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UNITED STATES
DEPARTMENT OF THE INTERIOR
GEOLOGICAL SURVEY

WATER AVAILABILITY, QUALITY AND USE IN ALASKA

OPEN-FILE REPORT
76-513

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BY
G. O. BALDING

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A supplementary study to Phase II, Activity 2, Specific Problem Analysis portion of the Water Resources Council's 1975 National Assessment of Water and Related Land Resources

August 1976

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ENGLISH-METRIC EQUIVALENTS

Multiply English units	By	To obtain metric equivalents
acres	4.047×10^{-3}	square kilometres (km^2)
acre-feet (acre-ft)	1,233	cubic metres (m^3)
acre-feet (acre-ft)	1.233×10^{-3}	cubic hectometre (hm^3)
cubic feet per second (ft^3/s)	2.832×10^{-2}	cubic metres per second (m^3/s)
feet (ft)	0.3048	metres (m)
gallons (gal)	3.785×10^{-3}	cubic metres (m^3)
gallons per day (gal/d)	0.0438×10^{-6}	cubic metres per second (m^3/s)
gallons per minute (gal/min)	0.6308×10^{-4}	cubic metres per second (m^3/s)
inches (in)	25.4	millimetres (mm)
miles (mi)	1.609	kilometres (km)
square miles (mi^2)	2.590	square kilometres (km^2)
millions of gallons per day (Mgal/d)	4.38×10^{-2}	cubic metres per second (m^3/s)
millions of gallons per year (Mgal/y)	0.012×10^{-2}	cubic metres per second (m^3/s)
ton	0.9072	metric ton

WATER AVAILABILITY, QUALITY, AND USE IN ALASKA

By G. O. Balding

ABSTRACT

The Alaska Water Assessment, sponsored by the Water Resources Council, is a specific problem analysis for Alaska of the National Assessment of Water and Related Land Resources. The assessment addresses water and water-related land problems, present and future. It was felt that a supplementary report, as a part of the assessment, was needed to state in general terms the present hydrologic conditions, including the availability, quality, and use of both surface water and ground water in the Alaska region.

Alaska covers an area of 586,412 square miles, about one-fifth of the total area of the United States. Characteristic of parts of the region is the presence of permafrost. The physiography of Alaska ranges from low coastal plains of the Arctic and deltas of the major rivers to peaks of the Alaska Range. Climate in the State ranges from the maritime rain forests of southeast Alaska to the frozen desert of the Arctic. Mean annual runoff for the region is estimated at 1,260,000 cubic feet per second which includes an estimated 163,000 cubic feet per second of inflow from Canada.

The Alaska region has been divided into six hydrologic subregions and eighteen subareas. For each subarea, estimated mean annual runoff per square mile, suspended-sediment concentrations that can be expected during "normal" summer runoff and, where data are available, flood magnitudes and frequencies are illustrated on maps. Also illustrated are estimated ground-water yields in each subarea. Tables listing water quality of both ground water and surface water from selected wells and

streams are also included. Water use according to the type of use is discussed, and estimates are given for the amounts used. Water-use categories in the State include domestic, irrigation, livestock, seafood processing, oil and gas development, petrochemical processing, pulp mills, hydroelectric, coal processing, steam electric, mineral processing, sand and gravel mining, and fish-hatchery operations. Also illustrated on maps are estimated ground-water yields in each subarea. Tables listing water quality of both ground water and surface water from selected wells and streams are also included.

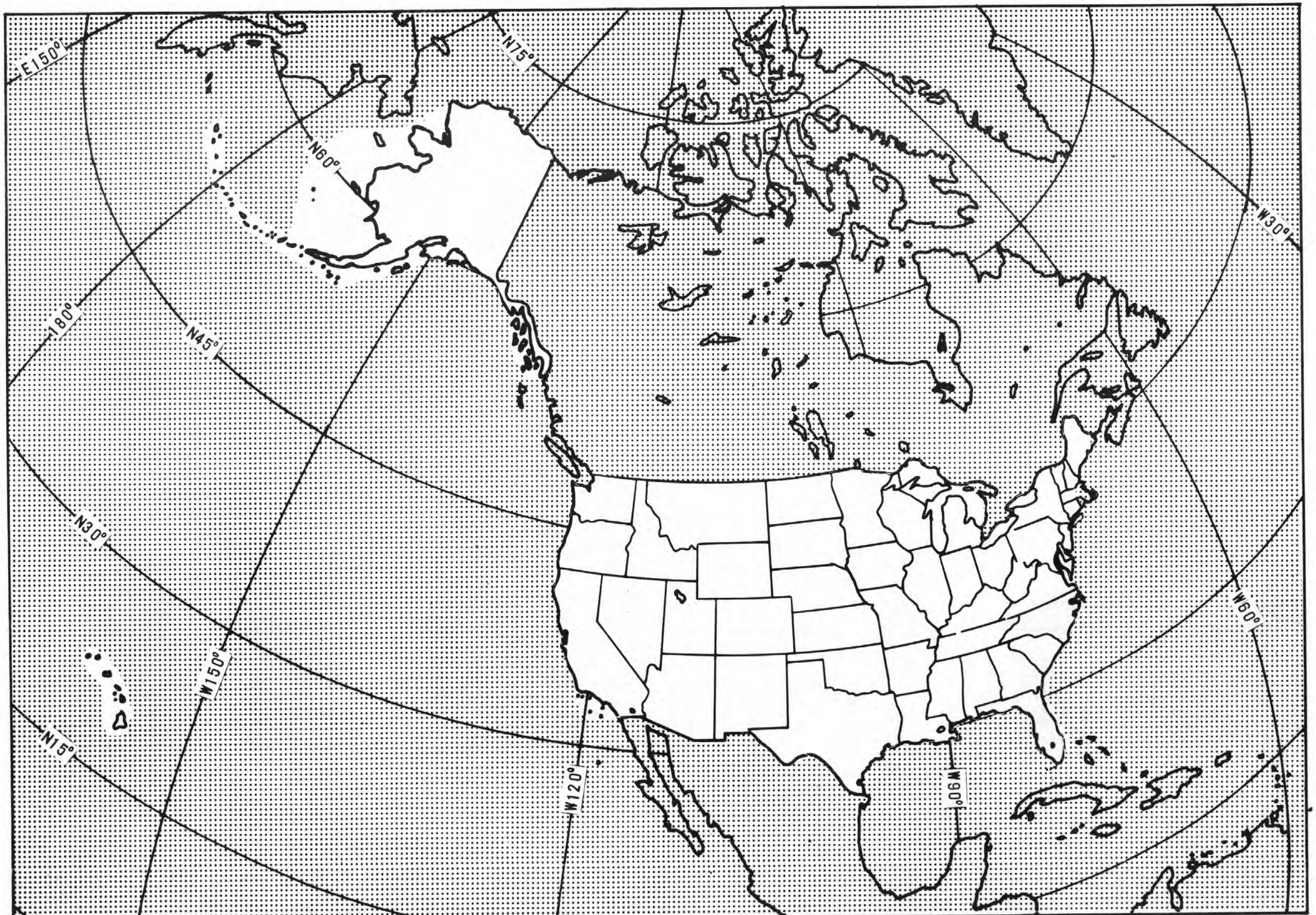
INTRODUCTION

Alaska, the largest state in the United States, has a land area of 586,412 square miles. From its southernmost latitude in the Aleutian Islands, it stretches north to Point Barrow, a distance of about 1,400 miles. Its east-west span is about 2,350 miles, between Hyder in the southeast corner of the State and Attu Island at the western-most tip of the Aleutian Islands. Alaska's land area is approximately one-fifth that of the rest of the United States. Figure 1 compares the size of Alaska with that of the "Lower 48"; figure 2 shows its position relative to the other 49 states.

Except for its international border with Canada, Alaska is surrounded by water. To the north is the Arctic Ocean, on the west are the Chuckchi and Bering Seas, and to the south is the Pacific Ocean. Alaska's shoreline totals about 34,000 miles; the area of its continental shelf (to a depth of 656 feet) is 546,900 square miles, almost equivalent to its onshore land mass.

The population of Alaska has fluctuated over the decades (table 1). The sharp rise during the 1890's was due to the discovery of gold. In the 1940's the population increased through post-war migration and homesteading; these provided enough momentum to continue the population increase on through the 1950's. During the 1960's the wave of migration ebbed somewhat, but the total population was still increasing. The

Figure 1. -- Alaska's size in relation to the conterminous United States.



From U.S.G.S. National Atlas, 1970

Figure 2. -- Alaska's geographic position in relation to the rest of the United States.

Table 1. -- *Population of Alaska, 1880 to 1974.*

Census year	Population	Percent increase(+), decrease(-)
1880	33,426	
1890	32,052	- 4
1900	63,592	+98
1910	64,365	+ 1
1920	55,036	-14
1930	59,278	+ 8
1939	72,524	+22
1950	128,643	+77
1960	226,167	+76
1970	302,173	+33
1974*	351,159	+16

* Alaska Department of Labor, 1974

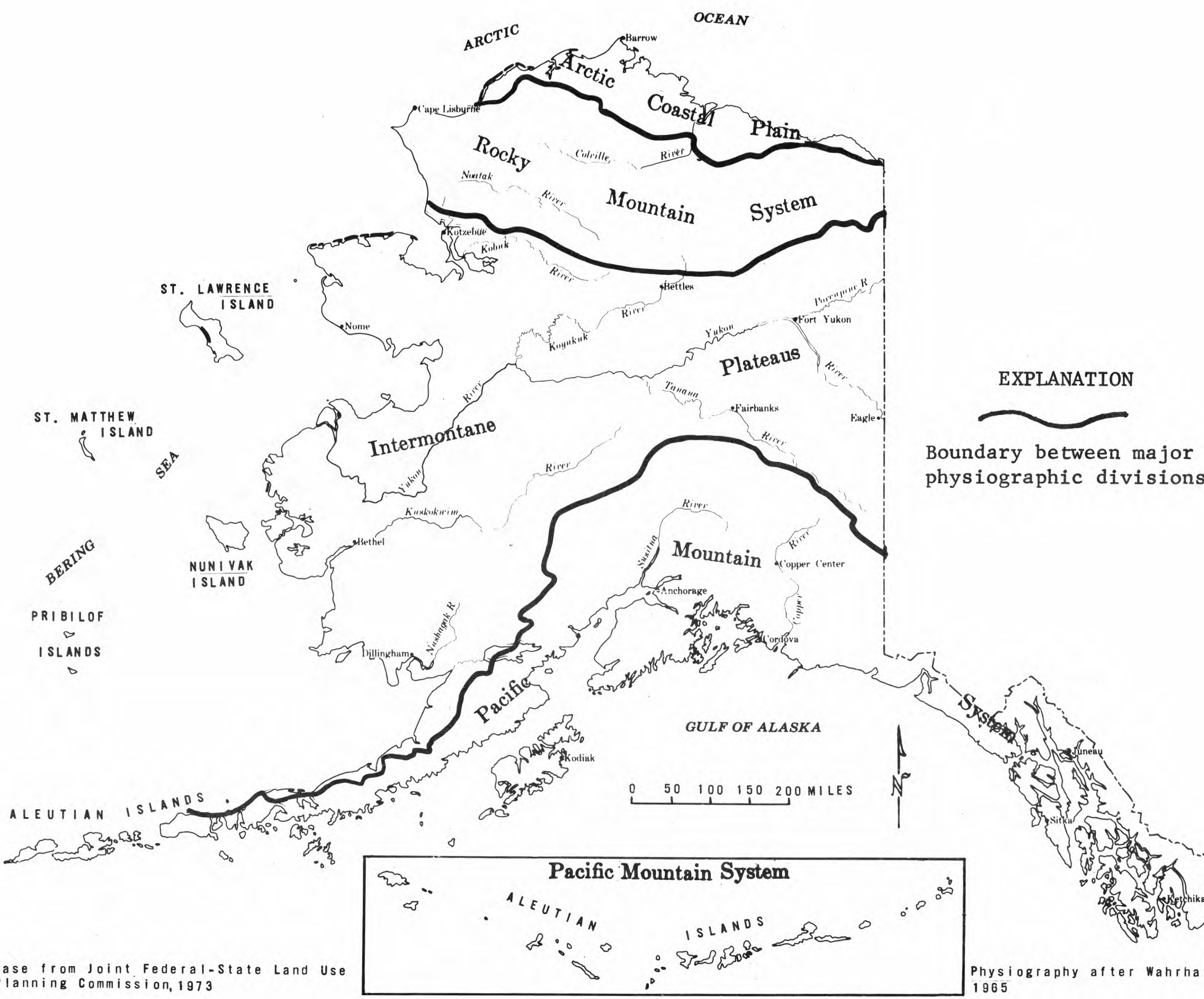
growth in the 1960's and early 1970's can be attributed to the discovery of oil at Prudhoe Bay and the related pipeline construction activities. The population density for the State, based on the 1974 figure, is 0.60 person per square mile. This figure, however, is somewhat misleading because about 60 percent of Alaska's citizens live in the urban centers of Anchorage, Fairbanks, Juneau, Ketchikan, Kenai, Kodiak, and Sitka.

Alaska's economy is growing along with its population. Its petroleum energy resources are receiving more attention now than at any time in the past. Still other energy proposals are under consideration including those for coal and hydroelectric development. Active mineral exploration is taking place; some discoveries are being made and old mining operations are being rejuvenated. Currently only about 15 percent of the food consumed is produced within the State, but there is potential for increased agricultural activity. Other renewable natural resources include forestry products and fish and wildlife harvests, both of which are an important part of the State's economy. Recreational activities play a major role in Alaska for both the resident and the visiting tourist.

All these developments and activities are dependent to a large degree on water. To the casual observer, Alaska's water resources, its thousands of lakes and rivers, seem to be unlimited. Generally there is an abundance of water, but it may not be readily available or useable during certain times of the year. The amount of precipitation, temperature extremes and the geology of the State are the factors controlling the availability and quality of Alaska's water resources. In addition, economic constraints and unavailability of technology may limit the supplies of useable water.

PHYSIOGRAPHY

Alaska is divided into four major phsiographic areas: The Arctic Coastal Plain, the Rocky Mountain System, the Intermontane Plateaus, and the Pacific Mountain System (fig. 3; Wahrahaftig, 1965).



Base from Joint Federal-State Land Use Planning Commission, 1973

Physiography after Wahrhaftig, 1965

Figure 3. -- Physiography of Alaska.

The Arctic Coastal Plain is the Alaskan counterpart of the Interior Plains of the conterminous United States and Canada. It is a smooth plain rising gradually from the Arctic Ocean to a maximum altitude of 600 feet at its southern margin. It is virtually without relief except for scattered groups of low hills east of the Colville River and "pingos" (see section on permafrost and glaciers) that range in height from 20 to 230 feet.

The Brooks Range is the northern extension of the Rocky Mountain System. From the Canadian border it extends westward for 600 miles to the Arctic Ocean. Many peaks in the eastern part of the range exceed 9,000 feet in altitude; in the west, peak altitudes decrease to an average of 3,000 feet.

The Intermontane Plateaus lie between the Brooks Range and the Alaska Range and consist of dissected uplands and broad, alluvium-filled basins. Basin floors range in altitude from over 6,500 feet in the Yukon-Tanana Uplands in the east to generally less than 1,000 feet in the Yukon-Kuskokwim and Bristol-Bay Nushagak Lowlands in the west.

The Pacific Mountain System is the continuation of the Coastal Mountain System of the conterminous United States and Canada. It consists of two parallel arcs that generally follow the coast line from southeast Alaska to and including the Aleutian Islands. The northern arc includes the Boundary, the Alaska and Aleutian Ranges, and the Aleutian Islands. The southern arc includes many of the islands of southeast Alaska as well as the Fairweather Range, the St. Elias Mountains, the Kenai-Chugach Mountains and Kodiak Island.

CLIMATE

Four climatic zones are recognized in Alaska by the National Weather Service: Arctic, Continental, Transition, and Maritime (Searby, 1968). These zones are illustrated in figure 4.

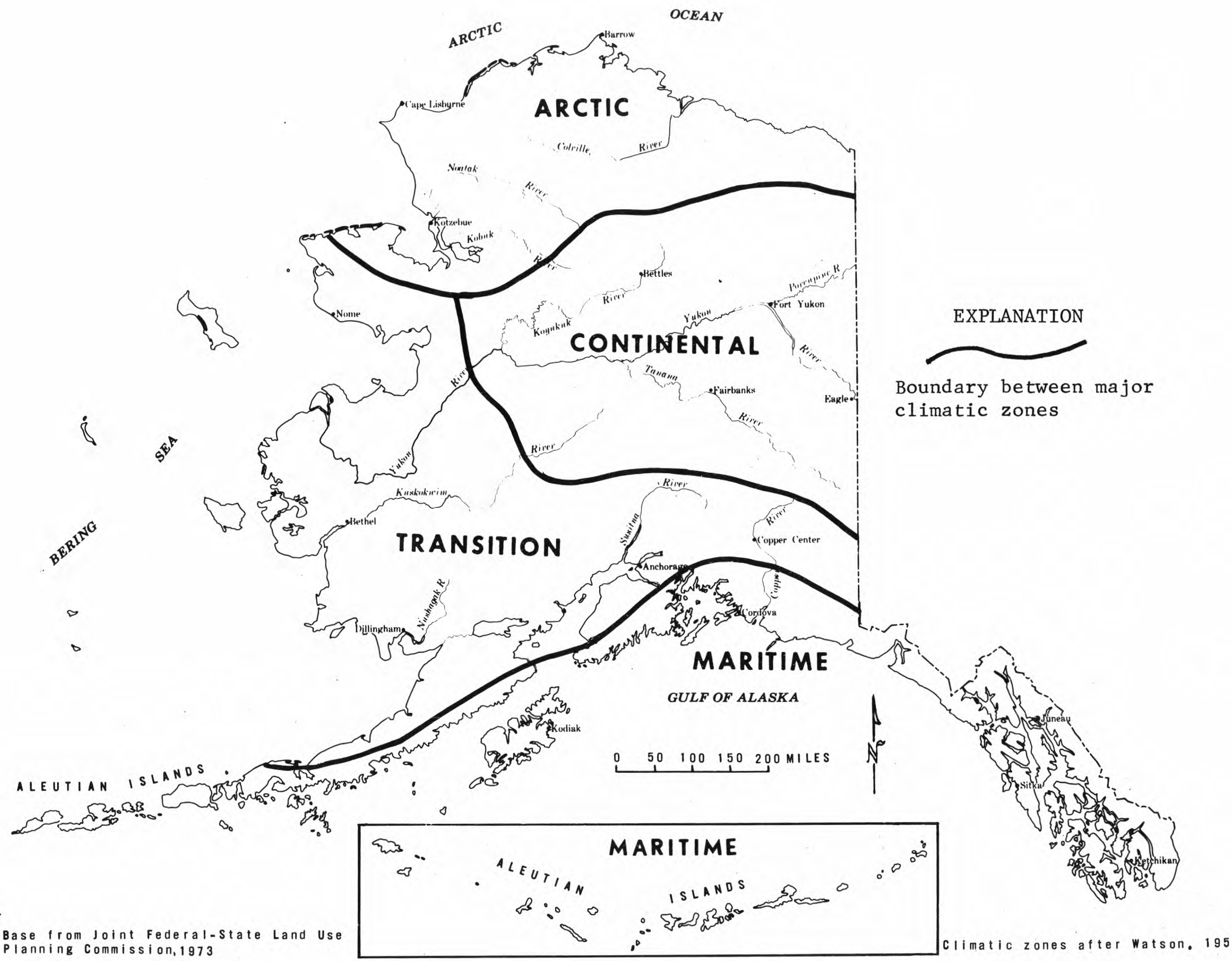


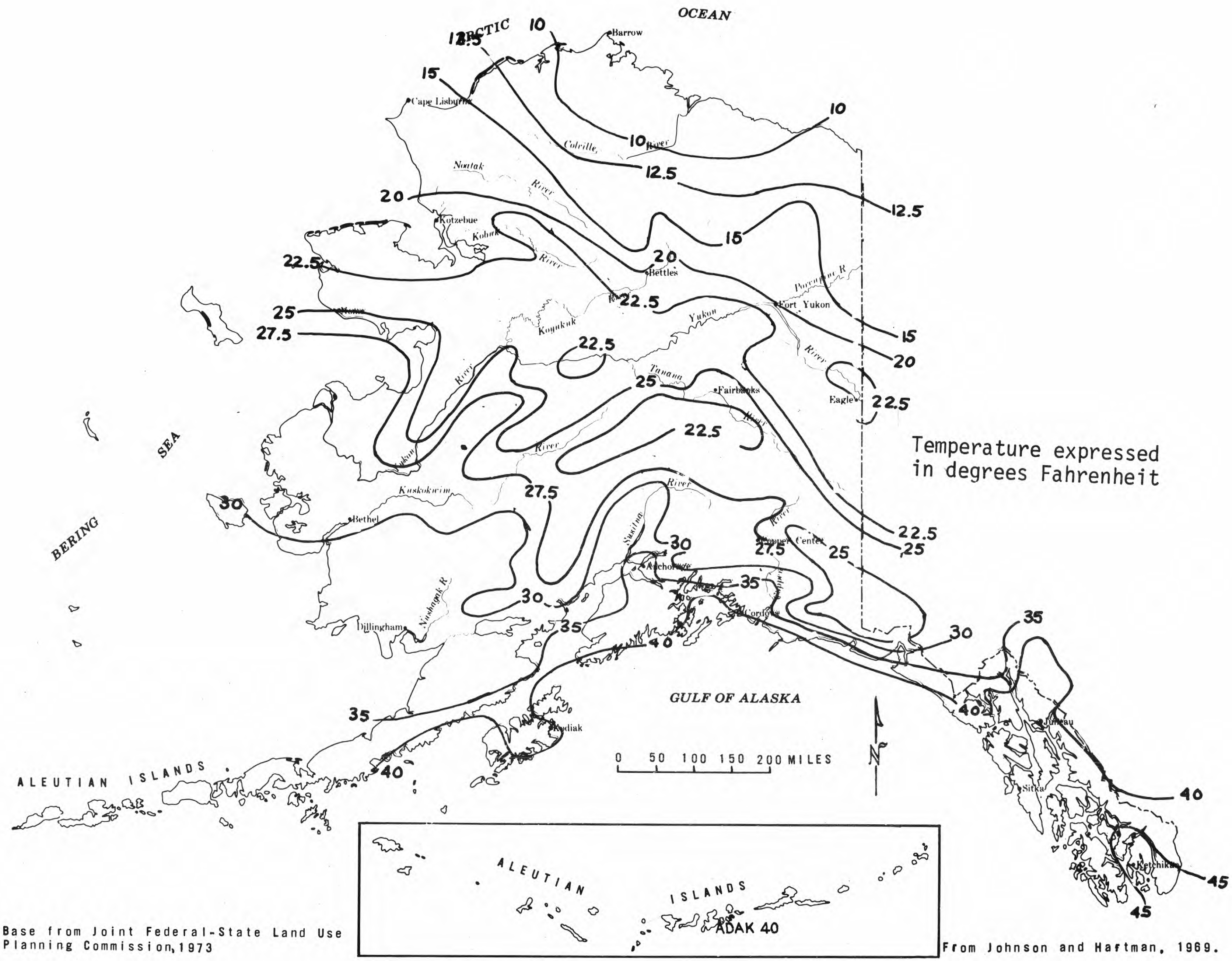
Figure 4. -- Climatic zones of Alaska.

The mean annual temperatures in Alaska range from about 42°F in the Maritime zone in the south to 10°F north of the Brooks Range along the Arctic Slope (fig. 5).

The widest seasonal temperature range is found in the central and eastern of the Continental zone in interior Alaska. In this area, the mean maximum summer temperature is about 75°F; extreme readings are above 90°F. The highest recorded temperature for the State is 100°F and occurred at Fort Yukon on June 27, 1915. In the winter the mean minimum temperatures are -20° to -30°F. The coldest temperature ever recorded in Alaska occurred on January 23, 1971, at Prospect Creek near Bettles, -80°F (H.W. Searby, oral commun., 1975).

In the rest of the State the seasonal temperature contrasts are more moderate. In the Maritime zone, the summer to winter range of average temperatures is from about 65° to 25°F. In the Transition zone, average temperatures range from near 60°F to near 0°F except in the Norton Sound area where the range is from about 55°F to about -10°F. The Arctic zone has an average annual temperature range from about 48° to -20°F.

Mean annual precipitation varies throughout the State (fig. 6). In the Maritime zone it is estimated to be as high as 320 inches per year recorded near the south end of Baranof Island in southeast Alaska, whereas precipitation may be as low as 40 inches per year in the Aleutian Islands. In the Transition zone annual precipitation has been less than 10 inches in the Copper River basin; it is commonly more than 80 inches north of Dillingham. In the Continental zone, mean annual precipitation ranges from less than 10 inches in the Fort Yukon area up to nearly 40 inches near Nome. In the Arctic zone annual precipitation ranges from less than 5 inches near Barrow to an estimated 20 inches or more on the north side of the Brooks Range. The lines of equal precipitation shown in figure 6 are based on actual records where available and are estimated from available streamflow records from areas from which no precipitation data are available.



Base from Joint Federal-State Land Use Planning Commission, 1973

From Johnson and Hartman, 1969.

Figure 5. -- Mean annual temperatures in Alaska.

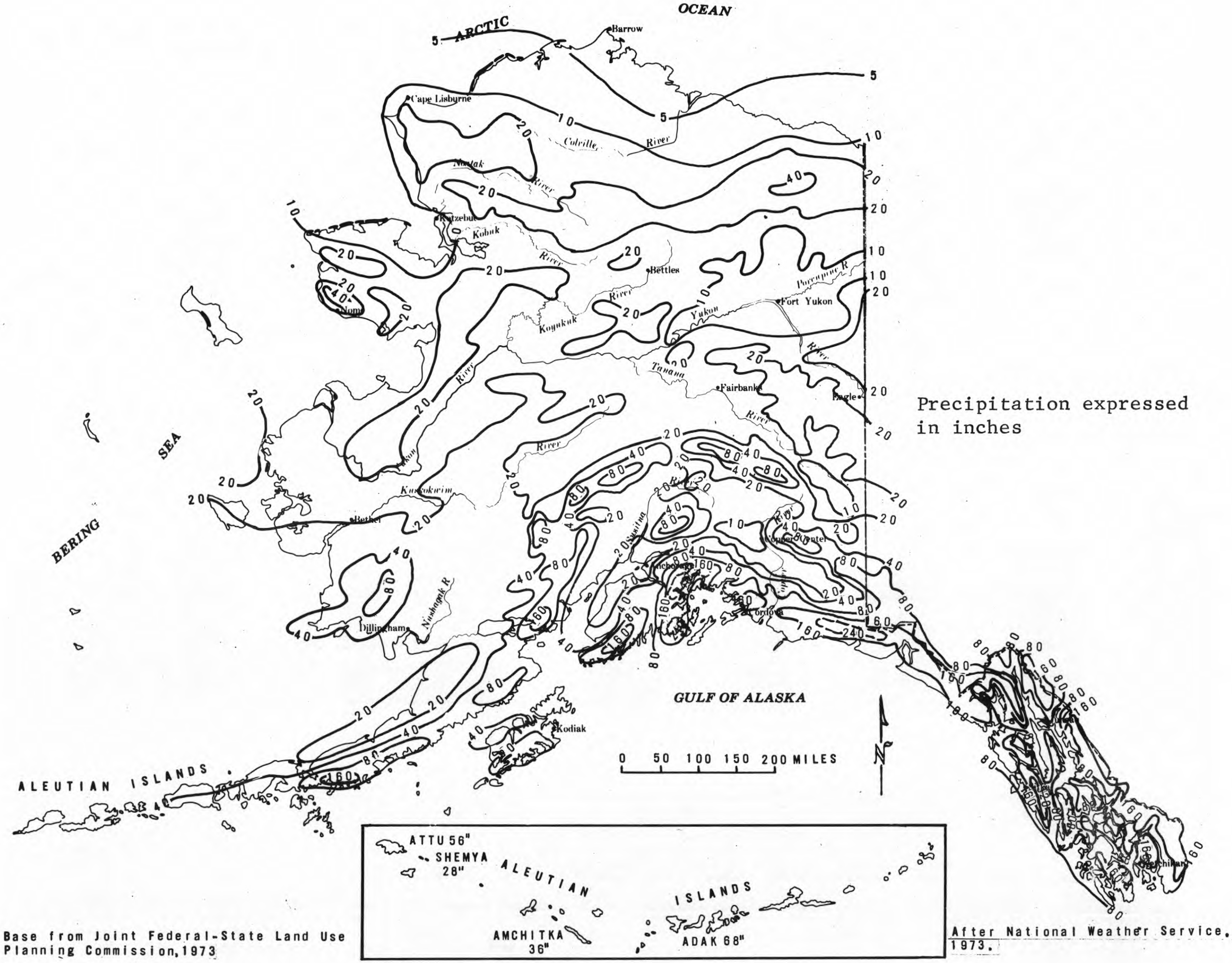


Figure 6. -- Mean annual precipitation in Alaska.

Precipitation extremes in the State are noteworthy. The greatest recorded amount of precipitation for a 1-year period occurred on the southeast tip of Baranof Island at Little Port Walter (altitude 14 feet) in 1943, a total of 269.3 inches. The maximum monthly amount was 61.46 inches measured at Jumbo Mine, northeast of Hydaburg on Prince of Wales Island. The maximum abount for a 24-hour period occurred at Cordova on December 29, 1955, 14.13 inches (Searby, 1968).

A large part of Alaska's total precipitation occurs as snow. Yakutat averages 216 inches of snow annually and has a total annual precipitation of about 130 inches. By comparison, Barrow averages 29 inches of snow and has a total precipitation of little more than 4 inches. The greatest known snowfalls have all occurred at Thompson Pass near Valdez. The seasonal snowfall record (1952-53) is 974.5 inches; the record month was February 1953 in which 298 inches of snow fell; the 24-hour record snowfall was 62 inches in December 1955 (Searby, 1968).

A large majority of storms crossing the northern part of the Pacific Ocean normally track along the Aleutian chain, the Alaska Peninsula, and the coastal area of the Gulf of Alaska. Wind velocities frequently exceed 50 mi/h (miles per hour) during the winter months and occasionally during the summer. Wind velocities approaching 100 mi/h have been measured and are usually associated with mountainous terrain and narrow passes. Shemya Island (western Aleutians) has had winds estimated at 140 mi/h (Searby, 1968). On Salisbury Ridge, south of Juneau, sustained wind speeds of 200 mi/h occurred, accompanied by gusts estimated at up to 250 mi/h, during the winter of 1974-75 (Maj. J.L. Perkins, Corps of Engineers, oral commun., 1975). Occasional summer storms develop in or move into the Bering Sea, creating strong onshore winds along the western coast. Flooding in the low-lying coastal areas frequently results.

GEOLOGY

The geology of Alaska is broadly similar to that of the western United States and western Canada. All the principal systems from Precambrian to Quaternary are represented. Figure 7 is a simplified geologic map of Alaska showing only contacts between igneous, metamorphic, and sedimentary rock units. The following discussion of geology is from Gates (1964).

The Arctic Coastal Plain and the foothills of the Brooks Range are underlain by thick sequences of sedimentary rocks (alluvium, glacial debris, and marine and nonmarine sandstone and shale). The Brooks Range itself is made up of thick sequences of folded and faulted limestone intruded by granitic bodies. Between the Brooks and Alaska Ranges are the Intermontane Plateaus consisting of low mountains underlain by altered sedimentary rocks and clastic and volcanic rocks that have been intruded by granitic bodies.

The limestone and shale of the Alaska Range and the Coast Mountains have been cut by large granitic plutons. In the Kenai and Chugach Ranges ultramafic rocks have intruded the sedimentary rocks that compose those mountain ranges. The Cook Inlet-Susitna and Copper River lowlands between the Alaska and Kenai-Chugach Ranges are underlain by thick sequences of clastic sedimentary rocks.

Large areas of unconsolidated surficial deposits (loess, glacial outwash, and alluvium) are found throughout most of Alaska. The largest and most spectacular of these areas are along the Yukon River and its tributaries and along the Kuskokwim, Kobuk, and Noatak Rivers. Other especially prominent areas of unconsolidated surficial deposits include the lower reaches of the Yukon and Kuskokwim Rivers and the upper Yukon-Porcupine River drainage areas.

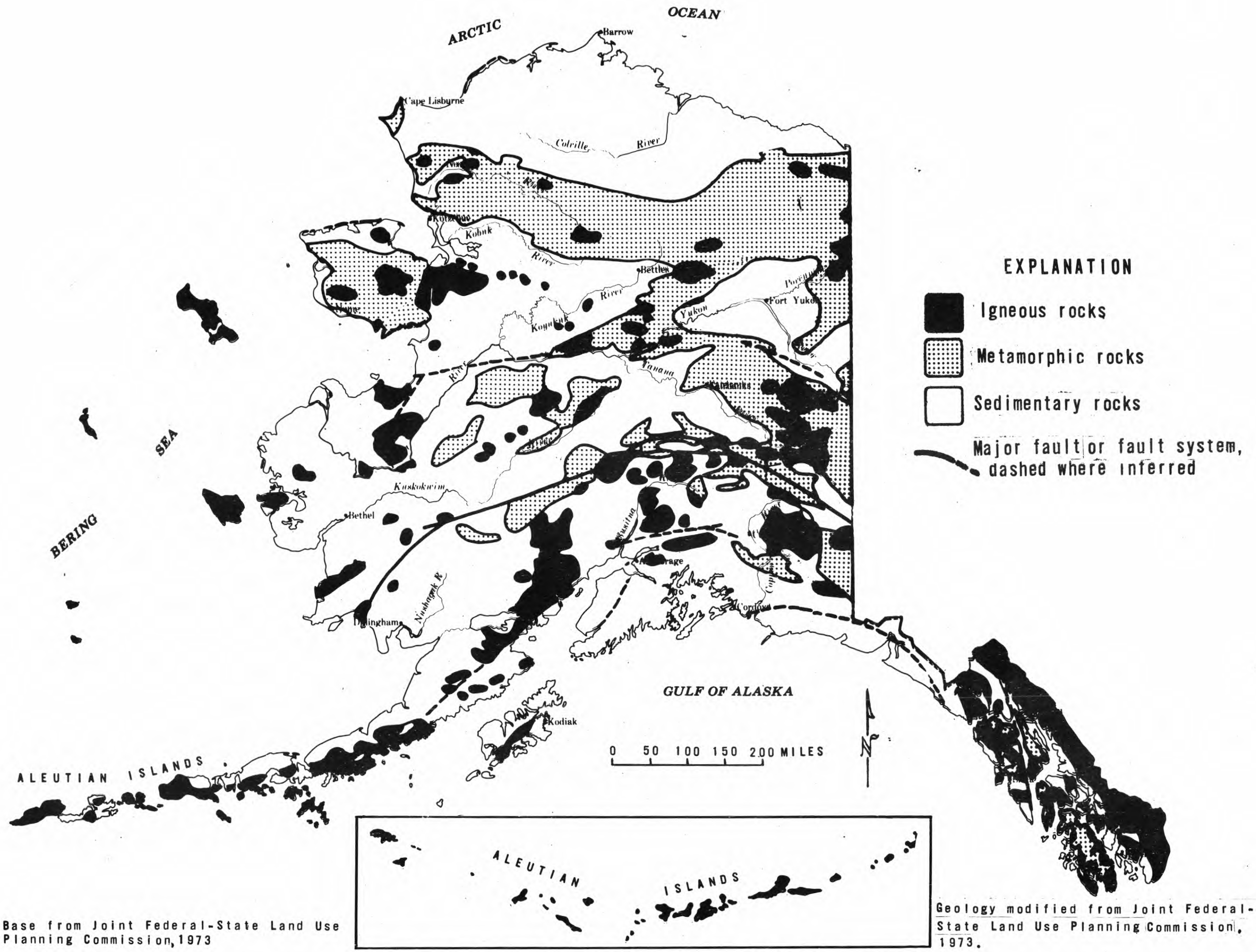


Figure 7. -- General geology of Alaska.

PERMAFROST AND GLACIERS

Permafrost is defined as soil, rock, or any other earth material (without regard to other conditions such as lithology, texture, degree of induration or water content) whose temperature remains at or below 32°F continuously for 2 or more years (Muller, 1947). Most permafrost contains ice in varying amounts from partial filling of the pore spaces to massive formations of segregated ice. The presence of ice (water) is not a necessary prerequisite of permafrost; however, its presence and amount in proportion to the frozen material is of extreme importance to the behavior of permafrost when it is degraded (thawed).

Most of the permafrost in Alaska is several thousand years old. Its area has been shrinking in some regions and growing in others. In the colder climatic regions of northern Alaska, permafrost forms a continuous layer to depths of several hundred feet. The maximum thickness thus far noted is 2,000 feet near Prudhoe Bay (Howitt and Clegg, 1970). To the south permafrost tends to thin and become discontinuous. Figure 8 illustrates the general distribution of permafrost in Alaska.

The factors that control the distribution of permafrost also control its temperature. Permafrost temperatures vary with depth, latitude, and geologic and topographic setting, but are especially affected by large, deep bodies of water. Heat from the water bodies (rivers, lakes, oceans) tends to increase the temperature of permafrost adjacent to the heat source.

Even in the coldest parts of Alaska, a thin layer of ground, the active layer, thaws every summer and separates the permafrost from the ground surface. The thickness of the active layer depends on the insulating capabilities of the overlying materials and can range from 0.5 foot to 5 or more feet. This thickness can change dramatically when the ground surface is disturbed.

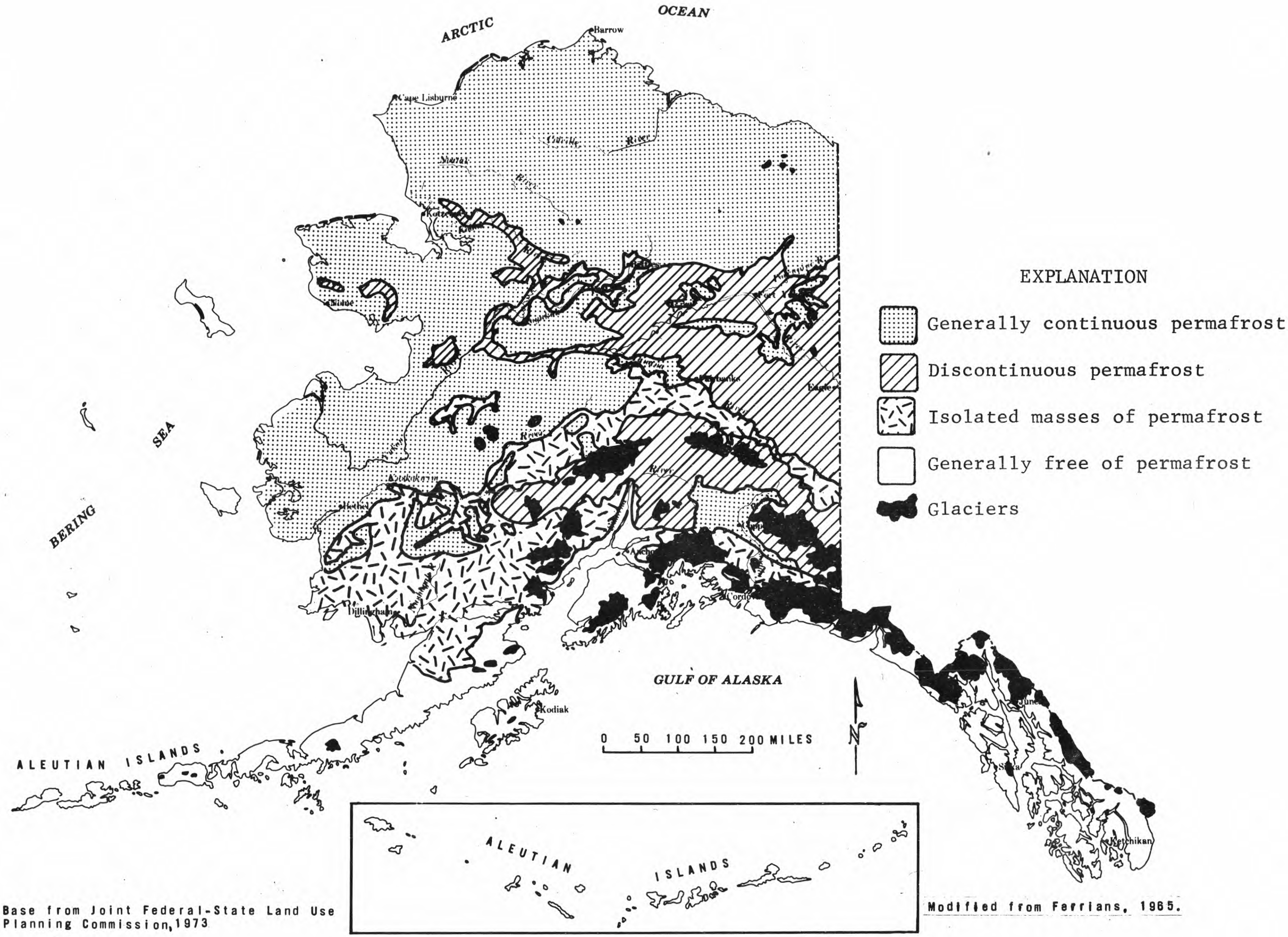


Figure 8. -- Occurrence of permafrost and general location of glaciers in Alaska.

Because it is virtually impermeable, permafrost ice restricts recharge, discharge, and movement of ground water, confines water under artesian pressure, and limits storage capacity (Anderson, 1970).

Other cold region phenomena include ice wedges and pingos. During winter, contraction of the ground surface creates cracks similar to mud cracks. In the summer, melt water pours into these cracks in the permafrost and freezes, thus forming a network of vertical, intersecting ice veins. The repeated seasonal cracking, filling, and freezing causes these veins to grow in width and depth, forming wedges. The intersections of these ice wedges form polygons in some areas of Alaska. Pingos form when ground water under hydrostatic pressure freezes beneath the ground surface or impermeable layer and forms an ice core. The continued growth of this ice core causes the overlying layer to rise, forming a dome on the surface. Pingos occur in both the continuous and discontinuous permafrost zones in Alaska.

Alaskan glaciers cover about 28,500 square miles (fig. 8) and are an integral part of the hydrologic regimen. Streams that originate at glaciers display peculiar characteristics of runoff (peak flow in midsummer, diurnal fluctuation in runoff, runoff much greater or much less than that derived from local, short-term precipitation, high silt content, and outburst floods) that are not shown by nonglacial streams (Meier, 1969).

Glaciers are sensitive and responsive to even minor changes in climate. If Alaska's regional climate were to become slightly cooler and wetter than at present, glaciers could reverse their present trend of apparent retreat.

Many Alaskan glaciers formerly had greater areas than they do at this time. At Black Rapids Glacier, in the Alaska Range, a terminal moraine east of the Richardson Highway is evidence that the ice previously crossed the location of the present highway. The moraine has been dated at approximately 1650 A.D. (Péwé, 1965). Moraines or small remnants of moraines show that within the past 300-350 years, the termini of Cantwell and Castner Glaciers, east of Black Rapids Glacier, have stood at the present location of the Richardson Highway (Péwé, 1965). The present terminus of Worthington Glacier lies within one-half mile of the Richardson Highway near Thompson Pass east of Valdez. Inspection of aerial photographs, taken by the Bureau of Land Management in August 1969, indicates that Worthington Glacier has been receding in the recent past. At least four terminal moraines can be distinguished west of the Richardson Highway. The present 800-foot long terminal lake was just beginning to form in 1953, giving an indication of the current rate of terminus retreat (about 35 feet per year).

Glaciers may advance because of favorable climatic conditions (snow and ice accumulation exceeding ablation) but may also advance by a glacial surge. A surging glacier is one which is characterized by "... sudden advance that does not seem to be related to variation in climate, and (or) exceptionally high speeds of glacier flow (two orders of magnitude greater than expected) and (or) a regular periodicity of either sudden advances or fast movements" (Meier and Post, 1969, p. 807).

In the winter of 1936-37, the terminus of Black Rapids Glacier advanced spectacularly, more than 4 miles (Moffit, 1942), at rates as great as 200 feet per day (Péwé, 1965). The extent of the glacier's advance is prominently marked by a terminal moraine that lies about 1 mile west of the Richardson Highway. "All surging glaciers surge repeatedly" (Meier and Post, 1969, p. 808), and this seems to be characteristic of Black Rapids Glacier. Multiple looped moraine patterns on the glacier's surface indicate an alternation of regular and fast rates of ice flow, corresponding to dormant and active phases of a surging glacier. Cantwell Glacier also has a sinuous moraine ridge that suggests periodic surges on one of its large tributaries.

Glaciers store a tremendous amount of water in the solid state and during the summer months glacier melt water helps to maintain flow in rivers that might otherwise become dry.

HYDROLOGY

The Alaska region has been divided into six hydrologic subregions based on the major drainage basins in the State as determined by the Inter-Agency Technical Committee for Alaska. These collectively have been divided into seventeen subareas. These divisions are illustrated in figure 9.

Surface Water

All major streams in the region originate in Alaska except for the Yukon and Porcupine Rivers (Upper Yukon subarea) and the Alsek, Taku, and Stikine (Southeast subregion) whose headwaters are in Canada. All of the streams in the region flow into either the Arctic Ocean, Bering Sea, or the Pacific Ocean.

The streams in the region fall into two general groups, glacial and nonglacial. Most glacial streams are found in the Southcentral and Southeast subregions and in the Tanana subarea.

The Yukon River is the largest in the State and ranks fifth in discharge among streams in the United States (Iseri and Langbein, 1974). It drains an area of about 327,000 square miles, 35 percent of which is in Canada. The Yukon drainage that is solely in Alaska covers about 35 percent of the State. The estimated mean annual discharge is 257,000 ft^3/s (cubic feet per second), about 32 percent of which flows into the State from Canada.

Streamflow is currently measured at more than 100 stream-gaging sites in the region. Figure 10 illustrates the current and selected discontinued sites in the region. A list of selected historical gaging stations by subarea and including only those operated by the Water Resources Division of the U.S. Geological Survey can be found on page 228.

The average runoff in Alaska amounts to an estimated 1,260,000 ft^3/s; an estimated 163,000 ft^3/s of that flows into the State from Canada. Table 2 lists the estimated mean monthly and mean annual runoff by subarea in the region.

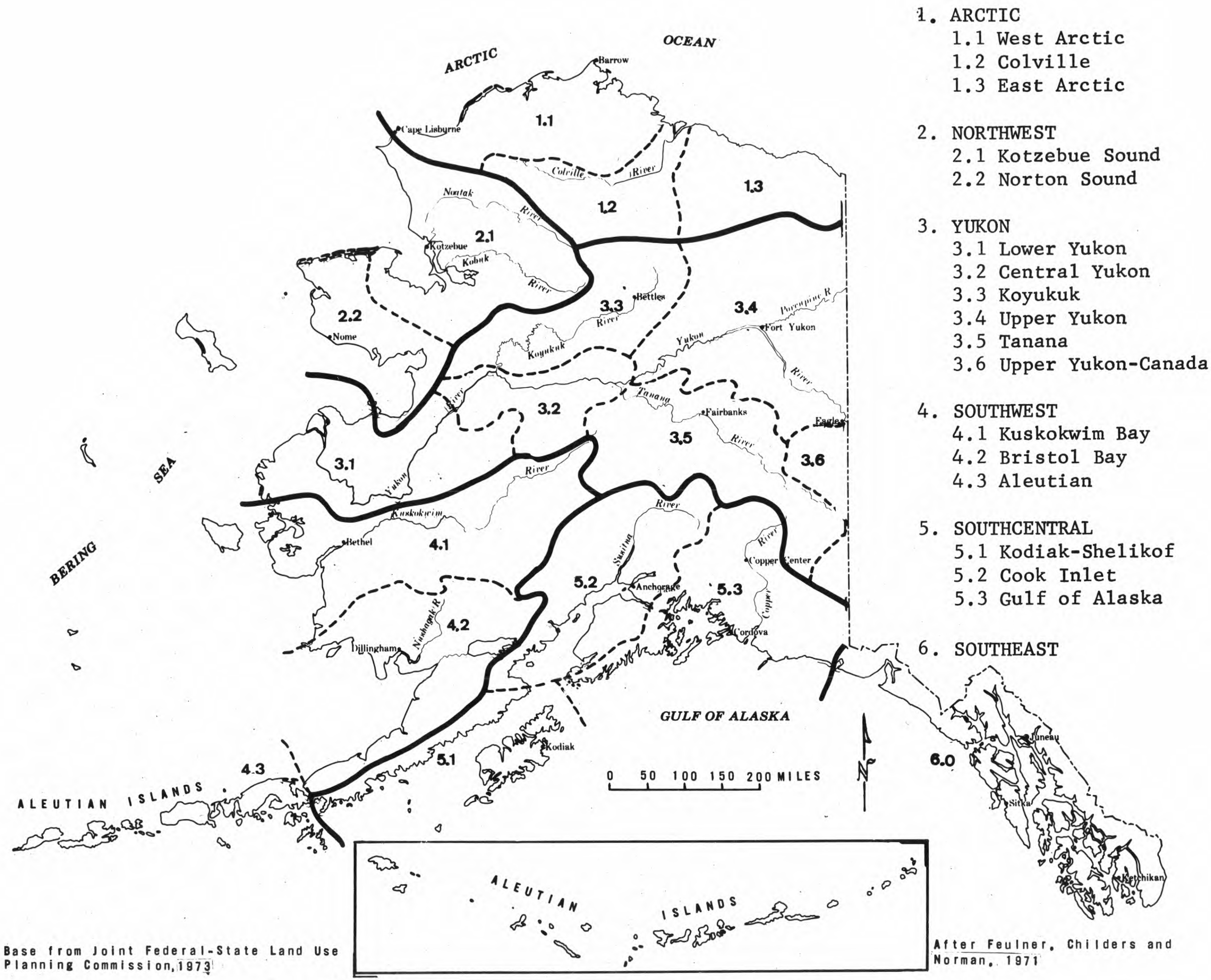


Figure 9. -- Hydrologic subregions and subareas of Alaska.

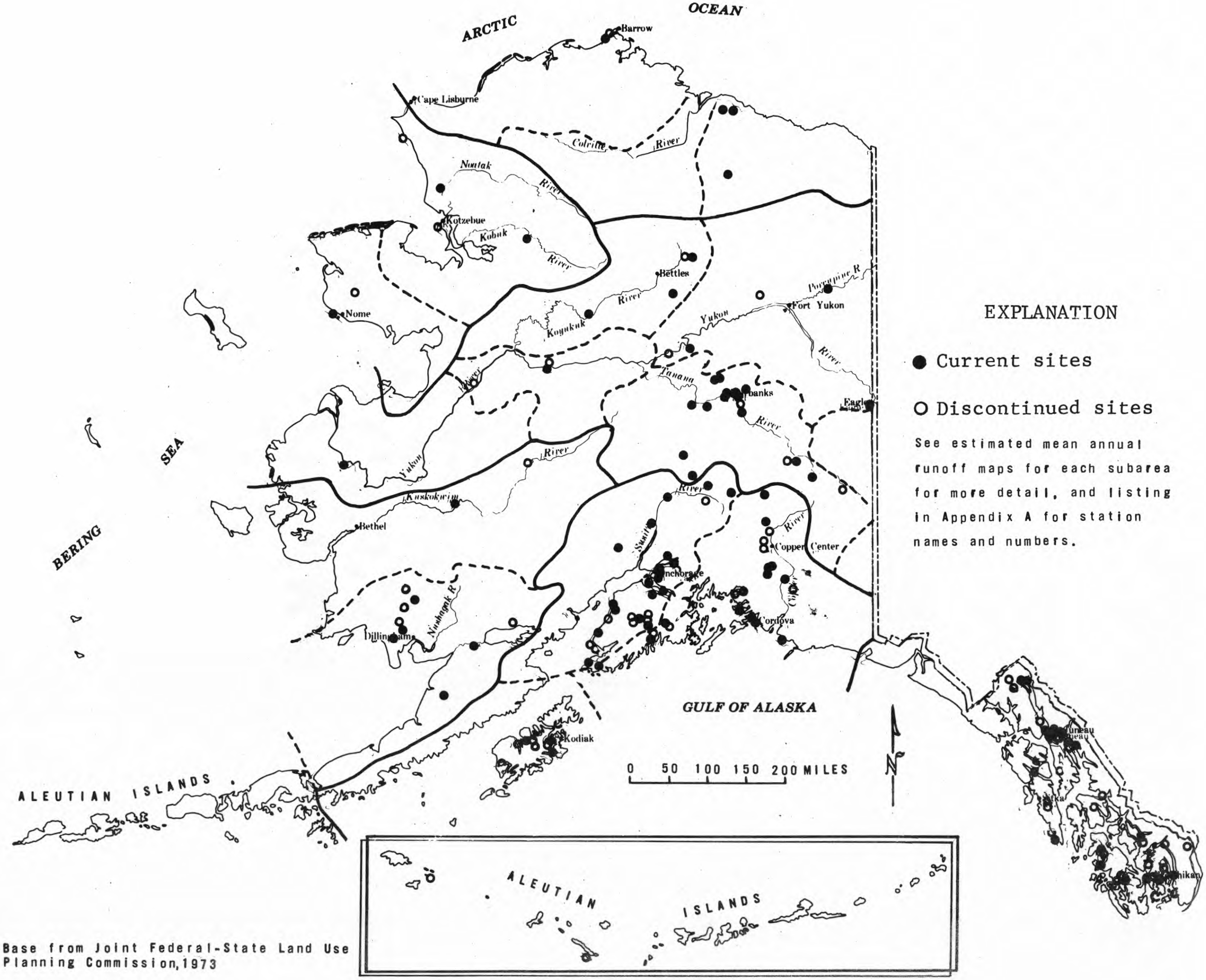


Figure 10. -- U.S. Geological Survey stream-gaging

Table 2. -- Estimated mean monthly and mean annual runoff by subarea in the Alaska Region in cubic feet per second (from U.S. Geological Survey reports; see page 232)

SUBAREA	Jan.	Feb.	March	April	May	June	July	August	Sept.	Oct.	Nov.	Dec.	mean annual runoff
West Arctic	0	0	0	0	0	132,000	12,400	26,700	6,510	0	0	0	14,800
Colville	72	62	62	62	6,000	83,800	29,300	32,200	13,000	2,640	960	192	14,000
East Arctic	77	68	67	68	6,490	90,800	31,800	34,800	14,000	2,940	1,080	212	15,200
Kotzebue Sound	9,490	7,860	6,930	7,180	98,600	217,000	94,900	105,000	69,300	57,800	22,000	12,700	59,100
Norton Sound	680	327	236	275	45,800	103,000	16,900	19,300	18,700	10,800	3,810	1,620	18,500
Up.Yukon-Can.(a)	684	765	747	819	9,900	17,600	15,100	12,400	8,640	4,320	1,800	846	6,140
Inflow from Can. to Up. Yukon(b)	18,800	17,100	15,600	16,100	135,000	281,000	202,000	167,000	130,000	76,600	37,700	23,300	93,400
Up. Yukon(b)	23,200	20,300	17,400	18,400	189,000	419,000	274,000	230,000	178,000	98,900	41,900	27,500	128,000
Inflow from Can. to Tanana(b)	125	120	120	135	470	685	910	785	430	215	140	125	355
Tanana(b)	10,300	10,100	10,000	12,200	56,000	83,400	96,300	93,500	52,100	27,000	13,700	10,800	39,600
Koyukuk(b)	1,240	910	737	778	47,400	94,200	33,100	46,300	32,900	13,900	3,880	1,860	23,100
Cen.Yukon(b)	45,500	37,900	31,600	32,600	316,000	645,000	458,000	401,000	332,000	199,000	80,900	51,900	219,000
Low.Yukon	61,800	47,700	36,800	34,400	352,000	718,000	540,000	448,000	435,000	288,000	113,000	69,400	262,000
Kuskokwim Bay	20,700	18,200	16,600	21,200	136,000	148,000	113,000	134,000	116,000	72,800	33,700	24,600	71,200
Bristol Bay	69,600	58,000	52,000	48,800	76,400	186,000	200,000	184,000	186,000	171,000	123,000	89,600	120,000
Aleutian	34,100	24,600	32,100	26,700	12,300	9,790	13,300	20,800	18,900	21,800	25,800	28,600	22,400
Kodiak-Shelikof	26,100	18,300	14,700	20,500	73,400	130,000	91,500	61,700	82,100	58,500	44,200	29,300	54,200
Cook Inlet	15,600	12,900	11,800	14,100	81,700	215,000	257,000	231,000	142,000	64,600	30,000	19,400	91,300
Gulf of Alaska	9,180	7,820	7,480	8,840	51,000	134,000	194,000	172,000	93,200	36,000	17,000	11,600	61,800
Inflow from Can. to Southeast(b)	10,200	9,450	10,200	16,400	86,400	205,000	176,000	128,000	86,400	60,200	29,800	15,400	69,500
Southeast	126,000	131,000	112,000	182,000	488,000	873,000	906,000	860,000	722,000	564,000	340,000	190,000	458,000
Total monthly runoff	373,000	327,000	291,000	364,000	1,430,000	3,040,000	2,500,000	2,330,000	1,930,000	1,350,000	755,000	477,000	
Total mean annual runoff													1,260,000

(a) Flows into Canada and back into Alaska via Yukon River and therefore is part of inflow into Upper Yukon subarea.
(b) Included in downstream flow figures.
(a&b) Not included in summation of total runoff figures.

Figures 11, 12, and 13 show the estimated mean annual, estimated mean annual peak, and mean of the lowest monthly runoff for each year of record (hereafter referred to as "the low month mean runoff") for the region and indicate the wide range of runoff characteristics. Low-lying areas adjacent to the Gulf of Alaska have high unit runoff and relatively little seasonal variation. In the mountainous areas adjacent to the Gulf, runoff is high and in the northern part of the region, runoff rates are low, relatively speaking.

Alaska has more than 3 million lakes ranging in area from ponds to the largest lake in the region, Iliamna, whose area is approximately 1,000 square miles. Iliamna Lake is the seventh largest lake in the United States. There are 94 lakes in the region that have surface areas in excess of 10 square miles and most are shown in figure 14. A listing of these lakes can be found on page 235.

Most of the lakes are along the north and west coast of the region in the wet tundra system at or near sea level. Other groups of lakes are in the Central Yukon, Koyukuk, Tanana, Upper Yukon, and Gulf of Alaska subareas. Glacier-fed and glacier-dammed lakes occur along the Alaska Range and the Chugach Mountains.

Glacier-dammed lakes are water bodies at least partly contained by glacier ice. These lakes usually form when a depression either on or adjacent to a glacier, a pocket beneath a glacier, or a valley blocked by a glacier is filled by rain and runoff from melting snow and ice. At some critical point during the lake's filling, the ice dam becomes unstable or is overtopped by the rising water. The water then erodes a channel through or beneath the ice and the lake drains rapidly. The resulting floods have sharp, sudden peaks that may cause extensive erosion and damage to man-made structures. Glacier-dammed lakes may form initially, break out, and never refill, or the filling-draining cycle may be repeated many times. Available data on the history of glacier-dammed lakes, their formation, the effects of their outburst floods, and a discussion of possible sites for these lakes are included in a U.S.

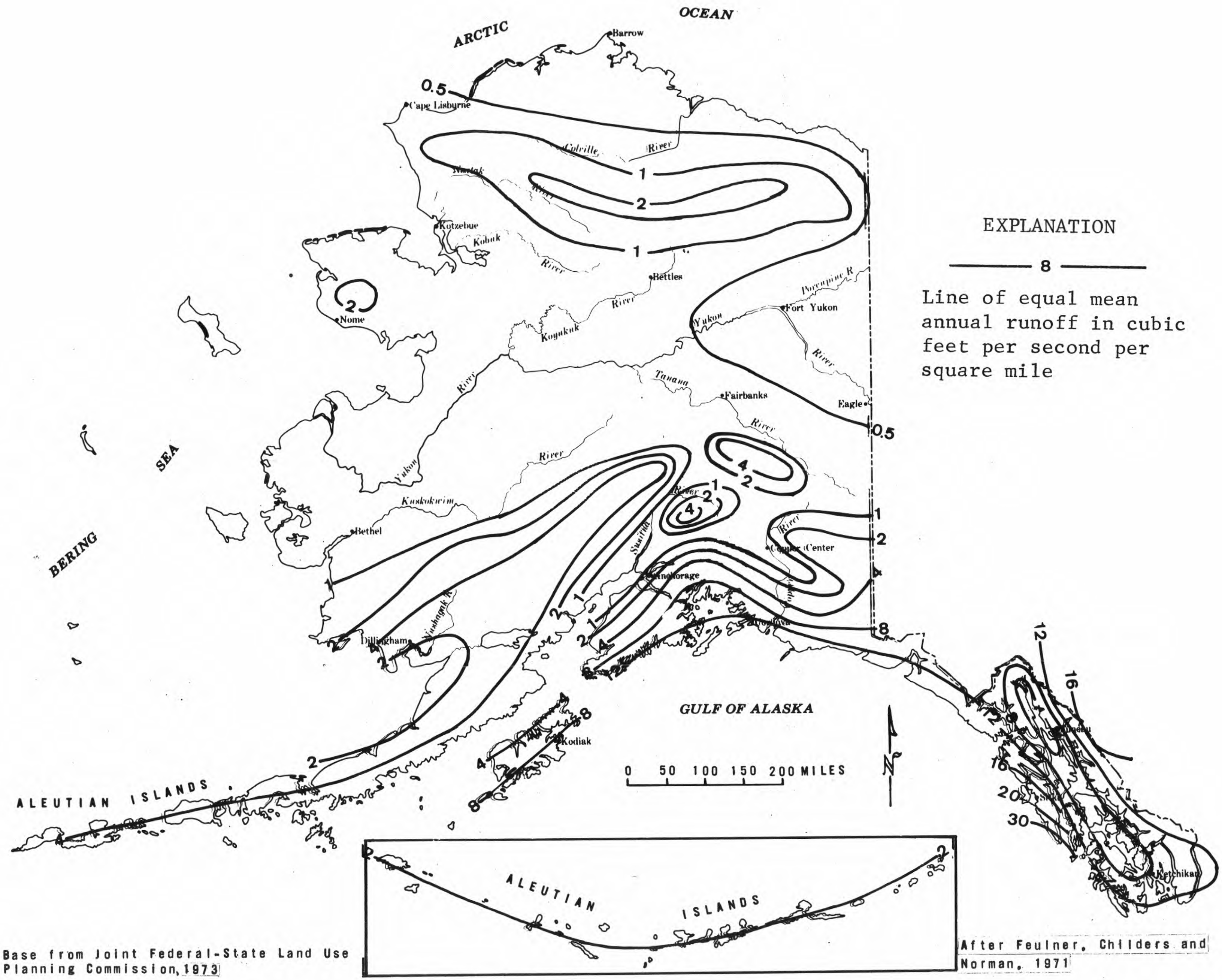


Figure 11. -- Estimated mean annual runoff.

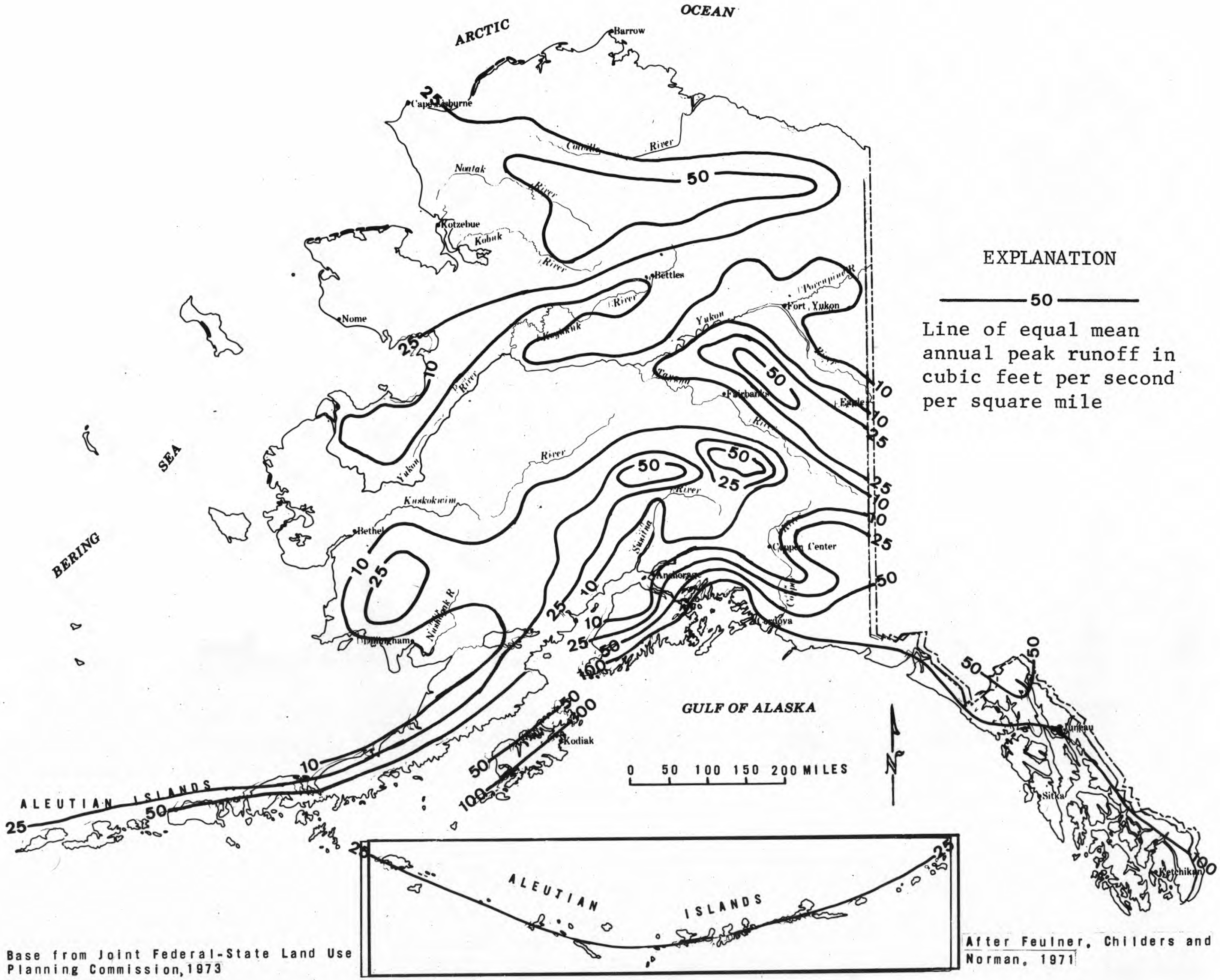
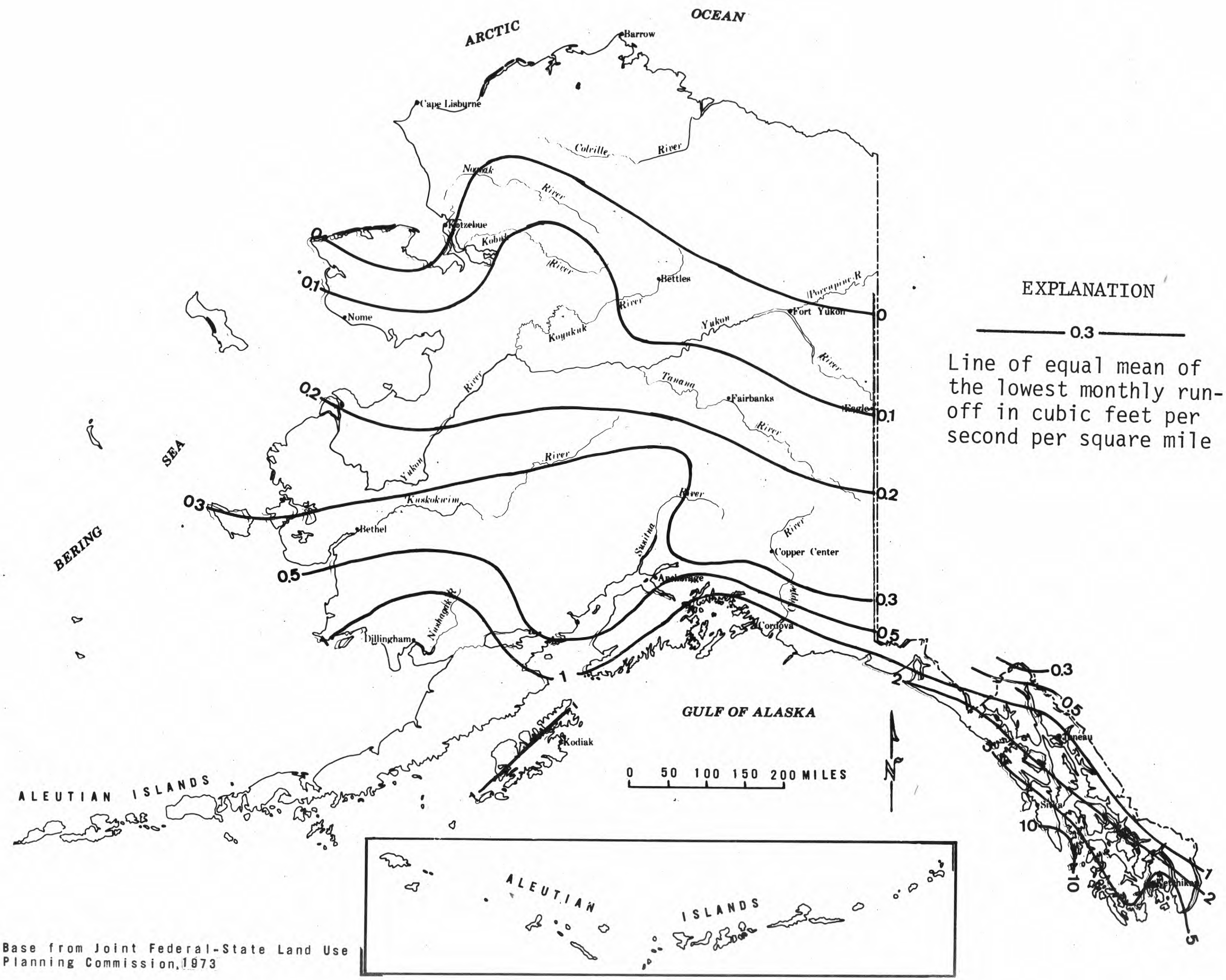


Figure 12. -- Estimated mean annual peak runoff.



Base from Joint Federal-State Land Use Planning Commission, 1973

Figure 13. -- Estimated mean of the lowest monthly runoff.

