Chapter Three: Description of the Cook Inlet Lease Sale Area

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Chapter Three: Description of the Cook Inlet Lease Sale Area

A. Property Description

1. Area Included in the Lease Sale

The Cook Inlet Areawide oil and gas lease sale area (Figure 2.1) consists of state-owned uplands located in the Matanuska and Susitna river valleys generally south and west of Houston and Wasilla, the Anchorage Bowl, the western and southern Kenai Peninsula from Point Possession to Anchor Point, and the western shore of Cook Inlet from the Beluga River to Harriet Point. The lease sale area also includes the tide and submerged lands in upper Cook Inlet from Knik Arm and Turnagain Arm south to Anchor Point and Tuxedni Bay. The area is bounded on the east by the Chugach and Kenai mountains and on the west by the Aleutian Range. The area is about 4.2 million acres and is divided into 815 tracts ranging from 640 to 5,760 acres.

L. Silliphant, DO&G

West side of Cook Inlet, Beluga River area.

The Cook Inlet area is used extensively for recreation, for subsistence and sport fishing, hunting and gathering, and for commercial and personal use fishing. Five species of Pacific salmon are fished throughout Cook Inlet, and numerous important anadromous fish streams are found within the lease sale area. The area provides important habitats for moose, black and brown bear, caribou, and waterfowl. Marine mammals found near or within the area include beluga whales, Steller sea lions, sea otters, and harbor seals. Species listed as threatened or endangered under the Endangered Species Act that inhabit the lease sale area include the Steller sea lion (threatened east of 144° longitude and endangered west of 144° longitude), the Steller’s eider (Alaska breeding population, threatened), and Cook Inlet beluga whale (endangered). Steller sea lions and Steller’s eiders are also listed as species of special concern by the state, as are olive-sided flycatcher, Gray-cheeked thrush, Townsend's warbler, Blackpoll warbler, Kenai Peninsula brown bear, harbor seal, beluga whale, and sea otter.

A number of state and federal wildlife refuges, critical habitat areas, recreation areas, and parks exist within or near the lease sale area. These areas encompass important fish and wildlife habitat, and have significant scenic and recreational value.

The Cook Inlet Areawide lease sale area is located within the boundaries of the Matanuska-Susitna Borough, the Municipality of Anchorage, and the Kenai Peninsula Borough. The boroughs and municipality have the powers of taxation, land management and zoning and are responsible for providing their communities with public works, utilities, education, health, and other public services. Over half of the population of the state resides in the area, and the region is the industrial and business center for Alaska. All have approved coastal management plans, which are incorporated in the Alaska Coastal Management Program.

2. Land and Mineral Ownership

The Alaska Statehood Act allowed the State of Alaska to select 102.5 million acres of land from the federal public domain as an economic base for the new state. The Act also granted to Alaska the right to all minerals underlying these selections and specifically required the state to retain this mineral interest when conveying the land (AS 38.05.125). Consequently, when state land is conveyed to an individual citizen, local government, or other entity, state law requires that the deed reserve the mineral rights to the state. There are a few exceptions. ANCSA, passed by Congress in 1971, allowed newly created regional Native corporations to select and obtain from the federal domain both the land and the mineral rights within Native corporation boundaries as an economic base. It also allowed for Native village corporations and individual Native Alaskans to receive land for their economic benefit.

The uplands in the lease sale area are a complex mosaic of ownership. The predominant landowners are the federal and state governments. Other institutional land owners include the Matanuska-Susitna Borough, Municipality of Anchorage, Kenai Peninsula Borough, Cook Inlet Region Incorporated, village corporations, Mental Health Trust, and the University of Alaska. Private land holdings include subdivisions, homesites, Native allotments, and homesteads.

The Cook Inlet Areawide lease sale contains tracts in which the state owns both the land estate and the mineral estate; and tracts where the state owns just the mineral estate, while the land estate might be either privately owned or owned by a municipality. Only those free and unencumbered state-owned oil and gas mineral estates within the tracts will be included in any lease issued.

B. Historical Background

At the time of first European contact, Tanaina Indians occupied the Cook Inlet area. Evidence from the Yukon Island site in Kachemak Bay shows that lower Cook Inlet was occupied by Eskimos from about 1500 BC to 1000 AD and then by Athabaskan Indians, probably the ancestors of the Tanaina who moved into the coastal area from the Interior (Selkregg 1975).

Example of Alaska Native fish traps, 1902.

Tanaina Indian groups entered the Cook Inlet subregion through the Alaska Range from the west, primarily through Rainy, Merrill, and Lake Clark passes, and continued this southeastward migration until most of their villages were located on or near the major salmon producing streams of Cook Inlet (Selkregg 1975). Tanaina villages consisted of four or five large semi-subterranean log structures; each occupied by several nuclear families belonging to the same clan. Clan dwellings were occupied throughout the winter and early spring. During the summer, families relocated to fish camps. In late summer and early fall, hunting groups traveled to the mountains, and occupied traditional, temporary campsites along established travel routes (ADF&G 1985).

Captain Cook’s 1778 expedition into Cook Inlet made contact with the Tanaina, but Russian fur traders and missionaries of the Russian Orthodox Church were the first to establish non-Native outposts in the region in the late eighteenth and early nineteenth centuries. These religious and cultural ties continue today. The Russian foothold in Cook Inlet survived early Tanaina resistance and hostilities, and eventually gained some acceptance. Epidemics devastated the Tanaina population during the 1830s. Survivors commonly abandoned traditional villages and concentrated in settlements at places such as Knik, Susitna Station and Tyonek (ADF&G 1985). The Russian period lasted until 1867 when Alaska was purchased by the United Sates.

The introduction of the tin can dramatically changed salmon processing and shipping, providing the impetus for large commercial salmon fisheries. A cannery was established at Kasilof in 1882, and a saltery built near Tyonek serviced the emerging Cook Inlet commercial fishing industry (ADF&G 1985). In the first 20 years of the 20^{th} century, canneries were established throughout coastal Alaska (Selkregg 1975).

The gold rush brought prospectors to mining districts in Alaska, but most of the Cook Inlet area was inaccessible and settlement of the area was sparse. Construction of the Alaska Railroad brought large numbers of construction workers into the Cook Inlet area. Anchorage at Ship Creek was founded as a railroad construction camp in 1914. Fish camps in the Anchorage area were also in use by local residents. By the time the railroad was completed in 1923 many more settlers had arrived from Europe and the United States. However, many of these newly arrived residents left Alaska in 1917 to fight in World War I and did not return (Selkregg 1975).

Anchorage Harbor and mouth of Ship Creek, 1921.

Anchorage Museum, AMRC-b75-134-9.

Population growth in the Cook Inlet area remained slow until World War II. A major influx of settlers colonized the Matanuska Valley in 1935 to create a farming community. Although the early settlers experienced many hardships, several thriving dairy farms were eventually founded to meet local residents' needs. The community of Palmer rapidly emerged as the center of the colony (Selkregg 1975).

The establishment of military bases at Anchorage in 1940 brought the first significant wave of migration to Alaska since the building of the railroad (Selkregg 1975). Base construction activities and newly stationed troops caused Anchorage's population to triple between 1940 and 1945. Because Anchorage was the state's transportation and financial hub, it benefited from economic activity anywhere in the state (ADF&G 1985).

The completion of the Glenn Highway in 1942, the Sterling and Seward highways in 1950 and 1951, and the George Parks Highway in 1971 opened central Alaska to fishing, hunting and tourism. A lucrative king crab fishery emerged in Kodiak in the 1950s, providing the necessary economic base for the development of other fisheries in shrimp and tanner crab, in addition to salmon. Oil was found on the Kenai Peninsula in 1957. The city of Kenai and the surrounding area immediately began a period of rapid growth. In 1958, convinced that the territory of Alaska had the resources to sustain its people, Congress passed the Statehood Act, making Alaska the 49^{th} state admitted to the Union. Oil development in Cook Inlet increased with the building of offshore platforms north of the Forelands between 1966 and 1968 (Selkregg 1975).

On March 27 (Good Friday), 1964, a magnitude 9.2 earthquake devastated coastal Alaska. Communities reconstructed and relocated with federal assistance. The discovery of oil at Prudhoe Bay in 1968 initiated another wave of settlement. Construction of the Trans-Alaska Pipeline in the 1970s fueled the growth of service-related industries, financial institutions, government, and in more recent years, tourism, by providing funding for government services and the construction of roads, docks, and airports (Selkregg 1975).

To expedite construction of the Trans-Alaska Pipeline which would be used to carry oil from Prudhoe Bay to Valdez, Congress passed ANCSA in 1971, granting title to more than 40 million acres of land and providing more than $900 million to Alaska Natives. The Act also set up corporate ownership of assets with Native residents as shareholders.

In 1980, the state legislature amended the state constitution, requiring that one quarter of all mineral lease rentals, royalties, royalty sales proceeds, federal mineral revenue sharing payments, and bonuses received by the state be placed in the Alaska Permanent Fund, the principal of which may only be used for income-producing investments (APFC 2005). Realized income from the fund’s investments may be appropriated by the legislature for dividends, inflation proofing, and other purposes the legislature designates. With the passing of the Alaska National Interest Lands Conservation Act (ANILCA) of 1980, Congress set aside more than 100 million acres of Alaska for national wildlife refuges, national wild and scenic rivers, national forests and national parks (ADF&G 1985). The population of Alaska has grown from 103,000 in 1946 to more than 670,000 in 2006 (USCB 2007; ADF&G 1985).

C. Boroughs and Communities Within the Lease Sale Area

The Cook Inlet Areawide lease sale area falls within the Matanuska-Susitna Borough, the Municipality of Anchorage, and the Kenai Peninsula Borough (Figure 2.1). The area includes about thirty cities, towns, villages and communities, ranging in population from a few hundred to almost 300,000 (Table 3.1).

The population of Alaska has been increasing steadily since 1990, and the total population was about 670,000 in 2006 (Figure 3.1). Over 60 percent of the population, or over 400,000 people, lives in the Matanuska-Susitna Borough, the Municipality of Anchorage, and the Kenai Peninsula Borough combined (Figure 3.2; USCB 2007). Demographically, almost 70 percent of Alaska’s population is white, and 15.6 percent is American Indian or Alaska Native, but characteristics of the Cook Inlet area boroughs and municipality are somewhat different (Table 3.2; USCB 2001).

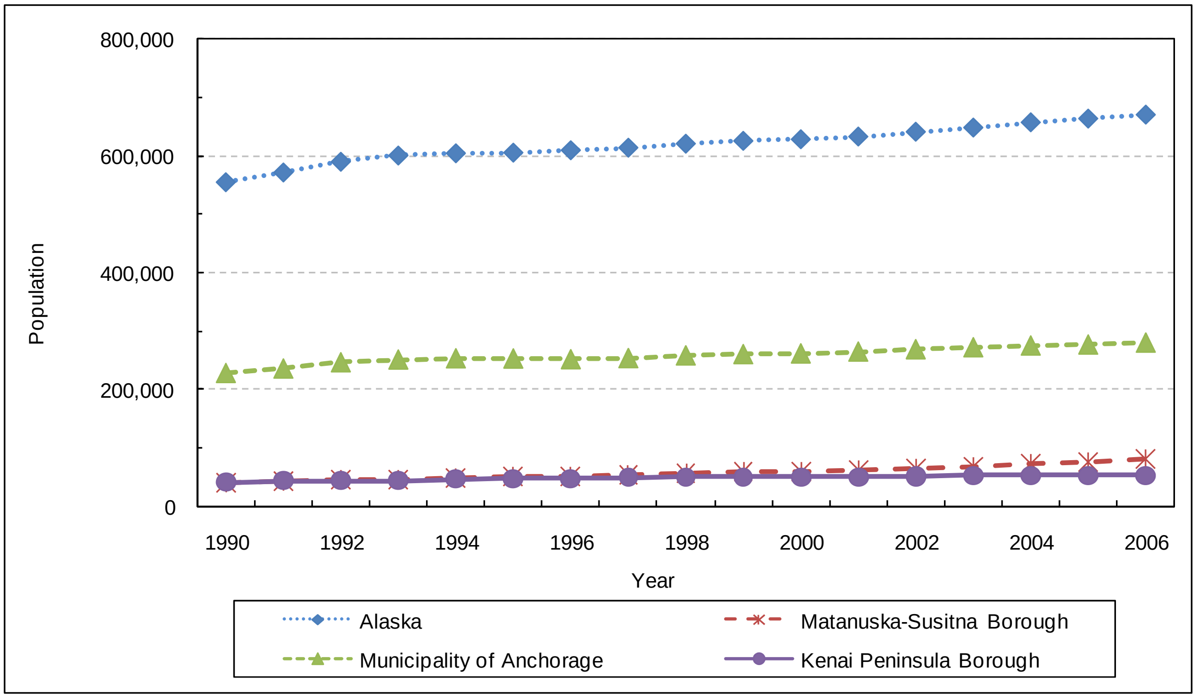
Many of the industries and businesses of the Cook Inlet area are supported directly or indirectly by natural resources of the area. Industries include fishing and fish processing, fishing and hunting guide and taxi services, timber harvesting and restoration, mining and reclamation, agriculture, mariculture, tourism by residents and non-residents, transportation, public works construction, trade, private commercial and residential development, and petroleum exploration, development, production, transportation, and support services. Additionally, local, state and federal governments, non-governmental organizations, health care, and education are large employers. In 2006, total annual earnings and average monthly employment were highest in the government and trade sectors (ADOL 2007; Figure 3.3; Figure 3.4). Statewide unemployment rates increased from 2001-2003, and then decreased through 2006 (Figure 3.5; USDOL 2008).

