Overview of Environmental and Hydrogeologic Conditions at Yakutat, Alaska

By Walter F. Holmes and Joseph M. Dorava

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Multiply	By	To obtain
millimeter (mm)	0.03937	inch
meter (m)	3.281	foot
kilometer (km)	0.6214	mile
hectare (ha)	2.471	acre
liter (L)	0.2642	gallon
liter per second(L/s)	15.85	gallon per minute
liter per day (L/d)	0.2642	gallon per day
cubic meter per second (m^3/s)	35.31	cubic foot per second
liter per second per meter [(L/s)/m]	4.831	gallon per minute per foot
square meter per day (m^2/d)	10.76	square foot per day
degree Celsius (°C)	°F = 1.8 x °C + 32	degree Fahrenheit (°F)

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 both the United States and Canada, formerly called Sea Level Datum of 1929.

Abbreviated water-quality unit used in this report:

mg/L, milligram per liter

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Abstract

The remote village of Yakutat Alaska has a mild, wet, maritime climate. The village depends on the fishing and forestry industries for its livelihood. Adequate drinking-water supplies are present in the thick glacial-moraine deposits underlying the village, which is situated between the St. Elias Mountains and the Gulf of Alaska. Alternative drinking-water sources are available from local surface water and from ground water contained in coarse-grained outwash deposits, but no public distribution or treatment system is in place for use of the surface-water sources.

INTRODUCTION

Purpose and Scope

The Federal Aviation Administration (FAA) owns and (or) operates airway support and navigational facilities throughout Alaska. At many of these sites, fuels and potentially hazardous materials such as solvents, polychlorinated biphenyls, and pesticides may have been used and (or) disposed of. To determine if environmentally hazardous materials have been spilled or disposed of at the sites, the FAA is conducting environmental studies mandated under the Comprehensive Environmental Response, Compensation, and Liability Act (CERCLA or "Superfund Act") and the Resource Conservation and Recovery Act (RCRA). To complete these environmental studies, the FAA requires information on the hydrology and geology of areas surrounding the sites. This report, the product of compilation, review, and summary of existing hydrologic and geologic data by the U.S. Geological Survey, in cooperation with the FAA, provides such information for the FAA facility and nearby areas at Yakutat, Alaska. Also presented in this report is a description of the history, socioeconomics, and physical setting of the Yakutat area.

Location

The village of Yakutat and the nearby FAA facilities are in southeastern Alaska (fig. 1) at about latitude 59°32'30" N, longitude 139°42'30" W., approximately 240 km west-northwest of Juneau. The immediate area is bordered by the Tongass National Forest on the east and southeast, the Gulf of Alaska on the south and west, and Yakutat Bay on the north.

The FAA maintains operations on 17 parcels of land, covering about 480 ha in or near Yakutat, including a maintenance area, living quarters area, sewer lagoon, antenna lot, direction finder (DF) site, very high frequency omni-directional radio range and tactical air navigation aid (VORTAC) site, remote communications air to ground (RCAG) site, and the range site (fig. 2) (Ecology and Environment, Inc., 1992). A remote repeater site is located about 48 km east-southeast of Yakutat Airport. A detailed account of FAA owned, leased, or transferred properties in Yakutat can be found in an environmental compliance investigation report done for the FAA (Ecology and Environment, Inc., 1992).

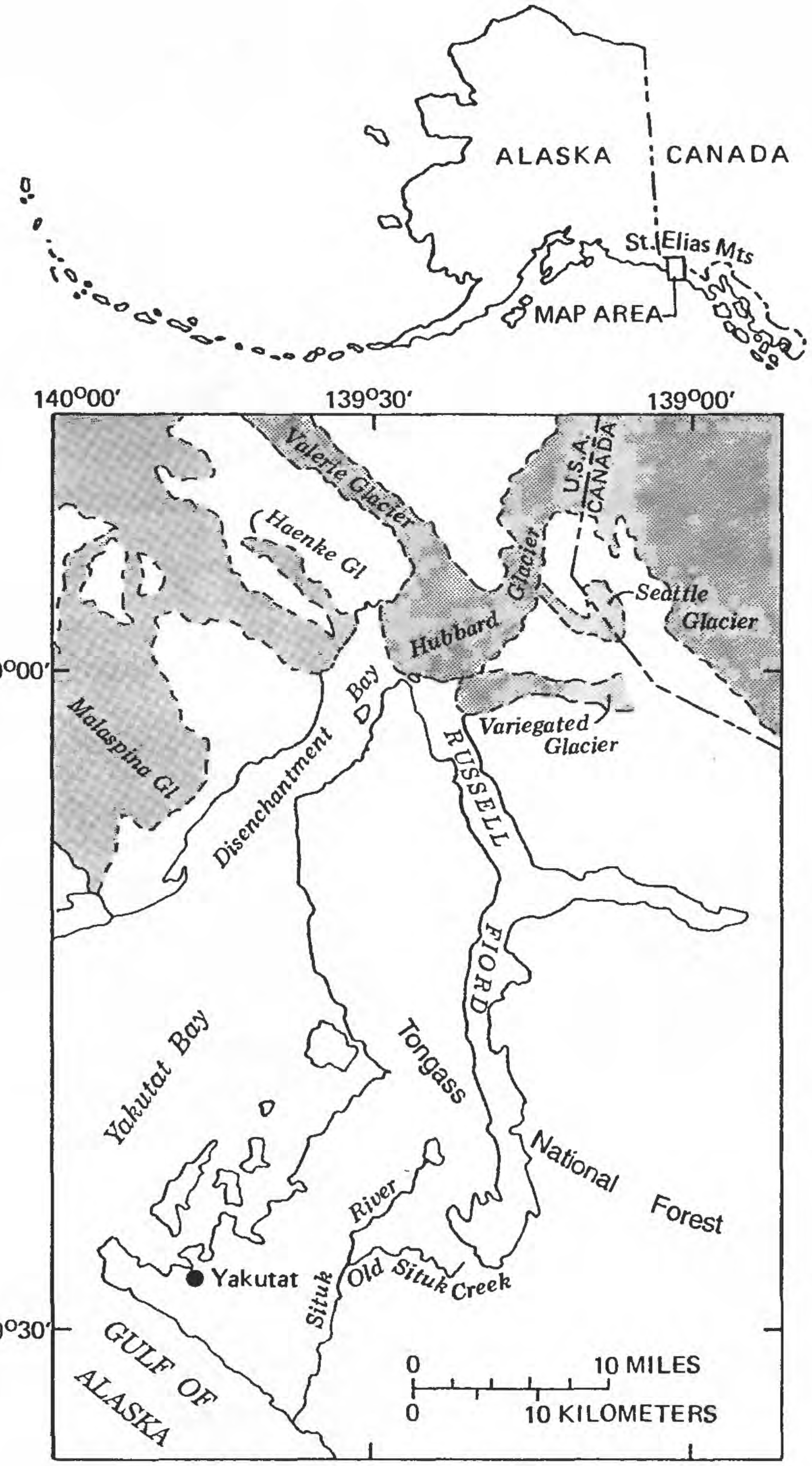


Figure 1. Location of Yakutat study area.

