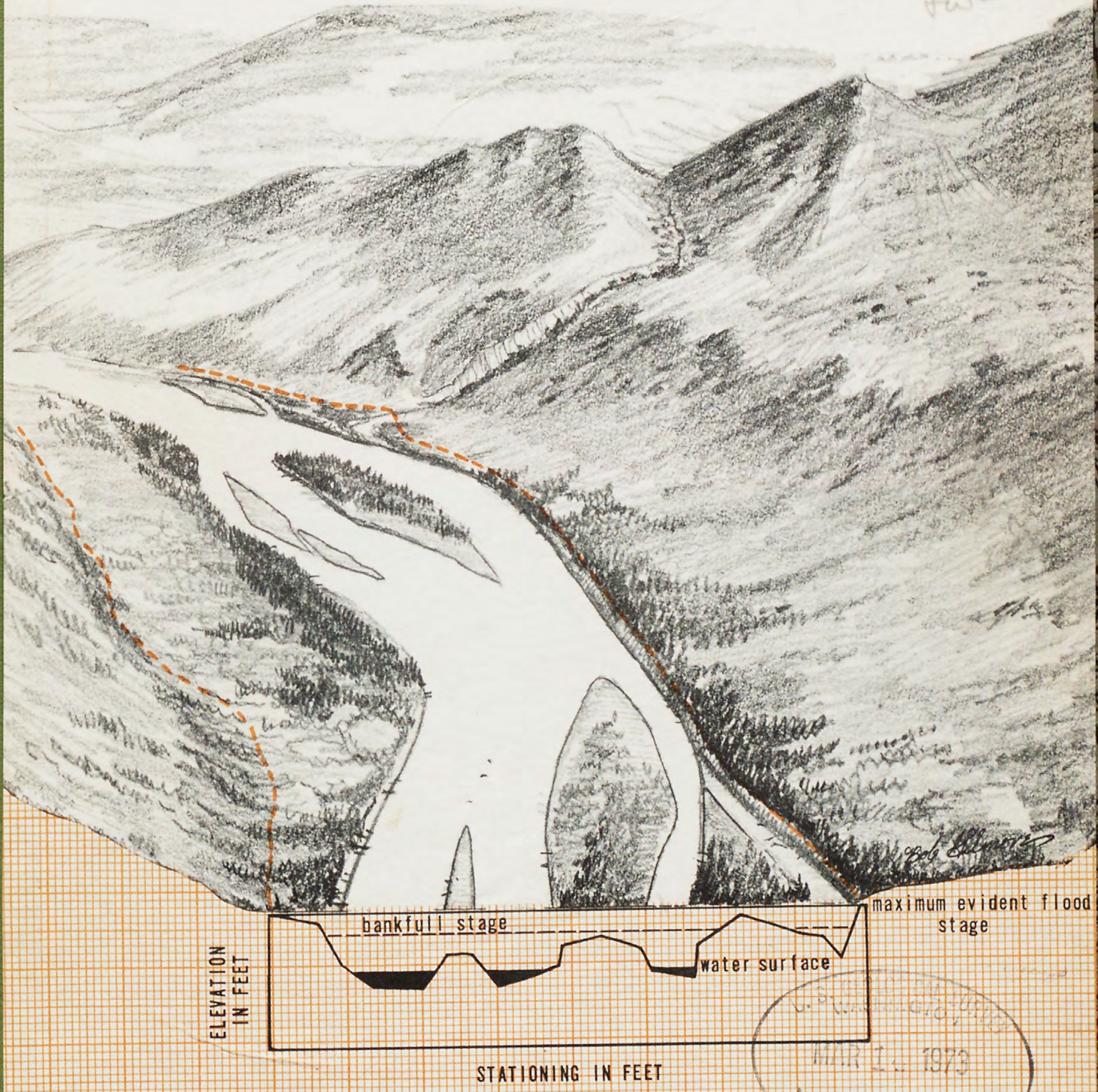
# FLOOD SURVEYS ALONG PROPOSED TAPS ROUTE, ALASKA






UNITED STATES DEPARTMENT OF THE INTERIOR - GEOLOGICAL SURVEY
Water Resources Division - Alaska District

