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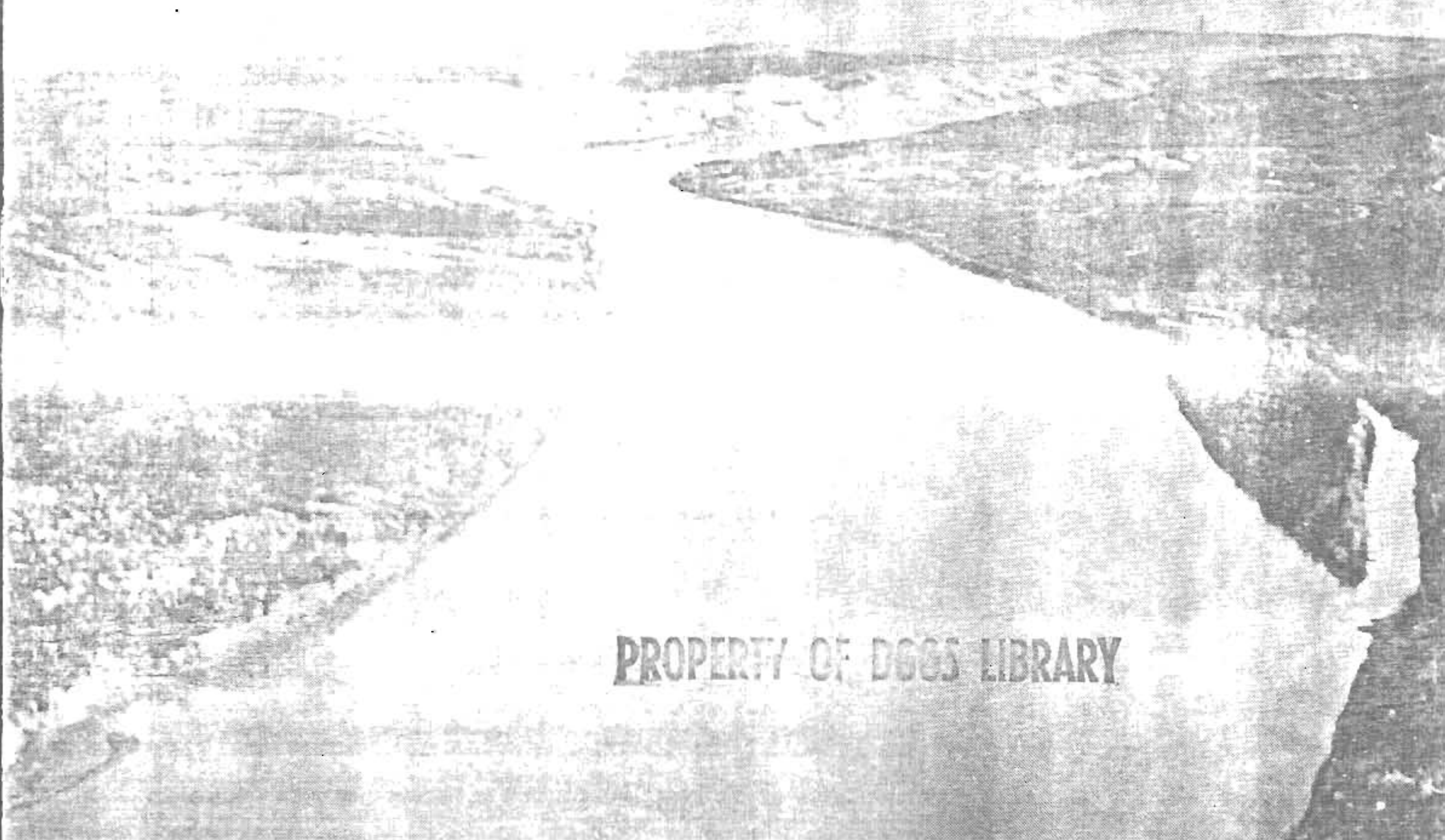



