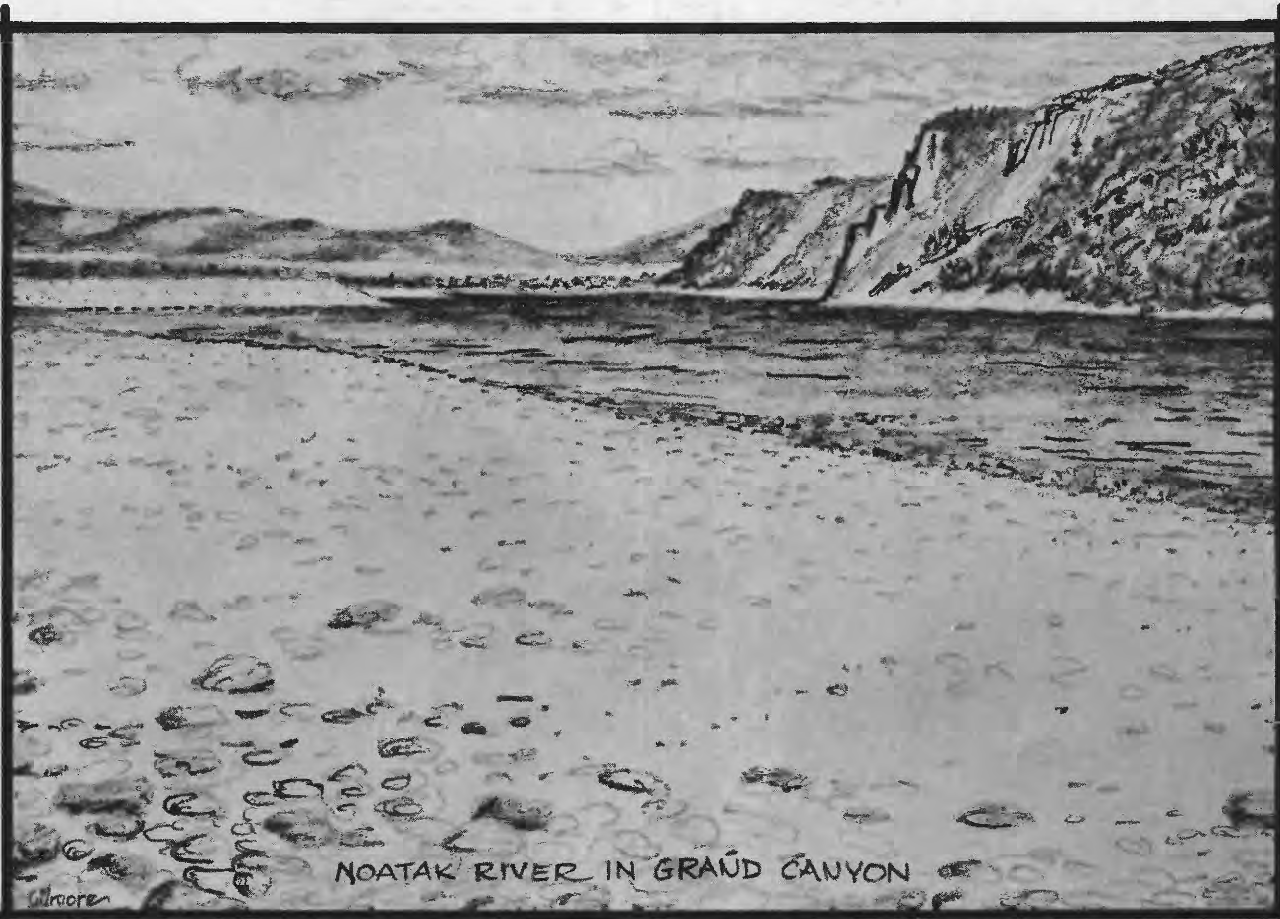
HYDROLOGIC RECONNAISSANCE OF THE NOATAK RIVER BASIN, ALASKA, 1978



U. S. GEOLOGICAL SURVEY

WATER-RESOURCES INVESTIGATIONS
OPEN-FILE REPORT 81-1005

UNITED STATES
DEPARTMENT OF THE INTERIOR
GEOLOGICAL SURVEY

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By Joseph M. Childers and Donald R. Kernodle

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Anchorage, Alaska
1981

UNITED STATES DEPARTMENT OF THE INTERIOR

JAMES G. WATT, Secretary

GEOLOGICAL SURVEY

Dallas Peck, Director

For additional information write to:

U.S. Geological Survey
Water Resources Division
733 West 4th Avenue, Suite 400
Anchorage, Alaska 99501

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Multiply	by	to obtain
inch (in.)	25.40	millimeter (mm)
foot (ft)	0.3048	meter (m)
mile (mi)	1.609	kilometer (km)
square mile (mi^2)	2.590	square kilometer (km^2)
miles per hour (mi/hr)	1.609	kilometers per hour (km/hr)
feet per second (ft/s)	0.3048	meters per second
cubic feet per second (ft^3/s)	0.02832	cubic meter per second (m^3/s)
cubic feet per second per square mile [$(ft^3/s)/mi^2$]	0.0109	cubic meter per second per square kilometer [$(m^3/s)/km^2$]
degrees Fahrenheit (°F)	(°F-32)/1.8	degrees Celsius (°C)

National Geodetic Vertical Datum (NGVD) of 1929 is a geodetic datum derived from a general adjustment of the first order level nets of Canada and the United States. In the adjustment, sea levels from selected tide stations were held as fixed. The last adjustment was made in 1929. The term sea level in this report refers to the NGVD of 1929.

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ABSTRACT

A reconnaissance-level study of the water resources of the Noatak River basin was made in April (late winter) and August (late summer) of 1978. The major purpose of the study was to evaluate the quantity and quality of the surface-water resource.

Streamflow varies seasonally. No flow was observed from the upper part of the basin in late winter (April). However, in the lower part of the basin springs support perennial flow in the Kugururok River and downstream along the Noatak River. The discharge of the Noatak River was 150 cubic feet per second in April 1978. During the summer, rainstorms are common, and runoff produces high flow. During August 1978, unit runoff averaged about 1 cubic foot per second per square mile, which would be normal for runoff at the discontinued streamgaging station, Noatak River at Noatak.

The Noatak is a gravel-bed stream of moderate slope. It drops about 1,800 feet in elevation from a point near the head waters to the mouth, a distance of 400 miles. Streambed material in most places is gravel, cobbles, and boulders. Maximum riffle depth and pool width increase in a downstream direction. Stream velocity also increases downstream. Velocity measured in August 1978 ranged from about 1 foot per second in the upper basin, to 4.5 feet per second in the Grand Canyon of the Noatak.

High-water marks of the maximum evident flood were found at elevations from bankfull to 5 feet above bankfull. Maximum evident flood unit runoff rates were estimated to be less than 50 cubic feet per second per square mile. Scars produced by ice jams were rarely seen above bankfull. Bank erosion appears to be most active in the lowlands.

Water in the Noatak River basin is virtually unaffected by man's activity. The composition and variability of the benthic invertebrate community suggest the river's undiminished natural quality. Water quality varies with location, weather, season, and source; the water is ordinarily clear, cool, and hard. During late winter, sea water intrudes into the Lower Noatak Canyon.

INTRODUCTION

This report describes results of a reconnaissance-level study of the water resources of the Noatak River basin made during April 1978 (late winter) by airplane and August 1978 (late summer) by boat. The Noatak, a wilderness river, is becoming a popular stream for float trips, and its character could be changed by this increasing use. The Noatak River salmon fishery is vital to the residents of Kotzebue, Noatak, and other local villages. Information in this report is intended for people interested in conditions of the basin's streams, springs, and lakes.

The report contains data on physiographic and climatic characteristics of drainage basins, stream channel hydraulic characteristics, seasonal quantity and quality of surface waters, floods, and channel erosion. The data can assist users in estimating streamflow, widths, depths, and velocities of flow for late winter and late summer conditions. These data can also help estimate flood and erosion hazards. The water-quality data will be useful in planning uses of the water.

This report is a product of a Geological Survey program, underway since the early 1970's, designed to study environmental conditions in selected frontier areas of Alaska where development has begun or is planned. This program has been active primarily in the Arctic region (north of the Yukon River) and along existing or proposed transportation corridors.

NOATAK RIVER BASIN

The Noatak River basin occupies 12,597 mi² (Selkregg, 1976). It lies south of the western part of the Brooks Range (fig. 1) and is entirely north of the Arctic Circle. The basin contains one village, Noatak, about 70 river mi above the mouth of the river and about 50 mi northwest of Kotzebue (fig. 2). Transportation in the basin is by boat in summer, snow vehicle in winter, and airplane year round. No roads have been built in the study area, although there are winter trails.

Long, severe winters characterize the Noatak River basin weather. Summers are often wet, with rainfall increasing as summer progresses. The short period of weather records for Noatak indicate that winter temperatures range from -21° to 3°F and summer temperatures range from 35° to 65°F. National Weather Service records show that precipitation over the basin averages 11 in., which includes 48 in. of snow. However, precipitation from the mountainous areas of the basin has been estimated to average 20 in. Winds average about 12 mi/hr year round and contribute to wind chill. Fog, rain, snow, and whiteout conditions are common. Daylight is continuous from May to August, but December days have only 6 to 7 hours of twilight.

The Noatak River begins and flows westward for 100 mi in the Central Brooks Range. It continues to flow westward 250 mi through the Aniuk Lowland and the Cutler River Upland, draining the DeLong Mountains from the north and the Baird Mountains from the south (fig. 2). The Noatak River then turns southward and flows for about 100 mi through the Mission Lowland to its mouth at Kotzebue Sound. The Noatak River passes through three canyons, Grand Canyon, Noatak Canyon, and Lower Noatak Canyon.

During Pleistocene time most of the Noatak basin was glaciated. The only glaciers now in the basin are a few small cirque glaciers near the Noatak River headwaters. The entire basin is underlain by continuous permafrost. Depth to the base of permafrost is probably as great as 600-800 ft. The basin has few rock-basin lakes but numerous thaw lakes and morainal lakes (Wahrhaftig, 1965).

The distribution of vegetation types in the Noatak River basin is related to elevation. Bottomland spruce-poplar forest covers the flood plain through the Mission Lowland downstream from Noatak Canyon (about 300 ft elevation). Upstream along the flood plains of the Noatak and its major tributaries is high brush. Above the flood plains along the rivers in the lowlands is moist or wet tundra.

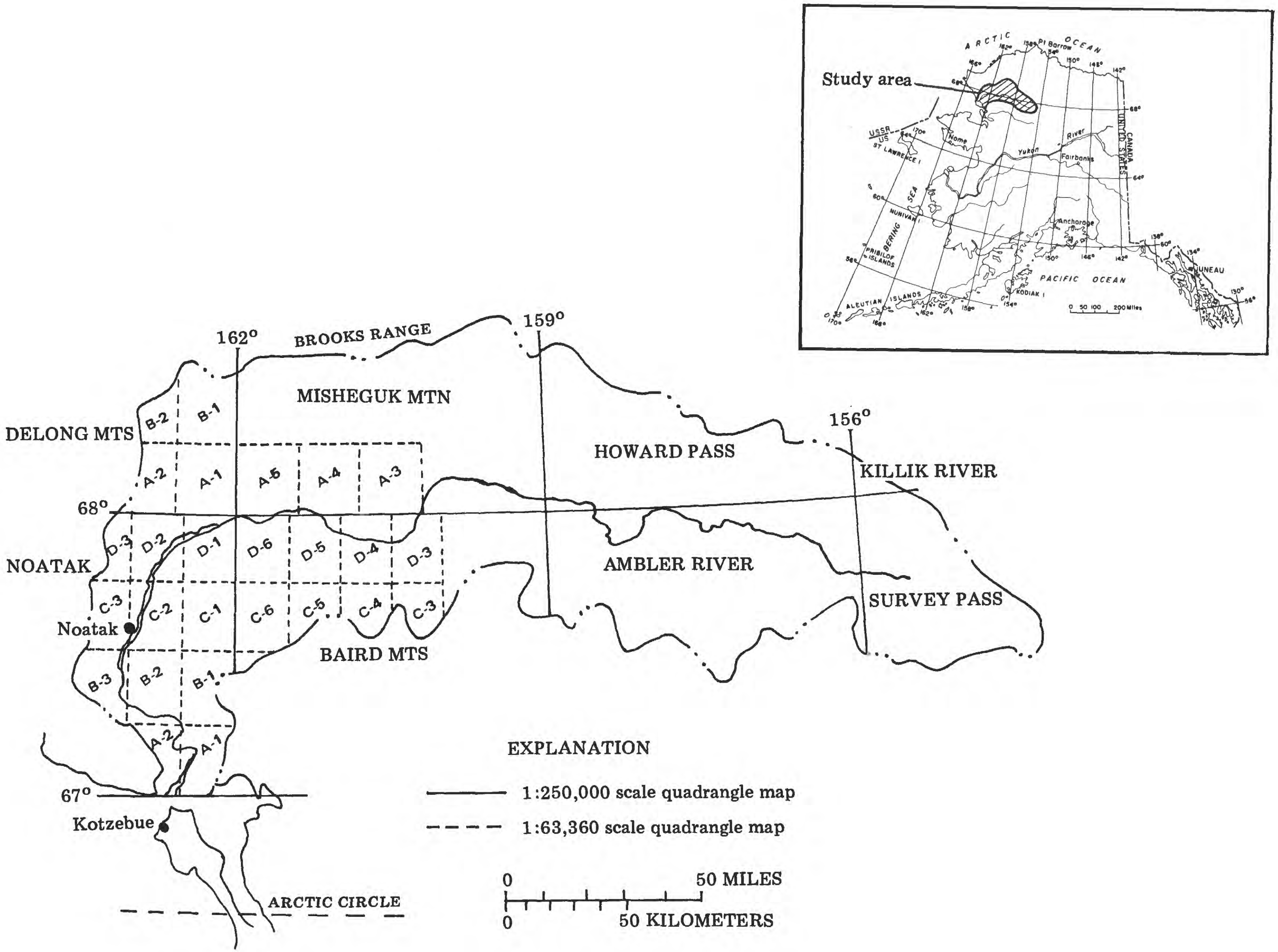


Figure 1.--Index of U.S. Geological Survey topographic maps by quadrangle for the Noatak River basin, Alaska.

