128-77

ECONOMIC MINING FEASIBILITY STUDIES OF SELECTED MINERAL DEPOSIT TYPES IN THE WESTERN BROOKS RANGE, ALASKA

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* Open File Report No. 128-77

UNITED STATES DEPARTMENT OF THE INTERIOR

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ECONOMIC MINING FEASIBILITY STUDIES OF SELECTED MINERAL DEPOSIT TYPES IN THE WESTERN BROOKS RANGE, ALASKA

by

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ABSTRACT

This report evaluates the economic mining feasibility of four selected mineral deposit types that can be anticipated to be found in (d)(2) lands in the western Brooks Range, Alaska. The major assumption made for this study is the availability of a rail system for transporting equipment and concentrates for the base metal mines. Commodity prices used are those in existence in July 1976. Mine models were first established based on known deposits and then evaluated.

A lead-zinc-silver-barite deposit for which grades were available but ore reserves were assumed would require approximately 25% higher ore grades or higher metal prices to yield a 15% discounted cash-flow rate of return on the investment if mined at a rate of 10,000 tons per day by open pit methods. Large copper-zinc mineral deposits could be mined economically at rates either of 5,000 tons per day underground or 10,000 tons per day by open pit methods. A high-grade copper deposit would require a copper price of over one dollar per pound to yield an economic profit to be mined at 2,000 tons per day by underground methods. A small high-grade gold underground mine would require a gold price of about $295 per ounce to yield a 20% discounted cash-flow rate of return

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1/ Geologist.

2/ Mining Engineer

on investment if all new mine equipment were used and if existing top labor rates were paid. Enterprising mining groups operating as partnerships might be able to operate this mine profitably at a gold price of about $152 per ounce, perhaps slightly less.

INTRODUCTION

This is the fourth in a series of publications by the Bureau of Mines designed to estimate mining and processing costs for developing various types of mineral deposits in Alaska. These reports (1, 2, 5) 3/ provide Federal and State governments with information necessary to appraise the potential for developing Alaska's mineral deposits. This particular study was done in conjunction with a resource evaluation of lands in the western Brooks Range that have been withdrawn from mineral entry under Section 17 (d)(2) of the Alaska Native Claims Settlement Act of 1971, Public Law 92-203. An attempt is made not only to assess the viability of certain types of mineral deposits should they be found on (d)(2) lands along the south flank of the Brooks Range, but also to indicate the ore reserves, ore grades, and/or metal prices necessary to mine the example deposits economically. The detailed cost tables used in this study may be of some use to industry in assessing those factors which raise mining and processing costs in Alaska over those in the 48 contiguous States.

In order to make these economic assessments, known mineral occurrences in the Brooks Range were chosen and, when necessary, "moved" to areas on (d)(2) lands having similar geologic settings. Because neither the tonnage nor the grade is well known for the partly explored or developed deposits used as example types, assumptions were made on the basis of available factual data and geologic and engineering

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3/ Underlined numbers in parentheses refer to items in the list of references preceding the appendixes.

inference in order to complete a preliminary economic evaluation. Although detailed economic evaluations of these deposits cannot be made with the data on hand, enough information is available to indicate (1) if these deposits make attractive exploration targets, (2) what grades and tons of reserve would be necessary to make these deposits economic, and (3) which operating factors must be observed to make these deposit types economic.

The geographical settings for the chosen mine locations are in the western and southern flanks of the Brooks Range (Fig's. 1 & 2). The mines are north of 68 degrees north latitude, and range from 220 to 450 air miles northwest of Fairbanks. No roads or railroads connect the selected minesites to the present transportation system. For these studies a railroad is assumed to be available to haul goods from existing facilities outside on a year-round basis (Fig. 1).

Transportation of metal concentrates to markets would be by the proposed rail system via Nenana to the coast at Whittier, Alaska, and barged from there to Seattle or Tacoma, Washington, and then hauled by rail to a smelter at Kellogg, Idaho.

The climate at the proposed minesites would be typical of subarctic northern Alaska. Ice and frost occur from mid-September to June. At Shungnak, the average precipitation for a 5-year period was 21.6 inches. The highest and lowest temperatures recorded were plus 90 degrees F. and minus 61 degrees F., respectively, while the average annual temperature was 21.7 degrees F. (6).

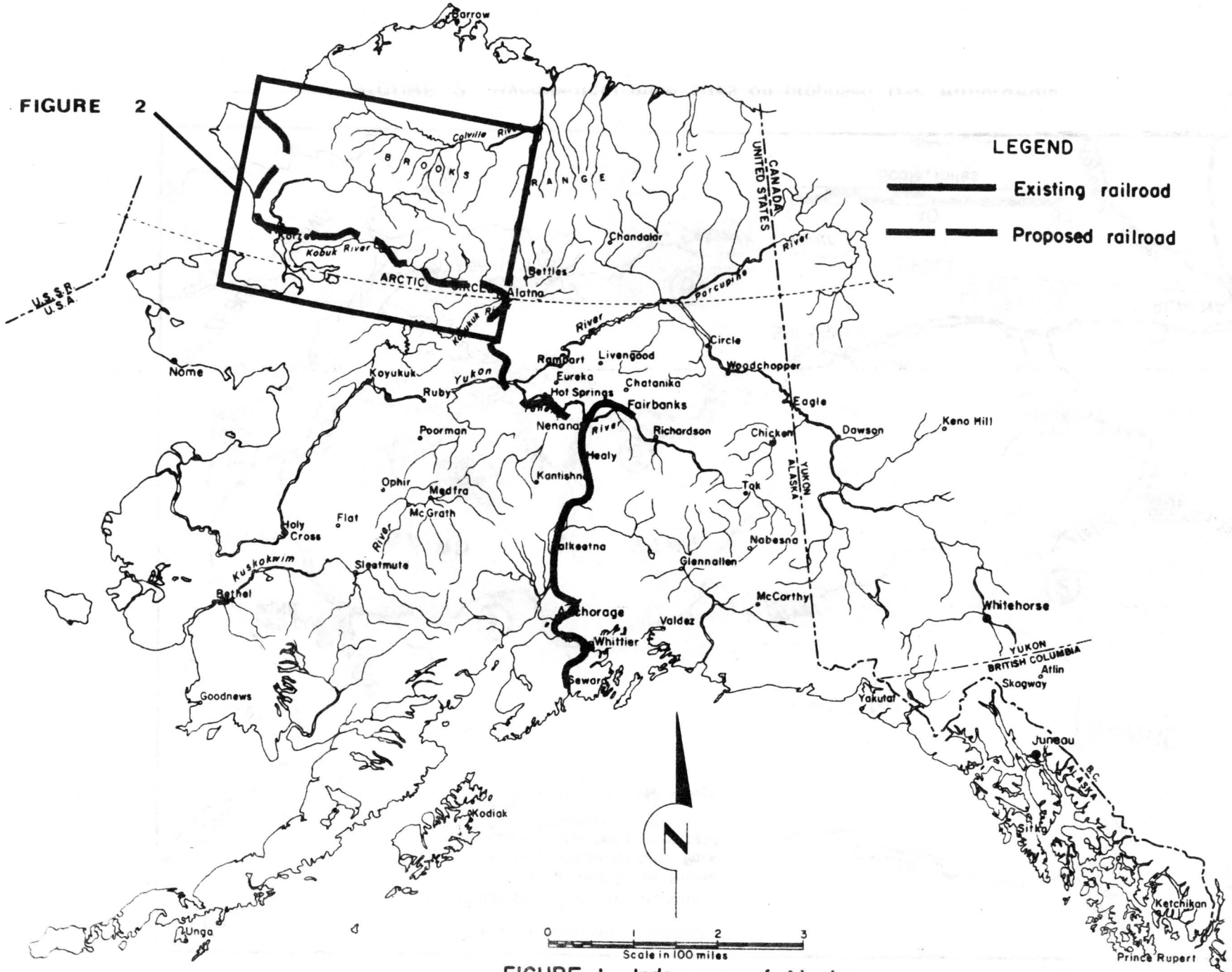

FIGURE I. Index map of Alaska

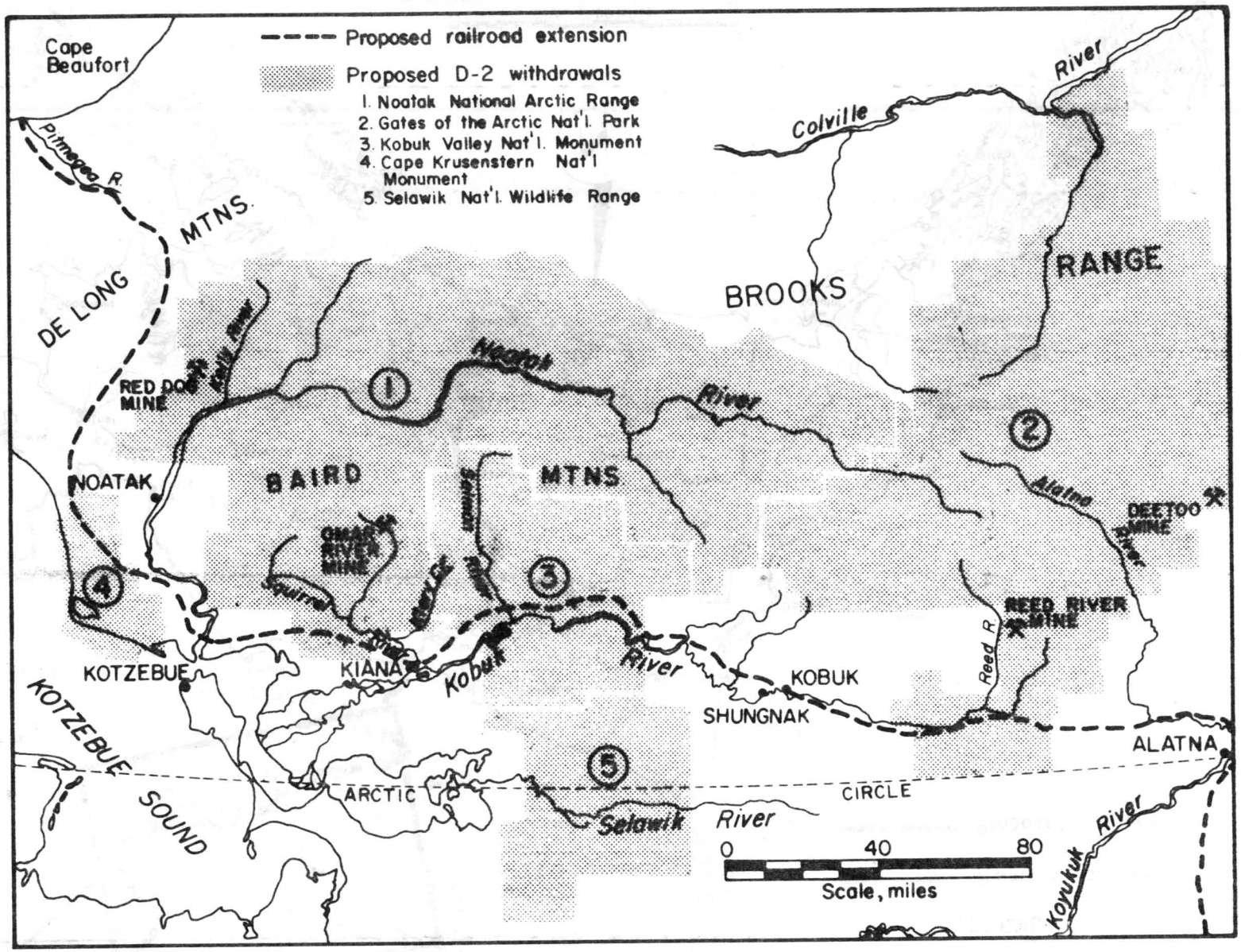

FIGURE 2. Hypothetical mine sites on proposed D-2 withdrawals

SITE EVALUATIONS

Economic evaluations were made for the following five hypothetical mining situations:

(1) a 30,000 ton per day, including 20,000 tons of waste, open pit moderate grade lead-zinc-silver-barite mine (here designated as the "Red Dog" mine) processing 10,000 tons of ore per day operating 20 years;

(2) a 5,000 ton per day underground high grade zinc-copper mine (here designated as the "Reed River" underground mine) with a 20-year life;

(3) a 50,000 ton per day, including waste, high grade zinc-copper mine (here designated as the "Reed River" open pit mine) processing 10,000 tons of ore per day operating 10 years;

(4) a 2,000 ton per day underground high grade copper mine (here designated as the "Omar River" mine) operating 15 years; and

(5) a 100 ton per day underground high grade gold mine (here designated as the "Deetoo Gold Mine") operating 5 years.

The locations for these hypothetical mines are shown on Figure 2.

Red Dog Mine

The Red Dog lead-zinc-silver-barite prospect is located approximately 2 miles inside the western boundary of the proposed Noatak National Arctic Range and about 35 miles north of the village of Noatak. The scattered mineralization covers an area about 9,000 feet long and 3,500 feet wide. Analytical results of 38 individual and chip channel

surface samples indicate that an ore body may contain 4.90 percent zinc, 2.73 percent lead, and 1.23 ounces of silver. Individual samples which apparently represent a small tonnage potential and contain up to 42.75 percent zinc and up to 20 percent lead were not included in the grade estimate.