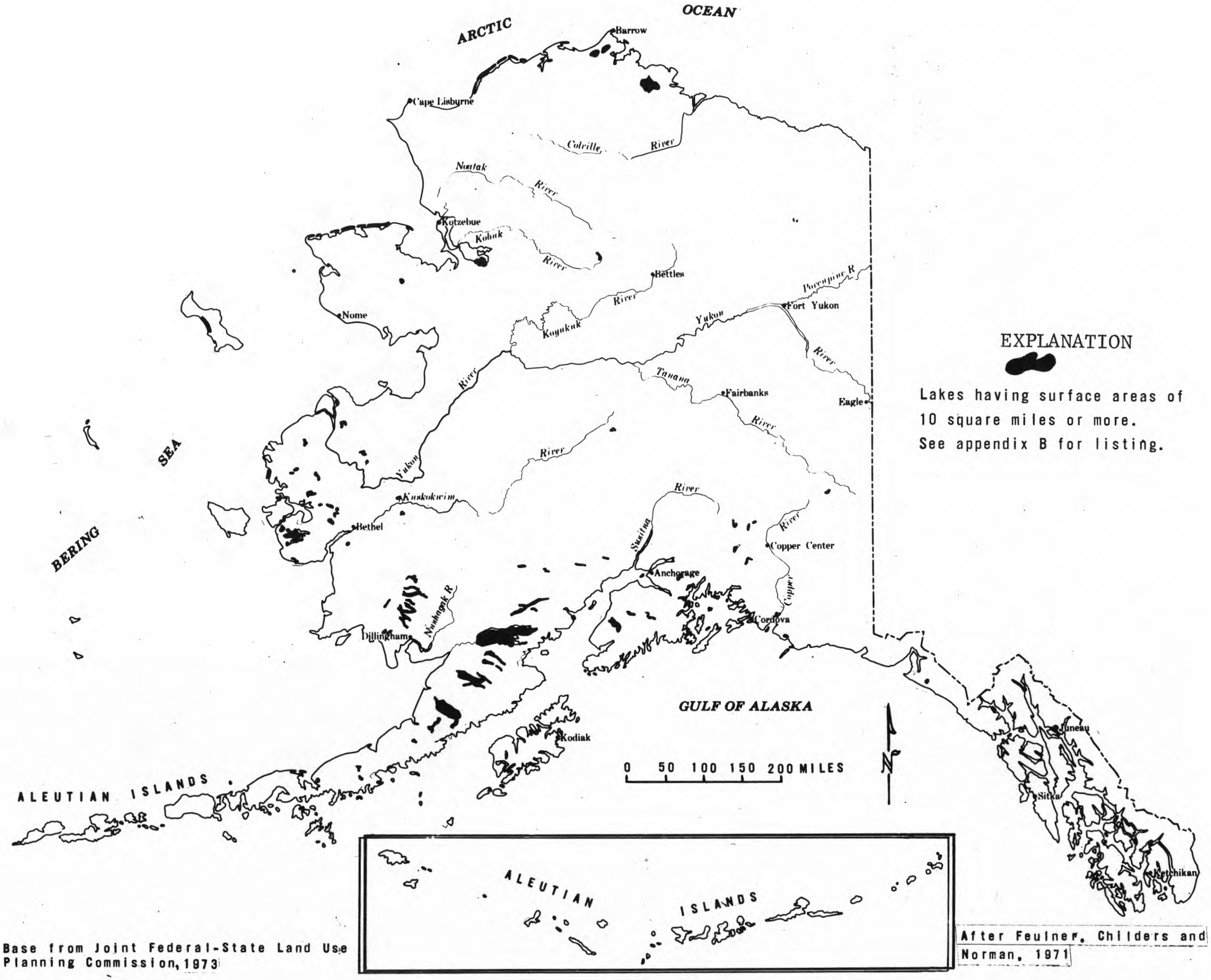


Figure 14. -- Major lakes in Alaska.

Geological Survey report, "Glacier Dammed Lakes and Outburst Floods in Alaska" (Post and Mayo, 1971). Some 750 glacier-dammed lakes have been recognized and are shown on maps in that report.

Glacier outburst floods, resulting from the sudden release of water stored beneath, on, or behind glacial ice, cannot be reliably predicted. Such floods have three times destroyed the Richardson Highway bridge at Sheep Creek, a tributary to the Lowe River above Keystone Canyon near Valdez (Hoffman, 1970).

Ground Water

Ground-water conditions in Alaska are highly variable. Unfrozen, recent alluvial deposits in river valleys, including the flood plains, terraces and alluvial fans, are the principal aquifers (Williams, 1970b). Alluvium, consisting largely of permeable sand and gravel, ranges in thickness from a few feet in small mountain valleys to about 2,000 feet in the Tanana Valley (Anderson, 1970). Glacial and glaciolacustrine deposits in the interior valleys, particularly the Copper River basin, are a much smaller source of ground water (Williams, 1970b). Consolidated bedrock is capable of small water yields from fractures and is used locally for water supplies. Ground water also occurs in cavernous carbonate rocks that support large springs. Figure 15 illustrates the general availability of ground water throughout the region, and figure 16 shows the location of springs in the region.

The extent and thickness of permafrost limits the availability of ground water. The volume of frozen ground decreases southward consistent with the regional zonation of permafrost (fig. 8), and there is a corresponding increase in the quantity of ground water available. Within the zone of continuous permafrost, unfrozen alluvium is found only under the major streams and beneath lakes deeper than about 7 feet (Williams, 1970b).

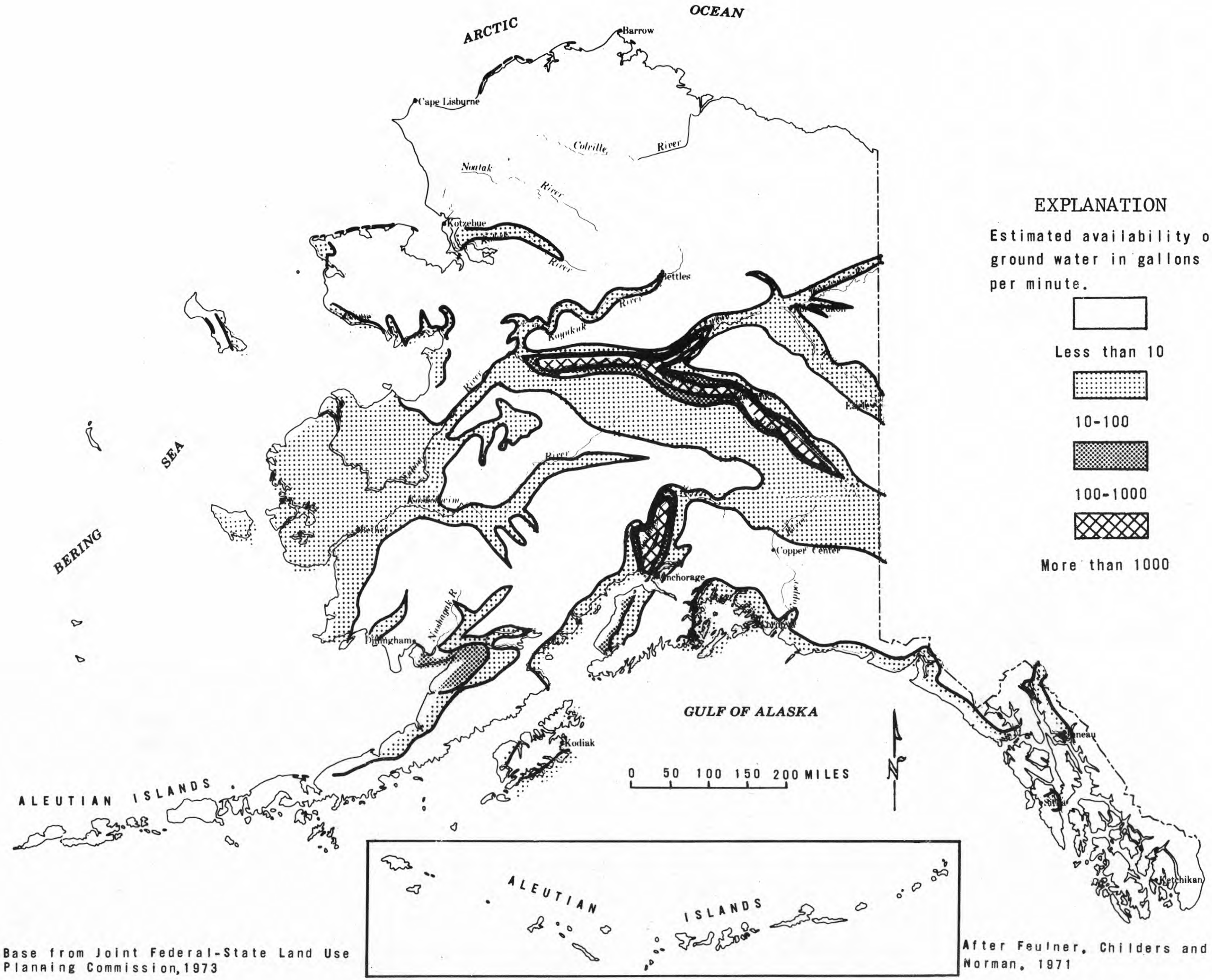


Figure 15. -- Generalized availability of ground water.

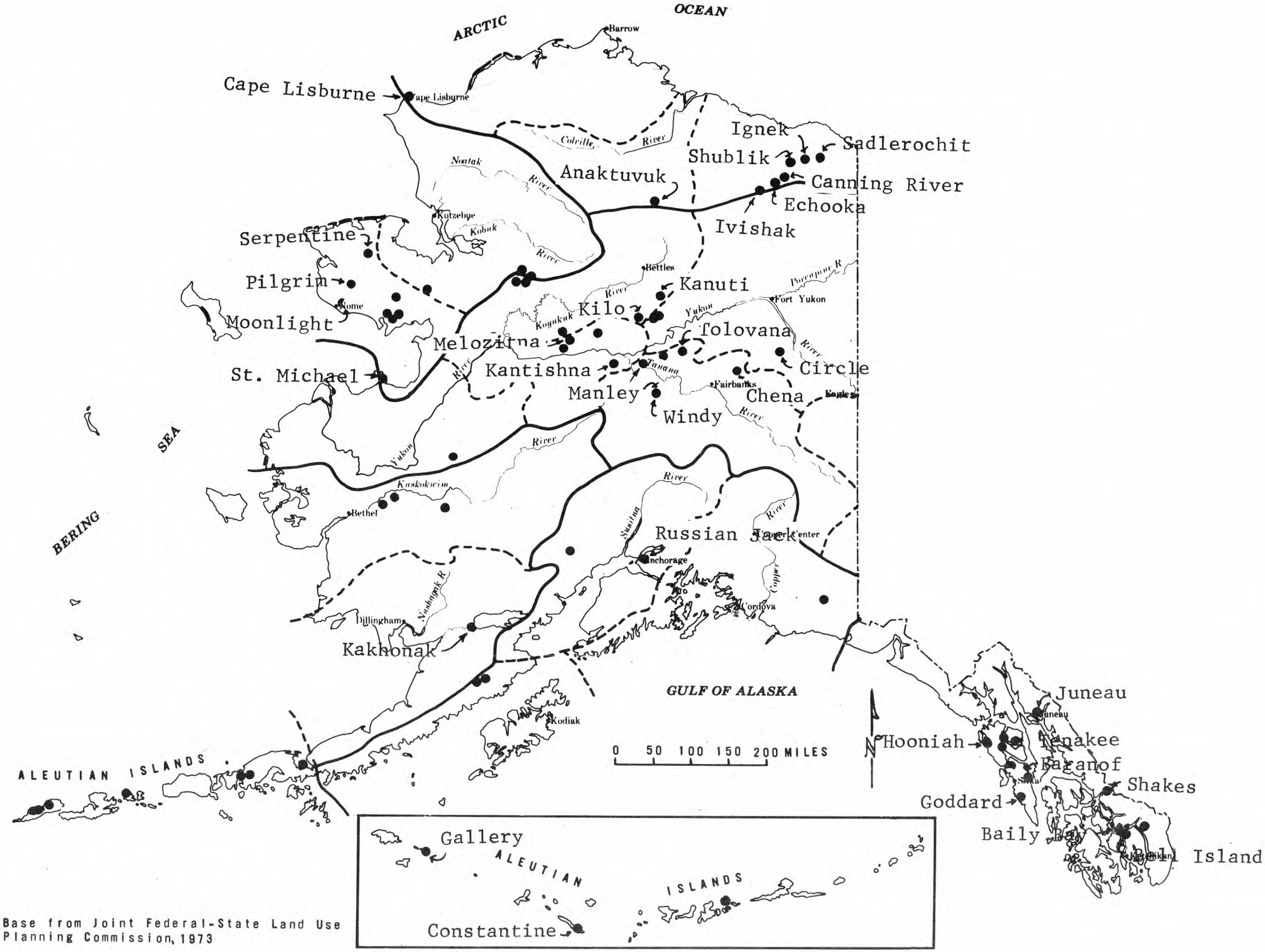


Figure 16. -- Selected springs in the Alaska region.

Icings form during the winter in river channels, on flood plains and alluvial fans. Icings are good evidence of the occurrence of ground water and extensive icings occur where large perennial springs discharge into river valleys (Williams, 1970b; Sloan, Mayo, and Zenone, 1975). Pingos, conical ice-cored hills formed by discharge of ground water under artesian pressure (Holmes, Hopkins, and Foster, 1968), are formed on the Arctic Coastal Plain and near Fairbanks on the Yukon-Tanana Upland.

Recharge of the principal alluvial ground-water reservoirs occurs largely through the unfrozen zones underlying streams. According to Anderson (1970), the most important source of ground water in the Tanana Basin is seepage from streams. He found that seepage losses from streamflow in Jarvis Creek near Big Delta averaged 10 ft^3/s or 6.5 Mgal/d (million gallons per day) per linear mile of channel. Dingman and others (1971) found that the ground-water outflow from the basin of the Delta River averaged 1,105 ft^3/s or 717 Mgal/d over the entire year and that most of the recharge occurred as seepage from the Delta River and Jarvis Creek between the front of the Alaska Range and the mouth of the streams. Recharge to other alluvial, glacial, and bedrock aquifers is from precipitation.

The direction of movement of water in the alluvial flood-plain deposits of the river valleys is generally parallel to the direction of streamflow, whereas direction of movement in the adjacent terrace, alluvial fan and upland deposits is, in general, parallel to the surface slope (topographic expression) of these land forms. The direction of water movement in confined zones within the alluvium or bedrock aquifers and within fracture or joint systems in bedrock is independent of surface features.

Discharge of ground water from principal alluvial aquifers occurs largely as base-flow discharge to streams. Ground water is also discharged at springs, lakes, and wetlands and directly by evapotranspiration from shallow ground-water reservoirs. Pumpage from wells is also a type of ground-water discharge.

Water Quality

The extent to which any water can be utilized depends upon its quality in addition to its availability. Water in Alaska is used for domestic supplies, processing of food and fiber, industrial supplies, and recreation. For the sake of discussion, the recommendations set forth by the Environmental Protection Agency (1972) for drinking water will be used as standards. The recommendations for selected constituents are listed in table 3. The State also has water-quality standards and these are presented in table 4.

Information about the chemical quality of ground water in Alaska is detailed for some areas, such as those near Anchorage and Juneau, but is virtually nonexistent for large parts of the State. Analyses indicate that the dissolved-solids concentrations range from as low as 19 mg/l (milligrams per litre) to as high as 64,200 mg/l. Most of the ground water sampled contains less than 250 mg/l dissolved solids and is thus considered acceptable for general use. In inland areas, calcium bicarbonate or calcium magnesium bicarbonate type water is most common. Water of sodium bicarbonate or sodium chloride type is fairly prevalent in coastal areas. Amounts of iron exceeding Environmental Protection Agency recommendations have been found in the water of a large number of wells in most subareas, particularly in the water from shallow wells. Water from below permafrost is varied in composition; some is highly mineralized and of the magnesium sulfate type. Figure 17 shows the general quality of ground water in some parts of Alaska.

Information on the concentration and types of chemical constituents in surface water is not equally abundant for all subareas. Some parts of the State have had regular or periodic sampling programs for many years at many stream points and at a number of lakes. Surface-water quality in other subregions is represented only by a few miscellaneous samples. Although the chemical characteristics of water in the streams and lakes of Alaska seem varied, the ranges in concentrations are not as large as those found in the conterminous United States. Most Alaskan streams above tidal reaches contain water of a calcium bicarbonate type

Table 3.--*Recommended quality criteria for public water supplies (after Environmental Protection Agency, 1972)*

Chemical constituent	Maximum concentration in mg/l
Chloride	250
Iron (dissolved)	.3
Manganese	.05
Nitrate	10
Sulfate	250

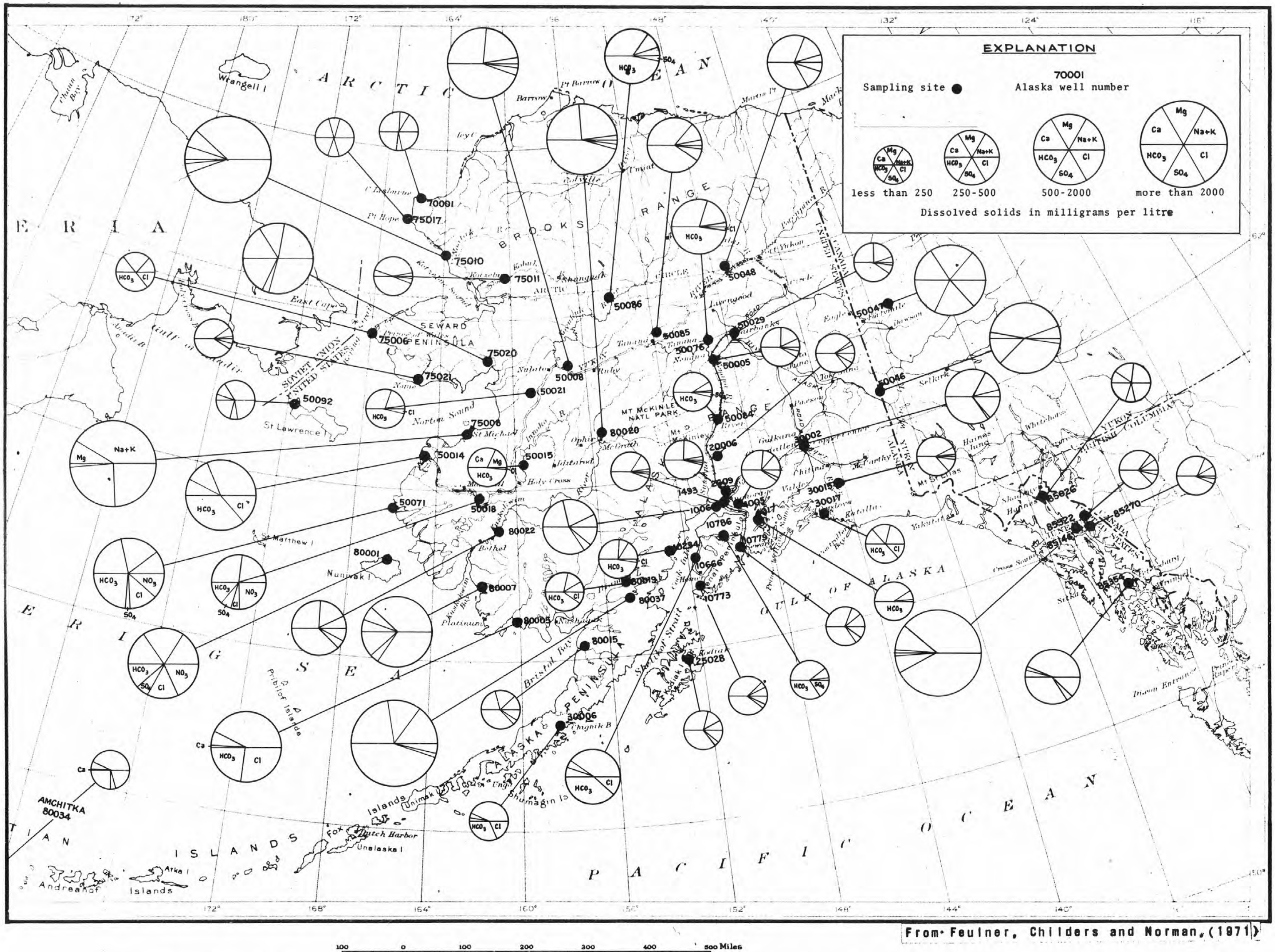
Water quality parameters / Water uses	(1) Total coliform organisms	(2) Dissolved oxygen, mg/l or percent saturation	(3) pH	(4) Turbidity, measured in Jackson Turbidity Units (JTU)	(5) Temperature, as measured in degrees Fahrenheit (°F)	(6) Dissolved inorganic substances
A. Water supply, drinking, culinary and food processing without the need for treatment other than simple disinfection and simple removal of naturally present impurities.	Mean of 5 or more samples in any month may not exceed 50 per 100 ml, except ground water shall contain zero per 100 ml.	Greater than 75 percent saturation or 5 mg/l.	Between 6.5 and 8.5	Less than 5 JTU	Below 60°F	Total dissolved solids from all sources may not exceed 500 mg/l.
B. Water supply, drinking, culinary and food processing with the need for treatment equal to coagulation, sedimentation, filtration, disinfection and any other treatment processes necessary to remove naturally present impurities.	Mean of 5 or more samples in any month may not exceed 1000 per 100 ml, and not more than 20 percent of samples during one month may exceed 2400 per 100 ml, except ground water shall contain zero per 100 ml.	Greater than 60 percent saturation or 5 mg/l.	Between 6.5 and 8.5	Less than 5 JTU above natural conditions.	Below 60°F	Numerical value is inapplicable.
C. Water contact recreation	Same as B-1	Greater than 5 mg/l.	Between 6.5 and 8.5	Below 25 JTU except when natural conditions exceed this figure; effluents may not increase the turbidity.	Numerical value is inapplicable.	Numerical value is inapplicable.
D. Growth and propagation of fish and other aquatic life, including waterfowl and furbearers.	Same as B-1 to protect associated recreational values.	Greater than 6 mg/l in salt water and greater than 7 mg/l in fresh water.	Between 7.5 and 8.5 for salt water. Between 6.5 and 8.5 for fresh water.	Less than 25 JTU when attributable to solids which result from other than natural origin.	May not exceed natural temperature by more than 2°F for salt water. May not exceed natural temperature by more than 4°F for fresh water. No change shall be permitted for temperature over 60°F. Maximum rate of change permitted is 0.5°F per hour.	Within ranges to avoid chronic toxicity or significant ecological change.
E. Shellfish growth and propagation, including natural and commerical growing areas.	Not to exceed limits specified in "National Shellfish Sanitation Program Manual of Operations." 1/	Greater than 6 mg/l in larval stage. Greater than 5 mg/l in the adult stage.	Between 7.5 and 8.5	Same as D-4.	Less than 68°F	Within ranges to avoid chronic toxicity or significant ecological change.
F. Agricultural water supply, including irrigation, stock watering, and truck farming.	Mean of 5 or more samples may not exceed 1000 per 100 ml with 20 percent of samples not to exceed 2400 per 100 ml for livestock watering, for irrigation of crops for human consumption, and for general farm use, except ground water shall contain zero per 100 ml.	Greater than 3 mg/l.	Between 6.5 and 8.5	Numerical values are inapplicable.	Between 60°F and 70°F for optimum growth to prevent physiological shock to plants.	Conductivity less than 750 micromhos at 25°C. Sodium adsorption ratio less than 2.5, sodium percentage less than 60 percent, residual carbonate less than 1.26 mg/l, and boron less than 0.3 mg/l.
G. Industrial water supply (other than food processing).	Same as B-1 whenever worker contact is present.	Greater than 5 mg/l for surface water.	Between 6.5 and 8.5	No imposed turbidity that may interfere with established levels of water supply treatment.	Less than 70°F.	No amounts above natural conditions which may cause undue corrosion scaling, or process problems.

1/ Houser, 1965.

2/ U.S.Public Health Service, 1962.

Table 4.--*Water-quality criteria for waters of the State of Alaska (from Alaska Administrative Code, title 18, Environmental Conservation, chapter 70, section 020)*

(7)	(8)	(9)	(10)	(11)	(12)
Residues including oils, floating solids, sludge deposits and other wastes	Settleable solids, suspended solids, (includes sediment and dredge spoil and fill)	Toxic or other deleterious substances, pesticides and related organic and inorganic materials	Color, as measured in color units	Radioactivity	Aesthetic considerations
Same as B-7	Below normally detectable amounts.	Carbon chlorform extracts less than 0.1 mg/l and other chemical constituents may not exceed "Public Health Service Drinking Water Standards." 2/	True color less than 15 color units.	The concentrations of radioactivity shall not: a) Exceed 1/30th of the NPCW values given for continuous occupational exposure in the National Bureau of Standards Handbook No. 69. b) Exceed the concentrations specified in the 1962 U.S. Public Health Service Drinking Water Standards 2/ for waters used for domestic supplies. c) Have a demonstrable detrimental effect on aquatic life. d) The concentration of radioactive materials in these waters shall be less than those required to meet the Radiation Protection Guides for maximum exposure of critical human organs recommended by the former Federal Radiation Council in the case of foodstuffs harvested from these waters for human consumption. Because any human exposure to ionizing radiation is undesirable, the concentration of radioactivity in these waters shall be maintained at the lowest practicable level.	May not be impaired by the presence of materials or their effects which are offensive to the sight, smell, taste or touch.
Residues may not make the receiving water unfit or unsafe for the uses of this classification; nor cause a film or sheen upon, or discoloration of, the surface of the water or adjoining shoreline; nor cause a sludge or emulsion to be deposited beneath or upon the surface of the water, within the water column, or the bottom or upon adjoining shorelines.	No imposed loads that will interfere with established levels of water supply treatment.	Chemical constituents shall conform to "Public Health Service Drinking Water Standards."	Same as A-10		Same as A-12
Same as B-7	No visible concentrations of sediment.	Below concentrations found to be of public health significance.	Secchi disc visible at minimum depth of 1 meter.		Same as A-12
Same as B-7 plus the following: Residues shall be less than those levels which cause tainting of fish or other organisms and less than acute or chronic problem levels as determined by bioassay.	No deposition which adversely affects fish and other aquatic life reproduction and habitat.	Concentrations shall be less than those levels which cause tainting of fish, less than acute or chronic problem levels as revealed by bioassay or other appropriate methods and below concentrations affecting the ecological balance.	Same as C-10		Same as A-12
Same as D-7	No deposition which adversely affects growth and propagation of shellfish.	Same as D-9	Same as C-10		Same as A-12
Same as B-7	For sprinkler irrigation, water free of particles of 0.074 mm or coarser. For irrigation or water spreading, not to exceed 200 mg/l for an extended period of time.	Less than that shown to be deleterious to livestock or plants or their subsequent consumption by humans.	Inapplicable		Same as A-12
Same as B-7	No imposed loads that will interfere with established levels of treatment.	Chemical constituents may not exceed concentrations found to be of public health significance.	Same as C-10		Same as A-12



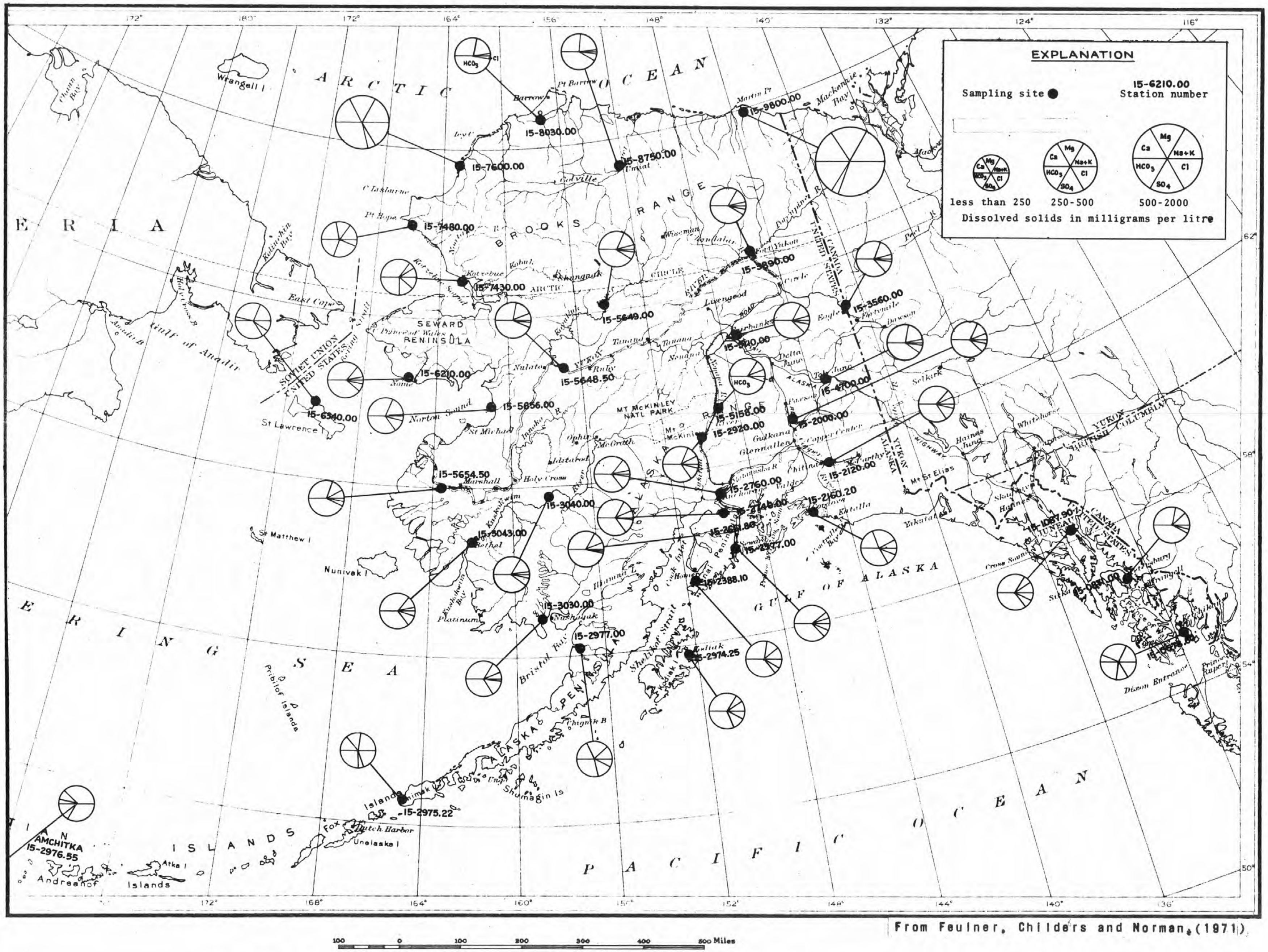
From Feulner, Childers and Norman, (1971)

Figure 17. -- Chemical quality of ground water in some parts of Alaska.

and have dissolved-solids concentrations less than 200 mg/l. The hardness generally increases with increased dissolved-solids concentration. Streams draining lowlands and intermontane basins usually contain harder water than streams at higher altitudes. Representative samples of surface-water quality are graphically illustrated on a map of Alaska (fig. 18).

In Alaska, as elsewhere, all natural streams transport suspended sediment, although the quantity, size distribution, and physical and chemical nature of the particles vary from time to time and stream to stream. Much of the sediment originates at higher altitudes as fragmentary material produced by the chemical and mechanical disintegration (freezing and thawing) of bedrock and unconsolidated material. Additional sediment load comes from the activities of man such as industry, mining, highway construction and maintenance, and urban development, and from agrarian activities such as farming, harvesting timber, and grazing animals. The quantity and nature of stream-borne sediments are influenced by the topography, precipitation, temperature, geology, soil conditions, and vegetative cover. In Alaska, the character and distribution of suspended sediments are made even more complex by the contribution by glaciers of large amounts of very fine material (glacial flour) to many streams.

Knowledge of suspended-sediment discharge in Alaskan streams is very limited and is restricted to data from a few short-term daily sampling sites on the larger rivers. Similarly, knowledge of total sediment load is severely restricted primarily because measurements of the bedload portion of the total load are limited. Normal summer suspended-sediment concentrations represent the midian (middle) value using time-weighted estimates based on flow and sediment concentrations. In general, nonglacial streams transport less than 100 mg/l of suspended sediment during the summer; in contrast as much as 2,000 mg/l is carried in glacial streams. Nonglacial streams often transport their highest sediment concentrations during the spring melt or during periods of



From Feulner, Childers and Norman, (1971)

Figure 18. -- Chemical quality of surface water in some streams of Alaska.

heavy rainfall, whereas glacial streams transport their highest concentrations during heavy melt-water runoff, usually in middle or late summer. During fall and winter, both glacial and nonglacial streams carry less sediment than in summer. The normal suspended-sediment concentration between January and April is 20 mg/l or less for all streams sampled. Probably less than 15 percent of the annual suspended-sediment load is carried during this period. The percentage (dry weight) of material finer than 0.062 mm (millimetre) (silt-clay fraction as generally defined) transported by nonglacial streams is usually less than 50 percent in contrast to more than 50 percent for glacial streams.

Water Use

A multitude of demands is placed on the water resources in the Alaska region. These demands include: domestic needs; agricultural needs such as for irrigation and livestock; mining and energy needs in oil and natural gas production, coal, metallic mineral and gravel mining, petrochemical plants, hydroelectric and steam-electric operation; and needs for food and fiber industries such as fish and shell fish processing and pulp mills.

Climatic conditions influence water use in the State. Figure 19 illustrates the relation between water use and mean monthly air temperature in various communities during 1974. As would be expected, when temperatures increase in the summer, water use also increases (lawn watering, cooling). However, in some communities, winter water use may be nearly equal to or exceed summer water use. The increased water use during the winter is attributed to the practice of keeping the kitchen tap barely turned on to prevent the water pipes from freezing. Table 5 lists the estimated amounts of water used in each subregion by type of use.

The estimated amount of water used for domestic needs in the region was based on the population and the type of water utilities available. The population figures used were supplied by the Alaska Department of Community and Regional Affairs (1975b) and are based on revenue-sharing

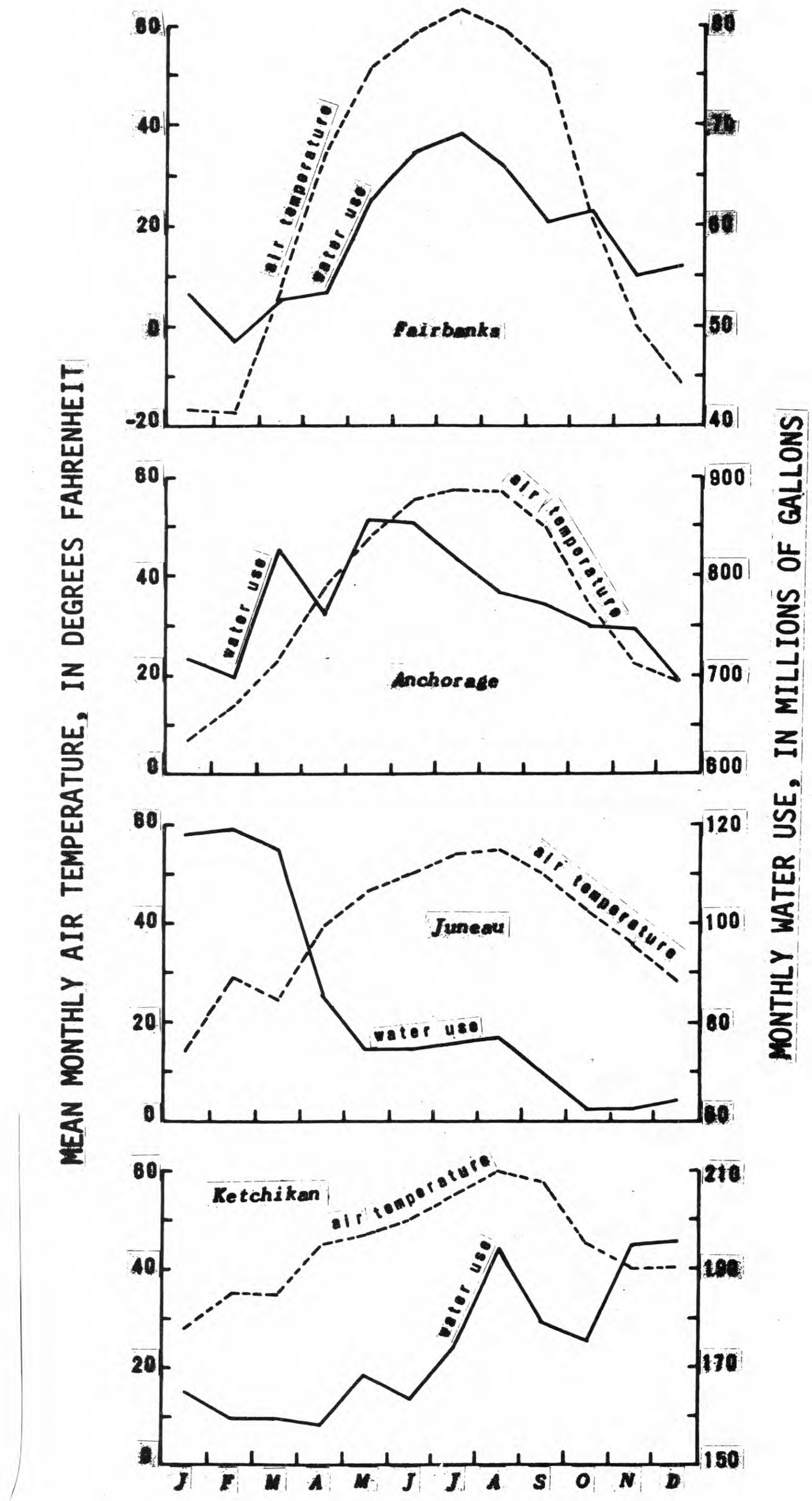


Figure 19. -- Water use as influenced by air temperature in some Alaskan communities during 1974.

Table 5.--*Estimated water use by subregion in millions of gallons per day.*

Water use	Subregion: Arctic	North-west	Yukon	South-west	South-central	South-east	Use totals
Domestic	0.551	0.485	9.403	0.864	38.604	17.400	67.307
Livestock		.045	.011	.112	.078		.246
Seafood processing				.515	3.299	1.260	5.074
Oil and gas development	.400				— *		.400
Petrochemical					2.578		2.578
Pulp mills						80.000	80.000
Coal processing			.270				.270
Steam electric			26.625		7.000		33.625
Mineral processing							
Sand and gravel			9.033	.231	1.570	.036	10.870
Fish hatcheries				.480	67.730	17,380	85.590
Irrigation (in acre-feet per year)			9,900		28,500		38,400
Hydroelectric (in acre-feet)					271,300	399,660	670,960

* Figures not available

statistics. Water utilities vary throughout the region. The larger cities and some of the remote villages have distribution systems. Other communities rely on individual private wells, a single community well, or a stream or lake watering point where the water is gathered on an individual basis or is hauled by truck to the users. Maximum domestic water demands range from 1,300 gal/d (gallons per day) per capita in Seward to 150 gal/d per capita in Fairbanks (R.G. Hansen, written commun., 1974). The remote villages use from 5 to 70 gal/d per capita depending on whether water is hand-carried from a watering point (5 gal/d), hauled by truck (10 gal/d), or distributed through a water system (70 gal/d) (J.A. Crum, Health, Education and Welfare, Environmental Health, Anchorage, oral commun., 1975).

Irrigation requirements were based on the number of planted acres and the gross water demands for the various crops. Livestock needs were based on the number of animals of each species and their respective water demands. The acreage and livestock figures were obtained from the publication "Alaska Agricultural Statistics" (U.S. Soil Conservation Service, 1973). Livestock water requirements (table 6) were obtained from the report "Livestock Water Use" (U.S. Soil Conservation Service, 1975). Information on the amount of water used for irrigation was obtained from R.M. Bell (written commun., 1975) of the Soil Conservation Service in Anchorage. J.R. Luick of the Institute of Arctic Biology has stated (oral commun., 1975) that reindeer take in about 4 gal/d in the summer and about 1 gal/d in the winter. Winter intake is chiefly in the form of snow.

Demands placed on the water resources by mining concerns will vary depending on the mineral involved. For a coal wash plant that processes over a million tons of coal a year, 700 gallons of water may be required per ton of coal. Likewise, in processing metallic ores by flotation methods, a thousand tons of ore a day (16 hours) may require 600 gal/min (gallons per minute) (576,000 gal/d) (R.G. Bottge, U.S. Bureau of Mines, Juneau, written commun., 1975).

Table 6.--*Water requirements for livestock (U.S. Soil Conservation Service, 1973)*

Livestock class	Consumption at moderate temperature (gallons per day) 1/
Cattle	
Bulls	11
Cows	7.75
Heifers	7.5
Steers	7.5
Calves	4
Milk cows	11-30 (used 15)
Sheep (stock)	2
Pork (breeders)	5
Hens (layers)	6.5 per 100 birds

1/ Consumption rates shown are at moderate temperatures. Increase consumption rates by 10 percent for areas having 90°F temperatures over 60 days a year.

The water requirement for oil and natural gas drill rigs amounts to about 40,000 gal/d per rig. This water is primarily used in boilers and drilling fluids at the drilling site.

Hydroelectric installations throughout the region range in peak output from 300 kw (kilowatts) to almost 48,000 kw (Alaska Power Administration, 1974). Table 7 lists the larger reservoirs, their useable storage, and subarea location.

The petrochemical industry is restricted to the Cook Inlet subarea, specifically the Kenai area. In 1974 the industry used about 820 million gallons of water.

Pulp mills are in Ketchikan and Sitka in the Southeast subregion. W.J. Sweeney, chief, Water Compliance Section, Environmental Protection Agency, Seattle, (written commun., 1975) indicated that one of the pulp mills in the Southeast subregion used on the average 39 Mgal/d of water from September 1974 through August 1975.

Approximately 60 seafood handling and processing facilities in the region are along the coast from as far north as Kotzebue south to Ketchikan. Their products are either fresh, frozen, cured, or canned and include salmon, halibut, herring, and other fish in addition to King, Dungeness, and Tanner crabs and shrimp, clams, abalone, and scallops. Water use depends on the size of each processing plant and the type of fish or shellfish processed. One processor of shellfish in the Kodiak-Shelikof subarea uses an average of between 350,000 and 400,000 gal/d; seasonal water use there ranges from 180,000 in the spring up to 520,000 gal/d during midsummer. R.G. Hansen (written commun., 1974) stated that the 15 processors in Kodiak use a total of about 5 Mgal/d. In 1974 Kodiak-based fishermen caught 187,200,000 pounds of salmon, crab, shrimp, and scallops; water used in processing is estimated to be 8.3 gallons of water per pound of seafood caught. The catch figure above does not include halibut and other bottom fish; therefore, a water-use factor of 5 gallons per pound of fish is probably more reasonable and was used in estimating the amount of water required by seafood processors in each subarea.

Table 7.--*Hydroelectric reservoirs in the Alaska region (Martin and Hanson, 1966)*

Reservoir	Useable storage (acre-feet)	Subarea
Annex Creek	23,360	Southeast
Blue Lake	150,000	Southeast
Cooper Lake	108,000	Cook Inlet
Crystal Lake (a)	8,300	Southeast
Eklutna Lake	163,300	Cook Inlet
Ketchikan Lake	18,000	Southeast
Long Lake	140,000	Southeast
Purple Lake	25,000	Southeast
Salmon Creek	19,000	Southeast
Upper Silvas Lake	16,000	Southeast

(a) M.F. Thomas, Federal Power Commission, written commun., 1976.

ARCTIC SUBREGION

West Arctic Subarea

The West Arctic subarea is one of three that make up the Arctic subregion (fig. 9). It covers an area of about 31,000 square miles and is bounded by the Colville River drainage and the DeLong Mountains on the east and south, respectively, and by the Arctic Ocean on the north and west. It lies in the Arctic climatic zone and has a distinctly polar climate, being exposed to the cold air blowing across the polar sea ice and the cold water of the Arctic Ocean.

Characteristic of the subarea are the long, cold winters and short, cool summers. The average annual temperature is about 17°F, the extremes being about -60° and 90°F. Precipitation averages approximately 7 inches annually and ranges from about 4 inches at Barrow to over 20 inches in the mountains. Rainfall is usually light during the summer, as is the snowfall during the winter.

The northern part of the subarea is a coastal plain, dotted with lakes and rising to altitudes as high as 600 feet. It is underlain by sedimentary deposits to depths of 200 feet or more. South of the Arctic Coastal Plain is the Arctic Foothills Province; altitudes there reach 1,500 feet or more. This province is underlain by sedimentary rocks that are faulted and have been intruded by mafic rocks. Most of the subarea is covered by peat and muskeg (Wahrhaftig, 1965).

The entire subarea is underlain by permafrost. Exceptions to this generalization may be sediments beneath lakes more than 7 feet deep and sediments beneath the larger rivers. Permafrost is reported to be in excess of 1,300 feet thick near Barrow (Ferrians, 1965) and may be nearly 1,000 feet thick throughout much of the subarea.

Surface Water.--Several rivers drain the subarea. They are: the Kukpowruk (drainage area 1,870 mi^2 [square miles]), Kokolik (2,310 mi^2), Utukok, (2,700 mi^2), Kuk (4,180 mi^2), Meade (3,850 mi^2), and Ikpikpuk

(4,540 mi^2) Rivers. None of these is a major stream, and there is little recorded data on them. Streamflow records have been gathered on three streams near Barrow (see page 228).

The estimated mean annual runoff of the subarea averages about 0.5 ft^3/s per square mile (fig. 20). In the northern part of the subarea runoff is generally less than 0.2 ft^3/s per square mile; this figure increases to about 1 ft^3/s per square mile on the southern limits of the subarea. Table 2 shows the estimated mean monthly and mean annual runoff for the entire subarea.

Severe flooding in larger stream channels is probably quite frequent, but little is actually known about the magnitude or frequency of flooding in the subarea. Flooding can be caused by rapid snowmelt or by intense, long periods of rainfall. During spring breakup, between late May and early July, the height of the floodflow is significantly increased by the presence of ice jams. Flooding is also caused by the growth of large icings (aufeis) that cover the flood plains to heights exceeding the open channel flood stages.

The estimated low month mean runoff of streams in the subarea is zero. Part of the water in a stream channel may remain fluid throughout the year; however, no detectable flow can be measured during winter months.

Surface water in the subarea is considered to be of acceptable chemical quality for domestic use. Calcium and bicarbonate make up over 80 percent of the dissolved-solids concentrations. Lake water is frequently characterized by objectionable color and odor and the presence of iron. Near the coast of the Arctic Ocean (where more lake waters have been sampled than in the other parts of the subarea) water is high in sodium chloride. Based on the little data at hand, the mineral content of surface water is within the limits recommended by the Environmental Protection Agency (1972) for public supplies. Table 8 shows the chemical concentrations of some selected stream waters in the subarea.

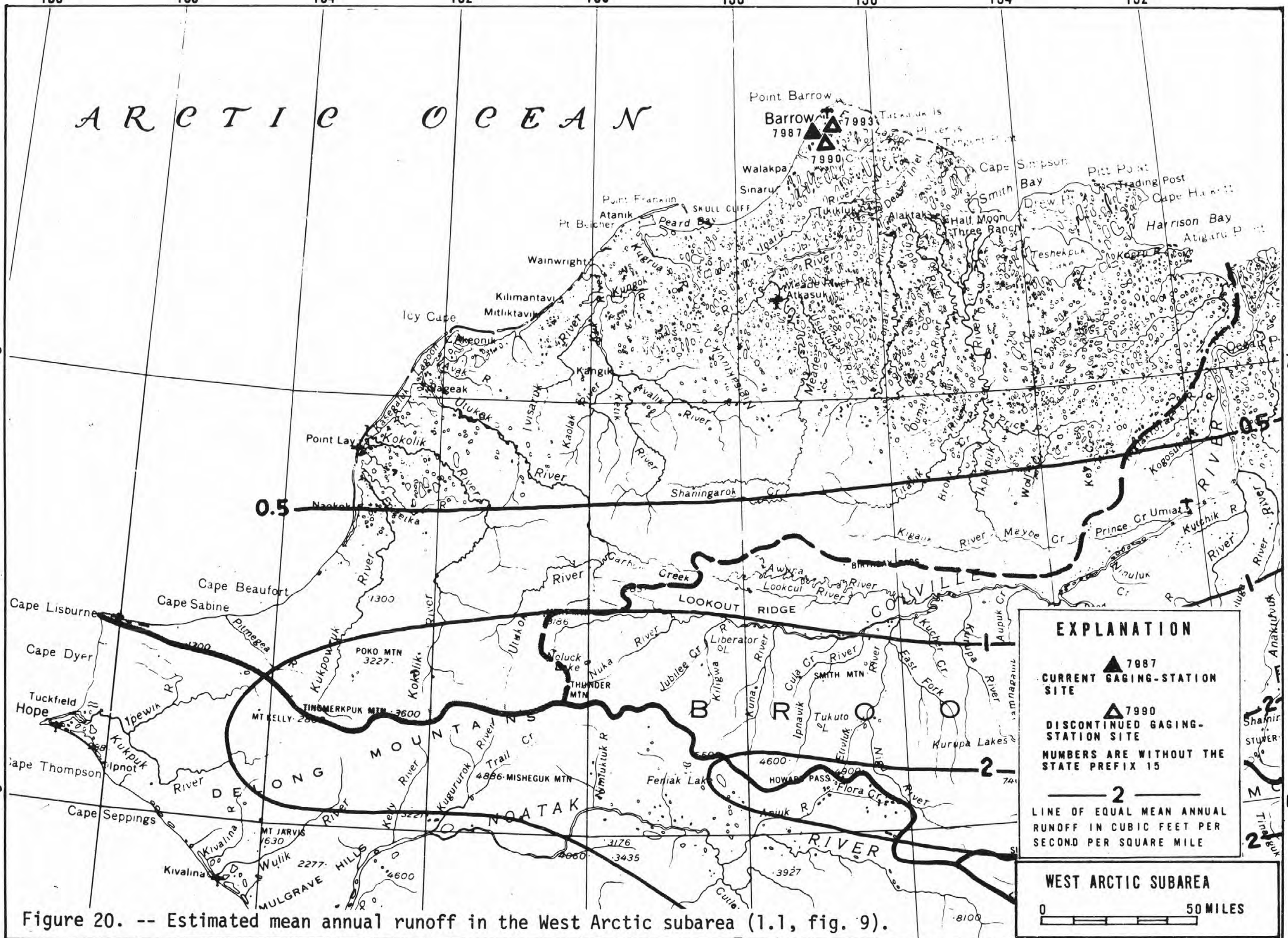


Figure 20. -- Estimated mean annual runoff in the West Arctic subarea (1.1, fig. 9).

Base from U.S.Geological Survey map E (scale 1:2,500,00) of Alaska

Data from Joint Federal-State Land Use Planning Commission (1974)

Table 8.--*Water quality of selected streams in the West Arctic subarea.*
[concentrations in milligrams per litre (mg/l) or micrograms per litre (µg/l)]

Date and discharge (ft^3/s)	mg/l	µg/l		mg/l												Specific conductance (µmhos/cm at 25°C)	pH units
	Silica (SiO_2)	Iron (Fe)	Manganese (Mn)	Calcium (Ca)	Magnesium (Mg)	Sodium (Na)	Potassium (K)	Bicarbonate (HCO_3)	Carbonate (CO_3)	Sulfate (SO_4)	Chloride (Cl)	Fluoride (F)	Nitrate (as N)	Dissolved solids	Total hardness		
15798700 Nunavak Creek near Barrow																	
07-10-72 0.54	0	350(a)	10(a)	11	5.1	8.8	0.2	43	0	0.2	22	0.1	0.05	69	49	145	7.4
08-29-72 8.6	.6	90(a)	0(a)	11	4.9	9.9	.4	35	0	2.3	26	.1	.00	73	48	149	7.1
15799000 Esatkuat Creek near Barrow																	
08-29-72 0.09	1.6	60(b)	10(b)	15	7.2	11	.8	56	0	13	21	.2	.01	97	67	184	6.9
06-13-73 21	.4	390(b)	170(b)	3.4	2.1	5.5	2.4	11	0	2.7	11	.0	.02	34	17	53	6.1

a Total
b Dissolved

Based, again, on scanty data, the temperature of surface water in the subarea is believed to have an annual range of from about 32° to 38°F. During the summer the water temperature in some lakes and slower flowing streams may exceed 38°F.

Figure 21 shows the estimated suspended-sediment concentrations that may be expected during normal summer runoff in the subarea.

Ground Water.--The only known development of ground water in the subarea is at Cape Lisburne. There, frozen gravels underlying a small stream were exposed by removing the overburden, allowing the permafrost to thaw to depths of nearly 20 feet. A gallery was then installed; it produces water throughout most of the year (Feulner and Williams, 1967).

Beneath sizable streams water is potentially available year-round from unfrozen alluvium. Permafrost may also be absent beneath large lakes and water may be available to wells at those sites; however, such water is generally highly mineralized. Figure 22 shows the estimated availability of ground water in the subarea. (The availability of ground water shown in figure 22 and other similar figures is largely theoretical. In many areas there are no wells, and the availability indicated is a generalized estimate.)

The only known information on quality of ground water in the subarea comes from the gallery system installed at Cape Lisburne (table 9) which reflects the quality of the stream flowing above it. The dissolved-solids concentrations range from about 94 mg/l during the summer months to a high of 225 mg/l in late winter. The water is of the calcium bicarbonate type. Ground-water temperature data are likewise limited to one point, Cape Lisburne. Water temperatures were taken at random intervals throughout the period of development and ranged between 32° and 36°F. After construction of the gallery the ground adjacent to it was heated with a steam line so that true ground-water temperatures can no longer be taken there.

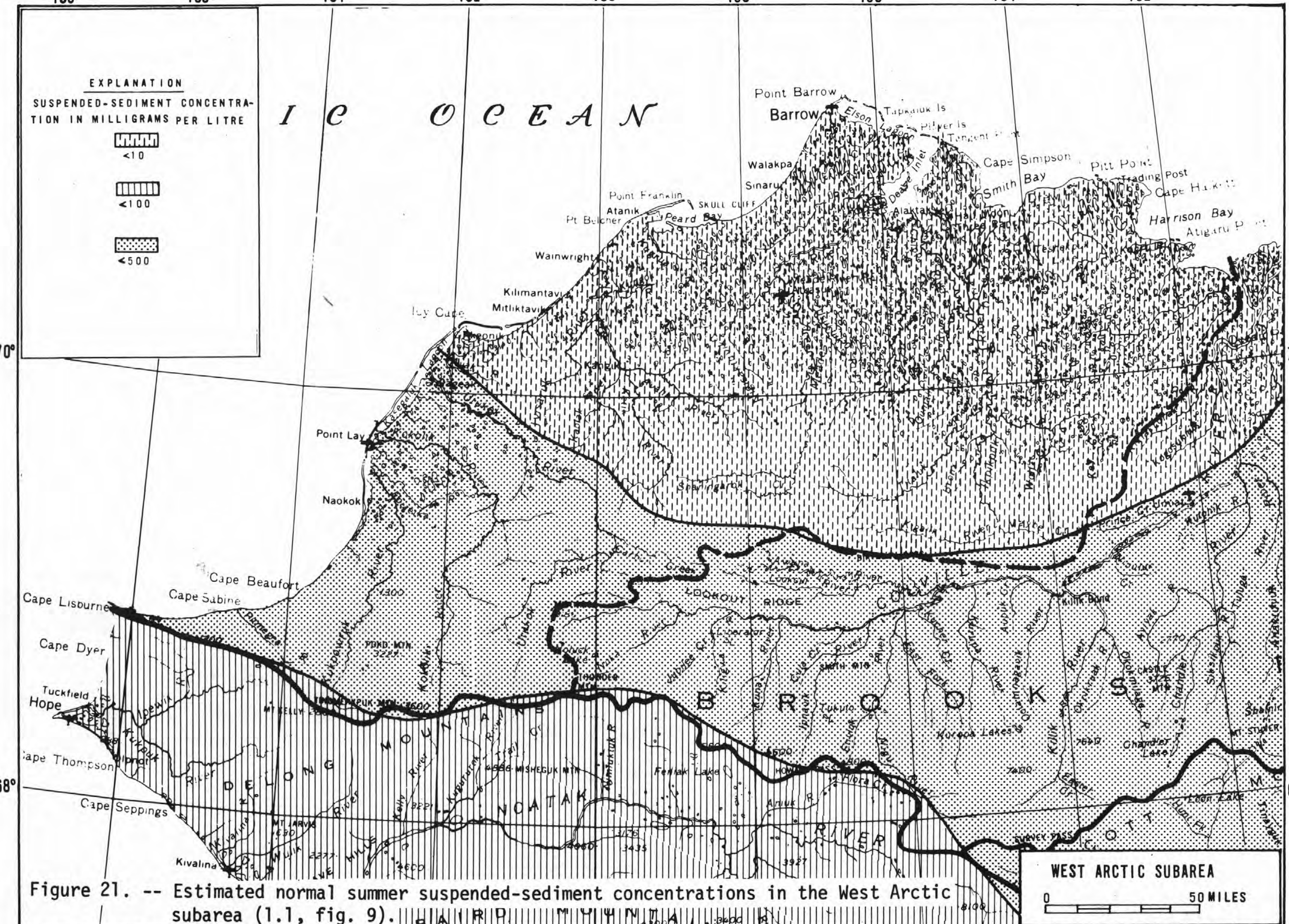


Figure 21. -- Estimated normal summer suspended-sediment concentrations in the West Arctic subarea (1.1, fig. 9).

Base from U.S.Geological Survey map E (scale 1:2,500,00) of Alaska

Data from Joint Federal-State Land Use Planning Commission (1974)

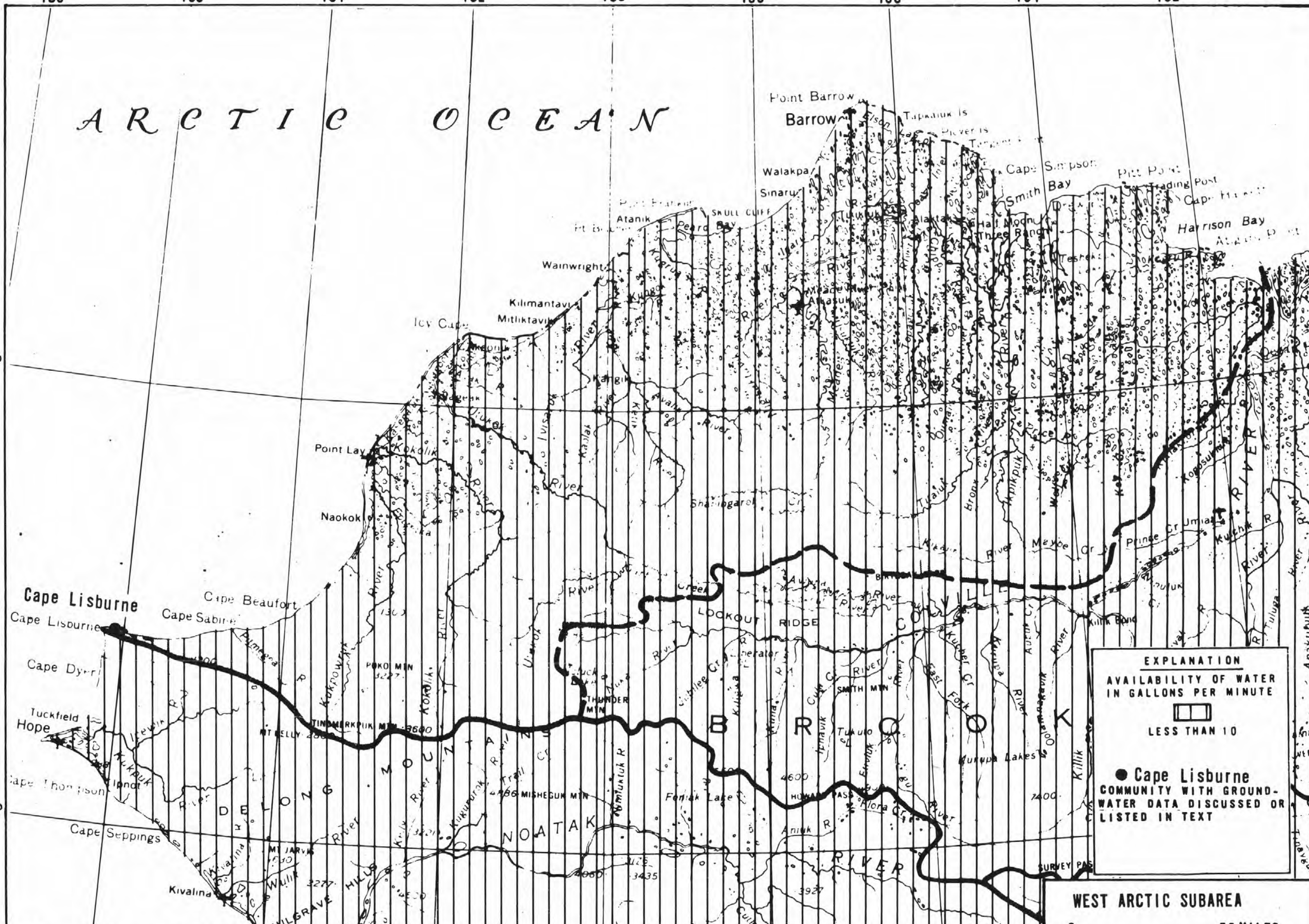


Figure 22. -- Estimated ground-water yields in the West Arctic subarea (1.1, fig. 9).

Base from U.S.Geological Survey map E (scale 1:2,500,00) of Alaska

Data from Joint Federal-State Land Use Planning Commission (1974)

Table 9.--*Chemical analyses of ground water in the West Arctic subarea.*

[concentrations in milligrams per litre (mg/l) or micrograms per litre (µg/l)]

				mg/l	µg/l		mg/l													
Location	Date	Well depth (ft)	Temperature (°C)	Silica (SiO_2)	Iron (Fe)	Manganese (Mn)	Calcium (Ca)	Magnesium (Mg)	Sodium (Na)	Potassium (K)	Bicarbonate (HCO_3)	Carbonate (CO_3)	Sulfate (SO_4)	Chloride (Cl)	Fluoride (F)	Nitrate (as N)	Dissolved solids	Total hardness	Specific conductance (µmhos/cm at 25°C)	pH units
WELLS																				
Cape Lisburne	03-26-73	--	--	2.1	60(a)	.00(a)	47	10	7.7	0.6	153	0	30	15	0.1	0.3	189	160	351	7.7

a Dissolved

Water Use.--There are no industrial or agricultural enterprises in the subarea; water consumption is limited to domestic use only. It has been estimated that people in Barrow use an average of from 50 gal/d per person (Alter, 1969) to 70 gal/d per person (J.A. Crum, Health, Education and Welfare, Environmental Health, oral commun., 1975). From recent population figures (Alaska Dept. of Community and Regional Affairs, 1975b) and the above use-rate figures, estimated water use in the subarea is about 119,000 gal/d.

Colville Subarea

The Colville subarea (fig. 9) covers 24,000 square miles and lies in the Arctic climatic zone. The average annual temperature is about 17°F. Precipitation ranges from less than 10 to more than 20 inches per year; the annual average is about 12 inches.

Only the narrow northern extremity of the Colville subarea is on the coastal plain. Most of the subarea lies in the Arctic Foothills Province but is bounded on the south by the crest of the Brooks Range (Wahrhaftig, 1965). Except for areas beneath the river or immediately adjacent to the river, the entire subarea is underlain with permafrost, believed to be nearly 1,000 feet thick (Ferrians, 1965).

Surface Water.--The principal stream system in the subarea is the Colville River (est. 24,000 mi^2) and its tributaries. The estimated mean annual stream discharge in the Colville subarea is about 1.0 ft^3/s per square mile. Along the northern coastal part the estimated runoff is less than 0.5 ft^3/s. In the southern, more mountainous part, estimated runoff exceeds 2 ft^3/s per square mile (fig. 23). Table 2 shows the estimated mean monthly and mean annual runoff for the subarea. As there are no long-term discharge records for the Colville River, the runoff values given here are based on unit runoff values for the East Arctic subarea.

Peak runoff and sediment discharge probably occur in late May through early July. Peak runoff is estimated to be about 10 ft^3/s per

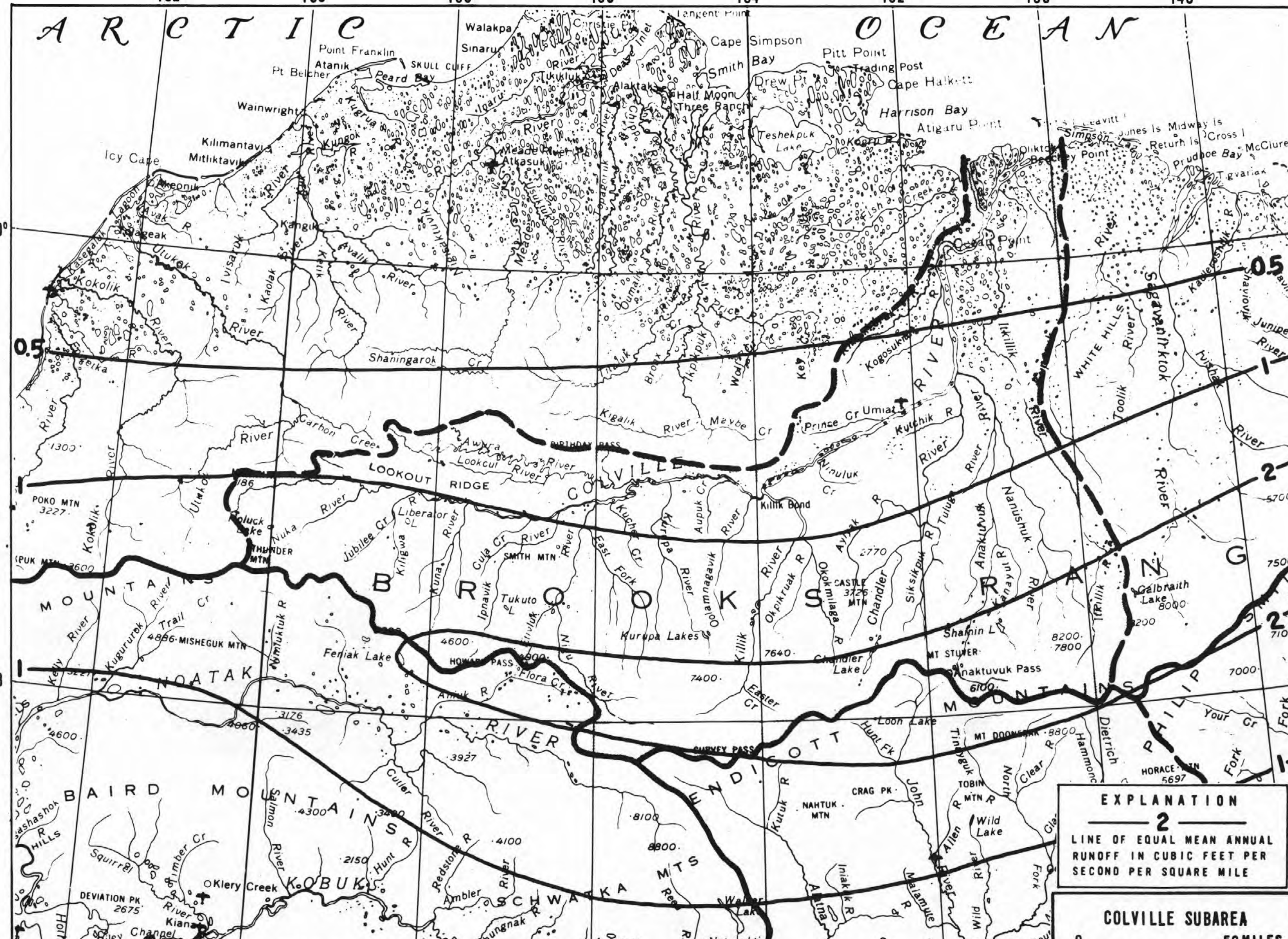


Figure 23. -- Estimated mean annual runoff in the Colville subarea (1.2, fig. 9).

Base from U.S. Geological Survey map E (scale 1:2,500,00) of Alaska

Data from Joint Federal-State Land Use Planning Commission (1974)

square mile throughout much of the subarea. Flooding in the downstream reaches of the river is relatively common. Rapid snowmelt or intense, long periods of precipitation cause flooding during the peak flow periods. Flooding is also caused by ice jams and the growth of large icings that form and cover the river flood plains to heights that exceed the open-channel flood stage.

The low month mean runoff of streams within the subarea is thought to be zero. The flow beneath ice is so slow that it is unmeasurable during the late winter months.

Surface water in the Colville subarea can be considered to be of acceptable chemical quality for domestic use. Calcium and bicarbonate generally constitute more than 80 percent of the dissolved-solids concentrations of surface waters in the subarea. In general, lake water is commonly characterized by objectionable color and odor and the presence of iron. Near the coast of the Arctic Ocean where some lakes have been sampled, water is high in sodium chloride. Based on sparse data at hand, the mineral content of surface water is within the limits recommended by the Environmental Protection Agency (1972) for public water supplies. Table 10 lists chemical analyses of the Colville River at different locations.

Sediment in streams along the Brooks Range is derived by means of a complex set of processes that involve primarily mechanical forces. These forces are: expansion and contraction of rocks owing to temperature changes, freezing and thawing of water (ice wedging), erosion of fine-grained deposits such as shales, and abrasion of rocks against one another in debris slides and solifluction. Several small glaciers are also sources of sediment.

The estimated annual rate of sediment yield of the Colville River is roughly the same as that estimated for the Yukon River (about 300 tons of sediment per square mile of drainage area). Maximum suspended-sediment concentrations during short-term observations have reached

Table 10.--*Water quality of the Colville River, Colville subarea.*

[concentrations in milligrams per litre (mg/l) or micrograms per litre (µg/l)]

Date and discharge (ft^3/s)	mg/l	µg/l		mg/l												Specific conductance (µmhos/cm at 25°C)	pH units
	Silica (SiO_2)	Iron (Fe)	Manganese (Mn)	Calcium (Ca)	Magnesium (Mg)	Sodium (Na)	Potassium (K)	Bicarbonate (HCO_3)	Carbonate (CO_3)	Sulfate (SO_4)	Chloride (Cl)	Fluoride (F)	Nitrate (as N)	Dissolved solids	Total hardness		
								Colville River near Umiat									
04-30-69 --	8	--	--	83	27	13	1.8	382	0	38	0	0.1	.00	359	318	637	7.6
05-01-69 --	5.2	230(a)	--	36	12	5.5	1.3	152	0	26	0	.1	.50	164	140	283	8.0
								Colville River near Nuiqsut									
04-29-75 --	4.0	--	--	--	--	160	6.1	198	0	65	290	.1	.29	--	292	1,520	7.5
08-14-75 12,700	2.1	20(b)	0(b)	22	5	2.5	.6	78	0	9.5	1.5	.1	.09	85	76	160	8.1

a Undifferentiated
b Dissolved

1,650 mg/l on the Colville River. Maximum values several times this high are believed possible at extreme high flows. Essentially all sediment in the subarea is probably carried in the months of May to October of each year. Figure 24 shows the estimated suspended-sediment concentrations that may be expected in the subarea during normal summer stream discharge.

