TANANA BASIN AREA PLAN

PHASE I
RESOURCE INVENTORY
August, 1983

MINERAL ELEMENT

STATE OF ALASKA
Department of Natural Resources
4420 Airport Way
Fairbanks, Alaska 99701

U.S. DEPARTMENT OF AGRICULTURE
Soil Conservation Service

EXECUTIVE SUMMARY

The Tanana Basin includes 21 million acres of land along the Tanana River stretching from the Canadian border on the east to the Yukon River on the northwest. As shown in Figure 1, it includes the most populated area of Alaska's Interior. The area which this plan addresses includes all state selected, tentatively approved and patented land within the Tanana Basin Boundary exclusive of those areas which have had area plans completed or which do not have state in-holdings.

The analysis presented here indicates that there are large areas of land in the Tanana Basin with high mineral potential. Many of these areas have been and continue to be very productive.

This report estimates the net benefits of minerals in the Basin to be on the order of 89.4 million per year currently. Current mineral activity also generates approximately $198 million annually in income effects and almost 1100 jobs in the Basin. Within the industry, gold generates both the largest producers benefit and the largest income effect, while exploration probably employs the most people.

The principal change expected in the industry within the next 20 years is the addition of major base metal mining to the gold, sand and gravel and coal activities which have been the basis of the industry for the past several decades. Base metals could become the most important commodity in terms of economic impact, considerably increasing producers benefits, income and employment. Gold, sand and gravel and coal also have considerable potential for expansion.

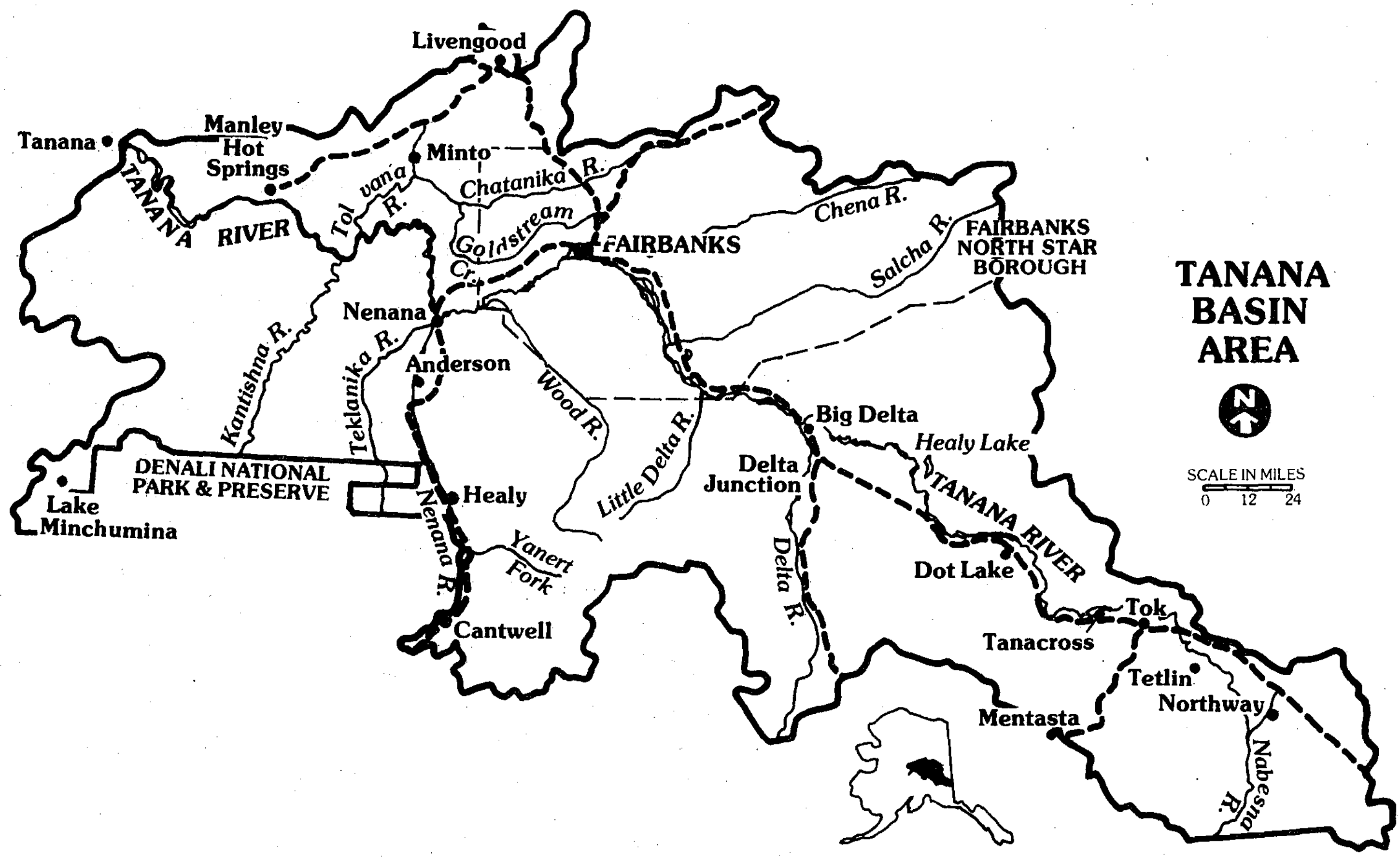


Figure 1. The Tanana Basin Planning Area.

Summary of Current Economic Effects of Mining in the Tanana Basin

Mining Activity by Commodity	Producers Benefits (Milllions $/year)	Income (Millions $/year)	Employment (Person-Years)
Precious Metals	4.4	64.0	140
Industrial and Structural Commodities	0.9	43.0	410
Coal	0.9	51.3	125
Exploration and Development Activities	--	39.4	390
Total	6.2	197.7	1,065.0

Summary of Potential Economic Effects of Mining in the Tanana Basin

Mining Activity by Commodity	Producers Benefits (Millions $/year)	Income (Millions $/year)	Employment (Person-Years)
Precious Metals			
Placer	6.4	94.	220
Hardrock	1 6	19.	30
Total	**8.0**	**113.**	**250**
Base Metals	12.0	700	900
Industrial and Structural Materials[b]	0.9	43	410
Coal			
Medium Scenario	2.9	142	155
Total	**24**[c]	**998**	**1465**

[a]Rounded to nearest 10 person-years.
[b]Current effects are shown as a minimum estimate.
[c]Rounded to nearest $1 million.
[d]Rounded to nearest 100 person-years.

CONTENTS

Chapter 1

Introduction

This report completes Phase I of the Alaska State Department of Natural Resources Tanana Basin Area Planning process. The report inventories information on minerals in the Basin and it will serve as the basis for the continuing phases of the planning process.

This information is part of a resource inventory of seven resources including fish and game, agriculture, forestry, minerals, outdoor recreation, settlement (land disposals) and water. The information included in this report was gathered by the Tanana Basin Area Planning staff of the DNR Division of Research and Development. People who participated in the production of this report include, Susan Todd (Project Manager, Tanana Basin Area Plan); Glenn Miller (Mining Engineer, Division of Minerals and Energy Management); and Jeffrey Pederson (Research Assistant).

The information presented here is not an exhaustive study of minerals in the Basin; such a study is beyond the scope of the Tanana Basin Area Plan. Due to the very nature of minerals, it is difficult to say with any confidence exactly where they are located or how much they are or will be worth. However, we have attempted to pull together much of the information available and present it in a way that will supplement existing information and be a useful tool for planners in developing resource policies.

Chapter 2

Issues and Local Preferences

CHAPTER 2.
ISSUES CONCERNING STATE LAND MANAGEMENT

I. Introduction

Issues and local preferences are important pieces of information which must be incorporated into the planning process. Issues concerning the use of a specific resource provide a focus and framework for the planning process; local preferences show how the public feels these issues should be resolved. In this section of this report, issues and local preferences are documented for incorporation in the planning process through the work of the Planning Team Members.

A. Issues

An issue is something which is debated. For example, the amount of land to be disposed of is an issue; some people favor more land and others would prefer less. Another issue is the effect of agriculture on fish and game; some feel that the effect is positive, others feel that it is negative or neutral. The purpose of this paper is simply to report the issues objectively without siding with any particular viewpoint. These issues are then to be addressed in the Tanana Basin Area plan which will create policies to deal with them. The issues reported here are those which the plan can affect through classifications or management guidelines.

The issues identified in this chapter were collected and summarized from three sources. The public meetings that were held in the Tanana Basin during the spring of 1982 was the first source of issues used for this chapter. Planning team members, after reading the comments from the public meetings developed a series of issues concerning the resource they represent. The Tanana Basin Plan sketch elements were a second source used to identify issues. The sketch elements were developed in 1981 to provide a starting point for the Tanana Basin Area plan. The issues identified in the sketch elements were based on conversations with agencies, resource experts and public interest groups. The third source was interviews with agency representatives.

B. Local Preferences

Local preferences about how these issues should be addressed were determined from two principal sources. One of the sources which will be used in the planning process for developing local preferences is a series of community originated land use plans. Several communities are currently working on proposed plans for state land in their area; others have already submitted proposals to DNR.

These local land use plans provide a clear indication of what a community prefers. This is particularly true when a proposal receives endorsement of village councils, city councils, native corporations, and other interest groups in the area.

The possibility of doing land use plans was mentioned at the public meetings and in a newsletter that was sent to all communities. Only a few of the communities, however, have decided to submit proposals. Most of these proposals will not be completed until February, but some have been on file with the State Department of Natural Resources and are included in this report.

The Tanana Basin Public Meetings are the other source of information on local preferences. Public meetings were held in all communities in the Basin in the spring of 1982 to discuss the Tanana Basin Area Plan. The notes from these meetings were then given to members of the planning team who then developed the summaries included here. The summaries represent the planning team members'understanding of how residents want state land in their area managed for a specific resource.

These sources of local preferences are not as accurate as a public survey, but in most cases, they represent the only information available. They should not be considered to be representative of the entire community; they are simply indications of the opinions of some of the residents.

A survey now being conducted by the Alaska Department of Community and Regional Affairs will provide a better indication of local preferences in the Tok area. The results of this survey will be available to the planning team by March of 1983.

ISSUES CONCERNING MINERALS

The following issues concerning minerals were drawn from the public meetings, sketch elements and interviews with agency representatives:

ISSUE 1. The amount of state land left open to mineral exploration and mining.

ISSUE 2. Disposal of surface rights over lands with known or potential minerals or energy resources.

ISSUE 3. The effect of recreation activity on mineral exploration and development.

ISSUE 4. The effect of habitat and forestry classifications on mineral exploration and development.

ISSUE 5. The effect of agricultural projects on mineral activity.

ISSUE 6. The effect of mineral-related activity on fish and game resources.

ISSUE 7. The effect of mineral-related activity on water quality and the environment.

ISSUE 8. The effect of mineral-related activity on recreation.

ISSUE 9. The effect of mineral-related activity on forestry.

ISSUE 10. The effect of mineral-related activity on agriculture.

ISSUE 11. The effect of mineral-related activity on land disposals.

MINERALS & ENERGY ISSUES BY COMMUNITY

ANDERSON:

- we would like to see disposals open to mining on a small scale if you own the land;
- no one can use the gravel except the state;
- let free enterprise build the roads.

CANTWELL:

- The state should look at very long term leases for minerals;
- Mining leases can be compatible with other uses. This helps diversify the economy;
- Fish and Game is too restrictive on the sediment in streams. Nature does more damage than most miners.

DOT LAKE:

- Study the impacts of disposals on local areas; the impact on the fish and game, minerals, communities and state residents;
- With mining, you should discourage something like strip mining which destroys habitat;

HEALY:

- The State shouldn't have mineral rights to the land. When the state sells land, it should include the minerals rights.

MANLEY HOT SPRINGS:

- Seems kind of outrageous when the state creates mining v. disposal conflicts. The state should look at what's going on in the area at present before they dispose;
- With oil and gas leases, the area will be criss-crossed with trails, providing open access to the area. It'll be a perfect place for people to get to moose; not for moose to get away. The area will look like California -- roads and trails all over the place;
- That oil and gas lease sale: given that geologists place such slim chances on finding things - it seems ridiculous to go ahead with the sale;
- There is a lot of small mining activity in the area. Although no one here tonight mines, there are a lot of people in the area concerned about it;

MENTASTA LAKES:

- There are some mines in the area like Slade Creek which don't really disturb the area;

MINTO:

- The beaver have all moved out. There are no fish because mining has bothered the rivers. No rat (Muskrat), no animals. We have seen animals stuck in the mud because of mining.
- We lost some land to mining activity. Sand has covered it.

MINTO continued:

- There's a place where there used to be a slough - but no slough anymore. Birch and Goldstream Creeks. Mining filled it up;
- We used to go all the time up to Dunbar but it's no creek anymore because of mining;
- All the lakes are getting filled up with sand. This hurts the animals. Caribou, moose get caught in the mud that is in all the creeks now; they can't get out;
- We don't want to loose the land, that's all;
- If the state gives mining claims the should control them and protect water;
- Put stronger control on mining;
- Hold off development just for a few years while we get our feet on the ground. All the people coming in, the roads, the change. The old people know it is coming. Just let it come slow. Give them a chance;
- Leave the Chatanika alone. It's a lifeline for us;

NENANA:

- Should be access to existing claims;
- Development of minerals could be good for the area;
- Oil development is compatible with agriculture;
- Access to mineral areas may cause problems;
- Farmers may not want compensation from mineral development activities on their land, but may want to keep their land instead;
- Oil and Gas can co-exist with settlement and agriculture;
- In the plan, consider and allow for change in what is considered a "significant mineral deposit";
- Keep settlement away from mineralized areas.

NORTHWAY:

- Mineral exploration doesn't really bother subsistence areas. Miners usually don't use heavy equipment and just go through an area. But, in areas of good hunting and lots of prospecting there is a problem.

TANACROSS:

-(note) no specific comments on mining/minerals and energy development, but concerned with habitat protection.

TANANA:

- Concern over the impact of mining on lakes. Mining filled up Fish Lake;
- Miners make a mining road out of a trail to Manley which means it isn't food for dogs anymore;
- Mining is going on in the area -- around Tozitna River Valley. It's just the start of mining in this area;
- But it's only seasonal, which helps;
- Up American Creek/Tofty there is mining going on. It hasn't bothered me as long as they stay over there.
- The road to Tofty hasn't changed much here. We haven't felt any impact.

Chapter 3

Past, Current and Planned Mining Activity

This chapter discusses the past, current and planned mining activity in the Tanana Basin. The information was obtained in the unpublished report entitled The Geology and Mineral Resources of the Tanana Basin, Alaska prepared by the staff of the DNR, Division of Geological and Geophysical Surveys (1982).

I. PAST PRODUCTION

Interest in gold placers of the Yukon-Tanana Basin in Alaska and Canada began in 1870 when prospectors ventured north from southern Canada and the USA. Initially the Fortymile, Circle, and Rampart districts were discovered prior to the 20th century--no doubt aided by proximity to navigable portions of the Tanana and Yukon Rivers. Most of the rest of the strikes in the Tanana Basin were "spin offs" of the Klondike gold rush.

Gold was discovered in the Fairbanks district in 1902, Bonnifield in 1903, Tenderfoot or Richardson in 1905, and finally Livengood in 1914. Essentially all mineral production that took place prior to 1950 involved activities within these camps. The pattern of development of the "yellow metal" in each area was similar. Initial discoveries of rich deposits resulted in high grading by individuals and small companies.

In most of the districts, underground drifting through frozen ground was the principal mining method. By World War I, most of the rich deposits were exhausted. Coincidentally many young miners enlisted into military service with America's entrance into the 'Great War', and never returned to the north country. By 1920 the gold industry was only a fraction of the size during peak 1903-1913 years.

Construction of the Alaska Railroad from Seward to Nenana--later extended to Fairbanks--was ordered by President Woodrow Wilson in 1915. Eight years later, President Warren Harding drove the golden spike at North Nenana. This important transportation mode would have far reaching effects on mineral development in the basin. In 1923, the USSR&M Company acquired large tracts of placer ground in the Fairbanks area with the intention of establishing large scale floating dredge production units. The company spent $28 million in exploration and development projects that included construction of a 90-mile-long 'Davidson Ditch,' dredges, roads, and a large power plant. The first dredge was in production in 1928 and by 1940 eight of these huge gold boats were extracting several hundred thousand ounces of placer gold annually (Boswell, 1979). The electric

Table 3-1
Cummulative volume and value of minerals, Tanana Basin 1880-1981[1]

Metals	District	Volume	Value (in 1982 dollars)
Gold	Fairbanks	7,940,000 oz	3,176,000,000
	Hot Springs	440,000 oz	176,000,000
	Tolovana (or Livengood)	387,000 oz	154,800,000
	Bonnifield	50,000 oz	20,000,000
	Richardson	103,000 oz	41,200,000
	Delta	2,500 oz	1,000,000
	Tok	500 oz	200,000
	Kantishna	65,000 oz	26,000,000
	Subtotal	8,988,000 oz	3,595,200,000
Antimony	Fairbanks	3,800,000 lb	3,850,000
	Tolovana	344,400 lb	347,844
	Tok	100,000 lb	101,000
	Kantishna	5,000,000 lb	5,050,000
	Bonnifield	50,000 lb	50,500
	Subtotal	9,294,000 lb	9,399,344
Tungsten	Fairbanks	4,700 short ton units	564,000
Tin	Manley	700,000 lb	4,795,000
Lead and zinc	Fairbanks Kantishna	150,000 lb	130,000
Industrial minerals			
Sand and gravel[2]		70 million tons	700,000,000
Building stone[2]		5 million tons	40,000,000
Coal		18 million tons	403,200,000
	Total value		$4,753,158,344

[1] All values are estimates. Approximately 1 million ounces of silver have been recovered as a by-product of gold refining; 250,000 ounces of silver were produced from primary lodes at Kantishna. Gold production modified from Robinson and Bundtzen (1979).