Capital and Operating Costs

In deriving the cost estimates, it was assumed that the sequence from initial exploration through property evaluation and commencement of production would be continuous. Exploration and mine evaluation were assumed to require 5 years; the design and construction of the concentrator and support facilities 3 years; and the design and construction of the mine facilities and equipment 2 years. Mine preproduction stripping required 1 year.

A 30,000 ton per day (tpd) mine, including 20,000 tons of waste, and 10,000 tpd concentrator were assumed adequate to develop this deposit. Operating 330 days per year over a period of 20 years, this operation would require an ore body of 66 million tons, a distinct possibility considering the size of the mineralized zone.

The 10,000 tpd concentrator, using conventional milling and ore dressing to recover 77 percent of the metal value in the ore, would be located near the mine. Daily it would receive the lead-zinc-silver ore from the mine and produce two marketable products, 409 tpd of lead-silver concentrates and 948 tpd of zinc-silver concentrates. The remaining 8,643 tons of waste material would be stored in a tailings disposal area near the minesite. The concentrates would be shipped

to a smelter, presumably in Idaho where the metal content of the concentrates would be recovered. The value of the barite in the ore, although significant, was ignored in this model.

The mining complex was assumed to include a townsite. An estimated 362 employees were required for this operation, 158 in the mine, 144 in the concentrator, and 60 in the support facilities. This number includes an extra 20 percent required to compensate for the employees on vacation, absent, and for turnover (commonly designated as VAT). The townsite would be constructed to include 72 service employees and 766 dependents, or 1,200 total. The townsite would include a commercial center, school, hospital, street, sewer, water and electricity.

The summary of costs related to the Red Dog mine is given on Table 1. The detailed costs are given in Appendix A.

Table 1. - Cost summary for the Red Dog Mine, in dollars

A. Capital cost summary		
Mine equipment	12,955,000	
Mine plant and buildings	10,513,000	
Mine development	11,812,000	
Exploration, acquisition, and studies	5,500,000	
Concentrator	132,124,000	
Support facilities	47,501,000	
Working capital	14,344,000	
Total investment	234,749,000	
B. Annual operating cost and cost per ton of ore		
Direct cost		
Mine	14,988,000	(4.54)
Concentrator	15,802,000	(4.79)
Support facilities	2,328,000	(0.71)
Total	33,118,000	(10.04)
Total cost		
Mine	20,693,000	(6.27)
Concentrator	29,146,000	(8.83)
Support facilities	7,513,000	(2.28)
Total	57,352,000	(17.38)
C. Total annual operating costs		
Mine, concentrator, support facilities	57,352,000	
Transportation of concentrates	40,199,000	
Smelting and refining costs	30,491,000	
Alaska State mining license tax	1,513,000	
Alaska State income tax	1,871,000	
Federal income tax	10,396,000	
Total	141,822,000	

Economic Evaluation

To recover capital and operating costs and to obtain a 15 percent discounted cash flow rate of return on the investment (DCFROI), revenues of $172,873,000 must be generated annually based upon the assumptions made. Based upon the averaged grades found on this property to date, only $133,817,000 would be obtained at the July 1976 prices for lead, zinc, and silver of $0.23, $0.37, and $4.88, respectively. The metal prices must rise 24.5 percent to $0.29 for lead, $0.46 for zinc and $6.10 for silver to generate the required revenues for a 15 percent DCFROI. Alternately, if the ore grade were 24.5 percent richer, (i.e. from 4.90 to 6.1 percent zinc and from 2.73 to 3.4 percent lead), they would then provide the required revenues. At 6.1 percent zinc and 3.4 percent lead, this deposit would have a tenor only slightly greater than that of the Cyprus Anvil Mining Company's presently operating mine in the Yukon Territory. The capital and operating costs for barite recovery and bagging was not calculated nor were revenues from such a section considered.

The Reed River Mine

The site selected for the hypothetical Reed River mine is on a geologic trend from zones of known massive volcanogenic sulfide deposits. Although zones of mineralization are not known to be present at the selected site, there are zones of anomalous geochemical values similar to those associated with known deposits in the Ambler district to the west. This site, about 50 miles east of Kobuk, was chosen for a mine having an ore deposit similar to the Arctic Camp prospect located northeast of Kobuk.

The ore body consists of a number of sulfide-bearing horizons within a suite of low to medium grade metamorphic rocks of volcanic to sedimentary origin. Both deep and near surface zones of sulfide mineralization have been found (6). The mineralized zones range from less than one foot to over 60 feet in thickness with waste rock layers in between. The ore zones contain from 20 to 90 percent sulfide minerals - primarily pyrite, sphalerite, and chalcopyrite. Lesser amounts of other copper, lead, gold, and silver minerals are also present. The hypothetical deposit is assumed to consist of 33 million tons of ore having an average grade of 5.5 percent zinc, 4.0 percent copper, 1.0 percent lead, 1.5 ounces of silver per ton, and trace amounts of gold.

As part of the deposit occurs near the surface and part extends to considerable depth, the possibibity of both open pit and underground mining was explored. While underground mining could be logical progression from an open pit, in this report, each type of mine is considered separately along with separate townsites. Capital and operating costs for the underground mine are discussed first.

Capital and Operating Costs for an Underground Mine

In deriving the cost estimates, it was assumed that eight consecutive years would elapse from the start of exploration until the start of production. Exploration, property evaluation, and feasibility studies would require five years. Three years would be required to design and construct the concentrator and townsite, and for mine design and development.

Each day the mine would produce 5,000 tons of ore by room and pillar methods using load-haul-dump units. It would operate 330 days each year for 20 years to recover 33 millions tons of ore. The ore would be treated by a concentrator located near the mine. The daily production would total 750 tons of copper-silver concentrate, 532 tons of zinc-silver concentrate, and 75 tons of lead-silver concentrate. The remaining 3,643 tons of material would be stored in a tailings pond near the mine.

The copper-silver concentrates were assumed to be acceptable at a smelter in Washington and the lead-zinc-silver concentrates at the smelter in Idaho.

Employment at the mining complex would total 383 of which 243 would be in the mine, 94 in the concentrator, and 46 in the townsite. These estimates include an extra 20 percent to cover the employees on vacation, absent, and for turnover (VAT). Additionally, there would be 76 service employees and 920 dependants bringing the size of the townsite to about 1,380 people.

A summary of costs related to a 5,000 tpd underground mine using room and pillar mining methods are given in Table 2. The detailed costs are given in Appendix B.

Table 2. - Cost summary for the Reed River Underground Mine, in dollars

A.	Capital cost summary		
	Surface plant and equipment	7,573,000	
	Underground plant and equipment	3,702,000	
	Mine development	15,220,000	
	Exploration, acquisition, and studies	6,750,000	
	Concentrator	71,609,000	
	Support facilities	43,638,000	
	Working capital	10,330,000	
	Total investment	158,822,000	
B.	Annual operating cost and cost per ton of ore		
	Direct cost		
	Mine	13,381,000	(8.11)
	Concentrator	9,183,000	(5.57)
	Support facilities	1,891,000	(1.15)
	Total	24,455,000	(14.82)
	Total cost		
	Mine	17,507,000	(10.61)
	Concentrator	16,542,000	(10.02)
	Support facilities	6,166,000	(3.74)
	Total	40,215,000	(24.37)
C.	Total annual operating costs		
	Mine, concentrator and support facilities	40,215,000	
	Transportation costs for copper-silver concentrates	17,715,000	
	Transportation costs for lead-zinc-silver concentrates	16,078,000	
	Smelting and refining costs for copper-silver concentrates	12,670,000	
	Smelting and refining costs for lead-zinc-silver concentrates	14,502,000	
	Alaska State mining license tax	973,000	
	Alaska State income tax	1,687,000	
	Federal income tax	9,375,000	
	Total	113,215,000	

Economic Evaluation of Underground Mine

To recover capital and operating costs and produce a 15 percent DCFROI would require revenues of $135,357,000 generated annually based on the assumptions made. Using lead and zinc prices of 23 and 37 cents per pound, respectively, copper prices of 72.1 cents per pound would have been required to generate this revenue. This price was four cents below the July 9, 1976 price when this study was done. Using the copper price in effect July 9, 1976, 76.5 cents per pound, the total revenues from this operation would be $140,558,000, which is sufficient for a 16 percent DCFROI.

Capital and Operating Costs for an Open Pit Mine

In deriving these cost estimates, it was assumed that eight consecutive years would elapse from the start of exploration to the start of production. Exploration, property evaluation, and feasibility studies would require five years. Three years would be required for design and construction of a concentrator and townsite and for mine design and development. Two years of preproduction stripping would precede ore production.

The mine would produce 10,000 tons of ore per day and remove 40,000 tons of waste per day. Operation 330 days each year for 10 years would be required to mine a 35 million ton ore body. The copper-lead-zinc ore would be treated at a concentrator near the mine to produce 1,500 tons of copper-silver concentrates, 1,064 tons of zinc-silver concentrates, and 150 tons of lead-silver concentrates each day. The remaining 7,286 tons of waste material would be stored in a tailings pond near the mine. The copper-

silver concentrates were assumed to be acceptable at a smelter in Washington, and the lead-zinc-silver concentrates at the smelter in Idaho.

A total of 416 employees were necessary to operate this complex, 211 in the mine, 144 in the concentrator and 62 in the support facilities. These estimates include an extra 20 percent for employees on vacation, absent, and for turnover (VAT). The townsite would also house 83 service employees and 980 dependents for a total of 1,479 people.

The summary of all costs for an open pit mine with a production of 10,000 tons of ore and 40,000 tons of waste each day over a ten-year life are summarized in Table 3. The detailed calculations are shown in Appendix C.

Table 3. - Cost summary for the Reed River Open Pit Mine, in dollars

A. Capital cost summary		
Mine equipment	18,472,000	
Mine plant and buildings	12,701,000	
Mine development	32,788,000	
Exploration, acquisition, and studies	5,500,000	
Concentrator	133,645,000	
Support facilities	50,190,000	
Working capital	16,689,000	
Total investment	269,985,000	
B. Annual operating cost and cost per ton of ore		
Direct cost		
Mine	20,153,000	(6.11)
Concentrator	15,630,000	(4.74)
Support facilities	2,451,000	(0.74)
Total	38,234,000	(11.59)
Total cost		
Mine	31,336,000	(9.50)
Concentrator	35,415,000	(10.73)
Support facilities	9,986,000	(3.03)
Total	76,737,000	(23.26)
C. Total annual operating costs		
Mine, concentrator and support facilities	76,737,000	
Transportation costs for copper-silver concentrates	35,431,000	
Transportation costs for lead-zinc-silver concentrates	32,164,000	
Smelting and refining costs for copper-silver concentrates	25,340,000	
Smelting and refining costs for lead-zinc-silver concentrates	29,011,000	
Alaska State mining license tax	1,929,000	
Alaska State income tax	2,385,000	
Federal income tax	13,251,000	
Total	216,248,000	

Economic Evaluation of Open Pit Mine

To recover capital and operating costs and to obtain a 15 percent DCFROI, revenues of $250,290,000 must be generated annually based upon the assumptions made. Using a lead price of 23 cents per pound and a zinc price of 37 cents per pound would require a copper price of 64 cents per pound to generate the required revenues. This is below the price 76.5 cents on July 9, 1976 when these costs were derived. Using a copper price of 76.5 centers per pound, lead at 23 cents, zinc at 37 cents and silver at $4.88 per ounce, revenues would total $281,716,000 providing a DCFROI of slightly over 19 percent.

The Omar River Mine

The site selected for the hypothetical Omar River mine is about 40 miles north-northwest of Kiana, Figure 2. A known zone of copper mineralization in carbonate rocks in this area is somewhat similar to copper mineralization to that of the partly developed Bornite deposits located north of Kobuk. There, a 2,500-foot carbonate complex is host to sulfide mineralization which included such copper, lead and zinc minerals as chalcopyrite, bornite, chalcocite, galena, and sphalerite. Both deep and near surface zones of copper mineralization are present. A potential aggregate ore reserve for the mineralized carbonate rocks of 100,000,000 tons grading 1.2 percent copper for the district has appeared in literature (4).

The probable tonnage and grade of part of the underground mineralization, estimated from some diamond drill core assay data, suggests the presence of extensive, more or less continuous zones of high but widely varying grades of mineralization. A probable 10 million tons of drill-indicated ore with an average grade of 5.3 percent copper may be present in the zone available for underground mining.

Capital and Operating Costs

In deriving the cost estimates, it was assumed that seven consecutive years would elapse between the start of exploration and the start of production. Exploration, property evaluation, and feasibility studies would require five years. Three years would be required for mine development and two years for design and installation of the mine facilities and equipment, the concentrator, and the townsite.

The mine would produce 2,000 tons of copper ore per day. It would operate 330 days each year, for 15 years. The ore would be treated at a concentrator located near the mine to produce 306 tons of copper concentrate each day and send 1,694 tons of waste material to a nearby tailings pond. It was assumed that the metal concentrate would be acceptable at a smelter in Washington.