# FLOOD SURVEY AT PROPOSED TAPS CROSSING OF YUKON RIVER NEAR STEVENS VILLAGE, ALASKA

UNITED STATES DEPARTMENT OF THE INTERIOR
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# FLOOD SURVEY AT PROPOSED TAPS CROSSING OF YUKON RIVER NEAR STEVENS VILLAGE, ALASKA

By

Joseph M. Childers and Robert D. Lamke

OPEN-FILE REPORT

Anchorage, Alaska
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## INTRODUCTION

The U.S. Geological Survey has a threefold responsibility along the proposed route of the trans-Alaska pipeline: 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 vitally needed to aid in the design and management of the pipeline and associated facilities. This report presents a description of a flood survey and a hydraulic analysis at the proposed pipeline and highway bridge crossing of the Yukon River.

Basic data and computations supporting the information presented in this report are in the files of the U.S. Geological Survey, Water Resources Division, Anchorage, Alaska. This report has been prepared under the general supervision of Harry Hulsing, district chief.

## OBJECTIVES

The Department of the Interior has stipulated that the proposed pipeline must be designed to accommodate a design flood based on the concept of the 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). However, the 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 because records are too few and short.

One purpose of this study was to estimate the peak discharge of the Maximum Evident Flood at the proposed Yukon River crossing. The computed Maximum Evident Flood may be used to help judge the reasonableness of the design flood. Another purpose of the study was to present data on channel hydraulic features at the proposed crossing. Bankfull channel dimensions may also be useful in ascertaining streamflow characteristics (Wolman and Leopold, 1957; Emmett, 1972).

The third purpose of this report is to present the stage-discharge relation for the proposed crossing. The relation can be used to estimate the water-surface elevation for any discharge (within the range of definition) at the proposed crossing.

## SITE DESCRIPTION

The proposed crossing of the Yukon River is located about 4 miles (6 km [kilometers]) upstream from the Ray River, about 1 mile (2 km) downstream from the end of the TAPS road, about 25 miles (40 km) downstream from Stevens Village, and about 100 miles (160 km) northwest of Fairbanks (fig. 1). The Yukon River flows westward in an incised channel past the proposed crossing. Looking downstream the left (south) bank is steep and high with no flood plain. The right (north) bank is a fairly level flood plain about one-half mile (800 m [meters]) wide. The channel widths shown on the U.S. Geological Survey topographic map,

