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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.

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The views and conclusions contained in this document are those of the authors and should not be interpreted as necessarily representing the official policies or recommendations of the Interior Department's Bureau of Mines or of the U.S. Government.

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.

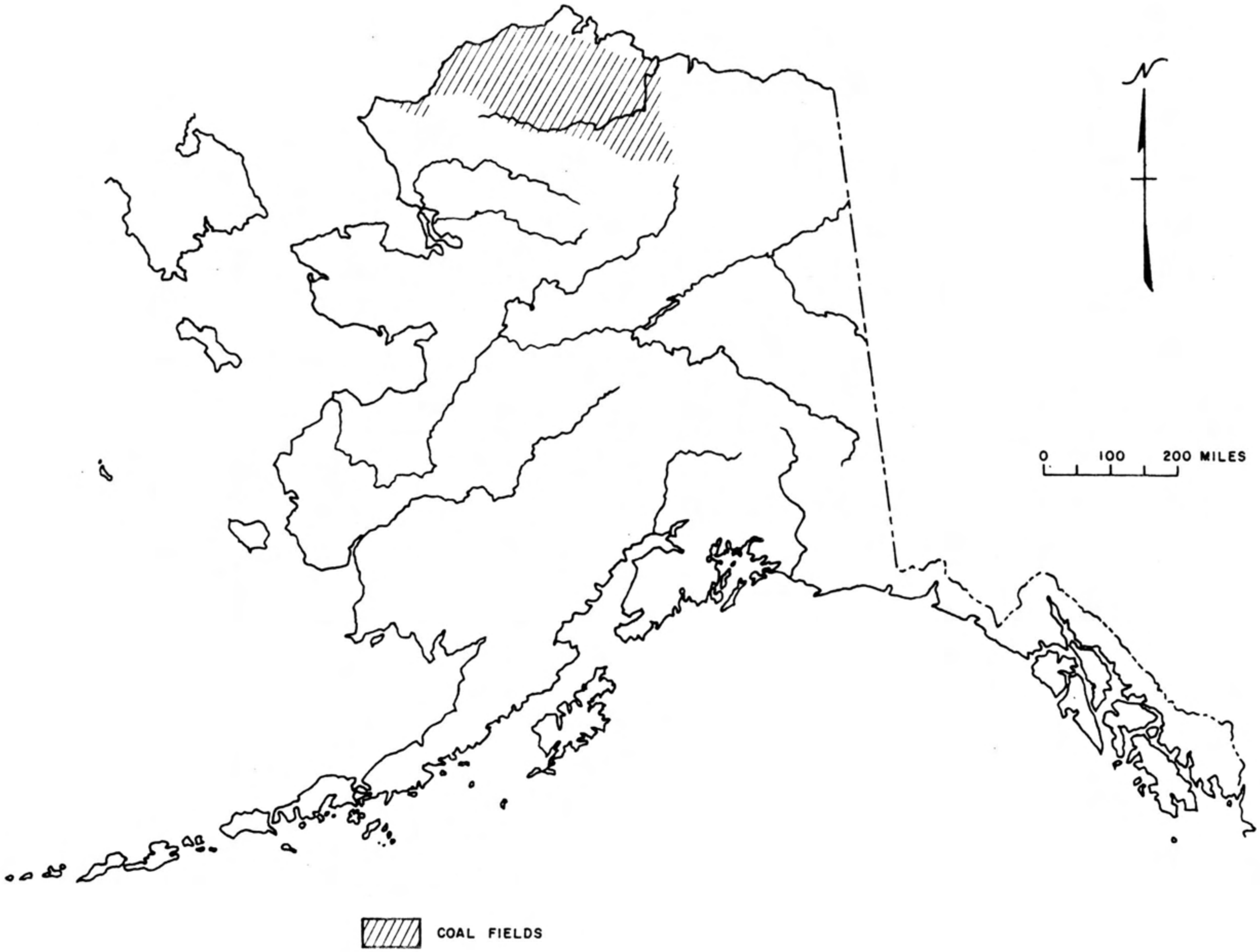
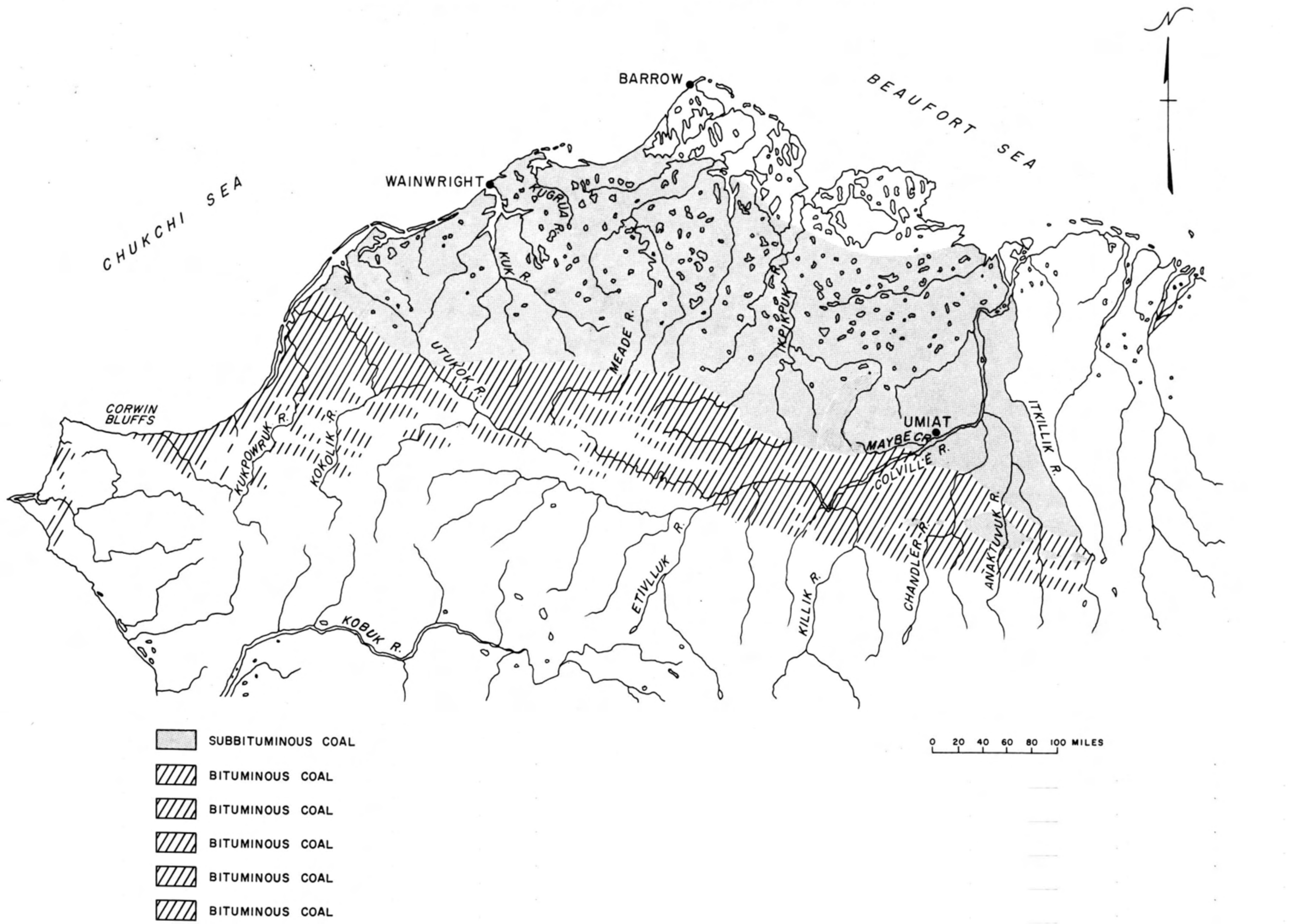


