment the force during an emergency or disaster. On the basis of minimum standards of police/population ratios of 1:750 in cities and organized territories and 1:1000 in rural and unorganized territories, the current Revelstoke staffing is more than adequate presently and until 1986.

Court services include a Provincial Court circuit judge who sits two days per week in Revelstoke, a part time Crown counsel and a sheriff. Court personnel are presently operating at capacity.

5.3.5 Fire Protection

The Revelstoke Fire Department consists of 6 firemen including the Fire Chief, and 26 volunteers. They operate from one fire hall where they have two pumpers and one elevating platform. The Fire Chief anticipates that a larger fire hall will be necessary by

1978. They operate within a radius of about 5 miles covering Revelstoke, South Revelstoke, Arrow Heights and Big Eddy.

The Fire Department also operates the ambulance service which consists of 2 ambulances and 2 full time staff persons. The ambulance service is financed by the Emergency Health Services Commission and services areas as far away as Glacier, Shelter Bay and Downie.

5.3.6 Recreation

Indoor facilities owned or available to the City Recreational Department include a school gymnasium available week nights, a forum with a seating capacity of 1,500 used for ice skating in the winter and roller skating in the summer, a curling rink, and a Civic Centre. Outdoor facilities include 2 farm league diamonds, 1 fast ball diamond, 1 softball diamond, 1 soccer field, 1 field hockey playing field, 3 tennis courts, 1 swimming pool, and an 18 hole golf course. Privately owned facilities include a bowling alley and ski developments for alpine and ski jump enthusiasts.

Many of the facilities require upgrading, particularly the playing fields. Curling and skating programs can accept new members. Although the 25 metre swimming pool was initially designed to be covered at a later date, it is still only used for three summer months. The 18 hole golf course could accommodate some new members without difficulty.

The feeling among local people is that while there are some disadvantages to living in a small community like Revelstoke, there are also certain advantages. One of them is easy access to sports and recreational activities. There are more than 80 community organizations involved in social, cultural, leisure and sports activities in the community. Membership counts for these groups indicate that the residents are enthusiastic supporters of organized leisure and recreational activities.

6.0 ENVIRONMENTAL IMPACTS AND MITIGATION

6.1 Land Resources

Generally speaking, well over 50% of the land required for the mining operation has already been cleared of trees. In those areas that have not yet been cleared, cut blocks can be planned to coincide with mine requirements.

The primary access road will be built regardless of whether we proceed with the project or not. In fact, the primary access road will be an improvement on the existing road.

Therefore, exclusive of tree clearing and the construction of the primary access road we shall cause the following land disturbances:

Facility	Acres
Plant Roads, Yards	30
Open Pit - Mining	15
- Waste Disposal	20
- Roads	20
Camp	20
Tailings Disposal	90
Total	195

These topographical changes and our related mining activities will alter wildlife habitat by removing vegetation cover, thus forcing resident species to vacate this part (195 acres) of their accustomed ranges for 12 - 15 years. This relocation process increases densities on adjacent ranges which in turn increases pressure on available food sources. This situation inevitably results in a reduction of animal populations during a critical period of the year, usually the winter season. However, since only a very small portion of land in the valley will be altered, it appears that the impact on indigenous wildlife habitat and movement will probably not be significant.

Topographical changes also detract from the natural beauty of the area until reclamation has been completed. Since the mine location is well removed from major population centres, exposure to the area by individuals who find such sites aesthetically objectionable is minimized.

Slash and debris from logging operations will be removed from streams and stream banks as moose use these areas as travel corridors during the winter. Slash accumulations could interfere with wildlife movement patterns. Bears will be attracted to kitchen wastes resulting in inevitable human bear encounters. Wastes will be burned daily at a disposal site remote from the camp.

There will be a greater risk of forest fires in the area due to mining activities, access roads, and accumulations of slash and other fuels. Once the campsite and plant have been largely cleared of timber, care will be taken to ensure that an adequate fire break exists between the buildings and surrounding forest.

The equipment service area will comprise a workshop, warehouse, and stores where servicing, repairs, and overhauls would be performed. A major concern at this location will be the disposal of waste crankcase oil, lubricants, and industrial chemicals; these must not be allowed to enter any watercourse. Preferably a disposal pit will be used where holding tanks can be discharged and the residue flared off or otherwise disposed of.

Other problems that must be contended with include increased dust, minor plant emissions, vehicular emissions and noise near the mine and plant sites. Suitable dust control facilities required in the crushing and screening plant will be employed to mitigate this problem. There may also be a dust problem created by overburden removal and vehicular movement during extended dry periods. In this event, a water truck will be necessary to minimize dust generated by vehicular movement.

A total volume of 600,000 metric tons of waste rock (1.67 metric tons/cubic metre) will be placed in dumps with a dump face height not exceeding 15 metres. These dumps will have a 14^{o} positive slope on the existing 22^{o} hillside slope. Because of the coarse and competent nature of the waste rock, no sliding is anticipated. The overburden dump, comprising 160,000 cubic metres, will be skirted with rock dumps in order to prevent excessive erosion and slumping.

The construction of the proposed hydro dam on the Goldstream will flood 265 acres of land and alter the natural flow patterns of the river. However, with the proper regulation of flow drawdown effects below the dam would be minimized allowing the successful maintenance of fish populations. The dam and reservoir are expected to have no detrimental effects on fish populations located upstream. The area to be flooded is not considered suitable winter range for moose and will have little effect on their habitat. Reports prepared by I. E. C. fully address the background and impacts of the reservoir. Summary and Conclusions from these reports are included in the Appendix and the full reports are available on request.

6.2 Water Resources

Environmentally, our main concern will be the water quality of the tailings effluent. Test results completed recently indicate that we could be faced with a tailings acidification problem at Goldstream due to the presence of pyrrhotite. Grinding and subsequent aeration of the pulp during flotation may cause formation of quantities of thiosalts. Oxidation of these thiosalts to H_2SO_4 may cause the pH to drop. These tests also indicate that certain metal ion concentrations may be unacceptable to meet Level A standards. Neutralization and precipitation may be required. A water treatment plant is anticipated. Test work will continue, to define treatment requirements.

B. C. Research was called upon to analyze the acid generation potential of various rock samples; their reports have been included in Appendix II. They confirmed that the ore zone has potential for acid generation. They indicate that a representative sample of the waste from the hangingwall will not generate acid and will not likely cause problems of disposal or when used in dam and road construction.

B. C. Research recommended that in disposing of potentially acid producing waste, the following precautions should be taken:

1) Avoid use of material in construction.

2) Dump in an area where run-off may be collected and treated if necessary.

3) Design waste dumps to avoid conditions favouring leaching (i.e. minimize the water and air access).

4) Institute a regular monitoring program to detect acidic drainage.

B. C. Research are also of the opinion that the tailings impoundment should be designed to allow treatment as the concentrator tailings may have acid production potential.

Suitable erosion control procedures will be necessary to prevent silt from reaching watercourses. Stream turbidity may be high, particularly during the construction phase of the project.

Drainage and diversion ditches will be designed to minimize water velocities. Culverts will be designed to pass any fish that utilize the affected streams. If culverts cannot meet this criteria then bridges will be considered. A diversion ditch will be required in the overburden above the open pit in order to prevent local run off from becoming contaminated in the pit.

Sewage treatment plant effluents and waste disposal procedures will meet government regulatory requirements. Storage and transfer sites for fuels and toxic chemicals will be dyked in order to contain any spills that may occur.

Water used for domestic and operational purposes will be utilized from Brewster Creek. No problems are anticipated during the summer (high flow) months; however, if this creeks' hydrology is aversely affected an alternate source of water will be found. This would probably take the form of wells.

The tailings disposal area will be enclosed by dams containing an impermeable core, thus minimizing seepage. In addition, a seepage dam will be constructed down stream of the main dam. Water contained by this dam would either be pumped back into the main pond or released into the natural watercourse. In order to conserve water, tailings water from the main pond will be pumped back to the concentrator.

As pointed out by I. E. C. in Appendix I, adit drainage water should not pose a problem as long as settling ponds are employed.

Monitoring activities (water quality in particular) will have two objectives: 1) to ensure that environmental guidelines are enforced in order to actually achieve the intended objective, and 2) to determine actual project impacts that are uncertain of prediction at the time of development. Monitoring during the construction and operation phases of the project should be performed by experienced biologists in close co-ordination with project engineering and administration staff. Government agencies with statutory responsibilities would be involved directly.

6.3 Reclamation

The Goldstream Project will principally be an underground operation with relatively little surface exposure. The underground mine, small open pit, waste dumps, tailings disposal area, and company buildings will form the bulk of environmental change. Care will be taken by the company not to disrupt the land or ecological balance unnecessarily. With proper reclamation techniques it should be possible to restore the disturbed land to its current land use capability.

The reclamation procedure will take the form of both research and experimental revegetation. Conservation efforts will be directed toward minimizing the extent and area of land to be disturbed as well as conserving excavated materials which may have a prospective use. Provincial and Federal resource departments as well as consultants may be called upon to provide assistance during the reclamation program.

Reclamation will begin 2 to 3 years into the operation phase of the project. At this time open pit mining will have been exhausted. The open pit and waste dumps which will be covered by overburden and seeded, provide an excellent means of assessing the nature of reclamation in the Goldstream Valley many years before the termination of the project.

The open pit could be developed so it would fill with water after abandonment - this would minimize oxidation.

Revegetation, if properly established will:

1) Provide effective erosion control.

2) Contribute significantly to chemical pollution control.

3) Improve the aesthetics, and

4) Return the land to its past usefulness.

Since loss of the soil zone is a major hinderance to revegetation, stockpiling of this material is encouraged.

Experimental revegetation will be conducted on test plots of tailings material in order to determine the optimum mixture of fertilizer, grasses and legumes. This procedure will take place several years before the pond has reached its ultimate capacity. Native species will be used wherever possible.

At the completion of the operation phase of the project the adit will be sealed, buildings will be dismantled and the camp and plant sites will be cleared. The tailings pond as well as the cleared areas will then be seeded. The area disturbed by the project will thereafter be monitored to ensure that the reclamation program is a success.

7.0 SOCIO - ECONOMIC IMPACTS AND MITIGATION

7.1 Population and Employment

Manpower requirements for the Goldstream Project are expected to peak at 250 during the preproduction period, stabilizing at 185 employees during operations. The distribution of manpower during the operational phase is shown in Table 3.

Direct employment in the mining industry is accompanied by indirect employment in industries providing materials and services to the industry. Income earned by these indirect employees is spent on other goods and services which in turn creates another level of employment and so on. The cumulative effect of direct expenditures in terms of indirect employment and expenditures is referred to as the multiplier effect. Different industries have different multipliers.

In the case of the mining industry which in 1975 employed over 15,000 people and spent $982,000,000, the multiplier effect has been estimated as follows: for every person directly employed by the mining industry approximately 2.8 other workers were supported in British Columbia, some 42,000 employees in total (Price, Waterhouse, 1975). Similarly, in Canada as a whole, 5.9 other workers were supported by each direct employee of the B. C. mining industry for a total of 105,000 workers.

The income multiplier effect relates to the thesis that the economic growth of a region is dependent upon income brought into the regional economy by its "export" industries, i.e. those industries shipping products out of the region.

This added income to the region is spent and respent by residents; their demands for goods and services creating higher levels of employment and hence higher income levels. As long as these demands are met by the region itself, the income continues to multiply.

The income multiplier effect of the mining industry in B. C. is therefore the cumulative effect of the expenditures of the mining industry in B. C. In 1975, the total income multiplier effect was estimated at $1,130,000,000 or 6% of gross provincial production.

Similarly, the income multiplier effect of the mining industry of B. C. in Canada as a whole was estimated in 1975 at $2,200,000,000.

In addition to the economic benefits of the mining industry, this industrial development is beneficial to society as a whole in that it provides employment for skilled workers at high rates of pay.

Direct participation by the industry in mining communities has also been beneficial. Between 1971 and 1975 the industry invested $32,000,000 in schools, hospitals and other community facilities.

Grants and donations to charity, the performing arts and other recreational projects amounted to $4,669,000 during the same period.

Some $3,709,000 was spent on research in 1975 together with $11,524,000 on environmental control divided as follows: $3,451,000 in capital expenditures and $8,073,000 in operating expenses. By 1976 environmental control expenditures increased to $14,174,000 with $8,031,000 in capital expenditures and $6,143,000 in operating expenses.

It has been estimated that roughly 50 - 75% of the Goldstream employees could be hired from the Revelstoke area; therefore, the influx of people to the area will be very small. As the majority of employees will originate from Revelstoke, this portion of the current population will receive income benefits they would not have otherwise. Along with an increase in basic employment there will also be a modest increase in non basic employment, thus creating more new jobs.

The supply of housing units is extremely tight in Revelstoke at the present time. This situation is not likely to improve until 1981 when the Revelstoke 1880 Project will reach its peak. It is not likely that our employees will seek housing in Revelstoke until this point in time.

TABLE 3

DISTRIBUTION OF MANPOWER

	Hourly Rate	Staff	Total
Mine Department	82	13	95
Mill Department, Assay	29	7	36
Maintenance & Plant	26	3	29
Administration	-	12	12
Caterers, Janitorial	-	13	13
	137	51	185

Although our own production life is dependent on the success of our exploration program, we can lessen the economic turndowns generated by the Hydro project. This can be accomplished by increased use of Revelstoke as a townsite in 1982. It should not be over looked that the Goldstream Project will provide economic stability through non related employment.

7.2 Land Use

There will be very little impact on the land use of the Goldstream Valley. Fishing should not be affected. The formation of the small reservoir on the river will probably provide improved sports fishing, at least for a short period. Game will be more scarce around the immediate mine site area but since most of the game is found in the upper Goldstream Valley, this should not affect hunting. Logging will also not be interfered with to any significant extent. Much of the area in the vicinity of the minesite and tailings pond have already been logged.

7.3 Community Services

Community services will not be stressed significantly by the Goldstream Project. The main reason for this stems from the fact that the majority of employees working at Goldstream will be current Revelstoke residents. Also, Revelstoke will not be used as a townsite until the Hydro economic turndown has begun. In this way the mining operation will reduce Hydro's negative impact.

People on fixed incomes will suffer a loss of purchasing power particularly due to the Hydro project as prices will rise in the local economy. On the other hand, unemployed employables presently on social assistance may be able to take advantage of the expanding job market created by the mine.

8.0 CONCLUSIONS

The proposed Goldstream Project will provide significant revenues to the Governments of Canada and B. C. as well as wages and employment for the residents of British Columbia. The mine will also somewhat reduce the economic turndown effects created by the Revelstoke 1880 Project after 1981.

Apart from an acid producing tails problem, the project faces relatively minor environmental and social problems. Regardless of whether or not waste rock from the open pit is used for access roads and/or tailings dam construction, monitoring of potential acid drainage will be necessary. In any event, further testing will be conducted.

APPENDIX I

"PREOPERATIONAL MONITORING AND BIOLOGICAL

INVENTORY OF THE GOLDSTREAM RIVER

COPPER-ZINC DEPOSIT NEAR

REVELSTOKE, B. C."

- by International Environmental
Consultants

NORANDA MINES LIMITED
GOLDSTREAM DIVISION
KAMLOOPS, BRITISH COLUMBIA

PRE-OPERATIONAL MONITORING AND BIOLOGICAL INVENTORY OF THE GOLDSTREAM RIVER COPPER-ZINC DEPOSIT NEAR REVELSTOKE, B.C.

31 MARCH 1977

Prepared by: M.L. Fanning
D.J. Jones

3027.1

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ACKNOWLEDGEMENTS

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LIST OF TABLES

1.0 INTRODUCTION

The Noranda Mines Limited, Goldstream Division property located approximately 50 miles north of Revelstoke, B.C. on the Goldstream River, is currently undergoing exploratory drilling and adit construction for a proposed 365,000 tons per year underground copper-zinc mine.

In 1976, Noranda retained IEC International Environmental Consultants Ltd. to conduct a biological inventory of the mine site property and initiate the pre-operational monitoring of the Goldstream River and selected tributaries. The following report describes the baseline data collected during four site visits in 1976.

The study objectives were to:

1. Collect, interpret and analyze the available terrestrial and aquatic environmental data related to the proposed minesite. Data sources reviewed included Government and academic agencies and industrial/technological sources, including the proposed mining plans.

2. Implement a pre-operational monitoring program.

3. Prepare a report reviewing Item 1 above which presents an environmental inventory of the property. Included in the report is an analysis of new pre-operational data collected in the 1976 monitoring program.

2.0 SUMMARY

This report outlines the results of the 1976 terrestrial and aquatic inventory of the Goldstream River valley and initiation of the aquatic monitoring program for Noranda Mines Limited, Goldstream Division. Site visits during 25-27 May, 9-11 August, 13-14 October and 1-2 December, 1976, were undertaken to complete the baseline inventory of aquatic invertebrates, fish, and water quality.

The results of the 1976 aquatic field studies indicated that invertebrate communities in the Goldstream River and its tributaries exhibited natural seasonal fluctuations in numbers and composition, with a dominance of sensitive organisms, indicative of clean water conditions. Resident mountain whitefish and cutthroat trout were observed in the Goldstream River during 1976, providing local residents with an easily accessible sports fishing resource.

Baseline water quality data obtained for the Goldstream River and its tributaries exhibited wide variations for many parameters, most notably suspended and dissolved solids, conductivity, sulfate, calcium, alkalinity, total iron, chemical oxygen demand, dissolved oxygen and temperature. Adit water drainage contained higher than normal concentrations of suspended solids and particulate iron, however the four settling ponds successfully reduced the suspended material to background levels.

Stream flow data exhibited expected seasonal gradients associated with climatic conditions and drainage from the surrounding mountains.

The information on terrestrial resources was extracted from the available literature sources and from discussions with local residents. The Goldstream valley supports low-moderate wildlife resources which because of accessibility is frequented by hunters and naturalists. The area is utilized by moose, black bear, grizzly bear, and waterfowl as well as a wide variety of other ungulates and fur-bearing mammals. No inventory of stocks has been undertaken to date.

The natural regrowth on old mining areas and adjacent logged and burned areas, suggests that reclamation of future mining will require minimal effort.