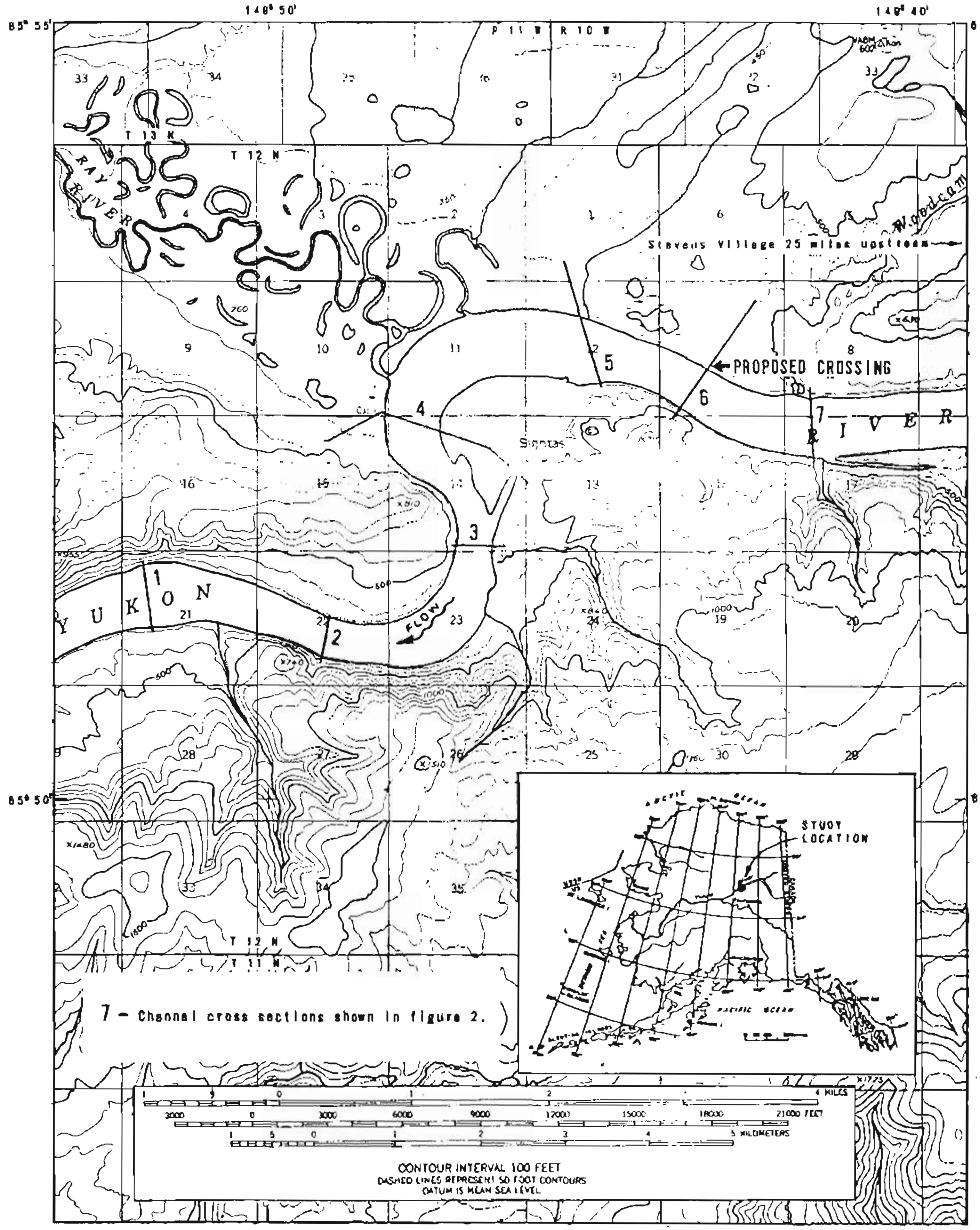


Figure 1.-- Location for proposed TAPS crossing of Yukon River near Stevens Village.

Livengood D-6 quadrangle (scale, 1:63,360), range from about 2,000 feet (600 m) at the proposed crossing to 3,000 feet (900 m) near the Ray River mouth and to 1,300 feet (400 m) at a constriction about 1 mile (1,600 m) downstream from the Ray River. Channel slope was estimated as 0.00013 by dividing the contour inverval (100 feet [30 m]) by the river distance between adjacent contours (147 miles or 780,000 feet [237 km]). All elevations are to datum established by the State of Alaska, Department of Highways.

## PRIOR INFORMATION

A discharge measurement of 19,500 $ft^3/s$ (550 $m^3/s$) was made April 27, 1970, under ice cover near the proposed crossing of the Yukon River. Four channel cross sections were surveyed with a boat and recording fathometer in June 1970.

The nearest stream-gaging station on the Yukon River was located at Rampart about 55 river miles (88 km) downstream from the proposed crossing. Twelve years of continuous discharge records are available for the Yukon River at Rampart (U.S. Geol. Survey Water-Supply Papers 1486, 1500, 1570, 1640, 1720, 1936, and Water Resources Data for Alaska 1966, 1967).

The U.S. Army, Corps of Engineers has evaluated a design flood for the proposed Rampart Canyon Project. The Standard Project Flood for Rampart is 1,600,000 $ft^3/s$ (45,300 $m^3/s$) (U.S. Army, Corps of Engineers, 1971).

## METHODS OF STUDY

The stage-discharge relation is most reliably defined using current-meter discharge measurements and corresponding gage heights (water stages) at a sufficient number of points to define the entire range of the relation. A primary goal of this Yukon River crossing study, though, was establishing the flood discharge range up to the Standard Project Flood. Current-meter measurements of discharge during floods are not always possible. Instead, water-surface profiles can be computed for selected flood discharges using the step-backwater method (Anderson and Anderson, 1964).

