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GENERALIZED REGIME-TYPE ANALYSIS
OF ALBERTA RIVERS

BY

© DALE I. BRAY

A THESIS

SUBMITTED TO THE FACULTY OF GRADUATE STUDIES AND RESEARCH

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The undersigned certify that they have read, and recommend to the Faculty of Graduate Studies and Research for acceptance, a thesis entitled GENERALIZED REGIME-TYPE ANALYSIS OF ALBERTA RIVERS submitted by DALE I. BRAY in partial fulfilment of the requirements for the degree of Doctor of Philosophy.

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Date March 14, 1972.................

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ABSTRACT

Basic data from 95 gravel and sand-bed river reaches in Alberta, Canada, are utilized in a generalized regime type analysis. Five to ten cross-sections are used to compute average channel properties for each reach. The majority of the slopes are average field slopes based on a reach length of from 10 to 40 channel widths. Reaches are only accepted for analysis if the hydrometric record is at least five years in length. All bed material data for the gravel reaches are based on a grid-by-number analysis. The major part of the analysis is for the 71 gravel-bed reaches.

After considering several definitions of a dominant discharge, the 2 year flood (log-normal distribution) is accepted as the hydrologically defined dominant discharge. The discharge corresponding to the elevation of the valley flat is accepted as the dominant discharge defined by a geomorphic feature.

The equations of Lacey, Blench, Henderson and Kellerhals are tested for the gravel river reaches for the two dominant discharges.

Best fit exponential expressions are developed to predict the width, area, depth, form factor, mean velocity, slope and Manning "n". From one to three parameters are introduced as independent variables in each case. The area-discharge and width-discharge relations are found to be well defined, whereas the slope-discharge relation is highly variable. The implication is that channels essentially are capable of maintaining an orderly cross-sectional adjustment regardless of the state of the

slope adjustment. When a characteristic bed material size is introduced as an independent variable the results based on the median size (DG50) are as good as those for the DG90 size.

The detailed goemorphic description of the reaches are used to stratify the data in an attempt to obtain better results for the slope-discharge relations.

Dimensionless ratios or numerics are developed for the case of a river flowing in deep alluvium. Dimensionless expressions of an exponential form are evaluated and compared with similar expressions obtained from the best fit relations for the gravel reaches. The field data are compared with the dimensionless plots from the Cooper analysis of world flume data.

Eight sets of regime equations for mean width, mean depth, mean velocity, and slope in terms of discharge and median bed material size are developed by considering different sets of three independent equations based on the data for the gravel river reaches. The width, depth, velocity, and slope estimated from the basic form of the Lacey equations, the Kellerhals equations, or a dimensionless set of equations not involving a viscosity term agree quite favourably with the estimates made by using the best fit equations.

"One knows that until now our understanding of hydraulics has been extremely limited; for however many great geniuses have applied themselves to it at different times, we are still, after so many centuries, in almost absolute ignorance of the true laws to which the movement of water is subject; after one hundred fifty years one has barely discovered, with the aid of experiment, the duration, the quantity, and the velocity of the flow of water from a given orifice. All that concerns the uniform course of the waters of the surface of the earth is unknown to us; and to obtain an idea of how little we do know, it will suffice to cast a glance over what we do not.

"To estimate the velocity of a river of which one knows the width, the depth, and the slope; to determine to what height it will rise if it receives another river in its bed; to predict how much it will fall if one diverts water from it; to establish the proper slope of an aqueduct to maintain a given velocity, or the proper capacity of the bed to deliver to a city at a given slope the quantity of water which will satisfy its needs; to lay out the contours of a river in such a manner that it will not work to change the bed in which one has confined it; .... All these questions, and infinitely many others of the same sort, are still unsolvable: who would believe it? ..."

Du Buat, 1786 [from Rouse and Ince (1957)]

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LIST OF SYMBOLS AND ABBREVIATIONS

A	Cross-sectional area of water in ft^2
a_{50}	Median value of a variable a
AM	Mean cross-sectional area of water for reach in ft^2
B	Mean width in ft.
B50	Median bed material size for grid-by-number analysis in mm.
C_b	Charge in ppm. (Essentially concentration of bed material in transport). Also denoted as C, and Ctb.
cfs.	Cubic feet per second
c.v.	Coefficient of variation
Cw	Concentration of wash load in ppm.
D	Depth (A/WS) in ft.
D50	Median bed material size for sieve analysis by weight in mm.
DG	Bed material size in ft. (Grid-by-number for gravels, and bulk sieve analysis for sands).
DM	Mean depth for reach (AM/WSM) in ft.
f	The Lacey silt factor in $ft.^{0.500}$ (Lacey originally used $in.^{0.500}$)
F	F-ratio from analysis of variance
Fb	Blench bed factor (VM^2/DM) in ft/sec^2
FD	Flow duration (e.g. 1% FD)
FF	Form factor (WSM/DM)
Fs	Blench side factor (VM^3/WSM) in ft^2/sec^3
ft.	Feet
g	Acceleration due to gravity in ft/sec^2
GBN	Grid-by-number analysis of bed material

LIST OF SYMBOLS AND ABBREVIATIONS (continued)

GBNP	Grid-by-number from photograph analysis of bed material
GBW	Grid-by-weight analysis of bed material
H	Depth (A/B) in ft.
in.	Inch
lb.	Pound
LLB	Low level bench (and/or trim line)
LTM	Long-term mean discharge based on annual records
mi.	Mile
mm.	Millimeter
n	Manning "n" defined by $n = 1.486 \cdot DM^{0.667} \cdot S^{0.500}/VM$
N	Sample size
P	Wetted perimeter in ft.
PHI	-Log2 (DG) where DG is expressed in mm.
ppm	Parts per million by weight
Q	Discharge in ft^3/sec.
R	Hydraulic radius (A/P) in ft.
R	Correlation coefficient for multiple linear regression
r^2	Coefficient of determination
s	Second
S	Sieve analysis by weight of a volumetric sample of bed material
S	Slope for the reach in ft/ft.
SCOR	Slope correction parameter. See SECTION 4.5.
S.E.	Standard error (expressin in log units for all exponential relations)

sec.	Second
THRES	A threshold parameter (VM/VMCRIT) where VMCRIT is based on the Cooper criterion. (See SECTION 4.5).
V	Mean velocity in ft/sec.
VF	Valley flat
VISK	Kinematic viscosity in ft^2/sec.
VM	Mean velocity for the reach in ft/sec.
VMCRIT	Critical mean velocity for initiation of motion in ft/sec.
WS	Water surface width in ft.
WSM	Mean water surface width for the reach in ft.
X...	Non-dimensional factors describing the shape and distribution of the bed material
YF	Year flood (e.g. 2 YF)
γ	Specific weight of water in lb/ft^3
γ'	Submerged specific weight in lb/ft^3
ν	Kinematic viscosity of water in ft^2/sec.
ρ	Mass density of water in lb.sec.$^2/ft^4$
ρ_s	Mass density of sediment in lb.sec$^2/ft^4$
φ	A function of ...

INTRODUCTION

1.1 The Problem

Rivers are not rigid boundary open channels, but must be considered to be mobile bed channels which have become adjusted, or are becoming adjusted to an imposed discharge spectrum of the water-sediment complex.

A channel which has attained a state of relative stability or equilibrium over a period of years is defined as a regime channel or a channel which is in regime.

The regime geometry is defined by the average width, depth, and slope for a stable reach which results from some characteristic flow of the water-sediment complex.

The main purpose of this investigation is to develop equations to predict the regime geometry of a channel based on data from relatively stable Alberta river reaches.

1.2 General Method of Analysis

There are two possible approaches to the problem which may be used: a deductive approach and an inductive approach. The deductive approach is based on a physical or conceptual model which attempts to explain the phenomenon under investigation. The results are then applied to all cases for the general class of problems encompassed by the model. The inductive approach is based on measurements of natural channels, canals, or models which are stable or in regime. The data are classified and analysed to obtain generalized relations from which specific evaluations are made. Since the phenomenon under investigation is very complex and difficult to define in detail, the inductive approach has been used to obtain regime type equations from stable river reaches. The analysis is based on average reach measurements in conjunction with broad geomorphic and geographic classifications and with general hydrologic parameters.

1.3 Systematic Collection of River Data

In 1961 the Water Resources Division, Alberta Department of the Environment, started to survey selected reaches of gravel rivers in Western Alberta. In 1966 the Highway and River Engineering Division of the Research Council of Alberta extended the program to cover approximately 100 reaches containing hydrometric gauging stations distributed throughout the province. The data used in this investigation were derived mainly from these long-term collection programs.

The writer has built on the work of these organizations to devise a standard data collection format for field parties and a standard office procedure for reducing the field data for analysis.

Special emphasis was placed on utilizing high quality data with regard to the hydrology, the cross-sections, the slope, the bed material properties and the geomorphology for each river reach. Some of the basic data were coded to provide a means of evaluating the relative quality of the data.

1.4 Scope of the Analysis

One of the main purposes of this study is to provide the basic data for testing the established theories available to predict the regime geometry of a river. The data also provides the basis for suggesting alternative regime type equations. An important aspect of this investigation is the classification of the rivers according to readily available geomorphic and geographic criteria in order to stratify the data for the analyses.

No attempt was made to predict changes in channel plan; that is, the meander pattern resulting from a change in the flow of the water-sediment complex.

Essentially no data were available concerning the sediment transport in the channel; consequently, no detailed evaluation of the effect of charge (concentration of bed material) has been incorporated into the analysis.

The data were used to test the regime equations of Lacey (1929, 1933), Blench (1941, 1969a) and Kellerhals (1967) and the equations proposed by Henderson (1961).

Relations between width, area, depth, form factor, velocity, slope and Manning "n" were established for various characteristic discharges and bed material sizes. Finally, various dimensionless equations were established between the variables for which data were available.

Most of the work related to natural channels or canals has been for the general class of sand-bed channels. This investigation considers some sand-bed channels, but the majority of the reaches considered for the analysis are located on gravel rivers. Special emphasis was placed on organizing the bed material data in a uniform manner.

Some specific topics which have been considered in conjunction with the development of generalized "regime type" equations for Alberta rivers are those related to:

1. A consistent criterion for dominant discharge.
2. The effect of the definition a characteristic bed material size on regime geometry.
3. The effect of different channel environments on the regime geometry.

Some of the practical uses of the results of this investigation could be:

1. To predict the type of adjustments that might be expected in a river as a result of major engineering works.
2. To obtain a general understanding of the relevant factors controlling the regime geometry of a river.

1.5 The Organization of this Report

This report is organized so that a brief survey of the literature related to the topic of river regime is presented in the next chapter. CHAPTER 3 presents a detailed description of the systematic collection and coding of the data for the river reaches. CHAPTER 4 outlines the method of analysis and CHAPTER 5 presents the results of the analysis. The final chapter summarizes these results and states the conclusions reached.

The technical details of procedure, the tables of basic data, the computer programs, the detailed examples, etc., are relegated to appendices.

CHAPTER 2

SURVEY OF LITERATURE

2.1 General

This chapter reviews selected basic works related to different aspects of river behavior. The work of some investigators will be considered in greater detail in CHAPTER 5.

Leliavsky (1955) summarized much of the early work related to fluvial hydraulics. He considered that there were two basic approaches to the problem -- one based on physical reasoning, and the other based on field observations. A third approach could also be considered, since the results obtained from flume experiments and mobile-bed models have been used to study certain problems related to river behavior.

Fluvial geomorphology provides a common meeting place for the engineer and the geomorphologist. Only recently has the hydraulic engineer recognized the contributions of the geomorphologist and the geologist. Lane (1955a) helped to introduce the concepts of fluvial geomorphology to river engineers in North America by illustrating some simple trend type predictions.

A historical development and a summary of much of the current knowledge related to the understanding of rivers were given by Leopold, Wolman, and Miller (1964) and Morisawa (1968). Raudkivi (1968) and Graf (1971) presented some background related to loose boundary hydraulics. Frenette and Harvey (1968) have compiled a comprehensive bibliography pertaining to the various aspects of river engineering.

This survey of literature associated with the topic of the channel or regime geometry of rivers is outlined under the following headings:

1. Concept of grade
2. Dominant discharge
3. Approaches to the study of channel geometry
4. Geologic and geomorphic constraints on channel geometry
5. Systematic evaluation of river regime

An effort has been made to select the more important references rather than to present an exhaustive survey of each topic. No review will be given for the vast amount of literature pertaining to the related fields of flow in rigid boundary channels, sediment transport, etc.

2.2 Concept of Grade

Davis (1902) employed the term "grade" for the balanced condition or state of equilibrium of a mature or old river. In this case the mature river is characterized by a relatively smooth longitudinal profile with the absence of rapids or falls. In the early 1940's the concept of grade was challenged by Kesseli (1941). Mackin (1948) closed the argument for some years with the following definition of grade:

> "A graded stream is one in which, over a period of years, slope is delicately adjusted to provide, with available discharge and with prevailing channel characteristics, just the velocity required for the transportation of the load supplied from the drainage basin. The graded stream is a system in equilibrium; its diagnostic characteristic is that any change in any of the controlling factors will cause a displacement of the equilibrium in a direction that will tend to absorb the effect of the change."

He recognized that grade was not as static as some of the earlier proponents considered it to be. His emphasis was placed on slope adjustment.

Rubey (1952) was of the opinion that the adjustment of a channel may either be in slope or cross-section. He stated:

> "It is not improbable that the precise form taken by the adjustment (of the river reach) is governed by something like the principle of least work and depends upon whether equilibrium can most readily be maintained by a change of slope or a change of cross-section.
>
> "... if the slope of a stream were determined inflexibly by the discharge and load, streams would be unable to adjust themselves as closely as they do to structural slopes and to earlier land surfaces. Without some such a means of adjustment to pre-existent slopes - if a certain discharge and load necessarily meant a certain stream profile - it seems that the flat slopes that would be required for some streams would make gorges and canyons far more numerous than they actually are in many regions, and, conversely, that many rivers would be compelled to build steep slopes that would raise their banks high above the intermediate lowlands which they traverse.
>
> "Even if these imposed conditions (discharge, load, grain size, and degree of sorting) are precisely the same for two streams, it does not necessarily follow that their graded slopes must be equal."

A further development of interest is the concept of "quasi-equilibrium" presented by Leopold and Miller (1956). They stated:

> "If a particular valley had been carved during the Pleistocene by a relatively large river, and through a change in climate and other physiographic factors the valley at present carries only a minor streamlet, it is likely that the small stream would not be able to recarve the valley bed to such an extent that the valley slope is materially altered. In such a circumstance the minor stream, initially at least, would have to accommodate itself to the slope of the valley in which it flows.
>
> "... nearly all rivers approach a condition of quasi-equilibrium which was formerly attributed only to a graded stream.
>
> "... if the degrees of freedom of the hydraulic parameters are reduced, the remaining factors tend toward a mutual accommodation or quasi-equilibrium."

Chorley (1962) considered the possibility of short term adjustment by viewing the fluvial process to be an open system. He stated:

> "Besides adjusting the general slope of its channel by erosion and deposition, a stream can very effectively and almost instantaneously control its transverse channel characteristics, together with its efficiency for the transport of water and load, by changes in depth and width of the channel.... It may be that a stream or reach may be virtually always adjusted, in the sense of being graded or in a steady state, without necessarily presenting the smooth longitudinal profile considered by the advocates of the geomorphic cycle as the hallmark of the 'mature graded condition'."

The last sentence in the quote by Chorley adequately summarizes the change in the concept of grade which has taken place over the last 70 or 80 years.

2.3 Dominant Discharge

In the case of a canal, the discharge may be maintained at a relatively constant value and the channel will become adjusted to this sustained discharge. A natural channel on the other hand is subjected to a whole spectrum of discharges. Several attempts have been made to define a dominant discharge for such cases.

Inglis (1941) states that:

> "Dominant discharge is the discharge which controls the meander length and breadth. It appears to be slightly in excess of bankfull stage."

Later Inglis (1949) used the term dominant discharge as the discharge at which equilibrium is most nearly approached. He stated that the dominant discharge:

> "... may be looked on as the integrated effect of all varying conditions over a long period of time. At this discharge with its associated dominant charge, slope and water temperature, the channel may be looked on as possessing a year to year stability."

Leopold and Maddock (1953) found that the mean annual discharge could be used as a representative or characteristic discharge when determining the width-discharge, depth-discharge, and velocity-discharge relations. FIGURE 2.1 illustrates that the functional forms of these relations when using discharges exceeded 1, 10, 30 or 50 percent of the time were very similar to those obtained by using the mean annual discharge; however, the coefficients differed. Leopold and Maddock do not imply that the mean annual discharge can be considered a dominant or formative discharge.

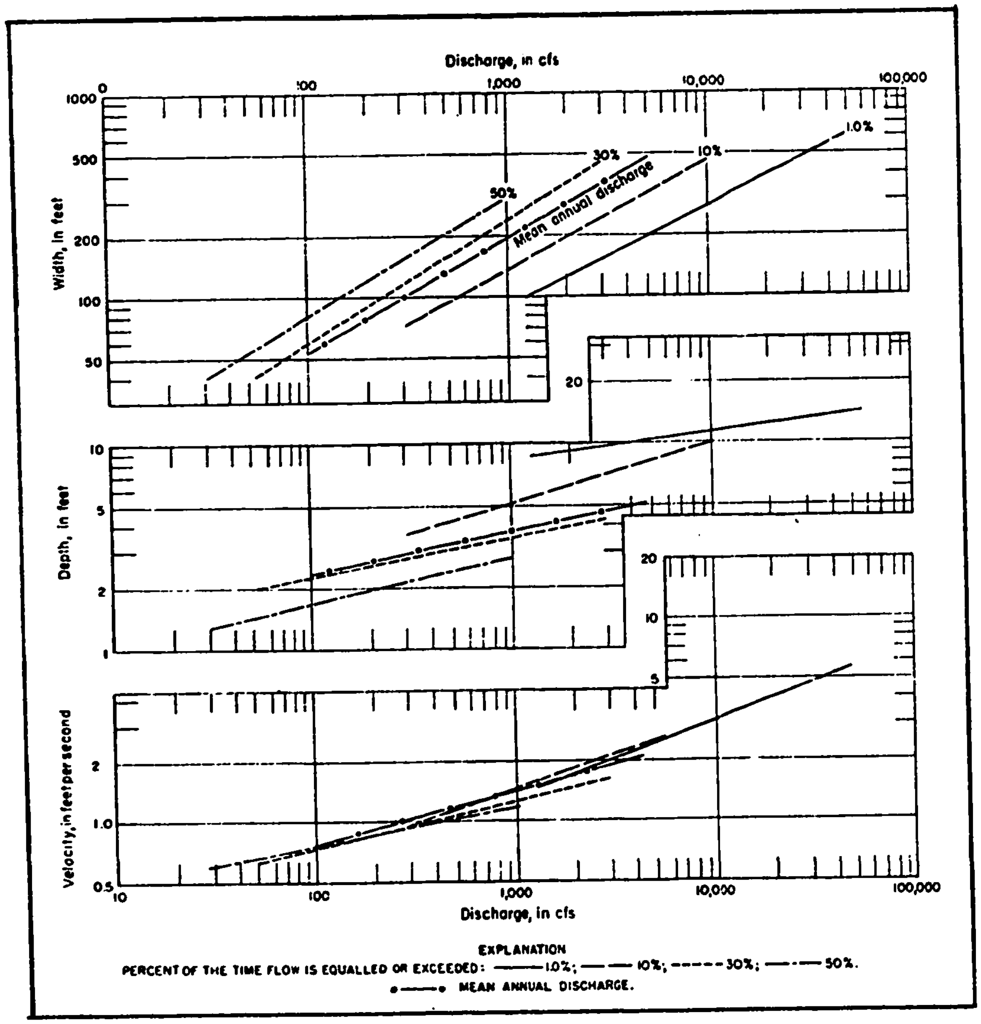
Nixon (1959) used bankfull discharge as the dominant discharge in an analysis of 29 British rivers. He found that for these rivers the bankfull discharge on the average corresponded to the discharge that was exceeded 0.6 percent of the time; however, the scatter was appreciable.

Dury (1961) showed that the bankfull discharge along two relatively large American rivers could not be defined by a discharge that was exceeded by a constant percent of the time. As the drainage area increased the bankfull discharge was exceeded an increasingly larger percent of the time.

Leopold, Wolman and Miller (1964) stated that:

"... the most meaningful discharge for any discussion of channel morphology is that which forms or maintains the channel. .... this is a complex relationship but that the effective discharge can often be approximated by bankfull discharge. In many rivers the bankfull discharge is the one that has a recurrence interval of about 1.5 years."

Harvey (1969) studied three relatively small streams in Southern



NOTE: Data from the Maumee and Scioto River Basins, Ohio, U.S.

FIGURE 2.1 WIDTH, DEPTH AND VELOCITY IN RELATION TO THE DISCHARGES THAT ARE EXCEEDED 1, 10, 30, and 50 PERCENT OF THE TIME, AND TO THE MEAN ANNUAL DISCHARGE [FROM LEOPOLD AND MADDOCK (1953)]

England and suggested that:

> "... flood regime stream segments appear to exhibit adjustment to the 1 to 2 year flood but with less frequent flooding downstream. Baseflow streams appear to be adjusted to rarer floods."

Several definitions of dominant discharge have been made which consider the transport of sediment rather than a characteristic discharge. These definitions have been primarily confined to sand-bed channels.

Prins (1969) outlined several methods of estimating dominant discharge by considering the flow duration data in conjunction with bed-load transport. FIGURE 2.2 illustrates the distribution of bed-load transport with stage when considered over a period of time, for example, a year or two.

Prins considers that the dominant stage (or discharge) may be defined in any of the following four ways:

1. The stage corresponding to the center of gravity of the bed-load distribution curve, or

2. The stage corresponding to the median value of the bed-load distribution curve; that is, the stage above which half and below which half of the total bed-load is transported, or

3. The stage corresponding to the peak value of the bed-load distribution curve, or

4. The stage that would produce the same amount of bed-load transport during a year under steady conditions; that is, the stage which if occurring for a year, would produce an equal area under the bed-load distribution curve.

Marlette and Walker (1968) essentially accepted the second definition given above to compute a dominant discharge at the

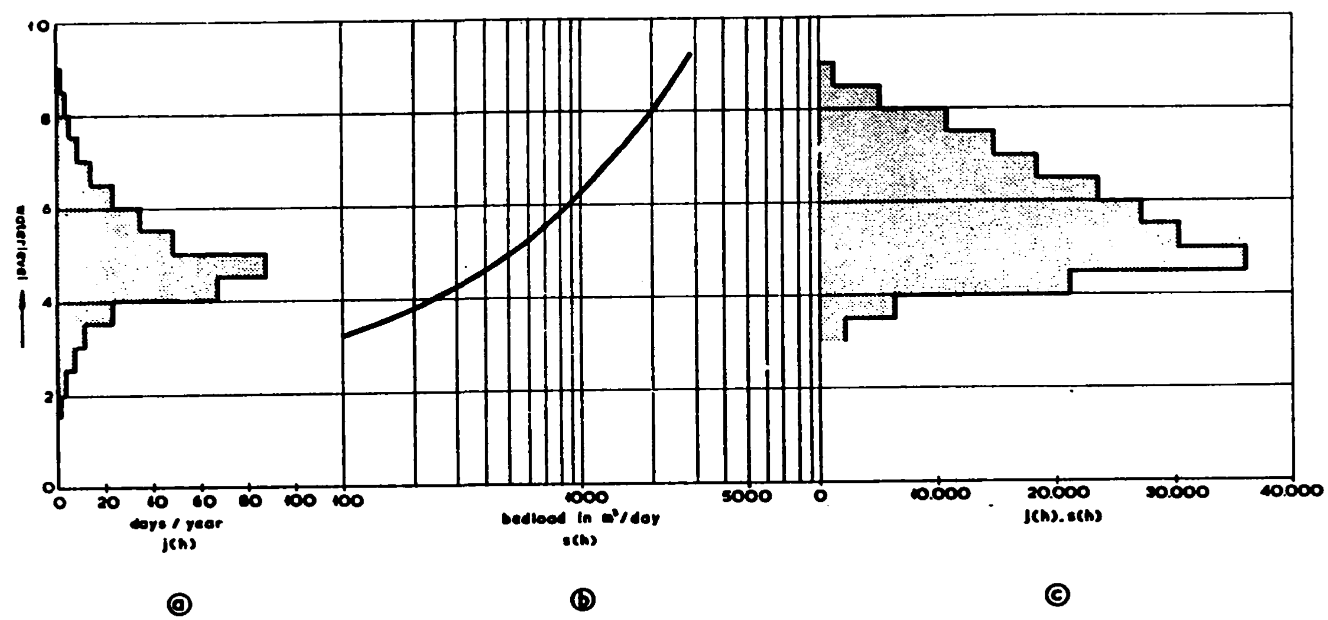


FIGURE 2.2 DISTRIBUTION OF STAGE WITH TIME, RELATION BETWEEN BED-LOAD TRANSPORT AND STAGE, AND DISTRIBUTION OF TOTAL BED-LOAD TRANSPORT OVER A PERIOD OF TIME WITH STAGE [FROM PRINS (1969)]

Platte-Missouri confluence. They employed the Frijlink (1952) bed-load transport equation in the analysis.

The fourth definition of a dominant discharge was used by Blench (1957) when he stated:

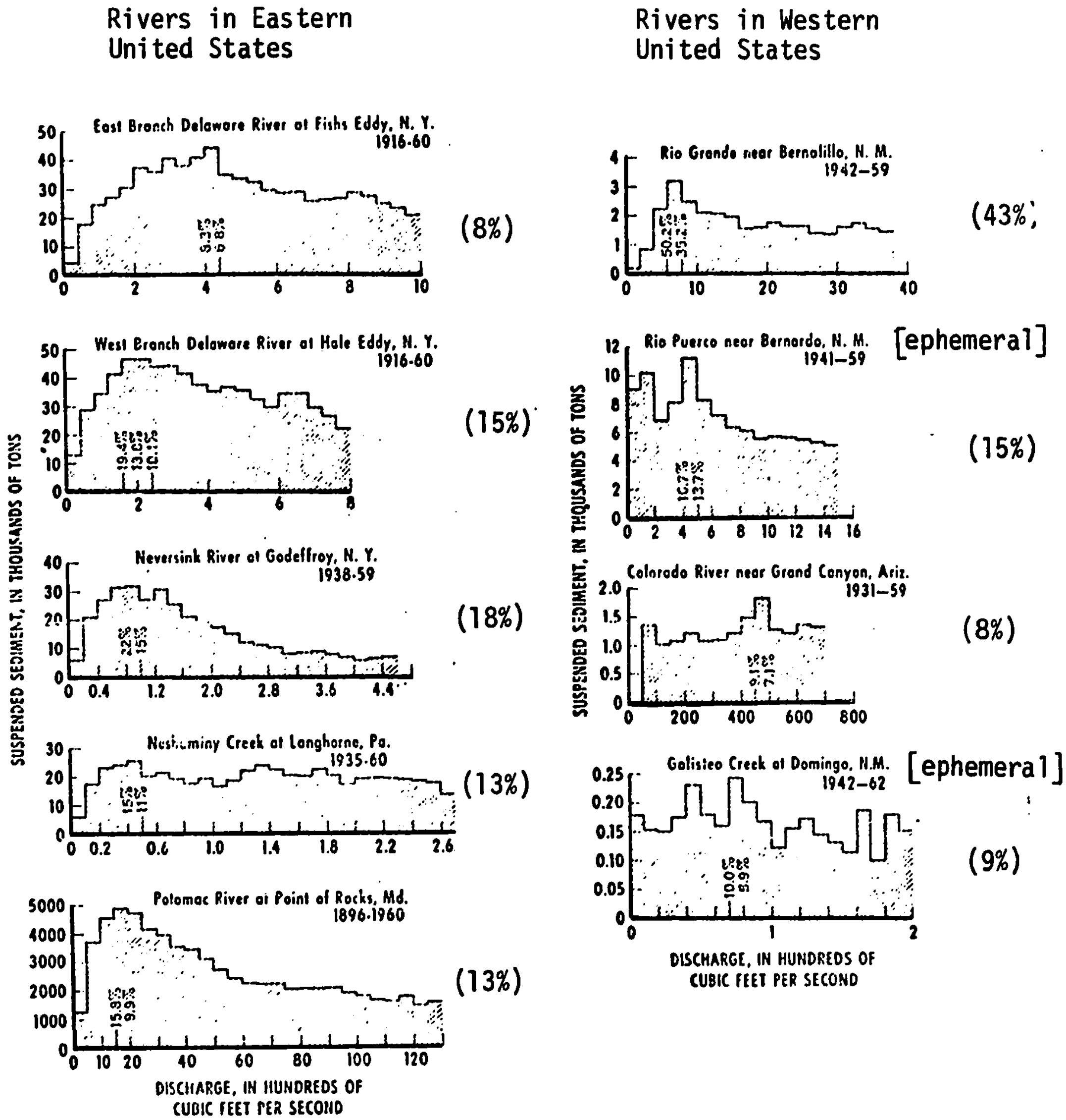
> "Algebraically, it is always possible, to select some discharge less than maximum, in a fluctuating canal, associate it with a bed factor less than maximum, and insert them in the regime slope formulas to derive a bedload charge, that multiplied by the discharge, gives the average load of any long period."

Benson and Thomas (1966) defined a dominant discharge as the discharge at which the maximum suspended sediment is transported. They used measured suspended sediment at gauging stations rather than computed bed-load for their analysis. FIGURE 2.3 shows plots of suspended sediment load versus discharge for five gauging stations in the Eastern United States and for four in the Western United States. The flow duration corresponding to the peak transport of suspended sediment was approximately 12 percent, although the peak was often ill-defined. Using this criterion Benson and Thomas concluded that the dominant discharge was much less than bankfull for many rivers.

In summary, there is no generally accepted definition of a dominant discharge. Most investigators do, however, associate the dominant or formative discharge with one which is capable of moving bed material through the channel.

2.4 Approaches to Study of Channel Geometry

Several distinct approaches have been used by geologists, geomorphologists and engineers to estimate width, depth and slope in



<u>NOTE</u>:

The bracketed value to the right of each plot is the percent of the time that the discharge corresponding to the peak of the histogram is exceeded based on daily flow duration data.

FIGURE 2.3 VARIATION OF SUSPENDED-SEDIMENT WITH DISCHARGE FOR FIVE RIVERS IN EASTERN UNITED STATES AND FOUR RIVERS IN WESTERN UNITED STATES [AFTER BENSON AND THOMAS (1966)] natural and artificial channels.

This section will briefly mention the various contributors. TABLE 2.1 summarizes the main equations or form of equations presented by these investigators. The symbols in TABLE 2.1 are not necessarily those originally given, since all relations are presented on a uniform basis.

One of the earliest contributions resulted from measurements on a canal system in the Indo-Gangetic Plain. Kennedy (1895) used this data to present a simple exponential relation between velocity and depth for stable canals. Lindley (1919) who was also working on the Indian canals made a statement which served as the basis of the thinking of the "regime" school by stating that:

> "When an artificial channel is used to convey silty water, both bed and banks scour or fill, changing depth, gradient and width until a state of balance is attained at which the channel is said to be in regime. The regime dimensions depend on discharge, quantity and nature of bed and berm silt, and rugosity of the silted section; rugosity is also affected by velocity, which determines the size of wavelets into which the silted bed is thrown."

This statement became the basis for obtaining three independent equations to satisfy the three degrees of freedom required for equilibrium.

Lacey (1929, 1933) used Indian data from stable sand-bed canals and some rivers in deep alluvium to develop equations relating wetted perimeter, hydraulic radius, and slope to discharge and a "silt factor" (a function of the bed material size).

TABLE 2.1

REGIME TYPE EQUATIONS AND OTHER EQUATIONS RELATED TO THE HYDRAULIC GEOMETRY OF RIVER REACHES

Investigator	Equation	Q	Comments
Kennedy (1895)	$V = 0.84 \cdot H^{0.64}$	FS	Based on data from one Indian sand-bed canal system, the Kutter Equation was used to determine slope. Note: Width adjustment not accounted for by Kennedy.
Lindley (1919)	$V = 0.95 \cdot H^{0.57}$ $V = 0.57 \cdot B^{0.355}$	FS	Based on 786 observations from one Indian sand-bed canal system, the Kutter equation was used to determine slope.
Lacey (1929, 1933)	$P = 2.67 \cdot Q^{0.50}$ $V = 1.17 \cdot f^{0.500} \cdot R^{0.500}$ $V = 16.0 \cdot R^{0.667} \cdot S^{0.333}$ $f = 27.8 \cdot DG50^{0.500}$	FS DD	Primarily developed from all sand-bed canal data collected from the Indian canal systems prior to 1927, DG50 was originally expressed in inches but is given in feet here. When rewritten these equations are of the form: $P \propto Q^{0.500}$; $R \propto Q^{0.333}$; $V \propto Q^{0.167}$; and $S \propto Q^{-0.167}$
Blench (1941)	$V^2/H = F_b$ $V^3/B = F_s$ $F_b = 33.3 \cdot DG50^{0.50}$	FS DD	Modification of Lacey equations by considering the Lacey "f" to be related to bed and bank conditions. The value of F_b in terms of DG50 is for sand-bed channels with small charge.
King (1943)	$V^2/(g \cdot H \cdot S) = 3.63 \cdot (V \cdot B/\nu)^{0.250}$	FS DD	For straight duned sand-bed channels with small charge. The functional form of Blench-King equations are the same as those of Lacey; that is, $B \propto Q^{0.500}$, $H \propto Q^{0.333}$; $V \propto Q^{0.167}$ and $S \propto Q^{-0.167}$
Blench and Erb (1957)	$F_b = F_{bo} \cdot (1 + 0.012 \cdot C)$ $V^2/(g \cdot H \cdot S) = 3.63 \cdot (1 + 0.00043 \cdot C) \cdot (V \cdot B/\nu)^{0.25}$	FS	These equations were developed from an analysis of the Gilbert (1914) flume data. For duned sand-bed channels with charge under 500 ppm. The value of F_{bo} is that given by Blench (1941) for vanishingly small charge.

TABLE 2.1 (cont'd.)

Investigator	Equation	Q	Comments
Leopold and Maddock (1953)	$WS = a \cdot Q^{0.50}$ $D = c \cdot Q^{0.40}$ $V = k \cdot Q^{0.10}$	MAD	The functional forms of these relations were developed from an analysis of 7 river systems and one canal system using data from over 100 hydrometric stations. These three relations are referred to as the "hydraulic geometry" of the downstream relations. The coefficients a, c, and k varied between systems.
Leopold (1953)	$S = 1 \cdot Q^{-0.49}$	MAD	This relation was based on essentially the same data as that used by Leopold and Maddock (1953). The coefficient 1 is variable.
Simons and Albertson (1960)	$P = K_1 \cdot Q^{0.50}$ $R = K_2 \cdot Q^{0.36}$ $V = K_3 \cdot (R^2 \cdot S)^m$ $V^2/(g \cdot H \cdot S) = K_4(V \cdot B/\nu)^{0.37}$ $B = 0.90 \cdot P$ $WS = 0.92 \cdot B - 2.0$ $H = A/B$ $H = 1.21 \cdot R$; for $R \leq 7$ ft. $H = 2.0 + 0.93R$; for $R > 7$ ft.	FS	Based on over 100 stable canal reaches in India and the United States, the value of K_1, K_2, K_3, K_4 and m were determined for five types of stable canal. The coefficients for three classes of channel are as follows:

BED BANKS C	SAND SAND LOW	SAND COHESIVE LOW	GRAVEL GRAVEL LOW
K_1	3.5	2.5	1.75
K_2	0.52	0.44	0.23
K_3	13.9	16.0	17.9
K_4	0.33	0.54	-
m	0.33	0.33	0.29

(Rounded coefficients from Henderson, 1966)

Note that two slope equations and two area equations are given.

Investigator	Equation	Q	Comments
Ackers (1964)	$WS = a \cdot Q^{0.53}$ $D = b \cdot Q^{0.35}$ $V = k \cdot Q^{0.12}$ $S = 1 \cdot Q^{-0.29}$	BF	Based on measurements obtained from sand bed models, with sand banks. A transport equation, a resistance equation, and width-depth relation were used to obtain the functional forms of these regime equations.
Kellerhals (1967)	$WS = 1.8 \cdot Q^{0.500}$ $V/(g \cdot D \cdot S)^{0.500} = 6.5 \cdot (D/DG90)^{0.25}$ $\gamma \cdot D \cdot S = 1.25 \cdot DG90^{0.800}$	DD	Based on data for stable gravel paved beds. The basic data were from 10 natural channels and 14 stable canal reaches. Data from 4 laboratory tests were also used.

TABLE 2.1 (cont'd.)

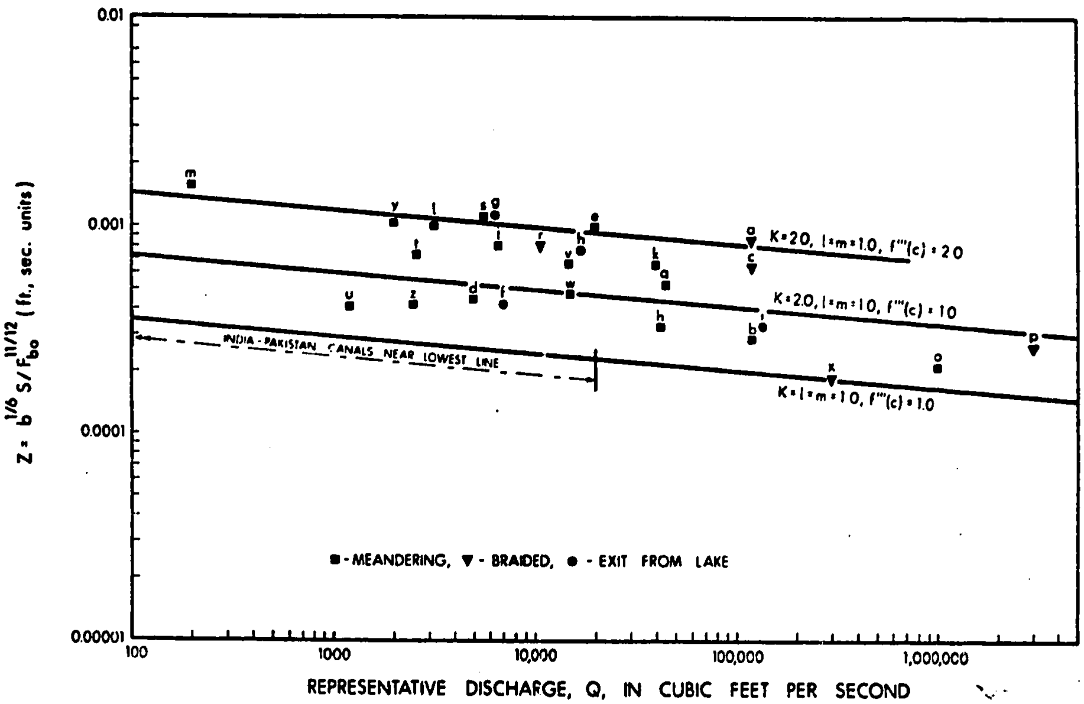
Investigator	Equation	Q	Comments
Schumm (1969)	$WS = 2.3 \cdot Q^{0.58}/M^{0.37}$	MAF	Based on data from 33 natural sand-bed channels in the semi-arid regions of Western United States and 3 similar channels from Australia.
	$D = 0.09 \cdot Q^{0.42}/M^{0.35}$		
	$S = 0.028/(Q^{0.32}M^{0.37})$		The parameters WS and D correspond to the bank-full conditions. Note: the slope equation was computed from the basic data given by Schumm (1969).
	Meander wavelength $= 234 \cdot Q^{0.48}/M^{0.74}$		
	Sinuosity $= 0.94 \cdot M^{0.25}$		M is the percent of the material finer than 0.074 mm. for a weighted volumetric sample obtained from the perimeter of the channel.
Henderson (1961, 1966)	$P = 1.14 \cdot Q \cdot S^{1.167}/DG75^{1.50}$	DD	Based on a threshold analysis for wide gravel rivers, primarily using the tractive force approach, given by Lane (1955b) and a resistance equation. No data from natural channels were directly employed in the development. The equations were developed primarily for design purposes.
	$R = 0.0910 \cdot DG75/S$	FS	
	$V = 32.0 \cdot R^{0.500}S^{0.333}$		
	$P = 8.75 \cdot R$	DD	Based on a threshold analysis for "type B" gravel paved channels using the tractive force approach by Lane. This is the case for the limiting slope. No data from natural channels were directly employed in the development.
	$R = 0.0527 \cdot DG75/S$	FS	
	$V = 30.0 \cdot R^{0.500} \cdot S^{0.333}$		
Leopold and Langbein (1962)	$WS = a \cdot Q^{0.55}$	RD	Based on a theoretical analysis using the concept of entropy as applied to landscape evolution. These equations are the downstream relations for natural channels. The coefficients a, b, k and l depend upon the river system.
	$D = b \cdot Q^{0.36}$		
	$V = k \cdot Q^{0.09}$		
	$S = l \cdot Q^{-0.74}$		
Langbein (1964)	$WS = a \cdot Q^{0.50}$	RD	These equations were developed theoretically for canals using the constraint of uniform concentration, and the concept of entropy.
	$D = b \cdot Q^{0.33}$		
	$V = k \cdot Q^{0.17}$		
	$S = l \cdot Q^{-0.17}$		

1. Definition of symbols for applicable discharge, Q; FS = full supply discharge for canals; DD = dominant discharge; MAD = mean annual discharge (long-term mean discharge based on full year record); BF = bankfull discharge; MAD = mean annual flood; RD = representative discharge.
2. The DG90 of Kellerhals, and the DG75 of Henderson are the sizes based on a surface sampling procedure for the paved gravel bed.

Blench (1941) built on the work of Lacey by introducing the terms "bed factor" and "side factor" to separate the influence because of the non-cohesive duned beds and the cohesive unduned banks encountered in some sand-bed channels. He also used width and depth rather than wetted perimeter and hydraulic radius in his relations. King (1943) proposed a slope equation of a different form than that given by Lacey, since it allowed for the effect of breadth and depth explicitly.

Blench and Erb (1957) introduced charge (essentially concentration of bed material in transport) into the Lacey equation for predicting depth and into the King equation for predicting the slope of a uniform straight duned sand-bed channel.

Blench and Qureshi (1964) employed this modified slope relation to devise a classification chart for duned sand-bed rivers or rivers of the same general type, assuming that a dominant discharge could be adequately assessed. FIGURE 2.4 shows the type of relation obtained from the analysis of 26 river reaches. If the channel under investigation was assumed to be from the above class of rivers, the plotted position implied a certain rate of transport for a specified sinuosity, or vice versa. No data concerning transport were available to test the results. Although the gravel river reaches located at lake outlets should have been excluded from the analysis, since they were not of the correct class, the study did attempt to extend the regime type analysis to natural channels.



<u>NOTE</u>:

k = coefficient to allow for meandering
l = coefficient to allow for variation in definition of representative discharge
m = coefficient to cover everything else imaginable, e.g. suspended load effects, banks being quite different from those of canals, etc.
$f'''(c)$ = bed load charge function
b = width

FIGURE 2.4 REGIME ANALYSIS CHART [FROM BLENCH AND QURESHI (1964)]

Other investigators have also used the "regime type" approach to study canals and natural channels. Some of the more important work carried out in parts of the world other than that of the Indo-Gangetic Plain are now presented.

One important study related to the hydraulic geometry (width-discharge, depth-discharge, and velocity-discharge relations) of natural rivers was that by Leopold and Maddock (1953). They presented the "at-a-station" and "downstream" variation of hydraulic geometry for seven major basins and one major canal system. FIGURE 2.5 shows the type of "downstream" relation obtained when using the mean annual discharge as the characteristic or representative discharge. They did not have any data concerning bed-load transport, but they did discuss the probable relations between width, depth, velocity and suspended sediment. FIGURE 2.6 illustrates the inferred relations which result from "at-a-station" and "downstream" analysis.

