Roughness Characteristics of Natural Channels

By HARRY H. BARNES, JR.

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Color photographs and descriptive data for 50 stream channels for which roughness coefficients have been determined

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Symbols

A	Area of channel cross section
C	Flow-resistance factor
d	Diameter of bed material
h	Water-surface elevation
h_v	Velocity head
h_f	Energy loss due to boundary friction
Δh_v	Upstream velocity head minus the downstream velocity head
k	A coefficient
K	Cross section conveyance
L	Length of reach
n	Coefficient of roughness
Q	Discharge
R	Hydraulic radius
S	Energy gradient
V	Average velocity

ROUGHNESS CHARACTERISTICS OF NATURAL CHANNELS

By Harry H. Barnes, Jr.

Abstract

Color photographs and descriptive data are presented for 50 stream channels for which roughness coefficients have been determined.

All hydraulic computations involving flow in open channels require an evaluation of the roughness characteristics of the channel. In the absence of a satisfactory quantitative procedure this evaluation remains chiefly an art. The ability to evaluate roughness coefficients must be developed through experience. One means of gaining this experience is by examining and becoming acquainted with the appearance of some typical channels whose roughness coefficients are known.

The photographs and data contained in this report represent a wide range of channel conditions. Familiarity with the appearance, geometry, and roughness characteristics of these channels will improve the engineer's ability to select roughness coefficients for other channels.

INTRODUCTION

The principal objective of this report is to present descriptive data and photographs for 50 different stream channels for which roughness coefficients have been determined. This information, which has been accumulated by the U.S. Geological Survey during the past 15 years, was previously available only in a photographic slide library in three-dimensional color. Numerous requests for copies of the slides from organizations and private individuals led to the justification for the present report.

All hydraulic computations involving flow in open channels require an evaluation of the roughness characteristics of the channel. At the present state of knowledge, the selection of roughness coefficients for natural channels remains chiefly an art. There are no resistance diagrams or quantitative relationships available similar to those used for steady flow in uniform pipes or for the frictional resistance of ships. Consequently the ability to evaluate roughness coefficients for natural channels representing a wide range of conditions must be developed through experience.

The experience necessary for the proper selection of roughness coefficients can be obtained in several ways, namely (1) to understand the factors that affect the value of the roughness coefficient, and thus acquire a basic knowledge of the problem, (2) to consult a table of typical roughness coefficients for channels of various types (Woodward and Posey, 1941), and (3) to examine and become acquainted with the appearance of some typical channels whose roughness coefficients are known.

Photographs of channels of known resistance are thus useful in estimating the roughness characteristics of similar channels. The photographs and data presented in this report cover a wide range in conditions. Familiarity with the geometry, appearance, and roughness characteristics of these channels will improve the engineer's ability to select roughness coefficients for other channels.

To the untrained beginner, the selection of a roughness coefficient can be no more than a guess, and different individuals obtain different results. Furthermore, it is sometimes difficult to convince either the layman or the scientist that consistently reliable roughness coefficients can be selected by trained engineers on the basis of sound judgment and experience. Fortunately, even though the selection of the coefficients is classified as an art, the accuracy of many selections can be evaluated in exact engineering or statistical terms.

The ability to evaluate the roughness characteristics of channels is important in the hydraulic work of the U.S. Geological Survey. This ability, for example, is involved in the

methods (Benson and Dalrymple, 1966; Dalrymple and Benson, 1966; Bodhaine, 1966; Matthai, 1966; Hulsing, 1966) which are used in defining the peak discharge of most major floods. For this reason the Survey maintains a program which both trains young engineers in the evaluation of channel roughness and tests the accuracy of roughness coefficients by veteran engineers. The results of these tests as reported by Bailey and Ray (1966) indicate that trained engineers can select roughness coefficients with an accuracy of plus or minus 15 percent under most conditions. These facts prove that present methods are sound but that there is much room for improvement. A quantitative procedure for determining the roughness characteristics of channels has been the goal of research in the Survey and in other organizations for many years, but as yet little practical success has been achieved.

ACKNOWLEDGMENTS

Data contained in this report represent contributions by many engineers of the U.S. Geological Survey. Much credit is due Hollister Johnson and Tate Dalrymple who conceived and promoted the Survey's program to verify roughness coefficients in natural channels.

The author gratefully acknowledges the advice and assistance of R. W. Carter, W. R. Stokes, E. D. Cobb, and R. E. Smith.

SCOPE OF REPORT

Information on the geometry and roughness characteristics of 50 different stream channels is presented in the report. All of the stream channels are considered to be stable. Sand-channel streams were not included in the report because roughness coefficients for streams of this type have been defined in terms of size of bed material and other variables (Simons and Richardson, 1962).

The 50 sites include a wide range of hydraulic conditions from the boulder-strewn mountain stream of the western conterminous United States to the heavily vegetated flat-sloped stream of the southern conterminous United States.

The techniques used in field investigations at each site are first discussed in the report. The procedures used in computing the value of the roughness coefficient are then described. The remainder of the report consists of the presentation of a set of data and photographs for each of the 50 sites.

FIELD INVESTIGATION

Sites were selected for study after a major flood had occurred in a given region. Each site met the following criteria:

1. The peak discharge of the flood was measured by the current-meter method, or determined from a well-defined stage-discharge relation;
2. Good high-water marks were available to define the water-surface profile at the time of the peak;
3. A fairly uniform reach of channel was available near the gage;
4. The flood discharge was within the channel banks—that is, extensive flow in flood plains did not exist.

A transit-stadia survey of each reach was completed shortly after the flood. The necessary information was obtained in this survey to plot accurately to a common datum (1) the water-surface profile as represented by high-water marks, (2) a plan view of the reach, (3) cross sections at intervals along the reach. Surveying techniques used in this investigation are described in detail by Benson and Dalrymple (1966).

Photographs of the reach were taken during the time of the survey. The photographs shown in this report thus represent conditions in the reach immediately after the flood.

A size description of the bed material at most of the sites was determined by sampling methods (Wolman, 1954). These samples were in general taken several years after the flood for which the roughness coefficient was determined. The samples may or may not be representative of the bed material at the time of the peak. Frequency distributions of bed-material size were determined by sieve analysis where the medium size of the material was less than 50 mm and, where the material was too large to sieve, by measuring the intermediate axis of particles selected at random from the bed surface.

COMPUTATION OF REACH PROPERTIES AND ROUGHNESS COEFFICIENTS

Formulas

Most open-channel flow formulas can be expressed in the following general terms,

$$Q = C\ A\ R^x\ S^y \tag{1}$$

where Q is the discharge, in cubic feet per second; C is a factor of flow resistance; A is the cross-sectional area of the channel, in square feet; R is the hydraulic radius, in feet; and S is the energy gradient. The Manning equation, one of the well-known variations of equation 1, was used as the basis for computing the reach properties and roughness coefficients given in this report. The Manning equation is

$$Q = \frac{1.486}{n} AR^{2/3}\ S^{1/2} \tag{2}$$

where n is a roughness coefficient and other variables in the equation are as defined above.

The Manning equation was developed for conditions of uniform flow in which the water-surface profile and energy gradient are parallel to the streambed, and the area, hydraulic radius, and depth remain constant throughout the reach. For lack of a better solution, it is assumed that the equation is also valid for nonuniform reaches, invariably found in natural channels, if the energy gradient is modified to reflect only the losses due to boundary friction. The energy equation for a reach of nonuniform channel between sections 1 and 2 in figure 1 is (see p. 9)

$$(h+h_v)_1 = (h+h_v)_2 + (h_f)_{1.2} + k(\Delta h_v)_{1.2} \tag{3}$$

where

h = elevation of the water surface at the respective sections above a common datum;
h_v = velocity head at the respective section $= \alpha V^2/2g$;
h_f = energy loss due to boundary friction in the reach;

Δh_v = upstream velocity head minus the downstream velocity head;

$k(\Delta h_v)$ = energy loss due to acceleration of velocity or deceleration of velocity in a contracting or expanding reach; and

k = a coefficient taken to be zero for contracting reaches and 0.5 for expanding reaches.

In computing the values of n listed in this report the value of α, the velocity head coefficient, was always considered to be 1.00.

The friction slope S to be used in the Manning equation is thus defined as

$$S=\frac{h_f}{L}=\frac{\Delta h+\Delta h_v-k(\Delta h_v)}{L} \tag{4}$$

where Δh is the difference in water-surface elevation at the two sections and L is the length of the reach.

In using the Manning equation the quantity $(1.486/n)AR^{2/3}$, called conveyance and designated K, is computed for each cross section. The mean conveyance in the reach between any two sections is computed as the geometric mean of the conveyance of the two sections. The discharge equation in terms of conveyance is

$$Q=\sqrt{K_1K_2\,S} \tag{5}$$

where S is the friction slope as previously defined.

In this investigation the average value of the Manning n was computed for each reach from the known discharge, the water-surface profile, and the hydraulic properties of the reach as defined by 2–17 cross sections. The following equation, which is based on the same concepts and definitions as equations 2–5, was used in these computations. The equation is applicable to a multisection reach of M cross sections which are designated 1, 2, 3, . . . $M-1$, M.

$$n=\frac{1.486}{Q}\sqrt{\frac{(h+hv)_1-(h+hv)_M-[(k\,\Delta hv)_{1.2}+(k\,\Delta hv)_{2.3}+\ldots+(k\,\Delta hv)_{(M-1).M}]}{\frac{L_{1.2}}{Z_1Z_2}+\frac{L_{2.3}}{Z_2Z_3}+\ldots+\frac{L_{(M-1).M}}{Z_{(M-1)}Z_M}}} \tag{6}$$

where $Z = AR^{2/3}$ and other quantities are as previously defined.

Computation Procedure

A planimetric map of each reach was developed by plotting from the notes of the field survey. The location of all high-water marks and cross sections was shown on the map. The distances between cross sections were determined from the map.

The profile of the water surface through the reach was developed separately along each bank by plotting the elevation and stationing of high-water marks. The water-surface elevation at each cross section was determined as the average of the water-surface elevation on each bank as taken from the water-surface profiles.

Cross sections were plotted from the field notes, and data on stationing, distance, ground elevations, depths, and top widths were tabulated. The area and wetted perimeter for each panel between given ground elevations were computed. The area, wetted perimeter, and hydraulic radius for each cross section were determined, and values of $AR^{2/3}$ were computed.

The average value of n for each reach was then determined by substituting the proper quantities in equation 6.

The computation procedure is virtually the same as for computation of discharge by the slope-area method. This procedure is described in detail by Dalrymple and Benson (1966).

APPLICATION OF ROUGHNESS COEFFICIENTS

The values of n presented in the report are intended for use in the Manning equation

$$V = \frac{1.486}{n} R^{2/3} S^{1/2} \qquad \text{(English units)}$$

or

$$V = \frac{R^{2/3} S^{1/2}}{n} \qquad \text{(metric units)}$$

The value of n may be converted to values of the Chezy C by the relation

$$C = \frac{1.486 R^{1/6}}{n} \qquad \text{(English units)}$$

and the value of C may then be used in the Chezy equation

$$V = C\sqrt{RS}$$

All these equations are limited to turbulent flow in fully rough channels. Flow in natural channels normally meets this criterion.

PRESENTATION OF INFORMATION

A four-page set consisting of channel data, plan sketches (not to scale) and cross sections, and photographs, is presented for each reach in the following section of the report. Each set of data is identified by the permanent gaging-station number and name used by the U.S. Geological Survey in publication of streamflow-records.

The data tabulation shows the location of the gage and a reference cross section, the drainage area of the stream, the date of the flood, the peak gage height at the gage and at section 1 during the flood, the peak discharge measured by current-meter method, the computed roughness coefficient for the reach, a general description of the channel, the median bed-material size, d_{50}, and the reference size for which 84 percent of the bed material is finer, d_{84}. The area, top width, mean depth (area/top width), hydraulic radius, and mean velocity corresponding to the water-surface elevation at the time of the peak are listed for each cross section. The distance or length between cross sections and the fall in water surface between cross sections are also shown. Information for two or more peak discharges is available at some sites. These data are listed according to the magnitude of discharge. Data corresponding to the largest discharge appear first.

At several sites a small percentage of the flow occurred in the shallow flood plain adjacent to the main channel. For each of these sites the data and computations reflect the flow of the main channel.

Data for the site, Rolling Fork at Boston, Ky., are unique in that roughness coefficients were computed for both the overflow plain and the main channel.

Two color photographs taken immediately after the flood are shown for each reach. The position of the camera and the

number of the picture are shown on the plan sketch by a pointer, which shows the direction in which the camera was pointed. The water level at the time of the peak is indicated in some of the photographs by a horizontal rod or tape.

The initial station for cross sections is at the left bank. Plots are arranged so that the left bank appears on the reader's left. The water levels shown on the cross sections correspond to the water-surface profile at the time of the peak as defined by high-water marks.

Sites are arranged according to the value of the computed roughness coefficient, in ascending order.

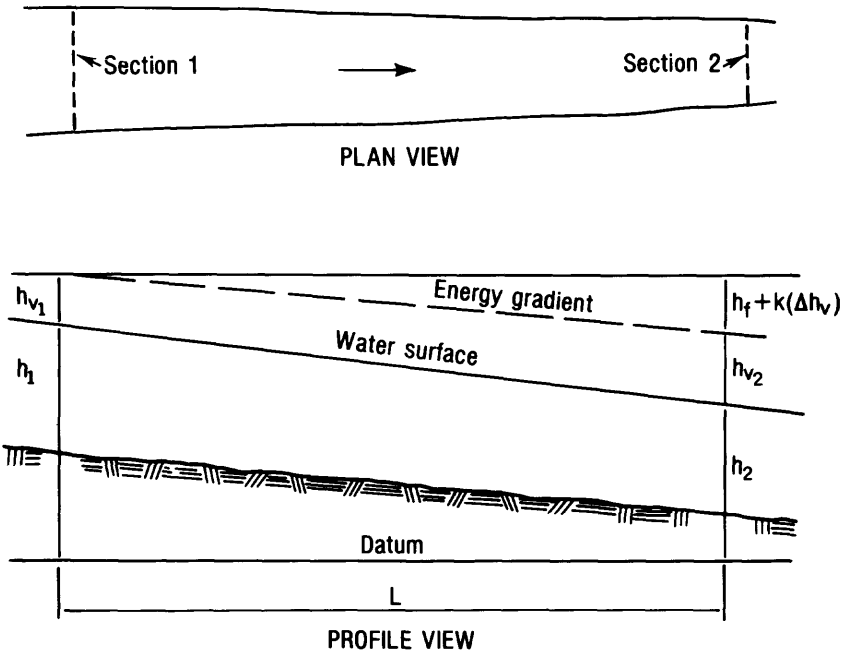


Figure 1. — Definition sketch of a slope-area reach.

12–4645. Columbia River at Vernita, Wash.

Gage location.—In sec. 11, T. 13 N., R. 24 E., at the Richmond ferry site, 0.5 mile north of Vernita station. Gage presently operated 50 miles upstream for station called Columbia River at Trinidad, Wash. Section 1 is 5,000 ft upstream from cableway at Vernita gage.

Drainage area.—89,700 sq mi, approximately.

Date of flood.—May 22, 1949.

Gage height.—48.33 ft at Trinidad gage; 29.5 ft (different datum) at section 1.

Peak discharge.—406,000 cfs.

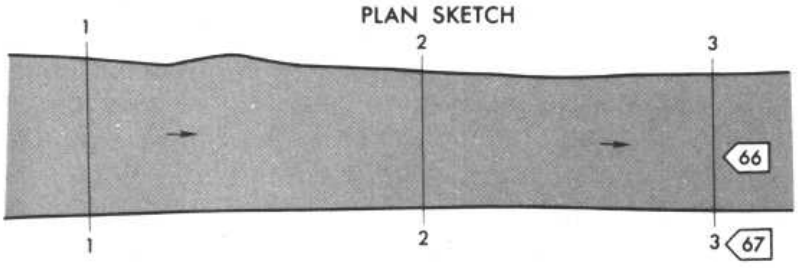
Computed roughness coefficient.—Manning $n = 0.024$.

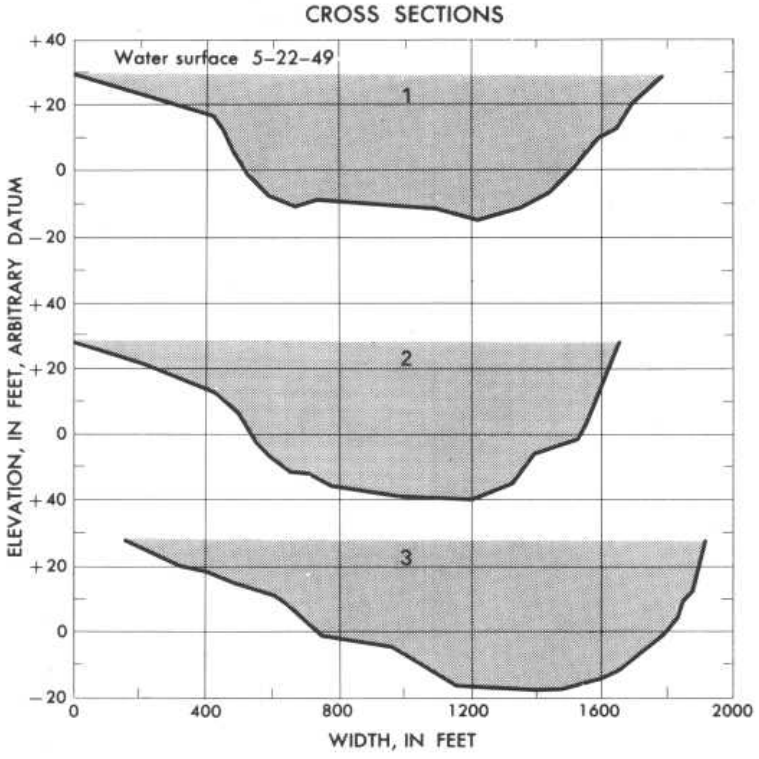
Description of channel.—Bed consists of slime-covered cobbles and gravel. The straight and steep left bank is composed of cemented cobbles and gravel. The gently sloping right bank consists of cobbles set in gravel and is free of vegetation.

Reach properties

Section	Area (sq ft)	Top width (ft)	Mean depth (ft)	Hydraulic radius (ft)	Mean velocity (ft per sec)	Length (ft) between sections	Fall (ft) between sections
1	47,100	1,800	26.2	26.16	8.65	.....	.....
2	49,000	1,650	29.7	29.56	8.28	2,500	0.48
3	49,600	1,760	28.2	28.10	8.17	2,500	.49

Notes.—



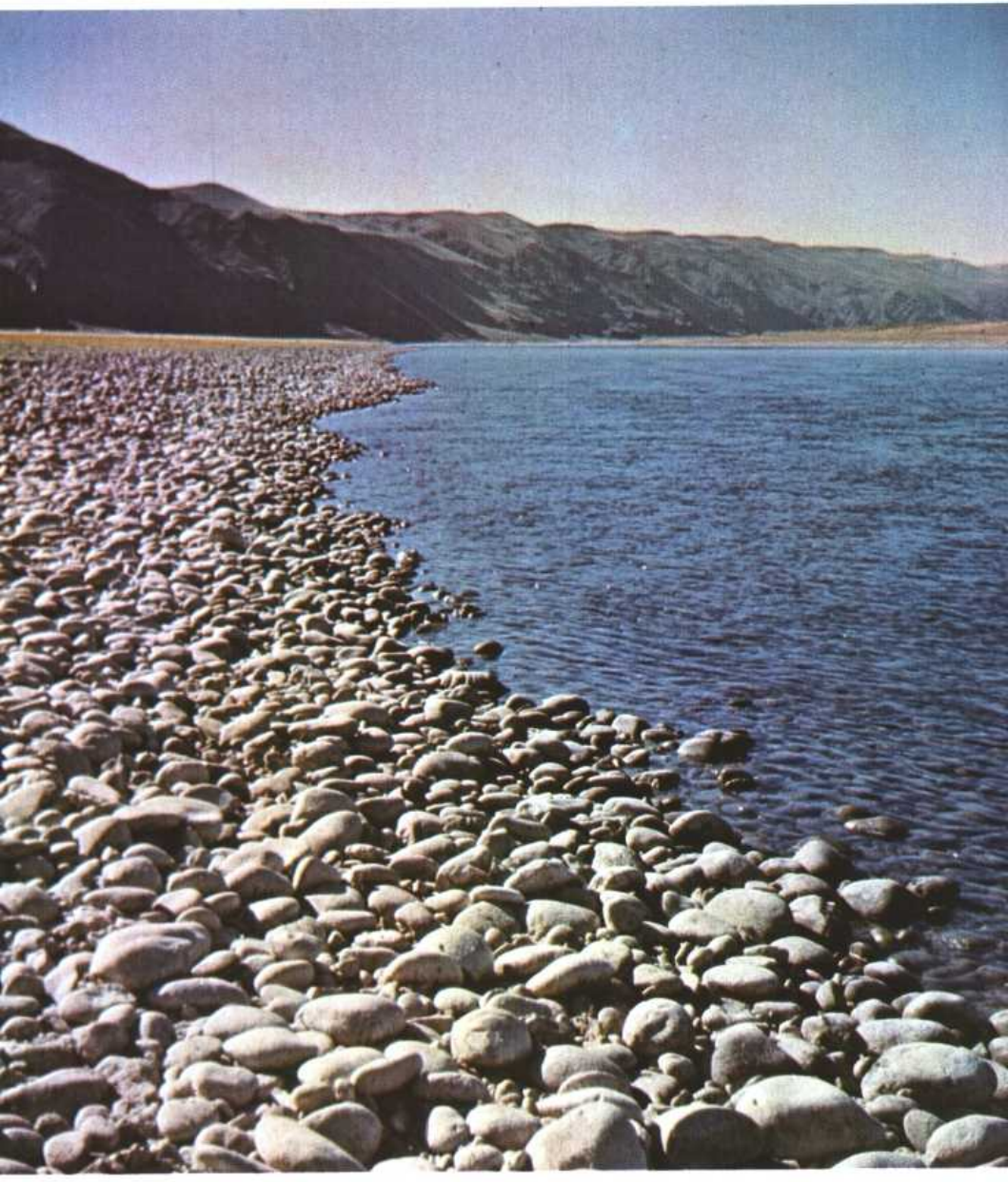


Plan sketch and cross sections, Columbia River at Vernita, Wash.

$n = 0.024$

No. 67 upstream from top of bank at section 3,
Columbia River at Vernita, Wash.

$n = 0.024$



No. 66 upstream along right bank from section 3,
Columbia River at Vernita, Wash.

3–1215. Indian Fork below Atwood Dam, near New Cumberland, Ohio

Gage location.—Lat 40°31′30″, long 81°17′20″, in SE¼ sec. 28, T. 15 N., R. 7 W., on left bank 500 ft downstream from Atwood Dam, 0.5 mile upstream from mouth, and 1.5 miles southeast of New Cumberland, Tuscarawas County. Section 1 is about 300 ft downstream from gage.

Drainage area.—70.3 sq mi.

Date of flood.—May 11, 1948.

Gage height.—10.27 ft at gage; 9.99 ft at section 1.

Peak discharge.—768 cfs.

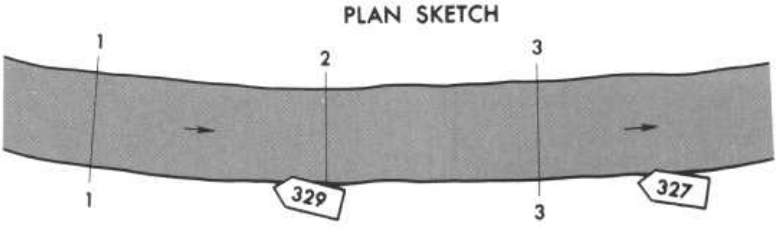
Computed roughness coefficient.—Manning $n = 0.026$.

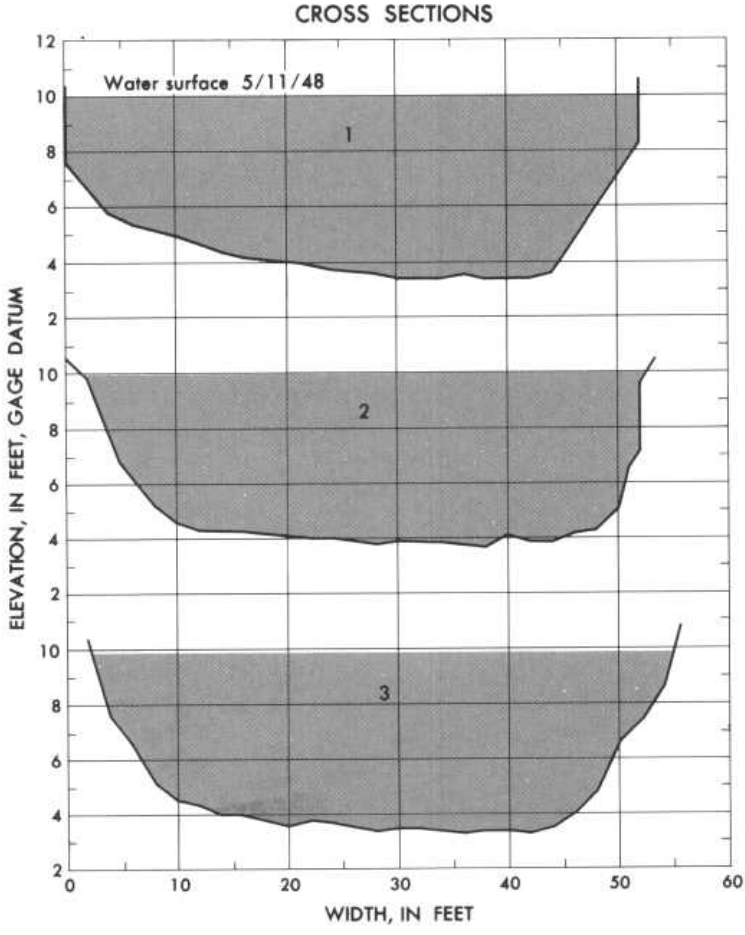
Description of channel.—Bed and banks are composed of clay. Banks are clear except for short grass and exposed tree roots in some places.

Reach properties

Section	Area (sq ft)	Top width (ft)	Mean depth (ft)	Hydraulic radius (ft)	Mean velocity (ft per sec)	Length (ft) between sections	Fall (ft) between sections
1	280	52	5.4	4.87	2.74	.....	.....
2	273	51	5.4	4.82	2.82	257	0.08
3	279	52	5.4	4.97	2.76	202	.05

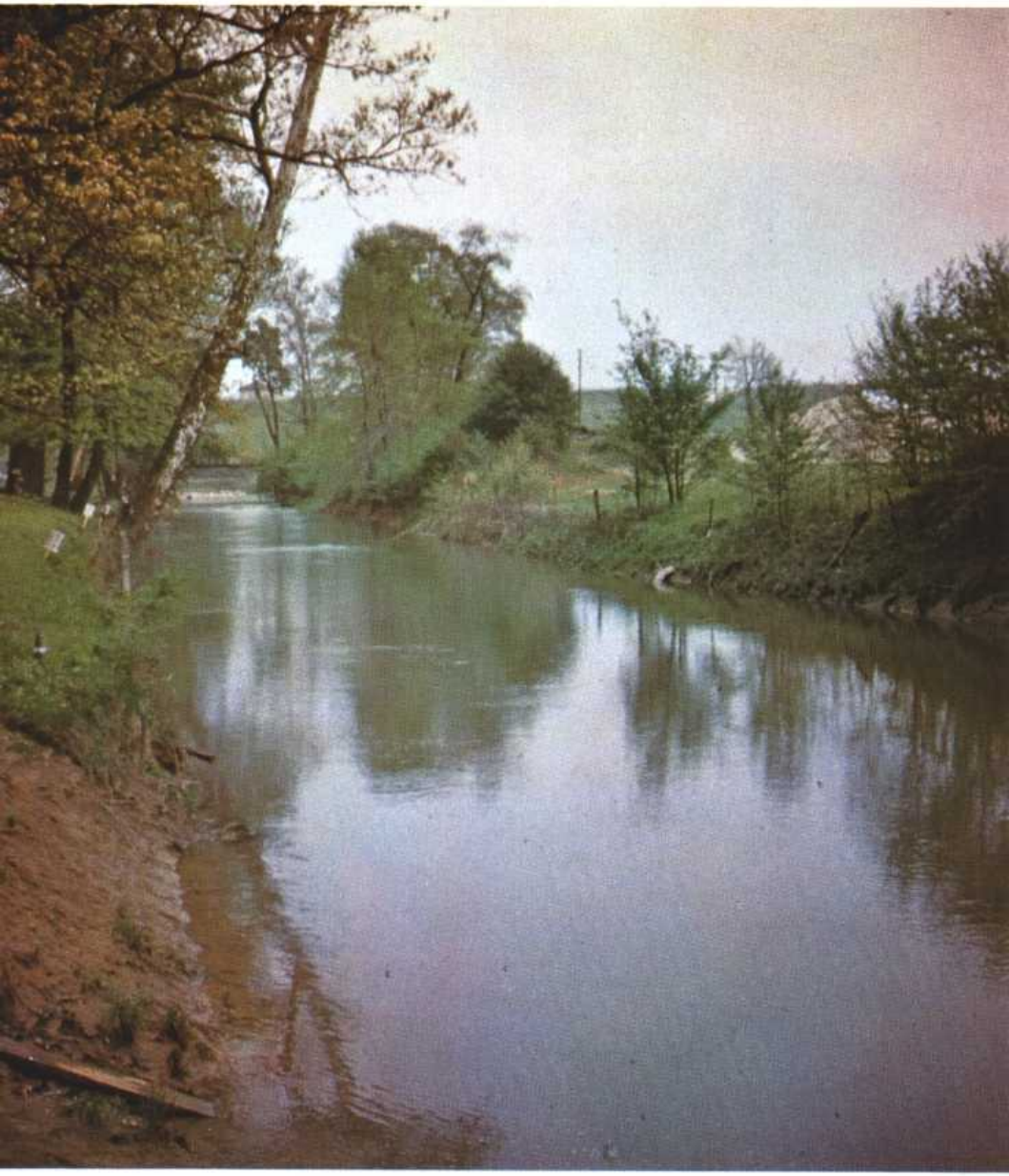
Notes.—





Plan sketch and cross sections, Indian Fork below Atwood Dam, near New Cumberland, Ohio.

$n = 0.026$



No. 327 upstream from right bank below section 3,
Indian Fork below Atwood Dam, near New Cumberland, Ohio.

$n = 0.026$

No. 329 upstream from right bank at section 2,
Indian Fork below Atwood Dam, near New Cumberland, Ohio.

$n = 0.027$

8–1235. Champlin Creek near Colorado City, Tex.

Gage location.—Lat 32°19′, long 100°49′, on right bank 600 ft downstream from South Fork, 5 miles southeast of Colorado City, Mitchell County, and 5.5 miles upstream from mouth. Section 2 is 350 ft downstream from gage.

Drainage area.—158 sq mi.

Date of flood.—May 17, 1949.

Gage height.—5.05 ft at gage; 4.24 ft at section 2.

Peak discharge.—2,390 cfs.

Computed roughness coefficient.—Manning $n = 0.027$.

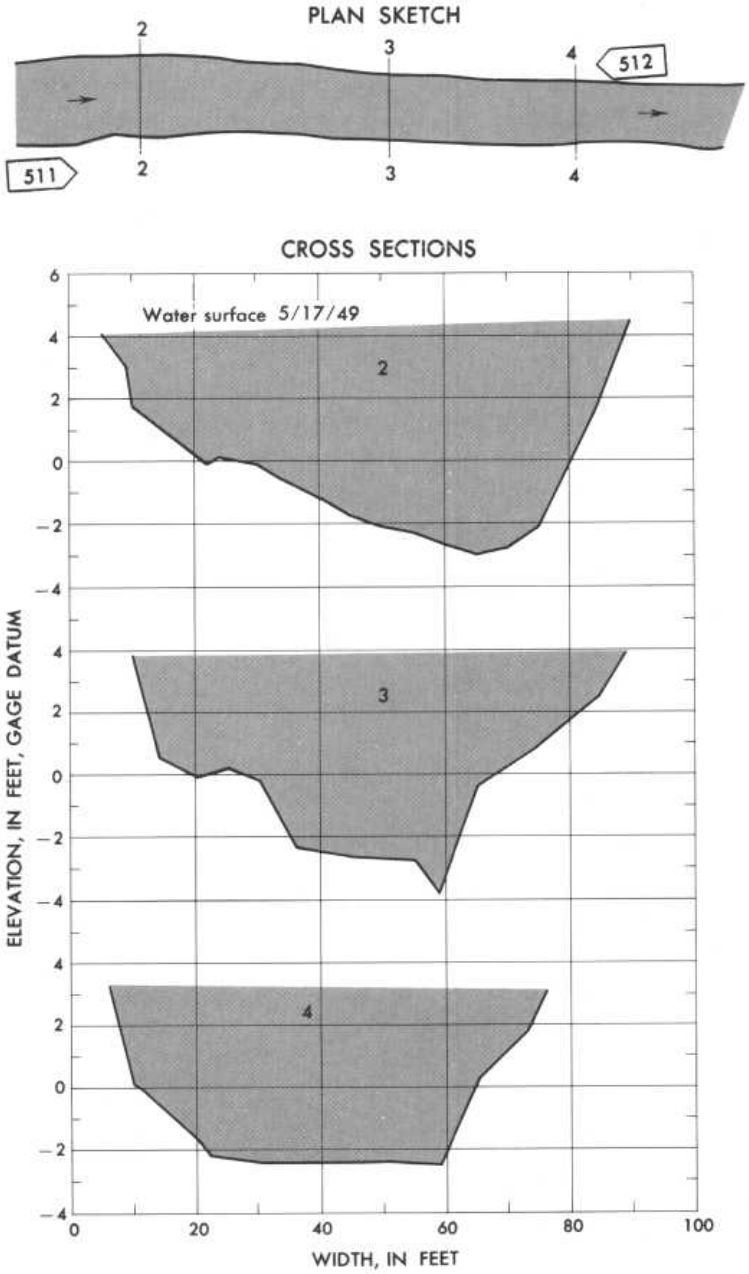
Description of channel.—Bed consists of gravel deposits over smooth to rough rock. Banks are covered with grass and have a few outcrops.