The study area does not appear to contain any important cultural features or artifacts which would require an archaeological investigation prior to development of the Goldstream property.

The Goldstream River valley has undergone extensive disruption during the past 100 years due to placer mining, sluicing and dredging for gold. The area is still being placer mined and is designated as placer land (as per Order in Council 1794, May 22, 1975).

3.0 RECOMMENDATIONS

3.1 The Mining Plan

The kinds of environmental work required on this property will be wholly decided by future exploration or mine development programs initiated by Noranda.

3.2 Environmental Management Alternatives

3.2.1 Immediate Minesite Development in 1977

In this case an environmental impact assessment of the project is required.

3.2.2 Deferred Minesite Development - Active Exploration

In this case it is recommended that:

- Annual environmental surveillance of the property should continue in 1977.
- Fish population studies should be expanded to provide more extensive documentation of numbers and species distribution in the Goldstream and its tributaries.
- Surface and adit water chemistry be sampled in 1977 as baseline data for future mining activity.
- Guidelines for exploration and minesite development proposed by the Provincial Department of Mines, Victoria, B.C., be incorporated into the study design.

3.2.3 Abandonment

In this case some reclamation may be necessary. No other environmental work will be required.

4.0 METHODS

4.1 Field Methods

4.1.1 Aquatic Invertebrates

Three representative aquatic invertebrate samples per station were collected 26-27 May and 13-14 October 1976 at French Creek, McCulloch Creek, Brewster Creek, Goldstream River above the falls and Goldstream River above Sweeper Bill Creek. At each sampling location a standard Surber sampler (measured .093 m^2) was set in the gravel substrate and the gravel was disturbed by hand sufficiently to dislodge the macroinvertebrates which were swept into the net by the river current.

Each sample was screen-washed to remove the extraneous debris, placed in labelled polyethylene containers and preserved in 10% formaldehyde.

Field observations on river flow, water color, stream bank stability, siltation, algae accumulations and shoreline vegetation were made during each site visit.

4.1.2 Fish

The Goldstream River was sampled 10-11 August 1976 at three locations for fish (see Appendix 1, Map). Due to the depth and width of the Goldstream River in August, electrofishing was abandoned as a method of fish collection. Beach seining was conducted using a 50 ft x 50 ft x 3/4 in. mesh seine towed midstream to shore. The fish collected in three hauls per station were identified to species, measured and released at each site. Detailed measurements of age/weight, age/length, or feeding relationships were not attempted in 1976.

Two tributary streams, McCulloch Creek and Brewster Creek, were sampled 10-11 August 1976 utilizing a 3500 Watt AC generator and probes. No fish were captured during the sampling period. French Creek was not sampled for fish.

4.1.3 Surface Water Chemistry

Surface water samples were collected 27 May, 10 August, 13 October and 2 December 1976 at French Creek, McCulloch Creek, Brewster Creek, Tails Creek, Goldstream River above falls and Goldstream River above Sweeper Bill Creek. At each sampling location, 5 litres of water were collected at the surface in labelled 1-litre polyethylene containers and sent to the laboratory for analysis. In situ measurements of dissolved oxygen and temperature were made at each location using a Y.S.I. Model 57 instrument.

4.1.4 Adit Water Chemistry

Drainage from the mine adit was noted in August 1976. Sample collection of adit water drainage was initiated 13 October 1976 and was repeated 2 December 1976. In addition, two of the four earth-filled settling ponds constructed to restrict adit water flow were sampled 13 October 1976.

4.2 Analytical Methods

4.2.1 Aquatic Invertebrates

In the laboratory, the three replicate benthic invertebrate samples per station were sorted from the sample residue, identified to the highest taxonomic level feasible (usually genus or species) and counted. For detailed identification, the following taxonomic sources were used: Jewett, 1959; Mason, 1969; Pennak, 1953; Usinger, 1963; and Ward and Whipple, 1959. Detailed identifications are presented in Appendix 3, Tables 1 and 2.

4.2.2 Surface Water - Adit Water Chemistry

For the majority of the parameters measured, the procedures used were those described in "A Laboratory Manual for the Chemical Analysis of Water, Wastewaters and Biological Tissues" published by the Government of British Columbia, 1973. A Perkin Elmer HGA Graphite Furnace was utilized for most of the trace metal determinations.

Nitrate Nitrogen was not measured in accordance with the above references, but rather, "Standard Methods for the Examination of Water and Wastewater, 1971, Method 213C". The results of these analyses are presented in Appendix 3, Tables 4-11.

5.0 RESULTS

5.1 Freshwater Systems

5.1.1 Aquatic Invertebrates

Aquatic invertebrates differ in terms of their water quality requirements and can be classified into groups according to their tolerance to pollution. For example, members of the Plecoptera (stoneflies), Ephemeroptera (mayflies) and Trichoptera (caddisflies) have been categorized as forms sensitive to environmental change (Wilhm and Dorris, 1968). Some members of the Simuliidae (black flies), Tendipedidae (midges) and Amphipoda (scuds and fleas) have been classified as of intermediate tolerance to pollution while Oligochaeta, particularly the Tubificidae (sludgeworms), can tolerate heavier pollution. The benthic invertebrate community which develops in a given area is indicative of a combination of recurring short term critical water conditions, long term environmental factors and biological interactions. Because benthic organisms are affected by such varied conditions and generally do not migrate over large distances they serve as valuable indicators of past as well as present river conditions (Beak, 1965).

The mean number of organisms per square metre ranged from 304.6 to 372.7 in May to 326.1 to 752.5 in October for two sampling locations of the Goldstream River (Appendix 3, Tables 1 and 2). An average of ten taxa per sample were collected during the two surveys. The benthic communities at both stations were completely dominated by pollution sensitive aquatic insects indicative of natural clean water conditions.

The results of field sampling discussed in the 1976 B.C. Hydro report suggested that the Goldstream River is moderately productive with a mean number of 157 organisms per square metre represented by the 14 taxa. No relevant comparisons can be made from this data as the sampling date and location were not provided.

The tributaries of the Goldstream River (French Creek, McCulloch Creek and Brewster Creek) displayed a greater variation in the numbers and complexity in their benthic communities. In comparison to the Goldstream River, productivity in the French and McCulloch Creeks was low during both surveys. Brewster Creek was the most productive tributary containing populations of 1049.9 to 1698.5 organisms per square metre with a maximum of 20 taxa per sample.

5.1.2 Fish

A total of 25 species of fish have been reported from the Columbia River system above the Hugh Keenleyside Dam. The Goldstream River, one of the major tributaries of the Columbia, has a major barrier to fish passage near its mouth at Goldstream Falls (Appendix 2, Figure 1). The Goldstream does contain native populations of two fish species; mountain whitefish and (Yellowstone) cutthroat trout. The abundance of these sport fishes in Goldstream River and its smaller tributary streams has not been documented to date.

The results of a fish seining survey undertaken in August, 1976, in the Goldstream River confirmed the existence of mountain whitefish. In nine beach seine sets in the slower moving oxbow portions of the river, nine mountain whitefish were captured, measured, and released (Appendix 3, Table 3). Although cutthroat trout were not captured during the beach seining operations, a few trout were caught by camp residents in September/October. Trout were also observed in deep pools of the Goldstream River in mid-October during the water sampling survey.

Electrofishing was also conducted during August 1976 in the larger pools of McCulloch and Brewster Creeks near the water sampling locations. No specimens were captured.

The smaller tributary streams are used for spawning in spring and early summer by cutthroat trout when the water temperature reaches about 10°C (Appendix 3, Table 14).

The mountain whitefish also spawn in the smaller tributary streams in the late fall and early winter. The fry likely move out of the spawning areas immediately on hatching and develop to maturity in the Goldstream River (Appendix 3, Table 14).

5.1.3 Surface Water Quality

Water quality data provides an indication of short term gross changes in the aquatic environment. The Goldstream River and its tributaries, however, have no present industry (except for periodic placer mining in McCulloch and French Creek) and water quality results reflect natural baseline conditions. Variations in water quality between sampling periods and stations represent seasonal climatic effects (Appendix 3, Table 4-9). The seasonal ranges measured in 1976 are summarized and presented as follows:

Parameter		Range		
Dissolved Oxygen (ppm)		9.2	-	14.9
Temperature (°C)		0.0	-	12.5
pH		6.2	-	8.08
Color (APHA units)		5.0	-	15.0
Conductivity (micromhos/cm)		60.0	-	202.0
Turbidity (JTU)	<	1.0	-	35.0
Suspended Solids (ppm)		1.2	-	142.0
Dissolved Solids (ppm)		46.0	-	186.0
Alkalinity as $CaCO_3$		22.7	-	92.7
Sulfate (ppm)		2.0	-	53.5
Phosphates (ppm)	<	0.01	-	0.06
Nitrates (ppm)	<	0.1	-	0.62
Calcium (ppm)		10.0	-	29.0
Magnesium (ppm)		0.9	-	7.4
Total Hardness (ppm)		32.4	-	103.0
Chemical Oxygen Demand (ppm)	<	7.0	-	37.0
Total Iron (ppm)	<	0.05	-	2.9
Total Manganese (ppm)	<	0.002	-	0.053
Total Copper (ppm)	<	0.001	-	0.003
Total Mercury (ppm)	<	0.001	-	0.003
Total Zinc (ppm)	<	0.001	-	0.030
Total Nickel (ppm)	<	0.001	-	0.009
Total Lead (ppm)	<	0.001	-	0.002
Total Arsenic (ppm)	<	0.010	-	not detectable
Total Cadmium (ppm)	<	0.001	-	not detectable
Total Molybdenum (ppm)	<	0.010	-	not detectable

In general, the Goldstream River and its tributaries contain excellent water for the production of aquatic invertebrates and fish. The water is alkaline (except for the unexplained pH of 6.2), cold and highly oxygenated. Sulphate, nitrate, calcium, magnesium, total hardness, dissolved solids, suspended solids and chemical oxygen demand were occasionally high but the levels were not excessive. Total iron, magnesium, zinc and nickel were detectable in variable concentrations while only trace amounts of the other metals were noted.

5.1.4 Adit Water Quality

The results of adit drainage water analysis are presented in Appendix 3, Tables 10 and 11. The slightly alkaline adit drainage water of pH 7.7-8.0 flows from the workings at an estimated rate of 0.1 cfs into four small settling ponds constructed adjacent to the adit. A high solids load in the flow can be considered a normal characteristic of this water as it drained the area of most activity during this phase of exploration.

In the summary of data presented below it can be seen that the high loads of suspended solids that occur at the portal are much reduced at pond #3. Total iron levels drop from 8.10 to 1.62, dissolved iron levels are less than 0.05 ppm in all cases. The pond appears an effective means of settling the heavy suspended load. The waters were slightly alkaline during sampling; iron is in suspension with very little in solution. Acid mine drainage did not occur.

Other levels of heavy metals analysed in the samples were similar to those found in the surface water drainage.

	ADIT PORTAL	POND NO. 1	POND NO. 3
Suspended Solids ppm			
Total	101.0	48.0	31.0
Fixed	96.0	42.5	27.0
Volatile	5.0	5.5	4.0
Dissolved Solids ppm			
Total	204.0	162.0	236.0
Fixed	124.0	134.0	146.0
Volatile	80.0	28.0	90.0
pH	8.0	7.7	7.7
Total Iron ppm	8.10	3.06	1.62
Dissolved Iron ppm	< 0.05	< 0.05	< 0.05

5.1.5 Stream Flow Regimes

Stream flow data was recorded in 1976 for the Goldstream River and some of its tributaries (Appendix 3, Table 12). Discharge rates were estimated for French Creek, McCulloch Creek, Brewster Creek, Tails Creek, Goldstream River (2 locations) and the adit drainage.

Continuous streamflow measurements for 1976 were made by the Water Survey of Canada at a recorder well on the Goldstream River below Old Camp Creek. The monthly data summary is presented in Appendix 3, Table 13. Maximum mean monthly discharge (5000 cfs) and gauge height (7.86 ft) was recorded during July, caused by snow melt. The minimum mean discharge rate of 196 cfs was recorded in February.

5.2 Terrestrial Systems

5.2.1 Geology

The Columbia River Valley is bordered on the west by the Monashee Mountains. The headwaters of the Goldstream River, a tributary of the Columbia River, originate in the Selkirk Mountains. Since the end of glaciation, the Goldstream River has eroded and reworked the outwash and lacustrine sediments forming its own flood plain and attendant terraces. The Goldstream River valley contains extensive areas of low lying alluvial deposits which are often poorly drained.

5.2.2 Soils

On the basis of the available literature and information reviewed by B.C. Hydro, general comments on the soil resources of the study area can be made.

Orthic humo-ferric podzols predominate on colluvial deposits and glacial till deposits. These are coarse textured soils with pH values around five and generally become less acid with depth.

On the glaciofluvial surface deposits, humo-ferric podzols again predominate. These soils tend to be acid and have even fewer fine grained materials in them than the soils developed on colluvium or till.

Regosols and organic soils are found on alluvial deposits; however, these are not as acid in character as the upland soils and are thus of higher inherent productivity. The relative distribution of regosols versus organic soil has not been determined to date.

It is quite likely that other soils occur in the study area, but no information about them is available.

5.2.3 Vegetation

In the lowland areas of the Goldstream River valley, shrub thicket areas with scattered conifer cover are designated as brush/forest complex. Conifer characteristics of this mapped unit include spruce, subalpine fir, western hemlock and western red cedar. In addition to willows and alder, shrub species often present in this unit are associated with fen (meadows) or peatland areas. They include Labrador tea, blueberry, saskatoon berry, and false azalea. The minesite and camp area are shown as previously logged on the forest cover map (B.C. Hydro Report, Plate 6.2). The logged areas have shown rapid natural regrowth (Appendix 2, Figure 8). There is abundant plant cover in the logged areas and erosion has not occurred.

Cottonwood and spruce groves are found associated with the Goldstream River floodplain. Shrub thickets of willow, alder, black twinberry, elderberry, red osier, dogwood, hazel, highbrush, cranberry and devil's club are often found.

Marsh areas are localized around permanent standing water of oxbows, small lakes and ponds as in some areas of the Goldstream and French Creek wetland areas. Some of the marsh areas support small populations of cattail, but more common plants include emergent species such as water horsetail, sedges, bulrush, spikerush, and burr reed. Buckbean and marsh cinquefoil may also occur in these habitats.

Construction and operational activities at the proposed mill, mine and tailings impoundment areas on benches above the valley bottom are expected to have only small localized impacts on existing vegetation.

5.2.4 Future Reclamation

Drillsite construction and road building were minimal during the study period and no problems of erosion or siltation were noted.

There is much circumstantial evidence of rapid plant recolonization of disturbed land.

Access to the property is gained along a former logging road bordered by dense stands of alderwood regrowth to heights of approximately eight feet. Large clearcut areas left from former logging activity show active recolonization and regrowth. No erosion caused by previous logging operations was noted.

This exploration site is located in a famous gold mining region of British Columbia. For 115 years to the present day, placer gold mining on a considerable scale has been undertaken in this area. The 1870's and 1930's were times of intense activity on McCulloch and French Creek. Very extensive land disturbances caused by hydraulic mining, stream diversion, road and camp construction have been recorded. At the presnt time, mechanized placer mining occurs in the headwaters of McCulloch Creek (Appendix 2, Figure 3) with limited panning and hand operated riffle box extraction methods used intermittently in the summer months on French Creek. Only traces of this former activity are now visible. In all but the active workings, a robust regrowth of the native vegetation has blanketed the disturbed areas (Appendix 12, Figure 8). Access to the former mine workings is now most difficult.

At the campsite, a small garden of domestic vegetables was planted and harvested in the same year the ground was cleared for the camp trailers (Appendix 2, Figure 9).

Based on these observations, it is reasonable to assume that recolonization by natural vegetation is vigorous and in its natural state the suitability of disturbed soils for plant growth is satisfactory. It seems that erosion control and reclamation planning of future mining disturbances can be approached confidently with the knowledge that natural recolonization is rapid and effective at this location.

5.2.5 Wildlife

The study area supports a wide variety of mammals and resident migratory birds. The diversity of animals is partially attributable to the complexity of habitats which include lakes, rivers, forest and alpine areas. In addition, the north-south orientation of the Columbia River provides a natural travel route for migrating birds.

Wild ungulates which have historically been observed in the Goldstream valley include mountain caribou, moose, muledeer, whitetail deer, mountain goat, and elk (Paish, 1974). Mountain caribou and moose are common in the valley, while mule and whitetail deer, mountain goat and elk have been sighted in adjacent areas and may occasionally utilize the valley. Areas identified as important moose winter range include the lower western bank of the Goldstream River, French Creek and the Goldstream River upstream of Sweeper Bill Creek. Upper Brewster Creek has been identified as potential summer and winter range for caribou.

Other large mammals occurring in the study area are grizzly bear, black bear, cougar and wolves. Grizzly and black bear are very common and often become a nuisance around the camp. Black bear are frequently sighted at the D.P.W. garbage dump and occasionally near the camp. In the spring of 1976 during early camp construction, a grizzly caused extensive damage to one of the Noranda trailers. Eight grizzlies were sighted during the fall of 1976 in the vicinty of McCulloch and French Creeks. Proper game management measures will be required to prevent the bears from causing future problems around the mine, mill, and camp during the operational phases.

Fur-bearers such as marten, beaver, squirrel, mink, wolverine, weasel, muskrat, coyote, fisher, and otter are trapped on registered traplines in the area. Porcupine were observed during a field visit to French Creek.

The upper reaches of the Goldstream River watershed that are outside the study area, are known to be extensively used by waterfowl.

The Goldstream is the most accessible valley for hunting in the Revelstoke area. Moose is the primary big game species pursued. Small harvests of caribou, deer or other species as well as waterfowl are reported. The valley accounted for only a small percentage of the provincial moose harvest in Game Management Area No. 9. However, it represents an important local wildlife amenity.

