U.S. DEPARTMENT OF THE INTERIOR
U.S. GEOLOGICAL SURVEY

Prepared in cooperation with the
FORT PECK TRIBES

WATER-RESOURCES INVESTIGATIONS REPORT 90-4169
(Sheet 1 of 2)

Figure 2.--Discharge-frequency relation, Poplar River near Poplar.

Figure 3.--Cross section 17. The cross section is typical of channel and flood-plain conditions in the downstream reach of the study area.

Figure 4.--Cross section 48. The cross section is typical of channel and flood-plain conditions in the upstream reach of the study area.
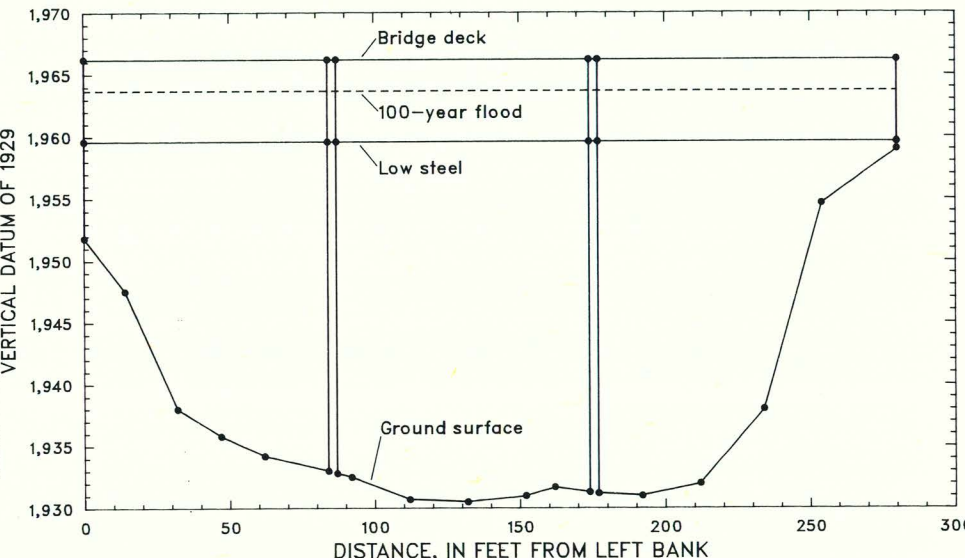

Figure 5.--Cross section 8. The cross section is typical of channel conditions at bridges.
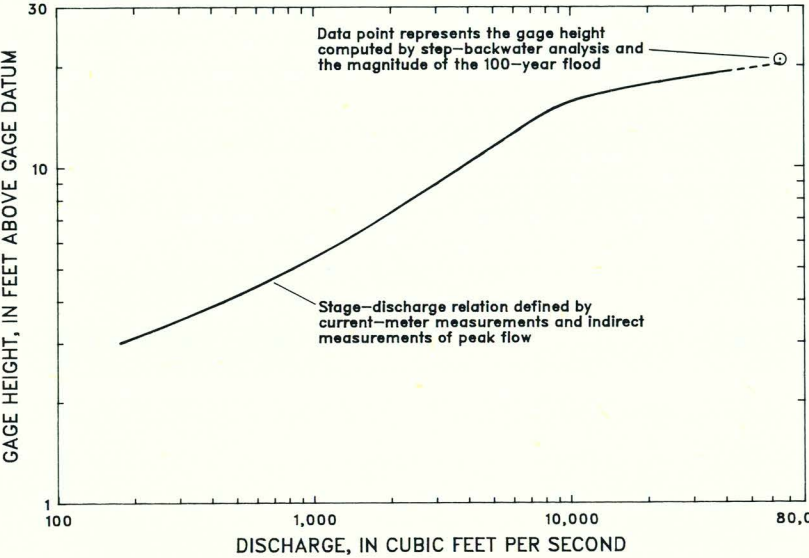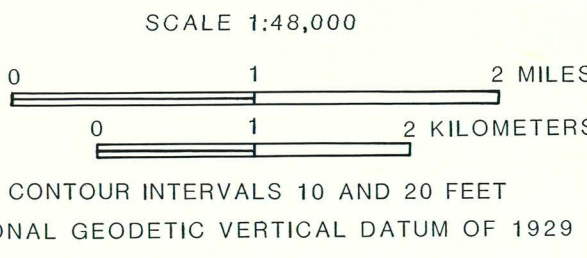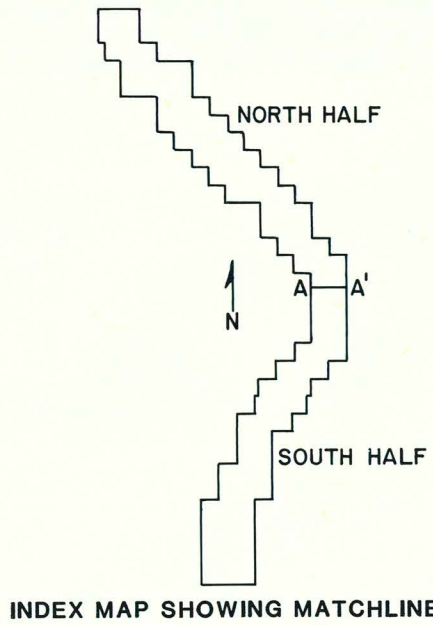

