Alaskan Outer Continental Shelf

OCS Report
MMS 87-0010

Surface-Transportation Networks of the Alaskan North Slope

U.S. Department of the Interior
Minerals Management Service

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By

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ABSTRACT

OCS Report MMS 87-0010 presents a historical and geographical perspective on the evolution of surface-transportation networks north of the 68th parallel. This report is unique in the body of technical literature about the Alaskan North Slope in that it is the first document in which transportation networks are the focus of analysis. The report concentrates on the two principal generators of transport movement on the North Slope--the oil industry and the Inupiat (Eskimo) subsistence hunters. In addition to describing the evolution of transportation patterns, the report discusses the administrative regulations governing location and construction of transport infrastructure on the North Slope. The analysis of surface-transportation patterns is set against the economic and technological forces that have influenced activities on the North Slope during the 20th century. The report contains sections on oil and gas exploration within the National Petroleum Reserve-Alaska, the Prudhoe Bay oil-industrial complex, and subsistence-harvest-travel patterns among Inupiat communities. The report concludes that (1) modern surface-transportation technology has increased man's range within the arctic and made the Alaskan North Slope accessible during all seasons, leading to a gradual coalescence of the region into a single economic entity; (2) increasing regulatory requirements generated primarily by environmental and cultural concerns have acted to shape and define the configuration of arctic oil and gas industrial-transportation networks; and (3) through the use of the snow machine and the resettlement of formerly abandoned community sites, Inupiat Eskimos have reasserted their presence within traditional subsistence-hunting areas. Methods of data collection included literature research, personal interview of experts, field research, and the use of color-infrared photography to establish patterns of Inupiat snow-machine travel.

I. INTRODUCTION

The purpose of this report is to provide an overview of the surface-transportation networks north of the 68th parallel by integrating the geographical, technological, and recent historical factors related to the principal generators of surface movement on the North Slope. These are: (1) petroleum-industry and related mineral-exploration activities (Graphic No. 2) and (2) Inupiat (Eskimo) travel in pursuit of subsistence-harvest activities (Graphic Nos. 1 and 3). Previous arctic-transportation studies, particularly those sponsored by the Alaska Outer Continental Shelf (OCS) Office, were oriented toward planning and dealt with systems-oriented issues (i.e., effects of the flow of goods and personnel, facility-siting requirements and construction restraints, legal restraints, condition of existing facilities, etc.).

This report compiles some of the obtainable facts and issues regarding surface movement in the arctic and provides background information for evaluating the onshore effects of offshore petroleum development, specifically as they affect or relate to (1) the issues surrounding the Section 810 analysis required by the Alaska National Interest Lands Conservation Act (ANILCA), (2) the evolution and design of stipulations regulating surface movement, and (3) the formulation of hydrocarbon-development scenarios. This reference document is intended for use by the general public and Federal analysts (or their contracted representatives), who will prepare developmental environmental impact statements (EIS's) if commercially recoverable quantities of hydrocarbons are discovered on the OCS of the Beaufort and Chukchi Seas. Section IV (Inupiat Travel and Subsistence-Hunting Patterns) describes surface-movement patterns and possible subsistence-harvest areas and focuses primarily on the issues of access and movement. The community-by-community analysis of subsistence-travel patterns provides the background information necessary to evaluate the access issue--a mandatory component of an ANILCA Section 810 evaluation.

This report is divided into three discrete sections: (1) the Prudhoe Bay oil complex and the contiguous industrial area; (2) the National Petroleum Reserve-Alaska (NPR-A); and (3) the eight communities that comprise the North Slope Borough (NSB) Inupiat population--Kaktovik, Anaktuvuk Pass, Nuiqsut, Barrow, Atqasuk, Wainwright, Point Lay, and Point Hope (Secs. II, III, and IV, respectively). These three components generate virtually all of the overland traffic above the 68th parallel.

Sections II, III, and IV, respectively, discuss (1) transportation networks and the social and administrative criteria upon which those networks are based, (2) the historical development of industrial-support trails, (3) the policies of the government agencies overseeing those developments, (4) and Inupiat-subsistence-use areas and movement corridors.

Section IV, which deals primarily with current Inupiat travel habits and patterns, discusses surface movement as an activity induced by the need to harvest subsistence resources. Historical Inupiat travel patterns, which are important to an understanding of the Inupiat culture, are the product of a seminomadic era. Current Inupiat travel patterns are a product of the availability and use of the snow machine, the consolidation of the Inupiat into communities, and the construction of petroleum-related infrastructure (pipelines and roads). Accordingly, many trails used frequently during the seminomadic era are used only infrequently at present, although they remain within the realm of the Inupiat culture.

Section V summarizes the report and presents some comparative observations.

The principal mission of the Minerals Management Service (MMS), Alaska OCS Region, is to lease blocks on submerged Federal OCS lands. Some of the numerous EIS's written in support of this oil-and-gas-leasing program hypothesized the construction of extensive linear facilities (pipelines and roads) across the North Slope. As offshore exploration continues in the Beaufort Sea--and in future years in the Chukchi Sea--the strong possibility of discovering commercially recoverable quantities of hydrocarbons may give life to these assumptions. The discovery of commercially recoverable hydrocarbons on offshore Federal leases will require the preparation of a variety of environmental documents, including an EIS that discusses in detail the logistics, transportation networks, and environmental effects that could occur as a result of offshore oil exploration and development.

This report, which serves as a reference document for future EIS's and related research on socioeconomic issues, was prepared in compliance with Council on Environmental Quality regulations issued in 1979 which specified a reduction in the size and complexity of EIS's published by the Federal Government, with no accompanying reduction in the quality of analysis. All or portions of this report may be incorporated by reference in future EIS's, thus reducing that portion of the National Environmental Policy Act (NEPA) document devoted solely to describing the affected environment.

Comments on the quality and technical accuracy of this document are welcome and should be submitted to the author at the following address:

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II. HISTORY OF PETROLEUM-RELATED SURFACE-TRANSPORTATION DEVELOPMENT BETWEEN THE COLVILLE AND THE CANNING RIVERS

A. Development Activities That Occurred Prior to the Prudhoe Bay Discovery Well (1924-1968)

The discovery, delineation, and production of North Slope petroleum fields occurred only after several decades of exploratory activities. U.S. Geological Survey (USGS) geological-mapping teams first visited this area during the mid-1920's when they crossed part of the North Slope in an effort to map the newly established Naval Petroleum Reserve No. 4 (NPR-4) (Reed, 1958). After a hiatus, investigation of the Colville-Canning region continued between 1944 and 1953, during which period the NPR-4 was prospected for hydrocarbons (see Sec. III). (In 1976, Congress changed the name of the NPR-4 to National Petroleum Reserve-Alaska [NPR-A].) Geological- and geophysical-survey teams spread beyond the NPR-4 boundary and mapped the upper reaches of the Colville, Sagavanirktok, Shaviovik, and Canning Rivers, among others. Between 1951 and 1953, seismic surveys were performed along the Itkillik and Kuparuk River drainages east and southeast of the NPR-4 (Reed, 1958).

Exploration activity on the North Slope ceased with the termination of the NPR-4 project in 1953, but the 1957 discovery of the Swanson River oil field on the Kenai Peninsula aroused industry interest in Alaska. In 1958, as a result of increased industry interest, the Bureau of Land Management (BLM) held a competitive-bidding/simultaneous-filing sale on 4 million acres of land east and southeast of the NPR-4. During the summer of that year, geological-survey teams ranged across the North Slope. Aided by helicopters, the teams mapped a substantial portion of the area east of the Colville River; but their eastern activities were bounded by the establishment of the Arctic National Wildlife Range (now Refuge) (ANWR) in 1960. Because commercial oil interests were not allowed to prospect in the NPR-4 at that time, future exploration for and development of arctic hydrocarbons were effectively limited to the coastal plains located between the Colville and Canning Rivers. By 1962, seismic surveys had begun on "the Slope." Five companies, including British Petroleum (BP), organized teams of seismic surveyors during that year. During the next 2 years, Sinclair Oil and BP drilled seven unsuccessful wells that dampened some of industry's earlier enthusiasm (Jamison, 1978).

Under the provisions of the Alaska Statehood Act of 1959, the new State was entitled to select certain Federal lands. During the 1960's, the State experienced public and political pressure to select lands that could be homesteaded or that had recognizable mineral or natural resources. But because BP's initial drilling program failed, the State had misgivings about selecting lands along the arctic coastal plain (Marshall, 1985, oral comm.). However, at the insistence of Tom Marshall (the State's only geologist at that time), the State selected 1.8 million acres between the Colville and the Canning Rivers. Marshall's reason for selecting lands in this region was based on geological and geographical considerations; he recognized a similarity between the geology of the Prudhoe Bay region and that of the oil-prone Powder River Basin in the Rocky Mountain province. The Lisburne limestone underlaying the Prudhoe region is enormously thick and persistent, and Marshall reasoned that the Lisburne Formation had the reservoir capacity for a volume of hydrocarbons sufficient to overcome the economic barriers to arctic petroleum development. His decision to nominate the Prudhoe acreage was strongly influenced by prior USGS studies, most specifically Bulletin No. 1094, "Geology of Possible Petroleum Provinces in Alaska," by Miller, Payne, and Gryc (1959).

Marshall's reasoning conflicted with the prevailing development perspective of the time. During the early 1960's, arctic petroleum-exploration efforts were concentrated in the neighborhood of Umiat, within the Colville geosyncline. However, Marshall believed that the Colville traps were too small to contain the petroleum reserves necessary for arctic production (Marshall, 1985, oral comm.). Marshall also argued that the selection of lands in the coastal plain would eliminate potential future disputes between the State of Alaska and the Federal Government over the definition of navigable streams in upland areas. He reasoned that if the surrounding lands were State lands, the State would not have to define the limit of navigability of streams flowing into the Arctic Ocean (Mull, 1982).

Although Marshall's recommendations for land selections were initiated in 1961, the State did not file for the Prudhoe acreage until 1965. As a result, the first State sale of arctic leases (in 1964) offered land within and adjacent to the Colville geosyncline; of the 625,000 acres offered for lease in the State's 1964 sale, 476,000 acres were purchased. During the same year, seismic teams jointly sponsored by Richfield (now the Atlantic Richfield Company [ARCO]) and Humble (now Exxon Company, U.S.A.) acquired sufficient data to map the outlines of the Prudhoe Bay structure. The first tractor-supply-train to travel from Fairbanks to the North Slope was organized during the winter of 1964 to support these seismic teams.

Subsequent State lease sales followed in 1965 and 1967, and much of the Prudhoe structure was purchased when the State offered an additional 6 million acres (Jamison, 1978). Unsuccessful drilling continued; between 1964 and mid-1968, 50 dry holes were drilled (State University of New York [SUNY], Research Foundation, 1984).

During that era of intensive but unsuccessful drilling activity, ARCO was the first North Slope operator to utilize a C-130 (Hercules) cargo aircraft to transport a drilling rig--coincidentally the first commercial use of the aircraft and the first time that an entire rig was moved by aircraft (Jamison, 1978; Mull, 1982). During January 1965, a C-130 made 80 trips between Fairbanks and ARCO's Susie No. 1 drill site southeast of Umiat (Jamison, 1978). The aircraft carried rig components, drilling supplies, and camp modules. The landing strip was composed of ice and snow and was the largest of its type built up to that time for a commercial venture on the North Slope. The airstrip at Susie No. 1 was constructed with equipment that had traveled overland from the Sagwon airstrip, built by ARCO in 1964, about 60 miles south of Prudhoe. In 1968, the strip was upgraded to handle C-130 traffic (Mull, 1985, oral comm.). Susie No. 1, drilled to a depth of 13,500 feet, was the deepest hole on the North Slope outside of NPR-4; and it was a dry hole. After the failure at Susie No. 1, ARCO joined with Exxon to drill a well near Prudhoe Bay. The Susie No. 1 rig was demobilized and transported by tractor train to the new drill site approximately 60 miles away (Jamison, 1978; Mull, 1982). The Susie No. 1 operation and the subsequent rig demobilization and move to the Prudhoe site was a refinement of logistics operations used by Navy contractors in previous arctic operations (see Sec. III).

The new well site, Prudhoe Bay State No. 1, was spudded in April 1967. At the time, it was the only active rig on the North Slope--a situation representative of industry's waning interest in the Colville-Canning region. ARCO's persistent interest in the North Slope and its pioneering drilling-support techniques were largely the project of ARCO's then-Chief of Northern Operations, Harry C. Jamison. Like Marshall, Jamison was convinced that large quantities of hydrocarbons lay beneath the arctic coast. Fortunately for both Marshall and Jamison, and for the State of Alaska, Prudhoe Bay State No. 1 was successful. In March 1968, the well tested at 1,152 barrels per day; by July of the same year, a confirmation well (Sag River No. 1) verified the existence of North America's largest oil field.

In response to the discoveries at Prudhoe Bay State No. 1 and Sag River No. 1, and in anticipation of the State lease sale in September 1969, activity on the North Slope intensified as industry scrambled to drill delineation wells and gather additional seismic data. During 1969, Chevron constructed a landing strip adjacent to one of its drill sites at Deadhorse. In 1970, the facility was sold to the Alaska Department of Natural Resources (DNR) for $1.00 (Smith, Copeland, and Grundy, 1985, oral comm.). In the same year, Mobil Oil bulldozed a 50-mile access road from Beechey Point to the Kuparuk River. The road was constructed by piling tundra in a center mound between narrow, parallel trenches. The mound was flattened to provide a relatively smooth surface for summer and winter transportation (Smith, Copeland, and Grundy, 1985, oral comm.). However, in time the process of thermokarsting caused the structure to give way to a series of ponds. (Thermokarsting is a process by which the underlying permafrost melts and causes the ground to slump.) In 1969, 23 drilling rigs were transported to the slope by C-130. Aircraft arrivals were estimated at 1,000 per day (SUNY, Research Foundation, 1984) as industry and service contractors established permanent facilities in this area. In the midst of this frenzied activity, the State of Alaska began the task of regulating vehicular traffic and land use on its lands.

B. <u>Historical Overview of Administrative Policies Affecting Surface-Transportation Development</u>

This section presents a historical overview of Federal and State administrative polices that affected surface-transportation development on the North Slope.

1. <u>Formulation of State Land Use Regulations</u>: Prior to 1969, there were no State regulations governing travel or land use on North Slope lands, except for a regulation on the sale of mineral-leasing rights. Industry was allowed to move on the tundra at any time of the year with any type of vehicle. However, in response to mounting concern by environmental groups regarding the effect of unregulated activities on the tundra, State officials acted to end all on-tundra industry activities by spring breakup of 1969--prior to the enactment of the National Environmental Policy Act later in 1969. The State feared that lawsuits filed by Native and environmental groups could indefinitely delay the 1969 lease sale (Smith, Copeland, and Grundy, 1985, oral comm.; Wienhold, 1985, oral comm.). After a false start, the State succeeded in stopping on-tundra operations by May 10, 1969 (Wienhold, 1985, oral comm.). Although the State had no authority to regulate land use or vehicle movement on the North Slope, the Alaska Department of Fish and Game

(ADF&G) had the authority to protect the ecological integrity of river drainages in order to maintain the proper fish habitat. Because almost all of the land between the Colville and the Canning Rivers is low and, in some cases, virtually featureless, it was considered entirely river drainage from a geographical point of view. Thus, in order to operate on the North Slope during 1969-1970, the operators had to obtain permission from the ADF&G (Grundy, 1985, oral comm.; Wienhold, 1985, oral comm.).

Virtually all on-tundra operations ceased during the summer of 1969, with one notable exception. The Cities Service Company (CITCO) requested permission to conduct summer seismic work with a prototype soft-tire, low-ground-pressure vehicle. The ADF&G denied the request; but the CITCO returned with a plan to use an air-cushion vehicle (ACV) for seismic work. After a test, the ADF&G approved the ACV for use on the tundra; however, the vehicle was not successful--vibrations from the Vibroseis seismic equipment damaged the ACV and eventually forced its withdrawal. The CITCO then used the ACV as a pipe and drilling-equipment transporter until pilot error resulted in a fatal accident. The CITCO next employed helicopter-borne Vibroseis equipment and operated successfully until the end of the summer. Needless to say, the CITCO's utilization of an ACV and a helicopter--and its attempted use of a soft-tire, low-ground-pressure vehicle--for seismic work were technological firsts on the North Slope. In spite of these efforts, however, the CITCO was not successful in obtaining producing leases (Grundy, 1985, oral comm.; Wienhold, 1985, oral comm.).

On September 10, 1969, the State of Alaska leased 412,548 acres of land scattered between the Colville and Canning Rivers through a competitive-bid process. The State reaped $900 million in revenue ($2.7 billion in 1985 dollars) from what was to be the last sale of State arctic lands for a decade. Following this landmark State lease sale, the oil industry was optimistic. Plans were made to delineate the Prudhoe Bay reservoir and have it producing into a completed trans-Alaska pipeline (TAP) by 1972 (SUNY, Research Foundation, 1984). Industry constructed a large gravel pad for the storage of barge shipments near what was to be the east dock and emplaced 56 miles of primary, secondary, and connecting-spine gravel roads during the 1970-1971 construction season (see Graphic No. 1) (Walker et al., 1984).

During 1970, ARCO and BP were designated as operators for the Prudhoe Bay field under the authority of the Alaska Oil and Gas Conservation Act (Sec. 31.05.110[a]). This Act was designed to prevent independent operations by several oil companies in the same field through unitization of the field under the authority of a principal operator. The State believed that unitization would maximize the ultimate recovery of resources and better protect the environment by preventing overdrilling and construction of duplicative surface facilities (Hennigh, 1982). Coincident with unitization, the Prudhoe field was divided into eastern (EOA) and western (WOA) operating areas. The EOA was administered by ARCO, the WOA by Standard Oil Company of Ohio (Sohio)-BP. However, official recognition of the Prudhoe unitization and Sohio's/ARCO's status was delayed until November 1977 because of litigation between the State of Alaska and the Prudhoe leaseholders. By 1974, both ARCO and BP had established permanent east and west base camps along the Prudhoe spine road (see Graphic No. 1).

Industry's anticipation of the rapid development and production of Prudhoe resources was not to be fulfilled. In December 1969, the Trans-Alaska Pipeline System (TAPS) applied to the U.S. Department of the Interior (USDOI) for a pipeline/construction-road right-of-way from Prudhoe to Livengood. After some review, the USDOI (under Secretary Hickel) granted the petition in January 1970, pending approval of project plans and the project EIS. Under the provisions of the NEPA (1969), the USDOI was required to issue an EIS on this proposed action because of its magnitude. The 10-page EIS drew immediate condemnation from Native and environmental groups, and several lawsuits were filed (Hennigh, 1982). As a result, industry optimism dimmed once again during 1971, and there was a reverse flow of drill rigs from the North Slope (SUNY, Research Foundation, 1984). Nevertheless, the oil industry persevered; in June of 1971; the newly created Alyeska Pipeline Service Company (Alyeska) entered into an agreement with the State for the construction of the North Slope Haul Road (NSHR) (now the Dalton Highway), pending the conclusion of then-ongoing lawsuits. Under the agreement, Alyeska would construct and operate the road during the construction of the trans-Alaska pipeline (TAP); upon completion of the pipeline, ownership of the road and right-of-way would revert to the State (Hennigh, 1982).

2. Passage of the Alaska Native Claims Settlement Act: By late 1971, the U.S. Congress had begun to take action to break the legal impasse in which the TAP was caught. During December, the Alaska Native Claims Settlement Act (ANCSA) was passed. In addition to settling Native land claims, the ANCSA opened the way for construction of the NSHR and the TAP by setting aside certain lands for a utility corridor. However, soon after passage of the ANCSA, opponents of the TAP successfully challenged in court Secretary Hickel's right to issue special land use permits for construction of a pipeline right-of-way. The Nixon administration then worked closely with Congressional proponents of the TAP to secure the necessary legislation that would enable pipeline construction. In November 1973, efforts were rewarded by the passage of the Trans-Alaska Pipeline Act. The TAP Act empowered the Secretary of the Interior to administer and enforce all permits for acquiring a right-of-way and constructing a pipeline on that right-of-way. The TAP Act also extended the Secretary's authority to approve the construction of ancillary facilities such as airstrips and roads. In essence, the TAP Act ratified the earlier agreement between Alyeska and the State of Alaska to construct the NSHR. On April 29, 1974, Alyeska awarded its first contract for construction of the road, which was completed by the fall of 1974 (Hennigh, 1982). From the town of Livengood to Prudhoe Bay, the road measured 358 miles. Road construction required 7 major construction firms, 3 million man-hours of labor, and 25 million cubic yards of gravel (Alaska Construction and Oil, September 1974).

3. Formulation of Alaska Department of Natural Resources Regulations: Commensurate with industry's increasing North Slope activities, the State renewed its effort to further regulate land use. On March 5, 1970, the Alaska Department of Natural Resources (DNR) promulgated "special land use designations." In short, the State regulation instructed industry to leave an area as they found it. Although brief, the special land use designations formed the basis for subsequent DNR policy decisions. Pursuant to the ideals stated in the special land use designations, the DNR began a vehicle-testing program in 1971. This program, which continues to the present, addresses

industry's need for year-round access to exploratory-well sites and on-tundra installations, and the State's responsibility to protect the fragile tundra environment.

During and after 1971, soft-tire, low-ground-pressure, tracked vehicles (Rolligons) were tested for their effects on the tundra. During the initial tests in 1971, two types of Rolligons were used: axle-mounted and roller-mounted. The axle-driven Rolligons had a drive assembly similar to that of an ordinary street vehicle. Accordingly, the axle-driven Rolligons could develop substantial torque and, in certain stress situations, dig into the soft tundra. The roller-mounted Rolligon was designed in a different manner--the roller that drove the wheels by friction was situated on top of the smooth-tired wheels. This latter method produced much less torque and fewer opportunities for spinning the tires and digging into the tundra. As a result, the DNR authorized the use of roller-driven Rolligons on the tundra during both summer and winter and restricted the axle-mounted Rolligon to winter use only (Smith, Copeland, and Grundy, 1985, oral comm.). However, some smaller, axle-driven vehicles, such as the Tucker Snow Cat, were allowed to operate on the tundra during the summer. As a result of this vehicle-testing program, Chevron became the first North Slope operator to employ a Rolligon on the North Slope during the 1971 summer cleanup of debris left on Chevron leases by seismic-train operators.

The State's vehicle-testing program continues to the present time, with operators required to submit new equipment for tundra-feasibility tests. The U.S. Navy tested ACV'S within the Colville River valley during 1974, but the tests were terminated when the Department of the Navy determined that the vehicles were slow and awkward and that the noise they generated threatened the endangered arctic peregrine falcon (Smith, Copeland, and Grundy, 1985, oral comm.). In 1981 and 1982, the ACV'S were successfully tested for on-tundra summer use on State lands between the Colville and the Canning Rivers.

4. <u>Regulations Affecting Construction of Gravel and Ice Roads</u>: The State's efforts to regulate surface-vehicle traffic occurred coincidentally with the State's incipient attempts to regulate gravel and water extraction. During the early 1970's, water and gravel for drilling and construction were removed primarily from active streams and streambeds. An enormous quantity of gravel was removed for drilling pads, facility pads, and road construction. By 1977 (1 year before the DNR's total ban on the removal of gravel from active streambeds), 3,000 acres of North Slope lands within the Prudhoe development zone were covered by gravel obtained primarily from active streambeds (Walker et al., 1984). The State recognized that the excessive use of gravel, particularly for road and pad construction, was both a waste of resources and a potential hindrance to the protection of fish.

Considering these and other factors, in 1975 the DNR prohibited the mining of gravel for roads constructed to exploratory-drilling sites. Because industry had left in place the gravel roads previously constructed to exploratory-drilling sites, the Prudhoe Bay region has a number of relic roads that serve no present purpose. The DNR currently is working with the Prudhoe Bay Unit (PBU) operators to incorporate these roads as reliable links in the expanding

Prudhoe Bay road network (Smith, Copeland, and Grundy, 1985, oral comm.). In order to forestall the construction of gravel roads to transient sites, the use of gravel is reserved for facility pads and roads to permanent facilities whose use is continuous.

During ice-road construction in winter, the Kuparuk and Sagavanirktok Rivers were the principal sources for water extraction. Native fish species exist in deep pools scattered throughout the arctic river systems, which generally do not flow during the winter. Thus, water extraction from arctic rivers during the winter can create difficulties for the fish species that inhabit the targeted sources. As early as 1970, the ADF&G was concerned about winter extraction of water from such pools (Grundy, 1986, oral comm.; Wienhold, 1985, oral comm.). With the slowdown of drilling activity on the slope, and pending the outcome of TAP-related litigation, this issue remained somewhat dormant. However, with the resolution of litigation, drilling activity increased sharply; and, because gravel roads to exploratory-drilling sites were forbidden, water was required not only for drilling but also for ice-road construction. Thus, the use of available water sources was accelerated; on July 10, 1976, the DNR issued an interim water policy prohibiting water extraction from the isolated pools of frozen rivers below the 2-foot level of the pool (Smith, Copeland, and Grundy, 1985, oral comm.).

In January 1978, the DNR established a policy prohibiting the extraction of gravel and water from all fish-bearing streams; and, in September 1979, the DNR required Prudhoe operators to consolidate gravel pits and gravel-extraction operations. Since then, industry has partially met its water requirements by flooding abandoned gravel pits for use as reservoirs. The DNR currently requires that active gravel pits typically be spaced at about 10-mile intervals throughout the Prudhoe and Kuparuk fields; however, gravel is not uniformly available throughout the fields (there is a 30-foot overburden in the Kuparuk field, versus 8 feet in the Prudhoe Bay field).

Although industry's hopes for rapid development of North Slope resources dimmed during the early 1970's, drilling and related construction activity continued in anticipation of approval of the TAP. Between 1971 and 1974, 15 exploratory wells were completed within the Prudhoe Bay area, and 5 exploratory wells were completed inland and along the Colville River. This level of activity contrasted with the 43 exploratory wells drilled and completed within the Prudhoe Bay area between 1969 and 1970 (Mull, 1985, oral comm.). North Slope lands covered by gravel pads and airstrips expanded from 600 to 700 acres in 1970 to approximately 1,000 acres in 1973. To facilitate this activity, approximately 50 miles of gravel roads were emplaced (Walker et al., 1984).

With the passage of the TAP Act and the rapid completion of the NSHR, the unit operators quickened the pace of development on the North Slope. During 1974, a 10,000-foot-by-40-foot gravel causeway with two unloading facilities to handle modules and barges was constructed on the northwest shore of Prudhoe Bay. The west dock was and remains the principal port facility for the Prudhoe complex. In 1982, the facility was expanded to accommodate a waterflood project. The causeway, widened for a water-intake facility and lengthened to a total of 2.5 miles, reached a depth of 12 feet (Kevin Waring and Assoc., Glenn Lundell and Assoc., and Fison and Assoc., 1985).

Throughout 1975, 1976, and 1977, ARCO and BP moved equipment onto the North Slope. Their goal was to have operations equipment in place--including development wells, gathering stations, and flow lines between the stations--by the end of 1976 (SUNY, Research Foundation, 1984). During the first quarter of 1977, ARCO completed the installation of its compression plant, and BP finished construction of its central power station. During 1977, most oil-service-contractor facilities adjacent to the Deadhorse airstrips also were completed. By the start of production for the TAP, ARCO and BP were to produce from 104 wells (55 located in the EOA and 49 in the WOA) (Simpson, 1977; ARCO, 1983).

This outpouring of equipment immediately prior to completion of the pipeline was reflected in the enormous quantities of gravel that were moved. At the end of 1973, the PBU area was covered by approximately 1,000 square acres of gravel; by mid-1977, the area covered had increased to approximately 2,300 square acres. During this period, an additional 50 miles of roads were emplaced--primarily pipeline-service roads and secondary roads that connected facilities and gravel-borrow pits (Walker et al., 1984). At the end of 1977, the PBU facilities had assumed a crescent-like spatial configuration that remains today (Graphic No. 1).