Employment at the mining complex would total 193 including 107 in the mine, 53 in the concentrator, and 33 in the support facilities. These estimates include an extra 20 percent for VAT employees. In addition to those employees associated with the company there would be 38 service employees and 462 dependants for a total townsite of 693 people.

A summary of all costs for a 2,000 tpd underground mine using room and pillar mining methods is given on Table 4. The detailed costs are given in Appendix D.

Table 4. - Cost summary for the Omar River Mine, in dollars

A. Capital cost summary		
Surface plant and equipment	5,450,000	
Underground plant and equipment	2,020,000	
Mine development	11,456,000	
Exploration, acquisition, and studies	3,100,000	
Concentrator	39,474,000	
Support facilities	30,204,000	
Working capital	5,777,000	
Total investment	97,481,000	
B. Annual operating cost and cost per ton of ore		
Direct cost		
Mine	6,915,000	(10.48)
Concentrator	5,709,000	(8.65)
Support facilities	1,260,000	(1.91)
Total	13,884,000	(21.04)
Total cost		
Mine	9,854,000	(14.93)
Concentrator	10,431,000	(15.80)
Support facilities	4,697,000	(7.12)
Total	24,982,000	(37.85)
C. Total annual operating costs		
Mine, concentrator, and support facilities	24,982,000	
Transportation costs for copper concentrates	10,147,000	
Smelting and refining costs for copper concentrates	6,706,000	
Alaska State mining license tax	885,000	
Alaska State income tax	1,096,000	
Federal income tax	6,087,000	
Total	49,903,000	

Economic Evaluation

To recover capital and operating costs and to obtain a 15 percent DCFROI would require revenues of $55,695,000 to be generated annually based on the assumptions made. This would require a copper price of 109.7 cents per pound which is about 33 cents above the July 9, 1976 price of 76.5 cents.

Deetoo Gold Mine

The site for the hypothetical Deetoo gold mine is approximately 70 miles north of Alatna in an area where small high grade vein deposits have been prospected in the past. It was assumed that a small high-grade gold deposit, similar to those at Chandalar could be found here. There the host rock for the gold lodes is mainly a Devonian pelitic schist that has been intruded by mafic to intermediate-grade igneous rocks. These, in turn, have been metamorphosed to a greenstone and greenstone schist (3). The gold-quartz lode deposits consist of numerous steeply dipping, sheeted, auriferous quartz veins.

The gold is confined mainly to the hanging walls in these structures which are generally less than 10 feet wide, and have limited horizontal and unknown vertical extent. Most of the gold in this district is present as free gold, but small amounts are associated with sulfides and arsenides. In addition to gold, these lodes also carry appreciable amounts of arsenopyrite, pyrite, and sphalerite; and traces of stibnite, galena, chalcopyrite, and siderite.

Capital and Operating Costs

In deriving the cost estimates, it was assumed that five years were necessary to bring this mine into production. Exploration and property evaluation would require three years. Two years would be required for design construction and for mine development. Whereas much of the equipment and supplies could be moved onto the site during the winter, most of the construction would proceed during the summer.

Using the shrinkage stope method of underground mining, a total of 100 tons of ore would be produced on two shifts for 100 days each year. The concentrator would include a ball mill grinding circuit and a jig to provide material for gravity concentration and amalgamation. It would run three shifts each day recovering 75 percent of the available free gold. At 10,000 tons of ore mined each year, five years of operation would be sustained. Ore treated at the concentrator would yield about 139 ounces of free gold each day and the annual rate of production would be 13,875 troy ounces or 1,156 pounds. Thus, nearly all of the 10,000 tons of material mined each year would go to a tailings pond located near the mine.

Transportation systems to and from this hypothetical deposit would include the construction of a 35-mile winter haul road from a transportation route which would be used to bring in equipment, machinery, housing facilities, and all ancillary equipment for the proposed mine and mill. Transportation of goods and personnel during the rest of the year, after breakup, would be by air freight, utilizing large aircraft. A 5,000-foot dirt airstrip would be constructed for this purpose.

Employment at the mine would total 27 (17 in the mine, six in the concentrator, four in maintenance) and two in services. As a company camp would be planned, no dependants would be included. Housing would consist of trailer-type bunkhouse units. These could be used because of the limited operating season and small labor force.

A summary of capital costs for a 100 tpd underground mine using shrinkage stoping mining methods is given in Table 5. The detailed costs are given in Appendix E.

Table 5. - Cost summary for the Deetoo Gold Mine, in dollars

A.	Capital cost summary		
	Surface plant and equipment	677,000	
	Underground plant and equipment	209,000	
	Mine development	731,000	
	Exploration, acquisition, and studies	350,000	
	Concentrator	1,339,000	
	Support facilities	936,000	
	Working capital	1,067,000	
	Total investment	5,309,000	
B.	Annual operating cost and cost per ton of ore		
	Direct cost		
	Mine	374,000	(37.40)
	Concentrator	175,000	(17.50)
	Support facilities	26,000	(2.60)
	Total	575,000	(57.50)
	Total cost		
	Mine	896,000	(89.60)
	Concentrator	533,000	(53.30)
	Support facilities	258,000	(25.80)
	Total	1,687,000	(168.70)
C.	Total annual operating costs		
	Mine, concentrator, and support facilities	1,687,000	
	Transportation costs	2,000	
	Refining costs	139,000	
	Alaska State mining license tax	107,000	
	Alaska State income tax	136,000	
	Federal income tax	753,000	
	Total	2,824,000	

Economic Evaluation

To obtain a 20 percent DCFROI based upon capital costs of $5,309,000 and operating costs of $1,687,000 would require a gold price of $295 per ounce. These costs were based upon new equipment prices and union labor rates and they were probably higher than what an enterprising mining person might spend. If the capital costs could be reduced by 50 percent by whatever means possible, the required gold price would drop to $177 per ounce. If both the capital and operating costs could be halved, then the required gold price would drop to $152 per ounce.

DISCUSSION

In an effort to determine the feasibility of developing some types of mineral deposits which could be expected to be found in the western Brooks Range, preliminary financial analyses were made of four deposit types that have been found on or near the (d)(2) lands and which, for geologic reasons, may be present on them. These are:

1. lead-zinc-silver-barite deposits in sedimentary rocks;
2. high-grade zinc-copper deposits in metamorphosed volcanic rocks;
3. high-grade copper deposits in carbonate rocks; and
4. high-grade gold deposits in quartz veins.

It was assumed that a surface rail transportation network would be made available by either a government agency, such as the Alaska Railroad, or by some other transportation company. Such a railroad could run from Cape Lisburne via Kiana, Kobuk, Alatna and tie into the Alaska Railroad

at Nenana. The economics of building and operating such a railroad extension are not discussed in this report. The freight rates for hauling concentrates from the various mines to a seaport at Whittier, Alaska were estimated on the basis of national railroad rates for comparable long-distance hauls and adjusted upward for Alaska. The construction of such a railroad or other surface transportation system is a necessity before mining can begin. It would be used not only for hauling concentrate to tidewater, but also for hauling the supplies and heavy equipment to the mine sites.

The summary financial data of the proposed western Brooks Range mines are presented on Table 6. The operating costs for revenues, taxes, and wages and salaries for each operation are shown annually and totalled for the life of each operation.

The combined annual operating costs for the four companies are given in Table 7 below. If the four proposed major mines were to operate simultaneously, employment at the mines would be provided for 1,624 people bringing a total of 5,242 people to the area.

Table 7. - Total annual operating costs for four mines in the Brooks Range

Mine, concentrator and townsite	$199,286,000
Transportation costs for concentrates	151,734,000
Smelting and refining charges	118,720,000
Alaska State mining license tax	5,691,000
Alaska State income tax	7,039,000
Federal income tax	39,109,000
Total	$521,579,000

If the four base metal mines were to commence production, total annual revenues of $621,680,000 would be required against total annual costs of $521,579,000. Of the total costs, about $200 million (38 percent) would go to operate the mines, concentrators, and townsites.

TABLE 6. - Summary of financial data for the proposed mines in the western Brooks Range, 1000's of dollars

Mine	Total investment	Annual revenues		Operating Costs 1/	Wages	Taxes			
		Required	Generated			Federal	State	Mining license	Tota
Red Dog									
Annual	-	172,873	133,817	129,443	9,144	10,396	1,871	1,513	13,7
20-year life	259,656	3,457,460	2,676,340	2,588,860	182,880	207,920	37,420	30,420	275,6
Reed River (underground)									
Annual	-	135,357	140,858	102,544	9,700	9,375	1,687	1,364	12,4
20-year life	171,182	2,707,140	2,817,160	2,050,880	194,000	187,500	33,740	27,280	248,5
Reed River (open pit)									
Annual	-	251,246	281,716	200,612	10,530	13,251	2,385	1,929	17,5
10-year life	270,249	2,512,460	2,817,160	2,006,120	105,300	132,510	23,850	19,290	175,6
Omar River									
Annual	-	62,204	40,406	42,720	4,893	6,087	1,096	885	8,0
15-year life	105,567	933,060	606,090	640,800	73,395	91,305	16,440	13,275	121,0
Deetoo Mine									
Annual	-	2,119	1,714	1,935	347	753	136	107	9
5-year life	5,309	10,595	8,570	9,675	1,735	3,765	680	535	4,9

1/ Includes mine concentrator, townsite, transportation, smelting and refining costs.

Over half of the costs, about $270 million (52 percent) would go for transportation, smelting, and refining charges; and about $52 million, 10 percent of costs (or 8.3 percent of the revenue) would be paid in taxes. This would leave about $100 million, or 16 percent, for the companies, of which about $65 million, or 10 percent, would be for depletion allowances, and $35 million, or 6 percent, would be for net profits.

For the gold mine, as proposed in this study, a price of near $295 per ounce would be required for a profit of 20 percent discounted cash flow rate of return on the investment. This required price is based upon a company's using new equipment and paying top wages. If an enterprising mining family or partnership can cut the capital costs in half, the price required can be reduced to $177 per ounce. Halving both the capital and operating costs would provide a required price to $152. While the price of gold in July 1976 was $123 per ounce, it was around $135 per ounce at the end of 1976 and rising.

The postulated small underground high-grade gold mine operation, while perhaps of limited national significance, gives not only an indication of any possible viability for this small gold company operation in these remote areas, but it also provides an indication as to the possible economic viability of other small mine operations that may produce products of high unit value, such as uranium, tungsten, or other commodity. This economic feasibility study did not evaluate small high-grade prospects such as placer gold, or others, that can be operated by a few

men, perhaps as working partnerships, etc.; these cannot be costed out by accepted standard methods. Their measure of success is that they can operate and provide enough return to make a way of life for those involved, which, presumably, is still socially and economically desirable within our society.

CONCLUSIONS

A major assumption for this report was the availability of ground transportation to the properties. The existence of a railroad was assumed from Cape Beaufort on the Arctic Ocean to Kiana, Kobuk, Alatna, and to Nenana on the present Alaska Railroad. The companies would pay for the railroad through their usage; they were not assumed to own it. Such a railroad would be necessary to carry supplies and heavy equipment to the mines as well as concentrates to an ice-free port.

Based upon the assumptions made in the report, an open pit mine operated for 10,000 tpd of lead-zinc-silver-barite ore and 20,000 tpd of waste would provide a 15 percent DCFROI at the site of the Red Dog prospect over a 20-year period given lead, zinc, and silver prices 24.5 percent greater than those quoted in July of 1976, 23 cents per pound for lead, 37 cents per pound for zinc, and $4.88 per ounce for silver. A deposit having about 25 percent richer ore would be able to provide the required revenue. The required grade would then be slightly higher than what is presently being mined in the Anvil district, Yukon Territory, Canada. The "Reed River mine" type deposits, both open pit and

underground, would have been economic yielding a DCFROI up to 19 percent. The "Omar River mine" type deposit alone would require a copper price over one dollar per pound to be economic. Conceivably, mining it in conjunction with a Reed River type property, if they were in close proximity and could share facilities, would make both these properties economically viable. The small, high-grade "Deetoo Gold mine" type deposit probably could be mined economically at a gold price of $152 per ounce, or slightly lower, by small enterprising groups at today's gold prices.

There appear to be mineral deposits located on the south flank of the Brooks Range which could be developed now, given ground access. While the ore grades used in the models were quite high, these kinds of grades can be expected in relatively unexplored areas. As exploration increases in a given area, more and lower grade deposits will be located, but, undoubtedly, a few additional larger or high-grade deposits will be found, too.