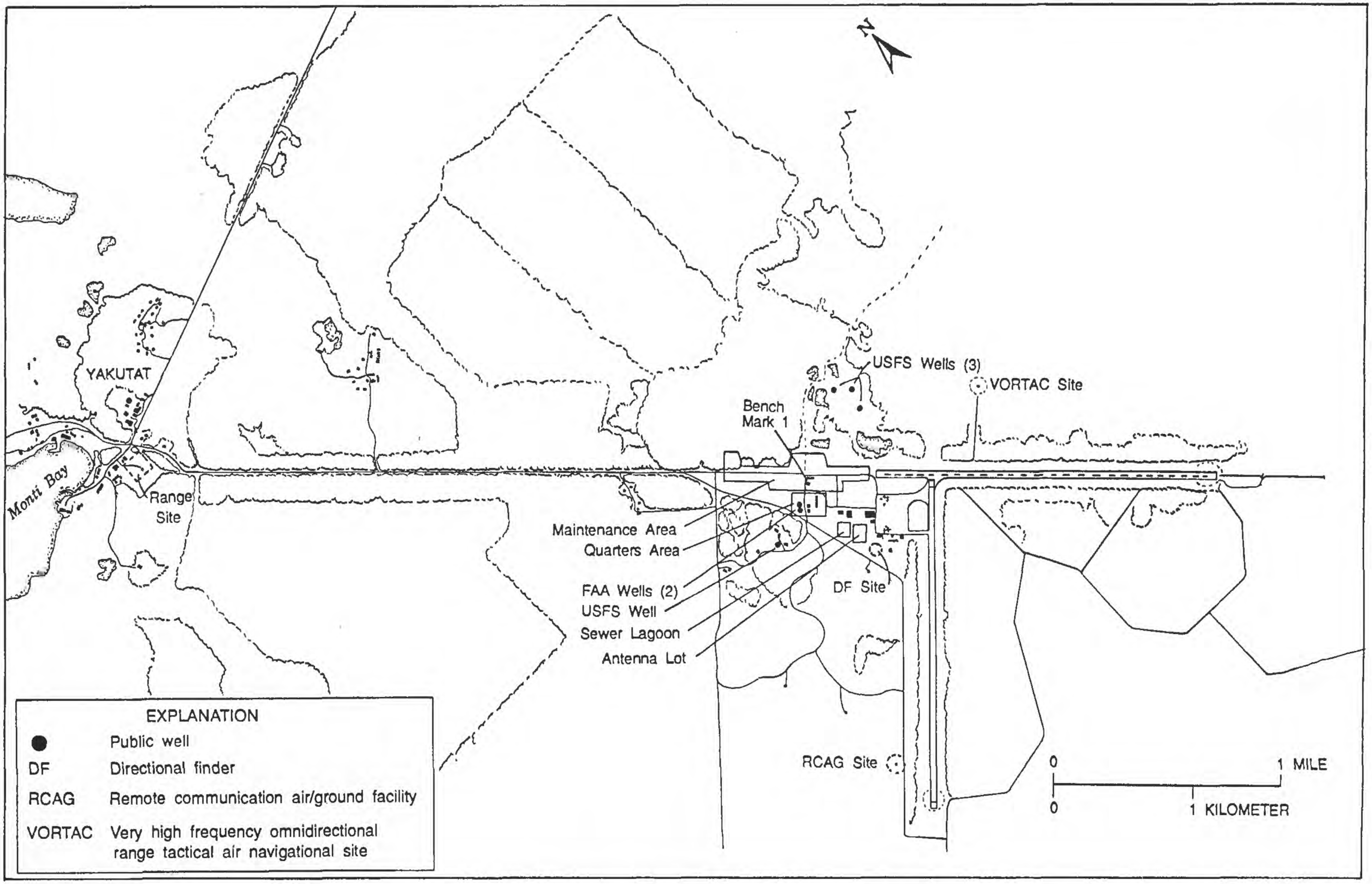


Figure 2. Location of current Federal Aviation Administration facilities in or near Yakutat and ground-water investigation sites (from aerial photographs by Aeromap US, September 26, 1990).

History

The area around Yakutat was explored during the 18th century, by the English, French, Spanish, and Russians. The original village of Yakutat was established in the late 1700's and by 1880 it had a population of about 500 (Orth, 1967). The original settlers were thought to be Eyak-speaking people from the Copper River area, although the language and culture of the area is now primarily Tlingit. Since first being settled, the area has attracted fur harvesters, gold miners, loggers, and commercial fisherman. A cannery was built in the area in 1904 and most of the families moved to the present town site to be near the cannery. The original townsite has been washed away. Yakutat was officially incorporated as a first-class city in 1948.

In 1943, the Department of War withdrew about 25,200 ha of land from the Tongass National Forest, adjacent to the Native-occupied village at Yakutat, to construct an airport and related facilities. In 1960, the total FAA land ownership was about 3,450 ha; however, the FAA has since transferred land ownership to the State of Alaska and to the U.S. Forest Service and does not currently own any land in the Yakutat area (Ecology and Environment, Inc.,1992).

Socioeconomics

Yakutat is a service and transportation center for the region and serves as a transfer and processing point for the commercial fishing industry. In 1990, the population was 534, of which 55 percent was Native Americans--primarily Tlingit Indians (U.S. Bureau of Census, 1991). The governmental functions of Yakutat are administered by an elected mayor and a six-member city council.

