Overview of Environmental and Hydrogeologic Conditions at Nine Coastal and Island Sites in South-Central and Southeast Alaska

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U.S. GEOLOGICAL SURVEY

Open-File Report 95-404

Prepared in cooperation with the

FEDERAL AVIATION ADMINISTRATION

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By Eppie V. Hogan

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Anchorage, Alaska
1995

U.S. DEPARTMENT OF THE INTERIOR
BRUCE BABBITT, Secretary

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CONVERSION FACTORS

Multiply	By	To obtain
centimeter (cm)	0.3937	inch
millimeter (mm)	0.03937	inch
meter (m)	3.281	foot
meter per kilometer (m/km)	5.280	foot per mile
kilometer (km)	0.6214	mile
square kilometer (km^2)	0.3861	square mile
liter (L)	0.2642	gallon
liter per second (L/s)	15.85	gallon per minute
cubic meter per second (m^3/s)	35.31	cubic foot per second
cubic meter per second per square kilometer ($(m^3/s)/km^2$)	91.4	cubic foot per second per square mile

In this report, temperature is reported in degrees Celsius (°C), which can be converted to degrees Fahrenheit (°F) by the following equation:

$$°F = 1.8\ (°C) + 32$$

ABBREVIATED WATER-QUALITY UNITS

Chemical concentration and water temperature are given only in metric units. Chemical concentration in water is given in milligrams per liter (mg/L) or micrograms per liter (μg/L). Milligrams per liter is a unit expressing the solute mass per unit volume (liter) of water. One thousand micrograms per liter is equivalent to 1 milligram per liter. For concentrations less than 7,000 milligrams per liter, the numerical value is about the same as for concentrations in parts per million.

VERTICAL DATUM

Sea level: In this report, "sea level" refers to the National Geodetic Vertical Datum of 1929—A geodetic datum derived from a general adjustment of the first-order level nets of the United States and Canada, formerly called Sea Level Datum of 1929.

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ABSTRACT

The Federal Aviation Administration owns or operates airway-support facilities at Middleton Island, Cape Yakataga, Gustavus, Haines, Biorka Island, Big Level Island, Annette Island, Sisters Island, and Duncan Canal. They wish to consider the environmental setting and hydrogeologic conditions when evaluating options for environmental remediation at these facilities. These coastal and island sites in south-central and southeast Alaska have a maritime climate characterized by mild winters and cool summers. Vegetation consists of coastal hemlock-spruce forest. Bedrock consists of sedimentary, volcanic, and metamorphic rocks that are either exposed or very near the land surface throughout the region. Relatively thin surficial deposits cover much of the lowland areas but are minimal or nonexistent in upland areas. Soils are continuous over the land surface except in areas of steep relief or areas covered by ice and snow. Most communities obtain their drinking water from surface-water sources, such as lakes, streams, and rivers. A few communities use water from shallow aquifers. Surface spills and disposal of hazardous materials may affect the quality of drinking water. Alternative drinking-water sources for residents in this area of Alaska include both surface water and ground water. Ground water may be found within fractured bedrock or unconsolidated deposits.

INTRODUCTION

The Federal Aviation Administration (FAA) owns and (or) operates airway-support and navigational facilities throughout Alaska. Fuels and potentially hazardous materials such as solvents, polychlorinated biphenyls (PCB's), and pesticides may have been used and (or) disposed of at many of these sites. The FAA is conducting comprehensive environmental studies mandated by the Comprehensive Environmental Response, Compensation, and Liability Act (CERCLA) and the Resource Conservation and Recovery Act (RCRA) to determine if environmentally hazardous materials have been spilled or disposed of at these sites. This report is a review and summary of existing hydrologic and geologic data, and other pertinent information for areas surrounding nine sites in coastal and island settings in south-central and southeast Alaska. The report provides information for the FAA facilities and nearby communities at Middleton Island, Cape Yakataga, Gustavus, Haines, Biorka Island, Big Level Island, Annette Island, Sisters Island, and Duncan Canal (fig. 1).

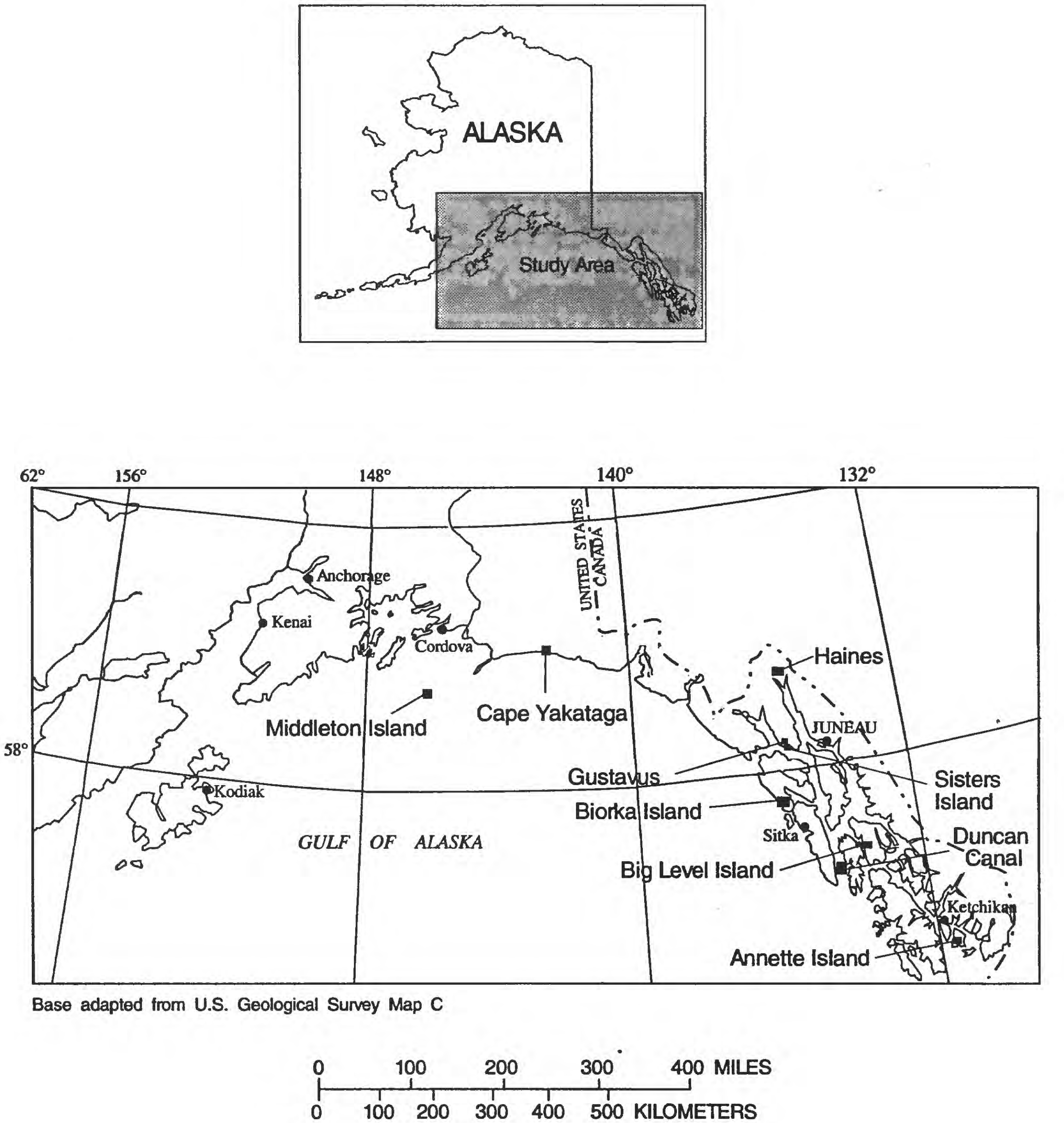


Figure 1. Location of nine coastal and island sites in south-central and southeast Alaska.

OVERVIEW

History

At the time of first western contact, two groups of Indians occupied coastal and island areas in south-central and southeast Alaska, the Tlingit and the Haida. Their settlement patterns were dictated by the variety and abundance of natural resources. Trade also was an integral part of their economic and social life (Selkregg, 1976).

In the early 18th century, a series of Russian voyages were made in an effort to locate the western opening of the Northwest Passage. Explorers landed at Cape St. Elias on July 17, 1741, marking the first European landfall on the coast of southeastern Alaska. Over the next several years, the Russians continued to move east in search of new sea otter hunting grounds. In 1804, the Russians established a capital at Sitka. The Russian hold on southeastern Alaska was tenuous and was challenged in the early 1820's by England and America (Selkregg, 1976).

In 1867, the United States purchased Alaska from Russia. After the discovery of gold in the late 1800's, southeastern Alaska's population boomed. Wrangell, Petersburg, Ketchikan, Craig, and other small towns were established, and in 1900, Juneau became the capital of the new territory (Selkregg, 1976).

The economy of this area of Alaska is dependent on natural resources, particularly marine resources, minerals, and forest products. Growth in State and local governments has provided employment opportunities and has stimulated development in other economic areas including tourism, retail trade, construction, and transportation services (Selkregg, 1976).

Climate

Climate in coastal areas of south-central and southeast Alaska is dominated by maritime influences (Hartman and Johnson, 1984). Climatic conditions are characterized by small temperature variations, high humidity, heavy precipitation, and frequent cloudy and foggy periods. Summers are cool and winters are mild. Surface winds generally are strong and persistent (Hartman and Johnson, 1984). Data on the local climate conditions are presented on a site-by-site basis later in this report.

Vegetation

Vegetation in coastal areas of south-central and southeast Alaska consists principally of coastal western hemlock and Sitka spruce forest. The vegetation is characterized by an overstory of Sitka spruce, western hemlock, Alaska cedar, and black cottonwood and an understory of blueberry, five-leaf bramble, gold thread, and several types of ferns, lichens, and mosses (Viereck and Little, 1972). Muskeg vegetation exists in many places on local islands and includes sphagnum moss, Labrador tea, and bog rosemary. Shoreline vegetation, common along coastal areas, includes silverweed, hair grass, yarrow, buttercup, and a variety of sedges. Alpine vegetation, starting at about 600 m above mean sea level includes mountain hemlock, low mat-forming shrubs, deer cabbage, heather, lichen, berries, and willow (Environmental Services Ltd., 1979).

Geology

In general, bedrock is either exposed or very near the land surface throughout the coastal and island areas of south-central and southeast Alaska. Bedrock consists of sedimentary, volcanic, and metamorphic rocks (Berg and Gehrels, 1992). The predominant northwest-trending bedrock pattern contains many folds and faults (Selkregg, 1976). Most of the bedrock in these areas of Alaska is overlain by unconsolidated deposits of Quaternary age (Berg and Gehrels, 1992). Surficial materials cover much of the lowland areas but are minimal or nonexistent in upland areas (Berg and Gehrels, 1992). Soils are continuous over the land surface except in areas of steep relief or areas covered by ice and snow.

Earthquakes

The nine FAA facilities described in this report lie within the active circum-Pacific seismic belt. Middleton Island and Cape Yakataga are near the Aleutian Trench, the Yakataga Seismic Gap, and the St. Elias fault. The rest of the facilities are in an area traversed by the Chatham Strait fault, the Fairweather fault, and numerous smaller faults (Brower and others, 1977; Stephens and others, 1986). In recent years, several earthquakes with Richter scale magnitudes greater than 7 have been recorded (Brower and others, 1977). The Yakataga Seismic Gap is considered to be a likely site for a 7.8 or larger earthquake within the next decade (Stephens and others, 1986). Much of the land in south-central and southeast Alaska has been uplifted since the last glaciation as shown by the widespread presence of emergent marine deposits (Selkregg, 1976). Studies on Middleton Island indicate a significant amount of vertical displacement as a result of past seismic activity (Prescott and Lisowski, 1977). Large, fast-moving sea waves (tsunamis) generated by earthquakes are a potential hazard for most coastal and island communities (U.S. Army Corps of Engineers, 1993; Brower and others, 1977).

Hydrology

Surface Water

Parts of Alaska's Pacific coast receive more than 2,500 mm/yr of precipitation (Hartman and Johnson, 1984). Because of steep topographic gradients, most of this precipitation runs off rapidly into lakes and streams as surface water, and only a minor amount infiltrates to the ground-water system (Selkregg, 1976). Most of the small lakes, rivers, and creeks in southeast Alaska drain from the west side of the Coast Mountains and St. Elias Mountains, and from the islands of the Archipelago directly into the sea. South-central and southeast Alaska are free of permafrost (Ferrians, 1980). Mean annual runoff rates range from about 0.02 to more than 0.14 $(m^3/s)/km^2$ (B.B. Bigelow, U.S. Geological Survey, written commun., 1995).

Tides

A two-layered estuarine circulation system is a common phenomenon in coastal areas of Alaska and is most likely to occur in protected bays and along passages near the outer coast. In this system, fresh water flows seaward along the surface and is replaced by sea water flowing toward the coast at greater depths. Fall storms, reduced runoff during the winter, and tidal variations combine to mix the layers and destroy the system (U.S. Army Corps of Engineers, 1989). Brower and others (1977) discuss diurnal tidal ranges, as well as the maximum and minimum tides predicted to occur at several coastal and island sites in Alaska. Estimated data for sites near FAA facilities are given in table 1.

Table 1. Estimated tide data near FAA facilities
[Diurnal range is the average difference in height between mean higher high water and mean lower low water in meters on a single day; maximum and minimum tide are the highest and lowest tide predicted to occur at the location in meters above mean sea level, a negative number indicates a level below mean sea level. m, meters]

Location	Diurnal range (m)	Maximum tide (m)	Minimum tide (m)
Middleton Island	3.6	4.5	-1.0
Cape Yakataga	3.0	3.8	-0.8
Gustavus	4.5	5.7	-1.4
Haines	5.1	6.3	-1.4
Biorka Island	3.0	3.8	-0.8
Big Level Island	4.8	5.9	-1.2
Annette Island	4.6	5.8	-1.3
Sisters Island	4.5	5.7	-1.4
Duncan Canal	4.6	5.8	-1.3

Floods

Although most of the island and coastal communities in south-central and southeast Alaska have low flood-hazard ratings, they are vulnerable to some degree of flooding by storm-driven or tsunami waves (U.S. Army Corps of Engineers, 1993). Tsunami waves are generated by seismic activity and are capable of traveling great distances across water striking shore areas with potentially destructive effects. Storm-driven waves also can affect low-lying coastal communities but have less potential to travel inland because of reduced wave velocity. Brower and others (1977) describe return periods for maximum wave heights for selected marine areas in Alaska (table 2). A 100-year storm wave that is more than 20 m in height is estimated for coastal areas in south-central and southeast Alaska.

Table 2. Estimated maximum wave heights for selected return periods

Location	Return period (years)	Maximum significant wave (meters)
Middleton Island	5	13.0
	10	14.5
	25	17.0
	50	19.0
	100	21.5
Cape Yakataga	5	12.5
	10	14.0
	25	17.0
	50	19.0
	100	21.5
Annette Island, Big Level Island, Biorka Island, Gustavus, Haines, Sisters Island, and Duncan Canal	5	12.0
	10	14.0
	25	16.0
	50	18.5
	100	20.5

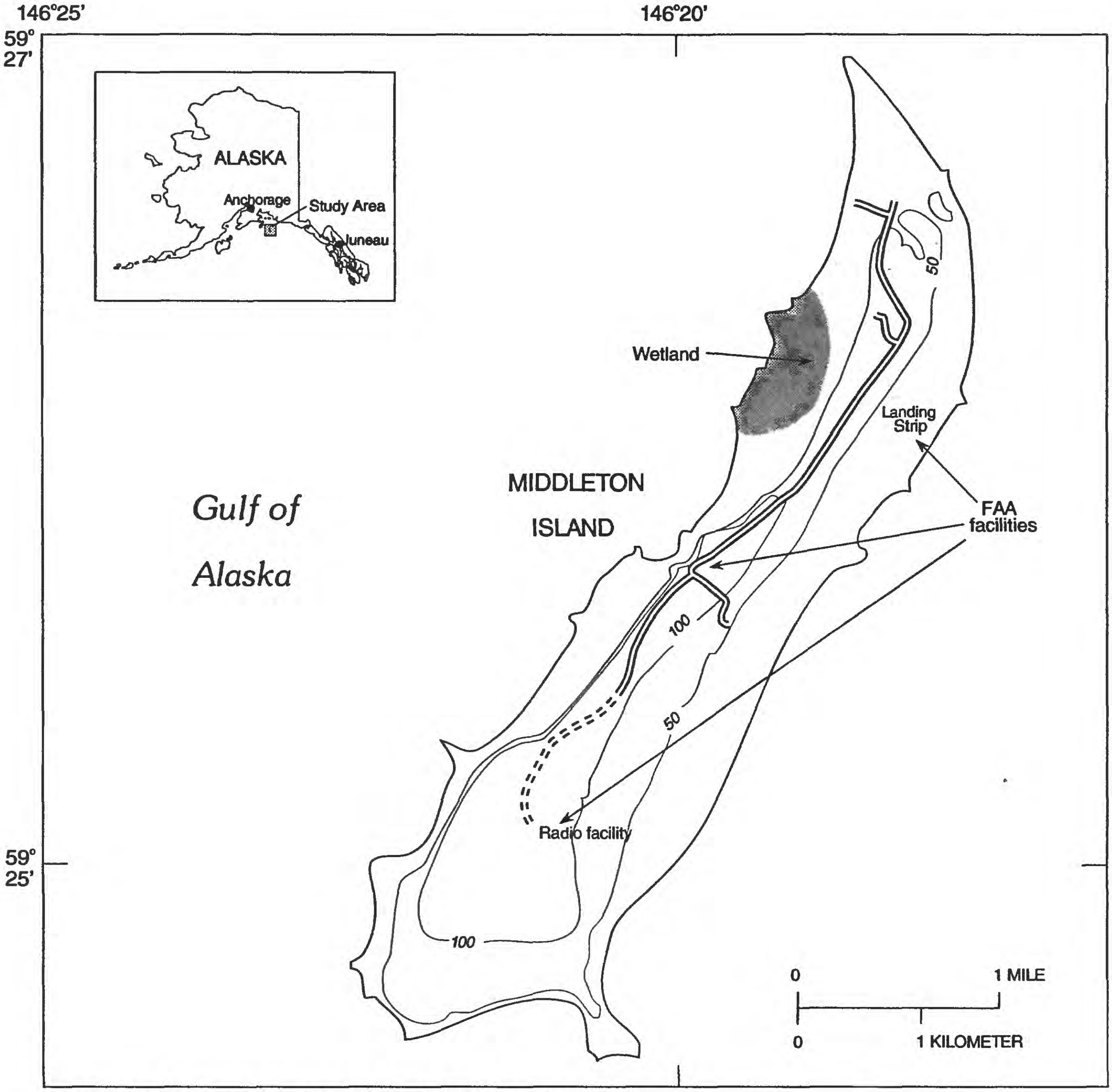
Overbank flooding of stream channels in south-central and southeast Alaska may occur as the result of intense rainfall augmented by snow and glacier melting (Selkregg, 1976; Jones and Fahl, 1994). Flood crests in southeastern Alaska are typically short in duration and are characterized by a very sharp increase and decrease of flow. Available flood data for Alaskan communities in this report along with the flood-hazard rating are given in table 3.

Table 3. Flood-hazard ratings for nine coastal and island sites
[U.S. Army Corps of Engineers, 1993, unless otherwise noted]

Community	Flood-hazard rating
Middleton Island	Not available, but assumed low; probably subject to local drainage problems and (or) tsunamis
Cape Yakataga	Low; glacial outburst flooding has occurred in the past (Selkregg, 1976)
Gustavus	Low; last flood in 1976 due to heavy rains
Haines	Low; some flooding in 1988 due to rain on frozen ground
Biorka Island	Low; local tsunami possible
Big Level Island	Not available, but assumed low; probably subject to local drainage problems and (or) tsunamis
Annette Island	Low; tsunamis and local drainage may be problems
Sisters Island	Not available, but assumed low; probably subject to local drainage problems and (or) tsunamis
Duncan Canal	Not available, but assumed low; probably subject to local drainage problems and (or) tsunamis

Ground Water

Ground-water data for the FAA facilities in south-central and southeast Alaska are sparse. Water-bearing surficial materials include alluvial and glacial deposits that are found at depths typically ranging from 3 to 30 m below land surface (Selkregg, 1976). Ground water may also occur in fractured bedrock. Freshwater occurs beneath islands and coastal areas as a "freshwater lens" that floats on saltwater (Hunt and others, 1988). This is sometimes referred to as basal water and it can occur under confined or unconfined conditions (Hunt and others, 1988). Basal water often extends to depths below sea level of about 40 times the water-table elevation or potentiometric surface. Near the base of the lens, freshwater grades into saltwater in a transition zone that may range from a few meters to a few hundred meters (Hunt and others, 1988). The possibility of saltwater intrusion into coastal and island aquifers increases with depth and pumping rate.



Base from U.S. Geological Survey, Middleton Island (B-7), Alaska, 1:63,360, 1955

Figure 2. Location of Middleton Island, Alaska and the Federal Aviation Administration facilities.

MIDDLETON ISLAND

Location and Facility History

Middleton Island is a small uninhabited island about 6.5 km long and about 1.5 km wide. It is about 200 km south of Valdez in the Gulf of Alaska at lat 59°27'N., long 146°18' W., (figs. 1 and 2). The first FAA navigational aids on Middleton Island were constructed in 1942. The FAA facilities currently include storage buildings, a gravel airstrip, and radio towers. FAA personnel stationed in Kenai carry out facility maintenance. Occupation of FAA buildings occasionally occurs during visits by other Federal agencies conducting seasonal research on Middleton Island. A detailed list of FAA-owned and operated facilities on Middleton Island, and a list of potential sources of contamination can be found in an environmental compliance investigation report by Ecology and Environment, Inc. (1992a).

Climate

Middleton Island has a mean annual temperature of 5.7 °C. Temperatures range from an August mean maximum of 14.4 °C to a February mean minimum of -0.8 °C (Leslie, 1989). Mean annual precipitation is about 1,460 mm and mean annual snowfall is about 860 mm. Mean monthly and annual temperature, precipitation, and snowfall are summarized in table 4 (Leslie, 1989).

Table 4. Mean monthly and annual temperature, precipitation, and snowfall, Middleton Island, Alaska, 1942-72

[Modified from Leslie (1989); °C, degree Celsius]

	Jan.	Feb.	Mar.	Apr.	May	June	July	Aug.	Sept.	Oct.	Nov.	Dec.	Annual
Temperature (°C)													
Mean maximum	2.5	2.6	3.4	5.6	8.1	11.1	13.6	14.4	12.4	8.6	5.6	2.9	7.6
	(Record maximum 22.2 °C, August 1957)												
Mean minimum	-0.7	-0.8	-0.3	1.3	3.9	6.8	9.3	10.2	8.4	4.9	2.2	-0.4	3.7
	(Record minimum -14.4 °C, February 1947)												
Mean	0.9	0.9	1.6	3.4	6.0	8.9	11.4	12.3	10.4	6.8	3.9	1.3	5.7
Precipitation, in millimeters													**Total**
	135	100	85	83	92	57	88	122	181	200	176	143	1,462
Snowfall, in millimeters													**Total**
	193	158	178	48	10	0.0	0.0	0.0	0.0	15	53	203	858

Geology

Bedrock on Middleton Island is composed of sedimentary rocks (Winkler and Plafker, 1993). Depth to bedrock typically is less than 10 m below land surface (Winkler and Plafker, 1993). Middleton Island lies within a major fault system and the geologic record illustrates significant tectonic uplift (Hudson and others, 1976; Prescott and Lisowski, 1977; Winkler and Plafker, 1993). The average uplift rate during the past 4,500 years is about 1 cm/yr. Unconsolidated deposits on Middleton Island are beach sand and till. The deposits are arranged in a unique series of step-like terraces ranging in height from 3 to 30 m above mean sea level (Hudson and others, 1976). Beach deposits consist of sand, minor amounts of gravel, and silt; till consists of unconsolidated silt, sand, gravel, and boulders.

Hydrology

Surface Water

Wetland areas and small ponds compose Middleton Island's surface-water system. Wetland areas extend along 1.5 km of the northwest coastline (fig. 2). Ponds on the island are shallow and are typically less than 0.02 km^2 in area. A topographic gradient of about 60 m/km directs water from the center of the island to the coast. Mean annual runoff on the island is estimated to be between 0.1 and 0.2 $(m^3/s)/km^2$ (B.B. Bigelow, U.S. Geological Survey, written commun., 1995).