Government spending is an integral part of Alaska’s economy. Public works spending varies from year to year. The state’s operating budget was $6.5 billion in fiscal year 2008, and the capital budget was $1.3 billion (Legislative Finance Division 2007). Federal spending in Alaska accounted for 33 percent of the state’s economy in 2003, and federal spending totaled $7.6 billion in Alaska in 2002 (DCCED 2008d). Aside from state and federal sources, municipalities and other incorporated communities derive revenues from sales taxes; property taxes; enterprise sources such as garbage collection, water, and sewer; and other revenues.

Table 3.1. Boroughs, municipalities, towns, and other communities in the Cook Inlet lease sale area.

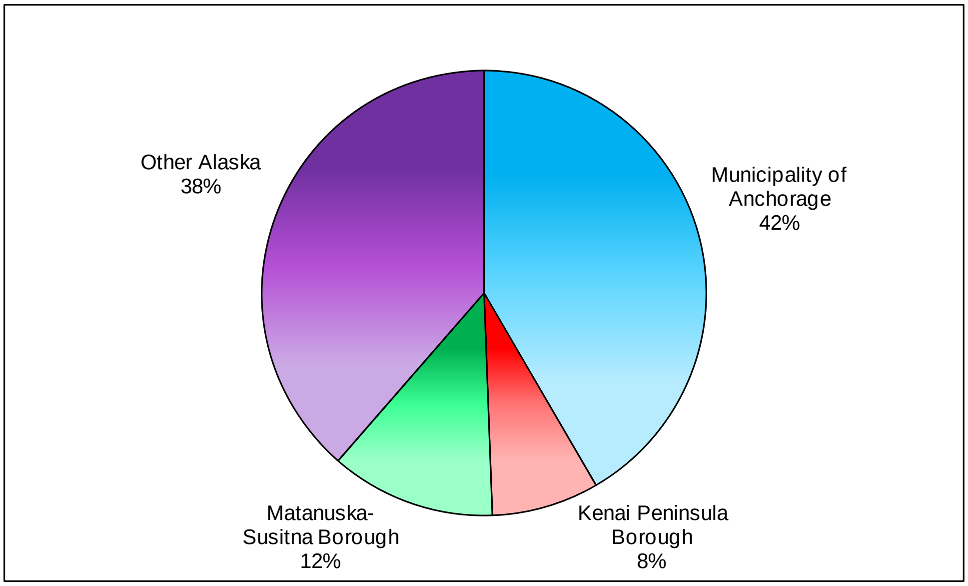
Community	Municipal Classification	Population
Municipality of Anchorage	Unified home rule municipality	282,813
Kenai Peninsula Borough	Second class borough	51,350
Matanuska-Susitna Borough	Second class borough	77,174
Kenai	Home rule city	6864
Palmer	Home rule city	5,574
Homer	First class city	5454
Seldovia	First class city & Unincorporated	287
Soldotna	First class city	3,807
Wasilla	First class city	6,775
Houston	Second class city	1537
Anchor Point	Unincorporated	1,803
Big Lake	Unincorporated	3,082
Clam Gulch	Unincorporated	165
Cohoe	Unincorporated	1,260
Eklutna	Unincorporated	368
Happy Valley	Unincorporated	472
Hope	Unincorporated	143
Kalifornsky	Unincorporated	6,914
Kasilof	Unincorporated	547
Knik-Fairview	Unincorporated	11,238
Nanwalek (English Bay)	Unincorporated	228
Ninilchik	Unincorporated	784
Nikiski	Unincorporated	4,179
Nikolaevsk	Unincorporated	297
Port Graham	Unincorporated	136
Ridgeway	Unincorporated	1,961
Salamatof	Unincorporated	906
Sterling	Unincorporated	5,036
Tyonek	Unincorporated	199

Source: DCCED 2008c, query of current population, June 5, 2008.



Source: USCB 2002, 2007.

Figure 3.1. Population estimates for Alaska, the Matanuska-Susitna Borough, the Municipality of Anchorage, and the Kenai Peninsula Borough, 1990-2006.



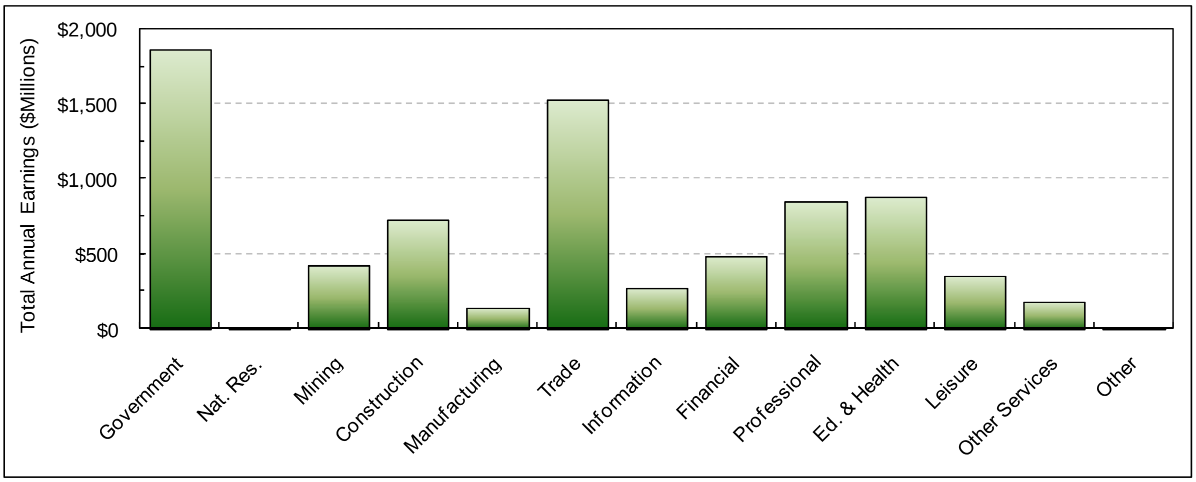
Source: USCB 2002, 2007.

Figure 3.2. Percentage of the population of Alaska in the Matanuska-Susitna Borough, the Municipality of Anchorage, the Kenai Peninsula Borough, and other Alaska locations, 2006.

Table 3.2. Ethnic diversity of Alaska's population in 2000.

Race	Alaska	Mat-Su	Anchorage	Kenai Peninsula
White	69.3	87.6	72.2	86.2
Black/African American	3.5	0.7	5.8	0.5
American Indian/Alaska Native	15.6	5.5	7.3	7.5
Asian	4.0	0.7	5.5	1.0
Native Hawaiian/Other Pacific Islander	0.5	0.1	0.9	0.2
Other	1.6	0.9	2.2	0.8
2 or more races	5.4	4.6	6.0	3.9

Source: USCB 2001.



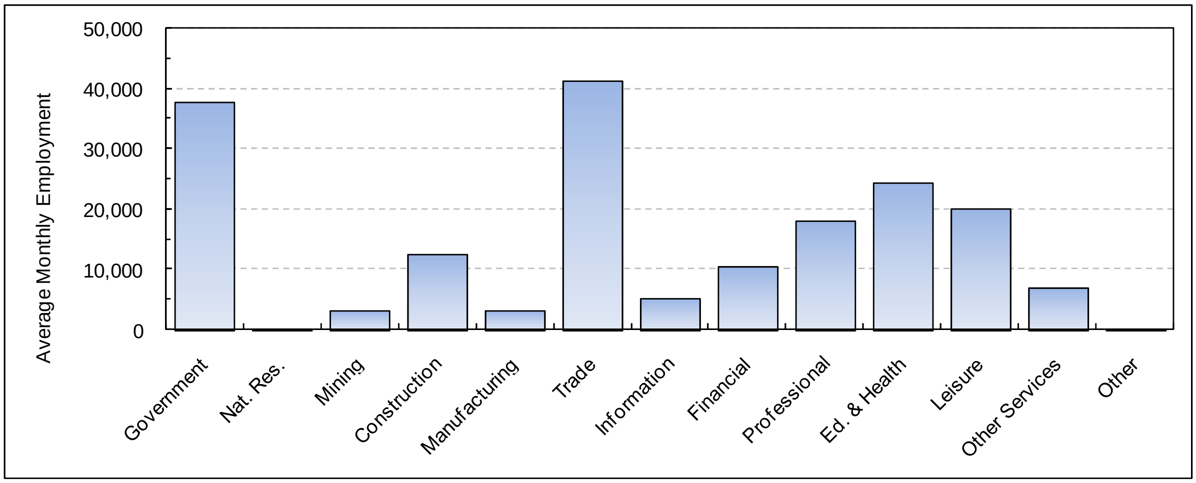
See footnote for source and notes.[1]

Figure 3.3. Total annual earnings in 2006, by industry, for the Matanuska-Susitna Borough, Municipality of Anchorage and Kenai Peninsula combined.

[1] Source: USDOL 2008.

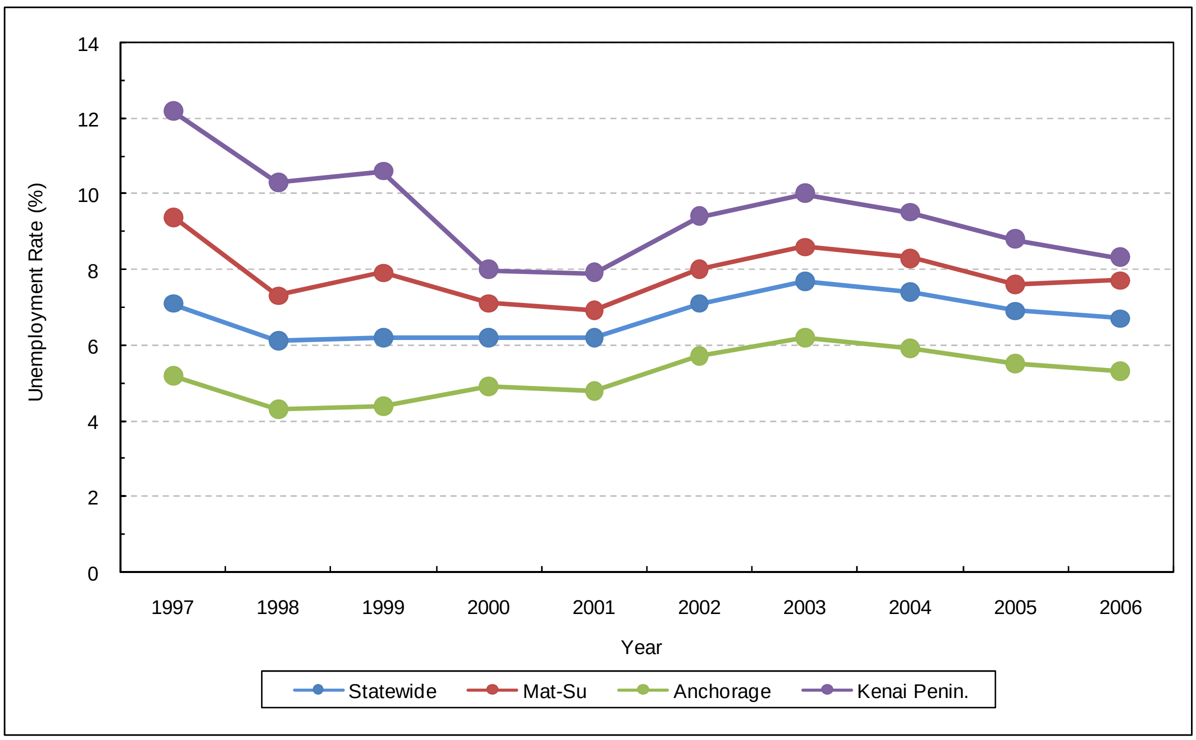
Notes: Government = "total government"; Nat. Res. = natural resources (agriculture, forestry, fishing, hunting); Mining = mining, oil and gas, and support; Trade = trade, transportation, and utilities; Financial = finance, insurance, real estate; Professional = professional and business services; Ed. & Health = education and health services; Leisure = leisure and hospitality services.

Excludes the following: self-employed individuals, fishers, unpaid family help, domestics, and most individuals engaged in agriculture.



See footnote on page 3-7 for source and notes.[1]

Figure 3.4 Average monthly employment by industry, for the Matanuska-Susitna Borough, Municipality of Anchorage, and Kenai Peninsula combined, 2006.



Source: USDOL 2008.

Figure 3.5. Unemployment rates for Alaska, the Matanuska-Susitna Borough, Municipality of Anchorage, and Kenai Peninsula Borough, 1997-2006.

1. Matanuska-Susitna Borough

a. Population

The population of the Matanuska-Susitna Borough (MSB) has doubled, from about 40,000 in 1990 to about 80,000 in 2006 (USCB 2002, 2007). Larger communities include Palmer, Wasilla, Knik-Fairview, Butte, Meadow Lake, and Big Lake (Table 3.3). Palmer, Houston, and Wasilla are the only incorporated communities in the MSB.

Table 3.3. Matanuska-Susitna Borough community profiles.

