REPORT DOCUMENTATION PAGE

1. Report No.	2.	3. Recipient's Accession No.
4. Title and Subtitle TECHNICAL and ECONOMIC FEASIBILITY SURFACE MINING COAL DEPOSITS NORTH SLOPE of ALASKA		5. Report Date RELEASED AUGUST 1977 6.
7. Author(s) KAISER ENGINEERS, INC.		8. Performing Organization Report No. 77-46-RE
9. Performing Organization Name and Address KAISER ENGINEERS, INC. 300 LAKESIDE DRIVE OAKLAND, CALIFORNIA 94666		10. Project/Task/Work Unit No. 76098 11. Contract or Grant No. J0265051
12. Sponsoring Organization Name and Address OFFICE of the ASSISTANT DIRECTOR-MINING BUREAU of MINES, DEPARTMENT of the INTERIOR WASHINGTON, D.C. 20241		13. Type of Report FINAL 14.
15. Supplementary Notes		

16. Abstract

This Kaiser Engineers report on the feasibility of surface mining on the North Slope of Alaska has considered the quantity and quality of the North Slope deposits with attention paid to the economic, technical, and environmental constraints of the mining systems suggested for the three candidate minesites at Kukpowruk River, Elusive Creek, and Kuk River. Site selection, based on coal rank and quality as well as seam thickness and geometry, also considered demonstrated and hypothetical reserves relative to three mining systems (dragline, shovel, dragline and shovel), mining equipment requirements, infrastructure, and transportation relative to the Arctic environment and costed for potential markets. Throughout the report the delicate permafrost environment has received particular consideration. Recommendations based on the technical, economic, and environmental feasibility of mining the coal deposits of Northern Alaska by surface mining techniques have resulted in two conclusions: 1. The coal deposits can be mined with currently available technology; 2. It is uneconomic to mine these coals given current coal resource estimates, costs, and market conditions.

A literature survey is included in appendix.

17. Originator's Key Words North Slope Deposits, Constraints to Development, Potential Mine Sites and Systems, Environmental Impact and Reclamation, Economic Evaluation		18. Availability Statement	
19. U. S. Security Classif. of the Report	20. U. S. Security Classif. of This Page	21. No. of Pages 155	22. Price

DISCLAIMER NOTICE

FOREWORD

This report was prepared by Kaiser Engineers, Inc., Oakland, CA. under USBM Contract Number J0265051. The contract was initiated under Advancing Mining Technology: Coal Mining Program. It was administered under the technical direction of DMRC, with Ms. Michalann K. Harthill acting as the Technical Project Officer. Mr. William R. Case was the contract administrator for the Bureau of Mines.

This report is a summary of the work recently completed as part of this contract during the period July 1, 1976 to July 1, 1977. This report was submitted by the authors on August 1, 1977.

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I. INTRODUCTION

A. PURPOSE AND SCOPE

The purpose of this report investigating the feasibility of surface mining of the coal deposits on Alaska's North Slope is defined in the request for proposal of the U. S. Bureau of Mines in the following statement.

> To study the problems to be encountered in the mining and reclamation of the Alaska North Slope coal deposits; to design surface mining systems to improve coal extraction, overburden handling, and reclamation; and to subject such conceptual mining systems to engineering/economic feasibility and environmental impact analyses.

The scope of work for the study is defined by the following RFP paragraph.

> The contractor shall gather pertinent information on capabilities of available and current equipment and on current mining practices. This information shall be used as base and background during the engineering development of mining concepts. Emphasis should be placed on effectiveness, agility, and flexibility of new methods, and the ability to facilitate the return of surface mined land to productive use. Single movement and/or handling of overburden will be a sought-after goal with specific overburden units, i. e. , topsoil and/or fertile components, being mined in a manner as to minimize handling and haulage and facilitate redisposition on the surface.

B. METHODOLOGY

Methodology for the study of the North Slope coal deposits consisted, in sum, of the following:

- A compilation of the environmental aspects of Northern Alaska was made.

- A study was conducted of factors which would constrain the development of North Slope coal.

- The areas with the greatest potential for surface mining were determined.
- The most appropriate systems for mining and reclaiming the Northern Alaskan coal fields were developed.
- Capital and operating costs for demonstrated and hypothetical coal resources were estimated. These costs were developed for the mines, the transportation systems and the related infrastructure.
- The estimated coal costs from Northern Alaska were compared with estimated costs of competing coals.

C. DATA SOURCES

Data was gathered in the following areas of interest.

- Environment
- Geology
- Marketing and transportation
- Mining equipment and technology
- Reclamation

This data was obtained from the following activities.

- Literature searches
- Field observations of North Slope coal deposits and northern mining operations
- Discussions with individuals knowledgeable in the areas of interest
- Interviews with equipment manufacturers

II. NORTH SLOPE COAL DEPOSITS

A. GEOGRAPHICAL SETTING

The coal-bearing formations of the North Slope are located in the foothills and coastal plain of the Arctic region. (See Figures 2-1 and 2-2.) Known coal resources are principally confined to the region west of the Itkillik River and north of the southern foothills of the Arctic mountains. Coal-bearing rocks do not exist on the extreme northern portion of the Arctic coastal plain.

The northern foothills vary in elevation from about 600 feet at their northern limit to approximately 1,200 feet in the south. The foothills form broad east-west ridges with occasional mesa-like features. The foothills do not contain any glaciers, although glacial debris from Ice Age glaciers is common. Permafrost features such as ice-wedge polygons and solifluction lobes and sheets are prevalent in the area.

Although the foothills have an east-west trend, the drainage in the Arctic region is northward, causing the foothills to be incised by rivers. The Colville River is an exception to the general drainage trend and follows an easterly course for 225 miles from its source before turning northward. The foothills contain infrequent thaw lakes which are seldom oriented in a specific direction.

The Arctic coastal plain rises from the Chukchi and Beaufort Seas to the northern limit of the northern foothills where it is approximately 600 feet in elevation. Between the Colville and Kuk Rivers, the coastal plain lacks relief except for occasional pingos and an area of sand dunes with a maximum relief of 40 feet.

The flat terrain and underlying permafrost inhibit drainage on the coastal plain. Therefore, most low areas are marshy. Rivers meander slowly in valleys which are 50 to 300 feet deep. Between the river valleys, the plain is covered with north-northwest trending thaw lakes which cover over one-half of the land surface. These lakes are up to 20 miles in length, but are generally less than 10 feet in depth. The formation and disappearance of the lakes is a continuous cyclical process. The entire coastal plain is underlain by 600 to 2,000 feet of permafrost. Evidence of the underlying permafrost is provided by prevalent ice-wedge polygons.

The coast of the Chukchi Sea consists of narrow gravel beaches in front of low banks and bluffs. At the western extremity of the Arctic mountains, rocky cliffs in excess of 150 feet in height are present. In the Chukchi coastal plain region, many of the river mouths are drowned estuaries caused by land subsidence or higher sea level. A considerable portion of the coastline is fronted by gravel spits.

The Beaufort Sea coast has few beaches and very low slump banks caused by the thermal undercutting of the coastal plain. Occasional spits are present. At the mouths of larger rivers are broad deltas which are caused by the recently emergent coastline.

B. ENVIRONMENTAL SETTING

1. Climate

The climate of the North Slope is cold. It imposes rigors on the landscape that control the development of soils, vegetation, and wildlife. The entire area lies well north of 66° 30' N latitude, the Arctic Circle. Barrow in the extreme north experiences continuous sunlight or twilight from late April to late August and continuous darkness from late November to late January.

The Barrow climate illustrates typical annual and seasonal patterns for the coastal environment. Frequently, thick clouds and fog blanket the area in summer. Relative humidity is high during most of the year, but precipitation is low, occurring mainly as snow. Winds sweep the land surface continually, creating chill factors and abrasive forces hazardous to all life.

The maximum temperature range along the coast spans approximately 134°F. The mean annual temperature is 10°F (Brewer, 1958). The average normal daily temperatures for January are -9°F maximum and -24°Fminimum; July temperatures average 45°F maximum and 33°F minimum (U.S. Weather Bureau Averages, 1931 - 1960). The lowest temperature recorded was -56°F and the highest was 78°F. Only during the months of June, July, and August do the mean daily temperatures rise above freezing.

Measurable precipitation at Barrow is low. Average annual rainfall is measured at 4+ inches, including a mean total snowfall of 28+ inches. During the summer months most of the precipitation falls as rain, although snow is possible at any time of the year.

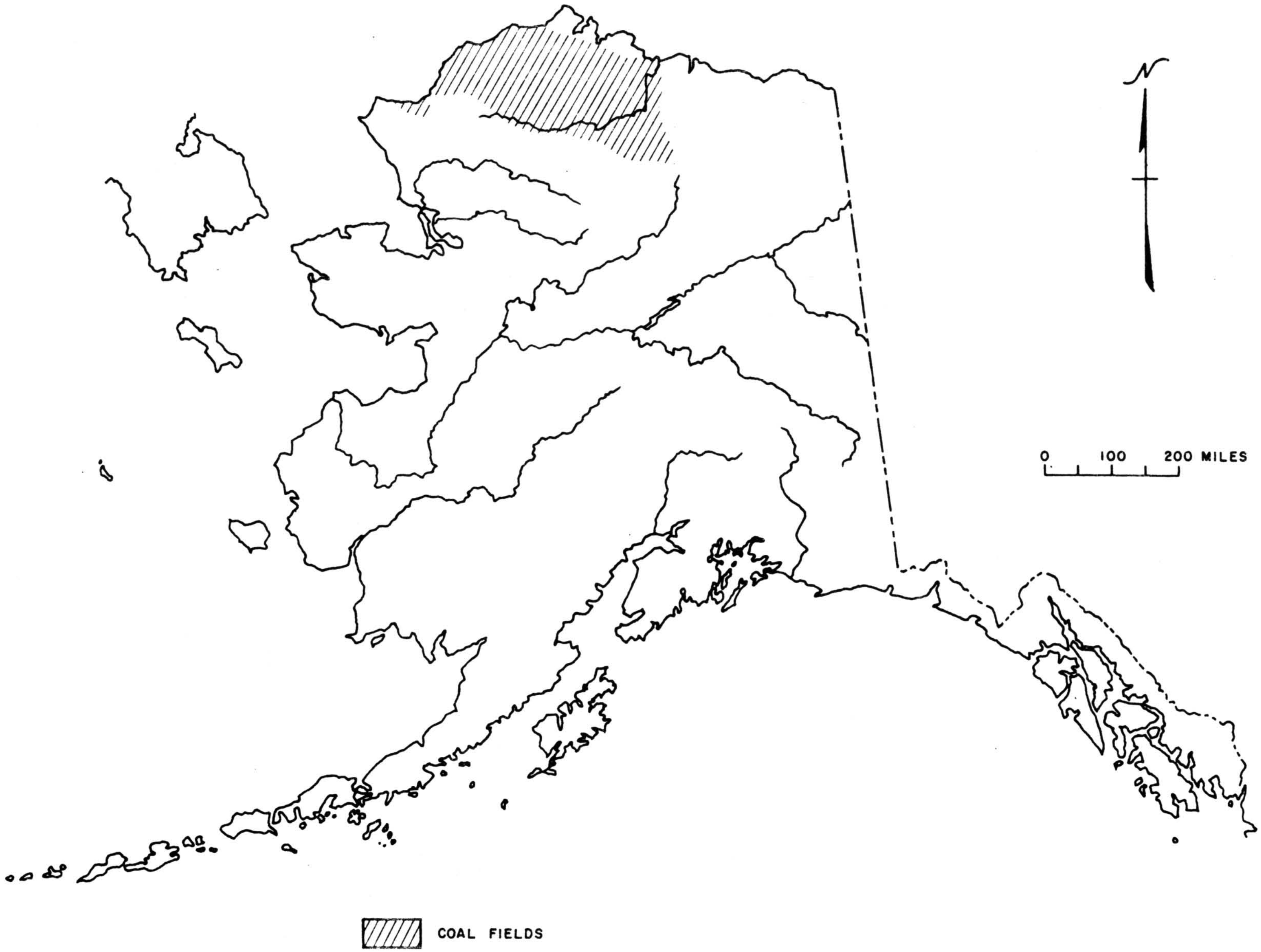
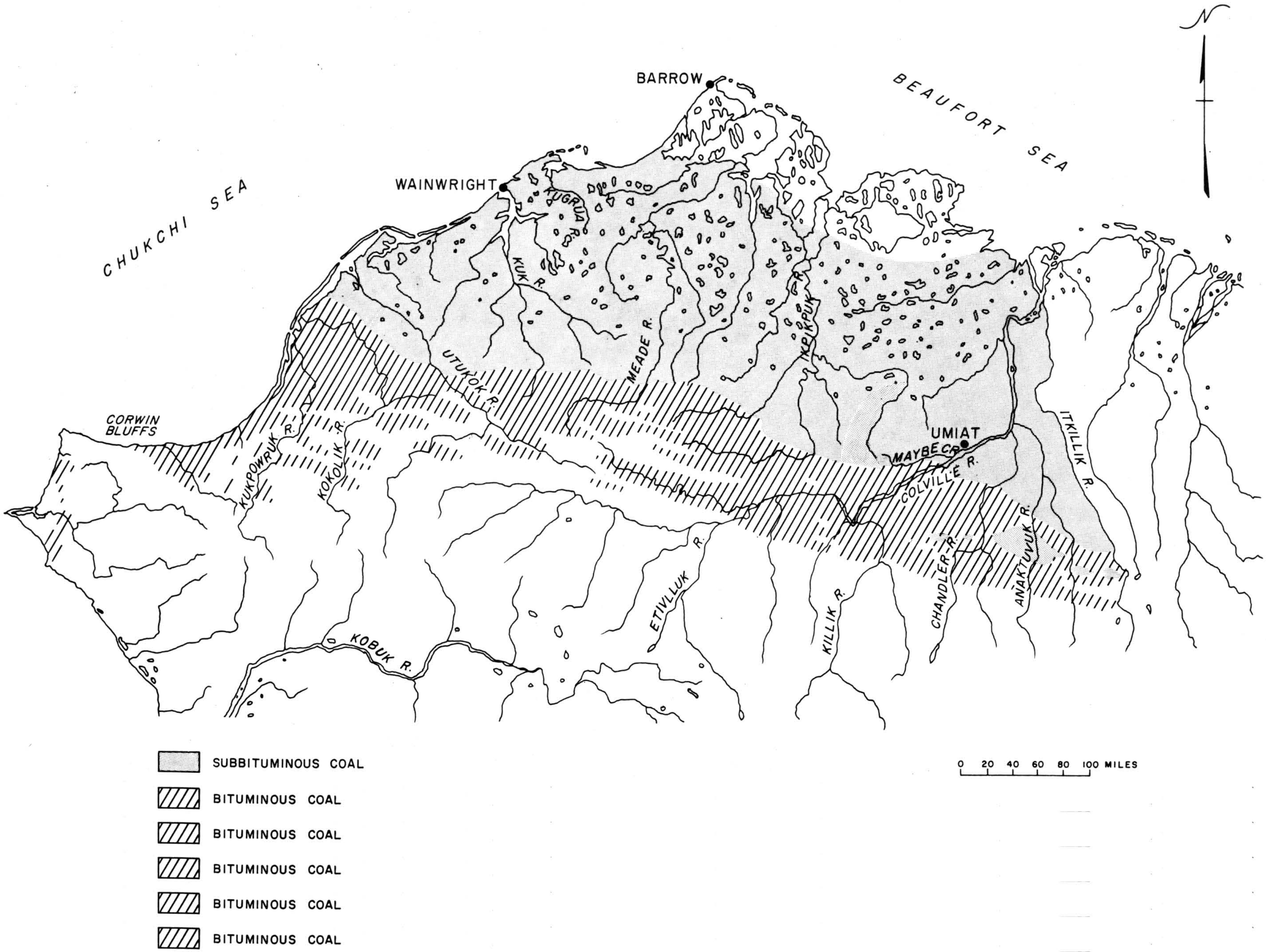


FIGURE 2 - 1
COAL FIELDS OF NORTHERN ALASKA

FIGURE 2 - 2

COAL BEARING ROCKS OF NORTHERN ALASKA



In contrast to the Barrow Area, the Umiat-Maybe Creek region of the central foothills offers a greater extreme in temperatures, with a range of up to 148°F with average summer and winter temperatures about 10°F warmer and cooler than along the coast. The average annual temperature is 10°F with a recorded low of -63°F in February and a recorded high of 85°F in July (Churchill, 1955).

Precipitation is greater in the foothills: between 10 and 15 inches (Brosge and Whittington, 1966). Precipitation occurs in the form of snow mainly during the months between September and May. Thunderstorms are reportedly rare. Snowcover along the foothills is greater than along the coastline and averages about three feet. The cover is complete and becomes deeper in drifts and snowbeds, and occasionally thins and is temporarily removed where exposed to strong winds.

2. Hydrology

The unique feature of Arctic hydrology is its pronounced seasonality. During the winter almost all of the surface water is frozen. In the summer, the surface water has melted, and the ground thaws to a depth of 4 to 48 inches. The continually frozen ground, under this layer, is called permafrost. Disruption of the permafrost can affect the stability of the soil. Because of this, special construction techniques are required in permafrost areas.

The rivers are quite extensive in the potential coal mining areas. The three principal rivers are the Kukpowruk, Kokolik, and Utukok. All three drain similar terrain, and are nearly the same size. The Utukok is the longest, being over 200 miles in length. The upper portion of each stream probably has a fairly steep gradient, large-diameter bed material, and nearly braided channels. As each stream enters the coastal plain, the channel retains less gradient and becomes more meandering. Most of the annual runoff takes place within the first few weeks of the breakup season, but a sustained summer flow does occur. Some winter-time flow might be present, but would be very small if not completely nonexistent, thereby deterring an easily available domestic or industrial water supply.

Because of the low temperature and long winter season, thermal considerations also become important for much of the year. Normal water utility practices become impossible; extensive measures become necessary to provide either sufficient insulation or enough heat input to prevent freezing of pipes and control works.

3. The Biological Environment

a. Sea and Freshwater

In the marine coastal environment, the biological chain depends on the Chukchi Sea's permanent plankton, sea mammals, and benthic invertebrates. A paucity of fish makes the marine mammals of the Chukchi Sea a life staple of the Eskimos. The biota of the freshwater environment includes macrovegetation and macrofauna. The Coleville River supports the greatest volume of fish, although all major rivers and tributaries of the North Slope as well as the larger elliptic lakes of the Coastal Plain, support fish of at least one or more species.

b. Animals

Large caribou herds, whose calving grounds and summer range are on the North Slope, winter south of the Brooks Range near the Chukchi Sea. Recently, moose have become year-round residents of some of the larger river valleys where sufficient willows exist to support small populations. Barren ground grizzly bears also summer on the North Slope. Polar bears seldom range more than a few miles inland from the seacoast. Other North Slope inhabitants are Dall sheep, moose, rodents, and predators such as the barren ground grizzly, wolves, wolverines, Arctic and red fox, and birds which, typically, are seasonal residents. Mosquitoes are the only reported insect.

c. Vegetation

Six major, broad classes of vegetation are distributed on the North Slope.

- Cottongrass meadows
- Wet sedge meadows
- Dry upland meadows
- Floodplain and cutbank vegetation
- Outcrop and talus vegetation
- Aquatic vegetation of lakes

In the cottongrass meadows, the dominant species forming tussocks up to 10 inches tall is cottongrass. Lichens, mosses, and liverworts are common in the narrow grooves between the cottongrass tussocks. Wet sedge tundra meadows characterize the vegetation of nearly half of the coastal plain, and a fourth of the foothill area. This type of vegetation occurs on flat, relatively poorly drained lowlands, flood plain margins, and lake margins. Wet sedge meadows often dominate in areas where frost polygons are well developed.

Dry upland meadows are a feature of the mid-elevation mountain front. Between elevations 2,000 and 4,000 feet, this community develops along ridges and on rubble slopes. The vegetation is sparse compared to all other types, except that found on outcrops and talus slopes at higher elevations in the Brooks Range. A prostrate woody member of the heath family is dominant with a scattering of different lichens. A number of secondary species of grasses, sedges, shrubs, and forbs occur depending upon the local conditions which favor their growth.

4. The Human Environment

The human population consists of native Eskimos and nonnatives associated with government activities and commercial developments. According to the 1970 census, 3,065 people lived in the Arctic region of Alaska excluding the community of Point Hope. Approximately 85 percent of this population was Eskimo.

Most of the native population is concentrated in the coastal communities of Barrow, Kaktovik, and Wainwright, and the inland community of Anaktuvuk. Most of the nonnatives living on the North Slope are located at DEW Line sites, the Arctic Research Laboratory at Barrow, support centers and drill sites associated with the Alaska pipeline, and mobile mineral exploration camps. The total number of nonnatives now exceeds 2,000 people and will probably increase in the future.

The archaeology of the North Slope has not been well defined. Many sites are scattered along the coastline of the region, but most remain unexcavated to date. Few interior sites have been discovered or identified.

The beliefs and lifestyle of the Eskimo may explain the lack of interior settlement. Overland travel was difficult except in winter, whereas the coastal environment was easily traversed in boats during the summer and sleds during the winter. Coastal living also facilitated trade among the settlements. The principal food of the Eskimo was seal and whale, supplemented by the meats of caribou and sheep in those areas where such game was obtainable. The resources of the sea, renewed yearly, were thus far more dependable than the fluctuating and migrating populations of ungulates. Eskimos are descended from a stock of seafaring people. Thus, a strong attachment to the sea environment and perhaps even a fear of overusing the land resource may account for the preponderance of coastal settlements.

C. GEOLOGY AND COAL RESOURCES

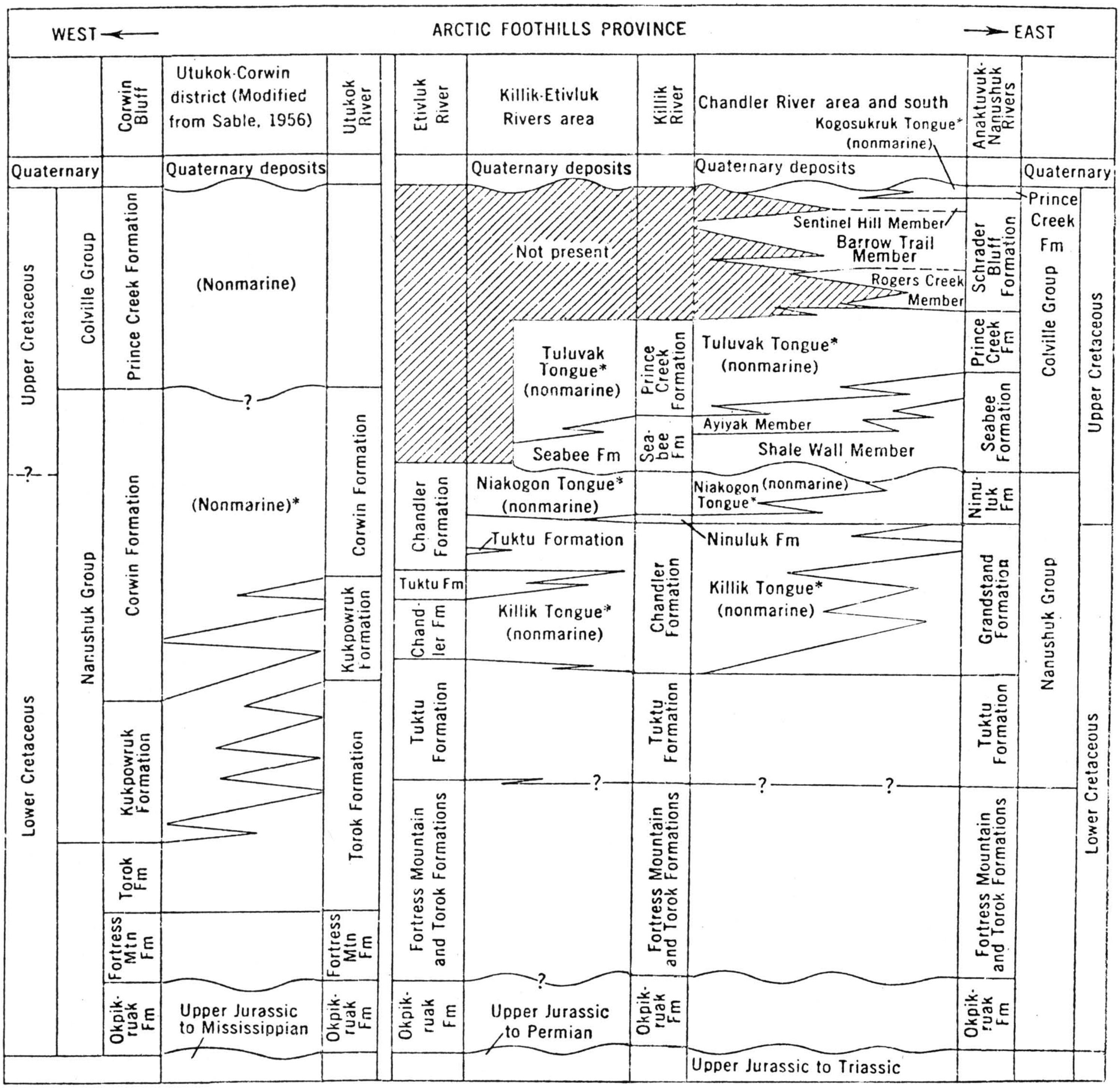
The regional geology of western Arctic Alaska has been described by the United States Geologic Survey in reports by Brosge and Wittington (1966); Chapman and Sable (1960); Chapman, Detterman, and Mangus (1964); and Detterman, Bickel, and Gryre (1963). The coal resources of this area have been calculated by Barnes (1967).

1. Stratigraphy

Most of northern Alaska is underlain by Cretaccous sediments of both marine and nonmarine origin. Unconsolidated fluvial and marine alluvium of Quaternary age overlies the Cretaceous rocks throughout much of the region. Generally, the depth of unconsolidated material increases northward from the foothills of the Arctic mountains. Stratigraphic-type sections throughout the foothills province are shown in Figure 2-3. Coal-bearing areas of the North Slope that have been mapped by the U.S. Geologic Survey are illustrated in Figure 2-1.

2. Structure

The structure of northern Alaska is a series of east-west trending folds parallel to the front of the Arctic mountains. The degree of deformation and faulting decreases northward. The Arctic mountains are characterized by overturned folds and large-scale thrust faults. The southern foothills are characterized by isoclinal folds, thrusts faults and high-angle reverse faults. The northern foothills area contains simple folds with high-angle reverse faults occurring principally on anticlinal axes. The structure of the Arctic coastal plain is largely masked by alluvial deposits, and consists of gently undulating folds.



* PRINCIPAL COAL-BEARING UNITS

Modified from Chapman and Others, 1964, Figure 62

FIGURE 2 - 3

STRATIGRAPHY OF NORTHERN ALASKA

Major mountain building took place during late Jurassic and early Cretaceous time. This was followed by two periods of folding. The first period of folding, which is considered more severe, occurred at mid-Cretaceous time. Additional folding took place during Tertiary time. The Brooks Range was probably caused by the Tertiary orogeny, which has little effect north of the southern foothills.

3. Coal Quality

The bulk of the coal in northern Alaska has been described as black and shiny with a blocky fracture. Some coal occurring in the Prince Creek Formation in the eastern portion of the region and in the Chandler Formation near the Arctic coast has been described as dull black with shaley fracture. Although few analyses have been performed, the bright blocky coal is generally bituminous and the dull shaley coal subbituminous. Barnes (1967) found that data on coal samples was often insufficiently complete to permit the assignment of rank according to ASTM standards. Therefore the rank assignments of the coal resources have often been made by considering the age and degree of deformation of the deposits rather than by using analytical data. The geographical distribution of bituminous and subbituminous coal is shown in Figure 2-2.

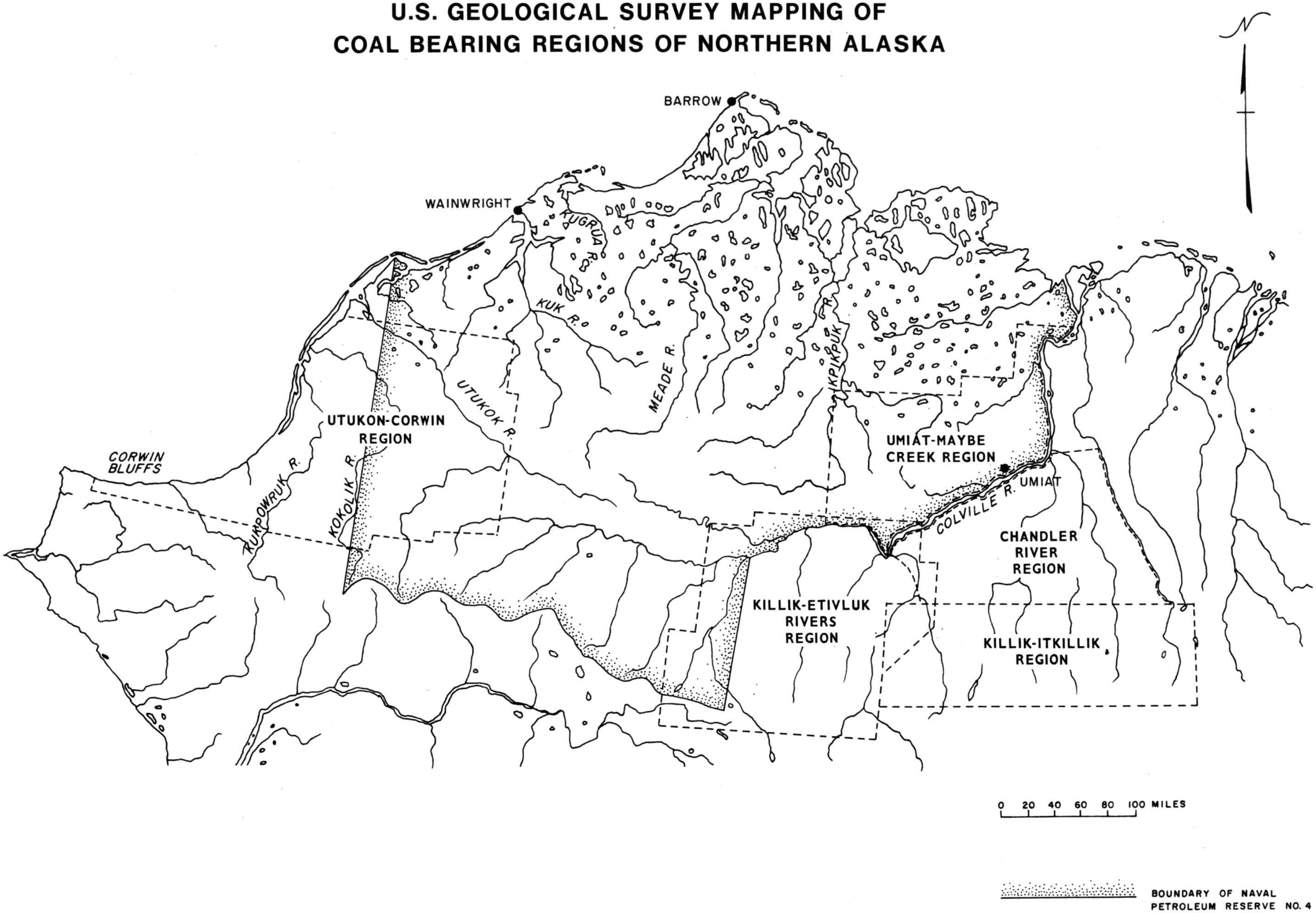
The rank of the coal is a function of age of deposition and degree of structural deformation. Younger and less-deformed coals tend to be of lower rank than older and strongly deformed coals. Therefore, the rank of coal in northern Alaska decreases northward from the southern limit of the northern foothills due to the fact that the degree of structural deformation decreases. In the eastern district, the rank of the coal decreases because younger sediments are exposed.