C. Development of Petroleum-Production Units Between the Colville and the Canning Rivers (1977-Present)

Subsequent to the completion of the TAP, seven hydrocarbon-producing areas have been unitized (see Table II-B-1 and Graphic No. 2). Six of these units have production potential. Three units--Prudhoe Bay, Kuparuk River, and Milne Point--are actually in production. One other unit (Duck Island) is being developed. A fifth field, the Point Thompson gas condensate, is in development limbo due to the presently unfavorable economic situation. The sixth unit (Gwydyr Bay) has production potential but not in the current economic climate (see Table II-B-1). (The former West Mikkelsen Unit is not noted in Table II-B-1; West Mikkelsen was unitized on August 7, 1978, and abolished on January 1, 1985, after the drilling of four unsuccessful exploratory wells.) This section discusses the activities that accompanied the development of the active units, particularly as they affected the development of surface-transport patterns on the North Slope. Federal blocks are not discussed because, to date, no development plans have been filed regarding resources discovered on Federal leases.

1. Prudhoe Bay Unit: In the years following the startup of the TAP, development of the Sadlerochit Formation has steadily continued. The field grew from 104 production-related wells in 1977 to 598 wells (not including gas-injection wells) drilled from 33 drill pads by the end of May 1984 (Tate and Martin, 1984). Of this total, 306 wells were active in ARCO's EOA and 292 in Sohio's WOA. It is anticipated that an additional 880 to 950 production-related wells will be drilled by 1988--up to 499 wells in the EOA and up to 451 in the WOA (Tate and Martin, 1984). In the early 1980's, ARCO and Sohio began to implement enhanced-recovery techniques for the maintenance of formation pressure and, hence, oil production; the unit operators began the PBU Waterflood Project with installation of a saltwater-treatment plant (STP). The project maintains formation pressure by flooding (begun in 1984) the Sadlerochit Formation with treated seawater.

Table II-B-1
Production-Unit Development
(1977-Present)

Unit	Operator	Unitization Date	Acreage	Wells Drilled	Comments
Duck Island	Exxon	August 1978	40,303 1/	7	Production of 100,000 bbls/day from 2 offshore islands expected to begin by 1987.
Gwydyr Bay	Conoco	September 1979	27,160 2/	9 wells drilled before and after September 1979.	Hydrocarbons appear in isolated pockets. Difficult to develop given present economic conditions.
Hemi Springs	ARCO	January 1984	114,171	1 well drilled during 1984.	Some difficulty with leases let in Dalton Highway Management Corridor.
Kuparuk River	ARCO	December 1981	294,986 3/	29 exploratory wells drilled from 1969-1981.	Presently producing 80,000 bbls/day with a maximum projected production of 200,000 bbls/day.
Milne Point	Conoco	July 1979	35,744 4/	18 wells drilled from 1969-1984. 24 additional production wells to be drilled during subsequent drilling seasons.	Production began in November 1985. Output of 30,000 bbls/day is expected in 1986. Facilities installation began in 4th quarter of 1984.
Point Thompson	Exxon	August 1977	40,786	12 wells drilled to date.	Development proceeding slowly due to distance from Prudhoe. Field is gas-prone 5/. Leases have been extended indefinitely until market is viable for gas production.
Prudhoe Bay	ARCO-Sohio	November 1977	251,527 6/	598 wells drilled as of May 1984. Additional 880-950 wells projected by 1988. 500 were projected for the EOA; 456 planned for the WOA. As of 1977, approximately 100 wells drilled in the PBU.	Mature producer. Field production expected to begin its decline during 1987-1988.

Sources: K. Fortney (1983); Oil and Gas Journal (1984); and C. Airey (1984).

1/ Original unit size 24,080 acres. Expanded to current size in November 1984.
2/ Lost 5,760 acres to PBU in February 1984.
3/ Expanded in March 1982. Original size 237,776 acres.
4/ Has undergone two expansions. Original size 18,527 acres.
5/ Field contains an estimated 350 million barrels of natural-gas condensates.
6/ Expanded in February 1984. Original size 245,767 acres.

Between 1977 and the present, the filling-in process of drilling production wells and constructing production-related facilities resulted in a sharp increase in roads, gravel pads, and related production/development facilities. In mid-1977, gravel pads and airstrips (except roads) covered 2,200 to 2,300 acres; by mid-1983, 4,500 acres were covered. The PBU road network also expanded during this period; however, the overall composite mix of the road types changed. In 1977, approximately 54 percent of the existing 140-mile road system was composed of secondary (i.e., pad) or pipeline-service roads. The balance of the system was composed of primary roads and the Prudhoe Bay spine road. By 1983, the PBU road system had increased to 220 miles, of which only one-third could be considered to be part of the spine road or a primary artery. The balance of the road system was almost evenly divided between secondary roads and pipeline-service roads (see Graphic No. 1) (Walker et al., 1984).

This proliferation of secondary and service roads is a direct result of field development; to some degree, it also is a result of the unit operators' philosophy regarding access to production facilities. Most of the production pads within the PBU are served by two separate roads--one serves the drill pad and a second serves the gathering pipeline. Unit operators have defended this dual-entry system on the basis of concern for the safety of men and equipment in the event of an accident. Should a blowout occur, or the pipeline rupture, the second road would provide a safe corridor for equipment and personnel to reach or withdraw from the situation, particularly during the nonfrozen season, when the surrounding tundra could be too unstable to negotiate either on foot or by vehicle. Graphic No. 1 illustrates the infilling of the PBU infrastructure; during this phase (1978 to the present), most of the roads were connector links that facilitated movement between the spine road and the various drill pads and pipeline-service roads.

As additional production wells and gas/water-injection wells are emplaced, the PBU road network will continue to develop a denser interstitial pattern. However, the development and production of two potential PBU reservoirs--the Eileen and the Lisburne--would significantly expand the outline of the PBU road system. The general location of the two potential fields is indicated in Graphic No. 2. The Eileen field, southwest of the main Sadlerochit Formation and seemingly separate from that formation, actually is a continuation of the Sadlerochit. The Lisburne reservoir is northeast of the Sadlerochit and occurs in a deeper horizon. Two drill sites are currently in operation in the Eileen Formation (Metz, 1986, oral comm.), and industry has submitted plans to develop and produce the Lisburne Formation by 1986-1987 (Tate and Martin, 1983). The development of the Eileen Formation would expand the infrastructure of the PBU to the southwest. Plans for development of the Lisburne Formation call for infrastructure development nearly adjacent to the Sagavanirktok River Delta, along the shore of Prudhoe Bay, and offshore in the bay.

2. Kuparuk River Unit: The Kuparuk River Unit (KRU) was officially organized into a unified production entity in December 1981. The Kuparuk field began producing in 1982 and currently flows into the TAP through a 24-inch pipeline at a rate of 250,000 barrels (1986) per day (Metz, 1986, oral comm.). Recoverable field reserves are estimated at 1.3 billion barrels. Discovery of the Kuparuk reservoir can be dated to Sinclair Oil's exploration

well--Ugnu No. 1--drilled in April 1969 (Sinclair Oil was later involved in a merger that formed ARCO). Between 1969 and December 1981, 29 exploratory wells were drilled as industry delineated the field (Tate and Martin, 1983). Because of the expense of arctic development, production of the Kuparuk field--the tenth-largest field discovered in the U.S.--was deferred until the TAP infrastructure was completed. The growth of the KRU complex is shown in Graphic No. 1. The 7.1-mile Kuparuk spine road, constructed during 1979, connects the Kuparuk field with the PBU complex (Graphic No. 1). Within 2 years after its emplacement, 5 drill sites, the Kuparuk Industrial Center, and the Central Production Facility were constructed. During this initial construction phase, 18 to 20 miles of primary roads were emplaced. By 1985, 18 additional production-related pads had been constructed, and total road mileage exceeded 130 miles (Metz, 1985, oral comm.) and included a 12- to 13-mile segment that links the Kuparuk STP at Oliktok Point with the main KRU service road. During the 1984 sealift, the KRU STP was transported to a site at Oliktok Point. Like the PBU STP, the KRU STP maintains formation pressure (hence production) by flooding the formation with treated seawater.

3. Milne Point Unit: The Milne Point Unit (MPU) is the third of four North Slope units to enter production. The MPU was organized into a single unit on October 29, 1979, with an original area of 18,527 acres. Most of the leases constituting the MPU were sold in 1969; but until unitization occurred, only 2 wells were drilled in the Milne Point area. The first of these wells was Chevron's Kavearak 32-25. Chevron discovered a producible reservoir, but the well was shut in during October 1969 pending the development of production-related infrastructure. Following unitization, Conoco (as operator of the MPU) drilled 19 exploratory wells through the summer of 1985 (Haley, 1984). In February 1984, Conoco publicly announced the first phase of a 4-phase, 8-year MPU development plan that called for production to begin by early 1986. However, because of the field's small size and falling world oil prices, the construction timetable was moved back and the facility began production of 10,000 barrels per day on November 2, 1985. Production should have reached 30,000 barrels per day in 1986 (Epler, 1985); however, production has been delayed due to the decrease in oil prices. Produced crude is transported via an 11.5-mile, 14-inch-diameter trunk pipeline to the Kuparuk pipeline.

Hydrocarbon production from the MPU eventually will be drawn from two reservoirs--one an offshoot of the Kuparuk River Formation, the other a shallower formation of Upper Cretaceous sandstone. The first phases of the project are scheduled to develop the Kuparuk Formation, while the latter phases would consider the Upper Cretaceous sandstone. Initially, production is expected to flow from 18 wells drilled from 2 pads. Total hydrocarbon reserves for the MPU are estimated at 100 million barrels. This estimate is split evenly between the Upper Cretaceous sandstones and the more easily produced Kuparuk Formation.

As of spring 1985, Conoco had 6 pads in place in the MPU. One of the pads is slated to be a central facilities pad, a second to be a general utility, and the remaining 4 to be drill sites. Conoco plans to bring the drill sites into service 2 at a time; the first 2 should be operational by early 1986, the second 2 by 1987. Both pads would produce from the Kuparuk Formation (Hastings, 1985, oral comm.). These pads are served by approximately 7 miles of roads, including a 1.5-mile segment to the MPU's gravel-borrow site located on an inactive arm of the Kuparuk River. The MPU will be connected to the Kuparuk spine roads primarily by a 12-mile service road that will parallel the existing Milne Point pipeline.

4. Gwydyr Bay Unit: The Gwydyr Bay Unit (GBU) was organized as a single production entity on September 28, 1979. As originally constituted, the unit spanned 27,160 acres of delta, coastal, and offshore submerged lands. Conoco is currently recognized as the GBU's principal operator. Economically producible quantities of oil within the GBU were first recorded in March 1976 as a result of Chevron's Gwydyr Bay South No. 1 test well. Following unitization, Conoco's Gwydyr Bay State No. 2A well reconfirmed the presence of producible hydrocarbons. Both wells found hydrocarbons in the Sadlerochit Formation. Conoco's later well (State No. 2A) also tested oil in the Kuparuk Formation (Haley, 1982; Fortney, 1983).

In Conoco's Annual Development Plan for the Gwydyr Bay Unit (1982), the company announced plans to develop the field and projected a 10,000- to 15,000-barrel-per-day flow of crude. However, in a subsequent meeting between Conoco and the unit's other principal owners, questions were raised regarding the geology of the area and the marginal economic viability of the GBU's resources. As a result, GBU development plans were postponed indefinitely.

5. Duck Island Unit: The Duck Island Unit (DIU), organized in August 1978, originally covered 24,080 acres. The first exploratory wells within this mostly offshore unit were drilled by Exxon Company, U.S.A. (the unit's principal operator), from an artificial island constructed in 3 feet of water in the Sagavanirktok River Delta. The island was constructed in the 1976-1977 drilling season and remained active during the 1977-1978 season. The first artificial (gravel) island built in the American Beaufort Sea, the Sag Delta, was emplaced during the winter by hauling gravel to the site in dump trucks traveling on ice roads. By 1981, four additional gravel islands had been constructed within the DIU. Two of these islands (Duck Island No. 1 and Niakuk No. 3) were constructed using the first Sag Delta method. The latter two (Sag Delta Nos. 7 and 8) were constructed during the summer utilizing spill barges in 7 and 11 feet of water, respectively (Roberts and Tremont, 1982). Eight wells were drilled from these islands (Fortney, 1985, oral comm.).

The exploratory-drilling program defined a reservoir of hydrocarbons located at a depth of approximately 10,400 feet. The stratum, known as the Endicott Formation (Graphic No. 2), contains estimated reserves of 280 to 425 million barrels of oil (Environmental Research and Technology [ERT], 1984). In November 1984, the DIU was expanded to 40,303 acres to fully embrace the defined limits of the Endicott reservoir. On September 3, 1982, Sohio submitted documentation to the U.S. Army Corps of Engineers (COE) to initiate an EIS for development of the Endicott reservoir, in compliance with the NEPA of 1969 (ERT, 1984). The final EIS for the Endicott project (published in August 1984) analyzed a series of development strategies. The proposed development alternative featured two drilling/production islands that would be located in waters between 4 and 13 feet deep. Two islands would be joined to shore by causeways of unequal lengths; the more distant island would require a 3.7-mile causeway, the closest island a 1.1-mile causeway. Once on shore, the pipeline and attendant service road would extend 11 miles to PBU Drill Site No. 9

(adjacent to the Duck Island Materials Facility and constructed during the 1979-1980 season to support the development of the unit). TAP Pump Station No. 1 is approximately 10 to 11 miles from the drill site. The configuration of the proposed project and the probable pipeline route are shown in Graphic No. 1.

6. Point Thompson Unit: The Point Thompson Unit (PTU), organized as a single producing unit on August 1, 1977, was the first unified producing area on the North Slope. The operators of the PTU attempted a formal unitization in 1970; however, as discussed previously, legal issues delayed formal approval of the PTU unit until November 1977. The PTU occupies 40,768 acres; and its principal operator is Exxon Company, U.S.A. (State of Alaska, DNR, 1977).

Development drilling first occurred in the PTU in February 1970 at Mobil's West No. 1 drill site. Twelve exploratory wells were spudded prior to the suspension of the 1981 drilling season. This activity identified a 350-million-barrel reservoir of gas condensates (Oil and Gas Journal, 1984). Although a field of this size could be economic in more favorable circumstances, the PTU is distant from the PBU infrastructure and--under arctic conditions--its extensive reserves are not sufficient to underwrite the construction of a suitable product-transportation system. The unit is currently in a state of developmental limbo, and the State has indefinitely extended unit leases pending a favorable economic situation (Fortney, 1985, oral comm.).

7. Hemi Springs Unit: The Hemi Springs Unit (HSU) was officially approved January 17, 1984, with a total unit area of 114,171 acres. ARCO Alaska, Inc., was designated as the unit's principal operator. To date, ARCO has drilled only one well (in January 1984) within the unit. However, in 1969, Mobil drilled an exploratory well near the unit's western boundary. Neither of these two efforts resulted in any significant shows of hydrocarbons (Fortney, 1985, oral comm.).

The leases constituting this unit resulted from two State sales--the first sale occurred in 1965 (Sale 14, from Prudhoe east to the Canning River) and the second (Sale 31, the Prudhoe Uplands) on September 16, 1980. Shortly thereafter (October 5), the State legislature approved Alaska Statute 19.40.200--the Dalton Corridor Bill. Under the provisions of this bill, disposal sites and the use of off-road vehicles are prohibited within 5 miles of either side of the Dalton Highway (NSHR) right-of-way. Unfortunately, 14 of the Sale 31 lease tracts are located within the boundaries of the corridor; and they were not officially approved until after the date of statute enactment. As a result, their legitimacy is somewhat in question; and the DNR currently is seeking an appropriate amending regulation (Beran, 1985, oral comm.).

D. Current Land Use Regulation of Development Between the Colville and the Canning Rivers

Since the publication of special land use regulations in March 1970, the Alaska DNR has been primarily responsible for permitting vehicular movements and construction projects on the North Slope. Until 1984, the DNR acted as the principal clearinghouse for North Slope permit applications. The DNR, in consultation with other State agencies (primarily the Departments of Fish and Game [ADF&G] and Environmental Conservation [DEC]) granted or denied permits and formulated the special conditions that govern the scope of activities encompassed by a permit. However, in 1984, the State Office of Management and Budget (OMB) assumed responsibility for receiving all permit requests, distributing them to agencies with appropriate statutory authority, coordinating comments, and establishing a unified State position on issues involving other government and private entities. One reason for establishing a new permit-review process was the increasing complexity of obtaining a permit for North Slope work. As a result of the Clean Water Act of 1978 (Public Law 92, Sec. 404), the COE became a participant in the permit-issuance process and thereby added another tier to the process. The North Slope Borough's land use authority has evolved concurrently with the Federal Government's increasing involvement in the permit-issuance process.

The following sections briefly discuss the authorities of the DNR, the COE, and the NSB.

1. Alaska Department of Natural Resources (State): Although the State OMB has assumed primary coordination authority over all State permit requests, each of the State agencies retains its statutory authority; therefore, the DNR remains the principal State permitting authority for all construction/travel activities on the North Slope. The DNR requirements regarding on-tundra movement and construction are neither formal nor a part of a department manual or a series of regulations. Rather, they are the result of precedents established by a series of evolving bureaucratic decisions made on a permit-by-permit basis.

The DNR issues water use permits and three categories of land use permits: Lease Operations Permits, Miscellaneous Land Use Permits, and Materials Sales Permits. Lease Operations Permits are issued to contractors engaged in development activities related to a specific leasehold. Such activities may include, among others, (1) pad emplacement for drilling, (2) construction of ice roads to exploratory wells, (3) gravel roads to production wells, and (4) airstrips and other permanent on-site facilities that are necessary when a lease proves to be productive. As the title implies, Miscellaneous Land Use Permits authorize a variety of activities, from installing communications towers and fuel caches to conducting seismic-train operations. Materials Sales Permits generally authorize activities related to the removal and transport of sand, gravel, and water.

Each category of contractor activity requires a separate permit and a separate set of land use stipulations termed "special conditions." These special conditions are established in conjunction with the ADF&G and other concerned State agencies on a permit-by-permit basis. However, certain transport-related special conditions persist from permit to permit and thus can be considered generic:

(1) No rig movement across unprotected tundra will be allowed. Rigs will be moved only on ice roads or gravel roads.

(2) Whenever possible, ice roads will follow a route along the unvegetated bars of the nearest major river system (if applicable) to minimize tundra travel.

(3) Snow ramps will be constructed when crossing steep banks.

(4) Watercourse banks will not be altered.

(5) In areas with a high density of small ponds, gravel roads will be constructed with sufficient culverts to avoid ponding.

(6) In situations where exploration or development requires more than one season of ice-road construction, the operators will locate the trail in a different alignment for each season. Operators are prohibited from using exactly the same trail in successive years.

(7) Only limited on-tundra travel performed specifically for maintenance will be allowed between breakup and freezeup.

(8) No vehicles will enter the actively flowing channel of a watercourse between breakup and freezeup.

(9) All activities will terminate seasonally sometime around the middle of May and start up when the tundra is covered by 4 to 6 inches of snow and frozen to a depth of 1 foot.

(10) All on-tundra operations will cease within 72 hours of the DNR's notice to cease.

(11) Operators will furnish reports regarding the amount of time spent in each camp and the extent of cleanup activities.

An operator's application for permit must list all vehicles to be involved in a proposed activity. If any of the vehicles have not been tested for effects on the tundra, the DNR requires that they be reviewed under the vehicle-testing program begun in 1971. The operators must also provide the DNR with a map of their proposed travel routes. The DNR reviews these routes and alters them if they are found to threaten biological or cultural resources. Operators (specifically seismic-train operators) may be issued general permits that allow them to move spontaneously on the basis of the data they are collecting. In such a case, general corridors of activity are reviewed and permitted; and the operator is required to provide a detailed route map to the DNR after the survey is completed.

Item (6) above has caused a proliferation of ice roads and the establishment of a DNR policy that prohibits the recurrent use of ice-road corridors. Ice-road/winter-trail alignments are changed from year to year to prevent the development of a definable transport corridor marked by a long-term impression or a "brown (ponded) trail." (A brown trail results from the destruction of the tundra mat, which causes thermokarsting [see Sec. III.A].) Transient use of a specific route may cause a "green-trail" effect that is acceptable to the DNR because green trails do not pond and therefore disappear after a few seasons. (A green trail is stimulated tundra growth that results from the accumulation of moisture and the release of nutrients from old vegetation in the vehicle-track depression that was once suspended in the vegetation mat above the water level.) However, a brown trail may persist for many years because of the slow revegetation process in the arctic. Some types of on-tundra vehicular activities are allowed during the ice-free season, but these activities are restricted to essential maintenance operations. On-tundra summer movement may result in the formation of green or brown trails.

These special conditions have the effect of (1) mitigating the effects of transport activities on the tundra by restricting the type of vehicles that may operate overland, (2) specifying the time and path in which these vehicles may operate, and (3) dictating the construction characteristics of the roads (trails) over which vehicles may operate (Smith, Copeland, and Grundy, 1985, oral comm.).

The authority to permit travel routes and permanent-road corridors is ultimately the power that shapes the spatial configuration of any potential production facility. Such authority was exercised in the layout of the KRU production facilities. Note the difference in the infrastructure outline between the PBU and the KRU in Graphic No. 1. The PBU has a higher level of resources and is in a more mature stage of development. Accordingly, its configuration is more complex; well spacings are denser, and there are more pads and production-related facilities. Each pad is generally accessible by two roads--one that serves the pad and a second that parallels the gathering pipeline. In contrast, the KRU has fewer arterials and a more diffuse pattern of facilities. The KRU pads are aligned in a north-south relationship to the spine road. One pad-access route serves both the gathering pipeline and the drill pad. The KRU spine road parallels the main KRU trunk pipeline for several miles.

Although many of the differences in facilities distribution and number between the two units could be attributed to unequal levels of resources and stages of development, the primary contrasts between the two units arise from the fact that the configuration of the KRU resulted from a series of negotiations held in Fairbanks in 1979 involving ARCO, the Alaska DNR, and allied State agencies. The KRU was designed and built with a minimum of roads, specifically east-west roads. Roads in general, and east-west roads in particular, were considered a hindrance to migrating caribou (Smith, Copeland, and Grundy, 1985, oral comm.). Other major linear features, such as pipelines, were constructed with migrating species (caribou) in mind; thus, the KRU pipelines were constructed with a minimum 5-foot clearance above ground (8-foot clearance above rivers), and the minimum complement of support facilities was constructed.

2. <u>U.S. Army Corps of Engineers (Federal)</u>: All operators who wish to deposit fill or dredged material on wetlands or to remove such materials from wetlands are required to seek a permit from the COE. Linear features such as roads, pipelines, causeways, and other construction activities within the coastal zone must be permitted by the COE and the Alaska DNR. Under the provisions of the Coastal Zone Management Act of 1972, all such activities must be consistent with the Alaska Coastal Management Program (ACMP), which may be supplemented by local plans (i.e., the North Slope Borough [NSB] Coastal Management Program [CMP]). Applicants for a COE permit must attend a preapplication conference to discuss the nature of the project and the extent of the permitting requirements. After submission of a permit application, the COE prepares a preliminary environmental assessment (EA) that is reviewed by

Federal and State agencies as well as private corporations and individuals. A final EA that addresses the public's input and concerns is then prepared. Based on the conclusion of the final EA, the COE decides whether to approve or reject the permit application or to prepare an EIS. If approved, a series of stipulations affecting the project is included in the permit. These stipulations are the result of comments (received from a variety of public and private organizations) that are evaluated by the COE, the Environmental Protection Agency, the National Marine Fisheries Service, and the Fish and Wildlife Service. In developing these stipulations, these agencies focus primarily on (1) water quality, (2) engineering standards, and (3) effects on wetlands (e.g., wildlife). Cultural, subsistence, and other socioeconomic resources are also considered.

3. North Slope Borough: The North Slope Borough (NSB) was established on July 12, 1972, 4 years after the PBU discovery well was drilled. In mid-1972, the DNR had just begun its formal regulation of industry activities; and construction of the PBU infrastructure was well underway. When constituted, the NSB did not have a comprehensive land use plan or land use regulations for oil and gas development. Although the NSB was included as a courtesy by the State in the permit-review process, lack of local regulatory authority minimized the Borough's role in the process. However, in 1979, the NSB secured the approval of its first series of Land Management Regulations. Concomitant with the approval of the Land Management Regulations, the NSB submitted its first CMP to the Alaska Coastal Policy Council for approval and incorporation into the CMP. The Borough withdrew its CMP when it became evident that it would not be approved. This left the DNR as the principal permitting authority for all State lands within the coastal zone (which extends 25 miles inland or to the 200-foot contour, whichever occurs first). However, as a result of its Land Management Regulations, the Borough's permitting authority was extended to all other State and private lands within Borough boundaries.

In December 1983, the NSB approved new Land Management Regulations that were effective on January 1, 1984. On April 22, 1985, the Borough's revised CMP was approved by the State and forwarded to the National Oceanic and Atmospheric Administration's Office of Coastal Resource Management (OCRM) for review and determination of Federal consistency. Approval by the OCRM is necessary before a regional or State CMP can be enacted. In August 1986, the OCRM rejected the Borough's CMP, stating that it "unduly restricts" energy-facility siting. Approval of the NSB's Land Management Regulations was an important step in consolidating the Borough's regulatory functions; however, because the majority of all oil/gas-drilling and -production activities lie within the coastal zone, the NSB will have greater authority to regulate petroleum exploration and production--when and if its CMP is approved. Although the NSB currently reviews and provides comments to the State OMB and the COE on all permit applications, its position cannot be given "due deference" until its CMP is fully implemented. Once the CMP is approved by the Department of Commerce, Federal, State, and Borough permitting processes and policies for all petroleum-industry activities on the North Slope will be in place.

The following transportation-related examples are excerpted from the NSB's 1983 Land Management Regulations and were referenced in the disapproved CMP. Among the various provisions of these pending regulations, there are two categories of regulations that potential developers would be required to consider in the design and construction of projects: (1) "best-effort" and (2) "mandatory" ordinances. Development may conflict with best-effort policies if the NSB Planning Department determines that the developer used best-effort policies to comply and that there is no feasible and prudent alternative to the proposed compliance. Conflict with mandatory policies requires a variance from the NSB Planning Commission. To be granted a variance, the developer must show by a preponderance of evidence both of the following: (1) the developer has implemented the spirit, but cannot meet the letter, of the policy; and (2) to meet the letter of the policy would work undue hardship without concomitant public purpose, or require site or building design out of character with surroundings with no concomitant public purpose.

Examples of best-effort policies include prohibition of:

(1) Development that depletes or decreases subsistence resources below the subsistence needs of residents.

(2) Public-highway development, except for village roads and streets.

(3) Duplicative transportation corridors from resource-extraction sites to railhead or tidewater locations.

(4) Development of any type of transport, including pipelines that significantly obstruct wildlife migration.

(5) Disturbance of subsistence-resource habitat or migration routes during migration periods by transportation modes or routes.

(6) Development that does not include siting, design, construction, and maintenance of transportation and utility corridors that eliminate or minimize disturbances or alterations of shorelines, watercourses, and significant topographic features.

(7) Development in floodplains and other geologic hazard areas.

(8) Development that restricts subsistence-user access to subsistence resources.

Examples of mandatory policies include prohibition of:

(1) Development that significantly disturbs cultural or historic sites that are:

  (a) On the National Register of Historic Sites;

  (b) Eligible for inclusion on the National Register of Historic Sites; or

  (c) Newly discovered and undergoing or awaiting excavation.

(2) Development that significantly interferes with traditional activities at cultural and historic sites.

(3) Development that precludes subsistence-user access to subsistence resources.

Potential project developers would also be required to:

(1) Confine all vessel, vehicle, and aircraft usage to certain corridors within designated Special Habitat Areas (a mandatory requirement).

(2) Combine transportation facilities to the maximum extent possible (a best-effort requirement).

(3) Undergo a preapplication conference in which the developer would be required to meet with NSB representatives prior to the submission of the plan and discuss policies regarding the tentatively chosen site.

Other regulations of the proposed NSB CMP deal with the "minimization of negative impacts" and the "maximization of beneficial impacts." Many of the requirements discussed under best-effort and mandatory policies are expanded upon and incorporated in those provisions dealing with adverse and beneficial impacts.

The policies and administrative requirements identified and discussed here have evolved over time and represent social as well as environmental concerns that have emerged during the many years of petroleum-related activities on the North Slope.