[2] Very rough estimates based on local interviews. Historical records are very incomplete.

dredges were furnished with power from a power plant in Fairbanks, the largest in the state until World War II. The source of the energy for the plant was the Healy coal fields--110 miles south of town. Except for a brief shut down in World War II, the USSR&M dredges operated until 1964, and seasonally employed 350-1,300 local area residents.

Beginning in the mid-1970s, all of the historic placer districts in the basin underwent a production revival. Today at least 60 nonfloat mechanized operations employing 350 people are active.

Hard rock gold development in the basin never seriously competed with placer operations. However, in the Fairbanks area, several hundred lodes were discovered in the Clear-Pedro Dome and Ester areas. Small stamp mills wer erected and selected, high grade ores were milled from at least 25 different deposits; the largest producing property was the Cleary Hill mines at the base of Cleary Summit (Hill, 1933). Other important producers include the Hi Yu, McCarty, Newsboy, and Kawalita deposits on Cleary Hill and the Mohawk, Ready Bullion, Billy Sunday, and Grant mines on Ester Dome. A substantial portion of development interest today centers on some of these lodes (see development section, p. 20). Other hard rock gold developments in the basin include the Old Smokey near Livengood, the Liberty Belle deposit east of Healy, and the Tibbs Creek area at the head of Salcha River.

Minerals other than gold and coal have been developed in the basin. During World War I European nations needed the strategic minerals tin, tungsten, and antimony. Development of all three commodities occurred in the Fairbanks and Manley areas. During 1915-18, lodes in the Pedro Dome-Ester area were among the largest domestic suppliers of antimony. Through 1971, antimony and tungsten have been exploited in the Fairbanks, Tok, Bonnifield, and Tolovana districts, coincident with the high price surges. Tin has enjoyed the most stable price levels and has been recovered annually since the 1920s as a by-product of gold mining near Manley (Table 1).

A few carloads of lead-zinc-silver concentrates have been shipped from two lodes in the Fairbanks area, by-product lead and zinc were shipped from silver-gold ores in the Kantishna district prior to 1973.

Beginning with the early 1950s, production of coal, sand, and gravel increased enormously, largely a result of demands from various military construction projects in the interior. Coal production again surged with a decision by

Golden Valley Electric Association to construct a mine mouth power plant at Healy. Sand and grvel production hit an all time high in the basin with construction of the Trans Alaska Pipeline.

Today the triad--gold, sand and gravel, and coal--forms the cornerstone of the mineral industry in the Tanana Basin.

II. CURRENT PRODUCTION

A. Metal Production

In 1981 the Tanana Basin as a whole accounted for roughly 55,000 ounces of gold; about 40 percent of the state's total output. Major producing areas were the Fairbanks, Hot Springs, Richardson, and Livengood districts (Bundtzen, 1982). Gold was also recovered from the Bonnifield and Delta districts. A new placer area was opened near Bitzshtini Mountain on the western boundary of the study area; at least three placer developments were active in 1981 and 1982. Although previous investigations indicated the presence of gold in this region, there is no known past production. Tungsten concentrates were shipped from Gilmore Dome lode in 1981; there was no production in 1982. However, tin concentrates were shipped from the Manley area during both 1981 and 1982. Information on exact quantities of tin and tungsten produced is not available.

B. Structural and Industrial Materials

In 1981, seven sand and gravel operators in the Fairbanks area mined about one million tons of material for landfill, construction, and road-building projects; the leading producer was Fairbanks Sand and Gravel. Yutana Construction Company operated the Browns Hill basalt quarry on Badger Road. Mining methods include bench drilling and blasting, grizzly and crusher processing, and mine haulage similar to small-scale, open-pit mining methodology. Remaining reserves are estimated at 30 million cubic yards.

At least 20 Fairbanks-area studio and production potters use montmorillonite clays from the Healy coal field for making a variety of pots and handcrafts. Usibelli Mines has, in the past, supplied railroad carloads of clay to local users. As much as 40 tons of wet clay may be used in a single year. Value of the finished product is uncertain, but may approach $75,000 annually.

C. Coal Production

Usibelli Mines (Healy) was the only significant coal mine in the state. Production in 1981 was about 800,000 tons, worth $17.6 million, a 6 percent increse over the previous year. Usibelli is involved in a significant expansion into the Pacific Rim export market.

A contract signed in 1981 calls for delivery of coal to Korea starting in 1982. The contract, which is for 200,000 tons in 1982 rising to 800,000 tons in 1984, covers a ten-year time span. There is some doubt concerning the completion of handling facilities to enable timely deliveries.

Table 3-2
Estimated Current Annual Mineral Production in the Tanana Basin

Metals	
Gold	55,000 ounces
Tungsten	actual quantity not available.
Tin	actual quantity not available.
Structural and Industrial Materials	
sand and gravel	1 million tons
riprap, ballast and fill	340,000 cubic yards
montmorillonite clay	40 tons
Coal	800,000 tons
Peat	10,000 cubic yards[1]

[1]Estimate based on interviews with local suppliers.

Source: ADNR, Division of Geological and Geophysical Surveys, Geology and Mineral Resources of the Tanana Basin, Alaska, 1982.

III. PLANNED MINING PROJECTS

Two medium sized mining ventures within the Basin have reached a development schedule, the Grant Mine on Ester Dome and the CNR placer operation near Livengood. Both of these mines will contribute to the local economy if they come into full production.

A.Grant Mine and Ester Dome Development, Tri-Con, Inc., Fairbanks.

Tri-Con, Inc., operator for Silverado Mines, Ltd., of Vancouver, British Columbia, has been engaged in an aggressive development program on Ester Dome (8 miles west of Fairbanks) for the last 3 years. The focus of the development is the reopening of the old Grant Mine on Happy Road. Exploration and development of the mine have been intermittent since the 1920s. Prior to 1950, about 6,000 tons of ore were selectively mined from the Irishman vein (Roger Burggraf, personal communication, 1981). Tri-Con, Inc., has been developing the property during the last several years and now has a gravity feed mill facility there.

During 1980, 870 tons of ore, with an average grade of 0.45 ounce/ton gold, were milled through the pilot plant. In 1981, just under 1,000 ounces of gold were recovered from approximately 1,500 tons of ore. According to recent estimates the company had blocked out about 75,000 tons of mill-feed ore through December of 1981.

Under a late 1980 agreement with Range Minerals Corporation, 262 state mining claims immediately surrounding the Grant Property were brought under control so that Silverado now manages about 14 square miles on Ester Dome. The company hopes to bring several auriferous veins into production to collectively feed the mill at a rate of 100-500 TPD.

Underground development work continued from May 1980 to December 1981, but the Grant Mine remained inoperative through the 1982 field season. Plans for 1983 are dependent on resolution of financing. A crew of 25, including exploration personnel, was employed during the year. Total 1981 development expenditures exceeded $2 million.

B. CNR Placer Operations, Livengood District.

Livengood Joint Ventures (LJV), consortium of Asamera Minerals, Canadian Natural Resources, and Stanford Mines of Canada and the United States, is attempting to develop one of the largest unworked placer deposits in the United States. The Livengood gold camp was discovered in 1914, and has since produced about 400,000 ounces of gold. By 1940, large bench deposits, which vary from 100 to 1,000 feet in width and extend for at least 6 miles were discovered on Livengood Creek. Drilling confirmed the presence of about 300,000 ounces of gold reserves, and in the 1940's a large dredge was moved into the area.

The present LJV consortium has learned that all phases of the gold-mining process cannot be feasibly completed during the short summer seasons, especially because the thick overburden must be mechanically moved by heavy equipment. Heavy equipment has difficulty maneuvering the thawed muck, and expensive mechanical failures and downtime have hindered the project. In the winter of 1981, LJV contracted Doyon, Ltd., to strip overburden from the bench and construct a large settling pond; both projects were completed in June. In 1981, one of the first Caterpillar D-10 tractors ever used in Alaska began work on the project.

Annual production since 1978 varies from 800 to about 3,000 ounces, and a 10-million cubic yard block of ground has been classified by LJV as their current reserve base. The present washing plant consists of two standard sluice boxes arranged en-echelon and fed by a dozer or front-end loader. For the project to sustain desired production levels, additions to the present wash facility are planned. A large washing plant acquired during 1981 operated through the 1982 season. LJV constructed a 200-man camp to serve their operation. Employment levels vary from 50 to 100 personnel throughout most of the mining season. Specific development figures have not been released for this study, but 1981 expenditures are believed to exceed $3 million. Expenditures for this season (1982) have not been released at the time of this writing.

Chapter 4

Mineral Potential of the Tanana Basin

PART 1. PHYSICAL CAPABILITY

Due to the nature of subsurface minerals, it is not possible to give estimates of the amount of mineral deposits in the Basin. Unlike many of the other resources, minerals cannot be inventoried easily and new deposits can be discovered in areas which were previously thought to contain few prospects. However, through the examination of several different pieces of information, areas with high probability for certain types of minerals can be delineated. This does not mean that minerals will not be found elsewhere, it simply means that the probability is greater that minerals will be found in these areas. Given new research and information, additional areas may be added to the map and this possibility should be kept in mind during the planning process.

This report summarizes what is currently known about the mineral resources in the Tanana Basin, including descriptions of promising mineral deposits and current levels of exploration . Commodities examined here include base and precious metals, coal, strategic minerals and industrial commodities.

I. CRITERIA USED TO PRODUCE THE MAPS OF PHYSICAL CAPABILITY FOR MINERAL RESOURCES

The map showing the region's mineral potential includes information on current mining claims, known mineral occurrences and mineral terranes. The map itself has not been reproduced for this report due to time constraints, but is available at the DNR, Division of Land and Water Management office in Fairbanks.

The map was based on methods described by Eakins and others (1979) and supplemented by the University of Alaska's AEIDC Mineral Terrane Map (Hawley, 1979). Private sector input on recent developments and exploration was also incorporated and gratefully acknowledged. The DGGS-MIRL Interior mining districts project provided important new information on mineral potential in the Fairbanks and Livengood areas. Much of the specific resource data shown on the map was compiled from Cobb (1973), Berg and Cobb (1964), MacKevett and Holloway (1977) and Eberlien et al. (1977).

Four basic factors were integrated to determine mineral potential for this study: (1) mineral terranes; (2) exploration activities; (3) mine developments; (4) mining claim blocks; (5) known reserves (based on subsurface work); (6) production (past or present); and (7) mineral indicators. Such factors can be scored in a relative sense resulting in a mineral potential per unit area of land. In 1978, DGGS completed evaluation of 15,000 townships statewide in such a manner (Eakins et al., 1979). The various criteria used to evaluate each township are summarized in Table 4-1.

It is important to keep in mind that such resource assessments are dependent upon the availability of information. The data base for most of Alaska is deficient and needs to be updated.

The concept of mineral terranes, which was one of the criteria used to develop the map is discussed below. In addition, current exploration activities are examined here. Current mining activity and developments, which were also used as criteria in the mapping process, were discussed in more detail in Chapter 3. A discussion of the geology of the Basin is presented in Appendix A.

A. Mineral Terranes

Geologists recognize that specific types of mineral lodes occur within unique lithologic rock packages. For example, most platinum, asbestos, chrome, and nickel lodes occur within basic or ultramafic rocks formed at high temperatures and pressures--conditions deep in the earth's crust. Recognition of new discoveries of these rocks usually leads to at least a cursory search for these commodities. Geologists have formulated numerous models of rock deposition that explain the distribution of mineral lodes. In Alaska, it has long been known that such mineral trends can be followed for many tens of miles along strikes.

Under these assumptions, Hawley (1979) assembled all available information on mineral resources of the 49th state and produced a mineral terrane map of Alaska at 1:1,000,000 scale. The approach stresses the genetic significance of many mineral deposits to both rock types and their environment of deposition. A modified version of these mineral terranes is summarized on the physical capability map (available at DRD) and in Table 4-2.

Most of the mining activities prior to World War II focused on placer gold districts. Prospectors and miners searched using the often valid assumption that placer gold was the geologic signature of many undiscovered metal lodes. However, important mineral lodes do not always produce sizeable placer gold in adjacent streams for a variety of reasons.

In the mid-1970s, modern mineral exploration conducted by mining companies and geologic mapping programs by government agencies have contributed significantly to the

Table 4-1

Criteria Used in DGGS Township Level Mineral Potential of Alaska, From Eakins and Others (1979)

1. Industry nominations
2. Claim density
3. Exploration activity
4. Mineral indicators
5. Deposit types including lithology, stratigraphy, age, trends, igneous association, structure, ore controls and geophysical indicators.
   A. Hydrothermal vein deposits
   B. Ultramafic deposits
   C. Marine evaporites and phosphorite deposits
   D. Placer deposits
   E. Stratiform and syngenetic
   F. Felsic igneous deposits
   G. Porphyry deposits
   H. Mafic igneous
6. Past production
7. Ore reserves
8. Unit value of ore
9. Ore processing requirements
10. Geophysical surveys
11. Regional geology
12. Tectonics: regional structure
13. Metamorphic grade
14. Strategic importance
15. Access
16. Transportation routes
17. Climate

Table 4-2
Mineral Terranes and Commodity Grouping for Tanana Basin, Modified from Hawley (1979)

Mineral terrane	Deposit types	Dominant mineral
Plutonic-igneous	Stockworks or disseminated porphyry, fracture fillings	Copper, molybdenum, gold, silver, tungsten, tin, base metals uranium, rare earths, platinum
Shales and carbonates	Replacement, syngenetic-stratiform, veins	Lead, zinc, silver, barite, phosphate, industrial grade limestone
Coal bearing	Bedded, roll fronts	Coal, uranium
Mixed igneous and sedimentary	Stratiform, veins; disseminated	Copper, lead, zinc, uranium, gold, silver, tungsten, tin

Basin. By 1975, it became apparent to economic geologists that certain volcanic and sedimentary rock units in the central Alaska Range (Bonnifield District) were not only lode sources of placer gold but also hosts of significant base metal stratiform mineral deposits (see Figure 4-1 for a map of the mining districts). The primary host lithologies have been members of the Totatlanika Schist, but other units are mineralized as well. At least six large deposits containing copper, lead, zinc, gold, and silver were discovered using a model suggesting metal accumulations in association with volcanic buildups on an ocean floor over 330 million years old (Gilbert and Bundtzen, 1979).

In 1977, geologists with Resource Associates of Alaska (RAA) recognized that a specific belt of volcanic and sedimentary rocks near Tok contained important metal occurrences. These host lithologies are similar but probably not identical to those found in the Bonnifield district further to the west. At least 25 deposits of significance have been discovered--in an area devoid of placer gold and considered to have low mineral potential prior to 1977.

During 1980-81, the DGGS and University of Alaska MIRL jointly conducted a geologic assessment of the Fairbanks mining district--historically known for placer and hard rock gold-antimony-tungsten deposits. Prior to this work, most geologists believed that hard rock gold and other metal deposits were classic hydrothermal 'veins' eminating from nearby igneous sources.

While most deposits in the Fairbanks area are cross-cutting, metal bearing quartz veins, Smith and others (1981) have shown that virtually all important mineral deposits in the district are hosted in rock types of the 'Cleary Sequence,' a distinctive group of volcanogenic rock particularly well exposed near Cleary Hill. Anomalous metal content in rocks, soil, and stream sediments and high arsenic values in ground water are ubiqutous indicators of the Cleary Sequence. Recognition of the Cleary Sequence has been and should continue to be an important factor in the land use policies of the general Fairbanks are. Both environmental quality and mineral potential need to be stressed. A remarkably similar group of rocks was found by Bundtzen (1981) to contain most of the mineral lodes in the Kantishna mining district in the southwest portion of the Tanana Basin.