The youngest coal-bearing formation is the Prince Creek Formation which is of late Cretaceous age. This formation was deposited subsequent to the most severe period of structural deformation which occurred in the region. Therefore, Prince Creek coals, which are confined primarily to the eastern portion of the study area, are predominantly subbituminous in rank.

Coals of Middle Cretaceous age are found in the Nanushuk Group. These coals are bituminous in the folded rocks of the foothills, and subbituminous in the relatively undeformed strata of the coastal plain.

FIGURE 2 - 4

U.S. GEOLOGICAL SURVEY MAPPING OF COAL BEARING REGIONS OF NORTHERN ALASKA



Analyses of the coals from the Corwin Bluffs, Cape Beaufort, Deadfall Syncline, Kukpowruk River, and Kokolik-Elusive Creek areas have been described by Callahan and Sloan (1976). All of the coals analyzed occur in the western portion of northern Alaska in the Corwin Formation. The coals that were analyzed petrographically were of bituminous rank, predominantly "High Volatile B." The coals in the Kukpowruk area were generally higher in rank than those from the other areas, being borderline "High Volatile A-B." The Kukpowruk coals are stated to be "anomolously high" in quality. Coking tests have been performed on Kukpowruk and Cape Beaufort coals. The carbonization properties compare favorably with Sunnyside coal from Utah.

4. Coal Resources

Barnes (1967) calculated a total coal resource in northern Alaska of 120,197 million tons, consisting of 19,292 million tons of bituminous and 100,905 million tons of subbituminous coal. Resources were estimated to a depth of 3,000 feet. Bituminous seams in excess of 14-inch thickness and subbituminous seams greater than 30 inches thick were included in the resource estimate.

Several estimates have been made of strippable coal in northern Alaska. In 1971, the US Bureau of Mines estimated the "strippable reserves" of the region to be 478 million tons of bituminous coal and 3,387 million tons of subbituminous coal. Seam thickness criteria were the same as those employed by Barnes (1967). Coal reserves were estimated to a depth of overburden of 120 feet. The 1977 U.S. Bureau of Mines estimate of the "reserve base" of strippable coal in northern Alaska is 81.7 million tons of bituminous coal and 86.7 million tons of subbituminous coal.

The USGS and US Bureau of Mines (1976) have defined reserve base to be that portion of the Identified Coal Resource from which reserves are calculated. Reserves are that portion of the Identified Coal Resource that can be economically mined at the time of determination. Reserves are determined by applying a recovery factor to the reserve base.

In the calculation of the reserve base, the U.S. Bureau of Mines used a maximum cover depth of 120 feet and minimum seam thicknesses of 28 inches for bituminous coal and 60 inches for subbituminous coal. The coal resource estimate from which the reserve base was calculated was that of Barnes (1967).

Kaiser Engineers has independently developed an estimate of strippable demonstrated coal resources using the same calculation criteria and data as were employed by the U.S. Bureau of Mines. Kaiser Engineers' estimate is 81.7 million tons of bituminous coal and 60.5 million tons of subbituminous coal. The divergence between the U.S. Bureau of Mines and the Kaiser Engineers estimate of strippable subbituminous coal is due to Kaiser Engineers' exclusion of coal resources derived from test wells on Naval Petroleum Reserve No. 4. Barnes (1967) does not document how much of this coal was encountered in the upper 1,000 feet of the wells. Since other data below 1,000 feet of cover was not incorporated into the Kaiser Engineers estimate, the coal from the test wells was excluded. Also, the quality of the test well coal is questionable. It is possible that some of the material logged as coal is actually coaly shale.

Both the Kaiser Engineers and U.S. Bureau of Mines estimates of demonstrated strippable coal are significantly lower than previous estimates. The very small tonnages are indicative primarily of the degree of geologic assurance of the coal rather than the amount of coal that is thought to exist in northern Alaska. 96% of the bituminous and 98% of the subbituminous coal resources are in the "inferred" category and have not been incorporated into the reserve base. Also, considering the limited amount of coal exploration that has been conducted in northern Alaska, it is probable that many of the coal seams occurring in northern Alaska have not been observed in the field. In press releases, the U.S.G.S. has estimated potential coal resources of 4 trillion tons. These figures seem to be overly optimistic because they place heavy emphasis on cuttings from oil wells that could be carbonaceous shale. Nevertheless, there is no doubt that the estimate of northern Alaskan coal resources as calculated by Barnes (1967) is understated.

Because of the sparsity of exploration information, the reserve base of strippable coals is more realistically portrayed when inferred resources are included. Although the degree of geologic assurance of such a reserve base is low in comparison to that for other states, the lack of exploration makes it unlikely that this inventory is conservative from a statistical point of view. The inventory of bituminous coal with a minimum seam thickness of 28 inches is 868.3 million tons. The inventory of subbituminous coal with a minimum seam thickness of five feet is 1,040.4 million tons.

The reserve base represents an estimate of all coal in the ground meeting specific geometrical requirements (seam thickness and depth of cover), whether economically recoverable or not. Coal reserves are estimates of coal which can be recovered economically using current technology. Reserves are calculated by government agencies by applying recovery factors to the reserve base. This is a very simplistic approach and does not give adequate consideration to the economic aspect of reserve determination.

Implicit in the reserve determination techniques is the assumption that the cost of mining and transporting coal to market is essentially the same in northern Alaska coal field as in coal fields in other states. However, it is obvious that mining and transportation costs and capital amortization charges will be significantly higher in northern Alaska than elsewhere. The maximum volumetric stripping ratios which have been included in the reserve base for northern Alaska are 50.5 for bituminous coal and 23.0 for subbituminous coal.

To account for the high anticipated costs in northern Alaska, Kaiser Engineers recommends that the minimum thickness of seams to be incorporated into the reserve base be increased. It is recommended that minimum thicknesses should be 42 inches for bituminous coal and 10 feet for subbituminous coal. These thicknesses have been chosen because they are the thickest cutoffs employed by Barnes (1967). Obviously, seams thinner than the above can be effectively removed in multiseam operations which also contain thicker seams. The modified reserve base using the increased minimum seam thickness is presented in Table 2-1 and Figure 2-5. With a minimum seam thickness of 42 inches, the inventory of strippable bituminous coal is 553.8 million tons. The inventory of strippable subbituminous coal in seams greater than 10 feet is 205.1 million tons.

It must be emphasized that the strippable coal inventories for each area do not represent estimates of minable coal tonnages which occur in the various districts. There is a high degree of geologic uncertainty with respect to the existence of the coal, and recover factors have not been applied. The estimates do form, however, a statistical basis for ranking the relative potential of the coal-bearing districts, and represent a very rough approximation of order-of-magnitude in situ coal tonnages which may be amenable to surface mining.

TABLE 2-1

RESERVE BASE OF STRIPPABLE COAL
IN NORTHERN ALASKA
(Demonstrated and Inferred Resources)
(Million Short Tons)

DISTRICT	BITUMINOUS COAL			SUBBITUMINOUS COAL		
	>28 in	>42 in	%>42 in	>5 ft	>10 ft	%>10 ft
Corwin Bluff-Cape Beaufort	17.8	12.1	68			
Kukpowruk R.	157.6	115.3	73			
Kokolik R.	112.3	88.9	79			
Utukok R.	142.4	134.9	95	121.4	89.7	74
Meade R.	146.9	145.5	99	135.9	0	0
Colville R.	291.3	57.1	20	546.0	0	0
Kuk R.				113.5	111.0	98
Kugrua R.				100.9	0	0
Ikpikpuk R.				22.7	4.4	20
TOTAL	868.3	553.8	64	1,040.4	205.1	20

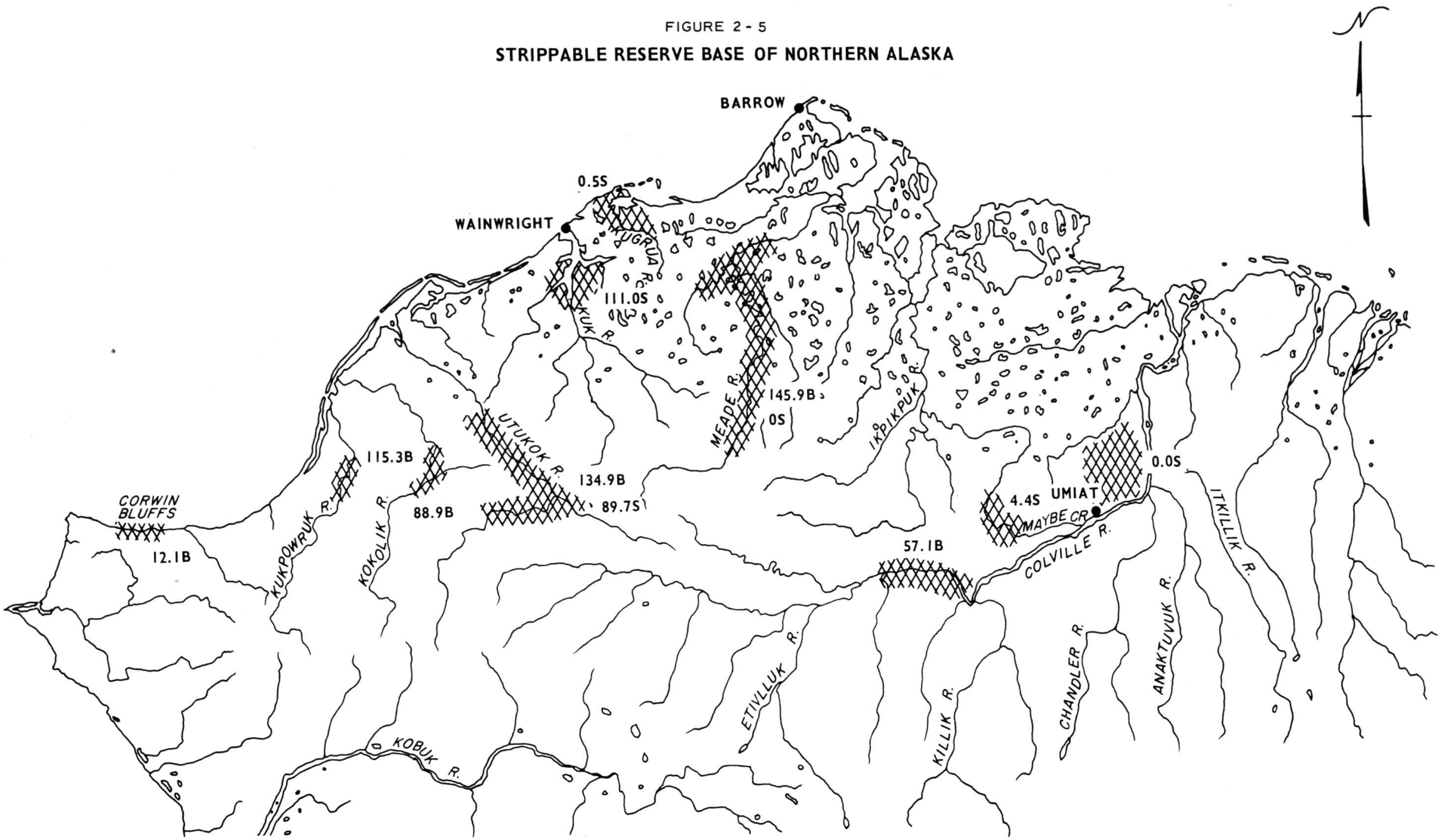
TABLE 2-2

RESERVE BASE OF STRIPPABLE COAL IN NORTHERN ALASKA
(Demonstrated Resources)
(Measured and Indicated Categories)

DISTRICT	BITUMINOUS COAL			SUBBITUMINOUS COAL		
	>28 in	>42 in	% >42 in	>5 ft	>10 in	> ft
Corwin Bluff-Cape Beaufort	3.7	2.6	71			
Kukpowruk R.	25.9	16.9	65			
Kokolik	10.6	9.3	88			
Utukok R.	9.4	8.3	89	7.4	2.5	34
Meade R.	11.6	10.1	87	4.1	0	0
Colville R.	20.5	5.9	29	31.9	0	0
Kuk R.				5.6	3.1	55
Kugrua R.				5.3	0	0
Ikpikpuk R.				6.2	4.4	71
TOTAL	81.7	53.1	65	60.5	10.0	17

FIGURE 2 - 5

STRIPPABLE RESERVE BASE OF NORTHERN ALASKA



B - BITUMINOUS COAL (MILLIONS OF TONS IN SEAMS THICKER THAN 42")

S - SUBBITUMINOUS COAL (MILLIONS OF TONS IN SEAMS THICKER THAN 10')

III. CONSTRAINTS TO NORTH SLOPE COAL DEVELOPMENT

The principal constraints to the development of northern Alaska coal resources are related to environmental problems, social and economic problems, technical problems, and marketing and transportation problems.

A. ENVIRONMENTAL CONSTRAINTS

Environmental constraints to coal mining in northern Alaska are classified in three general categories.

- Impact on the existing environment more from the influx of population than from the mining operation itself.
- Problems caused by climatic conditions: social and operational difficulties typical of a cold, remote location.
- Difficulties in reclaiming mined land: permafrost safeguards and revegetation.

From a macroscopic viewpoint, much of northern Alaska is considered to be environmentally sensitive. The harsh climate has resulted in many unique animal and plant species. Because of the limited ability of the land to support wildlife, many animal species either migrate or have a very large range area. However, the extent of the ungulate calving areas and bear denning areas is restricted. The location of mines or transportation systems in these areas could have major impact on wildlife populations. Also, the location of transportation systems on migration routes could affect wildlife species considerably.

Permafrost areas, especially wet tundra, are very susceptible to environmental degradation. Careless travel activities over the tundra surface during summer months could have long-term effects on the thermal equilibrium of the active zone. The reestablishment of equilibrium could result in either progressive erosion or replacement of vegetation with different plant communities than previously existed. Transportation corridors constructed across tundra would require surface insulation to prevent progressive melting of the underlying permafrost, and resulting problems of foundation instability.

The cold, harsh climate and strong, prevailing winter winds are constraints to mining operations. There are no year-round seaports in northern Alaska. Surface water freezes during the winter, causing difficulty in designing water and sewage systems. The effects of the cold weather and darkness upon various aspects of human activity represent major considerations. Labor productivity will decline significantly during winter months. Cold weather will also adversely affect the metallurgy and lubrication of machinery, as well as operator comfort.

During the summer months, poor surface drainage will cause mining problems. Handling of saturated, silty soils will be difficult. Dewatering of blastholes and mining pits will require careful attention.

The reclamation program will be constrained by surface conditions and biological factors. During the winter, frozen soil is difficult to handle. However, when the soil melts, it becomes a wet, soupy substance which could be even more difficult to handle. The extreme variations between seasons and the short growing season mean that scheduling of reclamation activities is more critical in northern Alaska than in the lower 48 states. Research work on Arctic reclamation techniques is still in the early stages. There has been insufficient time for feedback on test results, and resulting modifications to reclamation methods. The relative merits of using native or non-native species have not been determined. Much more work must be done before an acceptable reclamation procedure can be determined.

B. SOCIAL AND ECONOMIC CONSTRAINTS

The following social and economic problems will impede the development of coal mining in northern Alaska: labor, housing, and economic factors: transportation distances, high construction costs to accommodate permafrost conditions, high energy consumption for heating buildings and equipment, basic lack of existing utilities and infrastructure, and low labor and equipment productivity.

It will be difficult to attract and maintain a suitable labor force in the Arctic. The majority of the public does not wish to work and live in a remote location. In existing northern communities the incidence of mental illness, drug abuse, and alcoholism is far greater than in less isolated localities. Remote locations are typified by a shortage of qualified workers, high turnover, low productivity, and labor disharmony.

The design of appropriate living, commercial, and recreational facilities for northern Alaska will probably require more effort than the design of the mining facilities. Community plans must be based on both climatic and social parameters. Water supply, sewage, and garbage facilities will require special attention because of permafrost and freezing conditions. The shortage of natural recreation facilities will cause increased reliance upon manmade facilities.

C. TECHNICAL CONSTRAINTS

Problems involving technical constraints appear to be the most easily overcome of all problems relating to surface mining in northern Alaska. Noncoal surface mines are currently being operated under climatic conditions comparable to conditions in northern Alaska.

The principal cold-weather problems encountered in mining equipment are related to inadequacies in metallurgy, lubrication, hydraulic systems, and operator facilities. During very cold weather most metals become brittle and develop cracks even if normal loads are applied.

The welds made to repair the cracks often fail because it is very difficult to preheat and provide adequate stress relief at low temperatures. These metallurgical problems can be solved in two ways. Special low-temperature alloys can be specified for equipment parts subjected to stress such as dragline boom lacing, tub bottoms, and shovel carbodies. These parts are presently available in low-temperature alloys, and are used in northern applications. A second way to combat metallurgical problems is to derate equipment during cold weather. Shovels and draglines can be equipped with smaller dippers and buckets, and engine power can be reduced on dozers and other mobile equipment.

During recent years, lubrication and hydraulic system problems caused by low temperatures have been significantly reduced. Research work prompted by experience on the Alaska pipeline project has resulted in the development of low-temperature lubricants and hydraulic fluids that reduce the need to heat gearcases, oil sumps, and hydraulic fluid reservoirs. In the past few years, strip heaters have largely replaced immersion heaters in the few applications still requiring heating of lubricants and hydraulic fluids. The extreme temperature ranges experienced by internal combustion engines in cold weather can be limited by keeping the engines running all winter or by using warmup sheds. Though expensive, these alternatives are less costly than trying to start diesel engines in subzero temperatures.

Problems of operator discomfort have been greatly reduced in recent years. Environmental cabs are common, and the need for the operator to leave the cab has been significantly reduced by the development of brake moisture control systems and automatic lubrication systems. Related to operator comfort are the problems that will be encountered in blasting. Current practices involve a high degree of outside manual labor. Techniques will have to be found to mechanize the blasting process.

D. MARKETING CONSTRAINTS

Potential markets for Alaska coals are limited by coal quality and by problems in transporting coal from an isolated area with no infrastructure under Arctic conditions. Although some of the coal reserves are of coking quality, no high-quality, low-volatile coking coal has been discovered; thus, Alaskan coals cannot command a premium price. Potential markets would be available in Japan and Korea for both coking and thermal coal and in the western United States and Alaska for thermal coal. Thermal coal could also be converted to other energy forms by gasification or liquefaction to compete in other markets in Alaska. Transportation beyond the Pacific Ocean area would probably be too costly for coal of this quality to be competive with coal from other market areas.

In the near future, marketing of coking and thermal coal in Japan would be in direct competition with coal of equal or superior quality from Australia, Siberia, and probably from China and southeast Asia. High-volatile coking coal from the western United States would also be competitive. A market for thermal coal or coal conversion products may be developed in the western United States, although competition could be expected from coal produced in the western and northern plains states. However, environmental constraints to mining may be more restrictive in these states because of the greater population density and existing industry.

E. TRANSPORTATION CONSTRAINTS

Marine, land, and air transportation systems would be involved in northern Alaska coal development. Transportation constraints are principally related to climate, physical features, and lack of existing facilities.

Marine transportation from the North Slope of Alaska is generally limited to shallow-draft ships and barges operating during the short summer season. The shallow water and extensive continental shelf, together with the Arctic ice pack and lack of dock facilities, considerably complicate marine transportation and loading/unloading operations. Shallow water, extending to 12 miles or more offshore, limits the use of large, deep-draft ships and requires lightering of shallow-draft ships and barges over most of the coastline.

The Arctic ice pack extends south in the Bering Sea to approximately 61 degrees north latitude in the winter months, with floating ice extending as far south as the Pribilof Islands near the 56th parallel. During the summer months, the Bering Sea is ice-free for approximately 5 months, the Chukchi Sea for 3 months, and a narrow channel around Point Barrow is open for only 1 to 3 months. Pack ice may remain on or near Point Barrow until late summer, and occasionally remains throughout the summer. Eastward of Point Barrow, the pack ice seldom goes far offshore; ice movement and therefore coastal navigation along the Arctic coast is controlled primarily by winds.

Ground transportation in the North Slope area is presently limited to winter travel with tractors and sleds because the tundra, when thawed, will not support heavy vehicles and even low ground-pressure vehicles damage its surface. A newly constructed gravel highway paralleling the Alaska pipeline route from Fairbanks to Prudhoe Bay is presently the only land access route to the North Slope. Construction of transportation facilities for movement of coal overland to a seaport would be costly and require special construction methods adapted to Arctic conditions.

Ground transportation would probably be by rail, truck, belt conveyor, or slurry pipeline. Construction of transportation facilities in permafrost regions would require specialized techniques to reduce the effects of the permafrost. Insulation of road and track beds would be required. Mechanical stabilization of cut slopes and prevention of ice formation in culverts will require further attention. With pipelines, steps must be taken to prevent freezing within the pipe and thawing of permafrost if the pipe is buried. Above-ground pipelines and conveyor belts can interfere with animal migration routes. Mechanical components of transportation are subject to cold-weather problems such as starting system failures, lubrication failures, and low-temperature material failures.

Air transport has played a major role in the development of Alaska and has been the only reliable year-round transportation for the North Slope oil developments. Air transport of supplies and personnel may be feasible in conjunction with pipeline or belt conveyor movement of coal. Cost of air transportation is high and construction of landing strips equipped for instrument flying would be required. The Hercules and Super Hercules planes can be operated from gravel runways; however, larger jet planes require paved runways.

Helicopters have been used extensively for light freight and passenger movement in the Arctic, and larger craft have been used for lightering from ships and barges. Primary disadvantages of the helicopter are its short range, high operating cost, and limitations due to weather, ice, fog, and blowing snow.

Presently, no large-scale electrical power supply is available in northern Alaska. New electrical systems would have to be built and operated for coal mining projects. The extreme load fluctuations caused by cyclical mining equipment could cause severe electrical system difficulties.

IV. POTENTIAL MINING SITES

A. SELECTION CRITERIA

The following selection criteria were used to determine the best surface-mining sites in northern Alaska: coal rank, seam thickness, coal quantity, exploration information, and seam geometry.

1. Coal Rank

The coal districts of northern Alaska can be categorized as follows: 1. Bituminous districts (Corwin Bluff-Cape Beaufort, Kukpowruk River, Koklik River); (2. Subbituminous districts (Kuk River, Kugrua River, Ikpikpuk River); and 3. Mixed-bituminous and subbituminous districts (Utukok River, Meade River, Colville River). These districts were evaluated to determine the district with the best mining potential for each coal rank category.

2. Seam Thickness

Generally, seam thickness and mining costs are inversely proportional. Thick seams mean low costs. The low-cost surface mines of the northern Great Plains states, for instance, are on seams 60-80 feet thick. The following table, indicates seam thickness in the various North Slope coal-bearing districts.

TABLE 4-1

SUMMARY OF SEAM THICKNESS INFORMATION
Maximum Seam Thickness

Bituminous Districts:	1. Kukpowruk River	(20 ft)
	2. Corwin Bluff-Cape Beaufort	(9 ft)
	3. Kokolik River	(6 ft)
Subbituminous Districts:	1. Ikpikpuk River	(20 ft)
	2. Kuk River	(10 ft)
	3. Kugrua River	(5 ft)
Mixed Districts*:	1. Utukok River	(12 ft [s] and 11 ft [b])
	2. Colville River	(10 ft [s] and 4. 5 [b])
	3. Meade River	(6 ft [s] and 6 ft [b])

*s: subbituminous
b: bituminous

3. Coal Quantity

The economic potential of a coal field depends on the quantity of coal economically extractable with current technology. Since the economic viability of the northern Alaskan coal fields has not been established, the quantity of coal noted in Table 4-2 is based on the estimated demonstrated (measured and indicated) and total coal resources with less than 120 feet of cover and minimum seam thickness of 42 inches for bituminous coal and 10 feet for subbituminous coal.

TABLE 4-2

SUMMARY OF COAL QUANTITY INFORMATION
Coal Tonnage (Million Tons)

Demonstrated Resource		Total Resource	
Bituminous Districts			
1 Kukpowruk River	(16.9)	1 Kukpowruk River	(115.3)
2 Kokolik River	(9.3)	2 Kokolik River	(88.9)
3 Corwin Bluff-Cape Beaufort	(2.6)	3 Corwin Bluff-Cape Beaufort	(12.1)
Subbituminous Districts			
1 Ikpikpuk River	(4.4)	1 Kuk River	(111.0)
2 Kuk River	(3.1)	2 Ikpikpuk River	(4.4)
3 Kugrua River	(0)	3 Kugrua River	(0)
Mixed Districts			
1 Utukok River	(10.8)	1 Utukok River	(224.6)
2 Meade River	(10.1)	2 Meade River	(145.5)
3 Colville River	(5.9)	3 Colville River	(57.1)

4. Exploration Information

The coal deposits of northern Alaska are characterized by a notable lack of exploration. The only area in northern Alaska which has been explored as having potential for export markets is the Kukpowruk River region. The existence of a 20-foot seam in this area was first reported in 1923. In 1954, an adit was driven into this seam and a bulk sample was taken. Further bulk sampling was done in 1961, 1963, and 1970. Also, in 1966, four core holes were drilled in the area. The coal in the 20-foot seam is bituminous in rank. In addition to the above mining and bulk sampling programs, several of the coal fields in northern Alaska have been geologically mapped, notably the Kuk and Kukpowruk coal fields. In 1947 and 1949-53 additional mapping was done on and near Naval Petroleum Reserve No. 4. During the late 1950's and early 1960's, the United States Geological Survey mapped all of Alaska north of the Arctic Mountains. In 1969 and 1971, the United States Geological Survey prepared reports on specific coal deposits in the Kukpowruk and Cape Beaufort coal fields.

TABLE 4-3

SUMMARY OF EXPLORATION ACTIVITY IN NORTHERN ALASKA

Bituminous Districts:	1. Kukpowruk River	(Core Drilling, Bulk Sampling)
	2. Corwin Bluff-Cape Beaufort	(Detailed Mapping)
	3. Kokolik River	(Regional Mapping)
Subbituminous Districts:	1. Kuk River	(Native Mining, Field Investigation)
	2. Ikpikpuk River	(Regional Mapping)
	3. Kugrua River	(Regional Mapping)
Mixed Districts:	1. Meade River	(Drilling, Mining)
	2. Utukok River	(Regional Mapping)
	3. Colville River	(Regional Mapping)

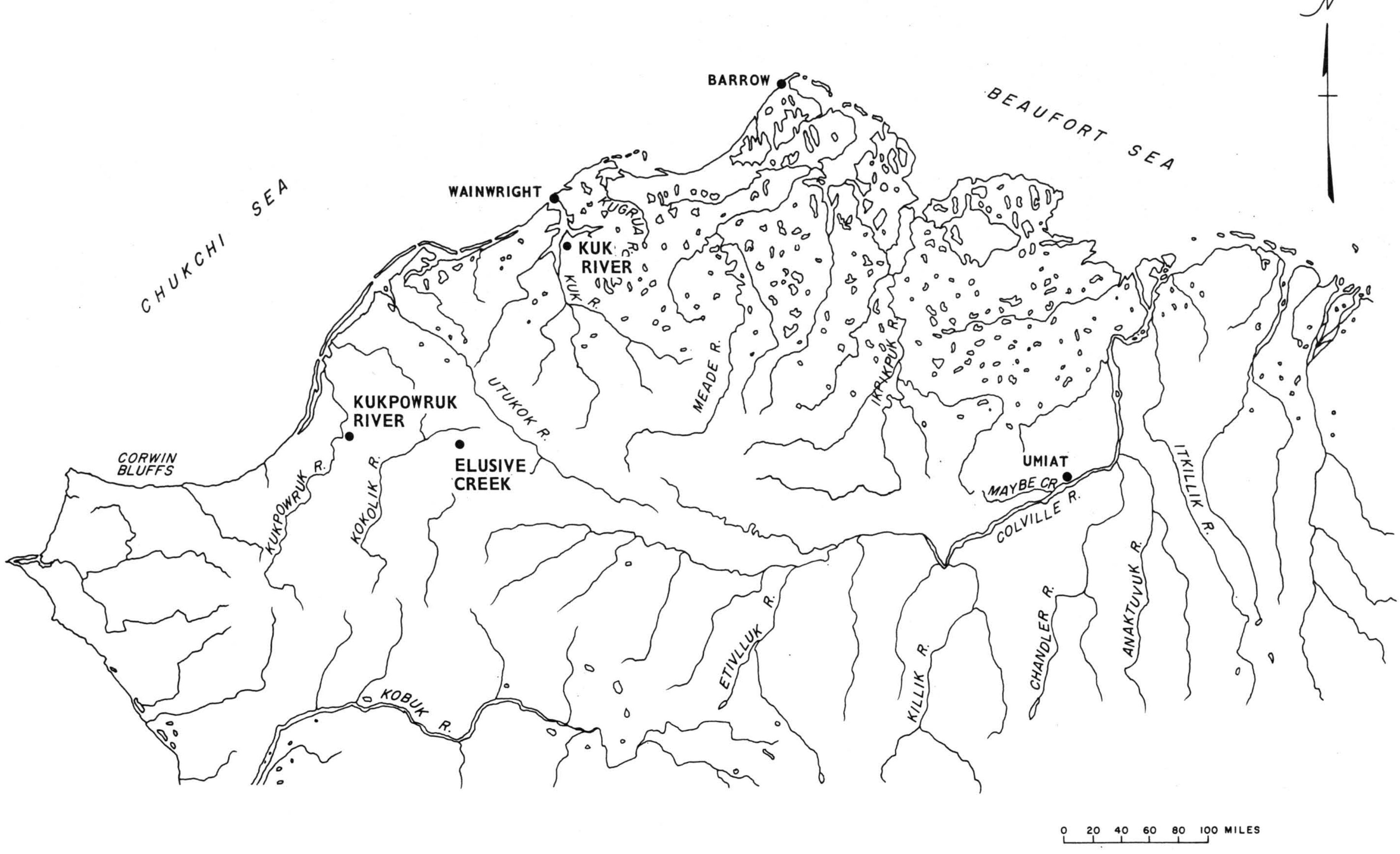
5. Seam Geometry

To achieve the efficient surface mining of coal, it is desirable that the seams be as flat-lying as possible. With steeply dipping seams, in flat lying terrain, the stripping ratio increases rapidly downdip, and the economic pit limit is reached in a relatively short distance from the seam crop. Thus, the surface-minable reserve of coal depends upon the dip of the coal seam.