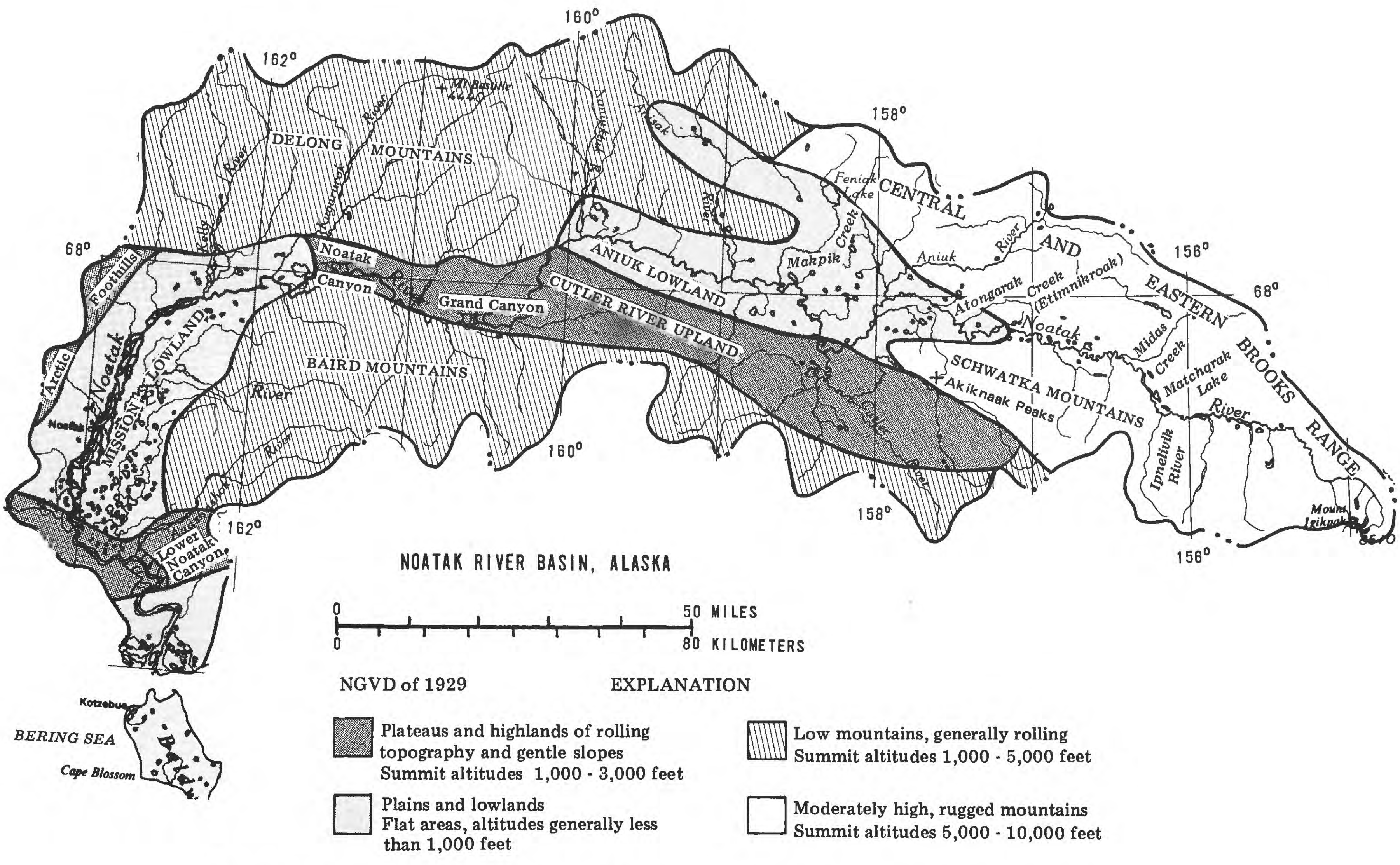


Figure 2.--Physiography of Noatak River basin, Alaska (adapted from Wahrhaftig, 1965).

Alpine tundra and barren ground cover high mountains. Wildfires have burned large areas of coniferous forest and tundra in the basin.

The Noatak River drops more than 1,800 ft in the 400-mi reach from Lake Omelaktavik to Kotzebue Sound. A profile of elevations along the Noatak River (fig. 3) indicates that the major part of the river has a fairly constant slope of about 4 ft/mi and the estuarine segment's slope is about 1 ft/mi. The headwaters and tributaries have much steeper slopes. Figure 3 may be used to estimate distance along the river between indicated points, as well as to determine slope and elevation.

SEASONAL VARIATIONS IN HYDROLOGY

The Arctic climate dominates the hydrology of the Noatak River basin. Streams begin to freeze in October, and most streams cease flowing by December. A few perennial streams have winter flows from rare springs. Flow begins again with "break-up" in May. The isolation during long daylight hours produces high snowmelt streamflow in June. Rainstorms are common during the cool summers and can cause high streamflow. Streams rise rapidly in response to snowmelt and rainstorms, then fall during dry periods. Infiltration of surface water is restricted by permafrost.

Knowledge of streamflow variability, which ranges from floods to low flow or no flow, is important to land-use planning and use of stream resources. Boaters need to know how deep, wide, and swift the river will be when they plan a river trip. Biologists studying the fishery need to know how much streambed area is inundated during salmon spawning runs. The person planning to build a house or other structure on a river bank needs to know how high the river's water surface is likely to rise during a flood. This can be estimated if the elevations of maximum evident flood high water marks are known.

The hydrologist studies streamflow variabilities by measuring streamflow discharge, the rate of flow (measured in cubic feet per second), at different times. Streamflow variability is dependent on many factors, including the amount and intensity of rainfall, the rate of snowmelt, the drainage area, and the amount of water stored in the drainage basin. Seasonal climatic conditions cause much variability of streamflow, as mentioned previously. In cold regions of Alaska the lowest flows or no flow usually occur in mid to late winter (January to April). Highest flows are usually in spring (May or June) and are caused by snowmelt, or at any time during summer (June to September) due to rainfall or rainfall combined with snowmelt. Hydrologists can confidently expect to measure low flow during late winter in cold regions of Alaska. They can also expect normal seasonal streamflow conditions during any particular season--that is, in half the years flow will be in the normal range, in one quarter it will be higher and in one quarter, lower than normal, by definition. Streamgaging data, continuous records of discharge over long periods of time, are necessary to define streamflow characteristics such as normal ranges of seasonal flow or other statistical discharge values. Streamflow records from a streamgaging station at a particular site on a particular stream can be used to define flow characteristics for that site and to help estimate flow characteristics for nearby sites on that stream or similar streams nearby. A minimum of 10 years of streamflow records at a gaging station is considered necessary to define streamflow records with acceptable accuracy (Childers, 1970). In

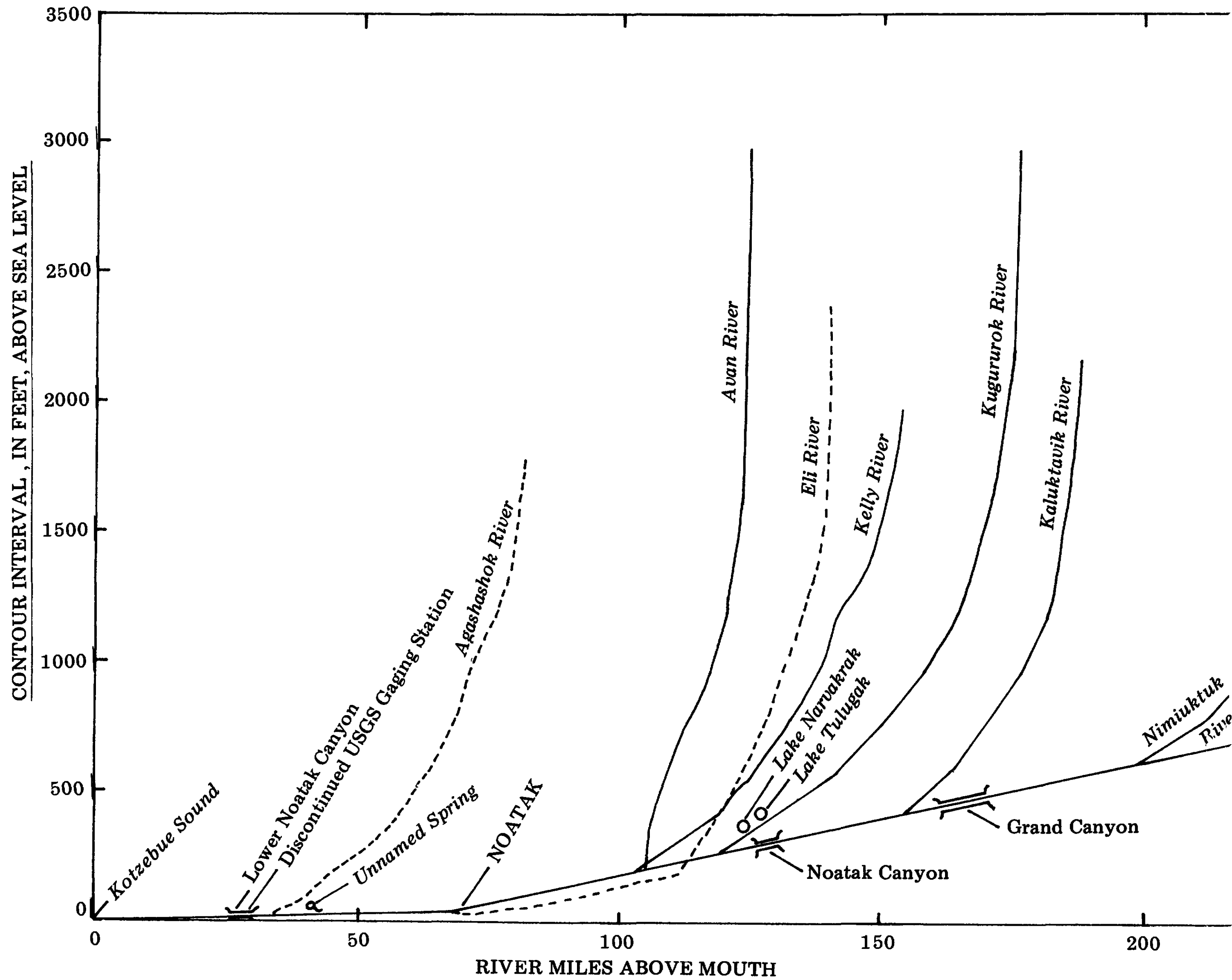
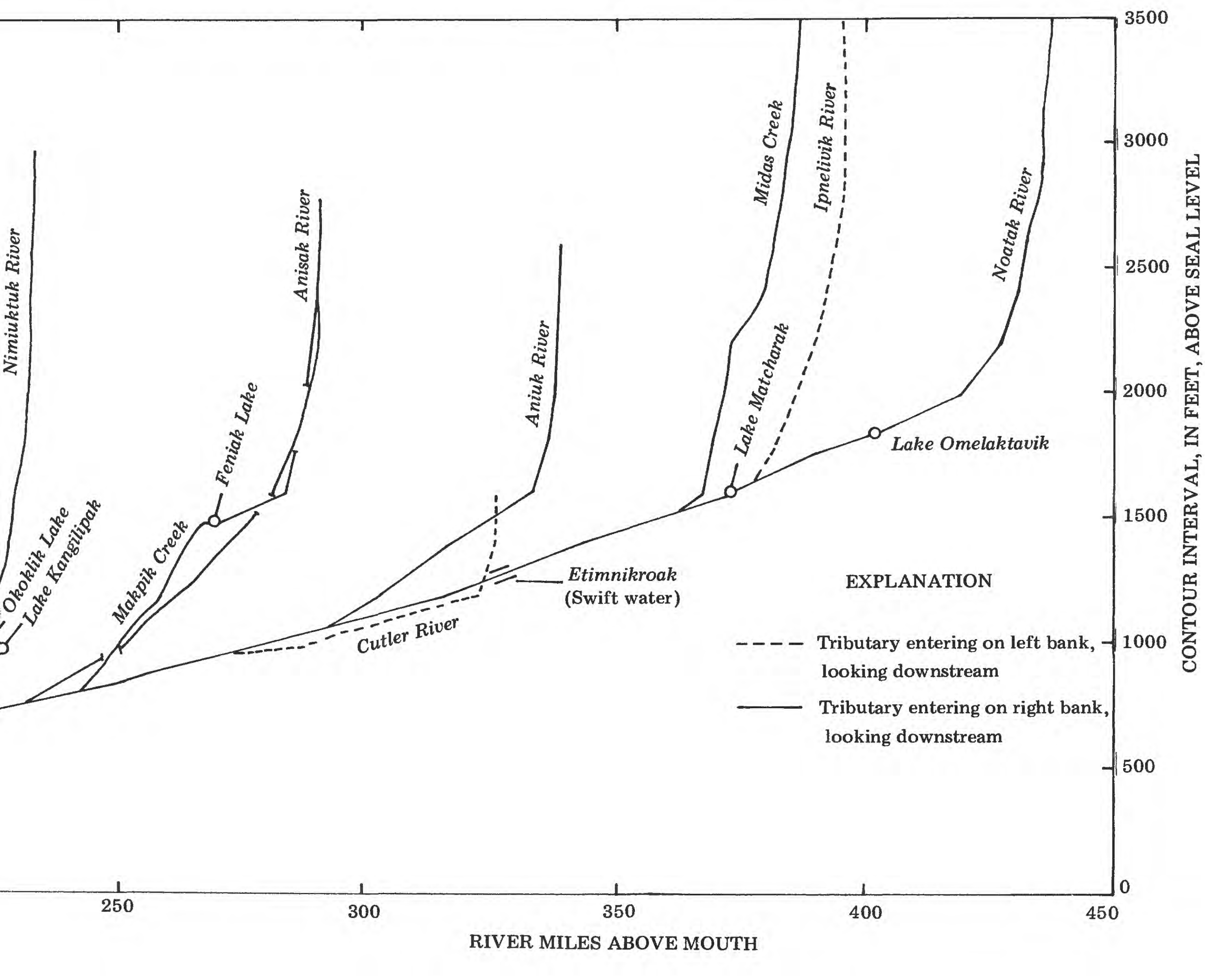


Figure 3. -- Profile of Noatak River and its major tributaries.