Reach properties

Section	Area (sq ft)	Top width (ft)	Mean depth (ft)	Hydraulic radius (ft)	Mean velocity (ft per sec)	Length (ft) between sections	Fall (ft) between sections
2	412	85	4.8	4.71	5.80	.....	.....
3	344	79	4.4	4.20	6.96	176	0.43
4	307	70	4.4	4.24	7.78	148	.71

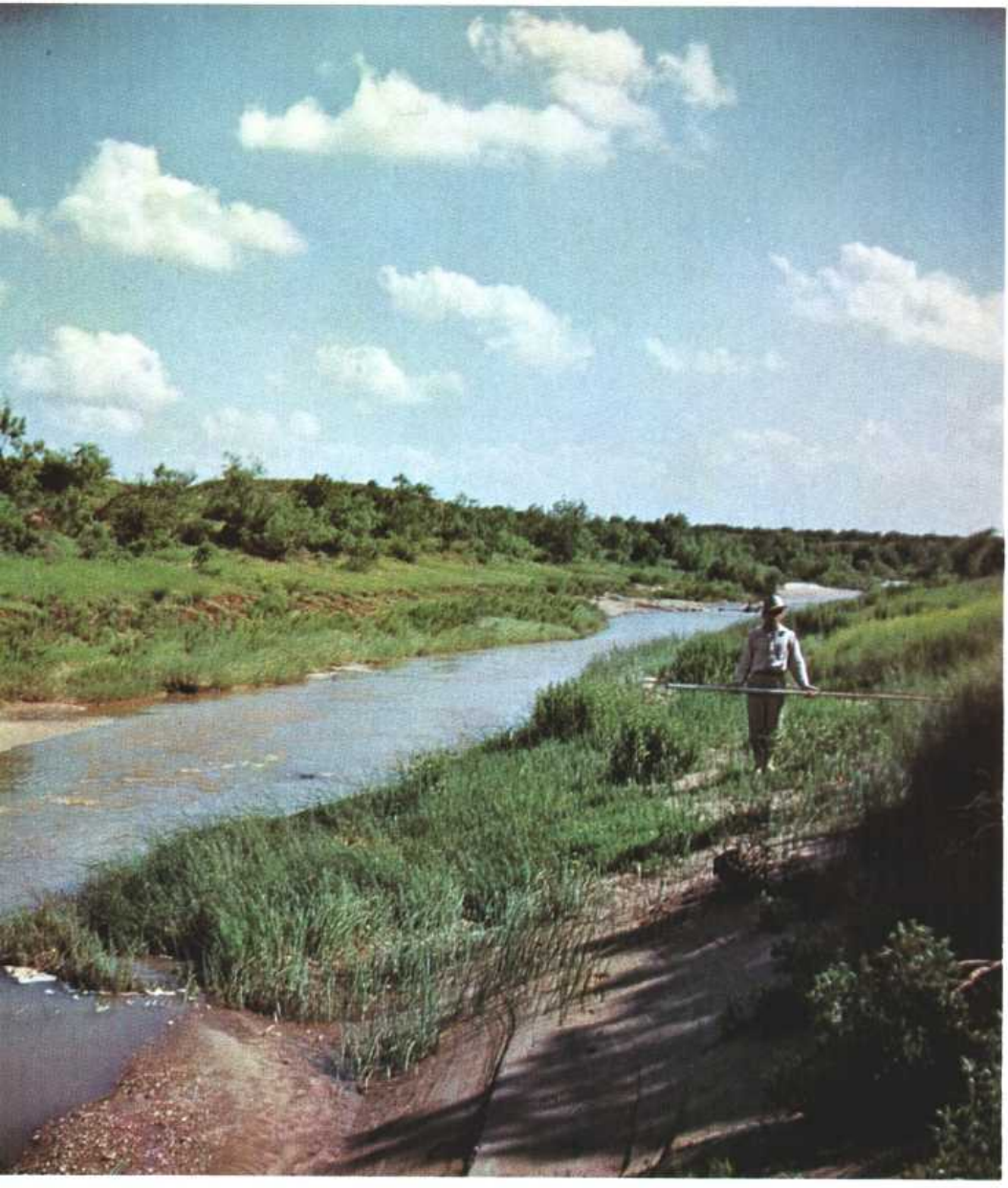
Notes.—

$n = 0.027$



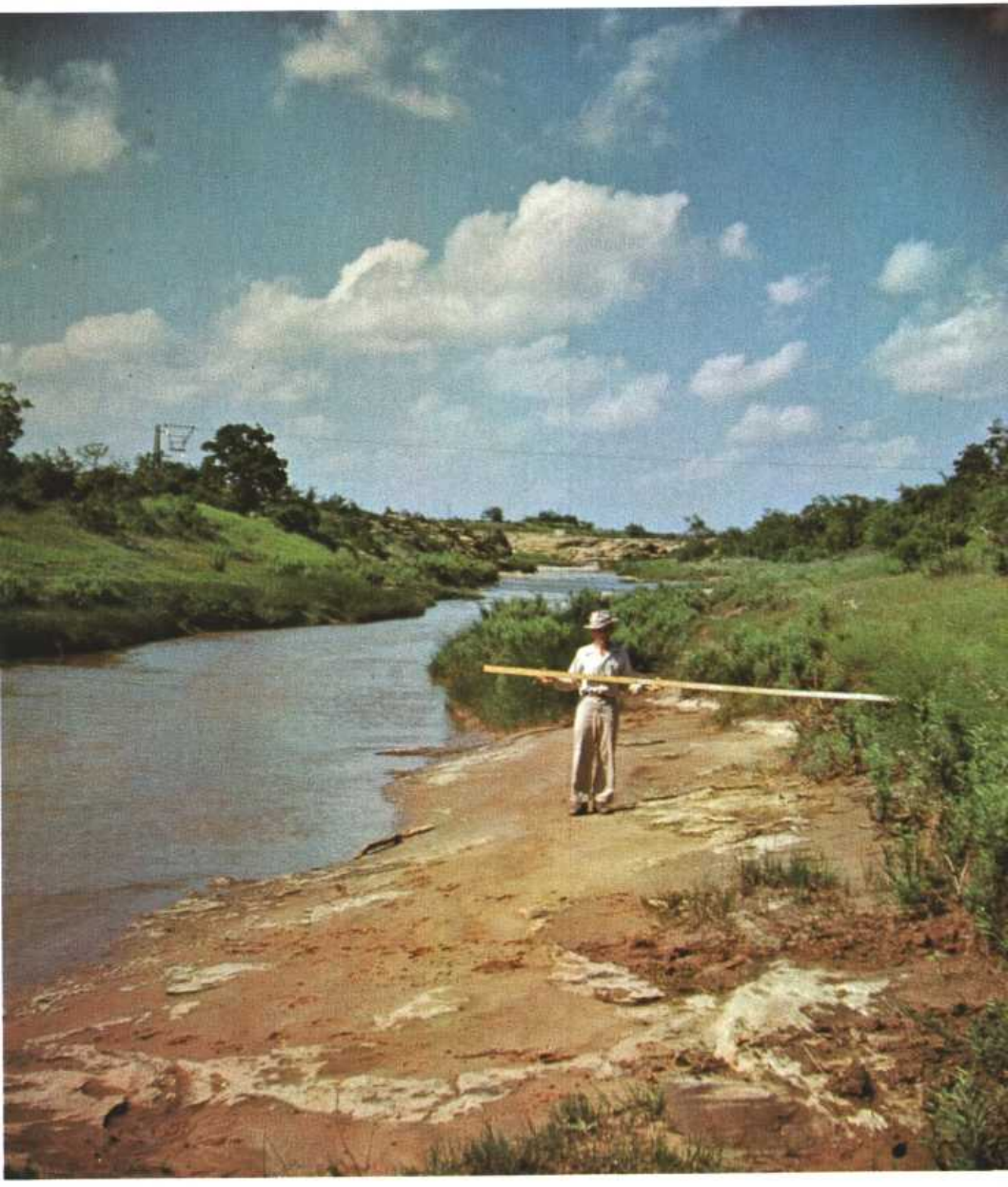
Plan sketch and cross sections, Champlin Creek near Colorado City, Tex.

$n = 0.027$



No. 511 downstream along right bank from above section 2, Champlin Creek near Colorado City, Tex.

$n = 0.027$



No. 512 upstream along left bank from below section 4, Champlin Creek near Colorado City, Tex.

12–3545. Clark Fork at St. Regis, Mont.

Gage location.—Lat 47°18′05″, long 115°05′15″, in center of SW ¼ sec. 19, T. 18 N., R. 27 W., on left bank at St. Regis, 0.5 mile downstream from St. Regis River. Section 1 is 660 ft upstream from gage.

Drainage area.—10,709 sq mi.

Date of flood.—May 24, 1948.

Gage height.—19.96 ft at gage; 20.42 ft at section 1.

Peak discharge.—68,900 cfs.

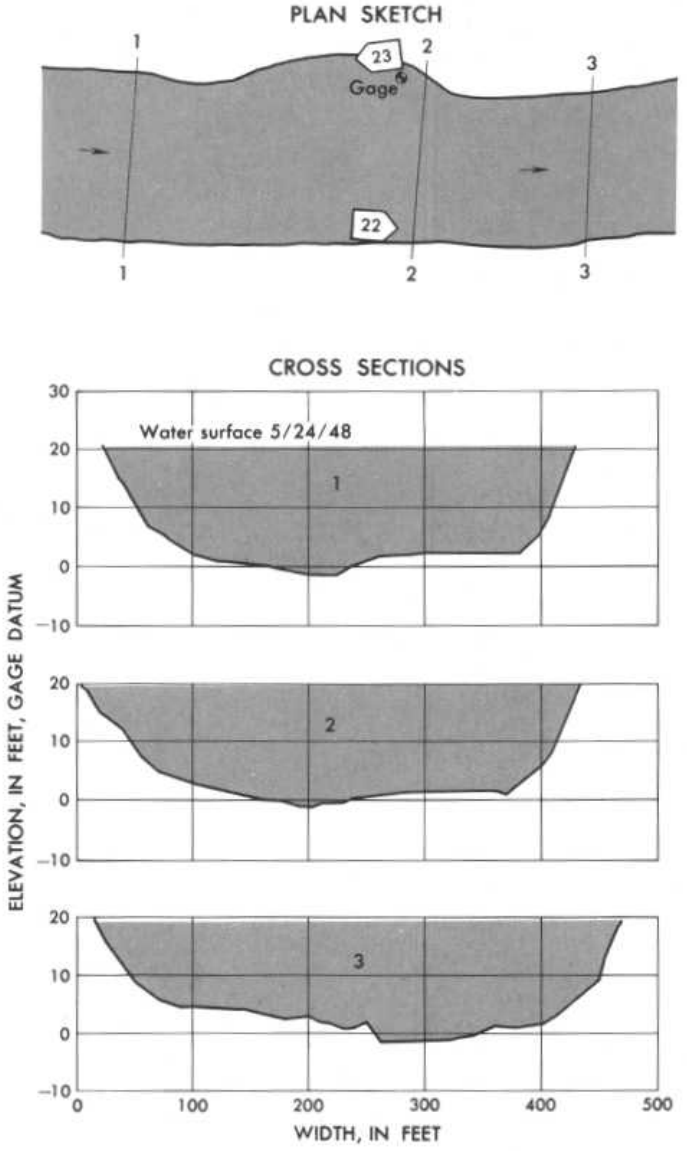
Computed roughness coefficient.—Manning $n = 0.028$.

Description of channel.—Bed consists of well-rounded boulders; $d_{50} = 135$ mm, $d_{84} = 205$ mm. Banks are composed of gravel and boulders, and have tree and brush cover.

Reach properties

Section	Area (sq ft)	Top width (ft)	Mean depth (ft)	Hydraulic radius (ft)	Mean velocity (ft per sec)	Length (ft) between sections	Fall (ft) between sections
1	6,860	404	16.98	16.70	10.04	.....	.....
2	6,976	429	16.26	16.04	9.88	755	0.555
3	7,194	454	15.85	15.64	9.58	438	.32

Notes.—



Plan sketch and cross sections, Clark Fork at St. Regis, Mont.

$n = 0.028$

No. 22 downstream along right bank from section 2, Clark Fork at St. Regis, Mont.

$n = 0.028$

No. 23 upstream along left bank from section 2,
Clark Fork at St. Regis, Mont.

12–3405. Clark Fork above Missoula, Mont.

Gage location.—Lat 46°52′40″, long 113°55′40″, in NW¼NW¼ sec. 19, T. 13 N, R. 18 W., on right bank 3 miles downstream from Blackfoot River and 3 miles east of Missoula. Section 1 is 405 ft upstream from gage.

Drainage area.—5,999 sq mi.

Date of flood.—May 23, 1948.

Gage height.—13.07 ft at gage; 14.54 ft at section 1.

Peak discharge.—31,500 cfs.

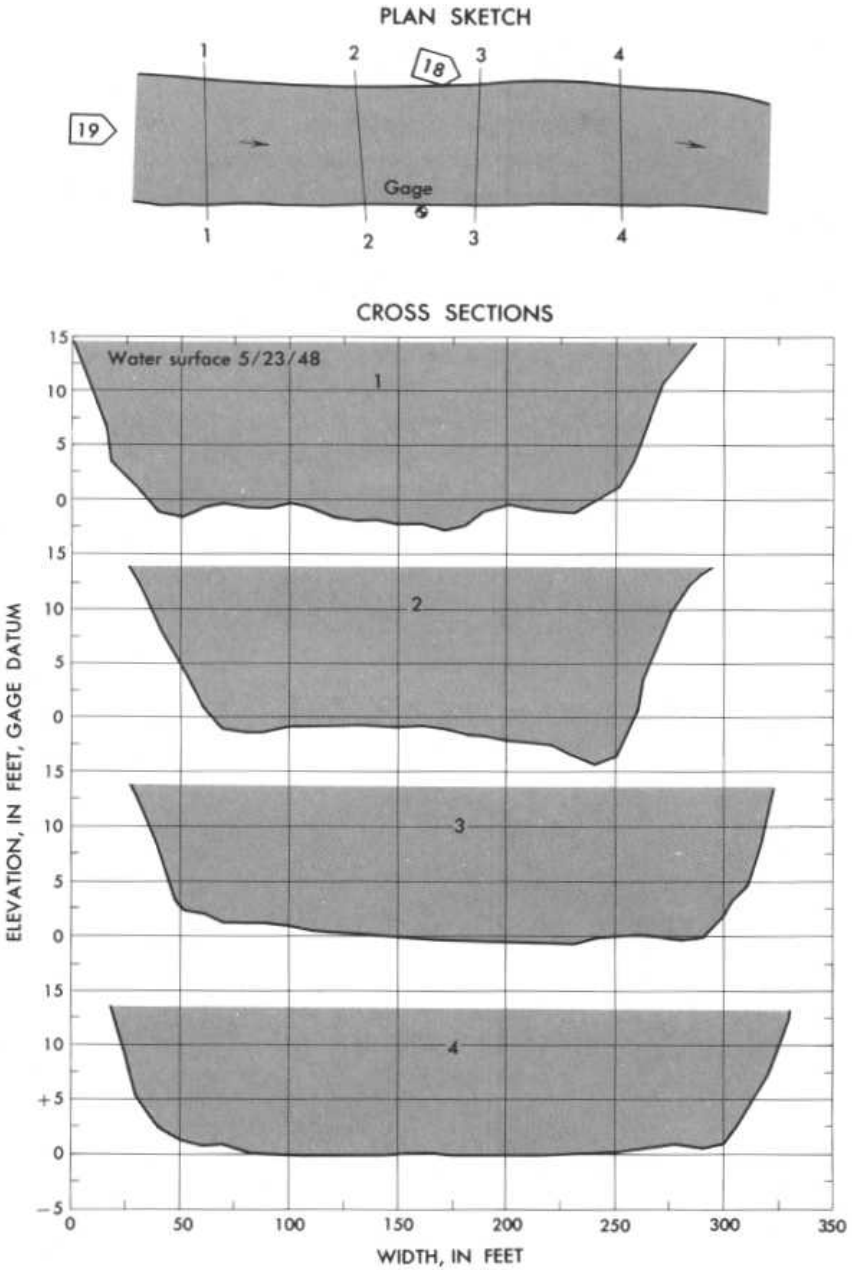
Computed roughness coefficient.—Manning $n = 0.030$.

Description of channel.—Bed is composed of sand, gravel, and boulders; $d_{50} = 175$ mm, $d_{84} = 325$ mm. Thick undergrowth is along right bank and along the left bank in the lower part of the reach.

Reach properties

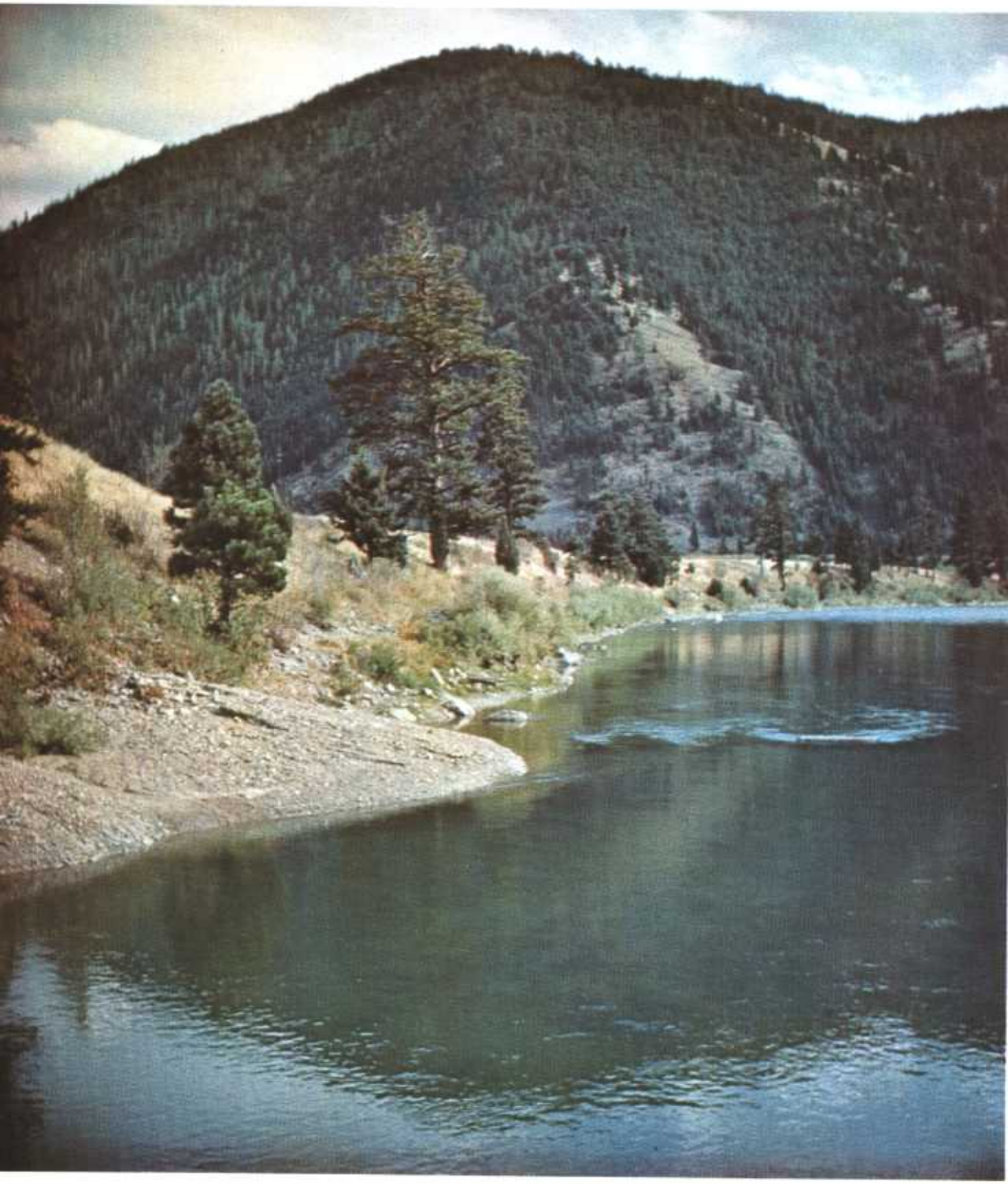
Section	Area (sq ft)	Top width (ft)	Mean depth (ft)	Hydraulic radius (ft)	Mean velocity (ft per sec)	Length (ft) between sections	Fall (ft) between sections
1	3,866	285	13.56	13.24	8.15	.....	.....
2	3,461	267	12.96	12.64	9.10	305	0.63
3	3,634	294	12.36	12.10	8.67	243	.25
4	3,798	312	12.17	11.95	8.29	297	.18

Notes.—



Plan sketch and cross sections, Clark Fork above Missoula, Mont.

$n = 0.030$



No. 18 downstream along left bank from above section 3, Clark Fork above Missoula, Mont.

$n = 0.030$

No. 19 downstream through reach from bridge 400 ft above section 1, Clark Fork above Missoula, Mont.

14–1057. Columbia River at The Dalles, Oreg.

Gage location.—Lat 45°36′10″, long 121°10′40″, in NW¼ sec. 3, T. 1 N., R. 13 E., at upstream end of Port of The Dalles dock at The Dalles, 3.2 miles downstream from The Dalles Dam and at mile 189.3. Section 4 is at cableway 9 miles upstream from gage.

Drainage area.—237,000 sq mi, approximately.

Date of flood.—May 31, 1948.

Gage height.—154.56 ft at gage; 171.44 ft at section 1.

Peak discharge.—1,000,000 cfs.

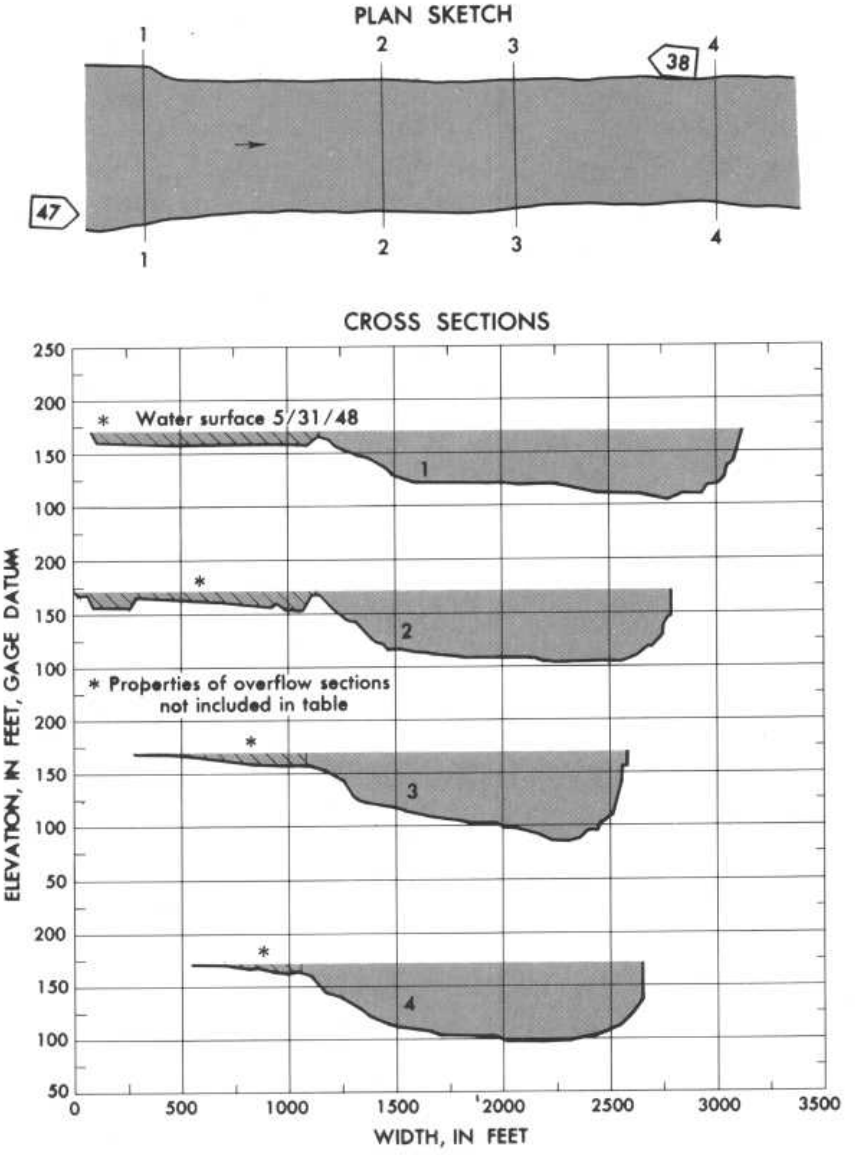
Computed roughness coefficient.—Manning $n = 0.030$.

Description of channel.—Left bank consists of sand, gravel, and boulders, and has light cover of brush in some places. Right bank is formed by severely scalloped basalt cliffs. The bed material is fairly well graded from 18-inch boulders along the left bank down to sand at the base of the right bank.

Reach properties

Section	Area (sq ft)	Top width (ft)	Mean depth (ft)	Hydraulic radius (ft)	Mean velocity (ft per sec)	Length (ft) between sections	Fall (ft) between sections
1	94,650	1,980	47.80	47.28	10.57	.....	.....
2	90,810	1,640	55.37	54.10	11.01	2,003	0.50
3	89,040	1,485	59.96	57.80	11.23	778	.20
4	91,890	1,600	57.43	55.81	10.88	1,394	.41

Notes.—



Plan sketch and cross sections, Columbia River at The Dalles, Oreg.

$n = 0.030$

No. 47 downstream along right bank from above section 1, Columbia River at The Dalles, Oreg.

$n = 0.030$

No. 38 upstream along left bank from section 4,
Columbia River at The Dalles, Oreg.

1–3625. Esopus Creek at Coldbrook, N.Y.

Gage location.—Lat 42°00′45″, long 76°16′10″, on left bank at downstream side of highway bridge at Coldbrook, Ulster County, 1.5 miles upstream from Ashokan Reservoir and 2.5 miles south of Mount Tremper. Section 1 is about 400 ft upstream from Highway 28–A, which is about 6 miles southeast of gage.

Drainage area.—192 sq mi.

Date of flood.—Mar. 22, 1948.

Gage height.—12.39 ft at gage; 15.60 ft (different datum) at section 1.

Peak discharge.—13,900 cfs.

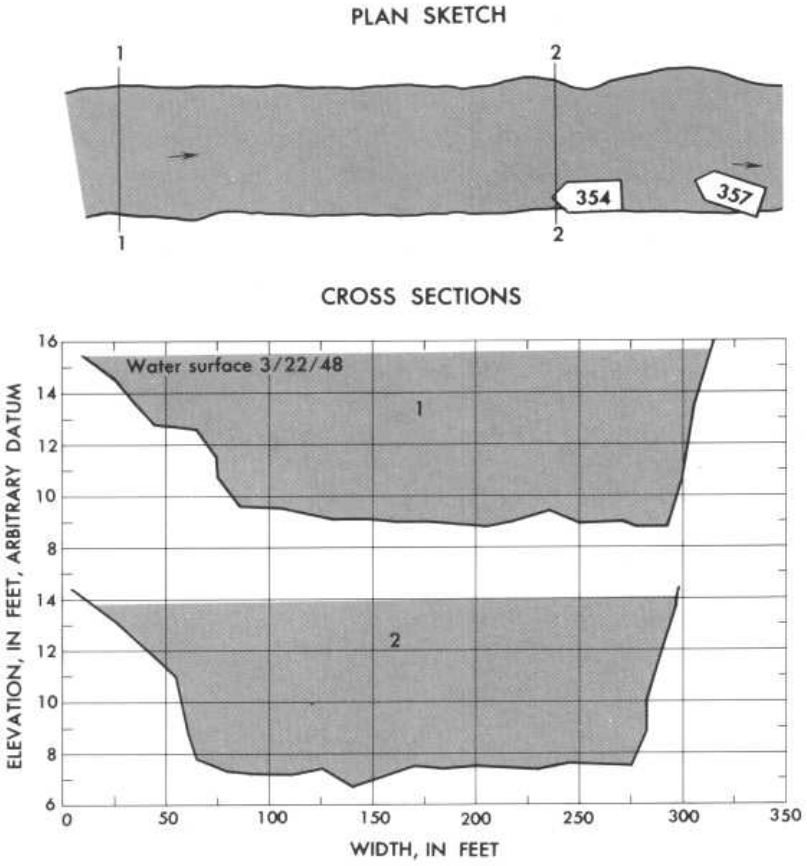
Computed roughness coefficient.—Manning $n = 0.030$.

Description of channel.—The bed is coarse gravel and both banks are lined with trees and brush.

Reach properties

Section	Area (sq ft)	Top width (ft)	Mean depth (ft)	Hydraulic radius (ft)	Mean velocity (ft per sec)	Length (ft) between sections	Fall (ft) between sections
1	1,600	301	5.3	5.28	8.70	.....	.....
2	1,589	284	5.6	5.54	8.77	471	1.60

Notes.—



Plan sketch and cross sections, Esopus Creek at Coldbrook, N.Y.

$n = 0.030$

No. 354 upstream along left bank from section 2,
Esopus Creek at Coldbrook, N.Y.

$n = 0.030$

No. 357 upstream from right end of bridge below reach, Esopus Creek at Coldbrook, N.Y. (at Highway 28–A).

6–8030. Salt Creek at Roca, Nebr.

Gage location.—Lat 40°39′33″, long 96°39′39″, in SW¼ sec. 17, T. 8 N., R. 7 E., on left bank 15 ft downstream from highway bridge at west edge of Roca. Section 1 is 75 ft downstream from gage.

Drainage area.—174 sq mi.

Date of flood.—May 2, 1954.

Gage height.—16.02 ft at gage; 15.94 ft at section 1.

Peak discharge.—1,860 cfs.

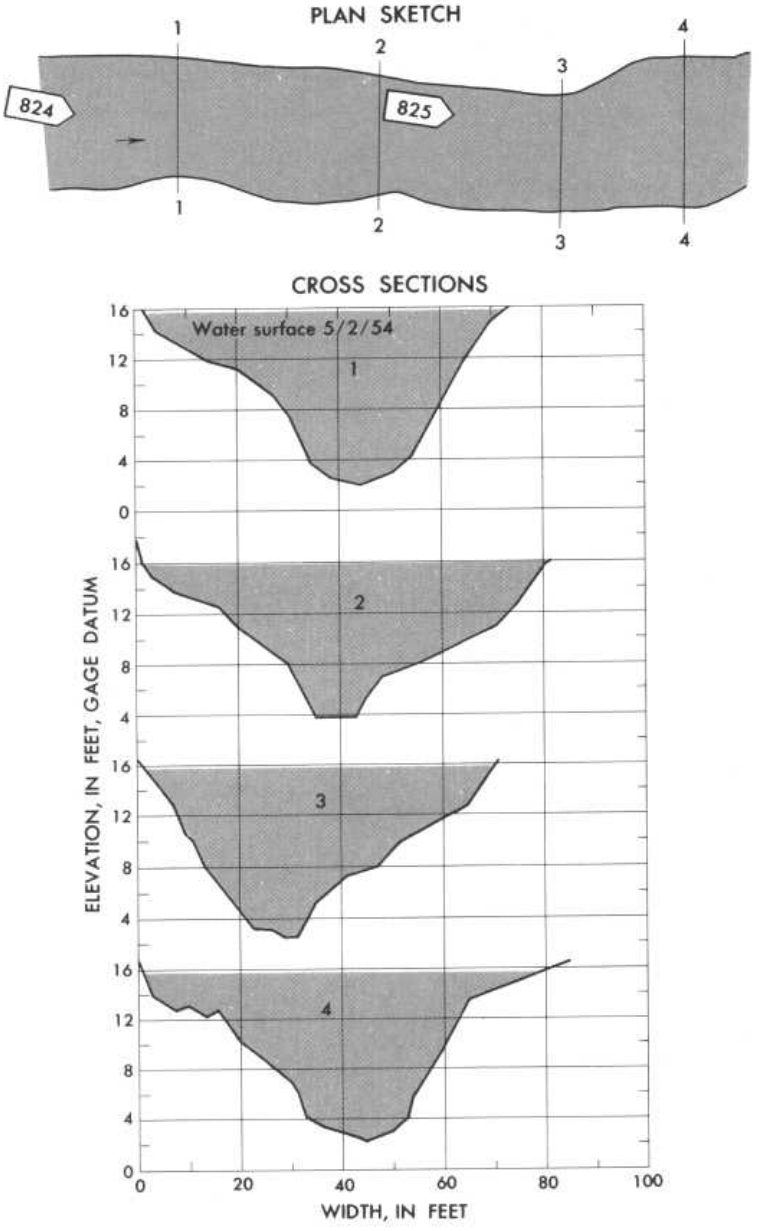
Computed roughness coefficient.—Manning $n = 0.030$.

Description of channel.—Bed consists of sand and clay. Banks are generally smooth and are free of vegetal growth during floods.

Reach properties

Section	Area (sq ft)	Top width (ft)	Mean depth (ft)	Hydraulic radius (ft)	Mean velocity (ft per sec)	Length (ft) between sections	Fall (ft) between sections
1	528	72	7.4	6.7	3.46	.....	.....
2	502	80	6.3	5.9	3.71	113	0.09
3	497	69	7.2	6.6	3.74	110	.06
4	497	78	6.4	5.9	3.74	134	.05

Notes.—



Plan sketch and cross sections, Salt Creek at Roca, Nebr.

$n = 0.030$

No. 824 downstream from above section 1,
Salt Creek at Roca, Nebr.

$n = 0.030$

No. 825 downstream from below section 2,
Salt Creek at Roca, Nebr.

12–3385. Blackfoot River near Ovando, Mont.

Gage location.—Lat 47°01′10″, long 113°13′40″, in SE¼NW¼ sec. 34, T. 15 N., R. 13 W., on left bank 0.25 mile upstream from Monture Creek and 5 miles west of Ovando. Section 1 is about 0.25 mile upstream from gage.

Drainage area.—1,274 sq mi.

Date of flood.—May 22, 1948.

Gage height.—6.84 ft at gage; 16.34 ft at section 1.

Peak discharge.—8,200 cfs.

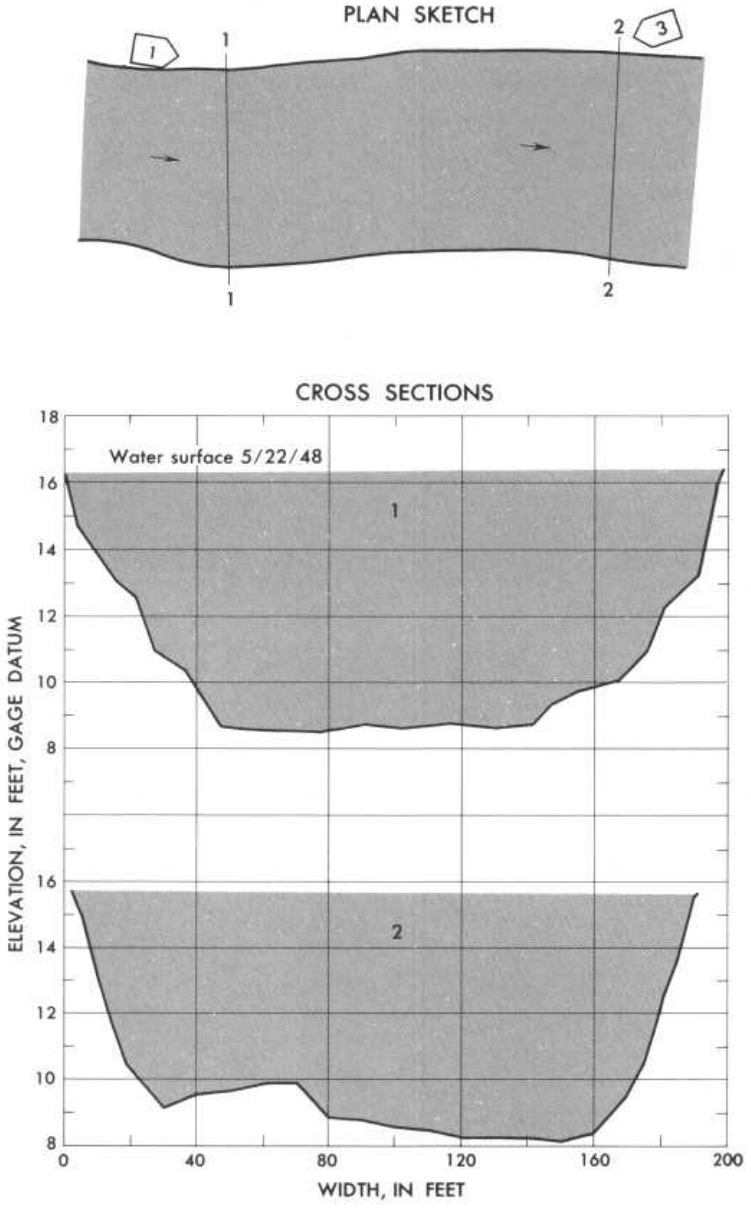
Computed roughness coefficient.—Manning $n = 0.031$.

Description of channel.—Bed is gravel and boulders; d_{50} = 155 mm, d_{84} = 280 mm. Banks consist of same material and are relatively free of vegetation.