5.2.6 Archaeology & Historical Features

Data provided by the Archaeological Sites Advisory Board (ASAB) were examined for potential sites on the Noranda property. No sites were identified in the Goldstream River valley and no field work has been reported above the 1800 ft elevation contour in the area. Mr. Ed Wallace, the Downie Creek resident, has trapped and hunted throughout the area for 30 years and reports never finding any artifacts or seeing any surface features. Mr. Wallace is an avid collector of anything concerned with natural history.

Archaeologically, the area does not appear to be rich on the surface. An Indian fishing station site is recorded at the junction of the Goldstream and the Columbia Rivers and no cultural material was evident. The site consists of three ledges of shale which extend into the confluence of the two rivers. The bank behind the site is also made of shale and, over the years, loose pieces have fallen on top of the ledge partially covering them. Any cultural material would likely be found beneath this deposit of loose shale. For this reason the site has little significance other than its natural availability as a fishing station. However, this is well removed from any mining activity.

Historically, this area is the centre of the Big Bend Gold Rush of 1865-1874. French and McCulloch Creeks were extensively mined for placer gold during this period. On French Creek, mining methods included sluicing, rocking, drifting, wing damming, and shaft sinking. The largest nugget from this creek weighed 14 oz, 2 pennyweights and was valued at $253 when gold was valued at $20/oz. This creek has yielded an estimated $800,000 in gold. The gold usually ran over 900 fine, the purest in the province. McCulloch Creek gold production approached $750,000.

During the 1976 field survey, a visit was made to the placer gold workings still active in the alpine regions on McCulloch Creek. An informal interview with a placer miner, who has worked the area for 45 years, revealed that a large camp of miners worked at French Creek in the 1930's. There is still occasional mining of the French Creek stream bed conducted at the present time. Traces of the mining camp in the form of two overgrown and abandoned cabins remain visible in the dense vegetation which has recolonized the area (Appendix 2, Figure 8). In the opinion of the miner interviewed during the visit, the mother lode (which has never been found) is located in the alpine ridges on the northwest of McCulloch Creek. Many placer mining claims are recorded along both streams but only a few are "active".

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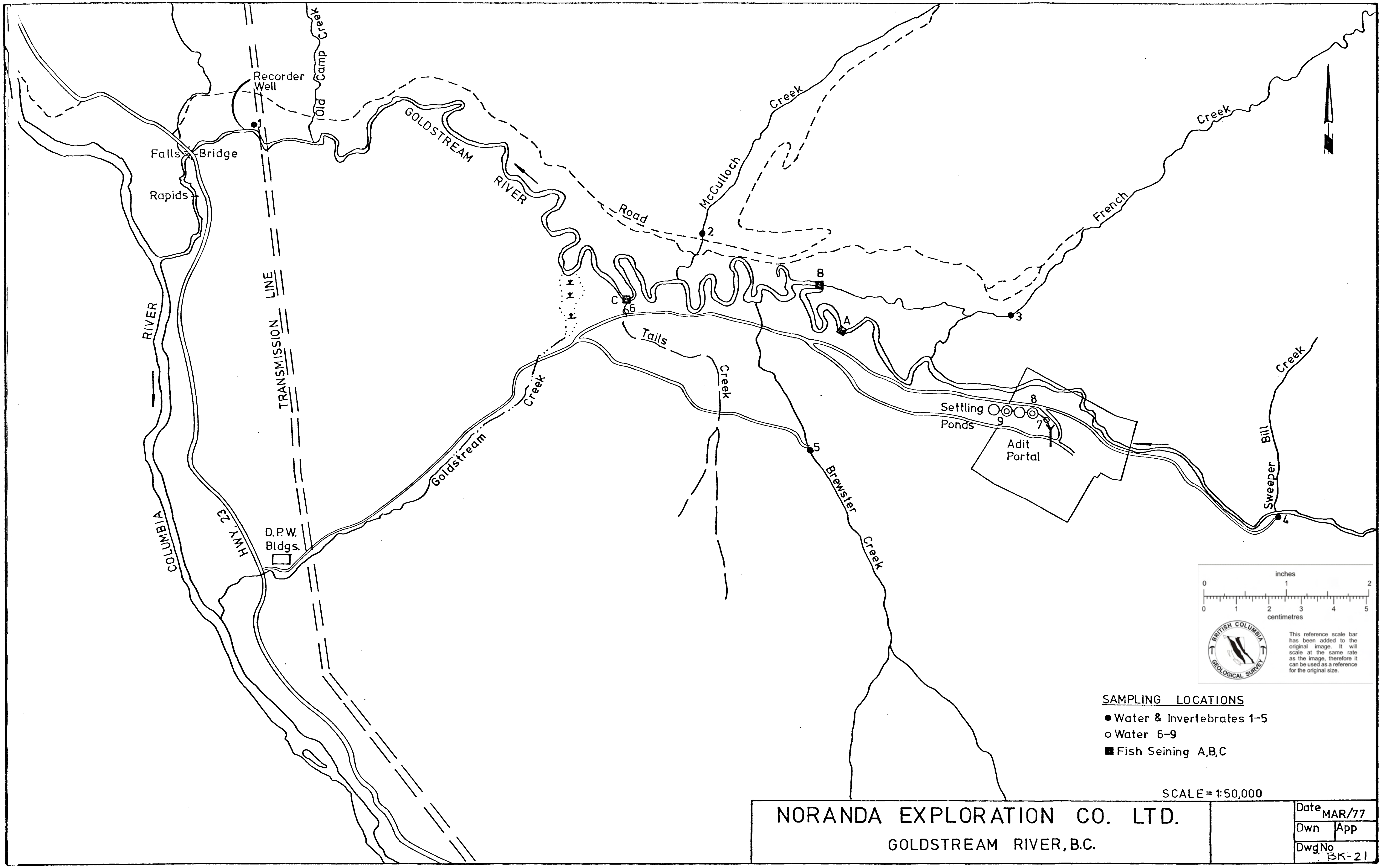
Recorder Well
1
Old Camp Creek
Falls
Bridge
Rapids
GOLDSTREAM RIVER
McCulloch Creek
Road
2
French Creek
B
C
6
A
3
Tails
Creek
TRANSMISSION LINE
RIVER
COLUMBIA
HWY. 23
D.P.W. Bldgs.
Goldstream Creek
Settling Ponds
8
9
7
Adit Portal
5
Brewster Creek
Bill Creek
Sweeper
4
inches
centimetres
BRITISH COLUMBIA GEOLOGICAL SURVEY
This reference scale bar has been added to the original image. It will scale at the same rate as the image, therefore it can be used as a reference for the original size.
SAMPLING LOCATIONS
● Water & Invertebrates 1–5
○ Water 6–9
■ Fish Seining A,B,C
SCALE = 1:50,000
NORANDA EXPLORATION CO. LTD.
GOLDSTREAM RIVER, B.C.
Date MAR/77
Dwn
App
Dwg No BK-21

DETAILED IDENTIFICATION OF INVERTEBRATES
COLLECTED 26 - 27 MAY 1976

LOCATION:	GOLDSTREAM[1] RIVER			GOLDSTREAM[2] RIVER			FRENCH CREEK			McCULLOCH CREEK			BREWSTER CREEK		
SAMPLE	1	2	3	1	2	3	1[3]	2	3	1[4]	2	3	1	2	3
SPECIES															
EPHEMEROPTERA															
Baetis sp.	2	3	4			4		10	8		1			18	26
Epeorus sp.	3	2	7		1	5							9	13	11
Neocleon sp.													2		
Cinygmula sp.					3	2			1				8	10	26
Ephemerella sp.	6	13	4		13	28		2	1				2	8	7
Ephemerella prosperina	1					1									
Heptagenia sp.	1		1		5									4	2
Rithrogena sp.			3	2		2		1	11					2	19
Ameletus sp.	1	1				2								1	
Parameletus sp.				1											
Centroptilum sp.					1										
TRICHOPTERA															
Parapsyche sp.			2								2	1			9
Rhyacophila sp.		5				1		1				1		1	7
Oligophlebodes sp.													35	42	147
Arctopsyche sp.		1			1	1		1					1		
Glossoma sp.	1												3	2	1
Neothremma sp.													1		
PLECOPTERA															
Arcynopteryx sp.		1		4	9	1		1				2	3	2	4
Peltoperla sp.														1	1
Isogenus sp.				1	2	3		2							2
Hastaperla sp.									1						16
Diura sp.		10	4		2	2		2	2						
DIPTERA															
Chironomidae															
Undetermined species			1		3	1								1	8
Corynoneura sp.															1
Penteneura sp.						1									
Empididae															
Clinocera sp.											1				8
Hemerodromia sp.			1												
Tipulidae															
Tipula sp.														5	
Psychodidae															
Pericoma sp.															1
Culicidae - Adult	1														
Tendipedidae - Pupae	1														
Hydracarina						1									
Turbellaria						1									
Oligochaeta															2
TOTAL NO. OF ORGANISM	22	36	27	8	40	56	-	20	24	-	4	4	64	110	300
TOTAL NO. OF TAXA	10	8	9	4	10	16	-	8	6	-	3	3	9	14	20
MEAN NO. PER M^2	304.6			372.7			236.5			43.0			1698.5		

[1]Goldstream River above Sweeper Bill Creek.
[2]Goldstream River above falls near Water Survey of Canada recorder well.
[3]No insects found in sample.
[4]Sample lost in transit

TABLE 2

DETAILED IDENTIFICATION OF INVERTEBRATES
COLLECTED 13 - 14 OCTOBER 1976

LOCATION:	GOLDSTREAM[1] RIVER			GOLDSTREAM[2] RIVER			FRENCH CREEK			McCULLOCH CREEK			BREWSTER CREEK		
SAMPLE	1	2	3	1	2	3	1	2	3	1	2	3	1	2	3
SPECIES															
EPHEMEROPTERA															
Ephemerella sp.	11	6	5	6	4	21							23	16	12
Ephemerella doddsi		1	3	1	1										
Epeorus (Ironopsis sp.)						5	9	6			1		18	1	22
Epeorus (Iron) sp.							1	1			1	1	35	1	25
Rithrogena sp.	24	5	11	6	13	19	1	12	4	1			40	25	34
Centroptilum sp.		1	3												
Baetis sp.										1					
Neocleon sp.									1						
TRICHOPTERA															
Arctopsyche sp.	1			5	17	8	2		1				4	2	1
Rhyacophila sp.	1	3	2		4	4	1	4	2				2	5	2
adult	1	3	2		4	4	1	4	2				2	5	2
pupae														2	
Agapetus sp.	2	2		7	27	5							8	1	
Diplectrona sp.	1				11	24					1	1	1		
Neothremma sp.													3		3
Atopsyche sp.							1								
Drusinus sp.				2	1	1									
Brachycentrus sp.						1									
Unidentified Pupae															3
PLECOPTERA															
Nemoura (Amphinemoura) sp.						2								2	
Nemoura (Zapada) sp.	1	1	1	2	4	3	1						5	6	4
Alloperla sp.	2	2	1		2	2	1	2		15	1	6	17	20	12
Hastaperla sp.		1											1		
Kathroperla sp.														1	3
Peltoperla (Yora Perla) sp.										1	6			1	1
DIPTERA															
Empididae															
Wiedemannia sp.										2	2		3	1	2
Roederiodes sp.													1		
Blepharoceridae															
Agathon sp.					1	1									
Chironimidae															
Cricotopus sp.										1					
Unidentified species								1							
TOTAL NO. OF ORGANISM	43	22	26	29	85	96	17	26	8	21	12	8	161	84	124
TOTAL NO. OF TAXA	9	10	8	7	11	13	8	6	4	6	6	3	14	13	13
MEAN NO. PER M^2		326.1			752.5			182.8			146.9			1049.9	

[1]Goldstream River above Sweeper Bill Creek
[2]Goldstream River above falls near Water Survey of Canada recorder well.

TABLE 3

FISH SEINING RESULTS (10 August, 1976)[1]

SAMPLING LOCATION	SPEC.	SPECIES	STANDARD LENGTH (cm)
A	1	Mountain Whitefish	5.0
	2	Mountain Whitefish	5.5
	3	Mountain Whitefish	7.0
	4	Mountain Whitefish	9.0
	5	Mountain Whitefish	12.0
	6	Mountain Whitefish	11.5
	7	Mountain Whitefish	6.5
	8	Mountain Whitefish	5.7
	9	Mountain Whitefish	4.5
			$\bar{x}$ = 6.6
B	No fish captured		
C	No fish captured		

1 Data for each sampling location represents the results of three seine hauls.

SURFACE WATER CHEMISTRY (1976)

LOCATION: Goldstream River Above Falls Near Recorder Well (Station 1)

Parameters Tested		Date Sampled May 27	Aug 10	Oct 13	Dec 2	$\bar{x}$
pH		7.80	7.75	6.2	7.70	7.36
Color		-	10.0	5.0	<5.0	6.7
Conductivity (micromhos/cm)		109.0	71.6	130.0	165.0	118.9
Turbidity (JTU)		6.3	23.0	1.4	0.60	7.8
Suspended Solids		142.0	39.2	8.0	3.0	46.8
Fixed		129.0	36.2	2.6	0.8	42.2
Volatile		13.0	3.0	0.40	2.2	4.7
Total Dissolved Solids		60.0	62.0	118.0	152.0	98.0
Fixed		30.0	40.0	24.0	65.0	61.5
Volatile		30.0	22.0	94.0	87.0	58.3
Dissolved Anions						
Alkalinity as	$CaCO_3$	45.3	29.5	52.5	69.6	49.2
Sulfate	SO_4	5.5	8.0	3.1	22.2	9.7
Phosphates	$O\text{-}PO_4$	0.06	<0.01	<0.01	<0.01	0.02
Nitrates	N	0.42	<0.1	<0.1	<0.1	0.11
Dissolved Cations						
Calcium	Ca	18.1	11.8	21.5	27.0	19.6
Magnesium	Mg	1.8	1.9	2.8	3.1	2.4
Total Hardness	$CaCO_3$	54.2	37.6	65.1	80.2	59.3
Metals (Total Basis)						
Arsenic	As	<0.004	<0.004	<0.01	<0.01	<0.01
Cadmium	Cd	<0.001	<0.001	<0.001	<0.001	<0.001
Copper	Cu	0.001	<0.001	0.001	0.003	0.002
Iron	Fe	2.0	2.0	<0.05	<0.05	1.03
Mercury	Hg	<0.001	0.002	<0.002	<0.002	<0.002
Manganese	Mn	0.050	0.034	0.012	0.018	0.029
Molybdenum	Mo	<0.005	<0.010	<0.005	<0.005	<0.010
Nickel	Ni	0.001	0.004	<0.001	0.009	0.004
Lead	Pb	<0.001	<0.001	0.001	0.001	0.001
Zinc	Zn	<0.001	0.006	<0.001	0.003	0.003
Chemical Oxygen Demand		29.0	16.8	<2.0	<2.0	12.5
Dissolved Oxygen		-	9.8	12.1	14.5	12.1
Temperature °C		-	9.5	7.2	0.0	5.2

All results in ppm unless otherwise indicated.

SURFACE WATER CHEMISTRY (1976)

LOCATION: Goldstream River above the Confluence of Sweeper Bill Creek (Stat. 4)

Parameters Tested		Date Sampled May 27	Aug 10	Oct 13	Dec 2	$\bar{x}$
pH		7.80	7.84	7.55	7.80	7.75
Color		-	10.0	5.0	<5.0	6.7
Conductivity (micromhos/cm)		106.0	66.2	117.0	157.0	111.6
Turbidity (JTU)		0.88	-	35.0	1.0	9.6
Suspended Solids		16.0	44.0	3.4	4.6	17.0
Fixed		13.0	41.2	3.0	3.4	15.2
Volatile		3.0	2.8	0.40	1.2	1.9
Total Dissolved Solids		76.0	59.0	128.0	145.0	102.0
Fixed		28.0	39.0	26.0	60.0	38.3
Volatile		48.0	20.0	102.0	85.0	63.8
Dissolved Anions						
Alkalinity as	$CaCO_3$	42.3	25.4	49.7	64.1	45.4
Sulfate	SO_4	6.7	17.0	3.5	19.1	11.6
Phosphates	$O\text{-}PO_4$	0.04	<0.01	<0.01	<0.01	0.02
Nitrates	N	0.62	<0.1	<0.1	<0.1	0.23
Dissolved Cations						
Calcium	Ca	17.3	10.9	19.6	25.7	18.4
Magnesium	Mg	1.6	1.6	2.4	2.7	2.1
Total Hardness	$CaCO_3$	51.1	34.4	58.7	75.4	54.9
Metals (Total Basis)						
Arsenic	As	<0.004	<0.004	<0.01	<0.01	<0.01
Cadmium	Cd	<0.001	<0.001	<0.001	<0.001	<0.001
Copper	Cu	<0.001	0.002	<0.001	0.001	0.001
Iron	Fe	0.56	2.0	0.20	<0.05	0.70
Mercury	Hg	<0.002	<0.002	<0.002	<0.002	<0.002
Manganese	Mn	0.015	0.030	0.017	0.03	0.023
Molybdenum	Mo	<0.005	<0.010	<0.005	<0.005	<0.010
Nickel	Ni	<0.001	0.005	<0.001	<0.003	0.003
Lead	Pb	<0.001	<0.001	<0.001	0.001	<0.001
Zinc	Zn	<0.001	0.006	<0.001	0.030	0.010
Chemical Oxygen Demand		37.0	12.6	<2.0	<2.0	13.4
Dissolved Oxygen		-	10.0	12.6	14.4	12.3
Temperature °c		-	8.1	3.5	0.0	3.5

All results in ppm unless otherwise indicated.