III. SURFACE-TRANSPORTATION PATTERNS CREATED BY EXPLORATION AND DEVELOPMENT OF THE NATIONAL PETROLEUM RESERVE-ALASKA

This section focuses on the surface-transportation patterns created by mineral exploration and associated activities within the National Petroleum Reserve-Alaska (NPR-A) (previously known as Naval Petroleum Reserve No. 4) (see Fig. III-A-1). The NPR-A's administrative history, the regulatory framework within which the NPR-A functioned, and the technology and methods used for surface transport within the NPR-A are also discussed in this section.

Much of the information presented here is based primarily on two works--J. C. Reed's "Exploration of Naval Petroleum Reserve No. 4" (1958) and J. F. Schindler's "History of the Second Exploration" (In Press [1983]). Information from various papers on the effects of activities within the NPR-A also is included, along with information obtained in interviews with individuals and BLM Resource Managers who were involved in NPR-A projects.

A. Initial Phase of Exploration Activities in Naval Petroleum Reserve No. 4 (1923-1953)

The NPR-A, or Naval Petroleum Reserve No. 4 (NPR-4) as it was then known, was established in February 1923 by President Warren Harding's Executive Order. Soon after its establishment, the reserve was visited by USGS reconnaissance teams. Traveling by foot, boat, and dogsled, the USGS teams traversed a wide portion of the NPR-4 and mapped some of the region's geographic and geologic features. Their efforts ceased in 1926, and the area received little attention until 1943.

By order of the Director of Naval Petroleum Reserves, exploration of the NPR-4 began in the summer of 1944. The mission of the project (known unofficially as Pet 4) was to determine the geology of the region and assess its hydrocarbon potential. Approved by President Roosevelt in June 1944, the Pet 4 project continued until the fall of 1953. During the lifetime of the project, 80 wells were drilled; 3,300 miles of seismic data were compiled; and several hundred square miles of the North Slope were surveyed for geologic and topographic characteristics. Beyond these notable achievements, the Pet 4 project represented the first large-scale intrusion of a mechanized society onto North American arctic lands.

During the nearly 10-year life of the Pet 4 project, tractor-drawn trains crossed and recrossed the arctic slope. A semipermanent record of these train movements remains today on the damaged and scarred arctic tundra, because the U.S. Navy and its contracted personnel were unfamiliar with the fragility of the tundra and the nature of the permafrost that lay beneath it.

In 1944, the U.S. Navy established two base camps to facilitate the Pet 4 project. The larger of the two facilities was located at Barrow; the smaller facility at Umiat served as a southern base. Although both camps hosted airstrips sufficient in extent to service the largest air carriers of the period, Barrow was designated the center of operations because of its coastal location and its vital marine-support role in this project. The Pet 4 project was essentially implemented by sea and land operations. Navy cargo ships delivered goods to staging locations (usually Barrow); from these points,

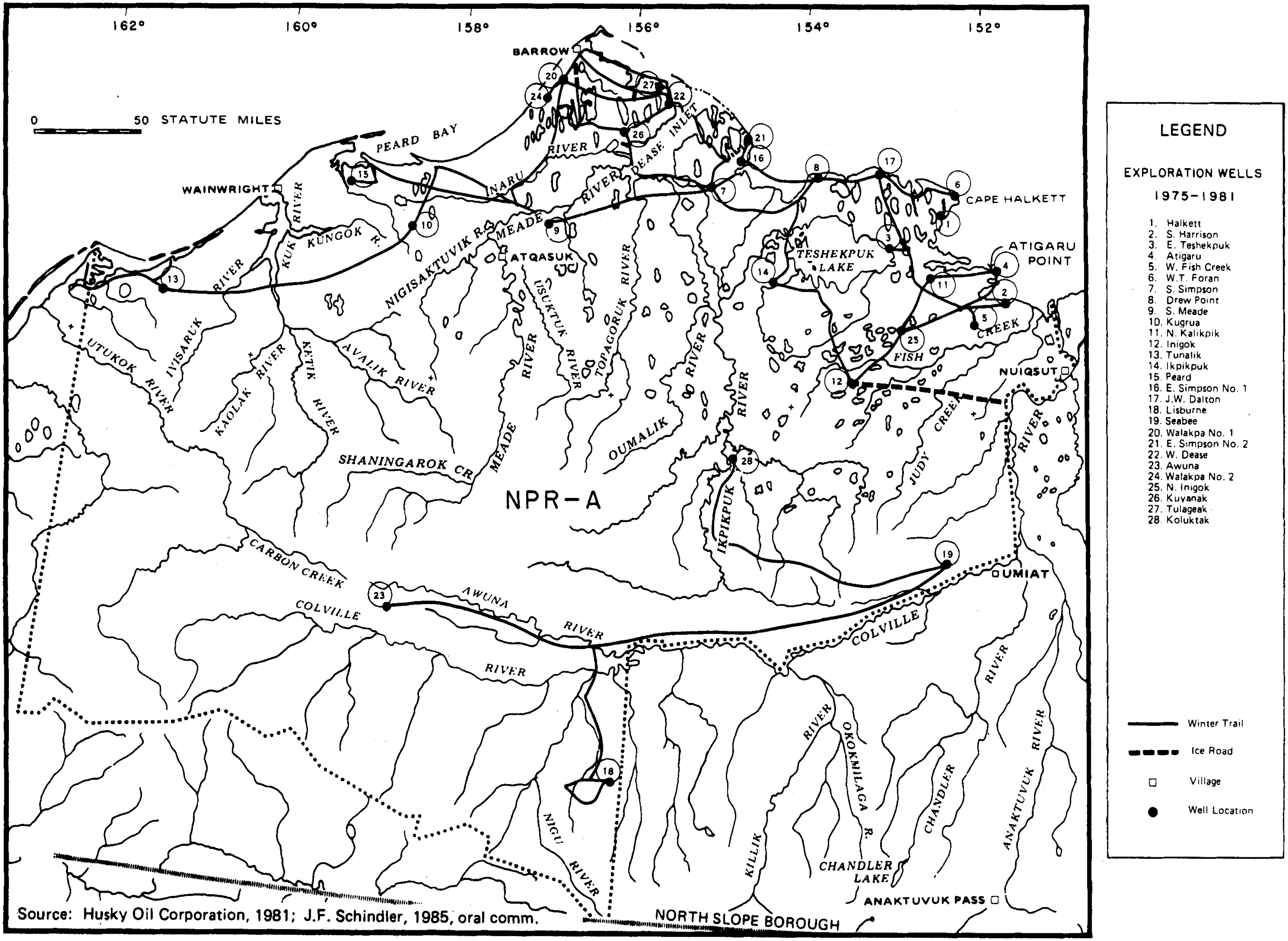


FIGURE III-A-1. HUSKY OIL CORPORATION WINTER TRAILS (1975-1981)

tractor-drawn trains carried food and tubular goods to the drill sites. Because of the limitations of aircraft and construction technology, air-cargo haulage did not play as important a role in this project as it played during the second phase of exploration in the NPR-4. Apart from the landing strips at Barrow and Umiat, winter landing strips for small aircraft were located on lake surfaces, gravel bars, and level areas convenient to drilling activities. During this initial exploration phase, aircraft apparently were used primarily for personnel rotation, medical evacuation, photo reconnaissance, and resupply of perishable goods and emergency drilling materials.

Overland movement related to the Pet 4 project was essentially divided into three categories: (1) geophysical-seismic surveys, (2) geological/topographic surveys, and (3) transport related to the construction of drilling pads, camps, and the drilling of wells. During the first season-year of geological field work (1944-1945), survey teams operating by boat and on foot were resupplied by air drops. By the second year, all land-transport operations were supported by tracked vehicles. Geophysical and geological field parties usually operated during summer and early fall, their movements aided by tracked vehicles such as the M29C Weasel and the LVT (landing-vehicle tank) amphibious carrier. These vehicles enabled Pet 4 personnel to overcome the marshy tundra and travel widely throughout the NPR-4 and adjacent regions.

The LVT was used in the arctic after completion of the Pet 4 project in 1953; in the mid-1960's, two LVT's were still being used at Barrow. One LVT was operated by the Naval Arctic Research Laboratory (NARL); the other was used by certain Barrow Inupiat for caribou hunting. As effective as the M29C's and LVT's were, they (particularly the M29C's) were subject to terrain and mechanical limitations. The M29C, orginally designed for World War II D-Day operations, was not expected to be used beyond 100 miles from the Normandy beachheads. (In fact, the M29C was originally constructed without any means to change the oil because the D-Day planners did not foresee an effective use of the vehicle beyond the Normandy beachhead [Schindler, 1976]). Special care was routinely exercised in their operation, and breakdowns frequently occurred. Caution accordingly determined the path of travel--routes through river valleys and areas of the gentlest terrain were preferred.

Interestingly, the M29C operated with a "footprint" pressure of only 1 pound per square inch (psi)--a pressure lower than later soft-tire vehicles (Abele, Brown, and Brewer, 1984). Because of the low psi, the long-term effects on the tundra were negligible. However, the same could not be said for the LVT--unless driven over ice or deep snow, it usually left a long-term impression (brown trail) on the tundra. In 1950, the Pet 4-project directors made an administrative decision not to pursue geological or geophysical field work in the foothills of the Brooks Range because of the difficulty of transporting personnel (Reed, 1958) on tracked vehicles that were consistently unable to travel over uneven terrain.

Barrow was the principal center of all land operations; a secondary center was located at Umiat. Construction trains generally were deployed from Barrow during the winter and early spring. Many of the tractors were driven with their blades down, which removed the tops of tundra tussocks. During the initial years of the Pet 4 project, 40 to 50 miles of bladed trails for summer rig movement were constructed in this manner. Other trains moved before fall freezeup had occurred or when breakup had begun (Schindler, 1985, oral comm.). This activity etched upon the surface of the North Slope a network of linear features, many of which were portrayed as tractor trails on USGS topographic quadrangle maps (1950's-1960's series). Drawn by tractors, the trains consisted of sled-mounted living quarters and equipment sheds. The sheds were unstable and had a tendency to tip over when transiting uneven terrain. For this reason, routes were carefully chosen. An M29C typically preceded a train and staked out a trail. Routes that emphasized the smooth-ice surfaces of riverbeds, lakeshore ice, and oceanic-shorefast ice generally were chosen when smooth-ice surfaces were not available. The route selected invariably represented the most level terrain.

Although it is difficult, if not impossible, to reconstruct all of the trails and their historical sequences, the locations of the two primary routes that connected Barrow and Umiat are well documented. One route paralleled the Chipp River, followed the Ikpikpuk after the two rivers joined, proceeded to the headwaters of the Ikpikpuk, and then moved 65 miles east to Umiat. The other route passed along the arctic coast over Teshekpuk Lake to the Colville Delta and from there upriver to Umiat. Both routes followed long-used Inupiat winter-hunting and -travel routes. In fact, the Navy used Inupiat guides to direct their tractor-train movements between Barrow and the Colville Delta (Silva, 1985). The route used was similar to those identified as industrial trails (see Figs. IV-C-6 and IV-C-7 in Sec. IV) except that the guides tended to follow the southern shore of Teshekpuk Lake to avoid an area of unstable ground along the northern shore. The terrain--and the ability of extant technology to cope with the terrain--limited access and thus the geographical scope of the drilling program; no wells were drilled in terrain that was not easily accessible. The locations of the deep test wells drilled during the Pet 4 project are shown in Graphic No. 1.

B. Second Phase of Exploration Activities in Naval Petroleum Reserve No. 4 (1953-1976)

In 1953, the Pet 4 program was recessed by Presidential Order. In his interesting postscript to "History of the Second Exploration," John F. Schindler (In Press [1983]) noted that, at the time of the recess, the Navy had a drilling rig and supplies ready to move from the Umiat area to a drill site near the Shaviovik River just east of Prudhoe Bay. Between 1953 and 1975, seven shallow wells were completed near Barrow in order to enlarge the capacity of the Barrow gas system; however, no other drilling activity occurred within the NPR-4 during this period. During the 1970's, drilling and oil-field construction took place at Prudhoe Bay. The Prudhoe work and the research conducted by the NARL, located immediately north of Barrow, enabled the second generation of activities in the Naval Petroleum Reserve to proceed more efficiently.

1. Husky Oil Corporation Exploration Activities in the National Petroleum Reserve-Alaska: As a direct result of the 1973 oil crisis, the Department of the Navy resumed exploratory operations within the NPR-A. Preparatory activities began in 1974, and the drilling program started in 1975. Drilling operations were curtailed in 1981, and the entire operation was terminated in 1982. Through May 1977, the Navy administered the drilling program; however, with the passage of the National Petroleum Reserves Production Act in 1976, operational control of drilling in the NPR-4 passed from the

Navy to the Department of the Interior, Geological Survey. The Act also provided for a name change--Naval Petroleum Reserve No. 4 became the National Petroleum Reserve in Alaska (NPR-A). Although administratively controlled by the Navy and then the Interior Departments, the program was actually implemented and operated by the project's prime contractor--the Husky Oil Corporation.

The Husky program was more sophisticated than its predecessor's. Advances in transportation and drilling technology and construction of the Prudhoe Bay infrastructure allowed for more flexible approaches to the support of NPR-A drilling operations. The Husky operations headquarters was located near the Pitt Point Distant-Early-Warning (DEW-Line) System station. Christened Camp Lonely, the operations base was initiated by the Navy during the summer of 1974. Unlike the Pet 4 camp at Barrow, Camp Lonely was not the only conduit for drilling supplies and equipment entering the North Slope. Air-cargo flights direct to drill sites and occasional tractor trains from Prudhoe Bay augmented the air, marine, and land operations conducted from Camp Lonely.

Because of the variety of operational assets available to Husky, logistic-support patterns for any drill site were quite flexible. A typical drilling season began in late October, when a construction train proceeded from Camp Lonely to a drill site where personnel constructed a camp, an ice runway, an ice road, and a drill pad, usually with gravel supplied by a nearby borrow pit. After completion of the initial drill site, the train moved to successive sites and eventually worked its way back to Camp Lonely or, with the advent of breakup, demobilized at a drill site until freezeup. When a camp was completed, the drill rig and associated equipment were flown in by C-130 (Hercules) air-cargo ships. Depending on a drill site's location and the size of the rig to be used, up to 200 C-130 loads were required for site preparation and construction. The number of air-cargo loads occasionally was reduced by surface transport of outsized rig components.

After the completion of drilling activities, the rig was (1) deactivated and stored on the spot for movement during a subsequent drilling season, (2) flown to a new drilling location, (3) demobilized by air to Camp Lonely or Prudhoe, or (4) moved by surface carrier to a new drill site. Because of the costs involved, it was usually cheaper to construct an ice runway for delivery of equipment by air; however, if a site was less than 50 miles from an existing drill site, it was more cost-effective to move rigs by surface transport. An exception to this general rule occurred when a targeted drill site could be reached via the shorefast-ice zone, where the smooth ice enabled the carriers to maintain a higher rate of speed and thereby substantially reduce travel time (Schindler, 1985, oral comm.).

The vehicles employed for overland transport featured wide tracks or large, soft-rubber tires, which created a low ground pressure and minimized tundra disturbance. Tractors pulled camp equipment and plowed snow; however, they were equipped with wide snow tracks and their blades were raised high enough not to strip the tops of tussocks or polygonal ridges. Some of the low-pressure-vehicle types used (known by brand names such as Rolligon, ARDCO, Trackmaster, Nordwell, and Flextrac) operated with ground pressures between 1.4 and 5.0 psi (Abele et al., 1978). Although these vehicles were relatively stable, vehicle operators avoided areas of deep snow and tussock tundra. The vehicles became high centered in deep snow, and the constant heave and pitch associated with crossing large tussocks tended to destabilize the load--if not the operator.

The routes proposed and selected by Husky personnel incorporated the following topographic features: marshlands, lake edges, the shorefast-ice zone of the Beaufort Sea, active streambeds, and gradually sloped areas. Marshlands were favored because they froze to the bottom rapidly and were relatively smooth after freezeup. For the same reasons, lake edges and the nearshore, sea-ice zone also were favored. Beds of active streams were selected because they annually redistributed their gravel and thus covered and disguised any evidence of the traffic. A fully loaded tundra vehicle theoretically could negotiate slopes of up to 30° and carry a 20,000-pound payload. However, in practice, 20° slopes were recommended; beyond that angle, tundra vehicles tended to bog down and dig into the snow. Areas characterized by willow, tussock tundra, steep terrain, and deep snow, and river banks greater then 3.5 feet high were avoided in the route-selection process. At -35°F, willow twigs became as hard as nails and punctured soft, rubber tires (see Sec. II.A). Vehicles could "crawl" no higher than 3.5 feet without destroying a river bank; therefore, drivers approached river banks at a low angle (the greater the angle of approach and the bank height, the higher the potential for tundra disturbance [Schindler, 1985, oral comm.]).

After routes were selected, Husky personnel overflew the routes during the following spring/summer and placed stakes at one-quarter-mile intervals along each path. After the stakes were placed, BLM anthropologists and archaeologists overflew the route in a helicopter to check for signs of prehistoric or historic human activity. After freezeup and approval of the route, snow cats traveled the trail and restaked it at 200-foot intervals--the maximum distance at which vehicle reflectors could be seen in near-whiteout conditions. During breakup, the stakes were retrieved--if they had not been scattered by the caribou, which found them handy for removing velvet from their antlers (Schindler, 1985, oral comm.).

Ice roads and airstrips were constructed at drill sites. Airstrips often were laid out on the surface of lakes. Ice roads frequently were constructed on tundra, but a bed of ice had to be at least 8 inches thick to provide enough support to protect the tundra. The most extreme example was the ice road constructed as a part of the Inigok test well. The gravel source nearest to the Inigok site was located on the Colville River (Fig. III-A-1). A 37.5-mile ice road constructed between the drill site and the borrow pits was started on February 1, 1978, and finished on March 8; gravel hauling and road maintenance continued until April 20. Upon completion of the drill pad, the road had carried 130,000 tons of gravel and 350 million gallons of water for road construction and repair. By the middle of April, the roadbed was 25 inches thick. Surprisingly, aerial photos taken by Husky during the following summer indicate that little construction damage occurred to the tundra mat.

The overland-access routes selected and utilized by Husky are shown in Figure III-A-1. A review of these routes and the drill-pad locations indicates a marked preference for locating drill sites in the coastal plain. The geology of the North Slope is such that potential hydrocarbon-bearing structures are thought to be closest to the surface near the Beaufort Sea and in the southern portion of the foothills province of the Brooks Range. The deepest test wells--Inigok and Tunalik--exceeded 20,000 feet and were drilled near the northern boundary of the foothills province, where the potential oil-bearing strata are farthest from the surface. In the southern foothills, drilling activity proceeded slowly; time and cost factors inhibited operations. Because of the area's topography, seismic surveys were complicated and time-consuming; thus, the gathering of information vital to locating drill sites in the southern foothills was completed late in the life of the Husky project. Further, the terrain lent itself to additional costs for transportation and camp/pad construction. Finally, the strata encountered were very hard and slowed the drilling process, thus resulting in additional rig costs.

Of the 28 wells drilled in the Husky project, only 3 were located in the southern foothills--Awuna, Seabee, and Lisburne. All 3 sites could be reached from the Colville River or one of its tributaries. Of the 3, the most difficult to drill was the Lisburne site. Built on a 7° slope, the camp, rig, and storage areas were located on 3 separate levels. The well was drilled to a depth of 17,000 feet at a total cost of approximately $53 million. On a per-foot basis, it was the most expensive well drilled ($3,127/foot) during the Husky project. Transportation and communications costs totaled more than $14.5 million--the highest cost for any NPR-4 drill site.

2. <u>Environmental and Administrative Considerations Affecting the Second Exploration Phase in the National Petroleum Reserve-Alaska</u>: Environmental issues played a key role during the second exploration phase. Winter-road construction and movement were governed by a series of stipulations initially drafted by the U.S. Navy and included in the first EIS written for the NPR-4 (USDOD, Dept. of the Navy, 1975). Although originally applicable only to seismic-survey teams, the stipulations were expanded to include all overland movement. After the NPR-4 was transferred to the Department of the Interior, the USGS enforced these and other stipulations in its role as the area's exploration manager.

The following provisions were among the 19 stipulations governing winter-road and -trail construction:

(1) Winter-road or -trail construction could begin only after the tundra had frozen to a depth of 12 inches and the average snow depth had reached 6 inches (conditions normally prevailing by sometime in October);

(2) Winter-road or -trail use should cease when the daytime snowmelt began (approximately May 5 in the foothill regions above the 300-foot elevation and May 15 in the northern coastal areas);

(3) The bulldozing of tundra areas for roads or trails would not be allowed;

(4) Camps used for road construction and seismic work should be situated on gravel bars, sand, or other durable land;

(5) Exploration activities should employ low-ground-pressure vehicles (tractors could be used to pull heavy equipment, but they had to be outfitted with snow tracks, could operate only under the restrictions of Stipulation [1] above, and could plow only in deep-snow conditions); and

(6) The crossing of waterways should be accomplished by using a low-angle approach in order not to disrupt the naturally occurring stream or lake banks.

Husky subcontractors were required to adhere to these stipulations and to institute cleanup operations aimed at removing the debris left from the Pet 4 exploration phase. Every well site used during the Pet 4 program was cleaned up, as were unrecorded sites that occasionally were discovered. In all, approximately 16,900 tons of debris were removed, buried, or burned. (By the end of 1982, drill sites, work-camp sites, and 373 miles of winter trails were reseeded and [in some cases] refertilized by overflying aircraft.)

C. Post-Exploration Activities in the National Petroleum Reserve-Alaska (1977-Present)

As mentioned in the previous section, management of Federal lands and petroleum resources within the NPR-A was delegated to the Department of the Interior (USGS) by authority of the National Petroleum Reserves Production Act of 1976. The Act redefined the role of the reserve and opened it for lease of its resources and development for commercial interests. Subsequent to the passage of this Act, the BLM and the USGS entered into a memorandum of understanding governing each agency's relationship to the reserve. While the BLM assumed overall administrative management of the reserve, management of all exploration activities was assigned to the USGS. However, when the Husky project was completed and the NPR-A was opened to commercial exploration and development, the USGS relinquished administration of the area to the BLM.

The BLM is currently responsible for permitting all surface-transport movement on Federal lands within the NPR-A. When it assumed this authority in 1976, the BLM inherited stipulations (designed by the Navy) that governed overland transport (see Sec. II.B). Throughout the Husky project these stipulations remained in force as the basis for protection of the landscape. Upon completion of the Husky project, the BLM revised its permit criteria for surface travel to take into consideration new information, new land use regulations, and changing land ownership patterns.

When the Husky project was completed, the BLM (at the direction of Congress) began its NPR-A oil-lease-sale program. The first NPR-A lease sale was held on January 27, 1982. To date, 1,224,024 acres (comprising 51 tracts) have been leased. However, only one tract--ARCO's Brontosaurus test-well site--has been drilled (during the 1984-1985 season). Other surface traffic generated by NPR-A lease sales is the result of seismic surveys. Operators of seismic trains and other overland conveyances must include in their permit application to BLM a list of equipment to be used, proposed methods of transport, and the proposed route to the area of operations.

The BLM evaluates and approves proposed routes on the basis of certain physical and sociocultural criteria, terrain, proximity of subsistence resources, previous use, public easements, and location of private property. Movement corridors are generally 3 miles wide and, whenever possible, sited through marshlands and lakes--areas that offer not only better opportunities for rapid movement but also provide minimal opportunities for interaction with caribou (tundra grazers that generally tend to avoid water features). Public easements are utilized when selecting a route through private property, and present or previous use of the area as a transport corridor is also considered. For example, the approved corridor to ARCO's Brontosaurus prospect parallels the route used to drill the Walakpa Nos. 1 and 2 wells (Fig. III-A-1) and feeds into the main Barrow-Atqasuk trail (USDOI, BLM, 1983). Before a final route determination is made, the route is overflown by a BLM helicopter carrying anthropologists and archaeologists who investigate for signs of prehistoric and historic use. As a result of thorough route evaluation, a series of stipulations specific to a particular activity are attached to each permit. Developed as a part of BLM's surface-management program, these stipulations are continuously evaluated to consider new data that might affect the permit.

If their activities fall within the coastal zone, operators who request a permit for surface transport within the NPR-A must also certify that their actions are consistent with the State of Alaska's Coastal Management Program (ACMP). The State then undertakes its own assessment to determine if the action is consistent and may concur or disagree with an applicant's statement. The coastal zone of the North Slope extends inland to either the 200-foot-elevation contour or a maximum of 25 miles, whichever occurs first. If a potential surface-transport operator requires a consistency determination, a surface-transport permit cannot be issued for the NPR-A until the State has ruled on the application. Alaska's coastal-management authority extends from the coast along the Colville River inland to include some of the Colville's major tributaries. The State's coastal-management authority relates only to private municipal and State (or non-Federal) lands and water; however, activities that, by extention, may have a bearing on areas within the coastal zone are included within the ACMP.

Apart from traffic generated by hydrocarbon exploration, the only other major industrial traffic within the NPR-A in recent years was and is a result of NSB activities. The Borough has been and is involved in a series of dredging projects that are located at Barrow, Nuiqsut, and Wainwright. Upon completion of assigned projects, the portable dredges are transported between communities by surface conveyance. Some of the routes used for surface haulage by the Borough are illustrated in Section IV (Figs. IV-C-6, IV-C-7, and IV-C-8). Route 2, the main travel corridor between Barrow and Atqasuk (shown in Fig. IV-C-7), is frequently used to transport fuel and heavy equipment to Atqasuk. It is a commonly used hunting route that once served as an access to a now-defunct coal mine located near Atqasuk.

A winter industrial trail between Barrow and Nuiqsut is outlined in Figures IV-C-6 and IV-C-7. There is evidence that the Navy used this general travel route to reach the Colville Delta during the first exploration phase; this route also was used by the snow-cat train that carried the supplies to resettle Nuiqsut in 1973. This particular route is among a series of coastal industrial trails that the BLM has designated for winter movement; in 1980, this route was utilized to move a dredge from Barrow to Nuiqsut. Portions of this corridor, particularly from Smith Bay east, were identified as an alternate supply-train route for ARCO's Brontosaurus well (USDOI, BLM, 1983). A transport corridor extending from Nuiqsut to Wainwright is shown in Figures IV-C-6, IV-C-7, and IV-C-8. In 1982, this route was used to transport a dredge between these two communities; its alignment follows trails previously used during the Husky program (Schindler, 1985, oral comm.) (compare Fig. III-A-1 with Figs. IV-C-6, IV-C-7, and IV-C-8).

The use of any particular trail within the NPR-A is approved by the BLM's Fairbanks District Office on a case-by-case basis. Existing weather and tundra conditions at the time of permit activity will affect the location of a proposed route. This section has discussed some of the industrial trails within the NPR-A that have been and still are used. It is apparent that BLM's policy requires that industrial-equipment movement through the NPR-A be confined to previously used corridors whenever possible.

Contrasts and similarities between Federal (BLM) and State policies concerning overland movement are discussed in Section V.

IV. INUPIAT TRAVEL AND SUBSISTENCE-HUNTING PATTERNS

A. Introduction

During the centuries before contact with Europeans, the Inupiat lived as seminomads. Their movements generally occurred within "home districts," throughout which they traveled extensively in pursuit of game. Some of these home districts contained quasi-permanent communities near which Europeans later established trading centers. The Inupiat seldom left their districts during fall and winter except to participate in traditional festivities. Most interregional travel occurred during spring and summer primarily for the purposes of hunting and, secondarily, for trading. Attendance at one of northwestern Alaska's five major regional trading fairs was a motivating reason for interregional summer traffic (Burch, 1975). As could be expected, winter movement occurred primarily by dogsled. Summer travel was accomplished by boat or on foot; foot travel was assisted by sled dogs, which doubled as pack animals. Dogs also occasionally assisted in boat travel--huskies harnessed to a boat walked alongshore and pulled the boat upstream.

In the late 1900's, more frequent contact with Euro-Americans began to change Inupiat lifestyles and travel patterns. During the 1880's, whaling stations were established near existing Native communities at Point Hope and Barrow. These communities became centers for settlement and trade. From 1900 to 1910, eight Bureau of Indian Affairs schools were built at various locations in northwestern Alaska. Shortly after school construction, the U.S. Government often established adjacent reindeer-herding stations; and some of the Inupiat began to stabilize in certain locations and enter the market economy.