UNITED STATES
DEPARTMENT OF THE INTERIOR
GEOLOGICAL SURVEY
Water Resources Division

# FLOOD SURVEYS ALONG PROPOSED TAPS ROUTE, ALASKA
JULY 1971

By
Joseph M. Childers, 1926

BASIC-DATA REPORT



Anchorage, Alaska
October 1, 1972

## CONTENTS



## ILLUSTRATIONS



## TABLES

UNITED STATES
DEPARTMENT OF THE INTERIOR
GEOLOGICAL SURVEY

Water Resources Division
218 "E" Street, Skyline Bldg.
Anchorage, Alaska 99501
December 27, 1972

FLOOD SURVEYS ALONG PROPOSED
TAPS ROUTE, ALASKA
JULY 1971

Enclosed for your public-information and reference file is the following basic-data report "Flood Surveys Along Proposed TAPS Route, Alaska, July 1971," by Joseph M. Childers and published by the U.S. Geological Survey.

The Geological Survey has the responsibility along the proposed route of the Trans-Alaska Pipeline System (TAPS) to investigate possible hydrologic hazards to the pipeline, to investigate possible impacts of the pipeline system on water resources, and to develop a better understanding of Arctic hydrology. One of the major hazards to the proposed pipeline and its associated roads and facilities is flooding. Consequently, information on floods along the pipeline corridor is needed to assess possible environmental damages and to aid in the design and management of the pipeline and associated facilities. This report presents a description of existing flood information and a description of flood surveys at 13 sites along the northern segment of the proposed TAPS route from Prudhoe Bay to the Salcha River.

If you have any questions concerning data or other information in this report or if you have a need for additional copies, please let me know.

Sincerely yours,

Harry Hulsing
Harry Hulsing
District Chief

Enclosure

# DEFINITION OF TERMS

Accelerated erosion - Erosion which has been increased beyond that which existed under natural environment either as a result of the destruction of the vegetative cover or by some activity of man.

Discharge - The volumetric flow rate of a stream past a site on the stream. The discharge is given in units of cubic feet per second (cfs).

Flood - Any streamflow overtopping the natural or artificial banks in any reach of a stream.

Hydraulic radius - The right cross-sectional area of a stream divided by the length of the wetted perimeter.

Recurrence interval (return period) - The average interval of time within which an event will be exceeded once.

Streamflow - The discharge that occurs in a natural channel.

Stream-gaging station - A site on a stream where systemmatic observations of gage height or discharge are obtained.

Stream stage - The elevation or height of the water surface.

# FLOOD SURVEYS ALONG PROPOSED TAPS ROUTE, ALASKA
JULY 1971

---

By Joseph M. Childers

---

## INTRODUCTION

The U.S. Geological Survey has a threefold responsibility along the proposed route of the Trans-Alaska Pipeline System (TAPS): to investigate possible hydrologic hazards to the pipeline, to investigate possible impacts of the pipeline system on water resources, and to develop a better understanding of Arctic hydrology. One of the major hazards to the proposed pipeline and its associated roads and facilities is flooding. Floods could inundate or erode foundations of structures, could cause pipeline rupture resulting in oil spillage, or could increase erosion especially where natural floodways have been altered by clearing, excavation, and other construction activities. The primary damage to the environment from accelerated flood erosion could be the degradation of water quality and its detrimental effects on fish and other organisms. Consequently, information on floods along the pipeline corridor is vitally needed to assess possible environmental damages and to aid in the design and management of the pipeline and associated facilities. This report presents a description of existing flood information and a description of flood surveys at 13 sites along the northern segment of the proposed TAPS route from Prudhoe Bay to the Salcha River. A similar report is planned for the southern segment of the TAPS route.