Figure 6.--Stage-discharge relation at streamflow-gaging station, Poplar River near Poplar (station 06181000).

EXPLANATION

- AREA THAT WILL BE INUNDATED BY THE 100-YEAR FLOOD--Centerline connects the centroids of flow of water at cross sections during the 100-year flood
- 16 CROSS SECTION AND NUMBER
- A—A' MATCHLINE--Line separating north and south halves of the study area
- 06181000 STREAMFLOW–GAGING STATION AND NUMBER
- RM7 ✕ ELEVATION REFERENCE MARK AND DESIGNATION

INDEX MAP SHOWING MATCHLINE

MAP SHOWING FLOOD-PLAIN BOUNDARIES, LOCATION OF CROSS SECTIONS, AND LOCATION OF ELEVATION REFERENCE MARKS

ENLARGED VIEW SHOWN AT RIGHT

ENLARGED VIEW OF AREA WEST OF POPLAR

SCALE 1:48,000
CONTOUR INTERVALS 10 AND 20 FEET
NATIONAL GEODETIC VERTICAL DATUM OF 1929

Base from U.S. Geological Survey Badger Creek, 1972; Bredette, 1973; Geddart Lake, 1983; Hay Creek NW, 1983; Long Creek East, 1983; Poplar, 1972; Poplar NE, 1972; Windy Butte, 1983; 1:24,000

INTRODUCTION

Areas that would be inundated by a peak discharge with a recurrence interval of 100 years (the 100-year flood) along streams in the Fort Peck Indian Reservation are of interest to the Fort Peck Tribes because of the potential of the land for development. A major concern is flooding along the Poplar River (fig. 1).

One approach to decreasing flood damage is controlling land use adjacent to the river by planned development and management of flood-hazard areas. Delineation of flood-hazard areas will allow selection of a flood risk according to the type of development desired. This study was undertaken to identify areas subject to flooding along the Poplar River, and will assist the Fort Peck Tribes in making decisions concerning sound flood-plain management. The study was conducted in cooperation with the Fort Peck Tribes.

General Description of the Area

The study area includes the Poplar River from the mouth of the West Fork downstream to the mouth near the town of Poplar. The Poplar River flows southerly from Saskatchewan, Canada, through part of northeastern Montana and joins the Missouri River about 65 mi south of the international boundary. The Poplar River basin, which is sparsely populated, consists of gently rolling hills and broad, flat valleys. The land surface has little relief, with elevations ranging from 1,930 to 2,310 ft.

The climate is typical of the northern plains, with hot, moderately dry summers and cold, dry winters. Mean daily temperatures at Poplar range from 88 °F in July to –4 °F in January. Average annual precipitation is about 13 in.; more than 9 in. of the total is received from May through September. June is the wettest month, with an average of about 3 in. of precipitation, and December the driest, with an average of 0.3 in. (U.S. Environmental Data Service, 1971, p. 10).

Streamflow Conditions and Flooding

The Poplar River has perennial flow, whereas all tributaries that enter the river are intermittent or ephemeral. Most runoff results from snowmelt in the spring and rainfall from thunderstorms during the summer. Occasionally, late snowmelt and rain combine to cause runoff.