Nimiuktuk River
Okoklik Lake
Lake Kangilipak
Makpik Creek
Feniak Lake
Anisak River
Aniuk River
Cutler River
Etimnikroak
(Swift water)
Midas Creek
Ipnelivik River
Lake Matcharak
Noatak River
Lake Omelaktavik
EXPLANATION
Tributary entering on left bank, looking downstream
Tributary entering on right bank, looking downstream
3500
3000
2500
2000
1500
1000
500
0
CONTOUR INTERVAL, IN FEET, ABOVE SEAL LEVEL
250
300
350
400
450
RIVER MILES ABOVE MOUTH

much of Alaska, including the Noatak River basin, streamgaging data are insufficient to meet this criterion.

Based on the existing knowledge of variability of streamflow, the April (late winter) and August (late summer) hydrologic reconnaissance surveys were timed to provide streamflow data that approximate those of normal annual low-flow (late winter) discharges and normal late summer discharges in the Noatak River basin.

Late Winter Conditions

During the April survey 16 stream and spring sites were visited. The sites are listed in table 1, and their locations are shown in figure 4. The sites are listed in downstream order from the headwaters of the Noatak to the discontinued streamgaging station, Noatak River at Noatak.

Winter discharge measurements indicate no flow from the upper part of the basin, that is, upstream from Noatak Canyon. Figure 5 shows site 18 where the stream had frozen to the bed. However, flow occurs there for short reaches in some channels. The discharge measurements on the Noatak River below the Ipnelivik River (site 1) and below the Anisak River (site 13) were of doubtful accuracy because current velocities were near the minimum that could be measured, and there may have been no flow at these sites. The Cutler River at its mouth (site 8) had no flow; it was frozen to bottom. Discharge was measured in an open lead at the Nimiuktuk River (site 15) shown in figure 6. Flow was also measured at an unnamed spring near Akiknaak Peaks (site 4) (figs. 7 and 8). (The existence of this spring was first suggested by identifying an icing on Landsat imagery. The spring was then located from an aircraft; the area first appeared from a distance as a small blue speck. On closer observation, it was seen to be an active icing with open leads upstream.)

In the lower basin of the Noatak River, below Noatak Canyon, the Kugururok River at sites 22 and 23 was flowing in April, as was the Noatak River downstream from the Kugururok (site 24). The combined flow measured at sites 26, 27, and 28 (table 1) was 122 ft^3/s. Additional flow was observed in open leads in anabranches of the braided Noatak River above the Eli River; this flow was not measured but was estimated to be about 25 ft^3/s. Adding the measured and estimated discharge, a total of approximately 150 ft^3/s was estimated to be flowing from the Noatak River at its mouth. At the Noatak River at the discontinued streamgaging station in Lower Noatak Canyon, the water was more than 27 ft deep beneath about 4 ft of ice cover. No current was detected. The water was saline, indicating tidal intrusion from Kotzebue Sound.

An unnamed spring near Noatak (site 28) is shown in figure 9. This spring, which flows from an easily accessible location out of the Noatak channel may have fish hatchery potential. When measured it had a discharge of 9.5 ft^3/s and temperature of 4°C.

Four lakes were surveyed by sampling once near the center of each. Lake Matcharak (site 2) was 42 ft deep below 4.7 ft of ice. Lake Tulugak (site 20) was 7 ft deep below 5.5 ft of ice. Okoklik Lake (site 14) was 11 ft deep below 3.8 ft of ice. Feniak Lake (site 9) had 32 ft of water below 5 ft of ice. Locations of sampled lakes are shown in figure 4.

Table 1.--Discharge measurements during April 1978 in Noatak River basin.
[See figure 4 for site locations.]

Site no.	Stream	Location (lat. long.)	Drainage area (mi²)	Date meas.	Discharge (ft³/s)	Remarks
1	Noatak River	below Ipnelivik River (67°44'16" 156°13'30)	1,033	4-11-78	*6.6	6 ft ice cover
4	Spring	near Akiknaak Peaks (67°51'24" 157°28'48")	1.95	4-11-78	18	no ice cover
5	Noatak River	above Atongarak Creek (67°54'42" 157°27'06")	--	4-08-78	0	4 ft ice cover, no water; frozen to bottom
6	Noatak River	above Cutler River (67°54'27" 158°10'18")	3,418	4-07-78	0	4 ft ice cover, no water; frozen to bottom
8	Cutler River	at mouth (67°50'54" 158°19'20")	1,102	4-07-78	0	4 ft ice cover, no water; frozen to bottom
13	Noatak River	below Anisak River (68°02'11" 159°02'36")	5,775	4-06-78	*0.82	5.6 ft ice cover
15	Nimiuktuk River	below Tumit Creek (68°12'57" 159°55'23")	516	4-07-78	12	open water
16	Noatak River	below Nimiuktuk River (68°00'24" 160°11'00")	6,753	4-08-78	0	6 ft ice cover, no water; frozen to bottom
18	Noatak River	above Noatak Canyon (68°00'18" 161°19'06")	8,461	4-11-78	0	7 ft ice cover, no water; frozen to bottom
22	Kugururok River	above Trail Creek (68°13'17" 161°29'14")	441	4-10-78	11	open water
23	Kugururok River	near Noatak (68°01'24" 161°50'08")	859	4-02-78	35	5 ft ice cover
24	Noatak River	below Kugururok River (67°56'48" 162°02'04")	9,556	4-01-78	46	6.2 ft ice cover
26	Noatak River	above Eli River (67°28'04" 163°04'48")	10,889	4-03-78	88	open water
27	Eli River	near mouth (67°25'28" 162°59'05")	514	4-04-78	25	open water
28	Spring	tributary to Noatak River near Noatak (67°14'36" 162°48'15")	0.54	4-03-78	9.5	open water
29 ***	Noatak River	near Noatak (67°15'24" 162°35'09")	12,000	4-04-78	**no meas.	4 ft ice cover

*Discharge measurement of doubtful accuracy--may be no flow. Stream velocity was less than 0.1 ft/s, which is near threshold value for measuring techniques.
**No apparent stream velocity, although about 150 ft³/s flowed into the reach from upstream.
***Discontinued streamflow gage, Noatak River at Noatak.

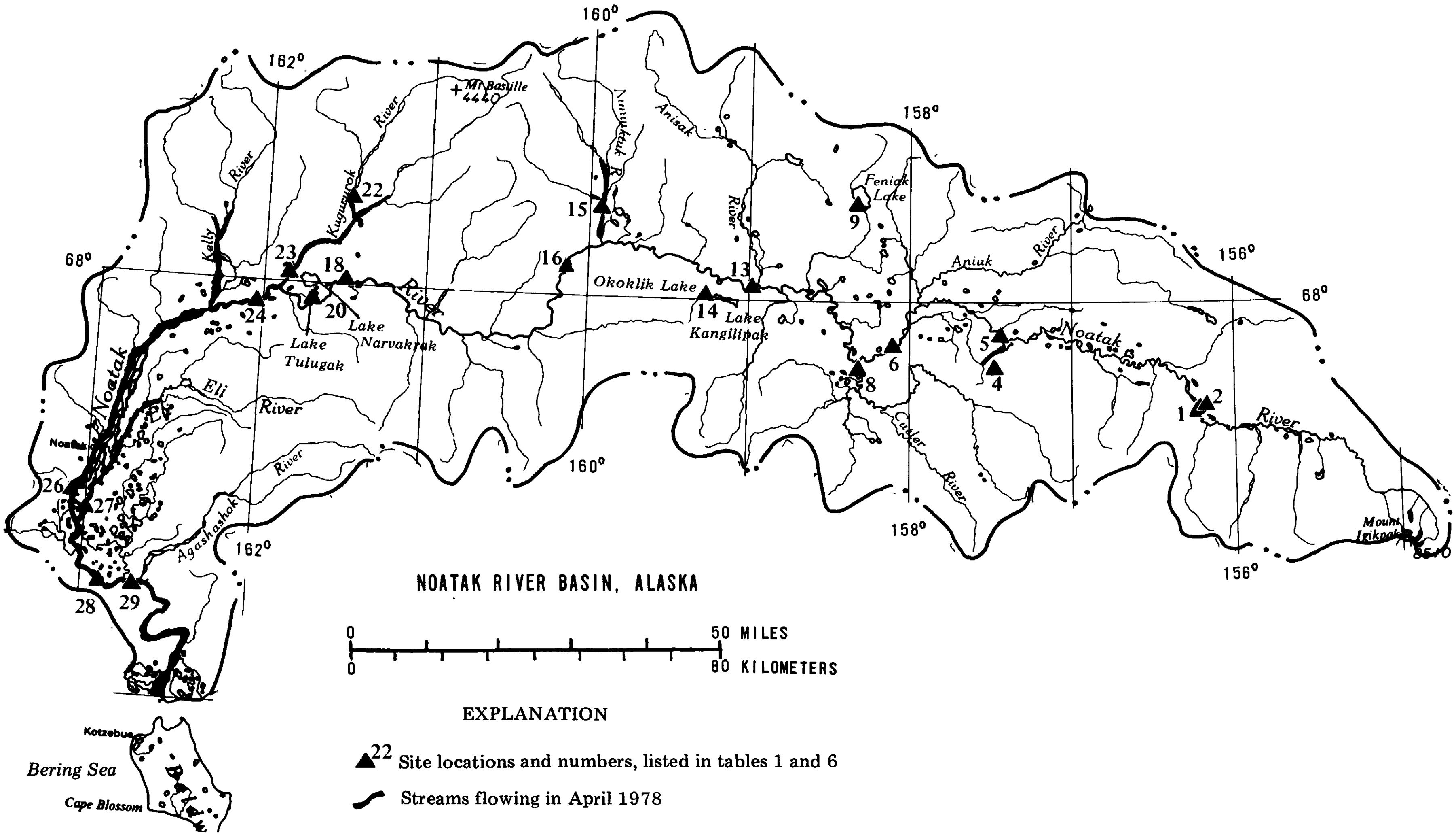


Figure 4.--Site locations, surveys of April 1978 in Noatak River basin.

Figure 5.--Site 18, on the Noatak River above Noatak Canyon, April 11, 1978. X indicates the location of site 18 where a hole was drilled through 7 feet of ice to the dry streambed. View downstream.

Figure 6.--Site 15, where discharge was measured in an open lead along Nimiuktuk River, April 11, 1978.

