Velocity-Head Coefficients in Open Channels

GEOLOGICAL SURVEY WATER-SUPPLY PAPER 1869-C

Prepared in cooperation with the California Department of Water Resources

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By HARRY HULSING, WINCHELL SMITH, *and* ERNEST D. COBB

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SYMBOLS

A	Cross-sectional area, in square feet.
ΔA	Incremental cross-sectional area.
D	Depth of water at point of observation, in feet.
d	Distance from water surface to point of observation.
F	Froude number.
g	Gravitational acceleration=32.16 feet per second per second.
K	Conveyance$=\frac{1.486\,AR^{2/3}}{n}$
n	Manning's roughness coefficient.
P	Wetted perimeter, in feet.
Q	Discharge, in cubic feet per second.
R	Hydraulic radius, in feet.
V	Mean velocity in a section, in feet per second.
v	Point velocity.
w	Unit weight of water.
$\overline{X}$, $\overline{Y}$	Coordinates of the centroid of flow relative to water's edge and water surface, respectively.

Subscripts

m	Denotes the mean in a cross section.
Max	Maximum value.
vv	Denotes that figure was derived from measurements based on multiple-point velocity observations.
$0.2d/0.8d$	Denotes velocities or computations based on velocities observed at points 0.2 and 0.8 of the stream depth below the water surface.
$0.6d$	Denotes velocities or computations based on velocities observed at points 0.6 of the stream depth below the water surface.

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RIVER HYDRAULICS

VELOCITY-HEAD COEFFICIENTS IN OPEN CHANNELS

By Harry Hulsing, Winchell Smith, and Ernest D. Cobb

ABSTRACT

This report presents the results of a detailed study of the velocity-head coefficient, alpha, in natural channels. It is based upon an analysis of point velocities obtained from discharge measurements made by the multiple-point method or by the two-point (0.2*d*/0.8*d*) method.

Computed values of alpha ranged from 1.03 to 4.70; the median value for trapezoidal channels was 1.40. Variation in the horizontal distribution of velocity is shown to have a greater effect on the value of alpha than variation in the vertical.

For channels without overbank flow, a significant correlation is shown between alpha and channel roughness, as expressed by Manning's n; no significant correlations were established with other channel or flow parameters. For channels with overbank flow, a rational method of estimating alpha is presented, based on Manning's n and on channel conveyance, K.

INTRODUCTION

PURPOSE AND SCOPE

Measurement of discharge in open channels is performed routinely by use of a current meter, but during flood periods, discharge frequently must be determined by such indirect methods as slope area, flow through culverts or bridges, and flow over dams. The hydraulic formulas used in these methods require an evaluation of the kinetic energy (velocity head) of the flowing water. This evaluation is based on the mean velocity of flow. Use of the mean velocity, however, will always result in a computed value for kinetic energy that is too low; to determine the true kinetic energy, a coefficient must be applied. The derivation of the kinetic-energy coefficient, alpha, is explained in the section "Definition of Kinetic-Energy Coefficient."

The purpose of this study is to provide a means whereby the kinetic-energy coefficient can be evaluated on the basis of channel cross-section parameters. The results presented herein are based on an analysis of point velocities obtained from current-meter measurements of discharge in streams and canals. The measured discharges ranged from 1.1 cfs (cubic feet per second) to 636,000 cfs.

ACKNOWLEDGMENTS

The study described in this report was done under a cooperative agreement between the U.S. Geological Survey and the California Department of Water Resources. Work was performed under the general direction of Walter Hofmann, district chief, Water Resources Division, U.S. Geological Survey, Menlo Park, Calif.

Programing assistance furnished by Mr. W. L. Isherwood, U.S. Geological Survey, Washington, D.C., was invaluable, as was technical assistance given by Mr. S. E. Rantz, U.S. Geological Survey, Menlo Park, Calif. The cooperation of many district offices of the U.S. Geological Survey in furnishing multiple-point velocity measurements of discharge and other pertinent data is also gratefully acknowledged.

DEFINITION OF KINETIC-ENERGY COEFFICIENT

Streambed roughness, irregularity of channel-bank and bed configuration, curved channel alinement, upstream obstructions, and perhaps other factors cause the velocity in a given cross section of a stream to vary from point to point. Because of this variation in velocity, the velocity head, or the kinetic energy per pound of water, is greater than the value computed from the expression, $\frac{V^2}{2g}$, where V is the mean velocity in the cross section. This is true because the square of the average velocity is less than the weighted average of the squares of the point velocities. The true velocity head may be expressed as $\frac{\alpha V^2}{2g}$, where alpha is the energy-head coefficient, or Coriolis coefficient, so named in honor of G. Coriolis, who first proposed it in 1836.

The derivation of kinetic-energy coefficients is described in most standard hydraulics texts. The following explanation is quoted from Chow (1959, p. 28):

> Let ΔA be an elementary area in a cross section A, and w the unit weight of water; then the weight of water passing ΔA per unit time with a velocity v is $wv\Delta A$. The kinetic energy of water passing ΔA per unit time is $wv^3 \frac{\Delta A}{2g}$. This is equivalent to the product of the weight $wv\Delta A$ and the velocity head $\frac{v^2}{2g}$. The total kinetic energy for the whole area is equal to $\Sigma wv^3 \frac{\Delta A}{2g}$.
>
> Now, taking the whole area as A, the mean velocity as V, and the corrected velocity head for the whole area as $\alpha \frac{V^2}{2g}$, the total kinetic energy is $\alpha A w \frac{V^3}{2g}$. Equating this quantity with $\Sigma wv^3 \frac{\Delta A}{2g}$ and reducing:

$$\alpha=\frac{\int v^3 da}{V^3 A}\approx\frac{\Sigma v^3 \Delta A}{V^3 A}. \tag{1}$$

SOURCES OF VELOCITY DATA

The basic data for this study consisted of point velocities obtained from measurements of discharge in streams and canals throughout the conterminous United States. In making a discharge measurement, a cross section of the stream is first divided into about 25 subsections. The mean velocity in a vertical line in the center of each subsection then is obtained, after which, the discharge in each subsection is computed by multiplying each mean velocity by the area of its respective subsection. The total discharge of the stream is then obtained by summing these incremental discharges. The measurements of width and depth required to obtain the area of a subsection are straightforward. The mean velocity in each vertical can be determined by several methods. Generally, either the two-point or the one-point method is used; but if more precise definition is desired, the multiple-point velocity method is used.

TWO-POINT (0.2*d*/0.8*d*) VELOCITY METHOD

The method most commonly used for determining mean velocity in a vertical section is the two-point (0.2*d*/0.8*d*) method, which requires that point velocities be obtained at points 0.2 and at 0.8 of the stream depth below the water surface in each vertical. Distribution of the velocity in a vertical is usually parabolic and such that the average of the velocities, measured at these two points, yields the mean velocity in the vertical. A complete two-point discharge measurement will include about 50 observations of point velocity.

ONE-POINT (0.6*d*) VELOCITY METHOD

In this method only one point velocity at 0.6 of the depth is obtained at each vertical. Experience and theory demonstrate the velocity at 0.6 depth is, on the average, a good measure of the mean velocity in the vertical. This method will include about 25 point-velocity observations in each discharge measurement.

MULTIPLE-POINT VELOCITY METHOD

In the multiple-point velocity method a series of velocity observations at points fairly evenly distributed between the water surface and the streambed is made in each vertical. This generally entails point-velocity observations at each 0.1 of the depth, but if the stream is deep enough, additional readings at the 0.05 and 0.95 depths are obtained. Depth is a factor because the current meter, when suspended on a cable above a sounding weight, can be placed no closer to the streambed than the distance from the meter to the bottom of the sounding weight. Furthermore, velocity observations are never made with the meter placed within a few tenths of a foot of either the water surface or streambed because the characteristics of the meter are such that it does not measure point velocities accurately in those circumstances. The mean velocity in the vertical is computed by weighting each observed velocity in proportion to the vertical increment which it represents. A discharge measurement made by this method will include about 250 point-velocity readings in the river cross section.

COMPUTATION PROCEDURES

ARITHMETIC METHOD

The alpha coefficient can be computed by arithmetic integration of equation 1. All that is needed is several point-velocity readings and their respective incremental areas.

Each velocity is assumed to be applicable to the incremental area surrounding it—that is, the area enclosed by boundaries one-half the distance to the point velocity above and below it and to the right and left of it (fig. 1). Accuracy of the computation increases correspondingly with the number of point-velocity observations in the measurement.

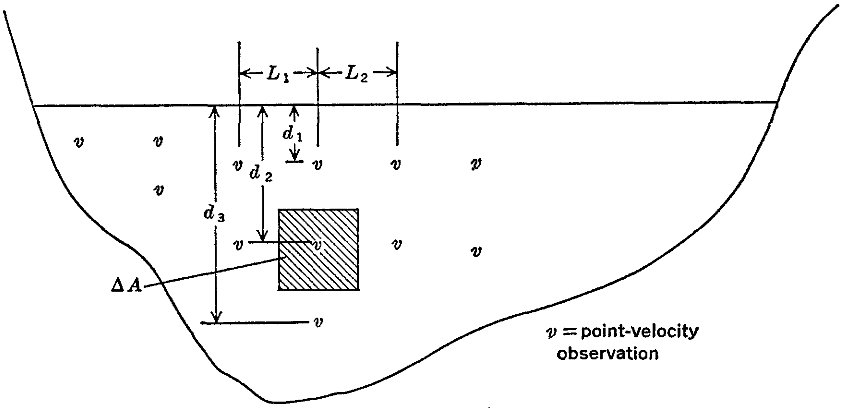
GRAPHIC METHOD

In the graphic method, point velocities are plotted on a diagram of the stream cross section. Lines of equal velocity (isovels) are drawn, and the area enclosed by adjacent isovels is determined. Alpha is computed by applying equation 1, using the area between isovels for ΔA, and the average of adjacent isovels for v.

The reliability of the graphic method is subjectively affected by the manner in which isovels are drawn and by the magnitude of the selected difference between adjacent isovels.

COMPUTER PROGRAM

Both the arithmetic-integration and graphic methods were tried, using conventional office equipment. The graphic method proved to be extremely slow and costly. More than 2 man-days per computation were required. The arithmetic method, using a desk calculator, reduced this time by half; but with the quantity of data that needed processing, even this method was too slow. The obvious approach



$$\Delta A = \left(\frac{L_1 + L_2}{2}\right)\left(\frac{d_3 - d_1}{2}\right)$$

$$\text{and } \alpha = \frac{\Sigma v^3 \Delta A}{V^3 A}$$

$$\text{where } A = \Sigma \Delta A$$

$$V = \frac{\Sigma v \Delta A}{A}$$

FIGURE 1.—Computation of alpha by arithmetic integration.

was to program the arithmetic-integration method on an electronic computer. This was done for the Burroughs 220 computer.

The computer program was written so that alpha coefficients were computed by use of point velocities and related incremental areas. This resulted in the following computational procedures each of which was dependent on the number of point observations made in the vertical:

1. Eleven velocity observations in each vertical (multiple-point velocity measurement).
2. Two velocity observations in each vertical (0.2*d*/0.8*d* measurement).
3. One velocity observation in each vertical (0.6*d* measurement).

From multiple-point velocity measurements three independent alpha coefficients could be obtained, because such measurements included observations at the 0.2*d*, 0.6*d*, and 0.8*d*. This is an important feature that will be discussed later in this report.

The decision was made to use an electronic computer, and the project was consequently expanded to include not only the computation of alpha coefficients but also the determination of various other parameters that might be used in correlation and peripheral studies of velocity distribution in natural channels. The computer was programmed to determine the following items:

A	Cross-sectional area.
α	Alpha coefficient, based on multiple-point velocity observations.
$\alpha_{0.2d/0.8d}$	Alpha coefficient, based on velocity observations made at 0.2/0.8 depths in each subsection.

$\alpha_{0.6d}$	Alpha coefficient, based on velocity observations made at 0.6 depth in each subsection.
B	Stream width.
$C_{0.5d} \cdots C_{0.95d}$	Velocity-profile coefficients; subscript indicates ratio of observation depth to total depth, measured from the water surface.
P	Wetted perimeter.
Q_{vv}, V_{vv}	Discharge and mean velocity, based on multiple-point velocity observations.
$Q_{0.2d/0.8d}, V_{0.2d/0.8d}$	Discharge and mean velocity, based on velocity observations made at 0.2 and 0.8 depths in each subsection.
$Q_{0.6d}, V_{0.6d}$	Discharge and mean velocity, based on velocity observations made at 0.6 depth in each subsection.
R	Hydraulic radius.
$\overline{X}, \overline{Y}$	Coordinates of the centroid of flow, as measured from the water surface and one bank.

Discharge measurements are very often made under conditions where the flow is not perpendicular to the selected cross section. To get the correct discharge, a horizontal-angle correction is applied to the velocity at each vertical. This is satisfactory for discharge computations, but where energy considerations are involved, the application of the horizontal-angle correction results in an erroneous evaluation of kinetic energy. For example, the kinetic energy for a flow at some given stage and discharge in a uniformly shaped channel has a unique value. Different values of mean velocity and alpha would be computed if measurement cross sections at various angles to the current were used, and if horizontal angle coefficients were applied to the velocities. Because of the complications associated with angularity of the current where variable horizontal angles are present, discharge measurements that included skewed currents in more than 10 percent of the subsections were excluded from this study.

The computation procedure used with data obtained from multiple-point velocity measurements of discharge required complete data for every vertical in the cross section. The inclusion of routines to fill gaps in the array of velocity data was consequently a major factor in the computer program.

The following procedure was used. Data for each vertical were examined by the computer to determine whether all 11 velocity values were present. If fewer than 11 values in the array were known, the missing items were supplied by the computer, which used a selected routine that was dependent on the actual number of observed point velocities. A primary requirement was that the data had to include, as a minimum, $v_{0.6d}$ or $v_{0.2d}$, and $v_{0.8d}$.

Two general computation processes were used. If three, or fewer, velocity observations were made in a vertical, the arithmetic mean was computed from the available data; all other points in the vertical were computed as the product of this mean and the standard vertical-velocity curve coefficient included in the program. These coefficients were derived from 48 multiple-point velocity measurements that were complete in every detail. The vertical-velocity curve coefficients derived from these data are given in table 1.

TABLE 1.—*Coefficients for standard vertical-velocity curve*

Ratio of observation depth to depth of water	*Ratio of point velocity to mean velocity in the vertical*
0.05	1.160
.1	1.160
.2	1.149
.3	1.130
.4	1.108
.5	1.067
.6	1.020
.7	.953
.8	.871
.9	.746
.95	.648

If more than three observations were made, each item was examined and those values missing from the array were inserted by a process of interpolation whereby the observed velocities were weighted in accordance with an average velocity distribution. The reliability of the computed value of alpha is, to some degree, dependent on the completeness of data supplied. Most multiple-point velocity measurements were complete, however, except for those shallow subsections where limitations of the measuring equipment precluded precise definition of the vertical distribution of velocity. Probably very little bias resulted from using these procedures in completing the array of point velocities in the vertical.

COMPARISON OF ALPHA DETERMINED GRAPHICALLY AND ARITHMETICALLY

Arithmetic accuracy of the computer program was verified by manual computation of simplified measurements. The results obtained by graphic procedures were compared with those obtained by arithmetic integration performed by desk calculator or by the computer (fig. 2).

The results agree closely, although the coefficients computed by the graphic method averaged about 1.5 percent higher than those computed by the machine, probably owing to the difference in treatment given to the bottom velocities in each vertical and to the subjectivity involved in the graphic procedure. In figure 2 the departures shown are within an allowable tolerance, verifying the assumption that equivalent computations can be made by either method.

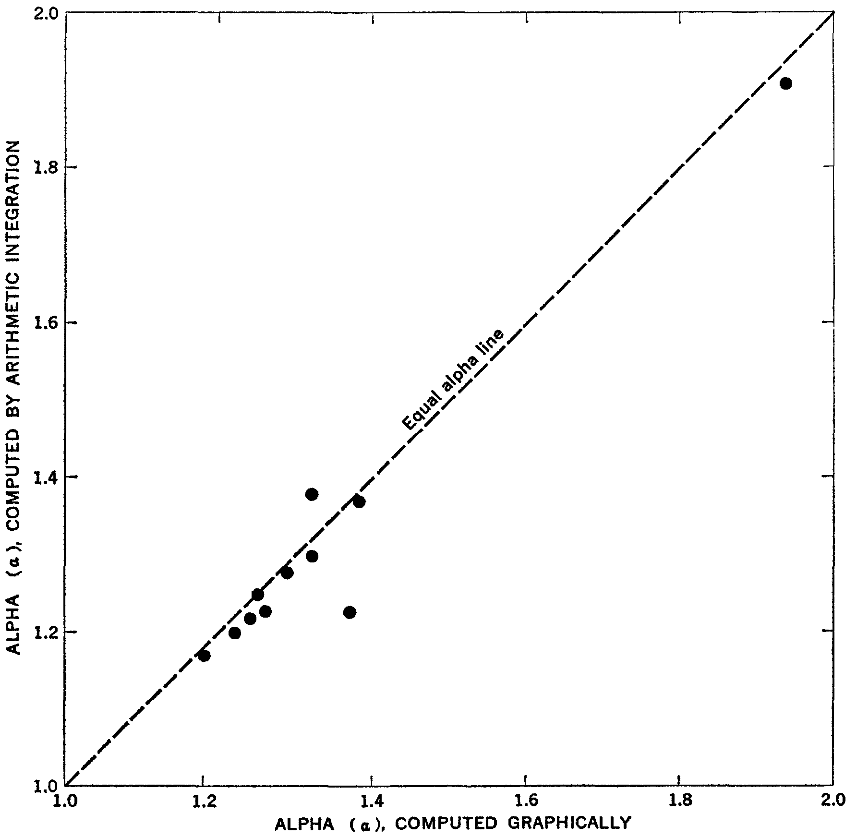


FIGURE 2.—Alpha values computed graphically compared with alpha values computed by arithmetic integration.

TYPES OF CROSS SECTIONS

The cross sections and channels represented by the measurements (given in "Basic Data" section) were classified into five types.

1. Type A: A natural trapezoidal-shaped channel without overbank flow and no bridge piers or other manmade obstructions.
2. Type B: A natural channel with bridge piers, abutments or manmade obstructions which may affect the flow pattern.
3. Type C: A canal or manmade channel without overbank flow.
4. Type D: Same as type A, but with overbank-flow sections.
5. Type E: Same as type C, but with overbank-flow sections.

