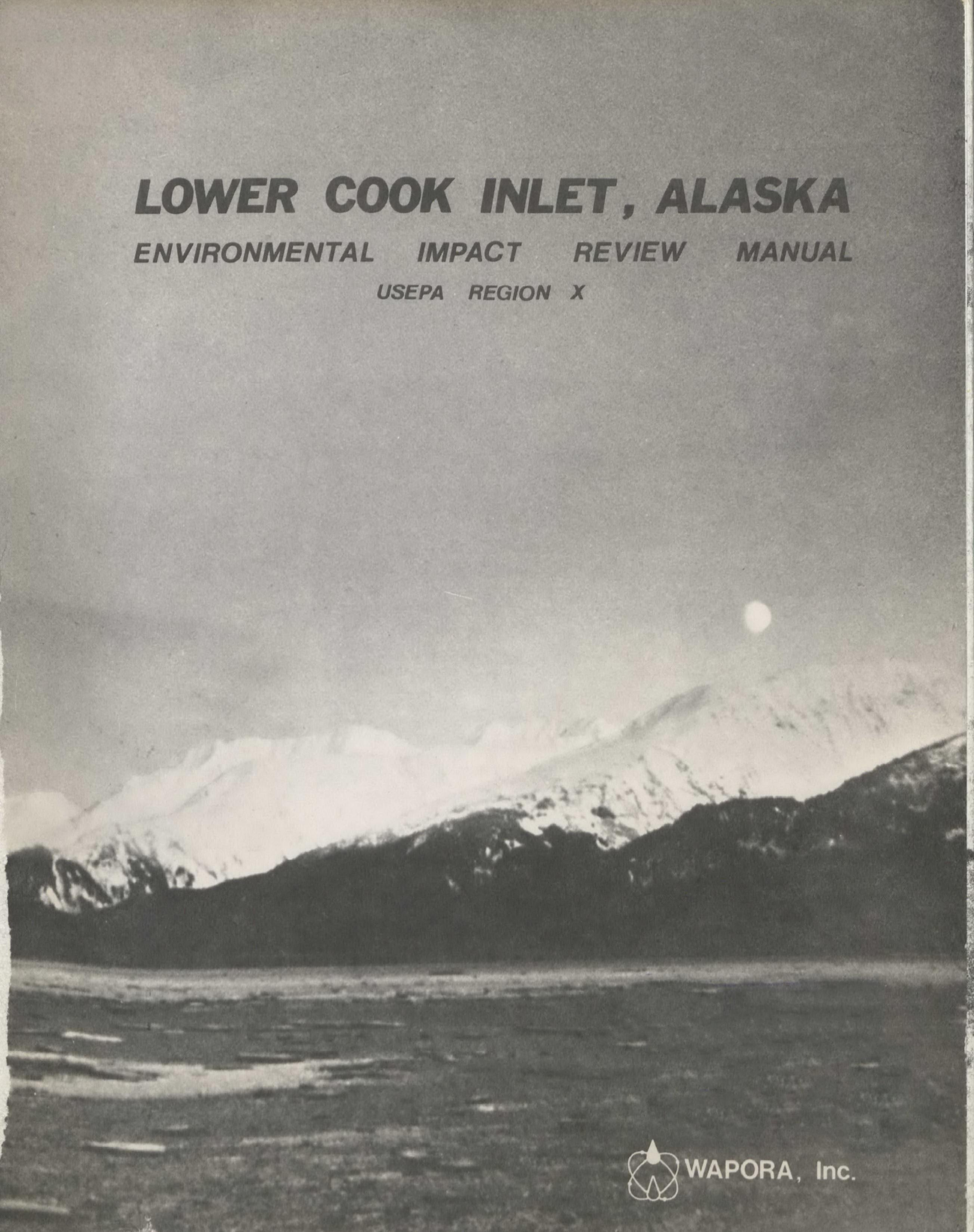
LOWER COOK INLET, ALASKA

ENVIRONMENTAL IMPACT REVIEW MANUAL

USEPA REGION X



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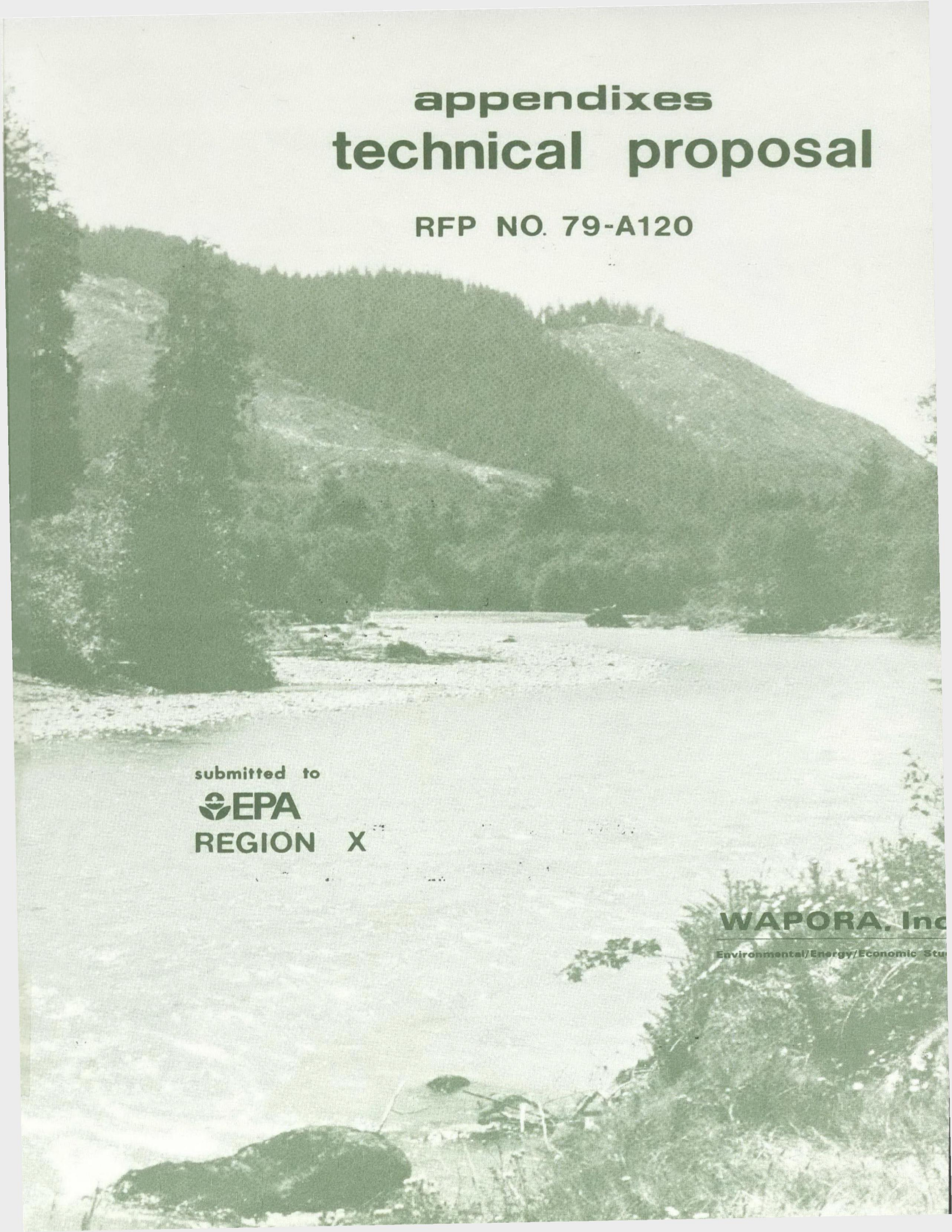

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Project No. 619

17 August 1979

LOWER COOK INLET, ALASKA

ENVIRONMENTAL EVALUATION/IMPACT REVIEW MANUAL

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AIR SOLID WASTE WATER

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1.0. EXECUTIVE SUMMARY

The New Source Environmental Evaluation/Impact Review Manual for the Lower Cook Inlet, Alaska, is designed to assist personnel of the US Environmental Protection Agency (USEPA) in the review of new source permit applications and in the preparation of environmental assessments pursuant to the requirements of the National Pollutant Discharge Elimination System (NPDES) program and the National Environmental Policy Act (NEPA). The Manual is not a site-specific document and does not provide criteria for the issuance or denial of individual NPDES permits. It is designed to be a useful tool that provides background information on existing conditions in the Lower Cook Inlet study area. The information presented in the Manual was developed through a review of published and unpublished documents and by contact with Federal, State, and local agencies.

The Lower Cook Inlet study area consists of all non-Federal lands and waters contiguous to Cook Inlet in the Kenai Peninsula Borough south of the Cook Inlet Forelands and north of an arbitrary line between Cape Elizabeth on the eastern shore and Cape Douglas on the western shore. Because of the large size and diversity of the study area, it was divided into six land Subareas and four water Subareas. The overall study area is profiled in Section 3.0., and the Subareas are described in Sections 5.0 through 14.0. Appendixes provide additional information on USEPA responsibilities in Lower Cook Inlet, air quality, key sources of information, and existing NPDES permits in the study area.

The study area profile (Section 3.0.) presents information on an area-wide basis. The discussion of the physical environment reviews the geology, hydrology, and oceanography of the study area. Special attention is directed at potential hazards and resources. A review of the climate and meteorology is included. Ambient air quality and emission sources are described. Information is limited on many aspects, therefore, data needs are identified.

The discussion of the biological environment includes sections devoted to marine, freshwater, and terrestrial biology. Major living systems and communities are presented. Important commercial fish species are described in detail. The life histories of major terrestrial animals also are presented. Consideration of critical habitat factors and of threatened and endangered species is included.

The section on land and water use reviews settlement patterns, land ownership, recreational lands, agriculture, forestry, and land and water use planning. The roles of the Federal government and of State and local agencies are described. Land ownership and land use planning are in a state of flux in Alaska at the present time. Settlement of Native land claims and conveyance of lands to the State of Alaska are important considerations that remain to be clarified. It is likely that large sections of the study area will remain as part of the Federal holdings in Alaska.

The Lower Cook Inlet study area has experienced significant growth in recent years. The section on study area socioeconomics includes reviews of demographics, housing, education, transportation, utilities, and public finance, as well as a discussion of the economic bases that

support the area. Commercial fishing and the petroleum industry are the two major segments of the study area economy. Tourism is increasing and is an additional important source of revenue. Population is expected to continue to increase, although the magnitude of future growth is difficult to project precisely. Some forecasts have included growth as a result of the potential location of a major petroleum refinery in the study area (Alpetco). Because Alpetco has selected Valdez as the site of its new plant, scenarios that incorporate such growth must be regarded as unsupported, but useful for comparison purposes.

Governmental institutions at the Federal, State, and local levels have important responsibilities in the study area. Key organizations and contacts are discussed in Section 3.5. of the study area profile. A brief description of each agency's activities is presented, and the mailing address and telephone number of key sources are listed. The importance and background of Alaskan Native corporations also are reviewed.

The cultural, historical, archaeological, and aesthetic resources of the Lower Cook Inlet study area are described in Section 3.6. The study area has a long history of human habitation, and the Native, Russian, and American periods are reviewed. Key resource studies are identified, and the problem of resource identification and listing is discussed. Specific sites included in the National Register of Historic Places are noted in the Subarea profiles.

The ten study area Subareas are described in Sections 5.0 through 14.0. Subareas I, II, III, IV, V, and VI are terrestrial in character. Subareas VII, VIII, IX, and X are water (marine) areas. The format for the discussion of the land Subareas is similar to that of the study area profile. The water Subarea presentations focus on offshore and nearshore conditions and resources. The most extensive information was available for Subareas I, II, and IV. These Subareas include the majority of the population of the study area and most of the industrial and economic concentrations. Subarea I includes the Kenai-Soldotna area; Subarea II is the Homer-Anchor Point region; and Subarea IV incorporates the southeastern shore of Kachemak Bay (Seldovia, Port Graham, etc.). Subarea III, the Fox River Flats at the head of Kachemak Bay, has few residents and no utilities or other public facilities. Subareas V and VI, on the west side of Cook Inlet, also are populated sparsely, with activity concentrated at the Drift River Petroleum Terminal and at Tuxedni Bay. Data for these latter Subareas are limited.

Discussion of the four marine Subareas is brief because of the extensive material provided in the study area profile (Section 3.0.). Sections 11.0. through 14.0 focus on the special characteristics that are found in each of the water Subareas.

Numerous graphics are provided throughout the Manual to supplement the textual descriptions. The visual presentations are designed to highlight key topics and to portray existing conditions on a general scale. They are not intended to define conditions at specific sites.

2.0. INTRODUCTION

2.1. Purpose, Goals, and Assumptions

The Lower Cook Inlet region is one of the most important areas in the State of Alaska. It is near the existing population centers and the limited transportation network, and it is rich in natural resources, including fossil fuels and minerals. Industry, commerce, and tourism are expanding rapidly in the region, and recent development has increased the number of applications for new source NPDES permits. USEPA permit activity is expected to continue to increase as offshore oil and natural gas, fisheries, and mineral resources are developed.

Although descriptions of existing conditions in the region are contained in a number of documents that were prepared previously by Federal, State, and local agencies, information usually was not assembled in a form that was easily retrieved for new source permit evaluations. The need for a single, comprehensive document for use by USEPA personnel resulted in the preparation of the New Source Environmental Evaluation/Impact Review Manual for the Lower Cook Inlet, Alaska (hereinafter called the Manual).

The Manual is designed to assist USEPA personnel in the review of new source permit applications and in the preparation of evironmental assessments pursuant to the requirements of the NPDES program and the National Environmental Policy Act (NEPA). Information is presented in a format that will enable users to obtain data regarding a particular subject or locality rapidly. Background material provides a detailed overview of local conditions and serves as a starting point for additional data acquisition. The Manual is organized in a series of profiles that present data pertinent to the overall study area and to each of the designated Subareas. The study area and Subarea profiles describe the physical and biological environment, land and water use, socioeconomics, institutions, and cultural, historic, archaeological, and aesthetic resources. The resource descriptions emphasize the factors that potentially may limit development and elements that may sustain adverse impacts. Sources of additional information, a list of ongoing studies (as of June 1979), and descriptions of current NPDES permits (as of June 1979) in the study area are appended.

It is anticipated that information contained in the Manual will be combined with data from permit applicants and will be used in the initial review process. Data gaps identified at this stage can be resolved by contact with the applicant and with additional information from the sources referred to in the Manual. The material gathered in this manner will assist in the identification of significant issues and will provide a firm foundation for the preparation of the environmental assessment by USEPA. A brief description of the new source NPDES program is presented in Section 2.3.

The information presented in the Manual was developed through a review of published and unpublished documents and by contact with Federal, State, and local agencies. No original data were collected.

2.2. Study Area Boundaries

The study area boundaries are designed to include the geographic areas and the natural and man-made communities that potentially will experience the most significant effects of new development in the Lower Cook Inlet region. The study area consists of all non-Federal lands and waters in the Kenai Peninsula Borough south of the Cook Inlet Forelands and north of an arbitrary line between Cape Elizabeth on the eastern shore of Cook Inlet and Cape Douglas on the western shore. The general location of the study area and the surrounding lands and waters are shown in Figure 1 (adapted from Joint Federal-State Land Use Planning Commission 1973b). Study area and subarea boundaries are depicted in Figure 2 (adapted from Joint Federal-State Land Use Planning Commission 1973b). Rationale for subarea designations are presented in Section 4.0. of the Manual.

2.3. New Source NPDES Program

Section 402 of the Federal Water Pollution Control Act, as amended, (P.L.92-500) provides for the establishment of the National Pollutant Discharge Elimination System (NPDES). Regulated discharges are defined in Sections 301, 302, and 502 of the Act; new sources are defined in Section 306. Procedures for the determination of new sources are contained in regulations promulgated by USEPA on 11 January 1977 (42 FR 2450), Section 6.906 and Appendix A. Issuance of a new source NPDES permit is subject to the requirements of the National Environmental Policy Act of 1969 (NEPA), 42 USC 4321 et seq., pursuant to Section 511(c)(1) of the Federal Water Pollution Control Act, as amended (FWPCA). NEPA provides that all agencies of the Federal government must prepare detailed environmental statements on major Federal actions that may affect significantly the quality of the human environment.

The Council on Environmental Quality (CEQ) issued final regulations on the implementation of the procedural provisions of NEPA on 29 November 1978 (43 FR 55978). The preparation of an environmental assessment (EA) is discussed in Sections 1501.3 and 1508.9 of the new regulations. Decisions on whether to prepare an environmental impact statement (EIS) must comply with Sections 1501.4 and 1507.3. Preparation of the EIS is detailed in Part 1502 of the new CEQ regulations. When a Federal agency determines, on the basis of the EA that an EIS will not be prepared, a finding of no significant impact must be issued (Section 1501.4). USEPA procedures to supplement the new CEQ regulations (Section 1507.3) currently are being developed.

In accordance with these regulations, USEPA Region X will be required to prepare EAs and EISs for new source NPDES permits. The New Source Environmental/Impact Review Manual for the Lower Cook Inlet, Alaska, will be an important tool for use in these undertakings. The Manual should assist USEPA personnel in achieving the goals of reduced paperwork and the minimization of delays that were expressed in the new CEQ regulations. Additional information regarding USEPA responsibilities in the Lower Cook Inlet study area is presented in Appendix A.

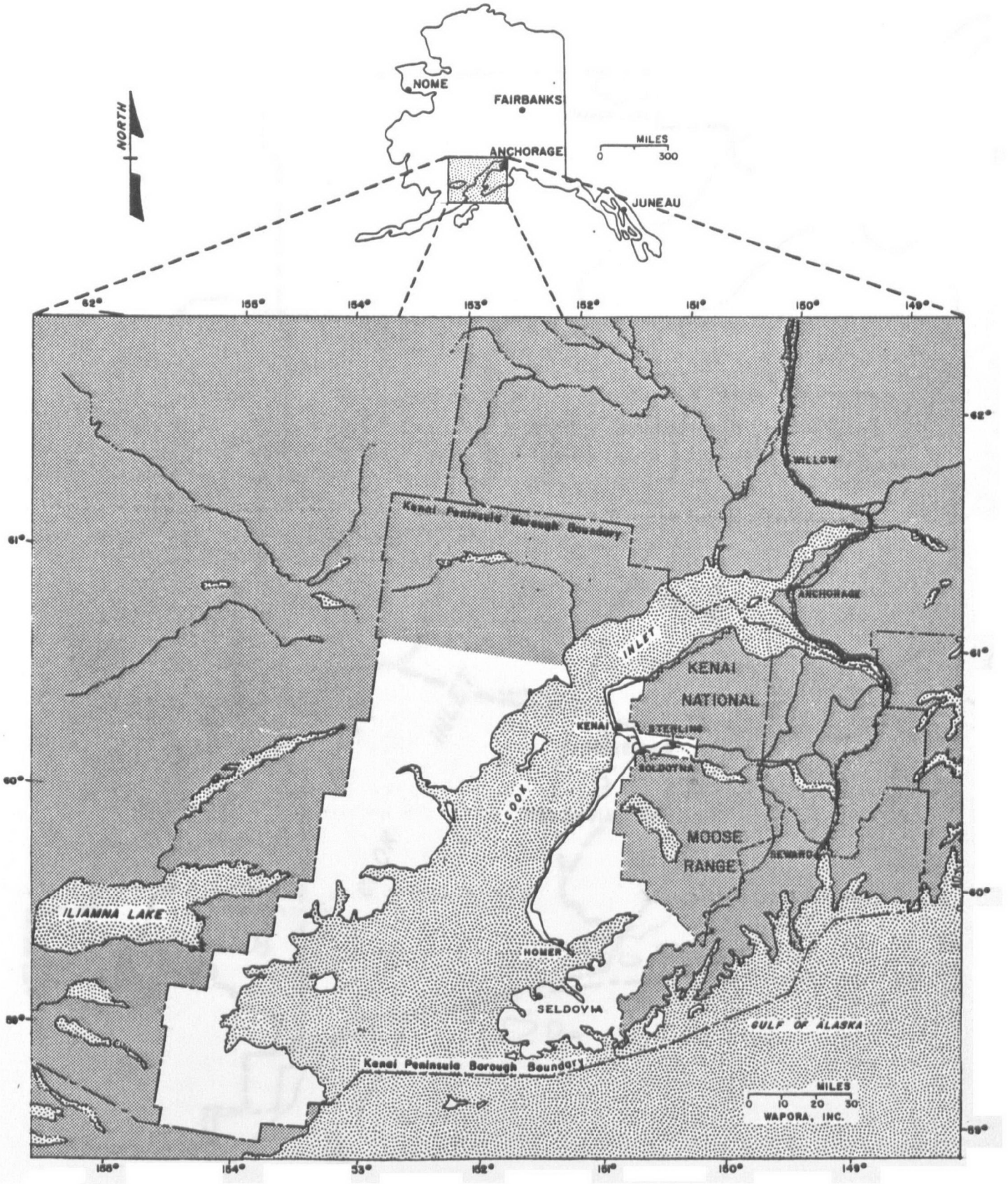


FIGURE 1

THE KENAI PENINSULA BOROUGH AND SURROUNDING LANDS AND WATERS. WATER IS INDICATED BY A "STIPPLED" PATTERN.

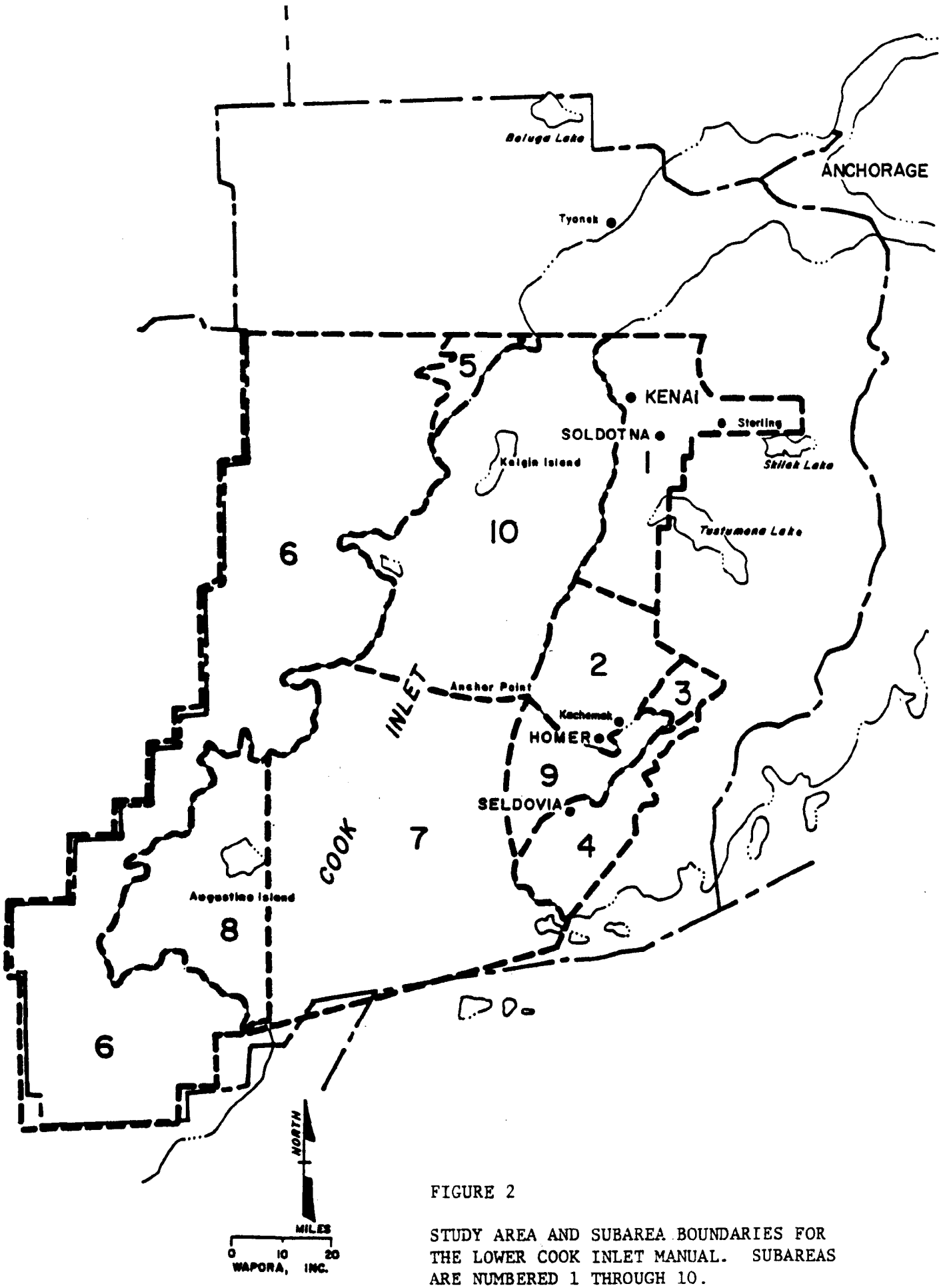


FIGURE 2

STUDY AREA AND SUBAREA BOUNDARIES FOR THE LOWER COOK INLET MANUAL. SUBAREAS ARE NUMBERED 1 THROUGH 10.

3.0. STUDY AREA PROFILE

3.1. Physical Environment

3.1.1. Geology

The Cook Inlet is a 200-mile-long tidal estuary contiguous to the Gulf of Alaska. The Inlet lies on a northeast-southwest axis and is bounded on the northwest by the Aleutian Range and on the southwest by the Kenai Peninsula. The Inlet is approximately 55 miles in width at its mouth. It expands into Kamishak Bay on the west and Kachemak Bay on the east, then gradually tapers to the Forelands, where it is approximately 10 miles wide.

Geologically, the Cook Inlet Basin resembles a graben -- a long, narrow section of the earth's crust that has subsided between bordering faults. Its origin, however, probably is associated more with geological folding than with subsidence. The Cook Inlet Basin lies between the Chugach Fault, the Bruin Bay Fault, and the Castle Mountain Fault. Only the Castle Mountain Fault has been active in recent times. The folding that initiated the Cook Inlet Basin occurred during the Tertiary Period (approximately 70 million years ago). Five recognized cycles of marine sediment deposition and mountain building during and following the Tertiary Period have modified the Basin extensively (Bureau of Land Management 1976).

3.1.1.1. Landforms

The terrestrial sections of the study area are composed of three major landforms: mountains, coastal lowlands, and the Kenai Lowlands Region. The landforms are defined both by present topography and by origin. The Chigmit Mountains and other mountains of the Aleutian Range rise from the western shores of the Cook Inlet and constitute the major landform in the western part of the study area. The tallest peaks are volcanoes more than 10,000 feet in height. The Chigmits primarily are composed of metamorphic and igneous material that was modified extensively by erosion and glacial action. The Kenai Mountains to the east of the Inlet run the length of the eastern Kenai Peninsula, then arc westward into the study area, where they form the southern boundary of Kachemak Bay. These also are of metamorphic origin, but have less igneous intrusion than the Chigmit Mountains. The Kenai Mountains contain the Harding Icefield and a number of smaller glaciers, several of which are located in the study area. Like the Chigmits, the Kenai Mountains are primarily of Tertiary origin and have been modified extensively by tectonic, glacial, and fluvial forces. Knife-edge ridges and steep-walled, U-shaped valleys, indicative of glacial action, are typical in the mountainous regions. Where the mountains are adjacent to Cook Inlet, the coastline is broken by deep bays and fiords.

The coastal lowlands represent less than 2 percent of the study area and are composed of depositions of various origins. They are defined separately because of their recent origin and their importance as land/sea interfaces. They consist of shoreline accretions of current and

tidal-borne silt, and depositions of glaciofluvial silt in bays and at river mouths. Soil particles range in size from coarse sand and shells to very fine silt. Wet soils may be firm to very soft. The largest coastal lowlands, the Bachatna Flats and the Fox River Flats, are on the lower reaches of glacier-fed streams. They rise gradually from tidal flats through saltmarshes and freshwater wetlands to low relief plains and terminate in the surrounding hills. These lowlands are dissected by braided or divided stream channels and tidal guts.

The Kenai Lowlands (as defined by Karlstrom 1964) extend from the Chugach Mountains to the Cook Inlet. Five periods of Pleistocene glaciation and two periods of post-Pleistocene glaciation, the last reaching its largest extent approximately 5,000 years ago, produced the present topography of this area. These repeated glaciations deposited a composite morainal system that is several thousand feet thick in some parts of the Kenai Lowlands. The Kustatan Lowlands, similar in topography and origin to the Kenai Lowlands, extend into the study area on the western shores of Cook Inlet.

The Kenai Lowlands are bordered by steep bluffs along Cook Inlet. Near the East Foreland the bluffs are approximately 100 feet in height. They gradually rise to the south and reach their maximum elevation of more than 700 feet at Bluff Point, near the mouth of Kachemak Bay. The bluffs are an effective barrier between Cook Inlet and the Kenai Lowlands, except where they are incised by river valleys. Topographically, the region consists of rolling hills of comparatively low relief and wetlands. In the northern lowlands the maximum elevation in the study area is approximately 400 feet. The lowlands rise to the south, reaching elevations of more than 2,000 feet in the hills north of Homer.

3.1.1.2. Geologic hazards

As modeled by the modern theory of continental drift, the continents and the oceans of the earth rest on vast crustal plates that are in constant motion due to convection of the molten inner earth. Two of these crustal plates meet along the Aleutian Trench (west of the study area), where the northward-moving Pacific crust is thrust beneath the North American crustal plate. The underthrusting movement is not smooth, but proceeds in sporadic "jerks" when the strain becomes too intense. The 1964 Alaska earthquake, one of the strongest earthquakes ever recorded, and many of the smaller earthquakes that are registered each year in south central Alaska are manifestations of these "jerks." Volcanism also is produced by plate convergence. The volcanoes of the Alaska Peninsula and the Aleutian Range, including the five active volcanoes in or adjacent to the Cook Inlet Basin, are located along the 100- to 110-kilometer depth contour of the underthrust Pacific crust.

Seismic hazards

A second major fault line in addition to the Aleutian Trench, is located near the study area. This fault parallels the coasts of British Columbia and Southeastern Alaska and terminates east of the study area, where it contributes to the seismicity of the region. Since 1899, eleven

earthquakes of 6.0 or more on the Richter Scale have been recorded in the study area (National Oceanic and Atmospheric Administration 1976). In 1971, the Federal Field Committee for Development Planning in Alaska (US Army Corps of Engineers 1974) placed the study area in seismic zone 3; the highest seismic risk zone of Alaska. In this zone earthquakes may have magnitudes of 6.0 to 8.8, and major structural damage may result. Although the Cook Inlet is seismically active, it is less active than Prince William Sound to the east or the Alaska Peninsula-Aleutian Trench region on the west, presumably because it is north of the very active crustal blocks that adjoin the Aleutian Trench.

If the seismicity gap theory of Kelleher (1970) is applied to the Aleutian seismic belt, severe earthquakes are predicted for highly active seismic areas that have not had severe earthquakes for a long period. Because the Cook Inlet has not had an earthquake exceeding 7.3 on the Richter scale since at least 1899, it might be considered by the Kelleher theory to be susceptible to a severe earthquake. However, the Cook Inlet Basin received comparatively few aftershocks following the 1964 earthquake. This is considered to be evidence that the seismicity gap theory does not apply to the Cook Inlet Basin (US Army Corps of Engineers 1974).

Severe earthquakes outside the Cook Inlet Region will be attenuated by distance, but may produce severe damage within the study area. The epicenter of the 1964 Alaska earthquake was near Valdez, more than 100 miles from the study area, but it produced severe earth tremors, ground fissuring, subsidence and slippage; injuries, fatalities, and property damage in the Cook Inlet study area.

Tsunamis (tidal waves) frequently follow earthquakes that occur in coastal regions. Tsunamis are caused by underwater subsidence, slippage, faulting, volcanic eruption or other manifestations of seismic activity. Tsunamis may affect points thousands of miles from their source, but local tsunamis are more common and may reach larger magnitudes. The most severe tsunami recorded in Alaska was the Lituya Bay Tsunami (not located in the study area), which reached a maximum height of 525 meters above sea level. Three tsunamis have been recorded in Cook Inlet (Cox and Pararas-Carayannis 1976). They were:

Location	Magnitude	Date
Cook Inlet	not recorded	30 December 1901
Port Graham	7.5 to 9 meters	6 November 1883
Seldovia	1.2 meters	27 March 1964

The 1883 and 1901 tsunamis were associated with eruptions by Mount Augustine. Deep, narrow bays tend to funnel tsunamic waters, thus amplifying the wave height and increasing the damaging effects. In the study area, the Tuxedni Channel, a few of the deeper (uninhabited) bays along the western Cook Inlet shore, and the deep bays of the lower Kenai Peninsula are particularly susceptible to tsunamic damage. Mount Augustine is considered to be the primary tsunami generation point in Lower Cook Inlet. The location of Mount Augustine adjacent to the west-

ern inlet bays and directly across from the lower Kenai Peninsula increases the chances that a tsunami generated by Mount Augustine would reach a bay where substantial damage would be caused.

Volcanic hazards

Five volcanoes are located in or near the study area. From north to south they are: Mount Spurr, Mount Redoubt, Mount Iliamna, Mount Augustine, and Mount Douglas (Figure 3; adapted from Alaska Department of Natural Resources 1978b). All but Mount Douglas have erupted in historic time. The eruption history of the four recently active volcanoes is summarized in Table 1.

The volcanoes of the Pacific Rim, including those in the Alaska Peninsula and Cook Inlet Basin, are andesitic (i.e., composed of a dark greyish rock that consists of oligioclase or feldspar). They tend to erupt lava and more viscous materials than the basaltic volcanoes of the Pacific Basin. Andesitic volcanoes are potentially more explosive than basaltic volcanoes, and the eruption of Mount Katmai in 1912 was one of the largest volcanic explosions ever recorded. Hazards associated with volcanic eruptions include: ash clouds, nuees ardentes (glowing ash clouds), mudflows, lava flows, landslides, corrosive rain, lightning discharges, flash floods, tsunamis, and earthquakes. Damage may be local or regional. The 1912 Katmai eruption covered much of Kodiak Island with 0.3 meter of ash and altered the vegetation of the upper Alaska Peninsula, thus virtually eliminating caribou on the upper Peninsula. Eruptions by Mount Spurr and Mount Augustine have deposited ash on Anchorage in recent years. Activity by Mount Redoubt melted snow and caused extensive flooding by the Drift River. The largest tsunami recorded in Cook Inlet followed an eruption and mudslide from Mount Augustine in 1883; Port Graham was destroyed.

Flooding

Flooding in the study area may be caused by runoff from rains, by snow and glacial meltwater runoff, by ice jams, or by glacial outbursts. Precipitation may result in flooding during the late spring, summer, or early autumn, especially along streams that also receive glacial meltwater runoff. Meltwater from snow usually is most voluminous during the late spring, whereas glacial meltwater runoff peaks near the end of the summer. Ice jams have caused the worst floods recorded on some systems. They may occur anytime between freezing and breakup, but are especially likely during breakup. Glaciers may cross valleys and permanent or intermittent watercourses; dams may form that can, in turn, create substantial temporary lakes. As a lake grows it exerts more and more pressure against the glacial dam and erodes the ice surface. Eventually, the stress causes the lake to break through the dam, either overtop or beneath the glacier. The entire lake may be released in a very short interval, and the resulting flash flood may be severe. Depending on the nature of the glacier and the stream it dams, outbursts may occur at fairly regular intervals or may be unpredictable.

Several of the river systems in the study area receive runoff and glacial outburst flooding and may be expected to receive flooding in the future. These rivers are identified in the Subarea profiles.

Table 1. Eruption history of Cook Inlet volcanoes (US Army Corps of Engineers 1974).

Mt. Augustine		Mt. Redoubt		Mt. Illiamna		Mt. Spurr	
Date	Activity	Date	Activity	Date	Activity	Date	Activity
1812	active	1778	active	1741	grew quiet	1953	ash eruption (fallout on Anchorage)
1883	violent eruption with ash and mudflows	1819	smoke	1768	smoke	1954	ash eruption
1885	steaming from shore to summit	1902	active	1778	active		
1895	crater steaming	1933	smoke	1779	active		
1935	lava eruption	1966 thru 1968	recurrent explosions and turbulent clouds to elevations over 40,000 feet; caused flooding of Drift River in 1966	1786	smoke		
1963	7 November			1867	ash eruption		
1964	5 July and 9 August			1876	smoke		
1976	recurrent eruptions, mudflows, glowing cloud; ash to 40,000 feet			1933	smoke		
				1947	smoke		
				1952	smoke		
				1953	smoke		

GEOLOGIC HAZARD

LANDSLIDE AND SLUMP

VOLCANIC AREA

FAULT ZONE

COASTAL EROSION

TSUNAMI HAZARD

EXTENT OF ICE

AREA OF SUBSIDENCE

POTENTIAL MELTWATER AND RUNOFF FLOODING

POTENTIAL GLACIAL OUTBURST FLOODING

FIGURE 3
GEOLOGIC HAZARDS

Other hazards

Avalanches and landslides are potential geological hazards in the mountainous regions of the study area. Landslides and erosion are hazards along the larger rivers of the study area and the bluffs of Cook Inlet. With few exceptions, the mountainous regions are remote from human populations and active resource extraction activities. Avalanche/landslide hazards present little danger to existing communities, industries, and communications, but should be considered during future development planning. Areas with potential for avalanches, landslides, and erosion are identified in the Subarea profiles.

3.1.1.3. Geologic resources

Commercially extractable concentrations and quantities of oil, coal, natural gas, metallic and non-metallic minerals, and building materials are found in the study area. Currently, the most economically important of these non-renewable resources are oil and natural gas. Oil seepages along the western shoreline (Oil Bay) were described by early settlers, and unsuccessful attempts to develop this resource were conducted on the Iniskin Peninsula in the early 1900s. On the Kenai Peninsula oil and natural gas have been produced since 1957, first from the Swanson River fields, then from the Upper Cook Inlet and from land sites around the Inlet. The locations of known petroleum and natural gas fields in and near the study area are shown in Figure 4 (adapted from Rao and Wolff 1975). Lease sales were conducted during October 1977 for petroleum and natural gas exploration and development in Lower Cook Inlet and on parts of the Kenai Lowlands. Exploratory drilling began during the summer of 1978. The drilling is expected to add to the known Cook Inlet reserves.

Proven recoverable oil reserves of the Cook Inlet region are estimated to total more than 500 million barrels. Proven natural gas reserves are estimated to total more than 5 trillion cubic feet. The oil production is largely from the Hemlock and lower Tyonek Formations. Most of the natural gas production is from the sands of the Beluga and Sterling Formations. Proven reserves and production of petroleum and natural gas until 1976 are listed in Table 2. Most of these wells are located beyond the study area in the Upper Cook Inlet or in the Susitna River Flats. Producing wells in the study area are discussed in the Subarea profiles.

The 1977 Lower Cook Inlet Lease Sale offered 135 tracts -- 89 on a fixed royalty of 16.66 percent plus a cash bonus and 46 on a royalty bid basis with a fixed cash bonus ranging from $193,848 to $3.4 million per tract. A total of 81 bids were accepted, and leases were signed on 200,448 hectares (495,307 acres), for a total price of almost $400 million. The highest single bid for a cash bonus tract was slightly more than $77 million. The highest royalty bid was 63.4444 percent. The tracts that were leased, including the tracts that received the highest bonus bids and the highest royality bids, are shown in Figure 5 (adapted from Bureau of Land Management 1977b).

Before the bidding, the Bureau of Land Management (1976) had predicted that the Augustine-Seldovia arch that crosses the Lower Cook Inlet

Table 2. Oil and gas fields, Cook Inlet (Magoon and others 1976).

Oil fields	Status	Cumulative Production as of 31 December 1975: Oil (bbl)	Cumulative Production as of 31 December 1975: Casinghead gas (Mcf)	Recoverable Reserves: Oil (bbl)
Beaver Creek	Producing	1,114,905	387,080	---
Granite Point	Producing	60,495,670	56,879,971	49,504,000
McArthur River	Producing	294,217,241	92,888,099	208,784,000
Middle Ground Shoal	Producing	96,332,793	45,821,890	89,166,000
Redoubt Shoal	Shut-in	1,596	456	---
Swanson River	Producing	163,099,388	528,772,426	60,101,000
Trading Bay	Producing	62,577,313	41,421,614	---

Gas fields	Status	Dry gas (Mcf)	Natural gas liquids (bbl)	Dry gas (Mcf)
Albert Kaloa	Shut-in	118,774	---	---
Beaver Creek	Shut-in	291,516	---	400,000,000
Beluga River	Producing	34,657,415		687,000,000
Birch Hill	Shut-in	65,331	---	20,000,000
Falls Creek	Shut-in	18,983	---	80,000,000
Ivan River	Shut-in	---	---	5,000,000
Kenai	Producing	639,619,605	9,888	2,250,000,000
Lewis River	Shut-in	---	---	785,000,000
McArthur River	Producing	36,919,664	---	785,000,000
Moquawkie	Shut-in	985,059	---	---
Nicolai Creek	Producing	921,385	---	50,000,000
North Cook Inlet	Producing	268,001,981	---	1,410,000,000
North Fork	Shut-in	104,595	---	20,000,000
North Middle Ground Shoal	Shut-in	---	---	125,000,000
Sterling	Producing	1,848,006	---	200,000,000
Swanson River	Shut-in	11,839,353	---	300,000,000
West Foreland	Shut-in	---	---	120,000,000
West Fork	Shut-in	---	---	100,000,000

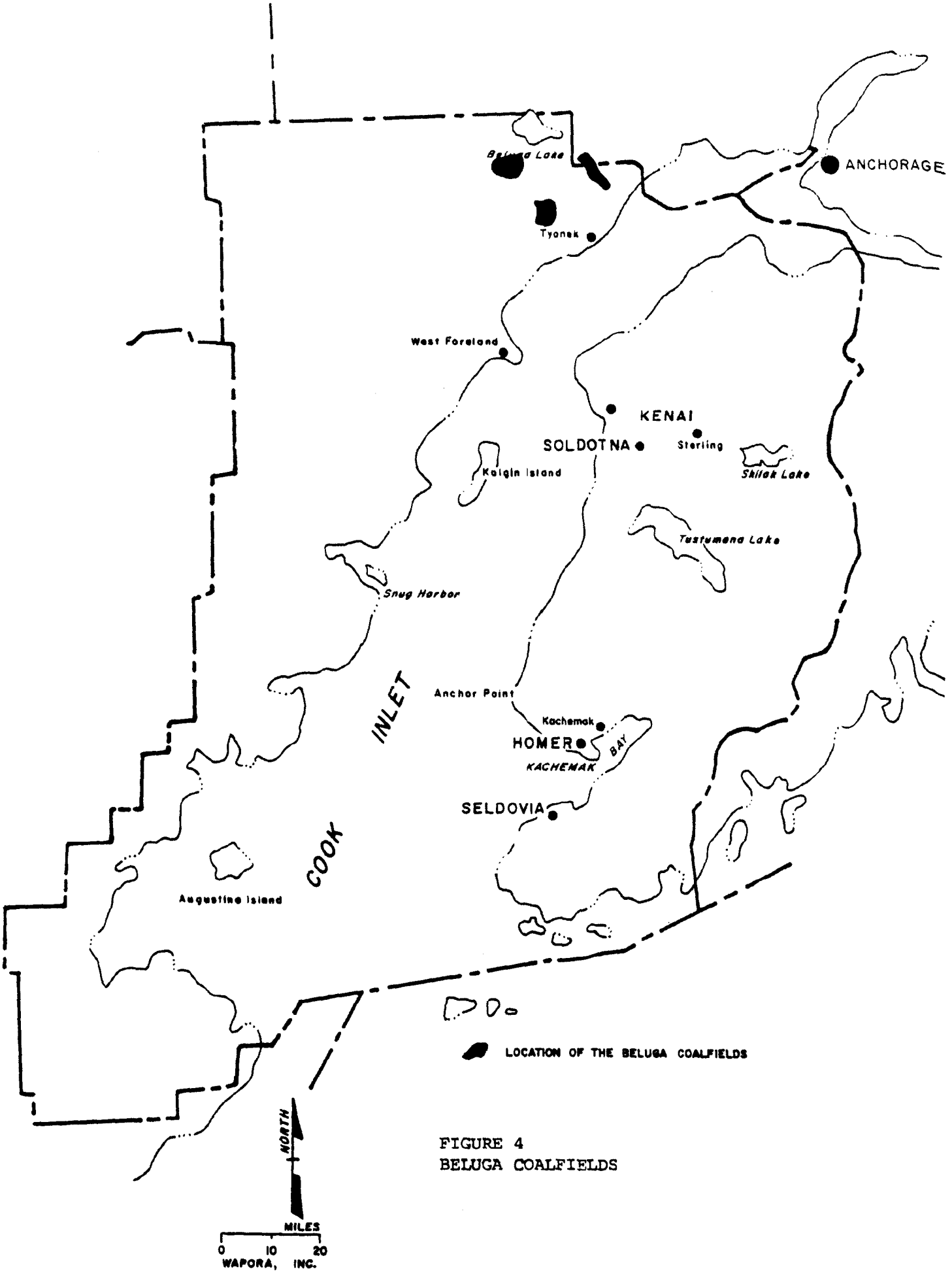


FIGURE 4
BELUGA COALFIELDS

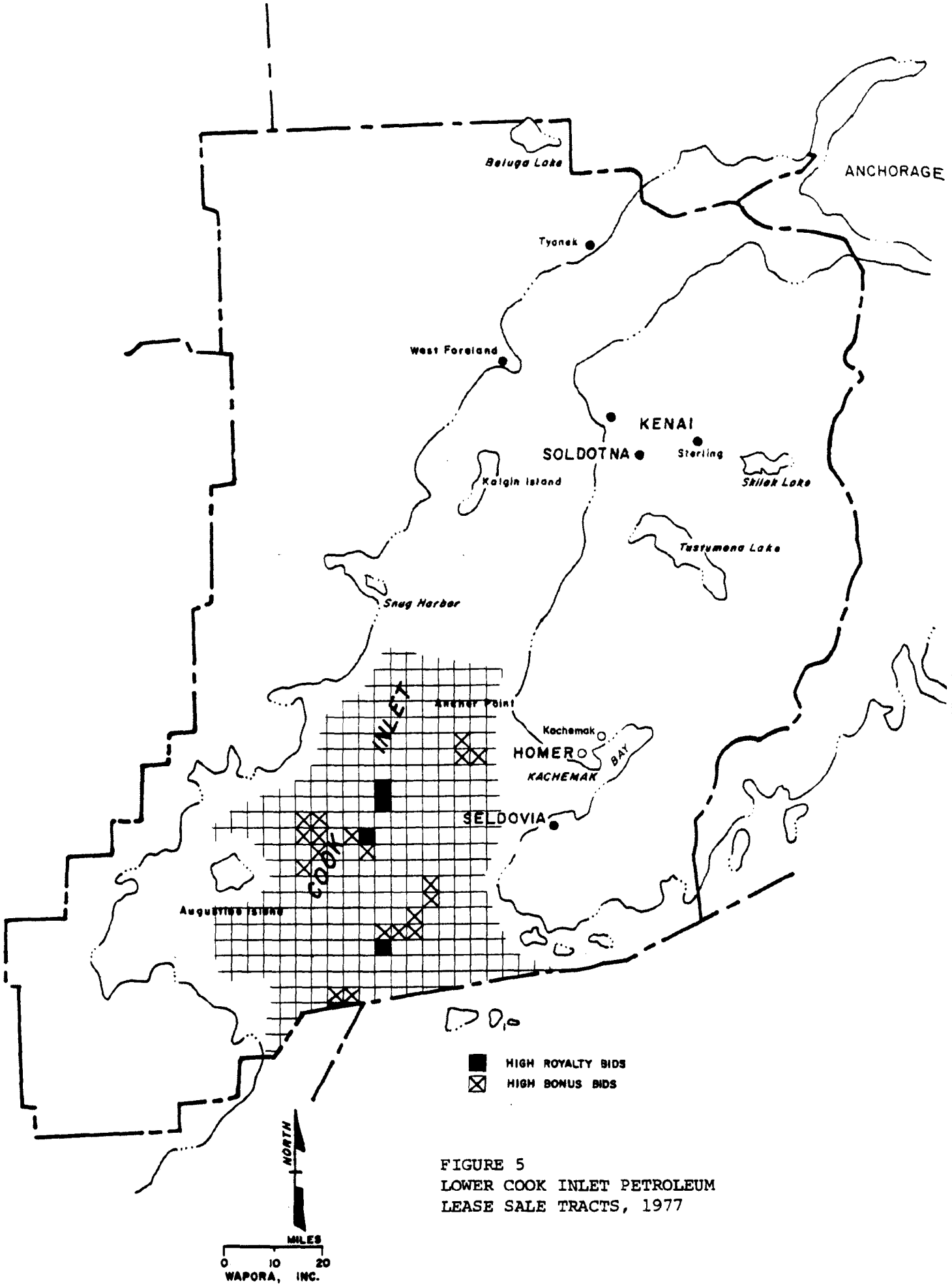


FIGURE 5
LOWER COOK INLET PETROLEUM
LEASE SALE TRACTS, 1977

might be the focus for oil exploration. The top three royalty bids and the top three bonus bids, however, were for tracts off Anchor Point, tracts (midway between Anchor Point and Augustine Island), and tracts near the mouth of the Lower Cook Inlet (Figure 5).

Coal has been mined sporadically in the study area since the Russian occupation during the nineteenth century. Known reserves of lignite and subbituminous coal include fields in the Beluga region, north of the study area, and fields on the Kenai Peninsula (Figure 4). Coal leases exist for the Beluga area and the southern Kenai Peninsula, but currently there is no coal mining at either location.

The huge coal reserves of Alaska (estimated at approximately 582 billion tons; Sanders 1975) are being exploited only at the Usibelli Mine in the Nenana Coalfield at the rate of approximately 700,000 tons per year. The remaining coalfields are undeveloped because of a wide range of problems, including:

> ... the high cost of operations, general lack of transportation, problem of land status, and the maze of permits, environmental studies, and antidevelopment actions, and unpredictably changing government policies ...(Sanders 1975).

Three major areas of coal resources have been reported from the Cook Inlet region: the Beluga Coalfield, northwest of the study area; the Matanuska Coalfield northeast of the study area; and the Kenai Coalfield in the western Kenai Peninsula. The Beluga Coalfield includes the Capps and Chuitna deposits that have been explored by Placer-Amex, Inc. Patsch (1975), a Placer-Amex representative, reported that the Capps deposit consisted of two major beds with a maximum thickness of 25 to 55 feet in a local coal basin. He reported that the Chuitna area contains at least six beds, at least one of which was a maximum of 40 feet in thickness. Both areas have local structures that bring the coal beds close to the surface. The Beluga coals are ranked as subbituminous "C" coals and are similar to those of the western US. Patsch (1975) reported that sulfur concentrations in Beluga coals were low enough to meet air quality criteria for direct burning.

Barnes (1967) estimated the coal reserves within 1,000 feet of the surface in the Beluga-Yentna Region to total approximately 2,400 million short tons. Of this total, he estimated that 2,100 million tons were in a 40-square-mile area, including the Beluga Coalfield, south of the latitude of Beluga Lake. These reserves contained the Beluga Bed (10 million tons), the Capps Bed (366 million tons), the Chuitna Bed (1,190 million tons), and others. The deposits are in simple beds that can be developed without unusual difficulty and are within 30 miles of the Cook Inlet. Patsch (1975) stated that development of these deposits and the required infrastructure would be feasible only if at least 5 million tons were extracted per year.

The Matanuska Coalfield contains reserves of approximately 112 million tons that are fairly close to the existing infrastructure. They would be difficult to develop, however, because much of the deposition is

deeply buried, intensely deformed, and lacks uniformity and continuity (Rao and Wolff 1975).

The Kenai Coalfield was mined by early Russian and American settlers, but has not been producing for many years. Estimated reserves in the Kenai Coalfield total approximately 318 million tons. Much of this coal is in accessible locations and could be developed economically should a market arise.

Potential geothermal energy sources have been identified on the western side of Cook Inlet. These potential resources are unlikely to be developed because of the associated tectonic hazards.

The potential for economically recoverable metallic deposits in the study area is considered good in the mountainous regions of the southern Kenai Peninsula and the western side of the Inlet. Gold, silver, chromium, copper, lead, zinc, tungsten, molybdenum, iron, and nickel may be present in commercial quantities.

Glacial deposits suitable for backfill and river gravel suitable for concrete and road aggregate are present. Clay suitable for brick firing also is available.

3.1.2. Hydrology

This section presents relevant data on the marine environments of the study area. The profiles for Subareas VII, VIII, IX, and X supplement the following discussion with specific information on the bathymetry, oceanography, and biology of the Lower Cook Inlet.

The Bureau of Land Management's Outer Continental Shelf Environmental Assessment Program (OCSEAP) was a frequently used source of information in the development of this section. Studies on trace metals, zooplankton, marine mammals, benthic organisms, marine birds, hydrocarbons, and sediment transport in the study area have been completed. The OCSEAP will continue to amass data on the Lower Cook Inlet that will be of value to its understanding.

3.1.3. Oceanography

At the Forelands the maximum depth of the Inlet is approximately 75 fathoms (450 feet), but a few miles south the maximum depth decreases to approximately 30 fathoms (180 feet). The Inlet gradually deepens between the Forelands and Anchor Point, about half way down the inlet, but the maximum depth seldom exceeds 40 fathoms (240 feet). South of Anchor Point the central part of the Inlet is approximately 25 to 40 fathoms (150 to 240 feet) in depth almost to the Inlet mouth. Near the mouth the Inlet deepens to 70 to 90 fathoms (420 to 540 feet). Preliminary bathymetric data for the Lower Cook Inlet are presented in Figure 6 (adapted from Science Applications, Inc. 1977).

3.1.3.1. Circulation patterns

The circulation patterns in the Lower Cook Inlet have been studied recently by numerous investigators. Drift cards, radar reflecting drogues, and ERTS-1 and LANSAT 1 imagery have been employed in various attempts to define the circulation patterns of Cook Inlet. Gatto (1976),

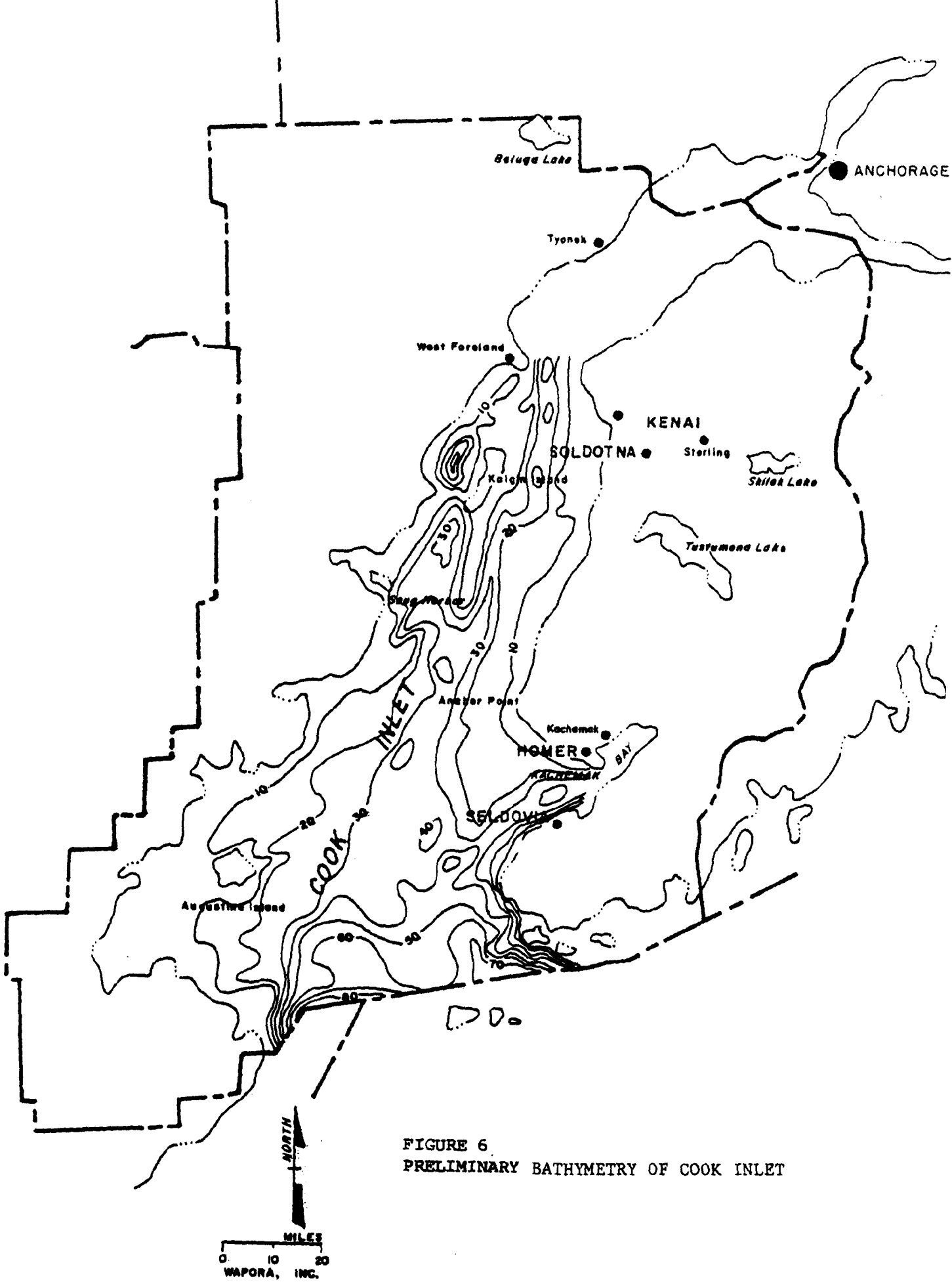


FIGURE 6
PRELIMINARY BATHYMETRY OF COOK INLET

Sharma and others (1976), and Burbank (1977) have assembled considerable data on the net circulation of the Inlet. The most recent, and possibly the most accurate, circulation model was developed by Burbank (1977). The following discussion is based on his work for the Alaska Department of Fish and Game.

Water from the Gulf of Alaska flows into Cook Inlet through the Kennedy entrance, located off the southern tip of the Kenai Peninsula. As the ocean water enters, it encounters a comparatively steep ramp at the mouth of the Inlet and upwells into the central part of the Inlet and Kachemak Bay. The nutrients and plankton carried in by this water contribute to the high primary productivity of the Kachemak Bay region.

The net flow pattern in Lower Cook Inlet circulates water from the Gulf of Alaska up the coast of the Kenai Peninsula to Anchor Point, across the Inlet, and south along the western shore. The net outflow from Cook Inlet exits to the south through the Shelikof Straits. The circulation patterns identified in the Lower Cook Inlet are shown in Figure 7 (adapted from Burbank 1977). Turbid water from the Upper Inlet mixes with clear water from the Gulf of Alaska north of Anchor Point. The west side of the Inlet receives most of this suspended silt due to the prevailing circulation pattern. The difference in the density between the waters from the Upper Inlet and those from the Gulf of Alaska tends to slow lateral mixing in the Inlet, although rapid currents keep the Cook Inlet waters well mixed vertically. Lateral mixing may produce convergence zones, in which denser saline waters flow under less saline waters and produce tide rips. The tide rips also display considerable horizontal shear, manifested by differing current velocities on either side of the frontal zone. The tide rips may be identified by the oil and flotsam that accumulate at the convergence. Tide rips may be important determinants controlling the dispersion of oil and other floating contaminants. The major tide rips in Lower Cook Inlet are charted in Figure 8 (adapted from Burbank 1977).

3.1.3.2. Tides

The tides in Cook Inlet are some of the largest in the world. At the mouth of the Inlet the mean diurnal tidal range is 13.7 feet. At Kenai the mean range is 19.8 feet; at Anchorage it is 29 feet; and at the ends of both the Knik Arm and the Turnagain Arm the mean range exceeds 35 feet. During the spring the highest and lowest tides may exceed the mean high and low tides by more than 5 feet, producing tidal ranges of more than 30 feet at Kenai and 40 feet at Anchorage. These maximum tides may produce currents exceeding 7 knots at the Forelands. Under normal conditions the currents at the Forelands are about 3.8 knots. Currents usually are slower in the Lower Cook Inlet.

3.1.3.3. Water chemistry

The chemistry of the Inlet waters changes seasonally, due primarily to variations in the volume of runoff and the rate of nutrient uptake by plankton. In 1972, salinity near the mouth of the Inlet was reported to be approximately 27 to 32 parts per thousand in May and approximately the same in September (Smith and Tilsworth 1975). Smith and Tilsworth reported a salinity of 28 parts per thousand in May at the Forelands. In

September the salinity there was less than 24 parts per thousand, demonstrating the diluting effects of the increased summer runoff. Gulf of Alaska waters are the primary source of inorganic nutrients in Lower Cook Inlet. Runoff, sewage from Anchorage, process wastes from Collier Chemical Company at Nikiski, and rainfall contribute comparatively small volumes of nitrogen to the Inlet. Active nitrate levels in the central part of the Inlet range from 5 to 18 mg/l (0.005 to 0.018 mg/l) at mid-channel, but nitrate may be undetectable in shallower waters during spring and summer plankton blooms (NOAA 1977). Levels of dissolved oxygen typically are near the point of saturation. Sediment loads are heavy near the Forelands, sometimes exceeding 100 mg/l near the West Foreland. The turbidity rapidly decreases south of Kalgin Island; near the Inlet mouth the sediment load was reported to be 2 to 3 mg/l (Sharma and others 1974).

The physical and chemical features of the Upper Inlet differ distinctly from those of the Lower Inlet. Most of the freshwater flow into Cook Inlet enters north of the Forelands from five rivers of glacial origin: the Susitna, Matanuska, Little Susitna, Knik, and Chakachatna Rivers. Besides diluting the seawater in the Upper Inlet, these rivers carry heavy loads of glacial silt. Most of the estimated 200,000 tons of silt that enters Cook Inlet each day from May through September is deposited in the Upper Inlet (D. L. Peterson and Associates 1971).

Silt deposition has shoaled the Upper Inlet to the extent that broad flats are exposed during low tide. The combination of fine silt particles and rapid currents produces unstable substrates and suspended solid loads as concentrated as 1,500 mg/l. Net outflow from the Upper Inlet carries the turbid, low-salinity waters through the Forelands into the Lower Cook Inlet.

3.1.3.4. Hazards

Sea ice may form in the Lower Cook Inlet by November or December and last until April or May. The extent of the ice pack depends on the severity of the winter. During a severe winter, continuous pack ice may extend as far south as Anchor Point on the east and Cape Douglas on the west. Sea ice tends to accumulate along the western shoreline as a consequence of the prevailing winds and circulation patterns. Sea ice in the Lower Cook Inlet may originate from the Lower Inlet, particularly on the flats of Kamishak Bay, or from the Upper Inlet. Ice from the Upper Inlet has a lower salinity, is harder, and consequently is more dangerous to fixed structures and shipping. Sea ice frequently interferes with winter shipping in the Upper Inlet and may cause problems at the Drift River Terminal and the Nikiski docks in northern Lower Cook Inlet. The Federal Power Commission (1976) reported that vessel casualty rates in northern Lower Cook Inlet were approximately double those reported for other locations in a survey of seven US harbors. Ice and currents were implicated in the higher casualty rates.

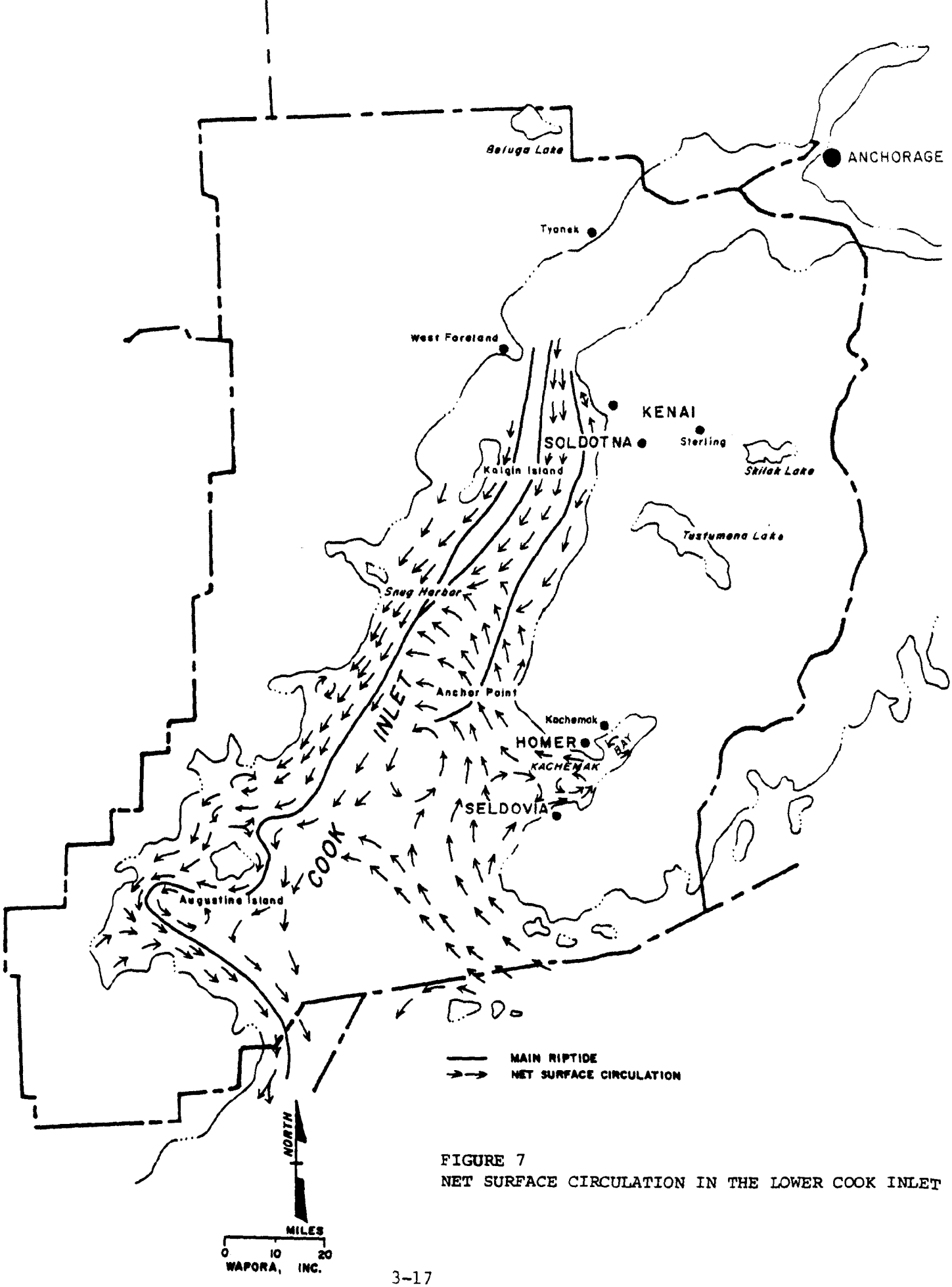


FIGURE 7
NET SURFACE CIRCULATION IN THE LOWER COOK INLET

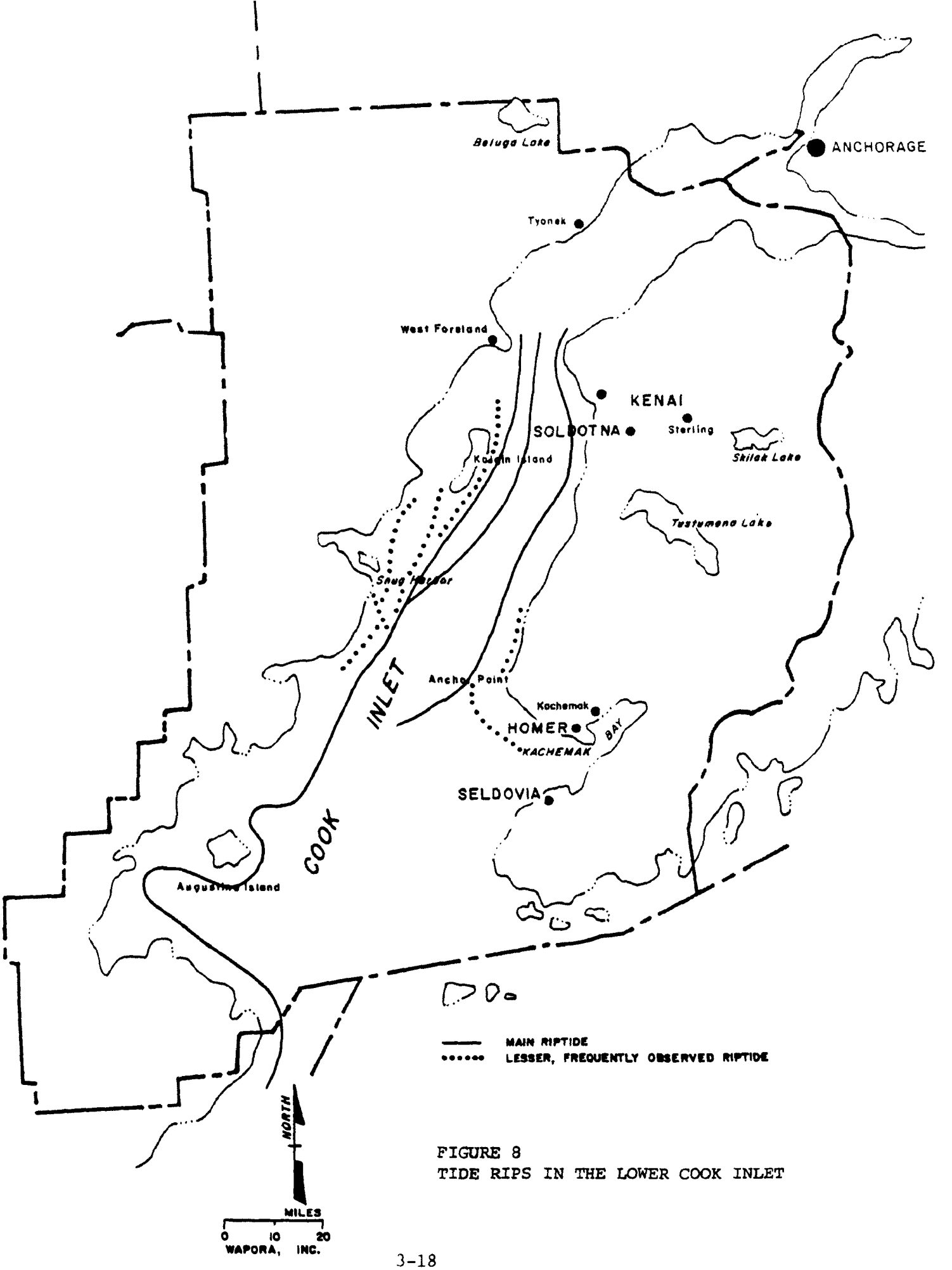


FIGURE 8
TIDE RIPS IN THE LOWER COOK INLET

3.1.4. Climatology and meteorology

The Lower Cook Inlet study area includes a wide range of climate, meteorology, and ambient air quality. Local conditions vary significantly. Because there are only two data collection points for meteorological and climatological data and only one major collection area for ambient air quality information in or near the study area, the following discussion must be regarded as a general review of the conditions in the study area. It is likely that site-specific data will need to be collected if a proposed new source is expected to have significant air quality impacts.

3.1.4.1. Climatic setting

Characterization of the study area

The characterization of the dispersion climatology in the study area presents some problems that are typical of such efforts in a coastal environment. Because the vertical atmospheric profile of temperature and wind varies within a short distance from the shoreline and with the relative orientation of land and water, routine observations taken at one location are not necessarily characteristic of an entire area. Moreover, it is difficult to describe the climate of an entire area, which is subject to various degrees of maritime influence, on the basis of climatological data from one, or a few, locations.

The climate of the southern coastal section of Alaska is influenced by contrasted air masses that originate in different regions during different seasons. During the winter, cold, dry continental air masses originate in the north; and mild, moist air masses with precipitation originate in areas from the southwest through the southeast. During the summer, warm, dry winds usually originate in the northeast and eastern quadrant, while moist winds accompanied by cooler maritime air originate in the southern quadrant.

Temperature and precipitation

In the southern coastal areas winters are mild, with a minimum average mean temperature near freezing and an average daily temperature in the range of 8°F (4°C). Summers are cool, with a maximum average mean temperature of 55°F (13°C) and an average daily temperature in the range of 10°F (6°C). Annual extremes of temperature may range from 0°F (-18° C) to 80°F (27°C).

Annual precipitation in the study area is likely to range from approximately 15 inches (38 cm) in the northern interior sections to 60 inches (150 cm) in the southern coastal sections. Some anomalies exceeding that range are likely in mountainous areas.

Data representative of the average conditions in the study area are contained in the Local Climatological Data Summary for Homer (National Climatic Center 1976). A copy of this report is provided in Appendix B. It should be noted that the applicability of these data is very general with respect to the study area.

Continental and maritime influences

The study area north of Kachemak Bay is affected most by the continental influence. The southern section and the Inlet waterway climate is almost entirely maritime. There are two upper air observing stations that are maintained by the National Weather Service in the general vicinity of the study area, at Anchorage and at Kodiak. The Anchorage climate is characterized by an alternation of continental and maritime conditions and that of Kodiak is almost entirely maritime. An average of the annual meteorological parameters between the two stations probably would describe the average climate of the study area.

During the Alaskan winter, the continental climate is characterized by very light winds and a steep temperature inversion, with mixing depths near zero the entire day. The maritime climate is characterized by a windspeed averaging 10 mph (4.5 meters/sec) or more and temperature lapse rates near neutral through the day. Mixing depths usually are over 300 meters and vary little throughout the day because the day is as short as 5.5 hours and the declination of the sun is very low.

During the Alaskan summer, areas characterized by maritime climate generally have more cloud cover than the interior, but the land warms sufficiently during the day to create a temperature differential between the land and the sea. This temperature differential causes the development of an onshore breeze that continues throughout most of the day. The summer night in both continental and maritime climates is characterized by inversions and mixing depths of near zero, with light winds.

The dispersion conditions in the study area result from a combination of continental and maritime influences throughout the year, depending on the large-scale wind flow and the movement of air masses. The northern section of the study area may be expected to have more frequent continental conditions, with strong continental characteristics. In the southern section of the study area, conditions may be expected to be maritime more frequently.

Dispersion meteorology

Copies of the STAR program output for the Cities of Kenai and Homer, Alaska, were examined to help describe the dispersion meteorology in the study area (National Climatic Center 1972, 1978a) and can be reviewed in Appendix B. The STAR program defines seasonal and annual wind distributions for the various Pasquill stability classes. Five stability classes are used to obtain the outputs: A, extremely unstable; B, unstable; C, slightly unstable; D, neutral; and E, stable. The stable class actually is a combination of Pasquill stabilities E (slightly stable), F (stable), and G (extremely stable). These stability classes are used to provide an indication of the atmospheric stability at the surface and are based on a calculated surface heating or cooling factor. This factor is a function of wind speed, cloud cover, and solar declination during the daylight hours. The more the ground is heated, the less stable the atmosphere becomes; the more the ground is cooled the more stable the atmosphere becomes. The data are not actual observations of atmospheric stability, but theoretical calculations of temperature-related stabilities immediately above the surface. The validity of the

factors used in these calculations, however, has been observed at the weather stations. Also, because the applicability of these stabilities extends through a layer immediately adjacent to the surface, these data do not indicate elevated inversions.

The average annual wind speed in the study area ranges from about 7 mph (3 meters/sec) in the interior sections to 10 mph (5.4 meters/ sec) in the southern coastal sections. Wind gusts of up to 30 mph (13 meters/sec) are not uncommon in coastal sections during storms; however, winds rarely reach 50 mph (22 meters/sec) except in the most exposed coastal locations.

A stability wind rose was prepared for each season of the year from STAR data for Kenai and Homer (Figures 9 through 20; adapted from National Climatic Center 1972, 1978a)). A wind rose is a graphic presentation of the wind frequency for each of sixteen compass directions (each direction contains 22.5 degrees). Each wind rose is oriented as if it were superimposed on a map, and the direction in which the frequency is plotted is the direction from which the wind comes.

As can be seen in the figures, Subarea V and the coastal sections of Subareas VI and VII have a major summer wind directional maximum from the south and a minor summer directional maximum from the northeast or east-northeast. A substantial, but minor, frequency of winds should be present from the east through the southeasterly quadrants. There are expected to be very few situations having southwest through northerly winds, due to the prevailing surface pressure gradients and the topographic blocking effect of the Aleutian Mountain Range.

The autumn and spring are transition periods in the study area with respect to wind direction frequencies. The north-northeasterly peak is present to varying degrees at both stations in the autumn and spring, as is the south to southwesterly peak (Figures 10,12,16, and 17).

During the autumn, the north-northeasterly peak is predominant at both stations, and the wind rose is more representative of winter than of summer. This probably is because the declination of the sun is low in the autumn, resulting in a lesser onshore wind component and a larger offshore component. Also, the frequency of low pressure or storm systems to the south and high pressure systems to the north increases over that of the summer, producing a more frequent northeasterly pressure gradient. There also is a minor southerly maximum present on the autumn wind roses. This probably is caused by the passage of low pressure systems to the west of the study area.

The spring wind rose for Homer shows about equal weight for the north-northeasterly and southwesterly peaks, but the Kenai wind rose shows that the north-northeasterly peak of winter still predominates. This is an excellent example of the difference of the maritime influence within the study area itself.

The trends observed at Homer and Kenai in the autumn and spring generally are representative of the wind direction frequencies on the eastern shores of Cook Inlet. The northern end should have more of the

continental influence, the southern end more of the maritime influence. The autumn and spring wind roses throughout the remainder of the Kenai Peninsula Subareas are modified by the varying coastline and mountain valley orientations.

The autumn and spring wind direction frequencies also should represent a transition state between winter and summer. The winter (north-northeasterly) and summer (southerly) peaks should be evident during both seasons, with the north-northeasterly peak predominating in the autumn. During the spring, the southerly peak is expected to be more predominant in the southern section of Kamishak Bay and along the Kamishak Bay coast, than it is in the north, due to the larger maritime influence in the south. In the mountainous zones of Subarea VI, where the wind is nearly always "up-valley" or "down-valley," the autumn and spring wind frequencies are in a transition between the summer and winter frequencies.

Mixing height data

The mixing height data presented herein are based on records of daily atmospheric mixing heights at Anchorage and Kodiak during 1976 and were obtained from the National Climatic Center (1978b, 1978c). For both stations the data summarize the daily mixing height and average wind speed through the mixed layer for the calendar year 1976.

A radiosonde upper air observation that measures temperature and wind as a function of height is taken twice each day at 1200 and 2400 GMT (0200 and 1400 Alaskan Standard Time). Early morning and afternoon mixing heights are computed from these radiosondes. The mixing height is the height above the surface up to which effective mixing of atmospheric contaminants would be expected. (If a ground-based temperature inversion exists, the mixing height is zero).

An indicator for each observation that notes precipitation and specific instances of ground-based inversion is provided with the observation data. These data were analyzed to define frequencies of mixing height as a function of average wind speed through the mixed layer for non-precipitation cases. A separate frequency distribution was produced for each station for each of the four seasons. Morning and afternoon cases also were separated. A summary of these data, which contains frequencies of mixing height only and does not include wind speed, is shown in Tables 3 and 4.

It is not possible to describe the dispersion climatology of any specific Subarea of the study area using the mixing height data for Anchorage and/or Kodiak. It is possible, however, to make general statements based on examination of these data plus a knowledge of the geography and climatic variations within the study area.

It appears that mixing height data for Kodiak are fairly representative of the onshore coastal sections south of 60°N within 5 miles of the coast (Subareas II, III, IV, VI, VII, and IX). For land areas in this latitude range more than 5 miles from the coast and up to the mountains, the Anchorage data would be more representative. For the section of the study area north of 60°N, the dispersion climatology for

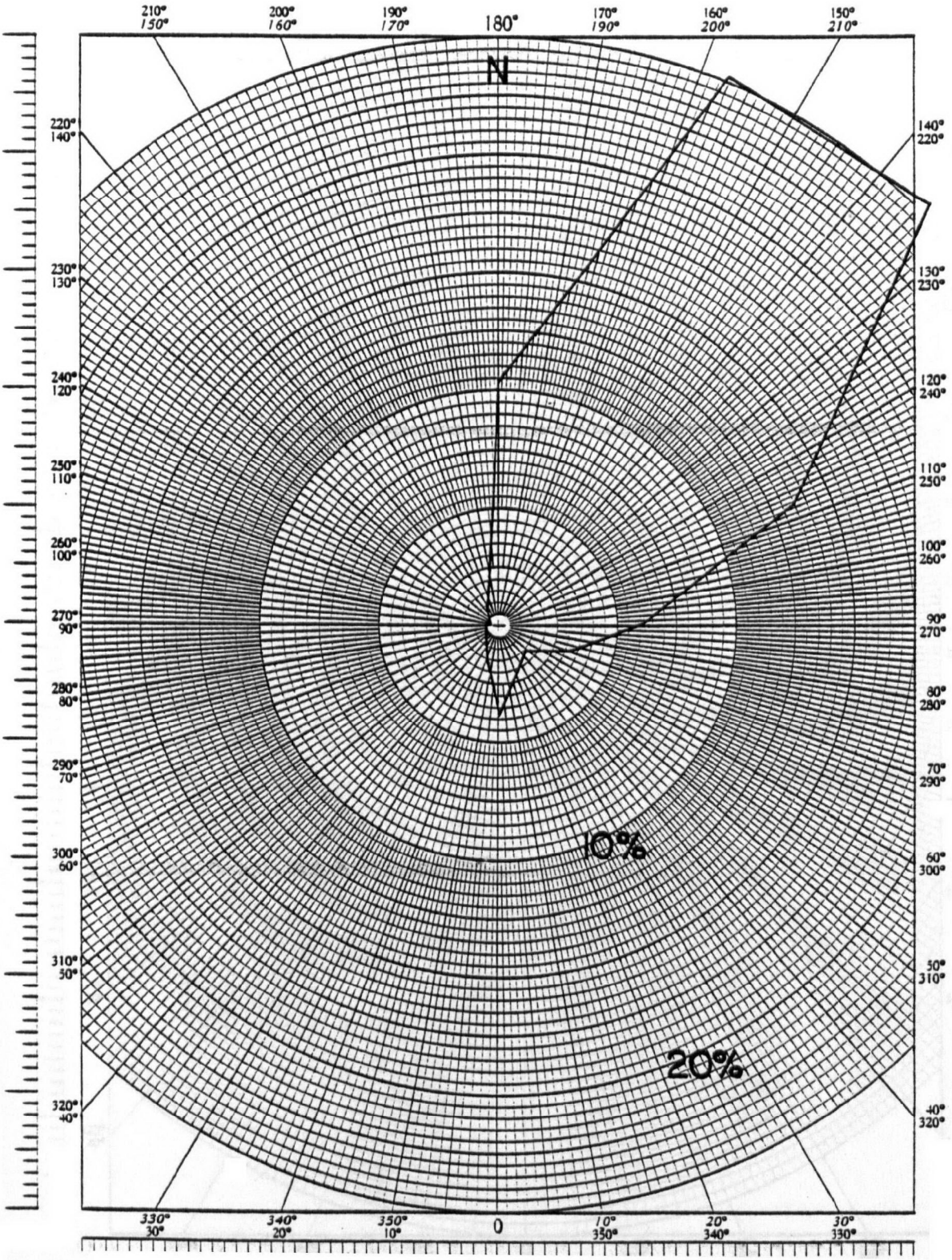


Figure 9. Kenai, Alaska, winter wind rose, all stabilities.

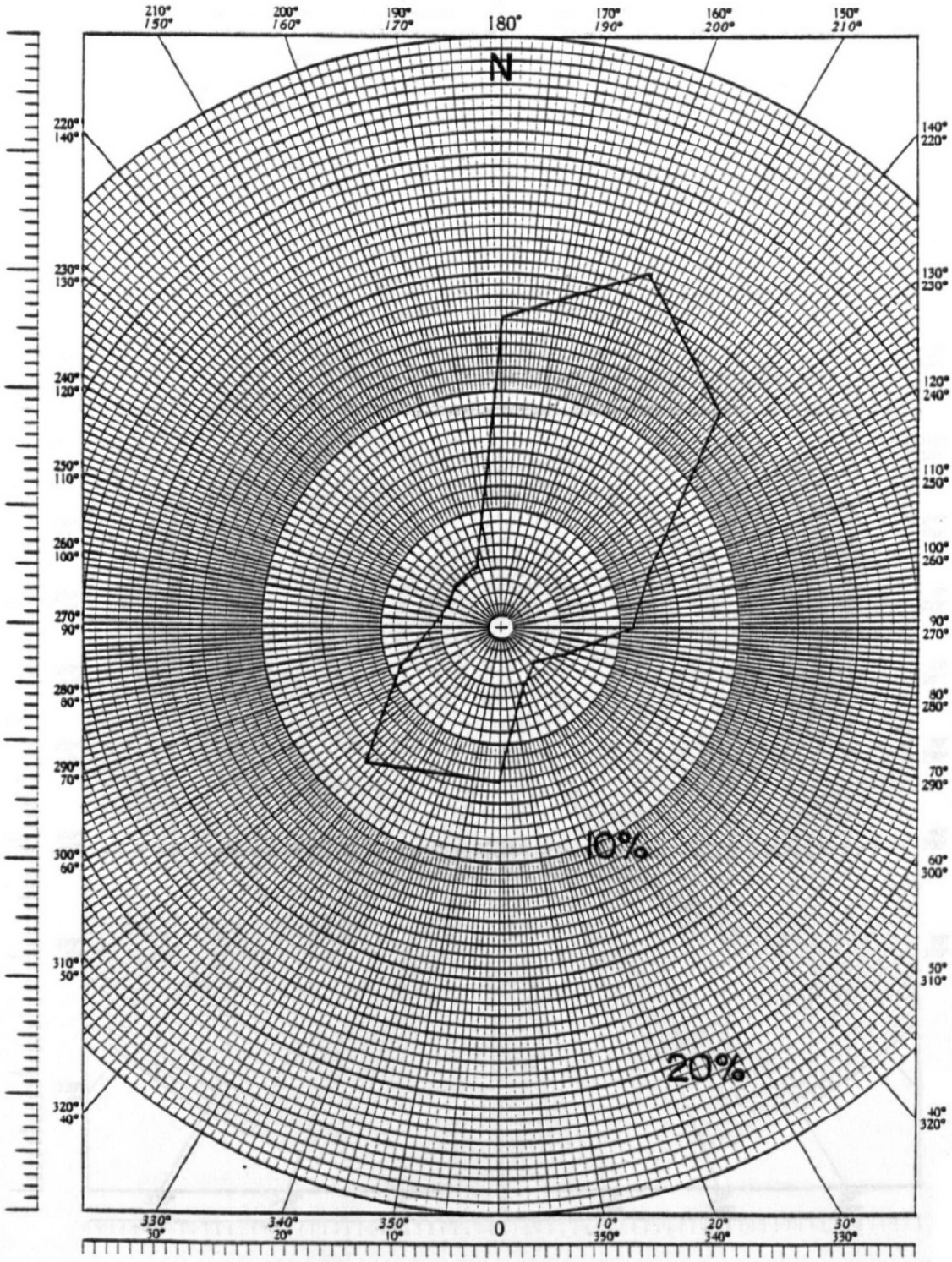


Figure 10. Kenai, Alaska, spring wind rose, all stabilities.

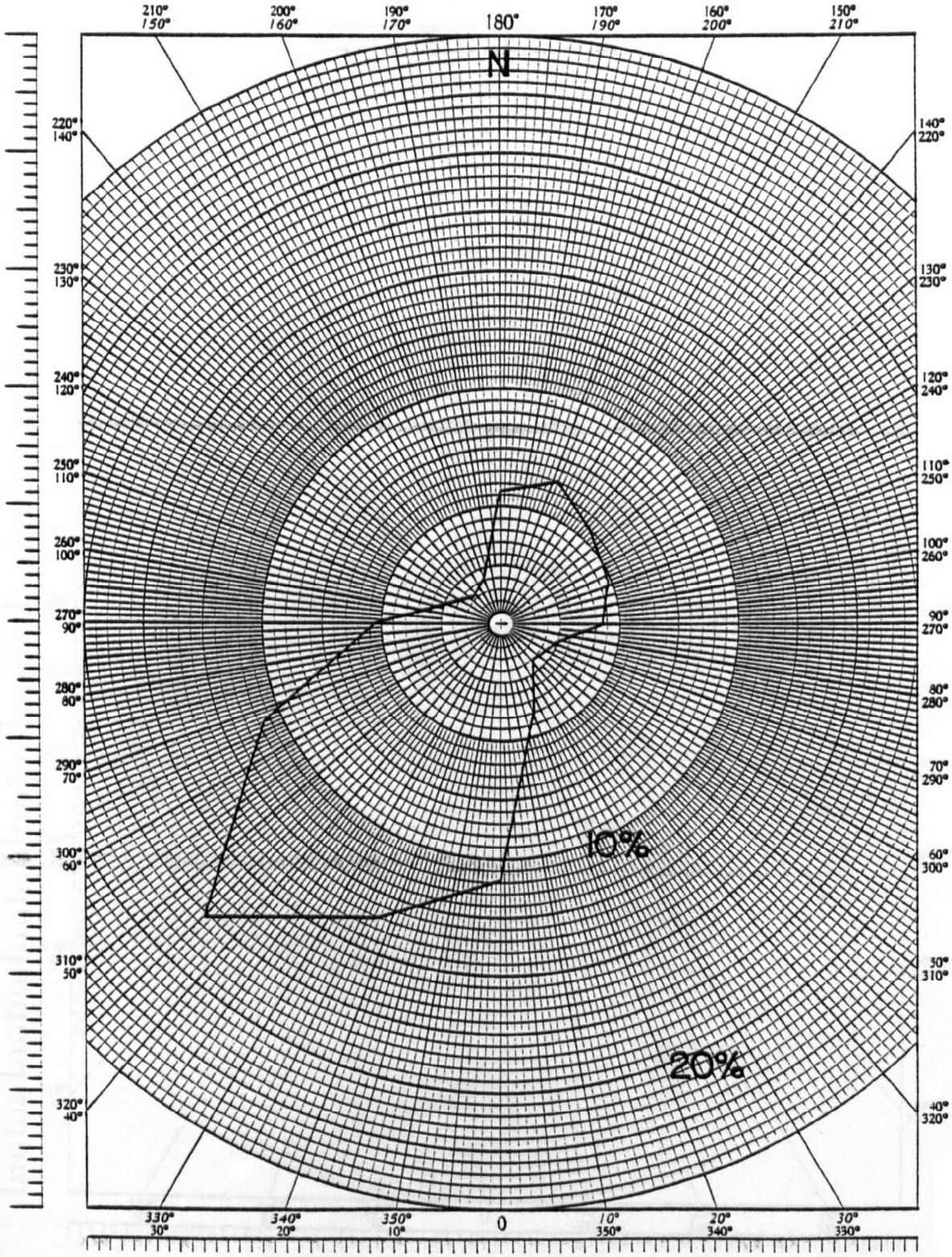


Figure 11. Kenai, Alaska, summer wind rose, all stabilities.

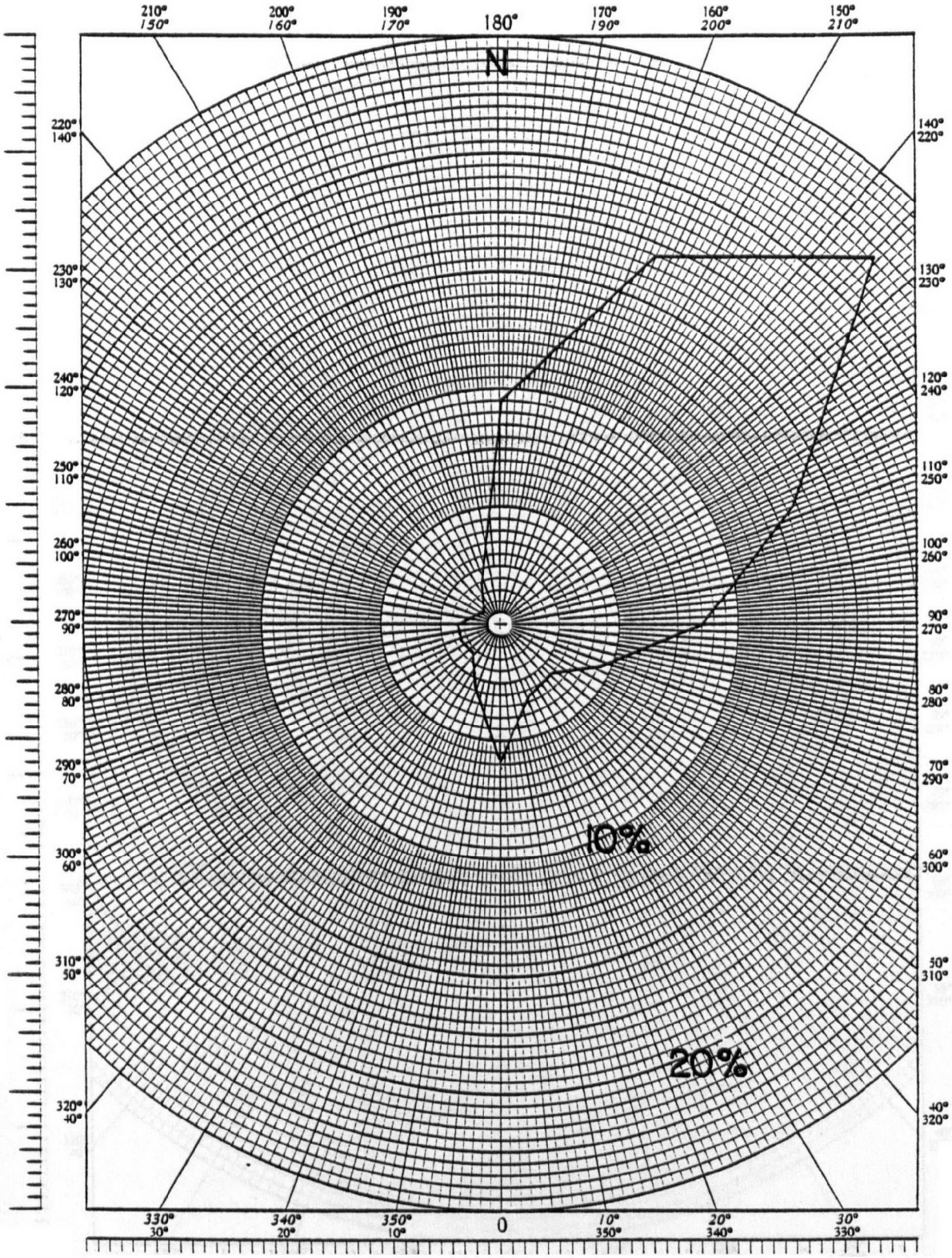


Figure 12. Kenai, Alaska, fall wind rose, all stabilities.

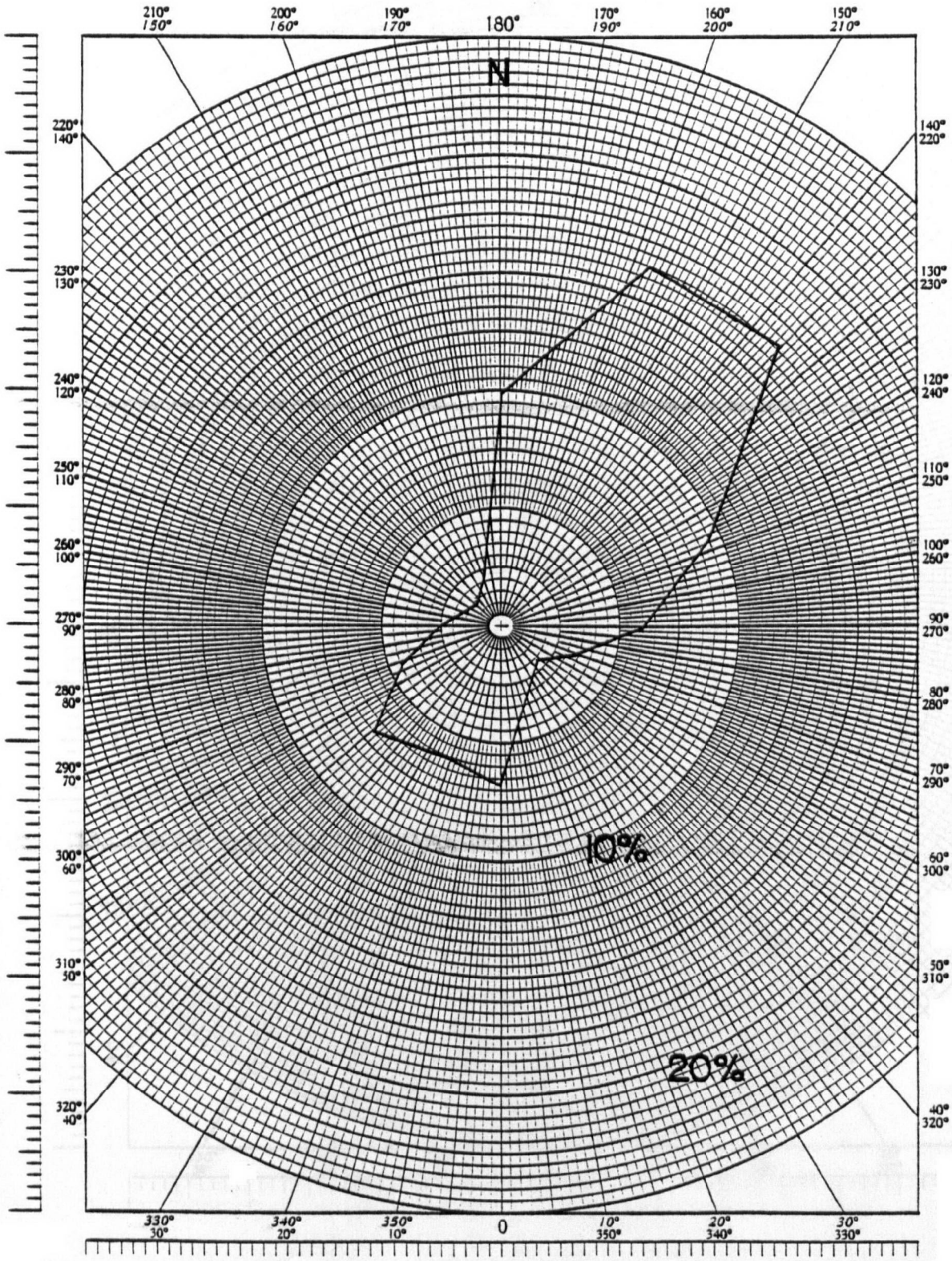


Figure 13. Kenai, Alaska, annual wind rose, all stabilities.

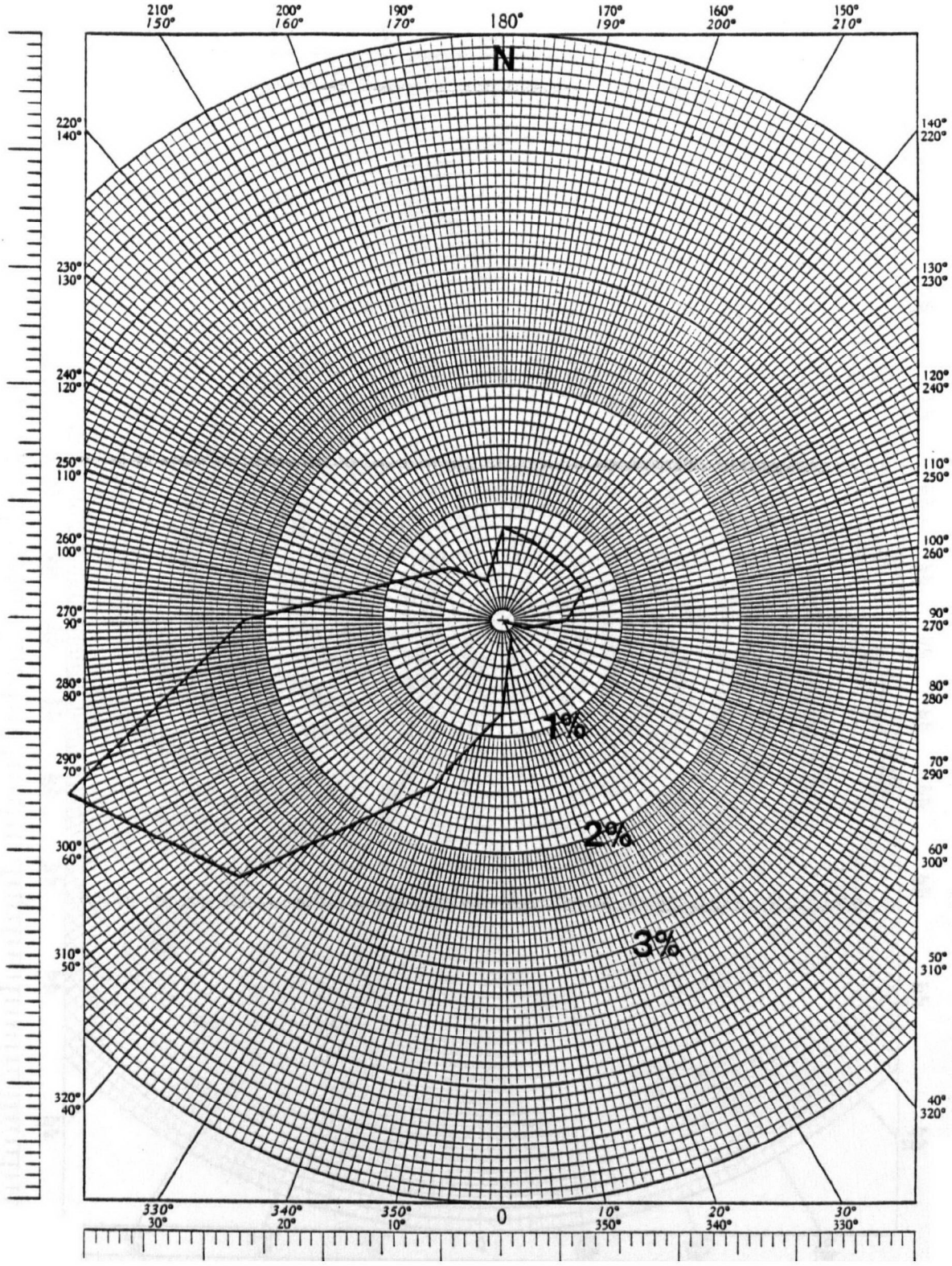


Figure 14. Kenai, Alaska, summer wind rose, B and C stabilities.

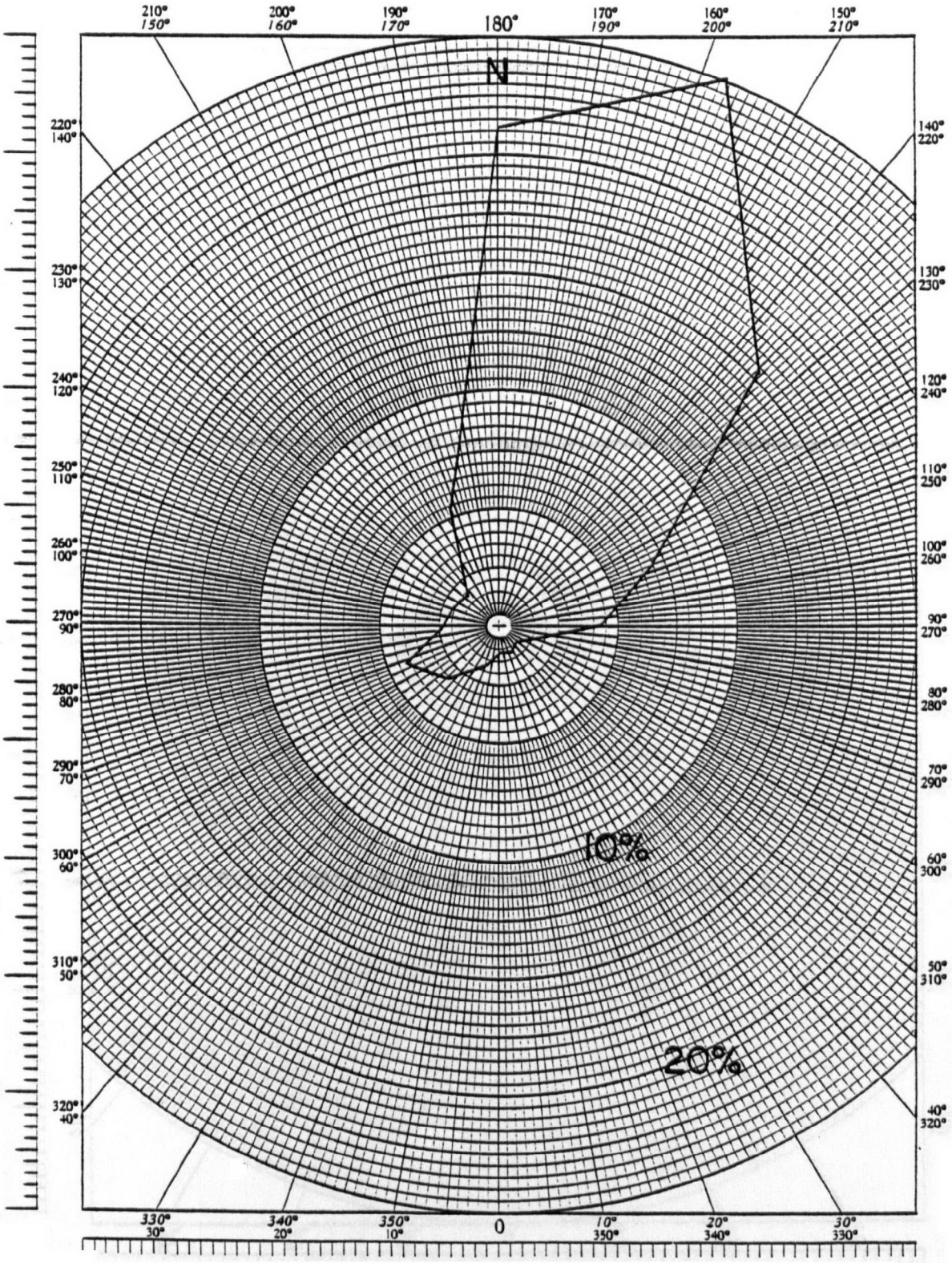


Figure 15. Homer, Alaska, winter wind rose, all stabilities.

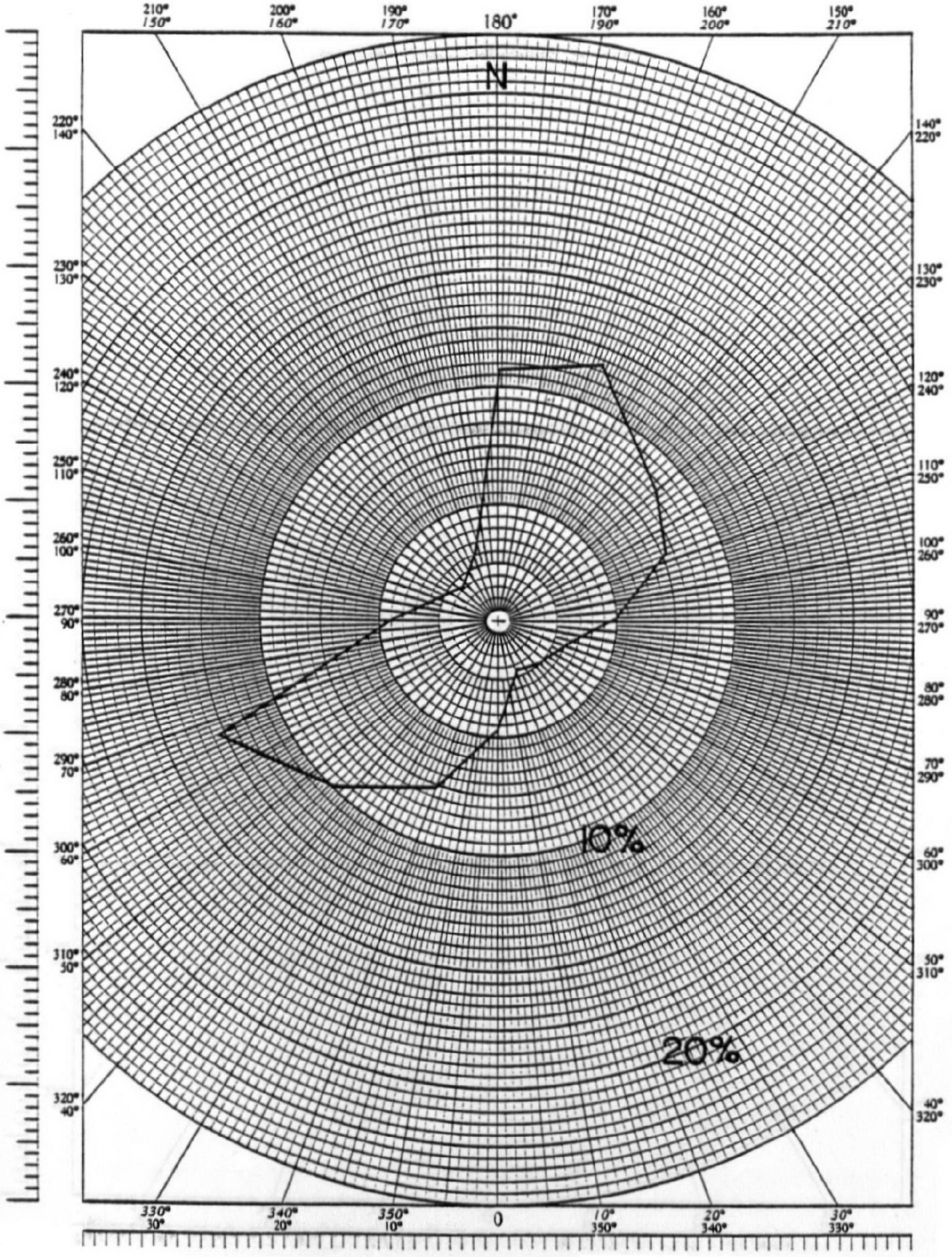


Figure 16. Homer, Alaska, spring wind rose, all stabilities.