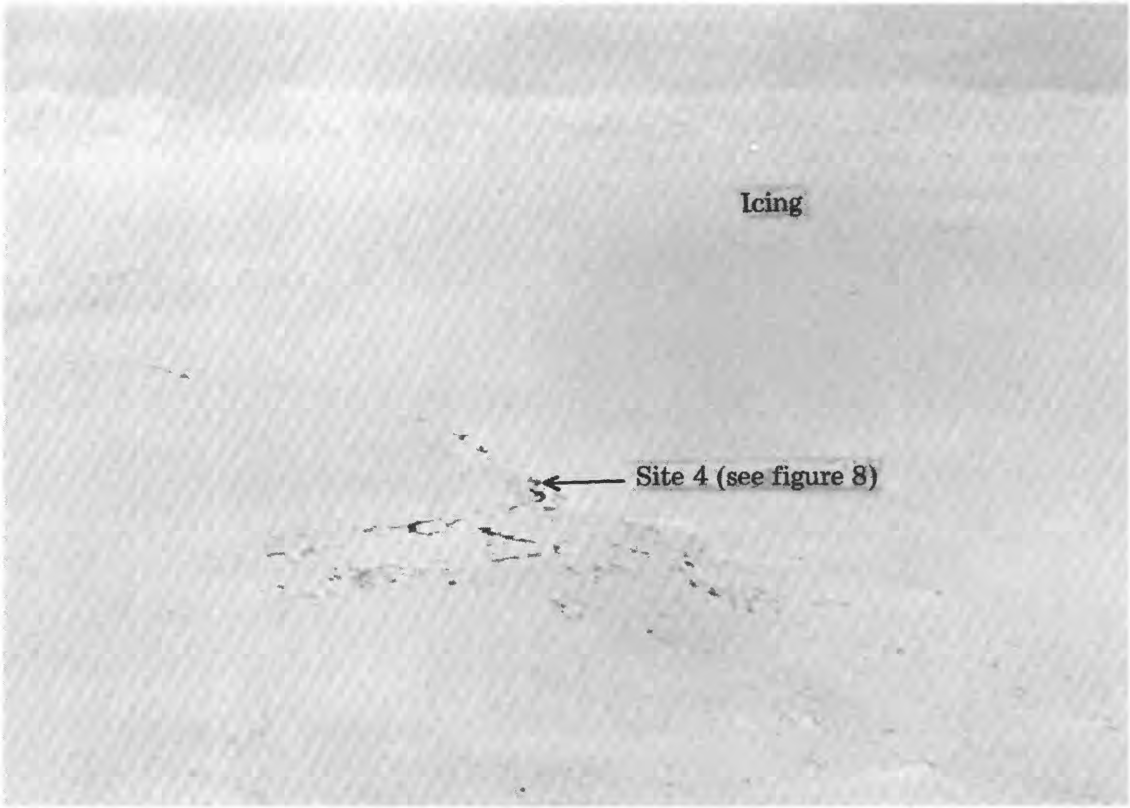


Figure 7.--Site 4, open leads (dark spots) at an unnamed spring near Akiknaak Peaks on April 11, 1978.


Figure 8.--Hydrologists packing equipment at an unnamed spring (site 4) near Akiknaak Peaks, April 11, 1978.

Figure 9.--Site 28, Unnamed spring near Noatak River downstream from Noatak and near Agashashok River, April 3, 1978. The tent shelters instruments from which leads pass to a probe sensor in the stream.

Late Summer Conditions

Streamflow data from the hydrologic reconnaissance in August 1978 (late summer) are used in this report to estimate normal flow conditions for late summer in the Noatak River basin. The streamflow in the Noatak River basin may vary greatly in late summer, depending primarily on weather. During very dry summers the stream discharge may drop to values of perhaps half those measured during August 1978, and during very rainy summers the streams may flood over their banks with discharge 30 to 40 times larger than those measured in late August of 1978. During rainy summers stream velocities may also exceed those reported herein, and during floods, velocities may be greater than 10 ft/s. However, values measured in August 1978 are considered to be within the normal range, that is, within a range of discharge that can be expected in late summer in about half the years. This is based on unit runoff of about 1.0 $(ft^3/s)/mi^2$ measured in August 1978 which would have been normal based on data from the discontinued streamgaging station, Noatak River at Noatak. The normal discharges support streams with widths, depths, and current velocities as reported in table 2.

Results of stream surveys (tables 2 and 3) along the Noatak River in August 1978 (fig. 10) indicate that discharge was proportional to drainage area and unit runoff was approximately 1.0 $(ft^3/s)/mi^2$ as measured at two of seven sites (site 1, and 17). Unit runoff was 1.0 $(ft^3/s)/mi^2$ or higher from the mountainous areas. Lower unit runoff occurred in the reach upstream from Anisak River to downstream from the Nimiuktuk River (site 16). Lower unit runoff, 0.4-0.5 $(ft^3/s)/mi^2$, was also measured in the Cutler River (site 8), Makpik Creek (site 10), and Anisak River (site 12). These basins are in the Cutler Upland or partly in the Aniuk Lowland, areas of low relief that generally produce less runoff than mountainous areas. The lower runoff from these basins accounts for the lower unit runoff in the Noatak River at sites 11 and 16.

Rain caused the Noatak River to rise slightly during the survey period; however, the stream remained well down in the cobble-and-boulder-lined channel (fig. 11). The rain may have increased the unit runoff slightly [to 1.2 $(ft^3/s)/mi^2$] at sites 19 and 25.

The hydraulic properties of the streamflow during the surveys are shown in table 2. Cross sections at survey sites along the Noatak River are shown in figure 12. The cross sections indicate (1) the maximum evident flood surface, (2) the bankfull channel surface, (3) the water surface at the time of the survey, and (4) the elevations of zero flow, or the lowest pool-surface elevation that will support flow over the riffle. The survey sites were selected to have (1) uniform bankfull channel flow, (2) minimum channel bend, and (3) good maximum evident flood high-water marks.

The typical late summer stream channel pattern along the Noatak River from the Ipnelivik River to the Eli River is a pool-and-riffle sequence. Pools were from 1,000 to 5,000 ft or more in length, and the channel shapes did not vary near the middle segments of the pool length. Pool widths increased downstream from about 200 ft at site 1 to 700 ft at site 25 along the Noatak River, and maximum depths ranged from about 6 ft to about 8 ft (table 2). The maximum depth of most riffles was generally less than the mean depth of adjacent pools. Riffles were wider than pools; some were twice as wide and some were oriented diagonally to the bankfull channel direction. Maximum depths of riffles increased from about 2 ft to about 4 ft between those same sites. Riffle bed material was composed of gravel, cobble, and boulders (table 3).

The Noatak River provides conditions favorable for recreational boating from the Ipnelivik River to the mouth. The flow through the three canyons is smooth. One 7-mi reach of boulder-strewn rapids upstream from Atongarak Creek is called Etimnikroak, or swift water, by the Eskimos. This was the only segment of the Noatak observed during August 1978 that might cause a navigational problem for boaters. Below the Eli River the Noatak was wide, deep, and smooth flowing.

STREAMGAGING RECORDS

No continuous climatic or stream-discharge data are available for the Noatak basin for 1978. Figure 13 shows the monthly mean discharge for the Noatak River at Noatak station, based on the period of record 1965-71; however, there are no winter records. This streamgaging station was located in the Lower Noatak Canyon to measure the Noatak River at its mouth. The gaging station was discontinued partly

Table 2.--Stream site descriptions, surveys of August 1978 in Noatak River basin.

[See figure 10 for site locations.]

Site no.	Stream (lat. long.)	Noatak River mile	Drainage area (mi^2)	Date (day)	Discharge (ft^3/s)	Unit runoff (ft^3/s) per mi^2)	Width (ft)	Mean depth (ft)	Maximum depth (ft)	Mean velocity rounded (ft/s)	Maximum surface velocity (ft/s)	Riffle maximum depth (ft)	Riffle material (table 3)
1	Noatak River below Ipnelivik River (at Matcharak Lake) (67°44'16" 156°13'30")	373	1,033	9	997	1.0	210	3.7	6.3	1.3	2.1	2.0	small boulders
3	Midas Creek at mouth (67°51'15" 156°25'27")	363	204	11	179	0.9	63	1.3	1.9	2.1	3.1	1.0	coarse gravel
7	Noatak River above Cutler River (67°51'50" 158°13'40")	280	3,418	14	2,310	0.7	260	4.8	7.6	1.9	2.7	3.0	small boulders
8	Cutler River at mouth (67°50'54" 158°19'20")	273	1,102	15	468	0.4	290	2.2	3.0	0.7	1.2	1.4	small boulders
10	Makpik Creek at mouth (68°01'39" 158°38'04")	239	273	16	125	0.4	78	1.7	2.5	1.0	1.4	1.2	small boulders
11	Noatak River above Anisak River (68°01'40" 158°55'35")	234	4,961	17	2,690	0.5	350	3.0	5.2	2.6	3.3	2.0	small boulders
12	Anisak River at mouth (68°02'40" 158°57'00")	231	805	18	390	0.5	136	1.5	2.2	1.9	2.3	1.8	small cobble
15	Nimiuktuk River below Tumit Creek (68°12'57" 159°55'23")	197	516	20	771	1.5	190	1.4	2.5	3.0	3.5	1.8	coarse gravel
16	Noatak River below Nimiuktuk River (68°00'24" 160°11'00")	190	6,753	21	3,980	0.6	350	3.3	6.0	3.4	4.6	4.0	small boulders
17	Noatak River in Grand Canyon (67°55'23" 160°56'10")	160	7,801	22	7,910	1.0	460	3.8	7.5	4.5	6.1	4.0	small boulders
19	Noatak River in Noatak Canyon (67°57'54" 161°36'40")	130	8,461	23	10,200	1.2	418	5.8	7.5	4.2	4.5	5.0	small boulders
25	Noatak River above Noatak (67°49'13" 162°41'50")	80	10,506	26	12,700	1.2	700	4.6	8.2	3.9	4.4	4.0	large cobbles, small boulders
29	Noatak River near Noatak (tidal) (67°15'24" 162°35'09")	30	12,000	31	--	--	1,100	22.0	37.0	--	--	--	--

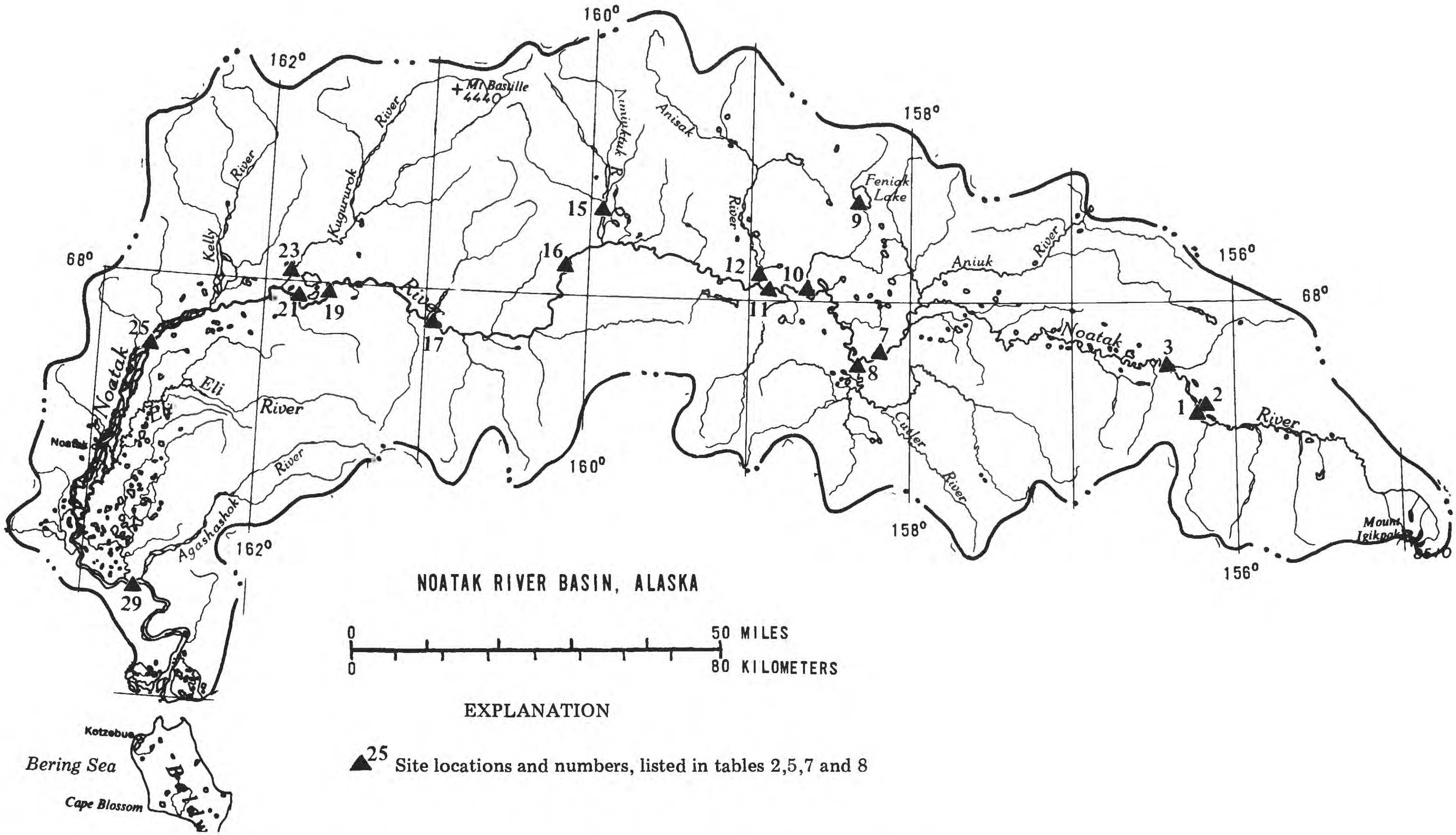


Figure 10.--Site locations, surveys of August 1978 in Noatak River basin.

Figure 11.--Site 17, Noatak River in Grand Canyon, August 22, 1978. The water surface is well down in the channel.

because it was in a stream reach affected by variable and indeterminate backwater from Kotzebue Sound during low-flow periods (November to April). Measurements of discharge of less than about 1,000 ft^3/s could not be made at the gaging station during the period of record because stream current velocity was too low for available equipment to measure. Table 4 presents the monthly mean discharge for the station. It was not possible to make reliable estimates of the variation in annual low flow for the Noatak River.

FLOODS AND EROSION

Rivers in northern Alaska are attractive for development and use because they offer transportation routes through mountain ranges and their valleys provide stable, level ground. River beds are sources of gravel for construction, and the rivers themselves provide water for many uses. The water temperature in rivers tends to reduce the extent of permafrost near their courses. This fact is important in influencing the selection of stable ground for structures; even if frozen, gravel-rich alluvium along rivers tends to remain stable when thawed. In addition, another attraction for development along rivers is that water supplies in winter are more likely to be found along the large rivers.