During the whaling period (roughly the 1850's-1910), the Inupiat supplied the whaling ships with fresh meat, baleen, and sundry items for which they received goods and cash. This arrangement ended when the whaling industry collapsed early in the 1920's. After a brief hiatus, the fur trade replaced the whaling industry as the region's principal source of cash. Following World War I, the demand for furs was great, as were the benefits to successful trappers. During the 1920's, fox furs sold for $50 a pelt, with blue fox pelts commanding up to $100 each (Spencer, 1959). The pursuit of furbearers became a primary motive for overland movement. To facilitate the fur trade, Europeans established trading posts along the coast, particularly along the deltas of major rivers. The fur trade continued until the Great Depression ended the demand for furs and, thus, the reason for much of the extended travel in the region. By 1931, the price of a pelt had fallen to $5 or less (Spencer, 1959).

By the end of the fur-trade era, the Inupiat had become primarily a settled people; and, although subsistence activities continued to be important and necessary, the Native people had generally become part of the market economy. World War II and the construction of strategic facilities during the Cold War completed the economic metamorphosis by providing both seasonal and full-time job opportunities for the Inupiat. As an increasingly settled people interacting with the market economy, the Inupiat traveled less frequently. Although the use of firearms enabled them to be more efficient hunters, the increasing need for many Inupiat to remain in their communities to engage in seasonal (if not full-time) employment reduced their hunting opportunities. However, some--if not all--of the communities were caught in a boom-bust cycle. Thus, subsistence hunting remained an intermittently crucial requirement. Employment requirements, coupled with the slowness of the dog team and the efficiency of firearms, tended to focus hunting activities in the areas immediately around the villages; in Wainwright, a typical hunting trip involved a day's journey (Nelson, 1982). Thus, the extent of Inupiat travel diminished to a low point during the 1950's and the early 1960's (Nelson, 1986, oral comm.).

Beginning in the mid-1960's, however, two technological innovations--the snow machine and the three-wheel, soft-tire-motorcycle/all-terrain vehicles (ATV's)--expanded Inupiat opportunities for travel. The Inupiat immediately recognized the value of both vehicles. Unlike sled dogs, snow machines and ATV's are fixed-capital acquisitions that require little maintenance when not in use. Although gasoline is expensive in the arctic region, a snow machine moving at moderate speeds can travel up to 40 miles on a hard surface on only a gallon of fuel. Although this range can be reduced to 20 miles per gallon during periods of soft or deep snow (particularly if the snow machine is pulling a sled), a hunter with a strategic cache of gasoline or additional gasoline supplies can travel hundreds of miles, if necessary, to locate a suitable hunting or trapping opportunity.

In addition to their remarkable speed and range capabilities, snow machines are easy to operate; and they provide the opportunity for family-oriented subsistence activities. On the other hand, snow machines and ATV's have limitations: (1) fuel for long-distance travel has to be stored along the route or carried along (sled dogs can survive not only on transported food but on a variety of animal life that can be hunted along the way); and (2) snow machines malfunction when stressed by travel over rough terrain--they are subject to metal fatigue in extremely cold weather, and they have an unfavorable weight distribution for the transit of all but the firmest ice. Thus, snow-machine (and ATV) travel requires preferential consideration of routes that offer gentle landscapes, shallow snow depths, and firm ice. Considering the potential for mechanical failure and the other uncertainties of arctic travel, Inupiat hunters seldom hunt alone by snow machine. Because of these limitations, snow machines compare unfavorably with the sled dogs' ability to endure much privation while negotiating varied or difficult terrain.

As a result of the new transportation technology and the Inupiat's altered socioeconomic conditions, many of the historic routes fell out of use. Some of the routes perceived as traditional overland-hunting and intercommunity-travel routes are shown in Graphic No. 3. These routes are still used to some degree--some more frequently than others; however, the Inupiat consider all of these routes as part of their cultural heritage and realm of activities.

Overland travel is less frequent during the snow-free season because of the prevalent marsh-like tundra. There currently are no roads between communities, and thawed tundra is difficult terrain on which to travel. Thus, Inupiat summer hunting and fishing activities are supported primarily by watercraft and occasionally by aircraft that travel along the seacoasts or inland along principal watercourses such as the Colville, Ikpikpuk, or Kuk Rivers, and are generally focused on fishing or the taking of marine mammals, waterfowl, and caribou. The summer take of game, however, is often greater than the winter take because of the greater abundance of game, the caribou's tendency to hug the seacoasts, and the widespread use and carrying capacity of motorized boats. Caribou usually are hunted within 2 miles of the seacoast or on river banks because the difficulties of traversing the tundra render a greater hunting range impractical. Fortunately, caribou tend to stay close to the seashore because the sea breezes moderate the effect of clouds of arctic insects. Thus, the scope of Inupiat summer-subsistence efforts does not require extensive overland-travel patterns; and summer travel is discussed only as a secondary, contributing factor in the general travel pattern of each community. Point Hope and Anaktuvuk Pass (and to some degree Atqasuk) are exceptions; a combination of well-drained soils and hilly terrain has created circumstances favorable to overland summer excursions, especially in the Point Hope and Anaktuvuk Pass subsistence-use zones.

The following sections focus on those winter-travel patterns and subsistence-harvest ranges that have evolved since the development of the Prudhoe Bay complex and the introduction of the snow machine and the ATV. The social, physical, and climatic factors that have guided the development of recent subsistence-travel patterns within the North Slope Borough are discussed in the following sections.

B. Inupiat Surface Navigation in the Arctic

A discussion of Inupiat travel patterns would be incomplete without some consideration of the elements of land navigation. In an urban society, movement is channeled and directed into predetermined transportation patterns by streets and highways. Such transportation patterns do not exist in the undeveloped and largely unpopulated arctic. The success of any arctic overland travel is determined by the traveler's understanding of his environment. Simply put, the essential component of Inupiat navigation is an intimate knowledge of local geographic and climatic conditions. Although this approach to navigation is consistent throughout the North Slope, the travel pattern of each village is characterized by the geographic or climatic condition of the arctic region in which the village is located. For instance, the residents of villages located in or near hilly or mountainous terrain choose as navigational points those landscape features most typically prominent within their region, such as high or unusually shaped peaks, unusual rock formations, wide and deep valleys, and mountain passes.

The residents of villages located on the arctic coastal plain search for much subtler navigational cues, such as irregularly shaped lakes; the changing shape and outline of rivers; the number and spacing of rivers; and small bluffs that fringe the shores of some lakes. Such features are used as navigational aids, and they are also used as conduits of movement. For example, the residents of Kaktovik use the region's broad, flat river valleys as convenient access routes across the arctic plain to the foothills of the Brooks Range. Traveling within a river valley spares the Inupiat the need to cross a relatively featureless plain and provides shelter in the event of a storm.

Wind is the climatic force that shapes all arctic travel. Hurricane-force winds occasionally sweep across the arctic plain or force their way through the passes of the Brooks Range. Such a force makes travel impossible, and the survival of life and equipment is the only imperative. In hilly or mountainous regions, strong winds may sweep one valley clean of snow while piling impassable drifts in another. However, approaching bad weather can be discerned by a number of signs: mare's-tail-cloud formations, a darkening of the horizon that blots out distant landmarks, and snow blowing off the mountain peaks that the traveler is approaching--an indication that an area of high wind is near.

Apart from natural features and climate, manmade artifacts and constructions affect navigation by providing points of reference. Lights in the clear arctic night can be seen for miles, to the extent that the curvature and topography of the earth will allow; and abandoned airstrips, equipment from past U.S. Government operations, and relic as well as working DEW-Line stations are located at intervals along the arctic coast (DEW-Line towers and lights are often used as navigational references).

A Winter Trip From Wainwright to Atqasuk

To illustrate the interplay of these elements and demonstrate arctic overland navigation, the following fictitious journey is based on a known arctic route and night-travel-navigation techniques (although the Inupiat travel at night, they prefer to travel in daylight [Nelson, 1969].) The route selected is the general travel pattern between Wainwright and Atqasuk (see Figs. IV-C-7 and IV-C-8). The traveler--a local Inupiat--leaves Wainwright in late November on a snow machine and travels along the shore of the Kuk River estuary until he reaches the arm of the inlet that narrows into the Kungok River. At that point, the traveler is approximately 60 miles west-northwest of Atqasuk.

Leaving the Kungok, the traveler moves at night, assisted by a full moon. For a while, he may follow Kolipsun Creek southeast to its headwaters or, instead, strike out across country. The traveler is experienced and feels no need to carry a compass (many Inupiat do not). In crossing the seemingly featureless terrain, the traveler constantly judges the direction at which he crosses the frozen lakes (the lakes of the northwest arctic plain were formed into northwest-southeast-trending structures by centuries of wind movement). To further verify his direction, the traveler gauges the direction at which the snowdrifts are crossed. The drifts generally align northeast-southwest; however, a recent freak windstorm has altered their pattern. Because of the unusual conditions created by the windstorm, the traveler stops and removes the snow crust, revealing the lay of the tundra shrubs from the first heavy storm of fall. These shrubs generally conform to a northeast-southwest-wind direction. During early winter, while the snow is still loosely compacted, it may be blown around into various drift patterns. However, with the passage of time, the wind forms the snow into hard ice sculptures called "sastrugi" (a Russian word). (The northeast-southwest drifts become sastrugi and may be buried by new snowfall, but they do not change shape until the spring thaw.) His observation of the tundra completed, the traveler discerns an aurora borealis, which gives him the opportunity to further verify his course (auroras generally trend east-west).

As the journey progresses, the traveler reaches the valley of the first major river system due east of Wainwright--the Meade River, on whose banks Atqasuk is located. Moving along the river valley, the traveler notes the Meade's serpentine course and makes a judgment that his location is south of

Atqasuk. If the traveler had veered north of Atqasuk, he would have noted the straighter outline of the river valley and the heavily used snow-machine routes from Barrow; and he would have moved south, toward Atqasuk. In clear weather, village-house lights would have been visible at a great distance and thus would have indicated the community's location. If the traveler had journeyed during the day, as is most often the case, he would have used to a greater degree the microrelief of the coastal plain (i.e., the subtle shapes of lakes and ground swells). The successful navigation skills exhibited by the Inupiat traveler are attributable to an intimate knowledge of nature and the topography of the area traversed.

C. Travel and Subsistence-Hunting Routes Among Inupiat Communities

The eight communities that comprise the focus of this section are located in landscapes that are subtly dissimilar for some communities and markedly similar for others. The character and pattern of movement in each community are presented, and contrasts between some of the communities are noted. Some readers may assume that the maps presented in this report are indicators of well-defined travel routes followed by the Inupiat; however, such an assumption would not be entirely valid. Valleys and river drainages are paths clearly preferred by some communities that are located in hilly/mountainous terrain. These drainages are convenient corridors whose terrain offers easy access to hunting and trapping opportunities. However, corridor use or disuse depends on weather, the location and availability of game, and the whim of the hunter.

Along the arctic seacoast and plain, there are few inhibitors of movement--hunters and trappers move in response to opportunity. Each hunter or family of hunters frequently exhibits a pattern of activity typical of that individual or group. Viewed over time, with no attempt to chart the movements, these activity patterns may not appear to resolve into a clear pattern. However, these movement concentrations correlate to a set of physical and natural criteria (i.e., targets of opportunity and the best way to get there). The reader is cautioned to keep this in mind when reviewing the maps in this section. For example, Graphic No. 3 appears to illustrate many Inupiat travel routes; however, the exact location, or even the use, of these historic trails varies from year to year based upon the aforementioned factors. Most of the trails illustrated in Graphic No. 3 are generalized, rather than exact, movement corridors. The trails along the arctic coast are particularly generalized, while the trails in mountainous areas--where topography more effectively defines movement--are more exact.

Not all offshore trails follow the coastline. The practice of cutting a road across the frozen sea ice to open water is particularly common to the communities of the western North Slope. During early winter--after the nearshore ice has frozen solidly and become "landfast," the Inupiat chop a road through the ice ridges to a persistently open body of water called an ice lead. Depending on local bathymetry and the severity of the winter, the location of the lead and hence the length of the trail may vary from year to year (usually less than 10 miles long). It is along the leads that whales and other marine mammals migrate, congregate, and are hunted. The trails take 1 to 3 days to complete and, after they are "worn in," may be traversed by a variety of vehicles. Because of the stability of the landfast ice, these routes persist until the spring thaw (Nelson, 1986, oral comm.).

Figure IV-C-1 was created from a map compiled by the University of Alaska's Arctic Environmental Information and Data Center (AEIDC) from information provided by the North Slope Borough; the map was compiled before the reestablishment of Point Lay, Atqasuk, and Nuiqsut and apparently was prepared as part of a legal proceeding. Figure IV-C-1 indicates areas of subsistence interest as opposed to subsistence use. The boundaries of these interest areas probably were defined by elders and heads of families with a rich and diverse hunting tradition dating from the period of a seminomadic lifestyle. Thus, it would be reasonable to observe that the depicted interest areas represent the outer boundaries of historic interest prior to the snow-machine era. This is particularly true for the Anaktuvuk Pass, Kaktovik, and Point Hope subsistence-interest areas.

Figure IV-C-2, which also represents the outer boundaries of arctic subsistence-harvest activities, was derived from a map based on interviews with a sample of respondents from each village. The respondents essentially were asked, "Where have you traveled while hunting?"--an interrogative approach that was open-ended in both spatial and temporal contexts. Figures IV-C-1 and IV-C-2 both represent an information base and an indication of the interest and outer hunting ranges of the NSB communities. Whenever possible, the boundary of the commonly used subsistence areas for each village is approximated. This approximation is a product of the identification of movement corridors.

Some of the information introduced in this section is based on the author's interpretation of BLM color-infrared (CIR), high-altitude photographs (scale 1:60,000). These photographs have blanketed the North Slope with images of varying degrees of usefulness. Because of less sophisticated enhancement techniques, many of the photographs taken before 1980 are of limited value. Other photographs, especially the 1982-1983 infrared series, are of excellent quality and show a remarkable degree of detail. Thus, although the results obtained from the photographs are spatially incomplete, they indicate some areas of use. (The author is aware that snow-machine travel extends over a much greater area than that portrayed in Figs. IV-C-3 through IV-C-9 of this report.) Information obtained from these photographic images was combined with information from informed sources and is used as an aid to (not the focus of) this analysis.

1. Kaktovik: The site of Kaktovik, on Barter Island, is historically significant as an Inupiat meeting and trading place (Fig. IV-C-3). Kaktovik began to form as a community in 1923, when a fur-trading post was established on Barter Island. In 1954, the U.S. Air Force provided an additional impetus toward the formation of Kaktovik by establishing a DEW-Line station and an airfield near the community. The community was soon moved to a location adjacent to the DEW-Line site. However, beach erosion forced the community to relocate some distance away. Many of the people who moved to Kaktovik had previously lived along the coast within 75 miles of the community. Because the people were--and still are--closely associated through family or friendship ties, the community could be considered extremely homogeneous. In July 1982, a Borough-sponsored census placed Kaktovik's population at 189 residents (Alaska Consultants, Inc., 1983).

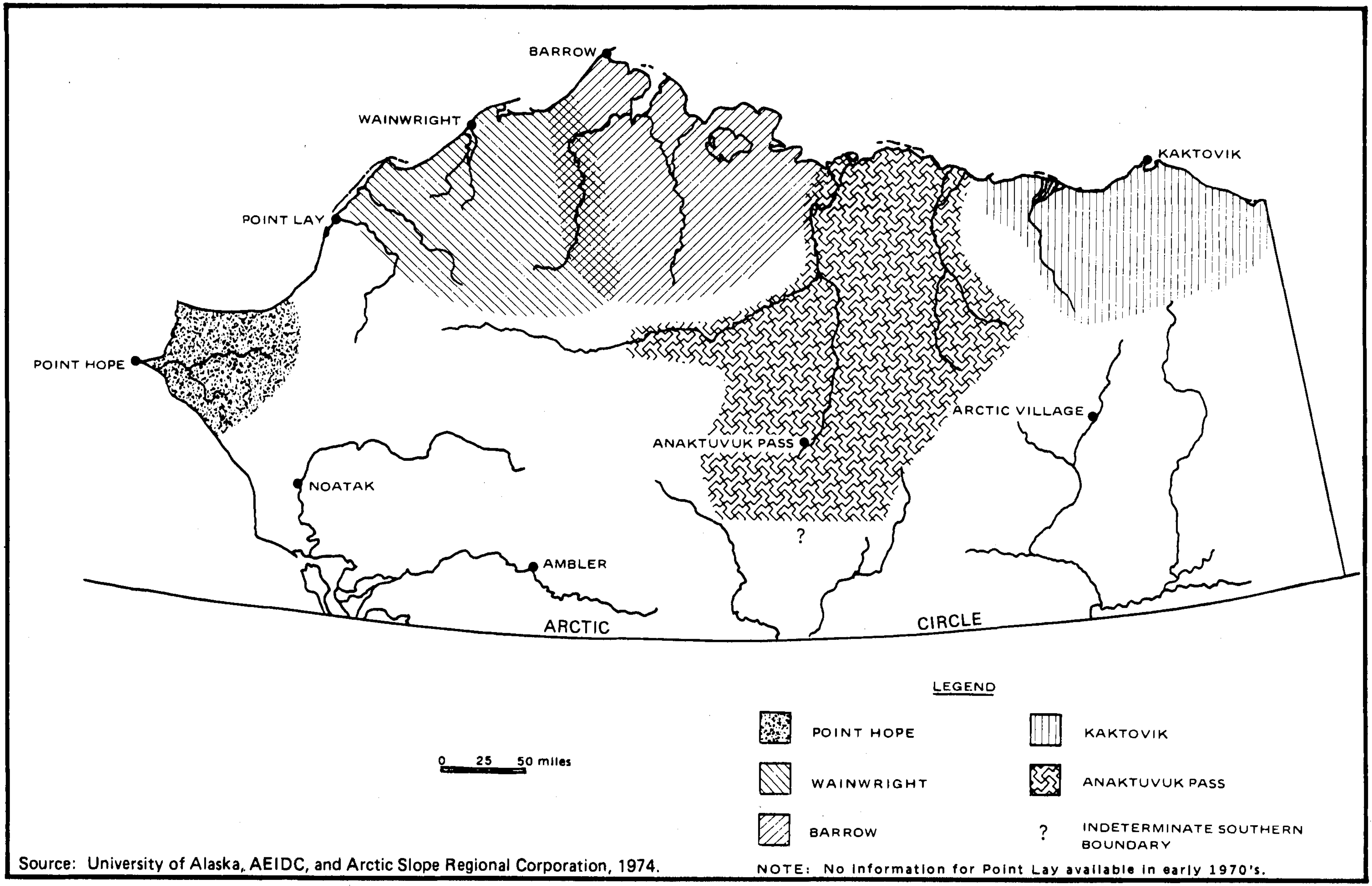


***FIGURE IV-C-1.* AREAS OF ARCTIC ALASKA VILLAGE SUBSISTENCE-HUNTING INTEREST IN THE EARLY 1970's**

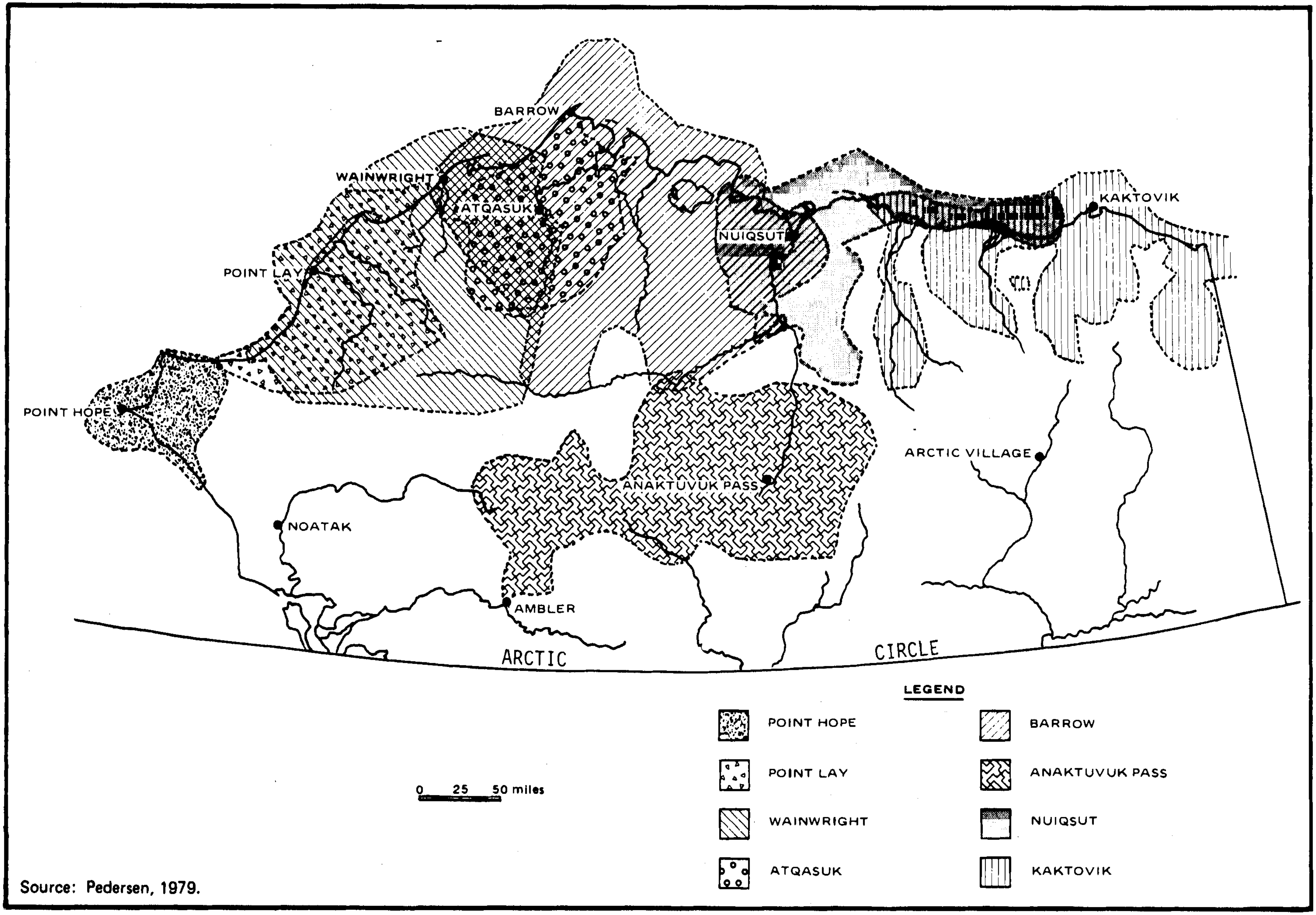


FIGURE IV-C-2. ARCTIC ALASKA VILLAGE SUBSISTENCE-HUNTING ZONES (1979)

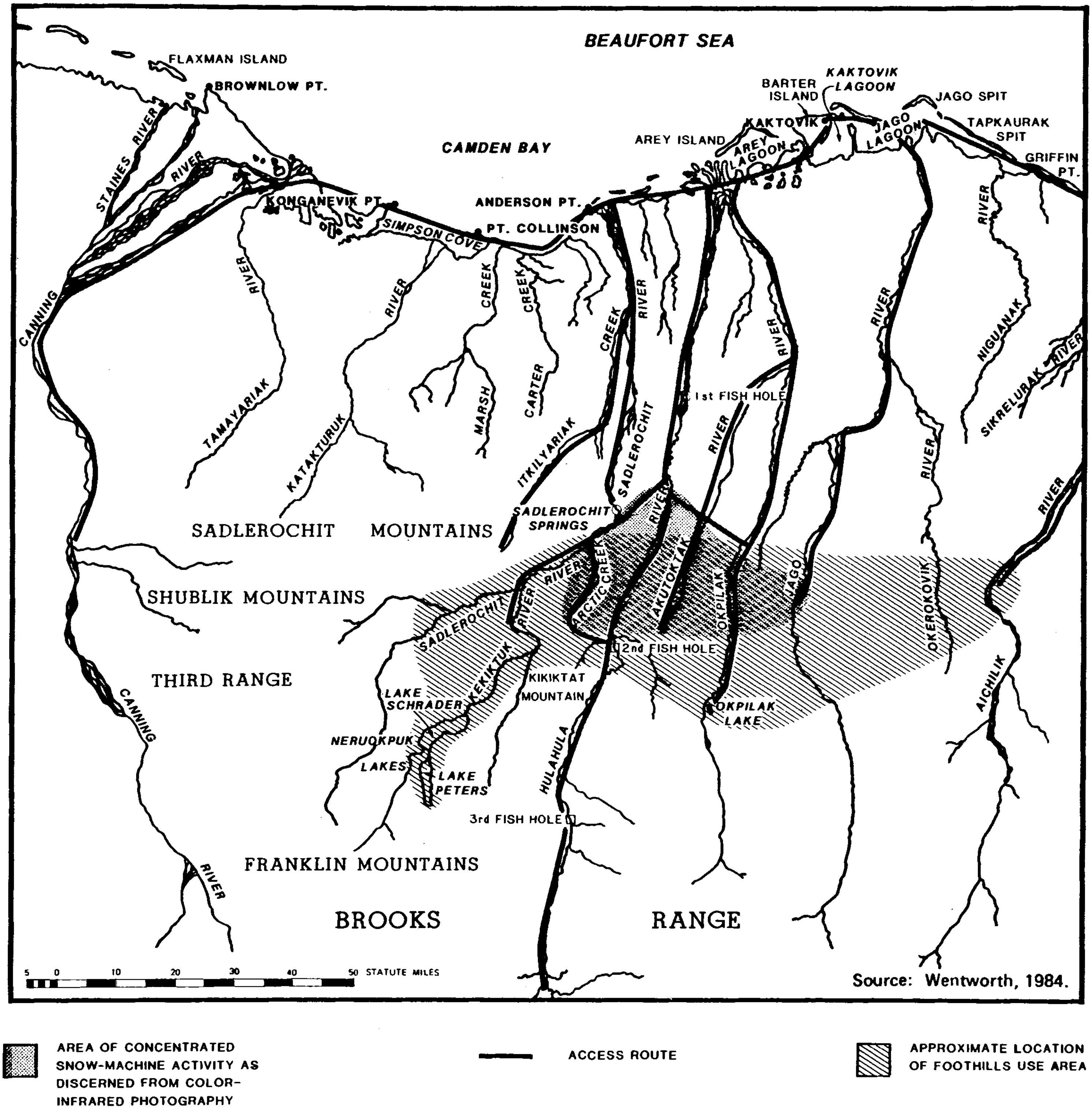


***FIGURE IV-C-3.* KAKTOVIK SUBSISTENCE-ACCESS ROUTES**

The Inupiat of this region traditionally ranged from Herschel Island in Canada on the east to Foggy Bay on the west, and south to the foothills of the Brooks Range (the approximate limits of subsistence hunting are shown on Figs. IV-C-1 and IV-C-2). Before Kaktovik was established, this entire area was used for hunting on a recurring basis. However, the concentration of population at Kaktovik substantially altered the region's hunting patterns. The area of high use has been reduced to the major rivers and river drainages proximate to Kaktovik (i.e., the Sadlerochit, the Hulahula, and the Okpilak Rivers, and to some degree the Jago River) (Jacobson and Wentworth, 1982). Graphic No. 3 illustrates some of the trails historically used by the people of the area for overland hunting and trapping (Fig. IV-C-3 represents current use).