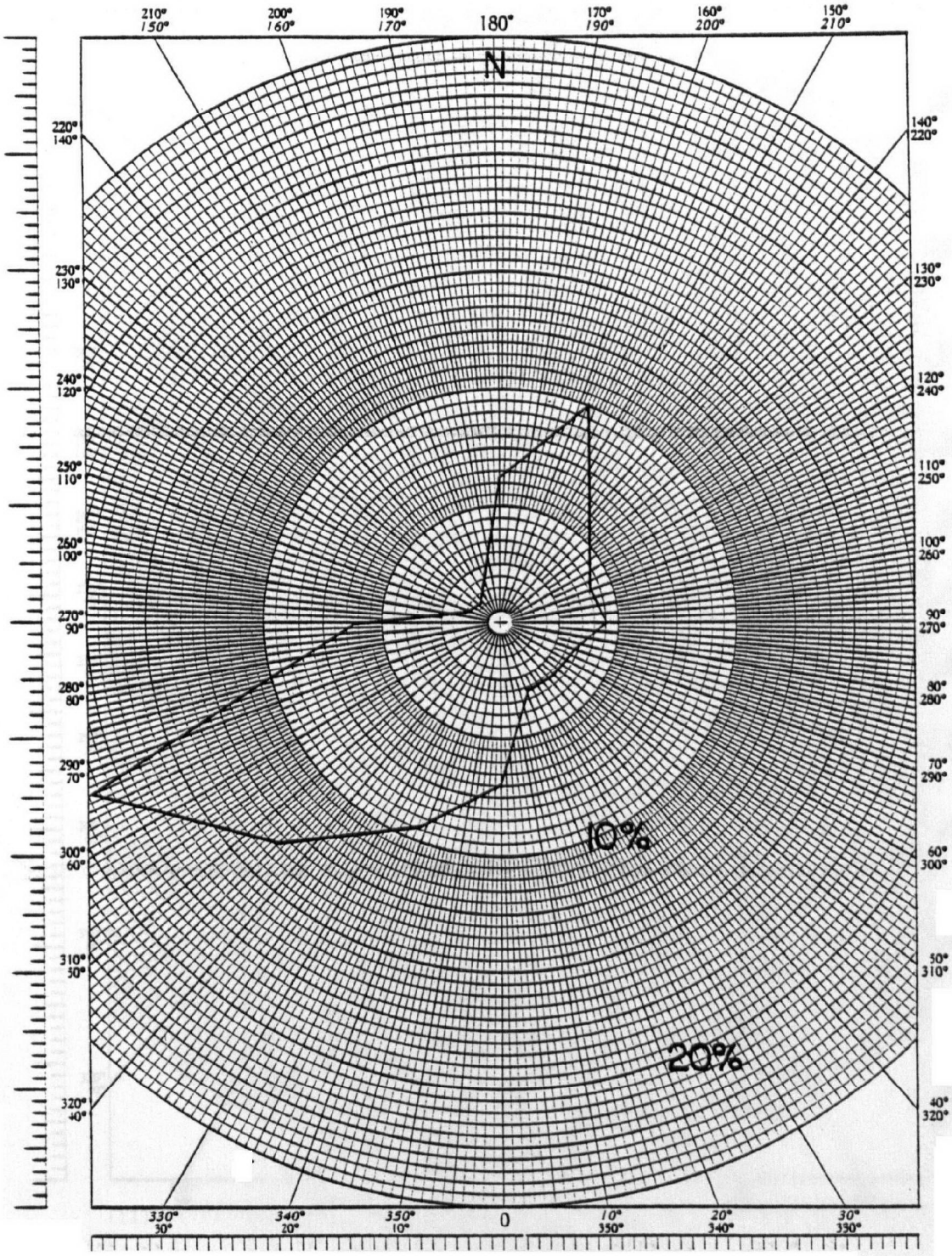


Figure 17. Homer, Alaska, summer wind rose, all stabilities.

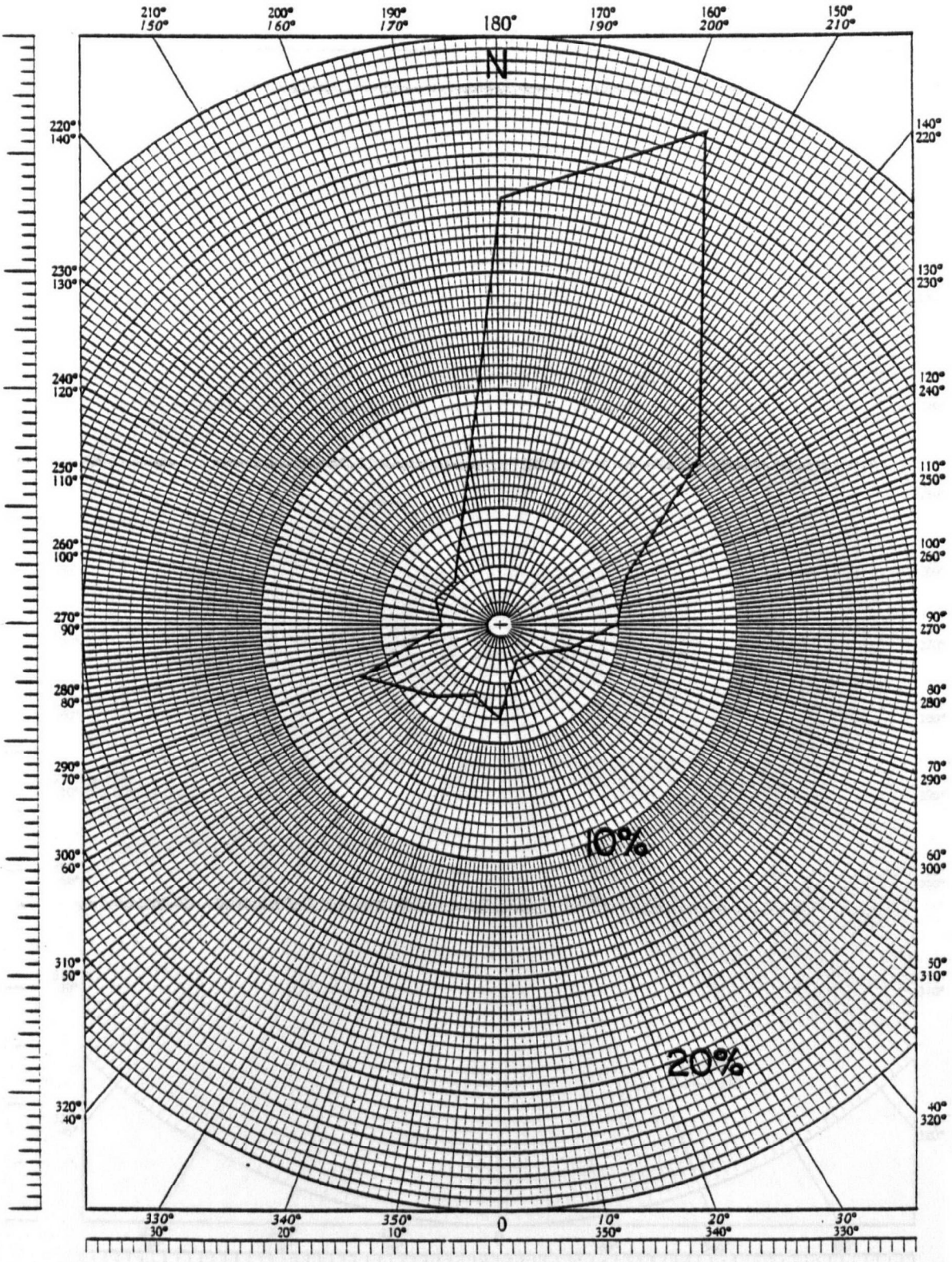


Figure 18. Homer, Alaska, fall wind rose, all stabilities.

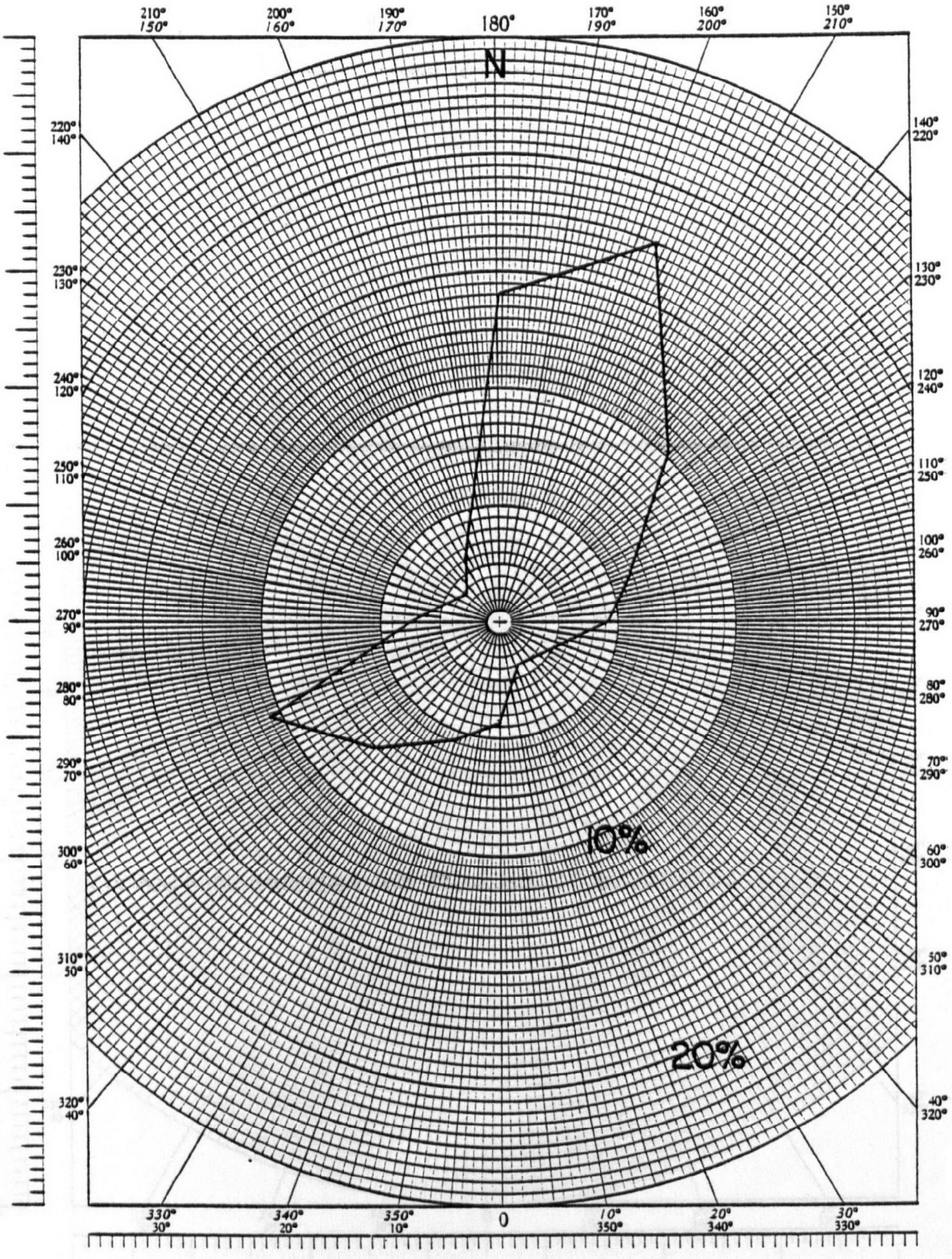


Figure 19. Homer, Alaska, annual wind rose, all stabilities.

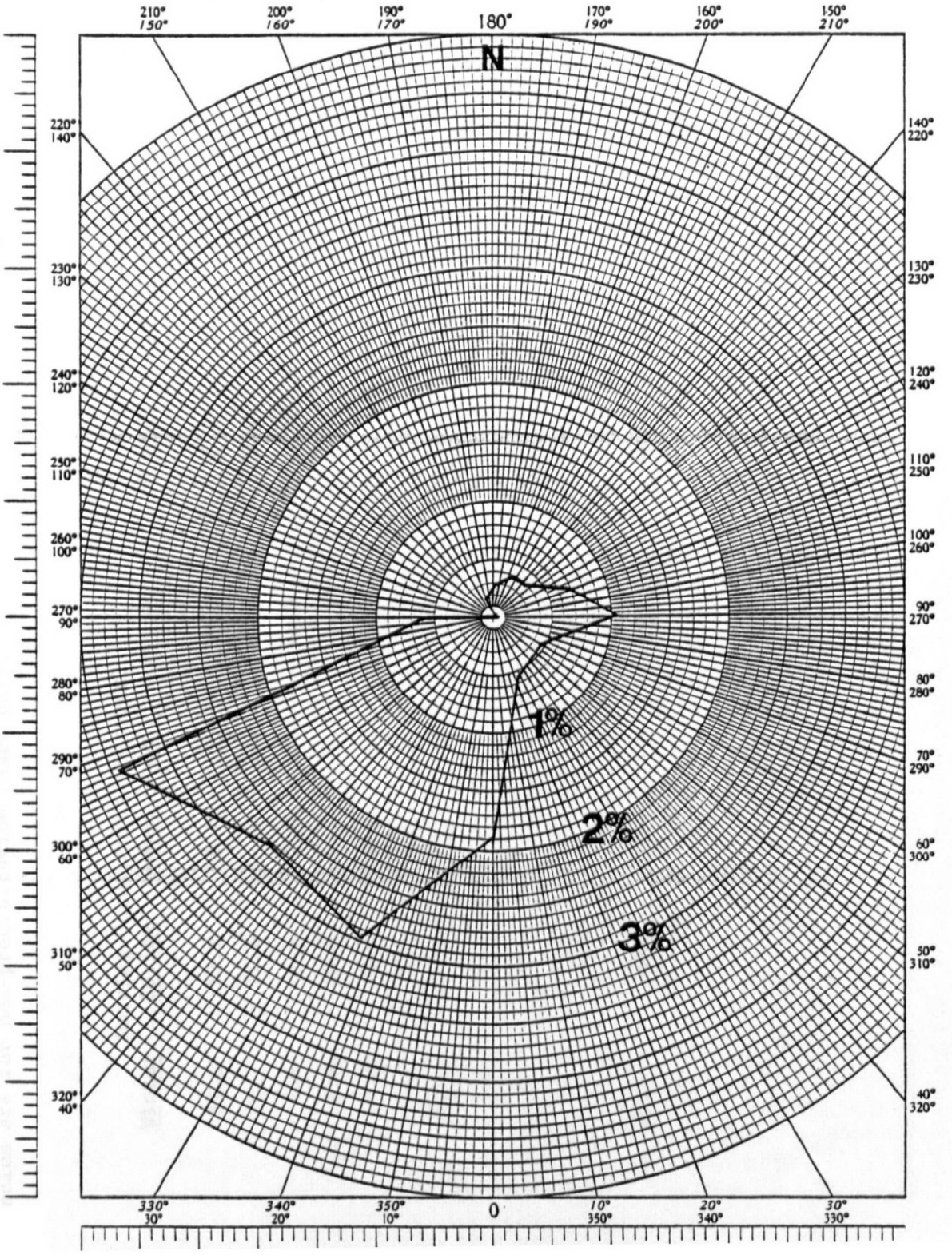


Figure 20. Homer, Alaska, summer wind rose, B and C stabilities.

Table 3. Frequency of occurrence of mixing heights, Anchorage, Alaska, 1976 (National Climatic Center 1978b). Frequencies are for non-precipitation cases only.

Mixing Height (Meters)	Morning Occurrences (Percent)					Afternoon Occurrences (Percent)				
	Winter	Spring	Summer	Fall	Annual	Winter	Spring	Summer	Fall	Annual
≤ 250	58.9	17.2	30.1	45.4	36.5	56.8	6.0	1.3	37.5	20.4
251-500	26.7	31.6	24.4	29.0	28.0	29.4	24.8	10.4	25.0	21.1
501-750	3.6	21.6	12.8	16.0	14.0	11.5	19.1	12.0	16.5	14.9
751-1000	1.8	10.0	8.5	3.2	6.2	--	11.8	10.6	6.3	8.1
1001-1500	5.4	9.8	22.8	4.8	11.1	2.3	14.8	39.4	10.5	19.5
1501-2000	--	8.4	1.4	1.6	3.0	--	11.7	18.4	4.2	10.2
2001-2500	1.8	--	--	--	0.4	--	8.8	7.9	--	5.0
2501-3000	1.8	1.4	--	--	0.8	--	3.0	--	--	0.8
3001-3500	--	--	--	--	--	--	--	--	--	--
3501-4000	--	--	--	--	--	--	--	--	--	--
> 4000	--	--	--	--	--	--	--	--	--	--
Total	100	100	100	100	100	100	100	100	100	100

Table 4. Frequency of occurrence of mixing heights, Kodiak, Alaska, 1976 (National Climatic Center 1978c). Frequencies are for non-precipitation cases only.

Mixing Height (Meters)	Morning Occurrences (Percent)					Afternoon Occurrences (Percent)				
	Winter	Spring	Summer	Fall	Annual	Winter	Spring	Summer	Fall	Annual
≤ 250	20.3	13.5	19.7	14.4	17.0	47.3	3.2	14.4	5.7	14.9
251-500	15.3	10.2	15.1	18.2	14.7	18.4	14.4	13.1	13.7	14.5
501-750	16.9	5.1	12.1	5.4	10.0	21.3	6.4	11.6	13.8	12.3
751-1000	17.0	13.6	13.6	9.0	13.4	7.8	21.0	24.5	25.7	20.9
1001-1500	23.7	32.2	29.0	29.3	28.6	5.2	35.6	21.6	23.8	23.2
1501-2000	3.4	16.9	10.5	21.9	13.0	--	14.5	5.9	11.7	8.7
2001-2500	1.7	8.5	--	1.8	2.9	--	4.8	7.4	3.8	4.6
2501-3000	1.7	--	--	--	0.4	--	--	1.5	--	0.5
3001-3500	--	--	--	--	--	--	--	--	1.9	0.4
3501-4000	--	--	--	--	--	--	--	--	--	--
> 4000	--	--	--	--	--	--	--	--	--	--
Total	100	100	100	100	100	100	100	100	100	100

land areas from the coastline to the mountains would be approximated best by the mixing height data for Anchorage (Subareas I, II, V, VI, and VII). For mountainous areas, a representation of mixing heights would be very difficult and data for either station are not likely to provide a close approximation.

A latitude of 60°N was chosen arbitrarily to divide the study area coastline into sections that are influenced predominantly by maritime airmasses and cloudiness (south) or a modified continental climate (north). Throughout the subareas that consist of water only, the data for neither station would be applicable, primarily because of the dependence of mixing height on ground heating and cooling.

Special dispersion considerations

Some special cases should be considered in which conditions are conducive to ground-level impact of an elevated point source or other type of plume. These special cases are the effects on dispersion of sea breezes, inversion breakup, and mountainous terrain.

When a sea breeze occurs, a shallow mixing layer develops at the shoreline and becomes thicker with distance inland, as the air becomes heated by the land surface. The mixing depth is near zero over the water and will be on the order of 100 to 200 meters within 1 mile (1.6 km) inland, depending on windspeed and solar angle. A plume that enters the stable maritime layer will experience very little mixing, but will "fumigate" rapidly down to the surface when it encounters the rising boundary of the mixed layer. This is a common coastal phenomenon during the summer months.

The onshore breeze is the cause of many of the lower mixing heights observed during the spring and summer afternoons at Kodiak and Anchorage. This type of fumigation process would affect any elevated point source located along the shoreline unless the source had enough plume rise to carry the plume above the mixed surface layer. The farther inland such a source is located, the less of a problem fumigation would be, because the mixing height increases with distance from the shore and the "lid" at the top of the mixed layer is not as strong farther inland. A low-level or ground-level emission along a coastline also would be affected by a sea breeze inversion in that it would be trapped vertically in this shallow but expanding mixed layer as it tracks inland.

Inversion breakup is a dispersion condition that has a different origin from that of a sea breeze but causes similar effects. This also is a type of fumigation, and the atmospheric temperature and stability profiles are quite similar to that of a sea breeze. A shallow, ground-based mixed layer is present under a stable layer. One essential difference between an inversion breakup and a sea breeze is that the proximity of a body of water is not needed for an inversion breakup to occur. Any plume released into such a stable layer, which may extend to heights of 200 meters or more, will experience very little horizontal or vertical dispersion.

Soon after sunrise, the ground begins to heat up and an unstable or

mixed layer is formed upward from the surface. The depth of this layer increases with time, as does the surface temperature. As soon as the upper boundary or "lid" of this layer reaches the height of a concentrated, poorly dispersed plume, it will mix the plume rapidly to the ground. This may result in a strong concentration at the surface.

Unlike sea breeze fumigation, which can reach a steady state and last for several hours, inversion breakup fumigation usually lasts for about 1.0 hour during the morning, because the rising mixing height must approximately equal the plume height. After the mixed layer increases in depth to encompass the plume throughout its dispersion, the effect is terminated. At this time a less critical limited-mixing situation will exist until the surface heating permits the stable layer to be penetrated completely.

Both of these fumigation effects are most likely to occur in the study area during the spring and summer months, when solar heating is the strongest. Fumigation is one of the major causes of high, short-term ground-level contaminant concentrations.

Finally, special consideration should be given to an effect that can aggravate any type of dispersion situation. The effects of terrain can cause a dispersing plume to become a serious problem. When a plume from a source that is standing on the ground at a particular level is released into a wind flow that carries it over terrain that is substantially higher than the ground at the source, the height of the plume axis will be reduced. This will increase the ground-level concentration over what it would be without the effect of terrain, sometimes by orders of magnitude.

Because there is so much mountainous terrain in the study area and the ground elevation rises so abruptly from the shore at certain points, the effect of terrain on plume dispersion must be considered in planning the location of point sources in the study area. In addition, when the effect of terrain is superimposed on a sea breeze or inversion breakup situation, the effect would be amplified.

Aside from the effects of terrain on point-source dispersion, the terrain in the study area has an effect on the overall air quality of the area. The mountains on either side of Cook Inlet form a natural boundary that restricts the movement of air at low levels to the east or west. This can be seen by examining the wind roses for Kenai and Homer. Thus, contaminants released from all kinds of sources at various levels will be somewhat restricted in their dispersion through this natural basin, especially in the narrower northern section. This restriction would be further aggravated by the occurrence of a low mixing height and light winds. The degree of this effect on contaminant concentrations is difficult to assess quantitatively, but it most likely would be most effective for averaging periods of 24 hours or more. In deeper, narrower valleys, a stagnation effect such as this could be very serious, as would the effect of point-source plume impact on higher terrain.

3.1.5. Ambient air quality

Although very little ambient air quality data exist for the study

area, background air pollutant levels are assumed to be very low because of the relatively low level of residential, commercial, and industrial development in most of the study area. The few exceptions are occasionally high total suspended particulate (TSP) levels and local concentrations of other pollutants.

3.1.5.1. Existing ambient air quality

Total suspended particulates

The entire State of Alaska has been designated by the USEPA as being in attainment with National Ambient Air Quality Standards (NAAQS) for total suspended particulates (43 Federal Register 8963). Although measured TSP levels throughout Alaska sometimes exceed the 24-hour TSP standard (150 ug/m^3), these occurrences generally are due to fugitive dust from traffic on unpaved roads and wind action on exposed, dry areas of land (Alaska Department of Environmental Conservation 1977). The USEPA recognizes that rural fugitive dust is less harmful than urban fugitive dust and particulates from industrial point emission sources; therefore, rural areas experiencing TSP violations attributable to fugitive dust are considered to be in attainment with TSP NAAQS (43 Federal Register 8963).

TSP data have been collected at a few sites in the study area (Towns 1978). These data, from one station at Homer, two at Kenai, and one at Nikiski, are summarized in Table 5. The annual geometric mean TSP concentrations at these sites generally were low. The only violations of the annual standard, at the Homer Fire Station site in 1975 and 1976, were attributed to traffic on unpaved roads and construction work (Towns 1978). Violations of the 24-hour standard that occurred at Homer and Kenai also may be attributed to fugitive dust.

In general, high TSP levels may occur in developing areas, such as the coastal regions of Subareas I and II, due to construction activities and traffic on unpaved roads. During the summer, fugitive dust caused by wind action on the dry, exposed soil may result in high TSP levels in the many regions of the study area where the land is not protected by vegetation. During the winter, however, snow cover reduces this dust noticeably.

Carbon monoxide

Carbon monoxide (CO) pollution is associated primarily with motor vehicle operation. Because motor vehicle usage in the study area is not heavy, ambient CO levels are assumed to be low. CO levels probably are highest in the more developed areas along the Kenai Peninsula coastline, from Homer north to Nikiski (Subareas I and II) because of the relatively concentrated motor vehicle traffic. The entire study area however, has been designated by the USEPA as being in compliance with the CO NAAQS (43 Federal Register 8966). In the more heavily developed areas, such as Nikiski and Homer, the ambient CO level is thought to be less than the standards (Dames and Moore, Inc. 1976). To date, ambient CO levels in the study area have not been monitored.

Table 5. Total suspended particulate data - Kenai Peninsula (Towns 1978; Dames and Moore, Inc. 1976)

Station Location	Year	Sampling Results (ug/m^3) Annual Geometric Mean	Highest Value	Second Highest Value
Homer	1975	190	2,336	1,032
Fire Station (1)	1976	61	532	367
	1977	42	314	259
Kenai	1975	48	271	175
Fire/Police Station (1)	1976	35	343	143
	1977	33	176	168
Kenai	1972	16	147	106
Phillips Petroleum	1973	17	50	37
Plant (1)	1974	14	76	58
	1975	36	346	123
	1976	41	476	199
	1977	22	158	134
Nikiski (1)	1970	16	<150	<150
	1971	12	<150	<150
	1972	15	<150	<150
	1973	17	<150	<150
	1974	14	<150	<150
	1975	32	<150	<150

Alaskan Standard (ug/m^3) Annual Geometric Mean	24-Hour Maximum (1)
60	150

Note: (1) Not to be exceeded more than once per year.

Nitrogen dioxide, sulfur dioxide, and hydrocarbons

Atmospheric nitrogen dioxide (NO_2), sulfur dioxide (SO_2), and hydrocarbon (HC) concentrations normally are influenced by the level of residential, commercial, and industrial development. For example, atmospheric NO_2 and SO_2 result from fuel combustion for power generation, space heating, and manufacturing; NO_2 and HC result from motor vehicle operation; and HC results from processing and transporting of petroleum and petroleum products. Consequently, the highest levels of these air contaminants in the study area would be expected in the more heavily industrialized and populated cities and ports along the Kenai Peninsula coast (Subareas I and II).

Although ambient concentrations of these pollutants have not been measured in the study area, levels are believed to be low even in Subareas I and II, based on limited data from areas such as Anchorage and Valdez and on the low density of sources in the study area. Limited monitoring data from Anchorage indicate that Anchorage SO_2 levels rarely exceed 25 ug/m^3 and that NO_2 levels are near zero (Alaska Department of Environmental Conservation 1977). Because the study area is less developed than Anchorage, ambient SO_2 and NO_2 levels in the study area should be lower. Ambient HC measurements made at Valdez in 1977 indicated that average non-methane hydrocarbon concentration ranged from 0 to 100 ug/m^3 (for comparison, the USEPA guideline for a 3-hour average non-methane hydrocarbon concentration is 160 ug/m^3) and that most of the hydrocarbon measured was non-reactive methane, which averaged about 1,000 ug/m^3. However, the maximum recorded three-hour average non-methane hydrocarbon concentration in Valez was 2,200 ug/m^3, which exceeds the USEPA guideline. Such high concentrations are due to the operation of petroleum vessels in the Valdez harbor. Ambient HC concentrations in the port areas of the study area are not expected to reach such high levels because the petroleum handling is on a much smaller scale, and the dispersion conditions are superior to those of the Valdez harbor. Ambient non-methane hydrocarbon concentrations at ports in the study area are expected to be less than the 160 ug/m^3 USEPA guideline.

Ammonia

The only major potential source of ambient ammonia in the study area is the Collier Carbon and Chemical Corporation Ammonia-Urea Plant at Nikiski (Subarea I). The ambient ammonia levels in other sections of the study area are assumed to be negligible. The normal operation of the Collier plant generally should not result in significant ambient ammonia concentrations, according to atmospheric dispersion modeling of calculated ammonia emission rates (Dames and Moore, Inc. 1976). It is possible that occasional plant malfunctions may occur. During such upsets, noticeable ammonia odors would be expected not more than approximately 10 km from the plant. Thus, ambient ammonia levels in the vicinity of the Collier plant generally should be insignificant, and ammonia levels elsewhere in the study area should be non-existent.

Odors

Sulfur compounds are emitted from petroleum refineries and terminals and may cause an odor nuisance in the surrounding area. Petroleum

operations in and adjacent to the study area are concentrated in the Forelands area, in Subarea I, and in the Upper Cook Inlet. There are isolated pumping stations and storage facilities elsewhere (Homer, Drift River, Kenai, Naptowne), but the atmospheric impact of these is not significant.

A potential odor source is the seafood processing industry on the Kenai Peninsula. Odors from these facilities may be noticeable in the vicinities of the processing plants, but usually do not impact surrounding regions.

3.1.5.2. Data needs

Only limited ambient air quality data have been collected in the study area. Consequently, the amount of data available is not sufficient to characterize adequately the ambient air quality of locations in the area with respect to most pollutants of concern. Ambient levels of the major air pollutants (TSP, NO_2, SO_2, HC, and oxidants) should be monitored to establish background levels of these pollutants and to follow changes in these levels that may accompany development in, and outside of, the study area.

In particular, atmospheric oxidant concentrations are known to be due to regional rather than local phenonmena. Oxidants and the precursor pollutants responsible for oxidant formation may be transported great distances from their origin. Oxidants formed as a result of pollutants emitted in Valdez or Anchorage could affect ambient oxidant levels in the study area. For this reason, it would be desirable to monitor oxidant levels in the study area even though there are relatively few oxidant precursor emission sources in the area.

Transport of SO_2 and NO_2 into the study area also must be considered, although the transport of these pollutants is considered to be less extensive than that of oxidants. SO_2 and NO_2 monitoring is needed primarily to determine background levels from development in the study area. The monitoring of rainfall acidity, a parameter closely associated with SO_x and NO_x pollution, also should be considered. As with oxidant formation, rainfall acidification is a regional phenomenon and could result from SO_x and NO_x emissions outside of the study area.

There is little reason to monitor the level of ambient CO_2 in any undeveloped part of the study area, because elevated CO levels usually will be found only in developed areas, near heavily traveled roadways. CO monitoring would be needed only in the principal urban areas, and even there the CO levels are expected to be relatively low.

The determination of accurate background pollutant levels in the study area will be particularly important for the evaluation of PSD permits. Although the air quality of the study area can be characterized to some extent by monitoring data from Anchorage, these data may not be truly representative of air pollutant levels in the study area because of its lower level of development.

3.1.6. Atmospheric emission sources

Industrial facilities, vehicular traffic, and residential/commercial

development comprise the sources of atmospheric emissions in the study area.

3.1.6.1. Industrial facilities

Industrial sources of atmospheric emissions within the study area are concentrated primarily in a few locations. A list of the principal industrial sources in the study area is presented in Table 6, along with the emission rates of each. The location of each source identified on Figure 21 (adapted from Alaska Department of Environmental Conservation 1975; Dames and Moore, Inc. 1976) is listed in column 3, and the Subarea location of each is shown in column 4. Emission rates, in tons per year, are presented in columns 5 through 9. Summaries of the sources located in and near each of the study area Subareas are presented in the Subarea profiles.

3.1.6.2. Vehicular traffic

The only major roadway system in the study area of concern from an air quality standpoint is the Sterling Highway and its principal tributaries. From its origin in Homer, the Sterling Highway extends northward along the coast of Subarea II for approximately 68 miles to the southern boundary of Subarea I. The route then extends northeasterly for approximately 50 miles to the eastern boundary of the study area. The Kenai Spur Road, located in Subarea I, is a major tributary of the Sterling Highway. From its junction with the Sterling Highway in Soldotna, the Kenai Spur Road extends westward for approximately 10 miles (16 km) to Kenai, then north along the Cook Inlet coast for approximately 18 miles (29 km) to the northern boundary of Subarea I at the East Foreland. The Spur continues northeastward for approximately 10 miles (16 km) to its termination. Traffic on the Sterling Highway and Kenai Spur Road is responsible for the bulk of the vehicular emissions in the study area.

The highest concentrations of vehicular emissions, which consist primarily of HC, CO, and NO_x, have been reported in the principal cities, particularly at intersections where traffic congestion may occur. However, traffic volumes in these cities are not sufficient to cause excessive pollutant concentrations.

The 1976 traffic volume on the Sterling Highway and Kenai Spur Road (Alaska Department of Highways 1976) and estimates of the yearly vehicular emission rates of HC, CO, and NO_x are summarized in Table 7. Emissions were calculated on the basis of the USEPA emissions factors for 1978 (Office of Transportation and Land Use Policy 1978).

3.1.6.3. Residential/commercial

Atmospheric emissions from residences principally consist of SO_2, NO_x, and TSP from fuel combustion for heating. Because the population of the study area is sparse, these emissions have a minor impact on the air quality.

An additional source of atmospheric emissions is the marine vessel traffic in Cook Inlet. Marine vessels emit SO_2, NO_x, and TSP from fuel combustion during passage through the Inlet and during maneuvering in port. Large vessel traffic in Cook Inlet totaled 613 arrivals and 615

Table 6. Lower Cook Inlet industrial atmospheric emission sources (Alaska Department of Environmental Conservation 1975, Dames and Moore, Inc. 1976).

Industry	Source Description	Area Location on Figure 21	Study Subarea Location	Emissions Metric Tons/year (Short tons/year) CO	HC	SO_2	NO_x	TSP
Chugach Electric	Bernice Lake Power Station	1	1	173 (157)	63 (57)	1 (1)	564 (622)	19 (21)
Kenai Pipeline	Nikiski Terminal	1	1		722 (655)			
Phillips Petroleum	LNG Plant	1	1	428 (388)	4,743 (4,302)	2 (2)	1,417 (1,562)	50 (55)
Standard Oil	Alaskan Refinery	1	1	1 (1)	277 (206)		40 (44)	3 (3)
Tesoro-Alaska Petroleum	Alaskan Refinery	1	1	21 (19)	2,826 (2,563)		180 (198)	16 (18)
Amoco Production	East Foreland Onshore Facility	1	1	7 (6)			14 (15)	5 (5)
Shell Oil	East Foreland Onshore Facility	1	1		813 (739)		17 (19)	2 (2)
Union Collier	Ammonia/Urea Plant	1	1	2,167 (1,965)	50 (45)	296 (268)	2,928 (3,228)	900 (992)
Shell Oil	Platform A	2	North of 11	53 (48)	19 (17)		171 (188)	7 (8)
Shell Oil	Platform C	2	North of 11	56 (51)	20 (18)		180 (198)	9 (10)
Amoco Production	Baker Platform	2	North of 11	23 (21)	8 (7)		71 (78)	5 (5)
Amoco Production	Dillon Platform	2	North of 11	31 (28)	10 (9)		102 (113)	5 (6)
Marathon Oil	Dolly Varden Platform	3	North of 5	164 (149)	58 (53)	1 (1)	528 (586)	23 (25)
Marathon Oil	Trading Bay Production Facility	3	North of 5	131 (119)	1,078 (978)		398 (439)	16 (18)
Union Oil	Grayling Platform	3	North of 5	144 (131)	50 (45)	1 (1)	465 (513)	21 (23)
Cook Inlet Pipeline	West Foreland Pump Station	3	North of 5	5 (5)	2 (2)		16 (18)	1 (1)
Kenai Pipeline	Soldotna Creek Pump Station	4	1	9 (8)	33 (30)		26 (29)	1 (1)
Standard Oil	Swanson River Gas	4	1	---	---	---	---	---
Alaska Pipeline	Naptowne Pump Station	5	1		1 (1)			
Union Oil	Kenai Oil Storage	6	1		11 (10)			
Cook Inlet Pipeline	Drift River Terminal	7	5	37 (34)	2,993 (2,715)	46 (42)	62 (68)	12 (13)
Chevron USA	Homer Storage Facility	8	2		11 (10)			
Arctic Asphalt Paving	Portable Asphalt Plant	8	2			1 (1)	2 (2)	21 (23)
Alaska Pipeline	Kalifonski Pump Station	8	2	3 (3)	1 (1)		9 (10)	

Table 7. Study area vehicular atmospheric emissions summary (Alaska Department of Highways 1976; Office of Transportation and Land Use Policy 1978).

Traffic Summary

Subarea	Route	Length miles (km)	Average Daily Traffic	Vehicle Miles (km) per Day
1	Kenai Spur Rd.	29.4 (47.2)	4,593	134,800 (216,900)
1	Sterling Hwy.	48.5 (78.1)	1,973	95,750 (154,100)
2	Sterling Hwy.	68.2 (109.7)	1,437	97,940 (157,600)

Atmospheric Emissions
tons/year (metric tons/year)

Subarea	HC	CO	NO_x
1	380 (344)	2,460 (2,230)	408 (370)
2	161 (146)	1,040 (943)	173 (157)

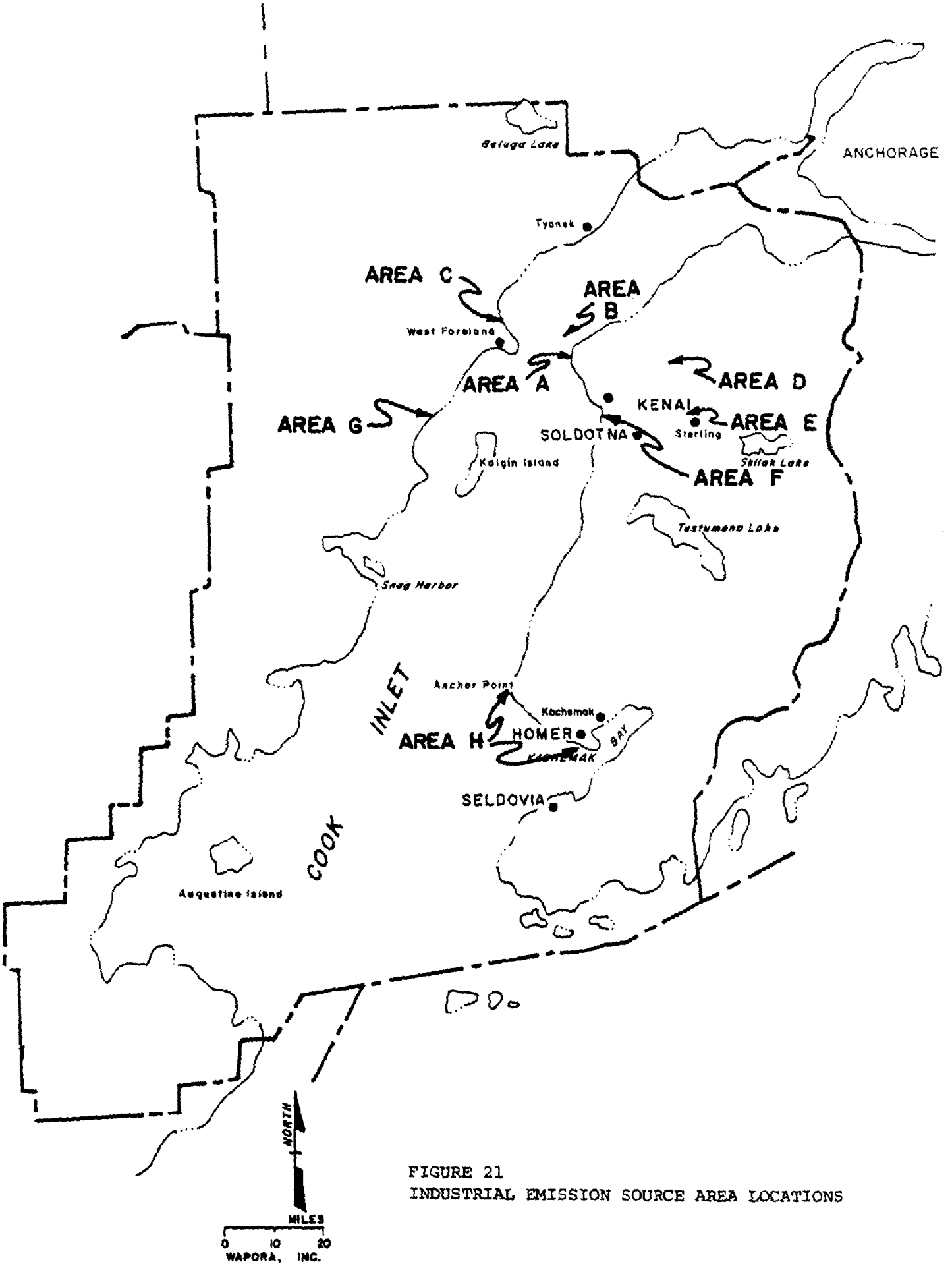


FIGURE 21
INDUSTRIAL EMISSION SOURCE AREA LOCATIONS

departures in 1974. The two large vessel ports in the study area, Nikiski and Drift River, received 373 and 153 vessel arrivals, respectively, in 1974 (Dames and Moore, Inc. 1976). This level of vessel traffic should not cause a significant impact on the air quality of the study area.

3.2. Biological Environment

3.2.1. Marine biology

Cook Inlet supports a rich and diverse marine biological system that is similar in composition to that present along much of the North Pacific coast. The macrophytes (plants larger than microscopic size) and phytoplankton (microscopic plants) that form the basis of this system provide food and, in the case of some macrophytes, the habitat that supports commercially valuable fish and shellfish.

3.2.1.1. Major biotic zones

Cook Inlet may be divided into three major biotic zones: intertidal, subtidal benthic, and pelagic. Within each zone numerous abiotic factors influence the composition of the community. These factors include:

- Light penetration
- Frequency and duration of exposure to air (in the intertidal zone)
- Currents
- Waves energy
- Nutritive materials in the water (organic and inorganic)
- Water chemistry and temperature.

Currents, waves, and the benthic biological communities interact to from a seventh abiotic feature, the substrate. Dames and Moore, Inc. (1977) defined six basic intertidal habitats:

- Pavement/bedrock, bench, or reef
- Boulder field
- Gravel/cobble beach
- Brown or grey sand beach
- Sand/gravel flats
- Mud flats.

Generally the first three habitats were observed in both protected and exposed locations, the fourth in exposed situations, and the last two in protected areas. Protected areas were observed in embayments and, in the

southern part of Kamishak Bay, behind offshore sandstone reefs and finger reefs (Dames and Moore, Inc. 1977).

Driskell and Dames and Moore, Inc. (1977) recorded six major benthic facies in the outer part of Kachemak Bay:

- Boulder-large cobble facies
- Shell debris facies
- Sand facies
- Mud sand facies
- Silt facies.

The subtidal facies from 10 to 100 meters in depth in outer Kachemak Bay were composed of sand, shell debris, and silt (Driskell and Dames and Moore, Inc. 1977). The southcentral portion of the Cook Inlet is known to contain extensive areas of rippled, presumably dynamic sand deposition. Based on other data it is apparent that extensive areas of outcrops and boulders exist in subtidal zones within the Cook Inlet.

3.2.1.2. Biotic communities

The intertidal and near subtidal zones are of particular importance to the Cook Inlet system. Macrophytes in the intertidal and subtidal zones have been estimated to provide a considerable part of the primary productivity that feeds the Cook Inlet system (Dames and Moore, Inc. 1977). Within these zones many species of fish and marine invertebrates find habitat, food, and spawning substrates.

3.2.1.3. Marine macrophytes

The producer components of the intertidal and near subtidal zones typically consist of various red (Rhodophyta), brown (Phaeophyta), and green (Chlorophyta) algae that are attached to the substrate. Eelgrass (*Zostera marina*) also is important in some localities. Within the mid-intertidal zone, red algae (including *Rhodymenia palmata*, *Callophyllis* spp., *Halosaccion glandiforme*, and *Odonthalia*) and two species of brown algae, or rockweed (*Fucus distichus*, and *Alaria* spp.) usually comprise most of the living producer component, both in biomass and in bottom coverage. In the lower intertidal zone three laminarian kelps (*Laminaria groenlandica*, *Alaria* spp., and *Hedophyllum sessile*) usually form the majority of the macrophytes. In the subtidal zone, two brown algae, bull kelp (*Nereocystis luetkeana*) and ribbon kelp (*Alaria fistulosa*), may form dense canopies in the near subtidal zone (waters up to 12 meters deep). In waters deeper than 25 meters, *Laminaria groenlandica* and *Agarum cribosum* usually are the main components. At the vertical extremes of the macrophyte range (from the upper limits of the high tides to the depths where light penetration is minimal), there usually is but a single layer, or canopy, of macrophytes. The macrophyte communities become more complex as they approach the near subtidal zone from each extreme, and distinct layers (canopies) develop. Mature communities develop as many as five distinct canopies, with the great

brown kelps (Laminaria or Nereocystis) in the uppermost layers and crustose coralline algae forming the thin bottom layer against the firm substrates.

On the east and west sides of the Inlet subtidal assemblages differ both in species composition and in maturity. On the east side, the subtidal assemblages typically are composed of larger individuals of the upper canopy macrophytes and have larger species diversity. Eelgrass beds are confined to coves and bays where the necessary substrates and some shelter from the waves are available. Glacial silt may prevent establishment of eelgrass beds (McRoy 1970). The locations of kelp and eelgrass beds in the Lower Cook Inlet are illustrated in the subarea profiles. The specimens of intertidal and subtidal algae collected by Driskell and Dames and Moore, Inc. (1977), and Dames and Moore, Inc. (1977) are listed in Table 8. A comprehensive literature search was not conducted, but the more common intertidal and subtidal macrophytes and many of the less common species as well are listed.

Dames and Moore, Inc. (1977) defined intertidal and subtidal communities in terms of the net import and export of plant and detrital material, and estimated that phytoplankton, subtidal and intertidal macrophytes, and organic input from terrestrial sources were approximately of equal importance as food sources at the primary trophic level. Communities with high aquatic macrophytic productivity usually are net exporters of plant material. In the Lower Cook Inlet, high macrophytic productivity occurs in rocky intertidal and subtidal zones in water depths of less than 50 meters and in eelgrass beds. Communities with low macrophytic production usually support low secondary (animal) productivity unless they are located so that they receive transported (exported) plant materials. These import communities occur in most of the Lower Cook Inlet that is deeper than 50 meters (approximately 27 fathoms), and include many of the communities associated with sand or mud substrate in waters shallower than 50 meters.

Three characteristic intertidal fauna assemblages occur in the Lower Cook Inlet, each determined by the substrate. The three major substrate types are mud flats, sand beaches, and rocks. These substrates may intergrade gradually (for example, from a sand to mud beach) or abruptly (such as a rocky outcrop on a sandy beach).

The mudflat assemblages usually occur in protected locations. The assemblages are composed chiefly of deposit and suspension feeders, including polychaete worms, the spoonworm (Echiurus echiuras alaskansus), and soft-shell and pink clams. On mudflats covered with eelgrass, the soft-shells largely are replaced by butter clams (Saxidonsus giganteus), little-neck clams (Protothaca staminea), and gapers (Tresus capax).

Sandy beach assemblages typically are import communities and primarily contain deposit and suspension feeders. Important fauna include redneck clams, razor clams, butterfly tellinas, and annelid worms.

The rocky intertidal and subtidal assemblages may be import or export communities. The intertidal fauna usually is composed of suspension feeders, such as mussels and barnacles, and their predators. The biomass and diversity of the assemblages increase where abundant macro-

Table 8. Macrophytes reported from the Lower Cook Inlet (Dames and Moore, Inc. 1977; Driskell and Dames and Moore, Inc. 1977).

Brown Algae - Phaecophyta

Ilea sp.
Melanosiphon sp.
Laminaria groenlandica
L. saccharina
Desmarestia sp.
D. viridis D. ligulata
Agarum cribrosum
Soranthera ulvoides
Costaria costata
Hedophyllum sessile
Cystoseira geminata
Alaria marginata
A. taeniata
A. praelonga
A. fistulosa
Nereocystis lutkeana
Pylaiella littoralis
Chorda filum
Analipus japonicus
Scytosiphon lomentaria
Chordaria flagelliformis
Ralfsia sp.
Ralfsia pacifica
Hildenbrandia sp.
Fucus sp.
F. disticus
Heterochordaria abietina

Green Algae - Chlorophyta

Enteromorpha sp.
E. linza
E. tabulosa
E. intestinalis
Ulva sp.
Ulothrix sp.
Urospora sp.
Monostroma sp.
M. Fuscum
Chlorophyta (unidentified)
Claophora sp.
Spongomorpha sp.
S. saxitillis

Red Algae - Rhodophyta

Constantinea sp.
C. subulifera
C. simplex
Membranoptera weeksiae
Corallina sp.
C. vancourveriensis

Red Algae (continued)

Erythroglossum sp.
Ceramium sp.
Gracilariopsis sp.
Gloiopeltis furcata
Hymenema setchelli
Iridaea lineare
Iridaea sp.
Polysiphonia hendryi var. *gardneri*
Lithophyllum sp.
Lithothrix aspergillum
Phycodrys sp.
Rhodophyta (unidentified)
Encrusting coralline algae
Opuntiella sp.
Ceramium eutonianum
Polysiphonia
P. collinsi
P. pacifica
Ptilota
P. tenuis
Rhodomela larix
Rhodomenia palmata
R. purtusae
Endocladia muricata
Endocladia sp.
Odonthalia
O. floccosa
O. kamschatica
Ahnfeltia plicata
Porphyra sp.
Schizymenia
Heterochordaria
Kallymenia
Pterosiphonia sp.
F. bipinnata
Cryptonemia
Codium ritteri
Rhodoglossum affine
Halesaccion glandiforme
Foliose red algae
Filamentous red algae
Callophyllis pilceanum
C. flabellulata

Ungrouped Algae

Prasiola meridionalus
Pterocelis
Cymathere triplicata
Chryptosiphonia woodi
Halicystis ovalis

phytes are present (Dames and Morre, Inc. 1977). The rocky subtidal fauna consists largely of suspension feeders, both in biomass and in numbers. Primary consumers include chitons, sea urchins, and limpets. Starfish and demersal fish, including greenling, sculpins, and flatfish are the most important predators. Subtidal faunal assemblages sampled by Dames and Moore, Inc. (1977) on the west side of the Inlet typically were less diverse and contained a smaller biomass than assemblages sampled on the east side. The differences were attributed to siltation, lower productivity, ice scouring, and more severe winter conditions on the west side of the Inlet.

The intertidal and subtidal assemblages contain several species that are of commercial and/or recreational importance, or are critical to the Lower Cook Inlet system or to other key species. On the producer level, Dames and Moore, Inc. (1977) estimated that phytoplankton, subtidal and intertidal macrophytes, and organic input from terrestrial sources were roughly equal in importance in fixing energy at the primary trophic level. Thus perhaps one-third of the food resources of the Lower Cook Inlet ultimately are derived from the macrophytes. Eelgrass plays the same role in the intertidal mudflats and also serves as a food source and staging area for migrating waterfowl. Both eelgrass and the macrophytes alter the substrates and provide additional substrates, thereby increasing both species diversity and productivity. The kelps also may reduce wave shock to the beaches behind them.

At the consumer trophic levels, the intertidal and shallow subtidal zones may provide essential habitats for the various life stages of commercial crabs and the kelps are essential spawning substrate for Pacific herring. The invertebrates, fish, and vegetation in these zones constitute the sole food source for many shorebirds and ducks and also are important sources of food for sea otters, seals, sea lions, sea birds, and juvenile fish. Salmon, sea-run char, and sea-run trout spend varying periods in this zone after they leave the freshwater streams.

In a general sense, the intertidal-shallow subtidal assemblages are, as an entity, a key element of the Lower Cook Inlet system. Any perturbation sufficient to affect one member of the assemblage will be felt by the entire assemblage and, if sufficiently widespread, eventually will be reflected by an alteration in the productivity of the system. The most significant dangers to the assemblages come as the consequence of their position at the interface between sea and land and their functions of fixing solar energy and being the primary consumers of that energy. Their position is perilous because anything floating on the sea (such as oil) will be concentrated at the shoreline (Hayes and others 1977). Their function is tenuous because any element, such as silt, that reduces light penetration also reduces production.

3.2.1.4. Commercial fisheries

Crabs, shrimp, salmon, halibut (*Hippoglossus stenolepis*), and Pacific herring (*Clupea harengas pallas*) are harvested commercially in the southern third of Cook Inlet. The potential also exists for the commercial harvest of groundfish and clams. Farther north, up the Inlet, salmon become the mainstay of the commercial fishing. Some halibut and clams are harvested commercially in the central part of the Inlet, but

salmon constitute the principal commercial fishery resource north of Anchor Point.

The Alaska Division of Commercial Fisheries has defined seven regulatory districts for commercial fishing in the Cook Inlet-Ressurrection Bay area (Figure 22; adapted from Alaska Department of Fish and Game 1975). Four of those districts are included in the study area: the Central District, the Kamishak Bay District, the Southern District, and approximately 40% of the Barren Island District. Preliminary commercial harvest data for these districts are presented in Table 9. Harvest data for halibut are not available for the study area. Halibut catch is controlled by the International Pacific Halibut Commission, and catch data are reported directly to the Commission. The Commission publishes the results for broad areas. The Cook Inlet data are included in the results for the Gulf of Alaska.

Commercial fish harvests are controlled by complicated systems based on closed seasons, emergency season openings and closings, harvest quotas, escapement data, age class distributions, and management goals. The systems are intended to provide an optimum sustainable yield to the combined commercial and sport fisheries. Life history, critical habitats, and factors limiting populations have been studied to varying degrees for each commercial species.

Salmon

Five species of salmon are harvested in the Lower Cook Inlet:

Sockeye (red) salmon	*Onchorhyncus nerka*
Chinook (kind) salmon	*Onchorhyncus tshawytscha*
Coho (silver) salmon	*Onchorhyncus kisutch*
Chum salmon	*Onchorhyncus keta*
Pink salmon	*Onchorhyncus gorbuscha*

Sockeye are the most valuable of the salmon -- chum and pink salmon bring substantially less at the dock, and stocks of chinook were depleted earlier in the century by commercial fishing. The catch now is regulated, and comparatively few are harvested commercially each year. Coho run later in the year than other species, and most reach the Inlet after commercial salmon fishing ceases.

Salmon probably are the most studied group of fishes in the world. The basic elements of their life history and requirements have been understood for many years, but it is recognized that a population may be discrete to a single river system or even a single tributary, and that even multiple spawning runs to a common stream represent separate populations that must be managed separately.

The life histories of the commercial salmon include a developmental phase in the spawning substrate (generally in freshwater, but sometimes in brackish or intertidal environments), development of the fry to juvenile or other sub-mature stages in freshwater or shallow marine environments, growth to near-maturity in open ocean, and migration to spawning habitat. Often the spawning site is the same tributary or site where the fry were "imprinted" with the "memory" of identifying olfactory characteristics of the surroundings. The period spent in each life

Table 9. Commercial harvest of salmon, herring, and shellfish in 1978 (preliminary data; Personal communication, Mr. Dennis Haanpaas, Alaska Department of Fish and Game, to Mr. Guy McConnell, WAPORA, Inc., 9 November 1978). Salmon data are numbers of fish; shellfish data are pounds of fish; herring data are tons of fish. Shellfish data are for the period from 1 January to 30 September 1978; other data are for the full 1978 season. The locations/extent of the districts are shown in Figure 22.

	DISTRICT						
Salmon	Eastern	Northern	Central	Southern	Outer	Kamishak	Total
King	0	1,104	16,527	1,348	236	0	19,215
Red	2	66,003	2,547,371	141,049	10,707	4,619	2,769,751
Coho	582	49,221	171,798	4,084	53	1,589	227,327
Pink	29,738	342,129	1,314,419	249,017	70,091	4,727	2,010,121
Chum	3,050	36,948	531,318	5,635	19,220	44,918	641,089
Total	33,372	495,405	4,581,433	401,133	100,307	55,853	5,667,503

Shellfish (through September)	Southern	Kamishak-Barren	Central-Outer-Eastern	Total
King crab	730,915	484,657	0	1,215,572
Tanner crab	1,115,942	2,060,664	488,360	3,664,966
Dungeness crab	1,041,376	0	0	1,041,376
Trawl shrimp	4,123,802	0	640	4,124,442
Pot shrimp	249,558	0	8,430	257,988
Razor clams	0	0	45,931	45,931

Herring 463 tons

history phase and each habitat type is different for each species and may differ appreciably between populations. Detailed descriptions of the life histories of the five species of salmon harvested from Cook Inlet are available from the Alaska Department of Fish and Game (1978a), Scott and Crossman (1973), Hart (1973), and a large number of monographs on the family Salmonidae. Salmon spawning sites are identified and discussed in each of the subarea profiles.

Salmon production and the numbers in each population are determined by escapement (numbers that survive to reach the spawning beds), spawning success, abiotic and biotic conditions in the "nursery" habitats, water temperatures and food availability in the open ocean, and predation throughout the life cycle. Human activities, such as commercial harvesting and unintentional disturbance or alteration of spawning and nursery habitat, may present the most serious threats to salmon populations. Typically, salmon eggs develop and hatch in the interstices of a gravel substrate, where the alevin remain until the yolksac is absorbed, and they emerge as swimup fry. For most salmon, development to swimup fry requires several months, and the emergence of the fry coincides approximately with the spring breakup. Any activity or event that disturbs the gravel substrate, such as severe floods, dredging, or other instream activity, will destroy the developing salmon. Reduction of water flow through the gravel interstices from siltation, biochemical oxygen demand from the decomposition of organic materials, drought, freezing, or reduction of groundwater may destroy the fry in a spawning bed.

Pink salmon and chum salmon fry typically begin migration to saltwater immediately after they emerge from the gravel. Coho, chinook, and sockeye salmon fry usually remain in rearing habitats in freshwater lakes or streams for one to three years. The success of each year-class of salmon is determined, in part, by the survival and growth rates of the fry and juveniles in the rearing habitats. Predation, competition, water quality, and primary productivity are factors that influence salmon year-class strength. In the typical oligotrophic environment of a salmon spawning stream, comparatively minor alterations in habitat, water quality, or productivity may be important determinants of year-class success. Alterations of habitat and water quality by erosion, the addition of chemical and organic wastes, dam construction and operation, water diversion, and the introduction of competing species are activities that have been cited as decreasing year-class success.

Pink and chum salmon fry usually reside in the shallow subtidal marine habitat during their first summer. Abiotic conditions and productivity in the marine habitat may be more stable than in a freshwater habitat, but predation may be more intense. Salmon fry in a marine habitat may be affected by broad shifts of productivity and by local changes in habitat or water quality. Boat harbors and other marine structures may form attractive habitats for salmon fry, and pollution associated with their operation may be detrimental to local salmon populations.

Salmon normally attain most of their growth in the open ocean. In that environment predators consist primarily of large fish, sea mammals, and man. Productivity in the marine environment may be affected by temperature and currents, which also may be factors in the determination

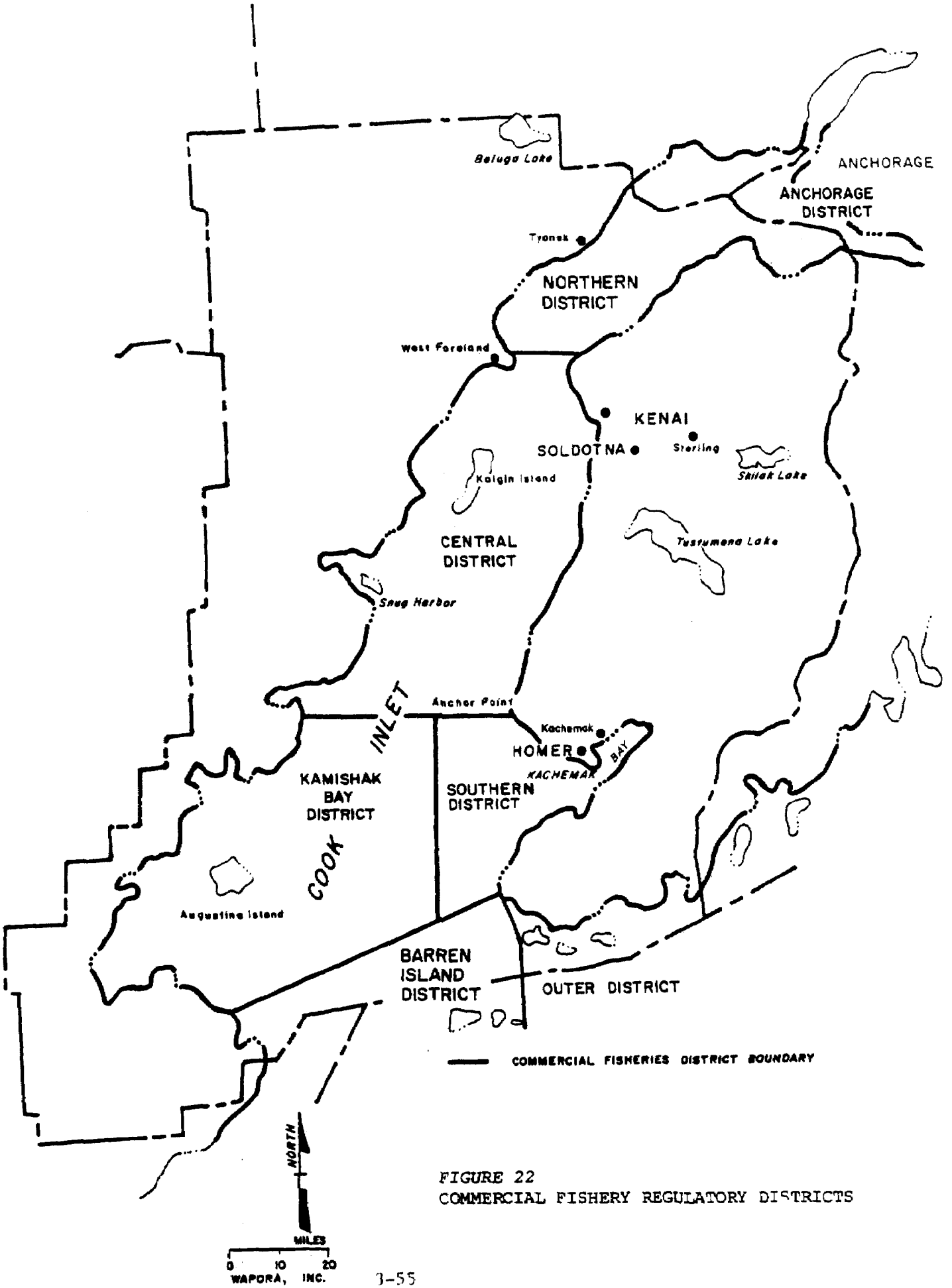


FIGURE 22
COMMERCIAL FISHERY REGULATORY DISTRICTS

of salmon survival, growth rates, and the timing of their return to spawning streams.

In the open ocean, salmon are caught commercially by trawling. During their return to spawning streams salmon are caught by trolling, by purse seining, by drifting gillnets, and in gillnets set along the shoreline. In the inshore waters and en route to the spawning streams, salmon are a major part of the summer hook-and-line sport and subsistence fishery. In some localities they are collected for subsistence or commercial purposes in set gillnets and in fish wheels.

The sport, commercial, and subsistence harvest seasons and quotas are set for each year and for each spawning population. They are based on expected returns and escapement goals and are modified throughout the spawning season by emergency season openings and closures.

Halibut

Mature halibut seldom are harvested in quantity in waters less than 30 meters in depth. Most of the harvest is from the open waters in the central and southern sections of Cook Inlet. A small percentage of the harvest is taken by sport (rod and reel) fishermen, but the commercial harvest is collected by set lines (skates), a series of hooks on a long weighted line, the location of which is marked with a surface buoy at one end. Skates are checked approximately every 24 hours. The Cook Inlet halibut season usually consists of a series of open seasons that begin during the spring, run for two weeks each month, and last until the Gulf of Alaska halibut harvest quota is filled (usually during the autumn). Comparatively little is known of the life history and critical habitat requirements of halibut in the Cook Inlet. Habitats where spawning and the early phases of life history occur should be considered critical at least until the importance and extent of such habitats has been defined. Known spawning/rearing localities are indicated in the Subarea profiles.

Pacific herring

Pacific herring (Clupea harengus pallas) were harvested in the early twentieth century for salting and human consumption. That harvest ceased after a few years and, until recently, the herring fishery was composed of a few tons collected each year for fish bait. During the last decade, the Japanese demand for herring roe has rejuvenated the market. Herring are collected by seining during the spring. The fish are brought on shore and stripped of their roe, which then is salted or sent to Japan for processing. The carcasses are made into a low-value by-product.

Pacific herring concentrate in spawning aggregations during the spring and may be extremely vulnerable to purse seining. Commercial fishing probably is the major control mechanism for the Cook Inlet herring populations. Herring spawn in macrophyte beds, and the eggs attach to the macrophytes. These beds, particularly the kelps, should be considered critical habitats. Herring are sensitive to petroleum-derived material, and minute concentrations of light petroleum distillates may reduce spawning success significantly.

Dolly Varden

Depending on the climate and the availability of saltwater the life history of the Dolly Varden char (Salvelinus malma) may vary considerably from one river system to the next. In the simplest case, Dolly Varden remain landlocked in the same freshwater system throughout their life history. These landlocked "yellow fins" frequently overpopulate and are stunted. Scott and Crossman (1973) described the life history of the Dolly Varden. Landlocked Dolly Varden spawn during the autumn, when water temperatures reach approximately 46°F, over medium- to large-diameter gravel in rivers or streams with moderate currents. The eggs hatch four to five months later during the early spring. The alevins emerge from the gravel approximately 18 days later, after the yolk is depleted. The young Dolly Varden eat a variety of insect larvae as well as snails, leeches, and other invertebrates. Larger Dollys also consume small fish and fish eggs. In streams accessible to saltwater, the Dolly Varden life history is the same as described above until the fish are several years old. At that time they may begin a cycle of migration between freshwater and saltwater each year. The migration pattern varies in different parts of Alaska and may become complex. Work by Armstrong (1965) in southeastern Alaska showed that migrating Dolly Varden move into the sea soon after breakup. They remain near the stream mouth for a few days and then move away. During the summer they ascend one or more freshwater streams and return to freshwater. In the autumn many return to their home streams to overwinter if there is a lake on the stream system. If the home stream has no lake, the Dolly Varden overwinter in one of the streams they explored during the summer. Spawning usually occurs in the home stream, but may occur in one of the streams the Dolly Varden enters near the end of summer. Farther north, the cooler temperatures and shorter summers tend to abbreviate the migration patterns. Dolly Varden still sea run, but may not enter more than one stream during the summer.

In Alaska, the major threats to Dolly Varden populations are overfishing in accessible streams, the disruption of spawning areas, and the blockage of migration routes by culverts, fords, logging slash, or other materials. Dolly Varden management efforts usually are directed toward stocking Dollys in depleted systems and clearing streams of debris and obstructions.

Rainbow trout

Rainbow trout (Salmo gairdneri) occur throughout most of the Kenai Peninsula and in a few streams on the western shore of the Cook Inlet. Rainbows frequently share lakes and streams with Dolly Varden and Pacific salmon, but may be unable to establish viable populations in the colder waters that Dolly Varden and Pacific salmon may use. Rainbow trout spawn during the late spring, generally in small streams, after the waters warm to above 40°F. They construct their redds in fine gravel. The eggs require two to four months to hatch, and the alevins may remain in the gravel for several more weeks. After emerging they usually remain near the spawning site for several years, then they may move into larger pools or into deeper waters of lakes. Anadromous rainbow trout (steelheads) may remain at sea for several years, then return to freshwater (usually to the home stream) to spawn. Unlike salmon, some steelheads survive spawning and return to the sea.

Eulachon

Eulachon (*Thaleichthys pacificus*), also commonly known as hooligan, is a smelt less than 8 inches in length that inhabits the Pacific Coast north of California. Its range includes the Cook Inlet. Eulachon migrate into tidal estuaries and the lower reaches of rivers to spawn in the sand each year. Most die, but a few may survive to spawn again. In the Cook Inlet, the major spawning areas are streams entering upper Turnagain Arm and the lower Kenai River. Eulachon provide some of the first openwater sportfishing of the year and support an intensive fishery for a few weeks each spring. Management consists of regulating the harvest. The populations are most vulnerable to disturbances of the spawning beds. This was illustrated by the 1964 earthquake, which disrupted many spawning areas in southcentral Alaska and severely reduced eulachon populations.

Crabs

Three crab species, king (*Paralithodes camtschatica*), Tanner or snow (*Chionoecetes bairdi*), and dungeness (*Cancer magister*), are harvested commercially in Cook Inlet. Seasons include various openings and closures for each species. There also are size limits and restrictions on the retention of females for each species. Crabs are caught commercially with baited crab pots. Dungeness crabs typically are found in shallower water (less than 50 meters) than either of the other species. All three species migrate each year for mating, feeding, or wintering. Crab populations in the Cook Inlet may be determined primarily by the harvest effort. Critical habitats are areas where crabs concentrate and areas where spawning and early development occur. Human activities affect crabs primarily in the larval stages, when they are most likely to be in shallow water, are most susceptible to pollution, and are least mobile.

The major commercial crab harvest areas are indicated in the subarea profiles. An area west of the Homer Spit that is especially important for dungeness and Tanner crab spawning has been established as a marine sanctuary, where crabbing is forbidden. This sanctuary also is shown in the subarea profiles.

Shrimp

The shrimp harvest is composed of three families: Crangonidae, Hippolytidae, and Pandalidae. Five species of the family Pandalidae constitute virtually all the commercial harvest from the study area (Trasky and others 1977). They are:

Pink shrimp	*Pandalus borealis*
Coonstripe shrimp	*Pandalus hypsinotus*
Humpy shrimp	*Pandalus goniurus*
Spot shrimp	*Pandalus platyceros*
Sidestripe shrimp	*Pandalopis dispar*

Pink shrimp and humpy shrimp are harvested by trawling. The other species usually are associated with substrates too rough for trawling and are harvested through the use of baited shrimp pots. The trawl shrimp

harvest in most years totals approximately 5.5-million pounds, and the pot shrimp harvest approximately 0.5-million pounds. Individual pot shrimp usually are larger than trawl shrimp and bring several times the price per pound of the trawl shrimp.

Within the study area, almost the entire shrimp harvest is from Kachemak Bay or adjacent Cook Inlet waters. Other areas may have commercially harvestable shrimp populations, but rough substrates and the distance to markets have prevented their development. The high productivity of Kachemak Bay probably is an important factor determining shrimp population levels in the Bay. Crow (1977) reported that pink and humpy shrimp had ingested amorphous organic material, hard invertebrate parts, diatoms, and fragments of macrophytes. The diatoms were epiphitic algae associated with eelgrass; thus, it is possible that eelgrass beds may be critical to trawl shrimp in Kachemak Bay.

The only identified concentrations of shrimp larvae were in Kachemak Bay, indicating that spawning occurs in or near the Bay and that the Bay provided critical spawning habitat. The currents form a gyre that may hold the larvae in the bay during their early development. The areas of largest shrimp larvae concentration are depicted in the subarea profiles.

Clams

Hard-shelled and soft-shelled clams and mussels, including the following eleven species, are abundant or potentially abundant within the study area (Paul and Feder 1975):

Razor	*Siliqua patula* and *S. alta*
Butter clam	*Saxidomus gigantea*
Littleneck clam	*Protothaca staminea*
Soft-shell clam	*Mya arenaria*
Soft-shell clam	*Mya priapus*
Truncate soft-shell clam	*Mya truncata*
Pinkneck clam	*Spisula polynyma*
Butterfly tellin	*Tellina lutea*
Blue mussel	*Mytilus edulis*

The bulk of the clams harvested commercially from the study area are razor clams, which also form the basis for most of the recreational clam harvest. The most abundant of the two species is *Siliqua patula*; the less common, *S. alta*, is collected infrequently, except in Kachemak Bay. Most of the commercial razor clam harvest is used for crab bait. Alaska statutes allow clams to be harvested for human consumption only from beds that are certified to be safe by the Alaska Department of Natural Resources. Clams may be harvested commercially from other sources, but must be colored with yellow dye. The recreational razor clam harvest is primarily from the Kenai Peninsula beaches between Anchor Point and Kasilof. During 1972, approximately 437,500 razor clams were harvested from this area by 15,400 recreational clam diggers (Paul and Feder 1975), and the recreational harvest since has increased. The Alaska Department of Fish and Game (1978a) estimated the 1978 recreational harvest at approximately one million razor clams. The Alaska Department of Natural Resources, recognizing the importance of this harvest, has designated the major clamming areas as "critical habitats."

The potential for an expanded commercial harvest is limited by paralytic shellfish poison (PSP), a toxin accumulated by filterfeeding molluscs, presumably from dinoflagellate phytoplankton. PSP has killed several hundred Alaskans during the last 200 years and is present in varying quantities in all clams. Acceptable quantities of the toxin have been defined, and a complex chemical testing regime is used to approve beds for harvest. Demand for clams and other bivalves is increasing, and if a field technique for evaluating PSP were to be developed, commercial harvest of clams might increase substantially.

Bivalve populations may be affected by predation, water temperature, pollution, siltation, and disturbance of the substrate. These problems may be amplified by the limited mobility of the bivalves. Because bivalves typically are concentrated in import communities, any change in the productivity of contributing export communities could be expected to affect the bivalve communities.

Potential fisheries

The potential exists for two other commercial fisheries in the Lower Cook Inlet. There is a potential fishery for scallops (*Patinopecten caurinus*), but it has not been developed because concentrations are marginal for commercial fishing. Also, scallop fishing could interfere with crabbing and is not permitted by the Alaska Department of Fish and Game. Groundfish, a general group of edible midwater and bottom fishes not included in other fisheries, have only begun to be exploited in Alaska. Exploratory trawls indicate that an ample stock of commercial species is present in the Lower Cook Inlet. Development of this resource has been delayed, because the expensive processing infrastructure and the large trawlers needed for the industry are not present.

3.2.1.5. Marine mammals

Several groups of marine mammals, including harbor seals (*Phoca vitulina*), northern fur seals (*Callorhinus ursinus*), Steller sea lions (*Eumetopias jubuta*), and sea otters (*Enhydra lutris*), inhabit the study area. Sea lions are restricted largely to the open marine environments near the mouth of Cook Inlet. Harbor seals are found throughout the Lower Cook Inlet. Beluga whales (*Delphinapterus leucus*) also may be found throughout the Inlet and in the river estuaries. Sea otters are found south of Anchor Point and the Iniskin Peninsula on both sides of the Inlet. Dall porpoises (*Phocoenoides dalli*), harbor porpoises (*Phocoena phocoena*), and killer whales, or orcas (*Orcinus orca*), enter Cook Inlet.

Twelve other species of whales have been reported from the Lower Cook Inlet:

Sperm whale	*Physeter catodon*
Minke whale	*Balaenoptera acutorostrata*
Grey whale	*Eschrichtius robustus*
Humpback whale	*Megaptera novaeangliae*
Fin whale	*Babenoptera physalus*
Pacific right whale	*Balaena glacialis*
Sei whale	*Balaenoptera boraelis*

Stejneger's beaked whale	Mescoplodon stejnegeri
Goose-beaked (Cuvier's beaked) whale	Ziphius cavirostris
Giant bottlenose (Baird's beaked) whale	Berardius bairdi
Blue whale	Balaenoptera musculus
North Pacific white-sided dolphin	Lagenorhynchus acutus

Northern fur seals are only occasional visitors to the study area, but harbor seals are widely distributed in the Lower Cook Inlet. The Alaska Department of Fish and Game (1978b) estimated the Lower Cook Inlet harbor seal population to be 3,000.

The Steller sea lions are concentrated throughout the year near several hauling-out areas in the Lower Cook Inlet. The largest concentrations are in the Barren Islands, south of the study area. The Alaska Department of Fish and Game (1978b) estimated the Lower Cook Inlet sea lion population to be 20,000. More than half of these individuals inhabited Sugarloaf Island in the Barren Island group.

Sea lions, harbor seals, and sea otters may be especially sensitive to human activity. Population recruitment of both sea lions and harbor seals may be affected; abandonment of pups and consequent mortality may result. Disturbances such as boat, aircraft, or foot traffic are especially detrimental during the early summer, soon after the seals bear their young.

Sea otters apparently are affected less by activity than sea lions or seals (as is evidenced by their abundance near the Homer boat harbor), but are especially vulnerable to petroleum pollution. Schneider (1977) reported:

> Sea otters are probably the most vulnerable of all marine mammals to the direct effects of oil. Unlike most marine mammals they have no thick blubber layer. They rely on air trapped in their dense fur for conservation of body heat and buoyancy ... it appears that relatively small amounts of both refined fuels and crude oil will cause death (by reducing the insulative qualities of the fur).

Two large sea otter populations are located in the study area. The first, centered around Augustine Island in Kamishak Bay, probably developed from a population remnant from the early 1900s, when exploitation by pelagic fur hunters almost caused the annihilation of the sea otter. The second population is centered in Kachemak Bay and extends north as far as Ninilchik and south to the outer Kenai Peninsula. Both population centers should be considered critical sea otter habitats.

Sea otter populations in Cook Inlet still are recovering and are expanding rapidly. As the populations approach the carrying capacity of the Inlet, sea otters may have profound effects on the near-shore benthic communities. Estes and Palmisano (1974) noted that sea otter populations in the Aleutian Islands, with a reported density of 20 to 30 individuals per square kilometer of habitat, reduced the populations of sea urchins and chitons to approximately 10% and to less than 3%, respectively, of the populations noted at sites not populated by sea otters. Foraging sea urchins reduce macrophyte biomass in the intertidal zones. Loss of these

macrophytes constitutes a loss of food, substrate, and habitat important to many nearshore fish invertebrates. If the sea otters control sea urchin populations in the Cook Inlet, as apparently they have on Rat Island in the Aleutians, they may cause a habitat shift that will favor a quite different nearshore community.

3.2.1.6. Birds

Erickson (1977) defines seabirds as "...species which, during some part of their life cycle, come in contact with the marine environment; this varies from a transitory association such as the migrating dabblers to the truly pelagic species such as the shearwaters."

He listed six seabird habitats in Lower Cook Inlet. They were:

- Offshore water -- waters more than 3 nautical miles (3.45 miles) from land
- Inshore water -- waters within 3 nautical miles of land
- Rock shore -- steep rocks or rubble beaches
- Sea cliffs -- near-vertical rock cliffs with little or no vegetation
- Sea beaches and tidal flats -- intertidal beaches
- Coastal floodplains -- large areas of low, wet lands from the normal high tide mark to the maximum storm water level.

Sea ducks, shearwaters, murres, gulls, puffins, guillemots, murrelets, and cormorants are the principal seabirds in offshore waters. These birds also inhabit inshore waters, where they nest on seacliffs or rocky shores. Many of the sea ducks and gulls nest and feed in the sea beach-tidal flat and coastal floodplain habitats. Geese, dabbling ducks (puddle ducks), and shorebirds, including black oystercatchers, plovers, snipe, turnstones, sandpipers, yellowlegs, dulin, dowitchers, surfbirds, and others, also nest and feed in these two wetland habitats.

Winter sea bird populations are small, consisting largely of sea ducks overwintering in small bays and in the mouth of Kachemak Bay. During the early spring and autumn, populations increase and decrease rapidly as sea birds migrate into the Inlet to breed or as transients. Summer nesting populations are centered around the rocky shores, sea cliffs, or floodplains used as nesting sites and as the feeding areas that support the nesting populations.

Critical seabird habitats include habitats that support dense concentrations of seabirds and habitats that are essential to any phase of a species' life history. Colonies and concentration areas for feeding or overwintering birds are critical habitats for pelagic marine birds. Nesting habitat may be critical for ducks and shorebirds. Staging areas, where waterfowl congregate prior to, or during, spring or autumn migration periods may be critical feeding and resting sites for geese and ducks.

3.2.2. Freshwater biology

3.2.2.1. System components and limiting factors

Freshwater streams and lakes typically are oligotrophic (lacking in plant nutrients) and are either nearly transparent or extremely turbid, depending on whether or not glacial meltwater is contributed to the watershed. In most lakes and streams of the study area, members of the sculpin, stickleback, and salmon families constitute the predominant fishes. The Salmonids include the five species of salmon harvested commercially -- rainbow trout (Salmo gairdneri), Dolly Varden (Salvelinus malma), lake trout (Salvelinus namaycush), Arctic grayling (Thymallus arcticus), and a species of white fish (Coregoninae). Two stickleback species are present -- the treespine stickleback (Gasterosteus aculeatus) and the ninespine stickleback (Pungitius pungitius). Several species of sculpin are present, including, at a minimum, the slimy sculpin (Cottus cognatus), coastrange sculpin (Cottus aleuticus), and staghorn sculpin (Leptocuttus armatus). Lampreys (Lampetra spp.), sturgeon (Acipenser sp.), American shad (Alosa sapidissima), blackfish (Dallia pectoralis), northern pike (Esox lucius), burbot (Lota lota), suckers (family Catostomidae), and several species of smelt (family Osmeridae) also have been reported to be present in these lakes and streams.

The diversity of fish species and of the organisms that comprise their diet generally are less than those in warmwater systems. Fish species often are adapted to utilize efficiently a broad range of food sizes. Trout fry, for example, use zooplankton as a primary food source. As they grow they are able to take larger invertebrates and fish, but throughout their life trout retain the ability to collect zooplankton on their gill rakers. Zooplankton may remain important components of their diet.

In Alaska, most of the research conducted in freshwater systems has focused on the salmonid species -- salmon, trout, and char -- and their management. Regulations governing the usage of freshwater systems generally are based on the assumption that protection of the public health and of salmonid species will provide adequate protection for the systems as a whole.

Factors limiting salmon, trout, and char production and populations include:

- Productivity of the waters
- Water quality, including concentrations of dissolved oxygen and other chemicals, mineral content, and temperature
- Predation on eggs, young, and adults
- Quality of the spawning substrate
- Quality of the habitat structure, including natural resting places, overwintering pools, and diversity of habitat types to meet other requirements of the various components of the population.

3.2.2.2. Productivity

Productivity determines the amount of plant material that is available as food to the aquatic invertebrates and fish. The productivity of a lake or stream is determined by the chemical composition of the water, the water temperature, the amount of solar radiation (insolation) the water receives, and other factors. In most unpolluted, northern aquatic systems, the productivity is limited by the availability of nutrients, particularly nitrogen, carbon, phosphates, and minerals. This is true of most Alaskan systems in the summer. During the colder months, when the water is covered with ice, insolation is reduced and may become the limiting factor. In general, waters in Alaska are much less productive than are most streams and lakes in the colterminous United States. This low productivity is reflected in the biomass, species diversity, and evolutionary adaptations of the fish and invertebrates inhabiting the lakes and streams. Because nutrient levels are the limiting factors in many systems, relatively small additions of phosphorus, nitrogen, or organic carbon compounds, as may be found in industrial and domestic waste water, can affect productivity significantly.

Nutrient enrichment would tend to benefit some elements of the system to the detriment of others. The degree of change effected by nutrient enrichment would depend on the nature of the receiving community and the composition and quality of the nutrients that would be added. In the coldwater, oligotrophic communities typical of Alaska lakes and streams, the addition of relatively small quantities of nutrients could cause considerable increases in primary productivity and in fish productivity. The benefits of increased fish production brought about by nutrient addition may be outweighed by the unfavorable results, which may include fish-kills when the water is ice and snow-covered for extended periods. Additions of large amounts of organic waste may cause oxygen depletion and elimination of desirable fish populations.

3.2.3. Water quality

Water, "the universal solvent," carries small quantities of many naturally-occurring organic and inorganic substances. Carbon dioxide, dissolved oxygen, and various metals, oxides, salts, and organic (carbon-containing) compounds usually constitute most of the dissolved material. Carbon dioxide and dissolved oxygen are necessary for plant and animal respiration. Phosphates and nitrates are needed for tissue growth and maintenance. A number of other minerals are needed in small quantities for metabolism and growth. In unusual situations, excessive amounts of naturally-occurring chemicals may drastically limit the diversity and/or production of an aquatic community.

Chemicals in municipal wastes, and particularly in industrial wastes, may be especially dangerous to aquatic systems because they may contain substances for which there are no evolved ecological adaptations. In addition, relatively high concentrations of toxins may occur. A broad range of poisonous by-products are dispensed from modern industrial processes. Most industrial wastes, when present in sufficient amounts, present a threat to aquatic organisms. Unfortunately, the short-term lethal doses to aquatic organisms are not well-defined for most indus-

trial chemicals, and the chronic and synergistic effects of industrial wastes are not understood.

3.2.2.4. Predation

Predation from other fish, birds, and mammals (including man), affects each species at various stages in its life history. Small fish prey on eggs and larval fish, as do some aquatic insects. Larval fish, including young of their own species, may constitute an important segment of the diets of trout, char, and juvenile salmon. In a natural system unaffected by man, the greatest predation pressure is on the smallest and youngest members of the population. As the fish age, a smaller percentage of each year-class is taken by predators. Angling and commercial fishing usually act on the population in a very different manner, selecting the older, larger individuals. Heavy fishing pressures usually reduce the biomass of small streams and lakes and also decrease the efficiency of nutrient cycling. Fishing pressures may become so intense that populations of target species are reduced to the level where insufficient stock remain to maintain reproduction. In these instances, the populations may become depleted.

During the spawning season, adult salmon constitute a large mass of available food for carnivorous birds and terrestrial mammals, especially brown bears. Where bears are concentrated, they may remove an excess of 70 percent of the spawning run, but usually are not considered a major factor limiting salmon recruitment of the spawning run (Gard 1971). Alaska Department of Fish and Game management plans take predation by bears into consideration when salmon escapement goals are established.

3.2.2.5. Spawning habitat

Each species of char, trout, or salmon requires specific spawning habitat for successful reproduction. In general, these salmonids spawn in a sand or gravel substrate in running water, or in sand and gravel bottoms of lakes. In the more heavily used salmon streams, the spawning substrate has been conditioned by years of redd (spawning bed) preparation. During years when the spawning runs are light, salmon use only the sites that most nearly resemble the optimum spawning substrates. During heavier runs poorer spawning substrates are used more frequently.

During years when salmon escapement is large, redds of late-spawning fish may be superimposed over earlier redds. This competition for spawning substrate may cause high mortality among the developing salmon fry. The destruction of an optimum habitat by siltation, modification of stream flow, or construction activities may significantly reduce spawning success in a stream.

Blocking of upstream migration routes also may reduce spawning success by preventing utilization of the substrate. Dams, culverts, and channel braiding caused by siltation or by fords may stop upstream salmon migration.

Streamflow volumes are important determinants of spawning success. If flooding occurs during the long period when the eggs and developing yolk-sac embryo are beneath the spawning gravel, the substrate may shift

and the embryonic salmon may be washed away. Severe floods may destroy most of the recruitment from a stream or from all the streams in a watershed. Flooding also may cause a shift in silt deposition that may bury the salmon eggs or fry. Low streamflows may reduce water levels sufficiently to dry the redds or to allow them to freeze during the winter. Drainage of adjacent wetlands may decrease the flow of ground water into the spawning redds during the winter, causing them to freeze and thus killing the fry.

3.2.6. Habitat structure

Good fish habitat must provide a variety of structures (arrangement of substrates, stream banks, submerged trees, and other objects in water). Habitat structures alter water current direction and velocity, provide resting stations and refuges from predators, and reduce stress by providing reduced light levels and the presence of covering or surrounding substrates. Deep pools are necessary for the survival of overwintering fish in smaller streams and rivers.

3.2.3. Terrestrial biology

The various landforms and climatic characteristics in the study area have produced diverse sets of abiotic conditions, which have resulted in the formation of terrestrial vegetation assemblages that are transitional between those characteristic of the coastal, mountainous interior, and Alaska Peninsula systems.

3.2.3.1. Vegetation

Work conducted by the Joint Federal-State Land Use Planning Commission (1973a) resulted in a broad classification scheme that identified characteristic plant assemblages, which they termed "ecosystems." The scheme largely is an adaptation of the work of Spetzman (1963).

<u>Plant communities</u>

The following nine "ecosystems" identified by the Joint Commission are present in the study area:

- Coastal Western Hemlock-Sitka Spruce
- Upland Spruce-Hardwood Forest
- Lowland Spruce-Hardwood Forest
- High Brush
- High Brush (burned areas)
- Low Brush, Muskeg-Bog
- Moist Tundra
- Wet Tundra

- Alpine Tundra and Barren.

Coastal Western Hemlock-Sitka Spruce is an extension of the rainbelt forests of the Pacific Coast. This type occurs throughout the lower two-thirds of the study area. On the western side of Cook Inlet, Sitka spruce (Picea sitchensis) is present north to Chitina Bay. Although some stands of Sitka spruce are known to occur near Mt. Susitna, the northern edge of the range of this species is thought to be near Chitina Bay, where it hybridizes with white spruce (Picea glauca). On the eastern side of the Inlet, Sitka spruce is present to the south of the City of Kenai. Sitka spruce also is present in the areas around Skilak Lake and Cooper Landing. These inland sites, however, are outside the study area.

Trees associated with this forest type are large near the coast and at lower elevations, particularly in valleys. Heights of up to 100 feet and diameters as large as 24 inches have been observed. Trees on valley slopes are smaller but closer together than those along the coastline or in the valley bottoms. Black cottonwoods (Populus trichocarpa) are found along streams.

A transition zone from coastal to interior forest occurs on the Kenai Peninsula. In this zone western hemlock (Tsuga heterophylla) and Sitka spruce are replaced by white spruce and mountain hemlock (Tsuga mertensiana). The latter often are associated with aspen (Populus spp.) and birch (Betula spp.).

The understory of this forest type consists of devil's club (Oplopanax horridus), blueberries (Vaccinium spp.), Sitka alder (Alnus sinuata), juniper (Juniperus communis), salmonberry (Rubus spectabilis), willows (Salix sp.), bunchberry (Cornus canadensis), and various ferns, bryophytes, and lichens.

Sitka spruce is the most important commercial species of this forest type. It is the basis for logging operations at Port Graham and Jackolof Bay. Stands with commercial potential are located near Red Glacier and Polly Creek. The problem of accessibility and the uncertainty of land ownership have limited the development of a timber resource on the western side of Cook Inlet.

Upland Spruce-Hardwood Forest is composed of moderately dense stands of white spruce, birch, aspen, and balsam poplar (Populus balsamifera). Some black spruce (Picea mariana) is present on north-facing slopes and poorly-drained flat areas.

White spruces occurring on south-facing slopes and well-drained soils will average 40 to 80 feet in height and may be up to 16 inches in diameter. White spruce and birch may be utilized commercially from this forest type, but their utilization is minimal.

Birches typically are the initial invaders of wet slopes following fire. The species establishes quickly and generally occurs in pure stands or interspersed with aspen. White and black spruce will grow in the stands at a later stage of succession. At maturity, birches average 60 to 80 feet in height and 8 to 9 inches in diameter.

In dry upland sites following a fire, aspen will develop. This species usually is replaced by white spruce or hemlock. Aspen trees mature in 60 to 80 years. Typical understory plants of the upland spruce-hardwood forest type include highbush cranberry (Viburnum edule), mountain cranberry (Vaccinium vitis idaea), raspberry (Rubus spp.), currant (Ribes spp.), and bunchberry.

Lowland Spruce-Hardwood Forest is an open, interior-forest type consisting of both evergreen and deciduous trees. In some areas pure stands of black spruce are present. Black spruce grows very slowly and seldom will exceed 8 inches in diameter or 50 feet in height. The species is especially prevalent on north-facing slopes and in poorly-drained areas, and often is associated with muskeg.

More mesic (drier) areas usually support a mixture of white and black spruce, birch, aspen, and poplar. Mesic areas will have an understory consisting of willow, dwarf arctic birch (Betula nana), blueberry, Labrador tea (Ledum spp.), and various lichens, mosses, and ferns. In moist areas the understory contains thick mats of sphagnum moss or other mosses and ferns.

Large regions of intermixed upland spruce-broadleaf and lowland spruce-broadleaf forests are present throughout the study area. These types can be separated only through a close examination of the vegetation.

High Brush is divided into three separate subsystems: coastal alder thickets, floodplain thickets, and birch-alder-willow thickets. Coastal alder thickets occur in areas between beach and forest, between timberline and alpine tundra meadows, and in avalanche paths on mountainsides. In the upland regions high brush will vary in successional stages between alder and grasses. In areas where grasses are dominant, bluejoint (Calamagrostis) may be cut for hay or utilized directly by livestock.

Floodplain thickets develop along newly-exposed alluvial deposits. These areas are flooded periodically and support a variety of shrubs. Willows and alders initially are the predominant species, but later are replaced by cottonwoods and poplars. These thickets occur along the floodplains of most streams and many lake margins throughout the study area. They are important wintering locations for moose.

Birch-alder-willow thickets typically occur near the timberline, and also are found in regions that have been burned. These stands may be quite dense, and usually consist of birch, several species of alder and willow, and several species of low, heath-type shrubs. They provide important browse habitat for moose. These areas are typical of secondary succession patterns in areas of the Kenai Peninsula that have been burned or disturbed.

Low Brush, Muskeg-Bog is interspersed among the other plant assemblages throughout the study area. These areas are found in wet basins but also may occur in depressions and on flat areas and gentle, poorly-drained slopes. Small ponds with a peat-like bottom may support some aquatic vegetation. Most of the vegetation, however, is composed of

mosses. Smaller herbaceous plants such as cottongrass, crowberry (Empetrum nigrum), and several sedges (Carex spp.) are common. Shrubs will replace sedges as the dominant plants on small, drier hummocks. These muskegs may be feeding habitat for moose, particularly when associated with shallow water.

Moist Tundra is characterized by uniform mats of cottongrass (Eriophorum spp.) and stands of dense, low-lying shrubs. Other plants associated with this type may include Labrador tea, American green alder (Alnus crispa), blueberry, Lapland rosebay (Rhododendron laponicum), and mountain cranberry. Moist tundra usually occurs at elevations between 2,000 and 4,000 feet.

Wet Tundra is characterized by standing water with large mats of sedges and cottongrass. Few, if any, tussocks are present. Some woody and herbaceous plants may occur above the water table. Rooted aquatics occur along adjacent shorelines and in shallower waters. Isolated pockets of this type occur in the study area. Plants found in this type include small willows, dwarf arctic birch, Labrador tea, cinquefoil (Potentilla spp.), lowbush cranberry, and bog cranberry (Vaccinium oxycoccos). Rooted aquatics include bur reed (Sparganium spp.), pondweed (Potamogeton spp.), pendant grass (Arctophila fulva), and mare's tail (Hippuris spp.). Lichens and bryophytes also are present.

Alpine Tundra and Barren systems are found in all mountain ranges. Barren rock and rubble and mats of low plants are characteristic of this type. In the Alaska Range white mountain-avens (Dryas octopetala) is predominant, often covering entire slopes and ridges. Other species include moss-campion (Silene acaulis), Arctic sandwort (Arenaria arctica), blackish oxytrope (Oxytropis nigrescens), grasses, and sedges. Numerous lichens also are present. Alpine tundra usually occurs at elevations of more than 2,500 feet.

3.2.3.2. Terrestrial animals

Amphibians and reptiles

Amphibian and reptile populations are limited by the long cold-season quiesence required by ectotherms in the north. They also are limited by permafrost and by cool mean summer temperatures that limit morphological development of the larvae (Hodge 1976). No reptiles are known to have been collected from the study area, and it is unlikely that any will be collected, except possibly for escaped or introduced specimens.

Three species of amphibians may be found in the study area. The wood frog (Rana sylvatica) is found in much of Alaska and probably occurs in suitable habitat (small streams and temporary ponds) throughout most of the study area. The rough-skinned newt (Taricha granulosa) was reported at Tyonek, just north of the study area (Hodge 1976). If the report is valid, this species probably occurs in the study area. The range of the boreal toad (Bufo boreas boreas) includes Prince William Sound and possibly extends into the Kenai Peninsula. Little else is known of amphibian distribution in the study area. Apparently, very little effort has been directed to amphibians in the study area. There

may be range extensions or even unclassified species in the study area. It was not possible to identify critical habitats.

Amphibians may play a minor role in small pond ecology. They utilize available plant and animal material and provide food to predaceous fish, birds, and mammals. Despite their minor ecological role, they deserve consideration in planning human activities because they represent the highly-adapted, northernmost populations of the species. These unique adaptations make them valuable objects of scientific investigations and subjects of interest to naturalists. Removal of habitat (drainage of small ponds) and water pollution are the consequences of human activities that are most likely to affect amphibian populations.

Mammals

Five species of large mammals are found in the study area:

- Black bear — *Ursus americanus*
- Brown bear — *Ursus arctos*
- Moose — *Alces alces*
- Caribou — *Rangifer tarandus*
- Mountain goat — *Oreamnos americanus*

The present ranges of these species probably are little changed from those of 200 years ago, with the exception of the caribou. During the last 200 years, population densities of large mammals have changed in response to natural biologic, geologic, and climatic events and in response to human activities. Pressures from human activities take the form of population loss from hunting, from kills and harassment by domestic dogs, and from accidental kills by vehicular traffic, fence entanglement, and other accidents related to human development. Fewer direct pressures occur when habitats are altered or their uses are denied by segmentation or other means. Habitat may be altered by fire, land clearing, lumbering, road building, or other construction or resource extraction activities. Segmentation divides a habitat into tracts too small to be used effectively by a population. The noise and activity associated with development also may prevent utilization of a habitat. Many diverse habitat types within the range of a species may be occupied at least occasionally by the species, but one or several types may be of particular importance. These can be termed "critical habitats," and their size may limit the population of the species. Critical habitats may be areas used for denning, wintering, calving, or feeding, depending on the species. Usage of a critical habitat may vary from year to year, depending on the extant vegetation in the critical habitat, the size of the population using the habitat, and the stresses on that population. Management techniques for wildlife frequently involve the reduction of the effect of limiting factors by alteration of a critical habitat to increase its carrying capacity (the number of animals the habitat will support).

Life history requirements for large mammals found in the study area have been described by the Alaska Department of Fish and Game and other sources. Critical habitats for these species have been defined and are mapped in the discussion of existing conditions for each Subarea. The more important life history elements of those large mammals are presented below.

Brown/grizzly bear

Brown bears and grizzly bears are considered to be variants of the same species, *Ursus arctos*. Both phenotypes may be found in the study area, but the *U. arctos* of the coastal regions (including the study area) usually is called brown bear, whereas the term "grizzly" is reserved for the *U. arctos* of the interior. For the sake of brevity, *Ursus arctos* is referred to as brown bear in this report. Brown bears are reported to be absent from most of Subarea IV, but may be found in suitable habitats throughout the study area.

Brown bears reach sexual maturity at 2.5 to 4.5 years of age, although most males mature at 3 to 5 years (Alaska Department of Fish and Game 1973; Glenn and Faro 1973). The bears mate in June or July, but implantation of the embryo is delayed until autumn. An average litter contains 2.2 cubs, which are born in the den during the following winter.

The cubs grow rapidly during their first summer, gaining more than a pound a day. They remain with the sow for 2 years and are abandoned in the third year before the sow breeds again. Cub mortality probably is low if the female remains with them for a full 2 years. Litters of cubs and yearlings observed by the Alaska Department of Fish and Game (1973) contained, on the average, slightly more than two cubs. This implies that although reproduction occurs only every third year, this low rate usually is ample in the absence of man.

Brown bears usually leave their dens in May and move to lower elevations. Bears near the coast may move out onto the beaches in search of marine animal carcasses cast up during the winter. Inland bears may search moose yards for winter kills and prey on caribou and moose calves at the calving grounds. As spring progresses, green vegetation, especially young grasses, sedges, and horsetail, becomes the principal diet. As the snow retreats the bears follow the spring growth away from the open beaches to higher ground. Green vegetation, with occasional small mammals, carrion, roots, and other plant materials, forms the diet mainstay until the appearance of berries and salmon during the summer.

Salmon become the primary component of the brown bear diet soon after they reach the spawning streams. The bears remain near the salmon streams through the remainder of the summer. There they feed primarily on salmon but supplement their diet with daily visits to berry patches. The time that a bear spends at a salmon stream each day probably depends on how intensively the stream is fished by bears. On streams that support a large bear population, each of the bears usually remains only for a short period. On streams receiving less intensive use, each bear may remain for several hours. The bears apparently prefer ripe female salmon. During the peak of the salmon runs the bears may eat only female fish, and sometimes only the egg-filled ovaries. Feeding bears may

reduce salmon spawning success, but their depredations generally are not regarded as significant (Gard 1971). After the salmon runs are completed, brown bears feed largely on berries, roots, and green vegetation, supplemented with occasional small mammals and carrion.

Denning in the study area probably occurs in November. Pregnant females usually den earlier than other bears. A bear may remain in the vicinity of its den for several weeks, sleeping for a period, emerging, feeding, and sleeping again. After settling for the winter, most bears remain in their dens until May, although they may emerge for brief periods during mild weather, or if disturbed.

The den site may be a cave or other preconstructed enclosure, or may be constructed by the bear. The den may be a simple hole in the ground, or the bear may spend considerable effort lining the den with leaves and other vegetation. After entering the den, the bear may collapse the entrance. Most bear dens are on hillsides. Glenn (1975) reported that brown bears at Black Lake on the Alaska Peninsula denned in locations from open tundra near sea level to 2,000 feet above sea level. The majority denned approximately 1,300 feet above sea level.

Alaska Department of Fish and Game reports indicate that brown bears are much more numerous on the west coast of the Cook Inlet than on the coast of the Kenai Peninsula. Both areas contain excellent bear habitat and food resources, but the human population on the Kenai Peninsula in the study area is much larger than on the west side of the Inlet. Human use of the fish resources and the land has forced the bears to retreat into less accessible habitat. The reduced resources available to the bears and bear-human conflicts have reduced brown bear populations on the Kenai Peninsula. The west coast of the Inlet, however, virtually is unsettled and is relatively inaccessible. Hunting pressure is low and bears compete less often with humans for habitat and food. The Alaska Department of Fish and Game (1976) considers brown bear populations on the west coast of the Inlet to be about as large as they ever were.

Denning areas, spring feeding areas, and salmon streams are probably the most critical habitats for brown bears. On the Kenai Peninsula, humans largely have displaced brown bears from the regions near the coast that comprise most of the study area. No critical bear habitat can be identified in that segment of the study area. On the west side of the Inlet, spring feeding areas include the flatlands at the head of most bays, the Bachatna Flats, and especially the flatlands along Kamishak Bay. Most of the salmon streams support brown bear concentrations and may be considered critical habitat during the salmon runs. Denning areas on the McNeil River and the Kamishak River should be considered critical habitats.

The future of the brown bear inevitably will be determined by human encroachment into bear habitat. The Alaska Department of Fish and Game (1973) accurately assessed the future of the brown bear:

> Of all Alaska's wildlife, brown-grizzly bears are probably least compatible with human activities. Without special consideration their numbers will be markedly reduced wherever substantial and sustained human occupation and

confrontation occur. Even with protection, a certain amount of conflict and consequent attrition of bears can be expected. The whole history of the species on this continent since the advent of the explorers has followed this pattern, and today grizzly bears have disappeared from most of their former range in the contiguous United States and Central America. Their numbers have been markedly reduced over much of Canada and in small portions of Alaska.

The brown bear in Europe has suffered a similar fate. The eventual survival of the brown-grizzly bear may not depend entirely on the designation of vast tracts of unspoiled "wilderness" as shown by conflicts occurring in large national parks. Instead, the future of the bear lies in the reassessment of human values to include reasonable coexistence with it. Bears are not constant competitors and the major conflicts usually have resulted from improper land planning and classification, marginal economic pursuits, and basic misunderstanding of bears and their behavior.

Within the study area, brown bears probably are more vulnerable to the secondary effects of development, especially increased access by hunters and increased incidental confrontations, than to most direct habitat modification impacts associated with development. Any activity that will increase human occupancy or access to the lands on the west side of the Cook Inlet should be evaluated to determine the potential for secondary impacts. Facilities should be designed to reduce bear-human interaction, particularly in critical habitats during periods of intensive bear usage.

Black bear

Black bears are primarily open forest animals. They tend to avoid dense forests and large open areas. In the coterminous United States black bears have received considerable attention from wildlife biologists, and their life history and population dynamics are understood fairly well. In Alaska, the comparatively little effort spent studying black bears indicates that the life history of Alaskan black bears is similar to that of black bears in the lower 48. Limited population studies (primarily assessment of hunter success) in the study area and observations by Alaska Department of Fish and Game biologists (Faro and others 1976), indicate that suitable habitats throughout the Kenai Peninsula support moderately large populations of black bear.

On the west side of the Inlet, populations became progressively thinner south of the West Forelands. There are few reported black bear sightings south of the Lake Illiamna, Inisken Bay, and Chinitna Bay areas, although rare sightings have been reported as far south as the Douglas River (Alaska Department of Fish and Game 1976).

The Alaska Department of Fish and Game (1976) and Erickson (1965) summarized Alaska black bear life history. Black bear usually reach maturity in their third year, although some females may not breed until they are 5 or 6 years of age. They mate in June or July, but implantation of the embryos is delayed until late autumn. The cubs, usually two

to three per litter, are born in the den in midwinter. Black bears in the study area generally emerge from their dens in May. Females with new cubs may emerge later and den earlier than others. Cub survival is high. Erickson (1965) reported that summer and fall litters average more than two cubs per litter. The cubs are weaned by the next September, but remain with the sow for another winter. They are abandoned in their second spring, and the female breeds again. The average weight of an adult black bear in Alaska probably is less than 200 pounds, although a large male may weigh more than 300 pounds. The maximum recorded age in captivity was 25 years. The average life span of wild black bears is certainly much shorter.

Black bears eat a wide variety of plant and animal material. During the spring, young grasses, sedges, horsetail (Equisetum), and early forbs form the bulk of their diet, supplemented by winter-killed carrion, insects, and occasional mammals. During the summer and early autumn, berries, along with some of the kinds of vegetation and animal material consumed in the spring, make up a large portion of the diet. In most localities black bears are much less dependent on salmon runs than brown bears, but in the study area, black bear concentrations and fishing observed along salmon streams indicate that salmon is an important component of the summer diet. In the autumn, leaves and grasses become more important diet components again as salmon and berries become less abundant.

Factors determining black bear mortality are well known. Hunting and other human activities may become the major limiting factors in accessible areas. Loss of habitat to development, loss of access to salmon streams and berry patches, harassment (both intentional and inadvertent) by outdoor recreation and transportation activities, and the incidence of nuisance bears that must be destroyed will increase as human populations and bear populations interface more frequently. Small, discrete black bear populations, such as those found along the Prince William Sound, may be especially vulnerable to over-harvest (McIlroy 1972). In the study area, where black bear populations infrequently are isolated from one another, the bears are less vulnerable to the effects of human activities.

Black bear usually inhabit open woodlands, avoiding extensive open areas and large tracts of dense forest. Where human contact has not been encouraged by dumps or handouts, habitat preference and native wariness permit black bears to withstand considerable human pressure. Increased development in the study area can be expected to depress local black bear populations. The continued existence of moderately large black bear populations on the Kenai Peninsula probably will be ensured by the large areas of potential habitat in the Kenai National Moose Range and the Chugach National Forest and by the management efforts of the Alaska Department of Fish and Game.

No critical habitats are identified for black bear in the study area. Protection of critical habitat for the other key species of large mammals in the study area (moose, brown bear, and caribou) should protect most of the areas that receive heavy black bear usage.

Moose

Moose range throughout the study area, except in Subarea IV, which is too mountainous. Moose calve during the spring in muskeg or swamps. One or two calves are the norm. Bulls and cows with calves from the previous years usually summer on higher ground. In early to mid autumn, bulls move down from the hills. Wintering grounds usually are in lowlands and river valleys and may hold dense aggregations of moose in "moose yards." "Yarding" occurs in response to heavy snow and difficult feeding conditions (Rausch and Bishop 1968; Coady 1973; Edwards and Ritchy 1956).

Moose eat a variety of vegetable matter, including browse (woody plant stems, buds, leaves, bark, and twigs), lichens, fungi, grasses, and forbs (non-woody annual and perennial plants other than grasses). The percentage of each component in the diet is determined in part by its seasonal availability. Moose were reported to eat alder and willow preferentially throughout the year, but the quantities of these plants that are available usually are less than sufficient for them to comprise the bulk of the diet. LeResche and Davis (1973) reported the following diet composition (based on the percentage of bites taken) for Kenai Peninsula moose (Table 10).

Table 10. Types of plants consumed by Kenai Peninsula moose (LeResche and Davis 1973).

	Percentage of Bites		
Plant	Summer	Normal Winter Range	Depleted Winter Range
Birch	60	72	22
Willow	5	3	1
Alder	trace	3	-
Poplar	trace	trace	-
Lowbush cranberry	trace	21	51
Aquatics	3	-	-
Sedges	4	-	-
Grasses	3	-	2
Forbs	25	trace	-
Lichens	trace	-	23

Birch, which constituted a large percentage of the diet, did not provide sufficient nutrition to support the moose for sustained periods. LeResche and Davis reported dead moose with rumens full of birch browse. They reported that low browse, forbs, and other plant material were essential to moose diets. Typically, vegetation on the best moose range is in the earlier seral stages (i.e., 5 to 25 years old).

Winter mortality of moose, including deaths associated with starvation and losses to predators caused by the weakened condition of the moose and loss of mobility in the deep snow, are the major factors limiting natural moose populations. Winter mortality is determined

primarily by food availability, which in turn is determined by competition for the food resources and by the depth, duration, and hardness of the snow. Adverse winter conditions first affect the calves, then the cows, and finally the bulls. During severe winters moose calf mortality may be nearly 100% (Joint Federal-State Land Use Planning Commission 1974b).

Predation by bears, wolves, and human hunters also may affect populations. Accidental kills by automobiles may be important locally, and traffic mortality will increase when roads are constructed through prime range or across migration routes. Automobile-moose collisions were estimated to have killed approximately 100 moose each year on the Sterling Highway (Kenai Peninsula) and are a major factor in the determination of moose population abundance in the Anchorage area (Alaska Department of Fish and Game 1976). Loss of moose habitat, both from direct development and from exclusion resulting from migration blockage are, and increasingly will be, determinants of moose populations on the Kenai Peninsula.

Caribou

Caribou range through parts of the Kenai Peninsula and may occasionally enter the study area on the west side of Cook Inlet. Two small herds on the Kenai Peninsula comprise most of the caribou population in the study area. The American Pass herd ranges over parts of the Chugach National Forest and the Kenai National Moose Range, but is not known to range into the study area proper. A smaller herd of fewer than 100 caribou, the Kenai herd, occasionally ranges into the study area near Kenai and is influenced by activities in the study area.

Caribou were eliminated from the Kenai Peninsula prior to 1920 by forest fires and hunting pressure. The present herds are the descendants of animals transplanted to the Kenai Peninsula during the 1960s by the Alaska Department of Fish and Game. The Kenai Peninsula is not prime caribou habitat, and extensive herds probably will never develop on the Kenai. Caribou primarily inhabit open lands, especially tundra, in the more advanced stages of succession. They eat a variety of browse, forbs, grasses, fungi, and other materials, but lichens are the mainstay of their diet. Destruction of tundra by fire or other causes may eliminate caribou from an area.

Caribou are well-equipped to survive most Alaska winters, and during a normal winter they may even gain weight. Ice storms, heavy snow crusts, and snow cover lasting into the spring calving period may cause mortality, and a very severe winter can almost eliminate caribou (Skoogs 1968). During the summer, the many species of biting flies that inhabit the tundra parasitize the caribou heavily, forcing them to the hilltops and ridgelines where the wind helps to repel the flies (Kelsall 1969).

The principal limiting factors for caribou populations are predation (principally by wolves and humans), disease, and food availability. Caribou tend to migrate to and from the same areas during each annual cycle. Disruption of these areas or the construction of barriers to migration could affect caribou populations.

Mountain goat

Mountain goats range through the coastal parts of the Chugach Mountains and the Kenai Mountains and are present in the study area in the Kenai Mountains near the southern end of the Kenai Peninsula (Subarea IV). The Kenai population is near the northern extent of the species' range and is subject to extensive declines during severe winters. Almost a decade may be required to repopulate the range after a particularly severe winter. During most of the year, the mountain goats remain well above the timberline and away from human activity. They may move down into heavy timber during the winter for protection and forage. Timbered mountain slopes in mountain goat ranges are regarded as critical winter mountain goat habitat (By telephone, Mr. Dave Hardy, Alaska Department of Fish and Game, Homer AK, to Mr. Guy McConnell, WAPORA, Inc., 23 August 1978).

Birds

Most of the study area contains potential habitat for at least one or two species of birds. A few areas have been identified as particularly important habitats for waterfowl, shorebirds, and raptors because they support concentrations of migratory, nesting, or overwintering populations. Most of the coastline of the Kenai Peninsula is inhabited by bald eagles during the summer, and open rivers are important winter eagle habitats. Shorebirds migrating through the study area may be present only for a few days, but during that time may number in the millions. Shoreline habitat that these birds use may be essential to these migrants and should be considered critical habitat. Ducks, geese, and other waterfowl nest along potholes, lakes, and other bodies of water throughout the lowlands of the study area. Migrating waterfowl stage (assemble prior to or during migration) on tidal flats, floodplains, and other lowlands near the mouth of rivers. Staging areas and areas where nesting waterfowl are concentrated should be considered critical habitats.