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APPENDIX A. - ASSUMPTIONS AND COST DATA FOR THE RED DOG MINE

30,000 tpd ore and waste, open pit

10,000 tpd ore

Mine, concentrator, support facilities

20 year life

330 days per year operating

2 products: Pb-Ag, Zn-Ag concentrates

Ore grades: 2.73% Pb, 4.90% Zn, 1.23 oz Ag

Reserves: 66,000,000 tons

Recovery: 77% of metal content

Railroad haulage of concentrates to Whittier on an assumed railroad

Barge to Tacoma or Seattle

Train to Idaho

TABLE A-1. - Total capital requirements

	Cost, dollars
Mine plant and buildings	$ 9,780,000
Mine equipment	12,051,000
Property acquisition	500,000
Exploration, development, feasibility and environmental studies	5,000,000
Mine development	11,250,000
Concentrator	121,070,000
Support facilities	43,334,000
Total plant cost (insurance, tax base)	$202,985,000
Interest during construction	17,420,000
Subtotal for depreciation	$220,405,000
Working capital	14,344,000
Total investment	$234,749,000

TABLE A-2. - Working capital

		Cost, dollars
Direct labor	3 months	$ 2,016,000
Payroll overhead	"	706,000
Operating supplies	"	5,624,000
Indirect cost	4 months	1,401,000
Fixed cost	.5% of insurance base	1,015,000
Spare parts inventory		2,500,000
Miscellaneous expense		1,082,000
Total		$14,344,000

TABLE A-3. - Mine equipment - 30,000 tpd open pit

Number	Item	Description	Hp	Cost, dollars
3	Shovel	10-yd, electric, erected	1,800	$ 3,699,000
10	Truck	100-ton, rear dump	10,000	4,400,000
2	Drill	9-in, rotary, electric	1,200	914,000
1	Drill	5-in, track mounted	-	52,000
1	Compressor	600 cfm	190	37,000
1	Tractor dozer	Rubber-tired dozer, articulated	300	135,000
2	Wheel loader	5-yd bucket, articulated	520	221,000
3	Crawler tractor	U-blade, single ripper	900	486,000
2	Motor grader	14-ft moldboard, scarifier	360	194,000
1	Backhoe	1/2-yd bucket	100	20,000
2	Truck	2000-gal water tanks	320	37,000
1	Crane	35-ton, crawler mounted	135	114,000
6	Vehicles	2-ton maintenance	900	90,000
10	Truck	3/4-ton pickups	1,860	80,000
	Subtotal			$10,479,000
	Contingency - 15%			1,572,000
	Subtotal			$12,051,000
	Interest during construction			904,000
	Total			$12,955,000

TABLE A-4 - Mine plant and buildings

	Cost, dollars
Electrical system	$ 844,000
Communications system	55,000
Drainage and disposal system	517,000
Repair shops and warehouses	5,362,000
Office and laboratories	275,000
Fuel tank, gasoline - 20,000-gal horizontal steel tank	110,000
Fuel tank, diesel - 30,000-bbl cone roof steel tank	1,238,000
Oil and lube tanks - 8,000 and 10,000-gal horizontal steel tanks	104,000
Subtotal	$ 8,505,000
Contingency @ 15%	1,275,000
Subtotal	$ 9,780,000
Interest during construction	733,000
Total	$10,513,000

TABLE A-5. - Mine development cost

	Cost, dollars
Preproduction stripping 7,500,000 tons @ $1.50 per ton	$11,250,000
Interest during development	562,000
Total	$11,812,000

TABLE A-6. - Cost of a 10,000 tpd lead-zinc-silver concentrator

	Cost, dollars
Equipment cost 1/	$ 7,241,000
Installation charges, service facilities, buildings, tailings pond, engineering, construction, fees	29,219,000
Estimated concentrator cost	$36,460,000
Alaska location factor = 2.75 plus 5.4 percent for extra buildings and equipment needed in Arctic environment	$105,278,000
Contingency - 15%	15,792,000
Subtotal	$121,070,000
Interest during construction	11,054,000
Total	$132,124,000

1/ 10,000 tpd concentrator revised downward from 11,000 tpd concentrator given in IC 8646 using .7 factor; costs inflated 25 percent for addition of zinc lines and revised from 1971 to 1976 using M&S index for second quarter, 1976.

TABLE A-7. - Support facilities cost

	Cost, dollars
Townsite - 362 employees	$29,052,000
Generating plant - 15 MW	6,452,000
Fuel tank - 17,000 bbls	932,000
Airport - 4,500 x 200 ft	1,221,000
Vehicles - 5 pickups and sedans	25,000
Subtotal	$37,682,000
Contingency - 15%	5,652,000
Subtotal	$43,334,000
Interest during construction	4,167,000
Total	$47,501,000

TABLE A-8. - Depreciation, dollars

Item	Years Straight-Line Depreciation	Mine	Concentrator	Support Facilities	Total
Buildings and facilities	20	425,000	4,902,000	1,597,000	6,924,000
Long life equipment	10	1,031,000	724,000	645,000	2,400,000
Short life equipment	5	34,000	-	5,000	39,000
Other 1/	20	1,090,000 2/	1,342,000	499,000	2,931,000
Total		2,580,000	6,968,000	2,746,000	12,294,000

1/ Includes contingency and interest during development

2/ Also includes property acquisition, exploration, development, feasibility studies, environmental studies and preproduction stripping.

TABLE A-9. - Power requirements and costs

Mine:	
3000 hp = 2238 kW x 24 hr/day = 53,712 kW-hr/day x 330 day/yr = kW-hr/yr	17,725,000
Mill:	
25 kW-hr/ton x 10,000 tpd = 250,000 kW-hr/day x 330 day/yr = kW-hr/yr	82,500,000
Support facilities:	
1,200 people x 7.5 kW-hr/day = 9,000 kW-hr/day 365 day/yr = kW-hr/yr	3,285,000
Total	103,510,000 kW-hr/yr

103,510,000 kW-hr/yr ÷ 7920 hr/yr = 13,069 kW -say 15 MW
fuel - 103,510,000 kW-hr/yr ÷ 13 kW-hr/gal = 7,962,000 gal/yr

Operating costs[1/]:

7,962,000 gal/yr x 75¢/gal =	$5,972,000
maintenance - $15/kW x 15,000 kW	225,000
	$6,197,000
$6,197,000/yr ÷ 103,510,000 kW-hr/yr	$0.06/kW-hr

[1/] Depreciation and manpower expenses included with support facilities.

TABLE A-10. - Estimated annual operating cost, dollars

Item	Mine	Concentrator	Support Facilities	Total
Direct cost:				
Operating labor- $12/hr x 2000 hrs	2,256,000	1,440,000	504,000	4,200,000
Supervisory staff -$14/hr x 2000 hrs	392,000	672,000	168,000	1,232,000
Maintenance staff -$14/hr x 2000 hrs	1,008,000	1,008,000	420,000	2,436,000
Operating & maintenance supplies	8,982,000	6,514,000	651,000	16,147,000
Power	1,064,000	4,950,000	197,000	6,211,000
Water	6,000	126,000	6,000	138,000
Payroll overhead @ 35% of payroll	1,280,000	1,092,000	382,000	2,754,000
Total direct cost	14,988,000	15,802,000	2,328,000	33,118,000
Indirect cost:				
Administrative, technical & clerical	319,000	547,000	410,000	1,276,000
Payroll overhead @ 35% of payroll	112,000	191,000	144,000	447,000
General overhead - 5% of direct cost	744,000	796,000	117,000	1,657,000
Total indirect cost	1,175,000	1,534,000	671,000	3,380,000
Fixed cost:				
Taxes & insurances -2% of plant cost	975,000	2,421,000	884,000	4,280,000
Depreciation	2,580,000	6,968,000	2,746,000	12,294,000
Property taxes - 2% of plant cost	975,000	2,421,000	884,000	4,280,000
Total fixed cost	4,530,000	11,810,000	4,514,000	20,854,000
Total operating cost	20,693,000	29,146,000	7,513,000	57,352,000

TABLE A-11. - Smelter charges

0.0490 Zn ÷ 0.671 = 0.0730 ZnS x 10,000 tpd = 730 tpd ZnS	
730 tpd ZnS ÷ 0.77 recovery x 330 dpy =	312,900 tpy
0.0273 Pb ÷ 0.0315 PbS x 10,000 tpd = 315 tpd PbS	
315 tpd PbS ÷ 0.77 recovery x 330 dpy =	135,000 tpy
1.23 oz Ag x 10,000 tpd = 12,300 oz per day ÷ 12 oz per lb =	0.51 tpd
0.51 tpd ÷ 0.77 recovery x 330 dpy =	168 tpy

Credits:

312,900 tpy Zn con x $299.79/ton =	$93,804,000
135,000 tpy Pb con x $296.39/ton =	40,013,000
	$133,817,000

Deductions:

312,900 tpy Zn con x $75.38/ton =	$23,586,000
135,000 tpy Pb con x $51.15/ton =	6,905,000
	$30,491,000

TABLE A-12. - Transportation charges

Railroad distance

Red Dog Mine to Kobuk	200 miles
Kobuk to Alatna	137 "
Alatna to Nenana	251 "
Nenana to Whittier	337 "
	925 miles

Train, mine to Whittier - 925 miles x 4¢/ton-mile =	$37.00 per ton
Barge, Whittier to Seattle - 1300 miles x 3¢/ton-mile =	39.00 " "
Train, Seattle to Idaho - 350 miles x 2.5¢/ton-mile =	8.75 " "
Handling and insurance	5.00 " "
	$89.75
447,900 tons concentrate x $89.75 per ton =	$40,199,000

TABLE A-13. - Financial analysis, dollars

Present worth of capital investment at 15% = $271,302,000

Cash flow: $271,302,000 ÷ 6.2593 =	$ 43,344,000
Less depreciation =	12,294,000
Net profit plus depletion	$ 31,050,000

Mine Cash Flow Analysis

Revenues	$172,873,000
Operating	57,352,000
Transportation costs, lead/zinc	40,199,000
Smelting and refining costs-lead/zinc	30,491,000
State mining license tax	1,513,000
Gross Profit	43,318,000
Depletion	21,659,000
Taxable income	21,659,000
Federal income tax	10,396,000
State income tax	1,871,000
Net Profit	9,392,000
Calculated positive cash flow	43,345,000
Net profit	9,392,000
Depletion	21,659,000
Depreciation	12,294,000

TABLE A-14. - Summary of expenditures and discounted cash flows, 1000's of dollars

Year	Capital Expenditures	Cash Flows	Present Worth Factor @ 15%	Present Worth Capital Investment @ 15%	Present Worth Cash Flow @ 15%	Mine Plant and Buildings	Mine Equipment	Property Acquisition	Exploration 1/	Mine Development	Concentrator	Support Facilities	Interest
-7	500	-500	2.6600	1,330	-1,330			250	250				
-6	750	-750	2.3131	1,735	-1,735			250	500				
-5	1,500	-1,500	2.0114	3,017	-3,017				1,500				
-4	2,000	-2,000	1.7490	3,498	-3,498				2,000				
-3	750	-750	1.5209	1,141	-1,141				750				
-2	31,870	-31,870	1.3225	42,148	-42,148						20,000	10,000	1,870
-1	96,556	-96,556	1.1500	111,039	-111,039	4,890	6,025				60,000	20,000	5,641
0	101,340 2/	-101,340	1.0000	101,340	-101,340	4,890	6,026			11,250	41,070	13,334	10,426
1		43,344	.8696		37,692								
2		43,344	.7561		32,772								
3		43,344	.6575		28,499								
4		43,344	.5718		24,784								
5	195	43,149	.4972	97	21,454								
6		43,344	.4323		18,738								
7		43,344	.3759		16,293								
8		43,344	.3269		14,169								
9		43,344	.2843		12,323								
10	24,000	19,344	.2472	5,933	4,782								
11		43,344	.2149		9,315								
12		43,344	.1869		8,101								
13		43,344	.1625		7,043								
14		43,344	.1413		6,125								
15	195	43,149	.1229	24	5,303								
16		43,344	.1069		4,633								
17		43,344	.0929		4,027								
18		43,344	.0808		3,502								
19		43,344	.0703		3,047								
20		43,344	.0611		2,648								
				271,302	2								

1/ Also includes development, feasibility and environmental study costs.

2/ Includes working capital.