DISCHARGE MEASUREMENTS USED

MULTIPLE-POINT VELOCITY MEASUREMENTS

A large group of multiple-point velocity measurements was available from an Operations Research project conducted by the Washington, D.C., office of the U.S. Geological Survey in 1959. These measurements were augmented by additional data from various other projects. Alpha coefficients were computed for 173 of these multiple-point velocity measurements. Computed discharge ranged from 1.1 cfs to 636,000 cfs, and mean velocity ranged from 0.41 to 10.44 fps (feet per second). Table 4 gives the station name and location and pertinent data for each measurement; the type of cross section is also indicated.

Plan views of the measuring sites and roughness coefficients (Manning's *n*), selected in the field, were obtained for each measurement through the cooperation of personnel responsible for the measurements. From the plan views, the length of tangent from the first upstream bend and the degree of curvature of this bend were determined.

TWO-POINT (0.2d/0.8d) VELOCITY MEASUREMENTS

In addition to the multiple-point velocity measurements, alpha coefficients were computed for 721 discharge measurements made by the usual 0.2*d*/0.8*d*-depth method. These measurements were selected to represent a wide variation in channel characteristics and in discharge at each site. Comparision of alpha with variations in roughness, discharge, velocity, and the various geometric channel parameters was thus possible. These measurements had a range in discharge from 12.3 to 505,000 cfs and a range in velocity from 0.27 to 11.37 fps. Roughness coefficients (Manning's *n*) were selected for each site, usually by on-site inspection, although a few were selected from pictures. Some complex cross sections (see fig. 3) were divided into subsections, and *n* values were selected for each subsection. Table 5 contains the name, location, type of cross section, and other pertinent data for each 0.2*d*/0.8*d*-depth velocity measurement. The formula used for the computation of alpha gave equal weight to velocity observations at the 0.2-depth and 0.8-depth positions.

ONE-POINT (0.6*d*) VELOCITY MEASUREMENTS

None of the discharge measurements selected for analysis was made by the 0.6*d* method. By abstracting the 0.6*d* observations included in the discharge measurements made by the multiple-point velocity method, however, 173 one-point velocity measurements were obtained for use in computation of alpha coefficients ($\alpha_{0.6d}$).

ANALYSIS OF VARIATIONS OF ALPHA

RANGE OF ALPHA

Table 2 summarizes the maximum, minimum, and median values of alpha determined for each type of cross section. This table

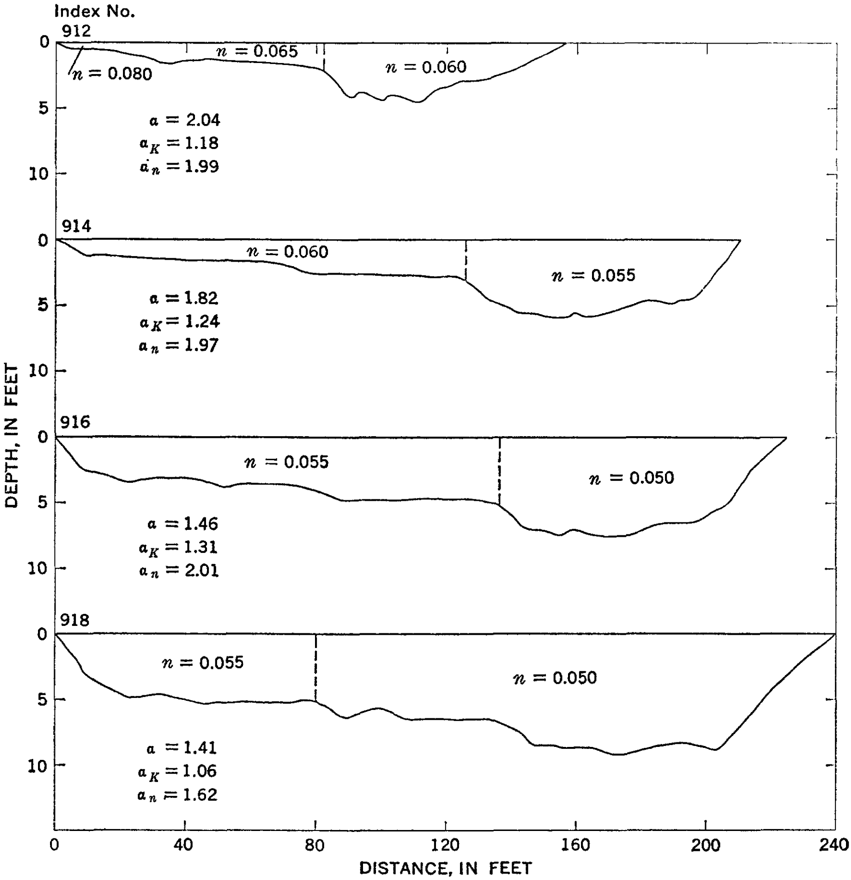


FIGURE 3.—Typical complex cross sections, Pit River near Bieber, Calif.

includes the results obtained from all multiple-point velocity and two-point (0.2*d*/0.8*d*) velocity measurements. The alpha coefficients computed for the 0.2*d*/0.8*d* measurements were adjusted by the equation next described.

TABLE 2.—*Summary of alpha coefficients for various types of cross sections*

Type of cross section	Number of measurements	Alpha coefficient (α)		
		Minimum	Maximum	Median
A	402	1.09	2.90	1.40
B	97	1.06	4.70	1.45
C	73	1.03	1.76	1.10
D	170	1.18	2.99	1.46
E	8	1.10	1.32	1.14

RELATION OF ALPHA COMPUTED FROM MULTIPLE-POINT VELOCITY MEASUREMENTS TO ALPHA COMPUTED FROM TWO-POINT (0.2*d*/0.8*d*) VELOCITY MEASUREMENTS

Multiple-point velocity measurements made in types A and C cross sections were studied first. A highly significant correlation was found to exist between the values of alpha computed from multiple-point velocity observations (α) and those of alpha computed solely on the basis of the $0.2d/0.8d$ observations ($\alpha_{0.2d/0.8d}$), which were abstracted from the complete array of point velocities (fig. 4). The regression

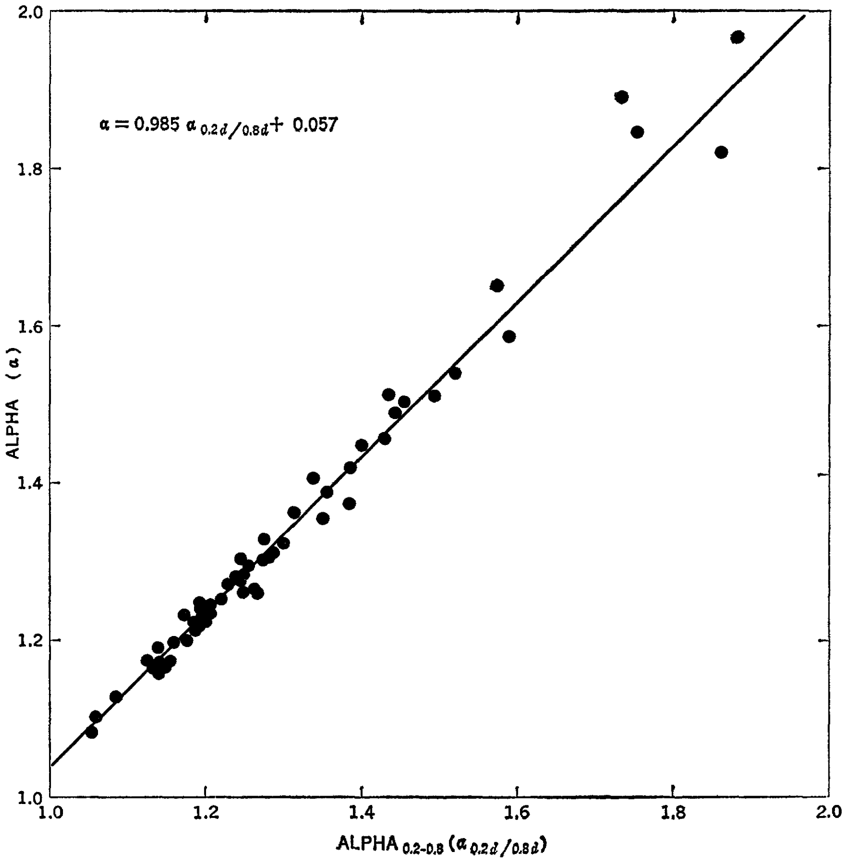


FIGURE 4.—Relation of alpha computed from multiple-point velocity observations (α) to alpha computed from $0.2d/0.8d$ velocity observations ($\alpha_{0.2d}/\alpha_{0.8d}$).

equation is

$$\alpha = 0.985(\alpha_{0.2d/0.8d}) + 0.057. \tag{2}$$

The correlation coefficient is 0.999, which is significant at the 1-percent level. The establishment of this relation was very important because it permitted the use of an almost limitless quantity of data (in the form of the conventional $0.2d/0.8d$ discharge measurements) for detailed study of the relation between alpha and the various channel and flow parameters.

RELATION OF ALPHA COMPUTED FROM MULTIPLE-POINT VELOCITY MEASUREMENTS TO ALPHA COMPUTED FROM ONE-POINT (0.6*d*) MEASUREMENTS

Again, using only multiple-point velocity measurements made in types A and C cross sections, a highly significant relation, shown in figure 5, was found to exist between the values of alpha computed from multiple-point velocity measurements and those of alpha computed only from point velocities at the $0.6d$ ($\alpha_{0.6d}$). The regression equation is

$$\alpha = 1.43\alpha_{0.6d} - 0.39.$$

The correlation coefficient is 0.975, which is significant at the 1-percent level.

CORRELATION OF ALPHA WITH ROUGHNESS COEFFICIENT

The only channel parameter that correlated significantly with alpha was the roughness coefficient n. This correlation (fig. 6) is based upon 371 discharge measurements made in types A and C cross sections. The correlation coefficient is 0.504, which is significant at the 1-percent level. The regression equation is

$$\alpha = 14.8n + 0.884.$$

This correlation is fairly well defined between the n values of 0.012 ($\alpha = 1.06$) and 0.070 ($\alpha = 1.92$). The scatter of plotted points in figure 6 indicates that factors other than n evidently influence the value of alpha. The combination of factors that results in values greater than 2.00 is not common in problems involving types A and C cross sections; therefore, 2.00 should be considered as the maximum alpha value for these cross sections.

For convenience, equation 4 is expressed in tabular form in table 3.

OTHER CORRELATIONS STUDIED

Correlations of alpha with 18 different parameters and various combinations of parameters were investigated to explain the scatter of points shown in figure 6. The parameters used included hydraulic radius, Froude number, maximum velocity, mean velocity, mean depth, standard deviation of depths, tangent length, channel curvature, stream width, and various combinations of these. None of the correlations with these parameters, either singly or in combination, yield statistically significant results. These correlation studies indicated, however, that the large alpha values were associated with cross

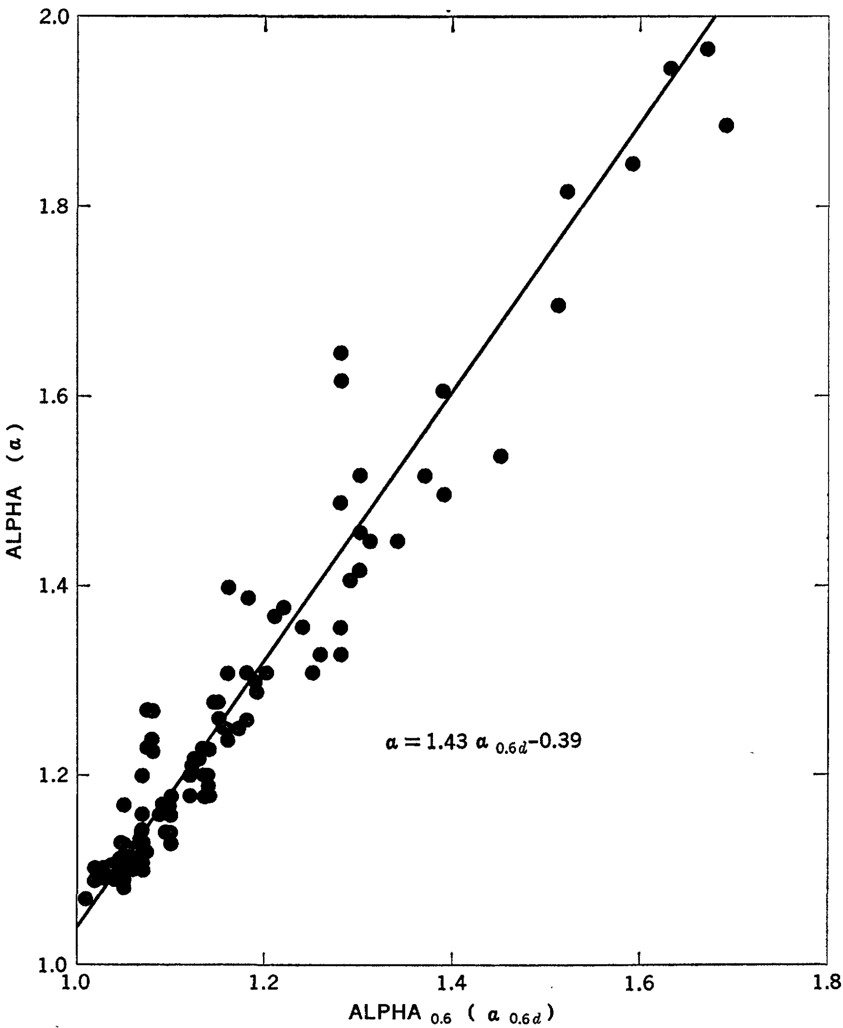


FIGURE 5.—Relation of alpha computed from multiple-point velocity observations (α) to alpha computed from 0.6d velocity observations ($\alpha_{0.6d}$).

sections in which large variations in velocity occurred horizontally across the section—in general, those sections with wide flood plains. Manipulation of equations 2 and 3 will demonstrate that the horizontal distribution of velocity is a dominant factor in the magnitude of alpha. The vertical distribution of velocity is of much less significance. This can also be demonstrated by a comparison of the empirically defined alpha coefficients of this study with the theoretical values which Streeter (1942) derived on the basis of the logarithmic law of velocity distribution in the vertical.

TABLE 3.—*Alpha coefficients, as based on* n *values*

n	Alpha	n	Alpha	n	Alpha
0.012	1.06	0.032	1.36	0.052	1.65
.013	1.08	.033	1.37	.053	1.67
.014	1.09	.034	1.39	.054	1.68
.015	1.11	.035	1.40	.055	1.70
.016	1.12	.036	1.42	.056	1.71
.017	1.14	.037	1.43	.057	1.73
.018	1.15	.038	1.45	.058	1.74
.019	1.17	.039	1.46	.059	1.76
.020	1.18	.040	1.48	.060	1.77
.021	1.19	.041	1.49	.061	1.79
.022	1.21	.042	1.51	.062	1.80
.023	1.22	.043	1.52	.063	1.82
.024	1.24	.044	1.54	.064	1.83
.025	1.25	.045	1.55	.065	1.85
.026	1.27	.046	1.56	.066	1.86
.027	1.28	.047	1.58	.067	1.88
.028	1.30	.048	1.59	.068	1.89
.029	1.31	.049	1.61	.069	1.91
.030	1.33	.050	1.62	.070	1.92
.031	1.34	.051	1.64	.075	2.00

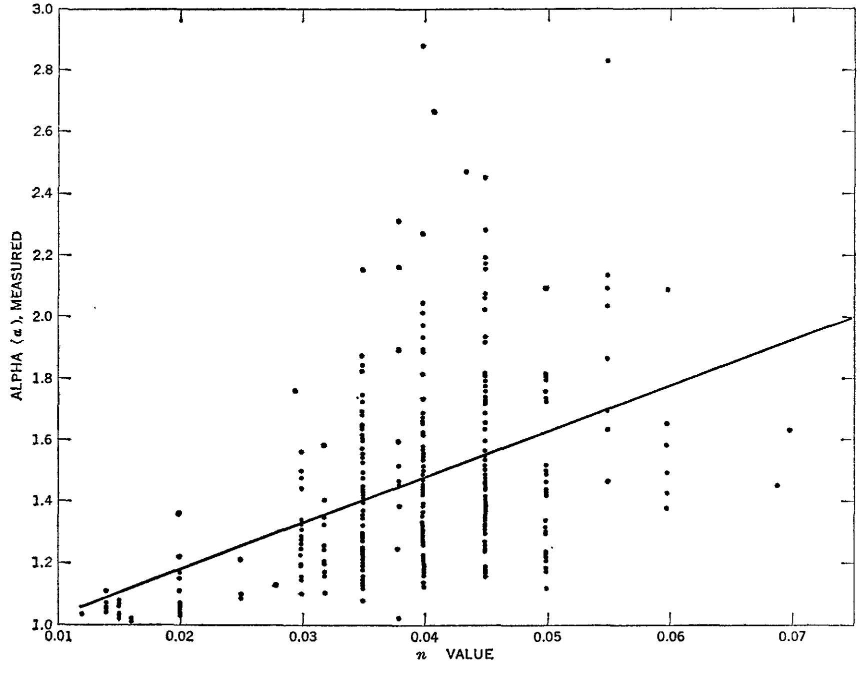


FIGURE 6.—Correlation between alpha and Manning's roughness coefficient (n).

Streeter showed that for wide channels alpha, expressed as a function of Chezy's C, ranges from 1.02 ($C \approx 180$) to 1.12 ($C \approx 65$). A direct comparison between Chezy's C and Manning's n can be made by use of the equation $C=\frac{1.486}{n}R^{1/6}$. For example, if we assume a hydraulic radius of 3.0, then for a C of 180 we can compute $n=0.010$, and for C of 65 we can compute $n=0.027$. For these n values, this report gives alpha values of 1.03 and 1.28, respectively, as compared with Streeter's 1.02 and 1.12. For very smooth channels, variations in velocity, both horizontally and vertically, are small; thus low alpha coefficients result. Where roughness increases and the cross section becomes irregular, large velocity variations occur, particularly in the horizontal direction. The preceding example demonstrated this by the large difference between the theoretical coefficient (1.12), based on variation in the vertical only, and the empirical coefficient (1.28), which reflects both horizontal and vertical variation. Unfortunately, the horizontal velocity variation could not be related to any combination of the parameters measured, and use of equation 4 (see also table 3) is the only means of estimating alpha values for simple geometric channels.