3.2.4. Endangered and threatened species

A list of the ten endangered species of animals that may be present in the study area during part or all of the year is presented in Table 11. It is not known which of the subspecies of peregrine falcon is present in the study area; thus both are noted. Both Federal and State of Alaska designations are presented for each species. All of these species, with the exception of both peregrine falcons, would inhabit or utilize the study area only on an occasional basis. Because little is known about the populations or movements of these species in the study area, they are not described further in the Subarea profiles.

Although no species of Alaskan plants have been included in the Federal list of endangered and threatened species, a number have been proposed for endangered status, including the six species listed in Table 12. No State list of endangered and threatened plants is known to exist. No threatened species of animal or plant is known to be present in the study area.

Table 11. Endangered and threatened species that may be present in the study area (Bureau of Land Management 1976; US Fish and Wildlife Service 1978a).

Common Name	Scientific Name	Status Designation Federal	State
American peregrine falcon	*Falco peregrinus anatum*	E	
Arctic peregrine falcon	*Falco peregrinus tundrius*	E	E
Blue whale	*Balaenoptera muscutus*	E	
Finback whale	*Balaenoptera physalis*	E	
Gray Whale	*Eschrichtius gibbosus*	E	
Humpback whale	*Megaptera novaeangliae*	E	
Right whale	*Eubalaena* spp.	E	
Sei whale	*Balaenoptera borealis*	E	
Sperm whale	*Physeter catodon*	E	

Table 12. Species of Alaskan plants proposed for designation as endangered species (41 Federal Register 24524). Common names indicated with an asterisk (*) are from Welsh (1974).

Family	Scientific Name	Common Name
Boraginaceae	*Cryptantha shockletteana*	Catseye (unnamed)
Brassicaceae (cruciferae)	*Smelowskia borealis* var. *villosa*	No common name
Cyperaceae	*Carex jacobi-peteri*	*Anderson sedge
Fabaceae (Leguminosae)		*Kobuk locoweed
Polygonaceae	*Eriogonum flavum* var. *aquilinum*	Wild buckwheat (unnamed)
Polypodiaceae	*Polystichum aleuticum*	*Aleutian holly-fern; Aleutian shield-fern

3.3. Land and Water Use

3.3.1. Settlement patterns

Land and water uses in the study area have developed near the natural resources and are dependent on the extraction of those resources. The earliest Native settlements were located along the Cook Inlet coastline in protected areas near the marine biotic resources -- sea mammals, fish, marine invertebrates, and seabird colonies. In the Lower Cook Inlet, these resources are most abundant and accessible in Kachemak Bay, along the shoreline of the lower Kenai Peninsula, and along the rocky western shoreline between Redoubt Bay and Iliamna Bay (De Laguna 1934). Later influxes of Natives either displaced the cultures in the existing communities or utilized inland resources such as large mammals, small mammals, fish (particularly salmon), and plants.

During the 18th century Russian trading companies exploited the pelagic and inland fur resources. When those resources were depleted, they sold their rights of possession to the United States. Both coal and gold were mined in small amounts by the Russians and were the focus of resource exploration during the last decade of the 19th century and the first two decades of the 20th century. Salmon was the next major resource developed. Salmon fishing and processing, along with homesteading, determined land-use patterns during the period from 1920 through 1955. More recently, the fishing industry has diversified to exploit other fish and shellfish resources. With the opening of the Sterling Highway in 1957, tourism and transportation have become important resources and have stimulated development along the highway and the Kenai River, Kalifonsky Beach, Tustumena Lake, Clam Gulch, and the Homer-Kachemak Bay recreational areas. The discovery of oil and natural gas in the northern Kenai Peninsula brought an influx of workers during the drilling phase and during the construction of the processing facilities. The construction boom has ended, at least temporarily, but the construction and operation of these facilities is a primary factor in the determination of settlement and land-use patterns on the Kenai Peninsula.

3.3.2. Land ownership

3.3.2.1. Federal

Ownership of the lands of Alaska was assumed to have passed to the Federal government at the time of the Alaska Purchase. During the territorial period, comparatively small areas of Alaska passed into private ownership via homesteading, patenting of mining and town site claims, Native claims, grants, sales, and other means. The Alaska Statehood Act provided for the transfer of 103.35 million acres of Alaska land to the new State government, boroughs, and municipalites.

Following court action by Alaska Native groups, the Alaska Native Claims Settlement Act (ANCSA) was signed into law in 1971. The ANCSA provided for the transfer of approximately 44 million acres of Federal lands in Alaska to Native ownership. Selection was to be based on historic use of the lands and was to transfer surface estates and mineral rights to village corporations and to thirteen Native corporations that

were established for that purpose. In cases where selections of tribal lands by individuals, the State, or Federal government already had been patented, provisions in the Act permitted Native selections to be made on other lands. In addition to the Native selections, a maximum of 80 million acres was to have been withdrawn by the Federal Government to be considered for National Park, Refuge, Wild and Scenic River, and Monument statuses.

Conflicting claims and land selections by the Federal Government, State and local governments, and by Native corporations have prevented rapid settlement of the land distribution legislation. Following the defeat of compromise legislation to determine the location and extent of lands to be protected under Section d-2 of the ANCSA, approximately 64 million acres were added to the US system of National Parks by Presidential Order under the provisions of the Antiquities Act of 1906. Enabling legislation that would complete Federal withdrawals of Alaska lands is pending. Conveyance of the bulk of the State's land will not occur until the Federal selections are completed and the terms of the Alaska Statehood Act are fulfilled. In many instances, selections by the Native corporations overlap or otherwise conflict with State or borough selections, and litigation has ensued or will ensue. In other instances, land trades between Native corporations and the State of Alaska, or with the US Government, have been proposed. Many of these actions still are pending and will decide the future land use for vast areas.

3.3.2.2. State

By the close of 1978, the State of Alaska had selected approximately 72 million acres of the 103.35-million-acre statehood entitlement. Of the selected acreage, the State has received title to approximately 21 million acres and tentative approval of an additional 15 million acres. Native corporations have received patent to approximately 5.2 million acres.

3.3.2.3. Local

The State of Alaska owns approximately 2.1 million acres in the Kenai Peninsula Borough and has applied for an additional 1.2 million acres under the Alaska Statehood Act. Under the provisions of the ANCSA and State legislative actions, ownership of some of these State lands will be transferred to Native corporations, the Kenai Borough, cities, and private individuals. Approximately 750,000 acres may be transferred from State ownership under these provisions, and village Native corporations could receive up to 350,000 acres. The Cook Inlet Native Corporation is entitled to 115,000 acres on the Kenai Peninsula and 188,000 acres on the west side of the Cook Inlet, and the Kenai Peninsula Borough will receive 155,780 acres. Approximately one-third of the land selected by the Borough has been conveyed.

3.3.2.4. Private

Land has been transferred to private ownership directly from the Federal Government through homesteading, patenting of mining claims and base camp sites, and direct sales and land transfers to Native corpora-

tions. Much of the land in private ownership has come from land disposal programs set up by the State of Alaska. Included are: sales of agricultural lands, town lots, and other lands; small parcels claimed or patented under State Open to Entry Programs; homesteading; and lands transferred by other means. Sales of agricultural lands are intended to increase the low agricultural production of Alaska and usually include the condition that the lands be used only for agricultural purposes. During 1978, 68,200 acres of agricultural land were sold, including 2,900 acres in the study area. Mining claims on State lands are exclusive, but cannot be patented. The State of Alaska is engaged in a continuing program of land sales by auction or by lottery. These sales are conducted only after the potential of the land has been studied and recommendations have been considered. The Beirne Initiative, passed during the 1978 general elections, would open up most of the State lands and the lands to be transferred under the Statehood Act, to acquisition by the citizens of Alaska. Under this initiative the amount of land allowed to each "homesteader" would be 40, 80, or 160 acres, depending upon the length of his or her residence in the State. The "homesteader" would not be required to reside on the land to validate the claim. The initiative required that the plan be implemented early in 1979. Almost a million acres of the Kenai Peninsula could have been transferred into private ownership under the terms of the initiative. The constitutionality of the initiative has been challenged, and the workability of the process has been questioned. Several years probably will be required to determine the constitutionality of the initiative and to develop an equitable land distribution system if the initiative were to be determined constitutional.

Legislation and judicial decisions that will determine land distribution under the Alaska Statehood Act, the ANCSA, and the Beirne Initiative probably will be completed during the early 1980s and will affect profoundly land-use patterns in the study area. At present, most of the lands on the west side of Cook Inlet are controlled by the Federal Government. On the Kenai Peninsula ownership is more diverse, but most of the land is in State or Federal ownership.

3.3.3. Recreational areas

3.3.3.1. Federal

Three US parks are in the study area: the Tuxedni National Wildlife Refuge, the Kenai National Moose Range, and the Katmai National Monument. Legislation proposed under Section d-2 of the ANCSA and implementation of the Antiquities Act could expand the Katmai National Moose Range and the Katmai National Monument. It also could create the proposed Lake Clark National Park and the Lake Iliamna National Wildlife Refuge on the west side of the Cook Inlet and the Kenai-Fjords National Monument on the Kenai Peninsula.

3.3.3.2. State

One large State park, the McNeil River Bear Sanctuary, is in the study area and might be expanded with lands transferred under the Statehood Act. Another State park, the Kachemak Bay State Park, has been proposed for the south shore of Kachemak Bay, and a third State park of

approximately 4,000 acres may be proposed for the north side of Kachemak Bay.

3.3.3.3. Local

Local parks are described in the subarea profiles.

3.3.4. Agriculture

The short growing season, cool temperatures, high costs, and scarcity of good soils have limited agriculture in the study area. No row crops are raised, and the principal crops are potatoes, hay, and truck garden vegetables. The US Soil Conservation Service does not classify any lands in the study area as Class I arable lands because of the cool soil temperatures. Class II and Class III soils are considered agricultural soils by the State and are sold for that purpose.

Cattle, hogs, chickens, and horses are raised in the study area. Chickens and hogs primarily are used by the owners. Husbandry of cattle and horses is centered in Subareas I, II, and III.

3.3.5. Forestry

White spruce and Sitka spruce are harvested from the study area. The trees are sawn into rough lumber at local mills, turned to produce logs of uniform diameter for home building, or exported. To satisfy US export regulations, timbers are slabbed into cants before they are shipped. Most of the logging in the study area is in Subarea IV and in the Kenai Moose Range by permit.

3.3.6. Land and water use planning

Almost any legislation or action by a government agency may affect land and water use. This may be done directly by land disposal, regulation of uses through zoning, institution of permit requirements, or regulation of resource exploitation. Indirect actions include controlling or influencing occupational, recreational, economic, and social opportunities offered to the potential populace and placing restrictions, such as taxes, assessments, and regulations on the use of those opportunities in the study area. The Federal Government, the State of Alaska, the Kenai Peninsula Borough, and the various city governments directly regulate public and private land and water use.

3.3.6.1. Federal

Of the Federal laws governing land and water use in Alaska, the most important in the direct determination of land ownership are the Alaska Native Claims Settlement Act, the Alaska Statehood Act, and the Antiquities Act. In addition, the Organic Act of 1884 still is of some importance in the distribution of land.

The activities of most Federal agencies influence land and water use in Alaska. The various divisions of the Departments of Interior, Defense, Transportation, and Energy and the USEPA are important determi-

nants of land and water use practices in the study area through their direct regulation and permit authority.

The Bureau of Land Management (BLM) in the Department of the Interior controls the disposal, protection, and usage of unappropriated Federal lands. BLM responsibilities include fire protection; permits for rights-of-way across Federal lands; Outer Continental Shelf petroleum and natural gas lease sales; and sales of timber, natural gas, coal, grazing rights, and other materials and rights from the lands under BLM control.

The US Fish and Wildlife Service controls the use of land, water, and other resources on Federal wildlife refuges. The Service has review authority for proposed major Federal activities, plays a major role in determining recreational and subsistence use of marine birds and mammals, and also participates in Coastal Zone Management and Coastal Energy Impact Planning. Within and adjacent to the study area, the Service controls the Tuxedni National Wildlife Refuge and the Kenai National Moose Range.

The US Department of Interior (USDI), through the National Park Service, controls the use of National Parks, Monuments, Wild and Scenic Rivers, and other specified Federal lands. This includes control of the Katmai National Monument adjacent to the study area.

The US Department of Defense, through the COE, controls activities in wetlands and navigable waters, and ocean disposal of dredged material. The Rivers and Harbors Act of 1899 empowers the Corps to regulate construction activities in and over the navigable waters of the United States. Section 404 of the FWPCA gives the COE the authority to issue permits for placement of fill material and dredged material into wetlands and most waters of the United States. Section 103 of the Marine Protection Research and Sanctuaries Act of 1972 gives the COE permit authority over the open-ocean dumping of dredged materials.

The US Department of Transportation issues permits for structures carrying materials over navigable waters and for waterfront facilities handling hazardous materials. The Farmers Home Administration and other Federal mortagage and loan assurance programs affect land use by denying loans or other services for homes in areas not meeting specifications.

The Joint Federal-State Land Use Planning Commission was formed under Section 17 of the Alaska Native Claims Settlement Act to inventory the resources that determine potential land values and to make recommendations concerning the disposition and use of Alaskan lands. The Commission was instrumental in developing present Alaska State land-use policy, and the inventories developed by the Resource Planning Team of the Commission are important planning tools.

3.3.6.2. State

Land and water use planning by the State of Alaska and Alaska State permits directly affecting land and water use, are controlled primarily by the Department of Natural Resources (DNR) and the Alaska Department of Environmental Conservation (ADEC). The Alaska Division of Lands (ADL) of the DNR is responsible for classifying, managing, and disposing of State

land through implementation of the Land Policy Act (Chapter 181, SLA 1978). The Land Policy Act is the principal implementing legislation for the State constitutional mandate to encourage the settlement of State lands and the development of resources by making them available for maximum use and development consistent with the public interest. The Act specifies that a balanced combination of land should be made available for both private and public use, and that:

> In allocating land for private use and public retention, the requirements of future generations shall be considered. To this end, a supply of State land of a variety of types and locations shall be reserved to provide an opportunity for future decisions.

The Act requires that year-round settlement be guided to areas where there is an existing or potential economic base, or where public services exist or can be extended economically; that public open space and access to resources be provided; and that State land beyond the range of existing public services and sources of employment be made available for recreational use or low-density settlement.

The Act lists the following uses for which lands should be retained in public ownership:

- To make them available on a sustained-yield basis for a variety of beneficial uses, including subsistence, energy development, aquaculture, forestry, grazing, sport hunting and fishing, hiking, snowmobiling, skiing, and other activities of a type that can be made available to more people and conducted more successfully if the land is in public rather than private ownership

- To facilitate mining and mineral leasing

- To protect critical wildlife habitats and areas of special scenic, recreational, scientific, or other environmental concern

- To guide the location of settlement and development to minimize public cost and maximize social and economic benefits.

Implementation of the Act is through inventory of State lands, waters, resources and hazards; development of a land management plan through agency and public participation; and classification of the land into sixteen categories, eight for retention and eight for disposal. The eight retention categories are:

- Watershed

- Public recreation

- Reserved use

- Grazing

- Material
- Mineral
- Timber
- Resource management.

The disposal categories are:

- Homesite
- Agricultural
- Commercial
- Industrial
- Private recreation
- Residential
- Utility
- Open to entry.

If the Beirne Initiative were to be instituted, land disposal, easement rulings, and identification of lands to be retained as State-interest lands would be accomplished by the ADL. The ADL is in the process of developing a regional land-use plan for the Kenai Peninsula and held public meetings during January 1979 to receive public comments. In the announcement of the meeting (Anonymous 1978e) the ADL noted that there were many potential issues and listed four examples: community expansion, public recreation, protection of valuable resources, and environmental concerns. In the same announcement, the ADL listed ten steps in the regional planning process: information assemblage, resource inventory, regional analysis, land-use plan, classification recommendation, and plan approval, plus four public meetings during the process.

The ADL also issues water use permits, and the Alaska Department of Natural Resources issues special use permits for coal deposit development, petroleum and natural gas leases, and tideland uses. Through the Alaska Department of Fish and Game, the DNR controls the recreational, subsistence, and commercial harvest of Alaska fish and wildlife, and restricts the usage of designated critical habitats and anadromous fish streams. Through the Division of Parks the DNR controls the usage of State parks; plans new parks, waysides, and recreation areas; and recommends archaeological sites for protection under State or Federal statutes.

The ADEC may directly and indirectly affect land use through permitting, assistance, and review programs. The ADEC issues permits for solid waste disposal sites, wastewater discharge, open burning, and emissions to the atmosphere.

3.3.6.3. Borough

Land-use planning at the borough level primarily is the responsibility of the Kenai Peninsula Borough Planning Commission. The Planning Commission inventories the resources, compiles demographic and economic data, and presents land-use planning programs to the Borough assembly for consideration. The Planning Commission also represents the interests of the Borough in Coastal Zone Management and Coastal Energy Impact Plan studies. The planning commission has presented zoning and land-use plans to the Borough assembly, but few land-use regulations have been adopted thus far, and enforcement of existing Borough regulations has been difficult. Zoning and land-use planning are difficult to implement because the majority of the populace is unwilling to accept controls over their individual freedom. Friedmann (1973), in his discussion of urban fields, explained that people moved from the cities into the surrounding countryside or suburbs to achieve more control over their environment. Borough residents have become accustomed to exercising options in land use that would not be available to them in most of the United States, and the privilege of exercising these options is, for many, a strong incentive to live in rural Alaska.

3.3.6.4. Local

At the local level, Kenai, Soldotna, Homer, and Seldovia have Advisory Planning Commissions, or committees appointed by those cities as needed to develop zoning, land-use, water-use, sewage, or other plans for their areas. The plans are submitted to the city council or the voting public for consideration. Plan approval by the Kenai Borough Planning Commission and/or the Borough assembly also may be required for implementation.

3.3.6.5. Ex officio

Large tracts of land in some parts of the study area are or will be owned and controlled by regional or village Native corporations. Corporation policy is a major factor in the determination of the use of these lands. Native corporation policies usually stress the preservation of Native life-styles and subsistence and the distribution of accrued profits to the corporate shareholders (Arnold 1976).

3.4. Socioeconomic Environment

3.4.1. Sensitivity indicators and constraints

The socioeconomic profile contains the economic and social characteristics that may be used as indicators of the sensitivity or insensitivity of the study area to changes that may occur in the level of economic activity. Because the profile also includes the numbers that reflect these characteristics, it provides a basis for comparing the status quo with expected future changes in the social and economic characteristics.

The sensitivity of an area to changes in economic activity is reflected by four types of constraints: one physical, two financial,

and one psychological. An area is sensitive to physical constraints if potential growth is limited by the availability of water, land, or other physical resources necessary for that growth. For example, an aquifer may be incapable of supplying the demand for water implied by the projected population and its per capita consumption. The aquifer thus sets an upper limit on growth, in the absence of other constraints, unless an additional source of water is obtained. In this case, the area is sensitive to physical limits to the projected population growth. This physical constraint may be removed by financial outlays that yield a supplementary or alternative source of water.

An area is financially sensitive in the first sense if the costs of overcoming the physical constraint (or of providing the infrastructure as a whole) are so great that the revenues required to defray the costs can be obtained neither from the profits to be derived from the sectors of economic activity causing the growth nor from outside sources. It is financially sensitive in the second sense if the revenues are obtainable, but the time period of their availability does not coincide with the needs of the area. In this case, an area may need to gear up, for example, by seeking front-end monies from the industrial sectors or from outside short-term loans. The need to gear up, and the extent to which it is required, may cause social strains indicative of sensitivity.

The fourth sense in which an area may be regarded as sensitive is the psychological sense. For example, even if a community is convinced that there are no physical contraints and that the area can financially afford the projected growth, the community may decide against permitting the growth because in their view it would disrupt a preferred life-style. Some data available on this issue for parts of the study area are summarized in Subarea profiles.

3.4.2. Economic bases

Basic industries are industries that produce goods for export from an area or that bring money into an area from outside. The spending and respending of those imported dollars supports the local trade and service sectors of the economy. The most important basic industries in the study area are the extraction and treatment of petroleum and natural gas and the associated petrochemical industries, fisheries, and fish processing, and tourism. Most agricultural and lumbering products are used locally; few export dollars are derived from these industries.

The 1976 nonagricultural wage and salary employment data for the Kenai-Cook Inlet Division, which is contained largely within the study area, is listed in Table 13. The agricultural wage and salary data do not include dollars paid to fishermen, farmers, or independent loggers. Commercial fishermen constituted an additional 9 percent of the 1976 labor force and were paid $22 million for catches landed at ports in the study area and at Seward. Forestry and farming employed comparatively few full-time workers and were primarily of local importance. Data on the number of workers in each employment sector in 1977 and 1978 are presented in Table 14.

Table 13. Payrolls for nonagricultural wage and salary employment[1] in the Kenai-Cook Inlet Census Division, 1976 (Alaska Department of Labor 1976).

Employment Sector	Payroll $1,000	(1976) Average No. of Personnel Employed	Percent of Total Payroll	Percent of Total Employment
Mining	23,272	741	17.2	11.0
Construction	30,524	1,057	22.6	16.3
Food Processing	4,023	445	3.0	6.9
Petroleum and Natural Gas Manufacturing	1,599	70	1.2	1.1
Total Manufacturing	12,030	960	8.9	14.8
Transportation, Communication, and Public Utilities	15,236	549	11.3	8.5
Wholesale Trade	5,843	221	4.3	3.4
Retail Trade	7,534	727	5.6	11.2
Finance, Insurance, and Real Estate	1,860	157	1.4	2.4
Services	12,283	774	9.1	12.0
Miscellaneous	2,229	103	1.6	1.6
Federal Government	1,483	83	1.1	1.3
State and Local Government	17,240	1,093	12.8	16.9
Total	135,116	6,465		

[1]Most, but not all, wage and salary employment is covered by these statistics.

Table 14. Nonagricultural wage and salary employment in the Kenai-Cook Inlet Census Division, 1977 and 1978.

Employment Sector	Number of Workers 1977	1978[1]
Mining	721	806
Construction	1,808	464
Total Manufacturing	1,015	986
Transportation, Communication, and Public Utilities	652	574
Wholesale Trade	220	238
Retail Trade	833	970
Finance, Insurance, and Real Estate	186	195
Services	823	840
Miscellaneous	Not Available	51
Federal Government	77	88
State and Local Government	1,140	1,321
	7,332	6,526

[1]Data for the last 3 months of 1978 are estimates. (By telephone, Mr. Neil Fried, Alaska Department of Labor, to Mr. Guy McConnell, WAPORA, Inc., 16 March 1979).

3.4.2.1. Petroleum and natural gas

Petroleum has been an important natural resource since the discovery of the Swanson River field in 1957. Most of the petroleum and natural gas produced in the Kenai Peninsula Borough is extracted from wells located north of the Forelands or on Federal lands outside the study area. The majority of the construction and operating personnel for these wells reside in the study area. Petroleum and natural gas fields in the Kenai-Cook Inlet region are listed in Table 15. Production figures are given in Table 16. Natural gas and petroleum are cleaned and shipped out or are refined or used as feedstocks for petrochemical manufacture. The main terminal for unrefined crude oil is the Drift River Terminal on the western shore of Cook Inlet. The petrochemical and refining industries in the study area are located north of Kenai, where Standard Oil and Tesoro operate refineries, Phillips-Marathon operates natural gas liquefaction plants, and Union Oil operates the Collier Ammonia and Urea plant. An additional major natural gas liquefaction plant is planned for the area by Pacific-Alaska LNG Associates.

Development of the natural gas and petroleum fields has been of major importance for industrial expansion and community development in the study area since 1957, and the industry is still a major basic industry in 1979. Almost all of the mining sector workers (Table 13) and important segments of the manufacturing, construction, transportation, and communication sector labor forces are employed in basic industries supported by the petroleum and natural gas industry. During 1976, the petroleum and natural gas industry was estimated to have provided approximately 15 percent of the nonagricultural employment of the Kenai-Cook Inlet census division (CH_2M Hill, Inc. 1978a).

3.4.2.2. Fisheries

In addition to fishermen, who are not represented in the nonagricultural wage and salary statistics, the fishing industry in the Kenai Borough employs virtually all of the personnel in the food processing industry and workers from the construction, manufacturing, and transportation industries. CH_2M Hill, Inc. (1978a) estimated that 15 percent of the Kenai Peninsula labor force was involved in fisheries or fish processing. Petroleum extraction is the primary basic industry in Subarea I, but fisheries and tourism are more important in the remainder of the study area. Most of the catch indicated previously in Table 9 for the four regulatory districts in the study area (the Central, Southern, and Kamishak Bay Districts and a small portion of the Outer District) is taken by fishing boats based in the study area and is processed in the study area. In addition, fishermen from the study area fish the Northern, Barren Island, Outer, and Eastern Districts and the surrounding regions (Figure 22). Some of the catch from these areas also is processed in the study area. Fishermen from Homer regularly fish as far north as the Forelands, around Kodiak Island, and in Prince William Sound, and may sell to processors in Kodiak, Anchorage, or Seward, or on the Kenai Peninsula.

Table 15. Petroleum and gas fields in the Kenai-Cook Inlet region (US Army Corps of Engineers 1978).

Field	Type	Location	Date of Discovery of Well	
Swanson River	Oil and Gas	Onshore	August	1957
Kenai	Gas	Onshore	October	1959
West Fork	Gas	Onshore	September	1960
Falls Creek	Gas	Tidelands	May	1961
Sterling	Gas	Onshore	August	1961
West Foreland	Gas	Onshore	April	1962
Middle Ground Shoal	Oil	Offshore	June	1962
North Cook Inlet	Gas	Offshore	September	1962
Beluga River	Gas	Onshore	December	1962
North Middle Ground Shoal	Gas	Offshore	November	1964
Trading Bay	Oil	Offshore	June	1965
Birch Hill	Gas	Onshore	June	1965
Granite Point	Oil	Offshore	June	1965
McArthur River	Oil and Gas	Offshore	October	1965
Moquawkie	Gas	Onshore	November	1965
North Fork	Gas	Onshore	December	1965
Nicolai Creek	Gas	Onshore	May	1966
Ivan River	Gas	Onshore	October	1966
Beaver Creek	Gas	Onshore	February	1967
Albert Kaloa	Gas	Onshore	January	1968
Redoubt Shoal	Oil	Offshore	September	1968

Table 16. Crude oil and gas production, Kenai-Cook Inlet, 1959 to 1976 (Alaska Department of Natural Resources n.d.).

Year	Crude Oil (1,000 bbl)	Gas ($ft^3 x10^6$)
1959	187	--
1960	578	137
1961	6,327	1,508
1962	10,259	3,556
1963	10,740	10,810
1964	11,054	11,865
1965	11,131	12,155
1966	14,365	41,218
1967	28,914	62,425
1968	66,143	99,849
1969	74,039	148,150
1970	82,414	216,620
1971	77,628	227,903
1972	72,638	222,789
1973	72,196	223,101
1974	70,098	228,528
1975	69,111	250,765
1976	62,404	264,762

The economic benefits from the commercial fisheries are difficult to determine. Fish may be caught in one area and processed in a second, and the boat may be based in a third area and crewed by personnel from a fourth. Further, harvest data for halibut and other important commercial fish in the study area are reported by major region. The Cook Inlet catch is included in the Gulf of Alaska total catch. Most fish caught are reported by weight, but salmon are reported by pound and total weights sold are difficult to obtain. Prices vary during the season and from processor to processor, and frequently are not reported on the fish tickets. The State of Alaska is approximately 3 years behind with fisheries economic data. Harvest totals and prices paid have increased so rapidly that three-year-old data are inadequate.

A rough estimate of commercial fisheries sales value to the fishermen is presented in Table 17. Wholesale prices typically are approximately double those paid to the fishermen. Data for Table 17 were obtained from the Alaska Department of Fish and Game (By telephone, Mr. Tom Schroeder and Ms. Nancy Frieze, to Mr. Guy McConnell, WAPORA, Inc., 13 and 14 March 1979). Salmon numbers were converted to weight by the following factors:

King salmon	1 = 32 lbs
Coho (silver) salmon	1 = 8 lbs
Chum salmon	1 = 8 lbs
Red (sockeye) salmon	1 = 7 lbs
Pink salmon	1 = 4 lbs

The conversion factors were provided by the Alaska Department of Fish and Game (By telephone, Ms. Nancy Freize to Guy McConnell, WAPORA, Inc., 14 March 1979) and are for Susitna River salmon populations. Susitna River salmon may be smaller than salmon from other runs, so the data were compared with average weights from Lower Cook Inlet catches for 1977 provided by a small processor (Personal communication, Dr. Lee Reid, formerly of Saguya Foods, to Mr. Guy McConnell, WAPORA, Inc., 14 March 1979). Red salmon processed by Saguya averaged approximately 1-pound heavier and chum salmon averaged approximately 1-pound lighter, than the weights obtained by using the Alaska Department of Fish and Game conversion factors. The weights of other salmon were approximately the same. Where a number of different prices was paid, the average price was used to calculate catch value.

Salmon, particularly red salmon, are the mainstay of the commercial catch, and that the Cook Inlet was the source of most of the catch (Table 17). The commercial fishery is seasonal, with the main effort occuring during the period from June through August. Employment also is seasonal. The peak summer employment by fish processors usually is about 2.5 times the yearly average. A comparison of the 1978 fisheries value and wages paid to processing plant workers (Table 13) with wages paid to mining sector workers indicates that within the study area commercial fishing, as a basic industry, is at least as important as the petroleum extraction/manufacturing industry in dollars paid to the community. It also employs a larger segment of the population.

The Cook Inlet commercial fishery has grown as salmon returns in-

Table 17. Estimated commercial catch value, Cook Inlet-Resurrection Bay Regulatory District, 1978. A single asterisk (*) indicates an estimated figure; a double asterisk (**) indicates that data are not available for the study area alone.

	Pounds Caught			Value of Catch ($)	
Species	Study Area	Region	Price Per Pound ($)	Study Area	Total Region
King Salmon	572,000*	614,880*	1.00-1.10	600,600	645,624
Red (Sockeye) Salmon	18,851,273*	19,388,257*	0.85-1.35	20,736,400	21,327,082
Coho (Silver) Salmon	1,419,768	1,818,976	0.70-1.35	1,455,262	1,864,450
Pink Salmon	6,272,652	8,040,484	0.35	2,195,428	2,814,169
Chum Salmon	4,654,968	5,128,712	0.61-0.80	3,281,752	3,615,748
Total Salmon	31,770,661	34,991,309		$28,269,442	$30,267,073
King Crab	1,215,572	1,215,572	1.23-1.77	1,823,358	1,823,358
Tanner Crab	3,176,606	3,664,966	0.55	1,763,016	2,034,056
Dungeness Crab	1,041,376	1,041,376	0.66-0.75	728,963	728,963
Trawl Shrimp	4,123,802	4,124,442	0.16	680,427	680,532
Pot Shrimp	249,558	257,988	0.70-0.75	180,929	187,041
Razor Clam	**	45,931	0.75-1.00	49,189	40,189
Herring		926,000**	0.35-0.40		317,250
Total				$33,486,324	$36,078,462

creased and the shellfish industry expanded. The next major expansion may be in the bottomfish industry. Exploitation of that resource, however, will require commitments of more capital for boats and processing facilities than is required for salmon and shellfish harvest and processing. The price offered for bottomfish during March 1979 (approximately 6.5 cents per pound) probably is not enough to attract development capital without some form of government protection or subsidy. Implementation of the 200-mile limit and the economic limitations that may be placed on foreign fishermen and processors may alter the potential profitability of a bottomfishing operation sufficently to encourage development of the industry. Should this occur, the City of Kenai and the Kachemak Bay area would be potential industry sites.

3.4.2.3. Agriculture

The entire 1974 production of agricultural products from the Kenai Peninsula was valued at $521,000 (US Forest Service 1975). Most of that production was consumed domestically. Thirty-one farms sold more than $1,000 of produce, and the total farm sales (crops and livestock) was $121,400. Between 1960 and 1975 the most important commercial crops were grasses, oats, barley, mixed grains, and truck garden crops. Livestock production in 1975 totaled 860 cattle, 20 hogs, and 300 chickens. Farming in the study area is primarily conducted in Subareas I, II, and III. The State of Alaska is encouraging the expansion of agriculture with a continuing program of agricultural land sales and grazing leases. The generally poor soil and high cost of farming in this area, however, probably will preclude agriculture from becoming a major economic factor in the near term.

3.4.2.4. Forestry

Lumbering in the study area is divided between the cutting of cants for the Japanese market and the production of rough lumber and turned logs for the local construction industry. Export lumbering is centered in Jakalof Bay on the lower tip of the Kenai Peninsula. Additional logging operations are planned for the Port Chatham area. There is a chipping mill at Tyonek, north of the study area, although it is not in operation at present. A similar mill may be feasible for the study area when land ownership finally is determined.

3.4.2.5. Tourism

Data are not available on the economic importance of this sector for the study area, its subareas, or its cities. Between 1964 and 1967, wages from tourism grew faster in Alaska than wages from all other sectors except oil and gas. During that period, the number of tourists increased by 46 percent, tourist expenditures increased by 69 percent, and wages in the tourism sector rose by 65 percent. In 1970, the number of out-of-state tourists visiting Alaska was projected to increase from a base figure of 86,700 in 1967 to 185,500 in 1975, to 233,700 in 1980, and to 600,000 by the year 2000. The Borough, the Kenai-Cook Inlet Census District, and by inference, the study area and its subareas and cities, have shared and will share in this growth.

One study estimates that 350,000 tourists visited the Kenai Peninsula in 1973, spending half their time on the Kenai National Moose Range and half elsewhere. Their gross expenditure was $31.5 million, of which $11 million was spent in the Borough. Using a multiplier of 1.4 times tourism expenditures (direct and indirect) in the Borough, the 1973 gross expenditures amounted to $15.4 million. This figure constitutes just over 30 percent of the gross sales and services receipts in the Borough in 1972, which totaled $50.4 million. Of the $15.4 million, half is attributed to expenditures by tourists visiting the Kenai National Moose Range, which is easily accessible from the Seward Highway both inside and outside of the study area. Given the small size of the communities east of the study area and the fact that in 1970 Seward (the only city outside the study area) had only 25 percent of the population of the study area's cities, it is not unreasonable to assume that the bulk of the $15.4 million was spent within the study area. The expenditures most likely were concentrated within three cities (Kenai, Homer, and Soldotna). Seldovia is excluded because it cannot be reached by road.

Tourist expenditures in the Borough are projected to increase from $15.4 million in 1973 to $113.4 million in the year 2000. This projection is based solely on a projected increase in the number of tourists (from 350,000 to 2.6 million). No allowance has been made for an increase in the number of recreation days, or in expenditures per recreation day.

As regards sport fishing, it has been estimated that $52 million was spent in the State in 1973, with 29 percent of the sport fishing effort taking place in the Kenai Peninsula, which is wholly within the Borough. If the gross assumption is made that the geographical distribution of expenditures is the same as that of the effort, a direct expenditure in the Borough of $15 million (0.29 x $52 million) occurred from sport fishing. This is more than the $11 million estimated earlier for all recreation, including sport fishing. There are insufficient data to reconcile these figures. It is likely that most of the fishing tackle and camping supplies used by tourists in the Kenai Peninsula were purchased in other areas, especially in Anchorage.

In summary, tourism, including recreational hunting and fishing, is a major basic industry in the study area, but the data are insufficient to identify the value of the industry to the various job sectors and other aspects of the economy. Because the population of Anchorage (a major source of tourists to the Kenai Peninsula) has increased rapidly since 1973 and other tourism also has increased, the 1973 data base is not current and is inadequate to evaluate the importance of tourism to the economy.

3.4.3. Demography

3.4.3.1. Census results

Population estimates for the Kenai Peninsula Borough are available from three sources: the 1970 population census, a 1977 special census of cities in the Kenai Peninsula and of the entire Kenai Peninsula Borough, and a special census conducted during the summer of 1978 by the US Census

Bureau. The results are difficult to compare because the enumeration divisions differed. The 1970 census was conducted by census district; the 1977 census was conducted for the Borough as a whole and the individual cities; and the 1978 special census was conducted by voting precinct. The 1970 census districts are indicated in Figure 23 (adapted from US Bureau of the Census 1973). The data from the 1978 special census are presented in Table 19.

The Kenai-Cook Inlet Census Division has 27 enumeration districts as shown in Table 18. In 1970 the Division had a permanent population of 14,250. Of this total, 7,902 persons were in 20 districts that are wholly within the study area, and 6,086 were in six districts that are partially within the study area. Thus only one district, Tyonek (population 232), is entirely outside the study area. The bulk of the population of the three most populous districts that are partly within the study area can safely be estimated to be in the study area. In 08 (East Foreland, etc.), Number Three Bay and Point Possession populations are small; in 09 (Kalifonsky, etc.), the population around Skilak and Tustumena Lakes is small relative to that along the Kalifonsky Beach; and in 19 (Diamond Ridge), settlement tends to be linked to the population nodes within the study area, rather than scattered throughout the district. Based on our knowledge of the area, we would estimate that at least 75 percent of the population of these three districts was within the study area in 1970. This constitutes an additional 4,499 (0.75 x the total population of 5,998). The 1970 total of 12,401 (7,902 x 4,499) is 87 percent of the total population of the Kenai-Cook Inlet Census Division (14,250) and 75 percent of the total population of the Kenai Peninsula Borough (16,586) in 1970.

Because the census districts do not coincide with the study area boundaries, the exact population of the study area in 1978 is not known. However, it can be assumed that the study area contains most of the population of the Kenai Peninsula Borough. The 26 precincts censused in 1978, which contained a total population of 25,281 are listed in Table 19. Fifteen of these precincts, with a combined population of 17,395, or 68.8 percent of the total Borough population, are entirely within the study area. Five of the remaining eleven precincts, including Sterling (population 1,408), are partly within the study area. The population of the Sterling precinct is distributed along the Sterling Highway and the Kenai River. Observations from aircraft and automobiles suggest that half of the Sterling precinct population, or 704 individuals, is within the study area. Nikiski 2 (population 2,010) extends across the northern boundaries of the study area, but should be considered a functional part of the study area. It is contiguous with the North Kenai population center, and essentially all government and services for Nikiski 2 come from the study area. Road access also is through the study area. The population of the Port Graham precinct is centered in Port Graham and Portlock, with a logging camp at Koyuktolik Bay and cabins at Chrome Bay. Perhaps 200 of the 230 persons censused in the Port Graham District live within the study area. Judged by observation from aircraft and automobile, more than two-thirds of the population of the Tustumena District, or 582 persons, is in the study area -- in Kasilof, Cohoe, and Clam Gulch, and along the Sterling Highway. The Tyonek District population is largely in Old Tyonek and New Tyonek, north of the study area.

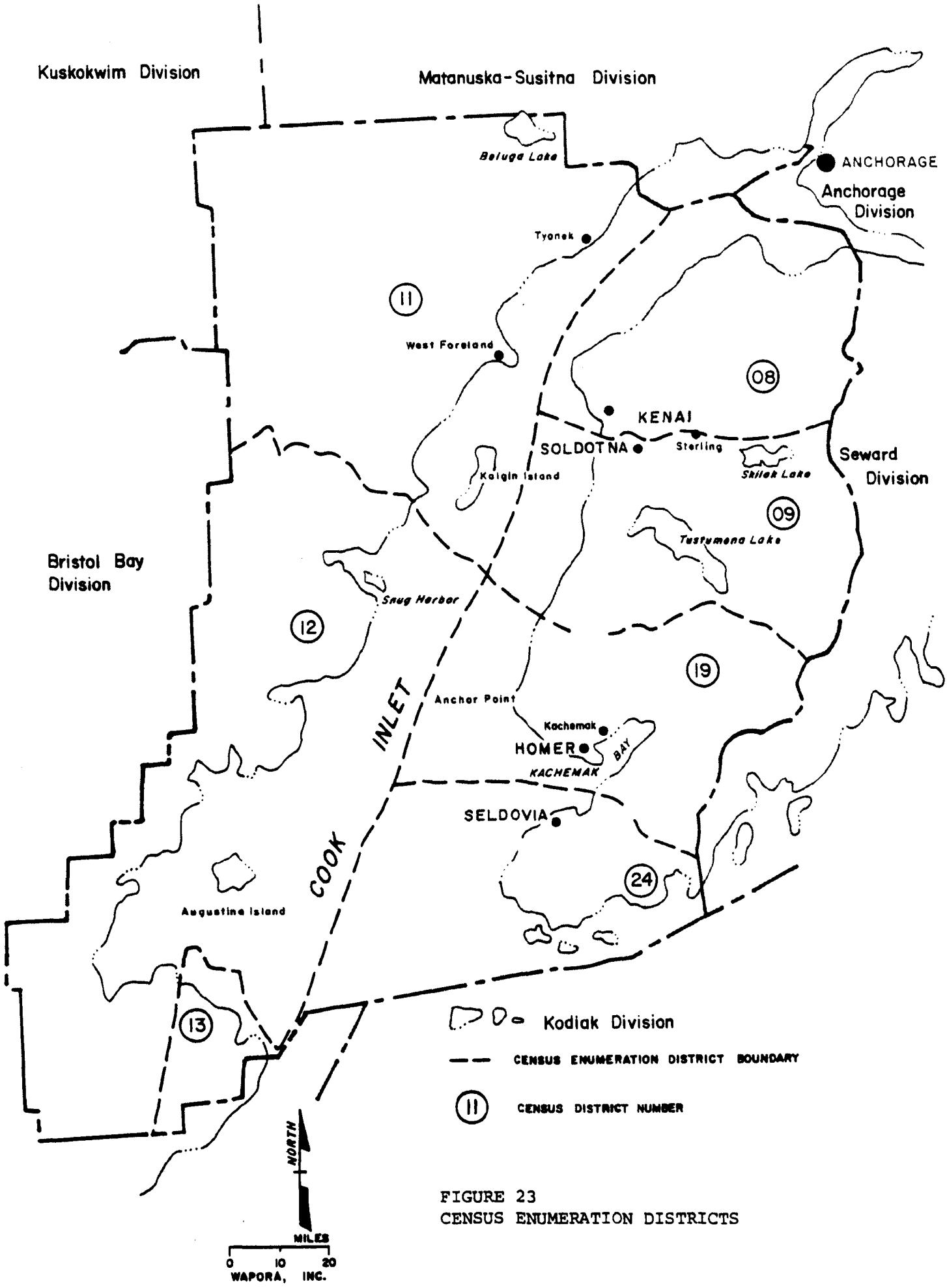


FIGURE 23
CENSUS ENUMERATION DISTRICTS

Table 18. Census data for Kenai Peninsula Borough, Kenai-Cook Inlet Census Division, study area, and Enumeration Districts, 1970 and 1977 (US Bureau of the Census 1973; By telephone, Mr. Neil Fried, Alaska Department of Labor, to Mr. Guy McConnell, WAPORA, Inc., 16 March 1979).

Unit	1970	1977
Kenai: Peninsula Borough	16,586	24,611
Kenai-Cook Inlet Census Division	14,250	
Study Area	12,401*	19,689*
Enumeration Districts		
01 Sterling	30	
02 Kenai	3,533	5,634
03 Soldotna	1,202	2,586
04 Cohoe	8	
05 Kasilof	71	
06 Clam Gulch	47	
07 Ninilchik	134	
08 East Foreland, etc.**	2,997	
09 Kalifonsky, etc.**	2,160	
10 Tyonek**	232	
11 Beluga Lake, etc.**	33	
12 Iniskin, etc.	5	
13 Katmai National Monument**	0	
14 Fritz Creek	27	
15 Anchor Point	102	
16 Homer	1,083	1,802
17 Kachemak	76	280
18 Halibut Cove	44	
19 Diamond Ridge	841	
20 Jakalof Bay	23	
21 Seldovia	437	
22 Port Graham	107	612
23 English Bay	58	
24 Chugach Islands, etc.**	55	
25 Wildwood Air Force Reservation	750	
9900 East Foreland Waters	67	
9901 Kachemak Bay	128	

*Estimate, derived by WAPORA, Inc.

**Wholly or partly outside the study area.

Table 19. Kenai Peninsula Borough special census results, 1978.

Precinct	Population
Anchor Point	1,447
Bear Creek	687
Cooper Landing*	238
Diamond Ridge	433
English Bay	110
Fritz Creek	872
Halibut Cove	85
Homer	2,055
Hope*	92
Kalifonski	1,701
Kenai 1	1,728
Kenai 2	1,779
Kenai 3	864
Moose Pass*	268
Nikiski 1	1,479
Nikiski 2**	2,010
Ninilchik	468
Port Graham**	230
Ridgeway	1,472
Seldovia	582
Seward 1*	606
Seward 2*	1,150
Soldotna	2,365
Sterling**	1,408
Tustumena**	881
Tyonek**	311
	25,281

*Wholly outside the study area.

**Partially outside the study area.

There are a few Tyonek Precinct residences along the West Foreland, near Polly Creek, on Chisik Island, and scattered along the western Cook Inlet coastline. These probably contain fewer than 50 people.

The total of the above estimates for the five precincts is 3,546. This figure, added to the 17,395 population figure for the other fifteen precincts, yields an estimated population of 20,941. Thus, approximately 83 percent of the Kenai Peninsula Borough population is within the study area.

Population data for the four cities in the study area are listed below:

	1970	1977	1978
Kenai	3,533	5,364	4,371
Soldotna	1,202	2,586	2,365
Homer	1,083	1,802	2,055
Seldovia	437	612	582
Total	6,255	10,364	9,373

The 1977 figures were estimates produced by the municipalities and, in light of the 1978 census data, probably were optimistic for Kenai, Soldotna, and Seldovia.

3.4.3.2. Population trends

Assuming that the population of the study area was 12,401 in 1970 and 20,941 in 1978, the population has increased by 8,539 (approximately 70 percent) in 8 years. During those 8 years the population of Kenai increased by 24 percent, that of Soldotna by 97 percent, that of Homer by 90 percent, and that of Seldovia by 33 percent. Homer and Soldotna almost doubled in population, whereas Kenai and Seldovia grew at a much slower rate.

The populations of the four cities combined grew from 6,255 to 9,373, an increase of approximately 50 percent. The combined growth of the cities, and in particular the growth of Kenai and Seldovia, did not keep pace with the remainder of the study area. The difference between the 1970 and 1978 enumeration districts makes comparison of the data difficult, but some growth trends are apparent. Sterling and Soldotna have grown more rapidly than the norm. The Port Graham precinct and the Seldovia precinct of the 1978 census approximate the Jakalof Bay, Seldovia, Port Graham, and Chugach Islands district of 1970. The population in those districts increased from 680 to 812, a 19 percent increase. The Halibut Cove, Fritz Creek, Diamond Ridge, Anchor Point, Homer, and Ninilchik precincts of 1978 are roughly equivalent to the similarly-named census districts of 1970. In these districts the total population has increased from 2,435 to 5,360, a 120-percent increase. Excluding Homer, the population increased from 1,352 to 3,305, a 144-percent increase.

The northern half of the Kenai-Cook Inlet Census Division roughly corresponds to the ten northern precincts used in the 1978 census. Both

the northern census districts and precincts are indicated in the following list:

Districts	Precincts
Sterling	Tustumena
Kenai	Kalifonsky
Soldotna	Ridgeway
Cohoe	Kenai I
Kasilof	Kenai II
Clam Gulch	Kenai III
East Forelands	Soldotna
Kalifonsky	Nikiski I
Wildwood Air Force Reservation	Nikiski II
East Foreland Waters	Sterling

In the northern districts the population increased approximately 44 percent, from 10,865 to 15,635. Of the 4,770 population increase, Kenai increased by 838, and Soldotna by 1,163 (total -- 2,001). This urban increase amounted to a 45-percent expansion of the population. The remaining population increase of 2,769 occurred outside the cities.

In summary, the population of the study area comprised an estimated 83 percent of the Borough in 1978. Almost the entire study area population is on the Kenai Peninsula. Populations on the west side of the Inlet are sparse. The population of the study area has increased by approximately 70 percent since the 1970 census. Homer, Soldotna, and the area around Homer received disproportionately large percentages of the increase. Populations in Kenai and Seldovia increased at a slower rate that the norm. Populations in the study area on the northern half of the Kenai Peninsula increased by approximately 45 percent, a rate intermediate between Kenai and Seldovia at one extreme and Soldotna and the Homer area at the other.

3.4.3.3. Population projections

The most recent population projections for the Lower Cook Inlet region have included the projected development that would accompany the construction and operation of the planned Pacific-Alaska Associates natural gas liquefaction (LNG) plant near Kenai and the petrochemical complex that Alpetco had considered it might build on the Wildwood Reservation north of Kenai. The LNG plant construction has been delayed by objections to the planned receiving facilities in California, and Valdez (pending EIS preparation and approval) has been selected for the Alpetco site. The delay of the LNG plant will move the potential impacts on the population at least one year into the future. The decision not to build the Alpetco plant at Wildwood removes the potential impact of a population increase of approximately 3,150 at the peak of construction and operation in 1982. Although the projections for both facilities are based on obsolete data, they are presented in the tables and narrative that follow because they are useful indicators of the population shift that could be expected to accompany future projects of similar scope.

Base case

Base-case population projections for the Kenai Peninsula Borough,

the study area, and the part of the Borough that is outside the study area are presented in Table 20. The projections assume that the annual rates of growth experienced by the cities and unincorporated areas over the period 1970 to 1977 will continue over the period 1977 to 1992. For this base case only, the population of the study area is projected to double between 1977 (19,689) and 1988 (40,624). Its share of the population of the Borough is projected to increase over that period from 80 percent (19,689 to 24,611) to 85 percent (40,624 to 47,882).

Within the study area, the total population of the incorporated areas is projected to grow at a slightly faster rate than that of the unincorporated areas. The projections are based in part on the 1977 population estimates given in Table 22, which have been shown to be in error. The projections may be high for the cities and low for the unincorporated areas.

Other cases

Four sets of population projections for the Kenai Peninsula Borough are compared in Table 21:

- Base case -- the projected population increase without the Lower Cook Inlet lease sale (the Outer Continental Shelf development), as shown in Table 20.

- Outer Continental Shelf (OCS) case -- the population increment resulting from the lease sale. Three ranges of estimates are given, which reflect different assumptions as to the level of development expected from the sale (a low scenario, a medium scenario, and a high scenario). The medium and high scenarios each contain two sets of alternative compositions and percentages of worker residency within the Borough

- Alpetco -- the population increment above the base case and various OCS case totals that are associated with the Alpetco refinery and petrochemical complex

- Pacific-Alaska Associates (P-A) -- the population increment above the base case and various OCS case totals that are associated with the Pacific-Alaska LNG facility.

The first year for which projections are contained in the sources is 1979; the last is 1992. The other years are selected from the sources to show the peak population levels estimated.

The base-case population of the Borough is expected to increase approximately 89 percent, from 25,281 to 47,882, between 1978 and 1988. By 1992, the population is expected to reach 61,487, a 143-percent increase over the 1978 figure.

The additional population projected for the Borough by 1988 from the Lower Cook Inlet Lease Sale ranges from a low of 1,559 in the OCS medium scenario MI1 to a high of 8,685 in the OCS high scenario HX2. The additional population projected for the Borough by 1988 from the proposed

Table 20. Population projections for the Kenai Peninsula Borough and the study area (base case), 1977-1992 (CH_2M Hill, Inc., 1978a, except as noted).

	1977	1979	1980	1982	1986[a]	1987[n]	1988	1992
Kenai Peninsula Borough	24,611	27,703	29,320	33,183	42,326	45,068	47,882	61,487
Study area	19,689[j]	22,471	23,880	27,327	35,598	38,060	40,624	53,101
Incorporated areas	10,644	12,304	13,151	15,356	20,658	22,316	23,992	32,449
Subarea I[a]	7,950	9,260	9,915	11,690	15,960	17,315	18,670	25,605
Kenai[b]	5,364	6,168[n]	6,570	7,525	9,860	10,575	11,290	14,800
Soldotna[c]	2,586	3,092[n]	3,345	4,165	6,100	6,740	7,380	10,805
Subarea II, Homer and Kachemak[d]	2,082	2,384	2,551	2,921	3,828	4,096	4,382	5,744
Subarea IV, Seldovia[e]	612	660	685	745	870	905	940	1,100
Unincorporated areas[f,g,h]	9,045[k]	10,167	10,729	11,940	14,940	15,744	16,632	20,652
Kenai Borough outside study area[i]	4,922	5,232	5,440	5,856	6,728	7,008	7,258	8,386
Incorporated areas, Seward[f]	2,279[l]	2,513	2,639	2,910	3,537	3,714	3,900	4,741
Unincorporated areas[f,h]	2,644[m]	2,719	2,801	2.946	3,191	3,294	3,358	3,645

[a]Calculated by WAPORA, Inc.

[b]7% compound annual growth rate.

[c]10% compound annual growth rate.

[d]The 7% compound annual growth rate estimated by Hill for Homer is applied to the combined 1977 figure for Homer (1,802) and Kachemak (280).

[e]4% compound annual growth rate.

[f]5% compound annual growth rate.

[g]Assumed that this will rise from the 77% of the unincorporated areas total for the Borough in 1977 to 85% in 1992.

[h]Unincorporated areas in Borough as a whole are assumed to grow at the 5% compound annual rate used by Hill for unincorporated areas in central and southern Kenai Peninsula Borough.

[i]Assumed to fall from 23% of total unincorporated areas in the Borough in 1977 to 15% in 1992.

[j]Table 18.

[k]Study area minus incorporated areas in study area.

[l]Borough minus study area.

[m]Borough outside study area minus incorporated areas outside study area.

[n]Straight-line interpolation by WAPORA, Inc.

Table 21. Population projections for the Kenai Peninsula Borough (Alaska Department of Community and Regional Affairs 1977, unless otherwise noted).

Case	Employees Living In Borough	1978	1979	1980	1981	1982	1984	1986	1988	1990	1992
Base Case		25,218[a]	27,703[b]	29,320[b]	31,352[c]	33,183	36,767	42,326	47,882	49,128	61,487
OCS Low Case		0	148	80	0	0	0	0	0	0	0
MI1	20% PSB + C	0	271	451	265	722	915	1,881	1,559	1,356	1,156
MI2[a]	80% PSB + C	0	353	561	467	1,234	1,851	3,575	3,279	2,852	2,426
MX1	20% PSB	0	271	451	265	472	915	1,481	1,559	1,356	1,156
MX2	80% PSB	0	353	561	467	984	1,851	3,175	3,279	2,852	2,426
OCS High Case											
HI1	20% PSB + C	0	841	1,703	2,888	2,685	5,974	6,095	4,217	3,541	3,419
HI2[a]	80% PSB + C	0	979	1,980	3,764	4,470	10,650	11,550	8,685	7,241	7,005
HX1	20% PSB	0	641	903	1,388	1,985	4,174	5,095	4,217	3,541	3,419
HX2	80% PSB	0	1,062	1,180	2,264	3,773	8,850	10,547	8,685	7,241	7,007
Alpetco[a]	All Employees	0	0	0	1,260	3,150	600	1,200	1,200	1,200	1,200
Pacific-Alaska LNG[a]	All Employees	0	380	630	1,350	1,060	180	180	180	180	180

LEGEND: PSB = Platform and supply boat workers.
C = Construction workforce at terminals and LNG plant.

[a] CH_2M Hill, Inc. 1978a.

[b] Table 20.

[c] Straight-line interpolation from 1980 and 1982 figures by WAPORA, Inc.

projects combined is 1,380 (1,200 from Alpetco and 180 from Pacific-Alaska).

The total of the 1988 projections for the base case, the OCS high scenario (HX2, with 80 percent of the platform and supply-boat employees residing in the Borough), and the Alpetco and Alaska-Pacific LNG projects results in a population figure for the Borough of 57,947 (47,882 + 8,685 + 1,380). This constitutes a 135-percent increase, or 33,336 persons, between 1977 and 1988. By 1992, with the same OCS case, the population would have risen by 45,263 to 69,874, a 184-percent increase.

The detailed analysis underlying these numbers is contained in the sources cited. In brief, the base case assumes that the compound annual rates of growth experienced by the individual cities and by the unincorporated areas during the period 1970 to 1977 will continue through the period 1977 to 1992. The OCS case is based on four major components: the levels of development postulated in the three scenarios (millions of barrels of oil and millions of cubic feet of gas, per unit time); the direct and indirect employment associated with these levels; employment/population ratios; and allocation of population increments to the Borough's individual cities and its unincorporated areas. The Alpetco and the Pacific-Alaska LNG cases use the same methods as the OCS case, except that only one scenario (rather than three alternative scenarios) is postulated for each.

In addition, further population increases may be expected in the Borough when and if the bottom-fisheries industry and the Beluga coalfields are developed. Estimates of these increases have not been developed for the Borough.

Base case plus OCS, Alpetco, and Pacific-Alaska projects

The base case, OCS medium scenario, Alpetco, and Pacific-Alaska LNG population projections for the Borough, the study area, and the Borough outside the study area for 1977 and 1988 are shown in Table 22. The medium scenario is chosen because the low and high scenarios have a low probability of occurring (5 percent or less). The medium scenario (MI2) selected includes the construction work force projected for the terminals and the LNG plant (which is not the same as the Pacific-Alaska LNG plant), and the assumption that 80 percent of the platform and supply-boat employees will live in the Borough.

A comparison of 1977 and 1988 projections indicates that the addition of the total OCS/Alpetco/LNG population increment changes the base-case pattern. The increment adds 11 percent to the base-case population projected for the study area in 1988, but changes the relationship of the study area to the Borough, and the relationships of the Subareas to one another within the study area, only slightly.

In the base case, the population of the study area is projected to increase from 19,689 in 1977 to 40,624 in 1988, i.e., by 106 percent. When the populations anticipated for the OCS scenario and the other two projects are added, the total 1988 population becomes 44,902, or an increase of 128 percent. This is approximately 11 percent more than the base-case number of 40,624.

Table 22. Population projections for the Kenai Peninsula Borough and the study area, 1977 and 1978; base case, plus OCS medium scenario (MI2), Alpetco, and Pacific-Alaska (Table 21; CH_2M Hill, Inc. 1978a).

	Base Case		OCS Medium Scenario[a]		Alpetco-Pacific-Alaska		Total	
	1977[b]	1988	1977	1988	1977	1988	1977	1988
Kenai Peninsula Borough	24,611	47,882	0	3,290[c]	0	1,380	24,611	52,552
Study area	19,689	40,624	0	3,014	0	1,264	19,689	44,902
Incorporated area	10,644	23,992	0	1,645	0	690	10,644	26,327
Subarea I	7,950	18,670	0	945	0	396	7,950	20,011
Kenai	5,364	11,290	0	565	0	237[e]	5,364	12,092
Soldotna	2,586	7,380	0	380	0	159[e]	2,586	7,919
Subarea II (Homer)	2,082	4,382	0	560	0	235[e]	2,082	5,177
Subarea IV (Seldovia)	612	940	0	140	0	59[e]	612	1,139
Unincorporated areas	9,045	16,632	0	1,369[d]	0	574	9,045	18,575
Borough outside study area	4,922	7,258	0	276	0	116	4,922	7,650
Incorporated areas (Seward)	2,279	3,900	0	0[d]	0	0[e]	2,279	3,900
Unincorporated areas	2,644	3,358	0	276[d]	0	116[e]	2,644	3,750

[a]Includes construction workforce at terminals and LNG plant; assumes that 80% of platform and supply boat workers live in Borough.

[b]All figures from Table 20.

[c]Minor discrepancy between two CH_2M Hill sources; although the figure 3,279 is used in Table 3-3, the sum of Tables 3-4 to 3-9 is 3,290, the figure used here.

[d]Distribution of CH_2M Hill total unincorporated areas using 1988 base proportions from Table 20.

[e]Distribution of Borough total using OCS medium scenario proportions.

These facts do not mean that the additional population from the OCS/Alpetco/Pacific-Alaska projects is so small relative to the base case that the projects can be ignored. The impacts on a particular community could be substantial, depending on the size of the community and the time-phasing of the projects.

Further research

The base-case population numbers for the Borough in Table 22 are those calculated by WAPORA, Inc., in Table 20, which give the base-case numbers for the incorporated and unincorporated areas in the Borough. The individual compound annual rates of growth for these areas over the period 1970 to 1977 were assumed to extend over the period 1977 to 1992 (CH_2M Hill, Inc. 1978a). This assumption needs to be examined for its appropriateness.

The OCS-case population numbers for the Borough in Table 22 are derived from OCS employment projections. The employment projections (and thus the population projections presented here) are those of the Alaska Department of Community and Regional Affairs (DCRA 1977). They differ markedly from those of the Bureau of Land Management (BLM 1976). The high-case total Alaska direct employment from the Lower Cook Inlet Lease Sale is projected by DCRA at 3,986 in 1992, whereas the BLM projection is 1,199. This difference stems not from different assumptions as to the level of development, but from different assumptions as to the direct employment required by that development: offshore production platforms; onshore support for offshore facilities; and construction of onshore terminals. These different assumptions need to be analyzed.

Summary

The foregoing has established that:

- The study area accounts for, and will continue to account for, the bulk of the population in the Kenai-Cook Inlet region and the Kenai Peninsula Borough.

This is important because data are not available for the study area as defined, but are available for the region and the Borough. Thus trends in the study area may be inferred from trends in the region and the Borough.

- The cities and the related settlements account for the bulk of the population in the study area.

This conclusion justifies the use of the cities as surrogates for the Subareas into which the study area is divided. Data are available for the cities (although to a lesser extent than for region and Borough), but not for the Subareas.

- The population of the study area is projected to increase by 106 percent between 1977 and 1988 in the base case, and by 128 percent if the OCS, Alpetco, and Pacific-Alaska projects are added to the base case. The OCS is the most likely of these projects to be undertaken.

This conclusion establishes a prima facie case that the study area as a whole is sensitive to the expected new levels of economic activity, for which new-source NPDES permits will be sought. This sensitivity is even more strongly indicated for the cities and the Subareas.

3.4.3.4. Public attitudes toward development

The results of surveys conducted in cities of the Kenai Peninsula Borough were presented in a document entitled A Profile of Five Kenai Peninsula Towns (Bureau of Management and Urban Affairs and Anchorage Urban Observatory 1977). Excerpts from those surveys concerning attitudes on community growth are presented in the Subarea profiles. In general, the respondents indicated that they preferred to live in communities of the size in which they currently resided and that they preferred that new development occur only in the education sector and in the traditional industrial sectors of their communities.

3.4.4. Housing

Housing data are available only for the cities of the study area. During 1976, 54 percent of the houses in the four cities were single-family residences, 20 percent were multi-family residences, 24 percent were mobile homes, and 1 percent was other types of housing (CH_2M Hill, Inc. 1978a). Outside the cities the percentage of multi-family housing probably was less. Housing vacancies in three of the four cities totaled 74 (5.4 percent of the total number of units). This is a low vacancy rate and indicates a tight housing market. Construction employment has decreased from 1,057 in 1976 to 464 in 1978. The exodus of construction workers that may have accompanied that decline may have increased housing vacancies significantly. Housing statistics for the individual cities are presented in the Subarea profiles.

3.4.5. Education

In the 1977-1978 school year the Kenai Peninsula Borough had 23 schools, 5,708 pupils, and a teaching staff of 355. The pupil/teacher ratio was approximately 16 to 1. The Borough is responsible for the construction and maintenance of the public schools throughout the study area. Construction is funded by voter-approved bond issues initiated by the Borough, with the State paying about 50 percent of the debt service requirements. Administration is funded by Federal, State, and local monies. Operating expenses rose from $12.7 million in the 1975-1976 school year to $15.4 million in the 1976-1977 school year, an increase of 22 percent. A study by the Kenai Peninsula Borough School District (1977) projected enrollment until the 1981-1982 school year (exclusive of additional enrollment from non-base-case activities), and recommended expansion. The projected additions are slightly different in a 1978 bond prospectus (Kenai Peninsula Borough 1978). The bulk of the Borough's 1978 $26 million school bond issue is for the new high school and elementary school at Soldotna ($18 million and $4 million, respectively). At present, Kenai serves Soldotna students of high school age. The prospectus notes that "the combined total costs of [additional] needed [school] projects is estimated at approximately $20 million." Additional projects still are under discussion. The estimated additional enrollment

in the Borough by 1992 is given in Table 23 for the three OCS scenarios.

Table 23. Estimated additional school enrollment for the Kenai Peninsula Borough, 1977-1992 (Kenai Peninsula Borough 1978).

	OCS Low	OCS Medium	OCS High
Base case	7,430	7,430	7,430 - 7,430
Increment	20	560	1,590 - 1,645
Total	7,450	7,990	9,020 - 9,075

3.4.6. Transportation

The two-lane Sterling Highway runs on a north-south axis through the study area on the Kenai Peninsula. It is the only road linking the study area to Anchorage. With the exception of a trail and a marine railroad from Iliamna Bay to Iliamna Lake, there are no roads in the subareas on the Alaska Peninsula. The Sterling Highway runs east from Soldotna to Seward and Anchorage, and south from Soldotna to Homer. Seldovia is not connected by road to the other subareas. Soldotna is linked by a two-lane highway to Kenai, North Kenai, and Nikiski. There is a two-lane loop road (the Kalifonsky Beach Road) off the Sterling Highway (southwest of Soldotna), a new bridge across the Kenai River linking Kenai to this loop road, and two loop roads off the road connecting Soldotna and Kenai (the Kenai Spur Road).

Commercial airline flights link the cities of Anchorage, Kenai, Soldotna, and Homer. From Homer an air taxi can be hired to Seldovia. A ferry links Homer and Seldovia. The Cook Inlet is an important shipping route for imports of commodities into Anchorage and for exports of petroleum products from the study area, and also is a major commercial fishing area. There are publicly- and privately-owned ports and docks at most of the population centers along the Kenai Peninsula coast. Specific transportation facilities are described in the subarea profiles.

3.4.7. Utilities

Each of the four largest communities in the study area provides public water and sewage facilities to at least a part of its population. The remainder of the population takes water from wells, cisterns, streams, or lakes, and disposes of its domestic wastes in septic systems, holding tanks, or privies. On the Kenai Peninsula, electricity is generated by the Chugach Electric Company at Bernice Lake, at Cooper Lake, and at Beluga (outside the study area). The Chugach Electric Company distributes electricity in the northern part of the Kenai Peninsula, and the Homer Electric Association distributes it in the southern part of the Kenai Peninsula. Smaller communities utilize diesel-powered generators. Several of the larger industries generate their own electricity. Anchorage Natural Gas Company, Kenai Utility Service Corporation, and the Collier and Phillips petrochemical plants distribute natural gas to parts of the study area on the Kenai Peninsula. Solid waste is collected at transfer points on the Peninsula and buried at landfill sites operated by the Borough.

3.4.8. Public finances

The tax base of the Borough is adequate to provide the desired level of services. The financial welfare of the Borough is important to the study area, because the Borough provides areawide education and selected services in the ad hoc service areas. Specific financial data for the cities is presented in the Subarea profiles.

The finances of the Borough and the study area, however, are complicated by three factors that render both entities sensitive to rapid growth or to abrupt changes in the level of economic activity. The first factor is the difference between the geographical distributions of the tax base (property value) and the population, primarily because the oil and gas properties are outside the cities. They are concentrated in the Nikiski area, outside the corporate limits of Kenai and Soldotna. The assessed value of these properties is about half that of the total assessed value for the Borough. Although Kenai and Soldotna are affected significantly by the economic and social impacts of these properties, the cities lack the power to tax them. This is shown in Table 24 for the 11 Tax Code Areas (TCAs), including five cities, in the Borough. The boundaries of each Tax Code Area are indicated in Figure 24 (adapted from CH_2M Hill, Inc. 1978a). The cities have only one percent of the assessed value of oil and gas properties in the Borough, but 43 percent of the population of the Borough. The assessed value (oil and gas only) per capita in the cities is $450, as compared with $39,165 for the service areas combined. Thus, even with millage rates in the cities very much higher than outside (19.36, versus 6.32 for the service areas), the property tax (oil and gas) levied per capita is very much less ($7, versus $247 for the service areas).

The second complicating factor is the complex nature of the provision of services in service areas that have overlapping boundaries, and contain the cities. The third factor is the time lag between expenditures and receipt of revenues. The result of these complications is that "Kenai's [recent] financial condition has been chaotic [as it struggled] to recover from the last oil boom" (CH_2M Hill, Inc. 1978a). Intergovernmental agreements (where one jurisdiction agrees to provide a service in another), which have been permitted by enabling legislation in Colorado, for example, "... could add to the already chaotic situation of identifying which agencies are providing which services and where tax monies are going" (Kenai Peninsula Borough 1976).

The 1976 property tax and sales tax rates for the eleven TCAs in the Borough are shown in Table 24. There are five first-class cities, one second-class city, and 5 service areas, including one "other" (TCA 50), which consists of the remainder of the Borough not included in the other four service areas. The Borough's ad valorem property tax rate, levied on 100 percent of full value, is 5 mills. The TCAs (except for TCA 50) have additional ad valorem property tax rates, so that the total property tax rates in the TCAs ranged from 5.2 to 25.0 mills in 1976. The sales tax rate for the Borough is 2 percent. Most of the TCAs have additional sales taxes, so that the total sales tax rates in the TCAs ranged from 2 to 5 percent in 1976.

With the 1978 $26 million school bond issue, the outstanding general

obligation debt of the Borough more than doubled. The bonded debt ratios for the Borough are shown in Table 25.

The signs of financial health are the low ratios of debt to assessed value, even with the recent doubling in debt (upwards of 19 percent, bond issues become increasingly difficult to market); the favorable bond rating (A); and the high assessed value per capita (reflecting the importance of oil and gas properties). Other indicators are that the State reimburses the Borough for 50 percent of the debt service requirements on the bond issue; the Borough is taxing oil and gas properties at $121 per capita, as compared with the $1,500 limit; and two oil and gas facilities that are at present untaxed (as a result of the 10-year tax moratorium established by the State as an inducement) will add $257 million to the tax base in 1979. The relatively high per capita debt figure ($2,018, as compared to $271 for all US cities having a population of less than 50,000 in 1975-1976) reflects these phenomena.

3.5. Institutions

Governing institutions in the study area essentially exist at four levels: Federal, State of Alaska, Kenai Peninsula Borough, and local. The Alaska Native corporations are not governing bodies, but they control land use in sufficiently large areas that, for land-use planning purposes, they can be considered to be an additional level of organization. Areas of responsibility frequently overlap between these institutions.

3.5.1. Federal Government organizations and responsibilities

The role of the government probably is more significant in Alaska than in any other state. This results from the vast amount of Federally-owned land, the significant Native American population, the long history of direct Federal rule (1867-1959), and a variety of other factors. It is beyond the scope of this report to discuss each Federal agency and its responsibilities. Subsequent sections briefly will review the major Federal organizations and their roles in the study area.

3.5.1.1. US Environmental Protection Agency

The US Environmental Protection Agency (USEPA) administers the Federal laws on air, water, and noise pollution; solid waste disposal; toxic substances; etc. USEPA activities play a major role in the Lower Cook Inlet study area. The importance of USEPA was discussed in Section 2.3.

3.5.1.2. US Department of the Interior

The US Department of the Interior (USDOI) has the major responsibility for activities on Federal lands and on the Outer Continental Shelf (OCS). USDOI agencies have an important role in the regulation of these areas. Specific information regarding the Kenai National Moose

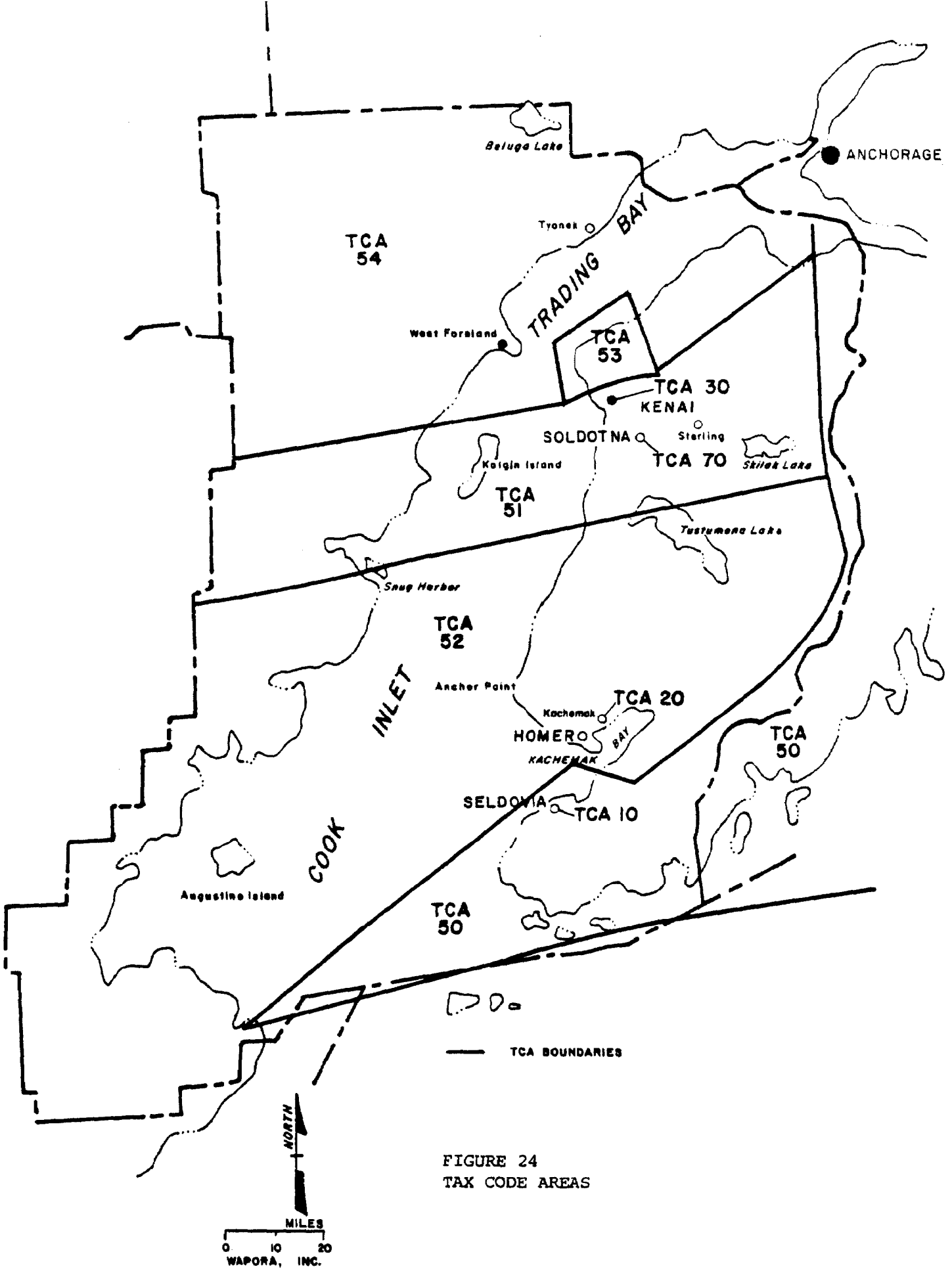


FIGURE 24
TAX CODE AREAS

Table 24. Property and sales tax rates for Kenai Peninsula Borough Tax Code Areas, 1976 (Mielke and others 1977; Waites and Brogan 1977a, 1977b, 1977c).

TCA	Name		Property Tax[a] (mills)	Sales Tax[b] (percent)
Service Areas				
50	Other		5.0	2.0
51	Central Hospital		5.2	2.0
52	South Hospital		7.0	2.0
53	Nikiski Fire		8.8	2.0
54	North Peninsula Recreational			
Cities				
Study Area				
Subarea I				
30	Kenai	(1st class)	21.2	5.0
70	Soldotna	(1st class)	15.2	4.0
Subarea II				
20	Homer	(1st class)	19.0	4.0
52	Kachemak	(2nd class)	9.0	2.0
Subarea IV				
10	Seldovia	(1st class)	21.5	3.0
Outside Study Area				
40	Seward	(1st class)	25.0	2.0

[a]Borough 5.0 mills included.

[b]Borough 2 percent tax included.

Table 25. Bonded debt ratios for the Kenai Peninsula Borough as of June 30, 1977 (Kenai Peninsula Borough 1978).

Assessed value	$1,188,172,242
Direct debt	$ 49,662,097
Direct and overlapping debt	$ 60,375,097
Ratio of direct debt to assessed value (percent)	4.18
Ratio of direct and overlapping debt to assessed value (percent)	5.08
Population	24,611
Assessed value per capita	$ 48,278
Direct debt per capita	$ 2,018
Direct and overlapping debt per capita	$ 2,453

Range and the Tuxedni National Wildlife Refuge may be obtained from:

Mr. Robert Frates, Refuge Supervisor
US Fish and Wildlife Service
Kenai National Moose Range
P. O. Box 500
Kenai AK 99611
Telephone: (907) 283-4877

3.5.1.2.1. Bureau of Land Management

The Bureau of Land Management (BLM) has authority over unclassified Federal lands. BLM is engaged in management, leasing, permitting, classification, planning, and enforcement. It also is responsible for offshore resource development activities on the Outer Continental Shelf (OCS). Public lands are managed under the principles of multiple use and sustained yield and are in accordance with appropriate land-use development plans.

The key contact for BLM activities in the Lower Cook Inlet study area is:

Mr. John Merrick, Manager
Peninsula Resource Area
4700 E. 72nd Avenue
Anchorage AK 95507
Telephone: (907) 344-9661

Leasing of Federal OCS land is managed by the Alaska OCS Office of BLM.

The mailing address is:

US Department of the Interior
Bureau of Land Management
Alaska OCS Office
P. O. Box 1159
Anchorage AK 99510

The office is located at 800 A Street; telephone number (907) 276-2955. Key contacts include:

- Dr. Dean Yoesting, Coordinator, Socioeconomic Studies Program
- Mr. Jerry Imm, Field Coordinator, Environmental Studies
- Ms. Connie Wassink, Public Affairs Officer.

The schedule for leasing of Alaskan OCS lands currently is before the US Congress. The latest available planning schedule for these activities is dated March 1978.

3.5.1.2.2. US Fish and Wildlife Service

The US Fish and Wildlife Service (USFWS) is responsible for the management of National Wildlife Refuges and National Wildlife Ranges. It

also administers the Federal Threatened and Endangered Species programs. Within the Lower Cook Inlet study area, USFWS manages the Tuxedni National Wildlife Refuge. It also is responsible for the Kenai National Moose Range, adjacent to the study area. Agency activities are designed to protect and conserve fish and wildlife resources. This includes enforcement of international treaties and conventions relating to wildlife.

Overall management of USFWS activities in the study area is carried out by agency offices in Anchorage, Alaska. The main office address is:

US Fish and Wildlife Service
1011 E. Tudor Road
Anchorage AK 99507
Telephone: (907) 276-3800

Key contacts with USFWS at this office include:

- Mr. Mel Monson, Supervisor, Land and Water, Alaska
- Mr. Calvin Lensick, Supervisor, Office of Biological Sciences.

Information from the USFWS library is available through:

- Ms. Janet McNaughton, Library Technician.

An extensive computerized data retrieval system is operated by USFWS. The key contact regarding this system is Mr. Robert Blansett, Supervisor, Alaska Information Management System. Many of the activities of USFWS in the Lower Cook Inlet study area are administered by the Western Alaska Ecological Services office. The mailing address is:

US Fish and Wildlife Service
733 W. 4th Avenue
Anchorage AK 99501
Telephone: (907) 276-8242

The key contact at this office is:

- Mr. Bob Bowker, Supervisor, Western Alaska Ecological Services.

Tentative sale dates are:

State/Federal Beaufort Sea (Nearshore) . . December 1979
Gulf of Alaska . . . . . June 1980
Kodiak . . . . . October 1980
Cook Inlet . . . . . March 1981
Bering Sea/Norton Sound . . . . . December 1981.

Draft environmental impact statements relating to each proposed sale are scheduled to be issued from 8-12 months prior to the tentative sale date. Specifics of the proposed Cook Inlet sale include the following:

Call for Nominations . . . . . December 1978
Nominations Due . . . . . February 1979
Tentative Tract Selection . . . . . May 1979

Draft Environmental Impact Statement . . . . February 1980
Public Hearing . . . . . June 1980
Final Environmental Impact Statement . . . . October 1980
Proposed Notice of Sale . . . . . December 1980
Notice of Sale . . . . . February 1981
Sale . . . . . March 1981.

3.5.1.2.3. US Geological Survey

The US Geological Survey supervises offshore activities related to OCS development and is a key agency for earth resources information. The office with responsibility for the Lower Cook Inlet study area is:

US Department of the Interior
US Geological Survey
508 W. 2nd Avenue
Anchorage AK 99501
Telephone: (907) 271-4138

The key contact for general questions is Mr. Harry Hulsing, Chief, Alaska District, Water Resources Division.

Questions regarding oil and gas activities should be directed to Mr. Joseph M. Jones, Assistant Conservation Manager, Conservation Division. The address for this office is:

US Department of the Interior
US Geological Survey
800 A Street, Room 109
Anchorage AK 99501
Telephone: (907) 271-4304

3.5.1.2.4. US National Park Service

The US National Park Service (NPS) is responsible for the management of national parks, national monuments, and national historic sites. The recent designation of large areas of Federal land in Alaska as national monuments affects areas in and near the Lower Cook Inlet study area. The new Kenai Fjords National Monument is adjacent to the study area, as is the enlarged Katmai National Monument. Portions of the Lake Clark National Monument are within the boundaries of the study area. All of these lands are administered by NPS. Headquarters for NPS operations in Alaska are in Anchorage. The address for this office is:

US Department of the Interior
National Park Service
540 W. 5th Avenue
Anchorage AK 99501

General questions may be directed to Mr. Bailey Breedlove, Professional Services. Mr. Breedlove's telephone number is (907) 271-4216. Additional key individuals include:

- Mr. John E. Cook, Director, Alaska Area Office
- Mr. Douglas Warnock, Deputy Director, Alaska Area Office

- Mr. Howard Wagner, Professional Services
- Mr. Paul Haertel, Chief of Operations
- Mr. James Larson, Chief Scientist.

3.5.1.2.5. Alaska Resources Library

The Alaska Resources Library (ARL) of the US Department of the Interior serves to assist research involving natural resources in the State of Alaska. It offers reference assistance, computerized search of bibliographic information, and circulation service. Over 25,000 articles are available on micro-fiche that have been reprinted and indexed by the US Army Cold Regions Research and Engineering Laboratories (CRREL). ARL also has a complete set of the resource inventory maps of Alaska prepared by the Joint Federal-State Land Use Planning Commission.

The key contact at ARL is Martha Shepard, Librarian. The office address is:

US Department of the Interior
Alaska Resources Library
701 C Street
Anchorage AK 99513
Telephone: (907) 271-5025

3.5.1.3. US Department of Commerce

The US Department of Commerce serves the business and commercial needs of the nation. A variety of agencies exist within this department. These range in mission from the Bureau of the Census and the Economic Development Administration to the National Weather Service and other scientific divisions of the National Oceanic and Atmospheric Administration.

3.5.1.3.1. National Oceanic and Atmospheric Administration

The National Oceanic and Atmospheric Administration (NOAA) conducts scientific and research activities in a wide variety of areas. Information may be obtained from:

US Department of Commerce
National Oceanic and Atmospheric Administration
Environmental Data and Information Service
707 A Street
Anchorage AK 99501
Telephone: (907) 271-4063

General information regarding fisheries is available through the office of:

Mr. Harry L. Rietze
Director, Alaska Region
National Marine Fisheries Service
National Oceanic and Atmospheric Administration
709 West 9th
Juneau AK 99801
Telephone: (907) 586-7221

Specific inquiries for scientific data may be directed to the office of:

Dr. Bill Smoker, Director
Auke Bay Fisheries Laboratory
National Marine Fisheries Service
National Oceanic and Atmospheric Administration
P. O. Box 1668
Juneau AK 99801
Telephone: (907) 789-7231

3.5.1.4. US Department of Housing and Urban Development

The US Department of Housing and Urban Development administers the Federal flood insurance program. At the present time, there are no official flood hazard areas maps for the Lower Cook Inlet study area. Hazard determinations are made on a case-by-case basis and utilize information from the US Army Corps of Engineers. Additional information may be obtained from:

US Department of Housing and Urban Development
Federal Housing Administration
Anchorage Area Office
334 W. 5th Avenue
Anchorage AK 99501
Telephone: (907) 271-4177

3.5.1.5. US Department of Transportation

The US Department of Transportation is responsible for a wide range of transportation-related activities. Its agencies include:

- US Coast Guard
- Federal Aviation Administration
- Federal Railroad Administration
- Federal Highway Administration
- National Highway Traffic Safety Administration
- Urban Mass Transportation Administration.

The United States Coast Guard (USCG) is a key agency of the Department of Transportation. Marine sanitation devices (MSDs) are regulated by the USCG. In addition, vessel traffic and safety may be important considerations in the operation of proposed new source NPDES activities. The USCG is a valuable source of information on these issues. Information may be obtained from:

Commander (dpl)
US Coast Guard
17th Coast Guard District
Planning Office
P. O. Box 3-5000
Juneau AK 99802
Telephone: (907) 586-7348

3.5.1.6. Southcentral Water Resources Study

The Southcentral Water Resources Study (SWRS) primarily is funded by the US Water Resources Council and will study the present and potential uses of the water resources of southcentral Alaska. The SWRS is the first comprehensive regional water and related land resources study to be carried out in the State of Alaska. More than 30 agencies and groups are involved, including Federal, State, borough, and local bodies, Native corporations, and the Joint Federal-State Land Use Planning Commission. The SWRS should be a valuable source of information on the status of water resources planning for the southcentral Alaska region, including the Lower Cook Inlet study area. Information may be obtained from:

Study Director
Southcentral Water Resources Study
1675 C Street
Anchorage AK 99501
Telephone: (907) 271-4313

3.5.1.7. US Department of the Army, Corps of Engineers

The most important functions of the US Army Corps of Engineers (COE) that are related to NPDES activities are carried out under the provisions of Section 10 of the Rivers and Harbors Act of 1899 (33 USC 403) and Section 404 of the Federal Water Pollution Control Act, as amended (commonly referred to as the Clean Water Act; Pub. L. No. 92-500, 33 USC 1344). The Clean Water Act has been amended numerous times, most notably in 1972 and 1977.

Section 10 of the River and Harbors Act of 1899 prohibits the construction of any structure in or over any navigable water of the United States without a permit from the US Army COE. Permits for the discharge of dredged or fill material, usually referred to as filling, into all waters of the United States, including wetlands, also must be obtained from the Department of the Army, pursuant to the provisions of Section 404 of the Clean Water Act.

A detailed discussion of these programs is contained in the Kenai River Review, issued in April 1978 by the US Department of the Army, Alaska District, Corps of Engineers.

The US Army COE office with jurisdiction over the Lower Cook Inlet study area is:

US Department of the Army
Alaska District, Corps of Engineers
P. O. Box 7002
Anchorage AK 99510

One of the key contacts is:

Mr. William Lloyd
Chief, Environmental Section
Telephone: (907) 752-2572

Additional information may be obtained through the office of:

Chief, Regulatory Functions Branch
Telephone: (907) 752-4942

3.5.2. State of Alaska government organizations and responsibilities

Although all State organizations have an important role in the Lower Cook Inlet study area, three agencies have particular prominence. These are the Alaska Department of Environmental Conservation (ADEC), the Alaska Department of Fish and Game (ADFG), and the Alaska Department of Natural Resources (ADNR). Brief descriptions of agency responsibilities and key contacts will be presented in subsequent sections.

Many other State agencies are involved in the regulation of business activities in the State of Alaska. There are a variety of permits, certificates, and licenses that are required by these organizations. A key source of information on this subject is the Alaska Permit Directory, compiled by the Alaska Department of Commerce and Economic Development in 1978. The Directory is a useful reference tool in the review of new source NPDES applications because it provides detailed information on permits, licenses, and certificates that an applicant may be required to obtain from the State of Alaska.

In addition to the information available from State regulatory agencies, data may be obtained from State-funded sources such as the University of Alaska. Key organizations that operate within the University of Alaska include the Arctic Environmental Information and Data Center (AEIDC) and the Institute of Social and Economic Research (ISER). Key contacts for these groups are listed in Sections 3.5.2.4.1. and 3.5.2.4.2., respectively.

3.5.2.1. Alaska Department of Environmental Conservation

The mission of the Alaska Department of Environmental Conservation (ADEC) is to protect and enhance the natural and man-made environment, while permitting appropriate use of Alaska's natural resources. ADEC is charged with enforcement and setting standards for the prevention and abatement of pollution and with coordination and formulation of environmental policies and programs. Major permit programs deal with wastewater discharges, air pollution, and solid waste disposal. It is likely that new source NPDES applicants also will require permits from ADEC. Key contacts include:

- Mr. Kyle Cherry
  Alaska Department of Environmental Conservation
  Southcentral Regional Office
  338 Denali
  Anchorage AK 99501
  Telephone: (907) 274-5527

- Mr. Howard R. Keiser
  Alaska Department of Environmental Conservation
  Kenai Field Office
  Farnsworth Building
  P. O. Box 587
  Soldotna AK 99669
  Telephone: (907) 262-5210

3.5.2.2. Alaska Department of Fish and Game

The major areas of responsibility of the Alaska Department of Fish and Game (ADFG) include commercial and sport fisheries; fisheries rehabilitation, enhancement, and development; and game management. ADFG operates major fish hatcheries and rearing and incubation facilities. Its operations affect both commercial and sport fishermen. Wildlife biologists from ADFG provide expert information to local, State, and Federal agencies and organizations. Personnel also work with Federal agencies on international problems. ADFG reviews hundreds of documents each year, including EISs, permit applications, development proposals, etc.

ADFG has a number of internal divisions that may be involved in regulatory and informational activities. The following information on key contacts was obtained from the Southcentral Regional Office of ADFG.

Anchorage (Southcentral Regional Office)

Phone: (907) 344-0541

Address: 33 Raspberry Road, Anchorage AK 99502

Commercial Fisheries Division: Regional Supervisor - Mr. Kenneth M. Middleton

Sport Fisheries Division: Regional Supervisor - Mr. Russ Redick

Game Division: Regional Supervisor - Mr. John Vania

FRED Division: Regional Supervisor - Mr. David Daisy

Habitat Protection Section: Regional Supervisor - Mr. Thomas Trent
Permits - Mr. Bruce Barrett

Marine and Coastal Habitat
Management Project
(Environmental Review and
CZM Project): Supervisor - Mr. Lance Trasky

Soldotna (area office)

Phone: (907) 262-9368

Address: Box 1809, Soldotna AK 99669

Commercial Fisheries Division: Area Management Biologist - Mr. Gary Sanders
Research Biologist - Mr. Tom Namvedt

Sport Fisheries Division: Area Management Biologist - Mr. Sid Logan

Game Division: Area Management Biologist - Mr. Ted Spraker

Homer (area office)

Phone: (907) 235-8191

Address: Box 234, Homer AK 99603

Commercial Fisheries Division: Area Management Biologist - Mr. Tom Schroeder
Shellfish Research Biologist - Mr. Joe Wallis

Game Division: Area Management Biologist - None (see Soldotna)

FRED Division: Fisheries Biologist - Mr. Nick Dudiak

FRED = Fisheries Rehabilitation, Enhancement and Development

3.5.2.3. Alaska Department of Natural Resources

The Alaska Department of Natural Resources (ADNR) is responsible for administration of "...the State program for the conservation and development of natural resources, including forests, parks and recreational areas, lands, waters, agriculture, soil conservation, and minerals, but excluding fish and game. It also develops, protects, and administers the State program for historic and archaeological sites, objects, and related matters" (State of Alaska 1977b). The authority of ADNR in the areas of land management, lease of State lands, granting of easements, and water appropriation make this agency a key factor in many activities. In addition to its regulatory role, ADNR is a valuable source of information on a variety of subjects. A comprehensive discussion of the many activities of the Alaska Department of Natural Resources and its divisions is beyond the scope of this report. Key contacts for some of the divisions that are likely to be involved in NPDES-related activities are presented in subsequent sections.

3.5.2.3.1. Division of Parks

The Division of Parks administers State parks and waysides and is involved in identification and protection of cultural, historic, and archaeological resources. Information on parks and waysides may be obtained from:

Director
Division of Parks
Alaska Department of Natural Resources
619 Warehouse Avenue, No. 210
Anchorage AK 99501
Telephone: (907) 274-4676

Information on cultural, historic, and archaeological resources may be obtained from:

State Archaeologist
Division of Parks
Alaska Department of Natural Resources
619 Warehouse Avenue, No. 210
Anchorage AK 99501
Telephone: (907) 274-4676

3.5.2.3.2. Division of Agriculture

The Division of Agriculture is active in marketing and promotional programs, animal and plant inspection services, and agricultural development. It is possible that seafood processors applying for a new source NPDES permit also may require a "Certificate and Permit" from the Division of Agriculture. Information on this subject may be obtained from:

Director
Division of Agriculture
Alaska Department of Natural Resources
Sims Building
P. O. Box 1088
Palmer AK 99645
Telephone: (907) 745-3236

3.5.2.3.3. Division of Forest, Land, and Water Management

The Division of Forest, Land, and Water Management is responsible for a wide variety of programs and regulatory activities. These include the management of State forest lands, development and implementation of State land policies, performance of hydrologic studies, and coordination of activities, etc. Many new source NPDES permit applicants may be required to obtain a Water Use Permit and Certificate of Appropriation to use the waters of the State of Alaska. General information may be obtained from:

Mr. Theodore G. Smith, Director
Division of Forest, Land, and Water Management
Alaska Department of Natural Resources
323 East 4th Avenue
Anchorage AK 99501
Telephone: (907) 279-5577

Key contacts in the three sections of the division are:

- Forestry Section
  Mr. Rod Ketchum
  Deputy State Forester

- Land Management Section
  Mr. Dick LeFebvre
  Chief

- Water Management Section
  Mr. Brent Petrie
  Chief

Additional information is available from:

Mr. Lawrence A. Dutton, Manager
Southcentral Land District
3327 Fairbanks Street
Anchorage AK 99504
Telephone: (907) 279-7691

3.5.2.4. University of Alaska

The University of Alaska is the single, state-wide public university system and is responsible for the public service, research, and teaching services that characterize public institutions of higher education. The research activities of the University of Alaska are carried out by the various academic departments and by specialized research units. These groups are important information sources. Key contacts for two of these specialized research units are presented in Sections 3.5.2.4.1. and 3.5.2.4.2.

3.5.2.4.1. Arctic Environmental Information and Data Center

The Arctic Environmental Information and Data Center (AEIDC) is a specialized research unit of the University of Alaska. AEICD personnel conduct research for a variety of local, State, and Federal agencies and groups. Extensive data retrieval facilities are available. AEIDC publishes numerous documents, including the Current Research Profile for Alaska (see Appendix C). Key contacts include:

- Ms. Linda Dwight, Supervisor
  Information Services

- Ms. Stetson Pennel
  Information Services

- Ms. Barbara Sokolov
  Information Services.

These individuals may be contacted at:

University of Alaska
Arctic Environmental Information and Data Center
707 A Street
Anchorage AK 99501
Telephone: (907) 279-4523

3.5.2.4.2. Institute of Social and Economic Research

Another specialized research unit of the University of Alaska is the Institute of Social and Economic Research (ISER). ISER is a valuable source of information on the socioeconomic aspects of many activities in the State of Alaska. Key contacts include:

- Mr. Lee Gorsuch, Director
- Ms. Ellie Clifford, Executive Assistant

These individuals may be contacted at:

University of Alaska
Institute of Social and Economic Research
707 A Street
Anchorage AK 99501
Telephone: (907) 275-5575

3.5.3. Borough government organization and responsibilities

The State of Alaska is divided into local governmental units called boroughs. "The name was chosen by the Convention as the best compromise designation for a new local area government unit that would not be confused with or limited by traditional units which exist in the older states" (State of Alaska 1977a). Areas of the State that meet specific criteria may petition to become an "organized borough." The remainder of the State is included in the "unorganized borough." A detailed discussion of the borough system is contained in the Alaska Blue Book (State of Alaska 1977a).

The Lower Cook Inlet study area is within the boundaries of the Kenai Peninsula Borough (KPB). The KPB was created as a second-class borough by a vote of the electorate on 3 December 1963. The Borough has area-wide responsibilities for assessment, taxes, air pollution control, education, solid wastes, planning, and zoning. The voters also have created special assessment service areas for hospitals, fire protection, and water distribution.

The Borough Assembly is the governing body and is represented by appointed members from city councils, elected members from within the cities, and elected members at large. The mayor, who is elected at large, provides administrative guidance and retains veto power over certain assembly actions.

Two members of the Borough Assembly sit as commissioners on the Cook Inlet Air Resources Control Commission. The Commission governs the Cook Inlet Air Resources Management District, which is a cooperative venture between the Anchorage Borough and Kenai Peninsula Borough. The District prepares ordinances and regulations, monitors ambient air quality, enforces regulations, and issues permits. It has the primary responsibility for air quality control throughout the study area except for large point sources, which the State of Alaska also regulates. The District is in the process of revising the regulations to bring about conformity with applicable Federal air quality standards.

Planning and zoning within the Borough and the cities is the responsibility of the Borough Planning Commission. It also is involved in coastal zone management studies. A subcommittee of the Commission forms the Platting Authority. Within the cities a local planning advisory committee reviews and comments on proposed planning and zoning cases

before the Commission. Appeals of the Commissions's actions are made to the Borough Assembly.

An interim coastal zone management (CZM) plan for the KPB currently is being prepared. In addition, a study of ports and harbors is underway. A major source of information on KPB activities is the Borough Planning Department. The key contact is:

Mr. Phillip Waring, Planning Director
Planning Department
Kenai Peninsula Borough
P.O. Box 850
Soldotna AK 99669
Telephone: (907) 262-4441

3.5.4. City government organization and responsibilities

There are five incorporated cities in the study area: Kenai, Soldotna, Homer, Kachemak City, and Seldovia. First-class cities include Kenai, Soldotna, Homer, and Seldovia. Kenai has adopted a home-rule charter and is designated as a "home-rule city," a special case within the first-class city category. Kachemak City is a second-class city.

First-class cities have a six-member council and a separately-elected mayor. A manager form of government may be used. If the manager form of government is used, a mayor still is elected but the council or assembly employs a manager to carry out the responsibility for implementing the policies set by the governing body. All first-class cities in the study area utilize the manager system of government.

Second-class cities are governed by a seven-person council. One member of the council serves as mayor of the city. The manager form of government may be used. Kachemak, the only second-class city in the study area, does not employ a city manager.

Because all of the cities in the study area are in the Kenai Peninsula Borough, the area-wide powers of taxation, education, planning, platting, and zoning reside with the Borough government. Municipalities may levy two taxes -- real and personal property taxes and sales and use taxes. Generally the maximum property tax is 30 mills in first-class cities and 5 mills in second-class cities. Sales taxes are limited to 3%, although home-rule cities may exceed this limit. Sales taxes imposed by cities in the study area are:

Kenai	-	3%
Soldotna	-	2%
Homer	-	2%
Kachemak	-	None
Seldovia	-	1%

Four of the cities provide municipal utility services of various kinds. Municipally-owned utilities include:

Kenai	-	Water, sewer, airport
Soldotna	-	Water, sewer, airport
Homer	-	Water, sewer, dock, harbor
Seldovia	-	Water, sewer, dock, refuse collection.

Specific information relating to each of the cities in the study area may be obtained from the respective municipal offices. Mailing addresses and telephone numbers are listed below:

City Manager
City of Kenai
P.O.Box 580
Kenai AK 99611
Telephone: (907) 283-7535

City Administrator
City of Soldotna
P.O. Box 409
Soldotna AK 99669
Telephone: (907) 262-4492

City Manager
City of Homer
P.O. Box 335
Homer AK 99603
Telephone: (907) 235-8121

Planning Director
City of Kachemak
P.O. Box 701
Kachemak via Homer AK 99603
Telephone: (907) 235-8748

City Manager
City of Seldovia
P.O. Drawer B
Seldovia AK 99663
Telephone: (907) 234-7643

3.5.5. Alaska Native corporations

To settle long-standing Native claims in Alaska, the US Congress passed, and President Nixon signed into law, the Alaska Native Claims Settlement Act of 1971 (ANCSA 43 USC 1601 et seq.) in December of that year (Arnold 1976). Among the provisions of the Act and amendments to the Act were a land settlement of approximately 44 million acres and a monetary payment of $962.5 million to the Native Alaskans. The Act also directed the formation of a ten-member Joint Federal-State Land Use Planning Commission to assist in the land selections and planning. Section 17(d)(2) of ANCSA authorized the Secretary of the Interior to withdraw up to 80 million acres of Federally-owned land for study and potential addition to National Parks, National Monuments, and National Wildlife Ranges and Refuges. Controversy over the provisions of Section 17(d)(2) resulted in a Congressional stalemate in 1978, and as the legal deadline for action approached, President Carter set aside 56 million acres of Alaska in new or enlarged National Monuments. The land was set aside under the provisions of the Antiquities Act of 1906. Part of the new, 2.5-million-acre Lake Clark National Monument is located in the Lower Cook Inlet study area, on the western shore of Cook Inlet north of Illiamna Bay.

The formation of Native corporations was an integral part of ANCSA. Regional Native corporations received money and land that were to form the "capital assets" of the new enterprises. The regional corporations would receive title to the subsurface rights on all 44 million acres. They were to pass along monies, lands, and profits to "shareholders" and to the village corporations.

Village corporations were to be formed based on three main eligibility criteria:

- At least 50 percent of the village must be Native population
- There must be at least 25 Native residents
- The village must not be modern or urban in character.

The village corporations could be either profit or non-profit in nature and were designed to provide various services to their residents ("stockholders"). Land entitlement of the village was determined by the Native enrollment as of 14 September 1974. The total amount of land to be conveyed was based on the following schedule:

Enrollment	No. of Townships of Entitlement	Area (Acres)
25 - 99	3	69,120
100 - 199	4	92,160
200 - 399	5	115,200
400 - 599	6	138,240
More than 600	7	161,280

As could be expected, this distribution schedule has a number of exceptions and there are many restrictions on land selections. Overall land distribution was to be:

- 22 million acres to regional corporations
- 16 million acres to village corporations
- 2 million acres to special corporations
- 4 million acres to corporations that had received partial compensation prior to 1971.

3.6. Cultural, Historical, Archaeological, and Aesthetic Resources

Alaska has a rich and varied history, and the Lower Cook Inlet study area has had an important place in the development of the State. It has been occupied in turn by Eskimos, Indians, Russians, and Americans. Prehistory is represented well in the study area, and it is likely that additional Indian artifacts will be discovered. Numerous Russian settlements occurred in the area, and various examples from the period still exist today. The Americans were the latest group to be attracted by the natural resources of Alaska.

The beauty of Alaska has been documented from the earliest written records of the Lower Cook Inlet area. Aesthetic resources in the study area range from beaches to mountain peaks and from swift-flowing streams to smoking volcanoes. Abundant wildlife add to the grandeur of the

physical environment. This wealth of aesthetic resources plays a vital role in attracting thousands of visitors each year to the study area.

3.6.1. Cultural, historical, and archaeological resources

The history of the Lower Cook Inlet has been a succession of settlement and exploration by a variety of peoples, including Eskimo, Tanaina Indian, Russian, and American. Explorations by the English, French, and Spanish also were important factors in the history of the study area. Three major periods of interest, designated as the Native, Russian, and American, are presented below. More specifics are presented in each Subarea profile.

3.6.1.1. Native period

Available evidence indicates that man has been present in Alaska for thousands of years. Anthropologists are not in agreement as to the origins of the prehistoric and recent native inhabitants. Dispersal across an inferred land bridge between Asia and North American frequently is hypothesized. The presence of this land bridge is indicated by the fossil record of animals rather than by direct geological or other evidence. According to Vaughan (1972), "when the fossil record indicates that a genus of mammal occurred in both Asia and North America during a given period, one can assume that at that time, or for some period before it, intercontinental migrations occurred across the Bering land bridge." Thus the passage of humans across this intermittent connection potentially was possible. To date, no skeletal remains of man that are contemporary with the remains of extinct Pleistocene animals have been found. However, Hulley (1970) stated that " ... the presence of ancient village sites in western Alaska and the finding of occasional flint implements in various parts of the territory suggest that man has been in Alaska for many thousands of years."

Three cultural subperiods have been identified within the Native period of the Lower Cook Inlet by De Laguna (1934). The first two periods, Kachemak I and II, were characterized by the use of bone and shell materials. The last period, Kachemak III, included Native use of copper fur knives, bracelets, and beads.

The earliest inhabitants of the study area appear to have been Eskimos. They are believed to have been responsible for the rock and cave paintings found in the area. There are indications of a settlement on Yukon Island, Kachemak Bay, dating back to 1500 B.C. The natives of the Lower Cook Inlet are thought to have been hunters and fishermen, primarily occupying the coastal and riverine areas. Widespread settlement is indicated by the many collapsed barabara (sunken houses) that have been discovered in the district (Barry 1973; Workman 1974).

The Eskimos were superceded by Tanaina Indians, initially in the northern sections near Cook Inlet and later in the southern areas. Indian culture existed in the study area for many years, and the early reports of European and Russian explorers contain a variety of accounts that describe the later part of the Native period.

3.6.1.2. Russian period

Documentation of the period of exploration of the Alaskan region by European man is more complete. Vitus Bering generally is credited with the discovery of the Aleutian Islands (and thus Alaska) in 1741, as part of the Second Kamchatka Expedition sponsored by the Russian government. Cook Inlet was not visited by the earliest Russian explorers, but it is possible that Cape Elizabeth was sighted by A. Chirikov in 1741 (Sherwood 1974). Chirikov was in command of the Russian vessel Sv. Pavel, which accompanied the Sv. Petr of Vitus Bering on the Second Kamchatka Expedition (Fedorova 1971). Cape Elizabeth was named by Captain James Cook in 1778. Cook was the first European explorer to venture into Cook Inlet (Sherwood 1974). Accounts of a possible 16th-century Russian village on the Kenai Peninsula have been exaggerated and generally discounted (Pierce 1973).

Russian fur-hunting expeditions slowly worked their way eastward along the Aleutian Islands, first setting up temporary camps and later permanent settlements. Major stations were established on Unalaska and Umnak. In 1784, G.I. Shelikhov arrived at Kodiak Island with a fleet of three vessels. When the expedition left Alaska in 1786, three settlements/forts were in place or under construction. In addition to the Kodiak settlement, forts were built on Afognak Island and at English Bay (Fedorova 1971). A rival merchant company founded Fort St. George at Kasilof about 1787 and the Nikolaevsk Redoubt at Kenai in 1791 (Sherwood 1974). English and Spanish voyagers to the area from 1786 to 1790 were not well-received by the Russians, who viewed the newcomers as poachers (Sherwood 1974). Foreign competition was minor, however, and the major rivalry was between two competing Russian merchant firms, those of Shelikhov-Golikov and Lebedev-Lastochkin. In 1791 Alexander Baranov became manager of the Shelikhov-Golikov company, and by 1799 his firm received a monopoly on all business in Alaska. The newly-privileged firm was designated as the "Russian-American Company." As Fedorova (1971) notes, "the Russian government was interested in transforming the still sparse network of fur trading factories into support bases on the Aleutian Islands and in northwestern America. In this the government interests coincided with those of influential groups of Russian merchants, which had acquired the experience of exploiting fur trade resources in the Pacific Ocean waters." By 1867 the Russian-American Company had set up posts at approximately 34 populated points in Alaska. In the Cook Inlet region, one-man posts were established at various points on Kodiak Island and at Afognak, Ukamok, Katmai, Nushagak, Iliamna, and Mednovsk. A redoubt stood at Kenai and a fort at Elena.

Overexploitation of the natural resources of Alaska led to a decline in the fortunes of the Russian-American Company during the period prior to 1867. The Crimean War had brought Imperial Russia to the brink of financial ruin and had shown that Russia was unable to protect her remote possessions against a strong naval power. Russian officials felt that Alaska was a liability and that the most effective means of disposal was a sale of the territory to the United States. This course of action, they believed, would thwart any ambitions of Great Britain and would strengthen the position of the United States in the Pacific (Hulley 1970). "The friendly state of Russian-American relations facilitated the sale of Alaska to the Americans, but there is no truth in the legend that

the Russians sold Alaska primarily because they loved the United States. The Czar and his advisors decided to unload their American possessions in such a way as to secure the maximum benefits to the Russian Empire. The United States fitted better than any other power into their schemes, and in pushing the sale they naturally capitalized on the warm friendship that had developed between Russia and United States during the 1860s" (Hulley 1970). Negotiations between the two nations took place during March 1867, and the highly secret talks resulted in an agreement by the United States to purchase Alaska for the sum of $7,200,000. The treaty for the sale was signed on 30 March 1867. Ratification by the Senate met with only minor opposition. Passage of an appropriations measure by the House of Representatives was stalled by lengthy debate, and the payment of the agreed-upon sum did not take place until the summer of 1868. Alaska was formally turned over to the United States on 18 October 1867, at a ceremony in Sitka, Alaska.

3.6.1.3. American period

The new territory of Alaska was placed under the control of the War Department and was governed by the US Army from 1867 to 1877. For many years, executive orders were the only legislation for Alaska. The Customs Act of July 1868 was the only body of law during the early years of Alaska. Throughout this period, the general feeling of the Congress was that Alaska was of little value, was too distant, and was too sparsely populated to merit much attention. The last American military detachment in Alaska was removed in 1877, and for the next seven years the territory of Alaska was under the control of a US customs collector at Sitka and a US Navy captain. In May of 1884 a bill entitled "An Act Providing a Civil Government for Alaska" was passed by the Congress and was signed into law by President Arthur. According to Hulley (1970), "the law, solely judicial in purpose, was designed rather to regulate the administration of privileges to the territory."

The next 20 years saw much exploration and prospecting in Alaska. In particular, the gold strikes in the Klondike region and at Nome spurred the influx of individuals seeking to "make their fortune." Many did not stay, but the search for precious metals resulted in the opening of new lands. "Boom towns" sprang up wherever discoveries were made. Many later were abandoned, but some continued to exist, as in the case of Juneau and Nome. The gold strikes almost literally put the Alaskan region "on the map." They demonstrated that the territory that had been considered worthless held many natural riches. The full extent of those riches still is not completely known.

In the Lower Cook Inlet area, the Modern American period has been characterized by resource discovery and exploitation. The fur trade of the early days has given way to coal extraction, fishing, gold, and chromite mining, and finally to the development of oil and natural gas fields. The study area has experienced rapid growth during the most recent phase of Americanization.

3.6.1.4. Sites in the National Register of Historic Places

Alaska has a wide variety of sites that are of National, State, or local significance. The Lower Cook Inlet study area contains hundreds of

such sites. Some are listed in the National Register of Historic Places, others have been designated as "eligible" for that register, and still others have been classified as possible National Register candidates. Information available from the Alaska Division of Parks, DNR, lists five sites within the study area as included in the National Register of Historic Places. Two other sites are described as "eligible," and six sites are indicated as possible candidates. In addition, there is one site that is designated as a National Historic Landmark.

Pursuant to Alaskan Statutes and an agreement with the US Department of the Interior, the State of Alaska has undertaken a state-wide survey of historic and prehistoric properties in Alaska, regardless of ownership (Alaska Department of Natural Resources 1978a). The results of that work are included in the Alaska Heritage Resources Survey (AHRS). When professional judgement indicates that a site fulfills minimal criteria in any one of a variety of categories, the property is included in the AHRS data file.

> All archaeological sites are entered in the belief that any one of them may yield information important in history and prehistory. Extant historical features associated with local, state, national, or international events or personages; commemorative locations to which popular importance is attached; and loci of phenomena reported in folk tradition are also recorded (Alaska Department of Natural Resources 1978).