A main conclusion was that:

> "... the gauging-station data taken at points distributed over a drainage system without regard to the existence of or lack of grade, define a change of width, depth, and velocity downstream with change in discharge as consistent as the changes observed in the same type of data within a graded reach. The same factors which tend to maintain equilibrium when a reach becomes graded are acting also on reaches not in complete equilibrium and this action is sufficiently potent to produce consistent patterns in the relation among the hydraulic factors of channel shape."

This paper served as the basis for many studies related to natural channels. For example, Stall and Yang (1970) carried out a study using the hydraulic geometry data from 300 stream gauging

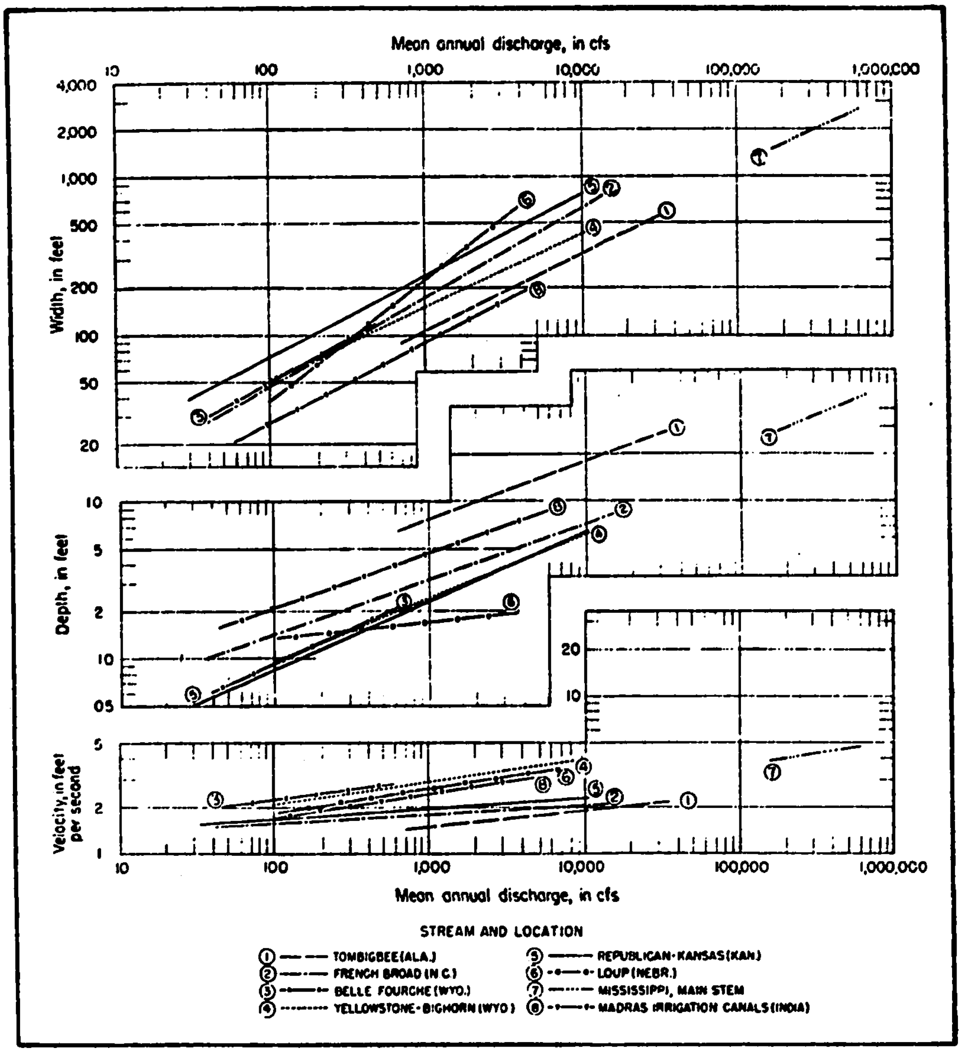


FIGURE 2.5 WIDTH, DEPTH, AND VELOCITY IN RELATION TO THE MEAN ANNUAL DISCHARGE AS DISCHARGE INCREASES DOWNSTREAM IN VARIOUS SYSTEMS [FROM LEOPOLD AND MADDOCK (1953)]

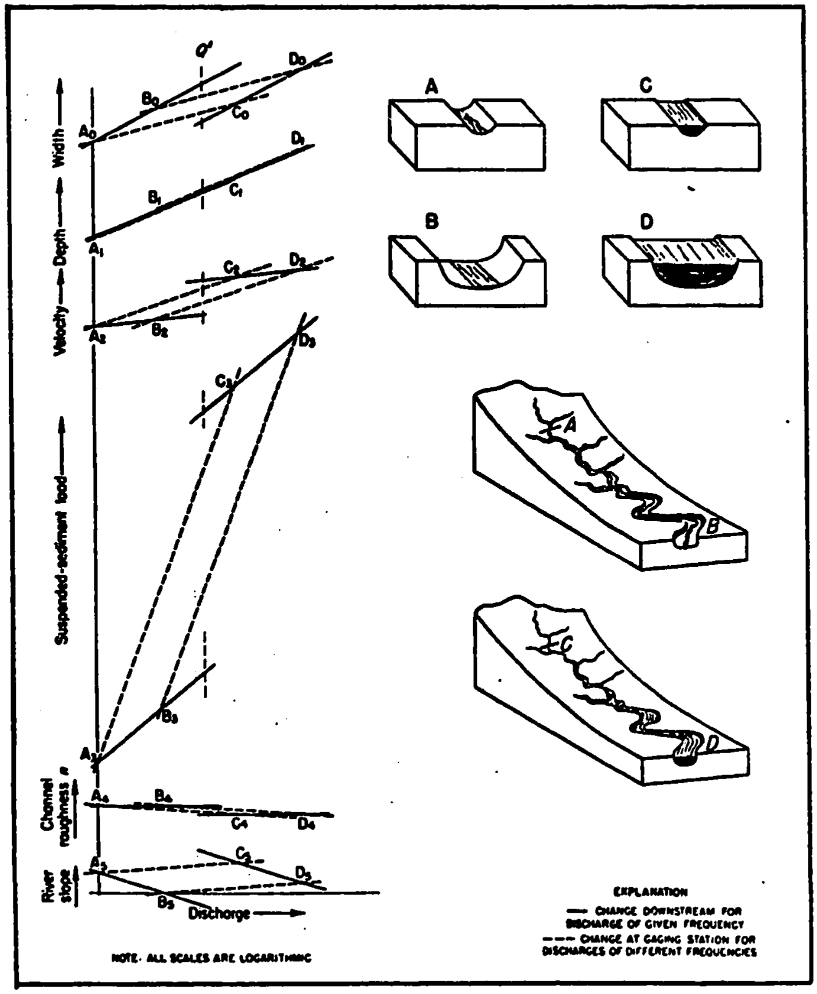


FIGURE 2.6 AVERAGE HYDRAULIC GEOMETRY OF RIVER CHANNELS EXPRESSED BY RELATIONS OF WIDTH, DEPTH, VELOCITY, SUSPENDED-SEDIMENT LOAD, ROUGHNESS, AND SLOPE TO DISCHARGE AT-A-STATION AND DOWNSTREAM [FROM LEOPOLD AND MADDOCK (1953)]

stations in 12 river basins in the non-arid parts of the United States. The results of their analysis were very similar to those obtained by Leopold and Maddock in 1953.

Simons and Albertson (1960) studied the hydraulic properties of stable canals by stratifying the data according to the type of bank and bed material in the channel. Based on data from 114 stable canals in the United States and India they found that:

> "... the area required to transport a given discharge is maximum for sand banks and beds, somewhat less for slightly cohesive to cohesive banks inclusive and a minimum for coarse non-cohesive banks and beds. The explanation of the preceeding is primarily a difference in the stability of the different bank materials."

Some of the results obtained by Simons and Albertson are shown graphically in FIGURE 2.7.

Ackers (1964) used sand-bed models to derive data related to the regime geometry of self-formed channels. He concluded that a resistance law and a transport law are fundamental to the understanding of the problem. In addition to these two relations, he found that the form factor (width to depth ratio) was a constant for small channels with sand banks or with cohesive banks. Using the expressions for the resistance law and the transport law as obtained from the model channels with sand banks and assuming that the form factor varied as square root of the mean depth, "regime type" equations were developed for small laboratory sand-bed channels. He found that these equations differed little in functional form from the Lacey-Blench regime equations for sand-bed canals with cohesive banks.

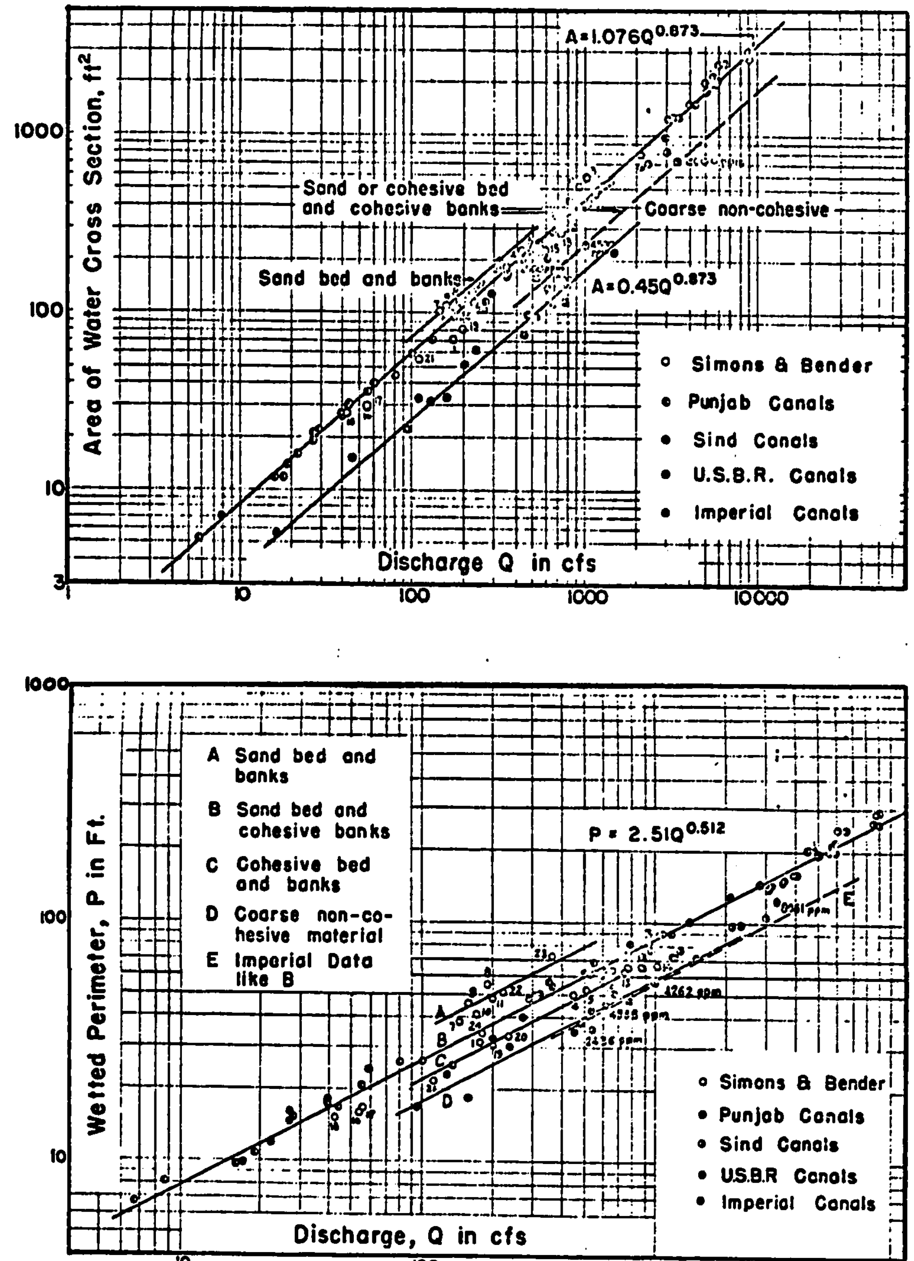
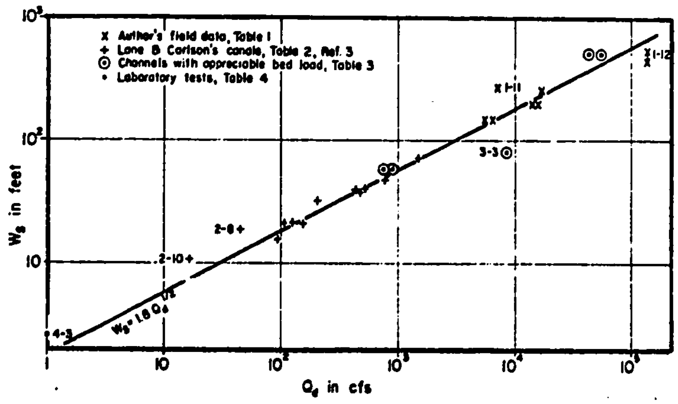


FIGURE 2.7 AREA VERSUS FULL SUPPLY DISCHARGE, AND WETTED PERIMETER VERSUS FULL SUPPLY DISCHARGE FOR STABLE CANALS WITH DIFFERENT TYPES OF BEDS AND BANKS [FROM SIMONS AND ALBERTSON (1960)]

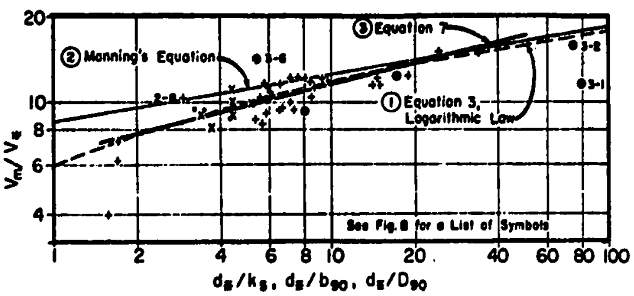
Kellerhals (1967) employed a "regime type" analysis for paved gravel river reaches near the outlet of lakes. The choice of the river reaches was made to ensure that the bed material transport was negligible. He used this data from natural channels along with data from stable gravel canals to obtain a width adjustment equation, a resistance to flow equation, and a shear stress equation (similar to an initiation of motion equation). The three relations that were developed are shown in FIGURE 2.8. The regime width, depth and slope of such channels were obtained by solving the three basic equations for width adjustment, resistance to flow, and shear stress.

Another contribution concerning river behavior has been made by Schumm (1969) who studied 36 stable sand-bed channels in the semi-arid parts of the United States and Australia. For these rivers, the percent of silt and clay (that is material passing the 0.074 mm. sieve) in the channel perimeter was used as an indication of the relative amount of material moved as bed-load. A high silt-clay content in the channel perimeter was associated with a channel that had a relatively small portion of the total load moved as bed-load. He presented equations relating bankfull width, depth, and slope to a characteristic discharge (mean annual discharge, or mean annual flood) and to the silt-clay content of the perimeter of the channel. He found that no acceptable relation existed between channel morphology and the bed and bank material size, since the range of sizes was limited.

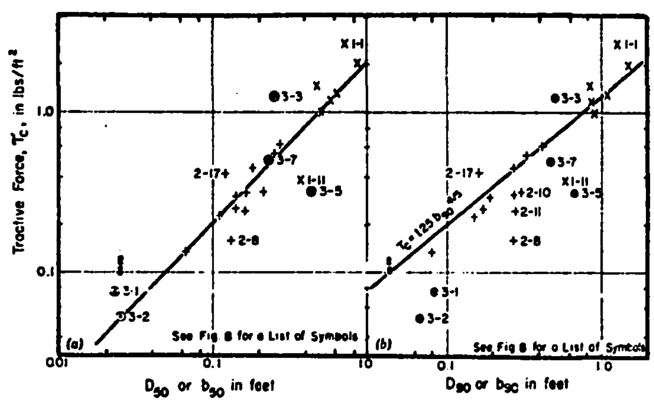
Some investigators have attempted to provide an alternative derivation of the Lacey-Blench regime equations for duned-sand bed channels.



a) Water surface width versus dominant discharge



b) Comparison of three friction equations (Equation 7 used in analysis)



c) Tractive force versus grain size

FIGURE 2.8 PLOTS OF THE THREE BASIC RELATIONS FOR THE DEVELOPMENT OF THE REGIME EQUATIONS FOR STABLE CHANNELS WITH PAVED GRAVEL BEDS [FROM KELLERHALS (1967)]

For example, Brebner and Wilson (1967) stated that it is their purpose:

> "... to show, by use of the principle of minimum energy-degradation rate, that the regime equations may be derived from relationships developed for pressurized two-phase flow."

The derived exponents for the equations obtained from the above model were very close to those of the Lacey-Blench regime equations. They also show that the hydraulic radius will adjust so that a certain value of the Froude number is obtained which is dependent upon the particle properties in the mobile bed and the concentration of solids in the flow, but independent of the discharge. Their experimental and theoretical results provide:

> "... a good agreement of the premise that the dimensions of a waterway with a moveable boundary tend to assume the values which minimize the rate of energy degradation; that is the product of velocity and slope."

In addition to the previous "regime type" approaches to the study of river behavior a few other lines of attack have been made on the problem. For example, Fortier and Scobey (1926) provided a set of design tables to give the values of limiting velocities for certain types of bed material. Corrections had to be applied for depth and suspended sediment concentration.

Lane (1955b) considered the design of gravel-bed canals by using a tractive force analysis. He found that this analysis was superior to the limiting velocity approach for canal design.

Henderson (1961) approached the study of natural channels by considering two main classes of channels: "live bed-channels" (sand) and "threshold channels" (gravel). He states:

"... it must be recognized that no one theory can embrace both the threshold condition, in which the bed is on the point of movement, and the regime condition, in which the bed movement is fully established."

He used a resistance to flow relation, a transport relation and a breadth adjustment relation for live bed channels. For threshold channels he used an initiation of motion equation in place of the transport equation. The threshold case was mainly developed from the tractive force model presented by Lane (1955b).

Leopold and Langbein (1962) attempted to deduce the functional forms of width-discharge, depth-discharge, velocity-discharge and slope-discharge equations for natural channels by considering the concept of entropy as applied to landscape evolution. They stated:

"... in geomorphic problems, the set of physical factors includes many variables such as the amount of water and sediment to be carried, the fluid friction, and the river transport capacity. The equations connecting these factors have several degrees of freedom remaining. In other words, a river system is "hydraulically indeterminant". A river can adjust its depth, width, or velocity to a given slope in several ways so that it is necessary to establish the river profile and the hydraulic geometry on the basis of maximum probability.

"... The principle of least work is one of several ways in which the condition of maximum probability may be satisfied."

Although Langbein (1964) was criticized when he introduced the above concept to the engineering profession, he did draw attention to the probabilistic nature of river behavior. Langbein (1964) and Maddock (1969) used some aspects of this concept to derive the functional forms of the Lacey-Blench regime equations for duned sand-bed channels under the constraint of constant sediment concentration.

Dimensional analysis has been used by several investigators to determine the numerics which result from the interaction of the relevant variables that are identified in the "statement of the problem". When the data are plotted by using the derived numerics, various classes or phases of the phenomenon under investigation may emerge. In some cases functional forms may be determined for specific phases.

One of the earliest applications of dimensional analysis to the study of river behavior was that by Blench and Erb (1957). Their statement of the problem was for the case of a channel with fixed width. One of the resulting set of numerics included the relative depth and the square of the Froude number. The second set of numerics contained the terms which appear in the King slope equation.

Yalin (1966) presented a statement of the problem for natural straight canals. He considered that certain "numerics" were of secondary importance. In this way a set of equations were established, such that the width equation had the same functional form as the Lacey regime equation for width; however, the functional form of the depth and slope equations were different from those of the Lacey-Blench regime equations.

Dimensional analysis provides a useful tool for analyzing river geometry, if the statement of the problem is complete, and if adequate justification can be made for rejecting certain numerics.

2.5 Geologic Constraints on Channel Geometry

In many natural channels which are in "dynamic or quasi-equilibrium" the mobile bed is not deep so the channel may be affected by local geologic controls. This section considers some of the findings related to the geologic constraints on channel geometry.

Lacey (1958) stated that it is:

> "... probable that in boulder and shingle rivers the slope is an independent variable, and the grade of material actually transported a variable dependent on the flood stage."

Hack (1957) studied the effect of different bedrock types on the shape of the longitudinal profile for streams in Virginia and Maryland. He found that in geologically similar areas the stream profiles were similar. FIGURE 2.9 shows the average relation between channel slope and stream length at localities on streams in seven geologically different zones within the study area. He also found that for two channels a break in profile occurred exactly at the break in the major geologic contact. Different bedrock types also were found to have some effect on the cross-sectional geometry, since

> "... streams in areas of softer rocks such as shale or phyllite tended to have deeper cross-sections than streams in more resistant rocks such as sandstone."

Based on a study of mountain streams in New Mexico, Miller (1958) found that:

> "... the relations of slope to channel width and drainage area show a lithologic separation into only two categories, hard rocks of the mountains and unconsolidated deposits of the Rio Grande Depression. This means that slope is a partially independent variable, determined by inherited conditions which the stream can gradually modify, but only within certain limits."

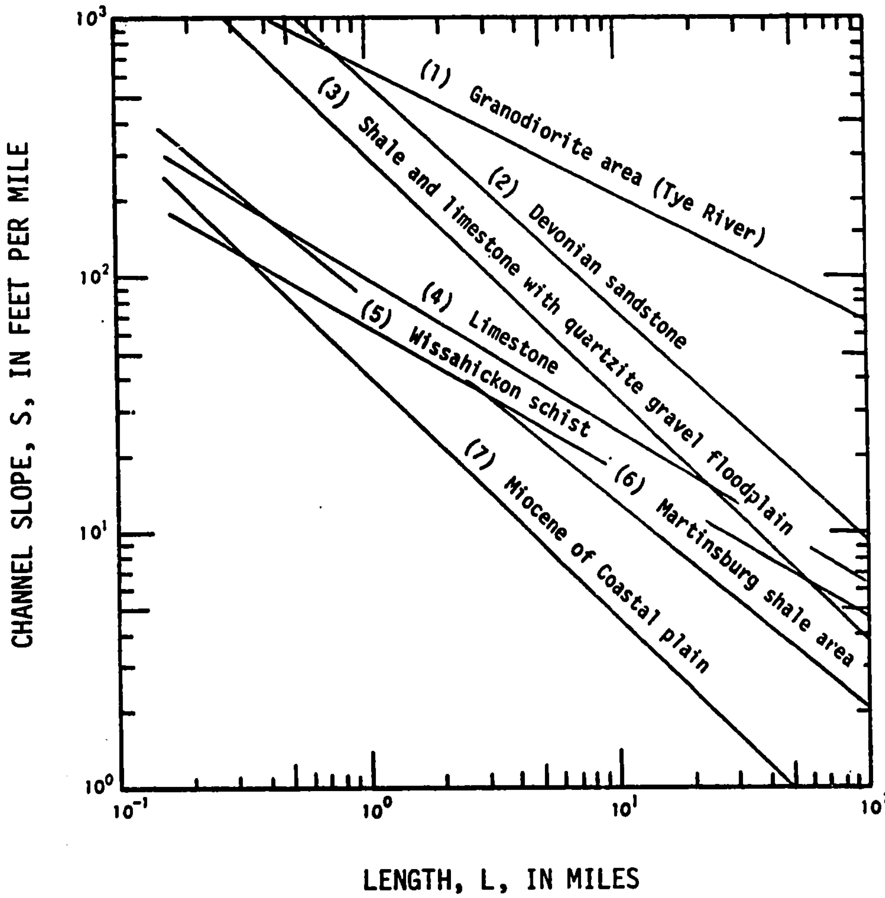


FIGURE 2.9 LOGARITHMIC GRAPH SHOWING THE AVERAGE RELATION BETWEEN CHANNEL SLOPE AND STREAM LENGTH AT LOCALITIES ON STREAMS IN SEVEN GEOLOGICALLY DIFFERENT AREAS [AFTER HACK (1957)]

In a summary of a study of 16 natural stream channels in Pennsylvania, Brush (1961) identified three main bedrock types underlying portions of the study reaches. He found that:

> "... slope tends to decrease in a downstream direction almost independently of bedrock character, but the absolute values of slope at any given length depends on bedrock."

He also found that:

> "... there is a slight suggestion that bedrock may influence the hydraulic geometry of streams. The effect is seen in small cross-sectional areas of streams flowing in limestone and dolomite."

In summary, the above statements indicate that the bedrock type is an important but complex factor when considering channels in shallow alluvium.

2.6 Systematic Evaluation of River Regime

Many papers found in the literature are concerned with a study on one reach of a particular river. Several such examples are quoted in the Proceedings of the Federal Interagency Sedimentation Conference (1965). The results from this type of study are often difficult to incorporate into a general analysis, since the data have not been collected in a uniform manner.

Data obtained systematically from many river reaches provide an opportunity for generalized analysis of river behavior. Leopold and Maddock (1953), Leopold and Miller (1956), and Leopold and Wolman (1957) have presented much of the basic data related to their important river studies; however, no simple method is available for stratifying their data according to geomorphic criteria.

Neill and Galay (1967) have outlined the data which should be obtained when studying river regime on a systematic basis. Leopold and Skibitzke (1967) have given some guidelines concerning the types of measurements that should be made on a remote river.

CHAPTER 3

THE DATA USED IN THE ANALYSIS

3.1 General

A special difficulty in a study related to a large field problem is that the data cannot usually be obtained during one or two field seasons or by one individual. This often results in a variation in the quality of the data during the period in which it is collected. It is essential to record adequate statements concerning the quality of the data in such cases. This chapter outlines the data sources, defines the types of data used, and gives some indication of the quality of the basic data used in this investigation.

3.1.1 Data Source

The field data for this study were obtained between the years 1961 and 1970 by the Research Council of Alberta and the Water Resources Division, Alberta Department of the Environment. During these years, as field techniques became established, the quality of the data generally improved. Most of the data utilized were obtained during the years 1966 to 1969 by G. Gehmlich and H. Schultz of the Highway and River Engineering Division of the Research Council of Alberta under the general direction of C. R. Neill. Some data were also obtained from theses presented by Qureshi (1962), Van der Giessen (1966) and Hollingshead (1968).

During 1970, the writer obtained additional basic survey data from five river reaches and missing bed material data for 44 reaches.

3.1.2 Data Storage

Since many types of data were available for each study reach, a data storage system was devised in collaboration with R. Kellerhals, formerly with the Highway and River Engineering Division, Research Council of Alberta. The system was designed to be relatively flexible and to be readily accessible. It was set up so that descriptive data could be coded and quantitative data could be qualified if necessary. The basic data for each reach were stored in a total of 37 tables. A complete listing of the data with explanatory notes is given in APPENDIX I

A detailed outline of the type and quality of the main data used in this study is presented under the following headings:

1. Hydrologic data
2. Cross-section data
3. Slope data
4. Bed material data
5. Geomorphological data

All reaches accepted for this analysis had a hydrometric station in or very near the reach, had at least five years of hydrometric data, and had at least five surveyed cross-sections.

3.2 Hydrologic Data

3.2.1 General

One of the most important variables related to a study of river regime is that of discharge. To ensure that the quality of the discharge data was adequate, the hydrometric station in or near each acceptable reach had a record of five or more years. A study by Neill et al (1970) of a few Alberta rivers with at least 50 years of records indicated that any five year mean discharge is usually within 10 to 30 percent of the 50 year mean. No estimates of the variability of other characteristic discharges based on a five year record were available.

No attempt was made to adjust the hydrologic records to a common period of record. Such additional detailed analysis was considered to be unwarranted for this study.

For most cases all the hydrologic data were used for the entire period of record, or up to 1967, the last year for which data were available on magnetic tape. For those cases with less than five years of data for the period ending in 1967, more recent data were used to meet the five year criterion.

In a few cases estimates had to be made for certain characteristic discharges, such as the long-term mean discharge based on an annual record for those reaches with an April - October record. All computations related to these estimates are available in the working files held by the Highway and River Engineering Division, Research Council of Alberta. A code is provided in the basic data tables (APPENDIX I) to show whether an estimate was made by considering:

1. An upstream and/or downstream station
2. A station in an adjacent basin
3. A station in a somewhat remote basin

4. No flow during the winter months at the station

5. Some estimated data for the station

Such coding of the data provides a means of quickly evaluating the quality of a given discharge.

For each reach the following characteristic discharges were obtained if the established criteria were met:

1. Long-term mean discharges based on the full year record and on the April to October record.

2. Flood discharges corresponding to the 1.5, 2, 5, 10, 25, 50 and 100 year return periods based on maximum annual daily mean discharges.

3. Discharges which are exceeded 0.5, 1, 5, 10, and 50 percent of the time based on the April to October record but computed on the basis of the entire year.

3.2.2 Long Term Mean Discharges

The long term mean discharges were computed with the assistance of the Water Resources Division, Alberta Department of the Environment. For stations with a full year record, long term mean discharges were computed for the year and for the period April to October using years with complete data. Many of the stations were only active during the period March to October or from April to October. In such cases, the long term mean was estimated from nearby stations, or by assuming that the winter flow was negligible. The data which are estimated are qualified by the code given in SECTION 3.2.1.

3.2.3 Flood Discharges

The flood frequency analysis for each station was based on the maximum annual daily mean discharges. Each analysis was carried out by using a straight line fit to the data when plotted on log-normal paper. In all cases the best fit line was established by eye. The log-normal distribution has been recommended by Kuiper (1957) and Ansley (1959). Spence (1971) found that the log-normal distribution gave the most consistant results for rivers in the plains of Western Canada.

The maximum return period used in any analysis was based on the following arbitrary rule:

Period of record	Maximum return period
5 - 7	5
8 - 12	10
13 - 24	25
25 - 49	50
50 - 99	100

The flood frequency data were not all updated to 1967, but in most cases all data up to the year 1964 were used. The data were updated to include the most recent events for those cases with a minimum number of years of record. In all cases, the number of years used in the analysis along with the date of the last year were tabulated.

No regional flood analysis studies were carried out to attempt to establish a more uniform estimate of flood frequencies. The station flood frequency analysis was used in the investigation unless it was found to be inconsistent with upstream and/or downstream stations with a longer period of record. In such cases, the flood frequency data were adjusted by considering the adjacent stations with a longer record.

3.2.4 Flow Duration Data

A computer program developed by the Water Resources Division, Alberta Department of the Environment was utilized for the analysis. The computations were carried out using the April to October records with a time base of an entire year. This assumes that the November to March flows were less than the discharge which was exceeded 50 percent of the year. Flow duration analyses based on the full year at some stations indicated that the above assumption was valid in the majority of cases. The reason for selecting the April to October record was that most of the hydrometric stations had adequate records for this period of the year.

In a few cases the period of record was shorter than April to October. Then the discharges exceeded 0.5, 1, 5, and 10 percent of the time and were computed from the May to September period and assumed to apply directly to the April to October period. Results based on stations with full years of record indicated that this assumption was also generally valid. The 50 percent flow duration discharge could not be evaluated, since the period May to September is less than one half of a year.

If the period of complete record was less than five years, the flow duration data were estimated from a nearby station. The estimates were usually based on the assumption that the flow durations and the long term mean discharges and/or flood discharges were related. All cases which involved estimates are noted in the tabulated data.

3.3 Cross-section Data

Some studies related to natural channels, such as those by Leopold and Maddock (1953) and Stall and Yang (1970), have only used one cross-section to define the channel properties. Usually the cross-section was at or near a hydrometric station, which may be located at an atypical location in order to provide a good hydraulic control. In this study, the channel properties for a river reach are the average cross-sectional area, and the average water surface width associated with a specific discharge. These properties are defined from 5 to 10 cross-sections in each reach with the hydrometric station located near the centre of the reach in most cases.

The method of survey varied over the period 1961 - 1970. Some of the surveys before 1965 were not carried out to a point above the high water line, and as a result the channel properties for high discharges were not well defined. In some cases in 1965 and 1966 the channel was sounded and the portion of the cross-section above the water on the day of the survey was determined from photogrammetric plots. However, the majority of the surveys were carried out in 1967, 1968, and 1969. In these later surveys, the entire cross-section was surveyed to a point well above the high water line.

As a result of the experience gained by the writer from field surveys and from a study of the field surveys of others, an outline of a recommended survey procedure for some classes of rivers is given in APPENDIX A. An example of a survey carried out by the writer on a relatively small river is presented in APPENDIX H.

3.3.1 Parallelism of Water Surfaces

The basic assumption used to determine the channel properties for a reach was that the water surface at any discharge was parallel to the water surface on the day of the survey. This assumption would be valid for a relatively uniform channel with few obstructions to flow. In this study no reaches are considered where major tributaries enter within the reach, since there could be backwater effects which would interfere with the assumption of parallelism.

One obvious case where the parallelism of flow is not strictly valid is for the pool and riffle sequence. If the survey is carried out at low flow, about 80 to 90 percent of the energy loss is at the riffles. However, at higher flows the water surface is more uniform. FIGURE 3.1 schematically illustrates this type of condition along with an indication of the error due to the assumption of parallelism. In most cases, however, this deviation is not substantial. Hollingshead (1968) obtained water surface profiles for Elbow River at Bragg Creek, a gravel river in the foothills of Alberta, at several discharges and found relatively good parallelism. A similar conclusion is noted from two surveys of the water surface profile of the North Saskatchewan River at Edmonton.

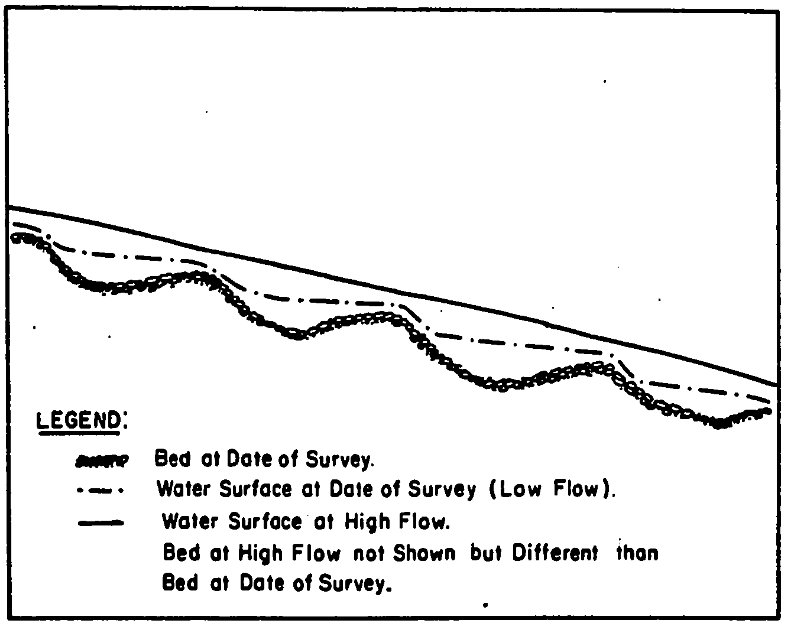


FIGURE 3.1 SCHEMATIC ILLUSTRATION OF THE DEVIATION FROM THE ASSUMPTION OF "PARALLELISM" FOR A POOL AND RIFFLE SEQUENCE

If parallelism is accepted, an increment in the stage above (or below) the surveyed stage at the gauging station is added (or subtracted) to the surveyed water surface elevation at all cross-sections. Then channel properties at discharges other than the one on the day of survey are obtained.

3.3.2 Limitations of Analysis

This analysis does not account for the change in a cross-section resulting from any scour which may occur at high stages. Each cross-section was assumed to remain unaltered over the whole range of discharges, since no simple means of estimating scour could be incorporated into the analysis.

Although there was no evaluation of the extent of scour during the passage of a flood, there is some evidence that a relatively major flood does not result in an appreciable change in the net channel properties. Hollingshead (1968) made measurements of the average channel properties on a reach of the Elbow River near Bragg Creek, Alberta before and after a flood with a return period of about 50 years. He found that some of the cross-sections had changed, but that the average channel properties for the reach were not appreciably altered.

Of course, catastrophic events such as the flood on Coffee Creek, California reported by Stewart and LaMarche (1967) can cause an appreciable change in the channel properties. However, no reaches included in this study were surveyed after such an extreme event.

One other factor which could not be accounted for directly in the analysis was the effect of sediment transport on the developed relations. No detailed data for bed material transport, or wash load were available for more than one or two reaches. Even with this limitation certain estimates of the relative effects of sediment transport could be made from the results of laboratory tests.

The effect of wash load for gravel bed rivers may not be of great importance but it should be considered for sand-bed rivers. The bed material load, either as bed-load or suspended load should be considered for all types of river for an exhaustive treatment of the problem.

3.3.3 Method of Computing Channel Properties

A program was written to compute the average channel properties for any reach with a maximum of 15 cross-sections and up to 50 coordinate points at each cross-section. The channel properties may be computed for as many as 14 different discharges. The coefficient of variation of the cross-sectional areas and the water surface widths are also given for each flow condition. A detailed write-up of this program is given in APPENDIX B.

The channel properties and the associated coefficients of variation for four characteristic discharges had been computed for the majority of reaches by G. Gehmlich and S. Wolanski of the Highway and River Engineering Division, Research Council of Alberta before this detailed analysis was initiated. The discharges used in the previous analysis were those corresponding to the date of survey, the approximate long-term mean, the 2-year flood, and a high or "bankfull" discharge. The results for 18 of these reaches appeared to be questionable; consequently, the channel properties were recomputed using the program developed for this study. All basic survey data obtained during 1970 were analysed with the aid of this program.

The analyses carried out prior to 1970 based on four discharges were accepted for the majority of the reaches. Using these previously computed data, the channel properties and the associated coefficients of variation for the characteristic discharges adopted for this investigation were obtained by linear interpolation on log-log or semi-log paper.

3.3.4 Channel Properties Related to Geomorphic Features

When determining the channel properties from field notes, the following three features, which are illustrated schematically in FIGURE 3.2, were noted:

1. low level bench
2. trim line
3. valley flat

The low level bench is associated with the current river; it is of very limited extent and can only be detected from relatively detailed field notes. This feature has been observed by Woodyer (1968) and others. The trim line is the distinct interface along the channel

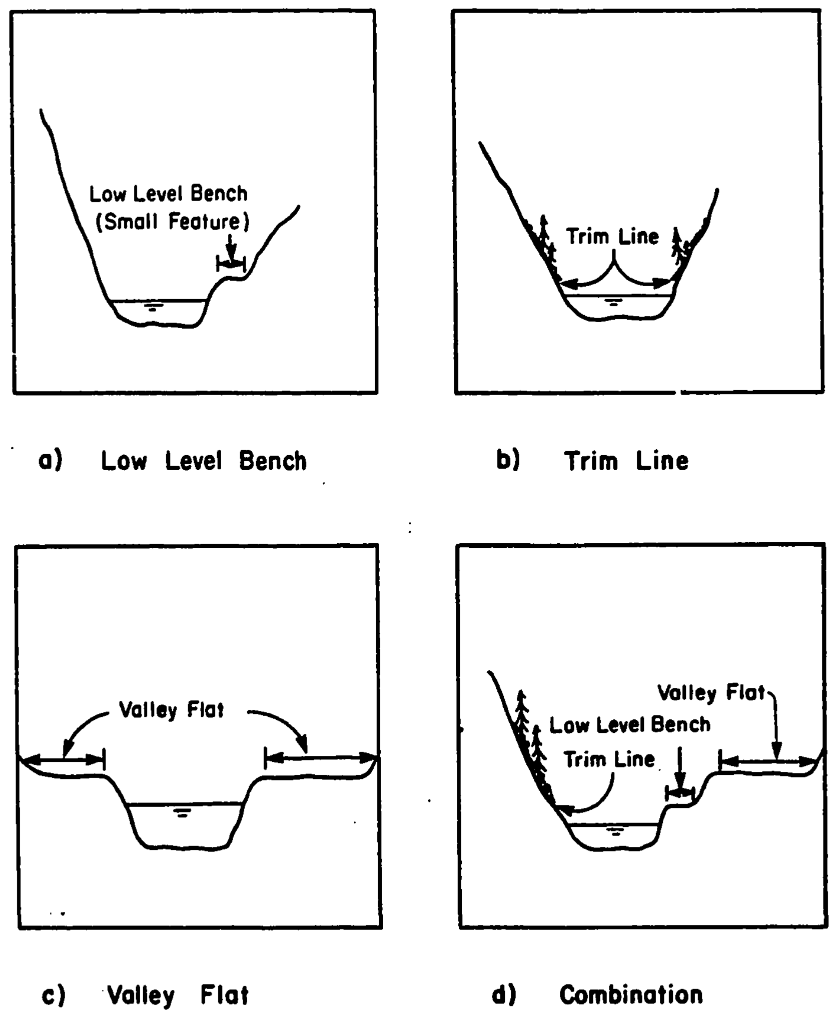


FIGURE 3.2 SCHEMATIC ILLUSTRATION TO DEFINE A LOW LEVEL BENCH, A TRIM LINE, AND A VALLEY FLAT

below which the vegetation, excluding grasses, is unable to become firmly established. The trim line is most prominent in channels that are along a valley wall. Leopold and Skibitzke (1967) have used this feature to define "bankfull" stage for channels with no well developed valley flat. The valley flat is the lowest recognizable flat which is associated with the present river. It may often be of limited extent, but is usually distinguishable on aerial photographs.

If the valley flat is subject to flooding with a return period of a few years (e.g. 1.1 to 5 years), it may be considered to be a genetic flood plain. If the valley flat is flooded very infrequently (e.g. 100 years), it is indistinguishable from a low terrace. For those cases between the two extremes given, the valley flat may be considered to be a flood plain by some investigators.

These features cannot be easily identified in all cases, but if detailed survey notes are available it is generally possible to locate the low level bench and/or a trim line. The valley flat can generally be recognized even if detailed surveys are not available.

Each reach was examined in order to obtain the average height of the low level bench and/or trim line and the valley flat above the water surface on the day of survey. A discharge corresponding to the average stage of these features was estimated by means of the rating curve. A return period was then estimated for this discharge by considering the flood frequency plot for the hydrometric station in the reach. The percent of the time for which this discharge was exceeded was also estimated by using the flow duration data. A detailed example of the determination of these features is presented in APPENDIX H.

When the stage corresponding to a high discharge was above the local valley flat for certain portions of the reach, an "artificial wall" was analytically inserted in order to provide realistic channel properties. (See APPENDIX B). In most cases such walls were not required, but this option did permit some control for high discharges.

3.3.5 Effect of the Rating Curve on the Computed Channel Properties

One limiting factor when computing the channel properties is the accuracy of the rating curve, especially at high stages. If the data from the rating curve or rating table were relatively linear when plotted on log-log paper, an extrapolation was made to the level of the valley flat. No discharges were used in the analysis in excess of the estimated discharge corresponding to the valley flat. If no valley flat was readily distinguishable, the rating curve was not extended beyond a discharge corresponding to the 10 year flood.

In all cases involving active hydrometric stations, the rating curve used in the analysis was the rating curve which was applicable at the time of the field survey of the river reach. In a few cases, the hydrometric station was inoperative for a period of several years before the field survey was carried out. The last or most appropriate rating curve was used in these cases.

A code was used to indicate whether each rating curve was stable, slightly unstable, moderately unstable, or highly unstable. These evaluations were made by the staff of the Calgary office of the Water Survey of Canada.

3.4 Slope Data

3.4.1 General

The slope of the river reach is often not measured in the field. Several river studies such as that by Stall and Yang (1970), only use the topographic slope, while other studies, such as that by Wolman (1955), are based on local slope measurements.