# EXISTING FLOOD INFORMATION

The following information is available from published reports of the Geological Survey:

a. "Flood Frequency in Alaska" (Childers, 1970). This open-file report presents an analysis of all flood records up to 1968 in Alaska and on streams in Canada draining into Alaska. Multiple regression equations for estimating flood peak magnitudes of up to 50-year recurrence intervals are presented for streams in Alaska. Drainage basin topographic and climatic characteristics, measured from existing maps, are used in these equations. The report also contains a list of the maximum known floods in Alaska as of 1968.

b. "Floods of August 1967 in East-central Alaska" (Childers and others, 1972). This water-supply paper (WSP 1880-A) describes the floods, the storms that caused them, and the effects of the floods on ground-water conditions and the environment. Comprehensive flood data for pertinent gaging stations and many miscellaneous sites are presented.

c. "Floods of August 1967 at Fairbanks, Alaska" (Childers and Meckel, 1967). This hydrologic atlas (HA-294) features a flood inundation map of Fairbanks and describes the flood.

d. "Floods of the Summer of 1971 in South-central Alaska" (Lamke, 1972). This open-file report describes the floods, their damage and cause, and presents comprehensive flood data for pertinent gaging stations and miscellaneous sites.

e. "Glacier Dammed Lakes and Outburst Floods in Alaska" (Post and Mayo, 1971). This hydrologic atlas (HA-455) describes glacier dammed lakes in Alaska and discusses some outburst floods.

Additional flood information is being acquired to supplement the above published information. Eight stream-gaging stations along the proposed pipeline route were established (see fig. 1) during 1970 and 1971. The acquisition of flood records at these new stations and at the other stations in the Alaska District stream-gaging network, not shown in figure 1, (U.S. Geological Survey, 1970) will gradually improve reliability of flood-frequency analysis. However, it will require at least 5 years of record to make a preliminary estimate of the discharge of the 10-year flood, at least 25 years of record to make a preliminary estimate of the discharge of the 50-year flood, and even longer to check the Standard Project Flood.

## OBJECTIVES OF STUDY

The Department of Interior has stipulated that the proposed pipeline must be designed to accommodate a Standard Project Flood. The Standard Project Flood is the maximum flood reasonably possible; it should exceed any known or evident flood (unless such a flood cannot be reasonably expected in the future). As an example, the Standard Project Flood computed by the Corps of Engineers for the Chena River at Fairbanks is about 98,000 cfs (cubic feet per second) which greatly exceeds the 50-year flood of 57,900 cfs, or even the maximum flood of record of 74,400 cfs on August 15, 1967. This and other stipulations should theoretically eliminate the risk of pipeline rupture caused by floods. However, computed values of the Standard Project Flood cannot be guaranteed to be the maximum flood reasonably possible. Flood records provide some basis for checking the Standard Project Flood, but this check is inadequate.

One purpose of this study was to estimate the peak discharge of the Maximum Evident Flood of selected streams along the proposed TAPS route. The Maximum Evident Flood can be computed by using the high-water marks that are usually left after extreme floods and by determining the floodway dimensions. The computed Maximum Evident Floods are presented in the report and may be used to help check the adequacy of "design" floods along the proposed TAPS route. Another purpose of this report is to present data on bankfull channel capacity, which was also determined at the selected sites. Bankfull channel capacity is thought by some hydrologists to be a good estimate of the mean annual flood, $Q_2$. Bankfull channel dimensions may also be useful in ascertaining streamflow characteristics (Wolman and Leopold, 1957, and Emmett, 1972).

## FLOOD SURVEYS

Site selection.--Thirteen channel sites at or near the proposed TAPS centerline were surveyed during July 1971. The locations of sites are shown on the map (fig. 1). Sites selected were reasonably straight, uniform, alluvial channel reaches of larger streams where the pipeline design was considered to be sensitive to flood magnitude.