There are few data on temperatures of surface water for the Colville subarea. Temperatures taken at random intervals range from about 32°F to a high of 38°F. During the summer, water temperatures in lakes on the coastal lowlands may exceed 38°F.

Ground Water.--The only known ground-water development in the area is at Anaktuvuk Pass where a well 76 feet deep produced water of good chemical quality (table 11). A study of the Umiat area (Williams, 1970a) suggested that ground water could be obtained in gravel deposits adjacent to the Colville River. No tests, however, have been made to prove this possibility. Figure 25 shows the estimated potential yield of the subarea. Most of the subarea is thought to have little or no ground-water potential, but in some places yields up to 10 gal/min may be obtained.

Water Use.--Water use in the subarea is limited to that by the few inhabitants at Nuiqsut and Anaktuvuk Pass who need it only for domestic purposes. Water use by natives in the remote settlements in the subarea is probably 1 to 5 gal/d per person. No industries are operating in the subarea; however, some seasonal oil and gas exploration is taking place in the form of seismic crews surveying the area. Their water needs are probably 10 to 20 gal/d per person. The current population in the subarea is not known at this time, but a total water-use rate of 2,000 gal/d is probably not unreasonable. Practically all the water is from surface-water sources except for the well at Anaktuvuk Pass.

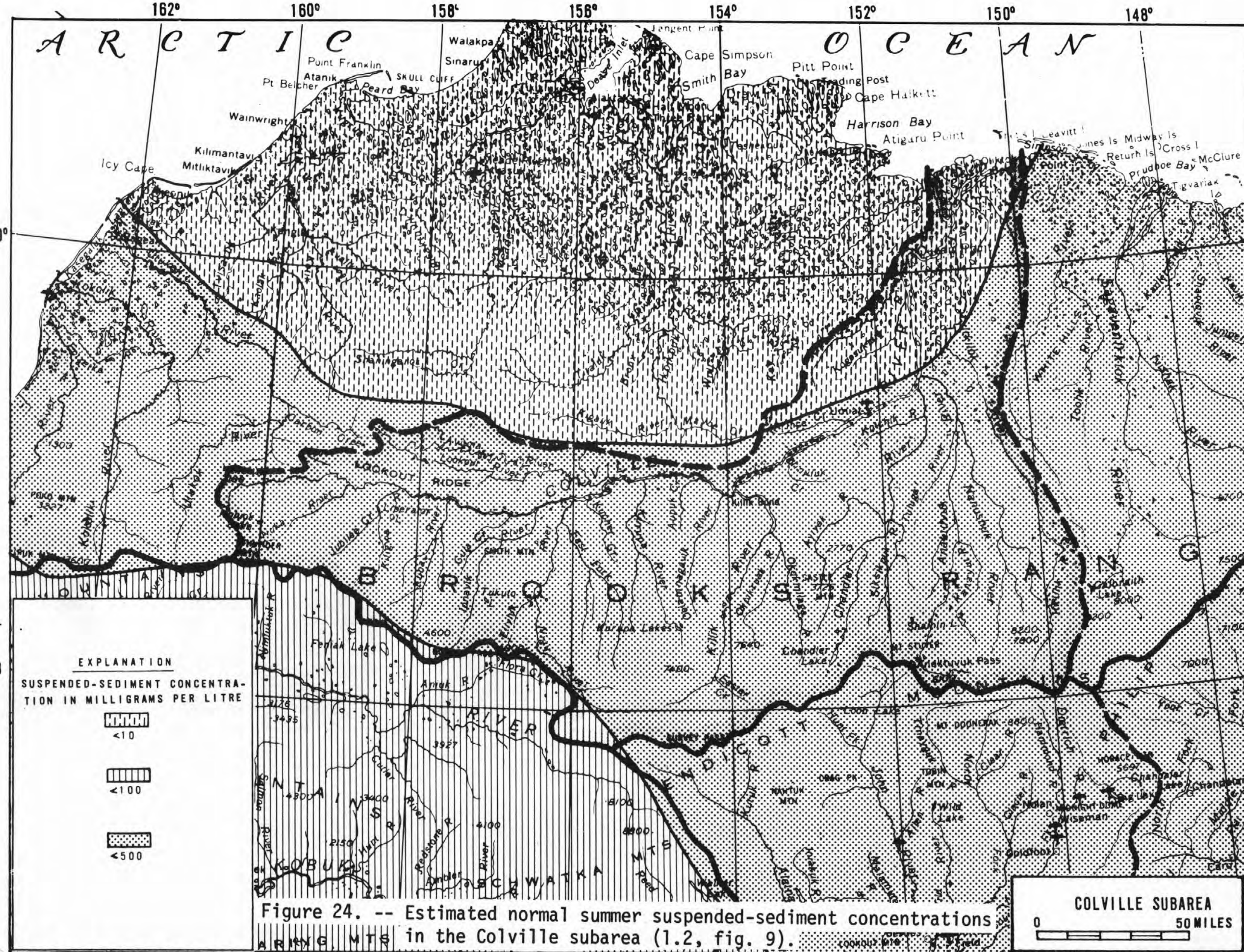


Figure 24. -- Estimated normal summer suspended-sediment concentrations in the Colville subarea (1.2, fig. 9).

Base from U.S.Geological Survey map E (scale 1:2,500,00) of Alaska

Data from Joint Federal-State Land Use Planning Commission (1974)

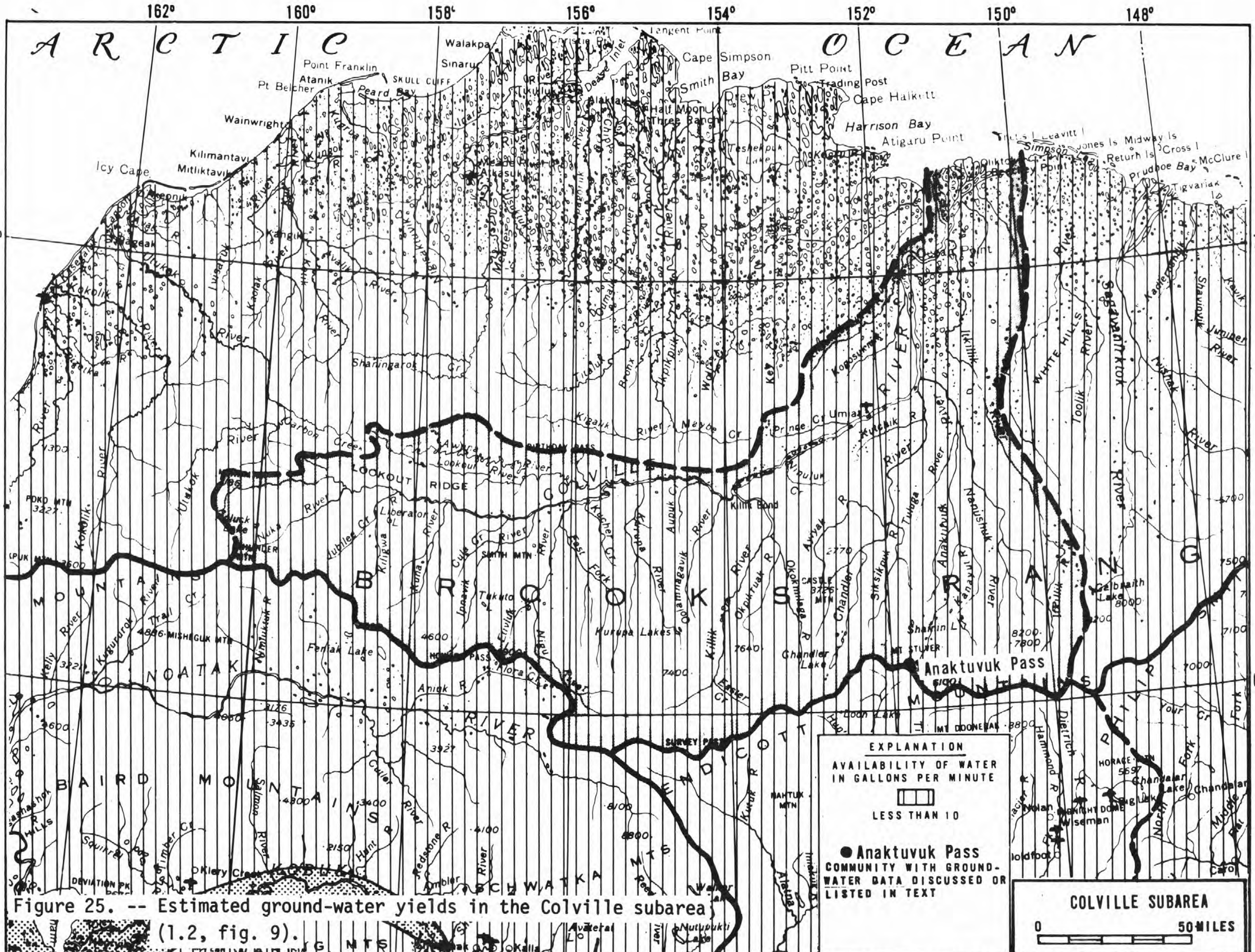


Figure 25. -- Estimated ground-water yields in the Colville subarea (1.2, fig. 9).

Base from U.S.Geological Survey map E (scale 1:2,500,00) of Alaska

Data from Joint Federal-State Land Use Planning Commission (1974)

Table 11.--*Chemical analyses of ground water in the Colville subarea.*

[concentrations in milligrams per litre (mg/l) or micrograms per litre (µg/l)]

Location	Date	Well depth (ft)	Temperature (°C)	mg/l	µg/l		mg/l												Specific conductance (µmhos/cm at 25°C)	pH units
				Silica (SiO_2)	Iron (Fe)	Manganese (Mn)	Calcium (Ca)	Magnesium (Mg)	Sodium (Na)	Potassium (K)	Bicarbonate (HCO_3)	Carbonate (CO_3)	Sulfate (SO_4)	Chloride (Cl)	Fluoride (F)	Nitrate (as N)	Dissolved solids	Total hardness		
WELLS																				
Anaktuvuk	05-02-74	72	3.5	3.2	40(a)	0(a)	28	3.8	0.2	0.3	97	0	5.8	0.7	0.0	0.57	92	86	177	7.7
SPRINGS																				
Anaktuvuk	03-07-72	--	5.0	4.3	40(b)	10(b)	60	12	2.6	.8	236	0	13	.8	.1	.20	211	199	379	7.7

a Dissolved
b Total

East Arctic Subarea

The East Arctic subarea (fig. 9) covers 26,000 square miles and lies entirely in the Arctic climatic zone. The average annual temperature is about 17°F, and the average annual precipitation ranges from 6 inches at Barter Island to more than 30 inches in the mountainous areas.

Nearly the entire East Arctic subarea is underlain by permafrost, the only exceptions being near major streams and at springs which flow throughout the year. Although the maximum thickness of permafrost is not known, tests in oil wells show that temperatures below 32°F extend to depths greater than 2,000 feet in the Prudhoe Bay area (Howitt and Clegg, 1970).

Surface Water.--The principal streams are the Kuparuk (est. drainage area 3,700 mi^2), Sagavanirktok (est. 5,600 mi^2), and Canning (est. 2,300 mi^2) Rivers. Several other shorter streams also flow from the mountains to the Arctic Ocean. The estimated mean annual stream discharge in the East Arctic subarea ranges from less than 0.5 to more than 2.0 ft^3/s per square mile and averages about 1.0 ft^3/s per square mile (fig. 26). Table 2 shows the estimated mean monthly and mean annual runoff for the subarea. Three gaging stations are currently being operated in the subarea.

Flooding occurs in June or early July due to excessive snowmelt, extended periods of precipitation, and ice jams. Flooding and peak sediment load of streams occur during the same period of the year. Data available thus far indicate that virtually the entire subarea has a low flow of zero ft^3/s per square mile.

Surface water in the subarea is generally of the calcium bicarbonate type. Lake water is commonly characterized by objectionable color and odor and the presence of iron. Based on the little data at hand, the mineral content of surface water is within the limits recommended by the Environmental Protection Agency (1972) for public water

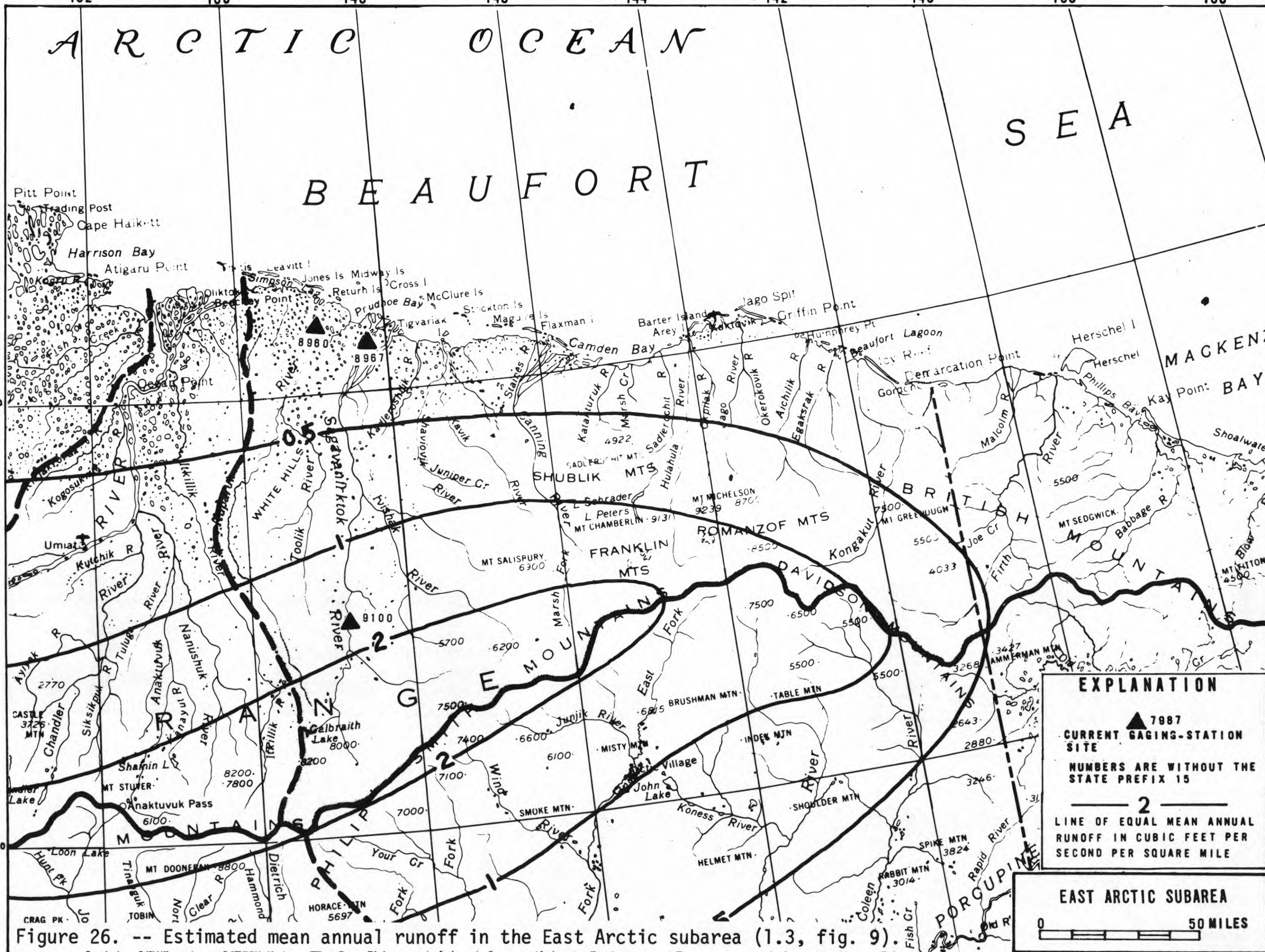


Figure 26. -- Estimated mean annual runoff in the East Arctic subarea (1.3, fig. 9).

Base from U.S.Geological Survey map E (scale 1:2,500,00) of Alaska 146° Data from Joint Federal-State Land Use Planning Commission (1974) supplies. Table 12 lists examples of chemical quality of surface waters in the subarea.

Figure 27 is a generalized map showing estimated suspended-sediment concentrations of the subarea during normal summer stream runoff. Sediment concentrations have been measured over short periods in Chamberlin Creek at more than 3,000 mg/l. The samples were taken at a point below a glacier where sediment discharge is probably greatest. The estimated annual suspended-sediment yield of Chamberlin Creek is 1,000 tons per square mile of drainage area.

Data on surface-water temperature in the East Arctic subarea is meager. Temperatures taken at random intervals and sites throughout the year suggest a range of between 32° and 38°F. Water temperatures in in lakes near the coast may exceed 38°F during summer months.

Ground Water.--Until recently no ground-water supplies were known to have been developed in the East Arctic subarea. However, with the beginning of the oil pipeline construction from Prudhoe Bay to Valdez, efforts have been made to develop ground-water supplies particularly at Franklin Bluffs, Galbraith Lake, Happy Valley, and Atigun camps and at pump stations 3 and 4. These sources are simply gallery systems adjacent to or directly in a streambed except for the wells at pump stations 3 and 4. The yields of these galleries are unknown at this time. Much of the subarea would have no ground-water yield because of the extensive presence of permafrost. Figure 28 indicates the estimated ground-water yield in the subarea and table 13 lists some chemical analyses of ground water in the subarea.

Water Use.--Water use in the area is for both industrial and domestic purposes. The village of Kaktovik and the various pipeline construction and petroleum exploration camps are the major domestic users. The villagers probably use 1 to 5 gal/d per person. In the camps where water and sewage-treatment plants and other modern facilities exist, the water use is probably 100 gal/d per person. Drill rigs

Table 12.--*Water quality of selected streams in the East Arctic subarea.*

[concentrations in milligrams per litre (mg/l) or micrograms per litre (µg/l)]

Date and discharge (ft^3/s)	mg/l	µg/l		mg/l												Specific conductance (µmhos/cm at 25°C)	pH units
	Silica (SiO_2)	Iron (Fe)	Manganese (Mn)	Calcium (Ca)	Magnesium (Mg)	Sodium (Na)	Potassium (K)	Bicarbonate (HCO_3)	Carbonate (CO_3)	Sulfate (SO_4)	Chloride (Cl)	Fluoride (F)	Nitrate (as N)	Dissolved solids	Total hardness		
15896000 Kuparuk River near Deadhorse																	
11-20-70 --	3.1	230(a)	70(a)	66	5.5	3.9	0.8	221	0	3.3	2.5	0.2	0.05	197	186	336	8.2
08-13-74 208	1.5	40(a)	0(a)	24	2.3	2.1	.3	87	--	2.4	1.7	.0	.13	77	69	125	7.9
15896700 Putuligayuk River near Deadhorse																	
06-23-72 200	1.1	50(a)	220(a)	33	2.5	2.8	.4	110	0	.2	7.8	.1	.05	99	93	170	8.1
08-30-72 79	2.3	30(b)	200(b)	64	4.6	4.3	.7	209	0	2.2	12	.2	.00	193	180	350	7.8
15910000 Sagavanirktok River near Sagwon																	
03-17-72 1.7	2.3	70(a)	0(a)	39	5.5	2.3	.2	133	0	11	.0	.1	.18	126	119	270	8.0
06-22-72 5,780	1.6	20(a)	120(a)	24	3.4	.5	.2	84	0	5.5	2.0	.2	.07	78	74	140	8.4

a Dissolved
b Total

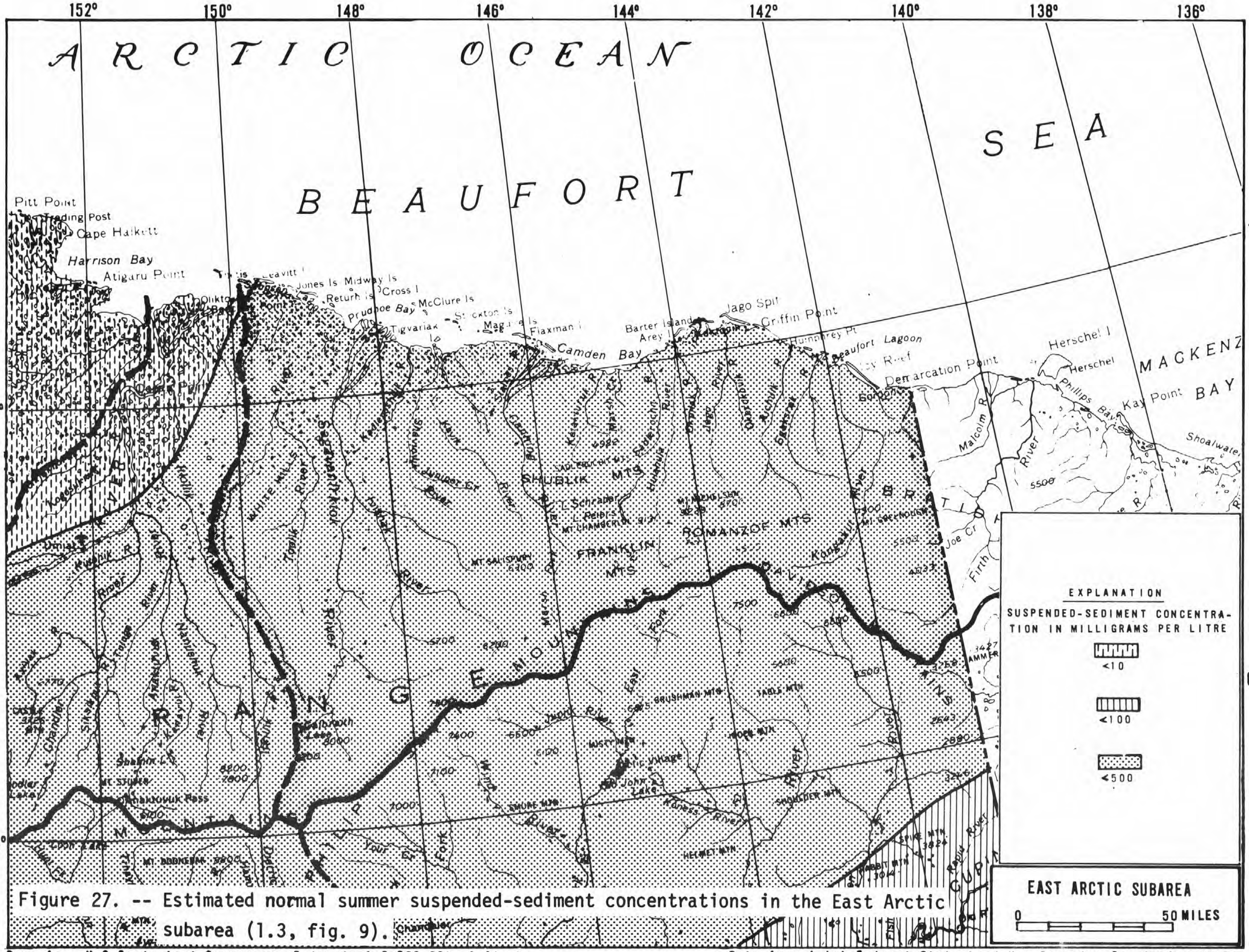


Figure 27. -- Estimated normal summer suspended-sediment concentrations in the East Arctic subarea (1.3, fig. 9).

Base from U.S.Geological Survey map E (scale 1:2,500,00) of Alaska

Data from Joint Federal-State Land Use Planning Commission (1974)

Figure 28. -- Estimated ground-water yields in the East Arctic subarea (1.3, fig. 9).

Base from U.S.Geological Survey map E (scale 1:2,500,00) of Alaska

Data from Joint Federal-State Land Use Planning Commission (1974)

Table 13.--*Chemical analyses of ground water in the East Arctic subarea.*

[concentrations in milligrams per litre (mg/l) or micrograms per litre (µg/l)]

Location	Date	Well depth (ft)	Temperature (°C)	mg/l	µg/l		mg/l												Specific conductance (µmhos/cm at 25°C)	pH units
				Silica (SiO_2)	Iron (Fe)	Manganese (Mn)	Calcium (Ca)	Magnesium (Mg)	Sodium (Na)	Potassium (K)	Bicarbonate (HCO_3)	Carbonate (CO_3)	Sulfate (SO_4)	Chloride (Cl)	Fluoride (F)	Nitrate (as N)	Dissolved solids	Total hardness		
WELLS																				
ARCO Prudhoe Bay	08-03-71	10	6.0	1.5	0(a)	40(a)	33	5.8	0.8	0.2	117	0	9.5	0.2	0.3	0.32	111	106	215	7.8
Galbraith Lake	08-12-71	19	2.0	3.5	0(a)	10(a)	43	7.9	.5	.2	159	0	5.4	.5	.4	.34	141	140	247	8.0
Happy Valley Camp	08-13-71	--	6.0	2.5	130(a)	20(a)	6.1	.8	.2	.2	17	0	4.0	.1	.4	.34	24	18	35	7.2
SPRINGS																				
Lupine	05-09-73	--	2.5	3.7	30(b)	0(b)	51	7.7	.4	.1	177	0	12	2.8	.3	.13	166	160	282	7.8
Ivashak	05-11-73	--	7.5	5.8	20(b)	10(b)	36	9.1	.4	.1	137	0	13	.6	.6	.04	133	130	225	8.0
Echooka	05-10-73	--	7.0	5.8	50(b)	0(b)	36	9.8	1.3	.2	131	0	24	1.3	.3	.03	143	130	241	7.9
Shublik	05-10-73	--	5.5	4.8	50(b)	0(b)	38	11	1.5	.3	127	0	37	1.3	.5	.03	157	140	225	8.0

a Total
b Dissolved

use water for boilers, drilling fluids, and drinking water at a rate of about 40,000 gal/d.

An estimated 4,000 persons using 100 gal/d each would use 400,000 gal/d. An estimated 10 drilling rigs each using 40,000 gal/d would use an additional 400,000 gal/d for an approximate total of 800,000 gal/d. This would be equivalent to a well pumping at a continuous rate of 555 gal/min.

Winter water use during 1974-75 by the camps resulted in depletion of the main pools in the Sagavanirktok River and the lowering of lake levels in the area until their water quality became unsatisfactory. During that time the search for surface-water pools in the river extended to as far as 30 miles from the base of operations. Studies are currently underway to find adequate water supplies in the area.

NORTHWEST SUBREGION

Kotzebue Sound Subarea

The Kotzebue Sound subarea is bounded on the north by part of the Arctic subregion, on the east by the Koyukuk subarea, on the south by the Norton Sound subarea, and on the west by Kotzebue Sound and the Chukchi Sea (fig. 9). It covers 41,000 square miles and lies mostly in the Arctic climatic zone; a few square miles in the east lie in the Continental climatic zone. Normal summer temperatures range between 30° and 50°F, and winter temperatures range from about 0° to 10°F. Precipitation in the subarea averages about 15 inches per year.

The lowland areas are covered by sand and gravel deposits of Holocene age. The mountains to the north consist of folded and faulted rocks which have been intruded by massive diabase sills. The northern part of the subarea is a great thrust sheet, thrust northward over the Arctic Foothills. Farther to the south, the Baird Mountains are composed of schist, quartzite, and limestone. Structural trends are generally east-west. Relatively flat-lying volcanic rocks are found in the Seward Peninsula part of the subarea (Wahrhaftig, 1965).

Thick permafrost is extensive in the northern part and is only slightly thinner in the southern part; exceptions, permafrost free areas, are found near the major river systems. Permafrost has been reported to be 1,200 feet thick near Cape Thompson, but is only about 200 to 300 feet thick in the Seward Peninsula area (Williams, 1970b). No glaciers occur within the subarea, but there are several snowfields which last from one year to the next.

Surface Water.--The Kobuk and Noatak Rivers are the principal streams in the subarea. Rapid rises in stream levels following heavy precipitation and the equally rapid drop to low flows in the absence of precipitation are characteristic of streams in the subarea. Estimated annual runoff averages less than 1 ft^3/s per square mile, but can be higher than 2 ft^3/s per square mile in the uplands near the mountains (fig. 29). Table 2 shows the estimated mean monthly and mean annual runoff for the subarea based on unit-area runoff of the Kobuk River at Ambler.

Estimated annual peak runoff averages more than 25 ft^3/s per square mile in the lowlands and ranges up to more than 50 ft^3/s per square mile in the uplands. Annual peak flows can be caused by summer rainstorms or by spring snowmelt. Icings in stream channels are common and may cause flooding in the spring. Figure 30 illustrates the flood frequency and magnitude of selected streams in the subarea. This illustration and similar ones that follow are based on the Log-Pearson Type III analysis (U.S. Water Resources Council, 1967).

Estimated low month mean runoff is very low. No measurable runoff in streams adjacent to the coastal areas has been observed; inland flow rates are exceedingly low, but flows do occur during winter months.

The overall chemical quality of surface water is acceptable for domestic use. Surface-water samples generally contain less than 200 mg/l of dissolved solids and most are of the calcium bicarbonate type. Water in coastal areas is generally higher in sodium chloride content than inland waters sampled. Table 14 shows the concentrations of some chemical constituents for water from selected streams in the subarea. Observed water temperatures range from 32° to 39°F.

Sediment samples have been taken for only a short period of time in the subarea. Data collected suggest that the suspended-sediment concentrations in streams generally range between 10 and 100 mg/l during normal summer stream discharge (fig. 31). Winter concentrations in the perennial streams are less than 20 mg/l. The only streams for which such data have been computed are the Kobuk River at Ambler and Ogotoruk Creek near Point Hope. They show a total annual sediment-yield rate of 60 tons per square mile.

[concentrations in milligrams per litre (mg/l) or micrograms per litre (µg/l)]

Date and discharge (ft^3/s)	mg/l	µg/l		mg/l												Specific conductance (µmhos/cm at 25°C)	pH units
	Silica (SiO_2)	Iron (Fe)	Manganese (Mn)	Calcium (Ca)	Magnesium (Mg)	Sodium (Na)	Potassium (K)	Bicarbonate (HCO_3)	Carbonate (CO_3)	Sulfate (SO_4)	Chloride (Cl)	Fluoride (F)	Nitrate (as N)	Dissolved solids	Total hardness		
						15743000 June Creek near Kotzebue											
05-26-67 50	0.8	560(a)	--	5.8	1.0	1.8	1.6	8.0	0	11	2.1	0.2	0.16	30	18	36	6.2
09-26-67 1.0	.7	340(a)	0(a)	8.6	2.1	1.9	.4	34	0	0	3.5	.0	.36	36	30	69	7.0
						15744000 Kobuk River at Ambler											
06-08-70 12,300	3.3	70(a)	0(a)	18	2.4	.6	.5	57	0	8.4	.1	.1	.11	62	54	110	7.9
03-26-72 933	6.8	10(b)	30(b)	32	5.3	1.6	.6	116	0	11	1.0	.1	.11	116	103	201	7.6
						15746000 Noatak River at Noatak											
06-17-55 --	2.3	50(a)	0(a)	22	3.9	2.5	.4	57	0	21	5.0	.1	.00	85	71	154	7.2
07-10-67 31,200	1.9	60(a)	--	32	7.4	1.4	.0	124	0	12	.4	.1	.27	117	110	210	7.8

a Undifferentiated
b Dissolved

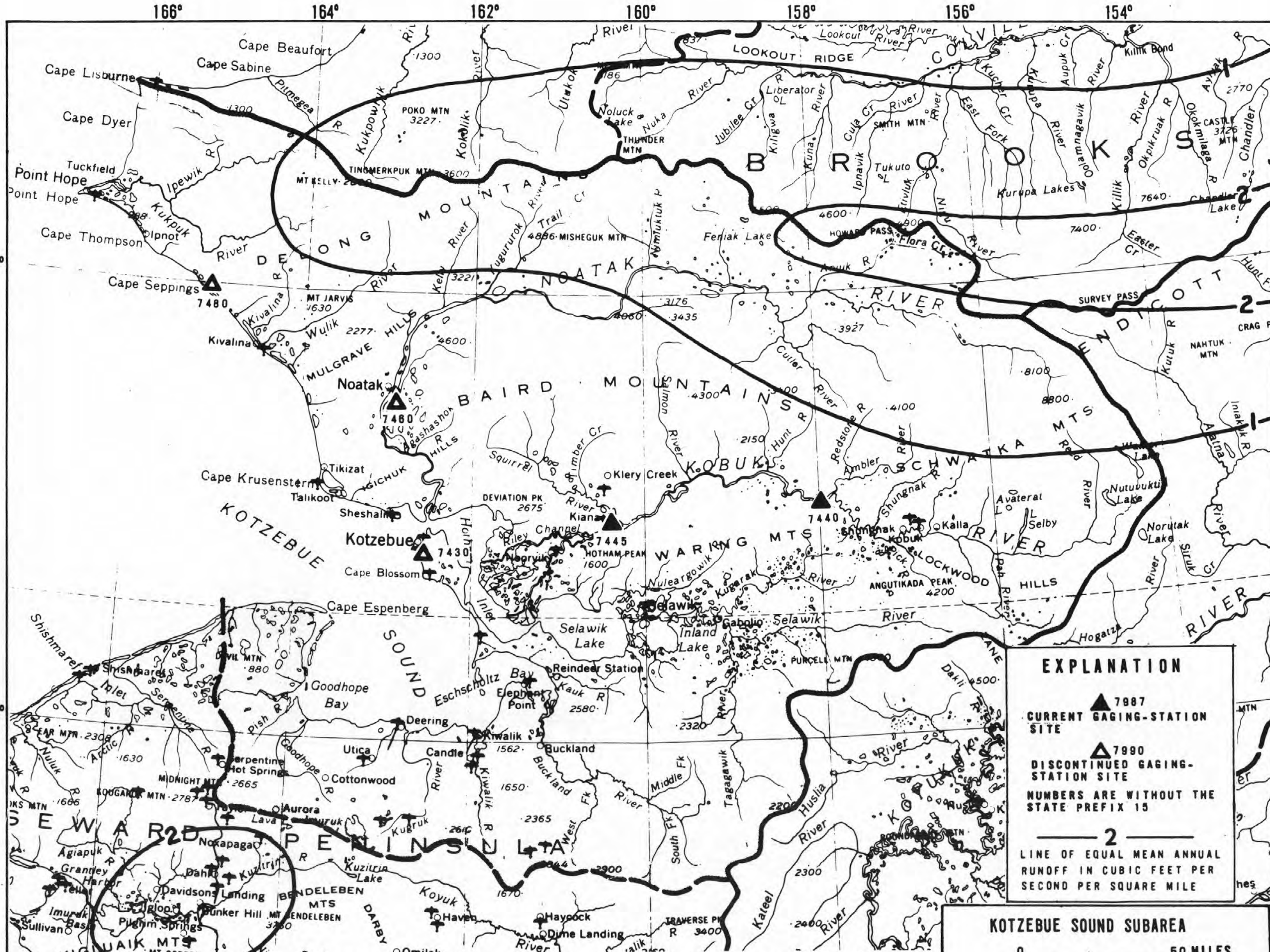


Figure 29. -- Estimated mean annual runoff in the Kotzebue Sound subarea (2.1, fig. 9).

Base from U.S.Geological Survey map E (scale 1:2,500,00) of Alaska

Data from Joint Federal-State Land Use Planning Commission (1974)

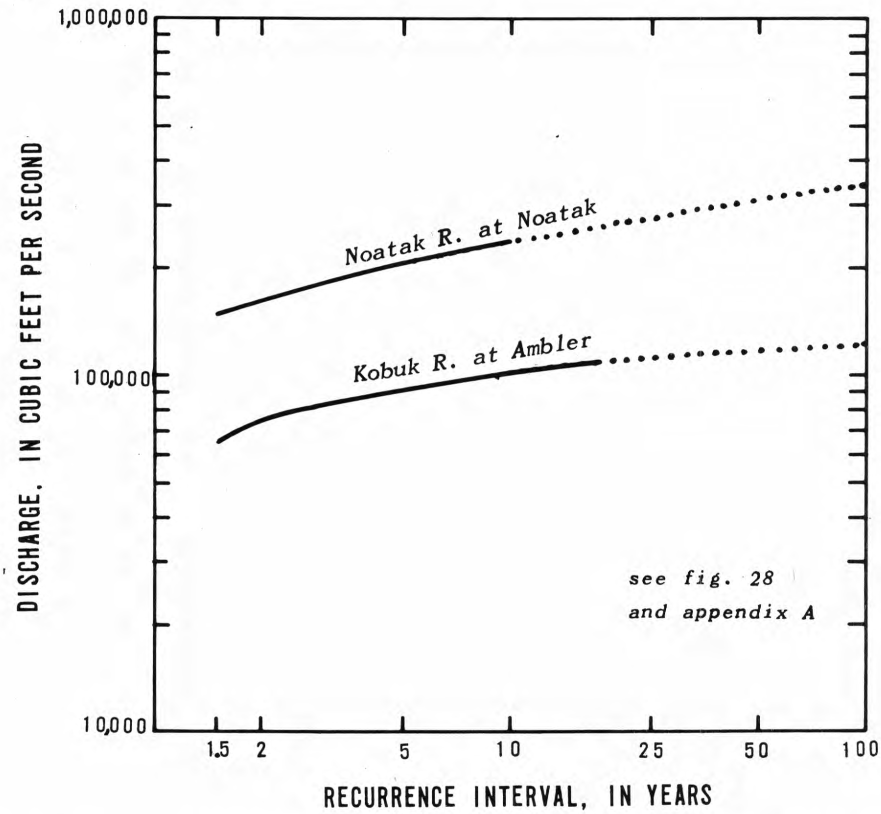


Figure 30. -- Flood magnitude-frequency relation of selected streams in the Kotzebue Sound subarea (2.1, fig. 9).

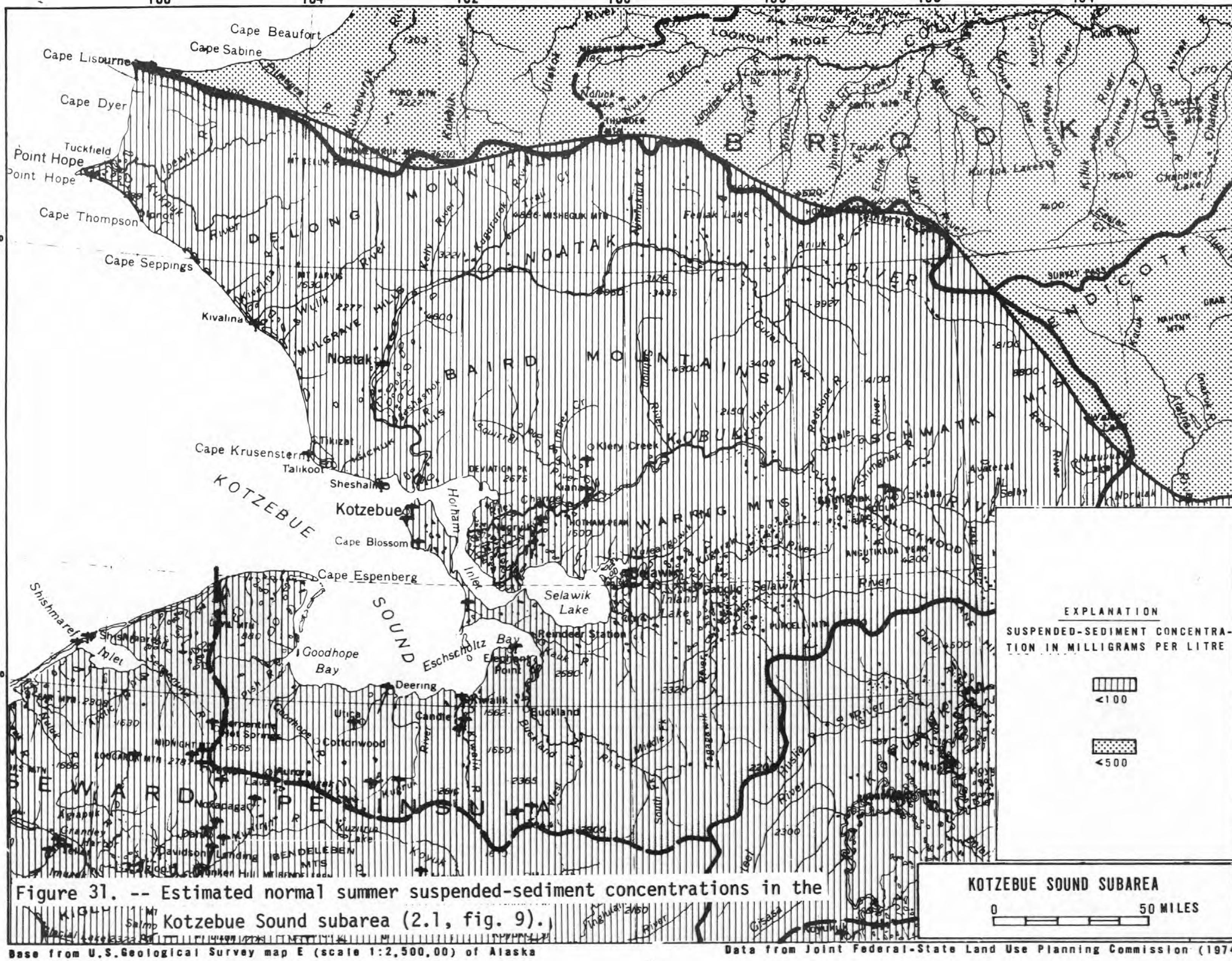


Figure 31. -- Estimated normal summer suspended-sediment concentrations in the Kotzebue Sound subarea (2.1, fig. 9).

Ground Water.--Ground-water yields to wells are mostly less than 10 gal/min in the subarea (fig. 32). Water is available in small amounts beneath the channels of the larger streams such as the Noatak and the Kobuk Rivers. If gravel beds are adjacent to either of these streams, much larger amounts could be developed from wells, perhaps in the order of hundreds or thousands of gallons per minute. Only a few communities in the subarea utilize ground water. The well at Kiana produces potable water of a calcium or magnesium bicarbonate type. Wells drilled by the U.S. Bureau of Indian Affairs at Point Hope and Kivalina produced water so high in sodium chloride that they were abandoned. Shallow dug wells are utilized during the summer at coastal areas such as Point Hope, but winter freezing and lack of water storage prevents year-round use of such installations. Table 15 lists chemical analyses of ground water in various communities in the subarea.

Several springs are known in the subarea; some are utilized as temporary water-supply sources. One at Cape Thompson produces highly saline water.

Very few data are available on the temperature of ground water which is believed to range from 32° to 39°F throughout the year.

Water Use.--Water is obtained from both surface and ground water, but predominantly from surface-water sources. There are no heavy demands on water in the subarea other than for domestic purposes. Some commercial fishing and small scale mining is occurring, but the real base for the economy is government employment and summer tourism, especially at Kotzebue. There is no agricultural activity requiring water for irrigation. However, there are approximately 6,200 herded reindeer in the area. Population in the subarea is about 4,800 with the major centers at Kotzebue (2,125), Noorvik (483), Selawik (429), and Point Hope (404) (Alaska Dept. of Community and Regional Affairs, 1975b).

Figure 32. -- Estimated ground-water yields in the Kotzebue Sound subarea(2.1, fig. 9).

Base from U.S.Geological Survey map E (scale 1:2,500,00) of Alaska

Data from Joint Federal-State Land Use Planning Commission (1974)

Table 15.--*Chemical analyses of ground water in the Kotzebue Sound subarea.*

[concentrations in milligrams per litre (mg/l) or micrograms per litre (μg/l)]

Location	Date	Well depth (ft)	Temperature (°C)	mg/l	μg/l		mg/l												Specific conductance (μmhos/cm at 25°C)	pH units
				Silica (SiO_2)	Iron (Fe)	Manganese (Mn)	Calcium (Ca)	Magnesium (Mg)	Sodium (Na)	Potassium (K)	Bicarbonate (HCO_3)	Carbonate (CO_3)	Sulfate (SO_4)	Chloride (Cl)	Fluoride (F)	Nitrate (as N)	Dissolved solids	Total hardness		
WELLS																				
Kiana	03-08-75	25	5.0	9.5	20(a)	2,200(a)	74	25	16	3.1	366	0	19	7.3	0.1	0.14	337	290	589	7.7
Kobuk	08-22-70	--	--	16	1,300(b)	1,300(b)	29	6.0	.9	.5	122	0	.0	.0	.1	.02	114	97	185	7.8
Kivalina	07-25-69	215	--	0	2,000(a)	4,200(a)	1,630	2,100	17,600	630	800	0	3,300	35,270	3.5	.41	57,000	12,700	76,000	7.8
Ambler	06-23-72	180	1.5	37	2,700(c)	70(c)	51	21	13	2.0	284	0	.4	1.5	.1	.02	266	214	423	7.5

a Dissolved
b Undifferentiated
c Total

Based on the population in the subarea and the type of water systems available, the estimated water use is about 251,000 gal/d. Reindeer requirements are estimated to be 4.5 Mgal/y (million gallons per year).

Norton Sound Subarea

The Norton Sound subarea includes St. Lawrence Island, the southern half of the Seward Peninsula and extends southward along the coast to include the community of St. Michael (fig. 9). It covers a land area of 26,000 square miles and is bounded on the north by the Kotzebue Sound subarea and on the east and south by the Yukon subregion. The Chukchi Sea is the northwest boundary and the entire southeastern part faces Norton Sound.

The subarea lies mostly in the Transition climatic zone. The extreme eastern part lies in the Continental climatic zone. Normal summer temperatures range from about 30° to 50°F and normal winter temperatures range from about 5° to 10°F. The average annual temperature is about 29°F. Precipitation normally ranges between 15 and 20 inches per year throughout the subarea. Precipitation is heavier in the highlands north of Nome than elsewhere in the subarea.

Bedrock in the subarea includes schist, gneiss, marble, and metamorphic volcanic rocks which are cut by granitic intrusive bodies. Volcanic and marine sedimentary rocks are exposed in the eastern part of the Seward Peninsula. The bedded rocks are complexly deformed. Deformation is accompanied by thrust and normal faulting and multiple intrusions. The interior basins and some places along the coast are mantled by sand and gravel deposits. Muskeg, peat, and silty deposits are the surface materials of the subarea (Wahrhaftig, 1965).

Permafrost is continuous throughout the subarea and appears to be thawed only under or near deep lakes or major streams. Where permafrost is known to be present, its thickness is about 250 to 300 feet (Ferrians, 1965). No glaciers exist within the Norton Sound subarea.

Surface Water.--A number of streams drain the subarea; these include the Agiapuk (est. drainage area 1,000 mi^2), Kuzitrin (est. 2,500 mi^2), Nuikluk (est. 1,900 mi^2), Koyuk (est. 2,000 mi^2), Shaktolik (est. 1,000 mi^2), and Unalakleet (est. 1,600 mi^2) Rivers as well as other smaller streams. Streams are characterized by rapid rises in water levels following heavy precipitation and an equally rapid drop to low flows in the absence of precipitation. Low precipitation, the presence of permafrost, and the numerous low mountains (2,000 to 3,000 feet in altitude) cause highly variable seasonal runoff and lead to low annual runoff rates.

Estimated mean annual runoff is 1 ft^3/s per square mile. In some places the estimated runoff probably exceeds 2 ft^3/s per square mile, but such areas are of limited size (fig. 33).

Mean annual peak runoff throughout the western part of the subarea is estimated to be in excess of 25 ft^3/s per square mile but declines to nearly 10 ft^3/s per square mile in the southwestern part. Figure 34 illustrates the flood frequency and magnitude of selected streams. The low month mean runoff is estimated to be between 0.2 and zero ft^3/s.

The chemical quality of surface water in the subarea is acceptable for domestic use. Surface water generally contains less than 200 mg/l of dissolved solids and is mostly of the calcium bicarbonate type. Water in coastal areas is generally higher in sodium chloride and magnesium than the inland waters. Table 16 lists chemical analyses of selected streams.

Data collected on the suspended-sediment content of streams suggest that summer concentrations during normal streamflow range between 10 and 100 mg/l (fig. 35). The Kuzitrin River near Nome has an estimated total annual suspended-sediment yield of 40 tons per square mile. This is the lowest rate of sediment discharge per square mile known in the State. Reasons for the low sediment yield in the Nome area may be: (1) the relatively low annual rates of stream runoff, (2) the generally low relief of the area through which the streams flow, and (3) the lack of

Figure 33. -- Estimated mean annual runoff in the Norton Sound subarea (2.2, fig. 9).

Base from U.S.Geological Survey map E (scale 1:2,500,00) of Alaska

Data from Joint Federal-State Land Use Planning Commission (1974)

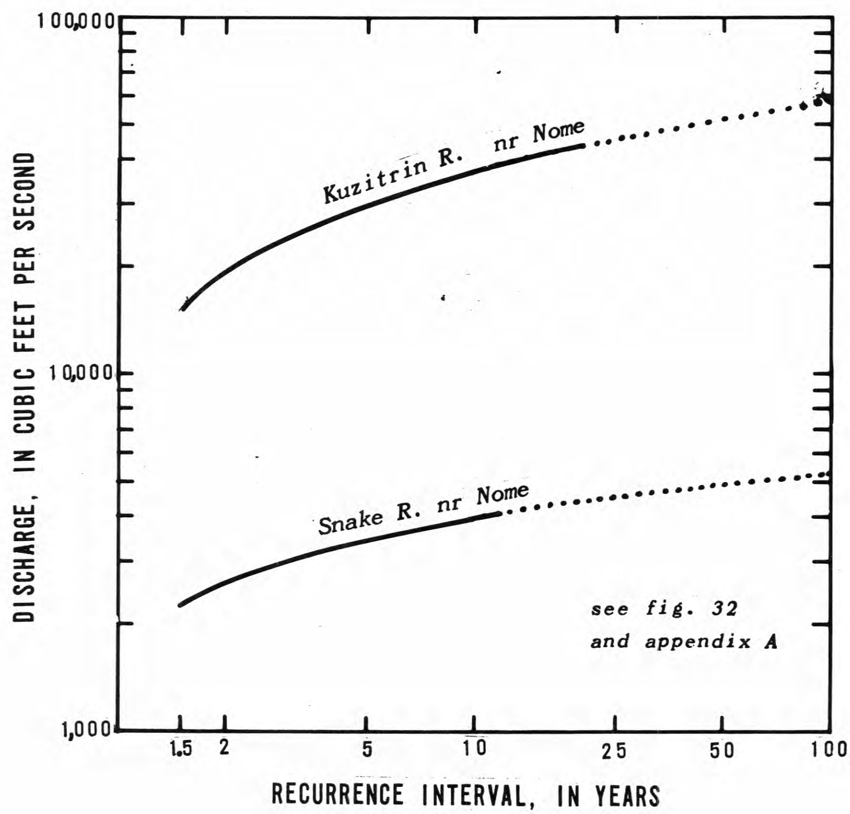


Figure 34. -- Flood magnitude-frequency relation of selected streams in the Norton Sound subarea (2.2, fig. 9).

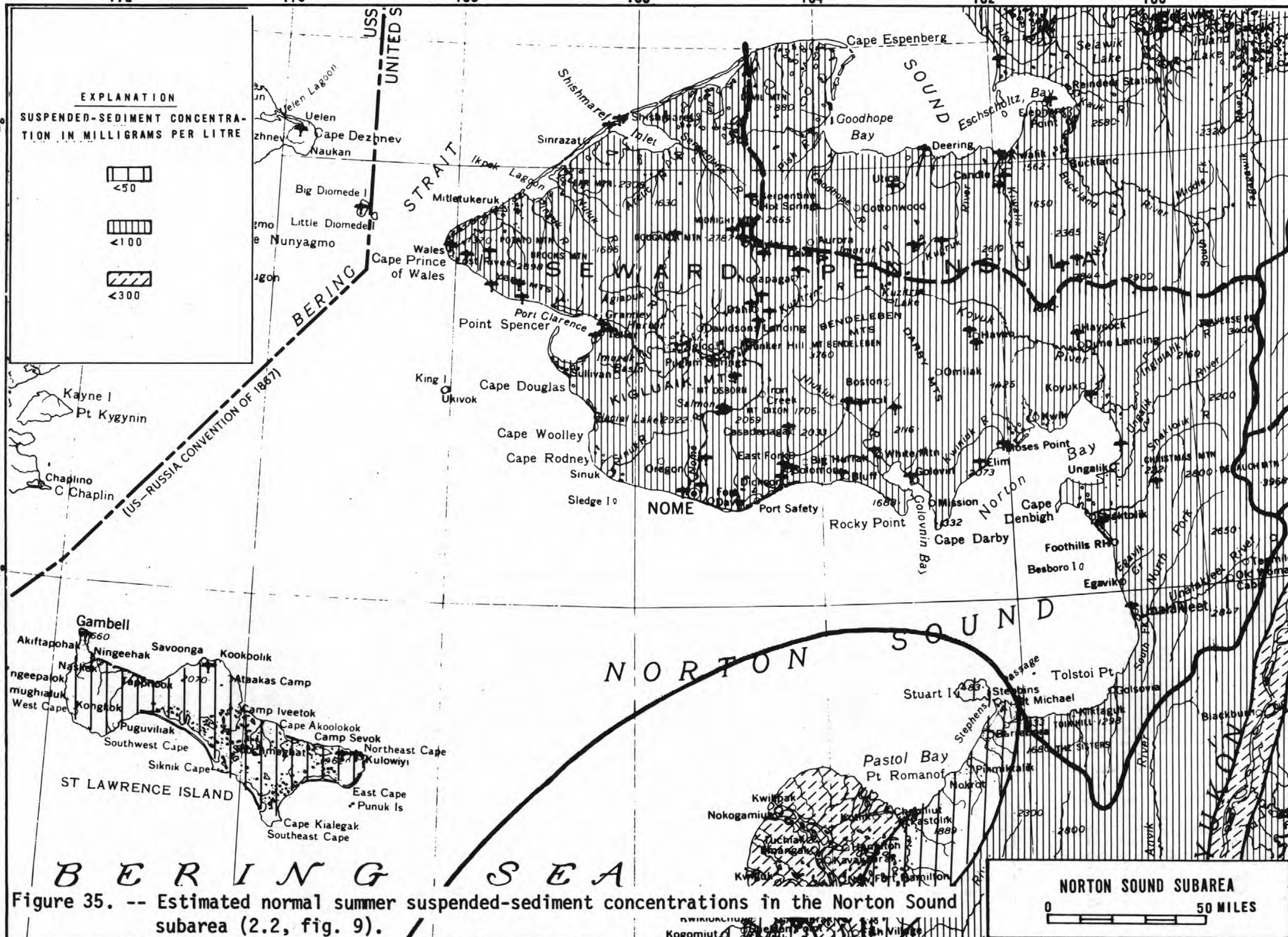


Figure 35. -- Estimated normal summer suspended-sediment concentrations in the Norton Sound subarea (2.2, fig. 9).

Base from U.S.Geological Survey map E (scale 1:2,500,00) of Alaska

Data from Joint Federal-State Land Use Planning Commission (1974)

Table 16.--*Water quality of selected streams in the Norton Sound subarea.*

[concentrations in milligrams per litre (mg/l) or micrograms per litre (µg/l)]

Date and discharge (ft^3/s)	mg/l	µg/l		mg/l												Specific conductance (µmhos/cm at 25°C)	pH units
	Silica (SiO_2)	Iron (Fe)	Manganese (Mn)	Calcium (Ca)	Magnesium (Mg)	Sodium (Na)	Potassium (K)	Bicarbonate (HCO_3)	Carbonate (CO_3)	Sulfate (SO_4)	Chloride (Cl)	Fluoride (F)	Nitrate (as N)	Dissolved solids	Total hardness		
15621000 Snake River near Nome																	
08-21-68 208	4.1	80(a)	--	29	5.7	2.2	0.2	98	0	16	4.0	0.1	0.02	109	96	192	7.9
03-26-72 9.6	5.7	130(b)	20(b)	31	6.2	6.2	.3	99	0	17	14	.1	.00	130	103	240	7.4
15712000 Kuzitrin River near Nome																	
05-27-67 9,840	2.5	170(a)	--	8.0	1.3	1.8	1.2	27	0	4.0	1.4	.1	.05	34	26	62	6.7
09-27-67 587	9.7	300(a)	0(a)	16	3.8	4.7	.5	68	0	4.0	3.9	0	.14	77	56	133	7.3

a Undifferentiated
b Dissolved

glaciers which normally contribute considerable amounts of sediment to streams.

Ground Water.--Ground-water yields are usually less than 10 gal/min in the subarea (fig. 36). Water is expected to be generally available in small amounts beneath the channels of larger streams in the southern part of the subarea and adjacent to larger lakes. If extensive gravel beds occur beneath the beds of major streams, large supplies (10-100 gal/min) of water should be available to galleries constructed beneath the stream channels. Wells are utilized at Unalakleet, Nome, Tin City, and other localities.

Springs are known within the subarea. The one at Nome (Moonlight) is a public supply that has a flow of about 100 to 300 gal/min throughout the year.

The dissolved-solids concentration of ground water ranges from a low of about 40 mg/l at Tin City to a high of 27,000 mg/l at Golovin. Many analyses of water quality are from coastal communities where wells yielded sodium chloride type water. The well at St. Michael penetrated frozen materials to a depth of about 200 feet, and saline water was obtained from an unfrozen zone beneath the permafrost. The well at Golovin taps a sand and gravel aquifer at 46 feet and produces a water with a high sodium chloride concentration.

Water having low dissolved-solids concentration is obtained from wells drilled at slightly elevated points back from coastlines. Table 17 lists chemical analyses of water from selected wells. The temperature of ground water appears to range between 32° and 39°F; the average temperature is near 35°F.

Water Use.--Domestic, mining, and agricultural needs place demands on water. The population in the subarea is estimated at about 5,050 (Alaska Dept. of Community and Regional Affairs, 1975b). Nome is the largest population center with 2,488 people, followed by Unalakleet (550), Shishmaref (309), and Stebbins (272). Based on the population

Figure 36. -- Estimated ground-water yields in the Norton Sound subarea (2.2, fig. 9).

Base from U.S. Geological Survey map E (scale 1:2,500,00) of Alaska

Data from Joint Federal-State Land Use Planning Commission (1974)

Table 17.--*Chemical analyses of ground water in the Norton Sound subarea.*

[concentrations in milligrams per litre (mg/l) or micrograms per litre (µg/l)]

Location	Date	Well depth (ft)	Temperature (°C)	mg/l	µg/l		mg/l												Specific conductance (µmhos/cm at 25°C)	pH units
				Silica (SiO_2)	Iron (Fe)	Manganese (Mn)	Calcium (Ca)	Magnesium (Mg)	Sodium (Na)	Potassium (K)	Bicarbonate (HCO_3)	Carbonate (CO_3)	Sulfate (SO_4)	Chloride (Cl)	Fluoride (F)	Nitrate (as N)	Dissolved solids	Total hardness		
WELLS																				
Shishmaref	04-18-69	--	--	1.8	6,300(a)	400(a)	12	6.2	20	1.6	50	0	0.4	38	0.0	0.68	115	55	200	6.6
Wales	--	33	--	7.2	120(a)	--	14	5.8	22	.2	59	0	9.1	37	.6	.07	125	59	240	7.3
Teller	04----72	--	--	3.7	--	20(a)	181	200	1,310	61	274	0	175	2,660	.3	2.3	4,740	1,270	9,100	7.6
Nome	11-26-71	--	--	14	180(b)	140(b)	74	108	1,240	61	522	0	381	1,875	.8	4.5	4,030	628	6,720	8.1
Elim	03-10-75	--	20.0	8.4	10(c)	20(c)	84	39	250	11	268	--	60	450	.1	1.4	1,040	370	1,980	--
Golovin	08-03-68	46	--	8.0	--	--	570	1,090	8,300	280	510	0	1,780	15,400	.5	.09	27,000	5,900	41,900	7.3
Koyuk	01-28-64	75	--	8.6	50(a)	0(a)	166	116	800	34	357	--	135	1,550	.0	2.2	3,000	890	5,280	8.0
Unalakleet	08-22-68	--	25.0	9.2	720(a)	--	28	5.1	5.2	.2	98	0	2.5	14	.2	.05	113	91	195	7.6
St. Michael	06-17-71	--	--	42	530(b)	110(b)	63	98	1,120	31	1,400	0	8.4	1,320	1.4	.36	3,370	560	5,660	7.3
Savoonga	01-31-70	179	--	42	8,600(a)	410(a)	205	1,100	8,400	360	284	0	2,030	15,400	.6	.02	27,700	5,030	38,800	6.7
SPRINGS																				
Moonlight	03-10-69	--	2.0	4.3	20(b)	--	46	2.6	2.7	1.5	153	--	6.6	3.2	.1	.00	142	126	251	7.9
Elim	06-12-73	--	--	9.5	30(c)	0(c)	57	12	6.0	.6	--	--	11	13	.0	.00	--	192	378	--
Pilgrim	--	--	55	100	--	--	530	1.4	1,450	61	30	--	24	3,346	4.7	--	--	--	--	6.8
Serpentine	--	--	60	100	--	--	47	.5	730	40	64	--	29	1,480	6.4	--	--	--	--	7.9

a Undifferentiated
b Total
c Dissolved

and the type of water systems in use, it is estimated that 234,000 gal/d of water is utilized for domestic purposes.

Placer mining is on the increase in the subarea and requires water, although it is not known at this time what the requirements are.

Agricultural activity consists of a reindeer herd of about 16,900 head. Summer water requirements for the herd are estimated at 8.1 million gallons; in the winter the herd uses an estimated 4.1 million gallons.

Commercial fishing produced 2 million pounds of salmon in 1974. No fish processors are listed for the subarea, so it is assumed that processing takes place elsewhere.

YUKON SUBREGION

Lower Yukon Subarea

The Lower Yukon subarea includes the drainage of the Yukon River downstream from Kaltag (fig. 9). The coast on the Bering Sea extends from Hazen Bay on the south to St. Michael on the north. The subarea covers 38,000 square miles and lies within the Transition climatic zone. The mean annual temperature is about 32°F and the annual range is about -40° to 80°F. The annual precipitation range is approximately 14 to 25 inches per year.

In the northern and eastern parts of the subarea, mountains reach approximately 3,000 feet in altitude. The southern part is overlain by extensive deltaic deposits laid down by the Yukon and Kuskokwim Rivers. The deposits are predominantly sand and gravel, but fine-grained alluvium is also common. Few consolidated rocks are exposed; however, both sedimentary and volcanic rocks have been mapped and near St. Michael extensive volcanic deposits are known.

Permafrost is present throughout the subarea. Thawed zones probably exist beneath large streams and lakes (Ferrians, 1965). There are no glaciers.

Surface Water.--The principal streams are the Yukon and its tributaries: the Andreafsky (est. drainage area 1,600 mi^2), the Anvik (est. 1,100 mi^2), and the Innoko (est. 12,000 mi^2). Low flow of the streams can be expected to occur in the late winter near the end of the freezing season. Annual spring flooding due to local ice jams follows the low-flow period. The summer peak flows result from heavy precipitation.

Until recently no discharge measurements had been made in this subarea. Discharge measurements at Pilot Station on the Yukon River were begun in 1975. Mean average runoff is estimated at about 1 ft^3/s per square mile (fig. 37). Table 2 shows the estimated mean monthly

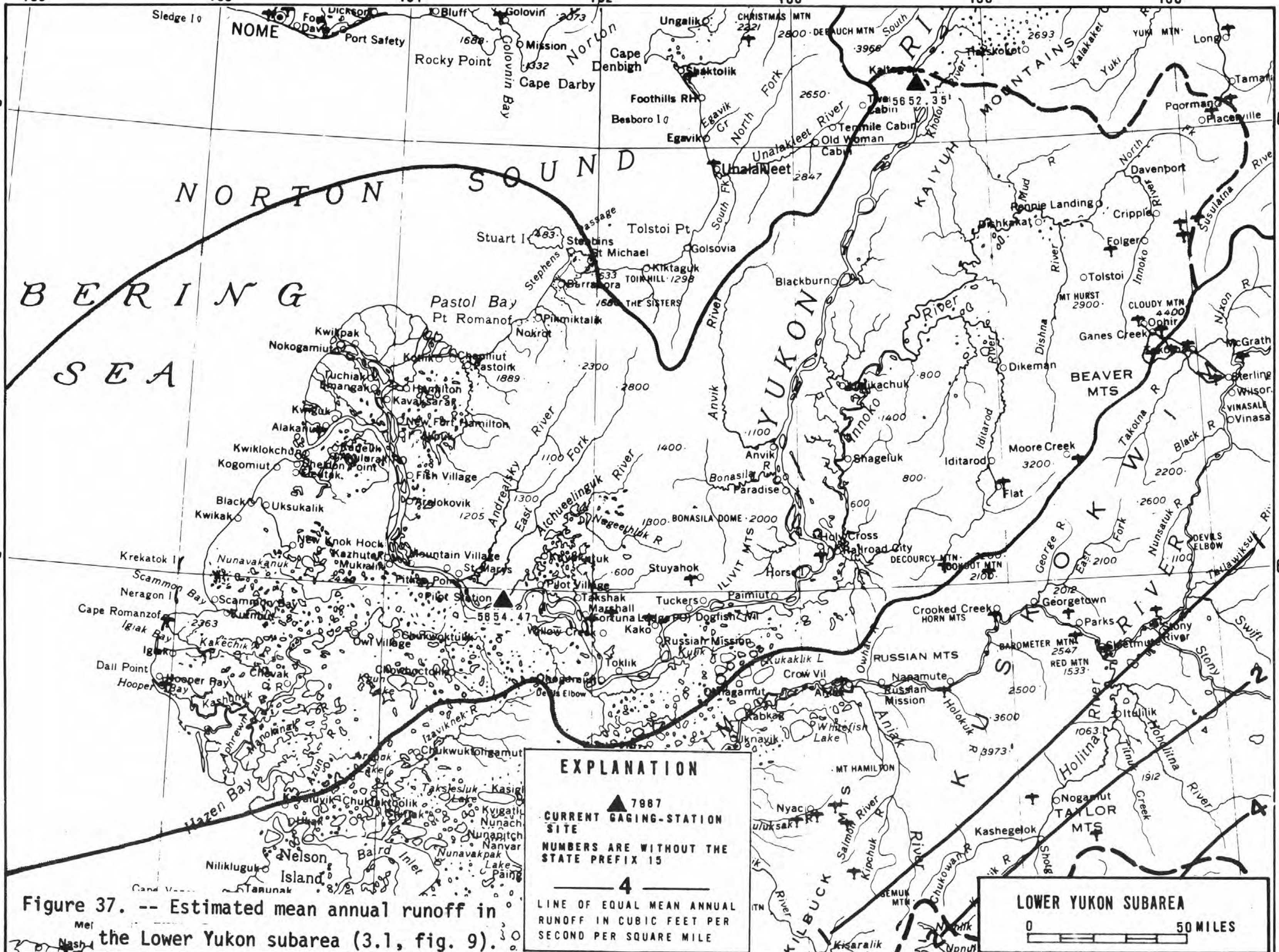


Figure 37. -- Estimated mean annual runoff in the Lower Yukon subarea (3.1, fig. 9).

Base from U.S.Geological Survey map E (scale 1:2,500,00) of Alaska

Data from Joint Federal-State Land Use Planning Commission (1974)

and mean annual runoff for the subarea. The mean annual peak runoff is estimated at less than 10 ft^3/s per square mile. Ice-jam flooding during spring breakup is common along the lower reaches of the river. In 1975, an area approximately the size of Lake Iliamna (1,000 mi^2) was flooded above Holy Cross. The low month mean runoff is probably between 0.2 and 0.3 ft^3/s per square mile.

Quality data on surface water in the subarea are sparse. From data available the annual range of dissolved-solids concentration of surface water is about 40 to 140 mg/l. All surface water thus far sampled is of the calcium bicarbonate type and of acceptable chemical quality for domestic purposes, exceeding Environmental Protection Agency (1972) recommendations only in iron content. Table 18 lists chemical analyses of water in the Yukon River at Pilot station.

Few sediment data have been collected. Based upon information gathered in adjoining subareas, the suspended-sediment concentration is probably less than 100 mg/l for all streams during normal summer discharge except for the Yukon River which carries a greater sediment load that originates upstream (fig. 38).

Temperature data on the Yukon Delta are also limited; the known annual range of surface-water temperature is from 32° to 60°F.

Ground Water.--Development of ground water has been limited mainly by permafrost. Ground water in the northern part of the subarea can be developed chiefly near the major streams. In the southern part wells in valleys have supplied ground water throughout the year. A well at Cape Romanzof was developed in fractured bedrock. Ground water near the coast generally has a higher mineral content than that farther inland, and wells are more subject to saltwater encroachment.

Springs do not occur in the southern part of the subarea largely because of lack of topographic variation. However, a few springs, mainly in the northern and eastern parts of the subarea, are potential water sources, although data on them are lacking.