Though there are many advantages to building along rivers, there are disadvantages--particularly flooding. Floods are natural phenomena subject to great variability and uncertainty. Floods can range from slightly over bankfull in the normal flow channel to situations in which the water not only occupies most or all of the flood plain but may also reshape the channel and flood plain by erosion and

Table 3.--Scale of streambed material particle sizes

Class and subclass	Millimeters	Inches
Boulders		
Very large boulders	4,096-2,048	160-80
Large boulders	2,048-1,024	80-40
Medium boulders	1,024-512	40-20
Small boulders	512-256	20-10
Cobbles		
Large cobbles	256-128	10-5
Small cobbles	128-64	5-2.5
Gravel		
Very coarse gravel	64-32	2.5-1.3
Coarse gravel	32-16	1.3-.6
Medium gravel	16-8	.6-.3
Fine gravel	8-4	.3-.16
Very fine gravel	4-2	.16-.078

Table 4.--Monthly mean discharge, in cubic feet per second, Noatak River at Noatak. No records for November thru April.

Water year	Oct.	May	June	July	Aug.	Sept.
1966	5,674	2,408	54,846	23,943	8,817	13,451
1967	9,648	3,300	112,836	49,529	30,067	12,323
1968	4,354	1,993	86,266	36,270	20,556	7,173
1969	1,253	--	--	34,467	67,564	18,456
1970	3,420	--	17,233	9,390	19,538	5,731
1971	--	--	73,790	20,060	13,690	8,207
Average	4,870	2,567	68,994	28,943	26,705	10,905

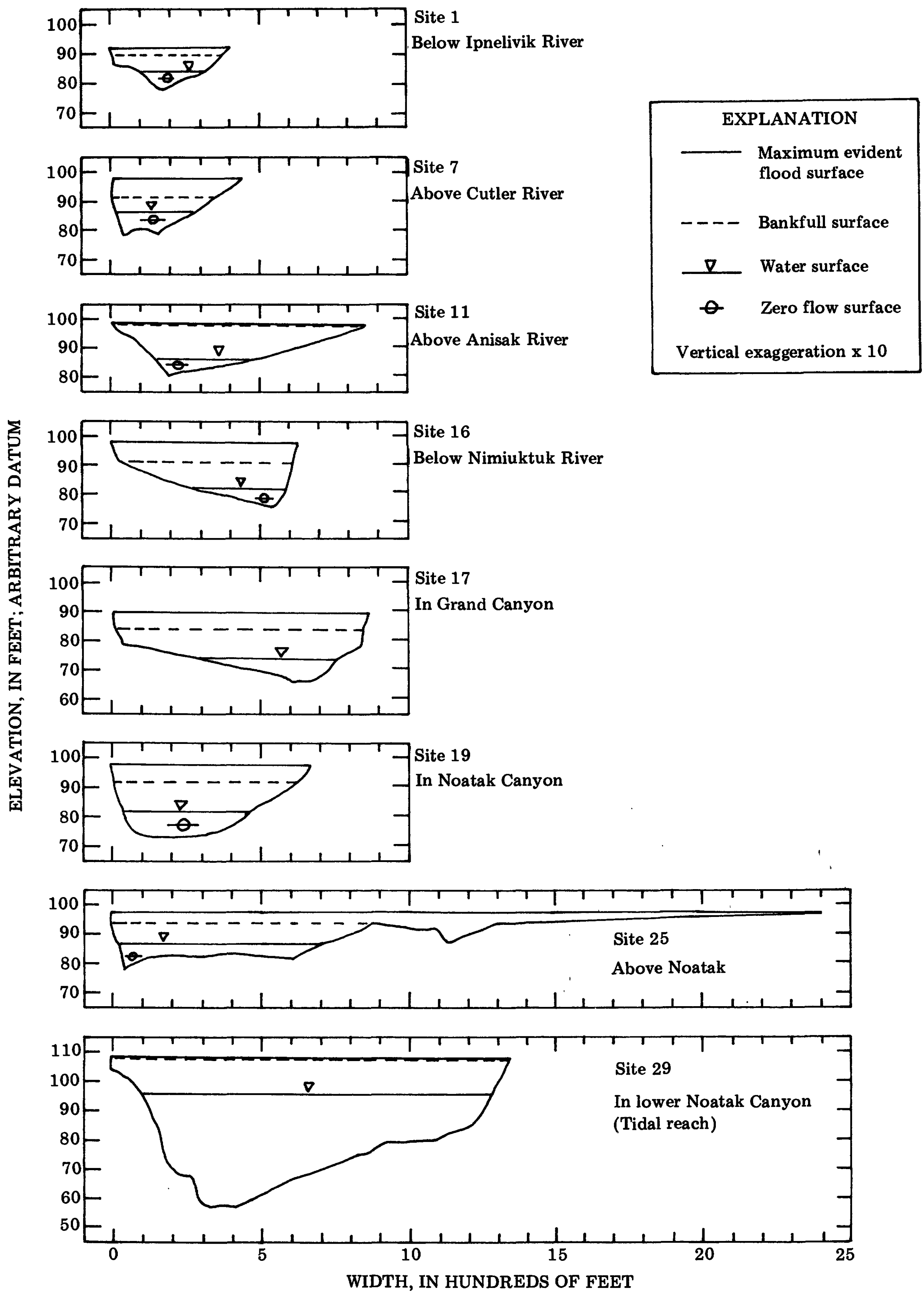


Figure 12.--Noatak River cross sections, August 1978.

deposition. Ice jams compound the flood hazards in northern Alaska; their size, location, and effects are variable and unpredictable. In places icings may fill the channel and parts of the flood plain. In addition, man's development activities near a river may interact with the channel to affect the ice and flood phenomena.

The flood hazard can be evaluated by studying evidence left by floods. Traces of past floods can be recognized in accumulations of flood debris, washlines on steep banks, and channels swept clear of vegetation. These flood signs are indications of maximum evident floods (MEF's). If significant floods have occurred in the recent past (within the last 50 years), floodmarks are usually evident. If there is no such evidence, then it is probable that no significant flood has occurred recently. While there are exceptions to this rule of thumb, the concept is still useful in evaluating flood hazards. Assuming that future flood conditions will be similar to those of the past, then these future conditions can be estimated by interpreting evidence of past floods. The areal extent of inundation can be determined by mapping MEF marks. Floodwater surface profiles can be determined by surveying MEF marks and noting the difference in elevations. Assuming channel position and configuration have remained stable since the MEF, the channel's hydraulic properties can be measured and used to compute stage-discharge relations for cross sections of interest (Riggs, 1976). The MEF discharge is the estimated maximum instantaneous peak discharge which has occurred in the channel in the recent past. Such a discharge can be anticipated in future floods and can be used to guide river bank development.

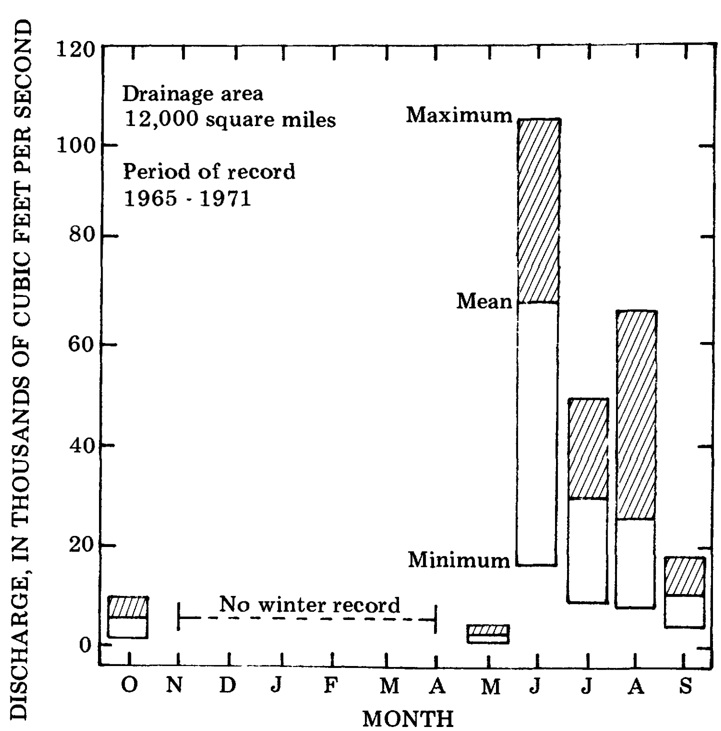


Figure 13.--Monthly mean discharge, Noatak River at Noatak.

Figure 14.--Maximum evident flood high-water marks, Noatak River below Ipnelivik River (site 1) August 9, 1978. Level rod is approximately parallel to top of twigs and other debris typical of a seed line deposited by floodwaters.

MEF marks were good to excellent at most sites. Piles of flood-deposited debris consisting of willow twigs, limbs, and seed lines were common (fig. 14). At some sites ice-gouged pits were observed on the unvegetated bars along the channel. Ice scars on vegetated banks were observed only at Makpik Creek and Nimiuktuk River.

Surveys were made to measure channel hydraulic geometry and MEF discharge at eight sites along the Noatak River and on five tributaries (fig. 10, table 5). At the site on the Nimiuktuk River near the mouth the evidence indicated that ice scouring and probable ice obstructions have complicated the flood conditions. Therefore, MEF discharge was not computed.

MEF discharge ranged from 36,000 ft^3/s at the Noatak River below Ipnelivik River to 460,000 ft^3/s at the Noatak River in Lower Noatak Canyon. (For comparison, the maximum discharge recorded at the discontinued gaging station Noatak River at Noatak was 242,000 ft^3/s on June 14, 1968.) MEF discharge was divided by drainage area to compute unit runoff for these flood conditions; values ranged from 11 to 37 $(ft^3/s)/mi^2$ along the Noatak River. Unit runoff for all sites surveyed on the Noatak and its tributaries was less than 50 $(ft^3/s)/mi^2$.

Table 5.--Bankfull channel, maximum evident flood, basin and flood characteristics at flood survey

[See figure 10 for site locations.]

Site no.	Stream site (lat and long)	Streambed material	Slope (ft/ft)	Bankfull channel Width (ft)	Mean depth (ft)	Max. depth (ft)	Discharge (ft³/s) (computed)
1	Noatak River 67°44'16" 156°13'30"	Large cobble	0.0023	370	7.2	12.3	26,000
3	Midas Creek 67°51'15" 156°25'27"	Medium gravel	.0038	150	5.4	8.2	6,100
7	Noatak River 67°51'50" 158°13'40"	Large cobble	.0007	345	7.4	11.9	15,000
8	Cutler River 67°50'54" 158°19'20"	Small cobble	.0004	385	5.7	7.5	10,000
10	Makpik Creek 68°01'39" 158°38'04"	Small cobble	.0002	150	3.8	6.3	1,200
11	Noatak River 68°01'40" 158°55'35"	Large cobble	.0007	828	9.7	17.6	70,000
12	Anisak River 68°02'40" 158°57'00"	Medium gravel	.0013	200	3.1	4.6	2,900
15	Nimiuktuk River 68°12'57" 159°55'23"	Ice jam evidence obliterated MEF high water marks.					
16	Noatak River 68°00'24" 160°11'00"	Small cobble	.0018	575	9.2	14.9	57,000
17	Noatak River 67°55'23" 160°56'10"	Large cobble	.0009	815	13.8	18.3	120,000
19	Noatak River 67°57'54" 161°36'40"	Large cobble	.0011	607	12.1	17.1	70,000
23	Kugururok River* 68°01'24" 161°50'08"	Coarse gravel	.0019	484	3.5	6.0	6,900
25	Noatak River 67°49'13" 162°41'50"	Small cobble	.0010	880	9.9	15.0	90,000
29	Noatak River* 67°15'24" 162°35'09"	Small cobble	.0006	1,320	26.2	47.0	460,000

*Survey in 1977

sites in the Noatak River basin, 1978.

Maximum evident flood			Basin characteristics					Flood characteristics	
Width (ft)	Discharge (ft^3/s) (computed)	Unit runoff [(ft^3/s)/mi^2)]	Drainage area (mi^2)	Mean annual precip. (in.)	Mean minimum January temp. (°F)	Area forests (percent)	Area lakes and ponds (percent)	Q_2 (2-yr flood) (computed)	Q_{50} (50-yr flood) (computed)
395	36,000	35	1,030	20	-16	6.1	1.5	13,900	37,400
172	8,800	43	204	20	-16	0.0	0.0	4,840	16,300
706	36,000	11	3,420	20	-16	2.1	2.1	46,200	106,100
440	42,000	38	1,100	20	-16	0.0	1.4	19,800	53,400
150	1,200	4.4	273	20	-16	0.0	4.8	4,730	15,100
828	70,000	14	4,960	20	-16	1.3	2.3	67,400	147,800
340	10,000	12	805	20	-16	0.0	1.9	14,300	40,000
625	120,000	18	6,750	20	-16	0.92	2.1	93,400	197,700
840	160,000	21	7,800	20	-16	0.81	2.0	108,500	223,650
644	120,000	14	8,460	20	-16	0.74	1.9	118,400	245,100
630	11,600	14	859	10	-16	1.1	0.3	9,400	25,700
2,440	160,000	15	10,500	20	-16	0.6	1.7	148,700	295,000
1,320	460,000	37	12,400	20	-16	2.42	0.90	172,000	312,000

Bankfull channel hydraulic geometry is listed in table 5. At most of the survey sites, one or more unvegetated channels were bounded by grassy or brush-covered, sloping banks and overbank areas covered with trees, brush, or tundra. Bankfull elevations were determined by observing the flood-plain surface (Leopold and Skibitzke, 1967) and the edge of mature flood-plain forest or vegetation (Sigafoos, 1964). Mature flood-plain vegetation along the Noatak River was from 25 to 50 years old as determined by counting annual growth rings in cut samples.