Bankfull channel capacity--The floodways usually were found to have one or more unvegetated channels bounded by intermittently grassy or brush-covered sloping banks and overbank areas covered with trees, brush, or muskeg. The most distinctive features were the boundaries defined by the edge of the mature flood-plain forest near the top of the channel banks. Bankfull stage was determined by observing flood-plain surface (Leopold and Skibitzke, 1967) and also the edge of mature flood-plain forest (Sigafoos, 1964). The delineation of bankfull stage profiles along the channels was approximate because the elevations of bank tops were found to vary considerably. Although bankfull channel capacity was often found to be distributed in a main channel and one or more small secondary channels, the secondary channels usually contained insignificant discharge capacity compared with the main channel. Consequently, bankfull channel capacity was computed for the main channel only.

Maximum Evident Flood.--Driftwood and other flood-deposited vegetal debris upon the overbank floodways were used as floodmarks to determine elevations of Maximum Evident Flood surfaces at the channel sites. Maximum Evident Flood surface profiles were approximate because floodmark elevations were found to vary considerably. Maximum flood evidence at most of the sites indicated a floodway much wider than the bankfull channel. The maximum evident floodmarks for these floods were found at elevations and locations which indicated that they were independent of ice scars. At some sites, ice scars were observed on trees and brush along the banks.

Methods.--The channel sites were surveyed using methods described in reports of the Geological Survey. Flood discharge and channel properties were determined by using methods presented by Dalrymple and Benson (1967). Channel roughness, used in computing discharge, was determined by using experience and bed material particle-size characteristics (Limerinos, 1969). Bed material particle sizes were analyzed using optical methods (Ritter and Halley, 1969).

The slope-area method for the indirect measurement of discharge used in this study is based on the Manning equation, $Q = \frac{1.5}{n} AR^{2/3} S^{1/2}$, where Q is discharge in cubic feet per second, n is a roughness coefficient, A is cross-sectional flow area in square feet, R is hydraulic radius in feet, and S is friction slope. The Geological Survey has used this method for years on many rivers and has improved the accuracy of the method notably by establishing site selection criteria and by providing techniques for improving the determination of the roughness coefficient (Benson and Dalrymple, 1968). Values of n may be estimated by comparison with n values that have been verified at similar sites (Barnes, 1967). Channel scour and fill, which occurs during floods in confined reaches, could affect the cross-sectional parameters, area (A) and hydraulic radius (R), and thus the discharge. The surveyed cross sections were bounded by coarse bed material (gravel, cobble, and boulders), and the surveyed geometry was considered to be unchanged from that at the time of the floods.

## ANALYSIS

Flood frequency and magnitude.--For the sites on streams with flood records, flood magnitude-frequency values shown in table 1 were derived from the station flood-frequency relation (Water Resources Council, 1967) defined by the station's flood records. Flood magnitude-frequency values of sites on ungaged streams were estimated using multiple-regression equations (Childers, 1970) which relate flood peak discharge magnitudes to the following four drainage basin parameters:

1. Drainage basin area in square miles (A).
2. Storage in lakes and ponds in percent of drainage area ($S_t$).
3. Mean annual precipitation (P) on the basin in inches as determined by U.S. Weather Bureau (Searby, 1968).
4. Precipitation intensity ($I_{24,2}$), the maximum rainfall in inches expected in 24 hours each 2 years (U.S. Weather Bureau, 1963).

A and $S_t$ may be computed from topographic maps. The multiple-regression equations using the computed basin parameters are:

2-year flood, $Q_2 = 1.99\ A^{0.90}(S_t+1)^{-0.24}\ P^{0.74}\ I_{24,2}{}^{0.53}$

50-year flood, $Q_{50} = 14.0\ A^{0.75}(S_t+1)^{-0.20}\ P^{0.76}$

Caution is recommended in using these equations, especially $Q_{50}$, because they are based only on a few available stream-gaging station records for the region north of the Yukon River.