Table 18.--*Water quality of the Yukon River at Pilot Station, Lower Yukon subarea.*

[concentrations in milligrams per litre (mg/l) or micrograms per litre (µg/l)]

	mg/l	µg/l		mg/l													
Date and discharge (ft^3/s)	Silica (SiO_2)	Iron (Fe)	Manganese (Mn)	Calcium (Ca)	Magnesium (Mg)	Sodium (Na)	Potassium (K)	Bicarbonate (HCO_3)	Carbonate (CO_3)	Sulfate (SO_4)	Chloride (Cl)	Fluoride (F)	Nitrate (as N)	Dissolved solids	Total hardness	Specific conductance (µmhos/cm at 25°C)	pHunits
						15565447 Yukon River at Pilot Station											
04-02-75 43,000	--	1,500(a)	150(a)	49	11	--	--	182	0	--	1.1	--	0.16	--	170	319	7.3
06-20-75 623,000	4.7	11,000(a)	280(a)	23	4.3	1.9	1.1	78	0	12	1.0	0.1	.11	88	75	150	7.9
07-10-75 466,000	7.2	--	--	23	4.5	1.8	1.0	78	0	15	.9	.1	.08	92	76	165	7.6
08-14-75 365,000	6.6	11,000(a)	310(a)	27	6.2	2.5	1.5	93	0	21	1.0	.1	.06	112	93	194	8.0
09-24-75 419,000	7.3	--	--	26	6.1	2.3	1.0	87	0	16	1.1	.1	.24	103	90	184	8.0

a Total

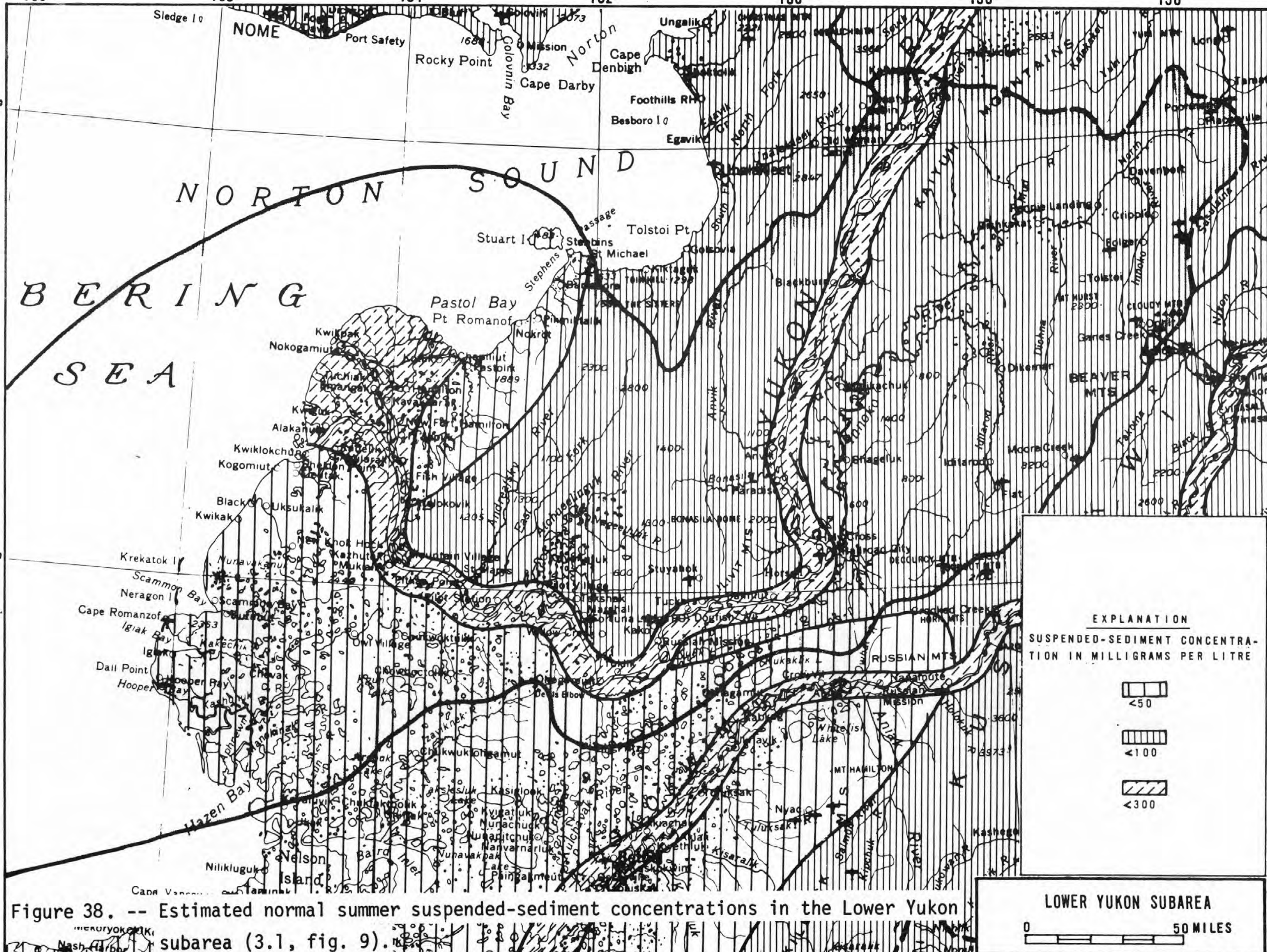


Figure 38. -- Estimated normal summer suspended-sediment concentrations in the Lower Yukon subarea (3.1, fig. 9).

Base from U.S.Geological Survey map E (scale 1:2,500,00) of Alaska

Data from Joint Federal-State Land Use Planning Commission (1974)

Figure 39 indicates the ground-water yields that may be expected in the subarea.

Dissolved-solids concentrations of ground water ranges from about 70 mg/l to about 21,000 mg/l. Most of the inland wells yield a calcium bicarbonate type of water, whereas coastal wells yield either a sodium bicarbonate or a sodium chloride type water. One well at St. Mary's has magnesium bicarbonate type water.

The ground water is generally of acceptable chemical quality for most general purposes, with the exception of some coastal waters in which the sodium chloride content is high. Fresh water in the subarea has dissolved-solids concentrations of less than 250 mg/l. It would be desirable to remove iron from the water of some wells before the water is used for domestic purposes. The temperature of ground water ranges from about 33° to 40°F throughout the year. Table 19 lists analyses of ground water in some of the villages in the subarea.

Water Use.--No industrial or mining activities are going on in the subarea; therefore, the only current demands placed on the water resources are to meet the domestic and small agricultural needs. The population in the subarea is about 4,800 (Alaska Dept. of Community and Regional Affairs, 1975b). The major villages and populations are as follows: Hooper Bay (556), Emmonak (502), Alakanuk (495), Mountain Village (491), Chevak (447), and St. Mary's (384). Based on the population in the subarea and the type of water facilities available, the domestic water use is estimated at 145,000 gal/d (0.2 ft^3/s).

A herd of about 800 reindeer is located near Stebbins. Their total water requirements are estimated to be 380,000 gallons in the summer and 200,000 gallons in the winter.

Central Yukon Subarea

The Central Yukon subarea includes the drainage of the Yukon River between Rampart on the east and Kaltag on the west (not including the

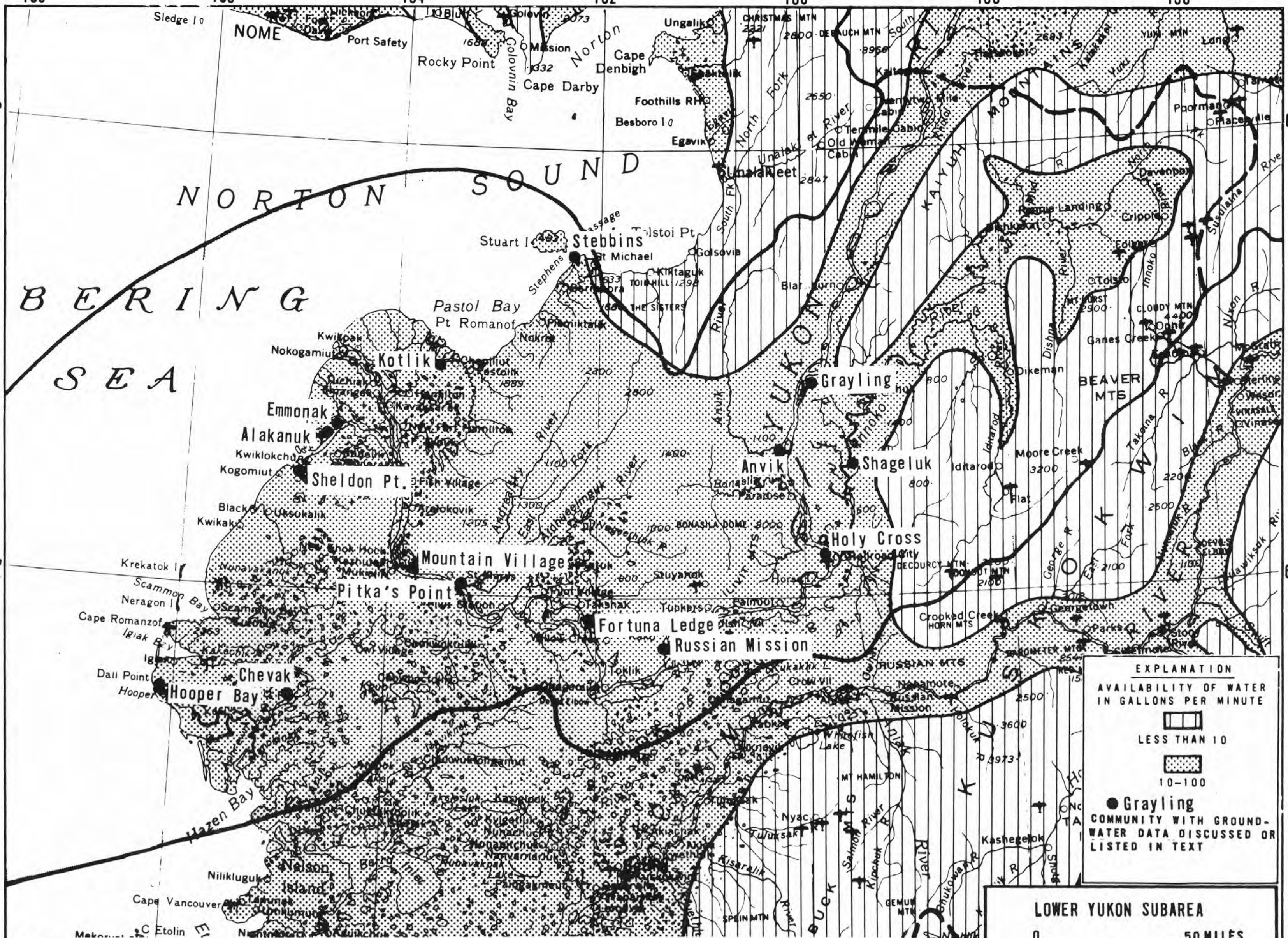


Figure 39. -- Estimated ground-water yields in the Lower Yukon subarea (3.1, fig. 9).

Base from U.S. Geological Survey map E (scale 1:2,500,00) of Alaska

Data from Joint Federal-State Land Use Planning Commission (1974)

Table 19.--*Chemical analyses of ground water in the Lower Yukon subarea.*

[concentrations in milligrams per litre (mg/l) or micrograms per litre (µg/l)]

Location	Date	Well depth (ft)	Temperature (°C)	mg/l	µg/l		mg/l												Specific conductance (µmhos/cm at 25°C)	pH units
				Silica (SiO_2)	Iron (Fe)	Manganese (Mn)	Calcium (Ca)	Magnesium (Mg)	Sodium (Na)	Potassium (K)	Bicarbonate (HCO_3)	Carbonate (CO_3)	Sulfate (SO_4)	Chloride (Cl)	Fluoride (F)	Nitrate (as N)	Dissolved solids	Total hardness		
WELLS																				
Stebbins	03-06-75	--	3.0	24	420(a)	60(a)	10	29	660	31	520	--	15	810	0	0.03	1,850	140	3,420	8.1
Kotlik	04-28-63	--	--	23	20(b)	0(b)	222	597	6,970	409	1,430	--	218	12,000	0.8	0.61	21,200	3,000	32,600	8.2
Emmonak	09-24-71	80	--	35	2,500(c)	140(c)	32	38	165	24	542	0	1.0	115	.4	4.5	698	236	1,140	7.1
Alakanuk	07-20-72	88	--	26	7,400(c)	300(c)	117	26	1,520	54	1,120	0	7.3	1,675	2.4	.16	4,027	400	6,500	7.5
Sheldon Point	04-02-75	--	1.0	26	30(a)	150(a)	110	360	3,800	160	1,800	--	30	6,200	.6	.02	11,600	1,800	19,500	--
Hooper Bay	04-02-75	--	4.5	27	410(a)	10(a)	14	5.9	310	16	595	--	8.5	190	1.7	1.0	888	59	1,440	--
Chevak	04-02-75	--	0.5	40	1,600(a)	440(a)	22	3.9	15	2.6	100	--	3.6	9.4	.0	.08	149	71	189	--
Mountain Village	05-06-71	60	--	17	200(b)	10(b)	40	5.4	7.4	.9	160	--	.0	1.5	.3	.00	152	122	253	8.0
Pitkas Point	02-16-72	86	--	14	1,700(c)	2,900(c)	73	14	8.9	1.7	306	0	6.5	.8	.1	.07	273	240	451	8.0
Pilot Station	10-28-71	200	--	10	80(c)	10(c)	41	9.2	4.5	.7	164	0	.2	5.5	.3	2.9	165	141	287	7.6
St. Mary's	04-08-66	78	1.0	17	880(b)	40(b)	5.2	50	4.2	1.5	277	0	1.0	4.2	.3	.05	220	219	426	7.4
Fortuna	09-07-68	--	3.5	21	90(b)	50(b)	19	2.7	3.8	1.0	73	0	5.2	2.6	.2	.72	95	58	137	6.6
Russian Mission	04-22-71	--	--	20	50(c)	10(c)	37	9.6	3.8	.9	141	0	2.6	1.5	.0	4.7	165	131	264	8.0
Holy Cross	01-26-72	73	--	18	330(c)	20(c)	20	5.9	3.8	.5	81	0	6.9	2.0	.1	1.8	106	74	167	7.0
Shageluk	02-01-75	--	2.0	30	1,600(a)	820(a)	55	16	6.1	.6	265	--	2.5	1.6	.2	.01	246	200	413	7.3
Anvik	11-22-68	77	--	27	8,300(b)	650(b)	56	16	5.0	2.3	270	0	.0	2.1	.1	.11	250	205	400	7.1
Grayling	02-01-75	--	--	23	20(a)	0(a)	8.6	2.0	4.2	1.0	35	--	1.8	4.2	.1	1.9	71	30	85	6.9

a Dissolved
b Undifferentiated
c Total

Koyukuk and Tanana River drainages) and covers an area of 19,000 square miles (fig. 9). The northern boundary is the Koyukuk subarea and to the south are the Kuskokwim and Tanana subareas. The entire subarea lies within the Continental climatic zone. The mean annual temperature is about 27°F; the annual range is from about -60° to nearly 90°F. Precipitation averages less than 20 inches per year.

The geology is complex. Volcanic and sedimentary rocks underlie the Yukon River basin. Schist, quartzite, recrystallized limestone, and volcanic rocks make up the hills and highlands. Granite plutons cut through and, in places, volcanic rocks overlie the metamorphosed sedimentary rocks. The major drainage valleys are filled with alluvial and glacial deposits to depths of about 200 feet; considerably thicker silt deposits locally underlie the glacial and alluvial deposits. The subarea is transected by the Kaltag fault along the Yukon River (Wahrhaftig, 1965; Patton and Hoare, 1968).

The subarea lies within the discontinuous permafrost zone. Permafrost is generally absent beneath and adjacent to the principal streams. Permafrost thicknesses of more than 400 feet have been recorded in wells drilled near Galena (Williams, 1970b). There are no glaciers in the subarea.

Surface Water.--The largest stream is the Yukon River. Some of its principal tributaries are the Melozitna (est. drainage area 2,700 mi^2) and Tozitna (est. 1,400 mi^2) Rivers which flow into the Yukon from the north, and the Nowitna (est. 5,500 mi^2) and Yuki (est. 1,100 mi^2) Rivers which flow into the Yukon from the south.

Mean annual runoff probably averages about 1 ft^3/s per square mile (fig. 40). Table 2 shows the estimated mean monthly and mean annual runoff. Mean annual peak runoff is probably less than 10 ft^3/s per square mile. The annual peak flows are caused by spring snowmelt and by heavy summer rainfall. Stream icing during winter months is common, and ice-jam flooding during spring breakup is nearly an annual event.

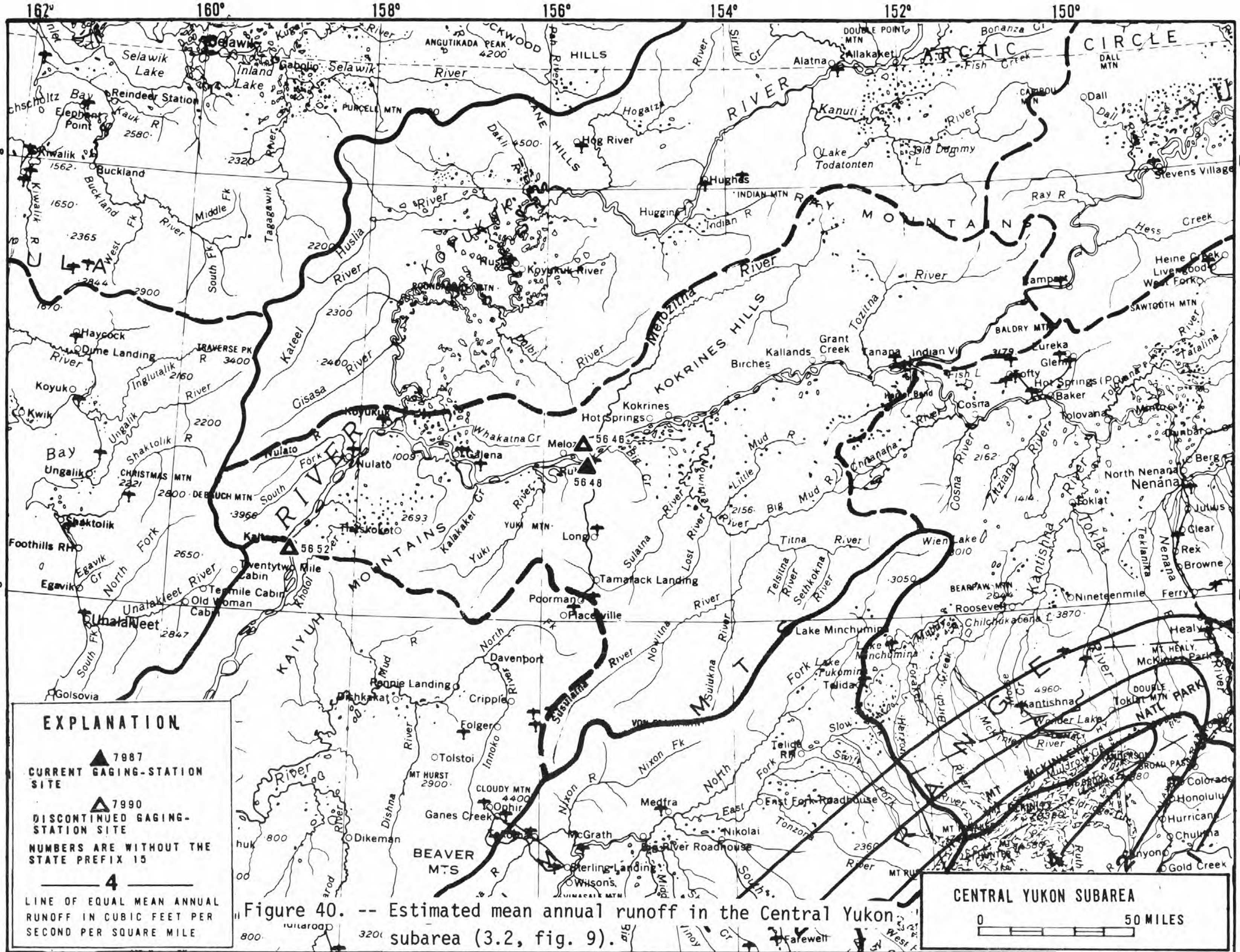


Figure 40. -- Estimated mean annual runoff in the Central Yukon subarea (3.2, fig. 9).

Base from U.S.Geological Survey map E (scale 1:2,500,00) of Alaska

Data from Joint Federal-State Land Use Planning Commission (1974)

Figure 41 illustrates the flood frequency and magnitude for some streams in the subarea. The low month mean runoff averages about 0.1 or 0.2 ft^3/s per square mile. Streams generally flow throughout the year, although winter flow usually reaches a minimum about April.

The chemical quality of surface waters is generally good by Environmental Protection Agency (1972) recommendations. All the surface waters sampled are of the calcium bicarbonate type. Dissolved-solids concentrations are moderate to low. Major streams have dissolved-solids concentrations of about 120 mg/l during summer months. A few streams which drain the lowlands contain amounts of iron in excess of Environmental Protection Agency (1972) recommendations. Table 20 shows chemical analyses for some selected streams in the subarea.

Streams in the subarea, except for the Yukon River, commonly carry sediment in concentrations of about 100 mg/l or less throughout the summer months during normal streamflow (fig. 42). The Yukon River is the most heavily silt-laden stream. It gathers most of its sediment load from glaciers in its headwaters or from the Tanana River system outside the subarea. The Yukon River between Rampart and Tanana carries about 200 to 300 mg/l of sediment. The Tanana River adds sediment to the Yukon River, increasing the sediment concentration of the Yukon to more than 300 mg/l.

The Yukon River at Ruby has an average annual suspended-sediment yield of 300 tons per square mile per year, equivalent to an average annual suspended-sediment yield of almost 80 million tons. Most of the suspended-sediment load is carried between the months of June and November.

The summer temperatures of surface water range between 45° and 50°F. The winter water temperatures range from 32° to 36°F.

Ground Water.--Ground-water availability is restricted by the presence of permafrost. The higher lands away from the river system are all apparently underlain by permafrost. Water is, however, potentially available from thawed areas adjacent to the Yukon River or its larger

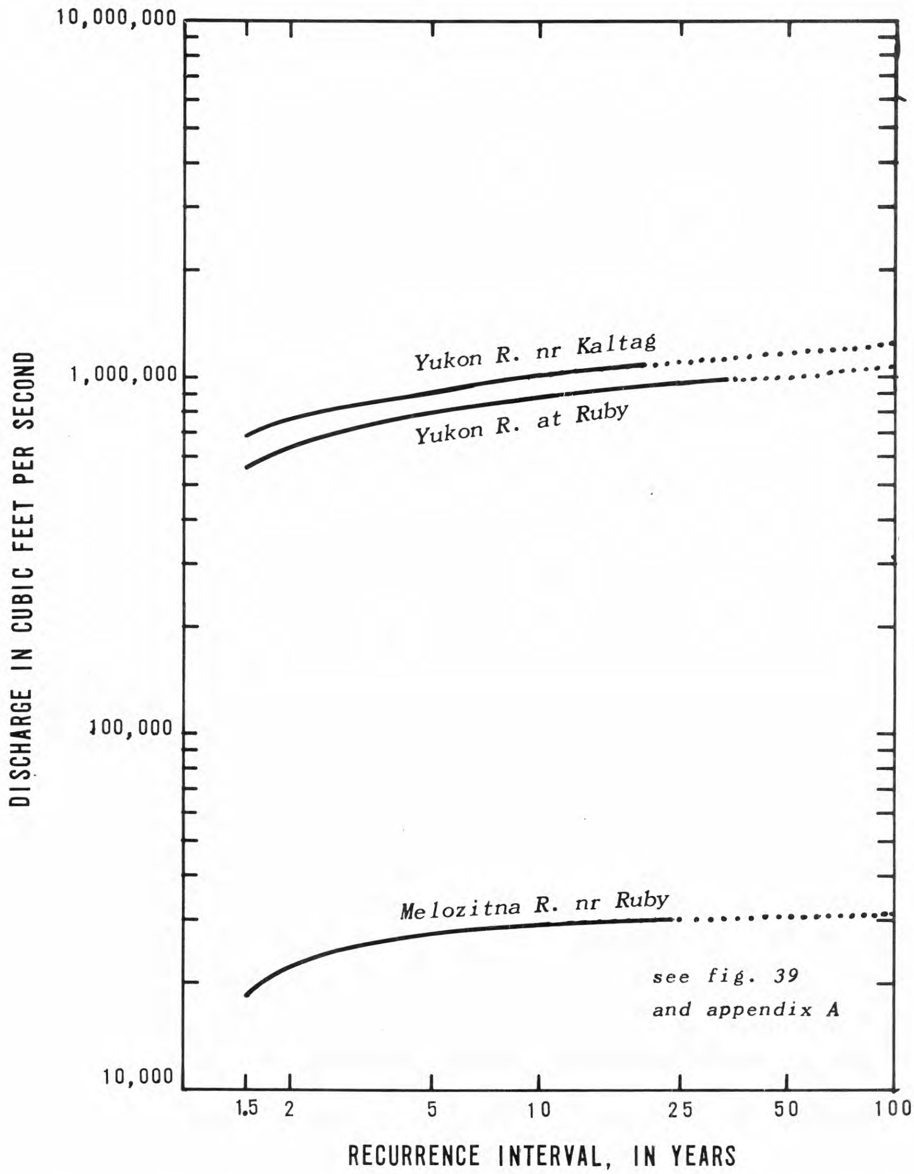


Figure 41. -- Flood magnitude-frequency relation of selected streams in the Central Yukon subarea (3.2, fig. 9).

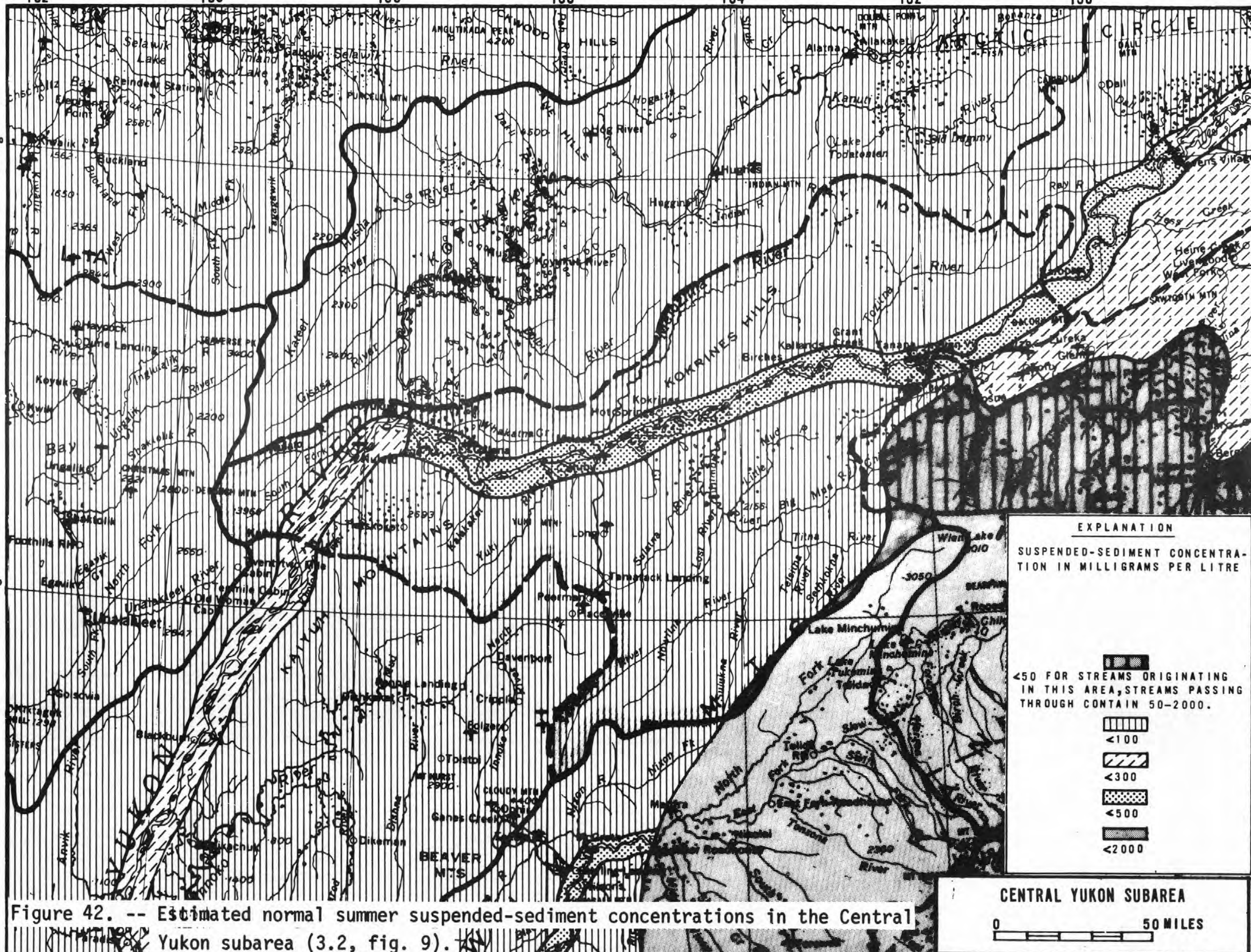


Figure 42. -- Estimated normal summer suspended-sediment concentrations in the Central Yukon subarea (3.2, fig. 9).

Base from U.S.Geological Survey map E (scale 1:2,500,00) of Alaska

Data from Joint Federal-State Land Use Planning Commission (1974)

Table 20.--*Water quality of selected streams in the Central Yukon subarea.*

[concentrations in milligrams per litre (mg/l) or micrograms per litre (µg/l)]

Date and discharge (ft^3/s)	Silica (SiO_2)	Iron (Fe)	Manganese (Mn)	Calcium (Ca)	Magnesium (Mg)	Sodium (Na)	Potassium (K)	Bicarbonate (HCO_3)	Carbonate (CO_3)	Sulfate (SO_4)	Chloride (Cl)	Fluoride (F)	Nitrate (as N)	Dissolved solids	Total hardness	Specific conductance (µmhos/cm at 25°C)	pH units
	mg/l	µg/l	µg/l	mg/l	mg/l	mg/l	mg/l	mg/l	mg/l	mg/l	mg/l	mg/l	mg/l	mg/l	mg/l		
15564600 Melozitna River near Ruby																	
04-15-59 29	9.0	0(a)	0(a)	19	8.3	6.6	0.2	97	0	16	3.0	0.2	0.18	111	82	189	7.0
09-24-71 1,790	7.5	530(b)	30(b)	9.2	2.9	2.0	.3	38	0	5.6	.8	.2	.16	49	35	75	7.0
15564800 Yukon River at Ruby																	
07-10-73 345,000	6.2	190(b)	20(b)	27	6.1	2.2	1.9	94	0	21	1.4	.2	.04	113	93	185	7.6
03-18-74 26,900	12	390(c)	20(c)	46	10	3.9	2.0	165	0	25	1.3	.2	.23	183	160	313	--
15565200 Yukon River near Kaltag																	
10-02-56 283,000	8.7	110(a)	0(a)	20	3.9	2.6	.4	72	0	10	.5	0	.11	82	66	140	7.6
01-22-57 39,200	11	0(a)	0(a)	39	9.4	4.0	1.8	143	0	25	1.8	.2	.05	162	136	278	7.7

a Undifferentiated
b Dissolved
c Total

tributaries throughout the year. Some wells drilled near the Yukon River produce potable water from beneath permafrost. Permafrost is absent from the flood plain near Galena but within about one-half mile of the Yukon River it has a thickness of 110 feet. Wells near Galena obtain potable water from beneath 400 feet of permafrost (Williams, 1970b). Figure 43 presents estimated ground-water availability in the subarea. The data used to compile this map were meager; on-site studies will provide more reliable estimates of ground-water yields.

Several springs are known. Warm and mineral springs are associated with the volcanic rocks; limited data are available on some of these springs. For others, data have not been collected.

The chemical quality of ground water has a wide range depending upon depth and the proximity of the river systems. Waters generally are of the calcium bicarbonate type and are chemically acceptable for domestic uses. Water from deep wells (not shown in table 21) appears to be highly corrosive owing to low pH values. Shallower wells may have objectionable amounts of iron and dissolved solids in their water. "Normal" ground-water temperatures range from about 32° to 38°F. The temperatures of thermal springs, based upon limited data, range from 80° to 110°F. Table 21 lists chemical analyses of ground water at some locations in the subarea.

Water Use.--Some mining is taking place, but the economy is mainly based on government employment and subsistence. The population in the area is about 1,670 people. The largest villages and their populations are: Galena (442), Tanana (406), Nulato (311), and Kaltag (240) (Alaska Dept. of Community and Regional Affairs, 1975b). Based on the population and the type of water-distribution systems available, the water used to meet domestic needs is estimated at 37,000 gal/d (0.1 ft^3/s). The extent of mining activities and their water demands are unknown at this time, and no estimate can be made of water requirements.

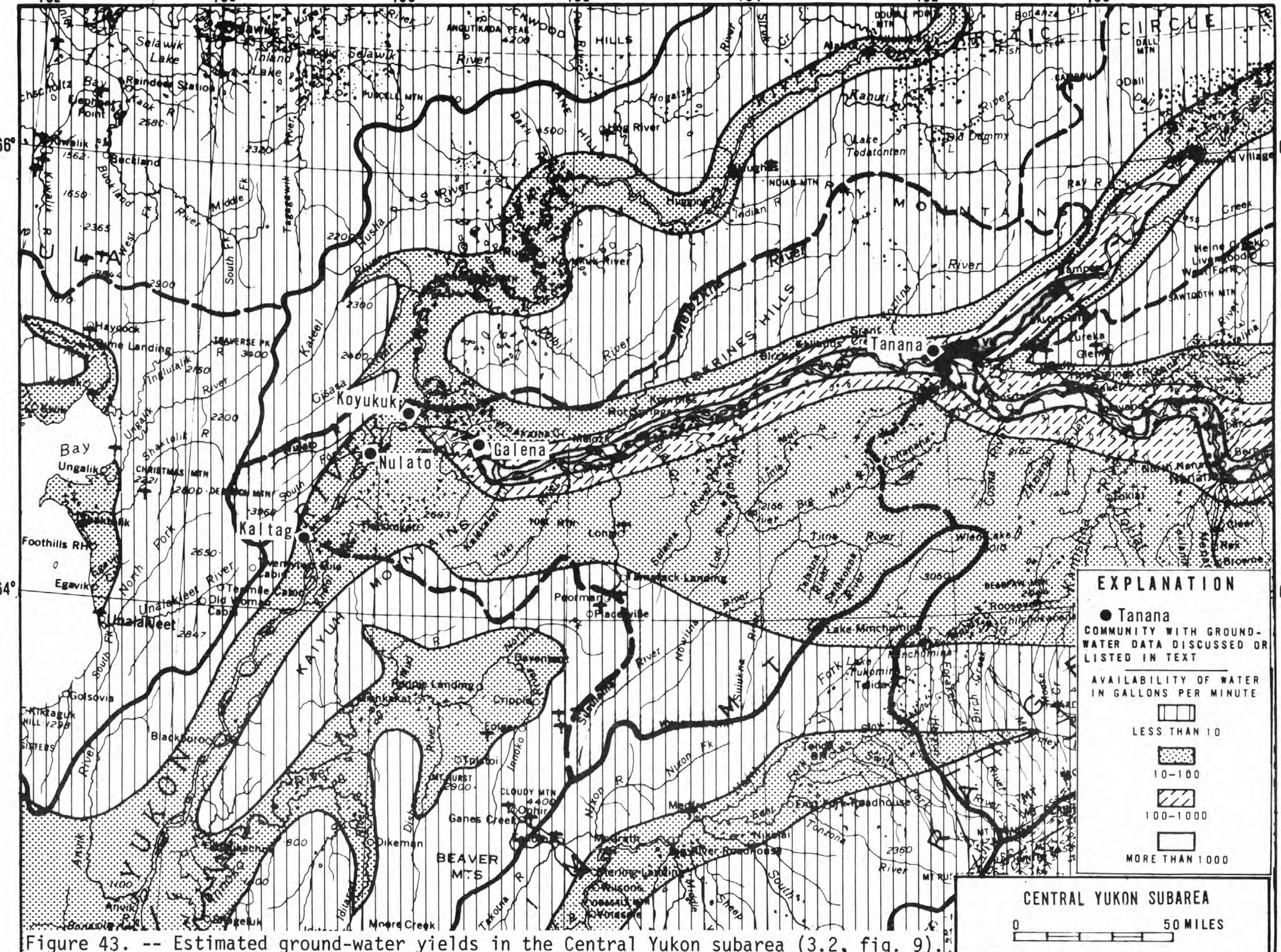


Figure 43. -- Estimated ground-water yields in the Central Yukon subarea (3.2, fig. 9).

Base from U.S.Geological Survey map E (scale 1:2,500,00) of Alaska

Data from Joint Federal-State Land Use Planning Commission (1974)

Table 21.--*Chemical analyses of ground water in the Central Yukon subarea.*

[concentrations in milligrams per litre (mg/l) or micrograms per litre (µg/l)]

Location	Date	Well depth (ft)	Temperature (°C)	mg/l	µg/l		mg/l													Specific conductance (µmhos/cm at 25°C)	pH
				Silica (SiO_2)	Iron (Fe)	Manganese (Mn)	Calcium (Ca)	Magnesium (Mg)	Sodium (Na)	Potassium (K)	Bicarbonate (HCO_3)	Carbonate (CO_3)	Sulfate (SO_4)	Chloride (Cl)	Fluoride (F)	Nitrate (as N)	Dissolved solids	Total hardness			
WELLS																					
Kaltag	06-21-67	85	--	22	7,700(a)	--	37	7.8	3.9	3.4	150	0	1.3	0.0	0.2	0.09	158	110		227	6.5
Nulato	03-06-72	80	--	23	20,000(b)	610(b)	53	15	7.2	1.0	232	0	.8	1.0	.2	3.4	231	193		372	6.6
Koyukuk	04-24-72	--	--	17	29,000(b)	3,000(b)	216	48	7.5	3.9	864	0	4.1	15	.0	.02	737	737		1,210	6.8
Tanana	09-20-62	35	--	15	20(a)	0(a)	127	23	6.8	3.1	436	--	70	4.0	.0	.79	466	410		914	7.5
Galena	01-09-73	76	--	34	10,000(b)	400(b)	54	17	2.7	2.2	280	0	2.6	1.3	.0	.03	252	200		412	7.7

a Undifferentiated
b Total

Koyukuk Subarea

The Koyukuk subarea includes the drainage of the Koyukuk River and its tributaries (fig. 9). It lies in interior Alaska and is bounded on the west by the Northwest subregion, on the north by the Arctic subregion, and on the east and south by the Upper Yukon and the Central Yukon subareas. It covers an area of 33,000 mi^2 and lies within the Continental climatic zone. The temperature range is from -80° to about 90°F and the average annual temperature is about 22°F. Precipitation averages more than 20 inches per year in the uplands and less than 20 inches per year in the lowlands. The average annual precipitation is probably about 20 inches.

The Brooks Range on the north is made up of sedimentary rocks which have been folded, faulted, and intruded by mafic rocks. The uplands to the east are underlain by deformed metasedimentary and volcanic rocks. The lowlands are made up of volcanic rocks, sandstone, shale, and conglomerate that are intruded by granite bodies and mantled by silt and sand deposits. Sand dunes are common (Wahrhaftig, 1965; Patton and Hoare, 1968).

The subarea lies within the discontinuous permafrost zone of the State. Areas adjacent to and beneath the principal streams are generally free of permafrost.

Surface Water.--The principal stream is the Koyukuk River with its many tributaries including the John (est. drainage area 2,100 mi^2), Huslia (est. 2,000 mi^2), Alatna (est. 3,900 mi^2), and Kanuti (est. 3,100 mi^2) as well as the Hammond, Dietrich, and Hogatza Rivers. The estimated mean annual runoff of the subarea is low, less than 1 ft^3/s per square mile. Only the mountains to the north contribute a higher amount which may exceed 2 ft^3/s per square mile (fig. 44). Table 2 lists the estimated mean monthly and mean annual runoff for the subarea.

The estimated mean annual peak runoff is less than 10 ft^3/s per square mile in the lowlands and increases to nearly 50 ft^3/s per square

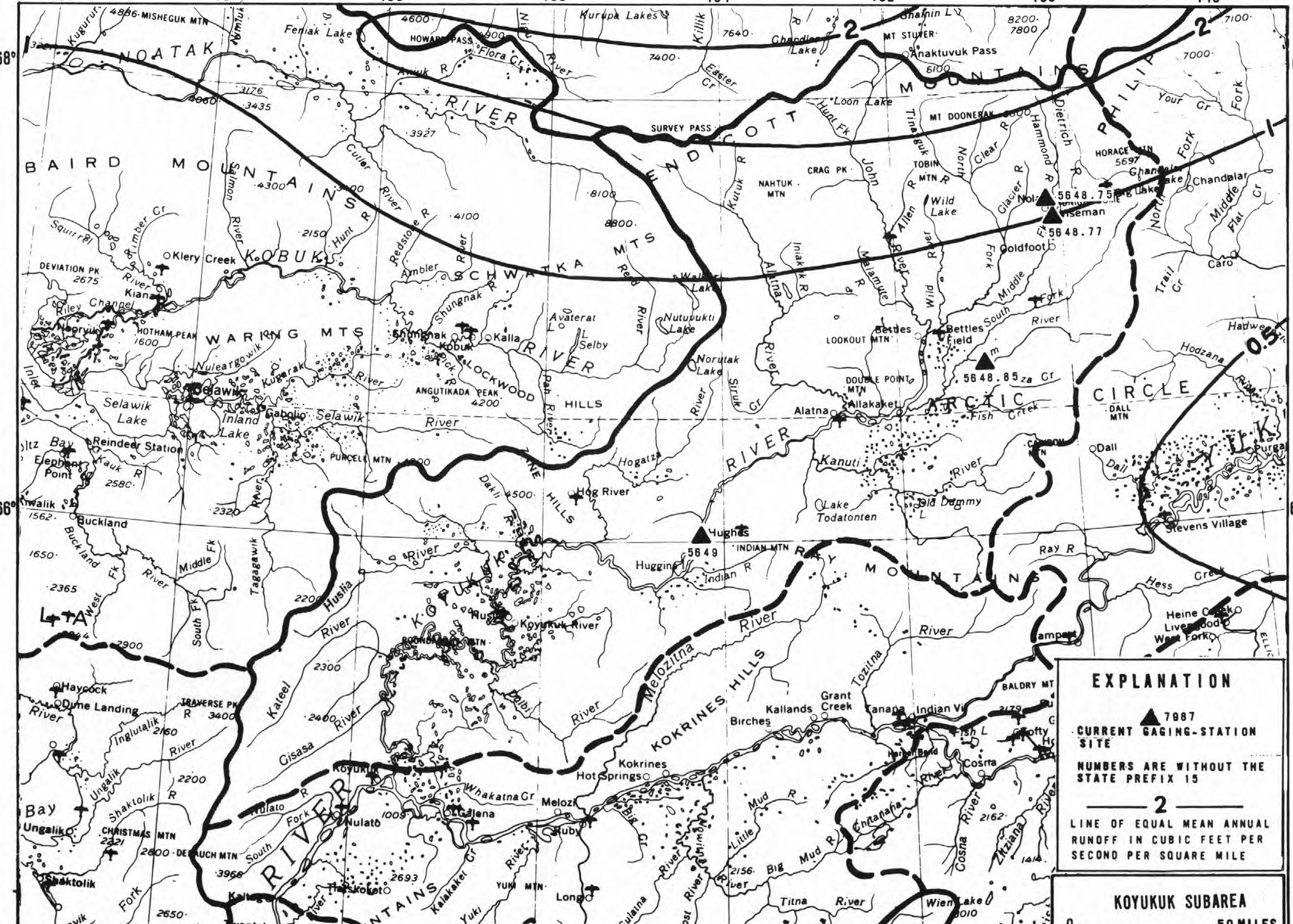


Figure 44. -- Estimated mean annual runoff in the Koyukuk subarea (3.3, fig. 9).

Base from U.S.Geological Survey map E (scale 1:2,500,00) of Alaska

Data from Joint Federal-State Land Use Planning Commission (1974)

mile in the mountains to the north. The average is probably about 10 ft^3/s per square mile for peak discharge. Annual peak flows are caused by spring snowmelt and by heavy precipitation during the summer months. Figure 45 illustrates the flood frequency and magnitude of selected streams in the subarea.

The higher stream discharge during summer from the mountains on the north recharges the aquifers. This permits the stored water to maintain the streamflow during the winter at lower altitudes. The low month mean runoff rates are very low. Streams in the northern part have virtually no winter discharge; flow is slightly more than 0.1 ft^3/s per square mile.

Dissolved-solids concentrations in surface waters range from less than 50 mg/l to about 280 mg/l. All waters are of the calcium bicarbonate type; no chemical constituents were found to exceed Environmental Protection Agency (1972) recommendations in the surface waters sampled. Table 22 lists chemical analyses of selected streams in the subarea.

Streams of the subarea commonly carry only a small amount of sediment. In the northern part maximum sediment concentrations of about 500 mg/l can be expected. In the rest of the subarea maximum concentrations of only about 100 mg/l can be expected during summer months. Figure 46 shows the normal summer suspended-sediment concentration that can be expected.

The Koyukuk River at Hughes has an average annual suspended-sediment yield of only 50 tons per square mile. This is a low yield in comparison with other rivers in the State. An estimated one million tons of suspended sediment per year is discharged from the Koyukuk subarea. Most of this suspended sediment is carried during the relatively short summer. Almost no sediment is carried by the streams during the winter months.

Surface-water temperature data in the subarea are limited. Temperatures range from 32° to 48°F.

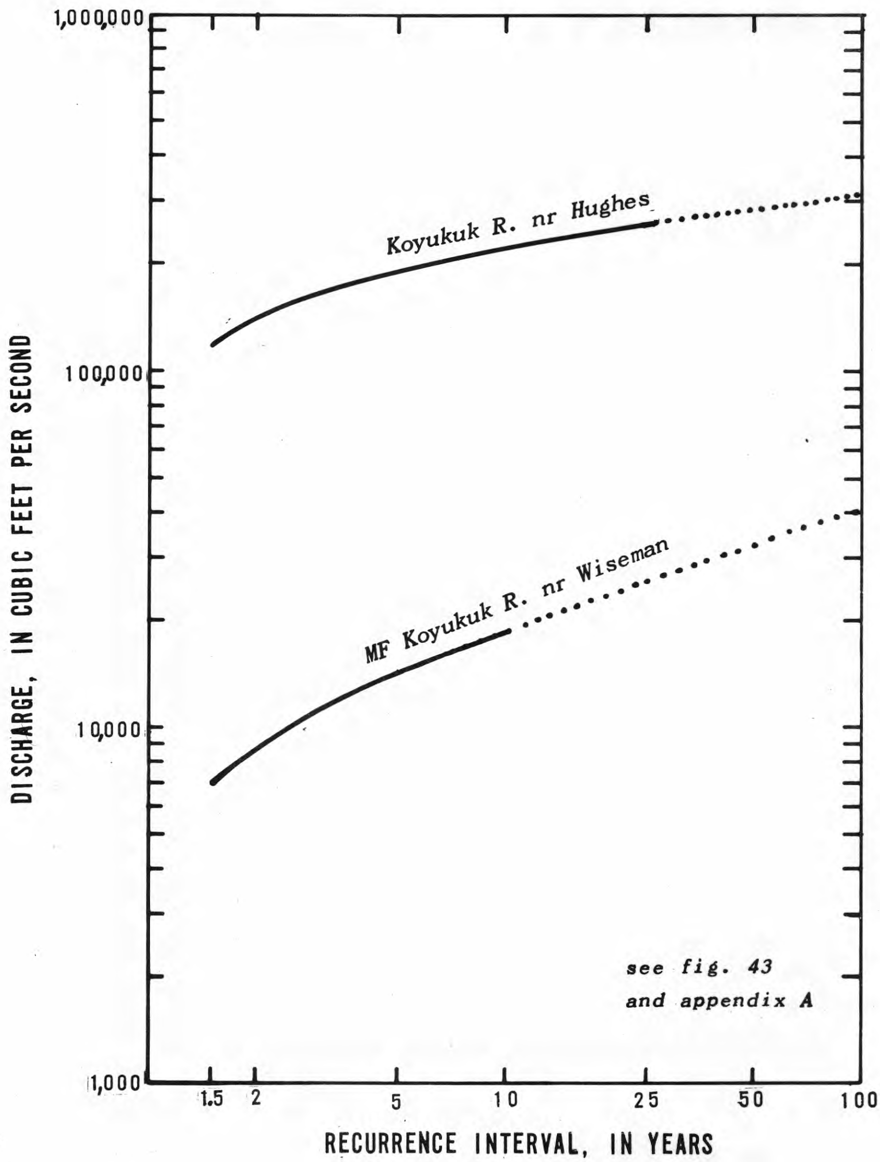


Figure 45. -- Flood magnitude-frequency relation at selected sites on the Koyukuk River (3.3, fig. 9).

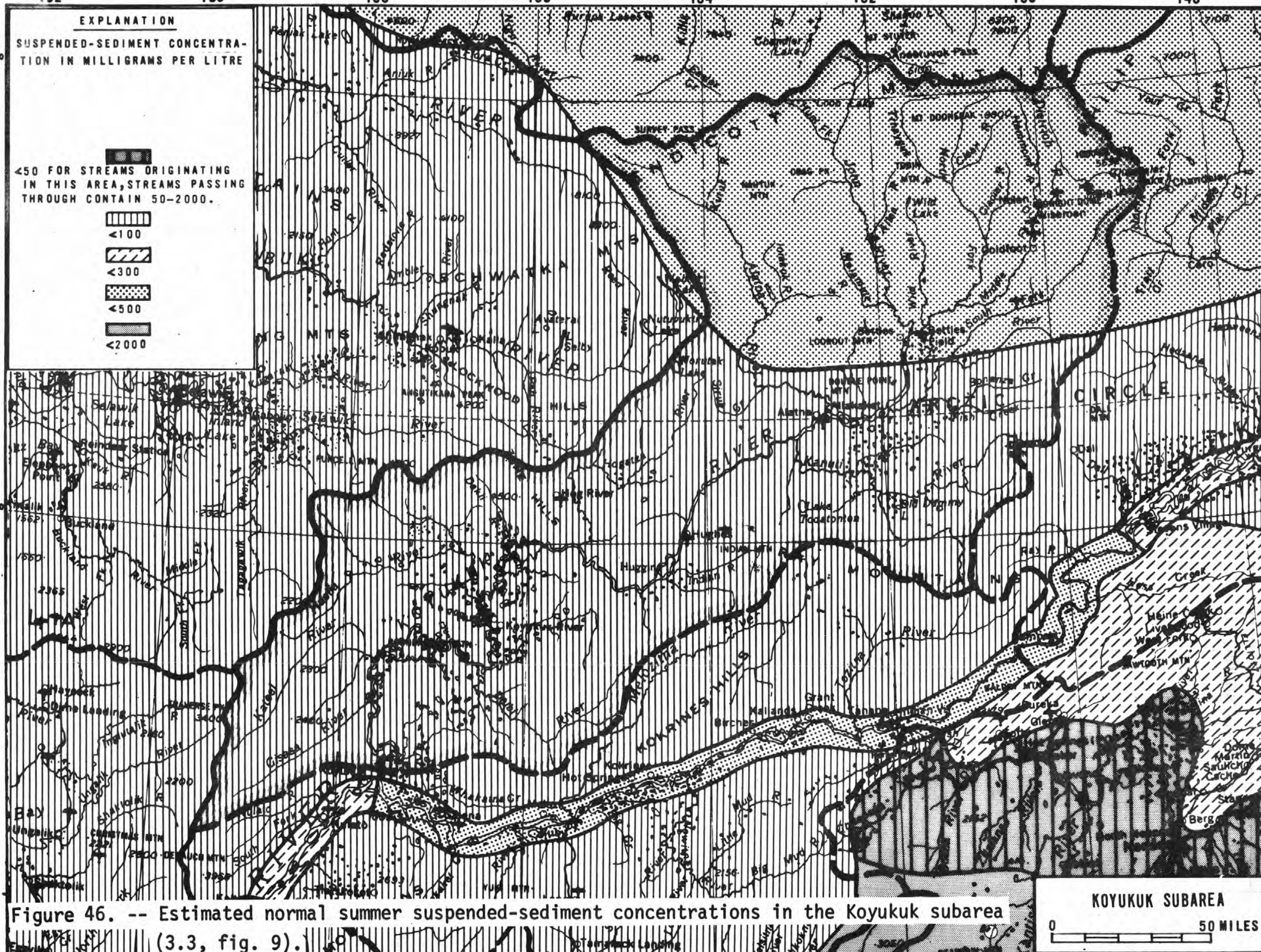


Figure 46. -- Estimated normal summer suspended-sediment concentrations in the Koyukuk subarea (3.3, fig. 9).

Base from U.S. Geological Survey map E (scale 1:2,500,00) of Alaska

Data from Joint Federal-State Land Use Planning Commission (1974)

Table 22.--*Water quality of selected streams in the Koyukuk subarea.*

[concentrations in milligrams per litre (mg/l) or micrograms per litre (µg/l)]

Date and discharge (ft^3/s)	mg/l	µg/l		mg/l												Specific conductance (µmhos/cm at 25°C)	pH units
	Silica (SiO_2)	Iron (Fe)	Manganese (Mn)	Calcium (Ca)	Magnesium (Mg)	Sodium (Na)	Potassium (K)	Bicarbonate (HCO_3)	Carbonate (CO_3)	Sulfate (SO_4)	Chloride (Cl)	Fluoride (F)	Nitrate (as N)	Dissolved solids	Total hardness		
15564875 Middle Fork Koyukuk River near Wiseman																	
04-16-71 5.0	4.6	0(a)	10(a)	61	26	3.4	0.5	231	0	72	1.0	0.1	0.11	283	259	476	7.9
11-27-72 105	3.7	110(a)	0(a)	65	26	3.6	1.6	176	0	84	1.1	.0	.17	273	270	429	8.3
15564900 Koyukuk River at Hughes																	
08-12-71 13,700	4.8	130(a)	10(a)	24	5.8	1.6	.5	86	0	18	.5	.2	.07	98	89	177	7.8
03-23-72 382	6.4	20(a)	20(a)	46	11	2.3	.6	173	0	19	.2	.1	.11	171	160	299	7.7

a Dissolved

Ground Water.--Ground water occurs throughout the subarea at lower altitudes and in zones adjacent to the river system where permafrost is absent (Williams, 1970b). Figure 47 presents the estimated ground-water availability throughout the area. The map has been compiled from the few available data and should be used with caution. There are a few springs within the subarea, but discharge data are not available. The chemical quality of ground water in the subarea has a relatively wide range of dissolved-solids concentrations, from 48 mg/l to 596 mg/l. Waters are all of the calcium bicarbonate type. Iron concentrations in excess of Environmental Protection Agency (1972) recommendations occur in some waters.

Temperatures of ground water have been measured at only a few locations in the subarea. Based upon these few data, the water temperature range is between 33° and 46°F. Table 23 shows chemical analyses of water at various places.

Water Use.--Water is used mostly for domestic purposes, for there are no agricultural or industrial activities. The five villages in the area have a total population of about 800. Pipeline construction camps (Dietrich, Cold Foot, Prospect, Atigun, Chandalar, and Old Man) during peak construction periods boost the population up to about 3,200 people. Based on the types of water services available, it is estimated that 340,000 gal/d are required to meet the domestic needs of the subarea.

Upper Yukon Subarea

The Upper Yukon subarea is the largest in the region having 60,000 square miles of drainage. The subarea adjoins Canada on the east and is bounded on the north by the Arctic subregion, on the west by the Koyukuk subarea, and on the south by the Central Yukon, Tanana, and Upper Yukon-Canada subareas (fig. 9).

The entire subarea lies within the Continental climatic zone. The temperature range is wide, with lows of more than -70°F and a recorded high of 100°F. The average annual temperature is probably

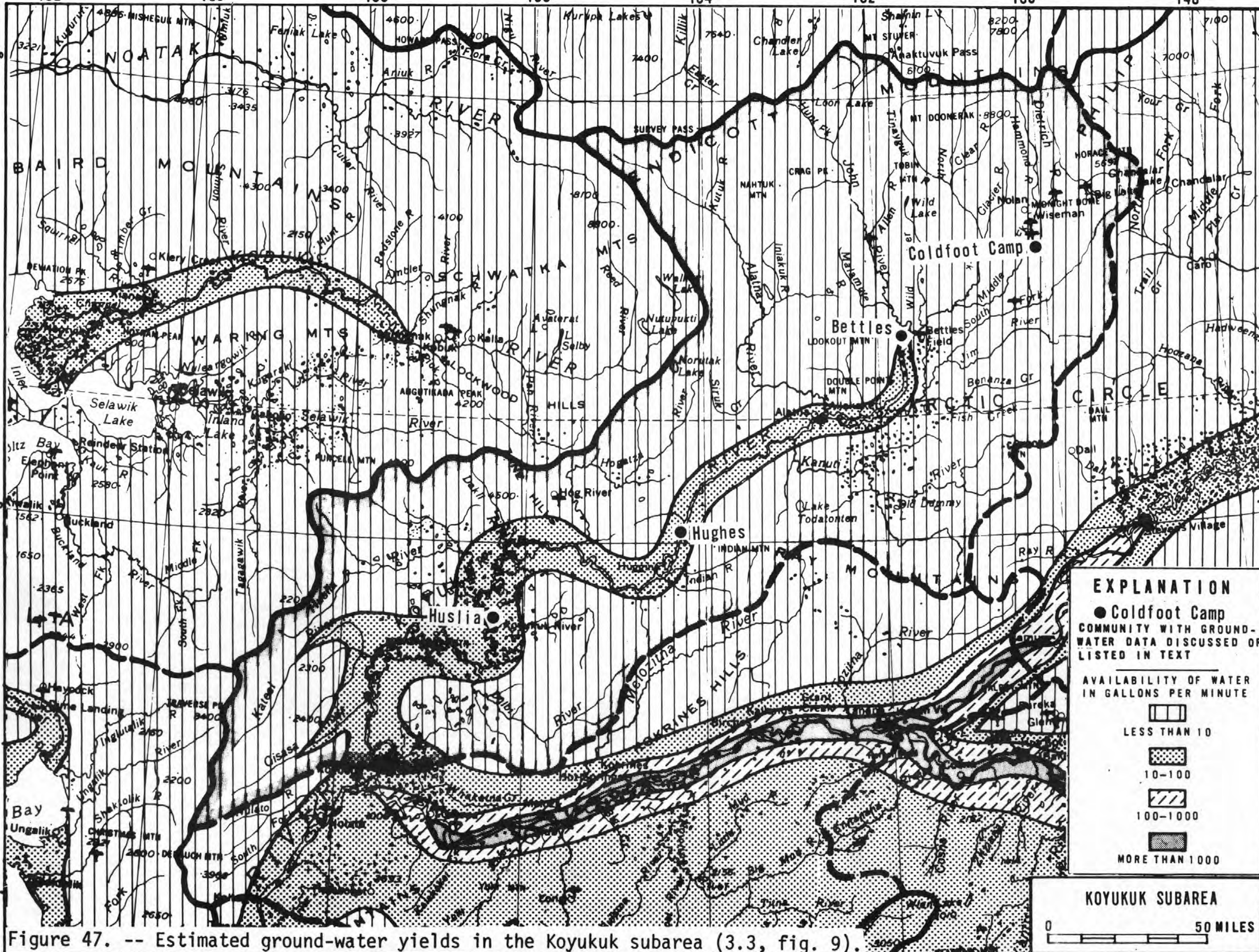


Figure 47. -- Estimated ground-water yields in the Koyukuk subarea (3.3, fig. 9).

Base from U.S.Geological Survey map E (scale 1:2,500,00) of Alaska

Data from Joint Federal-State Land Use Planning Commission (1974)

Table 23.--*Chemical analyses of ground water in the Koyukuk subarea.*

[concentrations in milligrams per litre (mg/l) or micrograms per litre (μg/l)]

				mg/l	μg/l		mg/l													
Location	Date	Well depth (ft)	Temperature (°C)	Silica (SiO_2)	Iron (Fe)	Manganese (Mn)	Calcium (Ca)	Magnesium (Mg)	Sodium (Na)	Potassium (K)	Bicarbonate (HCO_3)	Carbonate (CO_3)	Sulfate (SO_4)	Chloride (Cl)	Fluoride (F)	Nitrate (as N)	Dissolved solids	Total hardness	Specific conductance (μmhos/cm at 25°C)	pH units
WELLS																				
Huslia	03-27-73	--	--	7.9	7,700(a)	160(a)	69	11	1.9	0.7	271	0	1.8	0.9	0.0	0.02	236	220	413	7.4
Hughes	05-08-71	45	--	8.5	70(b)	510(b)	148	32	19	1.2	456	0	76	12	.2	17	596	501	945	7.0
Bettles	07----62	--	--	9.4	20(c)	2,100(c)	65	7.8	.9	.4	231	0	7.0	1.0	.0	.05	206	195	349	7.8
Old Man	05-02-74	285	3.0	13	110(a)	0(a)	17	5.2	2.0	1.1	80	0	1.3	.3	.2	.28	81	64	130	8.3
Prospect	08-11-71	20	7.5	7.0	0(b)	20(b)	10	2.1	2.0	.5	40	0	3.8	1.0	.2	.36	48	34	79	7.0
Coldfoot	08-12-71	20	--	3.0	330(b)	20(b)	22	3.8	2.9	.3	67	0	14	3.8	.2	.36	85	70	150	7.6
Dietrich	08-12-71	21	3.0	3.0	0(b)	100(b)	53	26	4.1	.5	225	0	60	.5	.2	.34	260	238	444	8.1

a Dissolved
b Total

about 20°F. Precipitation ranges from a high of more than 40 inches in the mountains of the Brooks Range to less than 10 inches along the Yukon River. The average annual precipitation is about 15 inches.

The Brooks Range, a complex geologic system at the north margin of the subarea, is made up of sedimentary rocks. The Yukon Flats to the south and west are generally underlain by sedimentary rocks. The entire lowland is filled and covered by glacial and alluvial materials, most of which are frozen to considerable depths (Wahrhaftig, 1965; Williams, 1970b).

The subarea lies within the discontinuous permafrost zone of the State. A well at Fort Yukon was drilled to a depth of 440 feet; most of this depth was in permafrost (Williams, 1970b). Permafrost-free areas generally occur adjacent to major streams and beneath lakes.

Surface Water.--The principal stream is the Yukon River which flows from the Canadian boundary westward to Rampart. Two major tributaries, the Chandalar (est. drainage area 9,900 mi^2) and the Porcupine (est. 45,000 mi^2) Rivers, enter the Yukon from the north. A number of smaller streams are tributaries either to the Yukon or to one of the other two major tributaries.

The estimated mean annual runoff throughout much of the subarea is very low, less than 0.5 ft^3/s per square mile in the lowlands. To the north the runoff increases to nearly 2 ft^3/s per square mile in the mountains. The average runoff for the subarea is about 0.5 ft^3/s (fig. 48). Table 2 lists the estimated mean monthly and mean annual runoff for the subarea and also the mean monthly and mean annual inflow of the Yukon and Porcupine Rivers into the subarea from Canada.

The estimated mean annual peak runoff is less than 10 ft^3/s per square mile in the lowlands. This low runoff increases to more than 25 ft^3/s on the subarea's margins. The subarea average, however, is not much more than 10 ft^3/s per square mile. Figure 49 illustrates the flood frequency and magnitude of selected streams in the subarea.

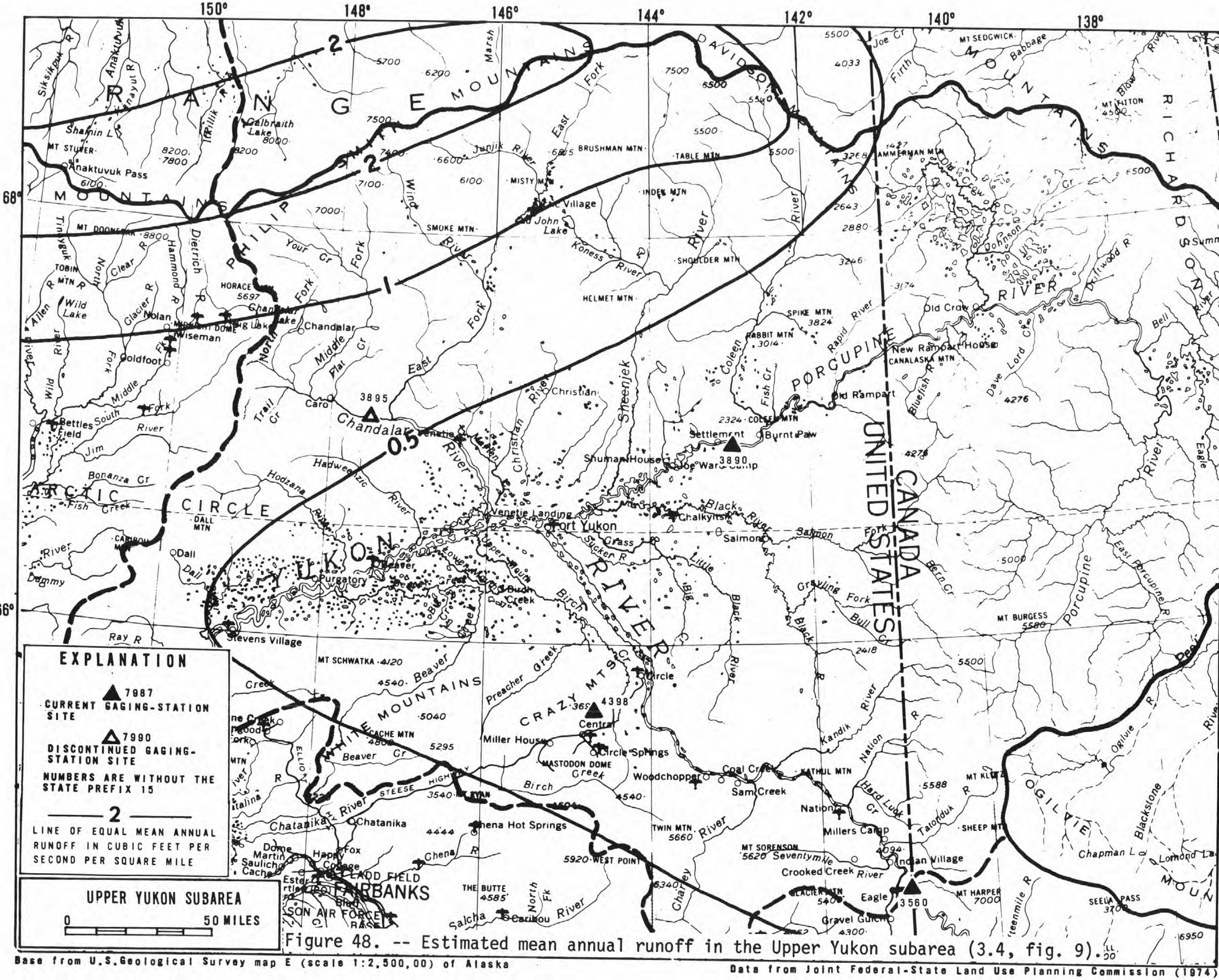


Figure 48. -- Estimated mean annual runoff in the Upper Yukon subarea (3.4, fig. 9).

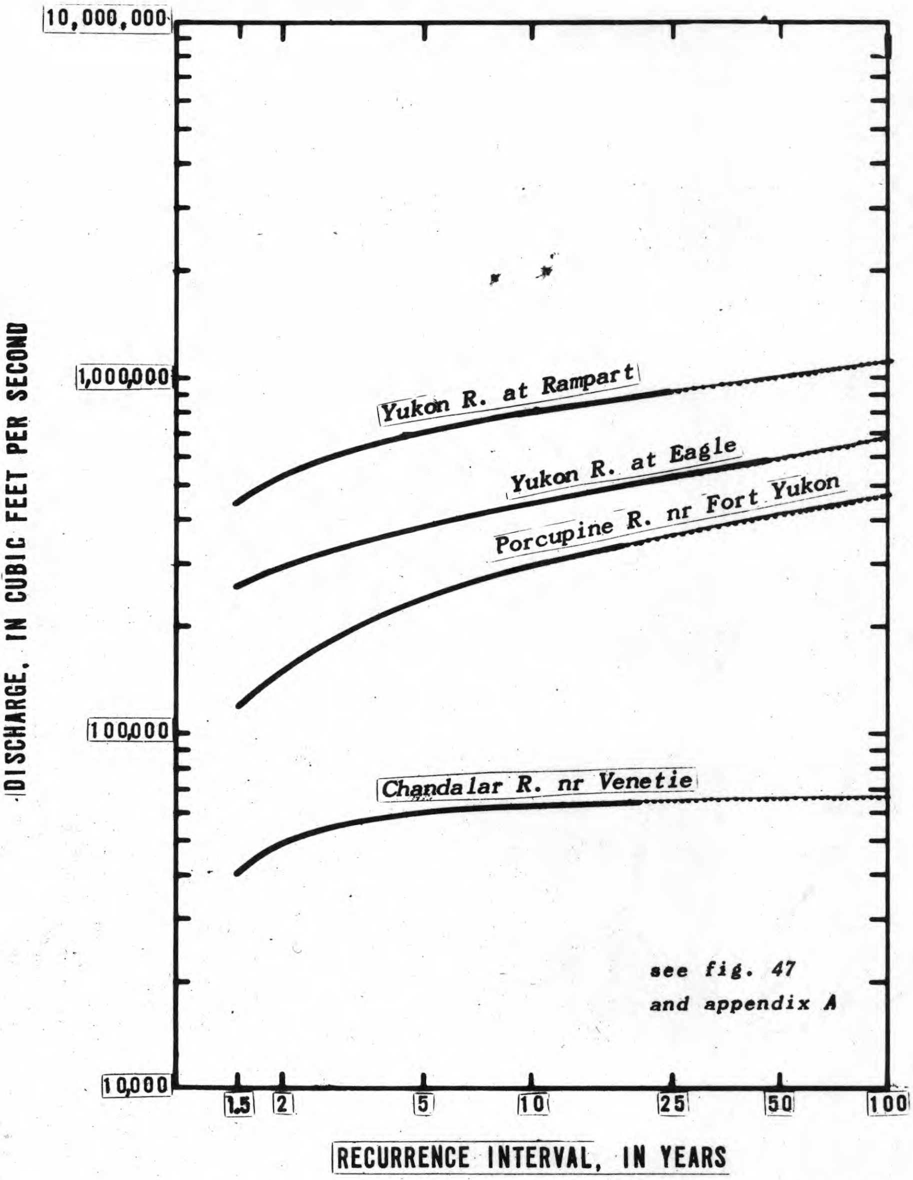


Figure 49. -- Flood magnitude-frequency relation of selected streams in the Upper Yukon subarea (3.4, fig. 9).

The low month mean runoff rates range from zero to a little more than 0.1 ft^3/s per square mile. The areas of zero runoff extend from the Brooks Range southward nearly to the Yukon River, which strongly suggests that there is little thawed ground in the northern part of the subarea from which streams may receive ground-water inflow during the winter months.

The dissolved-solids concentrations of surface water averages less than 200 mg/l. All of the waters sampled are of the calcium bicarbonate type. Table 24 shows some chemical analyses of selected streams in the subarea.

Streams in the central part of the subarea commonly carry less than 100 mg/l of suspended sediment during normal summer runoff; streams around the margin of the subarea may carry up to 500 mg/l. The average suspended-sediment load may not exceed 100 mg/l throughout most of the year. Figure 50 presents the suspended-sediment concentrations expected to be present in the streams during normal summer runoff.

The only stream in the subarea for which suspended-sediment yield has been calculated is the Yukon River at Eagle, a few miles downstream from the Canadian border. There the Yukon River carries an estimated annual suspended-sediment load of 270 tons per square mile from the upstream area, equivalent to 30.6 million tons of suspended sediment. Most of the sediment yield of the Yukon River is carried during the summer months; relatively low suspended-sediment loads have been measured during winter.