	Incorporation	Land	Population		
Community	Type	Area (sq. mi)	Current	2000	1990
Mat-Su Borough	2nd Class Borough	24,682	77,174	59,322	39,683
Big Lake	Unincorporated	132	3,082	2,635	1,477
Butte	Unincorporated	40	3,166	2,561	2,039
Chase	Unincorporated	93	30	41	38
Chickaloon	Unincorporated	79	282	213	145
Houston	2nd Class City	22	1,537	1,202	697
Knik-Fairview	Unincorporated	70	11,238	7,049	n/a
Knik River	Unincorporated	90	652	582	n/a
Lazy Mountain	Unincorporated	36	1,347	1,158	838
Meadow Lakes	Unincorporated	67	6,492	4,819	2,374
Palmer	Home Rule City	4	5,574	4,533	2,866
Skwentna	Unincorporated	443	71	111	85
Sutton-Alpine	Unincorporated	151	1,278	1,080	n/a
Talkeetna	Unincorporated	42	840	772	250
Trapper Creek	Unincorporated	365	415	423	296
Wasilla	1st Class City	12	6,775	5,469	4,028
Willow	Unincorporated	685	1,973	1,658	285

Source: DCCED 2008c, query of current population, June 5, 2008.

b. Economy

The MSB is the fastest-growing community in the state, primarily because it is close to Anchorage. Because housing costs are lower than Anchorage, it is an attractive community for commuters. Nearly 40 percent of borough residents work in Anchorage (ADOL 2008c). The fastest growing industries are community care facilities for the elderly, financial investment, engineering and construction, nursing and residential care facilities, and vocational rehabilitation services (ADOL 2008c). In 2006, the largest employers were government, trade, education and health, and leisure industries (Figure 3.6; ADOL 2007). Wages totaled about $579 million, about 26 percent from government, 20 percent from trade, 16 percent from education and health, and 13 percent from construction (ADOL 2007; Figure 3.7). Median family income was $69,100 in 2004, and per capita income was about $29,400 (ADOL 2008c). The unemployment rate was 6.4 percent in March 2008.

c. Transportation

The MSB is linked to other Alaskan communities and the lower 48 states by road, rail, water, and air transportation systems. The Glenn Highway connects the borough to Anchorage to the south, providing highway access to the Kenai Peninsula; and Glennallen to the east, providing highway access to the Richardson and Alaska highways, which lead to Valdez, Fairbanks, Canada, and the lower 48 states. The Parks Highway also connects the borough to Fairbanks. There are about 600 miles of borough-maintained roads (DCCED 2008f). The Knik Arm crossing project has been in the planning phase for several years. This 2-mile toll bridge, spanning Knik Arm from Point MacKenzie, would connect the MSB with Anchorage as an alternative to the Glenn Highway (KABATA 2007).

The borough is also linked by rail to Fairbanks, and the ports of Anchorage, Seward, and Whittier. In addition to passenger service, the railroad is important for commercial freight shipping, especially sand and gravel (DCCED 2008f). Other cargo shipped by rail includes construction steel, chemicals, coal, and concrete.

Port MacKenzie, completed in 2000 with additional improvements in 2004, is the northernmost deep-draft dock in North America (MSB 2008). It includes a 500 ft bulkhead barge dock, a 1,200 ft long deep-draft dock, and 14 sq. miles of adjacent uplands which are available for commercial development. In addition to the toll bridge described above, a ferry operating between Port MacKenzie and Anchorage, and a railroad spur are also planned for the port (MSB 2008).

Port MacKenzie

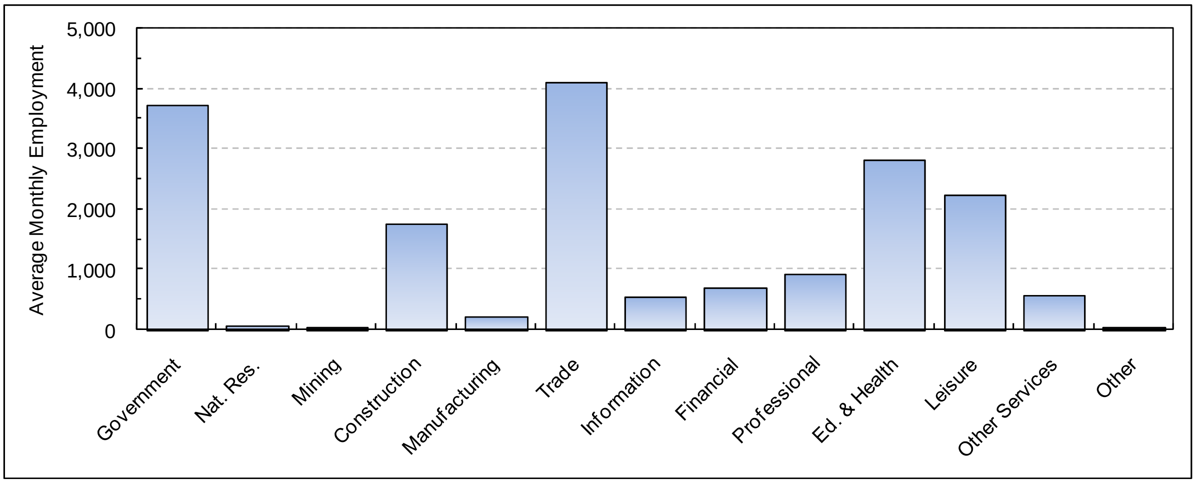
Port MacKenzie, 2007.

The Ted Stevens Anchorage International Airport is the nearest facility providing jet service. However, there are an additional 10 publicly owned airports and several private airports in the borough. These are located at Big Lake, Goose Bay, Lake Louise, Palmer, Sheep Mountain, Skwentna, Summit, Talkeetna, Wasilla, and Willow (DOWL Engineers 2007). The Palmer and Wasilla airports are owned and operated by the cities of Palmer and Wasilla; the other airports are owned and operated by the Alaska Department of Transportation and Public Utilities.

d. Government and Education

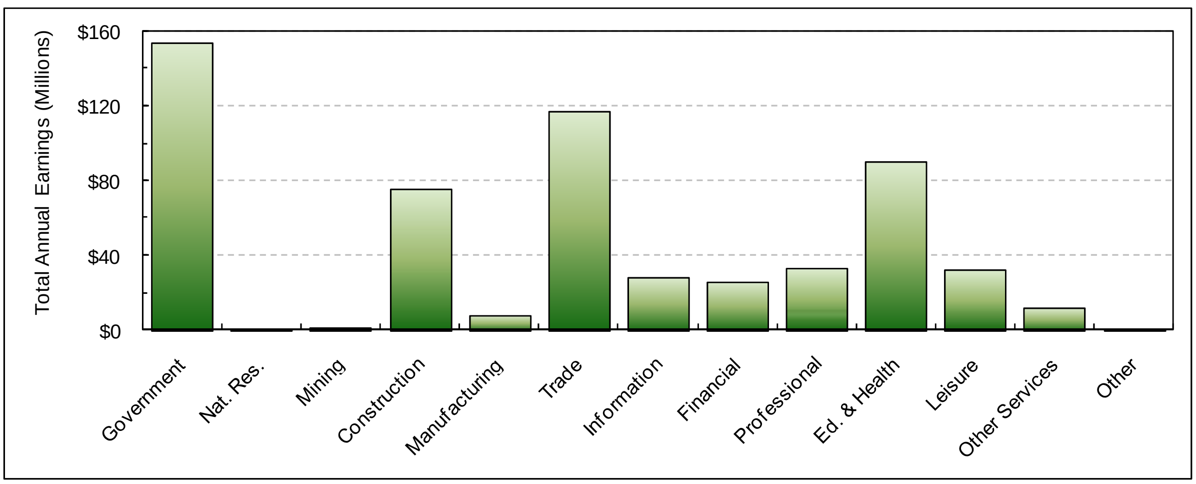
The MSB is a second class borough incorporated in 1964. The borough has no sales tax, although it does have real and personal property, bed, tobacco, and oil and gas property taxes. The 2007 assessed value of real and personal property was $7.1 billion (ADOL 2008c). Total tax revenue was about $90 million in 2007.

About 15,800 students were enrolled in MSB's 38 public schools during the 2006-2007 school year, and the borough expended almost $9,000 per student (Table 3.4; MSB 2007). In 2000, about 88 percent of borough residents age 25 or older had a high school diploma, and about 18 percent had a college degree (USCB 2001).



See footnote on page 3-7 for source and notes.[1]

Figure 3.6. Average monthly employment in 2006, by industry, in the Matanuska-Susitna Borough.



See footnote on page 3-7 for source and notes.[1]

Figure 3.7. Total annual earnings in 2006, by industry, in the Matanuska-Susitna Borough.

Table 3.4. Educational statistics for the Mat-Su Borough School District.

Educational Attainment[a]		School Information	
High school graduate or higher (%)	88.1	Number of Schools[b]	38
Bachelor's degree or higher (%)	18.3	Number of Students[c]	15,846
		Expenditure/student (FY2007)[c]	$8,973

[a] USCB 2001.
[b] DCCED 2008b.
[c] 2006-2007 school year; MSB 2007.

2. Municipality of Anchorage

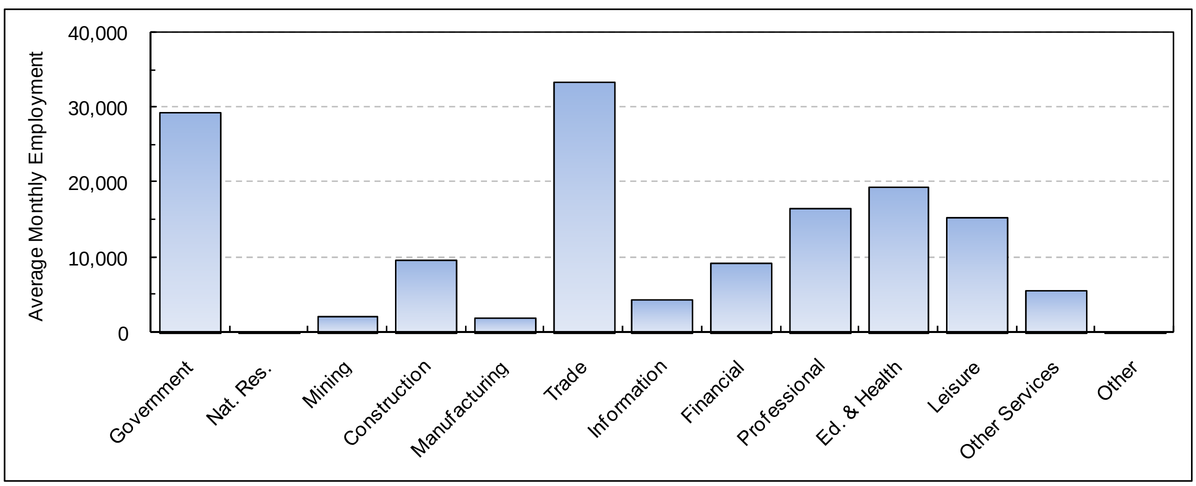
a. Population

With a population of about 280,000, about 42 percent of Alaska's population lives in the Municipality of Anchorage (USCB 2007). The population of Anchorage is culturally diverse, with a minority population of about 30 percent (Table 3.2). Communities within the Municipality of Anchorage include Girdwood, Bird, Indian, Eagle River, Birchwood, and Chugiak.

b. Economy

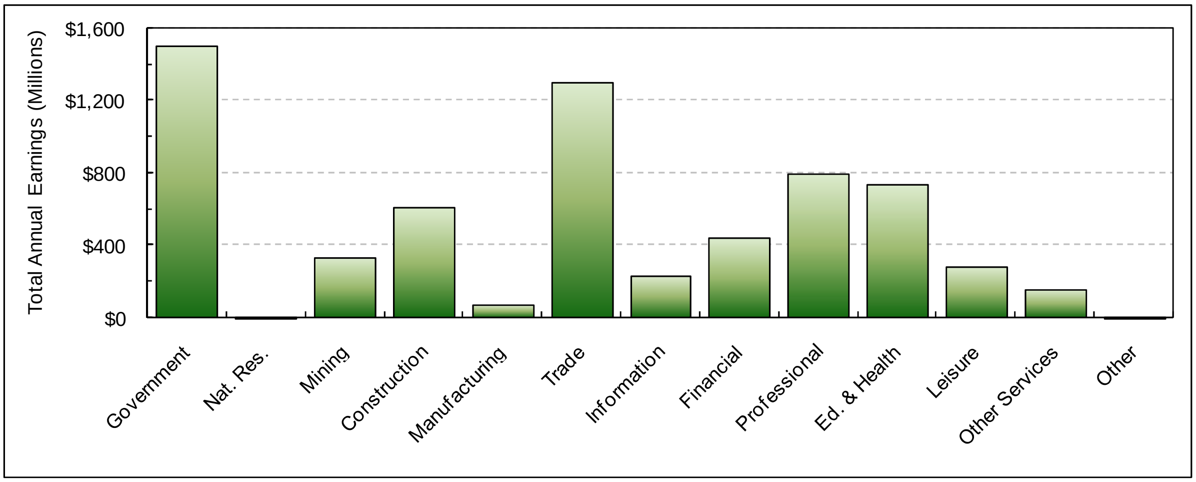
Anchorage is the center of trade, finance and transportation in Alaska. It is the primary transportation hub for the state, with the Port of Anchorage, the Ted Stevens International Airport, and the Alaska Railroad. Many Alaska industries have headquarters in Anchorage including oil and gas, construction and industrial services, communications, and government. Over 8,500 military personnel are stationed at Fort Richardson and Elmendorf Air Force Base.