For this study the slope used is the average for a length ranging from 10 to 40 channel widths. The vertical control was established by leveling for all field slopes. The distance measurements were made by using:

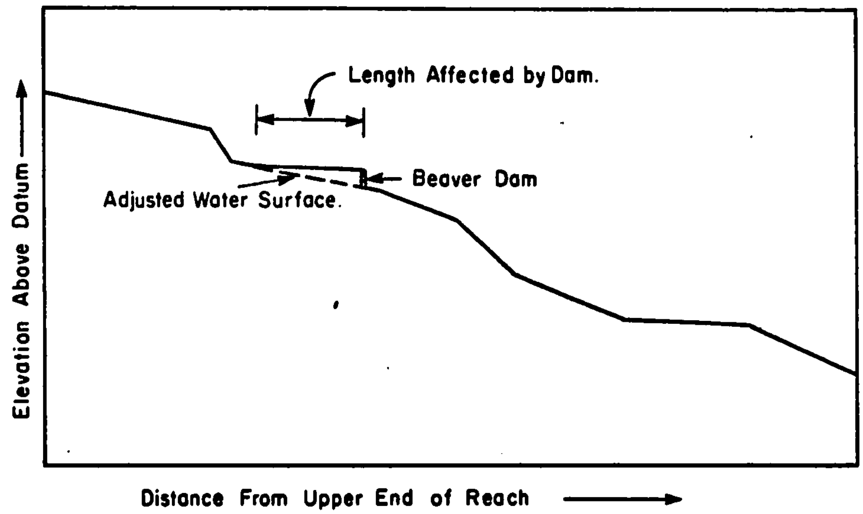
1. taped distances
2. stadia distances
3. distances scaled from calibrated aerial photographs
4. distances scaled from topographic or planimetric maps

In about 10 percent of the cases, the topographic slopes were used, since no field measurements of slopes were made for the study reaches.

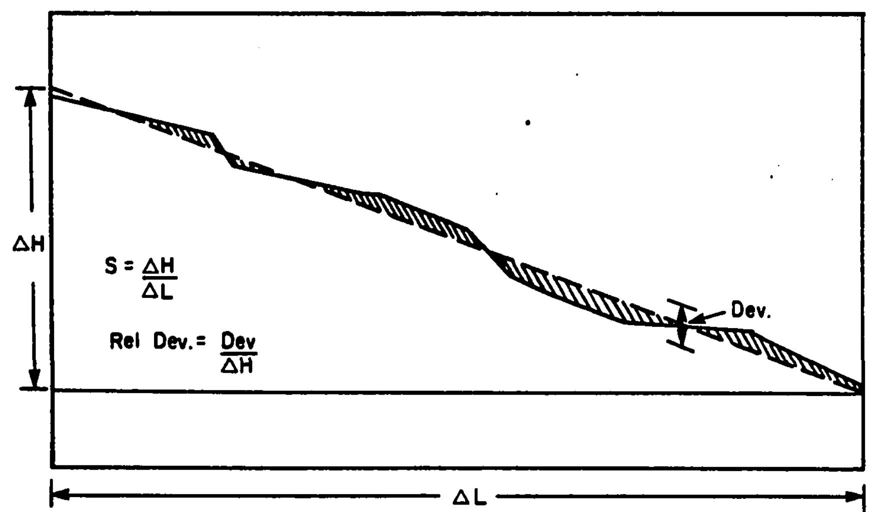
3.4.2 Method of Obtaining Average Field Slope

The method of obtaining the average slope is outlined schematically in FIGURE 3.3. The detailed procedure used is presented as follows:

1. The water surface profile for the day of survey was plotted.



a) Water Surface Profile Before and After Adjustment



ΔH=Fall of Average Slope or Length of Reach
ΔL =Length of Reach
Dev.=Maximum Vertical Deviation of Water Surface in Reach

b) Parameters Obtained from Water Surface Profile

FIGURE 3.3 METHOD OF DETERMINATION OF AVERAGE SLOPE FOR A RIVER REACH

2. The plotted profile was evaluated to remove the effect of any atypical rapids or other obstructions such as beaver dams, etc.

3. An average line was drawn by eye through the adopted water surface profile such that the area enclosed by the profile above and below the average line was about equal.

4. Straight lines parallel to the average line were drawn through the most remote point above and below the average line.

5. A measure of maximum deviation of the slope was determined by computing the ratio of the vertical distance between the parallel lines drawn through the most remote points and the fall associated with the average slope for the reach.

In most cases no adjustment was required. A note was provided to indicate the reason for any necessary adjustment of slope. The fitting of the average line could be carried out in an analytical manner, but this was not considered to be necessary.

Two measures of the variability of the slope within the reach were used. First, the maximum deviation divided by the fall of the average slope over the reach was used as an overall simple "goodness of fit" parameter. This parameter provides a means of classifying the slope according to an arbitrarily specified "goodness of fit" criterion. Second, a qualitative estimate of the variation of the slope throughout the reach was made. FIGURE 3.4 illustrates the following four categories used for this qualitative evaluation.

1. The water surface profile was close to the average slope for the reach.

2. The water surface exhibited relatively small deviations from the average but alternated above and below the average over the reach. (This was typical for a pool and riffle sequence.)

3. The water surface exhibited some deviations from the average

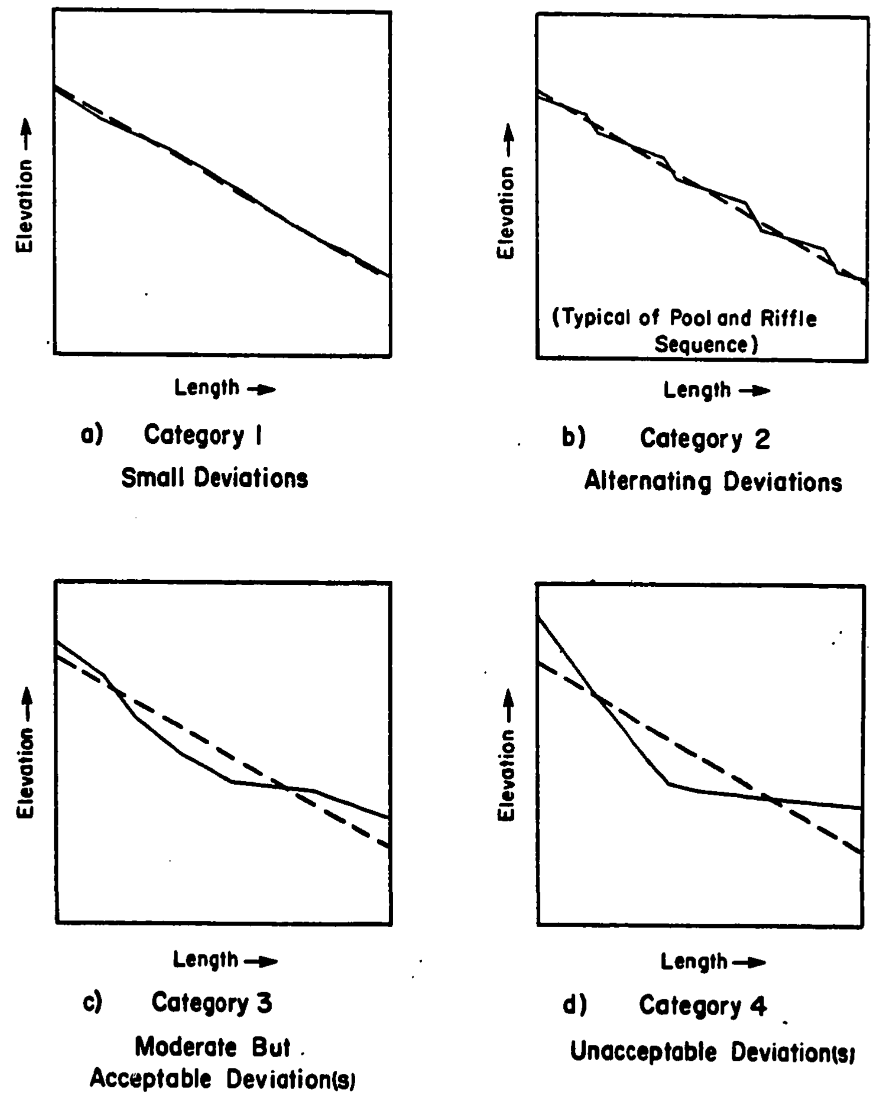


FIGURE 3.4 QUALITATIVE DESCRIPTION OF SLOPE VARIATION WITHIN A REACH

but not in an alternating fashion. In this case there was usually one major but acceptable deviation from the average.

4. The water surface exhibited a significant deviation from the average in the reach. The reach would have to be considered as two separate reaches based on slope.

In order to provide an evaluation of the relative magnitude of the deviation of the topographic slope from the average field slope for a reach, a simple analysis was carried out using 88 comparable field and topographic slopes. In only three cases did the topographic slope deviate from the average field slope by a factor greater than two. The average field slope for these reaches was less than 0.00055 ft./ft. More detail concerning these comparisons is presented in APPENDIX C.

3.5 Bed Material Data

3.5.1 Different Sampling Methods

Many studies have been carried out to determine the influence of a characteristic bed material size on the regime geometry of a river reach. When reviewing some of the previous work, for example that by Lane and Carlson (1953), Wolman (1954), or Muir (1969), it is apparent that several different methods of sampling and analysis have been utilized to obtain the bed material size for gravel rivers. One of the first problems encountered when collating the available data for this investigation was the variety of methods used to obtain the characteristic bed material sizes. This inconsistent presentation of data demonstrated the need for an overall evaluation of the bed material sampling process.

3.5.2 Distinction between Sand-bed Rivers and Gravel Rivers

Since the majority of river studies have been related to sand-bed rivers, the customary bulk sieving procedure has been the basis of most analyses involving bed material. Therefore, when carrying out studies on gravel rivers with a surface of coarse material, the bed material sample of the surface material should be obtained in such a way that it is "equivalent" to the customary bulk sieve analysis of a population which has a surface similar to that being sampled.

FIGURE 3.5 illustrates the difference between a sand-bed river and a typical gravel river with respect to the populations to be sampled. Since gravel rivers are usually analysed from a "threshold" point of view, the surface layer is important as it is the boundary offering the resistance to flow. Of course, the subsurface material would have to be considered if the bed became extremely active during a major flood. In this section, the emphasis is placed on surface sampling methods.

FIGURE 3.5b shows that the surface population for gravel rivers is different from the subsurface population because of the missing fines in the surface layer. These types of channels will be referred to as being paved if the coarser subsurface material is about the same size as the surface material. If the surface layer is obviously coarser than the coarser subsurface material, the surface is referred to as being armored. This effect is shown schematically in FIGURE 3.5c. FIGURE 3.6 shows the appearance of two paved gravel surfaces in the field.

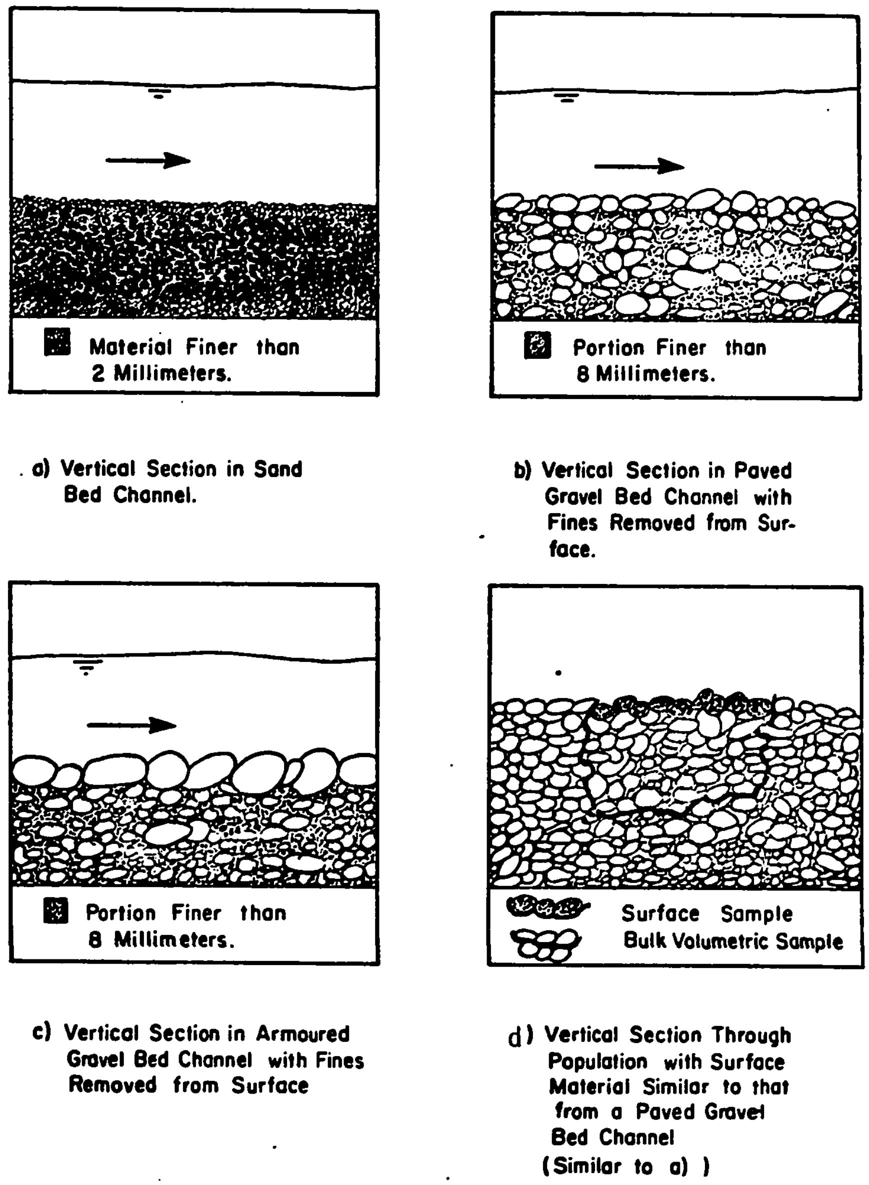
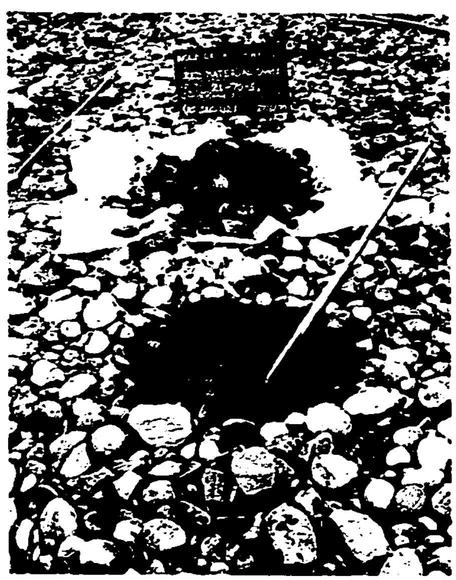


FIGURE 3.5 VERTICAL SECTION IN SAND-BED AND GRAVEL-BED CHANNELS

a) A normal paved gravel bed.
Only fines removed from surface.



b) A paved gravel surface which could be almost classed as an armored gravel surface.

FIGURE 3.6 TYPICAL GRAVEL PAVEMENTS

The surface and subsurface populations for the sand-bed channel are similar. That is, for a sand-bed channel the surface may be considered to be a random slice through the bed material. If a volumetric sample was taken from a population with the surface similar to the surface material of a gravel river as shown in FIGURE 3.5d, then a bulk sieve analysis of this sample would be comparable to the bulk sieve analysis from a sand-bed river. In this case the volumetric sample for sieve analysis is taken so that the size of the material does not influence the volume sampled (or in other words, the volumetric sample is essentially predetermined as shown in FIGURE 3.5d).

3.5.3 The Sampling Process

This section outlines the steps in a complete sampling process after a sampling site has been located in the field. Several sampling procedures are available and are outlined as follows:

1. Collection of a sample
    1. Volumetric sampling: a predetermined volume of bed material is collected.
    2. Grid sampling: a sample is collected at grid points established on the surface. The grid points may be established randomly or in a fixed manner such as a line grid.
    3. Areal sampling: the sample consists of all stones on a specified area of the gravel surface.
    4. Transect sampling: the sample consists of all stones falling under a straight line across the gravel surface.
2. Determination of a linear dimension
    1. Size based on square mesh sieves.
    2. b-axis measured with calipers on each stone.

3. b-axis scaled from photographs.

3. Frequency of occurrance of specified size classes

   1. by weight

   2. by number

   3. by area

Any combination of these steps may constitute a sampling procedure. The types of sampling procedures encountered in this study were:

1. Bulk sieve analysis (S)
   A volumetric sample which was sieved on square meshed sieves and analysed by weight (S). This is referred to as the customary bulk sieve analysis and includes surface and subsurface material.

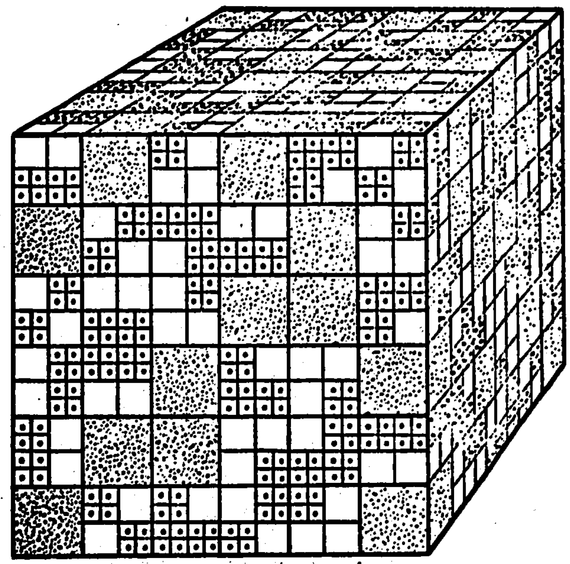
2. Grid-by-number (GBN)
   Stones were collected on a line grid or by a random step procedure; the b-axes were measured by calipers and analysed by number.

3. Grid-by-number from photograph (GBNP)
   A photograph of a square grid was taken of the gravel surface, the b-axes of the stones under the grid intersections were scaled from the photograph and analysed by number.

4. Grid-by-weight (GBW)
   Stones were collected on a line grid or by a random step procedure, then sieved on square mesh sieves and analysed by weight.

3.5.4 Simple Cube Model

In order to develop a surface sampling technique for paved gravel river beds which is equivalent to a bulk sieve analysis of a population with the same surface material, a simple model was used. The model was originally conceived by Kellerhals and later developed by Kellerhals and the writer. The cube model presented in FIGURE 3.7



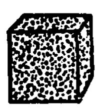
Particle	Linear Size D	Weight W	Total No. in Sample Volume	Total No. in Sample Surface
	1	1	4608	192
	2	8	576	48
	4	64	72	12

FIGURE 3.7 RANDOMIZED SAMPLE OF DENSELY PACKED CUBES OF THREE SIZES

is assumed to be homogeneous and to consist of a population similar to that of the surface material. For simplicity three different sizes are used in the sample. The sample is also considered to be infinite in extent and to have a random arrangement of particles. The table at the bottom of FIGURE 3.7 summarizes the distribution of particles in the sample.

If the entire block is considered as a volumetric sample which is sieved and analysed by weight, the resulting histogram would be that shown in FIGURE 3.8a. For this simplified case, the histogram is uniform. An "equivalent" surface sampling procedure is defined to be one which results in a histogram similar to that obtained for the sieve analysis of a volumetric sample from the same population.

Several surface sampling procedures may now be tested on the simple cube model. Consider the grid-by-number procedure first. In this case, the three size fractions are exposed over equal areas. If a line grid is used, equal numbers of each particle size would be picked up along the line. The resulting histogram would be "equivalent" to that obtained by the sieve analysis of a volumetric sample. From this analysis based on the simple cube model, it is concluded that the grid-by-number method is "equivalent" to the sieve analysis. The only other "equivalent" method is area-by-area.

Consider one further example, that of grid-by-weight. Again equal numbers of particles will be selected in each size class, but when analysed by weight, the resulting histogram is not equivalent

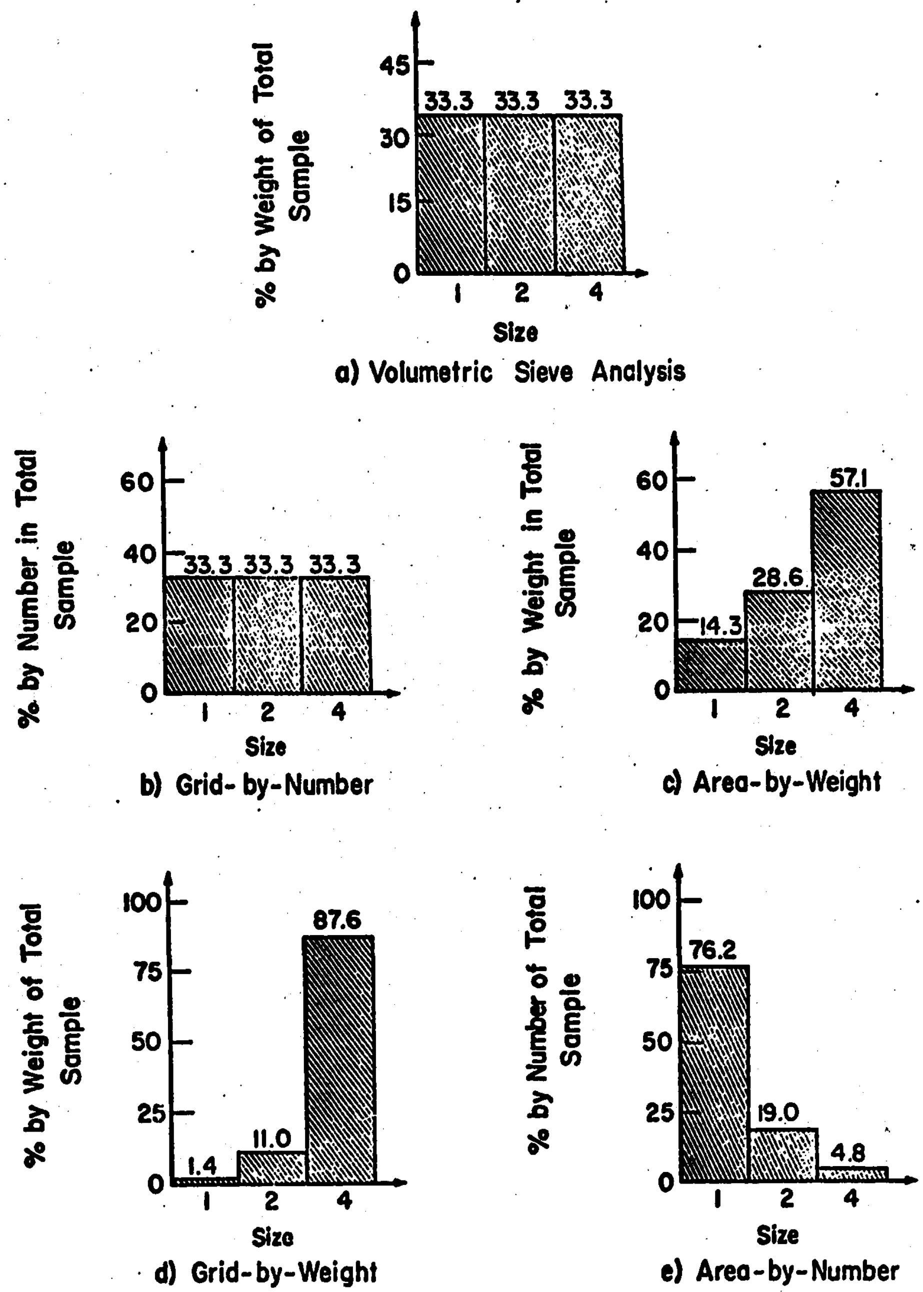


FIGURE 3.8 HISTOGRAMS FOR DIFFERENT SAMPLING PROCEDURES BASED ON THE CUBE MODEL IN FIGURE 3.7

to the sieve analysis, as illustrated in FIGURE 3.8. Another unfavorable feature of this procedure is that one or two large particles can dominate the shape of the histogram.

In a similar manner, the model may be used to obtain histograms for other surface sampling techniques. FIGURE 3.8 presents the histograms for area-by-weight and area-by-number.

One advantage of this model is that simple weighting factors may be derived to convert from one method to another. TABLE 3.1 summarizes these weighting factors for most conversions that are encountered.

3.5.5 Testing the Simple Cube Model

FIGURE 3.9a illustrates the distributions of four samples taken at the same locations but analysed by different methods. FIGURE 3.9b shows the effect of converting these distributions to "grid-by-number" (that is, the "equivalent" sieve curve) by means of the derived weighting factors. All curves are so close after the conversion that the remaining differences may be attributed to random effects.

Ten samples obtained from different Alberta rivers by the Water Resources Division, Alberta Department of the Environment were analysed as grid-by-number and grid-by-weight. When the samples were converted from grid-by-weight to grid-by-number, the computed grid-by-number sizes never deviated more than 2 millimeters from the original grid-by-number analysis. An example of one of the

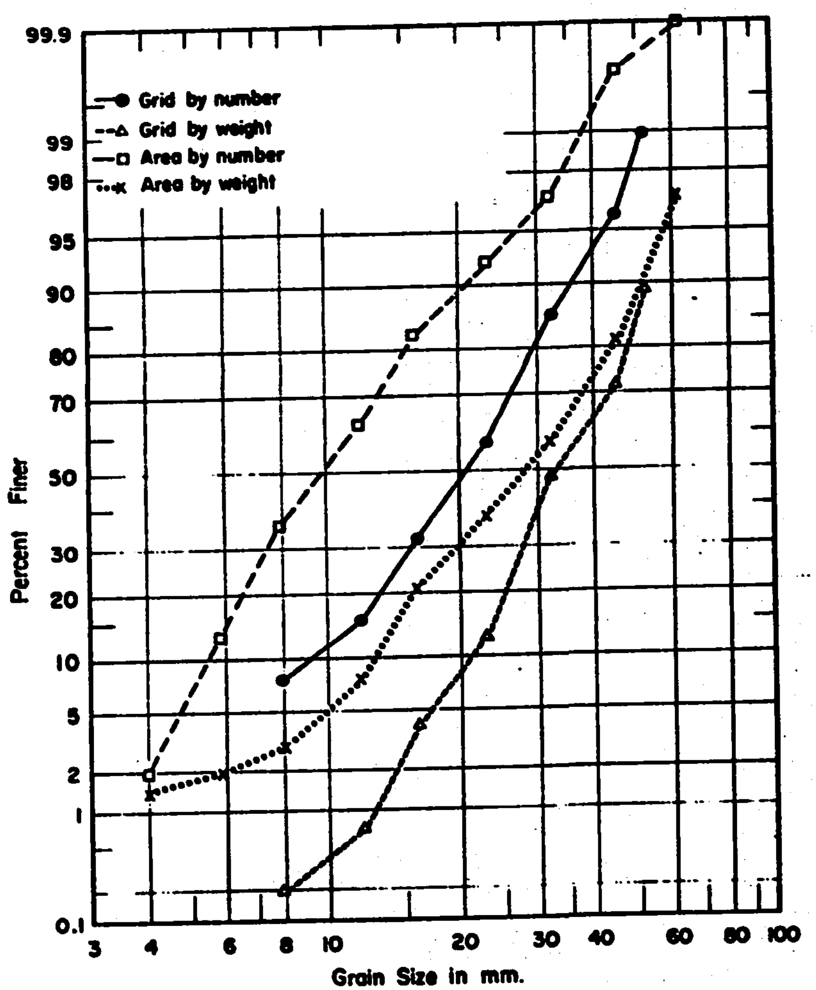
TABLE 3.1

WEIGHTING FACTORS FOR THE CONVERSION OF SAMPLING PROCEDURES

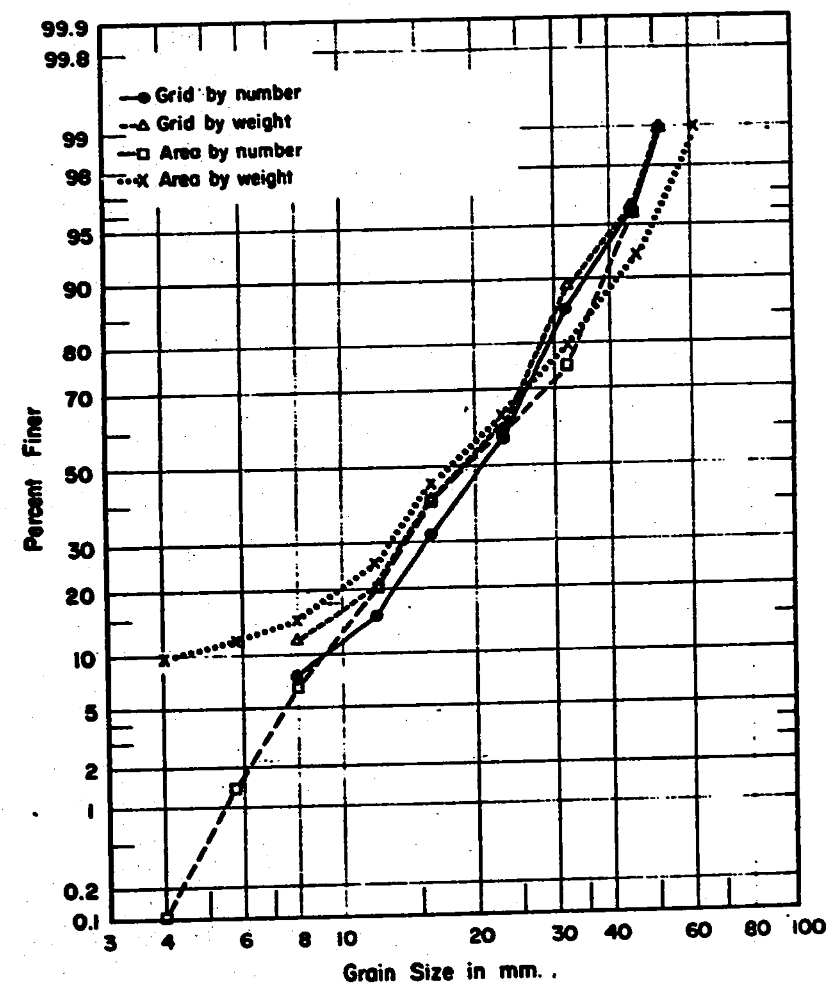
Conversion to from (1)	Sieve-by-weight (2)	Grid-by-number (3)	Grid-by-weight (4)	Area-by-number (5)	Area-by-weight (6)
Sieve-by-weight	1	1	D^3	$\frac{1}{D^2}$	D
Grid-by-number	1	1	D^3	$\frac{1}{D^2}$	D
Grid-by-weight	$\frac{1}{D^3}$	$\frac{1}{D^3}$	1	$\frac{1}{D^5}$	$\frac{1}{D^2}$
Area-by-number	D^2	D^2	D^5	1	D^3
Area-by-weight	$\frac{1}{D}$	$\frac{1}{D}$	D^2	$\frac{1}{D^3}$	1

<u>Notes</u>: 1. The weighting factors are derived for densely packed cubes in random arrangement

2. D is the geometric mean size of the size range to be adjusted by the weighting factor. D can be a sieve size or an intermediate axis.



a) Direct comparison of four sampling procedures [After Ritter and Helley (1969)]



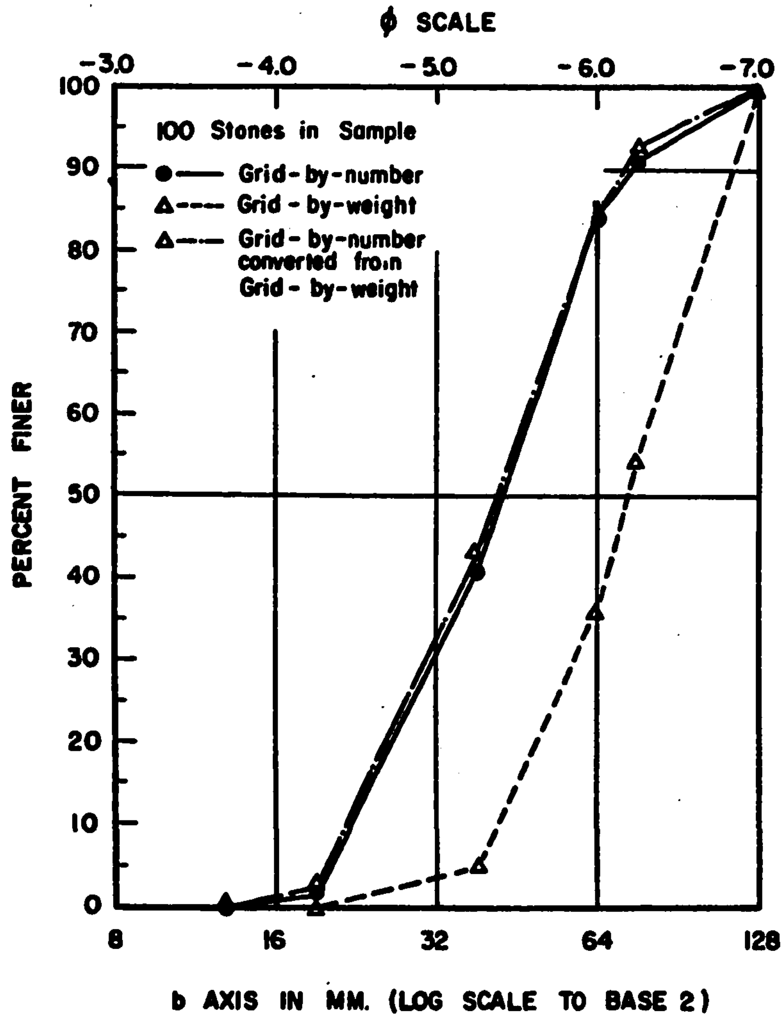
b) Comparison of four sampling procedures after conversion to grid-by-number

FIGURE 3.9 COMPARISON OF FOUR SURFACE SAMPLING PROCEDURES BEFORE AND AFTER CONVERSION TO EQUIVALENCE WITH GRID-BY-NUMBER conversions is shown in FIGURE 3.10.

The grain size curves for four samples are shown in FIGURE 3.11 to indicate the type of agreement over the whole distribution when a grid-by-number analysis and a volumetric sieve analysis of material greater than 8 mm. are compared. In all cases the volumetric sample of surface and subsurface material was obtained along the line grid established to collect the sample of 50 stones for the grid-by-number analysis. In three out of the four cases the agreement is quite satisfactory. The major deviation for the smaller sizes for reach number 95 is probably due to some armoring effect. If this hypothesis is correct, this type of plot could be used to establish criteria for predicting the degree of armoring for a gravel bed consisting of relatively large bed material. The normal paved gravel bed should show little or no deviation between the two types of analysis.

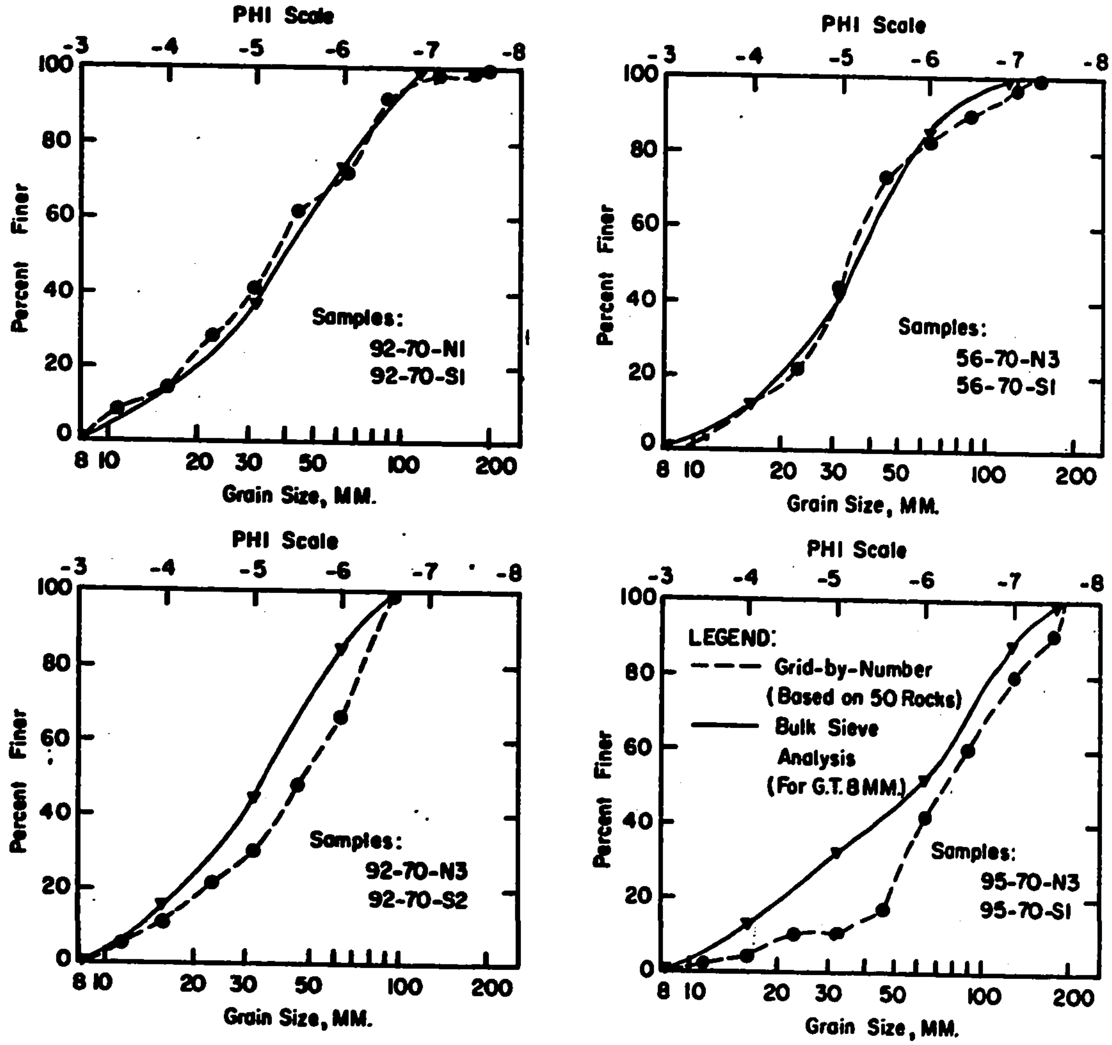
3.5.6 Grid-by-Number Established as Reference

Based on the "equivalence" of grid-by-number analysis and sieve analysis, the grid-by-number procedure was established as the reference method for all surface sampling from gravel rivers. One advantage of adopting this procedure is that the presentation of results from sand-bed and gravel rivers would be directly comparable for surface related phenomenon (e.g. initiation of motion, grain roughness, etc.). A practical reason for considering grid-by-number is that the analysis is not dominated by the presence of one or two large particles in the sample.



DATA SOURCE: Water Resources Division
Alberta Department of the Environment

FIGURE 3.10 COMPARISON OF GRAIN SIZE DISTRIBUTIONS FOR GRID-BY-NUMBER AND GRID-BY-WEIGHT



NOTE: Volumetric sample for sieve analysis taken along the line grid used to obtain the sample for grid-by-number analysis.

FIGURE 3.11 COMPARISON OF GRAIN SIZE CURVES OF GRID-BY-NUMBER ANALYSIS AND SIEVE ANALYSIS OF MATERIAL GREATER THAN 8 MM.

3.5.7 Bed Material Data Available Prior to 1970

Some of the bed material data that were available for Alberta rivers were obtained by Halferdahl (1969) from the period of 1957 - 1964. His data were not primarily collected to determine the effect of the bed material size on the hydraulic properties of the channel, but to determine the concentrations of heavy minerals in recently deposited river gravels and sands. However, in many cases his samples were taken at points in or near a study reach used in this investigation. Generally his samples were taken at the upper ends of bars or of mid-channel islands. That is, the material was not the finest in the area, but was more typical of the average to coarsest material.

Halferdahl obtained a customary bulk sieve analysis of the surface and subsurface material. The results of a typical sieve analysis from one of his many samples is presented in FIGURE 3.12. The histogram is bimodal with a lack of material between the 1 and 8 millimeter range. This deficiency has been observed by other investigators [Sundborg (1956), Leopold (1970)] and has primarily been attributed to selective transport or optimum breaking sizes. The probable cause is selective transport which implies more impacts per unit time for the 1 to 8 millimeter size range.

On most surfaces of gravel rivers, it is difficult to find an appreciable amount of material finer than 8 mm. Almost all of the material finer than 8 mm. is from the subsurface material. In order to make the customary bulk sieve analysis comparable to the surface

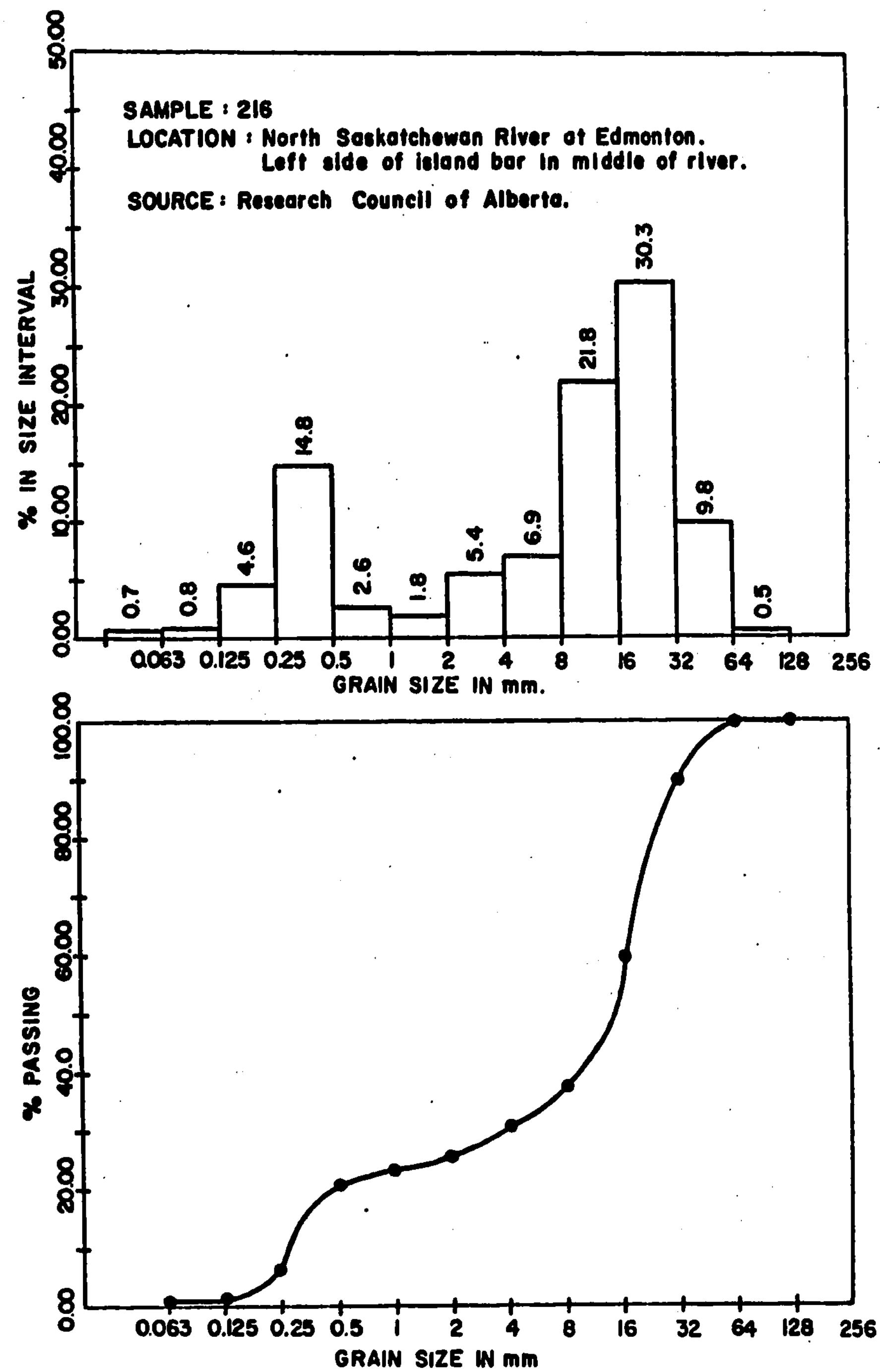


FIGURE 3.12 HISTOGRAM AND GRAIN SIZE CURVE FOR A SIEVE ANALYSIS OF A TYPICAL HALFERDAHL SAMPLE

population alone, all of the applicable Halferdahl samples were reanalysed by omitting the material finer than 8 mm. The adjusted sieve analysis can now be considered to be comparable to a sieve analysis of a population with a surface similar to the exposed surface. This assumption is clearly invalid if the surface is severely armored with material obviously larger than the coarse material under the armor layer.