The observed temperatures of surface water in the subarea range from 32° to 52°F.

Ground Water.--Ground water occurs throughout the southern part of the subarea near and beneath streams where permafrost is absent. North of the Yukon River no ground water has been found adjacent to streams. It is possible, however, to obtain water supplies by installing galleries in the beds of streams and to produce water by infiltration. The yields

Table 24.--*Water quality of selected streams in the Upper Yukon subarea.*

[concentrations in milligrams per litre (mg/l) or micrograms per litre (µg/l)]

Date and discharge (ft^3/s)	Silica (SiO_2) mg/l	Iron (Fe) µg/l	Manganese (Mn) µg/l	Calcium (Ca) mg/l	Magnesium (Mg) mg/l	Sodium (Na) mg/l	Potassium (K) mg/l	Bicarbonate (HCO_3) mg/l	Carbonate (CO_3) mg/l	Sulfate (SO_4) mg/l	Chloride (Cl) mg/l	Fluoride (F) mg/l	Nitrate (as N) mg/l	Dissolved solids mg/l	Total hardness mg/l	Specific conductance (µmhos/cm at 25°C)	pH units
						15356000 Yukon River at Eagle											
04-07-55 13,900	7.5	20(a)	--	35	9.9	2.9	1.3	126	0	25	0.5	0.2	0.11	145	128	251	6.4
06-22-68 230,000	6.0	3,200(a)	--	24	6.2	2.7	.8	84	0	20	.2	.2	.02	104	86	173	8.0
						15389000 Porcupine River near Fort Yukon											
05-24-67 20,600	2.4	230(a)	--	16	2.8	1.0	1.5	56	0	7.0	.0	.3	.05	59	52	106	7.1
09-23-67 30,200	4.4	740(a)	0(a)	21	4.0	1.5	.3	72	0	10	.7	.1	.20	79	69	141	7.2
						15389500 Chandalar River near Venetie											
06-07-70 11,600	1.5	50(a)	10(a)	23	4.4	.8	.7	77	0	15	.4	.2	.20	86	79	157	7.8
09-20-70 4,080	2.5	30(a)	100(a)	45	6.7	.8	.3	152	0	15	1.0	.2	.05	147	140	260	8.1
						15468000 Yukon River at Rampart											
01-16-59 20,000	7.6	20(a)	10(a)	36	13	4.2	1.6	154	0	26	2.5	.1	.09	167	144	286	7.1
05-25-67 280,000	4.8	520(a)	--	30	5.2	1.7	1.6	98	0	25	.4	.4	.20	119	97	188	7.4

a Undifferentiated

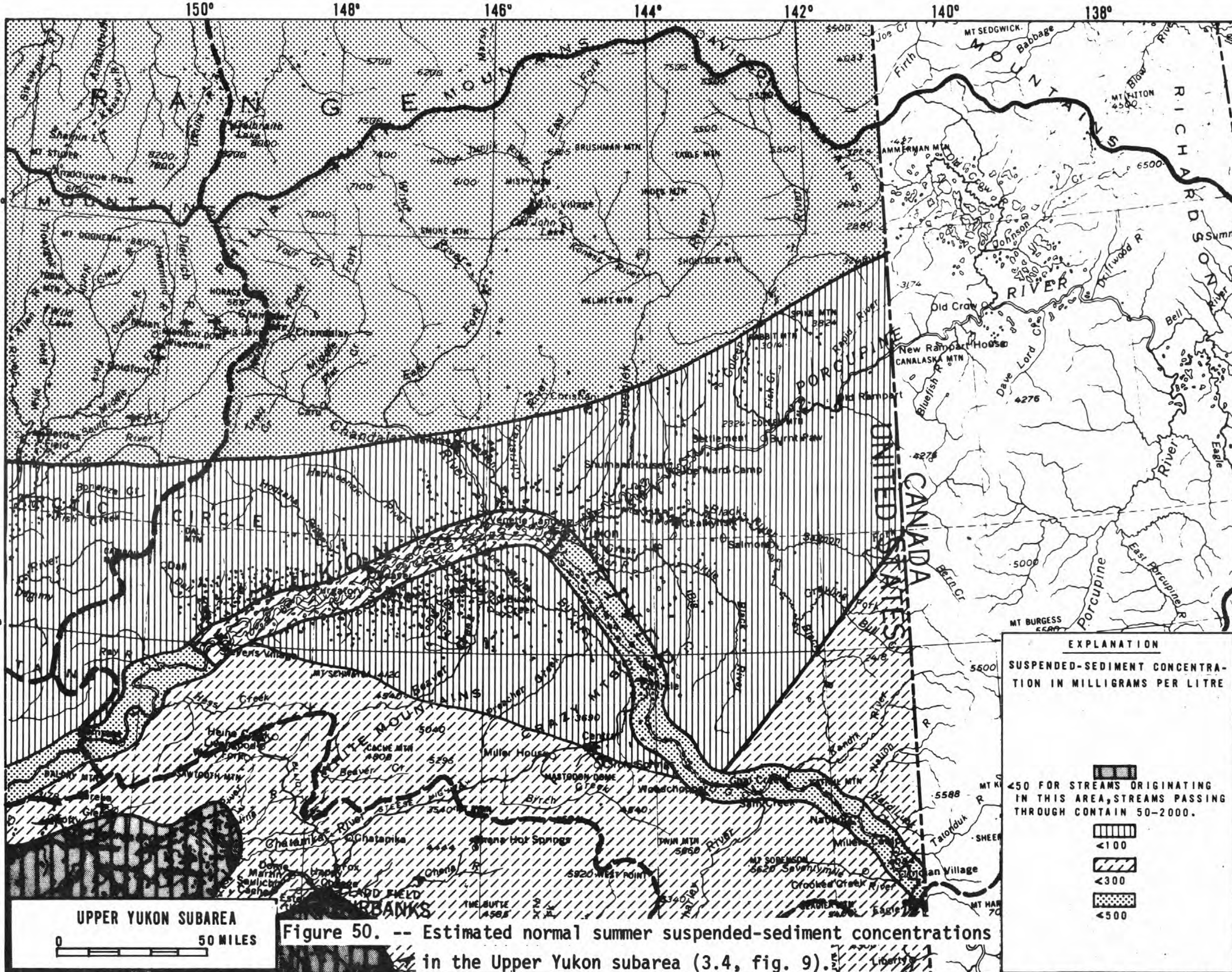


Figure 50. -- Estimated normal summer suspended-sediment concentrations in the Upper Yukon subarea (3.4, fig. 9).

Base from U.S.Geological Survey map E (scale 1:2,500,00) of Alaska

Data from Joint Federal-State Land Use Planning Commission (1974)

of wells throughout the subarea are low. The general availability of ground water shown in figure 51 is based upon the few data available. This information should be used with caution as it is only an approximation.

The ground water has rather high dissolved-solids concentrations which range from 250 mg/l to almost 800 mg/l. It is of the calcium bicarbonate type. The temperature range of ground-water sources appears to be between 34° and 36°F. Table 25 lists chemical analyses of water from some wells in the subarea.

Springs occur in the subarea. Chemical analysis of one spring sample is shown on table 25. No details are available on the flow of the springs.

Water Use.--The economy in the subarea is based mainly on subsistence. There are no agricultural, mining, or industrial operations (other than a few village sawmills) that place demands on the water resources. Water needs are primarily domestic. Based on a population estimated at about 2,700 people, including pipeline camps, the domestic water use in the subarea amounts to about 145,000 gal/d.

Tanana Subarea

The Tanana subarea includes the drainage of the Tanana River and its tributaries. It lies to the north of the Southcentral and Southwestern subregions and is bounded on the west and north by the Central, Upper Yukon, and Upper Yukon-Canada subareas (fig. 9). It covers an area of 45,000 square miles.

The subarea lies in both the Transition and Continental climatic zones; temperatures range from a low of -76°F to a high of 100°F. The average annual temperature is about 24°F. Precipitation ranges from about 8 to nearly 24 inches and averages about 12 inches annually.

The mountains surrounding the basin consist of folded, faulted, and metamorphosed sedimentary and igneous rocks, including slate,

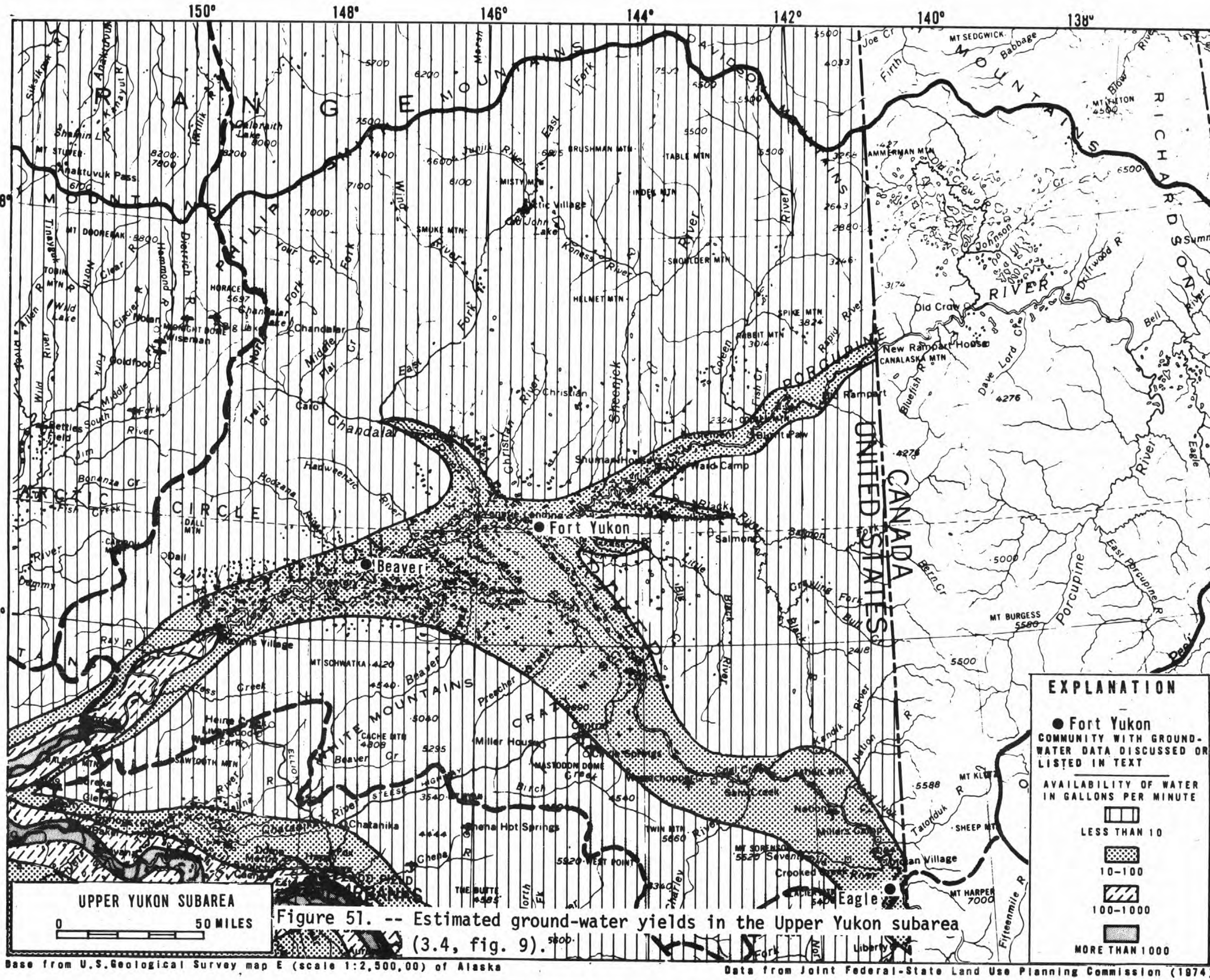


Figure 51. -- Estimated ground-water yields in the Upper Yukon subarea (3.4, fig. 9).

Table 25.--*Chemical analyses of ground water in the Upper Yukon subarea.*

[concentrations in milligrams per litre (mg/l) or micrograms per litre (µg/l)]

Location	Date	Well depth (ft)	Temperature (°C)	Silica (SiO_2) (mg/l)	Iron (Fe) (µg/l)	Manganese (Mn) (µg/l)	Calcium (Ca) (mg/l)	Magnesium (Mg) (mg/l)	Sodium (Na) (mg/l)	Potassium (K) (mg/l)	Bicarbonate (HCO_3) (mg/l)	Carbonate (CO_3) (mg/l)	Sulfate (SO_4) (mg/l)	Chloride (Cl) (mg/l)	Fluoride (F) (mg/l)	Nitrate (as N) (mg/l)	Dissolved solids (mg/l)	Total hardness (mg/l)	Specific conductance (µmhos/cm at 25°C)	pH units
WELLS																				
Five Mile	08-10-71	230	4.0	18	0(a)	110(a)	35	25	13	0.3	136	0	90	0.2	0.1	0.32	250	190	415	7.8
Beaver	08-19-68	42	1.0	8.7	--	--	84	18	6.4	2.3	301	0	33	8.2	.0	1.6	314	284	525	7.3
Fort Yukon	02-06-73	--	--	9.2	10(b)	340(b)	49	13	4.0	2.5	85	0	140	27	.1	.06	263	180	417	6.7
Eagle	09-29-64	101	--	4.3	20(c)	--	97	70	82	1.0	332	0	255	124	.0	.18	798	528	1,270	7.6
SPRINGS																				
Circle Hot Springs (d)	--	--	57	95	--	--	21	.3	230	9.8	185	--	96	249	9.7	--	--	--	--	7.6

a Total
b Dissolved
c Undifferentiated
d From Miller, 1973

schist, argillite, marble, and greenstone. The entire lowland area is mantled by Holocene deposits of sand, gravel, and silt that were deposited by glacial and alluvial action. Sand dunes and wind-borne silts occur in the subarea (Wahrhaftig, 1965).

The Tanana subarea lies entirely within the discontinuous permafrost zone of the State. Most of the lowlands are free of permafrost. Permafrost having a high ice content occurs in poorly drained areas of fine-grained sediment or in the uplands where the ground is covered by muskeg, peat, or other vegetation (Anderson, 1970).

Glaciers are found in the mountains along most of the southern boundary; the northern and central parts of the subarea have no glaciers.

<u>Surface Water</u>.--The principal stream is the Tanana River. Its larger tributaries are the Tolovana (est. drainage area 2,500 mi^2), Chatanika (est. 1,400 mi^2), Chena (2,000 mi^2), Salcha (2,170 mi^2 and Goodpaster (est. 1,400 mi^2) from the north and the Kantishna (est. 7,500 mi^2), Nenana (est. 3,500 mi^2), Delta (est. 1,500 mi^2), Nabesna (est. 2,000 mi^2), and Chisana (est. 3,300 mi^2) Rivers from the south.

The mean annual runoff ranges from about 0.5 ft^3/s per square mile in the north to more than 4 ft^3/s per square mile in the south. An average for the entire subarea is about 1 ft^3/s (fig. 52). Table 2 shows the estimated mean monthly and mean annual runoff of the subarea.

The mean annual peak runoff ranges from less than 10 ft^3/s per square mile throughout the central lowlands to maximums of more than 50 ft^3/s per square mile in the highlands in both the north and south. The average rate of peak annual runoff is probably between 20 and 25 ft^3/s per square mile. Figure 53 illustrates the flood frequency and magnitude of selected streams in the subarea.

The low month mean runoff averages about 0.2 ft^3/s per square mile across the entire subarea.

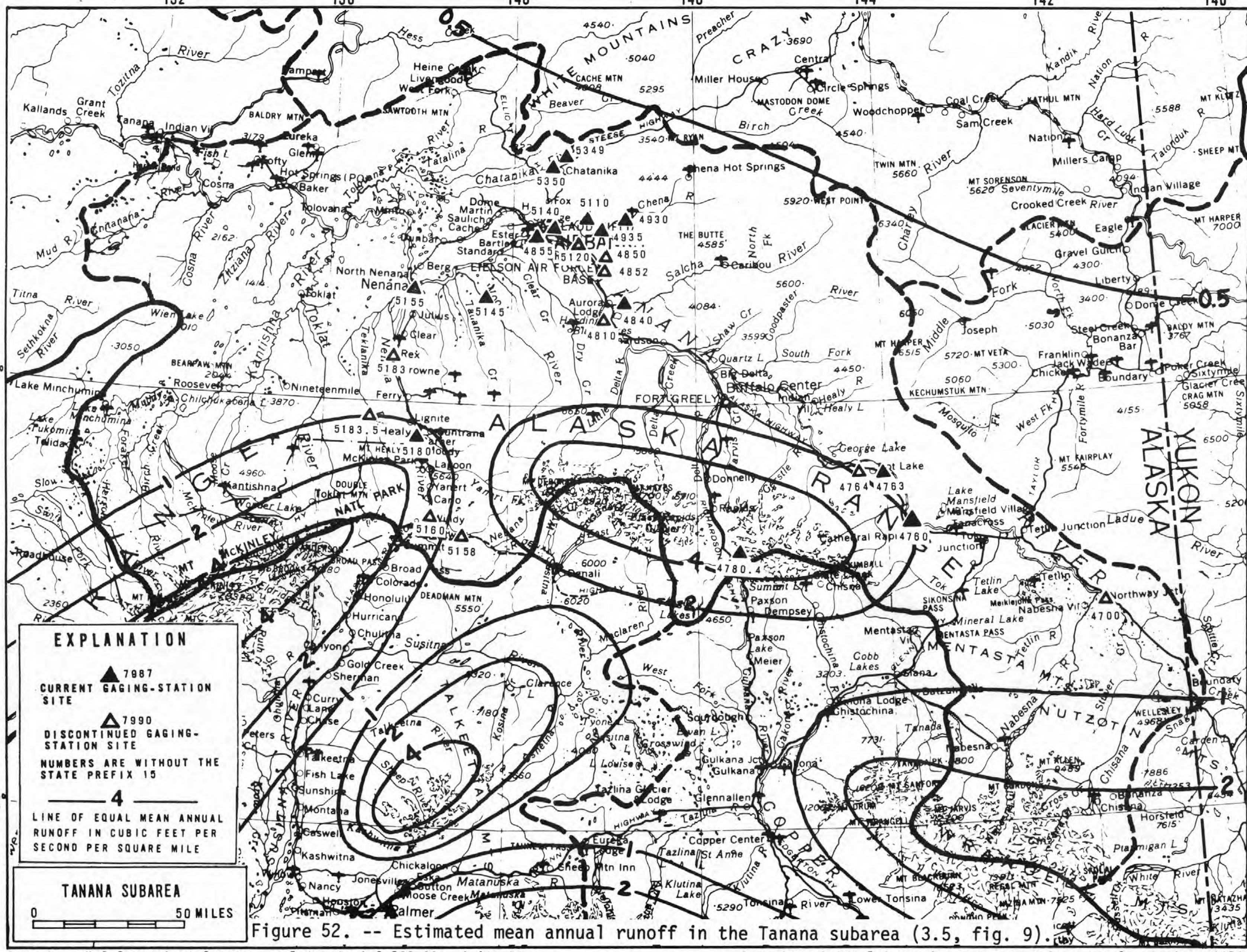


Figure 52. -- Estimated mean annual runoff in the Tanana subarea (3.5, fig. 9).

Base from U.S.Geological Survey map E (scale 1:2,500,00) of Alaska

Data from Joint Federal-State Land Use Planning Commission (1974)

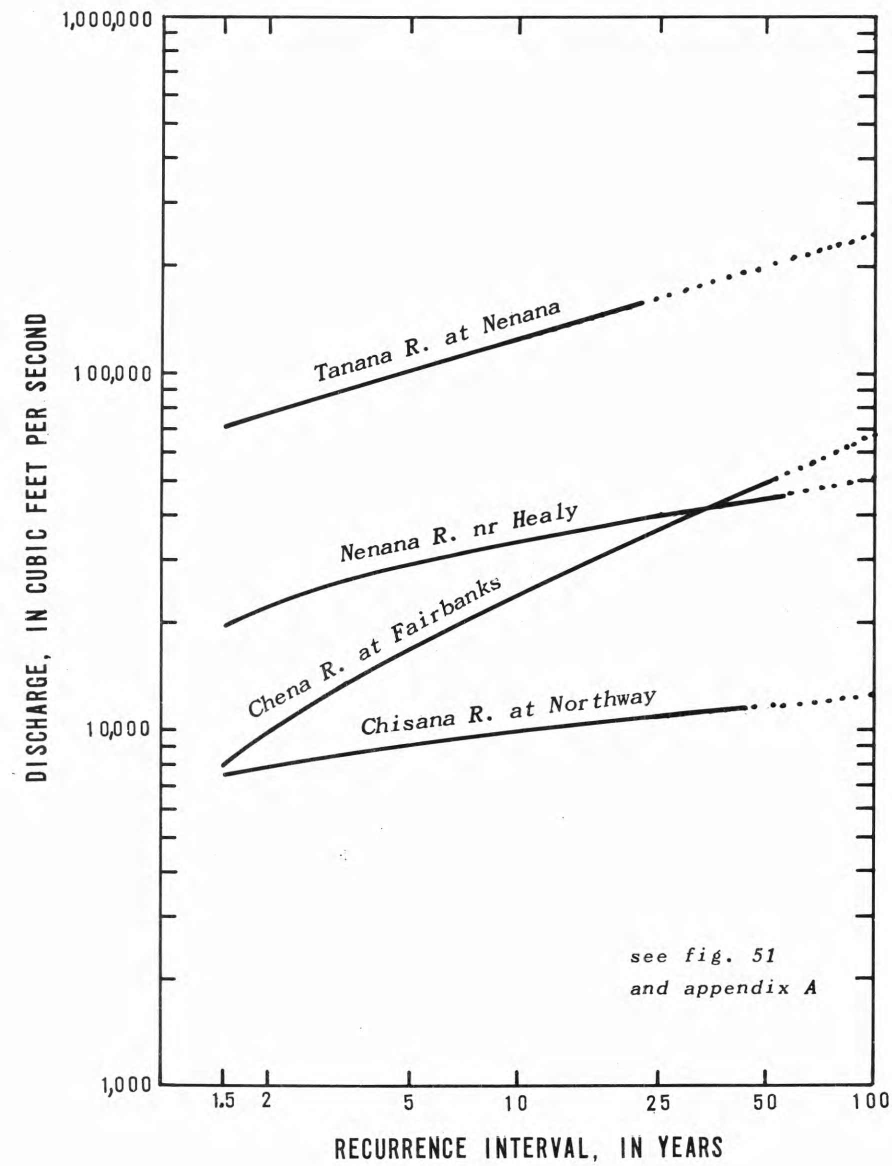


Figure 53. -- Flood magnitude-frequency relation of selected streams in the Tanana subarea (3.5, fig. 9).

The surface waters have dissolved-solids concentrations ranging from about 50 to about 500 mg/l. All the surface waters sampled are of the calcium bicarbonate type. Water temperatures range from 32° to 65°F during the year. Table 26 shows chemical analyses of selected streams in the subarea.

Streams flowing from the north commonly carry suspended-sediment loads of from 100 to 300 mg/l. The glacial streams flowing into the Tanana River from the south carry from 500 to 2,000 mg/l of suspended sediment during normal summer runoff. The Tanana River near Tanacross has an average annual suspended-sediment yield of 1,100 tons per square mile and the Nenana River near Healy yields 1,700 tons per square mile. The Chena River near Fairbanks yields only 200 tons per square mile annually. Nearly all the suspended sediment of these streams is carried during the summer months. Very little sediment is moved during winter. Figure 54 shows the estimated normal summer suspended-sediment concentrations expected in the subarea.

Ground Water.--Ground water is generally available in areas free of permafrost. Yields in excess of 50 gal/min and in some areas more than 1,000 gal/min can be expected from the unconsolidated materials. At higher altitudes, small amounts of ground water may be available in some areas. Much of the subarea is underlain by permafrost which reduces the availability of ground water (Anderson, 1970). Figure 55 presents estimated ground-water availability.

The ground water in this subarea has a fairly wide range of dissolved-solids concentrations and water types. Water from bedrock wells generally has dissolved-solids concentrations in excess of 400 mg/l and is of the magnesium bicarbonate or magnesium sulfate type. However, bedrock wells near Summit produce water of a sodium bicarbonate type. Most of the wells drilled in the lowlands tap aquifers in alluvial and glacial deposits and produce water of a calcium bicarbonate type. Much of the water obtained in the lowlands is high in iron, in places many times higher than the recommendations set by the Environmental Protection

Table 26.--*Water quality of selected streams in the Tanana subarea.*

[concentrations in milligrams per litre (mg/l) or micrograms per litre (μg/l)]

Date and discharge (ft^3/s)	mg/l	μg/l		mg/l												Specific conductance (μmhos/cm at 25°C)	pH units
	Silica (SiO_2)	Iron (Fe)	Manganese (Mn)	Calcium (Ca)	Magnesium (Mg)	Sodium (Na)	Potassium (K)	Bicarbonate (HCO_3)	Carbonate (CO_3)	Sulfate (SO_4)	Chloride (Cl)	Fluoride (F)	Nitrate (as N)	Dissolved solids	Total hardness		
						15470000 Chisana River at Northway											
04-08-59 --	14	20(a)	10(a)	46	9.3	6.0	2.6	158	0	27	3.0	0.1	--	194	153	319	6.5
08-23-72 6,490	6.9	140(b)	0(b)	28	4.7	4.3	1.2	99	0	18	1.9	.0	0.02	114	89	197	7.1
						15514000 Chena River at Fairbanks											
08-06-69 10,200	6.4	2,700(a)	750(a)	12	2.3	1.1	2.1	30	0	10	.7	.1	.27	54	40	83	7.0
03-03-70 182	23	3,200(a)	820(a)	36	7.6	4.9	2.8	140	0	13	2.1	.2	.52	165	119	252	6.6
						15515500 Tanana River at Nenana											
01-25-74 4,740	19	--	--	54	10	4.8	2.9	173	0	33	2.4	.2	.30	212	180	310	7.5
05-23-74 34,300	7.4	--	--	24	5.0	2.7	1.9	72	0	34	2.5	.3	.10	113	81	155	7.2
						15518000 Nenana River near Healy											
02-16-59 497	8.2	0(a)	0(a)	36	10	5.6	2.6	102	0	51	5.0	.0	.11	169	131	282	7.0
05-24-68 8,750	4.0	550(a)	--	18	3.6	2.7	1.4	57	0	14	1.1	.2	.09	74	60	123	7.0

a Undifferentiated
b Dissolved

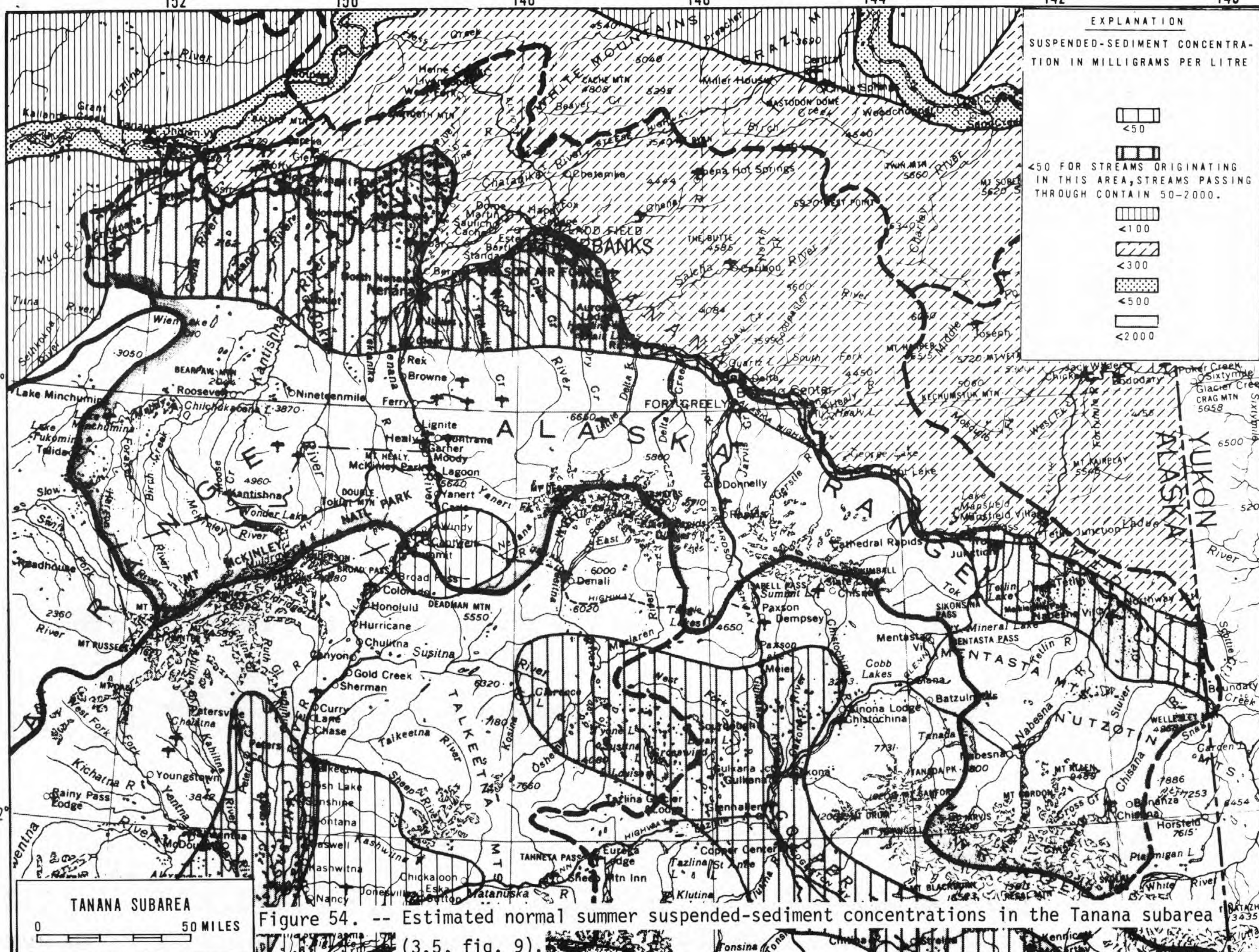


Figure 54. -- Estimated normal summer suspended-sediment concentrations in the Tanana subarea (3.5, fig. 9).

Base from U.S.Geological Survey map E (scale 1:2,500,00) of Alaska

Data from Joint Federal-State Land Use Planning Commission (1974)

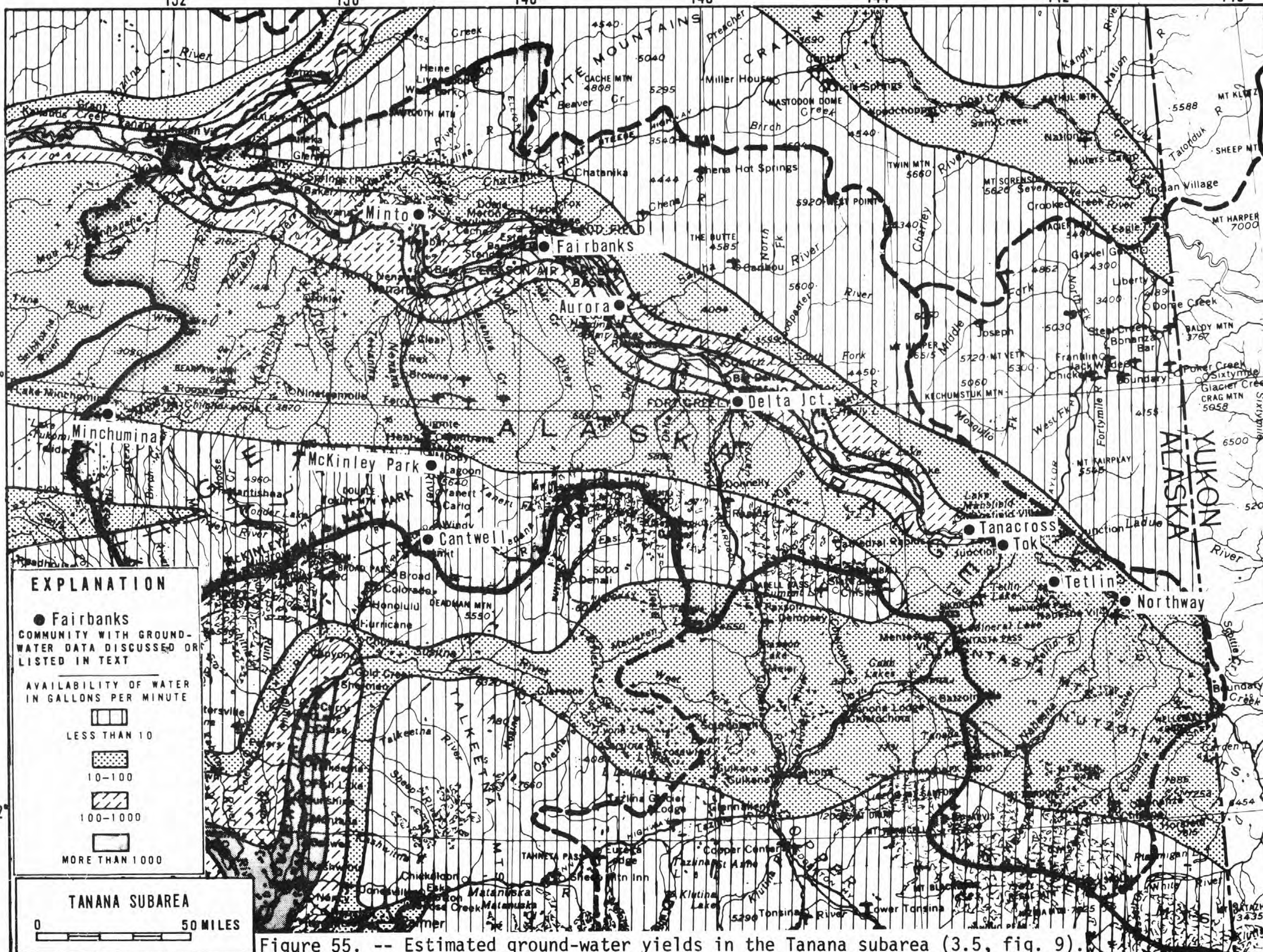


Figure 55. -- Estimated ground-water yields in the Tanana subarea (3.5, fig. 9).

Base from U.S.Geological Survey map E (scale 1:2,500,00) of Alaska

Data from Joint Federal-State Land Use Planning Commission (1974)

Agency (1972). Several thermal or mineral springs occur in the subarea. Chemical quality of their waters ranges from calcium bicarbonate type waters having low dissolved-solids concentrations to magnesium-sodium bicarbonate type waters with dissolved-solids concentrations as high as 2,900 mg/l (Anderson, 1970). Table 27 shows chemical analyses of ground water.

Ground water has a smaller range of temperature than does surface water. The normal year-round temperature range of ground water is from about 32° to about 40°F; most temperatures are at or near 35°F. Thermal springs have temperatures which range from 114° to 149°F.

Water Use.--With the increase in population owing to pipeline construction, it is estimated that the population of the subarea is now about 66,000. Fairbanks' population is close to 37,000, and the North Star Borough has a total of 63,350 people living in its boundaries. The economy of the area is based on government employment (military), agriculture, forestry, mining, and logistical support for the oil and gas industry on the North Slope.

It is estimated that the current domestic water needs of the subarea total 8.5 Mgal/d. Agricultural water needs are estimated at 9,900 acre-ft (acre-feet) per year for crops, and livestock requirements are estimated at 8,780 gal/d.

Coal mining produces about 700,000 tons per year. An estimated 20 percent of this is washed and requires approximately 98 million gallons of water per year.

Upper Yukon-Canada Subarea

The Upper Yukon-Canada subarea lies to the east of the Tanana subarea and south of the Upper Yukon subarea (fig. 9). Its streams drain eastward into Canada and flow into the Yukon River. The subarea includes a northern and a southern segment within the State. It covers an area of 9,000 square miles.

Table 27.--*Chemical analyses of ground water in the Tanana subarea.*

[concentrations in milligrams per litre (mg/l) or micrograms per litre (µg/l)]

Location	Date	Well depth (ft)	Temperature (°C)	mg/l	µg/l		mg/l												Specific conductance (µmhos/cm at 25°C)	pH units
				Silica (SiO_2)	Iron (Fe)	Manganese (Mn)	Calcium (Ca)	Magnesium (Mg)	Sodium (Na)	Potassium (K)	Bicarbonate (HCO_3)	Carbonate (CO_3)	Sulfate (SO_4)	Chloride (Cl)	Fluoride (F)	Nitrate (as N)	Dissolved solids	Total hardness		
WELLS																				
Manley Hot Springs	03-06-72	140	--	21	47,000(a)	960(a)	57	12	4.2	2.6	239	0	0.4	1.0	0.3	0.02	218	190	364	6.9
Minto	12----61	40	--	24	100(b)	1,200(b)	87	26	5.2	4.8	418	--	.0	1.0	.2	.07	355	325	599	7.3
McKinley	04-04-63	186	--	4.6	20(b)	0(b)	44	56	3.7	2.0	370	--	34	1.0	.1	.27	329	338	583	8.0
Minchumina	12-11-59	210	--	7.8	100(b)	460(b)	21	11	6.0	.7	106	0	20	2.0	.2	.05	121	98	207	7.0
Cantwell	07-02-68	--	3.0	6.0	1,200(b)	--	26	3.8	3.1	.5	52	0	43	3.0	.2	.02	110	80	191	7.6
Aurora	11-14-60	--	--	8.1	--	--	83	17	6.9	4.2	330	0	11	10	.3	.05	312	278	530	7.4
Fairbanks	12-15-70	--	--	23	40(a)	460(a)	43	12	4.6	3.1	194	0	11	.2	.4	.00	192	157	324	7.6
Delta Junction	07-21-65	150	--	6.1	20(b)	--	35	7.4	3.1	3.5	102	0	43	1.4	.1	.09	150	118	247	8.0
Tok	03-14-72	--	--	1.9	--	--	2.4	2.0	4.9	.2	20	0	9.2	.7	.0	.05	31	14	59	7.3
Tanacross	09-08-71	50	--	15	--	--	64	11	4.6	2.0	178	0	60	4.2	.2	.23	250	204	395	7.9
Tetlin	------69	--	--	31	--	--	42	8.7	7.2	2.2	194	0	.0	.0	.2	.00	188	141	286	7.4
Northway	09-02-71	95	--	28	1,800(a)	1,600(a)	49	11	30	2.3	223	0	.8	36	.5	.02	268	168	435	7.8
SPRINGS																				
Manley	01-14-70	--	--	54	--	--	8.2	.4	120	5.3	82	0	38	120	6.3	.11	393	22	623	7.8
Hutlinana	--	--	--	40	--	--	20	6.6	180	7.9	488	--	55	40	.8	--	--	--	--	7.7
Tolovana	--	--	--	75	--	--	82	1.2	321	23	49	--	40	615	.2	--	--	--	--	7.7
Chena	--	--	--	85	--	--	1.3	.1	110	3.3	115	--	68	29	19	--	--	--	--	9.1
Fox	09-30-66	--	36	11	--	--	40	23	6.5	3.7	200	0	41	.7	.2	.11	224	196	543	7.1

a Total
b Undifferentiated

The southern part of the subarea lies within the Transition climatic zone; the northern part is within the Continental climatic zone. The mean annual temperature in both zones is estimated to be between 22° and 28°F. Precipitation is estimated to average less than 20 inches per year in the northern part and ranges between 20 and 80 inches per year in the southern part.

The southern part of this subarea is largely underlain by greenstone schists and limestones intruded by granitic masses. The northern part is underlain by metamorphic rocks (Foster and Clark, 1970). The areas near the streams which drain both the northern and southern parts are covered by glacial and alluvial deposits.

The subarea lies within the discontinuous permafrost zone. Thawed areas near or beneath the major streams are probably present. Away from the major streams, however, permafrost extends to considerable depths. A well drilled at Chicken was still in permafrost when it was abandoned at a depth of 360 feet (Williams, 1970b).

Surface Water.--The principal stream in the southern part of the subarea is the White River (est. drainage area 1,100 mi^2 at Canadian border). A smaller stream, Snag Creek, also drains that part of the subarea. The northern part is drained by the Fortymile River (est. 6,000 mi^2 at Canadian border) and its tributaries, the North, Middle, Mosquito, and West Forks.

The mean annual runoff in the northern part of the subarea is low, an estimated 0.5 ft^3/s per square mile. Runoff in the southern part is estimated to be somewhat higher, averaging about 1.0 ft^3/s per square mile (fig. 56). Table 2 shows the estimated mean monthly and mean annual runoff for the subarea.

The estimated mean annual peak runoff is about 25 ft^3/s per square mile for both parts of the subarea. Peak flows generally are caused by spring snowmelt. The mean annual low monthly runoff rates are estimated to be between 0.1 ft^3/s and 0.3 ft^3/s, probably averaging about 0.2 ft^3/s for both parts of the subarea.

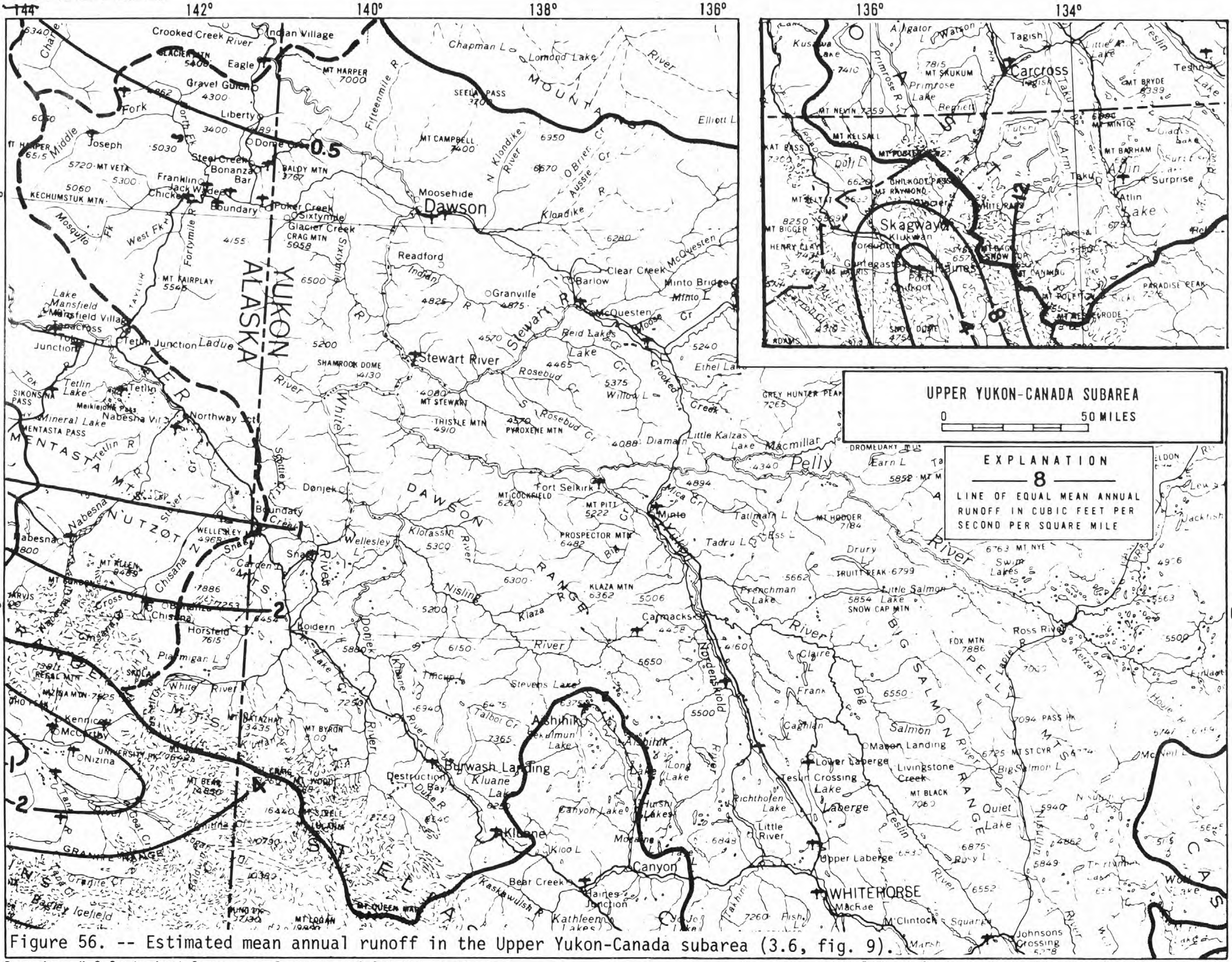


Figure 56. -- Estimated mean annual runoff in the Upper Yukon-Canada subarea (3.6, fig. 9).

Base from U.S.Geological Survey map E (scale 1:2,500,00) of Alaska

Data from Joint Federal-State Land Use Planning Commission (1974)

The mountains to the south support glaciers that contribute to the runoff in the southern part of the subarea. In the north numerous tributary streams feed into the principal stream, the Fortymile River; low flow in this part of the subarea is maintained by ground-water inflow.

The dissolved-solids concentrations of the sampled surface waters ranges from about 65 mg/l on the West Fork of the Fortymile River near Chicken to a high of about 240 mg/l at O'Brien Creek near Liberty. Most of the data was gathered several years ago (1953 and 1957), but there is no reason to expect significant changes since then. All waters are of the calcium bicarbonate type and contain little iron. Table 28 shows some chemical analyses of selected streams.

Only a few random sediment samples have been taken. Figure 57 presents the estimated suspended-sediment load that may be expected during normal summer runoff in the Upper Yukon-Canada subarea based on data gathered in adjacent areas.

Temperature data for surface waters in the subarea are limited. The observed temperature range is from 32° to 43°F.

Ground Water.--No records of wells or data on ground-water facilities in the subarea are known. Figure 58 is based upon ground-water conditions in adjacent subareas and is the general pattern thought to be present within the Upper Yukon-Canada subarea. The data presented herein should therefore be used with caution.

No data are available on the chemical quality or temperature of ground water in the subarea. Springs also are found within the subarea; however, no data on their chemical quality or temperatures are available.

Water Use.--The economy of the area is based on subsistence. No industrial or agricultural activities are present. However, there are placer gold operations that place unknown demands on the water resources. None of the 14 villages in the subarea was listed in the 1970 census. If it is assumed that there are no more than 25 people in each village, then the maximum population of the subarea would be 350. Assuming, further, a water-use rate of 10 gal/d per person, a daily-use rate for the subarea would be approximately 3,500 gallons.

Table 28.--*Water quality of selected streams in the Upper Yukon-Canada subarea.*

[concentrations in milligrams per litre (mg/l) or micrograms per litre (µg/l)]

Date and discharge (ft^3/s)	mg/l	µg/l		mg/l												Specific conductance (µmhos/cm at 25°C)	pH units
	Silica (SiO_2)	Iron (Fe)	Manganese (Mn)	Calcium (Ca)	Magnesium (Mg)	Sodium (Na)	Potassium (K)	Bicarbonate (HCO_3)	Carbonate (CO_3)	Sulfate (SO_4)	Chloride (Cl)	Fluoride (F)	Nitrate (as N)	Dissolved solids	Total hardness		
West Fork Dennison Fork near Chicken																	
07-30-57 97	14	190(a)	0(a)	7.9	4.1	3.0	1.2	28	0	14	1.5	0.3	0.81	64	36	83	7.0
Mosquito Fork Fortymile River near Chicken																	
07-30-57 178	11	110(a)	0(a)	15	5.8	4.7	1.3	55	0	26	.5	.3	.59	94	61	129	7.0
South Fork Fortymile River near Chicken																	
08-01-57 408	14	170(a)	0(a)	15	4.3	3.6	.9	57	0	11	1.0	.2	.50	78	55	111	7.5
Fortymile River near Steel Creek																	
07-31-57 1,100	11	80(a)	0(a)	20	7.5	4.6	1.2	65	0	37	.5	.3	.47	116	81	166	7.4
O'Brien Creek near Liberty																	
07-28-53 --	8.6	40(a)	--	46	16	2.2	1.8	142	0	66	.0	.2	.11	211	181	349	7.7

a Undifferentiated

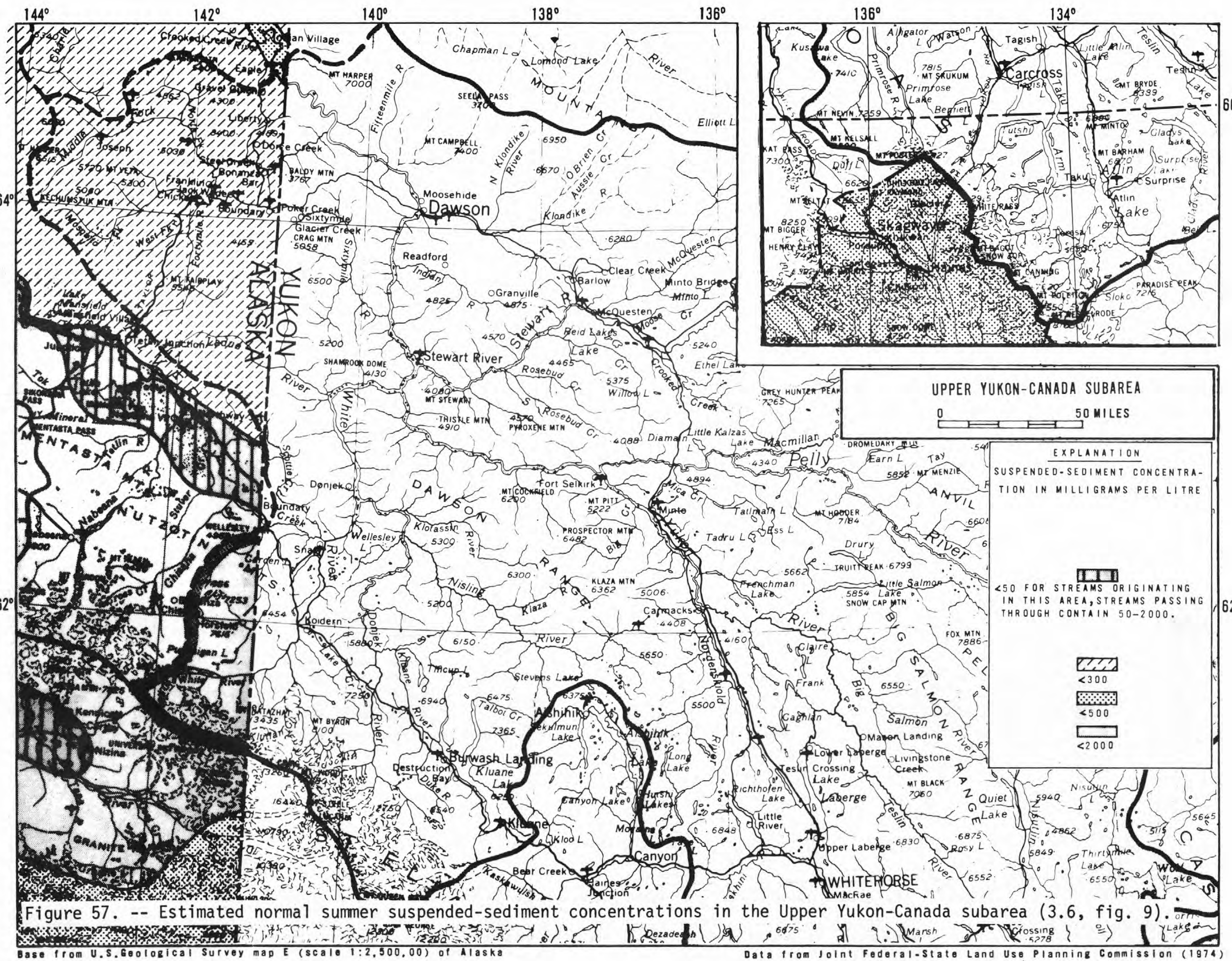


Figure 57. -- Estimated normal summer suspended-sediment concentrations in the Upper Yukon-Canada subarea (3.6, fig. 9).

Base from U.S.Geological Survey map E (scale 1:2,500,00) of Alaska

Data from Joint Federal-State Land Use Planning Commission (1974)

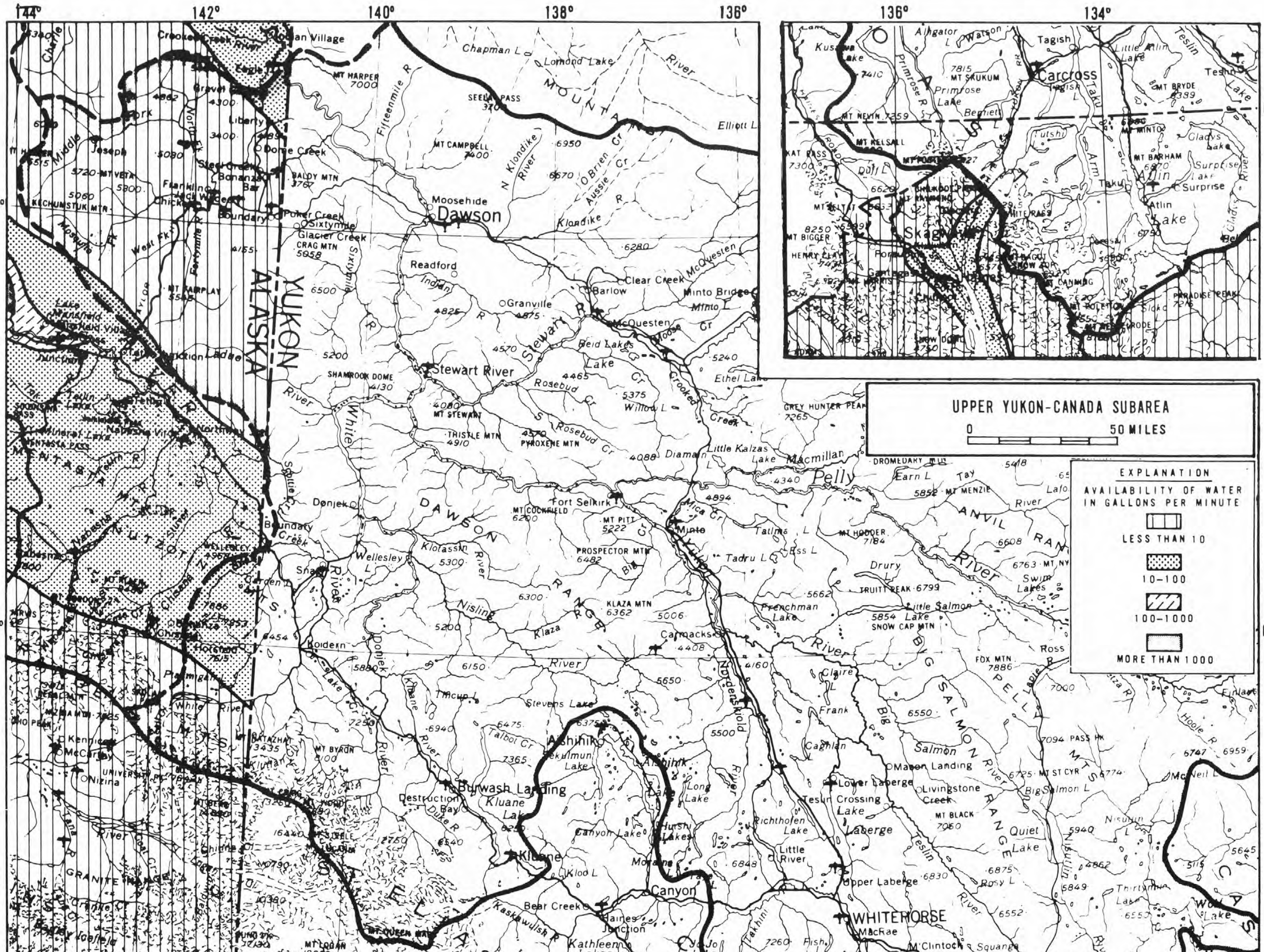


Figure 58. -- Estimated ground-water yields in the Upper Yukon-Canada subarea (3.6, fig. 9).

Base from U.S.Geological Survey map E (scale 1:2,500,00) of Alaska

Data from Joint Federal-State Land Use Planning Commission (1974)

SOUTHWEST SUBREGION

Kuskokwim Bay Subarea

The Kuskokwim Bay subarea includes the entire drainage basin of the Kuskokwim River as well as Nunivak and St. Matthew Islands (fig. 9). On the southwest the subarea faces the Bering Sea, and it extends from Cape Newenham on the south to Hazen Bay on the north. It covers a land area of 58,000 square miles.

Only the extreme eastern part of the area, east of McGrath, is in the Continental climatic zone; the rest of the subarea lies within the Transition climatic zone. The mean annual temperature is about 26°F at McGrath in the interior and 36°F at Cape Newenham on the coast. Precipitation at McGrath averages about 19 inches per year, whereas at Cape Newenham it averages about 30 inches per year. The lowest recorded precipitation in the subarea is on Nunivak Island where an average of 14 inches of precipitation falls annually.

Most of the lowland area is covered with thick deposits of alluvial and glacial deposits. At the eastern boundary is the Alaska Range where bedrock of sedimentary and volcanic origin has been intruded by a variety of igneous rock types. On the southwest, the mountains are composed of a wide variety of intrusive and volcanic rocks (Cady and others, 1955).

The subarea is within the discontinuous permafrost zone. Most of the rivers have no permafrost beneath them or, in some places, near them. Permafrost has been recorded to a depth of more than 600 feet near Bethel (Feulner and Schupp, 1964). Such thicknesses may also be found in the interior of the subarea. Glaciers occur in the Alaska Range at the eastern boundary of the subarea where mountain peaks commonly reach altitudes of from 8,000 to 12,000 feet. There are no glaciers in the western part of the subarea.

Surface Water.--The principal stream is the Kuskokwim River (est. drainage area 49,000 mi^2). Nearly all its principal tributaries flow into the main stream from the south. The estimated mean annual runoff in the subarea is about 1 ft^3/s per square mile in the north and western parts, 2 ft^3/s per square mile along the eastern boundary. The average throughout the entire subarea, however, is probably near 1 ft^3/s per square mile (fig. 59a,b). Table 2 shows the estimated mean monthly and mean annual runoff for the subarea.

Annual peak runoffs probably average about 10 ft^3/s per square mile or less in the lowlands and increase to about 25 ft^3/s per square mile in the uplands. Peak rates may be more than 50 ft^3/s per square mile in some of the steep, high basins in the Alaska Range. Low areas having extensive lakes or swamps will have runoffs of less than 10 ft^3/s per square mile. Peak runoff in the summer or fall may result from either snowmelt or rainfall. Channel icings in the uplands can cause winter or early spring flooding even when flows are low. Figure 60 illustrates the flood frequency and magnitude for some selected streams in the subarea.

The low month mean runoff ranges from about 0.2 to 0.5 ft^3/s per square mile and averages about 0.3 ft^3/s (or slightly more) per square mile and usually occurs in late winter.

The observed dissolved-solids concentrations of surface water in the subarea are less than 200 mg/l. All the streams have water of the calcium bicarbonate type and of acceptable quality for nearly all general uses (table 29).

On the basis of very little sampling, three areas of estimated normal summer suspended-sediment concentrations can be outlined in the subarea. The eastern section near the Alaska Range has the highest concentrations, probably exceeding 2,000 mg/l, in the streams draining the glaciers and higher slopes. The central and southern section of the area is believed to have suspended-sediment concentrations of more than 100 mg/l, and in the extreme western part of the area concentrations of 50-100 mg/l will probably be found (figs. 61a,b).

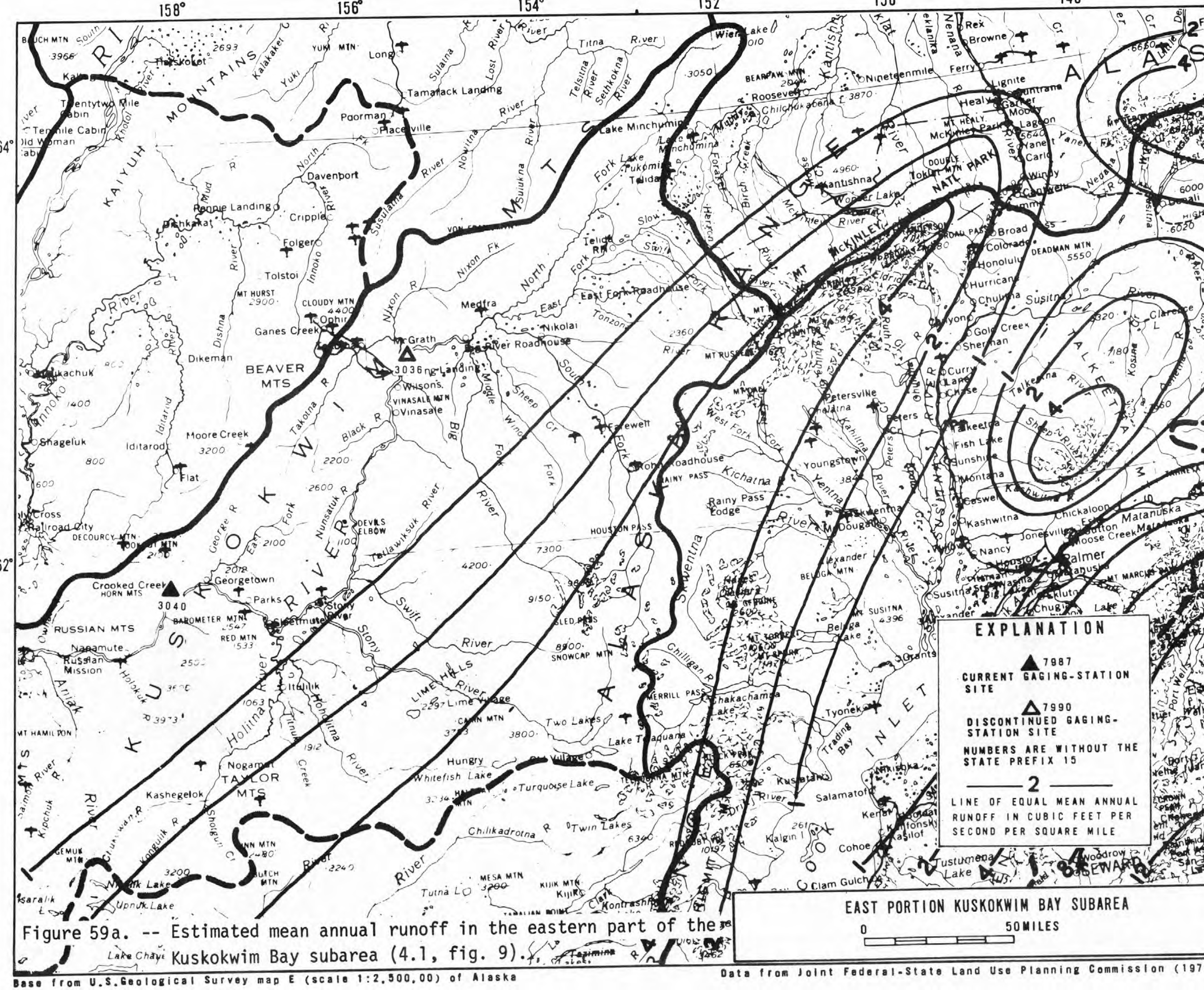


Figure 59a. -- Estimated mean annual runoff in the eastern part of the Kuskokwim Bay subarea (4.1, fig. 9).

Base from U.S.Geological Survey map E (scale 1:2,500,00) of Alaska

Data from Joint Federal-State Land Use Planning Commission (1974)

Figure 59b. -- Estimated mean annual runoff in the western part of the Kuskokwim Bay subarea (4.1, fig. 9).

EXPLANATION

—— 4 ——

LINE OF EQUAL MEAN ANNUAL RUNOFF IN CUBIC FEET PER SECOND PER SQUARE MILE

WEST PORTION KUSKOKWIM BAY SUBAREA

0 50 MILES

Base from U.S. Geological Survey map E (scale 1:2,500,00) of Alaska

Data from Joint Federal-State Land Use Planning Commission (1974)

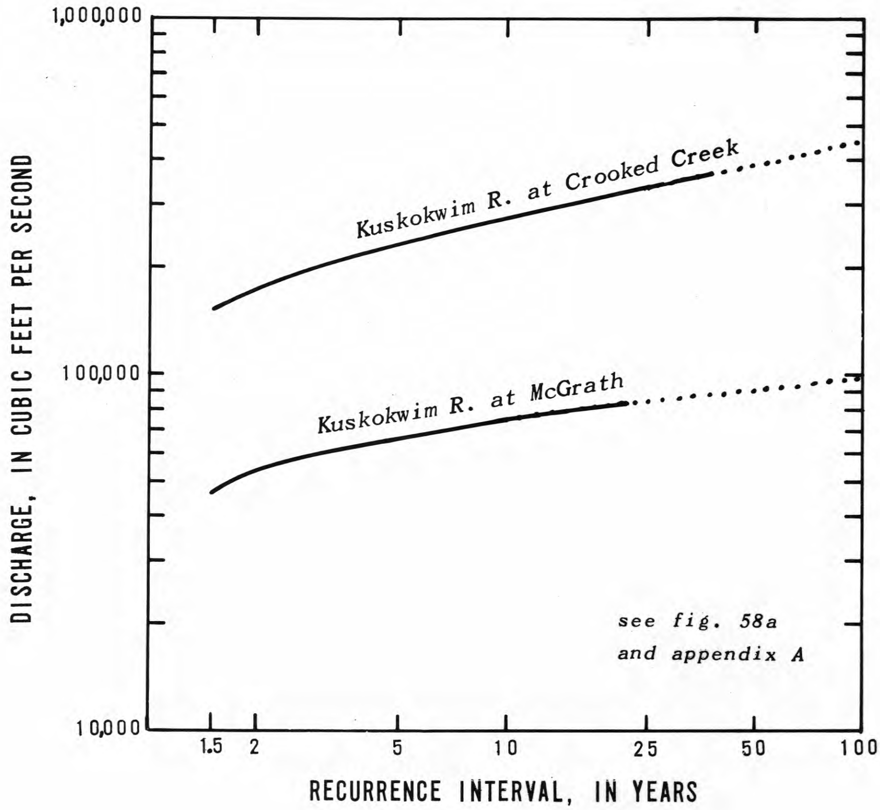


Figure 60. -- Flood magnitude-frequency relation at selected sites on the Kuskokwim River (4.1, fig. 9).

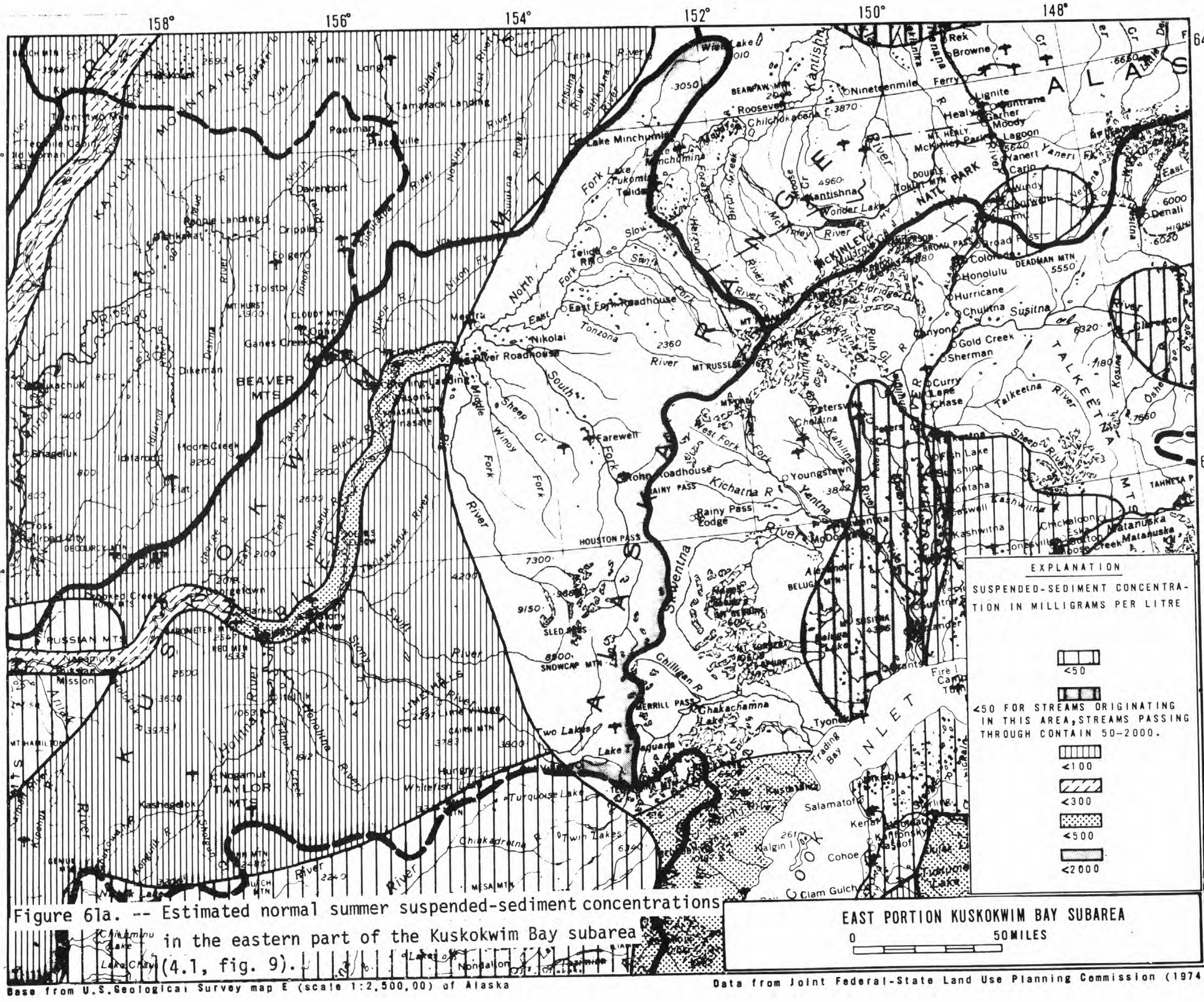


Figure 61a. -- Estimated normal summer suspended-sediment concentrations in the eastern part of the Kuskokwim Bay subarea (4.1, fig. 9).