In 2006, the largest employers were government, trade, professional, education and health, leisure, and construction industries (Figure 3.8; ADOL 2007). The fastest growing industries are community care facilities for the elderly, financial investment, engineering and construction, nursing and residential care facilities, and vocational rehabilitation services (ADOL 2008a). Wages totaled about $6,473 million, about 23 percent from government, 20 percent from trade, 12 percent from professional, 11 percent from education and health, and 9 percent from construction (ADOL 2007; Figure 3.9). Median family income was $78,700 in 2004, and per capita income was about $38,800 (ADOL 2008a). The unemployment rate was 6.4 percent in March 2008.



See footnote on page 3-7 for source and notes.[1]

Figure 3.8. Average monthly employment in 2006, by industry, in the Municipality of Anchorage.



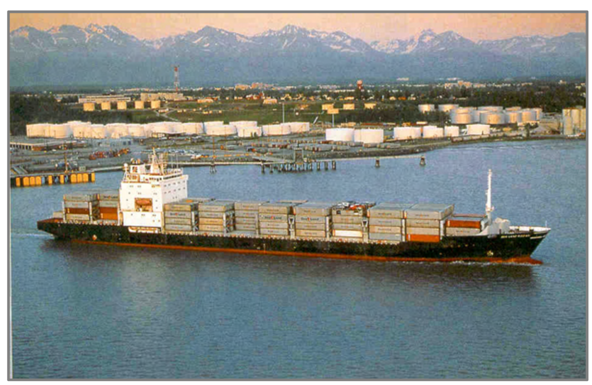
See footnote on page 3-7 for source and notes.[1]

Figure 3.9. Total annual earnings in 2006, by industry, in the Municipality of Anchorage.

c. Transportation

The Municipality of Anchorage has major highway, rail, water, and air transportation systems. Anchorage is the hub for vehicles and freight entering and leaving Southcentral, and is connected to all the major highway systems in Alaska (DCCED 2008a). These include the Glenn, Parks, Alaska, Seward, and Sterling highways. Truck freight ranges from small trucks with light loads to tractor and semi-trailer trucks transporting line haul and full container loads.

The Alaska Railroad is headquartered at the Port of Anchorage, which also serves as the Southcentral hub (DCCED 2008a). Rail transportation is available to the ports of Seward and Whittier, and as far north as Fairbanks. Commercial passenger demand has been increasing, but the railroad's mainstay continues to be commercial freight shipping, especially sand and gravel from the Matanuska-Susitna Borough (DCCED 2008a).


Port of Anchorage Administration

A Horizon Lines ship departing the Port of Anchorage.

The Port of Anchorage is critical to the supply of goods throughout the state, serving 80 percent of the state's population and 90 percent of communities along the railbelt (APET 2008). The port provides facilities for moving containerized freight, bulk petroleum, cement, and other products, totaling four million tons of goods and generating a $750 million economic impact annually. Two major carriers provide containerized service from Tacoma, WA twice weekly. Most of Alaska's refined petroleum products, such as jet fuel, are handled through the port, and Asian ships frequently transport construction materials and bulk cement to the port (APET 2008).

The Ted Stevens Anchorage International Airport provides passenger and cargo service to the Southcentral area, as well as being the primary air link for most of the state to connecting flights within and outside Alaska. Because it is within 9.5 hours by air from most of the industrialized world, the Anchorage Airport has become a leading crossroads for global air cargo activity (AEDC 2006). It ranks first in the U.S. for landed cargo weight, and third in the world for cargo throughput.

The two major terminals total more than 1.2 million sq. ft (AEDC 2006). In fiscal year 2007, over 5 million passengers passed through the airport (ADOT 2008). Other airports, airstrips, and water landing areas in the Municipality of Anchorage include Merrill Field, Lake Hood Seaplane Base and Lake Hood Airstrip, Campbell Lake/Sand Lake, Campbell Airstrip, Birchwood Airstrip, and Elmendorf Air Force Base.

d. Government and Education

The Municipality of Anchorage has no sales tax, although it does have real and personal property, bed, tobacco, oil and gas property, and vehicle rental taxes. The 2007 assessed value of real and personal property was $29 billion (ADOL 2008a). Total tax revenue was about $443 million in 2007.

Almost 50,000 students were enrolled in the Anchorage School District's 95 public schools during the 2006-2007 school year, and expenditures per student were over $9,000 (Table 3.5; ASD 2007). In 2000, about 90 percent of the municipality's residents age 25 or older had a high school diploma, and about 29 percent had a college degree (USCB 2001).

Table 3.5. Educational statistics for the Anchorage School District.

Educational Attainment[a]		School Information	
High school graduate or higher (%)	90.3	Number of Schools[b]	95
Bachelor's degree or higher (%)	28.9	Number of Students[c]	49,116
		Expenditure/student (FY2007)[c]	$9,158

[a] USCB 2001.
[b] DCCED 2008b.
[c] 2006-2007 school year; ASD 2007.

3. Kenai Peninsula Borough

a. Population

Over 50,000 people live in the Kenai Peninsula Borough (USCB 2007). Larger communities in the borough include Homer, Kalifornsky, Kenai, Nikiski, and Soldotna (Table 3.6). Some of the communities are outside the lease sale area, particularly those on the east side of the Kenai Peninsula and on Kachemak Bay.

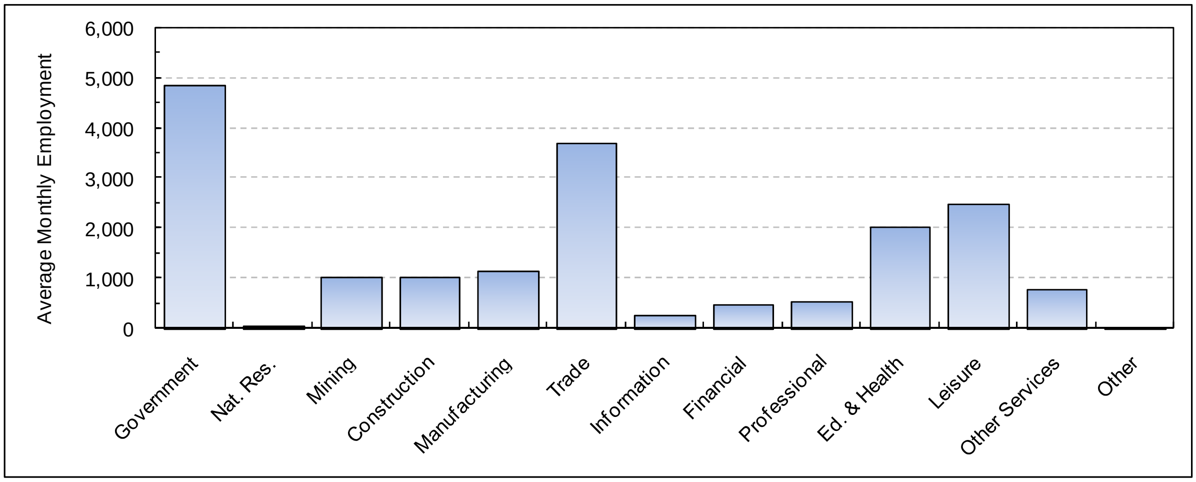
b. Economy

The economy of the Kenai Peninsula Borough is well diversified (ADOL 2008b). In 2006, the largest employers were government, trade, leisure, and education and health (Figure 3.10; ADOL 2007). The fastest growing industries are community care facilities for the elderly, financial investment, engineering and construction, nursing and residential care facilities, and vocational rehabilitation services (ADOL 2008b). Wages totaled about $660 million, about 31 percent from government, 18 percent from trade, and 13 percent mining (including oil and gas) (Figure 3.11; ADOL 2007). Median family income was $67,300 in 2004, and per capita income was about $29,400 (ADOL 2008b). The unemployment rate was 9.6 percent in March 2008.

Table 3.6. Kenai Peninsula Borough community profiles.

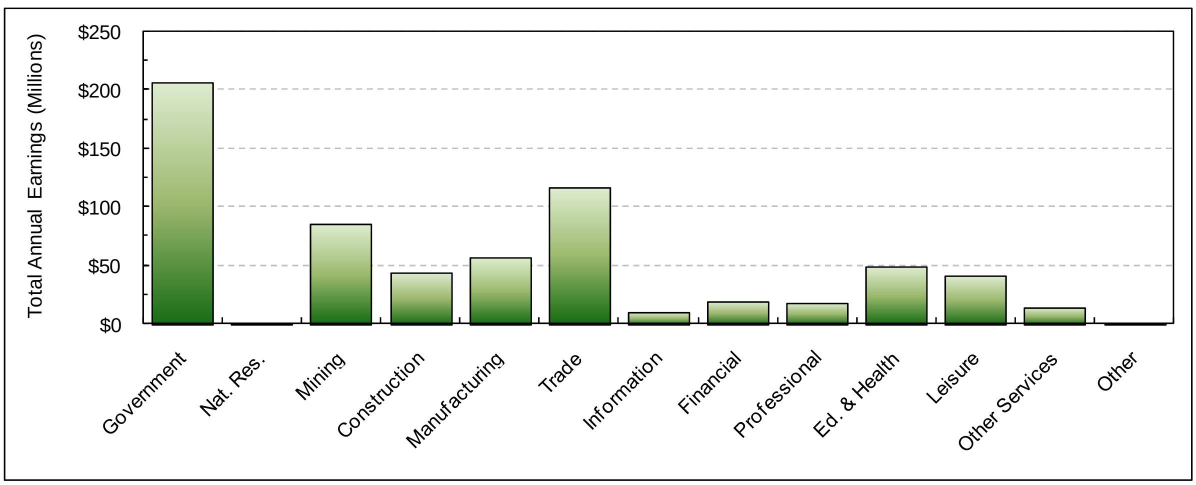
	Incorporation	Land	Population		
Community	Type	Area (sq. mi)	Current	2000	1990
Kenai Penin. Borough	2nd Class Borough	16,013	51,350	49,691	40,802
Anchor Point	Unincorporated	91	1,803	1,845	866
Clam Gulch	Unincorporated	14	165	173	79
Cohoe	Unincorporated	70	1,260	1,168	508
Cooper Landing	Unincorporated	66	357	369	243
Crown Point	Unincorporated	4	81	75	62
Fox River	Unincorporated	127	639	616	382
Fritz Creek	Unincorporated	54	1,723	1,603	1,426
Halibut Cove	Unincorporated	8	24	35	78
Happy Valley	Unincorporated	89	472	489	309
Homer	1st Class City	11	5,454	3,946	3,660
Hope	Unincorporated	52	143	137	161
Kachemak	2nd Class City	2	458	431	365
Kalifornsky	Unincorporated	69	6,914	5,846	n/a
Kasilof	Unincorporated	10	547	471	383
Kenai	Home Rule City	30	6,864	6,942	6,327
Moose Pass	Unincorporated	18	204	206	81
Nanwalek	Unincorporated	9	228	177	158
Nikiski	Unincorporated	70	4,179	4,327	2,743
Nikolaevsk	Unincorporated	36	297	345	371
Ninilchik	Unincorporated	208	784	772	456
Port Graham	Unincorporated	6	136	171	166
Primrose	Unincorporated	37	79	93	63
Ridgeway	Unincorporated	17	1,961	1,932	2,018
Salamatof	Unincorporated	8	906	954	999
Seldovia	1st Class City	0.4	287	286	316
Seward	Home Rule City	14	2,627	2,830	2,699
Soldotna	1st Class City	7	3,807	3,759	3,482
Tyonek	Unincorporated	68	199	193	154

Source: DCCED 2008c, query of current population, June 5, 2008.



See footnote on page 3-7 for source and notes.[1]

Figure 3.10. Average monthly employment in 2006, by industry, in the Kenai Peninsula Borough.



See footnote on page 3-7 for source and notes.[1]

Figure 3.11. Total annual earnings in 2006, by industry, in the Kenai Peninsula Borough.

c. Transportation

The Kenai Peninsula Borough is connected to the rest of Alaska and the lower 48 states by regional highway, rail, water, and air transportation systems. The Seward and Sterling highways are the primary highways on the Kenai Peninsula. Other major roads include the Kenai Spur and North Kenai roads. In addition, the borough maintains about 630 miles of local roads (DCCED 2008e). A system of gravel roads in the Beluga and Tyonek area on the west side of Cook Inlet provide local service but are unconnected to the main road system.

The Alaska Railroad provides rail service to the Port of Seward, which is on the Kenai Peninsula but outside the lease sale area. Commercial freight is shipped through Seward by rail, including coal, construction steel, chemicals, sand and gravel, concrete, timber, and other large building materials (DCCED 2008e).

Although most freight such as construction materials, petroleum products, automobiles, and other bulk materials arrive through the Port of Anchorage and are subsequently trucked to borough communities, the ports of Seward and Homer also handle these items (DCCED 2008e). The Port of Homer, located on Homer Spit, includes a deep-water cargo dock, an ocean pier, and a small boat harbor. The Port of Seward includes a deep-draft dock, three medium-draft docks, four shallow-draft docks, and a small boat harbor. Other docks in Seward include the Fourth Avenue City Dock, the Alaska Institute of Marine Science Dock, and the Seward Marine Services Dock. In addition, the Port of Kenai has a shallow-draft public dock and boat ramp. The Port of Nikiski is a private dock located north of Kenai that is owned by petroleum and freight shipping companies (DCCED 2008e).