In 1982, the DGGS evaluated state lands in the Livengood area for mineral potential as part of the Interior mining district's study. This study has shown a possible lithologic control for gold and base metals as

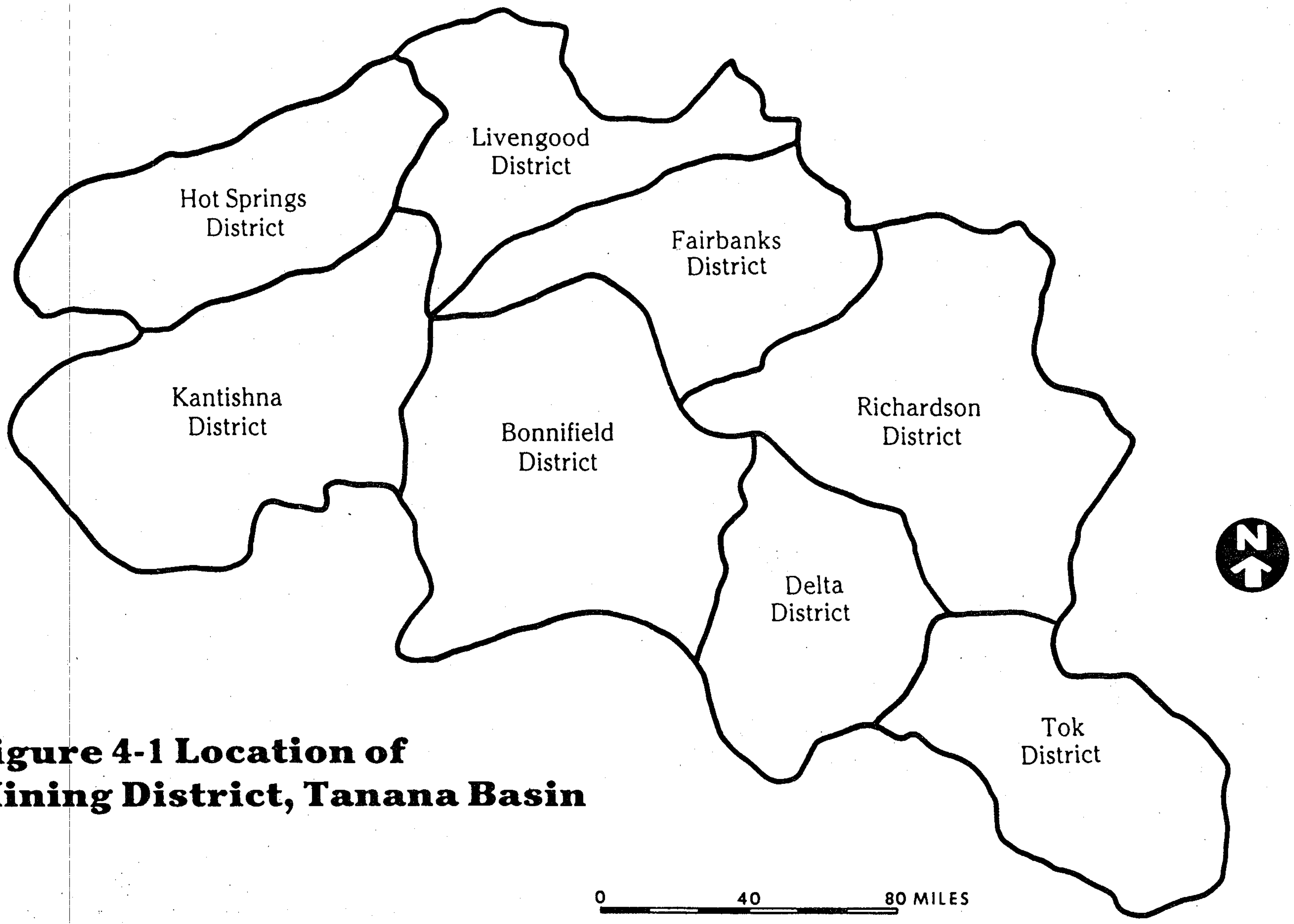


Figure 4-1 Location of Mining District, Tanana Basin

well as an untested new model for gold placer deposits (Robinson and others, 1982).

Similar studies in the Richardson district have shown that recognition of a linear feature, the Richardson Lineament, can aid in the discovery of new mineral deposits (Bundtzen and Reger, 1977).

B. Exploration Activities

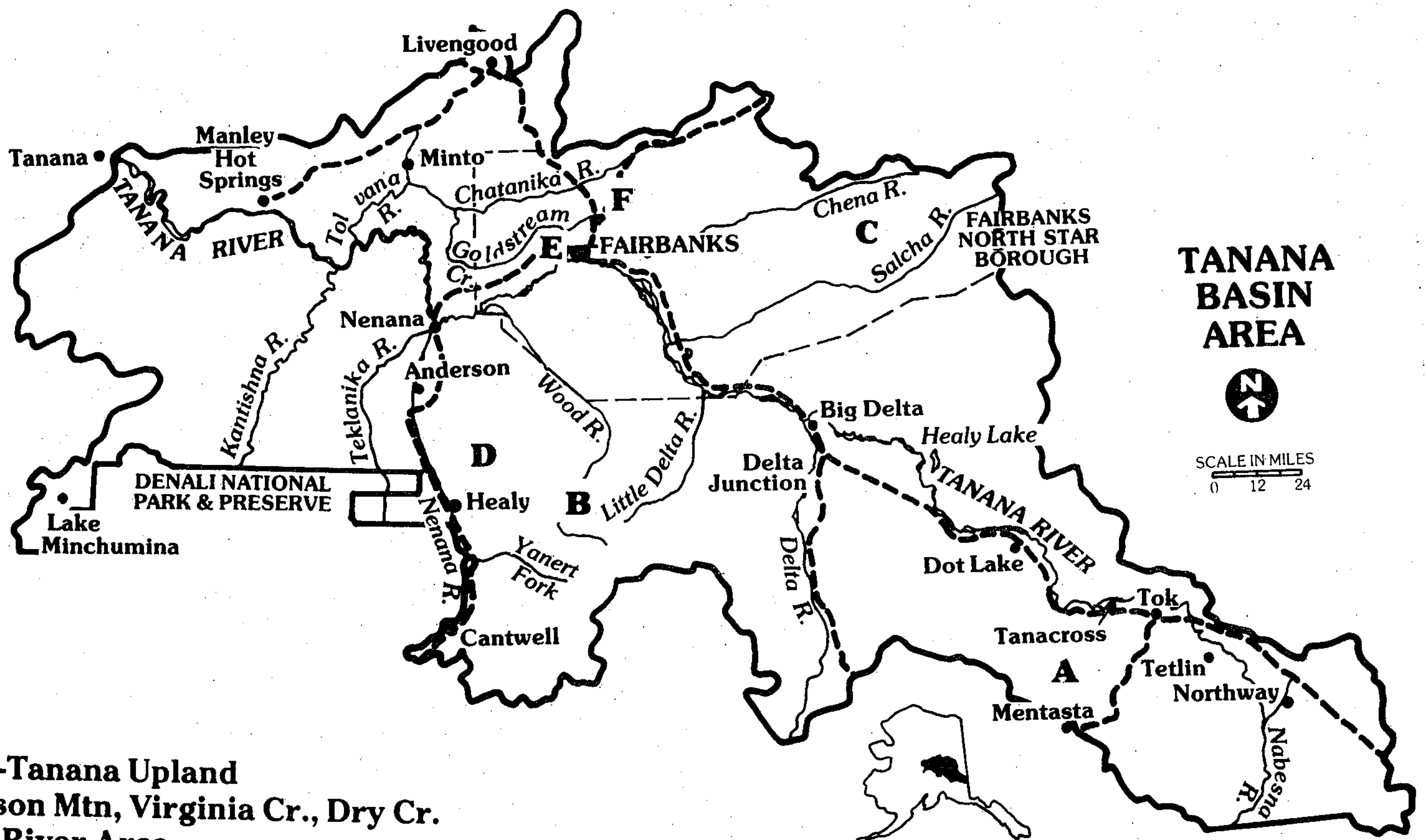
In addition to mineral terranes, exploration activities are an important indicator of the mineral potential of the Basin. Exploration activities discussed here are separated by commodity.

1. Exploration for Base Metals

Union Carbide, Phillips Minerals, Resource Associates of Alaska, Anaconda Minerals Co., Resource Associates of Alaska, Patino, WGM, Inc., and Northern Lights Exploration spent an estimated $5.4 million exploring for base metals, primarily along the north flank of the Alaska Range and in the Yukon-Tanana Upland (Site A, Figure 4-2). Numerous massive-sulfide deposits occur in a belt of deformed tuff, metavolcanic, and exhalative units of probable Devonian age in the eastern Alaska Range between the Tok and Robertson Rivers (Delta mineral belt; Tok mining district).

Geologists with Resource Associates of Alaska made the original discoveries in 1976 and 1977, and an exploration agreement was arranged with Anaconda Minerals Co. in 1980. At least 35 prospects have been examined over the last few years, and over $10 million have been expended in exploration. These fine-grained, pyritiferous, base-metal deposits have impressive strike lengths, contain high precious-metal values, and crop out in rugged terrane. Although Delta is a very promising district, no formal announcements have been made. One consultant suggested that several prospects could commence development by 1986.

Further to the west, work continues on stratiform, polymetallic (copper, lead, and zinc) deposits in the Bonnifield mining district east of Healy. In 1975 and 1976, Getty Oil and Resource Associtesof Alaska discovered deposits near Anderson Mountain, Virginia Creek, and Dry Creek (Site B, Figure 4-2). Reconnaissance diamond drilling was completed on several of the properties by 1977. Exploration, at a cost of several hundred thousand dollars, was completed in 1981. About the same level of activity continued in 1982.



A Yukon-Tanana Upland
B Anderson Mtn, Virginia Cr., Dry Cr.
C Salcha River Area
D Sheep Creek
E Ester Dome
F Cleary Hill

Figure 4-2. Exploration Sites for Base Metals

Resource Associates of Alaska, Union Carbide, Bear Creek Mining Company, and Houston International Minerals Company (HIMCO) explored deposits containing tungsten and tin. HIMCO continued work on tungsten bearing skarn mineralization north of Salcha River and drilling results indicate encouraging amounts of mineralization (Site C, Figure 4-2). Resource Associates of Alaska conducted ground and airborne geophysical investigations near Fairbanks in search of scheelite deposits.

Bear Creek Mining continued work on a massive sulfide deposit, with anomalous tin zones, near Sheep Creek, 13 miles east of the railhead at Healy (Site D, Figure 4-2). This occurrence of tin constitutes a new type of target that is poorly documented in Alaska.

2. Exploration for Precious Metals

Hard rock gold exploration efforts in the Tanana Basin include those directed by Resource Associates of Alaska, St. Joe Minerals, Placid Oil, Silverado Mines, Inc., Houston International Minerals, and Getty Oil. Interest in development of the area's numerous gold lodes has recently revived. Since 1979, St. Joe American has completed trenching, sampling, and 10,000 feet of diamond drilling on the Ryan Lode on Ester Dome near Fairbanks (Site E, Figure 4-2). Past reserve estimates suggest that about 2 million tons of gold ore may exist on site, and St. Joe's efforts have confirmed the presence of a large reserve of undisclosed grade. Poor ground hampered underground bulk sampling efforts in 1981, and a 500 foot long decline was abandoned. The company plans further work on the Ryan deposit in 1982; both open-pit and underground options are being considered.

Tri-Con, Ltd. is exploring a large claim block on Ester Dome in conjunction with operation of the Grant Gold Mine (Site E, Figure 4-2). A 25-man crew was active in 1981. This company conceptually views the development of several auriferous veins and shears that would provide feed for a medium-sized mill (200-500 TPD).

Placid Oil drove a 1,500 foot long adit into the Kawalita vein system on Cleary Hill and began an underground sampling program (Site F, Figure 4-2).

Twelve of an estimated 25 operators in the Fairbanks district spent $400,000 improving their reserve base with drilling and geophysical investigations in 1981. Almost $300,000 was expended for similar efforts in the Manley, Livengood, and Rampart districts (see Figure 4-1). Long a dormant region, the Bonnifield district east of Healy was explored for placer gold by five companies.

Twelker, Fitch, and Associates and Sedcore, Ltd., conducted contract exploration activities using sonic drilling techniques regionwide. This technological advance in drilling appears to hold promise because, among other advantages, normally expensive placer drilling costs could be substantially reduced.

3. Exploration for Industrial and Structural Materials

Although outside the Tanana Basin, the most significant industrial mineral exploration in the general region is focused on the asbestos deposits owned by Doyon, Ltd., at Slate Creek in the Yukon-Tanana Upland. These deposits are at an advanced exploration stage.

Several companies are also exploring for agricultural grade limestone suitable for use as a soil conditioner, under the assumption that the production of grain near Delta will eventually require a local source of mineral fertilizers. No figures of expenditures or results are available.

4. Exploration for Coal

Routine exploration is being conducted by Usibelli Mines, Inc. near Healy in conjunction with coal production. In addition, Canadian Superior examined coal deposits on the north flank of the Alaska Range and Fairbanks firm continued exploration and feasibility studies of the Jarvis Creek coal field south of Fort Greely. Published reserve-resource estimates are on the order of 70 million tons of subbituminous coals, one-third of which appear amenable to strip mining techniques (McGee and Emmel, 1979). Present plans are to supply coal to the Delta Junction area for local power generation and possibly for agricultural grain drying facilities. Preliminary demand estimates are on the order of 50,000 tons/year, about one-twelfth the size of production at Healy.

C. Other Criteria Used to Produce the Map of Mineral Potential

Other criteria used to map the mineral potential which have not been discussed in detail here are presented in Table 4-1 and in Chapter 3.

Chapter 5

Benefit - Cost Analysis

INTRODUCTION

This chapter presents the results of a preliminary study which assesses the relative economic value of mining in the Tanana River Basin. It is part of a study of the economic value of managing state land for six different resources: settlement, agriculture, fish and game, mineral development, forestry and recreation. Each resource is examined separately first; combined management for multiple use will be discussed in a separate paper.

The first part of this chapter discusses both the method used to evaluate the economics of all the resources and the specific application of this method to mineral development. The second part of the paper presents the results of the analysis.

The results are discussed according to five commodity groups and exploration activities. The commodity groups include 1) precious metals; 2) base metals; 3) industrial and structural materials; 4) coal and peat and 5) oil and gas. Exploration is included separately because often more than one commodity is sought and because even if no minerals are found, there is a positive economic impact from this activity.

The results of the benefit/cost analyses presented here are not absolute. In fact, they represent only an order-of-magnitude estimate of the economic value of the mining industry. Because this is a preliminary study, it is dependent on relatively incomplete data and therefore it is not possible to pinpoint the exact economic value. Nevertheless, this analysis indicates that the mining industry is making a substantial contribution to the current economy of the basin and it also has considerable potential.

PART 1. METHODS

I. General Approach To Economic Analysis

Before discussing in detail the method used to evaluate minerals some background is necessary on the general approach to the consistent evaluation of all of the land management alternatives and the reasons for examining the economic value of these alternatives.

There are three basic reasons for examining economic value. First, economic information complements the physical information presented in Chapter 4 of this report and gives perspective on both what is happening now in the Basin and what the potential is. Secondly, economic data supply important information concerning the profitability of resource development; if a resource cannot be developed profitably, it probably will not have a lasting effect on the economy. Finally, because two objectives of the state government are economic development and diversification, economic information is needed to make decisions which may benefit the economy.

The economic value of a resource has several meanings. Economists define economic value as the worth of an item or activity to society. This value can be measured in monetary prices in the market place or it can be non-monetary. In the case of a business, its economic value can be measured in a relatively straight-forward way, in the form of a financial analysis of the profitability of the enterprise. In other cases, such as recreation or hunting activities, there are economic values to the society which are not measured directly in monetary terms, but are imputed in people's behavior and spending patterns.

Economic analysis attempts to measure people's values, or the worth they place on different things, in terms of their behavior. It assumes that if people cherish something their economic behavior will reflect this, and thus their behavior can be used to indicate the worth which the people attach to something. In this respect, economic analysis is an analogous to an attitude survey which attempts to measure people's values.

For example, a view of Mt. McKinley may be considered a priceless experience. However, many people place a great deal of worth on this experience and expectedly, this worth is reflected in their economic behavior: the prices of homes with a good view of Mt. McKinley are significantly higher than those without such a view. Thus, the difference in the value of these homes compared to others of similar quality can indicate the minimum worth which people attach to the view. If the view were obstructed by some development, the property value decreases significantly.

A. Evaluation Techniques

There are two common methods available for determining the economic effects of public policy decisions. The first is referred to as cost-effectiveness and the second is benefit-cost analysis.

Cost-effectiveness is simply a method for finding the least cost alternative for meeting a single objective. For example, if the objective is to improve public health there may be several alternative ways to meet this: more hospitals, better health instruction in schools, etc. Each approach would be costed out and the least cost alternative would be chosen. Unfortunately, this method is not of use in choosing between objectives. If there is not enough money to meet all objectives, then choices between objectives will have to be made and this method will not be of assistance.

For this purpose, benefit-cost analysis has long been the preferred approach. First developed by the Corps of Engineers in the 1930's, the method has become increasingly common to all types of public policy decisions. In the 1950's, it was adapted to private sector decision-making and is now used by most of the major corporations to make investment decisions.

It is not a panacea, but it does provide a systematic approach and there is extensive literature which documents the ways in which benefit-cost analysis has been used to examine a vast variety of public policy questions. Therefore the benefit-cost approach is used in this report.

B. Benefit-Cost Analysis Applied to Land Management Alternatives

The approach used below determines net benefits (benefits minus costs) of each of six alterntive ways to manage land (mineral development, recreation, agriculture, fish and game, settlement and forestry). Each of these alternatives is examined separately at this stage, and combinations will be discussed during the next phase (Alternative Development) in order to evaluate the benefits of multiple use.

First it is necessary to define who gains and who loses from a particular land management alternative. Three groups are generally identified: producers, consumers and government. Producers are those who provide goods and/or services for a monetary return. Consumers purchase these goods and services. The government often incurs a cost for any land management approach and this is often offset by revenues received from user fees. For each of these three groups, it is necessary to know what their situation is now and what the effect of a change in land management policy would have.

For example, recreational users are receiving some benefit from the use of state land. What effect would a decrease in the amount of state land open to recreation have on these "consumers"? Likewise, what would be the effect on local sawmills of an increase in the state's allowable cut? Also, how much would it cost the state to increase the amount of land disposals and what would be the return to producers and consumers of doing so? Benefit-cost analysis attempts to answer such questions.

The results of the analysis are aggregated over a period of 20 years. This period of time was used for three reasons. First, the time horizon of the plan is twenty years. Secondly, forecasting for a period beyond 20 years is very speculative and thirdly, the operation of the time value of money renders cash flows after 20 years insignificant. For example, $1000 received 40 years from now is worth only $22 today at a discount rate of 10%.

The net benefits of any action must be discounted to arrive at their present value. The need to discount the net benefits arises from the fact that a dollar received several years from now is not worth as much as a dollar received today. Before the dollars received in different years can be added together, they must be converted to today's dollars by discounting. This process is similar to converting measurements in yards and feet, into inches before adding them together.