APPENDIX B.- ASSUMPTIONS AND COST DATA FOR THE REED RIVER UNDERGROUND MINE

5,000 tpd room and pillar

1% Pb, 5.5% Zn, 4% Cu, 1.5 oz Ag

1300 shaft

LHD mining

Three products: Cu-Ag, Pb-Ag, Zn-Ag concentrates

Mine, concentrator and support facilities

330 dpy operating

Railroad haulage to Whittier on existing railroad to mine site

Barge to Tacoma or Seattle

Train to Idaho

Reserves: 33,000,000 tons

Recovery: 77% of metal content

20-year life

TABLE B-1.- Total capital requirements

	Cost, dollars
Mine plant and buildings	$ 7,045,000
Mine equipment	3,484,000
Property acquisition	500,000
Exploration, development, feasibility and environmental studies	6,250,000
Mine development	13,924,000
Concentrator	65,580,000
Support facilities	39,655,000
Total plant cost (insurance, tax base)	$136,438,000
Interest during construction	12,054,000
Subtotal for depreciation	$148,492,000
Working capital	10,330,000
Total investment	$158,822,000

TABLE B-2.- Working capital

	Cost, dollars
Direct labor, 3 months	$ 2,220,000
Payroll overhead, 3 months	777,000
Operating supplies, 3 months	3,117,000
Indirect cost, 4 months	777,000
Fixed cost, .5% of insurance base	682,000
Spare parts and inventory	2,000,000
Miscellaneous expense	757,000
Total	$ 10,330,000

TABLE B-3.- Summary of surface plant and equipment costs

Item	Quantity	Size	Unit hp	Total hp	Total cost
Ore hoisting shaft	-				
Excavation and foundation	-	For headframe and hoist installation	-	-	$ 733,000
Headframe	1	150-ft-high steel	-	-	1,092,000
Ore bin	1	4,000-ton concrete	-	-	357,000
Hoist building	1	50 ft by 170 ft with 38-ft eave @ $70/sf	800	800	595,000
Ore hoist	1	10-ft-diam single drum with motor-generator set and flywheel	4,000	4,000	1,123,000
Ore skips and cable	-	8-ton skips, 1-3/8-in cable	-	-	77,000
Auxiliary hoist, cage, and cable	1	6-ft by 6-ft by 10-ft counter weighted cage, 1-1/4-in cable	180	180	226,000
Ventilation fan	3	5-ft axialvane (1 spare) including housing	200	600	88,000
Transformer station	1	7,000 kV-A, 69,000-volt to 2,200 volt, semipermanent building	-	-	60,000
Switch	1	Main disconnect 2,200 volts	-	-	6,000
Distribution wire	2,000 ft	Overhead line size 1-0 wire	-	-	2,000
.....do.....	12,000 ft	Overhead line size 4 wire	-	-	5,000
Poles	72	For distribution system	-	-	4,000
Accessories for distribution, wire line	-	Cross arms, insulators, etc., at $3,700 per mile	-	-	3,000
Compressor	1	4,500 cfm with motor	700	700	77,000
Compressor building	1	48 ft by 48 ft with 30-ft eave including 25-ton bridge crane at $50 per sq ft	-	-	115,000
Receiver	1	10 ft diam by 20 ft	-	-	5,000
Air line	1,000 ft	10-in pipe, victaulic couplings	-	-	14,000
Mine office lamp room and change room	1	60 ft by 50 ft with 20-ft eave including utilities at $65 per sq ft	-	-	195,000
Office furniture and equipment	1	30 ft by 30 ft at $20 per sq ft	-	-	18,000
Machine shop and equipment repair shop	1	60 ft by 125 ft with 20-ft eave including utilities at $60 per sq ft	-	-	450,000

TABLE B-3.- Summary of surface plant and equipment costs, Continued

Item	Quantity	Size	Unit hp	Total hp	Total cost
Shop equipment and tools	-	Includes hoists, welders, and general shop tools	-	-	$ 200,000
Warehouse	1	50 ft by 80 ft with 10-ft eave including utilities at $50 per sq ft	-	-	200,000
Explosives magazine	1	15 ft by 20 ft with 10-ft eave, buried and fenced at $40 per sq ft	-	-	12,000
Administration building	1	40 ft by 40 ft with 10-ft eave including utilities at $70 per sq ft, 1/2 charged to mine	-	-	56,000
Service vehicle	6	Crane, forklift, trucks, dozer, grader, and front-end loader	-	-	383,000
Utility vehicle	7	Four 1/2-ton pickups, 2 sedans, 1 station wagon	80	560	30,000
Subtotal					$6,126,000
Contingency					919,000
Subtotal					$7,045,000
Interest during construction					528,000
Total					$7,573,000

TABLE B-4. - Summary of underground plant and equipment costs

Item	Quantity	Size	Unit hp	Total hp	Total cost
Pump (drainage)	2	Vertical 8-stage 13-1/4-in bowl	600	1,200	$ 86,000
Drainage lines	3,000 ft	10-in pipe with victaulic couplings	-	-	210,000
Compressed air line	4,000 ft	.....do.....	-	-	294,000
.....do.....	2,000 ft	8-in pipe with victaulic couplings	-	-	413,000
.....do.....	7,000 ft	6-in pipe with victaulic couplings	-	-	261,000
Drill and culinary waterline	10,000 ft	4-in pipe with victaulic couplings	-	-	196,000
Blowers	6	Portable in workings (2 spares)	15	60	11,000
Electric distribution system	-	Cables, transformers, etc.	-	-	234,000
Telephone	-	Throughout mine and surface	10	10	95,000
Jumbo (development)	3	2 drills, 3-1/2-in pistons	-	-	96,000
Loading machine	2	Overshot type, air power	-	-	59,000
Stoper	2	31-in feed, 79 lb	-	-	6,000
Hoist	2	1,200-lb rope pull	-	-	8,000
Jumbo (stoping)	8	2 drills, 3-1/2-in pistons, rubber tired	-	-	330,000
Load-haul-dump vehicle	8	5-cu-yd diesel powered (2 spares)	195	1,170	935,000
Shop tools	-	Hoists, welders, general shop tools	-	-	96,000
Subtotal					$3,030,000
Contingency					454,000
Subtotal					$3,484,000
Interest during construction					218,000
Total					$3,702,000

TABLE B-5.- Mine development cost

	Cost, dollars
Shaft, 20-ft diameter, 1300 ft deep	$ 4,042,000
Ventilation shaft, 2 6-ft diameter, 1300 ft	3,382,000
Haulage drift, 14 ft x 12 ft x 2500 ft x 2 ft	3,575,000
Ore shoots and bins	2,925,000
Subtotal	13,924,000
Interest during development	1,296,000
Total	$15,220,000

TABLE B-6.- Cost of a 5,000 tpd copper-lead-zinc-silver concentrator

	Cost, dollars
Estimated concentrator cost 1/	$22,622,000.00
Alaska location factor: 2.75 x a factor for extra equipment and buildings needed for Arctic environment	x2.899
Subtotal	$65,580,000.00
Interest during construction	6,029,000.00
Total	$71,609,000.00

1/ 5,000 tpd concentrator taken from IC 8598 was updated to July, 1976 and given larger flotation and filtration sections.

TABLE B-7.- Support facilities costs

	Cost, dollars
Townsite, 383 employees	$ 28,683,000
Generating plant, 9 MW	3,871,000
Fuel tank, 11,000 bbl	688,000
Airport, 4,500 ft x 200 ft	1,221,000
Vehicles, 4 pickups, sedans	20,000
Subtotal	$ 34,483,000
Contingency, 15%	5,172,000
Subtotal	$ 39,655,000
Interest during construction	3,983,000
Total	$ 43,638,000

TABLE B-8.- Depreciation, dollars

Item	Years straight-line depreciation	Mine	Concentrator	Support Facilities	Total
Buildings and facilities	20	352,000	2,983,000	1,437,000	4,772,000
Long life equipment	10	170,000	592,000	387,000	1,149,000
Short life equipment	5	83,000	-	4,000	87,000
Other 1/	20	1,204,000 2/	301,000	458,000	1,963,000
Total		1,809,000	3,876,000	2,286,000	7,971,000

1/ Includes contingency and interest during development.

2/ Also includes property acquisition, exploration, development, feasibility and environmental studies.

TABLE B-9.- Power requirements and costs

Mine

3550 hp = 2648 Kw x 24 hr/day = 63,552 Kw-hr/day

x 330 dpy = Kw-hr/yr — 20,972,000

Mill

6689 hp = 4990 Kw x 24 hr/day = 119,760 Kw-hr/day

x 330 dpy = Kw-hr/yr — 39,521,000

Support facilities

1380 people x 7.5 Kw-hr/day = 10,350 Kw-hr/day

x 365 dpy = Kw-hr/yr

245,643 Kw-hr/day — 3,778,000

64,271,000

64,271,000 Kw-hr/yr ÷ 7920 hr/yr = 8,115 Kw (say 9 MW)

64,271,000 Kw-hr/yr ÷ 13 Kw-hr/gal = 4,944,000 gal/yr

Operating cost*

4,944,000 gal/yr x 75¢/gal = $3,708,000

Maintenance

$15/Kw x 9,000 Kw = 135,000

$3,843,000 ÷ 64,271,000 = $0.06/Kw-hr

*Depreciation and manpower expenses included with support facilities.

TABLE B-10.- Estimated annual operating costs, dollars

	Mine	Concentrator	Support Facilities	Total
Direct cost:				
Operating labor, $12/hr x 2000 hrs.	$ 3,552,000	$ 1,056,000	$ 408,000	$ 5,016,000
Supervisory staff, $14/hr x 2000 hrs.	700,000	252,000	168,000	1,120,000
Maintenance labor, $14/hr x 2000 hrs.	1,596,000	784,000	364,000	2,744,000
Operating & maintenance supplies	4,223,000	3,925,000	390,000	8,538,000
Power	1,258,000	2,371,000	227,000	3,856,000
Water	5,000	63,000	5,000	73,000
Payroll overhead @35% of payroll	2,047,000	732,000	329,000	3,108,000
Total direct cost	$13,381,000	$ 9,183,000	$1,891,000	$24,455,000
Indirect cost:				
Administrative, technical, clerical	296,000	296,000	228,000	820,000
Payroll overhead @35% of payroll	104,000	104,000	80,000	288,000
General overhead @5% of direct costs	669,000	459,000	95,000	1,223,000
	1,069,000	859,000	403,000	2,331,000
Fixed cost:				
Taxes and insurance, 2% of plant cost	624,000	1,312,000	793,000	2,729,000
Depreciation	1,809,000	3,876,000	2,286,000	7,971,000
Property taxes, 2% of plant cost	624,000	1,312,000	793,000	2,729,000
Total fixed cost	3,057,000	6,500,000	3,872,000	13,429,000
Total operating cost	$17,507,000	$16,542,000	$6,166,000	$40,215,000

TABLE B-11.- Smelter charges

0.04 ÷ 0.346 = 0.1156 $CuFeS_2$ x 5,000 tpd = 578 tpd $CuFeS_2$

578 tpd $CuFeS_2$ ÷ 0.77 recovery x 330 dpy = 247,700 tpy

0.055 Zn ÷ 0.671 = 0.0820 ZnS x 5,000 tpd = 410 tpd ZnS

410 tpd ZnS ÷ 0.77 recovery x 330 dpy = 175,700 tpy

0.01 Pb ÷ 0.866 = 0.0115 PbS x 5,000 tpd = 57.5 tpd PbS

57.5 tpd PbS ÷ 0.77 recovery x 330 dpy = 24,600 tpy

1.5 oz Ag x 5,000 tpd = 7,500 oz/day ÷ 24,000 oz/ton = 0.312 tpd

0.312 tpd ÷ 0.77 recovery x 330 dpy = 134 tpy

Credits:

247,700 tpy copper-silver concentrates x $326.52/ton =	$ 80,879,000
175,700 tpy zinc-silver concentrates x $299.79/ton =	52,673,000
24,600 tpy lead-silver concentrates x $296.39/ton =	7,306,000
	$140,858,000

Deductions:

247,700 tpy copper-silver concentrates x $51.15/ton =	$ 12,670,000
175,700 tpy zinc-silver concentrates x $75.38/ton =	13,244,000
24,600 tpy lead-silver concentrates x $51.15/ton =	1,258,000
	$ 27,172,000

TABLE B-12.- Transportation charges

Railroad distance:

Reed River mine to Alatna	100 miles
Alatna to Nenana	251 miles
Nenana to Whittier	337 miles
	688 miles

Copper concentrates:

Train, Reed River mine to Whittier	688 miles @4¢/ton-m	$ 27.52
Barging, Whittier to Tacoma	1300 miles @3¢/ton-m	39.00
Handling and insurance		5.00
		$ 71.52

247,700 tpy x $71.52/ton = $17,715,000/year

Lead-zinc concentrates:

Train, Reed River mine to Whittier	688 miles @4¢/ton-m	$ 27.52
Barge, Whittier to Seattle	1300 miles @3¢/ton-m	39.00
Train, Seattle to Idaho	350 miles @2.5¢/ton-m	8.75
Handling and insurance		5.00
		$ 80.27

200,300 tpy x $80.27/ton = $16,078,000/year

TABLE B-13.- Financial analysis, dollars

Present worth of capital investment at 15% = $186,032,000

Cash flow: $186,032,000 ÷ 6.2593 = $ 29,721,000

depreciation = 7,971,000

$ 21,750,000

Mine Cash Flow Analysis

Revenues	$ 135,357,000
Operating costs	40,215,000
Transportation costs copper	17,715,000
Transportation costs, lead/zinc	16,078,000
Smelting and refining costs, copper	12,670,000
Smelting and refining costs, lead/zinc	14,502,000
State mining license tax	1,364,000
Gross profit	32,813,000
Depletion	13,282,000
Taxable income	19,531,000
Federal income tax	9,375,000
State income tax	1,687,000
Net profit	8,469,000
Calculated positive cash flow	29,722,000
Net profit	8,469,000
Depletion	13,282,000
Depreciation	7,971,000

TABLE B-14. - Summary of expenditures and discounted cash flows, 1000's dollars

Year	Capital expen-ditures	Cash Flows	Present Worth Factor @ 15%	Present worth capital invest-ments @ 15%	Present worth cash flow @ 15%	Mine plant and Buildings	Mine equip-ment	Property acquisi-tion	Explor-ation 1/	Mine develop-ment	Concen-trator	Support Facil-ities	Interest
-7	500	-500	2.6600	1,330	-1,330			250	250				
-6	750	-750	2.3131	1,735	-1 735			250	500				
-5	1,500	-1,500	2.0114	3,017	-3,017				1,500				
-4	2,000	-2,000	1.7490	3,498	-3,498				2,000				
-3	2,000	-2,000	1.5209	3,042	-3,042				2,000				
-2	23,100	-23,100	1.3225	30,550	-30,550					2,000	10,000	10,000	1,100
-1	71,863	-71,863	1.1500	82,642	-82,642	3,522	871			8,000	35,000	20,000	4,470
0	57,109 2/	-57,109	1.0000	57,109	-57,109	3,523	2,613			3,924	20,580	9,655	6,484
1		29,721	.8696		25,845								
2		29,721	.7561		22,472								
3		29,721	.6575		19,542								
4		29,721	.5718		16,994								
5	435	29,286	.4972	216	14,561								
6		29,721	.4323		12,848								
7		29,721	.3759		11,172								
8		29,721	.3269		9,716								
9		29,721	.2843		8,450								
10	11,490	18,231	.2472	2,840	4,507								
11		29,721	.2149		6,387								
12		29,721	.1869		5,555								
13		29,721	.1625		4,830								
14		29,721	.1413		4,200								
15	435	29,286	.1229	53	3,599								
16		29,721	.1069		3,177								
17		29,721	.0929		2,761								
18		29,721	.0808		2,401								
19		29,721	.0703		2,089								
20		29,721	.0611		1,816								
				186,032	1								

1/ Also includes development, feasibility and environmental study costs.