A channel survey to obtain the data for computation of the stage-discharge relation at the proposed crossing was made in September 1972. A transit-stadia traverse and direct levels were used to survey the cross sections above the water surface. A 24-foot (7 m) riverboat equipped with a recording fathometer and current-meter discharge measuring equipment was used in surveying the cross sections below the water surface. Horizontal location along the cross sections on the river was determined by triangulation from a base line set on shore, using a sextant. The boat was kept on line by sighting along range lines defined by two on-shore markers set for each cross section.

In September 1972, a discharge of 187,000 $ft^3/s$ (5,300 $m^3/s$) was measured at the proposed crossing. In June 1973, a field trip was made to the proposed crossing site to measure discharge and determine the water-surface profile for the discharge measured during the high flows from snow-melt. This discharge, 630,000 $ft^3/s$ (17,800 $m^3/s$), and the 1972 measurement at 187,000 $ft^3/s$ (5,300 $m^3/s$) define the medium discharge range of the stage-discharge relation. Elevations of bankfull stage and of high-water marks, mainly driftwood and other vegetal debris deposited on the flood plain by the Maximum Evident Flood, were determined. The cross sections were resurveyed to determine any streambed changes due to scour or fill during high discharge. A search of the channel banks downstream and upstream from the proposed crossing was made to find ice scour evidence.

The floodway has an unvegetated main channel bounded either by steep bedrock banks or by grassy or brushy sloping banks. Overbank areas are covered with trees, brush, or muskeg. The most distinctive features of the floodway 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 the flood-plain surface (Leopold and Skibitzke, 1967) and the edge of the mature flood-plain forest (Sigafoos, 1964).

## RESULTS

The channel cross sections are shown in figure 2 (locations are shown in fig. 1). The bankfull stage and the elevation of the Maximum Evident Flood were found to coincide and are shown on the cross sections. The elevation of the Standard Project Flood is also shown.

The Maximum Evident Flood at the proposed crossing, section 6, was determined to be 890,000 $ft^3/s$ (25,200 $m^3/s$) at an elevation of 301 feet (92 m). The Standard Project Flood (or design flood), at 1,600,000 $ft^3/s$ (45,300 $m^3/s$), will reach an elevation of 322 feet (98 m) at the proposed crossing.

The discharges or stages given above were determined from the stage-discharge relation (fig. 3) which is defined by two current-meter measurements and step-backwater computations. The assumptions inherent in step-backwater computations and the coefficients selected were verified by close agreement between the water-surface profiles as computed and as observed when a discharge of 630,000 $ft^3/s$ (17,800 $m^3/s$) was measured.