The discount rate is generally set at the interest rate on borrowed funds. For this study, a discount rate of 10% was used which is the average interest rate charged on agricultural loans. Because it is important to be consistent, this rate was also used for the other resource evaluations.

Each major step of the analysis is described below. Producers, consumers and the state government are examined separately first and then the results are totaled.

1. Net Benefits to Producers

First it is necessary to define who the producers are. In this study, they are defined as those who expect to make a financial return on the use of a resource. For many resources, more than one product may be involved, in which case the producers of each product are examined separately first and then the results are summed. For example, there are producers of lumber and producers of fuelwood. The profits of each are examined separately and then the results are summed.

For each type of producer, net benefits are measured as profits.[1] The profits of an operation, such as a sawmill or farm, are measured in purely monetary terms. The first step in the analysis, is to determine if the resource development is financially feasible. If the development has been taking place for many years, this step is very straightforward: what are the estimated profits of the venture right now and what is the capacity for expansion?

If, however, there is no current operation or if the development is expected to expand beyond current capacity, then a detailed financial feasibility analysis must be done to determine if the venture would be financially profitable.

For example, if local sawmills have been turning a profit for many years, they can be assumed to be feasible. The next step is to determine the likely timber supply if all available forest land were managed for timber. If the sawmills can already handle this increase in supply, then it is simply necessary to estimate profits. If they could not handle the supply, then it would be necessary to do a financial analysis of the expected costs and revenues to a new sawmill.

A brief summary of the financial analysis required for each resource is given below:

Settlement is unique as the purchase of a homesite is assumed to be "financially feasible". It is assumed that a person would not buy a parcel for more than its financial value to him.

With forestry, preliminary estimates indicated that current capacity is likely to be able to handle the foreseeable increase in timber supply and therefore no detailed financial feasibility analysis was necessary. Only current and projected profits of existing operations were used.

With fish and game, the producers were defined as those whose "principal" objective was financial return (guides, commercial fishermen, and trappers). These ventures are expected to be able to handle the foreseeable supply and therefore no detailed financial feasibility analysis was necessary. Only current and projected profits of existing operations were used.

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[1]The analysis is complicated by the fact that a producer may also be contributing to the economy by such things as hiring people who may otherwise be unemployed. Due to limited time and data, these opportunity costs were not evaluated in this study.

In mineral development, some types of minerals may be developed or expanded and a preliminary financial feasibility analysis was performed to estimate the likely returns to this industry.

With agriculture, the Delta farming area is now operating so it is assumed to be feasible for present operators. Other areas in the Basin may not be feasible so it was necessary to perform a detailed financial feasibility analysis.

For recreation, there is currently no large group of producers dependent on state land for recreational enterprises. There is some interest in commercial alpine skiing ventures, and a preliminary examination of the financial feasibility of this type of venture has been included.

2. Net Benefits to Consumers

Consumers also stand to gain or lose due to changes in public policy. Consumers are defined in this study as those who purchase goods, services or "experiences" (as in the case of hunting or recreation). Benefits to consumers arise from two factors: 1) a decrease in the price of a good or an experience and 2) an increase in the quantity available of the good or of the experience. As in the analysis of producers, it is necessary to determine the status quo and/or potential and then the effect of a change in policy on consumers.

The benefit to consumers is an increase in the welfare or standard of living of the State's citizens (benefits and costs to non-Alaskans have not been counted in this analysis since state policies are generally aimed at only the citizens of this state). If a state policy changes either the price of a good or experience or the quantity available, then the welfare of the consumers is affected.

The analysis of consumers' net benefits requires an understanding of the demand curve for a resource. As an example, consider the market for fuelwood in Fairbanks. You may find someone who would be willing to pay $120 per cord for a few cords because it is that valuable to them. Someone else might pay up to $110 per cord for a few cords, but if the price went any higher, they would burn another fuel. Yet another person would consider $90 their upper limit. If you could find each of these people and graph their maximum willingness to pay against the cumulative number of cords they would buy, the curve might look like the one shown in Figure 1. If the supply were 20,000 cords, then all of the people who would pay $70 or more would have purchased wood. The person who considered the wood to be worth only $69 per cord would not buy wood until the supply expanded and the price fell to what she considered the wood to be worth.

The most difficult aspect of the analysis of the benefit to consumers is to estimate the demand curve. Ideally, information could be obtained on different people's willingness-to-pay (their upper limit) and this would be graphed against the quantity of the good or experience which they purchase. However, in many cases this information is not available.

Willingness to pay information is generally obtained from one of two sources: (1) through direct questions in a statistical survey and (2) indirectly through records on how much people actually paid for different quantities.[1] No accurate survey of the willingness-to-pay was available for any of the resources. However, it was possible to estimate the willingness-to-pay for hunting in the Basin through analysis of fish and game records.

For the other resources, a less desirable but necessary substitute was used, called replacement cost. This technique assumes that people would be willing to pay an amount equal to the cost of the next best alternative. For example, if no firewood were available, people may have to switch to fuel oil and the cost of an equivalent amount of heat in the form of oil could be used as a proxy for the willingness-to-pay.

This technique is less than ideal for two major reasons. First, it will underestimate what some people would be willing to pay. Someone may want to burn wood for aesthetic reasons and they will pay a lot for this pleasure. The willingness-to-pay approach should reflect such lifestyle or aesthetic values which people obtain from a resource. The replacement cost method assumes that only financial reasons are involved in the value consumers place on an activity or item, and is therefore a less desirable approach.

Secondly, the replacement cost value is not accurate for those who would not switch to the assumed alternative but who would use some other replacement. Therefore, the replacement cost is not a precise estimate of the the true benefit to consumers (which is represented by triangle ABC in Figure 2). However, it is often the only alternative short of a detailed and expensive survey and it has been used in this study to estimate the benefits to consumers for each resource except fish and game (which had adequate data available to use the willingness-to-pay approach).

3. Net Benefits to the State

The net benefit (or net cost) to the state was also estimated in order to give decision-makers an indication of what it costs the state, if anything, to provide benefits to producers and consumers.

[1]This occurs only when people pay different amounts to obtain the same good, service or experience, as in the case of hunting or recreation when non-residents generally pay much more to enjoy the same experience which Alaskans can enjoy everyday.

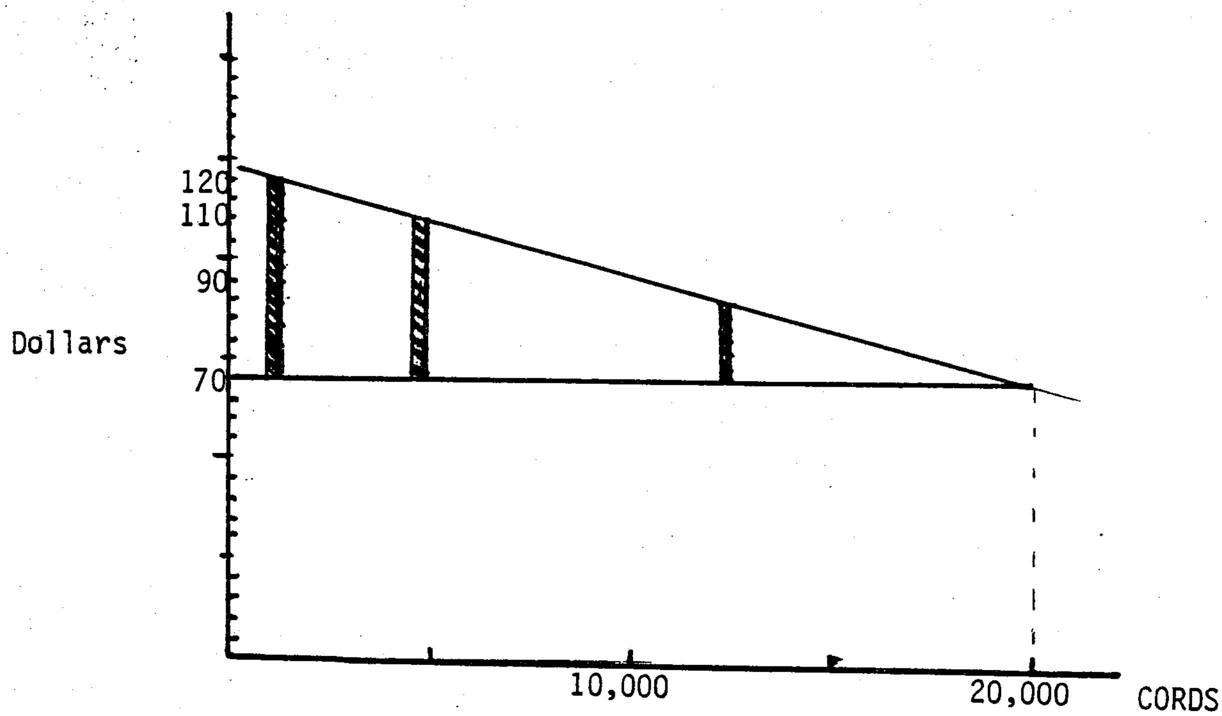

Figure 1. Demand Curve for Fuelwood

The shaded area in Figure 1 represents the value to each of the consumers. The person who was willing to pay $120/cord has gotten a bargain because she only had to pay $70. The same is true for the person who would have paid $110 and the one who would have paid $90. The one who would have paid only $70, however, must consider the deal just marginal; there is no "surplus" for him as he paid just what he thought it was worth. If the "surplus" for each individual who was willing to pay more were added together, the total value would be equal to the area of the triangle ABC shown in Figure 2. This shaded area determines the net benefit to the consumers.

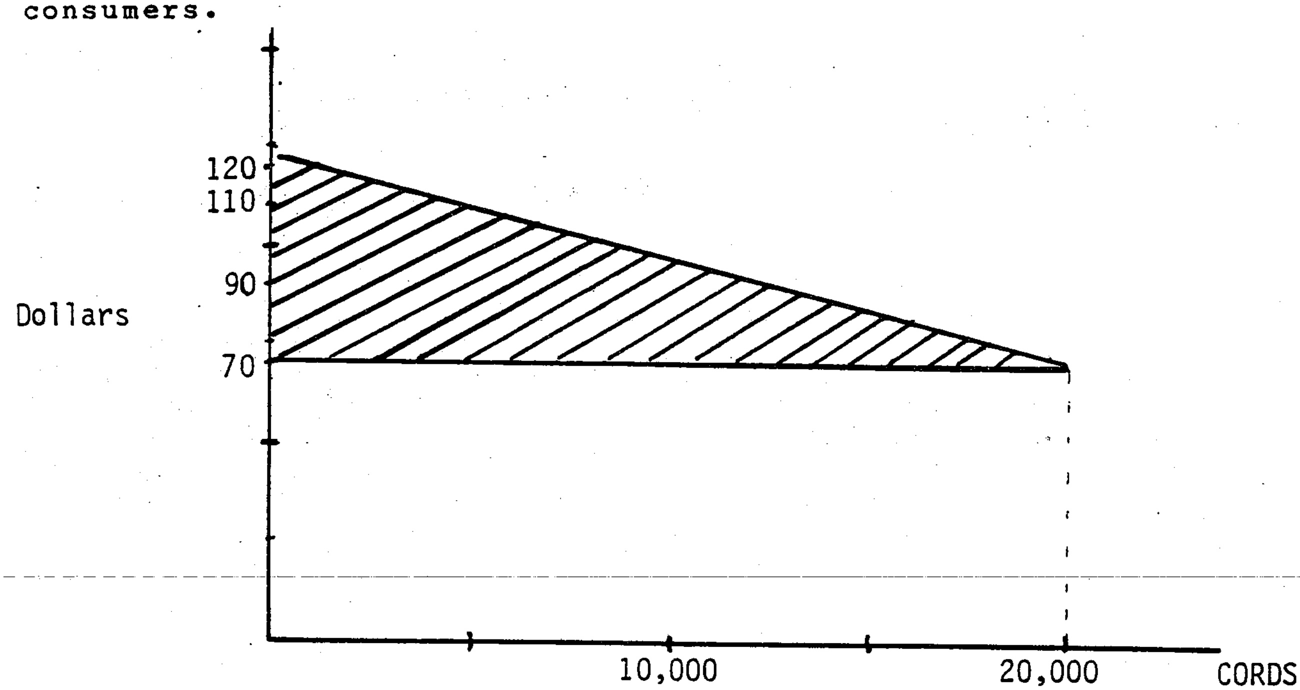

Figure 2. Hypothetical Consumer Benefits from Fuelwood

The net return to the state from the land disposal program, for example, is determined from the revenues obtained from the sale of land less the costs of administering the program and surveying the land.

If the costs of a program exceeded the revenues to the state, then the decision maker should examine the total net benefits or costs (the sum of net benefits to producers, consumers and the state) to determine if the program has a positive effect overall.

C. Other Important Indicators of Economic Effects

Although benefit-cost analysis is the most thorough single method available for determining the benefits and costs to society, it does not cover all of the important economic effects which decision-makers need to consider in allocating land to different uses. Other important measures of the economic impact of resource use are also evaluated in this study in order to give a more complete picture of the contribution of each resource to the economy.

1. Income Effects

Income effects are an important measure of the impact of a particular industry on the economy. These effects are important for the economic development of a region, which in many cases is an objective for the management of a resource. Therefore, these effects have been estimated for each resource.

2. Employment Effects

Another concern of many decision-makers is the effect on employment of a change in policy. Estimates of these effects are therefore included in the evaluation of each resource.

3. Net Fiscal Effects on Local Government

Although this study focuses on the benefits and costs to Alaskan consumers and producers, the effects of state decisions are also felt by local governments. Increases or decreases in tax revenue to local governments, balanced against changes in costs due to the policy, give an indication of the net fiscal effects to local governments.

4. External Costs and Benefits

External benefits and costs are defined here as those social, environmental and economic effects which are not quantifiable but which are very important to decision-making.

No analysis is ever truly complete in documenting every possible effect and evaluating each of them in some standard unit of measurement. This inadequacy is nowhere more evident than in the evaluation of external costs and benefits. These include the effects which even the most sophisticated analysis cannot quantify with ease. Yet they are as important, if not even more important, than the effects which are more easily quantified.

This study includes qualitative discussions of some of the possible effects of resource use which must be considered by decision-makers in determining land use allocations. These discussions are inevitably inadequate because the effects cannot be measured in dollar terms and therefore it is not possible to indicate their magnitude relative to the effects discussed earlier. Also, it is not possible to predict all of the possible external effects of resource use.

However, we have attempted to document what some of the possible non-quantifiable social, environmental and economic benefits and costs may be for each resource and we hope that this serves at a minimum to indicate the importance of these considerations.

PART 2. RESULTS

I. PRECIOUS METALS

The U.S. Bureau of Mines defines precious metals as the relatively scarce and valuable metals, such as gold, silver and platinum. By far the most important precious metal in the Basin is gold. The mining of gold represents the largest mining activity in the study area in terms of economic impact.

Precious metals occur in two types of deposits: hard rock deposits where the metal is combined with other minerals and requires processing to extract the metal; and placer deposits where the precious metals have been mined by the natural forces of weathering and erosion and have been deposited, typically in sand and gravel.

Because of the differing nature of precious metal deposits, the different methods employed in mining these deposits, and the economic uniqueness of these different mining activities; this section is broken down into placer and hardrock subsections.

A. Current Placer Mining of Precious Metals

Fairbanks grew up with gold placers, and they are still important, with 55 currently active placer mines in the Tanana Basin. These operations annually produce roughly 55,000 ounces of placer gold.

1. Current Net Producers Benefits

To determine current benefits of the placer precious metals industry to producers, it was necessary to determine the net profit after taxes of all the producers. Due to the lack of information on the profits of individual producers, it was necessary to construct a simple model of a typical placer operation that occurs in the Basin and examine the financial feasibility and profitability of the model at selected gold price levels. The model is described in detail in Appendix 5-A.

Using this model with an average world price of $400 per troy ounce of gold (or an average value of $10 per cubic yard), the model placer operation would be highly attractive compared to other investments. At the current $445 per troy ounce, the return would be even higher. Net benefits for the model operation, after taxes, were roughly $80,000 annually.

If this typical operation's financial outcome is used as an estimate of the average profit from the 55 active producing placer mines in the Basin, then the producers benefit can be estimated at roughly $4.4 million annually. The present value of this over a 20 year period would be roughly $34 million at a discount rate of 10%, if no major changes occurred in the industry.

2. Current Net Benefits to Consumer

There are some net benefits to consumers from local refining and jewelry making which may lower the price of manufactured products somewhat for local consumers. If this is the case, there are consumer benefits.

3. Current Income Effects

Current gold production in the Basin is approximately 55,000 ounces per year (Bundtzen, 1982). At the current price of about $400 per troy ounce, this equals $22 million in gross revenues.

The income multiplier for the mining industry is 2.93 (Logsdon, et. al., 1977). This would mean that the industry is creating indirectly $42 million dollars in the income effects for a total income effect of $64 million.

4. Current Job Effects

John Sims of the Alaska Department of Commerce and Economic Development reported at the 1982 Alaskan Placer Miners Conference, that the average placer mining operation employed 4.5 people. For the Basin's 55 active placer opertions, it can be estimated that 248 people are employed for six months, so that direct employment effects were roughly 125 person-years total. (Employment by local refiners was not available, but may be in the range of 30 people).

The employment multiplier is estimated to be 1.25 for the mining industry (Logsdon, et. al., 1977). The total direct and indirect employment effects of placer mining in the Basin is therefore about 140 person-years.

5. Current, Local Fiscal Effects

Currently there are no local property taxes on placer mining activities on state lands, unpatented federal claims or patented claims outside organized boroughs. Also, few direct service costs are associated with placer operations and therefore the net fiscal effect is probably insignificant.