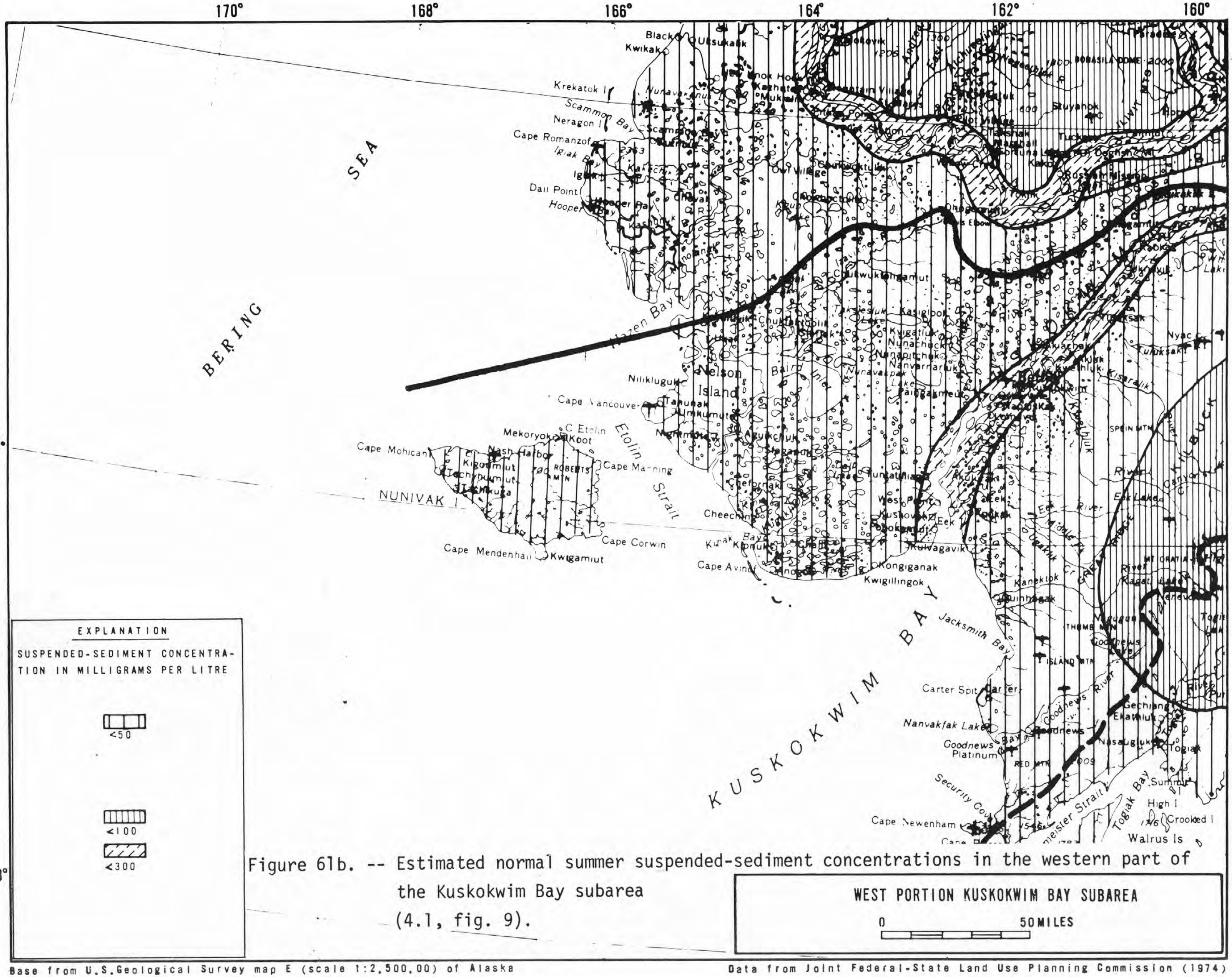


Figure 61b. -- Estimated normal summer suspended-sediment concentrations in the western part of the Kuskokwim Bay subarea (4.1, fig. 9).

Table 29.--*Water quality of the Kuskokwim River in the Kuskokwim Bay subarea.*

[concentrations in milligrams per litre (mg/l) or micrograms per litre (µg/l)]

Date and discharge (ft^3/s)	mg/l	µg/l		mg/l												Specific conductance (µmhos/cm at 25°C)	pH units
	Silica (SiO_2)	Iron (Fe)	Manganese (Mn)	Calcium (Ca)	Magnesium (Mg)	Sodium (Na)	Potassium (K)	Bicarbonate (HCO_3)	Carbonate (CO_3)	Sulfate (SO_4)	Chloride (Cl)	Fluoride (F)	Nitrate (as N)	Dissolved solids	Total hardness		
15303600 Kuskokwim River at McGrath																	
08-22-50 --	7.6	80(a)	--	34	9.4	--	--	122	0	34	1.0	0.2	0.02	153	124	264	7.3
03-22-72 3,950	12	30(b)	20(b)	48	13	2.6	1.1	180	0	30	.3	.3	.00	196	174	328	7.8
15304000 Kuskokwim River at Crooked Creek																	
03-11-69 8,630	11	50(a)	--	40	8.3	2.7	1.7	145	0	18	.0	.4	.18	154	134	251	7.9
05-25-70 86,000	5.7	290(a)	0(a)	13	3.1	1.3	.7	44	0	8.3	1.1	.1	.16	58	45	98	7.8

a Undifferentiated
b Dissolved

The Kuskokwim River at Crooked Creek has an average annual rate of suspended-sediment yield of 300 tons per square mile, or about 9 million tons per year. These suspended-sediment rates and loads are not typical of the entire subarea.

Temperature data for surface water are available from only a few scattered points in the subarea. The known water temperature range is from about 32° to about 44°F.

Ground Water.--Ground water in small to moderate amounts is probably available nearly everywhere in the subarea (figs. 62a,b). Ground-water yields in larger amounts (more than 100 gal/min) may occur only near the larger streams in the western part of the subarea. Potable water is available beneath rather thick permafrost away from the river in the Bethel area, but this kind of condition may not be present in the interior localities (Feulner and Schupp, 1964).

Springs exist within the subarea, but data on them are not available.

The chemical quality of ground water in the subarea is varied. Water at Kwethluk is of the magnesium bicarbonate type, Nightmute has a calcium magnesium bicarbonate type water, and Eek a sodium bicarbonate type water. Toward the interior, wells such as those at McGrath have a calcium bicarbonate type water.

Some ground waters in the subarea are high in nitrate. Water from wells at Mekoryuk on Nunivak Island have shown two to three times the maximum nitrate concentrations recommended by the Environmental Protection Agency (1972). Iron is noted in water from wells in some coastal communities and from some wells near streams. The temperature of ground water in the subarea ranges from about 32° to 40°F. Table 30 lists chemical analyses of ground water from various locations in the subarea.

Water Use.--The economy of the subarea is based mostly on subsistence. There are some small-scale mining activities (gold, platinum, mercury), a limited forest industry, and a reindeer herd on Nunivak Island.

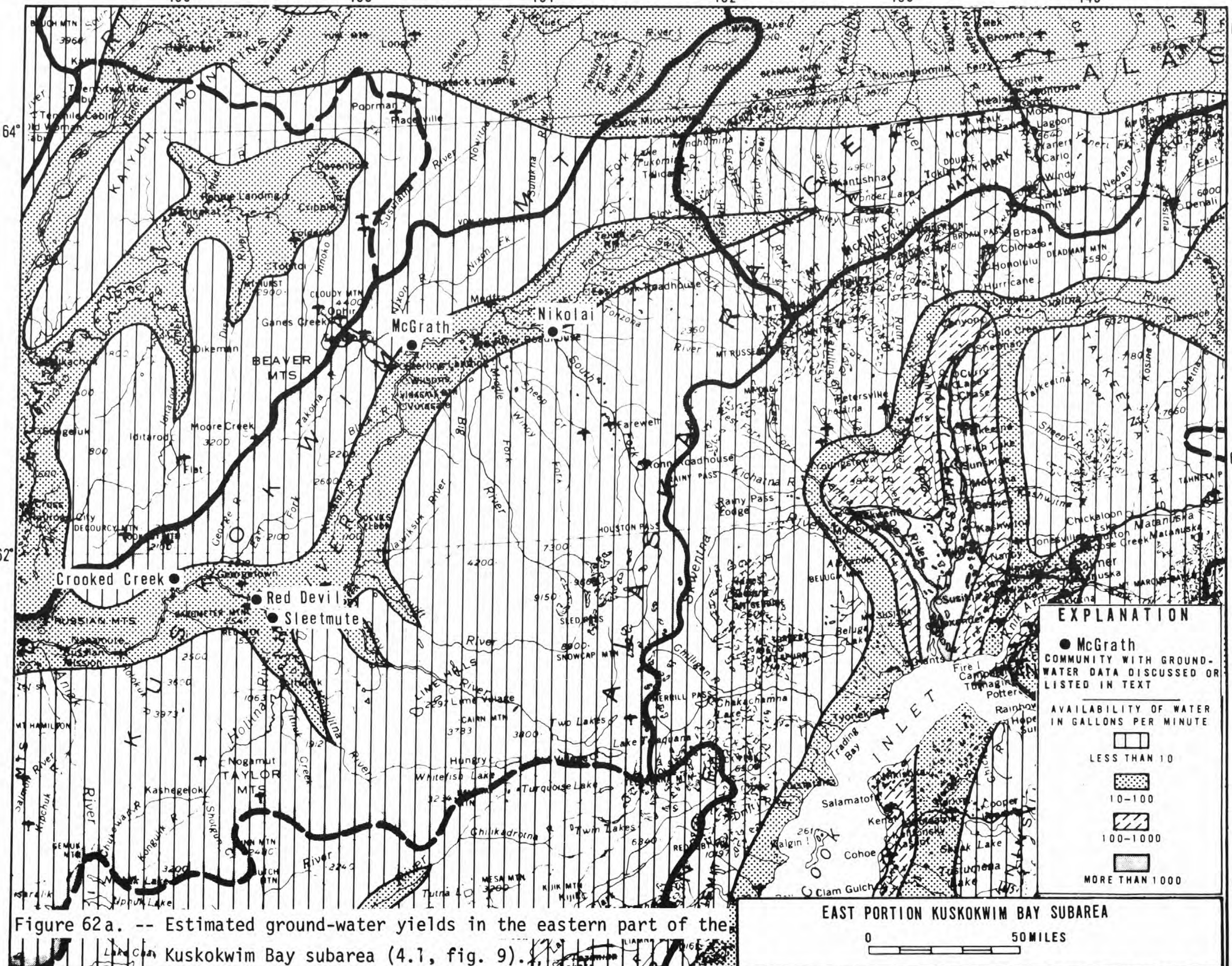


Figure 62a. -- Estimated ground-water yields in the eastern part of the Kuskokwim Bay subarea (4.1, fig. 9).

Base from U.S. Geological Survey map E (scale 1:2,500,00) of Alaska

Data from Joint Federal-State Land Use Planning Commission (1974)

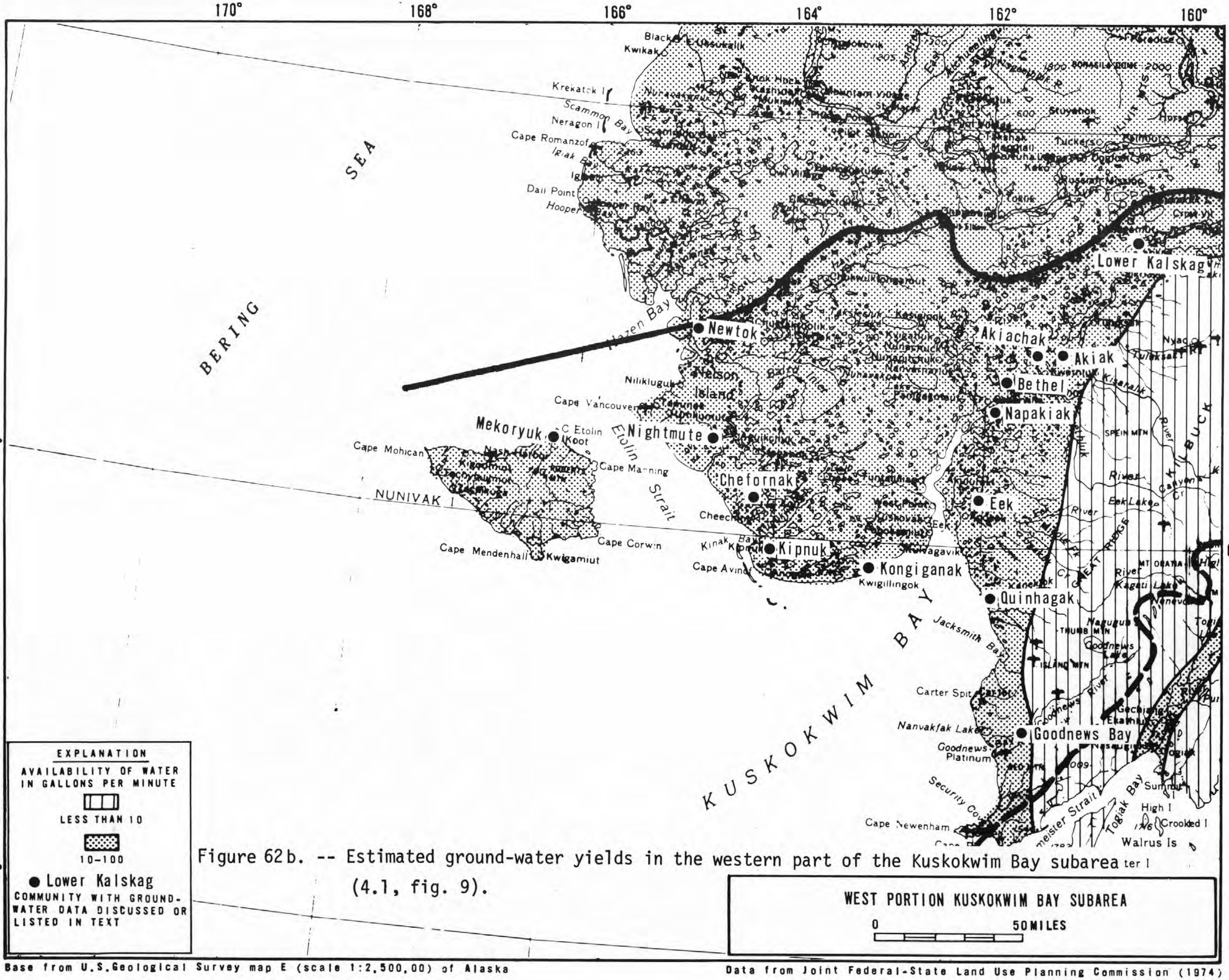


Figure 62b. -- Estimated ground-water yields in the western part of the Kuskokwim Bay subarea (4.1, fig. 9).

Table 30.--*Chemical analyses of ground water in the Kuskokwim Bay subarea.*

[concentrations in milligrams per litre (mg/l) or micrograms per litre (µg/l)]

Location	Date	Well depth (ft)	Temperature (°C)	mg/l	µg/l		mg/l												Specific conductance (µmhos/cm at 25°C)	pH units
				Silica (SiO_2)	Iron (Fe)	Manganese (Mn)	Calcium (Ca)	Magnesium (Mg)	Sodium (Na)	Potassium (K)	Bicarbonate (HCO_3)	Carbonate (CO_3)	Sulfate (SO_4)	Chloride (Cl)	Fluoride (F)	Nitrate (as N)	Dissolved solids	Total hardness		
WELLS																				
Akiachak	09-25-71	--	--	28	30,000(a)	2,300(a)	49	9.5	4.3	1.4	204	0	1.0	3.0	0.1	0.07	199	161	329	6.4
Akiak	02-03-75	--	--	13	6,900(b)	690(b)	80	10	13	3.2	245	--	17	7.8	.1	1.5	279	240	419	6.6
Bethel	01-30-75	--	0.0	35	2,700(b)	110(b)	27	7.2	4.4	2.5	131	--	3.1	2.3	.1	.05	150	97	214	7.4
Chefornak	02-04-71	--	3.0	30	--	--	13	23	186	23	365	0	.0	175	.6	.68	634	127	1,070	7.7
Crooked Creek	09-20-69	--	--	6.3	20(c)	10(c)	50	11	7.5	.8	182	0	31	2.8	.1	1.8	207	170	348	7.7
Eek	02-03-71	--	--	10	--	--	48	31	550	8.8	306	0	6.0	838	.4	2.1	1,650	247	2,970	7.3
Goodnews Bay	06-19-62	--	--	2.7	70(c)	100(c)	22	8.8	5.2	.8	112	--	.0	6.0	.1	.02	101	90	187	6.8
Lower Kalskag	02-03-75	--	1.0	22	510(b)	2,200(b)	32	6.0	2.5	1.9	135	--	3.0	2.3	.1	.04	139	100	223	6.8
Kipnuk	02-26-72	171	--	21	11,000(a)	250(a)	546	40	3,660	100	1,520	0	63	5,880	2.0	.05	11,100	1,530	18,100	8.0
Kongiganak	10-12-68	258	1.5	34	--	--	110	100	800	60	636	0	13	1,325	.3	.18	2,733	686	5,284	7.2
McGrath	------59	22	--	15	20(c)	20(c)	104	72	1.8	3.8	666	--	32	3.0	.2	.14	560	556	947	7.1
Mekoryuk	06----71	45	--	28	30(a)	700(a)	70	88	184	7.2	238	0	58	460	.2	12	1,060	536	1,910	7.7
Napakiak	01-30-75	123	1.0	30	2,900(b)	340(b)	62	11	27	3.7	282	--	16	9.9	.1	.05	302	200	492	7.3
Newtok	09-09-72	--	--	35	1,200(a)	50(a)	5.5	14	350	23	794	0	12	140	.9	2.5	998	71	1,630	7.5
Nightmute	08-29-66	56	1.0	25	10(c)	--	19	10	7.7	.6	115	0	1.0	7.8	.1	.05	128	90	209	6.7
Nikolai	03-16-70	76	1.0	21	2,700(c)	--	50	5.0	2.9	1.3	182	0	.0	1.1	.0	.00	174	142	279	7.6

Table 30.--*Chemical analyses of ground water in the Kuskokwim Bay subarea, continued.*

[concentrations in milligrams per litre (mg/l) or micrograms per litre (µg/l)]

				mg/l	µg/l		mg/l													
Location	Date	Well depth (ft)	Temperature (°C)	Silica (SiO_2)	Iron (Fe)	Manganese (Mn)	Calcium (Ca)	Magnesium (Mg)	Sodium (Na)	Potassium (K)	Bicarbonate (HCO_3)	Carbonate (CO_3)	Sulfate (SO_4)	Chloride (Cl)	Fluoride (F)	Nitrate (as N)	Dissolved solids	Total hardness	Specific conductance (µmhos/cm at 25°C)	pH units
Quinhagak	05----62	--	--	39	1,600(c)	450(c)	31	26	193	14	150	0	37	339	0.2	0.27	756	186	1,363	7.0
Red Devil	------70	18	--	4.3	50(c)	0(c)	14	8.4	1.5	.2	73	0	8.9	.2	.1	.45	76	69	138	7.1
Sleetmute	02-26-70	25	--	14	120(c)	0(c)	13	2.8	2.5	.9	45	0	2.8	3.2	.1	2.2	71	44	109	6.5
Toksook Bay	07-11-73	--	--	8.8	--	--	36	7.7	11	.02	155	0	7.4	11	.2	.04	159	120	284	7.3
Tuluksak	10-28-70	--	--	9.7	5,600(a)	3,000(a)	32	6.3	3.9	1.4	135	0	2.3	6.2	.1	.07	129	106	215	7.3

a Total
b Dissolved
c Undifferentiated

The population in the subarea is about 10,000. The largest centers are at Bethel (2,921), Akolmiut (608), Akiachak (330), Toksook Bay (304), and McGrath (280). Based on the population and the type of water-distribution facilities available, the domestic water consumption is estimated to be about 136,000 gal/d. Water requirements for the small-scale mining operations are unknown.

The reindeer herd on Nunivak Island numbers about 4,000 head. Total summer and winter water requirements for the herd are estimated at 1.9 and 1.0 million gallons, respectively.

Bristol Bay Subarea

The Bristol Bay subarea includes the drainage of the Nushagak and Kvichak Rivers and other small streams entering Bristol Bay (fig. 9). The subarea is bounded on the south by the Cook Inlet and Kodiak subareas and on the north by the Kuskokwim subarea. It includes a total of of 40,000 square miles.

The subarea lies completely within the southern part of the Transition climatic zone. The temperature averages about 29°F in the interior and nearly 38°F on the Alaska Peninsula. The precipitation ranges from less than 20 inches in the lowlands to highs of as much as 160 inches in the mountains.

The geology of the subarea is complex. Bedrock includes metamorphic, sedimentary, volcanic, and intrusive rocks. The Alaska Range along the eastern boundary is composed of granitic batholiths intruded into moderately metamorphosed and deformed volcanic and sedimentary rocks. The central lowland has been overridden by several Pleistocene ice masses and is now mantled by glacial and alluvial deposits. These deposits are more than 600 feet thick near Naknek (Muller, 1955).

The subarea is on the southern border of the discontinuous permafrost zone. On the mountainous eastern boundary, glaciers are present. In the western part there are no glaciers, although permafrost is present.

Surface Water.--The principal streams are the Kvichak (est. drainage area 9,000 mi^2) and the Nushagak (est. 12,400 mi^2) Rivers. Other smaller streams include the Egegik (est. 1,400 mi^2), Naknek (est. 2,700 mi^2), and Ugashik (est. 1,300 mi^2) Rivers. The average rate of runoff for the subarea is probably about 3 ft^3/s per square mile (fig. 63). Table 2 shows the estimated mean monthly and mean annual runoff for the subarea.

The average peak runoff is probably about 20 ft^3/s per square mile. The central part of the subarea contains many lakes which have a moderating effect upon runoff. The largest lake in Alaska, Lake Iliamna, lies within this subarea. Figure 64 illustrates the flood frequency and magnitude of selected streams. The low monthly mean runoff of streams probably averages a little more than 1 ft^3/s per square mile.

The dissolved-solids concentrations of streams in the subarea are low, ranging from about 25 to 75 mg/l. The dissolved-solids concentrations are probably higher during winter, perhaps in the range of 80 to 100 mg/l. Iron content is generally low, and the water requires little, if any, treatment for general purposes. Table 31 lists chemical analyses of water from selected streams.

Very few data are available on sediment loads. The streams along the eastern boundary are estimated to have suspended-sediment concentrations during the summer season of between 500 and 2,000 mg/l. The streams which drain from lakes probably are carrying less than 500 mg/l of suspended sediment. The lowland streams in the central part may transport less than 100 mg/l. Estimated normal summer suspended-sediment concentrations are shown on figure 65.

Data on the temperature of surface water are available for only a few places. The general range is believed to be from 32° to nearly 56°F. The higher temperature represents water in the smaller lakes.

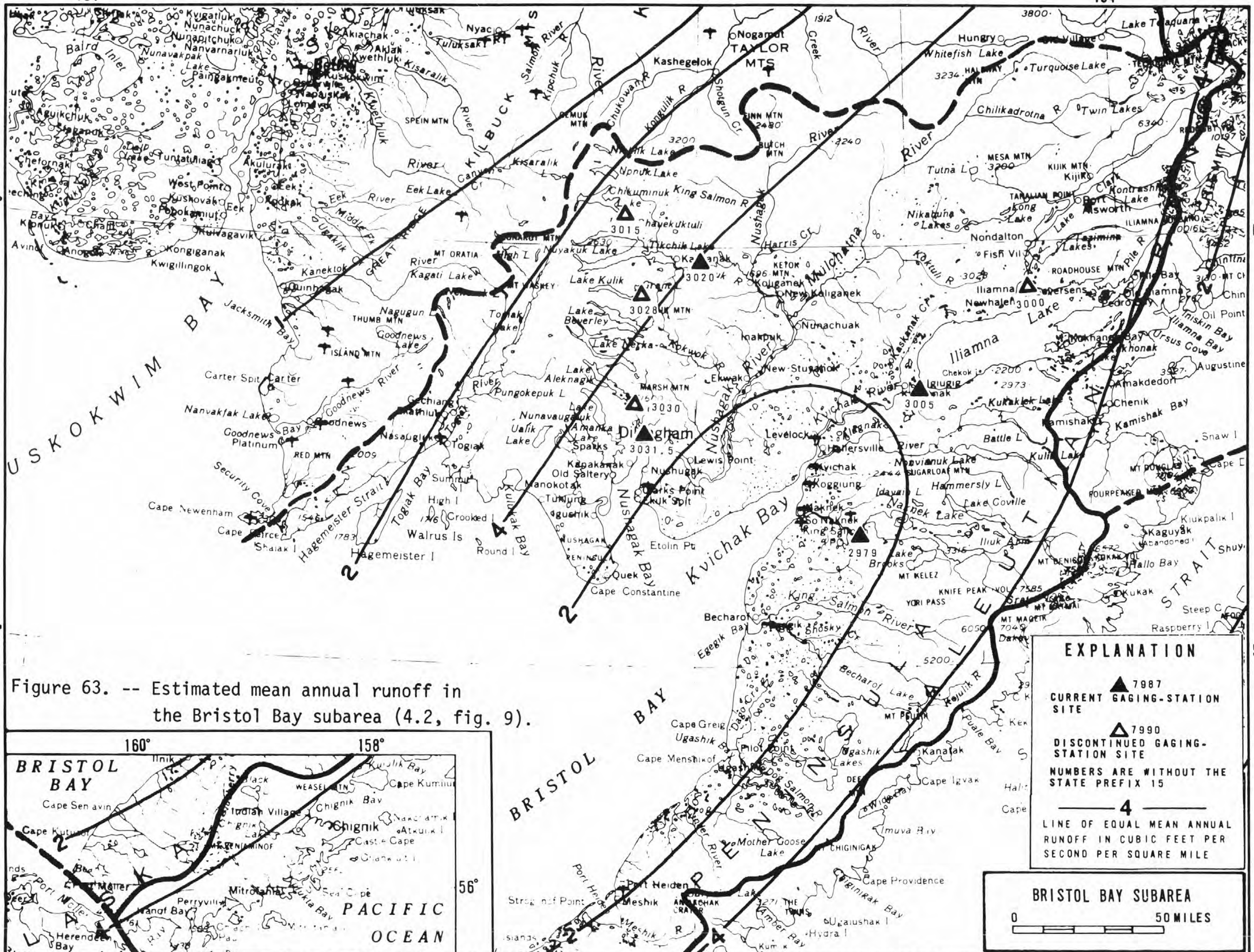


Figure 63. -- Estimated mean annual runoff in the Bristol Bay subarea (4.2, fig. 9).

Base from U.S. Geological Survey map E (scale 1:2,500,000) of Alaska

Data from Joint Federal-State Land Use Planning Commission (1974)

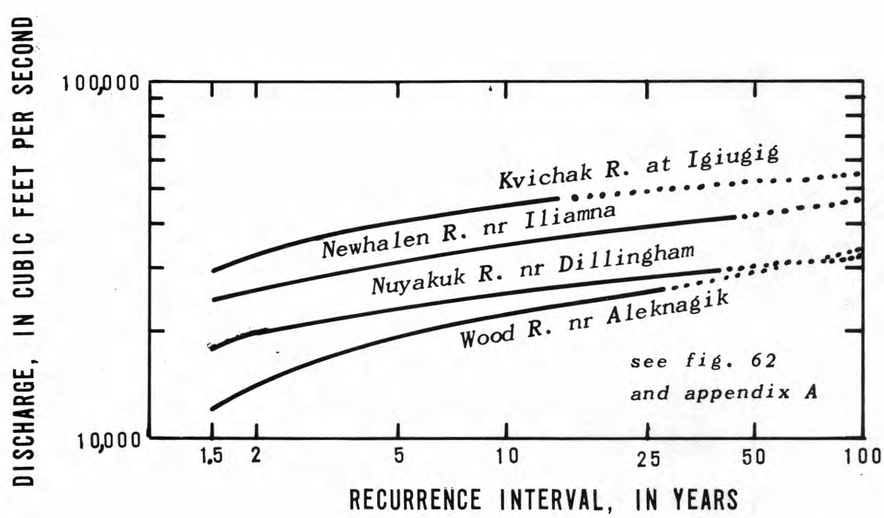


Figure 64. -- Flood magnitude-frequency relation of selected streams in the Bristol Bay subarea (4.2, fig. 9)

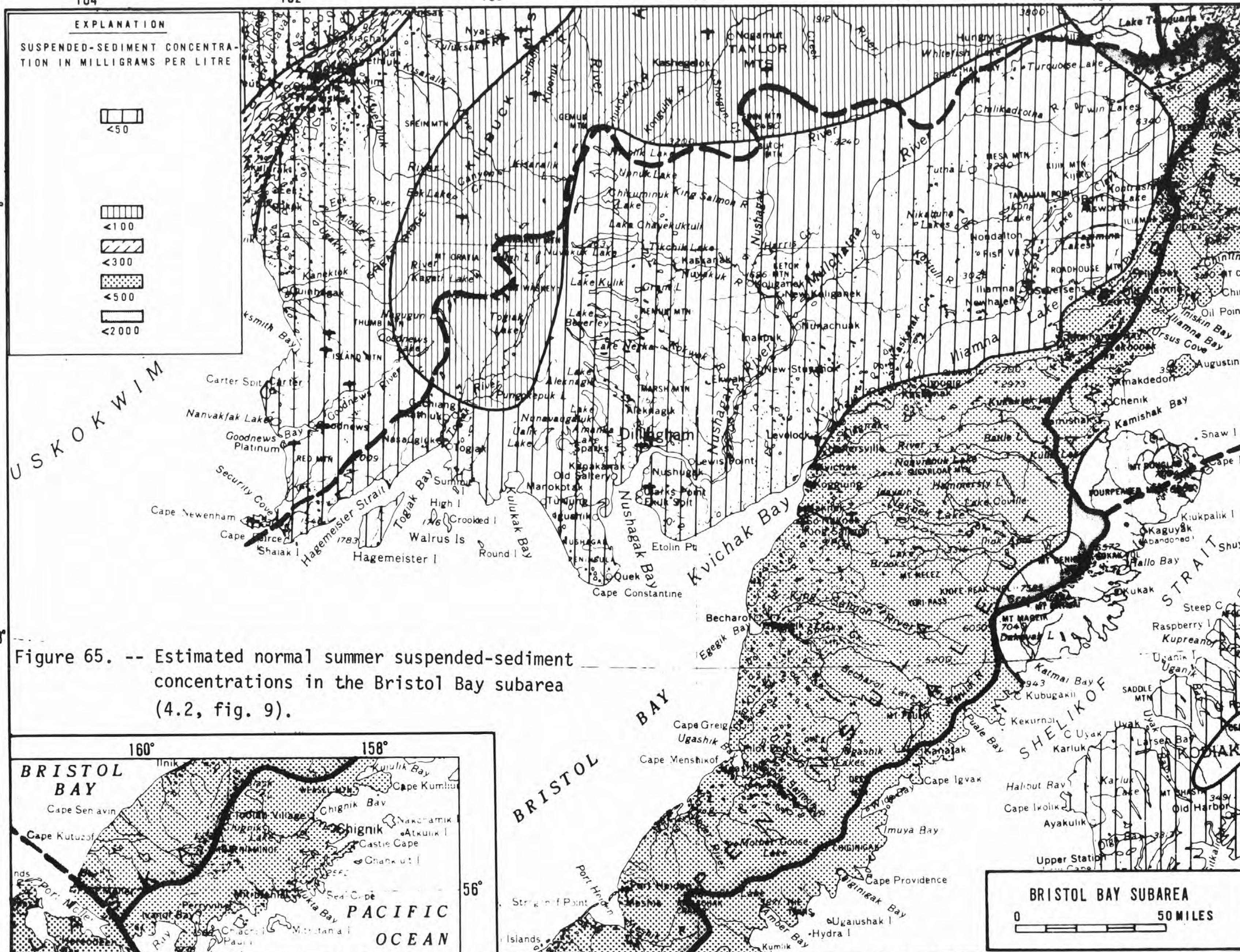


Figure 65. -- Estimated normal summer suspended-sediment concentrations in the Bristol Bay subarea (4.2, fig. 9).

Base from U.S.Geological Survey map E (scale 1:2,500,00) of Alaska

Data from Joint Federal-State Land Use Planning Commission (1974)

Table 31.--*Water quality of selected streams in the Bristol Bay subarea.*

[concentrations in milligrams per litre (mg/l) or micrograms per litre (µg/l)]

Date and discharge (ft^3/s)	mg/l	µg/l		mg/l												Specific conductance (µmhos/cm at 25°C)	pH units
	Silica (SiO_2)	Iron (Fe)	Manganese (Mn)	Calcium (Ca)	Magnesium (Mg)	Sodium (Na)	Potassium (K)	Bicarbonate (HCO_3)	Carbonate (CO_3)	Sulfate (SO_4)	Chloride (Cl)	Fluoride (F)	Nitrate (as N)	Dissolved solids	Total hardness		
						15300000 Newhalen River near Iliamna											
08-03-55 26,100	5.3	0(a)	10(a)	6.7	0.7	1.2	0.4	10	0	13	0.5	0.0	0.00	33	20	68	6.5
10-04-55 11,600	5.9	0(a)	0(a)	7.5	1.0	1.2	.6	24	0	4.5	.5	.0	.00	33	23	53	6.7
						15300500 Kvichak River at Igiugig											
02-11-72 15,000	1.6	30(b)	20(b)	8.4	.7	1.6	.5	25	0	4.1	1.9	.0	.20	32	24	59	8.6
06-16-72 18,700	2.1	--	20(b)	5.2	.7	1.5	.3	16	0	4.3	2.5	.0	.05	25	16	40	6.7
						15302000 Nuyakuk River near Dillingham											
06-29-55 17,800	4.5	0(a)	0(a)	6.4	1.2	.7	.4	20	0	8.0	.0	.0	.00	31	21	49	6.6
05-26-70 7,200	2.7	20(a)	0(a)	9.0	1.5	1.0	.3	28	0	5.9	.4	.0	.23	36	28	65	7.6

a Undifferentiated
b Total

Ground Water.--Ground water is believed to be available nearly everywhere in the subarea near the major streams and lakes and near the coast. Coastal ground water may be saline and not suitable as a potable water-supply source. Ground-water yields of up to 100 gal/min are known throughout much of the interior lowlands. The highest reported yield is 200 gal/min from the well at Dillingham. Little drilling has been done in the interior part of the subarea. Figure 66 illustrates the estimated potential ground-water yields of the subarea.

Most of the well waters contain less than 250 mg/l of dissolved solids. These waters are all of acceptable potable quality, containing relatively little iron and no objectionable concentrations of minerals. A well at Togiak (table 32), however, yielded water of sodium chloride type. The known temperature range of ground water is from a low of 33°F to a high of 44°F, however, little information is available. Table 32 shows chemical analyses of ground water found at various communities in the subarea.

Many springs flow from the mountains along the eastern boundary. No data are available on either the flow or the chemical quality of the water.

Water Use.--The population in the subarea is about 5,600, with most of these people living in Dillingham (1,025), Togiak (383), Manokotak (230), and New Stuyahok (229). The economy of the area relies heavily on the Bristol Bay fishery. Based on the population and the types of water utilities available, it is estimated that the domestic water needs amount to about 164,000 gal/d.

Seafood processors in the area use a large quantity of water in their operations. The 1974 salmon catch amounted to 16.5 million pounds (State of Alaska, 1974), resulting in an estimated water demand of 82.7 million gallons.

A herd of reindeer on Hagemeister Island consists of about 600 head. Their total summer and winter water requirements are estimated at 0.29 and 0.15 million gallons, respectively.

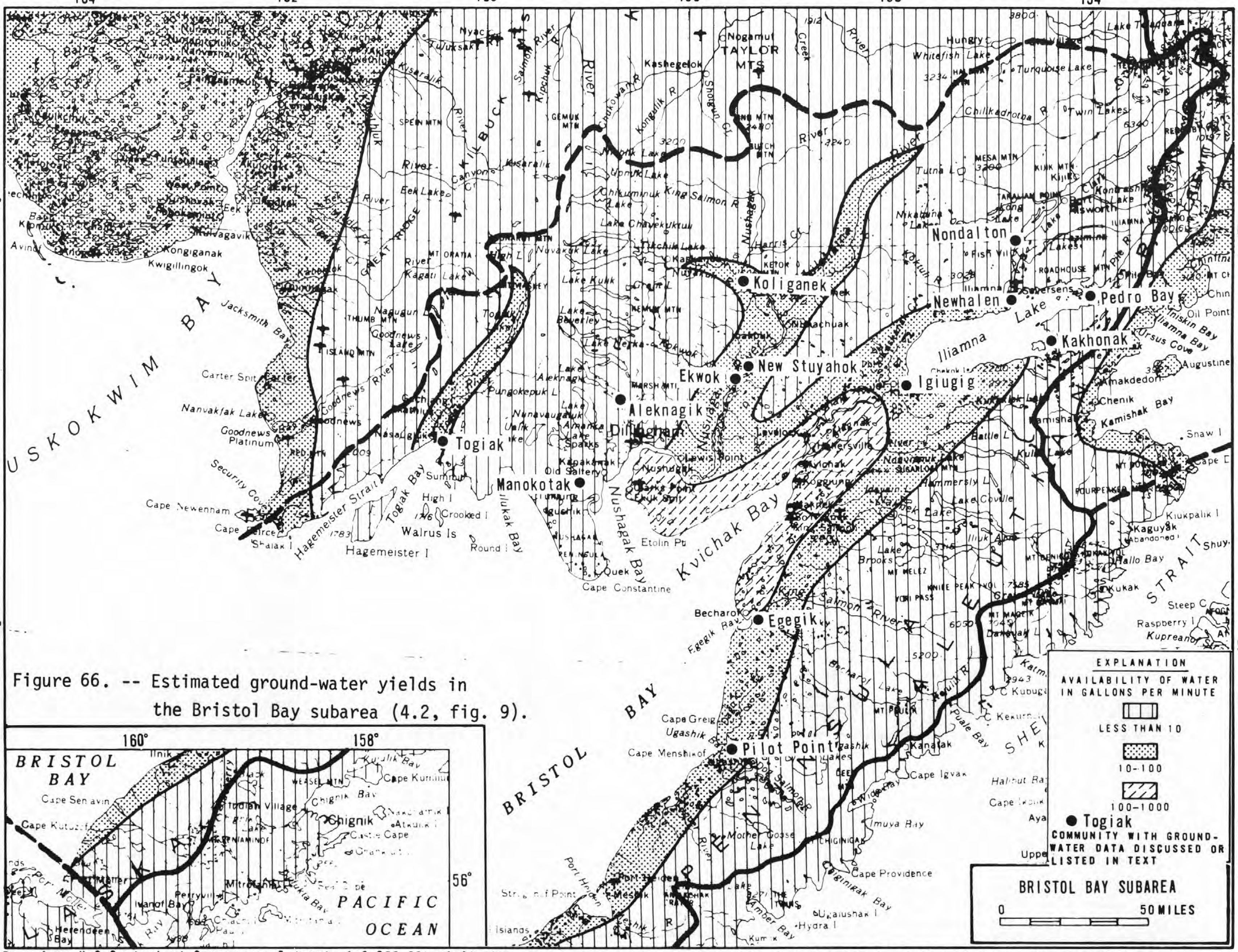


Figure 66. -- Estimated ground-water yields in the Bristol Bay subarea (4.2, fig. 9).

Base from U.S.Geological Survey map E (scale 1:2,500,00) of Alaska

Data from Joint Federal-State Land Use Planning Commission (1974)

Table 32.--*Chemical analyses of ground water in the Bristol Bay subarea.*

[concentrations in milligrams per litre (mg/l) or micrograms per litre (μg/l)]

Location	Date	Well depth (ft)	Temperature (°C)	Silica (SiO_2) mg/l	Iron (Fe) μg/l	Manganese (Mn) μg/l	Calcium (Ca) mg/l	Magnesium (Mg) mg/l	Sodium (Na) mg/l	Potassium (K) mg/l	Bicarbonate (HCO_3) mg/l	Carbonate (CO_3) mg/l	Sulfate (SO_4) mg/l	Chloride (Cl) mg/l	Fluoride (F) mg/l	Nitrate (as N) mg/l	Dissolved solids mg/l	Total hardness mg/l	Specific conductance (μmhos/cm at 25°C)	pH units
WELLS																				
Aleknagik	04-02-70	114	--	9.0	100(a)	70(a)	16	2.7	2.8	0.3	48	0	17	1.1	0.1	0.05	73	53	126	8.0
Egegik	11----61	102	--	28	50(a)	200(a)	11	6.0	8.7	3.3	68	0	10	7.0	.0	.05	107	52	124	7.2
Ekwok	04-09-70	32	--	14	80(a)	0(a)	4.1	.8	2.3	.5	16	0	.0	2.5	.0	.43	34	10	40	7.0
Igiugig	10-08-69	--	--	16	14,000(a)	2,700(a)	26	3.2	32	2.8	168	0	10	1.4	.0	.11	192	77	281	7.2
Kokhanok	02-12-72	120	--	12	1,400(b)	210(b)	29	5.4	33	.8	198	0	.4	3.4	.1	.02	181	94	319	7.3
Koliganek	02-24-71	--	--	16	4,900(b)	160(b)	4.4	1.4	3.9	.3	24	0	.2	4.0	.1	.05	43	17	55	7.3
Manokotak	02----71	--	--	9.4	--	--	7.0	1.1	2.4	.2	22	0	3.4	3.0	.1	.79	41	22	57	7.1
Newhalen	02-21-67	128	2.0	15	140(a)	--	4.0	.0	27	.0	24	18	5.0	3.9	.1	.09	86	10	124	8.9
New Stuyahok	06-30-71	46	--	21	--	--	3.8	1.1	2.7	.4	21	0	.0	2.5	.1	.00	42	14	41	7.2
Nondalton	01-11-73	--	0.5	16	50(a)	10(b)	22	3.7	5.5	.9	94	0	5.0	1.5	.1	.98	105	70	166	8.1
Pedro Bay	04-13-70	23	--	11	30(a)	0(a)	5.1	.4	2.5	.2	15	0	5.1	1.8	.0	.20	34	12	45	7.0
Pilot Point	04-09-72	--	--	11	590(b)	120(b)	3.2	2.1	8.9	1.2	18	0	.2	14	.0	.18	50	17	89	6.2
Togiak	05-02-68	--	1.5	36	260(a)	--	5.2	15	200	11	261	0	.0	228	.9	.11	625	76	1,163	7.3

a Undifferentiated
b Total

Aleutian Subarea

The Aleutian subarea includes all of the Aleutian Islands and that part of the Alaska Peninsula southwest of Port Moller (fig. 9). It covers a land area of 11,000 square miles.

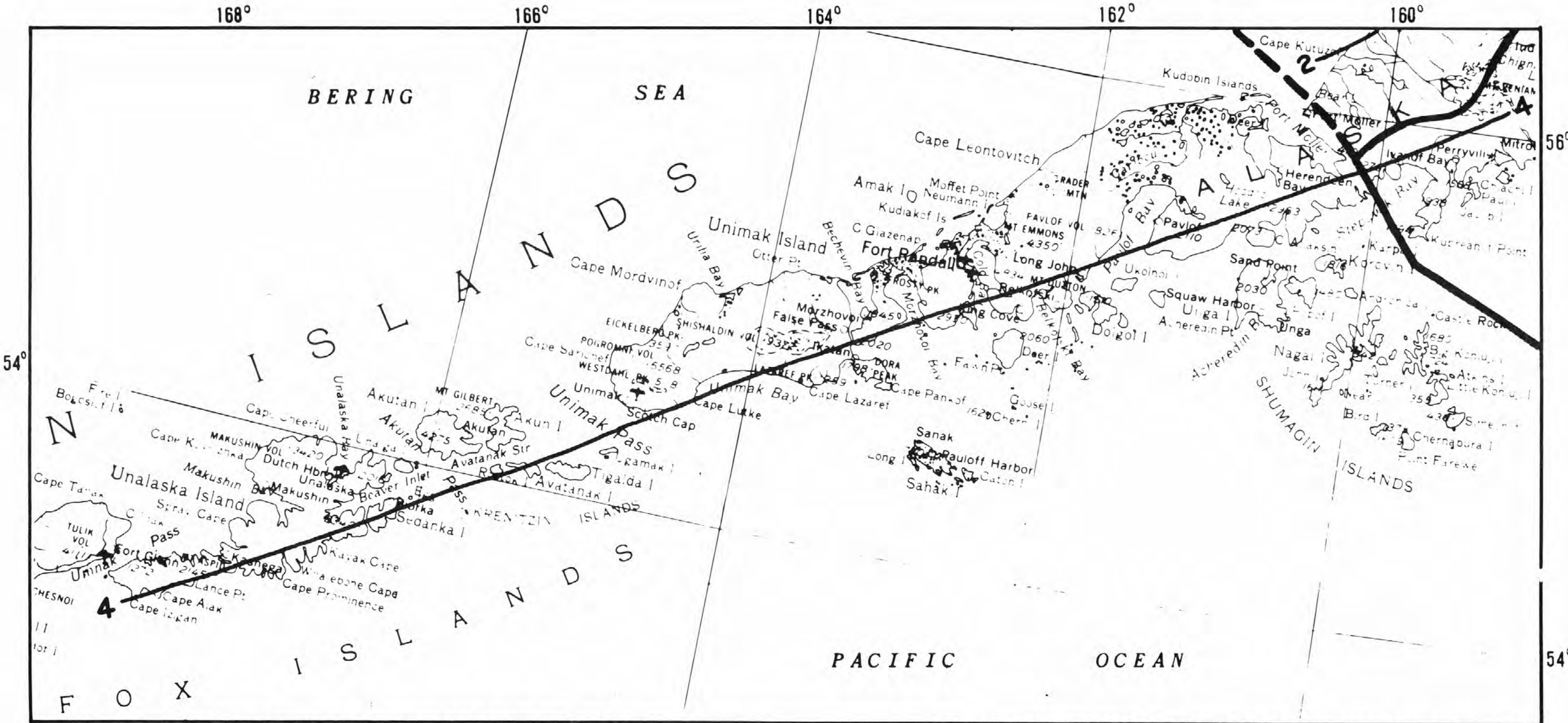
The subarea lies completely within the Maritime climatic zone. The mean annual temperature is about 40°F. The average annual precipitation is about 46 inches, ranging from about 30 inches at the western end of the Aleutian Islands to more than 60 inches in the mountains on the east.

The subarea consists of an arc-shaped chain of mountains and associated lowlands approximately 1,200 miles long and from 20 to 60 miles wide. Many of the mountains along the chain are active volcanoes. The associated lowlands are composed of older volcanic debris. Scattered, thin, glacial deposits occur on many of the island.

Permafrost has limited distribution. The lowlands are entirely free of permafrost; the uplands, however, may contain permafrost. Peaks rise to altitudes of 4,000 to 6,000 feet; some support small glaciers.

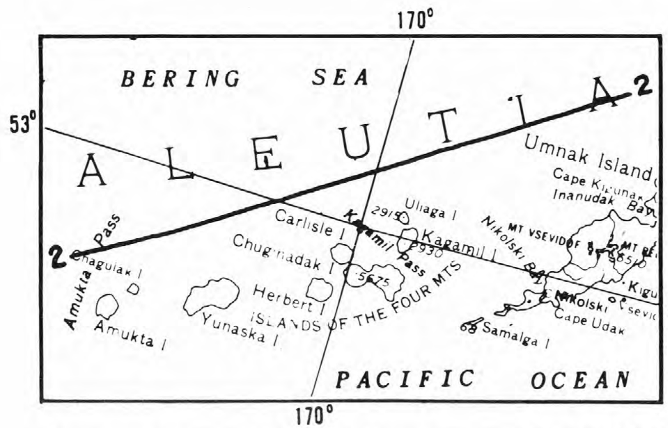
Surface Water.--There are no large streams in the subarea. Each island and the mainland part of the subarea have several small drainage systems. All these streams are short and most have steep gradients. Runoff rates have been measured at only a few locations. Mean annual runoffs probably average about 4 ft^3/s per square mile throughout (figs. 67a,b). Steep, high basins on the Pacific side of the eastern section produce runoff in excess of 4 ft^3/s per square mile. Table 2 shows the estimated mean monthly and mean annual runoff for the subarea, estimated from limited data.

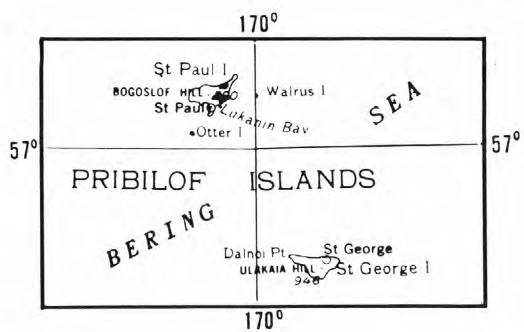
Mean annual peak runoff rates probably average about 25 ft^3/s per square mile; some basin averages may exceed this amount. Flooding in late summer or early fall usually results from heavy rains in the mountains. Figure 68 illustrates flood frequencies and magnitudes of some selected streams on Amchitka Island.



Base from U.S.Geological Survey map E (scale 1:2,500,00) of Alaska

Data from Joint Federal-State Land Use Planning Commission (1974)





EXPLANATION

—— 4 ——

LINE OF EQUAL MEAN ANNUAL RUNOFF IN CUBIC FEET PER SECOND PER SQUARE MILE

EAST PORTION
ALEUTIAN SUBAREA

0 50 MILES

Figure 67a. -- Estimated mean annual runoff in the eastern part of the Aleutian subarea (4.3, fig. 9).

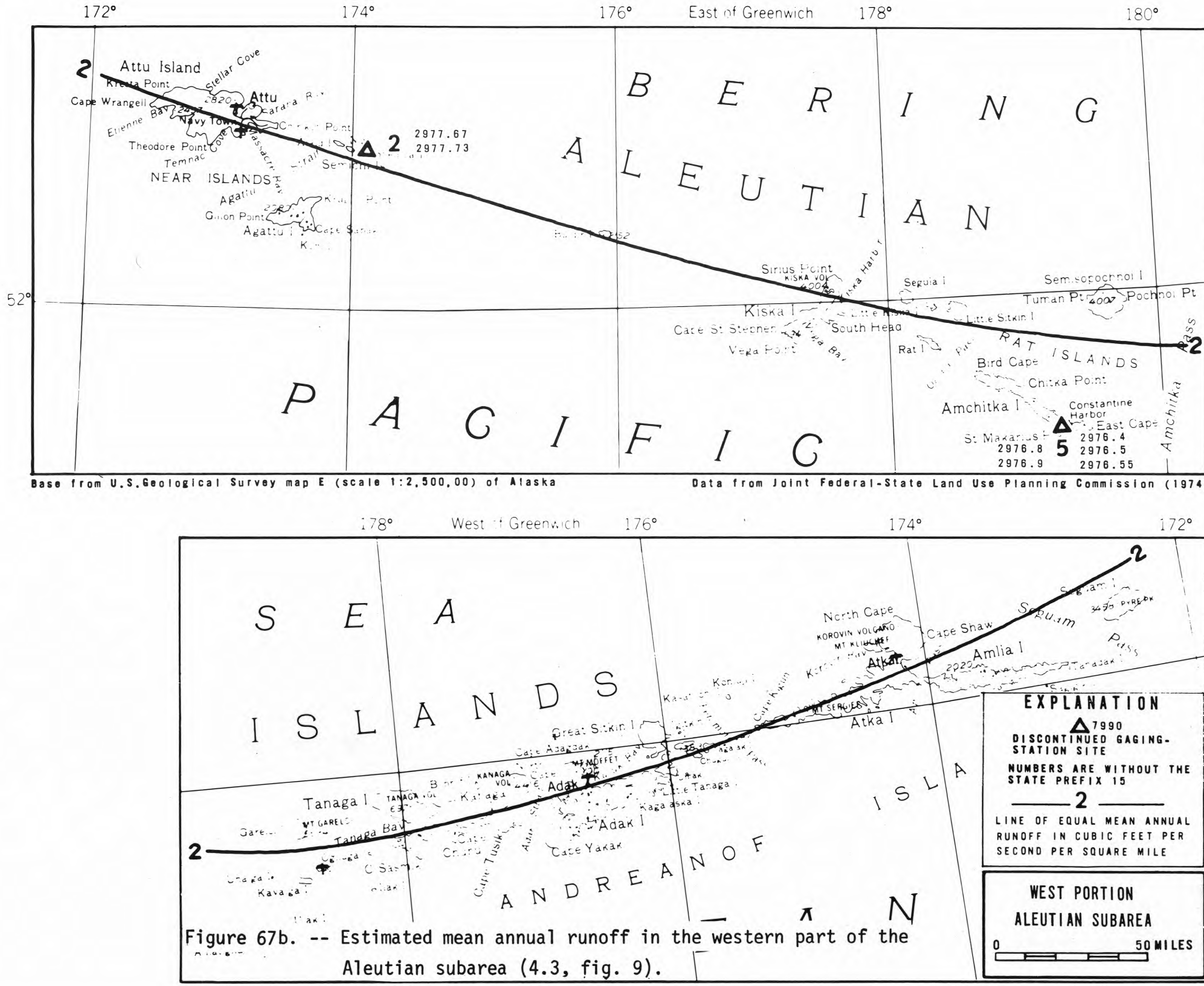


Figure 67b. -- Estimated mean annual runoff in the western part of the Aleutian subarea (4.3, fig. 9).

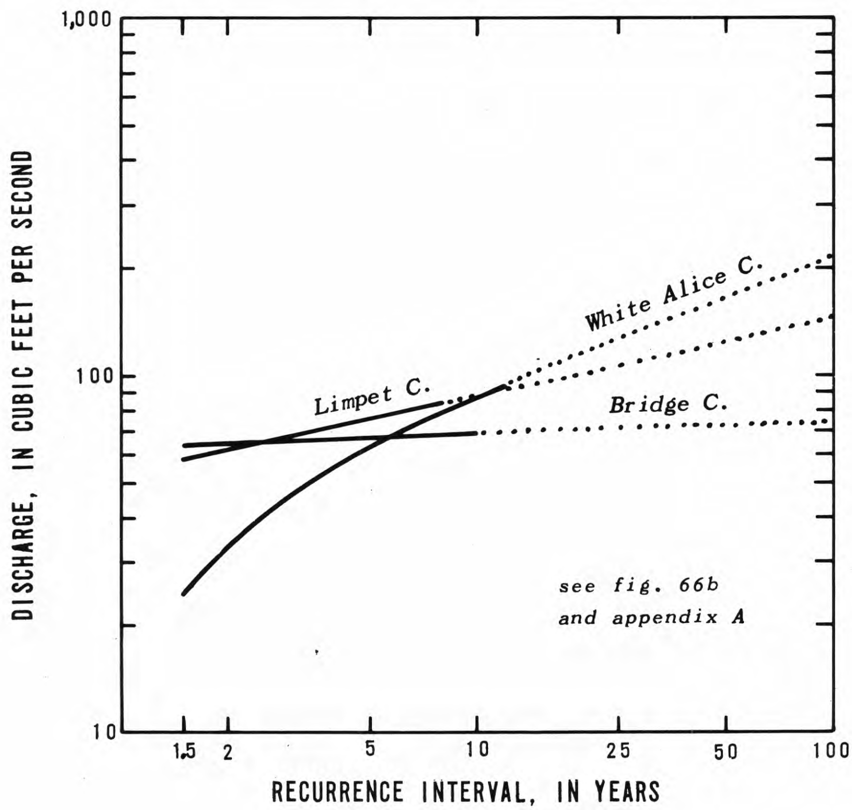


Figure 68. -- Flood magnitude-frequency relation of selected streams in the Aleutian subarea (4.3, fig. 9).

The low month mean runoff is probably greater than 1 ft^3/s per square mile. Precipitation along the Aleutians is distributed equally throughout the year. Low flow can occur during any month in which precipitation is light.

Surface water in the subarea generally contains less than 200 mg/l of dissolved solids. Waters analyzed are of the sodium chloride or calcium sodium bicarbonate types. Stream waters are low in mineral content, but water in a few streams which drain lowland areas may have high iron concentrations. Table 33 shows chemical analyses of selected streams.

No sediment samples have been taken from the Aleutian subarea. Estimates presented here are based upon information on adjacent subareas. Figures 69a and 69b show the estimated normal summer suspended-sediment load believed to be carried by streams in the subarea. Throughout a normal year, the suspended-sediment concentration is believed to be approximately 50 mg/l. North and east of Umnak Island, a few streams flowing from higher mountains where small glaciers exist could have sediment concentrations of 500 mg/l or more.

The temperature of surface water has an annual range of 33° to 49°F. The warmest temperatures have been recorded during June.

Ground Water.--The development of ground water is limited. Producing wells have been drilled at Cold Bay and at Shemya near the western end of the Aleutian Islands. Ground-water availability is believed to be limited to low, relatively flat areas where the alluvial or glacial deposits may contain water (figs. 70a,b).

Many springs are known in the subarea. Some of the springs are hot, such as those near Cold Bay. Springs flow from fracture systems in the underlying rocks and provide flow to streams. A spring on Amchitka Island is utilized for water supplies. Flow from this spring averages about 200 gal/min.

Table 33.--*Water quality of selected streams in the Aleutian subarea.*

[concentrations in milligrams per litre (mg/l) or micrograms per litre (µg/l)]

Date and discharge (ft^3/s)	mg/l	µg/l		mg/l												Specific conductance (µmhos/cm at 25°C)	pH units
	Silica (SiO_2)	Iron (Fe)	Manganese (Mn)	Calcium (Ca)	Magnesium (Mg)	Sodium (Na)	Potassium (K)	Bicarbonate (HCO_3)	Carbonate (CO_3)	Sulfate (SO_4)	Chloride (Cl)	Fluoride (F)	Nitrate (as N)	Dissolved solids	Total hardness		
						15297640 Limpet Creek on Amchitka											
04-22-70 9.2	8.7	300(a)	20(a)	2.5	2.3	18	1.4	15	0	6.4	30	<0.1	<0.02	76	16	140	5.4
06-25-70 1.5	23	50(a)	<10(a)	4.5	3.6	27	2.2	32	0	5.2	41	<.1	<.02	120	26	200	7.4
						15297680 Bridge Creek at Amchitka											
10-25-65 --	4.0	<10(a)	<20(a)	3.9	3.6	26	2.5	14	0	6.0	44	.1	<.02	97	25	192	6.3
02-23-68 1.7(b)	15	1,800(a)	--	6.6	6.7	54	3.2	85	0	11	58	.0	.00	199	44	357	7.3
						15297773 Gallery Creek at Shemya Air Force Base											
11-23-70 5.8	8.8	250(c)	90(c)	20	6.3	31	2.4	79	0	11	50	.1	.20	171	76	307	7.7
07-07-72 0.35	20	340(d)	440(d)	43	13	40	3.3	183	0	12	61	.1	.77	286	160	503	7.9

a Undifferentiated
b Mean daily discharge
c Total
d Dissolved

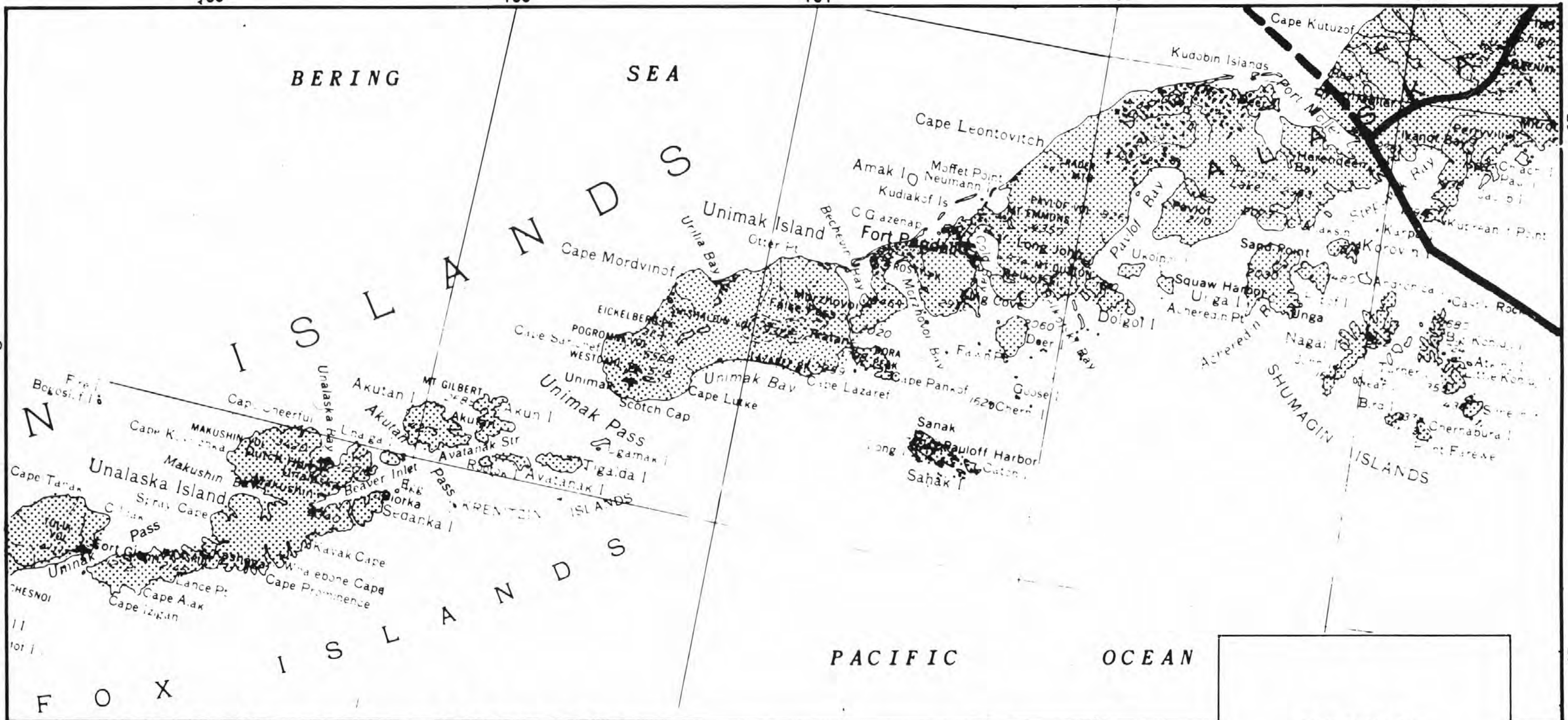
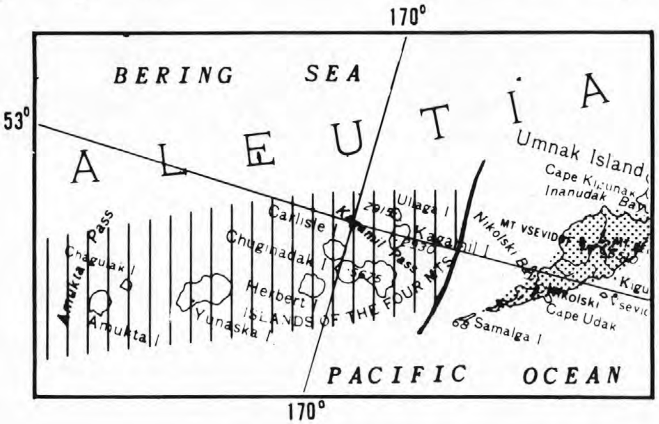
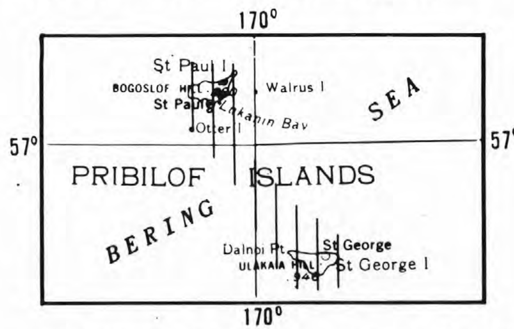
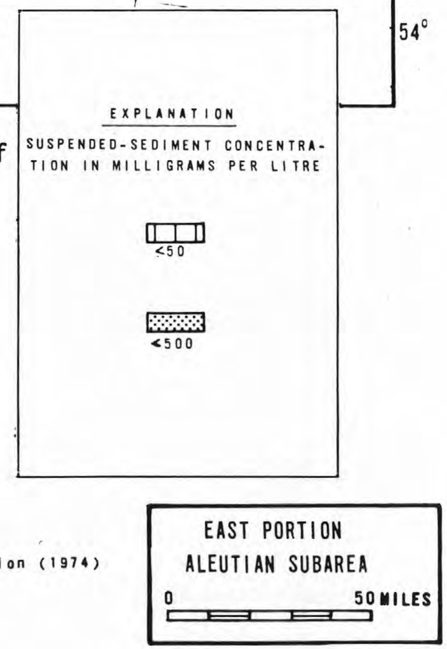


Figure 69a. -- Estimated normal summer suspended-sediment concentrations in the eastern part of the Aleutian subarea (4.3, fig. 9).





Data from Joint Federal-State Land Use Planning Commission (1974)



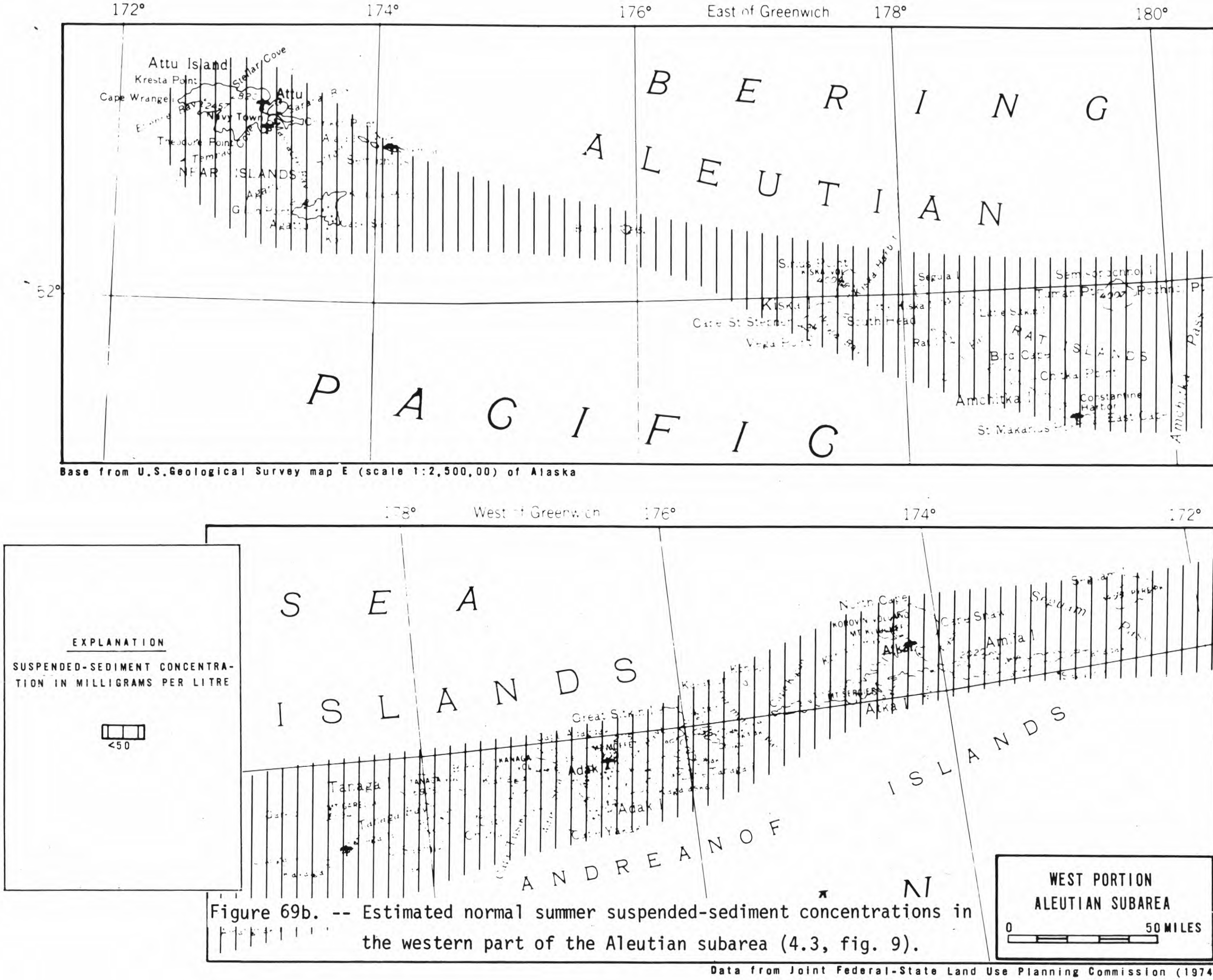
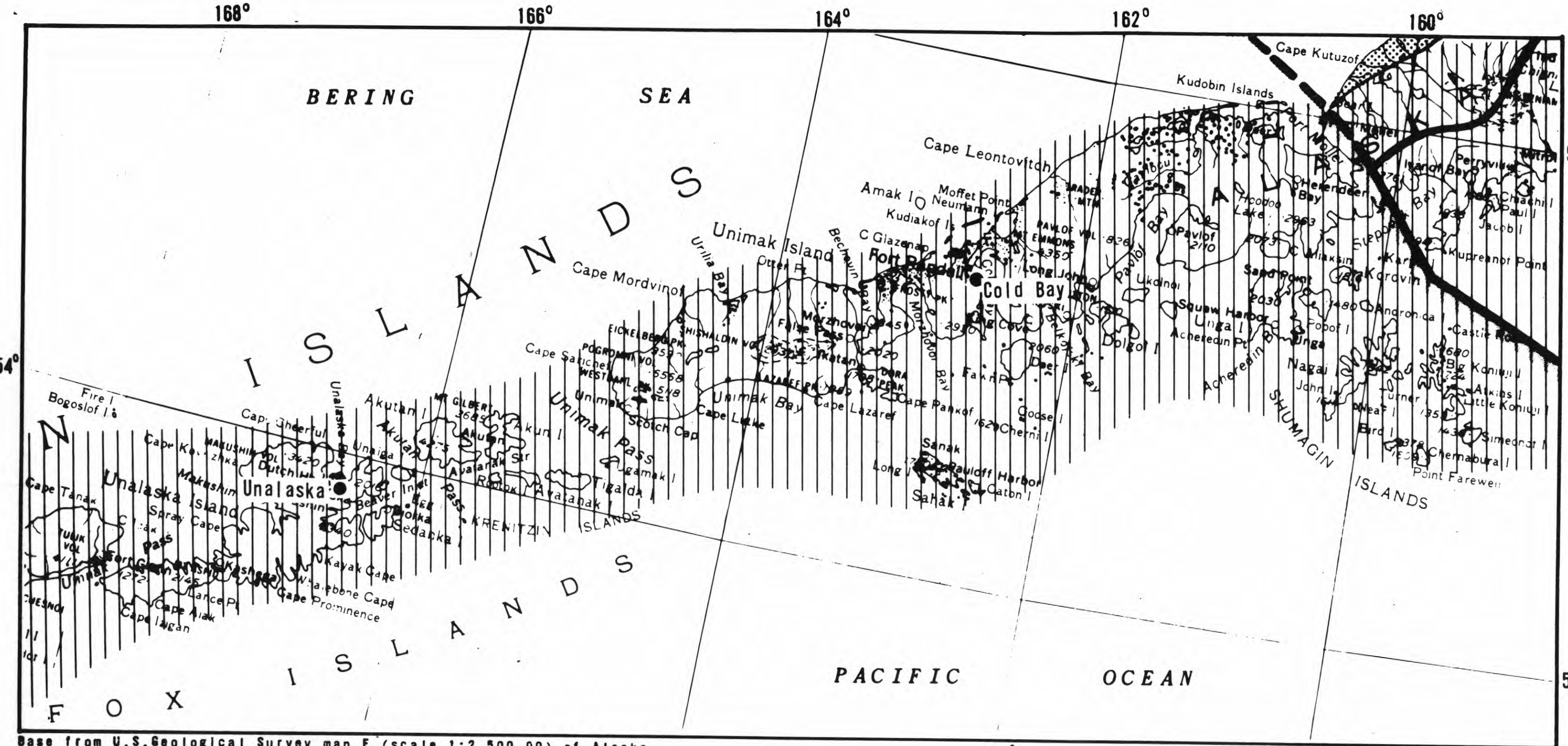
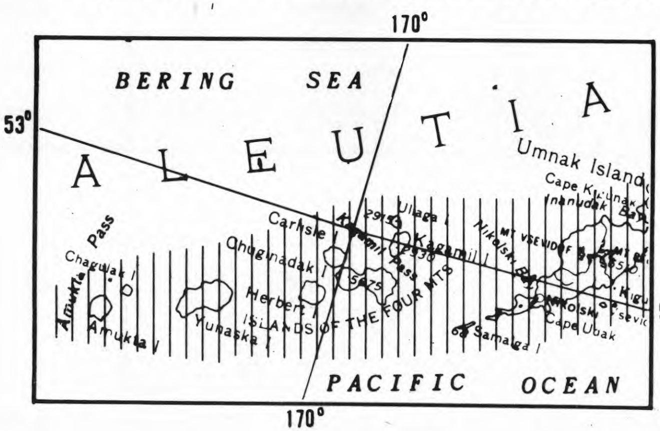


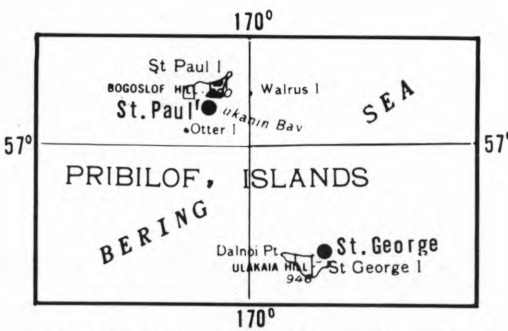
Figure 69b. -- Estimated normal summer suspended-sediment concentrations in the western part of the Aleutian subarea (4.3, fig. 9).