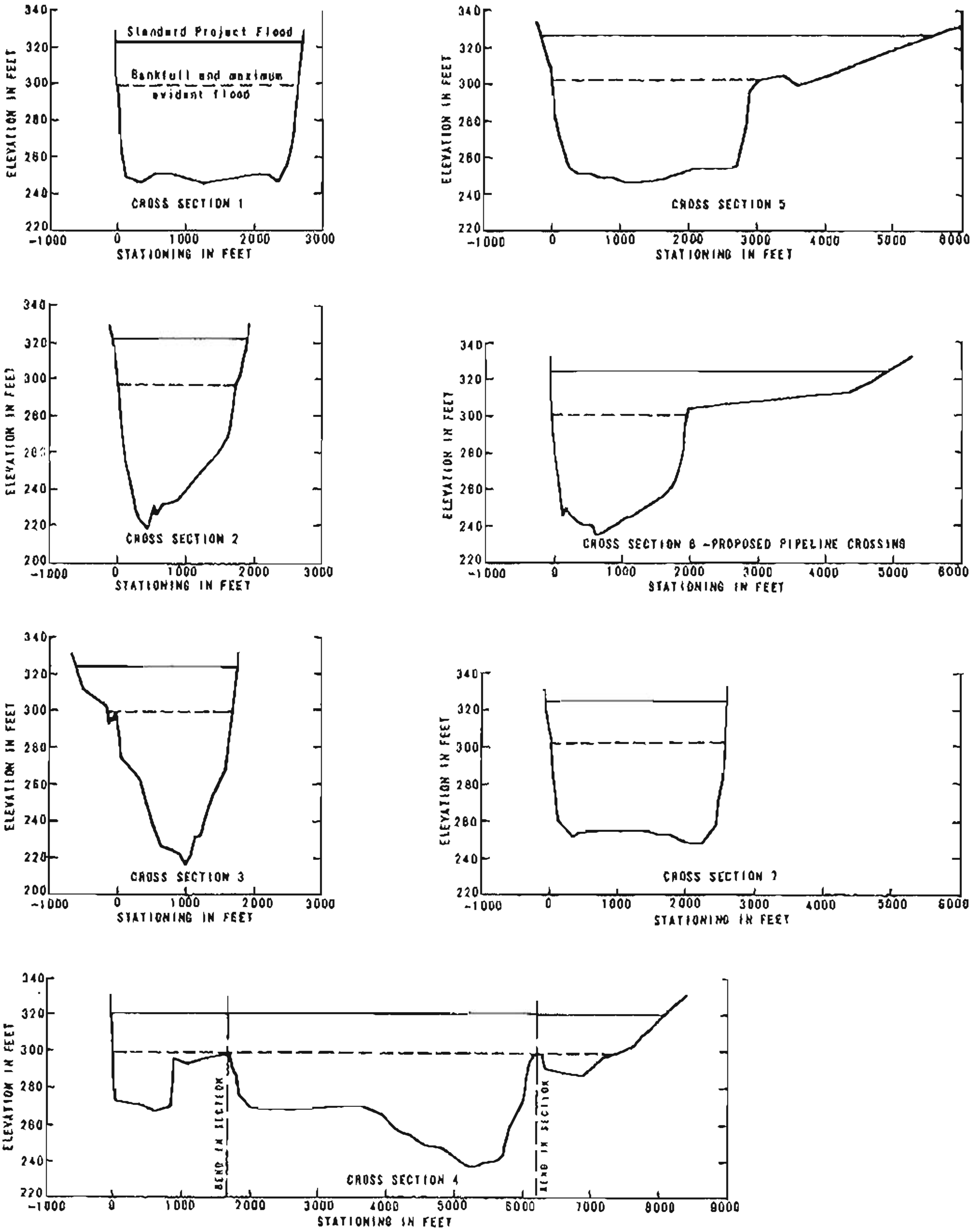


Figure 2.-- Channel cross sections, Yukon River near Stevens Village, September 1972. (Looking downstream)