6. External Costs and Benefits

External costs include the effects of stream siltation and erosion, soil disturbance, and scenic costs.

External benefits include provision of access into new areas and the hunting and recreation benefits which flow from this. Also, there are lifestyle benefits.

B. Potential Placer Mining Activity

The current level of activity was assumed to continue into the future, with the addition of production activity from the Livengood. The potential production of this mine is anticipated to be 10,000 to 15,000 ounces annually. The mine's reserves are estimated at 300,000 ounces (T. Bundtzen, Personal Communication). Total production for the basin under this scenario would be 65,000 to 70,000 ounces annually for placer operations.

Prices were assumed to be high enough at $400 per ounce to insure feasiblity of all operations. Also, this potential assumes no significant change in energy prices, legislative environment, land status, taxes or technology.

1. Potential Producer's Net Benefits

If costs and revenues stay at current levels, producers annual net benefits will be approximately $5.4 million (20% of estimated gross revenues of a 27 million average)[1]. The net present value of $5.4 million over a 20 year period at a 10% discount rate is $46 million.

[1]Assuming a 20% return on gross revenues of $20 million. (assuming $400 ounce).

2. Potential Net Benefits to Consumers

Since gold is not significantly cheaper locally, there are few net benefits to local consumers from gold production in the Tanana Basin. Therefore local buyers do not receive a significant benefit over imported gold.

3. Potential Income Effects

Gross revenues from an annual production level of 67,500 ounces equals $27 million (assuming $400 per ounce gold prices). Using the income multiplier for the mining industry of 2.93 (Logsdon, et. al., 1977), yields a total potential income effect of 79.1 million.

4. Potential Employment Effects

The potential employment scenario assumes 55 operations employing 4.5 people on the average, plus 100 jobs created from the LJV mine. Therefore, the total potential direct employment is 348. Using the mining industry employment multiplier of 1.25, the total employment effects from this potential placer gold production activity scenario is about 434 on a seasonal basis, or about 217 person-years.

5. Potential Local Fiscal Effects

Currently there are no local property taxes on placer mining equipment or on mining claims located on state lands, unpatented federal claims, or patented claims outside organized boroughs. With the growth of cities in the Basin or the organization of currently "unorganized boroughs", potential property taxes may be introduced, but no fiscal effects are presently foreseen.

6. Potential External Costs and Benefits

External costs include the effects of stream siltation, erosion, soil disturbance and scenic costs.

External benefits include provision of access into new areas and the hunting and other recreation benefits that flow from this. There are also, lifestyle benefits.

C. Hardrock Mining of Precious Metals

1. Current Hardrock Mining Activity

The principal hardrock gold mine in the Basin is the Grant Mine on Ester Dome, which produced about 1000 ounces in 1981. There are, however, many benefits from the exploration and the development activities occurring at several sites. The economic significance of these explorations and development activities is included under Exploration and Development (Section VI).

2. Potential Hard Rock Mine Model

The model presented here assumes that the Grant Mine is producing, and that there is a small amount of precious metal by-products from other non-precious hardrock mining activity.

The Grant Mine could process 100 tons of ore per day with an average grade of .45 ounces/ton gold (Eakins, et. al., 1982). Such an operation could run for 330 days annually. Twenty five people would be employed on a yearly basis.

a. Potential producer's net benefits.

Processing 100 tons of ore per day with an average grade of 0.45 ounces/ton gold, would yield a daily gold production of 45 ounces. A work year of 330 days would set annual production at roughly 15,000 ounces.

Fifteen thousand ounces of gold at $400 per ounce yields yearly gross revenues of $6 million. Assuming a profit margin of 20%, net producer's benefits from the Grant Mine operation would be $1.2 million annually.

Therefore, the total potential producers net benefits under this scenario would be $1.2 million annually. Their net present value over 20 years at a 10% discount rate would be $10.22 million.

b. Potential consumer's net benefits.

The benefits to consumers are difficult to determine. Any benefits would be due to savings in the price and quantity of gold available in-state as opposed to outside.

c. Potential net income effects.

Potential gross revenues for this scenario were estimated at $6.0 million annually. Using the mining income multiplier of 2.93 (Logsdon, et. al., 1977), the total income effects from this potential activity is 17.6 million annually.

d. Potential employment effects.

Twenty-five people were assumed to be directly employed by this scenario. Multiplying this figure by the mining industry's employment multiplier of 1.25 (Logsdon, et. al., 1977), the total potential employment effects would be 31 people. These jobs would be year-around.

e. Potential local fiscal impact.

Since the Grant Mine may be patented at some future date, Borough property taxes could be levied against this mining activity, but the amount of the tax cannot be determined until the Borough completes an appraisal.

Table 5-1
Estimated Current and Potential Economic Effects Of Precious Metal Activity

Types of Mining	Producers Benefits (Millions $/Year	Income Millions $/Year	Employment (Person-[1] Years
Current Placer	4.4	64.0	140
Current Hardrock	See Exploration & Development Section		
Current Total	**4.4**	**64.0**	**140**
Potential Placer	5.4	79.1	220
Potential Hardrock	1.2	17.6	30
Potential Total	**6.6**	**96.7**	**250**

[1] Rounded to nearest 10 person-years.

II. BASE METALS

The term base metals is usually applied to any of the more common and more chemically active metals, e.g., lead or copper. The non-precious metals which occur in the Tanana Basin include copper, zinc, antimony, tungsten, lead, tin and molybdenum.

Base metals, like precious metals, generally occur in two types of deposits: placer and hardrock. Thus, like precious metals, the base metal discussion is divided into a placer subcategory and a hardrock subcategory.

A. Placer Mining of Base Metals

1. Current Placer Mining Activity - Base Metals

Although base minerals occur in placer deposits in many areas of the Basin, their concentrations are not high enough to be conducive to economic exploitation at this time. Consequently, there are no exclusively base metal placer operations in the Basin. Some base metals, however, are produced as a by-product of gold placer operations. The best known by-products of placer gold production in the Basin are tin and tungsten.

Currently, only one operation in the Tanana Basin has reported producing significant levels of by-product base metals. This operation recovered tin (as cassiterite) as a by-product of gold mining in the Manley-Tofty area (Eakins, et. al., 1982). The total value of the recovered tin from this operation is estimated at less than $20,000 (FOB mine mouth). However, no detailed economic effects were calculated for this activity due to lack of information.

2. Potential Placer Mining Activity - Base Metals

No large scale placer deposits of base metals with economic significance have been identified in the Tanana Basin. Future activity will probably continue to be by-products of precious metal placers.

B. Hardrock Mining of Base Metals

1. Current Hardrock Mining Activity

Currently, there is no hardrock production activity associated with non-precious metals in the Tanana

Basin. There are, however, many prospects in various stages of development, such as Placid Oils underground sampling of the Kawalita Vein System on Cleary Hill or the Yellow Pup lode development on Gilmore Dome. Because these operations are in the exploration stage, their economic significance is included under the Exploration and Development section.

2. Potential Hard Rock Mining of Base Metals

There are many problems associated with forecasting hard rock base metal mining activity. First, there is the long lead time associated with much of the activity. After an exploration program has indicated that a deposit shows promise of being economic, the development of a large open pit mine may take from five to eight years from the time a feasibility study is initiated to the beginning of production. An underground mine may take one to two years longer, depending on the extent of underground excavation required to expose the productive ore body.

Secondly, the decision to invest is based on the projected price of the product and production costs over the estimated duration of the mining operation. However, future mineral prices are contingent not only on supply and demand, but also on the world economy and the degree to which free market competition is limited (for example, by long term contracts between miners and consumers) and on national policy (Louis Berger & Assoc., 1982).

a. Mine models

Given these realities, base metal mining potential was not assessed in the form of formal forecasts. Instead, a scenario was developed in an effort to provide some possible order-of-magnitude estimates of the economic contributions of base metal mining to the Tanana Basin. The scenario was based on the assumption that four mines will be in production. The mines were based on models presented in the Interior Transportation Study, Transportation Demand Forecasts (Louis Berger & Assoc., 1982) and on mine development activity currently taking place in the Basin.

The mines were assumed to be shipping concentrate out of the region for smelting and refining. The reader should bear in mind that revenue figures would more than triple if in-state smelting and refining were to occur. For example, a ton of 3% copper ore is worth \$42.60; a ton of pure copper concentrate is worth \$482.80; a ton of smelted copper is worth \$1,349 and a ton of refined copper is worth \$1,430 per ton. [1]

The four mines were the Dry Creek prospect, the Delta Belt prospect, the Gilmore Dome prospect and a prospect on Cleary Hill (See Figure 5-1). The mine models for the Delta Belt and Dry Creek operations were adopted directly from the Interior Transportation Study (ITS), the model used for the other two operations was a tungsten mine model, also presented in the ITS. A detailed description of these modes is presented in Appendix 5-C, but a brief synopsis appears in Table 5-1.

[1] Calculated from mineral prices presented in Engineering and Mining Journal, Vol. 183 No. 10, 1982.

Table 5-1
Summary of Mine Model Assumptions

Mine Name	Tons Per Day	Concentrate Produced Annually	Minerals Found
Dry Creek	1,200 tpd.	68,000 tons	Lead, zinc, silver, gold
Delta Belt	5,000 tpd.	448,000 tons	Copper, zinc, lead, silver
Cleary Hill	600 tpd.	36,000 tons	Lead, zinc, gold, silver
Gilmore Dome	600 tpd.	6,540 tons	Tungsten

tpd = tons per day

Source: Louis Berger and Associates, Interior Transportation Study, 1982

The reader should be aware that the probability of these mines producing within the near future is not known. Therefore, the following estimates should be viewed as order-of-magnitude figures only and not as absolute measures.

To estimate potential economic effects, it was assumed that the model mines used in this assessment each produced a single likely mineral. In actuality, the main product would be complemented by an array of by-products.

1. Producers benefits

If it is assumed that a 5% return on gross revenues is realized from these operations (see Table 5-2), then the potential producers net benefits would be $12 million. The net present value over a 20 year period with a 10% discount rate is $102 million.

Table 5-2
Estimated Annual Revenue of Potential Base Metal Mines

Model	Concentrate tons		World Price per ton[1]		Price Concentrate Adjuster[2]		Possible Annual Revenues (millions)
Dry Creek	68,000 Lead	x	500	x	.34	=	$ 11.6
Delta Belt	448,000 Copper	x	1420	x	.34	=	216.0
Cleary Hill	36,000 Lead/ zinc/gold/ silver	x	500	x	.34	=	6.1
Gilmore Dome	36,000 Tungs	x	200	x	1	=	7.2
							240.9

All prices were September 1982 quotes from the Engineering and Mining Journal.
The price concentrate adjuster for both copper and lead is based on the ratio of copper concentrate to world prices which is 0.34. Tungsten concentrate was assumed to be twice the current price of 65% minimum, tungsten ore.

2. Consumer benefits

Local consumers are unlikely to benefit directly in terms of measureably lower prices for lead, zinc, copper, etc. However, they are likely to benefit somewhat if the world price is affected by the supply from the Tanana Basin.

3. Income effects

Given possible annual revenues of $240 million, and using the mining income multiplier of 2.93 (Logsdon, et. al. 1977), the potential income effect of base metal mining in the Basin would be over $700 million per year.

4. Employment effects

From the models (Appendix 5C), direct employment from this level of activity would be 714 people. Using an employment multiplier of 1.25 for the mining industry (Logsdon et. al. 1977) the total employment effects would be in the range of 900 people).

5. Fiscal effects

No information is available on potential fiscal effects.

6. External benefits and costs

Some of the potential negative effects include a decrease in environmental quality and depletion of a non-renewable resource.

Table 5-3
Estimated Current and Potential Economic Effects Of Base Metal Mining

	Producers Benefits (Millions $/year)	Income (Millions $/year)	Employment (Person-Years)
Current Activity	Current activity is a by-product of Placer Operations. Economic effects not calculated.		
Potential Activity	12.0	700.0	900

Dry Creek, Delta Belt, Cleary Hill and Gilmore Dome assumed to be in production.

III. INDUSTRIAL AND STRUCTURAL MATERIALS

A. Current Industrial and Structural Materials Activity

Currently, there are seven sand and gravel operators in the Tanana Basin, working from private and state gravel pits. In 1981 one million tons of sand and gravel were mined for landfill, construction and road building projects in the Basin (Bundtzen, et. al. 1982). In addition, the Browns Hill basalt quarry supplied the local area with about 340,000 cubic yards of high quality rip rap, D-1 road metal (i.e., gravel), ballast material and crushed fill. There were also 25 personal use permits issued for 100 cubic yards of gravel each. Tailings are also an important by-product of gold placer mining.

1. Current Net Producers Benefits

From interviews with local producers, gross revenue for the industry was estimated to be $18.5 million. If it is assumed that industry profits amount to about 5 percent of gross revenue, then current net producer's benefits are about $925,000 per year. The net present value (NPV) of $925,000 over a 20 year period, given a discount rate of 10%, is $7.9 million dollars.

2. Current Net Consumer Benefits

If no sand or gravel were available within the Basin, gravel would probably be imputed by rail. The difference in cost was not available, but it probably represents substantial savings for Basin residents to have a local supply of this important commodity.

Personal use gravel permits resulted in $12,500 worth of consumer benefits, assuming that each of the 25 people who received permits acquired 100 cubic yards of gravel worth $10 per cubic yard. (DNR, 1982.) This amount does not take into account the opportunity cost of the labor involved.

3. Current Income Effects

Gross revenues for the industry were estimated at $18.5 million dollars. If it is assumed that the construction income multiplier of 2.34 applies to this industry (Logsdon, et. al. 1977), then the indirect income effects would amount to about $25 million dollars for a total income effect of $43 million dollars.

4. Current Employment Effects

From information collected from industry representatives, the employment in the industry was estimated at 198 people for an average of seven months per year, or a total of 116 person-years. Using the employment multiplier for the construction industry of 3.53 (Logsdon, et. al., 1977), the total direct and indirect employment effects are roughly 410 people for the Basin's sand and gravel industry.

5. Current Local Fiscal Effects

Miners located within organized boroughs and/or towns will be liable for real property taxes on buildings and patented claims as well as personal property. They may also have an effect on service costs, such as road maintenance. However, information was not available on the exact fiscal effects.

6. Current External Costs and Benefits

Gravel pits take a long time to revegetate. Consequently, erosion and other problems are commonly associated with the area, as well as a decrease in the scenic quality of the vicinity.

Many abandoned gravel pits have been transformed into mini-recreation areas for swimming, fishing and sport shooting. ADF&G has stocked fish in many of the lakes that form in the gravel pits. These are positive benefits.

B. Potential Industrial and Structural Materials Activity

Predicting potential activity in the sand, gravel and stone sector is an uncertain exercise at best. The major factors which would greatly affect production activity beyond current levels include:

a. The total length and standard of roads to be built in the Basin.

b. The possible extension of the Alaska Railroad to Delta, the Canadian border, or to the Red Dog or Bornite area in the Northwest.

c. The possible construction of the proposed gas pipeline.

Because of the uncertainty of these endeavors happening in the near future, a conservative scenario is presented which is the continuation of the current production levels. If one or more of the above projects are undertaken, the economic impact from the sand, gravel and stone industry would easily double and would probably triple or quadruple.

IV. COAL AND PEAT

Coal from the major fields in the Tanana Basin (i.e. the Nenana field and the Jarvis Creek field) is of a subbituminous rank which places its heat content in BTU's per pound between 8,300 BTU's and 13,000 BTU's. Proven reserves and indicated resources from the Nenana coal field are estimated to be 861.6 million and 6 billion tons respectively. Jarvis Creek's proven reserves and indicated resources are estimated to be 300,000 and 76 million tons respectively (Bundtzen, et al., 1982).

A. Current Coal Activity

The Usibelli Coal Mine near Healy is currently the only active coal mine in the state. The mine annually produces 800,000 tons of subbituminous coal from the Nenana coal field. Most of the coal is consumed by power plants. However, a small quantity (roughly 20,000 tons) is annually consumed for direct space heating needs. All of the current production is consumed in the Tanana Basin.

Upon completion of an export facility at Seward, the Usibelli operation will begin to export coal under a 10-year, 8-million-ton contract with Sun Eel, a Korean based firm. Completion is estimated to be sometime within the next two years, at which time the production at Healy is expected to double to 1.6 million tons to meet an export schedule of 800,000 tons annually. (MIRL, 1982)

1. Producers Net Benefits

Coal is currently selling for about $22 per ton to power plants with longterm contracts. This puts Usibelli's gross revenues in the range of $17.5 million. Usibelli Coal Mine profits were estimated at 5% of gross revenues, based on the profits of mines of similar size as listed in Standard and Poor's Index. This puts producer's net benefits from coal production in the Basin at about $875,000 annually. If it is assumed that Usibelli's contract for the export of coal is for roughly the same price per ton as domestic coal contracts, then when shipment commences, earnings can be expected to double to $1.75 million.

2. Consumers Net Benefit

Consumers save in two ways from the use of coal: a) in power generation and b) in space heating costs.

a) Power generation

Currently, roughly 75% of the Basin's electric power is generated by coal. For power generation in the

Basin, oil would be the most likely alternative to coal. Power utilities, which are the largest consumers of coal, use roughly 125 gallons of oil to generate one MWH compared to roughly 0.8 tons of coal to generate one MWH. Average price contracts are roughly 80¢ per gallon for fuel oil and $22 per ton for coal. These figures work out to 12.5¢ per KWH for fuel oil and 2.2¢ per KWH for coal (Community Research Center, FNSB, 1981). For civilian power generation facilities, switching to oil would require the consumption of 46.9 million gallons of fuel oil at an added cost of $30.9 million dollars (Appendix 5-D). This amount is "saved" by burning coal.