The Poplar River is affected by ice during winter and ice jams during spring breakup. The elevation of maximum observed ice-affected stage at the streamflow-gaging station for the period of record (intermittently 1909-88) was 1,969.1 ft in 1955. An ice-affected stage of 1,968.4 ft was observed in 1986.

Flow is partly regulated by a dam on the East Fork Poplar River, 2 mi north of the international boundary. This structure has no appreciable effect on the 100-year flood in the study area.

The largest known floods on the Poplar River recorded at the streamflow-gaging station were 40,000 ft³/s on July 10, 1946, and 37,400 ft³/s on April 6, 1954. These floods reached elevations of 1,971.3 and 1,971.1 ft, respectively. Both floods resulted from intense and prolonged rainfall.

Figure 1.--Location of study area.

Purpose and Scope

This report presents the results of hydrologic and hydraulic analysis of the Poplar River. Specific objectives were to determine the water-surface profile and the extent of flooding that would result from the 100-year flood.

The magnitude of the 100-year flood was determined using techniques developed in a report by Omang and others (1986), and using data from an existing U.S. Geological Survey streamflow-gaging station (station 06181000 located 4 mi north of Poplar) on the Poplar River. Forty-five channel and flood-plain cross sections were surveyed and 10 cross sections were synthesized along a 37-mi reach. Physical dimensions of hydraulic structures were measured. Manning's roughness coefficients were determined at each cross section. Field survey data were used to calculate water-surface elevations for the 100-year flood at each cross section. These elevations were used to determine the lateral extent of flooding at that cross section.

METHODS OF ANALYSIS

Standard hydrologic and hydraulic methods were used to analyze the flood hazard for the Poplar River. The magnitude of a flood that is expected to be equaled or exceeded once on the average during any 100-year period (recurrence interval) has been selected as having special significance for flood-plain management. This 100-year flood has a 1-percent chance of being equaled or exceeded in any given year. Although the recurrence interval represents the long-term average period between floods of a specific magnitude, rare floods could occur at shorter intervals or even within the same year. The analyses reported herein reflect flooding potentials based on conditions existing in the community and area at the completion of this study (1989).

Hydrologic Analysis

Hydrologic analysis was used to determine the magnitude of the 100-year flood for the Poplar River. Flood-discharge values are based on a statistical analysis of discharge records at the streamflow-gaging station. Thirty-seven years of peak-flow records are available at this station: 1909, 1915, 1921, 1923, 1946, 1948-63, 1965-69, 1975-79, 1982-87. Additional historical data were included in the analysis to effectively extend the period of flood record to 80 years. The peak flow of 1946 (40,000 ft³/s) was considered to be the largest flow since 1908. The recorded floods and historical data were analyzed by the standard log-Pearson type III method as described by the U.S. Water Resources Council (1981). The relation between peak discharge and recurrence interval is presented in figure 2. The 100-year peak discharge for the streamflow-gaging station Poplar River near Poplar is 65,000 ft³/s. The flood discharge at the streamflow-gaging station was transferred from the station to the upstream and of the study using the following transfer equation developed by Omang and others (1986, p. 23).

$$\hat{Q}_t = \left(\frac{Au}{Ag}\right)^{0.53} \cdot Q_t$$

where

$\hat{Q}_t$ = flood magnitude being estimated, in cubic feet per second;

Au = drainage area at ungaged site, in square miles;

Ag = drainage area at gaged site, in square miles;

Q_t = flood magnitude at gaged site, in cubic feet per second.

The transfer method gives reasonably accurate results when the ungaged drainage area does not differ from the gaged drainage area by more than about 50 percent. In the reach analyzed, the drainage area at the upstream end (2,830 mi²) differs from the drainage area at the gaging station (3,174 mi²) by 10.8 percent. The flood-discharge value computed by the transfer method was used from the mouth of the West Fork downstream to cross section 40, then was increased at cross section 39 to the discharge computed at the streamflow-gaging station for the rest of the study reach. The change was made at cross section 39 because of significant tributary inflow from Hay Creek at that location. The results determined by the transfer method are given in table 1.

Hydraulic Analysis

The hydraulic characteristics of the channel cross sections along the Poplar River were analyzed to determine the elevations of the 100-year flood. These elevations were then used as the basis for delineating the width of the flood plain that would be inundated.