Channel characteristics.--Bankfull channel parameters were computed for the 13 sites and include:

a. Top width, W, in feet.
b. Mean depth, d, in feet.
c. Slope of the longitudinal bank profile, S.
d. Bed-material size class for median particle.
e. Discharge in cubic feet per second, $Q_B$.

Bankfull channel characteristics were not used in regional analysis of Alaska streamflow, but they have been used in the conterminous United States (Thomas and Benson, 1970). However, results of these analyses indicated that the channel characteristics were insignificant in multiple regression analyses when combined with various basin characteristics. This does not mean, though, that in Alaska some channel characteristics would not be significant.

In addition to bankfull channel characteristics, the top width and discharge of Maximum Evident Flood were computed.

## RESULTS

In table 1, the survey results are presented. The sites are numbered for location on the map (fig. 1) and are arranged in numerical order from 1, Sagavanirktok River near Sagwon, to 13, Salcha River near Salchaket, preceding in a southerly direction along TAPS route.

The data in table 1 allow direct comparison of flood data with design flood magnitudes for these sites and also may have some transfer value for estimating design flood magnitudes at other sites on the same streams or on other nearby or similar streams having similar basin and channel characteristics.

The use of hydraulic methods to estimate bankfull and Maximum Evident Flood discharges provides significant data for planning and design of structures in floodways where man has had little experience. However, some of the surveys yielded poor estimates of discharge caused by the lack of good hydraulic conditions, lack of flood evidence, and uncertainties about the presence of channel ice during floods.

The selection of an acceptable site for study is most important. Some of the flood surveys were made in conjunction with erosion surveys at the same sites at selected proposed pipeline stream crossings. If hydraulics were judged to be acceptable for flood computations, this saved time but sacrificed some accuracy in estimating flood discharge. The erosion surveys are described by Childers (1972).

Flood evidence is lacking in some channels. For example, an unsuccessful attempt was made to survey maximum flood evidence on the Putuligayuk River near the Geological Survey gaging station in September 1970. Although it was known that a discharge of 1,900 cfs (as measured by current meter at the gage) occurred June 7, 1970, no floodmarks could be found. The channel at the survey site consisted of an unvegetated low-flow channel with a maximum discharge capacity of about 200 cfs and tundra-covered sloping overflow banks. A careful search failed to find flood evidence in the tundra. This may be characteristic of streams draining small watersheds (under 200 or 300 sq mi) on the Arctic Coastal Plain.

Another problem in evaluating flood evidence is that peak stages frequently occur in the spring when the stage-discharge relation may be indeterminant because of ice in the channel. Floodmarks observed after spring snowmelt flood runoff often may result from temporary rapidly changing channel icing conditions concurrent with rapidly changing flood discharge.

## FUTURE STUDIES

Considering these problems, site selection for future study should be based on the need for data, on acceptable flood hydraulics, and adequate flood evidence. Consideration should also be given to the possibility that floods in iced channels may be more serious problems than floods in open channels and that more study be planned to describe flood characteristics in the Arctic. In planning field surveys, low-altitude vertical aerial photograph coverage of sites at low-flow open water (probably September) should be obtained. The past season's work has suggested also that future survey teams should include a hydraulic engineer, a geomorphologist familiar with flood-plain features, and a botanist able to date flood events and determine periods of flood-plain stability from study of vegetation.

## SELECTED REFERENCES

Barnes, H.H., 1967, Roughness characteristics of natural channels: U.S. Geol. Survey Water-Supply Paper 1849, 213 p.

Benson, M.A., and Dalrymple, Tate, 1968, General field and office procedures for indirect discharge measurements: U.S. Geol. Survey Techniques Water-Resources Inv., book 3, chap. A1, 30 p.