It is difficult to quantify seam geometry parameters as a selection criterion. Seams which have dips which exceed 20° were not considered to be amenable to surface mining. Subject to other constraints, preference was given to flat-lying seams.

FIGURE 4 - 1

POTENTIAL MINE SITES IN NORTHERN ALASKA



B. POTENTIAL MINING SITES

Analysis through the four criteria yielded the following preferred districts:

- Bituminous - Kukpowruk River (Greatest seam thickness, coal quantity, and exploration information)
- Mixed Bituminous and Subbituminous - Utukok River (Elusive Creek) (Greatest seam thickness and coal quantity; second greatest exploration information)
- Subbituminous - Kuk River (Greatest coal quantity and exploration information; second greatest seam thickness) specific mine sites are shown in Figure 4-1.

1. Kukpowruk River

The Kukpowruk coal field is the only area in northern Alaska that has been subjected to significant exploration activity. The geology of the Kukpowruk coal field has been described by Callahan and Others (1969). Sampling and carbonization tests are the topic of a report by Warfield, Landers, and Boley (1966).

Shown in Figure 4-2, the Kukpowruk River District is the area with the thickest identified bituminous coal seam, the largest coal quantity, and the greatest amount of exploration activity. The dip of the 20-foot seam is approximately 15°; therefore, it is acceptable for surface mining.

a. Location

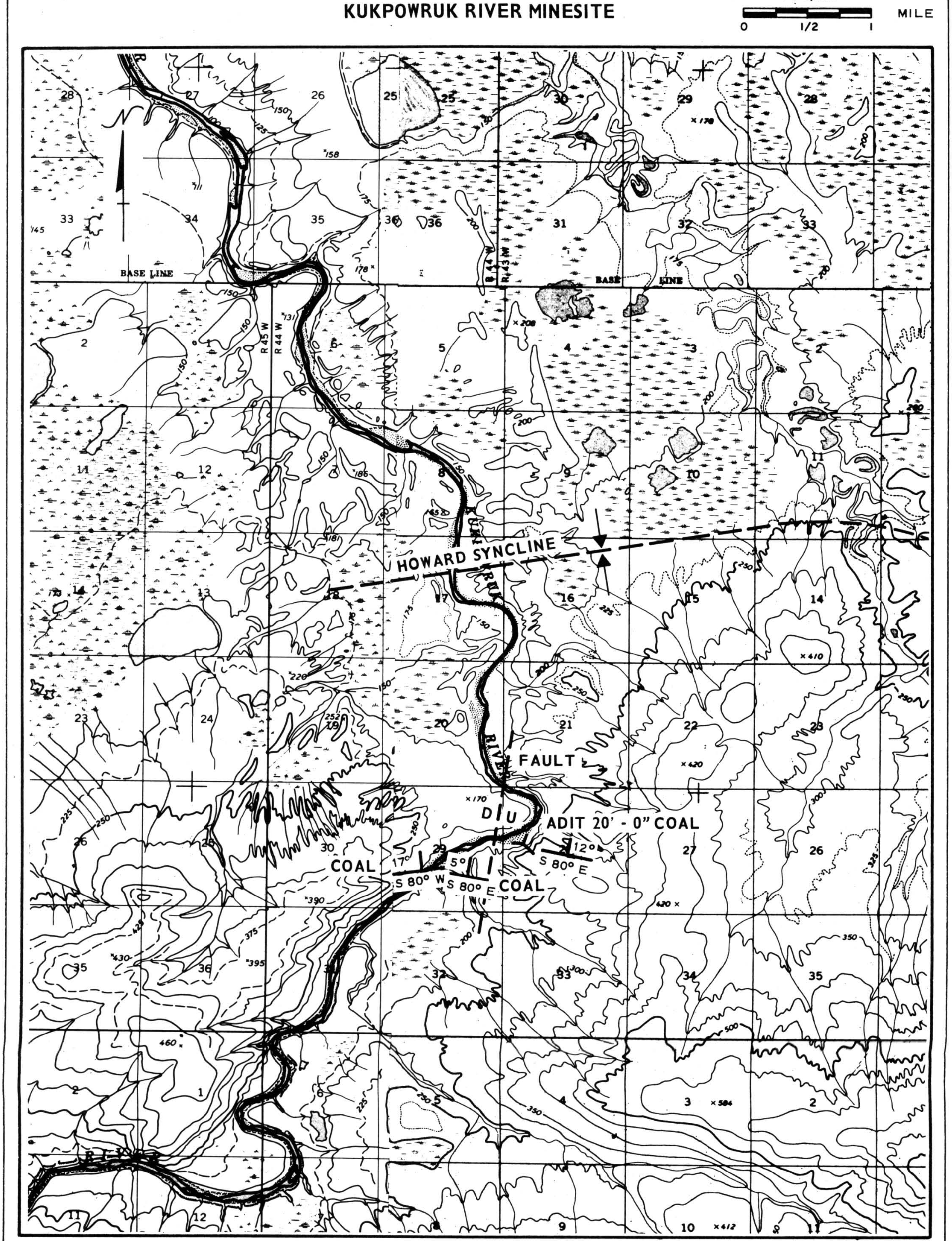
Location is at approximate latitude 69°20'N, longitude 160°30'W. The field is 23 miles southeast of the mouth of the Kukpowruk River. This location is at the northern margin of the northern foothills of the Arctic mountains, 14 miles east of the Chukchi Sea coast. Point Lay which is 28 miles north-northwest of the coal field is the nearest permenently inhabitated community. The closest sizeable community is Kotzebue, which is 170 miles due south of the coal deposits.

b. Exploration History

The coal deposits, which lie between Cape Lisburne and Wainwright, were the first exploited by whalers in 1879. In 1904, a geologic reconnaissance of the coastal deposits south of Cape Beaufort was made by A. J. Collier. The first account of the

FIGURE 4 - 2

KUKPOWRUK RIVER MINESITE



Kukpowruk River coal field was published by W. T. Foran in 1923. This report contains the first mention of the 20-foot seam occuring in the area.

Geologic mapping of the area along the rivers was done between 1947 and 1953. In 1954, a 76-foot adit was driven into the 20-foot Kukpowruk seam by J. S. Robbins and Associates, Inc. of Seattle, Washington, for the Morgan Coal Company of Indianapolis, Indiana. A large bulk sample was taken from an inclined raise at the adit face. Union Carbide Company of New York did additional sampling in the Morgan Adit and sent the samples to Japan for coking tests. This work was done 1961 and 1963.

In 1966, the U. S. Bureau of Mines drilled four core holes approximately one mile west of the Morgan Adit. This work was done to test the continuity of the coking properties of the Kukpowruk seam. During 1966 and 1967, the U. S. Geological Survey mapped the Kukpowruk area using 1:50,000-scale aerial photographs as a base. In 1970, further field reconnaissance was done by Kaiser Steel Corporation of Oakland, California.

c. Geology of the Deposit

The Kukpowruk coal deposit is on the southern limb of the Howard Syncline, a simple broad symmetrical fold which plunges westward. The dip of the bedding becomes almost vertical near the axis of the Snowbank Anticline to the north of the Howard Syncline. On the southern limb of the Howard Syncline, the dip reaches 40° at the contact of the Kukpowruk and Corwin Formations. At the site of the Morgan Adit, the strike of the seam is N40°W and the dip is 12°NE.

Coal occurs throughout the Corwin Formation and in thin beds in the transitional zone of the Kukpowruk Formation. In the Howard Syncline, a sequence of 4,632 feet of the Corwin Formation has been mapped. Thin beds of coal less than 1.5 feet in thickness are situated in the lower 3,100 foot layer of the Corwin Formation. The 20-foot thick seam occurs 3,132 feet above the Corwin-Kukpowruk contact. This seam is overlain by 1,500 feet of sediments consisting of claystone, sandstone, siltstone, and shale. Eight coal beds greater than 2 feet are located in this section.

d. Coal Quality

Most of the test work has been done on the Kukpowruk seam samples taken from the Morgan Adit. The coal has been ranked bituminous "High Volatile A-B." Proximate analysis is as follows:

Moisture	2.8 percent
Ash	3.5 percent
Fixed Carbon	58.5 percent
Volatile Matter	35.2 percent

This coal exhibits moderate coking qualities and is judged to compare favorably with western U. S. and Australian coals when coked in blend.

e. Strippable Reserves

Coal reserves were calculated by Callahan and Others (1969). Total measured, indicated, and inferred coal resources to a depth of 1,000 feet with seam thickness greater than 42 inches is 257 million tons. With a cut-off volumetric stripping ratio of 10:1, strippable reserves are estimated to be 20 million tons. Approximately 70 percent of this reserve tonnage is contained in the Kukpowruk (No. 1) seam.

2. Utukok River (Elusive Creek)

Although the geology and coal resources of the Utukok River have received some attention since 1923, the degree of activity is far less than in the Kukpowruk River area.

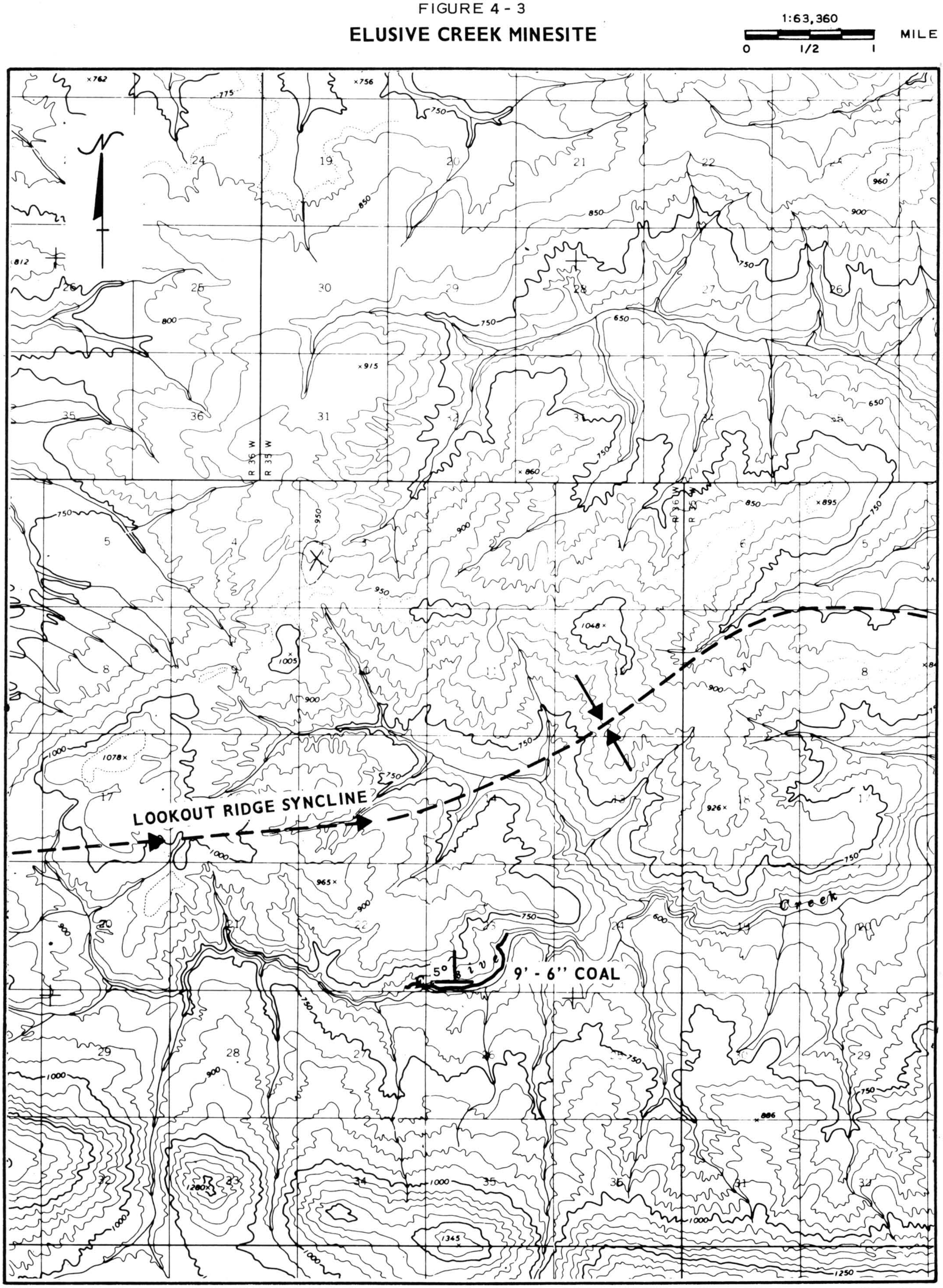
a. Location

Coal deposits are located along a 50-mile section of the Utukok River which begins 10 miles from the mouth of the river. The deposit which is thought to be the most amendable to surface mining is located on Elusive Creek, at latitude 69°23'N, longitude 160°35'E. This location is approximately 47 miles east-northeast of the Kukpowruk deposit. The nearest community is Point Lay, 65 miles west-northwest of the area.

The deposit is in the northern fringe of the northern foothills, in a well-drained area of moderate relief. The land surface is dry tundra. The Elusive Creek deposit is shown in Figure 4-3.

FIGURE 4 - 3

ELUSIVE CREEK MINESITE



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b. Exploration History

There is no history of coal exploration in the Elusive Creek area. Coal deposits in the area were investigated by Foran in 1924 and are summarized by Smith and Mertrie (1930). The geology of the area is described by Chapman and Sable (1960).

c. Geology of the Deposit

The Elusive Creek deposit is situated on the southern flank of the Lookout Ridge syncline. In the area of the deposit, the syncline plunges northeastward. The only identifiable seam of significant thickness is 9.5 feet thick, dipping 4 to 5^{o} north-northwest. The seam occurs well above the base of the Corwin Formation.

d. Coal Quality and Reserves

The coal is of bituminous rank. Although the surface exposure of the Elusive Creek seam appears quite dirty, a 11-foot seam located 10 miles northeast of the outcrop contains 3.2 percent ash. The 11-foot seam was not considered to have a good mining potential because of its steep (25^{o}) dip.

The reserves of the Elusive Creek deposit have not been calculated.

3. Kuk River

The Kuk River coal field has the greatest surface mining potential of all the subbituminous districts. This area has the largest coal quantity in terms of all resource categories and has received the most exploration activity. Although the thickest seam was reported in the Ikpikpuk River district, the coal tonnage attributed to it is minor. The area does offer surface mining potential because the seams are flat-lying and because of the proximity of the field to tide-water. The 10-foot seam on the Kuk River dips at less than 7^{o}. The Kuk River deposit is shown in Figure 4-4.

a. Location and Geology

The Kuk River deposits are principally located on the Kuk River estuary within 20 miles of the community of Wainwright. The deposits are described in U.S.B.M. RI 3934 (1946) and U.S.B.M. RI 4150 (1947). The land is wet tundra.

Outcrops are located on the eastern shore of the Kuk River. The structure in the area is relatively flat. Dips are generally less than 7°. The coal seams dip both toward and away from the river. The coal in this area occurs in the Chandler Formation.

The Kuk River deposit is thought to consist of one primary bed which is from 9.7 to 10.2 feet thick. Outcrops have been located along the east bank of the Kuk River for a distance of nine miles.

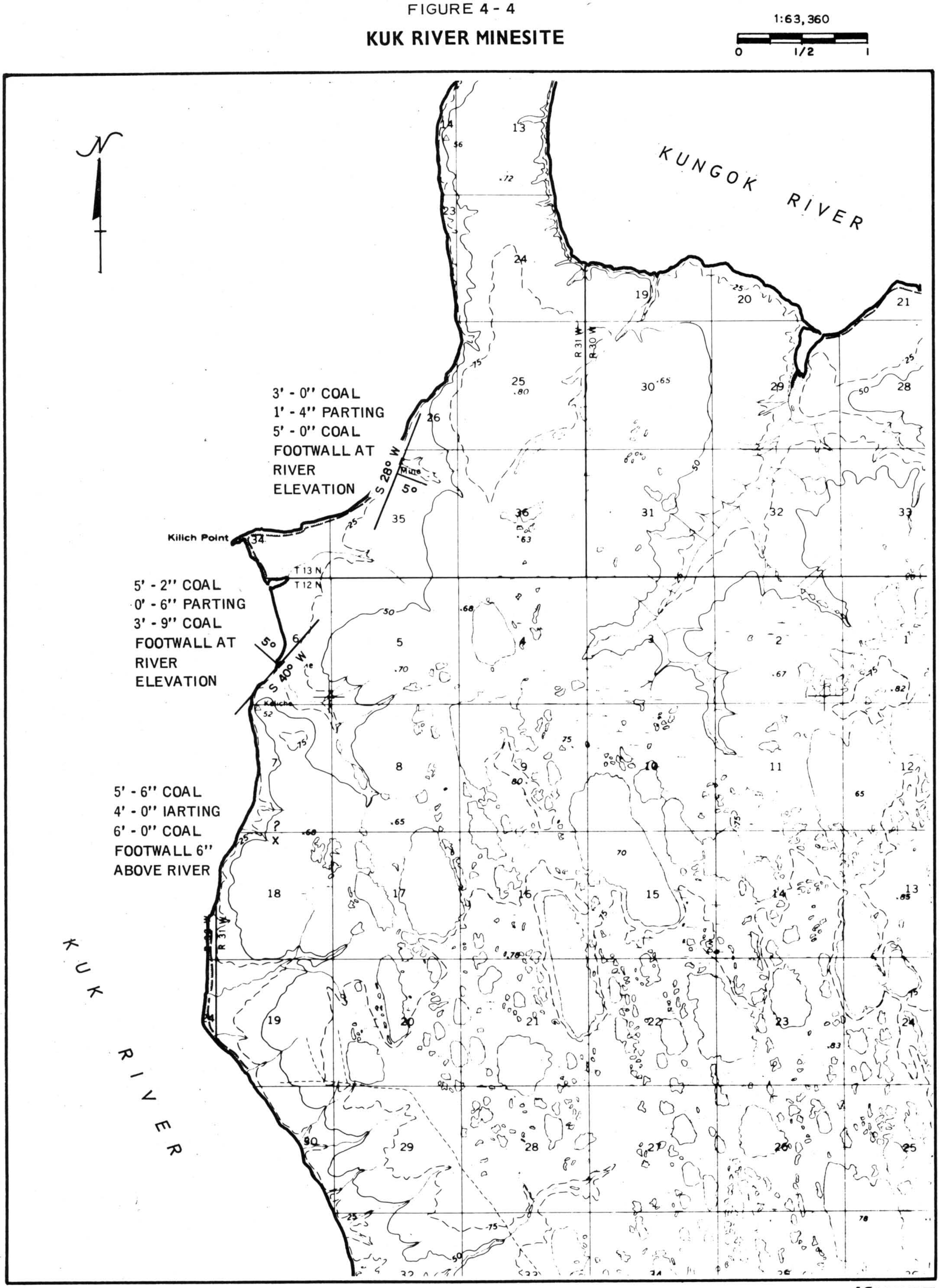
b. Coal Quality and Reserves

The coal is of subbituminous B and C rank. The few samples which have been analyzed are low (2.5%) in ash and high (24 to 27%) in moisture.

Reserves have not been calculated.

FIGURE 4 - 4

KUK RIVER MINESITE



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V. POTENTIAL MINING SYSTEMS

A. PRODUCTION LEVEL

The published coal inventory of the Kukpowruk River deposit indicates that it could sustain an annual output of 500,000 tons for more than 20 years. This output would probably be insufficient to support infrastructure costs. Kaiser Engineers also considered a hypothetical case of 5-million-tons-per-year output for each of the three minesites. It must be emphasized that there is no geologic justification for the larger output scale. The 5-million-tons-per-year rate at each minesite is the minimum output level considered to make the mining economically feasible.

B. MINING REQUIREMENTS

Throughout the study, the distinction has been made between

- a 500,000 ton/yr operation at Kukpowruk River, and
- a 5-million ton/yr operation at each of the three potential minesites.

1. General Description: 500,000 Ton/Yr

Because of the limited reserves and the requirements for a 20-year mine life, a production rate of 500,000 tons per year was selected. Average seam thickness is 20 feet with an average dip of 15° from a surface outcrop. A cut-off point of 100 feet of overburden has been selected as the maximum practical limit for a dragline operation of this scale, resulting in an average stripping ratio of 2.4 cubic yards of overburden per ton of coal recovered.

Overburden removal would be accomplished by a 12-cubic-yard, crawler-type dragline. Coal loading would be accomplished by a 10-cubic-yard front end loader into 50-ton end dump trucks. Overburden drilling would be done by an electric-powered rotary drill, drilling 9-7/8 inch holes on 20-foot centers. The proposed stripping equipment has adequate capacity to permit the production of 500,000 tons of coal in approximately 4,400 hours. This will permit a seasonal operation or a 2-shift, 5-day workweek. Coal loading can be accomplished in 2,000 hours per year, thus permitting coal loading to be done only during the shipping season.

Living accommodation would be on a single-status basis at a camp at the minesite. Power generation would be by diesel-powered generators.

2. General Description: 5 Million Ton/Yr

At all three minesites a cut-off depth of 150 feet of overburden has been established as the practical limit for the equipment selected. The average stripping ratios are:

- Kukpowruk River: 4.1 yd^3/ton
- Elusive Creek: 9.0 yd^3/ton
- Kuk River: 8.0 yd^3/ton

Three mining methods have been developed and costed:

- draglines (Figure 5-1)
- shovels and trucks (Figure 5-2)
- combinations of draglines and shovels and trucks (Figure 5-3).

In all three methods, topsoil would be excavated by means of either scrapers or 15-yd^3 loaders and 50-ton trucks. Overburden would be drilled with 12 $\frac{1}{4}$-inch diameter electric rotary drills. Blasting would be done with ammonium nitrate and fuel oil and nitro-carbo-nitrate slurry.

In the dragline operations, excavation of overburden would be by 50-yd^3 and 100-yd^3 electric walking draglines. The truck-and-shovel operation would use 22-yd^3 electric mining shovels and 170-ton diesel-electric rear-dump trucks. In the systems using combinations of shovels, trucks, and draglines, 22-yd^3 shovels and 170-ton trucks would be substituted for the 50-yd^3 draglines.

In all cases, coal is drilled and blasted prior to being loaded. At the Kukpowruk River site coal would be loaded by a 15-yd^3 electric shovel and a 15-yd^3 diesel front-end loaders. At the other minesites, coal is loaded with 15-yd^3 front-end loaders. Coal would be transported to the minesite stockpile in 180-ton diesel-electric bottom-dump trucks.

Specific requirements of major mobile equipment for each mining method at each minesite are summarized in Table 5-1.

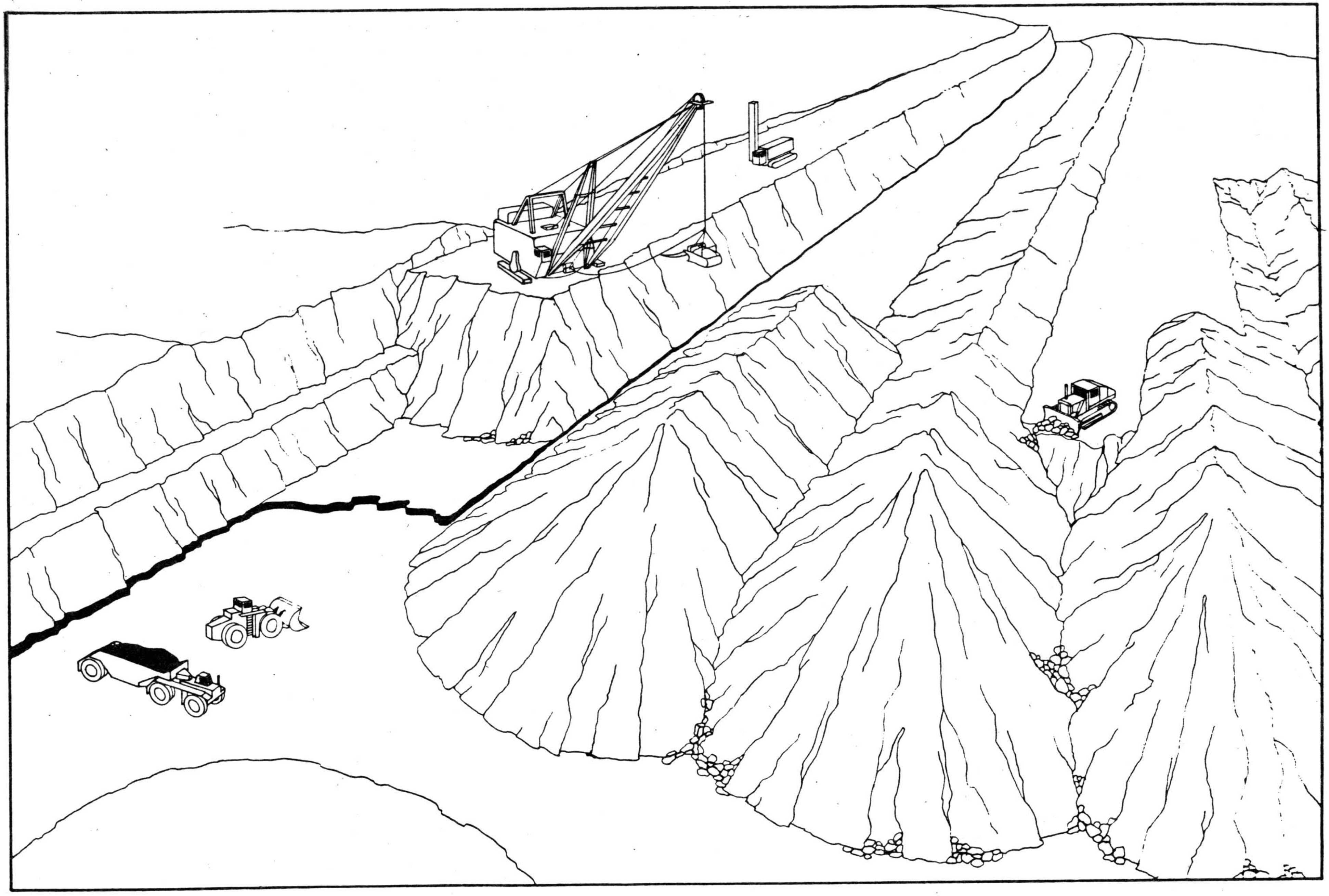

Figure 5 - 1 DRAGLINE EXCAVATION

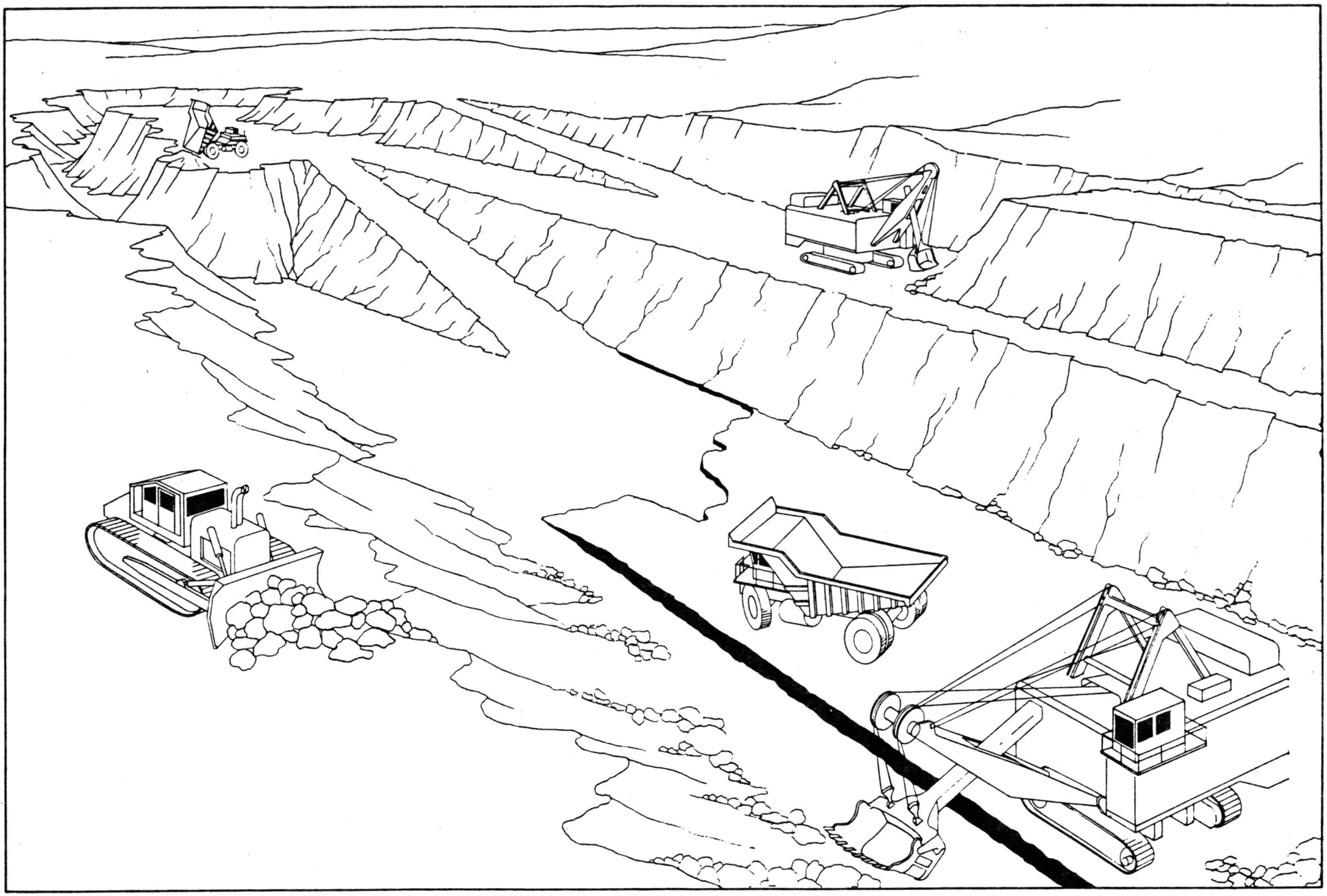

Figure 5 - 2 SHOVEL EXCAVATION

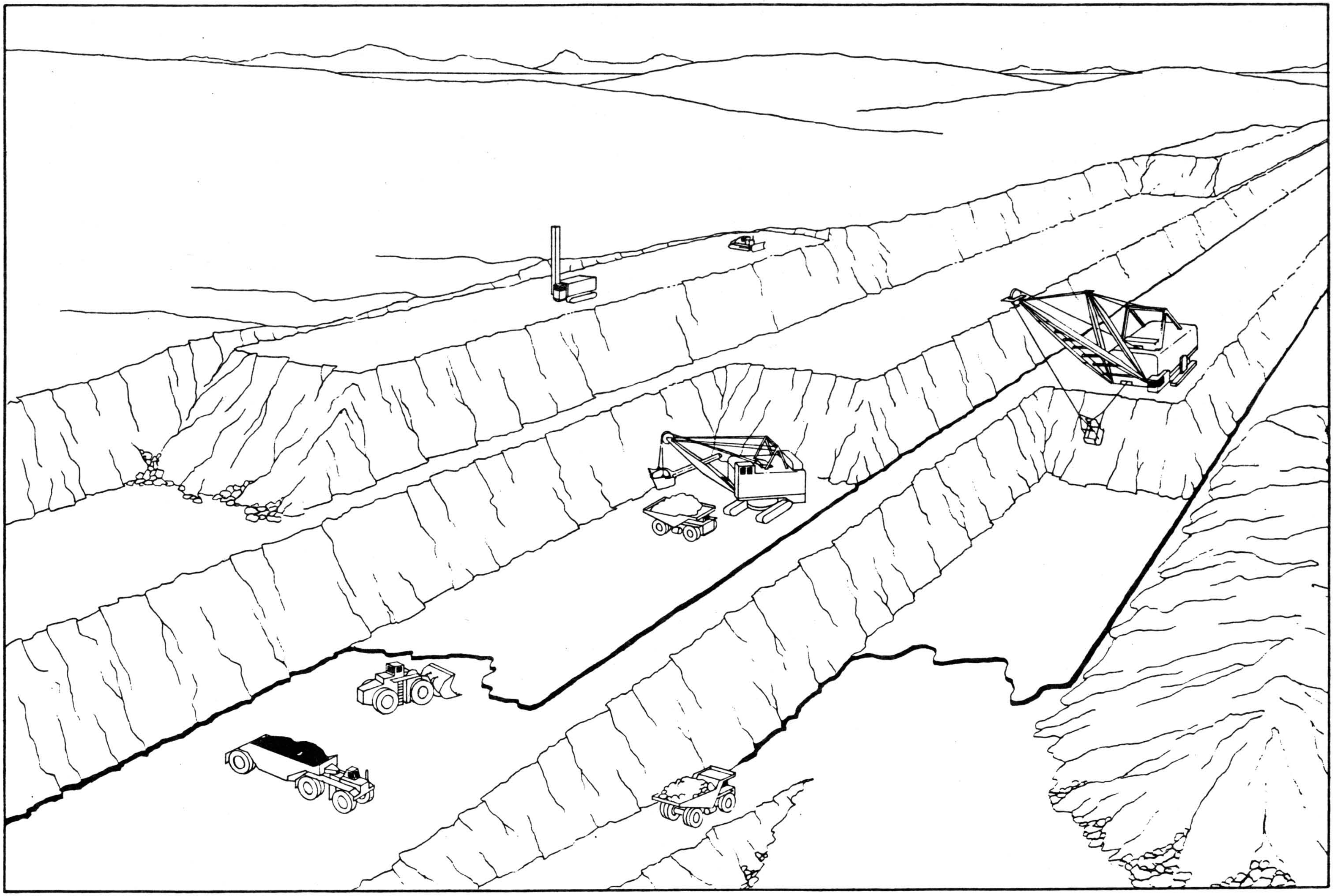

Figure 5 - 3 DRAGLINE - SHOVEL EXCAVATION

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TABLE 5-1

MAJOR MINING EQUIPMENT REQUIREMENTS 500,000 TON-PER-YEAR-PRODUCTION KUKPOWRUK RIVER

Equipment	Mining Method: Dragline
Dragline (12-yd^3)	1
Drill-overburden (9-7/8 inch dia.)	1
Truck - Coal - (50-ton)	6
Front End Loader - (10-yd^3)	2
Coal Drill	1
Bulldozer - Crawler	2
Mobile Crane - 25-ton	1