In order to distinguish the levels of use of river drainages and other potential hunting and trapping areas, Table IV-C-1 was produced from data contained in Jacobson's and Wentworth's "Kaktovik Subsistence" (1982). When reviewed in a purely spatial context, several areas used intensely as both hunting and/or staging areas can be identified. These areas are primarily the entire Hulahula River from the First Fish Hole to its headwaters, the area between the upper drainages of the Sadlerochit and the Hulahula Rivers, and the foothills of the Brooks Range from the upper Sadlerochit to the upper Okpilak River drainage. Thus, it can be inferred that current winter-hunting patterns depict a strong emphasis on the foothills of the Brooks Range (Table IV-C-1) rather than on the arctic plain. The coastal plain apparently is used primarily for hunting/trapping furbearers, harvesting caribou, and traveling between major river deltas. Movement flows up the Hulahula to the First Fish Hole, south of which hunters may cut over west to the Sadlerochit Springs or east to the Okpilak River. From the springs, Dall's sheep can be hunted in the Sadlerochit Mountains; or the hunters may continue up the Sadlerochit River to Lake Schrader, the approximate southern limit of their activity. Along the Okpilak, caribou are pursued upriver to Okpilak Lake, or eastward along the foothills to the Jago River and beyond. Travelers continuing up the Hulahula to beyond the First Fish Hole often choose to branch off from the Second Fish Hole, either to the lowlands south of Lake Schrader or eastward along the Brooks Range foothills. During sheep-hunting season, many hunters continue up the Hulahula to the Third Fish Hole, a staging area for Dall's sheep hunting. The Akutoktak River often is used as a connecting link between the area around the Second Fish Hole and the midcourse of the Okpilak River. The Canning, the Aichilik, and other, more distant river systems usually are reached during the spring months.

In consideration of these movement patterns, the reader might be tempted to assume that there is a gradation of increased use as hunters approach the Brooks Range. While this probably is the case, certain geographic and environmental factors should be considered. The foothills of the Brooks Range offer shelter from the bitter winds that sweep the arctic plain. The Kaktovik Inupiat usually set up camp within the protective valleys and hunt along the foothills, utilizing familiar navigation points. When queried about the locations of their catches within the foothills or mountainous areas, the Inupiat defined a fairly precise location (Kaktovik Notes, 1984). However, the same precise location cannot always be made for game caught on the plain. When the Inupiat venture from their mountain camps onto the plain, they have few natural references to mark the location of their hunting successes. Wentworth (1984, oral comm.) believes that this leads to a difficulty in reporting precise game locations and perhaps an unwarranted underestimation of

Table IV-C-1
Spatial Distribution of Subsistence-Hunting Activities in the Kaktovik Harvest Zone

Location	Species Hunted	Season (October-May)	Frequency
Hulahula River and Drainage Area	Caribou	October through May 1/	High
	Wolf and Wolverine	End of October through May	High
Upper Hulahula Drainage	Red Fox	End of October through May	Moderate
	Dall's Sheep	Mid-October through mid-December	High
First, Second, and Third Fish Holes	Inland Fishes	October through May	High
Sadlerochit River and Drainage Area	Inland Fishes 3/	October through May	Moderate
	Wolf and Wolverine 4/	End of October through May	High
Upper Sadlerochit Drainage	Caribou	October through May	High
	Dall's Sheep 5/	Mid-October	Moderate
Okpilak River and Drainage Area	Inland Fishes	October through May	Low
	Caribou 6/	October through May	High
	Wolf and Wolverine	End of October	Moderate
Upper Okpilak Drainage	Dall's Sheep 7/	Mid-October through mid-December	Low
Canning River and Drainage Area 8/	Inland Fishes	March through May	Low
	Caribou	March through May	Low
	Wolf and Wolverine	End of October through May	Low
Jago River and Drainage Area	Caribou	October through May	Low to Moderate
Old Man Creek 9/	Red Fox	End of October through May	Moderate
Aichilik River 10/	Inland Fishes	October through May	Low
Upper Aichilik River and Drainage Area	Dall's Sheep	Mid-October through mid-December	Low
Coastal Plain 11/	Arctic Fox	End of October to early May	High

Source: Jacobson and Wentworth, 1982.

1/ Most residents of Kaktovik wait until freezeup before moving up the Hulahula; however, some residents transport their snow machines inland by boat after the first heavy snowfall.
2/ The First and Second Fish Holes are important staging areas for caribou hunters; the Third Fish Hole is used as a staging area for Dall's sheep.
3/ Activity is concentrated downriver from the Sadlerochit Springs.
4/ The most favored hunting area is bounded on the north by the Sadlerochit Springs and on the south by Lake Schrader.

Table IV-C-1
Spatial Distribution of Subsistence-Hunting Activities in the Kaktovik Harvest Zone
(Continued)

5/ Hunting is carried on throughout the upper Sadlerochit drainage and the Sadlerochit Mountains.
6/ The Okpilak drainage, from roughly the vicinity of the Hulahula's First Fish Hole to Okpilak Lake, is considered good caribou habitat.
7/ During recent years, Dall's sheep hunting seems to have increased, not only in the upper Okpilak but also in the upper Jago and Aichilik drainages.
8/ The Canning River has many good fishing sites, and its immediate vicinity is considered good for hunting wolves; but, because of its distance from Kaktovik, the area's utilization is low.
9/ Of particular interest is that portion of the Old Man Creek drainage between the Sadlerochit and the Hulahula Rivers.
10/ The Aichilik and neighboring Kongakut drainages were used more extensively before the area's population became concentrated at Kaktovik.
11/ The coastal plain includes particularly that area between the Sadlerochit River and Griffin Point.

the subsistence resources of the coastal plain (particularly if the reader reviewed Table IV-C-1 without any tempering considerations). However, it appears that the areas of greatest use are spread along the foothills of the Brooks Range, from the headwaters of the Jago River to the vicinity of Lake Schrader. The principal travel route to the foothills evidently is the Hulahula River, with hunters branching from it to travel up the Sadlerochit or Jago. Other potential high-use areas, such as the Canning River and its tributaries, usually are reached only during the spring. During the summer, the lower Canning is used for fishing as well as hunting. Caribou are hunted from boats along the river bank.

High-altitude, CIR-photography coverage was obtained for most of the Kaktovik area, although only post-1980 coverage was available for the southern portion. As could be expected, the better photo-processing techniques applied in the post-1980 photographs and the more favorable terrain of the southern portion of the Kaktovik area resulted in a much higher observed incidence of snow-machine activity. On the photos, indications of snow-machine use are evident around the First Fish Hole and the Sadlerochit Springs, along the east bank of the Hulahula's Second Fish Hole, and in the upper drainage of the Sadlerochit to Lake Schrader, particularly along Arctic Creek. Snow-machine activity can be discerned along the Okpilak, east of the Hulahula; the tracks trend east-west and generally are positioned on the west bank of the Okpilak (an observation that seems to be in accordance with previous statements regarding the flow of movement between the Hulahula and the Okpilak). Along the foothills of the Brooks Range, there is evidence of snow-machine activity from Lake Schrader to beyond the headwaters of the Jago River (the limit of coverage). If photographic coverage were expanded, snow-machine activity probably would be observed as far east as the Aichilik River.

In summary, overland travel occurs primarily within the river valleys or along their banks and seems to occur most frequently to pursue hunting opportunities or to transfer to other river systems--not to move overland toward a distant location. When traveling to a distant river system (i.e., the Canning), the Kaktovik Inupiat often follow the coastline and congregate at a delta before heading upstream. This rather definite orientation to river-valley travel differs in the foothills, where snow-machine tracks are found between drainage systems. When queried as to the most important elements of land navigation, the interviewed hunters cited: (1) the outline and shape of the river banks; (2) the topographic features, such as low ridges; (3) the direction of wind drifts; and (4) compass readings. The first response can be attributed to the people's intense use of river valleys. A working knowledge of the outlines of the river valleys and the proximity of certain features to favored hunting locations is considered essential by successful hunters. Elements (2), (3), and (4) characterize land navigation between the river systems, particularly on the lower coastal plain, and are indicative of the flat, shelterless profile of the plain (Kaktovik Notes, 1984).

2. Anaktuvuk Pass: Anaktuvuk Pass is located near the headwaters of the Anaktuvuk and John Rivers in the Endicott Mountains of the Brooks Range, at a site that marks the community as the only NSB village located in a mountainous setting (Fig. IV-C-4). Until the latter decades of the 1800's, the interior mountains were widely populated by the nomadic Inupiat. However, between 1890 and 1920, social and economic forces caused the inland Inupiat to

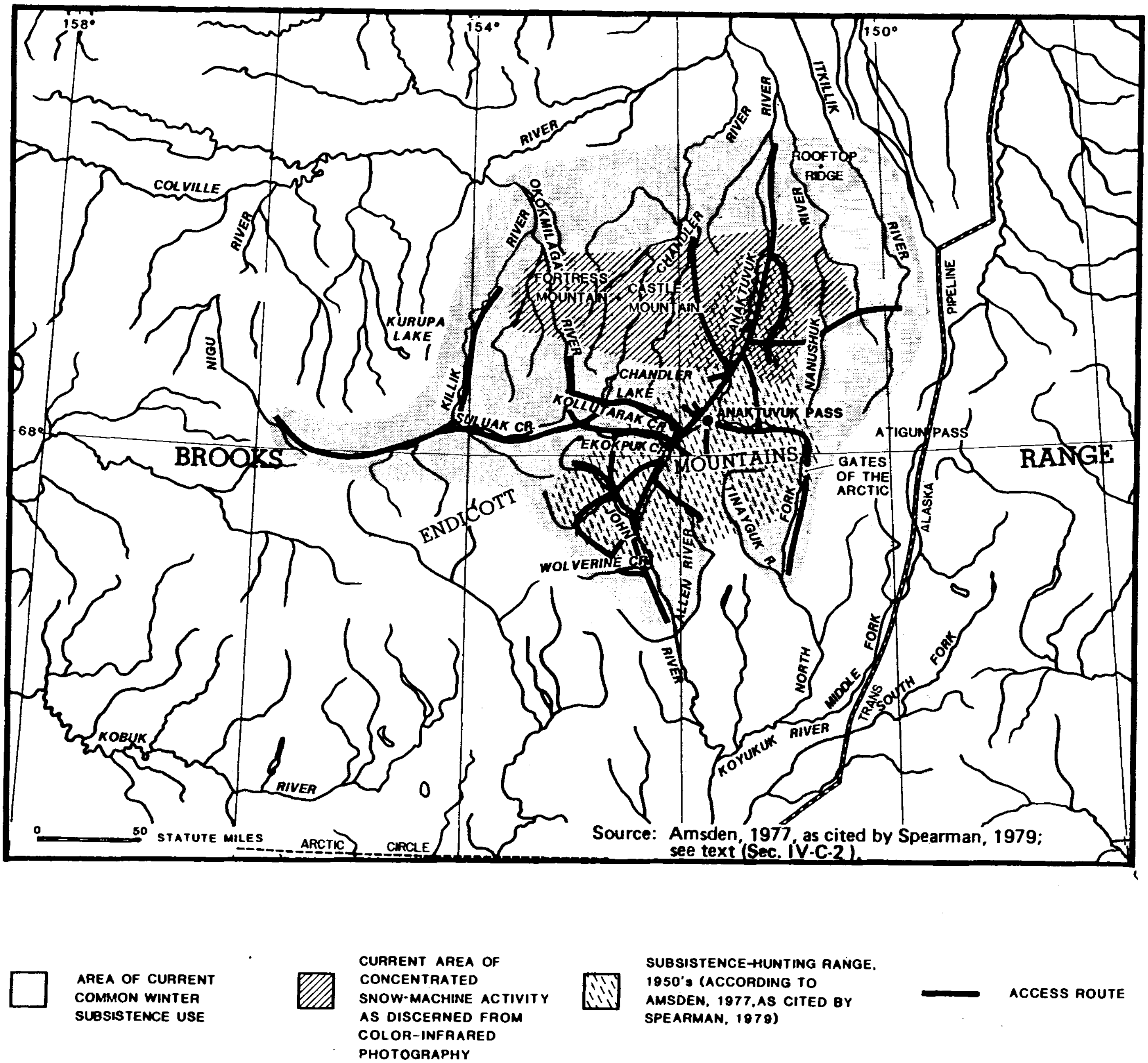


***FIGURE IV-C-4.* ANAKTUVUK PASS SUBSISTENCE-ACCESS ROUTES**

abandon their territories. By the late 1930's, some families had returned; by 1949, a band of 65 had reestablished the community around a store at Anaktuvuk Pass. A post office established at this site in 1951 reinforced the location as a central focal point. In 1961, a school was built at Anaktuvuk Pass; and mandatory attendance of all school-age children effectively ended the semi-nomadic Inupiat lifestyle. The 1970 census counted 99 residents; by 1982, the population had risen to 215 (Alaska Consultants, Inc., 1983).

The Inupiat historically ranged throughout much of the Brooks Range, entering the coastal plain and reaching the Beaufort Sea primarily by the Colville River and its southern tributaries such as the Anaktuvuk and Itkillik, which flow into the Colville from the mountainous interior. However, during the 1950's, the Inupiat hunting range shrank to the area indicated on Figure IV-C-2 as the people gradually coalesced around the present community of Anaktuvuk Pass (Amsden, 1977, as cited in Spearman, 1979). The traditional tie to the coastal lands is reflected in Graphic No. 3. Many families in Anaktuvuk Pass have relatives in Nuiqsut, and visits are common. Travel between the two communities is generally performed by aircraft; overland travel is uncommon (Pedersen, 1986, oral comm.). Thus, it is assumed that the use of coastal resources by the residents of Anaktuvuk Pass occurs in conjunction with the visitation of relatives and could not be considered, per se, a primary component of Anaktuvuk's subsistence-harvest activity. For example, James Nageak--a Barrow whaling captain--resides in, and is married to, an Anaktuvuk Pass woman. Although Nageak lives in Anaktuvuk Pass, during the whaling season he takes his boat out and hunts on behalf of Barrow. In this particular case, Nageak's primary area of subsistence activity is still a part of the general subsistence pattern of Barrow rather than Anaktuvuk Pass.

The subsistence-use boundaries shown by Pedersen (Fig. IV-C-2) can be considered the outer limits of present-day use by the community. Much of the portrayed range is used for the harvest of caribou. However, caribou are taken with great frequency near Anaktuvuk Pass because the community is close to a major caribou-migration route (Spearman, 1979). The western boundaries indicated on Figure IV-C-2 are sometimes reached during the warmer months of spring, usually in conjunction with visits to Kobuk River communities. Several Anaktuvuk Pass families retain strong ties with relatives in the Kobuk River communities and annually visit them (Spearman, 1984, oral comm.; Hall, Gerlach, and Blackman, 1985).

Inland-Inupiat-travel patterns are shaped by the mountainous region in which the people dwell--geography has focused their movement into natural corridors. Unlike their coastal kinsmen, who operate in an often featureless plain, the inland Inupiat can choose travel routes from only a finite number of valleys and passes. Therefore, it is not surprising that patterns of movement through the Anaktuvuk Pass subsistence-use area seem to have followed a consistent pattern through time.

The major routes indicated in Figure IV-C-4 are: (1) along the Anaktuvuk River downstream from the community some 40 miles north into the arctic plain, to approximately Rooftop Ridge; (2) up the Anaktuvuk River from the community over the watershed separating the Anaktuvuk River from the north fork of the Koyukuk, and then along the latter river to at least the Tinayguk River in the vicinity of Boreal Mountain and Frigid Peak (the "Gates of the Arctic");

(3) from Anaktuvuk Pass down the John River as far south as the confluence of the Allen and John Rivers; (4) from the John River westward over Kollutarak Creek to Chandler Lake, then either north into the foothills or south toward the John River; (5) from Chandler Lake via Suluak Creek to the Killik River, and down the Killik River to the foothills of the Brooks Range; or (6) westward along the Killik to the headwaters of the Nigu River and beyond. These primary routes utilize and/or provide access to virtually every major river drainage within a 70-mile radius of Anaktuvuk Pass. Most hunting and fishing opportunities are proximate to these major routes or the secondary routes that emanate from them. The foothills of the Brooks Range are used mostly for the pursuit of furbearers and some caribou. Caribou are hunted in the late summer and early fall before the southward fall migration and during the northward spring migration. Use of the foothills is most common during the longer, warmer days of spring, a time when the far-ranging pursuit of furbearers and fish generally occurs (Spearman, 1985, oral comm.).

A particular concentration of snow-machine tracks exists between the Brooks Range and the Fortress Mountain region; evidence of snow-machine activity was found from the Nanushuk River to the east, to the end of CIR-photo coverage near the Okokmilaga River on the west. The area around Fortress Mountain is of interest because it sits astride a caribou-migration corridor. Beyond the discussed foothill locations, hunting, fishing, and trapping activities occur along the Brooks from the Itkillik River on the east (sometimes as far east as the trans-Alaska pipeline) to the Nigu River region, sometimes including Kurupa Lake 15 miles west of the Killik (Spearman, 1984, oral comm.). The winter core-movement/subsistence-harvest area of Anaktuvuk Pass extends from the confluence of the Tinayguk River and the north fork of the Koyukuk River in the southeast to the Allen River to the south, to approximately the Rooftop Ridge area in the north, bounded on the east and west by the Itkillik and Nigu River drainages, respectively.

Figure IV-C-5 compares the core winter-use area with the outer range of summer ATV activities. The summer-use map is based on a 1985 study (Hall, Gerlach, and Blackman, 1985) that interviewed 30 villagers who represented various ages and lifestyles. Residents were asked to trace their summer-ATV-movement patterns (they were not asked to comment on frequency of use or nature of travel). The boundaries shown on Figure IV-C-4 can, therefore, be considered to represent aggregate use cumulative over a period of decades. Due to terrain limitations, most of the ATV movements stay within the Brooks Range and its foothills, apparently within 15 to 20 miles of Anaktuvuk Pass. On Figure IV-C-4, the bulge on the northern boundary of ATV activities represents the area where the Anaktuvuk River leaves the Brooks Range and enters the foothills. It also represents a favored caribou-hunting area (to avoid the summer heat, caribou drift up the Anaktuvuk River valley into the cooler foothills).

3. <u>Nuiqsut</u>: In 1973, the North Slope Borough reestablished the community of Nuiqsut--27 Barrow families with family ties to the Colville River region moved across country to resettle Nuiqsut at its present site near the Colville Delta (Fig. IV-C-6). The Colville River valley and the adjacent coastal lowlands comprise a traditional Inupiat harvest zone that was actively inhabited until the 1940's, at which time all of the residents--except for one family--moved to Barrow to satisfy the U.S. Government requirement that the

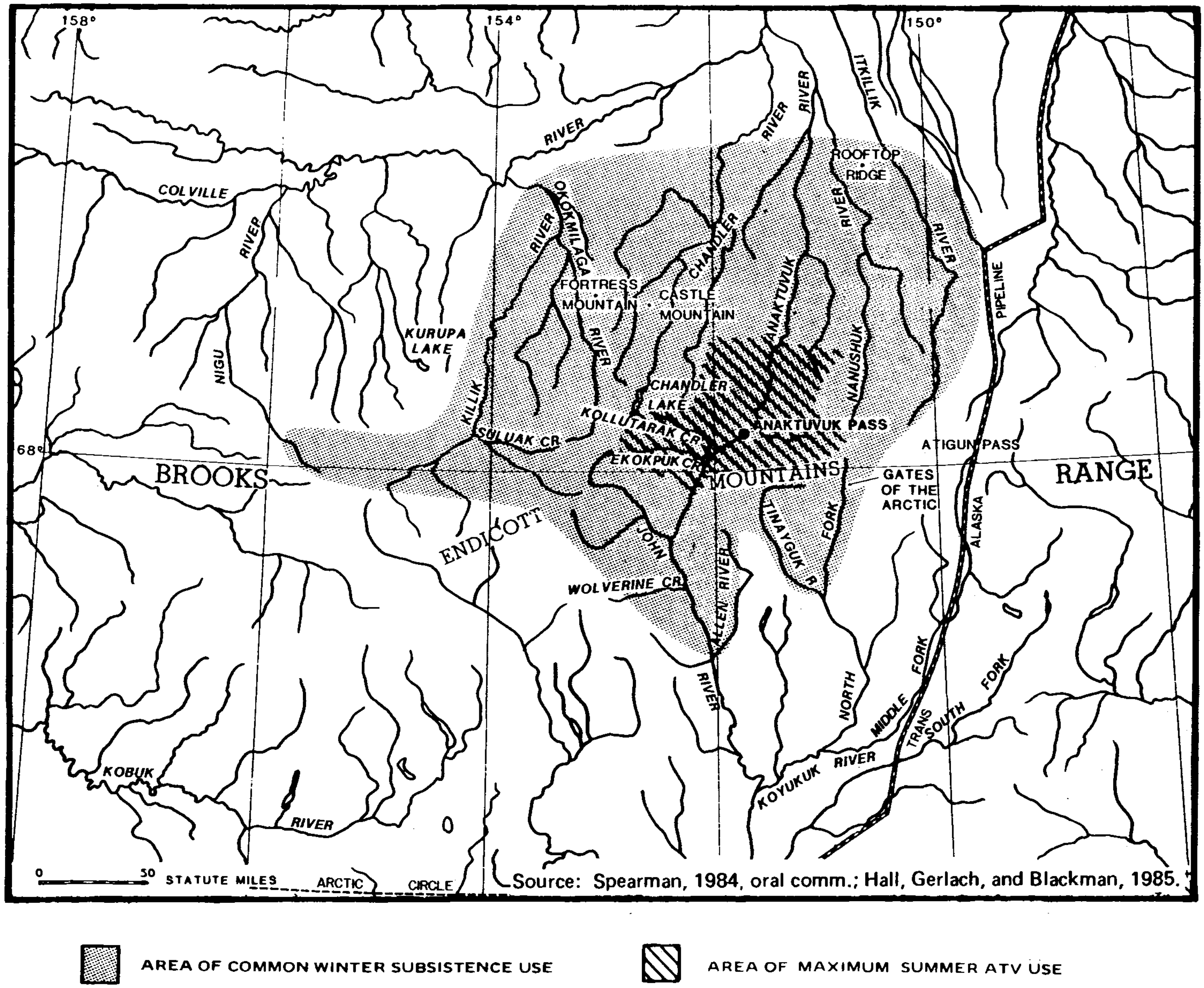
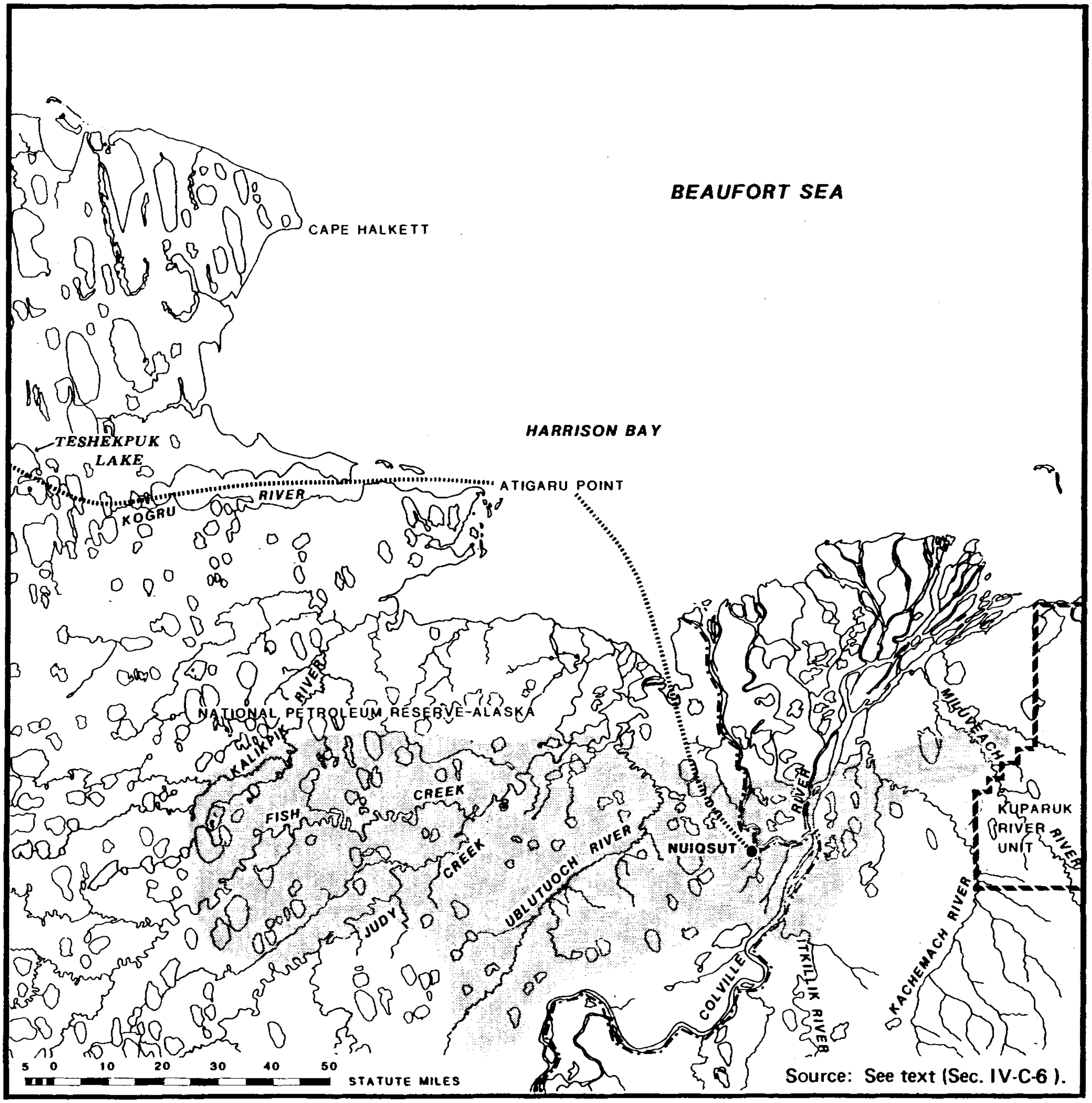


FIGURE IV-C-5. **AREAS OF SEASONAL SURFACE ACTIVITIES NEAR ANAKTUVUK PASS**



AREA OF CONCENTRATED SNOW-MACHINE ACTIVITY AS DISCERNED FROM COLOR-INFRARED PHOTOGRAPHY

WINTER INDUSTRIAL TRAIL TO BARROW AND ATQASUK

NATIONAL PETROLEUM RESERVE-ALASKA (NPRA) BOUNDARY

KUPARUK RIVER UNIT BOUNDARY

***FIGURE IV-C-6.* NUIQSUT**

children attend school. In 1974, Nuiqsut's population was 145; in July of 1982, the Borough census placed the population at 302 (Alaska Consultants, Inc., 1983).

The Colville River historically has been used by the coastal people as a link to the interior. It is the only major route identified on Graphic No. 3 as a traditional subsistence trail for the Nuiqsut area. Burch (1976) identified several routes in the upper Colville region; however, he identified only the Colville as a travel corridor in the Nuiqsut region. Beyond its function as an interregional link, the Colville River and its tributaries provide the people of Nuiqsut with an area rich in hunting, trapping, and fishing opportunities. Many of the current Nuiqsut inhabitants have a family history that identifies with the Colville. While living in Barrow, many of Nuiqsut's former residents returned to the vicinity of Nuiqsut to hunt and fish. Thus, even before moving back to Nuiqsut, the people had a storehouse of information about the area--from oral tradition as well as from personal experience (Pedersen, 1986, oral comm.).

The people of Nuiqsut do not consider the oil-related infrastructure that extends from Prudhoe Bay to the vicinity of the Colville River banks (Graphic No. 2) to be an optimum hunting area. During field work in Nuiqsut, MMS research contractors reported a directional bias in the habits of village hunters. While much was said about hunting to the north and the west, less was said about hunting to the south and the east; and the latter areas were considered to be closed off--an assumption due not just to the presence of industrial installations, but also to the hunters' perception that industrial activities have caused the quality of game to decline (SUNY, Research Foundation, 1984). Nevertheless, hunting activities occur east of the Colville; and some trapping opportunities continue within the industrial region. Because arctic and red fox can carry rabies, large populations of these species are not welcomed by the oil-rig operators. The Inupiat occasionally have been invited to set traps around the rigs to lower the number of foxes (Metz, 1984, oral comm.).