Reach properties

Section	Area (sq ft)	Top width (ft)	Mean depth (ft)	Hydraulic radius (ft)	Mean velocity (ft per sec)	Length (ft) between sections	Fall (ft) between sections
1	1,230	199	6.18	6.12	6.67	.....	.....
2	1,140	189	6.03	5,97	7.19	292	0.68

Notes.—



Plan sketch and cross sections, Blackfoot River near Ovando, Mont.

$n = 0.031$

No. 1 downstream from left bank above section 1, Blackfoot River near Ovanda, Mont.

$n = 0.031$

No. 3 upstream towards right bank from below section 2, Blackfoot River near Ovanda, Mont.

12–4120. Coeur d'Alene River near Prichard, Idaho

Gage location.—Lat 47°38′05″, long 115°58′55″, in lot 7, sec. 32, T. 50 N., R. 4 E., on right bank 0.2 mile downstream from Beaver Creek and 1.75 miles southwest of Prichard. Section 1 is 570 ft upstream from gage.

Drainage area.—583 sq mi.

Date of flood.—May 21, 1948.

Gage height.—9.24 ft at gage; 10.98 ft at section 1.

Peak discharge.—11,300 cfs.

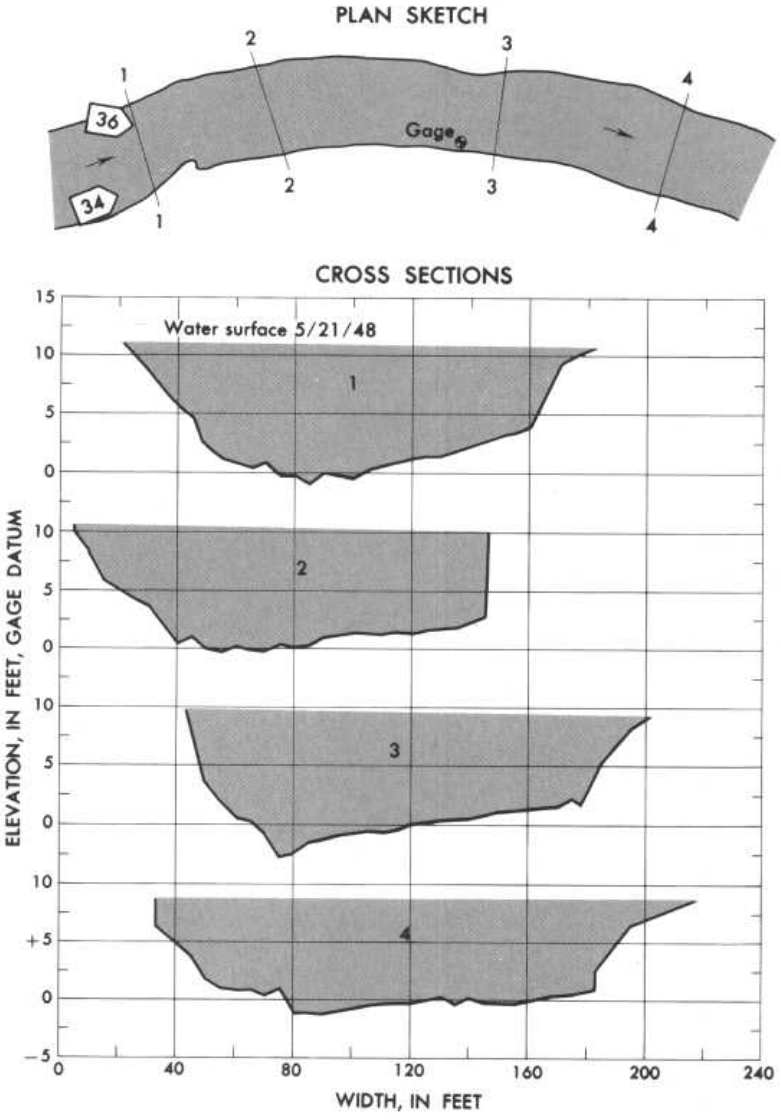
Computed roughness coefficient.—Manning $n = 0.032$.

Description of channel.—Bed is composed of rock along left edge, gravel and small boulders elsewhere; $d_{50} = 103$ mm, $d_{84} = 650$ mm. Left bank is irregular bedrock, steep and clean. Right bank consists of sand and gravel covered with heavy growth of brush and trees.

Reach properties

Section	Area (sq ft)	Top width (ft)	Mean depth (ft)	Hydraulic radius (ft)	Mean velocity (ft per sec)	Length (ft) between sections	Fall (ft) between sections
1	1,260	162	7.8	7.65	8.97	.....	.....
2	1,200	141	8.5	8.00	9.42	230	0.50
3	1,306	159	8.2	7.96	8.65	400	.88
4	1,312	185	7.1	6.87	8.61	302	.92

Notes.—



Plan sketch and cross sections, Coeur d'Alene River near Prichard, Idaho.

$n = 0.032$

No. 34 downstream through reach from right bank,
Coeur d'Alene River near Prichard, Idaho.

$n = 0.032$

No. 36 downstream along right bank at section 1,
Coeur d'Alene River near Pritchard, Idaho.

n = 0.032; 0.036

8–2900. Rio Chama near Chamita, N. Mex.

Gage location.—Lat 36°04′25″, long 106°06′39″, in NE¼NE¼ sec. 8, T. 21 N., R. 8 E., on left bank 200 ft downstream from bridge on U.S. Highway 285, 0.5 mile west of Chamita, 2.5 miles northwest of San Juan Pueblo, and 3 miles upstream from mouth. Section 1 is about 200 ft upstream from gage.

Drainage area.—3,140 sq mi.

Date of flood.—Mar. 24, 1950; Apr. 3, 1950.

Gage height.—3.41 ft, 2.95 ft at gage; 3.65 ft, 3.18 ft at section 1.

Peak discharge.—1,060 cfs; 684 cfs.

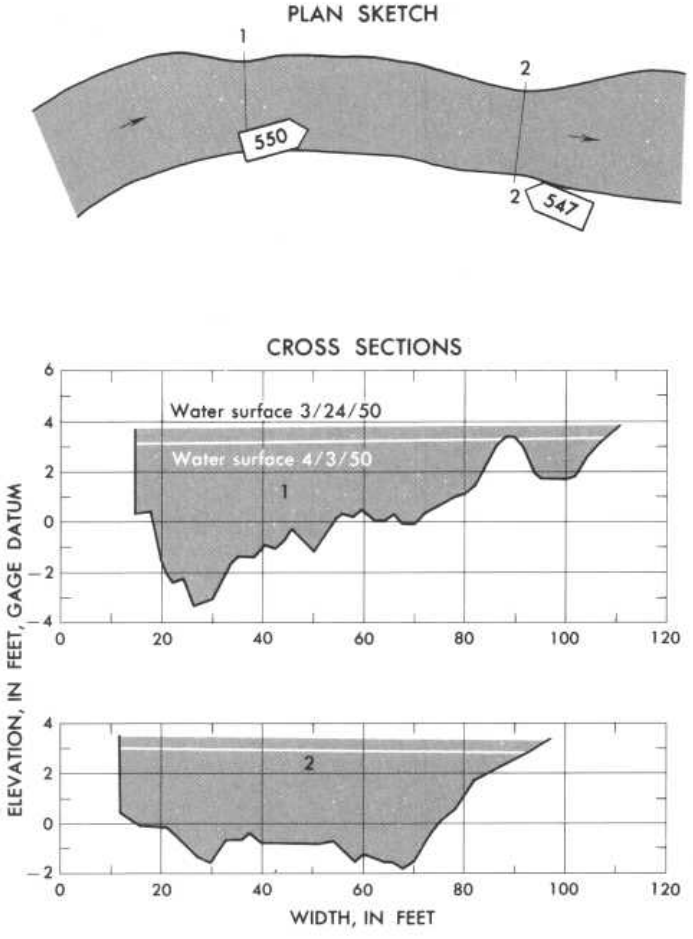
Computed roughness coefficient.—Manning n=0.032; 0.036.

Description of channel.—The bed consists of sand and gravel. The left bank is rock and the right bank is mostly gravel.

Reach properties

Section	Area (sq ft)	Top width (ft)	Mean depth (ft)	Hydraulic radius (ft)	Mean velocity (ft per sec)	Length (ft) between sections	Fall (ft) between sections
Mar. 24, 1950							
1	312	95	3.3	3.12	3.40	.....	.....
2	297	84	3.5	3.45	3.57	202	0.24
Apr. 3, 1950							
1	235	92	2.6	2.52	2.91	.....	.....
2	249	81	3.1	2.95	2.75	202	0.23

Notes.—



Plan sketch and cross sections, Rio Chama near Chamita, New Mex.

$n = 0.032; 0.036$

No. 547 upstream along right bank from below section 2, Rio Chama near Chamita, N. Mex.

$n = 0.032; 0.036$

No. 550 downstream from right bank at section 1, Rio Chama near Chamita, N. Mex.

$n = 0.032$

9–5020. Salt River below Stewart Mountain Dam, Ariz.

Gage location.—Lat 33°33′00″, long 111°34′31″, in N½NW¼ sec. 6, T. 2 N., R. 8 E. (unsurveyed), on left bank 3.5 miles downstream from Stewart Mountain Dam and 6 miles upstream from Verde River. Section 1 is about 2.25 miles downstream from gage.

Drainage area.—6,230 sq mi, of which 21 sq mi is below Stewart Mountain Dam.

Date of flood.—Mar. 24, 1950.

Gage height.—4.26 ft at gage; 99.26 ft (different datum) at section 1.

Peak discharge.—1,280 cfs.

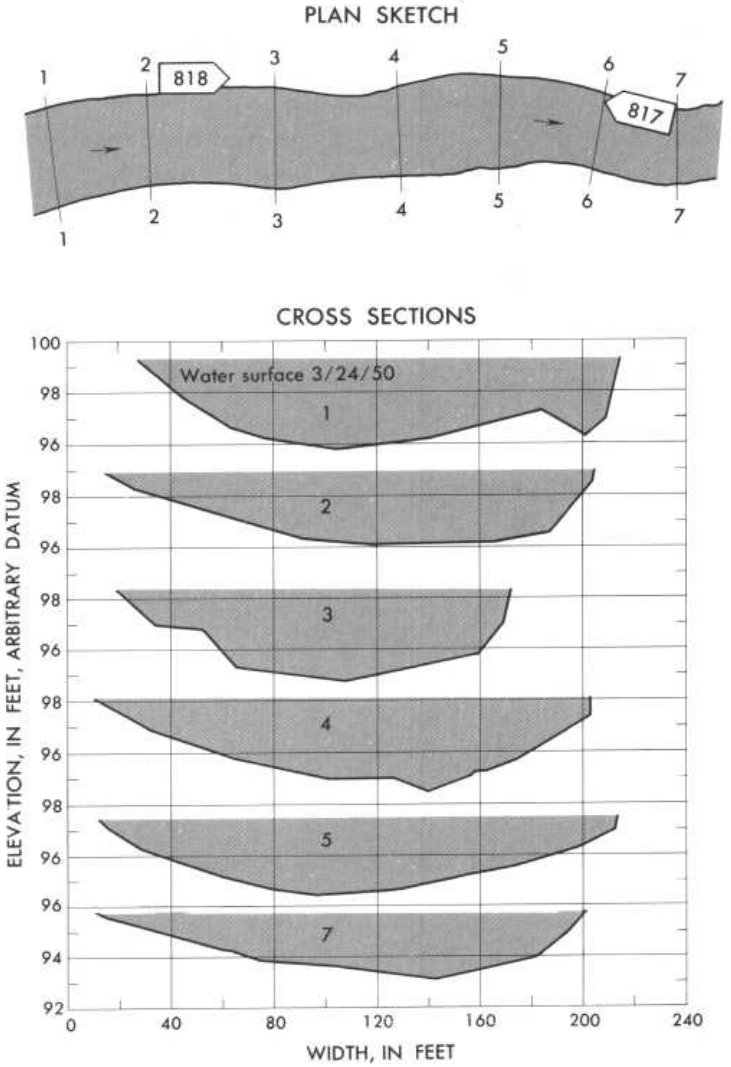
Computed roughness coefficient.—Manning $n = 0.032$.

Description of channel.—Bed and banks consist of smooth cobbles 4 to 10 inches in diameter, average diameter about 6 inches. A few boulders are as much as 18 inches in diameter.

Reach properties

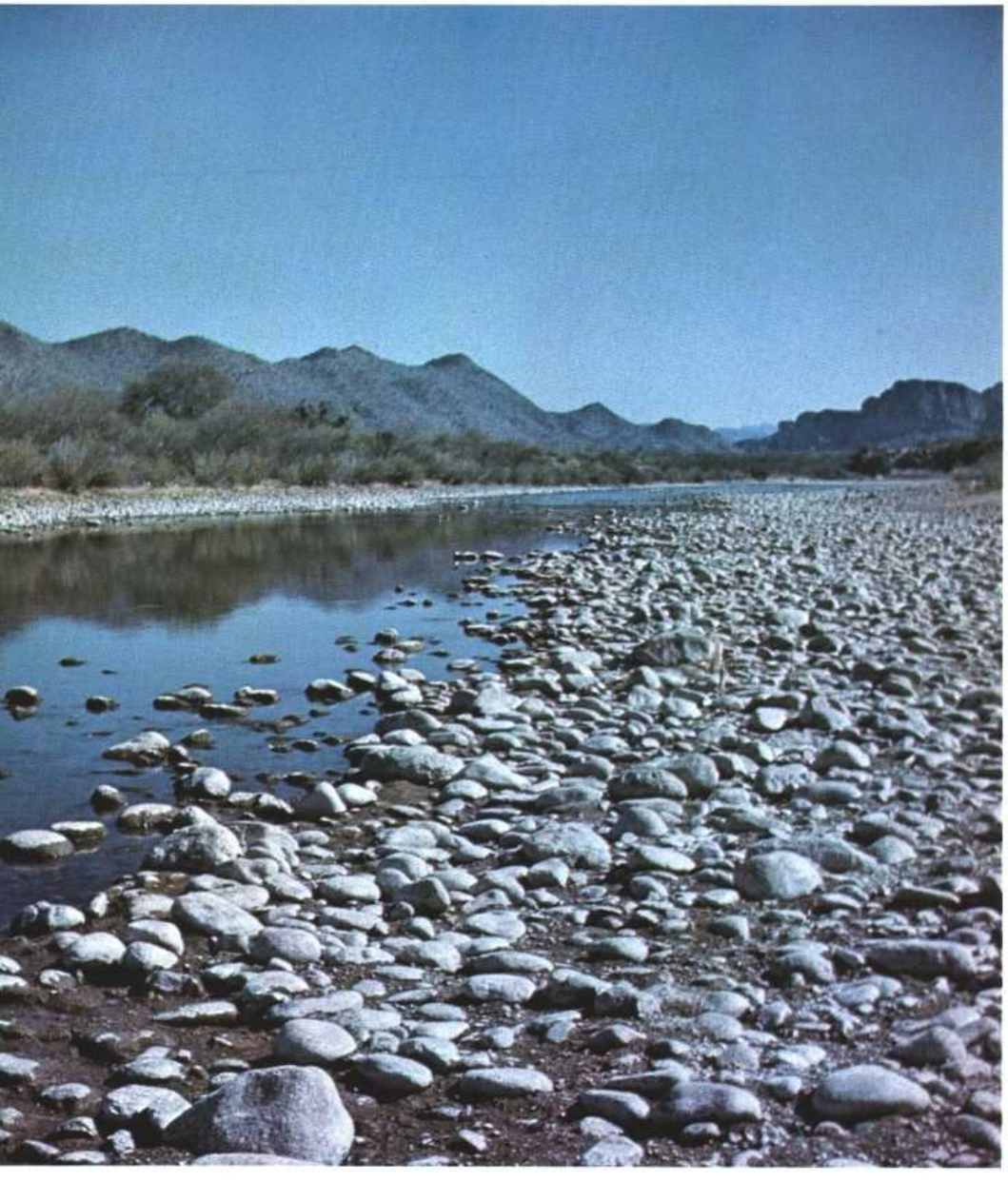
Section	Area (sq ft)	Top width (ft)	Mean depth (ft)	Hydraulic radius (ft)	Mean velocity (ft per sec)	Length (ft) between sections	Fall (ft) between sections
1	484	189	2.6	2.55	2.65	.....	.....
2	408	192	2.1	2.12	3.14	258	0.37
3	384	154	2.6	2.49	3.34	317	.50
4	449	194	2.3	2.30	2.86	294	.31
5	420	204	2.1	2.06	3.05	370	.63
6	381	207	1.8	1.84	3.36	333	.72
7	308	191	1.6	1.61	4.16	314	1.06

Notes.—



Plan sketch and cross sections, Salt River below Stewart Mountain Dam, Ariz.

$n = 0.032$



No. 817 upstream along left bank from below section 6
Salt River below Stewart Mountain Dam, Ariz.

$n = 0.032$

No. 818 downstream along left bank from section 2, Salt River below Stewart Mountain Dam, Ariz.

1–4205. Beaver Kill at Cooks Falls, N.Y.

Gage location.—Lat 41°56′50″, long 74°58′45″, on left bank 125 ft downstream from highway bridge in Cooks Falls, Delaware County, and 5.5 miles downstream from Willowemoc Creek. Section 5 is about 2,700 ft downstream from gage.

Drainage area.—241 sq mi.

Date of flood.—Mar. 22, 1948.

Gage height.—11.69 ft at gage; 42.65 ft (different datum) at section 5.

Peak discharge.—15,500 cfs.

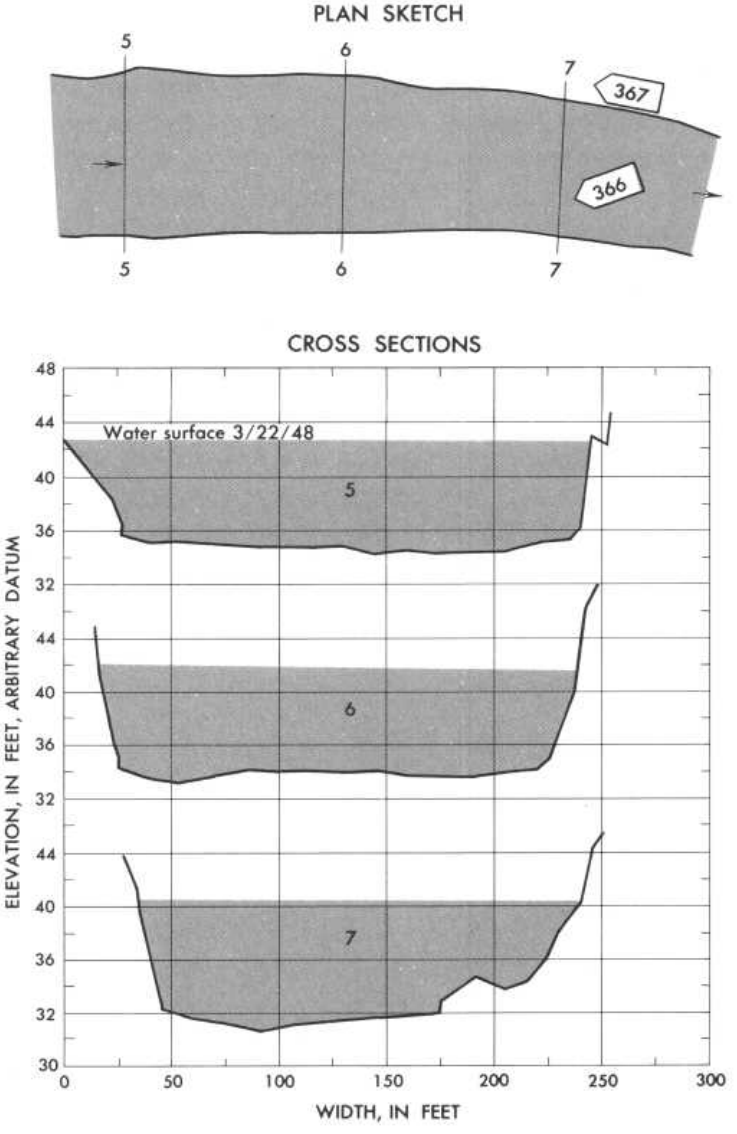
Computed roughness coefficient.—Manning $n = 0.033$.

Description of channel.—Bed consists of coarse gravel and cobbles with scattered boulders. Light brush is on both banks and some trees are near water's edge on right bank.

Reach properties

Section	Area (sq ft)	Top width (ft)	Mean depth (ft)	Hydraulic radius (ft)	Mean velocity (ft per sec)	Length (ft) between sections	Fall (ft) between sections
5	1,700	244	7.0	6.85	9.11	.....	.....
6	1,660	221	7.5	7.36	9.33	279	0.65
7	1,590	206	7.7	7.59	9.72	283	1.25

Notes.—

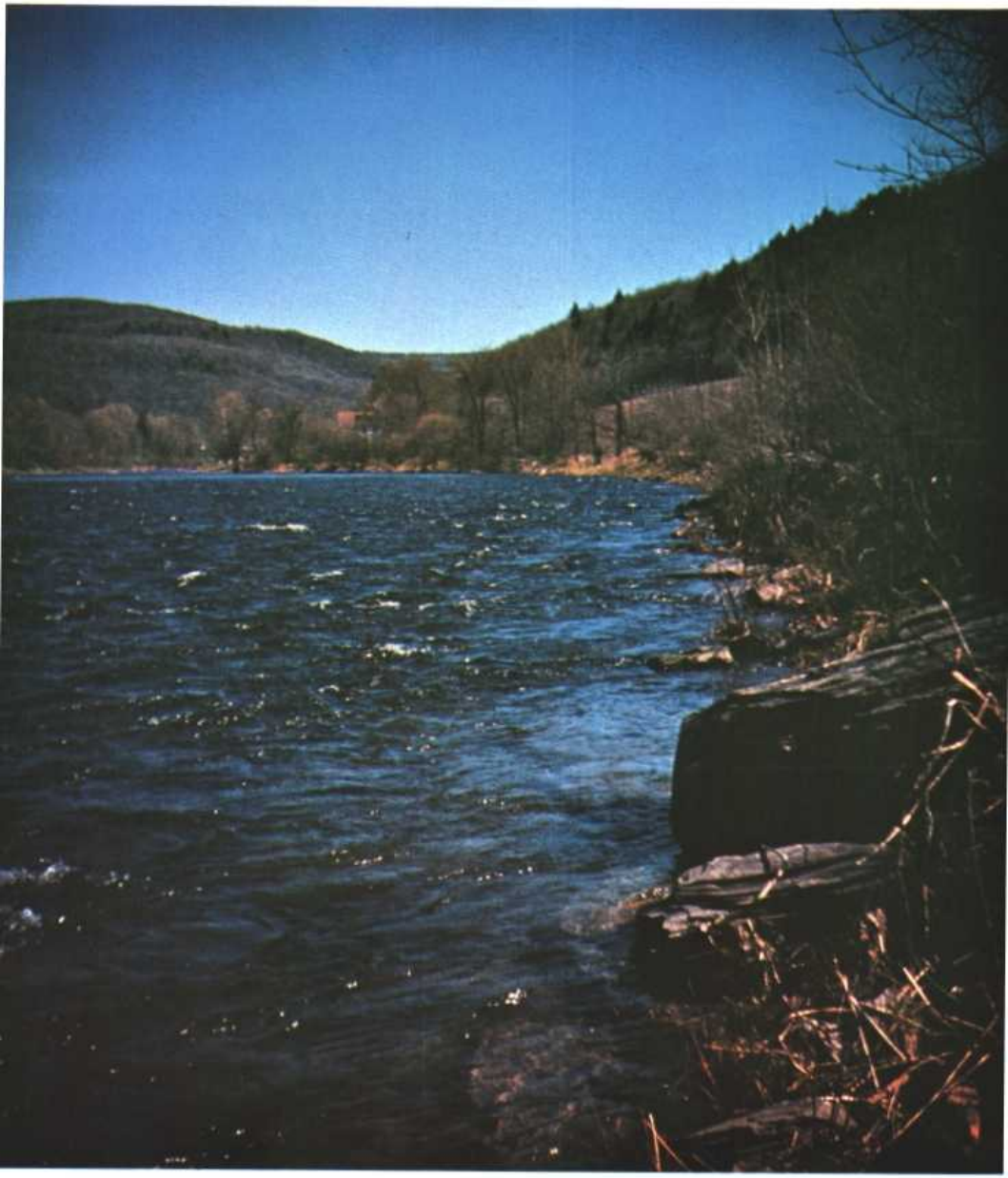


Plan sketch and cross sections, Beaver Kill at Cooks Falls, N.Y.

$n = 0.033$

No. 366 upstream toward right bank from section 7, Beaver Kill at Cooks Falls, N.Y.

$n = 0.033$



No. 367 upstream along left bank from section 7, Beaver Kill at Cooks Falls, N.Y.

13–3390. Clearwater River at Kamiah, Idaho

Gage location.—Lat 46°14′, long 116°01′, in sec. 1, T. 33 N., R. 3 E., on left bank 0.25 mile downstream from highway bridge at Kamiah, 0.75 mile downstream from Lawyer Creek, and 6 miles downstream from South Fork. Section 1 is about 5.8 miles downstream from gage.

Drainage area.—4,850 sq mi, approximately.

Date of flood.—May 29, 1948.

Gage height.—19.22 ft at gage; 46.17 ft at section 1.

Peak discharge.—99,000 cfs.

Computed roughness coefficient.—Manning $n = 0.033$.

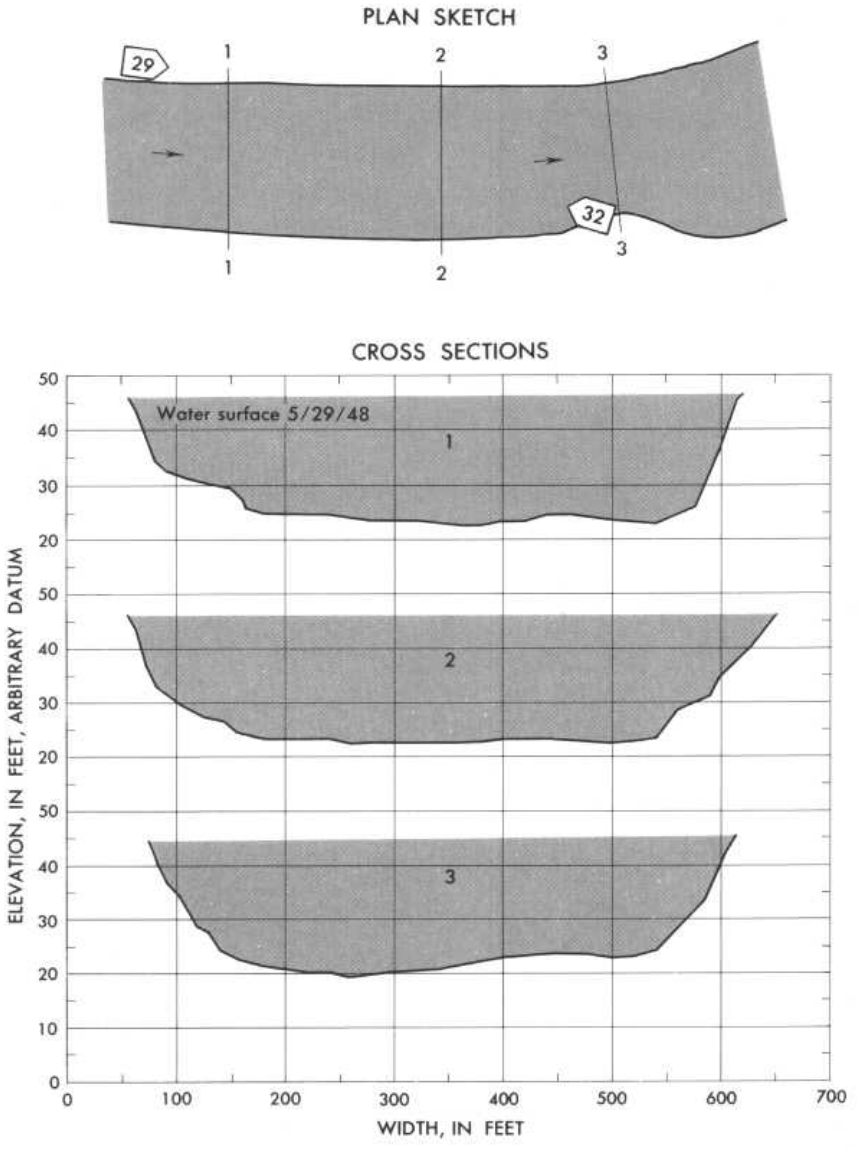
Description of channel.—Bed is composed of gravel and boulders with some exposed bedrock. Channel is bordered by railroad on the right and highway on the left. Banks are gravel and rock and have light vegetation cover.

Reach properties

Section	Area (sq ft)	Top width (ft)	Mean depth (ft)	Hydraulic radius (ft)	Mean velocity (ft per sec)	Length (ft) between sections	Fall (ft) between sections
1	11,100	562	19.25	19.45	8.92	.....	.....
2	11,603	593	19.58	19.34	8.53	732	0.35
3	10,937	538	20.32	20.04	9.05	560	.67

Notes.—

$n = 0.033$



Plan sketch and cross sections, Clearwater River at Kamiah, Idaho.

$n = 0.033$

No. 29 downstream along left bank from above section 1, Clearwater River at Kamiah, Idaho.

$n = 0.033$

No. 32 upstream from left bank at section 3. Clearwater River at Kamiah, Idaho.

n = 0.041; 0.039; 0.035

2–3890. Etowah River near Dawsonville, Ga.

Gage location.—Lat 34°23′, long 84°04′, on left bank 0.5 mile upstream from Palmer Creek, 1 mile downstream from Russell Creek, 4 miles southeast of Dawsonville, Dawson County, and 7.5 miles upstream from Shoal Creek. Section 7 is 477 ft downstream from gage.

Drainage area.—103 sq mi.

Date of flood.—Jan. 22, Feb. 13, Feb. 14, 1959.

Gage height.—9.45 ft, 7.95 ft, 2.85 ft at gage; 9.02 ft, 7.55 ft, 2.18 ft at section 7.

Peak discharge.—2,260 cfs; 1,850 cfs; 515 cfs.

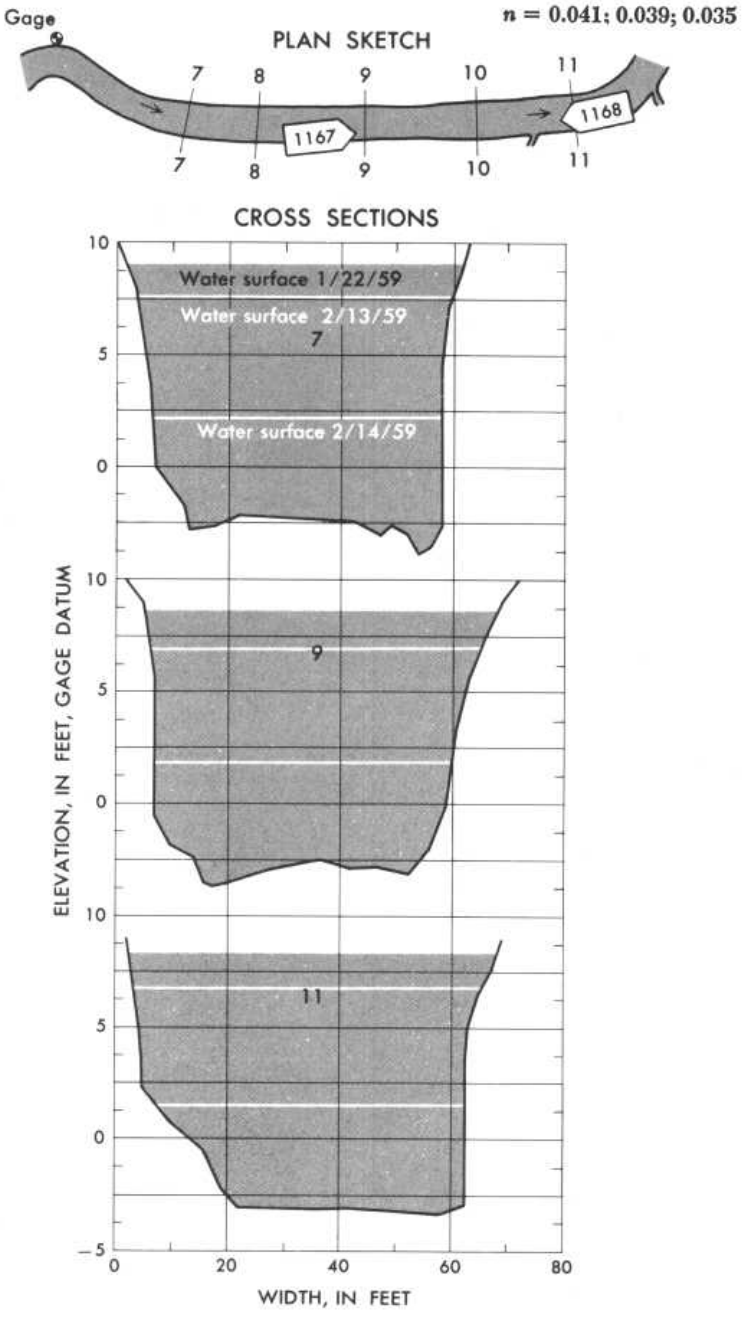
Computed roughness coefficient.—Manning n = 0.041; 0.039; 0.035.

Description of channel.—Bed is sand and gravel with several fallen trees in the reach. Banks are lined with overhanging trees and underbrush.

Reach properties

Section	Area (sq ft)	Top width (ft)	Mean depth (ft)	Hydraulic radius (ft)	Mean velocity (ft per sec)	Length (ft) between sections	Fall (ft) between sections
Jan. 22, 1959							
7	618	60	10.3	8.15	3.66	.....	.....
8	621	66	9.4	7.77	3.64	316	0.22
9	619	63	9.8	8.18	3.65	286	.18
10	610	63	9.7	7.77	3.70	293	.14
11	622	66	9.4	7.89	3.63	203	.17
Feb. 13, 1959							
7	528	57	9.3	7.37	3.50	.....	.....
8	531	64	8.3	6.95	3.48	316	0.19
9	532	59	9.0	7.56	3.48	286	.20
10	525	61	8.6	7.00	3.52	293	.14
11	530	62	8.6	7.10	3.49	203	.14
Feb. 14, 1959							
7	240	51	4.7	4.04	2.15	.....	.....
8	209	59	3.5	3.27	2.46	316	0.16
9	235	53	4.4	4.04	2.19	286	.17
10	203	59	3.4	3.19	2.54	293	.19
11	219	55	4.0	3.59	2.35	203	.15

Notes.—



Plan sketch and cross sections, Etowah River near Dawsonville, Ga.

$n = 0.041; 0.039; 0.035$

No. 1167 downstream from right bank above section 9, Etowah River near Dawsonville, Ga.

$n = 0.041; 0.039; 0.035$

No. 1168 upstream from right bank at section 11, Etowah River near Dawsonville, Ga.

12–3425. West Fork Bitterroot River near Conner, Mont.

Gage location.—Lat 45°44′, long 114°17′, in NE¼NW¼ sec. 26, T. 1 S., R. 22 W., on right bank 0.5 mile downstream from Painted Rocks Lake, 6 miles upstream from Nez Perce Creek, and 16 miles southwest of Conner. Section 1 is about 600 ft downstream from gage.

Drainage area.—317 sq mi.

Date of flood.—May 29, 1948.

Gage height.—6.08 ft at gage; 3.27 ft at section 1.

Peak discharge.—3,880 cfs.