In addition to the Halferdahl samples, bed material data were available from the Water Resources Division, Alberta Department of the Environment and the Highway and River Engineering Division, Research Council of Alberta. In some cases the samples were grid-by-number, in which case they were accepted without adjustment. All grid-by-weight samples were converted to grid-by-number. All customary bulk sieve analyses were adjusted in the same way as the Halferdahl sieve analyses. Many grid-photographs were also available. In all cases these photographs were analysed as grid-by-number from photograph.

3.5.8 Bed Material Sampling Program

After considering essentially all of the known bed material data for the study reaches, a sampling program was established to obtain data from the field for those river reaches with insufficient data. The main objectives considered when developing the field program were that:

1. Volumetric samples of bed material should be obtained from at least two sites for reaches with sand beds.

2. Line grid samples of bed material should be obtained from at least three typical sites for reaches with gravel beds.

3. A volumetric sample of bank material should be obtained for those reaches having banks of high clay-silt content.

4. At each reach of a gravel river the following samples should be taken at one site if feasible:

    1. two line grid samples of 50 each

    2. two grid photographs along one of the line grids

    3. one volumetric sample including the surface and subsurface material under one of the areas covered by a grid photograph.

A detailed explanation of the exact procedure used in the field is given in APPENDIX D.

Various investigators have suggested the use of different characteristic sizes for different aspects of flow in alluvial channels. Kellerhals (1967) used the B90 size in gravel rivers, since the coarser particles could be associated with effective resistance to flow. Leopold and Wolman (1957) utilized the B84 size to establish an empirical relation between the friction factor, f, and the relative depth. Einstein (1950) employed the D65 size as a roughness parameter for computing the velocity profile, and the D35 size for the effective material size related to bed material transport. Straub (1935) suggested the use of an effective size which was near the D50 size.

The characteristic sizes used in the study were B90, B65 and B50. These sizes were selected to provide data for alternative analyses. One reason for selecting these particular sizes was that for some reaches only the B90, B65 and B50 sizes were readily available [Van der Giessen (1966)].

3.5.9 Comparison of Sampling Procedures

The purpose of obtaining the data under item 4 in the list in SECTION 3.5.8 was to study the following:

1. The relation between a grid-by-number from photograph analysis and the grid-by-number analysis.
2. The relation between a sieve analysis of surface and subsurface material and the grid-by-number analysis.
3. The comparison of two grid-by-number samples of 50 stones each.

The detailed data used in the above analyses along with a discussion of the results are presented in APPENDIX F. A brief summary of the results are given in the following sections.

3.5.9.1 The Comparison of Grid-by-Number and Grid-by-Number from Photograph Analysis

In almost all cases in this analysis, two grid photographs (a 50 mm. grid spacing with 100 intersections) were taken along a line grid used to obtain a grid sample of 50. A total of 50 b-axes were scaled from the photographs (25 from each in most cases, and 50 from one in the few cases where only one grid photograph was taken).

An analysis was carried out using the characteristic sizes obtained from the grid photograph as an independent variable. The corresponding characteristic sizes obtained by the grid-by-number method were used as the dependent variable. The summary of a linear regression analysis of the results based on 55 data points is as follows:

	r^2	S.E.(mm.)
B90(50)GBN = -10.1 + 1.44·B90(50)GBNP	0.87	33.6
B65(50)GBN = -0.5 + 1.29·B65(50)GBNP	0.87	19.9
B50(50)GBN = 4.8 + 1.14·B50(50)GBNP	0.88	13.9

where: B90(50)GBN = the b-axis in millimeters obtained from a sample of 50, such that 90 percent of the stones are finer than this size using the grid-by-number (GBN) analysis.

B90(50)GBNP = similar to B90(50)GBN but by using grid-by-number from photograph (GBNP) analysis. (mm.)

r^2 = the coefficient of determination.

S.E. = the standard error of estimate of the dependent variable. (mm.)

These equations were derived from samples for which all values of B90GBNP were smaller than 263 mm. and all values of B50GBNP were larger than 11 mm.

From these results it is apparent that the two methods do not give identical results. If the cube model of SECTION 3.5.4 is considered, it would be expected that the results would be the same. Two reasons are given for the deviation:

1. The stones in the photograph are often tilted so that the proper b-axis is not readily measured.
2. In some cases the stones are not totally exposed and as a result the estimate of the b-axis from the photograph is somewhat smaller than it should be.

Both explanations are in agreement with the results obtained from the simple linear regression model; that is, the actual b-axis is larger than that indicated from the grid photograph. The discrepancy is greatest for the largest sizes indicating that the greatest amount of tilting may be associated with these sizes.

An alternate analysis was carried out where the regression line was forced through the origin. The results obtained were similar to those given by the best fit regression line. (See APPENDIX F.)

3.5.9.2 Comparison of Grid-by-Number and Sieve Analysis

For this case the grid-by-number procedure based on a sample of 50 stones was compared to one volumetric sample consisting of the material greater than 8 mm. In all cases the volumetric sample was taken at a point along the grid line and consisted of the surface and subsurface material. The detailed field procedure used to obtain the samples is presented in APPENDIX D. The reason for considering material greater than 8 mm. for the bulk sieve analysis has been given in SECTION 3.5.7.

The characteristic sizes obtained from the sieve analysis were considered to be the independent variable, and those from the grid-by-number method were considered to be the dependent variable. A summary of the results from a linear regression model based on 29 data points is presented as follows:

	r^2	S.E.(mm.)
B90(50)GBN = 11.4 + 0.96·D90 S	0.76	19.8
B65(50)GBN = 9.4 + 0.93·D65 S	0.75	12.1
B50(50)GBN = 5.0 + 1.02·D50 S	0.77	9.2

where: B90(50)GBN = the b-axis in millimeters obtained from a sample of 50 such that 90 percent of the stones are finer than this size using the grid-by-number (GBN) analysis.

D90 S = the size in millimeters of the square sieve mesh such that 90 percent of the material is finer by weight than this size when sieving all material greater than 8 mm. (S).

These equations were derived from samples for which all values of

D90 S were smaller than 195 mm. and all values of D50 S were larger than 16 mm.

The above results indicate that the grid-by-number size is almost the same as the characteristic size obtained from the bulk sieve analysis of material greater than 8 mm. About 75 percent of the variance is explained and consequently the amount of scatter in these relations is quite substantial. However, the scatter may be the result of random sampling and random degrees of paving.

3.5.9.3 Comparison of Two Grid-by-Number Samples of 50 Stones

Thirty-one pairs of adjacent grid samples of 50 were obtained at separate sites for 18 different river reaches. Each pair of fifty was tested to determine if the ratio of the variances based on "phi" diameters differed significantly from 1.00 at the 5 and 1 percent levels and if the difference of the means was significant at the 5 and 1 percent levels. The ratio of the variances was not significantly different from 1.00 at the tested levels. There was a significant difference of the means at the 5 percent level for two cases. No cases exhibited significant difference at the 1 percent level. These results would imply that for practical purposes a sample of 50 is adequate.

3.5.10 Bed Material Data for Reaches

An assessment of all available bed material data was necessary for each reach used in the investigation. All data used in this study for sand-bed rivers were based on bulk sieve analysis. For gravel rivers all data were converted or adjusted to grid-by-number. The following procedures were used:

1. If a sample was analysed as grid-by-weight (GBW), it was converted to grid-by-number (GBN) by the weighting factor $1/D^3$.

2. If a sample was analysed as grid-by-number from photograph (GBNP), it was adjusted to grid-by-number (GBN) by the use of the three equations in SECTION 3.5.9.1.

3. If a sample was analysed as a volumetric sample of surface and subsurface material, it was first converted to a sieve analysis of material greater than 8 mm. The converted analysis (S) was adjusted to grid-by-number (GBN) by using the three equations in SECTION 3.5.9.2.

Only one sample was used per site when estimating the value of the characteristic sizes. For example, only one of the three analysed samples in SECTION 3.5.9.1 to 3.5.9.3 was used, that being the grid-by-number with 50 stones. If the exact locations of the samples were unknown, it was assumed that the samples were from different sites.

All samples of the obviously finer material for gravel rivers were rejected, since this material was probably deposited during the falling limb of the flood hydrograph and was not associated with the general "threshold" condition.

In a few cases the reach was located at a place along the river where the material was mainly sand with local gravel. The gravel sizes were used if the slope was predominantly controlled by rapids at the local gravel deposits. If the energy loss was quite uniform for a case of sand with local gravel, the sand was considered to be the representative bed material.

If a sample was not located in the reach, it was rejected unless there was no other sample available or unless the sample was located very near the reach. In some cases a sample located outside the reach was considered, but given a smaller weight than those samples located in the reach.

When all of the acceptable samples for a particular reach were assembled, an average estimate of the characteristic sizes of the bed material was made. The basic procedure used to evaluate the values of B90, B65 and B50 for a river reach was as follows:

1. Obtain the arithmetic average of the B90, B65 and B50 sizes for all samples of each type in the reach.
2. Adjust the average values obtained in 1. from grid-by-number from photograph to grid-by-number, and from sieve analysis to grid-by-number by using the relations of SECTION 3.5.9.
3. Multiply the average adjusted sizes by the number of sample sites used to obtain the average of each sample type.
4. Add all weighted averages obtained in 3 and divide by the total number of sample sites to obtain the average for the reach.

An example of this procedure is presented in TABLE 3.2. In this example, samples were available from five different sites in the reach.

The detailed computations for all bed material data used in this study are on file with the Highway and River Engineering Division, Research Council of Alberta.

TABLE 3.2

EXAMPLE OF PROCEDURE USED TO OBTAIN CHARACTERISTIC BED MATERIAL SIZES FOR A REACH

Sample Type	No. of Sites	Characteristic Sizes B90	B65	B50	Comment
Grid-by-number	2	210	118	82	Site 1
		230	126	86	Site 2
		220	122	84	Average
		440	244	168	Weighted*
Grid-by-number from Photograph	2	118	52	39	Site 3
		126	56	41	Site 4
		122	54	40	Average
		166	69	50	Adjusted
		332	138	100	Weighted*
Sieve (>8 mm.)	1	120	84	67	Site 5
		126	87	73	Adjusted
		126	87	73	Weighted*
Total of Weighted Values*	5	898	469	341	
Average for Reach		180	94	68	

NOTE: All sample types are equivalent. No conversion is required but grid-by-number from photograph and sieve (>8 mm.) are adjusted to grid-by-number.

3.5.11 Qualification of Bed Material Data

In order to evaluate the quality of the accepted data, the following information was obtained for each reach:

1. Number of sites with grid-by-number analysis.
2. Number of sites with grid-by-number from photograph analysis.
3. Number of sites with a sieve analysis (for gravel rivers based on the material greater than 8 mm.).
4. The primary source of data.
5. The second most important source of data (if applicable).
6. The third most important source of data (if applicable).
7. The location of the samples
    1. in reach
    2. mainly in reach
    3. a short distance from reach
    4. a long distance from reach
8. Type of channel bed
    1. sand
    2. sand with local gravel
    3. gravel
    4. gravel with local sand
    5. sand and gravel
9. Representativeness
    1. not representative
    2. quite representative of the average material in the reach
    3. quite representative of the obviously coarser material in the reach; that is, local lag material, etc.
    4. quite representative of the obviously finer material in the reach; that is, material deposited during the recession of a flood, etc.

The bed material data may now be screened according to arbitrary criteria, such as number of sites used, etc. before an analysis is carried out.

3.5.12 Summary

This section has presented a model to justify the use of the grid-by-number procedure. Weighting factors were developed to convert the results of one sampling procedure to another. Comparisons of grid-by-number with grid-by-number from photograph and sieve analysis (> 8 mm.) were made to obtain appropriate adjusting factors.

The method used to obtain an average bed material size for a reach has been outlined and a code for the quality of the data has been developed.

3.6 Geographical and Geomorphological Data

In order to provide a means of classifying the different types of rivers, a geographical and geomorphological description of each reach was carried out. This classification provided alternatives for stratifying or grouping the data for analysis. For example, an analysis could be carried out for all entrenched gravel rivers located in the foothills with a sinuosity less than or equal to 1.3. The coded data could also help identify the reason for a particular major deviation in an analysis.

When considering the general types of codes and the detailed coding, some guidance was obtained from the work of Neill (1964) and Galay (1968). The standard references by Leopold, Wolman and Miller (1964) and Thornbury (1954) were often consulted during the evolution of the coding system.

3.6.1 The Approach Used

The general approach was to use a coding system for the various aspects of the reach description. The quantitative data were coded on a relative or an absolute scale. Each descriptive code was defined in such a manner to adequately describe the particular aspect under consideration with a minimum number of choices. Since a feature had to be described by one coded number, some borderline cases were encountered for which one category could be used as well an another. In such situations, comments were made to qualify a choice or to give additional information.

Multiple codes were used in a few cases to provide a more complete description of the aspect being considered. When multiple codes were used, the first code was dominant and the others were of decreasing importance.

The development of the coding system required a process of trial and error in order to make a relatively workable and consistent set of codes. The first coding scheme was based on an evaluation of a few river reaches. A number of contradictions and limitations became apparent after reviewing the results. A second coding scheme was developed and used to code all of the river reaches utilized in the study. After reviewing the coding for all of the reaches, it was found that additional codes were required. Some final changes were made and the entire coding procedure was repeated for all reaches.

Each reach was evaluated by considering the following general topics:

1. Terrain near the reach but not in the valley
2. Valley walls and terraces
3. Relation of channel to valley
4. Channel plan and channel activity
5. Channel banks and bed

This evaluation progressed from a broad view of the reach setting to the specific evaluation of the channel banks and bed.

Not all of the coded data were actually used in this study to classify and stratify the river reaches. All data are provided, however, to permit a relatively complete description of the river reaches.

A detailed write-up of the codes and coding procedure used for the geographical description is given in APPENDIX G. An example of the coding used for a specific reach is given in APPENDIX H.

3.6.2 Source of Data for Geographic Description

The major features related to the reach were primarily evaluated from aerial photographs and topographic maps. The more detailed evaluations were made with the aid of field notes, field photographs, bridge plans, etc.

An attempt was made to ensure that the data used in the geographical description corresponded to similar types of data used for other purposes in the study. For example, the valley flat identified in the section related to the channel geometry (SECTION 3.3) was the same valley flat used in the geographical description.

3.6.3 Summary

A relatively complete, workable coding system was developed to describe the geographical and geomorphological aspects of a river reach. All river reaches used in the study were coded according to the codes defined in APPENDIX G. The coding provided the possibility of stratifying the data for analysis and for evaluating the cause of major deviations in derived relations.

CHAPTER 4

METHOD OF ANALYSIS

This chapter indicates how the basic data presented in CHAPTER 3 were incorporated into a system to facilitate the analysis. It also presents the types of analyses used in the investigation.

4.1 River Reaches Used

A map of the Province of Alberta is presented in FIGURE 4.1, which shows the location of the 120 river reaches considered for the analysis. Some reaches have no survey data, and in some other reaches the hydrometric station was not active at the time of the survey. The map shows that the majority of the reaches are from the south-western portion of the province. Most stations in the northern part of the province are for relatively large rivers.

The data for each of the 120 reaches were stored in a total of 37 data tables. APPENDIX I includes all data and explanatory notes to define various codes used in the tables and to provide additional relevant information. Only 95 of the 120 reaches were accepted for this investigation.

4.2 Development of the System for Analysis and/or Plotting

In order to make a general analysis of the tabulated river data, a relatively flexible approach was used to manipulate the basic data by the computer. All of the basic data were stored on tape. Each table was considered independently and each item in each table was assigned a word number. A master form was constructed which identified

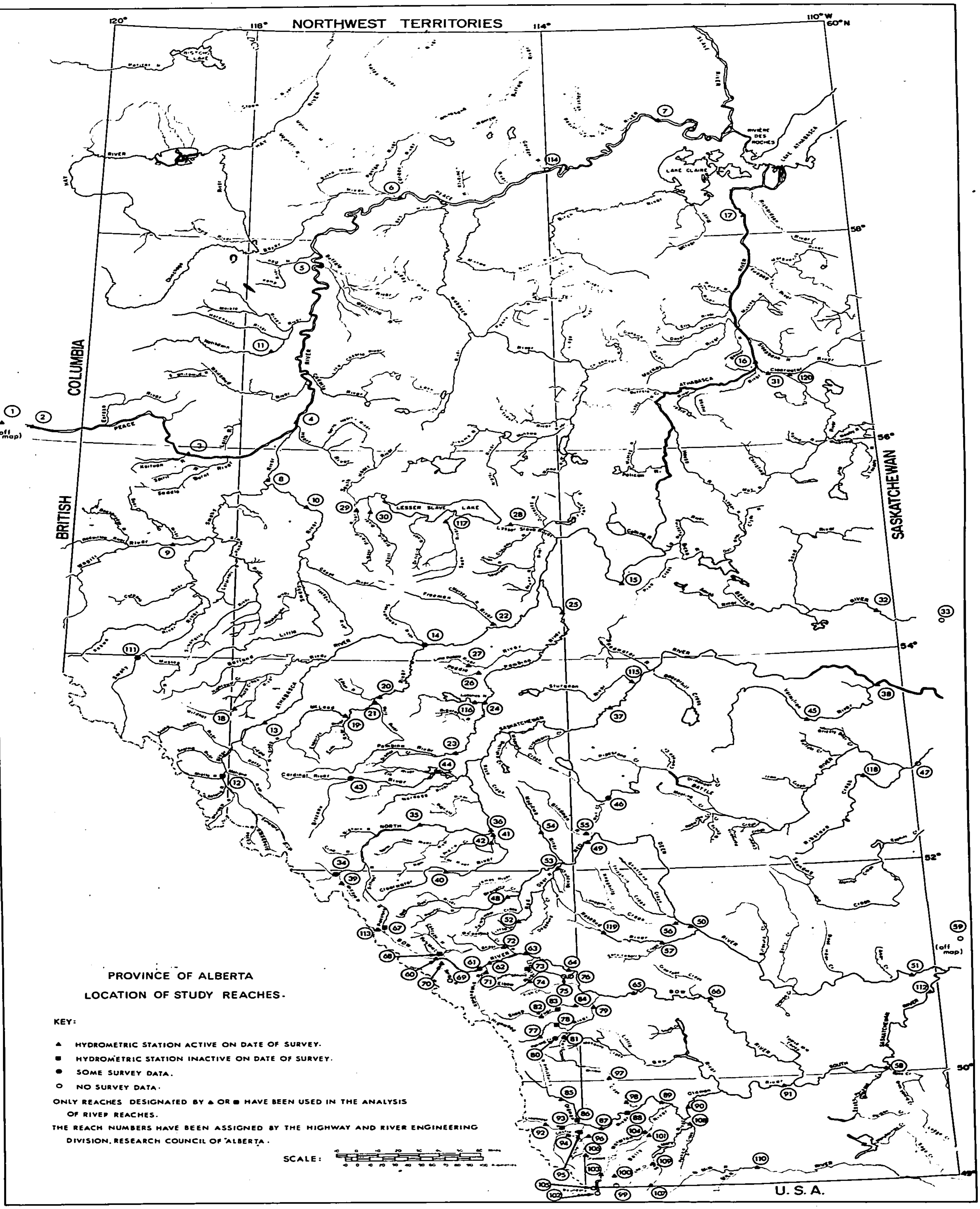


FIGURE 4.1 LOCATION OF STUDY REACHES

the table number and word number associated with each variable. For example, the code number for the representativeness of the reaches was word number 2 in data table 22.

A program written by Arora (1971) was utilized to construct a data file for the desired variables (defined by table number and word number) for the 120 river reaches.

FIGURE 4.2 is a macro-flow chart showing the major steps for any analysis. The following sections essentially follow the macro-flow chart.

First, the data placed in the river data file from the master tape are read into a matrix, ARRAY, in core. The size of ARRAY was 120 (rows-reaches) by 80 (columns-elements). Next, the names of the variable associated with each element number are read in. A general screening follows to exclude all reaches not meeting specified screening criteria. After the general screening, the element numbers for the desired discharge and the corresponding average cross-sectional area and average water surface width are read in. Based on these properties three working vectors (DM, VM, THRES) are formed. The remaining working vectors (S, SCOR, VISK, DG90, DG65, DG50) are then formed. After all the working vectors are established, further screening may be carried out. Next the analysis and/or plotting are carried out for the specified discharge for all reaches satisfying the screening criteria. Any number of specific analyses and/or plots may then be executed. The different types of analyses available are

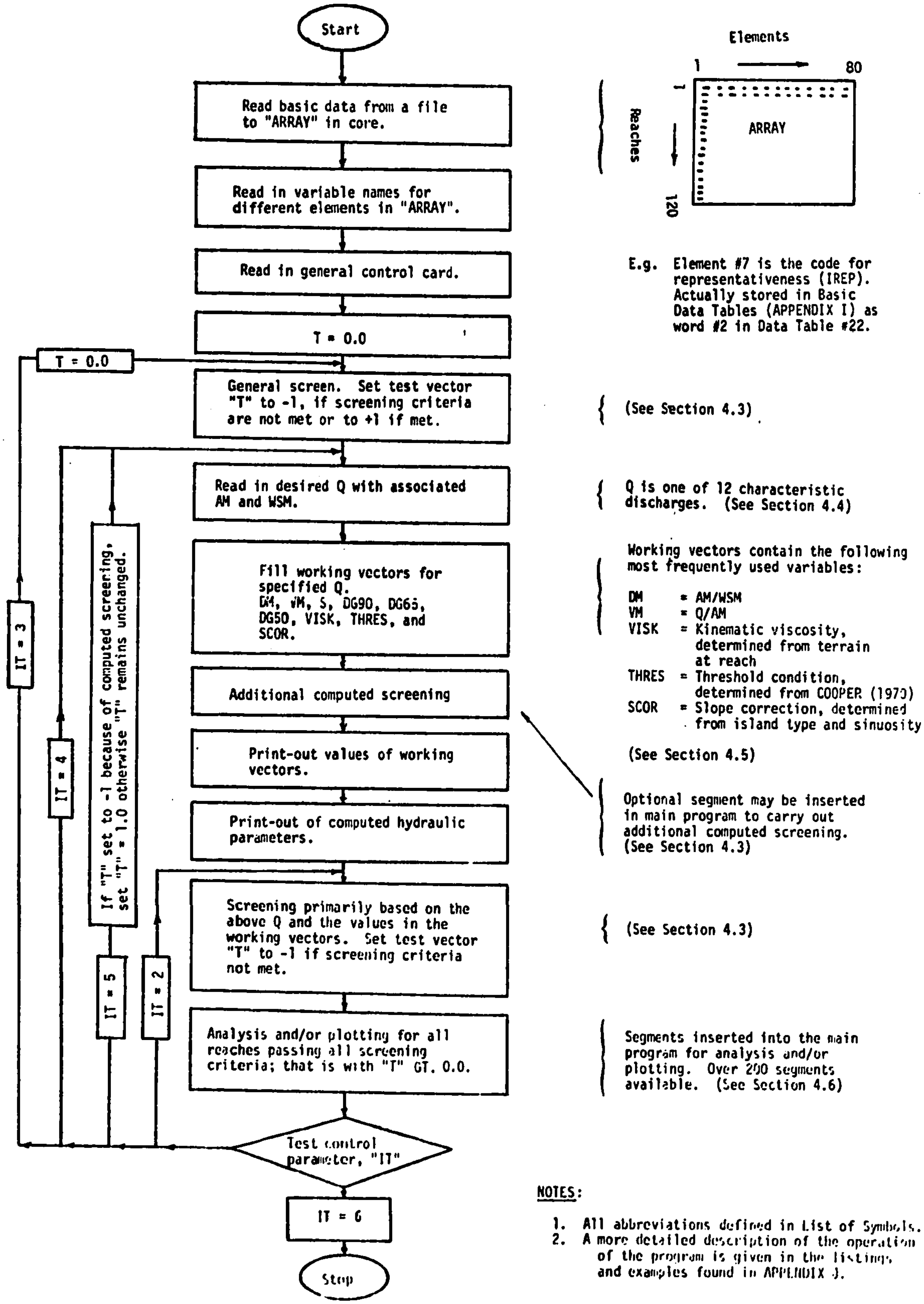


FIGURE 4.2 MACRO-FLOW CHART FOR ANALYSIS

presented in SECTION 4.6. When all analyses and plots are executed for a given set of conditions, a control is met which determines whether:

1. A new general screening; that is, a new problem follows, or
2. A new discharge and associated average area and average width follow, or
3. A new screening for the current discharge follows, or
4. All execution stops.

4.3 Screening of the Data

The screening of the data provides a method of stratifying the data according to predetermined criteria. As shown in FIGURE 4.2, the screening was carried out on the following levels:

1. General screening
2. Additional computed screening after the working vectors were formed
3. Screening after the desired discharge was read in and the working vectors were formed

In cases 1 and 3 the controls for the various screenings are the same. In the case of the additional computed screening, the test vector, T, was set to -1 by a program segment inserted into the main program. A detailed example of this option is given in APPENDIX J.

The following description applies to cases 1 and 3 given in the above list of available screenings. Each screening is carried out by considering upper and lower limits for one to three of the 80 variables in ARRAY. Eight types of screening are presented in TABLE 4.1. Using these controls, it is possible to carry out almost

TABLE 4.1

CONTROLS FOR SCREENING OF DATA FOR ELEMENTS IN THE MATRIX "ARRAY"

Screening Code	1st Element Tested LB1 UB1	2nd Element Tested LB2 UB2	3rd Element Tested LB3 UB3
1	Accept if the value of the first element is within limits LB1 and UB1		
2	Accept if the value of the first element is within limits LB1 and UB1 and the value of the second element is within limits LB2 and UB2		
3	Accept if the value of the first element is within limits LB1 and UB1 and the value of the second element is within limits LB2 and UB2 and the value of the third element is within limits LB3 and UB3		
4	Accept if the value of the first element plus the value of the second element is within limits LB1 and UB1		
5	Accept if the value of the first element plus the value of the second element plus the value of the third element is within the limits LB1 and UB1		
6	Reject if the value of the first element is within limits LB1 and UB1		
7	Reject if the value of the first element is within limits LB1 and UB1 and the value of the second element is within limits LB2 and UB2		
8	Reject if the value of the first element is within limits LB1 and UB1 and the value of the second element is within limits LB2 and UB2 and the value of the third element is within limits LB3 and UB3		

NOTES:

1. Within limits LB1 and UB1, etc. includes LB1 and UB1.
2. The use of the term first element does not mean element 1 in ARRAY but is the first element number from ARRAY to be tested for any one screen.
3. The required formats for the above controls are given in the listing of the program with an example of data and control cards in APPENDIX J.

any desired screening of the data. There is no limit to the number of such screens that may be applied to any one run. As an example, it may be desired to accept reaches which are representative (representativeness code = 1) and quite representative (representativeness code = 2). The representativeness codes are stored in Element 7 of ARRAY. In this case the screening control would be as follows:

Screen Type	Element	Lower Bound	Upper Bound
1	7	0.99	2.01

The following six main screenings were used in the analysis:

1. All
   - Accept if representative, or quite representative
2. Sand-1
   - Accept if representative, or quite representative
   - Accept if bed material is sand, or sand with local gravel
3. Sand-2
   - Accept if representative, or quite representative
   - Accept if bed material is sand
4. Gravel-1 (minimum screen)
   - Accept if representative, or quite representative
   - Accept if bed material is gravel
5. Gravel-2 (moderate screen)
   - Screening for Gravel-1, plus,
   - Accept if the rating curve is stable, slightly unstable, or moderately unstable
   - Accept if the hydrometric station was operational at the time of survey
   - Accept if bed material samples are representative
   - Accept if median bed material size for the reach is within the bounds of 8 mm. to 152.2 mm. (that is a "phi" range of 3 to 7.25)

6. Gravel-3 (severe screen)

- Screening for Gravel 2, plus,
- Accept if the relative deviation of the water surface profile is less than 33.33%
- Accept if the channel is laterally stable, slightly unstable, or moderately unstable
- Accept if the number of bed material sites used to obtain the characteristic bed material sizes is greater than, or equal to, 3
- Accept if the bed material samples are from the reach, or mainly from the reach

The Gravel-2 screening allowed some control over the definition of the channel properties by rejecting reaches with unstable rating curves, and/or with hydrometric stations which were inoperative at the time of the survey. Limited screening of the bed material was carried out.

For the Gravel-3 screening, more severe criteria had to be met. Only reaches with surveyed slopes having a relative deviation less than 33% were accepted. The screening for the bed material data was more restrictive.

In a few cases, additional screenings were used to investigate the effect of a particular variable or condition on the functional form of an equation. Since the main emphasis of the study is related to gravel rivers, the gravel screenings were used most often, the Gravel-1 screening being the most common.

4.4 <u>Selection of a Discharge for an Analysis</u>

Twelve discharges were available for analysis. Once a discharge is specified, various hydraulic properties may be computed.

The discharges used in this investigation along with the assigned symbols are given in TABLE 4.2

4.5 Forming the Working Vectors

When a discharge and corresponding average cross-sectional area, and average water surface width were accepted for an analysis, some simple hydraulic parameters were computed based on the average properties for the reach. The basic definition of these parameters are given as follows:

$$DM = AM/WSM \qquad \text{EQUATION 4.1}$$

$$VM = Q/AM \qquad \text{EQUATION 4.2}$$

where: DM = mean depth for the reach in ft.

AM = mean cross-sectional area for reach in $ft.^2$

WSM = mean water surface width for reach in ft.

Q = discharge in $ft.^3/sec.$ for which DM, AM, WSM and VM correspond

The average water surface width was accepted as a measure of the width, since it is easily obtained from the cross-sectional data and it resulted in a definition of the mean depth which is close to that of the hydraulic radius. The difference between the two was usually never more than ten percent, even for stages corresponding to the elevation of the valley flat. (See examples of reach analysis in APPENDICES B and H.)

The slope, S, in ft./ft. was the field slope unless no field measurements were available, in which case the topographic slope was used. About 90 percent of the reaches used in the analysis had field surveyed slopes.

Three characteristic bed material sizes in millimeters were placed in the working vectors. These sizes were converted to feet for all analyses and were designated as DG90, DG65, and DG50.

An estimate of the kinematic viscosity, ν, (or VISK), in ft.^{2}/sec. was made by referring to some measured water temperatures of Alberta Rivers published by the Water Survey of Canada (1970). In a rather general way, the average temperature, and therefore the approximate kinematic viscosity, could be assigned to the terrain type for the reach in the following manner:

Terrain at reach	Approximate Water Temperature °F	Kinematic Viscosity ft.^{2}/sec.
Mountains	40	0.0000166
Foothills, uplands	45	0.0000154
Hills, plains, and lowlands	50	0.0000141

The average water temperature normally occurred during the period of the year with the higher discharges; that is, those discharges of primary interest in this investigation.

Next a very tentative evaluation of the threshold parameter, THRES, at each reach was stored in a working vector. The definition used was:

$$THRES = VM/VMCRIT \qquad \text{EQUATION 4.3}$$

where: VM = the mean velocity for the reach in ft./sec.

VMCRIT = the critical mean velocity for the threshold condition in ft./sec.

The value of VMCRIT was estimated from the work of Cooper (1970) by utilizing the plot shown in FIGURE 4.3 for charge approaching zero (Ctb equal 0.1 ppht or 1 ppm). Using this plot, values of VMCRIT could be evaluated for relative depths, DM/DG50, ranging from 4 to 3000. The criteria for initiation of motion given by Neill (1968) for relative depths ranging from 2 to 100 is almost identical to that obtained from the Cooper plot for the same range of relative depths. The value of VMCRIT was based on the results of flume tests for relatively uniform materials and cross-sections. Therefore the extension of such a criterion to natural channels is questionable; however, the value of THRES should provide an index for evaluating the relative mobility of the bed material for various reaches. The expressions used to compute critical mean velocity were:

1. For relative depths, DM/DG50, GE. 4 and LT. 150

   $$VMCRIT = 12.1 \cdot DM^{0.133} \cdot DG50^{0.367} \qquad \text{EQUATION 4.4}$$

2. For relative depths, DM/DG50 GE. 150 and LT. 1000

   $$VMCRIT = 3.87 \cdot DM^{0.304} \cdot DG50^{0.196} \qquad \text{EQUATION 4.5}$$

3. Relative depths, DM/DG50 GE. 1000 and LT. 3000

   $$VMCRIT = 2.37 \cdot DM^{0.377} \cdot DG50^{0.123} \qquad \text{EQUATION 4.6}$$

The last variable in the working vectors was a parameter used to roughly evaluate a slope correction factor, SCOR. The main reason for including this parameter was to test a suggestion by Blench (1969a) that slopes for natural channels which are not straight are greater than those for equivalent straight regime channels. The only rationale used to determine SCOR was the following rough guidelines given by Blench:

TABLE 4.2

SYMBOLS AND DESCRIPTIONS FOR THE 12 CHARACTERISTIC DISCHARGES USED IN THE ANALYSIS

Symbols	Description of discharge
LTM	Long-term mean discharge based on the full year records
1.5 YF	Discharge corresponding to the 1.5 year flood
2 YF	Discharge corresponding to the 2 year flood
5 YF	Discharge corresponding to the 5 year flood
10 YF	Discharge corresponding to the 10 year flood
0.5% FD	Discharge exceeded 0.5 percent of the time based on the April - October record
1% FD	Discharge exceeded 1% of the time based on the April - October record
5% FD	Discharge exceeded 5% of the time based on the April - October record
10% FD	Discharge exceeded 10% of the time based on the April - October record
LLB	Discharge corresponding to the average elevation of the low level bench and/or the trim line
VF	Discharge corresponding to the average elevation of the valley flat
VF $\leq$ 20 YF	Discharge corresponding to the average elevation of the valley flat, <u>if</u> the return period for the discharge is less than or equal (LE.) to the 20 year flood

NOTE: The flow duration data (FD) are based on the discharges from the April to October record, but the time base used is the entire year.

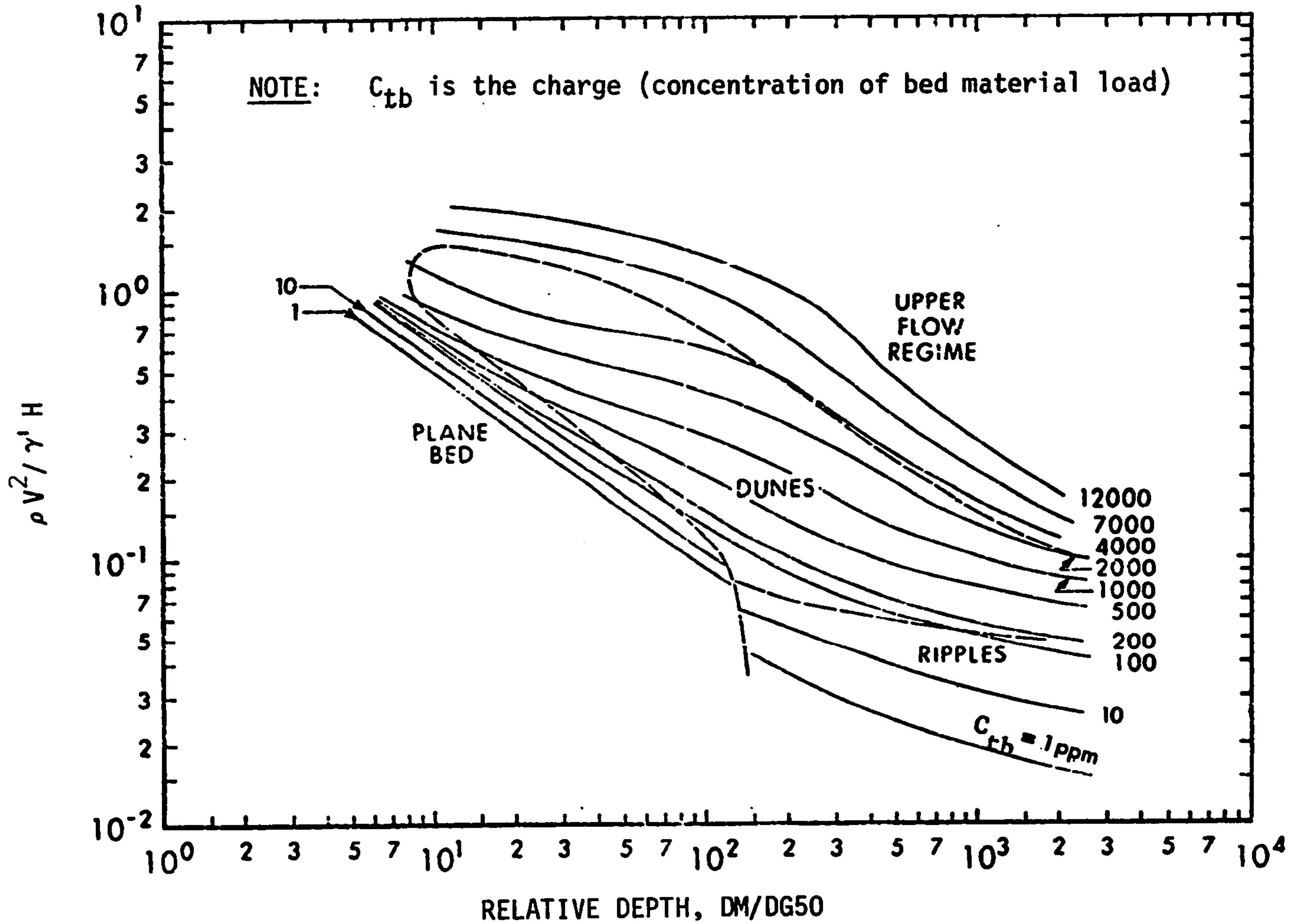


FIGURE 4.3 RELATION BETWEEN $\rho V^2/\gamma' H$ VERSUS RELATIVE DEPTH BASED ON GENERALIZED ANALYSIS OF FLUME DATA [AFTER COOPER (1970)]

Description of Channel	Slope Correction
River looks straight on an aerial photograph	1.25
Conspicuous well-developed meandering without braiding	2.0
For braiding (or split)	3.0
For extreme braiding	4.0

Using the island code and the sinuosity for each reach, an estimate of SCOR was made in the following manner:

1. For cases with no islands or occasional islands (greater than 10 channel widths apart)

   $$SCOR = 1.00 \cdot (0.25 + SINUOSITY) \qquad \text{EQUATION 4.7}$$

2. For cases with frequent islands (less than 10 channel widths apart)

   $$SCOR = 1.20 \cdot (0.25 + SINUOSITY) \qquad \text{EQUATION 4.8}$$

3. For cases with a split channel

   $$SCOR = 2.0 \cdot (0.25 + SINUOSITY) \qquad \text{EQUATION 4.9}$$

4. For cases with a braided channel

   $$SCOR = 2.8 \cdot (0.25 + SINUOSITY) \qquad \text{EQUATION 4.10}$$

In the above evaluation of SCOR, the sinuosity was often difficult to determine with reference to the reach. That is, the sinuosity, defined as river length to valley axis length, was usually computed over a length of the river in excess of the study reach. Notwithstanding, the estimate of SCOR was as good as that which could be determined by using the guidelines given by Blench.

With the values of Q, AM, WSM, DM, VM, S, DG90, DG65, DG50, VISK, THRES, and SCOR in the working vectors for all the reaches, most hydraulic computations could be readily carried out by using these prepared data.

4.6 The Analysis and/or Plotting

After the general screening, the preparation of the working vectors, and the final detailed screening (if desired), control passes to various segments of the main program that carry out the detailed analysis and/or plotting.

Each program segment used for analysis and/or plotting is a unit in itself in that it may be added or deleted from the main program without affecting other parts of the program. An individual program segment provides for one specific analysis or one specific plot. Each program segment consists of approximately 15 cards which tests to ensure that:

1. The screening criteria were satisfied; that is, the value of the test vector, T, was not -1.
2. The values to be used in the computations were not zero or less than or equal to zero if logarithms were to be used.
3. The desired computations were carried out.
4. The appropriate subroutines were called.

Any number of individual segments may be inserted into the main program. About 200 segments are now available to carry out various analyses and plots. A new segment for a special requirement may be prepared in 15 - 30 minutes.

The types of analysis used in this investigation are as follows:

1. Determination of the variability of a single variable for an equation of the form:

   $$Y = a \cdot X^b \qquad \text{EQUATION 4.11}$$

   where b is fixed or where X^b is equal to 1.0, etc.

   For this case the results include:

   1. the mean value of the coefficient "a"
   2. the 95% confidence limits for the mean assuming a normal distribution
   3. the coefficient of variation
   4. the minimum, median and maximum values in the distribution
   5. the sample size
   6. the data for the histogram

2. Determination of the best fit line for the simple linear regression equation of the form:

   $$Y = a + b \cdot X \qquad \text{EQUATION 4.12}$$

   In this case the results include:

   1. the best fit values of a and b
   2. the 95% confidence limits for a and b
   3. the correlation coefficient, r, the 95% confidence limits for r, and the value of the coefficient of determination
   4. the standard error of estimate of Y
   5. the value of the F-ratio from the analysis of variance
   6. the sample size

3. Determination of the best fit line for a multiple linear regression equation of the form:

   $$Y = a + b \cdot X_1 + c \cdot X_2 + d \cdot X_3 \qquad \text{EQUATION 4.13}$$

This option was only used when two or three independent variables were involved in an analysis. The results were those given by the standard output from the IBM SSP Library (1968) and included:

1. the best fit values of the constant, a, and the coefficients b, c, and d
2. the value of R, the multiple correlation coefficient
3. the standard error of estimate of Y
4. the values of the simple correlation coefficient, r, between the dependent variable and each of the independent variables
5. the computed value of "t" for the coefficients, b, c, d
6. the value of the F-ratio from the analysis of variance
7. the sample size

In most cases the analysis for the simple linear regression and multiple linear regression were carried out by transforming the basic data to logarithms to the base 10. The equation for the best fit lines when using the untransformed data were of the following exponential form:

1. For linear regression

$$Y = a \cdot X^{b} \qquad \text{EQUATION 4.14}$$

2. For multiple linear regression

$$Y = a \cdot X_1^{b} \cdot X_2^{c} \cdot X_3^{d} \qquad \text{EQUATION 4.15}$$

The standard error of estimate (S.E.) in such cases was expressed in log units, where one log unit may be easily visualized as one log cycle when the data are plotted on log-log paper.

The plotting was carried out primarily by means of a subroutine, GPLIB, written by Cooper and Howells (1969). This subroutine provided for the options of using arithmetic, logarithmic, or normal probability scales. A total of 13 symbols was available for plotting and a third parameter could be printed by a plotted point if desired. Each program segment for plotting provided the controls for the scaling of the plots and the names of the axis to be plotted, in addition to those aspects presented in SECTION 4.6.1.

At the present time, the desired segments for analysis or plotting must be physically inserted in the main program. With some further work, all program segments could be stored in some manner, so that they could be called into core by a single control card.