Bankfull surface elevations are indicated on the channel cross sections in figure 12. Bankfull elevations were from about 5 ft to more than 10 ft higher than the water surfaces observed during the surveys. MEF marks were found at elevations ranging from bankfull at some sites to as much as about 5 ft higher than bankfull at other survey sites. Bankfull flow would appear to be a minimal flood hazard condition along the Noatak River. However, the use of MEF marks appears to be a reasonable approach to flood evaluation along the Noatak River.

Characteristic flood discharges for the 2-year flood (Q_2) and the 50-year flood (Q_{50}) were computed for the flood survey sites (table 5), using multiple-regression equations (Lamke, 1979). A Q_2 flood discharge has a 50 percent chance of being exceeded in a given year; a Q_{50} has a 2 percent chance. These flood characteristics are related to climatic and physical conditions of a stream's drainage basin. The characteristics that Lamke found to be significantly related to flood characteristics are shown in table 5.

During the August survey, the Noatak River channel was observed to be stable at the surveyed sites and throughout most of its length except at braided or split-channel reaches which are mostly in lowlands.

Tundra vegetation generally protects soils from erosion. However, many bare, high banks, especially in the lowlands, are composed of silty sands that are easily eroded during brief periods of high water. Figure 15 shows erosion-prone banks of the Noatak River at Noatak on August 27. Noatak residents confirm that bank erosion threatens some of the townsite. Melting of exposed permafrost can also enhance erosion. When the soil-ice mass thaws, it is weakened and easily eroded by flowing water, or it may slump, sometimes as large chunks. Such erosion or slumping appeared to be uncommon in August 1978. Thawing ice masses were exposed in some eroding banks; such an ice bank about 3/4 mi long was located about 3 mi downstream from Noatak.

Gravel, cobble, and boulders were the dominant streambed materials, and in most channel reaches these materials formed the normal flow banks as well. Silt and sand were normally near the top of the banks. Only high flows would wash against silty or sandy banks with sufficient velocity to cause erosion. Little fine material was being transported in August (assumed to be normal summer flow), and the river water was clear.

WATER QUALITY

Water-quality data were gathered to delineate current conditions and to provide a scientific basis for management. Specific conductance, dissolved oxygen, water temperature, alkalinity, and pH are important properties of water that can give a basic indication of its general suitability for various uses. Specific

Figure 15.--Erosion-prone bank along Noatak River at Noatak, August 27, 1978.

conductance, or the ability of water to conduct electrical current, serves as a reliable indicator of the dissolved mineral concentration, which influences such things as taste and physiological conditions of plants and animals. The measurement of pH indicates the amount of free hydrogen ion in the water, and it is thus a measure of the acidity or basicity of the water. The pH directly affects fish and fish food organisms and regulates the toxicity of certain compounds in solution. Water temperature and dissolved oxygen are closely related and are vitally important in determining suitability of a given aquatic habitat.

In addition to measuring the above characteristics in the field, water samples were collected and quantitatively analyzed for selected dissolved inorganic constituents. These constituents in water affect conditions for fish and benthic invertebrates, as well as suitability for man's use. Nitrogen, phosphorus, and potassium whose concentrations are generally extremely low in Alaskan streams, are plant nutrients. High concentrations of dissolved solids, as in sea water, can make water unpotable and control the life forms that live in those waters. Arsenic and mercury in streams can be toxic to man and animals. Taste and odor of water are affected by many inorganic constituents. Iron and manganese in solution may stain clothing. Salmon may avoid waters containing copper and zinc. Hardness of water is caused primarily by calcium and magnesium and may be controlled by water treatment. Analysis of the water for organic constituents, suspended sediment, radioactivity, and other chemical characteristics was beyond the scope of the study.

The reconnaissance study shows the natural state of the Noatak basin water; surface-water quality varies with season, location, weather, and influence of ground water. Figures 16 and 17 are trilinear diagrams showing chemical composition of all water sampled during the April and August trips. The plotted points

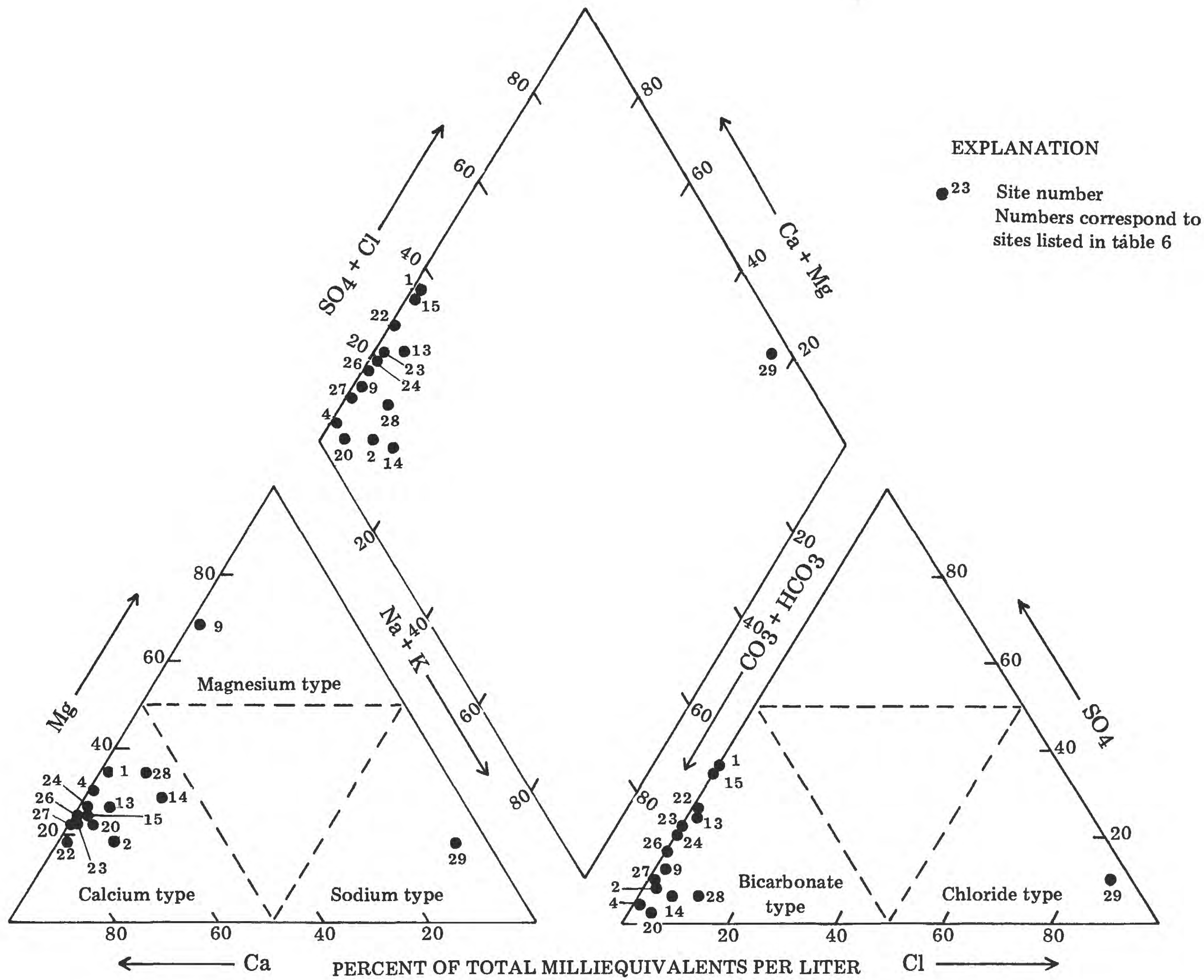


Figure 16.--Analyses of water from selected sites, Noatak River basin, April 1978.

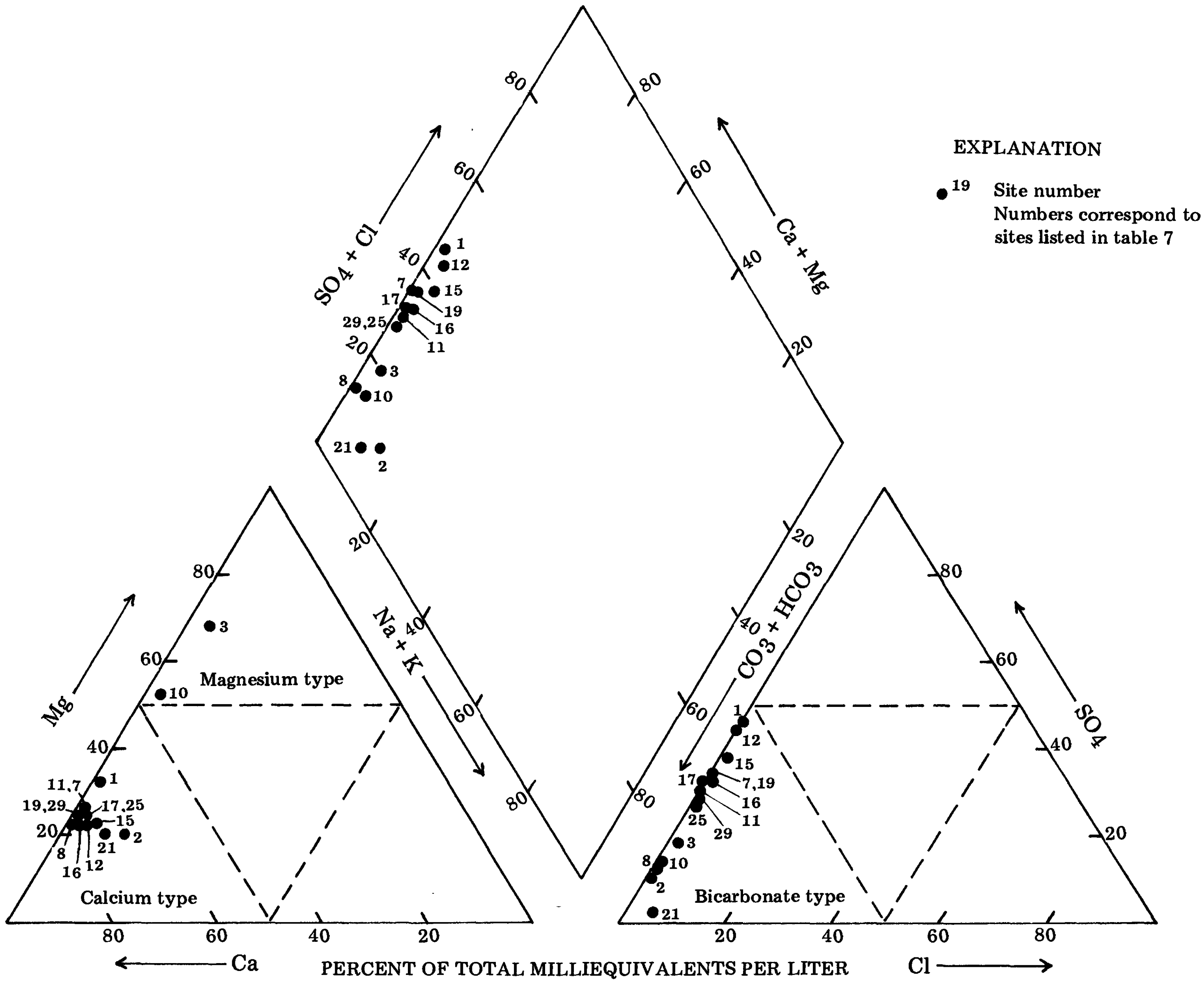


Figure 17.--Analyses of water from selected sites, Noatak River basin, August 1978.

represent percentage of total milliequivalents per liter. Numbers adjacent to the circles correspond to the sites listed in tables 6 and 7.

Most of the water sampled during both trips was of the calcium bicarbonate type - that is, calcium and bicarbonate made up more than 50 percent of the total dissolved ions. However, in April water at Feniak Lake (site 9) contained chiefly magnesium and bicarbonate ions. This was true also of water collected at Noatak River below Ipnelivik River (site 1), Midas Creek (site 3), and Makpik Creek (site 10) during August. At Noatak River (site 29) chemical character of the water sampled in April was influenced by sea water, and sodium and chloride ions were dominant.

The percentage of sulfate ions in the water shows considerable variation. On the basis of limited evaluation of geologic and mineral occurrence maps, this variation appears to be related to the presence of rock types containing sulfide minerals.

Figure 18 shows the relationship between specific conductance and some of the major dissolved constituents for all but two of the sites sampled during the reconnaissance. Two sites were not included: Noatak River below Ipnelivik River (site 1) which, as noted earlier in the report, represented essentially pooled water under ice cover with very low flow; and Noatak River near Noatak (site 29), which was influenced by sea water and did not represent Noatak River water composition.