FIGURE 2 - 1
COAL FIELDS OF NORTHERN ALASKA

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

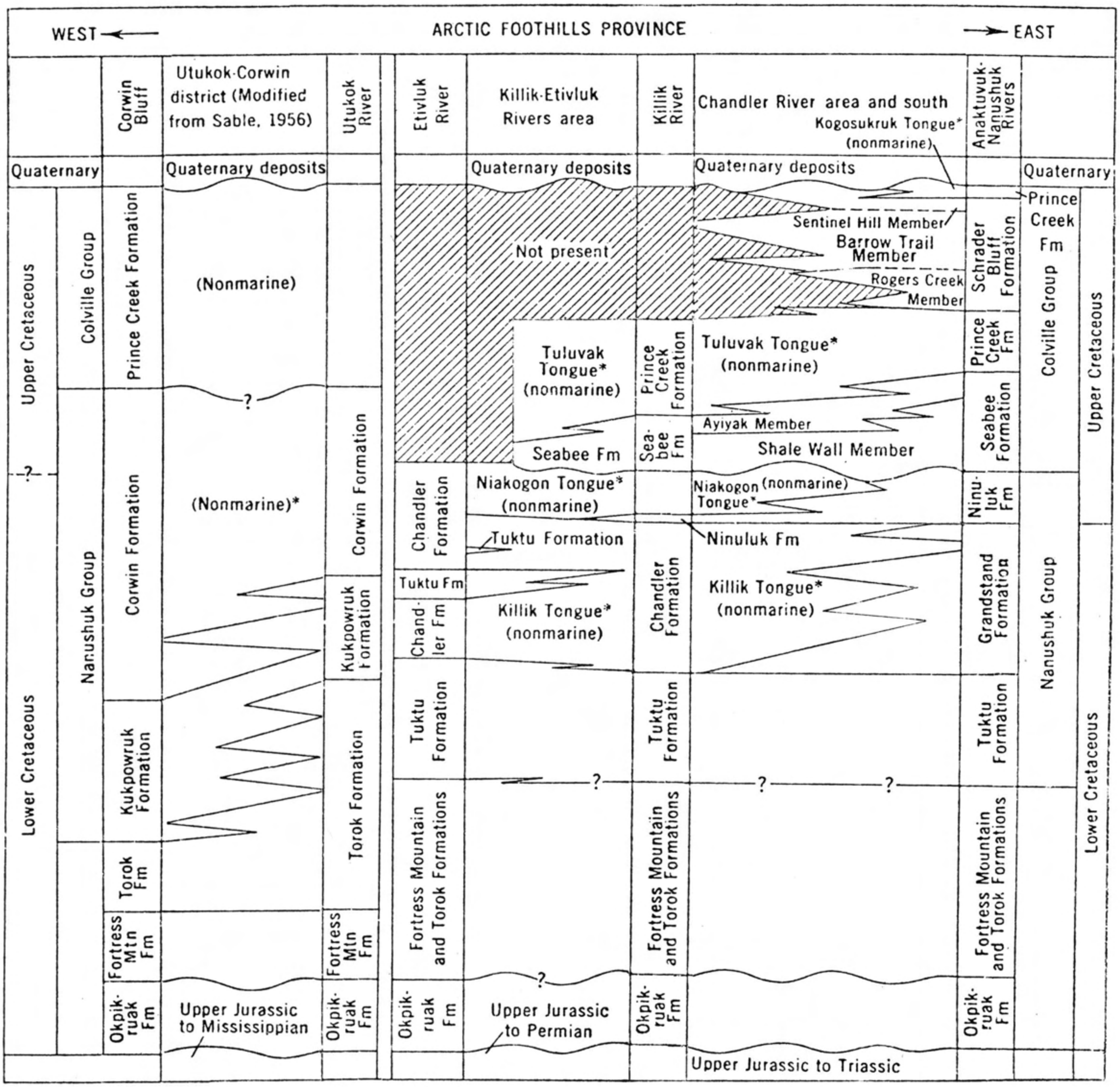
The regional geology of western Arctic Alaska has been described by the United States Geologic Survey in reports by Brosge and Wittington (1966); Chapman and Sable (1960); Chapman, Detterman, and Mangus (1964); and Detterman, Bickel, and Gryre (1963). The coal resources of this area have been calculated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