TABLE 6

SURFACE WATER CHEMISTRY (1976)

LOCATION: McCulloch Creek (Station 2)

Parameters Tested		Date Sampled May 27	Aug 10	Oct 13	Dec 2	$\bar{x}$
pH		8.00	8.08	7.7	7.95	7.95
Color		-	<5.0	5.0	<5.0	<5.0
Conductivity (micromhos/cm)		124.0	115.0	170.0	202.0	152.7
Turbidity (JTU)		6.7	2.7	1.5	0.51	2.85
Suspended Solids		62.0	18.6	8.0	1.80	22.6
Fixed		51.0	16.2	6.8	0.80	18.7
Volatile		11.0	2.4	1.2	1.0	3.9
Total Dissolved Solids		46.0	106.0	130.0	186.0	117.0
Fixed		23.0	80.0	50.0	75.0	57.0
Volatile		23.0	26.0	70.0	111.0	57.5
Dissolved Anions						
Alkalinity as	$CaCO_3$	56.9	53.6	85.3	92.7	72.1
Sulfate	SO_4	4.0	19.5	3.5	7.0	8.5
Phosphates	$O-PO_4$	0.06	<0.01	<0.01	<0.01	0.02
Nitrates	N	0.42	<0.1	<0.1	<0.01	0.16
Dissolved Cations						
Calcium	Ca	18.5	20.2	26.0	29.0	23.4
Magnesium	Mg	4.5	2.2	6.6	7.4	5.2
Total Hardness	$CaCO_3$	63.9	60.8	91.9	103.0	79.9
Metals (Total Basis)						
Arsenic	As	<0.004	<0.004	<0.01	<0.01	<0.01
Cadmium	Cd	<0.001	<0.001	<0.001	<0.001	<0.001
Copper	Cu	<0.001	<0.001	<0.001	0.002	<0.001
Iron	Fe	2.34	0.94	0.20	<0.05	0.88
Mercury	Hg	<0.002	<0.002	<0.002	<0.002	<0.002
Manganese	Mn	0.053	0.013	0.006	0.005	0.019
Molybdenum	Mo	<0.005	<0.010	<0.005	<0.005	<0.010
Nickel	Ni	<0.001	<0.001	0.004	0.008	0.004
Lead	Pb	<0.001	<0.001	0.001	<0.001	<0.001
Zinc	Zn	<0.001	0.010	<0.001	<0.001	0.003
Chemical Oxygen Demand		35.0	10.6	2.0	2.0	12.4
Dissolved Oxygen		-	9.3	12.0	14.9	12.1
Temperature °C		-	10.5	7.1	0.0	5.9

All results in ppm unless otherwise indicated.

TABLE 7

SURFACE WATER CHEMISTRY (1976)

LOCATION: French Creek (Station 3)

Parameters Tested		May 27	Aug 10	Oct 13	Dec 2	$\bar{x}$
		Date Sampled				
pH		7.90	7.95	7.35	7.80	7.75
Color		-	15.0	<5.0	<5.0	8.3
Conductivity (micromhos/cm)		114.0	82.2	125.0	163.0	121.1
Turbidity (JTU)		3.0	23.0	1.4	1.40	7.2
Suspended Solids		27.5	43.0	3.4	4.2	19.5
Fixed		22.0	39.6	2.8	2.8	16.8
Volatile		5.5	3.4	0.6	1.4	2.7
Total Dissolved Solids		76.0	75.0	154.0	150.0	113.8
Fixed		16.0	50.0	48.0	54.0	42.0
Volatile		60.0	25.0	106.0	96.0	71.8
Dissolved Anions						
Alkalinity as	$CaCO_3$	45.5	33.7	53.8	67.7	50.2
Sulfate	SO_4	6.7	15.0	4.1	6.6	8.1
Phosphates	$O\text{-}PO_4$	0.06	<0.01	<0.01	<0.01	0.02
Nitrates	N	0.52	<0.1	<0.1	<0.10	0.16
Dissolved Cations						
Calcium	Ca	18.5	14.2	22.3	28.0	20.8
Magnesium	Mg	1.6	1.7	1.7	2.2	1.8
Total Hardness	$CaCO_3$	54.6	43.4	62.7	79.2	60.0
Metals (Total Basis)						
Arsenic	As	<0.004	<0.004	<0.01	<0.01	<0.01
Cadmium	Cd	<0.001	<0.001	<0.001	<0.001	<0.001
Copper	Cu	<0.001	0.001	<0.001	0.002	0.001
Iron	Fe	0.90	2.9	0.20	<0.05	1.01
Mercury	Hg	<0.002	<0.002	<0.002	<0.002	<0.002
Manganese	Mn	0.014	0.031	0.016	0.017	0.020
Molybdenum	Mo	<0.005	<0.010	<0.005	<0.005	<0.005
Nickel	Ni	<0.001	0.004	<0.001	<0.003	0.002
Lead	Pb	<0.001	<0.001	0.002	<0.001	0.001
Zinc	Zn	<0.001	0.009	<0.001	0.003	0.004
Chemical Oxygen Demand		37.0	12.6	<2.0	13.3	16.2
Dissolved Oxygen		-	9.3	12.4	14.9	12.2
Temperature °C		-	11.1	5.7	0.0	5.3

All results in ppm unless otherwise indicated.

TABLE 8

SURFACE WATER CHEMISTRY (1976)

LOCATION: Brewster Creek (Station 5)

Parameters Tested		May 27	Aug 10	Oct 13	Dec 2	$\bar{x}$
		Date Sampled				
pH		7.75	7.70	7.3	7.65	7.60
Color		-	<5.0	5.0	<5.0	<5.0
Conductivity (micromhos/cm)		86.7	60.0	105.0	131.0	95.7
Turbidity (JTU)		0.80	0.52	0.51	0.47	0.58
Suspended Solids		3.0	2.0	0.80	0.40	1.55
Fixed		2.0	1.0	0.60	0.20	0.95
Volatile		1.0	1.0	0.20	0.20	0.60
Total Dissolved Solids		60.0	59.0	134.0	120	93.3
Fixed		26.0	44.0	32.0	42.0	36.0
Volatile		34.0	15.0	102.0	78.0	57.3
Dissolved Anions						
Alkalinity as	$CaCO_3$	34.0	22.7	43.9	51.3	38.0
Sulfate	SO_4	4.7	25.0	3.9	5.1	9.7
Phosphates	$O-PO_4$	<0.10	<0.01	<0.01	<0.01	<0.01
Nitrates	N	0.50	<0.1	<0.1	<0.1	0.2
Dissolved Cations						
Calcium	Ca	14.6	10.0	18.2	21.4	16.1
Magnesium	Mg	0.9	1.7	1.5	1.85	1.49
Total Hardness	$CaCO_3$	41.6	32.4	51.5	61.1	46.7
Metals (Total Basis)						
Arsenic	As	<0.004	<0.004	<0.01	<0.01	<0.01
Cadmium	Cd	<0.001	<0.001	<0.001	<0.001	<0.001
Copper	Cu	<0.001	<0.001	<0.001	<0.001	<0.001
Iron	Fe	0.14	<0.10	<0.05	<0.05	0.09
Mercury	Hg	0.003	<0.002	<0.002	<0.002	<0.002
Manganese	Mn	0.003	0.017	0.011	<0.005	0.010
Molybdenum	Mo	<0.005	<0.010	<0.005	<0.005	<0.010
Nickel	Ni	<0.001	<0.001	<0.001	<0.003	<0.003
Lead	Pb	<0.001	<0.001	0.001	<0.001	<0.001
Zinc	Zn	<0.001	<0.001	0.003	0.003	0.002
Chemical Oxygen Demand		37.0	8.4	<2.0	17.1	16.1
Dissolved Oxygen		-	9.5	13.5	14.0	12.3
Temperature °C		-	9.0	2.8	0.0	3.6

All results in ppm unless otherwise indicated.

SURFACE WATER CHEMISTRY (1976)
LOCATION: Tails Creek (Station 6)

Parameters Tested		May 27 [1]	Aug 10	Oct 13	Dec 2	$\bar{x}$
			Date Sampled			
pH			7.90	7.2	7.55	7.55
Color			10.0	10.0	<5.0	8.3
Conductivity (micromhos/cm)			94.0	94.9	103.0	97.3
Turbidity (JTU)			0.58	0.34	0.51	0.48
Suspended Solids			5.4	1.60	1.20	2.73
Fixed			2.6	0.80	0.80	1.33
Volatile			2.8	0.80	0.60	1.4
Total Dissolved Solids			109.0	134.0	98.0	113.7
Fixed			79.0	28.0	30.0	45.7
Volatile			30.0	106.0	68.0	68.0
Dissolved Anions						
Alkalinity as	$CaCO_3$		38.5	39.1	38.5	38.7
Sulfate	SO_4		53.5	2.0	8.0	21.2
Phosphates	$O-PO_4$		<0.01	<0.01	<0.01	<0.01
Nitrates	N		<0.1	<0.1	<0.1	<0.1
Dissolved Cations						
Calcium	Ca		15.8	15.8	15.4	15.7
Magnesium	Mg		1.8	1.5	2.0	1.8
Total Hardness	$CaCO_3$		47.6	45.8	46.8	46.7
Metals (Total Basis)						
Arsenic	As		<0.004	<0.01	<0.01	<0.01
Cadmium	Cd		<0.001	<0.001	<0.001	<0.001
Copper	Cu		<0.001	<0.001	<0.001	<0.001
Iron	Fe		0.24	<0.05	<0.05	0.11
Mercury	Hg		0.001	<0.002	<0.002	<0.002
Manganese	Mn		0.020	0.017	0.010	0.016
Molybdenum	Mo		<0.010	<0.005	<0.005	<0.010
Nickel	Ni		<0.001	<0.001	<0.003	<0.003
Lead	Pb		<0.001	<0.001	<0.001	<0.001
Zinc	Zn		<0.001	<0.001	0.002	0.001
Chemical Oxygen Demand			12.0	<2.0	22.8	12.3
Dissolved Oxygen			9.2	11.4	13.6	11.4
Temperature °C			12.5	7.8	0.0	6.4

All results in ppm unless otherwise indicated.

[1] Not Sampled

TABLE 10

ADIT WATER CHEMISTRY (1976)

		Oct. 13 Adit Portal (Station 7)	Oct. 13 Settling Pond #1 (Station 8)	Oct. 13 Settling Pond #3 (Station 9)
Suspended Solids				
Total		101.0	48.0	31.0
Fixed		96.0	42.5	27.0
Volatile		5.0	5.5	4.0
Dissolved Solids				
Total		204.0	162.0	236.0
Fixed		124.0	134.0	146.0
Volatile		80.0	28.0	90.0
Metals (Total Basis)				
Arsenic	As	<0.01	<0.01	<0.01
Cadmium	Cd	0.001	0.001	0.001
Copper	Cu	0.050	0.090	0.020
Iron	Fe	8.10	3.06	1.62
Mercury	Hg	<0.002	<0.002	<0.002
Manganese	Mn	0.15	0.10	0.10
Molybdenum	Mo	<0.005	<0.005	<0.005
Nickel	Ni	0.018	0.010	0.006
Lead	Pb	0.012	0.012	0.004
Zinc	Zn	0.036	0.035	0.033
DO		11.7	-	-
pH		8.0	7.7	7.7
Color		7.0	17.0	15.0
Dissolved Iron		<0.05	<0.05	<0.05
Turbidity (JTU)		68	52	33

All results in ppm unless otherwise indicated.

TABLE 11

ADIT WATER CHEMISTRY (1976)

		Dec. 2 Adit Portal (Station 7)	Dec. 2 Settling Pond #1 (Station 8)	Dec. 2 Settling Pond #3 (Station 9)
Suspended Solids				
Total		3.2	-	-
Fixed		2.0	-	-
Volatile		1.2	-	-
Dissolved Solids				
Total		120.0	-	-
Fixed		50.0	-	-
Volatile		70.0	-	-
Metals (Total Basis)				
Arsenic	As	<0.01	-	-
Cadmium	Cd	0.001	-	-
Copper	Cu	0.001	-	-
Iron	Fe	0.05	-	-
Mercury	Hg	<0.002	-	-
Manganese	Mn	0.05	-	-
Molybdenum	Mo	<0.005	-	-
Nickel	Ni	<0.003	-	-
Lead	Pb	0.001	-	-
Zinc	Zn	0.016	-	-
Flow (cfs)		0.1	-	-

All results in ppm unless otherwise indicated.

Settling Ponds #1 & 3 frozen.

TABLE 12

STREAM FLOW REGIMES (1976)

Location	May 27	Aug 10	Oct 13	Dec 2	$\bar{x}$
French Creek	311	661	124	85	295
McCulloch Creek	70	32	14	8	31
Goldstream River (above falls)	4020[1]	3600	751	268	2158
Goldstream River (above Sweeper Bill Creek)	1016	2368	442	165	998
Brewster Creek	124	121	39	22	78
Tails Creek	-	16	6	5	9
Adit Water	-	-	-	0.1	-

Flow recorded as cubic feet per second

[1] Environment Canada in Revelstoke estimated 3000 cfs

TABLE 13

GOLDSTREAM RIVER FLOW DATA FOR 1976
(Measured below Old Camp Creek at Recorder Well[1])

DATE	Discharge (cfs) MONTHLY MEAN	INST. MAXIMUM	INST. MINIMUM	Gauge Height (feet)[2] MONTHLY MEAN	INST. MAXIMUM	INST. MINIMUM
Jan	236	281	199	-	-	-
Feb	196	209	151	-	-	-
March	236	300	179	-	-	-
April	975	1800	320	-	-	-
May	3030	5000	1650	-	-	-
June	3360	5960	1500	7.08	8.30	6.50
July	5000	7240	3190	7.86	9.11	6.88
Aug	3970	5100	2980	7.25	7.94	6.62
Sept	2400	6280	1440	6.15	8.60	5.44
Oct	756	1540	474	4.63	5.52	4.22
Nov	381	531	255	4.11	4.39	3.92
Dec	325	536	202	3.92	4.33	3.68

[1] Figures are preliminary computations from data supplied by Water Survey of Canada.

[2] Data not available for January-June, 1976

TABLE 14

CHARACTERISTICS OF FISHES FOUND IN THE GOLDSTREAM RIVER[1]

NAME	HABITAT TYPES (adults)	TIME OF SPAWNING	SPAWNING HABITAT	TYPE OF FEEDING (adults)	USE BY MAN	OTHER COMMENTS
Mountain whitefish <u>Prosopium williamsoni</u> (Girard)	lakes and large rivers; prefers surface layers; small turbid pools and eutrophic lakes	late fall - early winter	gravel and rubble in streams and possibly lake shores at depths of 5 in. to 4 ft.	primarily a bottom feeder; takes aquatic insects and sometimes pelagic plankton	gaining popularity in B.C. and Alberta as a sports fish	eggs deposited in late Oct. - early Nov.; hatch in March; fry usually move out of spawning areas immediately
(Yellowstone) Cutthroat trout <u>Salmo</u> <u>clarki</u> (Richardson)	gravelly streams and lakes; alpine rivers and lakes	spring-early summer; 3-5 weeks after ice breakup	only in small gravelly streams with water temperature about 10°C	mainly on terrestrial and aquatic insects and small fishes; plankton, crustaceans, fish eggs, dead fish	sports fish but not as attractive as rainbow or brook trout	young may move from spawning streams to larger streams or lakes immediately after emergence or remain in streams for up to 3 years before moving to larger systems

[1] From Scott, W.B. and E.J. Crossman - 1973

APPENDIX II

"ACID PRODUCTION POTENTIAL OF

ROCK SAMPLES FROM THE

GOLDSTREAM PROSPECT"

- by B. C. Research

ACID PRODUCTION POTENTIAL OF TWO SAMPLES OF WASTE ROCK FROM GOLDSTREAM

Project # 1-07-209

May 25, 1979

Prepared for:

Noranda Mines Ltd.
Goldstream Division
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ACID PRODUCTION POTENTIAL
OF TWO WASTE ROCK SAMPLES
FROM GOLDSTREAM

SUMMARY

Both the samples, numbers "1" and "2", were non-acid producers as their acid consumption was in excess of their theoretical acid production.

INTRODUCTION

OBJECTIVE

To determine the acid production potential of two samples of waste rock from the Goldstream property of Noranda Mines Ltd.

BACKGROUND

Many sulfide minerals can be oxidized microbiologically to sulfuric acid and soluble metal sulfate salts. This phenomenon can result in a potential water pollution hazard if the amount of sulfuric acid which the bacteria produce exceeds the neutralizing capability of the host rock. If acidic drainage water occurs, the microbiological attack on sulfides contained in the sample, as well as the microbiologically produced acid, could solubilize heavy metals which could be toxic to aquatic flora and fauna in the area, if they were allowed to enter receiving waters.

B.C. Research has developed a two-part test which allows prediction of the acid producing potential of a particular sample (Appendix 1). This test has been used to analyze the two samples of waste rock from the Goldstream property submitted by Noranda Mines Ltd.

STAFF

The investigation was carried out by the Mineral Microbiology Group of the Division of Applied Biology under the direction of Mr. A. Bruynesteyn. The test work was performed by Miss H. Kurtz with assistance from Mr. R. Vos and Mr. D. Watt. The report was written by Mr. D. Watt.

RESULTS

INITIAL CHEMICAL TESTS

The number "1" and "2" samples had a sulfur content of 1.56% and 1.30% S respectively equivalent to 95.2 and 79.5 lb H_2SO_4/ton with acid consumptions of 252 and 619 lb H_2SO_4/ton. No confirmation test was done on these two samples.

DISCUSSION

These test results show that both waste rock samples are quite strongly alkaline, and have no potential to produce excess acid. This material is so acid consuming that there is little chance that bacterial action can occur, and if any should occur in localized areas, the acid produced will be neutralized by the surrounding material. As long as minimal precautions are taken to control an accumulation of pyritic wastes on the surface, there should be no problem with acidic mine drainage.

D.R.G. Watt
Metallurgical Technologist
Division of Applied Biology

Approved on Behalf of B.C. Research

A. Bruynesteyn, Manager
Mineral Leaching Program
Division of Applied Biology

TABLE 1

ACID PRODUCTION TESTS
INITIAL ACID PRODUCTION TEST

Sample	% S	Theoretical Acid lbH_2SO_4/ton	Natural pH 10 g sample + 100 ml H_2O	Acid Consumption lbH_2SO_4/ton	Potential Acid Producer
#1 - WASTE ROCK	1.56	95.2	8.9	252	NO
#2 - WASTE ROCK	1.30	79.5	9.3	619	NO

APPENDIX I

TEST PROCEDURES FOR EVALUATING ACID-PRODUCING POTENTIAL OF ORE AND WASTE ROCK

INITIAL TEST (CHEMICAL)

Sample

The sample selected must be taken in such a manner that it is truly representative of the type of mineralization being examined. A composite made up of split drill core or of randomly selected grab samples should be satisfactory. The number of samples to be examined will depend on the variability of the mineralization and must be left to the discretion of the geologist taking the samples. The bulk sample is crushed to a size which can be conveniently handled, (i.e. -2 in.) and then thoroughly mixed and approximately a 2-lb portion split out, by coning and quartering. This sample is then pulverized to pass a 100 mesh screen and used for assay, the titration test, and the confirmation test if necessary.