The magnitude of the problem of identifying and listing important sites in the AHRS is exemplified by the observation that "the inventory is, however, an incomplete listing of known sites (perhaps by a factor of more than 50 percent) and individual entries exhibit a high probability of inaccuracy" (Bureau of Land Management 1977a). The AHRS lists over 300 sites in, or adjacent to, the study area, and additional sites are added as they are identified and evaluated.

Another important survey was conducted in 1975 — the Cook Inlet Region Inventory of Native Historic Sites and Cemeteries. The inventory contains 220 sites in the Cook Inlet region, many of which are within the study area boundaries. Although there is a considerable overlap between the Cook Inlet inventory and other listings (such as the AHRS), the Cook Inlet inventory team made 51 original site identifications (Cook Inlet Native Corporation 1975).

It is beyond the scope of the present study to include detailed information on all sites of cultural, historical, or archaeological importance. Because of the likelihood of the discovery of additional sites, and because some sites may be added to the National Register in the future, it is important that contact be established with State and local historians and agencies on a case by case basis when an application is reviewed by USEPA personnel.

4.0. SUBAREA RATIONALE

The study area includes a large part of the Cook Inlet and of the adjacent lands. Because the study area is large (approximately 10,000 square miles) and encompasses several diverse geologic, biologic, geographic, and socioeconomic environments, the information in this report is presented both for the entire study area as a regional profile and for selected areas as Subarea profiles. The rationale for the division of the study area into six land Subareas and four marine Subareas includes:

- A logical method of presenting more homogeneous data on the topic discussed
- Less generalization and, consequently, less dilution of the specific data available
- More convenient and useful product for USEPA's use in understanding the local factors important to NPDES permit decisions.

The Subareas were selected because of their common characteristics. Subarea I contains the two largest cities in the study area, and virtually all of the hydrocarbon processing facilities in the Cook Inlet region. The most potential for future development and consequently for NPDES permit applications occurs in this subarea. Although Subarea II has landforms similar to Subarea I, the area is more rural. Growth in this Subarea is dependent on the future of Homer, and Homer's future is joined inextricably with the results of Lower Cook Inlet petroleum exploration, the future development in the fishing industry, and the popularity of the area to tourists. Subarea III is distinguished by a wide, flat-bottomed valley with many wetlands and few people. There are no communities, schools, public facilities, or significant roads in this subarea. Subarea IV is distinguished by rugged terrain and is characterized by glaciers in the eastern part and small fishing villages along the coast. Subarea V encompasses the extensive Bachatna tidal flats west of Cook Inlet. Sparse development and valuable estuarine wetlands distinguish this Subarea. Subarea VI contains the remaining land in the study area west of Cook Inlet. It includes rugged mountains, extensive glaciers, and short, glacier-carved floodplains. Subarea VII is a marine Subarea with extreme depths and is strongly influenced by the Gulf of Alaska. Subarea VIII is a broad, shallow embayment of the western shoreline of Cook Inlet with a rocky, rugged bottom. Subarea IX is located on the eastern shoreline of Cook Inlet and encompasses the extremely productive waters of Kachemak Bay. Finally, Subarea X includes the large estuarine part of Cook Inlet where the silt-laden waters of Upper Cook Inlet mix with clearer, more saline marine waters from the Gulf of Alaska.

5.0. SUBAREA I

The two largest cities in the study area, most of the proven petroleum and natural gas reserves in the study area, and virtually all of the hydrocarbon processing facilities in the Cook Inlet region are in Subarea I. More than half of the population of the study area and nearly all of the heavy industry also are in Subarea I; consequently, there is more information on the resources in Subarea I than for any other subarea.

5.1. Subarea I Boundaries

Cook Inlet forms the western boundary of Subarea I, and the Kenai National Moose Range surrounds most of the remainder of Subarea I. The northern boundary is defined by the study area boundary. The southern boundary is in the transitional zone between the Kenai-Soldotna population center of Subarea I and the Homer "urban field" in Subarea II. This boundary also is a logical separation between the lower, rolling terrain of the northern Kenai Lowlands and the more elevated terrain farther south. The Subarea I boundaries are indicated on the topographic map (Figure 25; adapted from Joint Federal-State Land Use Planning Commission 1973b).

5.2. Physical Environment

5.2.1. Landforms

Subarea I contains low hills; broad, level plains; bogs and muskegs; and many small lakes. Although elevations never exceed 500 feet above mean sea level (msl), many of the hills are steep or extremely rough and hummocky. The topography of Subarea I is shown in Figure 25. Thin lignite beds of the Kenai Group (Tertiary Period) outcrop at a few locations in the southern and eastern parts of Subarea I. However, throughout most of Subarea I the bedrock surface is buried by thick glacial, alluvial, and aeolian deposits.

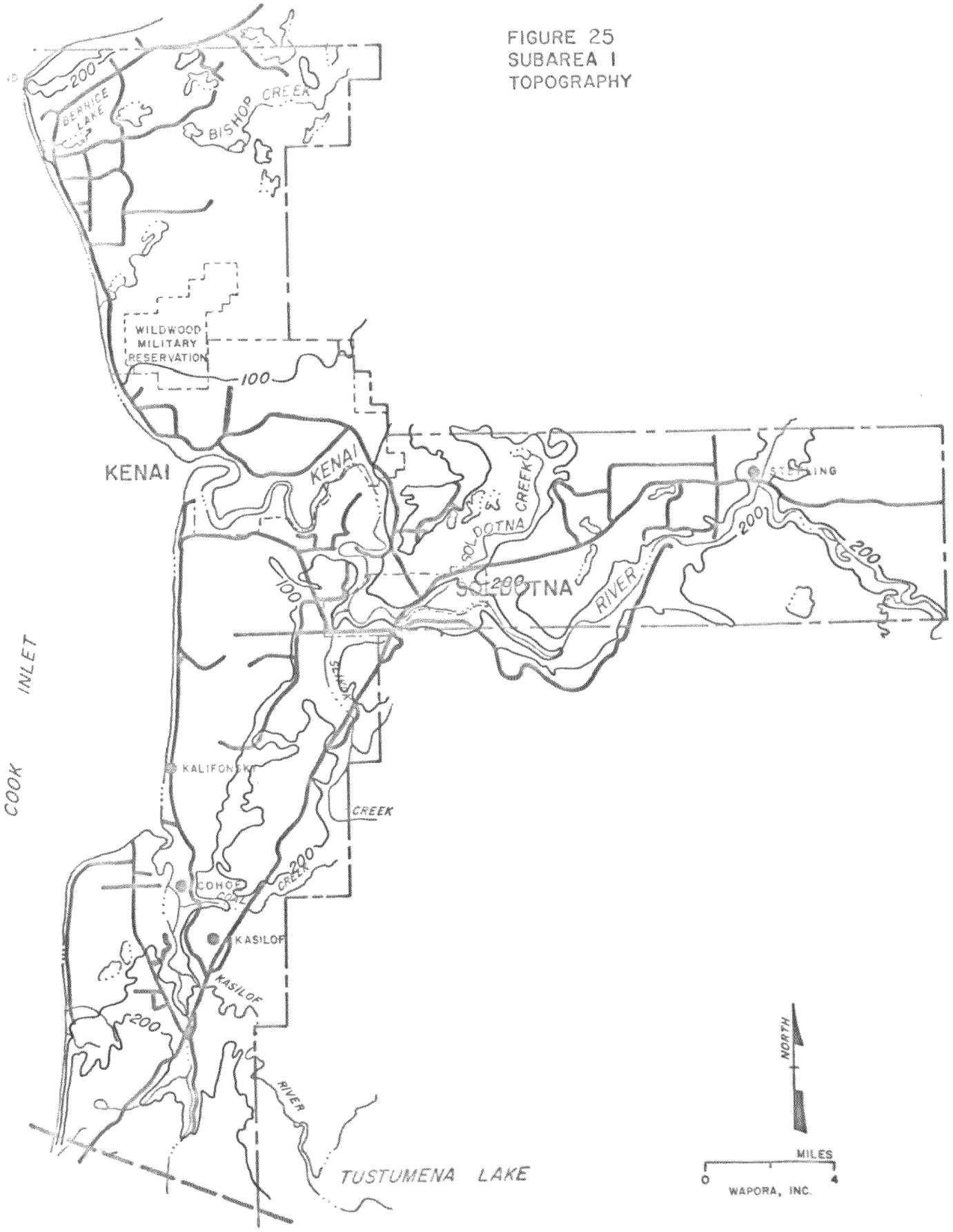
Most of Subarea I is covered by forest. Other types of vegetation include low shrubs and sphagnum moss associated with muskeg environments, and sedges, grasses, and forbs that grow near the mouth of principal streams. Suitable agricultural land may be found on broad plains bordering major rivers, on much of the western coastline, and on many less steeply sloping hillsides.

5.2.2. Geology

5.2.2.1. Bedrock geology

The bedrock surface of Subarea I is composed predominantly of rocks of the Beluga (Miocene) and Sterling (Miocene-Pliocene) Formations of the Kenai (Tertiary) Group (US Army Corps of Engineers 1978). The section of the Kenai Group in Subarea I consists of alternating strata of moderately indurated sand, silt, clay, and lignite. The depth to bedrock is extremely variable. The bedrock outcrops as sea cliffs and river bluffs near the southern border of Subarea I. Northward, the depth to bedrock increases to a maximum of approximately 700 feet near the City of Kenai, then gradually decreases to a minimum of approximately 300 feet near the northern boundary of Subarea I.

FIGURE 25
SUBAREA I
TOPOGRAPHY



5.2.2.2. Surficial geology

The surficial geology of Subarea I is mapped in Figure 26 (adapted from Magoon and others 1976). Surficial deposits of the study area include glacial moraine, outwash, coastal plain, abandoned channel, terrace and floodplain, and aeolian deposits. Lake, swamp, and aeolian deposits are not shown in Figure 26, because they occur as thin veneers. Although at most places the unconsolidated deposits differ in form, physical characteristics, and water-bearing properties, not all deposits can be classified precisely. Morainal deposits are transitional to outwash and shore deposits, which in turn are transitional to alluvium. Locally, moraine and outwash deposits are closely associated and are mapped as a single unit.

Two anticlines known to extend through the study area also are indicated in Figure 26. One runs north-south near Kenai and the other runs northeast-southwest immediately east of Soldotna. A buried fault (running northeast-southwest) occurs in the eastern part of Subarea I. Although some Triassic and Permian metamorphic and volcanic rocks have been mapped in the Chugach Terrain of the Kenai Peninsula, none are known to exist within Subarea I.

5.2.2.3. Soils

The soils of the Kenai-Kasilof area can be categorized into three general groups according to their topographic position: upland soils, mineral soils of depressions and valley floors, and soils of muskegs or bogs. Upland soils are excessively-drained to moderately well drained, silt loam to sandy loam soils on the uplands and terraces. Depressions and valley floors contain imperfectly-drained to very poorly drained, mineralized, silt loam to sandy loam soils. Soils of muskegs or bogs consist predominantly of poorly-drained and very poorly drained peat. In this section the soils of Subarea I are discussed in terms of wetland classification and their suitability for development and agriculture. The soil survey of the Kenai-Kasilof Area (Rieger and others 1962) was the only source of information for this discussion.

Wetlands

Twenty-eight soil series have been recognized and mapped in Subarea I. Twelve have constant water at depths of 1.0 foot or less. Soil series in this category include Clam Gulch silt loams, Clunie peat, Doroshin peat, Foreland silt loam, gravelly beach, Kalifonsky silt loam, Moose River silt loam, Moose River silt loam shallow, Salamatof peat, Salamatof peat forested, tidal flats, and tidal marsh. Field investigations conducted by WAPORA, Inc. in 1977 indicated wetland vegetation associated with these soil series. These twelve soils and the associated vegetation were the bases for delineation of the areas considered as wetlands for the Corps of Engineers Section 10 and Section 404 permit evaluations.

Agricultural soils

There are no prime (Class I) agricultural soils in Subarea I. Soils categorized as Class II or Class III soils are sold as agricultural land

GEOLOGY

SYNCLINE

Qs
KJm

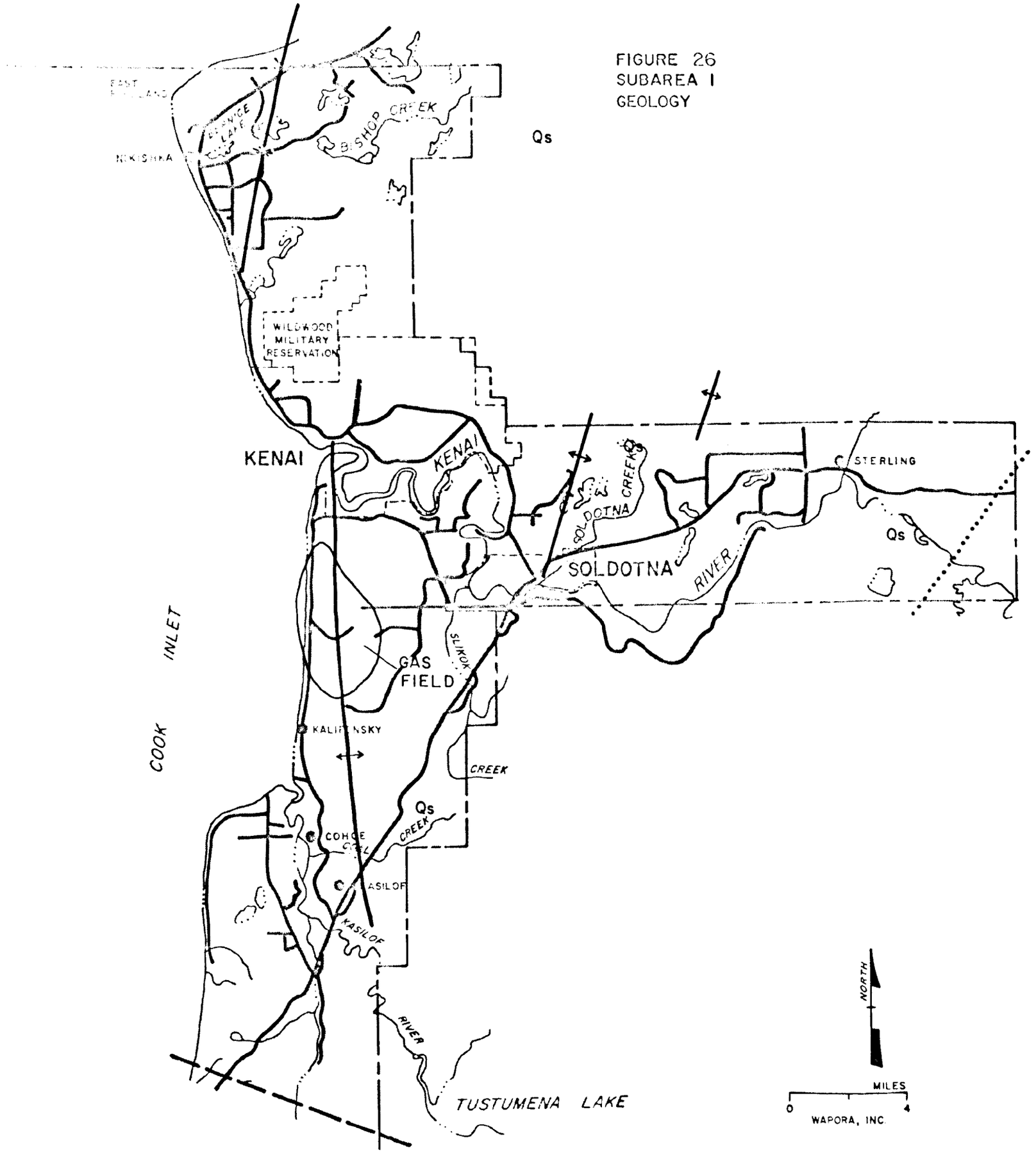
CONTACT

ANTICLINE

NORMAL FAULT - DOTTED WHERE CONCEALED
U - UPTHROWN SIDE
D - DOWNTHROWN SIDE

THRUST OR REVERSE FAULT - DOTTED WHERE CONCEALED
SAWTEETH ON UPTHROWN BLOCK

FIGURE 26
SUBAREA I
GEOLOGY



by the State of Alaska. Class II and Class III soils in Subarea I include:

Soil Type	Class
• Boulder Point very fine sandy loam, gently sloping	II
• Cohoe silt loam, nearly level	II
• Cohoe silt loam, gently sloping	II
• Cohoe silt loam, moderately sloping	III
• Island silt loam, nearly level	II
• Island silt loam, gently sloping	II
• Kenai silt loam, nearly level	III
• Kenai silt loam, gently sloping	III
• Longmare silt loam, nearly level	III
• Longmare silt loam, gently sloping	III
• Naptowne silt loam, nearly level	II
• Naptowne silt loam, gently sloping	II
• Naptowne silt loam, moderately sloping	III
• Nikishka silt loam, nearly level	III
• Nikishka silt loam, gently sloping	III
• Pincher silt loam	III
• Soldatna silt loam, nearly level	II
• Soldatna silt loam, gently sloping	II
• Soldatna silt loam, moderately sloping	III
• Tustumena silt loam, nearly level	II
• Tustumena silt loam, gently sloping	II
• Tustumena silt loam, moderately sloping	III

These soils are mapped in Figure 27 (adapted from Rieger and others 1962). No data are available that define the location or total area of land currently in agriculture, but informal observations indicate that most of this land in Subarea I is undeveloped or is developed for uses other than agriculture.

5.2.2.4. Geologic resources

The major mineral and hydrocarbon resources of Subarea I are mapped in Figure 28 (adapted from Joint Federal-State Land Use Planning Commission 1973b). Currently, extraction of geologic resources from Subarea I is limited to gas and petroleum extraction (mostly from lands adjacent to Subarea I) and extraction of gravel and other fill and building materials.

Petroleum and natural gas

Petroleum and natural gas fields in the adjoining Upper Cook Inlet lie between Kalgin Island and the Susitna River. Although most of the producing fields in the area lie offshore, significant amounts of petroleum and natural gas are produced from the Kenai Lowlands. The second-largest producing oil field, the Swanson River Field, lies to the north of Subarea I. This field contains about 60 million bbl in recoverable reserves of oil and 300 million Mcf in recoverable reserves of natural gas (Magoon and others 1976). The Kenai Gas Field, located about 6 miles south of Kenai, contains reserves of over 2 billion Mcf and is the largest producing gas field in the Cook Inlet region. The oil and gas fields that exist within Subarea I or in the immediate vicinity are listed in Table 26.

PRIME AGRICULTURAL SOILS

CLASS II AND III AGRICULTURAL SOIL

FIGURE 27
SUBAREA I
PRIME AGRICULTURAL SOILS

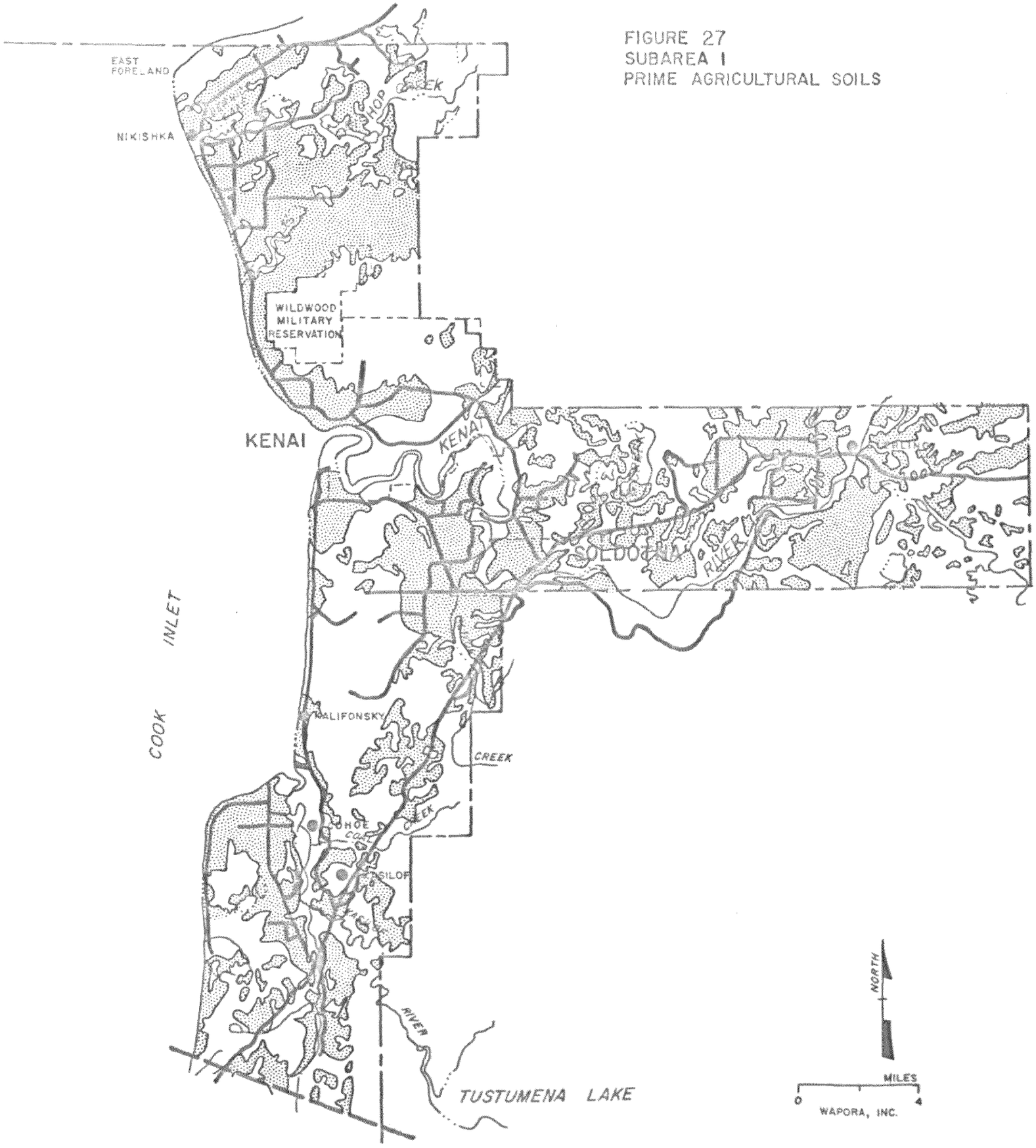


Table 26. Petroleum and natural gas fields in or near Subarea I (Magoon and others 1976).

		Cumulative Production to 12 December 1975		Recoverable Reserves
Oil Fields	Status	Oil (bbl)	Casinghead gas (Mcf)	Oil (bbl)
Beaver Creek	Producing	1,114,905	387,080	--
Swanson River	Producing	163,099,388	528,772,426	60,101,000
Gas Fields	Status	Dry gas (Mcf)	Natural gas liquids (bbl)	Dry gas (Mcf)
Beaver Creek	Shut-in	291,516	--	400,000,000
Birch Hill	Shut-in	65,331	--	20,000,000
Kenai	Producing	639,619,605	9,888	2,250,000,000
Sterling	Producing	1,848,006	--	200,000,000
Swanson River	Shut-in	11,839,353	--	300,000,000
West Fork	Shut-in	--	--	100,000,000

MINERAL RESOURCES

MAJOR MINERAL

SECONDARY MINERAL

MINERAL PROVINCE BOUNDARY

COAL PROVINCE BOUNDARY

COAL PROVINCE BOUNDARY IN WATER

PETROLEUM PROVINCE BOUNDARY

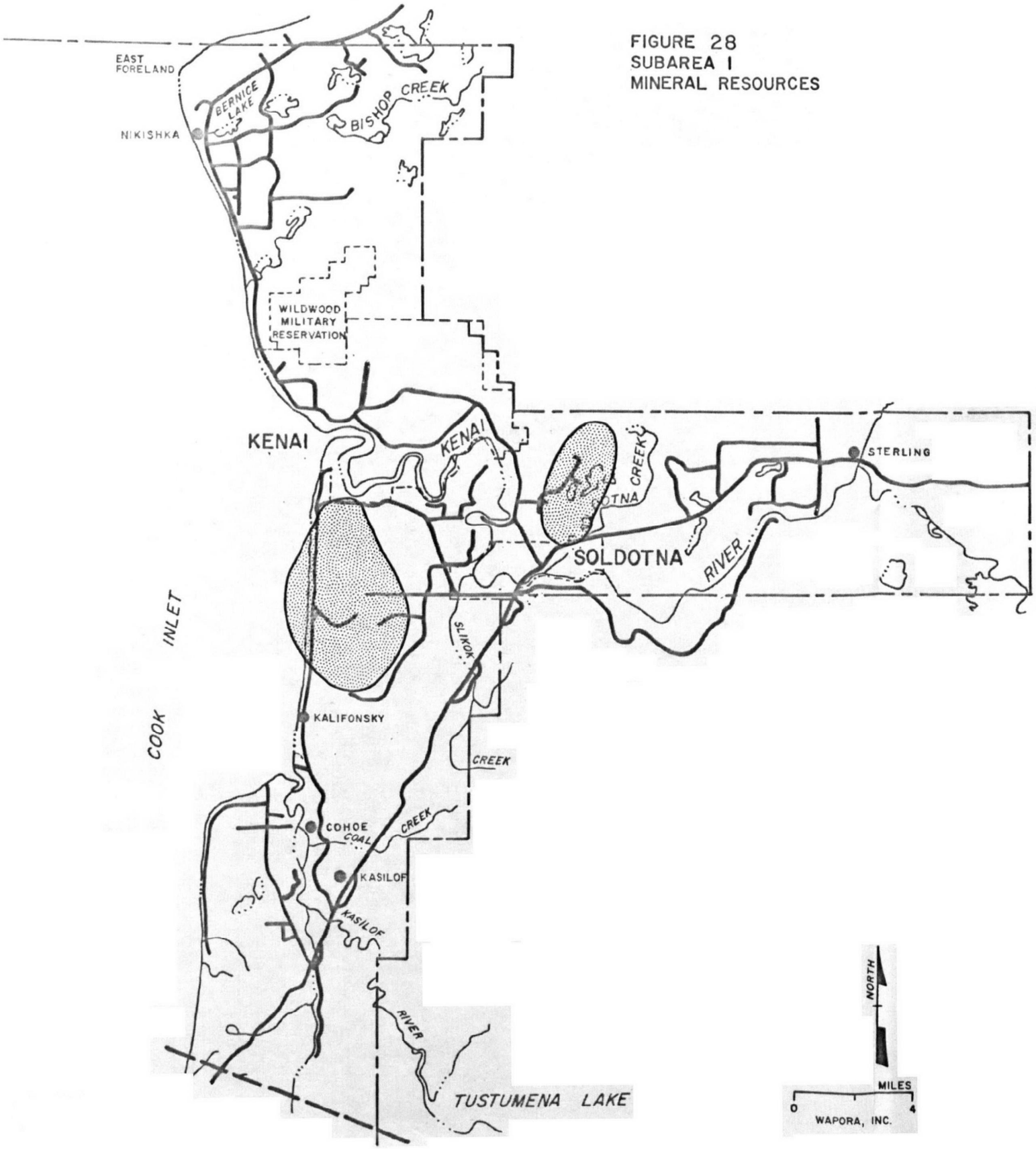
COAL FIELD

OIL FIELD

GAS FIELD

POTENTIAL GEOTHERMAL AREA

FIGURE 28
SUBAREA I
MINERAL RESOURCES



Eighty percent of the oil and gas production comes from the Hemlock Conglomerate (Late Tertiary), and much of the remaining 20% comes from the overlying Tyonek Formation. All fields are associated with major anticlines, which act as structural barriers or traps to the migration of hydrocarbons within the reservoir rock.

Coal

The western half of the Kenai Peninsula (the Kenai Lowlands) is underlain by considerable quantities of lignite to subbituminuous coal (Rao and Wolff 1975). In the southern part of the Kenai Lowlands, near Homer, coal beds are exposed at the surface. However, the most favorable coal-bearing section in Subarea I occurs only in the subsurface, where valuable coal reserves are not economically recoverable at the present time. McGee and O'Connor (1975) proved the intensity and continuity of the coal-bearing section under Cook Inlet. Resource estimates for the Beluga-Cook Inlet-Kenai region are 100 billion tons to the 2,000-foot depth and 1.7 trillion tons to the 10,000-foot depth.

Metallic resources

Placer deposits have been found in the foothills of the Kenai Mountains and southeast of Skilak Lake. Principal minerals were gold, silver, tungsten, and chromium. Based on available information, however, the exploitability of these deposits is not yet public (US Army Corps of Engineers 1978; Joint Federal-State Land Use Planning Commission 1974c). There are no known metallic mineral deposits in Subarea I.

Nonmetallic and industrial minerals

River gravel deposits generally are suitable as sources for road and concrete aggregate. Potential source areas of river gravel in the Kenai Lowland generally lie along the lower reaches of major streams and rivers. Glacial material may or may not be suitable for backfill material; suitability generally is determined on the basis of size distribution and the nature of the intended use. Glacial deposits generally are not suitable as economic sources for road and concrete aggregate because of the inordinate effort required to remove fines and other harmful materials.

Deposits of diatomaceous earth that may be developable commercially occur near the City of Kenai. This resource has not been developed.

5.2.2.5. Geologic hazards

Several types of geologic hazards exist in the Kenai Lowlands. Many are related directly to, or are made more severe by local earthquake activity. Those hazards include earthquake shocks, ground fissures, ground subsidence or uplift, earthquake-induced tidal waves, and ground failure. Other hazards, such as those associated with volcanic activity, most flooding, and erosion, are independent of local earthquake activity. The identified geologic hazards in Subarea I are indicated in Figure 29 (adapted from Alaska Department of Natural Resources 1978b).

GEOLOGIC HAZARD

LANDSLIDE AND SLUMP

VOLCANIC AREA

FAULT ZONE

COASTAL EROSION

TSUNAMI HAZARD

EXTENT OF ICE

AREA OF SUBSIDENCE

POTENTIAL MELTWATER AND RUNOFF FLOODING

POTENTIAL GLACIAL OUTBURST FLOODING

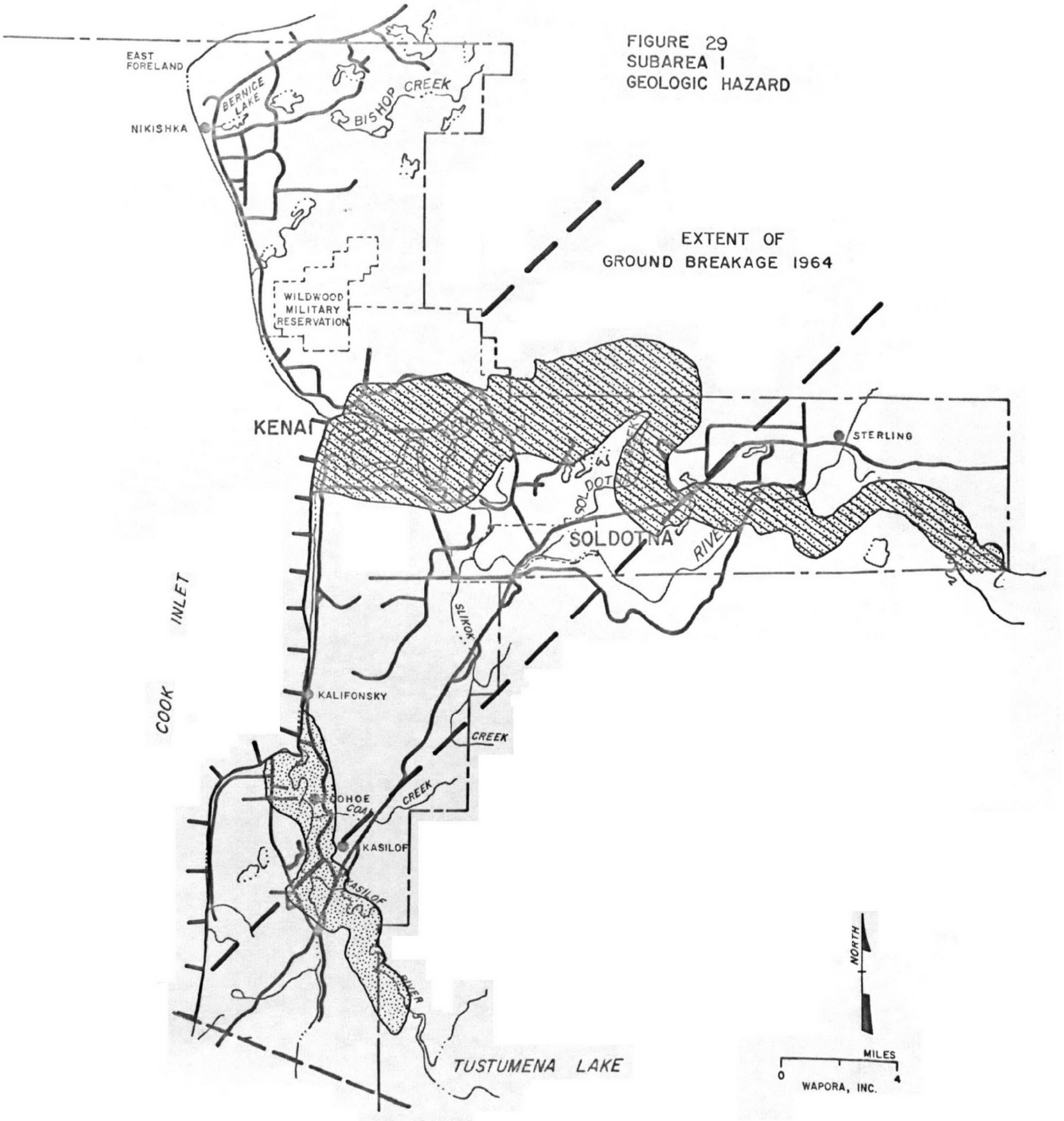


FIGURE 29
SUBAREA I
GEOLOGIC HAZARD

EXTENT OF
GROUND BREAKAGE 1964

The Kenai Lowlands are included in Seismic Risk Zone 3, defined as areas susceptible to earthquakes of Richter magnitude 6.0 to 8.8 and where major structural damage could occur. The last major earthquake to affect the Kenai Lowlands occurred on 27 March 1964 near Prince William Sound, and registered a Richter magnitude of between 8.3 and 8.7. Since 1899, 82 earthquakes of Richter magnitude 6.0 or more have occurred in the Cook Inlet area.

Earthquake shocks, or ground shaking, can produce heavy damage to man-made structures. Susceptibility of the ground to intense shaking usually is highest in areas underlain by saturated unconsolidated sediments and lowest in areas underlain by solid bedrock. Ground shaking also can destroy the competency of unconsolidated sediments, and thereby produce landslides, mudslides, avalanches, and ground fissures or cracks.

Foster and Karlstrom (1967) reported extensive ground fissures and groundwater eruption from the 1964 earthquake in the Kenai Lowlands study area. They speculated that the fissuring could be located over a buried fault. Tysdal (1976) cited extensive geophysical evidence to refute the buried fault hypothesis, but offered no independent explanation of the phenomenon.

Earthquakes may accompany permanent movement of the ground surface, either horizontally or vertically, or a combination of both. These movements may occur as relative displacement along a fault, or as a change in ground surface elevation. After the 1964 earthquake, it was found that ground surface elevations had been lowered by as much as 2 feet in the Kenai Lowlands, and by as much as 6 feet in the Kenai-Chugach Mountains.

Horizontal displacements of up to 70 feet were recorded in the vicinity of the earthquake epicenter at Prince William Sound. Horizontal surveys for the Kenai Lowland were not reliable enough to yield meaningful displacement data. Moreover, these displacements did not necessarily take place along known or suspected faults, although they were related to the fault distribution pattern in a complex way (Plafker 1969).

Tsunamis or seismic sea waves are produced by displacement of large volumes of sea water either by uplift of the sea floor or by landslides. Tsunamis produced by the 1964 earthquake caused extensive damage along the coast of the Kenai Peninsula, and a wave of 30 feet was reported to have run up on the shore of Kenai Lake (Plafker 1969). Historically, Subarea I has been less affected by earthquake-induced tsunamis and flooding than most other regions of the study area.

There is no evidence of any volcanic activity in the Kenai Lowlands. However, eruptions from Mt. St. Augustine, Mt. Iliamna, Mt. Douglas, Mt. Redoubt, and Mt. Spurr may have regional effects that would be felt in Subarea I. Regional damage would be in the form of ash falls or from tsunamis generated by lava flows or mud flows into shoal waters (Bureau of Land Management 1976).

Flooding of rivers due to ice jams, spring thaw, and storm events also presents a significant problem. One of the most serious types of flooding results from the sudden release of water from lakes that are

dammed by glaciers. These sudden surges, termed glacial outbursts, present a serious hazard to property and human life.

During the spring and summer, meltwater runoff and runoff from heavy rains may cause flooding. During the winter, ice jams may block river channels and cause severe flooding. The highest flood level recorded in the Kenai River (22.62 feet above gauge height at Soldotna) occurred when an ice jam dammed the river. Glacial outbursts may cause flooding during any season, but are most frequent during the late summer. Glacial outbursts on the Kenai River system are from two sources: an unnamed lake blocked by the Skilak Glacier and an unnamed lake blocked by a glacier on the Snow River (Post and Mayo 1971). The record-setting maximum discharge reported for the Kenai River (33,100 cubic feet per second) occurred after the simultaneous outburst of these glacial lakes. Outbursts also may cause flooding in the Tustumena Lake-Kasilof River system, but Tustumena Lake is large enough to ameliorate some of the impact.

5.2.3. Hydrology

5.2.3.1. Surface water hydrology

The major river in Subarea I, and the largest river in the study area, is the Kenai River. It begins at the outlet of Kenai Lake, near Cooper Landing, and flows about 18 miles to Skilak Lake at an average gradient of 24.2 feet per mile. The Kenai River flows about 50 miles from the outlet of Skilak Lake to its mouth at Cook Inlet at an average gradient of 4.1 feet per mile. Ten tributaries enter the Kenai River:

- Beaver Creek at River Mile 10.5
- Slikok Creek at River Mile 19
- Soldotna Creek at River Mile 22
- Funny River at River Mile 30.5
- Moose River at River Mile 36.5
- Killey River at River Mile 44
- Skilak River at Skilak Lake (near River Mile 64)
- Russian River at River Mile 73.5
- Cooper Creek at about River Mile 79
- Juneau Creek at River Mile 79.5.

The Kenai River is subject to tidal action inland as far as River Mile 12 (Anderson and Jones 1972). Salinity in the lower reaches of the River is as high as 25 percent (Gatto 1976).

Streamflow in the watersheds of Subarea I is of two types: glacial streams that originate in the Kenai Mountians or Chugach Mountains and that derive much of their flow from snowfields and glaciers, and nonglacial streams that derive their flow from precipitation runoff. Flow in glacial streams is high, and reflects the larger precipitation in the mountains. At Cooper Landing the average flow of the Kenai River is equivalent to 58.4 inches of precipitation in the watershed. In contrast, the flow near the mouth of Beaver Creek, a nonglacial stream located entirely in the Kenai Lowlands, is equivalent to 5.89 inches of precipitation annually in the watershed (Anderson and Jones 1972). Glacial streams typically display a period of high flow during the summer months and a period of low flow during the winter months. Nonglacial streams generally exhibit high flows during late autumn and during the spring. Low flows occur in midwinter, and baseflow is maintained by groundwater recharge in the Kenai Lowlands and by discharge from large lakes in the mountains. The discharge records for all large streams in Subarea I are presented in Table 27.

Water quality

Surface waters of Subarea I are generally of good quality and can be classified as calcium-bicarbonate waters. Table 28 indicates that concentrations of all major dissolved solids generally are low. Suspended sediment loads are relatively low because the sediment settles in the large lakes (Anderson and Jones 1972).

The chemical characteristics of stream water vary with the volume of flow and with the proportion of groundwater recharge to surface runoff. In general, concentrations of dissolved solids decrease with increasing flow and increase with increasing groundwater recharge (Anderson and Jones 1972). Many small streams, such as Beaver Creek, have a wider range of dissolved solids concentrations than the Kenai and Kasilof Rivers. During low-flow periods, runoff is sustained by groundwater recharge, which is high in dissolved solids. During high flows, groundwater recharge is diluted with rain and snowmelt, which are low in dissolved solids. The Kenai River and the Kasilof River have little variation in dissolved solids because the principal source of runoff is snowmelt, which is regulated throughout the year by lake storage.

5.2.3.2. Groundwater resources

Sand and gravel in glacial drift, alluvial, and coastal plain deposits constitute excellent aquifers for the Kenai-Kasilof area. Available data indicate that groundwater from bedrock formations is not used within Subarea I. Groundwater in surficial deposits exists under both water table and artesian conditions.

Water-table aquifers

Water-table aquifers that range in thickness from 5 feet to 100 feet occur in most parts of Subarea I and can yield modest quantities of potable water (Anderson and Jones 1972). Recharge to the water table aquifers was estimated to range from 4 to 15 inches of precipitation.

Table 27. Discharge records for major rivers in Subarea I (USGS 1978).

River	Drainage Area (Mi^2)	Period of Record	Mean Annual Discharge (cfs)	Maximum Discharge (cfs)	Minimum Discharge (cfs)
Kenai River at Cooper Landing	634.0	1947-1975	2,677.0	23,100.0[a]	190.0[b]
Kenai River at Soldotna	2,010.0	1965-1975	5,365.0	30,000.0	770.0
Beaver Creek near Kenai	51.0	1967-1975	26.6	598.0	8.2[c]
Killey River near Sterling	-	2 Nov. 1967	233.0	-	-
Funny River near Soldotna	-	1968-1970	55.0	107.0	30.0
Moose River at Sterling	-	1951-1968	96.6	128.0	62.0
Soldotna Creek near Soldotna	40.4	1968-1971	12.1	16.0	8.8
Slikok near Soldotna	-	1968-1971	4.8	9.3	0
Bishop Creek near Kenai	33.9	1968-1971	14.7	30.0	4.2
Swanson River NE of Kenai	-	1968-1970	43.6	98.0	22.0
Kasilof River near Kasilof	738.0	1949-1970	2,385.0	12,300.0	19.0

[a]Glacial outburst.

[b]No flow on 27 and 28 March 1964 due to earthquake.

[c]Temporary ice storage.

Table 28. Selected chemical analyses of surface water in the Kenai-Soldotna region of Subarea I (Anderson and Jones 1972).

Site Number and Location	Date of Collection	Mean Discharge (cfs)	Silica (SiO_2)	Iron (Fe)	Calcium (Ca)	Magnesium (Mg)	Sodium (Na)	Potassium (K)	Bicarbonate (HCO_3)	Sulfate (SO_4)	Chloride	Fluoride	Nitrate (NO_3)	Dissolved Solids (residue at 180°C)	Hardness as $CaCO_3$		Specific Conductance (micro-mhos at 25°C)	pH	Color
															Calcium, magnesium	Noncarbonate			
15-2420 Kasilof River near Kasilof	12 Dec 1957	2,020.0	5.0	0.17	4.8	1.2	1.6	1.7	20	3.0	1.0	0.0	0.3	28	17	0	43	6.6	20
15-2661 Kenai River at Skilak Lake Outlet	2 Nov 1967	3,230.0	3.1	0.60	10.0	0.8	0.7	1.0	27	6.0	0.4	0.0	0.7	36	29	7	64	7.2	5
15-2661.2 Killey River near Sterling	2 Nov 1967	233.0	9.8	0.20	8.2	1.0	3.1	0.7	26	7.0	1.4	0.0	1.2	46	25	4	71	7.1	0
15-2661.6 Kenai River near Sterling	2 Nov 1967	3,150.0	3.6	0.53	10.0	0.8	0.8	0.9	28	8.0	0.4	0.0	0.6	39	29	6	64	7.3	5
15-2661.8 Moose River near Sterling	1 Nov 1967	126.0	15.0	0.69	23.0	4.2	4.2	1.3	98	0.0	0.7	0.1	2.6	99	76	0	159	7.8	10
15-2662.1 Funny River near Soldotna	1 Nov 1967	107.0	18.0	0.91	10.0	3.6	3.0	0.9	54	0.0	0.4	0.0	0.6	64	41	0	93	7.3	15
15-2662.9 Soldotna Creek at Soldotna	2 Apr 1968	15.6	29.0	0.83	19.0	5.3	5.5	2.3	96	0.0	1.4	0.1	0.4	111	70	0	158	7.4	15
15-2662 Kenai River at Soldotna	7 Nov 1970	5,980.0	3.5	*0.03	9.8	1.0	1.6	1.0	29	6.3	0.0	0.1	1.2	39	29	5	69	7.0	0
15-2662 Beaver Creek near Kenai	1 Oct 1970	19.9	28.0	*1.20	18.0	3.9	5.1	2.1	79	3.0	3.5	0.2	0.1	106	61	0	137	8.0	20
15-2669 Bernice Creek near Kenai	3 Apr 1968	1.3	20.0	0.51	7.8	2.4	3.9	1.8	38	1.0	5.3	0.1	0.3	62	30	0	85	7.0	5
15-2670 Bishop Creek near Kenai	30 Sep 1970	15.1	14.0	*0.70	12.0	2.9	4.2	1.6	51	3.0	3.2	0.2	0.3	66	42	0	100	7.4	10
15-2670.5 Swanson River near Sterling	2 Dec 1958	--	15.0	1.10	21.0	5.5	6.5	1.8	103	1.0	3.5	0.1	0.3	107	75	0	171	7.0	45
15-2671.6 Swanson River near Kenai	20 Aug 1969	--	16.0	*0.48	29.0	6.4	10	2.5	140	0.4	3.5	0.1	0.0	129	99	0	229	8.3	--

Following infiltration, flow in the water-table aquifer is from areas of recharge, which typically are permeable topographic highs, to topographically lower areas of discharge. Discharge from the water-table aquifer occurs from a number of seeps along the cliffs of Cook Inlet and the banks of the Kenai River, where underlying clay forces water to the surface, and as groundwater recharge of streams. Groundwater recharge constitutes the base flow of the streams in the Kenai Lowlands. Available data are limited, but Anderson and Jones (1972) report that groundwater recharge to Beaver Creek was equivalent to 4 inches of precipitation during the 1969 and 1970 water years.

The water table in Subarea I shows marked seasonal fluctuations and long-term fluctuations that result from changes in precipitation. The water table usually is highest during the latter part of the summer and the early autumn. This period corresponds with the rainy season in the Kenai Peninsula. Recharge rates to the aquifer are reduced after the ground freezes in autumn. The lowest water-table levels, therefore, normally occur during the early spring. As the ground thaws, recharge to the water-table aquifer resumes, and the water table rises.

The elevation of the water table also responds to changes in precipitation. From the autumn of 1967 to the winter of 1970, the water table dropped 4 feet. During the same interval, the precipitation deficit was 18 inches (Anderson and Jones 1972).

Artesian aquifers

During 1970, about 2.8 million gallons per day (mgd), or 82 percent of the 3.4 mgd pumped came from artesian aquifers 100 feet to 300 feet below the surface. The artesian aquifers underlie sediments composed of clay, silt, and till that act as semipervious beds and retard the free flow of water vertically. These leaky, confining beds, many of which were deposited directly by glaciers, range from 20 feet to 100 feet in thickness. The artesian aquifers are discontinuous beds of fine sand that are interbedded with coarse sand or gravel. Although they are discontinuous, and some may be lens-shaped, the artesian aquifers are hydraulically connected. They form an artesian system that extends over much of the Kenai Lowlands.

5.2.3.3. Water supply

The major consumers of water in Subarea I are the Cities of Kenai and Soldotna and the industrial complex north of the City of Kenai. The City of Kenai is situated on outwash and coastal plain shoreline sediments. The principal aquifer is unconfined, ranging in thickness from 10 feet to 80 feet. Water pumpage in Kenai was estimated to be about 200,000 gpd during 1970, almost all from the water-table aquifer; the estimated sustainable yield ranges from 2 mgd to 7 mgd (Anderson and Jones 1972).

Water pumpage from the area of Soldotna is principally from the artesian aquifer, which consists of up to 60 feet of sand and gravel occurring from 75 feet to 220 feet below the surface. Well yields from the artesian aquifer range from 10 gpm to 516 gpm. Although there has

been a decline of the potentiometric head of the artesian aquifer in the vicinity of the high-yield wells, the decline is normal and there may be sufficient groundwater for future development.

The industries north of the City of Kenai use approximately 3 mgd of groundwater, and total usage in the area has been estimated to be approximately 4 mgd (Federal Power Commission 1976). It has been suggested that this withdrawal rate may exceed the recharge rate during drought years. The question is complicated by the possibility that more than one aquifer may be contributing groundwater to existing users and by the lack of data on the extent of the aquifers. The US Geological Survey is conducting a survey of the aquifers in Subarea I, which is expected to define the aquifers present and to evaluate the availability of groundwater for proposed new consumers in the area. The results of these investigations are expected to be available during 1979.

Groundwater quality

Water in the Kenai Lowlands varies in quality from excellent to objectionably hard, due to quantities of iron or chlorides. The most significant difference locally occurs between the water quality of the water-table aquifer and that of the artesian aquifer (Table 29). Water-table aquifers generally produce hard water (having carbonates and bicarbonates of calcium and magnesium) that may contain objectionable quantities of iron. Iron commonly is found in objectionable quantities in water-table aquifers along the coast and near Sterling; iron content is most objectionable from the water-table aquifer wells near the City of Kenai, where the aquifer is associated with poorly-drained, swampy areas.

The quality of water from artesian wells varies from superior to objectionable. Artesian-aquifer water often fails to meet one or more US Public Health Service standards for drinking water in the vicinity of the City of Kenai, as well as elsewhere along the coast of Cook Inlet (Table 29). Water from artesian aquifers near Cook Inlet may contain in excess of 250 milligrams per liter (mg/l) of chloride and may taste salty. The salty water probably was trapped in sediments when they were deposited, and the sediments have not been completely flushed by fresh water (Anderson and Jones 1972). Artesian water may contain objectionable quantities of iron near the inland recharge areas, but water from artesian aquifers is superior in the part of Subarea I between the recharge areas and the coastline.

5.3. Biological Environment

Subarea I has more industrial and residential development than any other area in the Lower Cook Inlet region. Because of this development, the importance of the Kenai River and other large streams in Subarea I to the commercial and recreational resources, and the proximity of the Kenai National Moose Range, Subarea I has been studied more thoroughly than the other subareas.

5.3.1. Vegetation

Eight biological communities, characterized by vegetation type, have been described in the Lower Cook Inlet study area (Joint Federal-State

Table 29. Relationship of 112 chemical analyses by geohydrologic groupings to US Public Health Service water quality limits (US-PHS 1962).

Water quality groupings	Iron		Dissolved solids		Chloride		Color		Percent with no excessive concen-trations
	Average mg/l	Percent greater 0.3mg/l	Average mg/l	Percent greater 500mg/l	Average mg/l	Percent greater 250mg/l	Average units	Percent greater 15 unit	
1. Water table aquifers (32 samples)	2.28	66	111	0	3.7	0	15	23	38
2. Artesian aquifers-generally suitable (50 samples)	0.52	52	203	0	18	0	15	26	38
3. Artesian aquifers-generally inferior quality (30 samples)	0.54	52	420	27	99	20	70	44	30

Land Use Planning Commission 1973a). Descriptions of the eight communities are presented in the biological profile for the region (Section 3.2.3.1.). All of these communities are found in the Kenai River drainage, and the following five are present in Subarea I:

- Upland spruce/hardwood
- Lowland spruce/hardwood
- High brush
- Muskeg
- Tidal marsh.

The upland spruce/hardwood and muskeg vegetation covers most of Subarea I. The bluffs along the Inlet are covered by upland spruce/hardwoods. Behind the bluffs, muskeg covers a wide belt of poorly-drained lowlands. Inland, the low hills along the Kenai River system are forested by white spruce and hardwoods on the well-drained hillsides and by black spruce and hardwoods or mixed black spruce, white spruce, and hardwoods on the poorly-drained terrain. Poorly-drained lowlands are muskegs in burned areas along the Kenai River east of Sterling. Reforestation has succeeded to the high brush stage. Where the coastal bluffs are dissected by the Kenai River and the Kasiloff Rivers, some of the mudflats along the meandering river courses support tidal marshes. The lower flats are scarred by tidal currents carrying abrasive silt and are nearly barren.

A vegetation map of Subarea I is presented in Figure 30 (adapted from Joint Federal-State Land Use Planning Commission 1973b). Vegetation may be more precisely defined through the use of the soil survey of the Kenai-Kasilof Area (Rieger and others 1962), which lists characteristic vegetation for each soil series, and in the files of the Alaska District Corps of Engineers (COE), which list vegetation inventoried on the Kenai River Lowlands and the associated soil types. The COE data are only for lowland soils near the Kenai River, but these data are recent and will serve to characterize vegetation on the soils for which they are available. These vegetation maps, plus the topographic maps and field observations by area biologists, are used to define wildlife habitats for land-use planning purposes and to produce the critical habitat maps that are presented later in this profile.

In Subarea I and in the surrounding Kenai National Moose Range, the upland spruce/hardwood and lowland spruce/hardwood forests are utilized directly by berry-pickers, and for firewood and building timber. Management includes timber sales, controlled burning, and tree-crushing to maintain the early successional stages that provide the most favorable moose feeding habitat. In southeastern Alaska, where logging is a major industry, acceptable logging methods, transportation methods, and buffer zones have been defined to protect the watersheds. These management techniques are applied to the Federal- and State-owned spruce/hardwood forests in Subarea I.

VEGETATION

	COASTAL WESTERN HEMLOCK/SITKA SPRUCE
1	UPLAND SPRUCE/HARDWOOD
2	UPLAND SPRUCE/HARDWOOD/LOWLAND SPRUCE/HARDWOOD
3	UPLAND SPRUCE/HARDWOOD/HIGH BRUSH
	LOWLAND SPRUCE/HARDWOOD
4	HIGH BRUSH
5	HIGH BRUSH BURNED
6	HIGH BRUSH BURNED/COASTAL WESTERN HEMLOCK/ SITKA SPRUCE
7	HIGH BRUSH/MOIST TUNDRA/ALPINE TUNDRA
8	LOW BRUSH/MUSKEG-BOG
9	MUSKEG
10	MOIST TUNDRA
11	WET TUNDRA
12	ALPINE TUNDRA/BARREN
13	ALPINE TUNDRA/BARREN/MOIST TUNDRA
M	MUD

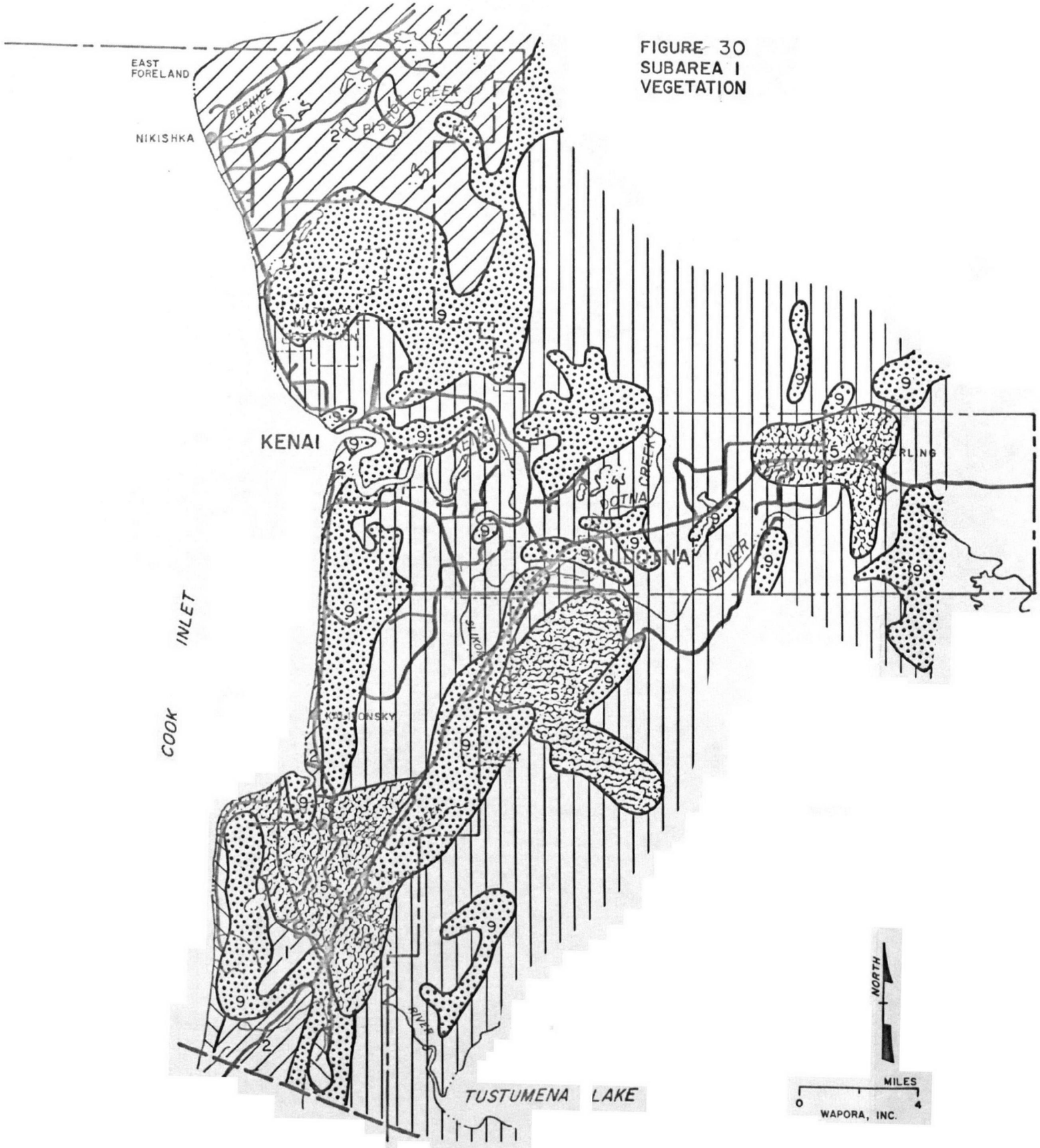


FIGURE 30
SUBAREA I
VEGETATION

The high brush vegetation may be a successional stage in areas disrupted by flooding, landslides, or fire, but frequently is the later seral stage in marginal soils, particularly at higher elevations. Land-use policies may be implemented to preserve high brush vegetation on steep, erosion-susceptible slopes.

Muskegs may be "perched" on poorly-drained soils or may be associated with the water table and adjacent water bodies. Management of these areas usually is limited to preservation through Corps of Engineers and State of Alaska permits, or removal by draining.

There are tidal marshes at the mouths of the Kenai River and the Kasiloff River in Subarea I. The vegetation in both is above most tides, or is flooded only briefly during the tidal cycle. During extreme high tides both marshes are flooded extensively. The Kenai River tidal flats are zoned for heavy industry and are being usurped by construction. The Kasilof River tidal marshes are unzoned and are sites for light fishing industries. Both tidal marshes qualify for protection under Corps of Engineers Section 404 permit regulations.

5.3.2. Aquatic biota

Lists of macroinvertebrates and fish collected by WAPORA, Inc., and the Alaska Department of Fish and Game (US Army Corps of Engineers 1978) are presented in Tables 30 and 31. The primary emphasis of fisheries management and research efforts in the study area has been the compilation of salmon life history and population data and the management of salmon stocks by escapement. Little research has been conducted on the other anadromous and freshwater fishes of the region. Fish species lists are not available for other streams in Subarea I. The species collected in the Kenai River probably are typical of the region, and similar species might be expected to be present in other streams in Subarea I.

Rainbow trout, Dolly Varden char, grayling, lake trout, steelhead, burbot, eulachon, and coho, pink, chinook, and sockeye salmon are harvested in the subsistence/sport fishery in Subarea I. Lake trout and burbot distribution is limited to lakes and the Kenai River. Grayling are stocked in a few lakes by the Alaska Department of Fish and Game. Eulachon spawn in the lower Kenai River during April and May and are the target of subsistence/sport gillnet fishing. Steelhead run in the Kasilof River during the autumn. Rainbow trout and Dolly Varden are present in most streams and lakes. Most streams and the larger lakes on the Kenai River and Kasilof River receive salmon spawning runs and are rearing habitat for one or more salmon species. The distribution of freshwater game and commercial fish species in Subarea I is reported by the Alaska Department of Fish and Game (1978a).

Salmon spawning areas have been identified in many streams of Subarea I and are considered to be critical habitat by State and Federal resource agencies. Mainstream spawning areas have not been defined for other rivers and lakes because of turbidity and collecting difficulties, but discontinuous spawning is known or suspected to occur in many of them. Known salmon spawning areas in Subarea I are shown in Figure 31 (adapted from Joint Federal-State Land Use Planning Commission 1973b).

Table 30. Macroinvertebrates collected during June 1977 by WAPORA, Inc., from the Kenai River System.

Taxa

Phylum/Class/Order/Family/Genus and species

P-Annelida
- C-Hirundinella (leeches)
  - *Haemopsis marmorata* (tentative)
  - *Placobdella parasitica* (tentative)

P-Arthropoda
- C-Crustacea
  - O-Amphipoda (scuds)
    - F-Gammaridae
      - *Gammarus lacustris*
      - *G.* (*Anisogammarus*) *confevicolus*
- C-Insecta
  - O-Coleoptera (beetles)
    - F-Gyrinidae
      - *Gyrinus picipes*
      - *G. minutus*
      - *G. pleuralis* (tentative)
    - F-Hydraenidae
      - *Octhebius disrectus*
    - F-Dytiscidae
      - *Agabus anthracinus*
      - *A. verus*
      - *Illybius augustior*
      - *Hydroporus tartaricus*
      - *H. occidentalis*
      - *H. griseostriatus* (tentative)
      - *H. tademus*
      - *Hygrotus* sp.
      - *Rhantus wallisi* (tentative)
      - *R. suturellus*
    - F-Hydrophilidae
      - *Helophorus auricollis*
      - *H. fenniculus*
      - *H. splendenoides* (tentative)
      - *Hydrobius fusipes*

Table 30. Macroinvertebrates collected from the Kenai River System (continued).

O-Diptera (flies)
- F-Chironomidae (at least four species)
- F-Dolichopodidae (undetermined genus, larvae in coastal marsh)
- F-Empididae
  - *Wiedomannia* sp. (tentative)
  - Undetermined genus
- F-Tipulidae
  - *Tipula* sp.
- F-Simuliidae (diversity not considered)
- F-Tabanidae
  - *Tabanus* sp. (coastal marsh only)

O-Ephemeroptera
- F-Ephemerellidae
  - *Ephemerella* (*Drunella*) *doddsi*
  - *E. inermis*
- F-Baetidae
  - *Baetis* sp. (two tails)
  - *Baetis* sp. (three tails)
  - *Baetis* sp.
- F-Heptageniidae
  - *Epeorus* (*Ironopsis*) sp.
  - *Cinygma* sp.
  - *Cinygmula* sp.
- F-Siphlonuridae
  - *Ameletus validus*

O-Hemiptera (true bugs)
- F-Corixidae
- F-Saldidae
  - *Soldula* sp.

O-Odonata (dragonflies and damselflies)
- F-Aeshnidae
  - *Aeshna juncea*

Table 30. Macroinvertebrates collected from the Kenai River System (continued).

O-Plecoptera (stoneflies)
F-Pteronarcidae
Pteronarcella badia

F-Perlidae
Alloperla sp.

F-Perlodidae
Isoperla sp.

F-Nemouridae
Nemoura (*Zapoda*) sp.

F-Leuctridae
Leuctra occidentalis (tentative)

F-Capniidae
Eucapnopsis brevidens

O-Trichoptera (caddisflies)
F-Rhyacophilidae
Rhyacophila (three species)

F-Glossosomatidae
Glossosoma alascense
G. intermedium
Glossosoma sp.

F-Philopotamidae
Wormaldia sp.

F-Hydropsychidae
Arctopsyche ladogensis
Hydropsyche sp. (*H. bifida* group)

F-Hydroptilidae
Oxyethira sp.

F-Limnephilidae
Ecclisomyia conspersa
Nemotaulius hostilis
Hesperophylax designatus
Onocosmoecus unicolor
Limnephilus sp.
Unidentified genera;
white median stripe, gills all single

Table 30. Macroinvertebrates collected from the Kenai River System (concluded).

F-Leptoceridae
Ceraclea excisa

F-Lepidostomatidae
Lepidostoma roafi

F-Brachycentridae
Brachycentrus americanus

P-Mollusca
C-Gastropoda (snails)
Stagnicola sp. (heavy-bodied)
Stagnicola sp. (slender-bodied)
Gyraulus sp.
C-Pelycypoda (clams)
F-Unionidae
Anodonta imbecilis

F-Sphaeriidae
Sphaerium sp.

SALMON HABITAT

------ SALMON PRESENT

..... SALMON SPAWNING

FIGURE 31
SUBAREA I
SALMON HABITAT

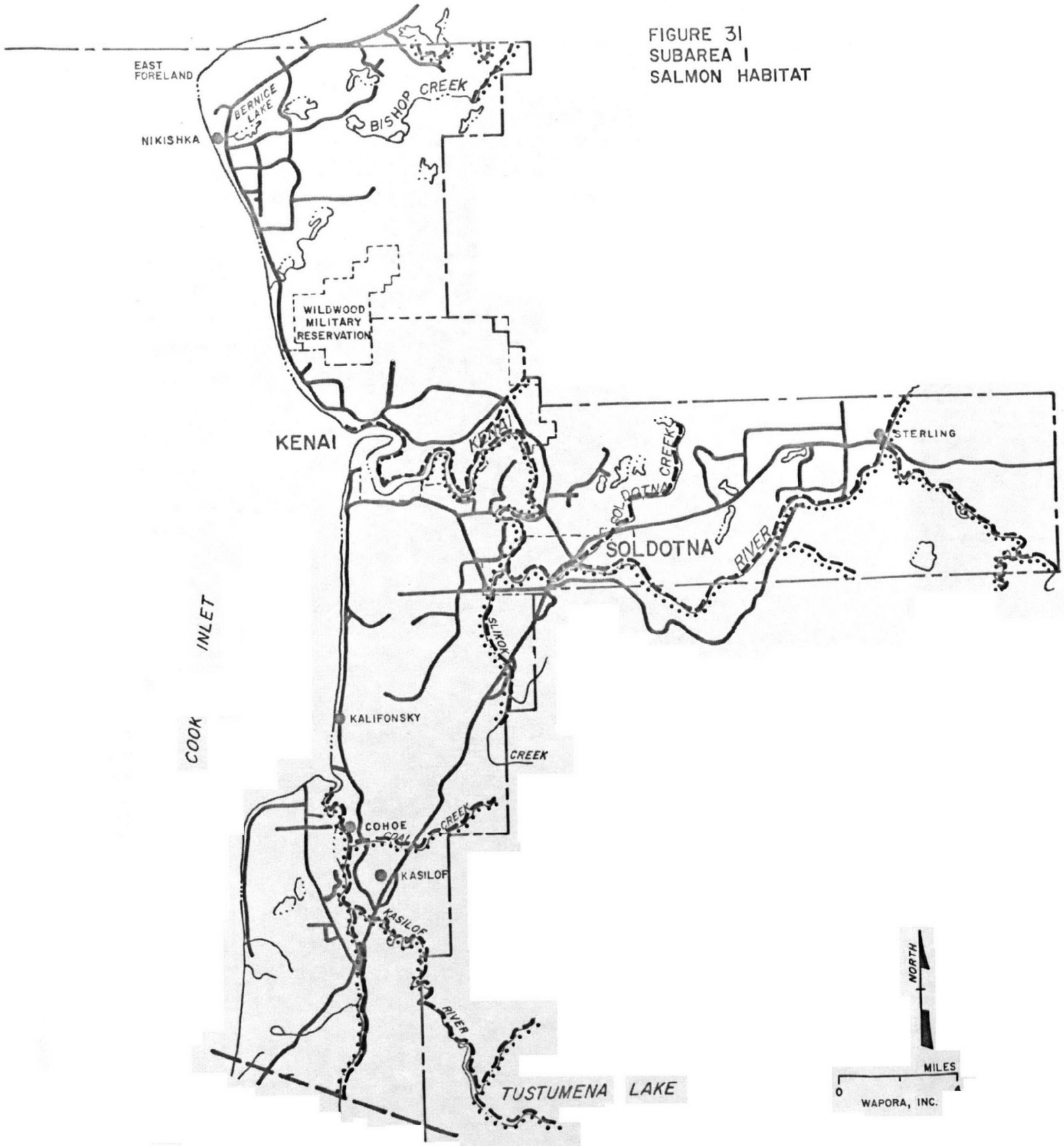


Table 31. Species of fish reported to occur in the Kenai River System (US Army Corps of Engineers, Alaska District 1978).

Common Name	Scientific Name
Arctic lamprey	*Lampetra japonica*
King (chinook) salmon	*Oncorhynchus tshawytscha*
Sockeye (red) salmon	*Oncorhynchus nerka*
Silver (coho) salmon	*Oncorhynchus kisutch*
Chum salmon	*Oncorhynchus keta*
Pink (humpback) salmon	*Oncorhynchus gorbuscha*
Rainbow trout	*Salmo gairdneri*
Dolly Varden	*Salvelinus malma*
Northern pike	*Esox lucius*
Lake trout	*Salvelinus namaycush*
Eulachon	*Thaleichthys pacificus*
Longfin smelt	*Spirinchus thaleichthys*
Sculpin	*Cottus* sp.
Slimy sculpin	*Cottus cognatus*
Coastrange sculpin	*Cottus aleuticus*
Staghorn sculpin	*Leptocottus armatus*
Round whitefish	*Prosopium cylindraceum*
Threespine stickleback	*Gasterosteu aculeatus*
Ninespine stickleback	*Pungitius pungitius*
Pacific herring	*Clupea harengus pallasi*
Starry flounder	*Platichthys stellatus*
Longnose sucker	*Catostomus catostomus*
Arctic grayling	*Thymallus arcticus*

The two most important salmon spawning systems on the Kenai Peninsula are the Kenai River and the Kasilof River, including their lakes and tributaries. These systems received an escapement of 850,000 sockeye salmon during 1977, along with smaller numbers of pink, coho, and chinook salmon. Virtually all of the sockeye salmon migrated through the study area and spawned in lakes and tributaries to lakes farther upstream in the Kenai National Moose Range or the Chugach National Forest. Most of the pink salmon and some of the coho and chinook salmon spawned in rivers and streams inside Subarea I. Regardless of the spawning site, these salmon used the rivers as migratory corridors and the young use them during their early development phases and during their migration to the sea.

Spawning areas are protected by permit requirements under the Anadromous Fish Protection Act (permits are required from the Alaska Department of Fish and Game). Each of the population-limiting factors described in Section 3.2.2.1. may act on salmon eggs and fry in Subarea I. In addition, because Subarea I is undergoing rapid development, human activities that disrupt spawning redds, reduce groundwater flow, or introduce pollutants are more likely to occur in Subarea I than in any other subarea.

5.3.3. Mammals

Most of the terrestrial mammal species in the study area (Section 3.2.3.2.) are present at least occasionally in Subarea I. Exceptions include arctic fox, marten, arctic ground squirrel, mountain goat, Dall sheep, and a few upland small mammals. No endangered or threatened mammals are known to inhabit Subarea I. Type localities for several subspecies, including subspecies of the northern red-backed mouse, red fox, gray wolf, black bear, marten, wolverine, mountain sheep, and river otter are on the Kenai Peninsula. Merriam (1904, 1917) described two species of brown bear found only on the Kenai Peninsula. For one of them, *Ursus kenaiensis*, the species type locality was Kasilof Lake in Subarea I.

The four species of large mammals present -- moose, caribou, black bear and brown bear -- represent the most important commercial and recreational terrestrial wild animal resources in Subarea I. They also may be the mammals most affected by development and habitat alteration.

Moose are present throughout Subarea I and occur in high densities during all seasons in most of Subarea I (Figure 32; adapted from Joint Federal-State Land Use Planning Commission 1973b). Moose usually winter in one area, calve in another, and summer in a third. The large, year-long concentrations in Subarea I indicate that each of the required habitat types -- wintering yards, black spruce bogs and muskegs for calving, and summer browse -- are available. Development in Subarea I has eliminated some moose habitat, and road mortality is becoming important in population dynamics. These detrimental impacts have been mitigated in part by the access provided by roads, reduction of natural predators, and the successionally earlier, more favorable vegetation types that have followed burning and clearing. Future development in Subarea I will continue to remove habitat and increase highway mortality and hunting pressures. In the Anchorage area, the comparatively isolated

moose population has declined gradually as the City has grown. The Kenai National Moose Range that surrounds Subarea I will act as a population reservoir for Subarea I, replenishing the losses and masking the effects of human activities.

Caribou were extirpated from the Kenai Peninsula prior to 1920. Small herds have been re-established on the Kenai Peninsula from animals introduced by the Alaska Department of Fish and Game in 1965 and 1966. One herd winters north of Skilak Lake in the Kenai National Moose Range and summers on the flats north of the City of Kenai and the Kenai Spur Road. The summer range of this herd extends almost to the coast and includes portions of the Wildwood Military Reservation and other lands outside the Moose Range (Figure 32). The calving grounds for this portion of the Kenai herd are located almost entirely outside the western boundaries of the Moose Range.

The quality of caribou food resources is determined, in part, by the successional stage of the vegetation. Caribou will consume a variety of browse, forbs, grasses, and even fish and small mammals, but depend upon foliose lichens and other late-successional vegetation for at least part of the year (Skoggs 1968; Kelsall 1969). Forest fires during the past 50 years have reduced range quality in Subarea I. Land development and road building have removed caribou habitat and hindered migration.

Two major threats to the segment of the Kenai herd in the study area are the continued industrial development in the Nikiski area and the possibility of fire removing the required late successional vegetation. Existing development in the North Kenai area includes petrochemical, refining, and transportation facilities. Planned development would remove between 50 and 100 acres for a liquefied natural gas (LNG) plant. Approximately 3,000 acres that are anticipated to be used for the proposed Alpetco petrochemical plant eventually may be used for other industrial sites. These sites are near the identified Kenai caribou herd calving grounds and probably will increase the frequency of caribou-man interactions. Continuing loss of critical calving grounds and summer habitat, plus the additional stresses associated with increasing human contact, eventually may eradicate the herd. A major forest fire could produce the same results.

Black bears are present throughout Subarea I. A large area used intensively by black bears in the spring coincides with the portions of the moose calving grounds that are located on the Kenai National Moose Range north of Sterling. This intensive use area, as identified by the Alaska Department of Fish and Game (1976), extends slightly into Subarea I. No other important black bear habitat has been identified in Subarea I. Continued commercial, residential, and industrial development in Subarea I will remove habitat and increase bear-human contact, probably to the eventual detriment of both. Black bears, however, can adapt to considerable human pressure. Black bear populations are not immediately threatened in Subarea I.

Brown bears occasionally range through Subarea I. On the Kenai Peninsula, humans largely have displaced brown bears from the regions near the coast that comprise most of the study area. Denning areas,

WILDLIFE HABITAT

SEA LION HAULING OUT AREA

HARBOR SEAL

BLACK BEAR

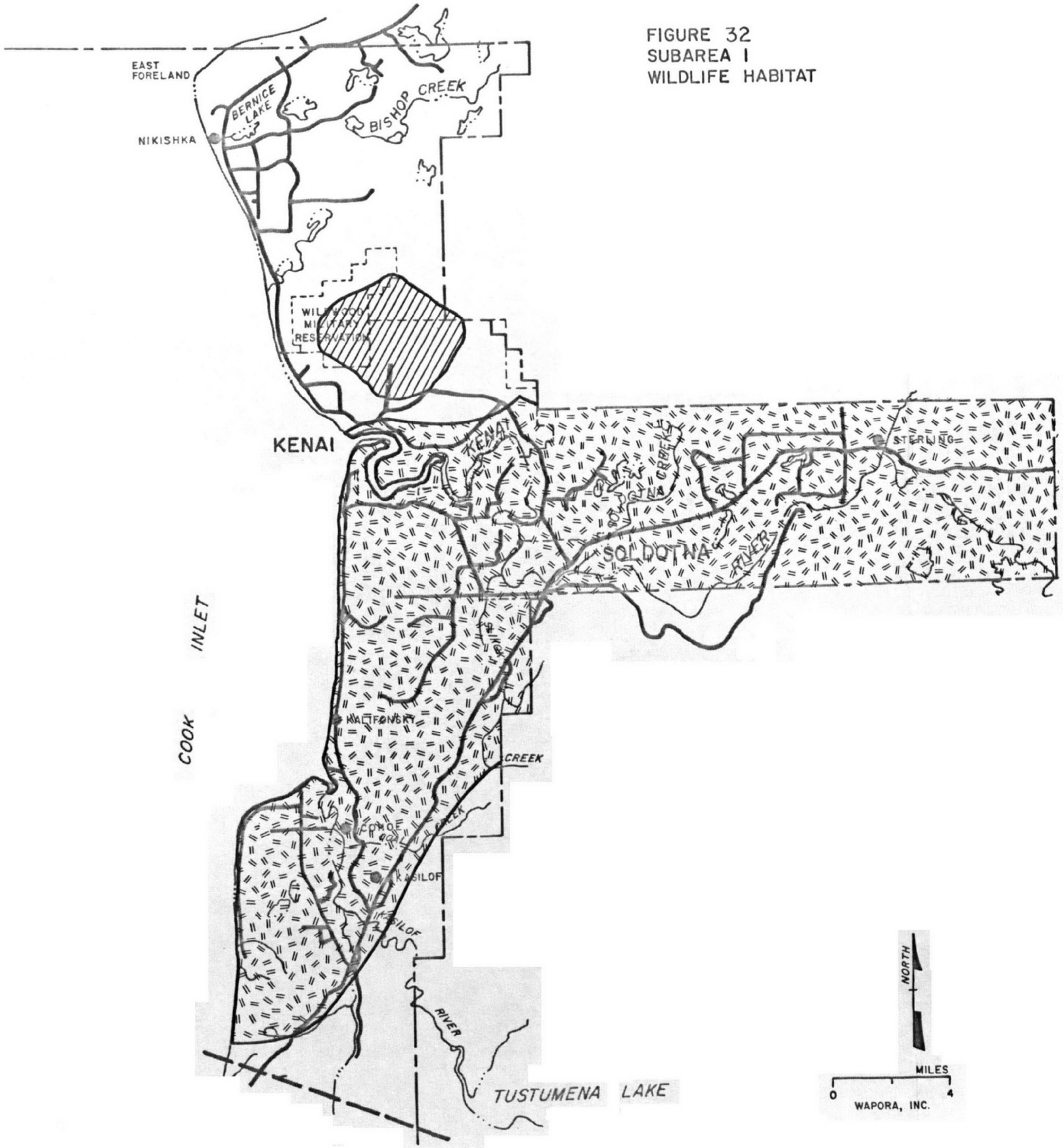
BROWN BEAR

MOOSE

GOAT

CARIBOU

FIGURE 32
SUBAREA I
WILDLIFE HABITAT



spring feeding areas, and salmon streams are critical habitats to brown bears. The Alaska Department of Fish and Game (1976) has not identified any critical brown bear habitat within Subarea I. Aspects of brown bear life history are described in Section 3.2.3.2. As that discussion suggests, increases in human populations and development in Subarea I may continue to reduce brown bear populations.

5.3.4. Birds

Species lists of birds observed in Cook Inlet and nearby regions (the Anchorage area and Prince William Sound) are available in Erickson (1977) and Isleib and Kessel (1973). Two subspecies of the peregrine falcon, an endangered species (Federal Register 1976), might be found in Subarea I.

Subarea I contains several important bird habitat types. The most important types, both in terms of concentrated usage and unique value, are the waterfowl habitats. Subarea I habitat is important to both breeding and migrating waterfowl. Most of the many potholes and ponds that dot the area contain one or two pairs of breeding waterfowl each summer, and densities have been estimated at five breeding pairs per square kilometer in suitable habitat. Migrating waterfowl, including snow geese, Canada geese, sandhill cranes, trumpeter swans, whistling swans, and several species of ducks stage (concentrate prior to migration) on the Kenai River and Kasilof River tidal marshes (Figure 32). These flats may receive concentrated use for only a few days each year, but during that period they may be extremely important to migrating waterfowl. The flats also are important sites for waterfowl hunting and photography. The Kenai River Flats adjacent to the City of Kenai are zoned for industrial use, and the value of the Flats as a staging area will be reduced if they are developed. Industrial and residential development of the Flats, or construction of bridges, roads, or electrical transmission lines, would reduce the available habitat and would cause direct mortality to waterfowl.

5.4. Land and Water Use

5.4.1. Settlement patterns

Human habitation in Subarea I has developed close to natural resources, processing sites for those resources, and along transportation corridors. Prior to World War II, resource exploitation in Subarea I was concentrated in fisheries and fish processing, with lesser portions of the population involved in mining, agriculture, and lumbering. Kenai, the largest of the villages, had a population of approximately 300 people that was concentrated around the old town site near the mouth of the Kenai River, close to the fisheries, the canneries, and water transportation. South of Kenai, the villages of Kasilof, Cohoe, and Kalifonsky were low-density aggregations of fishermen of Native, Russian, and American ancestry. There also were scattered habitations west of Kenai, especially along the Kenai River. Following World War II the area was opened to homesteading, and low-density populations became established on the better soils.

Three events occurred between 1950 and 1960 that profoundly affected population growth and settlement patterns in Subarea I:

- Seward Station (now Wildwood Military Reservation), an Army communications center, was constructed north of Kenai. The influx of military personnel, although small, was important to the community

- The Sterling Highway was opened, connecting Kenai to other towns on the Peninsula and to Anchorage. This was a major benefit to trade, and, as Anchorage grew, to tourism and development of recreational resources

- The Swanson River Oilfield came into production. The Swanson River, and eventually the oil resources in the Upper Cook Inlet, exerted a strong influence on population growth. Oil and gas facility development that began after the Swanson River strike still determines settlement patterns in Subarea I.

These events, particularly the development of hydrocarbon resources, caused rapid population increases that exceeded available services and determined land-use patterns throughout much of Subarea I.

Development during the period from 1960 to 1970 was related primarily to oil and gas development in the Cook Inlet and the Kenai Peninsula fields. In 1963, Standard Oil of California constructed a refinery at Nikiski off the North Kenai Road and residential development began in the North Kenai area. Additional hydrocarbon plants were constructed in the North Kenai area by Collier Carbon and Chemical Co., Phillips Petroleum Co., Marathon Oil Co., and Tesoro-Alaska Petroleum Co. Residences and service businesses developed along the North Kenai Road between the industries that provided the economic base and the Kenai City core that provided the required services.

During this period Soldotna grew rapidly, and residential dwellings also were constructed in Sterling, many of them for people employed in various oil-related jobs. Major development at both towns was adjacent to the Kenai Spur Road or the Sterling Highway, with little off-highway (lateral) development.

The total Kenai Peninsula Borough population in 1976 was estimated at 21,843. This included Seward and several smaller settlements outside the study area. An estimated 8,215 Borough residents, approximately 37% of the Borough population and most of the Subarea I population, were in the greater Kenai or greater Soldotna areas. Kenai and Soldotna contain such a preponderance of the Subarea I population that settlement patterns and land use in those cities are discussed separately later in this section. Outside Kenai and Soldotna, residential development is occurring in the community of Sterling, as single residences and small subdivisions, near the highways at points along the Kenai River that can be reached by lateral roads from the highways, and on the bluffs along the coast of Cook Inlet. Land in Subarea I that supports commercial or relatively dense residential usage is associated with the city cores or with higher population densities along the highways.

5.4.1.1. Kenai

Kenai is located south of Anchorage, approximately 60 miles away by air and 160 miles by highway. Kenai is the center of the oil industry service and supply activities in the Cook Inlet area and also is the center for fishing and fish processing industries in the central district of the Inlet.

The City of Kenai grew as a core around the original settlement and along the Kenai River. This development pattern was not interrupted until after World War II, when the Sterling Highway and the Kenai Spur Road were opened. Under the pressure of a growing work force employed in the nearby Swanson River oilfields and gasfields, new commercial and public facilities moved away from the Kenai City core to form a corridor along the highways. The development of oilfield support facilities in nearby Soldotna and a great influx of tourists on the highways have reinforced the corridor pattern.

The service and commercial businesses have concentrated along the highways, but the fisheries processors have remained on the lower Kenai River, where they are close to the fishing boats and to a convenient disposal site for the quantities of high biological oxygen demand (BOD) wastes generated by fish processing. Under current regulations the processing wastes (washwater, bones, skin, scales, shells, and other inedible parts) are passed through a grinder and are discharged into the River. Heavy industries, in the form of refinery, petrochemical, and LNG facilities, are concentrated north of Kenai, adjacent to the coast in the Nikiski area. Their locations are described later, in the discussion of NPDES point-source discharges (Section 5.5.3.). A major LNG facility also is planned for the North Kenai (Nikiski) area.

Residential development is centered around the Kenai core and in subdivisions or single family residences linked to the highways by secondary roads. Much of the land along the highways identified on the land ownership map as privately-owned has been subdivided for rural residences. A wide right-of-way, limited-access, and frontage roads have protected the Kenai Spur Road traffic flow. The Borough recognizes the problem associated with unrestrained residential development (CH_2M Hill, Inc. 1978a), particularly the difficulties in providing utilities, roads, and services to outlying residences, but zoning remains liberal. The same general pattern of residential development is occurring along the Kalifonsky Beach Road, south of the Kenai River.

Zoning for heavy industry in Kenai is confined to the lowlands along the lower Kenai River and to higher ground south of the River mouth. Both sites are, at best, marginal for heavy industry. The lowland site is advantageous only to fish processors; any other plant would necessitate extensive filling and would require approval of the Corps of Engineers. The other area zoned for heavy industry is being surrounded by residential housing. A large facility in this area probably would meet resistance from neighbors and access could be restricted.

Light industrial zoning is applied to lots along the North Kenai

Zoning for heavy industry in Kenai is confined to the lowlands along the lower Kenai River and to higher ground south of the River mouth. Both sites are, at best, marginal for heavy industry. The lowland site is advantageous only to fish processors; any other plant would necessitate extensive filling and would require approval of the Corps of Engineers. The other area zoned for heavy industry is being surrounded by residential housing. A large facility in this area probably would meet resistance from neighbors and access could be restricted.

Light industrial zoning is applied to lots along the North Kenai Road and in the Cook Inlet Industrial Park adjacent to the Kenai Municipal Airport. Both areas have been developed only sparsely.

5.4.1.2. Soldotna

Soldotna is located in the central part of the Kenai Peninsula Borough, on the north bank of the Kenai River. The economy is based on service companies (drilling, tool, and equipment firms) for the Swanson River Oilfield and on government, finance, and tourism. It is located strategically at the junction of the major highway system from Anchorage and the petroleum facilities of the Kenai Peninsula. The offices of the Kenai Peninsula Borough are located in Soldotna.

The City is located between the Kenai River, the Kenai Spur Highway, and the Sterling Highway, and extends along the Kenai Spur Highway. Most of the commercial activity is concentrated along the Kenai Spur Highway and the Sterling Highway in a strip development pattern. Residential development is scattered, with many vacant areas between residences. Unlike Kenai, where much of the land in the City belongs to the Borough or the City, most of Soldotna is in private ownership. Major exceptions are a half-section in the southwest corner of the City owned by the Borough, and the airport, which is owned by the City. There are three basic zoning categories: industrial, commercial, and residential. The industrial and commercial zones are located along the highways. Much of the City is not zoned.

Soldotna does not have the industrial base that has been the heart of the Kenai City development. Soldotna commerce is centered around providing goods and services to tourists, Soldotna residents (many of whom work in Kenai), and residents of the remainder of the Kenai Borough.

5.4.2. Land ownership

Land ownership in Subarea I is mapped in Figure 33 (adapted from Alaska Department of Natural Resources 1977). Most of the land is owned by the State of Alaska or is privately owned. Privately-owned land is concentrated in the vicinity of Kenai, along the highway west of Kenai, and along the Cook Inlet coastline. The Wildwood Military Reservation has been transferred to Kenai Native Corporation ownership or Federal Reserve status.

5.4.3. Recreational areas

The major recreational areas in the vicinity of Subarea I are associated with the 2,700-square mile Kenai National Moose Range, which forms

the boundary for much of Subarea I. The Moose Range offers camping hunting, fishing, boating, sightseeing, hiking, picnicking, and other outdoor activities. The cities of Kenai and Soldotna and the State of Alaska operate parks and other recreational facilities in the study area (Table 32).

5.4.4. Agriculture

Agriculture is not a major commercial resource in Subarea I. The Kenai Peninsula Borough (1976) reported that only 31 farms on the entire Kenai Peninsula sold more than $1,000 worth of crops in 1975. The 15-year average of commercial truck garden acreage, primarily planted in potatoes, was approximately 40 acres. An additional 1,300 acres were planted in livestock feed. Kenai Peninsula livestock production in 1975 was 860 cattle, 20 hogs, and 400 chickens. The total value of all agricultural production in 1974, including produce consumed domestically, was estimated at approximately $400,000.

5.4.5. Forestry

Information on forestry is not available for Subarea I as a unit. Data for the entire study area are contained in the regional profile.

5.4.6. Land-use planning

No overall plan or zoning ordinance exists for Subarea I. Zoning is controlled by the cities and is discussed in the land and water use and institutional sections of the regional profile (Section 3.3. and 3.5., respectively).

5.5. Socioeconomic Environment

5.5.1. Level of development

More than half of the population of the study area resides in Subarea I. Subarea I contains two first-class cities, Kenai and Soldotna; the communities of Sterling, Kasilof, Kalifonsky, and Cohoe; and an unincorporated area north of the City of Kenai that includes several unincorporated communities and generally is referred to as North Kenai.

Socioeconomic data usually have been compiled for the cities and for the whole Kenai Borough, so comparatively little data can be presented for Subarea I alone. The data for the cities of Kenai and Soldatna are representative of the remainder of Subarea I in most instances.

5.5.2. Demography

5.5.2.1. Population

The population of Subarea I has not been determined. The precincts in Subarea I censused during 1978 and their populations were as follows:

Kalifonsky	1,701
Kenai I	1,728

LAND OWNERSHIP

FEDERAL LAND

STATE LAND

TENTATIVELY APPROVED PATENTED

TIDELAND PATENTS

MANAGEMENT RIGHTS SELECTION APPROVED PATENTED

TIDELAND PATENTS

INTERIM CONVEYANCE PATENTED

TIDELAND PATENTS

FIGURE 33
SUBAREA I
LAND OWNERSHIP

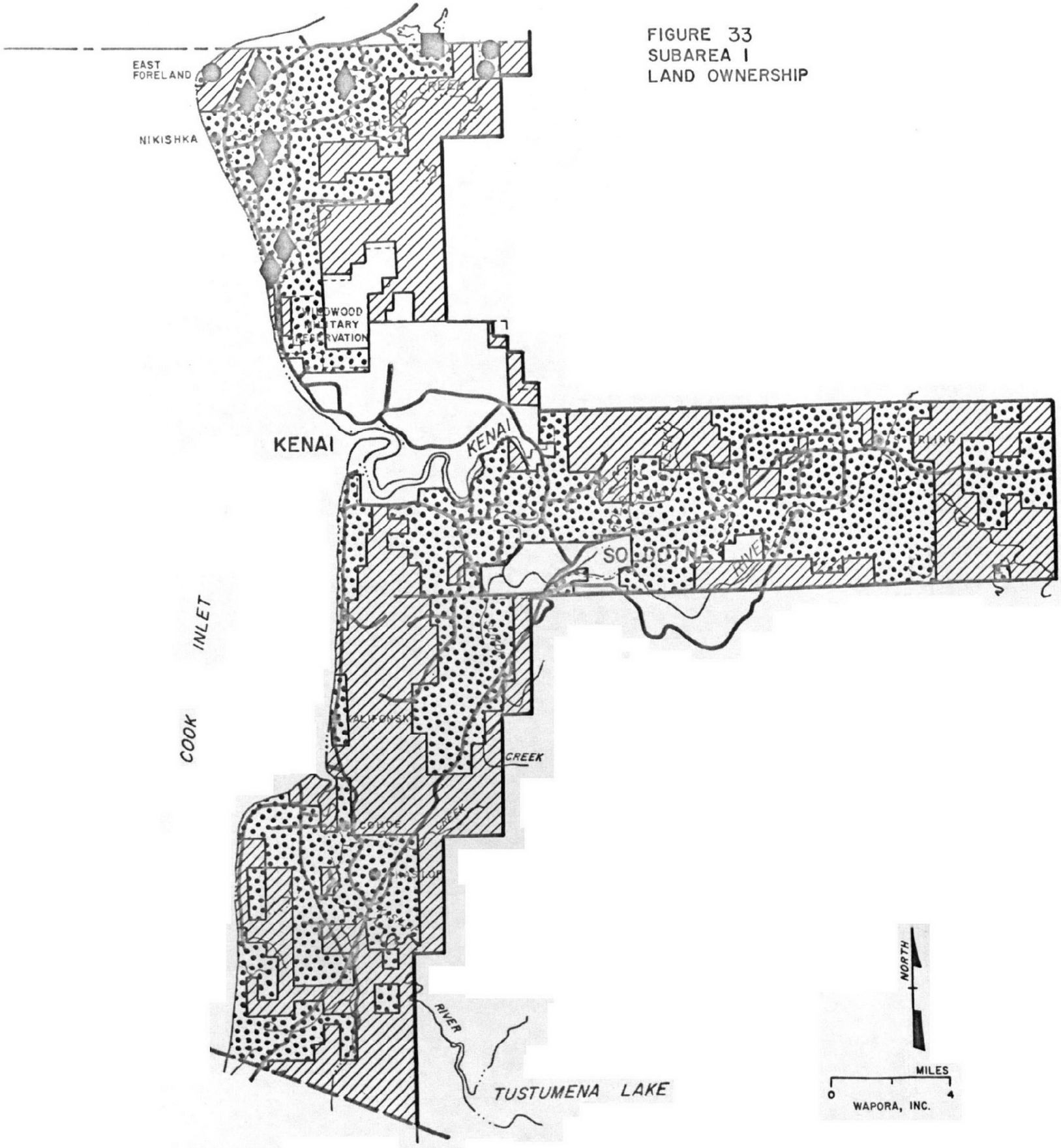


Table 32. Recreational areas in Subarea I.

Name	Location	No. Acres	Facilities
Birch Park	Kenai	1	Toilets
Kenai Municipal Park	Kenai	2	
Beaver Creek Park #1	Kenai	0.025	Camping, picnicking
Beaver Creek Park #2	Kenai	0.025	Camping, picnicking
Cunningham Park	Kenai	2	Toilets, boat launch, fishing
Arc Lake	Soldotna	12	Picnicking, fishing, boating, toilets
Swiftwater Camper Park	Soldotna	60	Picnicking, fishing, boating, toilets, drinking water, camping
Centennial Park	Soldotna	167	Picnicking, fishing boating, toilets, drinking water, camping
Kasilof Boat Dock	Kasilof River		Boat ramp

Kenai II	1,779	
Kenai III	864	
Nikiski I	1,479	
Nikiski II	2,010	(part is outside Subarea I)
Ridgeway	1,472	
Soldotna	2,365	
Sterling	1,408	(part is outside Subarea I)
Total	$14,806	

The boundaries of these precincts are illustrated in Figure 34 (adapted from US Bureau of the Census 1978). Two precincts include parts of areas outside Subarea I. Because most of those areas are part of the Kenai National Moose Range, which is virtually unpopulated, the majority of the population of those two precincts is assumed to have been in Subarea I.

Compared with the 1970 census, the population of Kenai in 1978 had increased by 24% to 4,371, and the population of Soldotna had increased by 96%, to 2,365. Census data for the entire study area are presented in Section 3.4.3.1 (Tables 18 and 19). With the exception of the Kenai and Soldotna results, the data are difficult to compare because different census unit boundaries were employed. Although there can be no direct comparison of census units outside of Kenai and Soldotna, the fact that the population of Subarea I in 1978 approximately equaled the entire 1970 population of the Cook Inlet Census Division indicates that the Subarea I pollution increased rapidly during the 1970s.

5.5.2.2. Population projections

CH_2M Hill, Inc. (1978a) prepared population projections from the 1977 census of the Kenai Peninsula Borough and the Borough cities, and from the official 1960 and 1970 census results. The projected population for the cities of Kenai and Soldotna were developed for five possible cases:

- Base case -- assumes no outer continental shelf (OCS) petroleum or natural gas development in the Lower Cook Inlet

- Low case -- assumes that only minor OCS petroleum or natural gas discoveries are made but not developed and that all OCS activities cease within 3 years

- Medium case -- assumes that petroleum and natural gas are discovered but that the volumes discovered are not sufficient to necessitate construction of new onshore support or shipment facilities

- Two high cases -- assume that substantial petroleum and natural gas discoveries will be made and that one or two new petroleum terminals and/or a new natural gas liquefaction facility would be required. One high case assumes the additional facilities would be located in the southern Kenai Peninsula, the other assumes they would be located in the central Kenai Peninsula.

Population projections based on these five cases are presented in Table 33 for the years 1977 through 1992, in 2-year intervals. The compound annual growth rates used for the base case for each city were derived from population increases reported by the 1960, 1970, and 1977 censuses and assume that future population increases will match those of the previous two decades. The 1978 special census results indicate that the 1977 Kenai and Soldotna population figures, upon which the projections in Table 33 were based, were inflated. If the population projections were based on the 1978 census data instead of the 1977 census data, a smaller compound growth rate multiplier and a smaller base population figure probably would be used. Recalculation of the projection from the 1978 census data would produce lower population projections for Kenai and Soldotna. The data are not sufficient to determine whether the difference in population would be added to areas outside of the two cities, or would not be located in Subarea I.

The projection data indicate that the population increase from high-case OCS development would be largest in Kenai and Soldotna if the support facilities were to be located in the central Peninsula. The maximum population added to both communities by OCS activities alone was projected to be approximately 3,300. This peak would be reached during the mid-1980s and would present a population addition of approximately 20 to 25 percent more than the base-case population. The projections for added population are based on industry manpower needs and do not consider the availability of residences or services in the affected cities. The shortage of housing and public services that would occur during the peak of high-case OCS development could be expected to distribute some of the influx into the surrounding communities. Development of other resource bases also could cause influxes of population. Projections have been made for population expansion that would result from mining of the Beluga Coalfield or the Kenai Coalfield, establishment of a major groundfish industry, or construction of major industries not related to OCS, with two exceptions. The exceptions were the projections for the Alpetco petroleum refinery that was considered for the Wildwood Station north of Kenai City and the Alaska-Pacific liquefied natural gas plant that is to be constructed in North Kenai. Projections for both projects are presented in Section 3.4.3.3. In both cases the majority of the work force could be expected to live in Subarea I. The Alpetco refinery is to be built in Valdez, so the populations associated with the refinery are obsolete. The Alpetco data are presented because they may be useful for predicting population from future industrial development.

5.5.2.3. Population composition

The Kenai and Soldotna populations were censused during 1976. The results are summarized in Table 34. The no-children household predominated in both cities, while households with two or fewer children accounted for 87 percent of the households in Kenai and 81 percent of those in Soldatna. The two-person household predominated in Kenai; the three-person household in Soldotna. Households with four or fewer persons accounted for 82 percent of the households in Kenai and 81 percent of the households in Soldotna. As a result, the two-adult household accounted for 72 percent of the households in Kenai and for 73 percent of the households in Soldotna. Most of these were one male-one female households, as shown by the fact that households with one adult

Table 33. Projected population increases in Kenai and Soldotna (CH_2M Hill, Inc. 1978a).

Year	Base Case: Kenai 7% Annual Growth Rate	Base Case: Soldotna 10% Annual Growth Rate	Low Case: Kenai	Low Case: Soldotna	Medium Case: Kenai	Medium Case: Soldotna	High Case (Southern Peninsula-Based): Kenai	High Case (Southern Peninsula-Based): Soldotna	High Case (Central Peninsula-Based): Kenai	High Case (Central Peninsula-Based): Soldotna
1977	5,365	2,585								
1980	6,570	3,345	6,590	3,455	6,685	3,520	6,745	3,560	6,990	3,725
1982	7,525	4,165			7,750	4,315	8,040	4,510	8,350	4,715
1984	8,615	5,040			8,940	5,255	9,880	5,885	10,545	6,325
1986	9,860	6,100			10,495	6,525	11,280	7,045	11,915	7,470
1988	11,290	7,380			11,855	7,760	12,390	8,110	12,795	8,385
1990	12,930	8,930			13,420	9,260	13,845	9,540	14,190	9,770
1992	14,800	10,805			15,386	11,065	15,684	11,395	16,020	11,615

FIGURE 34
SUBAREA I
POPULATION CENSUS

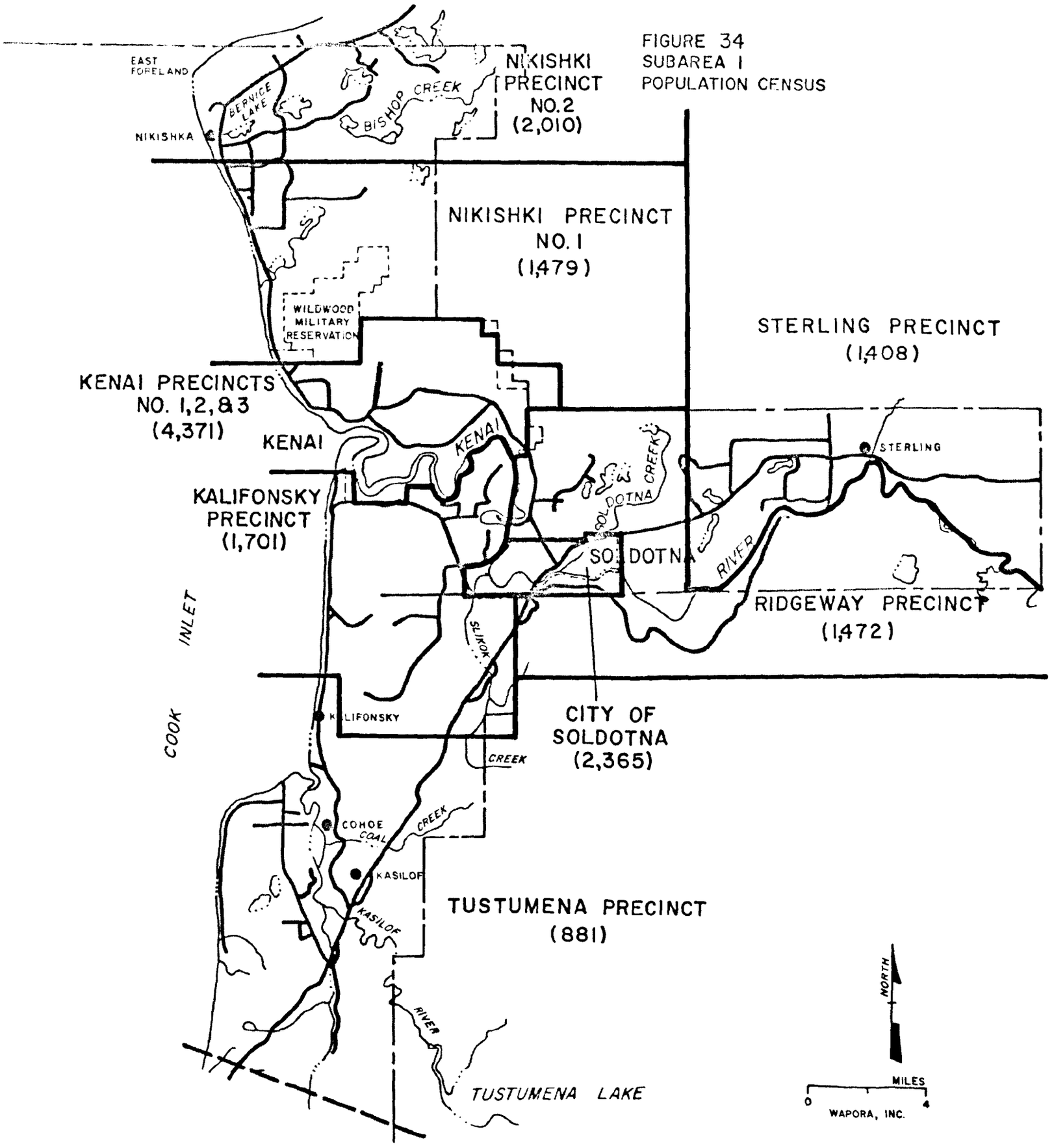


Table 34. Demographic and economic composition of Kenai and Soldotna during August and September 1976 (Bureau of Management and Urban Affairs and Anchorage Urban Observatory 1977).

	Kenai	Soldotna
Percentage of households with:		
1 person	6	7
2 persons	32	20
3 persons	22	29
4 persons	22	25
5 persons	12	9
6 or more persons	6	10
No children	44	32
1 child	19	24
2 children	23	24
3 children	10	9
4 or more children	3	7
1 adult	9	11
2 adults	72	73
3 adults	14	11
4 or more adults	6	5
No adult males	4	8
1 adult male	78	77
2 adult males	16	13
3 adult males	2	2
4 or more adult males	0	0
No employed adults	3	5
1 employed adult	60	66
2 employed adults	28	26
3 employed adults	8	3
4 or more employed adults	1	1
Percent of all household members who are male	51.3	51.1
Percent of population in household that is:		
0-9 years old	16	21
10-19 years old	21	20
20-59 years old	58	56
60 years old or more	5	3
Percent of all adults who are:		
Employed	67	64
Unemployed	5	6
Other (retired/student/housewife)	28	30
Percent of all employed adults employed:		
Full-time	91	90
Part-time	9	10
Locally	66	61
Within Borough	26	31
Percent of household heads who worked 12 months in previous year	74	73
Percent of unemployed heads of household:		
Receiving unemployment compensation in previous 12 mos.	75	42
Not receiving unemployment compensation in previous 12 mos.	25	58

Table 34. Demographic and economic composition of Kenai and Soldotna (concluded).

Persent employed heads of household employed in:		
Agriculture/commercial fishing	5	5
Mining/oil and gas production	26	12
Construction	16	17
Manufacturing (lumber and fish processing; oil and gas refining)	14	6
Transportation, communications, utilities	6	14
Wholesale and retail trade	8	14
Finance, insurance, real estate	1	5
Services (hotel, law, medicine, etc.)	12	19
Government	13	8
Other	0	1
Median school years completed, all adults	12	12
Median total family income ($1,000)	29.9	26.9
Percent of all household members who are:		
White	97	98
Eskimo	0	0
Aleut	0	0
Native not specified, Indian, Black, Asian	3	2
Percent of family's food supply from subsistence		
None	41	46
Less than 25%	48	31
25 - 49%	9	17
50 - 74%	2	4
75% or more	0	1
Median number of respondents' years in community	5	3
Percentage of respondents who lived in 1970 in:		
Same community	37	34
Other Kenai Peninsula	3	10
Other Alaska	13	14
Outside Alaska	47	42

male accounted for 78 percent of the households in Kenai and for 77 percent in Soldotna. Households with three or more adult males accounted for only 2 percent of the households in each city. In Kenai, 60 percent of the households had one employed adult, and 28 percent had two. The corresponding figures for Soldotna were 66 percent and 26 percent. That is, 88 percent of the households in Kenai, and 92 percent of those in Soldotna, had at least one employed adult.

The proportion of non-working to working population is an important economic indicator. The data require that persons aged 19 or less plus those 60 or more be compared with those aged 20 to 59. This ratio was 0.72 for Kenai. That is, for every adult aged 20 to 59 (and thereby presumed to be in the labor force) there was 0.72 people outside that age range. The corresponding number for Soldotna was 0.79. The age-range 15 to 19, for which data are not available, is a significant component of the ratio: the more individuals of those ages in the age-range 10 to 19, the lower the ratio will be in the near future, other things being equal. Data from the 1970 census (not given here) showed that the 15- to 19-year-olds accounted then for about one half of the 10- to 19-year-olds (US Bureau of the Census 1973). Males slightly outnumbered females in both cities.

5.5.2.4. Employment

Kenai and Soldotna showed similar employment patterns: about two-thirds of all adults were employed; of these, 90 percent were employed full-time, about two-thirds were employed locally, and less than 10 percent were employed outside the Borough.

The data do not permit a comparison between the percent of household heads who worked 12 months in 1976 and in 1975. For 1975, the numbers were 74 percent for Kenai and 73 percent for Soldotna. However, for those households whose head was unemployed in 1975, 75 percent in Kenai received unemployment compensation, but only 42 percent in Soldotna. The reasons for this are not clear, but may reflect the fact that a much higher proportion of the employed heads of household in Soldotna than in Kenai were employed in the tertiary sectors. The predominance of the mining sector in Kenai is evident. It alone accounted for 26 percent of the total household heads employed, and its links with the construction, manufacturing, and transportation sectors are strong. It has been estimated that, for the Borough, 60 percent of construction, 70 percent of manufacturing, and 30 percent of transportation payrolls are directly linked to the mining sector (Kenai Peninsula Borough 1976). Applying these percentages to Kenai and to employment, mining accounted for 47 percent of the total employed heads of households in 1976. For Soldotna, the corresponding number was 31 percent. Construction of major petrochemical facilities in Subarea I was completed recently, and the influence of the mining sector on the construction sector declined.

In 1975, the median total family income in Kenai was $29,000 -- somewhat higher than in Soldotna ($26,900). The number of adults employed and the composition of employment were the most important factors

that determined these figures. In Kenai, 37 percent of the households were households with two or more employed adults, whereas (from the above) 47 percent of the employed heads of households were employed in the relatively highly-paid mining sector or in sectors directly related to it. By contrast, 30 percent of the Soldotna households had two or more adults employed, and 31 percent worked in mining or in sectors directly related to mining.

Other factors explaining the income levels and differences were the differential earnings and the unemployment rates of males and females, which were reflected especially in the lower earnings of female-headed households (which averaged $14,300) than of male-headed households (which averaged $30,000). Racial composition does not explain the difference in income in Kenai and Soldotna. Kenai was 97 percent white, and Soldotna was 98 percent white, with few or no Eskimos or Aleuts.

Kenai and Soldotna were roughly comparable in that between 40 percent and 50 percent of the households obtained none of their food from subsistence efforts (such as clamming, hunting, and fishing), although such supplies are significant for both: between 50 percent and 60 percent of the households supplied up to half their food from subsistence.

In both cities, the residents had not been there long: 5 years was the median period of residency in Kenai; 3 years in Soldotna. About one-third of the residents who lived in each city in 1976 also resided there in 1970. More than 40 percent of the 1976 residents did not reside in Alaska in 1970.

The educational level was uniform. The median number of school years completed by all adults in each city was 12.

5.5.2.5. Housing

In Kenai and Soldotna, single-family and mobile homes predominated. They accounted for 73 percent of the occupied units in Kenai and 82 percent in Soldotna (Table 35).

Table 35. Types of housing in Kenai and Soldotna by occupied units and by vacancy rates, 1976 (CH_2M Hill, Inc. 1978a).

Type of Occupied Unit	Kenai No.	Kenai %	Soldotna No.	Soldotna %
Single-family	684	52.0	311	52.0
Multi-family	350	27.0	110	18.0
Mobile home	274	21.0	180	30.0
Other	1	0.6	0	0.0
Total occupied units	1,309	100.0	601	100.0
Vacant units	46		15	
Vacancy rate		3.4		2.4

Mobile homes were more common in Soldotna, where they accounted for 30 percent of the housing units, as compared with 21 percent in Kenai. The 1976 vacancy rates, 2.4 percent in Soldotna and 3.4 percent in Kenai

(Table 35), suggest a tight housing market; 5 percent to 6 percent is regarded as flexible. The 1977 vacancy rate in Kenai may have been somewhat higher because of the addition to the market of some apartment units that formerly were occupied by construction workers at the Collier Carbon (ammonia/urea) Plant at Nikiski and of 100 apartment units that were under construction in late 1977 (CH_2M Hill, Inc. 1978a). During the period 1970 to 1977, population growth exceeded growth in total housing units in Kenai, whereas the opposite was true in Soldotna. However, Kenai had a housing surplus in 1970 after completion of oil-related construction. Assuming that the vacancy rates of 1976 applied also in 1977, the implied occupancy rates (number of people per occupied housing unit) in 1977 were 3.2 percent in Kenai and 3.0 percent in Soldotna.