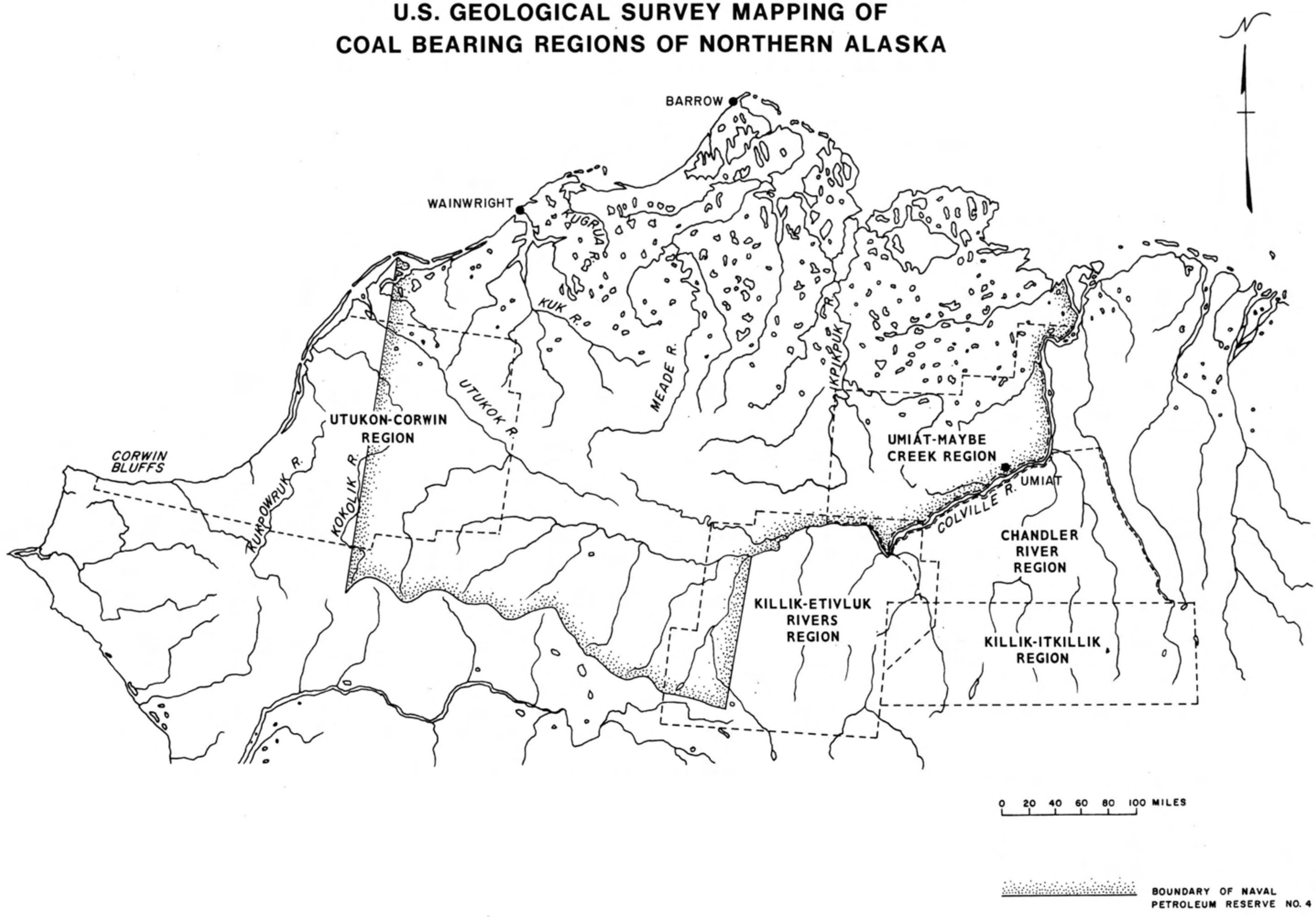
The rank of the coal is a function of age of deposition and degree of structural deformation. Younger and less-deformed coals tend to be of lower rank than older and strongly deformed coals. Therefore, the rank of coal in northern Alaska decreases northward from the southern limit of the northern foothills 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

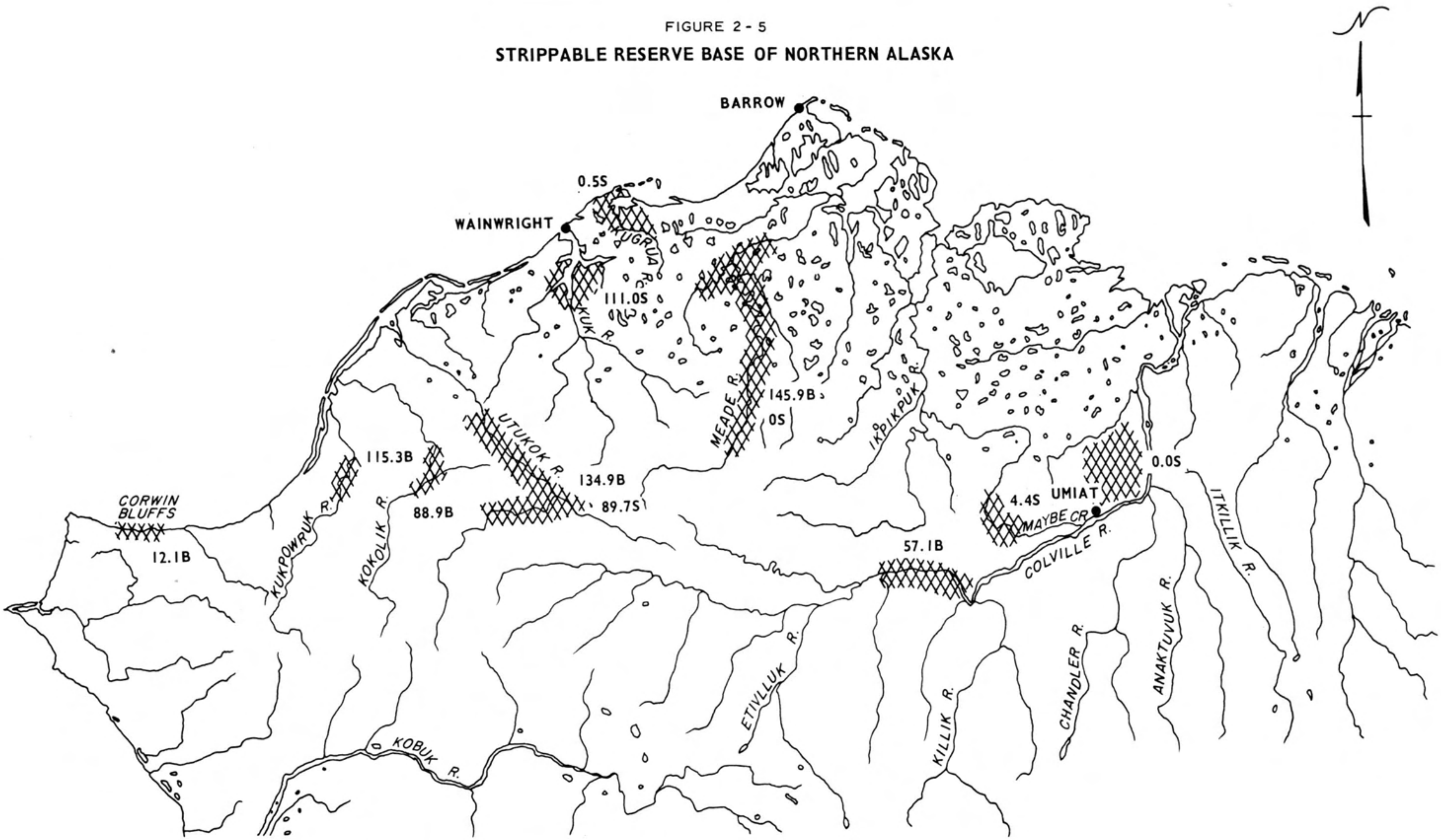
TABLE 2-2

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)