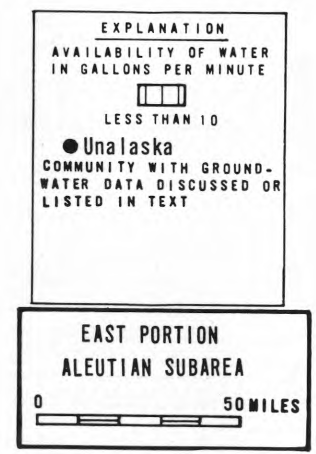
Base from U.S.Geological Survey map E (scale 1:2,500,00) of Alaska

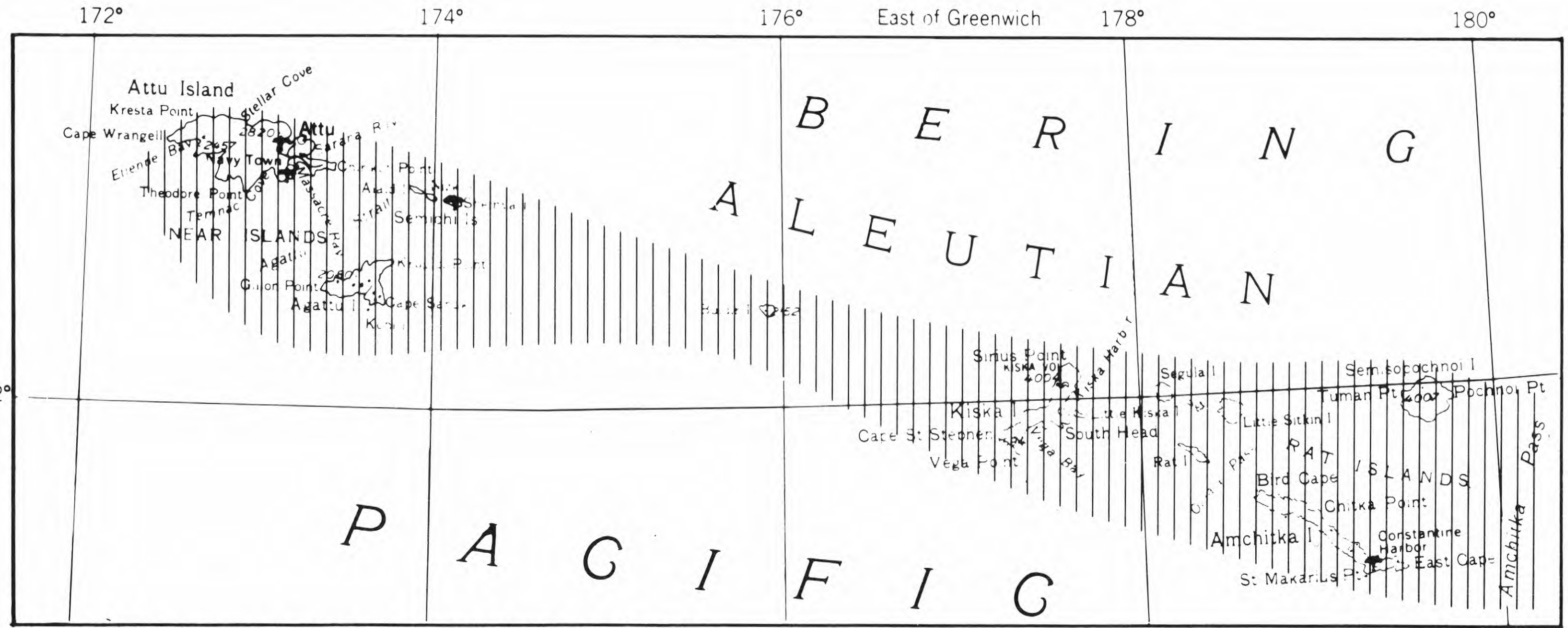
Figure 70a. -- Estimated ground-water yields in the eastern part of the Aleutian subarea (4.3, fig. 9).





Data from Joint Federal-State Land Use Planning Commission (1974)





Base from U.S.Geological Survey map E (scale 1:2,500,00) of Alaska

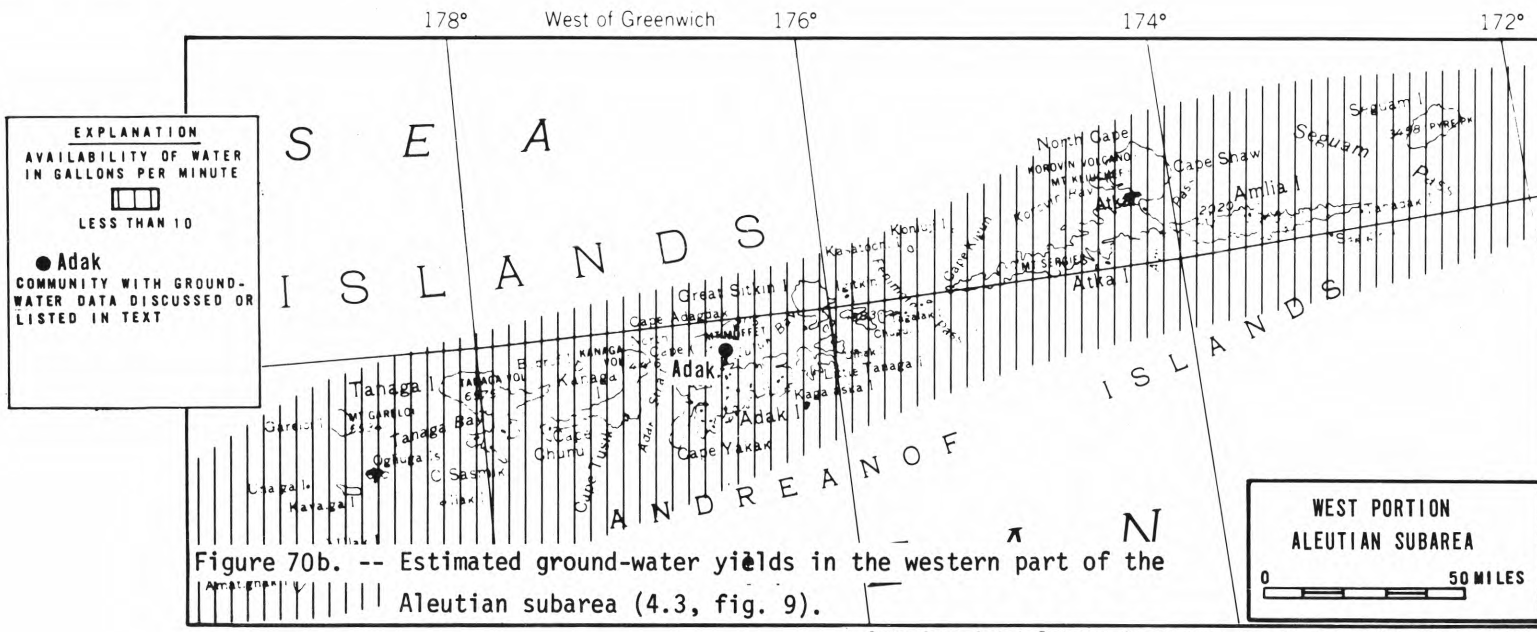


Figure 70b. -- Estimated ground-water yields in the western part of the Aleutian subarea (4.3, fig. 9).

Data from Joint Federal-State Land Use Planning Commission (1974)

Nearly all the ground waters sampled in the subarea have dissolved-solids concentrations of less than 200 mg/l. The water is generally acceptable for most uses. To the west, ground water is generally of the sodium chloride or sodium bicarbonate type. In the east, some wells produce calcium sodium bicarbonate type water. Table 34 shows chemical analyses of ground water from various locations in the subarea. Sparse information shows the temperature of ground water to have a range of from about 38° to 43°F.

Water Use.--The population in the subarea is about 8,000, including about 3,400 military personnel on Adak and Shemya Islands. The economy of the area is based on government employment, commercial fishing, sealing on the Pribilof Islands, and the raising of sheep.

Based on the population and the types of water services available, water use is estimated at about 564,000 gal/d for domestic purposes.

There are approximately 16,000 head of sheep on Umnak Island. Their water requirements are about 2 gal/d each, or a total water consumption of 32,000 gal/d.

Several seafood processors have facilities in the subarea. In 1974 about 21 million pounds of crab and shrimp were caught (State of Alaska, 1974); processing would require approximately 105 million gallons of water.

Table 34.--*Chemical analyses of ground water in the Aleutian subarea.*

[concentrations in milligrams per litre (mg/l) or micrograms per litre (µg/l)]

				mg/l	µg/l		mg/l													
Location	Date	Well depth (ft)	Temperature (°C)	Silica (SiO_2)	Iron (Fe)	Manganese (Mn)	Calcium (Ca)	Magnesium (Mg)	Sodium (Na)	Potassium (K)	Bicarbonate (HCO_3)	Carbonate (CO_3)	Sulfate (SO_4)	Chloride (Cl)	Fluoride (F)	Nitrate (as N)	Dissolved solids	Total hardness	Specific conductance (µmhos/cm at 25°C)	pH units
WELLS																				
Adak	08-06-71	--	--	2.8	80(a)	10(a)	8.4	0.6	6.1	0.4	26	0	2.8	10	0.0	0.02	44	24	80	6.9
Cold Bay	04-30-69	140	6.0	27	20(b)	0(b)	16	7.3	18	2.8	199	2.0	.0	18	.2	.81	142	70	227	8.4
St. George	07-12-72	--	--	24	700(a)	30(a)	6.6	4.3	25	1.9	34	0	6.5	35	.1	.66	123	34	197	7.4
St. Paul	06----61	--	--	29	20(b)	40(b)	13	7.4	45	5.0	90	0	11	59	.3	.02	214	63	351	7.3
Unalaska	04-23-65	--	4.5	7.0	40(b)	10(b)	4.2	1.6	6.2	.6	14	0	4.8	12	.0	.14	44	17	65	6.8
SPRINGS																				
Gallery	07-07-72	--	4.5	20	660(c)	410(c)	23	14	39	3.3	135	0	11	58	.1	.02	236	116	421	7.8
Constantine	02-28-70	--	--	13	70(c)	--	1.8	2.9	56	5.0	92	--	5.5	41	.5	.00	172	17	297	7.8

a Total
b Undifferentiated
c Dissolved

SOUTHCENTRAL SUBREGION

Kodiak-Shelikof Subarea

The Kodiak-Shelikof subarea includes the eastern part of the Alaska Peninsula between Stepovak Bay and Cape Douglas, as well as Kodiak and Afognak Islands (fig. 9). It covers a land area of 11,000 square miles and lies entirely within the Maritime climatic zone. Temperatures are moderate and range from about -12° to 85°F. The average annual temperature is about 40°F. No part of this subarea is more than 15 miles from the ocean. Rainfall is high, and most of the runoff is direct; little ground water is stored in the small basin areas. The average annual precipitation measured on the lowlands is about 60 inches per year, which is about one-half that which must fall in the mountains to account for the streamflow measured on Kodiak Island.

The subarea lies in the Pacific Border Ranges mountain system. Most of the subarea is mountainous, and many volcanic peaks have altitudes of about 4,000 feet. A few peaks on the Alaska Peninsula are 6,000 to 8,400 feet in altitude.

The bedrock in the subarea is generally made up of sedimentary and volcanic rocks that have been intruded and metamorphosed by granitic plutons and batholiths. Only limited amounts of unconsolidated materials occur in the subarea (Wahrhaftig, 1965).

The subarea is nearly free of permafrost. Only the crests of the mountains on the Alaska Peninsula and possibly some of the higher peaks on Kodiak Island are underlain by permafrost. A few peaks on the Alaska Peninsula support glaciers.

Surface Water.--The Uganik, Karluk, and Chignik Rivers are the principal streams of the subarea. All of these streams are less than 40 miles long. The estimated mean annual runoffs average about 4 ft^3/s per square mile for most of the area, but the average is about 8 ft^3/s per square mile on the southeast side of Kodiak Island and in the higher altitudes (fig. 71). Small low-lying basins have runoff rates of less than 4 ft^3/s per square mile. Table 2 shows the estimated mean monthly and mean annual runoff for the subarea.

The estimated mean annual peak runoffs average about 50 ft^3/s per square mile except on the southeast side of Kodiak Island and in the high altitudes along the Alaska Peninsula where the average is approximately 100 ft^3/s per square mile. Small low basins and basins having lakes that provide significant active storage can diminish mean annual peak rates to 10 ft^3/s or less per square mile. Floods often occur during winter when ice covers the channels, resulting in ice jamming and higher flood stages than would occur if the channels were open. Figure 72 illustrates the flood frequency and magnitude of selected streams in the subarea.

The low month mean runoff averages about 0.5 to 1 ft^3/s per square mile. Winter precipitation is mostly snow, particularly in the mountains. Warm periods during most winters cause sufficient snowmelt or rain to sustain streamflows. Streamflow will occasionally drop below 0.5 ft^3/s per square mile during a long, cold winter; serious deficiencies in water supplies to communities which rely upon streams or reservoirs in the higher mountains may result during those periods.

The chemical quality of surface waters is good for domestic uses. The known dissolved-solids concentrations of surface water range from a low of 17 mg/l at the outlet of Terror River to 45 mg/l at Monashka Creek near Kodiak. Nearly all the water is of the calcium bicarbonate type, although lakes near the ocean contain water of a sodium chloride or a sodium bicarbonate type. Table 35 lists chemical analyses of selected streams.

Although no suspended-sediment data have been collected in the subarea, three possible ranges of summer suspended-sediment concentrations are suggested by data from other subareas (fig. 73). Ash deposits from recent volcanic activity nearby contribute large amounts of sediment

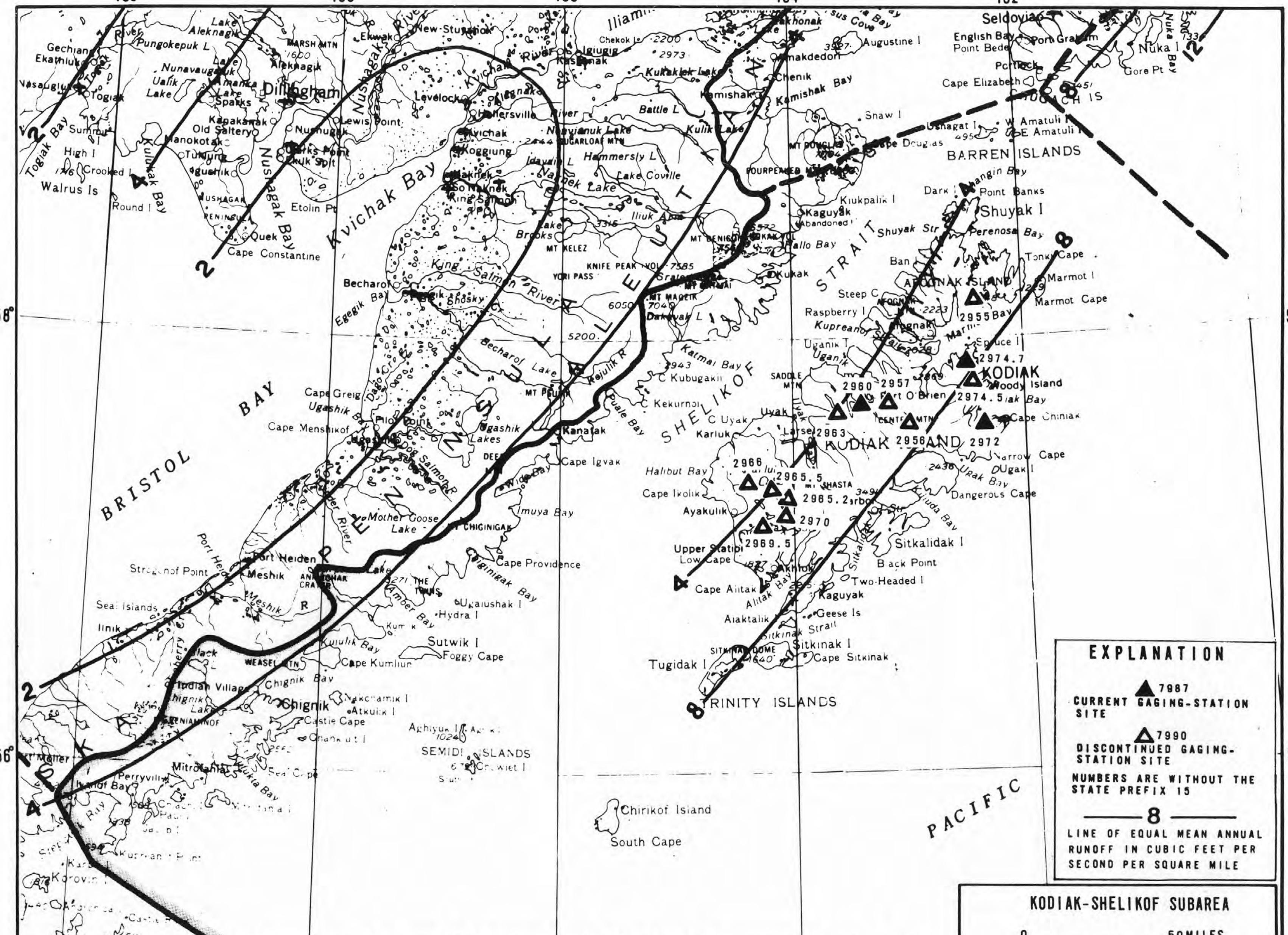


Figure 71. -- Estimated mean annual runoff in the Kodiak-Shelikof subarea (5.1, fig. 9).

Base from U.S.Geological Survey map E (scale 1:2,500,00) of Alaska

Data from Joint Federal-State Land Use Planning Commission (1974)

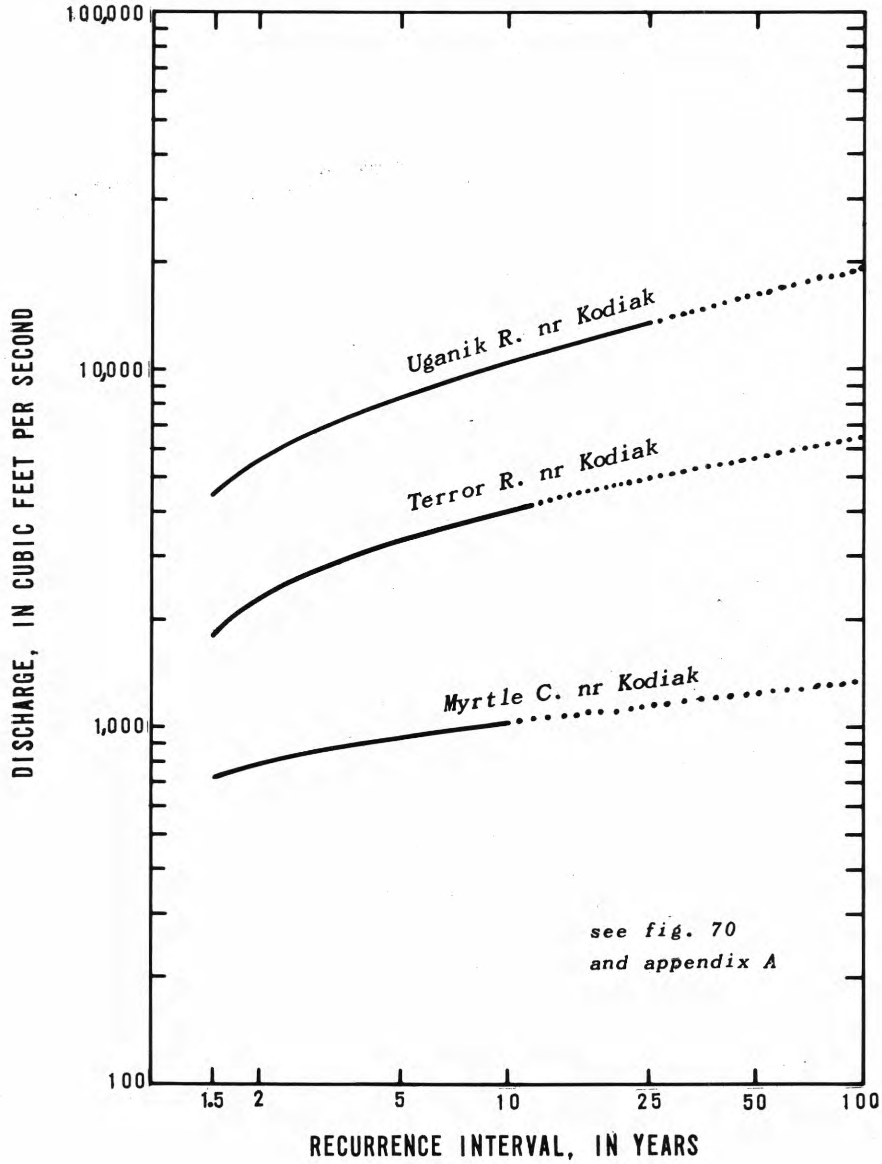


Figure 72. -- Flood magnitude-frequency relation of selected streams in the Kodiak-Shelikof subarea (5.1, fig. 9).

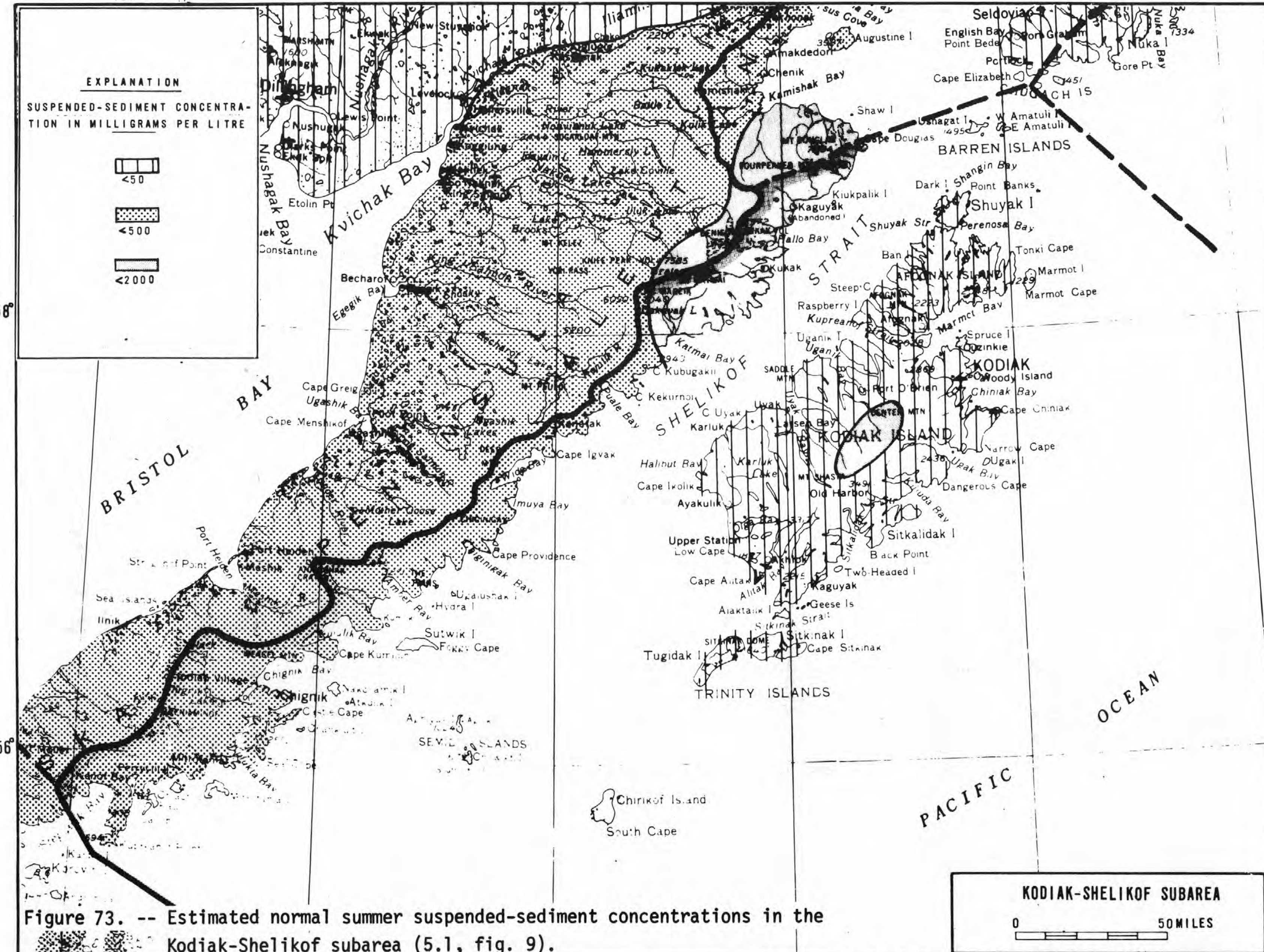


Figure 73. -- Estimated normal summer suspended-sediment concentrations in the Kodiak-Shelikof subarea (5.1, fig. 9).

Base from U.S.Geological Survey map E (scale 1:2,500,00) of Alaska

Data from Joint Federal-State Land Use Planning Commission (1974)

Table 35.--*Water quality of selected streams in the Kodiak-Shelikof subarea.*

[concentrations in milligrams per litre (mg/l) or micrograms per litre (µg/l)]

Date and discharge (ft^3/s)	mg/l	µg/l		mg/l												Specific conductance (µmhos/cm at 25°C)	pH units
	Silica (SiO_2)	Iron (Fe)	Manganese (Mn)	Calcium (Ca)	Magnesium (Mg)	Sodium (Na)	Potassium (K)	Bicarbonate (HCO_3)	Carbonate (CO_3)	Sulfate (SO_4)	Chloride (Cl)	Fluoride (F)	Nitrate (as N)	Dissolved solids	Total hardness		
15296000 Uganik River near Kodiak																	
05-09-68 281	5.6	--	--	6.8	1.5	2.9	0.2	24	0	4.2	2.5	0.1	0.09	36	23	66	6.9
08-03-70 1,710	4.2	40(a)	0(a)	4.4	.6	1.6	.2	13	0	4.8	2.1	.0	.18	25	14	38	7.3
15297200 Myrtle Creek near Kodiak																	
06-24-70 37	4.2	40(a)	0(a)	2.4	.5	2.9	.2	7	0	2.4	3.5	.1	.11	20	8	35	7.0
03-18-71 3.8	4.7	40(b)	0(b)	4.5	1.0	5.2	.3	9	0	2.4	11	.0	.32	35	16	60	7.1

a Undifferentiated
b Dissolved

to the larger streams; normal suspended-sediment concentrations may be as high as 2,000 mg/l during the summer. Elsewhere, runoff from small glaciers and high mountains probably carries between 5 and 500 mg/l of suspended sediment during most of the summer. The lowlands are generally well covered by vegetation, and streams carry only small quantities of suspended sediment. Normal winter concentrations are expected to be less than 10 mg/l for most streams. Some of the streams draining the Alaska Peninsula may have slightly higher concentrations.

The surface-water temperature ranges yearly between approximately 33° and 42°F.

Ground Water.--Ground-water exploration in the Kodiak-Shelikof subarea has not been extensive. A few wells have been drilled on Kodiak Island in or near the community of Kodiak. One well drilled on the Naval Base in the Buskin River valley had a reported yield of over 1,000 gal/min. This well was destroyed by the 1964 earthquake, and no other well in the area has obtained an equivalent yield. In 1968 a 200-foot-deep well was drilled for the Department of Highways in Kodiak. No information on yield has been reported, but it is assumed to be about 10 gal/min. Future testing in alluvial valleys may locate other places where yields of 100 gal/min or more could be obtained. Most of the area is considered to have a poor potential for large ground-water supplies because of a lack of proven aquifers. Figure 74 shows the estimated potential yield of the subarea.

Springs on Kodiak have not been studied. Several communities and canneries report the use of springs or spring-fed streams for water supplies.

Data on ground-water quality in the subarea have been gathered from several test wells augered near Kodiak in 1968 and several producing wells in and near Kodiak. The dissolved-solids concentrations of ground water in these test wells (all were drilled near streams) are about 44 mg/l. However, the dissolved-solids concentration of the Department of Highways' well at Kodiak is about 560 mg/l, and a well

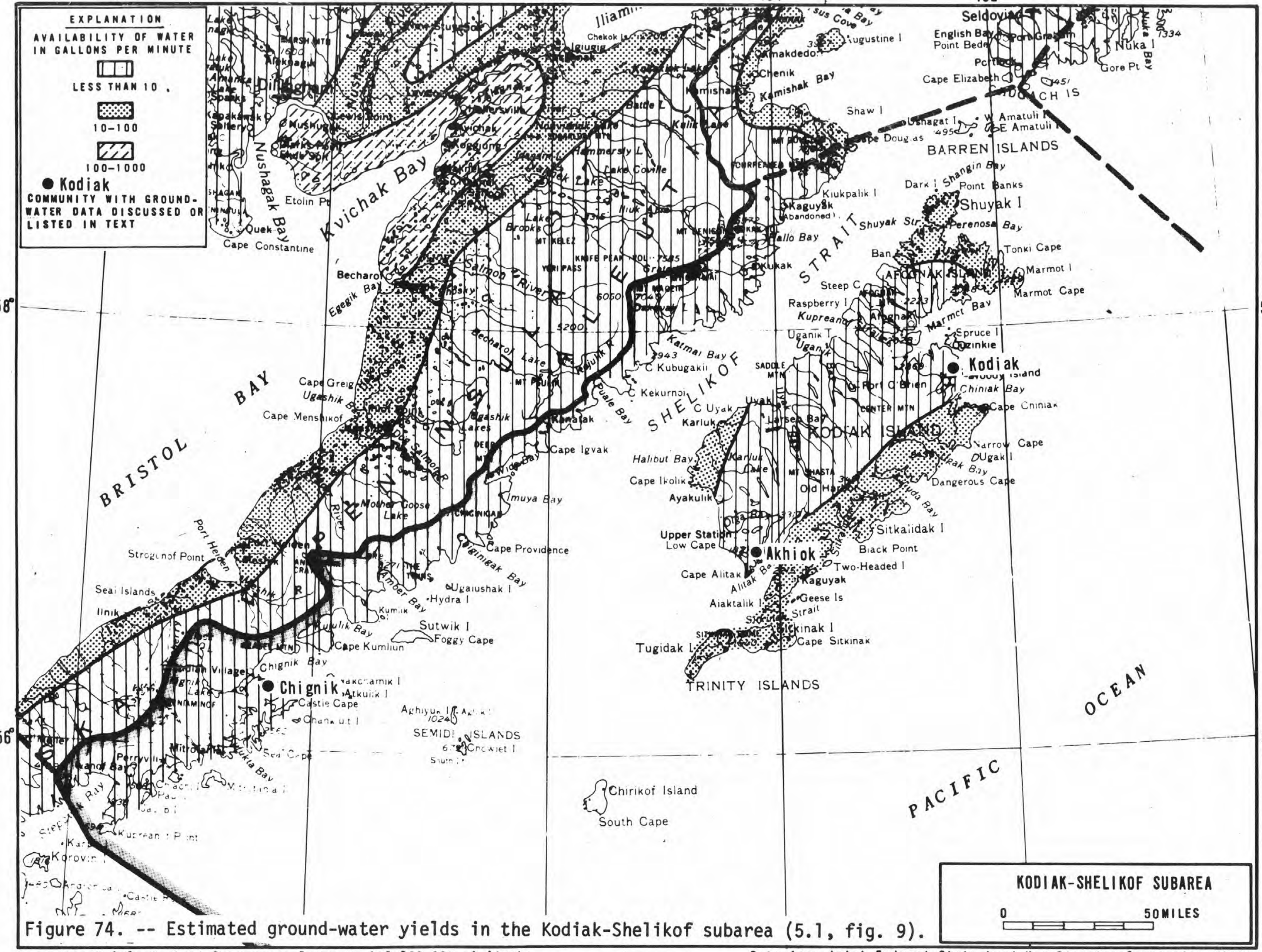


Figure 74. -- Estimated ground-water yields in the Kodiak-Shelikof subarea (5.1, fig. 9).

Base from U.S.Geological Survey map E (scale 1:2,500,00) of Alaska

Data from Joint Federal-State Land Use Planning Commission (1974)

drilled for the Federal Aviation Administration on Woody Island has a dissolved-solids concentration of 1,604 mg/l. Table 36 shows chemical analyses of ground water in other localities.

Shallow wells drilled in alluvium near streams produce water of generally acceptable quality for domestic use, although some water may have a high iron content. Water from bedrock wells on higher ground or wells drilled very near the coast may contain excessive quantities of sodium chloride. The few analyses of spring water show it to be low in dissolved solids, low in iron, and of good quality.

The meager data on ground-water temperature indicate that the range is from about 36° to 56°F. The highest temperatures observed were from the augered shallow wells near the city of Kodiak.

Water Use.--The economy in the subarea is based mainly on commercial fishing, seafood processing, and government employment. Agriculture also contributes to the economy and consists mostly of the raising of cattle, reindeer, and the growing of hay. The population of the subarea is about 9,500 people; Kodiak is the largest town (pop. 3,900).

Based on the population and water services available, the domestic water use is estimated at 950,000 gal/d. Requirements for cattle and irrigation are estimated at 36,000 gal/d and 300 acre-ft per year of water, respectively. The seafood processing in the subarea uses an estimated 935 million gallons a year.

A herd of 800 reindeer near the southern tip of Kodiak Island is currently used for subsistence rather than for commercial purposes. The water requirements of the herd are estimated to be a total of 0.38 and 0.20 million gallons during the summer and winter months, respectively.

Cook Inlet Subarea

The Cook Inlet subarea extends from the crest of the Aleutian and Alaska Ranges on the west to the northern divide between streams draining into the Gulf of Alaska and those draining to Cook Inlet (fig. 9).

Table 36.--*Chemical analyses of ground water in the Kodiak-Shelikof subarea.*

[concentrations in milligrams per litre (mg/l) or micrograms per litre (µg/l)]

Location	Date	Well depth (ft)	Temperature (°C)	mg/l	µg/l		mg/l												Specific conductance (µmhos/cm at 25°C)	pH units
				Silica (SiO_2)	Iron (Fe)	Manganese (Mn)	Calcium (Ca)	Magnesium (Mg)	Sodium (Na)	Potassium (K)	Bicarbonate (HCO_3)	Carbonate (CO_3)	Sulfate (SO_4)	Chloride (Cl)	Fluoride (F)	Nitrate (as N)	Dissolved solids	Total hardness		
WELLS																				
Akhiok	09-02-66	25	9.5	9.4	270(a)	--	8.8	8.0	20	2.7	44	0	13	28	0.1	2.5	125	55	209	6.5
Alitak	10----63	--	--	9.0	30(a)	20(a)	16	2.2	13	1.2	59	0	5.0	19	.1	.05	95	48	166	6.9
Chignik	04-20-68	32	1.0	5.2	30(a)	--	1.9	.6	3.0	.1	3.4	0	.0	5.0	.0	.29	19	7	34	5.7
Kodiak	05-29-69	--	--	5.2	20(a)	0(a)	1.8	1.1	5.0	.3	12	0	3.0	8.9	.3	.09	29	16	59	7.2

a Undifferentiated

It covers an area of 38,000 square miles and lies entirely within the Transition climatic zone. Annual temperatures in the subarea range between 38° and 86°F but average about 35°F in the northern part and 38°F in the southern part. Temperature and precipitation data are supplied by low-altitude weather stations; few stations are situated in the higher mountains. The precipitation falling on lowland areas throughout the year ranges from 12 to 24 inches with an average of between 15 and 18 inches.

The Cook Inlet subarea is ringed with mountains. The Aleutian and Alaska Ranges to the west and north reach from 3,000 to more than 20,000 feet. The Talkeetna and Kenai Mountains to the east have altitudes ranging from about 3,000 to more than 10,000 feet. The intervening lowland is drained by many streams and is underlain by thick glacial deposits.

The low areas are free of permafrost except, possibly, for small isolated patches beneath bogs or in dense forests. Permanently frozen ground may exist in the higher altitudes in the mountains. The Kenai Mountains and the Aleutian and Alaska Ranges support glaciers.

Surface Water.--The larger streams in the subarea are the Susitna (est. drainage area 20,000 mi^2) and its tributaries, the Knik (est. 3,300 mi^2), Kenai (est. 2,100 mi^2), Matanuska (est. 2,100 mi^2), and McArthur (est. 1,600 mi^2) Rivers. The mean annual runoff is about 0.5 to 1 ft^3/s per square mile in the central lowlands and increases to about 8 ft^3/s per square mile in the Kenai Mountains to the southeast (fig. 75). Table 2 shows the estimated mean monthly and mean annual runoff for the subarea.

Mean peak runoff is probably less than 10 ft^3/s per square mile in the central lowlands but may reach 50 to 100 ft^3/s per square mile in the mountains. Contributing to the seasonal peak runoff are rainstorms, spring snowmelt, and ice-jam flooding.

Floods have also been caused by periodic discharge from ice-dammed lakes in the Knik, Snow, and McArthur River drainage basins. Figure 76

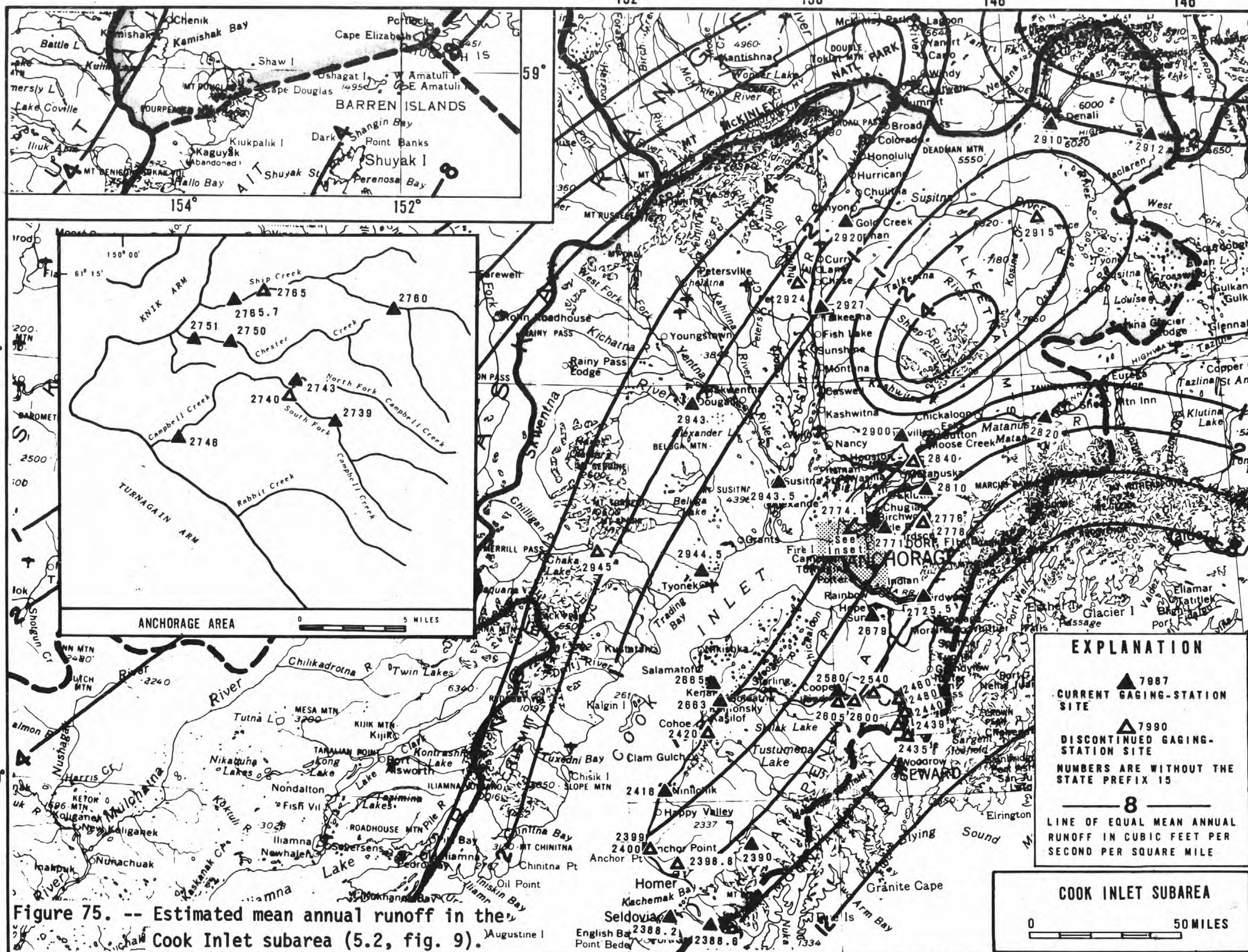


Figure 75. -- Estimated mean annual runoff in the Cook Inlet subarea (5.2, fig. 9).

Base from U.S.Geological Survey map E (scale 1:2,500,00) of Alaska

Data from Joint Federal-State Land Use Planning Commission (1974)

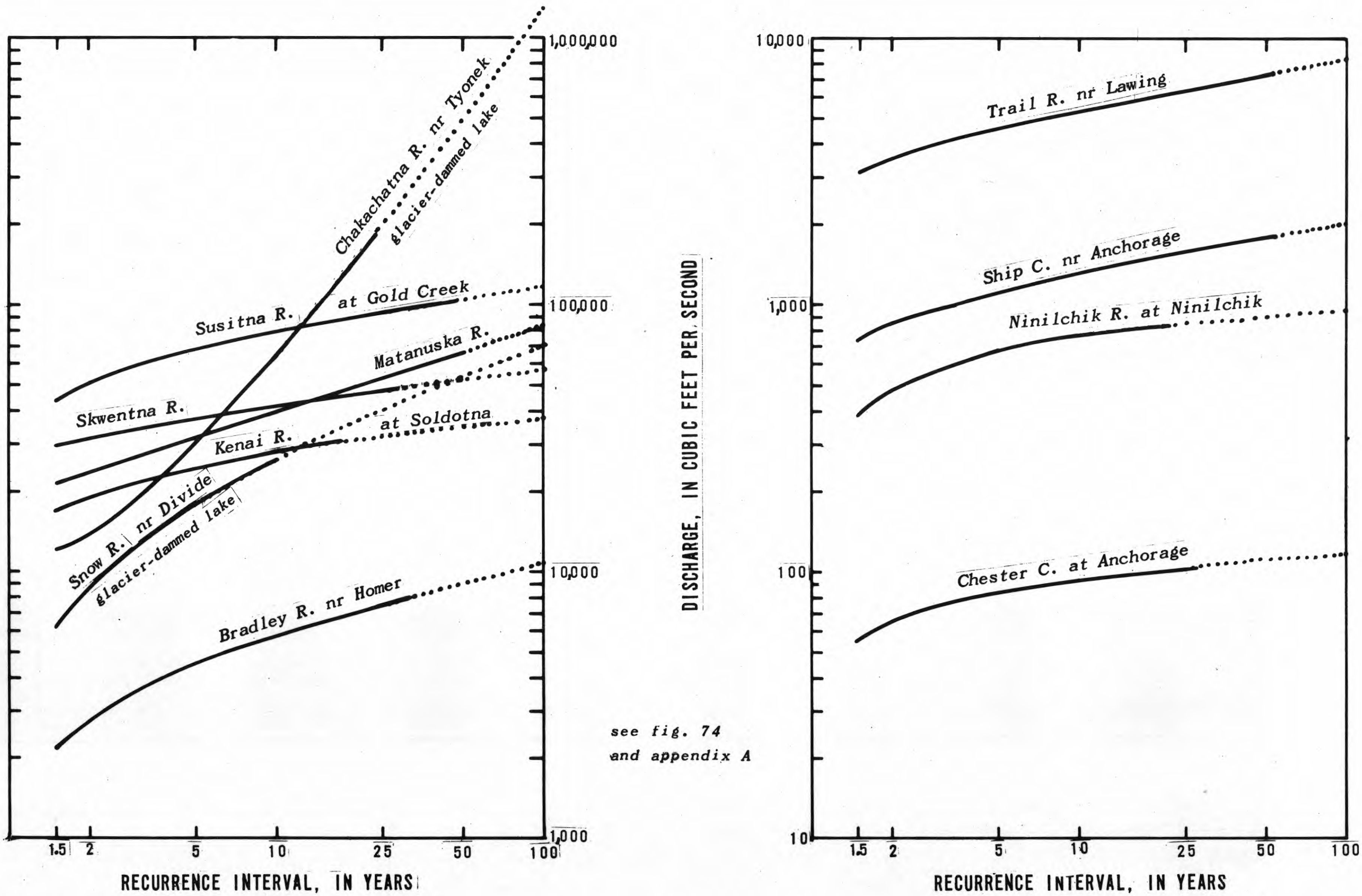


Figure 76. -- Flood magnitude-frequency relation of selected streams in the Cook Inlet subarea (5.2, fig. 9).

illustrates the flood frequency and magnitude of selected streams in the subarea.

The low month mean runoff is generally between 0.3 and slightly over 1 ft^3/s per square mile. Low flows generally occur during late winter and occasionally during the dry summer months. However, stream discharge during the summer is generally maintained by glacial melt.

All the surface waters in the subarea are chemically acceptable for most uses; most are of the calcium bicarbonate type and have low dissolved-solids concentrations. Table 37 shows chemical analyses of selected stream waters in the subarea. Temperatures of surface water range from an apparent winter low of near 32°F to a summer high of about 53°F. Shallow lakes generally have higher summer water temperatures than do streams; lake-water temperatures may reach 65°F.

The sediment load in the northeastern part of the subarea is one of the highest in the State. Glaciers at higher altitudes on the west, north, and east of the subarea make the greatest contribution to the sediment load of streams. The streams for which sediment data are available are the Eagle River at Eagle River, the Matanuska River near Palmer, the Knik River near Palmer, and the Susitna River near Gold Creek. The Knik River near Palmer has the highest rate of suspended-sediment yield per square mile in the subarea. The average annual yield is 6,000 tons per square mile per year, equal to 7.8 million tons per year. The sediment yields of other streams in the subarea are also relatively high. The bulk of the sediment load of these streams is carried during the summer months; very little is carried during the winter. Figure 77 shows the expected normal summer concentration of suspended-sediment throughout the subarea.

Ground Water.--The Susitna River lowland is probably the best potential source of ground water within the subarea. Wells drilled near the principal streams should have yields of 1,000 gal/min or more. Wells away from the streams may have yields of from 10 to more than 100 gal/min. In the Anchorage area, the region within a mile or two of Ship

Table 37.--*Water quality of selected streams in the Cook Inlet subarea.*

[concentrations in milligrams per litre (mg/l) or micrograms per litre (µg/l)]

Date and discharge (ft^3/s)	Silica (SiO_2)	Iron (Fe)	Manganese (Mn)	Calcium (Ca)	Magnesium (Mg)	Sodium (Na)	Potassium (K)	Bicarbonate (HCO_3)	Carbonate (CO_3)	Sulfate (SO_4)	Chloride (Cl)	Fluoride (F)	Nitrate (as N)	Dissolved solids	Total hardness	Specific conductance (µmhos/cm at 25°C)	pH units
	mg/l	µg/l		mg/l													
15239000 Bradley River near Homer																	
03-07-68 135	2.6	--	--	11	1.4	1.0	0.4	32	0	3.8	0.0	0.0	0.14	37	34	73	7.2
06-24-72 550	5.5	210(a)	20(a)	8.0	1.2	1.2	.3	26	0	5.0	1.5	.0	.16	36	25	59	7.5
15241600 Ninilchik River at Ninilchik																	
08-21-58 --	29	780(b)	0(b)	8.7	3.3	5.8	1.6	56	0	1.5	2.0	.1	.14	81	35	97	6.6
03-29-67 51	36	800(b)	--	10	4.6	9.7	2.7	80	0	.0	2.1	.1	.14	106	44	131	6.8
15248000 Trail River near Lawing																	
05-30-61 1,290(c)	5.1	50(b)	10(b)	13	2.1	1.0	.4	38	0	10	1.5	.0	.41	54	41	87	7.7
02-15-68 191	5.4	280(b)	--	19	1.2	1.3	.4	51	0	14	1.4	.0	.29	69	52	118	7.6
15266300 Kenai River at Soldotna																	
06-25-69 14,200	3.5	40(b)	--	9.0	.9	1.2	1.2	26	0	5.7	.0	.3	.14	36	26	62	7.5
01-07-70 2,860	5.5	480(b)	20(b)	10	1.6	3.2	1.3	34	0	6.3	3.9	.0	.20	50	32	86	7.8

Table 37.--*Water quality of selected streams in the Cook Inlet subarea, continued.*

[concentrations in milligrams per litre (mg/l) or micrograms per litre (µg/l)]

Date and discharge (ft^3/s)	mg/l	µg/l		mg/l												Specific conductance (µmhos/cm at 25°C)	pH units
	Silica (SiO_2)	Iron (Fe)	Manganese (Mn)	Calcium (Ca)	Magnesium (Mg)	Sodium (Na)	Potassium (K)	Bicarbonate (HCO_3)	Carbonate (CO_3)	Sulfate (SO_4)	Chloride (Cl)	Fluoride (F)	Nitrate (as N)	Dissolved solids	Total hardness		
15276000 Ship Creek near Anchorage																	
06-09-70 444	4.7	60(b)	0(b)	14	2.0	1.6	0.4	38	0	12	0.7	0.0	0.07	55	42	95	7.8
04-03-70 11	7.0	--	--	22	3.9	2.5	.3	70	0	19	.4	.1	.18	90	70	161	7.6
15284000 Matanuska River at Palmer																	
08-12-58 11,600	4.5	20(b)	0(b)	28	1.8	3.8	.9	61	.0	29	2.5	.0	.02	94	77	169	7.0
03-05-68 566	6.3	70(b)	--	44	4.8	8.9	.9	100	0	41	13	.0	.25	169	129	293	8.1
15292000 Susitna River at Gold Creek																	
06-03-57 34,100	5.7	0(b)	0(b)	12	1.4	3.1	1.3	36	0	6.0	4.0	.1	.14	52	35	90	6.8
01-11-68 1,960	11	190(b)	--	34	4.5	11	2.4	98	0	12	29	.1	.11	152	104	277	8.0
15294300 Skwentna River near Skwentna																	
09-04-59 6,760	11	0(b)	0(b)	17	5.0	4.4	.9	52	0	20	6.0	.2	.05	91	63	136	7.4
01-05-61 1,330	13	0(b)	0(b)	28	4.3	7.7	1.7	77	0	24	12	.2	.18	130	88	204	7.1

Table 37.--*Water quality of selected streams in the Cook Inlet subarea, continued.*

[concentrations in milligrams per litre (mg/l) or micrograms per litre (µg/l)]

Date and discharge (ft^3/s)	mg/l	µg/l		mg/l												Specific conductance (µmhos/cm at 25°C)	pH units
	Silica (SiO_2)	Iron (Fe)	Manganese (Mn)	Calcium (Ca)	Magnesium (Mg)	Sodium (Na)	Potassium (K)	Bicarbonate (HCO_3)	Carbonate (CO_3)	Sulfate (SO_4)	Chloride (Cl)	Fluoride (F)	Nitrate (as N)	Dissolved solids	Total hardness		
					15294500 Chakachatna River near Tyonek												
06-16-59 6,640	5.3	30(b)	10(b)	9.1	2.1	1.4	1.5	26	0	12	2.0	0.0	0.00	46	31	77	7.1
07-17-72 15,100	5.3	940(d)	50(d)	14	1.8	1.5	1.7	26	0	11	1.4	.1	.03	51	42	66	7.5

a Total
b Undifferentiated
c Mean daily discharge
d Dissolved

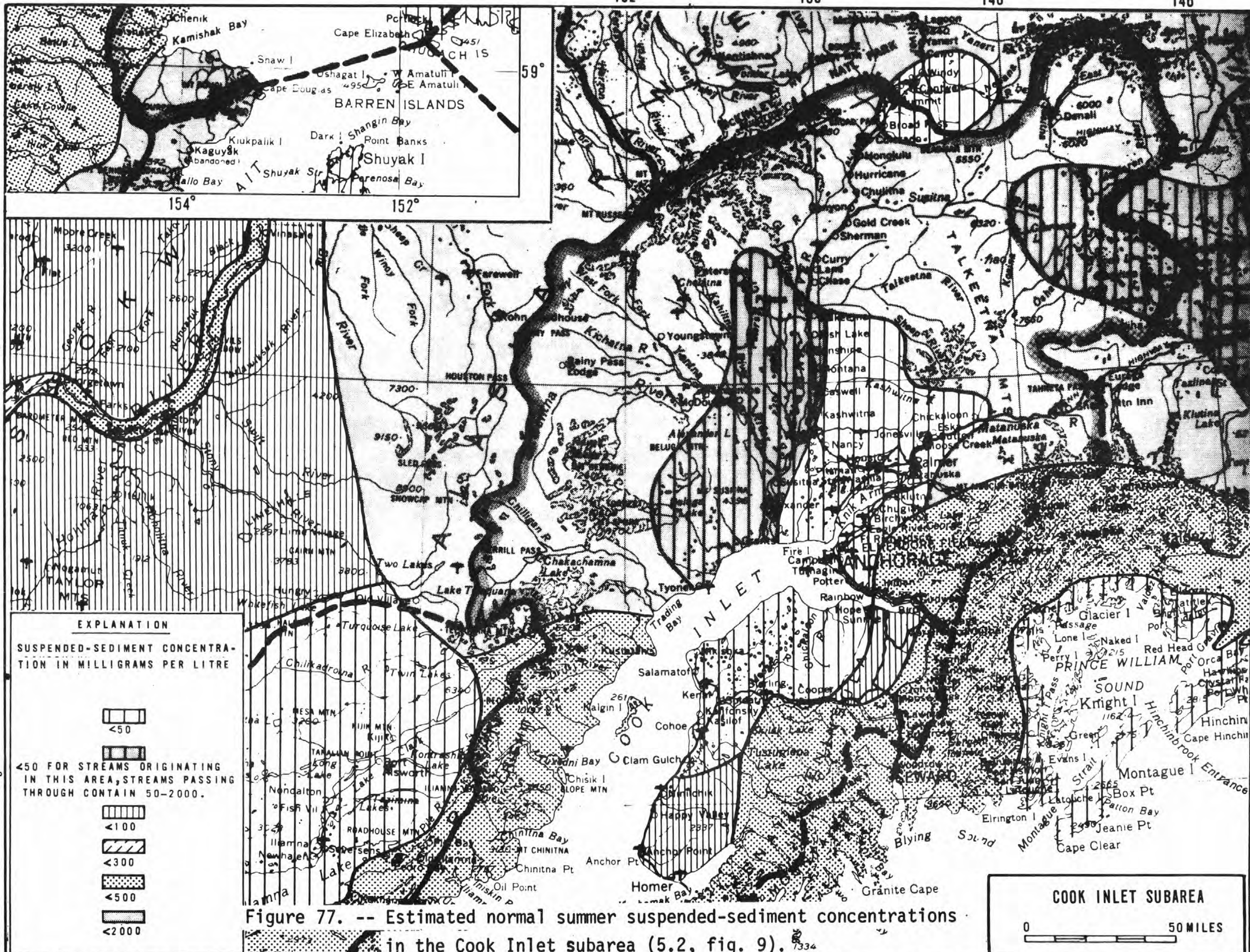


Figure 77. -- Estimated normal summer suspended-sediment concentrations in the Cook Inlet subarea (5.2, fig. 9).

Base from U.S.Geological Survey map E (scale 1:2,500,00) of Alaska

Data from Joint Federal-State Land Use Planning Commission (1974)

Creek on the south side of the stream has a much higher yield (from 1,000 to 1,500 gal/min) than the area immediately north or south of that zone; outside the zone well yields range from 1 to 10 gal/min. On the Kenai Peninsula the wells in the lowlands generally have yields of from 10 to 100 gal/min except for a limited area north and east of Kenai where yields of 1,000 gal/min can be obtained. Specific site studies will be necessary to define local yields. Figure 78 shows the general availability of ground water in the subarea.

Springs occur along the mountain flanks throughout the subarea. The largest known spring, near Palmer, has a flow ranging from about 150 to 200 gal/min. Many small springs flow from the bedrock escarpment just north of Homer, but most of these have flows of only 5 to 25 gal/min. Springs also occur along the flanks of the Alaska Range, but, again, flows are generally less than 100 gal/min. No special work has been done to locate springs or note their flows.

Ground-water quality throughout the northern part of the subarea is good. The amount of dissolved solids is relatively low. No special problems created by high iron content are known to occur, although on the Kenai Peninsula water from wells in both the alluvial materials and bedrock has a high iron content. The usual range of temperatures is between 38° and 45°F. Table 38 lists chemical analyses of ground water at various locations in the subarea.

Water Use.--The economy of the subarea is based on government employment, oil production and refining, agriculture, and commercial fishing and seafood processing. The population in the subarea is about 188,400 (Alaska Dept. of Community and Regional Affairs, 1975b). Domestic water requirements are estimated at 35 Mgal/d based on the current (1975) population and data in the report by Barnwell and others (1972). Industrial activity, including the petrochemical complex on the Kenai Peninsula and the logistical support of the oil platforms in the Cook Inlet area, requires an estimated 941 Mgal/y. Agricultural water needs in the Matanuska Valley and the Kenai Peninsula amount to an estimated

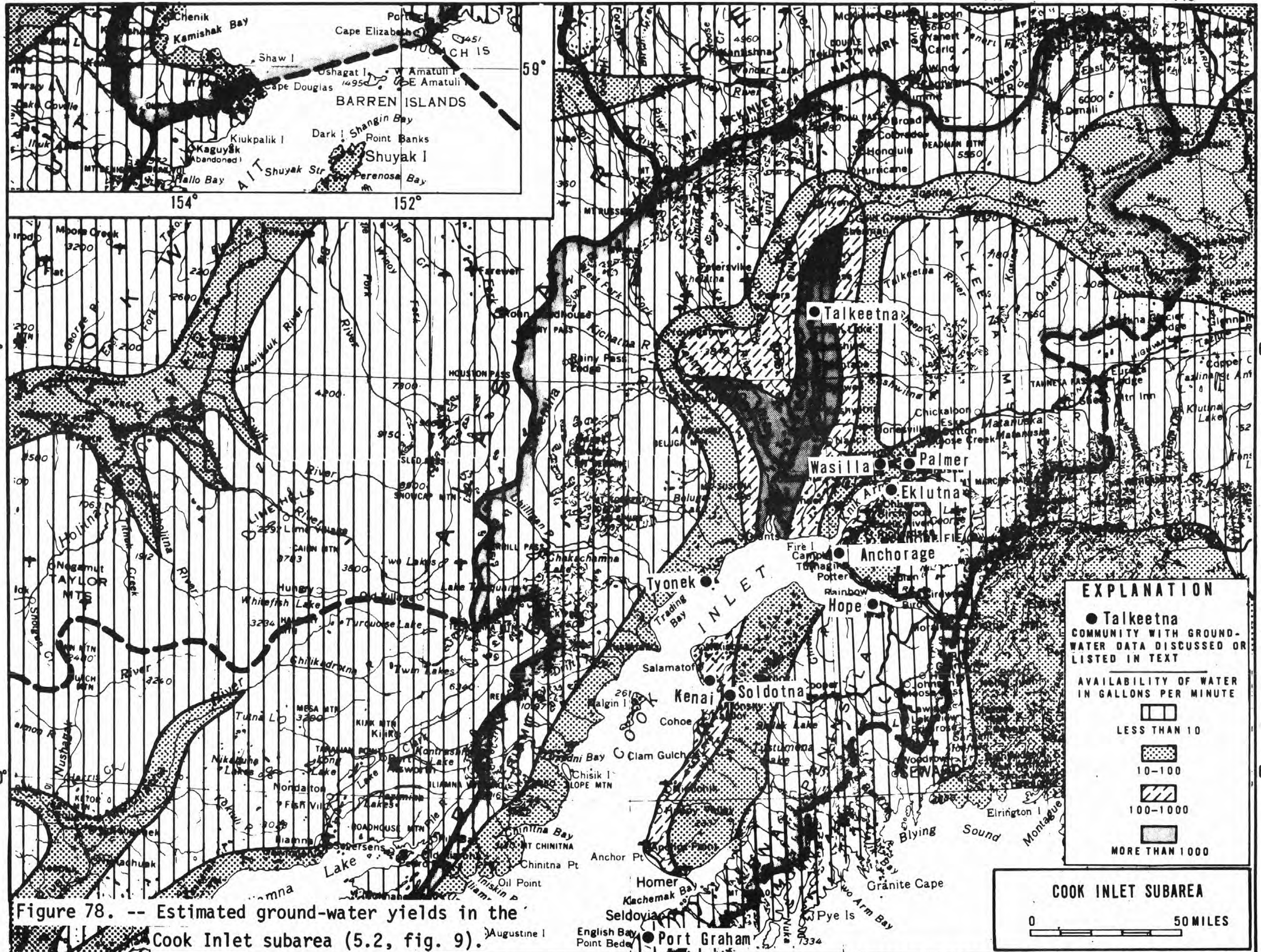


Figure 78. -- Estimated ground-water yields in the Cook Inlet subarea (5.2, fig. 9).

Base from U.S.Geological Survey map E (scale 1:2,500,00) of Alaska

Data from Joint Federal-State Land Use Planning Commission (1974)

Table 38.--*Chemical analyses of ground water in the Cook Inlet subarea.*

[concentrations in milligrams per litre (mg/l) or micrograms per litre (µg/l)]

Location	Date	Well depth (ft)	Temperature (°C)	mg/l	µg/l		mg/l												Specific conductance (µmhos/cm at 25°C)	pH units
				Silica (SiO_2)	Iron (Fe)	Manganese (Mn)	Calcium (Ca)	Magnesium (Mg)	Sodium (Na)	Potassium (K)	Bicarbonate (HCO_3)	Carbonate (CO_3)	Sulfate (SO_4)	Chloride (Cl)	Fluoride (F)	Nitrate (as N)	Dissolved solids	Total hardness		
WELLS																				
Anchorage	06-23-75	250	--	14	0(a)	20(a)	22	9.1	8.6	1.1	128	--	4.3	1.8	0.2	0.07	128	92	209	--
Eklutna	06-30-66	40	--	12	0(b)	10(b)	26	9.5	1.5	.6	126	0	1.4	2.5	.2	.25	117	104	228	7.4
Hope	06-27-69	--	--	5.6	2,300(b)	90(b)	27	8.6	206	2.8	183	8.8	7.2	277	.5	.00	634	103	1,192	8.4
Kenai	03-13-72	--	--	23	100(c)	80(c)	15	10	460	14	486	0	49	467	2.4	.36	1,280	78	2,300	8.0
Palmer	07-22-66	--	2.5	11	20(b)	--	37	6.7	5.7	1.8	162	0	5.8	2.1	.1	.00	150	120	253	8.0
Port Graham	03-08-67	63	--	11	0(b)	--	32	2.2	7.5	.2	102	0	4.0	10	.0	.16	118	89	199	6.9
Soldotna	01-05-70	185	--	43	270(b)	130(b)	16	9.2	65	4.7	157	0	5.5	68	.2	.16	290	78	447	8.3
Talkeetna	------64	--	--	18	90(b)	0(b)	18	3.6	3.7	.1	71	0	1.4	3.5	.0	.07	84	61	128	6.7
Tyonek	02-04-70	--	--	33	16,000(b)	1,100(b)	31	7.0	7.8	2.8	93	0	3.9	35	.1	.07	184	106	269	7.3
Wasilla	------61	--	--	14	20(b)	0(b)	34	3.6	2.4	.9	123	0	3.0	2.0	.0	.18	121	100	197	7.5
SPRINGS																				
Russian Jack	09-19-72	--	3.0	13	0(a)	0(a)	34	8.0	6.6	.9	130	--	--	--	--	.88	--	--	250	6.8

a Dissolved
b Undifferentiated
c Total

28,200 acre-ft a year for crops and 40,300 gal/d for livestock. About 34 million pounds of seafood was caught in the Cook Inlet subarea in 1974 (State of Alaska, 1974); that amount would require an estimated 170 million gallons of water for processing. There are two hydroelectric facilities in the subarea (table 7). They have a total usable storage capacity of 271,000 acre-ft.

Gulf of Alaska Subarea

The Gulf of Alaska subarea includes the drainage from the western tip of the Kenai Peninsula to Icy Bay on the east (fig. 9). It covers a land area of 34,000 square miles and an additional 1,000 square miles in Canada. The subarea lies within two climatic zones; the northern part is in the Transition zone and the southern part is in the Maritime zone. Mean annual temperatures range between 22° and 35°F in the Transition zone and precipitation ranges from about 9 to 20 inches. The Maritime zone has an average annual temperature of about 40°F and an average annual precipitation of between 80 and 100 inches. These temperature and precipitation figures are based upon data from low-altitude observation stations. Precipitation at higher altitudes exceeds these precipitation figures by 100 percent or more, as is reflected by streamflow in the area (fig. 6).

The subarea is divided by mountains into a relatively narrow strip of coastal lowlands adjacent to the Gulf of Alaska and the interior lowlands of the Copper River basin. The mountains generally are more than 5,000 feet in altitude. Peaks reach 12,000 to 16,000 feet.

The coastal areas are generally free of permafrost. The interior part, north of the mountains, is underlain by discontinuous permafrost. Permafrost is probably absent near the major streams.

The subarea contains many glaciers. They cover most of the higher peaks in the Wrangell Mountains to the northeast and nearly all of the crest of the Kenai-Chugach mountain range. The Bering Glacier, one of the largest glaciers on the North American continent, is in the subarea.

Surface Water.--The copper River (est. drainage area 24,000 mi^2) is the largest stream in the subarea. Its principal tributaries include the Bremner (est. 1,000 mi^2), Chitina (est. 8,000 mi^2), Chistochina (est. 900 mi^2), Gakona (est. 620 mi^2), Gulkana (est. 2,000 mi^2), Tazlina (est. 2,200 mi^2), and Tiekel Rivers. All of these, except the Gulkana River, are glacier-fed. Complete ice cover throughout the winter is common on streams in the interior part of the area. Ice occasionally builds up to cause overflow in the channels and flood plains at some locations.

Runoff is variable. Mean annual runoff averages about 10 ft^3/s per square mile in coastal regions (fig. 79). Smaller subsidiary basins in the upper Copper River lowlands have annual runoff rates of less than 1 ft^3/s per square mile. In the higher altitudes of the upper Copper River basin, mean annual runoff probably is more than 5 ft^3/s per square mile. Table 2 shows the estimated mean monthly and mean annual runoff for the subarea.