RECOMMENDATIONS FOR DETERMINING ALPHA

TRAPEZOIDAL CHANNELS

Equation 4, $\alpha=14.8\,n+0.884$, is recommended for estimating alpha for unit-shaped trapezoidal channels (types A and C). Its value should be limited to 2.00 despite the fact that greater values will be computed when n exceeds 0.075.

CHANNELS WITH OVERFLOW SECTIONS

For a cross section that carries overflow on either or both banks, the overflow areas are generally treated as separate units or subsections (fig. 3). To obtain the value of alpha for the entire cross section, an individual value of alpha is first determined for each subsection by use of equation 4, and a composite value of alpha for the entire cross section is then computed by the following equation:

$$\alpha=\frac{\alpha_1\frac{K_1^3}{A_1^2}+\alpha_2\frac{K_2^3}{A_2^2}+\ldots\alpha n\frac{K_n^3}{A_n^2}}{\frac{(K_1+K_2+\ldots K_n)^3}{(A_1+A_2+\ldots A_n)^2}}, \tag{5}$$

in which the subscripts refer to individual subsections.

Equation 5 is derived from equation 1 as follows: Let V_1, V_2. . . V_n, α_1, α_2 . . . α_n, and A_1, A_2 . . . A_n be the mean velocities, alpha coefficients, and areas respectively, of the subsections. Let V be the mean velocity and A, the cross-sectional area of the entire section. From the equations $Q=A_1V_1+A_2V_2+A_nV_n$ and $Q=K\sqrt{S}$, the following can be written:

$$V_1=\frac{K_1}{A_1}\sqrt{S},\ V_2=\frac{K_2}{A_2}\sqrt{S},\ \ldots\ V_n=\frac{K_n}{A_n}\sqrt{S},$$

$$Q=AV=V_1A_1+V_2A_2+\ \ldots\ V_nA_n,$$

$$Q=(K_1+K_2+\ \ldots\ K_n)\sqrt{S}=(\Sigma K)\sqrt{S},$$

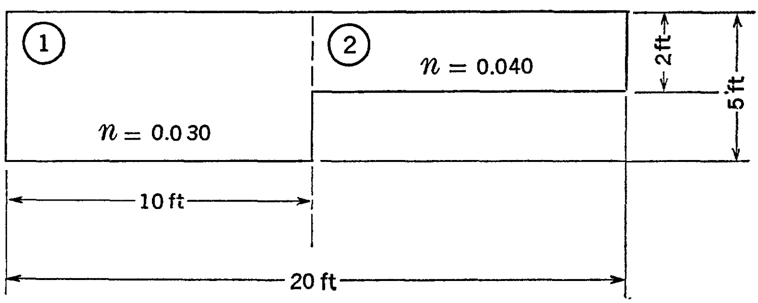
and

$$V=\frac{(\Sigma K)\sqrt{S}}{A}. \tag{6}$$

Equation 5 is obtained by substituting V from equation 6 in equation 1 and simplifying.

The following example illustrates the application of this procedure.

Example: Determining alpha for a subdivided type section.
Given:



Determine alpha:

$A_1=50$ sq ft
$P_1=18$ ft
$R_1=2.78$ ft
$R_1^{\frac{2}{3}}=1.98$
$K_1=\frac{1.486(50)1.98}{0.030}=4,904$
$A=70$ sq ft
$\frac{K_1^3}{A_1^2}=47.2\times10^6$
$A_2=20$ sq ft
$P_2=12$ ft
$R_2=1.67$ ft
$R_2^{\frac{2}{3}}=1.41$
$K_2=\frac{1.486(20)1.41}{0.040}=1,048$
$\Sigma K=4904+1048=5952$
$\frac{K_2^3}{A_2^2}=2.88\times10^6$
$\frac{(\Sigma K)^3}{A^2}=\frac{5,952^3}{70^2}=43.0\times10^6$

From table 3: alpha for $n=0.030$ is 5.33, and
alpha for $n=0.040$ is 1.48; accordingly,

$$\alpha=\frac{\alpha_1\frac{K_1^3}{A_1^2}+\alpha_2\frac{K_2^3}{A_2^2}}{\frac{(\Sigma K)^3}{A^2}}=\frac{1.33(47.2)+1.48(2.88)}{43.0}=1.56.$$

Because the manner in which a cross section is subdivided has a pronounced effect upon the magnitude of alpha, use of a consistent method in subdividing the cross section in a slope-area reach is desirable. Thus, if one cross section of the reach is subdivided, the next cross section should be subdivided in the same manner. Computation procedures used for evaluating alpha in complex cross sections are, at best, only approximations, and errors introduced by the subdivision process will be minimized if all cross sections in a slope-area reach are subdivided in the same way.

COMPARISON WITH PRESENT METHOD OF COMPUTATION

The need for a method of estimating alpha for use in indirect determinations of discharge has long been recognized by the Geological Survey. At present, only limited data summarizing alpha coefficients applicable to open channels are to be found in the literature. The most readily available published data are those of King (1954), Kolupaila (1956, 1961), and O'Brien and Hickox (1937). The published figures, however, are too generalized to be of much assistance in making a reliable estimate of alpha. Lacking more suitable information, hydrologists, including those of the Geological Survey, have usually used an alpha value of 1.00 for unit-shaped trapezoidal sections and for each subsection of complex channels where equation 5 has been applied. For most slope-area determinations this assumption has little effect on the computed discharge because the channel reaches selected for study are generally fairly uniform in cross-sectional area, and velocity head is therefore a minor factor. In steep channels that are contracting in area, however, the use of the alpha value of 1.00 can lead to an appreciable error in the computed discharge.

Figure 7 shows alpha values (α_k) for 41 complex sections (type D sections) computed from equation 5 by the conventional method, where the α for each subsection is assumed equal to 1.00, compared with values of alpha derived from multiple-point velocity measurements. Figure 8 shows alpha values (α_n) for the same group of sections computed from equation 5 by the method recommended in this study, where α for each subsection is computed from table 3, compared with the alpha values derived from the multiple-point velocity measurements. The improved accuracy resulting from the procedure recommended in this report is quite apparent.

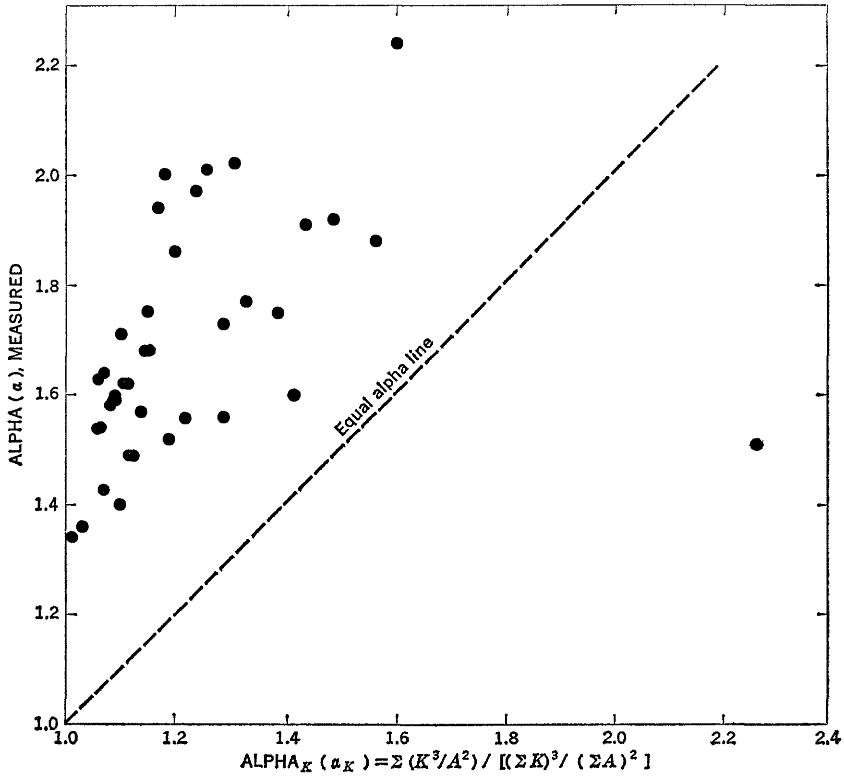


FIGURE 7.—Alpha computed from multiple-point velocity discharge measurements in complex cross sections compared with alpha computed from equation 5, assuming the alpha value to be 1.00 in each subsection (α_K).

SUMMARY AND CONCLUSIONS

This study demonstrates a reliable method of computing the energy-head coefficient, alpha, from conventional current-meter measurements of discharge, in which velocities are observed at 0.2 and 0.8 depths in each subsection. It also demonstrates that reasonable estimates of alpha for channels having no overflow can be made solely on the basis of the Manning roughness coefficient, n. This determination is important because the usually made assumption that the alpha value equals 1.00 in a channel with no overflow is greatly in error, particularly in the rougher channels. A rational method of estimating alpha for channels with overflow sections, based on Manning's n and on channel conveyance, K, is also presented in this report.

A major conclusion, illustrated by the study of factors influencing the magnitude of alpha, is that variation in the horizontal distribution of velocities is of even greater significance than variation in the vertical. Accordingly, these authors believe that a more intensive investigation

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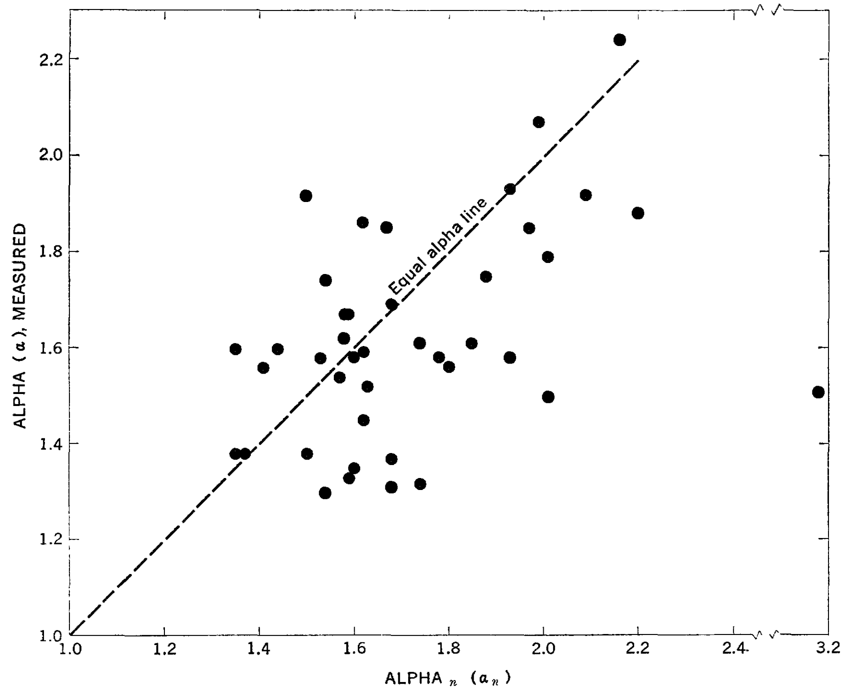

FIGURE 8.—Alpha computed from multiple-point velocity discharge measurements in complex cross sections compared with alpha computed from equation 5, in which alpha in each subsection has been computed from table 3 (α_n).

of factors influencing the horizontal distribution of velocity should be included in future studies. Data for this study were obtained from standard current-meter measurements, which were usually made at sites where roughness was low or in channels that were fairly straight. Data did not include information as to the amount of contraction in the reach or the significance of obstructions in the reach upstream from the point of measurement.

If further study is to be made, the authors suggest that it be done under more carefully selected conditions, where various parameters can be isolated and studied in detail. Methods should be devised to measure the expansion or contraction of the channel, the profile of the streambed and the water surface, the slope, and other physical characteristics, such as distance upstream to riffles, bends, or other obstructions that might affect the velocity distribution in the channel. The study of channels that have high roughness coefficients (n values of 0.070 or greater) would also be of value.

Routine discharge measurements do not provide enough specialized information, and more detailed field surveys will be required to refine results beyond that of this report.

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BASIC DATA

TABLE 4.—*Multiple-point velocity discharge-measurement data*

Index No.	Station and location	Type of cross section [1]	Width (ft)	Area (sq ft)	Mean velocity (fps)	Discharge (cfs)	Hydraulic radius (ft)	Maximum depth (ft)	Maximum point velocity (fps)	Roughness coefficient (n)	Alpha coefficient (α)
1	Caney Fork near Rock Island, Tenn	A	127	1,565	2.11	3,300	10.7	21.1	3.55	0.060	1.382
2	Big River at Byrnesville, Mo	A	129	1,080	1.18	1,270	8.2	12.5	2.69	.035	1.545
3	Pee Dee River at Pee Dee, S.C	B	381	5,810	1.88	10,900	14.9	21.2	3.67	.036	1.484
4	Snake Creek at S-29, North Miami Beach, Fla	B	111	1,192	.40	482	6.2	15.5	.73	----	1.443
5	Shiawassee River near Fergus, Mich	B	165	1,212	1.20	1,450	7.2	11.1	2.60	.035	1.673
6	Peace River at Arcadia, Fla	B	170	1,140	.83	950	6.6	11.7	2.28	----	2.707
7	Saco River at Cornish, Maine	A	250	3,190	3.48	11,100	12.4	17.0	5.42	.038	1.256
8	Rio Grande below Elephant Butte Dam, N. Mex	A	102	638	2.34	1,500	3.0	9.2	3.75	.036	1.464
9	Clark Fork near Plains, Mont	A	500	6,596	2.74	18,100	13.1	19.2	4.21	.030	1.265
10	Ochlockonee River near Havana, Fla	B	320	2,173	1.55	3,370	6.7	14.7	3.29	----	2.065
11	Conetoe Creek near Bethel, N.C	B	45	369	1.75	646	6.8	10.5	3.32	.025	1.776
12	Pearl River at Jackson, Miss	D	362	3,418	2.08	7,110	9.3	18.7	3.50	(2)	1.507
13	Pearl River at Edinburg, Miss	A	118	1,677	1.03	1,850	14.2	19.5	2.26	.035	1.850
14	Sangamon River at Monticello, Ill	B	127	873	.66	576	6.6	10.3	1.12	.035	1.677
15	Pearl River at Monticello, Miss	B	296	3,747	2.25	8,430	10.4	20.0	3.31	.030	1.255
16	Genesee River at Avon, N.Y	A	188	2,704	2.28	6,180	13.2	17.1	3.39	.035	1.288
17	Wabash River at Vincennes, Ind	B	572	6,125	2.69	16,500	10.0	13.8	3.85	(2)	1.222
18	Sugar Creek at Milford, Ill	B	168	1,381	.87	1,200	7.9	12.6	2.27	.035	2.205
19	Vermilion River below Lake Vermilion near Tower, Minn	A	50	346	.53	183	5.6	10.1	.92	.045	1.493
20	Missouri River at Boonville, Mo	B	1,322	14,500	3.55	51,500	10.5	23.5	5.82	.030	1.246
21	Savannah River near Clyo, Ga	A	360	3,481	2.08	7,230	9.5	13.2	2.94	.035	1.162
22	Kanawha River at Charleston, W. Va	B	918	10,860	2.54	27,600	11.3	16.5	3.76	.030	1.276
23	Missouri River at Toston, Mont	A	365	1,422	2.67	3,800	3.9	6.0	4.46	.035	1.421
24	Boise River (below Lucky Peak Dam) near Boise, Idaho	D	261	1,945	1.78	3,470	7.3	13.0	3.19	.030	1.518
25	Susquehanna River at Danville, Pa	B	1,305	7,998	4.34	34,700	6.3	11.6	6.35	(2)	1.192
26	White River at DeValls Bluff, Ark	B	592	17,570	1.34	23,600	22.8	45.9	2.05	.032	1.301
27	Trinity River at Romayor, Tex	B	195	3,170	.69	2,190	14.8	31.0	1.04	.030	1.292
28	Petit Jean Creek at Danville, Ark	B	138	1,128	1.88	2,120	7.2	14.2	3.42	----	1.495
29	Connecticut River at Montague City, Mass	A	460	5,383	2.79	15,000	11.6	17.6	4.73	.030	1.503
30	Merrimack River at Franklin Junction, N.H	A	266	3,565	3.06	10,900	13.2	20.7	5.97	.032	1.588
31	Angelina River at Horger, Tex	B	227	4,466	2.08	9,300	18.3	27.0	3.32	.035	1.334
32	Ohoopee River near Reidsville, Ga	B	138	1,332	1.62	2,160	9.2	13.0	2.44	(2)	1.368
33	Nahunta Swamp near Shine, N.C	B	57	339	2.63	892	4.8	8.7	4.18	(2)	1.366
34	Saluda River near Greenville, S.C	B	127	410	2.68	1,100	3.1	5.0	5.50	.040	1.923
35	Farmington River at Rainbow, Conn	A	90	649	3.93	2,550	6.9	10.8	5.38	----	1.232
36	Red River at Grand Forks, N. Dak	A	188	1,247	.99	1,230	6.5	8.7	1.59	.030	1.448