In 1976, there were no monthly rent or mortgage payments made for 10 percent of the units in Kenai and 6 percent of those in Soldotna; it is presumed that these units were owned by the occupant. Median rent was $311 per month in Kenai, where a two-bedroom apartment cost $400 per month and a three-bedroom apartment cost up to $600 per month. The typical price of a new home in Kenai was $60,000, whereas a single-family lot ranged from $12,000 to $16,000. The Farmers Home Administration (FmHA) since 1974 has played a significant role in transforming the demand for housing units into constructed units. In Fiscal Year (FY) 1976-1977 the Soldotna office of the FmHA lent $6.2 million for 128 single-family dwellings and $2.1 million for 69 rental units (including 24 for senior citizens) in Kenai. Its provision of long-term financing at low rates assisted in the transition from mobile homes to houses. It also stimulated the growth of interim financing loans by local commercial banks to the construction sector through its "conditional commitment" program. Thus, instead of financing individual homes at a rate of 20 to 30 per year, the FmHA began to finance homes for contractors building 12 or more homes at a time. The FmHA expected that its loans in FY 1977-1978 would be slightly less than the level of FY 1976-1977, primarily because of the reduction in industrial construction in Subarea I.

The FmHA finances about one-third of all housing in the Kenai-Soldotna area. The National Bank of Alaska finances another third, acting both as a normal commercial bank and as the conduit for monies from the Alaska Housing Finance Corporation and the Fannie Mae (Federal National Mortgage Association) and Freddie Mac (Federal Home Loan Mortgage Corporation) programs. The remaining one-third is financed by the State of Alaska, the First Federal Savings and Loan Association, and other sources (CH_2M Hill, Inc. 1978a). It does not appear that lack of housing finance will constitute a constraint to growth in Subarea I. The FmHA has recently reorganized, so that it now has a state office. Soldotna is to be the headquarters of the new, State-chartered, Peninsula Savings and Loan Association.

Gas is the major source of home heat, supplying 76 percent of the homes in Kenai and 70 percent of those in Soldotna. Oil is next, supplying 13 percent of the homes in Kenai, and 25 percent of those in Soldotna. Electricity is the source of heat for only 9 percent of the homes in Kenai and 3 percent of those in Soldotna. Wood or a combination of energy sources provides heat for the remainder of the homes in the two cities.

City water and well water are the main domestic water sources. Stream water supplies only a negligible proportion of the homes in the cities. In Kenai, 61 percent of the homes are supplied by city water; in Soldotna, 57 percent. Sewers and septic tanks are used for sewage disposal. Only a few homes have outhouses or chemical toilets. The city sewerage system serves 61 percent of the residences in Kenai and 68 percent of those in Soldotna. About two-thirds of the homes in each city have a telephone and one or two cars.

5.5.3. Utilities

5.5.3.1. Water supply

Two wells in the Beaver Creek aquifer supply the Kenai City Water System. The System serves approximately 1,000 residential units and 90 businesses in the City center, adjacent areas, and the Wildwood Military Reservation. Service to other areas is restricted because the cost of installation increases with increased distance between residences, while assessments are limited by the City charter. The pumping capacity of the system is approximately 2,300 gallons per minute (approximately 3.3 million gallons per day). The storage system is being upgraded to three million gallons by the construction of a reservoir on the Kenai Airport property. Pump, storage, and line capacity are sufficient to meet immediate and near-future requirements. Groundwater usage in the Kenai-Soldotna area was estimated at approximately 1 million gallons per day, and the North Kenai industrial complex used approximately 3 million gallons per day (Federal Power Commission 1976). Most of the water consumed in the North Kenai complex was used by Union Carbon and Chemical. The recharge rate to the North Kenai groundwater system was estimated to be more than 6.5 million gallons per day (Anderson 1972). Tests of aquifer recharge rates and configuration were scheduled to be conducted during 1978 and 1979 by the US Geological Survey.

During 1976, Soldotna supplied water to 320 customers and served a total of 408 living units, including motel rooms. The system has been expanded since that time. Water for the system is pumped from two wells with a combined capacity of approximately 713 gallons per minute. A 500,000-gallon reserve supply is maintained in a storage tank. Water use data for the system are not available, and future demands have not been projected. The low residential density composition of much of Soldotna has resulted in a low volume of water use per pipe length in many areas. Low flow rates and deep frost penetration have caused freezing of pipelines and associated damage in some parts of the water system. Many users run water all winter long to prevent such freezing, and the wasted water may overload the sewage treatment system.

5.5.3.2. Sewage disposal

The Kenai City Wastewater System serves 975 residential units and 85 commercial units in approximately the same area as the water system (CH_2M Hill, Inc. 1978b). The sewage is pumped through five lift stations to a secondary treatment plant with a design capacity of 0.5 million gallons per day. The treatment plant operates at more than design capacity for several months each year, partly because of inflow and infiltration from

water tables higher than some of the sewage lines. The treatment plant is located on the Kenai River due south of the airport and discharges into the River. The system is outdated and in poor condition, and frequently is plugged. A new system has been proposed.

Soldotna provided wastewater collection and treatment for 530 living units in June 1977 (CH_2M Hill, Inc. 1978b). The treatment facility, located on Kobuk Street, is designed to treat 0.26 million gallons of wastewater per day and to handle a peak of 0.4 million gallons per day. The peak recorded flow was 0.6 million gallons per day. The effluents are discharged into the Kenai River. Treatment capacities frequently are exceeded during the winter and spring. The shallow gradient in much of the system, combined with a lack of maintenance, has caused plugging.

Rural sewage disposal usually is by septic system. Gas toilets, chemical toilets, and holding tanks also may be used, but use data are not available. Tryck, Nyman and Hayes (1976), in a study of the Kenai Borough, noted that septic system disposal probably was satisfactory, provided the system was at least 4 feet above ground water level, the soil was sufficiently permeable (passed a percolation test), and there was at least 80,000 square feet of land per residence. Where these requirements could not be met, they recommended chemical or gas toilets or joint-venture sewage treatment systems.

5.5.3.3. Electricity

The Homer Electric Association purchases electricity from the Chugach Electric Association. Chugach Electric operates a generating station at Bernice Lake in the North Kenai area and also transmits electricity from a hydroelectric generating station on Cooper Creek and from generating stations in the Anchorage and Susitna Valley areas. Several of the heavy industries north of Kenai generate their own electricity but rely on the Homer Electric System for emergency power.

5.5.3.4. Point-source discharges

Discharges into the Kenai River and Cook Inlet by the municipalities of Kenai and Soldotna, and by seafood processors, pipeline terminals, refineries, and a petrochemical company, are currently licensed under NPDES regulations (Table 36, Figure 35; personal communication with Alaska Department of Environmental Conservation to Mr. Guy McConnell, WAPORA, Inc.).

5.5.3.5. Solid waste disposal

Solid waste disposal sites in Subarea I are shown in Figure 35. The Kenai Peninsula Borough operates sanitary landfills near Kenai and Soldotna and a special waste disposal site at Sterling. The Borough also operates solid waste transfer sites in Sterling and North Kenai, from which wastes are transported to the Kenai or Soldotna landfill sites. There are two private sanitary landfill sites in Subarea I licensed by

Table 36. Industries with NPDES permits for wastewater discharges in Subarea I.

Discharger	Location	Receiving Water	Type of Facility	Waste Description
Phillips Petroleum Co.	Kenai	Cook Inlet	Refinery	Oil, grease, phenols, biodegradable materials, sewage
Kenai Pipeline Co.	Nikiski	Cook Inlet	Pipeline terminal	Oil, grease, suspended solids
Tesoro-Alaskan Petroleum Co.	Nikiski	Cook Inlet	Refinery	Oil, grease, phenols, biodegradable materials, sewage
Union Oil Co.	Kenai	Cook Inlet	Gas plant	Oil and grease
Standard Oil Co.	Kenai	Cook Inlet	Refinery	Oil, grease, phenols, biodegradable materials, sewage
City of Soldotna	Soldotna	Kenai River	Secondary treatment facility	Municipal sewage
R - Lee Seafoods	Kenai	Kenai River	Seafood processor	Ground fish parts and washwater
City of Kenai	Kenai	Kenai River	Secondary treatment facility	Municipal sewage
Columbia Wards Co.	Kenai	Kenai River	Cannery	Wastewater, boiler water, cooling water, fish parts
Collier Carbon & Chemical Co.	Nikiski	Cook Inlet	Urea plant	Ammonia, organic nitrogen, oil, grease
Dragnet Fisheries	Kenai	Kenai River	Seafood processor	Ground fish parts and washwater (permit applied for)
Salamatof	Kenai	Kenai River	Seafood processor	Ground fish parts and washwater (permit applied for)
Kenai Salmon Packing Co.	Kenai	Kenai River	Seafood processor	Ground fish parts, canning wastes, washwater, cooling water, sewage

5.5.4. Transportation

5.5.4.1. Roads

The Sterling Highway is the major truck road running from the Seward Highway to Homer. The Kenai Spur Road and the Kalifonsky Beach Road lead from the Sterling Highway to Kenai. Secondary roads run from the Sterling Highway to Kasilof and Cohoe. In 1976, the system was considered to have adequate capacity by the Kenai Peninsula Overall Economic Development Program (Kenai Peninsula Borough 1976). The major highway serving Kenai is the Kenai Spur Road. It originates at the Sterling-Soldotna Highway and runs through Kenai and northward along the coast to the Nikiski industrial complex. A smaller highway, the Kalifonsky Beach Road, crosses the Kenai River. The City of Kenai maintains 40 miles of roads (CH_2M Hill, Inc. 1978a).

Three paved, State-maintained highways serve Soldotna: the Kenai Spur Road, the Sterling Highway, and the Kalifonsky Beach Road to the south of the town. With the exception of a short, paved access road to the hospital, the remaining 20 miles of City-maintained streets in Soldotna are unpaved. Daily average use is within the capacity of the system, but is increasing rapidly. Increasing commercial development along the Kenai Spur Highway and the Sterling Highway and unlimited traffic access eventually will cause traffic congestion on the major thoroughfares.

5.5.4.2. Airports

The two major airports in Subarea I are the Kenai Municipal Airport and the Soldotna Airport. There are several smaller airports recognized by the Federal Aviation Administration (FAA) and a number of short, private bush airstrips. Data for FAA-listed airfields in Subarea I are presented in Table 37.

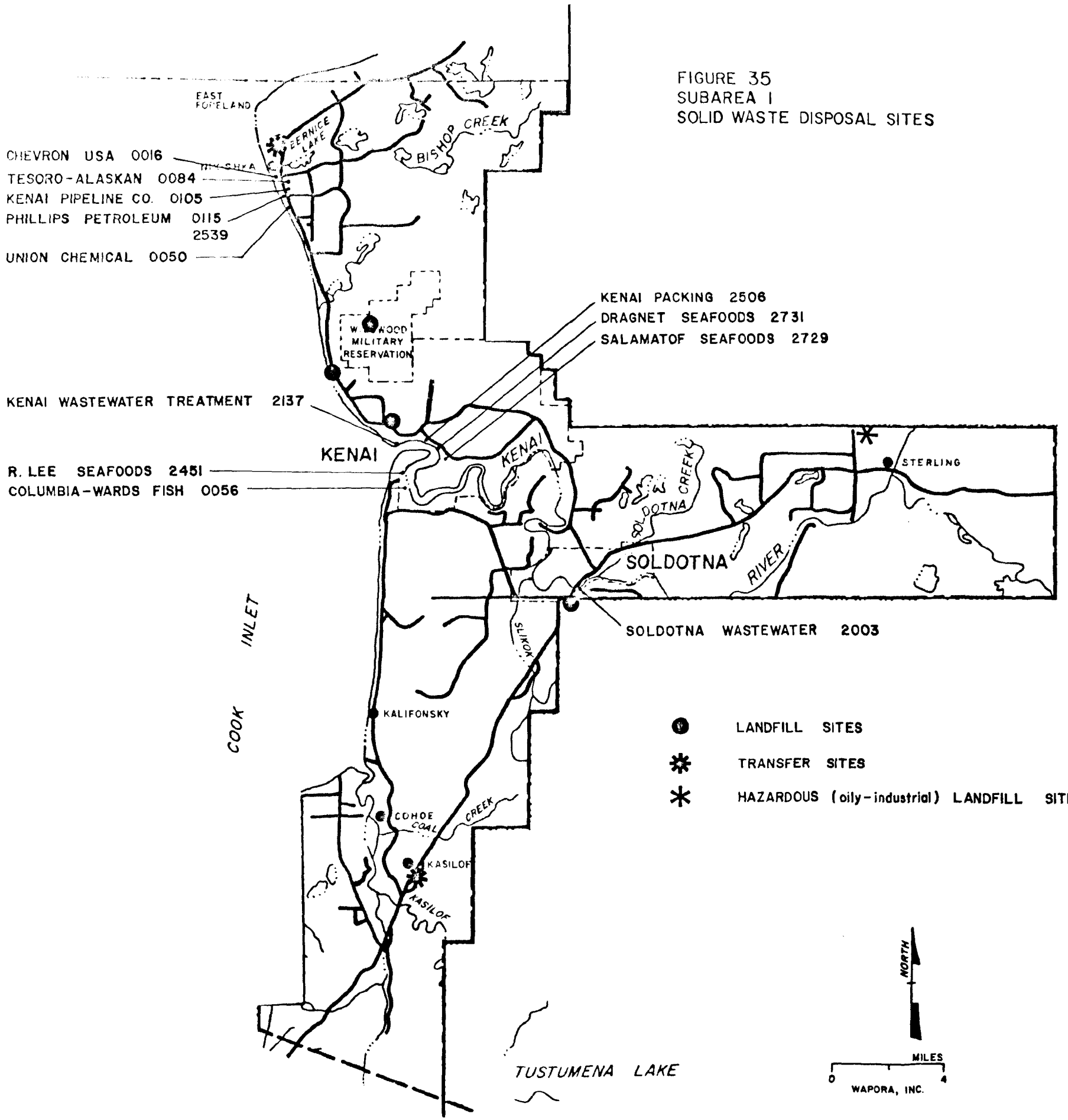
The City of Kenai operates the Kenai Municipal Airport. The Airport is located immediately north of town. It consists of a small, modern terminal and a single, hard-surfaced runway that is 7,500-feet long. An FAA flight-service station and an FAA control tower (part-time) are located at the airport. The Airport is served by scheduled flights to Anchorage, Homer, Kodiak, and other Alaskan cities. Air taxi service from the Airport provides off-the-road transportation and freight service to hunters, fishermen, prospectors, and others on the Kenai Peninsula and the western side of Cook Inlet.

The City of Soldotna owns and operates the Soldotna Airport. The Airport consists of a 5,000-foot asphalt runway and a small passenger terminal that is managed by the City Director of Public Works. There is no control tower. Aircraft entering and leaving the Soldotna traffic pattern receive traffic advisories from the FAA Kenai flight service station. Scheduled airline service is provided to Homer, Kenai, and Anchorage. Charter services to airstrips on both sides of Cook Inlet operate out of the Airport. The Airport is capable of handling much heavier traffic volumes, but increased usage will require expansion of the terminal, commercial, and tie-down facilities.

Table 37. Airport facilities in the Kenai-Soldotna area (Subarea I) charted by the Federal Aviation Administration.

Name	Location	Runway Length (ft.)	Runway Surface	Facilities
Arness Lake	6.1 mi NW of Kenai	1,700	Gravel	Also seaplane basin
Kenai Municipal	Adjacent to Kenai	7,500	Asphalt	Terminal, control tower, flight service station, repairs, fuel
GAEDE	6 mi W of Soldotna	2,700	Unpaved	Private, use restricted
Morgan Homestead	6 mi NE of Soldotna	2,300	Unpaved	Also seaplane lake, private, use restricted
Soldotna	0.9 mi SE of Soldotna	5,000	Asphalt	Small terminal, fuel, repairs
Kasilof	1.6 mi N of Kasilof	2,400	Gravel	
Butler Aviation	8.7 mi NW of Kenai	1,700	Gravel	Attended
Rigtenders Heliport	7.4 mi NW of Kenai	240 x 270	Gravel	

FIGURE 35
SUBAREA I
SOLID WASTE DISPOSAL SITES



5.5.4.3. Water-based transportation

Two marine transportation facilities are operated in Kenai: the Port of Kenai (privately-owned) and the Kenai Cook Dock (City-owned). The Port of Kenai provides a 300-foot-long dock, cranes, ramps, water, and warehousing and can dock medium-draft vessels. Approximately 60 fishing boats use the facility (Mielke and others 1977). The wharves at Nikiski constitute one of the major ports of Cook Inlet. They receive approximately 250 vessels each year, primarily tankers and LNG vessels. Approximately 17 percent of the Cook Inlet shipping is moved through Niskiski (Kenai Peninsula Borough 1976). The Niskiski wharves provides ample water depth, but tides, currents, and ice constitute significant docking hazards (Federal Power Commission 1976). There are no established shipping lanes in Cook Inlet, and fishermen report extensive fixed-gear destruction by ships. In addition to these port facilities, the City of Soldotna operates a small-boat dock and launching facility at Kasilof.

5.5.5. Social services

5.5.5.1. Educational facilities

Public educational facilities in Subarea I are listed in Table 38. The Kenai Peninsula Borough School District (1977) indicated the need for a new 10-room elementary school in Soldotna, an 800-student high school in Soldotna, and additional classrooms in Nikolaevsk, Sterling, and Tustumena. Base-case projections (CH_2M Hill, Inc. 1978a) indicate that 400 to 500 students will be added to the entire Kenai Peninsula Borough School System each year. Under projected peak OCS development conditions, an additional 2,622 to 2,718 pupils would be added to the School System during the 1985-1986 school year. Assuming that the development would occur in the central Peninsula, almost all of these new pupils would be enrolled in the Subarea I schools, and the present enrollment capacity would be exceeded. The projected additional enrollment would require an additional 109 classrooms during peak OCS development (CH_2M Hill, Inc. 1978a).

5.5.5.2. Police protection

The Kenai Police Department employs ten officers, has six vehicles, and has short-term jail facilities. The Police Department is undermanned (CH_2M Hill, Inc. 1978a).

The Soldotna Police Department has six officers, three police cars, and a small jail. The Public Safety Building needs replacement and the staff workload is full (CH_2M Hill, Inc. 1978a). Alaska State Troopers provide police protection outside Soldotna and Kenai on the Kenai Peninsula.

5.5.5.3. Fire protection

Kenai has ten full-time firemen, several volunteers, one crash truck, three pumper trucks, and one tanker truck. The Soldotna Fire

Table 38. Kenai Peninsula Borough schools in Subarea I (CH_2M Hill, Inc. 1978a).

Schools	Community	Grades	Capacity	Enrollment 1976-1977 School Year
Kenai Elementary	Kenai	4-6	500	279
Kenai Junior High	Kenai	7-9	600	492
Kenai Central	Kenai	10-12	800	687
Nikolaevsk	Near Kenai	K-8	150	118
North Kenai	Kenai	K-6	425	364
Sears	Kenai	K-3	550	353
Soldotna Elementary	Soldotna	K-6	650	572
Soldotna Junior High	Soldotna	K-9	450	315
Sterling	Sterling	K-8	150	190
Tustumena	Sterling	K-6	100	112

Department has a paid staff of three, twenty volunteers, two pumper trucks, two tanker trucks, and one rescue truck. The Nikiski Fire Service Area provides fire protection to part of Subarea I outside Kenai and Soldotna. The cities of Kenai and Soldotna have provided fire protection to outlying areas, but Kenai has indicated that these services will cease unless the unincorporated areas form a fire protection district to help share expenses.

5.5.5.4. Other services

Kenai and Soldotna operate a joint mental health program organized by the Kenai Mental Health Association. The Association's budget for 1977 was $120,000. The State-funded Cook Inlet Council on Alcoholism (with a staff of four), and two private groups organize alcoholism programs.

Both Kenai and Soldotna have small libraries staffed by paid employees. Both provide services to non-residents at no charge.

Park and recreation areas in Subarea I are operated by the cities of Kenai and Soldotna, the Kenai Peninsula Borough, and the Alaska Division of Parks. They range from small waysides and day parks to boat-landing and full-camping facilities. Kenai has six parks, totaling 117 acres. Soldotna has three city parks and a total of 264 acres of recreational land.

5.5.6. Public finances

Many of the data presented for the Kenai Peninsula Borough as a whole (Section 3.4.8.) are applicable to the discussion of Subarea I finances. Data specific to Subarea I are presented in this section.

Selected financial data for Kenai and Soldotna for the period 1970 through 1976 are presented in Table 39. Kenai's deficits and revenue swings are substantial. Changes in assessed property value and in millage rates have occurred in response to, and affect, these balances. The deficits especially reflect attempts to cope with the growth in population. For example, Kenai undertook substantial bond issues for its water, sewer, and other systems during the period 1965 through 1972. As a result, its water and sewer system has twice the capacity of the system at Soldotna. Such systems incur debt. The bonded debt ratios of the two cities are presented in Table 40. Both cities have low direct debt ratios, high debt per capita, and high assessed value per capita. The low debt ratios indicate financial strength. The direct debt of Kenai is three times that of Soldotna.

The patterns of general revenues and expenditures in the two cities during Fiscal Year 1976 are shown in Table 41. Their own sources of revenue (property and sales taxes, and business licenses) were critically important, accounting for 72 percent of total general revenues in Kenai and 62 percent of those in Soldotna. State and Federal revenues accounted for just over 10 percent in each city. Police, fire, and streets combined accounted for 58 percent of the general expenditures in both Kenai and Soldotna.

Table 39. Selected financial data for Kenai and Soldotna, 1970-1976 (Mielke and others 1977; Waites and Brogan 1977b).

Year (ending June 30)	Expenditures ($)	Revenue ($)	End-Year Balance ($)	Assessed Property Value ($/million)	Millage (c/$1,000)	Sales Tax Rate (%)
1970	N/A [a]	N/A	N/A	29.6 [b]	8.00	0.0
1971	1,820,000	1,772,538	(232,170)	47.0	7.00	0.0
1972	1,130,087	1,345,846	299,200	48.5	7.00	0.0
1973	1,371,026	989,951	(539,313)	49.4	10.50	1.0
1974	1,156,824	1,318,654	(24,330)	48.4	12.00	1.0
1975	1,056,800	1,015,136	(403,696)	54.7	16.75	3.0
1976	1,486,058	1,961,514	71,760	60.7	16.00	3.0
			Soldotna			
1970	N/A	N/A	N/A	13.6	6.0	0.0
1971	193,368	229,551	51,458	14.8	6.0	0.0
1972	270,834	227,971	8,595	16.5	10.0	0.0
1973	407,448	387,596	(12,755)	18.1	14.0	0.0
1974	529,309	519,778	27,392	19.7	15.0	0.0
1975	592,277	682,718	87,441	22.8	12.0	1.0
1976	798,598	836,978	123,821	30.9	10.0	2.0

[a] N/A = Data not available.

[b] Only real property assessed.

Table 40. Bonded debt ratios, 30 June 1978, for Kenai and Soldotna (CH_2M Hill, Inc. 1978a).

	Kenai	Soldotna
Assessed value	$85,178,136	$43,356,480
Direct debt	4,690,000	1,648,000
Direct and overlapping debt	6,295,482	2,465,217
Ratio of:		
Direct debt to assessed value (%)	5.5	3.8
Direct and overlapping debt to assessed value (%)	7.4	5.7
Population	5,364	2,586
Assessed value per capita	15,880	16,766
Direct debt per capita	874	637
Direct and overlapping debt per capita	1,174	953

Table 41. General fund revenues and expenditures for Kenai and Soldotna, FY 1976[1] (CH_2M Hill, Inc. 1978a).

Category	Kenai $	Kenai %	Soldotna $	Soldotna %
Revenues	2,443,971	100.0	1,212,602	100.0
Property tax	1,028,387	42.1	363.345	30.0
Sales tax	677,353	27.7	323,894	26.7
Business licenses	126,097	5.2	75,195	6.2
State shared revenues	220,750	9.0	112,768	9.3
Federal revenue sharing	40,849	1.7	42,349	3.5
Public Employee Program			42,981	3.5
Other	350,535	14.3	252,070	20.8
Expenditures	1,822,970	100.0	1,106,182	100.0
Government administration	355,547	18.4	198,788	18.0
Police	311,194	17.1	232,626	21.0
Fire	278,124	15.3	94,286	8.5
Streets	127,411	7.0	114,322	10.3
Library	50,977	2.8	23,795	2.2
Communications	82,608	4.5		
Municipal shop	178,595	9.8		
Non-departmental	333,667	18.3		
Parks			16,117	1.5
Airport			43,491	3.9
Debt service			33,061	3.0
Transfer to other funds			158,425	14.3
Other			191,271	17.3

[1] Year ending 30 June

5.5.7. Public attitudes toward development

The Bureau of Management and Urban Affairs and the Anchorage Urban Observatory (1977) conducted surveys of the attitudes of people in five Kenai Peninsula towns toward their communities. Their findings are discussed in the following section.

The population of Kenai was 4,371 in 1978. In 1976, 55 percent preferred a city with a population of 5,000 and 27 percent preferred one of 6,000 to 15,000. At the extremes, 11 percent preferred a city of 4,500 or less, and 7 percent preferred one of more than 15,000. The industrial sectors its residents would prefer to encourage in the City are matched, in exactly the reverse order, by those they would discourage (Table 42). Education, agriculture, commercial fishing, and a small-boat harbor were encouraged by over 90 percent of the respondents. Light manufacture, transport, tourism, and a deepwater port were encouraged by less than 90 percent, but by more than two-thirds of the respondents. Supply bases, petrochemical industries, and lumbering were encouraged by two-thirds or less of the respondents.

In general, if a respondent ranked a sector highly as a sector to be encouraged, he or she also rated it highly in terms of desirability. The petrochemical industry is an obvious, anomalous, and unexplained exception. It ranked tenth (of the eleven sectors) in terms of the percent of respondents who would encourage it in Kenai (55.0%), first in terms of the percent of respondents who placed it as most desired in Kenai (22.5%), and third in terms of least desired (17.0%).

Several related questions were asked. (The data for these are not presented in Table 42.) For example, when asked if they would like to see onshore facilities in this area, between 55 percent and 66 percent of the residents answered positively, depending on which of five facilities was specified. In descending order of preference these were: liquefied natural gas (66%), support bases (64%), pipelines (62%), refineries and petrochemical plant (60%), oil storage and tanker terminal (55%). When asked if the City and the Borough should prevent the location of a supply base for one of these facilities in this area, 63 percent responded affirmatively, and 28 percent negatively. Finally, when asked if the facilities should be located inside or outside the City limits, 74 percent preferred outside and 19 percent inside. These results do not clarify the attitudes of Kenai residents toward onshore oil and natural gas development, or the psychological sensitivity of the area.

The population of Soldotna was 2,365 in 1978. In 1976, 34 percent of the residents preferred to have a population of 3,000 to 4,500. However, the next largest group (32%), preferred a city of only half that size (1,500 population). Eighteen percent preferred a city with a population of 5,000 to 15,000, with 4 percent preferring one of less than 1,000, and 5 percent one of more than 15,000.

In Soldotna, as in Kenai, the encourage/discourage rankings of industrial sectors were a mirror image of each other. The rankings in Soldotna were similar to those in Kenai, with the obvious exception of

Table 42. Preferred development sectors in Kenai and Soldotna (Bureau of Management and Urban Affairs and Anchorage Urban Observatory 1977).

Kenai	Encourage		Discourage		Most Desired		Least Desired	
	(%)	(Rank)	(%)	(Rank)	(%)	(Rank)	(%)	(Rank)
Education and research	95.4	1	2.0	11	15.9	2	0.7	11
Agriculture	95.4	1	8.6	8	6.6	7	3.5	7
Commercial fishing	92.1	3	7.3	10	11.9	3	2.1	9
Small boat harbor	90.1	4	7.3	9	7.3	6	2.8	8
Light manufacture	84.8	5	10.6	7	8.6	5	6.4	5
Transport and storage	81.3	6	14.7	6	4.0	9	0.7	10
Tourism	77.5	7	21.2	4	9.3	4	19.1	2
Deep water port	75.8	8	18.8	5	6.0	8	3.5	6
Supply bases for offshore oil	66.2	9	27.2	3	2.6	11	7.8	4
Petrochemical industries	55.0	10	41.0	2	22.5	1	17.0	3
Lumber industry	37.7	11	57.0	1	4.0	10	28.4	1
None and don't know					1.4	--	7.8	--
Soldotna								
Education and research	96.4	1	2.2	11	17.8	2	0	11
Agriculture	80.4	4	13.0	9	10.4	5	4.7	6
Commercial fishing	87.7	2	10.9	10	9.6	6	0.8	10
Small boat harbor	61.3	9	30.7	4	2.2	10	2.3	7
Light manufacture	81.2	3	13.0	8	13.3	4	10.2	4
Transport and storage	71.7	5	21.0	7	3.0	9	0.8	9
Tourism	67.9	6	29.2	5	18.5	1	16.4	3
Deep water port	65.0	7	30.7	3	3.7	8	5.5	5
Supply bases for offshore oil	63.0	8	26.8	6	3.7	7	0.8	8
Petrochemical industries	43.5	10	51.4	2	16.3	3	27.3	1
Lumber industry	31.9	11	60.9	1	0.7	11	25.0	2
None and don't know					0.7	--	6.2	--

tourism (ranked higher) than in Kenai and small-boat harbor (ranked lower). Again, the anomalous ranking of petrochemicals is seen. It was ranked tenth in terms of encouragement (43.5%), but third as most-desired (16.3%), and first as least-desired (27.3%). The percentage who responded positively to the location of onshore facilities in the area was less than the percentage in Kenai for the five facilities. The range was 44 percent to 60 percent in Soldotna, versus 55 percent to 65 percent in Kenai. Fifty-five percent of the respondents in Soldotna felt that a supply base in the area should be prevented (63% in Kenai), and 74 percent (the same as in Kenai) felt that oil and natural gas facilities should be outside the City.

5.6. Cultural, Historical, Archaeological, and Aesthetic Resources

Subarea I includes the area from the East Forelands of Cook Inlet to the shoreland near Clam Gulch. It extends eastward along the Kenai River to the border of the Kenai National Moose Range. The Subarea contains a wide variety of cultural, historic, and archaeological resources, and the aesthetic pleasures of the region are enjoyed by thousands of residents and visitors each year.

5.6.1. Cultural, historical, and archaeological resources

The Master File of the Alaska Heritage Resource Survey (AHRS) (Alaska Department of Natural Resources 1979) lists 62 sites in Subarea I. The sites range from simple mounds of Native origin to surviving buildings from the Russian and Early American periods in Alaska. The *Cook Inlet Region Inventory of Native Historic Sites and Cemeteries* (Cook Inlet Native Association 1975) lists 31 sites in Subarea I as having important historical value. It is likely that additional sites will be discovered.

5.6.1.1. Native period

The early human history of Subarea I is not well understood. The Lower Cook Inlet study area appears to have been located in a region where a number of various cultures met and competed (Bureau of Land Management 1976). Dispersed Eskimo settlement sites are believed to have existed throughout the Cook Inlet area. The displacement of the Eskimo culture by the Tanaina group of Athabaskan (also called Athapaskan) Indians appears to have begun in the northern sections of the Kenai Peninsula and later spread southward. Tanaina settlements near the mouth of Kenai River may have been established as long ago as 1000 B.C. (Petersen 1976). The population expanded slowly in the region adjacent to the Kenai River. At the time of the first Russian contact, an estimated 1,000 Tanaina inhabited the Kenai area. It is believed that a Native population of 50,000 inhabited the Kenai Peninsula prior to Russian contact (Cook Inlet Native Association 1975).

The Native economy prior to European contact was based on hunting, trapping, fishing, and trading. Wood, stone, and other natural materials were employed (Cook Inlet Native Association 1975). The use of copper and coal was observed by early explorers (Barry 1973).

Seasonal movement appears to have been common, with permanent or winter villages established in coastal areas. A typical village seems to have consisted of 17 to 20 houses in a central section and a few outlying buildings. A site of this type, near Kalifonsky, has been designated as the Jackinsky Village (Cook Inlet Native Association 1975).

The transition from one culture to another during the Native period seems to have occurred gradually, although it is likely that occasional violent encounters may have occurred during the era of change. The coming of European man to the area increased the rate of change and resulted in virtual eradication of the old Native ways of life.

5.6.1.2. Russian period

Early Russian exploration of Alaska concentrated on the Alaska Peninsula and the Kodiak Island area. The first Russian permanent settlement on the mainland was established at Kasilof in 1786 (Barry 1973). Referred to as Fort St. George, the settlement consisted of two log buildings protected by a stockade (Bancroft 1886). The Fort was an outpost of the Lebedev-Lastochikin Company and served as a base for the fur trade. In 1791 the Company established the Nikolaevsk Redoubt settlement at the site of modern Kenai. This settlement also was known as Fort St. Nicholas. The leader of the personnel at Fort St. Nicholas was Grigor Konovalof. According to Barry (1973), "Konovalof proved to be a bother to everyone -- he raided the Indians, the Shelikov hunters and even his fellow companyman at Kasilof." Konovalof finally was captured and sent back to Siberia by forces under the command of Alexander Baranof.

The fortunes of the Russian-American Company declined in the Kenai area, as they did throughout Alaska. The report of gold along the Kenai River in 1834 by a Russian named Malakoff apparently drew little attention and even less action. The deteriorating trade situation led Russia to the sale of Alaska to the United States in 1867.

5.6.1.3. American period

In 1869 the US Army took over Fort St. Nicholas, and the post was renamed Fort Kenay (Kenai). Commercial activity revolved mainly around the fur trade, and there was little need for a military garrison. The soldiers stationed at Fort Kenay were in demand as the Indian Wars in the western United States continued. In the fall of 1870 the garrison was transferred and Fort Kenay officially was closed. Little growth occurred subsequently in the Kenai area; the 1880 census listed a population of 44 in Kenai.

The opening of the first salmon cannery in Kenai in 1882 resulted in a modest boom, and the permanent population began to grow slowly. By 1920 the official figure stood at 332. The population began to increase more rapidly after World War II, with the opening of the Kenai area for homesteading in 1947. The completion of a road linking Kenai to Anchorage, the increased construction in the area, and the discovery of oil and gas in the vicinity of Kenai stimulated extensive new growth. The towns of Soldotna and Sterling developed during this period of available land and increased access (Pedersen 1976).

The Kasilof-Cohoe area had been the site of Fort St. George under Russian rule. After the purchase of Alaska by the United States, there was an inflow of new settlers, principally homesteaders and fur farmers (Lewis 1976). The periodic decline in fur prices limited the growth in that industry, and population in the area grew slowly. As in the Kenai area, growth increased after World War II, especially with the completion of new road connections. Growth in the Kasilof-Cohoe area has not approached the magnitude of the population increase in the Kenai-Soldotna-Sterling area.

5.6.1.4. Sites in the National Register of Historic Places

Subarea I includes two sites listed in the National Register of Historic Places and one site designated as a National Historic Landmark. In addition, six sites have been designated as possible candidates for inclusion in the National Register by the AHRS. The following discussion of these sites is based on information obtained from the Master File of the AHRS, from the Final Environmental Impact Statement for the Proposed 1976 Outer Continental Shelf Oil and Gas Lease Sale, Lower Cook Inlet (Bureau of Land Management 1976), and other authors as noted.

The Victor Holm cabin, located near Kasilof, is listed in the National Register of Historic Places. The cabin was built in 1890 by Victor Holm. It has been converted into a museum that contains many handmade articles fashioned by Mr. Holm (Lewis 1976). The cabin is the oldest remaining example in the area of the dovetail method of construction. This technique was used prior to the Alaskan gold rushes and was replaced by the saddle corner method, which required the use of steel pins. The structure is located on private property and may be viewed by arrangement with the present owner. It is designated as KEN 038 by the AHRS.

The Moose River Site also is listed on the National Register of Historic Places. It is located within the Izaak Walton Wayside at the junction of the Moose River and the Kenai River. The Site is believed to date from approximately 400 A.D. It demonstrates Native occupation and resource utilization of the Kenai River area. The site is owned by the Alaska Division of Parks, State of Alaska, and is designated as KEN 043 by the AHRS.

The Assumption of the Virgin Mary Orthodox Church, located at the intersection of Mission Street and Overland Street in Kenai, is designated as a National Historic Landmark. The existing structure, built in 1894, was preceded by a log chapel (1841) and a log church (1849). It is an exceptional example of the vessel-quadrilateral ground plan and is the best-preserved Russian Orthodox church of its kind in Alaska. The Church still is in active use. The adjacent mission house has been designated as a possible candidate for listing on the National Register of Historic Places. The Church is privately owned and is designated as KEN 036 by the AHRS.

Six additional sites in Subarea I have been designated as possible candidates for inclusion in the National Register. Five of these are log cabins located in Kenai that date from the late 1800s to the early 1900s.

They are designated as KEN 069, 070, 071, 072, and 073 by the AHRS. The sixth site, known as the Petersen Complex, also is located in Kenai, near the Russian Orthodox church. It contains structures dating from 1880 to 1924 and is listed as KEN 080 by the AHRS.

Numerous additional sites of potential historic importance are listed in the Cook Inlet Region Inventory of Native Historic Sites and Cemeteries (Cook Inlet Native Association 1975). Many more sites may be discovered.

6.0. SUBAREA II

6.1. Subarea II Boundaries

Subarea II is bounded by Cook Inlet on the west, Kachemak Bay and Subarea III on the south and southeast, and the Kenai National Moose Range and Subarea I on the north and east (Figure 36; adapted from Joint Federal-State Land Use Planning Commission 1973b).

6.2. Physical Environment

6.2.1. Landforms

Subarea II is located in the southwestern section of the Kenai Lowlands. It is similar in landform and origin to Subarea I. In Subarea II the Kenai Lowlands tilt upward from north to south, as evidenced by the increased elevation of the terrain and improved drainage, than in Subarea I.

Landforms within Subarea II consist of plains, terraces, and glacial moraines. Steep eroded escarpments, sea cliffs, and canyons exist in sandstone and shale bedrock in the southern part of Subarea II. Elevations are generally less than 800 feet, but exceed 3,000 feet in the Caribou Hills. Other areas of high elevation include the Ninilchik Dome, Epperson Knob, Bald Mountain, and Lookout Mountain. Subarea II is drained by numerous streams that are tributaries to the Cook Inlet and Kachemak Bay. The most important streams are the Anchor River, the Ninilchik River, and Deep Creek (Figure 36).

6.2.2. Geology

The geologic structure of Subarea II consists of a series of northeast-southwest-trending anticlines and synclines. The axes of the most important folds are illustrated in Figure 37 (adapted from Magoon and others 1976). A buried fault is located immediately west of Bald Mountain. Available data suggest that it is a "normal" fault that roughly parallels major fold axes. No intrusive or volcanic rocks are known to exist in Subarea II.

6.2.2.1. Bedrock geology

The bedrock surface in Subarea II consists of gently-folded strata of the Kenai Group (Magoon and others 1976; Hinton 1971). The Kenai Group in this area consists of moderately indurated sand, silt, and clay that occurs in thin integrated beds and lenses. Thin lenses of conglomerate and beds of bituminous and lignite coal also occur. Outcrops of the Sterling Formation (Miocene-Pliocene) occur along the coastline of the Cook Inlet and Kachemak Bay, along reaches of Deep Creek and Fox Creek, and in the uplands of the southern part of Subarea II. The Beluga Formation (Miocene) comes to the surface in the uplands near Homer and along the southern coastline of Subarea II. This formation forms a steep escarpment that extends from Diamond Creek to Fritz Creek.

6.2.2.2. Surficial geology

The most important surficial deposits in Subarea II are depicted in

FIGURE 36
SUBAREA 2
TOPOGRAPHY

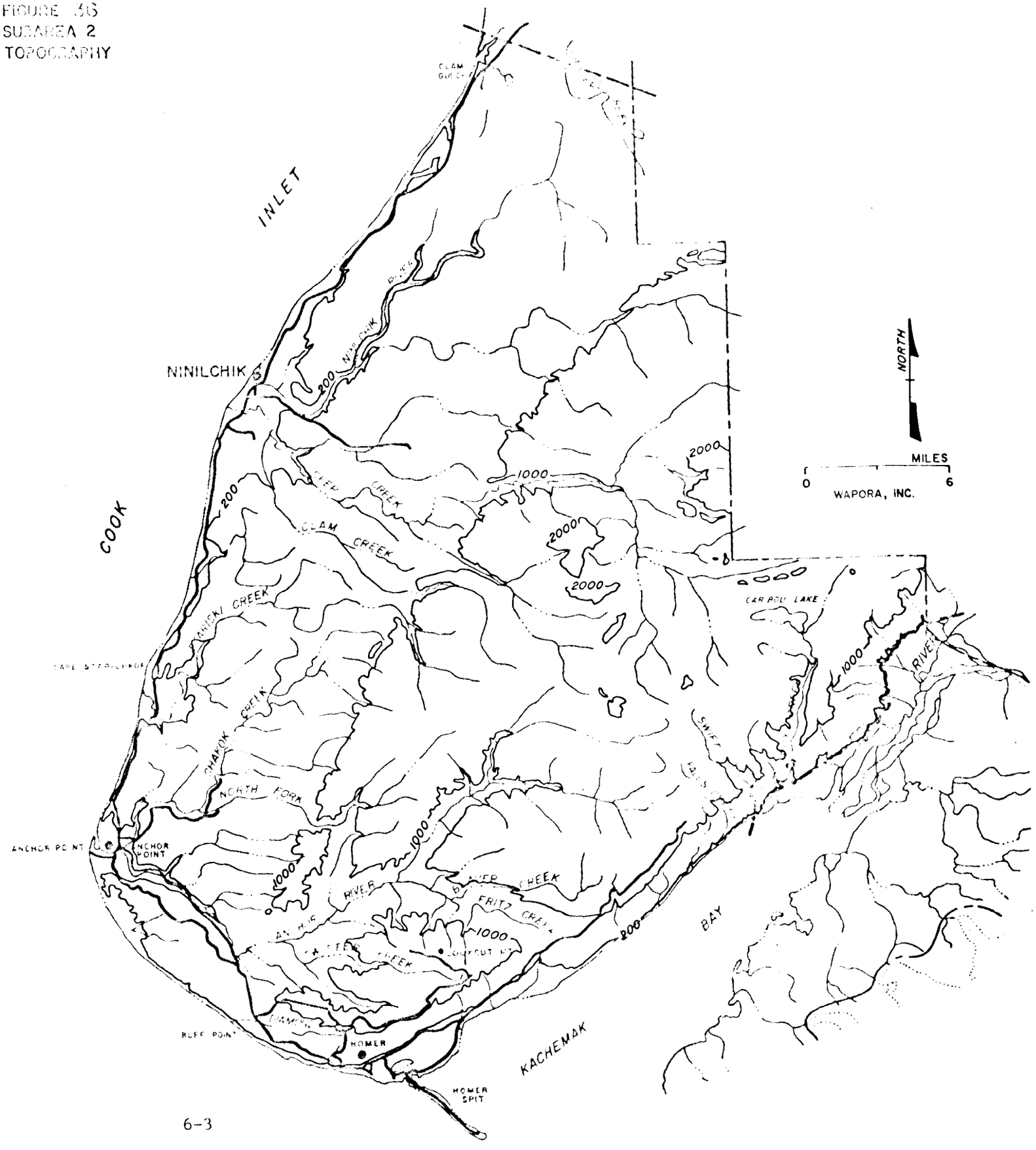


Figure 37. These deposits consist predominantly of glacial morain deposits, alluvial sediment, outwash, and lacustrine sediment (Karlstrom 1964). Uplands throughout Subarea II are mantled by deposits of aeolian silt (Hinton 1971). These deposits attain thicknesses of up to 60 inches and probably are mixtures of glacial material and ash from volcanoes in the Aleutian Range. Minor deposits of tidal silt, beach sand, and gravel occur at Ninilchik, Cape Starichkof, Anchor Point, and Homer (Hinton 1971; Karlstrom 1964; Waller and others 1968).

6.2.2.3. Soils

Soils in Subarea II have been categorized into six soil associations based on soil texture, topography, and character of the parent material:

- Cohoe-Salamatof association: deep, nearly level to moderately-sloping, well-drained silt loams that occur on uplands; and very poorly drained peat soils of muskegs

- Mutnala-Salamatof association: nearly level to steep, well-drained silt loams that are shallow over gravelly glacial till and occur on uplands; and very poorly drained peat soils of muskegs

- Kachemak association: nearly level to steep, well-drained silt loams that are shallow to moderately deep over shale and sandstone; on uplands

- Beluga association: nearly level to strongly-sloping, poorly-drained silt loams that are moderately deep and deep to stratified fine sandy loam to silty clay loam; on foot slopes

- Alluvial land-tidal marsh association: nearly level, very poorly drained to excessively-drained alluvial sand, silt, and clay; and very poorly drained soils on tidal marsh

- Rough broken land association: steep and very steep, eroded escarpments, sea cliffs, and canyon walls.

The soil types in Subarea II are discussed in the following paragraphs in terms of their suitability for development and agriculture. The soil survey of the Homer-Ninilchik Area, Alaska, by the US Soil Conservation Service was the only available source of information (Hinton 1971).

Wetlands

Twenty-two soil series have been recognized and mapped in Subarea II (Hinton 1971). Twelve are characterized by groundwater at depths of 1.0 foot or less. Soil series in this category include Beluga silt loam, Coal Creek silt loam, Doroshin peat, gravelly beach soils, Moose River silt loam, Nikolai silt loam, Salamatof peat, Slikok mucky silt loam, Spenard silt loam (nearly level), Starichkof peat, tidal marsh soils, and tidal flat soils. Available soils data indicate that wetland vegetation is associated with these soil series. Potential wetland areas (based on soils data) can be determined from the US Soil Conservation Survey (Hin-

GEOLOGY

SYNCLINE

Qs
KJm

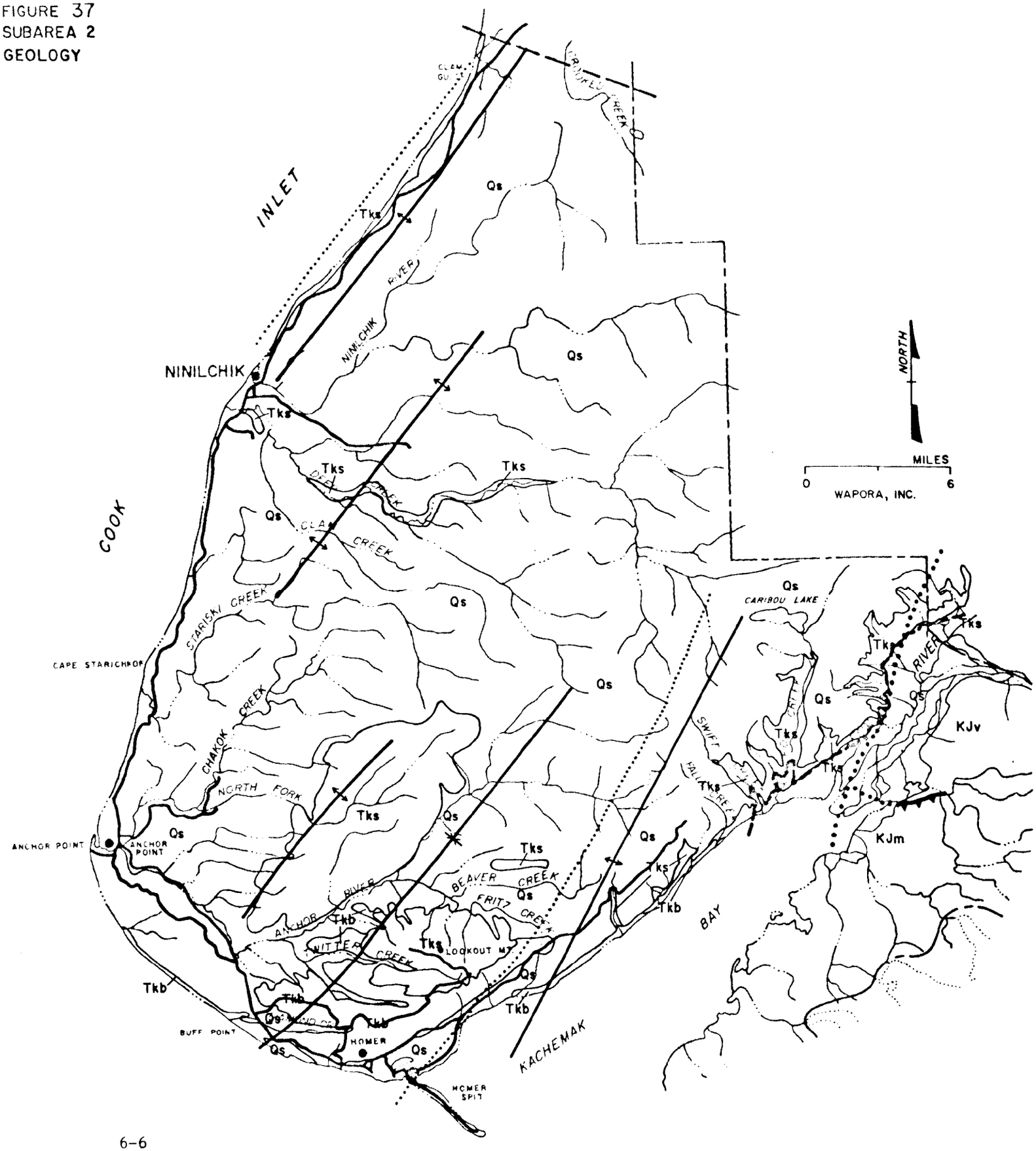
CONTACT

ANTICLINE

NORMAL FAULT - DOTTED WHERE CONCEALED
U - UPTHROWN SIDE
D - DOWNTHROWN SIDE

THRUST OR REVERSE FAULT - DOTTED WHERE CONCEALED
SAWTEETH ON UPTHROWN BLOCK

FIGURE 37
SUBAREA 2
GEOLOGY



ton 1971), but documentation of existing conditions would require field confirmation surveys.

Prime agricultural land

Prime agricultural soils include those mapped as Soil Capability Classes I and II by the Soil Conservation Service. Soils included in these classes are suitable for most field crops, and few (Class I) or moderate (Class II) limitations reduce the choice of crops because of soil limitations. No Class I soils were identified in Subarea II. Class II and Class III soils are sold for agricultural lands in Alaska. These potential agricultural soils include the following types:

Soil Type	Class
• Beluga silt loam, nearly level	III
• Beluga silt loam, gently sloping	II
• Beluga silt loam, moderately sloping	III
• Cohoe silt loam, nearly level	II
• Cohoe silt loam, gently sloping	II
• Cohoe silt loam, moderately sloping	III
• Island silt loam, nearly level	II
• Island silt loam, gently sloping	II
• Island silt loam, moderately sloping	III
• Kachemak silt loam, gently sloping	III
• Kachemak silt loam, moderately sloping	III
• Mutnala silt loam, nearly level	III
• Mutnala silt loam, gently sloping	III
• Mutnala silt loam, moderately sloping	III
• Nikolai silt loam	III
• Spenard silt loam, moderately sloping	III

The distributions of Class II and Class III agricultural soils in Subarea II are shown in Figure 38 (adapted from Hinton 1971).

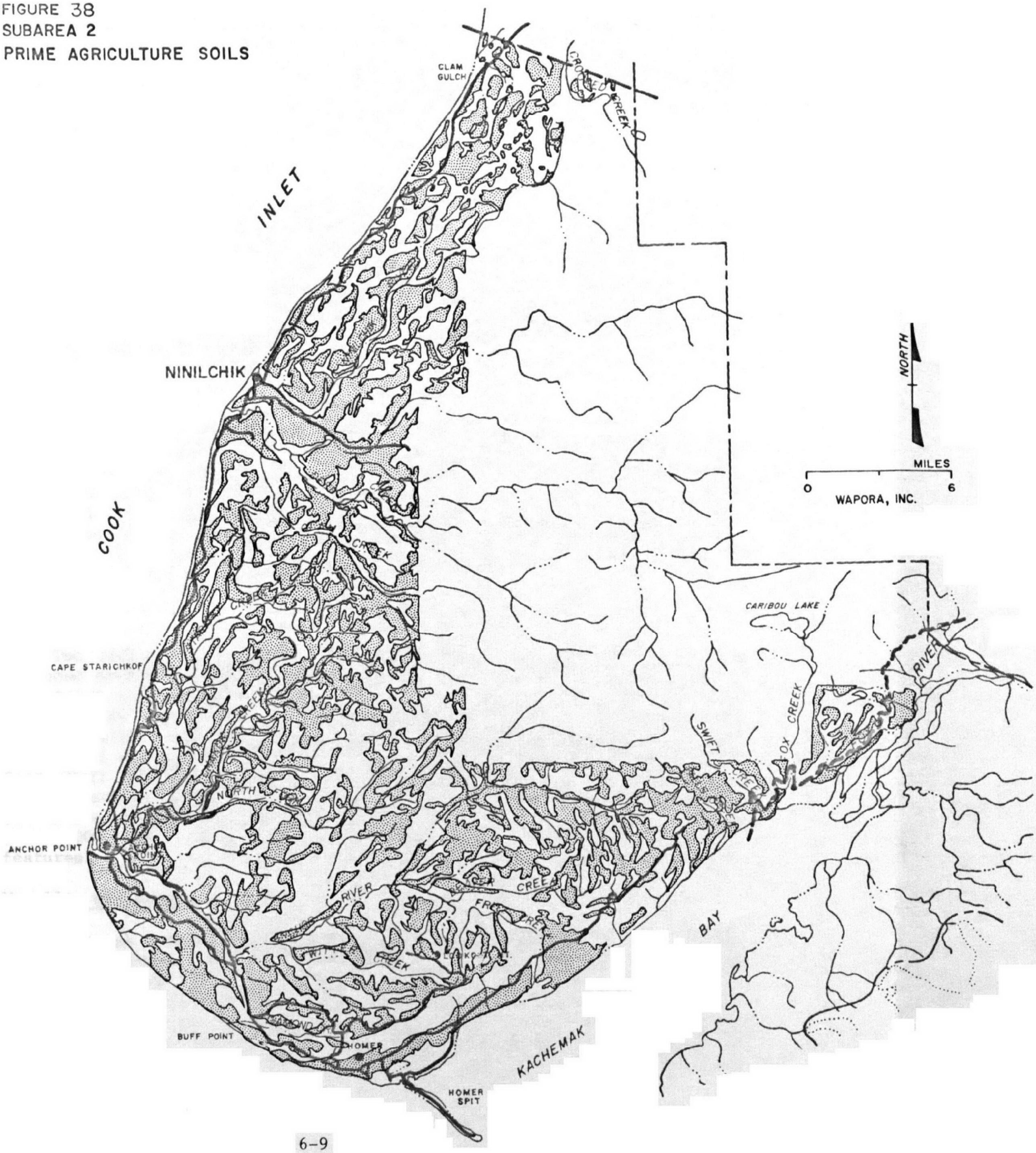
Slope capability

Light industrial structures, light-duty roads, residences, and most other construction can be built on slopes of less than 15% if the proper

PRIME AGRICULTURAL SOILS

CLASS II AND III AGRICULTURAL SOIL

FIGURE 38
SUBAREA 2
PRIME AGRICULTURE SOILS


CLAM GULCH
CROOKED CREEK
INLET
NINILCHIK
COOK
CAPE STARICHKOF
ANCHOR POINT
BUFF POINT
HOMER
HOMER SPIT
KACHEMAK
BAY
CARIBOU LAKE
SWIFT
FOX CREEK
RIVER
NORTH
NORTH FORK
RIVER
CREEK
NORTH
NORTH
NORTH

construction methods are used and the soil type is suitable (Personal communication, Mr. Lou Fletcher, US Soil Conservation Service, to Mr. Guy McConnell, WAPORA, Inc., 1978). Soils on slopes in excess of 25% are likely to present severe erosion hazards (Hinton 1971). Slope gradients of 0 to 15 percent, 15 to 25 percent, and more than 25 percent are mapped for Subarea II in Figure 39 (adapted from Hinton 1971).

6.2.2.4. Geologic resources

Coal and gold were mined at various times on the Kenai Peninsula, and coal is still collected along the beaches for domestic use. The extent of petroleum and natural gas resources in Subarea II has been explored initially and may be investigated further as the Lower Cook Inlet Outer Continental Shelf (OCS) leases are drilled for oil and natural gas. The locations of identified geologic resources in Subarea II are shown in Figure 40 (adapted from Joint Federal-State Land Use Planning Commission 1973b).

Coal

Subarea II, like Subarea I, is part of the Kenai Coalfield (Rao and Wolf 1975), and coal-bearing beds of the Kenai Group are exposed in many places. Surface mines have been operated in the vicinity of Homer since 1888, but total production was only a few thousand tons. Barnes (1967) estimated that coal reserves for the southern part of the Kenai Coal-field (Homer District) were approximately 318 million tons, in beds 2.5-feet to 10-feet thick (Joint Federal-State Land Use Planning Commission 1974c).

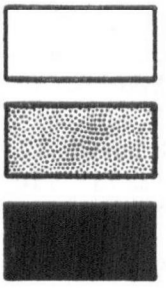
Oil and gas

Two small, non-producing gas fields exist in Subarea II. Gas is produced predominantly from the Beluga and Sterling Formations and is not associated with petroleum (Magoon and others 1976). The majority of this gas probably was formed by bacterial degradation of organic matter in coal deposits. The Falls Creek Field, located offshore south of Clam Gulch, had a cumulative production (as of 1975) of 18,983 million cubic feet (Mcf) and estimated reserves of up to 80,000 Mcf. The North Fork Field, located along the North Fork River near Epperson Knob, has a cumulative production of 104,595 Mcf and estimated reserves of up to 20,000,000 Mcf. Both fields are associated with major structural features.

Metallic minerals

Although a small amount of placer gold has been mined on the beaches near Anchor Point, there is no evidence of any economically significant metallic mineral deposits within Subarea II. Available information, however, indicates a high potential for metallic mineral development in the Kenai Mountains to the east. Lode mines in this region have been worked for gold, silver, and chromium, as well as minor amounts of copper, lead, zinc, and nickel (Joint Federal-State Land Use Planning Commission 1974c).

SLOPE HAZARDS

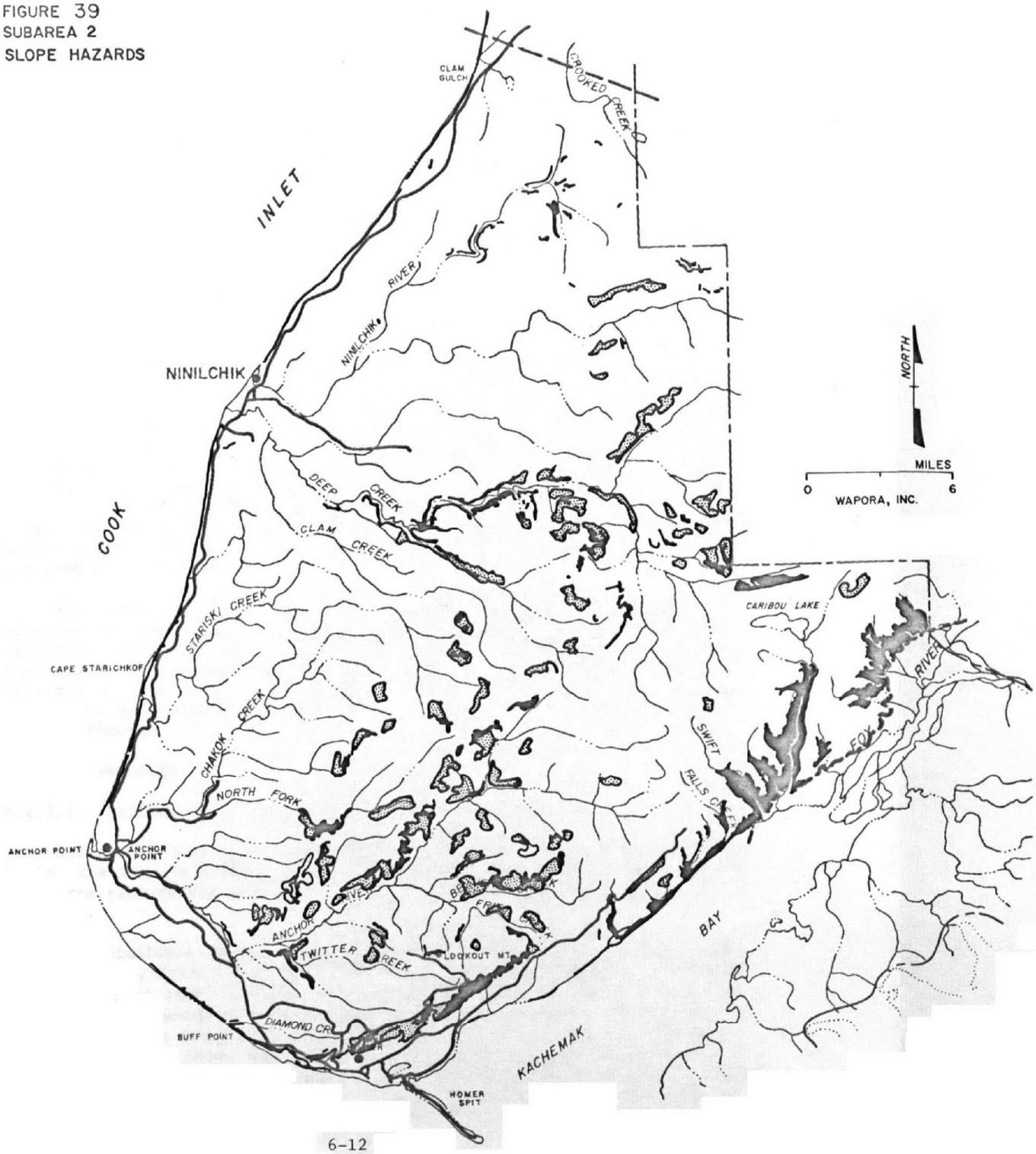


0 TO 15 PERCENT

15 TO 25 PERCENT

GREATER THAN 25 PERCENT

FIGURE 39
SUBAREA 2
SLOPE HAZARDS



Nonmetallic and industrial minerals

Clay, sand, and gravel are the only nonmetallic resources mined in Subarea II. Clay deposits that can be used for the manufacture of bricks occur near Homer. River gravel deposits generally are suitable as sources for road and concrete aggregate. Potential source areas of river gravel in the Kenai Lowlands generally lie along the lower reaches of the major streams and rivers. Glacial material may or may not be suitable for backfill material; suitability generally is determined from grain size distribution and from the intended use. As a rule, glacial deposits are not suitable as economic sources for road and concrete aggregate because of the effort required to remove fines and other harmful materials.

6.2.2.5. Geologic hazards

The geologic hazards that exist in Subarea II (Figure 41; adapted frm Alaska Department of Natural Resources 1978b) are predominatly related to earthquake activity. These include vibration damage, ground fissures, ground subsidence or uplift, mudslides, landslides, ground failure, and earthquake-induced waves (tsunamis). The higher elevations and steeper slopes in Subarea II, particularly along the coast, increase erosion hazards and may contribute to local flooding. Erosion and local runoff flooding problems, for example, affect some areas of the City of Homer and present an economic problem, because the Farmers Home Administration will not guarantee home mortgages in certain areas until the problem is resolved.

The Homer Spit is a low, narrow strip of sand, cobbles, and mud accreted by the tides of Kachemak Bay. During the high spring tides, especially when the tides coincide with westerly or southwesterly winds, the waters of Kachemak Bay may wash over the spit, flooding the lower sections of the Spit, and damaging the road. The Homer spit also is vulnerable to tsunamic flooding, and it subsided several feet during the 1964 earthquake.

6.2.3. Hydrology

6.2.3.1. Surface water hydrology

Subarea II comprises several watersheds, including the Anchor River Basin, the Ninilchik River Basin, and parts of the Kasilof River Basin. Discharge records for major and important minor streams are summarized in Table 43.

The Ninilchik River, Deep Creek, Stariski Creek, Anchor River, Diamond Creek, Fritz Creek, and all other streams tributary to Cook Inlet are subject to tidal action. This action decreases with increasing distance from the mouth of each stream. Because the gradient of each stream is comparatively steep near the stream mouth, tidal action affects only a short section of these streams. A tidal chart for Cook Inlet (Bureau of Land Management 1977a) indicates that the tidal amplitude (0.5 x mean tidal range) for Anchor Point is approximately the same as that for Kenai. Higher amplitudes can be expected for other coastal areas. No records of current velocities in the tidal segment of these streams are available.

MINERAL RESOURCES

MAJOR MINERAL

SECONDARY MINERAL

MINERAL PROVINCE BOUNDARY

COAL PROVINCE BOUNDARY

COAL PROVINCE BOUNDARY IN WATER

PETROLEUM PROVINCE BOUNDARY

COAL FIELD

OIL FIELD

GAS FIELD

POTENTIAL GEOTHERMAL AREA

FIGURE 40
SUBAREA 2
MINERAL RESOURCES

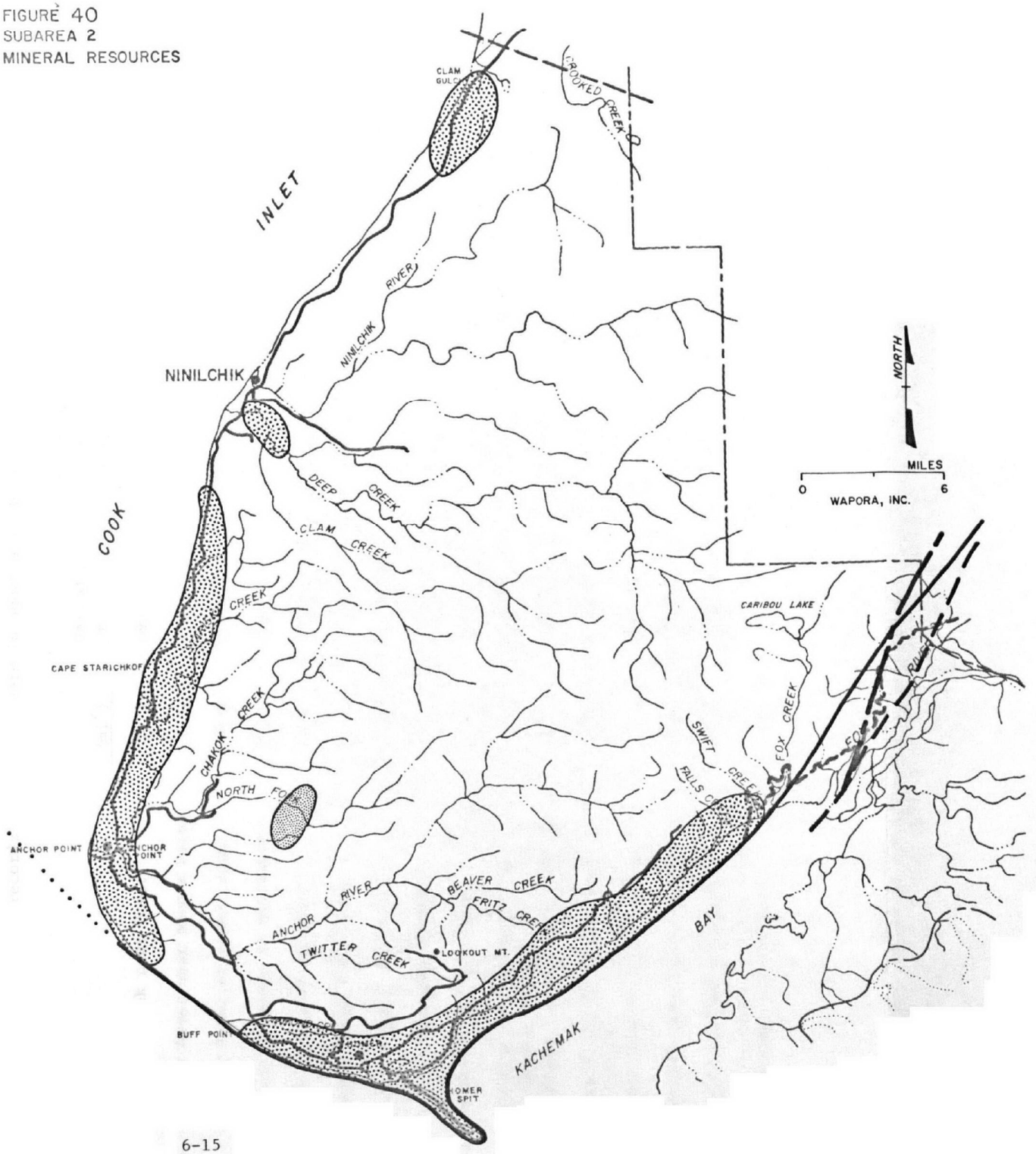


Table 43. Discharge records for major rivers in Subarea II (USGS 1978).

River	Drainage Area (mi^2)	Period of Record	Mean Annual Discharge (cfs)	Maximum Discharge (cfs)	Minimum Discharge (cfs)
Twitter Creek near Homer	16.1	1971-1973	21.2	536[a]	3.9
Anchor River near Anchor Point	133.0	1965-1973	184.0	2,240[a]	28.0
Anchor River at Anchor Point	226.0	1953-1966	299.0	3,030[a]	28.0
Ninilchik River at Ninilchik	131.0	1963-1975	104.0	1,240[a]	30.0
Fritz Creek NE of Homer	10.4	1962-1975	39.0	349	0.85
Palmer Creek NE of Homer	--	20 Mar. 1970	2.3	--	--
Diamond Creek NW of Homer	5.4	1962-1975	24.5	147	0.56
Beaver Creek NE of Homer	--	29 July 1970	8.9	--	--
Bridge Creek N of Homer	--	1970-1973	4.2	16	0.86
North Fork of Anchor River at Anchor Point	--	1951-1952	22.5	26	19.0
Stariski Creek N of Anchor Point	--	1951-1952	15.5	17	14.0
Cook Inlet Tributary SW of Ninilchik	1.7	1966-1974	18.8	73	0.76
Deep Creek SW of Ninilchik	--	1951-1968	255.3	1,480	43.0
Crooked Creek SE of Kasilof	53.8	1951-1975	31.9	50	18.0
Coal Creek SE of Kasilof	32.0	3 Aug 1973	4.8	--	--

[a]Temporary ice storage.

GEOLOGIC HAZARD

LANDSLIDE AND SLUMP

VOLCANIC AREA

FAULT ZONE

COASTAL EROSION

TSUNAMI HAZARD

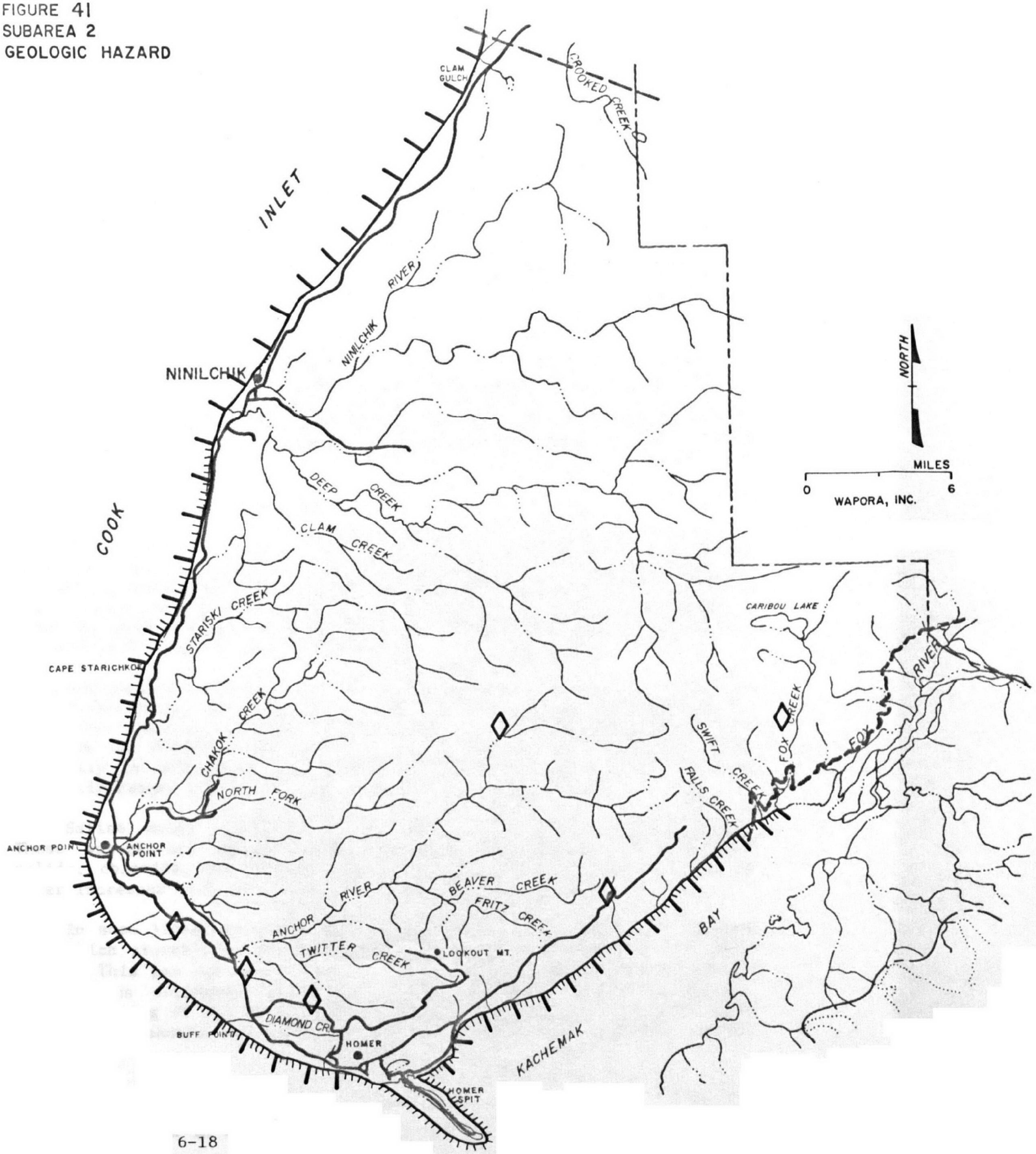
EXTENT OF ICE

AREA OF SUBSIDENCE

POTENTIAL MELTWATER AND RUNOFF FLOODING

POTENTIAL GLACIAL OUTBURST FLOODING

FIGURE 41
SUBAREA 2
GEOLOGIC HAZARD



There are no glacial streams in Subarea II, thus, there is no potential for glacial outburst flooding. However, the formation of ice jams may produce severe flooding. The streams in this subarea display high flows during the late autumn due to increased precipitation and during the spring due to snowmelt. Low flows occur in midwinter and are maintained by groundwater recharge.

Surface waters within Subarea II are generally of good quality and can be classified as calcium-magnesium bicarbonate waters. Water quality data for the Ninilchik River in Subarea II are presented in Table 44. Concentrations of silica (SiO_2), total dissolved solids (TDS), iron (Fe), calcium (Ca), and magnesium (Mg) are consistent with other analyses of non-glacial streams. These concentrations are particularly high in the 1967 analysis of the Ninilchik River, probably because the samples were taken during a period of low flow when the proportion of groundwater recharge was high.

The only large user of surface water in Subarea II is the City of Homer, which has a 145-million-gallon reservoir on Bridge Creek as its primary municipal water source. There are a number of small streams in moderately permeable soils that could be impounded to form surface water reservoirs. Some of these sites may be developed as populations grow and water demand increases.

6.2.3.2. Groundwater resources

Groundwater is used extensively throughout Subarea II for water supplies. It occurs under both water table and artesian conditions in Quaternary sand and gravel deposits, alluvium, and coastal plain deposits. Sandstones of the Kenai Group also may yield large quantities of water to wells. These sandstones probably constitute the most extensive and productive aquifer in the Homer area (Waller and others 1968).

Groundwater typically is composed of calcium bicarbonate and sodium bicarbonate types and contains as much as 30 mg/l of iron (Table 45). The water usually contains moderate amounts of dissolved solids but probably is suitable for most purposes. Water from the Kenai Group typically is soft, but water from Quaternary deposits is hard. The pH generally ranges from 6.6 to 8.5 (Waller and others 1968).

Saline water intrusion may present a problem in coastal areas. These waters are characterized by high concentrations of dissolved solids, chloride, and sodium. The potential for encroachment of saline water increases with well depth and proximity to the coast.

In some locations the groundwater contains large amounts of methane gas, which probably is derived from coal-bearing formations in the Kenai Group. This gas can ignite as it emerges from hot water taps in homes, and serious accidents may occur if its presence is not recognized. Proper venting of all gas-producing wells is recommended, and additional precautions should be exercised if the wells are enclosed within buildings.

6.3. Biological Environment

The terrain in Subarea II rises gradually from north to south, and

Table 44. Water quality of the Ninilchik River (Balding n.d.).

Date	Discharge (cfs)	Silica (SiO_2)	Iron (Fe)[1]	Manganese (Mn)[1]	Calcium (Ca)	Magnesium (Mg)	Sodium (Na)	Potassium (K)	Bicarbonate (HCO_3)	Carbonate (CO_3)	Sulfate (SO_4)	Chloride	Fluoride	Nitrate (NO_3)[1]	Dissolved solids	Total hardness	Specific conductance (umhos/cm at 25°C)	pH
Ninilchik River at Ninilchik																		
21 August 1958	-	29.0	780	0	8.7	3.3	5 8	1.6	56	0	1.5	2.0	0.1	.14	81	35	97	6.6
29 March 1967	51	36.0	800	-	10.0	4.6	9.7	2.7	80	0	.0	2.1	0.1	.14	106	44	131	6.8

[1] Concentrations in ug/l.

Table 45. Groundwater quality analyses for selected wells in Subarea II (Waller and others 1968). Concentrations are reported in milligrams per liter (mg/l).

Location (Township, Range, Section)	Year of Collection	Well Depth	pH	Silica (SiO_2)	Total Iron (Fe)	Calcium (Ca)	Magnesium (Mg)	Sodium (Na)	Potassium (K)	Bicarbonate (HCO_3)	Sulfate (SO_4)	Chloride	Fluoride	Nitrate (NO_3)	Dissolved Solids
T6S R13W S18 NW SE	1962	112	8.5	26.0	0.12	8.0	1.0	292.0	4.4	772	4.0	6.0	0.0	0.6	735
T6S R13W S18 NW SE	1962	195	8.3	50.0	0.90	6.4	1.0	117.0	6.3	310	2.0	8.5	0.2	0.2	348
T6S R13W S19 NW NE	1955	107	7.6	31.0	4.60	39.0	4.9	40.0	2.9	226	0.7	14.0	0.0	0.4	246
T6S R13W S10 SE SE	1963	72	7.5	40.0	6.80	13.0	3.8	127.0	3.4	354	4.0	14.0	0.2	0.8	383
T6S R13W S16 NE SW	1963	80	6.9	21.0	1.90	2.4	1.0	40.0	1.0	88	3.0	16.0	0.1	0.7	130
T6S R13W S12 SE NW	1962	187	7.2	17.0	0.72	4.0	0.0	308.0	4.0	800	1.0	16.0	0.2	0.3	744
T6S R13W S20 SE NW	1953	119	7.7	34.0	0.59	1.6	0.0	184.0	2.4	466	0.0	16.0	0.1	0.1	467
T6S R14W S15 NE SW	1960	73	6.7	40.0	11.00	25.0	4.2	8.0	1.2	90	1.0	19.0	0.2	0.0	154
T6S R14W S15 NE SW	1963	247	6.6	37.0	8.50	42.0	17.0	20.0	4.3	235	15.0	12.0	0.0	0.1	263
T6S R14W S2 SW SW	1963	550	7.0	48.0	3.10	15.0	13.0	7.0	6.4	112	1.0	6.0	0.3	8.0	170
T6S R13W S1 SW SW	1963	115	6.8	41.0	6.80	49.0	21.0	12.0	8.2	270	6.0	11.0	0.3	0.2	283
T6S R13W S21 SW NW	1962	41	8.2	33.0	10.00	25.0	11.0	13.0	1.7	88	7.0	41.0	0.1	0.0	175
T6S R13W S8 NW NW	1966	224	7.0	47.0	2.00	14.0	10.0	5.1	5.0	110	1.4	6.4	0.1	0.3	144

inland from the Cook Inlet and Kachemak Bay to the highest elevations in the Kenai Lowlands part of the study area. Drainage from the Kenai Mountains east of Subarea II flows into the Tustumena Lake system north of Subarea II and into the Fox River watershed in Subarea III. Drainage patterns in Subarea II radiate from the 2,000-foot-high Caribou Hills and from the Ninilchik Dome and Epperson Knob Highlands. Because the streams receive no glacial meltwater, they are nearly transparent and have comparatively low volumes. The radial drainage pattern produces a number of small, low-discharge streams that run only a short distance to the Cook Inlet and thus rarely converge to form rivers. The higher ground region in Subarea II contains some of the most well-drained areas of the Kenai Lowlands, and thus the vegetation, habitats, and wildlife populations differ from those of the Subarea I lowlands.

6.3.1. Vegetation

The vegetation in Subarea II, shown in Figure 42 (adapted from Joint Federal-State Land Use Planning Commission 1973b) differs according to the elevation of the terrain, the soil drainage, and the proximity to Cook Inlet or Kachemak Bay. In the northern lowland part of Subarea II, muskeg-bog and spruce-hardwood communities are approximately equal in area. Farther south, the muskeg-bog vegetation is confined to a band paralleling the coastline and to the bottomlands adjacent to streams. The remainder of Subarea II is covered by Sitka spruce and/or a hybrid of Sitka and white spruce along much of the coast, and by spruce-hardwood forest on the lower and moderate elevations. At higher elevations there is a transition from spruce-hardwood forest to high brush. Moist tundra may occur on the highest hilltops. The plants characteristic of each vegetation type are discussed in Section 3.2.3.1.

6.3.2. Aquatic biota

Inventory data are not available for the fish and macroinvertebrates in the streams of Subarea II. In the absence of other data, the species lists of organisms collected from the Kenai River in Subarea I (Table 30 and 31) probably are representative of those to be found in Subarea II.

Pink salmon, coho salmon, and chinook salmon spawn in the streams of Subarea II. The spawning sites and the areas where these salmon have been seen are indicated in Figure 43 (adapted from Joint Federal-State Land Use Planning Commission 1973b). Pink salmon spawn in the lower reaches of most of these streams. Coho salmon may be present in any of the indicated areas. Chinook salmon migrate up the Anchor River, the Ninilchik River, Deep Creek, and Chakok Creek. Because there are no large lakes on the streams that drain Subarea II, the Subarea does not experience the sockeye salmon runs that are the major component of the Subarea I fishery. The only sockeye salmon migration recorded in Subarea II is a small run up the Fox Creek to Caribou Lake.

Dolly Varden char and rainbow trout are present in many of the lakes and streams. Steelheads migrate up the Anchor River, the Ninilchik River, Deep Creek, Chakok Creek, and Stariski Creek during the late summer and autumn to spawn.

Each of the streams mentioned is a critical rearing habitat for salmon, trout, and char and is an important, or potentially important,

recreational fishing stream. Deep Creek, Stariski Creek, and the Ninilchik River receive the most intensive recreational angling pressure each spring during the chinook salmon spawning runs. The Anchor River has not been open for chinook fishing during recent seasons. Several streams, particularly the Anchor River, receive moderately intensive steelhead fishing during the late summer.

One of the most intensive recreational-subsistence fisheries is on the beaches at Clam Gulch, Deep Creek, and Whiskey Gulch, where during the last few years approximately 900,000 razor clams were harvested each year as a result of approximately 25,000 to 30,000 person-days of effort per year (By telephone, Mr. Steve Hammarstrom, Alaska Department of Fish and Game, to Mr. Guy McConnell, WAPORA, Inc., 1978).

6.3.3. Mammals

The species of terrestrial mammals present are approximately the same as those in Subarea I. Most of the terrestrial mammals found in the Lower Cook Inlet study area are present in Subarea II, except for arctic fox, arctic ground squirrel, mountain goat, and mountain sheep. No endangered or threatened terrestrial mammals have been reported from Subarea II. Type localities for the following subspecies occur in Subarea II:

Common name	Scientific name	Type locality
Gray wolf	*Canis lupis pambasileus*	Kachemak Bay
Red fox	*Vulpes fulva kenaiensis*	Kenai Peninsula
Black bear	*Ursus americanus perniger*	Homer
Wolverine	*Gulo luscus katschemakensis*	Kachemak Bay

Three species of big game animals -- moose, black bear, and brown bear -- are present in Subarea II. These species, as well as lynx, wolf, coyote, wolverine, and other large carnivores, are the mammals most likely to be affected by human activities.

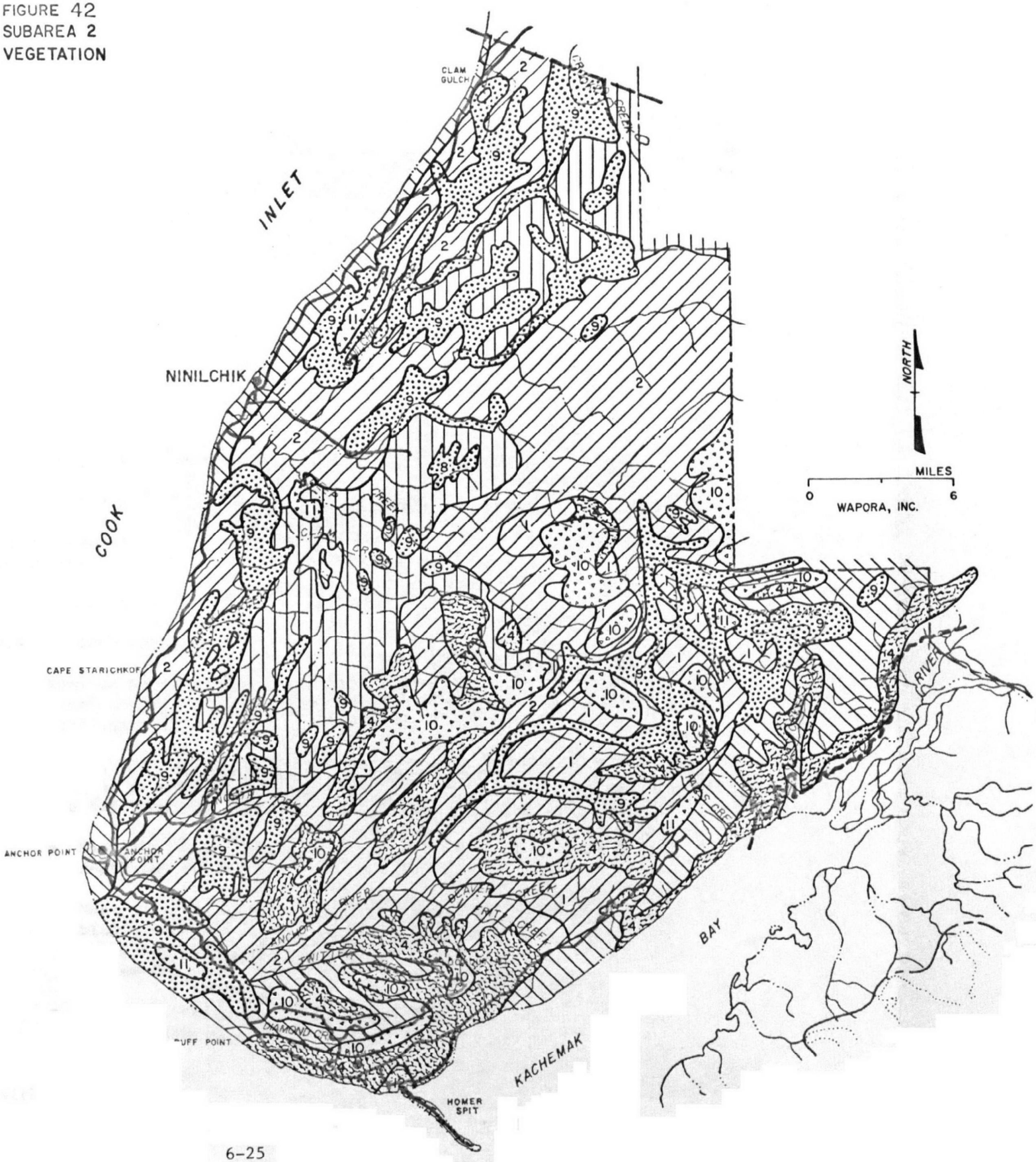
Moose

Moose range throughout Subarea II. They concentrate in summer feeding areas, on calving grounds, and in winter "moose yards" in river bottoms and on low-elevation plains. Each of these habitats is critical for moose populations, but the winter habitat probably is the most population-limiting of the three. Habitats identified as supporting winter concentrations of moose are shown in Figure 44 (adapted from Joint Federal-State Land Use Planning Commission 1973b). The lowlands around Homer constitute some of the most intensively-used moose winter habitats. Impacts such as loss of habitat, hunting pressure, highway mortality, and intentional and/or unintentional harassment have accompanied the development of the Kenai Peninsula. As in Subarea I, these impacts have been mitigated partially by reduction of natural predators and by man-induced changes in the vegetation. Moose populations may decline as the City of Homer expands and more habitat along the stream beds is utilized for homesites and farms.

VEGETATION

	COASTAL WESTERN HEMLOCK/SITKA SPRUCE
1	UPLAND SPRUCE/HARDWOOD
2	UPLAND SPRUCE/HARDWOOD/LOWLAND SPRUCE/HARDWOOD
3	UPLAND SPRUCE/HARDWOOD/HIGH BRUSH
	LOWLAND SPRUCE/HARDWOOD
4	HIGH BRUSH
5	HIGH BRUSH BURNED
6	HIGH BRUSH BURNED/COASTAL WESTERN HEMLOCK/ SITKA SPRUCE
7	HIGH BRUSH/MOIST TUNDRA/ALPINE TUNDRA
8	LOW BRUSH/MUSKEG-BOG
9	MUSKEG
10	MOIST TUNDRA
11	WET TUNDRA
12	ALPINE TUNDRA/BARREN
13	ALPINE TUNDRA/BARREN/MOIST TUNDRA
M	MUD

FIGURE 42
SUBAREA 2
VEGETATION



Bear

Black bear range throughout Subarea II. Intensive spring usage of the nearby Fox River flats has been reported, and the beaches along Kachemak Bay are used intensively (By telephone, Mr. Dave Hardy, Alaska Department of Fish and Game, to Mr. Guy McConnell, WAPORA, Inc., 1978). The Alaska Department of Fish and Game (1976) reported that black bear are common in Subarea II, but that hunting pressure has reduced populations in the Homer area. Increased human populations and activity, the secondary impacts of industrial development, are the most potentially harmful threats to black bear in Subarea II.

Brown bear also may be found throughout Subarea II, although the population is small. As in Subarea I, most of the brown bear have been destroyed or forced out by human activities. No brown bear concentrations or critical habitat were identified in Subarea II.

6.3.4. Birds

Waterfowl nest in ponds and potholes throughout Subarea II, but no staging areas or other critical migratory waterfowl habitat have been reported. Shorebirds occur along the coast, and large numbers may congregate during the fall and spring migrations, especially on the Homer Spit. Eagles also over-winter on Homer Spit, on the Bluffs overlooking Cook Inlet, and along the Kachemak Bay shoreline. The peregrine falcon, an endangered species (Federal Register 1976), may be found occasionally in Subarea II.

6.4. Land and Water Use

6.4.1. Settlement patterns

Non-native settlement in Subarea II began with the Russians in the eighteenth century. They explored and traded in the area, mined coal, and established a village at Ninilchik.

Homer, the major population center in Subarea II, was settled by gold miners in the late 1800s. A number of natural features made Homer the base for resource development in the lower Kenai Peninsula:

- Kachemak Bay offers a protected, deepwater boat shelter and moderates the climate
- Most of the northern shore of Kachemak Bay is hemmed by bluffs hundreds of feet high; the Homer town site was established on a break in the bluffs, where there is access to the Bay
- The town site is close to the fisheries resource and the surrounding agricultural and grazing lands.

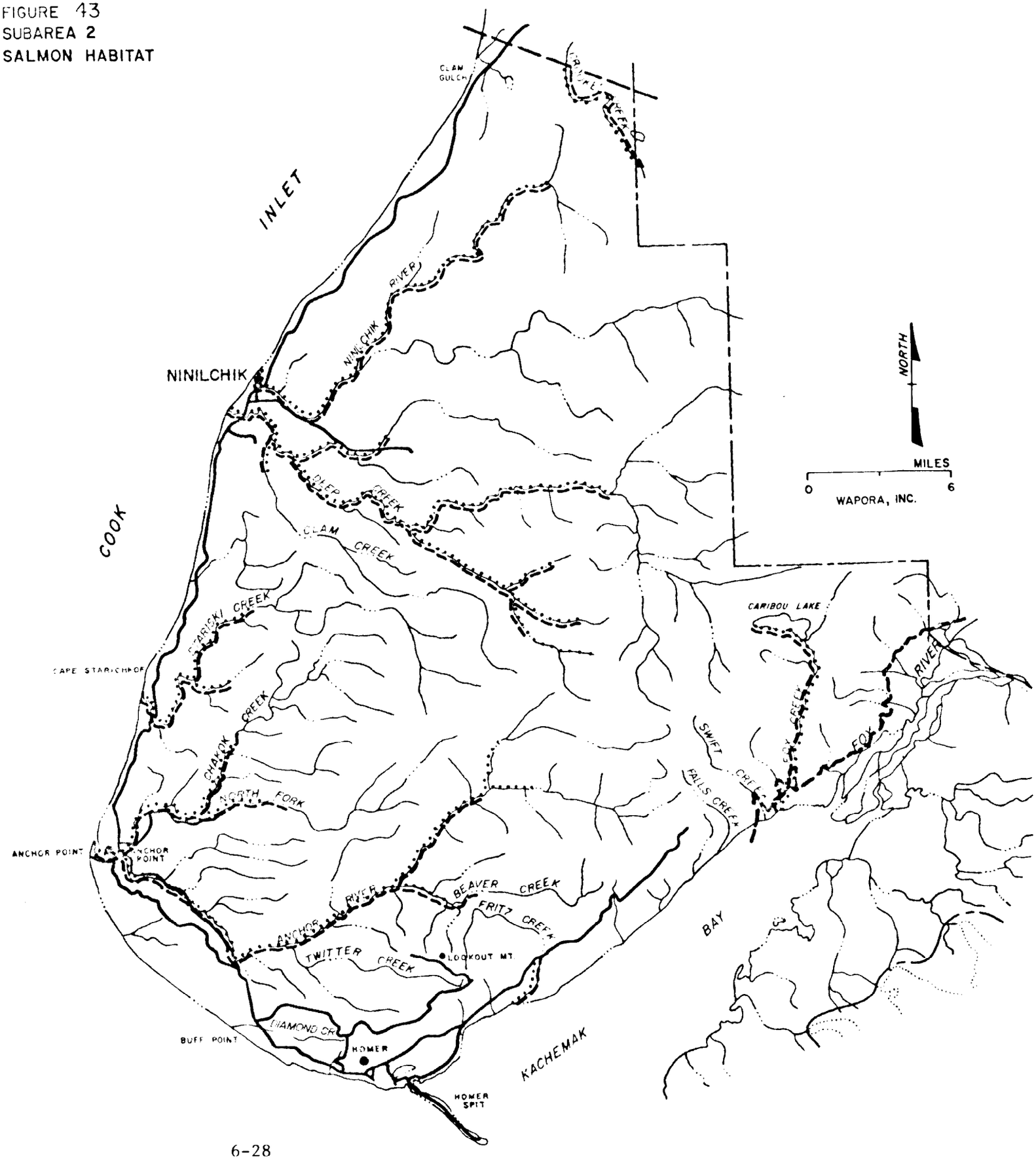
These advantages were recognized by the early settlers and, along with smaller settlements in protected coves on the south side of Kachemak Bay, Homer became the base for much of the Lower Cook Inlet fishery.

SALMON HABITAT

------ SALMON PRESENT

..... SALMON SPAWNING

FIGURE 43
SUBAREA 2
SALMON HABITAT



Homesteaders claimed some of the surrounding land, and by 1969 Homer was surrounded by a low-density population engaged in subsistence and commercial agriculture, trapping, mining, and fishing.

The completion of the Sterling Highway in the mid-1950s joined Homer with the other towns on the Kenai Peninsula and with Anchorage and opened the area to increased industry and tourism. Vacation and retirement homes began to be built along the highway, especially where the highway approached the bluffs and allowed a view of Cook Inlet. Small, resource- and tourist-oriented settlements have developed near Ninilchik, Anchor Point, and Clam Gulch. North of Anchor Point, development along the highway is sparse and follows a corridor pattern. Nearer to Homer, lateral roads radiate into the nearby low hills. Much of the lower terrain has been developed, and residents, especially those looking for large homesites, are building in the surrounding hills.

6.4.2. Land ownership

Subarea II is primarily in State and private ownership (Figure 45; adapted from Alaska Department of Natural Resources 1977). Private ownership is concentrated along the Cook Inlet bluffs between Kasilof and Anchor Point, around Homer, and on the hillsides overlooking the north shore of Kachemak Bay. Most of the coastline of Kachemak Bay is State-owned. The State of Alaska holds periodic land sales in the Homer region. During 1978 the State sold 15 parcels, totaling 2,960 acres, to be used for residential development and agriculture. Land ownership in Subarea II is unlikely to be affected significantly by Alaska Native Claims Act conveyances. Ownership will continue to be primarily by individuals, the Kenai Peninsula Borough, and the State of Alaska.

6.4.3. Recreational areas

The major recreational areas in Subarea II are associated with the Kenai National Moose Range, which forms the eastern boundary of Subarea II, and with Kachemak Bay and Cook Inlet, which form the southern and western boundaries. The Moose Range contains approximately 2,700 square miles of the Kenai Peninsula and offers opportunities for a wide range of outdoor activities, including camping, hiking, skiing, boating, hunting, fishing, and sightseeing. The Cook Inlet shoreline is used by boaters, fishermen, campers, hikers, picnickers, and clam diggers. With the exception of a short stretch of shoreline north of Anchor Point, the shoreline in Subarea II has been designated as "critical habitat" by the State of Alaska (Figure 46; adapted from Joint Federal-State Land Use Planning Commission 1973b). Several large streams in Subarea II flow into Cook Inlet. These streams, along with the Kenai River System, are the major recreational fishing streams on the Kenai Peninsula. The Alaska Department of Transportation and the Alaska Division of Parks have established highway waysides and campgrounds near the streams. These campgrounds usually are filled during the salmon sportfishing seasons.

Other public recreational facilities are operated by the City of Homer on the Homer Spit and in the City. The public recreational facilities in Subarea II are summarized in Table 46. In addition to the City campgrounds, camping is allowed on City land on the Spit. Homer i planning to use funds from the Federal Coastal Impact Program to devel

WILDLIFE HABITAT

SEA LION HAULING OUT AREA

HARBOR SEAL

BLACK BEAR

BROWN BEAR

MOOSE

GOAT

CARIBOU

FIGURE 44
SUBAREA 2
WILDLIFE HABITAT

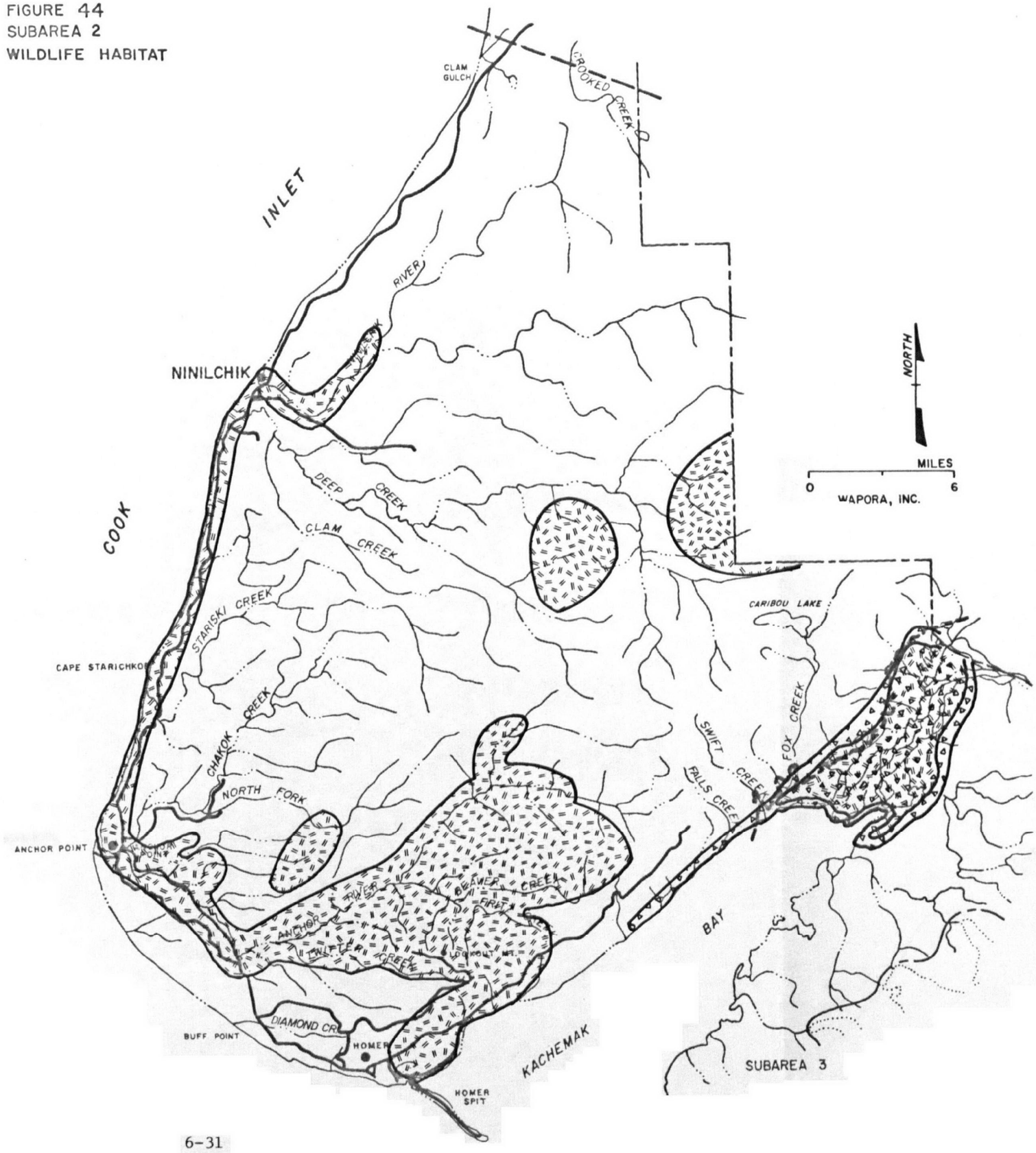


Table 46. Recreational areas in Subarea II.

Name	Location	Facilities
Hillside Campground	Homer	Camping, picnicking, toilets, drinking water
Homer Spit Campground	Homer	Boat harbor, fishing, boat ramp, restrooms, camping allowed
Kasilof River Wayside	Sterling Highway Crossing of Kasilof River	Camping
Johnson Lake Wayside	Near Sterling Highway and Kasilof River	Picnicking, camping
Clam Gulch Recreation Area	Clam Gulch	Picnicking
Ninilchik Wayside	Ninilchik	Boat harbor, picnicking, camping
Deep Creek Wayside	Ninilchik	Camping, picnicking, fishing, boat ramps
Stariski Wayside	North of Anchor Point	Camping
Anchor River Wayside	Anchor River	Camping, fishing

LAND OWNERSHIP

FEDERAL LAND

STATE LAND

TENTATIVELY APPROVED PATENTED

TIDELAND PATENTS

MANAGEMENT RIGHTS SELECTION APPROVED PATENTED

TIDELAND PATENTS

INTERIM CONVEYANCE PATENTED

TIDELAND PATENTS

FIGURE 45
SUBAREA 2
LAND OWNERSHIP

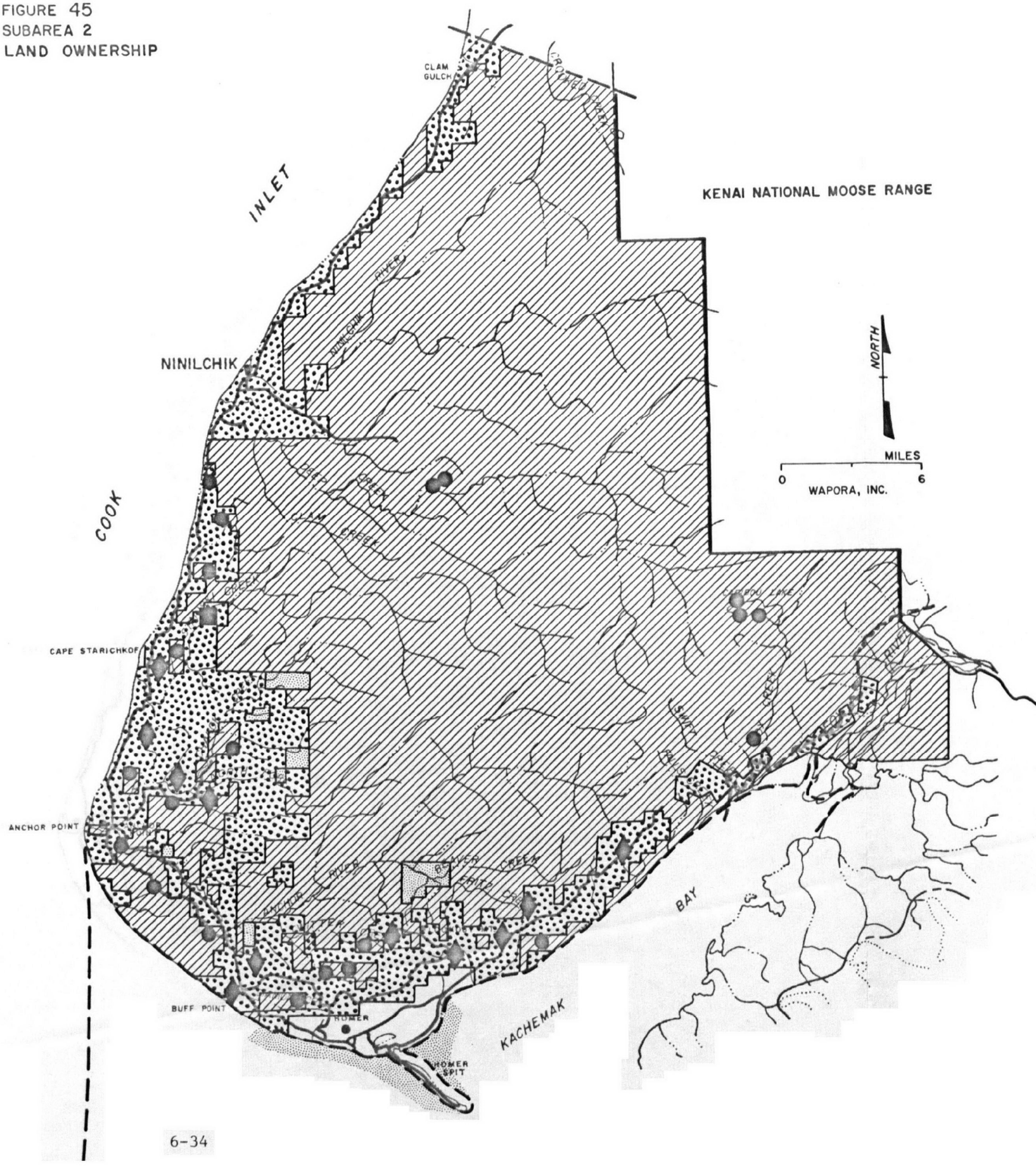
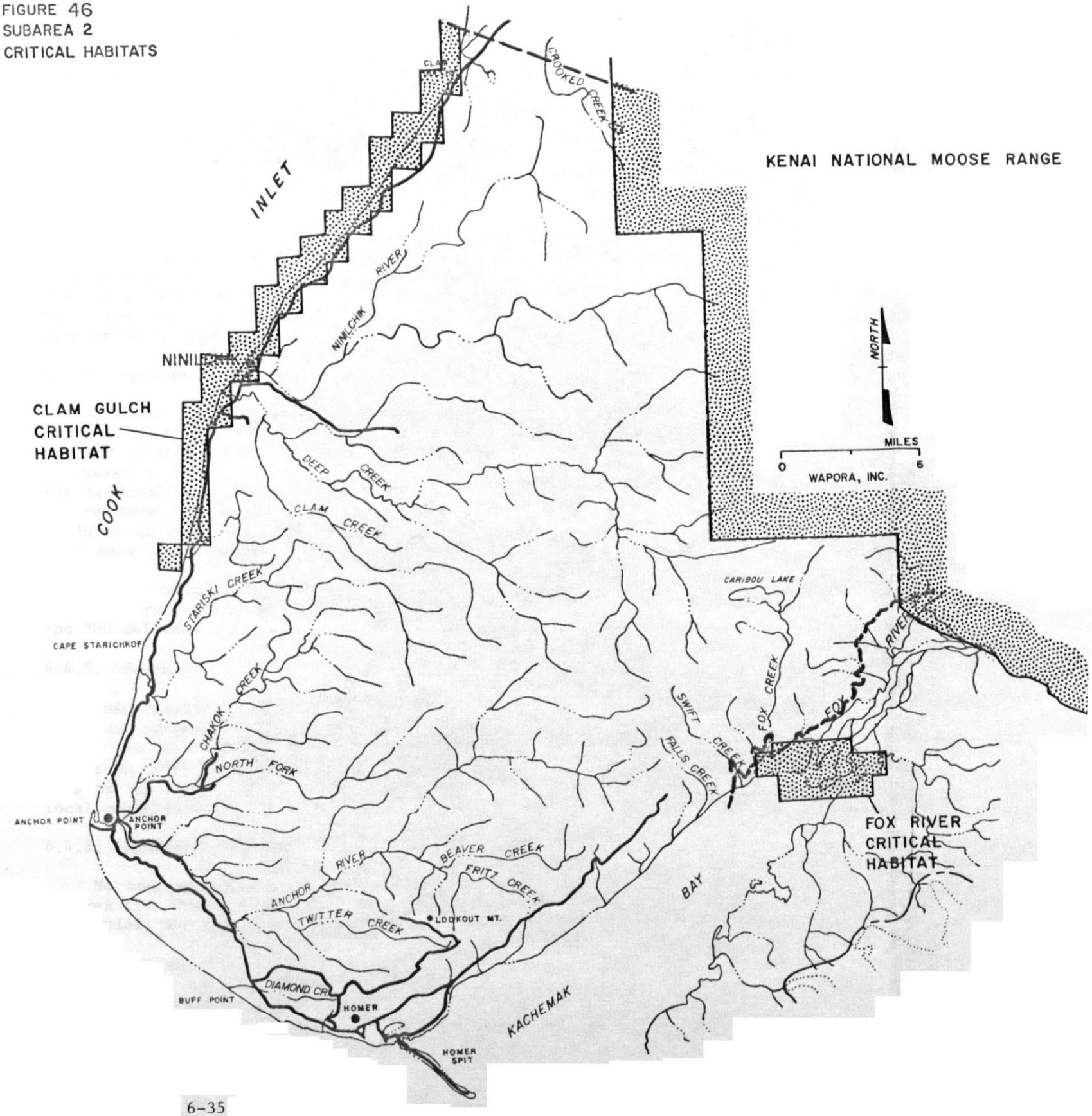


FIGURE 46
SUBAREA 2
CRITICAL HABITATS



a new 8-acre to 10-acre campground at the base of the Spit. The present campground near the end of the Spit may be lost as commercial and industrial development continues on the Split (Anonymous 1978c).