Ground Water

Ground water on Middleton Island is present at depths between 1 and 3 m below land surface (Winkler and Plafker, 1993). A 3-meter-deep well at the Middleton Island FAA facility reached the aquifer about 1 m below the land surface (Appendix 1; Ecology and Environment, Inc., 1992a). In general, flow of ground water is likely to follow surface topography toward the coast. The availability of ground water from bedrock is unknown. Ground water is recharged by infiltration of precipitation.

Drinking Water

Selkregg (1976) reports the use of both ground-water and surface-water sources for drinking water on Middleton Island; however, the FAA facility uses only ground water for drinking-water supplies (Ecology and Environment Inc., 1992a). The drinking-water system, constructed in 1980, is an infiltration gallery with a capacity of about 0.3 L/s. Before settling and filtration, the water is chemically treated with potassium permanganate, ammonium sulfate, and soda ash (Ecology and Environment Inc., 1992a). Small unnamed ponds represent drinking-water alternatives for Middleton Island. However, the quality and quantity of these water resources is undocumented.

CAPE YAKATAGA

Location and Facility History

Cape Yakataga is in the Yakataga Glacial Valley along the Gulf of Alaska. It is about 450 km southeast of Anchorage near lat 60°03' N., long 142°25' W. (figs. 1 and 3). The FAA facilities at Cape Yakataga consist of air-navigation and support equipment that has been operating since May 1942. Facilities include a nondirectional beacon, a powerhouse and shop, employee living quarters, and a beacon tower that are maintained by FAA personnel stationed in Cordova. A detailed list of FAA facilities at Cape Yakataga and potential sources of contamination can be found in an environmental compliance investigation report by Ecology and Environment Inc. (1992b).

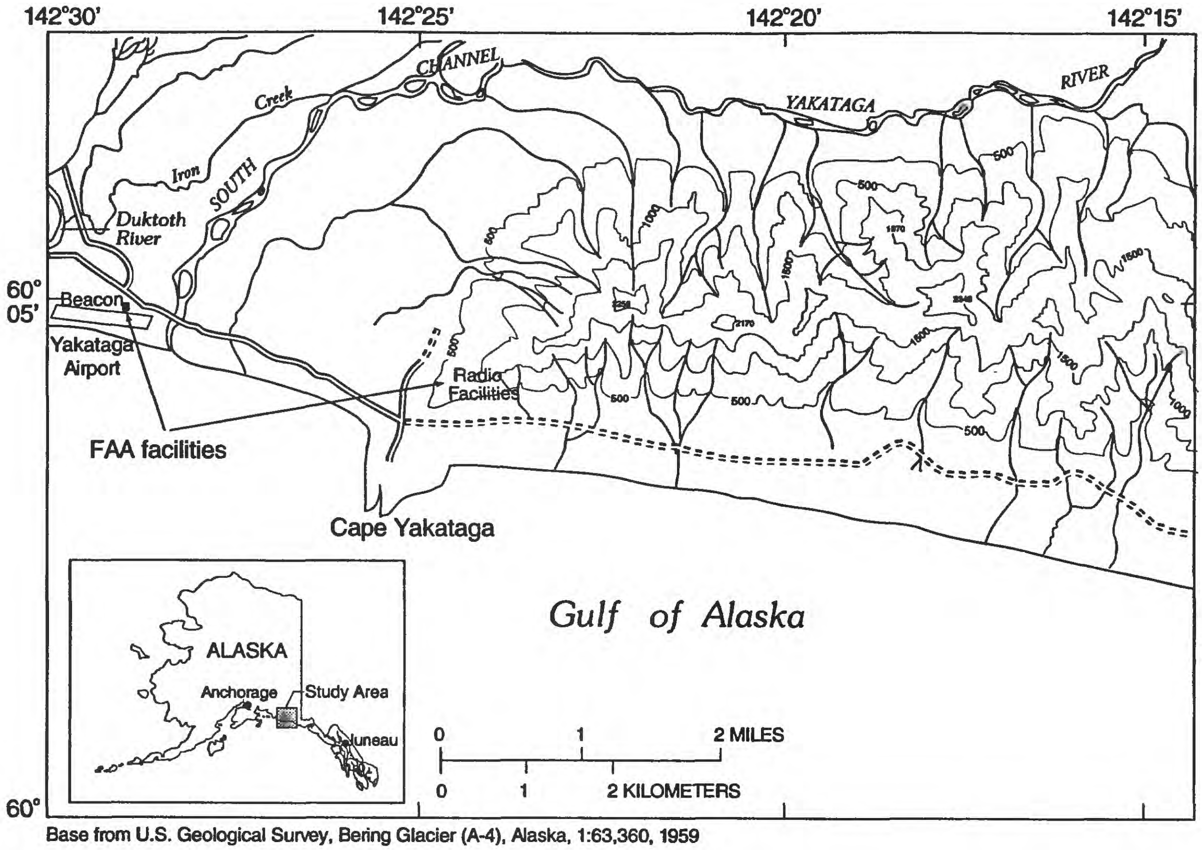


Figure 3. Location of Cape Yakataga, Alaska and the Federal Aviation Administration facilities

Climate

Cape Yakataga has a mean annual temperature of 4.4 °C. Temperatures range from a July mean maximum of 40.6 °C to a January mean minimum of -5.5 °C (Leslie, 1989). Mean annual precipitation is about 2,580 mm and mean annual snowfall is about 2,700 mm. Mean monthly and annual temperature, precipitation, and snowfall are summarized in table 5 (Leslie, 1989).

Table 5. Mean monthly and annual temperature, precipitation, and snowfall, Yakataga, Alaska, 1943-83.
[Modified from Leslie (1989); °C, degree Celsius]

	Jan.	Feb.	Mar.	Apr.	May	June	July	Aug.	Sept.	Oct.	Nov.	Dec.	Annual
						Temperature (°C)							
Mean maximum	0.7	2.5	3.8	6.4	9.7	36.8	40.6	14.7	12.7	8.5	4.1	1.3	7.6
	(Record maximum 25.6°C, July 1955)												
Mean minimum	-5.5	-4.4	-3.3	-0.8	2.8	6.6	8.9	8.3	5.9	1.9	-1.7	-4.3	1.2
	(Record minimum -23.8°C, March 1956)												
Mean	-2.4	-0.9	0.3	2.8	6.3	9.6	11.7	11.5	9.3	5.2	1.2	-1.5	4.4
						Precipitation, in millimeters							Total
	202	179	135	150	145	114	139	201	345	391	294	287	2,582
						Snowfall, in millimeters							Total
	521	541	450	117	203	0.0	0.0	0.0	0.0	61	226	587	2,706

Geology

The bedrock underlying Cape Yakataga consists of sedimentary rocks of Miocene and Pliocene age (Miller, 1971; Winkler and Plafker, 1993). The rocks include concretionary and pyritic siltstone, claystone, and sandstone and subordinate, organic-rich shale, silty shale, and calcareous sandstone (Miller, 1971; Winkler and Plafker, 1993). Depth to bedrock is greater than 9 m below land surface (Miller, 1971). Surficial materials near Cape Yakataga are principally outwash alluvium of Quaternary age consisting of thick, extensive sand and gravel deposits that are at least 9-m thick (Miller, 1971). Soils in the area are of two principal types (Rieger and others, 1979). Soils developed on well-drained outwash consists of gravelly loam and silt loam. Organic-rich soils are found in poorly drained low-lying areas and consist mostly of peat in various stages of decomposition (Rieger and others, 1979).

Hydrology

Surface Water

The South Channel of the Yakataga River, the Dukoth River, and Iron Creek are the principal freshwater bodies near the FAA facilities at Cape Yakataga (fig. 3). The South Channel of the Yakataga River passes due east of the airport, flows from northeast to southwest, and empties into the Gulf of Alaska. The Duktoth River passes due west of the facilities, flows from north to south, and also empties into the Gulf of Alaska. Iron Creek passes the airport about 1.5 km to the north and is a tributary of the Duktoth River (fig. 3). Surrounding the facilities are other unnamed tributaries of the Gulf of Alaska that originate in the Robinson Mountains. Mean annual runoff in the Cape Yakataga area is estimated to exceed 0.14 $(m^3/s)/km^2$ (B.B. Bigelow, U.S. Geological Survey, written commun., 1995).

Ground Water

Ground water near the FAA facilities at Cape Yakataga is found in the unconsolidated deposits of Quaternary age. A southward-sloping area of alluvial fans and outwash deposits, extending from the base of the Robinson Mountains to the coast, contains ground water (Rosenshein, 1988). On a regional scale, ground-water flow likely matches the local topography, flowing from the Robinson Mountains, south-southwestward to the coast. Locally, ground-water flow is generally towards drains such as rivers, streams, and ponds. Water was reached in a 8.5 meter-deep well at the FAA facilities between 4.5 and 7.5 m below land surface (Ecology and Environment Inc., 1992b). The availability of ground water from bedrock is unknown.

Recharge to the unconsolidated deposits primarily is from infiltration of precipitation and streamflow, and from subsurface inflow. Recharge is probably greatest when precipitation is high and streamflow is at or near maximum for the year, although the quantity of recharge to the ground-water system near Cape Yakataga is unknown. Ground water discharges from the unconsolidated deposits into springs, streams, and the Gulf of Alaska, and is lost through evapotranspiration and well withdrawal. Data are not available to determine the quantity of ground-water discharge.

Drinking Water

Selkregg (1976) reports that a well is the primary drinking-water source for the community of Cape Yakataga. Ecology and Environment Inc. (1992b), however, reports that well water is not used by FAA personnel or by residents within 6.5 km of the FAA facilities. Drinking water is flown or hauled in with other supplies.

The South Channel of the Yakataga River, Duktoth River, Iron Creek, and untapped areas of the aquifer represent alternative drinking-water sources for residents near the Cape Yakataga FAA facilities. Data for these water resources are unavailable.

GUSTAVUS

Location and Facility History

Gustavus is a small community adjacent to the southern boundary of Glacier Bay National Park. It is about 80 km west of Juneau near the north end of Icy Strait at lat 58°25' N., long 135°40' W. (figs. 1 and 4). The Gustavus FAA facilities were first constructed as a military support airstrip during World War II. Some of these facilities were transferred to the State of Alaska in 1965 (Ecology and Environment Inc., 1992c). The FAA currently operates communication and navigation support facilities at or near the Gustavus Airfield. A detailed list of FAA owned and operated facilities at Gustavus and a list of potential sources of contamination can be found in an environmental compliance investigation report by Ecology and Environment Inc. (1992c).

Climate

Gustavus has a mean annual temperature of 4.9 °C. Temperatures range from a July mean maximum of 17.4 °C to a January mean minimum of -5.9 °C (Leslie, 1989). Mean annual precipitation is about 1,370 mm and mean annual snowfall is about 1,790. Mean monthly and annual temperature, precipitation, and snowfall are summarized in table 6 (Leslie, 1989).

Table 6. Mean monthly and annual temperature, precipitation, and snowfall, Gustavus, Alaska, 1923-87.
[Modified from Leslie (1989); °C, degree Celsius]

	Jan.	Feb.	Mar.	Apr.	May	June	July	Aug.	Sept.	Oct.	Nov.	Dec.	Annual
						Temperature (°C)							
Mean maximum	0.3	1.6	4.3	8.6	12.9	16.2	17.4	17.2	14.2	8.9	4.0	1.1	8.9
	(Record maximum 30.6°C, August 1957)												
Mean minimum	-5.9	-5.4	-3.4	-0.2	3.1	6.4	8.7	7.8	5.4	2.5	-2.1	-4.7	1.0
	(Record minimum -31.7°C, January 1925)												
Mean	-2.9	-1.9	0.4	4.2	8.1	11.3	13.0	12.5	9.8	5.8	0.9	-1.8	4.9
						Precipitation, in millimeters							Total
	118	84	73	66	70	61	97	116	172	229	158	126	1,370
						Snowfall, in millimeters							Total
	446	340	302	48	5	0.0	0.0	0.0	0.0	20	178	446	1,785

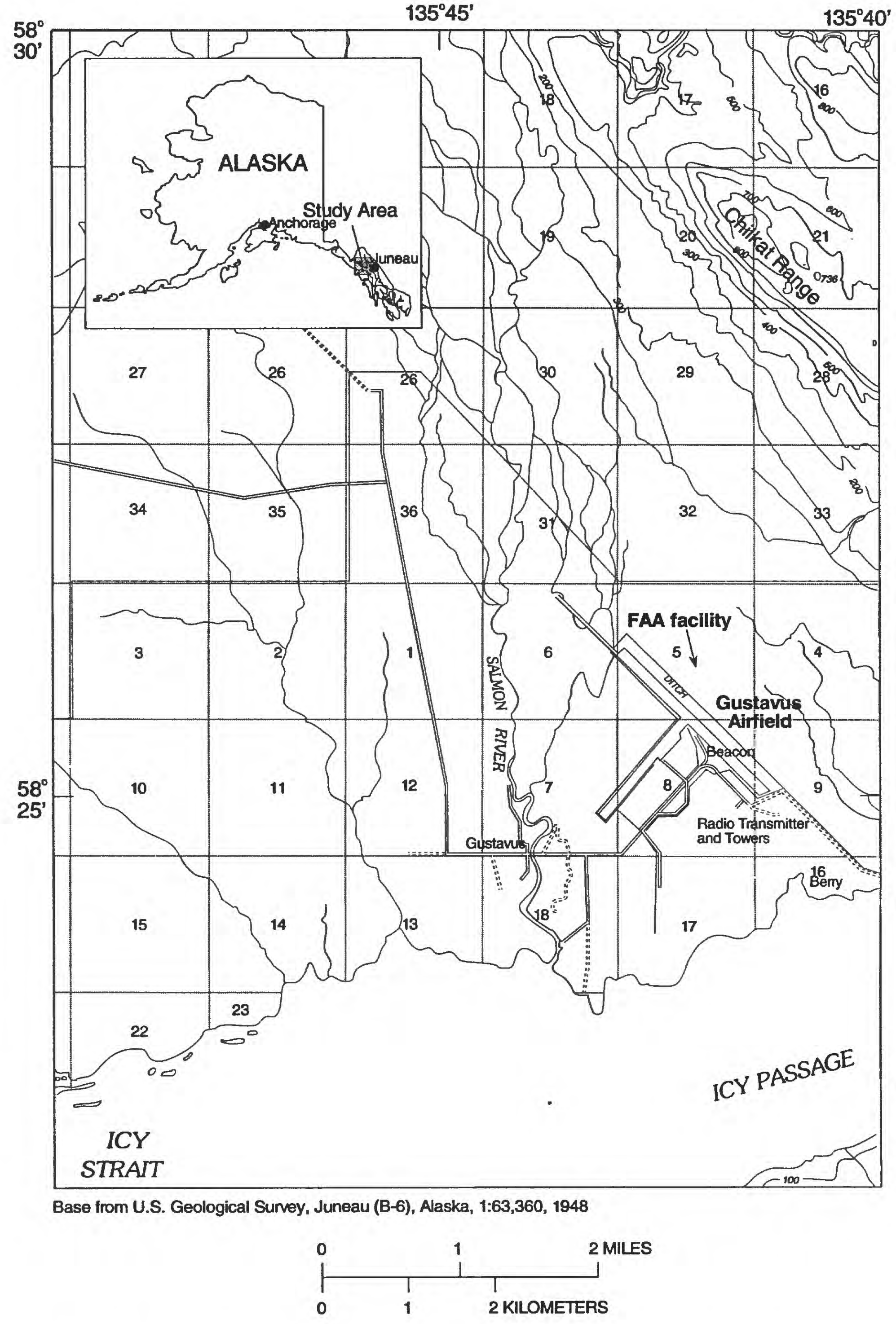


Figure 4. Location of Gustavus, Alaska and the Federal Aviation Administration facility.

Geology

Bedrock is exposed northeast of Gustavus in the Chilkat Range and consists of sedimentary graywacke, mudstone, and turbidites of Silurian age, interbedded with lenses of limestone and conglomerate rocks. Grandiorite intrusions are common (Berg and Gehrels, 1992). Depth to bedrock near Gustavus is unknown. Unconsolidated surficial materials near Gustavus include alluvial and glacial deposits (Rieger and others, 1979). Moderately well-drained alluvial deposits are found along streams and rivers and consist of well-sorted silt, sand, and gravel. Glacial deposits consist of sand, silt, gravel, and boulders (Rieger and others, 1979). Organic-rich soils occupy areas near Gustavus where the water table is shallow and the land gradient is less than 1 percent (Rieger and others, 1979). The soils formed on glacial deposits near Gustavus are typically well drained and consist of 0.3 to 0.5 m of dark-gray stratified silt loam (Rieger and others, 1979).

Hydrology

Surface Water

The Salmon River and several small tributaries to Icy Strait are the principal freshwater bodies near the FAA facility at Gustavus (fig. 4). Hydrologic data for these bodies of water were not found. Gustavus is about 30 m above mean sea level and a gradual topographic gradient of about 5 m/km directs runoff south towards Icy Strait. Average annual runoff near Gustavus is about 0.10 $(m^3/s)/km^2$ (Selkregg, 1976).

Ground Water

Ground water near Gustavus generally is present within alluvial and glacial materials. Individual wells reached water at depths ranging from 5 to 12 m below land surface (Appendix 3). A 17-meter-deep well was drilled near the FAA facility in September 1965 and water was reached at 6 m below land surface (Appendix 3). Drawdown in this well was 1.5 m after 24 hours of pumping at a rate of 1.9 L/s. Drawdown was 3 m after 24 hours of pumping at a rate of 4.4 L/s.

Ground water is recharged by infiltration of rainfall and the melting of snow. Ground-water flow is south to southwest toward Icy Strait. The presence of water in bedrock is unknown. Exposed bedrock north and east of Gustavus is dense and the occurrence of water in such rocks is unlikely.

Drinking Water

Ground water is the principal drinking-water source near Gustavus. Some residents, however, use surface-water sources (U.S. Bureau of Census, 1991). About 88 percent of the residents near Gustavus obtain their drinking water from individual wells, 10 percent use a single community well, and 2 percent use surface-water sources (U.S. Bureau of Census, 1991). The community well is within a 500-meter radius of the FAA facility and is completed to a depth of about 10 m below land surface. Between 1959 and 1968, ground-water samples were taken from at least six different wells near the FAA facility (Appendix 3), and major ions and water properties were analyzed. With the exception of iron, concentrations of measured constituents are within current U.S. Environmental Protection Agency (USEPA) regulations (table 7).

Table 7. Concentrations of selected inorganic constituents in ground water near the FAA facility, Gustavus, Alaska

[mg/L, milligrams per liter]

Constituent (or property)	USEPA Drinking-water regulation (mg/L)	Concentration range in ground water at the FAA facility (mg/L)
Chloride (Cl)	250	1.6 - 35
Iron (Fe)	0.3	0.02 - 4.0
Sulfate (SO_4)	250	11 - 53
Fluoride (F)	2	0.0 - 0.1
Total dissolved solids	500	232 - 322
pH (units)	6.5 - 8.5	6.7 - 8.2

The Salmon River and several small Icy Strait tributaries may be alternative drinking-water sources for residents near the FAA facility at Gustavus. However, quantity and quality data are not available for these water bodies.

HAINES

Location and Facility History

Haines is a small community at the northern end of Lynn Canal between the Chilkoot and Chilkat Inlets. It is about 150 km northwest of Juneau near lat 59°15' N., long 135°29' W. (figs. 1 and 5). The FAA involvement at Haines began in 1948, and the FAA currently operates navigation and communication aids. A detailed list of FAA owned and operated facilities at Haines, and a list of potential sources of contamination can be found in an environmental compliance investigation report by Ecology and Environment Inc. (1994).

Climate

Haines has a mean annual temperature of 5.3 °C. Temperatures range from a July mean maximum of 19.2 °C to a January mean minimum of -6.7 °C (Leslie, 1989). Mean annual precipitation is about 1,300 mm and mean annual snowfall is about 3,360 mm. Mean monthly and annual temperature, precipitation, and snowfall are summarized in table 8 (Leslie, 1989).

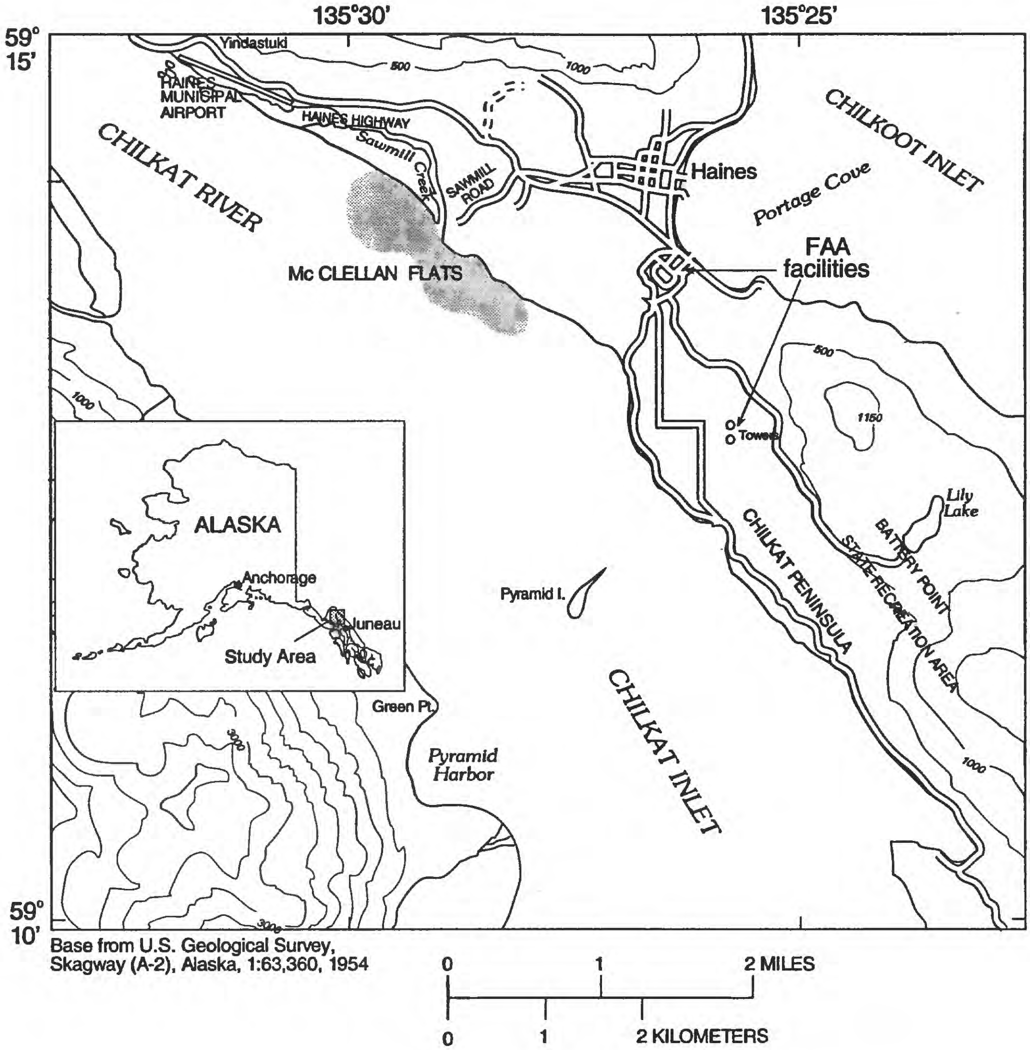


Figure 5. Location of Haines, Alaska and the Federal Aviation Administration facilities.

Table 8. Mean monthly and annual temperature, precipitation, and snowfall, Haines, Alaska, 1973-87.

[Modified from Leslie (1989); °C, degree Celsius]

	Jan.	Feb.	Mar.	Apr.	May	June	July	Aug.	Sept.	Oct.	Nov.	Dec.	Annual
Temperature (°C)													
Mean maximum	-0.6	1.2	4.6	9.3	14.3	17.8	19.2	19.0	14.8	8.8	2.4	-0.7	9.2
	(Record maximum, 36.7°C, July 1976)												
Mean minimum	-6.7	-5.2	-2.4	0.9	4.9	8.2	9.7	8.7	5.7	2.4	-3.8	-6.3	1.3
	(Record minimum, -25.6°C, February 1975)												
Mean	-3.6	-2.0	1.1	5.1	9.6	13.0	14.5	13.9	10.3	5.6	-0.7	-3.5	5.3
Precipitation, in millimeters													**Total**
	162	118	73	87	48	42	37	55	129	246	166	141	1,304
Snowfall, in millimeters													**Total**
	965	732	320	87	5	0.0	0.0	0.0	5	76	467	701	3,357

Geology

Metamorphosed bedrock of Mesozoic age underlies the Haines area and includes intrusive rocks of Cretaceous age and basaltic rocks of Triassic age (Berg and Gehrels, 1992; McConaghy, 1970). The intrusive rocks consist of magnetite-bearing hornblende, metabasalt, pyroxenite, tonalite, and diorite. At its deepest point, bedrock is about 180 m below land surface. (McConaghy, 1970).