Facilities providing air service in the Kenai Peninsula Borough include the Kenai Municipal Airport and the Homer Airport (DCCED 2008e).

d. Government and Education

The Kenai Peninsula Borough has a 3 percent sales tax, and real and personal property, and oil and gas property taxes. The 2007 assessed value of real and personal property was $46 million (ADOL 2008b). Total tax revenue was about $71 million in 2007.

Over 9,000 students were enrolled in the Kenai Peninsula District's 44 public schools during the 2006-2007 school year, and expenditures per student were about $10,000 (Table 3.7; KPB 2007b). In 2000, about 89 percent of the borough's residents age 25 or older had a high school diploma, and about 20 percent had a college degree (USCB 2001).

Table 3.7. Educational statistics for the Kenai Peninsula School District.

Educational Attainment[a]		School Information	
High school graduate or higher (%)	88.5	Number of Schools[b]	44
Bachelor's degree or higher (%)	20.3	Number of Students[c]	9,368
		Expenditure/student (FY2007)[c]	$10,073

[a] USCB 2001.
[b] DCCED 2008b.
[c] 2006-2007 school year; KPB 2007b.

D. Historic and Cultural Resources

Historic and cultural resources in the Cook Inlet area include a wide range of sites, deposits, structures, ruins, buildings, graves, artifacts, fossils, and other objects of antiquity. The Alaska Heritage Resources Survey (AHRS) is an inventory of all reported historic and prehistoric sites within the state of Alaska. Sites may be listed as historic if they are at least 50 years old (AHRS 2008). More than 530 historic or prehistoric sites are reported within the Cook Inlet lease sale area (AHRS 2008).

Sites in the Cook Inlet area date as early as 8,000 years B.P. Later prehistoric occupations include Dena'ina, Chugach, and Eskimo populations, as well as Russian and Euroamerican occupations during the historic period (AHRS 2008). Sites are often clustered near natural features, such as river mouths, bluffs, and natural transportation routes. Few archaeological surveys have been conducted on the west side of Cook Inlet, and the actual number of historic sites is unknown. Numerous sites are scattered along the east bank of the Susitna River and along the Iditarod trail route, although data are sparse to the west of the Susitna River. Few data are available for other drainages such as the Yentna, Theodore, Lewis, Beluga, Chuitna, Chakachatna, and Kustatan rivers and Nikolai Creek (AHRS 2008).


Div. of Community & Business Development

Alaska Native baskets.

The more populated areas and federal park units have been surveyed more intensively. Many sites have been discovered in the Houston and Big Lake region, and in the Wasilla and Palmer area. Over 250 buildings and farm sites at Palmer are from the Matanuska Valley agricultural colony period of the 1930s. Sites are clustered around existing communities of Tyonek, Knik, Eklutna, and Eagle River (AHRS 2008). Several sites exist at Fort Richardson and Elmendorf Air Force Base. There are more than 100 sites (historic buildings and structures) within the city of Anchorage. Many sites are scattered along Turnagain Arm (AHRS 2008).

On the Kenai Peninsula, more than 150 sites have been identified within the Cook Inlet lease sale area (AHRS 2008). The area south of the Kenai River is well known historically and archaeologically, although the townships north of Kenai are only sporadically surveyed (AHRS 2008). The Anchor River drainage is largely unexplored. Clusters of sites are reported around Anchor Point, Kasilof River, and the Kenai River. There are more than 50 sites in the area of the City of Kenai, the majority of which are historic (AHRS 2008).

E. Climate

The Cook Inlet area is characterized by three climate zones: the maritime zone, continental zone, and transition zone (Alaskool 2004). In the maritime zone areas, which encompass the coast and islands, annual precipitation averages about 60 inches. Mean maximum temperatures in the summer are in the upper 50s, and low means during winter are in the low 20s. Offshore winds average 12-18 knots, with winter extremes of 50-75 knots (Alaskool 2004). Areas further from the coast may have continental zone characteristics, with annual precipitation from 10-15 inches, mean maximum summer temperatures in the mid- to upper 60s, and mean lows in the winter ranging from -10 to -30 degrees. Surface winds tend to be lighter compared to coastal maritime areas. Other locations in the Cook Inlet area, such as interior portion of the Kenai Peninsula and the area around Talkeetna, have transition zone characteristics, with temperatures similar to continental zone areas, precipitation similar to maritime zone areas, and winds intermediate (BLM 2006; Alaskool 2004).

In the Matanuska-Susitna Borough, average January temperatures range from 6° - 14°, and July temperatures range from 47° - 67° (DCCED 2008b). Average precipitation is 16.5 inches. In the Municipality of Anchorage, January temperatures average 8° - 21°, and July temperatures average 51° - 65°. Anchorage has an average of 15.9 inches of rain and 69 inches of snow (DCCED 2008b). Average temperatures on the Kenai Peninsula, range from 4° - 22° in January, and from 46° - 65° in July. Annual precipitation averages 20 inches (DCCED 2008b). However, temperature and precipitation can vary greatly between years and among locations (Brabets and Whitman 2004).

Since the late 19th century, average global temperatures have increased 0.5°F to 1.0°F (BLM 2005). Temperature increase in Alaska over the last 50 years averages 3.4°F, although the temperature changes vary greatly across the state and most of the change has occurred in winter and spring months (ACRC 2008). Little additional warming has occurred since 1977, with the exception of a few locations (ACRC 2008). Regional climatic change is difficult to quantify and much less reliable than global estimations (BLM 2005; ACRC 2008).

Changes that could accompany warming trends include melting glaciers, reduction in seasonal sea ice cover resulting in increased storm effects and higher coastal erosion rates, increased permafrost melting, shifting vegetation zones, increased fires, insect outbreaks, changing animal migration paths, and changing subsistence patterns (DGGS 2008). In 2006, the Alaska Climate Impact Assessment Commission was formed to assess the effects of climate change on citizens, resources, economy, and assets of the State of Alaska (ACIAC 2008). In September 14, 2007, Administrative Order 238 was signed, creating the Climate Sub-Cabinet to develop an Alaska Climate Change Strategy. The strategy will serve as a guide for responding to climate change and will identify immediate priorities as well as long-term strategies, including recommendations for saving energy and reducing greenhouse gas emissions (SOA 2008b). On March 17, 2008, the Alaska Climate Impact Assessment Commission released a report to the legislature outlining recommendations, including a coordinated process for village relocation efforts; capital project planning to take into account potential future impacts resulting from climate change; assessing public infrastructure needs to protect against erosion and loss of permafrost; and researching needs (ACIAC 2008). As of May 2008, more than 100 Alaskans had been selected to serve on advisory groups and technical work groups under the Climate Change Sub-Cabinet (SOA 2008a), and development of the Alaska Climate Change Strategy is underway.

F. Waters of the Cook Inlet Area

1. Marine Waters

Cook Inlet is a 350 km long estuary that is semi-enclosed and has a free connection to the open ocean (MMS 2003; MMS 2000). Cook Inlet, and its channels, coves, flats, and marshes, are a mixture of terrestrial sources from numerous river drainages and marine waters of Shelikof Strait and the Gulf of Alaska (MMS 2003). Cook Inlet varies in width from about 100 m near the entrance to less than 20 m at its head (MMS 2000). Beach substrate may be sand, hard or soft mud, gravel or cobble (Pentec Environmental 2005).


Public domain

Cook Inlet, as viewed from downtown Anchorage.

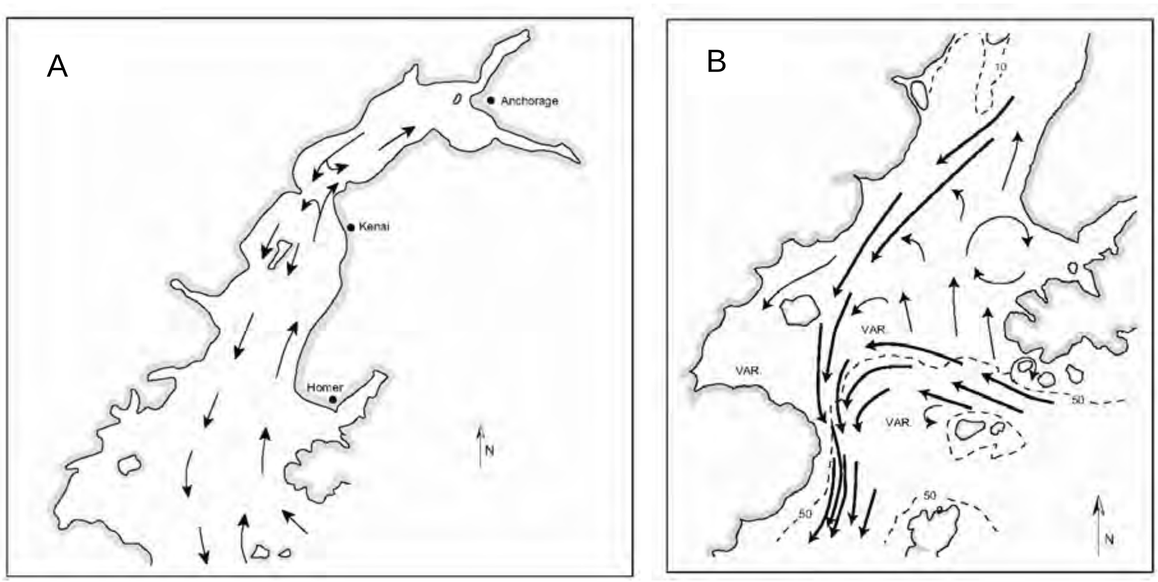
a. <u>Bathymetry</u>

The bottom of Cook Inlet is extremely rugged with deep pockets and shallow shoals (KPB 2007a). Upper Cook Inlet north of the Forelands is generally less than 120 ft deep; the deepest portion is in Trading Bay, east of the mouth of the McArthur River. Two channels extend southward on either side of Kalgin Island, joining west of Cape Ninilchik. This channel gradually deepens to the south, to about 480 ft, then widening to extend across the mouth of Cook Inlet from Cape Douglas to Cape Elizabeth (KPB 2007a). The 60 ft depth contour is generally located 2.5 to 3 miles offshore along lower Cook Inlet, but falls within 0.7 miles of shore for a length of about 3 miles near Cape Starichkof (KPB 2007a). The southeast coast of the Kenai Peninsula consists of a series of deep, glacially carved fjords (KPB 2007a).

b. <u>Tides and Currents</u>

Tides in Cook Inlet are semidiurnal, with two unequal high tides and two unequal low tides per tidal day (24 hours, 50 minutes). The mean diurnal tidal range varies from 13.7 ft at the mouth of Cook

Inlet to 29 ft in upper Cook Inlet (KPB 2007a). Strong tidal currents and inlet geometry produce considerable cross currents and turbulence within the water column. Tidal bores of up to 10 ft have occurred in Turnagain Arm (KPB 2007a). Current velocities are influenced by local shore configuration, bottom contour and possibly wind effects in some shallow areas (MMS 2003). Maximum surface current speeds average about 3 knots in most of Cook Inlet; however, currents may exceed 6.5 knots in the Forelands area, and have been reported at up to 12 knots in the vicinity of Kalgin Island and Drift River (KPB 2007a). The mixing of incoming and outgoing tidewater, combined with freshwater inputs, are the main forces driving surface circulation (Figure 3.12; MMS 2003).



Source: (Mulherin et al. 2001).

Figure 3.12. Surface currents of upper (A) and lower (B) Cook Inlet.

c. Sediment and Salinity

Cook Inlet receives large quantities of glacial sediment from the Knik, Matanuska, Susitna, Kenai, Beluga, McArthur, Drift, and other rivers. This sediment is redistributed by intense tidal currents. Most of this sediment is deposited on the extensive tidal flats or is carried offshore through Shelikof Strait and eventually deposited in the Aleutian trench beyond Kodiak (KPB 2007a; MMS 2003). Powered by the Alaska Coastal Current, sediments of the Copper River drainage drift into lower Cook Inlet and Shelikof Strait where they eventually settle to the bottom. MMS survey results indicate that about 10-20 percent of the bottom sediments in the Cook Inlet area are from the Copper River (MMS 2000).

Sediment in Cook Inlet is generally transported along the Kenai Peninsula into lower Cook Inlet, Kachemak, and Shelikof Strait (MMS 2000). Sediments transported down the west side of Cook Inlet are eventually deposited in the shallows of Kamishak Bay, while sediment is also deposited in Kachemak Bay, deeper portions of outermost Cook Inlet and Shelikof Strait (MMS 2000). Homer Spit is maintained by sediment transported from the north (KPB 2007a).

Salinity of Cook Inlet waters increases steeply and evenly along the inlet, from Point Possession to East and West Foreland. Slightly higher salinities are found on the east side. This rapid increase in salinity is due to high concentrations of glacial silt in runoff from the Matanuska, Susitna and Knik rivers and subsequent settling of sediment in upper Cook Inlet. Local areas of with less salinity occur near the mouths of large glacially fed streams such as the Tuxedni, Kenai, and Kasilof rivers (KPB 2007a).

d. Water Temperature and Ice Conditions

The water temperature in upper Cook Inlet varies with season from 32° to 60° F. Water temperatures of lower Cook Inlet, which are influenced by warmer waters entering from the Gulf of Alaska, range from 48° to 50°F (KPB 2007a).