A complete list of the presently available segments for analysis and plotting are presented in APPENDIX K. An example of a listing of the main program including a segment for each of the three types of analysis and a segment for a plot is presented in APPENDIX J. An example of the results for a Gravel-1 screening for a discharge corresponding to the 2 year flood are also illustrated for the above example segments. This same appendix shows how:

1. A value in ARRAY may be changed without reconstructing the basic data file.
2. An additional computed screening may be accomplished.
3. The necessary control cards are arranged for an analysis using Gravel-1, Gravel-2 and Gravel-3 screenings for discharges corresponding to the 2 year flood, the low level bench, the valley flat, and the valley flat for return periods less than or equal to 20 years.

4.7 Rejection of Data

The data were closely checked to ensure that no major errors were introduced into the study. For example, the discharges corresponding to the 2 year flood were plotted against the discharges which were exceeded 1 percent of the time. Two outlying points were found, which proved to be a punching error. Computations of mean depth and mean velocity were made. Cases were checked if the mean velocity or mean depth decreased with increasing discharge. In one or two cases, the data were in error and in a couple of cases, the survey was considered to be questionable.

Finally, outlying points were identified by considering the histogram resulting from the distribution of a sensitive coefficient. The distribution of the coefficient "a" in the following equations were satisfactory for this purpose:

$$VM^3/WSM = a \qquad \text{EQUATION 4.16}$$

$$WSM = a \cdot Q \cdot S^{1.167}/DG50^{1.50} \qquad \text{EQUATION 4.17}$$

EQUATION 4.16 is the Blench (1941) side factor, and EQUATION 4.17 is a form of the width equation given by Henderson (1966) for wide gravel rivers. The outlying points were evaluated by considering the original survey data. If no obvious error could be found in the survey data, the questionable reach was accepted with some qualification. However, if the survey or hydrology were questionable, the particular reach was rejected. In a few cases, surveyed reaches were rejected if the character of the reach varied significantly within the reach. The representativeness code was the primary code to determine the acceptability of a reach. Reaches which were questionable were rejected from all analysis in this investigation.

TABLE 4.3 presents the total number of reaches for the six screenings given in SECTION 4.3 and for the 12 characteristic discharges accepted for this investigation. The reach numbers satisfying the six main screenings are presented in TABLE 4.4 for the discharge corresponding to the 2 year flood, and in TABLE 4.5 for the discharge corresponding to the elevation of the valley flat.

4.8 Summary

This chapter has outlined the method adopted to make the basic data accessible for an analysis, the method used for an analysis and the types of analysis that were available. The method of computing commonly utilized parameters was also given. Finally the reach numbers actually used for analysis were presented. The following chapter discusses the results obtained from the many analyses carried out using the basic data of CHAPTER 3 and the method of analysis outlined in this chapter.

TABLE 4.3

NUMBER OF REACHES FOR 12 CHARACTERISTIC DISCHARGES WHICH SATISFY THE SIX MAIN SCREENINGS

Q	All	Sand-1	Sand-2	Gravel-1	Gravel-2	Gravel-3
LTM	95	18	10	71	47	30
1.5 YF	95	18	10	71	47	30
2 YF	93	17	9	70	46	29
5 YF	83	13	7	64	42	25
10 YF	62	8	5	48	32	17
0.5% FD	84	13	7	65	41	25
1% FD	86	13	7	67	43	27
5% FD	95	18	10	71	47	30
10% FD	95	18	10	71	47	30
LLB	55	8	6	45	30	18
VF	62	17	9	41	30	22
VF $\leq$ 20 YF	34	11	6	22	15	12

TABLE 4.4

REACH NUMBERS SATISFYING THE SIX MAIN SCREENINGS FOR THE DISCHARGE CORRESPONDING TO THE 2 YEAR FLOOD

Screening: All — Total number of reaches: 93

1	2	3	4	5	6	7	8	9	10	11	12	13	15	16
17	18	19	20	21	22	23	24	25	26	28	29	30	31	32
35	36	37	38	40	41	42	44	48	49	50	51	52	53	54
56	57	58	60	62	63	64	65	66	67	71	73	74	77	78
79	81	83	84	85	86	87	88	89	90	91	92	93	95	96
97	98	100	101	103	104	106	107	108	109	110	112	113	115	116
117	119	120												

Screening: All -reaches with no surveyed slope — Total Number: 10

4	8	9	23	35	36	38	90	110	112

Screening: All -reaches with no bed material data — Total Number: 9

4	5	11	15	16	31	44	58	120

Screening: Sand-1 — Total number of reaches: 17

5	6	7	16	17	23	25	28	29	30	31	32	51	54	60
117	120													

Screening: Sand-2 — Total number of reaches: 9

6	7	17	28	29	30	31	60	117

Screening: Gravel-1 — Total number of reaches: 70

1	2	3	4	8	9	10	11	12	13	18	19	20	21	22
24	26	35	36	37	40	41	42	44	48	49	50	52	53	56
57	62	63	64	65	66	67	71	73	74	77	78	79	81	83
84	85	86	87	88	89	90	91	92	93	95	96	97	100	101
103	104	106	107	108	109	110	113	115	116					

Screening: Gravel-2 — Total number of reaches: 46

1	2	3	8	9	10	13	18	20	21	22	24	26	35	36
37	40	41	42	48	49	50	52	53	57	64	77	79	81	85
87	89	90	92	96	97	100	101	103	104	107	108	110	113	115
116														

Screening: Gravel-3 — Total number of reaches: 29

1	18	20	21	22	24	26	37	40	41	42	49	50	52	53
57	64	79	85	89	92	96	97	100	101	104	108	113	116	

NOTE: The reach numbers for the 2 year flood are the same as those for the LTM, 1.5 YF, 5% FD and 10% FD except for reach numbers 45 (sand) and 94 (gravel). The discharge at the valley flat for these two reaches has a return period between 1.5 and 2.0 years.

TABLE 4.5

REACH NUMBERS SATISFYING THE SIX MAIN SCREENINGS FOR THE DISCHARGE CORRESPONDING TO THE VALLEY FLAT

Screening: All — Total number of reaches: 62

1	2	3	4	5	7	8	10	11	12	15	16	17	18	19
20	21	22	23	25	26	28	29	30	31	32	36	37	40	41
42	45	50	51	52	53	54	57	58	60	64	65	67	83	87
88	90	92	93	94	95	97	98	101	106	108	110	113	116	117
119	120													

Screening: Sand-1 — Total number of reaches: 17

5	7	16	17	23	25	28	28	30	31	32	45	51	54	60
117	120													

Screening: Sand-2 — Total number of reaches: 9

7	17	28	29	30	31	45	60	117

Screening: Gravel-1 — Total number of reaches: 41

1	2	3	4	8	10	11	12	18	19	20	21	22	26	36
37	40	41	42	50	52	53	57	64	65	67	83	87	88	90
92	93	94	95	97	101	106	108	110	113	116				

Screening: Gravel-2 — Total number of reaches: 30

1	2	3	8	10	18	20	21	22	26	36	37	40	41	42
50	52	53	57	64	87	90	92	94	97	101	108	110	113	116

Screening: Gravel-3 — Total number of reaches: 22

1	18	20	21	22	26	37	40	41	42	50	52	53	57	64
92	94	97	101	108	113	116								

CHAPTER 5

DISCUSSION OF THE RESULTS OF THE ANALYSIS

5.1 Introduction

With the available data, the extent of the analysis is almost unlimited. To make the investigation of reasonable scope, only the more important aspects of the overall problem of river regime have been studied. Further detailed studies may be carried out using the methods of this investigation as a basic framework.

This chapter is arranged in the following manner. Three methods of determining a dominant discharge are presented. Using the data from Alberta gravel rivers for the adopted dominant discharges, equations proposed by Lacey, Blench, Henderson, and Kellerhals are tested; various equations for directly predicting width, area, depth, form factor, mean velocity, slope and the Manning "n" are developed; dimensionless expressions related to river regime are developed and evaluated; and several sets of regime type equations are developed.

All tables containing detailed statistical results are presented in APPENDIX L. The analysis is generalized in the sense that no detailed discussion is presented for the outlying points. A few reach numbers are given on most figures to identify the obvious outliers.

5.2 Determination of a Dominant Discharge

The term dominant discharge is used in this study to mean a discharge which, when flowing steadily, would maintain a channel of dimensions similar to the present stable channel.

5.2.1 Discharge at Bankfull

Inglis (1941) considered the dominant discharge to occur at or near bankfull conditions. Leopold and Wolman (1957) and Dury (1961) consider that a discharge corresponding to a return period of about 1.5 years is closely associated with a bankful or dominant discharge. Nixon (1959) has indicated that the discharge which is exceeded 0.6 percent of the time is associated with the bankful or dominant discharge.

For this investigation two geomorphically defined bankfull discharges were considered:

1. The discharge associated with the low level bench and/or trim line, and
2. The discharge associated with the valley flat.

These two cases were considered, since it was hypothesized that the low level bench was more closely associated with the present river than the elevation of the valley flat, especially for those cases which are entrenched. The other reason was that the channel properties could more accurately be determined for a stage corresponding to the low level bench than for a stage corresponding to the valley flat.

FIGURE 5.1 is a plot of the discharge at the low level bench and/or trim line versus the associated return period for all rivers satisfying the Gravel-1 screening. The scatter is over a

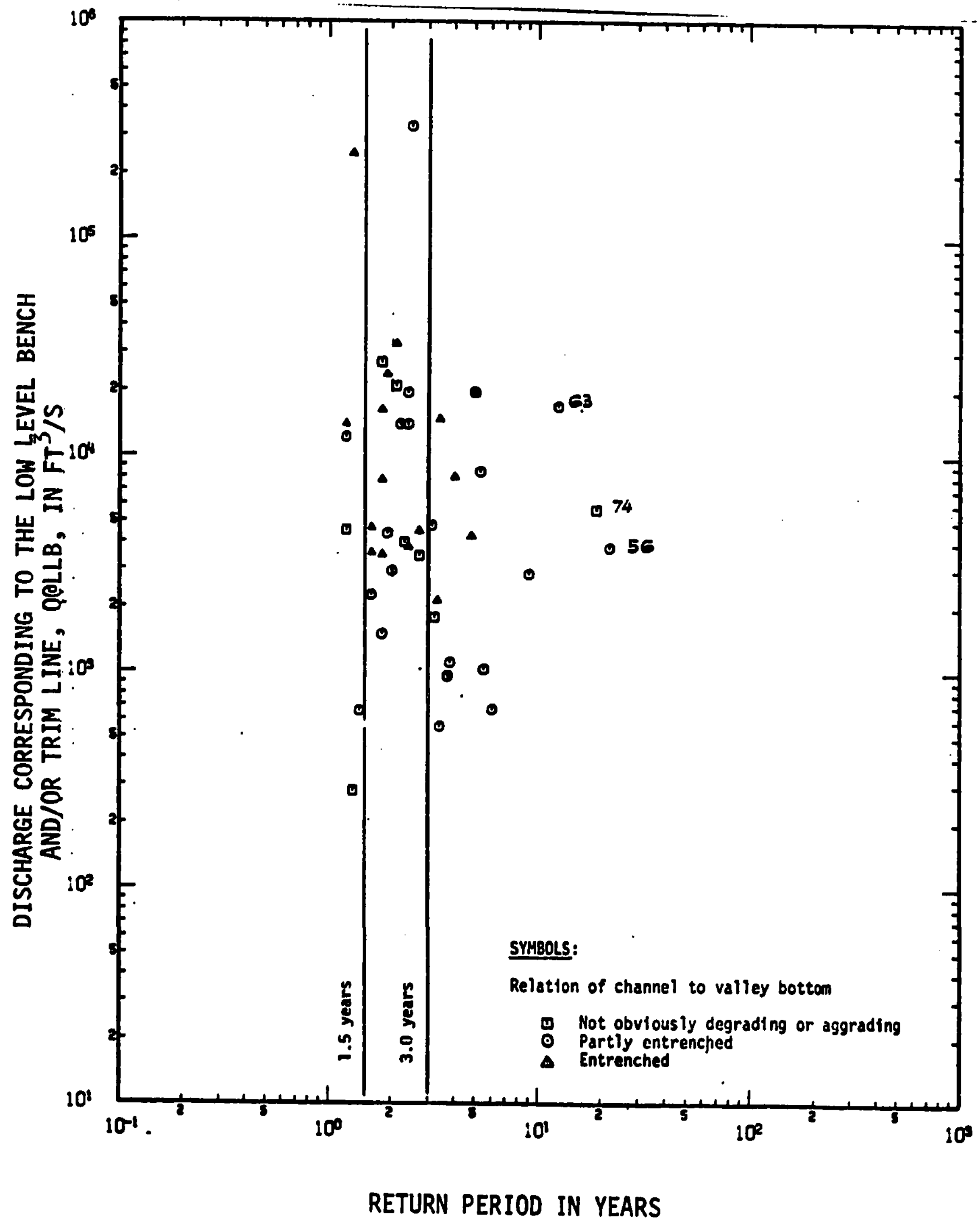


FIGURE 5.1 DISCHARGE CORRESPONDING TO THE LOW LEVEL BENCH AND/OR TRIM LINE VERSUS RETURN PERIOD IN YEARS FOR RIVERS SATISFYING THE GRAVEL-1 SCREENING

range from 1.1 to 20 years; however, there is a grouping of the plotted points between 1.5 and 3 years which is the range suggested by Leopold and Wolman (1957).

FIGURE 5.2 is a plot of the discharge at the low level bench and/or trim line versus the associated percent of the time for which the discharge is exceeded. The range of the percent durations is extreme ranging from less than 0.1 to 7 percent. The scatter in this case is not much greater than that found by Nixon (1959) for his study of British rivers based on bankfull discharges.

A final plot of discharge at the valley flat versus the associated return period is presented in FIGURE 5.3. This figure shows that many of the gravel rivers in Alberta are entrenched with return periods at the valley flat being in excess of 100 years. In all but one case, the return period at the valley flat is greater than or equal to 2 years. For those cases with the return period less than 100 years, the median return period is around 20 years. These results indicate that there is no well defined return period which may be associated with the bankfull discharge defined in terms of the valley flat.

5.2.2 Hydrophone Data

The hydrophone data obtained from several of the study reaches by the Water Resources Division, Alberta Department of the Environment (1969, 1970) were used to estimate the probable extent of bed material movement for various characteristic discharges. The basic data are presented in APPENDIX L and are plotted in FIGURE 5.4 for the case of the 2 year flood.

From these results it is apparent that bed material movement occurs for essentially all reaches with a discharge in excess of the

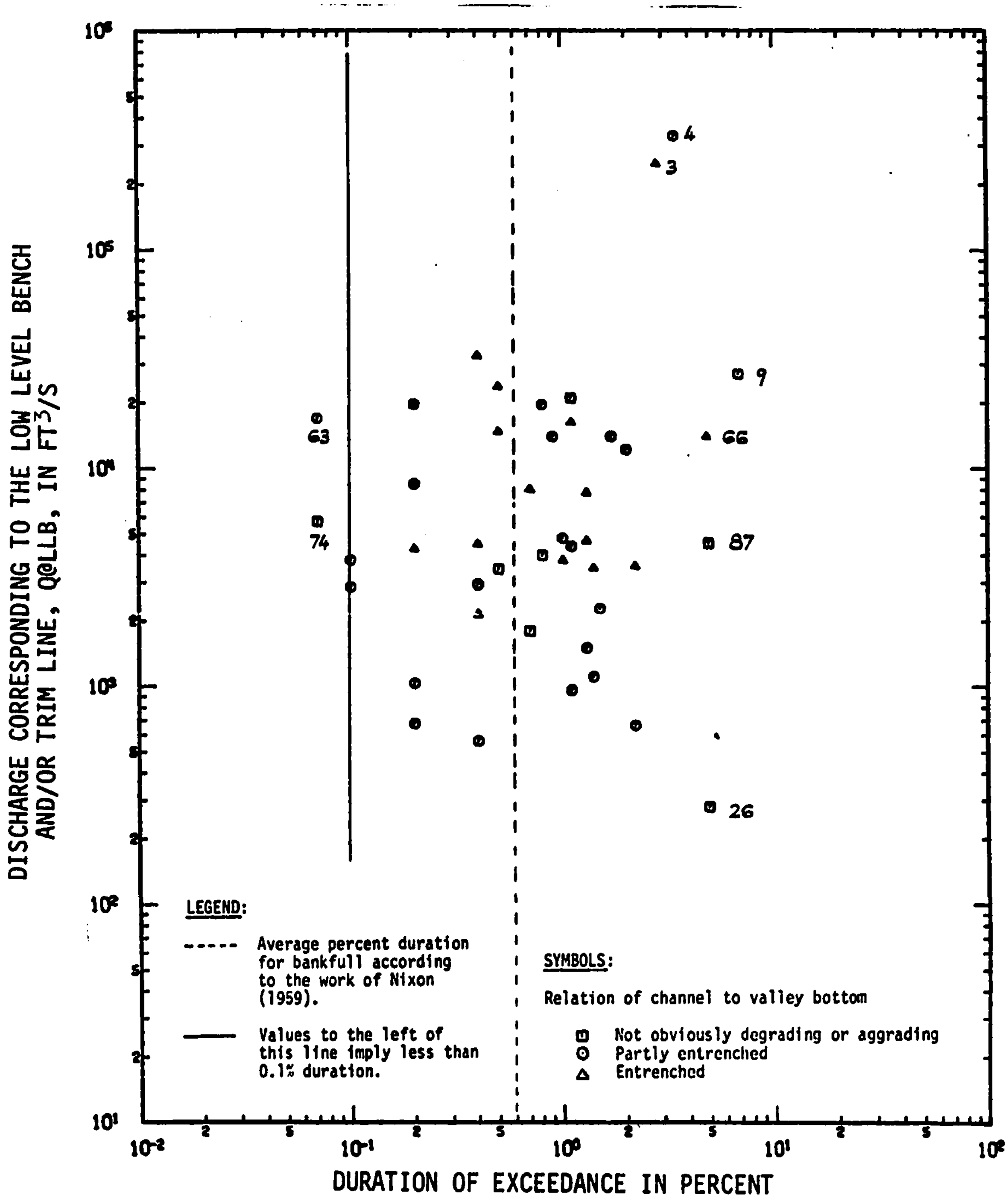


FIGURE 5.2 DISCHARGE CORRESPONDING TO THE LOW LEVEL BENCH AND/OR TRIM LINE VERSUS PERCENT OF THE TIME WHICH THE DISCHARGE IS EXCEEDED FOR RIVERS SATISFYING THE GRAVEL-1 SCREENING

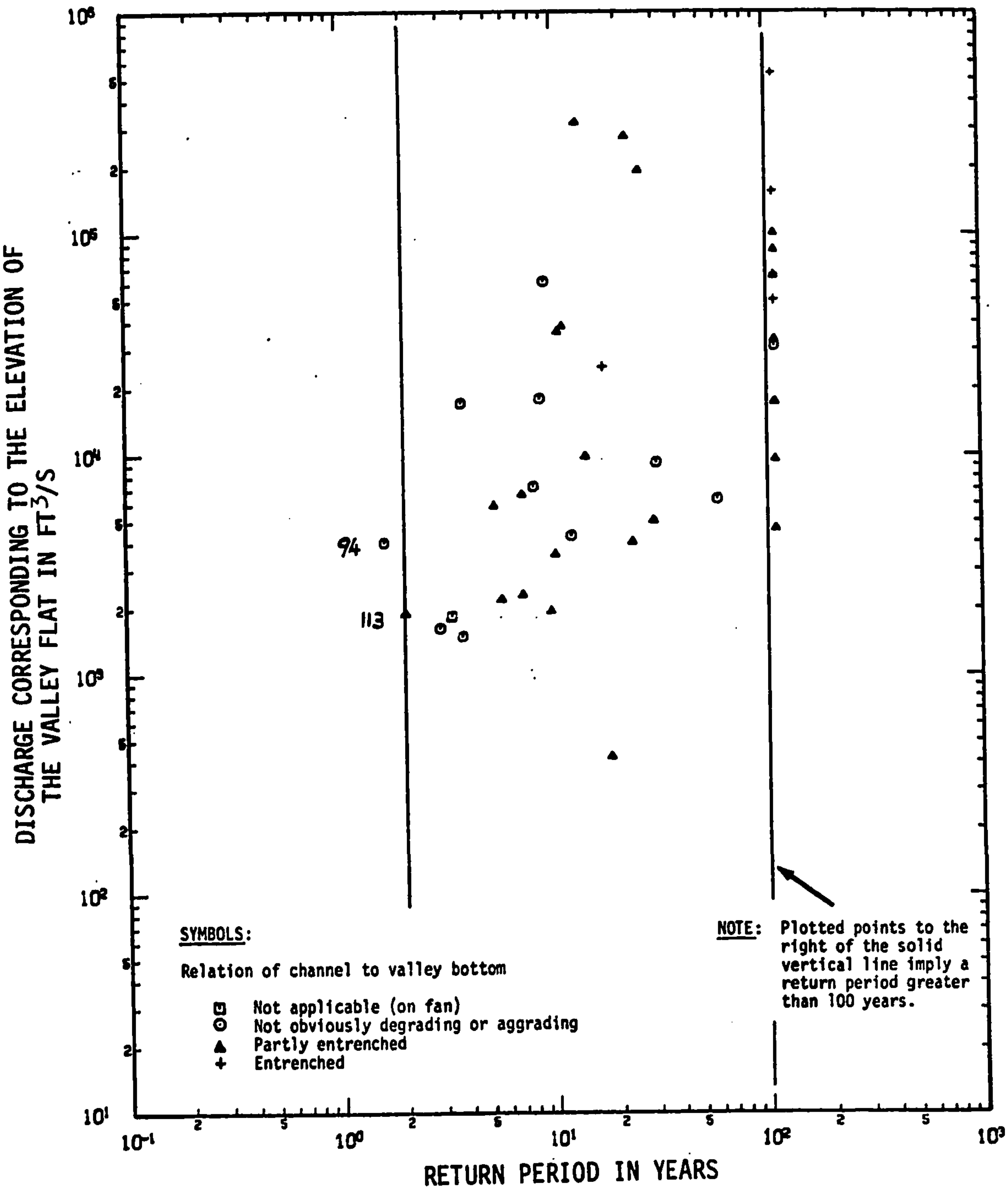


FIGURE 5.3 DISCHARGE CORRESPONDING TO THE ELEVATION OF THE VALLEY FLAT VERSUS THE RETURN PERIOD IN YEARS FOR RIVERS SATISFYING THE GRAVEL-1 SCREENING

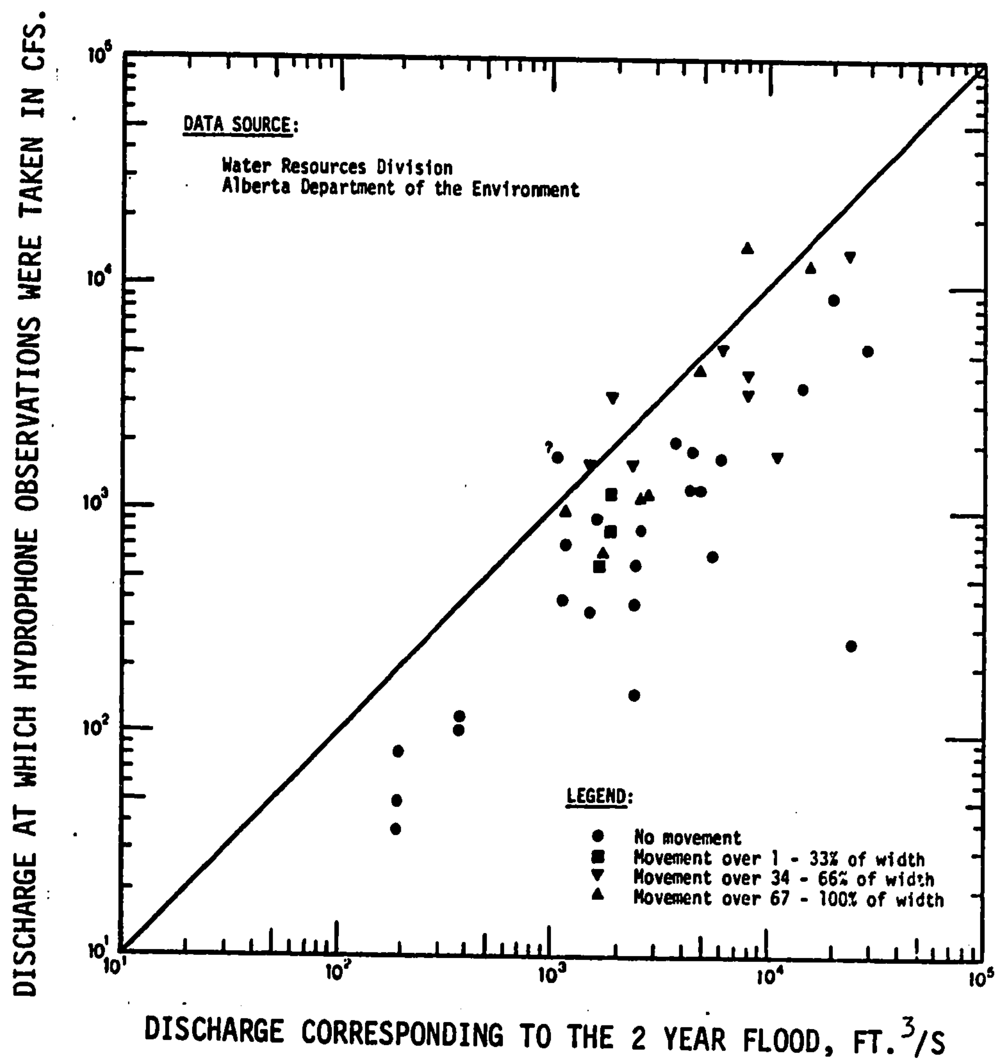


FIGURE 5.4 DISCHARGE AT THE TIME OF HYDROPHONE MEASUREMENTS VERSUS DISCHARGE CORRESPONDING TO THE 2 YEAR FLOOD

2 year flood. This does not imply that the 2 year flood is physically the dominant discharge, but it would be a more realistic dominant discharge than the long-term mean discharge for which there is no bed material movement for gravel rivers.

5.2.3 Threshold Condition

The threshold criteria of Shields (1936), Neill (1968), and Galay (1971) were used to indicate if the bed material was moving at the 2 year flood for those reaches with hydrophone data. In several cases there was measured movement in the field at discharges less than the 2 year flood; however, the Shields (1936) and the Neill (1968) threshold equations indicated no movement. Normally, the Galay (1971) criterion indicated movement of the bed if there was measured movement in the field.

It must be pointed out that the results obtained by the Shields (1936) and the Neill (1968) criteria are not directly compatible with the field measurements. For example, the bed material in movement as detected by the hydrophone may have been finer than the median size of the bed material. Other deviations are also noted; for example, the mean velocity used by Neill was the mean velocity across a two dimensional turbulent boundary layer while the mean velocity used in the computations in this study was based on data from several cross-sections in the reach.

In addition to the comparisons with field measurements of bed material movement, computations were carried out using the Shields (1936), the Neill (1968), and the Galay (1971) threshold criteria for a discharge corresponding to the 2 year flood.

FIGURE 5.5 is a Shields (1936) threshold type plot for all Gravel-1 and Sand-1 river reaches. The symbols indicate the relation of the channel to the valley bottom (See APPENDIX G). The sand bed channels are highly mobile while the gravel rivers are near threshold conditions. The value of the Shields parameter, $\rho \cdot (g.DM.S)/(\gamma' \cdot DG50)$, is greater than 0.03 for virtually all gravel river reaches which are not obviously aggrading or degrading. Neill (1968) has recommended that the Shields parameter of 0.03 be used for the design of stable gravel beds.

FIGURE 5.6 is a plot of the Neill (1968) parameters of $\rho \cdot VM^2/(\gamma' \cdot DG50)$ and relative depth for Gravel-1 reaches and for a discharge corresponding to the 2 year flood. The critical curve given by Neill for the initiation of motion is shown for the range of relative depths from 2 to 100. The channels which are not obviously aggrading or degrading are at least near the critical curve; whereas, the points for the reaches which are partly entrenched or entrenched cover a much greater range. This may be an indication that the entrenched channels are more likely to vary from paved beds to armoured beds than those which are not obviously aggrading or degrading.

The Galay (1971) critical velocity for the initiation of motion of gravels is only a function of bed material size:

$$VMCRIT = 8.0 \cdot (DG50)^{0.333} \qquad \text{EQUATION 5.1}$$

This expression is based primarily on field data and is not developed from a sound physical basis. It has been included to make comparisons with the Shields (1936) and the Neill (1968) criteria.

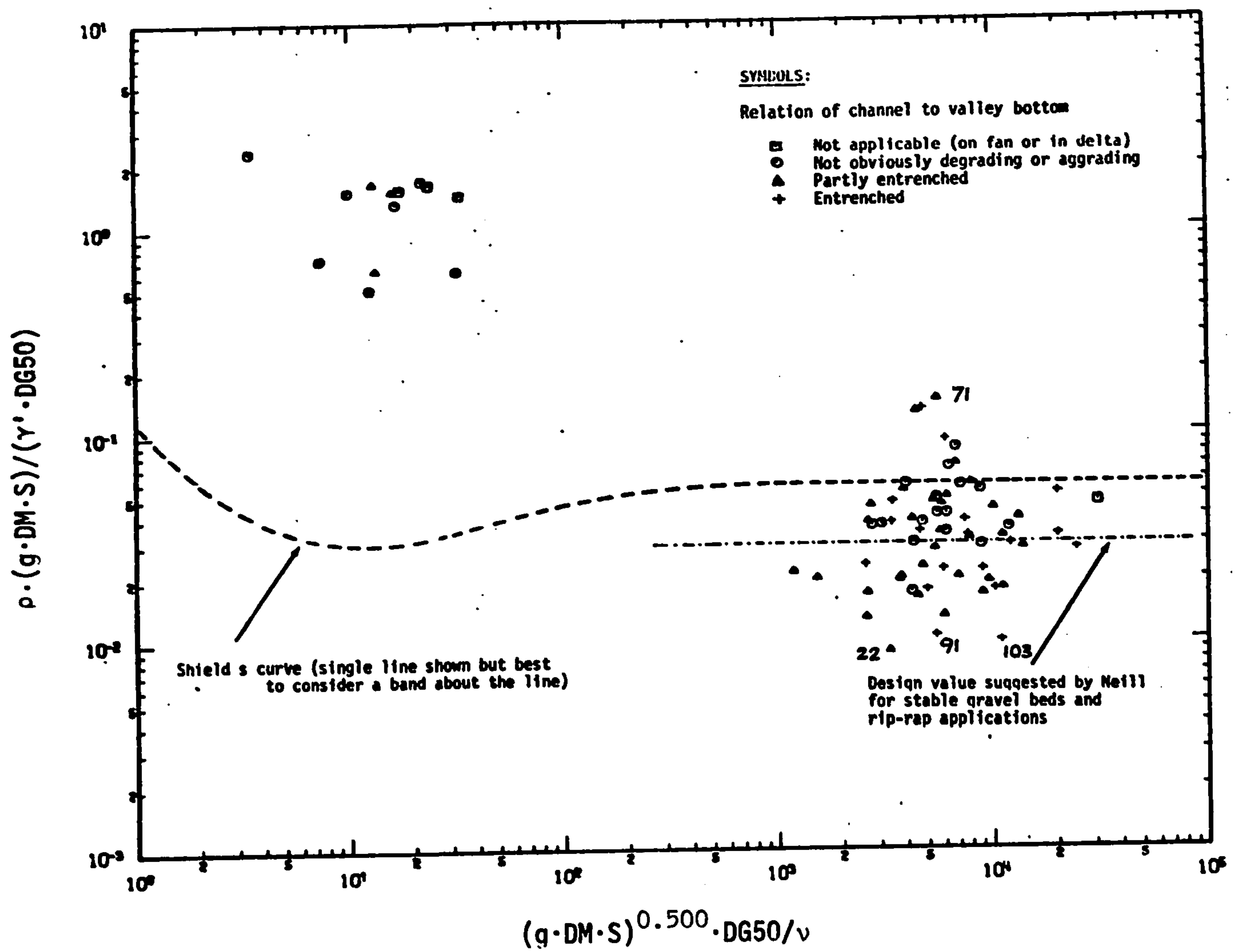


FIGURE 5.5 THRESHOLD CONDITIONS AS INDICATED BY THE SHIELDS CURVE FOR RIVERS SATISFYING THE SAND-1 OR GRAVEL-1 SCREENINGS AND FOR THE DISCHARGES CORRESPONDING TO THE 2 YEAR FLOOD

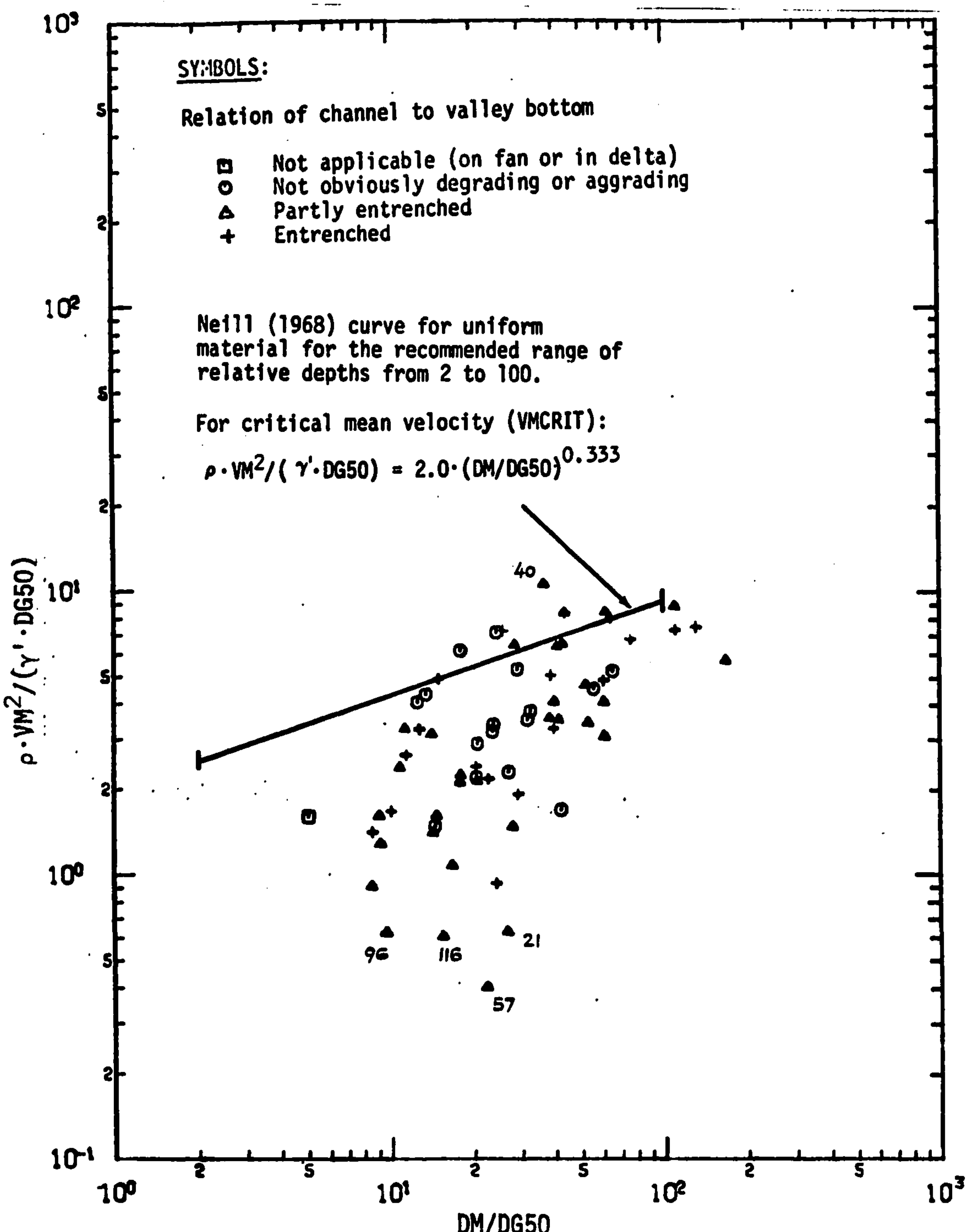


FIGURE 5.6 THRESHOLD CONDITIONS AS INDICATED BY THE NEILL CURVE FOR RIVERS SATISFYING THE GRAVEL-1 SCREENING AND FOR DISCHARGES CORRESPONDING TO THE 2 YEAR FLOOD

FIGURE 5.7 is a plot of the ratio of the mean velocity in the reach to the Galay critical mean velocity versus relative depth. The relative depth is used only as a parameter to distribute the plotted data points. This plot shows that essentially all reaches which are not obviously aggrading or degrading have a mean velocity greater than the computed critical mean velocity for movement.

As a final consideration, the Blench transport equation was used to indicate if there was movement at the 2 year flood. The equations utilized for the computations are given in the detailed write-up of the computer program and subroutines in APPENDIX J. The Blench equations indicated transport in essentially all cases where there was field confirmation of movement at a discharge near the 2 year flood. If there was movement measured in the field for a discharge less than the 2 year flood, the Blench transport equation generally indicates substantial movement at the 2 year flood.

The various results obtained in this section suggest that in the majority of cases the bed is mobile for gravel rivers at a discharge near the 2 year flood.

5.2.4 Dominant Discharge Based on Consistent Prediction of Channel Properties

Since there is limited data available concerning bed-load transport for the study reaches, it is not feasible to define a dominant discharge in terms of the bed-load transport distribution curve as suggested by Prins (1969). If such a definition was accepted, the results would be dependent upon the particular transport equation used.

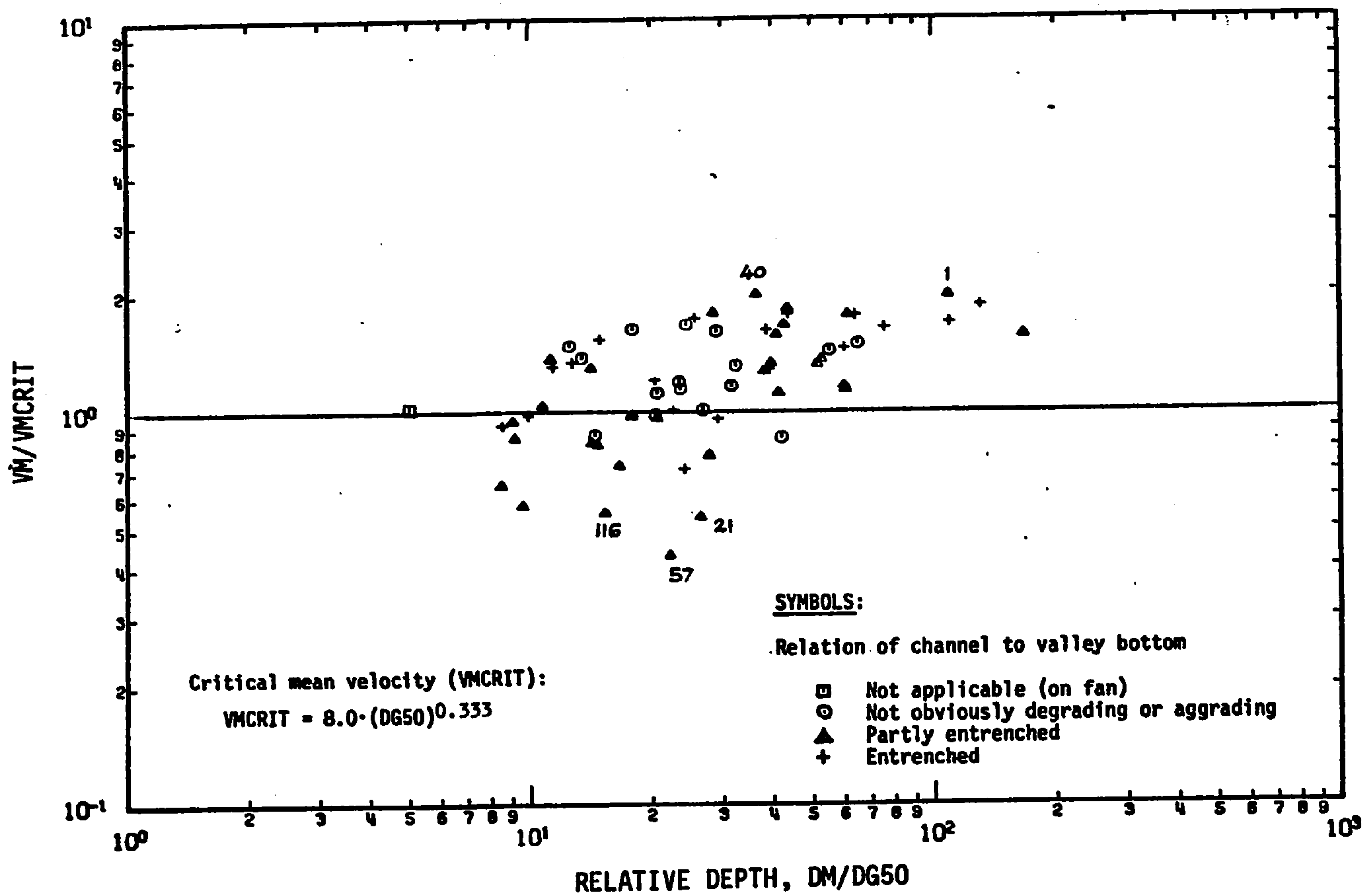


FIGURE 5.7 THRESHOLD CONDITIONS AS INDICATED BY THE GALAY CRITERION FOR RIVERS SATISFYING THE GRAVEL-1 SCREENING AND FOR DISCHARGES CORRESPONDING TO THE 2 YEAR FLOOD

As an alternative approach, a dominant discharge was defined in terms of fluid discharge alone. The selected characteristic discharge should be of such a magnitude to reasonably ensure bed material movement for most reaches. In addition, the correlation between specific channel properties and the selected characteristic discharge should be relatively high. This approach is similar to that used by Leopold and Maddock (1953) except that the mean annual discharge which was used by them is rejected due to a lack of bed material movement in gravel rivers at this discharge.

The expression used to define a dominant discharge in this manner is of the form:

$$Y = a \cdot Q^b \qquad \text{EQUATION 5.2}$$

where: Y is some dependent variable (average width, WSM; average area, AM; average depth, DM; average form factor, FF; mean velocity, VM; slope, S; or Manning "n").

Q is the specified discharge considered to be the independent variable (any of the 12 characteristic discharges given in SECTION 4.4).

The characteristic discharge which gave the most consistent results for any relation was considered to be the one with the highest value of the coefficient of determination, r^2, for the regression on the logarithms of the data. If the values of the coefficients of determination for one or two of the characteristic discharges were close, the minimum value of the standard error (expressed in log units) was considered.

A generalized summary of the results of this type of analysis for the Gravel-1 reaches is presented in TABLE 5.1. When making the evaluation of the discharge which gives the most consistent result, most consideration was given to the channel properties which

TABLE 5.1

GENERALIZED SUMMARY OF RESULTS FOR THE DETERMINATION OF A DOMINANT DISCHARGE

				Discharge Which Gives Most Consistent Relation	
Equation	Variation of a with Q	bmax-bmin / b 2 YF	Variation of b with Q	Based on Hydrologic Definitions	Based on Geomorphic Features
$WSM = a \cdot Q^b$	opposite	0.12	same	2 YF [1]	VF LE 20 YF
$AM = a \cdot Q^b$	opposite	0.11	same	2 YF [1]	VF
$DM = a \cdot Q^b$	opposite	0.26	same	1.5 YF [1]	VF
$FF = a \cdot Q^b$	opposite	0.64	same	LTM [1]	LLB
$VM = a \cdot Q^b$	same	0.66	opposite	10% FD [1]	VF
$S = a \cdot Q^b$	same	0.39	opposite	0.5% FD	VF [1]
$n = a \cdot Q^b$	opposite	1.89	same	10% FD [1]	LLB

1. The highest coefficient of determination, r^2, of any of the characteristic discharges.
2. See Appendix L for the detailed results.
3. Variation of coefficient "a" with discharge in a given equation. Opposite means that "a" decreases as the characteristic discharge increases.
4. "b max" and "b min" are the maximum and minimum values of "b" in a given equation, considering the 12 characteristic discharges used in the analysis; "b 2 YF" is the value of exponent "b" for the 2 year flood.
5. Variation of exponent "b" with discharge in a given equation. Opposite means that "b" decreases as the characteristic discharge increases.

are basic data; that is, average width, WSM; average area, AM; and the slope for the reach, S.