A proposed bond issue to expand the Silver King Wayside near the Anchor River will be voted on in the next election; the present wayside is being destroyed by the meandering Anchor River. The new facility, if approved, would expand capacity from the 28 campsites available at present by the addition of a 230-car camping-parking lot, trails, toilets, and a well (Anonymous 1978b).

The Alaska Department of Natural Resources (1976b) published an inventory of public recreational facilities near the coast of Cook Inlet. The Department recommended the establishment of a number of new facilities and the expansion of existing facilities. This publication also presents excellent data on bluff and shoreline stability.

6.4.4. Agriculture

Subarea II has a moderate climate, comparatively gentle topography, and some of the better soils in the Lower Cook Inlet study area. Much of the agriculture in the study area is conducted in Subarea II north and northeast of Homer. Agricultural production statistics are not available for Subarea II alone. The US Forest Service (1975) reported that the entire Kenai Peninsula produced approximately $521,000 of agricultural products in 1974, most of it for domestic consumption. Thirty-one farms sold more than $1,000 of produce, and total farm sales (all crops and livestock) were $121,400. Between 1960 and 1975 the most important commercial crops were grasses, oats, barley, mixed grains, and truck garden crops. Livestock production in 1975 totaled 860 cattle, 20 hogs, and 300 chickens.

6.4.5. Forestry

Commercially-acceptable stands of Sitka spruce and white spruce occur in Subarea II and in the surrounding Kenai Moose Range. Logging rights are sold periodically by State and Federal agencies. Most of the timber is sawn locally into rough lumber or is turned to produce cabin logs of uniform diameter. These timber products are used primarily for local construction.

6.4.6. Land-use planning

No comprehensive planning document or zoning ordinance exists for Subarea II. The City of Homer is zoned in three categories: industrial, commercial, and residential.

The entire Homer Spit is zoned industrial. This is the only industrially-zoned land in Homer. A broad band of land zoned for commercial activity, varying from approximately 0.5 to 1.0 mile wide, extends northwest from the Homer Spit Road and surrounds the airport. Another commercially-zoned area adjoins Lake Street and the junction of Lake Street and East End Road. The remainder of Homer is zoned residential.

Much of the planning conducted by the City of Homer has been concerned with the Homer Spit, most of which is owned by the City. The

Homer Spit is a narrow accretion of sea-borne silt, sand, and gravel that extends approximately 7 miles into Kachemak Bay from the bluffs that overlook much of the Kenai Peninsula coastline. At the widest point it is a few hundred yards across, and its maximum elevation is not much higher than the spring tides. A two-lane asphalt road runs the entire length of the Spit, and, for a short length, almost its entire breadth. A combination of extreme high tides and storm waves sends seawater over the road, closes the Spit, and frequently washes out the road.

Although the Spit is relatively insignificant as a landmass, it is the center of industry, commerce, recreation, social interaction, and tradition for most of the Lower Cook Inlet and the southwestern Kenai Peninsula. Homer is a town that grew up around commercial fishing, and Homer's entire commercial fishing fleet docks in the harbor near the end of the Spit. The Whitney-Fidalgo and Alaskan Seafoods plants, the only heavy industries in Homer, process the catch adjacent to the harbor and load their products into freighters calling at the Spit. An Alaska Marine Highway ferry, the Tustumena, also docks at the Spit, landing autos, trucks, and passengers. Nearly every visitor to the lower Kenai Peninsula comes to the Spit, where there is an unobstructed view of the mountains hemming Kachemak Bay, access to the beaches and boat ramps, fishing boats to view, a variety of retail establishments, and a private campground with the amenities of fences, showers, and toilets. In previous years the City has allowed free camping on parts of the Spit, and tents or "visqueen palaces" of driftwood and polyethylene have sheltered transients each summer.

The Spit is being used at near-capacity (some would say at over-capacity) for its present stage of development. The City must plan carefully the allocation of each parcel of land, considering each of the City's needs and balancing the use of each parcel between several potential users.

It is probable that the most-intensive, biggest-money industries will take over the Spit. Already the City is planning to relocate the campgrounds to a new site below the bluffs near the base of the Spit. Fish processors are petitioning for ground to build additional plants, and the fishermen want a bigger harbor. In addition to these potential users, the petroleum companies that expect to begin exploration in the Lower Cook Inlet during 1979 would like to use the Spit as a support base for drilling production.

The people of Homer recognize that the future of their City is inextricably joined with the future of the Spit. They view each potential change from a variety of perspectives, but with equal concern.

The use to which the Spit is put during the next few years will determine the growth patterns of Homer and eventually will decide the character of the town and of much of the southeastern Kenai Peninsula. The population of Homer in 1978 is about 2,000. The economy, tradition, and social structure are based on fishing and tourism, strongly influenced by the homestead-subsistence fishing tradition. A major influx of petroleum-based commerce and population would alter the character of Homer permanently and significantly.

6.5. Socioeconomic Environment

6.5.1. Level of development

Subarea II contains one first-class city, Homer; and one second-class city, Kachemak. The majority of the citizens of Kachemak voted to dissolve the incorporated city, but Alaska courts to date have denied petitions to allow the dissolution. The most recent decision is being appealed. The other incorporated communities in Subarea II are Clam Gulch, Ninilchik, and Anchor Point. Most of the socioeconomic data available for Subarea II are for Homer or for tax code areas. Although not representative of the entire subarea, these data reflect the services available to a substantial part of the Subarea II population and probably reflect the general attitudes of most of the populace.

6.5.2. Demography

6.5.2.1. Population

The results of the 1970 census, the 1977 special census, and the 1978 special census are presented in Section 3.4.3.1. The 1978 data are shown for Subarea II in Figure 47 (adapted from US Bureau of the Census 1978). The most reliable data are those from the 1970 census and the 1978 special census. They indicate that the population of Homer increased from 1,083 to 2,055 (almost 90%) during the period 1970 to 1978. The population of Homer in 1977 was estimated to be 1,802. Kachemak had 280 people in 1977. The data for the other communities and enumeration districts are not comparable, because different boundaries were used during each census.

The population of Homer in 1988 was projected to be 4,382 (Table 20; Section 3.4.3.3.). This projection was based on a 10% compound annual population growth (similar to the Homer population increase during the period 1970 through 1978). In the medium scenario for the outer continental shelf (OCS) oil lease development (Table 22), an increase of approximately 560 people would be expected in the Homer area by 1988 (Table 22). A petrochemical complex comparable in scope to the Alpetco project that was proposed for North Kenai could add another 235 people to the population of Homer. Thus, it is estimated that a medium scenario OCS development would increase the population by 12.8% by the end of a 10-year period and that construction and operation of a major petrochemical complex would cause an additional 5.3% increase. The total of these increases plus the base case projections is small compared to the total projection for the City of Kenai, but would be sufficient to require additional planning for facilities and social services if they were to occur in a town the size of Homer. Ultimately, the projections indicate that OCS development or the construction and operation of a major industrial complex at any place in the study area could be expected to affect populations in Subarea II significantly and would require special consideration and planning. Full-scale OCS development based in Homer, or construction and operation of a major petrochemical facility in the Homer area, could be expected to cause population increases similar to those projected for the cities of Kenai and Soldotna (Table 20).

6.5.2.2. Population composition

Data that describe the demographic and economic composition of the Homer population, including sex and age of household members, employment percentages, education, median family income, and racial composition are contained in Table 47. In 1976, the two-person household predominated in Homer, accounting for about the same percentage of total households as in Kenai, but for a significantly higher percentage than in Soldotna. At the same time, Homer had the highest percentage (of any of the cities) of households with six or more persons. Its male/female ratio was the same as in the other cities, whereas the percentage of its population in the 20-59 year age range was appreciably lower than that of the other cities. The percentage of employed adults was significantly larger than in Kenai or Soldotna. This may be accounted for by a larger proportion of female adults working to offset lower pay-scales. The percentage of full-time adults employed was slightly less than in Kenai and Soldotna. However, the percentage of household heads who worked for 12 months in 1975 (59%) was significantly lower than in Kenai or Soldotna. This may reflect the relative importance of (low-paid) seasonal work in Homer. The median household income ($21,350) was significantly less than that in Kenai or Soldotna. Although some reasons for this difference are suggested above, the data required for a definitive explanation are not available. Racial composition is not an explanatory factor. However, it is known that "fishing is Homer's primary industry ...[with] industrial activity limited principally to fish processing and a limited amount of light manufacturing and fabrication" (City of Homer 1978). Tourism is an important but non-quantified economic stimulus, providing employment in the services sector. There is little or no mining sector employment, nor, as a consequence, any mining-related employment in the construction, manufacturing, and transportation sectors. Fifty percent of Homer families rely on subsistence for 27 percent or more of their food supply, as compared with 11 percent of the families in Kenai and 25 percent of those in Soldotna. Residents of Homer in 1976 have not lived there long; 4 years is the median residency. This is between the 4.5 years reported for Kenai and the 2.5 years reported for Soldotna. Homer adults have completed a median of 13 years of schooling, slightly more than the adults in the other three cities.

6.5.2.3. Employment

Employment by occupation in the City of Homer and the surrounding area is listed in Table 48. Service workers, professional and technical personnel, and laborers and fishermen constitute most of the work force. More persons were employed in technical and professional, farming, and service occupations, and fewer in management, clerical and sales, and craftsmen and foreman occupations, than in most other Kenai Peninsula towns. The employment patterns were similar to those of Seward, another town that depends primarily on fishing and tourism. Seasonal employment data are not available for Homer or for Subarea II. Data for the entire study area (CH_2M Hill, Inc. 1978a) indicate that employment in the manufacturing, construction, sales, and service sectors is seasonal. The fishing and farming sectors also contain seasonal jobs. The categories for seasonal employment do not coincide with those for employment in

Table 47. Demographic and economic structure of Homer during August and September 1976 (Bureau of Management and Urban Affairs and Anchorage Urban Observatory 1977).

Percentage of households with:	
1 person	11
2 persons	30
3 persons	16
4 persons	19
5 persons	13
6 or more persons	11
Percent of all household members who are male	50.7
Percent of population in household that is:	
0-9 years old	21
10-19 years old	23
20-59 years old	50
60 or more years old	6
Percent of all adults who are:	
Employed	70
Unemployed	2
Other (retired/student/housewife)	28
Percent of all employed adults who are employed:	
Full-time	88
Part-time	12
Percent of household heads who worked 12 months in previous year	59
Median school years completed, all adults	13
Median total family income	$21,350
Percent of all household members who are:	
White	97
Eskimo	3
Aleut	0
Native not specified, Indian, Black, Asian	0
Percent of family's food supply from subsistence:	
None	21
Less than 25%	29
25-49%	23
50-74%	20
75% or more	7
Median number of respondents' years in community:	4

Homer (Table 48), but there is sufficient correlation to indicate that a significant part of the employment in the Homer area (and presumably that in the rest of Subarea II) is seasonal.

Table 48. Employment of persons surveyed in Homer and in the surrounding area during August and September 1977 (Bureau of Management and Urban Affairs and Anchorage Urban Observatory 1977).

Occupation	Percent of Total Employment: Homer	Percent of Total Employment: Homer and Surrounding Area
Professional, technical	21.0	17.1
Manager, official, proprietor	12.0	9.1
Clerical and sales	7.5	6.6
Craftsman, foreman	9.0	13.1
Operative Workers	6.5	6.6
Service workers	23.0	23.4
Laborers, fishermen	20.0	18.9
Farmers, farm managers	--	5.1

6.5.2.4. Housing

In Homer, single-family and mobile homes constitute 89 percent of the occupied housing units (58% single-family; 31% mobile). Data on vacancy rates and monthly rents are not available. During the period 1970-1977 the population rose at a faster rate than the number of housing units. The National Bank of Alaska provides the bulk of the financing; most mortgages held by the Bank are sold to the Alaska Housing Finance Corporation. Both Fannie Mae and Freddie Mac backing are used, but are limited. FmHA financing has been available since the mid-1960s, but always has been a small part of the market. For example, in FY 1976-1977 eight FmHA loans were made in Homer. However, FmHA financing probably will play an increasing role in the community after Homer implements a drainage plan to improve areas that presently are ineligible for these loans. Loans in FY 1979-1980 may total about $1 million, or approximately 15 to 17 loans at $60,000 to $65,000 per loan. The Alaska Bank of Commerce opened an office in Homer during March 1978 and currently is extending home mortgages.

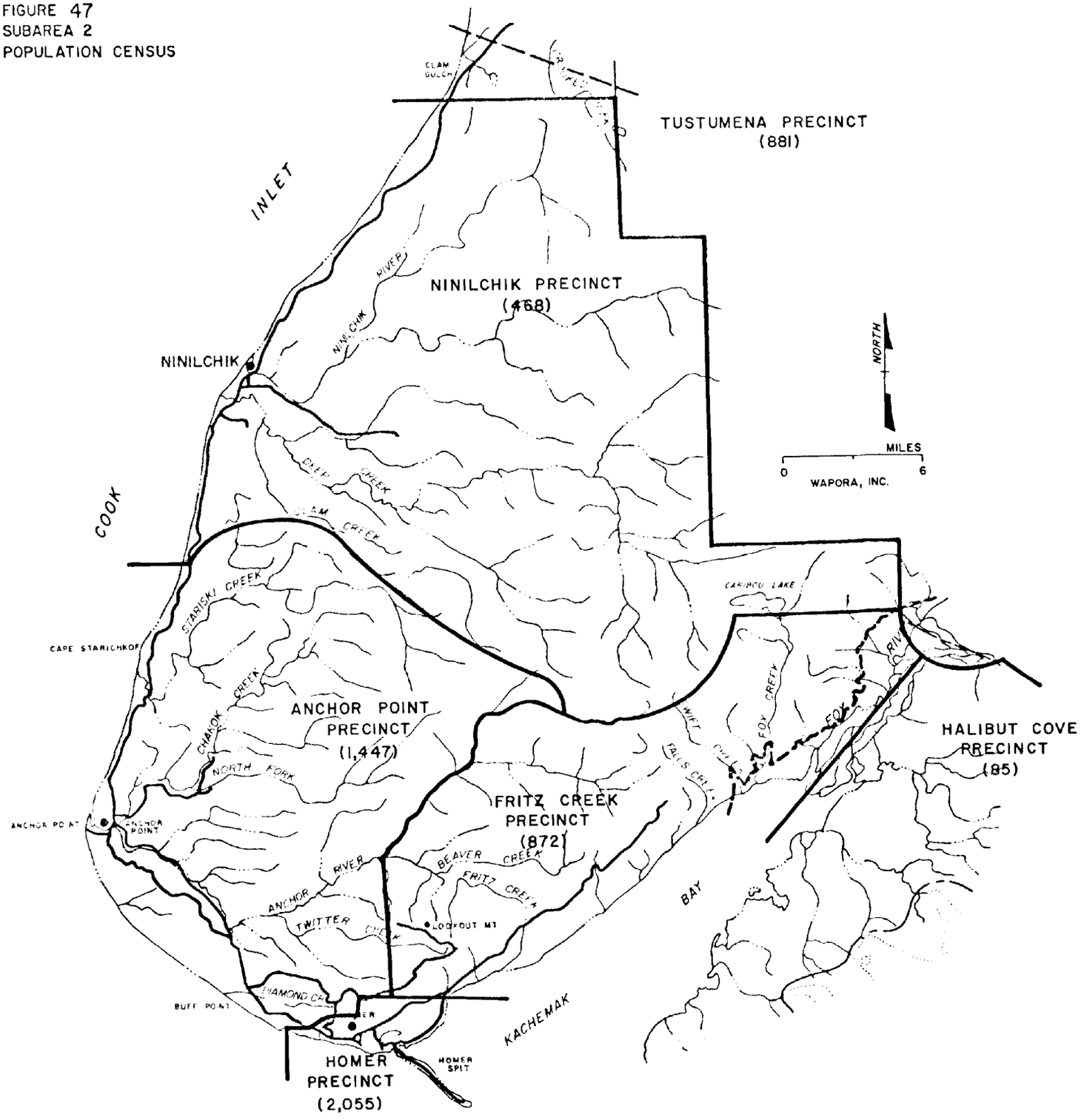
Data are not available on the sources of heat used, or on homes with or without telephones. Sixty-six percent of the homes have city water, and 23 percent have wells. Fifty-four percent used the city sewer, 42 percent have septic tanks, and 4 percent have outhouses.

6.5.3. Utilities

6.5.3.1. Water

The City of Homer provided water to 293 customers in 1975. Total water consumption in 1976 averaged 7.2 million gallons per month. Approximately 57 percent was used by seafood processors (Waites and Brogan 1977a). By 1978 the system had been expanded to serve approxi-

FIGURE 47
SUBAREA 2
POPULATION CENSUS



mately 1,200 customers (CH_2M Hill, Inc. 1978a). Groundwater resources in the Homer area are considered unreliable for municipal purposes and are of poor quality (Waites and Brogan 1977a). Following recommendations of a 1971 study by Clair A. Hill and Associates, the City dammed nearby Bridge Creek to form a reservoir with a 145-million-gallon capacity. The City has rights to withdraw a maximum of 1,200 gallons per minute. The Homer water system is operating at capacity to meet current demands. Expansion of the water treatment plant to more than double the present capacity has been approved (CH_2M Hill, Inc. 1978a).

The water main that serves the Homer Spit recently was suspected to have a large electrolysis failure. This leak is believed to have been local, but the cause has not been reported (CH_2M Hill, Inc. 1978a).

Surveys conducted in Homer during 1976 (Bureau of Management and Urban Affairs and Anchorage Urban Observatory 1977) found that 65.7 percent of the homes visited used city water, 22.7 percent used well water, and 11.4 percent hauled water or used streams and other sources. Outside the area served by the Homer municipal water system, individual household wells and surface water probably are the primary water sources.

6.5.3.2. Sewage disposal

Homer is the only community in Subarea II that is served by a sewerage system. Homer operates a secondary treatment plant adjacent to Beluga Slough that has a capacity of 277,000 gallons per day. The plant was designed for a population of less than 2,500 (Waites and Brogan 1977a). In 1977 this facility treated approximately 125,000 gallons per day, and discharged the treated wastewater into Kachemak Bay. The system served 224 customers in 1975 and was expanding rapidly. CH_2M Hill, Inc. (1978a) reported that the system served approximately 1,000 customers, that there were two potential service-limiting bottlenecks, and that additional service expansion was desired by the residents, who used private disposal systems. Upgrading of the bottlenecks was not considered necessary for the present level of service.

The Bureau of Management and Urban Affairs and the Anchorage Urban Observatory (1977) reported that 53.4 percent of the residences surveyed used the municipal sewage system for waste disposal, 41.9 percent used septic tanks, and 4.1 percent used outhouses, chemical toilets, or other disposal methods. Septic tanks and outhouses are the predominant waste disposal systems in the parts of Subarea II outside of Homer.

6.5.3.3. Electricity

The Homer Electric Association, a cooperative, supplies electricity to most of the west side of the Kenai Peninsula, including Subarea II. The Association purchases power from the Chugach Electric Corporation, and the electricity is transmitted from a connection north of Kenai and Soldotna. The Homer Electric Association served 7,208 customers in 1977 (Waites and Brogan 1977a). The number of these customers in Subarea II is not known. Waites and Brogan (1977a) reported that the present electrical generation available from Chugach Electric Company was inadequate and that the Homer Electric Association was predicting winter

power shortages in Homer. The impending electrical shortage has revived public support in the lower Kenai Peninsula for the proposed hydroelectric project on the Bradley River (in Subareas III and IV).

6.5.3.4. Telephone service

Telephone service in Subarea II is provided by the Glacier State Telephone Company. In September 1976 there were 817 stations in the Homer area (Waites and Brogan 1977a). Telephone service data are not available for the remainder of Subarea II.

6.5.3.5. Point-source discharges

Industry and commerce in Subarea II are centered in Homer. There also are small seafood-freezing operations in Ninilchik and Clam Gulch. Holders of NPDES permits issued to dischargers in Subarea II are listed in Table 49. All of the industrial permits are for seafood processing wastes, either canning wastes (head, scales, bones, boiler water, cooling water, and processing water) or freezing wastes (usually limited to process wastewater and the gut sac). In general, the permits require grinding of the fish parts and monitoring of sedimentation and water quality. The two seafood processing facilities in Homer are located near the end of the Homer Spit.

Municipal wastes from the City of Homer are given secondary treatment and are discharged into Kachemak Bay.

6.5.3.6. Solid waste disposal

Public solid waste disposal facilities in Subarea II consist of transfer points at Ninilchik and Anchor Point and a landfill site in a quarry east of Homer. The transfer points are collection sites for public solid waste disposal. Material collected at these sites is trucked to the Homer landfill or to a landfill in Subarea I. A second solid waste disposal site is planned for the Diamond Ridge area northwest of Homer. There is controversy over the selection of the site, but despite a series of appeals by neighboring landowners, the site was approved by the Kenai Borough Assembly and the Alaska Department of Environmental Conservation. Unless further appeals are successful, the site probably will be opened during 1979.

6.5.4. Transportation

6.5.4.1. Roads

Congestion occurs during the summer along the Sterling Highway because of the volume of traffic, the existence of only two lanes, and the narrow berm. (This congestion is particularly acute in Homer, the terminus of the Highway.)

The proposed Homer Bypass (a road through Homer that bypasses the main commercial road, replacing it as a link between the Sterling Highway and the Spit) is expected to reduce congestion in the City center, but

Table 49. NPDES wastewater discharge permits issued in Subarea II.

Discharger	Location	Receiving Water	Operation	Wastes
City of Homer	Homer	Kachemak Bay	Sewage treatment facility	Treated sewage
Dan's Cold Storage	Ninilchik	Ninilchik River	Seafood processor	Ground fish, process wastewater
Whitney-Fidalgo	Homer	Kachemak Bay	Seafood processor	Ground fish, process wastewater
Alaskan Seafoods	Homer	Kachemak Bay	Seafood processor	Ground fish, process wastewater, treated sewage
Osmar's Ocean Specialties	Clam Gulch	Cook Inlet	Seafood processor	Ground fish, process wastewater (permit applied for)

not on the more congested Spit. Level-C capacity on the Sterling Highway near Homer is projected to be reached by 1983 with base-case residential growth, and by 1980 with the base case in combination with the OCS high scenario. Annual average daily traffic on the Sterling Highway at Ninilchik increased by 73 percent from 1970 to 1975.

6.5.4.2. Airports

The Alaska Department of Transportation owns and maintains the Homer Airport, which has a paved runway 7,500 feet by 150 feet. It has a partial instrument landing system. Two commercial airlines link Homer to Anchorage, Kenai, and Kodiak. Two private carriers and many private planes also use the Airport. There is a float-plane landing area on nearby Beluga Lake. Present and future plans call for the construction of a parallel taxiway, expansion of the ground facilities, and a connection between Beluga Lake and the Airport's general aviation facility. A 2,500-foot gravel runway approximately 6 miles southeast of Ninilchik is capable of handling most single-engine aircraft.

6.5.4.3. Water-based transportation

Homer has the only deep-water port in Subarea II. The port, 30 feet deep at mean low water (MLW), can handle ships of up to 500 feet in length, with no weight restrictions. The dock is 410 feet by 60 feet. The main users are the ferry (Alaska Marine Highway System, Seward-Homer-Kodiak), seafood processors, Standard Oil, and the US Coast Guard. Other users include the lumber industry and offshore oil supply ships. It has a warehouse, cranes with up to a 70-ton capacity, and related facilities. Ferry traffic increased from 2,800 passengers and 1,250 vehicles embarking or disembarking in 1967 to 8,400 passengers and 3,200 vehicles in 1977. (There were 11,000 passengers and 3,200 vehicles in 1976.) Standard Oil tankers supply Homer oil distributors. Typical OCS supply boats are 200-feet long and need a minimum of 15 feet of water at low tide. The port has spare shipping capacity at present.

The Homer small-boat harbor is operated by the City, although major maintenance is the responsibility of the State. The harbor is severely congested. It has mooring berths, a loading wharf (fish dock with hoists), ramps, a grid for maintenance of boats below their water-level line, and floats with fuel and electrical power. The 433 berths (most for boats less than 75-feet long) are filled year-round, and there is a waiting list of over 800 boat owners. As many as 1,100 boats may be moored in the harbor in summer, 8 abreast. The congestion reflects the attractiveness of the Kachemak Bay area for tourism and sport fishing. The commercial fishing fleet uses the harbor extensively in winter.

If OCS-stimulated expansion of the port is to occur, a solution to the problem of wind-driven ice will be needed, and onshore land use conflicts (commercial and industrial, recreational, transportation, utilities, small-boat needs, etc.) will need to be resolved. A 50 percent expansion of the small-boat harbor is planned.

A small-boat launch at Anchor Point is used by recreational fishermen, and there is a small half-tide harbor at Ninilchik Harbor. The

Ninilchik Harbor is virtually empty during most of the year, but during the summer it provides moorage for commercial salmon fishermen and recreational boaters.

6.5.5. Social services

6.5.5.1. Educational facilities

Schools are built and maintained by the Borough and administered with local funds and State and Federal grant monies (CH_2M Hill, Inc. 1978a). Construction costs are financed through bond issues. Descriptions of school facilities in Subarea II are presented in Table 50.

Table 50. Educational facilities in Subarea II (CH_2M Hill, Inc. 1978a; Kenai Peninsula Borough School District 1978).

School	Grades	Capacity	Enrollment	Enrollment as Percent of Capacity
East Homer	K-6	375	314	84
Homer Junior/ Senior High	6-12	500	414	83
Anchor Point	K-8	100	98	98
Ninilchik	K-12	375	183	49

6.5.5.2. Police protection

Homer has six police officers, two dispatchers, one animal-control officer, and two part-time dispatcher/secretaries (CH_2M Hill, Inc. 1978a). The police department leases three patrol cars. The police station has four cells and is considered adequate for a population of 5,000 (CH_2M Hill, Inc. 1978a). The police department was considered adequately staffed for the permanent population but understaffed for the summer population, which contained an influx of seasonal workers and tourists (CH_2M Hill, Inc. 1978a). Police protection for the remainder of Subarea II is provided by the Alaska State Troopers. Two Troopers, one stationed in Anchor Point the other in Homer, are responsible for all of Subareas II, III, and IV outside of Homer and Seldovia.

6.5.5.3. Fire protection

Homer has a volunteer fire department with 25 firemen, 2 pumpers, 2 tankers, a service truck, and an ambulance. The fire department answers calls outside the City of Homer. Garage and storage facilities are considered to be inadequate (CH_2M Hill, Inc. 1978a).

6.5.6. Public finances

Selected financial data for Homer for the period from 1970 to 1976, including debt ratios and the pattern of expenditures and revenues, are

given in Table 51. Homer has had an increasing surplus in this decade, with expenditures and revenues both rising. Revenues doubled during the period from 1970 to 1976. The assessed value of Homer rose by 140 percent over the period. The millage rate is lower than in the other cities, and a sales tax was instituted in 1974. Debt ratios are low relative to the "10% or more" rule of thumb, whereas assessed value per capita and direct debt per capita are high in comparison with similar areas with a population of less than 50,000. Property taxes alone account for 57 percent of the total revenue for the City. Sales taxes (at 60% of property taxes) are earmarked for retirement of outstanding general obligation and revenue bonds for water and sewer facilities, the new public safety building, and others. The City has no oil or gas property. Administrative costs account for a lower proportion of expenditures than in the other cities in Subarea II, but the CETA program has provided from 9 percent to 16 percent of Homer's general fund revenues annually during the period from 1972 to 1977.

6.5.7. Public attitudes toward development

The Anchorage Urban Observatory surveyed populations on the Kenai Peninsula regarding the attitudes of the populace toward their communities, the services available, and future development (Bureau of Management and Urban Affairs and the Anchorage Urban Observatory 1977). The responses to questions concerning services are presented in Table 52. The majority of the respondents considered recreational facilities and road maintenance less than adequate. Other services were considered to be adequate or more than adequate. When polled as to their preferences for service or facility improvement, the respondents listed streets and roads, harbor and port facilities, cultural facilities, recreational facilities, and fire protection, respectively, in order of priority for improvement.

The 1978 population of Homer was 2,055. Forty-one percent of the survey respondents preferred a community population of 1,500, 29% preferred a population of 1,500 to 2,000, 9% preferred a population of less than 700, and 6% preferred a population of more than 6,000 people.

Responses to questions regarding preferred development in Homer are summarized in Table 53. In general, the respondents preferred to encourage research and education, industries utilizing renewable resources, and light manufacturing and service industries, and they ranked those industries as most desirable. The majority of the respondents did not want heavy industry, the petrochemical industry, or support bases for the petrochemical industry, to be encouraged. They consider those to be undesirable.

6.6. Cultural, Historical, Archaeological, and Aesthetic Resources

The southern section of Subarea II, including Homer and Kachemak Bay, is famous for its beautiful vistas and varied wildlife. Important archaeological discoveries have been made in Subarea II, and there are excellent examples of the Russian influence in Ninilchik.

Table 51. Selected financial data for the City of Homer, 1970-1976 (Waites and Brogan 1977a).

Year (ending 30 June)	Expenditures ($)	Revenues ($)	End-year Balance ($)	Real and Personal Property Assessed Value (1 million)	Millage	Sales Tax Rate (%)
1970	231,597	251,546	32,730	N. av.	—	N/A[1]
1971	188,749	249,171	95,311	12,969,350	—	N/A
1972	320,726	312,078	99,276	12,551,740	—	N/A
1973	276,481	290,327	113,721	17,615,935	12.0	N/A
1974	363,069	287,736	149,131	22,788,675	12.0	1.0
1975	465,567	490,877	160,041	25,406,160	14.0	1.0
1976	471,763	569,343	265,814	31,241,669	12.0	2.0

Debt ratios (FY 1976)

Assessed value	$42,918,151
Direct debt	2,366,000
Direct and overlapping debt	3,174,942
Ratio of direct debt to assessed value (percent)	5.5
Ratio of direct and overlapping debt to assessed value (percent)	7.4
Population	1,802
Assessed value per capita	$23,817
Direct debt per capita	1,313
Direct and overlapping debt per capita	1,762

Revenues (FY 1976)

Revenue source (FY 1976)	Revenue	Percent
Property tax	$417,189	57.3
State shared revenue	61,825	8.5
Business licenses	58,447	8.0
Public employees program	75,351	10.4
Mental health grant	39,356	5.4
Other	75,407	10.4
Total	$727,575	100.0

Expenditures (FY 1976)

	Expenditure	Percent
Government administration	$125,020	17.1
Police	194,645	26.7
Fire protection	39,274	5.4
Streets	76,696	10.5
Parks and recreation	9,156	1.3
Dept. service funds and water bond amortization	47,314	6.5
Comprehensive Employment Training Act and Public Employees Program	75,608	10.4
Judicial	13,722	1.9
Animal control	16,214	2.2
Public works	45,820	6.3
Other	85,354	11.6
Total	$728,823	100.0

[1] N/A = Data not available.

Table 52. Population rating of services in Homer, 1976 (Bureau of Urban Management and the Anchorage Urban Observatory 1977).

Service	Less Than Adequate* (%)	Adequate or More Than Adequate* (%)
City recreational facilities	55.5	37.5
Police services	14.9	80.6
Road maintenance	68.8	31.2
Hospital and health services	21.7	75.3
Water service	31.4	61.3
Sewer system	30.8	58.1
Elementary school	9.0	56.5
Junior-senior high school	29.4	40.5
Fire protection	26.3	64.4

* Percent of responses in each rating; discrepancy in totals is due to nonrespondents.

Table 53. Preferred development sectors in Homer (Bureau of Management and Urban Affairs and Anchorage Urban Observatory 1977).

Sector	Encourage (%)	Encourage (rank)	Discourage (%)	Discourage (rank)	Most Desired (%)	Most Desired (rank)	Least Desired (%)	Least Desired (rank)
Education and research	88.6	3	6.2	8	23.0	1	1.1	6
Agriculture	90.6	2	6.3	7	0.0	9	Not asked	
Commercial fishing	91.8	1	4.5	9	20.1	3	0.4	8
Light manufacture	80.3	4	16.2	6	20.5	2	1.8	5
Transport and storage	62.2	5	28.2	5	5.3	5	0.7	7
Tourism	59.2	6	32.0	4	10.6	4	10.7	4
Supply base for offshore oil	27.7	7	64.4	3	4.6	6	30.2	1
Petrochemical industries	17.4	9	74.7	1	2.8	7	22.1	3
Heavy industry	21.9	8	72.9	2	2.1	8	29.2	2
None and don't know	--	--	--	--	5.5	--	3.9	--

The Alaska Heritage Resource Survey Master File (Alaska Department of Natural Resources 1979) lists 23 sites in Subarea II. The nature of the resources is similar to that of Subarea I. The Cook Inlet Region Inventory of Native Historic Sites and Cemeteries (Cook Inlet Native Association 1975) lists 12 sites. There is some overlap between the two sources, and it is likely that additional sites will be discovered.

6.6.1. Native period

Early human settlement in the northern section of Subarea II appears to have been similar to that of Subarea I. Little work has been done between the Kasilof River and Homer, although various archaeological sites are known to exist (Workman 1974). It is believed that the Tanaina Indians inhabited the area, and it is possible that the Eskimos preceded that group, or that both groups coexisted at a few locations for a period of time.

More data have been gathered from the southern section of Subarea II. A pioneering study by Dr. Frederica De Laguna (1934) included excavations at Cottonwood Creek, northeast of Homer. The Kachemak Bay area appears to have been occupied for several thousand years by Eskimo peoples. The record between 1 and 1,000 A.D. is the best known (Workman 1974). The Eskimos of Kachemak Bay practiced a high level of craftsmanship and artistry. Hunting and fishing were the dominant pursuits. Solid wood houses were constructed, and objects such as stone saws, slate awls, elaborate stone lamps, and jewelry have been identified with this period (Kachemak III). Earlier Eskimo cultures are not as well documented.

The successors to the Eskimos were the Tanaina Athabascans. The Kachemak Tanaina have been characterized as hunters and fishermen whose culture was influenced heavily by Eskimo ways (Workman 1974). Occupation by the Tanaina persisted until contact with the Russians. The monograph on the Tanaina by Osgood (1937) provides insights into the life of that group gathered from a variety of informants, including Fitka Balishoff, who lived near Cottonwood Creek in the 1920s. Workman (1974) noted that by the early 1930s "...the cultural and physical dispersal of the Kachemak Bay Tanaina was virtually complete."

6.6.2. Russian period

The major focus of Russian influence in Subarea II was at Ninilchik. The date of original settlement is not known, but usually is placed during the period from 1800 to the 1840s. There is agreement that Ninilchik was an agricultural community. Various accounts describe it as a colony of retired personnel from the Russia-American Company (Sherwood 1974; Dimmick 1976):

> Few of the employees could afford to take their families back to Russia, had they desired to do so. They were unwilling to leave them when their contract was up, so many renewed their contracts until they were too old for the hardships imposed by life as a hunter for the Company. The agricultural colony would seem to be the logical solution for all concerned. Certainly they were a self-sufficient community long before

the United States purchase of Alaska, raising cattle, pigs, chickens, and vegetables; catching fish, fur farming, hunting and trapping (Dimmick 1976).

There is no mention of Russian activities on the north shore of Kachemak Bay. There may have been some isolated gold mining on the beaches between Homer and Ninilchik (Barry 1973). It is likely that a small amount of fur trading was carried on between the Russians and local groups of coastal natives throughout Subarea II.

6.6.3. American period

American interests in Subarea II initially focused on minerals. Gold was sought at Ninilchik, Anchor Point, and the beaches south and east to Homer. The high tidal range hampered efforts at Anchor Point, and the miners spent more time in moving their equipment than in actual sluicing (Barry 1973). The most ambitious project was organized in 1896 by Homer Pennock, after whom the present town of Homer was named. His consortium used the Homer area as a staging base for beach mining north of Ninilchik. Modest amounts of gold have been recovered sporadically since those early efforts.

The presence of coal also drew attention to Subarea II. The deposits on the north shore of Kachemak Bay had been noted by the Russians, but they had made no formal attempts at commercial mining (Barry 1973). The 1880s saw a concerted effort to develop the coal seams near Homer. The first mines probably were those of the Alaska Coal Company in 1888 (Barry 1973). A succession of coal-mining concerns worked the deposits in the area, but the total cumulative commercial production probably amounted to only a few thousand tons (Barry 1973).

The mining efforts brought in small groups of people, but no true "rush" developed. Growth in Subarea II was slow. Fishing grew in importance and canneries were established at various points, including Homer. The largest period of growth occurred after World War II, when lands were opened for homesteading. The completion of road links between Anchorage and Subarea II (the Sterling Highway and branch roads) also encouraged population growth. Homer has grown significantly, and future expansion in the oil industry may add new developmental pressures. The degree to which the Homer Spit is to be developed is a serious local issue.

The Village of Nikolaevsk is an interesting new settlement in Subarea II. It was founded in 1967 by a group of Russians emigrants and their descendants, referred to as "Old Believers" (Moore 1976). The Old Believers had suffered religious persecution in Czarist Russia, and a group of emigrants traveled from eastern Russia to China, through Hong Kong, thence to Brazil, on to Oregon, and finally to Alaska. In 1975, 59 residents of Nikolaevsk became US citizens. According to Moore (1976), "it is foreign, yet it stands for the same principles as did America's founding fathers. It is simple, yet so complex it baffles the imagination of its visitors. It is tradition with new ways of doing things." Nikolaevsk is an important ethnic community that is sensitive to outside pressures and customs.

6.6.4. Sites in the National Register of Historic Places

No sites in Subarea II are listed in the National Register of Historic Places. Two sites have been designated as eligible for inclusion in the National Register by the Alaska Department of Natural Resources, Alaska Heritage Resource Survey (AHRS). The discussion of these sites that follows is based on information from the Master File of the AHRS, from the Final Environmental Impact Statement for the Proposed 1976 Outer Continental Shelf Oil and Gas Lease Sale, Lower Cook Inlet (Bureau of Land Management 1976), and from other authors as noted.

The Holy Transfiguration of Our Lord Chapel has been designated as being eligible for inclusion in the National Register of Historic Places. The church is located in Ninilchik and was built around 1901. It is privately-owned and has been in continuous use since its construction. The cemetery behind the building is tended carefully and still is used (Dimmick 1976). The structure was built on the modified cruciform ground plan and faces west. It has been designated as KEN 047 by the AHRS.

The Cottonwood Creek Site also has been designated by the AHRS as being eligible for the National Register of Historic Places. It is located on the north shore of Kachemak Bay, northeast of Homer. Cottonwood Creek was investigated by Dr. Frederica De Laguna, and the Site provided important evidence used in the formulation of the Kachemak III tradition of the archaeology of the Lower Cook Inlet. It is likely that the larger part of the midden (refuse heap) at the Site was destroyed by erosion prior to 1930 (De Laguna 1934). The investigations at Cottonwood Creek revealed numerous artifacts, including adzes, projectile points, and stone lamps. The Site is owned by the State of Alaska and has been designated as SEL 030 by the AHRS.

Many additional sites of potential importance are located in Subarea II. Of particular note are the older structures in Ninilchik, most of which now are empty and deteriorating. These buildings have been referred to collectively as the Ninilchik Historic District (Bureau of Land Management 1976).

7.0. SUBAREA III

7.1. Subarea III Boundaries

Subarea III is bounded by the Kenai National Moose Range on the east, Kachemak Bay on the west, the 200-foot contour of the hillsides of the Kenai Mountains on the south, and bluffs that form the southernmost extension of the Kenai Lowlands on the north. The boundaries and topography of Subarea III are shown in Figure 48 (adapted from Joint Federal-State Land Use Planning Commission 1973b).

7.2. Physical Environment

7.2.1. Landforms

The major portion of Subarea III is characterized by a wide, flat-bottomed valley consisting of alluvial land and tidal marsh. Elevations in this region are less than 200 feet. The southeastern part of the area, however, consists of the northwest flank of the Kenai Mountains. Elevations at the southeast boundary of Subarea III may exceed 1,800 feet. The overall topography of Subarea III drops to the northwest at approximately 900 feet per mile. The northwestern part of Subarea III consists of eroded escarpments, sea cliffs, and canyon walls associated with Kachemak Bay, Fox Creek, and the Fox River. Subarea III is dissected repeatedly by divergent channels of the Fox River and the Bradley River and by the tidal guts at the mouths of their numerous channels.

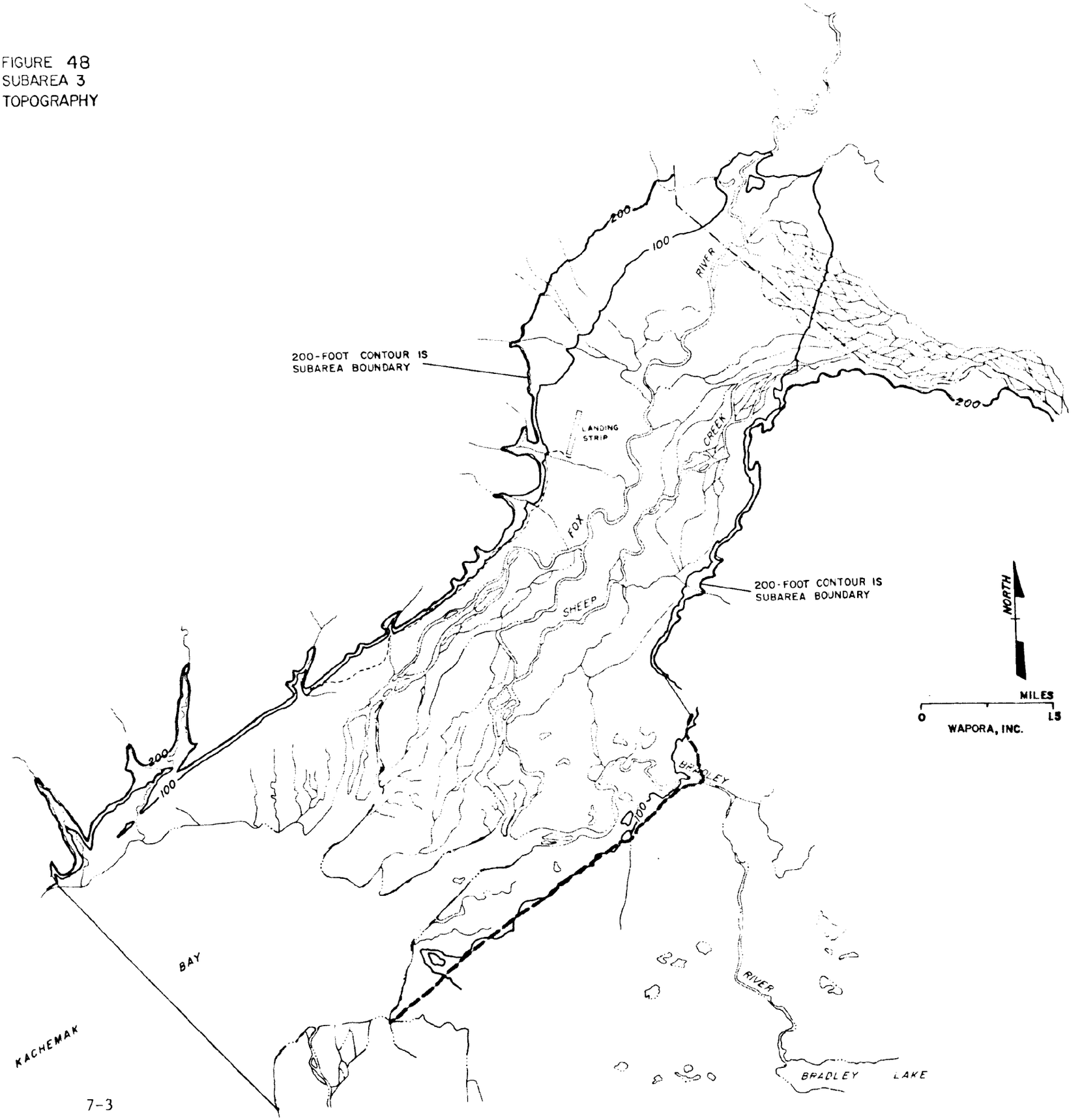
7.2.2. Geology

Subarea III can be subdivided into three regions on the basis of surficial geology and soils. The northwestern region consists of sandstone, siltstone, and shale beds of the Sterling Formation (Miocene-Pliocene) and the Kenai (Tertiary) Group. Thin lenses of conglomerate and beds ranging from a few inches to 7 feet in thickness commonly occur. Several coal beds contain thin layers of volcanic ash. These rocks have been eroded intensely by the waters of Fox Creek, Fox River, and Kachemak Bay, and form sea cliffs, canyon walls, and eroded escarpments (Hinton 1971).

The central and most extensive section of Subarea III is composed predominantly of deltaic, floodplain, and coastal plain sediments (Figure 49; adapted from Magoon and others 1976). Alluvial material (deltaic and floodplain) consists of sandy, silty, and clayey sediment that was derived from the Chernof Glacier and the Dinglestadt Glacier and deposited by the Fox River and Sheep Creek. This alluvial land is dissected by many sloughs and streams that continually change position. Tidal marsh occupies areas near the mouth of the Fox River and consists of fine-textured sediments that were deposited by the Fox River and reworked by the tidal action of Kachemak Bay (Hinton 1971; Magoon and others 1976).

The southeastern part of Subarea III is composed primarily of the weakly metamorphosed graywackes, argillites, and siltstones of the Valdex Group and the McHugh Complex. Conglomeratic sandstone, arkose, metachert, and greenstone also are present in the McHugh Complex. These metamorphic rocks are highly resistant to erosion and form steep northwesterly slopes. Sheep Creek forms a deep gorge in the Valdez Group in

FIGURE 48
SUBAREA 3
TOPOGRAPHY



the northeast part of Subarea III.

Subarea III is located on the border between the Matanuska-Wrangell Forearc Basin and the Chugach Terrain (Magoon and others 1976). The Border Ranges Fault, which separates the two structural regions, extends through the western part of Subarea III. The regional and local trend of this fault is northeast-southwest. This thrust fault is considered to be the boundary between the Oceanic Plate and the Continental Plate. Mineralogical evidence suggests that the major displacement occurred between the Late Triassic and the Early Jurassic. Because Mesozoic rocks are faulted, although Middle Tertiary rocks are not displaced, the most recent movement along the Border Ranges Fault probably occurred in Late Mesozoic or Early Tertiary times. Another major thrust fault exists in the southern part of Subarea III. Displacement along this fault may be similar to that of the Border Ranges Fault.

7.2.2.1. Soils

Soils information for Subarea III was obtained from the Soil Survey of the Homer-Ninilchik Area (Hinton 1971) and a surficial geology map of the Cook Inlet Region (Magoon and others 1976). Based on this information, soils can be categorized into three groups:

- Alluvial-tidal marsh association, consisting of nearly level, very poorly drained to excessively-drained alluvial sand, silt, and clay; and very poorly drained soils on tidal marsh

- Rough, broken land association, consisting of steep and very steep eroded escarpments, sea cliffs, and canyon walls formed in sandstone and siltstone of the Sterling Formation (Miocene-Pliocene)

- Rough, broken land, consisting of steep and very steep slopes formed on weakly metamorphosed, sedimentary rocks of the Valdez Group (?)[1] and the McHugh Complex (Jurassic).

Wetlands

Practically all of the alluvial-tidal marsh association is characterized by periodic flooding due to high tides and freshwater streams. However, wetlands are restricted to the tidal marsh environments at the mouth of the Fox River. The water table in this region is always at or near the surface (Hinton 1971).

Agricultural land

The rough, broken land association near the southeastern and northwestern boundaries of Subarea III have no potential for farmland. The alluvial lands and tidal marshes that comprise Subarea III also are

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[1] Question mark (?) indicates age of material is uncertain. The Group may contain some Cretaceous rocks.

GEOLOGY

SYNCLINE

Qs
KJm

CONTACT

ANTICLINE

NORMAL FAULT - DOTTED WHERE CONCEALED
U - UPTHROWN SIDE
D - DOWNTHROWN SIDE

THRUST OR REVERSE FAULT - DOTTED WHERE CONCEALED
SAWTEETH ON UPTHROWN BLOCK

FIGURE 49
SUBAREA 3
GEOLOGY

considered useless for crop production (Hinton 1971). The Beluga silt loams that lie over the lower slopes along the northwestern boundaries of Subarea III may be too wet for crop production, but may be suitable if drained. Much of the alluvial land that makes up the bulk of Subarea III is covered by grasses and horsetail and is leased by the Fox River Valley Cattlemen's Association for pasture.

7.2.2.2. Geologic resources

Coal

Because coal-bearing formations of the Kenai (Tertiary Group) lie at or near the surface in the northern and western parts of Subarea III, there may be potential for the development of coal resources. However, the thickness and extent of these formations is not known.

Petroleum and natural gas

The northwestern portion of Subarea III is within the region of high petroleum potential, as indicated in Figure 50 (adapted from Joint Federal-State Land Use Planning Commission 1973b). Although reservoir rock (Kenai Group) and structural traps (Border Ranges Fault) are present, the economic potential for petroleum production is questionable. No wells or dry holes are known to exist within Subarea III.

Metallic minerals

The metamorphic rocks of the Valdez Group and the McHugh Complex may contain metallic mineral deposits, particularly in fault zones and fractures. Lode mines in the Kenai Mountains of the Homer District have been worked for gold, silver, chromium, and minor amounts of copper, lead, zinc, and nickel. Some of these minerals may be present as placer deposits in the Fox River and Sheep Creek. However, no information concerning metallic minerals is available for Subarea III.

Nonmetallic minerals

No information concerning nonmetallic mineral resources is available for Subarea III. However, potential nonmetallic resources may consist of alluvial sand and gravel from the Fox River and Sheep Creek and clay from the tidal flats.

7.2.2.3. Geologic hazards

Geologic hazards for Subarea III consist predominantly of flooding and wave damage, landslides and avalanches, ash falls from volcanic eruptions, and earthquake-related damage. Due to the nearly level character of the tidal marsh and alluvial land, the potential for flooding is high. Because the Fox River and Sheep Creek are glacial streams, floods due to glacial outbursts can be expected.

Steep slopes in weathering rock on either side of the Fox River Lowlands present a potential for rock falls, landslides, and mudslides.

MINERAL RESOURCES

MAJOR MINERAL

SECONDARY MINERAL

MINERAL PROVINCE BOUNDARY

COAL PROVINCE BOUNDARY

COAL PROVINCE BOUNDARY IN WATER

PETROLEUM PROVINCE BOUNDARY

COAL FIELD

OIL FIELD

GAS FIELD

POTENTIAL GEOTHERMAL AREA

FIGURE 50
SUBAREA 3
MINERAL RESOURCES

Avalanches may occur in the Kenai Mountains southeast of the Lowlands. Rockfalls, landslides, mudslides, and avalanches may be triggered by seismic activity.

Earthquake-related hazards include vibration damage, ground fissures, ground subsidence or uplift, landslides or avalanches, ground failure, and tsunamis. Although the Border Ranges Fault is considered to be inactive, displacement along this Fault or other minor faults is possible.

There is no evidence of any volcanic activity in Subarea III, and therefore the potential for damage due to volcanic eruptions is low. However, Subarea III may be subject to ashfalls from eruptions in the Aleutian Range.

7.2.3. Hydrology

7.2.3.1. Surface water hydrology

There are no streamflow or water quality data for any stream in Subarea III. However, the following conclusions can be made on the basis of existing topographic and geologic maps:

- Both the Fox River and Sheep Creek are glacial streams. They derive water from the Chernof and Dinglestadt Glaciers, respectively

- Because they are glacial streams, they are probably characterized by ice jams and glacial outbursts. The flood potential is high for the entire Fox River Valley within Subarea III

- Because there are no large lakes to regulate streamflow, stage and discharge probably exhibit a high degree of seasonal variation

- During the spring and summer months, streams would probably have high flows derived from glacial meltwaters. High sediment loads and low dissolved solids contents would be associated with these flows

- During the winter months, streams would probably have low flows that would be sustained by groundwater recharge. The dissolved solids content probably would increase due to groundwater recharge and encroachment of saline water from Kachemak Bay

- Water levels, flows, and water quality of channels and streams near the mouth of the Fox River are subject to the tidal action of Kachemak Bay.

7.2.3.2. Groundwater resources

Although no information is available on groundwater resources in

Subarea III, the following conclusions can be made from existing geologic information:

- Sandstones of the Kenai (Tertiary) Group may yield large quantities of water to wells. The water may be soft, but saline water encroachment and methane gas may present problems

- Metasedimentary rocks of the Valdez Group (?) and the McHugh (Jurassic) Complex are probably poor aquifers, although joints and fractures may yield small quantities of water to wells

- Alluvial deposits of sand and gravel probably would yield large quantities of water to wells. However, this aquifer may be subject to contamination from surface sources due to permeable surface deposits and high water levels

- The alluvial aquifer may be subject to saline water encroachment. The potential for encroachment can be expected to increase with depth and with proximity to Kachemak Bay and associated tidal channels.

7.3. Biological Environment

Subarea III consists of approximately 30 square miles of uninterrupted lowlands. The topography and soils are distinctly different from those of the surrounding hills. Because of their low elevation and protected location, the Fox River Lowlands become snow-free each year before most other lands in the Cook Inlet Region. The early thaw and the broad, damp areas of alluvial and tidal lands contribute to the productivity potential of the region. The topography, climate, productive soils, and the proximity of Kachemak Bay, make the Fox River Lowlands especially valuable habitat for several species of waterfowl and wildlife.

7.3.1. Vegetation

In Subarea III the vegetation changes from barren mud to low, upper-tidal salt marsh vegetation, to taller salt marsh and freshwater marsh vegetation, and then to open spruce-hardwoods and brush (Figure 51; adapted from Joint Federal-State Land Use Planning Commission 1973b). On the higher ground, in the eastern part of Subarea III and on the lower slopes of adjacent hillsides, stands of Sitka spruce and areas of barren soil and rock are present. Over most of the forested areas, the stands of spruce or spruce-hardwoods are open timber or are interspersed with broad areas of grasses, forbs, and low brush. Characteristic vegetation for each of the vegetation types mapped in Figure 51 is described in Section 3.2.3.1. Hinton (1971) reported that alluvial soils and tidal marsh supported horsetail, willow, goosetongue, and cottonwood, and that Beluga soils had bluejoint, fireweed, cow parsnip, horsetail, lupine, devilsclub, red currant, wild cucumber, and elderberry bushes, plus sparse stands of Sitka spruce, paper birch, alder, and cottonwood.

7.3.2. Aquatic biota

The aquatic biology of Subarea III has received little attention.

Coho salmon and pink salmon are reported to migrate up and spawn in the multiple channels of the Fox River, Sheep Creek, and the Bradley River (Figure 52; adapted from Joint Federal-State Land Use Planning Commission 1973b). Rainbow trout and Dolly Varden char also are present in Subarea III.

As the most extensive tidal marsh-lowland area bordering Kachemak Bay, the Fox River Flats may be an important factor contributing to the high productivity of Kachemak Bay and the Lower Cook Inlet. Kachemak Bay is the most productive area of Cook Inlet and is the primary spawning and nursery site for much of the Cook Inlet crab and shrimp catch. The productivity of Kachemak Bay is believed to result from nutrients that upwell as the Gulf of Alaska waters enter Cook Inlet, from the relatively slow exchange rate of Kachemak Bay water, and from organic input from the Kachemak Bay wetlands. The wetlands, composed of mudflats and salt marshes, contribute nutritive detritus and living material from macrophytes and epibenthic microscopic algae. This material is believed to be a major part of the food taken up by some species of shrimp in Kachemak Bay (Crow 1977). The detrital material is also a primary food resource for many other marine invertebrates. Nutrients released by decomposed detritus and organic material from the Fox River and Sheep Creek may enrich the waters of Kachemak Bay and increase phytoplankton and invertebrate production. The wetlands also are spawning habitat for invertebrates and fish important in both commerce and in the marine food web. The comparative importance of the various shallow bays, mudflats, and salt marshes to the Kachemak Bay marine system has not yet been examined, but there is little doubt that they are important in the primary and secondary trophic levels of the system and that they ultimately contribute to the productivity of the Lower Cook Inlet.

7.3.3. Mammals

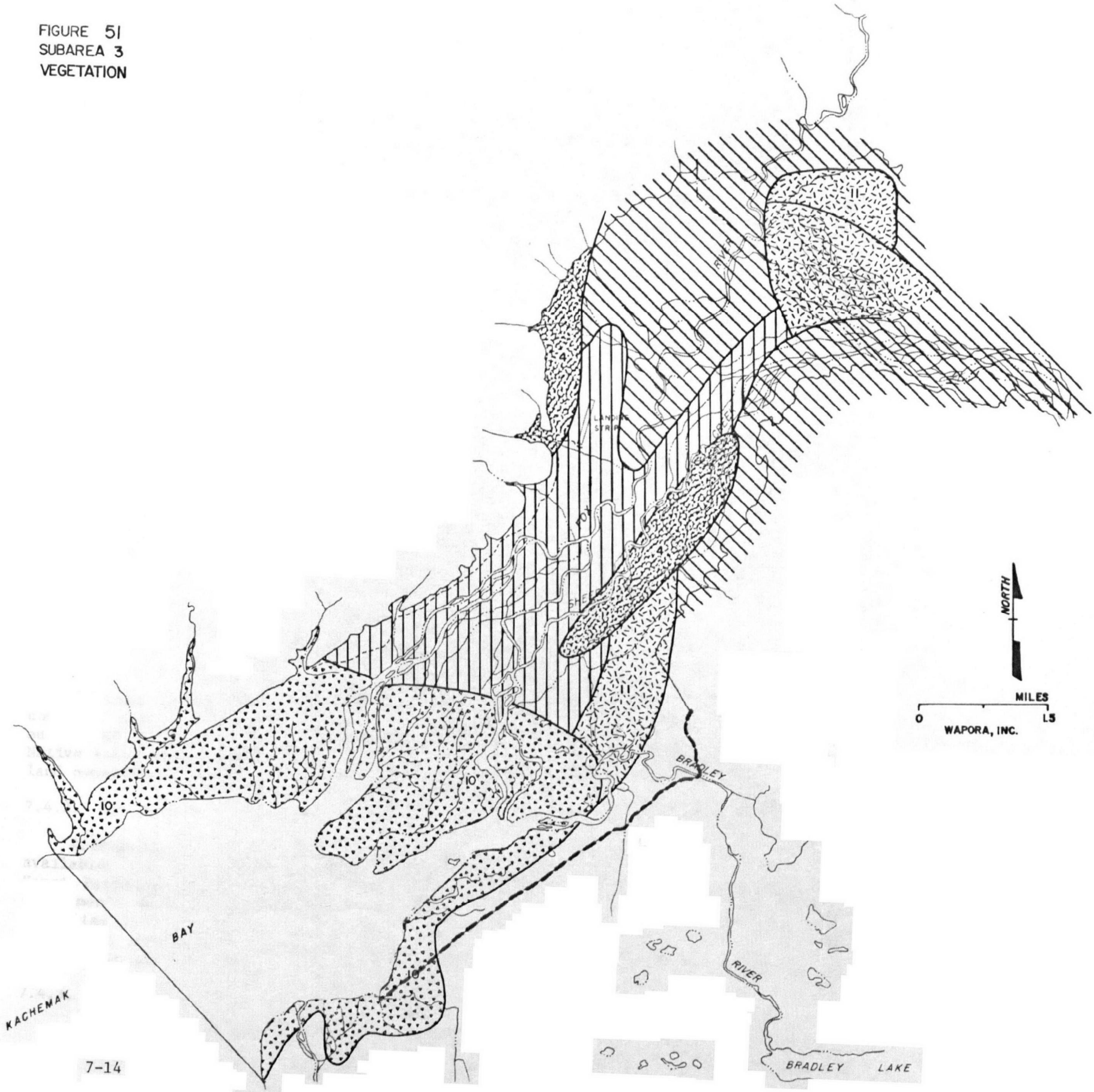
Most of Subarea III is critical habitat for black bear and moose (Figure 53; adapted from Joint Federal-State Land Use Planning Commission 1973b). Because of the low elevation, the maritime climate, and the windbreak formed by the surrounding hills, the Fox River Lowlands are some of the first areas in the Cook Inlet region to produce green vegetation each year. The late winter-early spring season is the period when the fat reserves of moose are depleted (Le Resche 1968; Le Resche and Davis 1973). During this period, the early availability of quality forage on the Fox River Lowlands may be an important factor that increases the viability of the moose population and the carrying capacity of Subarea III. Snow depth also is an important factor in moose mortality (Coady 1973; Rausch and Bratlie 1965), and the earlier snow melt on the Fox River Lowlands may increase moose survival rates. Subarea III also contains important calving grounds for the moose that utilize the surrounding range, and it provides food and shelter for moose through the late autumn and winter.

Brown bear have been reported to concentrate in Subarea III immediately following their hibernation period. Horsetails, grasses, sedges, and forbs are important elements in the early spring diets of both brown bear and moose (Wood 1973; Glenn 1975), and the availability of these foods may contribute to brown bear winter survival rates in Subarea III and the surrounding range.

VEGETATION

	COASTAL WESTERN HEMLOCK/SITKA SPRUCE
1	UPLAND SPRUCE/HARDWOOD
2	UPLAND SPRUCE/HARDWOOD/LOWLAND SPRUCE/HARDWOOD
3	UPLAND SPRUCE/HARDWOOD/HIGH BRUSH
	LOWLAND SPRUCE/HARDWOOD
4	HIGH BRUSH
5	HIGH BRUSH BURNED
6	HIGH BRUSH BURNED/COASTAL WESTERN HEMLOCK/ SITKA SPRUCE
7	HIGH BRUSH/MOIST TUNDRA/ALPINE TUNDRA
8	LOW BRUSH/MUSKEG-BOG
9	MUSKEG
10	MOIST TUNDRA
11	WET TUNDRA
12	ALPINE TUNDRA/BARREN
13	ALPINE TUNDRA/BARREN/MOIST TUNDRA
M	MUD

FIGURE 51
SUBAREA 3
VEGETATION



7.3.4. Birds

The tidal marshes, potholes, and bogs in Subarea III provide habitat and food for shorebirds, geese, and dabbling ducks each spring and autumn. The northward migration of geese each spring is paced by the advance of spring as reflected by the presence of open water and the availability of food. The Fox River tidal marsh is a staging area for geese because plant seeds and sprouting vegetation are available here before such food is available in most other parts of the Cook Inlet. Erickson (1977) counted 1,032 Canada geese on the Fox River tidal flats during May 1976, after the migration had peaked. During the autumn 1976 census (conducted prior to the peak Canada goose migration), he reported 1,821 dabblers and 370 geese on the Fox River Lowlands, and stated that the Lowlands supported low concentrations of nesting waterflow. The tidal flats also support several species of seagulls and migrating and nesting shorebirds.

In 1972, the State of Alaska recognized the value of the Fox River Flats by declaring approximately 6,720 acres of the tidal marsh as critical habitat area (Figure 53). This status requires special review procedures for projects proposed for the critical habitat area.

7.4. Land and Water Use

7.4.1. Land ownership

Land ownership in Subarea III is mapped in Figure 54 (adapted from Alaska Department of Natural Resources 1977). The majority of Subarea III is owned by the State of Alaska or the Federal Government. Exceptions include tideland or homestead patents and a 64-acre tract of agricultural land sold during the summer of 1978. The parcels in private ownership are on the lower slopes of the hillsides along the northwestern boundaries of Subarea III and near the mouth of the Bradley River. At present, 22,000 acres of the State-owned land is leased by the Fox River Cattlemen's Association for grazing purposes.

Portions of Subarea III near the Kenai National Moose Range boundary could be annexed into the Moose Range under proposed Federal withdrawals authorized by Section d-2 of the Alaska Native Claims Settlement Act. Native selections probably will not play an important part in the future land ownership of Subarea III.

7.4.2. Agriculture

Statistics for livestock production specific to Subarea III are not available. It is probable that a significant percentage of the total Kenai Peninsula cattle production can be attributed to the Fox River Cattlemen's Association members, who hold the livestock grazing lease that lies partly in Subarea III. Aerial observation showed that there were truck gardens at some of the cabins in Subarea III, but no other agriculture was observed.

7.4.3. Forestry

No commercial harvesting of timber is known to occur in Subarea III.

SALMON HABITAT

SALMON PRESENT

SALMON SPAWNING

WILDLIFE HABITAT

SEA LION HAULING OUT AREA

HARBOR SEAL

BLACK BEAR

BROWN BEAR

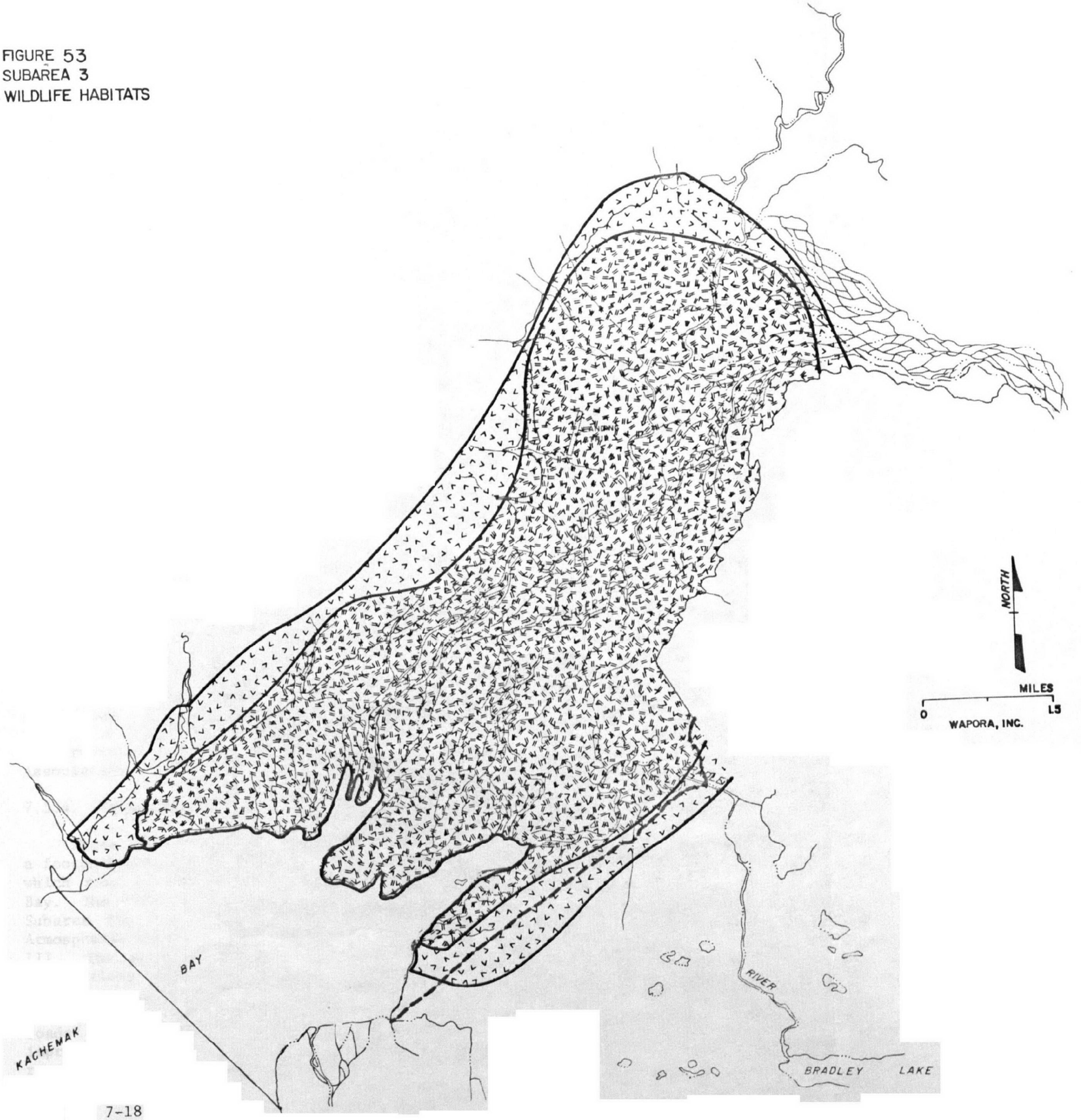
MOOSE

GOAT

CARIBOU

FIGURE 52
SUBAREA 3
SALMON HABITATS

FIGURE 53
SUBAREA 3
WILDLIFE HABITATS



7.4.4. Recreational areas

There are no designated recreational areas in Subarea III. The Kenai National Moose Range is northeast of Subarea III. Horseback pack trips organized by residents of Subarea III provide occasional income for the packers, and recreation and access for a small number of hunters and campers each year. The Fox River Flats are used by a few duck hunters each year.

7.5. Socioeconomic Environment

7.5.1. Level of development

There are no communities, schools, or other public facilities in Subarea III. There are no population data or employment data. Aerial observation by WAPORA personnel indicated that there were only a few residences in Subarea III. Because access to the local job market is difficult, the populace probably consists of several workers, farmers, or persons living on a combination of subsistence and occasional short-term employment. Many of the community services offered in the more populated subareas are available only on a limited basis in Subarea III.

7.5.2. Housing

No housing data are available for Subarea III. Because of the nature of the area, it is probable that all of the residences are single-family dwellings.

7.5.3. Utilities

Water for domestic purposes can be assumed to come from streams or from wells. Both solid and sanitary wastes would be disposed of on the individual properties. It is unlikely that electrical service reaches any of the residences. There are no public utilities in Subarea III, and no data regarding sanitary facilities, potable water usage, or electrical generation. If the Bradley Lake hydroelectric project were to be implemented, a high-voltage electrical transmission line probably would be constructed through Subarea III to the trunk lines of the Homer Electric Association.

7.5.4. Transportation

There are no roads in Subarea III. The closest ground access is by a footpath/horseback-riding trail from the terminus of the East End Road, which runs to the east of Homer through the hills overlooking Kachemak Bay. The extensive mudflats and shoals limit boat access, but parts of Subarea III can be reached by small boat. The National Oceanic and Atmospheric Survey (1978) reported that there was one airfield in Subarea III. The airstrip is 1,200-feet long, unpaved, and privately owned. Bush pilots occasionally land at smaller, uncharted airstrips or on unimproved, open land. The proposed Bradley Lake hydroelectric project probably would improve access to Subarea III through construction of roads or an airfield. It is probable that access to Subarea III will improve even without this project, either from a gradual extension of residential development along Kachemak Bay or as an extension of the

LAND OWNERSHIP

FEDERAL LAND

STATE LAND

TENTATIVELY APPROVED PATENTED

TIDELAND PATENTS

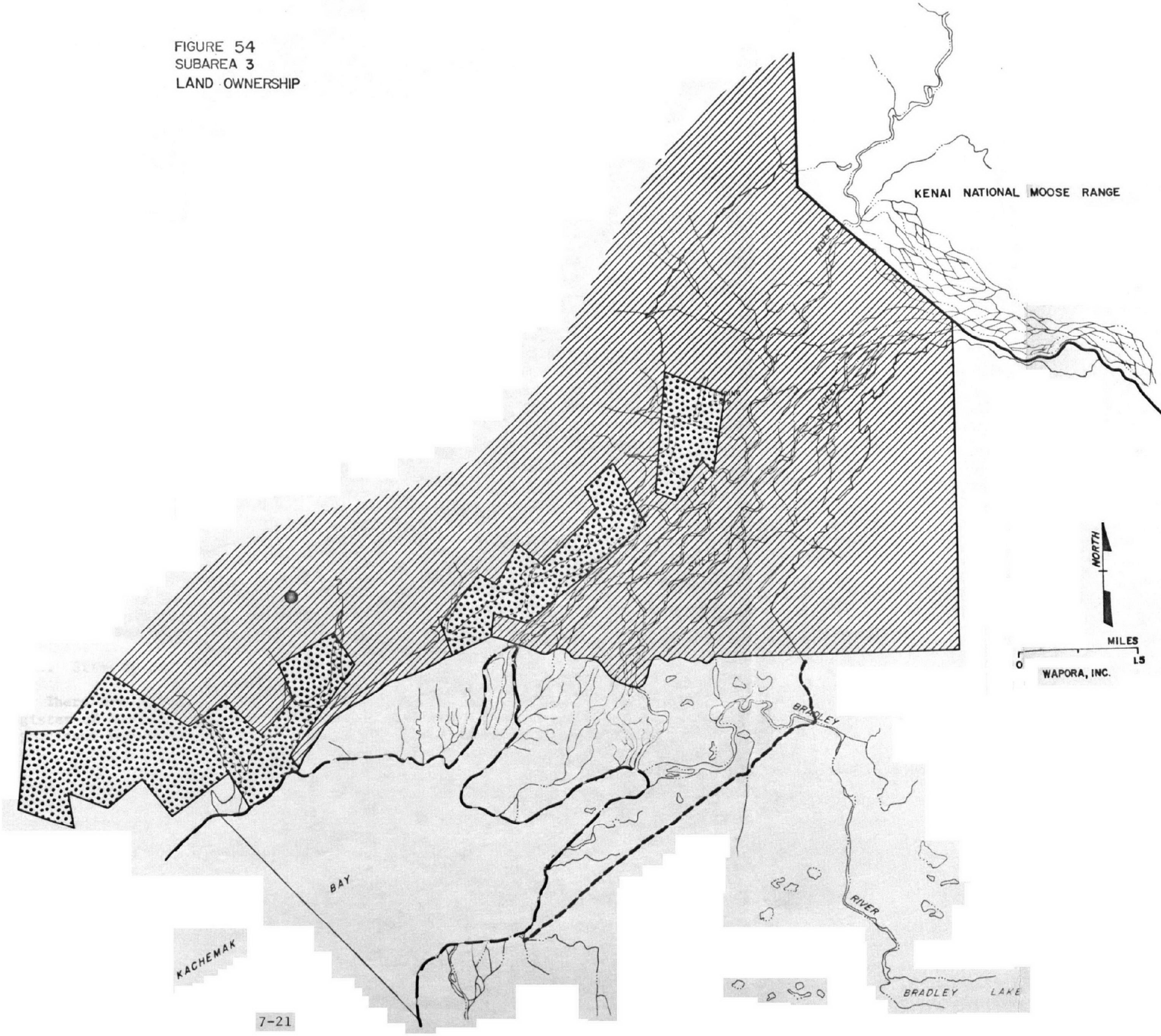
MANAGEMENT RIGHTS SELECTION APPROVED PATENTED

TIDELAND PATENTS

INTERIM CONVEYANCE PATENTED

TIDELAND PATENTS

FIGURE 54
SUBAREA 3
LAND OWNERSHIP



State highway system to communities on the south side of the Bay.

7.6. Cultural, Historical, Archaeological, and Aesthetic Resources

Subarea III includes a limited area at the head of Kachemak Bay. This section is bounded by the Fox River to the northwest and by the 200-foot contour to the southeast. This delta area includes limited grassy areas and has attractive vistas of Kachemak Bay.

There are no sites in Subarea III listed in the Master File of the Alaska Heritage Resource Survey (Alaska Department of Natural Resources 1979). The Cook Inlet Region Inventory of Native Historic Sites and Cemeteries (Cook Inlet Native Association 1975) does not include any sites in Subarea III. Apparently, very little work has been done in Subarea III, and the potential for future discoveries is unknown.

7.6.1. Native period

No information was available on Native settlement in or use of Subarea III. Because of the habitations located on the north and south shores of Kachemak Bay, it is possible that undiscovered Native sites are located on or adjacent to the Fox River Flats.

7.6.2. Russian period

No information was available on Russian utilization of Subarea III.

7.6.3. American period

Subarea III has experienced little permanent impact during the American period. A proposed settlement in the early 1900s never materialized. Utilization has centered on sports activities because of the limited access to the area. There is some farming and cattle ranching in the Fox River Valley, and approximately 22,000 acres of land are under lease to the Fox River Cattlemen's Association.

7.6.4. Sites in the National Register of Historic Places

There are no sites in Subarea III that are listed in the National Register of Historic Places. The potential for the future discovery of significant archaeological sites is unknown.

8.0. SUBAREA IV

8.1. Subarea IV Boundaries

Subarea IV encompasses the part of the Kenai Peninsula south of Kachemak Bay that is in the study area. It is bounded on the east by the Kenai National Moose Range, on the north by Kachemak Bay, on the west by Cook Inlet, and on the south by the study area boundary, which approximately follows the divide between the drainage of Cook Inlet and the drainage of the Gulf of Alaska (Figure 55; adapted from Joint Federal-State Land Use Planning Commission 1973b).

8.2. Physical Environment

8.2.1. Landforms

Subarea IV encompasses the southernmost mountains of the Kenai Range. This Subarea is characterized by rough mountainous terrain carved by glaciers, numerous streams, and tidal channels. Steep, eroded escarpments, sea cliffs, and deep valleys and canyons segment the land. Narrow, nearly-level floodplains occur along Kachemak Creek, the Naka River, the Wosnesenski River, Jakolof Creek, the Seldovia River, the Graham River, and the English Bay River. Tidal flats occur at Port Graham, Seldovia Bay, and McKeon Flats, and north of Halibut Cove. Glaciers are prevalent in the eastern part of the study area. Elevations range from sea level at the seaward boundaries and tidal flats to more than 4,000 feet msl in glaciated regions. The topography of Subarea IV is indicated in Figure 55.

8.2.2. Geology

8.2.2.1. Surficial geology

The surficial geology of Subarea IV (Figure 56; adapted from Fisher and Magoon 1977) consists largely of exposed sedimentary and metasedimentary rock. The most extensive geologic unit is the McHugh Complex, which contains weakly metamorphosed siltstone, graywacke, arkose, and conglomeratic sandstone. In the northern part of Subarea IV, metagraywacke and metasiltstone of the Valdez Group appear at the bedrock surface. Contorted chert and greenstone of Late Triassic age and pillow basalt of similar age occur locally along the northwest coast of Subarea IV. On the western tip of the Subarea, the Talkeetna Formation (Jurassic) and deposits of limestone and fine-grained tuff (Jurassic) occur in faulted blocks. The Talkeetna Formation consists predominantly of volcanic breccia, tuff, and lava flows (Magoon and others 1976). An ultramafic intrusion of peridotite, dunite, and pyroxenite exist in the southern part of Subarea IV.

The primary structural feature in Subarea IV is the Border Ranges Thrust Fault, which parallels the coastline. Thrust faults also exist in the northern part of Subarea IV and around the ultramafic intrusion (Paleozoic or Mesozoic) in the southern part of the Subarea (Figure 56). Two sets of normal faults exist in the western part. One set is located to the north of the Border Ranges Fault and trends approximately N 30° E, whereas the other set lies to the south of the Border Ranges Fault and trends approximately N 75° E.

FIGURE 55
SUBAREA 4
TOPOGRAPHY

Subarea IV is dissected by many streams and tidal channels. Long, narrow floodplains occur along Kachemak Creek, the Naka River, the Wosnesenski River, the Seldovia River, the Graham River and the English Bay River. Sediments in these areas consist of alluvial sand and gravel. Tidal deposits can be found north of Halibut Cove, McKeon Flats, Seldovia Bay, and Port Graham, and at Koyuktolik Bay.

8.2.2.2. Soils

Soils in Subarea IV are formed over volcanic rock, metasedimentary rock, alluvial sand and gravel, and tidal deposits. There are no soils data for Subarea IV, but existing geologic information indicates that there is no prime agricultural land within the area. It is possible that some alluvial land may be used for farming, but high groundwater levels and periodic flooding probably would present severe limitations.

Slopes of more than 25 percent are severely limiting to residential, road, and light industrial construction, and may present severe erosion potential and avalanche-landslide danger. Slopes of more than 25 percent are mapped in Figure 57 (adapted from Kline 1977).

8.2.2.3. Geologic resources

Potential geologic resources in Subarea IV are shown in Figure 58 (adapted from Joint Federal-State Land Use Planning Commission 1973b).

Coal

Magoon and others (1976) indicated the presence of the Tyonek (Oligocene-Miocene) Formation northeast of Seldovia. This Formation is coal-bearing, but the limited thickness and extent of the Formation at this location probably would discourage mining.

Oil and gas

With the exception of a small area near Seldovia, no Tertiary-age sediments exist in Subarea IV. Consequently, there is no potential for oil or gas development. However, thick deposits of potentially oil-bearing Tertiary rocks may exist under Kachemak Bay.

Metallic minerals

Subarea IV has a high potential for metallic mineral development. Numerous mining claims have been made in regions southwest of Tutka Bay (Joint Federal-State Land Use Planning Commission 1974c). Lode mines have been worked for gold, silver, and chromium. Copper, lead, zinc, and nickel occur as minor by-products. Minerals present in Subarea IV include native gold, native silver, native copper, pyrite, arsenopyrite, chaleopyrite, sphalerite, galena, tetrahedrite, covellite, and chalcocite.

Nonmetallic minerals

Available data indicate that there is no development of nonmetallic resources at this time. However, surficial geology maps (Magoon and others 1976) suggest that a potential exists for development of sand and gravel, limestone, clay, and gypsum.

GEOLOGY

SYNCLINE

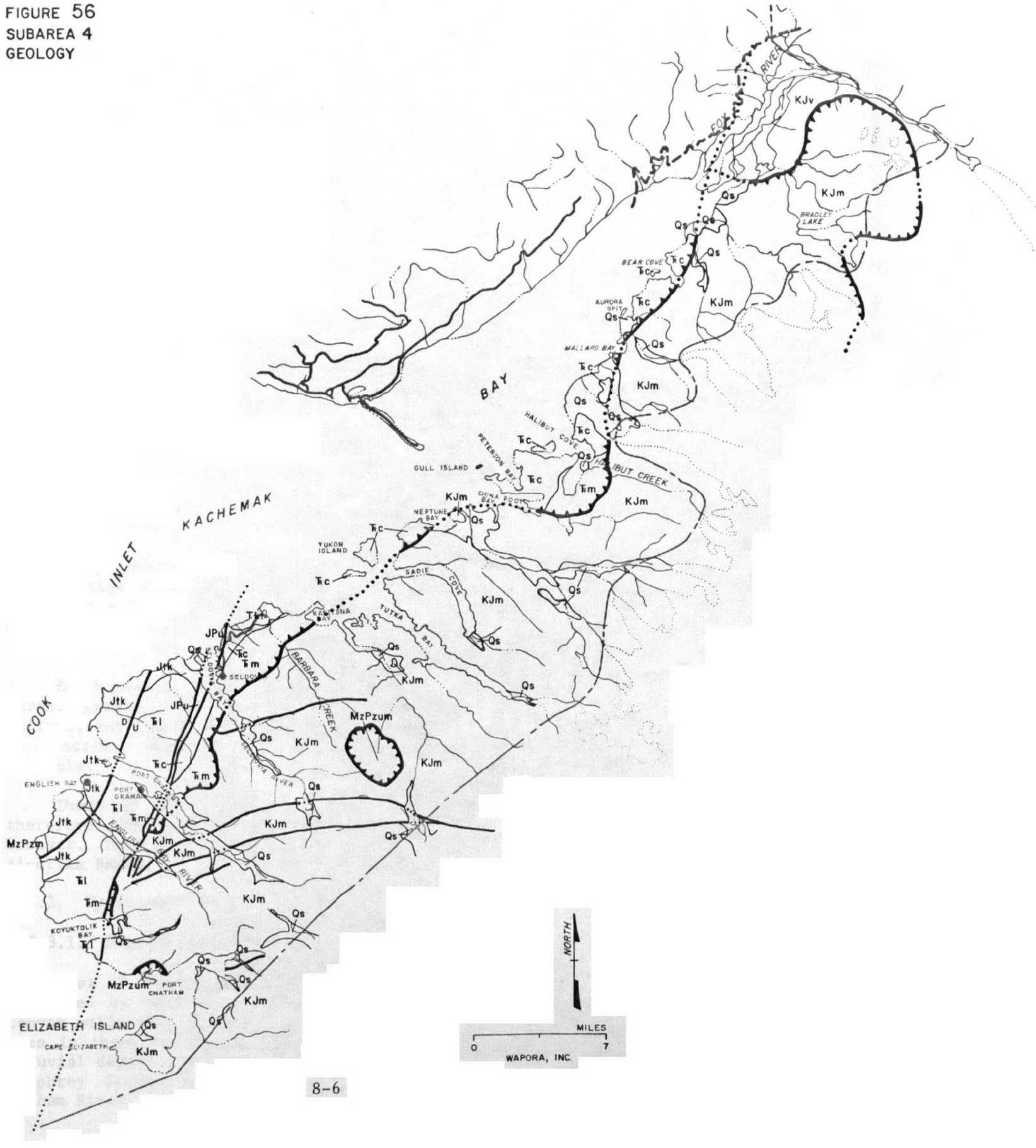
Qs / KJm CONTACT

ANTICLINE

NORMAL FAULT - DOTTED WHERE CONCEALED
U - UPTHROWN SIDE
D - DOWNTHROWN SIDE

THRUST OR REVERSE FAULT - DOTTED WHERE CONCEALED
SAWTEETH ON UPTHROWN BLOCK

FIGURE 56
SUBAREA 4
GEOLOGY



Sand and gravel may be quarried from alluvial deposits in the floodplains of Grenwingk Creek, the Wosnesenski River, the Seldovia River, the Graham River, and the English Bay River. The economic potential of these deposits is dependent on the sorting of the material, the extent of suitable deposits, hydrologic conditions, accessibility of potential sites, and the existence of surface transportation.

Mud flats associated with major bays may contain clay that can be used for the manufacture of bricks and ceramics, but no information on the quality of the clay is available.

Limestone is a potential resource in Subarea IV. Extensive surface exposures of Upper Triassic limestone exist in the western part of Subarea IV. However, the limestone is interbedded with fine-grained volcanic tuff (Magoon and others 1976) and may have limited suitability.

8.2.2.4. Geologic hazards

Geologic hazards in Subarea IV consist of flooding and wave damage, landslides and avalanches, ash falls from volcanic eruptions, and damage associated with earthquakes. Flooding is a potential hazard in all river valleys. Broad floodplains are associated with Grenwingk Creek, Humphrey Creek, the Wosnesenski River, the Seldovia River, the Port Graham River, and the English Bay River. Glacial outburst flooding can be expected in glacial streams in the northeastern part of the study area. Identified hazards are mapped in Figure 59 (adapted from Alaska Department of Natural Resorces 1978b).

Steep rocky slopes, which are prevalent throughout Subarea IV, present a high potential for rockfalls, landslides, and mudslides. This condition exists along the coastlines of many bays, harbors, and coves, and may be hazardous to navigation in these areas. Rockfalls, landslides, mudslides, and avalanches may be triggered by seismic activity.

Earthquake-related hazards include vibration damage, ground fissures, ground subsidence or uplift, landslides or avalanches, ground failure, and tsunamis. Although the Border Ranges Fault is considered to be inactive, displacement along this Fault or other minor faults is possible.

There is no evidence of any volcanic activity in Subarea IV, and therefore the potential for damage due to volcanic eruptions is low. However, the area may be subject to ashfalls from eruptions in the Aleutian Range.

8.2.3. Hydrology

8.2.3.1. Surface water hydrology

Most of Subarea IV is characterized by mountainous terrain that is dissected by many rivers and streams. Most stream valleys have steep canyon walls and little or no floodplains. The predominant alluvial process in these valleys is erosion. However, broad floodplains containing alluvial deposits of sand and gravel are associated with Grenwingk Creek, Humphrey Creek, the Wosnesenski River, the Seldovia River, the Port Graham River, and the English Bay River.

SLOPE HAZARDS

0 TO 15 PERCENT

15 TO 25 PERCENT

GREATER THAN 25 PERCENT

FIGURE 57
SUBAREA 4
SLOPE HAZARDS

A summary of streamflow data for major streams in Subarea IV is given in Table 54. Stream discharge generally is quite low, although Barbara Creek attained a maximum discharge of 744 cfs near Seldovia on 29 June 1975. Flooding is due primarily to spring thaw and storm events, although glacial outbursts may occur in the northeastern part of Subarea IV.

8.2.3.2. Groundwater resources

Groundwater in Subarea IV occurs predominantly in joints and fractures in limestone of the Kamishak Formation (Upper Triassic), in volcanic breccias and tuffs of the Talkeetna Formation (Lower Jurassic), in Triassic mafic rocks, and in metasedimentary rocks of the McHugh Complex. These formations have low permeabilities and can be expected to yield less than 10 gpm (Feulner 1973). However, higher yields might be obtained locally from alluvial deposits of sand and gravel. No groundwater data are available for Subarea IV.

8.3. Biological Environment

The steep mountains, deep valleys and fiords, and barren rock that make up much of Subarea IV are ecological barriers that segment the plant and animal communities to an extent not observed in the other subareas on the Kenai Peninsula. Isolated pockets in the river valleys and on the lower mountain slopes provide suitable habitat for all the large mammals except the mountain goat. The streams are short, and many are steep and laden with glacial silt.

8.3.1. Vegetation

The vegetation in Subarea IV is mapped in Figure 60 (adapted from Joint Federal-State Planning Commission 1973b). The valleys, the coastline, and the lower mountain slopes are covered with coastal western hemlock-Sitka spruce forests. At higher elevations and on the steeper slopes, the hemlock-spruce forest changes to a mixture of high brush, moist tundra, and alpine tundra. The highest elevations contain alpine tundra or are barren. The glaciers and the recent glacial moraines also are barren. Most bays along the Subarea IV coast that have tributaries of glacial origin also have a small tidal marsh and associated lowlands. These lowlands are vegetated with grasses, forbs, sedges, and shrubs similar to those of the Fox River Lowlands. The tidal marshes typically are productive and may be important primary production areas for Kachemak Bay invertebrates.

8.3.2. Aquatic biota

Comprehensive inventories have not been made of freshwater fish or invertebrates in the streams of Subarea IV. Salmon have been reported from most of the streams in Subarea IV, and the spawning areas have been defined (Figure 61; adapted from Joint Federal-State Land Use Planning Commission 1973b). Several of the salmon streams have only a short reach that is used for spawning, but that reach may be utilized intensively. Although all five species of Pacific salmon spawn in Subarea IV, most of the escapement is of pink salmon. Pink salmon and chum salmon may spawn in the intertidal zone as well as in the freshwater sections of the spawning streams. Recent fish rehabilitation efforts by the Alaska Department of Fish and Game have improved salmon returns

MINERAL RESOURCES

MAJOR MINERAL

SECONDARY MINERAL

MINERAL PROVINCE BOUNDARY

COAL PROVINCE BOUNDARY

COAL PROVINCE BOUNDARY IN WATER

PETROLEUM PROVINCE BOUNDARY

COAL FIELD

OIL FIELD

GAS FIELD

POTENTIAL GEOTHERMAL AREA

FIGURE 58
SUBAREA 4
MINERAL RESOURCES

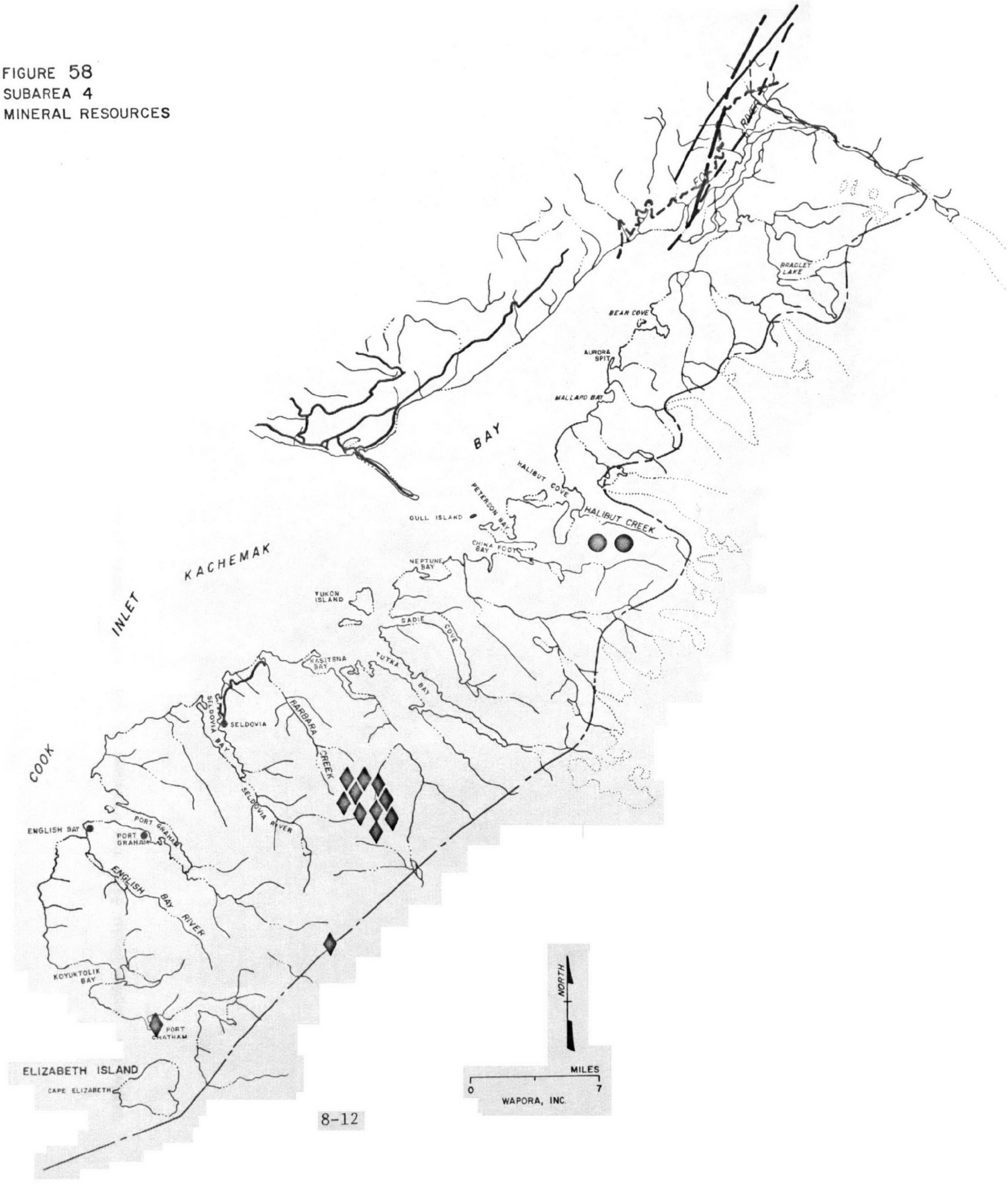


Table 54. Hydrologic data for streams in Subarea IV (USGS 1978).

River	Drainage Area (square miles)	Period of Record	Mean Annual Discharge (cfs)	Maximum Discharge (cfs)	Minimum Discharge (cfs)
English Bay River SE of Alexandrovsk	--	12 March 1968	99.0	--	--
Seldovia River 7.5 miles SE of Seldovia	--	1954	83.2	166.0	0.5
Fish Creek SE of Seldovia	3.8	1967-1973	7.9	25.0	0.98
Seldovia Lagoon Tributary E of Seldovia	0.9	1967-1973	1.9	8.3	0.17
Kachemak Bay Tributary 1.5 miles N of Seldovia	0.7	1972-1973	1.2	3.7	0.17
Seldovia River 3.7 miles SE of Seldovia	--	1967-1968	54.0	72.0	36.0
Kachemak Bay Tributary 2 miles N of Seldovia	1.3	1972-1973	3.7	9.4	0.34
Barbara Creek near Seldovia	20.7	1972-1975	81.1	744.0	16.0

GEOLOGIC HAZARD

LANDSLIDE AND SLUMP

VOLCANIC AREA

FAULT ZONE

COASTAL EROSION

TSUNAMI HAZARD

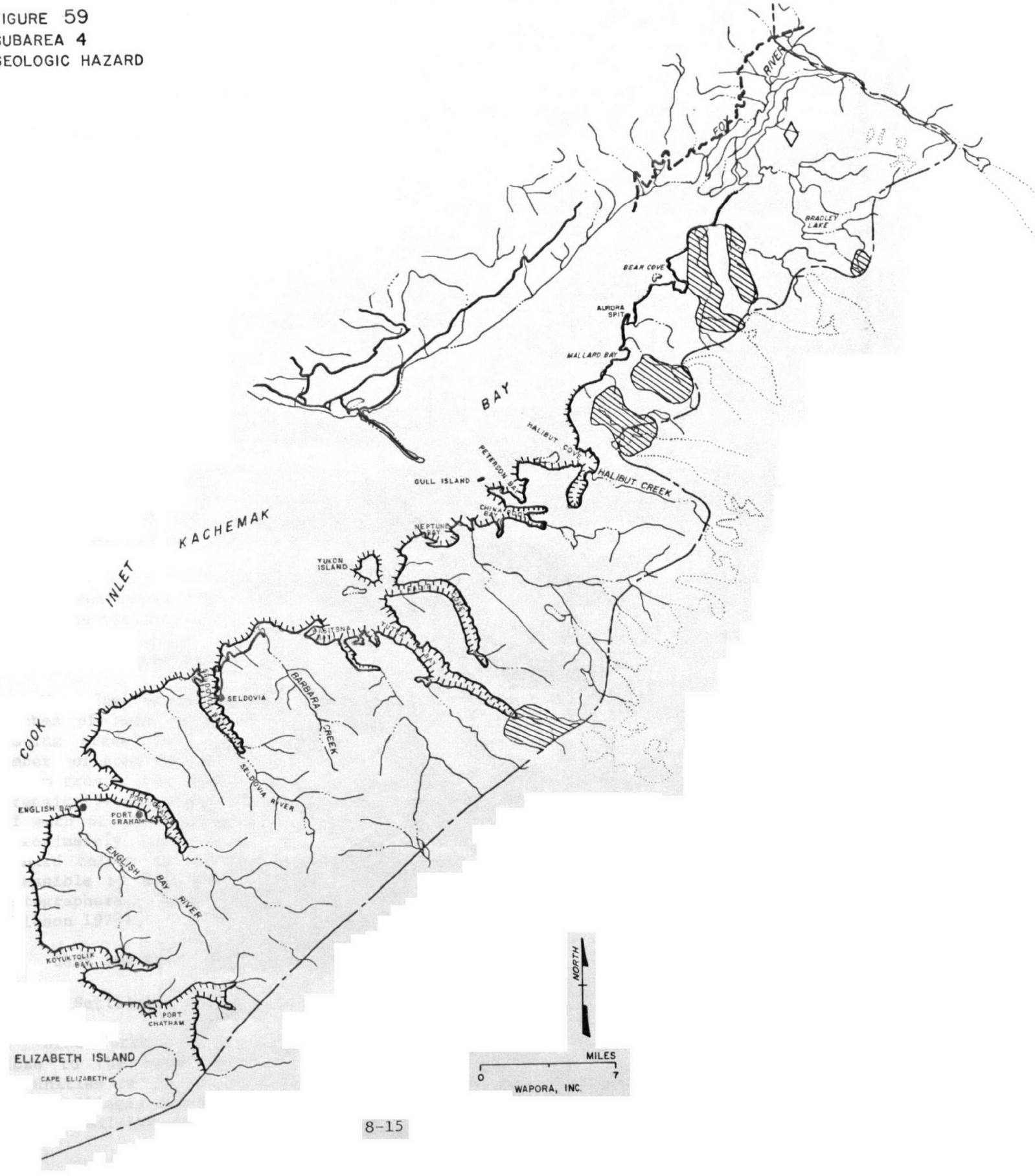
EXTENT OF ICE

AREA OF SUBSIDENCE

POTENTIAL MELTWATER AND RUNOFF FLOODING

POTENTIAL GLACIAL OUTBURST FLOODING

FIGURE 59
SUBAREA 4
GEOLOGIC HAZARD



to Subarea IV and introduced chinook salmon to streams in Subarea IV. Salmon stocked in Subarea IV, in the Homer Spit area, and in other areas of the Cook Inlet region are hatched or reared at facilities at Tutka Bay and at Halibut Cove. Most of the streams in Subarea IV contain Dolly Varden char. Rainbow trout also are present in Subarea IV.

8.3.3. Mammals

The wildlife populations of Subarea IV are more typical of montane regions than of the hills and lowlands of the Kenai Peninsula Lowlands. Coyote, moose, and brown bear are not abundant or are not present in large areas of Subarea IV. Muskrat and red fox are excluded from almost the entire Subarea. Marten, mountain goats, and Dall sheep, which are not present in the other Kenai Peninsula subareas, occur locally in Subarea IV. Wildlife concentrations and critical habitats in Subarea IV are shown in Figure 62 (Joint Federal-State Land Use Planning Commission 1973b).

Moose largely are restricted to the river valleys and the lower hillsides along the southern shores of Kachemak Bay. Winter moose ranges, probably the major factor that limits moose populations, are indicated in Figure 62. Dall sheep are reported to be present on the upper elevations near Bradley Lake, but are not reported from the remainder of the Subarea. Mountain goats are found on the upper elevations throughout Subarea IV. The Alaska Department of Fish and Game (1976) expressed concern that logging was removing mountain goat winter range. Winter mountain goat range also is identified in Figure 62.

Black bears are present in suitable habitat throughout Subarea IV, and concentrations have been reported along most of the salmon streams and in the vicinity of Halibut Cove (Figure 62). Brown bears are limited to the northeastern section of Subarea IV. No critical brown bear habitats have been reported.

Waterfowl overwinter in China Poot Bay and in the upper, sheltered reaches of most other bays. The bays also provide feeding areas and resting areas for migrating waterfowl and nesting areas for limited numbers of some species. Seabirds, primarily gulls, cormorants, puffins, and murres, nest along the rocky coast of Subarea IV. The most intensively-used sites are on the small, steep, rocky islands that occur off much of the coastline. The largest colony, on Gull Island, contains approximately 3,000 nesting pairs of seabirds and is the third largest seabird colony in the study area (Erikson 1977). Because it is easily accessible by boat from Homer, the Island is a popular attraction for photographers. Gull Island has been recommended for sanctuary status (Erikson 1977).

8.4. Land and Water Use

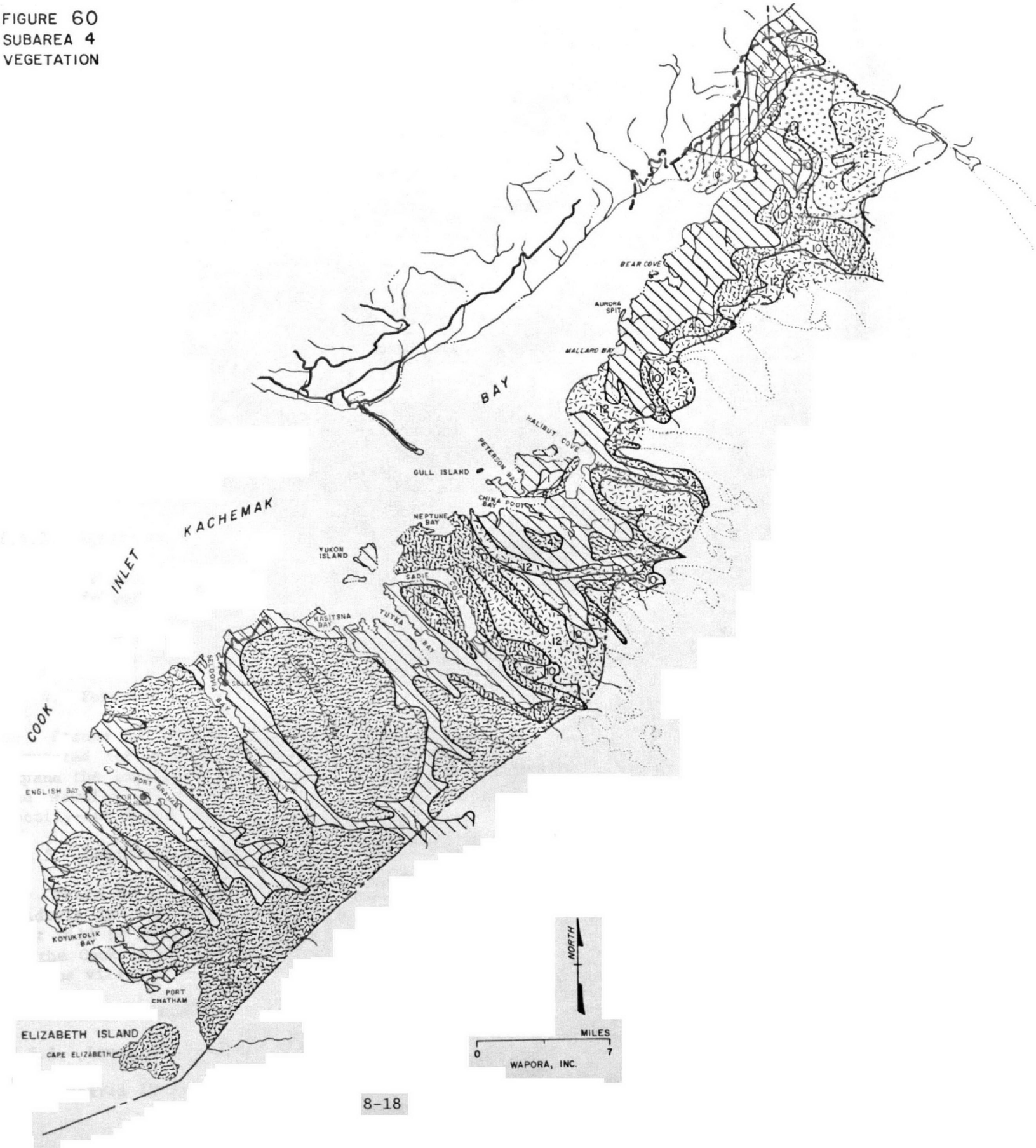
8.4.1. Settlement patterns

Since prehistoric times the settlements in Subarea IV have been close to the resources of Kachemak Bay and Cook Inlet. The present communities of Seldovia, Port Graham, and English Bay have grown from Native villages that were built on the small areas of comparatively level ground available at the heads of fiords off Kachemak Bay and Cook Inlet.

VEGETATION

	COASTAL WESTERN HEMLOCK/SITKA SPRUCE
1	UPLAND SPRUCE/HARDWOOD
2	UPLAND SPRUCE/HARDWOOD/LOWLAND SPRUCE/HARDWOOD
3	UPLAND SPRUCE/HARDWOOD/HIGH BRUSH
	LOWLAND SPRUCE/HARDWOOD
4	HIGH BRUSH
5	HIGH BRUSH BURNED
6	HIGH BRUSH BURNED/COASTAL WESTERN HEMLOCK/ SITKA SPRUCE
7	HIGH BRUSH/MOIST TUNDRA/ALPINE TUNDRA
8	LOW BRUSH/MUSKEG-BOG
9	MUSKEG
10	MOIST TUNDRA
11	WET TUNDRA
12	ALPINE TUNDRA/BARREN
13	ALPINE TUNDRA/BARREN/MOIST TUNDRA
M	MUD

FIGURE 60
SUBAREA 4
VEGETATION



The marine resources have remained the principal income source for the inhabitants of Subarea IV and are major components of the subsistence lifestyle. Because the commercial fishing industry does not require large population concentrations and because the land suitable for residential and industrial use is scarce and is segmented by topography, the populations in Subarea IV tend to be grouped in small fishing villages.

8.4.2. Land ownership

Land ownership patterns in Subarea IV are shown in Figure 63 (adapted from Alaska Department of Natural Resources 1977). The westernmost section of Subarea IV is in private (primarily Native corporation) ownership. Most of the remainder is owned by the State of Alaska or the Federal Government. There also are small, private holdings along the shoreline, concentrated primarily around Yukon Island, Halibut Cove, Seldovia, and Bear Cove. An area of 117,000 acres located immediately south and east of Subarea IV has been proposed for inclusion in the Kenai National Moose Range. The 420,000-acre Kenai Fiords-Harding Ice Field National Monument southeast of Subarea IV was established by Presidential decree during 1978. Some of the lands in Subarea IV adjoining the southern shoreline of Kachemak Bay are in Kachemak Bay State Park. These lands have been selected by the Seldovia Native Corporation under d-2 provisions and may pass into private ownership. The State is attempting to trade other, State-owned acreage for the selected park lands (Anonymous 1978a).

8.4.3. Agriculture

There are no data on agriculture in Subarea IV. Truck gardens are planted in suitable soils, but their products probably are used entirely by the gardeners and their neighbors. It is unlikely that agriculture would have a significant role in the economic base of Subarea IV because of topographic limitations.

8.4.4. Forestry

Stands of Sitka spruce on the valleys and hillsides have been harvested for several years. During 1978, timbering companies began to expand the logging operations southwestward into the Koyuktolik Bay area. One sawmill at Jakolof Bay saws cants for the Japanese market from locally-cut logs.

8.4.5. Land-use planning

There is no comprehensive land-use plan for Subarea IV. The City of Seldovia is developing zoning ordinances. Use of the large land areas that will be conveyed to Natives under d-2 provisions will be controlled by the Cook Inlet Native Corporation and the Native corporations of the various villages in Subarea IV.

8.5. Socioeconomic Environment

8.5.1. Level of development

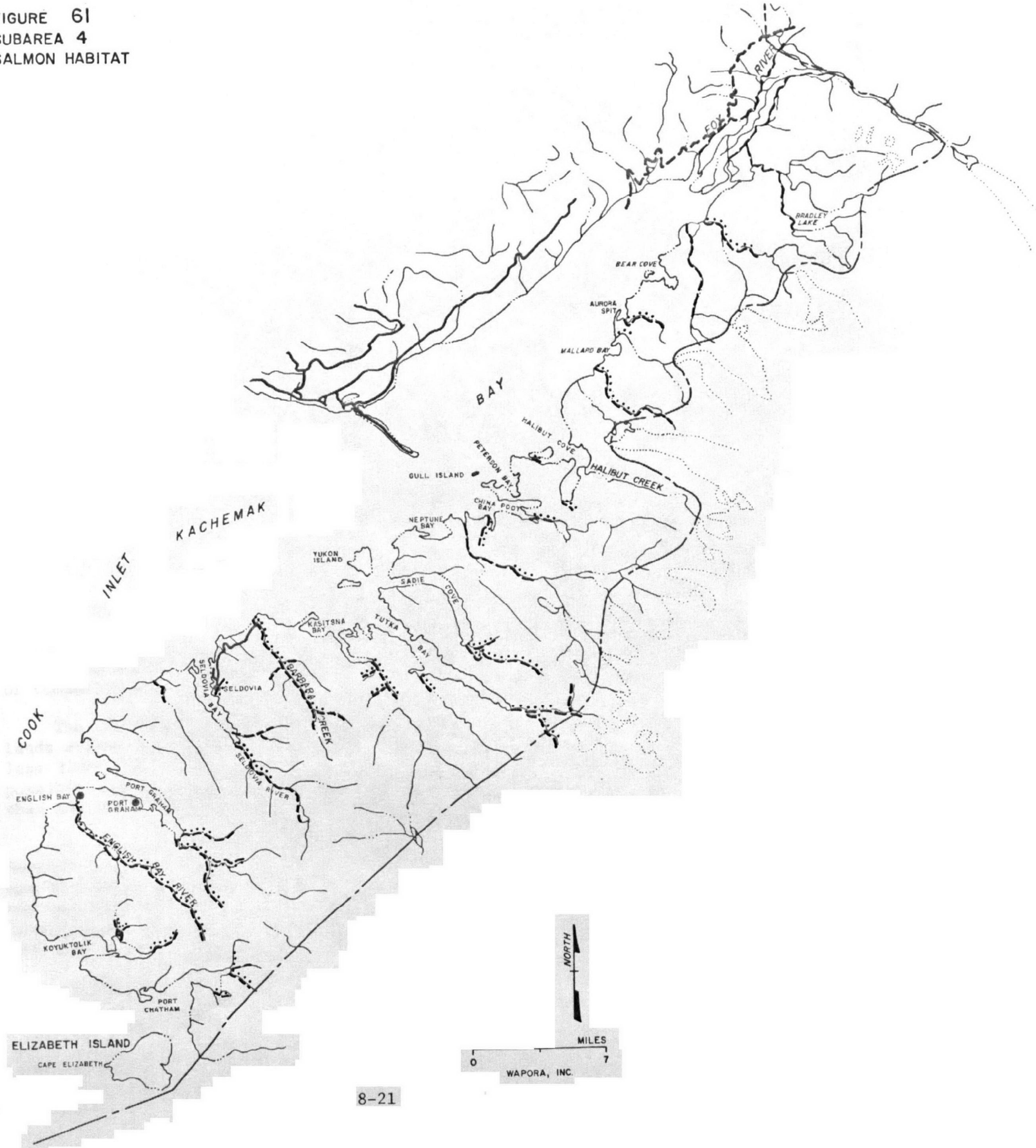
Subarea IV contains one first-class city, Seldovia, and a number of

SALMON HABITAT

------ SALMON PRESENT

..... SALMON SPAWNING

FIGURE 61
SUBAREA 4
SALMON HABITAT



smaller villages. Some are thriving, but others are almost extinct. The smaller communities include Port Graham, English Bay, Halibut Cove, Bear Cove, and the many small groups of people in almost every bay or cove. Fishing, the major resource base, does not require large communities, and the limited level land areas and difficulty of land transportation tend to discourage large communities.