Figure IV-C-2 portrays what should be considered the outer boundaries of the subsistence area used by the community of Nuiqsut. Although somewhat dated, this is the best map of its type available. A new subsistence-harvest map for the Nuiqsut region is being drafted by the Alaska Department of Fish and Game (ADF&G) and is expected to be available in early 1987. Caribou are hunted throughout this entire range and usually are taken within snow-machine range of Nuiqsut. Caribou also are hunted farther south along the Itkillik River. Moose hunting occurs throughout the Colville River valley from the delta to, occasionally, Umiat. During the summer, fishing occurs in the Colville Delta to a point upstream from Nuiqsut. In winter, ice fishing occurs around the village and inland along Fish Creek. The more important fishing sites are located in the lower delta, 20 miles northeast of Nuiqsut. Furbearers are either hunted or trapped throughout the entire area of common subsistence use (except along the coastal plains east of the Colville). They are generally taken as "targets of opportunity" during the pursuit of other quarry (Pedersen, 1986, oral comm.). The harvesting of furbearers apparently is an infrequent motivation for hunting ventures. During 1983, only two Nuiqsut men (elders) owned and used a large number of traps; and no one in the community ran a trapline. The two elders also were the only residents to persistently hunt wolves and wolverines (SUNY, Research Foundation, 1984). The principal watercourses used in pursuing the various subsistence resources are the Itkillik, Miluveach, and Ublutuoch Rivers; Judy and Fish Creeks; and the Colville River valley. During the winter, Nuiqsut hunters venture along the coast as far east as Flaxman Island. During the summer, they travel as far east as Cross Island by boat.

Analysis of CIR photography reveals a zone of more intense snow-machine activity around the lower reaches of Fish and Judy Creeks, virtually due west of Nuiqsut (outlined on Fig. IV-C-6). Although this location is considered to have more indications of snow-machine activity than the surrounding lands, tracks from snow-machine movement can be discerned in seven general locations on the west side of the Colville. Beyond Fish Creek, Nuiqsut hunters reach the southeast shore of Teshekpuk Lake, 85 miles to the west of Nuiqsut; the east side of the lake is often visited by Barrow Inupiat. Snow-machine travel from Nuiqsut to Barrow occurs occasionally (Pedersen, 1986, oral comm.). East of the Colville, the few snow-machine tracks observed occurred at or near the mouths of the Itkillik, Kachemach, and Miluveach Rivers. Farther east, ground disturbance due to oil-exploration activity has made the identification of snow-machine tracks difficult and unreliable.

Nuiqsut may be the first NSB community to be connected by the Dalton Highway to the North American road network. Thirteen million dollars of Federal highway funds have been appropriated by the State of Alaska for performance of feasibility studies on a gravel highway that would connect Barrow and Deadhorse (current terminus of the Dalton Highway). Considering the lengthy permit-review and environmental-analysis process, it will be several years before the proposed highway is constructed. The ultimate effect of road linkup on the subsistence-hunting and personal-travel habits of the community is unknown. However, since 1983, ice bridges have been constructed across the Colville. The first bridge facilitated drilling on a lease held by the Arctic Slope Regional Corporation; the second bridge--built in 1984--enabled the village to respond to a fuel crisis. Since then, the people of Nuiqsut have annually constructed an ice bridge across the Colville and traveled freely through the Prudhoe Bay industrial complex and on the Dalton Highway (Smith, Copeland, and Grundy, 1985; Pedersen, 1986, oral comm.). In summary, although the report prepared by the SUNY Research Foundation indicated a preference by Nuiqsut hunters for the west side of the Colville River--and an analysis of CIR-infrared photographs seemingly revealed evidence of greater snow-machine activity to the west of the Colville--it is premature at the present time to make a blanket statement regarding the hunting range of the Nuiqsut Inupiat. Additional data regarding Nuiqsut's subsistence-hunting habits need to be collected to determine the scope, intensity, and primary location of subsistence activities. Information gathered by the Subsistence Division of the ADF&G has not yet been published.

4. Barrow/Atqasuk: The communities of Barrow and Atqasuk are treated as a combined unit because the people of the two communities share a common ancestry and subsistence-harvest zones that overlap (Fig. IV-C-7). In 1884, a whaling station was established at the Barrow townsite; however, the community predated the station by many years. Barrow, the largest Inupiat community in North America and the seat of the North Slope Borough (1982 population: 2,882), is the focus of the Borough's oil-related wealth and the home of many individuals who are employed in the transportation, engineering,

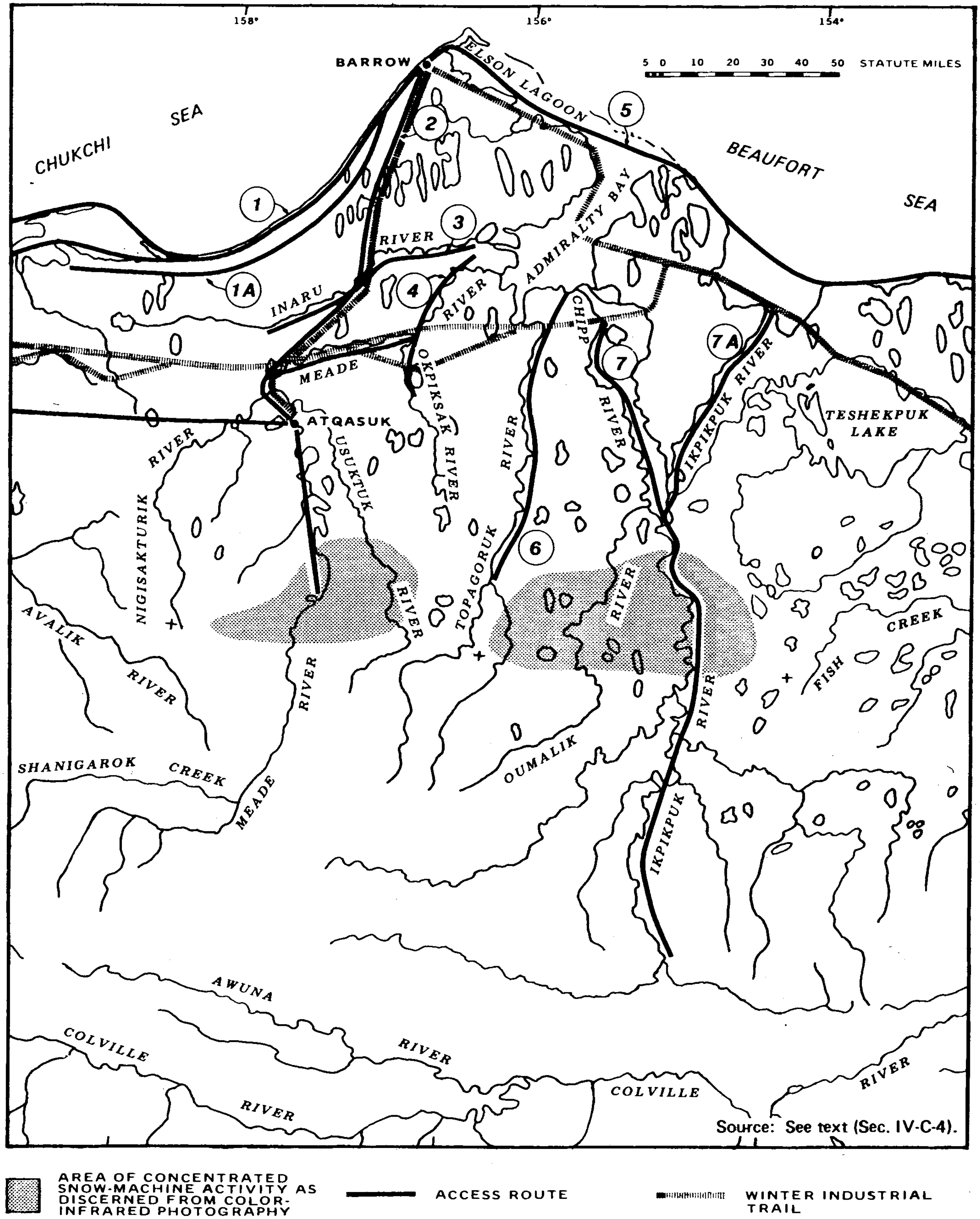


FIGURE IV-C-7. **BARROW/ATQASUK SUBSISTENCE-ACCESS ROUTES**

and administrative sectors. Atqasuk was reestablished in 1976 as a planned community populated by Inupiat from Barrow (1982 population: 210). Located some 60 miles southwest of Barrow on the banks of the Meade River, Atqasuk was constructed on the site of Tigaluk, a traditional base camp for hunting, trapping, and fishing. Tigaluk also was the location of a small subbituminous coal mine that began operating during World War II. The coal was transported by tractor-train to Barrow and used by Eskimos in Barrow, Tigaluk, and other nearby locations. By the early 1960's, natural gas had displaced coal; and coal-mining operations ceased (Nageak, undated).

In discussing the travel habits of the Barrow Inupiat with the people of other NSB communities, a common remark was, "They go all over." The outer range of the Barrow Inupiat extends from Nuiqsut in the east to Wainwright in the west, and from the upper Colville River in the south to the Beaufort Sea. This area is understandably the largest of any of the NSB communities' subsistence-harvest zones. During the 1970's, Barrow's harvest zone appears to have undergone a substantial increase, a probable continuation of the expansion set in motion during the 1960's. Figures IV-C-1 and IV-C-2 contrast the harvest zone--as construed by the NSB in 1974--with the boundaries calculated in a 1979 publication sponsored by the NSB. Allowing for time lags in data collection, errors in sampling, and different methodologies, it still appears that Barrow's subsistence-harvest zone has expanded. In the east on Figure IV-C-1 (1974), Barrow's harvest zone stopped short of the Colville and sloped sharply to the west. In Figure IV-C-2 (1979), the boundaries for the same quadrant extend beyond the Colville into the Kuparuk oil field and follow the Colville south to Umiat. In the south, Figure IV-C-1 indicates that the southern subsistence-use boundary terminated short of the Brooks foothills; Figure IV-C-2 pushes the boundary to the Colville. In the west, Figure IV-C-1 shows the boundary terminus at Kugrua Bay; Figure IV-C-2 shows a boundary at Wainwright on the Kuk River Inlet.

The expansion of Barrow's subsistence-harvest zone can be attributed to at least four factors. The first growth factor is population exported from Barrow--both Nuiqsut and Atqasuk were established primarily by people from Barrow. Close familial ties remain among the three communities, and hunting trips and visits are often combined. This includes a sharing of the extended families' hunting and/or trapping areas. When interviewed in Barrow, two respondents spoke about their younger relatives traveling to Atqasuk to use it as a base camp for hunting efforts farther into the interior (Barrow Notes, 1984). This type of use is consistent with Atqasuk's history as a base camp for interior hunting.

The second reason for expansion of Barrow's subsistence zone may be income; the beneficial economic effects of oil revenues accrued by the NSB have tended to focus in Barrow, resulting in a proliferation of job opportunities. While these individuals may not have time for extensive hunting activities, they do have the equipment to hunt extensively during weekends and vacation periods. Third, the current economy of Barrow is such that a higher proportion of the youth is staying home because there are job opportunities. These employment opportunities also are drawing a number of Inupiat from other NSB communities, which tends to introduce an increasing number of younger and possibly more adventurous hunters into Barrow's subsistence-harvest zone.

Finally, and perhaps most significantly, the natural population of Barrow has increased relatively far beyond that of other NSB communities during the last four decades. In 1939, the population was estimated at 363; in 1982, a census counted 2,882 residents. Between 1980 and 1982, Barrow's population increased 30.6 percent, primarily as a result of economic opportunity. The composition of Barrow's population is particularly interesting for two reasons: (1) the population is very young (the median age of Barrow's Native males is 23.1 years); and (2) the Native proportion of the population is decreasing (in 1970, 90.5% of Barrow's population was Native; by 1982, the Native component of the population had fallen to 77.9%). Because many recent non-Native arrivals are younger men capable of extensive hunting activities, a question arises regarding the proportion of total hunting activities that can be attributed to these non-Native newcomers (Alaska Consultants, Inc., C.S. Courtnage, and Stephen Braund and Assoc., 1984). In summary, Barrow's subsistence-harvest zone has increased principally due to four factors: (1) population export, (2) income levels that have allowed individuals to acquire the time and technology to hunt extensively, (3) the introduction of an increased number of younger males, and (4) the growth--in absolute terms--of Barrow's population.

Figure IV-C-7 indicates several routes that emanate from Barrow. Route 1 and the inland alternate, Route 1A, are used for travel toward Peard Bay and Wainwright. Depending on ice/snow conditions, a traveler may choose either the interior or the coastal path (Route 2). The main Atqasuk route was originally a trail to the inland community of Tigaluk, which is near a coal mine. Located near the present site of Atqasuk, Tigaluk was abandoned in the 1960's. This corridor is perhaps the most continuously traveled of any on the North Slope and may be the future alignment of an electric-transmission line to be constructed by the Borough. Route 3, which passes from Admiralty Bay inland through the Inaru River, is a much-used subsistence area. Route 4 proceeds up the Meade River from Admiralty Bay. A branch of this route passes down the Okpiksak River. Route 5 typifies a cluster of coastal and landfast-ice-based routes that follow the coastline toward the Colville. The Inupiat of Barrow travel extensively along the coast, hunting along the ice edge for seal or an occasional polar bear. From year to year, their travel patterns vary, depending upon ice conditions and the time of year. Route 6 coming off Admiralty Bay traverses the Topagoruk River some distance into the interior. Interestingly, Route 7, which travels down the Chipp River and joins the Ikpikpuk River, was identified only as a summer route on the 1974 map (Route 7 was added to this report in response to information gathered from several local sources).

Conversations with the Barrow Inupiat and a review of CIR photography lend credence to the assumption that subsistence-related travel continues along the Ikpikpuk and the Meade Rivers into the foothills of the Brooks Range. The Ikpikpuk-Colville route was a dogsled trail discussed by Burch (1976) in his paper on traditional overland-hunting routes. Subsistence activities probably extend to the Colville drainage.

Although the aforementioned routes could still be considered the principal corridors of movement, they were identified in the early 1970's prior to the reestablishment of Atqasuk. Through its status as an established community and its close kinship ties with Barrow, Atqasuk's location has reinforced interior-travel patterns. Movement has tended to become more channeled through the old coal-mine route and more intense along the Meade River, although travel to Wainwright also has occurred. The inhabitants of Atqasuk, who lack immediate access to the sea, travel to Barrow to join their relatives in hunting seals and other marine mammals. This reciprocal movement has further solidified the Barrow-Atqasuk corridor as the region's principal travel route.

Atqasuk's hunting and fishing activities could be considered a subset of the larger field of Barrow's activities. Figure IV-C-2 indicates an approximation of the Atqasuk subsistence-harvest zone in relation to the Barrow zone. However, Atqasuk's subsistence activities are focused on the Meade River (see Fig. IV-C-7), which is used intensively throughout its length, with activity occasionally occurring as far upstream as the headwaters. Historically, the Meade was used as part of an overland route to the upper reaches of the Noatak (Schneider, 1985). In addition to the Meade, the Usuktuk, Shaningarok, Nigisaktuvik, and Inaru River drainages (Fig. IV-C-7) also comprise an important component of Atqasuk's subsistence zone (Nageak, undated); these five drainage systems approximate Atqasuk's inland-subsistence boundaries. This outline appears to be a rough fit with the 1979 subsistence-harvest-area map compiled for Atqasuk (Pedersen, 1979). However, both Nageak's and Pedersen's works were published soon after the establishment of Atqasuk, whose population has almost doubled since the late 1970's. Therefore, it is likely that Atqasuk's subsistence-harvest zone also has expanded.

During the late 1970's, an undated NSB-sponsored study by Lloyd Nageak (and several Barrow residents) attempted to deal with the spatial issues of subsistence use. After delineating Barrow's general subsistence-harvest area (which, interestingly, seems to be an intermediate case between Figs. IV-C-1 and IV-C-2), Nageak divided the subsistence-harvest area into three intensity zones: (1) the first, a 12-mile-wide corridor, is located adjacent to river systems within the use area to at least the 100-foot-elevation contour; (2) the second, extending southward, occupies the area between the major north-south-trending rivers and truncates along an east-west line from the Price to the Meade Rivers (there are indications that it may extend farther up the Meade); and (3) the third area, one of marginal subsistence use, extends into the Brooks foothills to elevations that exceed 500 feet. The river systems that Nageak specifically included as conduits of movement for this region were the Inaru, the Meade, the Topagoruk, and the Ikpikpuk (Nageak, undated) (Fig. IV-C-7).

Much of the movement along these rivers in the first intensity zone occurs in summer, during fishing and caribou-hunting activities. While the rivers are used for boat movements, the river banks and bluffs provide reference points for both summer and winter movement in an otherwise featureless plain and are navigational essentials for overland travel. Thus, the river valleys are both corridors of movement and areas of concentrated subsistence use. The second intensity zone--between the river systems--is used primarily in winter and comprises the major post-freezeup caribou-hunting grounds. The third intensity zone is characterized as a marginal caribou-hunting zone in the foothills of the Brooks Range (Nageak, undated).

In discussing land navigation with some of the Barrow elders, they noted the subtle landforms that were used as reference points and emphasized the importance of memory. Some of the landforms referenced were the outlines and orientations of lakes, the contours of bluffs, the outlines of rivers at certain points in their courses, the alignment of snowdrifts, personal shadow, and virtually anything else that could be used as a point of reference in a relatively featureless landscape. However, the subtler features of arctic geography change from year to year and thus require an annual learning process. For instance, the course of a major river is not followed, per se, except during periods of inclement weather; instead, travelers memorize the serpentine outline of each watercourse and steer off the landmark bends--in contrast with the navigational practices of Kaktovik and other eastern communities, where topographic conditions have created straighter watercourses. When traveling near or offshore of Barrow, the Inupiat from other coastal communities memorize the prevailing ice geography. Different topographic features occur each year; once ice formations are formed in the nearshore areas of the frozen Beaufort and Chukchi Seas, they persist each year until the spring thaw.

CIR-photographic coverage was obtained for most of the Barrow/Atqasuk zone. Because post-1980 photography is available only for the southern portion of the arctic slope, this discussion is limited to that area. In general, CIR coverage shows a landscape well marked by vehicular traffic. An area beginning on an eastward line 10 miles south of Atqasuk, intersecting both the Topagoruk and the Ikpikpuk Rivers and extending south along their banks some 30 miles (Fig. IV-C-7), appears to be well used--probably by snow machines. The heaviest point of use within the zone appears to be along the banks of the Ikpikpuk. Other areas of apparently above-average use in the south are the Meade River corridor as it leaves a region of pothole lakes and the middle portion of the Usuktuk River. Snow-machine tracks appear in the south to the edge of the photographic coverage and indicate activity in the Brooks Range foothills, especially around the Meade and Ikpikpuk drainages.

5. Wainwright: The community of Wainwright is located near the entrance to the Kuk River estuary, an area rich in waterfowl and aquatic life (Fig. IV-C-8). In the early 1900's, a whaling station was established near Wainwright (Bockstoce, 1985, oral comm.). As of 1980, the resident population was 404. The Kuk River estuary is an abundant source of fish and game and is the principal source of subsistence resources for the community of Wainwright. Caribou are hunted along the Kuk and its tributaries, which are navigable throughout most of the river's extent and used most intensely during late spring and fall.

After freezeup, the Inupiat of Wainwright range along the coast and far into the interior. Figures IV-C-1 and IV-C-2 indicate the approximate boundaries of subsistence activities in 1974 and 1979, respectively. While much of this range was utilized for caribou hunting, virtually all of it was used for hunting and trapping furbearers. Some moose are taken by hunters in the far interior near the headwaters of the Utukok and the Colville Rivers (Fig. IV-C-8) (Nelson, 1982), and a few moose have recently been taken along the Kuk (Luton, 1985). A review of Figures IV-C-1 and IV-C-2 reveals a definite nonconformity between the southern and western boundaries of the two hunting zones. The northern and eastern boundaries are somewhat aligned, showing a terminus of most activities around Peard Bay, then extending eastward past

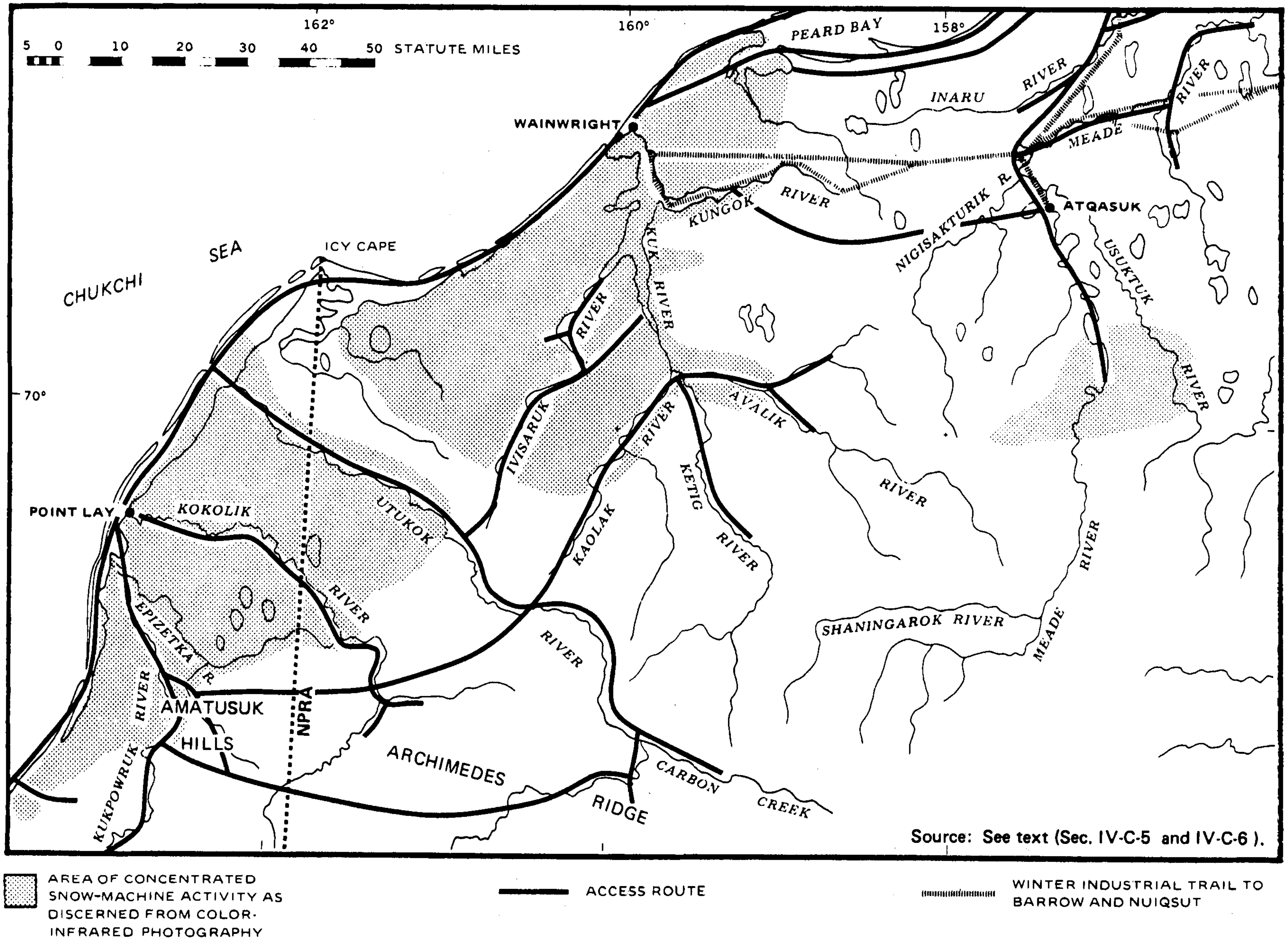


***FIGURE IV-C-8.* WAINWRIGHT SUBSISTENCE-ACCESS ROUTES**

Atqasuk, and then southward following the east bank of the Meade River. However, during the late 1970's, the boundary of subsistence activities was extended south past the Colville River and along the coast southwest to a point midway between Point Lay and Point Hope. This harvest-zone expansion was discussed with G. Ray Bane (1984, oral comm.) and addressed by Nelson (1982) in his work, Harvest of the Sea: Coastal Subsistence in Modern Wainwright. Nelson and Bane agreed that, after a long period of contraction, the territory regularly used by the people of Wainwright has expanded back to the extent of the traditional hunting grounds. Nelson stated that areas visited infrequently during the last three decades are now visited regularly (i.e., the headwaters of the Meade, Utukok, Kokolik, and Colville Rivers).

Figure IV-C-8 indicates the general overland-travel patterns used by Wainwright hunters. The Kuk River estuary and its tributaries are the center for both summer and winter movement. An area of abundant wildlife, the Kuk has been identified by Bane, Nelson, and others as the focus of Wainwright's subsistence activities. Caribou and wildfowl are taken along the Kuk and its navigable tributaries until freezeup. After freezeup, some of the Wainwright residents ferry their snow machines to certain points along the Kuk using four-wheel-drive vehicles, in preparation for an extended overland journey (Luton, 1984, oral comm.). A favorite point of departure is the intersection of the Kaolak and Ketig Rivers, a prominent fishing site. From this point, the hunters can proceed up the Kaolak, the Ketig, or the Avalik Rivers. The first two rivers can be used to reach the Utukok, while the headwaters of the Meade can be reached from the Avalik. The Utukok is used throughout its extent; and hunters follow it upstream to its source, branching off into its tributaries (such as Carbon and Disappointment Creeks--the latter waterway is used as a passage to the headwaters of the Colville).

Point Lay interviews revealed that Wainwright hunters very often pass through Point Lay, heading north after completing a "grand circuit" of the interior (Point Lay Notes, 1984). Wainwright hunters often use the Kaolak or Ketig Rivers for travel to the south. At the foothills of the Archimedes Ridge, they turn west toward the Kukpowruk River and, upon reaching it, follow it to Point Lay. On more adventurous journeys, the hunters travel up the Utukok to Carbon Creek and then follow Disappointment Creek to the south, turning west in the valley south of the Archimedes Ridge (or in any other suitable valley). This route takes the hunters to the Kukpowruk River; or they continue to the seacoast, where favorable ice conditions can ensure more rapid transport to the north. These are just two examples of several patterns the Wainwright Inupiat employ in "sweeping" the terrain south of their community. Although interior travel occurs at any time during the snow season, longer journeys generally are saved for the warmer, spring months.

In addition to the Ketig, Kaolak, and Avalik Rivers, the Ivisaruk and Kungok Rivers (tributaries of the Kuk River) are also used. Hunters travel the Ivisaruk to the Utukok. The Kungok is a well-used winter-subsistence area and often is used as the starting point for the Atqasuk trail (Bane, 1984, oral comm.). The coastline north and south of Wainwright is used for travel because the relatively flat shorefast ice provides an excellent surface for movement. In those periods when the shorefast ice has not hardened enough to sustain the weight of snow machines, land along the coastline is used for travel. If the ice is smooth, hunters often venture farther out. To the north of Wainwright, a series of ravines dissect the coastline and require the traveler to venture inland some distance when the strength of the shorefast ice is not reliable.

A review of CIR photographs yields evidence of snow-machine activity over 60 percent of Wainwright's subsistence-harvest range. Evidence of activity can be discerned on the banks of the Kuk River and along its principal tributaries, on the Utukok River, and over the entire coastal plain between the Ivisaruk River and the Arctic Ocean. Figure IV-C-8 shows the areas where activity seems most distinct; these include an area across the Kuk southwest of Wainwright, an area between Kolipsun Creek and the Kungok River, and the lower midregion of the Utukok. Because the Utukok is an intensely used subsistence area for both Point Lay and Wainwright, one could presume that many, if not the majority, of the snow-machine tracks identified by the CIR photography were made by the Inupiat of Point Lay.

Although no analysis similar to Nageak's study of the spatial component of Barrow's subsistence travel/land use has been performed for Wainwright, some similarities in travel patterns can be discerned between the two. Both communities apparently base their winter-travel patterns on those of summer travel (a situation somewhat dissimilar to Point Hope, Anaktuvuk Pass, and Kaktovik). Well-traveled waterways form the framework for channels of winter travel by providing hunters with reference points for land navigation. Bane (1984) noted this tendency for river-valley travel--Wainwright hunters prefer to travel in river valleys, which provide protection from wind and willows for fire, and (unlike the windblown-upland areas) usually have a snow pile that facilitates snow-machine travel.