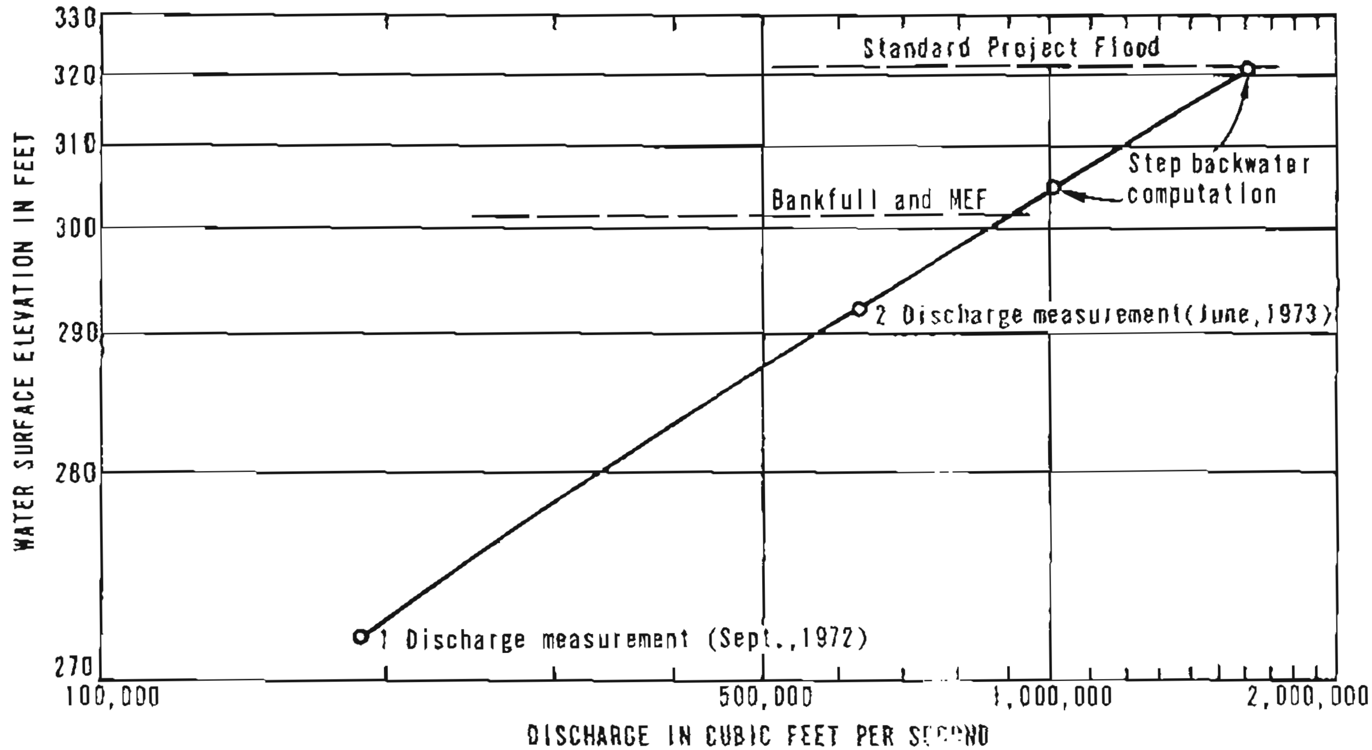


Figure 3.-- Stage discharge relation, Yukon River at proposed crossing near Stevens Village.

Several hydraulic properties at the proposed crossing are given in table 1.

Table 1.--*Hydraulic properties at proposed crossing.*

| Stage | Water surface elevation (ft) | Discharge ($ft^3/s$) | Main channel | | |
|---|---|---|---|---|---|
| | | | Area ($ft^2$) | Mean velocity (ft/s) | Manning's "n" |
| Highest measurement | 293 | 630,000 | 81,700 | 7.7 | 0.025 |
| Bankfull & Maximum Evident Flood | 301 | 890,000 | 99,000 | 9.0 | .025 |
| Standard Project Flood[a/] | 322 | 1,600,000 | 140,000 | 11.1[a/] | .024 |
| Standard Project Flood[b/] | 322 | 1,600,000 | 140,000 | 11.4 | .024 |

a/ Without bridge and road. Discharge in main channel estimated as 1,556,000 $ft^3/s$.

b/ With bridge and road.

NOTE: Backwater at section 7 caused by the bridge and roadway was computed as 0.35 foot (0.10 m). All flow is assumed to be in channel under bridge.

The reliability of the results given so far depends upon many factors. The streamflow record at Rampart is short, only 12 years, and the stage-discharge relation there has only fair definition at the high-water end. This record was used in the determination of the Standard Project Flood and the stage-discharge relation for initial input to the step-backwater computations.

The large expansion of the channel near the mouth of the Ray River and the two bends greater than 90 degrees in the studied reach are not ideal conditions for reliable step-backwater computations. Without discharge measurements for flows greater than 630,000 $ft^3/s$ (17,800 $m^3/s$), the extrapolation to conditions for the design flood is subject to question. However, other reasonable interpretations of the base data show that the chances are about equal that the design flood stage at the proposed crossing could be higher or lower than the 322 feet (98 m) computed.

The flood magnitude and frequency relation at the proposed crossing is probably similar to that for the Yukon River at Rampart because there is little intervening flood-flow and probably little attenuation of flood peak discharges because of channel storage between the two places. Since no historical flood peak discharge records are available at the proposed crossing, the flood magnitude frequency relations for the Yukon River at Rampart are presented in figure 4. The records are very short and extrapolation of the relation is not recommended beyond about 25 years.