Adding military power plants at Ft. Wainwright, Eielson A.F.B. and Clear Early Warning Missile Station, and the University of Alaska's physical plant (which are coal-fired facilities), the consumers benefit from burning coal as opposed to oil for power generation more than triples to $80.3 million (Appendix 5-D). The net present value of this figure over a twenty year period at a 10% discount rate is $684 million.

b) Space heating

Approximately 20,000 tons of coal (3% of total production) are used for space heating in the Basin (Louis Berger and Associates, 1982). If delivered fuelwood were substituted for coal in space heating applications, consumers would pay an additional $2.1 million annually for an equivalent amount of heat (see Appendix 5-E). The net present value of this over twenty years at a 10% discount rate is equal to $17.9 million.

3. Current Income Effects

The Usibelli Mine's gross revenues for 1981 amounted to about $17.5 million dollars. Using an income multiplier for the mining industry in Alaska of 2.93 (Logsdon, et. al., 1977), the total income effects are roughly $51.3 million dollars.

4. Current Job effects

At present, the Usibelli Coal Mine employs 100 people. The employment multiplier for the mining industry in Alaska is estimated to be 1.25 (Logsdon, et. al., 1977). Total employment effects in the Usibelli operation then are approximately 125 people.

5. Fiscal Effects

No information was available concerning fiscal effects.

6. External Benefits and Costs

The Usibelli Mine is a strip mine. This type of activity contributes to soil erosion and scenic degradation. However, Usibelli is attempting to revegetate the site and it is often mentioned that Dall sheep are common in the area despite the level of activity. Depletion of a non-renewable resource is also a cost.

Import substitution is a major positive external effect.

B. Potential Coal Activity

Future coal production scenarios are primarily dependent on the supply and demand for coal and the financial feasibility of the expansion of coal mining activity. As dicussed earlier, there are two coal fields in the Tanana Basin: the Nenana field and the Jarvis Creek field.

The growth of the domestic market is contingent on a number of factors including: 1) per capita power consumption trends; 2) grid expansion of electric utilities using coal-fired power generation facilities; 3) population growth and 4) the cost of coal relative to suitable alternatives.

In the Fairbanks North Star Borough, the per capita residential power consumption from 1979 to 1981 decreased at an annual rate of 4.6% (FNSB Community Research Center, 1982).

It is not known whether any of the utilities operating coal-fired generators are planning an expansion of service area at this time. With lands becoming available through disposal programs in rural areas, it is likely that the grids of the electric utilities will eventually expand to cover a larger market area as these regions become economically feasible to serve.

The population of the area served by the coal fired utilities is expected to grow in the Basin at 2.7% annually through the year 2000, when the population is forecasted to be 95,000 (DNR, DRD, 1982). Assuming that the current per capita coal consumption of 14.5 tons remains constant and also that the majority of the increases in gross power demand in the coal-fired utility service area are met by increases in coal consumption, the forecasted consumption will be roughly 1.4 million tons by the year 2000.

The costs of coal relative to other energy sources plays an important role in the local consumption of coal. Currently, power generated by coal fired utilities cost $.02 per KWH to produce as compared to oil-fired plants which produce power at a cost of 12.5¢ per KWH (Community Research Center, 1982). Therefore, coal remains very attractive.

Factors which could have a significant impact on the attractiveness of coal for both power generation and space heating include: 1) the cost of Susitna Hydropower; and 2) the possibility of inexpensive gas from the North Slope for space heating and power generation in the Fairbanks region.

If these two developments either do not occur or are significantly cheaper than current coal-generated electric power, then it can be concluded that a modest growth in domestic coal consumption can be expected.

For space heating, the demand for inexpensive coal could increase due to both high prices for oil and electric heat and the growing demand for a limited supply of fuelwood close to Fairbanks. The operator of the Coal Bunker contends that this market is growing 5% annually. However, if all fuelwood users switched to coal, current production would be increased by an almost insignificant 2% (since so much of the demand is for power generation) (See Appendix 5F). Therefore space heating is not expected to be a major factor in future production.

Commercial use of coal for space heating is not expected to grow much within the near future for several reasons. First, the cost advantage of coal over alternatives is still not great enough to compensate for the high initial costs and maintenance costs of coal heating systems. Secondly, it is necessary to have a large space to heat and there are not many large structures being built in the Basin and the large structures being built now and in the future will be increasingly energy efficient. Thirdly, the widely varying quality of coal presents problems for equipment.

In summary, the largest consumers of coal within the state is expected to be power plants. Space heating is not expected to require more than about 6% of total coal production (currently, space heating uses 4%). Unless Susitna Power or North Slope gas are more attractive sources of power, then coal consumption is expected to increase. The range for the increase is likely to be somewhere between the current level of demand of 800,000 tons and the per capita forecasted demand of 1.4 million tons.

Foreign demand has the greatest potential for expanding the coal production in the Basin. The Usibelli Coal Mine currently has an 8-million-ton, ten-year contract with Sun Eel, a Korean-based firm, and is also in the process of negotiating a contract with another foreign firm for an unspecified quantity. Export of the Sun Eel coal is not expected to begin until the coal export facility that is currently under construction in Seward is completed.

With the current world's oil reserves expected to diminish early in the 21st century some believe that the world will experience another world energy crisis between the years 1985 to 1995. Diamond Alaska and Placer-Amex (Beluga Coal Company) are currently proceeding with plans to develop the Beluga Coal field. Diamond Alaska believes that an export market as large as 13 million tons per year could be developed. Placer-Amex is projecting an annual production of 10 million tons for export as early as 1990. Although these developments are outside the Tanana Basin, the fact that these companies are actually investing for the purposes of exporting millions of tons of coal (as early as 1990) means that they seriously believe that such foreign markets will be found. With such development it is likely that the Usibelli Mine will capture part of the expanded foreign markets.

In addition to supply and demand, financial feasibility will play a major role in determining future production. The Usibelli Mine is currently expanding its production. This expansion of production is a concerted effort to use up idle capacity. Estimates from a Usibelli mining engineer and from the Mineral Industry Research Lab (MIRL) place the current annual capacity of the Usibelli operation at 2.0 to 2.2 million tons per year. Current production of 800,000 tons per year utilizes 36% of this capacity. The Sun Eel contract will increase utilization to almost 75% of capacity.

If and when production reaches capacity, many decisions will have to be made by Usibelli as to the path the company is to follow. The decision to expand or not, and if so, then by how much, will have the greatest impact on coal production in the Basin. Some of the factors which will probably enter into the decision process include interest rates, cash reserves, longterm contract possibilities, etc.

Jarvis Creek's potential will also rest on such factors as home space heating needs and possible construction of a coal-fired power plant in the area. The minimum size of coal-fired plants is about 1000 KW (Frank Abegg, MUS, Fairbanks) and this is probably larger than what is currently needed. However, as agriculture, settlement and mining develop the upper Tanana, the demand for power will increasingly make a coal-fired power plant more attractive, provided that the expense of transmission lines is not prohibitive.

THE SCENARIOS

Low Production - Current production level including the Sun Eel contract (1.6 million tons/year total). No production at Jarvis Creek.

Medium Production - Usibelli production at capacity of 2.2 million tons/year. Jarvis Creek producing 30,000 tons/year.

High Production - Doubling current capacity to 4.5 million. tons/year. Jarvis Creek producing 50,000 tons/year.

a. Potential net benefit to local producers

Low Scenario - Operating at 75% of capacity is not as profitable as operating at 100% capacity. The profit margin was assumed to be equal to the average value of the profit margins of coal mining companies of similar size which are listed in Standard and Poors Industrial Index (average net profit 5% as a percentage of gross revenue). This figure when applied to the low scenario, yielded a producers benefit of roughly $1.75 million dollars.

Medium Scenario - Operating at 100% capacity was assumed to improve the profit margin by 1% to 6%. Under this scenario $2.8 million dollars is an approximate value for producers surplus.

High Scenario - Operating at 200% of current capacity would, at 6% profit margin (as a percentage of gross revenue) yield a profit $5.7 million dollars.

b. Potential net benefits to consumers

Because the total quantity of coal on the domestic market is not expected to change significantly, regardless of the scenario, the price of coal will most likely increase at a real rate of about 2% per year (the average price inceases over the last several years). The consumer savings resulting from burning coal compared to alternative energy sources is expected to increase in the coming years, making coal increasingly attractive.

However, if the Susitna Dam is constructed or if gas is piped down from the North Slope to Fairbanks, the consumers net benefit from the use of coal could decrease.

c. Income effects

Low Scenario - Gross revenues of $35.2 million would result in an income effect of roughly $103 million.

Medium Scenario - Gross revenues of $48 million would result in an income effect of roughly $142 million.

High Scenario - Gross revenues of $95 million would result in an income effect of roughly $278 million.

d. Employment effects

Low Scenario - 100 people employed directly, 25 people indirectly.

Medium Scenario - 125 people employed directly, about 30 people employed indirectly.

High Scenario - 200 people employed directly, 50 people employed indirectly.

e. Externalities

Large amounts of land would be strip mined, causing possible erosion and disruption of scenic beauty.

Import substitution is a positive externality.

Table 5-4
Current and Potential Economic Effects from Coal Mining

	Producers Benefits (Millions $/year)	Consumers Benefits (Millions $/year)	Income[1] Effects (Millions $/year)	Employment Effects (Person Years)
Current Activity	0.9	83.2	51.	125
Potential Activity				
Low Scenario	1.8	N.A.	103.	125
High Scenario	5.9	N.A.	278.	250

N.A. = Not Available
[1]Rounded to nearest $1 million

C. Current Peat Activity

Peat resources in the Basin are estimated at roughly 24 billion cubic yards, however, much of this is frozen and none is considered fuel grade. This figure was arrived at from estimates of non-fuel grade peat acreages from the Peat Resource Map of Alaska, (Rawlinson and Hardy, 1982).

Peat is currently being mined commercially by five firms in the Tanana Basin. The largest of these producers mines an estimated 5,000 cubic yards annually. From interviews with local producers, the entire industry's output was estimated at 10,000 cubic yards. Most of this peat is used for landscaping purposes, but a small quantity is used for agricultural and horticultural purposes. None of the peat is used for fuel.

1. Producers Benefits

Peat is currently selling for $12 per cubic yard. Thus revenues are in the range of $120,000. If the peat industry has a 5% profit margin, then net benefits to peat producers would be about $6,000.

2. Consumers Net Benefits

Peat produced locally sells for $12 per cubic yard. Since there is no similar substitute it must be compared with imported peat. About 10,000 cubic yards of peat are consumed annually. Assuming that consumers would buy an equal amount of imported peat if a local supply did not exist, they would have to pay $400,000 (imported peat, sells for about $40 per cubic yard). Thus, consumers are saving about $280,000 through th use of locally produced peat.

3. Income Effects

For the peat industry, gross revenues for 1981 amounted to about $120,000. If the mining income multiplier is applied, the peat industry's total income effect is about $351,600.

4. Employment Effects

The peat industry currently employs six people seasonally. If the mining employment multiplier is applied to the peat industry, it is expected that 8 seasonal jobs result from the existence of the peat industry, or about 3 person-years.

V. OIL AND GAS EXTRACTION

Oil and gas extraction covers three phases; exploration, development and production. All three are treated in this chapter. Exploration was not separated out as in the preceding chapters, because it is readily identifiable and solely related to oil and gas activities.

A. Current Oil and Gas Activity

As of August 1982, an oil and gas lease has been in effect for part of a 921,000 acre tract of state land west of Nenana. Prior to this lease, the only other related activity in the basin was a well drilled in 1961 (in the vicinity of the present lease area) which was dry.

1. Current Net Producers Benefits

Currently, the annual rent for all tracts leased in Oil and Gas Lease Sale No. 37, is $165,000. There are no positive cashflows to offset this liability, but tax incentives do offset this amount.

2. Current Net Consumer Benefits

Since there is currently no production there are no current benefits to consumers.

3. Current State Net Benefits

The net benefit to the state can be calculated as the monies from the lease bonuses and rental fees minus the cost associated in the leasing of the land.

The range of cash bonuses for Sale No. 37 was between $5 and $30 per acre. Yearly rental rates are $1 per acre the first year rising to a maximum of $3.00 in the fifth year. Roughly 165,000 acres in 36 tracts were leased (DMEM, 1982). Since bonuses only accrue if production ensues, income to the state from rental fees is estimated at $165,000 for this year.

The cost of state administration is not known.

B. Potential Oil and Gas Activity

Projecting the potential impacts of oil and gas development in the basin is an uncertain exercise since the location, type and magnitude of potential development activity cannot be determined precisely. Therefore, it is necessary to speculate about the most likely course of events, based on available information concerning the geology of the area and other factors that may influence future development.

The potential oil and gas related economic activity in the Tanana Basin is indicated by the following: 1) four firms entered into leases with the State in Lease Sale 37[1]; and 2) petroleum and economic geologists are of the opinion that there is a low probability of commercial quantities of oil or gas in the Tanana Basin.

It seems likely that at least three shallow exploratory wells will be drilled in the Basin over the course of several years. The targeted petroleum bearing structures are of medium depth and an average well could be completed within 90 days

1. Potential Benefits

Due to the many unknowns, it is not possible to estimate benefits and costs of oil and gas at this time. It should be noted that there is potential, but more exploration is required before reasonable forecasts can be made.

2. Potential Income Effects

Roughly $6 million dollars can be expected to be expended for these three drilling operations. If the income multiplier for the oil and gas industry of 2.87 is used (Logsdon, et. al., 1977) then the expected income effects are estimated to be $17.2 million dollars (DMEM, 1982.)

3. Potential Employment Effects

Three exploration wells are each expected to employ 50 people for a four month period. Total direct employment would be 600 person-months or roughly 50 man-years.

[1]Brock, Burglin, Shell & Arco leased 36 tracts in the fall of 1982.

Logsdon, et. al., (1977) set the oil and gas industries employment multiplier at 1.19. If this is applied to the direct employment figures, then the expected total employment effects should be in the range of 60 man years. These employment effects have an expected life of from one to three years.

4. Potential Local Fiscal Effects

Unknown

5. Potential External Costs and Benefits

Some of the likely external costs and benefits include:

- non-locals hired for field crews (-)
- some local hiring for field crews (+)
- trails, access (+, -)
- abandoned camps (-)
- information on geology and heat flows of the region from drilling activity (+)
- destruction of habitat (-)
- creation of habitat (+)

VI. EXPLORATION

Exploration activity has been placed in a separate section because these types of activities are not involved in production, and so are unique in that there are no net benefits to producers or consumers. Also exploration may be for several kinds of minerals at once.

Most of the data used in this section came from the section on exploration in the eastern interior developed in Alaska Mineral Resources 1981-1982, by the DGGS staff. Only those activities within the Basin were included. A detailed description of current exploration and development activity is found in Chapter 4.

A. Current Exploration Activity

The dollar value spent on exploration in the Tanana Basin (Eastern Interior) represents the highest for any region in the state (excluding oil and gas). Most of the current activity is concentrated in the Yukon/Tanana Uplands and the Alaska Range. The relative share of expenditures by commodity type is as follow for the Tanana Basin: Precious metals -- placer 43%, lode 16%; base metals 39%; coal and peat 2%. The total amount spent in 1981 was estimated at 13.5 million.

1. Current Producers Net Benefits

As there is no current production from these exploration activities, the net benefits to producers can be described as negative (the cost of exploration). However, the information gathered as a result of these activities is assumed to be of at least an equivalent future value to potential producers, on the average. Consequently the net benefit is considered positive but not quantifiable.

2. Current Consumers Net Benefits

Since there is no production, there are no direct benefits to consumers.