Assay

The pulverized sample is assayed in duplicate for total sulfur, using a Leco furnace. The total sulfur assay value is expressed as pounds of sulfuric acid per ton of sample, assuming a 1:1 conversion factor, which is the acid-producing potential of the sample.

Titration Test

Duplicate 10-g portions of the pulverized sample are suspended in 100 ml of distilled water and stirred for approximately 15 minutes. The natural pH of the sample is then recorded and the sample titrated to pH 3.5 with 1.0 N sulfuric acid with a radiometer automatic titrator. The test is continued until less than 0.1 ml of acid is added over a 4-h period. The total volume of acid added is recorded and converted to lb per ton of sample. This is the acid-consuming ability of the sample, i.e.

$$\text{acid-consuming ability (lb/ton)} = \frac{\text{ml of 1.0 N } H_2SO_4 \times 0.049 \times 2000}{\text{wt of sample in g}}$$

$$\text{or for a 10-g sample} \qquad = \text{ml of 1.0 N } H_2SO_4 \times 9.8$$

Interpretation

If the acid consumption value (in lb of acid per ton of sample) exceeds the acid-producing potential (lb per ton) then the sample will not be a source of acid mine drainage and no additional work is necessary. If the acid consumption is less than the acid-producing potential, the possibility of acid mine water production exists and the confirmation test is conducted.

CONFIRMATION TEST (BIOLOGICAL)

Sample

The remaining portion of the pulverized sample is ball-milled (wet) for 2 to 3 h to produce a 400 mesh sample which is dried overnight at 105°C.

Shake-Flask Leaching Test

Duplicate 30-g portions (or a smaller amount if the sulfide content exceeds 2%) are placed in 250 ml Erlenmeyer flasks with 70 ml of a nutrient medium containing 3 g/l $(NH_4)_2SO_4$; 0.10 g/l KCl; 0.50 g/l K_2HPO_4; 0.50 g/l $MgSO_4 \cdot 7H_2O$; 0.1 g/l $Ca(NO_3)_2$. Add sufficient sulfuric acid (either 12 or 36 N) to bring the pH to 2.5. Shake the flasks for approximately 4 h and the pH should be between 2.5 and 2.8. If necessary add additional acid until the pH remains in that range, and then inoculate the flasks with 5 ml of an active culture of <u>Thiobacillus</u> <u>ferrooxidans</u>. Record the weight of the flasks and contents. Plug the flasks with a loose cotton plug and incubate at 35°C on a gyratory shaker.

The experimental leaching flasks are returned to their original weight before sampling by adding distilled or de-ionized water. Monitor the pH and concentration of a dissolved metal, e.g. iron, copper or zinc, for the first three days to ensure that the pH remains below 2.8. Thereafter, monitor every second day until microbiological activity has ceased, i.e. the pH no longer drops or the dissolved metal concentration remains constant.

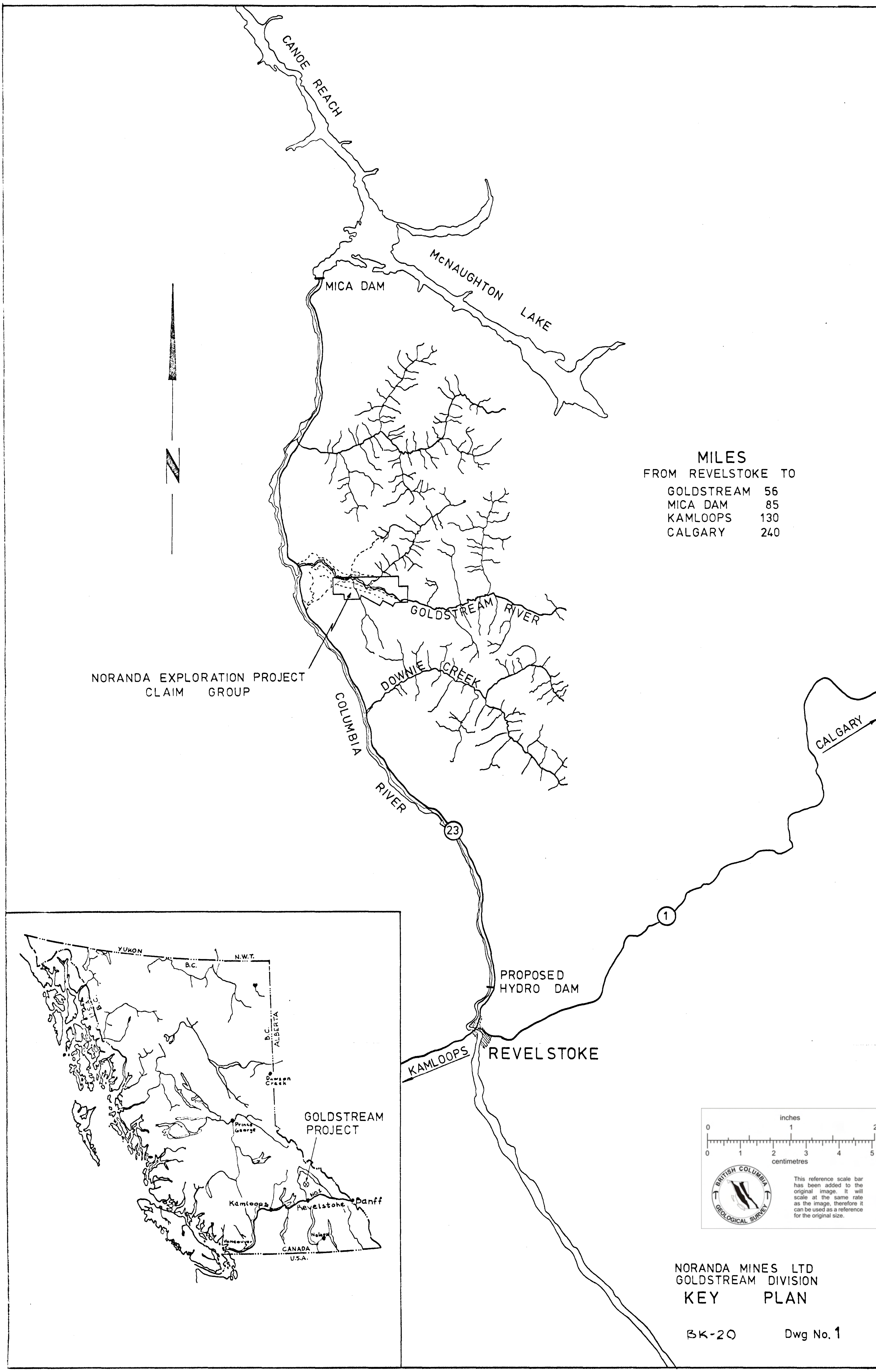
When microbiological activity has ceased, add half the weight of feed used originally (i.e. 15 g), shake 24 h and record the pH. If it is greater than pH 3.5, terminate the test. If it is 3.5 or less, again add half the weight of feed (i.e. 15 g) and shake for 24 h. If the pH is less than 3.5 or greater than pH 4, the experiment is terminated. If the pH is between 3.5 and 4.0, the sample is shaken an additional 48 h and the final pH value recorded.

Interpretation

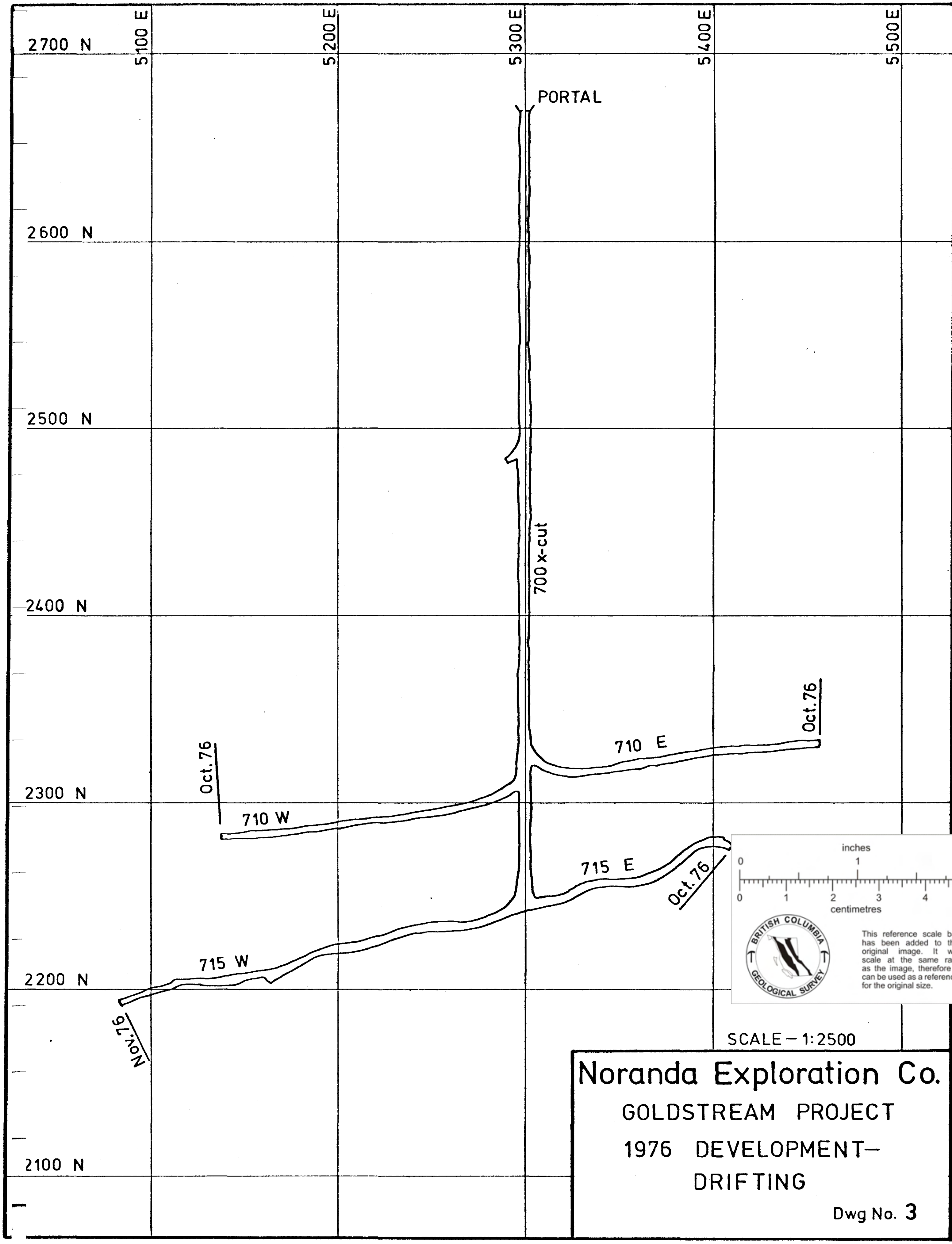
The object of this test is to determine if the sulfide-oxidizing bacteria can generate enough sulfuric acid from the sulfides present to satisfy the sample's acid demand. Experience has shown that not all sulfide minerals are amenable to microbiological attack nor do they all oxidize completely, so the acid-producing potential indicated by the sulfur assay may overestimate the danger. If the bacteria generate the acid, microbiological action will continue on a self-sustaining basis if it becomes established, and acidic mine water will result. In this test, the acid demand is satisfied initially by adding sulfuric acid. This permits the bacteria to generate the maximum amount of sulfuric acid from the sample concerned. Once microbiological action has ceased, half the original sample weight is added. If there has not been sufficient acid production, the pH will approach the natural pH of the sample (i.e. above pH 3.5) and the sample is reported as not being a potential source of acid mine water. If the pH remains at 3.5 or below, the remainder of the sample is added and the sample is shaken for up to 72 h before measuring the final pH. If the pH is still in the leaching range, i.e. pH 3.5 or below, there is a strong possibility that natural leaching will occur and acid mine drainage will be produced. If the pH is above 3.5, there is no possibility of acid mine drainage occurring.

If the sample produces excess acidity, there is the possibility of metal recovery by microbiological leaching. A measure of this potential can be obtained by estimating the percentage of the contained metal which has been solubilized during the leaching test. Under such circumstances, it may be desirable to promote microbiological action as a means of recovering valuable metals from a waste material. In such a system, suitable precautions must be taken to prevent the metal and acid-rich leach waters from entering the natural drainage system of the surrounding area.

LIST OF DRAWINGS & FIGURES


CANOE REACH
MICA DAM
McNAUGHTON LAKE
N
MILES
FROM REVELSTOKE TO
GOLDSTREAM 56
MICA DAM 85
KAMLOOPS 130
CALGARY 240
GOLDSTREAM RIVER
NORANDA EXPLORATION PROJECT
CLAIM GROUP
DOWNIE CREEK
COLUMBIA
RIVER
23
CALGARY
1
PROPOSED
HYDRO DAM
KAMLOOPS
REVELSTOKE
YUKON
N.W.T.
B.C.
B.C.
ALBERTA
Dawson Creek
Prince George
GOLDSTREAM
PROJECT
Kamloops
Revelstoke
Banff
Vancouver
Nelson
CANADA
U.S.A.
inches
0
1
2
0
1
2
3
4
5
centimetres
BRITISH COLUMBIA
GEOLOGICAL SURVEY
This reference scale bar has been added to the original image. It will scale at the same rate as the image, therefore it can be used as a reference for the original size.
NORANDA MINES LTD
GOLDSTREAM DIVISION
KEY PLAN
BK-20
Dwg No. 1


LEGEND
TREE FARM LICENCE 23
TREE FARM LICENCE 38
TIMBER LICENCE 1178
TIMBER LICENCE 2980
P.ML. 547
P.ML. 556
P.ML. 546
P.ML. 542
P.ML. 562
P.ML. 569
P.ML. 572
P.ML. 570
P.ML. 568
P.ML. 536
Old Camp Creek
McCulloch Creek
French Creek
GOLDSTREAM RIVER
Road
Bridge
Rapids
COLUMBIA RIVER
TRANSMISSION LINE
HWY 23
D.P.W. Bldgs.
TAILINGS POND
Goldstream Creek
Brewster Creek
NORANDA LEASE BOUNDARY
ADIT
WASTE DUMP
ORE BODY
Sweeper Bill Creek
DAM
RESERVOIR
Stitt Creek
Creek
NORANDA MINES LTD
GOLDSTREAM LAND OWNERSHIP
SCALE 1:50,000
Date 11 MAY 77
Dwn
App
Dwg No 2
GK-13
inches
centimetres
This reference scale bar has been added to the original image. It will scale at the same rate as the image, therefore it can be used as a reference for the original size.
BRITISH COLUMBIA GEOLOGICAL SURVEY

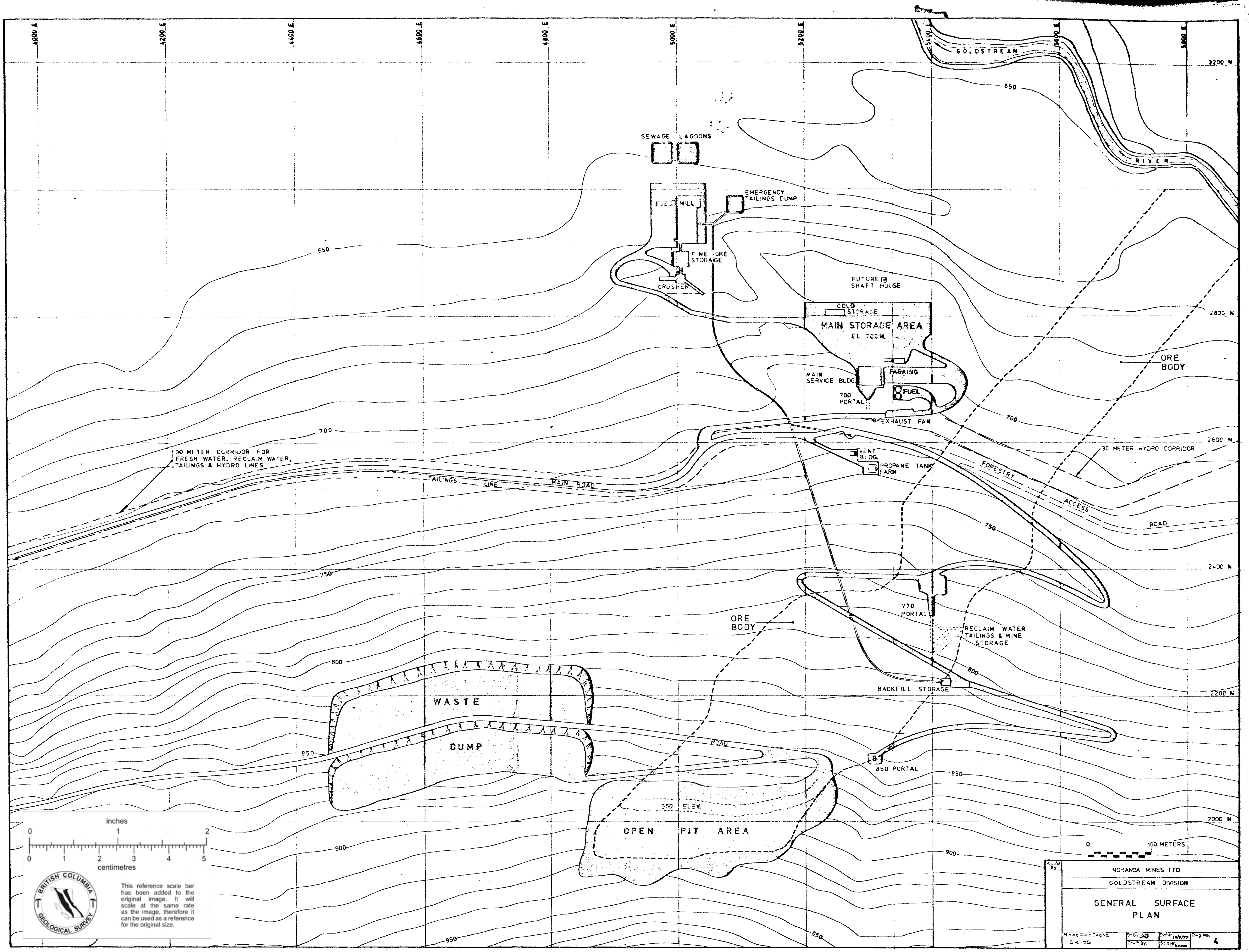


Noranda Exploration Co.