Table 1.--Summary of 100-year discharges

Flooding source	Drainage area (square miles)	100-year flood discharge (cubic feet per second)
Poplar River downstream from West Fork to cross section 40	2,830	61,000
Poplar River near Poplar	3,174	65,000

Cross-section data were obtained from field surveys conducted during the summer of 1989. Forty-five cross sections were surveyed and 10 were synthesized. The synthesized cross sections (sections 10, 11, 19, 30, 36, 37, 41, 44, 50, and 53 on the principal map) were estimated from adjacent surveyed sections and topographic maps. Structural geometry and elevations were also obtained for five bridges. Cross sections were located upstream and downstream from the bridges to permit computation of the backwater effects of these structures. Cross sections typical of channel and flood-plain conditions in the upstream and downstream reaches of the study area are shown in figures 3 and 4. A cross section typical of channel conditions at bridges is shown in figure 5.

The roughness of the stream channel affects the elevation of floods. Channel-roughness coefficients (Manning's "n") used in the hydraulic computations were based on engineering judgment of onsite observations of flood-plain areas. Roughness values along the Poplar River range from 0.030 to 0.040 for the main channel and from 0.045 to 0.065 for the overbank channel.

Water-surface elevations for the 100-year flood were computed using a step-backwater computer program (WSPRO) developed by the U.S. Geological Survey for the Federal Highway Administration (Shearman and others, 1986). In this computer program, the surveyed cross sections are used to define the hydraulic characteristics of the channel. The location of each cross section was selected to represent the hydraulic characteristics of a reach, and each section was surveyed to define its shape. The starting water-surface elevation used to compute the 100-year flood profile for the Poplar River at the downstream end of the study area was determined by using a slope-conveyance computation to estimate normal depth. This elevation was converted to the estimated 100-year flood elevation for the Missouri River at Poplar near the same location. The computed elevation for the 100-year flood was converted to the datum used for the streamflow-gaging station and plotted on the stage-discharge relation curve (fig. 6). The stage-discharge relation matches the computed, theoretical water-surface elevation to within 0.4 ft. The close agreement helps to substantiate the hydraulic model used.

WATER-SURFACE PROFILE

The water-surface profile for the 100-year flood (fig. 7) was drawn for the entire reach within the study area. The profile shows the location of the cross sections used in the hydraulic analysis, the computed water-surface elevations, and the streambed elevations.

The hydraulic analyses were based on unobstructed flow. The flood elevations shown on the profile thus are considered to be valid only if hydraulic structures remain unobstructed and do not fail.

For the assumption of gradually varied steady-state flow to be valid within a stream reach, the distance between cross sections needs to be short. However, for the great distance of the Poplar River involved in this study, the cost to survey sufficient cross sections to satisfy the step-backwater computation would have been prohibitive. Therefore, the number of cross sections surveyed for this report is limited. In the future, if additional cross sections are added to the WSPRO computer program for the Poplar River, computed water-surface elevations associated with the estimated peak discharge from a 100-year flood could be subject to change.

All field surveys and elevations are referenced to the National Geodetic Vertical Datum of 1929. The data were tied to a network of control points, and elevation reference marks were established during the field surveys. Locations of reference marks are shown on the principal map and descriptions of the reference marks are given in table 2.

FLOOD BOUNDARIES

The flood boundaries along the stream define an area that would be inundated as a result of the 100-year flood. For this study, the 100-year flood boundaries were delineated using flood elevations determined at each cross section. Between cross sections, where survey data were unavailable, the flood boundaries were interpolated using the contour lines on topographic maps. Some contour lines on the Geddart Lake quadrangle (between cross sections 26 and 30) did not agree with the elevations shown on the surveyed cross sections; these lines were adjusted using field-survey data.

The 100-year flood boundaries are shown on the principal map. Small flood-plain areas within the flood boundaries may lie above the flood elevations, but cannot be shown owing to limitations of the map scale or lack of detailed topographic data.

MAP SHOWING FLOOD-PLAIN BOUNDARIES, LOCATION OF CROSS SECTIONS, AND LOCATION OF ELEVATION REFERENCE MARKS

WATER-SURFACE PROFILE AND FLOOD BOUNDARIES FOR THE COMPUTED 100-YEAR FLOOD, POPLAR RIVER, FORT PECK INDIAN RESERVATION, MONTANA

By
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December 1990