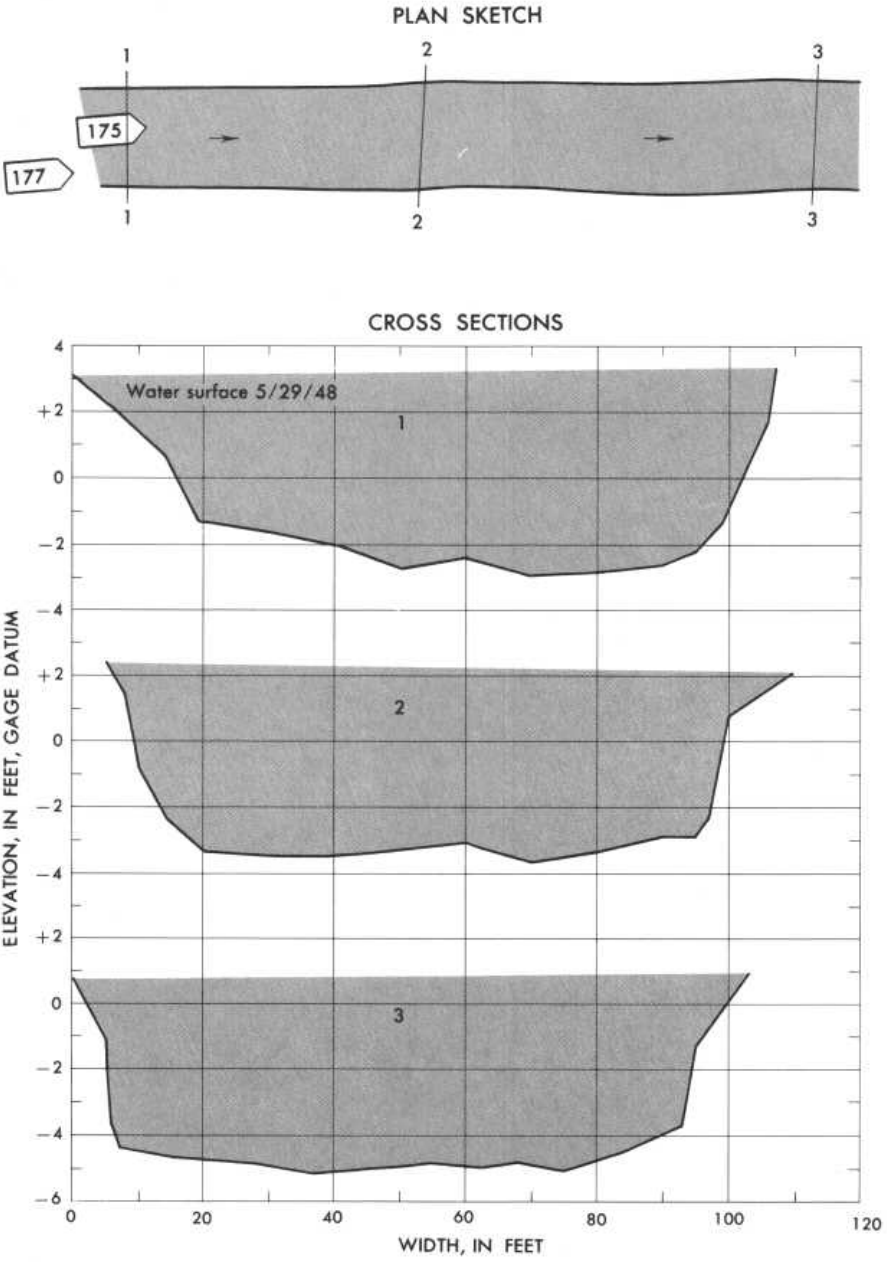
Computed roughness coefficient.—Manning $n = 0.036$.

Description of channel.—Bed is gravel and boulders; $d_{50} = 172$ mm, $d_{84} = 265$ mm. The left bank is lined with overhanging bushes. The right bank is lined with trees.

Reach properties

Section	Area (sq ft)	Top width (ft)	Mean depth (ft)	Hydraulic radius (ft)	Mean velocity (ft per sec)	Length (ft) between sections	Fall (ft) between sections
1	504	107	4.7	4.62	7.70	.....	.....
2	494	105	4.7	4.57	7.85	222	1.02
3	516	103	5.0	4.82	7.52	302	1.40

Notes.—



Plan sketch and cross sections, West Fork Bitterroot River near Conner, Mont.

$n = 0.036$

No. 175 downstream from section 1, West Fork Bitterroot River near Conner, Mont.

$n = 0.036$

No. 177 downstream from right bank above section 1, West Fork Bitterroot River near Conner, Mont.

12–4845. Yakima River at Umtanum, Wash.

Gage location.—Lat 46°51′45″, long 120°28′30″, in NW¼ sec. 20, T. 16 N., R. 19 E., on right bank at Umtanum, 0.5 mile upstream from Umtanum Creek and 10 miles south of Ellensburg. Section 1 is about 650 ft upstream from gage.

Drainage area.—1,590 sq mi, approximately.

Date of flood.—May 29, 1948.

Gage height.—38.98 ft at gage; 41.27 ft at section 1.

Peak discharge.—27,700 cfs.

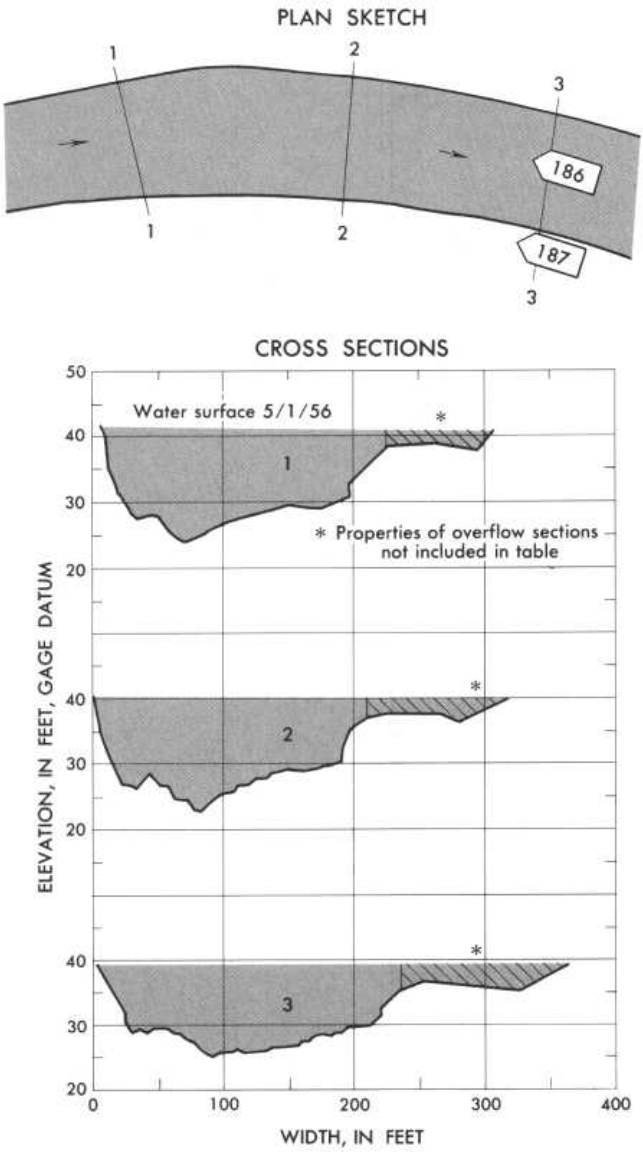
Computed roughness coefficient.—Manning $n = 0.036$.

Description of channel.—Bed consists of gravel and boulders. Left bank is rock riprap with bushes. Right bank is mildly sloped and has some boulders, brush, and weed cover.

Reach properties

Section	Area (sq ft)	Top width (ft)	Mean depth (ft)	Hydraulic radius (ft)	Mean velocity (ft per sec)	Length (ft) between sections	Fall (ft) between sections
1	2,680	222	12.1	11.62	10.34	.....	.....
2	2,550	208	12.3	11.61	10.86	324	0.99
3	2,490	232	10.7	10.32	11.12	302	.86

Notes.—



Plan sketch and cross sections, Yakima River at Umtanum, Wash.

$n = 0.036$

No. 186 upstream from section 3, Yakima River at Umtanum, Wash.

$n = 0.036$

No. 187 upstream along right bank from below section 3, Yakima River at Umtanum, Wash.

5–Misc. Middle Fork Vermilion River near Danville, Ill.

Gage location.—Lat 40°08′, long 87°45′, in NE¼SW¼ sec. 5, T. 19 N., R. 12 W., at downstream side of bridge in Kickapoo State Park. Section 1 is 30 ft downstream from bridge.

Drainage area.—417 sq mi.

Date of flood.—May 1, 1956.

Gage height.—549.20 ft at gage; 549.13 ft at section 1.

Peak discharge.—1,620 cfs.

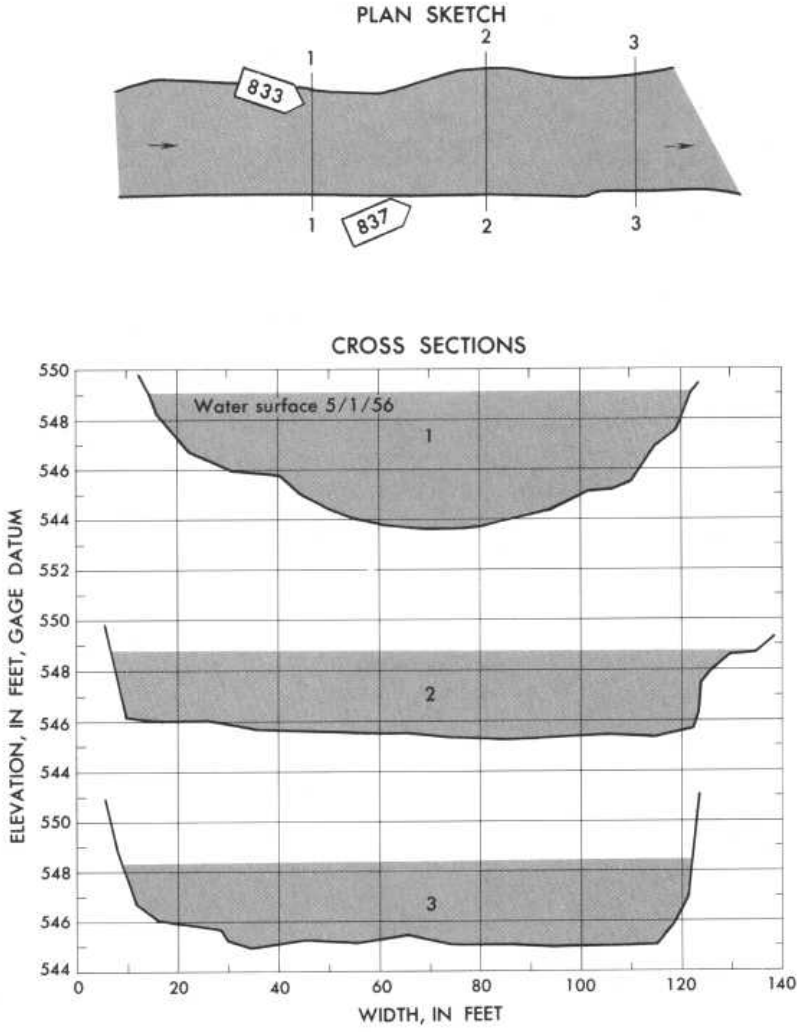
Computed roughness coefficient.—Manning $n = 0.037$.

Description of channel.—Bed is gravel and small cobbles. Banks are lined with trees and small underbrush.

Reach properties

Section	Area (sq ft)	Top width (ft)	Mean depth (ft)	Hydraulic radius (ft)	Mean velocity (ft per sec)	Length (ft) between sections	Fall (ft) between sections
1	423	108	3.9	3.88	3.82	.....	.....
2	369	129	2.9	2.82	4.40	123	0.36
3	344	114	3.0	2.97	4.72	106	.35

Notes.—



Plan sketch and cross sections, Middle Fork Vermilion River near Danville, Ill.

$n = 0.037$

No. 833 downstream from left bank at section 1, Middle Fork Vermilion River near Danville, Ill.

$n = 0.037$

No. 837 downstream from right bank at section 1, Middle Fork Vermilion River near Danville, Ill.

12–4570. Wenatchee River at Plain, Wash.

Gage location.—Lat 47°45′50″, long 120°39′30″, in lot 8, sec. 12, T. 26 N., R. 17 E., on left bank at Plain, 0.25 mile downstream from Beaver Creek, 7.5 miles downstream from Nason Creek, and 12 miles north of Leavenworth. Section 1 is 1,360 ft upstream from gage.

Drainage area.—591 sq mi.

Date of flood.—May 29, 1948.

Gage height.—12.43 ft at gage; 16.50 ft at section 1.

Peak discharge.—22,700 cfs.

Computed roughness coefficient.—Manning $n = 0.037$.

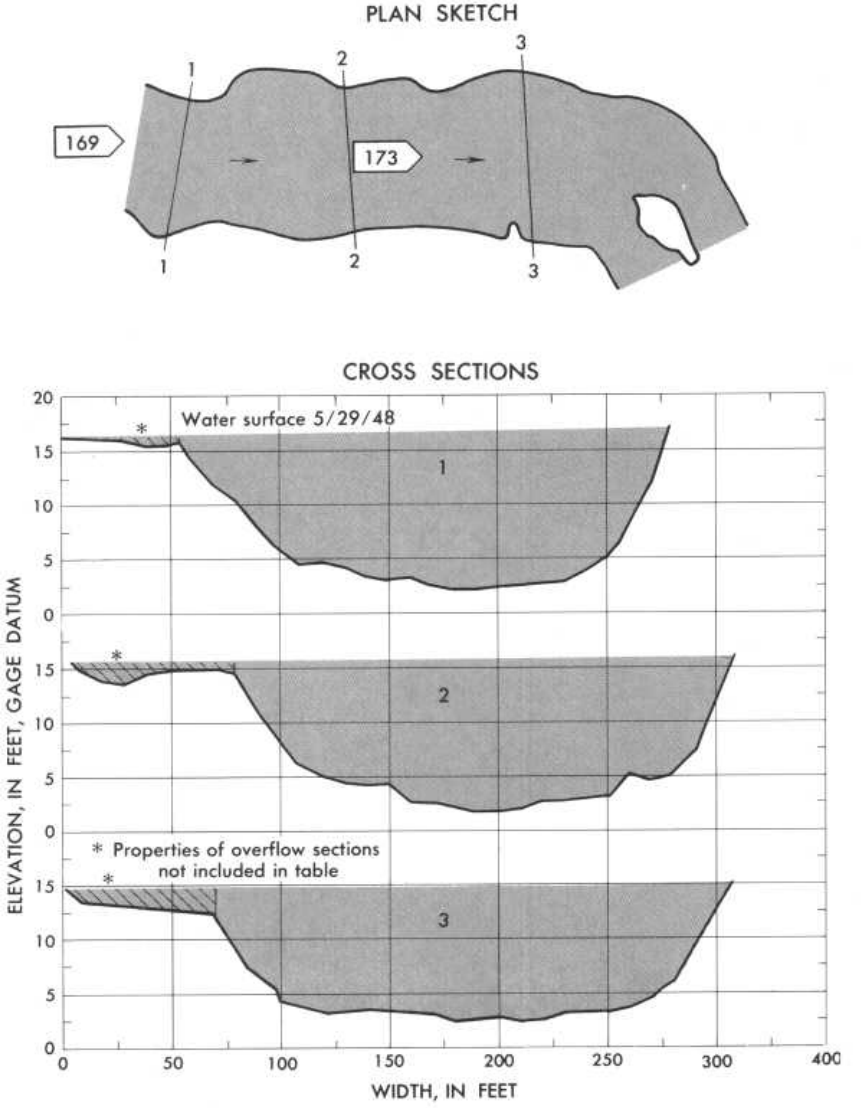
Description of channel.—Bed is boulders; $d_{50} = 162$ mm, $d_{85} = 320$ mm. Banks are lined with trees and bushes.

Reach properties

Section	Area (sq ft)	Top width (ft)	Mean depth (ft)	Hydraulic radius (ft)	Mean velocity (ft per sec)	Length (ft) between sections	Fall (ft) between sections
1	2,480	224	11.1	10.86	9.15	.....	.....
2	2,470	228	10.8	10.58	9.19	311	0.75
3	2,440	237	10.3	10.05	9.30	325	.75

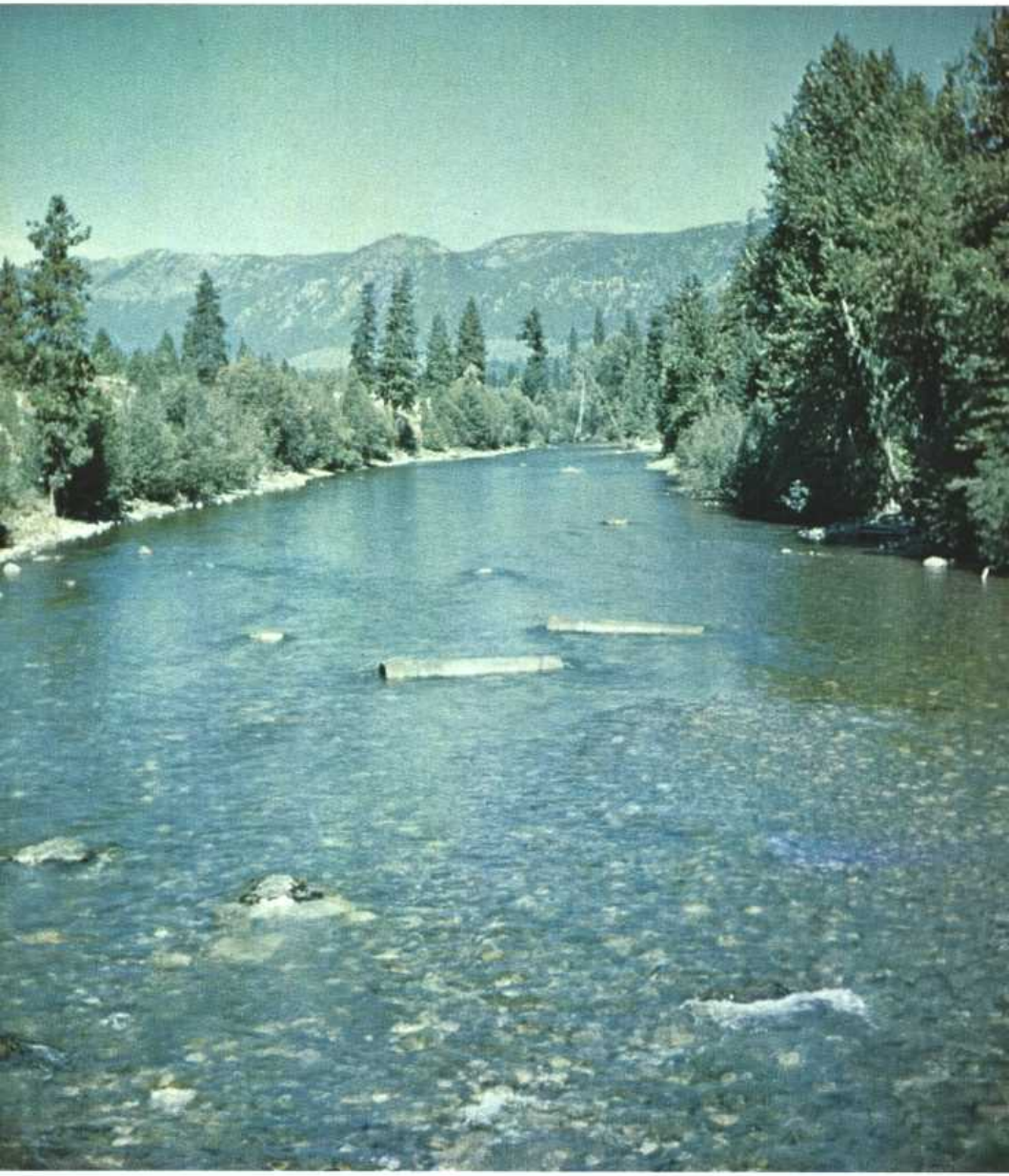
Notes.—

$n = 0.037$



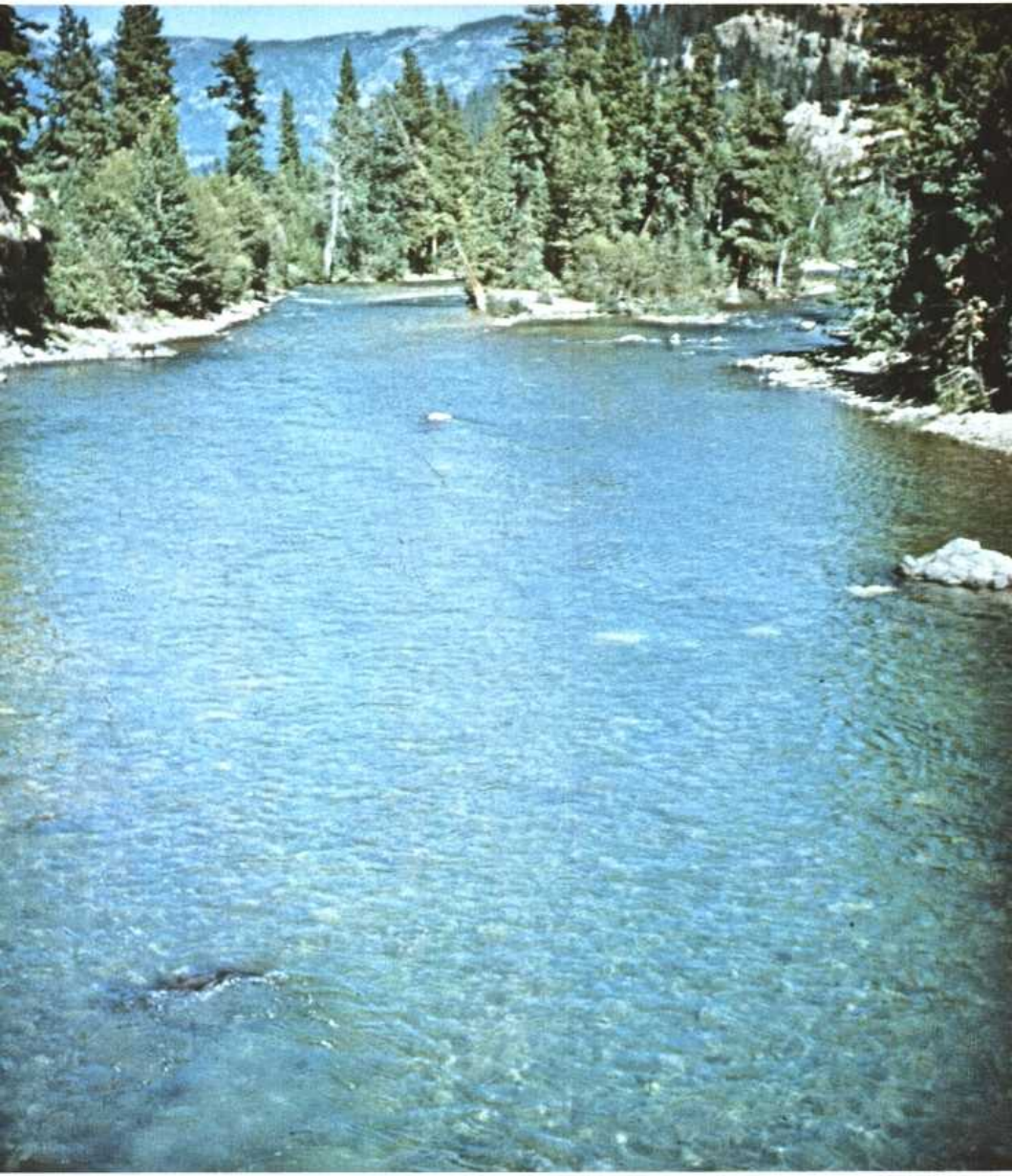
Plan sketch and cross sections, Wenatchee River at Plain, Wash.

$n = 0.037$



No. 169 downstream from above section 1, Wenatchee River at Plain, Wash.

$n = 0.037$



No. 173 downstream from section 2, Wenatchee River at Plain, Wash.

$n = 0.038$

12–3065. Moyie River at Eastport, Idaho

Gage location.—Lat 49°00′, long 116°11′, in SE¼ sec. 10, T. 65 N., R. 2 E., on left bank at Eastport, 1,000 ft downstream from international boundary. Section 1 is about 0.5 mile downstream from gage.

Drainage area.—570 sq mi, approximately.

Date of flood.—May 24, 1948.

Gage height.—10.25 ft at gage; 20.68 ft (different datum) at section 1.

Peak discharge.—8,030 cfs.

Computed roughness coefficient.—Manning $n = 0.038$.

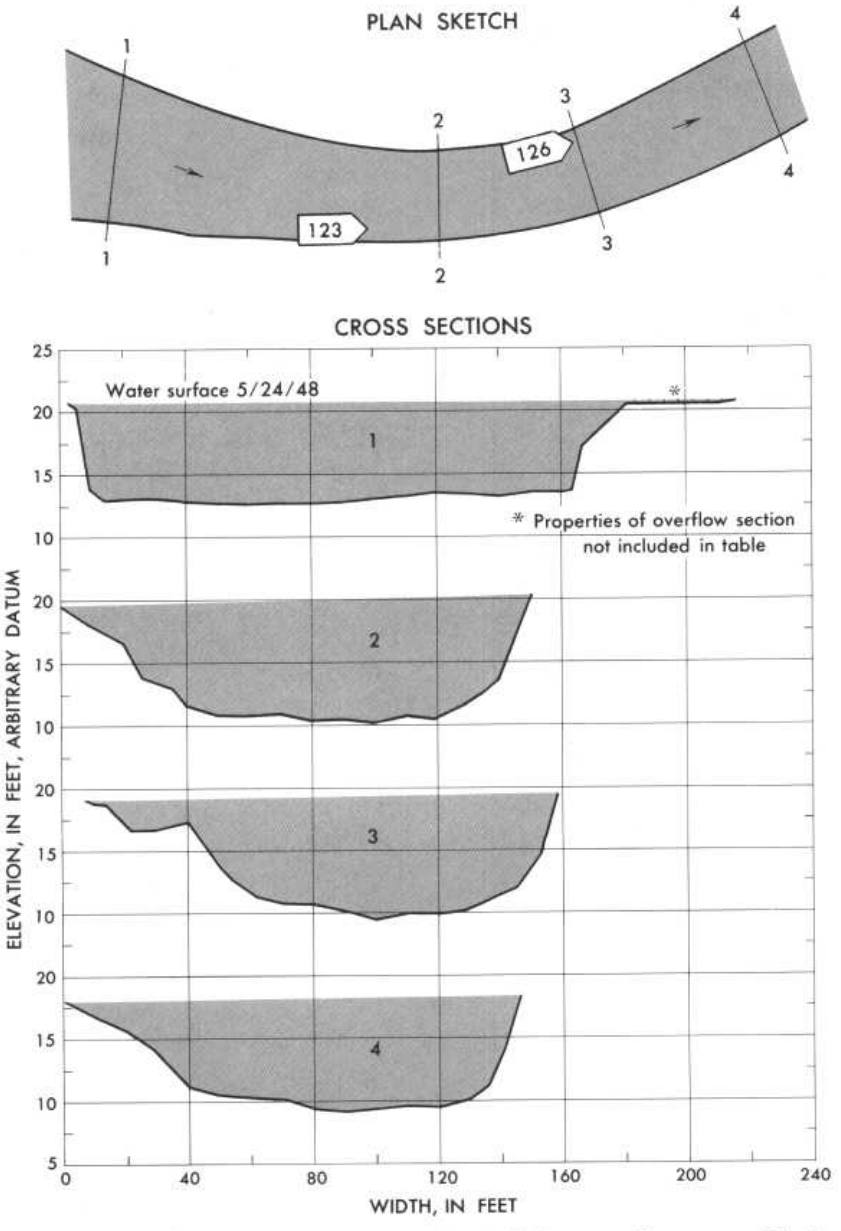
Description of channel.—Bed of gravel and well-rounded small boulders. Right bank is fairly steep and lined with trees and brush. Left bank slopes gently and has tree and brush cover below section 2.

Reach properties

Section	Area (sq ft)	Top width (ft)	Mean depth (ft)	Hydraulic radius (ft)	Mean velocity (ft per sec)	Length (ft) between sections	Fall (ft) between sections
1	1,224	176	6.96	6.74	6.56	.....	.....
2	1,090	150	7.27	7.13	7.37	269	0.73
3	919	118	7.78	7.47	8.74	185	.68
4	944	145	6.51	6.38	8.51	226	1.07

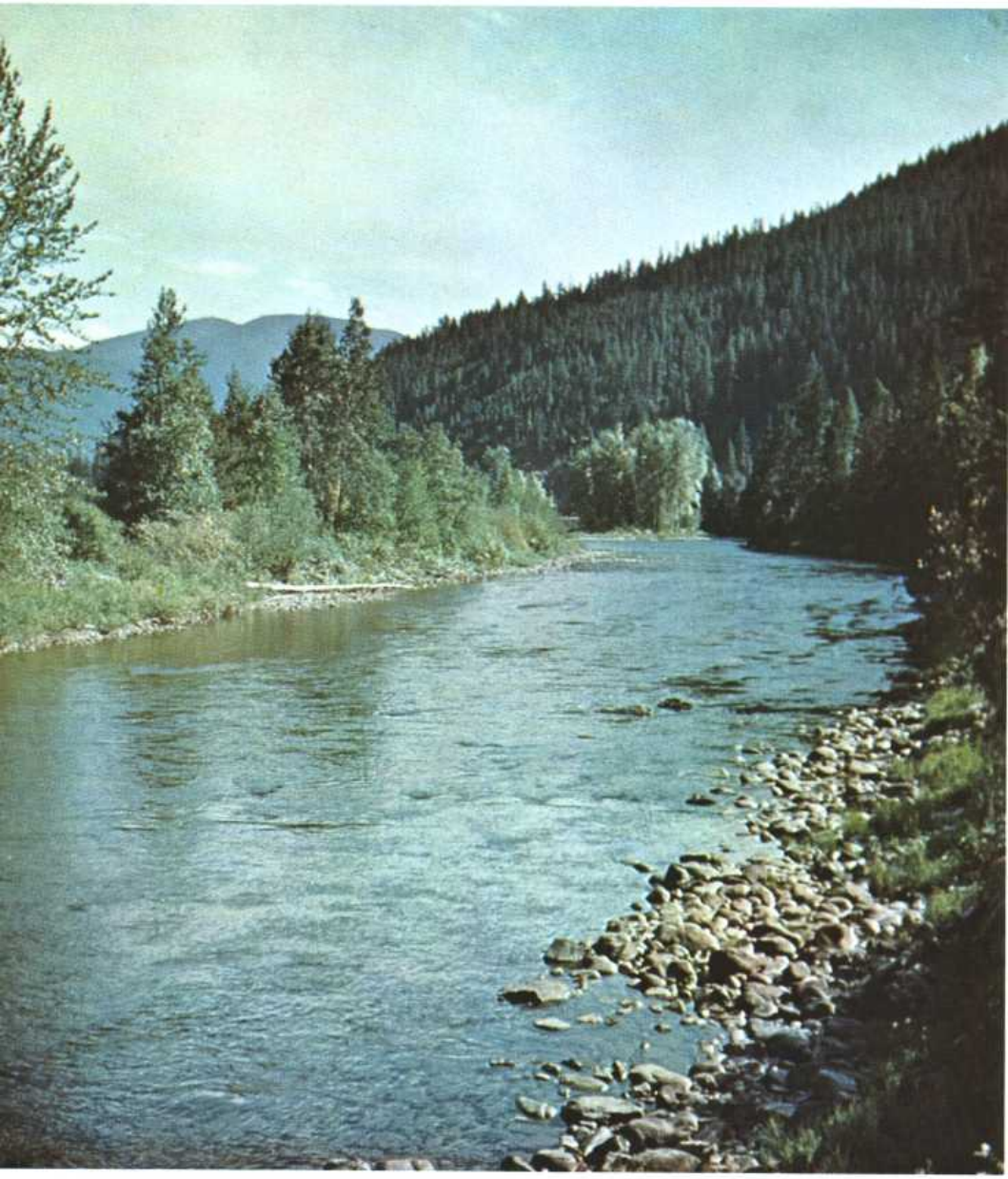
Notes.—

$n = 0.038$



Plan sketch and cross sections, Moyie River at Eastport, Idaho.

$n = 0.038$



No. 123 downstream from right bank above section 2, Moyie River at Eastport, Idaho.

$n = 0.038$

No. 126 downstream along left bank at section 3,
Moyie River at Eastport, Idaho.

$n = 0.038$

12–4225. Spokane River at Spokane, Wash.

Gage location.—Lat 47°39′35″, long 117°26′50″, in SW¼ sec. 13, T. 25 N., R. 42 E., on right bank at Cochran Street in Spokane, 0.5 mile upstream from Latah Creek. Section 1 is about 800 ft upstream from gage.

Drainage area.—4,290 sq mi.

Date of flood.—May 31, 1948.

Gage height.—28.35 ft at gage; 29.37 at section 1.

Peak discharge.—39,600 cfs.

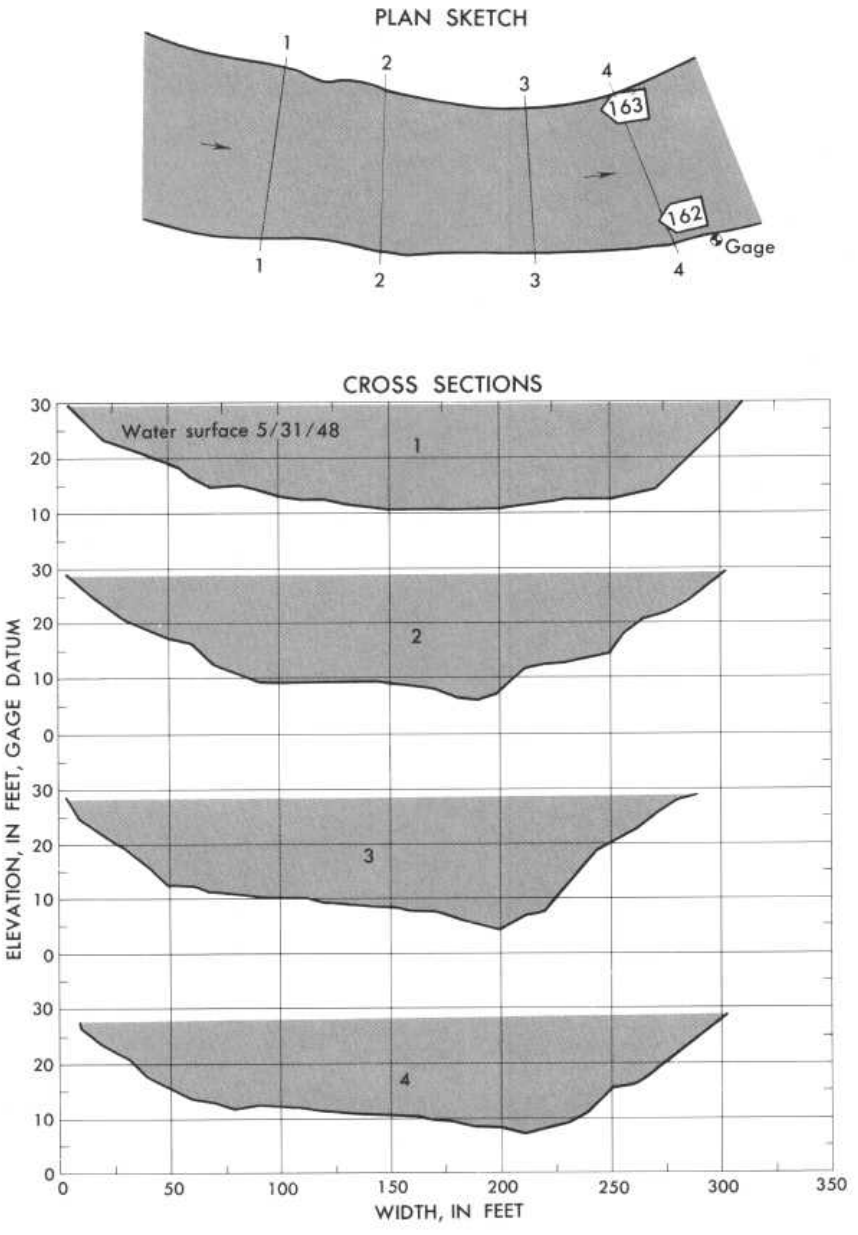
Computed roughness coefficient.—Manning $n = 0.038$.