High peak flows have been computed. Mean annual peak runoff ranges from about 10 ft^3/s per square mile in the northern part of the Copper River basin to about 100 ft^3/s per square mile in the southern part. Mean annual peak runoff exceeding 150 ft^3/s per square mile has been measured on the coastal plain and southern foothills, and rates greater than 300 ft^3/s per square mile probably occur there. These peaks usually result from rainstorms in the fall. However, winter rains combined with snowmelt occasionally produce unusually high peaks. Mean annual peak runoffs of less than 10 ft^3/s per square mile are common in the upper Copper River lowlands. Rates exceeding 50 ft^3/s per square mile have been measured in the uplands. Peak rates exceeding 100 ft^3/s per square mile might be expected in summer in some high, steep basins that received unusually large amounts of rainfall. Cold winters in the area commonly cause large icings to form in stream channels, particularly at culverts or bridges. Even small stream discharges cause flooding under these conditions. There are also numerous glacier-dammed lakes in the area, and breakout flooding from these lakes has caused large

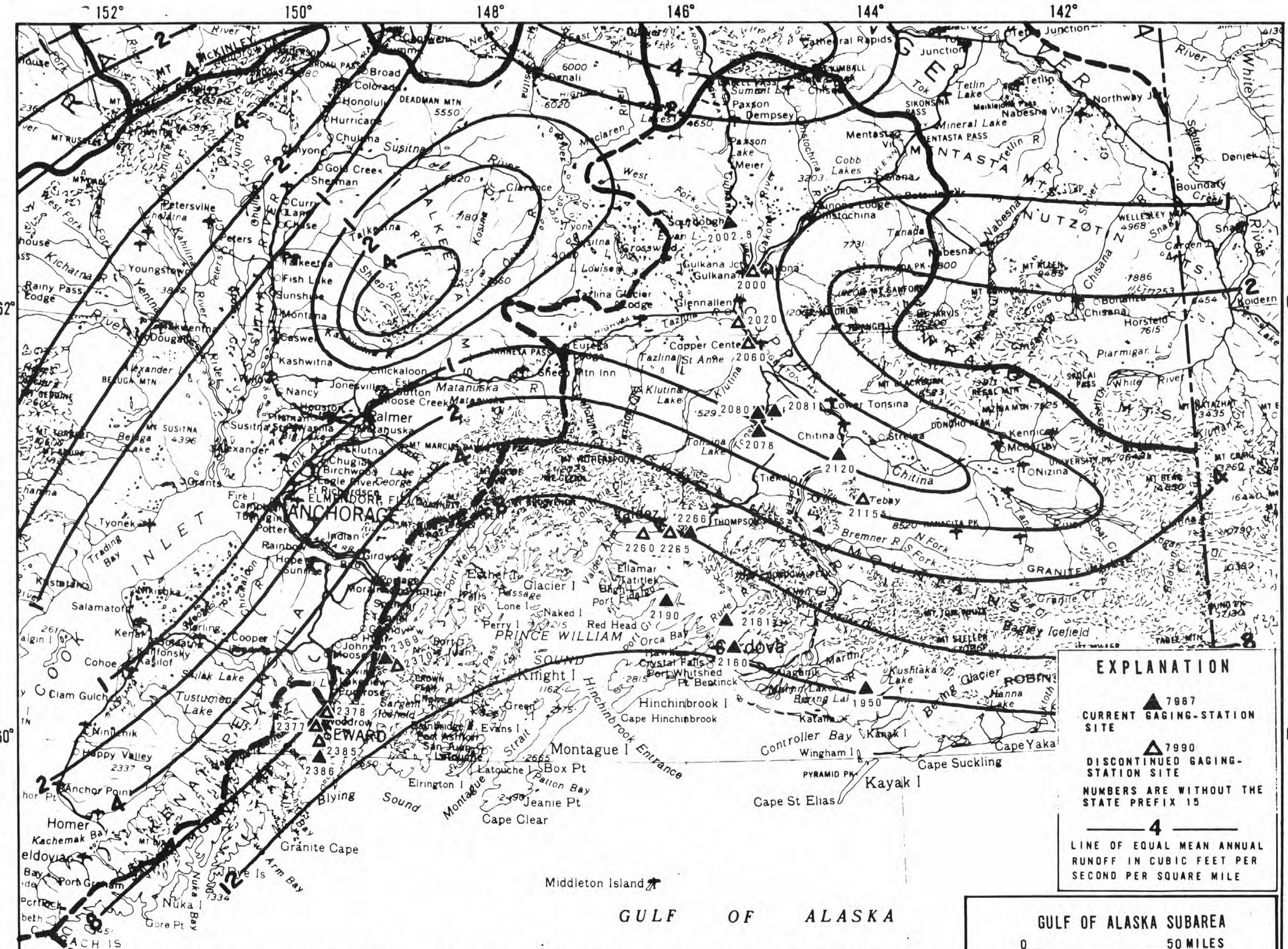


Figure 79. -- Estimated mean annual runoff in the Gulf of Alaska subarea (5.3, fig. 9).

Base from U.S. Geological Survey map E (scale 1:2,500,00) of Alaska

Data from Joint Federal-State Land Use Planning Commission (1974)

floodflows in the lower Copper River and on other streams. Figure 80 illustrates the flood frequency and magnitude of some selected streams in the subarea.

Low flows usually occur in late winter when most of the precipitation is stored as snow. In the northern part of the subarea, the low month mean runoff averages about 0.2 and 0.3 ft^3/s per square mile. The low month mean runoff in the southern part of the Copper River basin is probably about 0.5 to 1.0 ft^3/s per square mile.

The dissolved-solids concentrations in surface water are generally less than 200 mg/l. Lakes near the ocean generally contain water with higher sodium, chloride, and magnesium concentrations than do surface waters of the interior parts of the subarea. Nichols and Yehle (1961) have described highly mineralized springs in the Copper River basin. Table 39 lists chemical analyses of selected streams in the subarea.

The sediment load of streams throughout the interior part of the subarea is among the highest in the State. Glaciers probably produce the largest quantities of sediment, but lacustrine deposits that cover much of the lower land in the upper and middle Copper River basin also provide much sediment. The sediment load of streams is highest during the summer months and diminishes during the winter months. Figure 81 shows the expected normal summer concentrations of suspended sediment throughout the subarea.

Based on limited data, the Copper River near Chitina has an estimated average annual suspended-sediment yield of 3,500 tons per square mile, or an estimated total of 72.2 million tons per year.

Ground Water.--Ground water is available at depths of 150 to 250 feet throughout most of the interior lowlands, but in some places it occurs at greater depths. Small aquifers along the coasts may supply relatively large amounts of water. Figure 82 shows the general availability of ground water throughout the subarea.

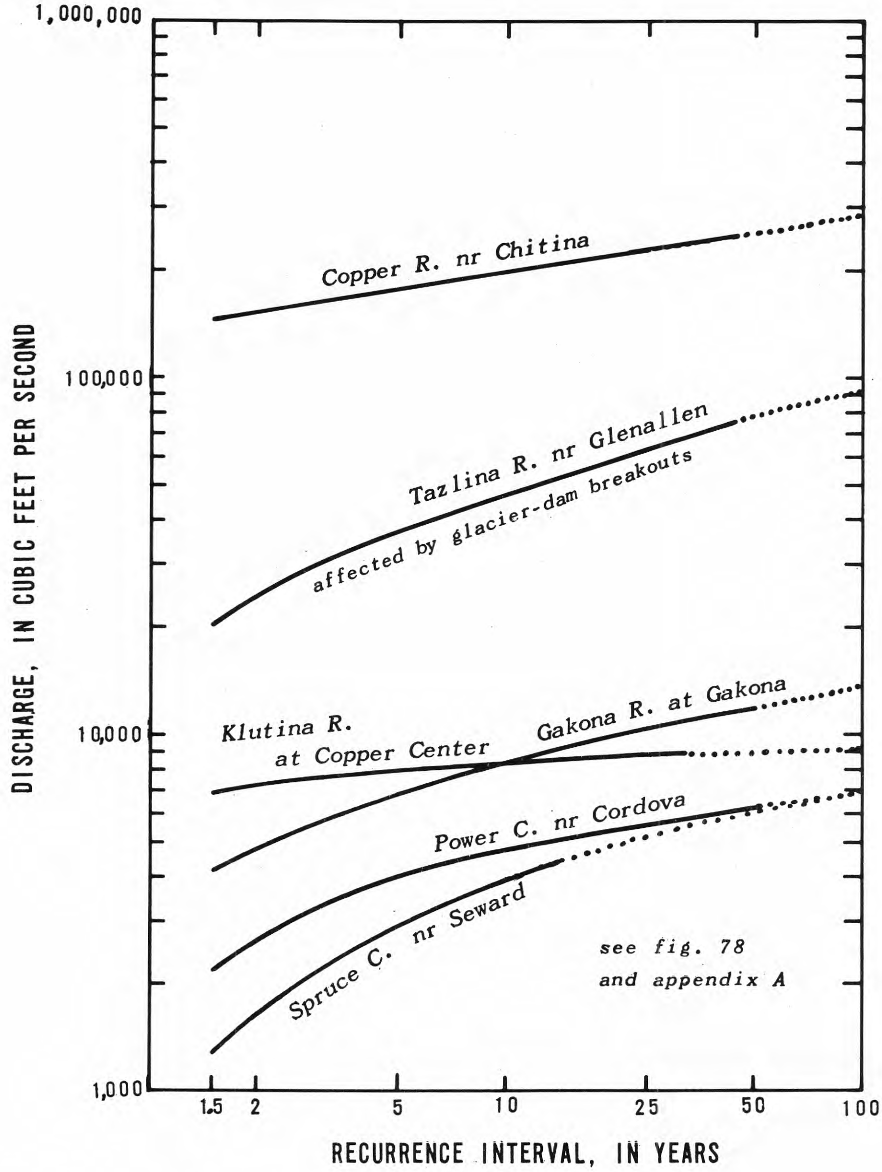


Figure 80. -- Flood magnitude-frequency relation of selected streams in the Gulf of Alaska subarea (5.3, fig. 9).

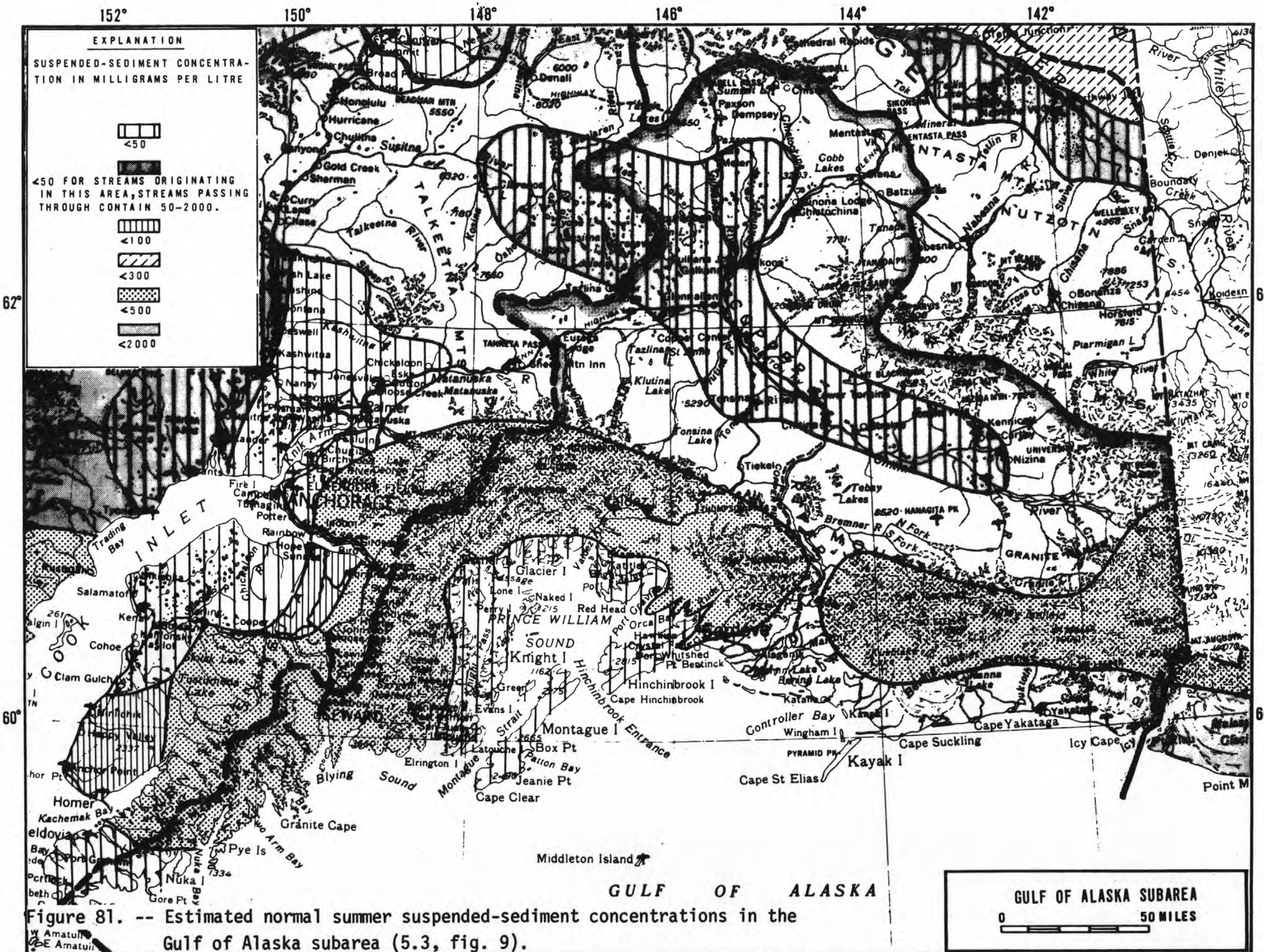


Figure 81. -- Estimated normal summer suspended-sediment concentrations in the Gulf of Alaska subarea (5.3, fig. 9).

Base from U.S. Geological Survey map E (scale 1:2,500,00) of Alaska

Data from Joint Federal-State Land Use Planning Commission (1974)

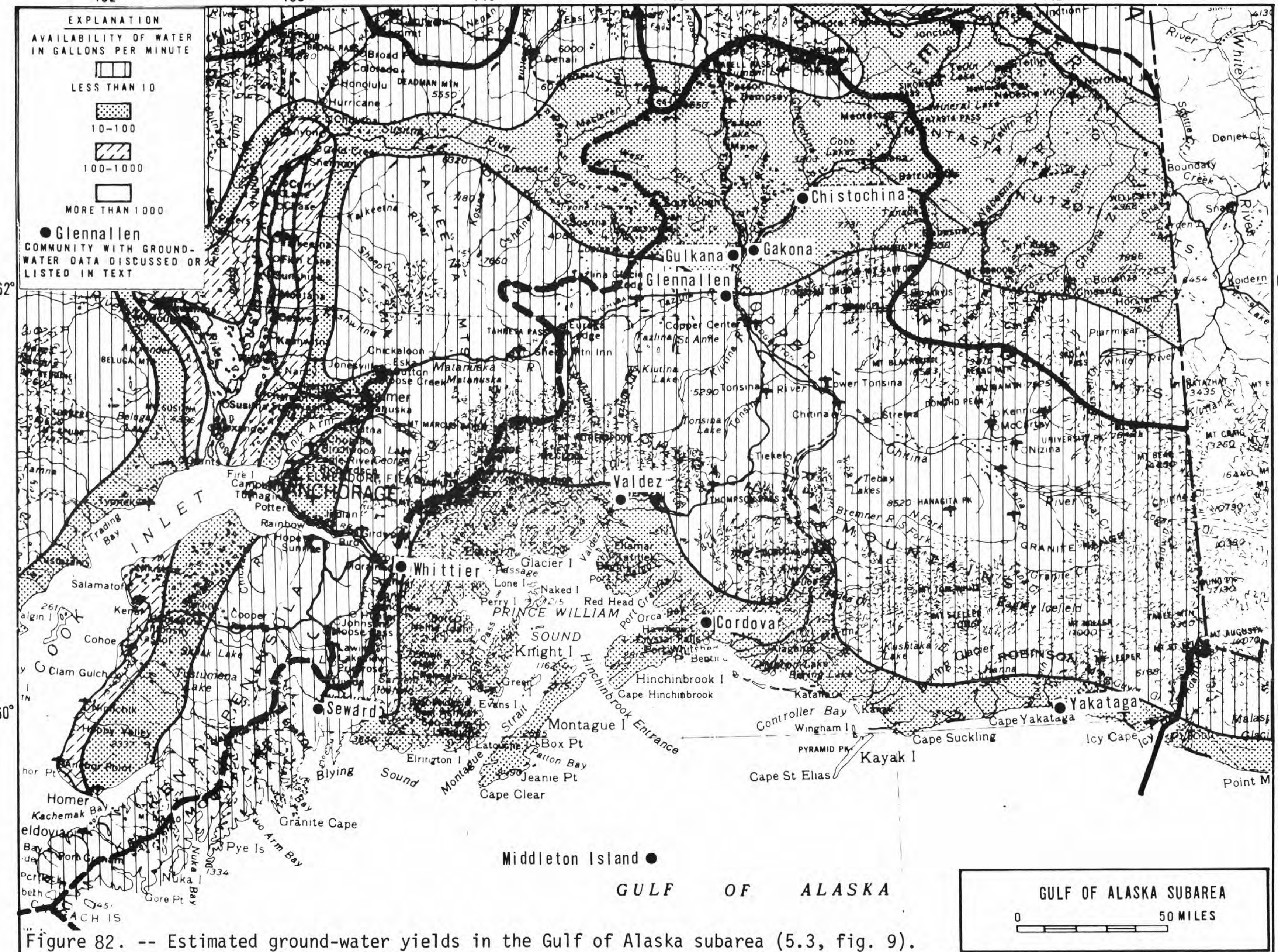


Figure 82. -- Estimated ground-water yields in the Gulf of Alaska subarea (5.3, fig. 9).

Base from U.S. Geological Survey map E (scale 1:2,500,00) of Alaska

Data from Joint Federal-State Land Use Planning Commission (1974)

Table 39.--*Water quality of selected streams in the Gulf of Alaska subarea.*

[concentrations in milligrams per litre (mg/l) or micrograms per litre (µg/l)]

Date and discharge (ft^3/s)	mg/l	µg/l		mg/l												Specific conductance (µmhos/cm at 25°C)	pH units
	Silica (SiO_2)	Iron (Fe)	Manganese (Mn)	Calcium (Ca)	Magnesium (Mg)	Sodium (Na)	Potassium (K)	Bicarbonate (HCO_3)	Carbonate (CO_3)	Sulfate (SO_4)	Chloride (Cl)	Fluoride (F)	Nitrate (as N)	Dissolved solids	Total hardness		
15200000 Gakona River at Gakona																	
01-15-59 100	15	0(a)	10(a)	55	11	18	3.0	198	0	38	16	0.0	0.00	254	182	421	7.2
05-26-68 4,580	5.0	1,400(a)	--	23	3.0	2.2	1.2	78	0	7.5	2.0	.0	.11	84	70	139	7.5
15212000 Copper River near Chitina																	
03-05-57 6,100	14	0(a)	0(a)	36	9.3	12	1.6	116	0	26	18	.2	.09	174	128	294	7.2
07-10-72 159,000	8.5	--	20(a)	23	3.5	4.3	2.0	78	0	15	3.2	.2	.00	98	72	162	7.6
15216000 Power Creek near Cordova																	
04-19-68 42	4.8	310(a)	--	10	.9	1.4	.1	29	0	4.2	.8	.1	.00	37	28	59	6.8
08-24-70 604	2.4	50(a)	10(a)	5.2	.5	1.1	.1	14	0	3.5	1.0	.0	.00	21	15	37	6.5
15226500 Lowe River near Valdez																	
04-16-55 --	5.0	0(a)	--	28	.8	1.2	2.7	57	0	3.2	.8	.0	.32	100	73	167	7.6
10-11-72 390	2.0	40(b)	20(b)	22	1.0	1.4	2.5	46	0	22	1.2	.4	.34	77	59	90	7.3

Table 39.--*Water quality of selected streams in the Gulf of Alaska subarea, continued.*

[concentrations in milligrams per litre (mg/l) or micrograms per litre (µg/l)]

	mg/l	µg/l		mg/l													
Date and discharge (ft^3/s)	Silica (SiO_2)	Iron (Fe)	Manganese (Mn)	Calcium (Ca)	Magnesium (Mg)	Sodium (Na)	Potassium (K)	Bicarbonate (HCO_3)	Carbonate (CO_3)	Sulfate (SO_4)	Chloride (Cl)	Fluoride (F)	Nitrate (as N)	Dissolved solids	Total hardness	Specific conductance (µmhos/cm at 25°C)	pH units
15238600 Spruce Creek near Seward																	
08-10-70 175	1.3	30(a)	30(a)	7.8	0.2	1.1	0.1	15	0	8.6	1.0	0.1	0.00	28	20	49	6.4
12-23-70 7.0	2.8	30(a)	10(a)	13	.5	1.6	.1	32	0	8.9	.5	.1	.20	44	34	78	7.4

a Undifferentiated
b Dissolved

Ground water in the coastal lowland areas is generally lower in dissolved-solids concentrations than ground water in the interior part of the subarea. Dissolved solids range from 50 mg/l in water from a well at Whittier to almost 900 mg/l in water from a well at Glennallen. Shallow wells yield water that generally has a low iron content and is acceptable for most uses. Deep wells drilled in the interior part usually yield water of a sodium chloride type. Table 40 lists chemical analyses of ground water from various sites throughout the subarea.

Both fresh and saline springs are known to occur along the mountain flanks in the subarea. Springs issuing from mud cones near Glennallen have been described by Grantz and others (1962). Most of the spring waters in the interior contain large amounts of sodium chloride.

Few data are available on the temperature of ground water in the subarea. The known range is 38° to 42°F. Springs near Glennallen have temperatures of 86°F.

Water Use.--A significant increase in population has taken place in the subarea, particularly in Valdez, which is the terminus of the trans-Alaska oil pipeline. In 1970 the population of the subarea was about 7,300. The Alaska Department of Labor (1974) estimated that the 1974 population was nearly 8,500; it may exceed that figure as this is written (1975).

The largest contributor to the economy is probably the oil pipeline construction, followed by government employment, and the catching and processing of seafood. There are some farms near Kenny Lake, but no crop or livestock production figures are available.

Based on an estimated population of 8,500, domestic water requirements are approximately 2 Mgal/d. The 1974 fisheries catch figures suggest that about 99 million gallons of water was used for seafood processing in that year.

Table 40.-- *Chemical analyses of ground water in the Gulf of Alaska subarea.*

[concentrations in milligrams per litre (mg/l) or micrograms per litre (µg/l)]

				mg/l	µg/l		mg/l													
Location	Date	Well depth (ft)	Temperature (°C)	Silica (SiO_2)	Iron (Fe)	Manganese (Mn)	Calcium (Ca)	Magnesium (Mg)	Sodium (Na)	Potassium (K)	Bicarbonate (HCO_3)	Carbonate (CO_3)	Sulfate (SO_4)	Chloride (Cl)	Fluoride (F)	Nitrate (as N)	Dissolved solids	Total hardness	Specific conductance (µmhos/cm at 25°C)	pH units
WELLS																				
Chistochina	08-17-71	--	--	11	0(a)	0(a)	50	6.6	3.1	1.6	150	0	28	1.5	0.2	0.34	178	153	297	7.2
Cordova	10-04-73	--	--	11	60(b)	40(b)	21	4.0	17	1.4	114	0	1.8	7.1	.2	.01	120	69	208	8.3
Gakona(c)	06-25-74	55	14	17	20(b)	130(b)	55	14	26	4.2	203	--	30	34	.2	.03	281	200	535	7.9
Glenallen	08-20-74	205	--	35	60(b)	230(b)	140	50	110	8.6	429	0	2.3	340	.1	.01	898	560	1,670	7.7
Gulkana	05-17-72	18	--	17	90(a)	900(a)	81	24	50	4.2	279	7	66	68	.2	.00	454	300	741	8.4
Middleton Island	04-25-70	--	--	.9	510(d)	30(d)	7.8	4.0	73	.7	92	0	31	65	.2	.11	228	34	404	7.6
Seward	06-13-69	--	--	4.9	80(d)	0(d)	23	.8	2.2	.4	56	0	14	2.1	.1	.59	78	60	133	7.6
Valdez	02-19-70	--	4.0	3.4	200(d)	0(d)	22	1.4	1.8	.2	62	0	10	1.4	.3	.54	74	62	135	6.8
Whittier	------66	82	--	3.0	0(d)	80(d)	16	1.7	.8	.0	49	0	4.3	.4	.0	.00	50	47	99	7.4
Yakataga	11-05-65	--	--	5.7	520(d)	40(d)	31	7.4	8.4	1.7	109	0	15	17	.0	.05	148	108	272	6.8

a Total
b Dissolved
c Sample collected from storage tank
d Undifferentiated

SOUTHEAST SUBREGION

Southeast Subarea

The Southeast subarea includes that part of Alaska east of 140° latitude. It stretches from Icy Bay in the north to Portland Canal in the south and includes a land area of 42,000 square miles. An additional 35,000 square miles in Canada contributes runoff that flows through the subarea (fig. 9).

The subarea, except for a few of the higher mountains, lies in the Maritime climatic zone. The average annual temperature is about 43°F near sea level. Temperatures can range from a low of about -40°F to a high of about 95°F. Precipitation in the winter usually falls as snow or rain at the lower altitudes and as snow at the higher altitudes. Most of the precipitation occurs in the fall or early winter. Measured precipitation ranges from about 26 inches per year at Skagway to more than 200 inches per year at Little Port Walter. Precipitation at higher altitudes is probably materially greater than that measured in lowlands. Temperature minimums will also be more severe at higher altitudes.

The subarea is located on the coast; several large islands are separated from the mainland by deep channels. The subarea is bordered on the east by high, rugged mountains. Glaciation has removed most of the surficial material on the upper slopes and exposed the bedrock. The lowlands are generally underlain by alluvial and glacial deposits.

Although no permafrost exists at the lower altitudes, the subarea contains extensive glaciers and ice fields. The Malaspina Glacier, one of the largest ice masses in North America, lies at the northwestern extremity of the subarea.

Surface Water.--Several rivers pass from Canada through the subarea to the Pacific Ocean. Among these are the Unuk (est. drainage area 1,200 mi^2), Stikine (est. 20,000 mi^2), Taku (est. 6,600 mi^2), and Alsek (est. 11,000 mi^2) Rivers. The Canadian drainage areas generally have different hydrologic regimens than those in the Southeast subarea; runoff rates are much lower.

The outer coastlines and the glacier-capped mountains seem to receive more precipitation and produce more runoff (more than 10 ft^3/s per square mile) than the inner islands. Relatively small amounts of runoff are produced by low basins, less than 10 ft^3/s per square mile (fig. 83). Mean annual runoff is about 20 ft^3/s per square mile on the southern part of Baranof Island. Table 2 shows the estimated mean monthly and mean annual runoff for the subarea.

Mean annual peak runoff ranges from about 100 ft^3/s per square mile to more than 200 ft^3/s per square mile. Annual peak rates average about 150 ft^3/s per square mile for drainage basins under 10 square miles and about 50 ft^3/s per square mile for basins over 100 square miles.

Glacier-dammed lakes occasionally break out and cause flooding downstream. This has happened on the Salmon River near Hyder and on the Taku River near Juneau. Flood-discharge rates exceeding 1,300 ft^3/s per square mile have been recorded on the Salmon River near Hyder. The breakout floods on the Tulsequah River, a tributary of the Taku River, have not been measured but are known to inundate the lower Taku River valley. Figure 84 illustrates the flood frequency and magnitude of selected streams in the subarea.

The low month mean runoff averages about 2 ft^3/s per square mile and generally ranges from about 0.2 ft^3/s per square mile for larger basins near Skagway to more than 20 ft^3/s per square mile for small basins near the south end of Baranof Island.

Surface water generally is of the calcium bicarbonate type and low in dissolved-solids concentrations. Dissolved-solids concentrations generally are less than 100 mg/l. Table 41 lists chemical analyses of water from some selected streams in the subarea.

The concentrations of suspended sediment in the Coast Mountain streams of southeast Alaska are about one-fourth those in the Alaska

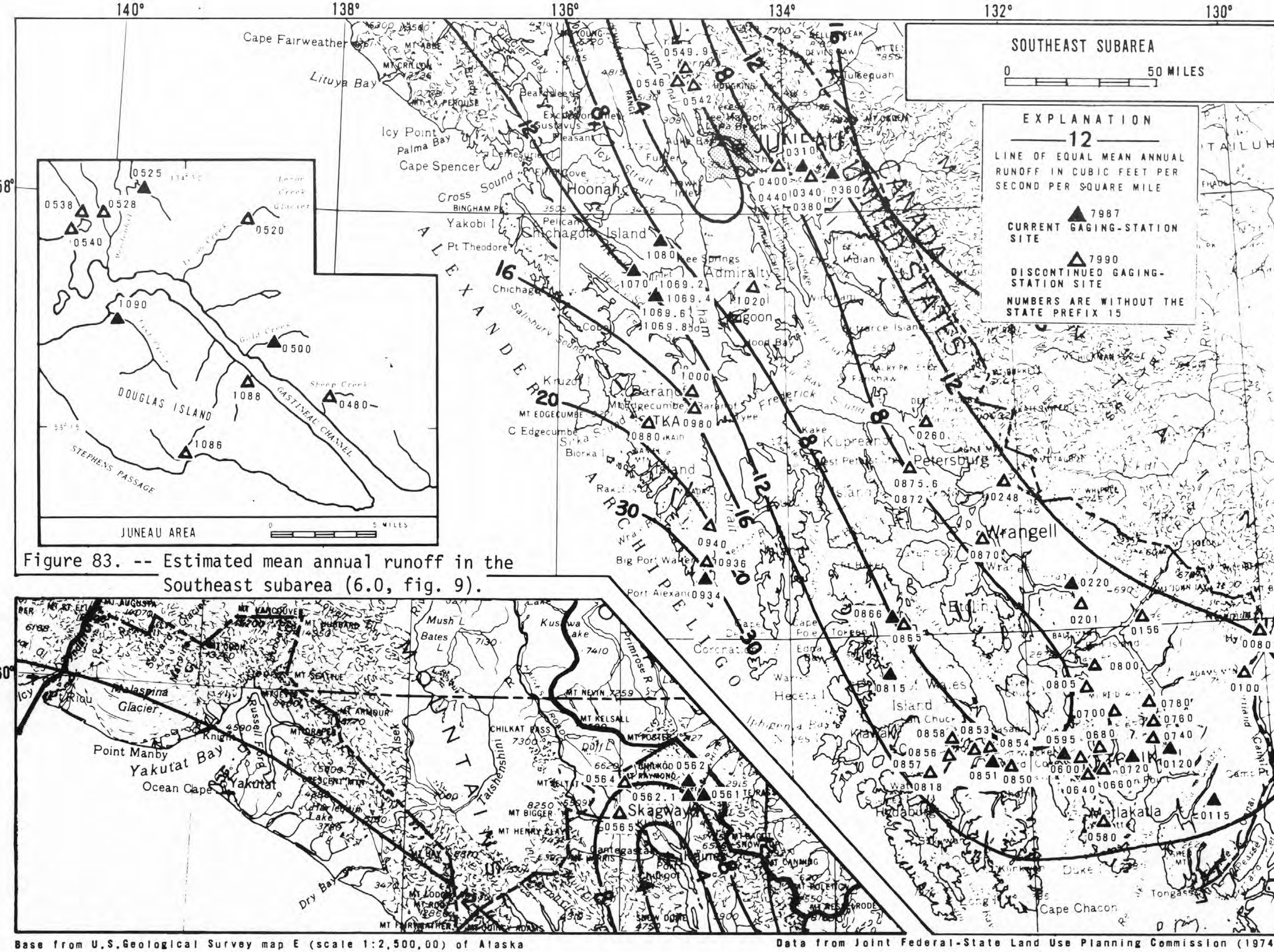


Figure 83. -- Estimated mean annual runoff in the Southeast subarea (6.0, fig. 9).

Base from U.S.Geological Survey map E (scale 1:2,500,00) of Alaska

Data from Joint Federal-State Land Use Planning Commission (1974)

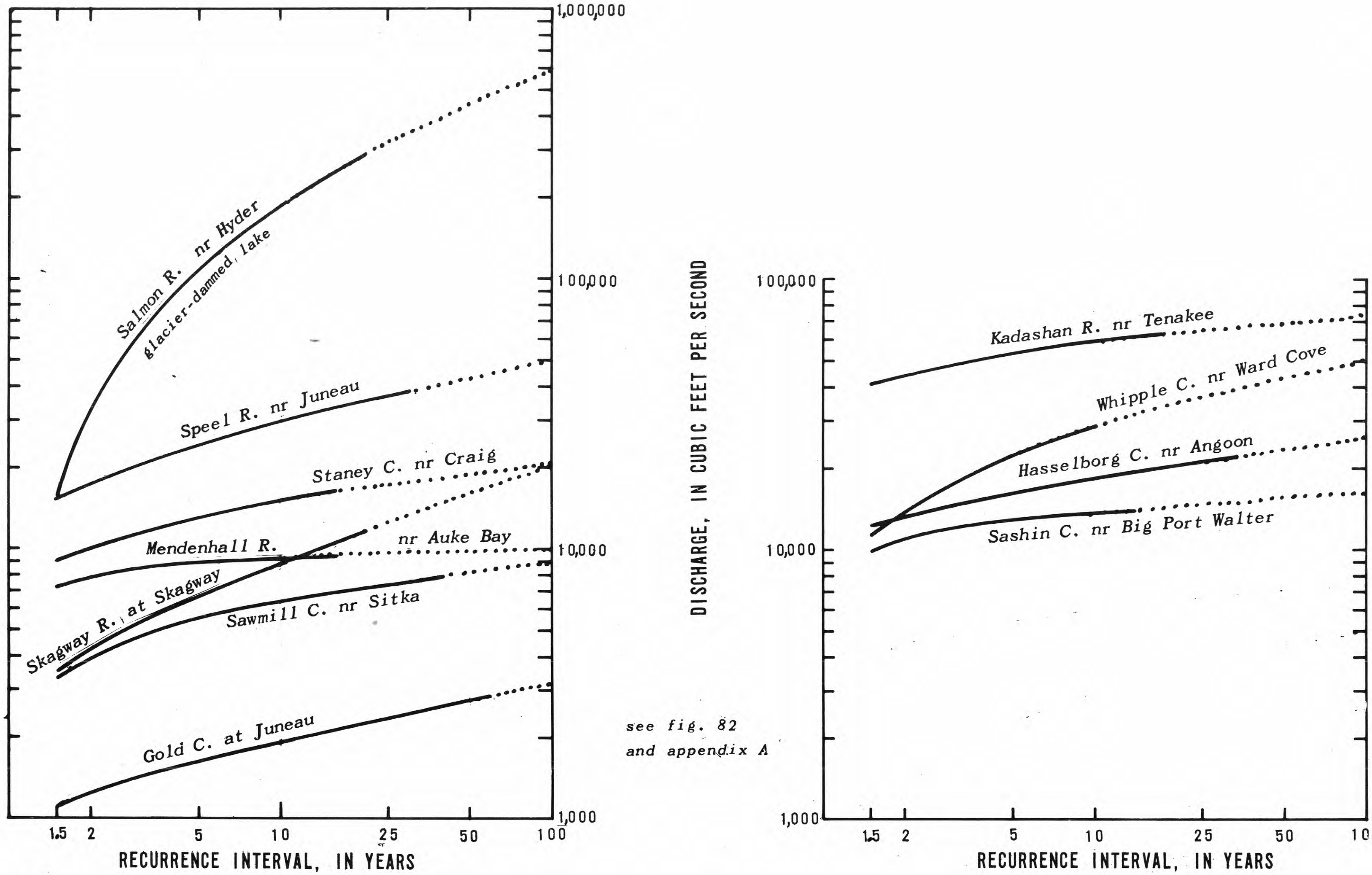


Figure 84. -- Flood magnitude-frequency relation of selected streams in the Southeast subarea (6.0, fig. 9).

Table 41.--*Water quality of selected streams in the Southeast subarea.*

[concentrations in milligrams per litre (mg/l) or micrograms per litre (µg/l)]

Date and discharge (ft^3/s)	Silica (SiO_2)	Iron (Fe)	Manganese (Mn)	Calcium (Ca)	Magnesium (Mg)	Sodium (Na)	Potassium (K)	Bicarbonate (HCO_3)	Carbonate (CO_3)	Sulfate (SO_4)	Chloride (Cl)	Fluoride (F)	Nitrate (as N)	Dissolved solids	Total hardness	Specific conductance (µmhos/cm at 25°C)	pH units
	mg/l	µg/l		mg/l													
15008000 Salmon River near Hyder																	
03-24-71 29	2.9	130(a)	30(a)	28	1.3	1.0	0.8	59	0	29	0.8	0.0	0.05	93	76	156	7.8
08-01-71 3,390	1.5	2,100(b)	30(b)	6.9	.7	.3	.5	21	0	1.0	1.4	.1	.16	23	20	42	7.4
15036000 Speel River near Juneau																	
07-22-68 5,760	1.6	630(c)	--	2.0	.3	.3	.5	7	0	3.6	.9	.0	.09	14	6	18	6.9
05-03-72 361	3.7	230(b)	30(b)	4.3	.5	1.0	.9	14	0	3.7	.8	.0	.09	22	13	36	6.9
15050000 Gold Creek at Juneau																	
09-25-50 325	3.0	20(c)	--	15	3.4	--	--	39	0	17	.8	--	.11	60	51	114	6.7
03-14-68 34	2.5	30(c)	--	19	5.3	.9	1.0	39	0	34	.4	.1	.45	84	73	156	7.2
15056100 Skagway River at Skagway																	
03-24-66 23(d)	3.9	0(c)	0(c)	5.6	5.8	1.8	1.6	39	0	8.2	1.8	.2	.18	48	59	92	7.5
06-25-69 1,280	1.7	30(c)	--	4.6	.7	.5	.8	16	0	1.4	.7	.1	.29	20	14	32	7.3

Table 41.--*Water quality of selected streams in the Southeast subarea, continued.*

[concentrations in milligrams per litre (mg/l) or micrograms per litre (μg/l)]

	mg/l	μg/l		mg/l													
Date and discharge (ft^3/s)	Silica (SiO_2)	Iron (Fe)	Manganese (Mn)	Calcium (Ca)	Magnesium (Mg)	Sodium (Na)	Potassium (K)	Bicarbonate (HCO_3)	Carbonate (CO_3)	Sulfate (SO_4)	Chloride (Cl)	Fluoride (F)	Nitrate (as N)	Dissolved solids	Total hardness	Specific conductance (μmhos/cm at 25°C)	pH units
							15059500 Whipple Creek near Ward Cove										
01-22-70 56	1.9	370(c)	0(c)	1.8	0.5	1.7	0.7	3	0	3.7	2.5	0.0	0.07	14	7	26	6.2
08-18-70 19	3.5	300(c)	--	2.6	1.6	2.1	1.2	9	0	8.0	1.4	.1	.02	25	13	38	6.9
							15081500 Staney Creek near Craig										
05-16-69 205	2.2	--	--	6.2	.5	2.2	.3	17	0	4.8	3.2	.0	.07	28	18	47	7.2
07-25-71 27	2.7	120(b)	20(b)	1.0	1.5	3.6	.4	36	0	4.0	3.2	.0	.09	44	32	76	7.4
							15088000 Sawmill Creek near Sitka										
01-24-57 62	2.3	0(c)	0(c)	5.2	.0	2.3	.6	15	0	1.3	3.0	.1	.11	22	13	48	6.7
09-22-57 785	1.5	0(c)	10(c)	4.0	1.0	.9	.1	10	0	5.0	1.0	.0	.05	19	14	27	6.0
							15102000 Hasselborg Creek near Angoon										
05-26-67 525	2.9	--	--	4.6	1.9	2.1	--	16	0	3.0	3.5	--	.07	26	20	40	7.3
04-05-68 175	2.7	70(c)	--	5.0	.6	.8	.1	15	0	.8	.8	.1	.14	19	15	33	6.6

Table 41.--*Water quality of selected streams in the Southeast subarea, continued.*

[concentrations in milligrams per litre (mg/l) or micrograms per litre (µg/l)]

Date and discharge (ft^3/s)	mg/l	µg/l		mg/l												Specific conductance (µmhos/cm at 25°C)	pH units
	Silica (SiO_2)	Iron (Fe)	Manganese (Mn)	Calcium (Ca)	Magnesium (Mg)	Sodium (Na)	Potassium (K)	Bicarbonate (HCO_3)	Carbonate (CO_3)	Sulfate (SO_4)	Chloride (Cl)	Fluoride (F)	Nitrate (as N)	Dissolved solids	Total hardness		
						15107000 Kadashan River near Tenakee											
02-06-69 27	6.4	--	--	11	1.2	2.9	0.3	36	0	5.1	4.6	0.2	0.07	51	33	83	7.7
03-23-70 436	2.4	340(c)	--	5.0	.6	1.6	.7	17	0	1.4	2.8	.1	.09	24	15	37	7.1

a Dissolved
b Total
c Undifferentiated

Range and Wrangell Mountains. Normal concentrations in glacial streams range from 90 mg/l to 500 mg/l. In the winter, concentrations drop to 10 mg/l or less. Forty to 100 percent of the normal summer suspended-sediment load is finer than 0.062 millimetre. Based on limited data, the Chilkat River near Klukwan has an estimated suspended-sediment yield of 1,080 tons per square mile or an estimated 818,000 tons per year.

Normal summer suspended-sediment concentrations in nonglacial streams are about 4 to 30 mg/l. Winter concentrations usually do not exceed 10 mg/l. Figure 85 shows the estimated suspended-sediment concentrations that can be expected during normal summer streamflows.

Summer temperatures of surface water range from 37° to 52°F. Winter temperatures range from 32° to 37°F.

Ground Water.--Ground water is present in the lowlands north and northwest of Juneau in outwash plains, beach deposits, and glacial moraines. Wells in Last Chance Basin, a deep alluvium-filled glacial valley, initially produced over 2,000 gal/min. Wells yielding in excess of 1,000 gal/min from glacial deposits have been reported in the Mendenhall Valley. Several other areas undoubtedly could produce large ground-water yields. Figure 86 presents the estimated ground-water availability in the subarea.

Many springs occur in the subarea. Mineral and thermal springs are discussed in Waring (1917, 1965) and Miller (1973).

The dissolved-solids concentrations of ground water range from about 25 mg/l to 19,000 mg/l. Most of the ground water seems to be of the calcium bicarbonate type, but it may be of the sodium chloride type in coastal areas. Some ground water has a relatively high iron content. Table 42 lists chemical analyses of ground water from various locations in the subarea.

Water Use.--The population in the Southeast subarea is about 46,900, the major centers being the City and Borough of Juneau (17,356), Ketchikan Gateway Borough (10,587), and the City and Borough of Sitka (6,700)

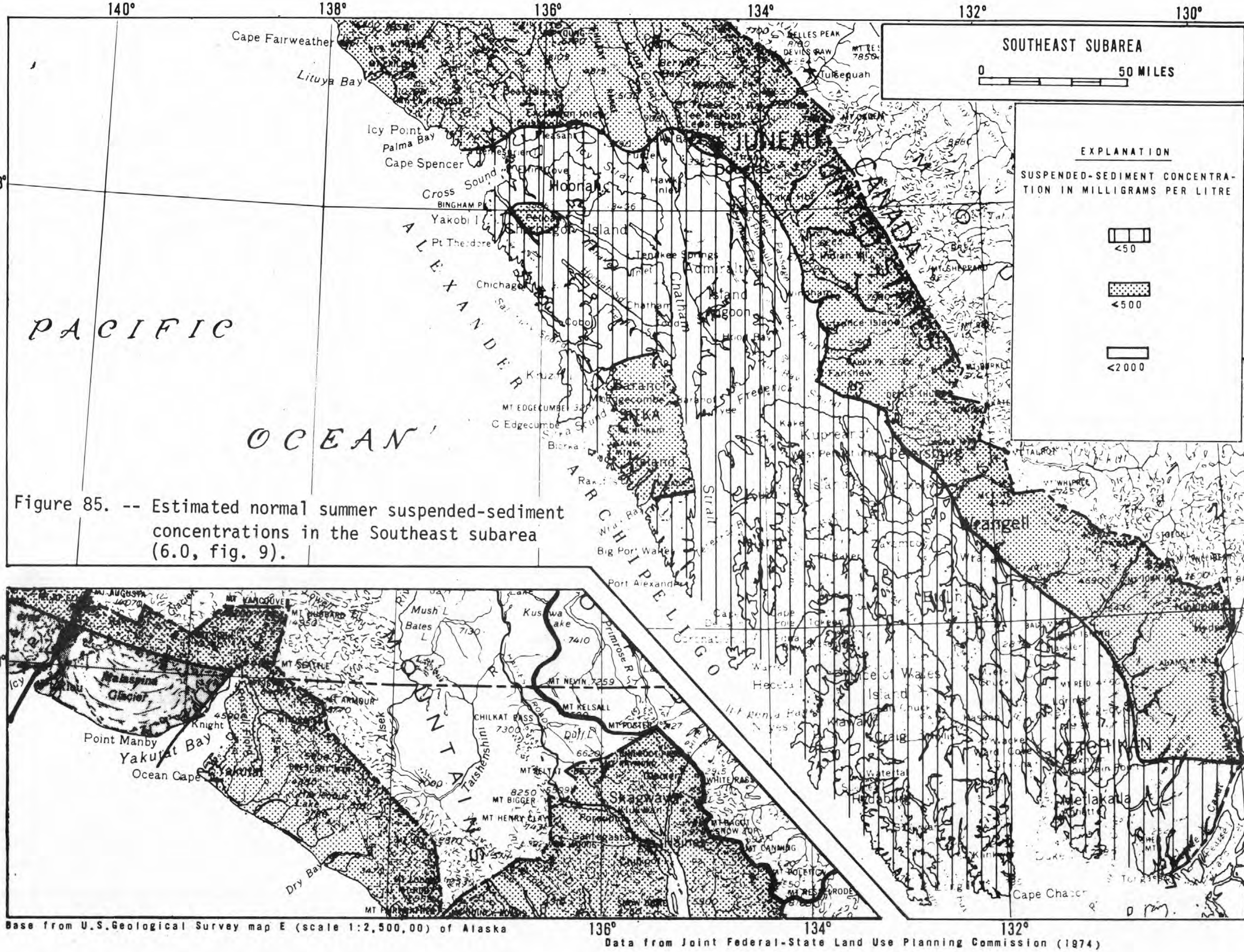


Figure 85. -- Estimated normal summer suspended-sediment concentrations in the Southeast subarea (6.0, fig. 9).

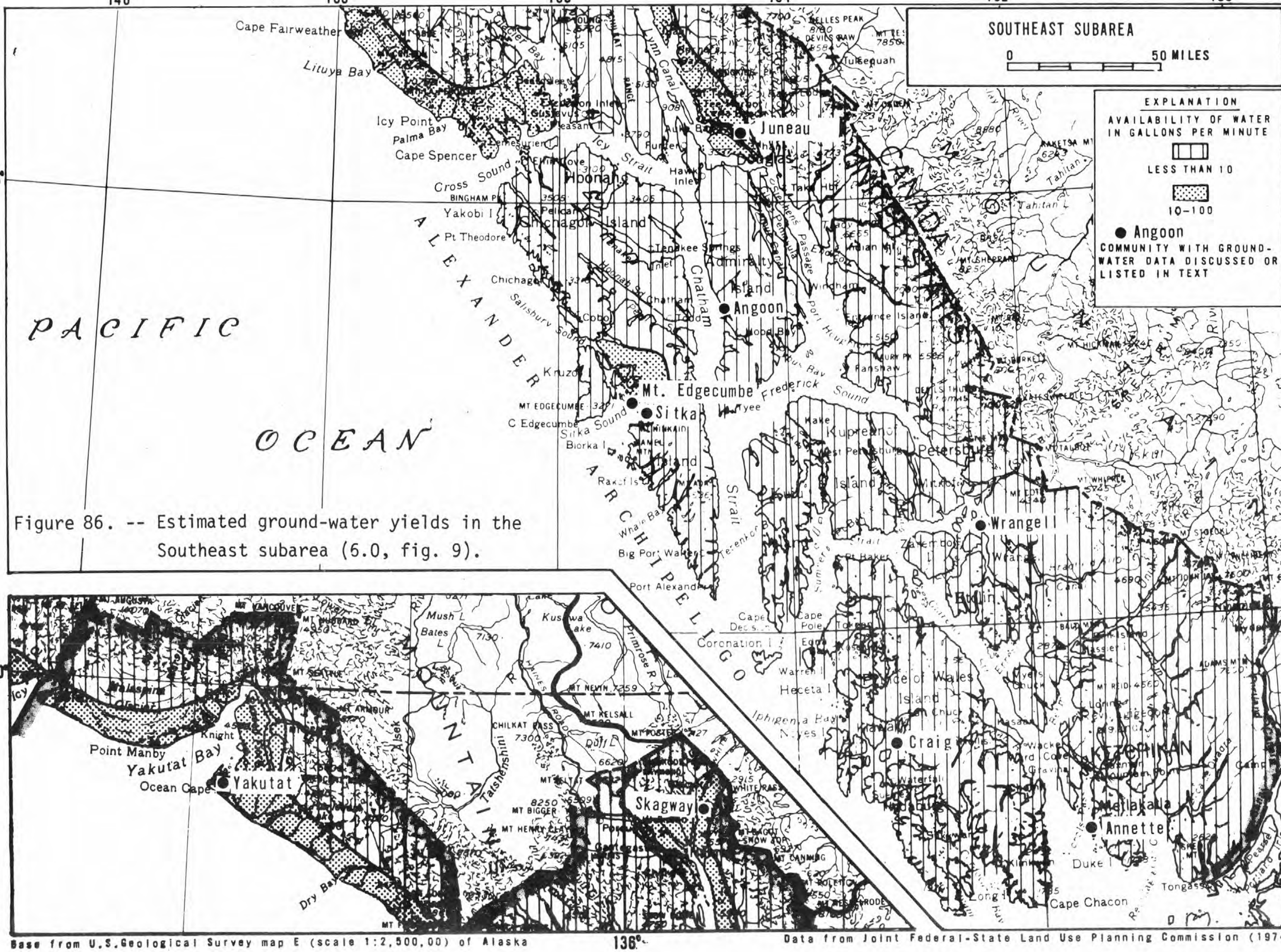


Figure 86. -- Estimated ground-water yields in the Southeast subarea (6.0, fig. 9).

Base from U.S.Geological Survey map E (scale 1:2,500,00) of Alaska

Data from Joint Federal-State Land Use Planning Commission (1974)

Table 42.--*Chemical analyses of ground water in the Southeast subarea.*

[concentrations in milligrams per litre (mg/l) or micrograms per litre (µg/l)]

Location	Date	Well depth (ft)	Temperature (°C)	Silica (SiO_2)	Iron (Fe)	Manganese (Mn)	Calcium (Ca)	Magnesium (Mg)	Sodium (Na)	Potassium (K)	Bicarbonate (HCO_3)	Carbonate (CO_3)	Sulfate (SO_4)	Chloride (Cl)	Fluoride (F)	Nitrate (as N)	Dissolved solids	Total hardness	Specific conductance (µmhos/cm at 25°C)	pH units
				mg/l	µg/l		mg/l													
WELLS																				
Angoon	06-27-60	80	--	8.2	2,100(a)	660(a)	64	17	6.5	2.6	280	--	5.0	3.0	0.0	0.09	247	232	419	7.8
Annette	09-03-71	--	--	3.0	160(b)	40(b)	5.9	3.2	3.9	.6	22	0	.6	12	.4	.09	41	28	78	7.0
Craig	10-03-58	93	--	9.3	0(a)	20(a)	365	156	1,070	22	122	0	85	2,630	.2	.27	4,399	1,550	8,230	6.8
Juneau	05-11-59	70	4.5	3.9	20(a)	0(a)	26	3.6	1.3	1.3	52	0	37	1.0	.1	.34	102	80	171	7.6
Sitka	06-15-67	--	4.5	14	4,700(a)	--	21	5.0	23	1.3	98	0	8.0	27	.0	.05	152	74	246	7.2
Skagway	12-22-70	80	--	4.7	30(b)	30(b)	18	2.3	2.5	2.0	60	0	6.0	2.2	.5	.34	69	54	121	7.4
Wrangell	04-22-59	242	--	13	410(a)	20(a)	24	17	15	4.7	172	0	19	3.0	.1	.52	184	130	314	7.3
Yakutat(c)	05-16-75	325	5.0	6.5	50(d)	20(d)	63	7.6	3.8	3.1	208	0	16	5.6	.2	.14	209	190	370	7.4
SPRINGS																				
Baranof	03-23-72	--	41	64	0(b)	10(b)	1.4	.1	48	1.1	14	33	28	5.8	1.2	.00	190	4	242	9.4

a Undifferentiated
b Total
c Chlorinated water
d Dissolved

(Alaska Department of Community and Regional Affairs, 1975b). The economy is based on government employment, commercial fishing and seafood processing, and the lumber and pulp industry.

Domestic water-use requirements for downtown Juneau have been calculated at about 370 gal/d per person. This high-use rate is due to the practice of running the kitchen tap during the winter months to prevent the water pipes from freezing; this is generally done throughout the subarea. Using the above water-use rate for the entire subarea, an approximate domestic water demand of 17.4 Mgal/d results.

There are about 15 seafood processors in the subarea. In 1974 the total catch of fish and shellfish amounted to 91.9 million pounds (State of Alaska, 1974). The estimated water required to process that catch would be 460 million gallons.

Two pulp mills operate in the subarea, one in Sitka, the other in Ketchikan. Between September 1974 and August 1975 one of the mills used on the average 39 Mgal/d of water. Based on that use rate and conversations with mill representatives, the water demand of both mills is estimated to be 80 Mgal/d.

There are eight hydroelectric generating plants in the subarea having water storage in excess of 5,000 acre-ft (table 6). The total usable water storage for all amounts to about 400,000 acre-ft.

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CURRENT AND SELECTED DISCONTINUED STREAM-GAGING STATIONS IN ALASKA

Station number	Station name	Years of record	Drainage area (mi^2)
West Arctic subarea			
15798700	Nunavak Creek near Barrow	1972-	2.79
15799000	Esatkuat Creek near Barrow	1972-73	1.46
15799300	Esatkuat Lagoon outlet at Barrow	1972-73	3.52
Coleville subarea			
	No gaging stations		
East Arctic subarea			
15896000	Kuparuk River near Deadhorse	1971-	3,130
15896700	Putuligayuk River near Deadhorse	1970-	176
15910000	Sagavanirktok River near Sagwon	1970-	2,208
Kotzebue Sound subarea			
15743000	June Creek near Kotzebue	1965-67	10.9
15744000	Kobuk River at Ambler	1965	6,570
15744500	Kobuk River near Kiana	1975-	9,520
15746000	Noatak River at Noatak	* 1965-71	12,000
15748000	Ogotoruk River near Point Hope	1960-62	35.0
Norton Sound subarea			
15621000	Snake River near Nome	1965-	85.7
15668200	Crater Creek near Nome	1975-	21.9
15712000	Kuzitrin River near Nome	1962-73	1,720
Lower Yukon subarea			
15565235	Ophir Creek at Ophir	1975-	6.19
15565447	Yukon River at Pilot Station	1975-	321,000
Central Yukon subarea			
15564600	Melozitna River near Ruby	1961-73	2,693
15564800	Yukon River at Ruby	1956-	259,000
15565200	Yukon River near Kaltag	1956-66	296,000

Station number	Station name		Years of record	Drainage area (mi^2)
Koyukuk subarea				
15564875	M.F. Koyukuk River near Wiseman		1970-	1,426
15564877	Wiseman Creek at Wiseman		1970-	49.2
15564885	Jim River near Bettles		1970-	465
15564900	Koyukuk River at Hughes		1960-	18,700
Upper Yukon subarea				
15356000	Yukon River at Eagle	*	1911-	113,500
15389000	Porcupine River near Fort Yukon		1964-	29,500
15389500	Chandalar River near Venetie		1963-73	9,330
15439800	Boulder Creek near Central		1966-	31.3
15457800	Hess Creek near Livengood		1970-	662
15468000	Yukon River at Rampart		1955-67	199,400
Tanana subarea				
15470000	Chisana River at Northway Junction		1949-71	3,280
15476000	Tanana River near Tanacross		1953-	8,550
15476300	Berry Creek near Dot Lake		1971-	65.1
15476400	Dry Creek near Dot Lake		1965-69	57.6
15478040	Phelan Creek near Paxson		1966-	12.2
15481000	Tanana River near Harding Lake	(a)	1969-72	17,240
15484000	Salcha River near Salchaket		1948-	2,170
15485000	Moose Creek at Eielson AFB		1964-65	136
15485200	Garrison Slough at Eielson AFB		1964-65	6.25
15485500	Tanana River at Fairbanks		1973-	--
15493000	Chena River near Two Rivers		1967-	941
15493500	Chena River near North Pole		1972-	1,430
15511000	Little Chena River near Fairbanks		1966-	372
15512000	Chena Slough near Fairbanks		1948-52	20.0
15514000	Chena River at Fairbanks		1948-	1,980
15514500	Wood River near Fairbanks		1968-	855
15515500	Tanana River at Nenana		1962-	25,600
15515800	Seattle Creek near Cantwell		1965-75	36.2
15516000	Nenana River near Windy		1950-73	710
15518000	Nenana River near Healy		1950-	1,910
15518300	Nenana River near Rex		1964-68	2,450
15518350	Teklanika River near Lignite		1964-74	490
15534900	Poker Creek near Chatanika		1971-	23.1
15535000	Caribou Creek near Chatanika		1969-	9.19

Station number	Station name		Years of record	Drainage area (mi^2)
Kuskokwim Bay subarea				
15303600	Kuskokwim River at McGrath		1963-73	11,700
15304000	Kuskokwim River at Crooked Creek		1951	31,100
Bristol Bay subarea				
15297900	Eskimo Creek at King Salmon		1973-	16.1
15300000	Newhalen River near Iliamna		1951-67	3,478
15300500	Kvichak River at Igiugig	*	1967-	6,500
15301500	Allen River near Aleknagik		1963-66	270
15302000	Nuyakuk River near Dillingham		1953-	1,490
15302800	Grant Lake outlet near Aleknagik		1960-65	34.3
15303000	Wood River near Aleknagik		1957-70	1,110
15303150	Snake River near Dillingham		1973-	113
Aleutian subarea				
15297640	Limpet Creek on Amchitka Island		1967-72	1.69
15297650	Falls Creek on Amchitka Island		1968-72	1.00
15297655	Clevenger Creek on Amchitka Island		1968-74	0.501
15297680	Bridge Creek at Amchitka Island		1967-74	3.03
15297690	White Alice Creek on Amchitka Is.		1968-74	.791
15297767	Lake Creek at Shemya AFB		1970-72	1.00
15297773	Gallery Creek at Shemya AFB		1970-72	1.00
Kodiak-Shelikof subarea				
15295500	Little Kitoi Creek near Afognak		1960-61	2.63
15295600	Terror River near Kodiak		1962-68	15.0
15295700	Terror River at mouth near Kodiak		1964-68	46.0
15296000	Uganik River near Kodiak		1951-	123
15296300	Spiridon Lake outlet near Larsen Bay		1962-65	23.3
15296520	Canyon Creek near Larsen Bay		1974-	8.82
15296550	Upper Thumb River near Larsen Bay		1974-	18.8
15296600	Karluk River at outlet nr Larsen Bay		1975-	100
15296950	Akalura Creek at Olga Bay		1975-	18.4
15297000	Dog Salmon Creek near Ayakulik		1960-61	72.9
15297200	Myrtle Creek near Kodiak		1963-	4.74
15297450	M.F. Pillar Creek near Kodiak		1968-70	2.02
15297470	Monashka Creek near Kodiak		1972-	5.51

Station number	Station name	Years of record	Drainage area (mi^2)
Cook Inlet subarea			
15238820	Barbara Creek near Seldovia	1972-	20.7
15238860	Tutka Lagoon Creek near Homer	1973-	10.8
15239000	Bradley River near Homer	1957-	54.0
15239880	Twitter Creek near Homer	1971-73	16.1
15239900	Anchor River near Anchor Point	1965-73	133
15240000	Anchor River at Anchor Point	1953-66	226
15241600	Ninilchik River at Ninilchik	1963-	131
15242000	Kasilof River near Kasilof	1949-70	738
1524350	Snow River near Divide	1960-65	99.8
15243900	Snow River near Seward	* 1970-	128
15244000	Ptarmigan Creek at Lawing	1947-58	32.6
15246000	Grant Creek near Moose Pass	1947-58	44.2
15248000	Trail River near Lawing	1947-74	181
15254000	Crescent Creek near Cooper Landing	1949-66	31.7
15258000	Kenai River at Cooper Landing	1947-	634
15260000	Cooper Creek near Cooper Landing	1949-58	31.8
15260500	Stetson Creek near Cooper Landing	1960-63	8.60
15266300	Kenai River at Soldotna	1965-	2,010
15266500	Beaver Creek near Kenai	1967-	51.0
15267900	Resurrection Creek near Hope	1967-	149
15272550	Glacier Creek at Girdwood	1965-	62.0
15273900	S.F. Campbell Creek at canyon mouth near Anchorage	1966-	25.2
15274000	S.F. Campbell Creek near Anchorage	1947-71	30.4
15274300	N.F. Campbell Creek near Anchorage	1974-	13.4
15274600	Campbell Creek near Spenard	1966-	69.7
15275000	Chester Creek at Anchorage	1958-	20.0
15275100	Chester Creek at Arctic Blvd. at Anchorage	1966-	27.2
15276000	Ship Creek near Anchorage	1946-	90.5
15276500	Ship Creek at Elmendorf AFB near Anchorage	1963-71	113
15276570	Ship Creek below power plant at Elmendorf AFB	1970-	115
15277100	Eagle River at Eagle River	1965-	192
15277410	Peters Creek at railroad bridge near Birchwood	1973-	87.8
15277600	E.F. Eklutna Creek near Palmer	1960-62	38.0
15277800	W.F. Eklutna Creek near Palmer	1960-62	26.0
15281000	Knik River near Palmer	1959-	1,180
15282000	Caribou Creek near Sutton	1955-	289

Station number	Station name	Years of record	Drainage area (mi²)
Cook Inlet subarea--Continued			
15284000	Matanuska River at Palmer	1949-73	2,070
15290000	Little Susitna River near Palmer	1948-	61.9
15291000	Susitna River near Denali	* 1957-74	950
15291200	Maclaren River near Paxson	1958-	280
15291500	Susitna River near Cantwell	1961-72	4,140
15292000	Susitna River at Gold Creek	1949-	6,160
15292400	Chulitna River near Talkeetna	1958-72	2,570
15292700	Talkeetna River near Talkeetna	1964-	2,006
15294300	Skwentna River near Skwentna	1959-	2,250
15294350	Susitna River at Susitna Station	1975-	19,400
15294450	Chuitna River near Tyonek	1975-	
15294500	Chakachatna River near Tyonek	1959-72	1,120
Gulf of Alaska subarea			
15195000	Dick Creek near Cordova	1970-	7.95
15200000	Gakona River at Gakona	1949-70	620
15200280	Gulkana River at Sourdough	1972-	1,770
15202000	Tazlina River near Glennallen	* 1949-72	2,670
15206000	Klutina River at Copper Center	* 1949-70	880
15207800	Little Tonsina River near Tonsina	1972-	22.7
15208000	Tonsina River at Tonsina	* 1950-	420
15208100	Squirrel Creek at Tonsina	1965-	70.5
15211500	Tebay River near Chitina	1962-65	55.4
15212000	Copper River near Chitina	1955-	20,600
15216000	Power Creek near Cordova	1947-	20.5
15216100	Humpback Creek near Cordova	1973-	4.37
15219000	W.F. Olsen Bay Creek near Cordova	1964-	4.78
15226000	Solomon Gulch near Valdez	1949-56	19.0
15226500	Lowe River near Valdez	1971-74	201
15226600	Lowe River in Keystone Canyon near Valdez	1975-	222
15236900	Wolverine Creek near Lawing	1966-	9.51
15237000	Nellie Juan River near Hunter	1960-65	125
15237700	Resurrection River at Seward	1964-68	169
15237800	Bear Creek trib. near Seward	1966-68	1.63
15238500	Lowell Creek at Seward	1965-68	4.02
15238600	Spruce Creek near Seward	1966-	9.26

Station number	Station name	Years of record	Drainage area (mi^2)
Southeast subarea			
15008000	Salmon River near Hyder	1963-73	94.0
15010000	Davis River near Hyder	1930-40	80.0
15011500	Red River near Metlakatla	1963-	45.3
15012000	Winstanley Creek near Ketchikan	* 1936-75	15.5
15015600	Klahini River near Bell Island	1967-73	58.0
15020100	Tyee Creek at mouth near Wrangell	1963-69	16.1
15022000	Harding River near Wrangell	1951-	67.4
15024800	Stikine River near Wrangell	1975-	
15026000	Cascade Creek near Petersburg	* 1917-73	23.0
15031000	Long River above Long Lake near Juneau	1965-75	8.29
15034000	Long River near Juneau	* 1916-73	32.5
15036000	Speel River near Juneau	* 1917-75	226
15038000	Crater Creek near Juneau	* 1917-32	11.4
15040000	Dorothy Creek near Juneau	* 1929-67	15.2
15044000	Carlson Creek near Juneau	1951-61	24.3
15048000	Sheep Creek near Juneau	* 1911-73	4.57
15050000	Gold Creek at Juneau	* 1917-	9.76
15052000	Lemon Creek near Juneau	1951-73	12.1
15052500	Mendenhall River near Auke Bay	1965-	85.1
15052800	Montana Creek near Auke Bay	* 1965-75	15.5
15053800	Lake Creek at Auke Bay	1963-73	2.50
15054000	Auke Creek at Auke Bay	* 1947-75	3.96
15054200	Herbert River near Auke Bay	1966-71	56.9
15054600	Bridget Cove trib. near Auke Bay	1970-73	0.95
15054990	Davies Creek near Auke Bay	1969-72	15.2
15056100	Skagway River at Skagway	1963-	145
15056200	West Creek near Skagway	1962-	43.2
15056210	Taiya River near Skagway	1969-	179
15056400	Chilkat River at gorge near Klukwan	1962-68	190
15056500	Chilkat River near Klukwan	1960-61	760
15058000	Purple Lake outlet near Metlakatla	1947-56	6.80
15059500	Whipple Creek near Ward Cove	1968-	5.29
15060000	Perseverance Creek near Wacker	* 1931-69	2.81
15064000	Ketchikan Creek at Ketchikan	* 1909-67	13.5
15066000	Beaver Falls Creek near Ketchikan	* 1920-32	5.80
15068000	Mahoney Creek near Ketchikan	* 1927-58	5.70
15070000	Falls Creek near Ketchikan	* 1917-59	36.5
15072000	Fish Creek near Ketchikan	* 1916-	32.1
15074000	Ella Creek near Ketchikan	* 1927-58	19.7
15076000	Manzanita Creek near Ketchikan	* 1927-67	33.9

Station number	Station name	Years of record	Drainage area (mi^2)
Southeast subarea--Continued			
15064000	Ketchikan Creek at Ketchikan	* 1909-67	13.5
15066000	Beaver Falls Creek near Ketchikan	* 1920-32	5.80
15068000	Mahoney Creek near Ketchikan	* 1927-58	5.70
15070000	Falls Creek near Ketchikan	* 1917-59	36.5
15072000	Fish Creek near Ketchikan	* 1916-	32.1
15074000	Ella Creek near Ketchikan	* 1927-58	19.7
15076000	Manzanita Creek near Ketchikan	* 1927-67	33.9
15078000	Grace Creek near Ketchikan	* 1927-69	30.2
15080000	Orchard Creek near Bell Island	* 1916-25	59.0
15080500	Traitors River near Bell Island	1964-68	20.8
15081500	Staney Creek near Craig	1964-	51.6
15081800	N.B.Trocadero Creek near Hydaburg	1967-73	17.4
15085000	Salter Creek near Kasaan	1962-64	5.53
15085100	Old Tom Creek near Kasaan	1949-	5.90
15085300	Cabin Creek near Kasaan	1962-64	8.83
15085400	Virginia Creek near Kasaan	1962-64	--
15085600	Indian Creek near Hollis	1949-64	8.82
15085700	Harris River near Hollis	1949-64	28.7
15085800	Maybeso Creek at Hollis	1949-63	15.1
15086500	Neck Creek near Point Baker	1960-67	17.0
15086600	Big Creek near Point Baker	1963-	11.2
15087000	Mill Creek at Wrangell	1964-67	0.09
15087200	Hammers Slough at Petersburg	1964-67	1.46
15087560	No Name Creek near Petersburg	1970-73	3.17
15088000	Sawmill Creek near Sitka	* 1920-57	39.0
15093400	Sashin Creek near Big Port Walter	* 1965-	3.72
15093600	E.B. Lovers Cove Creek near Big Port Walter	1965-71	--
15094000	Deer Lake outlet nr Pt. Alexander	1951-67	7.41
15098000	Baranof River at Baranof	* 1918-74	32.0
15100000	Takatz Creek near Baranof	1951-69	17.5
15102000	Hasselborg Creek near Angoon	1951-68	56.2
15106920	Kadashan River above Hook Creek near Tenakee	1968-	10.2
15106940	Hook Creek above trib. near Tenakee	1967-	4.48
15106960	Hook Creek near Tenakee	1966-	8.00
15106980	Tonalite Creek near Tenakee	1968-	14.5
15107000	Kadashan River near Tenakee	1964-	37.7
15108000	Pavlof River near Tenakee	1957-	24.3
15108600	Hilda Creek near Douglas	1966-71	2.62
15108800	Lawson Creek at Douglas	1966-71	2.98
15109000	Fish Creek near Auke Bay	1958-	13.6

* Broken years of record; (a) Gage heights only.

NATURAL FRESH-WATER LAKES OF ALASKA WITH SURFACE AREAS OF 10 SQUARE MILES OR MORE (AFTER BUE, 1963)

West Arctic subarea

	Area (mi^2)
Teshekpuk	315

Kotzebue subarea

	Area (mi^2)
Imuruk	26
Walker	14

Lower Yukon subarea

	Area (mi^2)
Kgun	31
Nunavakanuk	25
Five Day Slough	15
Kulik	10

Tanana subarea

	Area (mi^2)
Tetlin	27
Minchumina	23

Kuskokwim Bay subarea

	Area (mi^2)
Dall	100
Aropuk	57
Nunavakpak	53
Whitefish	33
Takslesluk	31
Nunavak	29
Kyigayalik	19
Telaquana	16
Whitefish	13
Kukaklik	10

Bristol Bay subarea

	Area (mi^2)
Iliamna	1,000
Becharof	458
Naknek	242
Clark	110
Upper Ugashik	75
Kukaklek	72
Lower Ugashik	72
Nerka	69
Nuyakuk	64
Nonvianuk	56
Chauekuktuli	34
Chikuminuk	34
Beverly	33
Aleknagik	31
Brooks	31
Upnuk	17
Togiak	15
Ualik	14
Amanka	13
Kakhonak	12
Mother Goose	12
Coleville	11
Bear	10
Kontrashibuna	10

Kodiak-Shelikof subarea

	Area (mi^2)
Black	14
Karluk	12
Chignik	10

Cook Inlet subarea	Area (mi^2)
Tustumena	117
Skilak	38
George	29
Chakachamna	26
Beluga	20
Kenai	19
Susitna	10

Gulf of Alaska subarea	Area (mi^2)
Tazlina	52
Louise	23
Klutina	22
Bering	17
Crosswind	12
Ewan	10
Miles	10
Southeast subregion	
Harlequin	11