2/ Includes working capital.

APPENDIX C. - ASSUMPTIONS AND COST DATA FOR THE REED RIVER OPEN PIT MINE

50,000 tpd ore and waste, open pit

10,000 tpd ore

Mine, concentrator, support facilities

10 year life

330 days per year operating

3 products: Cu-Ag, Pb-Ag, Zn-Ag concentrates

Ore grades: 4% Cu, 1% Pb, 5.5% Zn, 1.5 oz Ag, minor gold

Reserves: 33,000,000 tons

Recovery: 77% of metal content

Railroad haulage to Whittier on existing railroad to mine site

Barge to Tacoma or Seattle

Train to Idaho

TABLE C-1. - Total capital requirements

	Cost, dollars
Mine plant and buildings	11,815,000
Mine equipment	17,183,000
Property acquisition	500,000
Exploration, development, feasibility and environmental studies	5,000,000
Mine development	30,500,000
Concentrator	122,519,000
Support facilities	45,895,000
Total plant cost (insurance, tax base)	233,412,000
Interest during construction	19,884,000
Subtotal for depreciation	253,296,000
Working capital	16,689,000
Total investment	269,985,000

TABLE C-2. - Working capital

		Cost, dollars
Direct labor	3 months	2,285,000
Payroll overhead	"	800,000
Operating supplies	"	7,245,000
Indirect cost	4 months	948,000
Fixed cost	.5% of insurance base	1,167,000
Spare parts inventory		3,000,000
Miscellaneous expense		1,244,000
Total		16,689,000

TABLE C-3. - Mine equipment - 50,000 tpd open pit

Number	Item	Description	Hp	Cost dollars
4	Shovel	10 yd, electric, erected	2,400	4,932,000
15	Truck	100-ton, rear, dump	15,000	6,600,000
3	Drill	9-in rotary, electric	1,800	1,371,000
1	Drill	5-in track mounted	-	52,000
1	Compressor	600 cfm	190	37,000
2	Tractor dozer	Rubber tired, articulated	600	270,000
2	Wheel loader	5-yd bucket, articulated	520	221,000
2	Crawler tractor	U-blade, single ripper	600	324,000
2	Crawler tractor	U-blade, single ripper	800	417,000
3	Motor grader	14-ft mold board, scarifier	540	291,000
1	Backhoe	1/2-yd bucket	100	20,000
2	Truck	2000-gal water tanks	320	37,000
1	Crane	35-ton, crawler mounted	135	114,000
8	Vehicles	2-ton maintenance	1,200	120,000
17	Truck	3/4-ton pickup	3,162	136,000
	Subtotal			14,942,000
	Contingency - 15%			2,241,000
	Subtotal			17,183,000
	Interest during construction			1,289,000
	Total			18,472,000

TABLE C-4. - Mine plant and buildings

	Cost, dollars
Electrical system	784,000
Communications sytem	60,000
Drainage and disposal system	600,000
Repair shops and warehouses	6,703,000
Office, change building and laboratories	344,000
Fuel tank, gasoline 35,000 gal horizontal steel tank	144,000
Fuel tank, diesel 45,000 bbl cone roof steel tank	1,491,000
Oil and lube tanks - 12,000 and 15,000 gal horizontal steel tanks	148,000
Subtotal	10,274,000
Contingency - 15%	1,541,000
Subtotal	11,815,000
Interest during construction	886,000
Total	12,701,000

TABLE C-5. - Mine development cost

	Cost, dollars
Preproduction stripping 25,000,000 tons @ $1.22 per ton	30,500,000
Interest during development	2,288,000
	32,788,000

TABLE C-6. - Cost of a 10,000 tpd copper-lead-zinc-silver concentrator

	Cost, dollars
Estimated concentrator cost[1/]	36,750,000
Alaska location factor = 2.75 plus 5.4% for extra equipment and buildings needed for arctic environment	106,538,000
Contingency - 15%	15,981,000
Subtotal	122,519,000
Interest during construction	11,126,000
Total	133,645,000

[1/] 5,000 tpd concentrator discussed in Table B-6 was doubled in size, while costs were raised using the 0.7 factor

TABLE C-7. - Support facilities cost

	Cost, dollars
Townsite - 417 employees	31,274,000
Generating plant - 15 megawatts	6,452,000
Fuel tank - 17,000 bbls	932,000
Airport - 4500 x 200 ft	1,221,000
Vehicles - 6 pickups and sedans	30,000
Subtotal	39,909,000
Contingency - 15%	5,986,000
Subtotal	45,895,000
Interest during construction	4,295,000
Total	50,190,000

TABLE C-8. - Depreciation, dollars

Item	Years Straight-Line Depreciation	Mine	Concentrator	Support Facilities	Total
Buildings and facilities	10	1,027,000	9,924,000	3.343.000	14,294,000
Long life equipment	10	1,492,000	730,000	645,000	2,867,000
Short life equipment	5	47,000	-	6,000	53,000
Other 1/	10	4,424,000 2/	2,711,000	1,028,000	8,163,000
		6,990,000	13,365,000	5.022,000	25,377,000

1/ Includes contingency and interest during development

2/ Also includes property acquisition, exploration, development, feasibility studies, environmental studies, and preproduction stripping

TABLE C-9. - Power requirements and costs

Mine:	
4,200 hp = 3133 kw x 24 hr/day = 75,192 kw-hr/day x 330 day/yr = kw-hr/yr	24,813,000
Mill:	
24 kw-hr/ton x 10,000 tpd = 240,000 kw-hr/day x 330 day/yr = kw-hr/yr	79,200,000
Support facilities:	
1,500 people x 7.5 kw-hr/person/day = 11,250 kw-hr/day x 365 day/yr =	4,106,000
	108,119,000

108,119,000 kw-hr/yr ÷ 7,920 hr/yr = 13,651 kw say 15 mw

fuel = 108,119,000 kw-hr/yr ÷ 13 kw-hr/gal = 8,317,000 gal

Operating cost: [1]

8,317,000 gal/yr x 75¢/gal =	$6,238,000
maintenance -$15/kw x 15,000 kw =	225,000
	$6,463,000

$6,463,000/yr ÷ 108,119,000 kw-hr/yr = $0.06/kw-hr

[1] Depreciation and manpower expenses included with support facilities.

TABLE C-10. - Esimated annual operating cost, dollars

Item	Mine	Concentrator	Support Facilities	Total
Direct cost:				
Operating labor $12/hr x 2000 hr	3,000,000	1,440,000	528,000	4,968,000
Supervising labor $14/hr x 2000 hr	532,000	672,000	168,000	1,372,000
Maintenance labor $14/hr x 2000 hr	1,344,000	1,008,000	448,000	2,800,000
Operating & maintenance supplies	12,074,000	6,540,000	654,000	19,268,000
Power	1,489,000	4,752,000	246,000	6,487,000
Water	7,000	126,000	7,000	140,000
Payroll overhead @ 35% of payroll	1,707,000	1,092,000	400,000	3,199,000
Total direct cost	20,153,000	15,630,000	2,451,000	38,234,000
Indirect cost:				
Administrative, technical & clerical	433,000	547,000	410,000	1,390,000
Payroll overhead @ 35% of payroll	152,000	191,000	144,000	487,000
General overhead @ 5% of direct cost	1,008,000	782,000	123,000	1,913.000
Total indirect cost	1,593,000	1,520,000	677,000	3,790,000
Fixed cost:				
Taxes and insurance - 2% of plant cost	1,300,000	2,450,000	918,000	4,668,000
Depreciation	6,990,000	13,365,000	5,022,000	25,377,000
Property taxes - 2% of plant cost	1,300,000	2,450,000	918,000	4,668,000
Total direct cost	9,590,000	18,265,000	6,858,000	34,713,000
Total operating cost	31,336,000	35,415,000	9,986,000	76,737,000

TABLE C-11. - Smelter charges

0.04 Cu ÷ 0.346 = 0.1156 $CuFeS_2$ x 10,000 tpd = 1,156 tpd $CuFeS_2$
1156 tpd $CuFeS_2$ ÷ .77 recovery x 330 dpy = 495,400 tpy

0.055 Zn ÷ 0.671 = 0.0820 ZnS x 10,000 tpd = 820 tpd ZnS
820 tpd ZnS ÷ 0.77 recovery x 330 dpy = 351,400 tpy

0.01 Pb ÷ 0.866 = 0.0115 PbS x 10,000 tpd + 115 tpd PbS
115 tpd PbS ÷ 0.77 recovery x 330 dpy = 49,300 tpy

1.5 oz Ag x 10,000 tpd = 15,000 oz/day ÷ 24,000 oz/ton = 0.625 tpd
0.625 tpd ÷ 0.77 recovery x 330 dpy = 268 tpy

Credits:

495,400 tpy copper-silver concentrate x $326.52/ton =	$161,758,000
351,400 tpy zinc-silver concentrate x $299.79/ton =	105,346,000
49,300 tpy lead-silver concentrate x $296.39/ton =	14,612,000
	$281,716,000

Deductions:

495,400 tpy copper-silver concentrates x $51.15/ton =	$25,340,000
351,400 tpy zinc-silver concentrates x $75.38/ton =	26,489,000
49,300 tpy lead-silver concentrates x $51.15/ton =	2,522,000
	$54,351,000

TABLE C-12. - Transportation charges

Railroad distance:

Reed River mine to Alatna	100 miles
Alatna to Nenana	251 "
Nenana to Whittier	337 "
	688 miles

Copper concentrates:

Train - Reed River mine to Whittier; 688 miles @ 4¢/ton =	$27.52
Barge - Whittier to Tacoma; 1300 miles @ 3¢/ton	39.00
Handling and insurance	5.00
	$71.52

495,400 tpy x $71.52/ton = $35,431,000

Lead-zinc concentrates:

Train - Reed River mine to Whittier; 688 miles @ 4¢/ton =	$27.52
Barge - Whittier to Seattle; 1300 miles @ 3¢/ton =	39.00
Train - Seattle to Idaho: 350 miles @ 2.5¢/ton	8.75
Handling and insurance	5.00
	$80.27

400,700 tpy x $80.27/ton = $32,164,000

TABLE C-13. - Financial analysis, dollars

Present worth of capital investment at 15% =		303,006,000
Cash flow = 303,006,000 ÷ 5.0188 =	60,374,000	
Less depreciation	25,377,000	
	34,997,000	

MINE CASH FLOW ANALYSIS

Revenues	251,246,000
Operating Costs	76,737,000
Transportation Costs Copper	35,431,000
Transportation Costs Lead/Zinc	32,164,000
Smelting and Refining Costs-Copper	25,340,000
Smelting and Refining Costs-Lead/Zinc	29,011,000
State Mining License Tax	1,929,000
Gross Profit	50,634,000
Depletion	23,027,000
Taxable Income	27,607,000
Federal Income Tax	13,251,000
State Income Tax	2,385,000
Net Profit	11,971,000
Calculated Positive Cash Flow	60,375,000
Net Profit	11,971,000
Depletion	23,027,000
Depreciation	25,377,000

TABLE C-14. - Summary of expenditures and discounted cash flows, 1000's dollars

Year	Capital Expenditures	Cash Flows	Present Worth Factor @-15%	Present Worth Capital Investment @ 15%	Present Worth Cash Flow @ 15%	Mine Plant and Buildings	Mine Equipment	Property Acquisition	Exploration 1/	Mine Development	Concentrator	Support Facilities	Interest
-7	500	-500	2.6600	1,330	-1,330			250	250				
-6	750	-750	2.3131	1,735	-1,735			250	500				
-5	1,500	-1,500	2.0114	3,017	-3,017				1,500				
-4	2,000	-2,000	1.7490	3,498	-3,498				2,000				
-3	750	-750	1.5209	1,141	-1,141				750				
-2	31,500	-31,500	1.3225	41,659	-41,659						20,000	10,000	1,500
-1	116,736	-116,736	1.1500	134,246	-134,246	5,907	8,592			15,250	60,000	20,000	6,987
0	116,248 2/	-116,248	1.0000	116,248	-116,248	5,908	8,591			15,250	42,519	15,895	11,396
1		60,374	.8696		52,501								
2		60,374	.7561		45,649								
3		60,374	.6575		39,696								
4		60,374	.5718		34,522								
5	265	60,109	.4972	132	29,886								
6		60,374	.4323		26,100								
7		60,374	.3759		22,695								
8		60,374	.3269		19,736								
9		60,374	.2843		17,164								
10		60,374	.2472		14,924								
				303,006	1								

1/ Also includes development, feasibility and environmental study costs.