In late winter, water is unavailable in most of the Noatak basin except as snow or ice (fig. 4). Upstream from Noatak Canyon water occurs in a few springs that feed nearby icings, in a few deep rock basin or morainal lakes, in still pools beneath 6 or more feet of ice and snow cover along stream channels, and perhaps in some thaw lakes. In April 1978 the spring water was clear and cold, had moderate to low concentrations of dissolved oxygen and dissolved solids, and had a hardness equivalent to 160-170 mg/L as $CaCO_3$, which classified the waters of these springs as hard. Figure 4 shows the locations of all sites sampled in April 1978.

Specific conductances in April 1978 ranged from 62 to 9,500 µmhos/cm. The high conductivity value (9,500 µmhos) measured at site 29 (Noatak River near Noatak) is the result of saltwater influences from Kotzebue Sound. The maximum conductivity in water not influenced by saltwater was 1,500 µmhos. Calcium and bicarbonate were the dominant ions. Water in shallow, still pools (less than about 5 ft of water beneath ice cover) had large concentrations of dissolved solids because, as water becomes ice, dissolved solids are concentrated in the remaining liquid.

April dissolved-oxygen values were found to be low in general and especially low (4.0 to 5.0 mg/L) at four sites: sites 1 and 13 on the Noatak River, site 27 on the Eli River, and site 28, a spring near Noatak. Where there was discharge, and therefore movement of water, dissolved oxygen was ample to support life.

Springs feed perennial streamflow in the Noatak River and its larger tributaries. Springs also feed icings in the upper part of the Noatak basin. Water quality of the spring-fed streams was the same as that of spring water feeding icings in the upper part of the basin. Lakes deeper than 10 ft in both the upper and lower parts of the basin had water quality similar to springs; however, water

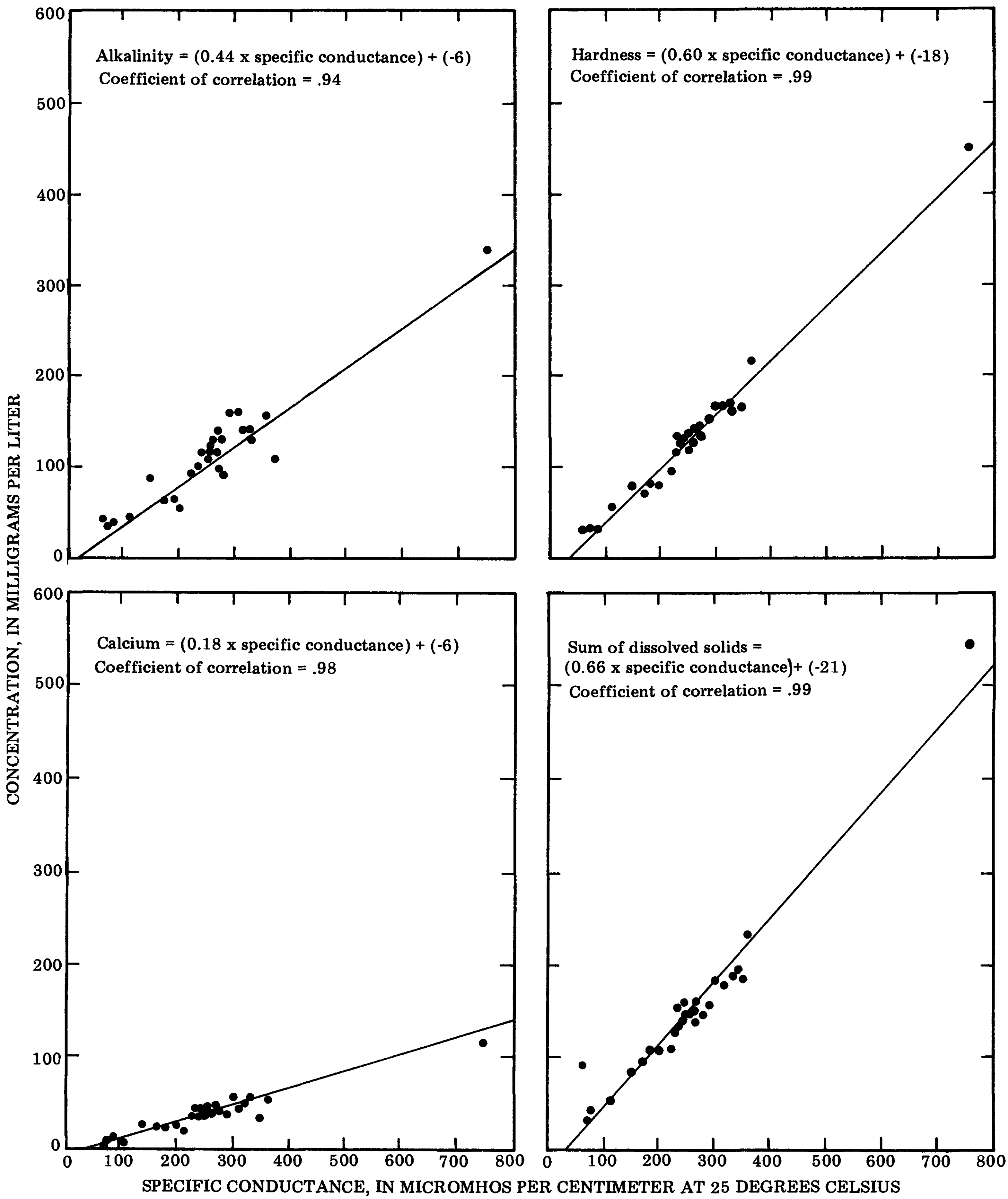


Figure 18.--Relation of specific conductance to alkalinity, hardness, calcium, and dissolved solids concentration, Noatak River basin, 1978.

Table 6.--Water quality at selected sites, Noatak River basin, April 1978.

Site number	1	2	4	9	13	14
Site name	Noatak R. bl Ipnelivik R.	Matcharak Lake	Spring nr Akiknaak Peaks	Feniak Lake	Noatak R. bl Anisak R.	Okoklik Lake
Day	11	11	8	9	6	6
Time	13:30	10:45	10:45	10:45	11:00	13:30
Streamflow (ft^3/s)	6.6*	--	17.7	--	0.82	--
Specific conductance (µmhos/cm at 25°C)	1,500	250	295	62	750	85
pH (units)	7.5	7.9	7.9	7.6	7.7	6.8
Water temperature (°C)	1.0	3.0	1.5	1.5	1.0	3.0
Air temperature (°F)	20.0	18.0	-4.0	18.5	-6.0	8.5
Color (platinum-cobalt units)	1	2	1	1	1	8
Dissolved oxygen (mg/L)	5.3	10.6	9.6	12.3	4.0	8.2
Alkalinity (mg/L as $CaCO_3$)	620	120	160	41	340	39
Hardness (mg/L as $CaCO_3$)	930	120	160	35	450	37
Calcium, dissolved (mg/L)	240	38	44	4.3	130	9.8
Magnesium, dissolved (mg/L)	80	6.1	12	5.9	31	3.0
Sodium, dissolved (mg/L)	6.4	6.0	0.3	0.3	13	2.5
Potassium, dissolved (mg/L)	3.1	0.7	0.0	0.0	1.2	0.7
Sulfate, dissolved (mg/L)	340	11	6.6	3.9	110	2.9
Chloride, dissolved (mg/L)	1.8	1.4	0.8	0.3	5.1	1.9
Fluoride, dissolved (mg/L)	0.4	0.3	0.0	0.0	0.1	0.0
Silica, dissolved (mg/L)	13	4.6	4.1	3.2	7.1	1.5
Dissolved solids, residue at 180°C (mg/L)	1,040	142	146	29	450	56
Dissolved solids, calculated sum (mg/L)	1,060	142	165	43	502	47
Nitrate plus nitrite, dissolved (mg/L)	0.78	0.05	0.20	~~0.00~~	0.22	0.13
Aluminum, total (µg/L)	0	30	160	0	20	20
Arsenic, total (µg/L)	2	2	1	1	1	1
Barium, total (µg/L)	0	0	100	100	100	200
Chromium, total (µg/L)	0	0	0	0	0	0
Copper, total (µg/L)	0	3	0	0	1	1
Iron, dissolved (µg/L)	10	10	10	20	10	40
Iron, total (µg/L)	70	10	340	20	70	40
Manganese, dissolved (µg/L)	0	0	0	0	40	10
Manganese, total (µg/L)	10	0	0	0	40	0
Mercury, total (µg/L)	0.0	0.0	0.0	0.0	0.0	0.0
Molybdenum, total (µg/L)	4	0	3	3	3	4
Nickel, total (µg/L)	0	5	0	1	0	0
Selenium, total (µg/L)	2	0	0	0	0	0
Silver, total (µg/L)	0	0	0	0	0	0
Zinc, total (µg/L)	20	20	10	10	10	10

*Discharge measurement accuracy doubtful. See table 1.

15 Nimiuktuk R. bl Tumit C.	20 Tulugak Lake nr Noatak	22 Kugururok R. ab Trail C.	23 Kugururok R. nr Noatak	24 Noatak R. bl Kugururok R.	26 Noatak R. ab Eli R.	27 Eli R. nr mouth	28 Spring nr Noatak	29 Noatak R. nr Noatak
7	2	10	2	1	3	4	3	4
15:00	14:00	12:20	10:10	14:00	13:00	14:45	10:45	18:00
12	--	11	35	46	88	25	9.5	--
190	265	325	320	312	270	300	350	9,500
7.3	6.9	8.1	7.5	7.5	7.6	7.3	7.4	7.5
1.0	3.5	1.0	1.0	1.0	1.0	1.0	4.0	1.0
7.0	32.0	12.0	23.0	14.0	50.0	23.0	14.0	21.0
1	5	1	1	1	1	1	1	1
10.2	12.8	10.8	10.8	7.5	9.0	5.1	4.8	7.4
66	140	130	140	140	130	160	160	150
90	140	170	170	170	150	170	170	990
27	42	55	51	49	45	53	42	98
5.5	7.5	7.6	9.4	11	8.6	9.5	15	180
0.9	2.4	1.3	1.5	0.9	0.6	0.8	8.0	1,400
0.3	1.4	0.2	0.2	0.3	0.3	0.3	0.3	51
32	2.6	46	37	34	23	16	11	380
0.4	3.9	0.6	0.9	0.7	0.7	1.3	15	2,500
0.0	0.1	0.0	0.0	0.1	0.0	0.1	0.4	0.3
5.2	0.7	3.7	4.6	4.6	5.3	6.3	4.9	4.6
99	148	188	182	177	144	165	--	4,750
111	143	193	189	187	160	182	191	4,700
0.11	0.02	0.04	0.14	0.22	--	0.18	0.13	0.22
0	20	60	20	30	0	20	0	0
1	1	1	1	1	1	0	1	1
200	300	200	200	200	200	300	200	200
0	0	0	0	0	0	0	0	20
0	0	0	0	0	1	1	0	1
20	10	20	10	20	20	10	20	60
30	10	40	20	50	70	0	20	40
0	0	0	0	10	0	130	0	50
0	0	0	0	0	0	130	0	60
0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
3	5	4	3	5	3	5	5	5
0	0	0	2	0	2	6	1	4
1	0	0	1	0	0	0	0	0
0	0	0	0	0	0	0	0	0
0	10	10	10	10	10	10	10	10

Table 7.--Water quality at selected sites, Noatak River basin, August 1978.

Site number	1	2	3	7	8	10
Site name	Noatak R. bl Ipnelivik R.	Matcharak Lake	Midas C at mouth	Noatak R. ab Cutler R.	Cutler R. at mouth	Makpik C at mouth
Day	9	8	11	14	15	16
Time	14:00	11:45	11:30	11:00	18:00	17:30
Streamflow (ft^3/s)	997	--	179	2,310	468	125
Specific conductance (µmhos/cm at 25°C)	362	215	110	270	260	75
pH (units)	7.9	8.0	7.7	8.1	8.0	7.5
Water temperature (°C)	13.0	14.0	10.0	12.5	13.5	13.0
Air temperature (°F)	--	57.0	50.0	59.0	59.0	71.5
Dissolved oxygen (mg/L)	--	--	11.8	12.0	12.0	11.0
Alkalinity (mg/L as $CaCO_3$)	110	98	46	97	130	33
Hardness (mg/L as $CaCO_3$)	210	93	57	150	150	37
Calcium, dissolved (mg/L)	57	29	6.5	43	45	7
Magnesium, dissolved (mg/L)	16	5.0	9.8	9.7	7.9	4.8
Sodium, dissolved (mg/L)	1.0	5.7	0.9	0.9	0.9	0.6
Potassium, dissolved (mg/L)	0.7	0.7	0.2	0.5	0.2	0.1
Sulfate, dissolved (mg/L)	90	10	9.6	49	17	4.9
Chloride, dissolved, (mg/L)	0.5	1.3	0.8	0.4	0.5	0.3
Fluoride, dissolved (mg/L)	0.1	0.2	0.0	0.1	0.0	0.0
Silica, dissolved (mg/L)	2.8	3.7	2.7	2.6	2.1	3.7
Dissolved solids, calculated sum (mg/L)	230	111	54	160	150	37
Nitrate plus nitrite, dissolved (mg/L)	0.07	0.02	0.52	0.21	1.3	0.35
Aluminum, total (µg/L)	210	--	--	--	--	--
Arsenic, total (µg/L)	0	--	--	--	--	--
Barium, total (µg/L)	0	--	--	--	--	--
Chromium, total (µg/L)	0	--	--	--	--	--
Copper, total (µg/L)	1	--	--	--	--	--
Iron, dissolved (µg/L)	40	30	50	50	20	50
Iron, total (µg/L)	540	--	--	--	--	--
Manganese, dissolved (µg/L)	10	0	0	0	10	0
Manganese, total (µg/L)	20	--	--	--	--	--
Mercury, total (µg/L)	0.0	--	--	--	--	--
Nickel, total (µg/L)	--	--	--	--	--	--
Selenium, total (µg/L)	1	--	--	--	--	--
Silver, total (µg/L)	0	--	--	--	--	--
Zinc, total (µg/L)	20	--	--	--	--	--