37	Oostanaula River at Resaca, Ga	A	132	1,261	1.55	1,950	9.2	15.0	2.54		1.406
38	Marias River near Shelby, Mont	B	142	752	3.54	2,660	5.1	9.9	4.80	.035	1.203
39	Loggy Bayou near Ninock, La	B	142	1,053	1.74	1,830	7.0	10.8	2.70	.025	1.504
40	Housatonic River at Stevenson, Conn	A	266	2,271	4.71	10,700	8.4	12.2	6.58		1.239
41	Big Blue River at Barneston, Nebr	A	111	323	1.74	561	2.9	3.5	2.66		1.309
42	Big Blue River near Crete, Nebr	B	107	529	1.38	728	4.2	9.6	2.62		1.693
43	West Side Canal near Collinston, Utah	C	18.1	107	6.00	643	3.6	5.9	7.03	.010	1.074
44	Iowa River at Iowa City, Iowa	B	308	3,501	2.60	9,110	11.2	14.9	4.01	(2)	1.241
45	All-American Canal (Station 60) near Imperial Dam, Ariz.-Calif.	C	213	2,967	2.57	7,620	13.4	17.2	3.31	(2)	1.137
46	Wolf River, above West Branch Wolf River, near Keshina, Wis	A	59	155	1.88	292	2.5	5.6	2.65	(2)	1.243
47	Holston River near Jefferson City, Tenn	A	357	3,734	2.92	10,900	10.3	14.1	4.19	.030	1.283
48	Farmington River above Collinsville, Conn	B	153	636	.58	371	4.1	7.2	1.19		2.152
49	Sabine River near Bon Wier, Tex	B	467	6,490	2.46	16,000	13.4	22.5	3.93	.030	1.265
50	Broad River near Bell, Ga	B	200	454	1.56	707	2.3	3.3	2.32	.038	1.210
51	Coal River at Ashford, W. Va	A	130	622	2.25	1,400	4.7	6.4	3.44	.035	1.452
52	Spokane River at Spokane, Wash	A	272	2,928	7.00	20,500	10.6	17.4	10.07		1.248
53	Little Androscoggin River near South Paris, Maine	A	100	459	1.83	841	4.4	6.4	2.78	.040	1.358
54	Bayou Cocodrie near Clearwater, La	B	179	1,227	.52	645	6.8	11.1	1.23	(2)	1.895
55	Mississippi River at Aitkin, Minn	B	170	1,320	.76	997	7.6	12.1	1.14	.035	1.256
56	Elkhorn River at Waterloo, Nebr	A	196	472	2.06	975	2.4	3.0	3.07		1.179
57	New River at Hinton, W. Va	D	694	4,739	2.26	10,700	6.8	10.8	4.94	.030	1.562
58	Colorado River near Cisco, Utah	A	447	3,076	4.16	12,800	6.8	8.5	5.52	.028	1.130
59	Lehigh River at Bethlehem, Pa	B	320	1,013	2.92	2,960	3.8	5.5	4.38	.035	1.241
60	Pilot Knob powerhouse near Pilot Knob, Calif	C	112	1,615	.79	1,280	13.1	19.8	1.63	(2)	1.761
61	Juniata River at Newport, Pa	B	560	2,246	1.65	3,710	3.9	6.9	3.07	(2)	1.401
62	Nezinscot River at Turner Center, Maine	A	95	408	4.58	1,870	4.2	7.0	6.80	.045	1.306
63	Klamath River near Klamath, Calif	A	264	5,997	4.68	28,100	21.4	34.9	8.28	.035	1.576
64	Colorado River near Lees Ferry, Ariz	D	342	1,980	2.70	5,350	5.7	9.2	3.94	.025	1.201
65	Souvis River near Foxholm, N. Dak	B	93	441	.71	313	4.7	6.2	1.08	.035	1.273
66	Connecticut River at White River Junction, Vt	D	512	4,318	4.47	19,300	8.4	12.6	6.33	.030	1.208
67	Green River near Ouray, Utah	A	440	3,229	2.97	9,600	7.3	10.5	4.36	.025	1.214
68	Similkameen River near Nighthawk, Wash	A	242	1,457	4.06	5,920	6.0	8.7	5.96		1.267
69	John Day River at Service Creek, Oreg	A	135	1,069	3.31	3,540	7.6		5.57	(2)	1.550
70	Duck River above Hurricane Mills, Tenn	A	236	1,444	2.60	3,760	6.0	8.7	3.56	.032	1.164
71	Missouri River at Kansas City, Mo	B	1,154	15,170	4.38	66,400	12.5	27.2	8.35	.030	1.136
72	Green River near Jensen, Utah	A	368	2,436	5.54	13,500	6.6	9.0	9.57	.030	1.312
73	Delaware River at Riegelsville, N.J	B	520	3,145	1.19	3,740	7.0	13.9	1.86	(2)	1.369
74	Hammond East Side Canal near Collinston, Utah	C	26	81.1	2.08	169	2.8	4.3	3.06	.020	1.361
75	Delaware River at Port Jervis, N.Y	B	606	1,767	1.37	2,420	3.1	4.6	2.59	.035	1.547
76	Arkansas River below John Martin Reservoir, Caddoe, Colo.	D	194	435	2.39	1,040	2.2	3.4	3.71	(2)	1.250
77	Cowlitz River near Kosmos, Wash	A	168	1,422	4.14	5,880	8.3	11.6	6.84		1.516

See footnotes at end of table.

TABLE 4.—*Multiple-point velocity discharge-measurement data*—Continued

Index No.	Station and location	Type of cross section [1]	Width (ft)	Area (sq ft)	Mean velocity (fps)	Discharge (cfs)	Hydraulic radius (ft)	Maximum depth (ft)	Maximum point velocity (fps)	Roughness coefficient (n)	Alpha coefficient (α)
78	Yodkin River at Wilkesboro, N.C.	A	115	740	3.69	2,730	6.2	8.3	4.84	0.032	1.176
79	Sacramento River near Red Bluff, Calif.	D	512	2,737	2.36	6,460	5.3	9.3	3.74	.030	1.333
80	Snake River near Irwin, Idaho	A	34.1	1,942	6.40	12,500	5.7	6.8	9.20	.030	1.231
81	Schroon River at Riverbank, N.Y.	A	82	624	6.25	3,900	7.0	11.2	7.58	.035	1.086
82	Wabash River at Delphi, Ind.	B	350	1,579	2.00	3,160	4.5	6.1	3.59	(2)	1.308
83	Kootenai River near Bonners Ferry, Idaho	A	615	8,250	1.93	15,900	13.3	17.0	2.86	.030	1.199
84	Broad River near Bell, Ga.	B	201	1,836	3.39	6,230	7.9	12.1	5.22	(2)	1.257
85	Calcasieu River near Oberlin, La.	B	212	1,548	1.74	2,690	6.7	9.8	3.04	.035	1.574
86	St. Croix River near Rush City, Minn.	A	490	3,696	2.87	10,600	7.5	10.4	4.55	(2)	1.276
87	Pecos River at damsite 3, near Carlsbad, N. Mex.	A	124	233	1.96	458	15.6	2.8	3.05	.040	1.271
88	North Platte River near Goose Egg, Wyo.	D	108	447	3.18	1,420	4.0	8.2	5.24	.040	1.398
89	Mississippi River at Chester, Ill.	B	1,769	47,040	4.40	207,000	24.6	37.2	6.11	.027	1.172
90	Missouri River at Pierre, S. Dak.	A	315	6,492	5.67	36,800	19.5	32.5	8.24	.030	1.193
91	Pudding River at Aurora, Oregon	A	74	360	1.62	582	4.7	7.5	2.05	.030	1.103
92	Colorado River along Colorado-Utah State Line	A	321	2,360	3.86	9,110	7.3	13.0	5.58	.035	1.218
93	Grond River at Ionia, Mich.	B	369	3,705	2.78	10,300	9.9	18.8	4.83	.040	1.736
94	Wabash River near New Corydon, Ind.	A	76	448	1.13	508	5.6	7.5	1.77	.030	1.329
95	Crooked River near Culver, Oreg.	A	108	950	2.59	2,460	7.9	14.6	4.42	(2)	1.517
96	Mississippi River at Thebes, Ill.	B	2,319	49,270	4.36	215,000	20.5	35.7	6.48	.026	1.136
97	Mississippi River at Alton, Ill.	B	1,824	46,870	4.08	191,000	23.3	57.1	7.52	.028	1.272
98	Sangamon River at Mahoment, Ill.	B	71	270	1.53	414	3.7	4.7	2.32	.035	1.258
99	Grand River at Lansing, Mich.	B	205	1,140	2.57	2,930	5.5	7.6	4.34	.045	1.555
100	Eel River at Scotia, Calif.	B	441	2,056	3.18	6,530	4.6	9.0	4.93	.035	1.292
101	Atwater Canal, near Atwater, Calif., site 1	C	17.2	46.0	2.56	118	2.3	4.3	3.28		1.121
102	do site 1	C	17.3	46.3	2.59	120	2.3	4.2	3.27		1.162
103	do site 2	C	16.9	43.2	5.92	256	2.5	4.0	3.20		1.104
104	do site 2	C	17.3	46.2	2.42	112	2.3	4.1	2.98		1.103
105	do site 3	C	15.6	36.2	3.04	110	2.1	3.6	3.79		1.102
106	do site 3	C	16.1	37.3	3.08	115	2.1	3.6	3.87		1.111
107	do site 4	C	15.9	37.0	3.05	113	2.1	3.6	3.79		1.143
108	do site 4	C	15.7	36.9	3.04	112	2.1	3.6	3.88		1.111
109	Arena Canal near Livingston, Calif., site 1	C	17.5	47.0	2.57	121	2.4	4.0	3.08		1.093
110	do site 1	C	18.0	47.3	2.47	117	2.3	4.0	3.13		1.132
111	do site 2	C	17.8	46.4	2.59	120	2.3	3.8	3.06		1.096
112	do site 2	C	17.7	46.1	2.58	119	2.3	3.9	3.19		1.118
113	do site 3	C	17.8	47.5	2.63	125	2.4	4.0	3.13		1.109

114	----do----site 3	C	17.7	47.6	2.52	120	2.4	4.0	3.19	----------	1.110
115	Sepulga River near McKenzie, Ala	B	101	847	4.05	3,430	8.0	12.1	8.39	.035	2.095
116	Bear Creek at Bishop, Ala	A	125	1,869	.60	1,120	13.7	19.6	1.25	.035	1.654
117	Cahaba River at Centerville, Ala	B	185	1,133	1.58	1,790	6.0	8.0	2.40	.035	1.428
126	Turlock Canal near La Grange, Calif	C	31.4	106	4.51	4,780	3.4	4.0	5.41	.015	1.062
127	Tuolumme River at Early Intake, Calif	A	108	634	1.17	744	5.5	9.4	2.69	----------	1.970
129	----do	A	96	616	1.19	733	5.9	10.4	2.73	----------	1.909
131	North Yuba River below Bullards Bar, Calif	A	132	2,279	3.07	7,000	14.6	22.0	4.99	----------	1.377
132	Sacramento River at Keswick, Calif	A	208	4,012	2.67	10,700	17.7	30.5	5.10	.040	1.892
133	Borel Canal at Isabella Dam, Calif	C	140	68.1	1.58	108	2.9	4.9	1.81	.012	1.033
134	Columbia River at the Dalles, Oreg	B	4,030	133,800	1.40	187,000	25.6	52.0	2.01	.030	1.173
135	----do	B	4,090	191,400	3.32	636,000	33.2	65.7	4.84	----------	1.280
136	Columbia River at Paterson Ferry, Oreg	A	2,492	86,270	6.93	598,000	34.6	46.5	10.66	.032	1.331
137	----do	A	2,206	43,980	1.87	82,300	19.9	27.0	2.69	----------	1.249
138	Columbia River at Bridgeport, Wash	A	890	19,050	5.72	109,000	21.3	28.9	7.87	----------	1.202
139	----do	A	1,060	40,540	10.43	423,000	37.8	49.2	15.77	----------	1.279
140	Columbia River at Grand Coulee Dam, Wash	A	570	24,070	4.74	114,000	40.3	57.9	7.51	----------	1.368
141	----do	A	765	41,820	10.31	431,000	52.2	88.3	15.73	----------	1.228
142	Columbia River at Priest Rapids, Wash	A	1,150	27,730	3.71	103,000	24.0	31.9	5.64	----------	1.234
143	----do	A	1,300	53,180	9.12	485,000	40.6	52.5	12.81	----------	1.173
144	Columbia River at Rocky Reach, Wash	A	930	28,380	4.02	114,000	30.2	56.3	5.91	----------	1.250
145	----do	A	1,240	50,160	8.81	442,000	40.1	59.3	12.95	----------	1.222
146	Columbia River at Trinidad, Wash	A	1,350	44,910	10.42	468,000	33.0	58.0	14.84	----------	1.299
164	San Joaquin River at Kerkhoff powerhouse, Calif	A	62	524	2.00	1,050	7.0	11.6	3.70	----------	1.824
181	Mozelle Experimental Canals at Metz, France	E	----------	----------	----------	16.2	----------	----------	----------	----------	1.100
182	----do	E	----------	----------	----------	38.8	----------	----------	----------	----------	1,320
183	----do	E	----------	----------	----------	1.2	----------	----------	----------	----------	1,130
184	----do	E	----------	----------	----------	2.1	----------	----------	----------	----------	1.140
185	----do	E	----------	----------	----------	2.8	----------	----------	----------	----------	1.140
186	----do	E	----------	----------	----------	2.6	----------	----------	----------	----------	1.220
187	----do	E	----------	----------	----------	2.7	----------	----------	----------	----------	1.140
188	----do	E	----------	----------	----------	2.7	----------	----------	----------	----------	1.170
189	Blue River above Green Mountain Reservoir, Colo	A	103	161	.78	126	1.5	2.3	1.26	----------	1.390
190	North Platte River above Seminoe Reservoir, Wyo	A	236	768	4.30	3,300	3.2	6.0	5.76	----------	1.168
191	----do	A	110	91.7	1.53	140	.8	1.4	2.24	----------	1.309
193	Coachella Canal, Calif	C	80	411	2.18	898	4.9	5.8	2.75	----------	1.095
194	----do	C	78	407	2.19	893	4.9	6.1	2.75	----------	1.104
195	----do	C	80	379	2.33	883	4.5	5.5	2.95	----------	1.104
196	----do	C	82	415	2.15	894	4.9	5.7	2.77	----------	1.129
197	----do	C	89	450	1.97	888	4.8	5.8	2.63	----------	1.172
198	----do	C	96.4	390	2.27	884	6.0	----------	----------	----------	1.080

See footnotes at end of table.

TABLE 4.—*Multiple-point velocity discharge-measurement data*—Continued

Index No.	Station and location	Type of cross section [1]	Width (ft)	Area (sq ft)	Mean velocity (fps)	Discharge (cfs)	Hydraulic radius (ft)	Maximum depth (ft)	Maximum point velocity (fps)	Roughness coefficient (n)	Alpha coefficient (α)
199	Georgia Institute of Technology flume, Georgia	----------	3.5	.6	8.35	5.0	----------	.19	8.89	----------	1.066
202	do	----------	3.5	1.3	2.25	3.0	----------	.56	2.90	----------	1.140
203	do	----------	3.5	1.0	1.71	1.7	----------	.46	2.18	----------	1.140
204	do	----------	3.5	1.2	2.17	2.6	----------	.51	2.85	----------	1.200
205	do	----------	3.5	1.0	2.20	2.2	----------	.39	2.64	----------	1.120
206	do	----------	3.5	1.1	3.91	4.3	----------	.40	4.94	----------	1.090
207	do	----------	3.5	1.1	5.73	6.3	----------	.40	7.24	----------	1.000
208	do	----------	3.5	1.5	1.53	2.3	----------	.53	1.88	----------	1.080
209	do	----------	3.5	.9	3.67	3.3	----------	.35	4.77	----------	1.130
211	do	----------	3.5	.7	5.28	3.7	----------	.29	6.96	----------	1.180
212	do	----------	3.5	.7	1.57	1.1	----------	.29	2.02	----------	1.196
213	do	----------	3.5	.7	3.00	2.1	----------	.30	3.92	----------	1.180
1155	Republican River, Section K, near Franklin, Nebr	D	353	880	2.08	1,830	2.5	5.6	3.51	----------	1.600
1158	do	D	352	910	2.24	2,040	1.3	5.6	4.08	----------	1.750
1159	Republican River, Section L, near Franklin, Nebr	D	410	1,110	2.99	3,310	2.9	7.7	5.66	----------	1.880
1160	Republican River, Section K, near Franklin, Nebr	D	354	1,530	2.25	3,450	4.3	7.4	4.28	----------	1.920
1169	Republican River, Section L, near Franklin, Nebr	D	206	854	3.57	2,960	4.1	7.7	5.66	----------	1.560
1179	do	D	176	254	1.39	354	1.4	4.7	2.70	----------	1.510

[1] Definitions of cross-section types is given on p. C8.

[2] Subdivided section, no composite n value available.