Brice, J.C., 1971, Measurement of lateral erosion at proposed river crossing sites of the Alaska pipeline: U.S. Geol. Survey open-file report, 39 p.

Childers, J.M., and Meckel, J.P., 1967, Floods of August 1967 at Fairbanks, Alaska: U.S. Geol. Survey Hydrol. Inv. Atlas HA-294.

Childers, J.M., 1970, Flood frequency in Alaska: U.S. Geol. Survey open-file report, 30 p.

Childers, J.M., Meckel, J.P., and Anderson, G.S., 1972, Floods of August 1967 in east-central Alaska: U.S. Geol. Survey Water-Supply Paper 1880-A, 77 p.

Childers, J.M., 1972, Channel erosion surveys along proposed TAPS route, Alaska, July 1971: U.S. Geol. Survey basic-data report.

Dalrymple, Tate, and Benson, M.A., 1967, Measurement of peak discharge by the slope-area method: U.S. Geol. Survey Techniques Water-Resources Inv., book 3, chap. A2, 12 p.

Emmett, W.W., 1972, The hydraulic geometry of some Alaskan streams south of the Yukon River: U.S. Geol. Survey open-file report, 102 p.

Lamke, R.D., 1972, Floods of the summer of 1971 in south-central Alaska: U.S. Geol. Survey open-file report, 88 p.

Langbein, W.B., and Iseri, K.T., 1960, General introduction and hydrologic definitions: U.S. Geol. Survey Water-Supply Paper 1541-A, 29 p.

Leopold, L.B., and Skibitzke, H.E., 1967, Observations on unmeasured rivers: Geografiska Annaler, v. 49, ser. A, p. 247-255.

Limerinos, J.T., 1969, Determination of the Manning coefficient from measured bed roughness in natural channels: U.S. Geol. Survey open-file report, 79 p.

Post, Austin, and Mayo, L.R., 1971, Glacier dammed lakes and outburst floods in Alaska: U.S. Geol. Survey Hydrol. Inv. Atlas HA-455.

Ritter, J.R., and Helley, E.J., 1969, Optical method for determining particle sizes of coarse sediment: U.S. Geol. Survey Techniques of Water-Resources Inv., book 5, chap. C3, 33 p.

Searby, H.W., 1968, Climates of the states, Alaska: U.S. Weather Bureau, Climatography of the United States, no. 60-49, 23 p.

Sigafoos, R.S., 1964, Botanical evidence of floods and flood-plain deposition: U.S. Geol. Survey Prof. Paper 485-A, 35 p.

Thomas, D.M., and Benson, M.A., 1970, Generalization of streamflow characteristics from drainage-basin characteristics: U.S. Geol. Survey Water-Supply Paper 1975, 55 p.

U.S. Geological Survey, 1971, Water resources data for Alaska 1970 - Pt. 1, Surface water records; Pt. 2, Water quality records: U.S. Geol. Survey open-file report, 263 p.

U.S. Water Resources Council Hydrology Committee, 1967, A uniform technique for determining flood flow frequencies: Washington, U.S. Water Resources Council Bull. 15, 15 p.

U.S. Weather Bureau, 1963, Probable maximum precipitation and rainfall-frequency data for Alaska: Washington, U.S. Weather Bur. Tech. Paper 47, 69 p.

Wolman, M.G., and Leopold, L.B., 1957, River flood plains: Some observations on their formation: U.S. Geol. Survey Prof. Paper 282-C, p. 87-109.