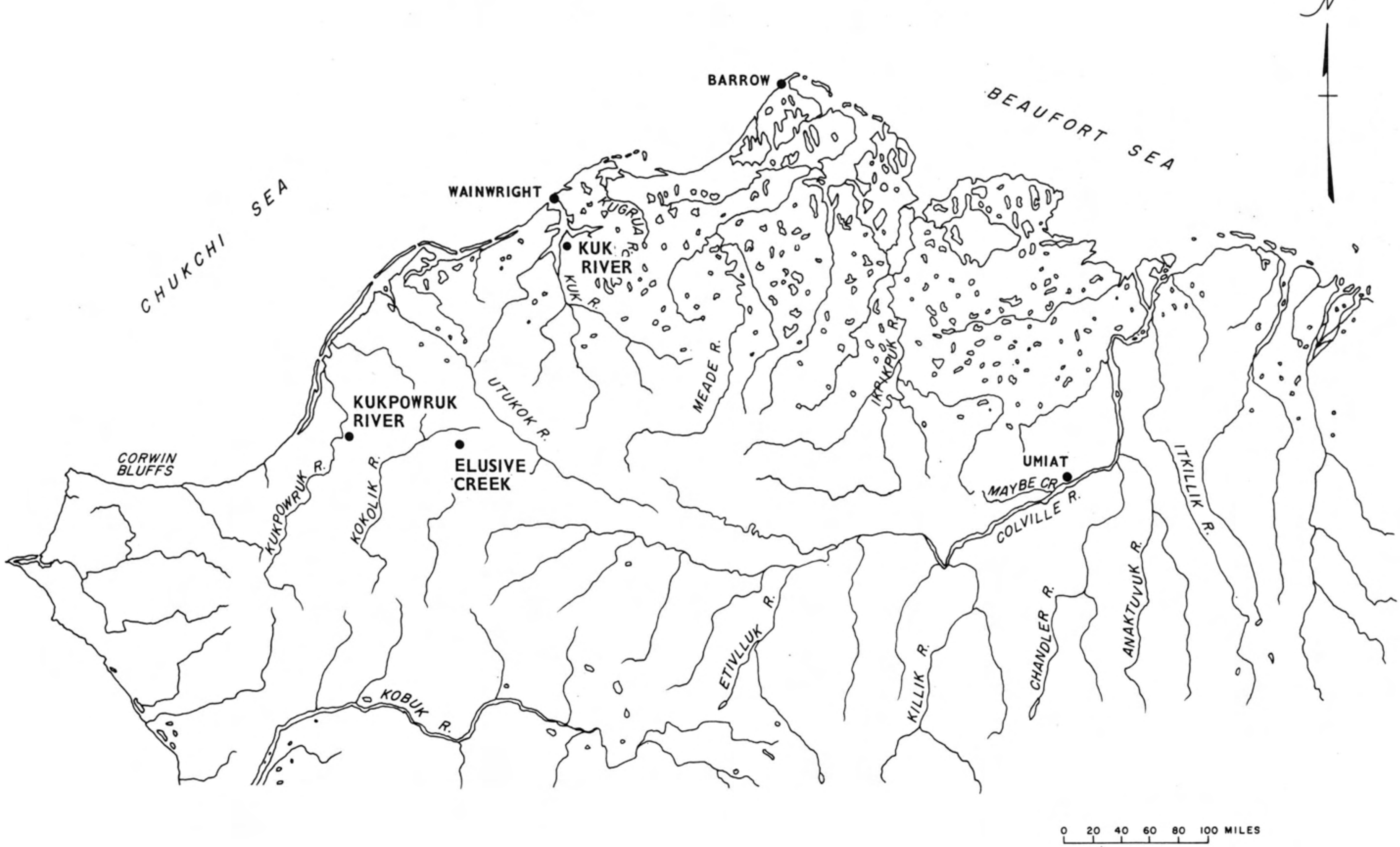
5. Seam Geometry

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

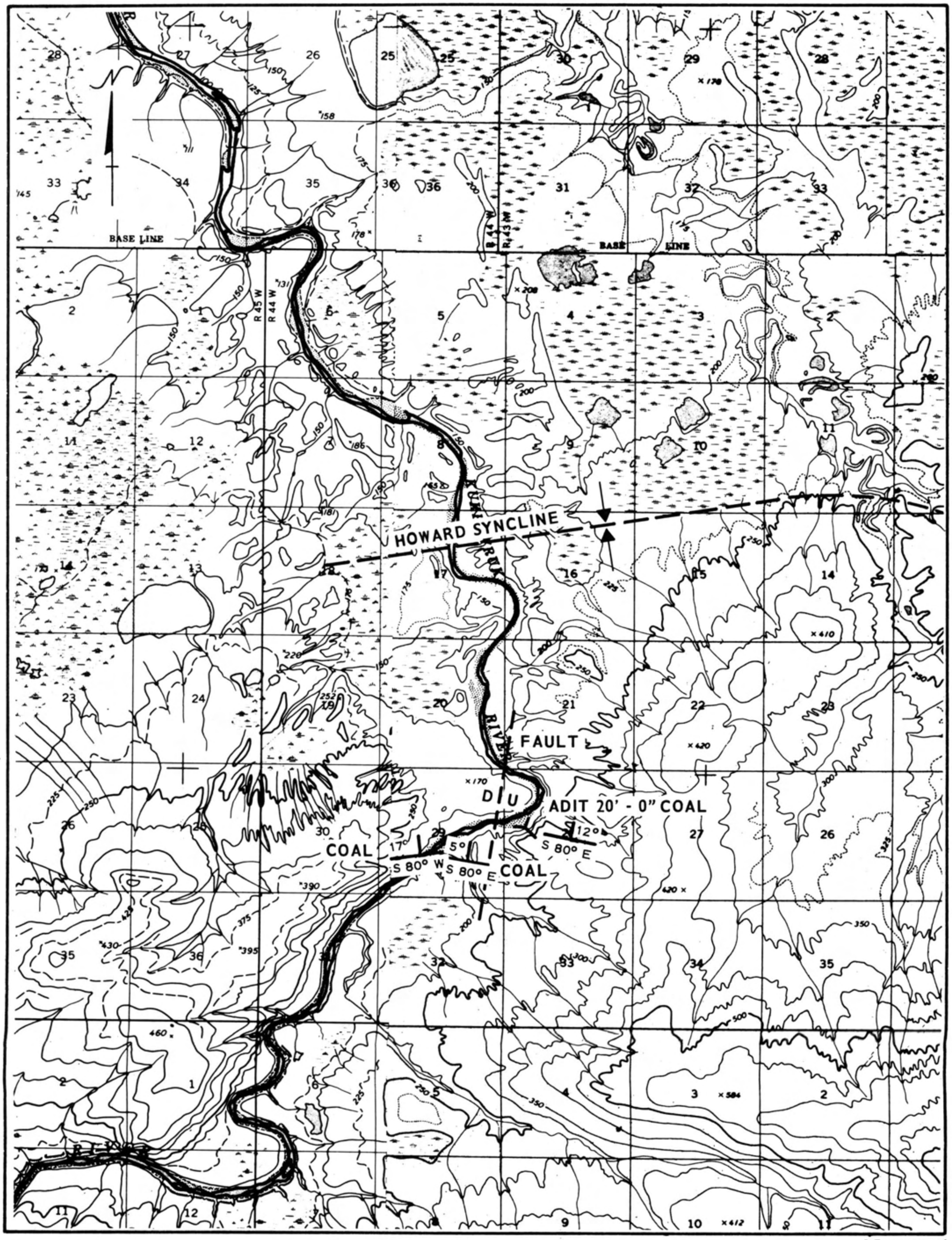
The coal deposits, which lie between Cape Lisburne and Wainwright, were the first exploited by whalers in 1879. In 1904, a geologic reconnaissance of the coastal deposits south of Cape Beaufort was made by A. J. Collier. The first account of the

FIGURE 4 - 2

KUKPOWRUK RIVER MINESITE

1:63,360

0 1/2 1 MILE



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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.