Description of channel.—Bed is gravel and boulders; $d_{50} = 195$ mm, $d_{84} = 360$ mm. Banks are lined with trees and brush.

Reach properties

Section	Area (sq ft)	Top width (ft)	Mean depth (ft)	Hydraulic radius (ft)	Mean velocity (ft per sec)	Length (ft) between sections	Fall (ft) between sections
1	4,350	305	14.3	14.03	9.10	.....	.....
2	4,370	298	14.7	14.38	9.06	202	0.44
3	4,290	285	15.1	14.71	9.23	268	.49
4	4,120	293	14.1	13.84	9.61	220	.29

Notes.—



Plan sketch and cross sections, Spokane River at Spokane, Wash.

$n = 0.038$

No. 162 upstream along right bank from section 4, Spokane River at Spokane, Wash.

$n = 0.038$

No. 163 upstream along left bank from section 4, Spokane River at Spokane, Wash.

n = 0.043; 0.041; 0.039

2–2135. Tobesofkee Creek near Macon, Ga.

Gage location.—Lat 32°48′, long 83°46′, on right bank at downstream end of pier of bridge on U.S. Highway 80, 8 miles west of Macon, Bibb County, and 14 miles upstream from mouth. Section 1 is about 1,800 ft upstream from gage.

Drainage area.—182 sq mi.

Date of flood.—Mar. 7, 1958; Feb. 6, 1959; Feb. 9, 1959.

Gage height.—11.84 ft, 11.03 ft, 7.55 ft at gage; 13.31 ft, 12.51 ft, 9.02 ft at section 1.

Peak discharge.—2,540 cfs; 2,240 cfs; 1,260 cfs.

Computed roughness coefficient.—Manning n = 0.043; 0.041; 0.039.

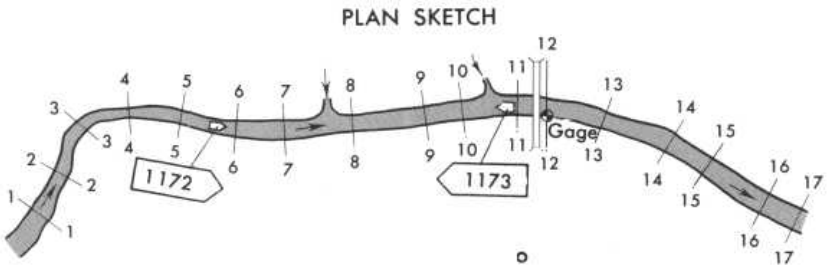
Description of channel.—Bed consists of sand, gravel, and a few outcrops. Banks are fairly uniform with overhanging trees and underbrush.

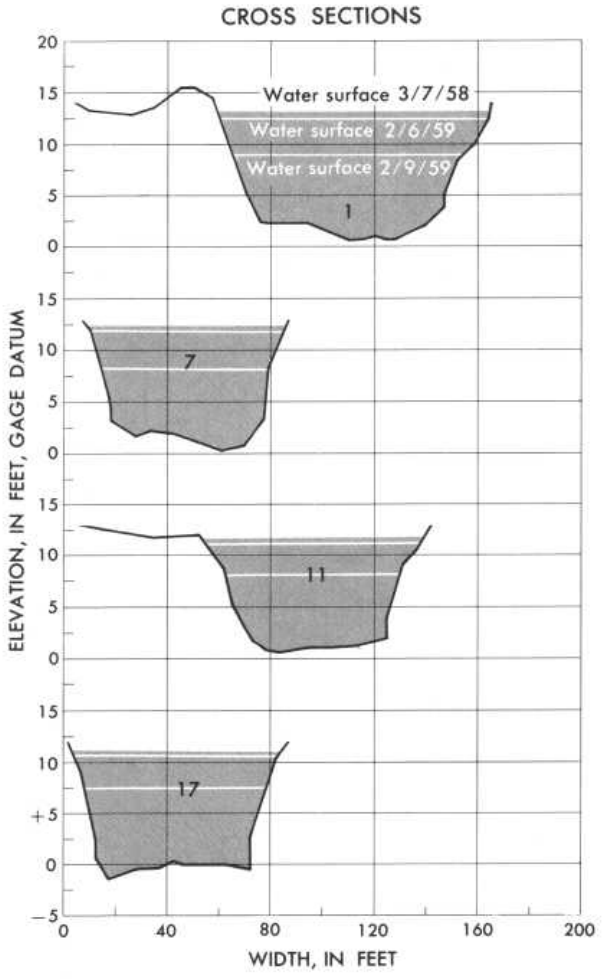
Reach properties

Section	Area (sq ft)	Top width (ft)	Mean depth (ft)	Hydraulic radius (ft)	Mean velocity (ft per sec)	Length (ft) between sections	Fall (ft) between sections
Mar. 7, 1958							
3	768	85	9.0	7.84	3.31	.....	.....
7	700	76	9.2	7.69	3.63	652	0.60
11	700	87	8.0	7.29	3.63	731	.58
14	761	80	9.5	8.36	3.34	495	.27
17	770	82	9.4	8.28	3.31	469	.36
Feb. 6, 1959							
3	700	81	8.8	7.65	3.20	.....	.....
7	640	74	8.7	7.40	3.50	652	0.60
11	625	83	7.6	6.80	3.58	731	.58
14	700	76	9.1	7.90	3.20	495	.27
17	715	79	9.1	8.00	3.13	469	.21
Feb. 9, 1959							
3	435	73	6.1	5.55	2.90	.....	.....
7	405	64	6.3	5.50	3.11	652	0.48
11	375	69	5.6	5.00	3.36	731	.60
14	450	64	6.5	5.85	2.80	495	.33
17	455	69	6.6	5.75	2.77	469	.30

Notes.—

$n = 0.043; 0.041; 0.039$





Plan sketch and cross sections, Tobesofkee Creek near Macon, Ga.

$n = 0.043; 0.041; 0.039$

No. 1172 downstream from section 6, Tobesofkee Creek near Macon, Ga.

$n = 0.043; 0.041; 0.039$

No. 1173 upstream from bridge section 12, Tobesofkee Creek near Macon, Ga.

$n = 0.041$

8–1185. Bull Creek near Ira, Tex.

Gage location.—Lat 32°36′02″, long 101°05′40″, on left bank 800 ft upstream from bridge on Farm to Market Road 2085, 1.9 miles upstream from Colorado River, 5.3 miles downstream from Chimney Creek, 5.5 miles west of Ira, Scurry County, 7.7 miles northwest of Cuthbert, and 8.3 miles downstream from Bull Creek diversion dam. Section 1 is about 1,000 ft downstream from gage.

Drainage area.—388 sq mi, approximate contributing area.

Date of flood.—June 1, 1948.

Gage height.—8.84 ft at gage; 8.26 ft at section 1.

Peak discharge.—3,220 cfs.

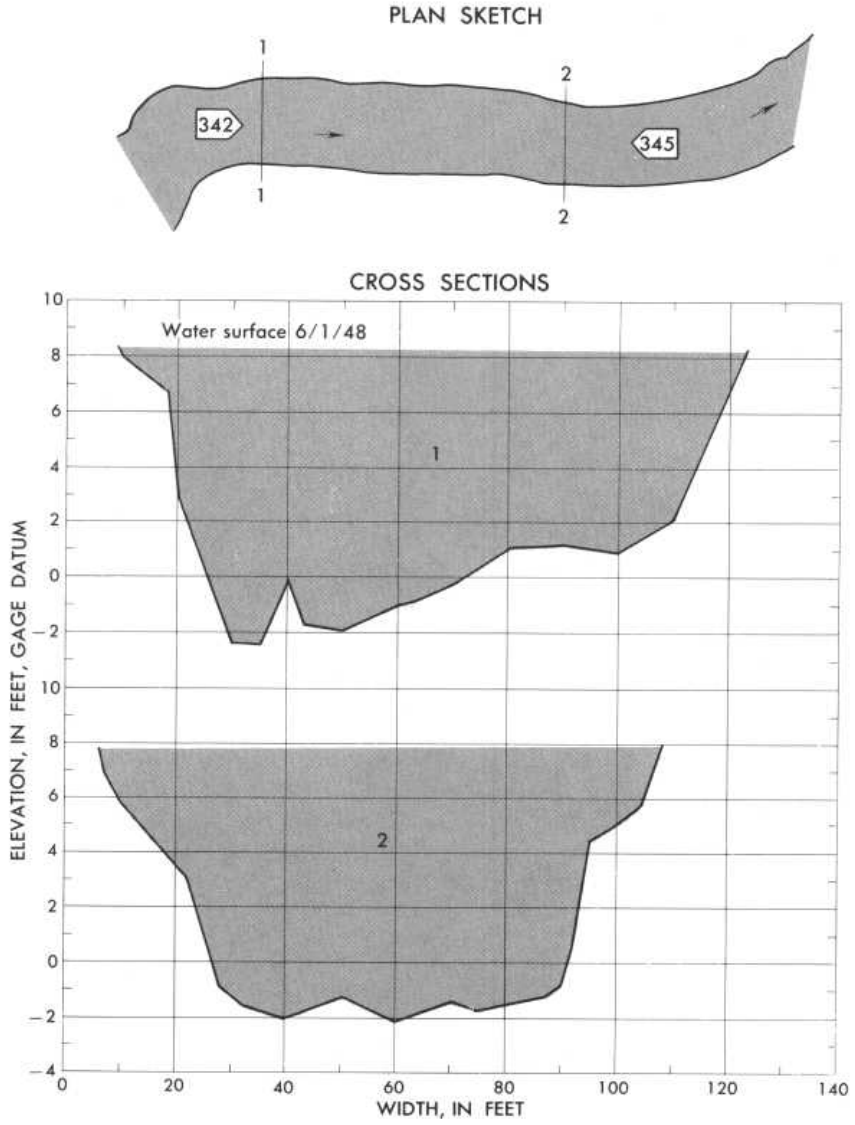
Computed roughness coefficient.—Manning $n = 0.041$.

Description of channel.—Bed is composed of sand, gravel, and small boulders with scattered large angular rocks. Banks are irregular and eroded, and have sparse cover of grass and scattered small trees. The channel reach between sections 1 and 2 is fairly straight. The channel curves sharply above the reach and moderately below it.

Reach properties

Section	Area (sq ft)	Top width (ft)	Mean depth (ft)	Hydraulic radius (ft)	Mean velocity (ft per sec)	Length (ft) between sections	Fall (ft) between sections
1	818	114	7.2	6.79	3.94	.....	.....
2	735	102	7.2	6.87	4.38	315	0.38

Notes.—



Plan sketch and cross sections, Bull Creek near Ira, Tex.

$n = 0.041$

No. 342 downstream from above section 1, Bull Creek near Ira, Tex.

No. 345 upstream from below section 2, Bull Creek near Ira, Tex.

$n = 0.041$

12–3557. Middle Fork Flathead River near Essex, Mont.

Gage location.—Lat 48°10′20″, long 113°32′40″, near center of sec. 19, T. 28 N., R. 15 W., on right bank 0.25 mile downstream from Spruce Park Cabin, 1 mile downstream from Charlie Creek, and 7.5 miles southeast of Essex. Section 1 is 600 ft upstream from gage.

Drainage area.—408 sq mi.

Date of flood.—May 22, 1948.

Gage height.—10.95 ft at gage; 14.21 ft at section 1.

Peak discharge.—14,500 cfs.

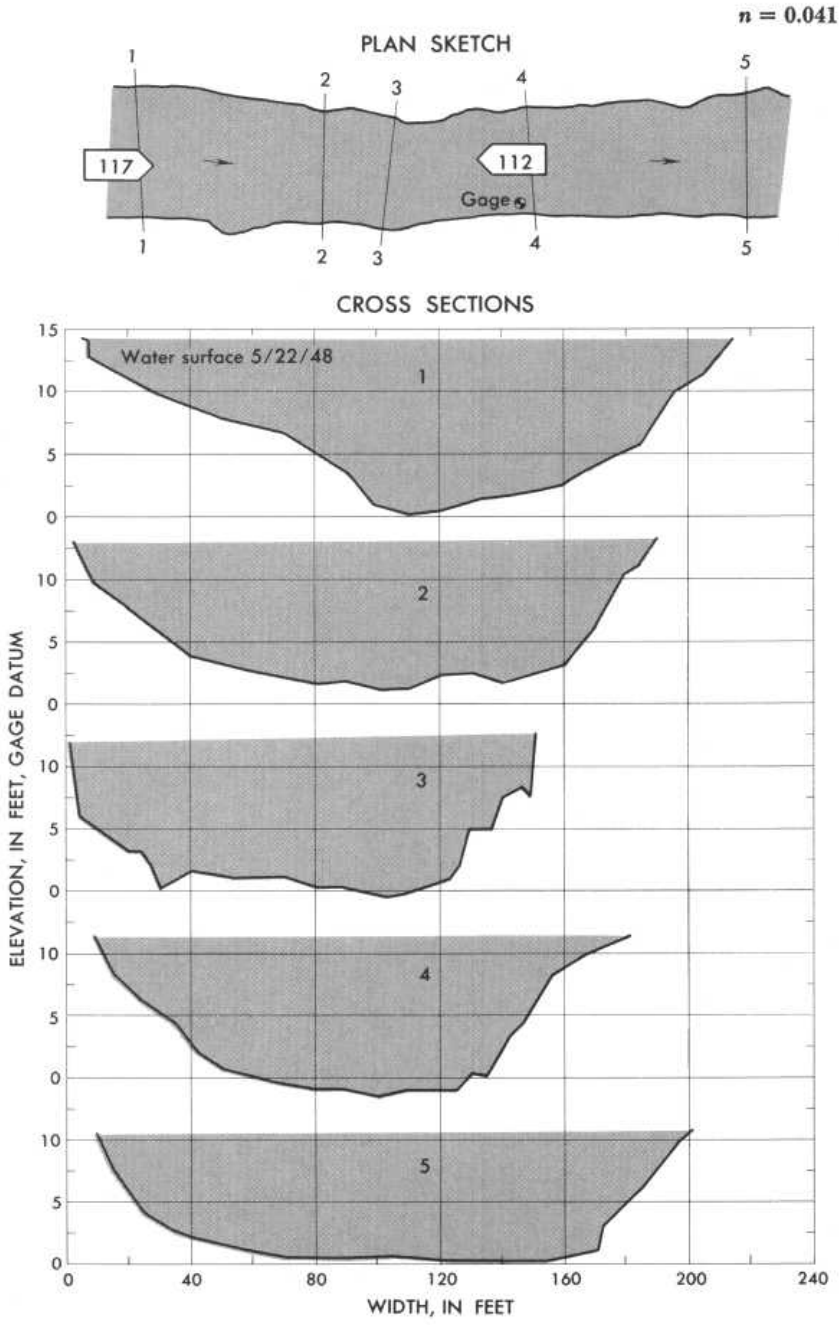
Computed roughness coefficient.—Manning $n = 0.041$.

Description of channel.—Bed consists of boulders; $d_{50} = 142$ mm, $d_{84} = 285$ mm. Banks are composed of gravel and boulders, and have trees and brush along the tops.

Reach properties

Section	Area (sq ft)	Top width (ft)	Mean depth (ft)	Hydraulic radius (ft)	Mean velocity (ft per sec)	Length (ft) between sections	Fall (ft) between sections
1	1,745	208	8.39	8.23	8.31	.....	.....
2	1,658	187	8.87	8.73	8.75	291	1.07
3	1,504	150	10.03	9.35	9.64	109	.64
4	1,472	172	8.56	8.37	9.85	221	.88
5	1,601	191	8.38	8.22	9.06	346	.87

Notes.—



Plan sketch and cross sections, Middle Fork Flathead River near Essex, Mont.

$n = 0.041$

No. 112 upstream from section 4, Middle Fork Flathead River near Essex, Mont.

No. 117 downstream from section 1, Middle Fork Flathead River near Essex, Mont.

2–2175. Middle Oconee River near Athens, Ga.

Gage location.—Lat 33°58′, long 83°25′, on left bank 0.5 mile upstream from U.S. Highway 29, 2 miles west of Athens, Clarke County, and 5 miles upstream from Barber Creek. Section 3 is about 3,100 ft upstream from gage.

Drainage area.—398 sq mi.

Date of flood.—May 31, May 27, Apr. 17, 1959.

Gage height.—11.68 ft, 7.04 ft, 4.90 ft at gage; 13.34 ft, 8.96 ft, 7.24 ft at section 3.

Peak discharge.—6,110 cfs; 3,140 cfs; 2,210 cfs.

Computed roughness coefficient.—Manning n = 0.042; 0.041; 0.044.

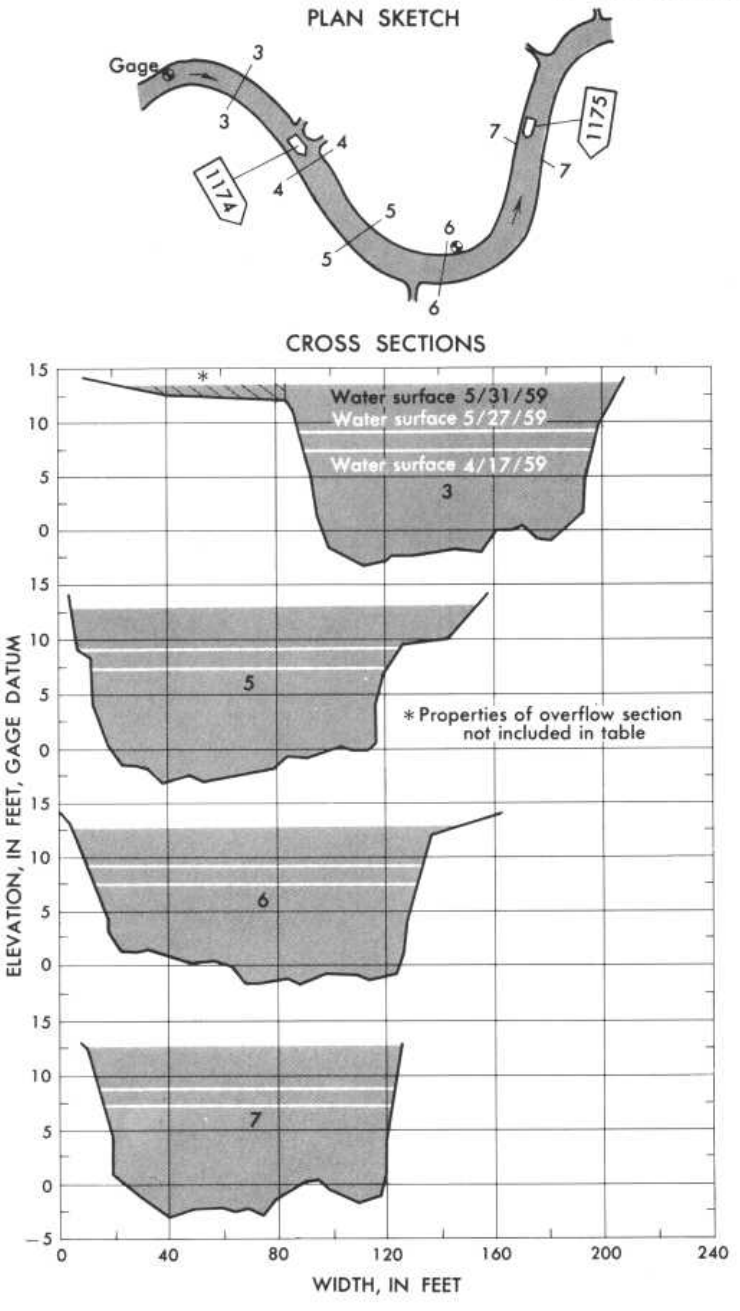
Description of channel.—Bed is sand and gravel with several outcrops in the reach. Banks are steep and lined with overhanging trees and bushes.

Reach properties

Section	Area (sq ft)	Top width (ft)	Mean depth (ft)	Hydraulic radius (ft)	Mean velocity (ft per sec)	Length (ft) between sections	Fall (ft) between sections
May 31, 1959							
3	1,560	161	9.7	8.91	3.92	.....	.....
4	1,510	140	10.8	10.38	4.05	278	0.07
5	1,560	146	10.7	9.94	3.92	554	.34
6	1,540	142	10.8	10.13	3.97	333	.10
7	1,450	116	12.5	11.19	4.20	399	.22
May 27, 1959							
3	1,020	108	9.5	8.83	3.09	.....	.....
4	940	116	8.1	7.70	3.34	278	0.21
5	1,000	112	8.9	8.38	3.12	554	.21
6	970	121	8.0	7.52	3.24	333	.16
7	950	107	8.9	8.05	3.30	399	.23
Apr. 17, 1959							
3	840	105	8.0	7.57	2.63	.....	.....
4	735	110	6.7	6.50	3.01	278	0.20
5	810	104	7.8	7.23	2.73	554	.29
6	758	116	6.5	6.11	2.92	333	.15
7	760	103	7.4	6.79	2.91	399	.28

Notes.—

n = 0.042; 0.041; 0.044



Plan sketch and cross sections, Middle Oconee River near Athens, Ga.

n = 0.042; 0.041; 0.044

No. 1174 downstream from above section 4, Middle Oconee River near Athens, Ga.

$n = 0.042; 0.041; 0.044$

No. 1175 upstream from right bank at section 7, Middle Oconee River near Athens, Ga.

6–3940. Beaver Creek near Newcastle, Wyo.

Gage location.—Lat 43°32′05″, long 104°07′00″, in NW¼ sec. 18, T. 41 N., R. 60 W., at highway bridge, 2.5 miles downstream from Sheep Creek, and 23 miles south of Newcastle. Section 1 is about 300 ft downstream from gage.

Drainage area.—1,320 sq mi, approximately.

Date of flood.—May 30, 1953.

Gage height.—12.75 ft at gage; 11.98 ft at section 1.

Peak discharge.—1,600 cfs.

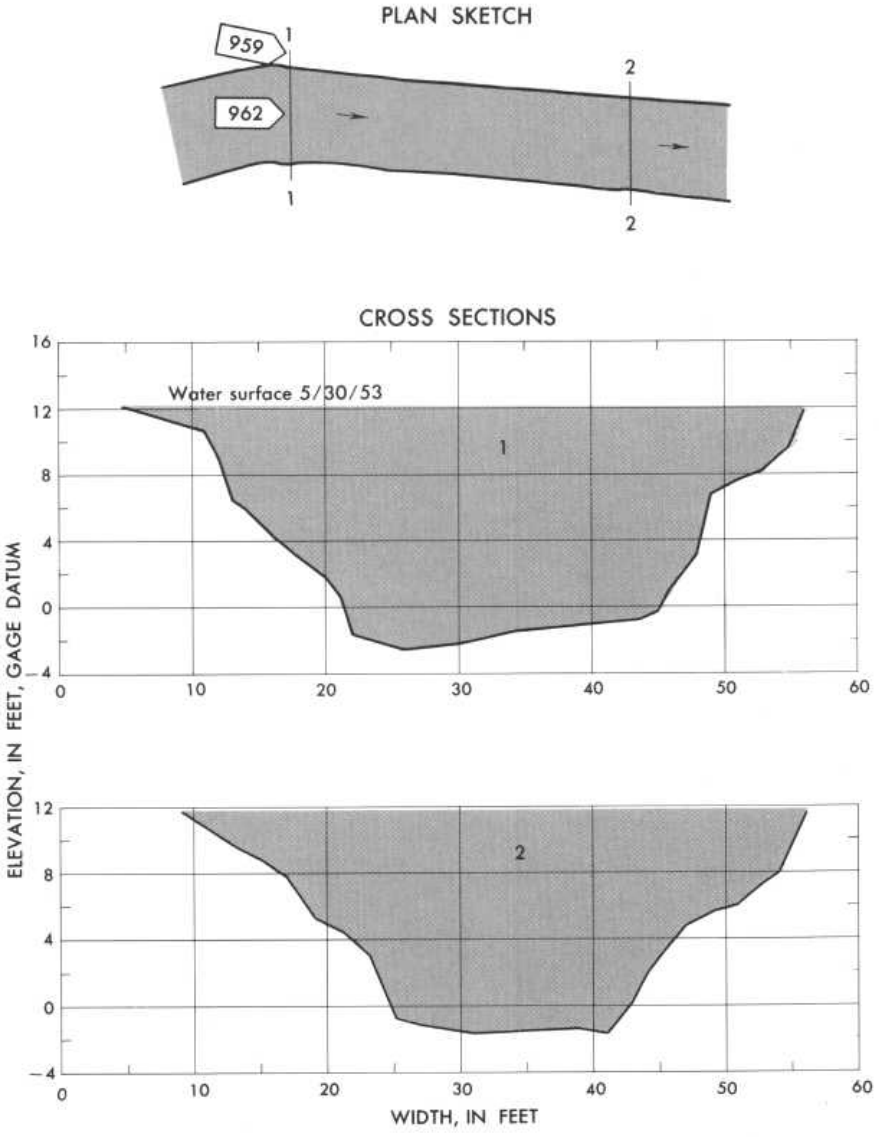
Computed roughness coefficient.—Manning $n = 0.043$.

Description of channel.—Bed is mostly sand and silt. Banks are irregular and have thick growth of brush. Channel curves about 20° to the right above the reach and straightens below it.

Reach properties

Section	Area (sq ft)	Top width (ft)	Mean depth (ft)	Hydraulic radius (ft)	Mean velocity (ft per sec)	Length (ft) between sections	Fall (ft) between sections
1	461	51	9.0	7.20	3.49	.....	.....
2	389	47	8.3	6.68	4.11	194	0.24

Notes.—



Plan sketch and cross sections, Beaver Creek near Newcastle, Wyo.

$n = 0.043$

No. 959 downstream from left bank at section 1, Beaver Creek near Newcastle, Wyo.

$n = 0.043$

No. 962 downstream from above section 1, Beaver Creek near Newcastle, Wyo.

13–3200. Catherine Creek near Union, Oreg.

Gage location.—Lat 45°09′20″, long 117°46′40″, in SE¼ sec. 2, T. 5 S., R. 40 E., on right bank 3 miles downstream from Little Catherine Creek and 6 miles southeast of Union. Section 1 is about 0.75 mile downstream from gage.

Drainage area.—105 sq mi.

Date of flood.—May 27, 1948.

Gage height.—4.57 ft at gage; 21.21 ft (different datum) at section 1.

Peak discharge.—1,740 cfs.

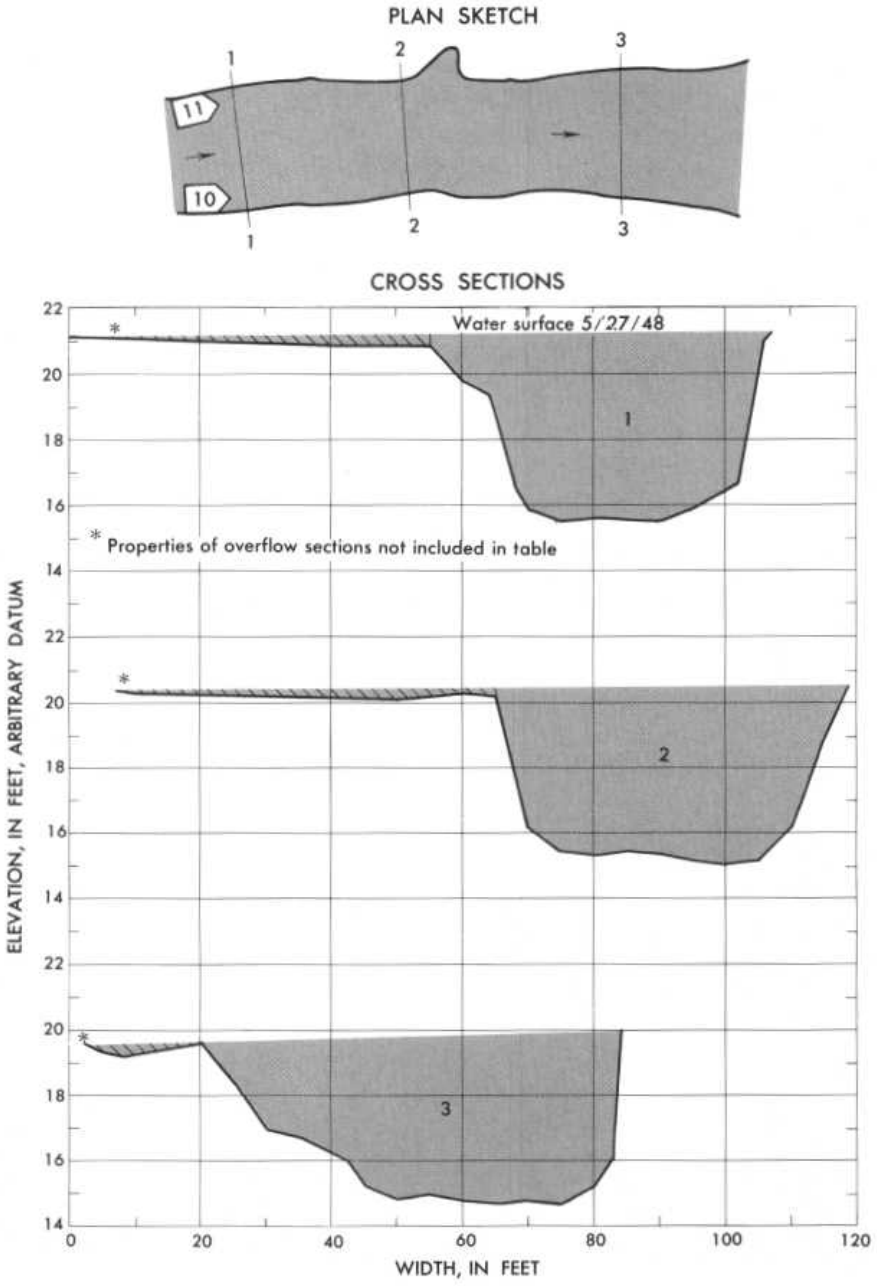
Computed roughness coefficient.—Manning $n = 0.043$.

Description of channel.—Bed consists of cobbles and small boulders. Banks are lined with small trees and brush, and limbs overhang along left bank.

Reach properties

Section	Area (sq ft)	Top width (ft)	Mean depth (ft)	Hydraulic radius (ft)	Mean velocity (ft per sec)	Length (ft) between sections	Fall (ft) between sections
1	220	52	4.23	4.00	7.91	.....	.....
2	236	54	4.37	4.15	7.37	102	0.73
3	256	64	4.00	3.76	6.80	116	.72

Notes.—



Plan sketch and cross sections, Catherine Creek near Union, Oreg.

$n = 0.043$

No. 10 downstream along right bank from above reach, Catherine Creek near Union, Oreg.

$n = 0.043$

No. 11 downstream along left bank from above reach, Catherine Creek near Union, Oreg.

$n = 0.043$

12–4565. Chiwawa River near Plain, Wash.

Gage location.—Lat 47°50′30″, long 120°39′40″, in SE¼ sec. 13, T. 27 N., R. 12 E., on right bank 0.5 mile upstream from Goose Creek, 6 miles north of Plain, 7 miles upstream from mouth, and 11 miles northeast of Chiwaukum. Section 1 is 90 ft downstream from gage.

Drainage area.—170 sq mi.

Date of flood.—May 29, 1948.

Gage height.—9.17 ft at gage; 9.62 ft at section 1.

Peak discharge.—5,880 cfs.

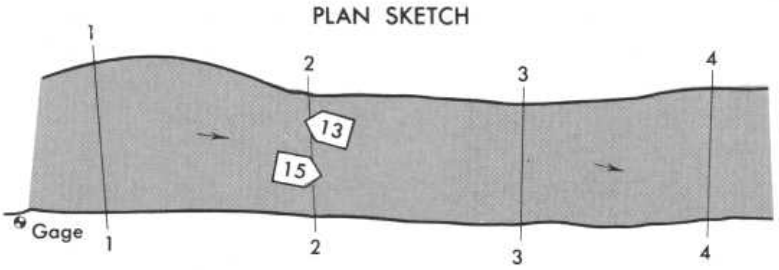
Computed roughness coefficient.—Manning $n = 0.043$.

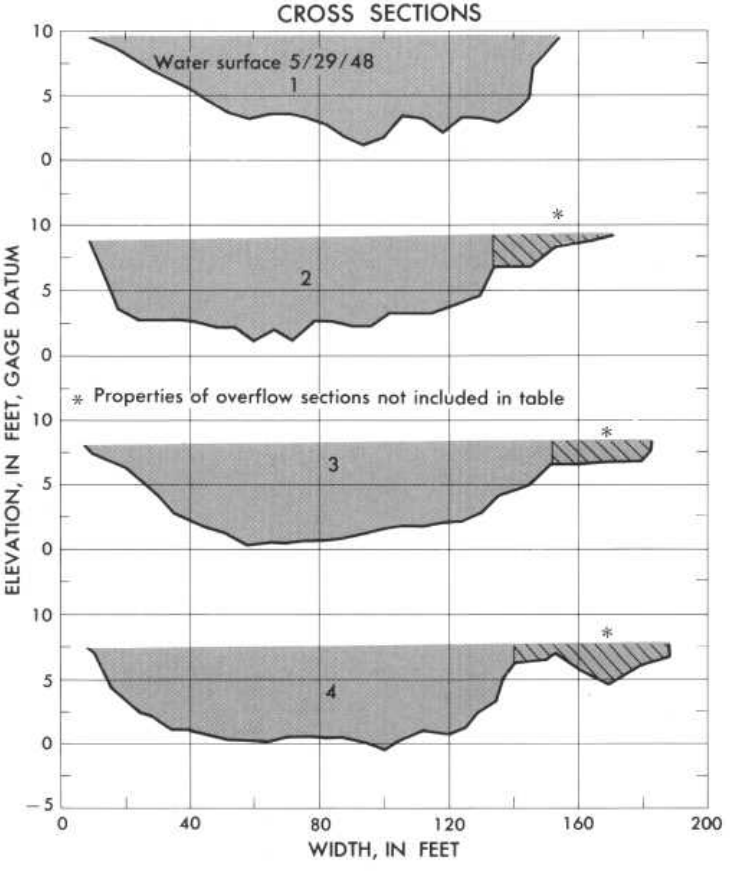
Description of channel.—Bed generally extends to bedrock throughout reach with cover of boulders as much as 1½ ft in diameter in some places. Banks are mildly sloped and have trees along the tops.

Reach properties

Section	Area (sq ft)	Top width (ft)	Mean depth (ft)	Hydraulic radius (ft)	Mean velocity (ft per sec)	Length (ft) between sections	Fall (ft) between sections
1	744	145	5.13	5.03	7.90	.....	.....
2	747	125	5.97	5.74	7.87	165	0.55
3	803	145	5.54	5.42	7.32	163	.80
4	770	131	5.89	5.75	7.64	145	.99

Notes.—





Plan sketch and cross sections, Chiwawa River near Plain, Wash.

$n = 0.043$

No. 13 upstream along left bank from section 2, Chiwawa River near Plain, Wash.

$n = 0.043$

No. 15 downstream along right bank from section 2, Chiwawa River near Plain, Wash.

1–3625. Esopus Creek at Coldbrook, N.Y.

Gage location.—Lat 42°00′45″, long 76°16′10″, on left bank at downstream side of highway bridge at Coldbrook, Ulster County, 1.5 miles upstream from Ashokan Reservoir and 2.5 miles south of Mount Tremper. Section 1 is 400 ft upstream from gage.