8.5.2. Demography

8.5.2.1. Population

The results of the 1970 census, the 1977 special census, and the 1978 special census are presented in Section 3.4.3.1. The results of the 1978 special census in Subarea IV and the surrounding area are presented in Figure 64 (adapted from US Bureau of the Census 1978). Subarea IV includes part or all of the Halibut Cove, Seldovia, English Bay, and Port Graham precincts. Three of these precincts include areas south of the Kenai Mountain Divide that are outside the study area, but populations in that region are extremely sparse. Disregarding those small populations, the total population of the four precincts (1,017) roughly approximates the population of Subarea IV. These results cannot be compared directly with the 1970 or 1977 census results because different boundaries were used. However, if the Halibut Cove and Diamond Ridge enumeration districts of the 1970 census and the Halibut Cove Precinct of the 1978 special census are disregarded, the remainder of Subarea IV is in units that can be compared. The Seldovia, Jakalof Bay, Port Graham, English Bay, and Chugach Islands enumeration districts of the 1970 census include very nearly the same areas as the Seldovia, Port Graham, and English Bay precincts used for the 1978 special census. The total population of this area was 698 in 1970 and 932 in 1978. The data are not adequate to allow comparisons of village populations between 1970 and 1978.

The population of Seldovia in 1970 was 437 (US Bureau of the Census 1973). In 1977 the population was estimated to be 612 (Alaska Department of Community and Regional Affairs 1977).

The population of the entire Seldovia Precinct (which included the lands around Soldovia shown in Figure 64) during the 1978 census was 582, less than the estimate for the City of Seldovia alone in 1977. It is possible that different population enumeration methods were employed or that the 1977 estimates were optimistic.

The population projections for Seldovia that were presented in Section 3.4.3.3. (Table 20) assumed that the 1977 population of Seldovia was 612 and that a compound annual population growth rate of 5 percent was appropriate. Under those conditions and with no impetus from OCS development, the population of Seldovia was projected to exceed 900 by 1987 and to reach 1,100 by 1992.

Projections that included medium case OCS development (Table 22) indicated that an additional 140 persons would be present in Seldovia by 1988. It was predicted that if a major petroleum refinery and a natural gas liquefaction plant were to be built in the North Kenai area, and if construction were to begin during 1978, another 59 people would be added to the population of Sedovia by 1988. There are no projections for the population increases that would accompany the construction of a major

WILDLIFE HABITAT

SEA LION HAULING OUT AREA

HARBOR SEAL

BLACK BEAR

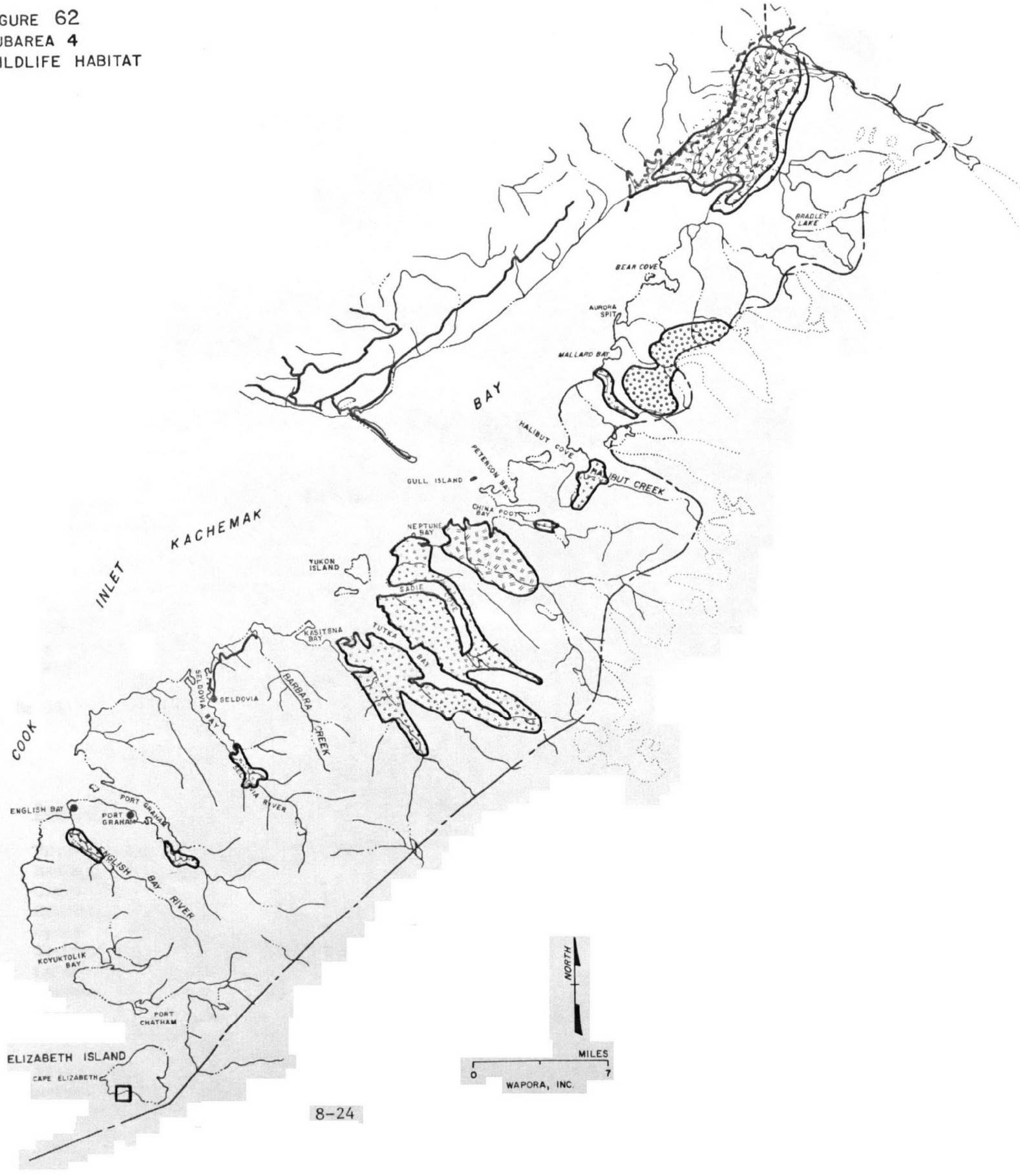
BROWN BEAR

MOOSE

GOAT

CARIBOU

FIGURE 62
SUBAREA 4
WILDLIFE HABITAT



hydrocarbon facility in the southern Kenai Peninsula or the development of a major bottomfish industry in the Kachemak Bay area.

8.5.2.2. Population composition

Data that describe the demographic and economic composition of Subarea IV in 1976 are presented in Table 55. The most striking fact about Seldovia was that whites constituted 74% of the population, as compared with 97% to 98% for the other cities. The percentage of its employed adults who were employed full time was 78%, significantly less than in the other cities. The Bureau of Management and Urban Affairs and the Anchorage Urban Observatory (1977) stated that the lower employment in Seldovia reflected "the much higher unemployment rate among heads of households who are natives and/or females." However, the percentage of adults who were employed was significantly higher than in the other cities. Twenty-seven percent of its household consist of one-person households, and 48 percent of the households had no children. At the same time, households with no adult males constituted 19 percent of the total, as did those with no employed adults. Only 14 percent of its families did not rely on subsistence for any of their food (compared with 21 percent in Homer, and over 40 percent in Kenai and Soldatna). Yet the median family income of $21,600, although significantly lower than those of Kenai and Soldotna, was slightly higher than that of Homer. A higher proportion of adults employed in Seldovia, and the high percentage (81%) of unemployed heads of households who receive unemployment compensation in the previous years, may partially explain this level of income.

8.5.2.3. Employment

The occupations of Seldovia citizens in 1976 are summarized in Table 56. Fishing was the primary occupation, and a large percentage of the workers in the other sectors were engaged in activities that supported the fishing or the processing of the catch.

Table 56. Occupations of persons surveyed in Seldovia during August and September 1976 (Bureau of Management and Urban Affairs and Anchorage Urban Observatory 1977).

Occupation	Percent of Total Employment
Professional, technical	11.5
Manager, official, proprietor	9.8
Clerical, sales	13.1
Craftman, foreman	6.6
Operative worker	9.8
Service Worker	9.8
Labor, fisherman	39.3
Farmer, farm manager	0.0

8.5.2.4. Housing

Sixty-seven percent of the homes in Seldovia in 1976 were single-family residences, 18 percent were mobile homes, and 9 percent were multi-family dwellings (Bureau of Management and Urban Affairs and

LAND OWNERSHIP

FEDERAL LAND

STATE LAND

TENTATIVELY APPROVED PATENTED

TIDELAND PATENTS

MANAGEMENT RIGHTS SELECTION APPROVED PATENTED

TIDELAND PATENTS

INTERIM CONVEYANCE PATENTED

TIDELAND PATENTS

FIGURE 63
SUBAREA 4
LAND OWNERSHIP

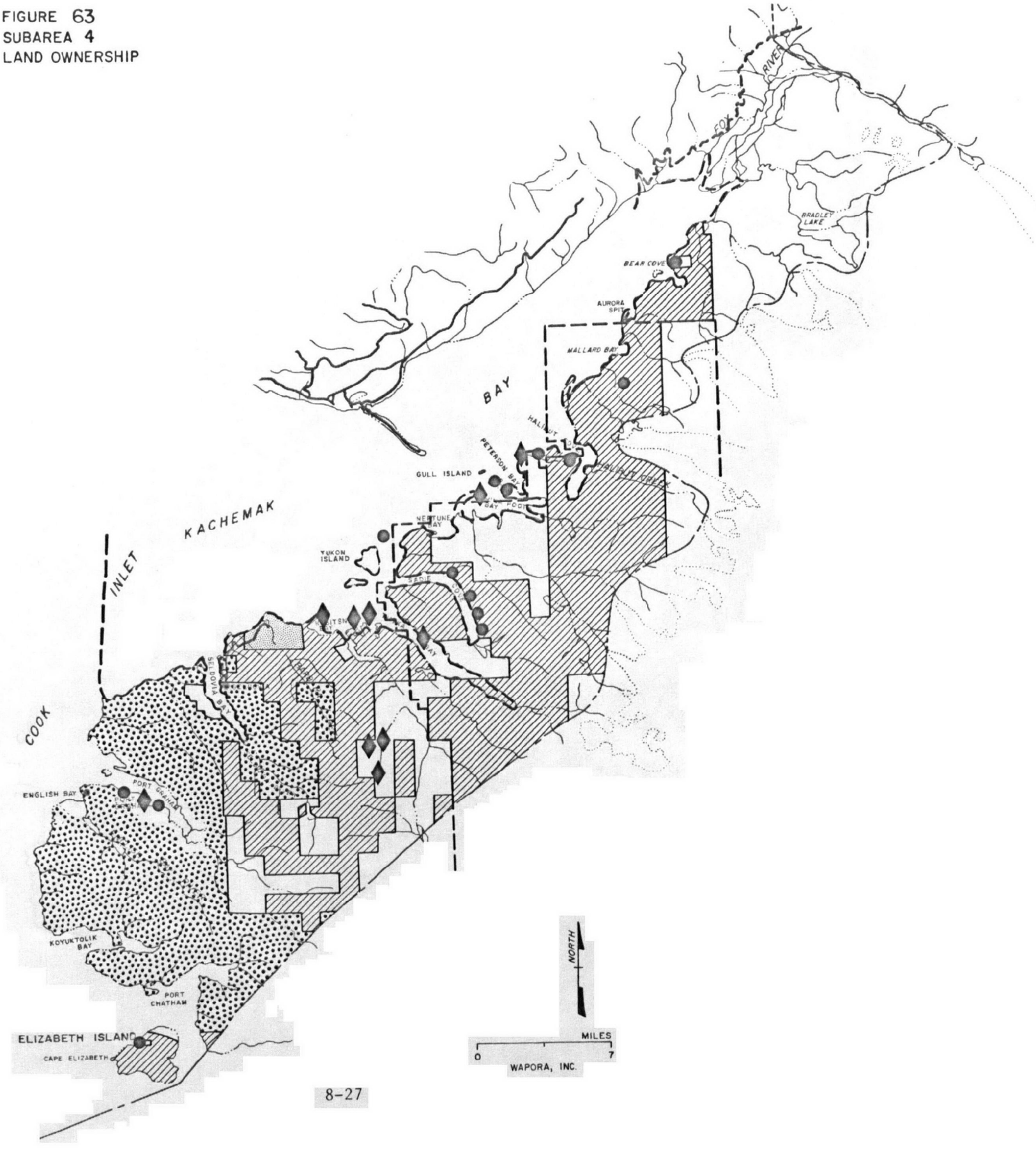


FIGURE 64
SUBAREA 4
SPECIAL CENSUS DISTRICTS

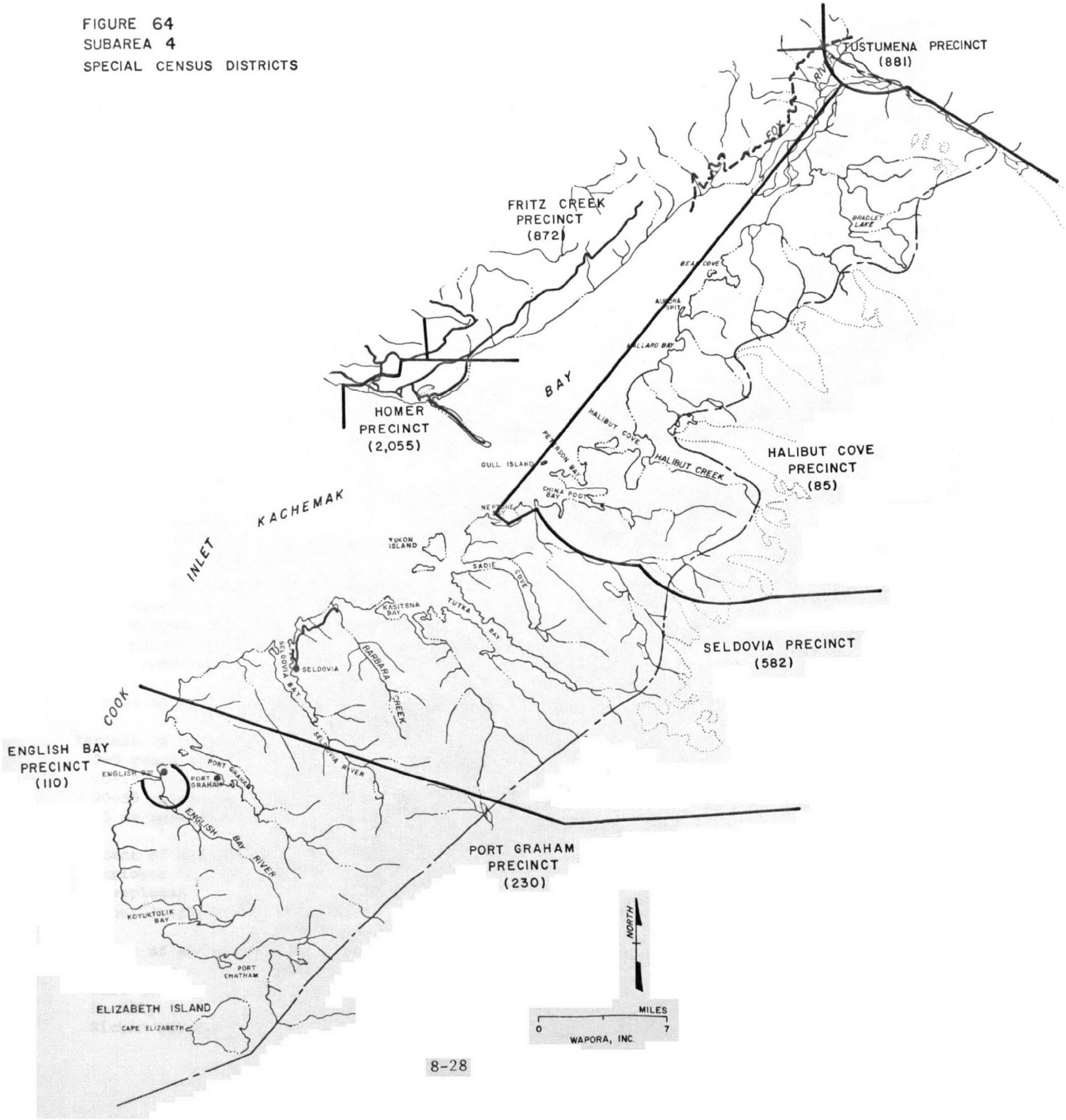


Table 55. Demographic and economic composition of Seldovia, August - September, 1976 (Bureau of Management and Urban Affairs and Anchorage Urban Observatory 1977).

Percentage of households with:	
1 person	27
2 persons	23
3 persons	15
4 persons	14
5 persons	17
6 or more persons	4
No children	48
1 child	15
2 children	15
3 children	17
4 or more children	4
1 adult	33
2 adults	62
3 adults	2
4 or more adults	4
No adult males	19
1 adult male	73
2 adult males	4
3 adult males	4
4 or more adult males	0
No employed adults	19
1 employed adult	39
2 employed adults	39
3 employed adults	2
4 or more employed adults	2
Percent of all household members who are male	51.7
Percent of population in household that is:	
0-9 years old	21
10-19 years old	19
20-59 years old	54
60 or more years old	5
Percent of all adults who are:	
Employed	74
Unemployed	7
Other (retired/student/housewife)	19
Percent of all employed adults employed:	
Full-time	78
Part-time	22
Locally	88
Within Borough	3

Table 55. Demographic and economic composition of Seldovia (concluded).

Percent of household heads who worked 12 months in previous year	35
Percent of unemployed heads of household:	
Receiving unemployment compensation in previous 12 months	81
Not receiving unemployment compensation in previous 12 months	19
Percent of employed heads of household employed in:	
Agriculture/commercial fishing	37
Mining/oil and gas production	7
Construction	2
Manufacturing (lumber and fish processing, oil and gas refining)	17
Transportation, communications, utilities	12
Wholesale and retail trade	5
Finance, insurance, real estate	5
Services (hotel, law, medicine, etc.)	7
Government	7
Other	0
Median school years completed, all adults	12
Median total family income	$21,600
Percent of all household members who are:	
White	74
Eskimo	1
Aleut	12
Native not specified, Indian, Black, Asian	13
Percent of family's food supply from subsistence	
None	14
Less than 25%	44
25-49%	17
50-74%	19
75% or more	6
Median number of respondent's years in community	8
Percent of respondents who lived in 1970 in	
Same community	58
Other area of Kenai Peninsula	2
Other area of Alaska	8
Outside Alaska	32

Anchorage Urban Observatory 1977). Most of the single-family and mobile homes were occupant-owned, and most of those who lived in mobile homes owned the land on which the homes stood. Half of the homes were not encumbered. The average costs for the other homes were appreciably less than were the costs for homes in the other first-class cities in the study area. Approximately 50 percent of the homes in Seldovia were adjacent to graveled or paved roads. City water supplied 88.6 percent of the homes, 64.2 percent were connected to city sewers, and approximately 64 percent had telephone service. Most of the homes were heated by oil. The housing vacancy rate during the 1976 survey was 5.4 percent. This indicated that the housing market was flexible but could not withstand a major population influx.

8.5.3. Utilities

8.5.3.1. Water supply

Water and sewage collection services are provided in Port Graham and in Seldovia. In Port Graham, water is piped from a small impoundment to individual residences. The available flow averages approximately 50 gallons per minute.

An impoundment on an unnamed tributary provides the primary water source for Seldovia. This primary reservoir has a capacity of 6 million gallons. A diversion on nearby Fish Creek that holds approximately 500,000 gallons provides a secondary source. However, leaks from the primary reservoir result in a significant loss of water, and silting in of the basin and destruction of the diversion by floods have reduced the usefulness of the secondary reservoir. Also, water from the secondary source is of doubtful purity, and in the present system it bypasses the treatment plant. Seldovia has encountered water shortages, and continued shortages are predicted. The average water consumption was approximately 460,000 gallons per day in 1976 (Waites and Brogan 1977b). Approximately 100,000 gallons per day were used by industry. The remainder was residential consumption. The large residential usage volume was attributed to wastage resulting from the absence of water meters and the continuous winter flows maintained to prevent freezing. Tryck and others (1976) projected a 600,000 gallon per day usage in the year 2000, based on increased domestic usage but without consideration of industrial demands. The projection was based on a slow population growth rate (3% per year), which could be upset easily by petroleum development in the Lower Cook Inlet. Proposed industries, including the recently approved fish processing facility, would place additional demands on the water system. If surplus water becomes available, it may be used for petroleum exploration and development activities. The Tryck, Nyman and Hayes study (1976) recommended improvements to the water system that included:

- Repair of water lines from the primary reservoir
- Elimination of leakage from the primary reservoir
- Construction of a better dam at the Fish Creek source
- Provision of treatment for water from Fish Creek

- Protection of the primary and secondary watersheds
- Construction of a 250,000-gallon storage tank
- Expansion of the area served by the system.

8.5.3.2. Sewage disposal

In Port Graham, sewage is treated in multiple-residence septic systems. In Seldovia, the sewage is collected from approximately 75 percent of the buildings by a City-operated system and then is emptied into Seldovia Bay without treatment.

8.5.3.3. Electricity

Electricity is provided to Seldovia by the Homer Electric Association (HEA). HEA also operates generators at Port Graham and English Bay.

8.5.3.4. Telephone service

Glacier State Telephone Company provides telephone service to approximately 120 stations in Seldovia. A RCA radio-telephone provides service to a single telephone at Port Graham and another at English Bay.

8.5.3.5. Point-source discharges

There are three point-source dischargers with NPDES permits in Subarea IV: the City of Seldovia (municipal wastewater), the Wakefield-Pacific Pearl Company at Seldovia (seafood-processing wastes), and the Whitney-Fidalgo Company at Port Graham (seafood-processing wastes). The Seldovia Native Association recently won approval from the City of Seldovia to purchase City land to construct the first phase of a $600,000 salmon, herring, and bottomfish processing plant (Anonymous 1978d). When completed, this plant also would require a NPDES point-source discharge permit.

8.5.3.6. Solid waste disposal

The Kenai Peninsula Borough operates landfills at Seldovia, Port Graham, and English Bay. There are no other publicly-operated solid waste disposal sites in Subarea IV.

8.5.4. Transportation

The City of Seldovia operates a wharf 40-feet wide and 220-feet long. The wharf is used by the State ferry system, fishermen, small tankers, freighters and the US Coast Guard. The marine traffic at the Seldovia City Dock and the air traffic at the Seldovia, Port Graham and English Bay airports provide communication between Subarea IV and the remainder of Alaska. Airports in Subarea IV are listed in Table 57.

There are no highways in Subarea IV. A State-maintained road connects Seldovia with logging operations at Jakolof Bay, and there are logging roads across some of the Subarea. The City of Seldovia maintains six miles of unpaved roads. Land travel between Port Graham, English Bay, and Seldovia is by footpath.

Table 57. Airport facilities in Subarea IV (National Oceanic and Atmospheric Administration 1978).

Airport Name	Location	Runway Length (ft)	Runway Surface	Facilities
Halibut Cove	Mouth of Halibut Cove	600	Unpaved	None
Jakalof Bay	4.3 mi. E of Seldovia	1,100	Gravel	None
Seldovia	0.9 mi. E of Seldovia	2,600	Gravel	Also sea-plane basin
English Bay	Adjacent to town	1,800	Gravel	None
Port Graham	Adjacent to town	1,800	Gravel	None

8.5.5. Social services

8.5.5.1. Educational facilities

There are three schools in Subarea IV (Table 58). Students unable to attend these schools may receive their education from public-financed correspondence courses and local, State-paid, part-time, or temporary tutors. The data indicate that enrollment is slightly less than capacity in all three schools, but that OCS development or any other development that would significantly enlarge the population of Subarea IV would exceed existing classroom capacity.

Table 58. Kenai Peninsula Borough schools in Subarea IV (CH_2M Hill, Inc. 1978a).

School	Grades	Enrollment	Capacity
English Bay	K-8	18	25
Port Graham	K-8	33	50
Susan B. English (Seldovia)	K-12	168	230

8.5.5.2. Police protection

Seldovia has one police officer and one police vehicle. Two State Troopers, one in Homer and one in Anchor Point, are responsible for the remainder of Subarea IV.

8.5.5.3. Fire protection

Seldovia has two pumper trucks, one jeep pumper truck, and 24 volunteers. The volunteer fire department provides services to Seldovia and to the parts of the surrounding area that can be reached by road or by trail.

8.5.5.4. Other services

The City of Soldotna operates an outpatient clinic staffed by a doctor, two nurses, and a visiting dentist. The City has 48 acres of parks and is attempting to acquire an additional 2.5 acres of beach parkland from the State. The new $200,000 library has approximately 5,000 books. It is staffed by volunteers. Nonresidents may use the park and library facilities at no charge.

8.5.6. Public finances

Selected financial data for the City of Seldovia are presented in Table 59.

Seldovia has had a fluctuating deficit each year over the period from 1970 to 1976. Both expenditures and revenues have risen. The former increased by 125 percent over the period. Even with a significant increase in the millage rate in 1976, property taxes rose by a smaller percentage than expenditures over the period from 1971 to 1976. The

Table 59. Selected financial data for the City of Seldovia, 1970-1976 (CH_2M Hill, Inc. 1978a; Waites and Brogan 1977c).

Year (ending 30 June)	Expenditures ($)	Revenues ($)	End-year Balance ($)	Real and Personal Property Assessed Value (1 million)	Millage	Sales Tax Rate (%)
1970	102,172	117,128	(85,222)	NA[1]	--	0.0
1971	109,098	129,635	(66,148)	2,549,960	--	0.0
1972	91,521	130,008	(57,758)	2,476,795	--	0.0
1973	133,751	127,335	(6,856)	3,293,970	13.50	0.0
1974	160,065	134,720	(32,002)	3,786,300	13.50	0.0
1975	172,592	199,835	(4,999)	3,786,300	13.50	0.0
1976	230,332	219,582	(16,249)	5,181,424	16.50	1.0

Debt ratios (FY 1976)

Assessed value	$6,733,035
Direct debt	505,000
Direct and overlapping debt	631,907
Ratio of direct debt to assessed value (percent)	7.5
Ratio of direct and overlapping debt to assessed value (percent)	9.1
Population	612
Assessed value per capita	$11,002
Direct debt per capita	825
Direct and overlapping debt per capita	1,033

Revenues (FY 1976)

Revenue source	Revenue	Percent
Property tax	$62,499	22.7
Sales tax	17,436	6.3
State-shared revenue	28,966	10.5
Dock revenues	34,353	12.5
Small boat harbor	17,485	6.3
Sewer fees and assessments	22,981	8.3
Airport contract	16,603	6.0
Other	74,348	27.4
Total	$275,671	100.0

Expenditures (FY 1976)

Expenditure Item	Expenditure	Percent
Government administration	$62,499	34.2
Police department	16,814	5.8
Fire protection	3,154	1.1
Harbor and dock	17,356	6.0
Maintenance	57,918	20.1
Transfers to other funds	71,224	24.8
Other	29,911	8.0
Total	$287,766	100.0

[1] NA = Data not available.

increase in the millage rate was for the water system, which in previous years had been supported by a service area levy of 3.0 mills. The sales tax was instituted in 1976. Seldovia's debt ratios were the highest of any of the cities in the study area, and its assessed value per capita was the lowest -- only half that of Homer. The property and sales taxes accounted for a relatively small proportion of its revenues. Dock and harbor revenues and government assistance provided most of the revenues. The largest expenditures were for administration, maintenance, and transfers to other funds (including debt service). They accounted for 79 percent of general fund expenditures in 1976.

An important component of Seldovia's financial status in 1976 was its eligibility for HUD Community Development Block Grant monies, which it could use directly or as local matching funds. The grant was for $496,000, of which $123,00 was applied in 1977 for capital improvements. The remainder was to be disbursed over the next two years. The Economic Development Administration (EDA) also provided $390,000 for improvements to the water system, and Seldovia has requested an additional $650,000 from EDA for the system in 1979. Other grants received by Seldovia included:

- $149,000 from EDA for the City's health facility
- $10,000 (plus 10,000 in local matching funds) from the State Department of Transportation for dock improvements
- $150,000 (plus $50,000 in local matching funds) from the State of Alaska for library improvements.

8.5.7. Public attitudes toward development

Public attitudes in Seldovia were reported by the Bureau of Management and Urban Affairs and the Anchorage Urban Observatory (1977). Seldovia had a population of 582 in 1978. Fifty-two percent preferred a city size of 700, and 28 percent one of 700 to 1,500. At the extremes, 4 percent preferred a population of 700 or less, and 8 percent preferred one of 3,000 to 10,000.

The predominance of commercial fishing and the small-boat harbor in the economic life of the City was preferred. The third-ranked sector was education, with onshore facilities (and related transport) ranked as least-preferred. Tourism and the small-boat harbor received anomalous rankings. Tourism was ranked second (behind commercial fishing) of nine sectors as the first choice for the most-desired type of development, but only seventh in terms of the percentage of the City residents who would encourage it. The small-boat harbor, which was ranked second in terms of sectors that should should be encouraged, was the least-desired sector.

The percentage of those responding favorably to the location of onshore facilities in the area was the lowest of the three cities in the study area. (This question was not asked in Homer). Seventy-three percent of the respondents in Seldovia thought that a supply base in the area should be prevented, and 70 percent indicated that oil and natural gas facilities should be located outside the City.

In summary, a majority of the residents of Seldovia wanted conditions to remain the same. They did not favor population growth, they were wary of oil and natural gas development, and they preferred that growth occur in the renewable-resource sector (fishing/harbors) and the education sector.

8.6. Cultural, Historical, Archaeological, and Aesthetic Resources

Subarea IV has a rich history of Native, Russian, and American endeavors, and contains some of the most beautiful terrain in the study area. It has steep mountains, fiords, glaciers, and ice fields.

The Alaska Heritage Resource Survey (AHRS) Master File (Alaska Department of Natural Resources 1979) lists 92 sites in Subarea IV. These include important sites of Native occupation, especially those of the Kachemak Bay Eskimos. In addition, there are significant remnants of the Russian period and of Early American activities. The Cook Inlet Region Inventory of Native Historic Sites and Cemeteries (Cook Inlet Native Association 1975) lists 48 sites in Subarea IV. There is considerable overlap between the two sources, although the latter inventory does not include English Bay and the areas south of English Bay. It is very likely that additional sites will be discovered and that the significance of known sites will be determined more completely.

8.6.1. Native period

Archaeological evidence indicates that Subarea IV was inhabited for thousands of years by Eskimo peoples. The discussion of the Kachemak Bay Eskimo in Section 6.6.1. is pertinent to the Native period of Subarea IV. The available data are more numerous for this subarea than for any other. Even today, there are residents of English Bay and Port Graham who speak Suxston Eskimo (locally-termed Aleut; Workman 1974). The origin of these communities is not known, but they may extend back to the Kachemak Bay Eskimo period. Rock paintings were found at three locations in Subarea IV. Those on Yukon Island were simple, vertical streaks of red paint. The paintings found on Bear Island and at Sadie Cove were small in scale and exhibited considerable artistry. The paintings are believed to be of Eskimo origin (De Laguna 1934).

The Eskimo culture in Subarea IV lasted longer than in any other part of the study area. Finally, as in the other subareas, the Tanaina Athabaskan Indian group spread to Subarea IV. "Why much of Kachemak Bay was ultimately abandond after 2,000 years or more of successful occupancy remains one of the pressing provisions for future research" (Workman 1974). There are indications of trade and conflict between the Eskimo and the Tanaina, and subsequent Tanaina artifacts show a strong Eskimo influence. Future studies in Subarea IV may lead to a better understanding of the transitional period between Eskimo and Tanaina cultures. It is possible that the Native presence may date back beyond 5,500 years in Kachemak Bay, as it has on Kodiak (Workman 1974).

8.6.2. Russian period

It is believed that the Russian explorer A. I. Chirikov sighted Cape Elizabeth on 1 August 1741 (Sherwood 1974). There seems to have been a

period without further Russian activity, between 1741 and 1786, during which more attention was paid to the Aleutian Islands, Kodiak Island, and the Alaska Peninsula. In May 1778, Captain James Cook sighted Cape Elizabeth. After exploring the inlet that now bears his name, the expedition continued onward. By the time the English returned, the Russians had become established in Cook Inlet (Sherwood 1974).

The Shelikhov-Golikov Company established a post at English Bay called Alexandrovsk. The Russians initially concentrated on the profitable fur trade. The potential for other resource exploitation was apparent after the discovery of coal deposits near the mouth of Port Graham in 1786 by the English explorer Portlock. He named the area Coal Harbor (now Coal Cove). Small quantities of the coal were used occasionally by Russian vessels until full-scale mining was started in 1855 by the Russian-American Company (Barry 1973). The mine was the first in Alaska and may have been the first on the Pacific Coast of North America. Although more than 2,700 tons of coal were mined from 1857 to 1862, the inefficient operation and low grade of the coal resulted in financial loss. The mine continued to supply small amounts of coal for local use until 1867 (Barry 1973).

8.6.3. American period

The American purchase of Alaska resulted in the transfer of the holdings of the Russian-American Company to a new firm known as the Alaska Commercial Company. The US Census of 1880 listed the population of Seldovia-Ostrovki as 74 and the population of Alexandrovsk (English Bay) as 88. By 1890 the population of Seldovia had grown to 99 and that of English Bay had increased to 107 (Pedersen 1976). Development was slow and centered on fishing and trapping. Seldovia began to grow consistently, while Port Graham and English Bay remained small. Salmon canneries helped to spur the local economies. Fur farming became profitable after World War I. After the decline in fur prices, local economies again turned to fishing. Herring were an important product until the resource was depleted. The economy of Subarea IV rose and fell with the fishing industry's fortune. The king crab fishery increased, and in 1963 Seldovia appeared to be headed for an economically-sound future (Pedersen 1976).

The increased population brought problems as well as economic prosperity. Then the 1964 earthquake struck. The waterfront of Seldovia was lowered by up to 4 feet, and the higher tides inundated the area. A controversial urban renewal scheme changed the old town substantially. The town was slow to recover but now appears to be thriving again.

8.6.4. Sites in the National Register of Historic Places

Subarea IV includes three sites listed in the National Register of Historic Places and one site that has been designated as a National Historic Landmark. The multitude of other known sites and the likelihood of significant new discoveries make it possible that additional locations will be afforded protection. The discussion of the sites that follows is based on information from the Master File of the Alaskan AHRS, from the Final Environmental Impact Statement of the Proposed 1976 Outer Continental Shelf Oil and Gas Lease Sale, Lower Cook Inlet, and from other sources sources as noted.

Chugachik Island (Indian Island) is listed in the National Register of Historic Places. It is located near the head of Kachemak Bay. Shell middens have been found adjacent to a number of coves on the island. Excavations have revealed a large number of artifacts, and the site has been described as the best representative of the Kachemak II (possibly Sub-III) tradition in Kachemak Bay (Bureau of Land Management 1976). The main midden is approximately 300-yards long and from 8-feet to 10-feet deep. The site is subject to tidal erosion. It has been designated as SEL 033 by the AHRS.

The Coal Cove Village Site, located near Port Graham, is listed in the National Register of Historic Places. The site was called English Bay by the Russians and is believed to date from as early as 1787. The site contains the remains of the Russian-American Company's coal-mining venture during the mid-1800s. The mine probably was the first on the Pacific coast of North America (Barry 1973). Only structural foundations, mine depressions, and parts of a small railroad remain today. The site is owned by the State of Alaska, but is under Native claim. It has been designated as SEL 021 by the AHRS.

The Coal Cove Village Site, located near Port Graham, is listed in the National Register of Historic Places. The Site is located on the north shore of Port Graham and is privately owned. It is hoped that the unexcavated, large shell midden will provide valuable insights into the prehistory of the area. The AHRS designation for this Site is SEL 054.

The Yukon Island Main Site has been designated as a National Historic Landmark. It is on Yukon Island in Southwestern Kachemak Bay, almost due south from Homer. The site includes a large midden that was examined by Dr. Frederica De Laguna in the early 1930s. It was important in her formulation of the Kachemak Bay tradition. The site was damaged by the 1964 earthquake, and the remains of the midden now are subject to tidal erosion (Bureau of Land Management 1976). The site is under multiple ownership and has been designated as SEL 001 by the AHRS.

The importance of Subarea IV is demonstrated by the large number of identified sites and by their significance. A great deal of work remains to be done, and careful consideration should be given to the preservation of all archaeological and historic resources.

9.0. SUBAREA V

9.1. Subarea V Boundaries

Subarea V consists of that part of the Bachatna Flats south of the West Foreland and less than 200 feet MSL elevation. Subarea V is bordered on the north by the study area boundaries (an east-west extension of a line between the Cook Inlet Forelands), on the west and south by the Subarea VI boundaries, and on the east by the waters of Redoubt Bay. The boundaries, topography, and major landform features of Subarea V are illustrated in Figure 65 (adapted from Joint Federal-State Land Use Planning Commission 1973b).

9.2. Physical Environment

9.2.1. Landforms

The northeastern section of Subarea V consists predominantly of alluvial land, tidal marsh, and tidal flats. The topography is nearly level and elevations generally are less than 100 feet MSL (Figure 65). The alluvial land is dissected by many streams and sloughs, which may change position with time. Similar landforms exist near the mouth of Redoubt Creek and at Harriet Point.

There is an area of rough, broken land northwest of Harriet Point. The land surface in this area consists of sandstones and conglomerates of the Tyonek, Hemlock, and West Foreland formations. The remainder of Subarea V includes the lower slopes of steep, mountainous terrain. Rock formations in these areas are composed of intrusive rocks and weakly metamorphosed sedimentary rocks. This mountainous topography is dissected by broad, flat-bottomed valleys and floodplains associated with the North Fork River, Montana Bill Creek, the Drift River, and Redoubt Creek. Floodplains also are associated with Harriet Creek, Cannery Creek, and other small tributaries of the Cook Inlet.

9.2.2. Geology

9.2.2.1. Surficial geology

The surficial geology of Subarea V consists predominantly of tertiary siltstones, sandstones, and conglomerates overlain by Pleistocene and Holocene sediments (Figure 66; adapted from Magoon and others 1976). Unconsolidated sediment consists of glacial drift and recent alluvial deposits. Alluvial material is mostly sand, silt, and clay that was deposited in deltas and floodplains. The alluvium was derived largely from glaciers in the Aleutian Range and was transported by the Drift River, the Big River, and the North Fork River. Coastal regions of Subarea V are characterized by tidal marsh and tidal flats of fine-grained sediments that have been reworked by the tidal action of Redoubt Bay (Rao & Wolff 1975; Magoon and others 1976).

Subarea V lies on the northwestern flank of the Matanuska-Wrangell Forearc Basin (Magoon and others 1976). It is bounded on the west by surface exposures of undifferentiated metasedimentary rocks (Jurassic and/or Cretaceous) and the Talkeetna Formation (Lower Jurassic). The

FIGURE 65
SUBAREA 5,6A
TOPOGRAPHY

major structural feature of the Subarea is the Bruin Bay Fault, a buried thrust fault that trends northeast-southwest through the area (Figure 66).

9.2.2.2. Soils

Soils in Subarea V were formed over glacial drift and recent alluvium and probably are variable. At present, there are no soil data for Subarea V.

9.2.2.3. Geologic resources

Coal

The Beluga Coalfield contains a high grade of low sulphur lignite and subbituminous coal in the Beluga and Tyonek Formations of the Tertiary Kenai Group (Magoon and others 1976; Rao and Wolff 1975). The Beluga Coalfield (described in Section 3.2.2.) may underlie Quaternary deposits in Subarea V. In recent years, this area has been explored extensively. The geologic structure is simple, and the coal beds are well-suited for exploration.

Oil and gas

Subarea V is in a region of high petroleum potential (Alaska Department of Natural Resources n.d.). Potential reservoir rock consists predominantly of sandstones and conglomerates (Tertiary) of the Kenai Group (Magoon and others 1976). Oil and gas also may exist in upper Mesozoic rocks beneath Subarea V (Joint Federal-State Land Use Planning Commission 1974a). It is possible that the Bruin Bay Fault or other minor faults may act as structural traps. None of the oil and gas wells that have been drilled in Subarea V have been productive.

Metallic minerals

Subarea V belongs to the Redoubt Mining District. There is no record of any mining in the Subarea. The Aleutian Range to the southwest and west of Subarea V offers some potential for metallic mineral development, but the potential for development in Subarea V is very low (Figure 67, Joint Federal-State Land Use Planning Commission 1973b; Joint Federal-State Land Use Planning Commission 1974c).

Nonmetallic resources

No information concerning nonmetallic resources of Subarea V is available. Potential nonmetallic resources include alluvial sand and gravel from the numerous streams and clay from the tidal flats.

9.2.2.4. Geologic hazards

Geologic hazards in Subarea V consist largely of flooding and wave damage, ash falls from volcanic eruptions, and earthquake-related damage (Figure 68; adapted from Alaska Department of Natural Resources 1978b). The nearly level topography of the tidal marsh and alluvial land creates a high potential for flooding. Because the North Fork River, the Big River, and the Drift River are glacial streams, flooding from glacial

GEOLOGY

SYNCLINE

Qs
KJm

CONTACT

ANTICLINE

NORMAL FAULT - DOTTED WHERE CONCEALED
U - UPTHROWN SIDE
D - DOWNTHROWN SIDE

THRUST OR REVERSE FAULT - DOTTED WHERE CONCEALED
SAWTEETH ON UPTHROWN BLOCK

FIGURE 66
SUBAREA 5, 6A
GEOLOGY

outbursts may occur. Glacial outbursts of the Drift River may be triggered by volcanic activity of the Redoubt Volcano. Landslides, rockfalls, mudslides, and avalanches may occur in mountainous regions to the west of Subarea V; however, these hazards would not affect the majority of the Subarea.

Potential earthquake-related hazards include vibration damage, ground fissures, ground subsidence or uplift, horizontal displacement, landslides or avalanches (on the western border of the Subarea), and tsunamis. Due to the nearly level character of Subarea V, wave damage from tsunamis could extend inland for large distances.

Subarea V is located less than 25 miles northeast of the Redoubt Volcano, an active and potentially eruptive volcano (Magoon and others 1976). Potential hazards associated with this volcano include ash falls, lava flows, gas clouds, mud flows, landslides, flash floods, corrosive rains, lightning discharges, earthquakes, and tsunamis. Although most of these phenomena are local in their effects, flash flooding and ash falls may present a serious hazard in the Subarea. The activity of the Redoubt Volcano is summarized in Section 3.1.1.2. (Table 1). During 1966, the heat generated by the Redoubt Volcano during a period of activity melted snowfields on the flank of the volcano and caused severe flooding of the Drift River floodplain.

9.2.3. Water resources

9.2.3.1. Surface water hydrology

Subarea V is dissected by a complex system of streams and sloughs. The major streams of the subarea are Bachatna Creek, West Fork, North Fork, South Fork, the Big River, the Seal River, Montana Bill Creek, Rust Slough, and the Drift River. At present, there are no hydrology data for any of these streams. However, the following conclusions can be made based on previous studies of similar environments:

- Glaciers in the Aleutian Range are the primary source of water for the streams of Subarea V
- The spring and summer stream flows are derived primarily from glacial meltwaters. High sediment loads and low concentrations of dissolved solids are associated with these flows
- During the winter, streams have low flows that are sustained by groundwater recharge; dissolved solids concentrations probably increase because of the contributions from groundwater and encroachment of saline water from Redoubt Bay
- Water levels, flows, and water quality at the mouths of channels and streams are subject to the tidal action of Redoubt Bay
- There is a potential for flooding caused by ice jams and glacial outbursts.

9.2.3.2. Groundwater resources

There are no groundwater hydrology data for Subarea V. The prima

MINERAL RESOURCES

MAJOR MINERAL

SECONDARY MINERAL

MINERAL PROVINCE BOUNDARY

COAL PROVINCE BOUNDARY

COAL PROVINCE BOUNDARY IN WATER

PETROLEUM PROVINCE BOUNDARY

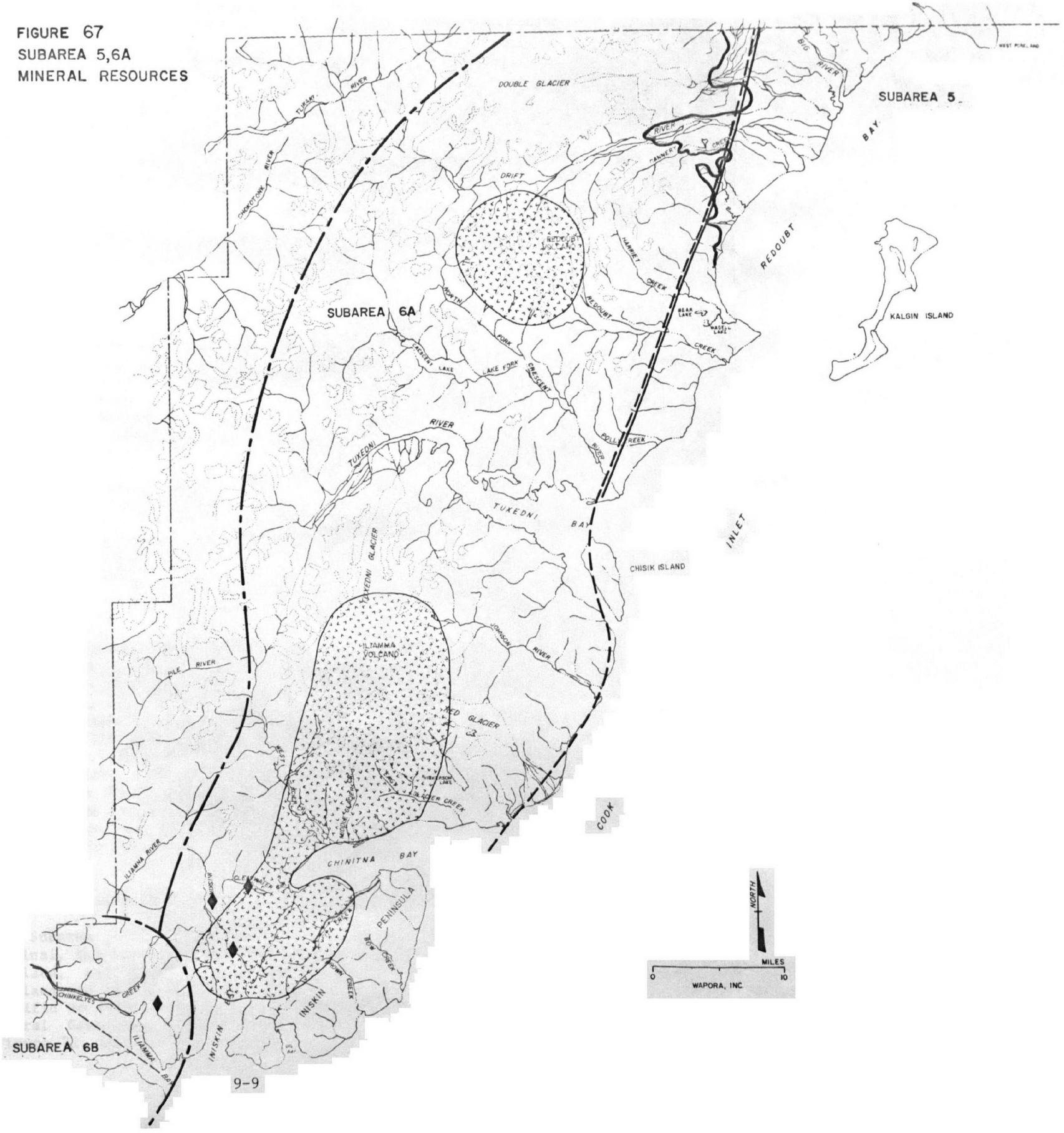
COAL FIELD

OIL FIELD

GAS FIELD

POTENTIAL GEOTHERMAL AREA

FIGURE 67
SUBAREA 5,6A
MINERAL RESOURCES



sources of groundwater probably are sand and gravel deposits in alluvium and glacial drift, and underlying tertiary sandstones and conglomerates.

9.3. Biological Environment

Ecologically, Subarea V is distinctly different from the surrounding lands of the study area. Subarea V is the southernmost member of a series of lowlands or flats originating east of the Susitna River. Although the flats overlie the huge, untapped Beluga Coalfield, it essentially is undisturbed except at the mouth of the Drift River where a petroleum storage site is operated. Drilling sites and their service roads are scattered through the area.

9.3.1. Vegetation

Much of Subarea V is treeless. The upper intertidal zone supports sparse sedge and marsh grasses. Farther inland the vegetation becomes thicker but remains predominantly wetlands (muskeg). The muskeg is broken by occasional potholes, tidal guts, and streams. Along the streams, the largest of which is the Drift River, alluvial deposits have formed natural dikes vegetated by spruce-hardwood or occasional stands of Sitka spruce-western hemlock. Where higher ground rises from the muskeg, brush becomes the prominent form of vegetation. The flats are dotted with sharp, rocky outcroppings and lower, more gentle mounds. The mounds support white spruce or Sitka spruce at the upper levels, grading into black spruce and then into muskeg. The outcrops and mounds become more abundant toward the western boundary of the flats, and mixed spruce-hardwoods become the prominent form of vegetation. The vegetation is mapped in Figure 69 (adapted from Joint Federal-State Land Use Planning Commission 1973b). The vegetation types are described in Section 3.3.

The Bachatna Flats support concentrations of black bears and brown bears in the spring and along the salmon streams in the summer (Figure 70; adapted from Joint Federal-State Land Use Planning Commission 1973b). The most significant value of the Flats as wildlife habitat is in the numbers of nesting and migrating waterfowl that use them. Timm (1976) reported 29,369 breeding waterfowl on the Flats adjoining Redoubt Bay and Trading Bay. During migration the Flats are major staging areas for geese and ducks. The Alaska Department of Fish and Game (1976) considers the Bachatna Flats critical habitat for waterfowl. The Drift River and other streams crossing Subarea V are spawning streams for pink salmon and silver salmon, but the runs are comparatively small. The salmon streams are mapped in Figure 71 (adapted from Federal-State Land Use Commission 1973b).

9.4. Land and Water Use

Subarea V is populated only by the workers at the Drift River Terminal, the residents of cabins along the south shoreline of the West Foreland, and seasonal residents of fishing cabins along the West Foreland and the Bachatna Flats shoreline. There are no population data specific to Subarea V. The land in Subarea V primarily is owned by the Federal Government; exceptions are several small private holdings. (Figure 72; adapted from Alaska Department of Natural Resources 1978b).

GEOLOGIC HAZARD

LANDSLIDE AND SLUMP

VOLCANIC AREA

FAULT ZONE

COASTAL EROSION

TSUNAMI HAZARD

EXTENT OF ICE

AREA OF SUBSIDENCE

POTENTIAL MELTWATER AND RUNOFF FLOODING

POTENTIAL GLACIAL OUTBURST FLOODING

FIGURE 68
SUBAREA 5,6A
GEOLOGIC HAZARD

At present there is no reported agriculture in Subarea V and no reported commercial timber usage. Most of the land probably is too wet to support cultivated crops, but possibly could produce hay or could be used for pasture land. Most of Subarea V is open grassland and shrubs. The few stands of spruce and other trees are of little commercial timber value.

There is no zoning or comprehensive land use plan for Subarea V. The Alaska Division of Lands, the Bureau of Land Management, and the Kenai Peninsula Borough may be involved in land use planning for Subarea V. In large part, land use in Subarea V will depend on the economic and other factors that will determine development of the coal resources under the Bachatna Flats.

9.5. Socioeconomic Environment

With the exception of the Drift River Terminal and a few cabins and fish camps (setnet sites) along the shoreline, Subarea V is undeveloped. Employment probably consists entirely of jobs at the Drift River Terminal and seasonal fishing. The Terminal employees probably will maintain their permanent residences outside Subarea V.

The Drift River Terminal has a small domestic wastewater treatment facility and potable water system. Wastewater disposal and water data for other parts of the Subarea V are not available. There is no public telephone, electrical, or other public utility service to Subarea V. There are no licensed solid waste disposal sites in Subarea V. The Drift River Terminal is the only NPDES permit holder in Subarea V. The Terminal discharges sanitary wastes and industrial wastewater associated with cleaning and maintenance.

Transportation to Subarea V is by boat, airplane, or helicopter. There is an unpaved airstrip at the Drift River Terminal that is suitable for most light planes, and there are several small "bush" airstrips along the coast that may be used by experienced bush pilots in specially-adapted light airplanes. Equipment and supplies for the Drift River Terminal are brought in by aircraft or by boat. The Drift River Terminal loads approximately half of the total tonnage shipped from Cook Inlet each year.

There are no educational facilities in Subarea V. There is no public fire protection. Police services are provided by State Troopers from Anchorage and from the Kenai Peninsula. No library or other social services are provided in Subarea V.

There are no public finance data specific to Subarea V. Property would be taxed by the Kenai Peninsula Borough. There are no retail trade establishments and, presumably, there is no sales tax collected. There are no data that describe the attitude of the residents toward economic development.

9.6. Cultural, Historical, and Archaeological Resources

There has been very little archaeological investigation of the

VEGETATION

	COASTAL WESTERN HEMLOCK/SITKA SPRUCE
1	UPLAND SPRUCE/HARDWOOD
2	UPLAND SPRUCE/HARDWOOD/LOWLAND SPRUCE/HARDWOOD
3	UPLAND SPRUCE/HARDWOOD/HIGH BRUSH
	LOWLAND SPRUCE/HARDWOOD
4	HIGH BRUSH
5	HIGH BRUSH BURNED
6	HIGH BRUSH BURNED/COASTAL WESTERN HEMLOCK/ SITKA SPRUCE
7	HIGH BRUSH/MOIST TUNDRA/ALPINE TUNDRA
8	LOW BRUSH/MUSKEG-BOG
9	MUSKEG
10	MOIST TUNDRA
11	WET TUNDRA
12	ALPINE TUNDRA/BARREN
13	ALPINE TUNDRA/BARREN/MOIST TUNDRA
M	MUD

FIGURE 69
SUBAREA 5,6A
VEGETATION

western shoreline of Cook Inlet. In recent times the area was occupied by the Tanaina Indians.

The Alaska Heritage Resource Survey Master File (Alaska Department of Natural Resources 1979) lists one site in Subarea V. There are three sites noted in the Cook Inlet Region Inventory of Native Historic Sites and Cemeteries (Cook Inlet Native Association 1975). The limited number of known sites reflects the lack of field studies in Subarea V.

9.6.1. Native period

There is little information on the Native period in Subarea V. The possibility of early settlement of Kustatan by Eskimo peoples was indicated by the discovery of artifacts that were suggestive of types characteristic of the Kachemak Bay Eskimo (De Laguna 1934). Data on settlement by the Tanaina are limited. De Laguna (1934) described a "modern village" of Tanaina from Polly Creek at Kustatan. Trails in the area indicate the presence of the Tanaina in less recent times (Cook Inlet Native Association 1975).

9.6.2. Russian period

Little specific information was available relevant to Russian presence in Subarea V. Because of the importance of the fur trade, it is likely that there were occasional Russian contacts with Natives near Kustatan. A map showing areas of contact between Russians and Aborigines is not detailed enough to document occurrences in Subarea V (Fedorova 1971).

9.6.3. American period

Subarea V has changed little under American rule. What activity has occurred has centered around Kustatan and the Drift River. Fishing has been the main industry of the area and several canneries were in operation in the 1930s (Cook Inlet Native Association 1975). The discovery of offshore oil and natural gas in Cook Inlet led to the building of the Drift River Petroleum Terminal at the mouth of the Drift River.

9.6.4. Sites in the National Register of Historic Places

There are no sites in Subarea V that are listed in the National Register of Historic Places. A description of the Kustatan area is contained in the Cook Inlet Region Inventory of Native Historic Sites and Cemeteries (Cook Inlet Native Association 1975). Future investigations may reveal significant historical sites.

WILDLIFE HABITAT

SEA LION HAULING OUT AREA

HARBOR SEAL

BLACK BEAR

BROWN BEAR

MOOSE

GOAT

CARIBOU

SALMON HABITAT

SALMON PRESENT

SALMON SPAWNING

FIGURE 70
SUBAREA 5,6A
WILDLIFE HABITAT

FIGURE 71
SUBAREA 5,6A
SALMON HABITAT

10.0 SUBAREA VI

10.1. Subarea VI Boundaries

Subarea VI includes all of the study area on the western side of Cook Inlet; except for the Bachatna Flats (Subarea V). It is bounded on the north by the study area boundary and Subarea V, on the west by the study area (Kenai Peninsula Borough) boundary, on the south by the Katmai National Monument and the study area boundary (a line extending west from Cape Douglas), and on the east by Cook Inlet. The boundaries and major terrain features in Subarea VI are presented in Figures 65 and 73 (adapted from Joint Federal-State Land Use Planning Commission 1973b).

10.2. Physical Environment

10.2.1. Landforms

Subarea VI includes part of the Chigmit Mountains of the Aleutian Range, other mountains of the Aleutian Range south of Kamishak Bay, and part of the southern end of the Alaska Range that extends into the northwestern quarter of Subarea VI. These mountains dominate the Subarea VI landform. The tallest peaks are more than 10,000 feet MSL, and extensive areas are more than 5,000 feet high (Figures 65 and 73). The mountain ranges have been scoured by glaciers, and U-shaped, steep-walled valleys and knife-edge ridgelines typical of glaciated terrain are the characteristic forms in Subarea VI. Extensive glaciers still overlie terrain above 5,000 feet, and many glaciers extend much lower on the mountain slopes. The very difficult terrain and the extensive glaciated and barren rock areas are major barriers to the establishment of plants and to human movement.

There are no extensive lowlands or plateaus in Subarea VI. Lowland terrain is restricted to the lower hills and mountain slopes, valleys, and small coastal lowlands, particularly near the mouths of rivers that are of glacial origin. Lower terrain occurs at the southern end of the Chigmit Mountains between Kamishak Bay and Iliamna Lake, in the Polly Creek area north of Tuxedni Bay, and on the Iniskin Peninsula.

10.2.2. Geology

10.2.2.1. Surficial geology

Subarea VI is located on the northwestern flank of the Matanuska-Wrangell Forearc Basin. Rocks of Subarea VI are faulted internally and folded. The principal structural feature in the area is the Bruin Bay Fault, which extends through the region from northeast to southwest. Magoon and others (1976) consider this to be a high-angle reverse fault that juxtaposes Jurassic granitic rock and early Jurassic and pre-Jurassic sedimentary rocks on the west side against middle Jurassic and younger sedimentary rocks on the east. Sedimentary rocks on the southeast or downthrust side of the fault are steeply dipping to overturned. Figures 66 and 74 (adapted from Joint Federal-State Planning Commission 1973b) depicts the geologic formations and major structural features in Subarea VI.

LAND OWNERSHIP

FEDERAL LAND

STATE LAND

TENTATIVELY APPROVED PATENTED

TIDELAND PATENTS

MANAGEMENT RIGHTS SELECTION APPROVED PATENTED

TIDELAND PATENTS

INTERIM CONVEYANCE PATENTED

TIDELAND PATENTS

FIGURE 72
SUBAREA 5,6A
LAND OWNERSHIP

FIGURE 73
SUBAREA 6B
TOPOGRAPHY

Exposures of Tertiary volcanic rocks occur throughout the southern half of the area. They are most prevalent southwest of Subarea VI in the vicinity of Iliamna Lake. Exposures of Quaternary lava flows occur at the Redoubt, Iliamna, Mt. Douglas, and Augustine Volcanoes.

Pleistocene and Holocene sediments occur in the floodplains of major streams throughout the area. Deposits probably consist of alluvial gravel, sand, silt, and clay.

10.2.2.2. Soils

Soils are formed over exposed rock throughout most of Subarea VI and over alluvial sediment in the floodplains. Erosion generally has prevented the soils on the hillsides and mountain slopes from becoming well developed. The soils of Subarea VI have not been mapped.

10.2.2.3. Geologic resources

Coal

The northeastern part of Subarea VI is located in the Beluga Coalfield (Figures 67 and 75; adapted from Joint Federal-State Land Use Planning Commission 1973b). The Beluga (Tertiary) and Tyonek (Tertiary) formations of the Beluga Coalfield are estimated to contain large amounts of high grade, low-sulfur coal. At present the Beluga Coalfield is undeveloped. There is little or no potential for coal development throughout the remainder of Subarea VI.

Oil and gas

Oil and gas resources currently are being developed from offshore oil fields in the West Foreland region (Magoon and others 1976). Oil and gas resources also may exist east of Subarea VI in Cook Inlet. The oil and gas exists predominantly within the Hemlock and Tyonek Formations (Tertiary). Upper Mesozoic (upper Jurassic and Cretaceous) rocks also may contain oil and gas reservoirs (Joint Federal-State Land Use Planning Commission 1974c). The potential for oil and gas development within Subarea VI generally is considered to be moderate to low.

Metallic minerals

Subarea VI lies within the Redoubt Mining District. Figures 67 and 75 depict areas that show high potential for mineral development. Although local metal production has been insignificant, several lode deposits are of significant size (Joint Federal-State Land Use Planning Commission 1974c). Mineral deposits are predominantly magnetite, which occurs in faults and fractures near plutons in metamorphosed volcanic and sedimentary rocks.

Nonmetallic resources

There are no data available on nonmetallic resources in Subarea VI. However, potential resources may include sand and gravel from alluvial deposits, clay from glacial drift or tidal flat deposits, and limestone from the Kamishak Formation (Triassic).

GEOLOGY

SYNCLINE

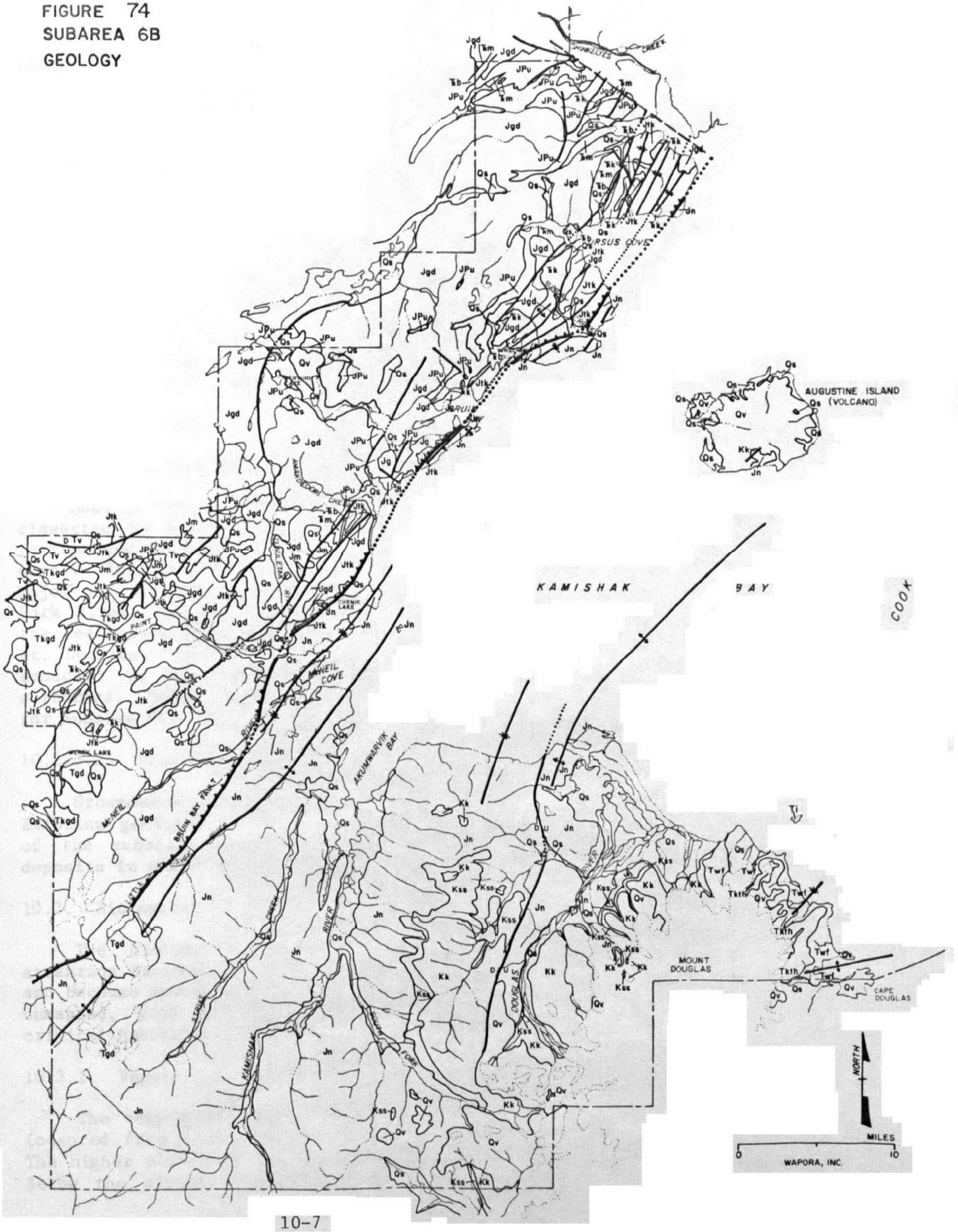
Qs
KJm
CONTACT

ANTICLINE

NORMAL FAULT - DOTTED WHERE CONCEALED
U - UPTHROWN SIDE
D - DOWNTHROWN SIDE

THRUST OR REVERSE FAULT - DOTTED WHERE CONCEALED
SAWTEETH ON UPTHROWN BLOCK

FIGURE 74
SUBAREA 6B
GEOLOGY



Potential geologic hazards in Subarea VI include flooding, wave damage, volcanic activity, landslides and avalanches, and earthquake-related damage. The major potential geologic hazards that may occur in Subarea VI are presented in Figures 68 and 76 (adapted from Alaska Department of Natural Resources 1978b).

Earthquake-related hazards include vibration damage, ground fissures, ground subsidence or uplift, horizontal displacement, landslides and avalanches, and tsunamis. Hazards related to volcanic activity include lava flows, ash falls, fissures, gas clouds, mudflows, landslides, glacial outburst floods, corrosive rains, lightning discharges, earthquakes, and tsunamis. Most of these hazards are local in their effects, but ash falls and corrosive rains may affect large areas. Potentially eruptive volcanoes within Subarea VI include Mt. Augustine and Redoubt Volcano (Magoon and others 1976). Other volcanoes include Mt. Douglas (quiescent), Iliamna Volcano (active but recently quiescent), and Mt. Spurr (active but recently quiescent).

10.2.3. Hydrology

10.2.3.1. Surface water hydrology

Most of Subarea VI is characterized by mountainous terrain that is dissected by numerous rivers and streams. Although deep canyons and ravines are the most common features, broad, level floodplains and deltas occur. Both glacial and non-glacial streams are present in Subarea VI. Major glacial streams include the Drift River, Redoubt Creek, the North Fork River, the Lake Fork River, the Tuxedni River, the Johnson River, the Red River, West Glacier Creek, and numerous streams associated with Mt. Douglas. Because they are of glacial origin, these streams can be expected to have large sediment loads and potentials for glacial outbursts. There are no stream flow data or surface water quality data for Subarea VI.

10.2.3.2. Groundwater resources

Groundwater resources in Subarea VI have not been described. Existing geologic information suggests that the most important aquifers of the subarea consist of sandstone formations and sand and gravel deposits in alluvium and glacial drift.

10.3. Biological Environment

The biological resources of Subarea VI have received little attention because access is difficult, because the area is undeveloped, and because human usage is infrequent. Vegetation south of Ursus Cove is unmapped, game and fish populations have not been inventoried, and critical habitats largely are undefined.

10.3.1. Vegetation

The vegetation north of Ursus Cove is mapped in Figures 69 and 77 (adapted from Joint Federal-State Land Use Planning Commission 1973b). The higher elevations are barren glacier and rock, or are alpine tundra. Below the alpine tundra, the slopes and lower hilltops generally are

MINERAL RESOURCES

MAJOR MINERAL

SECONDARY MINERAL

MINERAL PROVINCE BOUNDARY

COAL PROVINCE BOUNDARY

COAL PROVINCE BOUNDARY IN WATER

PETROLEUM PROVINCE BOUNDARY

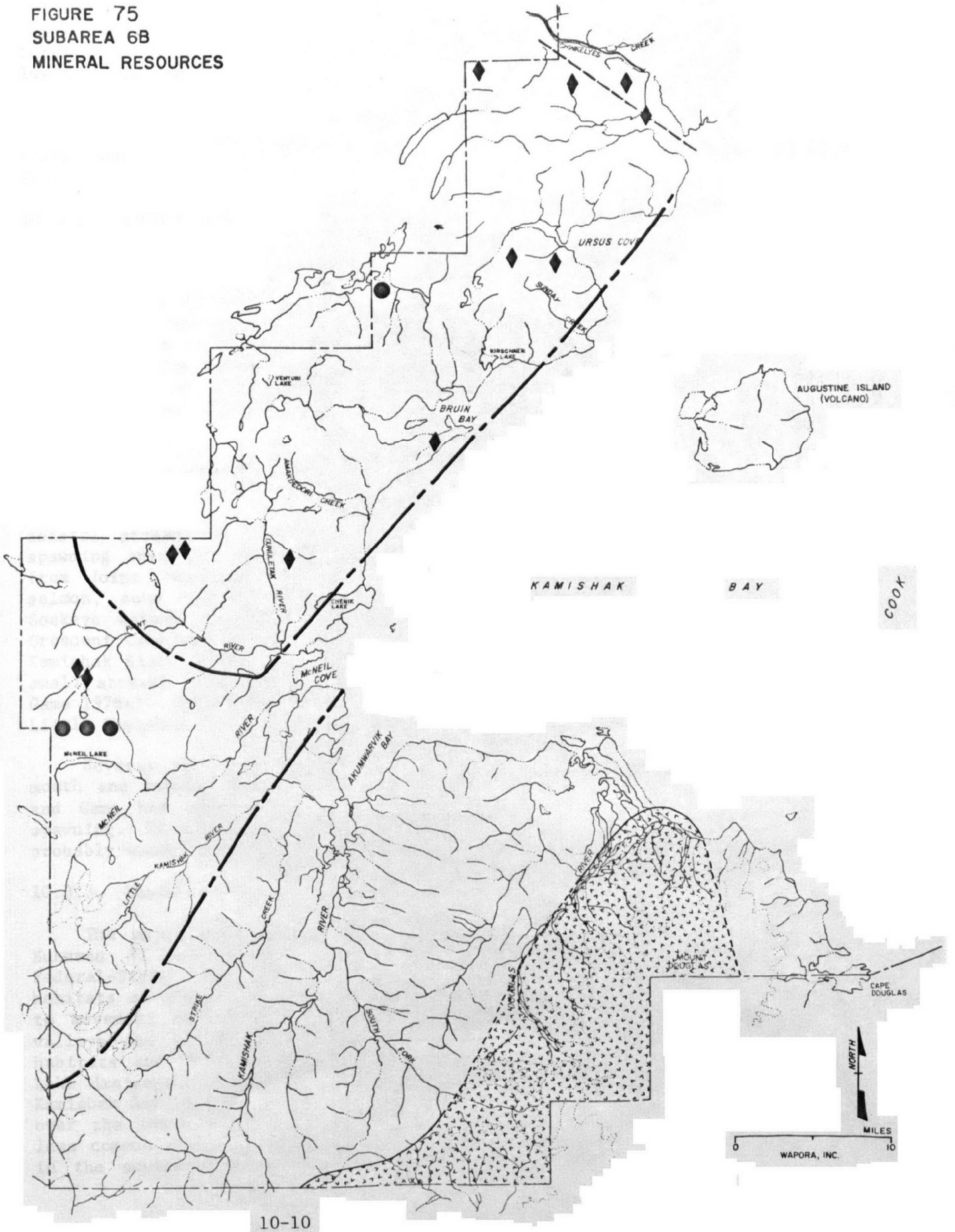
COAL FIELD

OIL FIELD

GAS FIELD

POTENTIAL GEOTHERMAL AREA

FIGURE 75
SUBAREA 6B
MINERAL RESOURCES



brush-covered. Well-drained lower slopes support upland spruce/hardwood forests, or stands of Sitka spruce or western hemlock. Poorly-drained lowlands are muskeg. South of Bruin Bay the land is swept by strong winds, and the prevailing weather conditions are more severe than farther north. In this region the timberline is at lower elevations than farther north, and even the lowest slopes may not support forests. Sedges, saltgrasses, and, where silt loads are light, eelgrass grow on the tidal flats.

10.3.2. Aquatic biota

Except for salmon, the aquatic biota of Subarea VI have not been inventoried. Invertebrate and fish populations probably are similar in many respects to those found in the Kenai River system, but may be modified by the more severe weather conditions and possibly poorer nutrient loads in Subarea VI. Rainbow trout, burbot, and northern pike are absent from the Cook Inlet drainage in most of Subarea VI, but are present west of the Chigmit Mountain divide in the Iliamna Lake-Lake Clark drainage. Dolly Varden are present in suitable habitat throughout Subarea VI.

Salmon streams in Subarea VI are comparatively short, and there are fewer large rivers and large lakes than on the Kenai Peninsula. Consequently, the salmon species that typically use smaller streams and coastal streams are the most common species in Subarea VI. Salmon spawning areas in Subarea VI are mapped in Figures 71 and 78 (adapted from Joint Federal-State Land Use Planning Commission 1973b). Pink salmon, coho salmon, and chum salmon are the most common species. Sockeye salmon spawn in the Packer Creek system on Kalgin Island, in Crescent Lake and its tributaries, in several smaller lakes, and in the Kamishak River system, the Little Kamishak River system, and in several small streams tributary to Kamishak Bay (Alaska Department of Fish and Game 1978a). King salmon spawning has been reported in Subarea VI in the Little Kamishak River and in the McNeil River.

Several potential salmon streams are blocked by waterfalls at the mouth and cannot be ascended by salmon. The Alaska Department of Fish and Game has studied the possibility of removing these obstacles to spawning. If such action is taken, the Paint River in lower Kamishak Bay probably would be one of the first rivers to be opened.

10.3.3. Mammals

The major mammal concentrations and critical habitats reported in Subarea VI are shown in Figures 70 and 79 (adapted from Joint Federal-State Land Use Planning Commission 1973b). The ranges and habitats of the wildlife in Subarea VI are limited by elevation barriers to movement and other ecological barriers. Moose are present in the valleys and on the lower slopes in most of Subarea VI, but critical habitats are reported only in the upper end of valleys on the Iliamna Lake drainage. Caribou are reported to range into Subarea VI south of Kamishak Bay, but no concentrations have been reported. Black bear range over the lower elevations in much of northern Subarea VI, but are much less common south of the Iniskin Peninsula and rarely have been reported in the southern part of Subarea VI. Spring feeding areas that hold

GEOLOGIC HAZARD

LANDSLIDE AND SLUMP

VOLCANIC AREA

FAULT ZONE

COASTAL EROSION

TSUNAMI HAZARD

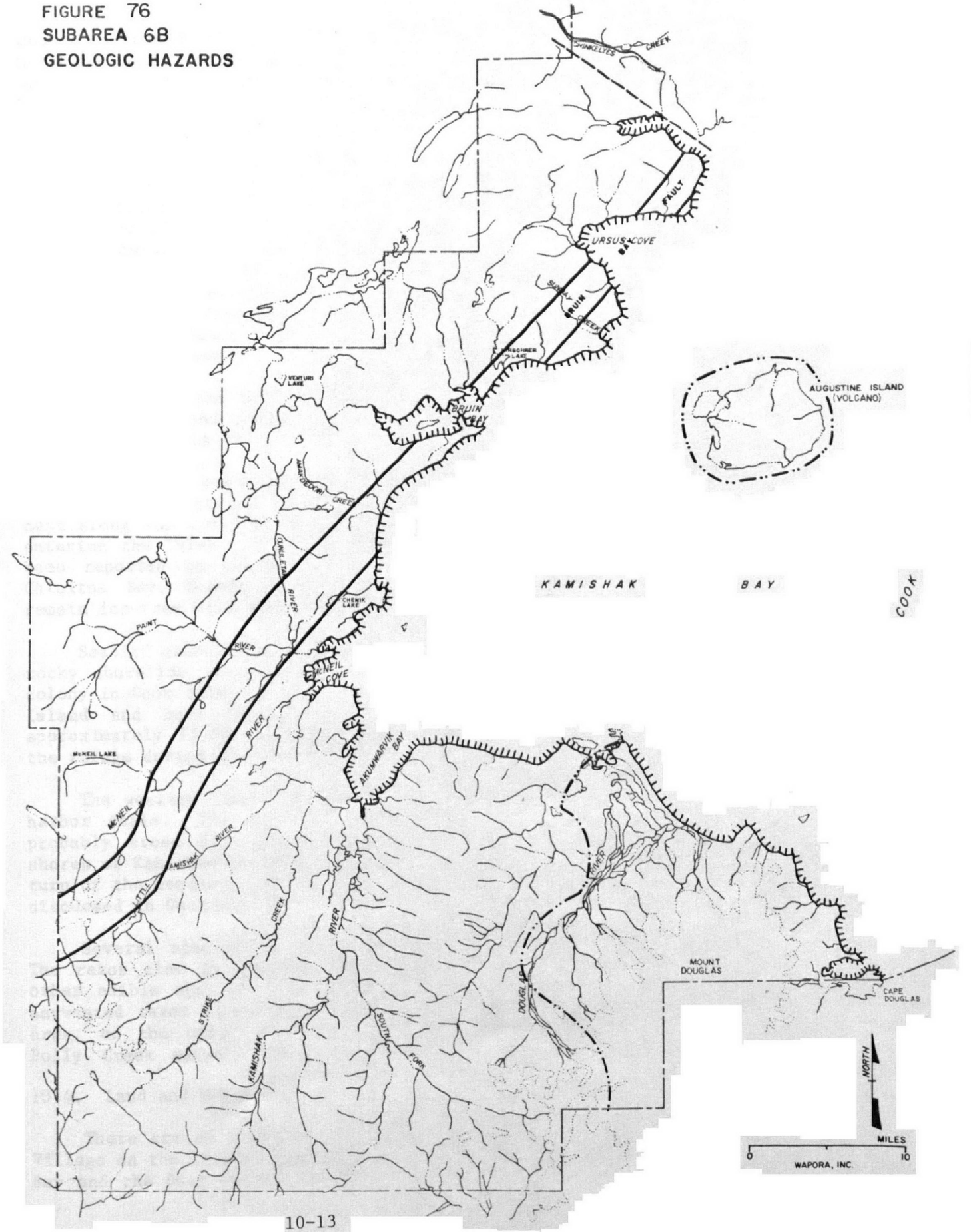
EXTENT OF ICE

AREA OF SUBSIDENCE

POTENTIAL MELTWATER AND RUNOFF FLOODING

POTENTIAL GLACIAL OUTBURST FLOODING

FIGURE 76
SUBAREA 6B
GEOLOGIC HAZARDS



concentrations of black bears have been reported for several areas in the northern half of Subarea VI. Principal areas include the coastal lowlands along northern Tuxedni Bay and the south- and east-facing hillsides overlooking the Drift River, Montana Bill Creek, and the Bachatna Flats.

Brown bear concentrations have been reported in denning areas, along salmon streams, and in spring feeding areas. Brown bear spring feeding concentrations have been reported on the Bachatna Flats and the surrounding hillsides, and on the flats at Tuxedni Bay. South of Tuxedni Bay the lowlands that occur at the heads of most bays are spring feeding areas for brown bears. Most of the salmon spawning streams south of Tuxedni Bay are feeding areas for brown bears during the salmon spawning runs. One major denning area, on the McNeil River, is in Subarea VI. Most of this denning area and one major concentration are in the McNeil River Bear Sanctuary.

Dall sheep and mountain goats are absent from Subarea VI. Most of the furbearers and predatory mammals found on the Kenai Peninsula are present in Subarea VI.

Much of the coastline and adjacent lands in Subarea VI are important waterfowl and seabird habitat. Ducks, geese, and shorebirds feed and nest along the tidal flats and the many streams, rivers, and tidal guts entering the Inlet. Staging areas for migrating ducks and/or geese have been reported on the mud flats off the Douglas River, in Bruin Bay, Chinitna Bay, Tuxedni Bay, and on Kalgin Island. The few bays that remain ice-free hold overwintering seaducks.

Seabird colonies are abundant on the small islands and on the steep, rocky shoreline that comprise much of the coast. The largest seabird colony in Cook Inlet is at the Tuxedni National Wildlife Refuge on Chisik Island and Duck Island in Tuxedni Bay. Erickson (1977) reported approximately 75,000 seabirds, primarily gulls, murres, and puffins, at the refuge during his summer survey in 1976.

The western coastline also is important habitat for sea otters and harbor seals. The present, expanding Cook Inlet sea otter population probably arose from a few sea otters around Augustine Island or the shores of Kamishak Bay that were missed by pelagic fur hunters before the turn of the century. Sea otter life history and habitat requirements are discussed in Section 3.3.

Several species of clams are found along the coast of Subarea VI. The razor clam is the only species harvested in any quantity, although other edible species are present and often are numerous. Most of the harvested razor clams from Subarea VI are collected from the Polly Creek area, on the north coast of Tuxedni Bay, by recreation clam diggers. Polly Creek supports an intermittent, small commercial clam fishery.

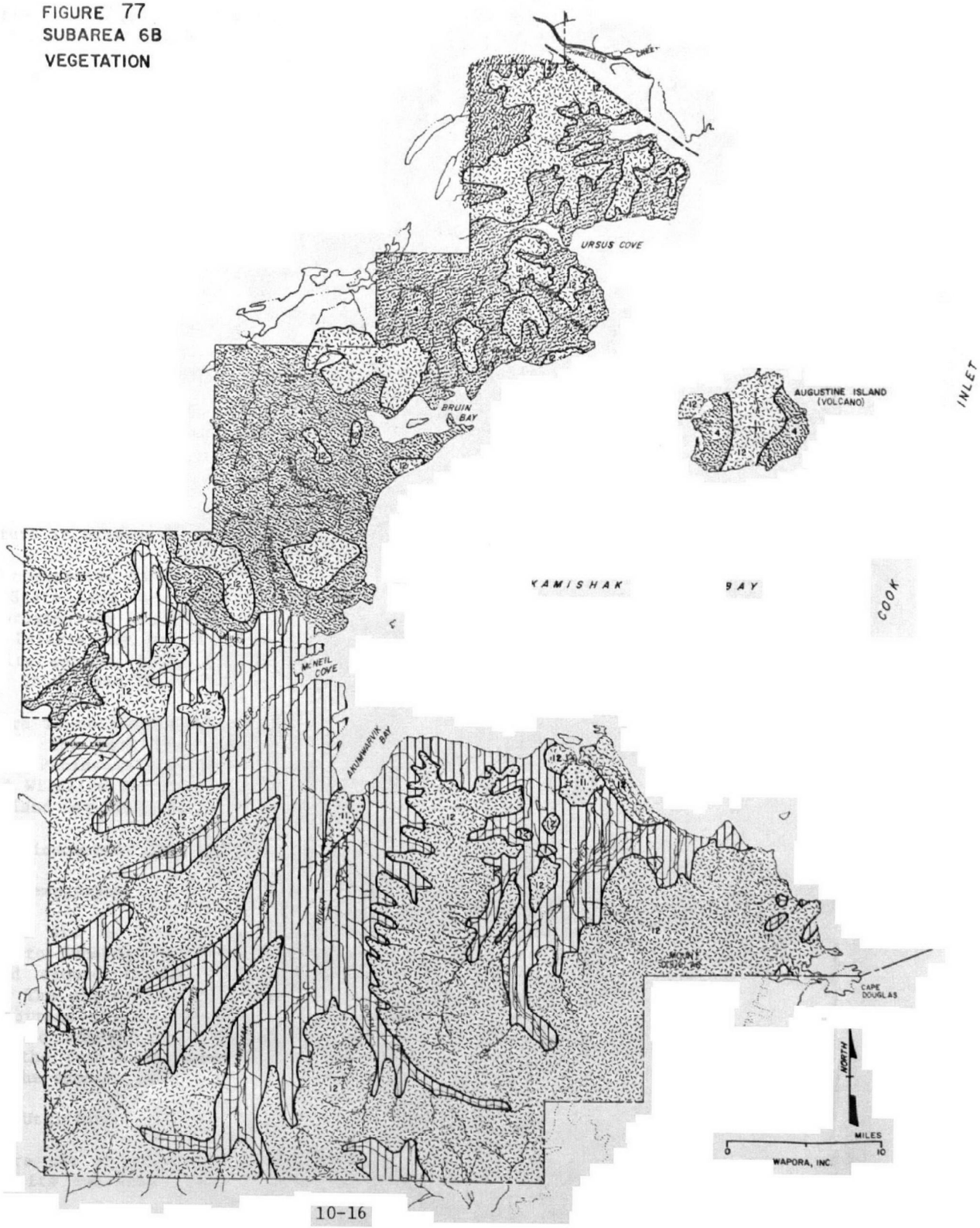
10.4. Land and Water Use

There are no permanent settlements in Subarea VI except for Iniskin Village on the Iniskin Peninsula and a group of residences around Tuxedni Bay and the Snug Harbor Cannery. Historically, there were trading posts

VEGETATION

	COASTAL WESTERN HEMLOCK/SITKA SPRUCE
1	UPLAND SPRUCE/HARDWOOD
2	UPLAND SPRUCE/HARDWOOD/LOWLAND SPRUCE/HARDWOOD
3	UPLAND SPRUCE/HARDWOOD/HIGH BRUSH
	LOWLAND SPRUCE/HARDWOOD
4	HIGH BRUSH
5	HIGH BRUSH BURNED
6	HIGH BRUSH BURNED/COASTAL WESTERN HEMLOCK/ SITKA SPRUCE
7	HIGH BRUSH/MOIST TUNDRA/ALPINE TUNDRA
8	LOW BRUSH/MUSKEG-BOG
9	MUSKEG
10	MOIST TUNDRA
11	WET TUNDRA
12	ALPINE TUNDRA/BARREN
13	ALPINE TUNDRA/BARREN/MOIST TUNDRA
M	MUD

FIGURE 77
SUBAREA 6B
VEGETATION



and Native villages in Subarea VI, but during the past century populations were not large.

Subarea VI is Federally-owned with the exception of few parcels of private land smaller than 100 acres, a few parcels of State-owned land on the Iniskin Peninsula, and the State-owned McNeil River Bear Sanctuary (Figures 72 and 80; adapted from Alaska Department of Natural Resources 1978b). One national wildlife refuge and two national monuments are in, or partially in, Subarea VI (Figure 81; adapted from Joint Federal-State Land Use Planning Commission 1973b). The Katmai National Monument covers 2,399,000 acres south of Kamishak Bay and the Tuxedni Wildlife Refuge on Chisik Island at the mouth of Tuxedni Bay was established to protect seabirds. The Lake Clark National Monument, approximately 2.4 million acres, was formed by Presidential action during 1978.

Disposition of the remaining lands will be determined by withdrawals and selections under the Alaska Native Claims Settlement Act and the Alaska Statehood Act. The McNeil River Sanctuary may be expanded. The Katmai National Monument was expanded by Presidential action. Most of the remaining lands between the McNeil River Sanctuary and the Lake Clark National Monument have been selected by Native corporations and probably will be conveyed to them or will be incorporated in the proposed Iliamna National Wildlife Refuge.

There are no data on agriculture in Subarea VI. Most of the agriculture in Subarea VI probably is gardening for domestic use.

No commercial forestry has been reported in Subarea VI. The Joint Federal-State Land Use Planning Commission (1973a) estimated that there were approximately 45,000 acres of commercial grade timber in Subarea VI between Iniskin Bay and the Drift River. Commercial species primarily were white spruce, Sitka spruce, and poplar. There are no commercial sawmills in Subarea VI.

There is no comprehensive land use plan for Subarea VI. The State of Alaska, the Cook Inlet Native Corporation and village corporations, the Kenai Peninsula Borough, the US Bureau of Land Management, the US Fish and Wildlife Service, and the US National Park Service, each have a role in land use planning in Subarea VI.

10.5. Socioeconomic Environment

10.5.1. Demography

There are no population data, housing data, or employment data specific to Subarea VI. Most of the population of Subarea VI is concentrated around Tuxedni Bay and the Snug Harbor Cannery on Chisik Island. The cannery is the only industry in Subarea VI and may be the most important single employer. Most of the remainder of the population probably is engaged in commercial fishing and subsistence activities. Part of the population is seasonal, present only during the summer or part of the summer.

10.5.2. Utilities

There are no public utilities in Subarea VI. Snug Harbor Cannery operates its own water supply, sanitary waste system, radio communica-

SALMON HABITAT

SALMON PRESENT

SALMON SPAWNING

WILDLIFE HABITAT

SEA LION HAULING OUT AREA

HARBOR SEAL

BLACK BEAR

BROWN BEAR

MOOSE

GOAT

CARIBOU

FIGURE 78
SUBAREA 6B
SALMON HABITAT

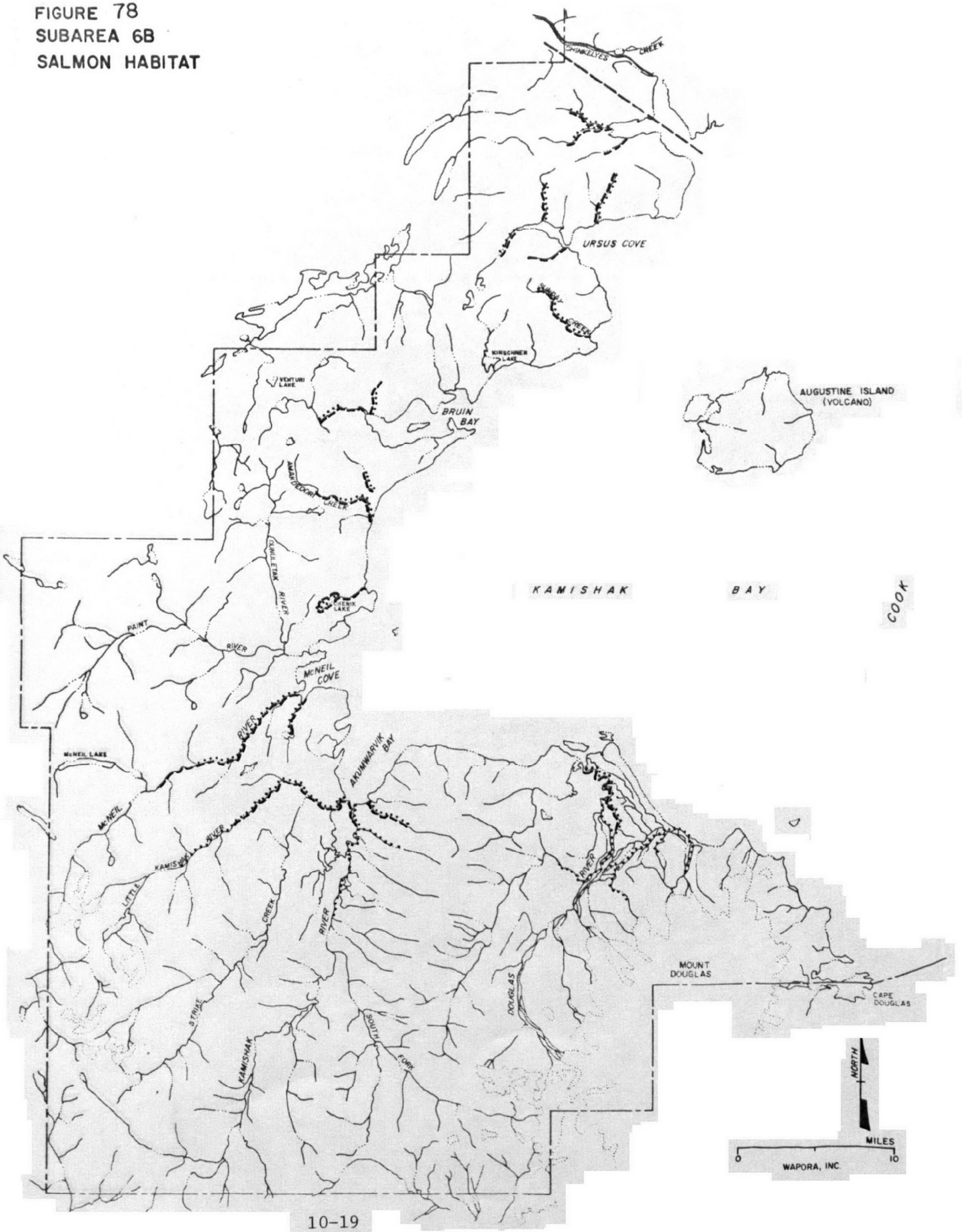
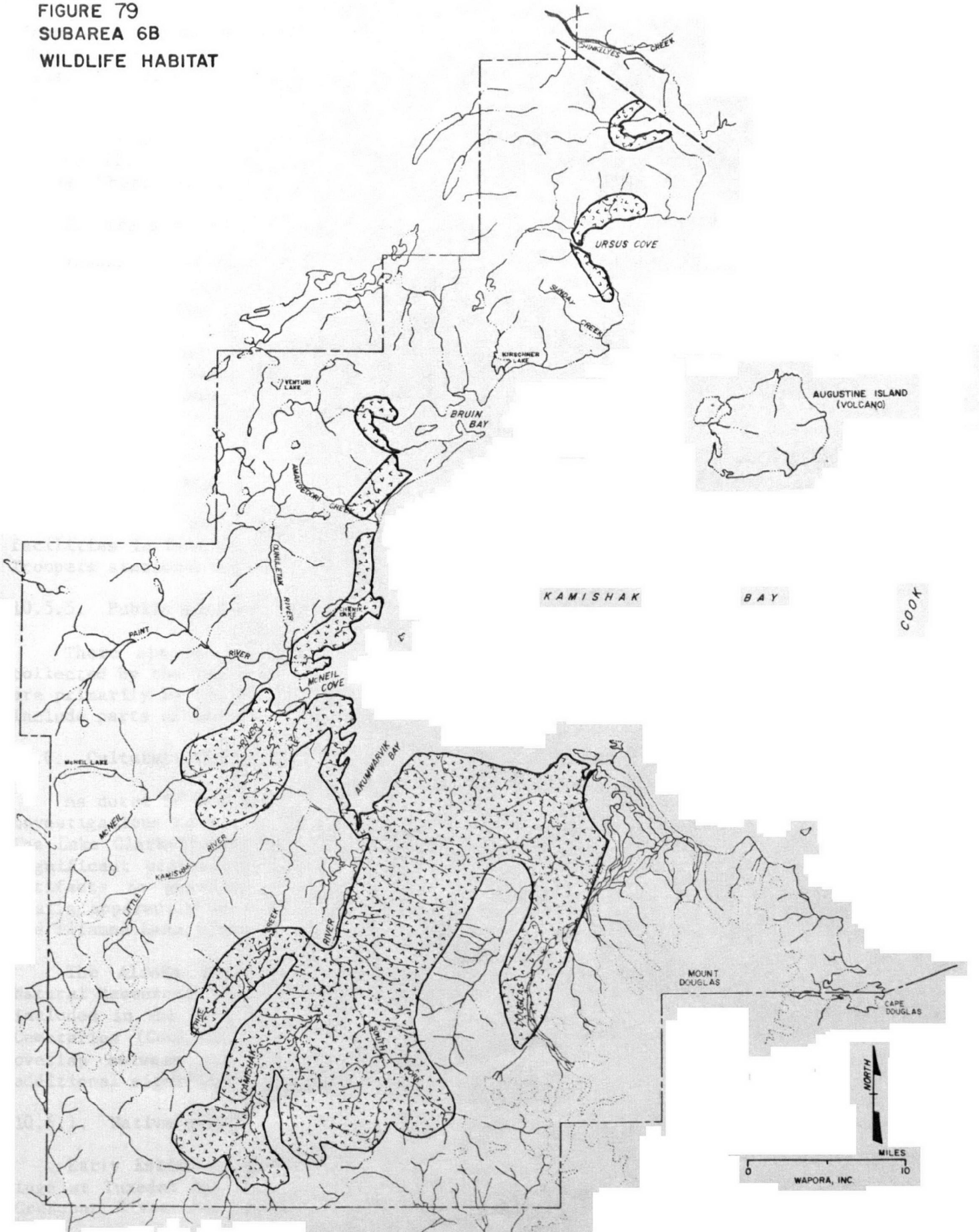


FIGURE 79
SUBAREA 6B
WILDLIFE HABITAT



tions, and electrical system. There are no data on private utilities. Other residents probably obtain water from surface water sources or from wells, and dispose of sewage in septic systems, privies, or by other methods.

The Snug Harbor Cannery is the only point discharge source in Subarea VI. The cannery discharges ground fish parts and processing wastes. There are no licensed solid waste disposal sites in Subarea VI.

10.5.3. Transportation

Access to Subarea VI is by boat over Cook Inlet, by aircraft, or overland during the winter when lakes, rivers, and muskeg are frozen. There are no roads into Subarea VI, and there are only two unpaved roads in the Subarea. One lies between Chinitna Bay and the village of Iniskin; the other follows a narrow-gauge marine railroad that was used to haul fishing boats overland between Iliamna Bay on Cook Inlet to Pile Bay on Iliamna Lake. There are four unpaved "bush" airstrips in Subarea VI. There is no scheduled air service or marine ferry service to Subarea VI.

10.5.4. Social services

There are no libraries, public fire protection, or educational facilities in Subarea VI. Police protection is provided by Alaska State Troopers stationed outside Subarea VI.

10.5.5. Public finances

There are no financial data specific to Subarea VI. Taxes are collected by the Kenai Peninsula Borough, and expenditures for Subarea VI are primarily by the Borough or the State of Alaska. Tax code areas that include parts of Subarea VI are presented in Section 3.5.

10.6. Cultural, Historical, and Archaeological Resources

As noted in the discussion of Subarea V, only minimal archaeological investigations have been conducted on the western shores of Cook Inlet. The Lake Clark-Iliamna Lake area, west of Subarea VI, incorporates many significant prehistoric and historic sites, but the connection of those artifacts to possible sites in the study area is not defined. Native trails apparently were used for travel between Cook Inlet and Lake Clark and Iliamna Lake (Cook Inlet Native Association 1975).

The Alaska Heritage Resource Master File (Alaska Department of Natural Resources 1979) lists eight sites in Subarea VI. Seven sites are included in the Cook Inlet Region Inventory of Native Historic Sites and Cemeteries (Cook Inlet Native Association 1975). There is substantial overlap between the two sources. Future investigations may discover additional significant locations.

10.6.1. Native period

Early Eskimo culture in Subarea VI is suggested by the cave paintings at Tuxedni Bay and the midden on a rocky point at the mouth of the Crescent River (De Laguna 1934). More modern sites appear to be of

LAND OWNERSHIP

FEDERAL LAND

STATE LAND

TENTATIVELY APPROVED PATENTED

TIDELAND PATENTS

MANAGEMENT RIGHTS SELECTION APPROVED PATENTED

TIDELAND PATENTS

INTERIM CONVEYANCE PATENTED

TIDELAND PATENTS

FIGURE 80
SUBAREA 6 B
LAND OWNERSHIP

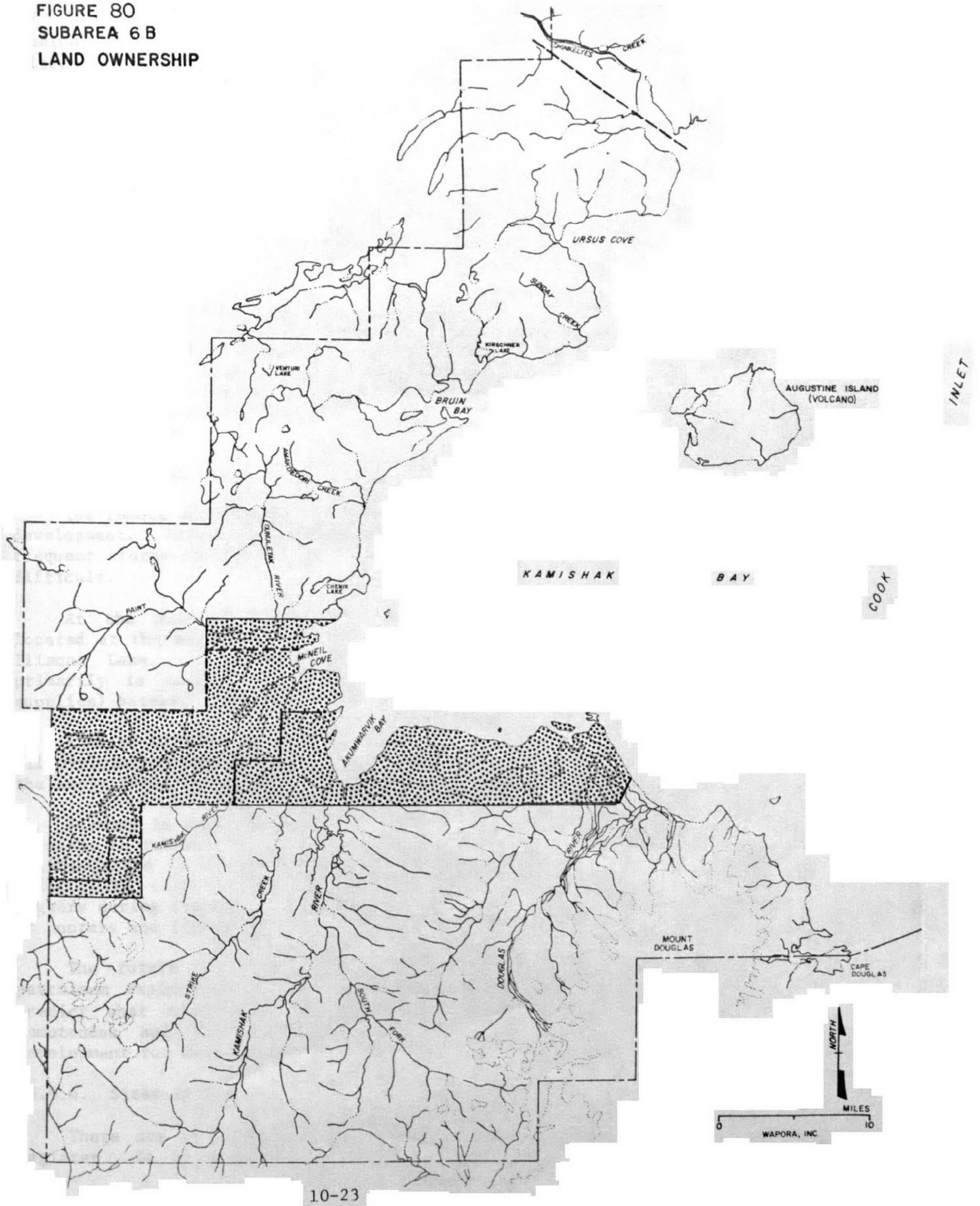
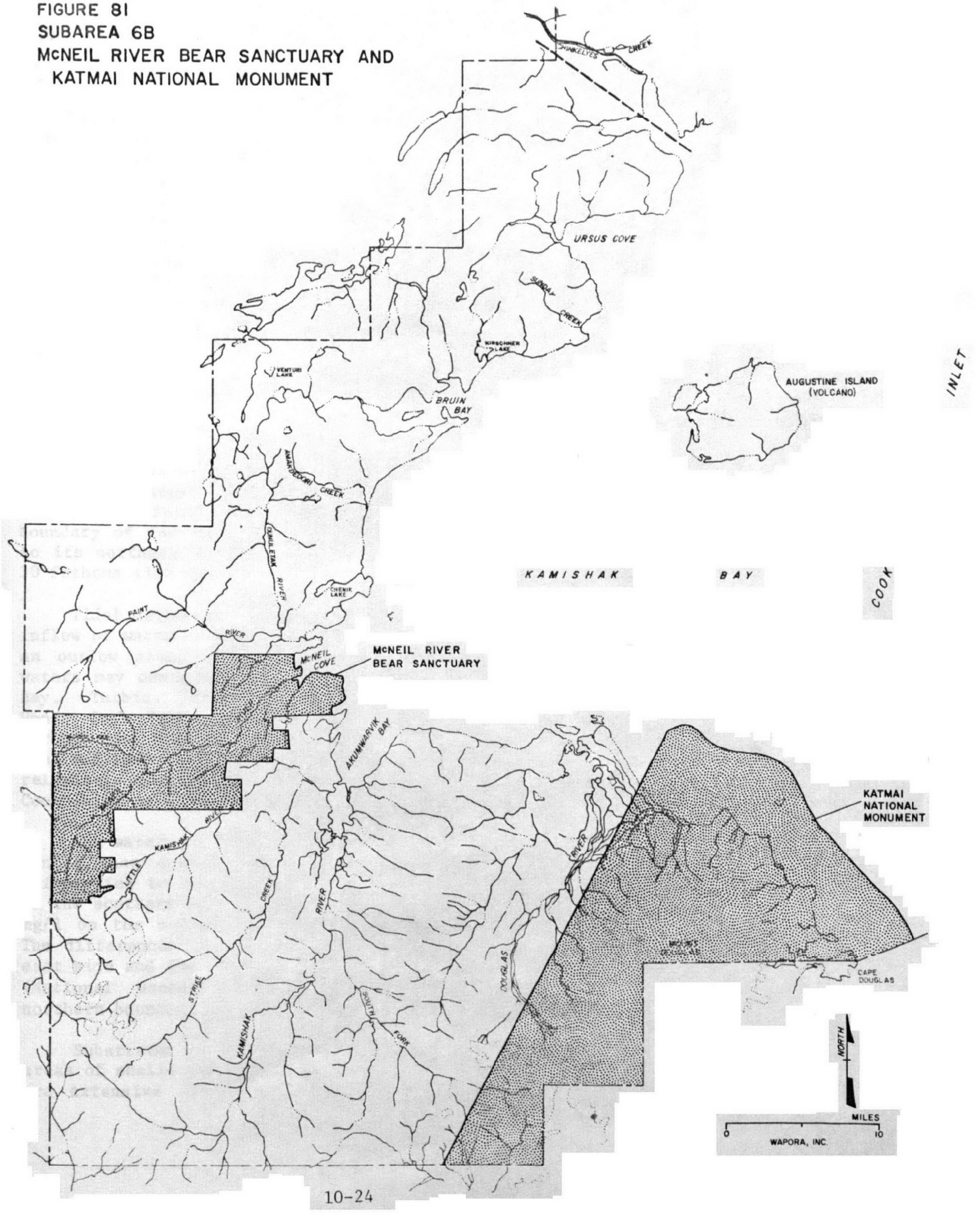


FIGURE 81
SUBAREA 6B
McNEIL RIVER BEAR SANCTUARY AND
KATMAI NATIONAL MONUMENT



Tanaina origin. This would be consistent with the inferred pattern of cultural succession in other sections of the study area. The life-styles of the Eskimo and Tanaina of Subarea VI probably were similar to those of the peoples of Subarea IV. This conclusion is based on the similarity of the artifacts and paintings thought to be Eskimo by De Laguna to those of the Katchemak Bay tradition. As for the Tanaina, De Laguna recounts informant reports that the Polly Creek clan supposedly drifted across Cook Inlet on the ice. To the extent that this represents an origin on the Kenai Peninsula, it is reasonable to suppose that the Tanaina cultures on both sides of Cook Inlet shared similar cultures.

10.6.2. Russian period

Little specific information was available. The presence of "an old Russian and later American trading post" on Iliamna Bay is noted in the Cook Inlet Region Inventory (Cook Inlet Native Association 1975). The Russian post on Iliamna Lake may have been reached by portage from Iliamna Bay. In any case, it is likely that Russian explorers, fur traders, and missionaries passed through Subarea VI on at least an occasional basis.

10.6.3. American period

The remote and inhospitable nature of much of Subarea VI has limited development. Access is only feasible by boat or aircraft, and the frequent storms and other severities of the weather make many endeavors difficult.

At the head of Iliamna Bay, the small town of Williamsport is located at the eastern terminus of a road that connects with Pile Bay on Iliamna Lake. This is the only maintained road in the area. It primarily is used to transport fishing boats (and to some degree, supplies) between Cook Inlet and Bristol Bay.

Limited mineral prospecting has not resulted in commercial mining. Oil exploration focused on the Dry Bay-Oil Bay area, but the efforts of the early 1900s did not result in producing fields.

Fishing in Cook Inlet, and to some extent in the less-exposed bays adjacent to Subarea VI, continues as a modest industry. The cannery on Chisik Island is the only operating facility on the west side of Cook Inlet. The clam beds of Polly Creek Beach attract many weekend clam diggers during the clamming season. The area also attracts small numbers of hunters and fishermen.

The future development of this area may be influenced by new petroleum exploration in the Lower Cook Inlet. It is impossible to predict what significant discoveries would mean to Subarea VI. The remoteness and limited accessibility of this subarea may constrain development for many years.

10.6.4. Sites in the National Register of Historic Places

There are no sites in Subarea VI that are listed in the National Register. It is possible that sites may be discovered in the future

11.0 SUBAREA VII, LOWER COOK INLET CENTRAL SUBAREA

11.1. Subarea VII Boundaries

The boundaries of Subarea VII are delineated in Figure 82 (adapted from Joint Federal-State Land Use Planning Commission 1973b). The Lower Cook Inlet Central Subarea includes the open water of Cook Inlet between Kachemak Bay and the southern Kenai Peninsula on the east and Kamishak Bay and the Iniskin Peninsula on the west. The southern boundary of Subarea VII is the southern boundary of the study area (a line between Cape Douglas and Cape Elizabeth), and the northern boundary is a line between Chinitna Point on the Iniskin Peninsula and Anchor Point on the Kenai Peninsula. Subarea VII includes only two relatively short segments of coastline: a segment approximately 20-miles long between Chinitna Point and Oil Bay, and a segment of approximately 50 miles from Point Pogishi to Cape Elizabeth.