In summary, based on the criteria that Nageak applied to Barrow, one may surmise a three-tiered subsistence-harvest/travel-intensity zone for Wainwright: (1) intense use of the lands immediately surrounding the Kuk River valley, followed by (2) active winter use of the flatter lands between the major river systems, with (3) gradually declining use toward the more mountainous headwaters of the major rivers.

6. Point Lay: The community of Point Lay is located immediately south of the mouth of the Kokolik River on the shores of Kasegaluk Lagoon (Fig. IV-C-8). Residents of this area historically were spread along the coast in small family bands that began to consolidate at Point Lay during the 1920's. A trading post and school were established in the community during the 1930's; by 1939, there were 117 residents (Alaska Consultants, Inc., 1983). However, during the 1940's, the population began to decline. Reindeer herding, which augmented the subsistence diet, ceased due to the collapse of the market for meat; and residents departed for better living and working conditions in other communities. The population loss continued through the 1950's. In the 1960's and 1970's, the U.S. census count did not recognize Point Lay as an established community because of its small population (Alaska Consultants, Inc., 1983). In 1970, the Inupiat--primarily from Wainwright, with family ties to the Point Lay area--began to reestablish the community. By 1971, a school had opened in Point Lay. In 1977, the community was moved from its original site on the barrier spit to an island in the Kokolik River Delta, and finally to its present location near the DEW-Line Station in 1981. In 1982, the population was estimated at 105.

Like Atqasuk and Nuiqsut, Point Lay is a product of the NSB's effort in the 1970's to recolonize lands once used extensively for subsistence harvesting. Figure IV-C-1 (areas of subsistence interest in the early 1970's) does not illustrate a subsistence-harvest zone for Point Lay. The community was in the midst of reestablishment at that time, and its harvest zone probably had not been formalized. Figure IV-C-2 indicates the approximate outer range of the Point Lay subsistence-harvest zone in 1979. Just as Atqasuk's subsistence-harvest area is a subset of Barrow's, Point Lay's subsistence area--for the most part--functions within Wainwright's larger subsistence-harvest zone. To the southwest, Point Lay hunters travel as far as the Utukok tributary of Carbon Creek (Fig. IV-C-8); to the south, they travel to Igloo Mountain and the Pitmegea River system (Fig. IV-C-9); and to the north, they travel to Icy Cape and inland to the southern tributaries of the Kuk River. In interviews regarding village-hunting habits, the mature hunters indicated a preference for the areas south of the Utùkok (Point Lay Notes, 1984). Of particular interest are the areas to the extreme south, where wolf and wolverine can be taken. The Pitmegea River drainage and Igloo Mountain region probably are outside of Wainwright's commonly used subsistence zone.

According to local elders, movement by Point Lay hunters tends to concentrate within about 50 miles of the coast--between Cape Beaufort and Icy Cape. This is particularly the case for the younger hunters (Point Lay Notes, 1984). Caribou usually can be taken in relatively close proximity to Point Lay; however, during the winter of 1983-1984, hunting was extremely poor, and the hunting range was extended southwest into the Point Hope region and northeast to nearby Wainwright. One of the more adventurous Point Lay hunters stated that use of such an extensive coastal range is rare and that hunters seldom proceed northeast of Icy Cape or south of the Pitmegea River.

In the interior, three river systems are widely used--the Kokolik, the Utukok, and the Kukpowruk. The area between the Utukok and the Kokolik is the most extensively used of any of Point Lay's interior subsistence-harvest zones. A variety of game is either hunted or trapped in this area. A particularly notable area is characterized by a small uplift--approximately 12 miles by 12 miles--located 40 to 50 miles inland between the rivers. This landform reaches an elevation of 500 feet on its southeastern flank and is frequently used for hunting, trapping, and observing of game (Point Lay Notes, 1984). A fall-caribou-migration path is located near this area (University of Alaska, AEIDC, 1974). A commonly used interior-travel pattern involves moving north to the Utukok, following the river to the Brooks Range foothills, then cutting back along the Kokolik or along the face of the Kiklupiklak Hills to the Kukpowruk. More extended journeys find some hunters taking the Utukok to near its headwaters, then passing west through the valley north of Archimedes Ridge to the Kukpowruk (Fig. IV-C-8).

The Kukpowruk River, the site of a number of major fishing camps, is used as a primary route to the south, particularly during periods of bad or questionable weather. The Inupiat interviewed in Point Lay stated that the rivers were used as navigational-reference points (Point Lay Notes, 1984); however, because of their meandering nature, the rivers are followed only during periods of bad weather. The Kukpowruk is most often used to pass into fur-trapping regions south of the Amatusuk Hills. However, because of the

Kukpowruk's often-narrow, meandering course, some hunters prefer to use the coastal landfast-ice zone during good weather for transit south of the hills and passage inland through a convenient ravine.

Because high-altitude, CIR-photographic coverage of the Point Lay area is mostly complete and relatively recent, photo analysis yields some interesting results. The snow-machine route discussed above is quite visible for several miles--to Igloo Mountain. A fall-travel route, this trail evidently has been used for some years (Fig. IV-C-9). In general, snow-machine activity appears to be widely dispersed over the coastal plain, with few areas of concentration. One concentration area mentioned in Section IV.C.5 (Wainwright) appears to occur along the lower reaches of the Utukok River. Another suggested area of concentrated activity is located around the shallow rise between the Utukok and the Kokolik Rivers (discussed above). However, it must be noted that portions of the rise are more exposed to wind, have less snow cover, and thus are more prone to scarring by snow machines.

7. Point Hope: When a whaling station was established on Point Hope Spit in 1887, contact with Euro-Americans was already quite regular--Yankee whalers had frequented the area since 1849 (Fig. IV-C-9). In 1890, a mission school was begun; and in 1908, the establishment of a reindeer-herding station provided a further impetus to population consolidation. By 1920, the community had become sufficiently dominant to justify relocation of the area's Government school from an adjacent community to Point Hope. Point Hope's current population is approximately 540 (June 1982), an increase over a low of 260 counted during the 1940's. During the period 1980-1982, Point Hope's population increased by 64, due primarily to NSB-construction activities (Alaska Consultants, Inc., 1983).

Among the NSB communities, Point Hope has the smallest subsistence-harvest zone in both relative and absolute terms. Figures IV-C-1 and IV-C-2 identify Point Hope harvest zones in 1974 and 1979, respectively. During the 1970's, when harvest zones for other communities were being redefined and/or expanded, the Point Hope zone apparently remained static or actually contracted. Several factors may contribute to the continued existence of the community's comparatively small and stable subsistence-harvest zone. The primary factor was, and is, the abundance of hunting and fishing opportunities within the region. G. Ray Bane (1984, oral comm.) and others have pointed out that Point Hope has a proportionately higher level of available subsistence resources than other NSB communities. Depending on the season, bowhead and beluga whales, walrus, seals, and polar bear may be found in coastal waters/ice near Point Hope. During the summer, seabirds inhabit the lagoonal marshes and cliffs along the coast and nest in the cliffs in sufficient numbers to encourage community residents to harvest the eggs. Moose and grizzly bear are taken in the interior. Beyond the Lisburne Hills--in the foothills approaching the DeLong Mountains--fox, wolf, and wolverine are trapped. Caribou also migrate through the area and often winter near, or on, the Lisburne Peninsula. The generally abundant caribou are taken in both summer and winter. During the winter of 1983-1984, Point Lay hunters had great difficulty locating caribou and traveled south to the Lisburne Peninsula to find suitable hunting opportunities. Point Hope hunters apparently did not, and seldom do, suffer a similar situation (Point Lay Notes, Point Hope Notes, 1984).

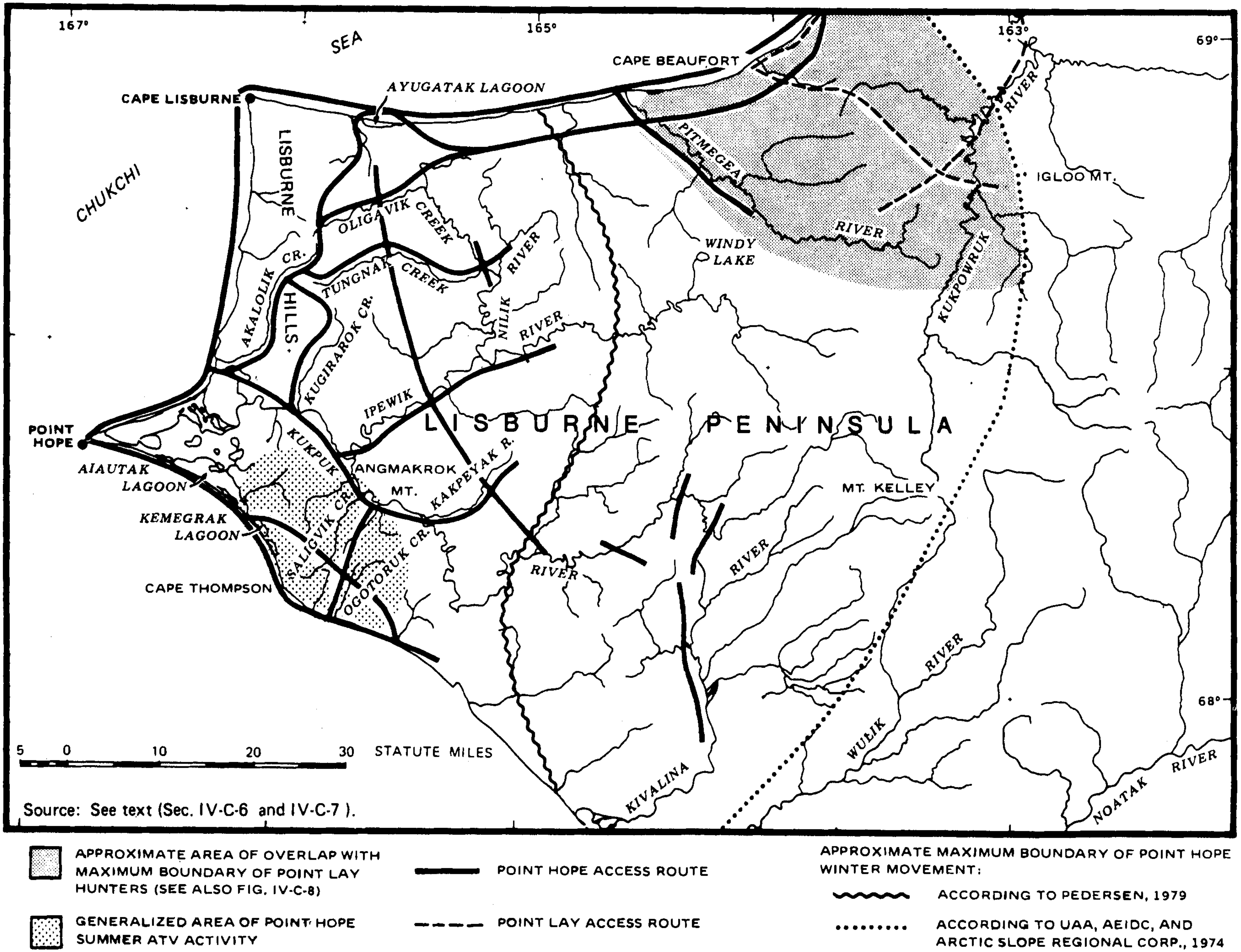


***FIGURE IV-C-9.* POINT HOPE SUBSISTENCE-ACCESS ROUTES**

Two Point Hope subsistence-harvest boundaries are shown in Figure IV-C-9. The inner boundary corresponds to that indicated in Figure IV-C-2; the outer boundary is taken from Figure IV-C-1. Local people stated that the more adventurous hunters sometimes travel to Kivalina via the Kivalina River, then penetrate to the vicinity of Mount Kelly to the east, and cross the Pitmegea River to the north (where they have been seen by the Point Lay Inupiat). The spatial extent of this activity is somewhat consistent with the boundaries portrayed in Figures IV-C-1 and IV-C-2. However, discussions with the Point Hope Inupiat indicate that active travel and hunting efforts generally tend to focus between the coast and 40 to 50 miles inland, specifically between the sea and the Lisburne Hills--a realm of activities more in keeping with Pedersen's portrayal (Fig. IV-C-2).

Unlike the residents of other NSB communities, Point Hope's summer use of its subsistence-harvest zone is not limited to navigable-river systems and a narrow corridor along the waterway. Because Point Hope residents are not constrained from summer vehicular travel in the interior by excessively marshy or mountainous terrain, extensive ATV travel occurs during the snow-free months. Most ATV use is contained between the Lisburne Hills and the Arctic Ocean and extends from the Akalolik Creek in the north to the Kivalina routes in the south (see Fig. IV-C-9). The hills to the south of Point Hope and the east ridges were pointed out as areas of particularly concentrated ATV use (Point Hope Notes, 1984).

Some of the subsistence trails used by Point Hope residents (Fig. IV-C-9) are a refinement of the information indicated in Figure IV-C-1. Although the topography of the Lisburne Peninsula is gentler than that of Anaktuvuk Pass, it is sufficiently steep to channel movement inland from Point Hope. The trails used by the people of Point Hope are very well defined--so much so that some trails have assumed the status of quasi-roads. In fact, the Akalolik Creek route has been staked; during favorable winter conditions, the people of Point Hope occasionally travel to and on the creek in four-wheel-drive trucks. The Akalolik River routes, the Pitmegea River route, the routes emanating from the Kukpuk River, the various coastal routes to Kivalina, and the interior route to Kivalina are shown in the northern portion of Figure IV-C-9 and discussed in the following paragraphs.

Beginning at the mouth of the Akalolik, a summer and winter trail passes north along the creek into the Lisburne Hills. Toward the headwaters of the Akalolik, the trail forks up the canyon of a tributary creek, across a low watershed into the headwaters of Tungnak Creek. After passing over the Akalolik watershed, the route splits again, following a fork of Oligavik Creek. The Akalolik route terminates at a cabin near Ayugatak Lagoon. From the lagoon, the coastal-ice route can be followed north to Point Lay. Given unfavorable ice conditions, travelers generally swing inland along Isuk Creek to avoid coastal ravines. During the spring months, the Pitmegea River system is reached via the coastal route. The Pitmegea is followed to the Windy Lake area, where Point Lay and Point Hope residents are most likely to meet during subsistence-harvest activities. The Kukpuk River routes--primarily winter routes--provide the principal access into Point Hope's central and southern hinterlands. The Kukpuk River, which feeds into the lagoon and marsh system immediately east of Point Hope, is navigable to the junction of the Ipewik River and contains a number of fishing/hunting camps that are used in all seasons.

The first route to split off of the Kukpuk travels up Kugirarok Creek and its tributaries. This route is used in both summer and winter, primarily for the pursuit of caribou. The watershed of the left fork of the Kugirarok is occasionally used to cross into Akalolik Creek. At the intersection of the Ipewik, a winter route follows the Ipewik River northeast into the interior. This route can be plagued by extreme winds in its path through the Lisburne Hills. Near Angmakrok, another route that is also subject to extreme winds forks off of the Kukpuk and down the Saligvik and Ogotoruk Creek valleys to join the coastal routes. The main Kukpuk route continues into the interior, following the Kakpeyak River. The fourth group of routes along the coast is used in both summer and winter for hunting and traveling south to Kivalina. During the winter, travel to the south is generally accomplished by moving along the coast on the landfast-ice zone. In those periods when the conditions prohibit offshore travel, an interior route is used. This trail begins at Kemegrak Lagoon and passes inland to the Ogotoruk valley, to a landing strip just south of Cape Thompson on the coast. An alternative trail continues inland. The last route is sometimes used by hunters of the interior who wish to terminate their efforts by visiting relatives in Kivalina. This route down the Kivalina River is used as part of a hunting excursion, whereas the trails along the coast are used primarily for travel to Kivalina.

In addition to these defined travel patterns, the entire eastern flank of the Lisburne Hills serves as an area of subsistence-related movement, as does the coastline between Cape Thompson and Point Lisburne. In the former case, hunters tend to travel along the bases of the hills; in the latter case, during periods of favorable ice conditions, hunters travel the coastline, darting up and down the narrow coastal-river valleys.

Although only the northern portion of the North Slope had been CIR-photographed by 1980 or later, the entire area--specifically that portion contained in the Point Hope quadrangle--shows evidence of extensive snow-machine and ATV use. Virtually all of the routes discussed in this section, as well as some not identified as movement corridors, show indications of snow-machine or ATV use. Some of those areas are Tungnak and Tukingarak Creeks, the Ipewik and Nilik Rivers, the Akalolik route, the Saligvik and Ogotoruk valleys, and smaller coastal-river valleys.

V. SUMMARY

A. History of Surface-Transportation Development Between the Colville and the Canning Rivers

In the late 1950's, interest in Alaska's hydrocarbon potential was awakened as a result of successful prospecting on the Kenai Peninsula. At that time, commercial exploration on the North Slope was focused on the geological structure known as the Colville geosyncline, which was identified as a potential hydrocarbon field during the first phase of NPR-A exploration. The State of Alaska shared that opinion and, under the provisions of its Statehood Act, selected lands along the Colville geosyncline and offered them in the first State sale of North Slope land in 1964. These prospects proved to be noncommercial, and industry interest in North Slope lands began to wane. At the time of the Prudhoe Bay discovery, there was only one active rig on the North Slope.

Before and during the development scurry that followed the Prudhoe Bay discovery well, several technological innovations occurred in the field of transportation logistics--air-cushion vehicles and soft-tire, low-pressure vehicles used for ground travel, and helicopters used for seismic work. Perhaps the most notable innovation was the first commercial use of the C-130 military cargo plane. The size and power of the C-130 enabled entire rigs to be airlifted to ice/snow airstrips. This method of operation sharply reduced the temporal constraints of movement logistics and created the opportunity for an ambitious drilling program.

Prior to 1970, industry movement over arctic terrain was unrestricted and governed only by the season, the methods of operation and construction, and the equipment used. This lack of regulation resulted in scars on the fragile arctic tundra and precipitated concern among increasingly powerful environmental groups. The State was anxious because of the potential lawsuits that could disrupt the first post-Prudhoe-discovery State lease sale on the North Slope and thus prohibited all surface-vehicle movement on State lands north of the Brooks Range after the spring breakup of 1969. During 1970, the Alaska Department of Natural Resources began its long-term regulation of surface movement.

The DNR established a vehicle-testing program in 1971 to identify those vehicles that left the least residual effect on the tundra. In subsequent years, the DNR took additional steps to regulate surface transport and the construction of access routes--the mining of gravel for roads to areas of exploratory or nonpermanent operations was prohibited in 1975, and a ban on the extraction of water from isolated pools located in frozen rivers was enforced in 1976. Until 1984, the DNR acted as the chief permitting agency for North Slope surface-transport activities on State land. Seismic-train operators and others involved in exploratory or developmental activities were, and still are, required to submit to the DNR detailed lists describing the types of equipment and vehicles to be used and a map indicating the intended path and schedule of movement.

The developmental boom following the 1969 State lease sale was subdued by a series of legal challenges to the construction of the trans-Alaska pipeline. Once these obstacles were negotiated, development of the Prudhoe Bay hydrocarbon structures was rapid. During the 1970's, the DNR gradually regulated the methods of oil-field construction by restricting consumption of gravel and water and mandating the periods during which construction activity could occur. Although the configuration or spatial outline of the Prudhoe Bay field was unregulated and generally left to the desires of the operator prior to the late 1970's, this development approach was altered in 1978, when the DNR and allied State agencies met with ARCO (the operator of the Kuparuk River Unit) to discuss the configuration of future Kuparuk-field facilities. The results of that meeting are evident in Graphic No. 1, which reflects a rather altered Kuparuk Unit transport infrastructure that generally contains considerably fewer interstitial roads and fewer facilities than the Prudhoe complex. The same pattern can be perceived in the development of the Milne Point Unit. To date, only the Prudhoe Bay, Kuparuk River, and Milne Point Units have permanent roads. Because industry plans to develop the Endicott reservoir, the Duck Island Unit should have a permanent road system sometime in the future.

The administration and regulation of surface-transport networks on the North Slope has grown increasingly complex. During the late 1970's, two other entities--in addition to the DNR--emerged as regulatory authorities governing North Slope activities. The first entity--and the agency responsible for administering the Clean Water Act passed by the Congress in 1978--was the U.S. Army Corps of Engineers, which assumed permit-review-and-approval authority for all activities that require disposal or removal of fill in wetlands. Because the North Slope is classified as almost entirely wetlands, all permanent surface structures must be approved by the COE. The second entity--and the authority most likely to exercise potential regulatory impact--is the North Slope Borough, which currently has an approved set of Land Management Regulations and a Coastal Management Program approved by the State but not yet approved by the U.S. Department of Commerce. Upon approval, the NSB's CMP will become an integral part of the Alaska Coastal Management Program as the principal land management code governing activities within the coastal zone.

All State permitting functions for approval of surface travel and construction on the North Slope are presently (1986) coordinated through the State Office of Management and Budget. Consolidation of all State permitting functions was initiated to shorten the waiting time for permit approval and to solidify the State's position on key issues. Stipulations governing overland movement (which are attached to State permits) cover a wide array of issues and are aimed at preventing the severe alteration of the tundra and eventual brown or ponded trails. Beyond these stipulations, which affect exploratory efforts, the DNR has worked to prevent duplicative permanent roads and ensure that permanent linear surface facilities offer a minimum obstacle to migrating caribou. This general agency policy--a product of the bureaucratic applications of precedent--has not been codified. The NSB's Land Management Regulations and CMP expand on DNR policy and confer a codified status on many of these stipulations. The NSB Land Management Regulations are fully effective and will add another rather significant level of requirements that affect both temporary- and permanent-transport routes. Federal approval of the NSB CMP is pending at this time.

In summary, the history of North Slope development has moved from initial high-intensity exploration-and-development activities through gradual stages of increasingly complex development patterns, accompanied by increasingly complex regulatory requirements. The North Slope's current surface-transport network, particularly that of the Prudhoe Bay Unit complex, is the product of an era of limited regulatory requirements. The NSB's growing authority will subject future industrial-road systems that extend some distance from the Prudhoe Bay complex to an increased variety of regulatory requirements, including conformance with NSB economic and cultural dictates.

B. Surface-Transportation Patterns Created by Exploration and Development of the National Petroleum Reserve-Alaska

The National Petroleum Reserve-Alaska was established in 1923 and known as Naval Petroleum Reserve No. 4, or Pet 4, until 1976. The history of the NPR-A is characterized by two periods of intense exploration. The first phase, which started during World War II, lasted from 1944 to 1953. The second phase, which was precipitated by the Arab oil embargo, lasted from 1975 to 1982. Both exploratory actions were responses to national crises; however, the interval of time between phases rendered the two phases different in terms of applied technology and philosophy of operations.

The first exploration phase--the Pet 4 project (1944-1953)--was remarkable in that it represented the first large-scale intrusion of a mechanized society on the North Slope. Conducted in response to World War II, the Pet 4 project was hastily initiated by individuals who, unfamiliar with the arctic, employed transport technology developed for European battlefields. The Pet 4 project was supported primarily by sea, with the principal center of operations at Barrow and a secondary center at the Umiat airstrip. From these operations bases, tractor-drawn trains transported rig components and living quarters to various drill sites. Smaller, tracked vehicles that were mechanically unreliable in difficult terrain were used by personnel involved in geological reconnaissance and general logistics activities. This lack of reliability limited the area that could be reached by Department of the Navy contractors and tended to limit operations to terrain that was easily accessible. Operations were conducted during all seasons, although the advantages of winter movement over tundra were quickly recognized. Nonwinter movement and winter movement over insufficiently protected tundra left deeply scarred and ponded (brown) trails that persist for decades before the slow arctic revegetation process obliterates the evidence of movement. When Pet 4 activities were suspended, only minimal efforts were made to remove waste material; as a result, tons of debris were left scattered throughout the NPR-A.

The second exploration phase (1975-1982) was initiated by the Department of the Navy. Throughout most of the project's life, however, it was administered by the U.S. Geological Survey. The Husky Oil Corporation was the primary Government contractor for exploratory-drilling operations. Unlike the first exploration phase, the second phase benefited from several years of research on arctic conditions conducted by the Naval Arctic Research Laboratory at Barrow, and from over a decade of oil-field-development activities in and around the Prudhoe Bay complex. As a result, Husky personnel were cognizant of the fragility of the arctic terrain and employed methods of operation that minimized damage to the tundra. They also were able to utilize technologies that were both cost-effective (rig movement by aircraft) and environmentally preferable (soft-tire, low-ground-pressure vehicles).

Overland movement was governed by a series of Navy, and subsequently USGS, stipulations that forbade the alteration of stream banks and other topographic features, as well as any movement after breakup and before freezeup and snow burial of the tundra. In addition, Husky operators used routes that incorporated such topographic features as marshlands, lake edges, the oceanic-shorefast-ice zone, active streambeds, and gradually sloped areas. These features assisted in maintaining vehicular stability and speed and minimized the potentially damaging effects on land surfaces.

Little drilling occurred between the two NPR-A exploration phases. Some shallow-gas wells were drilled near Barrow to provide power and heat for the community. Since the conclusion of the second exploration phase, the Bureau of Land Management--as custodian and administrator of Federal lands within the NPR-A--has held four lease sales within the NPR-A. Fifty-one lease tracts have been sold to date, but only one--ARCO's Brontosaurus prospect southwest of Barrow--has been drilled. The most recent sale received no bids.

As the NPR-A's current land manager, the BLM regulates surface movement. Operators of seismic trains are required to submit to the BLM a detailed list describing the equipment to be used and a map of prospective routes. The routes, which are checked for cultural and natural resources that may be in proximity, are often adjusted by the BLM to maximize passage over frozen-water features or previously used corridors. In addition, each overland-travel permit includes a series of stipulations governing surface operations. Further, all permittees whose operations impinge directly or indirectly on lands within Alaska Coastal Management Program jurisdiction must comply with the ACMP's consistency provisions before the permit is approved by the BLM.

In summary, the history of surface transportation within the NPR-A is characterized by periodic exploration punctuated by long periods of inactivity. The BLM carefully manages industrial surface movement within the NPR-A on a case-by-case basis. Because no development or production activities have yet occurred within the NPR-A, the BLM has not encountered the level of regulatory complexity that the State of Alaska has encountered in association with development of the Prudhoe Bay industrial complex.

C. Inupiat Travel and Subsistence-Hunting Patterns

The Inupiat people of Alaska's arctic slope have been seminomadic hunters for several thousand years. This lifestyle was interrupted and eventually altered by the introduction of the Euro-American culture during the 19th century. As the Inupiat interacted with the "western" culture, they began to enter the market economy and became increasingly sedentary. During the latter part of the 19th century, the Inupiat provided foodstuffs and baleen to the Yankee whalers. In the early part of the 20th century, the Inupiat trapped large quantities of fur in response to the fashion trend of the pre-Depression era and tended large reindeer herds. The U.S. Government's insistence that all Native children attend school also encouraged community formation. Because the schools were limited in number and location, the nomadic Inupiat lifestyle began to end for all but the old and the unmarried. In the aftermath of World

War II, a number of military installations were constructed on the North Slope. These DEW-Line stations offered employment opportunities to the Inupiat, and the attendant airfields facilitated transportation and commerce--thus providing a further impetus for community formation. By the time of the Prudhoe Bay discovery well in 1967, the North Slope Inupiat were consolidated in five communities--Kaktovik, Barrow, Wainwright, Point Hope, and Anaktuvuk Pass.

During the period of gradual urbanization, Inupiat-hunting patterns became spatially constricted. The communities still relied on dog teams during the 1950's and early 1960's. Although reliable, dog teams were slow and time-consuming; and opportunities for extensive overland travel were now minimal because of social and job-related responsibilities. Thus, subsistence-related travel and the range of subsistence activities generally reached a nadir during the 1950's. However, certain technological, economic, and social forces intervened during the 1960's and 1970's and arrested the decline in hunting activities. The introduction and use of the snow machine in the mid-1960's provided the Inupiat with a conveyance that enabled them to roam, in a 1- to 2-day-or-longer period, over wide expanses in pursuit of game. The economic condition of the Inupiat improved with the Prudhoe Bay discovery well, and the oil-related wealth enabled the Inupiat to acquire current technology.