Drainage area.—192 sq mi.

Date of flood.—Mar. 22, 1948.

Gage height.—12.39 ft at gage; 14.0 ft at section 1.

Peak discharge.—13,900 cfs.

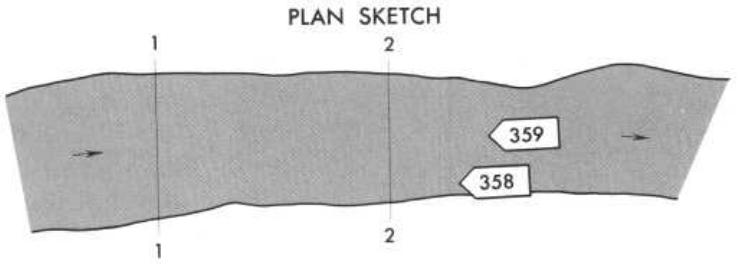
Computed roughness coefficient.—Manning $n = 0.043$.

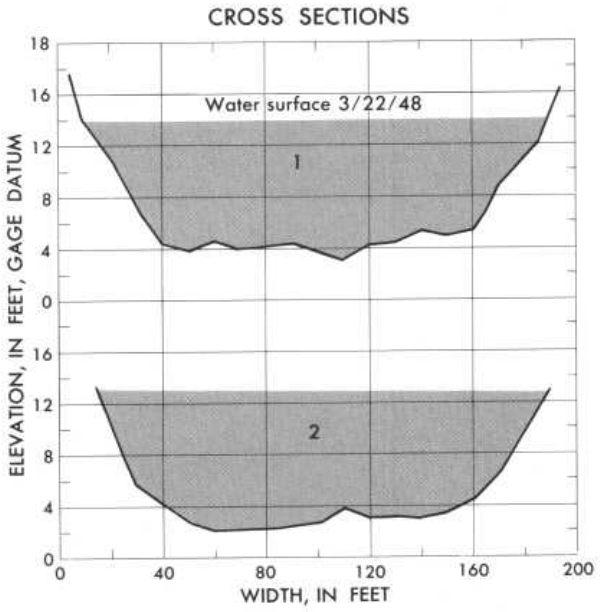
Description of channel.—Bed material ranges from coarse gravel to a few large boulders. Banks are lined with boulders and scattered trees and brush.

Reach properties

Section	Area (sq ft)	Top width (ft)	Mean depth (ft)	Hydraulic radius (ft)	Mean velocity (ft per sec)	Length (ft) between sections	Fall (ft) between sections
1	1,460	181	8.1	7.97	9.48	.....	.....
2	1,470	175	8.4	8.28	9.45	258	1.15

Notes.—





Plan sketch and cross sections, Esopus Creek at Coldbrook, N.Y.

$n = 0.043$

No. 358 upstream along right bank from below reach,
Esopus Creek at Coldbrook, N.Y.

$n = 0.043$

No. 359 upstream along left bank from below reach, Esopus Creek at Coldbrook, N.Y.

13–3190. Grande Ronde River at La Grande, Oreg.

Gage location.—Lat 45°21′, long 118°08′, near center of sec. 36, T. 2 N., R. 37 E., on left bank 2 miles northwest of La Grande and 5 miles downstream from Fivepoint Creek. Section 1 is 0.65 mile downstream from gage.

Drainage area.—678 sq mi.

Date of flood.—May 22, 1948.

Gage height.—7.04 ft at gage; 12.95 ft (different datum) at section 1.

Peak discharge.—4,620 cfs.

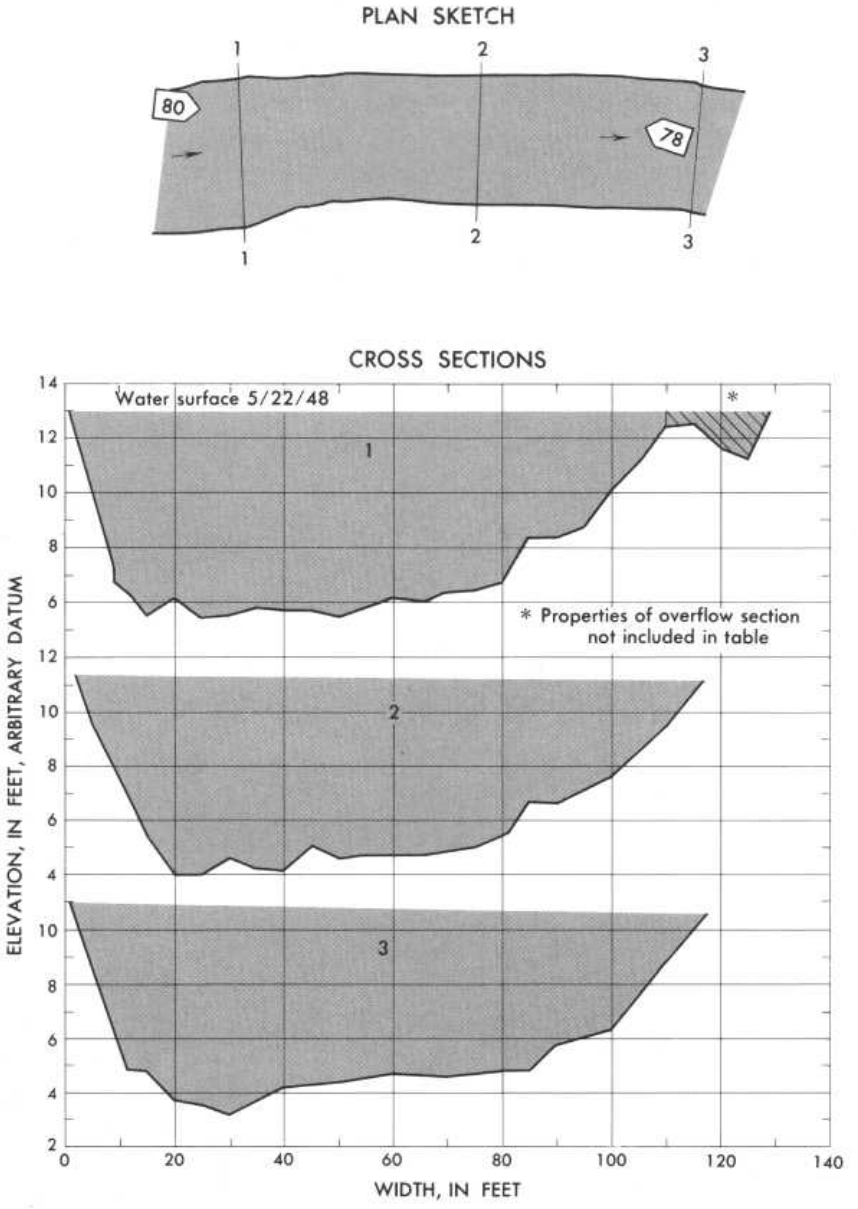
Computed roughness coefficient.—Manning $n = 0.043$.

Description of channel.—Bed consists of boulders; $d_{50} = 93$ mm, $d_{84} = 157$ mm. Right bank is fairly steep and has dense overhanging bushes.

Reach properties

Section	Area (sq ft)	Top width (ft)	Mean depth (ft)	Hydraulic radius (ft)	Mean velocity (ft per sec)	Length (ft) between sections	Fall (ft) between sections
1	637	110	5.79	5.64	7.25	.....	.....
2	599	115	5.21	5.12	7.71	212	1.68
3	624	117	5.33	5.24	7.40	199	.48

Notes.—



Plan sketch and cross sections, Grande Ronde River at La Grande, Oreg.

$n = 0.043$

No. 78 upstream along left bank from channel below section 3, Grande Ronde River at La Grande, Oreg.

$n = 0.043$

No. 80 downstream from left bank above section 1, Grande Ronde River at La Grande, Oreg.

2–2210. Murder Creek near Monticello, Ga.

Gage location.—Lat 33°25′, long 83°40′, on left bank 350 ft upstream from bridge on State Highway 229, 0.75 mile upstream from Pittman Creek, 1.75 miles downstream from confluence of Robinson and Sheppard Creeks, and 8 miles north of Monticello, Jasper County. Section 2 is about 630 ft upstream from gage.

Drainage area.—24 sq mi, approximately.

Date of flood.—Feb. 7, 1958.

Gage height.—4.68 ft at gage; 6.32 ft at section 2.

Peak discharge.—840 cfs.

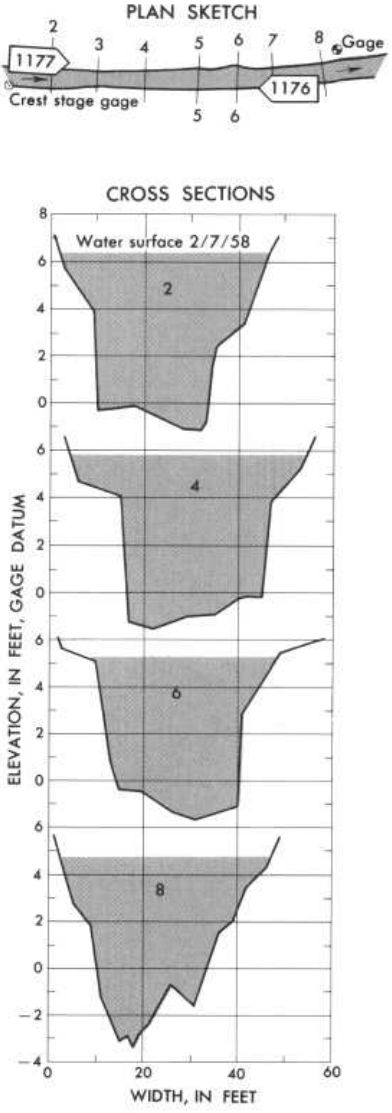
Computed roughness coefficient.—Manning $n = 0.045$.

Description of channel.—Bed consists of sand and gravel. Both banks are lined with trees above low waterline.

Reach properties

Section	Area (sq ft)	Top width (ft)	Mean depth (ft)	Hydraulic radius (ft)	Mean velocity (ft per sec)	Length (ft) between sections	Fall (ft) between sections
2	215	45	4.8	4.21	3.93	.....	.....
3	212	42	5.0	4.20	3.99	78	0.21
4	227	50	4.5	4.02	3.73	124	.35
5	202	43	4.7	4.02	4.19	92	.21
6	187	41	4.6	3.74	4.52	71	.35
7	200	48	4.2	3.64	4.23	88	.11
8	198	45	4.4	3.94	4.27	149	.38

Notes.—



Plan sketch and cross sections, Murder Creek near Monticello, Ga.

$n = 0.045$

No. 1176 upstream from right bank at section 7,
Murder Creek near Monticello, Ga.

$n = 0.045$

No. 1177 downstream from left bank at section 2,
Murder Creek near Monticello, Ga.

10–1550. Provo River near Hailstone, Utah

Gage location.—Lat 40°36′, long 111° 22′, in SE¼ sec. 34, T. 2 S., R. 5 E., on right bank 3 miles upstream from Ross Creek and Hailstone. Section 1 is about 120 ft upstream from gage.

Drainage area.—233 sq mi.

Date of flood.—June 13, Oct. 7, 1952.

Gage height.—4.66 ft, 1.58 at gage; 5.66 ft, 2.14 ft at section 1.

Peak discharge.—1,200 cfs, 64.8 cfs.

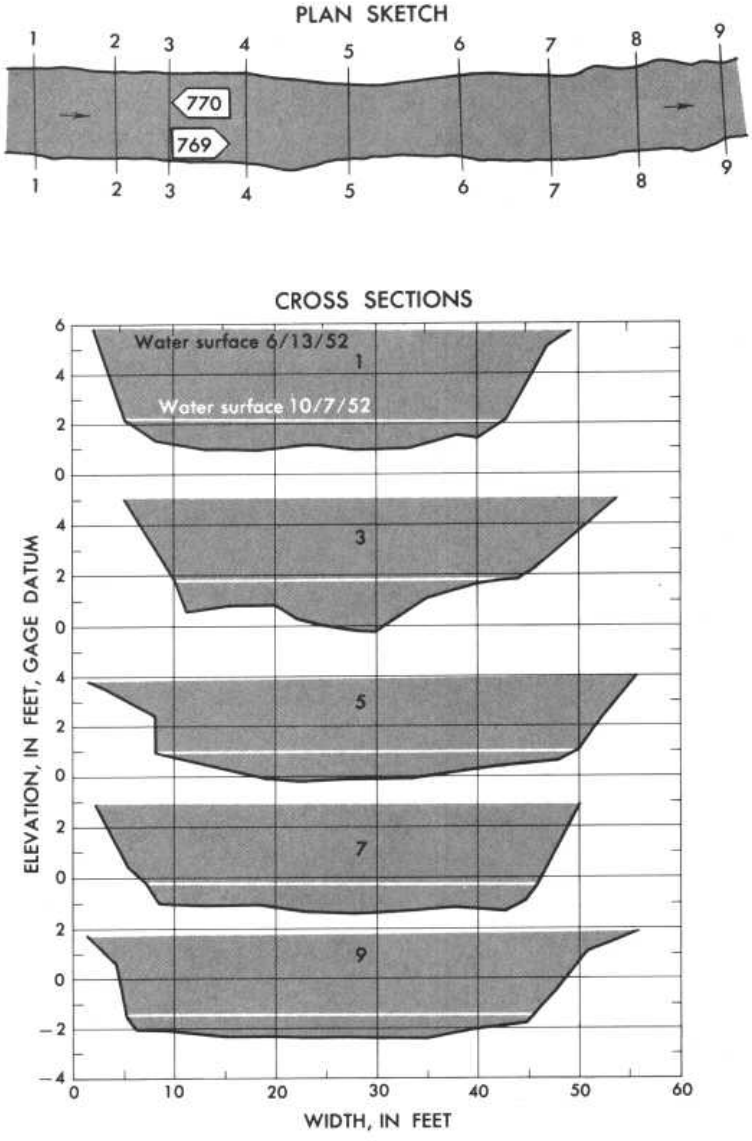
Computed roughness coefficient.—Manning $n = 0.045$; 0.073.

Description of channel.—Bed and banks consist of smooth rounded rocks as much as 1 ft in diameter. Some undergrowth is below water elevations of June 13.

Reach properties

Section	Area (sq ft)	Top width (ft)	Mean depth (ft)	Hydraulic radius (ft)	Mean velocity (ft per sec)	Length (ft) between sections	Fall (ft) between sections
June 13, 1952							
1	184	47	3.9	3.70	6.52	.....	.....
3	171	49	3.5	3.33	7.02	88	0.67
5	173	55	3.1	3.02	6.95	109	1.04
7	173	48	3.6	3.43	6.95	117	1.10
9	183	55	3.3	3.22	6.56	116	1.04
Oct. 7, 1952							
1	36	38	1.0	0.95	1.79	.....	.....
3	38	34	1.1	1.10	1.70	88	0.32
5	34	32	1.1	.82	1.90	109	.84
7	34	39	.9	.86	1.91	117	1.28
9	31	41	.8	.76	2.08	116	1.12

Notes.—



Plan sketch and cross sections, Provo River near Hailstone, Utah.

$n = 0.045; 0.073$

No. 769 downstream from section 3, Provo River near Hailstone, Utah.

No. 770 upstream from section 3, Provo River near Hailstone, Utah.

n = 0.046; 0.097

3–3015. Rolling Fork near Boston, Ky.

Gage location.—Lat 37°46′02″, long 85°42′14″, on downstream side near center of span of bridge on U.S. Highway 62, 0.4 mile downstream from Beech Fork and 2.3 miles southwest of Boston, Nelson County. Section 1 is 650 ft upstream from gage.

Drainage area.—1,299 sq mi.

Date of flood.—Mar. 11, 1949.

Gage height.—26.30 ft at gage; 26.63 ft at section 1.

Peak discharge.—6,094 cfs (5,770 cfs in main channel and 324 cfs in right overflow channel).

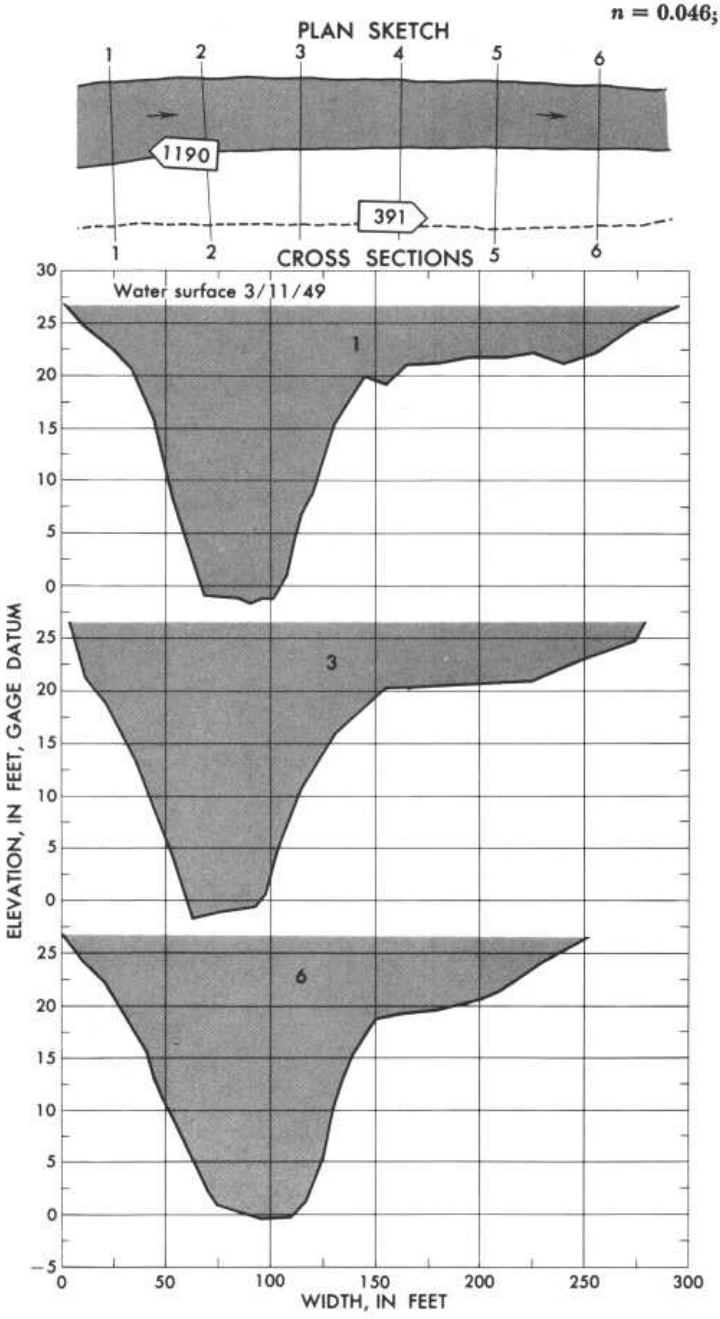
Computed roughness coefficient.—Manning $n = 0.046$ in main channel and 0.097 in right overflow channel.

Description of channel.—Main channel bed is clay and silt. Both banks are lined with overhanging trees. Right overflow channel is rather uniform with fairly dense stand of trees as much as 6 inches in diameter.

Reach properties

Section	Area (sq ft)	Top width (ft)	Mean depth (ft)	Hydraulic radius (ft)	Mean velocity (ft per sec)	Length (ft) between sections	Fall (ft) between sections
Main channel							
1	2,301	143	16.1	14.25	2.51	.....	.....
2	2,304	139	16.6	15.33	2.51	136	0.011
3	2,524	152	16.6	15.50	2.28	103	.028
4	2,416	140	17.2	15.95	2.39	127	.014
5	2,544	147	17.3	16.12	2.27	117	.004
6	2,483	150	16.6	15.52	2.32	86	.033
Right overflow channel							
1	668	150	4.4	4.44	0.48	.....	.....
2	643	138	4.7	4.63	.50	136	0.011
3	601	124	4.8	4.83	.54	103	.028
4	602	120	5.0	5.00	.54	127	.014
5	593	112	5.3	5.27	.55	117	.004
6	513	104	4.9	4.93	.63	86	.033

Notes.—



Plan sketch and cross sections, Rolling Fork near Boston, Ky. Dashed line shows limit of overbank flooding.

$n = 0.046; 0.097$

No. 1190 upstream from left bank below section 6, Rolling Fork at Boston, Ky.

$n = 0.046; 0.097$

No. 391 downstream through right overflow from section 2, Rolling Fork at Boston, Ky.

2–1885. South Beaverdam Creek near Dewy Rose, Ga.

Gage location.—Lat 34°11′, long 82°57′, on left bank 50 ft upstream from highway bridge, 1 mile northeast of Dewy Rose, Elbert County, and 3 miles upstream from confluence with North Beaverdam Creek. Section 1 is about 100 ft downstream from gage.

Drainage area.—35.8 sq mi.

Date of flood.—Nov. 26, 27, 1957.

Gage height.—8.02 ft, 4.86 ft at gage; 7.83 ft, 4.64 ft at section 1.

Peak discharge.—820 cfs; 221 cfs.

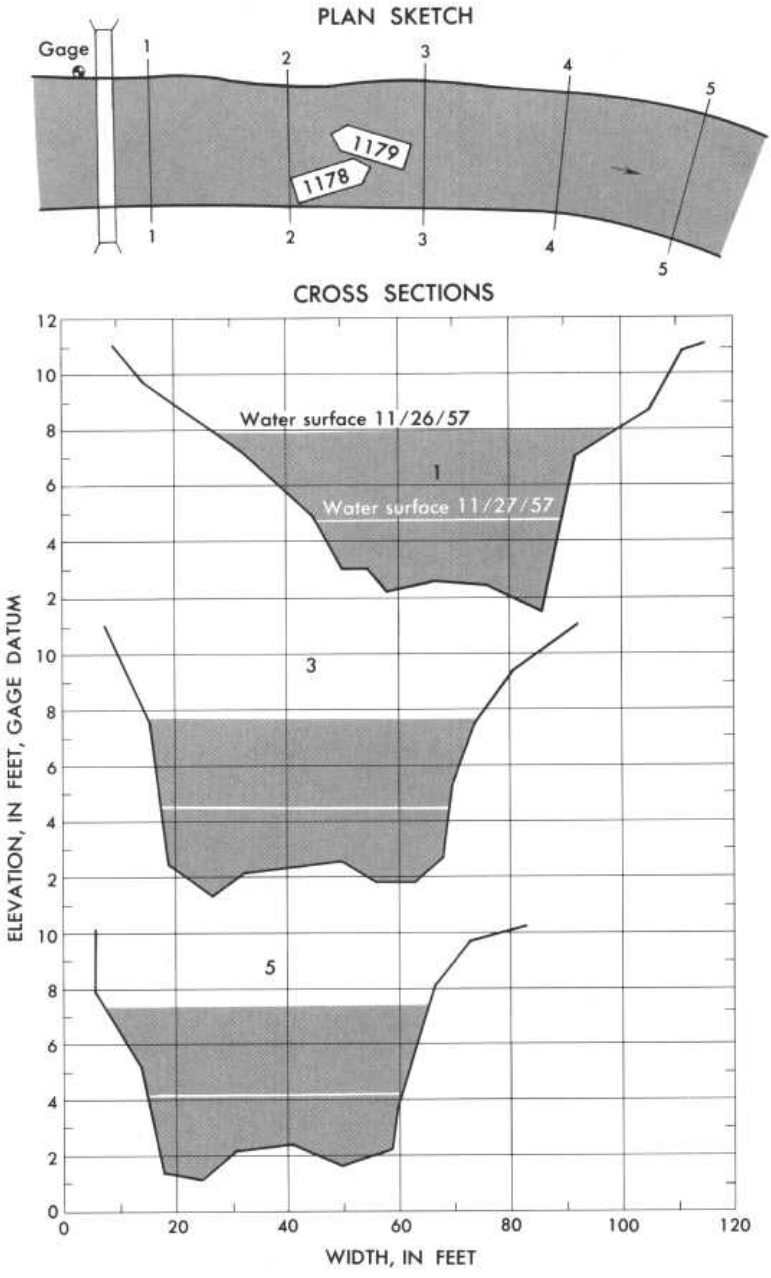
Computed roughness coefficient.—Manning n = 0.052; 0.047.

Description of channel.—Bed consists of sand about 1 ft deep over clay and rock. Banks are irregular with trees and bushes growing down to the low waterline.

Reach properties

Section	Area (sq ft)	Top width (ft)	Mean depth (ft)	Hydraulic radius (ft)	Mean velocity (ft per sec)	Length (ft) between sections	Fall (ft) between sections
Nov. 26, 1957							
1	268	71	3.8	3.62	3.06	.....	.....
2	288	56	5.1	4.97	2.85	71	0.14
3	278	59	4.7	4.34	2.95	66	.12
4	281	59	4.8	4.41	2.92	81	.13
5	260	58	4.5	4.13	3.15	64	.06
Nov. 27, 1957							
1	91	44	2.1	2.02	2.43	.....	.....
2	128	46	2.8	2.69	1.73	71	0.11
3	108	51	2.1	2.00	2.05	66	.10
4	108	54	2.0	1.98	2.05	81	.08
5	101	46	2.2	2.04	2.19	64	.14

Notes.—



Plan sketch and cross sections, South Beaverdam Creek near Dewy Rose, Ga.

$n = 0.052; 0.047$

No. 1178 downstream along left bank from section 2, South Beaverdam Creek near Dewy Rose, Ga.

$n = 0.052; 0.047$

No. 1179 upstream from section 2,
South Beaverdam Creek near Dewy Rose, Ga.

2–1005. Deep River at Ramseur, N.C.

Gage location.—Lat 35°44′, long 79°30′, on right bank 0.25 mile downstream from Main Street bridge in Ramseur, Randolph County, 0.5 downstream from mill dam, and 1.5 miles downstream from Sandy Creek. Section 1 is about 30 ft downstream from gage.

Drainage area.—346 sq mi.

Date of flood.—Dec. 28, 1958.

Gage height.—13.65 ft at gage; 13.62 ft at section 1.

Peak discharge.—8,300 cfs.

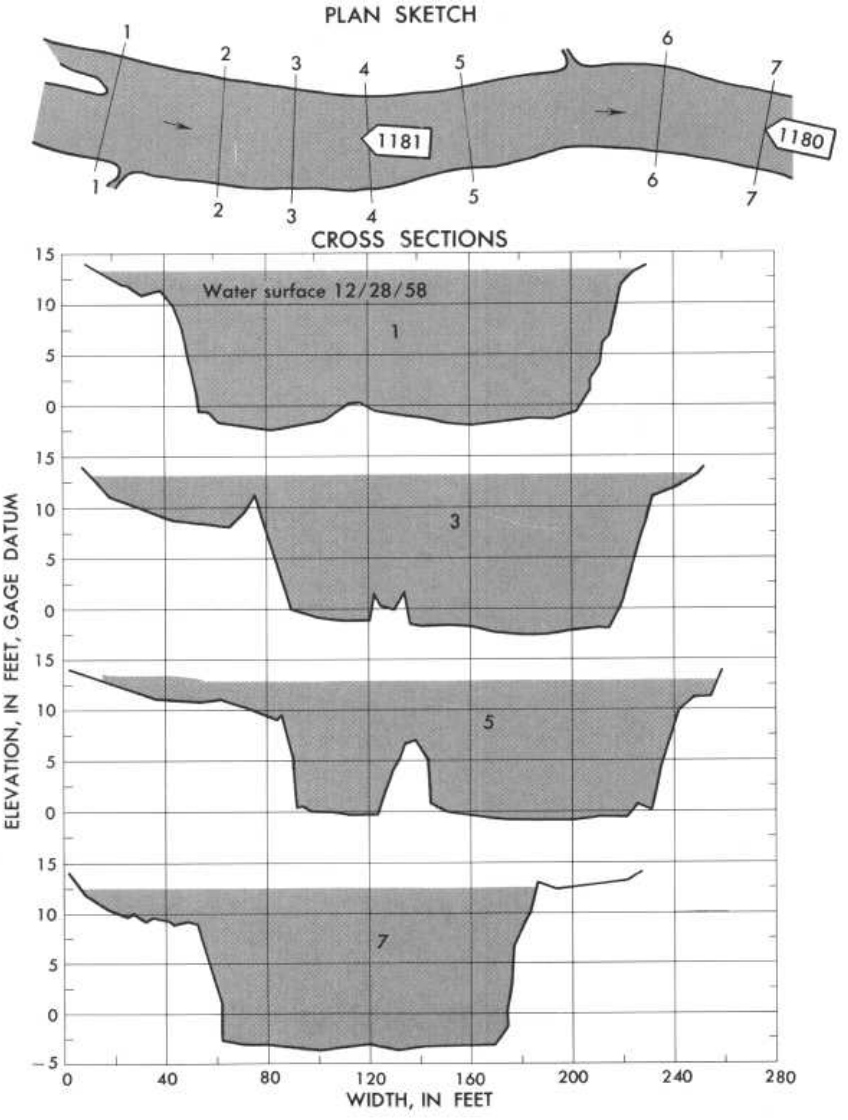
Computed roughness coefficient.—Manning $n = 0.049$.

Description of channel.—Bed is mostly coarse sand and contains some gravel and one conspicuous outcrop. Three small islands in the reach have a dense stand of small birch trees. The banks are fairly steep and contain medium growths of underbrush and large trees.

Reach properties

Section	Area (sq ft)	Top width (ft)	Mean depth (ft)	Hydraulic radius (ft)	Mean velocity (ft per sec)	Length (ft) between sections	Fall (ft) between sections
1	2,474	215	11.5	10.8	3.36	.....	.....
2	2,135	198	10.8	10.4	3.89	219	0.17
3	2,137	240	9.8	9.34	3.88	218	.05
4	2,403	250	9.6	8.73	3.45	182	.12
5	2,061	244	8.4	7.94	4.03	185	.20
6	2,265	194	11.8	10.8	3.66	337	.30
7	2,026	189	10.7	10.4	4.10	265	.24

Notes.—



Plan sketch and cross sections, Deep River at Ramseur, N.C.

$n = 0.049$

No. 1180 upstream from section 7, Deep River at Ramseur, N.C.

$n = 0.049$

No. 1181 upstream from section 4, Deep River at Ramseur, N.C.

n = 0.050

6–7195. Clear Creek near Golden, Colo.

Gage location.—Lat 39°45′05″, long 105°14′55″, in NE¼ sec. 32, T. 3 S., R. 70 W., on left bank 0.5 mile downstream from Golden Canal diversion and 1 mile west of Golden. Section 12 is about 3.5 miles upstream from gage.

Drainage area.—399 sq mi.

Date of flood.—May 26, 1958.

Gage height.—5.25 ft at gage; 61.70 ft (different datum) at section 15.

Peak discharge.—1,380 cfs.

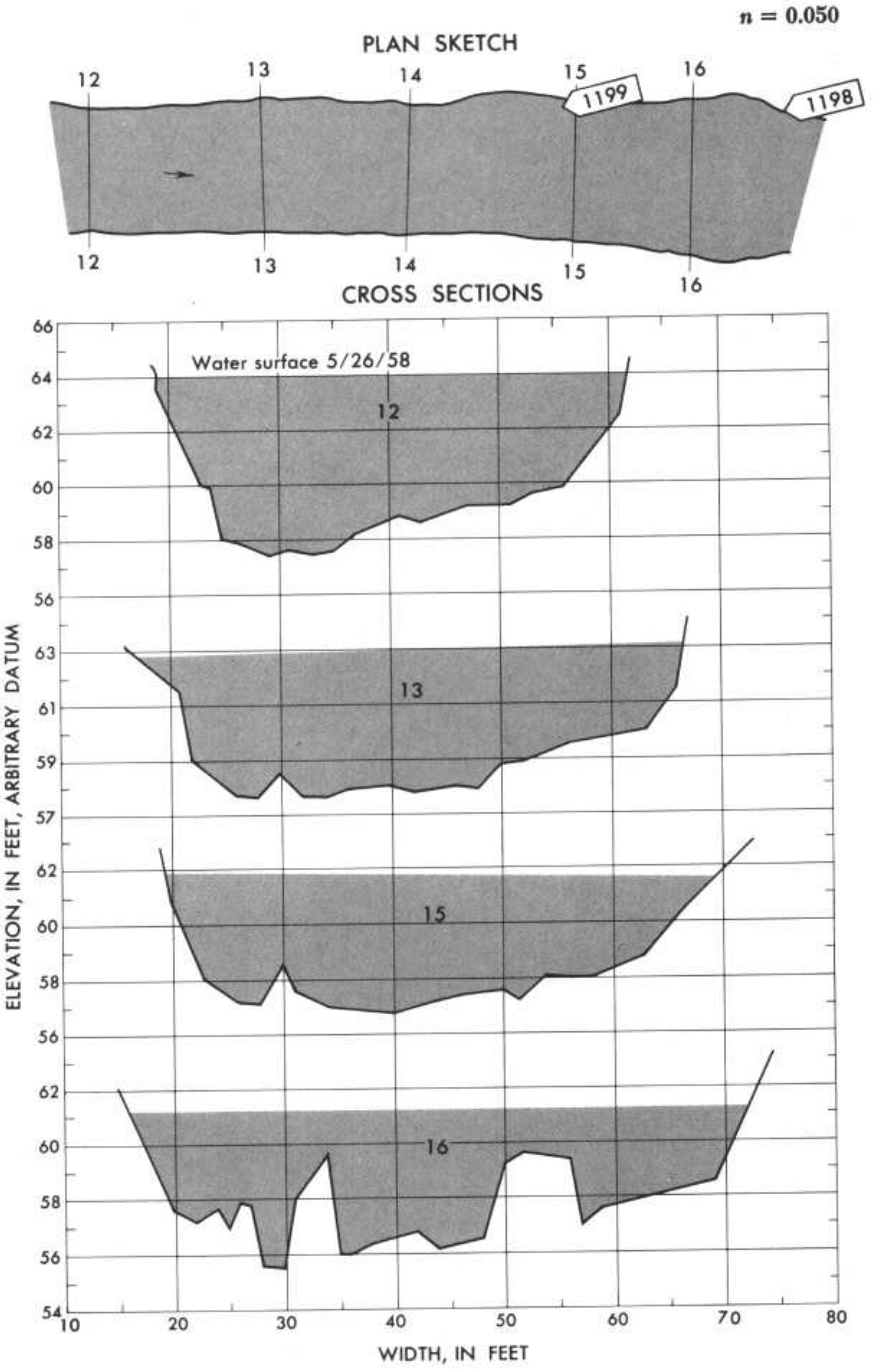
Computed roughness coefficient.—Manning $n = 0.050$.

Description of channel.—Bed and banks are composed of angular boulders as much as 2 ft in diameter.

Reach properties

Section	Area (sq ft)	Top width (ft)	Mean depth (ft)	Hydraulic radius (ft)	Mean velocity (ft per sec)	Length (ft) between sections	Fall (ft) between sections
12	200	43	4.6	4.22	6.90	.....	.....
13	206	50	4.1	3.83	6.70	47	0.85
14	183	52	3.5	3.29	7.54	39	.65
15	184	51	3.6	3.36	7.50	46	.65
16	184	55	3.3	2.69	7.50	32	.60

Notes.—



Plan sketch and cross sections, Clear Creek near Golden, Colo.

$n = 0.050$

No. 1198 upstream from section 16, Clear Creek near Golden, Colo.

No. 1199 upstream from left bank at section 15,
Clear Creek near Golden, Colo.

2–3310. Chattahoochee River near Leaf, Ga.

Gage location.—Lat 34°35′, long 83°38′, on left bank 700 ft upstream from bridge on State Highway 115, 1.5 miles east of Leaf, White County, 2.5 miles downstream from Blue Creek, 3 miles upstream from Soque River, 7.5 miles southeast of Cleveland, and at mile 405.6. Section 2 is about 680 ft upstream from gage.

Drainage area.—150 sq mi.

Date of flood.—Feb. 7, Feb. 27, 1959.