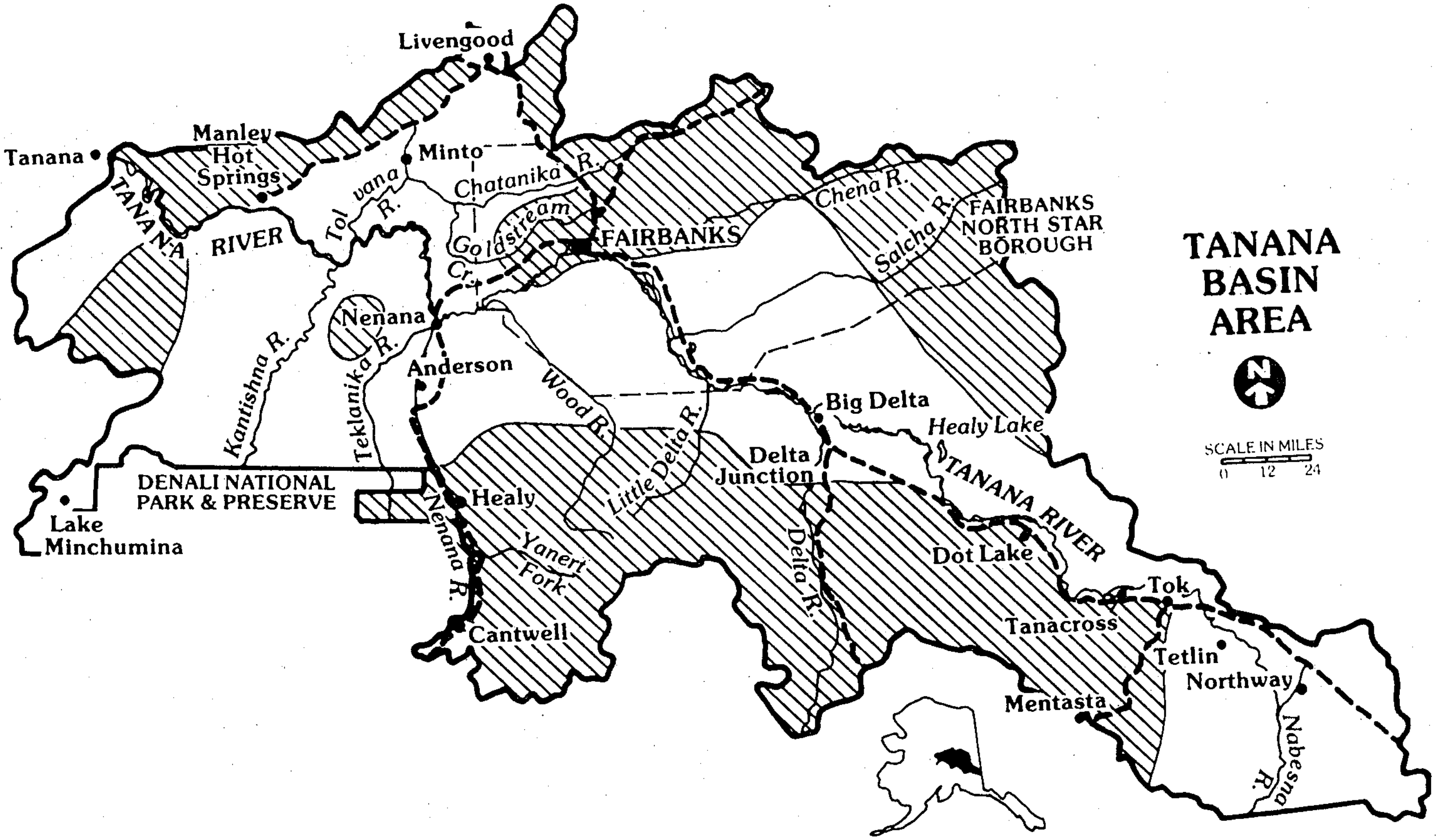

FIGURE 5.1 Areas of Active Exploration in the Tanana Basin

3. Current Net Benefits to the State

The state receives fees from miners for exploration permits. The state also incurs costs for monitoring exploration activity. The net effects are assumed to be small.

4. Income Effects

If expenditures are treated as revenues then the total income effects are estimated to be $13.5 million direct effects and $39.4 million indirect, using the mining income multiplier of 2.93.

5. Employment Effects

Bundtzen, et. al. (1982) estimated employment for the "Eastern Interior" to be above 552 on exploration. A rough estimate of employment within the Basin is 500. An estimated 75% of this is assumed to be seasonal (6 months). Thus there are about 310 person-years of direct employment and 80 indirect jobs, for a total of 390 person-years of employment due to exploration in the Basin.

6. External Costs and Benefits

The same as for oil and gas exploration (See Section V).

B. Potential Exploration Activity

Major new mineral finds (e.g. massive sulfides in the Fairbanks area) could spur large exploration expenditures, but for the purposes of this analysis, a similar level to the current activity was assumed for the potential scenario.

See current exploration activity for potential economic effects.

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[1]Adjusted from Bundtzen, et. al., (1982) which indicated that employment for the "Eastern Interior" was about 552 in exploration. A rough estimate of employment within the Tanana Basin is 500.

VII. NONMETALLIC MINERAL ACTIVITY

A. Current Nonmetallic Minerals Activity

There currently is no nonmetallic production activity in the Basin.

B. Potential Nonmetallic Minerals Activity

Currently agricultural grade limestone is being examined in the Canwell Glacier area for use at Big Delta. However, the potential benefits of this activity are unknown at the current time.

VIII. SUMMARY

Currently, precious metals, industrial and structural materials, coal and exploration activities have the largest economic impact. These activities generate an estimated $6 million in benefits to producers, $155 million in income and over 800 jobs [out of an estimated 22,000 person-years of employment available in the Basin (DNR, DRD, 1982)]. Gold generates most of the producers benefits and the largest income effect, while exploration may generate the most employment. (See Table 5-4).

The present value of these activities is shown in Table 5-5. This table is intended to be used to compare the economic effects of the different resources. Unfortunately, much of the information necessary to complete Table 5-5 was not available. This table includes some general statements on possible external (or nonquantifiable) benefits and costs which should also be kept in mind when making comparisons.

Table 5-6 presents a summary of the estimated potential effects of mining. These estimates are not intended to be used as absolute measures. They are estimates intended to show the potential of the mining industry in the next 20 years.

These estimates do indicate that the principal expected change is the addition of major base metal mining to the gold, sand and gravel and coal activities which have been the basis of the industry for the last several decades. Base metals could become the most important commodity in terms of economic impact, considerably increasing producers benefits, income and employment. Gold, sand and gravel and coal also have considerable potential for expansion.

Table 5-5
Summary of Current Economic Effects of Mining in the Tanana Basin

Mining Activity by Commodity	Producers Benefits (Millions $/year)	Income (Millions $/year)	Employment (Person-Years)
Precious Metals	4.4	64.0	140
Industrial and Structural Commodities	0.9	43.0	410
Coal	0.9	51.3	125
Exploration and Development Activities	--	39.4	390
Total	6.2	197.7	1,065.0

TABLE 5-6
ESTIMATED CURRENT ECONOMIC EFFECTS OF MINING IN THE TANANA BASIN

	NET BENEFITS									DIRECT & INDIRECT INCOME EFFECTS	DIRECT & INDIRECT EMPLOYMENT EFFECTS	NET FISCAL EFFECTS ON LOCAL GOVERNMENTS	EXTERNAL COSTS AND BENEFITS
	TO PRODUCERS		TO CONSUMERS		NET RETURN TO THE STATE		TOTAL		VALUE PER ACRE				
	MILLIONS $/YEAR	PRESENT VALUE (a) OVER 20 YRS	MILLIONS $/YEAR	($ MILLIONS) PRESENT VALUE OVER 20 YRS	(+) $/YEAR	(±) PRESENT VALUE OVER 20 YRS	$/YEAR	PRESENT VALUE OVER 20 YRS	$/ACRE	MILLIONS $/YEAR	PERSON YEARS	(+) $/YEAR	
Precious Metals	4.4	37.5	N.S.	N.S.	N.A.	N.A.	N.A.	N.A.		64.0	140	N.S.	See text
Industrial and Structural Materials	0.9	8.0	N.A.	N.A.	N.A.	N.A.	N.A.	N.A.		43.0	410	N.A.	See text
Coal	0.9	7.6	83.2	676	N.A.	N.A.	N.A.	N.A.		51.3	125	N.A.	See text
Exploration and Development	NOT APPLICABLE		NOT APPLICABLE		N.A.	N.A.	N.A.	N.A.		39.4	390	N.A.	See text
TOTAL	6.2	53.1	N.A.	N.A.	N.A.	N.A.	N.A.	N.A.		197.7	1065	N.A.	

N.S. = Not significant.
N.A. = Not available.
(a) Discounted at 10%. Present value assumes current production remains constant. But as explained in the text, current production is expected to increase for all commodities. Therefore, this is only a minimum estimate (see Potential Benefits).

Table 5-7
Summary of Potential Economic Effects of Mining in the Tanana Basin

Mining Activity by Commodity	Producers Benefits (Millions $/year)	Income (Millions $/year)	Employment (Person-Years)[a]
Precious Metals			
Placer	6.4	94.	220
Hardrock	1.6	19.	30
Total	**8.0**	**113.**	**250**
Base Metals	12.0	700	900
Industrial and Structural Materials[b]	0.9	43	145
Coal			
Medium Scenario	2.9	142	155
Total	**24[c]**	**998**	**1400[d]**

[a]Rounded to nearest 10 person-years.
[b]Current effects are shown as a minimum estimate.
[c]Rounded to nearest $1 million.
[d]Rounded to nearest 100 person-years.

Chapter 6

Management Recommendations

I. STATEWIDE GOALS AND THEIR IMPLICATIONS FOR MINERALS MANAGEMENT IN THE TANANA BASIN

A. Introduction

The preceding chapters describe existing and expected production of minerals and the likely economic benefits of mineral production. These analyses, together with the goals for minerals laid out in the FY83 Statewide Natural Resources Plan, form the foundation for the minerals management recommendations that follow.

B. Relationship of Statewide Mineral Goals to the Tanana Basin

The Statewide Natural Resurces Plan is the broadest of the plans developed by the Department of Natural Resources. It provides the context for the area plans, such as the Tanana Area Plan, by setting forth goals and objectives for each resource. The Statewide Plan is used in formulating ADNR's budget and setting inventory and planning priorities.

1. Statewide Goal: Economic Development

Develop mineral and energy industries which will provide stable and diverse job opportunities, increase per capita income, increase local tax revenues and stimulate growth of the industry.

Historically, the Tanana Basin has been a very productive mining area in the state. Today, mining remains a very important industry, employing approximately 1065 people and generating an estimated $200 million in income.

Because of the importance of mining in the Tanana Basin in both the regional and the statewide economy, areas should remain open to mineral entry unless there is overwhelming evidence to indicate that an area should be closed. Areas which are currently producing large quantities of minerals should have minerals designated primary use.

2. Statewide Goal: Mineral and Energy Supplies

Develop coal and geothermal resources to contribute to the energy supply of the U.S. and Alaska. Develop metallic and industrial mineral resources to contribute to the industrial needs of the U.S., particularly critical and strategic minerals.

Much of the state land in the study area is known to have high or moderate potential for minerals. The Tanana Basin is currently producing an estimated 55,000 ounces of gold, 1.6 million tons of coal and over one million tons of sand and gravel each year. This represents a large percentage of total state production of each of these commodities.

Because of the importance of the Tanana Basin in supplying minerals and energy, designation of land for mineral use and leaving land open to mineral entry must be a high priority.

3. Statewide Goal: Revenue Base

Establish a stable source of revenues to assist the state in meeting the public needs of people of Alaska in the decades following the decline of Prudhoe Bay production.

Through continued production and development of minerals, the Tanana Basin can make a significant contribution to the local and state revenue base. Every effort should be made to encourage and protect mineral entry and development in this region.

4. Statewide Goal: Environmental Quality and Cultural Values

Maintain existing environmental quality and cultural values.

Mineral development is not incompatible with protecting environmental and cultural values. Mineral exploration and development, when conducted in accordance with existing regulations and plan guidelines, will not cause undue harm to these important values. In almost all cases, compromises can be worked out which allow development to take place while protecting the environmental quality and cultural values of the Tanana Basin.

II. MANAGEMENT RECOMMENDATIONS

A. Recommendations for Designations

1. Designate Active Mining Areas and Areas of Very High Potential Primary Use Minerals.

On these high value areas, minerals should be at least a coprimary use. All of the areas designated on Alternative 4 as 501, 601, 602, 603, and 607 have both very high mineral potential and high levels of historic and current production. The following guidelines are proposed for the management of these lands:

a. Land disposals should be few and small in nature.

b. Land sales should not proceed without careful design to avoid mining claims and mineral concentrations.

c. These areas should remain open to road development.

d. Timber harvesting, material sales, agricultural leases, trapper cabins, remote cabins, commercial leases, grazing and habitat enhancement would be allowed after consultation with DMEM.

2. Retain Areas of High Mineral Potential in Public Ownership and Open to Mineral Entry.

Areas are designated as 502 or 605 on Alternative 4 have known potential for minerals but generally few active claims. On these areas, minerals should be a secondary use and the area should be left open to mineral entry. The following guidelines are proposed for the management of these lands:

a. These areas should be left open to mineral entry. Land sales may be permitted with consultation of DMEM, but they should be small and their design should take mining claims and mineral values into account.

b. Large project agricultural sales would not be acceptable in these areas.

c. Trapper cabins and remote cabin permits would be acceptable, as would timber harvesting, material sales, grazing and road development. Scattered small tracts may be acceptable with DMEM consultation.

3. Whenever Possible Leave Areas Open to Mineral Entry.

Other areas should not be closed to mineral entry unless irreversible damage would be done to a scarce or very valuable surface resource. Areas designated for disposal will be closed to mineral entry during the LADS disposal process. The following management guidelines would apply to these undesignated lands:

a. These areas should be left open to mineral entry because their mineral potential is as yet largely unknown.

b. If there is an overriding concern regarding another resource or if the area is of very high value for disposals, a mineral closure may be acceptable. However, prior to closing an area, all possibilities for leaving it open to leasehold location should be pursued.

c. These areas should be left open to coal prospecting and leasing and to oil and gas leasing unless there is an overriding concern for the protection of another resource.

Appendices

APPENDIX 4A

GEOGRAPHY AND GEOLOGY OF THE TANANA BASIN

Geography

The Tanana River or 'River of the Mountain Men' as it was known to Indians and early explorers, flows 440 miles from the confluence of the Nabesna and Chisana Rivers northwest to the Yukon River. The 35,000 mi^2 drainage basin is bounded on the south by the Alaska Range, on the north by a hydrologic divide with the Yukon River, and on the west by a low hydrologic divide with the Kuskokwim Mountains. The study area lies in four physiographic provinces: the Alaska Range, Tanana River lowlands, Yukon Tanana Upland, and the Kuskokwim Mountains (Wahrhaftig, 1965). The legal boundary of the study area omits a significant portion of the Tanana drainage basin: hence we have included the Kantishna Hills in this summary.

Bedrock Geology

Yukon Crystalline Terrane

About three-fourths of the bedrock underlying the Tanana Basin can be assigned to the Yukon Crystalline Terrane, a polymetamorphic-igneous-complex ranging in age from Precambrian to upper Paleozoic (Foster and others, 1973). This large unit underlies portions of all four physiographic provinces, including the Tanana River lowlands where it is deeply buried by Quaternary fill. The southern boundary of the crystalline rocks lies just north of the Denail Fault, a fundamental geologic feature that separates the metamorphic sequence from younger largely unmetamorphosed rock units on the south. Originally known as the 'Birch Creek Schist,' the Yukon Crystalline Terrane has been subdivided into at least five distinctive lithologic packages that differ in metamorphic history, genesis, and age. Recent work in the Kantishna Hills, north-central Alaska Range, and Fairbanks areas by both industry and DGGS have shown that certain metamorphic sequences are mineralized and host numerous metal deposits. Some of these will be described in the mineral resources section.

Precambrian-Mesozoic Sedimentary and Minor Volcanic Rocks

In the western portion of the Yukon Tanana Uplands near Livengood, relatively unmetamorphosed sedimentary and minor volcanic rocks are tectonically juxtaposed to the Yukon Crystalline Terrane. These rocks range in age from late Precambrian to Cretaceous and consist of sandstone, limestone, shale, chert, greenstone, and minor ultramafic intrusions.

Similar rocks (but not related) occur south of the Denali Fault in the Alaska Range from Cantwell eastward to the Clearwater Mountains. Altered basalt, andesite, and some sedimentary rocks of Permian, Triassic, and Jurassic age underlie much of the Clearwater Mountains-Paxon Mountain area. Some metamorphic rocks also occur south of the Denali Fault but are believed by most geologists to be unrelated to those in the Yukon-Crystalline Terrane previously described.

Igneous Rocks

Granitic plutons are scattered throughout the Alaska Range (but mainly concentrated east of the Richardson Highway), and in the Yukon-Tanana Upland. These composite bodies range in composition from quartz diorite to granite and appear to average quartz monzonite in composition. Several large bodies in the Alaska Range are signatured by prominent magnetic highs. The plutons range in age from Devonian to Early Tertiary (350-60 m.y.); 90 percent crystallized during Cretaceous-Early Tertiary time (140-60 m.y.). Rare to uncommon alkalic and ultramafic dikes intrude a crystalline schists of the eastern Alaska Range (Foley, 1981). These dikes bear some interest in terms of potential for platimum and gemstones. Small felsic porphyry plugs of Late Cretaceous age in the Richardson and Livengood areas are lode sources for placer gold.

Ultramic rocks occupy a thin discontinuous belt trending from the head of the Salcha River southwest toward Wood River Butte in the Tanana Lowland. An important asbestos find on Slate Creek near Eagle (outside the study area) is hosted within this rock package.

Tertiary Sediments

Tertiary coal bearing rocks underlie several hundred square miles of the central Alaska Range near Healy and about 16 square miles in the eastern Alaska Range near Jarvis Creek. These rocks have been subdivided into several formations near Healy, but not at Jarvis Creek. However, the stratigraphic sections in both fields is similar and can be subdivided into three major members: a basal portion of micaceous sandstone and conglomerate, middle units of arkosic sand, coal, and lacustrine silt, and upper units of claystone, sandstone, and thin coal seams (Wahrhaftig, 1968). All coal bearing rocks range in age from Miocene to Pliocene. They are believed to underlie at least portions of the Tanana Lowlands.

Capping the coal bearing group in both areas is aerially extensive Nenana Gravel of the late Pliocene age. Carter (1981) has suggested that portions of the Nenana gravel are outwash or till deposited by a late Tertiary glaciation.

Pleistocene-Holocene Geology

Pleistocene glaciation took place in much of the Alaska Range but is absent in most of the Kuskokwim Mountains, Tanana Upland, and Tanana Lowlands. Several advances of Wisconsinan and pre-Wisconsinan ice left deposits in major north flowing streams leaving the Alaska Range (Pewe, 1975). In general, glacial deposits are progressively modified through time and landforms such as moraines, kettles, eskers, and outwash fans are absent in the oldest deposits. Glaciation is an important consideration in a regional appraisal of placer gold deposits because glacial ice tends to scour out, disseminate, or bury heavy mineral placers (Bundtzen, 1980). There are significant exceptions to this generalization.