Unconsolidated surficial materials in the Haines area include beach deposits, marine clay, alluvial deposits, and glacial outwash (McConaghy, 1970). The most common surficial deposit near the FAA facility is glacial outwash which consists of gravel, sand, silt, and clay that is at least 1 m thick (McConaghy, 1970). A driller's log of a 34-meter-deep well in the Haines area indicates that soil, silty clay, and "rock" occur to 4 m; layered clay and gravel to 16 m; coarse gravel and boulders to 22 m; blue-black clay to 25 m; clay and fine sand to 26 m; and mixed gravel and clay to 34 m below land surface (Appendix 4). Additional well logs are given in Appendix 4.

Two soil types are present near the FAA facilities (Rieger and others, 1979; Environmental Services Ltd, 1979). Soils found in areas of steep relief are typically well drained and acidic (Rieger and others, 1979). These soils are characterized by a thin, gray surface layer over black-to-reddish brown subsurface layers (Rieger and others, 1979). Organic-rich soils are formed in poorly drained low-lying areas and consist of partially to highly decomposed peat (Rieger and others, 1979).

Hydrology

Surface Water

Freshwater resources near the Haines FAA facilities include Sawmill Creek, the Chilkat River, and Lily Lake (fig. 5). Sawmill Creek passes 2 km northwest of the FAA facilities and flows from northwest to southeast draining into the Chilkat River. Low flow of the creek during winter months is estimated to be about 0.3 m^3/s (McConaghy, 1970; Bugliosi, 1988).

The Chilkat River passes the FAA facilities less than 2 km to the east and flows from northwest to southeast. The river represents the largest drainage within southeastern Alaska. Flow of the Chilkat River near Klukwan, about 30 km north of Haines, was recorded from 1959 to 1961 at USGS stream-gaging station 15056500, Chilkat River near Klukwan. From June to August, mean flow of the river is greater than 200 m^3/s, and from January to March, mean flow is less than 13 m^3/s (fig. 6, table 9; U.S. Geological Survey, 1962). The Chilkat River drains an area of about 2,000 km^2 upstream from Klukwan.

Table 9. Mean monthly flow at 15056500, Chilkat River at Klukwan, water years 1959-61
[Values in cubic meters per second]

	Oct.	Nov.	Dec.	Jan.	Feb.	Mar.	Apr.	May	June	July	Aug.	Sept.
Mean	47.2	28.4	23.2	12.6	7.7	8.6	21.6	112	235	256	209	94.0
Maximum	51.7	30.7	24.4	12.7	8.22	9.46	24.9	132	239	282	264	109
Minimum	42.7	26.1	22.2	12.5	7.22	7.85	18.4	92.4	231	229	162	72.6

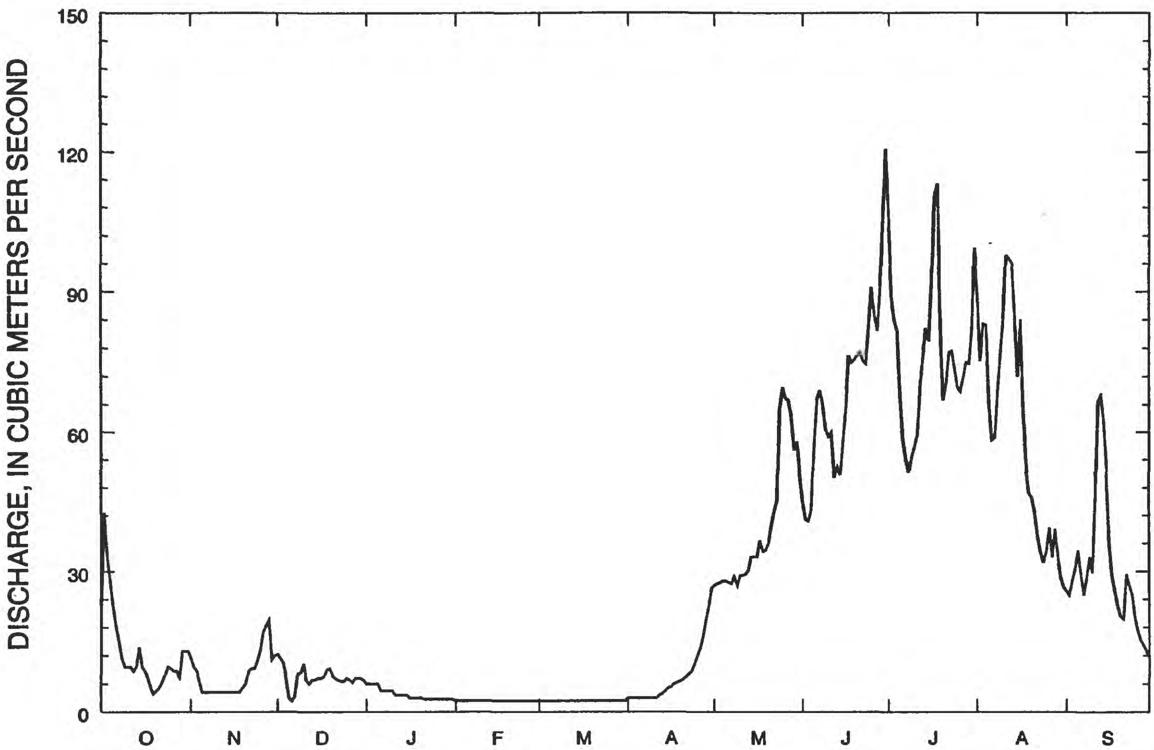


Figure 6. Daily mean discharge of the Chilkat River near Klukwan, water year 1960.

Lily Lake is about 2 km southeast of the FAA facilities at an elevation about 75 m above mean sea level. The lake is the principal drinking-water supply for the Haines community. Lily Lake has a surface area of about 0.13 km^2 and supplies about 3 million L/d to the municipal system (Environmental Service Ltd., 1979).

Near the FAA facility, a southeasterly topographic gradient of about 75 m/km generally causes runoff to flow towards tributaries that drain to the Chilkat River. Annual runoff rates in the area are about 0.2 $(m^3/s)/km^2$ (Selkregg, 1976).

Ground Water

McConaghy (1970) describes the ground-water system in the Haines area. Sand and gravel constitute the unconfined aquifers; clay and silty sand constitute the confining beds. Data on ground-water availability in the Haines area are given in Appendix 4. Ground water is available from alluvium south of the Haines Highway and Sawmill Road (fig. 6). These gravelly deposits, however, are not continuous. The wetland west of Sawmill Road and the raised beach deposits near Portage Cove also have ground-water potential. Wetland areas, however, are subject to periodic tidewater flooding and are unlikely to contain significant amounts of freshwater. The bedrock in upland areas near Haines is exposed or is near the land surface and probably is not a reliable source of ground water.

Several wells between 3 and 79-m deep were drilled in the Haines area (Appendix 4). Water was reached at depths between 1 and 12 m below the land surface. Upland slopes northwest and southwest of the City of Haines are the principal recharge areas (McConaghy, 1970). Most of the ground-water movement is through the valley to the west of the city. Ground water discharges into small streams, wetland areas, the Chilkat River, Chilkat Inlet, and Portage Cove (McConaghy, 1970).

Drinking Water

Lily Lake is the principal drinking-water source near Haines (fig. 5). The city of Haines owns and operates the water-treatment and distribution facility that provides water to all users within the city limits (Environmental Services, Ltd., 1979; U.S. Bureau of Census, 1991). A 15-centimeter transmission line connects the water supply at Lily Lake to a water-treatment plant and two water tanks with a combined capacity of about 660,000 L (Environmental Services, Ltd., 1983). Water treatment consists of filtration followed by chlorination. Average demand for water in Haines is about 490,000 L/d. Peak demand during the summer averages 820,000 L/d. Lily Lake is an abundant water source, and the capacity of the treatment plant could accommodate a 100-percent increase in population (Environmental Services, Ltd., 1979). The water in Lily Lake is reportedly of adequate quality (McConaghy, 1970). Analyses indicated a dissolved-iron concentration of 0.01 mg/L; a chloride concentration of 2.5 mg/L; a hardness as $CaCO_3$ of 98 mg/L; and a total dissolved-solids concentration of 133 mg/L.

Ground water represents an alternative drinking-water source near the Haines FAA facilities. Ground water is found in the glacial outwash south of the Haines Highway and Sawmill Road, the wetland west of Sawmill Road, and the raised beach deposits near Portage Cove (McConaghy, 1970). With the exception of iron and chloride, major ions and water properties are within current USEPA and Alaska Department of Environmental Conservation (ADEC) drinking-water regulations (table 10; Appendix 5; ADEC, 1995). A well near McClellan Flats contained high concentrations of chloride, probably from naturally occurring salt water (McConaghy, 1970).

Table 10. Concentrations of selected inorganic constituents in ground water near Haines, Alaska
[mg/L, milligrams per liter]

Constituent (or property)	USEPA drinking-water regulation (mg/L)	Concentration range in ground water (mg/L)
Chloride (Cl)	250	2.8 - >250
Iron (Fe)	0.3	0.0 - 3.2
Sulfate (SO_4)	250	13 - 99
Fluoride (F)	2	0.0 - 0.6
Total dissolved solids	500	89 - 268
pH (units)	6.5 - 8.5	7.3 - 8.1

BIORKA ISLAND

Location and Facility History

Biorka Island is a small, circular island in Sitka Sound of the western Necker Islands. It is about 175 km southwest of Juneau near lat 56° 51' N., long 135° 31' W. (figs. 1 and 7). The FAA activities on Biorka Island began in 1951 when an operating agreement was signed with the United States Coast Guard (USCG). The FAA facilities currently include communication and navigation aids. A detailed list of FAA facilities on Biorka Island and a list of potential sources of contamination can be found in an environmental compliance investigation report by Ecology and the Environment Inc. (1992d).

Climate

Biorka Island has a mean annual temperature of 6.5 °C. Temperatures range from an August mean maximum of 16.8 °C to a January mean minimum of -2.9 °C (Leslie, 1989). Mean annual precipitation is about 2,400 mm and mean annual snowfall is about 500 mm. Mean monthly and annual temperature, precipitation, and snowfall are summarized in table 11 (Leslie, 1989).

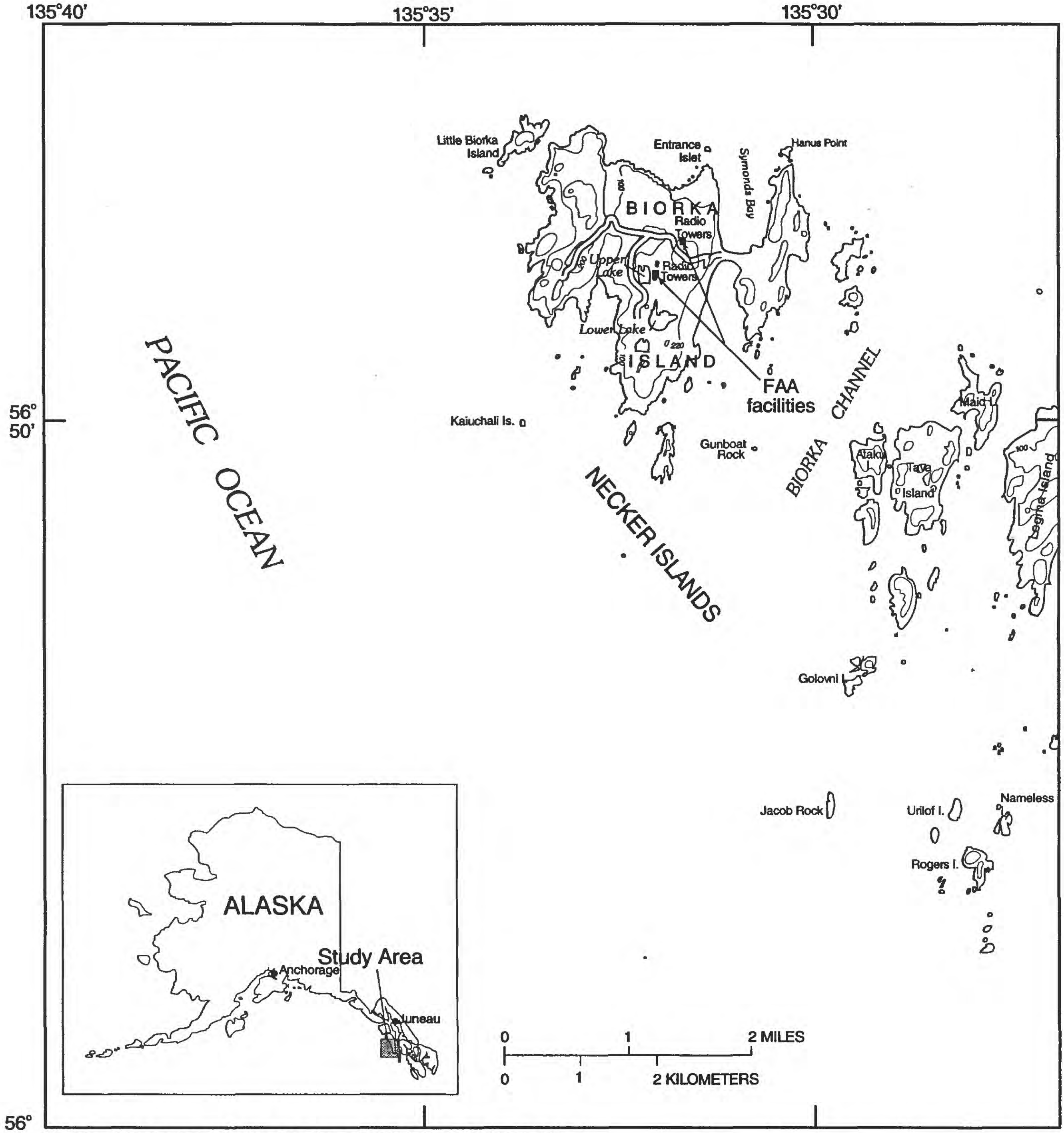
Table 11. Mean monthly and annual temperature, precipitation, and snowfall, Biorka Island, Alaska, 1972-79.

[Modified from Leslie (1989); °C, degree Celsius]

	Jan.	Feb.	Mar.	Apr.	May	June	July	Aug.	Sept.	Oct.	Nov.	Dec.	Annual
						Temperature (°C)							
Mean maximum	3.9	5.3	5.9	8.7	11.1	12.9	15.4	16.8	15.3	10.9	6.5	4.1	9.7
	(Record maximum, 23.9 °C, May 1975)												
Mean minimum	-2.9	-1.4	0.1	1.2	4.4	6.8	9.4	10.0	7.9	3.8	0.3	-0.7	3.2
	(Record minimum, -20.6 °C, December 1975)												
Mean	0.6	2.1	3.1	5.0	7.8	9.8	12.5	13.2	11.6	7.3	3.4	1.6	6.5
						Precipitation, in millimeters							Total
	178	189	199	148	165	127	122	114	231	422	252	249	2,396
						Snowfall, in millimeters							Total
	191	178	79	15	0.0	0.0	0.0	0.0	0.0	0.0	0.0	38	501

Geology

Bedrock on Biorka Island consists principally of dark-gray, medium- to thick-bedded, feldspathic, lithic, and arkosic graywacke, with lesser amounts of argillite, conglomerate, and chert (James Riehle, U.S. Geological Survey, oral commun., 1995; Berg and Gehrels, 1992). Surficial deposits on Biorka Island are mainly the products of volcanic eruptions (Rieger and others, 1979). These deposits consist mainly of ash and fine pumice and typically are 0.06 to 0.08 m thick (James Riehle, U.S. Geological Survey, oral commun., 1995).



Base from U.S. Geological Survey, Port Alexander (D-5), Alaska, 1:63,360, 1951

Figure 7. Location of Biorka Island, Alaska and the Federal Aviation Administration facilities.

Hydrology

Surface Water

Upper and Lower Lakes compose Biorka Island's principal freshwater resources (fig. 7). Upper Lake is within 800 m of several FAA facilities, and Lower Lake is about 400 m south of Upper Lake (fig. 7). Small, intermittent streams may occur during abundant rainfall or spring thaw. The FAA facilities near the middle of the island are about 60 m in elevation. From these facilities to the coast, the land surface drops about 75 m/km. Low-lying areas covering the island form a single drainage basin that is about 1.5 km^2 in area. Mean annual runoff on the island is estimated at 0.15 $(m^3/s)/km^2$ (B.B Bigelow, U.S. Geological Survey, written commun., 1995).

Ground Water

Ground-water data for Biorka Island are scarce. Water from two wells within a 10-kilometer radius of the FAA facilities was once used for purposes other than drinking (Appendix 5). The depths of these wells and water levels are unknown. A well drilled by Ecology and Environment Inc. (1992d) reached water at a depth of about 0.2 m below land surface. The availability of ground water from bedrock on Biorka Island is unknown.

Drinking Water

Lower Lake is the principal drinking-water source on Biorka Island and is used by seasonal residents (fig. 7). The water is not currently used by FAA personnel. The quality and quantity of water in Lower Lake is unknown. Drinking water for the FAA facilities is flown or hauled in with other supplies. Shallow lakes, including Upper Lake, small streams, and ground water represent alternative drinking-water sources for Biorka Island. However, the quality and quantity of these resources are unknown.

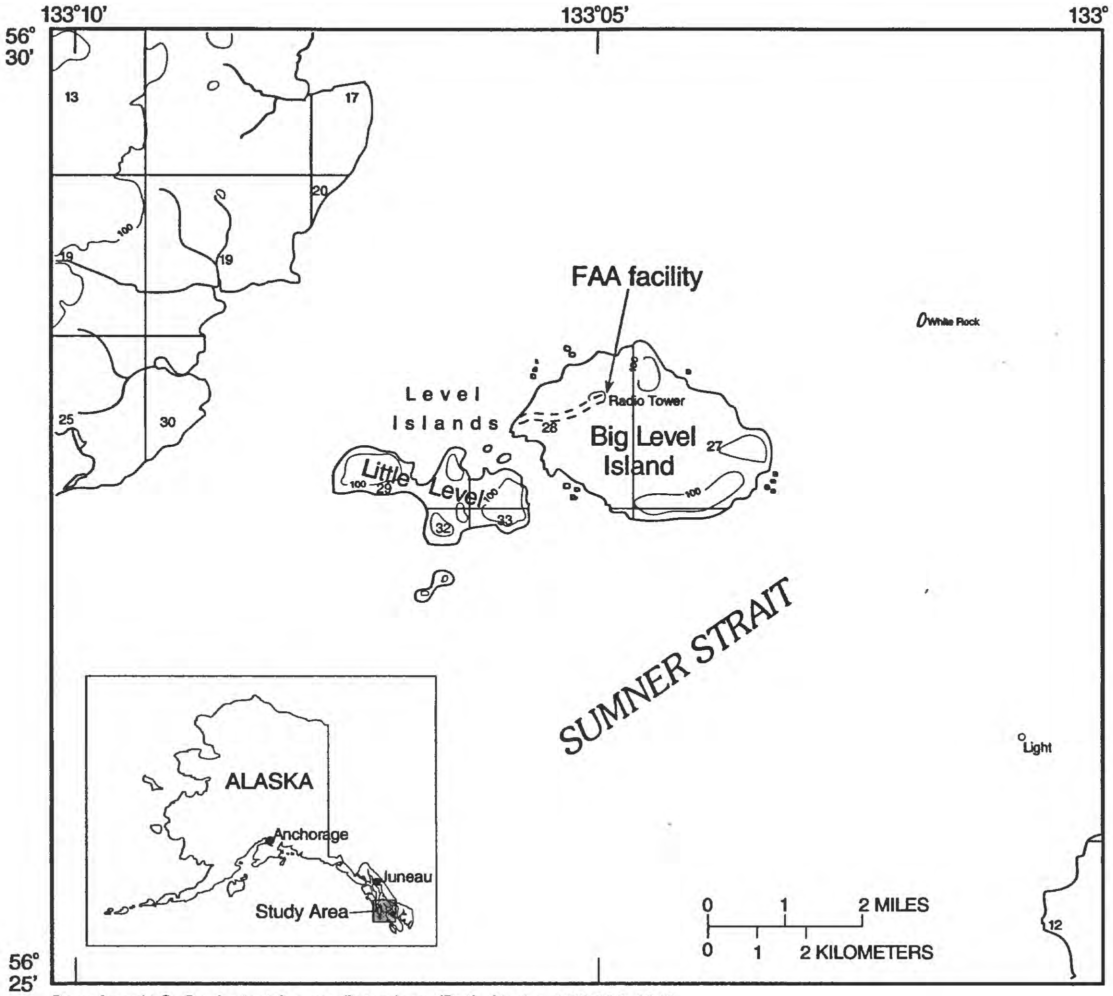
BIG LEVEL ISLAND

Location and Facility History

Big Level Island is an uninhabited, circular island about 2 km in diameter. It is in Sumner Strait, 40 km south of Petersburg and 30 km west of Wrangell, at lat 56° 28' N., long 133° 05' W. (figs. 1 and 8). The FAA facility on Big Level Island was constructed in 1964. The facility includes airway navigation and communication aids. The facility is currently maintained by FAA personnel stationed in Wrangell who visit the site once a month. A detailed description of the FAA facility on Big Level Island and a list of potential sources of contamination can be found in an environmental compliance investigation report by Ecology and Environment Inc. (1992e).

Climate

Big Level Island has a mean annual temperature of 6.3 °C. Temperatures range from an August mean maximum of 17.3 °C to a January mean minimum of -3.3 °C (Leslie, 1989). Mean annual precipitation is about 1,740 mm and mean annual snowfall is about 1,160 mm. Mean monthly and annual temperature, precipitation, and snowfall are summarized in table 12 (Leslie, 1989).



Base from U.S. Geological Survey, Petersburg (B-4), Alaska, 1:63,360, 1949

Figure 8. Location of Big Level Island, Alaska and the Federal Aviation Administration facility.

Table 12. Mean monthly and annual temperature, precipitation, and snowfall, Big Level Island, Alaska, 1973-78.
[Modified from Leslie (1989); °C, degree Celsius]

	Jan.	Feb.	Mar.	Apr.	May	June	July	. Aug.	Sept.	Oct.	Nov.	Dec.	Annual
						Temperature (°C)							
Mean maximum	1.3	4.5	5.3	9.1	12.4	14.1	17.2	17.3	14.7	9.9	4.8	4.2	9.6
	(Record maximum 30.0°C, July 1975)												
Mean minimum	-3.3	-1.1	-0.7	2.1	4.1	6.8	8.7	7.3	4.6	0.3	-0.3	3.1	0.8
	(Record minimum, -18.3°C, January 1975)												
Mean	-1.0	1.7	2.3	5.6	8.3	10.5	12.9	13.0	11.0	7.3	2.6	1.9	6.3
						Precipitation, in millimeters							Total
	166	147	109	113	82	101	114	90	181	279	157	198	1,737
						Snowfall, in millimeters							Total
	427	137	135	15	0.0	0.0	0.0	0.0	0.0	0.0	114	333	1,161

Geology

Big Level Island is underlain by marine sedimentary rocks, primarily graywackes and mudstones. Some andesitic to basaltic volcanic rocks and granitic intrusions also are present (Berg and Gehrels, 1992). Bedrock is exposed at low tide along the perimeter of the island (U.S. Fish and Wildlife Service, 1989). Inland, bedrock typically is less than 3 m below land surface. Surficial deposits on Big Level Island are principally till consisting of gravel and boulders in a sandy silt matrix (U.S. Fish and Wildlife Service, 1989).

Hydrology

Surface and Ground Water

Although no large rivers exist on Big Level Island, freshwater wetlands and small streams are common. Poorly drained wetlands occur in areas of shallow relief where small streams converge (U.S. Fish and Wildlife Service, 1989). Elevations on the island do not exceed 30 m. Drainage on the island is toward the coast.

Ground-water data for Big Level Island are scarce. Some ground water is available at depths less than 3 m below land surface (Ecology and Environment Inc., 1992e). Currently, ground water is used only as a nonpotable water source on the island (Ecology and Environment Inc., 1992e).