Yakutat has an elementary school, a high school, approximately 125 single-family homes, 2 lodges, a post office, an airport, and several businesses (Alaska Department of Community and Regional Affairs, 1983). The airport, which consists of two runways measuring 2,361 and 2,381 m in length, serves as the main transportation link to most other communities. No road access is available to Yakutat from the rest of Alaska. The public water-supply system in Yakutat delivers about 870,000 L/d to about 100 connections. A central sewage collection system was built in 1972 and serves most of the village.

The economy of Yakutat is generally based on the fishing and fish-processing industry, forestry, government operations, and service industries (Alaska Department of Community and Regional Affairs, 1983). The limited cash income is supplemented by a subsistence lifestyle in which a family's livelihood is generated from the land. About half of the households obtain some of their food by subsistence activities. The main source of subsistence food is salmon, halibut, trout, and shellfish, supplemented by moose and small game. These natural food sources are further supplemented by limited vegetable gardening and gathering of seasonal foods such as wild berries.

PHYSICAL SETTING

The Yakutat area is part of the Gulf of Alaska Coastal Section, a lowland bounded on the south by the Gulf of Alaska and on the north by the St. Elias Mountains (Wahrhaftig, 1965). These mountains are a continuation of the Pacific Mountain System of the western United States and Canada. The elevation of the lowland area ranges from sea level to about 1,200 m. Most of the area slopes gently toward the south, except near the coastline of Yakutat Bay where steep coastal bluffs expose glacial deposits.

Climate

The Yakutat area has a maritime climate that is characterized by mild temperatures and small temperature variations, high humidity, heavy precipitation, and frequent cloudy and foggy conditions (Hartman and Johnson, 1984). Surface winds are generally strong and persistent. The Yakutat area has cool summers and warm winters. Precipitation and temperature data (table 1) collected at the Yakutat airport (elevation, 9 m) indicate that the mean annual temperature is about 3.8 °C, the minimum January temperatures is about -7.7 °C, and the maximum August temperature is about 15.4 °C. Annual precipitation is about 3,535 mm and 182 days per year have more than 2.5 mm of precipitation. The area receives about 5,278 mm of snowfall annually (Leslie, 1989).

Vegetation, Surficial Geology, and Soils

The vegetation in the Yakutat area consists of coastal spruce-hemlock forest, interspersed with open treeless bogs (Viereck and Little, 1972). The treeless bogs are found in low elevation coastal areas and the forest extends from sea level to an elevation of about 900 m.

Yehle (1979) has mapped six major surficial deposits in the Yakutat area. They include organic, beach, delta-estuarine, alluvial, outwash, and end- and ground-moraine deposits.

Organic deposits cover most of the treeless, inland parts of the Yakutat area. The deposits consist of organic material primarily derived from the decomposition of small woody plants, mosses, and sedges. These deposits are less than 2 m thick and are underlain either by coarse materials deposited by streams or by fine materials deposited in ponds, small lakes, or former tidal lagoons.

Beach deposits are restricted to the shoreline of the Gulf of Alaska on the southern part of the Yakutat area; some less extensive beach deposits occur along the shoreline of Yakutat Bay. The beach deposits consist of sand or pebbly sand along the outer coast of the Gulf of Alaska and sand, pebbly cobble gravel with some boulders, and driftwood along shorelines in Yakutat Bay. The deposits are about 2 to 7 m thick and generally overlie end- and ground-moraine deposits or delta-estuarine deposits. Eolian sand is found in a small area near the mouth of the Lost River on the shoreline of the Gulf of Alaska. These deposits are the least extensive in area. The sand is about 10 m thick and is characterized by sparse vegetation.

Delta-estuarine deposits comprise the active and inactive deltas and estuaries of the Lost, Situk, and Ahrnklin Rivers and Tawah and Ophir Creeks. The delta-estuarine deposits range in thickness from about 2 to 17 m and consist primarily of silt and sand. The finest grained deposits, referred to as the "clayey silt delta-estuarine deposits," are primarily composed of firm clayey silt and are present along the estuary of the Lost River, at depths of between 17 and 67 m.

Alluvial deposits are most extensive along the Situk River northwest of the airport and consist of pebble gravel, sand, and some cobble gravel. The thickness of the deposits ranges from 1 to 33 m. The oldest alluvial deposits are found along Old Situk Creek (fig. 1), which formed in the mid 1800's by drainage from a glacier-dammed lake in Russell Fiord, northeast of the Yakutat airport.

End moraines deposited by the Yakutat Bay glacier form curvilinear ridges that parallel the general alignment of shores along Yakutat Bay. Ground-moraine deposits are located on the mainland between the end-moraine deposits and Yakutat Bay or on islands in the bay. Till in the moraines consists of granule- and pebble-rich silt and sand, with some cobbles, clay, and boulders. Drillers' logs (table 2) indicate that the moraine deposits have a maximum thickness of about 67 m.

Table 1. Mean monthly temperature, precipitation, and snowfall for the period 1948 to 1987, Yakutat

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

	Jan.	Feb.	Mar.	Apr.	May	June	July	Aug.	Sept.	Oct.	Nov.	Dec.	Annual
Temperature (°C)													
Mean maximum	-0.3	1.6	3.3	6.2	10.0	13.2	15.2	15.4	13.0	8.4	3.4	0.6	7.5
	(Record maximum, 30.0 °C, August 1957)												
Mean minimum	-7.7	-6.1	-5.1	-1.9	2.4	6.2	8.7	8.0	4.9	1.4	-3.2	-6.1	0.1
	(Record minimum, -31.1°C, December 1964)												
Mean	-4.0	-2.2	-0.9	2.2	6.2	9.7	12.0	11.7	9.0	4.9	0.1	-2.8	3.8
Precipitation (mm of moisture)	283.2	247.4	237.2	227.3	229.1	156.0	200.7	270.0	430.8	530.4	382.8	340.9	3535.7
Snowfall (mm)	960.1	1010.9	1023.6	513.1	40.6	0.0	0.0	0.0	0.0	144.8	566.4	1016.0	5278.1

Table 2. Information about wells within an 8-kilometer radius of Yakutat

[Data from the Ground-Water Site Inventory of the U.S. Geological Survey; D, driller's log; QW, water quality; WL, water level; --, no data available]