The ice in Cook Inlet comes from four different sources: pack ice, shorefast ice, stamukhi, and estuary and river ice (Mulherin et al. 2001). Pack ice forms in seawater and is formed by the direct freezing of seawater. Shorefast ice is formed from freezing of surrounding water, from ice being piled and refrozen. Mud exposed to the air by the ebbing tide can freeze, and when seawater contacts the frozen mud, beach ice forms. Stamukhi are massive ice blocks created by repeated wetting and accretion of seawater, crushing and piling of ice blocks, and stranding of successive layers of ice which freeze together. Estuary ice forms from freshwater in estuaries and rivers. River ice is much stronger than sea ice and is generally unaffected by tidal action until spring breakup (Mulherin et al. 2001).

The primary factor for ice formation in upper Cook Inlet is air temperature, and the major influences in lower Cook Inlet are the Alaska Coastal Current temperature and inflow rate (MMS 2003). Cook Inlet ice generally begins forming in October, covers a large area by November, and melts completely in the spring (Mulherin et al. 2001). On the east side of Cook Inlet, ice may extend to Anchor Point, and on the west side, to Cape Douglas (Mulherin et al. 2001). Ice concentrations or cover are sometimes found in Kamishak Bay extending outward to Augustine Island, and Chinitna, Tuxedni and other western Cook Inlet bays (KPB 2007a).

2. Freshwaters

The Cook Inlet area includes many watersheds (Figure 3.13), including 11 that drain major mountain ranges (BLM 2006). These include the Kenai Mountains on the Kenai Peninsula, the Chugach Mountains adjoining the Municipality of Anchorage, the Talkeetna Mountains in the Matanuska-Susitna area, the Alaska Range in the northwest, and the Chigmit, Neacola, and Tordillo mountains in the west (BLM 2006). Freshwater sources include glaciers and icefields; glacial, runoff, and spring-fed streams; rivers; lakes; and wetlands. Glaciers and snowmelt provide a large portion of the input to watersheds in the Cook Inlet area (BLM 2006). In fact, glaciers cover 11 percent of the land area of the Cook Inlet basin, storing massive amounts of water as ice (Brabets and Whitman 2004).


USFWS

Kenai River

Major rivers in the Matanuska-Susitna area include the Matanuska, Knik, Little Susitna, and Susitna rivers and their tributaries such as the Talkeetna and Yentna rivers; important lakes include Big, Nancy, Alexander, and Eklutna lakes (BLM 2006). In the Anchorage area, the primary rivers are Ship, Campbell, and Bird creeks, and Eagle and Twentymile rivers. Larger rivers on the Kenai Peninsula include the Kenai, Ninilchik, and Anchor rivers; and among the larger lakes are Tustumena, Kenai, and Skilak lakes. Important rivers on the west side of Cook Inlet include the Drift, McArthur, Theodore, McNeil, and Kamishak rivers (BLM 2006).

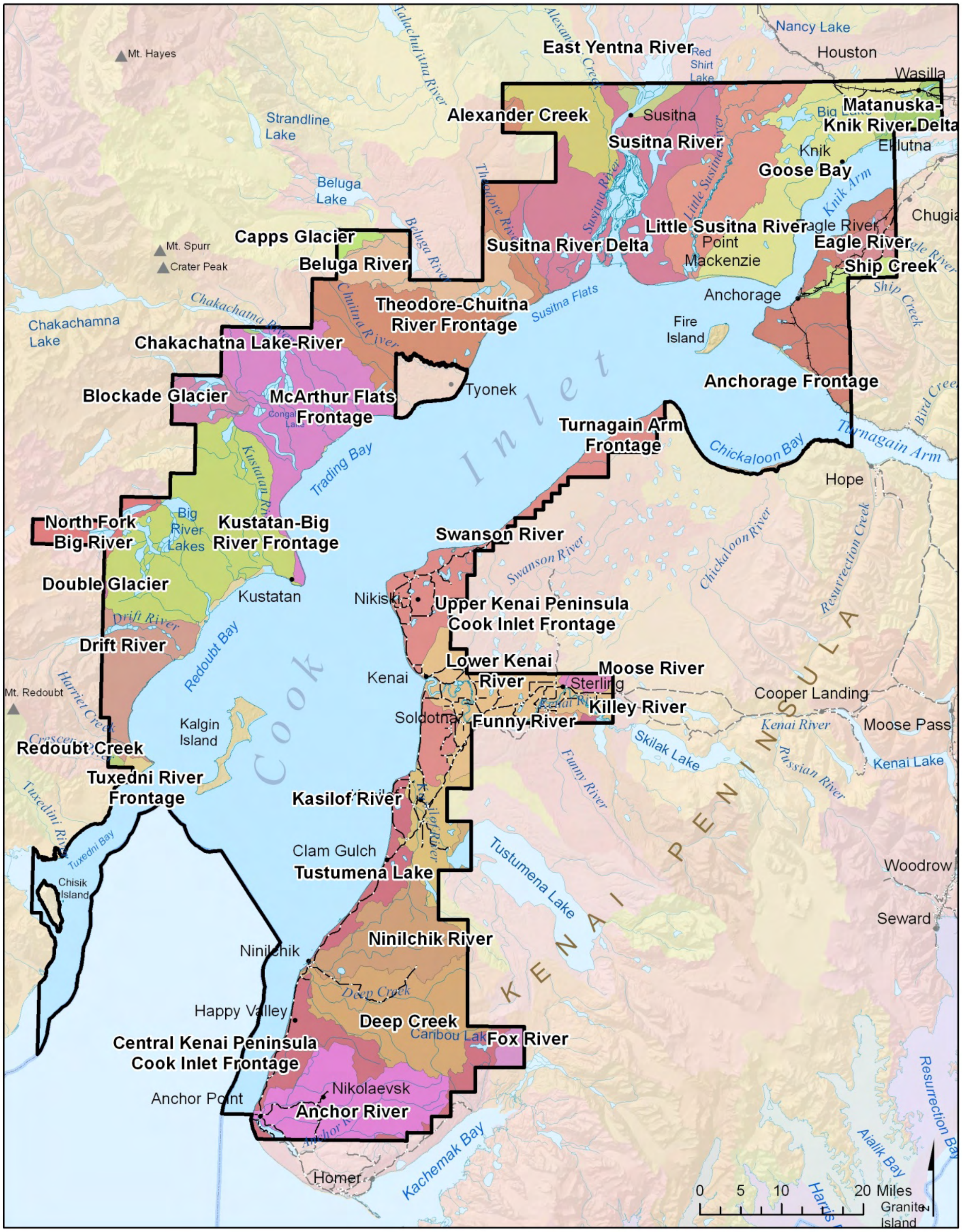


Figure 3.13. Watersheds of the Cook Inlet area.

A large aquifer system is found beneath much of Cook Inlet area lowlands, composed of unconsolidated glacial-outwash and alluvial deposits (Glass 1999). In upland areas, groundwater is also found in saturated fractures in bedrock. Groundwater provides most of the water in streams of the area during the winter. Groundwater yields range from 1.34-133.68 cfm on the Kenai Peninsula and up to 133.68 in the Susitna River Valley (BLM 2006).

G. Geologic Hazards

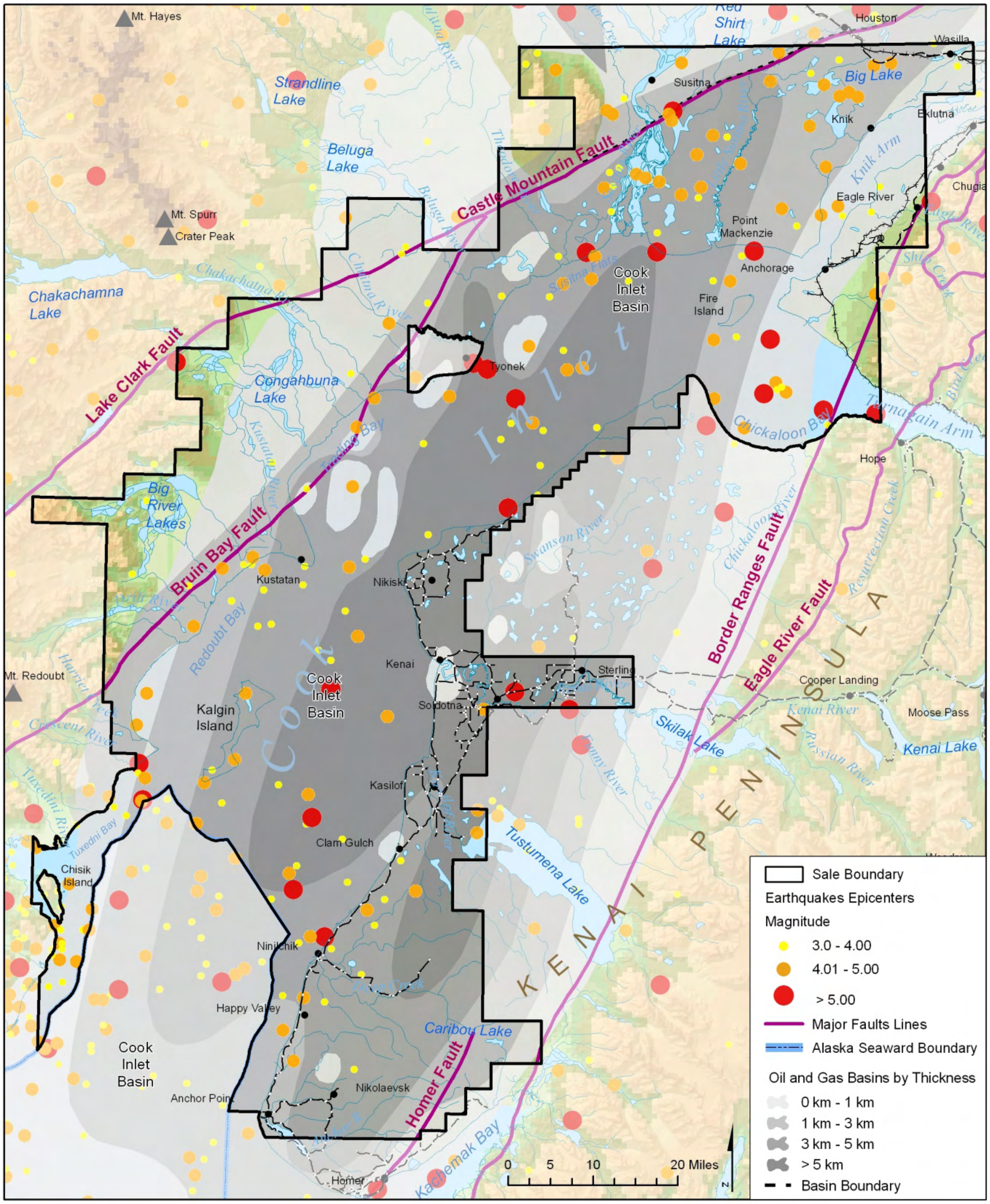
Several geologic hazards that could pose potential problems to oil and gas installations both onshore and offshore exist in the Cook Inlet area. These include earthquakes, volcanoes, tsunamis, flooding, ice, current and sediment hazards, and coastal erosion. The Cook Inlet area is located in one of the most seismically active regions in the world, is in close proximity to several active volcanoes, and has some of the highest tides in the world. “In spite of these environmental constraints, petroleum extraction and processing facilities have functioned, both onshore and offshore, without significant environmental damage since the Swanson River field was discovered in 1957” (Combellick et al. 1995, citing to Magoon and others 1976).

1. Faults and Earthquakes

The Cook Inlet trough is a forearc basin between the Aleutian Arc to the west and the Kenai Mountains to the east (Combellick et al. 1995, citing to Kelley 1985). Subduction of the Pacific crustal plate beneath the Kenai Mountains and Aleutian Arc (North American plate) accumulates crustal stresses that are periodically relieved by deep-focused earthquakes (Figure 3.14). The Castle Mountain fault is the only surface fault in the Cook Inlet region with unequivocal evidence of Holocene offset. Geologic evidence of four events in the past 2,700 years indicates an average recurrence interval of about 700 years for significant (magnitude 6-7) earthquakes on the fault. Considering it has been 600-700 years since the last event, an event of this magnitude may be likely on the Castle Mountain fault in the near future (Haeussler et al. 2002). In 1984, a magnitude 5.7 earthquake with an epicenter in the Matanuska Valley, near the town of Sutton was attributed to subsurface movement along the Castle Mountain fault (Combellick et al. 1995, citing to Lahr and others 1986).

The Bruin Bay fault system consists of a family of four or five echelon faults[2] in a zone as much as 5 miles wide. The fault zone crosses the lease sale area through the northwestern quadrant of T12N, R11W, Seward Meridian and extends more than 250 miles southwest from the Castle Mountain fault west of Anchorage to Becharof Lake on the Alaska Peninsula. The fault plane dips between 45 degrees and vertical, although most of the fault system dips between 60-70 degrees as measured in the Kamishak Bay area. Evidence seems to suggest at least two major movements along this fault system, the first occurring in late Jurassic time (approximately 160 million years ago) and the second more than 25 million years ago during the mid-Cenozoic. The major activity on the main part of the fault system probably ceased during the Oligocene time (approximately 30 million years ago). Offset across the Bruin Bay fault system appears to be dip-slip with a possible strike-slip component. The amount of throw along this system could be as much as 10,000 feet with the southeast block relatively downthrown and a possible left-lateral offset of 12 miles (DO&G 1993, citing to Detterman and Hartsock 1966) to 40 miles (DO&G 1993, citing to Detterman and Reed 1980). During the 1964 earthquake, the west side of Cook Inlet rose as part of a broad uplift, but no differential uplift took place across the Bruin Bay fault system (DO&G 1993, citing to Detterman and Reed 1980).