TABLE 5.—*Two-point (0.2d/0.8d) velocity discharge-measurement data*

Index No.	Station and location	District No.	Type of cross section	Width (ft)	Area (sq ft)	Mean velocity (fps)	Discharge (cfs)	Hydraulic radius (ft)	Maximum depth (ft)	Maximum point velocity (fps)	Roughness coefficient (n)	Alpha coefficient (α)
165	Columbia River at Bridgeport, Wash.		A	1,100	43,000	11.37	489,000	38.7	49.7	15.73		1.23
166	do		A	1,100	42,700	11.15	476,000	38.4	51.5	15.36		1.24
167	Columbia River at Grand Coulee Dam, Wash.		B	754	38,100	9.82	374,000	48.5	81.1	13.72		1.14
168	do		B	785	44,600	11.32	505,000	54.3	91.7	15.01		1.16
169	Columbia River below Priest Rapids Dam, Wash.		B	1,230	39,600	6.24	247,000	32.0	41.9	8.72		1.16
170	Columbia River at Priest Rapids, Wash.		A	1,245	42,000	6.83	287,000	33.6	43.8	9.58		1.14
171	do		A	1,300	53,700	9.20	494,000	41.0	53.0	11.97		1.12
172	do		A	1,305	54,200	9.32	505,000	41.2	53.5	12.66		1.14
173	do		A	1,205	35,900	5.40	194,000	29.6	38.7	7.78		
174	Columbia River below Rocky Reach Dam, Wash.		A	1,005	35,200	6.48	228,000	34.7	46.4	8.56		1.17
175	Columbia River at Rocky Reach, Wash.		A	1,070	40,000	7.70	312,000	37.5	51.1	10.75		1.17
176	do		A	1,310	53,900	9.48	511,000	40.8				1.20
177	do		A	1,260	51,000	9.29	474,000	40.1	60.0	12.81		1.17
178	Columbia River at Trinidad, Wash.		D	1,470	48,400	10.95	530,000	32.7	60.1	14.84		1.25
179	do		D	1,440	47,600	10.61	505,000	32.8	59.6	14.52		1.27
180	Columbia River at Bridgeport, Wash.		A	1,026	38,100	10.26	391,000	36.7	50.6	14.32		1.18
500	Sowinlovey Creek at Mississippi 504 near Rosehill, Miss.		B	376	3,420	2.08	7,110	8.8				2.05
503	Leaf River at Interstate Highway near Moselle, Miss.		B	643	11,800	2.95	34,800	18.0				1.87
505	Tallahala Creek at Interstate Highway 59 at Laurel, Miss.		B	595	6,190	2.91	18,000	10.3				1.56
506	Leaf River at McLain, Miss.		B	2,158	35,100	3.48	122,000	15.2				3.52
507	Tallahoma Creek at Mississippi 15 near Laurel, Miss.		B	258	1,880	3.13	5,880	7.0				1.45
509	Buccatunia Creek at Mississippi 18 near Quitman, Miss.		B	489	1,850	2.40	4,340	3.8				1.51
510	Pascagoula River at Merrill, Miss.		B	5,530	79,100	1.99	158,000	14.0				4.71
512	Long Creek at Mississippi 18 near Quitman, Miss.		B	344	1,080	2.43	2,620	3.1				1.47
513	Tallahala Creek at Mississippi 42 near Runnelstown, Miss.		B	1,221	14,000	2.21	31,000	11.5				2.60
514	Wolf River at Mississippi 26 near Poplarville, Miss.		B	252	2,540	3.36	8,540	9.8				1.34
518	Big Rock River at Vaiden, Miss.		B	1,030	8,800	2.56	22,500	8.7				1.98

TABLE 5.—*Two-point (0.2d/0.8d) velocity discharge-measurement data*—Continued

Index No.	Station and location	District No.	Type of cross section	Width (ft)	Area (sq ft)	Mean velocity (fps)	Discharge (cfs)	Hydraulic radius (ft)	Maximum depth (ft)	Maximum point velocity (fps)	Roughness coefficient (n)	Alpha coefficient (α)
519	Big Black River at Pickens, Miss		B	1,360	9,360	2.01	18,800	6.8				2.91
524	Big Black River at State Highway 16 near Canton, Miss		B	674	6,990	2.99	20,900	10.4				1.42
534	Big Black River at Bentonia, Miss		B	530	4,880	.87	4,260	9.1				2.06
535	Big Black River at Bentonia, Miss		B	383	7,690	3.88	29,800	19.4				1.54
539	Big Black River near Bovina, Miss		B	626	13,000	2.50	32,500	20.2				2.03
542	Pearl River near Burnside, Miss		B	358	3,490	1.62	5,660	9.5				2.04
544	do		B	405	2,860	2.27	6,490	6.9				1.86
545	Pearl River at Meek's Bridge, near Canton, Miss		B	570	12,300	2.79	34,300	16.5				2.27
554	Yockanookany River near Ofahoma, Miss		B	640	5,750	1.64	9,410	8.8				1.93
556	West Fork Tombigbee River at Nettleton, Miss		B	1,240	8,600	3.30	28,400	6.9				2.62
557	Little Wabash River at Louisville, Ill		B	553	6,100	2.77	16,900	10.5				1.71
559	Mississippi River at St. Louis, Mo		B	2,000	59,300	4.03	239,000	27.8				1.20
560	South Fork American River near Kyburz, Calif	339	D	89	349	1.12	390	3.8	6.9	1.71		1.30
562	do	327	A	110	477	2.77	1,320	4.3	8.4	4.98		1.40
563	West Fork Tombigbee River near Nettleton, Miss.	331	B	1,255	12,600	4.96	62,500	9.9	31.3	9.94		1.61
564	Yockanookany River at Kosciusko, Miss	289	B	545	2,780	2.33	6,490	5.0	11.7	4.98		1.46
565	Eel River at Alderpoint, Calif	35	D	314	1,760	2.74	10,100	5.6	9.0	9.76	0.040	1.40
566	do	56	A	328	2,770	5.99	16,600	8.3	11.2	9.33	.038	1.39
567	do	31	A	345	3,430	5.95	20,400	9.8	12.5	10.56	.038	1.60
568	do	43	A	330	4,830	6.60	31,900	14.1	18.0	10.06	.035	1.48
569	do	32	A	367	6,540	7.16	46,800	17.3	25.0	12.47	.035	1.73
570	South Fork American River near Camino, Calif	305	D	113	536	2.29	1,230	4.5	10.2	3.91	.045	1.64
571	do	315	D	129	826	3.17	2,620	6.1	12.7	5.22	.042	1.58
572	Klamath River at Somesbar, Calif	243	A	160	877	1.10	965	5.4	7.9	2.26	.045	1.82
573	do	286	A	170	1,090	1.75	1,910	6.3	9.6	3.56	.040	1.68
574	do	218	A	201	2,420	4.00	9,680	12.1	16.8	9.08	.038	2.32
575	do	279	A	220	3,550	7.28	25,900	15.2	15.0	13.20	.038	1.90
576	do	270	A	246	5,560	7.84	43,600	21.4	33.6	15.03	.038	2.17
577	Klamath River near Klamath, Calif	20	A	690	15,100	8.68	131,000	21.5	31.5	12.10	.035	1.20
578	do	31	A	660	9,180	5.76	52,900	13.8	21.5	8.24	.035	1.25
579	do	27	D	610	4,100	3.66	15,000	6.7	12.7	4.69	.038	1.14
580	do	46	D	454	1,660	1.93	3,210	3.6	7.7	2.51	.042	1.19

581	New River at Denny, Calif.	9	D	82	391	5.47	2,140	4.5	6.7	7.62	.035	1.24
582	do	10	D	72	250	2.84	711	3.2	5.3	4.16	.040	1.26
583	do	8	D	68	182	1.63	297	2.5	4.1	2.20	.040	.122
584	do	19	D	80	302	4.04	1,220	3.5	6.0	5.55	.035	1.28
585	do	17	D	95	439	6.04	2,650	4.2	7.9	8.54	.035	1.43
588	Salmon River at Somesbar, Calif.	280	A	206	809	5.78	4,680	3.9	4.7	8.55	.035	1.29
589	do	224	A	188	462	2.40	1,110	2.4	3.0	3.59	.035	1.30
590	Van Duzen River near Bridgeville, Calif.	110	A	191	1,400	8.36	11,700	7.2	11.4	13.71	.040	1.40
591	do	109	D	165	916	5.90	5,400	5.4	8.9	9.20	.040	1.40
592	do	70	D	137	558	3.48	1,940	4.0	7.1	5.37	.040	1.45
593	do	63	D	118	552	1.56	812	4.3	7.5	2.58	.043	1.62
594	do	69	D	112	315	.88	276	2.8	4.9	1.46	.045	1.54
595	Pit River at Big Bend, Calif.	219	D	129	416	.65	270	3.2	5.7	1.27	.055	1.88
596	do	205	A	145	732	2.06	1,510	5.0	7.4	3.52	.050	1.47
598	South Fork Salmon River near Forks of Salmon Calif.	6	B	86	413	5.50	2,270	4.6	8.3	9.55	.040	1.63
599	do	10	B	82	355	3.86	1,370	4.2	8.1	9.07	.040	2.30
600	North Fork Salmon River near Forks of Salmon, Calif.	17	A	50	369	3.79	1,400	6.1	9.5	5.72	.032	1.26
601	do	6	A	48	385	2.44	941	6.5	10.4	3.78	.035	1.35
603	do	4	A	45	264	.96	253	4.9	7.4	1.53	.038	1.47
604	South Fork Trinity River at Hyampon, Calif.	29	A	218	1,150	6.23	7,160	5.2	8.8	9.09	.035	1.24
605	do	6	A	206	800	1.01	806	3.8	6.5	1.76	.040	1.67
606	do	50	A	221	705	4.50	3,170	3.2	4.7	6.46	.038	1.25
607	Trinity River near Burnt Ranch, Calif.	24	D	285	4,020	9.55	38,400	13.7	23.5	16.05	.035	1.50
608	do	28	A	190	1,670	7.01	11,700	8.6	13.0	11.33	.038	1.46
609	do	27	A	181	1,340	5.57	7,480	7.3	11.4	9.60	.040	1.43
611	do	32	D	127	394	1.59	628	3.1	5.2	2.42	.045	1.16
613	Tuolumne River below Hetch Hetchy, Calif.	412	A	149	1,310	5.13	6,720	8.5	11.6	7.84	.035	1.28
614	do	411	A	139	1,060	3.49	3,700	7.5	9.9	6.39	.038	1.52
616	do	404	A	136	844	2.52	2,120	6.1	8.3	5.58	.040	1.98
617	Kaweah River near Three Rivers, Calif.	283	A	81	230	1.25	288	2.8	3.8	2.05	.035	1.61
619	do	321	D	92	438	1.14	499	4.6	7.9	2.41	.035	2.39
621	do	323	D	100	492	1.72	845	4.8	8.7	3.94	.035	2.64
622	do	295	D	104	579	2.56	1,480	5.4	10.2	5.23	.035	2.62
623	do	291	A	108	537	3.35	1,800	4.9	8.3	7.27	.035	1.88
624	do	294	D	112	688	3.49	2,400	6.0	10.7	6.85	.035	2.36
625	do	293	A	116	757	4.04	3,060	6.4	11.1	8.17	.035	2.16
626	do	266	A	122	689	6.86	4,730	5.5	9.5	10.17	.035	1.53
627	Kaweah River at Three Rivers, Calif.	10	B	118	286	1.67	478	2.4	3.1	2.63	.040	1.29
628	do	72	B	117	344	2.24	772	2.9	3.6	3.52	.040	1.30
631	do	71	B	117	442	3.28	1,450	3.7	4.6	5.11	.040	1.29
632	do	70	B	117	453	3.31	1,500	3.7	4.6	5.11	.040	1.30
633	do	66	B	220	606	3.10	1,880	2.7	4.8	5.78	.040	1.94
635	do	69	B	220	620	3.53	2,190	2.7	5.0	7.01	.040	1.74

TABLE 5.—*Two-point (0.2d/0.8d) velocity discharge-measurement data*—Continued

Index No.	Station and location	District No.	Type of cross section	Width (ft)	Area (sq ft)	Mean velocity (fps)	Discharge (cfs)	Hydraulic radius (ft)	Maximum depth (ft)	Maximum point velocity (fps)	Roughness coefficient (n)	Alpha coefficient (α)
636	Tule River near Springville, Calif.	75	A	45	169	2.25	380	3.6	4.9	4.19	0.040	1.66
637	do	26	A	53	177	2.76	489	3.1	5.0	4.99	.040	1.56
638	do	73	A	53	191	2.76	528	3.5	5.1	5.68	.040	1.82
639	do	24	A	57	201	3.48	699	3.4	5.3	6.29	.040	1.57
640	do	12	D	60	211	3.95	833	3.4	5.8	7.27	.040	1.67
641	do	18	D	72	240	4.30	1,030	3.2	6.5	7.97	.040	1.65
643	do	22	D	223	552	5.85	3,230	2.4	7.5	13.60	.040	2.21
645	Kern River below Isabella Dam, Calif.	246	A	75	265	2.79	740	3.5	5.1	3.91	.050	1.32
647	do	248	A	81	300	3.67	1,100	3.6	5.2	5.00	.050	1.30
648	do	247	A	81	351	3.94	1,380	4.2	6.2	5.50	.050	1.30
649	do	186	A	84	396	4.82	1,910	4.6	6.8	6.57	.050	1.19
650	do	179	A	85	451	5.50	2,480	5.1	7.4	7.64	.050	1.21
651	do	183	A	84	466	5.79	2,700	5.3	7.6	8.21	.050	1.21
652	do	185	A	90	587	5.10	3,580	6.2	9.1	9.12	.050	1.34
653	do	138	D	282	1,660	4.79	7,950	5.8	10.6	7.47	.050	1.28
654	South Fork Kern River near Onyx, Calif.	450	A	40	93.1	.58	53.7	2.2	2.9	.88	.032	1.35
655	do	490	A	46	108	1.05	113	2.3	3.1	2.11	.032	1.41
657	do	440	A	51	156	2.44	381	3.0	4.3	3.33	.032	1.21
658	do	438	A	62	204	4.75	970	3.2	5.1	6.71	.032	1.25
659	do	439	A	63	239	5.02	1,200	3.6	6.0	6.99	.032	1.25
660	Silver Creek near Placerville, Calif.	229	A	58	306	.52	159	5.0	7.9	1.34	.040	2.89
662	do	234	D	78	426	1.42	605	5.2	9.6	3.69	.040	2.96
663	do	222	D	78	438	1.65	723	5.4	9.7	3.80	.040	2.19
664	Silver Creek near Placerville, Calif.	205	D	104	544	2.70	1,470	5.0	10.9	5.36	.045	1.83
665	do	216	D	113	690	3.91	2,700	5.9	12.0	7.07	.045	1.71
666	Silver Creek below Camino diversion dam, Calif.	25	D	83	211	2.32	489	2.4	4.6	5.74	.055	2.74
667	do	13	D	79	246	2.85	702	3.0	----	----	.055	2.78
668	do	20	D	92	265	3.36	890	2.8	----	----	.055	2.80
669	do	22	D	91	290	3.38	979	3.1	5.7	9.13	.055	2.98
670	do	23	D	91	285	3.54	1,010	3.0	5.7	8.95	.055	2.63
671	do	26	A	91	322	4.07	1,310	3.4	5.9	10.19	.055	2.84
672	Kings River above North Fork, Calif.	328	D	140	311	2.39	743	2.2	----	----	.035	1.33
673	do	291	D	172	409	2.57	1,050	2.4	3.6	4.03	.035	1.34
674	do	279	D	183	492	3.01	1,480	2.7	3.9	4.77	.035	1.34
676	do	305	D	209	623	4.16	2,590	3.0	4.8	6.22	.035	1.32

677	----do----	316	D	212	706	4.48	3,160	3.3	5.0	7.16	.040	1.41
678	----do----	317	D	213	820	5.10	4,180	3.8	5.6	8.03	.040	1.41
679	----do----	320	D	225	919	5.74	5,280	4.1	5.6	9.03	.040	1.41
680	----do----	318	D	220	1,070	6.39	6,840	4.8	6.8	9.75	.040	1.38
681	Big Creek above Pine Flat Reservoir, Calif.	50	A	59	110	.59	65.2	1.8	3.0	.96	.045	1.36
682	----do----	45	A	71	170	1.27	216	2.3	3.2	2.02	.045	1.34
683	----do----	188	A	87	304	2.72	826	3.4	5.5	4.40	.040	1.45
684	----do----	166	A	95	269	4.31	1,160	2.8	4.1	6.86	.040	1.37
685	Kings River below North Fork, Calif.	256	D	140	346	.82	284	2.5	4.1	1.42	.065	1.32
686	----do----	267	D	156	507	1.91	968	3.2	5.4	2.62	.060	1.21
687	----do----	252	D	174	618	2.30	1,420	3.5	6.1	3.42	.060	1.24
688	----do----	247	D	213	857	3.13	2,680	4.0	7.4	4.58	.050	1.34
689	----do----	242	D	224	1,040	3.79	3,940	4.6	8.2	5.68	.050	1.33
690	----do----	265	D	259	1,230	4.71	5,790	4.7	9.5	6.59	.050	1.23
691	----do----	125	D	295	1,980	5.91	11,700	6.7	11.5	8.75	.045	1.29
692	Kings River below Pine Flat Dam, Calif.	286	A	284	984	.61	598	3.5	4.5	.86	.040	1.20
693	----do----	296	A	290	1,180	.83	984	4.1	5.2	1.26	.040	1.22
694	----do----	301	A	300	1,510	1.28	1,930	5.0	6.3	1.97	.035	1.23
695	----do----	320	A	309	1,700	1.52	2,590	5.5	7.0	2.30	.035	1.24
696	----do----	331	A	307	1,840	1.63	3,000	5.9	7.2	2.44	.035	1.29
697	----do----	221	A	317	2,000	2.04	4,070	6.3	7.8	2.88	.035	1.26
698	----do----	330	A	324	2,110	2.27	4,800	6.5	8.2	3.20	.035	1.20
699	----do----	328	A	356	2,450	2.78	6,810	6.9	9.1	3.96	.035	1.23
700	----do----	327	A	359	2,500	2.81	7,020	6.9	9.3	4.05	.035	1.24
701	----do----	180	A	372	2,900	3.20	9,290	7.8	10.5	5.46	.035	1.42
702	----do----	184	A	380	3,130	3.61	11,300	8.2	11.0	5.87	.035	1.36
703	Kings River near Hume, Calif.	57	D	136	317	3.31	1,050	2.3	3.8	5.33	.060	1.33
704	----do----	58	D	161	571	6.15	3,510	3.5	5.4	9.18	.055	1.27
705	----do----	59	D	165	603	6.67	4,020	3.6	5.3	10.13	.055	1.28
706	----do----	62	D	197	933	9.60	8,960	4.7	7.1	15.91	.050	1.36
707	Fresno River near Dalton, Calif.	349	D	163	494	3.81	1,880	3.0	6.3	6.08	.035	1.34
708	----do----	424	D	175	586	4.73	2,770	3.3	6.7	6.61	.035	1.22
709	----do----	383	D	178	674	4.72	3,180	3.8	6.6	7.14	.035	1.26
710	----do----	426	D	181	757	4.77	3,610	4.1	7.2	6.87	.035	1.24
711	----do----	425	D	180	735	5.47	4,020	4.0	6.7	7.23	.035	1.14
712	----do----	348	A	186	1,090	5.66	6,170	5.8	11.0	8.22	.035	1.22
713	San Joaquin River near Newman, Calif.	633	D	213	1,250	.52	648	5.8	8.9	.79	.030	1.28
714	----do----	676	D	220	995	1.06	1,050	4.5	7.5	1.87	.030	1.49
715	----do----	682	A	235	1,160	1.52	1,770	4.9	8.4	1.15	.030	1.25
716	----do----	686	A	226	1,170	1.75	2,050	5.1	7.6	2.55	.030	1.25
717	----do----	681	D	270	1,420	1.79	2,540	5.2	10.0	2.38	.030	1.24
718	----do----	685	A	282	1,740	1.96	3,420	6.1	10.1	2.90	.030	1.34
719	----do----	680	A	324	2,830	2.38	6,750	8.6	15.0	3.41	.030	1.28
721	----do----	626	A	403	4,430	3.25	14,400	10.9	20.7	4.42	.030	1.29