11	12	15	16	17	19	21	25	29
Noatak R. ab Anisak R.	Anisak R. at mouth	Nimiuktuk R. bl Tumik	Noatak R. bl Nimiuktuk R.	Noatak R. in Grand Canyon	Noatak R. in Noatak Canyon	Tulugak Lake at outlet	Noatak R. ab Noatak	Noatak R. nr Noatak
17	18	20	21	22	23	24	26	31
13:00	10:30	14:00	11:30	14:45	15:45	13:00	15:00	09:00
2,690	390	771	3,980	7,900	10,200	1 (est)	12,700	--
270	200	170	240	230	245	150	240	250
8.2	7.6	7.6	7.8	7.8	7.9	8.2	7.9	7.9
13.5	10.0	10.0	11.5	11.5	13.0	13.0	10.0	11.0
64.5	70.0	63.0	57.0	59.0	62.5	77.0	55.0	52.0
12.2	10.0	10.8	11.0	11.0	10.8	10.0	12.0	11.2
95	54	52	87	82	95	72	90	93
140	87	78	140	120	140	81	130	130
40	27	24	42	37	43	25	38	41
8.9	4.8	4.3	7.6	7.6	8.6	4.4	7.8	7.7
0.9	1.4	1.7	1.4	1.1	1.2	2.8	0.9	1.0
0.4	0.4	0.4	0.7	0.4	0.4	1.3	0.4	0.4
38	40	32	41	37	49	2.0	33	35
0.5	0.3	0.5	0.4	0.4	1.0	2.6	0.5	0.7
0.1	0.0	0.0	0.1	0.1	0.1	0.1	0.1	0.1
2.5	4.1	5.0	3.6	3.6	3.7	0.4	3.8	4.0
150	110	94	150	130	160	82	130	140
0.11	0.01	0.11	0.19	0.18	0.21	0.17	0.18	0.07
--	--	--	--	--	--	--	80	170
--	--	--	0	--	--	--	0	0
--	--	--	0	--	--	--	0	100
--	--	--	0	--	--	--	0	0
--	--	--	6	--	--	--	3	4
100	60	20	50	30	20	50	40	20
--	--	--	60	--	--	--	110	340
10	0	0	0	0	0	0	0	0
--	--	--	10	--	--	--	10	20
--	--	--	0.0	--	--	--	0.0	0.0
--	--	--	3	--	--	--	--	--
--	--	--	0	--	--	--	0	0
--	--	--	0	--	--	--	0	0
--	--	--	240	--	--	--	10	10

temperature was found to be a maximum of 4.0°C in one spring and 3.5°C at one lake outlet.

In late summer Noatak basin surface waters are normally clear, cool, generally hard, and in a few instances very hard; the dominant ions are calcium and bicarbonate. At many places the water has high dissolved-iron concentrations. Dissolved-oxygen values during August were at or near saturation at all sites visited. Figure 10 shows sites sampled in August 1978; the analyses are listed in table 7.

During the August survey trip nearly all streams and lakes were very clear. Though flow was low, the Nakolik River at mouth near the Grand Canyon appeared turbid. Local rain probably accounted for the turbidity. The turbidity imparted to the Noatak by this river persisted for more than 40 mi downstream. It was also noted that wind-generated waves caused local bank erosion and turbidity on Tulugak Lake (site 21, fig. 10) during August 1978.

AQUATIC INVERTEBRATES

The presence or absence of certain organisms in a given reach of a stream is influenced by stream characteristics such as water temperature, pH, dissolved-oxygen concentration, type of substrate, and velocity. Long-term water-quality conditions have important bearing on aquatic invertebrates in a stream. These organisms, when considered in the context of groups rather than as individual species, can be used as an indicator of stream conditions over periods of time much longer than the sampling visits (Hynes, 1970; Hart and Fuller, 1974; Whitton, 1975). In general, moderate numbers of invertebrates with no very large numbers of any one taxon (a group of organisms having similar characteristics) tend to indicate waters in a natural and undamaged state.

The sampling areas chosen were in most instances the same sites where other information was collected during the trip. Sampling procedure involved placing the dip net on the stream bed, then disturbing bottom material upstream from the net to dislodge organisms present. These were subsequently carried into the dip net by stream flow. Sampling was carried out in riffles, pools, areas having submerged brush and roots, side pools, and undercut banks.

Dip-net sampling was conducted for one 15-minute period at each site (fig. 10) during the August trip. (No biological sampling was done during the April trip.) This process was designed to collect a sample which would indicate in a general way the composition of the benthic invertebrate community at a particular site. Total numbers of taxa collected ranged from 8 to 20 (table 8).

Chironomid (midge) larvae were present in all samples collected. Ephemeroptera were present at all sites sampled except one. While Plecoptera and Trichoptera were not present at every site, they were generally present throughout the basin. Samples from the Cutler River and from Makpik Creek, which drains Feniak Lake, contained large numbers of snails, water fleas, and seed shrimp, all generally associated with lake environments.

Results of this limited biological sampling (table 8) show that the Noatak basin streams support an assemblage of invertebrates that are considered to be important fish food. These forms are also indicative of clean waters. Analysis of

Table 8.--Aquatic organisms, Noatak River basin, August 1978.

Results shown as percentages collected using dip net.

Phylum	Class	Order	Family	Common name	Noatak R. bl Ipnelivik R.	Midas C. at mouth	Noatak R. ab Cutler R.	Cutler R. at mouth	Makpik C. at mouth	Noatak R. ab Anisak R.	Anisak R. at mouth	Nimiuktuk R. bl Tumit C.	Noatak R. bl Nimiuktuk R.	Noatak R. in Grand Canyon	Noatak R. Noatak Canyon	Noatak R. ab Noatak	Noatak R. nr Noatak
				Site number	1	3	7	8	10	11	12	15	16	17	18	25	29
				Day	9	11	14	15	16	17	18	20	21	22	23	26	31
Arthropoda	Insecta	Diptera	Chironomidae	midges	15	37	54	21	45	25	55	35	55	46	14	20	11
			Ceratopogonidae	biting midges													1
			Simuliidae	black flies	1	2			1		P	P				12	
			Tipulidae	crane flies	1	1	2	P	P	1		P	P	3		6	
		Ephemeroptera	Baetidae	may flies	57	23	2	1	4	5	15	7	8	19	18		3
			Heptageniidae		1	12	12	P	2	4	12	36	5	3	8		
		Plecoptera	Choloroperlidae	stone flies								1					
			Nemouridae			1			P	1		5			2	23	
			Perlodidae			1		P		1	2			1		1	
		Trichoptera	Brachycentridae	caddis flies		2	3		6	28	P						
			Hydropsychidae										1				
			Leptoceridae										13	5		7	
			Molannidae		4												
			Rhyacophilidae						P			1					
		Coleoptera	Dytiscidae	diving beetles		4	1				P		P			1	
		Hemiptera	Corixidae	water boatmen												3	4
		Collembola		springtails		P						1					2
	Crustacea	Cladocera		water fleas			2	25	15		3	2		1		2	9
		Copepoda			1	1	4	7	5	1	2	6	P		43	1	23
		Ostracoda		seed shrimp		2	1	20	2	2	1	1			2		25
	Arachnoidea	Acarina		water mites	22	15	18	3	13	33	10	2	15	14	2	11	4
	Aphididae			plant lice					1							1	
Annelida	Oligochaeta			aquatic earthworms			1	1	3		P	2	P	3	10	11	16
Nematoda				round worms				P	1	1				6		1	
Mollusca	Gastropoda			snails		1		21	2								2
Chordata	Pisces	Osteichthyes	Cottidae	sculpins					P	1							
		Salmoniformes	Salmonidae	salmon					P								
Number of taxa per sample					8	14	11	12	18	12	12	14	10	10	8	14	11
Number of organisms collected per sample					192	379	100	1,697	944	178	362	513	223	79	49	122	134

P - Present but less than 1 percent

all the samples collected suggests that these waters possess no chemical or biological characteristics which would tend to limit utilization of this water resource for fishing, boating, and recreational purposes.

CONCLUSION AND SUMMARY

Future exploration and development in the Noatak River basin will require planning for various uses of water supplies, flood control, and related activities. The types of hydrologic information required will govern the design of future data-collection programs. Because data collection in the Noatak basin has scarcely begun, early identification of priorities for water information will allow data collection to be tailored to those needs. Some means of satisfying those needs are described in the paragraphs that follow.

Estimates of streamflow characteristics may be required at any site on any stream, but the means of meeting those needs depend on the nature of the project. For large water development projects such as hydroelectric generation, flood control, or water storage, long-term streamgaging records are desirable. Similarly, definition of instream flow requirements for protection or enhancement of aquatic life should also be based on streamgaging records. To provide streamflow data for sites on principal streams (drainage areas greater than 1,000 mi^2), streamgaging stations should be located at the proposed development site or near enough to produce hydrologically equivalent records. The accuracy of estimates of streamflow characteristics at any site depends primarily on the length of gaging station record. Statistical analysis of Alaska streamgaging records indicates, for example, that the standard error of estimate of mean monthly discharge is 12 percent for 10-year records and 6 percent for 25-year records. Prediction accuracy, which is based on these statistics, is a factor in major project planning.

For other types of projects, less precise records may suffice. Estimates of streamflow characteristics for ungaged sites may be derived from appropriate records of adequate length at hydrologically similar sites. The selection of representative gaging station sites requires consideration of pertinent factors such as topography, precipitation, geology, and basin size. Again, the accuracy of the estimate will depend on the length of the gage record and the similarity of the sites.

On the basis of this reconnaissance study, the authors conclude that gaging stations at several of the survey sites described in the report would be useful in delineating streamflow characteristics. A station on the Numiuktuk River below Tumit Creek (site 7) and another on the Cutler River (site 5) would provide records to compare characteristics of a perennial and an intermittent stream, respectively, in the upper part of the Noatak basin. Gage sites on the Noatak River could be located either in Noatak Canyon or the Grand Canyon of the Noatak. Tidal action in Kotzebue Sound caused variable and indefinite flow conditions at the former gage site and probably throughout the lower canyon. Careful placement of the gage could facilitate collection of accurate discharge records during periods of low flow (less than 5,000 ft^3/s). Low flow could also be estimated by adding discharges from stations in mainstem and tributary channels upstream of the tidal influence.

Perennial streams are important for fish and wildlife. They may also serve as year-round sources of potable water for villages or other facilities. Perennial flow can be detected by the presence of open leads and icings that are active through late winter. Leads can be seen from aircraft or on air photos, and icings, particularly remnants of large icings, may be visible on satellite imagery. However, the authors have found that icings are often difficult to distinguish in areas of snow cover or drifts. Information in this report may help identify sites having perennial flow for possible fishery use or for other resource development.

Flood characteristics are essential elements of land-use planning for flood plains. The 1978 survey showed the MEF water-surface elevations were at or above bankfull levels at all survey sites in the basin. Although the frequency of the MEF is unknown, it is reasonable to consider the MEF as one that will probably be exceeded during the next 25 to 50 years. However, until sufficiently long flood-discharge records are available in the Noatak basin, better flood magnitude-frequency definition is impossible.

Information about flood probability in small streams (drainage areas less than about 100 mi^2) is important in the design of roads, pipelines, or other facilities to be located in the basins. Data-collection sites could be placed on small streams near potential road sites for ease of access. Flood probability may be estimated using regional relationships based on records from a network of regionally representative gaging stations. To provide statistically adequate data for defining flood-frequency relations at a gaging station, a minimum of 10 years of annual peak discharge records is required. Long records (25 years) for a few index stations are needed to help extend the applicability of the short records at any station so that the 50-year flood magnitudes can be defined reliably.

Harsh weather, expensive transportation, and construction difficulties all contribute to the very high cost of data collection in the Arctic. In addition, it is difficult to make measurements of some characteristics with present data collection equipment. Some modifications or improvements of present equipment would improve the efficiency of data collection under winter conditions.

The reconnaissance study has provided information that can serve as a basis for more detailed topical or site-specific studies. Among the more important facts are the following:

- In late winter there is very little or no flow in the Noatak River above the Kugururok River. Perennial flow has been noted in some streams in the lower part of the basin.
- Summer runoff averaged 1 $(ft^3/s)/mi^2$ in August 1978. Maximum evident flood runoffs are estimated to be less than 50 $(ft^3/s)/mi^2$. Historic records show that discharge at the mouth in August averaged about 27,000 ft^3/s; in April 1978, discharge was about 150 ft^3/s.
- High water marks indicate that maximum evident flood levels are from bankfull elevations to about 5 ft above those levels.
- Along most of its course, the slope of the Noatak River is about 4 ft/mi. The streambed material in most places is gravel, cobbles, or boulders. The river channel in summer is typically a pool-riffle sequence.
- Field and laboratory chemical analyses and biological sampling indicate that the water is cool, clear, and hard. In most water in the basin the predominant ions are calcium and bicarbonate; salt water intrudes into the lower reaches at low flow. There is good correlation of alkalinity, calcium concentration, hardness, and dissolved solids with specific conductance.

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