5,000,000 TON-PER-YEAR-PRODUCTION KUKPOWRUK RIVER

Equipment	Mining Method		
	Dragline	Shovel	Dragline & Shovel
Dragline (100 yd^3)	1	0	1
Dragline (50 yd^3)	1	0	0
Shovel-Overburden (22 yd^3)	0	3	1
Truck-Overburden (170 ton)	0	14	5
Drill-Overburden ($12\frac{1}{4}$ inch dia.)	4	4	4
Shovel - Coal (15 yd^3)	1	1	1
Truck - Coal (180 ton)	8	8	8
Front End Loader (15 yd^3)	1	1	1
Coal Drill	2	2	2
Bulldozer - Crawler	9	11	10
Bulldozer - Rubber Tired	2	3	2
Mobile Crane (100 ton)	1	1	1
Mobile Crane (50 ton)	1	1	1

TABLE 5-1 (Continued)

ELUSIVE CREEK

Equipment	Mining Method		
	Dragline	Shovel	Dragline & Shovel
Dragline (100 yd^3)	2	0	2
Dragline (50 yd^3)	2	0	0
Shovel-Overburden (22 yd^3)	0	7	3
Truck-Overburden (170 ton)	0	30	13
Drill-Overburden ($12\frac{1}{4}$ inch dia.)	8	8	8
Truck - Coal (180 ton)	10	10	10
Front End Loader (15 yd^3)	3	3	3
Coal Drill	2	2	2
Bulldozer - Crawler	15	18	17
Bulldozer - Rubber Tired	2	4	2
Mobile Crane (100 ton)	1	1	1
Mobile Crane (50 ton)	1	1	1

KUK RIVER

Equipment	Mining Method		
	Dragline	Shovel	Dragline & Shovel
Dragline (100 yd^3)	2	0	2
Dragline (50 yd^3)	2	0	0
Shovel-Overburden (22 yd^3)	0	6	2
Truck-Overburden (170 ton)	0	27	10
Drill-Overburden ($12\frac{1}{4}$ inch dia)	7	7	7
Truck - Coal (180 ton)	10	10	10
Front End Loader (15 yd^3)	3	3	3
Coal Drill	2	2	2
Bulldozer - Crawler	14	17	16
Bulldozer - Rubber Tired	2	4	3
Mobile Crane (100 ton)	1	1	1
Mobile Crane (50 ton)	1	1	1

3. Mining Costs

Mining costs for a 500,000 ton-per-year operation at Kukpowruk River and for 5-million-ton-per-year mines at all three locations are summarized in Table 5-2. The cost estimates are presented in the Appendix. Currently, there is insufficient demonstrated coal to sustain the 5-million-ton output level, however costs were developed in order to determine the economics of relatively large-scale production in northern Alaska.

For the 500,000-ton-per-year operation the required price of coal at the minesite to provide an after-tax rate of return of 15 percent would be $30.01 per ton or $1.25 per million Btu. The larger scale of operation would permit prices of $17.98 to $20.04 at Kukpowruk River, $29.63 to $33.99 at Elusive Creek, and $27.82 to $31.00 at Kuk River. Price per million Btu's would range from $0.75 to $1.68.

C. TOWNSITE AND INFRASTRUCTURE REQUIREMENTS FOR 5,000,000 TON-PER-YEAR OUTPUT

1. Townsite Description

The determination of an appropriate townsite plan for a large northern Alaska coal mine is a major study in itself. However, it is more likely that a townsite, company-owned rather than employee-owned, would be better established than a single-status camp, since if only single-status accommodations were provided and workers were flown into the minesite on a regularly-scheduled basis from southern Alaska, other problems would develop. The distance to Fairbanks is approximately 500 miles and to Anchorage approximately 650 miles. These distances could be excessive for routine commuting. Also, the weather in northern Alaska is too foggy and windy to allow complete reliance on scheduled air service.

The following assumptions were used to determine the potential townsite population. There would be a ratio of mine to non-mine employees of 2:1. Seventy percent of all employees would be married. The average family size for married employees would be 3.2 people. An allowance for more than one employee would give an approximate townsite population of 375 percent of the mine payroll.

TABLE 5-2

MINING COST SUMMARY
500,000 Ton/Yr Production

Mine Location	Mining System	
	Dragline	
	$ per ton	$ per million Btu's
Kukpowruk River	30.01	1.25

5,000,000 Ton/Yr Production

Mine Location	Mining System					
	Dragline		Shovel		Shovel & Dragline	
	$ per ton	$ per million Btu's	$ per ton	$ per million Btu's	$ per ton	$ per million Btu's
Kukpowruk River	13.83	0.58	15.40	0.64	14.40	0.60
Elusive Creek	22.94	0.96	26.13	1.09	24.59	1.02
Kuk River	21.28	1.25	23.51	1.38	22.00	1.29

These assumptions provide the following estimates of townsite population.

Mine Location/Mining System	Mine Employees	Townsite Population
Kukpowruk River		
Dragline	307	1,151
Shovel and Truck	437	1,639
Combination	346	1,298
Elusive Creek		
Dragline	486	1,823
Shovel and Truck	727	2,726
Combination	568	2,130
Kuk River		
Dragline	469	1,759
Shovel and Truck	685	2,569
Combination	527	1,976

Since the type of housing required was not determined, townsite space requirements were calculated on the basis of 500 square feet per townsite inhabitant. This includes residential, recreational, and services facilities.

2. Utility Description

The generation of electricity for the 5-million-ton-per-year mines would be by a coal-fired steam plant located near the minesite. Standby diesel-powered generating capacity would also be provided. Mine power demand and consumption has been calculated from mine equipment specifications. Townsite demand was assumed to be 5.0 kilowatts per inhabitant and townsite consumption was assumed to be 27,000 kilowatt-hours per year per inhabitant. This is based on electricity providing all of the townsite energy requirements.

For the various potential mines, the capacity of the required generating facilities, including spare units for emergencies, was determined.

The following is a summary of power plant requirements.

		Mining System	
Location	Dragline	Shovel and Truck	Dragline and Shovel and Truck
Kukpowruk River	45.0 MVA	22.5 MVA	37.5 MVA
Elusive Creek	75.0 MVA	45.0 MVA	60.0 MVA
Kuk River	75.0 MVA	45.0 MVA	60.0 MVA

3. Townsite and Utility Costs

The criteria for and estimates of cost for townsite and utility facilities for the three 5-million-ton-per-year mines are presented in the Appendix. A summary of these costs is presented in Table 5-2. As there is no townsite as such at the 500,000 ton/yr operation, the cost of the minesite camp is included in the mining cost.

As is shown in Table 5-3, there is a tendency for the power plant costs to offset townsite costs. Because of the high power requirements of the dragline operation, the capital cost is almost the same as for a shovel-and-truck operation which has a greater townsite requirement. Because operating costs for the mine power consumption are included in the mining costs, the operating costs for a shovel-and-truck operation are significantly higher than for a dragline operation.

D. TRANSPORTATION OF COAL

In the same manner as infrastructure development costs in remote areas, the need to construct and operate a transportation system significantly affects the economics of a remote mining project, particularly with a bulk commodity of relatively low unit value such as coal. It has been assumed that most supplies would be backhauled on the coal transportation system or barged to a point near the minesite. The transportation of high-value or perishable supplies would be by air. Personnel would also be transported from southern Alaska to the minesite by air.

1. System Descriptions

a. All-Year Shipping by Railway

This system would involve the construction of a railway through delicate permafrost region from the minesite to the Alaska

TABLE 5-3

TOWNSITE, EMPLOYEE HOUSING, AND POWER PLANT SUMMARY
ESTIMATED CAPITAL AND OPERATING COST
($/ton)

500,000-TON-PER-YEAR PRODUCTION
KUKPOWRUK RIVER

Housing and power plant capital and operating costs for a 500,000-ton-per year operation, employing 99 persons at a campsite rather than a townsite, are included in the total mining cost estimate.

5,000,000-TON-PER-YEAR PRODUCTION

No. Mine Employees/, Town Population	Mining System		
	Dragline	Shovel	Dragline & Shovel
KUKPOWRUK RIVER			
307/1,151	4.15		
437/1,639		4.64	
346/1,298			4.25
ELUSIVE CREEK			
486/1,823	6.69		
727/2,726		7.86	
568/2,130			6.93
KUK RIVER			
469/1,759	6.54		
685/2,569		7.49	
527/1,076			6.57

Railway at Nenana, southwest of Fairbanks. For the Kukpowruk River minesite, approximately 720 miles of new railway would be constructed. For the Elusive Creek minesite, 650 miles would be required, and for the Kuk River minesite, 730 miles. This route would also permit development of other resources in the Alaskan interior. Potential rail routes are shown in Figure 5-4.

Haulage would be done in 125-car unit trains carrying 13,000 tons and powered by eight 3,000 horsepower locomotives. The average loading time would be three hours and the average unloading time four hours per train. The average travel speed would be 30 miles per hour. For each of the proposed minesites five trains would be required.

The unit trains would be unloaded at an ice-free port in the Seward-Whittier area. Because this transportation system would operate all year, stockpile requirements would be nominal. A stockpile of 250,000 tons capacity should be adequate to ensure a smooth flow of coal. The port facility would be designed so that train unloading and ship loading could take place simultaneously.

b. Seasonal Shipping by Barge

Coal would be transported from the minesite to the Chukchi Sea coast by means of haulage trucks, belt conveyor, or slurry pipeline. Potential routes are shown in Figures 5-5 and 5-6. Truck haulage would be done by 180-ton bottom-dump trucks over a heavy duty all weather road which would connect the minesite to the coal storage and barge-loading facility on the Chukchi Sea. This distance would be 25 miles for the Kukpowruk River mine, 75 miles for the Elusive Creek mine, and 35 miles for the Kuk River mine.

An alternative method of transporting the coal from the mine to the barge loading facility would be by means of a 36-inch belt conveyor over substantially the same route as would be used for truck haulage. The belt would be in 3-mile flights and would travel at a speed of 1,000 feet per minute. Primary drives would be 1,350 horsepower and secondary drives would be 330 horsepower.

TABLE 5-4

SUMMARY OF TRANSPORTATION COSTS
($/ton)

500,000-TON-PER-YEAR PRODUCTION
KUKPOWRUK RIVER

Transportation Mode	Mining System
	Dragline
Truck and Barge	19.22

5,000,000-TON-PER-YEAR PRODUCTION
KUKPOWRUK RIVER

Transportation Mode	Mining System		
	Dragline	Shovel	Dragline & Shovel
Railroad	82.71	82.71	82.71
Truck and Barge	11.76	12.07	11.87
Conveyor and Barge	11.64	11.98	11.78
Slurry Pipeline and Barge	11.60	11.91	11.71

ELUSIVE CREEK

Transportation Mode	Mining System		
	Dragline	Shovel	Dragline & Shovel
Railroad	75.50	75.50	75.50
Truck and Barge	17.96	18.57	18.15
Conveyor and Barge	18.05	18.66	18.24
Slurry Pipeline and Barge	15.16	15.78	15.35

TABLE 5-4 (Continued)

KUK RIVER

Transportation Mode	Mining Method		
	Dragline	Shovel	Dragline & Shovel
Railroad	83.75	83.75	83.75
Truck and Barge	13.42	13.95	13.59
Conveyor and Barge	13.25	13.78	13.42
Slurry Pipeline and Barge	12.73	13.26	12.90

A third method of transporting the coal from the minesite to the Chukchi Sea coast would be by means of a slurry pipe constructed over the same route as would be used for the haulage road and the belt conveyor. The slurry system would consist of a 16-inch slurry line and a 12-inch return water line. Pumping stations consisting of 3 operating and 1 spare, 1,750 horsepower slurry pumps would be located at 20-mile intervals. Return water pumping stations consisting of three 150 horsepower pumps would be located at 20-mile intervals. The coal would be de-watered and stockpiled at the barge-loading facility for shipment during the ice-free season.

At the barge-loading facility at the Chukchi Sea coast, sufficient stockpile capacity would be required to permit the storage of a minimum of 9 months' production of coal or 3.75 million tons of coal. Loading facilities would have the capacity to load two 60,000-ton load capacity barges simultaneously. To reach water deep enough for safe barge operation, a long rock-filled pier would be required.

Coal haulage to an ice-free port at Dutch Harbor would be by seven 4,400 horsepower tugs and nine 60,000-ton load capacity barges which would be 611 feet long and 135 feet wide with a loaded draught of 33 feet. Tugs would drop off barges at both ends of the trip and pick up other barges which would have been either loaded or unloaded at the respective port facility. This operating procedure would maximize the productivity of the tugs.

The barges would be unloaded at the ice-free port of Dutch Harbor. This port facility would have stockpile capacity of 3.75 million tons of coal and sufficient berthing capacity to permit the unloading of two barges and the loading of one bulk carrier simultaneously. Transportation routes are shown in Figure 5-4.

2. Transportation Costs

Transportation cost estimates have been based on the investigation of Clark (1973). Clark did not escalate any of the cost information included in his study. Kaiser Engineers has modified some of Clark's data where calculation errors were found and altered some estimates where more recent information was available. The modified estimates were escalated in accordance with the highway bid price index and the building cost index published in the December

23 edition of "Engineering News Record." Escalation factors of 1.70 for road and railway construction and 1.96 for equipment and other construction were applied to 1969 cost data. Cost data for 1972 was escalated by a factor of 1.47.

A summary of transportation costs is presented in Table 5-4. The estimate of transportation costs and the criteria from which the estimate was made are in the Appendix.

Rail transportation is expensive because there would be insufficient volume to ammortize capital costs efficiently. The three systems involving seasonal barge systems have similar costs for each minesite.

FIGURE 5 - 4

TRANSPORTATION ROUTES FOR NORTHERN ALASKA COAL

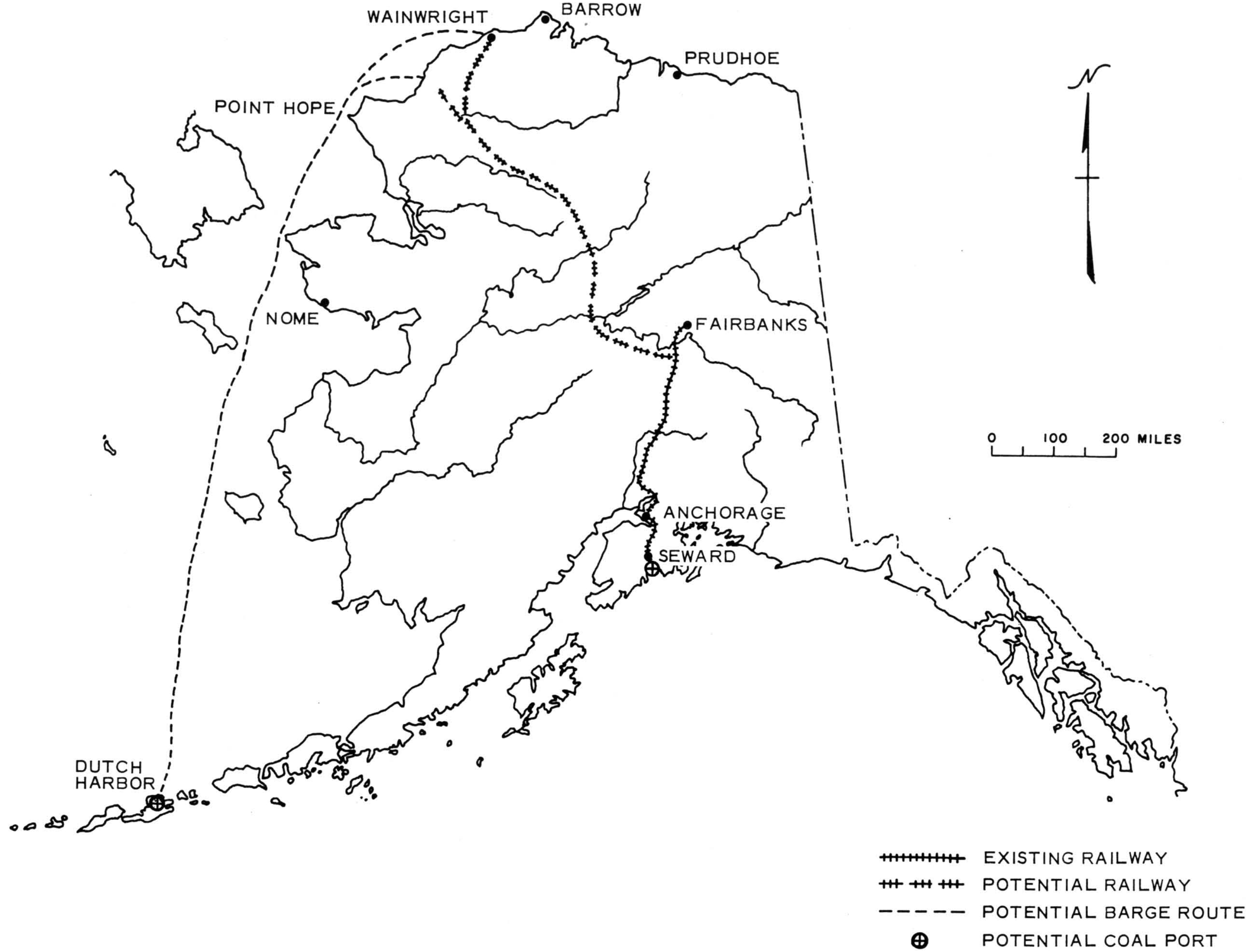


FIGURE 5 - 5

KUK RIVER MINE SITE & TRANSPORTATION CORRIDOR

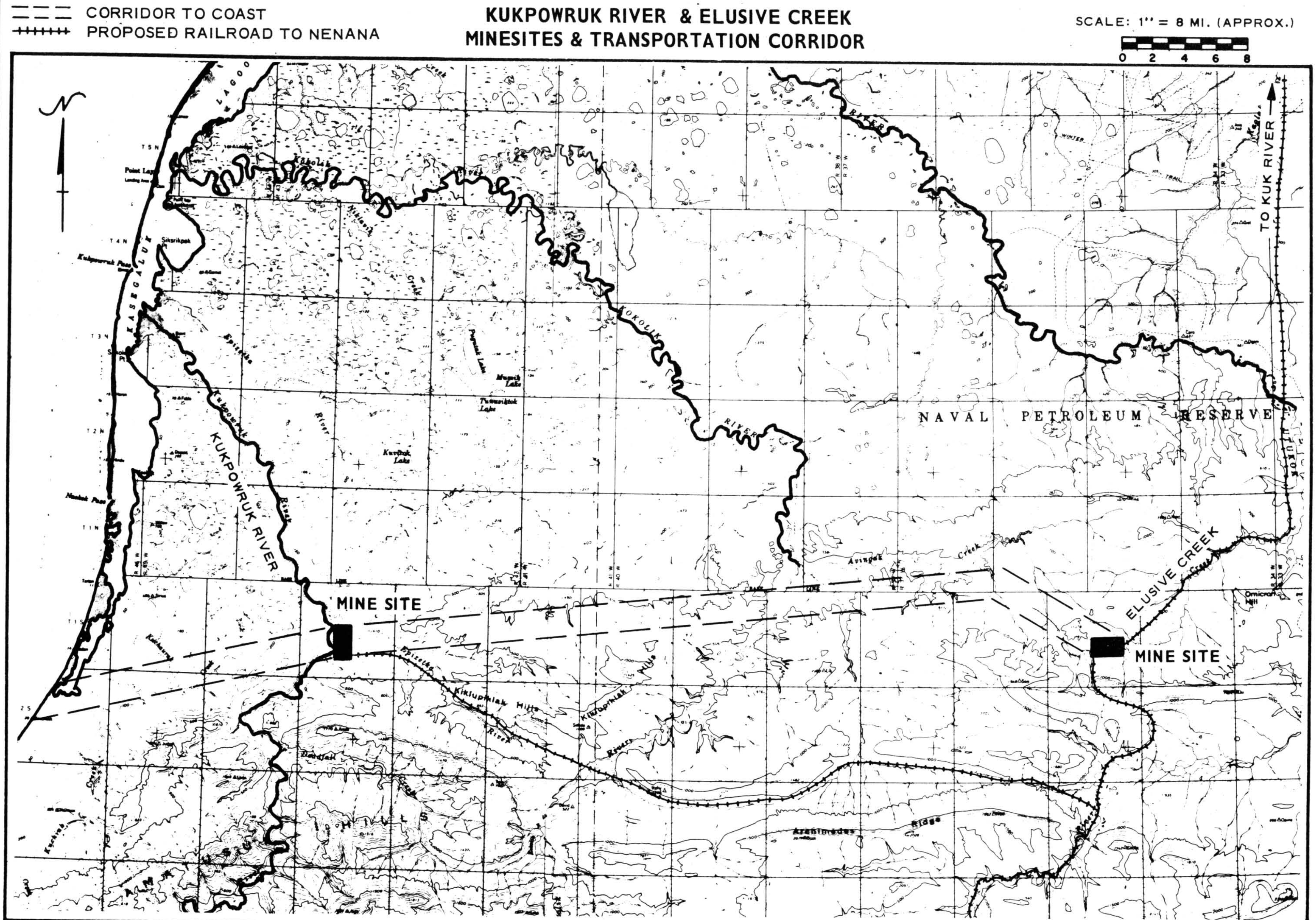
CORRIDOR TO COAST
PROPOSED RAILROAD TO NENANA

1:500,000
0 2 4 6 8 MILES

KAISER ENGINEERS

FIGURE 5 - 6

KUKPOWRUK RIVER & ELUSIVE CREEK MINESITES & TRANSPORTATION CORRIDOR



VI. ENVIRONMENTAL IMPACT AND RECLAMATION

In the harsh climate of Northern Alaska, environmental impact and reclamation is of as much concern as the special construction and equipment operating techniques required for such a delicate permafrost regime. Studied for little more than a decade, Arctic reclamation projects have had too little time to be proven conclusively effective. Currently, insufficient data exists to make detailed environmental impact assessment of potential Northern Alaska mining activity.

A. ENVIRONMENTAL IMPACT

Impacts to the environment will result from the mines, the townsite and utility facilities, and the transportation systems.

1. Mines

a. Environmental Impact of 500,000 Ton/Yr Operation

The environmental impact of a 500,000 ton-per-year operation with seasonal shipping and single status accommodation would be less severe than those which would be caused by larger-scale mining activities. The mine would be located near the banks of the Kukpowruk River near the northern extremity of the northern foothills. Mining would be done by one electric 12-cubic-yard dragline, one 9-7/8-inch electric drill, two 10-cubic-yard wheel loaders, six 50-ton trucks, and miscellaneous support equipment. Power would be generated at the minesite by diesel-powered generators. Camp accommodation for 100 employees would be located at the minesite. Approximately 13 acres would be mined per year.

This mining operation will have impact upon water resources, air resources, vegetation, wildlife, and existing human population. The greatest potential impact of the project would be the effects on surface water quality.

The mine and camp operation would have a water demand of approximately 50,000 gallons per day during the summer and 10,000 gallons per day during the winter. This demand would not have much effect on the Kukpowruk River during the summer. However, during the winter, when stream flow is very low, the mine demand could have more impact. Sewage treatment and disposal could be a problem in northern Alaska, particularly during the winter, and will have to be studied closely.

There would be several minor effects upon air quality. Because diesel fuel would be the source of all energy and because the total number of engines would probably be limited to less than 40, pollution of the air would not be a problem. Airborne particulate matter could result from blasting or during periods of high winds. However, it is not thought that particulate air pollution would be a problem. Noise from the mining and power generating facilities would not be great. With the exception of blasting noise, it is anticipated that noise from the mine would not be perceived outside of a 2- to 3-mile radius of the minesite.

The mining pit and plantsite would have impact on vegetation and existing soil resources. Repair shops, offices, and camp facilities would occupy approximately 10 acres. The rate of mining would be approximately 13 acres per year. During the course of a 20-year mine life, approximately 270 acres of mined land and plantsite would have to be reclaimed.

The mining activity itself should not have any significant impact on wildlife, but the human population associated with the mine could affect the population of large mammals if proper wildlife management policies are not pursued.

b. Environmental Impact of 5 Million Ton/Yr Operations

The surface mining of 5 million tons per year of coal will have major, but localized impact on the Arctic environment.

Mining would be done by draglines, shovels and trucks, or a combination of draglines and shovels and trucks. The electrically-powered draglines would be of 100-cubic-yard and 50-cubic-yard capacity. Electrically-powered mining shovels would be of 22-cubic-yard capacity. Haulage trucks with a 170-ton capacity would be used for rock, and 180-ton trucks would be used for coal. Electrically-powered rotary overburden drills, and diesel-powered dozers, graders, and wheel loaders would also be used.

The scale of overburden mining activity is almost twice as great for Elusive Creek (9.0 cubic yards overburden per ton coal) and Kuk River operation (4.1 cubic yards per ton) as it is for the Kukpowruk River operation (8.0 cubic yards per ton). Therefore, environmental impact due to manpower and equipment requirements would be lowest at Kukpowruk River, with the other two locations being considerably higher.

The mines would not have a great effect on water resources, provided that effective measures are taken to control erosion and prevent stream siltation due to erosion. Only the Kuk River minesite offers a unique problem. The minesite is located in wet tundra and would require specific strategies for handling surface water.

There would be effects on air quality due to mining operations. Blasting operations and wind-erosion from unstabilized dumps will result in airborne particulate matter. Because most of the large equipment would be electrically powered, air pollution from internal combustion engines would be insignificant. The only significant noise from the mining operations would be blasting noise. Mining systems that use trucks to haul overburden would be noisier than systems that use draglines.

The mining operations would have impact upon vegetation. Mining would be at the rate of 143 acres per year at Kukpowruk River, 302 acres per year at Elusive Creek, and 359 acres for Kuk River. Allowing 10 acres for plant installation, reclamation requirements during a 20-year mine life would be: Kukpowruk River, 2,870 acres; Elusive Creek, 6,050 acres; and Kuk River, 7,190 acres. For this scale of land restoration, reclamation planning and execution is of great importance.

The impact of the mine operation on wildlife is a function of minesite location. For instance, there is a possibility that the Elusive Creek minesite could be located near a calving area. If so, mining at this location could have profound effects on herd population. It is also possible that the minesites could be located on caribou migration routes.

All three minesites could be in grizzly bear range. It is unlikely that one mining operation would have significant impact upon the grizzly bear population, but the advent of significant and widespread human population could severely restrict grizzly bear range.

2. Townsites

Much of the environmental impact of 5-million-ton-per-year North Slope coal mining is the effect of the influx of population rather than of the mining operation itself. This people-related impact will be discussed in this section. Additionally, major impact resulting from the operation of a coal-fired electrical-generating plant will be considered in this section.

Townsite population would range from 1,151 inhabitants for a dragline operation at the Kukpowruk River deposit to 2,726 inhabitants for a shovel-and-truck operation at Elusive Creek. These estimates do not include the population required to operate the transportation system.

The townsite would have two fundamental effects on surface-water quality. During the winter there is very little unfrozen surface water. Townsite water and water required for the power plant would probably be taken from unfrozen surface water sources and would reduce stream flows. Because of permafrost and the slow rate of bacterial activity, sewage disposal will be difficult, particularly during winter months. Groundwater is generally frozen; therefore, sewage effluent will report to surface water. Consequently, a relatively high level of sewage treatment would be required.

The principal impact upon air quality would be related to the power plant. The 75-megawatt power plant would require approximately 20 tons per hour of 10,000 Btu per pound coal at full output, and smaller plants would require proportionally less fuel. North Slope coal from the proposed minesites has a low sulfur content of 0.2 to 0.3 percent, so sulfur dioxide emissions from the plant would not be a problem. Nevertheless, emissions of particulate matter from the power plant could be a problem unless mitigating steps are taken. Ash disposal should not be a problem. Townsite noise should have little environmental impact.