TABLE 5.—*Two-point (0.2d/0.8d) velocity discharge-measurement data*—Continued

Index No.	Station and location	District No.	Type of cross section	Width (ft)	Area (sq ft)	Mean velocity (fps)	Discharge (cfs)	Hydraulic radius (ft)	Maximum depth (ft)	Maximum point velocity (fps)	Roughness coefficient (*n*)	Alpha coefficient (α)
723	Merced River at Pohono Bridge, Yosemite, Calif.	316	A	104	242	3.02	730	2.3	3.5	4.40	0.045	1.25
724	do	341	A	105	288	3.27	941	2.7	3.9	4.69	.045	1.30
725	do	329	A	114	326	3.65	1,190	2.8	4.2	5.60	.040	1.33
726	do	350	D	123	395	4.56	1,800	3.2	4.8	6.87	.040	1.25
729	South Fork Merced River at Wawona, Calif.	29	A	76	175	2.12	372	2.3	2.9	3.24	.040	1.30
730	do	17	A	79	196	2.41	472	2.4	3.3	3.65	.040	1.33
731	do	18	A	79	222	3.10	688	2.7	3.7	4.70	.040	1.33
732	do	19	A	80	239	3.32	793	2.9	3.8	5.27	.040	1.40
733	do	5	A	75	272	4.26	1,160	3.5	4.6	6.39	.040	1.31
734	South Fork Merced River near El Portal, Calif.	84	A	78	393	.52	205	4.9	7.1	1.01	.045	1.69
735	do	108	A	83	420	1.17	490	4.9	7.2	2.53	.045	2.16
737	do	94	A	83	452	1.66	751	5.3	7.7	3.51	.045	2.08
738	do	96	A	82	456	2.04	929	5.3	7.9	4.44	.045	2.46
739	do	74	D	87	483	2.71	1,310	5.3	8.2	6.11	.040	2.54
740	do	78	D	99	585	4.03	2,360	5.7	9.3	7.71	.040	2.19
741	Merced River at Bagby, Calif.	123	D	141	689	1.23	845	4.8	7.0	2.07	.045	1.38
743	do	151	A	144	951	2.21	2,100	6.5	10.5	3.37	.045	1.41
744	do	141	A	145	1,060	2.49	2,640	7.2	12.2	4.38	.045	1.55
745	do	165	A	150	1,160	3.41	3,950	7.6	13.0	5.18	.045	1.33
746	do	142	A	149	1,200	3.73	4,480	7.9	12.9	5.53	.040	1.23
747	do	126	A	152	1,260	4.41	5,560	8.1	13.0	7.36	.040	1.39
748	do	125	A	165	1,550	5.68	8,800	9.1	15.9	10.78	.040	1.67
749	Merced River at Happy Isles Bridge near Yosemite, Calif.	356	B	79	209	2.36	494	2.6	3.7	3.93	.055	1.29
750	do	333	B	78	209	2.64	551	2.6	3.7	5.00	.055	1.87
751	Merced River at Happy Isles Bridge near Yosemite, Calif.	347	B	82	232	2.67	619	2.8	4.1	4.17	.055	1.35
752	do	348	B	76	330	4.67	1,540	4.1	5.4	6.89	.050	1.23
753	do	367	B	73	330	5.15	1,700	4.2	5.2	8.00	.050	1.25
754	do	332	B	91	456	5.90	2,690	4.8	6.9	9.34	.050	1.39
755	Merced River at Exchequer, Calif.	315	D	124	273	1.40	383	2.2	3.2	2.05	.040	1.30
757	do	337	D	172	690	3.67	2,530	4.0	6.1	5.01	.040	1.22
758	do	336	D	180	889	4.41	3,920	4.9	7.2	6.26	.040	1.19
760	do	300	A	184	1,170	5.16	6,040	6.2	8.9	7.66	.040	1.21
761	Merced River near Stevinson, Calif.	389	A	122	1,030	1.08	1,110	8.1	11.8	1.76	.030	1.48
762	do	393	A	135	810	1.90	1,540	5.8	9.4	2.68	.030	1.25

763	do	385	A	139	1,650	1.45	2,400	11.2	17.2	2.62	.030	1.57
764	do	392	A	148	1,330	2.58	3,430	8.5	14.2	3.77	.030	1.28
765	do	330	A	169	1,640	3.30	5,430	9.3	12.6	4.28	.035	1.14
766	do	335	A	177	2,660	2.56	6,820	14.1	24.8	3.77	.035	1.30
767	do	331	A	190	2,360	3.64	8,600	11.9	18.8	4.80	.035	1.18
768	do	332	A	196	2,940	3.26	9,600	14.3	23.4	4.70	.035	1.26
769	Clavey River near Buck Meadows, Calif	19	D	51	122	2.29	279	2.3	4.1	3.97	.040	1.46
770	do	9	A	54	154	2.47	380	2.8	4.8	4.49	.040	1.52
771	do	8	A	55	162	2.54	411	2.9	4.8	4.70	.040	1.63
772	do	7	A	57	203	2.96	602	3.4	5.5	5.59	.040	1.68
773	do	33	A	60	258	3.40	876	4.1	6.4	6.22	.040	1.56
774	do	30	A	63	275	3.51	966	4.2	6.7	6.84	.040	1.74
776	Woods Creek near Jacksonville, Calif	430	A	43	101	3.22	325	2.3	3.2	4.48	.040	1.20
777	do	436	A	48	143	4.92	704	2.9	3.8	7.95	.040	1.32
778	do	433	D	100	190	4.57	869	2.6	4.6	7.62	.040	1.59
779	do	453	D	107	325	5.57	1,810	3.0	5.7	10.04	.045	1.55
780	do	454	D	116	385	5.92	2,280	3.3	6.4	10.04	.045	1.55
782	do	437	D	130	503	7.00	3,520	3.8			.045	1.60
783	Clark Fork Stanislaus River near Dardanelle, Calif	45	A	43	123	2.63	324	2.7	4.0	6.10	.045	2.29
784	do	53	A	45	131	3.13	410	2.7	3.8	5.60	.045	1.73
785	do	76	A	44	132	3.78	499	2.7	3.7	6.75	.045	1.54
786	do	60	A	46	178	3.75	667	3.6	5.1	7.53	.045	1.78
788	do	43	A	49	211	4.33	913	4.0	6.2	9.01	.045	2.18
789	Middle Fork Stanislaus River at Hells Half Acre Bridge, Calif	13	D	86	186	1.38	256	2.1	4.0	2.57	.045	1.82
790	do	26	D	87	203	1.96	399	2.3	4.2	4.13	.045	1.66
791	do	45	D	123	354	3.19	1,130	2.8			.045	1.58
792	do	71	D	125	419	3.91	1,640	3.3			.045	1.56
793	do	27	D	149	494	3.76	1,860	3.3	6.4	6.75	.045	1.55
794	do	70	D	158	519	4.03	2,090	3.3	6.1	7.39	.045	1.56
795	Middle Fork Stanislaus River below Beardsley Dam, near Strawberry Calif.	52	A	111	599	.38	226	5.2	9.5	.66	.035	1.45
796	do	59	A	110	654	.56	366	5.7	10.1	.87	.035	1.26
797	do	48	A	113	714	.81	576	6.1	10.7	1.23	.035	1.24
799	do	36	A	114	817	1.36	1,110	6.9	11.8	1.94	.035	1.22
800	do	55	A	117	918	1.79	1,640	7.5	12.3	2.55	.035	1.25
801	do	56	A	118	997	2.32	2,320	8.1	13.2	3.24	.035	1.19
802	do	17	A	120	994	3.99	3,970	7.9	13.0	5.03	.035	1.13
805	South San Joaquin Canal near Knights Ferry, Calif.	298	C	16.8	93	8.03	748	8.8			.020	1.05
807	do	268	C	19.8	154	7.53	1,160	7.7	10.1	9.04	.020	1.06
808	do	291	C	20	18	7.51	1,330	8.7			.020	1.05

TABLE 5.—*Two-point (0.2d/0.8d) velocity discharge-measurement data*—Continued

Index No.	Station and location	District No.	Type of cross section	Width (ft)	Area (sq ft)	Mean velocity (fps)	Discharge (cfs)	Hydraulic radius (ft)	Maximum depth (ft)	Maximum point velocity (fps)	Roughness coefficient (n)	Alpha coefficient (α)
810	Stanislaus River below Goodwin Dam near Knights Ferry, Calif.	42	A	125	622	2.86	1,780	4.9	7.6	6.22	0.055	2.10
811	do	47	A	125	639	3.21	2,050	5.0	7.6	6.59	.055	1.87
813	do	16	A	153	1,120	4.35	4,870	7.1	11.4	8.22	.050	1.82
814	do	15	A	151	1,240	4.77	5,920	8.0	12.5	9.59	.050	1.74
815	Stanislaus River at Ripon, Calif	442	D	83	208	1.73	360	2.4	6.0	2.50	.035	1.27
816	do	399	A	93	302	1.80	544	3.2	4.3	2.34	.035	1.12
817	do	449	D	122	650	1.68	1,090	5.2	8.1	2.73	.035	1.43
818	do	443	D	136	1,110	1.94	2,150	7.8	13.1	3.73	.035	2.02
819	do	389	D	197	2,850	2.97	8,460	13.8	23.6	4.98	.035	1.71
820	South Fork Calaveras River near San Andreas, Calif.	49	D	101	439	.80	350	4.3	6.8	1.28	.045	1.37
822	do	100	A	110	575	1.93	1,110	5.1	8.2	3.12	.045	1.48
823	do	48	A	113	725	4.50	3,260	6.2	9.3	7.56	.045	1.40
825	Calaveritas Creek near San Andreas, Calif	44	A	93	441	6.46	2,850	4.6	8.8	11.08	.035	1.61
827	Mokelumne River near Mokelumne Hill, Calif	1,041	A	103	329	3.03	996	3.2	4.4	4.34	.045	1.26
828	do	1,039	A	101	333	3.12	1,040	3.3	4.4	4.54	.045	1.27
829	do	1,033	A	112	346	3.21	1,110	3.1	4.5	4.59	.045	1.25
830	do	1,037	A	128	555	4.38	2,430	4.3	6.0	7.08	.045	1.38
831	Mokelumne River at Woodbridge, Calif	2,658	A	50	137	1.68	230	2.6	4.5	2.62	.035	1.48
833	do	63	A	58	263	2.09	550	4.2	7.2	3.12	.035	1.41
834	do	2,653	A	61	331	2.23	738	5.0	8.2	3.29	.040	1.44
837	do	2,656	A	81	805	2.89	2,330	9.0	14.8	4.16	.040	1.36
838	North Fork Cosumnes River near Eldorado, Calif	101	A	80	208	1.42	296	2.5	3.3	2.28	.035	1.40
839	do	123	A	81	244	1.40	343	2.9	4.6	2.53	.035	1.75
840	do	122	A	84	371	2.09	777	4.2	6.2	3.55	.035	1.69
841	do	100	A	87	391	2.29	897	4.3	5.8	3.86	.035	1.62
842	do	99	A	88	415	2.60	1,080	4.5	6.7	4.38	.035	1.44
843	do	75	A	96	565	4.37	2,470	5.7	7.6	7.47	.035	1.56
845	Cosumnes River at McConnell, Calif	386	B	134	697	3.36	2,340	5.1	6.9	5.22	.030	1.13
846	do	366	B	125	890	3.68	3,280	6.8	9.6	5.18	.030	1.20
848	do	365	D	155	1,430	5.16	7,380	8.9	14.4	7.25	.030	1.25
849	South Fork Cosumnes River near River Pines, Calif	6	A	36	111	1.96	218	2.9	4.6	3.04	.040	1.35
851	do	24	A	40	202	4.89	988	4.5	7.0	8.26	.040	1.40

852	do	31	A	42	239	4.98	1,190	5.0	8.0	8.52	.040	1.52
854	do	10	A	51	330	5.73	1,890	5.7	9.2	9.24	.040	1.49
857	Middle Cosumnes River near Somerset, Calif	13	A	42	174	3.36	585	3.8	6.5	5.84	.040	1.62
859	do	12	A	55	284	4.82	1,370	4.7	8.5	8.86	.035	1.83
861	Sacramento River at Delta, Calif	144	A	76	213	.92	196	2.7	4.3	1.57	.045	1.47
864	do	104	A	120	493	3.67	1,810	4.1	7.0	8.25	.045	2.20
866	do	129	A	130	586	5.19	3,040	4.4	7.6	11.59	.045	2.03
867	do	111	A	139	694	5.95	4,130	4.9	8.9	12.66	.045	2.03
868	do	93	A	148	912	6.88	6,280	6.0	10.2	13.62	.045	2.07
870	Sacramento River near Keswick, Calif	407	A	224	3,390	.96	3,270	14.6	22.8	1.80	.040	1.90
871	do	420	A	237	4,070	1.46	5,930	16.5	25.0	2.83	.040	2.02
872	do	424	A	240	4,190	1.72	7,210	16.8	25.6	3.30	.040	1.94
873	do	428	D	261	4,700	2.06	9,670	17.2	27.2	4.08	.040	2.19
874	do	381	A	220	4,340	2.95	12,800	18.1	31.4	5.52	.040	2.05
875	do	378	A	225	4,750	3.01	14,300	19.4	32.5	6.97	.040	2.28
876	Sacramento River at Colusa, Calif	705	A	305	1,870	2.17	4,050	6.1	7.7	2.94	.035	1.15
877	do	742	A	303	2,200	2.60	5,710	7.2	9.6	3.55	.035	1.13
878	do	736	A	325	3,450	2.88	9,950	10.4	13.1	3.97	.035	1.15
880	do	721	A	325	4,870	3.39	16,500	14.6	17.8	4.42	.035	1.12
881	do	735	A	370	7,590	3.35	25,400	19.9	25.4	4.44	.035	1.21
882	do	674	A	330	7,710	4.03	31,100	22.1	28.9	5.59	.035	1.22
883	Sacramento River below Wilkens Slough, Calif	428	A	190	1,950	1.92	3,750	9.9	13.9	2.45	.032	1.11
884	do	445	A	218	3,300	2.65	8,760	14.5	20.0	3.68	.032	1.16
886	do	382	A	235	5,290	3.34	17,700	21.0	29.7	4.57	.032	1.20
887	do	398	A	248	6,260	3.80	23,800	23.3	35.0	5.20	.032	1.26
888	do	377	D	310	7,760	3.63	28,200	23.4	38.1	5.22	.032	1.33
889	Sacramento River at Knights Landing, Calif	736	B	204	2,820	1.35	3,810	13.4	21.4	1.62	.030	1.06
890	do	713	B	205	2,880	2.19	6,300	13.4	21.2	2.79	.030	1.12
891	do	752	B	210	3,610	2.52	9,110	16.4	24.9	3.02	.030	1.08
893	do	680	B	208	7,300	3.79	27,700	28.6	43.0	4.67	.030	1.14
894	Sacramento River at Verona, Calif	659	A	445	3,450	1.85	6,380	7.7	10.4	2.51	.030	1.16
897	do	686	A	510	8,620	3.48	30,000	16.6	19.7	4.42	.030	1.10
898	do	640	A	515	12,040	3.68	44,300	22.8	28.5	4.76	.030	1.15
900	Pit River near Montgomery Creek, Calif	133	D	215	625	.92	573	2.9	4.1	1.36	.045	1.20
901	do	117	D	218	848	1.90	1,610	3.8	5.0	2.51	.045	1.18
903	do	131	D	225	1,240	3.47	4,300	5.4	6.8	4.51	.045	1.17
904	do	128	A	228	1,550	4.75	7,360	6.7	8.4	6.32	.045	1.24
905	do	93	A	228	1,760	6.19	10,900	7.6	9.3	8.39	.040	1.20
906	do	92	A	230	2,050	7.22	14,800	8.7	10.5	9.91	.040	1.28
907	South Fork Pit River near Likely, Calif	259	A	47	137	1.58	217	2.8	3.4	2.87	.050	1.49
908	do	244	A	47	143	1.94	277	2.9	3.6	3.31	.050	1.50
909	do	251	A	48	152	2.00	304	3.0	3.8	3.45	.050	1.47
910	do	258	A	50	185	2.82	521	3.5	4.3	4.87	.050	1.44

TABLE 5.—*Two-point (0.2d/0.8d) velocity discharge-measurement data*—Continued

Index No.	Station and location	District No.	Type of cross section	Width (ft)	Area (sq ft)	Mean velocity (fps)	Discharge (cfs)	Hydraulic radius (ft)	Maximum depth (ft)	Maximum point velocity (fps)	Roughness coefficient (n)	Alpha coefficient (α)
911	Pit River near Bieber, Calif	52	D	130	290	.85	246	2.2	4.1	1.81	0.065	1.90
912	do	78	D	157	357	1.17	418	2.3	4.6	2.73	.065	2.04
913	do	70	D	200	509	1.57	798	2.5	5.4	3.54	.060	1.76
914	do	46	D	210	646	1.87	1,210	3.1	5.9	3.82	.060	1.82
915	do	39	D	217	899	2.86	2,580	4.1	7.0	5.34	.055	1.58
916	do	61	D	224	1,040	3.51	3,650	4.6	7.7	5.76	.055	1.46
917	do	31	D	232	1,270	4.00	5,080	5.4	8.6	6.61	.050	1.48
918	do	30	D	240	1,410	4.45	6,280	5.8	9.2	7.28	.050	1.41
919	McCloud River near McCloud, Calif	238	A	100	255	3.26	831	2.5	4.1	5.47	.045	1.41
920	do	262	A	98	272	3.57	972	2.7	4.2	6.08	.045	1.42
922	do	233	A	104	332	4.34	1,440	3.1	4.9	7.44	.045	1.44
923	do	223	A	107	364	4.40	1,600	3.3	5.3	7.28	.045	1.37
924	do	231	A	130	705	6.26	4,410	5.3	8.1	10.89	.045	1.60
925	McCloud River above Shasta Lake, Calif	127	D	96	392	2.51	984	4.0	6.1	3.38	.050	1.17
927	do	106	A	105	480	3.77	1,810	4.4	6.6	4.98	.050	1.17
928	do	105	A	111	623	5.63	3,510	5.5	8.1	7.28	.050	1.12
929	do	87	D	125	749	6.57	4,920	6.0	9.5	8.58	.050	1.14
930	do	86	A	139	906	7.00	6,340	6.4	10.0	9.28	.050	1.19
931	Squaw Creek above Shasta Lake, Calif	97	A	72	251	.93	233	3.4	5.2	1.39	.040	1.29
932	do	118	D	73	300	1.21	364	3.9	7.5	1.89	.040	1.43
933	do	106	A	73	338	1.76	594	4.5	6.8	2.57	.040	1.36
934	do	126	A	72	306	2.35	718	4.1	6.8	3.40	.040	1.28
935	do	96	A	76	429	2.91	1,250	5.4	7.7	4.29	.035	1.37
936	do	136	A	80	554	3.21	1,780	6.5	11.5	4.87	.035	1.40
937	do	135	A	80	561	3.37	1,890	6.6	11.4	9.26	.035	1.36
938	Mill Creek near Los Molinas, Calif	427	A	60	211	1.46	308	3.4	4.2	1.94	.040	1.13
939	do	443	A	67	228	1.78	406	3.3	4.0	2.56	.040	1.20
940	do	399	A	66	257	2.58	663	3.7	4.5	3.59	.040	1.17
941	do	435	A	63	270	3.22	869	4.1	5.2	4.67	.040	1.19
942	do	404	A	66	323	3.96	1,280	4.7	6.1	5.80	.040	1.18
943	Thomas Creek at Paskenta, Calif	288	A	88	256	4.34	1,110	2.8	4.0	6.31	.035	1.24
944	do	262	A	100	297	4.81	1,430	2.9	4.1	6.96	.035	1.25
945	do	271	A	107	381	5.59	2,130	3.5	5.7	7.83	.035	1.18
946	do	261	D	157	478	6.99	3,340	3.0	5.6	10.33	.035	1.24
947	do	278	D	158	728	7.01	5,100	4.5	8.9	9.85	.035	1.21
948	Cow Creek near Millville, Calif	107	A	163	468	1.31	615	2.8	4.3	2.37	.035	1.48