Local well number[1]	Depth of well (meters)	Date well constructed	Owner	Type of log available	Type of data available
CD02703325AACB1 001	24.7	06-13-61	Yakutat, City of	--	--
CD02703325AACB2 001	102	05-03-61	Yakutat, City of	D	--
CD02703325ADBA1 001	5.5	--	Malotte Mayor	--	--
CD02703325ADBA2 001	18.3	1961	Malotte Mayor	--	--
CD02703329CDAA1 001	23.2	08-60	RCA Yakutat	--	QW
CD02703329CDAA2 001	1.8	1960	RCA Yakutat	--	--
CD02703329CDAA3 001	--	05-63	RCA Yakutat	--	QW
CD02703419CDCC1 001	99	10-14-72	Yakutat, City of	D	--
CD02703419CDCC2 001	54.5	07-14-72	Yakutat, City of	D	--
CD02703430CBCA1 002	22.6	--	FAA Yakutat	--	QW
CD02803311ABAC1 001	12.2	05-29-75	USCG Yakutat	--	--
CD02803404ACCB1 003	3.2	07-20-89	USFS Yakutat	D	WL
CD02803404BDAA1 002	3.0	07-19-89	USFS Yakutat	D	WL
CD02803404BDDA1 007	4.4	07-19-89	USFS Yakutat	D	WL
CD02803404CBDC1 001	5.5	01-01-50	FAA Yakutat	--	QW
CD02803404CBDC2 001	4.3	01-01-50	FAA Yakutat	--	--
CD02803404CBDC3 001	4.5	01-01-50	FAA Yakutat	--	--
CD02803404CBDC4 001	7.3	09-23-63	FAA Yakutat	--	--
CD02803404DBBD1 004	3.2	07-20-89	USFS Yakutat	D	WL
CD02803404DCAA1 005	3.3	07-20-89	USFS Yakutat	D	WL
CD02803404DCCD1 008	4.1	07-21-89	FAA Yakutat	--	WL
CD02803404DCDA1 006	3.3	07-20-89	USFS Yakutat	D	WL
CD02803409ABAA1 001	4.1	07-21-89	FAA Yakutat	--	WL

[1]The "Local Number" is derived from the official rectngular subdivision of public lands. The first letter indicates the Cordova baseline and principal meridian, and the second letter represents the quadrant formed by the intersection of the baseline and the principal meridian in which the well is located. The first three digits indicate the township in which the well is located, the next three digits the range, and the next two, the section. Letters following the section number indicate the 1/4 1/4 1/4 1/4 subdivisions of the sections. Each of these successively smaller subdivisions is lettered counterclockwise beginning at the northeast corner. The next digit is a sequential number assigned to distinguish between wells that fall within the same site. The last three numbers are assigned sequentially to wells within each section.

Outwash gravel deposits are found slightly inland from Yakutat Bay downstream from the moraines. These deposits vary in thickness from about 1 to 17 m. The outwash formed during retreat of the glacier about 500 to 600 years ago. The deposits have been subdivided into a coarse-grained and a fine-grained outwash. The coarse-grained deposits begin near the outermost end moraines near Yakutat Bay and extend inland about 3,000 m, ending near the Yakutat airport. The deposits primarily consist of moderately well-sorted beds of sandy pebble gravel. The fine-grained deposits primarily consist of sand and occupy areas farther downstream from the end moraines.

The soils in the area of Yakutat have been mapped in general by Rieger and others (1979) and in greater detail by Van Patten (1978). The parent materials upon which the soils form are generally of one consistent association of deposits occupying parts of broad alluvial fans and outwash plains near glaciers and braided, glacial-fed streams (Rieger and others, 1979). The soils have little or no alteration and are almost identical with parent materials. The soils in the area generally form on materials that consist of shallow silty and sandy alluvial sediments over very gravelly sand.

The soils of the Yakutat Series, mapped extensively near the city of Yakutat, are generally well drained and consist of a mat of organic material made up of forest litter overlying a thin gray layer overlying a dark reddish layer above the unweathered substratum (Van Patten, 1978). The soils near the Yakutat airport are characteristically well drained on artificially raised terraces upon which the airport was constructed and on flood plains of the local streams. They are naturally poorly drained in low-lying areas surrounding the runways. In well-drained areas, soils consist of dark gray silty and sandy sediments containing black lenses and pockets of organic matter over coarse sand, gravel, and cobblestones. In poorly drained areas, the soils are a mottled dark gray silt loam and sand over loose very gravely sand.