The effect of the townsite upon vegetation depends upon the townsite population and the type of town planning and construction employed. Generally speaking, because yards are of little use in the Arctic and because of the risk of freezing sewer and water lines, space requirements for an Arctic community of a given population would be less than for a southern community with the same population. The townsite will require the destruction of vegetation. After the completion of mining, the townsite could be torn down and the land restored.

The effects of the townsite on wildlife would be more likely to be caused by the townsite population than by the townsite itself. The preservation of animal populations could require strict game management policies. Unlike a mine location, which is dependent upon the location of a mineral deposit, a townsite location can be determined with some flexibility. Because of this, impact upon wildlife due to the location of the townsite can be minimized. Calving and denning areas can be avoided and migration routes can be left unimpeded. The townsites for all 3 minesite locations would probably reduce grizzly bear populations. The Kuk River townsite would probably affect the polar bear population. Care should be taken to avoid polar bear denning areas when determining a townsite location. Polar bears have been known to be real safety hazards, particularly in Churchill, Manitoba, on the shore of Hudson Bay.

All three minesites are in the range of the Arctic caribou herd, and the Elusive Creek is in the general calving area for this herd. The extent to which the towniste would interfere with the calving areas and migration routes is unknown.

A townsite with a population of 1,000-3,000 would have significant impact upon the existing population of northern Alaska. It would be either the largest or the second largest community in northern Alaska. It would provide shopping, recreational, educational, transportation, and medical facilities for much of northern Alaska. Therefore, the location of a townsite and the size of its population would have a profound effect on the existing human population of northern Alaska.

3. Transportation Systems

A detailed assessment of the environmental impact of the transportation systems for northern Alaskan coal would be a major undertaking. In this section, Kaiser Engineers wishes to summarize some of the major environmental impact associated with the alternative transportation systems and to provide subjective comparisons of the relative environmental effects.

a. All-year Railway System

The railway system to southern Alaska would have the largest infrastructure requirements and probably the greatest environmental impact of the proposed systems. From Nenana, on the existing railway system, to the minesite would be approximately 650 miles for Elusive Creek, 720 miles for Kukpowruk River, and 730 miles for Kuk River.

Kaiser Engineers has not investigated the impact of the rail system south of the Brooks Range. Because of the very high transportation costs of the rail system, it is unlikely that a railway would be built to transport coal from northern Alaska. The following discussion is limited to general environmental impacts of the rail system and more specific impacts in northern Alaska.

The effect of the railway on surface water quality would not be great if embankments are adequately stabilized to prevent erosion. The greatest risk of stream siltation would occur during construction and initial operation of the system, before embankments could be adequately stabilized. Even at its worst, siltation due to the railway would not be excessive, because of the generally low precipitation and runoff on the proposed route. The railway system would have minimal effect on ground water quality.

Air quality could be degraded by coal dust from the trains. During recent years, mine operators have sprayed coal cars with binder material to reduce dusting. Because of this, dust is no longer a major problem. Trains will be noisy. The noise will have effects on animal and human population near the right-of-way. However, the relative infrequency of trains (eight coal trains per week) would tend to offset the noise of the individual trains.

The railway system would have an impact upon vegetation. The right-of-way would have to be cleared of vegetation when the railway is constructed. During recent years, revegetation of cut-and-fill slopes has become a primary method of slope stabilization and erosion prevention. It is unlikely that most of the railway would be torn up and reclaimed after the completion of mining. The system could probably be used for other freight.

Railways do have effects on wildlife, particularly large mammals. They transect migration routes and displace calving and denning areas. Moose often charge at locomotives, with predictable results. Nevertheless, railways generally have less impact on wildlife than highways for two reasons. Traffic is less frequent on railways. Therefore the duration of disturbance to animals is less than with highways. Also, railways do not permit human access to an area for hunting, fishing, and other purposes, to the extent that highways do. Therefore, with a rail system the wildlife population is less likely to be affected by people.

The impact of any new transportation system upon the human population of northern Alaska would be great. Transportation costs for supplies should be lower. More employment opportunities would be provided. Access to areas that were difficult to reach would be improved. A rail system would reduce the dependence upon air and water transportation.

b. Seasonal Barge System

The most likely way to ship five million tons of coal per year from northern Alaska would be to use a seasonal tug-and-barge system to an ice-free harbor in southern Alaska. The methods of transporting coal from the minesite to the Chukchi Sea coast are: trucks, belt conveyors, and slurry pipelines. A stockpile and barge-loading facility would be constructed on the Chukchi Sea coast and a coal port would be constructed at Dutch Harbor in the Aleutian Islands.

This coal transportation system would have impact upon surface water quality. Erosion from the roads and rights-of-way required for the three land transportation systems could alter surface water quality. Coal dust from haulage trucks or belt conveyors could also pollute streams. Jetty construction and/or channel dredging would have short-term impact upon the Chukchi Sea. Tugs and barges would be used to haul fuel to the Chukchi Sea harbor, and a risk of oil spills would exist, particularly with ice conditions. Stockpiles of 3.75 million tons maximum capacity would be required at the Chukchi Sea coast. There would be a risk of erosion or windblown dust from these piles affecting neighboring waters. With a slurry pipeline, there is a possibility of slurry spillage into lakes and streams.

The greatest impact upon air quality of a seasonal shipping system is the risk of spontaneous combustion of the coal stockpiles. This risk is higher with low-rank Kuk River coal than with Elusive Creek or Kukpowruk River coals. If a stockpile were to catch fire at the Chukchi Sea port during the winter, it would be almost impossible to extinguish. If loaded barges were delayed in transit by labor difficulties, weather, or ice, there would be a risk of the coal catching fire on the barge. The risk of spontaneous combustion is one of the reasons that ocean shipping of subbituminous coal is not done on a large scale.

Coal dust associated with the large stockpiles and the truck-haulage and belt-conveyor systems could also have a deleterious effect upon air quality. Noise from the transportation system could affect wildlife. The impact of the continuous noise of a cross-country conveyor on northern wildlife is not known.

The transportation systems would have impact upon vegetation. The roads, rights-of-way, stockpiles, causeways, and loading systems would displace vegetation. Windblown dust from stockpiles could inhibit plant growth. Post-mining reclamation programs would be required to replace vegetation in affected areas.

The transportation system would also have effects on wildlife. The land transportation systems, particularly the Kukpowruk River and Elusive Creek systems would cross the range and migration routes of the Arctic caribou herd. A slurry pipeline would probably not deter caribou migration, and a road may not have a great effect, but a belt conveyor system would have major impact upon caribou migration. The transportation system from the Elusive Creek minesite could cross caribou calving areas. The impacts of transportation modes and routes on caribou would have to be studied before the transportation system is designed. Transportation routes will also cross grizzly bear range. With proper wildlife management techniques, the impact of transportation systems upon grizzly bear population can be minimized.

There is a likelihood that harbor facilities on the Chukchi Sea could interfere with polar bear range and denning areas. This would have to be considered in the siting studies for port installations.

The seasonal transportation system would have an impact on the human population of northern Alaska. The benefits would not be as great as those associated with a railroad. Nevertheless, transportation costs for supplies should be reduced, and employment opportunities would be increased.

B. NORTH SLOPE RECLAMATION

1. Criteria

There are two basic objectives to any reclamation program: (1) prevention of erosion, and (2) restoration of esthetic values. In northern Alaska, a third objective should be: (3) reestablishment of wildlife habitat.

2. Available Data

Only limited information applicable to the reclamation of northern Alaska surface mines is available, and then only from academic research or research associated with current and proposed natural resource development projects within the last five to ten years. Therefore, the data could be indicative of short-term trends unrepresentative of the long-term success of reclamation efforts.

a. Arctic Areas

All or portions of the following natural resource development projects are located in high Arctic areas north of the Brooks Range in Alaska.

(1) Meade River Mine

Although no effort was made to reclaim the areas disturbed by mining, the natural revegetation near the mine shafts on the banks above the river is very complete with little surface indication of any mining activity. Growth on the hydraulic cut where the top soils were removed remains sparse.

(2) Trans-Alaska Pipeline System

Some information on the reclamation activities planned by the Trans-Alaska Pipeline system developers is contained in the final EIS published in March, 1972 by the U.S. Department of the Interior and the "Agreement and Grant of Right-of-Way for Trans-Alaska Pipeline" signed by the Federal government and the pipeline developers on January 23, 1974. The objectives of the reclamation effort are:

- To control erosion, stabilize soils, and reestablish vegetation
- To avoid or minimize disturbances to the thermal regime
- To avoid or minimize degradation of air, land, and water quality
- To protect wildlife

Reclamation activities to date on the Alaska North Slope have generally been limited to control of erosion and stabilization of soils. As yet, extensive revegetation efforts have not been conducted on the North Slope because construction repairs continue and because the availability of suitable seeds has been limited.

(3) Alaska Natural Gas Transportation System

The Alaska Natural Gas Transportation System is a 5,580 mile buried pipeline that has been proposed to transport natural gas from Prudhoe Bay, Alaska, across Canada and eventually to markets in the lower United States.

Reclamation activities planned by the developers are discussed in the final EIS published in March, 1976, by the U.S. Department of the Interior. The overall plan for controlling erosion is to minimize interference with natural drainage whenever possible and to revegetate disturbed areas to establish thermal equilibrium.

The objectives of the revegetation activities are to promote soil stability and to encourage the reestablishment of natural plant communities. A combination of slow-establishing, hardy species and faster-establishing, less hardy species will be used for the initial seeding in an attempt to optimize erosion protection and longevity. The proposed specifications for revegetation of the Alaskan portion of the Pipeline route are presented in table 6-1.

TABLE 6-1

PROPOSED SPECIFICATIONS FOR REVEGETATION

Erodability Rating	Common Name	Seed Specifications (pounds per acre)		Revegetation Measures		
		Initial	Follow-up	Sod Replacement	Seed Mats	Stem Cuttings
High	Arctared Creeping Red Fescue	15	8	No	Yes	Only at Stream Crossings
	Nugget Kentucky Bluegrass	7	4			
Medium	Arctared Creeping Red Fescue	15	8	Yes	No	No
	Engmo Timothy	3	4			
	Meadow Fox Tail	3	-			
	Redtop	3	-			
Low	Arctared Creeping Red Fescue	9	None Planned	Yes	No	No
	Nugget Kentucky Bluegrass	3				

b. Sub-Arctic Areas

Both of the following natural resource development projects are located in southern Alaska or Canada were inspected on the Kaiser Engineers field trip.

(1) Usibelli Coal Mine

A successful reclamation program has been conducted since 1972 at the Usebelli Coal Mine located in Healy, Alaska near Mount McKinley National Park. This surface coal mine supplies coal to the Fairbanks area.

(2) Great Canadian Oil Sands

At the Great Canadian Oil Sands operation in Tar Sands in northern Alberta, there is a reclamation program underway to stabilize the slopes of the tailings dams and the overburden dumps. The revegetation effort has been conducted for the last five years and so far it has been necessary to refertilize every year. Some native plants have begun to invade the revegetated areas, but there has been no attempt to revegetate with native plants.

3. Proposed Reclamation Plan

The following list itemizes several techniques, studied and presented previously with greater detail, for minimizing environmental impact and reclaiming surface-stripped lands in Arctic areas.

- Erosion Control
- Soil Stabilization
- Revegetation

Based on the review of available literature and discussions with researchers who have been working on reclamation of areas in the Arctic, the following potential plan for reclamation of a northern Alaska surface mine is proposed. This plan would be refined or modified depending on the results of other reclamation efforts, research conducted for other reclamation efforts, and detailed research conducted specifically for a surface coal mine in northern Alaska.

a. Salvage of Topsoils

The first step in the reclamation plan would be to strip and save topsoils in areas to be mined. These would either be stockpiled or respread immediately in other areas.

b. Overburden Removal

During the overburden removal stage, waste rock would be excavated and backfilled into previously mined areas. Solid wastes from the town may be buried in the backfill area with the waste rock. It would be desirable to replace alluvial material above the backfilled bedrock.

c. Spread Topsoil

After overburden piles have been spread out and contoured to the desired shape, topsoil would be spread above the overburden to provide nutrient material. It would be desirable to remove topsoils and respread them as soon as possible to take advantage of any natural revegetation that may occur. Any physical soil stabilization techniques necessary would be applied at this time. Steep slopes would be avoided to minimize the requirement for physical soil stabilization techniques.

d. Seed Topsoil

After topsoil has been spread, it would be revegetated using seeding methods. Agronomic species would be used to stabilize soils and to establish a nurse crop that would help the latter establishment of native species.

e. Fertilization and Maintenance

Fertilizer would be applied to help the agronomic species establish a good vegetative cover on the topsoils. The vegetative mat established would be maintained by reseeding and refertilization until a thermal equilibrium and soil conditions suitable for native plants had been established.

f. Establishment of a Native Plant Community

After the agronomic species start to die out, efforts to establish a native plant community would be made by reseeding with native grass species and refertilization. The native plant communities established would be inspected regularly to review the success of the reclamation efforts. Any problems would be corrected by reseeding and refertilizing until a native plant community is permanently established completing the reclamation activities. More research is needed on native species to determine which are the most promising for revegetation.

VII. ECONOMIC EVALUATION

The economic evaluation of northern Alaska surface mining will consist of (1) estimating the total delivered cost of surface-mined North Slope coal at an ice-free port in southern Alaska and (2) comparing this cost with f. o. b. port prices for competing North American coals. The ice-free port that will be considered for the small-scale Kukpowruk River mine and for large-scale mines with rail transportation is Seward. Large-scale mines with seasonal tug-and-barge shipments will have Dutch Harbor as a transshipment point.

A. COAL PRICES F. O. B. ICE-FREE PORT

The estimated prices of coal delivered to an ice-free port are shown in Table 7-1. The determination of cost per million Btu's is based on a heating value of 12,000 Btu's per pound for Kukpowruk River and Kuk River bituminous coals and 8,500 Btu's per pound for Kuk River subbituminous coals. Because of the relative lack of exploration data and the lack of established mining and transportation systems in northern Alaska, these cost estimates are probably inaccurate. Although the productivity of the mining equipment upon which cost estimates have been based is probably accurate, Kaiser Engineers' estimate of wage rates and fringe benefits that would be required to attract and maintain a work force could be low. Transportation, townsite, and utility estimates are order-of-magnitude estimates.

Although it is difficult to ascertain the accuracy of the estimates summarized in Table 7-1, it would not be surprising if actual costs were more than 30 percent higher than the estimate. Cost experience with the Alaska oil pipeline suggests that this could be true.

The cost of coal delivered to an ice-free port with an annual mining rate of 500,000 tons per year is estimated to be $49.23 per ton or $2.05 per million Btu's. This is the maximum level of output that can be justified with current demonstrated coal reserves in northern Alaska.

In Kaiser Engineers' judgement, a seasonal mining operation producing 500,000 tons of run-of-mine coal per year would be too small to be feasible. Therefore, estimates were made for mining operations with annual outputs of 10 times that which would be justified by current demonstrated reserves.

As can be seen in Table 7-1, a 5-million-ton mine with railway transportation would produce very expensive coal. Estimated costs range from $100 to $115 per ton, or $4.20 to $6.75 per million Btu's. Seasonal shipping by tug and barge would yield significantly lower cost coal. The land-transportation component of the tug-and-barge system does not appear to have a significant impact upon the delivered cost of coal. Also the range in coal prices from the least costly mining method (draglines) to the most costly mining system (shovels and trucks) is within 10 percent.

With the lowest-cost mining method and the lowest cost transportation system, the price of Kukpowruk River bituminous coal at an ice-free port is $29.58 or $1.23 per million Btu's. The lowest cost mining and transportation costs for Elusive Creek coals would result in a coal price of $44.79 per ton or $1.87 per million Btu's at an ice-free port. Similarly, Kuk River subbituminous coals would have an estimated price of $40.55 per ton or $2.38 per million Btu's at an ice-free port.

B. ECONOMIC ANALYSIS

One way to determine whether or not northern Alaskan coal mining is economically justified is to compare the estimated coal prices shown in Table 7-1 with the current price of competing coals. Competing coals have been costed on a f.o.b. ship basis at west coast ports. This will give an indication of competitiveness for the Asian market. Obviously, these coals would have an even greater price advantage over Alaskan coals in the western North American market.

The current selling price of bituminous coal from the Crowsnest Pass area of British Columbia is $32.50 loaded on ships at Vancouver, B.C. With heating value of 11,500 Btu's per pound, this coal has an energy cost of $1.41 per million Btu's. This compares with $2.05 per million Btu's for Kukpowruk River coal with current reserves, $1.23 per million Btu's from hypothetical Kukpowruk deposits, and $1.87 per million Btu's from hypothetical Elusive Creek deposits.

Subbituminous coal could be shipped from the Powder River area of Wyoming and Montana. Current mine prices are $15.00 for 9,500 Btu's per pound of coal and $7.50 for 8,500 Btu's coal. Rail freight to existing port facilities near Vancouver, British Columbia, is estimated to be $12.50 per ton and port charges would be $2.00 per ton. Therefore, the f.o.b. price for Wyoming coals at Vancouver would be $22.00 for 8,500 Btu's per pound coal ($1.29 per million Btu's) or $29.50 for 9,500 Btu's per pound coal ($1.55 per million Btu's).

A second source of subbituminous coal is the Nenana coal field in southern Alaska. Cost estimates are based on escalated price and transportation data from Rao and Wolff (1975). Mine selling price is estimated to be $13.00 per ton. Rail freight from Healy to Whittier would be approximately $8.00 plus port charges. These costs would give an f.o.b. cost of $23.50 per ton for 8,500-9,500 Btu's per pound coal. This would give an energy cost of approximately $1.31 per million Btu's.

A third source of subbituminous coal would be the Beluga coal field near Cook inlet, 50 to 60 miles west of Anchorage. It is estimated that 8,000-Btu subbituminous coal could be loaded on ships at Cook inlet for approximately $15.00 per ton at a production rate of approximately 5 million tons per year. Beluga coal would cost approximately $0.94 per million Btu's. From this analysis it can be seen that competing subbituminous coal can be loaded on ship for $0.94 to $1.55 per million Btu's. This compares with a minimum f.o.b. ship price for Kuk River subbituminous coals of $2.38 per million Btu's.

From the above analysis, it is evident that the only coal source from northern Alaska which would be competitive with other coals is Kukpowruk River coal when mined at a rate of 5 million tons per year. Assuming a minimum production life of 20 years and 80 percent recovery of in-place coal, geologic reserves would have to be 125 million tons to support the mining operation. This is far in excess of the current demonstrated geological reserves of 12 million tons to a depth of 120 feet and with a minimum seam thickness of 42 inches.

TABLE 7-1

SUMMARY OF COAL PRICES
(F.O.B. ICE-FREE PORT)
$/ton
($/million Btu)
500,000 Ton/Yr

TRANSPORTATION SYSTEM	MINE LOCATION & MINING SYSTEM
	KUKPOWRUK RIVER
	Dragline
Truck & Barge	$ 49.23 (2.05)

5,000,000 Ton/Yr

TRANSPORTATION SYSTEM	MINE LOCATION & MINING SYSTEM								
	KUKPOWRUK RIVER			ELUSIVE CREEK			KUK RIVER		
	Dragline	Shovel & Truck	Combination	Dragline	Shovel & Truck	Combination	Dragline	Shovel & Truck	Combination
Railroad	$100.69 (4.20)	$102.75 (4.28)	$101.36 (4.22)	$105.13 (4.38)	$109.49 (4.56)	$107.02 (4.46)	$111.57 (6.56)	$114.75 (6.75)	$112.32 (6.61)
Truck & Barge	$ 29.74 (1.24)	$ 32.11 (1.34)	$ 30.52 (1.27)	$ 47.59 (1.98)	$ 52.56 (2.19)	$ 49.67 (2.07)	$ 41.24 (2.42)	$ 44.95 (2.64)	$ 42.16 (2.48)
Conveyor & Barge	$ 29.62 (1.23)	$ 32.02 (1.33)	$ 30.43 (1.27)	$ 47.59 (1.99)	$ 52.56 (2.19)	$ 49.67 (2.07)	$ 41.07 2.41)	$ 44.95 (2.63)	$ 41.99 (2.47)
Slurry Pipeline & Barge	$ 29.58 (1.23)	$ 31.95 (1.33)	$ 30.36 (1.27)	$ 44.79 (1.87)	$ 49.77 (2.07)	$ 46.87 (1.95)	$ 40.55 (2.38)	$ 44.26 (2.60)	$ 41.47 (2.44)

TABLE 7-1

SUMMARY OF COAL PRICES
(F.O.B. ICE-FREE PORT)
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($/million Btu)
500,000 Ton/Yr

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	Dragline
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5,000,000 Ton/Yr

TRANSPORTATION SYSTEM	MINE LOCATION & MINING SYSTEM								
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	Dragline	Shovel & Truck	Combination	Dragline	Shovel & Truck	Combination	Dragline	Shovel & Truck	Combination
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VIII. CONCLUSIONS AND RECOMMENDATIONS

The analysis of the technical and economic feasibility of surface mining northern Alaska has resulted in several conclusions. Based upon these conclusions, recommendations will be made concerning future work to be done regarding the surface mining of northern Alaskan coal deposits.

A. CONCLUSIONS

As a result of the investigation of the feasibility of surface mining the coal deposits, certain conclusions have been made:

1. Geology and Reserves

(a) The degree of exploration has not been sufficient to provide good estimates of demonstrated coal resources in coal-bearing areas of northern Alaska.

(b) Past estimates of strippable coal in northern Alaska are overstated.

(c) Coal in seams greater than 20 feet thick has not been identified to any great extent in northern Alaska. The exceptions are the 20-foot-thick Kukpowruk Seam and coal intersections of up to 30 feet in thickness which were encountered in test wells on Naval Petroleum Reserve No. 4. It is suspected much of the coal intersected by the test wells is carbonaceous shale. Generally, the coal seams encountered in northern Alaska are thinner than those encountered in other western states.

(d) Very little flat-lying coal exists in northern Alaska. Therefore coal reserves with less than 120 feet of overburden are limited.

(e) Given the geology and the costs of northern Alaska, most coal cannot be mined economically with current technology. Therefore, the criteria for calculating the reserve base in northern Alaska should be re-evaluated.

2. Environment and Reclamation

(a) The environment of northern Alaska is harsh. Special construction and equipment operating techniques will be required.

(b) The potential for success of reclamation projects in the Arctic is unknown.

(c) Insufficient data exists to make detailed environmental impact assessments of potential northern Alaskan mining activity.

3. Technical Feasibility

The coal deposits of northern Alaska could be mined with currently available equipment and mining techniques.

4. Economic Feasibility

(a) Currently identified demonstrated strippable coal resources are not economically minable. Therefore the strippable reserve of northern Alaska coal is 0 tons.

(b) The only potential minesite which showed economic promise was the Kukpowruk River coalfield. "Reserves" would have to be expanded by a factor of 10 before this coal would be competitive with existing coal sources.

B. RECOMMENDATIONS

Kaiser Engineers recommends, that no further work except for geological exploration be done until one of the following conditions is met:

- Demonstrated strippable resources for a coal deposit of more than 125 million tons at a stripping ratio of less than 5:1 are blocked out;
- Coal prices escalate at a rate which exceeds coal costs to the extent that existing demonstrated reserves become economic;
- A market for coal is found in the North Slope area.

It is tempting to make recommendations concerning equipment development, environmental baseline studies, reclamation studies, investigations of transportation systems, and sociological studies; however, presently known strippable coal deposits are not attractive enough to warrant any further work other than geologic exploration. When these studies are required, they should be done on a site-specific basis.

APPENDIX

A. MINING REQUIREMENTS AND COSTS

1. Operating Criteria

Equipment requirements and mining costs are estimated for hypothetical mining operations in each of the three selected areas with separate estimates for each of the three mining systems. Since measured or indicated reserves are inadequate to support a large strip mining operation in these locations, it is assumed, for comparison purposes only, that additional reserves can be proven in these areas to support a production level of 5 million tons of coal per year over a period of 20 years.

The Kukpowruk River area has been explored to a greater extent than any of the other areas. Measured and indicated in-situ surface minable reserves of 20 million tons of bituminous coal with some coking characteristics have been delineated. A separate estimate for a small surface mine, producing 500,000 tons per year, has been prepared to determine the feasibility of supplying a limited domestic or foregin market.

Capital cost estimates are based on equipment prices in effect in December 1976 with no escalation projected for delivery time. Allowances for freight to the North Slope have been included, assuming barge shipment from Seattle, Washington, with air freight for necessary winter shipments. Material prices are based on late 1976 costs with a factor of 50 percent added for freight and handling. Wage rates are UMW rates effective December 6, 1976, in the Western Surface Coal Wage Agreement of 1975, increased by 25 percent to reflect the Alaskan differential at the Usibelli Coal Mines, Fairbanks, Alaska. Payroll overhead is estimated at 40 percent of direct payroll cost. UMW welfare royalties are based on December 1976 rates for bituminous and subbituminous coal. Lease royalties are assumed to be 12½ percent of the mine selling price. An annual item for deferred expense is included to cover capital that must be expended over the life of the mine for equipment replacements and additions.

All operations are based on three shifts per day seven days per week. with an average of 335 available working days per year after allowance for lost time due to weather, major equipment failures, and work stoppages.

Transportation costs are not included in mining costs because of the different modes of transport under consideration for this area. Raw coal is considered to be sold at the minesite for purposes of percentage royalties and no preparation is anticipated other than sizing of coal in the raw coal storage and handling facilities. Heating value of bituminous coals in the Kukpowruk River and Elusive Creek areas is estimated at 12,000 Btu/lb, and subbituminous coal in the Kuk River area at 8,500 Btu/lb.

Shop, office, warehouse, and changehouse facilities with the necessary water and sewage facilities will be constructed at the mine site to provide service and supply functions for the mining operation separately from any townsite or living accommodations infrastructure. A 5-mile access road is included in mine cost on the assumption that living accommodations will not be located at the minesite.

- 500,000 - Tons Per Year (Kukpowruk River)

  Measured and indicated reserves currently indicate 20 million tons of strippable coal available in this area. Within the limits of these reserves and a mine life of at least 20 years, equipment was selected and operations planned for a mine producing 500,000 tons of bituminous coal per year. Average seam thickness is 20 feet with an average dip of 15 degrees from a surface outcrop. A cutoff point of 100 feet of overburden has been selected as the maximum practical limit for a dragline operation of this scale, resulting in an average stripping ratio of 2.4 cubic yards of overburden per ton of coal recovered.

  Overburden removal will be accomplished by a 12-cubic-yard, crawler-type dragline and coal loading by a 10-cubic-yard front-end loader into 50-ton end-dump trucks. Overburden drilling will be done by an electric-powered rotary drill drilling 9-7/8-inch holes on 20-foot centers.

  Electric power will be supplied at 7,200 volts by portable, diesel-powered generator sets with two substations, each with capacity to supply full requirements.

  Operations are based on three shifts per day seven days per week. However, equipment sized for anticipated physical and geologic conditions has greater capacity than required at this level and a seasonal operation or reduced working schedule may be indicated.

- 5 Million Tons Per Year (Kukpowruk River, Elusive Creek, and Kuk River)

  Hypothetical strip mines in these areas at a production level of 5 million tons per year have been selected for all three minesites.

The operation is designed for a production level of 5 million tons of bituminous coal per year, with a mine life of 20 years. The coal seam of Kukpowruk River averages 20 feet in thickness, with an average dip of 15 degrees from a surface outcrop. At Elusive Creek, the seam is 9.5 feet thick, with an average dip of 5 degrees from surface outcrop. The Kuk River seam was assumed to be flat lying and eight feet thick. A cutoff point at 150 feet of overburden has been established as the practical limit for the equipment selected. Mining methods are based on current mining practices in western surface mines.

Separate capital and operating cost estimates have been made for each of the three selected mining systems: dragline operation, combined dragline-shovel operation, and shovel operation.

Electric power is assumed to be purchased from a community power plant at 69 KV and reduced to 23 KV at a main substation for distribution to the pit area. Skid-mounted transformers and switchgear will supply power through training cables to operating equipment.

Raw coal storage and handling facilities are based on regular shipments of coal, and no provisions are included for large-scale storage for seasonal shipment.

2. Coal Selling Price

The capital and operating costs which have been developed for northern Alaska lack the accuracy of similar costs which would be developed for less remote areas. Whether the wage rates and fringe benefits which Kaiser Engineers has developed would attract a suitable work force is not known. Transportation costs to the minesite and construction costs could be subject to error. The cost overruns incurred during the construction of the Alaska oil pipeline demonstrate the lack of precision of cost estimates for Arctic projects.

Because of the relative lack of accuracy of the developed cost estimates, Kaiser Engineers has chosen not to use discounted cashflow techniques for estimating the selling price of coal at the minesite. Instead, the calculation of coal selling price has been done on an annuity basis. The required rate of return of the project is 15 percent after tax with a 20-year project life.

The annual after-tax cashflow which would be required is the annuity which would yield 15 percent and return initial capital after 20 years. The components of after-tax cashflow are: after-tax profit, depreciation, and depletion.

After-tax cashflow is determined by dividing initial investment by 6.259 which is the factor for determining the annuity which will yield 15 percent on initial capital and reutrn the initial investment after 20 years. Depreciation is the amount calculated from the depreciation table.

Given that depreciation and after-tax cashflow are known, depletion and after-tax profit can be determined. For coal, depletion is 15 percent of revenue, to a maximum of 50 percent of gross profit. Because of the relatively low gross profit in terms of revenue, depletion is generally 50 percent of gross revenue for coal mines. The revenue remaining after depletion is subject to Federal income tax of 50 percent. Therefore, depletion plus after-tax profit equal 75 percent of gross profit, with depletion being equal to 50 percent of gross profit and after-tax income equal to 25 percent of gross profit. After-tax cashflow then equals depreciation plus 75 percent of gross profit.

Sales volume equals production cost (including depreciation and deferred expense) plus royalty plus gross profit. Royalty expense is assumed to be 12.5 percent of sales. Therefore, 87.5 percent of sales volume equals production cost plus gross profit.

Since gross profit equals (1/.75) of after-tax cashflow minus depreciation, sales volume equals (1/.875) times the sum of production cost and 75 percent of after-tax cashflow minus depreciation.

$$\text{Sales volume} = \frac{1}{.875} \times (\text{production cost} + 1.333 \times (\text{after-tax cashflow} - \text{depreciation}))$$

This is the annual sales volume which will provide a 15 percent after-tax yield on initial capital and return initial capital after 20 years.

From these costs, it can be seen that North Slope coal will not be economically attractive unless much larger strippable reserves are blocked out. To be economically sound today, a North Slope deposit near the seacoast would have to contain a minimum of 125 million tons of bituminous coal with a stripping ratio of less than 5 cubic yards of overburden per ton of coal. This is in the order of 10 times the size of the largest demonstrated strippable resource in Northern Alaska.