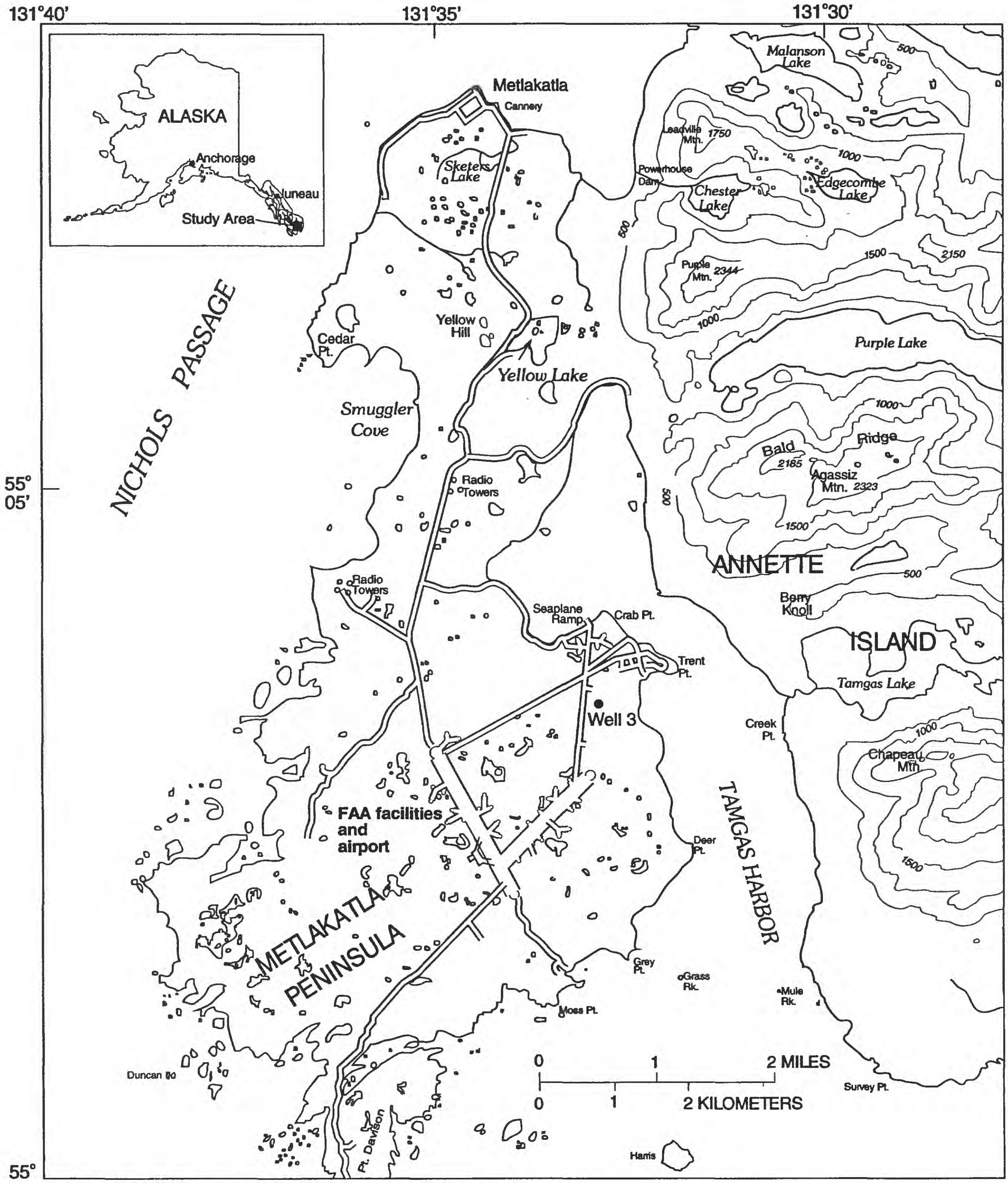
Drinking Water

Surface water and ground water are not currently used as drinking-water sources on Big Level Island. Drinking water is shipped in from an outside source. Freshwater wetlands, small streams, and ground water represent alternative drinking-water sources on Big Level Island; however, the quality and quantity of these sources are unknown. Natural water sources on the island support large deer and other wildlife populations indicating the potential for acceptable drinking water (Doerr and Sandburg, 1986).

ANNETTE ISLAND

Location and Facility History

Annette Island is about 35 km^2 in size and is at the southern end of Southeast Alaska near the Canadian border. It is about 25 km south of Ketchikan near lat 55° 02' N., long 131° 34' W. (figs. 1 and 9). The Metlakatla Peninsula extends west-southwest of the island. The village of Metlakatla is near the northern end of the peninsula. The FAA operations on Annette Island began in 1948 when air-navigation facilities were constructed there. Currently, the FAA facilities include air navigation and communication aids concentrated at the airport. Facility maintenance is carried out by FAA personnel stationed in Ketchikan. A detailed list of FAA facilities on Annette Island and a list of potential sources of contamination can be found in an environmental compliance investigation report by Ecology and Environment Inc. (1992f).



Base from U.S. Geological Survey, Ketchikan (A-5), Alaska, 1:63,360, 1955

Figure 9. Location of Annette Island, Alaska and the Federal Aviation Administration facilities.

Climate

Annette Island has a mean annual temperature of 7.6 °C. Temperatures range from an August mean maximum of 18.0 °C to a January mean minimum of -1.7 °C (Leslie, 1989). Mean annual precipitation is about 2,820 mm and mean annual snowfall is about 1,320 mm. Mean monthly and annual temperature, precipitation, and snowfall are summarized in table 13 (Leslie, 1989).

Table 13. Mean monthly and annual temperature, precipitation, and snowfall, Annette Island, Alaska, 1949-87.

[Modified from Leslie (1989); °C, degree Celsius]

	Jan.	Feb.	Mar.	Apr.	May	June	July	Aug.	Sept.	Oct.	Nov.	Dec.	Annual
Temperature (°C)													
Mean maximum	3.4	5.2	6.6	9.4	13.0	15.7	17.8	18.0	15.5	10.9	6.7	4.5	10.6
(Record maximum, 32.2°C, August 1960)													
Mean minimum	-1.7	0.0	0.7	2.6	5.6	8.7	10.9	11.1	8.9	5.4	1.7	-0.3	4.5
(Record minimum, -19.4°C, November 1985)													
Mean	0.9	2.7	3.7	6.0	9.3	12.3	14.4	14.6	12.2	8.2	4.2	2.1	7.6
Precipitation, in millimeters													Total
	252	242	221	218	168	124	119	180	248	425	322	302	2,821
Snowfall, in millimeters													Total
	348	285	241	66	5	0.0	0.0	0.0	0.0	5	84	287	1,321

Geology

The FAA facilities on Annette Island are situated on a section of the island known as the Metlakatla Peninsula. Bedrock underlying the peninsula consists of deformed and metamorphosed volcanic rocks and clastic sedimentary rocks of Ordovician to Silurian age. Volcanic rocks consist of greenschist and greenstone. Sedimentary rocks are intruded by diorite, quartz diorite, and bodies of magnetite-bearing hornblende (Marcher, 1971a; Yehle, 1977; Berg and Gehrels, 1992). Most of the Metlakatla Peninsula was sheared flat by past glaciation (Yehle, 1977). The exception is an outcrop of resistant dunite known as Yellow Hill, about 4 km north of the FAA facilities. Depth to bedrock ranges from 15 cm to about 9 m below the land surface.

The principal surficial deposits found on Annette Island are beach sand, alluvium, and till (Marcher, 1971b). Beach deposits consisting of sand and gravel along the coast can be as much as 300 m wide and 10 m thick. Alluvial deposits on the island include stratified gravel, sand, and silt. These deposits are between 1.5 and 5 m thick and are found along streams and rivers. The till consists of gravel and boulders in a silty matrix (Pacific Rim Planners, 1979; Marcher, 1971b; Selkregg, 1976). A well log from an 8.5-meter-deep well drilled near the FAA facilities indicates organic muck to about 2.5-meter depth; gravel to about 2.7 m; clay and gravel to about 7.0 m; clay, gravel, and water to 8.5 m; and bedrock below 8.5 m (Appendix 6; Marcher, 1971a).

Hydrology

Surface Water

The rain that falls on Annette Island, particularly during the fall season, runs into the sea through numerous small streams. Streamflow ranges from 0.01 to 2.8 m^3/s (Pacific Rim Planners, 1977). Elevations on Metlakatla Peninsula do not exceed 60 m. Runoff generally is towards surface-water drainages that eventually empty into Nichols Passage to the west and Tamgas Harbor to the east. The basin on the west side of the peninsula drains an area of about 25 km^2, and the basin on the east drains an area of about 22 km^2 (Pacific Rim Planners, 1979).

Lakes on the Metlakatla Peninsula are shallow and are fed by runoff from the surrounding muskeg. Chester Lake and Yellow Lake are the principal freshwater bodies near the FAA facilities (fig. 9). Chester Lake is about 6 km northeast of the facilities and has a surface area of about 0.4 km^2. The lake is the main source of drinking water for the Metlakatla community. Yellow Lake is about 4 km north of the facilities and has a surface area less than 0.2 km^2. Yellow Lake currently supplies water to the Annette Island airport and the FAA facilities. Expanses of wetland and bog surround the facilities in all directions.

Ground Water

Ground water on Annette Island occurs within bedrock fractures and beach deposits (Appendix 6; Marcher, 1971a and b). In general, the metamorphic and igneous bedrock underlying most of the island will yield less than 0.6 L/s of water (Selkregg, 1976). Wells drilled in the highly fractured ultrabasic rocks south of Yellow Lake may yield larger amounts. Marcher (1971a) reported that a 110-meter-deep well was pumped from 99 m below land surface at a rate of 2.3 L/s for 72 hours. A 24.4-meter drawdown was recorded. After pumping, the static water level was maintained at 7.0 m below ground surface. The aquifer has a freshwater/seawater contact. Extensive pumping of wells may lower the water table allowing saltwater intrusion.

Beach deposits on Annette Island are a potential aquifer (Appendix 6; Marcher, 1971b). These deposits are between 1.5 and 3.0 m thick and receive nearly continuous recharge because of well-distributed yearly precipitation (table 13). A well log from well 3 (fig. 9) indicated that water was reached at depths between 0.6 and 2.7 m, and between 7.3 and 8.5 m below land surface (Appendix 6).

Drinking Water

Chester Lake and Yellow Lake are the principal drinking-water sources on the Metlakatla Peninsula (fig. 9). Chester Lake has been used as a source of water since the founding of the Metlakatla community. The water is chlorinated and piped to local residents (Selkregg, 1976; Environmental Services, Ltd., 1983). Analyses of water from Chester Lake in 1961 indicated that most major ions and water properties were within current USEPA regulations (table 14; Appendix 6). Yellow Lake provides drinking water to residences and businesses at the southern end of the peninsula including the FAA facilities, the National Weather Service, and a local hatchery. The water is abundant and is of acceptable quality (table 14; Appendix 6).

Analyses of ground water indicated that some major ions exceeded current USEPA drinking-water regulations (table 14; Appendix 6; Marcher, 1971a). About 30 percent of the samples contained iron concentrations above the current regulation of 0.3 mg/L. Concentrations of sodium, sulfate, chloride, and total dissolved solids increased with depth, and suggest a mixture of seawater with freshwater (Marcher, 1971a).

Table 14. Water-quality data for Annette Island, Alaska
[Concentrations in mg/L, milligrams per liter]

Constituent (or property)	USEPA drinking-water regulation	FAA facility, well water 1964-65	Chester Lake 1961,1968	Yellow Lake 1961-68
Chloride (Cl)	250	5.7 - 642	1.4 - 2.5	.2 - 6 4
Iron (Fe)	.3	.04 -.7	.02 -.1	.03-.1
Sulfate (SO_4)	250	3.8 - 327	.0 - 1.0	.0 - 5.0
Fluoride (F)	2	.1 - 1.2	0	.0 -.7
Total dissolved solids	500	280 - 1,970	5.0- 8.0	27 - 30
pH (units)	6.5 - 8.5	8.2 - 9.0	5.9 - 6.1	6.6 - 7.1

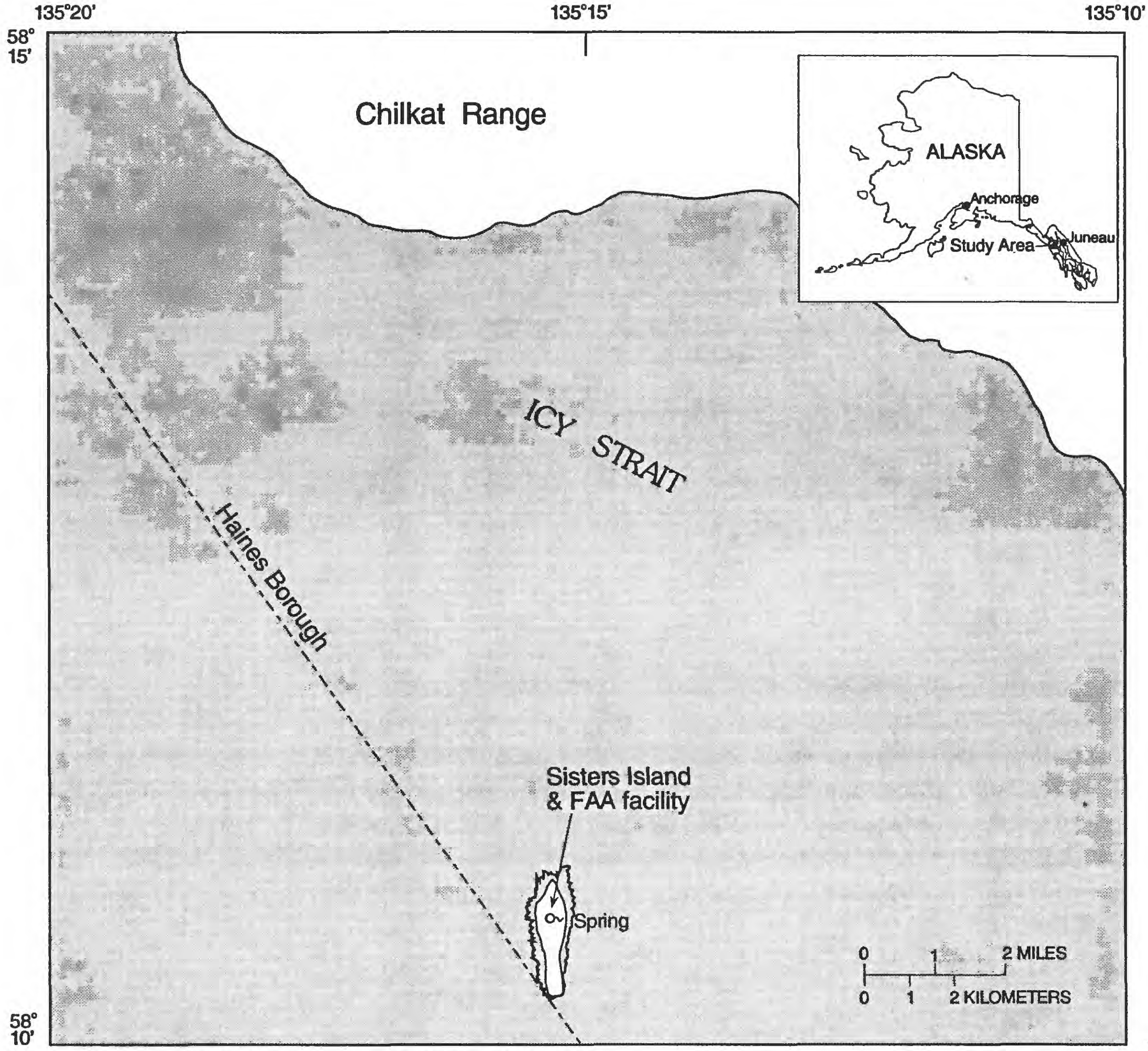
SISTERS ISLAND

Location and Facility History

Sisters Island is a 0.15 km^2 volcanic island in Icy Strait. It is about 75 km west of Juneau near lat 58° 10' N., long 135° 15' W. (figs. 1 and 10). In 1945, the FAA established air-navigation facilities on Sisters Island. The FAA facilities on Sisters Island include an H-Marker facility, a Very-High Frequency Omnidirectional Range Tactical Air Navigation (VORTAC) facility, emergency quarters, a underground fuel-storage tank, a helicopter landing area, and living quarters. A more detailed list of FAA facilities on Sisters Island and a list of potential sources of contamination can be found in an environmental compliance investigation report by Ecology and Environment Inc. (1992g).

Climate

Sisters Island has a mean annual temperature of 6.7 °C. Temperatures range from a July mean maximum of 15.5 °C to a January mean minimum of -0.3 °C (Leslie, 1989). Mean annual precipitation is about 830 mm and mean annual snowfall is about 430 mm. Mean monthly and annual temperature, precipitation, and snowfall are summarized in table 15 (Leslie, 1989).



Base from U.S. Geological Survey, Juneau (A-4), Alaska, 1:63,360, 1949

Figure 10. Location of Sisters Island, Alaska and the Federal Aviation Administration facility.

Table 15. Mean monthly and annual temperature, precipitation, and snowfall, 1982 to 1984, Sisters Island, Alaska.

[Modified from Leslie (1989); °C, degree Celsius]

	Jan.	Feb.	Mar.	Apr.	May	June	July	Aug.	Sept.	Oct.	Nov.	Dec.	Annual
Temperature (°C)													
Mean maximum	3.4	4.8	6.2	8.0	10.8	14.2	15.5	15.1	12.8	8.8	3.4	3.7	8.9
	(Record maximum, 22.8°C, June 1982)												
Mean minimum	-0.3	1.3	1.5	2.3	5.1	8.6	10.6	10.7	8.1	5.0	-0.1	1.4	4.5
	(Record minimum, -13.3°C, January 1983)												
Mean	1.6	3.1	3.9	5.2	8.0	11.4	13.1	12.9	10.5	6.9	1.7	2.6	6.7
Precipitation, in millimeters													**Total**
	113	70	45	27	61	35	57	133	77	116	67	31	832
Snowfall, in millimeters													**Total**
	305	122	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	427

Geology

The geology of Sister Island has been described by Lathram and others (1959), Couch and Gemperle (1974), Brew and Ford (1985), and Berg and Gehrels (1992). The bedrock underlying the island is a volcanic flow breccia of dark greenish-gray basalt (Lathram and others, 1959; Brew and Ford, 1985). Bedrock lies close to the land surface, and about 30 m^2 of bedrock are exposed (Brew and Ford, 1985). Surficial materials are predominately glacial sand, gravel, and silt. The soils that develop on these well-drained deposits are typically less than 50 cm thick over bedrock. The soils are characterized by an organic-rich layer 5 to 12 cm thick, and dark, acidic sublayers (Rieger and others, 1979).

Hydrology

Surface water

No large streams, rivers, or lakes are present on Sisters Island; however, a spring, small seeps, marshes, coastal tidelands, and freshwater wetlands exist in several places (Ecology and Environment, Inc., 1992g). Regional runoff for the Sisters Island area is estimated to be about 0.1 $(m^3/s)/km^2$ (Selkregg, 1976).

Ground water

In general, geologic factors such as porosity, permeability, topography, and mineralogic composition control the occurrence and availability of ground water. A spring on Sisters Island (fig. 10) originates from the underlying bedrock. Basalt-flow bedrock tends to exhibit minimal porosity and hydraulic conductivity in the middle to lower section of a given unit, and higher porosities and permeabilities in the interflow zone—the area between the top of one unit and the bottom of the next (Wood and Fernandez, 1988). Porosities for basalt flows average about 5 percent; hydraulic conductivities range from less than 10^{-11} to greater than 10^{3} m/d (Wood and Fernandez, 1988). Specific values for the hydraulic properties of the bedrock underlying Sisters Island are unknown. Water from the Sisters Island spring is pumped to a holding tank and is used as nonpotable "gray" water for the emergency living quarters. The quantity and quality of water available from this spring are unknown, although a sample collected by Ecology and Environment Inc. (1992g) indicated low concentrations of zinc and copper.

Drinking Water

Surface water and ground water are not used for drinking water on Sisters Island because no one resides on the island. When needed, drinking water is brought in from outside sources (Ecology and Environment Inc., 1992g). No surface- or ground-water data are available to determine their use as potential drinking-water sources. Selkregg (1976) describes ground-water availability in southeast Alaska as about 0 to 0.6 L/s.

DUNCAN CANAL

Location and Facility History

Duncan Canal is at Indian Point on Kupreanof Island about 16 km southwest of Petersburg at lat 56° 45' N., long 133° 15' W. (figs. 1 and 11). In 1945, the FAA began operations at Duncan Canal when an air-navigation station was established. The FAA vacated the property in 1976 and the operational responsibilities for fuel tanks and associated pipes and pumps were transferred to the U.S. Forest Service. Formerly owned and operated FAA facilities at Duncan Canal include navigation and communication equipment and support structures. A detailed list of FAA facilities at Duncan Canal and a list of potential sources of contamination can be found in an environmental compliance investigation report by Ecology and Environment Inc. (1992h).

Climate

No specific climate data are available for the FAA facility at Duncan Canal. The nearest site for which climate data are available are Petersburg, about 16 km northeast, and Kake, about 50 km northwest. There are significant differences in the amount of annual precipitation that falls on Kake and Petersburg; Kake receives about 1,440 mm and Petersburg receives about 2,690 mm. The amount of precipitation that Duncan Canal receives probably falls within this range. Most rainfall occurs from October through January. The mean annual temperature for the Duncan Canal area likely ranges from 9.3 to 9.7 °C. Temperatures range from mean maximums in July and August between 17.2 and 17.6 °C to mean minimums in January between -3.3 and -5.4 °C (Leslie, 1989). Mean monthly and annual temperature, precipitation, and snowfall for Kake and Petersburg are summarized in tables 16 and 17 (Leslie, 1989).

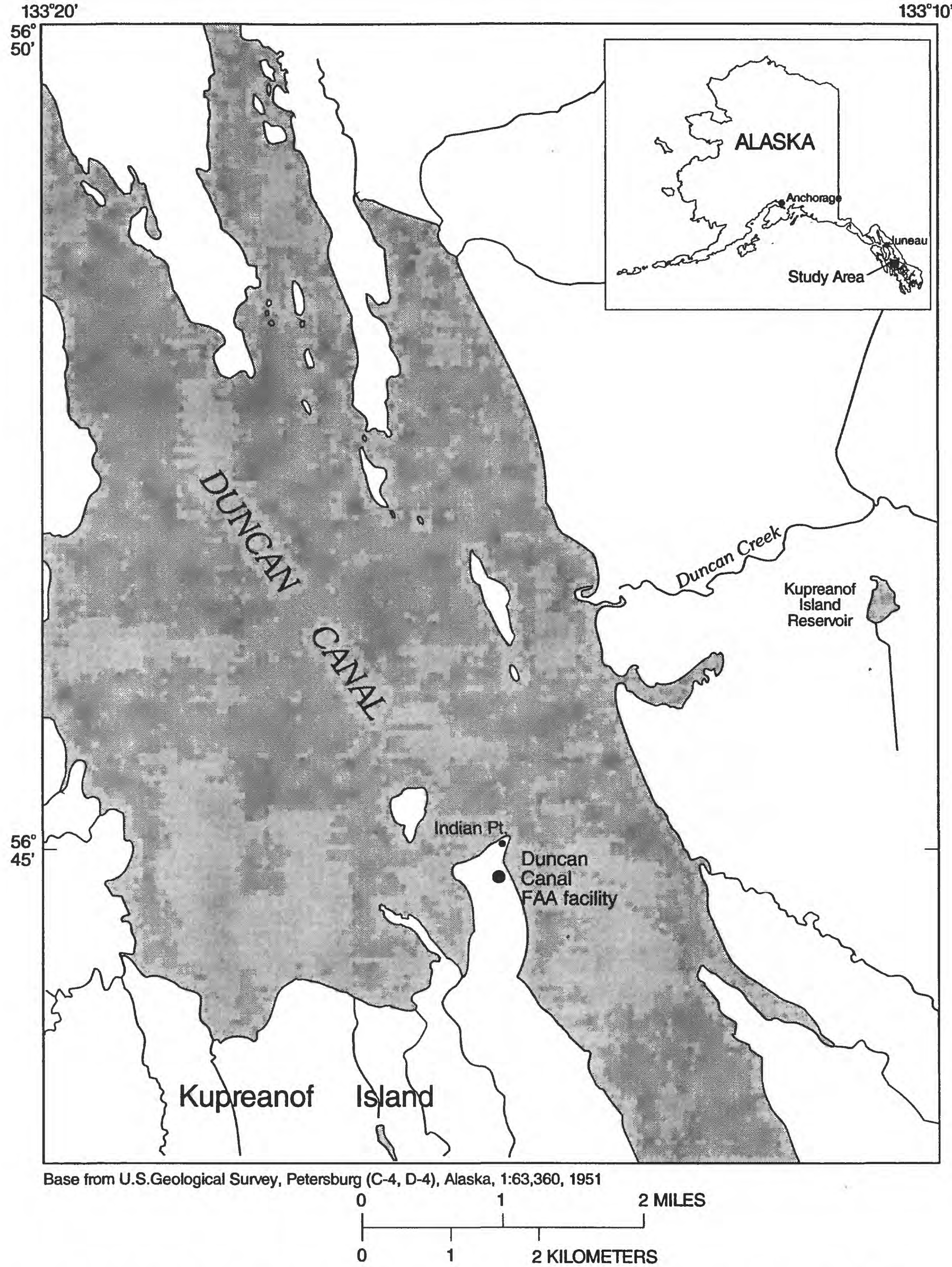


Figure 11. Location of Duncan Canal, Alaska and the Federal Aviation Administration facility.