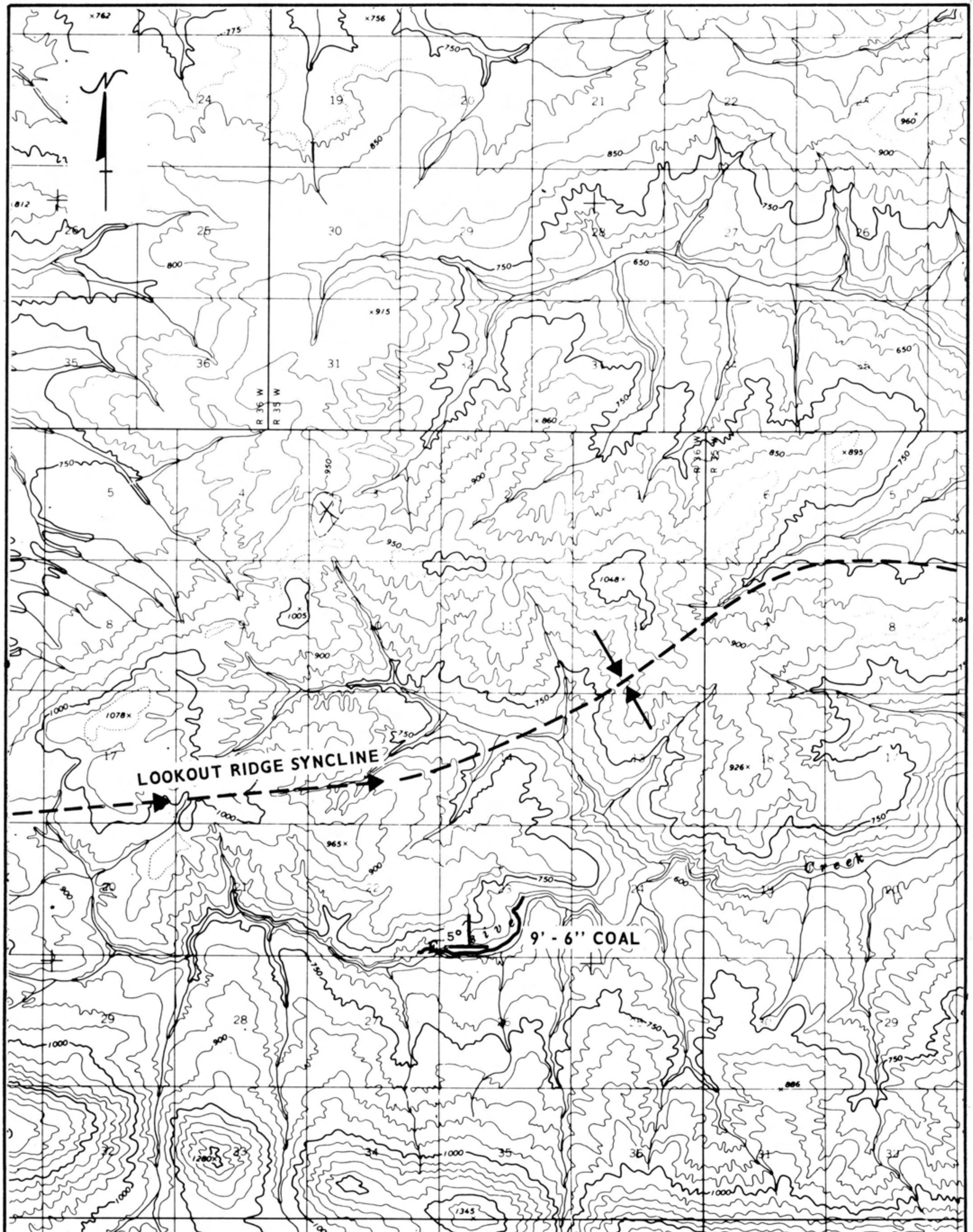
The deposit is in the northern fringe of the northern foothills, in a well-drained area of moderate relief. The land surface is dry tundra. The Elusive Creek deposit is shown in Figure 4-3.

FIGURE 4 - 3

ELUSIVE CREEK MINESITE

1:63,360

0 1/2 1 MILE



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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.

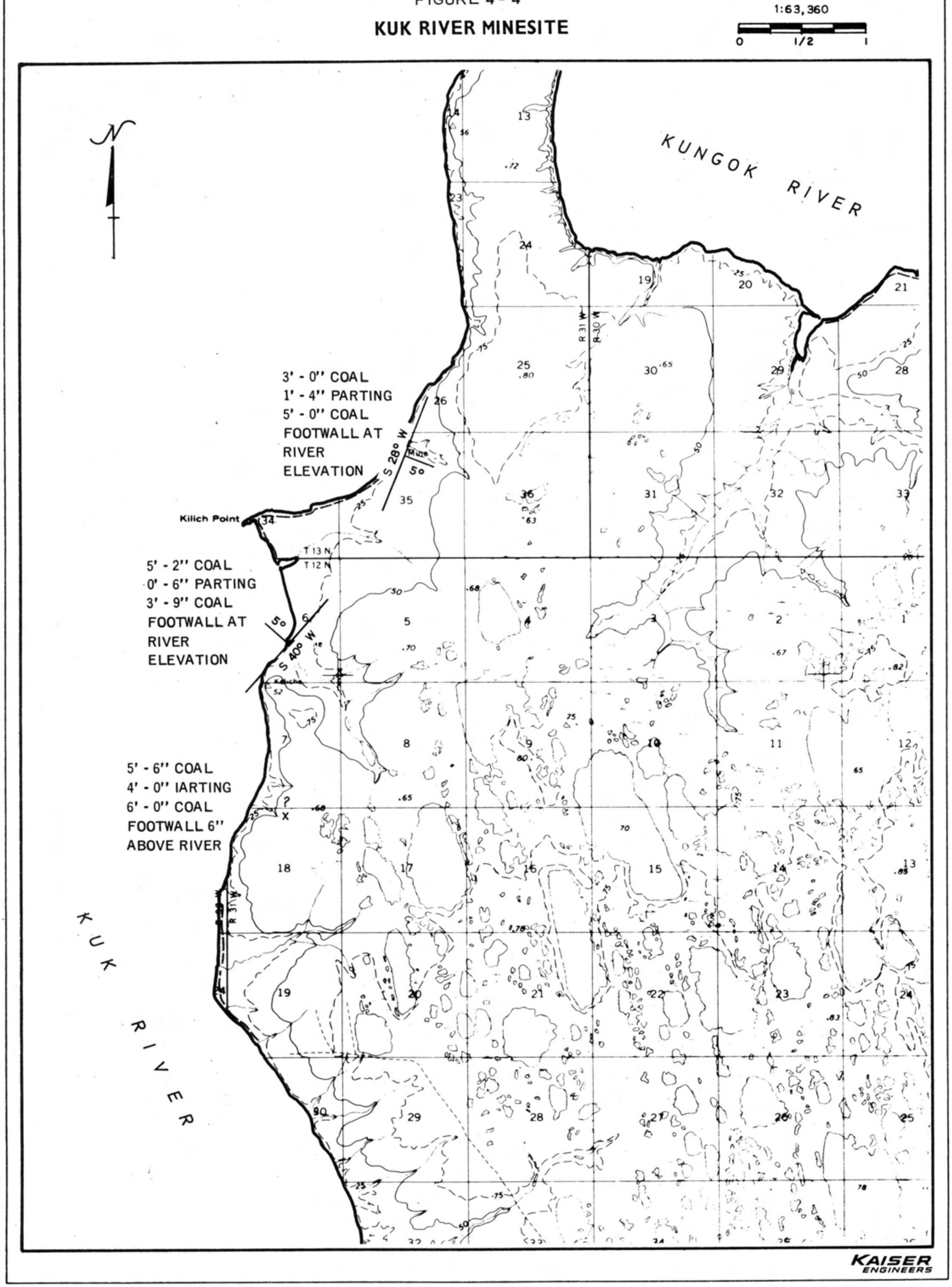
b. Coal Quality and Reserves

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.