TABLE A-1

KUKPOWRUK RIVER
EQUIPMENT COST SUMMARY
500,000 ton/yr

	No.	Unit Cost	Total Cost ($000's)
Dragline - 12 yd^3	1	$3,355,000	$ 3,355
Dragline		-	
Shovel - Overburden		-	
Truck - Overburden		-	
Drill - Overburden 9-7/8 inches	1	547,000	547
Shovel - Coal		-	
Truck - Coal (50 ton)	6	229,000	1,374
Front End Loader - 10 yd^3	2	307,000	614
Coal Drill	1	72,000	72
Bulldozer - Crawler	2	241,000	482
Bulldozer - R. T.		-	
Explosives Truck - 5/ton	1	36,000	36
Motor Grader	1	156,000	156
Scraper Loader		-	
Truck - 50/ton dump		-	
Fuel and Lube Truck		-	
Sand and Water Truck	1	218,000	218
Mobile Crane - 100/ton		-	
Mobile Crane - 25/ton	1	160,000	160
Tower - Floodlight	3	10,000	30
Hydroseeder Truck		-	
Utility Truck	2	21,000	42
Pickup Truck	6	7,000	42
Station Wagon	2	7,000	14
Ambulance	1	12,000	12
Communications Equipment		25,000	25
Tools and Auxiliary Equipment		250,000	250
Diesel Generator - 600 kW	5	83,000	415
Substation		75,000	75
Power Line		150,000	150
Coal Lease			150
Access Road	5 Mi.	425,000	2,125
Office and Changehouse		325,000	325
Shop and Warehouse		1,300,000	1,300
Exploration		250,000	250
Bus - 36 Passenger	1	25,000	25
Coal Transfer and Storage System			2,000
Camp Accommodation		3,000,000	3,000
TOTAL			$17,244

TABLE A-2

KUKPOWRUK RIVER
TOTAL ESTIMATED CAPITAL REQUIREMENTS
500,000 ton/yr

	$000's
Camp Accommodations	$ 3,000
Exploration, Roads, and Buildings	4,175
Mining Equipment	8,069
Coal Storage and Transfer Equipment	2,000
Total Direct	17,244
Field Indirect (7-1/2%)	1,293
Total Construction	18,537
Engineering (3%)	556
Subtotal	19,093
Overhead and Administration (7-1/2%)	1,432
Subtotal	20,525
Contingency (15%)	3,079
Subtotal	23,604
Fee (3%)	708
Total Plant Cost (Insurance - Tax Base)	24,312
Interest During Construction	3,282
Subtotal	27,594
Working Capital {1 year material; 9 months labor}	3,307
Total Capital Requirements	30,901

TABLE A-3

KUKPOWRUK RIVER
MANNING TABLE
500,000 ton/yr

Personnel	Total	Wages - Dollars Per Day	Annual Cost
Production			
Dragline Operator	3	$112.00	$ 61,460
Dragline Oiler	3	104.60	57,421
Driller	2	99.80	33,946
Driller Helper	2	92.70	31,525
Shooter	1	99.80	3,569*
Dozer Operator	4	99.80	110,947
F. E. Loader Operator	2	112.00	42,000
Truck Operator	6	99.80	149,760
Driller and Shooter - Coal	1	99.80	14,726*
Grader Operator	1	99.80	24,960*
Service Truck Driver	1	93.80	23,460
Utility Man	8	92.70	184,490
Subtotal	34		$ 738,264
Maintenance			
Master Electrician	3	112.00	61,460
Mechanic	7	108.30	182,790
Electrician	3	108.30	62,392
Repairman	5	99.80	139,526
Subtotal	18		$ 446,168
Total Wage Personnel	52		$1,184,432

*The employee is assigned other duties when not required for his primary position; costs for secondary duties are included in the wage totals for secondary duties.

TABLE A-3 (Cont)

Personnel - Salaried	Annual Rate	Total	Annual Cost
Superintendent	$43,750	1	$ 43,750
General Foreman, Mine	31,250	1	31,250
Pit Foreman	25,250	3	78,750
General Foreman, Maintenance	31,250	1	31,250
Maintenance Foreman	26,250	2	52,500
Mine Engineer	31,250	1	31,250
Surveyor	22,500	1	22,500
Drafter	18,750	1	18,750
Paymaster	23,000	1	23,000
Accountant	23,000	1	23,000
Purchasing Agent	23,000	1	23,000
Personnel Supervisor	23,000	1	23,000
Warehouseman	15,000	4	60,000
Clerk, General	15,000	8	120,000
Total Salaried Personnel		27	$ 582,000
Total Wage and Salaried Personnel		79	$1,766,432

TABLE A-4

KUKPOWRUK RIVER
ESTIMATED ANNUAL PRODUCTION COST
500,000 ton/yr

Direct Cost	Total Annual Cost	Cost Per Ton
Wages		
Operating Labor	738,264	1.48
Maintenance Labor	446,168	.89
Subtotal	1,184,432	2.37
Salaries		
Production	153,750	.31
Maintenance	83,750	.17
Administrative	344,500	.69
Subtotal	582,000	1.17
Payroll Overhead	706,573	1.41
Total Wage and Salary Cost	2,473,005	4.95
Operating Supplies		
Spare Parts	520,368	1.04
Explosives	242,892	.49
Fuel and Lubricants	285,440	.57
Tires	175,288	.35
Miscellaneous	288,356	.46
Total, Operating Supplies	1,452,344	2.91
Camp Operation	1,100,000	2.20
Power	109,434	.22
Union Welfare	555,000	1.11
Subtotal	1,764,434	3.53
Total Direct Cost	5,689,783	11.37
Indirect Cost (15% of Labor and Material)	588,802	1.18
Taxes and Insurance - 2% of Plant Cost	486,240	.97
Depreciation	1,868,100	3.74
Deferred Expense	404,940	.81
Subtotal	3,348,082	6.70
Total Annual Production Cost	9,037,865	18.07
Royalty (12-1/2% of Selling Price)	1,875,686	3.75
TOTAL ANNUAL COST	10,913,551	21.82

TABLE A-5

KUKPOWRUK RIVER
DEPRECIATION SCHEDULE
500,000 ton/yr

	Straight Line Depreciation, Years	Yearly Charge
Camp Accommodations	20	$ 150,000
Exploration	20	12,500
Diesel Generators	20	20,750
Mine Buildings	20	81,250
Substation	20	3,750
Power Line	20	7,500
Communications Equipment	20	1,250
Roads	20	106,250
Dragline - 12 yd^3	20	167,750
Drill - Overburden	20	27,350
Truck - Coal	5	274,800
Front End Loader	10	61,400
Coal Drill	10	7,200
Bulldozers	10	48,200
Explosives Truck	10	3,600
Motor Grader	10	15,600
Sand and Water Truck	10	21,800
Mobile Crane - 25 ton	20	8,000
Tower - Floodlight	10	3,000
Utility Truck	5	8,400
Pickup Truck	3	14,000
Station Wagon	3	4,700
Ambulance	10	1,200
Tools and Auxiliary Equipment	10	25,000
Bus - 36 Passenger	10	2,500
Coal Storage and Transfer System	20	100,000
Coal Lease	20	7,500
TOTAL		$1,185,250
Depreciation for field indirect, engineering, overhead and administration, contingency, fee and interest during construction	20	682,850
TOTAL YEARLY DEPRECIATION		$1,868,100

TABLE A-6

KUKPOWRUK RIVER
DRAGLINE OPERATION
CALCULATION OF COAL SELLING PRICE
(F. O. B. Mine Site)
500, 000 ton/yr

15 Percent Return on Investment - 20 Year Capital Recovery

R = $30, 901, 000/6. 259 = $4, 937, 051

Less Depreciation 1, 868, 100

$3, 068, 951 = Depletion + Net Profit

Depletion + Net Profit = 3/4 Gross Profit

Gross Profit = $3, 068, 951/. 75 = $4, 091, 935

Sales = Production Cost + Royalty + Gross Profit

Royalty = 12. 5% of Sales

Sales = ($9, 037, 865 + $4, 091, 935)/. 875 = $15, 005, 486

Royalty = $15, 005, 486 x . 125 = $1, 875, 686

Selling Price/Ton = $15, 005, 486/500, 000 = $30. 01

Depletion = 50% of Gross Profit

F. I. T. = 50% of Taxable Income

Gross Profit	$4, 091, 935
Depletion	2, 045, 968
Taxable Income	$2, 045, 967
Federal Income Tax	$1, 022, 984
Net Profit	$1, 022, 983

Annual Cash Flow = Net Profit + Depreciation + Depletion

= $1, 023, 983 + $1, 868, 100 + $2, 045, 968

= $4, 937, 051

TABLE A-7

COST SUMMARY
KUKPOWRUK RIVER MINESITE
500,000 TONS PER YEAR

COST ITEM	COST
MINE	
Capital Cost ($ thousands)	$30,901
Annual Cost ($thousands)	15,005
[1] Price Per Ton ($)	30.01
[1] Price Per Million Btu ($)	1.25
SEASONAL TRUCK AND BARGE SYSTEM	
Capital Cost ($ thousands)	26,126
Annual Cost ($ thousands)	9,611
[2] Cost Per Ton ($)	19.22
[2] Cost Per Million Btu ($)	0.80
TOTAL COST	
Capital Cost ($ thousands)	57,027
Annual Cost ($ thousands)	24,616
[3] Price Per Ton ($)	49.23
[3] Price Per Million Btu ($)	2.05

[1] Price fob minesite
[2] Transportation from mine to ice-free port
[3] Price at ice-free port

TABLE A-8

KUKPOWRUK RIVER
5 MILLION TONS PER YEAR
EQUIPMENT COST SUMMARY
($1,000's)

Equipment	Unit Cost	Mining Method					
		Dragline		Shovel		Dragline & Shovel	
		No.	Cost	No.	Cost	No.	Cost
Dragline (100 yd^3)	$26,628	1	$26,628	0	$ 0	1	$26,628
Dragline (50 yd^3)	13,318	1	13,318	0	0	0	0
Shovel-Overburden (22 yd^3)	2,826	0	0	3	8,478	1	2,826
Truck-Overburden (170 ton)	630	0	0	14	8,820	5	3,150
Drill-Overburden ($12\frac{1}{4}$ inch dia.)	738	4	2,952	4	2,952	4	2,952
Shovel-Coal (15 yd^3)	1,538	1	1,538	1	1,538	1	1,538
Truck-Coal (180 ton)	647	8	5,176	8	5,176	8	5,176
Wheel Loader (15 yd^3)	396	1	396	1	396	1	396
Coal Drill	72	2	144	2	144	2	144
Bulldozer-(Crawler)	241	9	2,169	11	2,651	10	2,410
Bulldozer-(Rubber Tired)	151	2	302	3	453	2	302
Explosives Truck (10 ton)	42	2	84	2	84	2	84
Motor Grader	156	2	312	3	468	2	312
Scraper Loader (31 yd^3)	239	2	478	2	478	2	478
Dump Truck (50 ton)	259	2	518	2	518	2	518
Fuel & Lube Truck	66	1	66	1	66	1	66
Sand & Water Truck	218	1	218	1	218	1	218
Mobile Crane (100 ton)	329	1	329	1	329	1	329
Mobile Crane (50 ton)	216	1	216	1	216	1	216
Tower-Floodlight	10	5	50	7	70	5	50
Hydroseeder Truck	51	1	51	1	51	1	51
Utility Truck	21	6	126	7	147	6	126
Pickup Truck	7	20	140	21	147	20	140
Station Wagon	7	5	35	5	35	5	35
Ambulance	12	1	12	1	12	1	12
Communications Equipment	50		50		50		50
Tools & Auxiliary Equipment	500		500		500		500
Bus (36 passenger)	25	2	50		75		50
Substation	500		500		500		500
Power Line	500		500		500		500
Coal Lease			1500		1500		1500
Access Road	425	5mi	2125		2125		2125
Office & Change House	975		975		1170		1040
Shop & Warehouse	4407		4407		6955		4875
Water & Sewage System	780		780		800		780
Exploration	1500		1500		1500		1500
Coal Storage & Transfer System			4500		4500		4500
TOTAL			$72,645		$53,622		$66,077

TABLE A-9

KUKPOWRUK RIVER
TOTAL ESTIMATED CAPITAL REQUIREMENTS
5 MILLION TONS PER YEAR
($000's)

	Dragline	Shovel	Dragline & Shovel
Exploration, Roads, and Buildings	$ 11,287	$ 14,050	$ 11,820
Mining Equipment	56,858	35,072	49,757
Coal Storage and Transfer Equipment	4,500	4,500	4,500
Total Direct	72,645	53,622	66,077
Field Indirect	5,448	4,022	4,956
Total Construction	78,093	57,644	71,033
Engineering	2,343	1,729	2,131
Subtotal	80,436	59,373	73,164
Overhead & Administration	6,033	4,453	5,487
Subtotal	86,469	63,826	78,651
Contingency	12,970	9,574	11,798
Subtotal	99,439	73,400	90,449
Fee	2,983	2,202	2,713
Total Plant Cost (Insurance-Tax Base)	$102,422	$ 75,602	$ 93,162
Interest During Construction	18,436	13,608	16,769
Subtotal	120,858	89,210	109,931
Working Capital	6,000	9,000	7,000
Total Capital Requirements	$126,858	$ 98,210	$116,931

TABLE A-10

KUKPOWRUK RIVER
5 MILLION TONS PER YEAR
PERSONNEL REQUIREMENTS

Category	Daily Rate	Mining Method: Dragline No.	Dragline $/Year	Shovel No.	Shovel $/Year	Dragline & Shovel No.	Dragline & Shovel $/Year
Wage Personnel Production							
Dragline Operator	$112.00	8	$ 213,360	-	$	4	$ 112,560
Dragline Oiler	104.60	8	199,263	-		4	105,163
Shovel Operator	112.00	4	98,000	14	400,120	7	193,732
Shovel Oiler	104.60	4	91,560	14	373,826	7	181,001
Driller	99.80	12	284,918	12	284,918	12	284,918
Driller Helper	92.70	12	264,570	12	264,560	12	264,560
Blaster	99.80	1	18,283	1	18,283	1	18,283
Dozer Operator	99.80	27	673,171	36	909,917	33	830,269
Wheel Loader Operator	112.00	2	57,820	2	57,820	2	57,820
Truck Operator	99.80	16	417,331	57	1,420,623	29	735,322
Driller & Shooter-Coal	99.80	6	145,766	6	145,766	6	145,766
Grader Operator	99.80	4	100,339	8	200,678	6	133,786
Service Truck Driver	93.80	3	62,873	4	94,309	4	94,309
Scraper Operator	99.80	3	62,400	3	62,400	3	62,400
Utility	92.70	28	653,502	32	754,335	29	684,563
Subtotal		138	$3,343,156	201	$4,987,555	160	$3,904,452
Maintenance							
Master Electrician	112.00	10	282,618	16	444,010	12	337,946
Mechanic	108.30	40	1,093,341	63	1,717,684	48	1,307,368
Electrician	108.30	17	455,553	26	715,724	20	544,741
Repairman	99.80	17	435,677	27	666,806	21	536,016
Subtotal		84	$2,267,198	132	$3,544,224	101	$2,726,071
Total Wage Personnel		222	$5,610,345	333	$8,531,779	261	$6,630,523

TABLE A-10

KUKPOWRUK RIVER
5 MILLION TONS PER YEAR
PERSONNEL REQUIREMENTS

Category	Annual Rate	Mining Method: Dragline No.	Dragline $/Yr. Cost	Shovel No.	Shovel $/Yr. Cost	Dragline & Shovel No.	Dragline & Shovel $/Yr. Cost
Salaried Personnel							
Administrative							
General Manager	$50,000	1	$ 50,000	1	$ 50,000	1	$ 50,000
Chief Engineer	37,500	1	37,500	1	37,500	1	37,500
Environmental Engineer	28,750	1	28,750	1	28,750	1	28,750
Mine Engineer	31,250	1	31,250	1	31,250	1	31,250
Surveyor	22,500	2	45,000	2	45,000	2	45,000
Drafter	18,750	2	37,500	2	37,500	2	37,500
Manager, Administrative Services	43,750	1	43,750	1	43,750	1	43,750
Industrial Relations Supervisor	37,500	1	37,500	1	37,500	1	37,500
Personnel Supervisor	28,750	1	28,750	1	28,750	1	28,750
Safety Supervisor	28,750	1	28,750	1	28,750	1	28,750
Training Supervisor	28,750	1	28,750	1	28,750	1	28,750
Training Instructor	25,000	1	25,000	2	50,000	1	25,000
Employment Supervisor	28,750	1	28,750	1	28,750	1	28,750
Purchasing Agent	31,250	1	31,250	1	31,250	1	31,250
Buyer	25,000	1	25,000	1	25,000	1	25,000
Purchasing Clerk	15,000	2	30,000	3	45,000	2	30,000
Traffic Supervisor	28,750	1	28,750	1	28,750	1	28,750
Comptroller	37,500	1	37,500	1	37,500	I	37,500
Paymaster	26,250	1	26,250	1	26,250	1	26,250
Payroll Clerk	15,000	2	30,000	3	45,000	2	30,000
Senior Cost Accountant	28,750	1	28,750	1	28,750	1	28,750
Cost Accountant	26,250	2	52,500	2	52,500	2	52,500
Clerk-General	15,000	7	105,000	9	135,000	7	105,000
Secretary	13,750	2	27,500	2	27,500	2	27,500
Typist	11,250	2	22,500	3	33,750	2	22,500
Warehouse Supervisor	25,000	1	25,000	1	25,000	1	25,000
Warehouse Clerk	15,000	4	60,000	5	75,000	4	60,000
Warehouseman	15,000	6	90,000	9	135,000	6	90,000
Subtotal		49	$1,071,250	59	$1,227,500	49	$1,071,250
Production							
Mine Superintendent	43,750	1	43,750	1	43,750	1	43,750
General Foreman	31,250	1	31,250	1	31,250	1	31,250
Pit Foreman	26,250	4	105,000	8	210,000	4	105,000
Blaster Foreman	26,250	1	26,250	1	26,250	1	26,250
Coal Loading Foreman	26,250	4	105,000	4	105,000	4	105,000
Labor Foreman	26,250	1	26,250	1	26,250	1	26,250
Clerk	15,000	4	60,000	4	60,000	4	60,000
Subtotal		16	$ 397,500	20	$ 502,500	16	$ 397,500

TABLE A-10

KUKPOWRUK RIVER
5 MILLION TONS PER YEAR
PERSONNEL REQUIREMENTS

		Mining Method					
		Dragline		Shovel		Dragline & Shovel	
Category	Annual Rate	No.	$/Yr. Cost	No.	$/Yr. Cost	No.	$/Yr. Cost
Salaried Personnel							
Maintenance							
Superintendent, Maintenance	$37,500	1	$ 37,500	1	$ 37,500	1	$ 37,500
General Foreman	31,250	1	31,250	1	31,250	1	31,250
Mechanical Foreman	26,250	4	105,000	8	210,000	4	105,000
Electrical Foreman	26,250	4	105,000	4	105,000	4	105,000
Shop Foreman	26,250	4	105,000	4	105,000	4	105,000
Design Engineer	26,250	1	26,250	1	26,250	1	26,250
Drafter	18,750	1	18,750	2	37,500	1	18,750
Clerk	15,000	4	60,000	4	60,000	4	60,000
Subtotal		20	$ 488,750	25	$ 612,500	20	$ 488,750
Total Salaried Personnel		85	1,957,500	104	2,342,500	85	1,957,500
GRAND TOTAL		307	$7,567,845	437	$10,874,279	346	$8,588,023

TABLE A-11

KUKPOWRUK RIVER
5 MILLION TONS PER YEAR
ESTIMATED ANNUAL PRODUCTION COST

Cost Item	Mining Method: Dragline $/Year	Dragline $/Ton	Shovel $/Year	Shovel $/Ton	Dragline & Shovel $/Year	Dragline & Shovel $/Ton
Direct Cost						
Wages						
Operating Labor	$ 3,343,156	$ .67	$ 4,987,555	$1.00	$ 3,904,452	$ .78
Maintenance Labor	2,267,189	.45	3,544,224	.71	2,726,071	.55
Subtotal	$ 5,610,345	$1.12	$ 8,531,779	$1.71	$ 6,630,523	$1.33
Salaries						
Production	397,500	.08	502,500	.10	397,500	.08
Maintenance	488,750	.10	612,500	.12	488,750	.10
Administrative	1,071,250	.21	1,227,500	.25	1,071,250	.21
Subtotal	$ 1,957,500	$ .39	$ 2,342,500	$ .47	$ 1,957,500	$ .30
Payroll Overhead	3,027,138	.61	4,349,712	.87	3,435,209	.69
Total Wage & Salary Cost	$10,594,983	$2.12	$15,223,991	$3.05	$12,023,232	$2.41
Operating Supplies						
Spare Parts	3,884,370	.78	6,824,220	1.36	4,918,902	.98
Explosives	3,665,316	.73	3,665,316	.73	3,665,316	.73
Fuel & Lubricants	1,543,510	.31	3,060,878	.61	2,096,877	.42
Tires	784,575	.16	2,392,401	.48	1,333,665	.27
Miscellaneous	1,837,140	.37	2,273,346	.45	2,198,222	.44
Total, Operating Supplies	$11,714,911	$2.35	$18,216,161	$3.63	$14,212,982	$2.84
Power	1,897,140	.38	572,240	.11	1,425,306	.29
Union Welfare	4,800,000	.96	5,150,000	1.03	4,900,000	.98
Subtotal	$ 6,679,140	$1.34	$ 5,722,240	$1.14	$ 6,325,306	$1.27
Total Direct Cost	$28,989,034	$5.81	$39,088,892	$7.82	$32,561,520	$6.52
Indirect Cost (15% of Labor & Material)	3,346,484	.67	4,977,435	1.00	3,935,432	.79
Taxes & Insurance - 2% of Plant Cost	2,048,440	.41	1,512,040	.30	1,863,240	.37
Depreciation	7,234,000	1.45	7,042,350	1.41	7,193,150	1.44
Deferred Expense	1,518,625	.30	3,231,063	.65	2,124,313	.42
Subtotal	$14,147,549	$2.83	$16,762,888	$3.36	$15,116,135	$3.02
Total Annual Production Cost	$43,136,583	$8.64	$55,851,780	$11.18	$47,677,655	$9.54
Royalty (12½% of Selling Price)	8,645,054	1.73	9,626,189	1.93	8,999,457	1.80
TOTAL ANNUAL COST	$51,781,637	$10.37	$65,477,969	$13.11	$56,677,112	$11.34

TABLE A-12

KUKPOWRUK RIVER
5 MILLION TONS PER YEAR
DEPRECIATION SCHEDULE
(Yearly Charge)

Capital Cost Item	Straight Line Depreciation Years	Mining Method		
		Dragline	Shovel	Dragline & Shovel
Exploration	20	$ 75,000	$ 75,000	$ 75,000
Coal Storage & Transfer System	20	225,000	225,000	225,000
Mine Buildings	20	308,100	446,250	334,750
Substation	20	25,000	25,000	25,000
Power Line	20	25,000	25,000	25,000
Communications Equipment	20	2,500	2,500	2,500
Roads	20	106,250	106,250	106,250
Dragline (100 yd^3)	20	1,331,400	-	1,331,400
Dragline (50 yd^3)	20	665,900	-	-
Shovel-Overburden (22 yd^3)	20	-	423,900	141,300
Truck-Overburden (170 ton)	5	-	1,764,000	630,000
Drill Overburden (12-1/4 inch dia.)	20	147,600	147,600	147,600
Shovel-Coal	20	76,900	76,900	76,900
Truck-Coal (180 ton)	5	1,035,200	1,035,200	1,035,200
Wheel Loader (15 yd^3)	10	39,600	39,600	39,600
Coal Drill	10	14,400	14,400	14,400
Bulldozers (Crawler & Rubber Tired)	10	247,100	310,400	271,200
Explosives Truck	10	8,400	8,400	8,400
Motor Grader	10	31,200	46,800	31,200
Scraper Loader	5	95,600	95,600	95,600
Dump Truck (50 ton)	5	103,600	103,600	103,600
Fuel & Lube Truck	10	6,600	6,600	6,600
Sand & Water Truck	10	21,800	21,800	21,800
Mobile Crane (100 ton)	20	16,450	16,450	16,450
Mobile Crane (50 ton)	20	10,800	10,800	10,800
Tower-Floodlight	10	5,000	7,000	5,000
Hydroseeder Truck	10	5,100	5,100	5,100
Utility Truck	5	4,200	29,400	25,200
Pickup Truck	3	46,700	49,000	46,700
Station Wagon	3	11,700	11,700	11,700
Ambulance	10	1,200	1,200	1,200
Tools & Auxiliary Equipment	10	50,000	50,000	50,000
Bus (36 passenger)	10	5,000	7,500	5,000
Coal Lease	20	75,000	75,000	75,000
TOTAL		$7,234,000	$5,262,950	$5,000,450
Depreciation for field indirect, engineering, overhead and administration, contingency, fee and interest during construction	20	2,410,000	1,779,400	2,192,700
TOTAL YEARLY DEPRECIATION		$7,234,000	$7,042,350	$7,193,150

TABLE A-13

KUKPOWRUK RIVER
5 MILLION TONS PER YEAR
CALCULATION OF COAL SELLING PRICE

20 YEAR PROJECT LIFE - 15% RETURN ON INVESTMENT

	Mining Method		
	Dragline	Shovel	Dragline & Shovel
Annual Gross Profit			
After-Tax Cash Flow (Initial Investment/6.259)	$20,268,094	$15,691,005	$18,682,058
Less Depreciation	7,234,000	7,042,350	7,193,150
Depletion & After-Tax Profit (=3/4 Gross Profit)	13,034,094	8,648,655	11,488,908
GROSS PROFIT	$17,378,792	$11,531,540	$15,318,544
Annual Sales			
(Sales= Production Cost + Royalty + Gross Profit)			
Production Cost	$43,136,583	$55,851,780	$47,677,655
Gross Profit	17,398,792	11,531,540	15,318,544
Subtotal	60,515,375	67,383,320	62,996,199
Royalty (12.5 x subtotal) (87.5) ($12\frac{1}{2}$% of Sales)	8,645,054	9,626,189	8,999,457
Annual Sales	69,160,429	77,009,509	71,995,656
Selling Price Per Ton	$ 13.83	$ 15.40	$ 14.40
Cash Flow			
Gross Profit	$17,378,792	$11,531,540	$15,318,544
Depletion (50% of Gross Profit)	8,689,396	5,765,770	7,659,272
Taxable Income	8,689,396	5,765,770	7,659,272
Federal Income Tax	4,344,698	2,882,885	3,829,636
After Tax Income	4,344,698	2,882,885	3,829,636
After Tax Income	4,344,698	2,882,885	3,829,636
Plus Depreciation	7,234,000	7,642,350	7,193,150
Plus Depletion	8,689,396	5,765,770	7,659,272
Cash Flow	$20,268,094	$15,691,005	$18,682,058

TABLE A-14

ELUSIVE CREEK
5 MILLION TONS PER YEAR
EQUIPMENT COST SUMMARY
($1000's)

Equipment	Unit Cost	Mining Method: Dragline No.	Dragline Cost	Shovel No.	Shovel Cost	Dragline & Shovel No.	Dragline & Shovel Cost
Dragline (100 yd^3)	$26,628	2	$ 53,256	-	$ -	2	$ 53,256
Dragline (50 yd^3)	13,318	2	26,636	-	-	-	-
Shovel-Overden (22 yd^3)	2,826	-	-	7	19,782	3	8,478
Truck-Overburden (170 ton)	630	-	-	30	18,900	13	8,190
Drill-Overburden ($12\frac{1}{4}$ inch dia.)	738	8	5,904	8	5,904	8	5,904
Shovel-Coal (15 yd^3)	-	-	-	-	-	-	-
Truck-Coal (180 ton)	647	10	6,470	10	6,470	10	6,470
Wheel Loader (15 yd^3)	396	3	1,188	3	1,188	3	1,188
Coal Drill	72	2	144	2	144	2	144
Bulldozer-(Crawler)	241	15	3,615	18	4,338	17	4,097
Bulldozer-(Rubber Tired)	151	2	302	4	604	2	302
Explosives Truck (10 ton)	42	2	84	2	84	2	84
Motor Grader	156	2	312	2	312	2	312
Scraper Loader (31 yd^3)	239	2	478	2	478	2	478
Dump Truck (50 ton)	259	2	518	2	518	2	518
Fuel & Lube Truck	66	1	66	2	132	1	66
Sand & Water Truck	218	1	218	1	218	1	218
Mobile Crane (100 ton)	329	1	329	1	329	1	329
Mobile Crane (50 ton)	216	1	216	1	216	1	216
Tower-Floodlight	10	7	70	11	110	7	70
Hydroseeder Truck	51	1	51	1	51	1	51
Utility Truck	21	8	168	10	210	8	168
Pickup Truck	7	23	161	25	175	23	161
Station Wagon	7	5	35	5	35	5	35
Ambulance	12	1	12	1	12	1	12
Communications Equipment	60		60		80		60
Tools & Auxiliary Equipment	500		500		500		500
Bus (36 passenger)	25	5	125	7	175	6	150
Substation	750		750		500		750
Power Line	750		750		750		750
Coal Lease			1,500		1,500		1,500
Access Road	425	5mi	2,125	5mi	2,125	5mi	2,125
Office & Change House	1,380		1,380		1,940		1,500
Shop & Warehouse	8,400		8,400		11,250		9,400
Water & Sewage System							
Exploration	1,500		1,500		1,500		1,500
Coal Storage & Transfer System			4,500		4,500		4,500
TOTAL			$121,823		$85,030		$113,482

TABLE A-15

ELUSIVE CREEK
TOTAL ESTIMATED CAPITAL REQUIREMENTS
5 MILLION TONS PER YEAR
($000's)

	Dragline	Shovel	Dragline & Shovel
Exploration, Roads, and Buildings	$ 14,905	$ 18,315	$ 16,025
Mining Equipment	102,418	62,215	92,957
Coal Storage and Transfer Equipment	4,500	4,500	4,500
Total Direct	121,823	85,030	113,482
Field Indirect	9,137	6,377	8,511
Total Construction	130,960	91,407	121,993
Engineering	3,929	2,742	3,660
Subtotal	134,889	94,149	125,653
Overhead & Administration	10,117	7,061	9,424
Subtotal	145,006	101,210	135,077
Contingency	21,751	15,182	20,262
Subtotal	166,757	116,392	155,339
Fee	5,003	3,492	4,660
Total Plant Cost (Insurance-Tax Base)	171,760	119,884	159,999
Interest During Construction	30,917	21,579	28,800
Subtotal	202,677	141,463	188,799
Working Capital	10,775	17,400	13,400
Total Capital Requirements	$213,452	$158,863	$202,199