Gage height.—7.50 ft, 4.95 ft at gage; 9.12 ft, 6.92 ft at section 2.

Peak discharge.—5,100 cfs; 2,350 cfs.

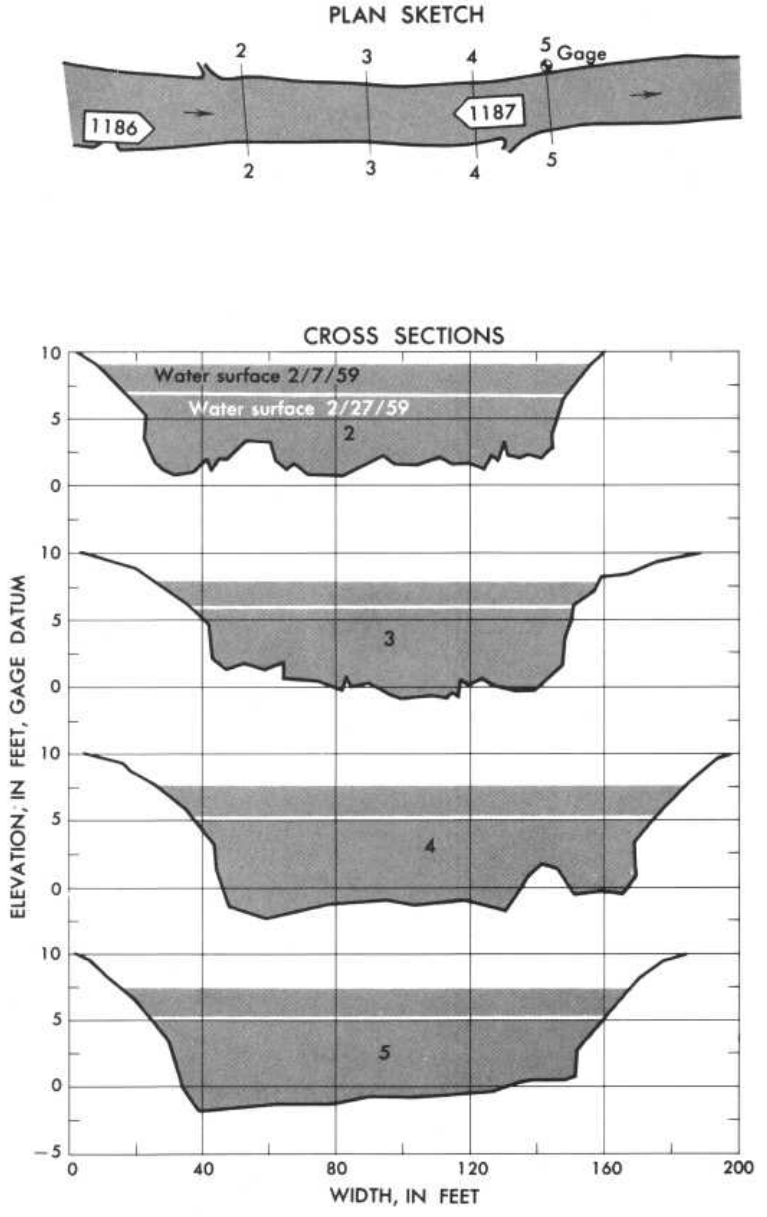
Computed roughness coefficient.—Manning n = 0.051; 0.074.

Description of channel.—Bed is mostly rock and very irregular. Banks are covered with low thick rhododendron and small trees.

Reach properties

Section	Area (sq ft)	Top width (ft)	Mean depth (ft)	Hydraulic radius (ft)	Mean velocity (ft per sec)	Length (ft) between sections	Fall (ft) between sections
Feb. 7, 1959							
2	1,510	147	10.3	9.84	3.38	.....	.....
3	850	133	6.4	6.18	6.00	353	1.19
4	1,110	158	7.0	6.79	4.59	214	.35
5	1,070	151	7.1	6.84	4.77	125	.14
Feb. 27, 1959							
2	1,215	132	9.2	8.90	1.93	.....	.....
3	555	112	5.0	4.80	4.23	353	1.42
4	750	138	5.4	5.26	3.13	214	.37
5	720	134	5.4	5.18	3.26	125	.13

Notes.—



Plan sketch and cross sections, Chattahoochee River near Leaf, Ga.

$n = 0.051; 0.074$

No. 1186 downstream from above section 2,
Chattahoochee River near Leaf, Ga.

$n = 0.051; 0.074$

No. 1187 upstream from section 4,
Chattahoochee River near Leaf, Ga.

13–3380. South Fork Clearwater River near Grangeville, Idaho

Gage location.—Lat 45°55′, long 116°01′, in SE¼NW¼ sec. 30, T. 30 N., R. 4 E., on right bank just downstream from powerhouse of Washington Water Power Co., 6 miles east of Grangeville. Section 1 is about 1.8 miles upstream from gage.

Drainage area.—865 sq mi.

Date of flood.—May 29, 1948.

Gage height.—12.50 ft at gage; 30.85 ft at section 1.

Peak discharge.—12,600 cfs.

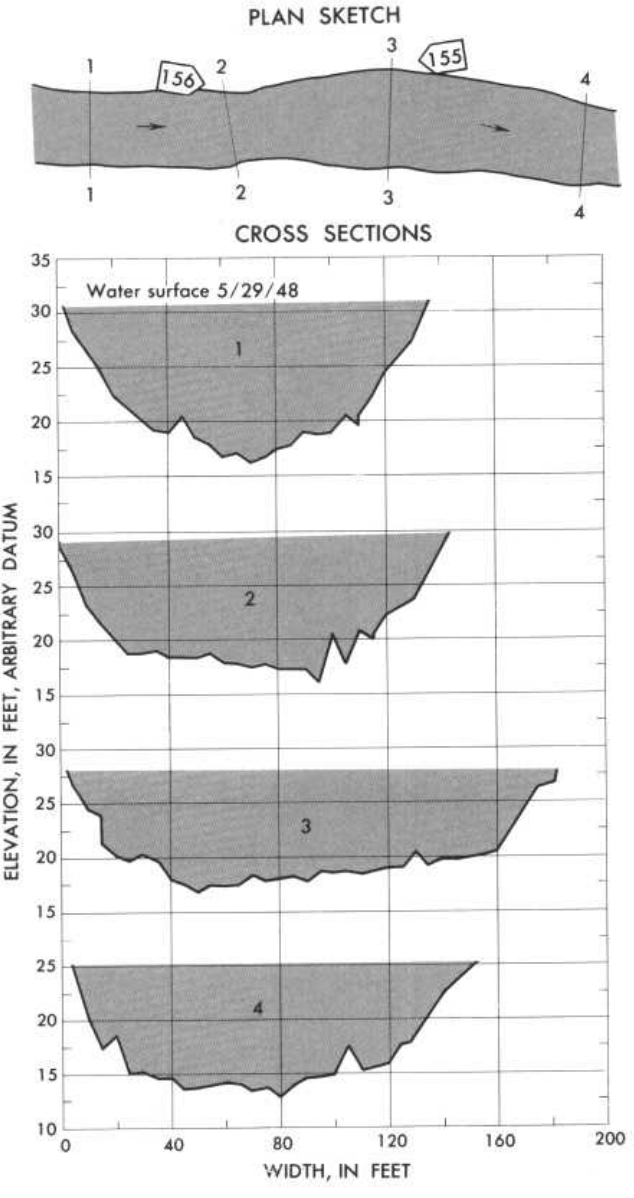
Computed roughness coefficient.—Manning $n = 0.051$.

Description of channel.—Bed consists of rock and boulders; $d_{50} = 250$ mm, $d_{84} = 440$ mm. Banks are mostly boulders and have trees and brush along tops.

Reach properties

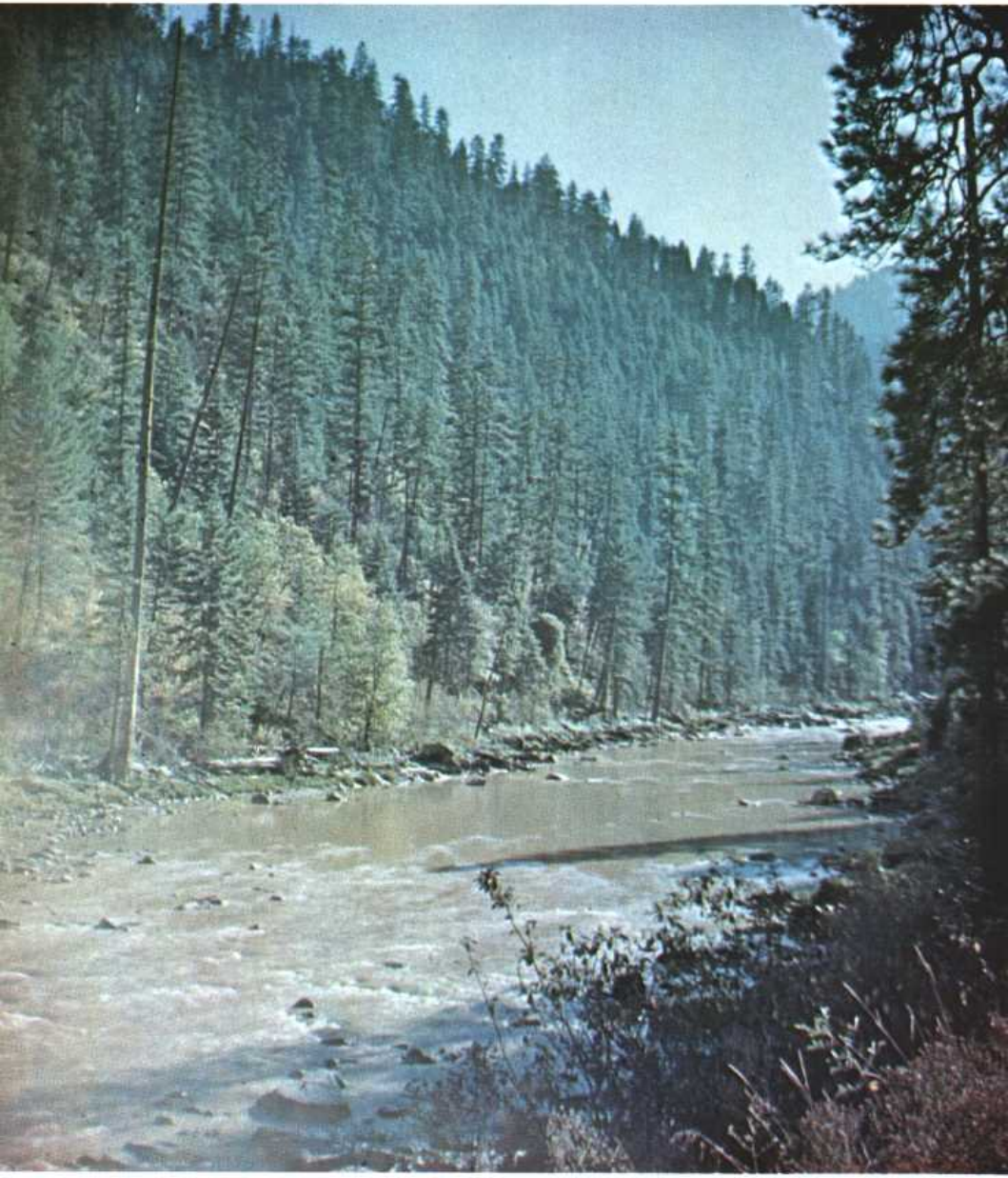
Section	Area (sq ft)	Top width (ft)	Mean depth (ft)	Hydraulic radius (ft)	Mean velocity (ft per sec)	Length (ft) between sections	Fall (ft) between sections
1	1,326	134	9.90	9.40	9.50	.....	.....
2	1,310	143	9.16	8.68	9.62	255	1.40
3	1,434	181	7.92	7.71	8.79	295	1.45
4	1,267	148	8.56	8.23	9.94	357	2.85

Notes.—



Plan sketch and cross sections, South Fork Clearwater River near Grangeville, Idaho.

$n = 0.051$



No. 155 upstream from left bank at section 3, South Fork Clearwater River near Grangeville, Idaho.

$n = 0.051$

$n = 0.053; 0.079$

No. 1191 downstream from left bank above section 1, Cache Creek near Lower Lake, Calif.

$n = 0.053; 0.079$

No. 1193 downstream from channel above section 1, Cache Creek near Lower Lake, Calif.

4–2750. East Branch Ausable River at Au Sable Forks, N.Y.

Gage location.—Lat 44°26′20″, long 73°40′55″, on left bank 700 ft upstream from upper highway bridge in Au Sable Forks, Essex County, and 0.5 mile upstream from confluence with West Branch. Section 1 is about 0.75 mile upstream from gage.

Drainage area.—198 sq mi.

Date of flood.—Mar. 31, 1951.

Gage height.—8.20 ft at gage; 94.08 ft (different datum) at section 1.

Peak discharge.—7,790 cfs.

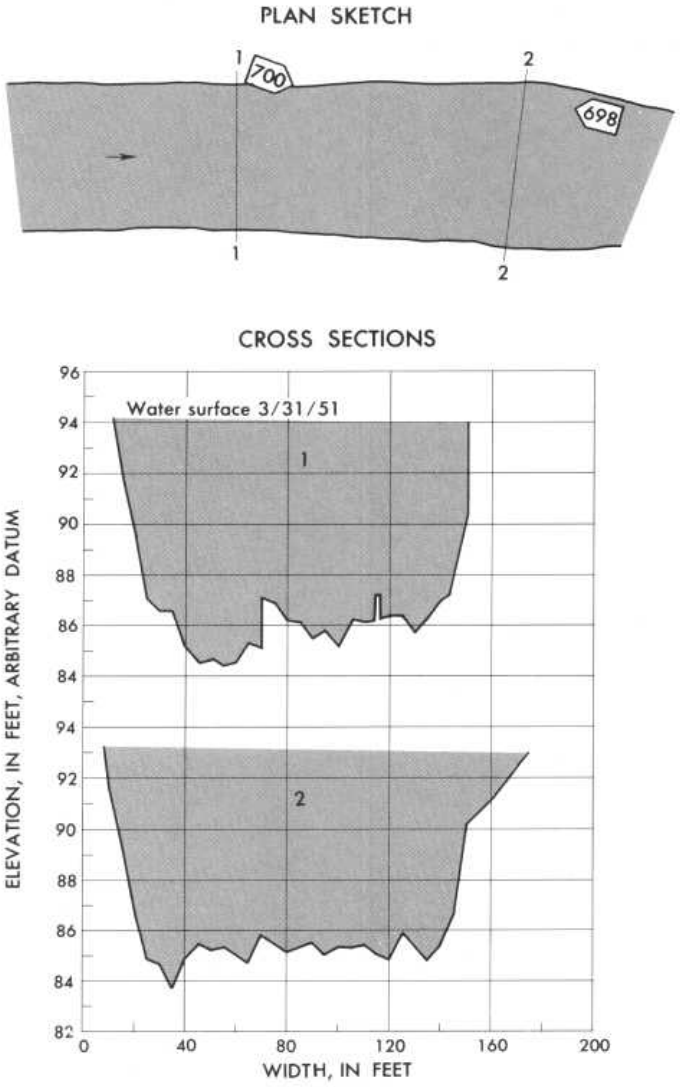
Computed roughness coefficient.—Manning $n = 0.055$.

Description of channel.—Bed consists of gravel, rock, and boulders as much as 5 ft in diameter. Banks are lined with boulders, small trees, and bushes.

Reach properties

Section	Area (sq ft)	Top width (ft)	Mean depth (ft)	Hydraulic radius (ft)	Mean velocity (ft per sec)	Length (ft) between sections	Fall (ft) between sections
1.....	1,050	139	7.6	7.01	7.40	.....	.....
2.....	1,090	166	6.6	6.42	7.13	178	1.00

Notes.—



Plan sketch and cross sections, East Branch Ausable River at Au Sable Forks, N.Y.

$n = 0.055$

No. 698 upstream along left bank from below section 2, East Branch Ausable River at Au Sable Forks, N.Y.

$n = 0.055$

No. 700 downstream from left bank at section 1,
East Branch Ausable River at Au Sable Forks, N.Y.

1–1805. Middle Branch Westfield River at Goss Heights, Mass.

Gage location.—Lat 42°15′31″, long 72°52′23″, on right bank at upstream side of highway bridge at Goss Heights, Hampshire County, 0.35 mile upstream from mouth, and 1.7 miles north of Huntington. Section 1 is about 1,000 ft downstream from gage.

Drainage area.—52.6 sq mi.

Date of flood.—Mar. 22, 1948.

Gage height.—6.46 ft at gage; 19.07 ft at section 1.

Peak discharge.—3,400 cfs.

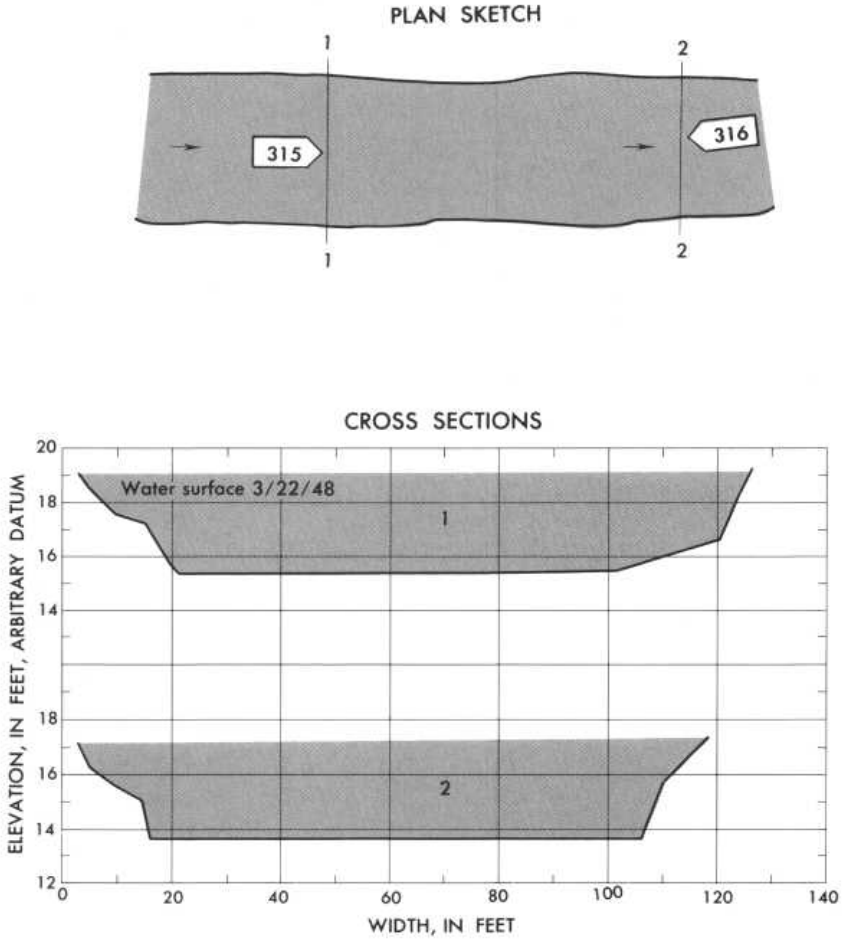
Computed roughness coefficient.—Manning $n = 0.056$.

Description of channel.—Bed is rocks and coarse gravel with boulders as much as 5 ft in diameter.

Reach properties

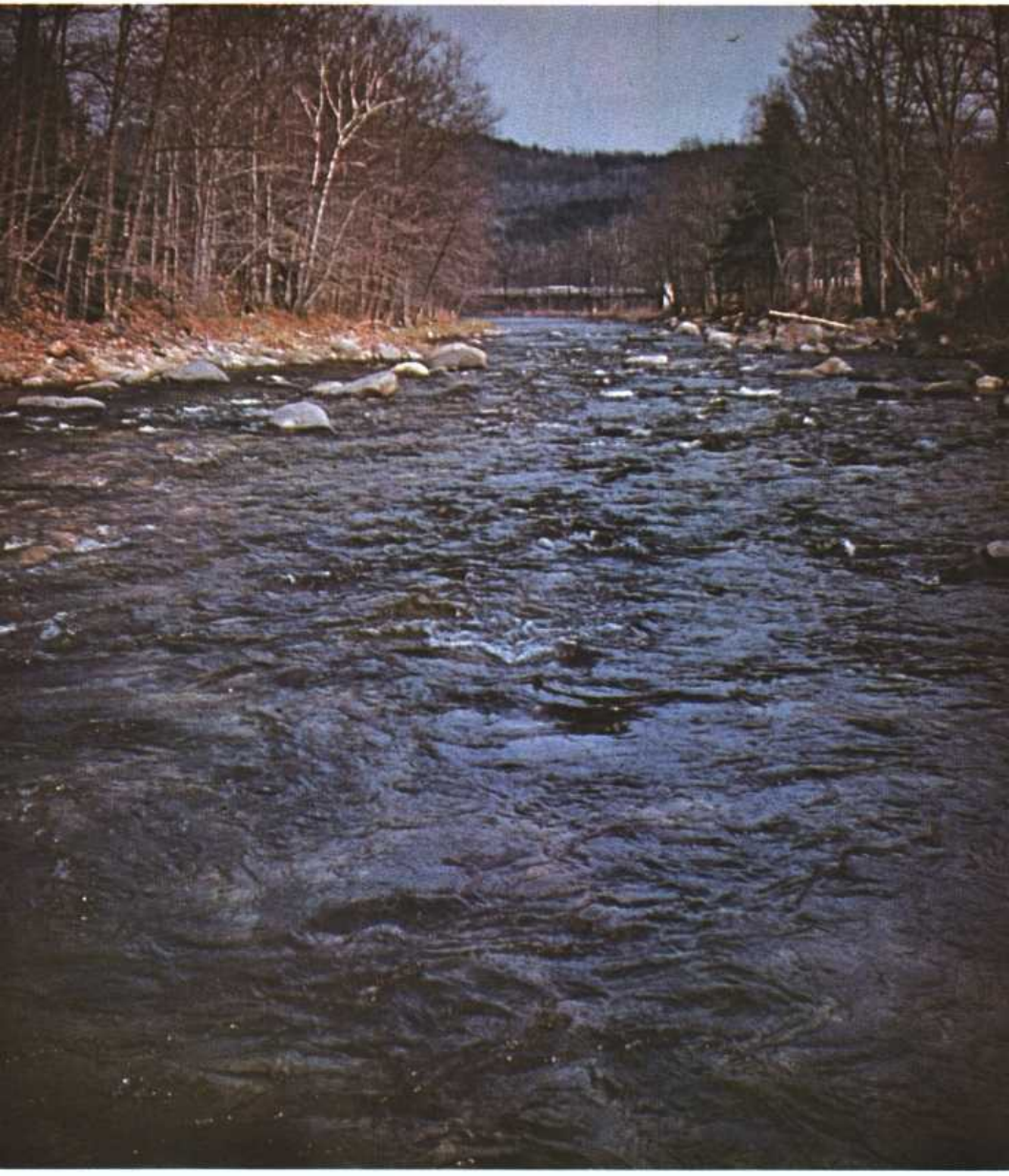
Section	Area (sq ft)	Top width (ft)	Mean depth (ft)	Hydraulic radius (ft)	Mean velocity (ft per sec)	Length (ft) between sections	Fall (ft) between sections
1	502	123	4.1	4.05	6.78	.....	.....
2	531	114	4.6	4.50	6.42	159	1.38

Notes.—



Plan sketch and cross sections, Middle Branch Westfield River at Goss Heights, Mass.

$n = 0.056$



No. 315 downstream from above section 1, Middle Branch Westfield River at Goss Heights, Mass.

$n = 0.056$

No. 316 upstream from below section 2, Middle Branch Westfield River at Goss Heights, Mass.

12–4620. Mission Creek near Cashmere, Wash.

Gage location.—Lat 47°30′15″, long 120°28′30″, in SE¼NE¼ sec. 8, T. 23 N., R. 19 E., on right bank 1.5 miles upstream from mouth and 1.5 miles south of Cashmere. Section 1 is about 0.5 mile downstream.

Drainage area.—79.1 sq mi.

Date of flood.—May 19, 1955.

Gage height.—1.73 ft at gage; 14.00 ft (different datum) at section 1.

Peak discharge.—123 cfs.

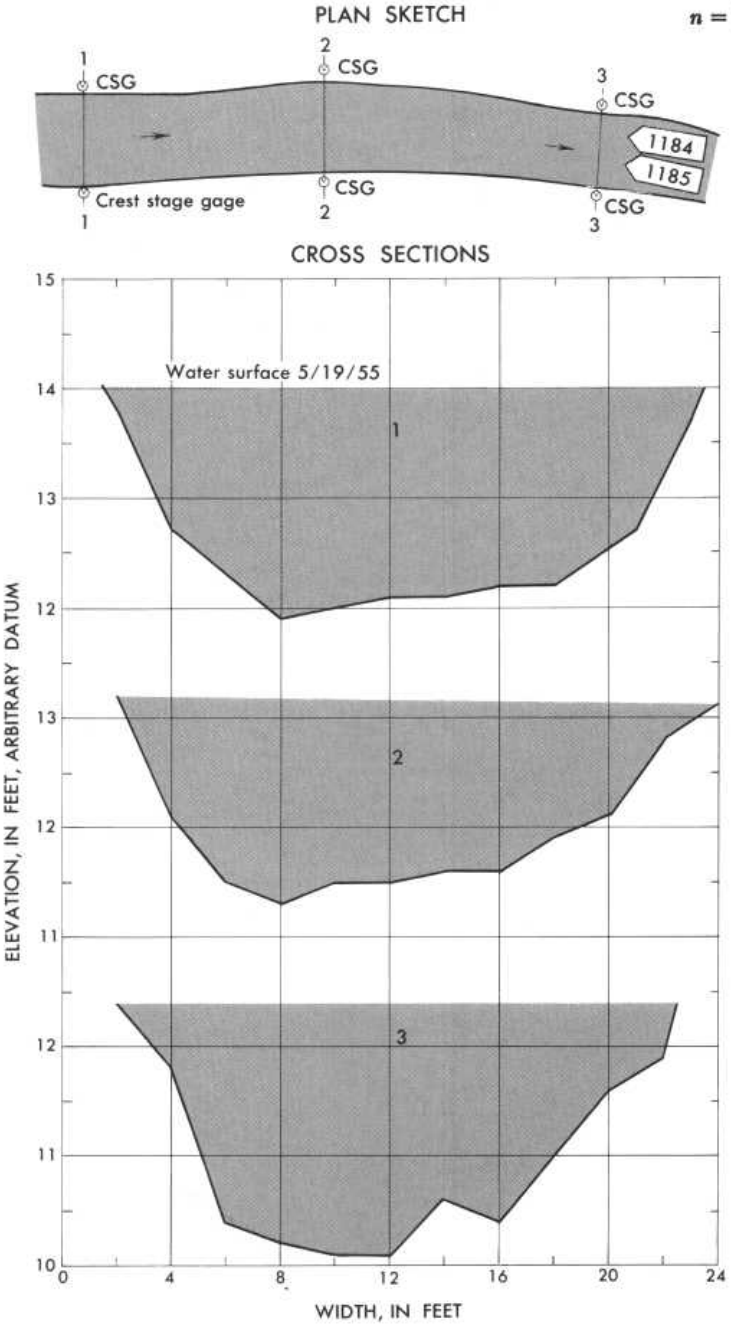
Computed roughness coefficient.—Manning $n = 0.057$.

Description of channel.—Bed of angular-shaped boulders as much as 1 ft in diameter. Both banks are lined with overhanging bushes.

Reach properties

Section	Area (sq ft)	Top width (ft)	Mean depth (ft)	Hydraulic radius (ft)	Mean velocity (ft per sec)	Length (ft) between sections	Fall (ft) between sections
1	34	22	1.54	1.50	3.64	.....	.....
2	28	22	1.27	1.24	4.39	44	0.82
3	31	20.5	1.53	1.46	3.92	51	.79

Notes.—

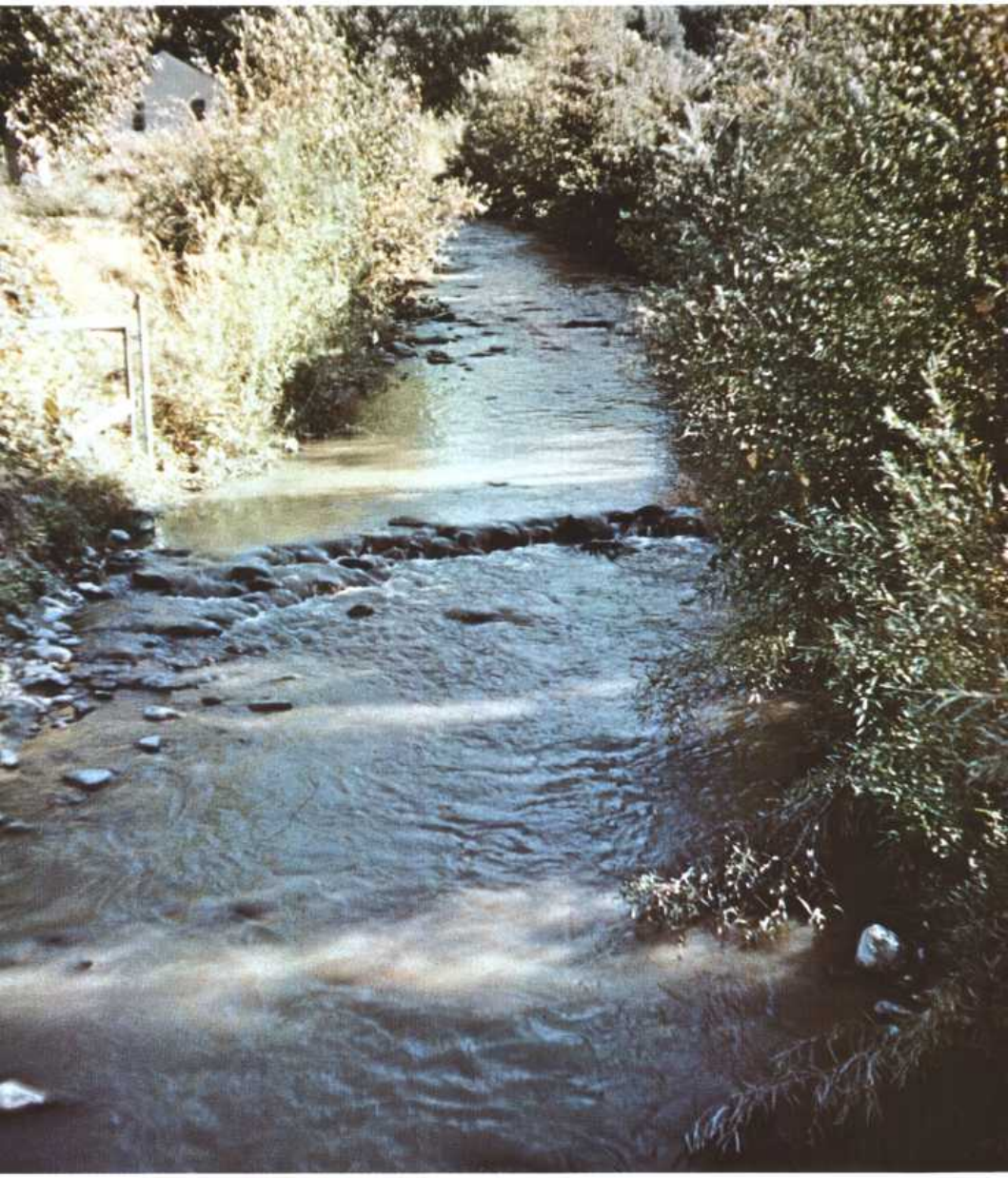


Plan sketch and cross sections, Mission Creek near Cashmere, Wash.

$n = 0.057$

No. 1184 upstream from below section 3, Mission Creek near Cashmere, Wash.

$n = 0.057$



No. 1185 upstream from below section 3, Mission Creek near Cashmere, Wash.

2–935. Haw River near Benaja, N.C.

Gage location.—Lat 36°16′, long 79°34′, on left bank 200 ft upstream from site of old High Rock Mill, 500 ft upstream from bridge on Secondary Road 2620, 0.5 mile upstream from Rockingham-Guilford County line, 6 miles downstream from Troublesome Creek, and 6 miles east of Benaja, Rockingham County. Section 4 is about 400 ft upstream from gage.

Drainage area.—168 sq mi.

Date of flood.—Dec. 29, 1958.

Gage height.—5.70 ft at gage; 6.09 ft at section 4.

Peak discharge.—1,000 cfs.

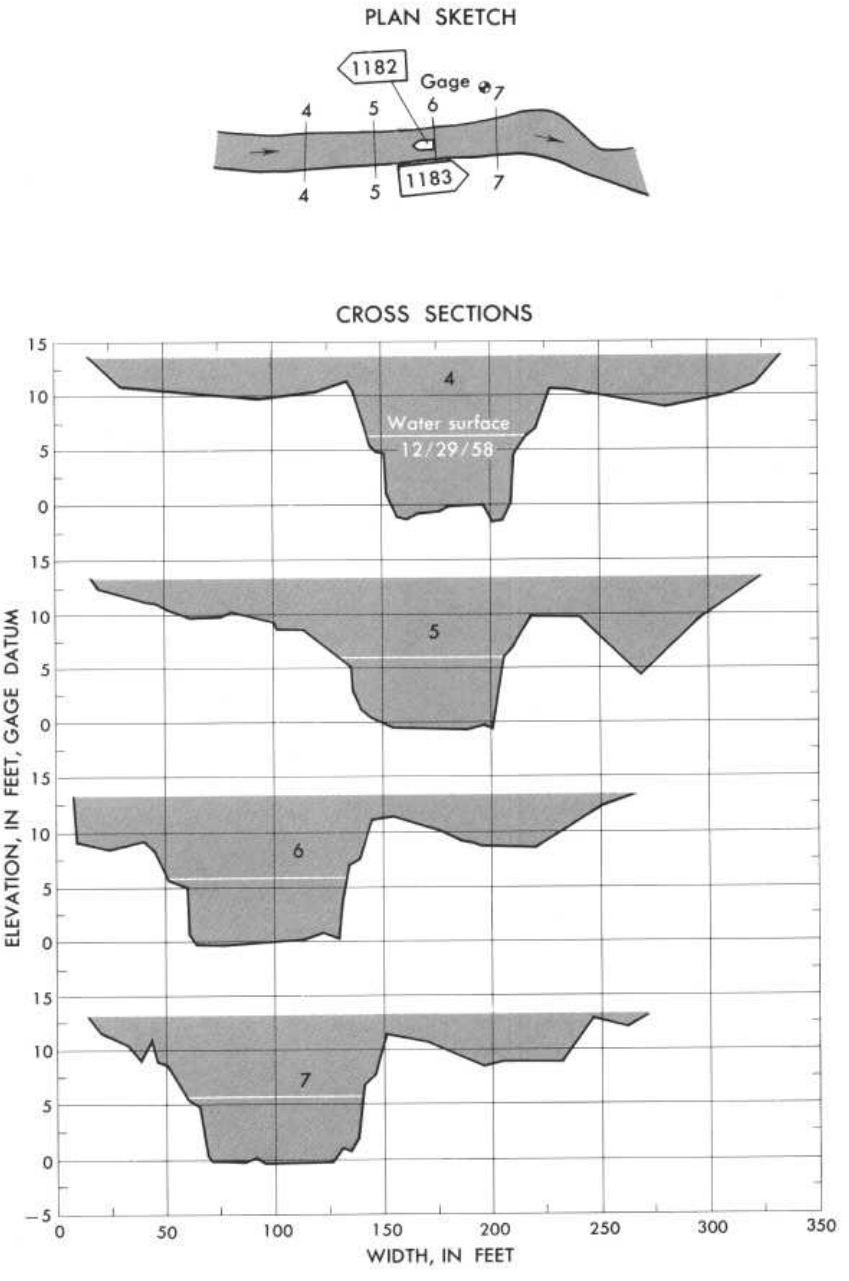
Computed roughness coefficient.—Manning $n = 0.059$.