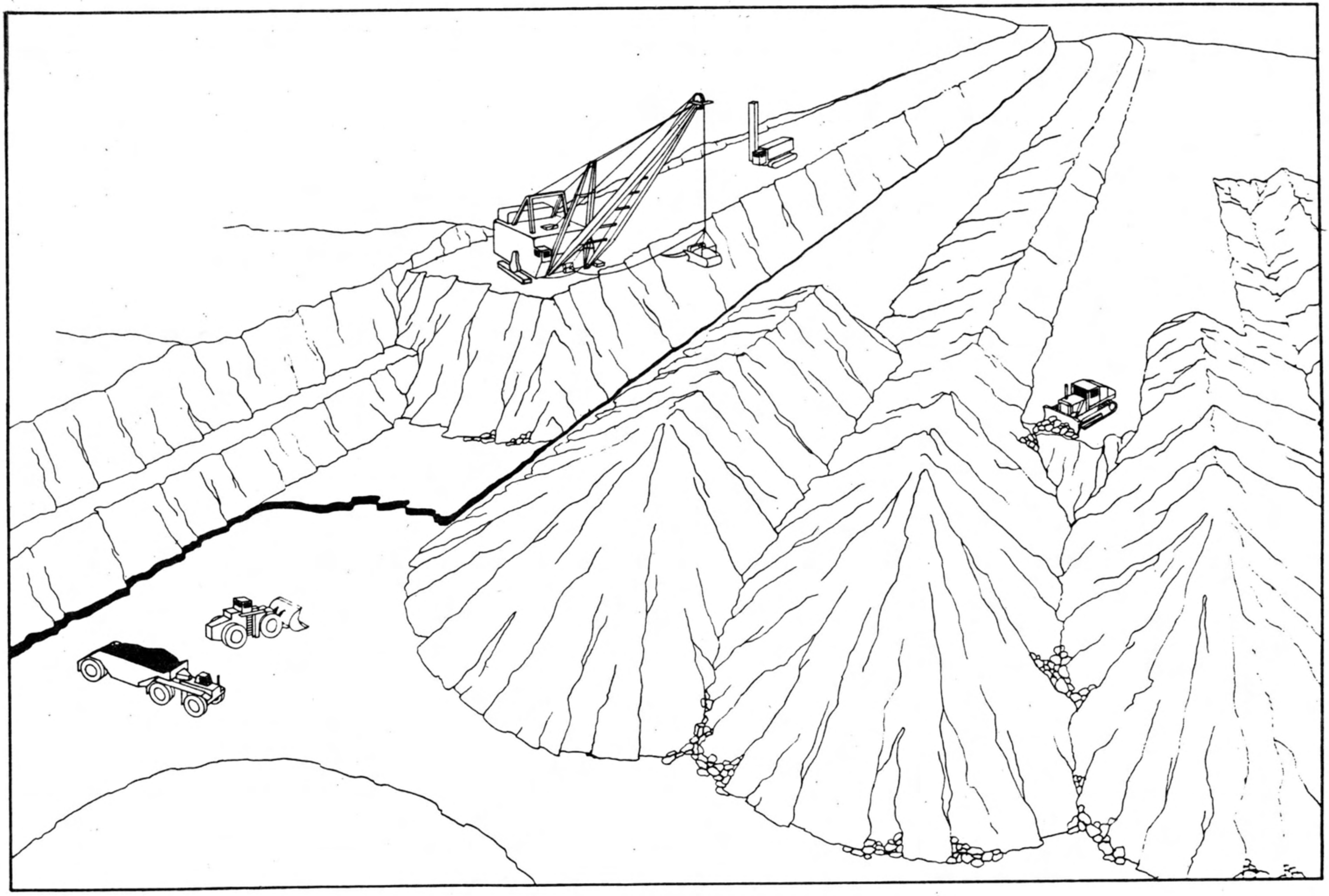

Figure 5 - 1 DRAGLINE EXCAVATION

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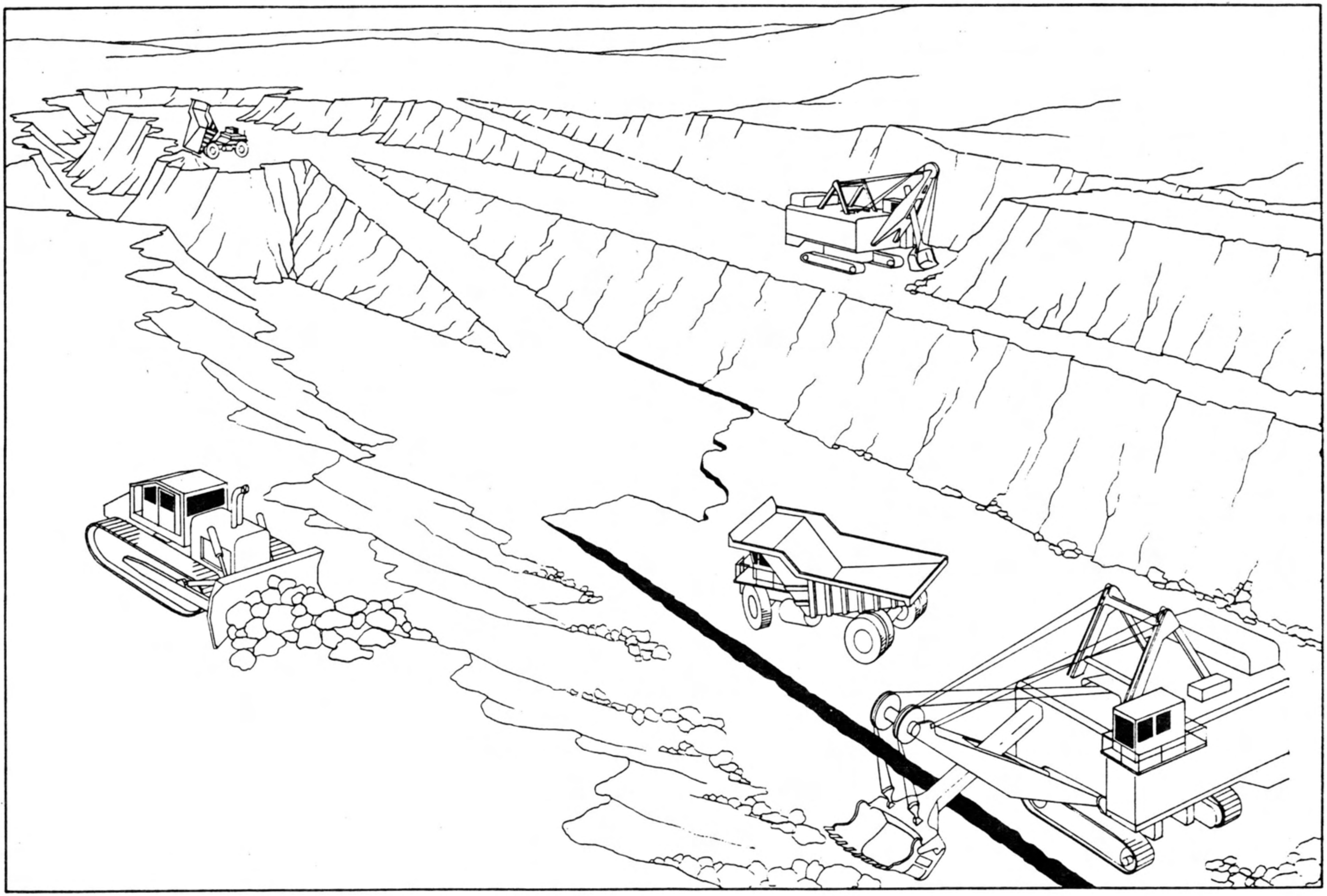