TABLE A-16

ELUSIVE CREEK
5 MILLION TONS PER YEAR
PERSONNEL REQUIREMENTS

		Mining Method					
		Dragline		Shovel		Dragline & Shovel	
Category	Daily Rate	No.	$/Year	No.	$/Year	No.	$/Year
Wage Personnel							
Production							
Dragline Operator	$112.00	16	$ 476,560	-	$ -	8	$ 225,120
Dragline Oiler	104.60	16	445,243	-	-	8	210,326
Shovel Operator	112.00	-	-	24	663,180	9	250,600
Shovel Oiler	104.60	-	-	24	619,600	9	234,132
Driller	99.80	25	625,373	25	625,373	25	625,373
Driller Helper	92.70	25	580,775	25	580,775	25	580,775
Blaster	99.80	2	40,123	2	40,123	2	40,123
Dozer Operator	99.80	45	1,115,837	56	1,407,994	51	1,282,320
Wheel Loader Operator	112.00	8	203,420	7	203,420	7	203,420
Truck Operator	99.80	19	479,731	112	2,800,387	54	1,356,451
Driller & Shooter-Coal	99.80	6	145,766	6	145,766	6	145,766
Grader Operator	99.80	6	133,786	7	167,232	7	167,232
Service Truck Driver	93.80	4	94,309	5	125,746	5	125,746
Scraper Operator	99.80	5	125,800	5	124,800	5	124,800
Utility	92.70	43	991,119	48	1,126,826	44	1,022,180
Subtotal		220	$5,456,842	346	$8,631,222	265	$6,594,364
Maintenance							
Master Electrician	112.00	18	498,400	30	838,180	22	627,200
Mechanic	108.30	71	1,932,429	119	3,242,559	89	2,426,368
Electrician	108.30	30	792,699	50	1,351,130	37	1,011,154
Repairman	99.80	29	733,574	45	1,118,083	34	858,998
Subtotal		148	$3,957,102	244	$6,549,952	182	$4,923,720
Total Wage Personnel		368	$9,413,944	590	$15,181,174	447	$11,518,084

TABLE A-16

ELUSIVE CREEK
5 MILLION TONS PER YEAR
PERSONNEL REQUIREMENTS

Category	Annual Rate	Mining Method: Dragline No.	Dragline $/Yr. Cost	Shovel No.	Shovel $/Yr. Cost	Dragline & Shovel No.	Dragline & Shovel $/Yr. Cost
Salaried Personnel							
Administrative							
General Manager	$50,000	1	$ 50,000	1	$ 50,000	1	$ 50,000
Chief Engineer	37,500	1	37,500	1	37,500	1	37,500
Environmental Engineer	28,750	1	28,750	1	28,750	1	28,750
Mine Engineer	31,250	2	62,500	2	62,500	2	62,500
Surveyor	22,500	4	90,000	4	90,000	4	90,000
Drafter	18,750	4	75,000	4	75,000	4	75,000
Manager, Administrative Services	43,750	1	43,750	1	43,750	1	43,750
Industrial Relations Supervisor	37,500	1	37,500	1	37,500	1	37,500
Personnel Supervisor	28,750	1	28,750	1	28,750	1	28,750
Safety Supervisor	28,750	1	28,750	1	28,750	1	28,750
Training Supervisor	28,750	1	28,750	1	28,750	1	28,750
Training Instructor	25,000	2	50,000	3	75,000	2	50,000
Employment Supervisor	28,750	1	28,750	1	28,750	1	28,750
Purchasing Agent	31,250	1	31,250	1	31,250	1	31,250
Buyer	25,000	2	50,000	3	75,000	2	50,000
Purchasing Clerk	15,000	3	45,000	4	60,000	3	45,000
Traffic Supervisor	28,750	1	28,750	1	28,750	1	28,750
Comptroller	37,500	1	37,500	1	37,500	1	37,500
Paymaster	26,250	1	26,250	1	26,250	1	26,250
Payroll Clerk	15,000	3	45,000	3	45,000	3	45,000
Senior Cost Accountant	28,750	1	28,750	1	28,750	1	28,750
Cost Accountant	26,250	2	52,500	2	52,500	2	52,500
Clerk-General	15,000	11	165,000	15	225,000	12	180,000
Secretary	13,750	2	27,500	2	27,500	2	27,500
Typist	11,250	3	33,750	5	56,250	4	45,000
Warehouse Supervisor	25,000	1	25,000	1	25,000	1	25,000
Warehouse Clerk	15,000	5	75,000	6	90,000	5	75,000
Warehouseman	15,000	9	135,000	10	150,000	9	135,000
Assistant Paymaster	22,500	1	22,500	1	22,500	1	22,500
Subtotal		68	$1,418,750	78	$1,596,250	70	$1,445,000
Production							
Mine Superintendent	43,750	1	43,750	1	43,750	1	43,750
General Foreman	31,250	1	31,250	1	31,250	1	31,250
Pit Foreman	26,250	8	210,000	8	210,000	8	210,000
Blaster Foreman	26,250	2	52,500	2	52,500	2	52,500
Coal Loading Foreman	26,250	4	105,000	4	105,000	4	105,000
Labor Foreman	26,250	2	52,500	2	52,500	2	52,500
Clerk	15,000	8	120,000	8	120,000	8	120,000
Equipment Foreman	26,250	-	-	4	105,000	-	-
Subtotal		26	$ 615,000	30	$ 720,000	26	$ 615,000

TABLE A-16

ELUSIVE CREEK
5 MILLION TONS PER YEAR
PERSONNEL REQUIREMENTS

		Mining Method					
	Annual	Dragline		Shovel		Dragline & Shovel	
Category	Rate	No.	$/Yr. Cost	No.	$/Yr. Cost	No.	$/Yr. Cost
Salaried Personnel							
Maintenance							
Superintendent, Maintenance	$37,500	1	$ 37,500	1	$ 37,500	1	$ 37,500
General Foreman	31,250	1	31,250	1	31,250	1	31,250
Mechanical Foreman	26,250	8	210,000	8	210,000	8	210,000
Electrical Foreman	26,250	4	105,000	8	210,000	4	105,000
Shop Foreman	26,250	4	105,000	4	105,000	4	105,000
Design Engineer	26,250	1	26,250	1	26,250	1	26,250
Drafter	18,750	2	37,500	3	56,250	2	37,500
Clerk	15,000	4	60,000	4	60,000	4	60,000
Subtotal		25	612,500	30	736,250	25	612,500
Total Salaried Personnel		118	2,646,250	137	3,052,500	121	2,672,500
GRAND TOTAL		464	$11,502,211	727	$18,233,674	527	$13,114,411

TABLE A-17

ELUSIVE CREEK
5 MILLION TONS PER YEAR
ESTIMATED ANNUAL PRODUCTION COST

Cost Item	Mining Method					
	Dragline		Shovel		Dragline & Shovel	
	$/Year	$/Ton	$/Year	$/Ton	$/Year	$/Ton
Direct Cost						
Wages						
Operating Labor	$ 5,456,842	1.09	$ 8,631,222	1.73	$ 6,594,364	1.32
Maintenance Labor	3,957,102	.79	6,549,952	1.31	4,923,720	.98
Subtotal	9,413,944	1.88	15,181,174	3.04	11,518,084	2.30
Salaries						
Production	615,000	.12	720,000	.14	615,000	.12
Maintenance	612,500	.12	736,250	.15	612,500	.12
Administrative	1,418,750	.28	1,596,250	.32	1,445,000	.29
Subtotal	2,646,250	.52	3,052,500	.61	2,672,500	.53
Payroll Overhead	4,824,078	.96	7,293,470	1.46	5,676,234	1.14
Total Wage & Salary Cost	16,884,272	3.36	25,527,144	5.11	19,866,818	3.97
Operating Supplies						
Spare Parts	6,702,120	1.34	12,854,085	2.57	9,013,395	1.80
Explosives	7,692,381	1.54	7,692,381	1.54	7,692,381	1.54
Fuel & Lubricants	2,372,312	.47	5,525,900	1.11	3,606,651	.72
Tires	1,097,805	.22	4,568,475	.91	2,452,755	.49
Miscellaneous	3,687,615	.74	4,153,092	.83	4,016,277	.80
Total, Operating Supplies	21,552,233	4.31	34,793,933	6.96	26,781,459	5.35
Power	3,968,800	.79	1,090,090	.22	2,796,444	.56
Union Walfare	5,250,000	1.05	5,900,000	1.18	5,500,000	1.10
Subtotal	9,218,800	1.84	6,990,090	1.40	8,296,444	1.66
Total Direct Cost	47,655,305	9.51	67,311,167	13.47	54,944,721	10.98
Indirect Cost (15% of Labor & Material)	5,765,476	1.15	9,048,162	1.81	6,997,242	1.40
Taxes & Insurance - 2% of Plant Cost	3,435,200	.69	2,397,680	.48	3,199,980	.64
Depreciation	11,678,040	2.34	11,511,650	2.30	12,437,990	2.49
Deferred Expense	1,922,813	.38	5,553,500	1.11	3,490,125	.70
Subtotal	22,801,529	4.56	28,510,992	5.70	26,125,337	5.23
Total Annual Production Cost	70,456,834	14.07	95,822,159	19.17	81,070,058	16.21
Royalty (12-1/2% of Selling Price)	14,336,723	2.87	16,330,762	3.27	15,365,690	3.07
TOTAL ANNUAL COST	$84,793,557	16.94	$112,152,921	22.44	$96,435,748	19.28

TABLE A-18

ELUSIVE CREEK
5 MILLION TONS PER YEAR
DEPRECIATION SCHEDULE
(Yearly Charge)

Capital Cost Item	Straight Line Depreciation Years	Mining Method		
		Dragline	Shovel	Dragline & Shovel
Exploration	20	$ 75,000	$ 75,000	$ 75,000
Coal Storage & Transfer System	20	225,000	225,000	225,000
Mine Buildings	20	489,000	659,500	545,000
Substation	20	37,500	25,000	37,500
Power Line	20	37,500	37,500	37,500
Communications Equipment	20	3,000	4,000	3,000
Roads	20	106,250	106,250	106,250
Dragline (100 yd^3)	20	2,662,800	-	2,662,800
Dragline (50 yd^3)	20	1,331,800	-	-
Shovel-Overburden (22 yd^3)	20	-	989,100	423,900
Truck-Overburden (170 ton)	5	-	3,780,000	1,638,000
Drill Overburden (12-1/4 inch dia.)	20	295,200	295,200	295,200
Shovel-Coal				
Truck-Coal (180 ton)	5	1,294,000	1,294,000	1,294,000
Wheel Loader (15 yd^3)	10	118,000	118,000	118,000
Coal Drill	10	14,400	14,400	14,400
Bulldozers (Crawler & Rubber Tired)	10	391,700	494,200	439,900
Explosives Truck	10	8,400	8,400	8,400
Motor Grader	10	31,200	31,200	31,200
Scraper Loader	5	95,600	95,600	95,600
Dump Truck (50 ton)	5	103,600	103,600	103,600
Fuel & Lube Truck	10	6,600	13,200	6,600
Sand & Water Truck	10	21,800	21,800	21,800
Mobile Crane (100 ton)	20	16,450	16,450	16,450
Mobile Crane (50 ton)	20	10,800	10,800	10,800
Tower-Floodlight	10	7,000	11,000	7,000
Hydroseeder Truck	10	5,100	5,100	5,100
Utility Truck	5	33,600	42,000	33,600
Pickup Truck	3	63,670	58,330	63,670
Station Wagon	3	11,670	11,670	11,670
Ambulance	10	1,200	1,200	1,200
Tools & Auxiliary Equipment	10	50,000	50,000	50,000
Bus (36 passenger)	10	12,500	17,500	15,000
Coal Lease	20	75,000	75,000	75,000
TOTAL		$ 7,635,340	$ 8,690,000	$ 8,672,140
Depreciation for field indirect, engineering, overhead and administration, contingency, fee and interest during construction	20	4,042,700	2,821,650	3,765,850
TOTAL YEARLY DEPRECIATION		$11,678,040	$11,511,650	$12,437,990

TABLE A-19

ELUSIVE CREEK
5 MILLION TONS PER YEAR
CALCULATION OF COAL SELLING PRICE
20 YEAR PROJECT LIFE - 15% RETURN ON INVESTMENT

	Mining Method		
	Dragline	Shovel	Dragline & Shovel
Annual Gross Profit			
After-Tax Cash Flow (Initial Investment/6.259)	$34,103,211	$25,381,530	$32,305,320
Less Depreciation	11,678,040	11,511,650	12,437,990
Depletion & After-Tax Profit (= 3/4 Gross Profit)	22,425,171	13,869,880	19,867,330
GROSS PROFIT	29,900,228	18,493,173	26,489,773
Annual Sales			
(Sales = Production Cost + Royalty + Gross Profit)			
Production Cost	70,456,834	95,822,159	81,070,058
Gross Profit	29,900,228	18,493,173	26,489,773
Subtotal	100,357,062	114,315,332	107,559,831
Royalty (12.5/87.5 x subtotal) (12-1/2% of Sales)	14,336,723	16,330,762	15,365,690
Annual Sales	114,693,785	130,646,094	122,925,521
Selling Price Per Ton	22.94	26.13	24.59
Cash Flow			
Gross Profit	29,900,228	18,493,173	26,489,773
Depletion (50% of Gross Profit)	14,950,114	9,246,587	13,244,887
Taxable Income	14,950,114	9,246,586	13,244,886
Federal Income Tax	7,475,057	4,623,293	6,622,443
After Tax Income	7,475,057	4,623,293	6,622,443
After Tax Income	7,475,057	4,623,293	6,622,443
Plus Depreciation	11,678,040	11,511,650	12,437,990
Plus Depletion	14,950,114	9,246,587	13,244,887
Cash Flow	$34,103,211	$25,381,530	$32,305,320

TABLE A-20

KUK RIVER
5 MILLION TONS PER YEAR
EQUIPMENT COST SUMMARY

		Mining Method					
	Unit	Dragline		Shovel		Dragline & Shovel	
Equipment	Cost	No.	Cost	No.	Cost	No.	Cost
Dragline (100 yd^3)	$26,628	2	$ 53,256	-	$ -	2	$ 53,256
Dragline (50 yd^3)	13,318	2	26,636	-	-	-	-
Shovel-Overburden (22 yd^3)	2,826	-	-	6	16,956	2	5,652
Truck-Overburden (170 ton)	630	-	-	27	17,010	10	6,300
Drill-Overburden ($12\frac{1}{4}$ inch dia.)	738	7	5,166	7	5,166	7	5,166
Shovel-Coal (15 yd^3)						-	-
Truck-Coal (180 ton)	647	10	6,470	10	6,470	10	6,470
Wheel Loader (15 yd^3)	396	3	1,188	3	1,188	3	1,188
Coal Drill	72	2	144	2	144	2	144
Bulldozer-(Crawler)	241	14	3,374	17	4,097	16	3,856
Bulldozer-(Rubber Tired)	151	2	302	4	604	3	453
Explosives Truck (10 ton)	42	2	84	2	84	2	84
Motor Grader	156	2	312	2	312	2	312
Scraper Loader (31 yd^3)	239	2	478	2	478	2	478
Dump Truck (50 ton)	259	2	518	2	518	2	518
Fuel & Lube Truck	66	1	66	2	132	1	66
Sand & Water Truck	218	1	218	1	218	1	218
Mobile Crane (100 ton)	329	1	329	1	329	1	329
Mobile Crane (50 ton)	216	1	216	1	216	1	216
Tower-Floodlight	10	7	70	10	100	7	70
Hydroseeder Truck	51	1	51	1	51	1	51
Utility Truck	21	8	168	10	210	8	168
Pickup Truck	7	23	161	25	175	23	161
Station Wagon	7	5	35	5	35	5	35
Ambulance	12	1	12	1	12	1	12
Communications Equipment	60	-	60	-	80	-	60
Tools & Auxiliary Equipment	500	-	500	-	500	-	500
Bus (36 passenger)	25	4	100	7	175	5	125
Substation			750		500		750
Power Line			750		750		750
Coal Lease			1,500		1,500		1,500
Access Road	425	5mi	2,125	5mi	2,125	5mi	2,125
Office & Change House			1,365		1,885		1,430
Shop & Warehouse			8,151		10,595		8,944
Water & Sewage System							
Exploration			1,500		1,500		1,500
Coal Storage & Transfer System			4,500		4,500		4,500
TOTAL			$120,555		$ 78,615		$107,387

TABLE A-21

KUK RIVER
TOTAL ESTIMATED CAPITAL REQUIREMENTS
5 MILLION TONS PER YEAR
($000's)

	Dragline	Shovel	Dragline & Shovel
Exploration, Roads, and Buildings	$ 14,641	$ 17,605	$ 15,499
Mining Equipment	101,414	56,510	87,388
Coal Storage and Transfer Equipment	4,500	4,500	4,500
Total Direct	120,555	78,615	107,387
Field Indirect	9,042	5,896	8,054
Total Construction	129,597	84,511	115,441
Engineering	3,888	2,535	3,463
Subtotal	133,485	87,046	118,904
Overhead & Administration	10,011	6,528	8,918
Subtotal	143,496	93,574	127,822
Contingency	21,524	14,036	19,173
Subtotal	165,020	107,610	146,995
Fee	4,951	3,228	4,410
Total Plant Cost (Insurance-Tax Base)	169,971	110,838	151,405
Interest During Construction	30,595	19,951	27,253
Subtotal	200,566	130,789	178,658
Working Capital	10,000	16,000	12,000
Total Capital Requirements	$210,566	$146,789	$190,658

TABLE A-22

KUK RIVER
5 MILLION TONS PER YEAR
PERSONNEL REQUIREMENTS

		Mining Method					
		Dragline		Shovel		Dragline & Shovel	
Category	Daily Rate	No.	$/Year	No.	$/Year	No.	$/Year
Wage Personnel							
Production							
Dragline Operator	$112.00	15	$ 411,180	-	$ -	8	$ 225,120
Dragline Oiler	104.60	15	384,160	-	-	8	210,326
Shovel Operator	112.00	-	-	21	589,540	6	176,820
Shovel Oiler	104.60	-	-	21	550,799	6	165,200
Driller	99.80	22	555,984	22	555,984	22	555,984
Driller Helper	92.70	22	516,334	22	516,335	22	516,335
Blaster	99.80	2	35,693	2	35,668	2	35,693
Dozer Operator	99.80	48	1,057,555	54	1,342,349	49	1,216,550
Wheel Loader Operator	112.00	8	203,420	8	203,420	7	203,420
Truck Operator	99.80	19	479,731	101	2,542,550	44	1,098,365
Driller & Shooter-Coal	99.80	6	145,766	6	145,766	6	145,766
Grader Operator	99.80	6	133,786	7	167,232	7	167,232
Service Truck Driver	93.80	4	94,309	5	125,746	5	125,746
Scraper Operator	99.80	5	124,800	5	124,800	5	124,800
Utility	92.70	42	978,694	48	1,114,402	43	1,009,756
Subtotal		208	5,121,412	322	8,014,591	240	5,977,113
Maintenance							
Master Electrician	112.00	16	463,078	27	767,452	20	556,416
Mechanic	108.30	66	1,791,450	109	2,968,916	79	2,152,508
Electrician	108.30	27	746,447		1,237,055	33	896,876
Repairman	99.80	29	733,574		1,118,083	34	858,998
Subtotal		138	3,374,549	226	6,091,506	166	4,464,798
Total Wage Personnel		346	$8,855,961	548	$14,106,097	406	$10,441,911

TABLE A-22

KUK RIVER
5 MILLION TONS PER YEAR
PERSONNEL REQUIREMENTS

Category	Annual Rate	Mining Method: Dragline No.	Dragline $/Yr Cost	Shovel No.	Shovel $/Yr Cost	Dragline & Shovel No.	Dragline & Shovel $/Yr Cost
Salaried Personnel							
Administrative							
General Manager	$50,000	1	$ 50,000	1	50,000	1	$ 50,000
Chief Engineer	37,500	1	37,500	1	37,500	1	37,500
Environmental Engineer	28,750	1	28,750	1	28,750	1	28,750
Mine Engineer	31,250	2	62,500	2	62,500	2	62,500
Surveyor	22,500	4	90,000	4	90,000	4	90,000
Drafter	18,750	4	75,000	4	75,000	4	75,000
Manager, Administrative Services	43,750	1	43,750	1	43,750	1	43,750
Industrial Relations Supervisor	37,500	1	37,500	1	37,500	1	37,500
Personnel Supervisor	28,750	1	28,750	1	28,750	1	28,750
Safety Supervisor	28,750	1	28,750	1	28,750	1	28,750
Training Supervisor	28,750	1	28,750	1	28,750	1	28,750
Training Instructor	25,000	2	50,000	3	75,000	2	50,000
Employment Supervisor	28,750	1	28,750	1	28,750	1	28,750
Purchasing Agent	31,250	1	31,250	1	31,250	1	31,250
Buyer	25,000	2	50,000	3	75,000	2	50,000
Purchasing Clerk	15,000	3	45,000	4	60,000	3	45,000
Traffic Supervisor	28,750	1	28,750	1	28,750	1	28,750
Comptroller	37,500	1	37,500	1	37,500	1	37,500
Paymaster	26,250	1	26,250	1	26,250	1	26,250
Payroll Clerk	15,000	3	45,000	3	45,000	3	45,000
Senior Cost Accountant	28,750	1	28,750	1	28,750	1	28,750
Cost Accountant	26,250	2	52,500	2	52,500	2	52,500
Clerk-General	15,000	11	165,000	15	225,000	12	180,000
Secretary	13,750	2	27,500	2	27,500	2	27,500
Typist	11,250	3	33,750	5	56,270	4	45,000
Warehouse Supervisor	25,000	1	25,000	1	25,000	1	25,000
Warehouse Clerk	15,000	5	75,000	6	90,000	5	75,000
Warehouseman	15,000	9	135,000	10	150,000	9	135,000
Assistant Paymaster	22,500	1	22,500	1	22,500	1	22,500
Subtotal		68	$ 1,418,750	78	$ 1,596,250	70	$ 1,445,000
Production							
Mine Superintendent	$43,750	1	43,750	1	43,750	1	43,750
General Foreman	31,250	1	31,250	1	31,250	1	31,250
Pit Foreman	26,250	8	210,000	8	210,000	8	210,000
Blaster Foreman	26,250	2	52,500	2	52,500	2	52,500
Coal Loading Foreman	26,250	4	105,000	4	105,000	4	105,000
Labor Foreman	26,250	2	52,500	2	52,500	2	52,500
Clerk	15,000	8	120,000	8	120,000	8	120,000
Equipment Foreman	26,250			4	105,000		
Subtotal		26	$ 615,000	30	$ 720,000	26	$ 615,000
Maintenance							
Superintendent, Maintenance	$37,500	1	37,500	1	37,500	1	37,500
General Foreman	31,250	1	31,250	1	31,250	1	31,250
Mechanical Foreman	26,250	8	210,000	8	210,000	8	210,000
Electrical Foreman	26,250	4	105,000	8	210,000	4	105,000
Shop Foreman	26,250	4	105,000	4	105,000	4	105,000
Design Engineer	26,250	1	26,250	1	26,250	1	26,250
Drafter	18,750	2	37,500	3	56,250	2	37,500
Clerk	15,000	4	60,000	4	60,000	4	60,000
Subtotal		25	$ 612,500	30	$ 736,250	25	$ 612,500
Total Salaried Personnel		118	$ 2,646,250	137	$ 3,052,500	121	$ 2,672,500
GRAND TOTAL		469	$ 11,502,211	685	$17,158,597	527	$ 13,114,411

TABLE A-23

KUK RIVER
5 MILLION TONS PER YEAR
ESTIMATED ANNUAL PRODUCTION COST

Cost Item	Mining Method					
	Dragline		Shovel		Dragline & Shovel	
	$/Year	$/Ton	$/Year	$/Ton	$/Year	$/Ton
Direct Cost						
Wages						
Operating Labor	$ 5,121,412	1.02	$ 8,014,591	1.60	$ 5,977,113	1.20
Maintenance Labor	3,734,549	.75	6,091,506	1.22	4,464,798	.89
Subtotal	8,855,961	1.77	14,106,097	2.82	10,441,911	5.09
Salaries						
Production	615,000	.12	720,000	.14	615,000	.12
Maintenance	612,500	.12	736,250	.15	612,500	.12
Administrative	1,418,750	.28	1,596,250	.32	1,445,000	.29
Subtotal	2,646,250	.52	3,052,500	.61	2,672,500	.53
Payroll Overhead	4,600,884	.92	6,863,439	1.37	5,245,764	1.05
Total Wage & Salary Cost	$16,103,095	3.21	$24,022,036	4.80	$18,360,175	3.67
Operating Supplies						
Spare Parts	6,260,543	1.25	11,821,223	2.36	7,979,243	1.60
Explosives	6,869,709	1.37	6,869,709	1.37	6,869,709	1.37
Fuel & Lubricants	2,283,990	.46	5,115,586	1.02	3,195,846	.64
Tires	1,095,660	.22	4,194,450	.84	2,078,370	.42
Miscellaneous	3,442,972	.69	3,928,722	.79	3,791,740	.76
Total, Operating Supplies	$19,952,874	3.99	$31,929,690	6.38	$23,914,908	4.79
Power	3,517,600	.70	973,834	.19	2,680,028	.54
Union Welfare	1,800,000	.36	2,450,000	.49	2,000,000	.40
Subtotal	5,317,600	1.06	3,423,834	.68	4,680,028	.94
Total Direct Cost	41,373,569	8.26	59,375,560	11.86	46,955,111	9.40
Indirect Cost (15% of Labor & Material)	5,408,395	1.08	8,392,759	1.68	6,341,262	1.27
Taxes & Insurance - 2% of Plant Cost	3,399,420	.68	2,216,760	.44	3,028,100	.61
Depreciation	11,550,000	2.31	10,728,600	2.15	11,433,490	2.29
Deferred Expense	1,906,188	.38	5,183,438	1.04	3,128,563	.63
Subtotal	22,264,003	4.45	26,521,557	5.31	23,931,415	4.80
Total Annual Production Cost	63,637,572	12.71	85,897,117	17.17	70,886,526	14.20
Royalty (12-1/2% of Selling Price)	13,299,104	2.66	14,694,611	2.94	13,751,014	2.75
TOTAL ANNUAL COST	$76,936,676	15.37	$100,591,728	20.11	$84,637,540	16.95

TABLE A-24

KUK RIVER
5 MILLION TONS PER YEAR
DEPRECIATION SCHEDULE
(Yearly Charge)

Capital Cost Item	Straight Line Depreciation Years	Mining Method		
		Dragline	Shovel	Dragline & Shovel
Exploration	20	$ 75,000	$ 75,000	$ 75,000
Coal Storage & Transfer System	20	225,000	225,000	225,000
Mine Buildings	20	475,800	624,000	518,700
Substation	20	37,500	25,000	37,500
Power Line	20	37,500	37,500	37,500
Communications Equipment	20	3,000	4,000	3,000
Roads	20	106,250	106,250	106,250
Dragline (100 yd^3)	20	2,662,800	-	2,662,800
Dragline (50 yd^3)	20	1,331,800	-	-
Shovel-Overburden (22 yd^3)	20	-	847,800	282,600
Truck-Overburden (170 ton)	5	-	3,402,000	1,260,000
Drill Overburden (12-1/4 inch dia.)	20	258,300	258,300	258,300
Shovel-Coal	20	-	-	-
Truck-Coal (180 ton)	5	1,294,000	1,294,000	1,294,000
Wheel Loader (15 yd^3)	10	118,800	118,800	118,800
Coal Drill	10	14,400	14,400	14,400
Bulldozers (Crawler & Rubber Tired)	10	367,600	470,100	430,900
Explosives Truck	10	8,400	8,400	8,400
Motor Grader	10	31,200	31,200	31,200
Scraper Loader	5	95,600	95,600	95,600
Dump Truck (50 ton)	5	103,600	103,600	103,600
Fuel & Lube Truck	10	6,600	13,200	6,600
Sand & Water Truck	10	21,800	21,800	22,800
Mobile Crane (100 ton)	20	16,450	16,450	16,450
Mobile Crane (50 ton)	20	10,800	10,800	10,800
Tower-Floodlight	10	7,000	10,000	7,000
Hydroseeder Truck	10	5,100	5,100	5,100
Utility Truck	5	33,600	42,000	33,600
Pickup Truck	3	53,700	58,300	53,670
Station Wagon	3	11,700	11,700	11,670
Ambulance	10	1,200	1,200	1,200
Tools & Auxiliary Equipment	10	50,000	50,000	50,000
Bus (36 passenger)	10	10,000	17,500	12,500
Coal Lease	20	75,000	75,000	75,000
TOTAL		$ 7,549,500	$ 8,119,900	$ 7,869,940
Depreciation for field indirect, engineering, overhead and administration, contingency, fee and interest during construction	20	4,000,500	2,608,700	3,563,550
TOTAL YEARLY DEPRECIATION		$11,550,000	$10,728,600	$11,433,490

TABLE A-25

KUK RIVER
5 MILLION TONS PER YEAR
CALCULATION OF COAL SELLING PRICE
20 YEAR PROJECT LIFE - 15% RETURN ON INVESTMENT

	Mining Method		
	Dragline	Shovel	Dragline & Shovel
Annual Gross Profit			
After-Tax Cash Flow	$ 33,642,115	$ 23,452,468	$ 30,461,416
(Initial Investment/6.259)			
Less Depreciation	11,550,000	10,728,600	11,433,490
Depletion & After-Tax Profit	22,092,115	12,723,868	19,027,926
(= 3/4 Gross Profit)			
GROSS PROFIT	29,456,153	16,965,157	25,370,568
Annual Sales			
(Sales = Production Cost + Royalty + Gross Profit)			
Production Cost	63,637,572	85,897,117	70,886,526
Gross Profit	29,456,153	16,965,157	25,370,568
Subtotal	93,093,725	102,862,274	96,257,094
Royalty (12.5 x subtotal) / (87.5)	13,299,104	14,694,611	13,751,014
(12-1/2% of Sales)			
Annual Sales	106,392,829	117,556,885	110,008,108
Selling Price Per Ton	21.28	23.51	22.00
Cash Flow			
Gross Profit	29,456,153	16,965,157	25,370,568
Depletion (50% of Gross Profit)	14,728,077	8,482,579	12,685,284
Taxable Income	14,728,076	8,482,578	12,685,284
Federal Income Tax	7,364,038	4,241,289	6,342,642
After Tax Income	7,364,038	4,241,289	6,342,642
After Tax Income	7,364,038	4,241,289	6,342,642
Plus Depreciation	11,550,000	10,728,600	11,433,490
Plus Depletion	14,728,077	8,482,579	12,685,284
Cash Flow	$ 33,642,115	$ 23,452,468	$ 30,461,416

TABLE A-26

MINING COST SUMMARY
(5,000,000 Tons Per Year)

COST ITEM	KUKPOWRUK RIVER Dragline	KUKPOWRUK RIVER Shovel	KUKPOWRUK RIVER Dragline & Shovel	ELUSIVE CREEK Dragline	ELUSIVE CREEK Shovel	ELUSIVE CREEK Dragline & Shovel	KUK RIVER Dragline	KUK RIVER Shovel	KUK RIVER Dragline & Shovel
MINING									
Capital Cost ($ thousands)	126,858	98,210	116,931	213,452	158,863	202,199	210,556	146,789	190,658
Annual Cost ($ thousands)	51,782	65,477	56,677	84,794	112,153	96,436	76,937	100,592	84,638
*Selling Price ($/ton)	13.83	15.40	14.40	22.94	26.13	24.59	21.28	23.51	22.00
*Selling Price ($/million Btu)	0.58	0.64	0.60	0.96	1.09	1.02	1.25	1.38	1.29
TOWNSITE & UTILITIES									
Capital Cost ($ thousands)	85,294	79,856	82,913	138,788	140,419	134,550	136,556	134,906	129,169
Annual Cost ($ thousands)	20,747	23,183	21,267	31,987	39,279	34,663	32,695	37,425	32,854
Cost Per Ton ($)	4.15	4.64	4.25	6.40	7.86	6.93	6.54	7.49	6.57
Cost Per Million Btu ($)	0.17	0.19	0.18	0.27	0.33	0.29	0.38	0.44	0.39
TOTAL MINING									
Capital Cost ($ thousands)	212,152	178,066	199,844	352,240	299,282	336,749	347,112	281,695	319,827
Annual Cost ($ thousands)	72,529	88,660	77,944	116,781	151,432	131,099	109,632	138,017	117,492
*Price Per Ton ($)	17.98	20.04	18.65	29.63	33.99	31.52	27.82	31.00	28.57
*Price Per Million Btu ($)	0.75	0.84	0.78	1.23	1.42	1.31	1.64	1.82	1.68

MINESITE LOCATION AND MINING SYSTEM spans all location columns.