No ice-jam evidence was found. However, scars were noted on trees at about elevation 301 feet (92 m) on the right bank at section 5. This closely coincides with the Maximum Evident Flood stage. Downstream at Rampart the maximum ice-jam stage known was 8.7 feet (2.6 m) higher than the maximum known open-water stage. Upstream at Stevens Village the highest known stage occurred in June 1964 during open water.

The cross sections resurveyed in June 1973 showed no significant scour or fill at the higher flow.

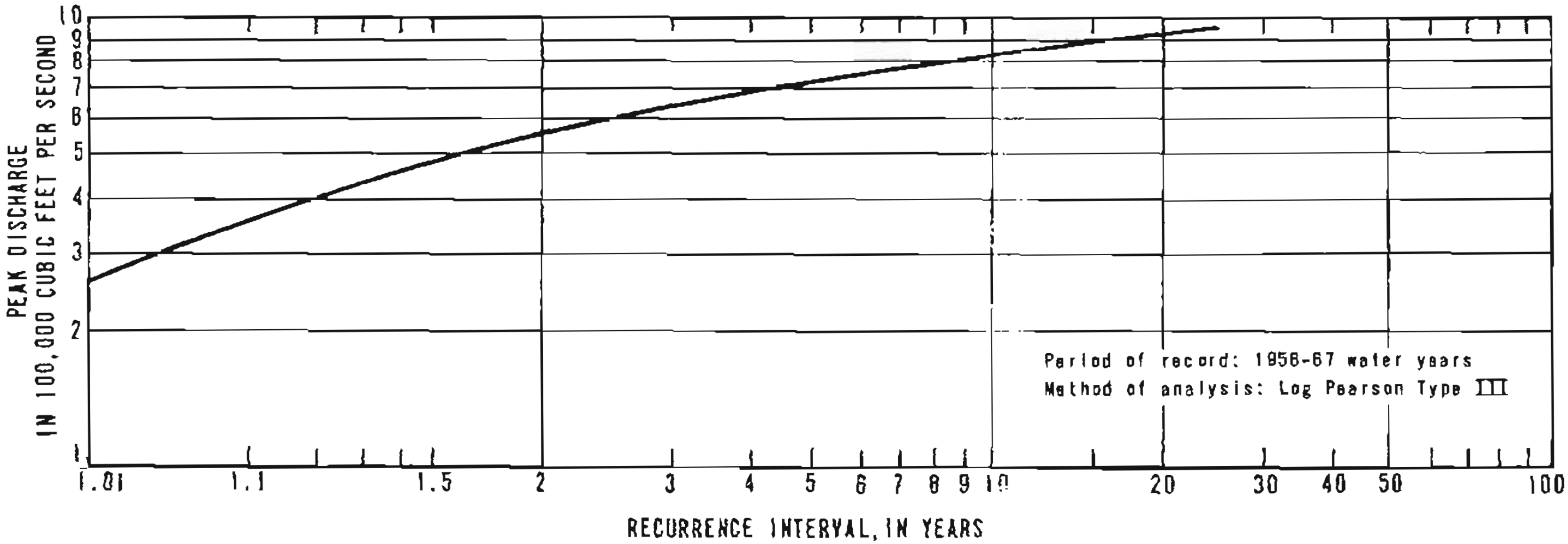


Figure 4.-- Flood magnitude-frequency relation, Yukon River at Rampart.

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## APPENDIX

### FACTORS FOR CONVERTING ENGLISH UNITS TO INTERNATIONAL SYSTEM (SI) UNITS

| Multiply English units | By | To obtain SI units |
|---|---|---|
| feet (ft) | .3048 | meters (m) |
| miles (mi) | 1.609 | kilometers (km) |
| square miles ($mi^2$) | 2.590 | square kilometers ($km^2$) |
| cubic feet per second ($ft^3/s$) | .02832 | cubic meters per second ($m^3/s$) |