Table 16. Mean monthly and annual temperature, precipitation, and snowfall, Kake, Alaska, 1922-87.

[Modified from Leslie (1989); °C, degree Celsius]

	Jan.	Feb.	Mar.	Apr.	May	June	July	Aug.	Sept.	Oct.	Nov.	Dec.	Annual
						Temperature (°C)							
Mean maximum	2.5	3.7	5.9	8.8	12.3	15.4	17.2	17.6	14.1	10.0	6.0	3.1	9.7
	(Record maximum, 22.8°C, June 1982)												
Mean minimum	-3.3	-2.9	-1.2	0.8	3.7	6.4	8.6	8.8	6.4	3.2	0.0	-2.4	2.3
	(Record minimum, -13.3°C, January 1983)												
Mean	-0.4	0.4	2.3	4.8	8.0	10.8	12.9	13.2	10.2	6.6	3.0	0.3	6.0
						Precipitation, in millimeters							Total
	147	135	95	88	77	60	67	96	136	230	184	121	1,436
						Snowfall, in millimeters							Total
	356	343	170	18	0.0	0.0	0.0	0.0	0.0	13	64	226	1,190

Table 17. Mean monthly and annual temperature, precipitation, and snowfall, Petersburg, Alaska, 1922-87.

[Modified from Leslie (1989); °C, degree Celsius]

	Jan.	Feb.	Mar.	Apr.	May	June	July	Aug.	Sept.	Oct.	Nov.	Dec.	Annual
						Temperature (°C)							
Mean maximum	0.5	2.7	5.1	9.0	13.2	16.3	17.6	17.2	14.1	9.4	4.7	1.7	9.3
	(Record maximum 28.9 °C, July 1927)												
Mean minimum	-5.4	-3.7	-2.2	0.3	3.6	7.2	8.8	8.3	6.2	3.3	-0.8	-3.4	1.8
	(Record minimum -28.3 °C, January 1947)												
Mean	-2.4	-0.5	1.5	4.7	8.4	11.7	13.2	12.8	10.2	6.4	2.0	-0.8	5.6
						Precipitation, in millimeters							Total
	237	199	183	176	150	127	136	192	283	428	304	271	2,686
						Snowfall, in millimeters							Total
	724	533	399	56	0.0	0.0	0.0	0.0	0.0	15	241	607	2,575

Geology

Sedimentary bedrock of Cretaceous to Devonian age underlies the Duncan Canal FAA facility (Berg and Gehrels, 1992). The bedrock consists of highly deformed, disrupted, and metamorphosed graywacke, siltstone, mudstone, and minor amounts of chert, limestone, and volcanic and intrusive rocks (Berg and Gehrels, 1992). Depth to bedrock is unknown. Sand and gravel are the principal surficial materials found near the FAA facility. The material is probably derived from the weathering and glacial erosion of rocks on Kupreanof Island. The thickness of surficial materials is unknown.

Soils on Kupreanof Island near Duncan Canal are of two major types (Rieger and others, 1979). Well-drained acidic soils are associated with nearby forested areas. Under a thick mat of partially to highly decomposed forest litter, these soils have a thin gray, organic-rich surface layer and black, acidic subsurface layers (Rieger and others, 1979). Thick layers of poorly drained, organic-rich soils are found in low-lying areas and on slopes that are subject to ground-water seepage (Rieger and others, 1979). Kupreanof Island is in an area that typically is free of permafrost (Ferrians, 1965).

Hydrology

Surface Water

Several small streams and ponds are present south-southwest of the Duncan Canal FAA facility. The ponds are less than 0.4 km^2 in size and are at elevations between 55 and 80 m above sea level. The streams flow from upland areas toward the coast (fig. 11). Specific streamflow and drainage-area data are not available for these streams. Mean annual runoff near the Duncan Canal facility is estimated to be 0.09 $(m^3/s)/km^2$ (Selkregg, 1976). The Kupreanof Island Reservoir is about 5 km northwest of the facility across Duncan Canal (fig. 11). It lies about 90 m above sea level. Wetland areas lie within 0.2 km of the FAA facility (Ecology and Environment Inc., 1992h).

Ground Water

Site-specific ground-water data are not available for the Duncan Canal FAA facility. An abandoned well used by the FAA was drilled to a depth of 8 m indicating that ground water is probably present above this depth. Ground water probably is recharged along the slopes south and west of the FAA facility and likely follows local topography and flows toward the coast.

Drinking Water

The Duncan Canal FAA facility is currently uninhabited and there are no people living within a 6.5 km radius (Ecology and Environment Inc., 1992h). When needed, drinking water is transported to the island. Alternative sources of drinking water may include local streams and ponds; however, data are inadequate to characterize the quality or quantity of these sources. The use of the Kupreanof Island Reservoir would be uneconomical.

SUMMARY

Coastal areas of south-central and southeast Alaska—including Middleton Island, Cape Yakataga, Gustavus, Haines, Biorka Island, Big Level Island, Annette Island, Sisters Island, and Duncan Canal—have a maritime climate characterized by mild winters and cool summers. Most communities obtain their drinking water from surface-water sources, such as lakes, streams, and rivers, whereas other communities use water from shallow unconfined aquifers. Surface spills and disposal of hazardous materials may affect the quality of drinking water.

Parts of Alaska's Pacific coast receive more than 2,500 mm/yr of precipitation (Hartman and Johnson, 1984). Because of steep topographic gradients, most of this precipitation runs off rapidly into lakes and streams as surface water, and only a minor amount infiltrates to the ground-water system (Selkregg, 1976). Most of the small lakes, rivers, and creeks in southeast Alaska drain from the west side of the Coast Mountains and St. Elias Mountains, and from the islands of the Archipelago directly into the sea. Coastal and island sites in south-central and southeast Alaska are areas that typically are free of permafrost (Ferrians, 1980). Mean annual runoff rates range from about 0.02 to more than 0.14 $(m^3/s)/km^2$ (B.B. Bigelow, U.S. Geological Survey, written commun., 1995).

Ground-water data for the FAA facilities in south-central and southeast Alaska are sparse. Water-bearing surficial materials include alluvial and glacial deposits that are found at depths that typically range from 3 to 30 m below land surface (Selkregg, 1976). Ground water may also occur in fractured bedrock. Freshwater occurs beneath islands and coastal areas as a "freshwater lens" that floats on saltwater within the aquifer (Hunt and others, 1988). This is sometimes referred to as basal water and can occur under confined or unconfined conditions (Hunt and others, 1988). Basal water often extends to depths below sea level of about 40 times the water-table elevation or potentiometric surface. Near the base of the lens, freshwater grades into saltwater in a transition zone that may range from a few meters to a few hundred meters (Hunt and others, 1988). The possibility of saltwater intrusion into coastal and island aquifers increases with depth and pumping rate.

In general, surface water in southeastern Alaska is of acceptable drinking-water quality (Selkregg, 1976). Dissolved-solids concentrations typically are below the current USEPA drinking-water regulation of 500 mg/L. Streams draining low-lying areas may contain excessive amounts of iron and organic material. Large glacier-fed rivers may contain high silt concentrations especially in the summer. In general, ground water also is of acceptable quality and typically is a calcium bicarbonate type. Ground water in coastal areas may be a sodium chloride or sodium bicarbonate type due to salt-water influences.

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APPENDIX 1

Data for Middleton Island, Alaska

MIDDLETON ISLAND - 2.5 MILE RADIUS

LOCAL WELL NUMBER	PRIMARY USE OF WATER	DEPTH OF WELL (FEET)	WATER LEVEL (FEET)	DATE WELL CONSTRUCTED	OWNER	ASSIGNOR OF OTHER IDENTIFIER	OTHER IDENTIFIER	TYPE OF LOG AVAILABLE
CC02800607DDBD1 001	T	10.0	--	--	FAA MIDLTN I	--	--	-

APPENDIX 2

Data for Cape Yakataga, Alaska

LOCAL WELL NUMBER	PRIMARY USE OF WATER	DEPTH OF WELL (FEET)	WATER LEVEL (FEET)	DATE WELL CONSTRUCTED	OWNER	ASSIGNOR OF OTHER IDENTIFIER	OTHER IDENTIFIER	TYPE OF LOG AVAILABLE
CD02101722ADCA1 001	T	28.0	--	--	FAA YAKATAGA	--	--	--
CD02101725DAAB2 001	T	--	--	--	RCA YAKATAGA	--	--	--

APPENDIX 3

Data for Gustavus, Alaska

9-185
(October 1950)

UNITED STATES
DEPARTMENT OF THE INTERIOR
GEOLOGICAL SURVEY
WATER RESOURCES DIVISION

WELL SCHEDULE

Date 9/29, 1965 Field No. ______

Record by ______ Office No. ______

Source of data ______

1. *Location:* State Alaska County Glacier Bay NM
   Map Juneau - N5815 - W13540/15X20
   NE ¼ NW ¼ sec. 32 T 39 ~~N~~ S R 58 E ~~W~~
2. *Owner:* Nat'l Park Serv. Address Gustavus, Alaska
   Tenant " Address "
   Driller H.O. Meyers Address Seattle, Wn.
3. *Topography* ______
4. *Elevation* 55 ft. above ~~below~~ sea level
5. *Type:* ~~Dug~~, drilled, ~~driven, bored, jetted~~ 8/1965
6. *Depth:* ~~Rept.~~ 36 ft. ~~Meas.~~ EL. 19° ft.
7. *Casing:* Diam. 6 in., to 6 in., Type C.I.
   Depth 36 ft., ~~Finish~~ Top Elev. 55°
8. *Chief Aquifer* Fine Sand From 0 ft. to 36 ft.
   Others Some gravel trace
9. *Water level* Elev. 36 ft. rept. meas. ______ 19__ above ~~below~~ ______
   ______ which is 19 ft. ~~above~~ below surface
10. *Pump:* Type ______ Capacity ______ G. M.
    Power: Kind ______ Horsepower ______
11. *Yield:* Flow 70 G. M., ~~Pump~~ 10' Draw D. ~~G.M.~~, Meas., Rept. Est. ______
    Drawdown 5 ft. after 24 hours pumping 30 G. M.
12. *Use:* Dom., Stock, PS., RR., Ind., Irr., Obs. Domestic
    Adequacy, permanence Yes
13. *Quality* ______ Temp ______ °F.
    Taste, odor, color little or none Sample ~~Yes~~ ~~No~~ Lic. #8580
    Unfit for ______
14. *Remarks:* (Log, Analyses, etc.) Log Available NPS, Juneau. Sand Samples Avail., Aquifer Sieve Analysis Available.

U. S. GOVERNMENT PRINTING OFFICE 16—62891-1

UNITED STATES DEPARTMENT OF THE INTERIOR
GEOLOGICAL SURVEY
WATER ANALYSIS

Location FAA Receiving Station at Gustavus County ____
Source ____ Depth (ft) 18 Diam (in.) ____
Cased to (ft) ____ Date drilled ____ Point of coll. ____
____ Owner ____
Treatment ____ Use ____
WBF ____ WL ____ Yield ____
Temp (°F) 43 Appear. when coll. ____
Collected June 17, 1965 (1200 hours) By ____
Remarks

	~~ppm~~ mg/l	epm		~~ppm~~ mg/l	epm
Silica (SiO_2)	8.8		Bicarbonate (HCO_3)	213	3.49
Aluminum (Al)	---		Carbonate (CO_3)	0	.00
Iron (Fe)	1.45				
			Sulfate (SO_4)	35	.73
			Chloride (Cl)	1.6	.04
			Fluoride (F)	.0	.00
Calcium (Ca)	68	3.39			
Magnesium (Mg)	7.4	.61	Nitrate (NO_3)	.0	.00
Sodium (Na)	1.8	.08			
Potassium (K)	3.3	.08			
Total		4.16	Total		4.26

	~~ppm~~ mg/l		
		Specific conductance (micromhos at 25° C)	390
Dissolved solids: Calculated	232	pH	7.8
Residue on evaporation at 180° C		Color	0
Hardness as $CaCO_3$	200		
Noncarbonate	25		

Lab. No. Col 11555-65-654 Field No. Project Alaska Dept. of Health and Welfare

2GW

UNITED STATES DEPARTMENT OF THE INTERIOR
GEOLOGICAL SURVEY
WATER ANALYSIS

Location [illegible] FAA housing well at Gustavus County
Source Depth (ft) 18 Diam (in.)
Cased to (ft) Date drilled Point of coll.
Owner
Treatment Use
WBF WL Yield
Temp (°F) 44 Appear. when coll.
Collected June 17, 1960 (1040 hours) By
Remarks

	~~ppm~~ mg/l	epm		~~ppm~~ mg/l	epm
Silica (SiO_2)	16		Bicarbonate (HCO_3)	248	4.06
Aluminum (Al)	--		Carbonate (CO_3)	0	.00
Iron (Fe)	4.04				
			Sulfate (SO_4)	21	.44
			Chloride (Cl)	16	.45
			Fluoride (F)	.0	.00
Calcium (Ca)	75	3.74			
Magnesium (Mg)	7.3	.60	Nitrate (NO_3)	.1	.00
Sodium (Na)	8.3	.36			
Potassium (K)	4.3	.11			
Total		4.81	Total		4.95

	~~ppm~~ mg/l		
Dissolved solids:		Specific conductance (micromhos at 25° C)	456
Calculated	263	pH	7.8
Residue on evaporation at 180° C		Color	5
Hardness as $CaCO_3$	217		
Noncarbonate	14		

Lab. No. Col 11584-63-653 Field No. Project Alaska Dept. of Health and Welfare

2GW

UNITED STATES DEPARTMENT OF THE INTERIOR
GEOLOGICAL SURVEY
WATER ANALYSIS

Location: Federal Aviation Agency at Gustavus, Alaska County:
Source: Depth (ft): Diam (in.):
Cased to (ft): Date drilled: Point of coll.: Quarters 101
Owner:
Treatment: Use:
WBF: WL: Yield:
Temp (°F): Appear. when coll.:
Collected: August 19, 1964 By:
Remarks:

	ppm	epm		ppm	epm
Silica (SiO_2)	8.2		Bicarbonate (HCO_3)	229	3.76
Aluminum (Al)			Carbonate (CO_3)	0	0.00
Iron (Fe) (dis)	0.19				
Manganese (Mn)	0.00		Sulfate (SO_4)	27	0.57
			Chloride (Cl)	5.3	0.15
			Fluoride (F)	0.1	0.01
Calcium (Ca)	3.6	0.18			
Magnesium (Mg)	0.5	0.04	Nitrate (NO_3)	0.1	0.00
Sodium (Na)	100	4.35			
Potassium (K)	0.1	0.00			
Total		4.57	Total		4.49

	ppm		
		Specific conductance (micromhos at 25° C)	416
Dissolved solids: Calculated	258	pH	7.8
Residue on evaporation at 180° C		Color	10
Hardness as $CaCO_3$	11		
Noncarbonate	0		
Alkalinity as $CaCO_3$	188		

Lab. No. Col 8180 Field No. Project

15058300 - CHESTER LK AT METLAKATLA AK

WATER-QUALITY DATA, WATER YEAR OCTOBER 1967 TO SEPTEMBER 1968

DATE	SODIUM AD-SORP-TION RATIO (00931)	SODIUM PERCENT (00932)	POTAS-SIUM, DIS-SOLVED (MG/L AS K) (00935)	CHLO-RIDE, DIS-SOLVED (MG/L AS CL) (00940)	SULFATE DIS-SOLVED (MG/L AS SO4) (00945)	FLUO-RIDE, DIS-SOLVED (MG/L AS F) (00950)	SILICA, DIS-SOLVED (MG/L AS SIO2) (00955)	SOLIDS, SUM OF CONSTI-TUENTS, DIS-SOLVED (MG/L) (70301)	SOLIDS, DIS-SOLVED (TONS PER AC-FT) (70303)	NITRO-GEN, NITRATE DIS-SOLVED (MG/L AS NO3) (71851)	IRON (UG/L AS FE) (71885)
JUN											
18...	0.7	84	0.0	1.4	0.0	0.0	0.90	5	0.01	0.10	100

15058300 - CHESTER LK AT METLAKATLA AK

WATER-QUALITY DATA, WATER YEAR OCTOBER 1960 TO SEPTEMBER 1961

DATE	COUNTY	CON-TRIB UTING DRAIN-AGE AREA	HYDRO-LOGIC UNIT CODE	LAT-I-TUDE	LONG-I-TUDE	MEDIUM CODE	RECORD NUMBER	COLOR (PLAT-INUM-COBALT UNITS) (00080)	SPE-CIFIC CON-DUCT-ANCE (US/CM) (00095)	PH WATER WHOLE FIELD (STAND-ARD UNITS) (00400)
MAR 15...	190		19010102	55 07 33 N	131 31 30 W	9	96100004	5	11	6.1

DATE	CARBON DIOXIDE DIS-SOLVED (MG/L AS CO2) (00405)	ALKA-LINITY WAT WH TOT FET FIELD MG/L AS CACO3 (00410)	BICAR-BONATE WATER WH FET FIELD MG/L AS HCO3 (00440)	NITRO-GEN, NITRATE DIS-SOLVED (MG/L AS N) (00618)	HARD-NESS TOTAL (MG/L AS CACO3) (00900)	HARD-NESS NONCARB WH WAT TOT FLD MG/L AS CACO3 (00902)	CALCIUM DIS-SOLVED (MG/L AS CA) (00915)	MAGNE-SIUM, DIS-SOLVED (MG/L AS MG) (00925)	SODIUM, DIS-SOLVED (MG/L AS NA) (00930)	SODIUM AD-SORP-TION RATIO (00931)	SODIUM PERCENT (00932)
MAR 15...	2.5	2	2	0.050	3	2	0.80	0.20	1.1	0.3	45

DATE	POTAS-SIUM, DIS-SOLVED (MG/L AS K) (00935)	CHLO-RIDE, DIS-SOLVED (MG/L AS CL) (00940)	SULFATE DIS-SOLVED (MG/L AS SO4) (00945)	FLUO-RIDE, DIS-SOLVED (MG/L AS F) (00950)	SILICA, DIS-SOLVED (MG/L AS SIO2) (00955)	SOLIDS, SUM OF CONSTI-TUENTS, DIS-SOLVED (MG/L) (70301)	SOLIDS, DIS-SOLVED (TONS PER AC-FT) (70303)	NITRO-GEN, NITRATE DIS-SOLVED (MG/L AS NO3) (71851)	MANGA-NESE (UG/L AS MN) (71883)	IRON (UG/L AS FE) (71885)
MAR 15...	0.10	2.5	1.0	0.0	0.80	8	0.01	0.20	0	20

WATER-QUALITY DATA, WATER YEAR OCTOBER 1967 TO SEPTEMBER 1968

DATE	TIME	COUNTY	CON-TRIB UTING DRAIN-AGE AREA	HYDRO-LOGIC UNIT CODE	LAT-I-TUDE	LONG-I-TUDE	MEDIUM CODE	RECORD NUMBER	TEMPER-ATURE WATER (DEG C) (00010)	COLOR (PLAT-INUM-COBALT UNITS) (00080)	SPE-CIFIC CON-DUCT-ANCE (US/CM) (00095)
JUN 18...	1405	190		19010102	55 07 33 N	131 31 30 W	9	96800108	13.0	10	10

DATE	PH WATER WHOLE FIELD (STAND-ARD UNITS) (00400)	CARBON DIOXIDE DIS-SOLVED (MG/L AS CO2) (00405)	ALKA-LINITY WAT WH TOT FET FIELD MG/L AS CACO3 (00410)	BICAR-BONATE WATER WH FET FIELD MG/L AS HCO3 (00440)	CAR-BONATE WATER WH FET FIELD MG/L AS CO3 (00445)	NITRO-GEN, NITRATE DIS-SOLVED (MG/L AS N) (00618)	HARD-NESS TOTAL (MG/L AS CACO3) (00900)	HARD-NESS NONCARB WH WAT TOT FLD MG/L AS CACO3 (00902)	CALCIUM DIS-SOLVED (MG/L AS CA) (00915)	MAGNE-SIUM, DIS-SOLVED (MG/L AS MG) (00925)	SODIUM, DIS-SOLVED (MG/L AS NA) (00930)
JUN 18...	5.9	6.0	2	3	0	0.020	0	0	0.0	0.10	1.0

15057860 - YELLOW LK NR ANNETTE AK

WATER-QUALITY DATA, WATER YEAR OCTOBER 1967 TO SEPTEMBER 1968

DATE	TIME	COUNTY	CONTRIB UTING DRAIN-AGE AREA	HYDRO-LOGIC UNIT CODE	LAT-I-TUDE	LONG-I-TUDE	MEDIUM CODE	RECORD NUMBER	TEMPER-ATURE WATER (DEG C) (00010)	COLOR (PLAT-INUM-COBALT UNITS) (00080)	SPE-CIFIC CON-DUCT-ANCE (US/CM) (00095)
JUN											
18...	1320	190		19010102	55 06 11 N	131 33 49 W	9	96800107	15.5	10	48

DATE	PH WATER WHOLE FIELD (STAND-ARD UNITS) (00400)	CARBON DIOXIDE DIS-SOLVED (MG/L AS CO2) (00405)	ALKA-LINITY WAT WH TOT FET FIELD MG/L AS CACO3 (00410)	BICAR-BONATE WATER WH FET FIELD MG/L AS HCO3 (00440)	CAR-BONATE WATER WH FET FIELD MG/L AS CO3 (00445)	NITRO-GEN, NITRATE DIS-SOLVED (MG/L AS N) (00618)	HARD-NESS TOTAL (MG/L AS CACO3) (00900)	HARD-NESS NONCARB WH WAT TOT FLD MG/L AS CACO3 (00902)	CALCIUM DIS-SOLVED (MG/L AS CA) (00915)	MAGNE-SIUM, DIS-SOLVED (MG/L AS MG) (00925)	SODIUM, DIS-SOLVED (MG/L AS NA) (00930)
JUN											
18...	6.8	5.1	16	20	0	0.020	15	0	0.0	3.6	3.0

DATE	SODIUM AD-SORP-TION RATIO (00931)	SODIUM PERCENT (00932)	POTAS-SIUM, DIS-SOLVED (MG/L AS K) (00935)	CHLO-RIDE, DIS-SOLVED (MG/L AS CL) (00940)	SULFATE DIS-SOLVED (MG/L AS SO4) (00945)	FLUO-RIDE, DIS-SOLVED (MG/L AS F) (00950)	SILICA, DIS-SOLVED (MG/L AS SIO2) (00955)	SOLIDS, SUM OF CONSTI-TUENTS, DIS-SOLVED (MG/L) (70301)	SOLIDS, DIS-SOLVED (TONS PER AC-FT) (70303)	NITRO-GEN, NITRATE DIS-SOLVED (MG/L AS NO3) (71851)	IRON (UG/L AS FE) (71885)
JUN											
18...	0.3	30	0.30	6.4	0.0	0.0	3.4	27	0.04	0.10	90

15057860 - YELLOW LK NR ANNETTE AK

WATER-QUALITY DATA, WATER YEAR OCTOBER 1962 TO SEPTEMBER 1963

DATE	SODIUM PERCENT (00932)	POTASSIUM, DISSOLVED (MG/L AS K) (00935)	CHLORIDE, DISSOLVED (MG/L AS CL) (00940)	SULFATE DISSOLVED (MG/L AS SO4) (00945)	FLUORIDE, DISSOLVED (MG/L AS F) (00950)	SILICA, DISSOLVED (MG/L AS SIO2) (00955)	SOLIDS, SUM OF CONSTITUENTS, DISSOLVED (MG/L) (70301)	SOLIDS, DISSOLVED (TONS PER AC-FT) (70303)	NITROGEN, NITRATE DISSOLVED (MG/L AS NO3) (71851)	MANGANESE (UG/L AS MN) (71883)	IRON (UG/L AS FE) (71885)
MAR 08...	28	0.60	5.0	2.0	0.70	3.8	29	0.04	0.30	0	100