Based on the above criteria, the discharge corresponding to the 2 year flood gives the most consistent definition of average width and area. However, there is no great difference between the coefficients of determination for the 2 year flood and the other characteristic discharges. The discharge corresponding to the elevation of the valley flat gives the most consistent definition of slope. This latter result is expected, since the value of the slope is considered to be constant for all discharges and the data points extend over a great range for the case of the discharge at the valley flat.

Based on the data in TABLE 5.1, the hydrophone data, and the threshold analysis, it is apparent that the 2 year flood can reasonably be accepted as a dominant discharge which is unrelated to a geomorphic feature. The discharge at the valley flat, regardless of the return period, is a reasonable discharge to accept as a dominant discharge associated with a geomorphic feature. Of these two characteristic discharges, the 2 year flood is preferred, since it may be adequately estimated from hydrologic records. The rating curve is generally not too well defined beyond the 2 year flood stage and is often only poorly defined at the valley flat. Many of the Alberta rivers are entrenched; consequently, the return period at the valley flat is often in excess of 100 years.

No consideration is given to the flow duration discharges when defining a dominant discharge, since the discharges exceeded a given percent of the time are quite closely associated with the flood frequency data. As an example, FIGURE 5.8 shows the relation between the discharge exceeded 1 percent of the time versus the 2 year flood.

5.3 Discharge Relations for Different Screenings

The above definitions of the dominant discharge were based on the Gravel-1 screening for gravel rivers, since most emphasis is placed on this class of rivers in this study. As an extension of the analysis, width-discharge, area discharge, depth-discharge, form factor-discharge, mean velocity-discharge, slope-discharge and Manning "n"-discharge relations were obtained for the six main screenings given in SECTION 4.3 and for characteristic discharges corresponding to the 2 year flood, the elevation of the valley flat, and the long term mean discharge. The long term mean discharge was included to make comparisons with other well known studies, such as that by Leopold and Maddock (1953). All results are presented in APPENDIX L. No detailed discussion is presented concerning the results; however, reference is made to some aspects of this analysis in SECTION 5.5.

5.4 Evaluation of Past Work

In this section the equations presented by Lacey, Blench, Henderson,and Kellerhals are tested with the field data from Alberta gravel rivers.

All detailed results are presented in tabular form in APPENDIX L. The procedure used is as follows:

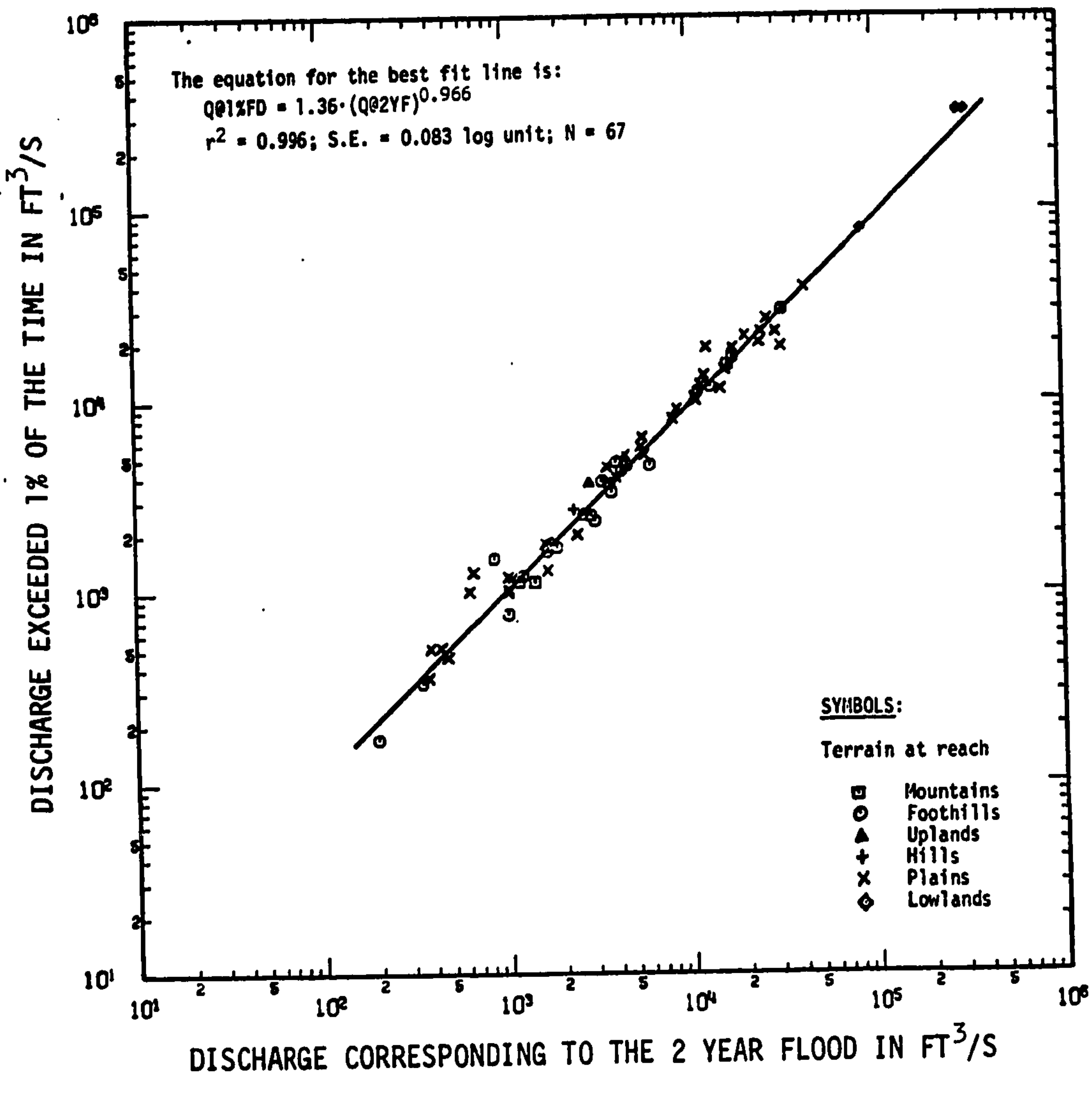


FIGURE 5.8 THE DISCHARGE EXCEEDED 1 PERCENT OF THE TIME VERSUS THE DISCHARGE CORRESPONDING TO THE 2 YEAR FLOOD FOR RIVERS SATISFYING THE GRAVEL-1 SCREENING

1. The functional form of the exponential equation given by a particular investigator is accepted and the variability of the coefficient is evaluated from the field data, and

2. The coefficient and the exponent(s) are then determined from the field data using a linear regression on the logarithms of the data.

In some cases an alternate form of an equation originally presented by the investigator is given; for example, the original paper may have used DG90 for the characteristic grain size, but in this study the DG50 size as well as the DG90 size was used to test the difference in the results. The results are presented for the 2 year flood and the discharge corresponding to the valley flat. The computations were carried out for the Gravel-1, Gravel-2, and Gravel-3 screenings. If there was no major difference between the screenings, only the results for the Gravel-1 screening are presented.

5.4.1 Lacey Type Relations

Lacey (1929, 1933) based most of his work on sand-bed canals. However, he did use a few data points from gravel rivers with median bed material sizes up to 10 inches to establish the relation between the "silt factor" and rugosity. Lacey described his sections with the wetted perimeter and the hydraulic radius; whereas, the water surface width and the mean depth were used in this study.

The width equation presented by Lacey was:

$$WSM = 2.67 \cdot Q^{0.500} \qquad \text{EQUATION 5.3}$$

if it is assumed that there is no difference between the wetted perimeter and the water surface width. If the discharge at the valley flat is accepted as the dominant discharge for this analysis, the coefficient is 2.78 and the exponent is 0.438. The Lacey coefficient of 2.67 corresponds to a discharge between the 1.5 and 2 year floods. If the 2 year flood is accepted as the dominant discharge, the coefficient is 2.38 and the exponent is 0.527.

The Lacey equation for mean velocity in terms of mean depth and slope is given as follows:

$$VM = 16.0 \cdot DM^{0.667} \cdot S^{0.333} \qquad \text{EQUATION 5.4}$$

if it is assumed that the hydraulic radius and the mean depth are the same. When the coefficient is determined from the data for gravel rivers, it is within three percent of the value of 16.0 given by Lacey. The best fit relation for the 2 year flood results in a coefficient of 12.6 and exponents of 0.608 and 0.288 for the mean depth and slope, respectively. Only about 50 percent of the variance is explained by the relation. The exponents for the best fit relation are closer to the Lacey exponents than they are to the Manning exponents for the adopted dominant discharges.

The other Lacey equation for mean velocity is expressed in terms of the mean depth and a characteristic bed material size as follows:

$$VM = 1.17 \cdot f^{0.500} \cdot DM^{0.500} \qquad \text{EQUATION 5.5}$$

if it is assumed that the mean depth is equal to the hydraulic radius. The silt factor, f, may be evaluated as:

$$f = 27.7 \cdot DG50^{0.500} \qquad \text{EQUATION 5.6}$$

where DG50 is the median bed material size in feet. The Lacey velocity equation may be rewritten as:

$$VM = 6.18 \cdot DM^{0.500} \cdot DG50^{0.250} \qquad \text{EQUATION 5.7}$$

Based on the functional form of EQUATION 5.7 the coefficient for the 2 year flood is 4.08. The best fit relation for the 2 year flood results in a coefficient of 4.25 and exponents of 0.255 and 0.103 for the mean depth and the median bed material size, respectively. Only about 20 percent of the variance is explained by the relation. For the best fit relations, the exponent for the bed material parameter is small and the choice of the DG50 size or the DG90 size does not result in an appreciable change in the magnitude of the coefficient of determination or the standard error. This result is typical of many of the relations involving one or more parameters and the bed material size.

If EQUATIONS 5.3, 5.4 and 5.7 are solved the following slope equation is obtained:

$$S = 6.85 \cdot DG50^{0.833} \cdot Q^{-0.167} \qquad \text{EQUATION 5.8}$$

The coefficient of variation was greater than 0.80 when the variability of the coefficient was evaluated. For the 2 year flood, the best fit coefficient was 10.4 and the exponents were 0.586 and -0.334 for the median bed material size and the discharge, respectively. The exponent for the bed material size is about two thirds of the value given by Lacey for sand-bed channels and the exponent for the discharge is doubled.

5.4.2 Blench Type Relations

Blench (1941) built on the work of Lacey and developed a regime theory for the straight duned sand-bed class of channels. This section discusses the extension of the Blench relations to natural gravel rivers. The three basic equations are a bed factor relation, a side factor relation, and a slope equation based on the work of King (1943).

Blench (1969a) shows that the bed factor must be evaluated for the different phases encountered in natural channels. For the sand-bed channel phase with large relative depths, the bed factor, VM^2/DM is considered to be a function of charge and bed material size, but for the gravel river phase with small, relative depths, the bed factor is considered to be a function of relative depth and charge. A transition between these two main phases is suggested where the bed factor is a function of relative depth, charge, and bed material size.

The expression for the bed factor for gravel rivers with small relative depths and with vanishingly low charge as given by Blench (1971) is:

$$Fbo = VM^2/DM = 48 \cdot (DM/DG50)^{-0.500} \qquad \text{EQUATION 5.9}$$

This relation was tested for the Gravel-1 screening for the case of movement or no movement of the bed material, and for the case of no movement using an initiation of motion criterion. The results indicate that a somewhat better correlation does result if the reaches with movement are rejected. If the Cooper (1970) criterion for movement, THRES, at low relative depths is used to reject cases with mobile beds, seven reaches are omitted from the analysis, and the resulting equation for the discharge corresponding to the 2 year flood is:

$$Fbo = 21.6 \cdot (DM/DG50)^{-0.418} \qquad \text{EQUATION 5.10}$$

and for the discharge corresponding to the valley flat the relation is:

$$Fbo = 42.7 \cdot (DM/DG50)^{-0.597} \qquad \text{EQUATION 5.11}$$

Since the criterion given by Cooper (1970) for vanishingly low charge is essentially the same as that obtained from flume experiments by Neill (1968) for initiation of motion, the criteria for rejection of gravel reaches with mobile beds is denoted as the Cooper-Neill criteria. The Cooper-Neill criteria should only reject those cases which have a highly mobile bed (See SECTION 5.2).

The results for the relation between the bed factor and relative depth are presented in FIGURE 5.9 for all reaches satisfying both the Gravel-1 and Sand-1 screening in order to show the distinction between the two phases. FIGURE 5.10 is a similar plot of all Gravel-1 rivers which have no movement according to the Cooper-Neill criterion.

The analysis based on the case of movement or no movement indicates that there was no appreciable difference between the results obtained by using the DG90 size and the DG50 size; consequently, the DG50 size was adopted. The coefficient of determination for the relation of the bed factor to the relative depth is highest for the discharge corresponding to the valley flat.

Based on the results obtained by using the Cooper-Neill criterion for initiation of motion, it is recommended that the value of the coefficient given by Blench (1971) be changed from 48 to 30 if the exponent -0.500 is to be adopted. This result compares favourably with that presented by Galay (1971) who recommended that the coefficient be 29 and the exponent be -0.500.

One difficulty with using the concept of Fbo for gravel rivers is that there is little evidence to support the condition

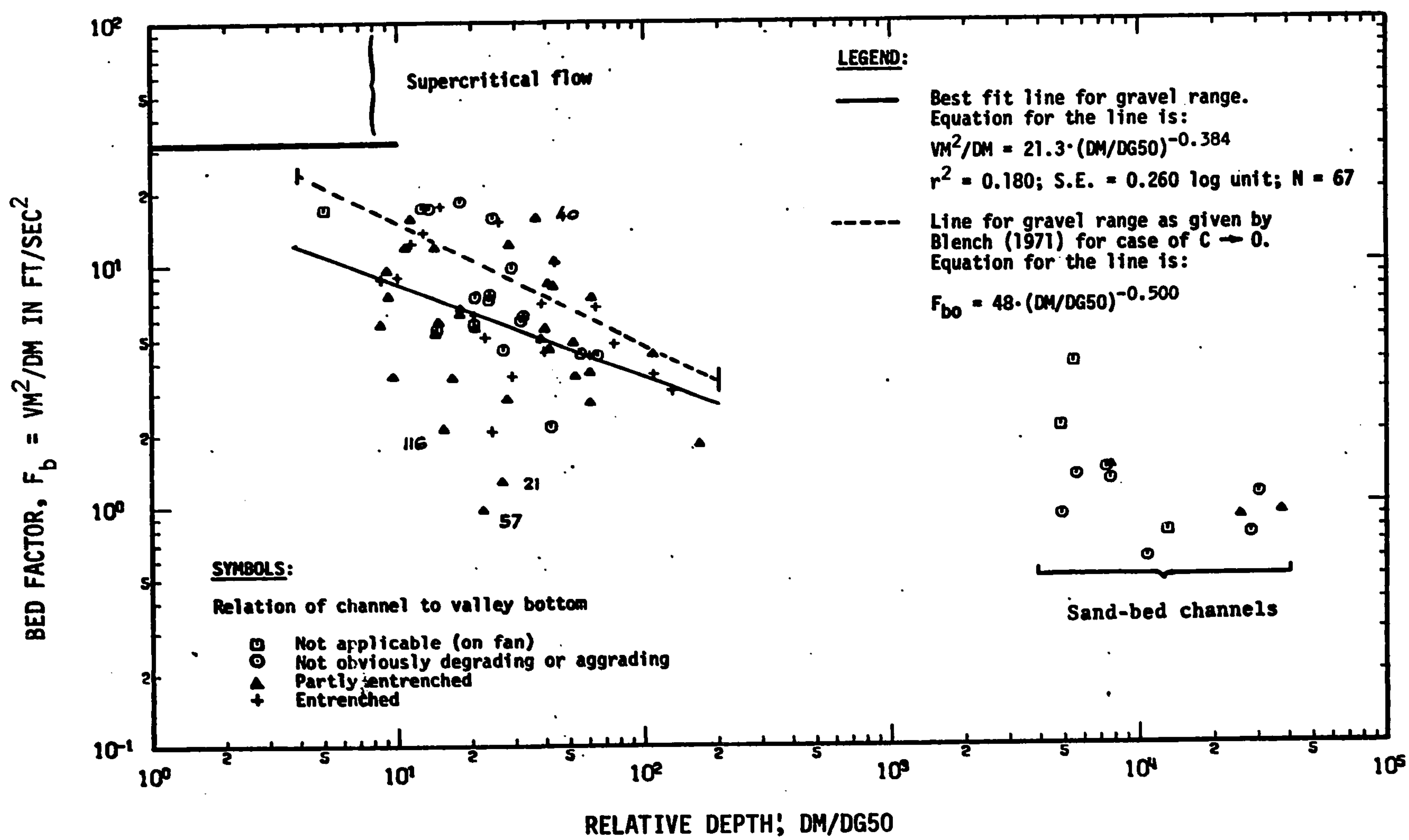


FIGURE 5.9 BED FACTOR VERSUS RELATIVE DEPTH FOR RIVERS SATISFYING THE SAND-1 OR GRAVEL-1 SCREENING AND FOR DISCHARGES CORRESPONDING TO THE 2 YEAR FLOOD

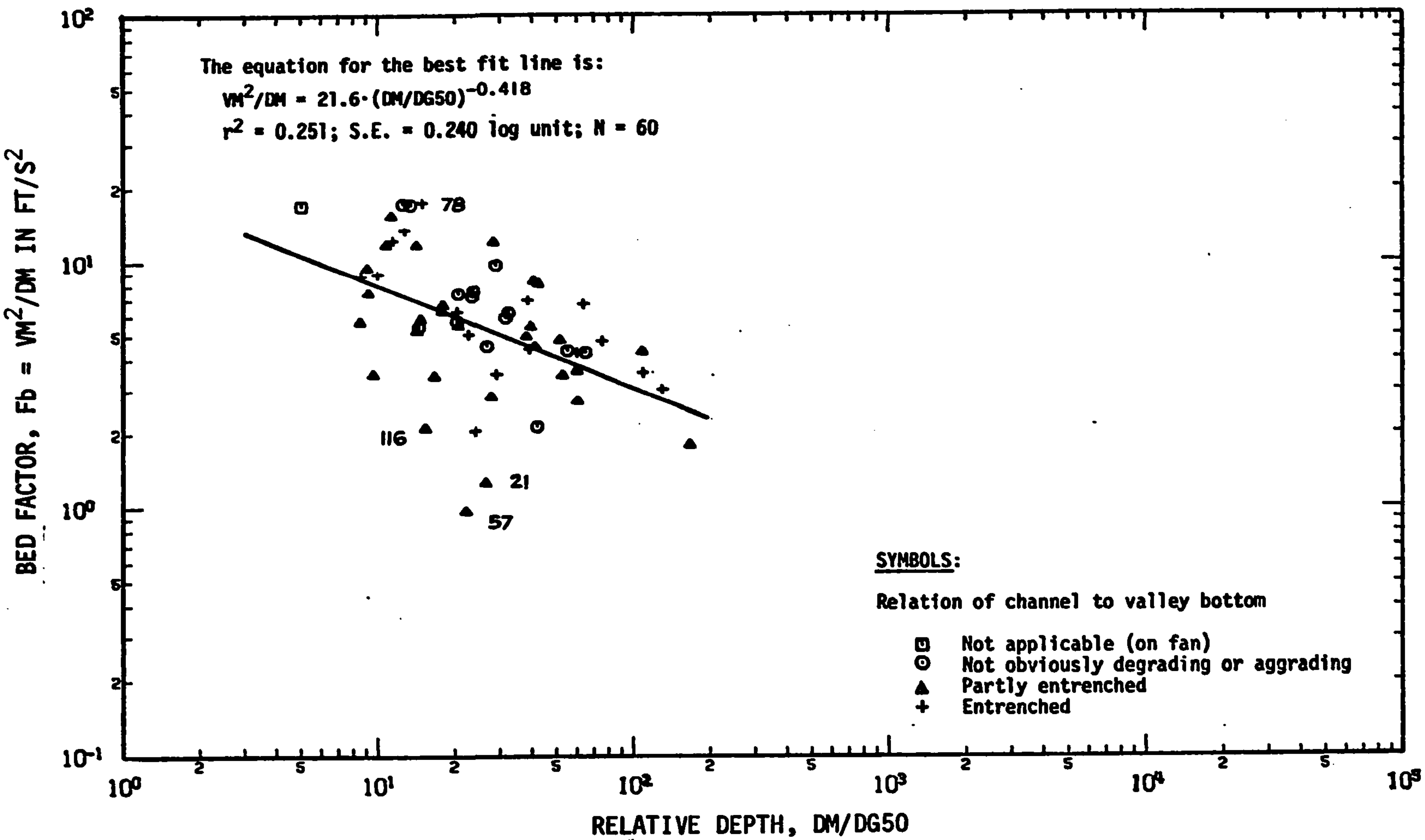


FIGURE 5.10 BLENCH BED FACTOR, Fb, VERSUS RELATIVE DEPTH FOR RIVERS SATISFYING THE GRAVEL-1 SCREENING WHICH ARE IMMOBILE ACCORDING TO THE COOPER CRITERION AND FOR A DISCHARGE CORRESPONDING TO THE 2 YEAR FLOOD

that the charge approaches zero. As illustrated in this particular analysis, an initiation of motion criterion has to be accepted in order to reject all cases with highly mobile beds. Perhaps the highly immobile cases should also have been rejected by some criteria. Obviously this approach to the problem is unsatisfactory, since the investigator introduces a bias into the analysis.

Blench (1969a) suggested that for relative depths greater than about 200, the zero bed factor, Fbo, could be estimated as:

$$Fbo = 7.3 \cdot (DG50)^{0.25} \qquad \text{EQUATION 5.12}$$

where the bed material size was obtained as grid-by-weight. In this analysis the size was that obtained as grid-by-number, which results in a somewhat smaller median bed material size than that obtained as grid-by-weight. However, if there is a small difference in the median sizes, the results should not be greatly affected if EQUATION 5.12 is of the correct form, since the exponent is small. Based on the available data, it was found that there were essentially no gravel reaches with a relative depth greater than 200. When an analysis of an exponential form was carried out between Fbo and DG50 for all Gravel-1 reaches, it was found that the relation was poor.

Next the Blench side factor, VM^3/WSM, was tested for gravel rivers with two types of banks:

1. Gravel banks overlain by silt or cobble banks overlain by silt, and

2. Gravel or cobble banks.

The magnitude of the side factor, Fs, is supposedly an indicator of the ability of the channel to withstand bank erosion. The regime theory associates the side factor with the square of the shear stress at the banks if they behave or though they are hydraulically smooth.

The general results for the two classes of gravel rivers are reasonable if the above explanation is accepted qualitatively. The channels with silt banks in contact with the river at the 2 year flood are more easily erodible (median Fs = 0.40) than the channel with gravel or cobble banks (median Fs = 0.78). No comparable results are given by Blench.

The variation of the side factor for all Gravel-1 and Sand-1 rivers is shown in FIGURE 5.11. The abscissa scale of relative depth used in this figure is to provide a means of separating the plotted points and no relation between the side factor and relative depth is implied.

Blench (1969a) does suggest that the side factor for gravel rivers may be estimated from the following rule of thumb:

$$Fs = 0.125 \cdot Fbos^{2.0} \qquad \text{EQUATION 5.13}$$

where Fbos is the zero bed factor of a channel with a bed corresponding to the material in the gravel sides.

This relation could not be tested directly, since no detailed measurements of bank material size were available. The assumption was made that the side factor, Fs, was an exponential function of the bed factor, Fb. The following relation was established for the class of gravel rivers with gravel or cobble banks for discharges corresponding to the 2 year flood:

$$Fs = 0.0660 \cdot Fb^{1.25} \qquad \text{EQUATION 5.14}$$

The plotted points and the best fit line are presented in FIGURE 5.12. About 86 percent of the variance was explained by the relation between

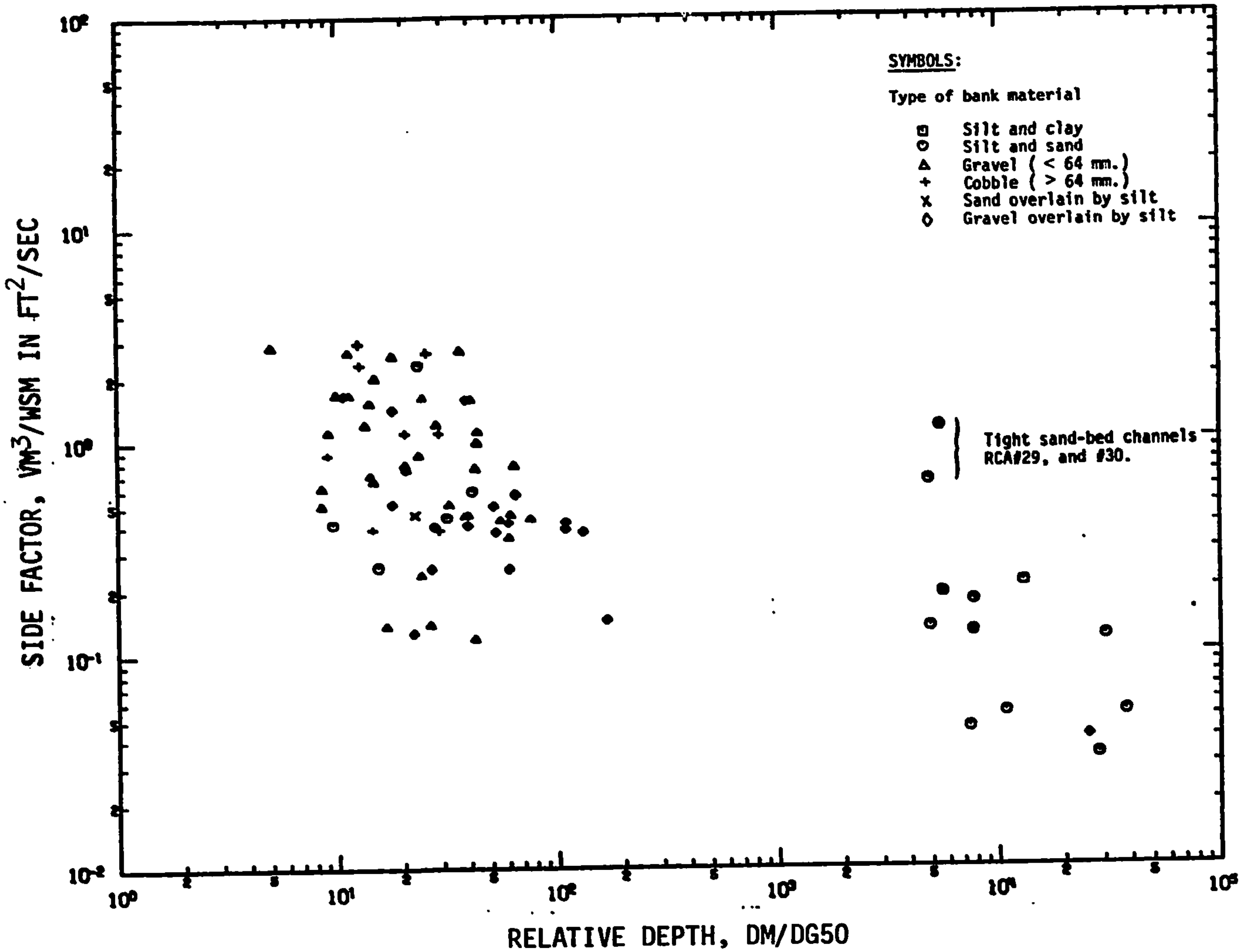


FIGURE 5.11 BLENCH SIDE FACTOR, Fs, VERSUS RELATIVE DEPTH FOR RIVERS SATISFYING THE SAND-1 OR GRAVEL-1 SCREENING AND FOR DISCHARGES CORRESPONDING TO THE 2 YEAR FLOOD

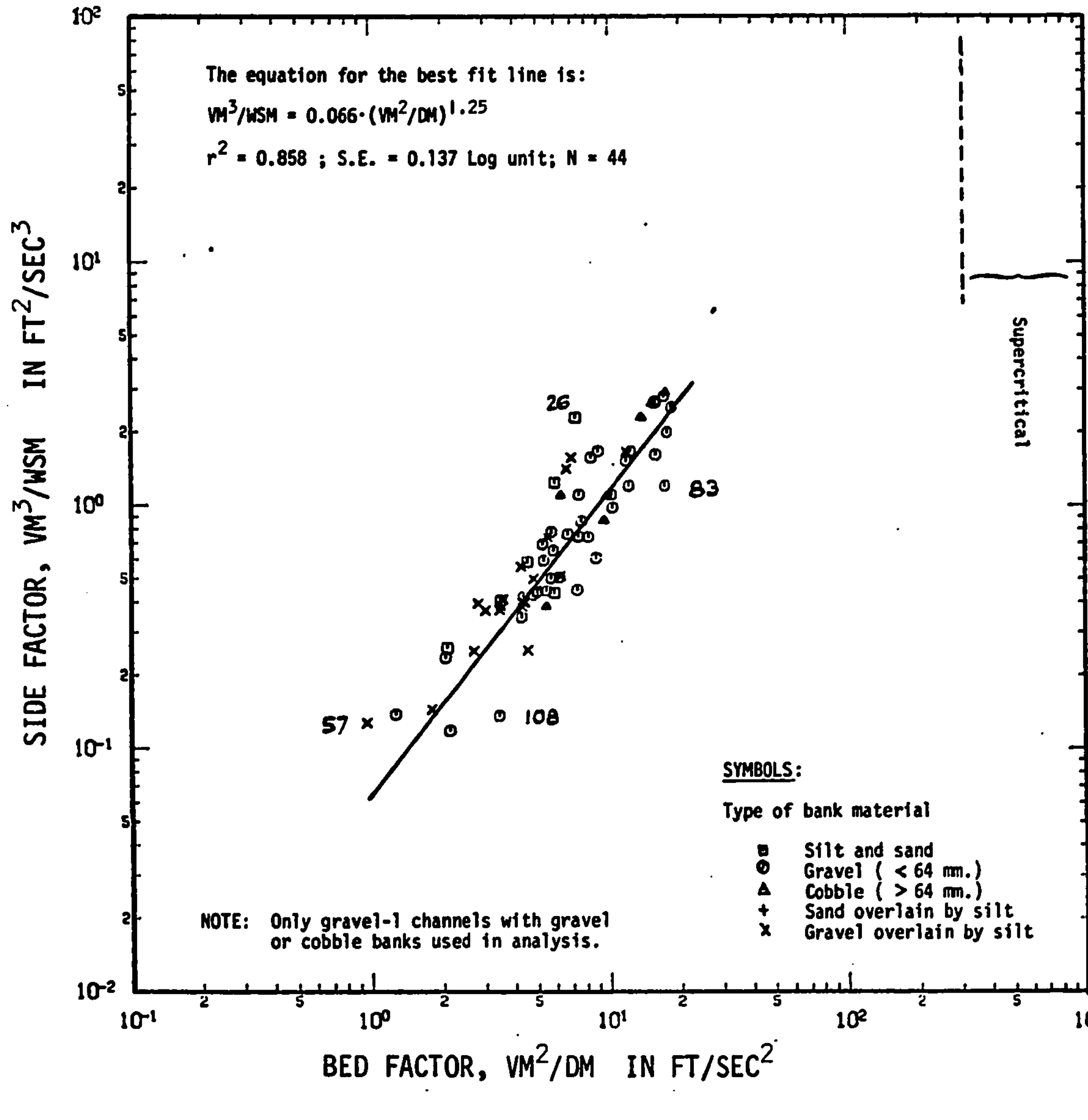


FIGURE 5.12 BLENCH SIDE FACTOR, Fs, VERSUS BED FACTOR, Fb, FOR RIVERS SATISFYING THE GRAVEL-1 SCREENING AND FOR DISCHARGES CORRESPONDING TO THE 2 YEAR FLOOD

side factor and bed factor; however, there is a degree of spurious correlation. The form is quite different from that suggested by Blench; however, the expressions are not quite comparable, since the derived relation involves Fb rather than Fbos.

The result given by EQUATION 5.14 may be rewritten in the following manner:

$$WSM/DM = 15.0 \cdot VM^{0.500} \cdot DM^{0.250} \qquad \text{EQUATION 5.15}$$

This equation implies that the form factor for gravel rivers with gravel or cobble banks is a function of the mean velocity and depth.

Finally the following form of the King resistance equation was evaluated for the Gravel-1 river reaches:

$$VM^2/(g.DM.S) = a \cdot (VM.WSM/\nu)^b \qquad \text{EQUATION 5.16}$$

This form of the King equation involving slope has been incorporated into the regime theory for duned sand-bed channels by Blench. In this study, the relation was tested for the Gravel-1 reaches with and without the slope correction parameter, SCOR (See SECTION 4.5). When the slope was corrected, the parameter S/SCOR was substituted for S. The results of the analysis indicated that the slope correction parameter did not improve the overall relation. However, from a physical basis the slope correction parameter should account for energy losses due to bends or islands.

Based on the analysis using Gravel-1 rivers and the 2 year flood, the value of the exponent b, was 0.430 with 95 percent confidence limits of 0.329 and 0.521. The value of the exponent of 0.250 given by the regime theory for duned sand-bed channels is significantly different from the results obtained for the gravel rivers used in this study; however, the value of the exponent of 0.370

reported by Simons and Albertson (1960) for stable sand-bed canals is not significantly different.

The maximum error in slope introduced by a poor estimation of the kinematic viscosity is about 10 to 15 percent. It is to be noted that it is not physically realistic to incorporate a viscosity term into this type of equation for the case of fully developed turbulent flow over a rough boundary.

The plotted data for Sand-1 rivers and Gravel-1 rivers are shown in FIGURE 5.13 with the dimensionless terms used by King for the ordinate and abscissa. The sand-bed channels generally fall below the King line for the case of no slope correction. If a slope correction was applied, the sand-bed channels would plot closer to the line represented by the King equation which was developed for the case of straight duned sand-bed channels. The best fit line for the Gravel-1 rivers is also shown for comparison.

The analysis was also carried out for the following two conditions:

1. Movement or no movement of bed material
2. No movement as indicated by the Cooper-Neill threshold criterion.

The results indicated that the highest correlation was obtained when all data were included in the relation.

5.4.3 Henderson Type Relations

The work of Henderson (1961, 1967) as it is related to gravel rivers has been primarily developed from a consideration of the tractive force approach given by Lane (1955). The Shields (1936) criteria for initiation of motion for fully developed turbulent flows

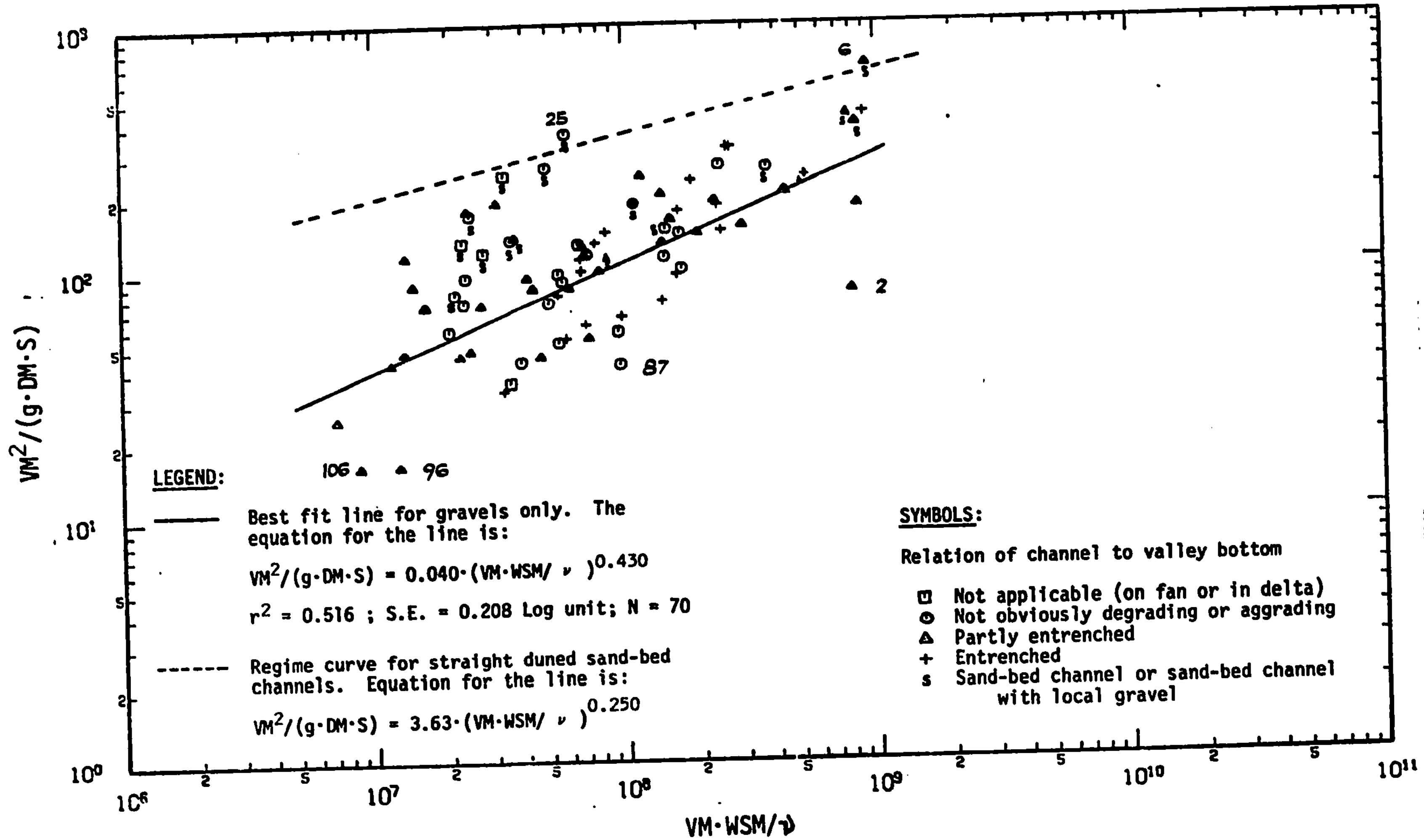


FIGURE 5.13 $VM^2/(g \cdot DM \cdot S)$ VERSUS $VM \cdot WSM/\nu$ FOR RIVERS SATISFYING THE SAND-1 OR GRAVEL-1 SCREENING AND FOR DISCHARGES CORRESPONDING TO THE 2 YEAR FLOOD

is also incorporated into his analysis along with the Manning flow equation and the Strickler estimate of "n". These equations presented by Henderson are primarily intended for the design of canals based on the threshold approach, but may be applied to rivers which do not have highly mobile beds.

The Henderson width equation for wide gravel rivers is as follows:

$$WSM = 1.14 \cdot Q \cdot S^{1.167}/DG^{1.50} \qquad \text{EQUATION 5.17}$$

The best fit width equation of the same form obtained from the Gravel-1 rivers was as follows:

$$WSM = 1.96 \cdot Q^{0.520} \cdot S^{-0.024}/DG50^{0.055} \qquad \text{EQUATION 5.18}$$

where the discharge was the 2 year flood. It is apparent that the width equation obtained from this analysis is primarily defined by discharge since the exponents for slope and bed material size are so small. The coefficient of determination is 0.961 when discharge, slope and bed material size is considered and is 0.962 when discharge is considered alone. This implies that the introduction of slope and bed material size do not even compensate for the loss in the statistical degrees of freedom.

As an alternate form of analysis the equation of the following form was evaluated:

$$WSM = a\ (Q \cdot S^{1.167}/DG50^{1.50})^{b} \qquad \text{EQUATION 5.19}$$

for the discharge corresponding to the 2 year flood. FIGURE 5.14 shows the best fit equation of the form given by EQUATION 5.19 and two lines for the Henderson threshold equation assuming the Henderson DG to be the DG50 size and to be two times the DG50 size.

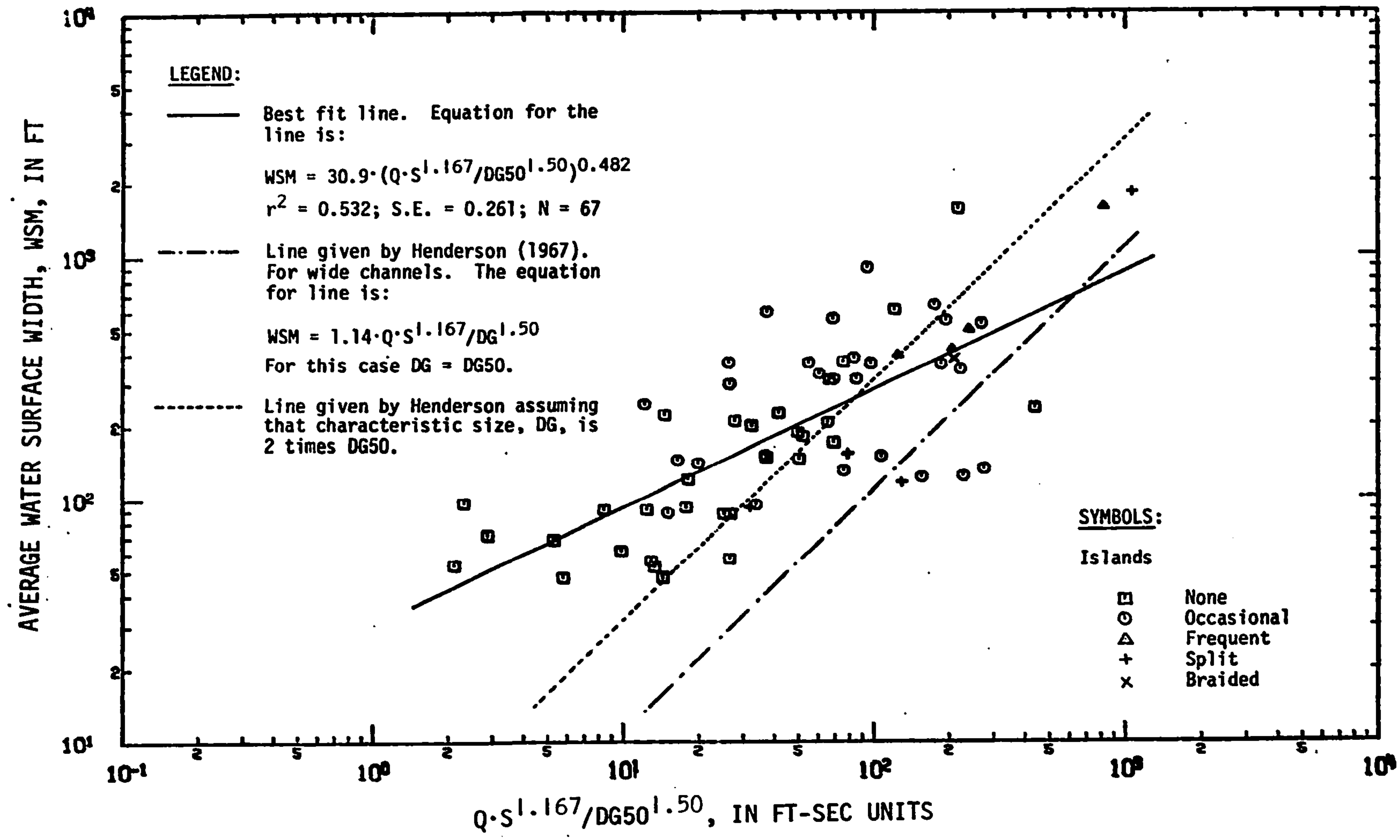


FIGURE 5.14 AVERAGE WATER SURFACE WIDTH VERSUS $Q \cdot S^{1.17}/DG50^{1.50}$ FOR RIVERS SATISFYING THE GRAVEL-1 SCREENING AND FOR DISCHARGES CORRESPONDING TO THE 2 YEAR FLOOD

The final Henderson equation which is considered is the velocity equation based on the Manning equation with the Manning "n" evaluated by means of the Strickler equation. The bed material size is then eliminated by utilizing the Shields parameter for threshold conditions. The resulting equation is as follows:

$$VM = 32.0 \cdot DM^{0.500} \cdot S^{0.333} \qquad \text{EQUATION 5.24}$$

The best fit result for the 2 year flood is:

$$VM = 12.6 \cdot DM^{0.608} \cdot S^{0.288} \qquad \text{EQUATION 5.25}$$

This equation has exponents quite close to the theoretical threshold expression given by Henderson; however, the agreement is not as good as that for the Lacey velocity equation. There is no appreciable improvement in the relation by rejecting those cases which have a mobile bed according to the Cooper-Neill criterion.