[2] A grouping of faults that are arranged in a step-like manner.



Source: Alaska Earthquake Information Center.

Figure 3.14. Earthquakes, faults, and volcanoes in the Cook Inlet area.

The inferred trend of the Bruin Bay fault crosses several townships of the lease sale area from the vicinity of Tyonek to near Harriet Point on the west side of Cook Inlet (Combellick et al. 1995, citing to Magoon and others 1976). Several northeast-trending faults have been identified or inferred in the western Kenai Lowlands. “Several of these structural breaks are known to cut Tertiary age rocks of the Kenai Group, but they are not known to offset younger deposits and their activities and subsurface extents remain speculative.” (Combellick et al. 1995, citing to Barnes and Cobb 1959, Kirschner and Lyon 1973, Tysdal 1976). There is no evidence of movement on the Bruin Bay fault in Holocene or historic time.

The Border Ranges fault is considered a former boundary between the subducted oceanic plate and the continental plate and is considered the eastern boundary of the Cook Inlet basin. The Border Ranges fault forms an arc from Kodiak Island, across the Kenai Peninsula, to the eastern Chugach Mountains, a distance of more than 320 miles. The Border Ranges fault is not exposed along much of the Kenai Peninsula, but it outcrops northeast and east of Anchorage (referred to as the Knik fault) and along Kachemak Bay in the southwestern Kenai Peninsula (DO&G 1993, citing to MacKevett and Plafker 1974). The fault plane generally dips between 70 degrees and vertical with the most recent movement along this fault occurring approximately 70 million years ago in the late Mesozoic or early Tertiary time. There is indirect evidence in the Twin Peaks area of the western Chugach Mountains that the Border Ranges fault may have had minor displacement since the Holocene time (10,000 years ago; Reger and Petrik 1993, citing to Reger and Updike 1983).

Geologic studies indicate that seven great (1964-style) subduction earthquakes have occurred in the Cook Inlet region during approximately the past 4,000 years, indicating an average recurrence interval of about 600 years (Shennan et al. *In press*). Smaller but potentially damaging earthquakes (magnitude greater than 5.5) have occurred more frequently. There have been 119 earthquakes with magnitudes of 5.0 or greater in the Cook Inlet region since 1899. Most of these earthquakes had magnitudes of 5.0 to 6.0; four had magnitudes of greater than 7.0 (AEIC 2008).

Diffuse seismicity shallower than 35 km in the Cook Inlet area results from transpressional deformation. A 1933 magnitude 6.9 event near Anchorage which caused intensity VII effects on the Mercalli scale[3] may have been related to this shallow deformation. Some buried folds in the upper Cook Inlet area, such as at the Middle Ground Shoal oil field, are cored with blind reverse faults that may be capable of generating magnitude 6-7+ earthquakes (Haeussler et al. 2000).

The epicenter of the 1964 earthquake (moment magnitude 9.2) was in Prince William Sound. However, geologic effects were widespread in the Cook Inlet area and included seismic shaking, ground breakage, landslides and other surface displacements, liquefaction, falling objects, and structural failures (Combellick et al. 1995, citing to Waller 1966, Stanley 1968, Foster and Karlstrom 1967, Tysdal 1976). Future strong earthquakes can be expected to produce similar effects.

Anchorage Museum, AMRC-b76-118-16

Damage to the J.C. Penney store and other buildings in downtown Anchorage, from the March 27, 1964 earthquake.

Other types of ground failure include liquefaction and sliding of water saturated soils, rockfalls, translatory block sliding such as occurred at Anchorage in 1964, horizontal movement of vibration-mobilized soil which was the cause of extensive damage to Alaskan railways and highways in 1964, and ground fissuring and

3 The Mercalli scale measures damage done by an earthquake on a scale from I (not felt) to XII (damage total).

associated sand extrusions typical of areas where the ground surface is frozen. Extensive occurrence of all these phenomena has been documented for large earthquakes. No producing oil and gas wells or pipelines in the Cook Inlet region were damaged by the 1964 earthquake. In Nikiski, a fuel storage tank was buckled at its base and several floating roofs on storage tanks were damaged by earthquake-generated waves inside the containers (Plafker et al. 1969).

The northern half of the Kenai Peninsula coastline is underlain by till, outwash, and gravely glaciomarine deposits. The southern half is underlain by the Tertiary Beluga formation, which is composed of thinly interbedded layers of sand, shale, and coal. Both of these areas are relatively stable under earthquake loading and should not be compared to the highly unstable sensitive-clay deposits under Anchorage or extensive liquefaction-susceptible sands. Liquefaction of coarse glacial deposits under earthquake loading is probably low, particularly if they remain overconsolidated due to ice loading. However, recent evidence of gravel liquefaction in the Portage area during the 1964 great earthquake indicates that gravel may be more susceptible to liquefaction than previously thought. Site specific testing of liquefaction susceptibility is advisable (Combellick et al. 1995).

The USGS has a series of seismic hazard maps for Alaska, which are available on the USGS Website at http://earthquake.usgs.gov/research/hazmaps/ . These maps depict earthquake hazard by showing, with contour values, the earthquake ground motions that have a given probability of being exceeded in 50 years. The ground motions being considered at a given location are those from all future possible earthquake magnitudes at all possible distances from that location. The ground motion coming from a particular magnitude and distance is assigned a probability based on the annual probability of occurrence of the causative magnitude and distance from the source. The method is based on historical earthquake occurrences and geological information on the recurrence rate of fault ruptures. To prepare these maps, the USGS analyzed all known seismic sources (surface faults, subduction zone and volcanic sources). Included in the computations are all historical and instrumental recordings of ground motions, gathered using a grid of 1-sq. km polygons. It is therefore possible to see the probabilistic ground motion for any location. The USGS seismic hazard maps are incorporated into the International Building Code for establishing the seismic design values for a selected location.

2. Volcanic Hazards

Alaska contains about 80 percent of all the active volcanoes in the United States and about 8 percent of the active volcanoes in the world. The western shore of Cook Inlet contains seven volcanoes that have erupted in Holocene time (10,000 years ago). These are, from north to south, Mt. Hayes, Mt. Spurr, Mt. Redoubt, Mt. Iliamna, Mt. Saint Augustine, Mt. Douglas, and Fourpeaked Mountain (about 8 miles southwest of Mt. Douglas). Three of these (Mt. Spurr, Mt. Redoubt, and Mt. Saint Augustine) have erupted more than once this century and could well erupt again in the next few years or decades (Combellick et al. 1995). Augustine erupted recently with a series of explosive eruptions January 11-28, 2006, continuing with an effusive phase through late March. Fourpeaked had its first historic eruption on September 17, 2007, with an ash plume to 20,000 feet asl (Alaska Volcano Observatory 2008).


USFWS

Augustine Volcano.

Study of tephras (volcanic ash layers) in the Cook Inlet region indicates that eruptions have occurred every 1 to 200 years (Combellick et al. 1995, citing to Riehle 1985). In the 20th century, these events have occurred every 10 to 35 years, and, for the last 500 years, tephras were deposited at least every 50 to 100 years, with Mt. Redoubt, Mt. Spurr, and Mt. Saint Augustine being the most active (Combellick et al. 1995, citing to Stihler 1991, Stihler and others 1992, Beget and Nye 1994, Beget and others 1994). Mt. Saint Augustine is one of the most active volcanoes in Alaska, with major eruptions in 1883, 1935, 1964, 1976, and 1986. Mt. Redoubt erupted in 1968 and 1989-90, and Mt. Spurr erupted in 1953 and 1992 (Combellick et al. 1995, citing to Wood and Kienle 1990). No historic eruptions are known for Mt. Douglas or Mt. Iliamna, although geologic evidence shows that each has erupted during the past 10,000 years (Combellick et al. 1995).

During their periodic violent eruptions, the active glacier-clad stratovolcanoes produce abundant ash and voluminous mudflows that have threatened air traffic and onshore petroleum facilities (Combellick et al. 1995, citing to Riehle and others 1981, Brantley 1990). These are examples of the two major categories of volcanic hazards that will continue to threaten activities in the region. Proximal hazards are those close to volcanoes and consist of a wide variety of flow phenomena on the flanks of volcanoes or in drainages which head on the volcanoes (Combellick et al. 1995). Distal hazards are those farther from volcanoes, such as ashfall and tsunamis (Combellick et al. 1995).

A proximal hazard of particular concern to the lease sale area are floods generated by the rapid emplacement of large volumes of hot volcanic ejecta onto snow and ice on the upper flanks of volcanoes. All the volcanoes in Cook Inlet except Mt. Saint Augustine have permanent snow and ice stored in snowfields and glaciers on their upper flanks (Combellick et al. 1995).

The largest volcanically generated flood this century was caused by the January 2, 1990, eruption of Redoubt Volcano. The flood impacted the operation of the Drift River Oil Terminal (Combellick et al. 1995, citing to Brantley 1990). The state allowed normal loading operations to resume once a protective dike was installed around the tank farm and support facilities to provide protection from flooding. This work was accomplished by August 1990 and the facility was fully operational. Another, and probably much smaller, flood came down the Chakachatna River in response to the 1953 eruption of Mt. Spurr. Floods caused by eruptions can impact any drainage on a volcano (Combellick et al. 1995).

In the area of the lease sale, drainages that could be impacted by volcanigenic floods are the Chakachatna River drainage (from Trading Bay to the McArthur River), Drift River drainage (from Montana Bill Creek to Little Jack Slough), Redoubt Creek, and the Crescent River. This is approximately half of the lease sale lands on the western shore of Cook Inlet. Drift River and Chakachatna River are the most likely to host floods.

A very large debris avalanche came down Redoubt Creek and formed the land that now underlies Harriet Point in latest Pleistocene time (1 million years ago), but that drainage does not appear to have had a large flow since that time (Combellick et al. 1995, citing to Beget and Nye 1994). Large flows, some of which reached the present shoreline, came down Crescent River between about 3,600 and 1,800 years ago (Combellick et al. 1995, citing to Beget and Nye 1994). The most probable volcanically induced floods are small, water-rich floods, which depending on the local hydrographic conditions, could impact roads, pipelines, and other infrastructure (Combellick et al. 1995).

Other proximal volcanic hazards on the western shore of Cook Inlet are lava flows, block-and-ash flows, pyroclastic[4] flows, and hot gas surges. The lands included in the lease area are far enough from the volcanoes that they are out of range of all but the very largest eruptions (eruptions on the scale of the 1980 Mount St. Helens or 1991 Mt. Pinatubo eruption). Eruptions this large are rare, although they are certainly possible and have happened at several of the Cook Inlet volcanoes, the most recent being the eruption of Mt. Katmai in 1912.

[4] Volcanic material that has been explosively ejected from a vent.

The most common distal hazard is ashfall, where volcanic ash (finely ground volcanic rock) is lofted into the atmosphere and stratosphere by explosive eruptions, drifts downwind, and falls to the ground. There have been dozens of such events from Cook Inlet volcanoes since 1900. In most cases, volcano ashfalls have been a few millimeters or less in thickness. The primary hazard of such ashfalls is damage to mechanical and electronic equipment such as engines, which ingest ash past the air filter, computers, and transformers, possibly causing electrical shorts. Ashfalls of a few millimeters should be expected throughout the Cook Inlet and Susitna basins with a long-term average frequency of a few every decade or two. Ashfalls thick enough to collapse buildings are possible but rare (Combellick et al. 1995).

The Alaska Volcano Observatory has recently produced volcano-hazard assessment reports for Augustine, Iliamna, Redoubt, and Spurr volcanoes, published by the U.S. Geological Survey.

3. Tsunamis

Tsunamis (large water waves induced by earthquakes, subsea landslides, or volcanic activity) are a potential hazard for lower Cook Inlet (south of the Forelands). The most likely cause of a tsunami in Cook Inlet is either a large magnitude earthquake similar to the 1964 quake or a violent eruption of Mt. Saint Augustine. Tsunamis are generated when large volumes of sea water are displaced, either by tectonic displacement of the sea floor or by large rockfalls or landslides. The narrow, elongate geometry of Cook Inlet should reduce the chances that a tsunami generated outside the inlet will propagate significant destructive energy into it. For example, the tsunami generated by the 1964 earthquake produced damage in the lower Cook Inlet at Rocky Bay and Seldovia, and hit much of the west coast of the lower inlet, but caused no damage in upper Cook Inlet. Conversely, if a tsunami were caused by a displacement of the sea floor in Cook Inlet, it probably would have little effect in open waters but could produce significant damage along the coastline (DO&G 1993, citing to Hampton).

Anchorage Museum, AMRC-b70-15-35

View of damage from the March 27, 1964 earthquake and tsunami, Seward.

Marine portions of the lease sale area are relatively shallow and protected from open ocean; therefore the hazard from distant tsunamis is low. The hazard from local earthquake generated tsunamis is also low because there are no known active surface faults in the inlet, no adjacent steep slopes to serve as sources of massive slides into the inlet, and no evidence of thick, unstable seafloor deposits that would fail in massive underwater slides. There is no known geologic evidence of prehistoric tsunamis in the lease sale area (Combellick et al. 1995).