11.2. Bathymetry and Oceanography

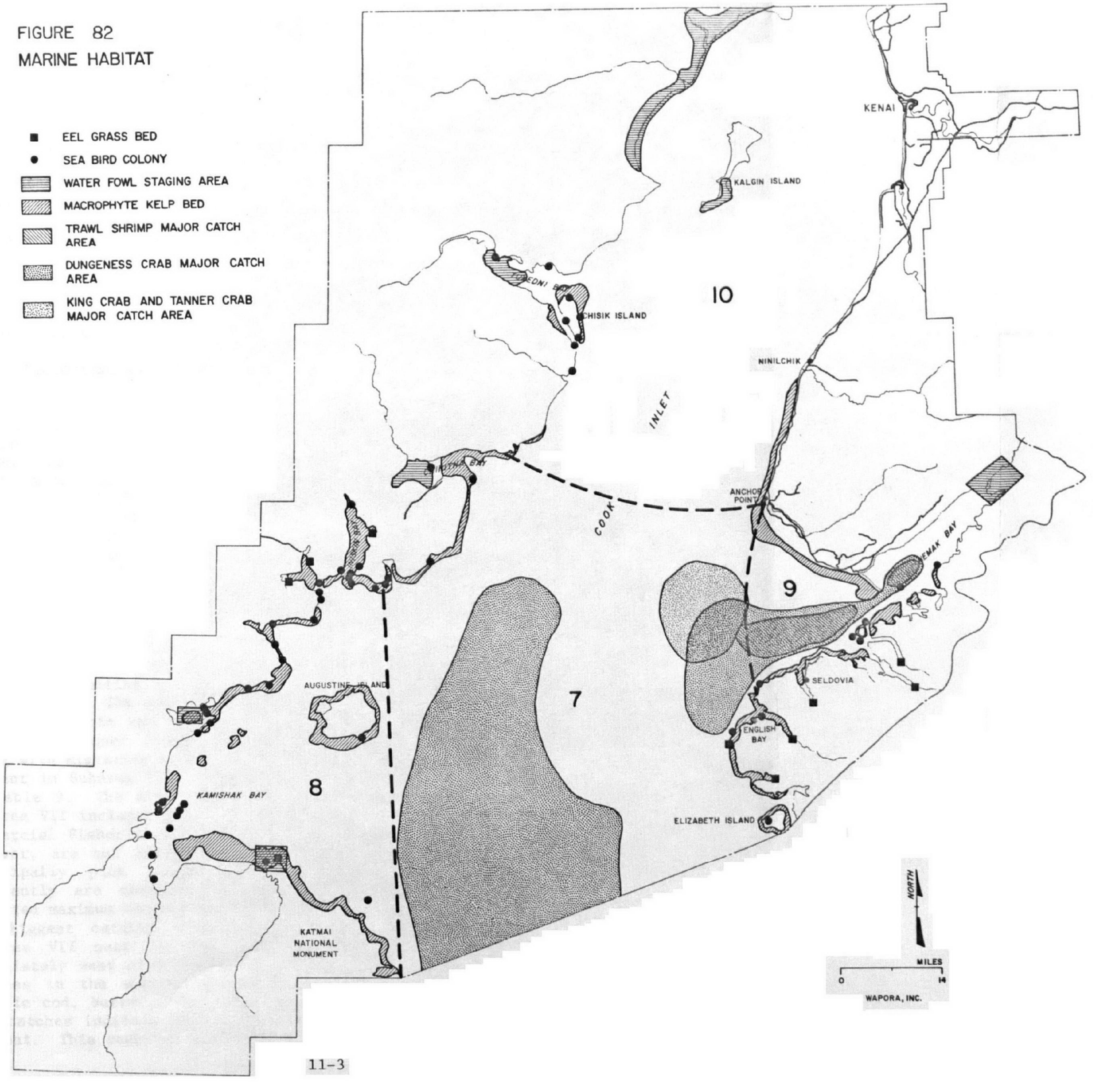
With the exception of shallow areas off the mouth of Kachemak Bay (14 fathoms or 84 feet) and the southern shore of the Iniskin Peninsula (12 fathoms or 72 feet), Subarea VII is more than 20-fathoms (120-feet) deep. The largest depths, ranging from approximately 50 to 100 fathoms (300 to 600 feet), occur at the mouth of Cook Inlet along the southern boundary of the subarea. Farther north, from the center of the Subarea to its northern boundary, the maximum depth encountered is approximately 30 fathoms (180 feet).

Tidal action is the predominant circulatory mechanism. There is net inflow of water from the Gulf of Alaska on the east side of the inlet and an outlow along the western side of the inlet. Upwelling of inflow waters may contribute substantially to the high productivity of Kachemak Bay. Turbid, low-salinity water, originating from glacial runoff in Upper Cook Inlet, enters Subarea VII from the north, flows southward through the Subarea and Kamishak Bay, and eventually flows out through the Shelikof Straits (Figure 7; Burbank 1977). Circulation may be relatively sluggish in the middle of the Inlet. Circulation patterns for Cook Inlet as a whole are discussed in Section 3.1.3.1.

The waters of Subarea VII are slightly more saline during the cooler months than during the summer when the increased runoff volumes from tributaries to the Inlet decrease the salinity slightly. Sediment loads in the southern part of the Subarea are low, ranging from approximately 2 mg/l on the eastern side to approximately 20 mg/l on the western side. The differences reflect the inflow of clear, Gulf of Alaska water on the east side and the outflow of water carrying glacial silt on the west side (National Oceanic and Atmospheric Administration 1977). Near the northern boundary of Subarea VII silt loads may be larger.

Substrates in Subarea VII predominantly are poorly-sorted sands with areas of shells and shell fragments, gravel, cobbles, and boulders. There are extensive fields of sand waves that are presumed to be dynamic.

FIGURE 82
MARINE HABITAT



11.3. Geologic Resources

There are no proven reserves of oil or gas in this marine subarea. However, the 1977 Lower Cook Inlet Lease Sale clearly demonstrated that the major oil companies are interested in the production potential of parts of Subarea VII. As indicated in Section 3.1.1.3., the highest three royalty and bonus bids received from the lease sale were for tracts near Anchor Point, a tract midway between Anchor Point and Augustine Island, and tracts near the mouth of the Lower Cook Inlet. These high bids can be considered a reliable indicator of the areas where the companies expect to find substantial amounts of oil and gas.

Lease Sale No. 60 for Lower Cook Inlet-Shelikof Straits, scheduled for 1981, will offer additional areas in Subarea VII. The results of this offering will provide further evidence of the potential hydrocarbon resources of the Lower Cook Inlet.

11.4. Biological Environment

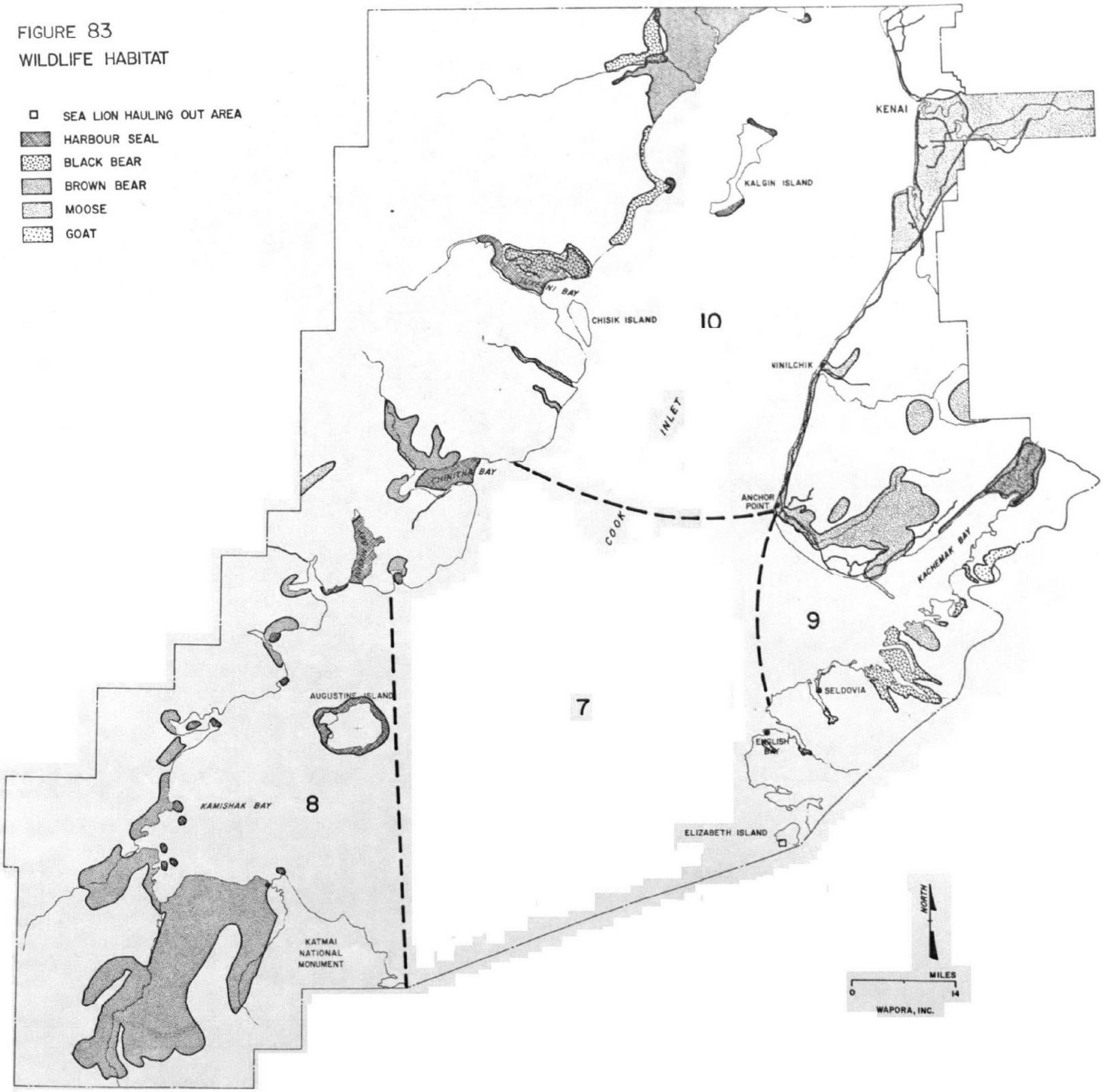
Primary production in Subarea VII is from both phytoplankton and attached macrophytes. Phytoplankton probably account for a larger proportion of the total primary production in Subarea VII than in either Kachemak Bay or Kamishak Bay because of the larger proportion of deep water, which is too deep to support attached macrophytes. Larrance (1976) reported that the peak phytoplankton productivity coincided with the onset of thermal stratification during late May and that phytoplankton production was not nitrogen limited. There are kelp beds along the short segments of shoreline in Subarea VII and eelgrass beds at Port Graham, at Bede Point, and in Koyuktolik Bay (Figure 82). The Koyuktolik Bay Lagoon eelgrass bed is one of the largest in the State of Alaska (National Oceanic and Atmospheric Administration 1977).

The fauna of Subarea VII are pelagic, demersal, and benthic forms characteristic of both the shallower subtidal region and the continental shelf. Communities in the deeper regions probably are net importers of fixed energy. The principal benthic primary consumers are clams (Feder; National Oceanic and Atmospheric Administration 1977). Several species of shrimp, Tanner crabs, king crabs, halibut, and herring are present. Along with migrating salmon they represent the commercial seafood species present in Subarea VII. The 1978 commercial catch results are presented in Table 9. The major shellfish fishing areas are shown in Figure 82. Subarea VII includes parts of the Southern, Kamishak, and Barren Islands Commercial Fisheries Regulatory Districts; data specific to the Subarea, however, are not available. The salmon harvest in those districts was principally pink salmon, coho salmon, and chum salmon. Halibut apparently are abundant in parts of Subarea VII. Blackburn (1977) reported maximum catches of approximately 40 halibut per 20-minute trawl. The biggest catches that he reported were from the eastern side of Subarea VII near the mouth of Kachemak Bay and from Kamishak Bay immediately west of the Subarea. Blackburn (1977) also reported maximum catches in the subarea exceeding 100 pounds per 20-minute trawl for Pacific cod, butter sole, Tanner crab, walleye pollack, and Irish lords. His catches indicate that a potential commercial groundfish resource is present. This resource is likely to be exploited during the next decade.

Most of the pelagic sea mammals listed in Section 3.2.1.5. are present at least occasionally in Subarea VII. Concentrations of most species have not been defined. There is one Steller sea lion hauling-out area in the Subarea on Elizabeth Island (Figure 83; adapted from Joint Federal-State Land Use Planning Commission 1973b). Another large hauling-out area is located in the Barren Islands, south of Cook Inlet. Sea lions from both areas may feed in Subarea VII. No large concentrations of harbor seals have been reported, but harbor seals are abundant on some of the nearby beaches (Figure 83) and probably feed in and migrate through the Subarea. Sea otter concentrations have been reported in the adjacent waters of Kamishak Bay and Kachemak Bay. The sea otter range extends along the Cook Inlet coastline in Subarea VII to south Kachemak Bay, and sea otters from other areas feed in the Subarea.

Pelagic seabirds, including murres, gulls, shearwaters, fulmars, puffins, cormorants, seaducks, and others are present in Subarea VII. Erickson (1977) reported that pelagic seabirds were sparse in Lower Central Cook Inlet during the winter, but that during the summer some of the densest concentrations of pelagic seabirds in Cook Inlet were in Kachemak Bay and off the coast of the lower Kenai Peninsula in the western part of Subarea VII. Seabird colonies in Subarea VII are at the mouth of Oil Bay, on Flat Island, and on Elizabeth Island. The US Fish and Wildlife Service (1978b) reported almost 4,000 seabirds, mostly tufted puffins, in the Flat Island Colony.

FIGURE 83
WILDLIFE HABITAT



12.0. SUBAREA VIII, KAMISHAK BAY

12.1. Subarea VIII Boundaries

Subarea VIII includes all of Kamishak Bay west of a line between Oil Bay on the Iniskin Peninsula to the north and Cape Douglas to the south (Figure 82).

12.2. Bathymetry and Oceanography

Kamishak Bay is a broad, shallow, open embayment. Almost half the Bay is less than 10-fathoms (60-feet) deep, and there are only a few small areas more than 30-fathoms (180-feet) deep. In general, the deepest waters of Kamishak Bay are in the southeastern sector.

East of Augustine Island most of the Bay is less than 10-fathoms (60-feet) deep, and there are extensive shelves and shallows only a few feet deep during low tide (National Ocean Survey 1977). The floor of the Bay is uneven and rocky; outcrops and reefs are numerous.

Kamishak Bay is a relatively low energy environment. Tidal currents that average less than 0.5 mile per hour are the main circulatory force. The net circulatory movement through Kamishak Bay carries silt-laden water from the western side of Cook Inlet into the upper bay and out through the lower bay to the Stevenson Entrance and the Shelikof Strait. Because of this influx of silt, the average concentrations of suspended solids in Kamishak Bay are several times higher than for the eastern side of Cook Inlet.

In contrast with Kachemak Bay, the Kamishak Bay environment is affected severely by prevailing winds from the Gulf of Alaska and by ice. During severe winters, sea ice may accumulate along most of the shoreline of Kamishak Bay. The sea ice scours the intertidal zones, and during severe winters the abrasion is a major determinant of intertidal productivity in Kamishak Bay (Dames and Moore, Inc. 1977).

12.3. Geologic Resources

Proven oil or gas resources do not exist in Subarea VIII. Hard rock mining in Subarea VIII is unlikely because of the uncertainty of the resource and the unfavorable economics of submarine mining.

12.4. Biological Environment

Although turbidity reduces light penetration, productivity in Kamishak Bay is high; 3 to 4 grams of carbon per square meter per day (Larrance and others 1977), possibly because of stratification (National Oceanic and Atmospheric Administration 1977). Productivity in the intertidal zones has not been determined. Compared with the coast of the southern Kenai Peninsula, the Kamishak Bay intertidal zone supports a sparse, less diverse macrophyte and invertebrate community. The larger perennial forms of macrophytes that are a substantial part of the intertidal and shallow communities in western Cook Inlet are less abundant and smaller in Kamishak Bay. High turbidity levels and glacial silt deposition restrict eelgrass beds and may be an additional factor

limiting the Kamishak Bay intertidal macrophyte productivity (McRoy 1970). Eelgrass beds and beds of attached algal macrophytes in Kamishak Bay are located in Figure 82.

Dames and Moore (1977) reported that the more common invertebrates on the rocky intertidal areas of Kamishak Bay were crabs, sea stars, sea urchins, barnacles, sea anemones, and an unknown species of sponge. In the siltier intertidal and shallow subtidal regions, spoonworms, several species of polychaetes, and soft-shelled clams were common. Juvenile king crabs were reported to be locally abundant under rocks in the lower intertidal zone at Iniskin Bay (Dames and Moore, Inc. 1977). Adult king crab and Tanner crab are abundant in the deeper waters of Kamishak Bay and in the adjacent waters. A substantial percentage of the commercial king crab and Tanner crab catch comes from the Kamishak Bay-Barren Island District (Table 9).

Herring, halibut, and salmon are the most important commercial fishes harvested from Kamishak Bay. The Cook Inlet herring catch, 463 tons during 1978, has been almost entirely from Kamishak Bay in recent years (Table 9). Kamishak Bay also is a major herring spawning area and may be an important spawning area for halibut (National Oceanic and Atmospheric Administration 1977). English (1976) reported that of the sites sampled, the Kamishak Bay sampling site was second only to inner Kachemak Bay in numbers of larval fish per unit of collecting effort.

Most of the streams tributary to Kamishak Bay are short; many are blocked by falls or ledges near the mouth; and there are few lakes on the tributaries. Consequently, pink salmon and chum salmon, species that are well-adapted to spawning in short streams and in the intertidal zones, are the major components of the salmon fishery in Kamishak Bay. The Kamishak Bay salmon fishery yielded only approximately 55,000 salmon, mostly chums, during 1978 (Table 9). The fishery probably is under-utilized because of adverse fishing conditions and special gear requirements mandated by the shallow, rocky bottom.

Most of the marine mammals that occur in Subarea VII also may be present occasionally in Kamishak Bay. The most abundant marine mammals are harbor seals (Figure 83) and sea otters. The present sea otter population in Cook Inlet probably expanded from a remnant population in the Augustine Island region that escaped pelagic fur hunters. The Augustine Island region has one of the two largest concentrations of sea otters in the Lower Cook Inlet, and that population may be approaching the carrying capacity of the habitat (Schneider 1977).

Seabird colonies in and adjoining Kamishak Bay are mapped in Figure 82. The rocky shores and uninhabited coastline provide excellent nesting habitat for several species, and several of the larger seabird colonies in the study area are in Subarea VIII. The largest colonies are clustered at the mouth of McNeil Cove, at the mouths of Iniskin Bay and Iliamna Bay, on Contact Point, and a single colony on Shaw Island. The US Fish and Wildlife Service reported a total of 15,281 seabirds from Subarea VIII. The most numerous species were glaucous-winged gull (4,930), tufted puffin (4,819), common murre (2,500), pelagic cormorant (765), horned puffin (762), and double-crested cormorant (707). Some of

the bays remain ice-free during the milder winters and may hold overwintering seabirds and ducks. Sea ice and severe weather usually restrict overwintering seabird populations in Kamishak Bay, and overwintering seabirds are much more common on the eastern side of Cook Inlet. Waterfowl staging areas are present on the Douglas River tidal flats and in upper Bruin Bay (Figure 82).

13.0. SUBAREA IX, KACHEMAK BAY

13.1. Subarea IX Boundaries

Subarea IX includes all of Kachemak Bay east of a line between Anchor Point and Point Pogisbshi. The Subarea IX boundaries are shown in Figure 82.

13.2. Bathymetry and Oceanography

Kachemak Bay lies between two geologic formations that are very different in origin and physiography. The northern shoreline and the floor of the northern part of Kachemak Bay are the southernmost extension of the Kenai Lowland. The Lowland drops abruptly to a narrow beach that extends the length of Kachemak Bay, then slopes gently toward the centerline of the Bay. The southern shoreline of the Bay is formed by the southern extension of the Kenai Mountains. The Kenai Mountains are much older than the Kenai Lowlands to the north. They were extensively folded by the upthrusting forces that formed them and have been dissected by glacial and fluvial actions. The southern shoreline of the Bay is a series of steep, rocky fiords divided by ridges that reach 3,000 feet or more above sea level. The bottom of the southern part of Kachemak Bay drops steeply to a depth of several hundred feet.

Tutka Bay, the deepest of the Kachemak Bay fiords, is less than 1.0-mile wide, but is reported to be more than 400-feet deep. There is deep water close to shore along almost all of the southern coastline (National Ocean Survey 1977).

The substrates of outer Kachemak Bay were defined by Driskell and Dames and Moore (1977). They reported that along most of the shoreline of the outer bay (west of the Homer Spit) the intertidal substrate and the subtidal substrate to a depth of approximately 60 feet were boulders and large cobbles. In deeper waters, to approximately 250 feet, the substrate was usually a mixture of cobbles, shell debris, sand, and silt where the bottom was swept by currents, and muddy sand where the currents were slower. The substrate in the outermost sections of Kachemak Bay was sand formed into "waves" with a maximum height of 6.0 feet. In the deepest part of Kachemak Bay, in the trough past the Homer Spit that connects the outer and inner bays, the substrate was silty. The substrate of inner Kachemak Bay, east of Homer Spit, has not been studied as intensively. Substrates in the inner bay may be similar to those of outer Kachemak Bay, but because the inner bay receives glacial silt and because the currents usually are slower, substrates probably contain larger amounts of silt. Siltation is evident along the northern shoreline of the bay and in the tidal flats on the east side of Homer Spit.

The major geologic hazards in Kachemak Bay are associated with tectonic activity. The 1964 Alaska earthquake caused subsidence and uplifting that affected the intertidal regions adjacent to Homer Spit and in bays along the southern shore of Kachemak Bay. Tsunamis produced by the 1964 earthquake and by other earthquakes and volcanic activity have caused extensive damage to Kachemak Bay settlements. These hazards are

threats to developments along the shoreline of Kachemak Bay, to offshore drilling and support facilities, and to the biota of Kachemak Bay. The sand waves in outer Kachemak Bay are presumed to be dynamic (Bouma and others 1977) and could endanger pipelines or other structures that might be laid over them (National Oceanic and Atmospheric Administration 1978).

Net inflow into Kachemak Bay is composed of marine waters and freshwater runoff. Waters from the Gulf of Alaska circulate into Cook Inlet through the Kennedy Entrance and are circulated into Kachemak Bay by a gyre in the outer bay and by tidal action (Figure 7). The inflowing ocean water is clear (sediment loads are approximately 1-2 mg/l), high in salinity compared to other Cook Inlet waters, and, through the upwelling of nutrients, may contribute to the productivity of Kachemak Bay. Freshwater runoff principally is from the Fox River and associated streams entering at the head of Kachemak Bay. This freshwater carries glacial silt, other inorganic silt, detritus, and dissolved nutrients into Kachemak Bay. The runoff volume from the Fox River system and the salinity of the inner bay varies with the season; salinities are lowest during the summer, highest during the winter. The nutrient loads in influent freshwater and stratification of the water column during the spring and summer may contribute to the high productivity of Kachemak Bay (National Oceanic and Atmospheric Administration 1977; Larrance and others 1977).

13.3. Geologic Resources

The geologic resources of Kachemak Bay have not been explored. The oil and gas rights to the State of Alaska interests in outer Kachemak Bay were sold at the 28th Alaska Oil and Gas Lease Sale in 1973. In response to public concern over potential environmental impacts from oil and gas development, the lease tracts were repurchased by the State of Alaska. The tracts have not been explored or developed.

13.4. Biological Environment

The combination of high nutrient loads, stratification, good light penetration, and favorable currents make the Kachemak Bay waters highly productive. This productivity is reflected by the summer phytoplankton and macrophyte biomasses and in the richness and diversity of the marine fauna.

Diatoms comprise most of the phytoplankton in the Lower Cook Inlet. Of the more than 30 species in Lower Cook Inlet, Chaetoceros debilis, Thalassiosira sp., and Ceratulina sp. are the most numerous in Kachemak Bay (National Oceanic and Atmospheric Administration 1977). Eelgrass and attached algae (discussed in Section 3.2.1.3.) are important primary producers. Much of the intertidal and shallow subtidal waters of outer Kachemak Bay support kelp and other macrophytes (Figure 82). Eelgrass beds are located in Port Graham, Seldovia Bay, Tutka Bay, Sadie Cove, Mud Bay, and on Point Bede (Figure 82). The eelgrass and attached algal macrophytes provide attachment sites, structural habitat, and spawning sites for fish and invertebrates; are consumed by invertebrates, fish, and waterfowl; and are important sources of detritus. The diatoms and

other phytoplankton taxa are consumed by fish, particularly juveniles, and invertebrates, and are important as food for shrimp in Kachemak Bay (Crow 1977). The China Poot Bay was one important source of diatoms in the shrimp diet.

Zooplankton in Kachemak Bay are primarily holoplankton (organisms that remain planktonic throughout their life cycle), but meroplankton (organisms that are planktonic only during part of their life cycle) are significant components (National Oceanic and Atmospheric Administration 1977). Copepods, euphausiids, and chaetognaths are abundant holoplankton. The meroplankton include the early life history stages of shrimp, crabs, other invertebrates, and fish. Plankton collections in the Kachemak Bay region (English 1976) indicate that most of the Kachemak Bay meroplankton are derived from reproduction in Kachemak Bay and not imported into the Bay from other sources.

Kachemak Bay contains a variety of intertidal and subtidal substrates that support both import and export communities. Polychaetes and clams are abundant in soft sand, silt, and mud substrates. Sponges, chitons, snails, barnacles, sea star, and urchins are the principal components of communities on hard substrates. Several species of clams are collected locally in the subsistence/recreational fishery but are not harvested commercially. Some of the charter boat operators transport clammers from the Homer small-boat harbor to clam beds on the south side of Kachemak Bay.

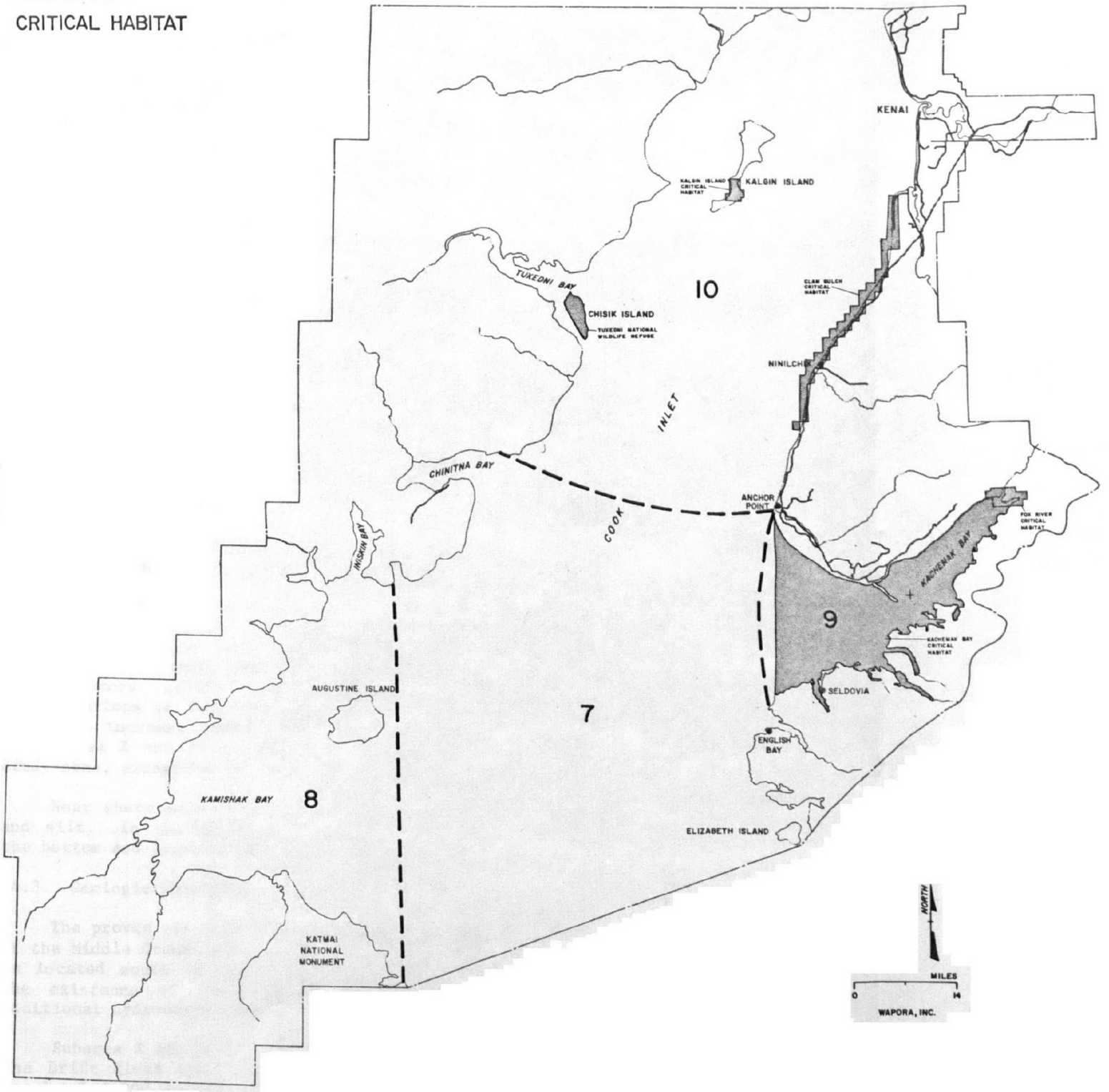
Crabs and shrimp are the main commercial shellfish caught in Kachemak Bay. All three commercial crab species are taken, primarily from the outer bay. Crab harvests vary, but usually exceed 3.5 million pounds per year. In 1978, 730,915 pounds of king crab and 1,115,942 pounds of Tanner crab were harvested. The trawl shrimp harvest exceeded 4 million pounds in 1978, and 24,558 pounds of pot shrimp were caught that year (Table 9). The major commercial fishing areas for king crab, dungeness crab, Tanner crab, and trawl shrimp are shown in Figure 82. Kachemak Bay is a critical spawning area for several shrimp species and for all three commercial crab species. Reproduction in the Bay may be of major importance to the shellfish harvest in the central Cook Inlet. The principal king crab and Tanner crab spawning areas are protected by a State sanctuary established in outer Kachemak Bay (Figure 84; adapted from Traskey and others 1977).

The deeper waters of Kachemak Bay are halibut fishing areas for commercial and subsistence fishermen. No data specific to Kachemak Bay are available. Prior to 1970, Kachemak Bay was the site of most of the Lower Cook Inlet herring fishery. Populations since have declined, and other areas of Cook Inlet now receive the major herring fishing effort.

There are both recreational and commercial fisheries for salmon in Kachemak Bay. Approximately 400,000 salmon, mostly sockeye and pink salmon, were netted by commercial fishermen in the Southern District (Kachemak Bay and nearby waters) during 1978 (Table 9). Salmon spawn in several of the streams tributary to Kachemak Bay (Figures 43, 52, and 61). The salmon juveniles remain in Kachemak Bay for varying time periods after they leave the spawning streams.

The unique physical attributes of Kachemak Bay have produced a highly productive environment that is especially suited to the requirements of a number of ecologically, recreationally, and commercially important marine organisms. To protect this exceptionally rich environment, the State of Alaska has classified Kachemak Bay as a "Critical Habitat" (Figure 84).

FIGURE 84
CRITICAL HABITAT



14.0. SUBAREA X

14.1. Subarea X Boundaries

Subarea X includes all of the Cook Inlet south of the Forelands and north of a line between Anchor Point and the north side of the mouth of Chinitna Bay (Figure 82). Subarea X is bounded by the Kenai Peninsula on the east and the western coast of Cook Inlet on the west.

14.2. Bathymetry and Oceanography

Cook Inlet in Subarea X is divided laterally into two troughs by Kalgin Island and the associated shoals that trend south-southeast and north-northwest from Kalgin Island through the middle of the central Cook Inlet. The water over the shoals is less than 10-fathoms (60-feet) deep, and parts of the shoals are exposed during extreme low tides. The deepest regions of Subarea X are near the West Foreland where the bottom is scoured by currents that may exceed 5 miles per hour. At the West Foreland the maximum recorded depths exceed 75 fathoms (450 feet). South of the Foreland on both sides of Kalgin Island the bottom gradually rises from maximum depths of approximately 30 fathoms (180 feet) to the Kalgin Island shoals and to the Kenai Peninsula and western coastline. Along most of the coastline in Subarea X the 10-fathom (60-feet) depth line is approximately 3 to 5 miles offshore. South of the mid-inlet shoal, the floor of the inlet slopes gently deeper toward the center of the inlet and toward the south.

Circulation in Subarea X is controlled by a combination of tidal action, net influx of low-salinity, silt-laden water from Upper Cook Inlet, and net influx of clearer, more saline marine waters from the Gulf of Alaska via the eastern side of Lower Cook Inlet (Figure 7). The system is dynamic; tide levels exceed 13 feet, current velocities may exceed 5 miles per hour, and there are strong tidal rips where the lighter, low-salinity waters from Upper Cook Inlet converge with the denser, more saline waters from Lower Cook Inlet (Figure 8). Concentrations of suspended solids vary in Subarea X, but generally show a gradual increase toward the west and toward the north. Concentrations in Subarea X are the highest found anywhere in the marine part of the study area, exceeding 100 mg/l near the West Foreland.

Near shore substrates in most of Subarea X consist of gravel, sand, and silt. In the deeper areas, the more dynamic circulation may scour the bottom and produce substrates of larger particles or rocks.

14.3. Geologic Resources

The proven oil reserves of all of the Redoubt Shoal Field and a part of the Middle Ground Shoal Field occur in Subarea X. The Kenai Gas Field is located south of Kenai along the eastern shoreline of the Subarea. The existence of these proven reserves increases the possibility of additional hydrocarbon resources occurring in the subarea.

Subarea X has been impacted in the past by significant oil spills. The Drift River spill occurred about 6:00 am on 30 December 1967. A total of 1,700 barrels of crude oil spread south past Tuxedni Bay and

coated vegetation on the shoreline with a brown, oily material (Evans 1972).

Other than the Beluga Coalfields, perhaps the low-grade titaniferous magnetite (iron) deposits and associated cooper, silver, and gold occurrences are the most promising hard rock minerals in the study area. These deposits form a 200-mile belt extending from Tuxedni Bay west to Iliamna Lake. The deposits in Tuxedini Bay may represent, therefore, a future exploitable resource.

14.4. Biological Resources

The combination of rapid currents, scouring, scarcity of attachment substrates, and high turbidity keep primary productivity of both phytoplankton and macrophytes lower in Subarea X than in the other Cook Inlet Subareas. Macrophyte beds are restricted to the shoreline south of Ninilchik on the eastern side of the Subarea and to the area around Chisik Island and the Iniskin Peninsula on the western coast (Figure 82). These macrophyte beds are smaller in extent, generally are sparsely vegetated, and are less productive than many of the beds in other parts of Lower Cook Inlet.

Macroinvertebrate populations in Subarea X probably include larger percentages of filter feeders and scavengers than the other Subareas in Cook Inlet and smaller percentages of herbivores. This is especially true of the more turbid areas, such as Chinitna Bay, Nikishka, the mouth of the Kenai River, and the Kasilof River. Dames and Moore (1977) sampled intertidal and subtidal organisms in a variety of environments on both sides of Cook Inlet in Subarea X. Their report indicates that at Chinitna Bay and Polly Creek razor clams and other clams were the most common larger invertebrates in the softer substrates. The hard substrates, boulders, and rocky outcrops generally supported a more diverse assemblage. The community structure on rocky substrates was restricted by ice. In soft, sandy, and silty beaches at Deep Creek, Clam Gulch, and Whiskey Gulch, Dames and Moore (1977) reported that the macroinvertebrate community relied almost entirely on imported organic material at the primary consumer level. The macroinvertebrate fauna in the beach substrates was predominantly clams, worms, and other filter feeders. Small Tanner crabs are abundant at times on these beaches, and the eastern coastline of Subarea X may be important habitat for both juvenile and adult Tanner crabs. Rocky substrates generally supported simple assemblages including barnacles, snails, and mussels. Near Anchor Point at the southern boundary of Subarea X, the photic zone was deeper, beds of attached algae were present, and macroinvertebrate species diversity increased. North of Cape Kasilof the intertidal fauna was very sparse, particularly near the mouth of the Kasilof River where the turbidity was high. The substrates were sticky mud, and salinity levels may have been variable.

The commercial fishery in Subarea X is focused on salmon. Subarea X approximately corresponds with the Central Gillnet District of Cook Inlet, the most productive salmon fishing district in the Inlet. During 1978, more than 4.5 million salmon were caught in the Central District by commercial fishermen. This was approximately 80% of the total 1978

commercial salmon harvest from the study area. Approximately 2.5 million of these salmon were sockeye, 1.3 million were pink salmon, 0.5 million were chum salmon, and the remainder were coho and king salmon. The salmon were migrating toward spawning areas in Upper Cook Inlet, in the Kenai and Kasilof River systems, and the many other river systems tributary to the upper and central Inlet.

Trawl sampling reported by Blackburn (1977) indicated that fish stocks north of Anchor Point generally were sparser than south of the Point. There may be some halibut fishing in the southern part of Subarea X.

Beluga whales and harbor seals are the major marine mammals in Subarea X. Belugas are observed frequently in Subarea X during the months when the central inlet is ice-free. During the salmon runs they may concentrate off the mouths of the major salmon streams on the west side of Cook Inlet. Harbor seal concentrations have been reported in Chinitna Bay, Tuxedni Bay, Harriet Point, the West Foreland, and at both the north and south ends of Kalgin Island.

The largest seabird colony in Cook Inlet is on Chisik Island. There are other seabird colonies near the mouth of Chinitna Bay, in Tuxedni Bay, and on the steep, rocky coastline south of Tuxedni Bay (Figure 82). These colonies are described in the Subarea VI profile (Section 10.3).

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APPENDIX A

USEPA Responsibilities in the Lower Cook Inlet

The Lower Cook Inlet of Alaska will require increasing attention by USEPA. It includes one of the State's most populous areas and the population is expected to continue to grow with increasing development. Offshore land-based petroleum and natural gas activity is likely to increase and additional production of seafoods products can be expected. New industries will require permits under the provisions of the National Pollutant Discharge Elimination System (NPDES). Growing populations will require centralized wastewater treatment and will generate large amounts of solid wastes. Developmental pressures will add to current air pollution problems. These and other issues will result in increased involvement by USEPA.

A major part of the involvement of USEPA in the Lower Cook Inlet will result from the provisions of the Federal Water Pollution Control Act, as amended (FWPCA), especially in the area of NPDES permit activities. Section 402 of FWPCA provides for the NPDES program. This section is designed to supplant the provisions of the Supervisory Harbors Act of 1888 and the Rivers and Harbors Act of 1899 that had been used to regulate pollutant discharges prior to the enactment of FWPCA. Implementation of the NPDES program is designated as the responsibility of the Administrator of USEPA. The Act also provides for state administration of the NPDES program when a state desires such authority and presents proof of its ability to manage and enforce the regulations. Although a number of states have received NPDES authority, the State of Alaska has not and the program is administered by USEPA.

Regulated discharge

The legal definitions of the discharges regulated under FWPCA are contained in Sections 301, 302, and 502 of the Act. All point-source discharges are included, with the exception of return flows from agricultural irrigation and pollutants resulting from dredging and filling operations covered by Section 404 of the Act. Permits for discharges may be issued under the provisions of Section 402.

Prior to issuance of a new source NPDES permit, an environmental review is performed by USEPA under the auspices of the National Environmental Policy Act of 1969, as amended (NEPA). The USEPA new source permit program is discussed in Section 2.3.

Finding of no significant impact

If, upon review of an application for an NPDES permit, USEPA determines that an environmental impact statement (EIS) will not be prepared, it will issue a written announcement called a "finding of no significant impact". This is an explanation of the proposed action and includes the reasons why an EIS will not be prepared. It also will include an environmental assessment (EA) or a summary.

Environmental impact statements

If the proposed action is determined to fall into the category of "a major Federal action" that significantly will affect the quality of the human environment, an EIS normally would be required. USEPA procedures

for EIS preparation pursuant to the new regulations of the Council on Environmental Quality (CEQ) (43 FR 55978) currently are being developed.

The responsibilities of USEPA extend beyond the provisions of FWPCA. It is not possible to discuss in detail all of the USEPA programs in the Lower Cook Inlet study area. The following sections will describe briefly several major areas of involvement.

Clean Air Act

USEPA has the primary Federal responsibility for implementation and enforcement of the provisions of the Clean Air Act (42 USC 1857 et seq.). Ambient air quality standards include primary and secondary standards. The primary standards are designed to protect the public health and include regulation of particulate matter, sulfur oxides, hydrocarbons, carbon monoxide, photochemical oxidants, oxides of nitrogen, and lead.

The intent of Congress was to place the burden of air pollution prevention and control programs on individual states. The role of the Federal Government was to be that of overseer and technical assistant. To that end, Congress required the submission of State Implementation Plans (SIPs) to USEPA. After review, SIP revisions must be submitted and approved. The process has fallen behind schedule, but it appears that the states are attempting to comply with the requirements.

Air pollution is a complicated problem and the situation in Alaska is no exception. There are indications that air quality has improved in Alaska over the past five years, but problem areas still exist.

One of the areas in the State of Alaska in which primary standards are being exceeded is the Kenai-Cook Inlet Election District, the bulk of which is included in the Lower Cook Inlet study area. Total suspended particulates (TSP) are the major problem in the Kenai-Cook Inlet area. The average annual number of days on which the primary standard for TSP is exceeded is the largest of all Alaskan areas for which data are available. Standards are violated almost 40 days per year, with over 50% of the violations reaching the "alert" level (USEPA 1978).

Although there is some question as to the role of natural conditions in the air pollution problem in the Kenai-Cook Inlet area, USEPA involvement in air quality management will continue to be significant. This especially is true when potential industrial development in the study area is considered.

Resource Conservation and Recovery Act

The Resource Conservation and Recovery Act (RCRA) of 1976 (Pub. L. 94-580) was enacted "...to deal with the environmental problems posed by solid waste and to promote resource recovery and other resource conservation measures as waste management alternatives" (USEPA 1978). Solid waste disposal practices have been implicated in water quality problems in many locations. Implementation of RCRA will help to achieve the goals of FWPCA by reducing contamination of surface waters and groundwaters.

Although industrial and farm wastes are minimal in Alaska, climate, geology, and population distribution present serious solid waste disposal problems. Siting of disposal facilities may be constrained by the lack of surface transportation, unsuitability of soils, contested ownership of lands, distance from the waste source, and a variety of climatic factors. Approximately 67% of Alaska's population is served by approved solid waste disposal facilities (USEPA 1978). Recovery studies are underway in Anchorage and Sitka.

The Lower Cook Inlet study area faces significant solid waste management problems. As the population increases and development continues, the volume of waste also will increase. The Kenai-Soldotna area and Homer are likely to experience the greatest impacts. A major concern will be the potential expansion of the petroleum and chemical industries. In addition to other solid wastes, these industries may produce substantial quantities of wastes that are designated as toxic. USEPA will have an important role in solid waste and resource recovery programs in the Lower Cook Inlet study area.

Toxic Substances Control Act

In an effort to learn more about the dangers of chemicals and to protect human health, Congress enacted the Toxic Substances Control Act (TSCA) in 1976 (Pub. L. 94-469). It directs USEPA to gather data on chemicals and chemical mixtures and to regulate their manufacture, processing, distribution, use, and disposal. The mandate overlaps, to a certain extent, a variety of other legislation, including the Federal Water Pollution Control Act, the Clear Air Act, and the Resource Conservation and Recovery Act.

USEPA involvement in the Lower Cook Inlet study area as a result of TSCA will focus on the development of commercial chemical industries and on the use and distribution of chemical materials. Disposal of hazardous waste basically is covered under RCRA. Certain products regulated under other laws are exempt from the provisions of TSCA, including tobacco, pesticides, nuclear material, food, food additives, drugs, cosmetics, and firearms and ammunition.

Safe Drinking Water Act

In recognition of the need to protect the Nation's public water supplies, Congress passed the Safe Drinking Water Act of 1974 (Pub. L. 95-190). "Under the Safe Drinking Water Act, the Federal Government-EPA has the primary responsibility of establishing the national standards; the states are responsible for enforcing the standards and otherwise supervising public water supply systems and sources of drinking water" (USEPA 1975). The Act provides that a state may qualify for primary enforcement responsibility and the State of Alaska was granted primacy in September 1978.

The regulations include primary and secondary standards for public water supplies. The primary standards are designed to ensure public health, while the secondary standards deal with taste, odor, and the physical appearance of water for human consumption. The Safe Drinking

Water Act includes provisions for the protection of underground sources of drinking water, such as aquifers. Special attention is directed at those aquifers that have been designated as the "sole-source" of public water supplies.

Public water supplies in the Lower Cook Inlet study area generally are taken from wells. Increasing industrialization and development may threaten these sources. The problem of water use by industry already is a major issue in the Kenai area. In many cases, the specific boundaries and recharge areas for aquifers is not known. Studies will be required to determine the extent of underground water supplies. Utilization of surface water presents difficulties in those areas where the water contains large amounts of "glacial flour". Public water supply eventually may be a significant constraint to growth in some sections of the study area.

Other responsibilities

In addition to participation in the programs under its direct control, USEPA is involved in many other activities, especially in the review of a wide variety of permits and projects. USEPA frequently works with such Federal agencies as the US Army Corps of Engineers, the US Fish and Wildlife Service, the Department of Housing and Urban Development, the Bureau of Land Management, and many others. In some cases, review by USEPA is mandatory, while at other times reviews are sought because of USEPA's environmental expertise. USEPA also prepares and funds numerous reports and research activities.

While it is beyond the scope of this report to discuss all of USEPA's responsibilities and activities in the Lower Cook Inlet study area, the preceding sections have attempted to present a brief review of the major aspects of USEPA involvement. It is clear that USEPA will be active in future developmental decisions affecting the study area.

APPENDIX B

Climate and Meteorology

N.C.C. FILE COPY

U.S. DEPARTMENT OF COMMERCE
NATIONAL OCEANIC AND ATMOSPHERIC ADMINISTRATION
ENVIRONMENTAL DATA SERVICE

JOB NO. 13373

SEASONAL AND ANNUAL
WIND DISTRIBUTION BY PASQUILL STABILITY CLASSES
STAR PROGRAM

Station: #26523, Kenai, Alaska

Period: Jan. 1966 - Dec. 1970

Source: TDF 14 (8 Obs/Day)

DATE Oct. 19, 1972

NATIONAL CLIMATIC CENTER

FEDERAL BUILDING, ASHEVILLE, N.C.

U.S.COMM-NOAA-ASHEVILLE

PREPARED FOR: Mr. Vince Leggio
Dames and Moore
Atlanta, Ga.

ANNUAL RELATIVE FREQUENCY DISTRIBUTION STATION #26523 KENAI, ALASKA 66-70 24 OBS

SPEED(KTS)

DIRECTION	0 - 3	4 - 6	7 - 10	11 - 16	17 - 21	GREATER THAN 21	TOTAL
N	0.017178	0.035851	0.028242	0.012202	0.002742	0.001645	0.097861
NNE	0.025767	0.049904	0.042569	0.035488	0.010351	0.002125	0.166704
NE	0.022872	0.045654	0.052509	0.041267	0.005484	0.000069	0.167854
ENE	0.018919	0.033178	0.031944	0.011242	0.000274	0.000000	0.095457
E	0.014951	0.027146	0.014464	0.004319	0.000411	0.000000	0.061291
ESE	0.009132	0.016178	0.006032	0.001645	0.000137	0.000000	0.033124
SE	0.004411	0.011859	0.004456	0.000823	0.000000	0.000000	0.021549
SSE	0.006819	0.014875	0.007472	0.001371	0.000000	0.000000	0.030537
S	0.010082	0.024267	0.024952	0.009049	0.000411	0.000206	0.068966
SSW	0.003978	0.011174	0.025226	0.018714	0.002399	0.000480	0.061971
SW	0.003823	0.011242	0.033384	0.021662	0.001028	0.000137	0.071276
WSW	0.003241	0.008294	0.023992	0.008980	0.000069	0.000000	0.044577
W	0.003609	0.008157	0.012819	0.002194	0.000000	0.000069	0.027047
WNW	0.002215	0.005964	0.006581	0.001234	0.000000	0.000000	0.015993
NW	0.002230	0.005690	0.005827	0.001097	0.000069	0.000000	0.014912
NNW	0.004292	0.008363	0.006718	0.001302	0.000137	0.000069	0.020881
TOTAL	0.153619	0.317795	0.327186	0.173087	0.023512	0.004798	

TOTAL RELATIVE FREQUENCY OF OBSERVATIONS = 1.000000

TOTAL RELATIVE FREQUENCY OF CALMS DISTRIBUTED ABOVE = 0.096038

ANNUAL RELATIVE FREQUENCY DISTRIBUTION STATION #26523 KENAI, ALASKA 66-70 24 OBS

SPEED(KTS)

DIRECTION	0 - 3	4 - 6	7 - 10	11 - 16	17 - 21	GREATER THAN 21	TOTAL
N	0.000000	0.000000	0.000000	0.000000	0.000000	0.000000	0.000000
NNE	0.000000	0.000000	0.000000	0.000000	0.000000	0.000000	0.000000
NE	0.000000	0.000000	0.000000	0.000000	0.000000	0.000000	0.000000
ENE	0.000000	0.000000	0.000000	0.000000	0.000000	0.000000	0.000000
E	0.000000	0.000000	0.000000	0.000000	0.000000	0.000000	0.000000
ESE	0.000000	0.000000	0.000000	0.000000	0.000000	0.000000	0.000000
SE	0.000000	0.000000	0.000000	0.000000	0.000000	0.000000	0.000000
SSE	0.000000	0.000000	0.000000	0.000000	0.000000	0.000000	0.000000
S	0.000000	0.000000	0.000000	0.000000	0.000000	0.000000	0.000000
SSW	0.000000	0.000000	0.000000	0.000000	0.000000	0.000000	0.000000
SW	0.000000	0.000000	0.000000	0.000000	0.000000	0.000000	0.000000
WSW	0.000000	0.000000	0.000000	0.000000	0.000000	0.000000	0.000000
W	0.000000	0.000000	0.000000	0.000000	0.000000	0.000000	0.000000
WNW	0.000000	0.000000	0.000000	0.000000	0.000000	0.000000	0.000000
NW	0.000000	0.000000	0.000000	0.000000	0.000000	0.000000	0.000000
NNW	0.000000	0.000000	0.000000	0.000000	0.000000	0.000000	0.000000
TOTAL	0.000000	0.000000	0.000000	0.000000	0.000000	0.000000	

RELATIVE FREQUENCY OF OCCURRENCE OF A STABILITY = 0.000000

RELATIVE FREQUENCY OF CALMS DISTRIBUTED ABOVE WITH A STABILITY = 0.000000

ANNUAL RELATIVE FREQUENCY DISTRIBUTION STATION =26523 KENAI, ALASKA 66-70 24 085

SPEED(KTS)

DIRECTION	0 - 3	4 - 6	7 - 10	11 - 16	17 - 21	GREATER THAN 21	TOTAL
N	0.000876	0.000206	0.000206	0.000000	0.000000	0.000000	0.001288
NNE	0.000581	0.000069	0.000069	0.000000	0.000000	0.000000	0.000718
NE	0.000364	0.000069	0.000069	0.000000	0.000000	0.000000	0.000501
ENE	0.000335	0.000206	0.000069	0.000000	0.000000	0.000000	0.000610
E	0.000541	0.000000	0.000069	0.000000	0.000000	0.000000	0.000610
ESE	0.000216	0.000000	0.000000	0.000000	0.000000	0.000000	0.000216
SE	0.000000	0.000000	0.000000	0.000000	0.000000	0.000000	0.000000
SSE	0.000108	0.000000	0.000000	0.000000	0.000000	0.000000	0.000108
S	0.000256	0.000069	0.000137	0.000000	0.000000	0.000000	0.000462
SSW	0.000523	0.000343	0.000206	0.000000	0.000000	0.000000	0.001071
SW	0.000425	0.000548	0.000754	0.000000	0.000000	0.000000	0.001728
WSW	0.000584	0.000823	0.000685	0.000000	0.000000	0.000000	0.002092
W	0.000375	0.000274	0.000206	0.000000	0.000000	0.000000	0.000855
WNW	0.000238	0.000411	0.000206	0.000000	0.000000	0.000000	0.000855
NW	0.000079	0.000137	0.000343	0.000000	0.000000	0.000000	0.000559
NNW	0.000187	0.000137	0.000000	0.000000	0.000000	0.000000	0.000325
TOTAL	0.005690	0.003290	0.003016	0.000000	0.000000	0.000000	

RELATIVE FREQUENCY OF OCCURRENCE OF B STABILITY = 0.011996

RELATIVE FREQUENCY OF CALMS DISTRIBUTED ABOVE WITH B STABILITY = 0.003290

ANNUAL RELATIVE FREQUENCY DISTRIBUTION STATION =26523 KENAI, ALASKA 66-70 24 OBS

SPEED(KTS)

DIRECTION	0 - 3	4 - 6	7 - 10	11 - 16	17 - 21	GREATER THAN 21	TOTAL
N	0.002607	0.002536	0.003907	0.000137	0.000000	0.000000	0.009188
NNE	0.002964	0.002673	0.003222	0.000137	0.000000	0.000000	0.008997
NE	0.002700	0.000960	0.003085	0.000069	0.000000	0.000000	0.006813
ENE	0.002311	0.001645	0.002536	0.000069	0.000000	0.000000	0.006561
E	0.002373	0.000891	0.000960	0.000000	0.000000	0.000000	0.004224
ESE	0.001057	0.000823	0.000548	0.000000	0.000000	0.000000	0.002428
SE	0.000311	0.000480	0.000137	0.000000	0.000000	0.000000	0.000928
SSE	0.000509	0.000480	0.000206	0.000000	0.000000	0.000000	0.001195
S	0.001253	0.001714	0.000274	0.000000	0.000000	0.000000	0.003241
SSW	0.000888	0.001782	0.004044	0.000206	0.000000	0.000000	0.006921
SW	0.001116	0.001851	0.008226	0.000617	0.000000	0.000000	0.011810
WSW	0.001041	0.001234	0.010488	0.000617	0.000000	0.000000	0.013380
W	0.000881	0.001097	0.006169	0.000411	0.000000	0.000000	0.008559
WNW	0.000463	0.000823	0.002811	0.000206	0.000000	0.000000	0.004302
NW	0.000372	0.000617	0.002331	0.000069	0.000000	0.000000	0.003388
NNW	0.000677	0.000411	0.001508	0.000000	0.000000	0.000000	0.002596
TOTAL	0.021525	0.020016	0.050452	0.002536	0.000000	0.000000	

RELATIVE FREQUENCY OF OCCURRENCE OF C STABILITY = 0.094530

RELATIVE FREQUENCY OF CALMS DISTRIBUTED ABOVE WITH C STABILITY = 0.012750

ANNUAL RELATIVE FREQUENCY DISTRIBUTION STATION #26523 KENAI, ALASKA 66-70 24 OBS

SPEED(KTS)

DIRECTION	0 - 3	4 - 6	7 - 10	11 - 16	17 - 21	GREATER THAN 21	TOTAL
N	0.003083	0.013847	0.019948	0.012065	0.002742	0.001645	0.053330
NNE	0.004524	0.019194	0.032698	0.035851	0.010351	0.002125	0.104743
NE	0.004695	0.019057	0.042775	0.041198	0.005484	0.000069	0.113477
ENE	0.003878	0.015081	0.025432	0.011174	0.000274	0.000000	0.055838
E	0.003353	0.014670	0.012613	0.004319	0.000411	0.000000	0.035365
ESE	0.002595	0.009186	0.004936	0.001645	0.000137	0.000000	0.018499
SE	0.001134	0.006512	0.003427	0.000823	0.000000	0.000000	0.011896
SSE	0.002198	0.008569	0.005758	0.001371	0.000000	0.000000	0.017896
S	0.003149	0.012065	0.019262	0.009049	0.000411	0.000206	0.044141
SSW	0.000980	0.005964	0.018645	0.018508	0.002399	0.000480	0.046977
SW	0.001360	0.005895	0.021319	0.021045	0.001028	0.000137	0.050785
WSW	0.000880	0.004113	0.012407	0.008363	0.000069	0.000000	0.025832
W	0.001334	0.005141	0.006032	0.001782	0.000000	0.000069	0.014359
WNW	0.000854	0.003359	0.003153	0.001028	0.000000	0.000000	0.008395
NW	0.000875	0.002948	0.002536	0.001028	0.000069	0.000000	0.007456
NNW	0.001308	0.004387	0.003907	0.001302	0.000137	0.000069	0.011111
TOTAL	0.036400	0.149986	0.234850	0.170551	0.023512	0.004798	

RELATIVE FREQUENCY OF OCCURRENCE OF D STABILITY = 0.620099

RELATIVE FREQUENCY OF CALMS DISTRIBUTED ABOVE WITH D STABILITY = 0.022621

ANNUAL RELATIVE FREQUENCY DISTRIBUTION STATION #26523 KENAI, ALASKA 66-70 24 OBS

SPEED(KTS)

DIRECTION	0 - 3	4 - 6	7 - 10	11 - 16	17 - 21	GREATER THAN 21	TOTAL
N	0.011322	0.019262	0.004182	0.000000	0.000000	0.000000	0.034766
NNE	0.018498	0.027968	0.006581	0.000000	0.000000	0.000000	0.053047
NE	0.015069	0.025569	0.006581	0.000000	0.000000	0.000000	0.047238
ENE	0.012432	0.016246	0.003907	0.000000	0.000000	0.000000	0.032586
E	0.008381	0.011583	0.000823	0.000000	0.000000	0.000000	0.020788
ESE	0.004903	0.006169	0.000548	0.000000	0.000000	0.000000	0.011620
SE	0.002666	0.004867	0.000691	0.000000	0.000000	0.000000	0.008424
SSE	0.003521	0.005827	0.001508	0.000000	0.000000	0.000000	0.010856
S	0.005099	0.010420	0.005278	0.000000	0.000000	0.000000	0.020797
SSW	0.001634	0.003085	0.002331	0.000000	0.000000	0.000000	0.007050
SW	0.000955	0.002948	0.003085	0.000000	0.000000	0.000000	0.006987
WSW	0.000961	0.002125	0.000411	0.000000	0.000000	0.000000	0.003497
W	0.001077	0.001645	0.000411	0.000000	0.000000	0.000000	0.003134
WNW	0.000526	0.001371	0.000411	0.000000	0.000000	0.000000	0.002408
NW	0.000825	0.001988	0.000617	0.000000	0.000000	0.000000	0.003430
NNW	0.002018	0.003427	0.001302	0.000000	0.000000	0.000000	0.006748
TOTAL	0.090005	0.144502	0.038868	0.000000	0.000000	0.000000	

RELATIVE FREQUENCY OF OCCURRENCE OF E STABILITY = 0.273375

RELATIVE FREQUENCY OF CALMS DISTRIBUTED ABOVE WITH E STABILITY = 0.057376

Local Climatological Data

Annual Summary With Comparative Data

1975

HOMER, ALASKA

Narrative Climatological Summary

Homer Airport is located at the head of Coal Bay, on the north shore of Kachemak Bay just to the east of its confluence with Cook Inlet. The shore line to either side of the station curves toward the north, such that water lies within a distance of less than one mile through south from west to east. To the northwest through northeast the ground has a gradual rise to 500 feet at a distance of one and one half mile and then rises abruptly to 1,000 feet at a distance of two miles from the station. The nearest 1,500 feet elevation in this direction is Lookout Mountain, four miles to the north and northeast. The nearest 2,000 feet elevation lies about 12 miles to the southeast across Kachemak Bay, in the foothills of the Kenai Mountains. The width of the Bay in this direction is approximately nine miles. Continuing southeastward beyond Kachemak Bay, at a distance of 15 to 20 miles is the ridgeline of the northeast-southwest oriented Kenai Mountains with elevations of 4,000 to 6,000 feet.

The climate of Homer is marine but with precipitation amounts modified by the Kenai Mountains. The annual precipitation is reduced when air being lifted over mountains leaves most of its moisture on the windward side. For this reason the usual Gulf Coast amount of near 60 inches is reduced to less than half that amount. The relatively low annual snowfall is a reflection of the mild winter temperatures. Often precipitation will begin as snow but turn to rain shortly afterwards. The occurrence of the heaviest monthly amounts during the fall and winter months is the result of the increased frequency of storms into the Western Gulf of Alaska during those months.

Temperatures experienced at Homer are more nearly representative of marine climate than is precipitation. Winters are mild, seldom getting colder than zero and summers are cool with the maximum temperature seldom going above 70°. The range between average maximum and minimum temperatures does not exceed 16 degrees during any of the 12 months. The freeze-free period on the average begins in late May and ends in mid September with an effective growing season of about 100 days.

Surface winds at the station are seldom strong even in winter. However, a short distance to the southeast, over Kachemak Bay, and to the west over Cook Inlet, wind speeds requiring warnings to small craft are fairly common in winter and summer.

The occurrence of a thunderstorm is rare. Heavy fog is infrequent and of short duration, but patchy ground fog is common in spring and fall.

noaa NATIONAL OCEANIC AND ATMOSPHERIC ADMINISTRATION / ENVIRONMENTAL DATA SERVICE / NATIONAL CLIMATIC CENTER ASHEVILLE, N.C.

Meteorological Data For The Current Year

Station: NOME, ALASKA — MUNICIPAL AIRPORT — Standard time used: ALASKAN — Latitude: 64° 30' N — Longitude: 165° 30' W — Elevation (ground): 23 feet — Year: 1973

Month	Temperature °F: Average: Daily maximum	Temperature °F: Average: Daily minimum	Temperature °F: Average: Monthly	Temperature °F: Extremes: Highest	Temperature °F: Extremes: Date	Temperature °F: Extremes: Lowest	Temperature °F: Extremes: Date	Degree days Base 65 °F: Heating	Degree days Base 65 °F: Cooling	Precipitation in inches: Water equivalent: Total	Precipitation: Water equivalent: Greatest in 24 hrs.	Precipitation: Water equivalent: Date	Precipitation: Snow, ice pellets: Total	Precipitation: Snow, ice pellets: Greatest in 24 hrs.	Precipitation: Snow, ice pellets: Date	Relative humidity, pct.: Hour 02 (Local time)	Relative humidity: Hour 08	Relative humidity: Hour 14	Relative humidity: Hour 20	Wind: Resultant: Direction	Wind: Resultant: Speed m.p.h.	Wind: Average speed m.p.h.	Wind: Fastest mile: Speed m.p.h.	Wind: Fastest mile: Direction	Wind: Fastest mile: Date	Percent of possible sunshine	Average sky cover, tenths, sunrise to sunset	Number of days: Sunrise to sunset: Clear	Number of days: Sunrise to sunset: Partly cloudy	Number of days: Sunrise to sunset: Cloudy	Number of days: Precipitation .01 inch or more	Number of days: Snow, ice pellets 1.0 inch or more	Number of days: Thunderstorms	Number of days: Heavy fog, visibility ¼ mile or less	Number of days: Temperature °F: Maximum (b): 90° and above	Number of days: Temperature °F: Maximum (b): 32° and below	Number of days: Temperature °F: Minimum: 32° and below	Number of days: Temperature °F: Minimum: 0° and below	Average station pressure mb: Elev 73 feet m.s.l.
JAN	24.2	12.9	18.6	42	22	-17	5	1439	0	2.50	0.89	16	14.3	5.3	1	73	75	71	72	03	3.0	9.9	29	23	1		6.8	9	4	18	13	6	0	0	0	16	24	9	1004.6
FEB	27.0	10.4	18.7	40	28	-6	12	1293	0	3.38	1.00	25	18.9	4.2	20-21	75	75	71	76			9.7	32	07	20		6.1	10	3	15	15	8	0	0	0	17	27	4	1000.0
MAR	34.0	18.0	26.0	45	27	-1	23	1199	0	1.64	0.37	9-10	17.1	3.2	31	81	80	71	74	05	0.6	7.4	35	22	29		6.5	7	9	15	13	4	0	1	0	12	30	2	1005.1
APR	39.0	26.4	32.7	47	15	12	3	960	0	2.17	0.74	16-17	9.6	4.6	24-25	86	80	70	78	33	0.5	8.3	29	27	17		7.3	6	4	20	14	3	0	0	0	1	23	0	1007.5
MAY	48.4	35.7	42.1	58	9	28	3	703	0	1.94	0.97	10	1.0	1.0	21-22	89	78	68	78			9.5	40	11	25		8.4	2	8	21	14	0	0	0	0	0	7	0	1007.1
JUN	55.3	40.8	47.9	68	28	32	11	504	0	0.95	0.41	18-19	0.0	0.0		93	79	65	76	24	4.2	8.9	23	14	29		7.5	1	14	15	12	0	0	0	0	0	1	0	1010.2
JUL	60.4	48.2	52.9	72	9	37	2	367	0	0.99	0.26	16	0.0	0.0		94	84	72	80	24	3.3	7.4	23	10	3		6.9	2	16	13	8	0	0	2	1	0	0	0	1010.8
AUG	60.5	44.3	52.3	69	3	35	29	387	0	0.51	0.17	5	0.0	0.0		93	83	70	83	23	1.9	7.1	21	03	12		7.4	4	9	18	8	0	0	6	0	0	0	0	1010.2
† SEP	54.7	41.1	47.9	60	24	30	30	504	0	3.48	†1.11	10-11	0.0	0.0		91	87	75	84	13	2.2	7.0	23	13	17		6.6	1	5	24	16	0	0	0	0	0	0	0	1007.1
OCT	44.3	29.9	36.9	52	8	2	31	863	0	1.90	0.52	13-14	0.0	0.0		83	83	66	77				28	02	15		6.2	10	5	16	13	0	0	0	0	3	18	0	
NOV	29.1	15.3	22.2	45	21	1	3	1274	0	1.02	0.50	19	4.4	3.2	9	77	79	71	80			7.3	29	24	9		7.0	5	7	18	8	2	0	0	0	20	26	0	998.7
DEC	26.0	12.8	19.1	41	16	-12	6	1413	0	4.07	1.09	21-22	16.5	4.6	17	75	76	77	76	04	5.3	7.5	30	01	19		6.5	9	5	17	16	5	0	1	0	14	28	11	999.3
YEAR	41.9	27.6	34.8	72	JUL 9	-17	JAN 5	10908	0	24.53	1.11	SEP 10-11	83.8	5.3	JAN 1	84	80	71	78				40	11	MAY 25		7.1	66	89	210	152	28	0	10	1	83	184	26	

† DATA CORRECTED AFTER PUBLICATION OF THE MONTHLY SUMMARY.

Normals, Means, And Extremes

Month	Temperature °F: Normal: Daily maximum	Temperature °F: Normal: Daily minimum	Temperature °F: Normal: Monthly	Temperature °F: Extremes: Record highest	Temperature °F: Extremes: Year	Temperature °F: Extremes: Record lowest	Temperature °F: Extremes: Year	Normal Degree days Base 65 °F: Heating	Normal Degree days Base 65 °F: Cooling	Precipitation in inches: Water equivalent: Normal	Precipitation: Water equivalent: Maximum monthly	Precipitation: Water equivalent: Year	Precipitation: Water equivalent: Minimum monthly	Precipitation: Water equivalent: Year	Precipitation: Water equivalent: Maximum in 24 hrs.	Precipitation: Water equivalent: Year	Precipitation: Snow, ice pellets: Maximum monthly	Precipitation: Snow, ice pellets: Year	Precipitation: Snow, ice pellets: Maximum in 24 hrs.	Precipitation: Snow, ice pellets: Year	Relative humidity pct.: Hour 02 (Local time)	Relative humidity: Hour 08	Relative humidity: Hour 14	Relative humidity: Hour 20	Wind ‡: Mean speed m.p.h.	Wind ‡: Prevailing direction	Wind ‡: Fastest mile: Speed m.p.h.	Wind ‡: Fastest mile: Direction	Wind ‡: Fastest mile: Year	Pct. of possible sunshine	Mean sky cover, tenths, sunrise to sunset	Mean number of days: Sunrise to sunset: Clear	Mean number of days: Sunrise to sunset: Partly cloudy	Mean number of days: Sunrise to sunset: Cloudy	Mean number of days: Precipitation .01 inch or more	Mean number of days: Snow, ice pellets 1.0 inch or more	Mean number of days: Thunderstorms	Mean number of days: Heavy fog, visibility ¼ mile or less	Mean number of days: Temperature °F: Max. (b): 90° and above	Mean number of days: Temperature °F: Max.: 32° and below	Mean number of days: Temperature °F: Min.: 32° and below	Mean number of days: Temperature °F: Min.: 0° and below	Average station pressure mb: Elev 73 feet m.s.l.
(a)				32		32					40		40		40		40		40		2	8	8	8	7	20	3	3			5	5	5	5	19	7	7	7	35	35	35	35	3
J	26.0	14.7	21.4	51	1961	-18	1972	1352	0	1.70	4.85	1965	0.39	1969	1.74	1960	38.8	1962	24.0	1939	69	74	70	72	7.7	NE	31	07	1971		5.4	13	4	14	12	4	0	*	0	19	30	5	1005.2
F	31.8	17.9	24.9	51	1954	-18	1947	1123	0	1.54	5.25	1941	0.14	1950	1.68	1941	46.0	1974	19.2	1945	79	80	73	78	7.8	NE	32	07	1975		7.1	6	4	18	11	6	0	1	0	13	25	3	1000.4
M	35.0	20.2	27.6	53	1974	-21	1971	1159	0	1.22	3.87	1941	0.21	1953	1.24	1968	32.0	1945	13.2	1954	80	79	69	75	7.0	NE	35	22	1975		6.5	8	5	18	12	4	0	1	0	10	28	2	1002.1
A	42.3	27.7	35.0	63	1965	-9	1944	900	0	1.09	3.49	1959	0.01	1954	1.44	1950	17.4	1972	7.4	1972	86	76	67	75	7.0	NE	29	27	1974		7.6	5	5	20	9	3	0	1	0	2	23	6	1005.9
M	50.3	34.2	42.3	69	1964	6	1949	704	0	0.91	2.04	1953	0.08	1974	0.97	1975	6.6	1971	6.0	1971	88	74	67	74	7.3	SW	40	11	1975		8.0	3	7	21	10	1	0	1	0	*	11	0	1005.8
J	56.7	40.7	48.7	80	1953	29	1950	489	0	1.04	3.37	1961	0.09	1957	1.19	1949	T	1969	T	1963	92	75	67	73	6.8	WSW	31	13	1972		7.9	2	8	20	9	0	0	*	*	0	1	0	1008.6
J	60.1	44.5	52.3	78	1967	34	1959	394	0	1.70	3.79	1948	0.14	1953	1.32	1948	0.0		0.0		92	79	70	77	5.9	WSW	23	10	1975		7.5	4	9	18	11	0	*	1	1	0	0	0	1011.7
A	60.1	44.6	52.4	78	1944	31	1953	391	0	2.56	3.56	1939	0.31	1975	1.80	1936	0.0		0.0		92	81	71	82	5.3	WSW	23	19	1972		7.6	4	7	20	13	0	*	2	1	0	*	0	1011.4
S	54.8	39.2	47.0	68	1965	20	1956	540	0	2.85	5.30	1961	0.83	1969	1.43	1974	0.5	1962	0.4	1966	92	85	70	82	5.5	NE	29	07	1971		7.3	3	6	19	15	0	0	1	0	0	4	0	1006.8
O	44.4	30.3	37.4	64	1954	2	1975	856	0	3.38	8.55	1969	0.91	1953	2.24	1946	11.5	1961	8.0	1946	84	83	71	80	6.4	NE	32	09	1972		7.1	7	5	19	15	*	0	0	0	1	18	0	996.9
N	34.3	21.8	28.2	52	1962	-7	1969	1104	0	2.76	8.59	1952	0.12	1958	3.02	1952	37.4	1945	24.5	1945	80	80	74	80	7.3	NE	29	24	1975		6.9	7	5	18	11	2	0	1	0	11	26	*	1000.0
D	27.6	15.2	21.4	50	1949	-16	1944	1352	0	2.29	8.01	1939	0.00	1933	1.93	1931	44.2	1959	14.0	1968	77	80	78	79	6.8	NE	30	01	1975		6.8	8	5	18	14	5	0	1	0	19	28	4	994.7
YR	45.8	29.2	36.5	80	JUN 1953	-21	MAR 1971	10364	0	23.84	8.59	NOV 1952	0.00	DEC 1933	3.02	NOV 1952	44.0	FEB 1974	24.5	NOV 1945	84	79	71	77	6.7	NE	40	11	MAY 1975		7.1	72	70	223	141	24	*	8	2	74	195	13	1004.2

NOTE: Due to less than full time operation on a variable schedule, manually recorded elements are from broken sequences in incomplete records. Daily temperature extremes and precipitation totals for portions of the record may be for other than a calendar day. The period of record for some elements is for other than consecutive years.

(a) Length of record, years, through the current year unless otherwise noted, based on January data.
(b) 70° and above at Alaskan stations.
* Less than one half.
T Trace.

NORMALS - Based on record for the 1941-1970 period.
DATE OF AN EXTREME - The most recent in cases of multiple occurrence.
PREVAILING WIND DIRECTION - Record through 1963.
WIND DIRECTION - Numerals indicate tens of degrees clockwise from true north. 00 indicates calm.
FASTEST MILE WIND - Speed is fastest observed 1-minute value when the direction is in tens of degrees.

‡ For the calendar day prior to 1968, and based on 6-hourly data thereafter.
‡ For the period April 1950 through 1954 plus available data beginning with January 1968.
† Record for 1940-1951 and January 1968 to date when available for full year.
# Data incomplete due to less than full time operation of station.

Average Temperature

Year	Jan	Feb	Mar	Apr	May	June	July	Aug	Sept	Oct	Nov	Dec	Annual
1943	16.1	26.2	29.8	38.5	42.2	49.6	52.5	51.4	45.7	40.1	33.5	29.9	37.8
1944	25.3	34.5	28.4	34.8	44.4	50.9	54.2	55.5	47.5	39.5	30.9	27.9	39.5
1945	33.3	29.9	27.7	33.1	41.6	49.9	53.5	53.1	46.4	37.6	20.8	22.9	37.5
1946	24.7	24.2	21.1	33.7	42.0	47.4	51.7	50.8	46.0	39.8	26.2	12.9	35.0
1947	9.4	26.4	31.1	38.3	42.3	47.5	51.7	50.8	45.8	37.4	32.8	28.2	36.7
1948	25.1	21.1	25.2	31.9	42.2	48.1	50.4	49.4	44.0	38.2	21.5	17.7	34.6
1949	22.1	15.1	32.0	32.1	39.2	46.9	50.4	51.4	47.6	37.5	32.5	17.9	35.3
1950	20.1	14.0	32.8	34.9	40.2	47.2	50.6	52.8	47.2	36.2	20.1	20.4	34.9
1951	13.4	23.1	18.5	36.4	41.7	48.2	52.2	52.8	47.5	35.3	30.1	21.3	35.3
1952	14.4	24.5	27.0	33.2	38.6	45.3	52.0	52.5	46.8	39.9	35.2	25.6	36.6
1953	19.0	28.4	26.5	37.1	42.1	52.2	53.9	53.3	47.2	35.8	29.2	27.5	37.5
1954	18.3	14.1	26.5	32.7	43.6	49.2	52.8	52.4	48.5	41.1	32.9	14.6	35.6
1955	27.8	23.5	29.6	32.0	41.5	46.5	51.5	51.6	46.2	35.0	22.3	15.0	35.2
1956	14.1	17.4	22.8	34.1	41.4	46.7	51.5	51.5	44.9	32.3	23.6	14.7	32.9
1957	24.0	20.5	32.9	38.7	43.1	50.6	52.9	53.6	48.6	41.4	37.5	18.7	38.4
1958	26.7	29.1	33.2	38.4	44.4	50.5	53.6	52.7	45.4	34.0	26.7	24.9	38.3
1959	19.6	29.1	17.9	33.8	42.9	49.5	52.0	52.4	46.5	37.7	31.9	23.5	36.4
1960	25.3	30.5	26.3	33.7	45.1	47.9	53.2	50.8	45.9	38.0	27.5	32.6	38.1
1961	27.5	23.0	20.3	35.3	42.9	49.5	52.7	52.1	47.6	33.6	25.0	14.3	35.3
1962	22.3	26.8	24.9	36.3	41.2	48.7	53.0	52.9	43.1	38.8	29.5	23.8	36.8
1963	27.3	27.1	28.7	33.2	43.2	47.1	53.8	53.7	49.7	38.5	20.0	32.3	37.9
1964	24.5	25.9	24.0	34.1	39.0	50.1	51.8	52.7	48.7	38.1	28.6	12.2	35.8
1965	19.4	18.9	39.7	36.0	40.4	45.9	51.1	51.1	50.4	33.0	27.0	18.6	35.1
1966	22.9	23.1	19.1	35.6	39.6	49.4	52.5	52.2	48.5	34.7	27.4	20.6	35.4
1967	18.2	23.4	30.0	36.7	44.3	50.2	55.2	55.0	48.3	37.5	33.0	22.7	37.9
1968	18.7	27.4	30.4	34.2	43.8	48.6	53.4	54.3	49.3	35.3	31.3	15.2	36.6
1969	13.2	22.3	31.4	38.3	43.8	50.9	53.3	50.7	47.1	42.1	27.3	33.4	37.8
1970	16.3	33.3	39.3	35.0	43.6	48.9	51.3	51.3	49.1	34.3	32.9	19.7	37.3
1971	9.7	24.4	18.3	32.9	38.4	46.6	51.6	53.2	45.9	36.8	25.9	23.0	33.9
1972	15.2	19.1	14.0	27.1	40.0	46.6	52.1	53.4	46.5	37.7	30.0	21.7	33.8
1973	11.6	21.8	29.6		41.5	48.2	52.4	51.3	45.8	35.9	22.9	24.6	
1974	14.1	19.5	26.0	36.5	42.7	49.4	52.9	53.9	49.7	38.4	29.7	24.1	38.4
1975	18.6	18.7	26.0	32.7	42.1	47.9	52.9	52.3	47.9	36.9	22.2	19.1	34.8
RECORD MEAN	20.2	24.0	24.7	34.5	42.0	48.6	52.4	52.4	46.9	37.3	28.3	21.8	36.2
MAX	26.8	31.0	34.3	41.8	49.8	56.4	60.2	60.0	54.5	44.1	34.5	27.9	43.4
MIN	13.5	16.9	19.1	27.2	34.1	40.7	44.6	44.8	39.3	30.4	22.0	15.6	29.0

Heating Degree Days

HOMER, AK

Season	July	Aug	Sept	Oct	Nov	Dec	Jan	Feb	Mar	Apr	May	June	Total
1960-61	362	434	564	831	1117	995	1156	1170	1377	884	676	458	10024
1961-62	374	391	514	962	1192	1568	1329	1066	1235	852	732	480	10096
1962-63	365	365	608	809	1059	1275	1160	1056	1121	949	670	530	9966
1963-64	340	344	493	819	1344	1008	1253	1136	1253	920	797	438	10108
1964-65	401	374	482	829	1087	1631	1409	1284	901	861	754	568	10577
1965-66	424	427	430	987	1133	1431	1310	1166	1417	876	780	459	10940
1966-67	380	394	491	932	1118	1368	1444	1157	1077	843	638	438	10278
1967-68	296	302	496	844	953	1307	1423	1085	1066	920	649	452	9793
1968-69	356	327	586	919	1004	1535	1601	1189	1033	796	652	416	10410
1969-70	355	439	530	704	1123	972	1500	884	912	894	658	473	9446
1970-71	419	418	593	949	960	1396	1711	1132	1447	956	820	545	11340
1971-72	409	360	548	866	1168	1297	1538	1324	1509	1128	764	562	11471
1972-73	394	351	546	841	1045	1332	1645	1201			730	488	
1973-74	385	416	568	894	1258	1247	1571	1269	1201	858	886	464	10807
1974-75	368	336	455	817	1052	1261	1439	1293	1199	960	703	506	10389
1975-76	367	387	504	863	1274	1413							

Cooling Degree Days

Year	Jan	Feb	Mar	Apr	May	June	July	Aug	Sept	Oct	Nov	Dec	Total
1969	0	0	0	0	0	0	0	0	0	0	0	0	0
1970	0	0	0	0	0	0	0	0	0	0	0	0	0
1971	0	0	0	0	0	0	0	1	0	0	0	0	1
1972	0	0	0	0	0	0	0	0	0	0	0	0	0
1973	0	0			0	0	0	0	0	0	0	0	0
1974	0	0	0	0	0	0	0	0	0	0	0	0	0
1975	0	0	0	0	0	0	0	0	0	0	0	0	0

Precipitation

Year	Jan	Feb	Mar	Apr	May	June	July	Aug	Sept	Oct	Nov	Dec	Annual
1943	1.09	1.67	0.47	0.98	1.26	0.71	1.58	2.33	3.67	2.53	7.25	3.01	26.46
1944	3.63	1.12	1.46	0.19	1.88	1.46	2.99	3.56	2.21	2.30	4.00	1.80	27.79
1945	4.85	3.97	3.78	0.33	0.42	0.36	1.44	5.30	3.87	6.32	2.92	1.30	34.86
1946	3.37	2.26	1.34	1.20	1.96	0.39	1.64	2.04	2.40	6.80	1.38	1.31	26.09
1947	0.84	1.19	1.53	0.69	0.76	0.30	2.11	2.16	3.64	3.41	2.84	2.78	22.67
1948	2.41	0.53	0.46	0.00	0.70	0.62	3.79	2.28	2.40	3.46	0.95	0.51	19.31
1949	3.88	0.40	2.30	0.90	0.68	2.21	1.65	1.34	3.46	2.66	3.13	2.16	24.35
1950	0.71	0.16	1.08	2.79	0.30	1.40	1.02	1.34	2.63	2.36	0.08	1.46	15.47
1951	1.49	0.90	0.36	1.62	0.16	2.08	0.72	2.14	3.01	1.40	1.14	0.28	15.10
1952	0.69	0.78	0.34	0.66	0.27	0.48	1.69	1.99	2.16	4.59	8.59	5.65	27.87
1953	0.98	3.57	0.21	1.49	2.04	0.74	0.16	4.81	2.43	3.42	2.74	2.20	25.19
1954	1.12	0.76	1.93	0.01	0.43	0.26	1.90	4.13	1.47	4.63	2.44	1.34	20.42
1955	2.09	1.04	0.44	1.10	0.36	2.76	0.92	4.02	1.94	3.71	0.12	2.56	21.06
1956	1.05	0.85	0.70	1.69	1.17	0.52	1.45	2.24	1.81	1.41	2.99	0.16	15.84
1957	0.94	0.83	0.42	0.76	0.37	0.09	2.26	3.04	4.30	3.63	6.00	2.35	24.99
1958	3.74	0.48	1.69	0.88	1.12	1.12	2.48	2.89	2.37	2.08	4.72	1.73	24.62
1959	0.81	1.80	0.62	3.69	0.64	0.12	3.32	1.64	1.88	2.25	3.22	4.27	23.96
1960	2.34	1.31	1.02	1.30	1.37	0.37	2.62	2.48	3.19	2.81	1.35	3.22	25.38
1961	3.62	2.57	0.70	1.47	0.96	0.87	1.40	1.89	5.30	2.12	3.65	1.95	26.50
1962	1.80	0.36	1.46	1.46	1.44	2.47	1.02	0.32	2.18	3.22	2.15	1.48	19.32
1963	2.06	1.50	1.44	0.99	0.42	1.68	1.86	2.20	2.47	3.14	0.45	4.44	22.67
1964	1.02	4.07	0.84	1.22	1.39	0.82	0.95	2.37	1.78	3.27	2.86	0.48	21.09
1965	0.98	0.90	2.30	1.18	1.10	1.79	2.31	2.04	4.51	1.86	1.55	2.62	23.10
1966	1.27	1.08	1.38	0.80	1.47	0.72	2.79	5.25	4.40	2.32	1.32	1.30	24.29
1967	0.94	1.64	0.30	0.73	0.29	1.70	0.86	3.65	5.39	2.39	2.83	3.35	23.97
1968	0.69	1.77	1.79	0.62	1.96	0.39	0.18	1.16	1.80	2.16	1.17	0.69	14.34
1969	0.39	2.34	1.28	0.36	1.22	0.43	1.21	0.96	0.83	8.55	3.81	7.85	29.25
1970	0.42	2.65	2.68	2.05	0.38	0.48	1.25	2.37	1.29	3.69	1.77	1.19	20.18
1971	0.69	3.25	1.37	1.02	1.90	1.17	1.95	1.99	1.59	4.23	1.48	1.69	22.29
1972	0.76	1.03	0.79	1.20	1.03	0.57	0.78	3.41	4.76	3.16	1.89	0.22	19.39
1973	0.94	1.26			2.30	2.03	0.32	2.10	2.82	1.59	1.77	2.01	
1974	0.74	4.30	0.59	1.32	0.08	0.43	1.36	1.96	4.08	3.23	4.56	3.58	26.47
1975	2.50	3.38	1.64	2.17	1.94	0.93	0.99	0.51	3.48	1.90	1.02	4.07	24.93
RECORD MEAN	1.69	1.70	1.22	1.12	0.98	0.95	1.66	2.50	2.89	3.34	2.70	2.38	23.11

Snowfall

Season	July	Aug	Sept	Oct	Nov	Dec	Jan	Feb	Mar	Apr	May	June	Total
1942-43	0.0	0.0	0.0	T	0.8	14.5	12.9	7.5	2.0	T	0.0	0.0	37.7
1943-44	0.0	0.0	0.0	T	8.5	6.5	16.5	5.5	10.7	0.7	0.0	0.0	50.4
1944-45	0.0	0.0	0.0	0.0	0.5	3.0	0.2	20.0	32.0	T	2.0	0.0	63.7
1945-46	0.0	0.0	0.0	T	37.4	11.2	15.4	8.7	10.6	4.4	0.0	0.0	87.9
1946-47	0.0	0.0	0.0	T	1.6	14.3	7.6	6.6	3.1	T	T	0.0	33.2
1947-48	0.0	0.0	0.0	0.4	2.3	24.1	21.7	4.2	8.1	0.0	0.0	0.0	60.8
1948-49	0.0	0.0	0.0	T	2.1	4.0	18.8	4.2	11.1	8.7	2.8	0.0	52.5
1949-50	0.0	0.0	0.0	1.8	2.1	12.5	3.6	T	T	8.3	T	0.0	30.3
1950-51	0.0	0.0	0.0	T	T	12.7	9.3	8.8	4.5	2.5	0.0	0.0	37.8
1951-52	0.0	0.0	0.0	2.2	0.9	4.6	2.2	13.8	5.2	4.1	T	0.0	32.8
1952-53	0.0	0.0	0.0	T	5.6	5.6	4.0	23.0	5.6	0.4	0.0	0.0	44.2
1953-54	0.0	0.0	0.0	1.2	3.0	17.3	13.3	11.1	23.2	T	0.0	0.0	69.1
1954-55	0.0	0.0	0.0	T	1.9	25.0	10.0	8.7	2.5	7.1	0.0	0.0	55.2
1955-56	0.0	0.0	0.0	2.3	1.0	17.2	16.9	12.4	9.6	8.1	T	0.0	67.5
1956-57	0.0	0.0	T	2.0	9.3	3.1	3.0	13.0	T	T	0.0	0.0	30.4
1957-58	0.0	0.0	0.0	0.0	1.6	11.0	29.5	1.3	2.3	T	T	0.0	45.7
1958-59	0.0	0.0	0.0	1.3	12.6	3.9	7.4	13.3	10.0	2.2	0.0	0.0	52.9
1959-60	0.0	0.0	0.0	0.5	2.9	44.2	10.3	8.5	1.5	5.7	0.0	0.0	74.6
1960-61	0.0	0.0	0.0	0.3	10.8	3.3	3.1	33.6	9.3	0.9	0.0	0.0	61.3
1961-62	0.0	0.0	0.0	11.5	17.6	13.8	33.8	6.3	14.0	1.0	0.0	0.0	98.2
1962-63	0.0	0.0	0.5	7.8	8.1	5.5	11.6	6.0	24.0	4.7	T	T	68.2
1963-64	0.0	0.0	0.0	T	1.8	4.2	3.9	16.4	8.1	4.6	3.0	0.0	44.0
1964-65	0.0	0.0	0.0	1.6	10.3	6.4	4.4	17.2	3.1	1.5	0.8	0.0	45.3
1965-66	0.0	0.0	T	3.7	11.4	12.0	8.1	14.8	13.0	2.0	T	0.0	63.0
1966-67	0.0	0.0	0.0	2.5	2.7	15.0	8.1	11.8	T	2.0	0.0	0.0	42.1
1967-68	0.0	0.0	0.0	4.9	0.8	8.3	4.6	4.5	14.8	4.0	1.9	0.0	43.8
1968-69	0.0	0.0	0.4	2.0	5.6	19.3	8.7	25.0	9.8	0.9	0.0	0.0	72.1
1969-70	0.0	0.0	0.0	0.0	8.8	24.1	6.3	5.3	3.0	1.0	0.0	0.0	50.7
1970-71	0.0	0.0	0.0	3.6	8.7	16.4	8.6	21.2	28.6	10.8	0.6	0.6	96.5
1971-72	0.0	0.0	0.0	1.7	14.9	17.1	15.8	12.2	12.5	17.4	1.6	0.0	95.2
1972-73	0.0	0.0	0.0	T	6.5	1.9	9.6	5.3			0.0	0.0	
1973-74	0.0	0.0	0.0	T	20.5	6.0	8.9	46.0	8.1	4.5	0.0	0.0	92.0
1974-75	0.0	0.0	0.0	T	18.0	38.3	16.3	18.9	17.1	9.6	1.0	0.0	119.2
1975-76	0.0	0.0	0.0	0.0	4.4	16.5							
RECORD MEAN	0.0	0.0	T	1.6	7.0	13.2	10.7	13.0	9.6	3.6	0.6	T	59.3

# Indicates a station move or relocation of instruments. See Station Location table.

Record mean values above are means through the current year for the period beginning in 1943.

U.S. DEPARTMENT OF COMMERCE
NATIONAL OCEANIC AND ATMOSPHERIC ADMINISTRATION
ENVIRONMENTAL DATA SERVICE

JOB NO. 54843

SEASONAL AND ANNUAL
WIND DISTRIBUTION BY PASQUILL STABILITY CLASSES (5)
STAR PROGRAM

STATION: #25507 Homer, AK

PERIOD: 1/66-12/70

SOURCE: TDF 1440

DATE Jun 5, 1978

NATIONAL CLIMATIC CENTER

FEDERAL BUILDING, ASHEVILLE, N.C.

NOAA Form 47-318
(Rev. 7/75)

U.S. COMM-NOAA-ASHEVILLE

ANNUAL RELATIVE FREQUENCY DISTRIBUTION STATION #25507 HOMER, AK 8DBS 1966-70

SPEED(KTS)

DIRECTION	0 - 3	4 - 6	7 - 10	11 - 16	17 - 21	GREATER THAN 21	TOTAL
N	0.000000	0.000000	0.000000	0.000000	0.000000	0.000000	0.000000
NNE	0.000000	0.000000	0.000000	0.000000	0.000000	0.000000	0.000000
NE	0.000000	0.000000	0.000000	0.000000	0.000000	0.000000	0.000000
ENE	0.000000	0.000000	0.000000	0.000000	0.000000	0.000000	0.000000
E	0.000000	0.000000	0.000000	0.000000	0.000000	0.000000	0.000000
ESE	0.000000	0.000000	0.000000	0.000000	0.000000	0.000000	0.000000
SE	0.000000	0.000000	0.000000	0.000000	0.000000	0.000000	0.000000
SSE	0.000000	0.000000	0.000000	0.000000	0.000000	0.000000	0.000000
S	0.000000	0.000000	0.000000	0.000000	0.000000	0.000000	0.000000
SSW	0.000000	0.000000	0.000000	0.000000	0.000000	0.000000	0.000000
SW	0.000000	0.000000	0.000000	0.000000	0.000000	0.000000	0.000000
WSW	0.000000	0.000000	0.000000	0.000000	0.000000	0.000000	0.000000
W	0.000000	0.000000	0.000000	0.000000	0.000000	0.000000	0.000000
WNW	0.000000	0.000000	0.000000	0.000000	0.000000	0.000000	0.000000
NW	0.000000	0.000000	0.000000	0.000000	0.000000	0.000000	0.000000
NNW	0.000000	0.000000	0.000000	0.000000	0.000000	0.000000	0.000000
TOTAL	0.000000	0.000000	0.000000	0.000000	0.000000	0.000000	

RELATIVE FREQUENCY OF OCCURRENCE OF A STABILITY = 0.000000

RELATIVE FREQUENCY OF CALMS DISTRIBUTED ABOVE WITH A STABILITY = 0.000000

ANNUAL RELATIVE FREQUENCY DISTRIBUTION STATION =25507 HOMER, AK BOBS 1966-70

SPEED(KTS)

DIRECTION	0 - 3	4 - 6	7 - 10	11 - 16	17 - 21	GREATER THAN 21	TOTAL
N	0.000108	0.000000	0.000000	0.000000	0.000000	0.000000	0.000108
NNE	0.000324	0.000000	0.000000	0.000000	0.000000	0.000000	0.000324
NE	0.000324	0.000000	0.000000	0.000000	0.000000	0.000000	0.000324
ENE	0.000036	0.000072	0.000072	0.000000	0.000000	0.000000	0.000180
E	0.000432	0.000216	0.000072	0.000000	0.000000	0.000000	0.000720
ESE	0.000648	0.000216	0.000000	0.000000	0.000000	0.000000	0.000864
SE	0.000144	0.000072	0.000072	0.000000	0.000000	0.000000	0.000288
SSE	0.000648	0.000648	0.000000	0.000000	0.000000	0.000000	0.001297
S	0.001333	0.000504	0.000432	0.000000	0.000000	0.000000	0.002269
SSW	0.000684	0.000937	0.001009	0.000000	0.000000	0.000000	0.002629
SW	0.000648	0.000648	0.000144	0.000000	0.000000	0.000000	0.001441
WSW	0.000252	0.000288	0.000216	0.000000	0.000000	0.000000	0.000756
W	0.000216	0.000000	0.000144	0.000000	0.000000	0.000000	0.000360
WNW	0.000108	0.000000	0.000000	0.000000	0.000000	0.000000	0.000108
NW	0.000108	0.000000	0.000000	0.000000	0.000000	0.000000	0.000108
NNW	0.000036	0.000072	0.000000	0.000000	0.000000	0.000000	0.000108
TOTAL	0.006051	0.003674	0.002161	0.000000	0.000000	0.000000	

RELATIVE FREQUENCY OF OCCURRENCE OF B STABILITY = 0.011887

RELATIVE FREQUENCY OF CALMS DISTRIBUTED ABOVE WITH B STABILITY = 0.003242

ANNUAL RELATIVE FREQUENCY DISTRIBUTION STATION #25507 HOMER, AK 8005 1966-70

SPEED(KTS)

DIRECTION	0 - 3	4 - 6	7 - 10	11 - 16	17 - 21	GREATER THAN 21	TOTAL
N	0.002066	0.000504	0.000288	0.000000	0.000000	0.000000	0.002859
NNE	0.002984	0.001729	0.001009	0.000000	0.000000	0.000000	0.005721
NE	0.001948	0.001801	0.001441	0.000000	0.000000	0.000000	0.005189
ENE	0.001948	0.001801	0.003170	0.000000	0.000000	0.000000	0.006918
E	0.002894	0.003746	0.001729	0.000000	0.000000	0.000000	0.008369
ESE	0.001270	0.001729	0.001369	0.000000	0.000000	0.000000	0.004368
SE	0.000989	0.001153	0.000504	0.000000	0.000000	0.000000	0.002646
SSE	0.000738	0.001297	0.000504	0.000000	0.000000	0.000000	0.002539
S	0.002396	0.003602	0.002666	0.000072	0.000000	0.000000	0.008735
SSW	0.002180	0.003818	0.007636	0.000144	0.000000	0.000000	0.013778
SW	0.001061	0.001081	0.007132	0.000792	0.000000	0.000000	0.010067
WSW	0.001772	0.001441	0.008213	0.001441	0.000000	0.000000	0.012867
W	0.000567	0.000504	0.000864	0.000144	0.000000	0.000000	0.002080
WNW	0.000319	0.000216	0.000216	0.000072	0.000000	0.000000	0.000824
NW	0.000000	0.000000	0.000216	0.000000	0.000000	0.000000	0.000216
NNW	0.000785	0.000072	0.000360	0.000000	0.000000	0.000000	0.001217
TOTAL	0.023918	0.024494	0.037317	0.002666	0.000000	0.000000	

RELATIVE FREQUENCY OF OCCURRENCE OF C STABILITY = 0.088394

RELATIVE FREQUENCY OF CALMS DISTRIBUTED ABOVE WITH C STABILITY = 0.015049

ANNUAL RELATIVE FREQUENCY DISTRIBUTION STATION =25507 HOMER, AK 0085 1966-70

SPEED(KTS)

DIRECTION	0 - 3	4 - 6	7 - 10	11 - 16	17 - 21	GREATER THAN 21	TOTAL
N	0.014098	0.028744	0.012391	0.004899	0.000937	0.000792	0.061862
NNE	0.015361	0.034652	0.030041	0.014048	0.001729	0.000144	0.095975
NE	0.007452	0.020243	0.026007	0.017434	0.002305	0.000432	0.073874
ENE	0.004262	0.012319	0.015129	0.012391	0.002666	0.001225	0.047991
E	0.003582	0.008429	0.012607	0.009365	0.001369	0.000216	0.035568
ESE	0.001862	0.004322	0.007276	0.005979	0.000792	0.000144	0.020376
SE	0.001187	0.003026	0.003962	0.007420	0.001657	0.000504	0.017756
SSE	0.001577	0.003890	0.004178	0.006412	0.000792	0.000000	0.016850
S	0.004617	0.009365	0.009149	0.006484	0.000360	0.000000	0.029975
SSW	0.003536	0.010446	0.013904	0.009509	0.000360	0.000144	0.037900
SW	0.004482	0.011382	0.022117	0.021684	0.001873	0.000144	0.061682
WSW	0.006163	0.016065	0.027159	0.031050	0.001873	0.000144	0.082454
W	0.003980	0.007492	0.010158	0.004755	0.000288	0.000072	0.026745
WNW	0.002148	0.004394	0.002449	0.002017	0.000144	0.000000	0.011154
NW	0.002299	0.002810	0.002521	0.001585	0.000360	0.000072	0.009647
NNW	0.004006	0.005763	0.003098	0.002161	0.000288	0.000288	0.015605
TOTAL	0.080614	0.183344	0.202146	0.157193	0.017794	0.004322	

RELATIVE FREQUENCY OF OCCURRENCE OF D STABILITY = 0.645415

RELATIVE FREQUENCY OF CALMS DISTRIBUTED ABOVE WITH D STABILITY = 0.051797

ANNUAL RELATIVE FREQUENCY DISTRIBUTION STATION =25507 HOMER, AK 80BS 1966-70

SPEED(KTS)

DIRECTION	0 - 3	4 - 6	7 - 10	11 - 16	17 - 21	GREATER THAN 21	TOTAL
N	0.020401	0.045818	0.009005	0.000000	0.000000	0.000000	0.075224
NNE	0.013982	0.041712	0.016353	0.000000	0.000000	0.000000	0.072047
NE	0.004656	0.012535	0.004899	0.000000	0.000000	0.000000	0.022089
ENE	0.001447	0.003026	0.001441	0.000000	0.000000	0.000000	0.005914
E	0.000862	0.001945	0.000432	0.000000	0.000000	0.000000	0.003239
ESE	0.000291	0.000937	0.000216	0.000000	0.000000	0.000000	0.001444
SE	0.000182	0.000432	0.000288	0.000000	0.000000	0.000000	0.000902
SSE	0.000301	0.000576	0.000144	0.000000	0.000000	0.000000	0.001021
S	0.000833	0.001009	0.000864	0.000000	0.000000	0.000000	0.002706
SSW	0.000689	0.001153	0.000720	0.000000	0.000000	0.000000	0.002562
SW	0.000862	0.001945	0.001657	0.000000	0.000000	0.000000	0.004464
WSW	0.002718	0.005763	0.002954	0.000000	0.000000	0.000000	0.010935
W	0.002657	0.005763	0.002305	0.000000	0.000000	0.000000	0.010725
WNW	0.003803	0.006196	0.000648	0.000000	0.000000	0.000000	0.010647
NW	0.002591	0.006268	0.001297	0.000000	0.000000	0.000000	0.010155
NNW	0.005821	0.012247	0.002161	0.000000	0.000000	0.000000	0.020229
TOTAL	0.061595	0.147323	0.045386	0.000000	0.000000	0.000000	

RELATIVE FREQUENCY OF OCCURRENCE OF E STABILITY = 0.254304

RELATIVE FREQUENCY OF CALMS DISTRIBUTED ABOVE WITH E STABILITY = 0.037317

ANNUAL RELATIVE FREQUENCY DISTRIBUTION STATION #25507 HOMER, AK BOAS 1966-70

SPEED(KTS)

DIRECTION	0 - 3	4 - 6	7 - 10	11 - 16	17 - 21	GREATER THAN 21	TOTAL
N	0.038754	0.075067	0.021684	0.004899	0.000937	0.000792	0.142133
NNE	0.034100	0.078092	0.047403	0.014048	0.001729	0.000144	0.175516
NE	0.014550	0.034580	0.032346	0.017434	0.002305	0.000432	0.101647
ENE	0.007392	0.017218	0.019811	0.012391	0.002666	0.001225	0.060702
E	0.006836	0.014336	0.014840	0.009365	0.001369	0.000216	0.046962
ESE	0.003563	0.007204	0.008861	0.005979	0.000792	0.000144	0.026544
SE	0.002194	0.004683	0.004827	0.007420	0.001657	0.000504	0.021284
SSE	0.002817	0.006412	0.004827	0.006412	0.000792	0.000000	0.021260
S	0.008139	0.014480	0.013111	0.006556	0.000360	0.000000	0.042647
SSW	0.006085	0.016353	0.023269	0.009653	0.000360	0.000144	0.055865
SW	0.006749	0.015057	0.031050	0.022477	0.001873	0.000144	0.077349
WSW	0.010281	0.023557	0.038542	0.032490	0.001873	0.000144	0.106888
W	0.007593	0.013760	0.013472	0.004899	0.000288	0.000072	0.040083
WNW	0.006656	0.010806	0.003314	0.002089	0.000144	0.000000	0.023009
NW	0.005309	0.009077	0.004034	0.001585	0.000360	0.000072	0.020437
NNW	0.011160	0.018154	0.005619	0.002161	0.000288	0.000288	0.037672
TOTAL	0.172177	0.358835	0.287011	0.159858	0.017794	0.004322	

TOTAL RELATIVE FREQUENCY OF OBSERVATIONS = 1.000001

TOTAL RELATIVE FREQUENCY OF CALMS DISTRIBUTED ABOVE = 0.108205

APPENDIX C

Key Information Sources

The Kenai Peninsula and Cook Inlet have been the subject of numerous studies and a large body of information has been amassed. Additional investigations currently are underway and, undoubtedly, more will be conducted in the future. This appendix will describe five important sources of information which discuss a variety of available data sources. Essentially annotated bibiliographies, these sources can provide valuable assistance in obtaining information regarding a specific project or location.

Current Research Profile for Alaska

The Current Research Profile for Alaska is prepared by the Arctic Environmental Information and Data Center (AEIDC), Anchorage, Alaska. It lists research in the physical, biological, and social sciences on a yearly basis. The fifth edition was issued in 1978 and covered studies conducted in 1977. Each entry includes the following information:

- Principal investigator, affiliation, address, and telephone number
- Co-investigator and affiliation
- Fund agency, funding period, and funding amount
- Geographic location of research site
- Objectives of research.

Geographic locations are listed as "Statewide", if appropriate, or are included in one of 7 major geographic regions. Four indexes are provided in the fifth edition. These include an investigator index, an affiliation index, a funding source index, and a general key word index. Information for inclusion in the document is obtained through contacts with investigators and program managers with Alaskan, out-of-state, and foreign organizations and with investigators listed with the Smithsonian Science Information Exchange and the US National Oceanographic Data Center's OASIS/ENDEX system.

Entries are assigned to the following 27 categories:

Atmosphere	Birds
Geology	Fish
Geomorphology	Marine invertebrates
Minerals and fossil fuel	Mammals, marine
Seismology	Mammals, terrestrial
Glaciology	Agriculture
Snow	Archaeology
Permafrost	Socio-cultural
Hydrology	Land use planning
Oceanography	Economics
Limnology	Technology
Botany	Water supply and utility systems
F[illegible]try	Transportation
S[illegible]s	

The Current Research Profile for Alaska is an excellent source of information on current research. Searches for information regarding specific geographic areas take some time, however, because the entries are not grouped into listings by location. The usefulness of this publication is not impaired greatly by this minor shortcoming.

Bibliography of Products - Alaska Coastal Management Program, Office of Coastal Management

This document is another publication of the Alaska Environmental Information and Data Center (AEIDC), Anchorage, Alaska. Issued in 1978, it lists the products available from a variety of programs.

Kenai Resource Inventory

This publication, dated 1977, was prepared by Mr. Roger Maggard under the auspices of the Western Interstate Commission for Higher Education, Boulder, Colorado, through an internship program with the State of Alaska, Department of Natural Resources. It is an annotated bibliography that lists sources of information relating to the Kenai Peninsula Borough. The sources are organized into 8 categories. These include:

- Socioeconomic characteristics
- Recreation
- Forestry
- Hydrology
- Land status
- Fish and wildlife
- Soils
- Geology.

The Kenai Resource Inventory especially is useful for data searches relating to projects in the Kenai Peninsula Borough.

Annotated Bibliography of Writings in the Kenai Peninsula Borough Planning Department Library

Published in December, 1977, this document contains an annotated listing of materials in the Kenai Peninsula Borough Planning Department Library. It is arranged in a topical sequence and is divided into six categories:

- o Land use
- o Natural resources and environment
- o Public facilities and services
- o Demography
- o Government, law, and public policy
- o Miscellaneous and interdisciplinary.

The majority of the sources listed in this document especially are pertinent to the Kenai Peninsula Borough. In addition to making a searcher aware of sources of data, this publication indicates that the

sources are available in the library of the Kenai Planning Department. There is significant overlap between the listings in this document and those in the Kenai Resource Inventory.

Alaska OCS Socioeconomic Studies Program, Literature Survey

This report was prepared for the US Department of the Interior, Bureau of Land Management, Alaska Outer Continental Shelf Office, and was issued in April 1977. It focuses on literature pertinent to developmental activities affecting the Alaskan Outer Continental Shelf (OCS). The report is organized in sixteen category chapters, including the following:

- Economy
- Oil and gas resources
- Population
- Revenue and taxation
- Government
- Education
- Health
- Social services
- Public safety
- Cultural patterns
- Subsistence
- Land use and land status
- Transportation, communications, utilities
- Housing
- Archaeological/historical and recreational/scenic resources
- Natural constraints to development

Discussions also are organized by regions. These are the Beaufort Sea Region, the Bering Sea Region, the Southwestern Region, and the Gulf of Alaska Region. Literature of statewide importance also is covered. Subject chapter and master bibliographies are provided. Material is indexed by subject, key word, and by region. An important item included in this document is a discussion of data gaps for each of the subject chapter topics. Although these gaps are those that are pertinent to the Alaska OCS Socioeconomic Studies Program, they indicate areas of information that lack documentation.

There undoubtedly are other important bibliographies that address key studies and information sources for the State of Alaska. In addition, the key agency contacts discussed elsewhere in this document can be valuable sources of information or current and proposed studies and reports. A combination of personal contacts with these, and other, individuals and use of literature surveys and bibliographies will be a most effective method of obtaining information relevant to specific projects and geographical areas.

APPENDIX D

NPDES Permit Holders in the Lower Cook Inlet Study Area

Current NPDES permit holders in the Lower Cook Inlet study area were determined by a review of the May, 1979, Permits Issuance Tracking System listing prepared by Region X, USEPA. The majority of permits were issued for three main activities: seafood processing; petroleum and natural gas-related industries; and, municipal wastewater treatment plant discharges. Appendix D presents NPDES permit holders by subarea. Land-based operations were relatively easy to identify. The situation regarding offshore permit holders (i.e., mobile drilling platforms) is not as clear. These platforms are moved periodically and it is not possible to determine exact locations from the permit tracking system. Therefore, the permit holders listed are those that appear most likely to be operating in the Lower Cook Inlet study area, based on information available from the permit tracking system and from knowledge of the study area. It is probable that most, or all, of the offshore operations are conducted in Subarea VII. Numerous offshore petroleum production platforms are located immediately north of the study area, especially in the Trading Bay area. NPDES permit information for those facilities is not included in this report, but is listed in the Permits Issuance Tracking System.

Additional information is available from the latest edition of the Permits Issuance Tracking System and from the individual permit files of USEPA. Specific data concerning permits and permit holders may be obtained from these sources.

SUBAREA 1 - Current NPDES Permit Holders

Permit ID #	Name	Location	Source Activity
AK0000027	Kenai Salmon Packing Co.	Kenai AK	Seafood processing
AK0000167	Chevron USA, Inc.	Kenai AK	Petroleum
AK0000507	Union Chemical Div. of Union Oil	Kenai AK	Chemicals
AK0000841	Tesoro-Alaskan Petroleum Corp.	Kenai AK	Petroleum
AK0001058	Kenai Pipeline Co.	Kenai AK	Petroleum
AK0001155	Phillips Petroleum Co.	Kenai AK	Petroleum
AK0020036	City of Soldotna	Soldotna AK	Municipal wastewater
AK0021377	City of Kenai	Kenai AK	Municipal wastewater
AK0024511	Sea Catch, Inc.	Soldotna AK	Seafood processing
AK0024554	Union Oil Co.	Soldotna AK	Petroleum
AK0027294**	Salamatof Seafoods, Inc.	Kenai AK	Seafood processing
AK0000566	Columbia-Wards Fisheries	Kenai AK	Seafood processing

**Permit applied for - pending issuance

SUBAREA II - Current NPDES Permit Holders

Permit ID #	Name	Location	Source Activity
AK0000159	Seward Fisheries	Ninilchik AK	Seafood processing
AK0000639	Seward Fisheries	Homer AK	Seafood processing
AK0001007	Whitney Fidalgo Seafoods	Homer AK	Seafood processing
AK0021245	City of Homer	Homer AK	Municipal wastewater

SUBAREA IV Current NPDES Permit Holders

AK0001031	Whitney Fidalgo Seafoods	Port Graham AK	Seafood processing
AK0021512	City of Seldovia	Seldovia AK	Municipal wastewater
AK0026743**	S-A Packers	Seldovia AK	Seafood processing
AK0028347***	Pacific Pearl Seafoods	Seldovia AK	Seafood processing

**Permit application only

***Permit application and new source determination completed - determined to be existing source

SUBAREA V - Current NPDES Permit Holders

Permit ID #	Name	Location	Source Activity
AK0000396	Cook Inlet Pipeline Co.	Drift River Terminal	Petroleum
AK0023337	Cook Inlet Pipeline Co.	Drift River Terminal	Petroleum

SUBAREA VI - Current NPDES Permit Holders

AK0021849	Snug Harbor Packing Co.	Chisik Island	Seafood processing

OFFSHORE - Current NPDES Permit Holders

AK0024635	Phillips Petroleum Co.	Offshore	Petroleum
AK0025208	Amarex, Inc.	Offshore	Petroleum
AK0027553**	Japan Drilling Company	Offshore	Petroleum
AK0028169	Global Marine Drilling, Inc.	Offshore	Petroleum
AK0028177	Odeco, Inc.	Offshore	Petroleum
AK0028185	Odeco, Inc.	Offshore	Petroleum
AK0028215	Global Marine Drilling, Inc.	Offshore	Petroleum
AK0028223	Marathon Oil Co.	Offshore	Petroleum
AK0028231	Japan Drilling Company	Offshore	Petroleum

**Permit application and draft permit complete - permit issuance pending

OFFSHORE - Current NPDES Permit Holders (concluded).

Permit ID #	Name	Location	Source Activity
AK0028240	Japan Drilling Company	Offshore	Petroleum
AK0028258	Global Marine Drilling, Inc.	Offshore	Petroleum
AK0028266	Global Marine Drilling, Inc.	Offshore	Petroleum
AK0028274	Exxon Corp.	Offshore	Petroleum
AK0028282	Western Offshore Drilling	Offshore	Petroleum
AK0028495**	Diamond M "General"	Offshore	Petroleum

**Draft permit complete; determined to be existing source - permit issuance pending