Henderson also presented the results for the "Type B" canal of Lane. In this case the form factor defined as the wetted perimeter divided by hydraulic radius was a constant equal to 8.75. The smallest form factor (defined by average water surface width divided by mean depth) encountered in this study of gravel rivers was about 15, which is nearly double that for the "Type B" channel. The slope equation resulting from the analysis of the "Type B" channel as given by Henderson is:

$$S = 0.44 \cdot DG75^{1.15} \cdot Q^{-0.46} \qquad \text{EQUATION 5.26}$$

The comparable equations for the 2 year flood based on 67 natural gravel river reaches are:

$$S = 0.0555 \cdot DG90^{0.499} \cdot Q^{-0.332} \qquad \text{EQUATION 5.27}$$

$$S = 0.0965 \cdot DG50^{0.586} \cdot Q^{-0.334} \qquad \text{EQUATION 5.28}$$

The next set of equations which were evaluated are the initiation of motion equations for the DG90 and the DG50 bed material sizes. For fully developed turbulent flow the Shields threshold criterion is given as follows:

$\gamma \cdot DM \cdot S/(\gamma' \cdot DG50) = 0.056$ EQUATION 5.20

This expression may be rewritten to obtain the following equation for the estimation of mean depth if the bed material is assumed to have a specific gravity of 2.65:

$DM = 0.091 \cdot DG50/S$ EQUATION 5.21

The results obtained by using this expression for the DG50 size are slightly better than those for the DG90 size and no substantial improvement results if those cases which are most probably in motion are rejected. In all cases considered the best estimate of DM is obtained if the term (DG50/S) has an exponent less than 1.00. Based on the 2 year flood, an approximate relation is:

$DM = 0.500 \cdot DG50^{0.500}/S^{0.500}$ EQUATION 5.22

and the best fit relation is given as follows:

$DM = 0.228 \cdot DG50^{0.283}/S^{0.516}$ EQUATION 5.23

These results imply that $DM \cdot S^{0.500}$ is a constant for reaches with the same characteristic bed material size. This result is quite different from that given by Henderson who states that for the threshold condition the product $DM \cdot S$ should be a constant. For duned sand-bed channels, the regime equation shows that the product, $DM^{0.500} \cdot S$, should be constant. From the results of this analysis of gravel rivers based on the 2 year flood, the product $DM \cdot S^{0.500}$ tends to be constant.

These results indicate that the slope for the "Type B" channel has a different form with regard to the bed material sizes with the exponent greater than 1.00 in the "Type B" channel and less than 1.00 for the natural channels considered in this analysis.

5.4.4 Kellerhals Type Relations

Kellerhals (1967) obtained data from paved gravel river reaches below lake outlets to ensure that bed material transport would be low even at the highest stages. In addition, he utilized the San Luis Canal data as reported by Lane and Carlson (1953). A few laboratory tests were carried out using fine gravel to obtain data points at the lower end of the discharge range. A width adjustment equation, a resistance equation of the exponential form, and a shear stress equation were combined into a set of regime equations.

The width adjustment equation presented by Kellerhals was:

$$WSM = 1.8 \cdot Q^{0.500} \qquad \text{EQUATION 5.29}$$

This equation is of the same form as the Lacey width equation. The coefficient obtained in this study of Alberta gravel rivers for the 2 year flood was 2.38 and the coefficient for the discharge corresponding to the valley flat was 2.78. The coefficient presented by Kellerhals is close to the value obtained for the 5 year flood; however, the exponent for this characteristic discharge was 0.536.

The resistance equation presented by Kellerhals was:

$$VM/(g \cdot DM \cdot S)^{0.500} = 6.5 \cdot (DM/DG90)^{0.250} \qquad \text{EQUATION 5.30}$$

The best fit relation obtained for the Gravel-1 rivers for the case of the 2 year flood is:

$$VM/(g \cdot DM \cdot S)^{0.500} = 3.84 \cdot (DM/DG50)^{0.281} \qquad \text{EQUATION 5.31}$$

The results of this study indicate that a slightly better relation is obtained by using the DG50 size rather than the DG90 size. There is no improvement by rejecting those cases which are considered to be mobile by the Cooper-Neill criterion. The exponent of 0.281 is close to that of 0.250 presented by Kellerhals; however, only about 40 percent of the variance is explained by the relation. The plotted points and the best fit line for the Gravel-1 rivers are shown in FIGURE 5.15 over the range of relative depths from 4 to 200. The plotted points for the Sand-1 rivers are also shown in the same figure.

The form of the resistance equation given by EQUATION 5.31 may be compared with other forms of the resistance equation. If the Manning equation is rewritten by accepting "n" to be the average Strickler value of:

$$n = 0.0342 \cdot DG50^{0.167} \qquad \text{EQUATION 5.32}$$

Then:

$$VM/(g \cdot DM \cdot S)^{0.500} = 5.50 \cdot (DM/DG50)^{0.167} \qquad \text{EQUATION 5.33}$$

Based on the reanalysis of the Nikuradse data by Williamson (1951), the equation may be written as:

$$VM/(g \cdot DM \cdot S)^{0.500} = 8.43 \cdot (DM/DG)^{0.167} \qquad \text{EQUATION 5.34}$$

if the grain size roughness is replaced by DG. If the DG90 size is used for the characteristic roughness DG, the results would be similar to those obtained from the Manning-Strickler equation. Logarithmic expressions have also been presented by Keulegan (1938) and others but are not considered in this analysis.

The data from natural channels indicate that the exponent for the relative depth is slightly higher than that of 0.167 given

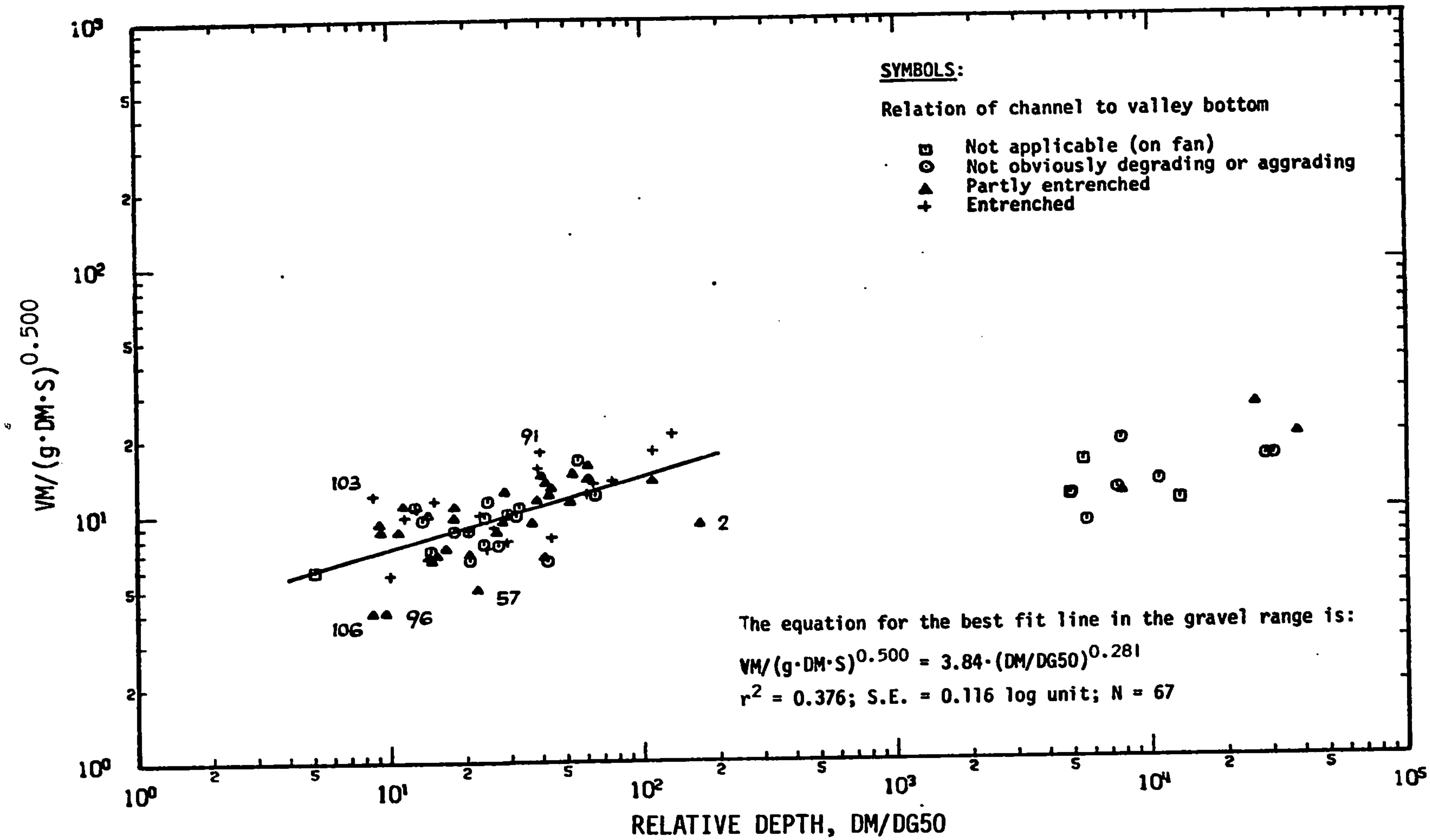


FIGURE 5.15 $VM/(g \cdot DM \cdot S)^{0.500}$ VERSUS RELATIVE DEPTH FOR RIVERS SATISFYING THE SAND-1 OR GRAVEL-1 SCREENING AND FOR DISCHARGES CORRESPONDING TO THE 2 YEAR FLOOD

in the above two equations, but compares quite favourably with the value of 0.250 presented by Kellerhals.

When the resistance equation was evaluated for the Gravel-3 screening (minimum of three bed material sample sites per reach), it was found that the resulting exponent for the 2 year flood was 0.409. No entirely satisfactory explanation was found for the better fit with the refined data which resulted in an exponent two and one half times that obtained by using the Manning-Strickler equation and over one and one-half times that found by Kellerhals. The exponent is also significantly different from the results obtained by using the Gravel-1 Screening. A qualitative explanation for the difference is based on a visual inspection of the plotted points for the Gravel-1 reaches and the Gravel-3 reaches. The data points at the extreme ends of the Gravel-1 data have been rejected for the Gravel-3 screen. Consequently the best fit line rotated to a new position determined by the remaining data points. The plotted data and the best fit line for the Gravel-3 screening are presented in FIGURE 5.16.

The third equation presented by Kellerhals was the following shear stress equation:

$$\gamma \cdot DM \cdot S = 1.25 \cdot DG90^{0.800} \qquad \text{EQUATION 5.35}$$

The best shear stress relation obtained in this study for Gravel-1 reaches and for the 2 year flood is:

$$\gamma \cdot DM \cdot S = 2.02 \cdot DG50^{0.769} \qquad \text{EQUATION 5.36}$$

This result was obtained by using the DG50 size rather than the DG90 size and by rejecting the data for the seven reaches which were mobile according to the Cooper-Neill criterion. Only about 30 percent of the variance is explained by the relation. The results for this analysis are presented in FIGURE 5.17.

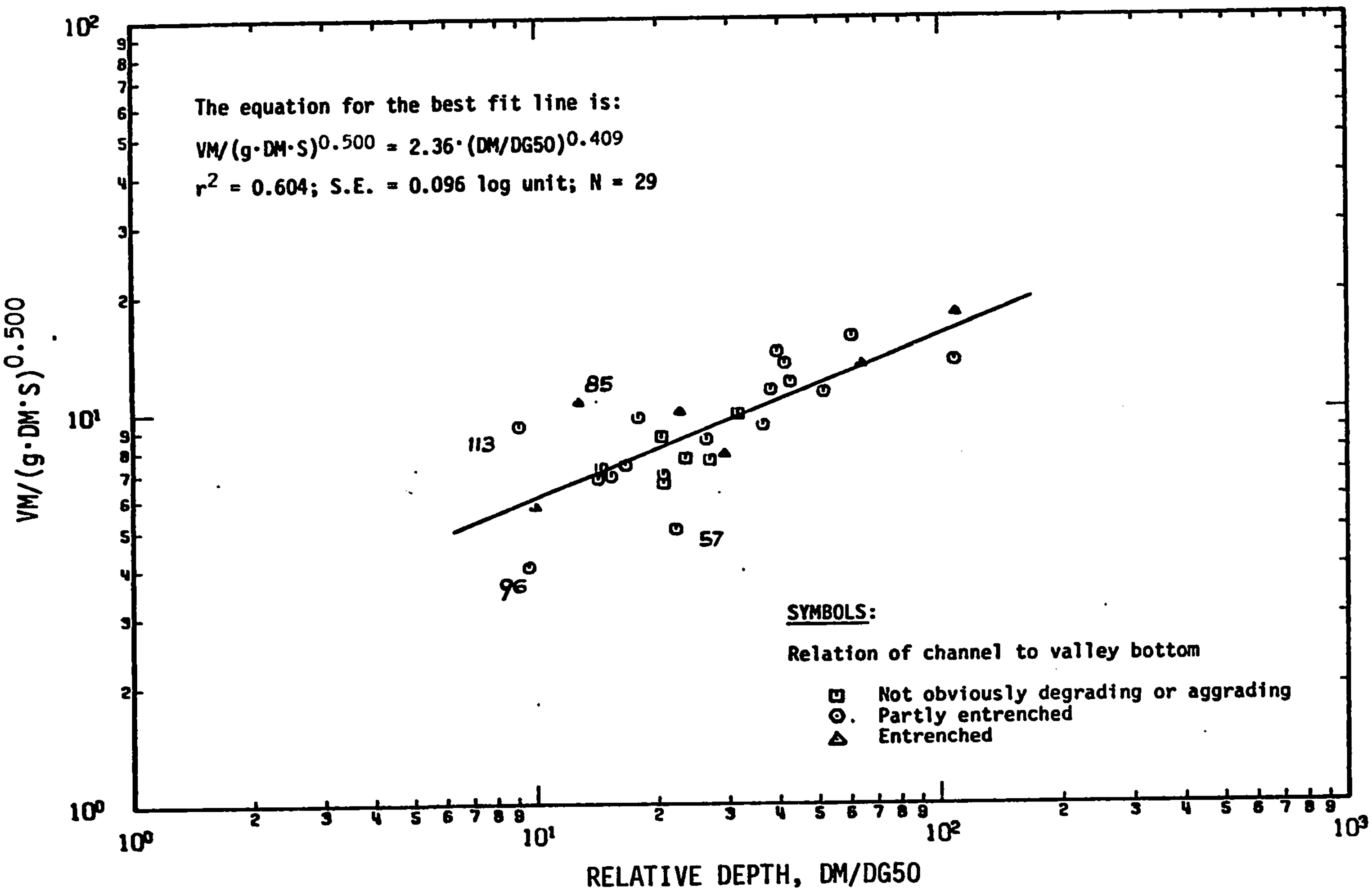


FIGURE 5.16 $VM/(g\cdot DM\cdot S)^{0.500}$ VERSUS RELATIVE DEPTHS FOR RIVERS SATISFYING THE GRAVEL-3 SCREENING AND FOR DISCHARGES CORRESPONDING TO THE 2 YEAR FLOOD

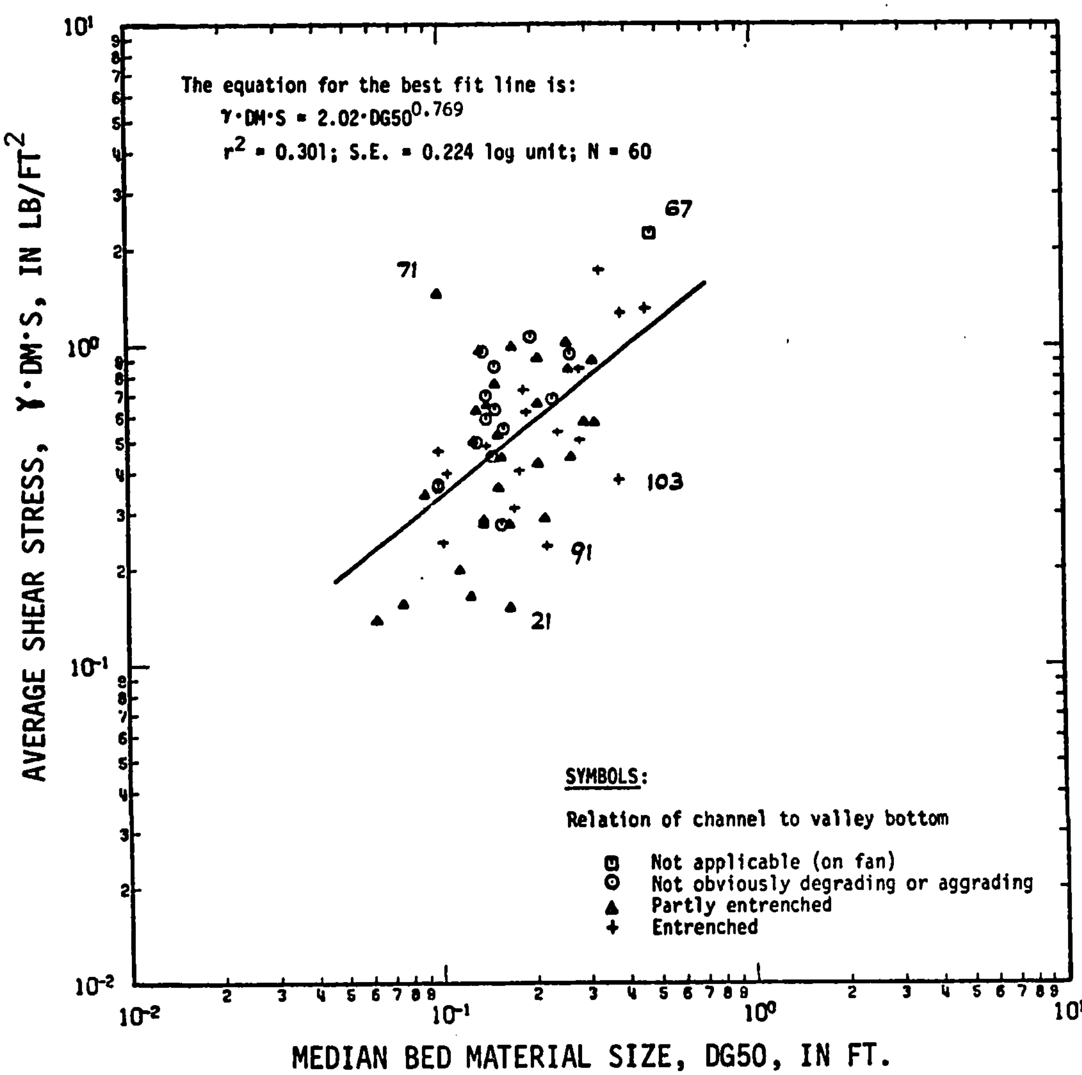


FIGURE 5.17 AVERAGE SHEAR STRESS VERSUS MEDIAN BED MATERIAL SIZE FOR RIVERS SATISFYING THE GRAVEL-1 SCREENING WHICH ARE IMMOBILE ACCORDING TO THE COOPER CRITERION AND FOR A DISCHARGE CORRESPONDING TO THE 2 YEAR FLOOD

It is noted that the exponent in the Kellerhals shear stress equation is 0.800 and the exponent for best fit equation for this study is 0.769. If the exponent had a value of 1.00 the expression would be of the form of the Shields initiation of motion criterion for fully developed turbulent flow over a rough boundary.

Finally the best fit relation for DM, VM and S are given in terms of discharge and bed material size. The overall results compare quite favourably with the Kellerhals regime equation for paved gravel rivers. The exponents for discharge are closer in agreement than the exponents for the bed material size term.

5.5 Evaluation of Different Classes of Equations

This section considers the effect of introducing from one to three independent variables when establishing relations for width, area, depth, form factor, velocity, slope, or Manning "n". One difficulty of using these types of relations is that the results are not dimensionally homogeneous and the form of the relation may not be compatible with a model based on deductive reasoning.

In the majority of cases, the results are presented for the Gravel-1 screening and for the discharge corresponding to the 2 year flood. If the results for the Gravel-3 screening are appreciably different from the Gravel-1 screening, those results are also presented. Brief statements are made concerning the main points for each of the exponential relations. All statements are made with respect to the detailed results presented in the appropriate tables in APPENDIX L.

All results are based on the exponential model of the form:

$$Y = a \cdot X_1^{b} \cdot X_2^{c} \cdot X_3^{d} \qquad \text{EQUATION 5.37}$$

which was fitted with a linear regression on the logarithmic transformed data. In SECTION 5.5.8 the best fit exponential form of the width-discharge relation, area-discharge relation, etc., are compared with the exponential form of the comparable expressions given by Lacey and Blench and those given by Leopold and Maddock.

5.5.1 Width Relations

The average width for a reach of a gravel river is primarily dependent upon discharge alone. The best fit equation for the Gravel-1 rivers based on the 2 year flood data is:

$$WSM = 2.38 \cdot Q^{0.527} \qquad \text{EQUATION 5.38}$$

The exponent in this case is close to that derived by Langbein (1964) by using minimum variance considerations.

The plotted points for the width-discharge relation along with the best fit line are shown in FIGURE 5.18. There is a tendency for the entrenched reaches to have a slightly smaller width than for those cases which are not obviously aggrading or degrading.

The width equations in terms of discharge and slope, and discharge and bed material size are as good as that given by EQUATION 5.38.

5.5.2 Area Relations

The average cross-sectional area for a reach of a gravel river is primarily dependent upon discharge and slope. The best fit relation for the Gravel-1 rivers based on the 2 year flood is:

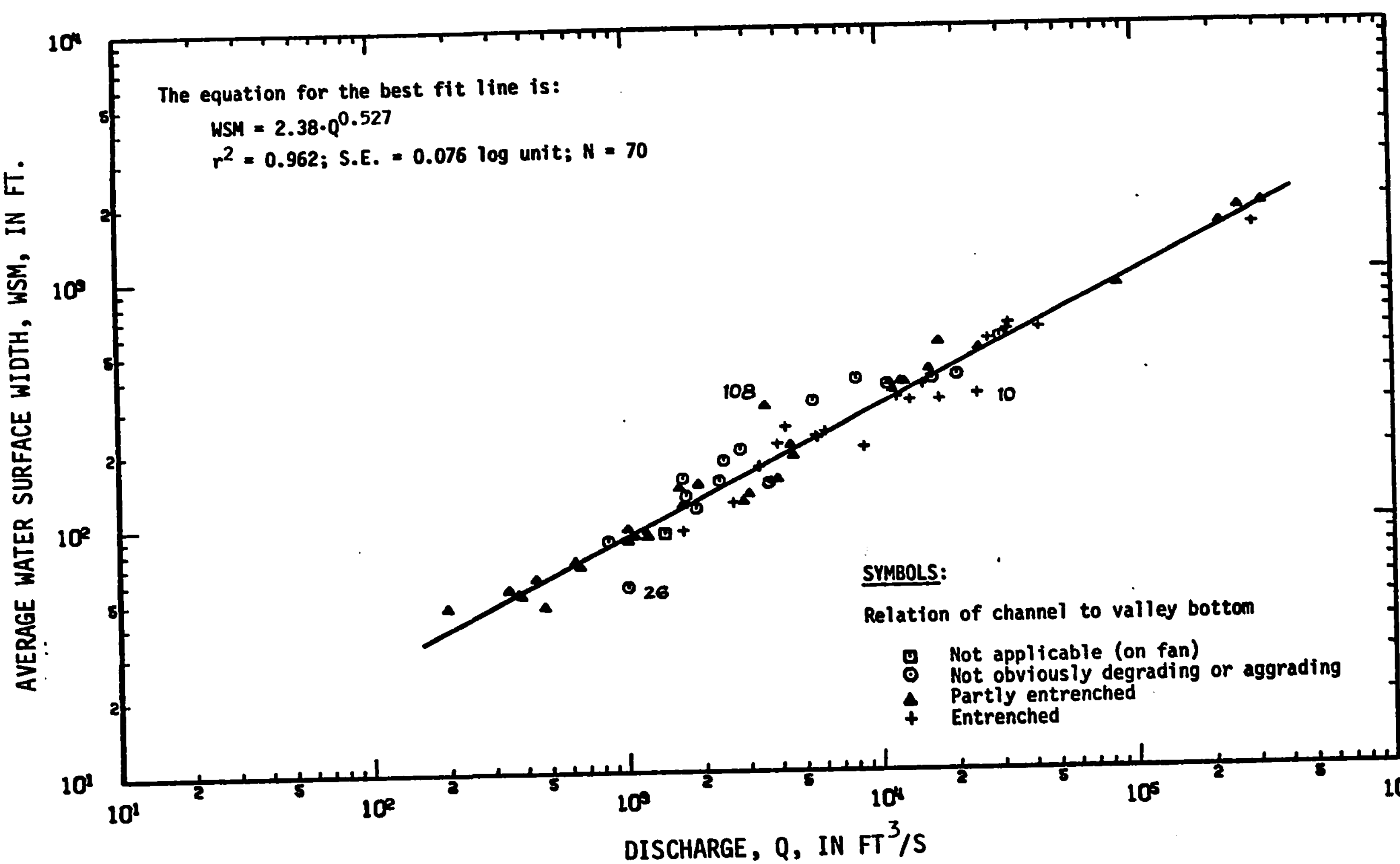


FIGURE 5.18 AVERAGE WATER SURFACE WIDTH VERSUS DISCHARGE FOR RIVERS SATISFYING THE GRAVEL-1 SCREENING AND FOR DISCHARGES CORRESPONDING TO THE 2 YEAR FLOOD

$$AM = 0.290 \cdot Q^{0.780} \cdot S^{-0.234} \qquad \text{EQUATION 5.39}$$

This relation may be interpreted by stating that the cross-sectional area increases with a characteristic discharge and decreases with slope. The introduction of bed material size into the relation does not result in any improvement.

The plotted data points and the best fit line for the average area versus discharge are shown in FIGURE 5.19. The coefficient of determination for this relation is 0.974 which is the highest of any of the discharge relations.

5.5.3 Depth Relations

The depth relation is primarily dependent upon discharge and slope. The best fit relation for the Gravel-1 river based on the 2 year flood is:

$$DM = 0.137 \cdot Q^{0.265} \cdot S^{-0.199} \qquad \text{EQUATION 5.40}$$

This equation indicates that the depth increases with an increase in the characteristic discharge and decreases with an increase in slope. This result is expected, since the average depth is computed as the average area divided by the average water surface width.

When mean depth is estimated by considering the bed material size and slope, it was found that the DG90 size and the DG50 size resulted in essentially the same coefficient of determination and the same standard error. The best fit relation for this case was:

$$DM = 0.294 \cdot DG50^{0.283} \cdot S^{-0.516} \qquad \text{EQUATION 5.41}$$

Only about 60 percent of the variance was explained by this equation. The exponent for the bed material size was higher in this relation for mean depth than that obtained by using discharge and bed material size to estimate the mean depth.

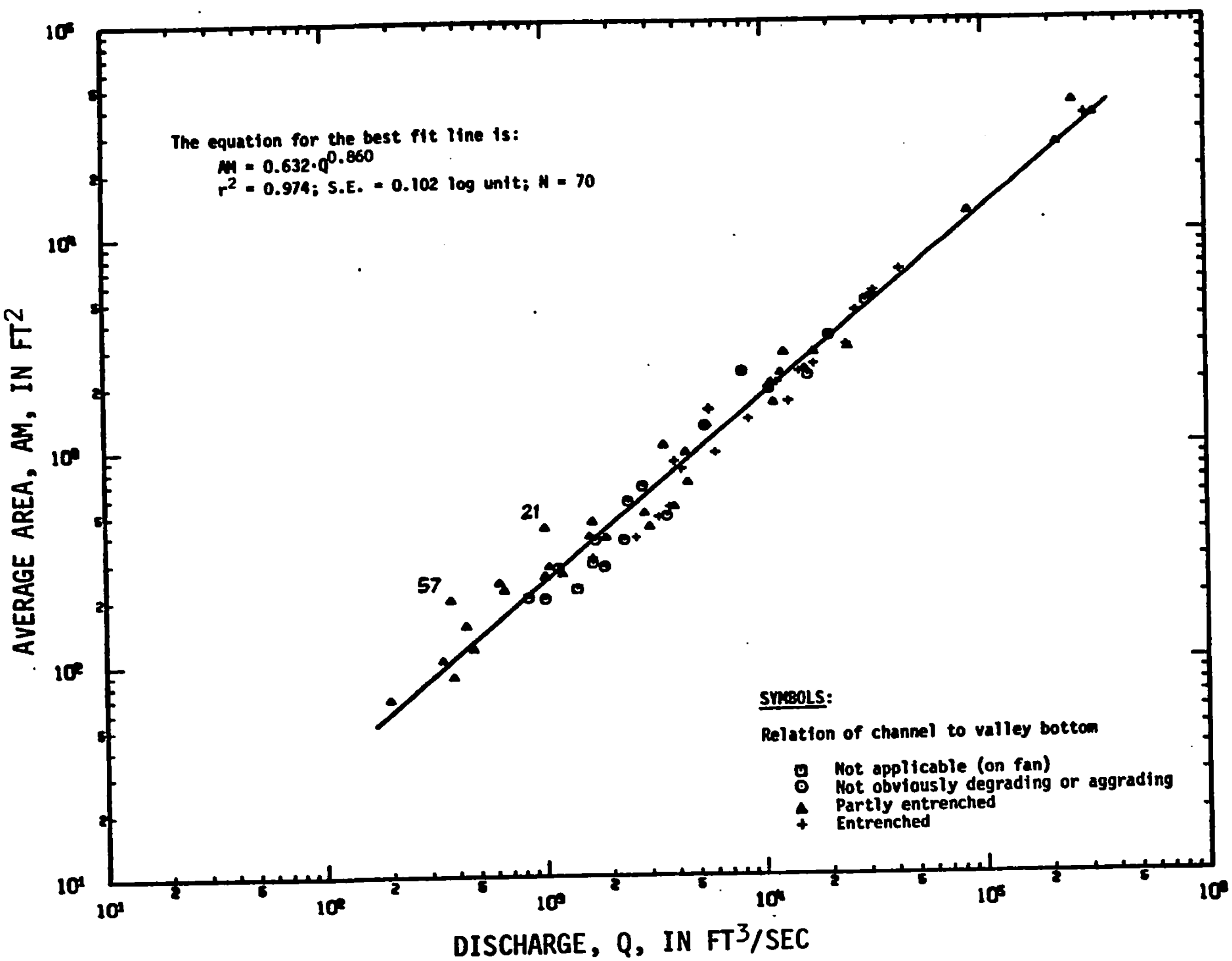


FIGURE 5.19 AVERAGE CROSS-SECTIONAL AREA VERSUS DISCHARGE FOR RIVERS SATISFYING THE GRAVEL-1 SCREENING AND FOR DISCHARGES CORRESPONDING TO THE 2 YEAR FLOOD

The basic data for the depth-discharge relation along with the best fit line are plotted in FIGURE 5.20. Essentially all reaches which are not obviously aggrading or degrading fall below the best fit line indicating that they flow at a shallower depth than those which are partly entrenched.

5.5.4 Form Factor Relations

In this study the form factor is defined as the average water surface width divided by the average depth. In terms of the basic data, it is defined as follows:

$$FF = WSM^2/AM \qquad \text{EQUATION 5.42}$$

The best fit form factor relation for the Gravel-1 reaches for the 2 year flood is:

$$FF = 12.8 \cdot Q^{0.263} \cdot DG50^{-0.159} \cdot S^{0.196} \qquad \text{EQUATION 5.43}$$

About 60 percent of the variance is explained by this relation. The above expression for the form factor is only slightly better than that obtained by considering discharge and slope as independent variables.

The data for the form factor-discharge relation are plotted in FIGURE 5.21 along with the best fit line. The position of the plotted points in FIGURE 5.21a indicates that those reaches which are neither aggrading or degrading have a slightly larger form factor than average.

A second plot of the form factor versus discharge is presented in FIGURE 5.21b to show the effect of the predominant alluvial bank material on the form factor. The position of the plotted points suggest that the form factor for channels with gravel and cobble banks is slightly larger than that for silty banks, especially for

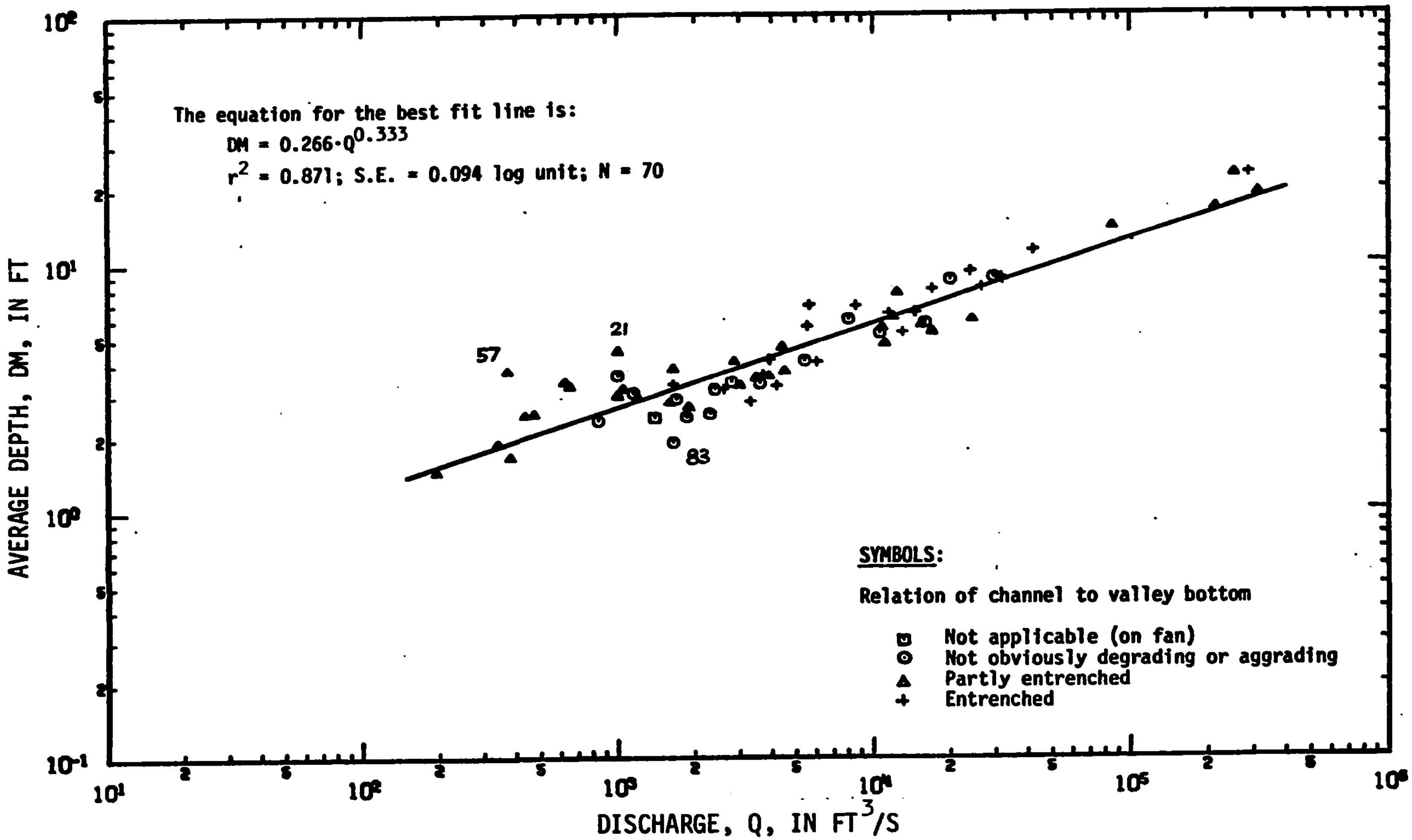
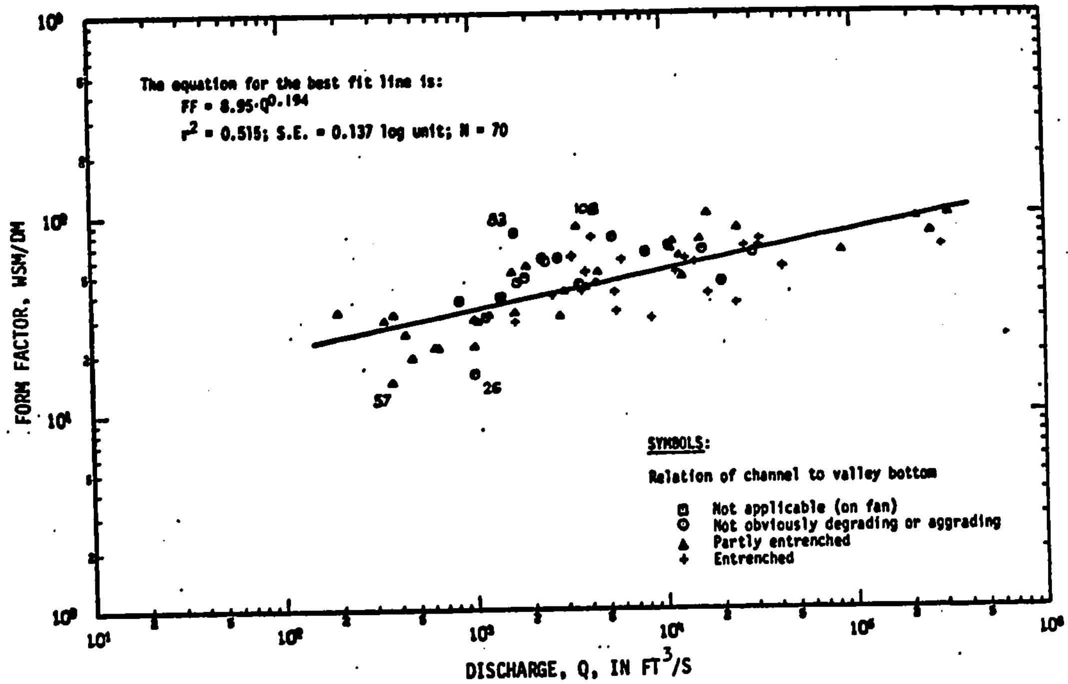
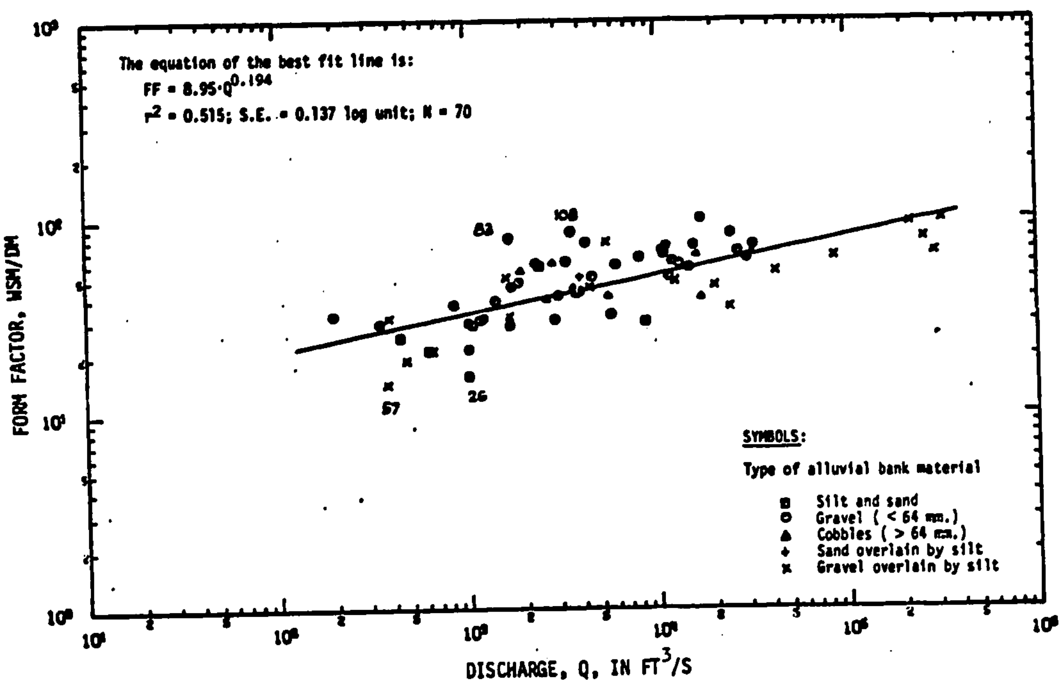


FIGURE 5.20 AVERAGE DEPTH VERSUS DISCHARGE FOR RIVERS SATISFYING THE GRAVEL-1 SCREENING AND FOR DISCHARGES CORRESPONDING TO THE 2 YEAR FLOOD



a) Symbols: Relation of Channel to Valley Bottom



b) Symbols: Type of Alluvial Bank Material

FIGURE 5.21 FORM FACTOR VERSUS DISCHARGE FOR RIVERS SATISFYING THE GRAVEL-1 SCREENING AND FOR DISCHARGES CORRESPONDING TO THE 2 YEAR FLOOD the larger discharges. From this plot it might be considered that the best fit line is slightly biased toward the channels with banks of gravel overlain by silt, since no other bank types were present for the highest discharges.

The results of this plot cannot be considered alone, for no indication of the longitudinal extent of the alluvial bank material is given. However, this result does show how any particular equation may be studied in more detail by evaluating the influence of geomorphic and geographic features associated with the reach.

5.5.5 Mean Velocity Relations

The standard forms of the velocity equation using mean depth and slope or mean depth and bed material size are not as good as those involving discharge and slope. The best fit relation for the Gravel-1 rivers and for the 2 year flood is:

$$VM = 4.52 \cdot Q^{0.220} \cdot S^{0.234} \qquad \text{EQUATION 5.44}$$

About 75 percent of the variance is explained by this expression.

When the discharge, bed material size and slope are considered as independent variables, the exponents indicate that the mean velocity increases with increasing discharge, decreases with increasing bed material size, and increases with increasing slope. For this case the exponent for the bed material size is relatively small compared to the other exponents.

Mean velocity is more closely estimated by mean depth and slope than by mean depth and bed material size. The best fit relation for mean velocity by considering mean depth and slope to be the independent variables is:

$$VM = 12.6 \cdot DM^{0.608} \cdot S^{0.288} \qquad \text{EQUATION 5.45}$$

when the Gravel-1 data and the 2 year flood are utilized. About 50 percent of the variance is explained by this relation.

The plotted points and the best fit line for the velocity-discharge relation are shown in FIGURE 5.22.