Today the Tanana Basin is actively undergoing modification through various periglacial erosional processes. Loess; i.e., homogeneous deposits of silt, have been transported by strong winds from the Alaska Range and cover the uplands near Fairbanks with accumulations of many feet thick. Stream deposited reworked silt fans and slope deposits fill valley bottoms. Thick accumulations of Sphagnum peat cover poorly drained lowlands. Hugh alluvial fans extending north from the Alaska Range have buried the Tanana Lowland, a deep structurally controlled trough. Many of the stream valleys in the Fairbanks, Livengood, Manley, and Richardson areas contain gold bearing gravel deposits in ancient stream deposits. The gravels vary in thickness and are often overlain by younger sediments such as reworked silt, peat, and sand termed 'muck overburden.' The Fairbanks district is well known for extensive dredging operations of these gravels---described in the mineral resource section.

Altiplanation terraces, stone polygons, stone stripes, and solifluction lobes are common geomorphic features in higher altitudes (_1,500 ft) on all upland areas within the basin. Thaw lakes, pingos, abandoned oxbow lakes, and thermokarst topography are common in valley fills, particulary in the Yukon-Tanana Upland. The entire region is in the zone of discontinuous permafrost. Modern day geologic "hazards" associated with these geomorphologic feature include permafrost, ground water distribution, landslide potential, hillside erosion, and flooding. Of these, permafrost is a constant engineering problem in much of the basin; failing to recognize this condition during construction projects can have dire consequences. The City of Fairbanks is built entirely on the flood plains of the Tanana and Chena Rivers. Such hazards should be important considerations for disposal of settlement, agricultural, or industrial development lands. The reader is encouraged to review an excellent summary by Pewe (1982) of these processes as they affect the general Fairbanks area.

Structural Geology

Several major folding episodes have folded pre-Quaternary bedrock units in the Tanana Basin. Much of the folding is associated with a complex history of mountain building deformation and plate boundary interactions. Young parallel high angle faults have formed 'grabens' in the Alaska Range and are responsible for the distribution of Tertiary coal bearing units. Major faults in the study area include the Tintina Fault, a major structure that forms the boundary between the Yukon-Tanana Upland and Yukon River Basin on the north, and the Denali Fault in the Alaska Range. 'Tear' faults oblique to these two parallel structures include the Shaw Creek, Minook, and Minto Faults, all of which appear to be active.

Alaska is part of the circum-Pacific seismic belt where more than 7 percent of world seismic energy is released. Even though many do not consider the Tanana Basin seismically active, nine earthquakes with Richter magnitudes exceeding 6.0 have shook the region in the last 80 years (fig. 3). A ten-year period has been well established for these large quakes. One such earthquake, the October 15, 1947 Nenana 'Shake' reached a magnitude of 7.0 and was partially responsible for cancellation of plans to build an air force base at the present site of Clear, Alaska.

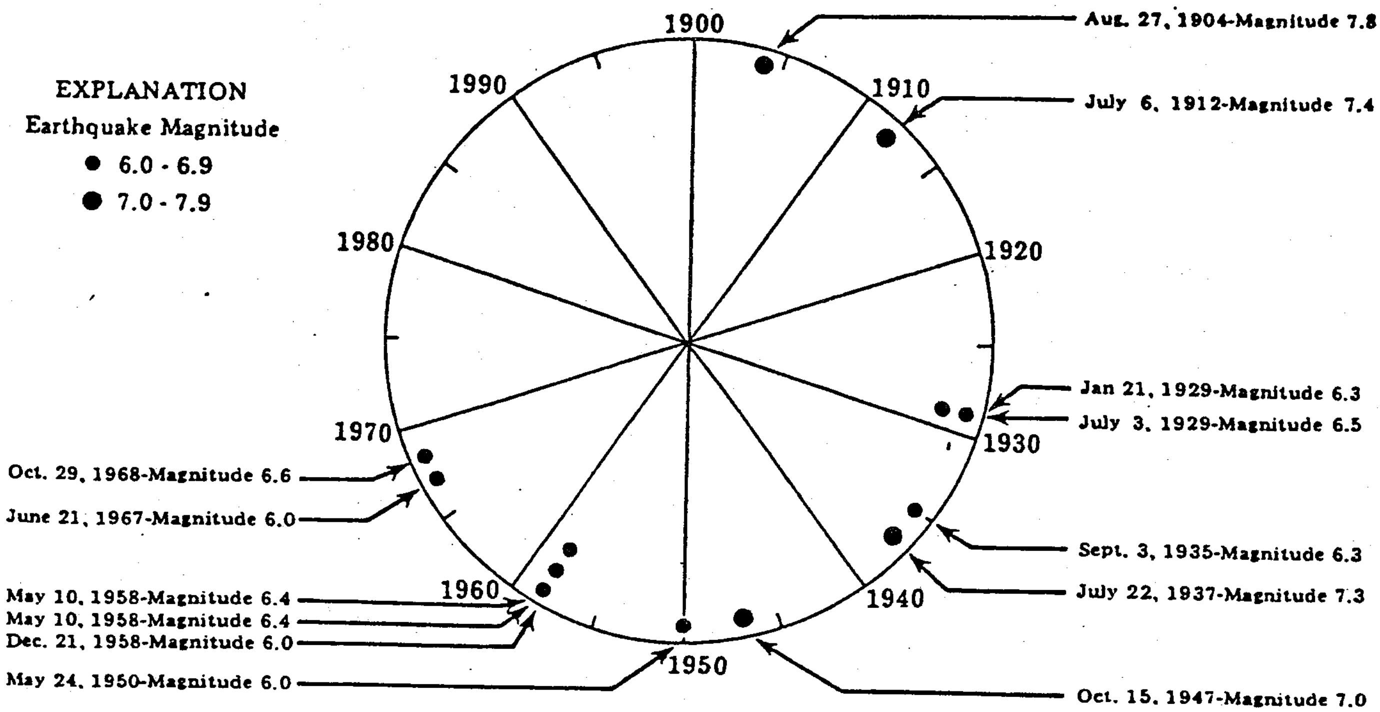

Figure 3. Earthquake periodicity in Tanana Basin, from Pewe (1982).

APPENDIX 5A

1. PLACER MINING MODEL (BOTH PRECIOUS AND BASE METALS)

The model is based on four state mining claims (160 acres) with 15 percent of the land containing placer values (24 acres). It was assumed that 15 feet of overburden ("muck") cover 10 feet of pay-gravels, containing values at $10 per cubic yard. It is further assumed that 100 $yards^3$ per hour of material are moved with 40% of being run through the sluice box. An average work day of nine hours, and 110 work days were considered the working season. The operation employs 4 people.

Capital Costs

The equipment complement consisted of the following:

		1982 Price
1	D8 CAT dozer	$349,820
1	966 Loader	182,180
	Large capacity sluice box	5,000
	Pump	3,000
	Transportation & set up	50,000
		$600,000

Revenues

The operation is assumed to use water pumped from a creek to run through the box. The D-8 dozer strips the overburden and loads the sluice box while the 966 Loader removes tailings. Clean up is once-a-week.

Given these assumptions it was figured that $400,000 in gross revenues are generated each year ($400/ounce).

100	yard^3 moved/hr
9	hr. workday
900	yard^3/day of material moved
110	workdays per season
100,000	yard^3/season of material moved
.40	percent of material run through the box
40,000	yard^3 processed gravels
10	average values/yard^3
$400,000	Gross Revenues per season

Operating Costs

Typical annual operating expenses are roughly $180,000 for such an operation, assuming that it employs 4.5 people at $20 per hour. (see following table).

Typical Operating Expenses per Year

Payroll	$80,000
Workmans Comp & Other Ins.	16,100
Fuel, Lube, etc.	25,000
Maintenance	60,000
TOTAL	$181,100/year

Profitability

If these figures represent reasonable operating costs, then a net cash flow of roughly $150,000 per year could be expected from this operation. Using a capital expenditure figure of $600,000 presented on the previous page, this operation would have an IRR of 21% over the life of this operation given stable gold prices which held the gravel values at an average of roughly $10/cubic yard ($400/ounce). This indicates that this is a good investment, and that the operation would be profitable.

If the values were $7.50 per yard^3 (assuming a drop in prices from $400 oz to $300 oz) this operation would generate $300,000 in revenue each year, which after deducting operating costs, and taxes would yield a cash flow of roughly $100,000 per year. This yields an IRR of +10.6% over the life of the mine. Under these conditions the model operation becomes only marginally feasible.

APPENDIX 5B. ALASKA TAX STRUCTURE

Taxes imposed by the State of Alaska that directly affect mining are as follows:

1. Alaska Corporate Income Tax

Alaska's corporate income tax is based on the federal tax code. Generally, income, deductions and tax credits generated within the state are treated the same as under federal tax laws. Investment tax credits are limited to 18% of the federal credit.

The tax rates are:

Taxable Income	Base Amount of Tax	Percent	of	Excess Over
$ 10,000 - 20,000	$ 100 plus	2	$	10,000
20,000 - 30,000	300 plus	3		20,000
30,000 - 40,000	600 plus	4		30,000
40,000 - 50,000	1,000 plus	5		40,000
50,000 - 60,000	1,500 plus	6		50,000
60,000 - 70,000	2,100 plus	7		60,000
70,000 - 80,000	2,700 plus	8		70,000
80,000 - 90,000	3,600 plus	9		80,000
90,000 - 1,000,000	4,500 plus	9.4		90,000
1,000,000 - 4,000,000	90,040 plus	10		1,000,000
4,000,000 or more	390,040 plus	11		4,000,000

It should be noted that Alaska has eliminated individual income taxes. Partnerships and sole proprietorships therefore do not pay state taxes on profits from mining ventures.

2. Mining License Tax

Three and one-half years after production begins, mining operations are liable for a license tax based on net income as follows:

Net Income	Tax Rate
$40,000 - $ 50,000	3%
$50,001 - $100,000	$1,500 plus 5% of the excess over $50,000.
Over $100,000	$4,000 plus 7% of the excess over $100,000.

Net income is determined by standard federal tax accounting methods. The depletion allowance is limited to 15% for metal mines.

3. Local Government Taxes

Mines located within organized boroughs and/or towns will be liable for real property taxes on buildings and patented claims as well as personal property taxes on equipment.

4. Employment Security Taxes

Employers pay a minimum of 4.9% tax on the first $14,400 of employee wages annually to the State's Unemployment fund.

APPENDIX 5C MINE MODELS

DELTA BELT MINE

ASSUMPTIONS:

Open Pit mine, 5,000 tons per day ore
Waste-to-Ore ratio 3:1
330 operating days per year
Production 448,000 tons per year of Copper-Lead-Zinc Silver concentrates
Logistics model based on "Arctic Mine" (WAATS; Janson and Bottge), and scaled from porphyry Cu - Mo mine model (Table 3.1 - 2.9)
228 employees

SUPPLIES:

Explosives @$0.75 lb/ton Ore and Waste			
0.75lb. x 20,000 T/Day x 330 Days/Yr. / 2,000	=	2,475	Tons
Tires @ 20% of Cu - Mo mine			
0.2 x 411 tons	=	82	Tons
Lube and Grease @ 20% of Cu - Mo mine			
0.2 x 561 tons	=	112	Tons
Repair Parts, Mine and Mill @ 20% Cu - Mo mine 0.2 x 231 tons	=	46	Tons
Overhaul/Replacement @ 20% Cu - Mo Mine	=	194	Tons
Mill Steel and liner consumption at @1.19 lb/Ton Ore			
1.9 lb x 5,000 TPD x 330 days/Yr. / 2,000	=	1,568	Tons
Reagents 0.9 lb/Ton Ore			
0.9 lb. x 5,000 TPD x 330 Days/Yr. / 2,000	=	743	Tons
Support @10 lb/employees/Day			
10 lb. x 228 Employee x 365 Days/Yr. / 2,000	=	416	Tons
Total Dry Supplies	=	5,636	Tons

FUEL REQUIREMENTS

Diesel Fuel: 65% working factor for open pit equipment		
4,200 HP @ 0.037 Gal/HP/hr.		
0.037 x 4,200 HP x 24 Hrs/Day x 330 Days	=	1,321,000 Gal.
Coal: mill @25 Kwh/Ton Ore		
25 x 5,000 TPD x 330 Days/Yr.	=	41,250,000
Support @ 7.5 Kwh/Employee/Day		
7.5 x 228 x 365	=	624,150
Total Power Requirement	=	41,874,150
@ 1,220 Kwh/Ton of coal (based on GVEA coal power generation):		
41,874,150 Kwh/Yr. / 1,220 Kwh/T	=	34,300 Tons

Source: Interior Transportation Study

DENALI AND DRY CREEK

ASSUMPTIONS:

Denali - Underground Mine, 600 Tons per day ore.
Logistical model based on Tungsten Mine Model (Table 3.1 - 2.5) and "Green Creek" Mine Model (WAATS)
330 operating days per year
Production: 34,000 Tons Zinc-Lead-Copper-Silver Gold concentrates per year

Dry Creek Equivalent to 2 Denali-Type Mines

SUPPLIES:

Dry supplies	821 Tons

FUEL:

Liquid Fuel	1,110,000 Gal.
Coal (heating and drying), if substituted for	

Propane:

Propane = 91,800 BTU/Gal.
Coal = 17.4×10^6 BTU/Ton

$$\frac{240{,}000 \text{ Gal. Propane} \times 91{,}800}{17.4 \times 10^6} = 1{,}266 \text{ Tons}$$

Source: Interior Transportation Study.

TUNGSTEN MINE

ASSUMPTIONS:

Underground Mine, 600 Tons per day Ore mined
Mine - 300 operating days per year
Mill - 500 tons per day, 7 days per week
Production: 6,540 tons of Tungesten concentrates per year
143 Employees

SUPPLIES:

Explosives @ 0.65 lb/Ton Ore			
$\frac{0.65 \times 600 \text{ TPD} \times 300 \text{ Days/Yr.}}{2{,}000}$	=	59	Tons
Tires, Lube, repair parts, drill steel (est.)	=	90	Tons
Reagents @ 316/Ton Ore			
$\frac{3 \times 600 \times 300}{2{,}000}$	=	270	Tons
Mill steel and liner consumption @ 1.32 lb/Ton	=	119	Tons
Overhaul @ 20% of Equipment wt.			
0.2 x 112 Tons	=	22	Tons
Support @ 10 lb/Employee/Day			
$\frac{143 \text{ Employees} \times 10 \text{ lb./Day} \times 365 \text{ Days}}{2{,}000}$	=	261	Tons
Total Supplies	=	821	Tons

FUEL:

Mine equipment, Diesel-powered		150,000	Gal.
Power plant (diesel) @ 80,000 gal/mo		960,000	Gal.
Propane: (Heating and Drying)			
Average - 20,000 gal/mo x 12	=	240,000	Gal.
Total Fuel	=	1,350,000	Gal.

Source: Interior Transportation Study.

APPENDIX 5D

CONSUMER BENEFITS FROM COAL USED FOR POWER GENERATION

The cost of an equivalent amount of oil was used as an estimate of the value of coal for power generation.

Cost of a coal contract = $22.00/ton[a]
Cost of an oil contract = $ .80/gallon

125 gallons of oil = 1MWH (megawatt hour)[a]
0.8 tons of coal = 1MWH (megawatt hour)[a]

A. Civilian Power Generation Facilities require 300,000[a] tons of coal to produce 375,000 MWH

Oil used to generate 375,000 MWH = 46.9 million gallons

46.9 million gallons at $0.80/gal	=	$37.5 million
Less current cost of 300,000 tons of coal at $22/ton	=	6.6 million
Savings due to burning coal instead of oil	=	$30.9 million

B. Military and University Facilities require 480,000[b] tons of coal to produce an estimated 600,000 MWH This would require 75.4 million gallons of oil.

75.4 million gallons at $0.80/gal	=	$60.0 million
Less current cost of 480,000 tons of coal	=	10.6 million
Savings due to burning coal instead of oil		$49.4 million

Total savings due to burning coal	
Civilian Facilities	$30.9 million
Military and University Facilities	49.4 million
TOTAL	$80.3 million

[a] Fairbanks North Star Borough Research Center Energy Report, 1982

[b] Estimate based on 800,000 tons total production, 300,000 used by MUS and 20,000 used for space heating.

APPENDIX 5E

VALUE OF COAL FOR SPACE HEATING

If coal were not available, people may switch to the next cheapest alternative, which is currently fuelwood.

An estimated 20,000 tons of coal are used for space heating in the Basin,[a] costing $75 per delivered ton,[b] and having an average value of 9,500 BTU's per pound. (19 million BTU's per ton)[c]

The cost of one million BTU's of fuelwood is about $10.81 (see Appendix 5F).

20,000 tons of coal at 19 MMBTU's/ton = 380,000 MMBTU's
An equivalent amount of fuelwood would cost $4.1 million.
($10.81/MMBTU x 380,000 MMBTU's = $4.1 million).

This amount of coal costs $2.0 million

Savings due to burning coal is then $2.1 million.

[a] Louis Berger & Assoc., Mineral Potential Working Paper, Interior transportation Study, 1982.

[b] Interviews with the manager of the Coal Bunker, Fairbanks.

[c] Fairbanks North Star Borough, Research Center, Energy Report

APPENDIX 5 F

ENERGY COST PER MILLION BTU'S (1982 DOLLARS)

SOURCE	$/MMBTU
Electricity	28.52
Propane	20.88
Heating oil	16.62
Wood (delivered)	10.81
Lump coal (delivered)	5.19[1]
Wood (personally gathered)	2.83

[1]Assuming 15 mile delivery radius from coal bunkers.
Source: Forestry Element Paper, Economic Analysis, Tanana Basin Area Plan, 1982, with coal prices modified to reflect current prices.

36,500 cords fuelwood	x	0.514 tons coal equivalent im BTU's	=	18,800 tons

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