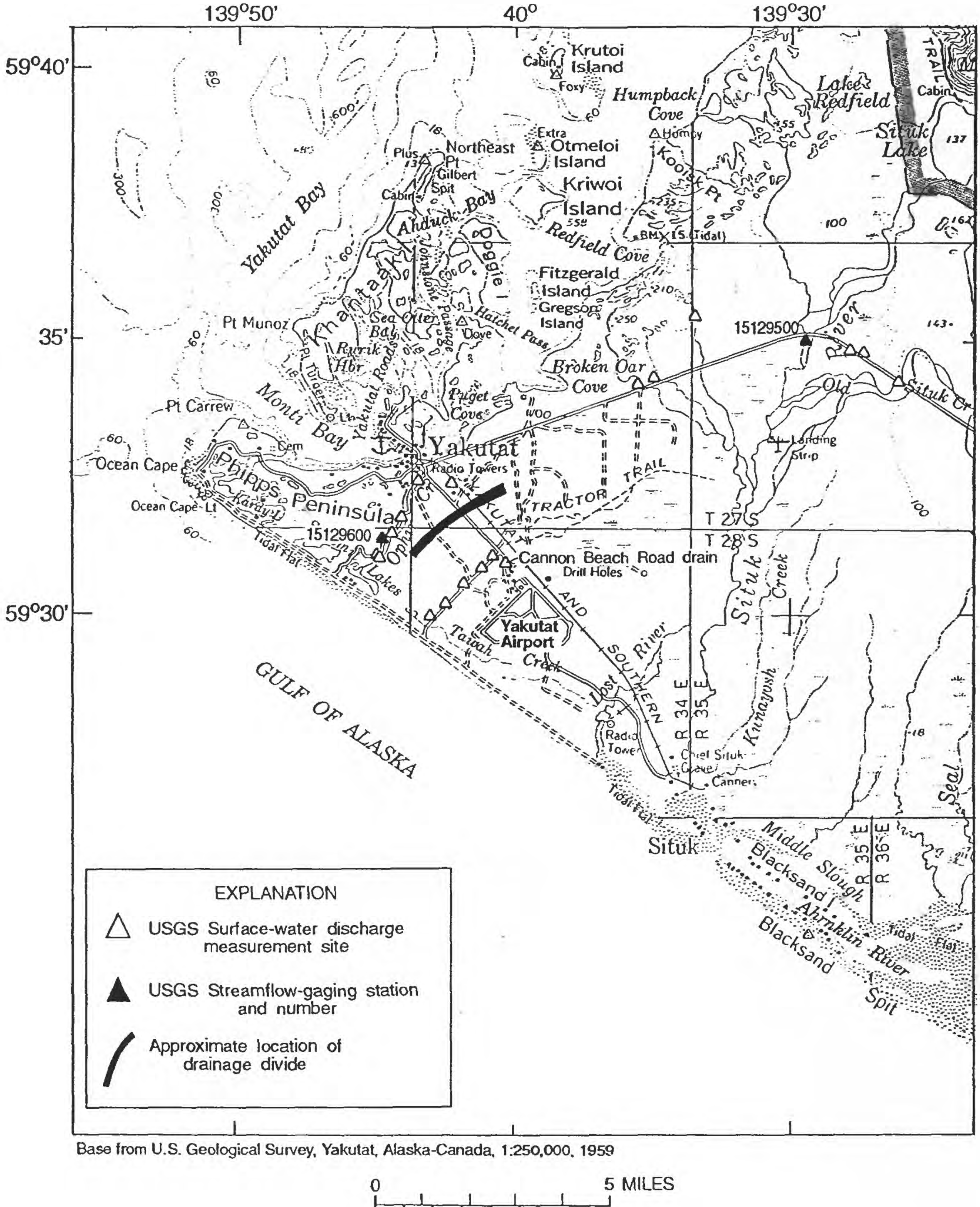
SURFACE WATER

Surface water is abundant in the Yakutat area. The Gulf of Alaska bounds the area on the south and west. The Situk River enters the area on the north, and along with Ahrnklin River, drains most of the eastern part of the area. The Lost River and its two main tributaries, Tawah and Ophir Creeks, drain most of the western part of the area. Numerous small lakes are located on top of glacial moraine deposits near the shoreline of Monti Bay and most of the interior land is classified as saturated or seasonally flooded (U.S. Fish and Wildlife Service, 1993).

Most of the drainages run in a north-to-south direction, with the exception of Tawah Creek. This creek flows to the southeast because glacial moraine deposits form a topographic barrier to surface-water flow near the present shoreline of Monti Bay and beach deposits form a topographic barrier along the Gulf of Alaska on the southern shoreline of the area. Tawah Creek, which collects tributary flow from numerous small streams and man-made drains originating within the area, discharges to the Lost River near its confluence with the Gulf of Alaska.

Streamflow

The U.S. Geological Survey operates two continuous recording gaging stations in the area and has measured instantaneous discharge at a number of other miscellaneous sites (U.S. Geological Survey 1990, 1991, 1992, 1993). The locations of streamflow gaging stations and surface-water discharge measurement sites are shown in figure 3. Streamflow in the area is dominated by rainfall runoff.



Base from U.S. Geological Survey, Yakutat, Alaska-Canada, 1:250,000, 1959

0 5 MILES
0 5 KILOMETERS

CONTOUR INTERVAL 200 FEET
NATIONAL GEODETIC VERTICAL DATUM OF 1929

Figure 3. Location of surface-water data-collection sites near Yakutat.

Gaging station No. 15129500, Situk River near Yakutat, about 14.2 km northeast of Yakutat, has been operated since May 1988. The annual mean discharge for the 1989-93 water years was 9.4 m^3/s. The highest daily mean discharge was 75.9 m^3/s on December 16, 1988 and the lowest daily mean discharge was 1.3 m^3/s on March 5-7, 1989. The highest instantaneous flow was 92 m^3/s on December 15, 1988.

Gaging station No. 15129600, Ophir Creek near Yakutat, about 3.2 km south of Yakutat, has been operated since October 1991. The annual mean discharge for the 1992-93 water years was 0.46 m^3/s. The highest daily mean discharge was 2.3 m^3/s on March 11, 1992 and the lowest daily mean discharge was 0.008 m^3/s on July 31, 1993. The highest instantaneous peak flow was 2.5 m^3/s on March 10, 1992.

Floods

Flood hazards in the area of Yakutat are rated as low by the U.S. Army Corps of Engineers (1993). Floods can originate from high water in local rivers and in areas along the coast from storm tide surges and tsunamis. The Situk River, which passes near the Yakutat Airport, can be the source of significant flooding generated by overflow from the south end of a glacier-dammed lake that has formed in Russell Fiord by the advance of Hubbard Glacier (fig. 1) (Seitz and others, 1986). Paul (1988) analyzed floods that could occur in the Situk River and estimated a maximum peak discharge of about 1,420 m^3/s.

Surface disturbances associated with earthquake activity along a major fault are present within about 175 km of Yakutat and the fault passes as close as 53 km to the northeast (Yehle, 1979). Waves from tsunamis generated by earthquake activity can significantly affect coastal communities and have reportedly run up as high as 530 m. However, the highest tsunami wave recorded in Yakutat had a height of about 5 m and occurred during an earthquake in 1899. The 1964 earthquake generated a tsunami that was about 2.5 m high when it reached Yakutat. The coastal areas near Yakutat may have a different tsunami wave history because the character of the waves and potential damage from these waves depend on the configuration of the near-shore ocean floor and the coastline, which is highly variable near Yakutat. For example, the islands and submerged glacier moraines near Monti Bay can act to reduce tsunami wave heights and the steep coastal bluffs near Yakutat will help protect the inland areas. One tsunami susceptibility study (U.S. Coast and Geodetic Survey, 1965) indicated that all areas lower than 17 m in elevation and within 1.6 km of the open ocean would be potentially affected by tsunamis. These tsunami hazards could result in significant flooding at the Yakutat airport, which is entirely below 15 m in elevation. In addition, much of the northeast-southwest trending runway is closer than 1.6 km from the open ocean.