GOLDSTREAM PROJECT

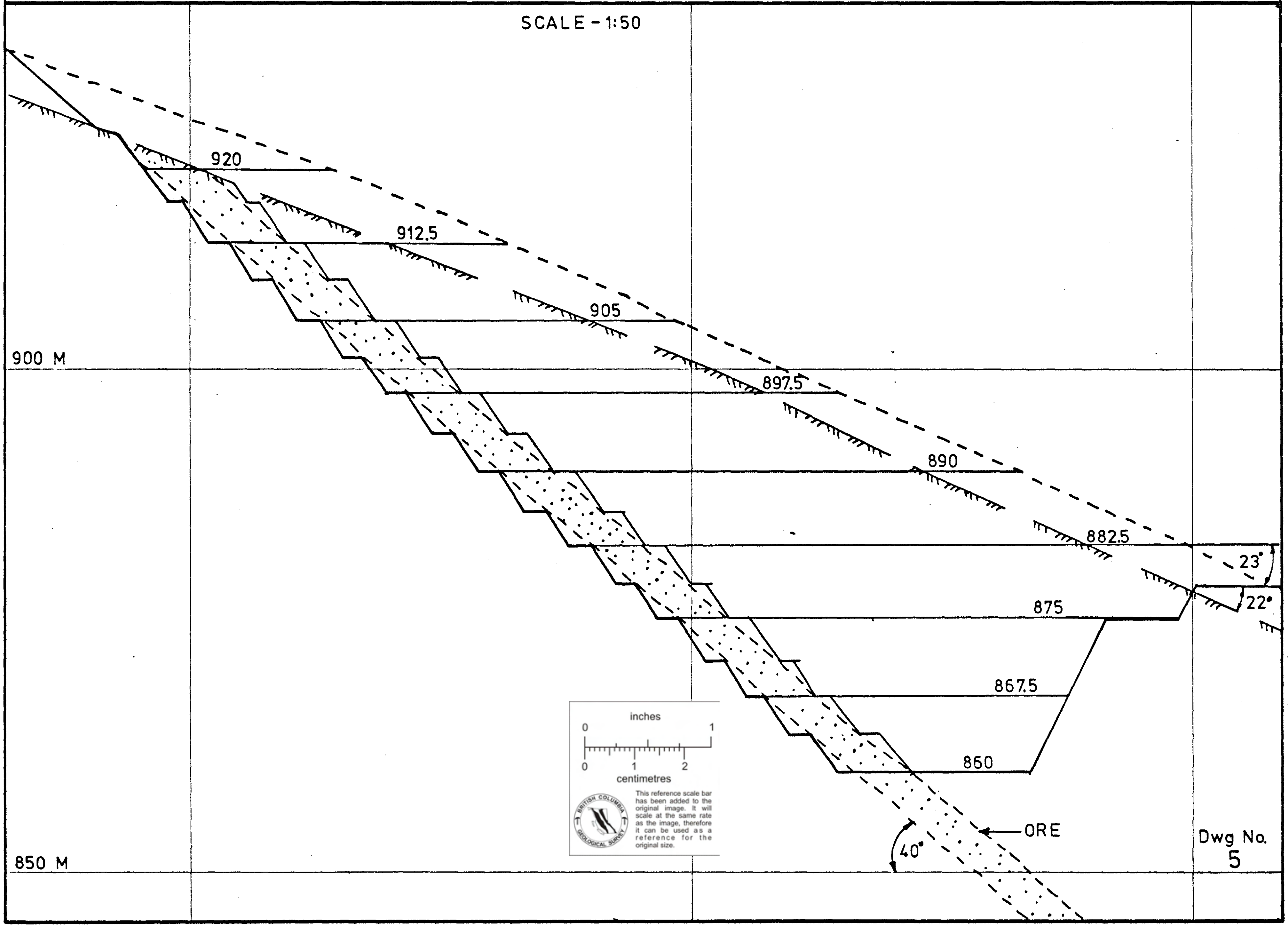
1976 DEVELOPMENT—DRIFTING

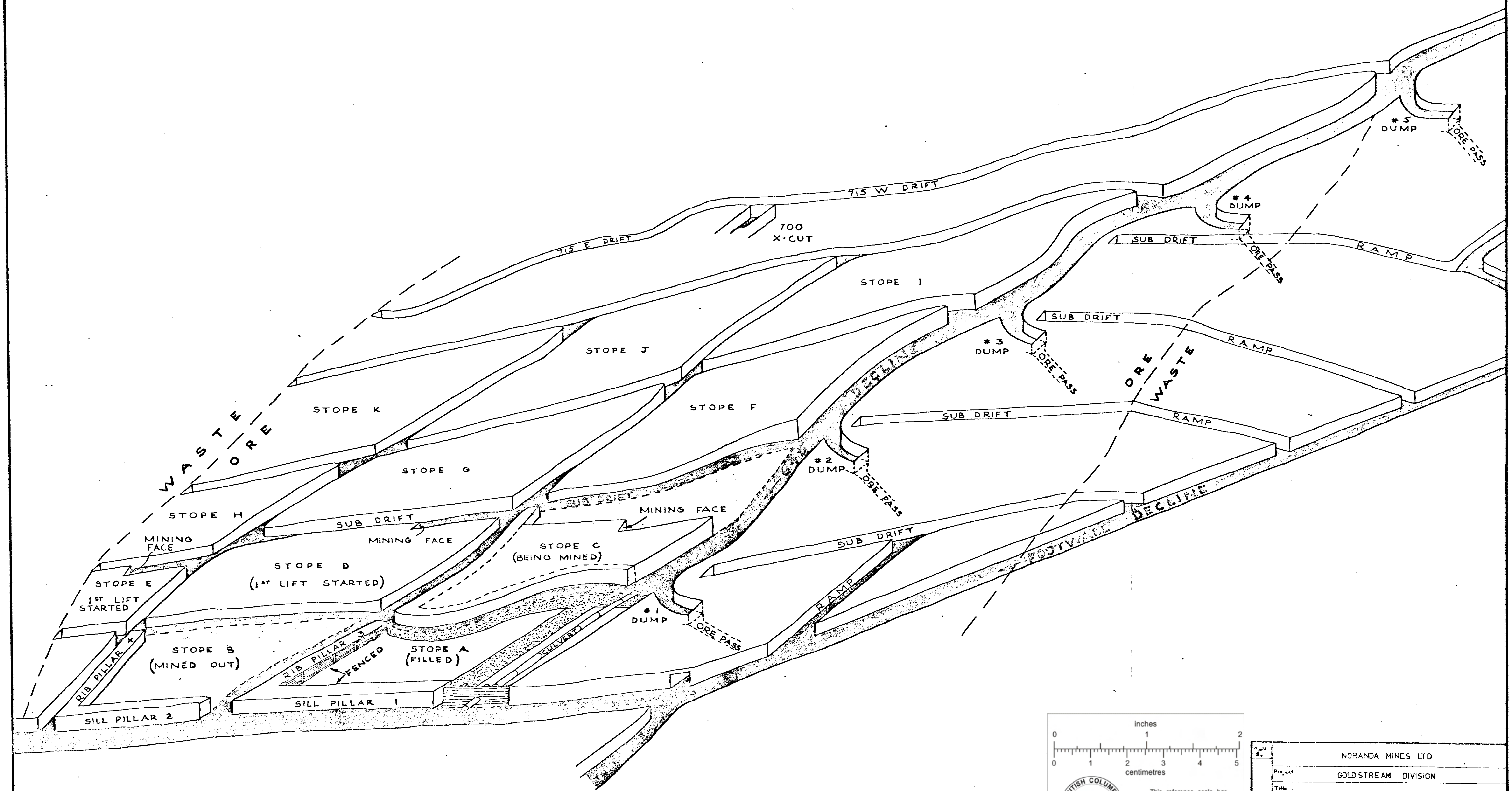
Dwg No. 3



6000 E
6200 E
6400 E
6600 E
6800 E
5000 E
5200 E
5600 E
5800 E
3200 N
2800 N
2600 N
2400 N
2200 N
2000 N
GOLDSTREAM
RIVER
650
SEWAGE LAGOONS
EMERGENCY TAILINGS DUMP
FUEL
MILL
FINE ORE STORAGE
CRUSHER
FUTURE SHAFT HOUSE
COLD STORAGE
MAIN STORAGE AREA
EL. 700 M.
ORE BODY
MAIN SERVICE BLDG.
PARKING
FUEL
700 PORTAL
EXHAUST FAN
700
30 METER CORRIDOR FOR FRESH WATER, RECLAIM WATER, TAILINGS & HYDRO LINES
TAILINGS LINE
MAIN ROAD
VENT BLDG.
PROPANE TANK FARM
30 METER HYDRO CORRIDOR
FORESTRY ACCESS ROAD
750
770 PORTAL
ORE BODY
RECLAIM WATER TAILINGS & MINE STORAGE
800
BACKFILL STORAGE
WASTE DUMP
ROAD
850
850 PORTAL
850 ELEV.
OPEN PIT AREA
900
950
0 100 METERS
inches
0 1 2
0 1 2 3 4 5
centimetres
BRITISH COLUMBIA GEOLOGICAL SURVEY
This reference scale bar has been added to the original image. It will scale at the same rate as the image, therefore it can be used as a reference for the original size.
NORANDA MINES LTD
GOLDSTREAM DIVISION
GENERAL SURFACE PLAN

TYPICAL SECTION of PIT





inches
0 1 2
0 1 2 3 4 5
centimetres

NORANDA MINES LTD

Project: GOLDSTREAM DIVISION

Title: PROPOSED MINING METHOD
TYPICAL STOPING BLOCK
STEP-ROOM AND FILL

Mining Corp Dwg No. DK-11 | Dr. By: Z.S. | Date: Dec. 76 | Dwg No 6

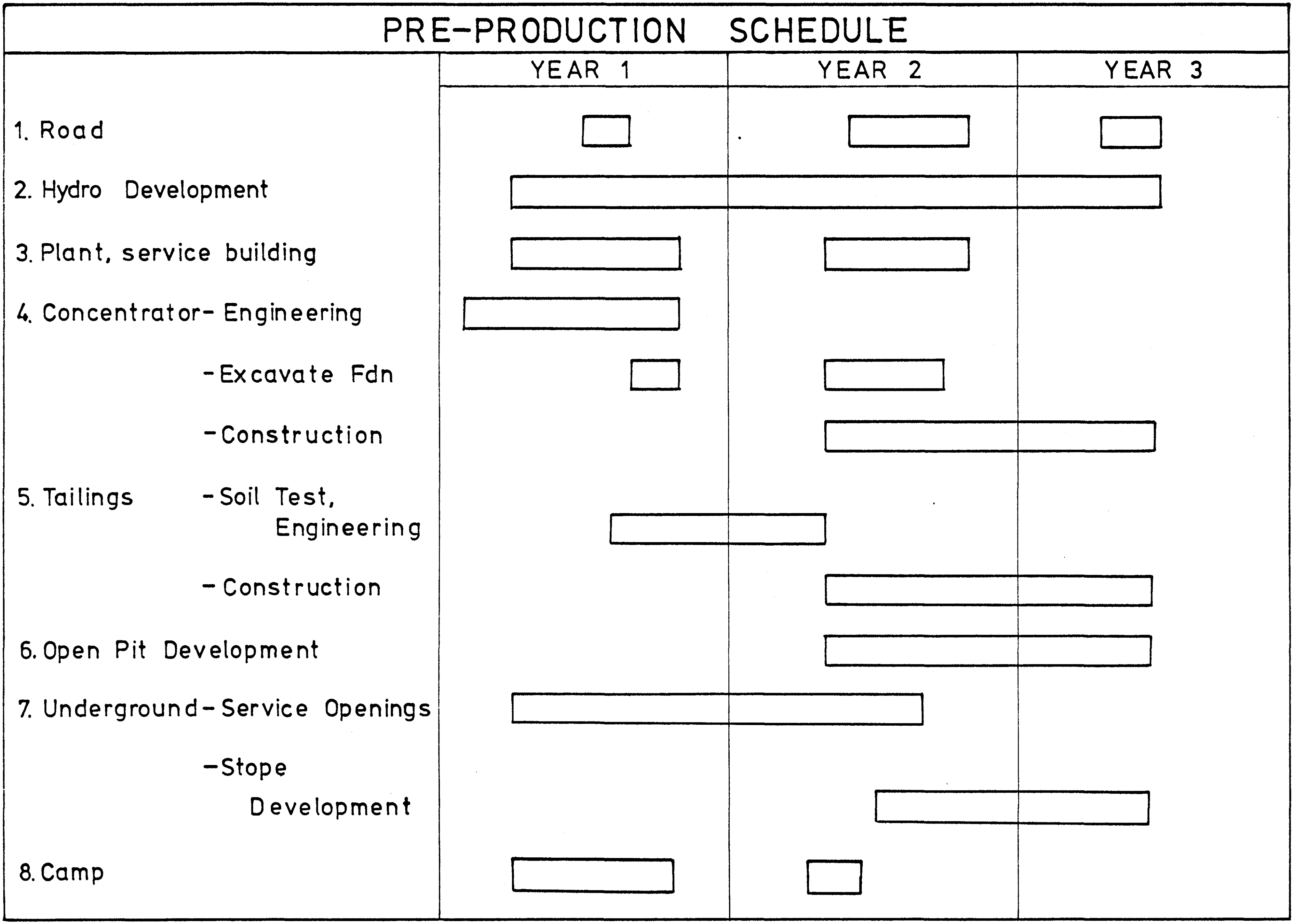
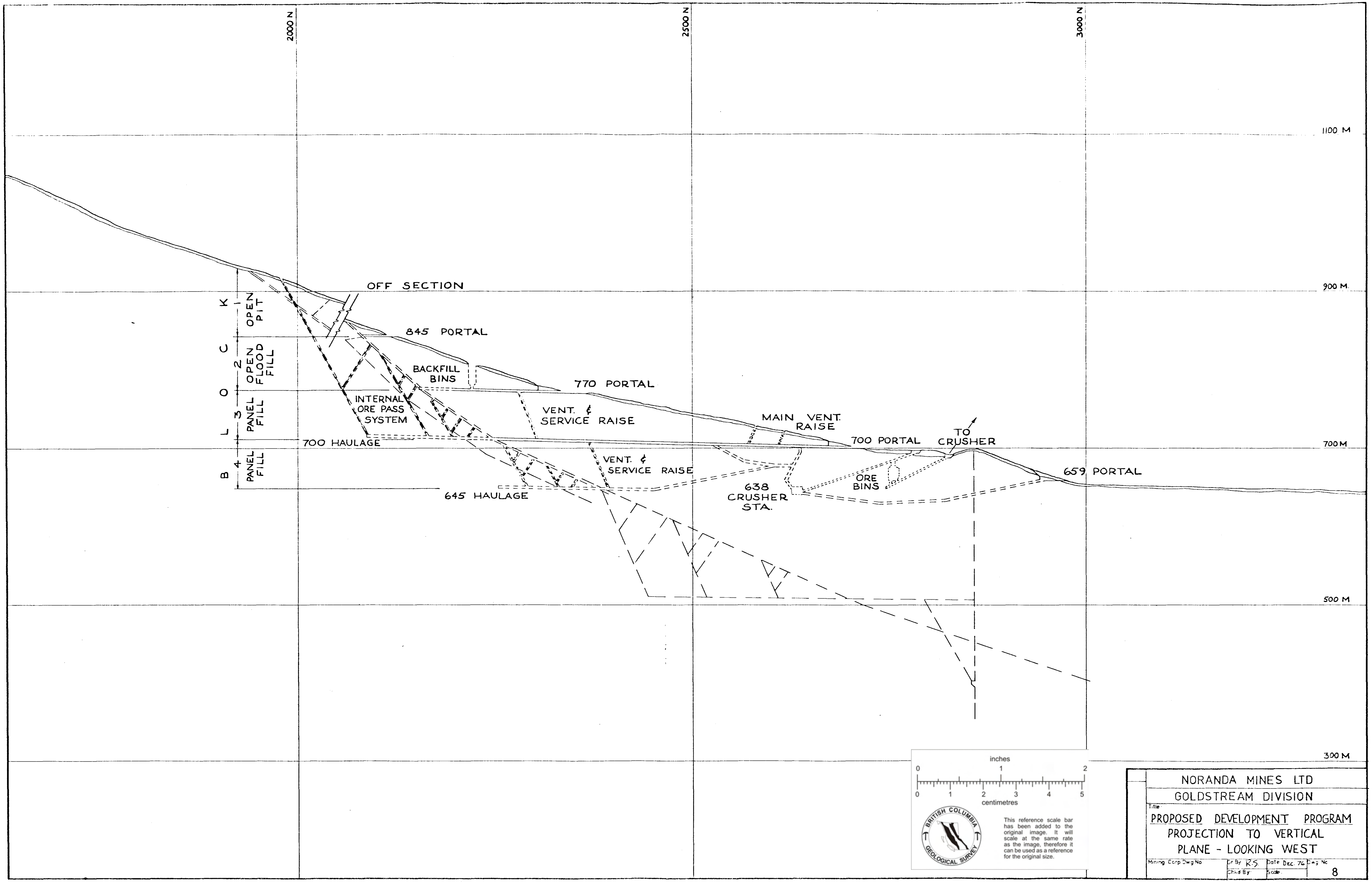
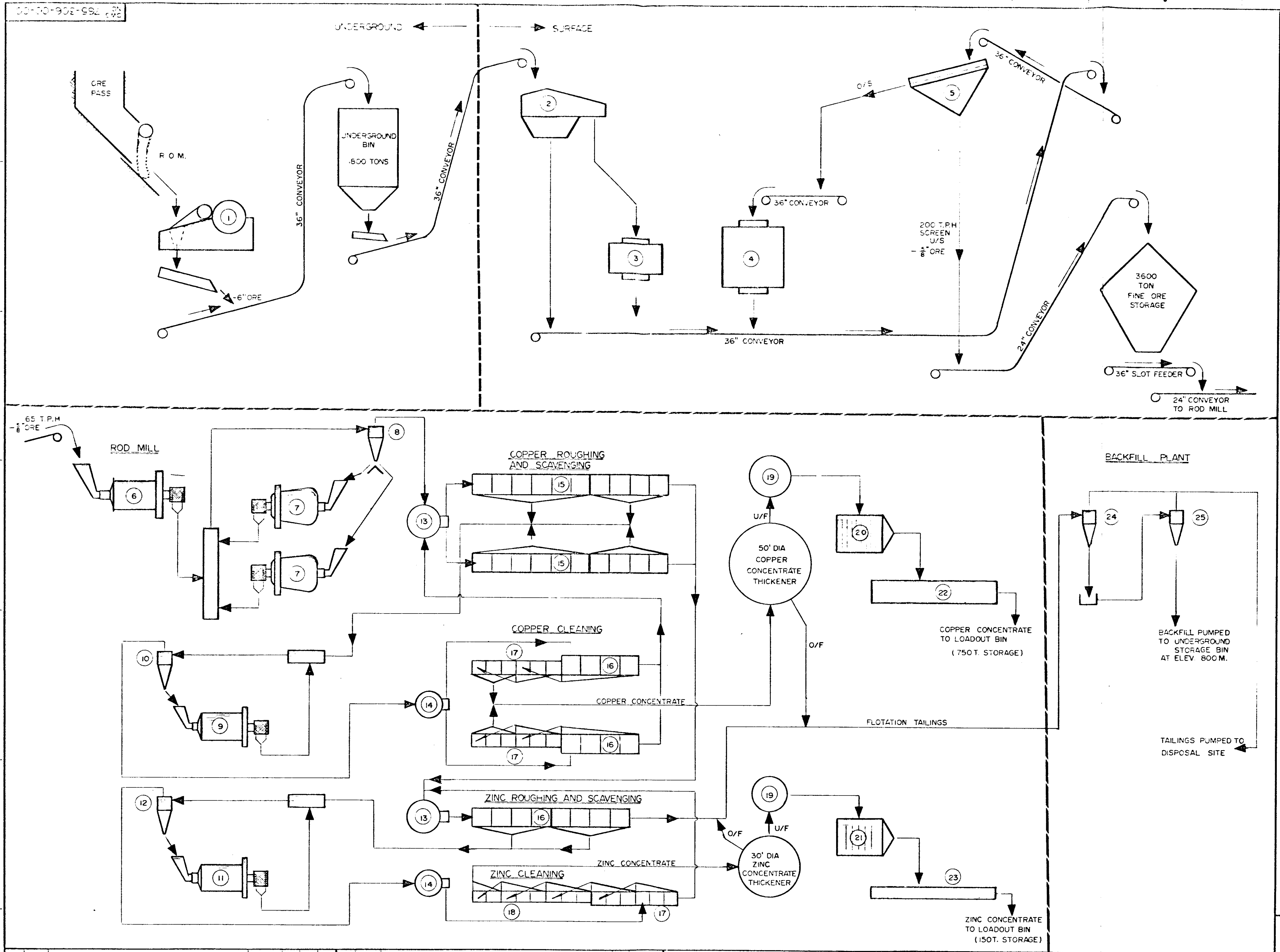