WATER-QUALITY DATA, WATER YEAR OCTOBER 1965 TO SEPTEMBER 1966

DATE	COUNTY	CONTRIBUTING DRAINAGE AREA	HYDROLOGIC UNIT CODE	LATITUDE	LONGITUDE	MEDIUM CODE	RECORD NUMBER	COLOR (PLATINUM-COBALT UNITS) (00080)	SPECIFIC CONDUCTANCE (US/CM) (00095)	PH WATER WHOLE FIELD (STANDARD UNITS) (00400)
MAR 03...	190		19010102	55 06 11 N	131 33 49 W	9	96600034	30	48	7.1

DATE	CARBON DIOXIDE DISSOLVED (MG/L AS CO2) (00405)	ALKALINITY WAT WH TOT FET FIELD MG/L AS CACO3 (00410)	BICARBONATE WATER WH FET FIELD MG/L AS HCO3 (00440)	CARBONATE WATER WH FET FIELD MG/L AS CO3 (00445)	NITROGEN, NITRATE DISSOLVED (MG/L AS N) (00618)	HARDNESS TOTAL (MG/L AS CACO3) (00900)	HARDNESS NONCARB WH WAT TOT FLD MG/L AS CACO3 (00902)	CALCIUM DISSOLVED (MG/L AS CA) (00915)	MAGNESIUM, DISSOLVED (MG/L AS MG) (00925)	SODIUM, DISSOLVED (MG/L AS NA) (00930)	SODIUM ADSORPTION RATIO (00931)
MAR 03...	2.0	13	16	0	0.160	15	2	0.80	3.2	2.9	0.3

DATE	SODIUM PERCENT (00932)	POTASSIUM, DISSOLVED (MG/L AS K) (00935)	CHLORIDE, DISSOLVED (MG/L AS CL) (00940)	SULFATE DISSOLVED (MG/L AS SO4) (00945)	FLUORIDE, DISSOLVED (MG/L AS F) (00950)	SILICA, DISSOLVED (MG/L AS SIO2) (00955)	SOLIDS, SUM OF CONSTITUENTS, DISSOLVED (MG/L) (70301)	SOLIDS, DISSOLVED (TONS PER AC-FT) (70303)	NITROGEN, NITRATE DISSOLVED (MG/L AS NO3) (71851)	MANGANESE (UG/L AS MN) (71883)	IRON (UG/L AS FE) (71885)
MAR 03...	28	0.80	6.0	3.8	0.10	3.9	30	0.04	0.70	0	60

15057860 - YELLOW LK NR ANNETTE AK

WATER-QUALITY DATA, WATER YEAR OCTOBER 1960 TO SEPTEMBER 1961

DATE	COUNTY	CON- TRIB UTING DRAIN- AGE AREA	HYDRO- LOGIC UNIT CODE	LAT- I- TUDE	LONG- I- TUDE	MEDIUM CODE	RECORD NUMBER	COLOR (PLAT- INUM- COBALT UNITS) (00080)	SPE- CIFIC CON- DUCT- ANCE (US/CM) (00095)	PH WATER WHOLE FIELD (STAND- ARD UNITS) (00400)
MAR 15...	190		19010102	55 06 11 N	131 33 49 W	9	96100003	10	44	6.6

DATE	CARBON DIOXIDE DIS- SOLVED (MG/L AS CO2) (00405)	ALKA- LINITY WAT WH TOT FET FIELD MG/L AS CACO3 (00410)	BICAR- BONATE WATER WH FET FIELD MG/L AS HCO3 (00440)	NITRO- GEN, NITRATE DIS- SOLVED (MG/L AS N) (00618)	HARD- NESS TOTAL (MG/L AS CACO3) (00900)	HARD- NESS NONCARB WH WAT TOT FLD MG/L AS CACO3 (00902)	CALCIUM DIS- SOLVED (MG/L AS CA) (00915)	MAGNE- SIUM, DIS- SOLVED (MG/L AS MG) (00925)	SODIUM, DIS- SOLVED (MG/L AS NA) (00930)	SODIUM AD- SORP- TION RATIO (00931)	SODIUM PERCENT (00932)
MAR 15...	5.6	11	14	0.070	16	4	1.6	2.8	2.7	0.3	27

DATE	POTAS- SIUM, DIS- SOLVED (MG/L AS K) (00935)	CHLO- RIDE, DIS- SOLVED (MG/L AS CL) (00940)	SULFATE DIS- SOLVED (MG/L AS SO4) (00945)	FLUO- RIDE, DIS- SOLVED (MG/L AS F) (00950)	SILICA, DIS- SOLVED (MG/L AS SIO2) (00955)	SOLIDS, SUM OF CONSTI- TUENTS, DIS- SOLVED (MG/L) (70301)	SOLIDS, DIS- SOLVED (TONS PER AC-FT) (70303)	NITRO- GEN, NITRATE DIS- SOLVED (MG/L AS NO3) (71851)	MANGA- NESE (UG/L AS MN) (71883)	IRON (UG/L AS FE) (71885)
MAR 15...	0.20	7.0	1.0	0.0	4.1	27	0.04	0.30	0	30

WATER-QUALITY DATA, WATER YEAR OCTOBER 1962 TO SEPTEMBER 1963

DATE	COUNTY	CON- TRIB UTING DRAIN- AGE AREA	HYDRO- LOGIC UNIT CODE	LAT- I- TUDE	LONG- I- TUDE	MEDIUM CODE	RECORD NUMBER	TEMPER- ATURE WATER (DEG C) (00010)	COLOR (PLAT- INUM- COBALT UNITS) (00080)	SPE- CIFIC CON- DUCT- ANCE (US/CM) (00095)
MAR 08...	190		19010102	55 06 11 N	131 33 49 W	9	96300004	5.5	15	42

DATE	PH WATER WHOLE FIELD (STAND- ARD UNITS) (00400)	CARBON DIOXIDE DIS- SOLVED (MG/L AS CO2) (00405)	ALKA- LINITY WAT WH TOT FET FIELD MG/L AS CACO3 (00410)	BICAR- BONATE WATER WH FET FIELD MG/L AS HCO3 (00440)	NITRO- GEN, NITRATE DIS- SOLVED (MG/L AS N) (00618)	HARD- NESS TOTAL (MG/L AS CACO3) (00900)	HARD- NESS NONCARB WH WAT TOT FLD MG/L AS CACO3 (00902)	CALCIUM DIS- SOLVED (MG/L AS CA) (00915)	MAGNE- SIUM, DIS- SOLVED (MG/L AS MG) (00925)	SODIUM, DIS- SOLVED (MG/L AS NA) (00930)	SODIUM AD- SORP- TION RATIO (00931)
MAR 08...	6.7	5.7	15	18	0.070	17	2	0.80	3.6	3.2	0.3

LOCAL WELL NUMBER	PRIMARY USE OF WATER	DEPTH OF WELL (FEET)	WATER LEVEL (FEET)	DATE WELL CONSTRUCTED	OWNER	ASSIGNOR OF OTHER IDENTIFIER	OTHER IDENTIFIER	TYPE OF LOG AVAILABLE
CD07409322ADCA1 001	P	255	66.00	10-10-81	USCG SHOAL COVE	--	--	D
CD07509217CBBD1S	U	--	--	--	PETERSON	--	--	-
CD07609104ADAD1 001	H	40.	--	01-05-65	BERKEY JOHN H	USMS 1473	L0K&0L	-

of gravel which, in turn, is overlain by about 4 feet of organically rich muck. Near the middle of the gravel layer is a wedge of silty peat containing fragments of partly lignitized wood as much as 2 feet long. The gravel at this locality, in contrast to that of the other localities, is well sorted, as shown by a sorting coefficient of 1.4, and most of the particles are subrounded to well rounded. About 80 percent of the sample is larger than 4 mm, and the mediun size is about 7 mm.

Differential thermal analysis of a clay sample from locality 36-1 shows that the clay is illite, a common constituent of both marine and glacial deposits (Grim, 1955, p. 484).

ORIGIN

The origin of the deposits herein referred to as raised beaches is reflected in their beltlike pattern of distribution and stratigraphy. Based on Chapin's suggestion (1918, p. 99) that the Metlakatla peninsula is a wave-cut bench, raised beach deposits are logically expected in this area. A more complex origin was postulated by Buddington (1927, p. 51) who suggested that the peninsula is largely the product of subaerial erosion and glaciation subsequently modified by marine erosion between successive uplifts. Periods of stable sea level would allow time for the accumulation of beach deposits, and uplift would preserve such deposits by removing them from the zone of wave erosion.

At least part of the raised beach deposits is derived by wave and tidal current erosion of marine or glaciomarine deposits. Indication of marine origin is provided by fossils, such as fragments of clams, snails, and barnacles in samples of silty clay from drill hole 2 at a depth of 11–14 feet. However, the clay contained no microfossils. Similar silty clay was penetrated in drill holes 1 and 3, but no samples were collected; hence, the presence or absence of fossils in the deposits at these sites is not known.

Modern beach deposits on the Metlakatla peninsula appear to consist of both locally derived and exotic fragments. The older raised beach deposits, however, apparently consist of material derived mainly from glaciomarine and glacial deposits that have been reworked by wave and tidal current action. Modern beach gravel on Prince of Wales Island has been described by Sainsbury (1961, p. 332) who points out that the gravel is rounded and unstriated and that most of the rock-flour matrix has been removed. Sainsbury further states that typical glacial deposits could probably be found at shallow depth beneath many of the beaches. Material described in the logs of drill holes in Metlakatla peninsula suggests glacial material such as the hardpan noted in drill hole 3. However, no striated or faceted rock particles were recovered during test drilling nor were any noted in surface outcrops.

Information on uplift required to elevate the raised beach deposits above the zone of wave erosion, thus preserving them, is provided by Twenhofel (1952, p. 523–548) who reviewed and summarized the literature relating to shoreline changes along the Pacific coast of Alaska. Most of his evidence for uplift is based on fossil-bearing marine deposits, commonly derived from glacial and glaciomarine material and very similar to those in the Metlakatla peninsula. Twenhofel describes deposits that have been elevated from a few to several hundred feet above sea level and cites evidence obtained by previous workers to show that uplift has amounted to 500 feet or perhaps more in the Portland Canal and Juneau areas.

Hicks and Shofnos (1965, p. 3315–3320) present sea-level data to show that nearly all southeastern Alaska is rising. The center of uplift is in the vicinity of Glacier Bay about 320 miles north of Annette Island. At Ketchikan, only 15 miles north of Annette Island, uplift amounts to about 3 centimeters per century. Uplift on nearby Gravina Island has been as much as 80 feet as shown by marine fossils in blue clay and gravel at that altitude (Chapin, 1918, p. 99). Uplift can take place suddenly and dramatically as shown by more than 7 feet of uplift associated with the Alaskan earthquake of March 27, 1964 (Grantz and others, 1964, p. 4).

WATER-SUPPLY POTENTIAL

With average precipitation of 117 inches fairly well distributed throughout the year, the raised beach deposits on Metlakatla peninsula should receive nearly continuous recharge. However, the several feet of overlying muck are poorly permeable; thus the rate of recharge may be rather slow.

During an extended dry period the beach deposits at higher altitudes would drain first. Therefore, the most favorable sites for ground water from these deposits are in low areas but above the tidal range to eliminate the danger of contamination by salt water. Infiltration galleries in the raised beach deposits beside or beneath streams would probably be the best means of development. Horizontal galleries in trenches reaching bedrock and perpendicular to the direction of ground-water flow would intercept the greatest amount of water and would, therefore, provide the greatest yield. Methods of installing and maintaining infiltration galleries for developing shallow ground-water supplies have been described by Feulner (1964).

No analyses of water from the raised beach deposits were made during the study of the Metlakatla peninsula, but the chemical quality is probably good. Because the raised beach deposits are near the surface, they are subject to pollution; thus the area around an infiltration gallery would have to be protected. Dark color derived from decomposition of vegetation in the muskeg and muck may be a problem, although the color might be eliminated by special treatment.

REFERENCES

Buddington, A. F., 1927, Abandoned marine benches in southeastern Alaska: Am. Jour. Sci., 5th ser., v. 13, p. 45–52.

Chapin, Theodore, 1918, The structure and stratigraphy of Gravina and Revillagigedo Islands, Alaska: U.S. Geol. Survey Prof. Paper 120-D, p. 83–100.

Table 1.—*Driller's logs of drill holes penetrating raised beach deposits*

[Logs provided by A. J. Lappi, Federal Aviation Administration]

	Thickness (feet)	Depth (feet)
Drill hole 1—Altitude 10 feet (altimeter)		
Rock fill	3	0– 3
Muskeg and muck	4	3– 7
Brown gravel and sand, some silty clay (some water).	4	7–11
Granite	..	11
Drill hole 2—Altitude 15 feet (altimeter)		
Rock fill	1	1– 2
Muskeg and muck (some water)	3	2– 5
Sand (some water)	1	5– 6
Sand and gravel (some water)	4	6–10
Blue silty clay and some gravel (some water). Fragments of clams, snails, and barnacles.	5	10–15
Gravel with white clay (some water)	4	15–19
White clay mixed with gravel (no water)	5	19–24
Brown clay mixed with gravel	5	24–29
Brown clay	4	29–33
Granite	4	33
Drill hole 3—Altitude 50 feet (altimeter)		
Rock fill	2	0– 2
Muskeg and muck (some water)	6	2– 8
Gravel (some water)	1	8– 9
Blue silty clay	1	9–10
Blue silty clay mixed with gravel	3	10–13
Hardpan mixed with gravel	8	13–21
Clay and some gravel	3	21–24
Hardpan mixed with gravel (some water)	4	24–28
Granite	..	28

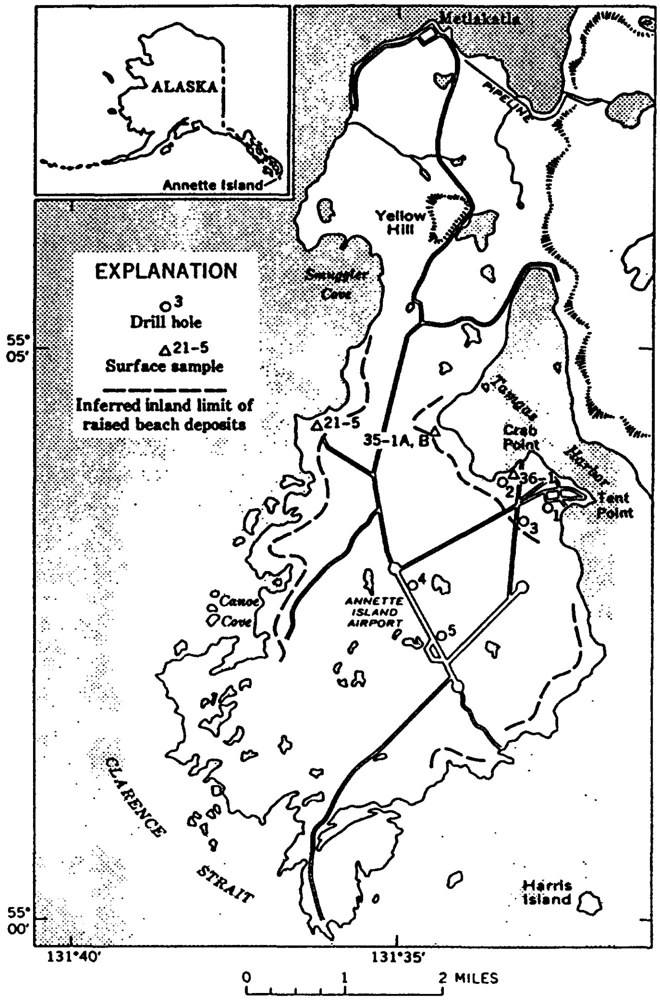

Figure 1.—Map of the Metlakatla peninsula, showing location of drill holes and surface samples, and inferred limit of raised beach deposits.

distances. At locality 21-5 (fig. 1) raised beach deposits, about 10 feet thick, exposed about 40 feet above tide level, consist mainly of interbedded layers and lenses of gravel, sand, silt, and clay containing cobbles up to 8 inches in diameter. Visual estimation indicates that about two-thirds of the gravel and cobbles are subangular and about one-third are subrounded to rounded. The upper 2 feet of the exposure is heavily stained by iron oxide and organic matter; within this interval a few layers less than 1 inch thick are weakly cemented by iron oxide. Size analysis of a grab sample from this locality shows that about 50 percent of the sample is larger than 4 mm (millimeters) in diameter (fig. 2). The particle-size distribution curve (fig. 2) shows that sorting is poor.

At locality 35-1 the raised beach deposits consist of 4–6 feet of sandy gravel overlying silty and clayey bluish-gray sand of unknown thickness. Analysis of a sample (35-1A) from the gravel shows that sorting is poor and that about 55 percent of the sample is larger than 4 mm; the median particle size is between 5 and 6 mm. The larger particles are subangular to well rounded; perhaps 30–50 percent subangular. Analysis of a sand sample (35-1B) from this locality shows that the sand has a sorting coefficient of 1.7, indicating that it is well sorted. About 50 percent of the sample is in the fine and very fine size range; the medium size is 0.075 mm.

The stratigraphic sequence at locality 36-1 consists of an unknown thickness of bluish-gray clay overlain by about 6 feet

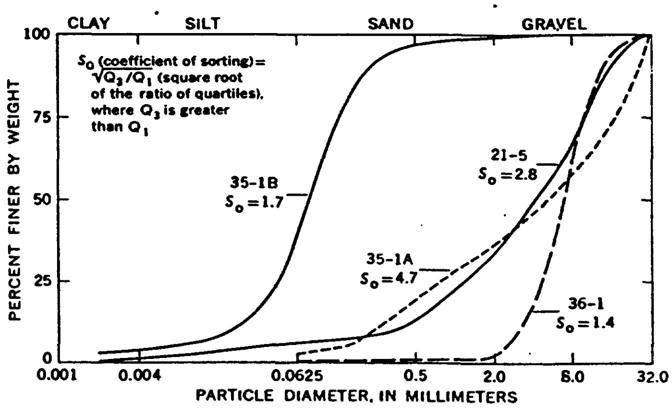

Figure 2.—Particle-size distribution of surface samples from raised beach deposits. See figure 1 for sample localities.

RAISED BEACH DEPOSITS AND THEIR GROUND-WATER POTENTIAL IN THE SOUTHERN PART OF THE METLAKATLA PENINSULA, ANNETTE ISLAND, ALASKA

By MELVIN V. MARCHER, Oklahoma City, Okla.

Work done in cooperation with the Federal Aviation Administration

Abstract.—Interbedded layers of gravel and sand on the Metlakatla peninsula are interpreted as raised beach deposits derived largely from marine, glaciomarine, and glacial deposits reworked by waves and tidal currents. Such deposits and similar deposits elsewhere in southeastern Alaska may be potential sources of small ground-water supplies.

Ground-water supplies in bedrock of southeastern Alaska, which are described in a companion paper (Marcher, 1971) (p. D198–D201, this chapter), may be difficult and costly to locate. Thus, in some parts of the region the search for ground water is most logically directed toward locating alluvial or similar deposits sufficiently thick and permeable to store and yield water. Layers of gravel and sand that make up ancient beach deposits in some areas may be potential sources of water. These deposits are also potential sources of aggregate materials in a region where bedrock is almost everywhere at or near the surface.

As part of a project to locate water supplies on the Metlakatla peninsula, the raised beach deposits were studied briefly. Drill holes, scattered surface exposures, and excavations near Crab Point provide information on the thickness, stratigraphy, and general lithology of the deposits. Size analyses of surface samples and differential thermal analysis of a clay sample were made in the laboratories of the U.S. Geological Survey, Denver, Colo.

DISTRIBUTION AND THICKNESS

In regard to the inferred distribution of the raised beach deposits, L. A. Yehle reports (written commun., Nov. 1970) as follows:

> * * * a 1:20,000 scale topographic map of the southern part of Metlakatla peninsula prepared in 1940 by the U.S. Geological Survey * * * shows several levels of benches or terraces * * *. Altitudinally, the lowest cluster of levels is up to about 30 to 35 feet above msl (mean sea level) and many others have their inner margin about 25 feet above msl. An intermediate cluster of bench or terrace levels is between about 50 and 55 feet above msl. A much less well developed, and higher, cluster of levels is between about 95 and 110 feet above msl. Between all these clusters of levels there are other scattered benches or terraces.

Yehle also notes (written commun., Nov. 1970) as follows:

> At Metlakatla town, Dick Lemke and I noted sand and gravel underlying the ground surface up to an altitude of at least 50 feet above mean sea level. These (presumably) wave and tidal current-worked materials well may extend to slightly higher altitudes. In the central part of town there is a hint of a very minor break-in slope at about 35 feet above msl. In the western part of town this altitude is at the lower margin of a more prominent break-in slope. However, in the latter area, no data on materials are available.

Drill-hole records and scattered outcrops along streams in the southern part of the peninsula show that at least some of the benches noted by Yehle are underlain by raised beach deposits. The highest known raised beach deposits underlie a terrace at the 50-foot level at the site of drill hole 3. The deposits are absent at higher levels in at least part of the area as shown by the logs of drill holes 4 and 5 (95 and 115 feet above sea level, respectively); both drill holes passed directly from muck into bedrock.

Drill-hole logs (table 1) show that raised beach deposits are as much as 5 feet thick. Exposures near the modern beach and in stream banks near the narrow part of the peninsula show that the deposits are at least 10–12 feet thick in this part of the area. Similar thicknesses were seen in construction excavations near Tent and Crab Points and in nearby surface outcrops.

LITHOLOGY

Drill-hole logs and surface exposures show the general lithology and stratigraphy of the raised beach deposits and indicate that lateral changes in lithology take place over short

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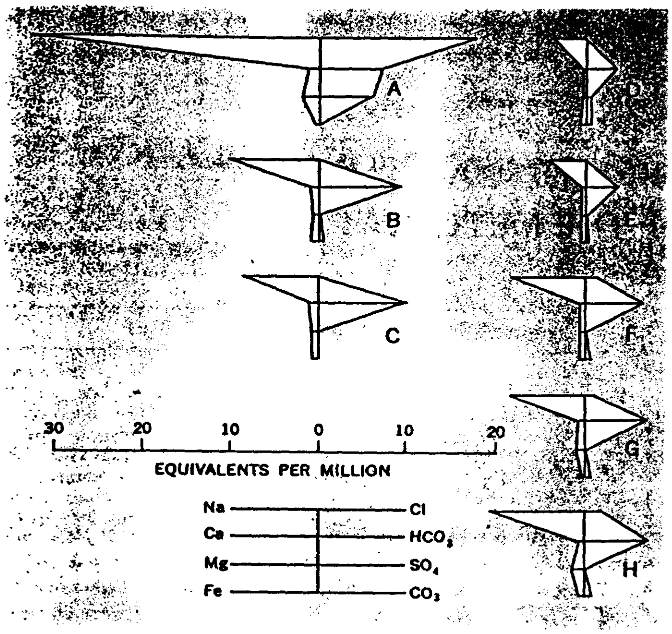

Figure 3.—Chemical characteristics of ground water from Metlakatla peninsula. A, drill hole 1; B, drill hole 2; C, drill hole 3; D, drill hole 5, 109–121 feet; E, drill hole 5, 183–209 feet; F, drill hole 5, 272–282 feet; G, drill hole 5, 297–305 feet; H, test well, composite of all producing zones.

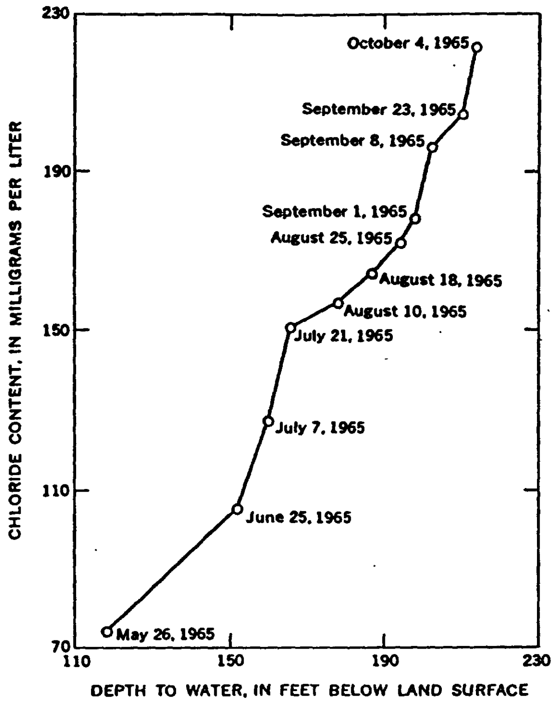

Figure 4.—Increase of chloride content of water in test well with increasing drawdown.