Description of channel.—Bed is composed of coarse sand and a few outcrops. Banks on both sides are heavily lined with overhanging birch trees.

Reach properties

Section	Area (sq ft)	Top width (ft)	Mean depth (ft)	Hydraulic radius (ft)	Mean velocity (ft per sec)	Length (ft) between sections	Fall (ft) between sections
4	403	73	5.5	4.98	2.48	.....	.....
5	417	73	5.7	5.22	2.40	172	0.16
6	400	81	4.9	4.58	2.50	115	.15
7	397	79	5.0	4.70	2.52	121	.16

Notes.—



Plan sketch and cross sections, Haw River near Benaja, N.C.

$n = 0.059$

No. 1182 upstream from section 6, Haw River near Benaja, N.C.

$n = 0.059$

No. 1183 downstream along right bank from section 6,
Haw River near Benaja, N.C.

12–1135. North Fork Cedar River near Lester, Wash.

Gage location.—Lat 47°19′10″, long 121°30′05″, in SW¼ sec. 11, T. 21 N., R. 10 E., on left bank 120 ft downstream from falls, 1.5 miles upstream from confluence with South Fork, and 7.5 miles north of Lester. Section 1 is about 700 ft upstream from gage.

Drainage area.—8.81 sq mi.

Date of flood.—Dec. 15, 1959.

Gage height.—3.85 ft at gage; 24.88 ft (different datum) at section 1.

Peak discharge.—996 cfs.

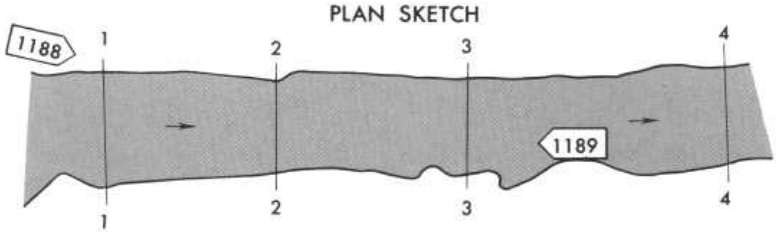
Computed roughness coefficient.—Manning $n = 0.059$.

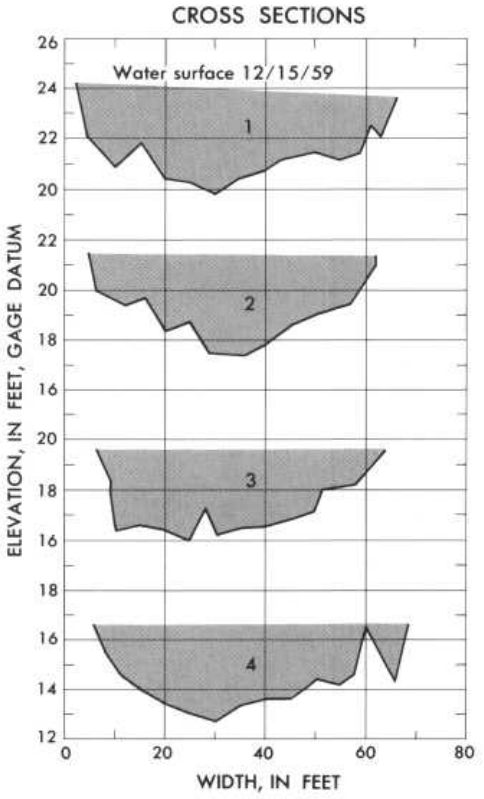
Description of channel.—Bed is large boulders. Banks are irregular and lined with brush, tree stumps, and roots.

Reach properties

Section	Area (sq ft)	Top width (ft)	Mean depth (ft)	Hydraulic radius (ft)	Mean velocity (ft per sec)	Length (ft) between sections	Fall (ft) between sections
1	178	64	2.7	2.65	5.60	.....	.....
2	150	58	2.6	2.53	6.60	86	2.54
3	144	58	2.5	2.40	6.92	96	1.82
4	157	63	2.5	2.39	6.34	130	3.04

Notes.—





Plan sketch and cross sections, North Fork Cedar River near Lester, Wash.

$n = 0.059$

No. 1188 downstream from left bank above section 1, North Fork Cedar River near Lester, Wash.

$n = 0.059$

No. 1189 upstream from right bank below section 3, North Fork Cedar River near Lester, Wash.

3–4485. Hominy Creek at Candler, N.C.

Gage location.—Lat 35°32′28″, long 82°40′35″, on left bank 0.1 mile downstream from Pole Creek, 0.4 mile downstream from bridge on State Highway 112, and 1 mile east of Candler, Buncombe County. Section 1 is about 250 ft downstream from gage.

Drainage area.—79.8 sq mi.

Date of flood.—June 16, 1949.

Gage height.—13.75 ft at gage; 13.33 ft at section 1.

Peak discharge.—6,800 cfs total; 6,460 cfs in the main channel.

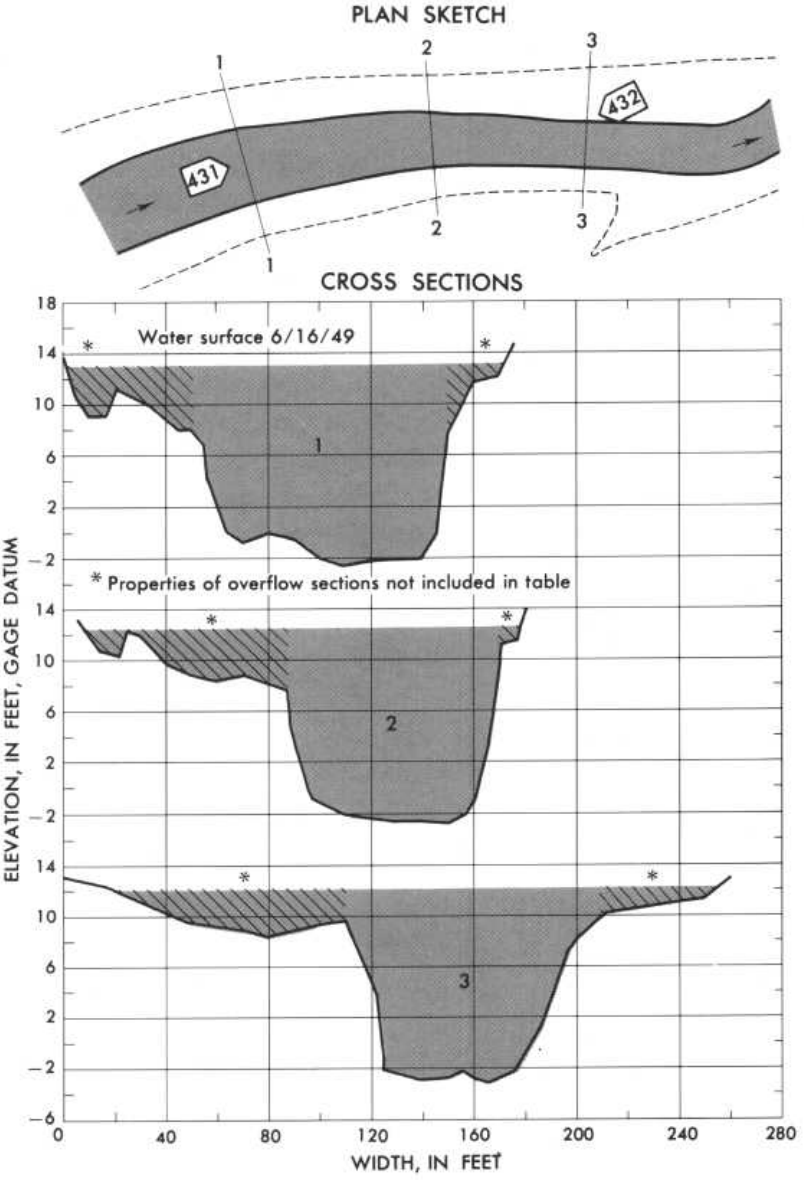
Computed roughness coefficient.—Manning $n = 0.060$.

Description of channel.—Bed is sand and gravel with some boulders as much as 20 inches in diameter. Both banks are lined with overhanging trees and bushes.

Reach properties

Section	Area (sq ft)	Top width (ft)	Mean depth (ft)	Hydraulic radius (ft)	Mean velocity (ft per sec)	Length (ft) between sections	Fall (ft) between sections
1	1,400	110	12.7	11.77	4.76	.....	.....
2	1,160	90	12.9	11.62	5.50	308	0.68
3	1,090	90	12.2	11.28	5.72	262	.46

Notes.—



Plan sketch and cross sections, Hominy Creek at Candler, N.C. Dashed lines show limits of overbank flooding.

$n = 0.060$

No. 431 downstream from above section 1, Hominy Creek at Candler, N.C.

$n = 0.060$

No. 432 upstream from left bank at section 3, Hominy Creek at Candler, N.C.

12–3455. Rock Creek Canal near Darby, Mont.

Gage location.—Lat 46°04′40″, long 114°12′40″, in SW¼ sec. 28, T. 4 N., R. 21 W., on downstream side of footbridge, 0.25 mile downstream from diversion dam, 1.5 miles downstream from Como Lake, and 4 miles northwest of Darby. Section 1 is about 0.25 mile upstream from gage.

Date of flood.—Sept. 23, 1948.

Gage height.—3.34 ft at gage; 15.33 ft at section 1.

Peak discharge.—138 cfs.

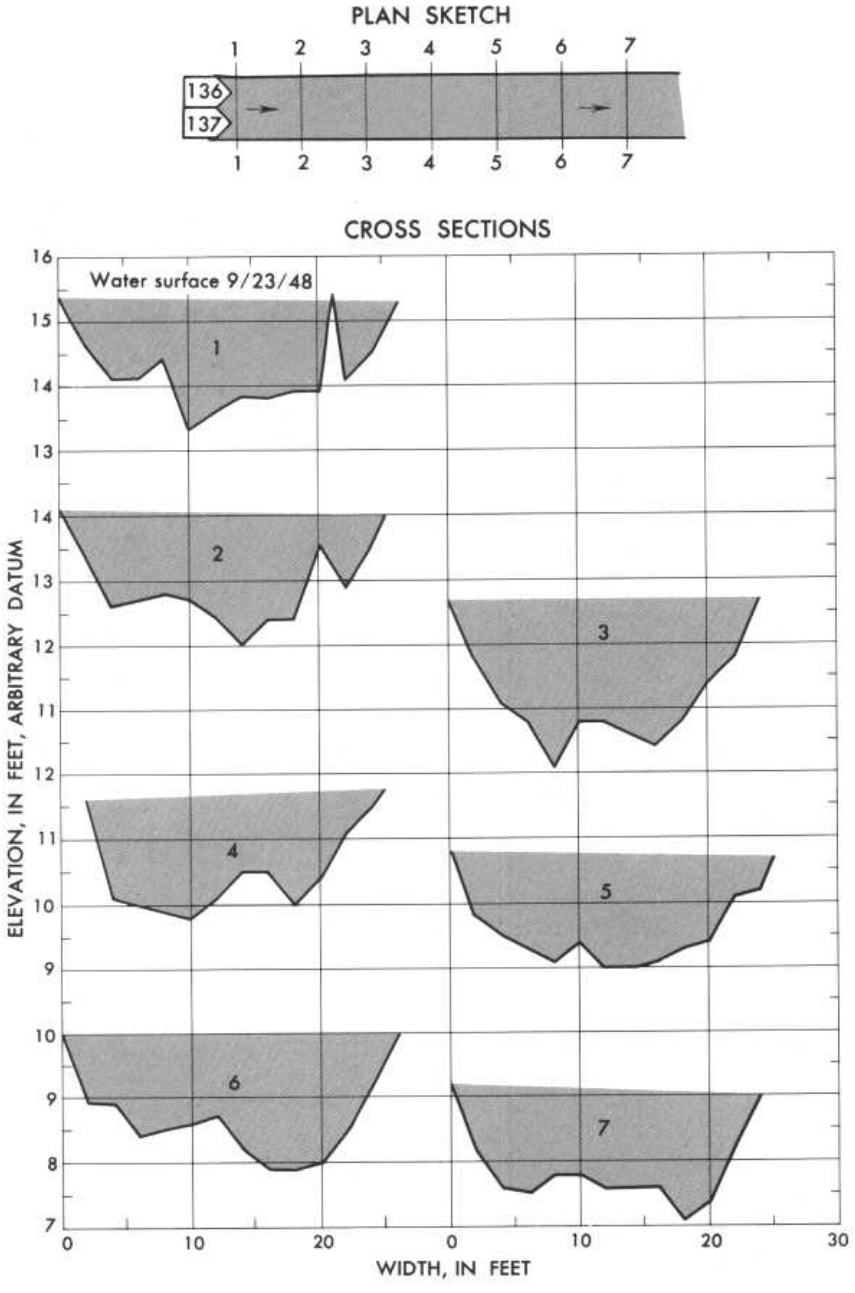
Computed roughness coefficient.—Manning $n = 0.060$.

Description of channel.—Bed and bank consist of boulders; $d_{50} =$ 210 mm, $d_{84} = 375$ mm.

Reach properties

Section	Area (sq ft)	Top width (ft)	Mean depth (ft)	Hydraulic radius (ft)	Mean velocity (ft per sec)	Length (ft) between sections	Fall (ft) between sections
1	30	26	1.15	1.07	4.60	.....	.....
2	31	25	1.24	1.19	4.45	45	1.25
3	39	24	1.62	1.56	3.54	50	1.36
4	30	25	1.20	1.25	4.60	50	1.02
5	32	25	1.28	1.28	4.31	50	.93
6	37	26	1.42	1.37	3.73	50	.78
7	32	24	1.33	1.28	4.31	50	.85

Notes.—

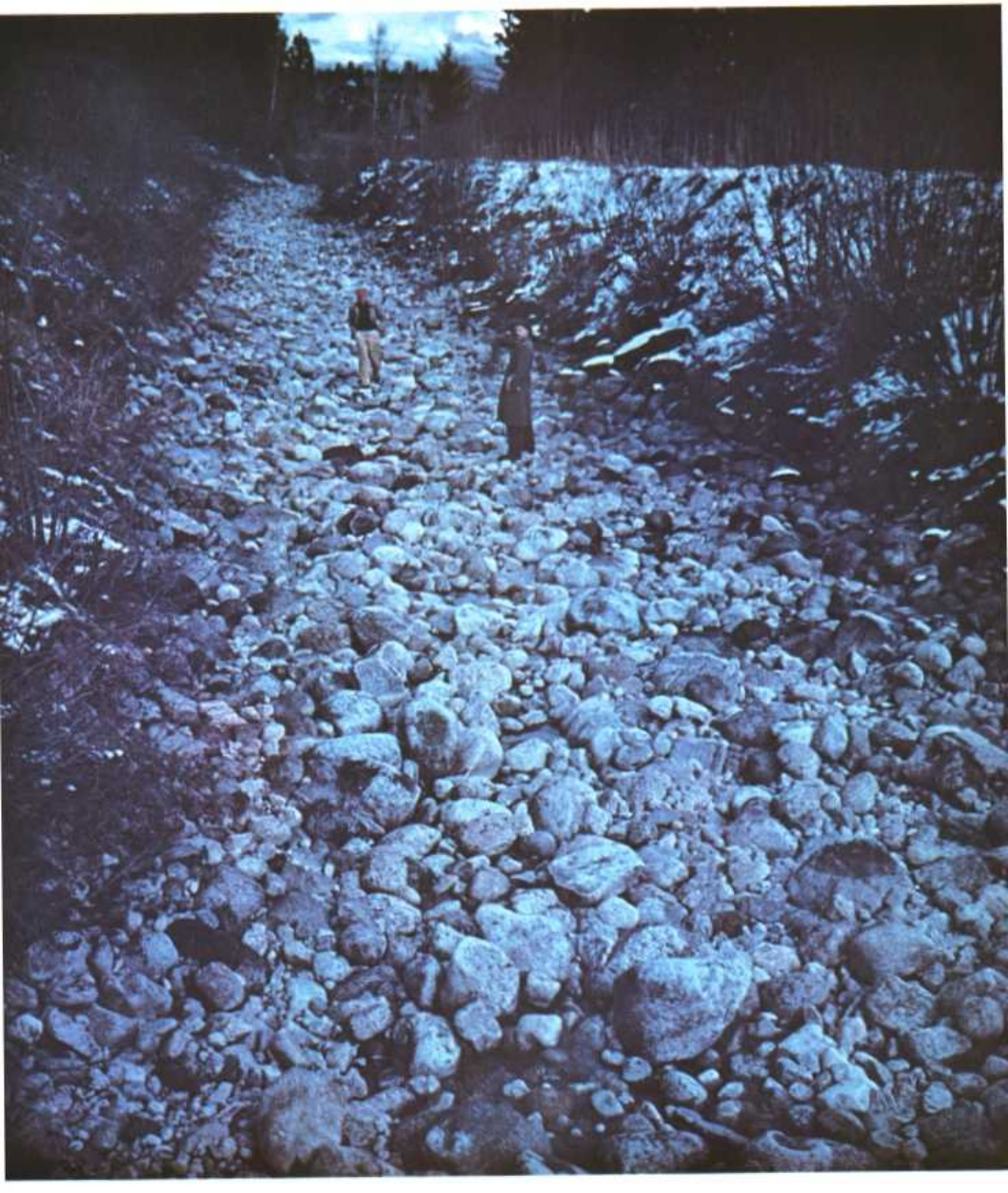


Plan sketch and cross sections, Rock Creek Canal near Darby, Mont.

$n = 0.060$

No. 136 downstream from above section 1,
Rock Creek Canal near Darby, Mont.

$n = 0.060$



No. 137 downstream from above section 1,
Rock Creek Canal near Darby, Mont.

11–2645. Merced River at Happy Isles Bridge, near Yosemite, Calif.

Gage location.—Lat 37°43′54″, long 119°33′28″, on right bank 10 ft downstream from Happy Isles Bridge, 0.4 mile downstream from Illilouette Creek, and 2 miles southeast of Yosemite National Park Headquarters, Mariposa County. Section 1 is about 1,000 ft downstream from gage.

Drainage area.—181 sq mi.

Date of flood.—May 17, 1950.

Gage height.—6.06 ft at gage; 97.40 ft (different datum) at section 1.

Peak discharge.—1,950 cfs.

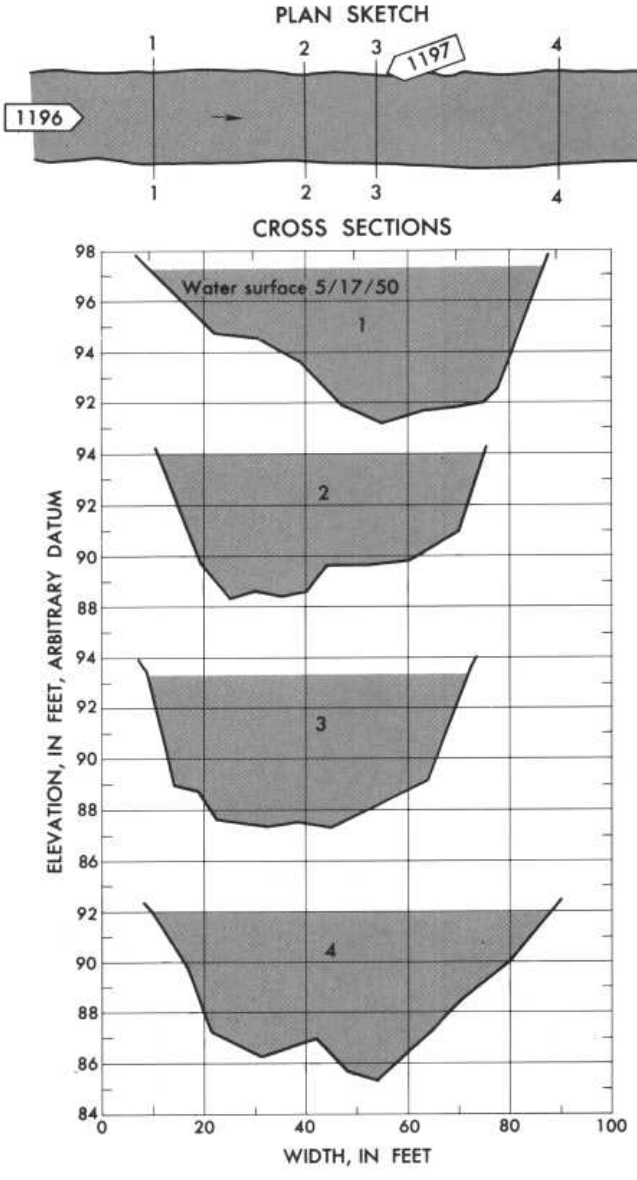
Computed roughness coefficient.—Manning $n = 0.065$.

Description of channel.—Fairly straight channel is composed of boulders with trees along top of banks; $d_{50} = 253$ mm, $d_{84} = 550$ mm.

Reach properties

Section	Area (sq ft)	Top width (ft)	Mean depth (ft)	Hydraulic radius (ft)	Mean velocity (ft per sec)	Length (ft) between sections	Fall (ft) between sections
1	308	78	4.0	3.90	6.33	.....	.....
2	263	64	4.1	3.98	7.41	200	3.40
3	309	63	4.9	4.68	6.31	40	.50
4	327	78	4.2	4.09	5.96	180	1.55

Notes.—



Plan sketch and cross sections, Merced River at Happy Isles Bridge, near Yosemite, Calif.

$n = 0.065$

No. 1196 downstream from above section 1, Merced River at Happy Isles Bridge, near Yosemite, Calif.

$n = 0.065$

No. 1197 upstream from right bank at section 3, Merced River at Happy Isles Bridge, near Yosemite, Calif.

$n = 0.070$

3-3020. Pond Creek near Louisville, Ky.

Gage location.—Lat 38°07′11″, long 85°47′45″, on downstream side of bridge on Manslick Road, 0.4 mile south of Third Street Road, 0.6 mile downstream from Bee Lick Creek, and 2.4 miles south of Louisville City Limits, Jefferson County. Section 1 is about 550 ft upstream from gage.

Drainage area.—64.0 sq mi.

Date of flood.—Feb. 14, 1950.

Gage height.—15.00 ft at gage; 15.1 ft at section 1.

Peak discharge.—1,480 cfs.

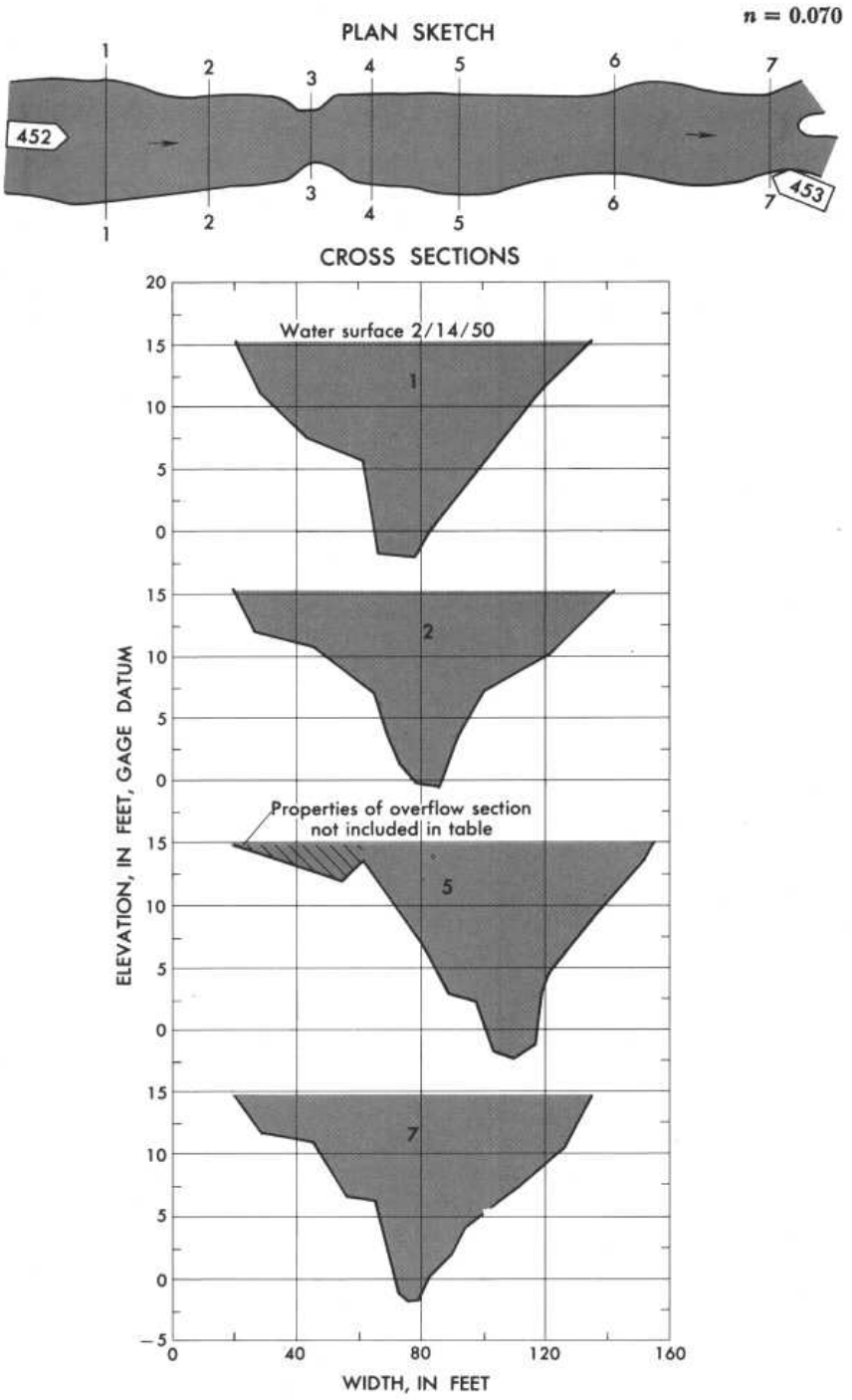
Computed roughness coefficient.—Manning $n = 0.070$.

Description of channel.—Bed is fine sand and silt. Banks are irregular with fairly heavy growth of 2- to 8-inch trees on the banks above low water, particularly on the left bank. Reach sections 1, 2, 5, 6, 7 used to determine roughness coefficient. Bridge abutments form constriction at section 3.

Reach properties

Section	Area (sq ft)	Top width (ft)	Mean depth (ft)	Hydraulic radius (ft)	Mean velocity (ft per sec)	Length (ft) between sections	Fall (ft) between sections
1	888	115	7.7	7.10	1.67	.....	.....
2	830	122	6.8	6.48	1.78	90	0.05
3	591	52	11.4	8.23	2.50	95	.10
4	837	116	7.2	6.80	1.77	45	.02
5	818	94	8.7	8.06	1.81	79	.05
6	791	107	7.4	7.00	1.87	156	.10
7	854	115	7.4	7.00	1.73	147	.07

Notes.—



Plan sketch and cross sections, Pond Creek near Louisville, Ky.

$n = 0.070$

No. 452 downstream from above section 1,
Pond Creek near Louisville, Ky.

$n = 0.070$

No. 453 upstream from right bank at section 7,
Pond Creek near Louisville, Ky.

12–3215. Boundary Creek near Porthill, Idaho

Gage location.—Lat 48°59′50″, long 116°34′05″, in SW¼ sec. 11, T. 65 N., R. 2 W., on left bank near mouth of canyon, 0.2 mile south of international boundary, and 3 miles west of Porthill. Section 1 is 413 ft upstream from gage.

Drainage area.—97 sq mi, approximately.

Date of flood.—May 28, 1948.

Gage height.—5.34 ft at gage; 13.60 ft at section 1.

Peak discharge.—2,530 cfs.

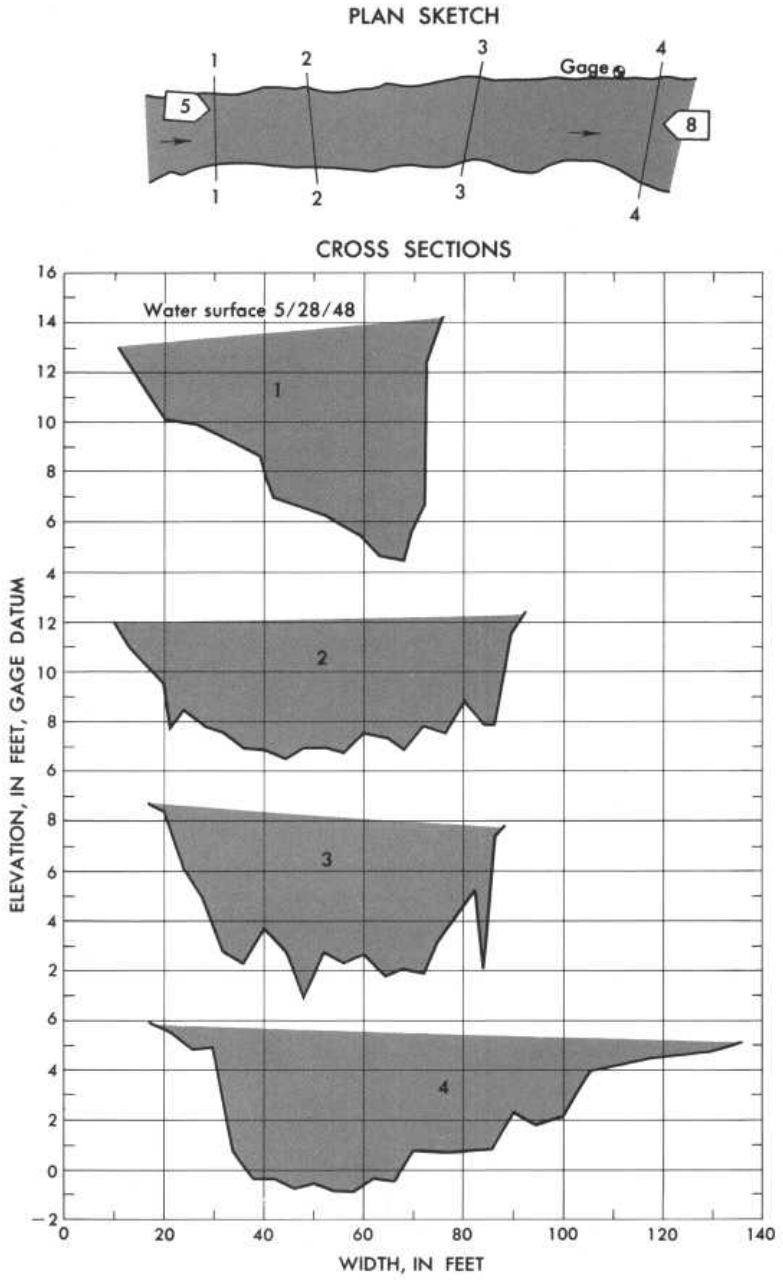
Computed roughness coefficient.—Manning $n = 0.073$.

Description of channel.—Bed consists of boulders; $d_{50} = 210$ mm, $d_{84} = 375$ mm. Banks are composed of boulders and have trees and brush along top.

Reach properties

Section	Area (sq ft)	Top width (ft)	Mean depth (ft)	Hydraulic radius (ft)	Mean velocity (ft per sec)	Length (ft) between sections	Fall (ft) between sections
1	351	64	5.48	4.87	7.21	.....	.....
2	338	82	4.12	3.93	7.49	94	1.45
3	327	71	4.61	4.09	7.74	163	3.95
4	400	118	3.39	3.30	6.32	177	2.70

Notes.—



Plan sketch and cross sections, Boundary Creek near Porthill, Idaho.

$n = 0.073$

No. 5 downstream from left bank above section 1,
Boundary Creek near Porthill, Idaho.

$n = 0.073$

No. 8 upstream from below section 4,
Boundary Creek near Porthill, Idaho.

12–3450. Rock Creek near Darby, Mont.

Gage location.—Lat 46°04′10″, long 114°13′20″, in SE¼SE¼ sec. 29, T. 4 N., R. 21 W., on left bank 0.6 mile downstream from Como Lake, 0.7 mile upstream from Rock Creek Canal, and 4 miles northwest of Darby. Section 1 is about 0.25 mile upstream from gage.

Drainage area.—55.4 sq mi.

Date of flood.—May 27, 1948.

Gage height.—5.78 ft at gage; 23.85 ft at section 1.

Peak discharge.—1,500 cfs.

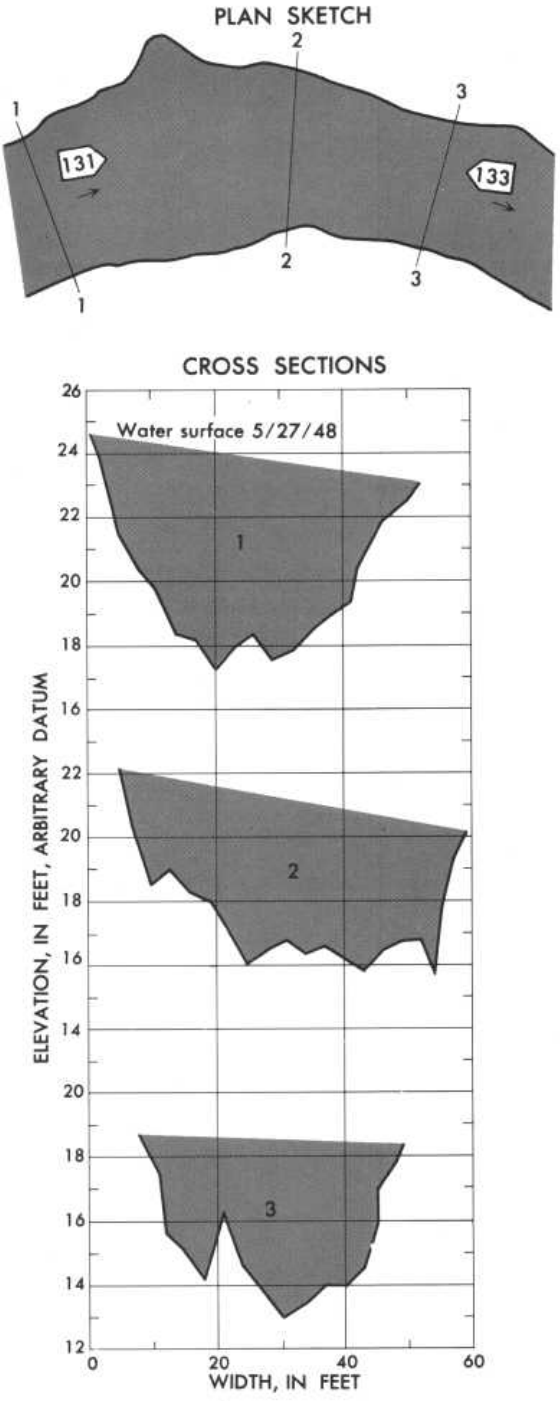
Computed roughness coefficient.—Manning $n = 0.075$.

Description of channel.—Bed consists of boulders; $d_{50} = 220$ mm, $d_{84} = 415$ mm. Banks are composed of boulders and have trees and brush.

Reach properties

Section	Area (sq ft)	Top width (ft)	Mean depth (ft)	Hydraulic radius (ft)	Mean velocity (ft per sec)	Length (ft) between sections	Fall (ft) between sections
1	214	51	4.20	3.96	7.01	.....	.....
2	203	54	3.76	3.50	7.39	79	2.65
3	134	43	3.12	2.91	11.19	47	2.45

Notes.—



Plan sketch and cross sections, Rock Creek near Darby, Mont.

$n = 0.075$

No. 131 downstream from above section 2,
Rock Creek near Darby, Mont.

$n = 0.075$

No. 133, upstream from below section 3,
Rock Creek near Darby, Mont.

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