2/ Includes working capital.

APPENDIX D. - ASSUMPTIONS AND COST DATA FOR THE OMAR MINE

2,000 tpd room and pillar mine

Mine, concentrator and townsite included

15 year life

330 days of operation per year

One product: copper concentrate

Ore grade: 5.3% Cu

Reserves: 10,000,000 tons

Recovery: 77% of metal content

Railroad haulage of concentrates to Whittier on an assumed railroad

Barge to Tacoma

TABLE D-1. - Total capital requirements

	Cost, dollars
Mine plant and buildings	5,070,000
Mine equipment	1,901,000
Property acquisition	400,000
Exploration, development, feasibility, and environmental studies	2,700,000
Mine development	10,482,000
Concentrator	36,720,000
Support facilities	28,097,000
Total plant cost (insurance, tax base)	85,370,000
Interest during construction	6,334,000
Subtotal for depreciation	91,704,000
Working capital	5,777,000
Total investment	97,481,000

TABLE D-2. - Working capital

		Cost, dollars
Direct labor	3 months	1,104,000
Payroll overhead	3 "	386,000
Operating supplies	3 "	1,980,000
Indirect cost	4 months	446,000
Fixed cost	.5% of insurance base	427,000
Spare parts and inventory		1,000,000
Miscellaneous expense		434,000
Total		5,777,000

TABLE D-3. - Surface plant and equipment cost summary

Item	Quantity	Size	Unit hp	Unit hp	Total Cost
Ore hoisting shaft					
Excavation and foundation	-	For headframe and hoise installation	-	-	$ 366,000
Headframe	1	100-ft-high steel	-	-	546,000
Ore bin	1	2,000-ton concrete	-	-	110,000
Hoist building	1	40 ft by 150 ft with 32-ft eave @ $70	-	-	420,000
Ore hoist	1	8-ft-diam single drum with motor-generator set and flywheel	400	400	1,046,000
Ore skips and cable		3-ton skips, 2-1/4-in cable	-	-	39,000
Auxiliary hoist, cage, and cable	1	6-ft by 6-ft by 10-ft counter weighted cage, 1-1/4-in cable	180	180	226,000
Ventilation fan	2	5-ft axialvane (1 spare) including housing	200	200	60,000
Transformer station	1	7,000 kV-A, 69,000-volt to 2,200-volt, semipermanent building	-	-	60,000
Switch	1	Main disconnect 2,200 volts	-	-	6,000
Distribution wire	1,000 ft	Overhead line size 1-0 wire	-	-	1,000
.....do.....	6,000 ft	Overhead line size 4 wire	-	-	3,000
Poles	10	For distribution system	-	-	3,000
Accessories for distribution, wire line	-	Cross arms, insulators, etc., at $3,700 per mile	-	-	2,000
Compressor	1	4,500 cfm with motor	700	700	77,000
Compressor building	1	48 ft by 48 ft with 30-ft eave including 25-ton bridge crane at $18 per sq ft		-	155,000
Receiver	1	10 ft diam by 20 ft	-	-	5,000
Air line	1,000 ft	10-in pipe, victaulic couplings	-	-	14,000
Mine office, lamp room and change room	1	60 ft by 30 ft with 20-ft eave including utilities at $65 per sq ft	-	-	117,000
Office furniture and equipment	1	30 ft by 30 ft at $20 per sq ft		-	18,000
Machine shop and equipment repair shop	1	60 ft by 100 ft with 20-ft eave including utilities at $60 per sq ft	-	-	360,000

TABLE D-3. - Surface plant and equipment cost summary, continued

Item	Quantity	Size	Unit hp	Unit hp	Total Cost
Shop equipment and tools	-	Includes hoists, welders, and general shop tools	-	-	$ 160,000
Warehouse	1	50 ft by 80 ft with 10-ft eave including utilities at $30 per sq ft	-	-	200,000
Explosives magazine	1	15 ft by 20 ft with 10-ft eave, buried and fenced at $40 per sq ft	-	-	12,000
Administration building	1	40 ft by 40 ft with 10-ft eave including utilities at $70 per sq ft, 1/2 charged to mine	-	-	56,000
Service vehicle	6	Crane, forklift, trucks, dozer, grader, and front-end loader	-	-	383,000
Utility vehicle	5	3 1/2-ton pickups, 1 sedan, 1 station wagon	80	400	22,000
Subtotal					$ 4,400,000
Contingency					660,000
Subtotal					$ 5,070,000
Interest during construction					380,000
Total					$ 5,450,000

TABLE D-4. - Underground plant and equipment cost summary

Item	Quantity	Size	Unit hp	Total hp	Total Cost
Pump (drainage)	2	Vertical 8-stage 13-1/4-in bowl,(3 spares)	600	1,200	$ 86,000
Drainage lines	2,000 ft	10-in pipe with victaulic couplings		-	140,000
Compressed air line	2,000 ft	.....do.....	-	-	147,000
.....do.....	1,000 ft	8-in pipe with victaulic couplings		-	63,000
.....do.....	3,500 ft	6-in pipe with victaulic couplings		-	131,000
Drill and culinary waterline	5,000 ft	4-in pipe with victaulic couplings	-	-	98,000
Blowers	4	Portable in workings (2 spares)	15	70	7,000
Electric distribution system	-	Cables, transformers, etc.	-	-	117,000
Telephone	-	Throughout mine and surface	10	10	47,000
Jumbo (development)	2	2 drills, 3-1/2-in pistons	-	-	64,000
Loading machine	2	Overshot type, air power	-	-	50,000
Stoper	2	31-in feed, 79 lb	-	-	6,000
Hoist	2	1,200-lb rope pull	-	-	8,000
Jumbo (stoping)	4	2 drills, 3-1/2-in pistons, rubber tired	-	-	165,000
Load-haul-dump vehicle	4	5-cu-yd diesel, powered (2 spares)	195	780	467,000
Shop tools	-	Hoists, welders, general shop tools	-	-	57,000
Total direct cost					$1,653,000
Contingency - 15%					248,000
Subtotal					$1,901,000
Interest during construction					119,000
Total					$2,020,000

TABLE D-5. - Mine development cost

	Cost, dollars
Shaft - 15 ft diam., 1100 ft	$ 3,206,000
Ventilation shaft, 2 - 6 ft diam, 1100 ft	2,959,000
Haulage drifts, 14 x 10 x 2500 ft	1,788,000
Ore shoots and bins	2,529,000
Subtotal	$10,482,000
Interest during development	974,000
Total	$11,456,000

TABLE D-6. - Cost of a 2,000 tpd copper concentrator

	Cost, dollars
Estimated concentrator cost 1/	$12,717,000
Alaska location factor = 2.75 plus 5.4 percent for extra buildings and equipment needed in Arctic environment	36,720,000
Interest during construction	2,754,000
Total	$39,474,000

1/ 5,000 tpd concentrator from IC 8598 updated to July 9, 1976 and given a double-sized flotation and filtration sections. Concentrator reduced from 5,000 tpd to 2,000 tpd using a .6 factor.

TABLE D-7. - Support facilities cost

	Cost, dollars
Townsite: 193 employees	$19,615,000
Generating plant, 7,000 kW	3,011,000
Fuel tank - 8,500 bbl	575,000
Vehicles - 2 pickups	10,000
Airport - 4,500 x 200 ft	1,221,000
Subtotal	$24,432,000
Contingency - 15%	3,665,000
Subtotal	$28,097,000
Interest during construction	2,107,000
Total	$30,204,000

TABLE D-8. - Depreciation, dollars

Item	Years Straight-line Depreciation	Mine	Concentrator	Support Facilities	Total
Buildings and facilities	15	312,000	2,203,000	1,347,000	3,862,000
Long life equipment	10	99,000	367,000	301,000	767,000
Short life equipment	5	81,000	-	2,000	83,000
Other[1/]	15	1,064,000 [2/]	184,000	385,000	1,838,000
Total		1,556,000	2,754,000	2,035,000	6,345,000

1/ Includes contingencies and interest during development.

2/ Also includes property acquisition, exploration, development, feasibility and environmental studies.

TABLE D-9. - Power requirements and costs

Mine:

2920 hp = 2178 kW x 24 hr pd = 52,272 kW-hr/day x 330 dpy = kW-hr/yr	17,250,000

Concentrator:

6689 hp for 5000 tpd concentrator reduced by .6 factor to 2000 tpd - 6689 ÷ 1.7329 = 3860 kW x 24 hr/day = 92,640 kW-hr/day x 330 dpy = KW-hr/yr	30,571,000

Support facilities:

696 people x 7.5 kW-hr/day = 5,220 kW-hr/day x 365 dpy = kW-hr/yr	1,905,000
Total	49,726,000

49,726,000 kW-hr/yr ÷ 7920 hr/yr = 6,279 kW - say 7 MW

49,726,000 kW-hr/yr ÷ 13 kW-hr/gal = 3,825,000 gal/yr

Operation costs[1/]:

3,825,000 gal/yr x 75¢/gal =	$2,869,000
Maintenance = $15/kW x 7,000 =	105,000
Total	$2,974,000 ÷
49,726,000 =	$0.06/kW/hr

1/ Depreciation and manpower expenses included with support facilities

TABLE D-10. - Estimated annual operating cost, dollars

Item	Mine	Concentrator	Support Facilities	Total
Direct cost:				
Operating labor, $12/hr x 2000 hr	1,512,000	600,000	288,000	2,400,000
Supervisory staff, $14/hr x 2000 hr	280,000	140,000	112,000	532,000
Maintenance labor, $14/hr x 2000 hr	756,000	448,000	280,000	1,484,000
Operating & maintenance supplies	2,437,000	2,265,000	225,000	4,927,000
Power	1,035,000	1,834,000	114,000	2,983,000
Water	3,000	6,000	3,000	12,000
Payroll overhead @ 35% of payroll	892,000	416,000	238,000	1,546,000
Total direct cost	6,915,000	5,709,000	1,260,000	13,884,000
Indirect cost:				
Administrative, clerical and technical	159,000	159,000	159,000	477,000
Payroll overhead @ 35% of payroll	56,000	56,000	56,000	168,000
General overhead - 5% of direct cost	346,000	285,000	63,000	694,000
Total indirect cost	561,000	500,000	278,000	1,339,000
Fixed cost:				
Taxes and insurance - 2% of plant cost	411,000	734,000	562,000	1,707,000
Depreciation	1,556,000	2,754,000	2,035,000	6,345,000
Property taxes - 2% of plant cost	411,000	734,000	562,000	1,707,000
Total fixed cost	2,378,000	4,222,000	3,159,000	9,759,000
Total operating cost	9,854,000	10,431,000	4,697,000	24,982,000

TABLE D-11. - Smelter charges

0.053 Cu ÷ 0.346 = 0.1532 $CuFeS_2$ x 2,000 tpd = 306 tpd $CuFeS_2$

306 tpd $CuFeS_2$ ÷ 0.77 recovery x 330 dpy = 131,100 tpy

Credits:

131,100 tpy $CuFeS_2$ con x $308.21/ton = $40,406,000

Deductions:

131,100 tpy $CuFeS_2$ con x $51.15/ton = $6,706,000

TABLE D-12. - Transportation charges

Railroad distance:

Omar mine to Kobuk	110 miles
Kobuk to Alatna	137 "
Alatna to Nenana	251 "
Nenana to Whittier	337 "
Total	835 miles

Train, mine to Whittier - 835 miles x 4¢/t-m =	$33.40	per ton
Barge, Whittier to Tacoma - 1300 miles x 3¢/t-m	39.00	" "
Handling and insurance	5.00	" "
Total	$77.40	" "

131,100 tons concentrate x $77.40 per ton = $10,147,000

TABLE D-13 - Financial analysis

Present worth of capital investment at 15% =	$109,028,000
Cash flow = $109,028,000 ÷ 5.8474 =	$18,646,000
Less depreciation	6,345,000
Net profit plus depletion	$12,301,000

Mine Cash Flow Analysis

Revenues	$62,204,000
Operating Costs	24,982,000
Transportation costs copper	10,147,000
Smelting and refining costs-copper	6,706,000
State Mining License Tax	885,000
Gross Profit	19,484,000
Depletion	6,803,000
Taxable Income	12,681,000
Federal Income Tax	6,087,000
State Income Tax	1,096,000
Net Profit	5,498,000
Calculated positive cash flow	18,646,000
Net profit	5,498,000
Depletion	6,803,000
Depreciation	6,345,000

TABLE D-14. - Summary of expenditures and discounted cash flow, 1000's of dollars

Year	Capital Expenditures	Cash Flows	Present Worth Factor @ 15%	Present Worth Capital Investment @ 15%	Present Worth Cash Flow @ 15%	Mine Plant and Buildings	Mine Equipment	Property Acquisition	Exploration[1/]	Mine Development	Concentrator	Support Facilities	Interest
-6	350	-350	2.3131	810	-810			200	150				
-5	600	-600	2.0114	1,207	-1,207			200	400				
-4	1,000	-1,000	1.7490	1,749	-1,749				1,000				
-3	1,000	-1,000	1.5209	1,521	-1,521				1,000				
-2	2,250	-2,250	1.3225	2,976	-2,976				150	2,000			100
-1	42,539	-42,539	1.1500	48,920	-48,920	2,535	475			5,000	18,360	14,048	2,121
0	49,743	-49,743	1.0000	49,743	-49,743	2,535	1,426			3,482	18,360	14,049	4,114
1		18,646	.8696		16,215								
2		18,646	.7561		14,098								
3		18,646	.6575		12,260								
4		18,646	.5718		10,662								
5	415	18,231	.4972	206	9,064								
6		18,646	.4323		8,061								
7		18,646	.3759		7,009								
8		18,646	.3269		6,095								
9		18,646	.2843		5,301								
10	7,670	10,976	.2472	1,896	2,713								
11		18,646	.2149		4,007								
12		18 646	.1869		3,485								
13		18,646	.1625		3,030								
14		18,646	.1413		2,635								
15		18,646	.1229		2,292								
				109,028	1								

1/ Also includes development, feasibility and environmental study costs.