Samples from drill holes 2 and 3 and the composite sample from the test well show that the water is a sodium bicarbonate type.

The high sodium, magnesium, sulfate, and chloride contents in water from drill hole 1 suggest admixture of sea water with normal ground water.

During drilling of the test well, samples were collected from water-bearing zones at depths of 109–121, 183–209, 272–282, and 297–305 feet. These samples were collected after the hole had been pumped to remove all drilling fluids, thereby assuring a representative water sample. After each sample was collected, the water-bearing zone was sealed with cement and drilling continued. Thus, each sample from above 305 feet represents water from a single fracture zone. Samples from below a depth of 305 feet are a composite of all water-bearing zones penetrated by the well.

Chemical analyses show that the concentration of some constituents changed little with depth (table 1). Other constituents, particularly sodium and bicarbonate, increased rather markedly with depth. These increases are presumably the result of the water being in contact with the rock longer as it slowly moves downward or incomplete flushing of sea water from deeper crevices.

Because of the potential hazard of salt-water intrusion with progressive lowering of the water level in the test well during pumping, samples were collected intermittently between April and October 1965 and tested for chloride content. Figure 4 shows that the average chloride content increase was about 15 mg/l for every 10 feet of drawdown.

CONCLUSIONS

Four out of five drill holes produced small amounts of water from bedrock in the Metlakatla peninsula; geologically similar terranes in southeastern Alaska also might be expected to provide small supplies. Fractured zones at depths of less than 150 feet are more likely to provide a continuing supply of water because recharge can take place more rapidly. Although the test well drilled during this study cannot be pumped continuously at a rate of 35 gpm, it will provide that amount intermittently. However, drawdown must be carefully controlled to prevent encroachment of salt water. Additional supplies may be available from fracture zones, which can be located only by test drilling.

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Marcher, M. V., 1971, Raised beach deposits and their ground-water potential in the southern part of the Metlakatla peninsula, Annette Island, Alaska, *in* Geological Survey Research 1971: U.S. Geol. Survey Prof. Paper 750-D, p. D202–D205.

Stiff, H. A., Jr., 1951, The interpretation of chemical water analysis by means of patterns: Jour. Petroleum Technology, v. 3, no. 10, sec. 1, p. 15–16; sec. 2, p. 3.

yield of 100 gpm could not be maintained without excessive drawdown.

Subsequent to the recovery test a pump was installed in the well and operated almost continuously at a rate of 35 gpm for more than 3 months. Water-level measurements made during this period, plotted against time, are shown in figure 2. Examination of the drawdown curve shows that from a level of 127 feet shortly after pumping started, the water level declined to 206 feet after 100 days of pumping. Total drawdown from static level was 125 feet.

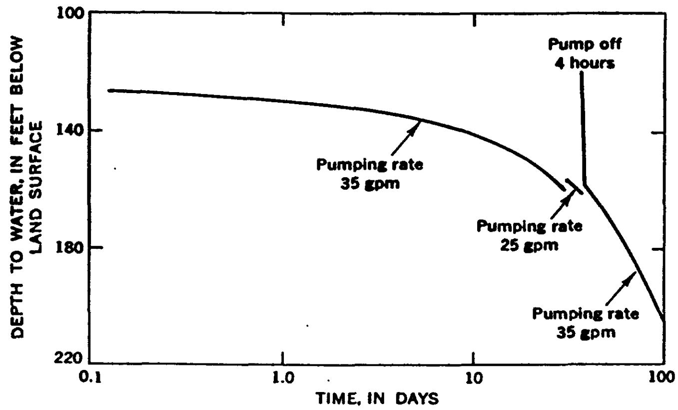

Figure 2.—Drawdown in the test well after pumping 100 days. Water level at start of pumping was 81 feet.

During the 3-month pumping period, the rate of drawdown was far in excess of that estimated on the basis of the test. Apparently the water-yielding zones are separated from one another and from surface recharge by considerable thicknesses of unfractured rock so that when they are drained of their stored water, replenishment takes place slowly. Hydrologic boundaries undoubtedly are present, because the fracture zones are not continuous and because the degree of fracturing along individual zones differs from place to place.

Chemical quality

At least one sample of water for chemical analysis was collected from each drill hole except number 4, and samples from four of the water-bearing zones in the test well were analyzed to determine variations in chemical quality with depth. Several samples were collected from the completed well after different periods of pumping and analyzed to determine changes in chemical quality that would indicate salt-water intrusion. The results of the analyses are given in table 1.

By plotting the results of the chemical analyses according to a method devised by Stiff (1951, p. 15–16), the gross chemical characteristics of the water can be compared as shown in figure 3.

Table 1.—*Chemical analyses of ground water from Metlakatla peninsula, Annette Island, Alaska*

[All analyses made by U.S. Geological Survey. Results in milligrams per liter except where indicated]

Source of water	Date of collection	Silica (SiO_2)	Iron (Fe)	Calcium (Ca)	Magnesium (Mg)	Sodium (Na)	Potassium (K)	Bicarbonate (HCO_3)	Carbonate (CO_3)	Sulfate (SO_4)	Chloride (Cl)
Drill hole 1	7-29-64	2.7	0.43	12	14	720	2.2	471	24	327	642
2	8- 8-64	7.7	.60	6.4	.5	220	.8	551	12	7.2	9.2
3	9- 1-64	20	.40	12	1.2	200	.3	558	0	4.8	5.7
5	9-13-64	31	.73	7.2	3.2	89	1.7	235	4	6.1	12
	9-21-64	25	.27	1.6	1.9	105	1.0	215	12	7.2	14
	9-28-64	15	.25	1.6	2.4	193	6.7	404	11	3.8	24
	10- 2-64	15	.04	.8	1.9	200	.6	451	17	4.3	42
Test well	5-26-65	17	.29	.0	7.1	235	8.5	493	30	6.7	74
	7- 7-65	18	.02	.0	4.4	276	9.2	480	22	25	125
	8-10-65	17	.00	.0	3.9	300	9.0	487	19	16	155
	8-26-65	16	.2	4	2.6	300	8.8	502	18	23	172

Source of water	Date of collection	Fluoride (F)	Nitrate (NO_3)	Dissolved solids (calculated)	Hardness as $CaCO_3$	Specific conductance (micromhos) at 25°C	pH (pH units)	Color (Pt-Co scale units)	Remarks
Drill hole 1	7-29-64	1.2	0.2	1,970	86	3,260	8.4	45	Water from 86–126-foot zone.
2	8- 8-64	1.1	.3	337	18	859	8.3	50	Water from 94–96-foot zone.
3	9- 1-64	.1	.8	520	35	830	8.2	30	Water from 92–95-foot zone.
5	9-13-64	.1	.6	260	31	434	8.4	30	Water from 109–121-foot zone.
	9-21-64	.1	1.2	287	12	449	9.0	10	Water from 183–209-foot zone.
	9-28-64	.2	1.0	463	14	758	9.0	10	Water from 272–282-foot zone.
	10- 2-64	.2	.9	506	10	859	9.0	10	Water from 297–305-foot zone.
Test well	5-26-65	.2	.3	592	29	958	8.9	12	After pumping 72 hours.
	7- 7-65	.2	.2	705	18	1,190	8.7	5	After pumping 730 hours.
	8-10-65	.3	.1	750	16	1,290	8.7	5	After pumping about 1,550 hours.
	8-25-65	.2	.1	782	21	1,355	8.6	10	After pumping about 1,900 hours.

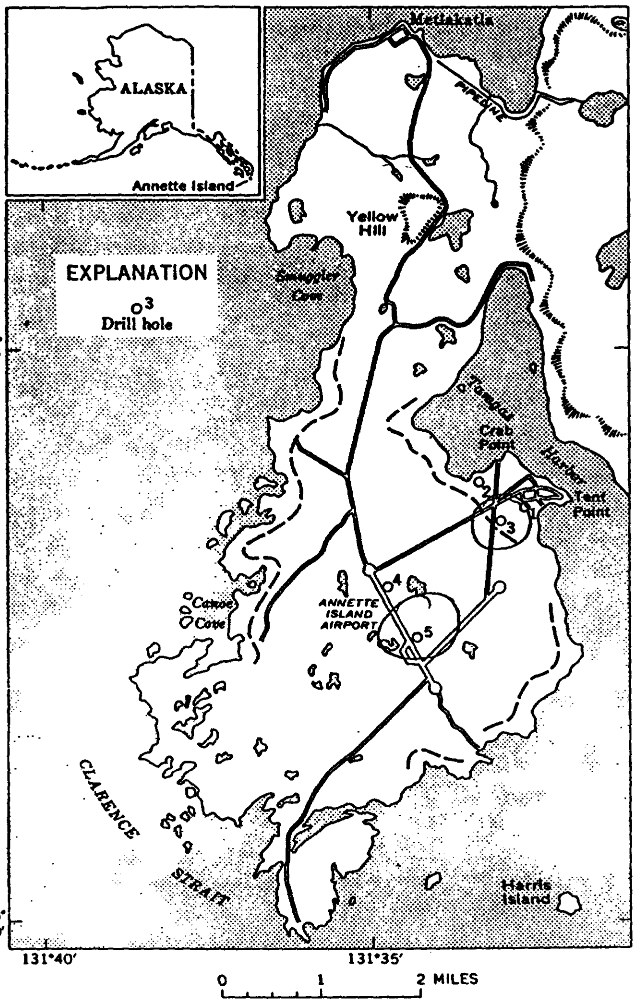

Figure 1.—Map of Metlakatla peninsula, Annette Island, Alaska, showing location of drill holes.

47–70 feet provided information on shallow subsurface joints. This core showed about 70 joints for an average of about three per foot. The width of these joints ranges from a hairline to about one-sixteenth inch, and many were partly or completely healed with quartz. Where the fractures were not fairly well healed, the core broke and the width of the fractures could not be determined. Because most of the fractures had been healed or were very narrow, the test hole did not yield a significant amount of water.

Highly fractured ultrabasic rocks south of Yellow Hill provide openings for seeps and small springs. Other small seeps issue from fractured rocks along the west side of the peninsula; these seeps undoubtedly go dry in the summer.

Rocks penetrated in the interval above 305 feet in the test well were nearly free of fractures, but zones of fractured rock were indicated below this depth by the difficulty experienced in maintaining a straight and round hole. Furthermore, the increase in well yield and reduction in drawdown described in the summary of test pumping suggest that the abundance of fractures increases with depth. The interval between 305 and 362 feet in the test well is interpreted as a fault zone because normally the number of fractures decreases with depth. Even though a fault zone may yield the major supply of ground water to the well, most recharge to the faults probably takes place through overlying jointed rock.

Test drilling and pumping

Results of test drilling and yield tests are summarized as follows:

Drill hole 1 reached a total depth of 295 feet and was abandoned because brackish water was obtained at that depth. A water-bearing zone, between 86 and 126 feet, was tested by pumping with air for 12 hours at a rate of one third gpm (gallon per minute).

Drill hole 2 reached a total depth of 113 feet. A water-bearing zone between 94 and 96 feet was tested by pumping with air at a rate of one-half gpm that increased to 1 gpm after 30 hours.

Drill hole 3 reached a total depth of 215 feet. A water-bearing zone between 92 and 95 feet was pumped with air at a rate of two-thirds gpm for 4 hours but did not increase in yield.

Drill hole 4 reached a depth of 104 feet, but no water was obtained.

Drill hole 5 was drilled using a core drill to a depth of 305 feet. The hole was then redrilled for a test well to a depth of 362 feet using a 6-inch churn drill. The results of testing the various water-bearing zones in this well are summarized below.

Depth (feet)	*Summary of testing*
70– 90	Pumped with air ½ gpm for 8 hours. Cemented in after pumping.
109–121	Pumped with air 2/3 gpm for 8 hours. Cemented in after pumping.
183–209	Pumped with air 2/3 gpm for 8 hours. Cemented in after pumping.
272–282	Pumped with air 1 2/3 gpm for 8 hours. Cemented in after pumping.
297–305	Pumped with air 8 gpm for 24 hours.
305–313	Pumped with air 12½ gpm for 16 hours with 130 feet drawdown. Static level 10 feet.
313–320	Pumped 16 hours at 30 gpm with 94 feet of drawdown. Static level 13 feet.
321–326	Pumped 72 hours at 37 gpm with drawdown of 80 feet. Static level 23 feet.
332–336	Pumped 23 hours at 37 gpm with drawdown of 67 feet. Static level 23 feet.

Fresh ground water beneath Annette Island is in contact with sea water. Excessive lowering of the water table in a pumping well may cause salt water to enter and contaminate the aquifer. To forestall such a possibility, drawdown in the well must be carefully controlled.

To estimate the amount of drawdown after pumping the production well for an extended period of time and to estimate the long-term yield, a 12-hour recovery test was run. Analysis of the test data indicates that impermeable boundaries are present in the vicinity of the well and that the initial

RECONNAISSANCE OF GROUND-WATER SUPPLIES FROM BEDROCK IN THE METLAKATLA PENINSULA, ANNETTE ISLAND, ALASKA

By MELVIN V. MARCHER, Oklahoma City, Okla.

Work done in cooperation with the Federal Aviation Administration

Abstract.—Bedrock in the western part of Annette Island, herein referred to as the Metlakatla peninsula, consists of igneous and metamorphic rocks that yield water only from fractures. A test well, 362 feet deep, obtained water between 305 and 362 feet. Initial production of the well was 100 gpm (gallons per minute), but results from a 12-hour recovery test suggested that this rate probably could not be maintained because of hydrologic boundaries. When the well was pumped continuously at a rate of 35 gpm for more than 3 months, the water level declined 125 feet at an average rate of 0.6 foot per day to about 115 feet below sea level. Chemical analyses show that ground water is a sodium bicarbonate type. During pumping of the test well, the chloride content of the water increased from 75 to 222 mg/l (milligrams per liter) indicating that salt water was entering the aquifer.

Although annual precipitation in southeastern Alaska is as much as 269 inches, the igneous and metamorphic rocks underlying most of the region generally yield only small amounts of water. This report describes the results of a project to develop ground-water supplies from bedrock on Annette Island. Some of the conclusions derived from the project are applicable to other areas because the climate, topography, and geology of the island are typical of much of southeastern Alaska.

As a major part of the project, five small-diameter holes were drilled to determine the subsurface distribution of fracture zones and, where possible, to test the water-yielding capabilities of each zone. Drill hole 5 had the greatest potential as a source of water and, therefore, was redrilled as a test well. Each water-bearing zone in this well was tested for yield, a water sample collected for chemical analysis, and, upon completion of drilling, a 12-hour recovery test was made.

Interbedded gravel, sand, silt, and clay interpreted as raised beach deposits, which may be potential sources of ground water, were studied in some detail and are described more fully in a companion paper (Marcher, 1971) (p. D202–D205, this chapter).

GENERAL SETTING

Annette Island is in extreme southeastern Alaska (fig. 1). The western part of the island, an area of about 20 square miles herein referred to as the Metlakatla peninsula, is mostly a swampy, heavily vegetated lowland generally less than 200 feet above sea level.

Annette Island lies in the Wrangell-Revillagigedo belt of metamorphic rocks (Buddington and Chapin, 1929, p. 181–183). Mapping by Berg (1969) shows that bedrock in the Metlakatla peninsula is chiefly schist, gneiss, and hornfels. These rocks are locally mixed and in part gradational with, foliated granitic rocks, which, in turn, grade into foliated quartz diorite and diorite. An area of about 1.5 square miles in the vicinity of Yellow Hill is underlain by dunite and pyroxenite. Sedimentary rocks include muck, glacial till, and raised beach deposits.

GROUND WATER IN BEDROCK

Bedrock fractures

The number, spacing, attitude, size, and interconnection of fractures such as joints and faults control the occurrence, storage, and movement of ground water in bedrock in the Metlakatla peninsula. Observations, mainly along the beach, showed a wide variety in the degree and type of jointing. For example, in some areas three sets of uniform, well-developed joints in coarse-grained dioritic rocks intersect to produce sharply defined trihedral blocks. Elsewhere, similar rocks are rather thoroughly fractured but the fractures do not follow any discernible pattern. Measurements showed that the major sets of joints strike between N. 15° E. and N. 15° W. Other sets strike N. 25°–35° E. and N. 55°–65° W. Of 63 measurements of joint dips, about 47 percent dip at angles greater than 80°, and nearly 95 percent dip at angles greater than 45°.

A 23-foot drill core taken from drill hole 4 from a depth of

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APPENDIX 6

Data for Annette Island, Alaska

LOCAL WELL NUMBER	PRIMARY USE OF WATER	DEPTH OF WELL (FEET)	WATER LEVEL (FEET)	DATE WELL CONSTRUCTED	OWNER	ASSIGNOR OF OTHER IDENTIFIER	OTHER IDENTIFIER	TYPE OF LOG AVAILABLE
CD05806317CCCA1S	M	--	--	--	PUBLIC DOMAIN	--	--	--
CD05806317CCCA2S	M	--	--	--	PUBLIC DOMAIN	--	--	--

APPENDIX 5

Data for Biorka Island, Alaska

15056330 - SAWMILL C AT HAINES AK

WATER-QUALITY DATA, WATER YEAR OCTOBER 1967 TO SEPTEMBER 1968

DATE	CARBON DIOXIDE DIS-SOLVED (MG/L AS CO2) (00405)	ALKA-LINITY WAT WH TOT FET FIELD MG/L AS CACO3 (00410)	BICAR-BONATE WATER WH FET FIELD MG/L AS HCO3 (00440)	CAR-BONATE WATER WH FET FIELD MG/L AS CO3 (00445)	NITRO-GEN, NITRATE DIS-SOLVED (MG/L AS N) (00618)	HARD-NESS TOTAL (MG/L AS CACO3) (00900)	HARD-NESS NONCARB WH WAT TOT FLD MG/L AS CACO3 (00902)	CALCIUM DIS-SOLVED (MG/L AS CA) (00915)	MAGNE-SIUM, DIS-SOLVED (MG/L AS MG) (00925)	SODIUM, DIS-SOLVED (MG/L AS NA) (00930)	SODIUM AD-SORP-TION RATIO (00931)
JUN											
14...	25	63	77	0	0.140	91	28	30	4.0	7.0	0.3

DATE	TIME	LAT-I-TUDE	LONG-I-TUDE	MEDIUM CODE	SAMPLE TYPE	RECORD NUMBER	TEMPER-ATURE WATER (DEG C) (00010)	DIS-CHARGE, INST. CUBIC FEET PER SECOND (00061)	COLOR (PLAT-INUM-COBALT UNITS) (00080)	SPE-CIFIC CON-DUCT-ANCE (US/CM) (00095)	PH WATER WHOLE FIELD (STAND-ARD UNITS) (00400)
JUN											
14...	1740	59 14 09 N	135 28 13 W	9	9	96800099	11.0	3.0	15	218	6.7

DATE	SODIUM PERCENT (00932)	POTAS-SIUM, DIS-SOLVED (MG/L AS K) (00935)	CHLO-RIDE, DIS-SOLVED (MG/L AS CL) (00940)	SULFATE DIS-SOLVED (MG/L AS SO4) (00945)	FLUO-RIDE, DIS-SOLVED (MG/L AS F) (00950)	SILICA, DIS-SOLVED (MG/L AS SIO2) (00955)	SOLIDS, SUM OF CONSTI-TUENTS, DIS-SOLVED (MG/L) (70301)	SOLIDS, DIS-SOLVED (TONS PER DAY) (70302)	SOLIDS, DIS-SOLVED (TONS PER AC-FT) (70303)	NITRO-GEN, NITRATE DIS-SOLVED (MG/L AS NO3) (71851)	IRON (UG/L AS FE) (71885)
JUN											
14...	14	1.1	6.5	37	0.20	8.6	133	1.08	0.18	0.60	530

15056330 - SAWMILL C AT HAINES AK

WATER-QUALITY DATA, WATER YEAR OCTOBER 1966 TO SEPTEMBER 1967

DATE	TIME	LAT-I-TUDE	LONG-I-TUDE	MEDIUM CODE	SAMPLE TYPE	RECORD NUMBER	TEMPER-ATURE WATER (DEG C) (00010)	DIS-CHARGE, INST. CUBIC FEET PER SECOND (00061)	COLOR (PLAT-INUM-COBALT UNITS) (00080)	SPE-CIFIC CON-DUCT-ANCE (US/CM) (00095)
APR										
13...	1400	59 14 09 N	135 28 13 W	9	9	96700067	1.0	12	--	140
27...	1100	59 14 09 N	135 28 13 W	9	9	96700068	1.0	10	50	89

DATE	PH WATER WHOLE FIELD (STAND-ARD UNITS) (00400)	CARBON DIOXIDE DIS-SOLVED (MG/L AS CO2) (00405)	ALKA-LINITY WAT WH TOT FET FIELD MG/L AS CACO3 (00410)	BICAR-BONATE WATER WH FET FIELD MG/L AS HCO3 (00440)	NITRO-GEN, NITRATE DIS-SOLVED (MG/L AS N) (00618)	HARD-NESS TOTAL (MG/L AS CACO3) (00900)	HARD-NESS NONCARB WH WAT TOT FLD MG/L AS CACO3 (00902)	CALCIUM DIS-SOLVED (MG/L AS CA) (00915)	MAGNE-SIUM, DIS-SOLVED (MG/L AS MG) (00925)	SODIUM, DIS-SOLVED (MG/L AS NA) (00930)	SODIUM AD-SORP-TION RATIO (00931)
APR											
13...	6.9	8.1	33	40	0.050	55	22	18	2.4	4.6	0.3
27...	6.8	6.8	22	27	0.090	35	13	11	1.8	2.7	0.2

DATE	SODIUM PERCENT (00932)	POTAS-SIUM, DIS-SOLVED (MG/L AS K) (00935)	CHLO-RIDE, DIS-SOLVED (MG/L AS CL) (00940)	SULFATE DIS-SOLVED (MG/L AS SO4) (00945)	FLUO-RIDE, DIS-SOLVED (MG/L AS F) (00950)	SILICA, DIS-SOLVED (MG/L AS SIO2) (00955)	SOLIDS, SUM OF CONSTI-TUENTS, DIS-SOLVED (MG/L) (70301)	SOLIDS, DIS-SOLVED (TONS PER DAY) (70302)	SOLIDS, DIS-SOLVED (TONS PER AC-FT) (70303)	NITRO-GEN, NITRATE DIS-SOLVED (MG/L AS NO3) (71851)	IRON (UG/L AS FE) (71885)
APR											
13...	--	--	8.0	19	0.20	6.0	79	2.56	0.11	0.20	470
27...	14	0.90	3.9	16	0.10	5.7	56	1.51	0.08	0.40	600

near Haines, Alaska—Continued

Diameter of casing (inches)	Use of water	Depth to water	Altitude of land surface	Date of measurement	Remarks
N	TW	————	183.0	————	GS, L, D
N	TW	————	127.0	————	GS, L, D

wells and streams near Haines, Alaska

Chloride (Cl)[2]	Fluoride (F)[2]	Nitrate (NO_3)[2]	Hardness[2] as $CaCO_3$		Specific conductance (micromhos at 25°C)	Total dissolved solids[2]	pH	Remarks[3]
			Calcium magnesium	Noncarbonate				
6.0	0.2	0.1	100	16	300	140	7.9	
5.0	.1	.2	112	28	255	145	7.9	ADF (8837).
7.0	.1	.1	125	92	275	179	6.8	
9.0	.4	.2	407	349	950	524	7.1	
5.0	.2	.1	164	19	350	170	7.6	
14	.2	2.1	105	.0	450	251	7.2	
6.0	.0	.0	165	74	383	253	7.9	ADF (6359).
3.9	.1	.1	313	237	600	421	7.7	ADF (8838).
4.0	.1	.0	235	160	600	340	7.9	
198	.5	.1	179	40	1,020	543	7.3	
6.7	.0	.6	62	5	138	82	7.0	ADF (10130); aresnic 0.00.
1,050	.45	.2	439	94	3,550	2,030	7.9	After 1 hr., pump at 32 ft.
950	.5	.4	400	84	3,300	1,900	7.8	After 2 hrs., pump at 32 ft.
10	.2	.2	60	2.0	160	80	7.3	After 1 hr., pump at 22 ft.
3.0	.2	.2	684	607	1,200	877	7.6	
60	.1	.1	107	12	442	246	7.7	ADF (8836).
7.4	.1	.2	42	8	126	63	8.4	ADF (8839).
2.0	.1	.1	20	2	50	27	6.0	
1.0	.1	.1	25	4	57	35	7.0	ADF (6731); sec. 29, T. 28 S., R. 56 E.
5.0	.1	1.1	70	17	160	86	7.6	
5.0	.2	.2	165	83	300	157	7.4	
3.9	.1	.4	35	13	89	56	6.8	ADF (10129); arsenic 0.00.
2.0	.1	.2	70	19	170	101	7.3	Sec. 6, T. 31 S., R. 59 E.
6.0	.0	.0	48	17	113	72	7.2	ADF (6360).
2.8	.5	1.2	71	46	201	89	8.1	ADF (8725); sec. 9, T. 30 S., R. 59 E.