A major current concern in Cook Inlet today is the possibility of tsunamis being generated by volcanic activity on Mt. Saint Augustine. A volcanic eruption can produce debris avalanches with velocities of up to 328 feet per second. When the avalanche reaches the sea, the displaced water mass can become a tsunami. These waves would hit both the east and west shores of Cook Inlet. While the west shore is largely unpopulated, populated areas on the east shore within lower Cook Inlet could be subject to extensive damage. These include Port Graham, Anchor Point, Nanwalek, Seldovia, Homer and several small communities (DO&G 1993, citing to Kienle et al. 1987). Mt. Saint Augustine volcano presents the greatest threat to shoreline and offshore structures because of its island location in southwestern Cook Inlet. Mt. Saint Augustine experiences frequent violent eruptions, and has a propensity for producing unstable summit domes that periodically collapse into large, rapidly moving debris avalanches. These enter Cook Inlet and generate rapidly spreading tsunamis (Reger and Petrik 1993, citing to Begét and Kienle 1992). Other major volcanoes in the Cook Inlet region, including Mt. Iliamna, Mt. Redoubt and Mt. Spurr, are located farther inland, and are not considered likely to produce similar submarine debris flows and corresponding tsunamis.

The volcanogenic tsunami hazard in Cook Inlet is presently poorly understood, although the potential for the generation of large waves is real. There is some anecdotal evidence in historic records that the 1883 eruption of Augustine generated a wave that was several meters high when it impacted Nanwalek, on the east side of Cook Inlet (Combellick et al. 1995, citing to Beget and Kienle 1992). There are also historical documents that discount the existence of this. In any event, geologic evidence of repeated anomalous waves has not been found (Combellick et al. 1995, citing to Waythomas 1995). The explosive eruptions of Augustine Volcano in early 2006 did not produce a tsunami.

4. Marine and Seafloor Hazards

Cook Inlet has a maximum tidal range of 4 to 11 m, depending on location, which produces rapid tidal flows and strong riptides (Combellick et al. 1995, citing to Evans and others 1972, Hayes and others 1976, National Oceanic and Atmospheric Administration 1977). High tidal-current velocities in upper Cook Inlet prevent deposition of clay and silt-size sediments, which largely remain in suspension. Bottom sediments in the lease sale area are mainly gravel and sandy gravel with gravel content of 50-100 percent (Combellick et al. 1995, citing to Sharma and Burrell 1970). Similar deposits in lower Cook Inlet are thought to be reworked and redistributed coarse-grained glacial material (Combellick et al. 1995, citing to Rappeport 1981). These deposits show no evidence of gravitationally unstable slopes or soft, unconsolidated sediment (Combellick et al. 1995, citing to MMS 1995).

Several pipeline failures in upper Cook Inlet have been directly attributed to the current-sediment interaction. (See Chapter 6 for additional information on pipelines and oil spills.) As the bottom sediments shift under the influence of bottom currents, sections of the pipeline are undermined and become unsupported. The pipeline may then flutter, which causes fatigue and failure. Actions taken in Cook Inlet to prevent this situation include conducting annual side-scan sonar surveys, attaching pipelines to piles driven into the seafloor, placing large bags of a sand-cement mixture around the pipelines to anchor them, and using heavy walled pipe (DO&G 1993, citing to Whitney and others 1979).

During the winter months, ice forms up to three feet thick on upper Cook Inlet. This ice, propelled by the swift tidal currents, creates very large load stresses on the offshore platforms. Since the platforms are designed to withstand the ice loads, this should not present a problem. Ice is not as severe a problem in the southern part of the inlet due to a higher salinity, less fresh water inflow, and a greater proportion of warm ocean waters.

Winter ice conditions combined with tidal action may occasionally hinder offshore operations in the upper inlet from December through April (Combellick et al. 1995, citing to Sharma and Burrell 1970). During the winter of 1970-1971, inlet ice extended as far south as Anchor Point and Cape Douglas. Although blocks of floe ice generally reach a thickness of 1.2 m in Cook Inlet, grounding of these blocks forms large piles of ice blocks (stamukhi) that exceed 12 m in thickness and, where floated, stamukhi have damaged ships in the inlet (Combellick et al. 1995, citing to Evans and others 1972). Numerous large erratic blocks in shallow, nearshore waters are hazards to ship navigation.

5. Flood Hazards

In addition to volcanigenic flooding on the west side of Cook Inlet, flood hazards in the Cook Inlet area may result from glacial outburst (jökulhlaups), ice jams, and high rainfall.

Glacial outburst occurs when glacial movement opens a pathway for water trapped behind a glacier to escape. Rivers are subject to large magnitude outburst floods as a result of the sudden drainage of large, glacier-dammed lakes, particularly on the west side of Cook Inlet. Major rivers affected by outburst floods include Beluga, Chakachatna, Middle, McArthur, Big, and Drift rivers (Combellick et al. 1995, citing to Post and Mayo 1971). For example, in September 1982, over 95 percent of Strandline Lake drained, releasing about 700 million cubic meters (185 billion gallons) of water. Strandline Lake has drained catastrophically into Beluga River every 1 to 5 years since about 1954 (Combellick et al. 1995, citing to Sturm and Benson 1988). The most reliable predictor of outburst floods from Strandline Lake is the development of a calving embayment in the lobe of Triumvirate Glacier, which dams the lake (Combellick et al. 1995).

Ice jam flooding occurs during breakup when ice blocks a river or stream, in effect becoming a dam. This causes water to back up and flood the adjacent land. Ice jam flooding is localized, but affects the greatest number of residents over time because of the high population concentration along rivers (Combellick et al. 1995, citing to J. M. Dorava, U.S. Geological Survey, personal communication, 1995).

G. Litchfield, ADF&G

Ice and flood damage, Kenai River.

On the east side of Cook Inlet, in the Kenai Lowlands, high water levels in the Kenai River frequently occur due to the sudden drainage of glacier-impounded lakes at the head of the Snow River tributary east of Kenai Lake, and lakes held in by Skilak Glacier located in the Harding Ice Field above the Skilak River. Several small lakes impounded by Tustumena Glacier are potential sources of unexpected floods in Kasilof River. Outbursts from a Skilak Glacier dammed lake can result in extensive lowland flooding, as occurred in 1969 when severe damage resulted in Soldotna (Combellick et al. 1995, citing to Post and Mayo 1971). In October 1995, Skilak Glacier released an outburst flood that resulted in water levels cresting about 0.5 m below flood stage at Kenai Keys and Soldotna (Combellick et al. 1995, citing to unpublished data, National Weather Service, October 1995). This outburst flood had a total volume considerably less than previous events in 1985 and 1990; no damage was reported from the 1995 event. In January and February 2007, an ice jam flood occurred on the Kenai River, triggered by the release of the Skilak Glacier dammed lake (Kenai River Center 2007). The Kenai River at Skilak Lake rose about 3.8 feet, causing the ice cover to break up and form ice jams and localized flooding in the Soldotna area. The rapid increases in water level and moving ice caused significant property damage.

Signs of impending outburst releases are high lake water levels, abundant calving into the lake, and water present on northern margins of the glacier, including small marginal lakes (Combellick et al. 1995, citing to unpublished data, National Weather Service, October 1995).

The flooding in the Cook Inlet area may also be caused by heavy rainfall. For example, heavy flooding of the Kenai River in September 1995 resulted from interaction of tropical moisture and a deep low pressure center in the north Pacific Ocean; blockage of the eastward movement of this low by a high-pressure ridge in eastern Alaska and western Canada; saturated soil conditions; and greater than normal glacial melt due to preceding storms. Excess sediment deposition in channels due to rapid runoff decreased the carrying capacity of the streams. As a result, the lower Kenai River remained above flood stage for over 10 days. Crest water levels were 1.1 m above flood stage at Kenai Keys and 0.76 m above flood stage at Soldotna (Combellick et al. 1995, citing to unpublished data, National Weather Service, October 1995). An analysis of this flood indicates that it represents a 100-year event at Soldotna (USGS 1998).

In August 2006, days of heavy rain caused major flooding of the Little Susitna River, Willow Creek, Montana Creek, the Talkeetna River, and Moose Creek in the Matanuska-Susitna Borough. These rivers crested well above the flood stage, resulting in the evacuation of about 150 people, 46 borough roads and 6 major state roads flooded or damaged, 8 bridges damaged, closures and damage to the Parks Highway and Alaska Railroad, and over 150 homes flooded or damaged (MSB 2006).

The primary hazards to facilities from river flooding are high water levels, bank erosion, deposition at the river mouth, high bedload transport, and channel modification (Combellick et al. 1995).

Seasonal flooding of lowlands and river channels is extensive along major rivers that drain into Cook Inlet. Thus, measures must be taken prior to facility construction and field development to prevent losses and environmental damage. Pre-development planning should include hydrologic and hydraulic surveys of spring break-up activity as well as flood frequency analyses. Data should be collected on water levels, ice floe direction and thickness, discharge volume and velocity, and suspended and bedload sediment measurements for analysis. Also, historical flooding observations should be incorporated into a geologic hazard risk assessment. All inactive channels of a river must be analyzed for their potential for reflooding. Containment dikes and berms may be necessary to reduce the risk of flood waters that may undermine facility integrity.

6. Coastal Erosion

Coastal erosion and deposition is another potential threat to development located on or near the coastline. Frequent storms accompanied by strong winds result in strong wave action that erodes shorelines composed of unconsolidated sediments and weakly cemented Tertiary sedimentary rocks (Combellick et al. 1995, citing to Hayes and Michel 1982). The coastal bluffs around the inlet range from 20 to 200 feet in height, and are currently receding in response to natural processes such as wave action, precipitation, and wind (DO&G 1993, citing to KPB 1990). Development, such as roads and gravel excavation in the coastal areas, also has a destabilizing effect on the coastal bluffs and further contributes to erosion as well as subsidence and ground failure related to earthquakes.


L. Silliphant, DO&G

Bluffs along eastern shore of Cook Inlet, near Clam Gulch.

Erosion rates, sediment grain size and cohesiveness, riverbank stability, and nearshore bathymetry must all be considered in determining facility siting, design, construction, and operation. They must also be considered in determining the optimum oil and gas transportation mode. Structural failure can be avoided by proper facility setbacks from coasts and river banks. Mitigation Measure A1c (Chapter 9) prohibits the siting of permanent facilities, other than roads, docks, utility or pipeline corridors, or terminal facilities, within one-half mile of the banks of many major rivers, except where land use plans classify an area for development, or established usage and use history show development. Docks and road or pipeline crossings can be fortified with concrete armor, and the placing of retainer blocks and concrete-filled bags in areas subject to high erosion rates.

7. Shallow Gas Deposits

Shallow gas deposits have been encountered in the Cook Inlet area and pose risks similar to overpressured sediments. The Steelhead and Grayling platforms have experienced blowouts due to shallow gas. The same mechanisms for blow-out prevention and well control are employed to reduce the danger of loss of life or damage to the environment.

8. Mitigation Measures and Other Regulatory Protections

Several geologic hazards exist in the Cook Inlet area that could pose potential risks to oil and gas installations both onshore and offshore. As discussed above, these potential hazards include earthquakes, volcanoes, tsunamis, flooding, ice, current and sediments, and coastal erosion. Although the Cook Inlet area is seismically active, is in close proximity to several active volcanoes, and has extremely high tides, the onshore and offshore oil and gas industry has operated in the area for about 50 years without significant environmental damage.

The risks from earthquake damage can be minimized by siting onshore facilities away from potentially active faults and unstable areas, and by designing them to meet or exceed national standards and International Building Code seismic specifications specific for Alaska. National industry standards help assure the safe design, construction, operation, maintenance, and repair of pipelines and other oil and gas facilities. Sometimes referred to as “technical standards” they establish standard practices, methods, or procedures that have been evaluated, tested, and proven by analysis and/or application. These standards are intended to assure the safe design, construction, operation, maintenance, and repair of infrastructure. National consensus standards, such as the American Petroleum Institute (API), American Society of Mechanical Engineers (ASME), National Fire Protection Association (NFPA), and National Association of Corrosion Engineers (NACE), can carry the equivalent weight of law. In fact, many of them are codified by incorporation of all or parts of them into regulations by reference. They are constantly reviewed and upgraded by select committees of engineers and other technical experts (PHMSA 2008).

Design for offshore drilling and production platforms should consider all environmental events which influence the design of an arctic structure (API Recommended Practice 2N). Design conditions are those environmental conditions to which the structure is designed. Additional precautions should be taken to identify and accommodate site-specific conditions or events that can act on a structure such as unstable ground, flooding, and other localized hazards. Proper siting and engineering will minimize the detrimental effects of these natural processes (Combellick et al. 1995).

Safe design of offshore drilling and production platforms use design codes and recommended practices that assist the engineer by setting out procedures for achieving acceptable levels of safety. Recommended practices provide guidance for the design of arctic structures and pipelines considering the environment, sea ice, and permafrost. Once the design conditions have been established for each process, they become the basis for that system’s design. The primary goal of codes is safety, which is accomplished by providing a minimum set of rules which must be incorporated into a sound engineering design concerning materials, fabrication, testing, and examination practices used in the construction of these systems. All of these are intended to achieve a set of engineering requirements deemed necessary for safe design and construction of these structures and their associated piping systems.

Although geologic hazards could damage oil and gas infrastructure, measures in this best interest finding, along with regulations imposed by state, federal, and local agencies, in addition to design and construction standards discussed above, are expected to avoid, minimize, or mitigate those hazards. Mitigation measures address siting of facilities, design and construction of pipelines, and oil discharge prevention and contingency plans. A complete listing of mitigation measures is found in Chapter 9.

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