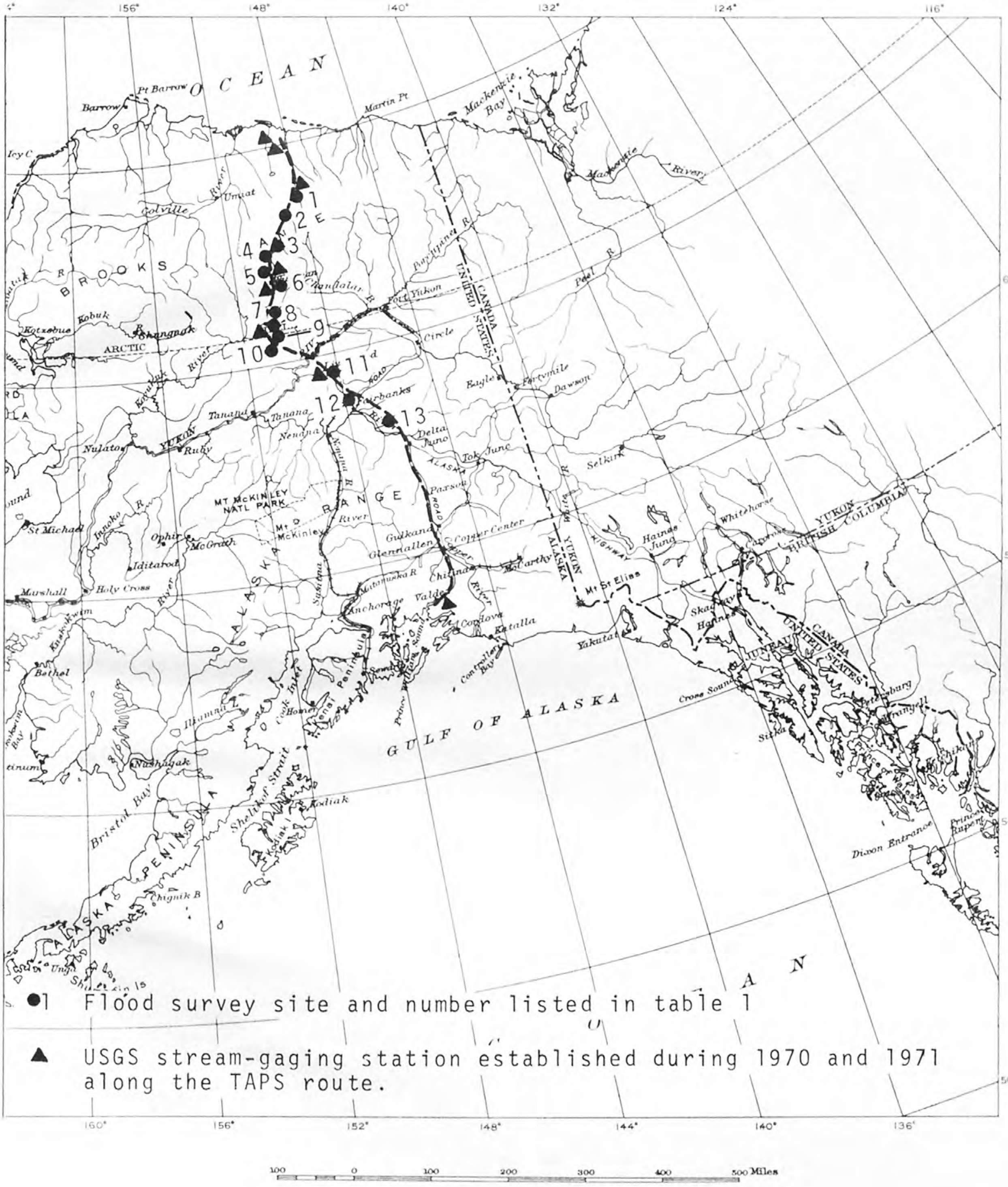



Figure 1.--Flood survey sites along the trans-Alaska pipeline route.