949	----do----	90	A	164	475	2.23	1,060	2.9	4.8	3.38	.035	1.28
950	----do----	78	A	168	556	2.55	1,420	3.3	5.4	3.59	.035	1.28
951	----do----	120	A	178	972	2.82	2,740	5.4	6.4	4.98	.035	1.64
952	----do----	66	A	186	1,490	3.99	5,940	7.8	10.0	7.22	.035	1.60
953	----do----	87	A	188	1,430	4.96	7,100	7.4	10.0	7.87	.035	1.48
954	Cottonwood Creek near Cottonwood, Calif	269	D	308	957	3.72	3,560	3.1	4.7	5.47	.035	1.17
955	----do----	242	D	315	1,400	3.80	5,320	4.4	8.8	5.34	.035	1.16
956	----do----	283	D	315	1,370	5.87	8,040	4.3	7.2	8.28	.035	1.17
958	----do----	254	A	467	3,150	6.06	19,100	6.7	9.8	10.14	.045	1.66
959	Battle Creek near Cottonwood, Calif	198	A	85	156	4.05	632	1.8	2.6	5.76	.045	1.19
960	----do----	208	A	94	185	4.76	881	1.9	2.7	6.30	.045	1.16
961	----do----	190	A	95	208	4.81	1,000	2.2	3.1	6.44	.045	1.17
962	----do----	207	A	96	214	5.23	1,120	2.2	3.1	6.97	.045	1.18
963	----do----	197	D	100	270	5.48	1,480	2.6	3.6	7.75	.045	1.26
964	Deer Creek near Vina, Calif	368	A	97	236	1.75	413	2.4	3.1	2.68	.040	1.46
965	----do----	422	A	94	261	2.03	531	2.7	3.3	3.05	.040	1.44
966	----do----	383	A	97	286	2.56	732	2.9	3.7	4.08	.040	1.37
967	----do----	418	A	95	304	2.97	902	3.1	4.3	4.50	.040	1.34
968	----do----	382	A	102	325	3.17	1,030	3.1	4.1	4.87	.045	1.36
969	----do----	380	A	107	485	4.68	2,270	4.4	5.8	7.95	.045	1.52
970	----do----	427	D	150	706	5.94	4,190	4.6	7.2	10.66	.045	1.56
971	Clear Creek near Igo, Calif	200	D	76	200	1.96	392	2.6	3.5	2.88	.040	1.29
972	----do----	210	D	104	256	2.70	692	2.7	3.9	4.22	.040	1.36
973	----do----	188	D	107	297	2.95	876	2.8	4.3	4.57	.040	1.41
974	----do----	187	D	111	410	4.56	1,870	3.6	5.3	7.12	.040	1.36
975	----do----	212	D	111	471	5.44	2,560	4.1	6.0	8.40	.040	1.34
976	----do----	211	D	117	522	5.73	2,990	4.4	6.5	8.91	.040	1.43
977	----do----	176	D	134	696	7.67	5,340	5.1	7.6	11.01	.040	1.32
978	----do----	153	A	152	929	9.01	8,370	6.0	9.1	12.97	.040	1.26
979	Clear Creek at French Gulch, Calif	104	A	66	126	3.60	454	1.9	3.3	5.60	.040	1.26
980	----do----	132	A	81	175	4.20	735	2.1	4.0	6.02	.040	1.26
981	----do----	135	A	83	223	4.71	1,050	2.6	4.5	6.37	.040	1.23
982	----do----	116	A	85	288	5.56	1,600	3.3	5.5	7.98	.040	1.31
983	----do----	93	A	89	347	6.08	2,110	3.8	5.9	8.77	.035	1.25
984	----do----	62	A	97	461	5.96	2,750	4.6	7.4	8.57	.035	1.32
985	----do----	61	A	108	629	7.22	4,540	5.6	8.9	10.91	.035	1.43
986	Middle Fork Feather River near Clio, Calif	261	D	55	199	2.13	424	3.2	5.2	3.61	.040	1.47
987	----do----	288	A	92	363	1.21	438	3.8	5.4	1.91	.040	1.47
988	----do----	254	A	95	612	1.45	889	6.1	8.5	2.42	.040	1.51
989	----do----	289	A	97	611	2.31	1,410	6.0	8.1	3.73	.035	1.41
990	----do----	253	A	103	808	2.54	2,050	7.3	8.0	4.20	.035	1.50
991	----do----	269	A	109	874	3.24	2,830	7.6	10.0	5.25	.035	1.45
992	----do----	295	A	124	1,050	4.39	4,610	8.1	12.4	6.98	.035	1.44
993	----do----	230	D	133	1,410	4.39	6,190	9.9	14.9	7.14	.035	1.56

TABLE 5.—*Two-point (0.2d/0.8d) velocity discharge-measurement data*—Continued

Index No.	Station and location	District No.	Type of cross section	Width (ft)	Area (sq ft)	Mean velocity (fps)	Discharge (cfs)	Hydraulic radius (ft)	Maximum depth (ft)	Maximum point velocity (fps)	Roughness coefficient (n)	Alpha coefficient (α)
994	Middle Fork Feather River below Sloat, Calif.	142	A	110	312	5.22	1,630	2.8	3.6	7.55	0.050	1.23
995	do	194	A	110	376	6.33	2,380	3.4	4.0	9.31	.050	1.24
996	do	136	A	112	506	6.84	3,460	4.4	5.5	9.94	.050	1.24
997	do	151	A	121	665	9.56	6,360	5.4	7.0	12.99	.050	1.22
998	do	137	A	130	924	8.84	8,170	6.9	9.9	15.09	.050	1.43
999	South Fork Feather River near Forbestown, Calif.	30	A	78	189	1.75	331	2.4	3.4	3.04	.070	1.64
1000	do	31	D	83	264	2.68	708	3.1	4.4	5.19	.060	1.61
1001	do	14	A	87	357	3.89	1,390	4.0	5.6	7.82	.055	1.70
1002	do	20	A	91	447	5.59	2,050	4.6	6.6	8.90	.050	1.73
1006	South Fork Feather River at Enterprise, Calif.	304	A	95	575	2.49	1,430	5.7	8.3	3.76	.035	1.37
1007	do	346	A	102	571	5.34	3,050	5.4	7.2	8.46	.035	1.40
1009	Indian Creek near Crescent Mills, Calif.	205	A	170	739	1.08	797	4.3	7.4	1.59	.040	1.28
1010	do	221	A	173	665	1.91	1,270	3.8	5.1	2.62	.040	1.13
1011	do	222	A	173	866	2.41	2,090	4.9	6.2	3.23	.040	1.14
1012	do	213	A	175	1,120	2.79	3,130	6.2	8.0	3.85	.040	1.16
1013	do	214	A	176	1,340	2.96	3,970	7.3	9.8	3.92	.040	1.16
1015	West Branch Feather River near Yankee Hill, Calif.	309	A	93	499	.54	271	5.1	9.4	.89	.045	1.25
1016	do	286	A	93	521	.68	353	5.3	9.7	1.11	.045	1.32
1017	do	308	A	96	560	.89	501	5.5	9.9	1.47	.045	1.42
1018	do	307	A	96	594	1.26	752	5.7	10.2	1.91	.045	1.30
1019	do	274	A	97	630	1.98	1,250	6.1	10.2	2.94	.045	1.30
1021	do	271	A	105	855	5.27	4,510	7.6	13.2	7.98	.045	1.25
1022	West Branch Feather River near Paradise, Calif.	45	A	66	191	1.27	242	2.8	4.7	2.08	.045	1.46
1023	do	15	A	66	275	2.36	650	3.9	6.5	4.08	.045	1.57
1024	do	14	A	75	345	3.19	1,100	4.4	7.4	5.34	.045	1.57
1025	do	55	A	79	465	4.28	1,990	5.5	8.7	7.99	.045	1.76
1027	do	10	A	83	629	6.38	4,010	6.8	11.5	11.87	.045	1.72
1028	do	9	A	87	704	6.41	4,510	7.3	12.3	11.59	.045	1.76
1029	Spanish Creek above Blackhawk Creek at Keddie, Calif.	189	D	90	236	.27	64.7	2.6	5.1	.34	.030	1.18
1030	do	226	D	94	276	.84	232	2.8	5.6	1.16	.030	1.16
1031	do	223	D	94	339	1.32	448	3.5	6.1	1.95	.030	1.26
1032	do	191	D	95	399	2.38	950	4.1	6.8	3.45	.030	1.22

1033	----do----	180	A	93	443	2.98	1,320	4.6	7.5	4.39	.035	1.20
1034	----do----	215	A	95	463	3.24	1,500	4.7	7.4	4.59	.035	1.18
1035	----do----	178	A	97	510	4.08	2,080	5.1	8.0	5.67	.035	1.18
1036	----do----	177	A	105	615	4.85	2,980	5.7	8.5	7.14	.035	1.26
1037	Middle Fork Feather River near Merrimac, Calif	69	D	139	398	2.32	923	2.7	4.5	3.95	.045	1.52
1038	----do----	62	D	141	542	2.45	1,330	3.8	5.9	4.50	.045	1.62
1039	----do----	56	A	148	1,030	5.35	5,510	6.7	9.0	9.11	.045	1.55
1040	----do----	54	A	143	1,140	5.96	6,790	7.5	10.0	9.51	.045	1.42
1041	----do----	45	A	162	1,540	8.25	12,700	9.2	12.0	14.97	.045	1.64
1042	East Branch North Fork Feather River near Rich Bar, Calif	119	D	154	440	1.50	662	2.8	6.0	2.33	.045	1.27
1043	----do----	99	D	166	577	2.03	1,170	3.5	6.0	3.09	.045	1.31
1044	----do----	107	D	170	633	2.59	1,640	3.7	7.3	3.76	.045	1.29
1045	----do----	97	D	185	865	3.49	3,020	4.7	7.7	5.21	.045	1.26
1046	----do----	98	A	198	995	4.78	4,760	5.0	8.3	6.60	.045	1.35
1047	----do----	106	A	208	1,270	7.11	9,030	6.1	10.5	10.46	.045	1.32
1050	Feather River near Oroville, Calif	273	A	282	4,150	3.47	14,400	14.4	22.0	5.61	.040	1.44
1051	----do----	272	A	290	4,820	4.40	21,200	16.2	24.0	7.13	.040	1.42
1052	----do----	239	A	307	7,470	7.08	52,900	23.2	33.9	12.48	.040	1.54
1053	Feather River at Bidwell, Calif	370	A	158	520	.59	307	3.3	5.4	1.15	.050	1.76
1054	----do----	399	A	168	737	2.21	1,630	4.3	6.6	4.56	.050	1.81
1055	----do----	398	A	176	836	3.12	2,610	4.7	7.1	6.58	.050	1.80
1056	----do----	406	A	193	1,070	4.80	5,140	5.5	8.3	9.55	.045	1.92
1057	----do----	368	D	250	1,300	5.62	7,310	5.1	9.1	10.92	.045	1.73
1059	----do----	405	A	308	2,900	9.86	28,600	9.3	17.5	15.09	.045	1.38
1063	South Yuba River near Cisco, Calif	85	A	66	308	3.60	1,110	4.4	6.8	8.03	.055	2.14
1064	----do----	105	A	67	292	3.87	1,130	4.1	6.4	8.75	.055	2.04
1065	South Yuba River near Washington, Calif	110	A	73	177	1.66	294	2.4	3.7	2.13	.050	1.23
1066	----do----	81	A	77	265	2.03	539	3.3	5.1	3.12	.050	1.42
1067	----do----	79	A	84	310	2.76	855	3.6	5.2	4.45	.050	1.52
1070	----do----	130	A	119	941	7.28	6,850	7.6	11.8	13.68	.045	1.69
1071	Deer Creek near Smartville, Calif	216	A	61	164	3.12	511	2.6	3.8	5.24	.050	1.43
1072	----do----	276	D	89	229	3.78	865	2.5	4.6	7.25	.050	1.74
1073	----do----	215	D	90	268	4.14	1,110	2.9	5.1	7.96	.050	1.69
1074	----do----	234	D	98	3,020	4.50	1,360	3.0	5.5	8.69	.050	1.76
1075	----do----	236	D	113	477	5.81	2,770	4.2	7.0	11.50	.050	1.97
1076	North Yuba River at Goodyears Bar, Calif	253	D	83	232	1.63	378	2.8	4.2	2.01	.045	1.14
1077	----do----	259	A	91	361	2.28	822	3.9	5.8	3.32	.045	1.25
1078	----do----	266	A	96	379	3.17	1,200	3.9	5.5	4.70	.045	1.32
1079	----do----	236	A	93	415	4.67	1,940	4.3	5.7	6.27	.045	1.31
1080	----do----	252	A	99	606	5.05	3,060	5.9	8.2	7.46	.035	1.24
1081	----do----	233	A	97	629	6.76	4,250	6.3	8.9	10.57	.035	1.36

TABLE 5.—*Two-point (0.2d/0.8d) velocity discharge-measurement data*—Continued

Index No.	Station and location	District No.	Type of cross section	Width (ft)	Area (sq ft)	Mean velocity (fps)	Discharge (cfs)	Hydraulic radius (ft)	Maximum depth (ft)	Maximum point velocity (fps)	Roughness coefficient (n)	Alpha coefficient (α)
1082	Middle Yuba River above Oregon Creek, Calif.	165	A	77	228	2.93	669	2.9	3.7	5.52	0.060	1.43
1085	do	149	A	81	349	4.73	1,650	4.2	5.0	7.82	.060	1.59
1088	do	147	A	93	491	6.64	3,260	5.1	7.5	11.15	.060	1.66
1089	Middle Yuba River near Alleghany, Calif.	33	D	60	224	1.40	313	3.5	7.2	2.37	.050	1.58
1090	do	6	D	66	289	2.39	690	4.1	7.2	4.25	.050	1.52
1091	do	10	A	65	341	2.99	1,020	4.8	7.9	4.87	.050	1.31
1092	do	9	A	70	399	3.96	1,580	5.2	8.5	6.32	.045	1.33
1094	Bear River near Auburn, Calif.	178	A	58	132	2.04	269	2.2	3.7	2.97	.045	1.37
1095	do	191	D	74	199	2.68	533	2.6	4.5	4.20	.045	1.51
1096	do	166	A	73	209	3.06	640	2.8	4.7	4.60	.045	1.34
1098	do	165	A	89	309	3.95	1,220	3.4	5.7	6.12	.045	1.41
1099	do	155	A	116	641	5.83	3,740	5.4	9.1	11.07	.045	1.74
1100	do	157	A	118	762	5.88	4,480	6.3	10.0	10.93	.045	1.94
1103	Middle Fork American River near Auburn, Calif.	378	A	104	511	1.69	865	4.8	6.6	2.86	.040	1.63
1104	do	364	A	109	650	2.22	1,440	5.8	7.6	3.93	.040	1.63
1105	do	382	A	112	746	3.86	2,880	6.3	8.5	6.78	.040	1.58
1106	do	377	A	114	962	4.33	4,170	7.9	10.7	7.48	.040	1.68
1107	do	266	A	141	1,550	7.94	12,300	10.4	15.7	11.68	.045	1.40
1108	Middle Fork American River near Foresthill, Calif.	26	D	109	362	2.52	912	3.2	6.1	3.33	.040	1.14
1109	do	33	D	121	428	3.55	1,520	3.5	6.7	4.60	.040	1.15
1110	do	13	A	140	636	4.56	2,900	4.5	8.0	5.84	.040	1.21
1111	do	31	A	144	735	4.94	3,630	5.0	8.8	6.59	.040	1.20
1112	do	39	D	150	744	6.91	5,140	4.8	7.7	10.20	.040	1.29
1113	Rubicon River near Georgetown, Calif.	107	A	95	338	1.83	618	3.4	5.8	3.11	.060	1.50
1116	do	88	A	105	572	3.37	1,930	5.2	7.9	6.32	.055	1.64
1117	do	100	A	114	728	5.12	3,730	6.1	9.6	8.31	.055	1.47
1118	Rubicon River near Rubicon Springs, Calif.	24	A	44	109	1.65	180	2.4	3.3	2.72	.035	1.43
1119	do	8	A	56	240	1.82	438	4.1	5.3	3.08	.035	1.70
1120	do	40	D	73	285	2.03	579	3.7	6.0	3.07	.035	1.34
1121	do	9	D	86	364	2.06	749	4.1	7.2	3.45	.040	1.52
1122	do	7	D	96	517	2.03	1,050	5.1	8.8	3.39	.040	1.50
1123	do	17	D	97	585	1.98	1,160	5.7	9.6	3.28	.040	1.54
1124	Rubicon River near Foresthill, Calif.	11	D	70	190	1.80	343	2.6	4.6	3.11	.045	1.71
1125	do	21	D	80	266	2.72	725	3.1	5.3	4.59	.045	1.56