The people of the North Slope became more politically cohesive when, in 1972, they established the North Slope Borough. The Borough embraced all of the Inupiat communities of the North Slope and thereby consolidated the geographically diverse communities under a single institutional entity. During the 1970's, three abandoned traditional communities were reestablished within the Borough--Nuiqsut, Atqasuk, and Point Lay. As a result of the availability and use of the snow machine, the improved economic situation, and the additional population, the Inupiat extended the outer boundaries of their subsistence-harvest zones to include most of the North Slope and much of their presettlement-hunting areas. This pattern of growth--most evident during the 1970's--has continued into the 1980's.

Inupiat travel patterns are predicated on a variety of factors--primarily climate, geography, and availability of game and, secondarily, visitation of kin. Most Inupiat communities exist in a world devoid of prominent topographic features. Navigation from point to point occurs primarily by reference to river valleys or coastal trails. Navigation between river systems is based on reference to subtle features--the direction of snowdrifts, the shapes and locations of lakes, and the number and outline of intervening creeks. A North Slope traveler must be cognizant of the climate, the potential arrival of wind and the attendant lack of visibility, and the lethal wind-chill factor. Therefore, the Inupiat tend to travel close to sheltering river valleys. If these valleys are broad and straight, such as those around Kaktovik, they are used as "highways" to the foothills. Farther west--where the streams tend to have a more meandering outline--stream valleys are used only during inclement weather. In all cases, the experienced Inupiat traveler memorizes the outlines of the principal river systems and the notable topography associated with them. The Inupiat of Anaktuvuk Pass and Point Hope move in mountainous areas characterized by confining topography. Route selection in these subsistence-harvest zones is limited and marked by prominent features.

As the Inupiat expanded their hunting range over the last 10 to 15 years, they increased their use of the Brooks Range foothills. This is specifically true for the hunters of Kaktovik, Barrow, Atqasuk, Point Lay, Anaktuvuk Pass, and Wainwright. The foothills offer shelter from storm winds, dependable navigational reference points, good observation points for spotting game, and perhaps more abundant subsistence resources. In most NSB communities, snow-machine activity occurs within a 50-mile radius (about a 1-day range) from the community. Within this zone, travel occurs for both hunting and/or recreational purposes. However, beyond the 1-day range, activity dissipates and is oriented almost entirely toward subsistence hunting.

Not all future travel by the Inupiat will be based on the pursuit of subsistence resources. In addition to incidental intercommunity movement for recreation purposes, the NSB occasionally transports heavy machinery overland between communities. The people of Nuiqsut--recently linked temporarily to the Kuparuk River Unit-road system--have expressed a desire to be permanently linked to the North American road network. In anticipation of economic benefits, other communities--namely Barrow--also have expressed a similar interest.

D. Summary Observations

The development pattern of any surface-transport network is a natural outgrowth of man's desire to achieve a given topographic position by the most direct and effective method possible. The exact outline of any network is dependent on geography, technology, and social and political conditions. Transportation links, specifically those that develop over time, range from the relatively simple to the complex--from footpath to superhighway. Because the beginnings of most historical transport routes were technologically primitive, the path normally followed the course of least resistance. Through time, the "rut" became deeper; the principal regional-transport component formed and secondary feeder lines branched from it. This form of highway development is common to civilized man. At a certain point in the evolution of a society, however, technology and economic conditions demand routes that do not offer the path of least resistance--such as tunnels through mountains, under water bodies, or over extensive wetlands. Beyond this point (or perhaps coincident with it), surface-transport networks are often emplaced in isolated regions solely for military or industrial purposes that have little to do with the natural development of regional commerce or the desires of the local inhabitants.

In reviewing the development of surface-transport networks north of the 68th parallel, it appears that the road-building circumstances described above have occurred to some degree. The Prudhoe Bay complex illustrates an industrial network emplaced without any tempering considerations given to the desires of the region's indigenous culture. As could be expected in a frontier- or isolated-development situation, the North Slope industrial complex initially grew with minimal regulatory restrictions. As the complex expanded in both scope and complexity, however, governmental entities placed additional restraints on development. Although the Prudhoe Bay Unit was developed with minimal restraint, the development of the satellite Kuparuk River and Milne Point Units was characterized by negotiation, planning, and increasing regulation. As the power of the NSB increases through the authority of its Land Management Regulations (and potentially through its CMP), industrial-service-road networks will have to conform to the desires and needs of the indigenous culture.

Development of the NPR-A has not reached the same level of maturity as the development between the Colville and the Canning Rivers because no discoveries of economically recoverable quantities of hydrocarbons have occurred in the NPR-A. However, the NPR-A's lengthy exploration history accounts for the appearance of numerous trails over its fragile tundra. Unlike the Alaska DNR, whose policy is aimed at retarding brown trails by scattering access routes from year to year to specific drilling sites, the BLM has channeled development activity into the preexisting patterns of previous activities. This BLM rationale regarding route selection has been demonstrated numerous times and, if carried on indefinitely, could result in the establishment of permanent transport corridors within the NPR-A. However, the North Slope Borough's growing regulatory powers may temper this policy to some degree.

The very nature of North Slope geography encourages extensive travel among the Inupiat communities. Relatively featureless and vast, the arctic requires travelers to navigate by landmarks and celestial signs, much as one would navigate in a boat or aircraft. Nevertheless, certain pragmatic considerations reflective of geography, climate, and the Inupiat's presently concentrated living patterns have caused the establishment of preferred movement corridors. The route between Barrow and Atqasuk is the most extreme example of an established North Slope movement corridor outside of the Prudhoe Bay complex. First used as an inland route to the subsistence resources of the Meade River and the Tigaluk campsite--located near present-day Atqasuk--the route assumed importance during the 1940's, when coal from a small deposit near Tigaluk was mined and carried to Barrow. This route, used frequently during the Pet 4 project, was further formalized by the reestablishment of Atqasuk during the mid-1970's. A portion of this same route is being studied for the proposed Barrow/Atqasuk electric-transmission line and has been utilized for the drilling of ARCO's Brontosaurus test well in the NPR-A.

Considering the presently relatively sedentary Inupiat lifestyle, their travel patterns still reflect their former land use patterns. Ironically, the evolution of modern-transport technology has preserved this nomadic spirit.

Continuing advances in transport technology should widen the array of surface conveyances available to the inhabitants of the North Slope. Air-cushion vehicles and similar conveyances that are in service throughout the world have been used successfully on the North Slope. (The idea of connecting scattered communities in the treeless reaches of Canada's Northwest Territories has been advanced by Canadian Government officials, transport consultants, and Inuit Association executives.) These vehicles could be designed in various forms, including a hybrid that would utilize tracks to negotiate uneven terrain. These vehicles do not require a permanent roadbed in order to operate and they are capable of obtaining high speeds--two attributes that account for a favorable economic comparison between ACV's and conventional surface vehicles for commercial transport (Lafromboise and Alepin, 1982; Rawlyk, 1982). The use of such a family of vehicles would eliminate seasonal restrictions on overland travel and enable the North Slope Inupiat to expand their subsistence-harvest zones both spatially and temporally, as well as commercially unite the Inupiat communities by providing an inexpensive means of overland transport and access to the Dalton Highway.

Apart from considerations relevant to the Inupiat, the use of advanced surface-vehicle models by the mineral industry will also similarly expand the seasonal and spatial ranges of exploratory and developmental activities. However, the use of such conveyances will, of course, generate additional regulatory requirements peculiar to their operation. One could conclude that the economic, industrial, and administrative evolution of the North Slope--together with the continuing development of appropriate technology and an expanded road system--could eventually create transport networks that unite the North Slope region into a single economic entity.

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Appendix

Chronology of Exploration and Development on the North Slope (1923-Present)

Chronology of Exploration and Development on the North Slope (1923-Present)

1923	President Harding established Naval Petroleum Reserve No. 4 and USGS exploration teams made an initial survey of the reserve.
1926	USGS exploration of Naval Petroleum Reserve No. 4 was terminated.
1944	President Roosevelt authorized the Pet 4 project.
1953	Pet 4 project was recessed.
1958	BLM opened North Slope lands for competitive bidding and simultaneous filing; 4 million acres were offered.
1959	Six petroleum companies sent geological-reconnaissance teams to the North Slope.
1960	Arctic National Wildlife Range (ANWR) was established.
1962	Sinclair/BP operated first seismic team on the North Slope after recess of the Pet 4 project.
1963	Sinclair/BP drilled seven dry wildcat wells.
1964	State offered 625,000 acres east of the Colville River on December 1, 1964; 476,000 acres were purchased. During 1964, seismic teams began to map the Prudhoe Bay structure. First tractor supply train traveled from Fairbanks to the North Slope.
1965	State offered leases covering part of the Prudhoe Bay structure. The Richfield Corporation employed a Hercules C-130 for rig transport to the North Slope (first commercial use of the C-130 aircraft series). State filed for acreage over the Prudhoe Bay structure.
1966	Industry operations largely ceased after several unsuccessful wells were drilled.
1967	The 18th competitive State lease sale allowed ARCO and Humble Oil to acquire strategic acreage over the Prudhoe Bay structure. In December, ARCO-Humble's (Exxon) Prudhoe Bay State No. 1 well showed significant quantities of hydrocarbons. At the time of the Prudhoe discovery, this was the only well being drilled on the North Slope.
1968	Delineation of the Prudhoe Bay field continued, with reserves estimated at 5 to 10 billion barrels.
1969	Drilling activity intensified with the Kuparuk River Unit discovery well. Hickel Highway was completed. CITCO attempted to use an air-cushion vehicle (ACV) for seismic work (first use of this type of vehicle on the North Slope). State lease sale on September 1 reaped $900 million and finalized the Prudhoe Bay leaseholder patterns.
1970	The Alaska Department of Natural Resources issued special land use designations on March 5 (first land use regulations enacted for the North Slope). USDOI issued Public Land Order 4760 authorizing construction of the Trans-Alaska Pipeline System (TAPS); several groups filed suit. Prudhoe Bay spine road was constructed.
1971	Drilling/construction activities declined on the North Slope. Chevron employed a soft-tire, low-pressure vehicle (Rolligon) for cleanup operations (first use of this type of vehicle on the North Slope).
1972	North Slope Borough (NSB) was organized on July 1.
1973	TAP Act was passed.

1974 Dalton Highway was constructed in 89 days. Construction began on the TAPS. Navy tested ACV's in Colville River valley; tests were abandoned due to effect of noise on endangered peregrine falcon.

1975 Husky project began in National Petroleum Reserve-Alaska (NPR-A). State prohibited gravel extraction for roads to exploratory drill sites only.

1976 National Petroleum (Reserves) Production Act was passed. State prohibited all winter water extraction from active stream channels.

1977 The TAPS was completed. Prudhoe Bay and Point Thompson Units were organized. First Beaufort Sea offshore island--Sag Delta No. 1--was constructed in 3 feet of water.

1978 Duck Island and West Mikkelsen Units were organized. Congress passed the Clean Water Act, which authorized the Army Corps of Engineers to permit and regulate all wetlands activities on the North Slope.

1979 Gwydyr Bay and Milne Point Units were organized. Kuparuk River Unit operators met with State officials in Fairbanks to discuss the spatial outline of the Kuparuk facilities. NSB Land Use Regulations were approved. Kuparuk spine road was constructed. Federal Government held first sale of offshore leases in the Beaufort Sea (Sale BF).

1981 ACV's were tested and found suitable for summer tundra use. The Kuparuk River Unit was formed and began production.

1982 Seal Island discovery well was drilled. Husky's NPR-A project was recessed. Federal Government offered first NPR-A leases.

1983 Milne Point development began. NSB Land Use Regulations were reapproved.

1984 Drilling offshore of the ANWR occurred near Barter Island; 24-inch Kuparuk production pipeline replaced original 16-inch line, and production reached 190,000 barrels/day.

1985 Texaco discovered oil in the Colville Delta. NSB Coastal Management Program approved by the State of Alaska. ARCO's Brontosaurus No. 1 became the first commercial well drilled on an NPR-A lease. State abolished West Mikkelsen Unit. Milne Point Unit came online.

Glossary

GLOSSARY OF ACRONYMS AND ABBREVIATIONS

ACMP	Alaska Coastal Management Program
ACV	air-cushion vehicle
ADF&G	Alaska Department of Fish and Game
AEIDC	Arctic Environmental Information and Data Center
ANCSA	Alaska Native Claims Settlement Act
ANILCA	Alaska National Interest Lands Conservation Act
ANWR	Arctic National Wildlife Refuge
ARCO	Atlantic Richfield Company
ATV	all-terrain vehicle
bbls	barrels
BLM	Bureau of Land Management
BP	British Petroleum
CIR	color-infrared (high-altitude photographs)
CITCO	Cities Service Company
CMP	Coastal Management Program
COE	U.S. Army Corps of Engineers
C-130	Hercules cargo aircraft
DEW Line	Distant Early Warning System
DIU	Duck Island Unit
DNR	(Alaska) Department of Natural Resources
EA	Environmental Assessment
EIS	Environmental Impact Statement
EOA	eastern operating area
GBU	Gwydyr Bay Unit
HSU	Hemi Springs Unit
KRU	Kuparuk River Unit
LVT	landing-vehicle tank
MMS	Minerals Management Service
MPU	Milne Point Unit
M29C	M29C Weasel (tracked off-road vehicle)
NARL	Naval Arctic Research Laboratory
NEPA	National Environmental Policy Act
NPR-A	National Petroleum Reserve-Alaska
NPR-4	Naval Petroleum Reserve No. 4
NSB	North Slope Borough
NSHR	North Slope Haul Road
OCS	Outer Continental Shelf
OMB	(Alaska) Office of Management and Budget
Pet 4	Project in Naval Petroleum Reserve No. 4
PBU	Prudhoe Bay Unit
PTU	Point Thompson Unit
Sohio	Standard Oil Company of Ohio (now Standard Alaská Production Company)
STP	saltwater-treatment plant
SUNY	State University of New York
TAP	trans-Alaska pipeline
TAPS	Trans-Alaska Pipeline System
USDOD	United States Department of Defense
USDOI	United States Department of the Interior
USGS	United States Geological Survey
WOA	western operating area

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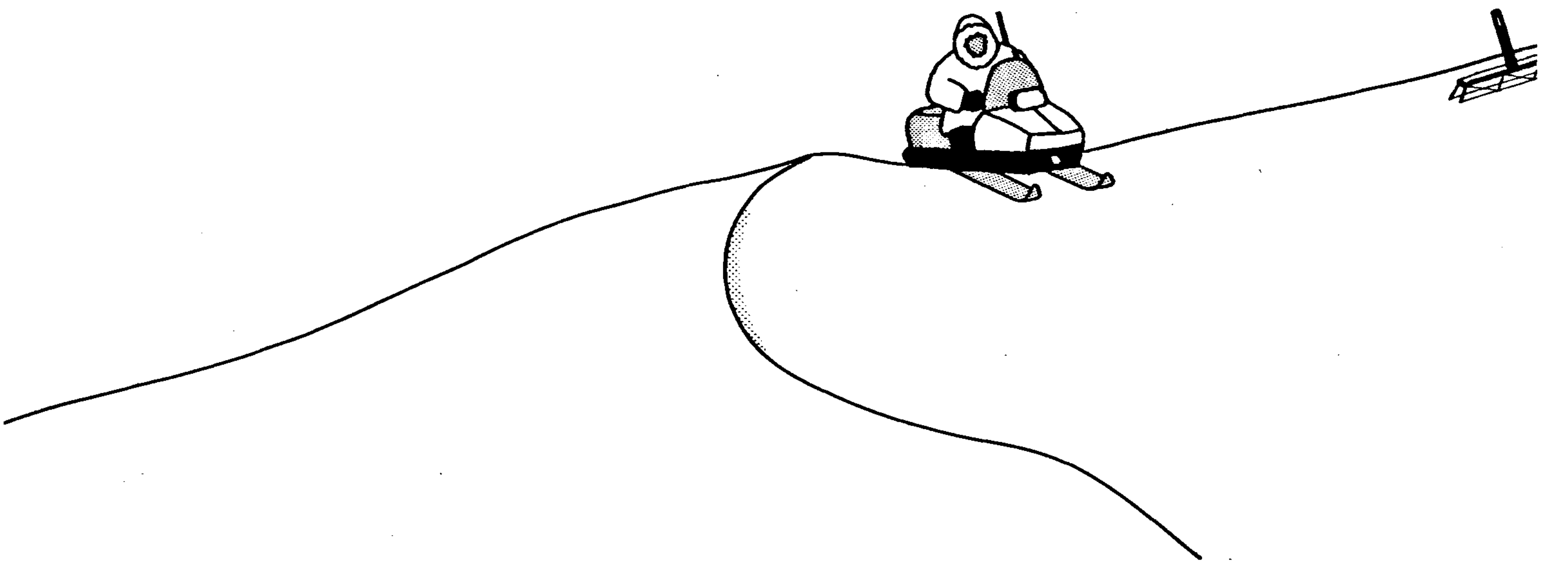
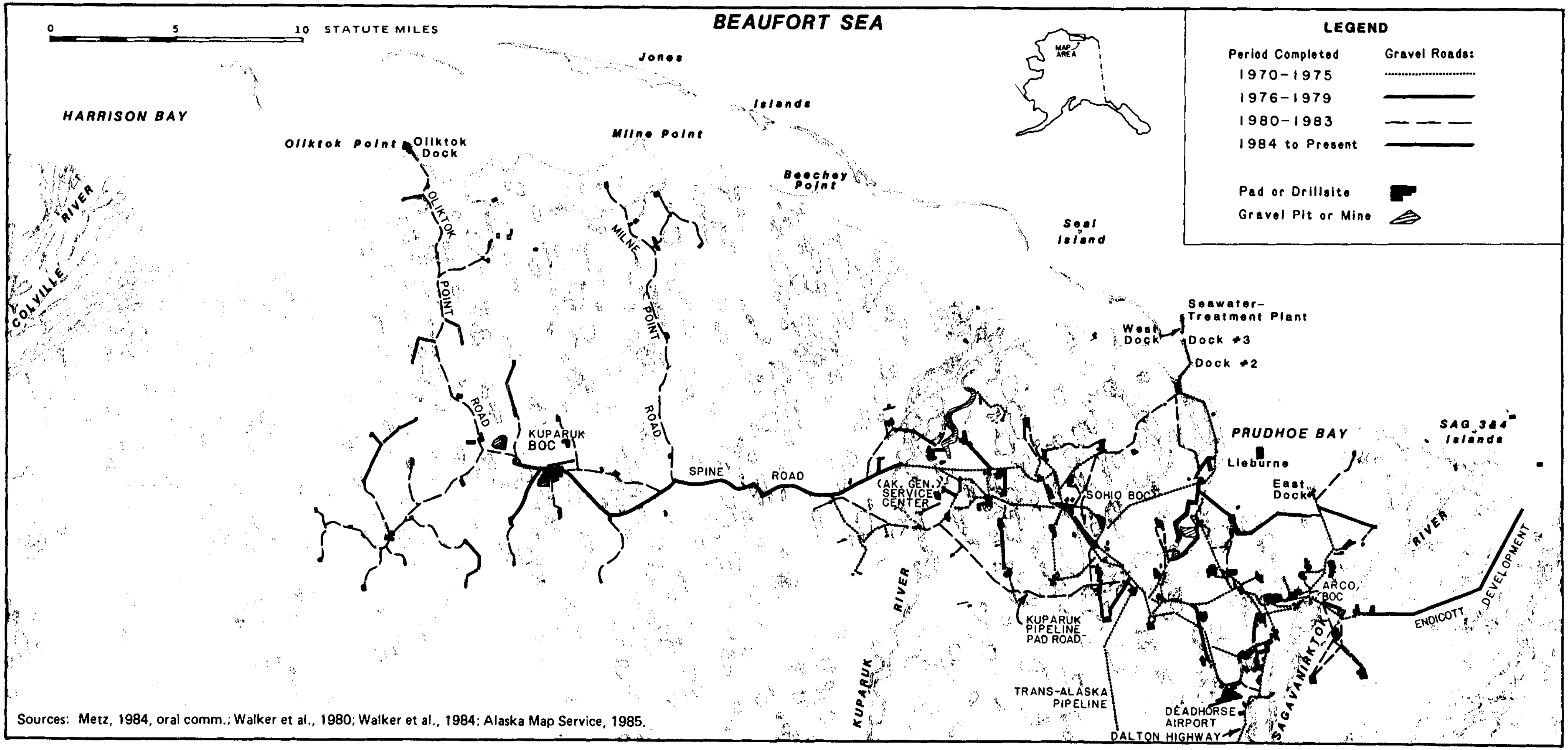
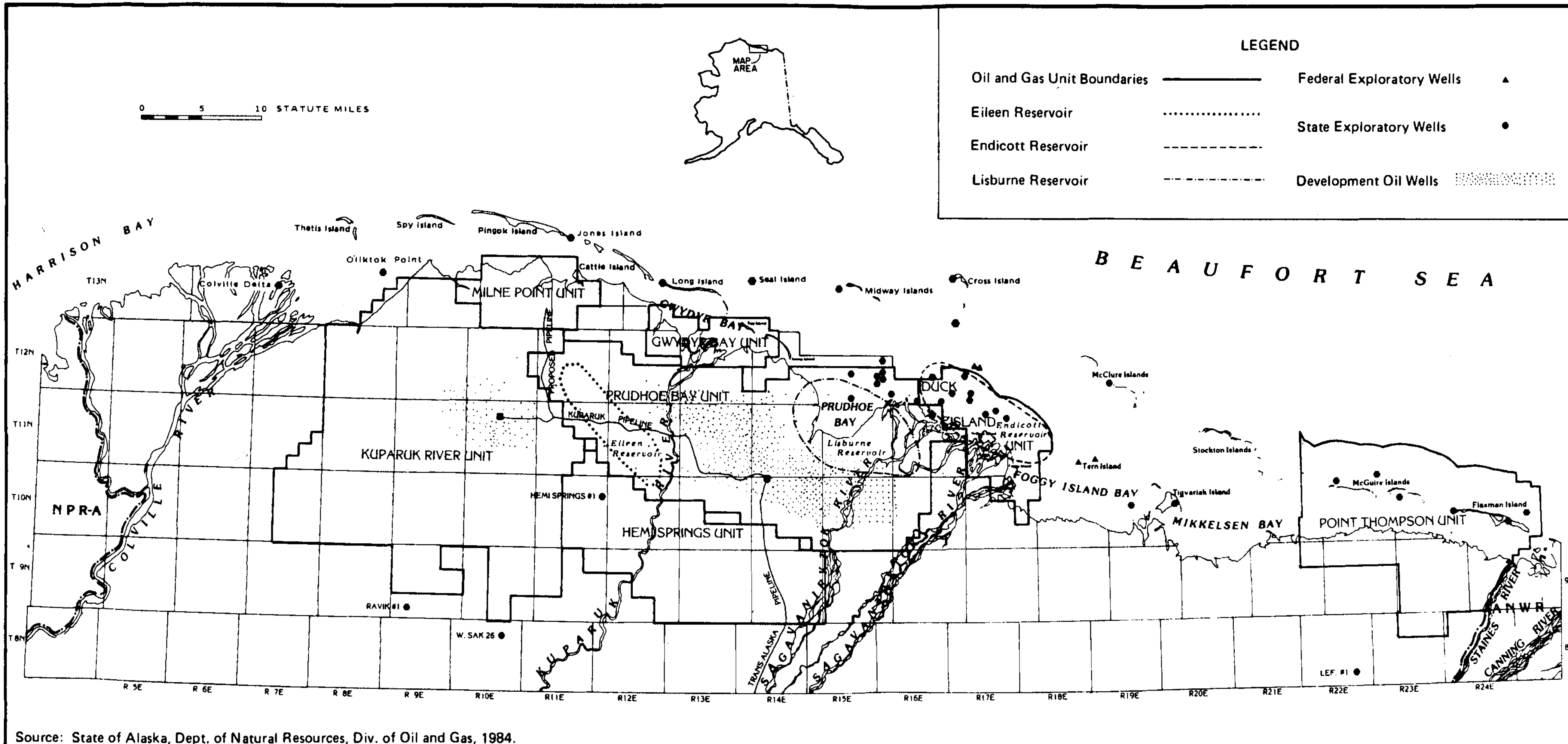
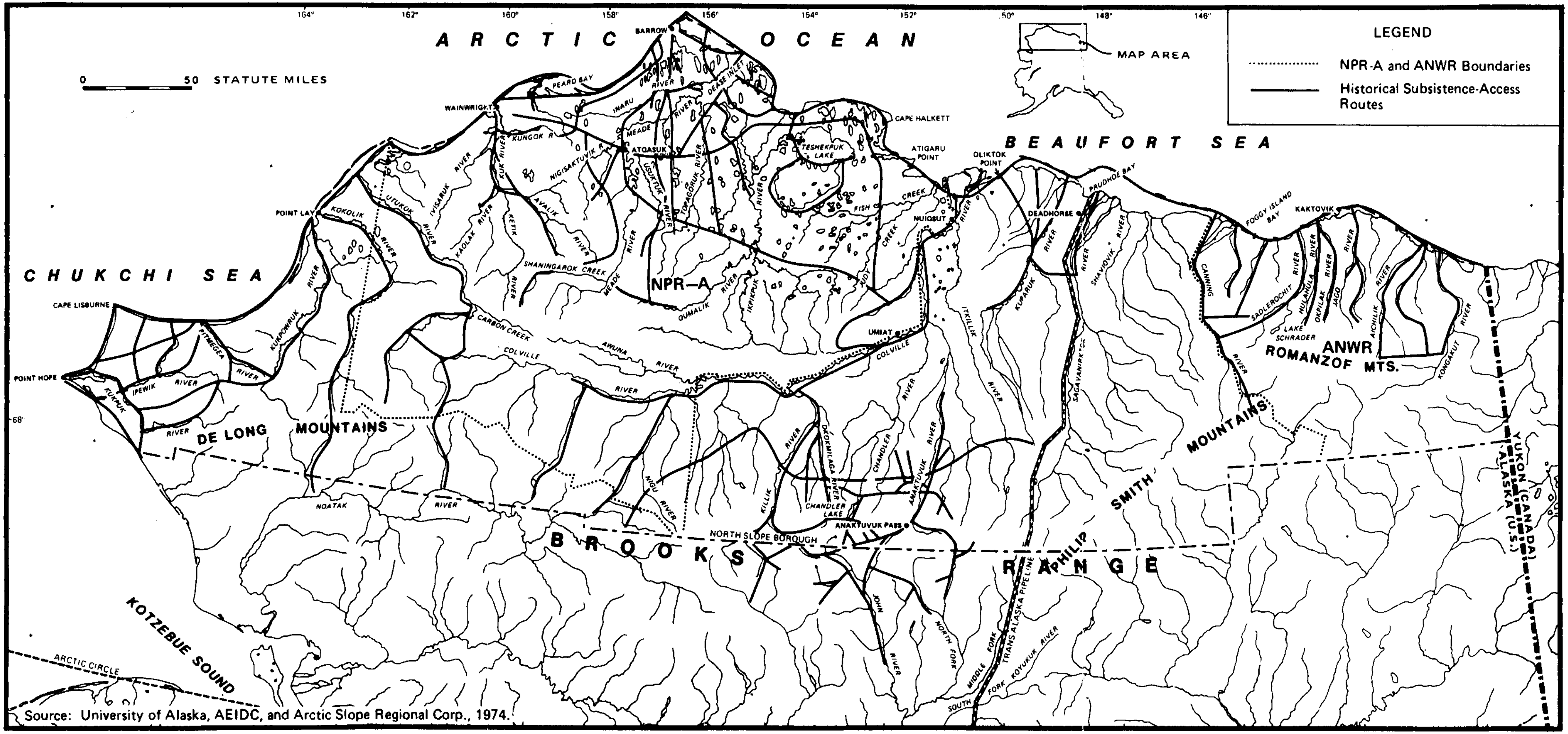




GRAPHIC NO. 1. **SPATIAL AND TEMPORAL GROWTH OF NORTH SLOPE SURFACE-TRANSPORTATION INFRASTRUCTURE**



***GRAPHIC NO. 2.* NORTH SLOPE ACTIVITY MAP**



Source: University of Alaska, AEIDC, and Arctic Slope Regional Corp., 1974.

GRAPHIC NO. 3. HISTORICAL SUBSISTENCE-ACCESS ROUTES ON THE NORTH SLOPE