Figure 5 - 2 SHOVEL EXCAVATION

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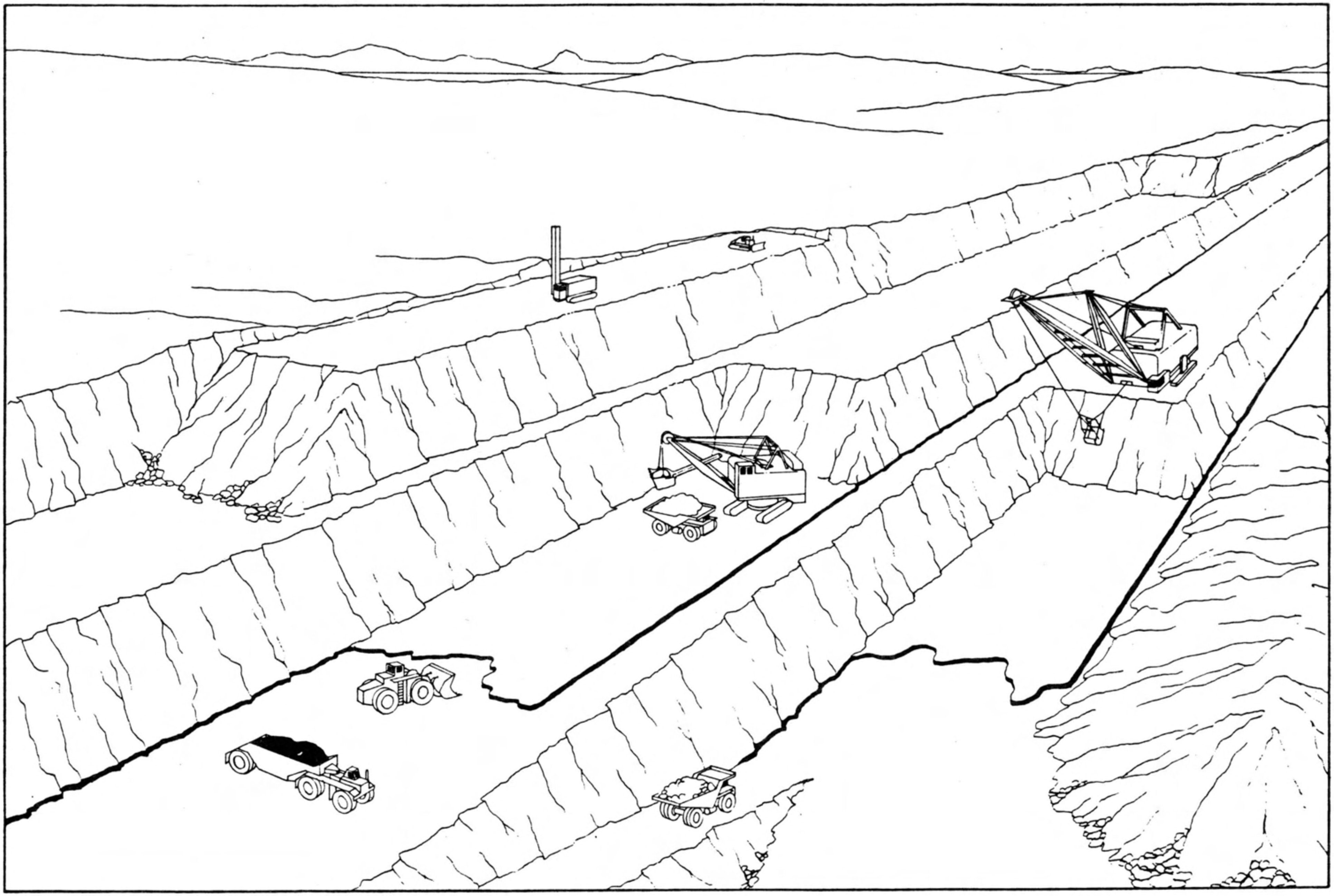

Figure 5 - 3 DRAGLINE - SHOVEL EXCAVATION

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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	Mining System: Dragline $ per million Btu's
Kukpowruk River	30.01	1.25

5,000,000 Ton/Yr Production

Mine Location	Dragline $ per ton	Dragline $ per million Btu's	Shovel $ per ton	Shovel $ per million Btu's	Shovel & Dragline $ per ton	Shovel & Dragline $ 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 dewatered 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