PRE-PRODUCTION SCHEDULE
YEAR 1
YEAR 2
YEAR 3
1. Road
2. Hydro Development
3. Plant, service building
4. Concentrator - Engineering
- Excavate Fdn
- Construction
5. Tailings - Soil Test, Engineering
- Construction
6. Open Pit Development
7. Underground - Service Openings
- Stope Development
8. Camp

FIG. 7


2000 N
2500 N
3000 N
1100 M
900 M.
700 M
500 M
300 M
OFF SECTION
845 PORTAL
770 PORTAL
700 PORTAL
659 PORTAL
BACKFILL BINS
INTERNAL ORE PASS SYSTEM
VENT. & SERVICE RAISE
MAIN VENT. RAISE
TO CRUSHER
ORE BINS
638 CRUSHER STA.
700 HAULAGE
645 HAULAGE
BLOCK
1 OPEN PIT
2 OPEN FLOOD FILL
3 PANEL FILL
4 PANEL FILL
inches
0 1 2
0 1 2 3 4 5
centimetres
BRITISH COLUMBIA GEOLOGICAL SURVEY
This reference scale bar has been added to the original image. It will scale at the same rate as the image, therefore it can be used as a reference for the original size.
NORANDA MINES LTD
GOLDSTREAM DIVISION
Title
PROPOSED DEVELOPMENT PROGRAM
PROJECTION TO VERTICAL
PLANE - LOOKING WEST
Mining Corp Dwg No
Dr By R.S.
Date Dec. 76
Dwg No
8
Chkd By
Scale



MAJOR EQUIPMENT

1. 36" x 48" JAW CRUSHER
2. 50" x 8' ROD GRIZZLY
3. 4 1/4' STANDARD CRUSHER
4. 5 1/2' SHORTHEAD CRUSHER
5. 6' x 16' SCREEN
6. 8' x 12' ROD MILL - 400 HP
7. HARDINGE BALL MILL - 600 HP
8. 4 + 1 15" CYCLONES
9. 8' x 8' Cu REGRIND BALL MILL - 200 HP
10. 3 + 1 10" CYCLONES
11. 5' x 8' Zn REGRIND BALL MILL - 75 HP
12. 1 + 1 10" CYCLONE
13. 10' x 10' CONDITIONER/MAXWELL CELL
14. 8' x 8' CONDITIONER/MAXWELL CELL
15. NUMBER 30 DENVER "DR" FLOTATION CELLS
16. NUMBER 30 DENVER "SUB" "A" CELLS
17. NUMBER 24 DENVER "SUB" "A" CELLS
18. NUMBER 18 DENVER FLOTATION CELLS
19. 14' x 14' FILTER FEED AGITATED STOCK TANK
20. 8'-6" - 7 DISC FILTER
21. 6'-0" 4 DISC FILTER
22. 5' x 30' COPPER CONCENTRATE DRYER
23. 4' x 35' ZINC CONCENTRATE DRYER
24. 4 + 1 10" CYCLONES
25. 2 + 1 10" CYCLONES

NO.	DATE	REVISION
1	20 DEC 1976	TAILINGS THICKENER REMOVED

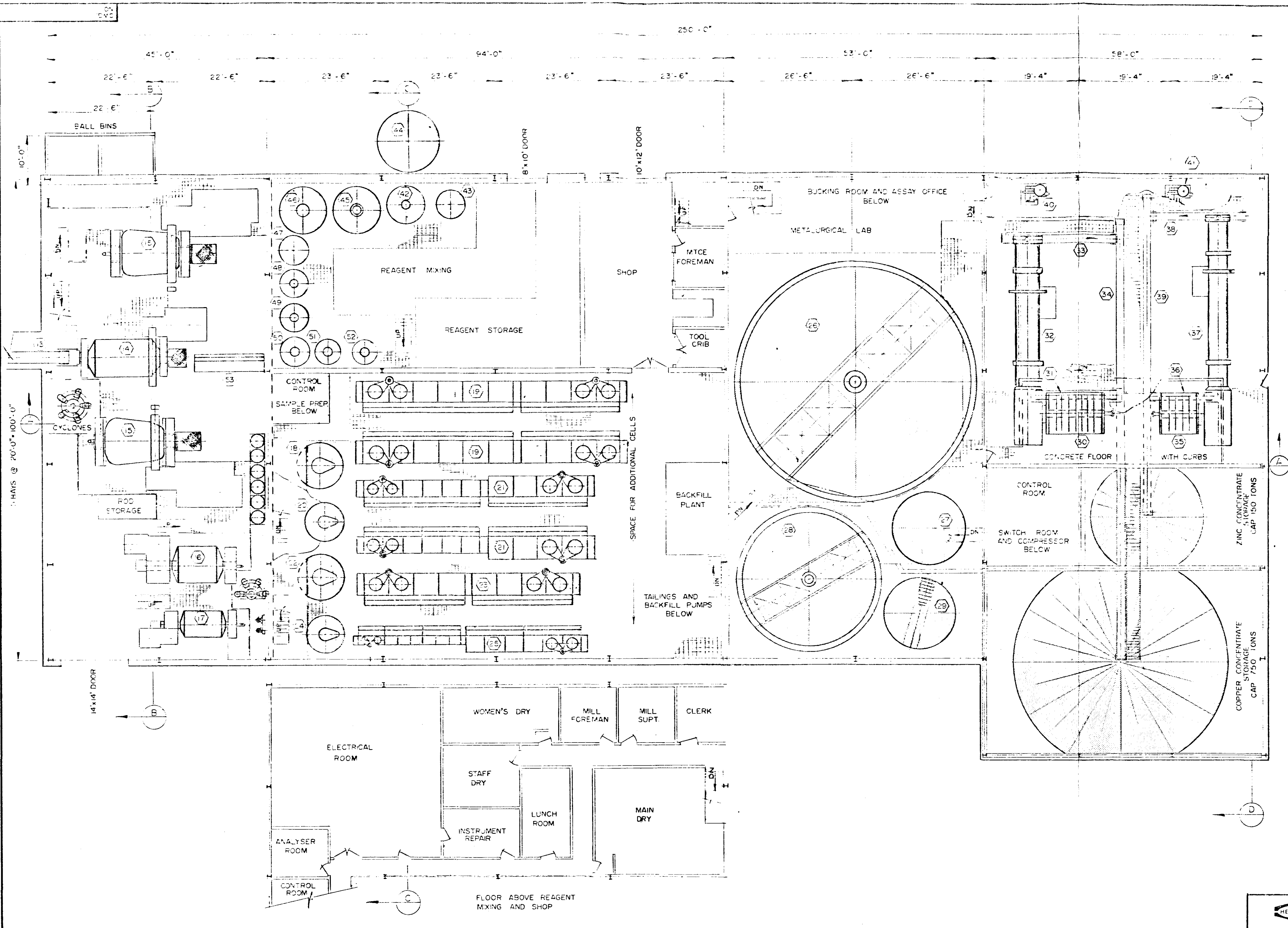
ISSUED ONLY FOR CONSTRUCTION APPROVAL

HEATHWOOD ENGINEERING ASSOCIATES LIMITED
CONSULTING ENGINEERS
KIRKLAND LAKE ONTARIO CANADA

NORANDA MINES LTD
GOLDSTREAM DIVISION

PROCESS FLOW SHEET

PROJ. NO. 5306 DWG. NO. 765-306-00-00 9



MAJOR EQUIPMENT

- (13) — 24" ROD MILL FEED CONVEYOR
- (14) — 8'x12' ROD MILL
- (15) — HARDINGE TRICONE BALL MILL
- (16) — 8'x8' Cu REGRIND BALL MILL
- (17) — 5'x8' Zn REGRIND BALL MILL
- (18) — Mx10 Cu CONDITIONER MAXWELL CELL
- (19) — Cu ROUGHING & SCAVENGER FLOT. CELLS
- (20) — Mx8 Cu CONDITIONER/MAXWELL CELL
- (21) — Cu CLEANER FLOTATION CELLS
- (22) — Mx10 Zn CONDITIONER MAXWELL CELL
- (23) — Zn ROUGHING & SCAVENGER FLOT. CELLS
- (24) — Mx8 Zn CONDITIONER/MAXWELL CELL
- (25) — Zn CLEANER FLOTATION CELLS
- (26) — 50' DIA Cu CONCENTRATE THICKENER
- (27) — 14' DIA x 4' Cu CONC. STORAGE TANK
- (28) — 30' DIA Zn CONCENTRATE THICKENER
- (29) — 14' DIA x 4' Zn CONC. STORAGE TANK
- (30) — 6'-6" DIA x 7 DISC Cu DISC FILTER
- (31) — 24" Cu FILTER DISCHARGE CONVEYOR
- (32) — 30'x5' DIA Cu DRYER
- (33) — 24" Cu DRYER DISCHARGE CONVEYOR
- (34) — 24" Cu CONC. STORAGE FEED CONVEYOR
- (35) — 8'-6" DIA x 4 DISC Zn DISC FILTER
- (36) — 24" Zn FILTER DISCHARGE CONVEYOR
- (37) — 35'x4' DIA Zn DRYER
- (38) — 24" Zn DRYER DISCHARGE CONVEYOR
- (39) — 24" Zn CONC. STORAGE FEED CONVEYOR
- (40) — 30' DIA Cu WET SCRUBBER DUST COLLECTOR
- (41) — 30' DIA Zn WET SCRUBBER DUST COLLECTOR
- (42) — 8' DIA x 8' Cu SO_4 MIXING TANK
- (43) — 6' DIA x 8' AEROFLOAT STORAGE TANK
- (44) — 12' DIA x 30' LIME STORAGE BIN
- (45) — 10' DIA x 10' LIME MIXING TANK
- (46) — 10' DIA x 10' LIME STORAGE TANK
- (47) — 6' DIA x 8' MIBC STORAGE TANK
- (48) — 6' DIA x 8' Z 200 STORAGE TANK
- (49) — 6' DIA x 8' R343 MIXING TANK
- (50) — 6' DIA x 8' R208 + R3501 MIXING TANK
- (51) — 6' DIA x 8' FLOCCULANT MIXING TANK
- (52) — 6' DIA x 8' SPARE MIXING TANK
- (53) — ROD CHARGER

NO.	DATE	REVISION	LOC.	BY	APP.	APP.
1	20 DEC 1976	FLOTATION AREA EXTENDED				

REFERENCES DRAWINGS | NUMBER

ISSUED ONLY FOR

CONSTRUCTION APPROVAL

CLIENT | CLIENT | H.E. PROJ. SUPV. | H.E. PROJ. ENG. | H.E. PRINC.

SCALE 1/8" = 1' | DRAWN BY | DATE 12 NOV 1976 | DES. BY | CHKD. BY | CO-ORD BY

HEATHWOOD ENGINEERING ASSOCIATES LIMITED
CONSULTING ENGINEERS
KIRKLAND LAKE ONTARIO CANADA

NORANDA MINES LTD
GOLDSTREAM DIVISION

GRINDING AND CONCENTRATOR
GENERAL ARRANGEMENT
PLAN

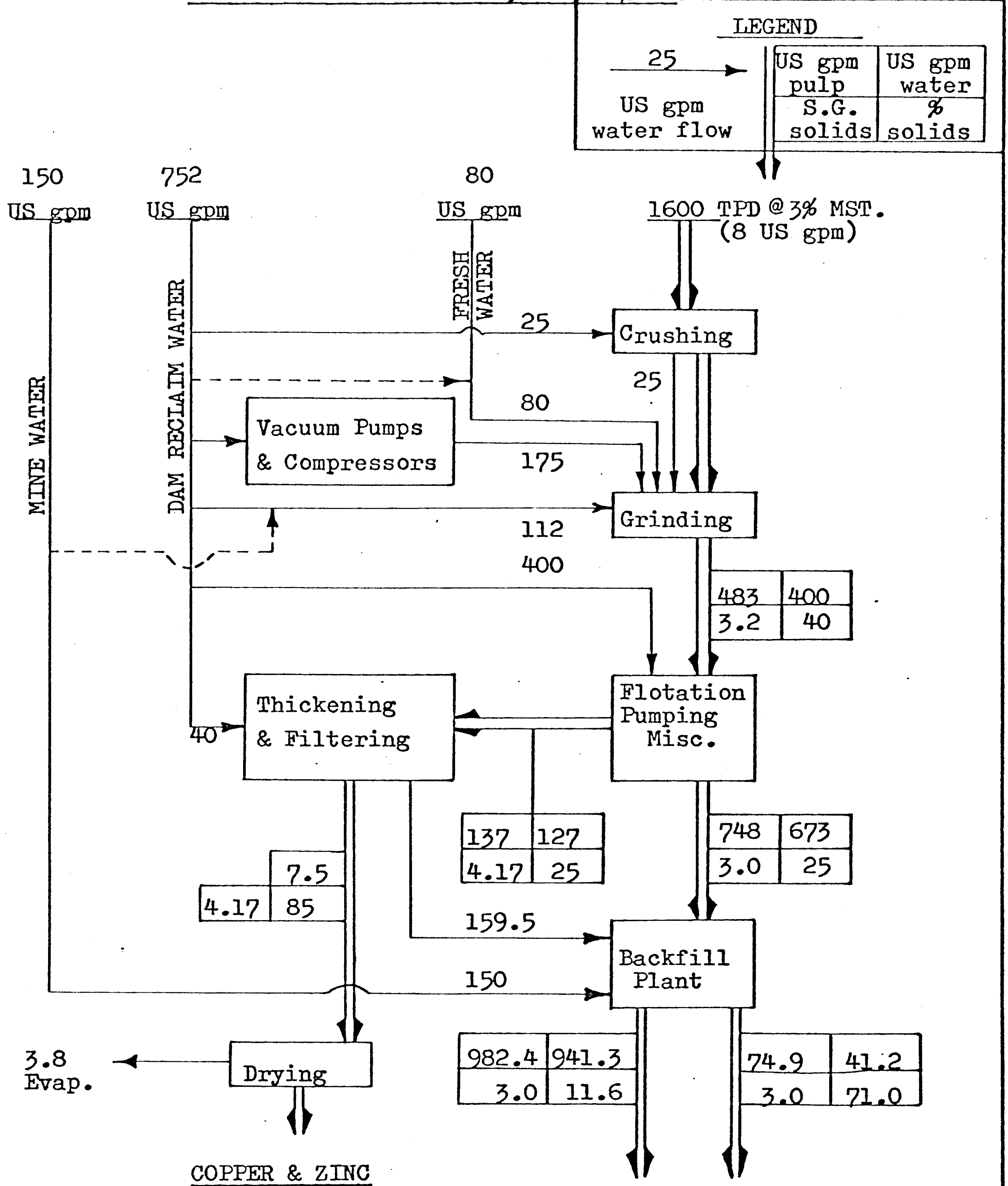
PROJ. NO. 5306 | DWG. NO. 765-306-03-01 | 10

Figure 11

GOLDSTREAM PROJECT

WATER BALANCE - AVERAGE OPERATING

CONDITION - 1600 TPD X 342 DAYS/YR.