APPENDIX E. - ASSUMPTIONS AND COST DATA FOR THE DEETOO GOLD MINE

100 tpd shrinkage stope

100 dpy operating time

500 foot shaft, 100 foot levels

Reserves: 50,000 tons of 1.85 oz gold with dilution

Recovery: 75% as free gold

Geology: gold in steeply dipping quartz veins in faulted schist

Located in the Chandalar area

Access is by frozen trail in the winter or by air year-round

TABLE E-1. - Total capital requirements

	Cost, dollars
Surface plant and buildings	$ 630,000
Underground plant and equipment	194,000
Property acquisition	50,000
Exploration, development and feasibility studies	300,000
Mine development	680,000
Concentrator	1,246,000
Support facilities	891,000
Total plant cost (insurance, tax base)	3,991,000
Interest during construction	251,000
Subtotal for depreciation	4,242,000
Working capital	1,067,000
Total investment	5,309,000

TABLE E-2. - Working capital

		Cost, dollars
Direct labor	100 days	287,000
Payroll overhead	100 "	101,000
Operating supplies	100 "	187,000
Indirect cost	4 months	125,000
Fixed cost	.5% of insurance base	20,000
Spare parts and inventory		250,000
Miscellaneous expense		97,000
Total		1,067,000

TABLE E-3. - Summary of surface plant and equipment costs

Item	Quantity	Size	Unit hp	Total hp	Total Cost
Headframe	1	56-foot	-	-	$ 18,000
Ore bin	1	200-ton, elevated	-	-	8,000
Hoist building	1	30 ft x 50 ft @ $70/sf	-	-	105,000
Ore hoist	1	48-in diam, single drum	75	75	36,000
Wire rope	1	600 ft of 3/4-in	-	-	700
Mine cage	1	3-ton capacity	-	-	2,500
Sheave	1	48-in	-	-	1,800
Compressor	1	1200 cfm, portable	380	380	61,000
Ventilation fan	1	4000 cfm	15	15	20,000
Surface piping	200 ft	4-in pipe	-	-	1,000
Surface wiring	2,000 ft	Wire, switches	-	-	2,000
Mine office lamp and change room	1	20 ft x 30 ft @ $60/sf	-	-	36,000
Machine shop and repair shop	1	40 ft x 50 ft @ $60/sf	-	-	120,000
Shop equipment and tools	1	Includes hoists, welders, etc.	-	-	50,000
Warehouse	1	40 ft x 50 ft @ $40/sf	-	-	80,000
Explosives, magazine	1	10 ft x 15 ft @ $40/sf	-	-	6,000
Subtotal				470	$ 548,000
Contingency					82,000
Subtotal					$ 630,000
Interest during construction					47,000
Total					$ 677,000

TABLE E-4. - Summary of underground plant and equipment costs

Item	Quantity	Size	Unit hp	Total hp	Total cost
Locomotive	1	3 ton, w/battery and charger	-	-	$ 36,000
Mine cars	20	50 cf rocker-type	-	-	40,000
Mucking machine	1	8 cf bucket, 325 cfm air	-	-	9,000
Slusher	3	Double drum	10	30	25,000
Drifter drill	5	3-in bore, 150 cfm air	-	-	11,700
Drill steel, bits	-	600 ft 1-in steel, 50 1-1/2-in bits	-	-	5,500
Hose	1,600 ft	1-in rubber hose	-	-	4,700
Piping	1,000 ft	3-in steel pipe	-	-	5,600
Pump	2	3-1/2-in sump pump	10	20	16,700
Track, ties	1,000 ft	30-pound rail, ties, spikes, etc.	-	-	6,800
Blower	2	Portable	10	20	3,000
Hand tools	-	Lamps, hats, picks, shovels	-	-	5,000
Subtotal				70	$169,000
Contingency					25,000
Subtotal					$194,000
Interest during construction					15,000
Total					$209,000

TABLE E-5. - Mine development cost

	Cost, dollars
Shaft, 10 x 12-ft, 2 compartment, 520 ft	$ 417,000
Drifts and crosscuts, 6 x 7-ft, 1500 ft	184,00
Raises, 5 x 6 ft, 1000 ft	79,000
Subtotal	$ 680,000
Interest during development	51,000
Total	$ 731,000

TABLE E-6. - Cost of a 100 tpd gold mill

Item	Description	Hp	Cost, dollars
Coarse ore bin	500 ton, ground level	-	11,600
Ore bin gate	20 x 24-in	-	600
Grizzly	2 x 4-ft, 3-in opening	-	900
Crusher	10 x 20-in jaw	-	12,300
Motor	Electric	25	1,500
Conveyor	14-in x 50-ft belt	1-1/2	3,800
Fine ore bin	100 ton, elevated	-	12,200
Feeder	14-in x 10-ft	1	2,800
Ball mill	5 x 6 ft	-	56,400
Motor	Electric	60	2,900
Ball mill charge	15,000 pounds	-	3,100
Jig	12 x 18-in duplex	1	4,400
Classifier	24-in x 16-ft	3	12,800
Amalgamator	32 x 48-in	5	5,900
Concentrating table	6 x 15-ft	2	5,400
Samplers (2)	21-in	1	3,200
Conveyor	14-in x 50-ft belt	1-1/2	3,800
Concentrate bin	2-ton, ground level	-	400
Subtotal		100	144,000
Installation			376,000
Process piping			52,000
Instrumentation			26,000
Building and site development			260,000
Auxiliaries			65,000
Subtotal			923,000
Engineering and construction			185,000
Contingency			138,000
Subtotal			1,246,000
Interest during construction			93,000
Total			1,339,000

TABLE E-7. - Support facilities cost

Item	Cost, dollars
Townsite, 30 employees, trailers	350,000
Generating plant, 300 kW	55,000
Fuel tank, 50,000 gallons	150,000
Landing strip, 4500 x 200 ft gravel	100,000
Vehicles, 1 pickup, 1 flatbed truck, 20-ton crane	100,000
Subtotal	775,000
Contingency	116,000
Subtotal	891,000
Interest during construction	45,000
Total	936,000

TABLE E-8. - Depreciation, dollars

5-year life of mine

Mine 1/	=	$393,000
Concentrator	=	268,000
Support facilities	=	187,000
Total	=	$848,000

1/ Also includes property acquisition, exploration, development, and feasibility studies.

TABLE E-9. - Power requirements and costs

Mine:

160 hp = 119 kW x 16 hr/day = 1904 kW hr/day x 100 dpy = kW-hr/yr	190,400

Concentrator:

100 hp = 75 kW x 24 hr/day = 1800 kW-hr/day x 100 dpy = kW-hr/yr	180,000

Support facilities:

30 people x 7.5 kW-hr/day = 225 kW-hr/day x 100 dpy = kW-hr/yr	22,500
Total	392,900

392,900 kW-hr/yr ÷ 2400 hr/yr = 164 kW (say 300 kW)

392,900 kW-hr/yr ÷ 13 kW-hr/gal = 30,000 gal/yr

Operating cost*:

30,000 gal/yr x $1.00/gal	=	$30,000	
Maintenance			
$15/kW x 300 kW	=	4,500	
Total		$34,500 ÷ 392,900 =	$0.09/kW-hr

TABLE E-10. - Estimated annual operating costs, dollars

Item	Mine	Concentrator	Support Facilities	Total
Direct cost:				
Operating labor	137,000	48,000	10,000	195,000
Supervisory labor	25,000	25,000	-	50,000
Maintenance labor	31,000	11,000	-	42,000
Operating & maintenance supplies	95,000	41,000	9,000	145,000
Power	17,000	16,000	2,000	35,000
Water	1,000	5,000	1,000	7,000
Payroll overhead @ 35% of payroll	68,000	29,000	4,000	101,000
Total direct cost	374,000	175,000	26,000	575,000
Indirect cost:				
Administrative, technical, clerical	27,000	27,000	6,000	60,000
Payroll overhead @ 35% of payroll	9,000	9,000	2,000	20,000
General overhead @ 5% of direct costs	19,000	4,000	1,000	24,000
Total indirect cost	55,000	40,000	9,000	104,000
Fixed cost:				
Taxes and insurance, 2% of plant cost	37,000	25,000	18,000	80,000
Depreciation	393,000	268,000	187,000	848,000
Property taxes, 2% of plant cost	37,000	25,000	18,000	80,000
Total fixed cost	467,000	318,000	223,000	1,008,000
Total operating cost	896,000	533,000	258,000	1,687,000

TABLE E-11. - Refining charges

Credits:

1.85 oz per ton x 75% recovery x $123.55/oz = $171.42/ton

$171.42/ton x 10,000 tpy = 1,714,000

Deductions:

13,875 oz free gold x $10 per oz = $138,750

TABLE E-12. - Transportation charges

Delivery to refinery by company personnel after the close of the season. Arbitrarily assumed to be $2,000

TABLE E-13. - Financial analysis

Present worth of capital investment at 20% = $6,347,000

Cash flow = $6,347,000 ÷ 2.9906 = $2,122,000

Mine Cash Flow Analyses

	Case #1 1/	Case #2 2/	Case #3 3/
Revenues	$4,098,000	$2,463,000	$2,119,000
Operating costs	1,687,000	1,263,000	844,000
Transportation costs	2,000	2,000	2,000
Refining costs	139,000	139,000	139,000
State Mining License Tax	107,000	44,000	52,000
Gross Profit	2,163,000	1,015,000	1,082,000
Depletion	594,000	348,000	297,000
Taxable income	1,569,000	667,000	785,000
Federal income tax	753,000	320,000	377,000
State income tax	136,000	58,000	68,000
Net profit	680,000	289,000	340,000
Calculated positive cash flow	2,122,000	1,061,000	1,061,000
Net profit	680,000	289,000	340,000
Depletion	594,000	348,000	297,000
Depreciation	848,000	424,000	424,000
Required gold price	$295	$177	$152

1/ 100% of estimated capital costs, 100% of estimated operating costs

2/ 50% of estimated capital costs, 100% of estimated operating costs

3/ 50% of estimated capital costs, 50% of estimated operating costs

TABLE E-14. - Summary of expenditures and discounted cash flows, dollars

Year	Capital Expenditures	Cash Flows	Present Worth Factor @ 20%	Present Worth Capital Investment @ 20%	Present Worth Cash Flow @ 20%	Mine Plant and Buildings	Mine Equipment	Property Acquisition	Exploration[1]	Mine Development	Concentrator	Support Facilities	Interest
-4	150,000	-150,000	2.4883	373,000	-373,000			50,000	100,000				
-3	100,000	-100,000	2.0736	207,000	-207,000				100,000				
-2	100,000	-100,000	1.7280	173,000	-173,000				100,000				
-1	1,444,000	-1,444,000	1.4400	2,079,000	-2,079,000	315,000	97,000			340,000	623,000		69,000
0	3,515,000[2]	-3,515,000	1.0000	3,515,000	-3,515,000	315,000	97,000			340,000	623,000	891,000	182,000
1		2,122,000	.8333		1,768,000								
2		2,122,000	.6944		1,474,000								
3		2,122,000	.5787		1,228,000								
4		2,122,000	.4822		1,023,000								
5		2,122,000	.4019		853,000								
				6,347,000	1,000								

1/ Also includes development, feasibility and environmental study costs.

2/ Includes working capital.