*Price at minesite

B. TRANSPORTATION COSTS

The following data is included as a guide to demonstrate order-of- magnitude total cost for coal from the North Slope of Alaska at a deep-water, year-round shipping port.

Capital and operating costs for the different modes of transportation are based on estimates and data contained in Clark (1973), "Transportation Economics of Coal Resources of Northern Slope Coal Fields, Alaska."

Clark's estimates were not based on site specific data. In some instances portions of the systems involve designs or methods which have not been proven technically feasible.

Clark's estimates have been escalated in accordance with the highway bid price index and building cost index published in "Engineering News Record," December 23, 1976. Escalation factors of 1.7 for road and railway construction and 1.96 for equipment and other construction have been applied to the 1969 data and a factor of 1.47 to 1972 data.

For the 5-million-ton-per-year mines, the transportation systems considered consist of the following:

- Year-round shipping by railroad from the minesite to a deep water port at Seward. A new railroad would be constructed from the existing railroad at Nenana to the minesite. New locomotives and cars would be required and a port with stockpiling and shiploading facilities would be constructed at Seward.

- Seasonal shipping by barge from a point on the Chukchi Sea Coast near the minesite to Dutch Harbor in the Aleutian Islands for stockpiling and year-round shipping by barge or large bulk cargo vessels.

This would require construction of: a port on the Chukchi Sea Coast for shallow draft tugs and barge loading facilities; a deep-water port at Dutch Harbor with barge unloading, coal storage and ship-loading facilities. Tugs and barges required for seasonal movement of coal to Dutch Harbor could be used the remainder of the year to transport coal to the final destination.

Transportation from the minesite to the barge port on the Chukchi Sea is estimated for three modes: truck haulage in large coal haulers; conveyor belt; and pipelining of a coal-water slurry with a return line for water. In the case of pipelining, dewatering facilities are required and dry storage, reclaiming and barge loading would be used in all cases.

For the 500,000-ton-per-year mine at Kukpowruk River, the following transportation system would be used:

- truck haulage from the mine to a barge port on the Chukchi Sea
- seasonal barge transport to an assumed existing transshipment facility in the Seward-Whittier area

TABLE A-27

CRITERIA FOR TRANSPORTATION ESTIMATES

Railroad

Operating Basis

Production	5,000,000 tons/yr
Schedule	350 Operating d/yr
Average Travel Speed	30 mi/h
Loading Time	3 h/train
Unloading Time	4 h/train
Size of Train	13,000 tons/train (8 locomotives, 125 cars)
Number of Operating Trains	5

Cost of Equipment

Locomotive - 6 Axle, 3,000 HP @ $660,000 ea.	$26,400,000
Gondola Cars @ $30,000 ea.	18,750,000
Loading Equipment	1,100,000
Unloading Equipment	2,850,000
Total	$49,100,000

Cost of Railroad

Construction, Engineering, and Contingency	$3,060,000 per mile
Communications	$8,500 per mile
Buildings and Auxiliary Equipment	$8,500,000

Train Operating Cost

Locomotives	$2.35 per locomotive mile
Gondola Cars	$0.12 per car mile
Labor - 87 men	$40,000 per man per year

TABLE A-27 (Cont)

Annual Maintenance Cost

Railroad	$27,500 per mile
Loading and Unloading Equipment	$100,000 per year

Harbor at Seward

Capital Costs

Stockpile Area	$ 225,000
Dock and Shiploader	15,000,000
Stacker-Reclaimers	6,000,000
Total	$21,225,000

Operating Cost

Labor, Supervision	$ 300,000 per year
Stacking, Reclaiming, Shiploading	3,000,000 per year
Maintenance	300,000 per year
Total	$ 3,600,000 per year

Pipeline

Construction Cost

Slurry Line - 16 in (Incl. Pumps, Controls)	$ 600,000 per mile
Water Line - 12 in (Incl. Pumps, Controls)	300,000 per mile
Preparation Facility	$15,000,000
Receiving Facility	$15,000,000

Operating Cost

Slurry Line

Power @ $0.045 per KWH	$ 62,700 per mile
Pumps	3,500 per mile

TABLE A-27 (Cont)

Pipeline - 2% of Original Cost	\$ 12,000 per mile
Inhibitor @ \$0.15 per Ton	\$ 750,000 per year
Labor, Administration, etc. @ \$0.15 per ton	\$ 750,000 per year

Water Line

Power	\$ 4,000 per mile
Maintenance - 2% of Original Cost	\$ 6,000 per mile
Pipe Heating	\$ 2,500 per mile
Labor, Administration, etc.	\$ 3,000 per mile
Total	\$ 15,500 per mile

Belt Conveyor

Construction Cost

Conveyor - 36 in	\$ 1,830,000 per mile

Operating Cost - Annual

Power	\$ 140,000 per mile
Labor	40,000 per mile
Maintenance	10,000 per mile
Total	\$ 190,000 per mile

Truck Haulage

Operating Basis

Average Travel Speed	30 miles per hour
Load and Unload	.10 hrs/trip
Delay Allowance	10%
Tons per Load	180
Mechanical Availability	70%

TABLE A-27 (Cont)

Equipment Cost

Truck - 180 Ton Bottom Dump	$ 647,000 each

Construction Cost

Haul Road	$ 425,000 per mile

Operating Cost (Annual)

Haul Road Maintenance @ $0.30/Ton Mile	$ 150,000 per mile
Truck Operating Cost @ $84.00 per Hour	$ 675,000

Barge Transport to Dutch Harbor

Operating Basis

Tug-Barge Speed	11 knots
Barge Size	60,000 tons
Tug Size	4,400 hp
Crew Size	10 men
Ice-Free Season	90 days
Distance to Dutch Harbor	1,000 nautical miles
Loading and Unloading Time	2 days per barge
Round-Trip Time	9.5 days
Number of Barges	9
Number of Tugs	7

Chukchi Sea Harbor

Construction Cost

Stockpile Area	$ 825,000
Pier-Rock and Gravel	30,000,000
Total	$30,825,000

TABLE A-27 (Cont)

Equipment	
Stacker-Reclaimers	$ 6,000,000
Shiploader and Conveyor	9,000,000
Total	$15,000,000
Operating Cost - Annual	$ 5,000,000
Dutch Harbor	
Construction Cost	
Dock and Stockpile Area	$15,500,000
Equipment	15,000,000
Total	$30,500,000
Operating Cost, Annual	$ 5,200,000
Barges and Tugs	
Capital Cost	
Barges @ $12,130,000 each	$109,170,000
Tugs @ $2,365,000 each	16,555,000
Total	$125,715,000
Operating Costs - Annual	
Barges	$ 1,593,000
Tugs	7,182,000
Total	$ 8,775,000
Total Capital	$202,050,000

TABLE A-27 (Cont)

Total Annual Cost

Capital

Chukchi Sea Harbor	$ 4,624
Coal Handling Equipment	2,400
Dutch Harbor - Dock & Stockpile Area	2,325
Coal Handling Equipment	2,400
Barges & Tugs (3 mos.)	5,029
Total Capital	$16,778

Operating

Chukchi Harbor	5,000
Dutch Harbor	5,200
Barges & Tugs	8,775
	$18,975

Access Road to Mine and Townsite Area

Construction Cost per mile	$425,000
Maintenance Cost per mile	75,000

Kikpowruk River

Capital Cost	$ 000's
Road Construction - 25 miles	$ 10,625

Annual Cost

Capital	$ 1,594
Maintenance	1,875
Total Annual Cost	$ 3,469

TABLE A-27 (Cont)

Elusive Creek

Capital Cost

Road Construction - 75 miles	$ 31,875

Annual Cost

Capital	$ 4,781
Maintenance	5,625
Total Annual Cost	$ 10,406

Kuk River

Capital Cost

Road Construction - 35 miles	$ 12,750

Annual Cost

Capital	$ 1,913
Maintenance	2,625
Total Annual Cost	$ 4,538

Additional Power Plant Costs for Transportation

Conveyor Belt

36-in Conveyor Belt - 1,680 installed hp for 3 mi	= 560 hp/mile
kVA @ 75% x .746	= 313 kVA/mile
Capital Cost @ $1,000/kVA	= $313,000/mile

Pipe Line

Slurry Line - 237 hp/mile	
Water Line - 15.3 hp/mile	
Total hp (Operating)	252.3/mile
kVA @ .746	188.2/mile
Capital Cost @ $1,000/kVA	$188,200/mile

TABLE A-27 (Cont)

Additional Capital & Annual Costs for Power Plant

	$ 000's
Kukpowruk River	
Conveyor	
Capital Cost - 25 miles	$ 7,825
Annual Cost	1,252
Pipeline	
Capital Cost	4,705
Annual Cost	753
Elusive Creek	
Conveyor	
Capital Cost - 75 miles	23,475
Annual Cost	3,756
Pipe Line	
Capital Cost - 75 miles	14,115
Annual Cost	2,258
Kuk River	
Conveyor	
Capital Cost - 35 miles	10,955
Annual Cost	1,753
Pipe Line	
Capital Cost - 35 miles	6,587
Annual Cost	1,054

TABLE A-28

TRANSPORTATION COST ESTIMATE ALL-YEAR RAILWAY SYSTEM (5 MILLION TONS PER YEAR)

COST ITEM	MINESITE					
	Kukpowruk River		Elusive Creek		Kuk River	
	No.	Cost($000)	No.	Cost($000)	No.	Cost($000)
Capital Cost						
Track and Communication Equipment	720 mi	2,209,320	650 mi	1,994,525	730 mi	2,240,005
Buildings		8,500		8,500		8,500
Rolling Stock and Coal Handling Equipment		49,100		49,100		49,100
Harbor Facilities - Seward		15,225		15,225		15,225
Stackers and Reclaimers		6,000		6,000		6,000
Working Capital	3 mo	16,802	3 mo	15,866		16,936
TOTAL CAPITAL COST		2,304,947		2,089,216		2,335,766
Annual Cost						
Capital						
Track and Communication Equipment		331,398		299,179		336,001
Buildings		1,360		1,360		1,360
Rolling Stock and Coal Handling Equipment		7,856		7,856		7,856
Harbor Facilities - Seward		2,284		2,284		2,284
Stackers and Reclaimers		960		960		960
Working Capital		2,520		2,380		2,540
TOTAL CAPITAL COST		346,378		314,019		351,001
Operating						
Train Operations	1,122 mi	32,652	1,052 mi	30,832	1,132 mi	32,912
Track Maintenance		30,855		28,930		31,130
Coal Handling Equipment		100		100		100
Harbor		3,600		3,600		3,600
Total Operating Cost		67,207		63,462		67,742
TOTAL ANNUAL COST		413,585		377,481		418,743

TABLE A-29

TRANSPORTATION COST ESTIMATE SEASONAL BARGE SYSTEM (5 MILLION TONS PER YEAR)

COST ITEM	MINESITE					
	Kukpowruk River		Elusive River		Kuk River	
	No.	Cost($000)	No.	Cost($000)	No.	Cost($000)
Truck Haul to Chukci Sea Coast						
Capital Cost						
Haul Road Construction	25 mi	10,625	75 mi	31,875	35 mi	14,875
Trucks	12	7,764	33	21,351	16	10,352
Working Capital (1 yr)		9,205		26,806		12,750
TOTAL CAPITAL COST		27,594		80,032		37,977
Annual Cost						
Capital						
Haul Road		1,594		4,781		2,231
Trucks (5 yr life)		2,198		6,045		2,931
Working Capital		1,381		4,021		1,913
TOTAL CAPITAL COST		5,173		14,847		7,075
Operating						
Haul Road Maintenance		3,750		11,250		5,250
Truck Operating Cost		5,455		15,556		7,500
TOTAL OPERATING COST		9,205		26,806		12,750
TOTAL ANNUAL COST		18,128		41,653		19,825
Conveyor to Chukchi Sea Coast						
Capital Cost						
Conveyor and Power Plant	25 mi	53,575	75 mi	160,725	35 mi	75,005
Working Capital (1 yr)		4,750		14,250		6,650
TOTAL CAPITAL COST		58,325		174,975		81,655

TABLE A-29 (Cont)

COST ITEM	MINESITE					
	Kukpowruk River		Elusive Creek		Kuk River	
	No.	Cost($000)	No.	Cost($000)	No.	Cost($000)
Annual Cost						
Capital						
Conveyor and Power Plant		8,482		25,716		12,001
Working Capital		713		2,138		998
TOTAL CAPITAL COST		9,195		27,854		12,999
Operating		4,750		14,250		6,650
TOTAL ANNUAL COST		13,945		42,104		19,649
Slurry Pipeline to Chuckchi Sea Coast						
Capital Cost						
Slurry Line	25 mi	15,000	75 mi	45,000	35 mi	21,000
Water Line	25 mi	7,500	75 mi	22,500	35 mi	10,500
Preparation and Receiving Facilities		30,000		30,000		30,000
Power Plant		4,705		14,115		6,587
Working Capital (1 yr)		3,843		8,528		4,780
TOTAL CAPITAL COST		61,048		120,143		72,867
Annual Cost						
Capital Cost						
Equipment		9,153		17,858		10,894
Working Capital		576		1,279		717
TOTAL CAPITAL COST		9,729		19,137		11,611
Operating Cost		3,843		8,528		4,780
TOTAL ANNUAL COST		13,572		27,665		16,391

TABLE A-29 (Cont)

COST ITEM	MINESITE					
	Kukpowruk River		Elusive River		Kuk River	
	No.	Cost($000)	No.	Cost($000)	No.	Cost($000)
Barge Transport to Dutch Harbor						
Capital Cost						
Chukchi Harbor Facility		15,000		15,000		15,000
Dutch Harbor Facility		30,500		30,500		30,500
Tugs and Barges		125,715		125,715		125,715
Working Capital (1 yr)		18,975		18,975		18,975
TOTAL CAPITAL COST		221,025		221,025		221,025
Annual Cost						
Capital Cost						
Chukchi Harbor Facility		7,024		7,024		7,024
Dutch Harbor Facility		4,725		4,725		4,725
Barges and Tugs (3 mo/yr)		5,029		5,029		5,029
Working Capital		2,846		2,846		2,846
TOTAL CAPITAL COST		19,624		19,624		19,624
Operating Cost						
Chukchi Harbor		5,000		5,000		5,000
Dutch Harbor		5,200		5,200		5,200
Barges and Tugs		8,775		8,775		8,775
TOTAL OPERATING COST		18,975		18,975		18,975
TOTAL ANNUAL COST		38,599		38,599		38,599
Stockpile Cost (9 month stockpile)						
Capital Cost						
Dragline Operation		38,836		63,596		57,702
Shovel and Truck Operation		49,109		84,115		75,444
Combination Operation		42,507		72,327		63,479

TABLE A-29 (Cont)

COST ITEM	MINESITE					
	Kukpowruk River		Elusive Creek		Kuk River	
	No.	Cost($000)	No.	Cost($000)	No.	Cost($000)
Annual Cost						
Dragline Operation		5,825		9,539		8,655
Shovel and Truck Operation		7,366		12,617		11,317
Combination Operation		6,376		10,489		9,522

TABLE A-30

SUMMARY OF TRANSPORTATION COSTS BY LOCATION, MINING METHOD, AND TRANSPORTATION MODE (5 MILLION TONS PER YEAR)

Railroad Transportation to Ice-Free/Port at Seward

Mine	Total Capital ($000)	Annual Costs ($000) Capital	Operating	Total	Cost per Ton
Kukpowruk River	2,304,947	346,378	67,207	413,585	$82.71
Elusive Creek	2,089,216	314,019	63,462	377,481	$75.50
Kuk River	2,335,766	351,001	67,742	418,743	$83.75

Truck and Barge Transportation to Ice-Free/Port at Dutch Harbor

	Total Capital ($000)	Annual Costs ($000) Capital	Operating	Total	Cost per Ton
Kukpowruk River					
Dragline	287,455	30,622	28,180	58,802	$11.76
Truck and Shovel	297,718	32,163	28,180	60,343	$12.07
Combination	291,116	31,173	28,180	59,353	$11.87
Elusive Creek					
Dragline	364,653	44,010	45,781	89,791	$17.96
Truck and Shovel	373,384	47,088	45,781	92,869	$18.57
Combination	385,172	44,960	45,781	90,741	$18.15
Kuk River					
Dragline	316,704	35,354	31,725	67,079	$13.42
Truck and Shovel	334,446	38,016	31,725	69,741	$13.95
Combination	322,481	36,221	31,725	67,946	$13.59

TABLE A-30 (Cont)

Mine	Total Capital ($000)	Annual Costs ($000) Capital	Operating	Total	Cost per Ton
Conveyor and Barge Transportation to Ice-Free Port at Dutch Harbor					
Kukpowruk River					
Dragline	318,186	34,644	23,725	58,369	$11.64
Truck and Shovel	328,459	36,185	23,725	59,910	$11.98
Combination	321,857	35,195	23,725	58,920	$11.78
Elusive Creek					
Dragline	459,596	57,017	33,225	90,242	$18.05
Truck and Shovel	480,115	60,095	33,225	93,320	$18.66
Combination	468,327	57,967	33,225	91,192	$18.24
Kuk River					
Dragline	360,382	40,629	25,625	66,254	$13.25
Truck and Shovel	378,124	43,291	25,625	68,916	$13.78
Combination	366,159	41,496	25,625	67,121	$13.42

Slurry Pipeline Transportation to Ice-Free Port at Dutch Harbor

Mine	Total Capital ($000)	Annual Costs ($000) Capital	Operating	Total	Cost per Ton
Kukpowruk River					
Dragline	320,929	35,178	22,818	57,996	$11.60
Truck and Shovel	331,202	36,719	22,818	59,537	$11.91
Combination	324,600	35,729	22,818	58,547	$11.71
Elusive Creek					
Dragline	404,764	48,300	27,503	75,803	$15.16
Truck and Shovel	425,283	51,378	27,503	78,881	$15.78
Combination	413,495	49,250	27,503	76,753	$15.35
Kuk River					
Dragline	351,594	39,890	23,755	63,645	$12.73
Truck and Shovel	369,336	42,552	23,755	66,307	$13.26
Combination	357,371	40,757	23,755	64,512	$12.90

TABLE A-31

TRANSPORTATION COST SUMMARY
(5,000,000 Tons Per Year)

TRANSPORTATION SYSTEM AND COST ITEM	MINESITE LOCATION AND MINING SYSTEM								
	KUKPOWRUK RIVER			ELUSIVE CREEK			KUK RIVER		
	Dragline	Shovel	Dragline & Shovel	Dragline	Shovel	Dragline & Shovel	Dragline	Shovel	Dragline & Shovel
ALL YEAR RAILROAD									
Capital Cost ($ thousands)	2,304,947	2,304,947	2,304,947	2,089,216	2,089,216	2,089,216	2,335,766	2,335,766	2,335,766
Annual Cost ($ thousands)	413,585	413,585	413,585	377,481	377,481	377,481	418,743	418,743	418,743
Cost Per Ton ($)	82.71	82.71	82.71	75.50	75.50	75.50	83.75	83.75	83.75
Cost Per Million Btu ($)	3.45	3.45	3.45	3.15	3.15	3.15	4.93	4.93	4.93
SEASONAL TRUCK AND BARGE									
Capital Cost ($ thousands)	287,455	297,718	291,116	364,653	373,384	385,172	316,704	334,446	322,481
Annual Cost ($ thousands)	58,802	60,343	59,353	89,791	92,869	90,741	67,079	69,741	67,946
Cost Per Ton ($)	11.76	12.07	11.87	17.96	18.57	18.15	13.42	13.95	13.59
Cost Per Million Btu ($)	0.49	0.50	0.49	0.75	0.77	0.76	0.79	0.82	0.80
SEASONAL CONVEYOR AND BARGE									
Capital Cost ($ thousands)	318,186	328,459	321,857	459,596	480,115	468,327	360,382	378,124	366,159
Annual Cost ($ thousands)	58,369	59,910	58,920	90,242	93,320	91,192	66,254	68,916	67,121
Cost Per Ton ($)	11.64	11.98	11.78	18.05	18.66	18.24	13.25	13.78	13.42
Cost Per Million Btu ($)	0.49	0.50	0.49	0.75	0.78	0.76	0.78	0.81	0.79
SEASONAL SLURRY PIPE-LINE AND BARGE									
Capital Cost ($ thousands)	320,929	331,202	324,600	404,764	425,283	413,495	351,594	369,336	357,371
Annual Cost ($ thousands)	57,996	59,537	58,547	75,803	78,881	76,753	63,645	66,307	64,512
*Cost Per Ton ($)	11.60	11.91	11.71	15.16	15.78	15.35	12.73	13.26	12.90
*Cost Per Million Btu ($)	0.48	0.49	0.49	0.63	0.66	0.64	0.75	0.78	0.76

*Transportation cost from minesite to ice-free port (Seward for railway system; Dutch Harbor for other systems)

TABLE A-32

KUKPOWRUK RIVER COAL FIELD
TRANSPORTATION CHARGES
500,000 ton/yr

Capital Costs

Camp Facilities			1,600,000
Power Plant			250,000
Shops, Office, Warehouse			500,000
Conveying Equipment			700,000
Dock Facilities			3,000,000
Haul Road	20 mi	@ $300,000	6,000,000
Haulage Trucks	4	@ 415,000	1,660,000
Front-End Loaders	2	@ 307,000	614,000
Wheel Dozer	1	@ 151,000	302,000
Grader			156,000
Utility Vehicles			100,000
TOTAL DIRECT COST			14,882,000
Field Indirect Cost			1,117,000
TOTAL CONSTRUCTION			15,999,000
Engineering			480,000
Subtotal			16,479,000
Overhead and Administration			1,236,000
Subtotal			17,715,000
Contingency			2,657,000
Subtotal			20,372,000
Fee			611,000
TOTAL PLANT COST			20,983,000
Interest During Construction			2,833,000
Subtotal			23,816,000
Working Capital (3 month operating cost)			2,310,000
TOTAL CAPITAL REQUIREMENTS			26,126,000

TABLE A-33

KUKPOWRUK RIVER COAL FIELD
TRANSPORTATION CHARGES
OPERATING COSTS
500,000 ton/yr

Annual Costs

Capital Costs

Mobile Equipment	(5 year life)	805,000
Fixed Facilities	(20 year life)	1,925,000
Indirect Charges	(20 year life)	1,796,000
Total Capital		4,526,000

Operating Costs

Haul Road Maintenance	($.02 per ton mile)	250,000
Truck Operating	($.06 per ton mile)	750,000
Barge Loading	($.75 per ton)	375,000
Camp Operation	($5,000/direct employee)	210,000
Administration and Overhead	($.50 per ton)	250,000
Shipping Charges	($4.00 per ton)	2,000,000
Transshipment Charges	($2.50 per ton)	1,250,000
Total Operating		5,085,000
TOTAL ANNUAL CHARGES		9,611,000
Freight Rate for Kukpowruk Coal		$19.22/ton

C. Townsite and Power Plant Costs

Any mining operation on the northern slope of Alaska will require construction of housing and service facilities for mine employees, since there are no such facilities in the area. The cost of these facilities will, more than likely, have to be borne by the mining operation to a great extent, although some state or federal aid may become available. In order to provide an overview of the total cost associated with a mining operation in this area, an order-of-magnitude estimate has been made for the capital and operating cost of a townsite, employee housing, service facilities and a power plant to supply all power requirements for the complex. An estimate has been made for each of the selected areas and mining systems, since the number of employees and power requirements vary for these combinations.

These estimates are based on estimated space requirements and estimated construction costs per square foot for the general type of construction anticipated. Conceptual designs and specific requirements for housing and services in isolated arctic areas would have to be determined before an accurate estimate could be made. The following summary is therefore intended only as a guide to indicate the general magnitude of costs for living accommodations that may have to be supported by the mining operation.

TABLE A-34

NORTH SLOPE INFRASTRUCTURE CRITERIA

Capital Costs:

Townsite and Employee Housing

Housing - 400 ft^2 per person.

Business and Commercial - 100 ft^2 per person.

Total Building Area - 500 ft^2 per person.

Service Personnel - 0.5 for each basic mine employee.

Dependent Personnel - 1.5 for each basic and service employee.

Total Population - 3.75 x number of basic mine employees.

Construction Cost estimated at $50/$ft^2$.

Service facilities, water, sewage, and power distribution estimated at $10,000 per person.

Total cost per basic employee:

Buildings - 500 ft^2 x 3.75 x $50/$ft^2$	= $ 93,750
Service Facilities - $10,000 x 3.75	= $375,000
Total per Basic Employee	= $131,250

Power Plant - Coal-fired, estimated at $1,000 per installed kW.

Operating Costs:

Townsite and Employee Housing

Labor - 0.5 service employees/basic employee at $35,000.

Maintenance - 2 percent of total capital cost.

Power - 100,000 kWh per basic employee annually at $0.03 per kWh or $3,000 per basic employee.

TABLE A-35

TOWNSITE AND UTILITY COSTS

		Mining System					
		Dragline		Shovel and Truck		Combination	
		No.	($000)	No.	($000)	No.	($000)
Kukpowruk River							
Capital Cost							
Townsite and Services	(131,250/employee)	307	40,294	437	57,356	346	45,413
Power Plant	($1 million/MVA)	45.0	45,000	22.5	22,500	37.5	37,500
Total Capital Cost			85,294		79,856		82,913
Annual Cost							
Capital			13,647		12,777		13,266
Operating							
Labor			5,373		7,648		6,055
Town Maintenance			806		1,447		908
Town Power			921		1,311		1,038
Total Operating			7,100		10,406		8,001
Total Annual Cost			20,747		23,183		21,267
Elusive Creek							
Capital Cost							
Townsite and Services	($131,250/employee)	486	63,788	727	95,419	568	74,550
Power Plant	($1 million/MVA)	75.0	75,000	45	45,000	60	60,000
Total Capital Cost			138,788		140,419		134,550
Annual Cost							
Capital			22,206		22,467		21,528
Operating							
Labor			8,505		12,743		9,940
Town Maintenance			1,276		1,908		1,491
Town Power			1,458		2,181		1,704
Total Operating			9,781		16,812		13,135
Total Annual Cost			31,987		39,279		34,663
Kuk River							
Capital Cost							
Townsite and Services	($131,250/employee)	469	61,556	685	89,906	527	69,169
Power Plant	($1 million/MVA)	75.0	75,000	45.0	45,000	60.0	60,000
Total Capital Cost			136,556		134,906		129,169
Annual Cost							
Capital			21,849		21,585		20,667
Operating							
Labor			8,208		11,987		9,223
Town Maintenance			1,231		1,798		1,383
Town Power			1,407		2,055		1,581
Total Operating			10,846		15,840		12,187
Total Annual Cost			32,695		37,425		32,854

TABLE A-36

DELIVERED COAL COST AT ICE-FREE PORT*
(5,000,000 Tons Per Year)

TRANSPORTATION SYSTEM AND COST ITEM	KUKPOWRUK RIVER Dragline	KUKPOWRUK RIVER Shovel	KUKPOWRUK RIVER Dragline & Shovel	ELUSIVE CREEK Dragline	ELUSIVE CREEK Shovel	ELUSIVE CREEK Dragline & Shovel	KUK RIVER Dragline	KUK RIVER Shovel	KUK RIVER Dragline & Shovel
ALL YEAR RAILROAD									
Capital Cost ($ thousands)	2,517,099	2,483,013	2,504,791	2,441,456	2,338,498	2,425,965	2,682,878	2,617,461	2,655,593
Annual Cost ($ thousands)	486,114	502,245	491,529	494,262	528,913	508,580	528,375	556,760	536,235
Cost Per Ton ($)	100.69	102.75	101.36	105.13	109.49	107.02	111.57	114.75	112.32
Cost Per Million Btu ($)	4.20	4.28	4.22	4.38	4.56	4.46	6.56	6.75	6.61
SEASONAL TRUCK AND BARGE									
Capital Cost ($ thousands)	499,607	475,784	490,960	716,893	672,666	721,921	663,816	616,141	642,308
Annual Cost ($ thousands)	131,331	149,003	137,297	206,572	244,301	221,840	176,711	207,758	185,438
Cost Per Ton ($)	29.74	32.11	30.52	47.59	52.56	49.67	41.24	44.95	42.16
Cost Per Million Btu ($)	1.24	1.34	1.27	1.98	2.19	2.07	2.43	2.64	2.48
SEASONAL CONVEYOR AND BARGE									
Capital Cost ($ thousands)	530,338	506,525	521,701	811,836	779,397	805,076	707,494	659,819	685,986
Annual Cost ($ thousands)	130,898	148,570	136,864	207,023	244,752	222,291	175,886	206,933	184,613
Cost Per Ton ($)	29.62	32.02	30.43	47.68	52.65	49.76	41.07	44.78	41.99
Cost Per Million Btu ($)	1.23	1.33	1.27	1.99	2.19	2.07	2.42	2.63	2.47
SEASONAL SLURRY PIPE-LINE AND BARGE									
Capital Cost ($ thousands)	533,081	509,268	524,444	757,004	724,565	750,244	698,706	651,031	677,198
Annual Cost ($ thousands)	130,525	148,197	136,491	192,584	230,313	207,852	173,277	204,324	182,004
Cost Per Ton ($)	29.58	31.95	30.36	44.79	49.77	46.87	40.55	44.26	41.47
Cost Per Million Btu ($)	1.23	1.33	1.27	1.87	2.07	1.95	2.39	2.60	2.44

Minesite location and mining system columns as above.

*Ice-free port is Seward for railway system and Dutch Harbor for other systems.

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