1126	do	22	D	94	353	3.91	1,380	3.6	6.3	6.22	.040	1.54
1127	do	30	D	98	473	5.24	2,480	4.6	7.3	7.96	.040	1.38
1128	do	5	A	103	616	6.20	3,820	5.7	9.2	10.62	.040	1.55
1129	Middle Fork American River at French Meadows, Calif	73	A	57	166	1.51	250	2.8	5.5	2.65	.040	1.56
1130	do	82	A	59	180	1.54	277	2.9	4.6	2.72	.040	1.54
1131	do	48	A	60	259	1.54	399	4.0	6.9	2.85	.040	1.74
1132	do	81	A	65	258	2.40	619	3.8	6.1	4.16	.040	1.69
1135	North Fork American River at North Fork Dam, Calif	200	A	107	438	.54	236	4.0	6.7	.87	.045	1.46
1137	do	203	A	122	733	1.43	1,050	5.9	9.1	2.18	.045	1.34
1139	do	215	A	164	1,300	3.25	4,220	7.8	13.1	5.50	.045	1.45
1140	do	162	A	174	1,500	3.98	5,970	8.4	14.3	6.69	.045	1.46
1141	do	227	A	209	2,810	8.26	23,200	13.0	20.8	14.19	.045	1.79
1143	South Fork American River near Lotus, Calif	91	A	163	942	.74	696	5.7	10.0	1.24	.045	1.45
1144	do	55	A	165	958	.95	911	5.7	9.6	1.56	.045	1.42
1145	do	82	A	163	1,040	1.32	1,370	6.2	10.7	1.87	.045	1.33
1146	do	69	A	170	1,220	2.24	2,730	7.0	11.1	3.73	.045	1.39
1147	do	83	A	180	1,540	3.68	5,660	8.3	13.6	5.84	.045	1.38
1148	North Yuba River below Bullards Bar Dam, Calif	102	D	118	315	.68	215	2.7	4.1	1.01	.045	1.27
1149	do	103	D	121	405	1.32	536	3.3	4.9	2.03	.045	1.27
1150	do	96	A	136	702	2.48	1,740	5.1	7.4	4.11	.045	1.35
1151	do	85	A	146	807	3.05	2,460	5.4	7.9	5.02	.045	1.41
1152	do	67	A	158	1,170	4.42	5,170	7.3	9.5	7.63	.045	1.51
1153	do	44	A	163	1,320	5.06	6,680	7.9	10.9	8.56	.045	1.47
1154	do	65	A	189	2,080	6.59	13,700	10.7	14.5	12.70	.045	1.81
1161	Tuolumne River above Early Intake, Calif	193	A	96	617	.95	585	6.1	9.6	2.17		2.17
1163	do	204	D	126	1,040	3.76	3,910	7.7	13.5	7.98		2.19
1164	San Joaquin River below Kerchoff powerhouse, Calif	380	D	48	200	.42	83.1	3.7	6.3	.98		2.22
1165	Tuolumne River near Hetch Hetchy, Calif	441	A	126	474	1.40	663	3.7	5.6	2.88		2.32
1166	do	445	A	133	841	2.47	2,080	6.1	8.3	5.59		2.05
1167	do	444	D	144	1,180	4.32	5,100	7.9	10.8	7.31		1.43
1171	Southern California Electric Co. Borel Canal at Isabella Dam, Calif	387	C	14	64.4	1.45	93.1	4.3	4.6	1.62	.016	1.02
1172	do	409	C	14	74.2	2.18	162	4.9	5.3	2.31	.016	1.02
1173	do	410	C	14	93.8	3.76	353	6.1	6.7	3.91	.016	1.01
1174	do	411	C	14	98.0	4.21	413	6.4	7.0	4.40	.016	1.01
1175	do	415	C	14	111	5.18	575	7.1	7.9	5.49	.016	1.01
1176	American River Flume near Gamino, Calif	208	C	7.0	27.9	5.73	160	3.6	4.0	6.62	.012	1.03
1178	Cherry Creek Canal near Early Intake, Calif	49	C	7.7	8.5	1.45	12.3	1.1	1.4	1.75	.014	1.07
1179	do	55	C	8.0	11.4	1.80	20.5	1.4	1.8	2.28	.014	1.11
1180	do	51	C	8.5	14.0	2.10	29.4	1.6	2.1	2.62	.014	1.09
1181	do	46	C	11.5	37.1	3.83	142	3.2	4.3	4.68	.014	1.07

TABLE 5.—*Two-point (0.2d/0.8d) velocity discharge-measurement data*—Continued

Index No.	Station and location	District No.	Type of cross section	Width (ft)	Area (sq ft)	Mean velocity (fps)	Discharge (cfs)	Hydraulic radius (ft)	Maximum depth (ft)	Maximum point velocity (fps)	Roughness coefficient (n)	Alpha coefficient (α)
1182	El Dorado Canal near Kyburz, Calif.	307	C	16.3	63.5	2.16	137	3.9	5.1	2.75	0.020	1.15
1183	do.	305	C	16.7	69.3	2.19	152	4.1	5.4	2.65	.020	1.11
1184	Huntington-Shaver conduit at outlet, California	298	C	10.9	38.6	.80	30.8	3.4	4.0	1.15	.020	1.22
1185	do.	279	C	10.9	43.0	1.25	53.8	3.8	4.4	1.81	.020	1.22
1187	do.	254	C	10.7	46.5	2.49	116	4.0	4.7	3.29	.020	1.17
1189	Marble Fork Kaweah conduit 3 near Potwisha Camp, Calif.	224	C	6.0	10.4	4.27	44.4	1.6	1.8	5.23	.014	1.04
1192	do.	236	C	6.0	13.0	5.23	68.0	2.0	2.2	6.33	.014	1.05
1193	do.	243	C	9.3	12.9	3.10	40.0	1.4	1.6	3.82	.014	1.06
1195	do.	243a	C	9.5	22.7	4.28	97.1	2.3	2.6	4.99	.014	1.04
1196	Kern River canal 3 near Kernville, Calif.	640	C	8.5	22.2	6.26	139	2.5	2.7	7.80	.020	1.07
1197	do.	660	C	8.5	23.5	6.13	144	2.6	2.8	7.47	.020	1.07
1198	do.	652	C	8.5	37.1	7.25	269	4.0	4.4	8.42	.020	1.04
1199	do.	651	C	8.5	51.2	8.30	425	5.3	6.0	9.95	.020	1.04
1200	do.	661	C	8.5	70.2	8.87	623	6.9	8.4	10.14	.020	1.03
1201	Kern River conduit 1 near Democrat Springs, Calif.	189	C	8.1	21.1	4.49	94.8	2.4	2.6	5.34	.020	1.03
1202	do.	190	C	8.1	26.7	5.17	138	3.1	3.3	6.19	.020	1.04
1203	do.	206	C	8.1	32.6	5.58	182	3.7	4.0	6.58	.020	1.04
1204	do.	193	C	8.1	41.6	6.15	256	4.6	5.2	7.28	.020	1.04
1205	do.	207	C	8.1	58.3	6.54	381	6.1	7.2	7.62	.020	1.04
1207	Modesto Canal near La Grange, Calif.	320	C	19.8	78.0	3.90	304	3.9	4.3	4.37	.015	1.02
1209	do.	321	C	21.4	143	6.71	959	6.6	7.5	7.47	.015	1.03
1210	do.	316	C	22.4	173	7.69	1,330	7.6	8.7	8.59	.015	1.03
1212	Pacific Gas & Electric Co. conduit 3 below Bass Lake, Calif.	215	C	10.5	21.7	4.61	100	2.1	3.0	5.76	.015	1.08
1213	do.	213	C	11.5	27.2	5.84	159	2.4	3.5	7.25	.015	1.08
1214	Philadelphia Canal near Strawberry, Calif.	151	C	5.8	15.1	3.70	55.8	2.4	2.6	4.14	.015	1.03
1216	Southern California Electric Co. conduit on Tule River near Springville, Calif.	318	C	7.8	9.6	2.00	19.2	3.6	1.6	2.62	.025	1.10
1217	do.	317	C	8.5	12.2	2.23	27.2	1.4	1.9	2.88	.025	1.09
1218	do.	307	C	8.5	13.0	2.44	31.7	1.5	2.0	3.14	.025	1.09
1219	do.	316	C	9.1	15.1	2.41	36.4	1.7	2.3	3.08	.025	1.10
1220	Turlock Canal near La Grange, Calif.	509	C	31.0	89.8	3.83	344	2.9	3.5	4.68	.015	1.07
1222	do.	510	C	32.6	150	5.49	824	4.6	5.3	6.44	.015	1.04
1223	do.	511	C	32.7	200	6.30	1,260	6.1	6.9	7.46	.015	1.03

1224	do	515	C	33.5	254	6.46	1,640	7.5	8.6	7.63	.015	1.03
1225	do	512	C	34.6	293	6.79	1,990	8.3	9.6	7.80	.015	1.04
	San Joaquin River below Kerckhoff powerhouse, Calif	219		86	1,510	8.01	12,100	13.1	24.9	12.42		1.41
	do	303		84	1,140	6.10	6,950	11.6	20.3	9.32		1.38
	do	336		78	970	5.00	4,850	10.4	17.5	7.64		1.36
	do	373		65	616	2.82	1,740	8.0	12.7	4.39		1.54
	do	375		62	342	1.36	464	4.9	9.0	2.60		1.72
	do	381		61	500	2.34	1,170	6.9	11.3	4.02		1.59
	do	385		65	618	2.85	1,760	8.1	13.0	4.77		1.56
	do	386		67	591	2.84	1,680	7.7	12.7	4.47		1.51
	do	387		66	604	2.93	1,770	7.7	12.8	4.74		1.59
	do	390		48	189	.36	68.6	3.5	6.0	.83		2.30
	Trinity River near Hoopa, Calif	2		140	787	1.05	827	5.5	7.9	2.00		1.82
	do	20		217	1,800	5.89	10,600	8.1	13.2	9.92		1.52
	do	28		209	1,860	5.43	10,100	8.7	14.4	9.30		1.59
	do	29		199	1,730	4.74	8,200	8.5	13.8	8.37		1.70
	do	31		185	1,500	3.67	5,510	8.0	12.4	6.98		1.92
	do	32		175	1,400	3.38	4,730	7.8	11.8	6.45		1.92
	do	33		162	1,200	2.47	2,960	7.2	10.6	4.68		1.85
	do	34		154	1,060	1.96	2,080	6.8	9.8	3.51		1.79
	do	36		144	853	1.22	1,040	5.8	8.4	2.24		1.88
	do	37		142	820	1.12	915	5.7	8.1	2.04		1.76
	do	60		193	1,660	4.69	7,780	8.4	13.5	7.89		1.60
	do	61		226	2,090	6.03	12,600	9.0	15.5	10.54		1.57
	do	62		184	1,520	4.16	6,320	8.1	13.0	7.25		1.62
	do	63		205	1,810	5.40	9,780	8.7	14.5	9.43		1.58
	do	64		155	1,210	2.85	3,450	7.7	10.4	5.31		1.83
	do	69		465	4,060	8.03	32,600	8.6	19.0	10.83		1.18
	do	70		266	2,140	7.10	15,200	7.9	15.0	11.36		1.43
	do	71		208	1,750	6.00	10,500	8.2	14.5	10.30		1.54
	do	72		147	1,080	2.51	2,710	7.2	10.0	4.37		1.71
	do	207		150	837	1.16	974	5.5	8.1	2.70		2.46
	do	208		142	740	.84	626	5.1	7.2	2.22		2.97
	do	210		182	1,350	3.13	4,230	7.3	11.2	6.23		2.00
	do	211		180	1,410	3.52	4,970	7.6	12.0	6.85		1.71
	do	213		182	1,360	2.95	4,010	7.3	11.6	6.09		2.14
	do	214		220	1,900	5.74	10,900	8.5	14.5	9.98		1.67
	do	215		158	963	1.71	1,650	6.0	9.1	3.16		1.74
	do	216		298	784	.51	403	2.6	4.0	.62		1.09
	do	217		340	611	.87	534	1.8	3.6	1.72		1.44
	do	218		178	531	.83	441	3.0	4.2	1.30		1.36
	do	219		465	2,530	5.57	14,100	5.4	16.5	8.21		1.24
	do	220		466	2,660	5.56	14,800	5.6	16.0	8.21		1.29

TABLE 5.—*Two-point (0.2d/0.8d) velocity discharge-measurement data*—Continued

Index No.	Station and location	District No.	Type of cross section	Width (ft)	Area (sq ft)	Mean velocity (fps)	Discharge (cfs)	Hydraulic radius (ft)	Maximum depth (ft)	Maximum point veocity (fps)	Roughness coefficient (n)	Alpha coefficient (α)
	Trinity River near Hoopa, Calif	221		475	4,450	8.09	36,000	9.2	16.9	10.42		1.12
	do	222		475	4,520	7.88	35,600	9.4	18.0	10.42		1.13
	do	224		300	1,700	5.16	8,780	5.6	8.7	8.41		1.38
	do	225		300	1,770	5.41	9,570	5.8	9.2	9.20		1.38
	do	226		234	1,190	5.24	6,230	5.0	9.6	9.60		1.80
	do	227		140	461	3.43	1,580	3.2	5.8	6.77		1.96
	do	257		161	394	1.30	511	2.4	3.7	1.98		1.33
	do	258		120	516	2.17	1,120	4.2	7.5	4.32		2.06
	do	259		140	695	3.55	2,470	4.9	8.0	6.64		1.72
	do	260		190	1,300	4.42	5,740	6.7	12.8	9.34		2.38
	do	262		284	2,180	6.33	13,800	7.6	16.3	11.82		1.75
	do	263		255	1,870	5.99	11,200	7.2	15.8	11.76		1.87
	do	264		184	1,170	3.25	3,800	6.2	11.5	7.55		2.62
	do	265		130	605	1.37	829	4.6	8.0	3.49		2.92
	do	266		155	352	1.26	445	2.3	3.7	2.34		1.71
	Sacramento River near Red Bluff, Calif	202		574	11,600	6.91	80,200	19.9	24.7	10.28		1.31
	do	241		580	11,800	6.62	78,100	20.1	25.2	9.42		1.26
	do	252		550	8,460	4.99	42,200	15.2	18.3	7.36		1.30
	do	253		542	7,170	4.49	32,200	13.1	16.3	6.63		1.31
	do	257		519	4,370	3.02	13,200	8.3	12.0	4.26		1.31
	do	262		511	2,700	1.62	4,390	5.2	8.8	2.39		1.32
	do	265		527	5,820	4.00	23,300	10.9	14.4	5.62		1.31
	do	266		578	11,300	6.90	78,000	19.2	23.7	10.03		1.32
	do	267		519	4,440	3.15	14,000	8.5	12.0	4.43		1.28
	do	275		526	5,050	3.68	18,600	9.5	13.4	5.19		1.26
	do	276		527	5,690	4.06	23,100	10.7	14.4	5.82		1.29
	do	277		520	4,830	3.35	16,200	9.2	12.4	4.65		1.25
	do	278		517	4,540	3.26	14,800	8.7	12.3	4.48		1.24
	do	281		511	2,460	1.51	3,710	4.8	8.2	2.18		1.33
	do	288		504	1,940	1.09	2,110	3.8	7.3	1.77		1.39
	do	293		509	2,260	1.37	3,090	4.4	7.7	2.05		1.34
	do	295		513	3,720	2.59	9,650	7.2	10.6	3.67		1.26
	do	296		510	3,110	2.08	6,480	6.1	9.4	2.94		1.27
	do	299		510	2,810	1.88	5,270	5.5	8.9	2.71		1.25
	do	303		511	3,020	2.01	6,070	5.9	9.5	2.94		1.28
	do	306		517	5,370	3.78	20,300	10.2	13.8	5.20		1.25

do	315		509	2,740	1.66	4,550	5.4	8.6	2.40		1.30
do	316		517	5,580	3.96	22,100	10.6	14.2	5.67		1.27
do	331		513	3,860	2.64	10,200	7.5	10.8	3.65		1.29
do	332		512	3,520	2.29	8,050	6.8	10.0	3.31		1.34
do	333		511	3,780	2.58	9,750	7.3	10.6	3.58		1.27
do	337		509	3,070	2.04	6,260	6.0	9.5	2.94		1.32
do	343		506	3,640	2.44	8,900	7.1	10.4	3.45		1.31
do	349		507	2,840	1.86	5,270	5.6	8.7	2.70		1.29
Tuolumne River above La Grange Dam, Calif.	448		87	423	2.04	864	4.7	8.2	2.93		1.32
do	451		91	999	7.59	7,580	10.2	14.0	10.64		1.28
do	459		92	156	1.19	186	1.7	2.9	2.00		1.25
do	465		87	358	1.35	485	4.0	7.3	1.92		1.26
do	470		87	327	1.04	340	3.6				1.28
do	471		89	458	2.60	1,190	5.0				1.31
do	475		122	912	9.19	8,380	7.2				1.25
do	476		114	644	7.42	4,780	5.5				1.23
do	477		90	760	4.58	3,480	8.0				1.24
do	478		90	659	3.41	2,250	7.0				1.30
do	479		89	795	4.82	3,830	8.4				1.24
do	480		92	952	6.70	6,380	9.6				1.19
do	481		97	1,020	7.22	7,360	10.0				1.24
do	482		97	1,050	7.43	7,800	10.2				1.27
do	491		86	469	1.24	580	5.1				1.37
do	492		90	674	3.68	2,480	7.2				1.28
do	494		90	747	4.35	3,250	7.7				1.23
do	500		87	443	1.09	484	4.9				1.30
do	503		93	995	7.42	7,380	10.1				1.26
do	504		98	1,180	8.56	10,100	11.2				1.33
do	506		92	856	5.36	4,590	8.8				1.24
Mokelumne River near Lancha Plana, Calif.	1197		121	886	.75	661	7.0	9.7	1.30		1.47
do	1198		122	895	.77	686	7.1	9.8	1.29		1.38
do	1199		123	929	1.10	1,020	7.3	9.7	1.81		1.41
do	1214		125	941	1.25	1,180	7.3	10.0	2.08		1.41
do	1219		122	885	.78	695	7.0	9.8	1.25		1.29
do	1235		180	2,390	5.86	14,000	12.7				1.62
do	1236		135	1,080	2.12	2,290	7.8				1.52
do	1237		134	1,080	1.94	2,090	7.8				1.45
do	1238		149	1,420	3.48	4,950	9.2				1.71
do	1239		132	1,100	2.21	2,430	8.0				1.61
do	1241		130	998	1.79	1,790	7.4				1.55
do	1242		133	1,100	2.48	2,730	8.0				1.73
do	1257		133	1,080	2.29	2,470	7.8				1.84
do	1258		138	1,230	2.69	3,310	8.5				2.10
do	1259		129	1,010	1.88	1,900	7.5				1.75