Storm surge waves can also significantly affect low-lying coastal communities. The estimated height of the 100-year storm wave for the Yakutat area is 21.5 m (Brower and others, 1977). These waves may affect many of the same areas as the tsunamis, but have less potential to travel inland because of their reduced celerity or wave velocity, which is commonly much lower than that of tsunamis.

Water Quality

The U.S. Geological Survey collected several water samples in 1990 and 1991 at gaging station No. 15129500, Situk River near Yakutat (fig. 3) (U.S. Geological Survey, 1991; 1992). The samples were analyzed for major ions and nutrients. The pH of the water was about 7.8 and the dissolved solids concentration of the water was less than 100 mg/L. The concentrations of major ions were within acceptable limits for drinking water (U.S. Environmental Protection Agency, 1992). Samples were not analyzed for pesticides, organics, bacteria, radionuclides, or other compounds to determine their suitability for drinking water.

GROUND WATER

Ground water in the Yakutat area is found mainly in the unconsolidated deposits of Quaternary age. Outwash deposits are probably the most productive water-bearing materials because they generally contain coarser grained material, are better sorted, and are more extensive than other deposits. Yehle (1979) indicated that the outwash deposits have excellent permeability. Beach and eolian sand deposits have high permeability, but, because of the their limited extent, are less productive. Glacial moraine deposits have a wide range of permeability. Numerous lakes perched on glacial moraine deposits along the shoreline of Monti Bay indicate that these deposits are poorly sorted and have low permeability.

Recharge

Recharge to the unconsolidated deposits primarily is from infiltration of precipitation and streamflow and subsurface inflow. Most of the recharge from precipitation and streamflow probably occurs along an area mapped as Holocene outwash or artificial fill deposits by Yehle (1979) and also mapped as non-wetland areas by the U.S. Fish and Wildlife Service (1993). These deposits have good-to-excellent permeability, which allows rapid infiltration of precipitation or streamflow. Recharge occurs during most of the year, but probably is greatest when precipitation and streamflow are at or near a maximum for the year. The amount of recharge to the ground-water system is unknown.

Movement

Ground-water movement generally follows the topography and is toward streams, lakes, and drains. A drainage divide about 3.2 km northeast of the airport (fig. 3) probably also serves as a ground-water divide. On the basis of water-level measurements in wells (table 2) and the elevation of the water surface in drains and streams in the area, the approximate direction of ground-water flow is generally in a south or southwest direction. However, the direction of flow near springs, drains, gaining streams, and lakes is toward these discharge points.

In response to concerns related to reports of potential drinking-water contamination (Ecology and Environment, Inc., 1993), the U.S. Geological Survey investigated ground-water flow near the Yakutat airport. Measurements of the depth to ground water were made in two FAA wells and four U.S. Forest Service wells (fig. 2) between the airport and the coast. The measurements were made to determine flow direction and flow gradient. Global Positioning System techniques were used to determine the horizontal and vertical position of bench mark 1 (fig. 2) near the wells. The elevation of the ground water was determined using a theodolite, an electronic distance measuring instrument, and conventional surveying techniques. These measurements indicated that shallow ground water flows from northeast to southwest and the water-table gradient is 0.0026. The two FAA wells are near the FAA maintenance area: the water surface elevation in one well was 8.98 m and that in the other was 8.87 m, which is about 0.55 m below the land surface.

Discharge

Discharge from the unconsolidated deposits is to springs, drains, wells, streams, lakes, and evapotranspiration. Numerous unnamed springs occur at the headwaters of streams in the area. Data are not available to determine the amount of ground-water discharge to these springs. Significant base flow of about 2 m^3/s occurred in the Situk River during the summer of 1993 (fig. 4), indicating a relatively dynamic ground-water system in the area.