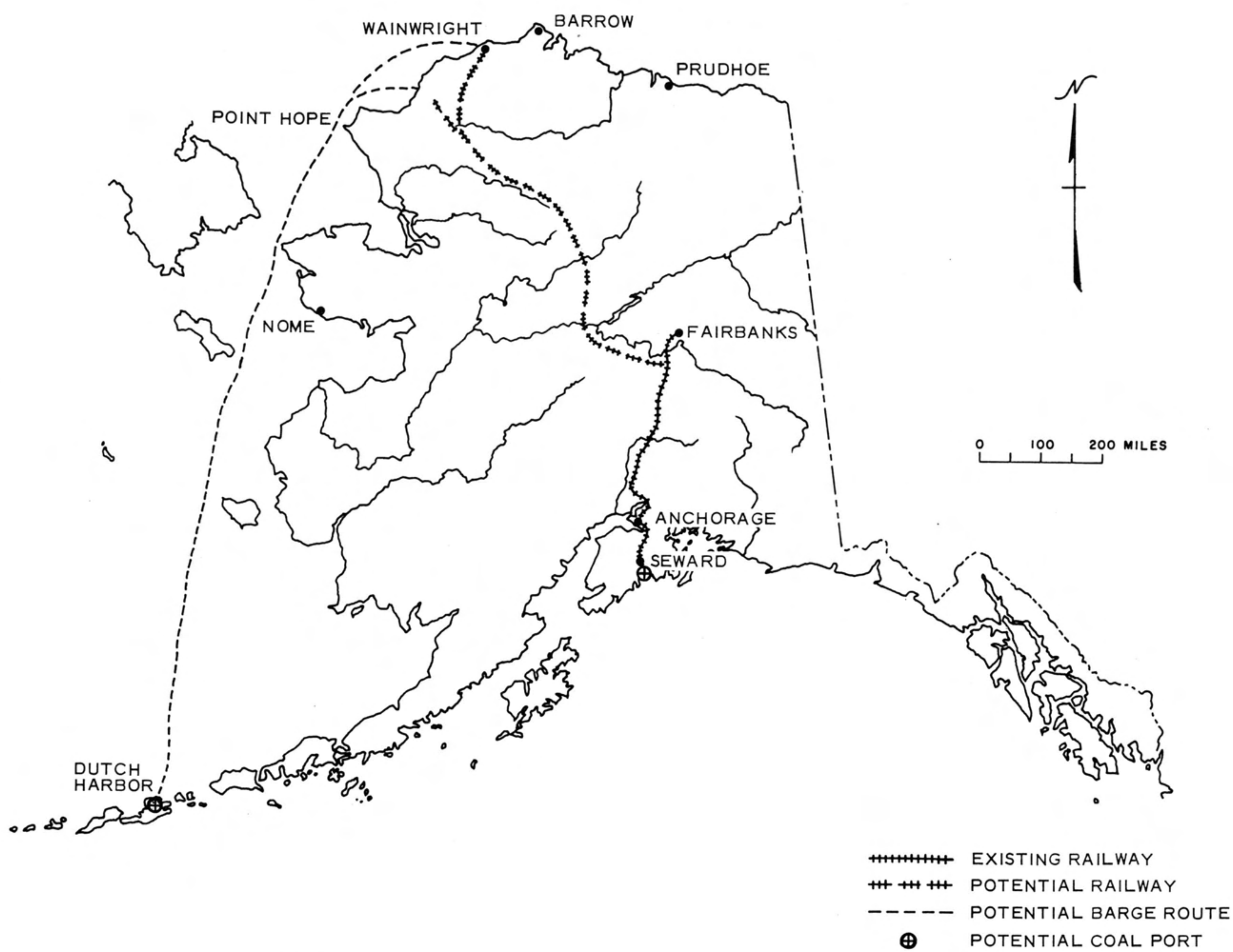

FIGURE 5 - 5

KUK RIVER MINE SITE & TRANSPORTATION CORRIDOR

- - - CORRIDOR TO COAST
+++++++ PROPOSED RAILROAD TO NENANA

1:500,000
0 2 4 6 8 MILES

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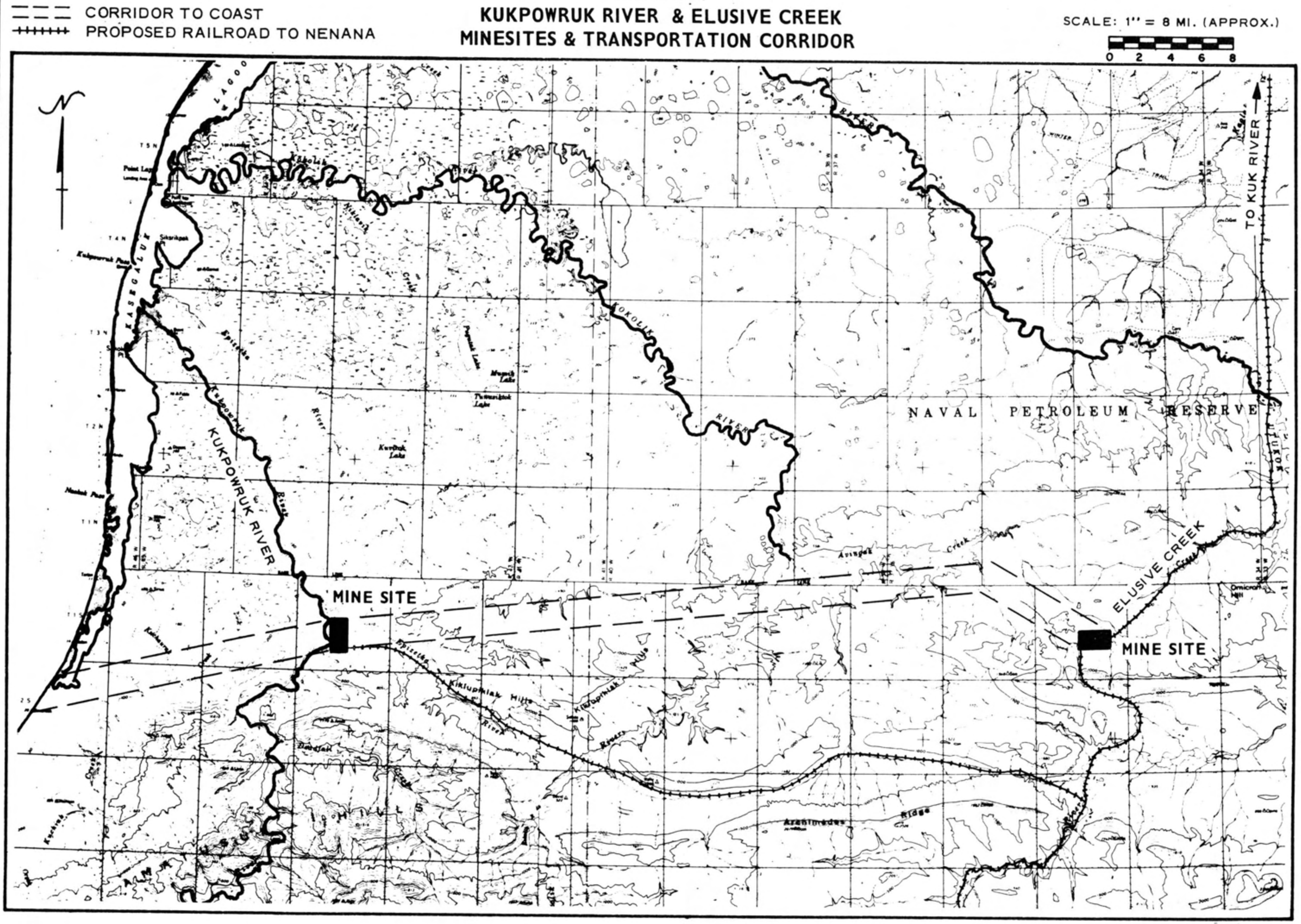
FIGURE 5 - 6

KUKPOWRUK RIVER & ELUSIVE CREEK MINESITES & TRANSPORTATION CORRIDOR



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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

		Seed Specifications (pounds per acre)		Revegetation Measures		
Erodability Rating	Common Name	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.