Table 1.--Flood survey results.

| Site no. | Stream name | Location | | Drainage basin characteristics | | | | Flood characteristics | | Bankfull channel characteristics | | | | | Maximum evident flood | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | | Latitude | Longitude | Drainage area $A$ (sq mi) | Basin storage $S_t$ (percent) | Mean annual precipitation $P$ (inches) | Precipitation intensity $I_{24,2}$ (inches) | 2-year flood $Q_2$ (cfs) | 50-year flood $Q_{50}$ (cfs) | Width $W$ (feet) | Mean depth $d$ (feet) | Slope $S$ | Median bed material | Bankfull discharge $Q_B$ (cfs) | Top width (feet) | Discharge (cfs) |
| 1 | Sagavanirktok R near Sagwon | 69°05'15" | 148°45'10" | 2,208 | 0 | 8 | 1.25 | 11,600 | 22,500 | 540 | 7.94 | 0.0026 | Small boulders | 35,000 | 560 | 62,000 |
| 2 | Atigun R near Galbraith Lake | 68°22'25" | 149°21'00" | 173 | 0 | 8 | 1.25 | 1,090 | 3,260 | 400 | 5 | 0.001 | Fine gravel | 8,800 | 500 | 12,000 |
| 3 | Snowden C near Dietrich Camp | 67°44'20" | 149°45'00" | 15.6 | 0 | 10 | 1.5 | 160 | 630 | 70 | 1.97 | 0.023 | Large cobbles | 1,200 | 70 | 1,200 |
| 4 | Dietrich R at Bettles R | 67°38'40" | 149°42'50" | 349 | 0 | 8 | 1.5 | 2,240 | 5,500 | 370 | 4.1 | 0.0028 | Small cobbles | 5,700 | 770 | 6,400 |
| 5 | Hammond R near Wiseman | 67°27'50" | 150°01'40" | 244 | 0 | 10 | 1.25 | 1,750 | 5,000 | 592 | 2.0 | 0.0041 | Large cobbles | 5,400 | 592 | 5,400 |
| 6 | Middle Fk Koyukuk R near Wiseman | 67°22'20" | 150°04'45" | 1,426 | 0 | 12 | 1.5 | 10,700 | 21,500 | 300 | 8.33 | 0.0016 | Small cobbles | 16,000 | 1,250 | 20,000 |
| 7 | South Fk Koyukuk R near Wiseman | 67°01'10" | 150°16'40" | 693 | 2 | 12 | 1.25 | 3,900 | 10,000 | 400 | 6.4 | 0.0022 | Coarse gravel | 18,000 | 550 | 38,000 |
| 8 | Jim R near Prospect C Camp | 66°53'00" | 150°30'00" | 236 | 0 | 12 | 1.5 | 2,120 | 5,600 | 280 | 3.5 | 0.0045 | Coarse gravel | 5,700 | 500 | 13,000 |
| 9 | Prospect C near Prospect C Camp | 66°46'50" | 150°40'30" | 113 | 0 | 8 | 1.25 | 745 | 2,350 | 70 | 5.24 | 0.005 | Coarse gravel | 3,500 | 145 | 6,800 |
| 10 | Kanuti R near Bettles | 66°26'30" | 150°37'30" | 157 | 3 | 8 | 1.25 | 716 | 2,300 | 85 | 5.4 | 0.0004 | Angular small cobbles | 1,200 | 150 | not determined |
| 11 | Hess C near Livengood | 65°40'30" | 149°04'20" | 491 | 0 | 12 | 1.0 | 3,280 | 9,600 | 190 | 5.8 | 0.0022 | Coarse gravel | 8,100 | 190 | 8,100 |
| 12 | Chatanika R near Olnes | 65°03'41" | 147°48'39" | 578 | 0 | 12 | 1.25 | 4,290 | 10,900 | 117 | 7.12 | .0017 | Coarse gravel | 4,400 | 2,500 | * 25,000 |
| 13 | Salcha R near Salchaket | 64°28'22" | 146°55'26" | 2,170 | 2 | 12 | 1.6 | 12,400 | 23,300 | 360 | 11.7 | 0.0013 | Coarse gravel | 33,000 | 4,260 | * 97,000 |

* Occurred in August 1967.