[3]ADF ( ) = Additional data in files for laboratory analysis indicated.
[4]Sample locations that occur off map are not shown.

Table 1.—*Records of wells*

Well	File	Map distance North (feet)	Map distance West (feet)	Owner of user	Year completed	Depth of well (feet)
36	2bdd	2,750	3,000	Federal Aviation Agency	1967	3
37	2cad	1,950	3,050	do	1967	58

Table 2.—*Quality-of-water analyses from*

Sample (well or gaging site)[1]	Date of collection	Source	Depth of well (feet)	Temperature (°F)	Temperature (°C)	Iron (Fe)[2]	Calcium (Ca)[2]	Magnesium (Mg)[2]	Bicarbonate (HCO_3)[2]	Sulfate (SO_4)[2]
4	4–10–67	Aluvium	51	40	4.5	0.07	32	4.9	103	28
6	3–12–66	do	64	——	——	.04	28	10	102	33
7	4–30–67	do	60	——	——	.10	40	6.1	40	76
8	4–10–67	do	92	40	4.5	.05	120	26	71	320
9	4– 6–67	do	95	41	5.0	.03	44	13	116	37
10	4– 6–67	do	43	——	——	.20	30	7.3	190	30
11	12– 5–60	do	60	42	5.5	.18	51	9.3	111	98
12	3–14–66	do	64	——	——	.00	118	4.5	93	232
13	5– 2–67	do	284	——	——	.20	88	3.6	91	175
21	4–14–67	do	72	42	5.5	.02	32	24	169	60
22	4–27–67	do	22	40	4.5	.00	20	2.9	70	5.0
22	4–13–67	do	32	40	4.5	.05	44	80	421	36
22	4–13–67	do	32	40	4.5	.05	52	66	386	28
22	4–13–67	do	22	39	4.0	.02	20	2.4	71	4.0
23	7–25–67	do	120	——	——	.05	260	8.5	94	520
26	3– –67	do	64	——	——	.02	15	17	116	30
32	3–14–67	do	105	——	——	.38	8.8	4.9	39	11
35	4–22–67	do	18	41	5.0	.05	4.0	2.4	22	2.0
[4]38	7– 5–61	Chilkat River	——	——	——	.03	8.0	1.2	26	6.0
40	4–21–67	Johnson Creek	——	34.5	1.5	.02	24	2.4	65	14
41	4–15–67	Haines Public supply.	——	——	——	.02	42	6.1	58	62
42	4–27–67	Creek crossing Sawmill Road.	——	34	1.5	.60	11	1.8	27	16
[4]43	4–21–67	Haska Creek	——	33.5	1.0	.03	22	3.6	63	28
44	12– 6–60	Port Chilkoot public supply.	——	——	——	.74	15	2.6	38	19
45	——	Tank Farm supply.	——	——	——	3.21	28	.0	64	25

[1]Sample numbers (4–35) are identical to well numbers on table 1; numbers 40–45 refer to surface-water or public-supply samples.

[2]Constituents given in milligrams per liter.

Table 3.—*Summary of ground-water availability in the Haines-Port Chilkoot area, Alaska*

Area (fig. 5)	Geologic summary	Present development	Ground-water potential in surficial deposits[1]
1	Thin surficial deposits over bedrock.	No wells, no test wells.	As much as 25 gpm (possibly more near Mink Creek).
2	Isolated surficial deposits over bedrock.	do	Less than 5 gpm; generally drained or thinly saturated.
3	Slide and slopewash or glacial deposits over bedrock.	No wells, two test wells.	As much as 25 gpm; composed of poorly sorted material containing many boulders.
4	Alluvial fan and slopewash deposits over bedrock.	do	As much as 50 gpm; poorly sorted material with perched water.
5	At least 100 feet of clay overlying a few hundred feet of unknown sedimentary rocks which overlie bedrock.	Three wells, two test wells.	No yield upper 100 feet. Less than 100 gpm from lower sediments.
6	Similar to area 5 except that clay might be thinner because of possible faulting and subsequent erosion.	Three wells, four test wells.	No yield upper 50 feet. Less than 100 gpm from lower sediments.
7	Thick surficial deposits over bedrock; tidal flats in part.	One well, no test wells.	As much as 100 gpm; quality of water may be poor.
8	Glacial outwash, beach deposits, or younger alluvium in eroded channel; thick upper clay of areas 5 and 6 has been eroded.	No wells, four test wells.	As much as 500 gpm; quality of water variable. Considerable drainage from muskeg areas.
9	Glacial and beach deposits terrace over bedrock.	One well, nine test wells.	As much as 100 gpm; water-bearing beds are not extensive and may be partly drained.
10	Thin surficial deposits over bedrock.	No wells, no test wells.	Less than 10 gpm.
11	Surficial deposits over bedrock.	One well, five test wells.	As much as 25 gpm. Excellent to poor quality of water.
12	Isolated surficial deposits over bedrock.	No wells, no test wells.	Less than 5 gpm.

[1]Less than 5 gpm from bedrock.

Haines, Alaska   Hole # 11 at Highway Comm. Garage   March 14, 1966

Material	Depth From	To
Fill of brown gravelly soil	0	4
Brown gravel with little silt, wet, very little silt 10 to 13 feet mostly gravel, water 16 to 18'	4	18
Clay, blue-gray soupy, mixed with gravel and sand	18	33
Heavier clay mixed with gravel or sand, becoming less dense at a depth of about 45 feet	33	57
Heavy clay mixed with fine gravel and sand, blue gray soupy	57	65
Fine sand and clay mixed, blue gray soupy	65	78
Sand or sand and clay mixed, soupy	78	87

About 35 feet of 2 inch casing with a 6 foot drive point put down the hole.

Haines, Alaska Hole 9 March 8, 1966

Material	Depth From	Depth To
Soil with small broken rock	0	2
Gravel and water, gravel fine to coarse with a brown silt matrix	2	5
Gravel with silt becoming more gray in color	5	10
Clay, very hard and dense, gray to blue-gray	10	16
Drills softer, possibly fine sand or silt, water	16	18
Harder drilling, clay sandy gray to blue gray with a band of gravel at about 24 feet	18	24
Drills like sand or soft clay, with some fine gravel, more gravel at about 45 feet water (no return)	24	53
Gravel	53	55
Soft again, clay or sand mixed with gravel	55	67
Gravel and heavy clay, coarse gravel at about 71 feet to 75 feet and more sandy below	67	77
Clay and gravel interbedded	77	87

So much gravel caved into the hole upon removal of the auger that it was not possible to put more than 15 feet of pipe in the hole, pipe pulled and hole filled.

Haines, Alaska   Hole #6 SW of small boat harbor   March 2, 1966

Material	Depth From	To
Fill, sandy, dry	0	8
Clay, grey - blue, damp, soft	8	15
Clay, with sandy and pebble zones, tillite?	15	23
Sandy clay mixed with pebbles and gravel up to 3 inches in diameter, gray to blue in color	23	30
Sand fine with interbedded clay and minor gravel (no return) drills easily	30	35
Hard clay and gravel mixed (no return)	35	42
Clay and gravel coarse up to 3 inches in diameter hard drilling (no return)	42	46
Hard gravel (?) (no return)	46	48
Gravel with hard clay, very hard drilling (no return)	48	49
Very hard drilling (clay?) no return	49	50

Hit boulder or bedrock at depth of 50 feet

Haines, Alaska | Hole #5 on Waterfront Road | March 3, 1966

Material	Depth From	To
Silt and rock mostly small gravel, brown - fill?	0	4
Silt with gravel slightly larger than pea gravel, water in brownish black matrix	4	10
Gravel and silt, gravel slightly coraser than above water	10	17
Silt or clay, less gravel than above, blue-gray in color	17	26
Heavier clay, soft, blue gray in color, some material with more sand, more gravel after 38 feet and possibly in pure sand at 40 feet, mixed with blue clay	26	46
Heavy clay (no return) hard drilling, easier drilling after 51 feet and gravel at about 52 feet	46	59
Sand, mixed with gravel (no return)	59	64

Hole cased with 2 inch casing to a depth of 35 feet below lsd, 4.8 feet of casing left afove lsd. Flowing well. good quality Hardness 7 grains per gallon, pH 8.0 Chloride 22-27 ppm, Iron 0.5 ppm.

Lab # 8840

	Depth (feet)
Soft rock with some hard rock and seams of soft clay - - - - - - - - - - - - - - - -	236
Soft rock with some hard rock and seams of soft clay - - - - - - - - - - - - - - - -	271
Bottom -	284

Results: Pumped well for 5 hours. Maximum capacity with pump at 265-foot level was 15 G.P.M. Sprung well with 3 shots of 21 lbs. dynamite each at approximately 210-foot, 240-foot, and 270-foot levels. Well was pumped constantly, but average yield was only 15 G.P.M., so the well was abandoned.

Log Furnished by Gene Robertson U.S.G.S.

Log of water well No. 2, Haines, Alaska, drilled by Foley Brothers, Inc., August-September, 1943. Collar at 92.8 ft. elevation.

Site presumably ~ 0.1 mi. E of intersection Allen and Comstock Rd

	Depth (feet)
Surface gravel -	0
Blue grey clay -	1 - 80'
Gravel; slight water content - - - - - - - - - - - - -	80
Sand and gravel; well made a small amount of water	81
Sand and gravel - - - - - - - - - - - - - - - - - - -	85
Coarse gravel and fine sand - - - - - - - - - - - - -	88
Blue grey clay -	96
Coarse gravel; very little sand content - - - - - - -	98
Large gravel and boulders up to 6" in size; some sand - - - - - - - - - - - - - - - - - -	106
Gravel with some fine sand - - - - - - - - - - - - -	111
Fine to large gravel with some fine sand - - - - -	118

Stopped drilling at 122 feet.
Casing was perforated with 7 holes at 115'; then casing was perforated to within 32 of the top with 180 perforations; cleaned out the well, and installed test pump. Test showed about 15 G.P.M.

Blue grey clay -	122
Fine gravel and sand - - - - - - - - - - - - - - - -	124
Hard rock -	130
Rock, slightly water bearing - - - - - - - - - - - -	137
Rock, slightly water bearing - - - - - - - - - - - -	149
Rock, slightly water bearing - - - - - - - - - - - -	169
Rock -	175
Soft rock -	182
Soft porous rock - - - - - - - - - - - - - - - - - -	187
Soft porous rock with seams of fine clay - - - - -	207
Soft porous rock. Drilled to 236 feet and then pumped well for 4 hrs.; average yield was 16 G.P.M. with drawdown to 166' - - - -	224

Log Furnished by Gene Robertson U.S.G.S.

Log of water well No. 1, Haines, Alaska, drilled by Foley Brothers, Inc., August, 1943. Collar at 40.0 ft. elevation.

Site presumably ~0.1 mile E of Customs house

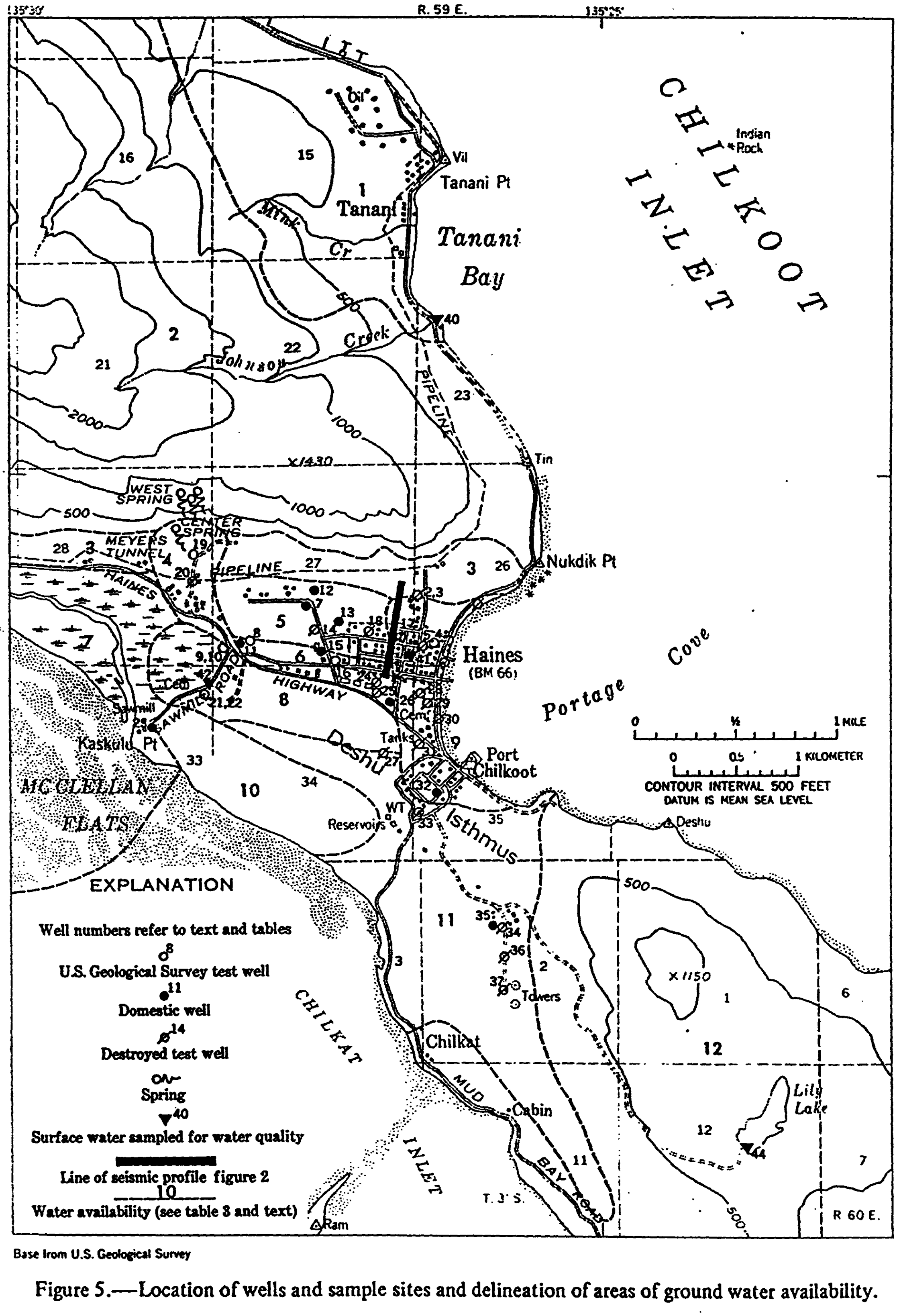
	Depth (feet)
Muskeg -	0
Fine gravel containing surface water - - - - - - -	1
Blue grey clay - - - - - - - - - - - - - - - - - - -	9 - 44'
Fine gravel containing surface water - - - - - - -	44
Fine gravel mixed with clay - - - - - - - - - - -	48
Coarse gravel, clay and boulders - - - - - - - - -	50
Fine grey sand with some 1/2" to 1-1/2" gravel. Sand is water soaked; well made a small amount of water. - - - - - - - - - - - - - -	53
Fine grey sand with small amount 1/2" to 1-1/2" gravel- - - - - - - - - - - - - - - - - - - -	63
Blue grey clay - - - - - - - - - - - - - - - - - - -	73 - 121'
Fine water bearing sand. Well made water at approximately 35 G.P.M. Pressure forced the water up 110 feet in well - - - - - - - -	121
Bottom -	123

Results: Water found to be salty, and so the well was abandoned.

Log of well at Port Chilkoot, Alaska

Material	Thickness	Depth
Soil and rock..	2	2
Brown silty clay and rock............................	17	19
Layered gravel and glacial clay......................	35	54
Boulders...	2	56
Gravel...	4	60
Boulders, gravel and clay, mixed.....................	5	65
Gravel, coarse to medium.............................	7	72
Clay, bluish black...................................	3	75
Gravel, small, mixed with clay, blue.................	8	83
Clay, blue...	1	84
Clay and fine sand mixed with gravel	2	86
X Gravel, egg sized (reported).......................	19	105
Clay and gravel mixed................................	5	110

Well completed at depth of 110 feet, water was cut off when casing was driven to [illegible] feet depth and casing was pulled back to 10[illegible] feet. Water reportedly stood between 20 and 25 feet below ground surface when the well was completed in 196[illegible]. No screen has been installed and no pump placed on the well.



Base from U.S. Geological Survey

Figure 5.—Location of wells and sample sites and delineation of areas of ground water availability.

Source

(McConaghy, 197

LOCAL WELL NUMBER		PRIMARY USE OF WATER	DEPTH OF WELL (FEET)	WATER LEVEL (FEET)	DATE WELL CONSTRUCTED	OWNER	ASSIGNOR OF OTHER IDENTIFIER	OTHER IDENTIFIER	TYPE OF LOG AVAILABLE
CD02805526DCDB1S		-	--	--	--	PUBLIC DOMAIN	--	--	-
CD02805634CCAC1S		U	--	--	--	PUBLIC DOMAIN	--	--	-
CD02805634CCAC2	002	U	30.0	--	12-01-82	USGS TSIRKU VC-01	--	--	-
CD02805634CCDB1	001	-	20.0	--	--	USGS TSIRKU VC-02	--	--	-
CD02805634CCDB2	001	-	10.0	--	--	USGS TSIRKU VC-03	--	--	-
CD02805912BAAD1	001	P	80.0	--	08-14-67	SKAGWAY CITY OF	--	--	-
CD02805912BAAD2	001	P	75.0	--	08-14-67	SKAGWAY CITY OF	--	--	-
CD02905601ABAA1	001	U	258	8.00	11-07-82	USGS TSIRKU AR-03	--	--	D
CD02905601ABAA2	001	U	38.0	8.00	11-07-82	USGS TSIRKU AR-04	--	--	D
CD02905601BBAC1	002	U	38.0	9.00	11-08-82	USGS TSIRKU AR-10	--	--	D
CD02905601DBCA1	003	U	108	--	11-03-82	USGS TSIRKU AR-02	--	--	D
CD02905612ADDD1	001	U	38.0	34.00	11-08-82	USGS TSIRKU AR-09	--	--	D
CD02905612BACB1	002	U	220	40.00	11-02-82	USGS TSIRKU AR-01	--	--	D
CD02905612BACB2	002	U	18.0	18.00	11-09-82	USGS TSIRKU AR-11	--	--	D
CD02905706DBAD1	001	U	38.0	11.00	11-07-82	USGS TSIRKU AR-05	--	--	D
CD02905707AAAD1	001	U	38.0	8.00	11-07-82	USGS TSIRKU AR-06	--	--	D
CD02905707BBAA1	002	U	38.0	29.00	11-08-82	USGS TSIRKU AR-08	--	--	D
CD02905707DBAD1	003	U	38.0	17.00	11-08-82	USGS TSIRKU AR-07	--	--	D
CD03105902CCAD1	001	H	70.0	--	07-26-78	TRUCE ROGER	--	--	D
CD03106030BBBB1	001	H	92.0	4.00	06-19-64	COMERFORD MARTIN	--	--	D
CD03106030BBCA1	002	H	104	15.00	07-23-64	COMERFORD MARTIN	--	--	D
CD03106031ACCD1	001	P	186	170.00	10-29-79	AK DIV PKS CHILKAT P	--	--	D
CD03106031BDAD1	002	P	200	--	11-30-79	AK DIV PKS CHILKAT P	--	--	D
CD03106031DBBA1	003	P	250	--	11-01-79	AK DIV PKS CHILKAT P	--	--	D

APPENDIX 4

Data for Haines, Alaska

2GW

UNITED STATES DEPARTMENT OF THE INTERIOR
GEOLOGICAL SURVEY
WATER ANALYSIS

Location: Gustavus Inn, Gustavus, Alaska County:
Source: Depth (ft): 26 Diam (in.):
Cased to (ft): Date drilled: Oct., 1967 Point of coll.: Kitchen tap
Owner:
Treatment: Use:
WBF: WL: Yield:
Temp (°F): Appear. when coll.: clear
Collected: November 18, 1967 By: Jack Lesh, MD
Remarks:

	ppm mg/l	epm		ppm mg/l	epm
Silica (SiO_2)	16		Bicarbonate (HCO_3)	290	4.75
Aluminum (Al)	--		Carbonate (CO_3)	0	0.00
Iron (Fe)	0.56				
			Sulfate (SO_4)	11	0.23
			Chloride (Cl)	35	0.98
			Fluoride (F)	0.0	0.00
Calcium (Ca)	91	4.54			
Magnesium (Mg)	6.8	0.56	Nitrate (NO_3)	9.0	0.01
Sodium (Na)	11	0.48			
Potassium (K)	5.9	0.15			
Total		5.73	Total		5.97

	ppm mg/l		
Dissolved solids:		Specific conductance (micromhos at 25° C)	554
Calculated	322	pH	7.8
Residue on evaporation at 180° C		Color	5
Hardness as $CaCO_3$	260		
Noncarbonate	20		

Lab. No. Col 10801-68-147 Field No. Project: Alaska Department of Health, Education and Welfare

2GW

UNITED STATES DEPARTMENT OF THE INTERIOR
GEOLOGICAL SURVEY
WATER ANALYSIS

Location FAA Stn, Gustavus, Alaska County
Source Shallow well, dug Depth (ft) 18' Diam (in.)
Cased to (ft) Date drilled Point of coll. Well pump
Owner
Treatment Use
WBF WL Yield
Temp (°F) Appear. when coll. Clear
Collected 15 Apr. 1959 By Station Manager
Remarks Return analysis toFAA, Box 440, Attn: AN-675 BU, Anchorage, Alaska

	ppm	epm		ppm	epm
Silica (SiO_2)	12		Bicarbonate (HCO_3)	244	4.00
Aluminum (Al)			Carbonate (CO_3)		
Iron (Fe)	2.0				
Mn	0.39	0.01	Sulfate (SO_4)	53	1.10
			Chloride (Cl)	9.0	0.25
			Fluoride (F)	0.0	0.00
Calcium (Ca)	75	3.74			
Magnesium (Mg)	15	1.23	Nitrate (NO_3)	0.0	0.00
Sodium (Na)	6.5	0.28	PO_4	0.0	0.00
Potassium (K)	3.9	0.10			
Total		5.36	Total		5.35

	ppm		
		Specific conductance (micromhos at 25° C)	492
Dissolved solids: Calculated	295	pH	6.7
Residue on evaporation at 180°C		Color	0
Hardness as $CaCO_3$	248		
Noncarbonate	48		

Lab. No. ~~Cat~~ 5227 Field No. Project

G

UNITED STATES DEPARTMENT OF THE INTERIOR
GEOLOGICAL SURVEY

2GW

WATER ANALYSIS

Location FAA Station @ Gustavus, Alaska County 1st Judicial Div.
Source Well 2200' from housing area Depth (ft) ____ Diam (in.) 3
Cased to (ft) ____ Date drilled ____ Point of coll. ____
____ Owner ____
Treatment ____ Use ____
WBF ____ WL ____ Yield ____
Temp (°F) ____ Appear. when coll. ____
Collected November 1, 1960 By ____
Remarks

	ppm	epm		ppm	epm
Silica (SiO_2)	14		Bicarbonate (HCO_3)	244	4.00
Aluminum (Al)			Carbonate (CO_3)		
Iron (Fe) in sol.	0.02				
Manganese (Mn) in sol.	0.03	0.00	Sulfate (SO_4)	40	0.83
			Chloride (Cl)	4.0	0.11
			Fluoride (F)	0.1	0.00
Calcium (Ca)	6.4	0.32			
Magnesium (Mg)	1.9	0.16	Nitrate (NO_3)	0.1	0.00
Sodium (Na)	100	4.35			
Potassium (K)	2.3	0.06			
Total		4.89	Total		4.94

	ppm		
		Specific conductance (micromhos at 25° C)	456
Dissolved solids: Calculated	289	pH	8.2
Residue on evaporation at 180° C			
Hardness as $CaCO_3$	24	Color	0
Noncarbonate	0		
Alk as $CaCO_3$	2		
CO_2	200		

Lab. No. Col 6292 Field No. Project