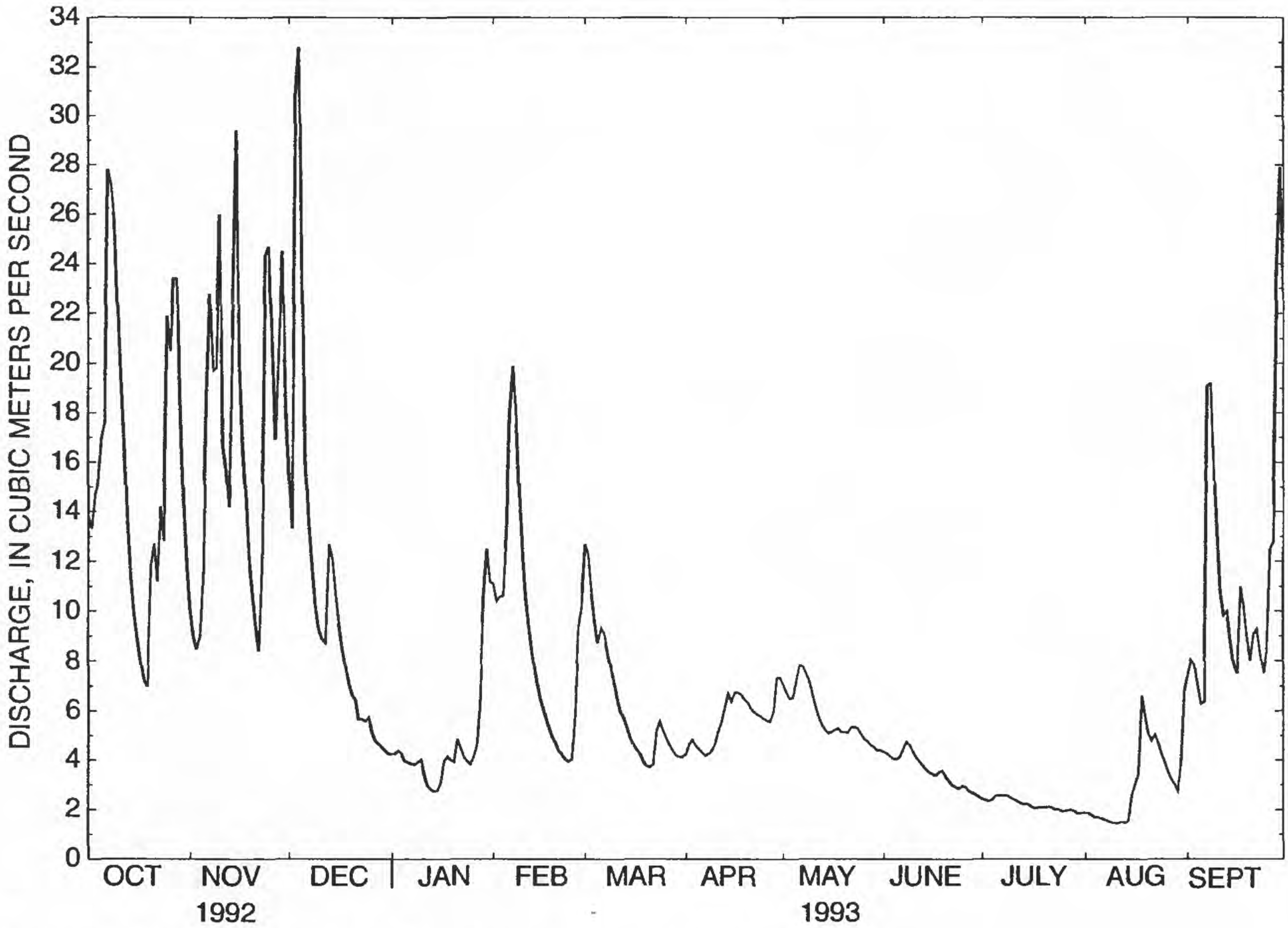


Figure 4. Discharge for Situk River near Yakutat, 1993 water year.

Measurements of discharge (U.S. Geological Survey, 1990, 1991, 1992) indicate that manmade drains collect ground water which eventually discharges to streams in the area. Measurements of the discharge of the Cannon Beach Road drain (fig. 3) were made in 1989, 1990, and 1991. The discharge from the drain is highly variable, but was measured at about 0.11 m^3/s on July 13, 1989 about 0.48 km upstream from the mouth.

Discharge from unconsolidated deposits from wells is estimated to average less than 14 L/s. This estimate is based on 10 L/s of discharge from public supply wells (Alaska Department of Community and Regional Affairs, 1983) and less than 4 L/s of discharge from privately owned wells.

Surface-water measurements indicate that the streams in the area are gaining from ground-water sources. Measurements of the streamflow of Ophir Creek show gains of about 0.45 m^3/s in about 5.0 km of stream in 1992 and about 0.09 m^3/s in about 3.2 km of stream in 1989. Numerous other streams in the area probably are gaining from ground-water sources, but data have not been collected to estimate the amount of ground-water discharge to streams. In addition, data on ground-water discharge to numerous lakes and ponds in the area are not available.

Ground-water discharge by evapotranspiration occurs throughout the area. In many locations, soils overlying the shallow ground-water system are saturated and evaporation from the soil occurs. In addition, numerous plants transpire water from the shallow ground-water system. Data on evapotranspiration from soils and plants are not available to estimate ground-water discharge from evapotranspiration.

Aquifer Properties

The absence of any continuous confining layers in the unconsolidated deposits means that water can move both vertically and horizontally with little impedance to flow. Values of specific capacity reported for three wells in the U.S. Geological Survey Ground-Water Site Inventory data base were 2.44, 1.66, and 0.06 (L/s)/m of drawdown. Values of transmissivity determined from these values of specific capacity (Theis and others, 1963) are 7.95, 0.34, and 4.92 m^2/d. The specific yield of the unconsolidated deposits ranges from 0.1 to 0.3, which was estimated from descriptions of materials found during drilling and reported in drillers' logs and results of previous studies (Johnson, 1967).

SURFACE- WATER AND GROUND-WATER INTERACTION

Shallow ground-water flow is controlled, in part, by the elevation and flow of water in local streams, drains, and lakes. Generally, the elevation of the water surface in streams, lakes, and drains reaches maximum elevations during high flow of streams. On the basis of streamflow records (1989-93) from U.S. Geological Survey gaging station No. 15129500, Situk River near Yakutat (fig. 3), the highest monthly mean flow occurs in October and the lowest monthly mean flow occurs in July. Ground-water recharge probably reaches a maximum at about the same time and because the ground-water system is likely a shallow circulating system, discharge probably reaches a maximum at about the same time.

When streams flood and are at a high stage, the streams may contribute surface water to the ground-water system, even in reaches where ground-water normally discharges to streams. This inflow of water resulting from an increase in river stage will temporarily alter the direction of ground-water flow. During the period when river stage is higher than the ground-water table, shallow ground-water flow will be away from the river. When the river returns to a stage below the ground-water table, usually several days after a flood or high water, shallow ground-water flow will again be towards the river. This flow of water into and out of the aquifer in response to changing stage of the river is known as "bank storage effects" (Linsley and others, 1982).

The construction of drains near Yakutat affects water levels and the direction of ground-water flow. Drains artificially lower the water-table elevation and create artificial discharge points for shallow ground water. The discharge of the drains will decrease with time until a new steady-state condition near the drains has been reached. It is possible that recharge of precipitation will increase in the vicinity of the drains. The rejected recharge associated with the saturated soils will be allowed to infiltrate, because water levels have been lowered.

Pumping of wells near streams and lakes or other large bodies of water may cause discharge from the ground-water system to these sources to decrease or stop. In the Yakutat area, discharge from wells is generally less than about 14 L/s. A study by the U.S. Geological Survey (Feulner and others, 1967, p. C189) at Ocean Cape (fig. 3), indicated that pumping of a well near the Gulf of Alaska at a rate greater than 1.26 L/s caused infiltration of sea water into the well making it unusable for drinking water. Data on the effect of pumping wells on surface-water discharge in other areas near Yakutat have not been collected.

Determining the extent of the surface-water and ground-water interaction near Yakutat would require a program of monitoring river stage and ground-water elevations on a continuous basis or during many stream fluctuations. No continuous records of ground-water elevation near Yakutat are available, and no single elevation control exists for the surface-water stage records that are available for floods in Yakutat. Variations in stream stage near Yakutat can be inferred from discharge records for gaging station No. 15129500, Situk River near Yakutat (U.S. Geological Survey, 1989-93). The peak flow for the 1993 water year occurred in early December and minimum flow occurred in early August (fig. 4).