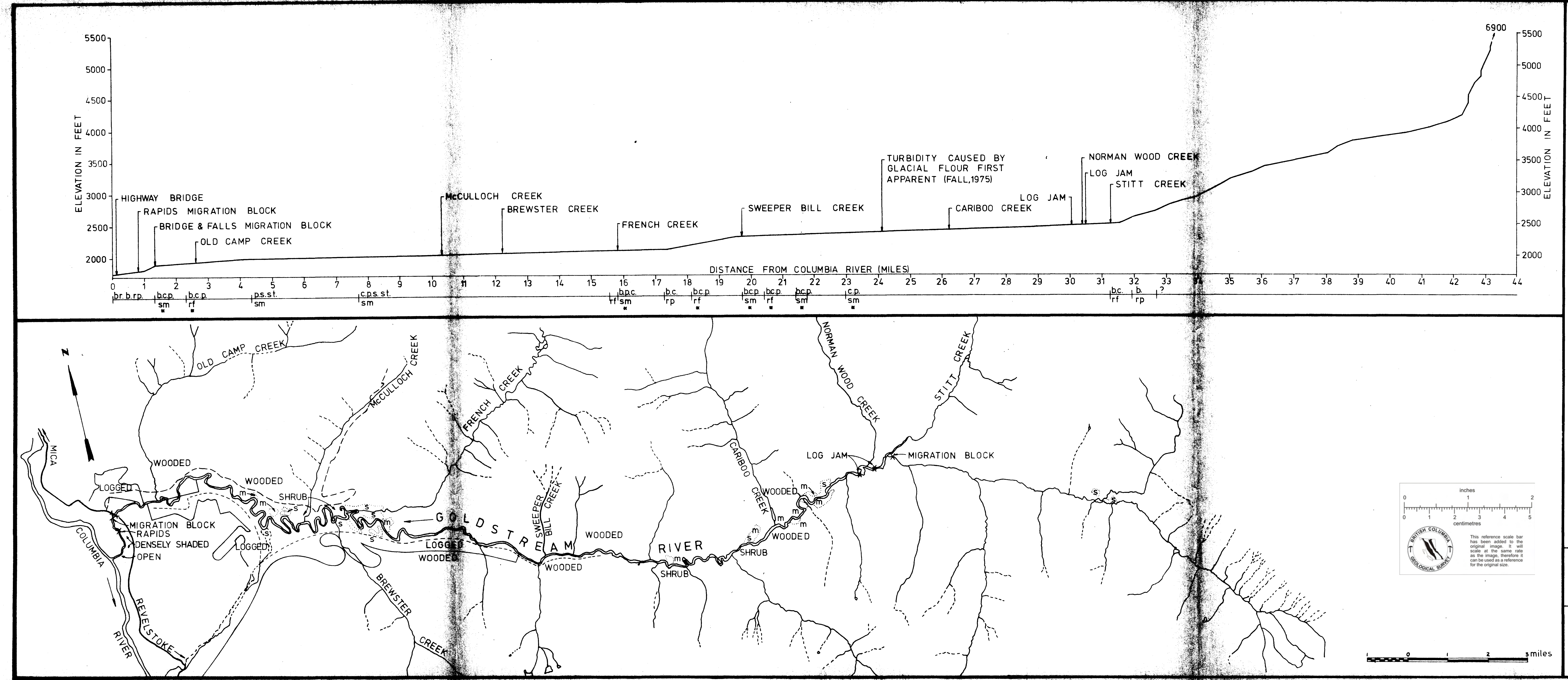
COPPER & ZINC CONCENTRATES TO SMELTER-254 TPD CONT. 3.7 US gm WATER LOSS

740 TPD SLIME TO DISPOSAL

606 TPD BACKFILL TO MINE BINS


LEGEND
ALLUVIUM & COLLUVIUM
ALLUVIUM & ORGANIC
MORAINAL
EXPOSED BEDROCK or SOIL MANTLE LESS THAN 10cm.
1- HIGH PRODUCTION
2- MODERATELY HIGH PRODUCTION
3- MODERATE PRODUCTION
4- LOW MODERATE PRODUCTION
Bridge
Rapids
Old Camp Creek
GOLDSTREAM RIVER
Road
McCulloch Creek
French Creek
Sweeper Bill Creek
Cariboo Creek
Norman Creek
Gliff Creek
Goldstream Creek
Brewster Creek
Adit Portal
TRANSMISSION LINE
UNKNOWN
COLUMBIA RIVER
HWY 23
D.P.W. Bldgs.
SCALE = 1:50,000
NORANDA MINES LTD
SOIL and LANDFORM CAPABILITY MAP
GK-8
Date 27APR.77
Dwn
App
Dwg No 12
inches
centimetres
BRITISH COLUMBIA GEOLOGICAL SURVEY
This reference scale bar has been added to the original image. It will scale at the same rate as the image, therefore it can be used as a reference for the original size.


LEGEND
INTERIOR WESTERN HEMLOCK ZONE
ENGELMAN SPRUCE - SUBALPINE FIR ZONE
ALPINE TUNDRA ZONE
UNKNOWN
COLUMBIA
RIVER
HWY 23
Bridge
Rapids
D.P.W. Bldgs
TRANSMISSION LINE
Old Camp Creek
GOLDSTREAM RIVER
Road
McCulloch Creek
French Creek
Goldstream Creek
Brewster Creek
Adit Portal
Sweeper Bill Creek
GOLDSTREAM
RIVER
Cariboo Creek
Creek
inches
0
1
2
0
1
2
3
4
5
centimetres
BRITISH COLUMBIA
GEOLOGICAL SURVEY
This reference scale bar has been added to the original image. It will scale at the same rate as the image, therefore it can be used as a reference for the original size.
NORANDA MINES LTD
VEGETATION PATTERNS
GK-9
3 MAY 77
Dwg No 13



LEGEND

PROFILE

br	BEDROCK
b	BOULDER
c	COBBLES
p	PEBBLES
st	SILT
s	SAND
rp	RAPIDS
sm	SMOOTH FLOW
rf	RIFFLE
▪	GOOD SPAWNING AREA

MAP

—	HIGHWAY
(l)	LOGGED
s	SWAMP
m	MARSH
⟼	BRIDGE
X	MIGRATION BLOCK
---	LOGGING ROAD

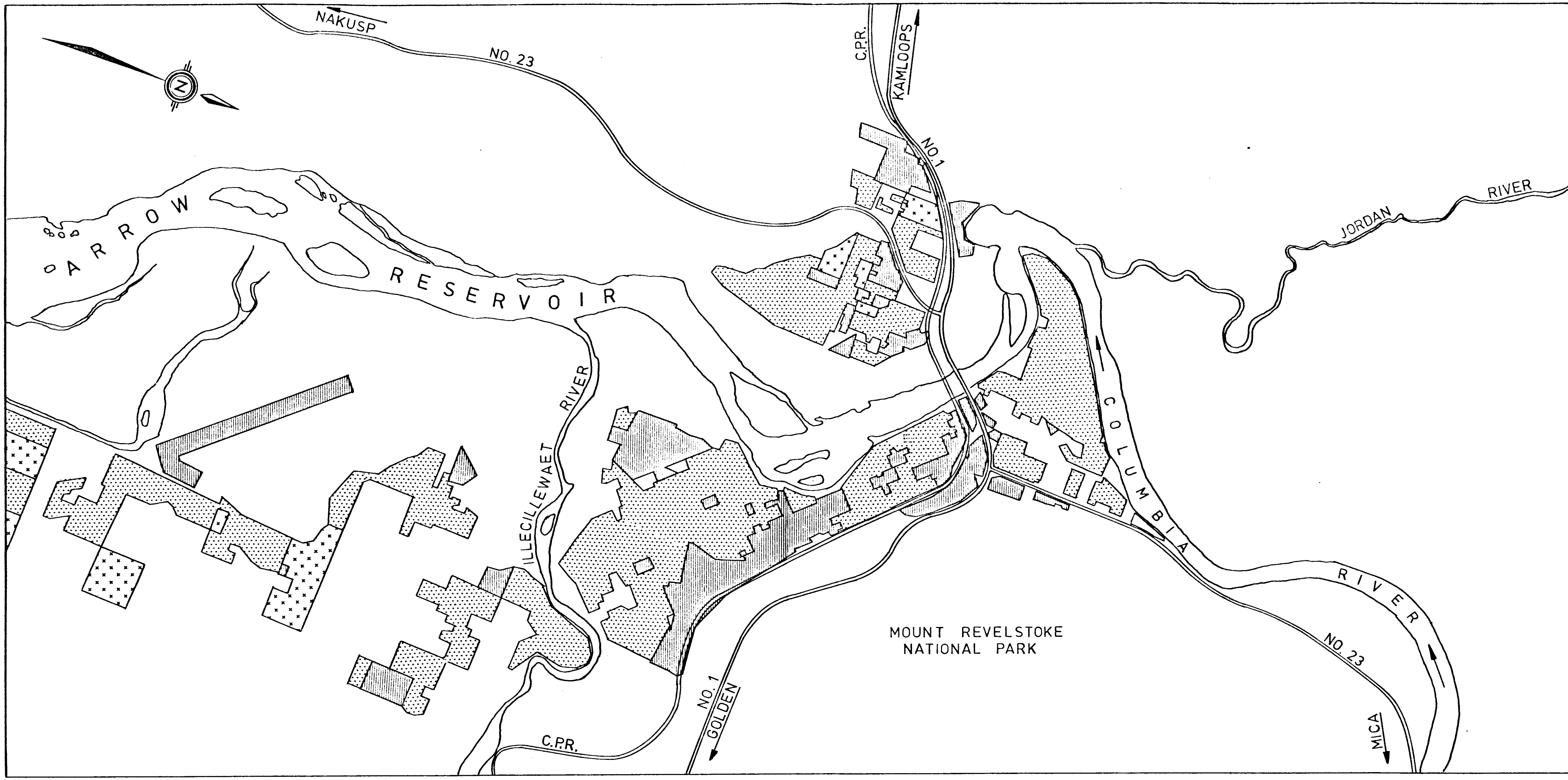
PLAN AND PROFILE OF
THE GOLDSTREAM RIVER WATERSHED

Scale:	AS SHOWN
Date:	26/4/77
Contract No:	
Dwg No:	14

GK-10

LEGEND
WINTER RANGE
MODERATE LIMITATIONS TO PRODUCTION OF UNGULATES
MODERATELY SEVERE LIMITATIONS TO PRODUCTION OF UNGULATES
SEVERE LIMITATIONS TO PRODUCTION OF UNGULATES
CARIBOO RANGE
Bridge
Rapids
Old Camp Creek
GOLDSTREAM RIVER
COLUMBIA RIVER
UNKNOWN
TRANSMISSION LINE
HWY 23
D.P.W. Bldgs.
Goldstream Creek
French Creek
Sweeper Bill Creek
Cariboo Creek
Stitt Creek
SCALE = 1:50,000
NORANDA MINES LTD
UNGULATE CAPABILITY
Date 29 APR 77
Dwn
App
Dwg No 15
GK-11
inches
0 1 2
0 1 2 3 4 5
centimetres
BRITISH COLUMBIA GEOLOGICAL SURVEY
This reference scale bar has been added to the original image. It will scale at the same rate as the image, therefore it can be used as a reference for the original size.


FI
Bridge
Rapids
LI
F
RIVER
COLUMBIA
HWY 23
D.P.W.
Bldgs.
TRANSMISSION LINE
Old Camp Creek
GOLDSTREAM RIVER
Road
McCulloch Creek
Goldstream Creek
French Creek
H
Adit
Portal
Sleeper Bill Creek
GOLDSTREAM
F
RIVER
Brewster Creek
Caribou Creek
Wood Creek
Vernon
Stitt Creek
LI
inches
0
1
2
0
1
2
3
4
5
centimetres
BRITISH COLUMBIA
GEOLOGICAL SURVEY
This reference scale bar has been added to the original image. It will scale at the same rate as the image, therefore it can be used as a reference for the original size.
LEGEND
HIGH RECREATIONAL CAPACITY
MODERATELY HIGH RECREATIONAL CAPACITY
MODERATE RECREATIONAL CAPACITY
LOW TO MODERATE RECREATIONAL CAPACITY
LOW RECREATIONAL CAPACITY
F - WATERFALL
FI - WATERFALL LANDSCAPE
LI - CANYON
H - HUNTING
F - FISHING
SCALE = 1:50,000
NORANDA MINES LTD
RECREATIONAL INVENTORY & CAPABILITY
GK-12
Date 29 APR 77
Dwn . App
Dwg No 16



LEGEND:

RESIDENTIAL, PARKS, GOLF COURSES

AGRICULTURE

COMMERCIAL, INDUSTRIAL, INSTITUTIONAL

inches 0 1
0 1 2 centimetres

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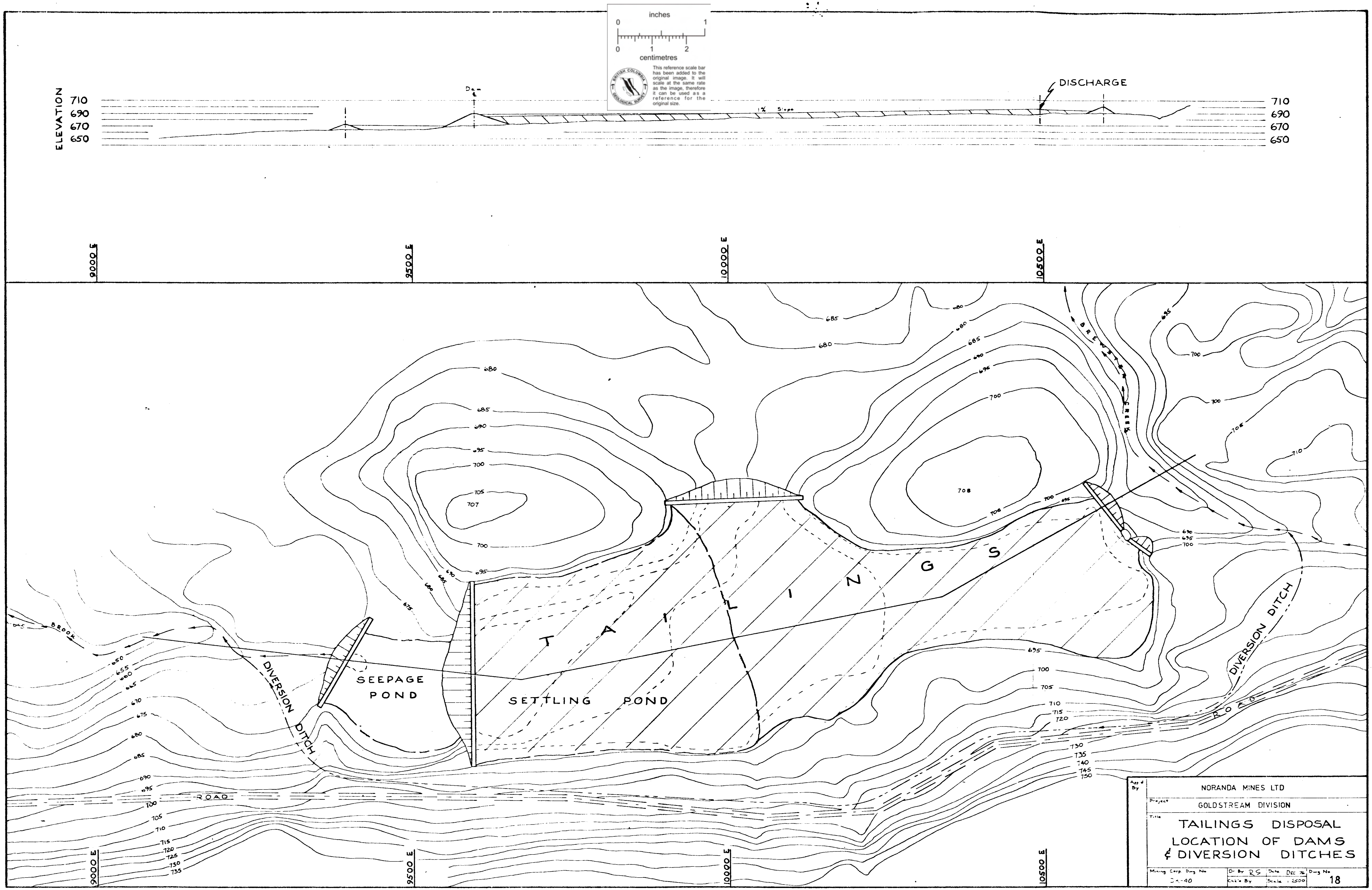
EXISTING REVELSTOKE LAND USE AND OWNERSHIP

0 1/2 1 MILE

BK-22

Dwg No. 17


inches
0
1
0
1
2
centimetres
This reference scale bar has been added to the original image. It will scale at the same rate as the image, therefore it can be used as a reference for the original size.
BRITISH COLUMBIA
GEOLOGICAL SURVEY
ELEVATION
710
690
670
650
DISCHARGE
1% Slope
9000 E
9500 E
10000 E
10500 E
TAILINGS
SEEPAGE POND
SETTLING POND
DIVERSION DITCH
DIVERSION DITCH
BROOK
BREWSTER CREEK
ROAD
ROAD
680
685
690
695
700
705
707
708
710
NORANDA MINES LTD
Project
GOLDSTREAM DIVISION
Title
TAILINGS DISPOSAL
LOCATION OF DAMS
& DIVERSION DITCHES
Mining Corp. Dwg No
Dr By RS
Date DEC 76
Dwg No
18
Chk'd By
Scale 1:2500