POTENTIAL FOR CONTAMINATION OF DRINKING-WATER SUPPLIES

The potential for contamination of drinking water in the Yakutat area is related to the type (surface or ground water) and location of current drinking-water supplies, location and concentrations of contaminants, and potential pathways for movement of contaminants into drinking water supplies.

Present Drinking-Water Supplies

Present drinking water for the town of Yakutat is supplied by two wells with a combined production capacity of about 870,000 L/d and a storage capacity of 910,000 L (Alaska Department of Environmental Conservation, 1985). Ground water from the unconfined aquifer in the thick glacial-moraine deposits underlying Yakutat supplies more than half the residents with drinking water. Such an aquifer may be designated as a "sole source aquifer" if no other "reasonable" alternative supply exists (U.S. Environmental Protection Agency, 1987).

The main well used for water supply was drilled and cased to a depth of about 99 m in 1972. The well is perforated or slotted from approximately 48.2 to 51.8 m and from 62.5 to 64.3 m. The well was test pumped at a rate of about 9.6 L/s. The backup well for the town was drilled and cased to a depth of 24.7 m in 1961: the screened interval is from 22 to 24.7 m. The well was test pumped at a rate of 7.6 L/s. Other wells in the area withdraw water for domestic and industrial use but the amounts are small. Ecology and Environment, Inc. (1992) lists 15 small wells with depths less than 15.2 m that are used for drinking water and are within 1.6 km of the FAA station at Yakutat.

Quality of Present Supplies

Water-quality analyses made from 1961 to 1975 are available in U.S. Geological Survey files. They show that both the main and backup wells for the town of Yakutat had concentrations of dissolved solids of about 200 mg/L, less than 0.1 mg/L of dissolved nitrate (N), and pH values ranging from 7.1 to 8.1. Concentrations of major ions were within acceptable limits for drinking water

(U.S. Environmental Protection Agency, 1992). A sample collected in 1967 from the Yakutat backup well had an iron concentration of 3.1 mg/L. Two additional samples collected in 1961 and 1968 showed 0.02 and 0.06 mg/L respectively.

Alternative Drinking-Water Supplies

Alternative drinking-water supplies are available from both surface- and ground-water sources. Samples collected from the Situk River by the U.S. Geological Survey and analyzed for physical properties such as pH and temperature, major ions, and nutrients indicate no quality problems with the surface water in the area. Treatment and conveyance systems would have to be constructed to deliver water from surface-water sources to the inhabitants of the area.

Ground-water sources appear to be of adequate quantity and of good enough quality to provide alternative supplies of drinking water to the inhabitants. Chemical analyses are available in the files of the U.S. Geological Survey for water from 17 wells in the Yakutat area, not including the two town wells previously discussed. The water, which was analyzed primarily for physical properties, major ions, and nutrients, did not indicate any water-quality problems.

An emergency surface- and ground-water sampling program conducted at the FAA station at Yakutat in 1993 was initiated because 2,4,5-Trichlorophenoxyacetic acid (2,4,5 T) and 2,4-Dichlorophenoxyacetic acid (2,4 D) were discovered in soil samples. The results of the sampling and analyses are summarized in a report to the FAA by Ecology and Environment, Inc. (1993). The sampling and analyses did not show any pesticide, herbicide, or dioxin concentrations in surface or ground water that exceed maximum contaminant levels based on public health considerations (U.S. Environmental Protection Agency, 1992). Additional testing for organics, bacteria, and other compounds would be required to determine the suitability of ground water for drinking-water supplies.

Potential Contaminants and Pathways to Drinking-Water Supplies

Potential contaminants in the area of the Yakutat FAA facilities have been identified in an environmental compliance investigation report prepared for the Federal Aviation Administration by Ecology and Environment, Inc. (1992). The report lists PCB's, fuel, waste oil, barium, chromium, lead, cadmium, silver, asbestos, dibromochloromethane, dichloroethane, bromodichloromethane, and chlorinated, volatile organic carbon (VOC) as possible contaminants in the Yakutat area. Most of the identified contaminants are located at the Yakutat airport which was constructed on artificial fill.

Ground water is probably the most likely pathway for contaminant movement to drinking-water supplies. Surficial deposits in the area consist of artificial fill that is highly permeable and would allow rapid infiltration of liquid contaminants into the underlying ground-water system. Precipitation in the Yakutat area is about 3,535 mm per year and recharge from precipitation on the artificial fill would move contaminants to the ground-water system in a short period of time. The depth to which the contaminants would move in the ground-water system is dependent on many factors including the properties of the contaminant, the amount of infiltrating precipitation, depth to water, the horizontal vertical permeability of the underlying deposits, and the geochemical processes acting on the contaminant.

Any fuels and oils entering the ground-water system through the artificial fill would probably remain on top of the water table, move down-gradient and eventually discharge to drains, Tawah Creek, Summit Lake, or other wetland areas. The depth to water (table 2) under the artificial fill is generally less than 3.05 m.

Water-soluble contaminants, including dissolved metals and organic compounds, may find pathways to enter the deeper parts of the ground-water system. Underlying the artificial fill are organic deposits underlain by coarse-grained deposits. The average thickness of the organic deposits is less than 2 m. These organic deposits have low permeability. Descriptions of materials found during drilling are located in the files of the U.S. Geological Survey. The records do not indicate the occurrence of any thick clay or silt zones in the first 60 m of unconsolidated fill. Clay zones, if they were present, would impede the migration of contaminants to deeper zones where drinking-water supplies are being withdrawn. Data are insufficient to determine the types of geochemical reactions that may take place as the contaminant moves through the ground-water system.

Infiltration of surface water is a pathway for contaminants to enter shallow ground water in the Yakutat area. Many of the small withdrawal wells are screened at shallow depths. Movement of water from streams to shallow aquifers could occur locally during floods. Overland flow during heavy precipitation could also enter shallow wells through improperly sealed casing by ponding and infiltrating soils near wells.

SUMMARY

The mild, wet climate of Yakutat, Alaska provides an abundant supply of surface and ground water. The quality and quantity of these sources are generally adequate for drinking-water supplies. The thick, coarse-grained, glacial and alluvial deposits and artificial fill in the area are very permeable and allow rapid infiltration of rainfall and contaminants. The direction of shallow ground-water flow in the Yakutat area is generally from the mountains in the northeast towards the coast in the southwest.

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