5.5.6 Slope Relations

5.5.6.1 Slope Relations Using All Gravel River Data

The slope versus discharge plot for the 2 year flood is presented in FIGURE 5.23. From the positions of the plotted points in this figure it is apparent that the slope-discharge relation is poorly defined when compared to the width-discharge relation (FIGURE 5.18) or the area-discharge relation (FIGURE 5.19) for the same class of Gravel-1 rivers.

The best fit relation for estimating slope for Gravel-1 rivers includes discharge and bed material size as independent variables. This relation for the 2 year flood is:

$$S = 0.0965 \cdot Q^{-0.334} \cdot DG50^{0.586} \qquad \text{EQUATION 5.46}$$

This is one of the few relations in which the exponent for the bed material size is dominant. The coefficient of determination for this relation is 0.43.

When slope is estimated from bed material size alone, the results obtained by using the Gravel-3 screening (at least 3 bed material sample sites per reach, see SECTION 4.3) are better than the results obtained by using the Gravel-1 reaches.

For Gravel-1 rivers the slope is essentially a function of the square root of the bed material size, whereas the result from the

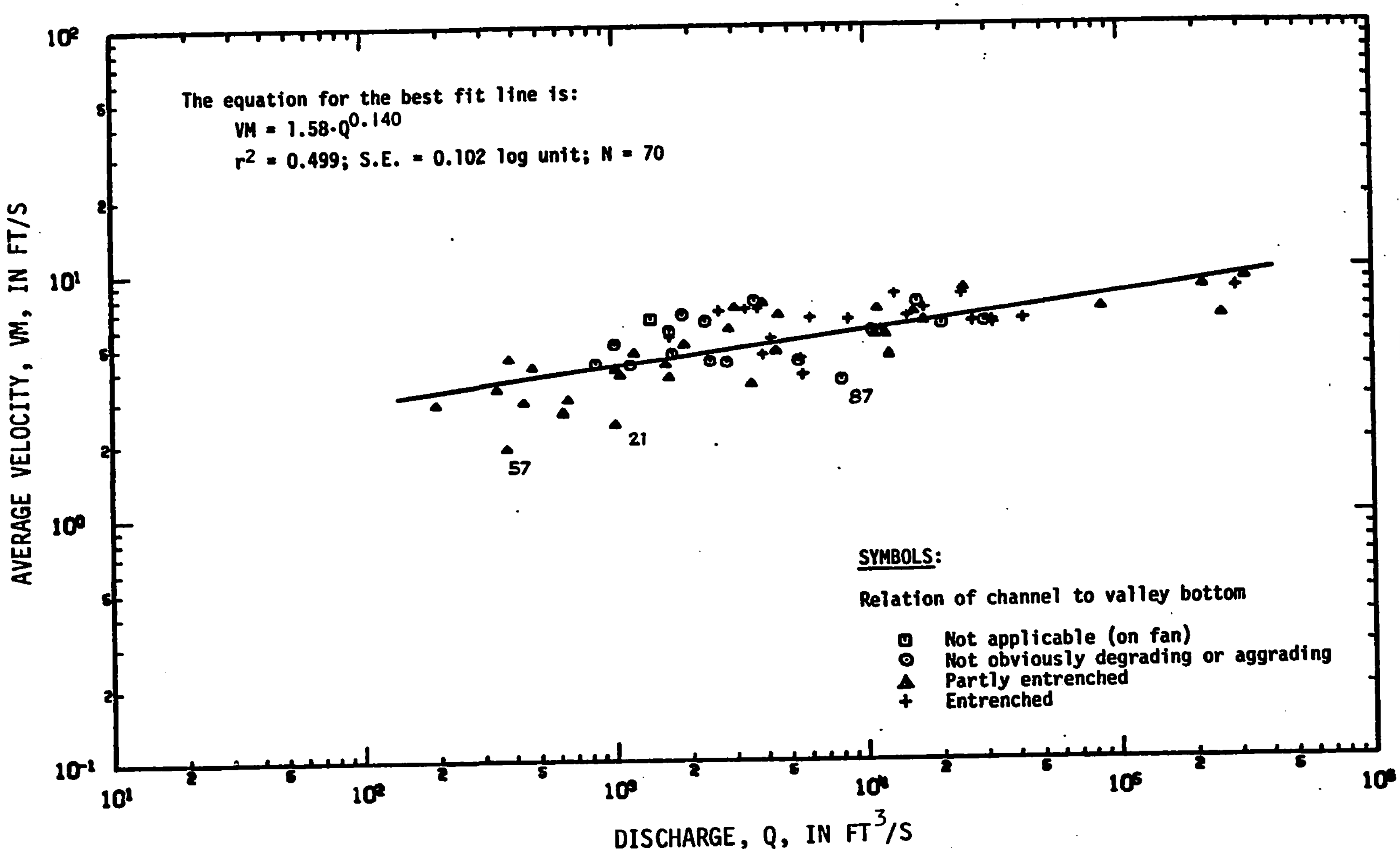


FIGURE 5.22 MEAN VELOCITY VERSUS DISCHARGE FOR RIVERS SATISFYING THE GRAVEL-1 SCREENING AND FOR DISCHARGES CORRESPONDING TO THE 2 YEAR FLOOD

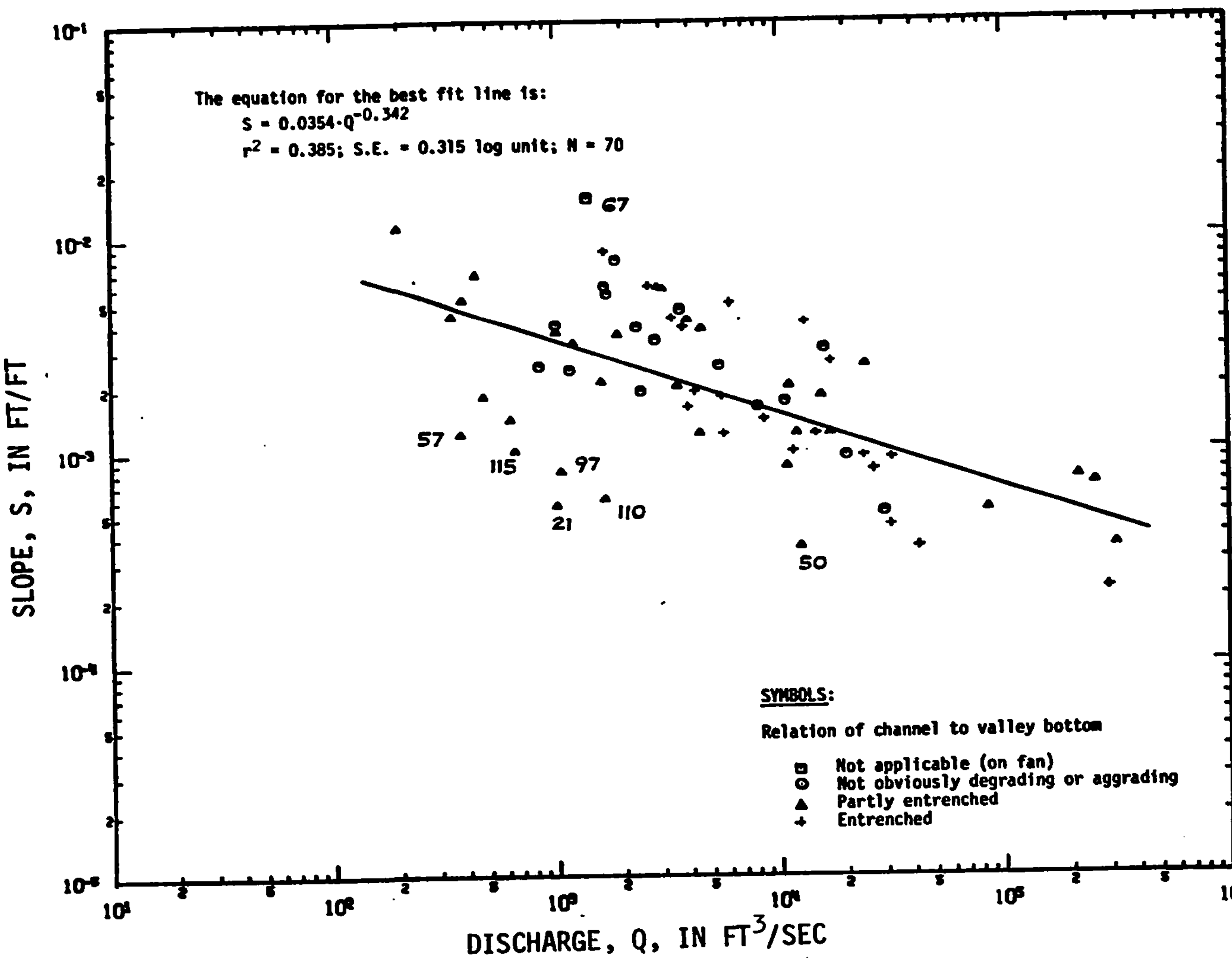


FIGURE 5.23 SLOPE VERSUS DISCHARGE FOR RIVERS SATISFYING THE GRAVEL-1 SCREENING AND FOR DISCHARGES CORRESPONDING TO THE 2 YEAR FLOOD

Gravel-3 screening shows that the slope is essentially linearly related to bed material size. Hack (1957) found that the slope varied in an essentially linear relation with bed material size for drainage basins with areas between 50 and 100 square miles. This result by Hack compares with the result obtained for the Gravel-3 rivers. Less than 30 percent of the variance is explained for the slope-bed material size relation when the Gravel-3 data are used.

In all cases the introduction of the slope correction parameter, SCOR, results in a reduction in the overall correlation when the simple exponential model is used.

5.5.6.2 Evaluation of Effect of Geomorphic Features on the Slope-Discharge Relation for Gravel Rivers

Since the slope-discharge relations were highly variable, a more detailed analysis was carried out to attempt to reduce the variance for subsets of the Gravel-1 reaches by stratifying the slope data according to certain geomorphic and geographic criterion.

The two subsets used for this analysis of the Gravel-1 river reaches were:

1. Terrain at the Reach
    1. Mountains or foothills
    2. Plains
2. Relation of Channel to Valley Bottom
    1. Not obviously aggrading or degrading
    2. Partly entrenched
    3. Entrenched

The data were also stratified according to the "Relation of the Channel to the Valley Walls" and according to the "Relative Depth of Alluvium" but the results were inconclusive. A detailed description of the above terms is presented in APPENDIX G.

The summary of the results for this analysis is presented in TABLE 5.2. Based on the available data, these results indicate that there is no significant difference at the 5 percent level in the functional form between channels in the plains and those in the mountains or foothills. That is, the exponent for the reaches in the plains falls within the 95 percent confidence limits of the value of the exponent obtained for the reaches in the mountains or foothills, and vice versa. On the average the exponent for the channels in the plains is less than that for reaches in the mountains or foothills. Over the range of discharges encountered in this study, the slope in the mountains is about four times the slope in the plains for small channels (about 200 cfs.) and about two times the slope in the plains for the large channels (about 100,000 cfs.). This interpretation should be considered to be tentative, since the coefficient of determination for the plains rivers was only about 0.26.

When considering the slope equation with regard to the relation of the channel to the valley bottom, it is noted that the exponent for the reaches which are entrenched is significantly different from the exponent for those reaches which are partly entrenched. In all cases the coefficient of determination is relatively high. If the entrenched reaches are compared with the reaches which are not obviously aggrading or degrading, it is found that at low discharges the entrenched channels have a steeper slope than those which are neither aggrading or degrading. For a discharge

TABLE 5.2

RELATIONS BETWEEN SLOPE AND DISCHARGE FOR VARIOUS GEOMORPHIC SETTINGS FOR GRAVEL RIVERS SATISFYING THE GRAVEL-1 SCREENING AND FOR DISCHARGES CORRESPONDING TO THE 2 YEAR FLOOD[1].

Condition	a	b	95% confidence limits for b		r^2	S.E.	F	N
Gravel-1 (basic)	0.035	-0.342	-0.446	-0.237	0.385	0.32	42.6	70
Mountains or foothills	0.048	-0.312	-0.449	-0.174	0.456	0.21	21.8	28
Plains	0.0083	-0.220	-0.347	-0.092	0.258	0.26	12.2	37
Not obviously aggrading or degrading	0.099	-0.440	-0.695	-0.185	0.495	0.22	13.7	16
Partly entrenched	0.014	-0.254	-0.392	-0.115	0.312	0.33	14.0	33
Entrenched	0.867	-0.679	-0.887	-0.471	0.723	0.23	47.0	20
Not confined or occasionally confined	0.420	-0.593	-1.490	0.305	0.366	0.28	2.8 [2]	7
Frequently confined	0.0094	-0.198	-0.443	0.047	0.155	0.35	2.9 [2]	18
Confined	0.027	-0.311	-0.467	-0.154	0.401	0.32	16.7	27
Depth of alluvium Nil or shallow	0.044	-0.368	-0.565	-0.172	0.364	0.35	14.9	28
Depth of alluvium Moderate or deep	0.409	-0.567	-0.790	-0.345	0.838	0.25	36.3	9

1. The equation is of the form: $S = a \cdot Q^b$
2. Not significant at the 5% level.

of about 5,000 cfs. the slope is the same for both. The best fit slope-discharge lines for the different relations of the channel to the valley bottom are shown in FIGURE 5.24.

If it can be assumed that the channels which are not obviously aggrading or degrading are in a long term equilibrium with the environment, then it may also be assumed that the channels which are entrenched are in the process of adjusting to a new condition however slow this slope adjustment may be. Actually the slope adjustment must be relatively slow, since other results of this study have shown that all classes of channels essentially maintain their width-discharge, area-discharge adjustment whether the channel is entrenched or not.

The detailed evaluation of slope adjustment is very complex and is beyond the scope of this generalized analysis of river regime. For example, the whole region or at least the plains region of Western Canada is still responding to the removal of the ice load from the last glaciation. The slopes must adjust to this dynamic response of the crust of the earth. Major changes in geologic structures are also reflected in the slope of channels. The slopes in the plains may also be controlled to some extent by pre-existant regional slopes as suggested by Rubey (1952).

5.5.6.3 Comparison of S-Q Relation with the Leopold and Wolman Relations

Other investigators have studied the slope-discharge relation for rivers with regard to certain geomorphic features. For example Leopold and Wolman (1957) in a study of rivers in the United

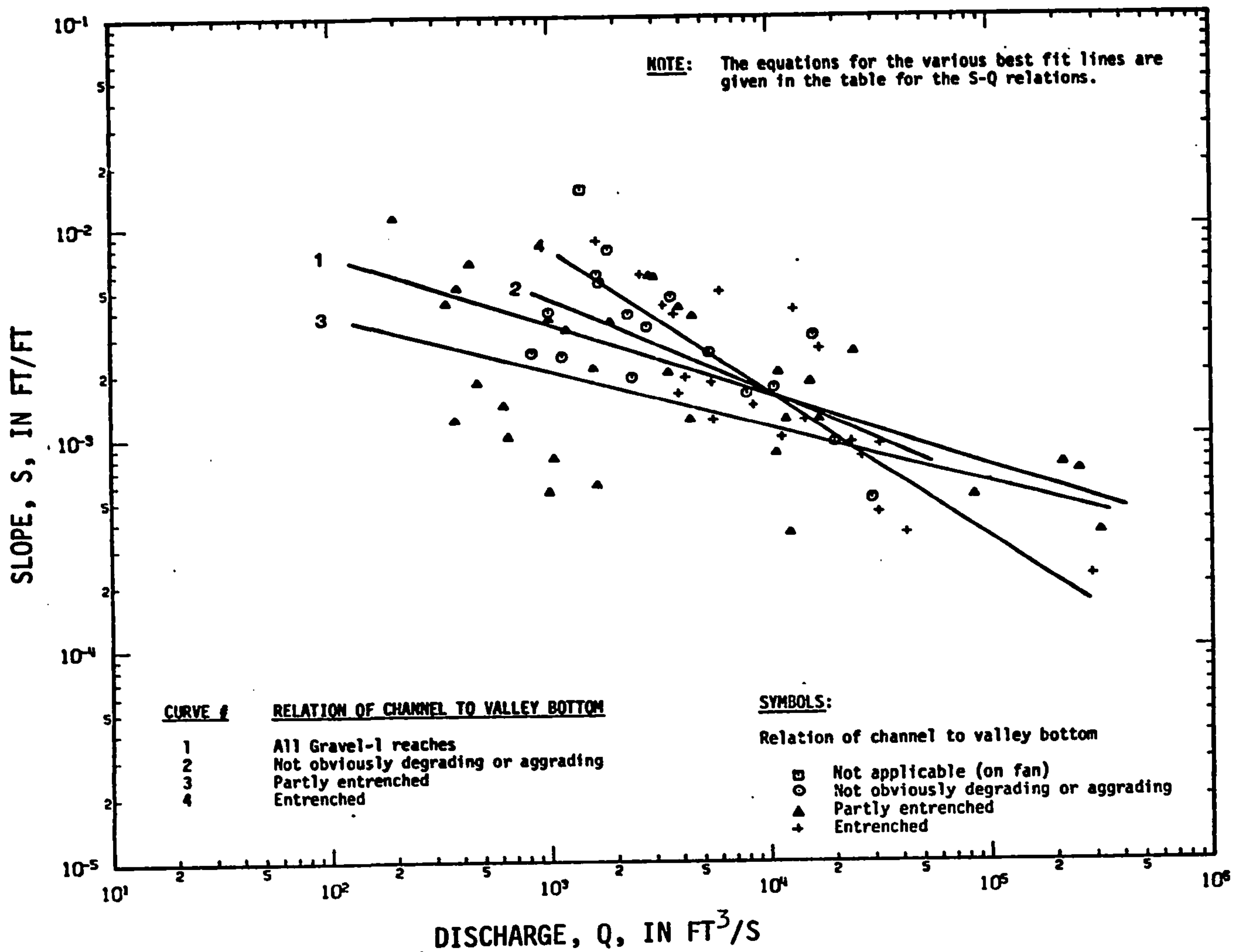


FIGURE 5.24 SLOPE-DISCHARGE RELATIONS FOR VARIOUS RELATIONS OF THE CHANNEL TO THE VALLEY BOTTOM FOR RIVERS SATISFYING THE GRAVEL-1 SCREENING AND FOR A CHARACTERISTIC DISCHARGE CORRESPONDING TO THE 2 YEAR FLOOD

States found that braided or split rivers could be separated from single thread meandering rivers by a line given by the following expression:

$$S = 0.06 \cdot Q^{-0.44} \qquad \text{EQUATION 5.47}$$

where the discharge was the bankfull discharge in cfs. The braided or split river reaches utilized by Leopold and Wolman plotted above the line given by EQUATION 5.47.

FIGURE 5.25 is a plot of the Gravel-1 data used in this analysis for a discharge corresponding to the valley flat. The value of the third parameter is the slope correction parameter, SCOR. This parameter could have relatively high values for braided channels or for a meandering channel. Channels which are relatively straight and without islands have values near 1.3 (See SECTION 4.5). The data in this plot do not clearly distinguish between the two types of channel, since it is expected that channels with low values of SCOR should be located near the Leopold and Wolman line.

FIGURE 5.26 is a similar plot except that the third parameter is sinuosity and the symbols for the plotted points represent the island code for the reach. The position of the plotted points indicate that those reaches which are split, braided, or have frequent islands, fall above the line suggested by Leopold and Wolman. The sinuosity for the reaches with no islands near the dividing line is quite low while the sinuosity is relatively high for the reaches with no islands and which are plotted at a position remote from the Leopold and Wolman line.

Based on the data from Alberta gravel rivers, the single thread channels with no islands generally fall below or near the

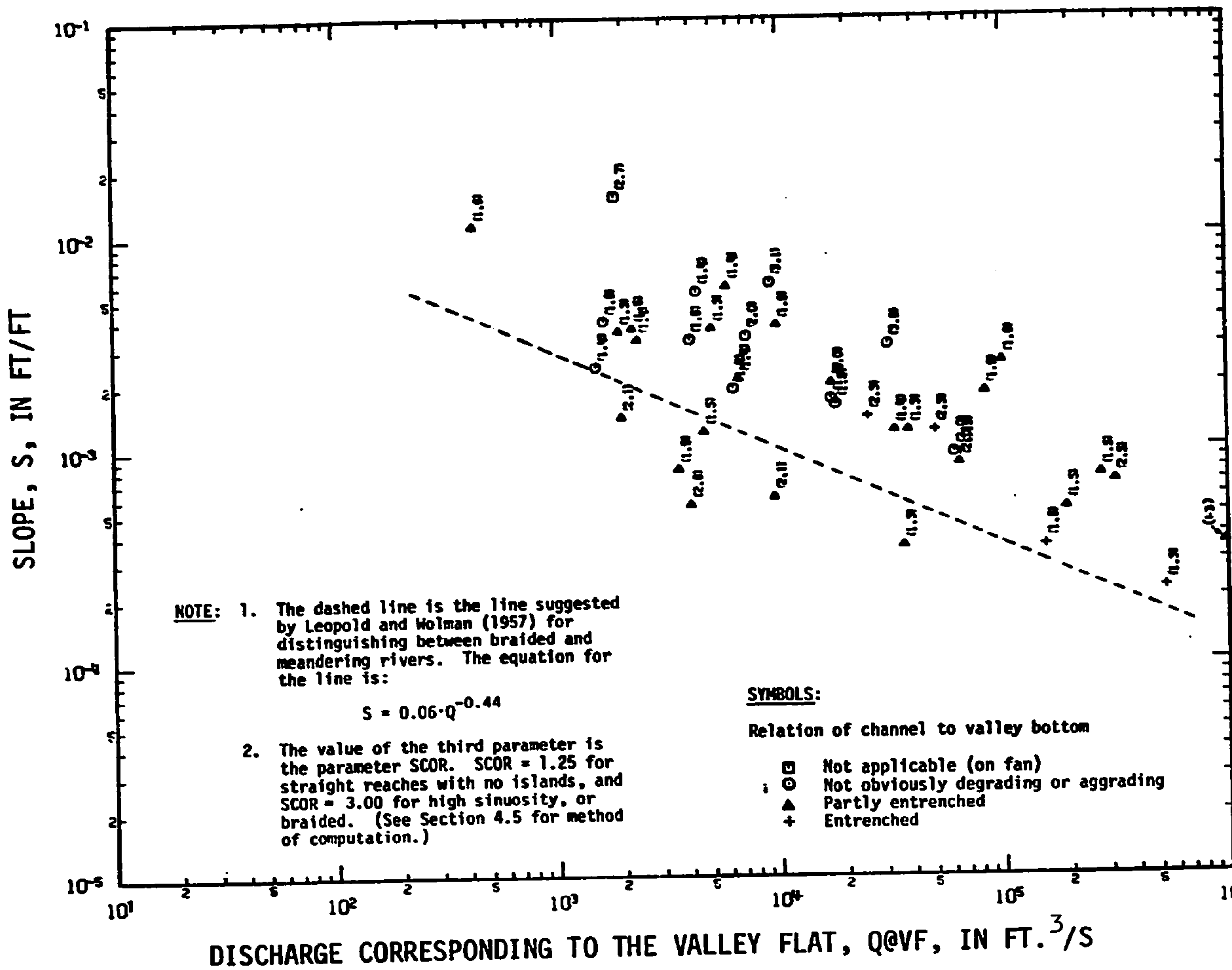


FIGURE 5.25 SLOPE VERSUS DISCHARGE FOR RIVERS SATISFYING THE GRAVEL-1 SCREENING AND FOR DISCHARGES CORRESPONDING TO THE ELEVATION OF THE VALLEY FLAT (SYMBOLS: RELATION OF CHANNEL TO VALLEY BOTTOM)

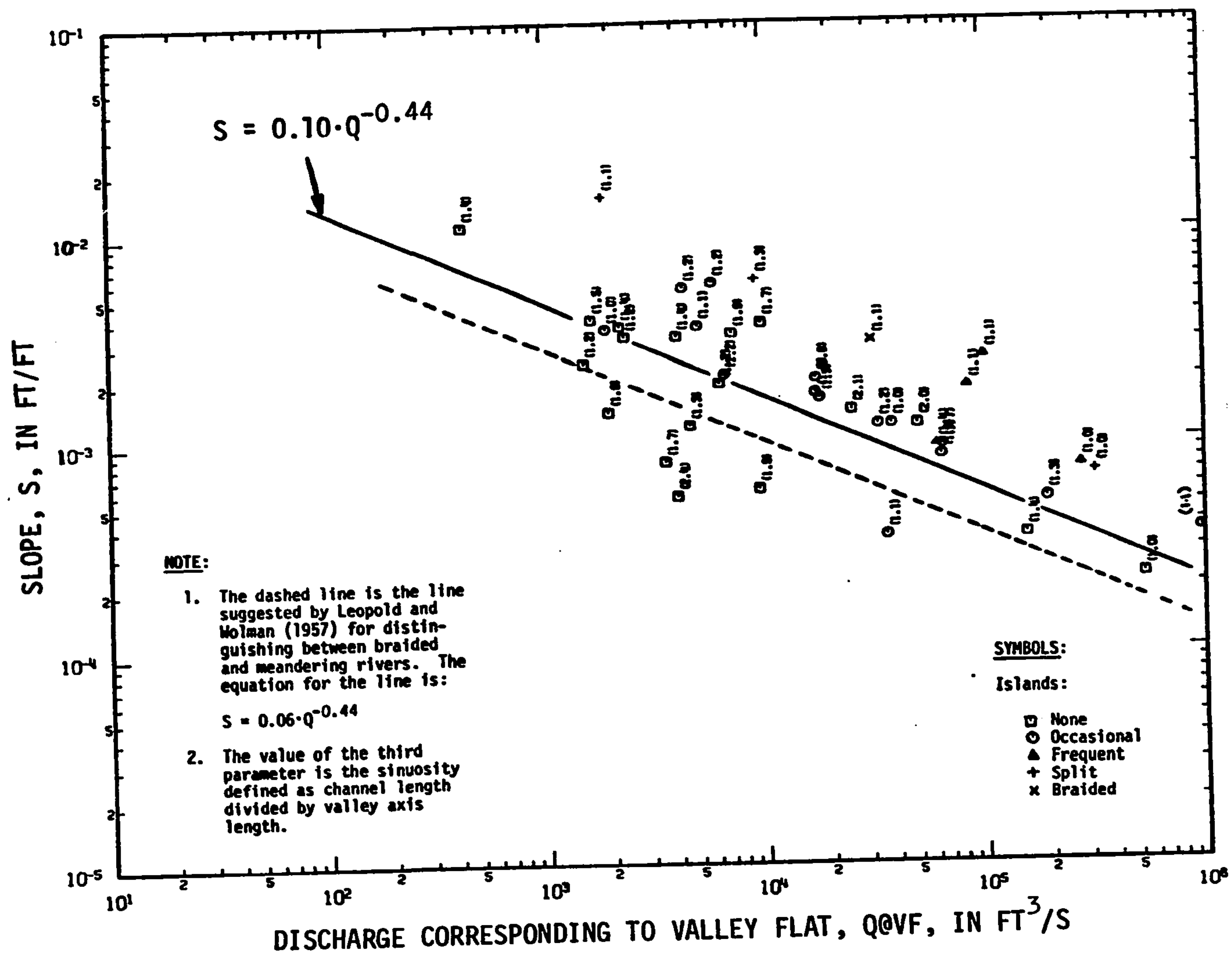


FIGURE 5.26 SLOPE VERSUS DISCHARGE FOR RIVERS SATISFYING THE GRAVEL-1 SCREENING AND FOR DISCHARGES CORRESPONDING TO THE ELEVATION OF THE VALLEY FLAT (SYMBOLS: ISLAND CODE)

line defined by the following equation:

$$S = 0.10 \cdot Q^{-0.44} \qquad \text{EQUATION 5.48}$$

Only one case with occasional islands falls below this line. The functional form of this expression is the same as that given by Leopold and Wolman (1957).

5.5.7 Manning "n" Relations

The estimation of this parameter has been studied in some detail, since it is familiar to many practicing engineers.

One problem encountered when evaluating "n" from the following definition is that DM,S and VM are all subject to error:

$$n = 1.486 \cdot DM^{0.667} \cdot S^{0.500} / VM \qquad \text{EQUATION 5.49}$$

A maximum error for "n" is about 75 percent when considering the reasonable maximum errors of DM,S and VM.

The results in this section are presented under two main groupings; first, those relations whereby the value of Manning "n" is estimated by one independent variable; and second, those relations involving more than one independent variable for the estimation of "n".

5.5.7.1 Relations Involving One Independent Variable

The best estimate of "n" for the Gravel-1 rivers is obtained by using slope as the independent variable. For the 2 year flood, the expression is:

$$n = 0.107 \cdot S^{0.183} \qquad \text{EQUATION 5.50}$$

Only about 35 percent of the variance is explained by this relation. This estimation of "n" results in a degree of spurious correlation, since S has already been considered in the computation of "n" as a dependent variable. If the estimate of "n" given by EQUATION 5.50 is substituted in the Manning equation, the expression for the mean velocity becomes

$$VM = 13.9 \cdot DM^{0.667} \cdot S^{0.317} \qquad \text{EQUATION 5.51}$$

The coefficient and exponents for the best fit relation between mean velocity, mean depth and slope are 12.6, 0.608 and 0.288 respectively (See EQUATION 5.45). The comparable coefficient and exponents given by Lacey (1933) are 16.0, 0.667 and 0.333 (See EQUATION 5.4). Since the result presented in EQUATION 5.51 is very similar to the Lacey equation, it is recommended that the Lacey type velocity equation be used more frequently when estimating the mean velocity for relatively high flows since no estimate of "n" is required.

The data points for the "n"-discharge relation are shown in FIGURE 5.27 along with the best fit line for the estimation of "n" from Gravel-1 rivers for a discharge corresponding to the 2 year flood. There is no apparent grouping of the plotted points according to the relation of the channel to the valley bottom.

Based on the Gravel-1 rivers, the estimates of "n" resulting from the consideration of bed material size alone is very poor, with a coefficient of determination less than 0.100. For these poor correlations, the result obtained by using the median size, DG50, is as good as that obtained by using the DG90 size. The relation for the 2 year flood is:

$$n = 0.048 \cdot DG50^{0.180} \qquad \text{EQUATION 5.52}$$

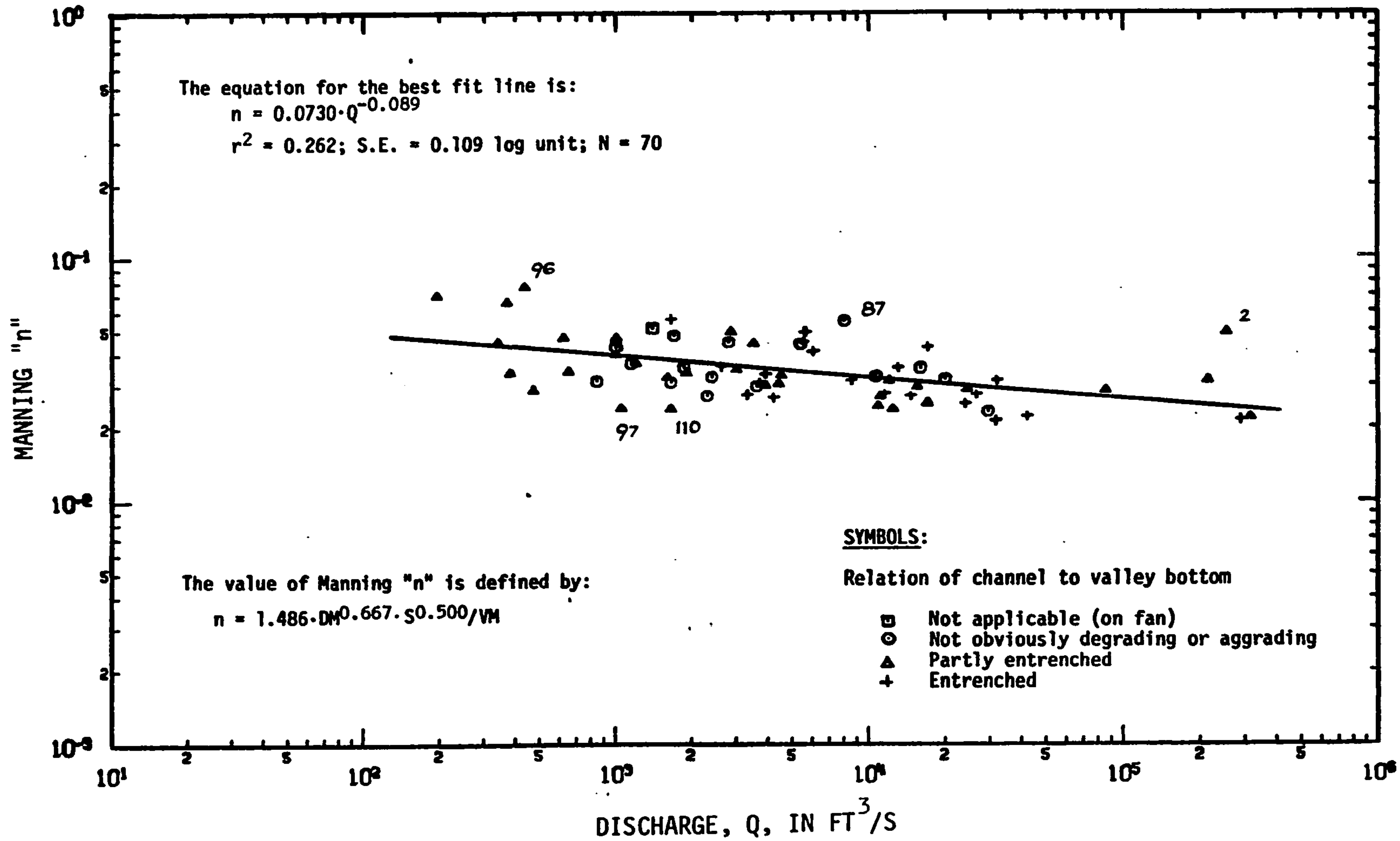


FIGURE 5.27 MANNING "n" VERSUS DISCHARGE FOR RIVERS SATISFYING THE GRAVEL-1 SCREENING AND FOR DISCHARGES CORRESPONDING TO THE 2 YEAR FLOOD

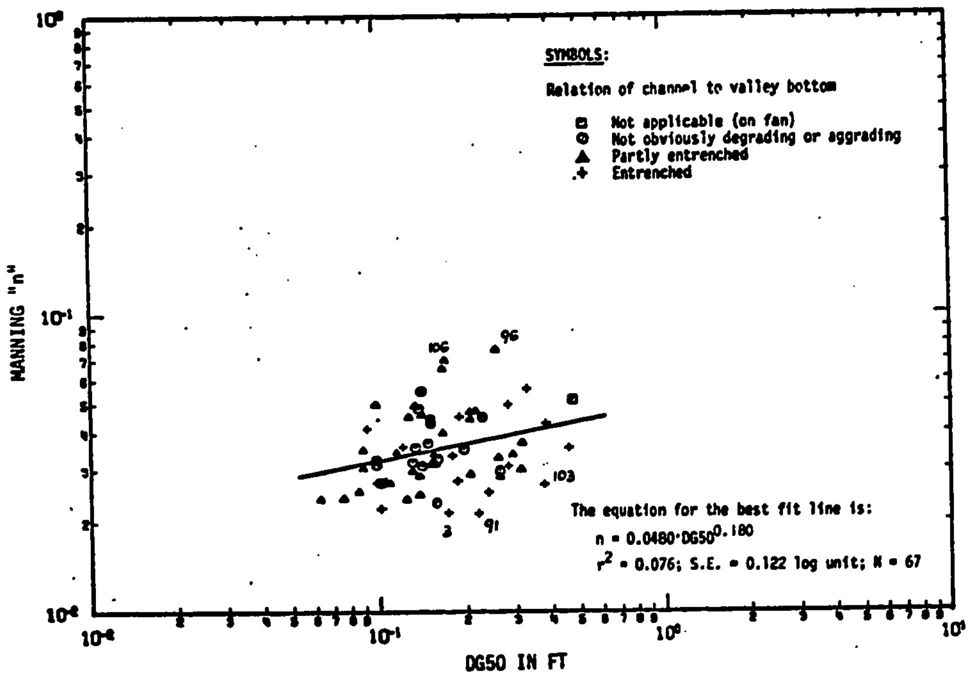
Chow (1959) gives the average coefficient and exponent obtained by Strickler from a study of Swiss rivers for the exponential relation between "n" and median bed material size as:

$$n = 0.0342 \cdot DG50^{0.167} \qquad \text{EQUATION 5.53}$$

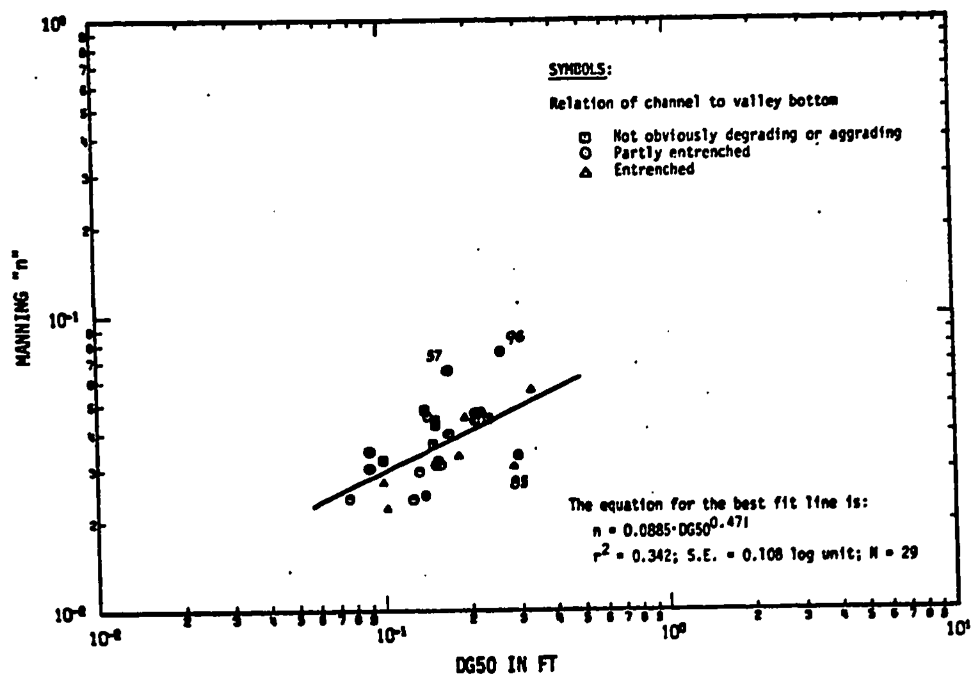
The coefficient and exponent for this equation are very similar to those obtained for the comparable Gravel-1 rivers used in this study. The plotted points for the "n"-DG50 relation are shown in FIGURE 5.28a along with the best fit line.

The results obtained by using the data for the Gravel-3 screening were better than those obtained by using the Gravel-1 screening when bed material size alone was used to estimate the value of the Manning "n". The plotted points and the best fit "n" -DG50 relation are presented in FIGURE 5.28b for the case of the Gravel-3 screening and for a discharge corresponding to the 2 year flood. Although the exponents are quite different for the Gravel-1 and the Gravel-3 screenings, the overall results are similar over the range of DG50 from 0.075 ft. (23 mm.) to 0.25 ft. (76 mm.).

Another analysis involving the bed material size was carried out between the parameter $n/(DG50)^{0.167}$ and the relative depth, DM/DG50. FIGURE 5.29 shows a plot of $n/DG50^{0.167}$ against relative depth for Sand-1 and Gravel-1 rivers along with the best fit line for the Gravel-1 rivers. The results of this plot indicate that in the gravel range the parameter $n/DG50^{0.167}$ is not constant, but shows a slight decrease with increasing values of DM/DG50. The regression equation fitted to the data for a discharge corresponding to the 2 year flood and for the Gravel-1 screening is:



a) Data for Gravel-1 Screening



b) Data for Gravel-3 Screening

FIGURE 5.28 MANNING "n" VERSUS DG50 FOR GRAVEL RIVERS AND FOR DISCHARGES CORRESPONDING TO THE 2 YEAR FLOOD

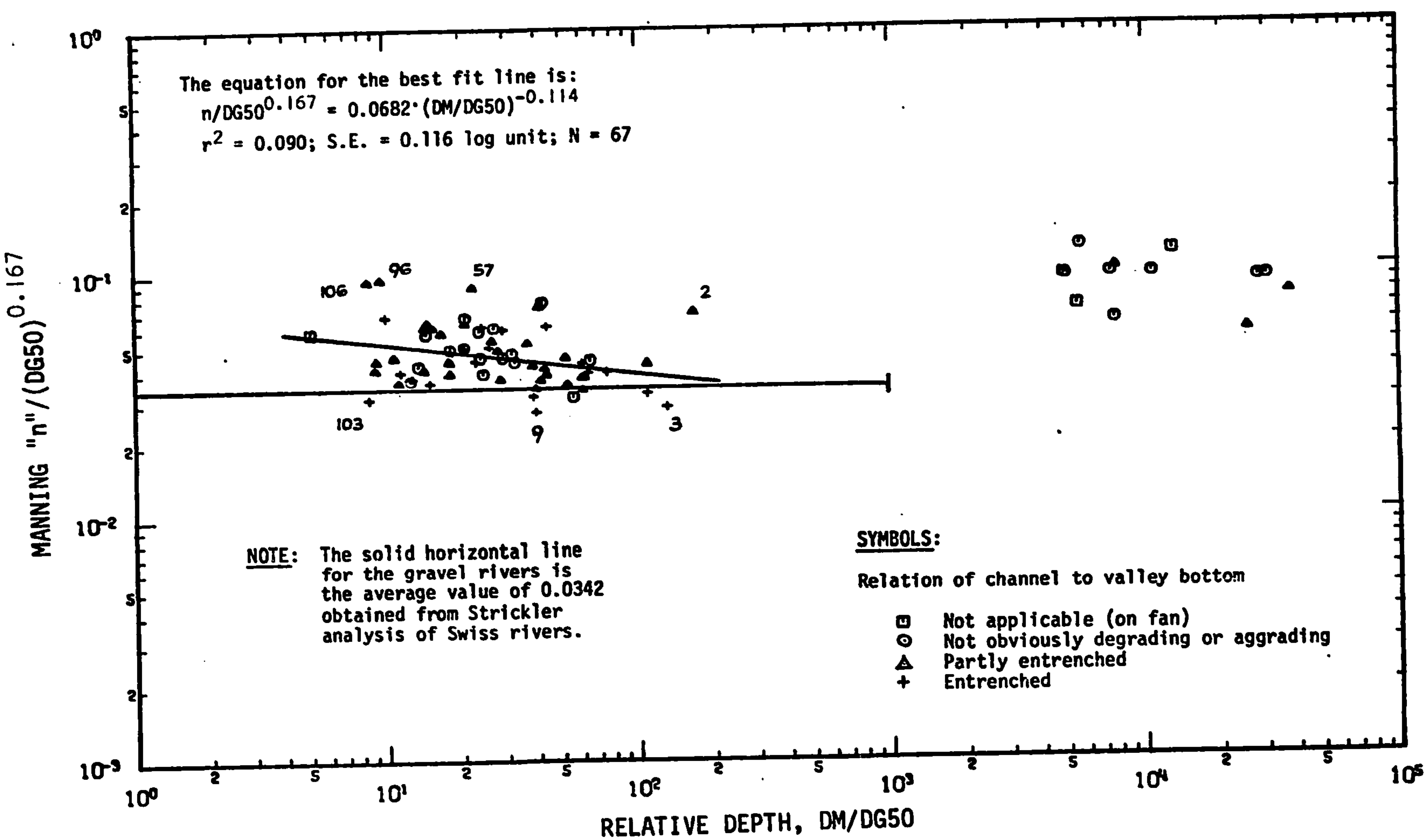


FIGURE 5.29 MANNING "n"/DG50$^{0.167}$ VERSUS RELATIVE DEPTH FOR RIVERS SATISFYING THE GRAVEL-1 OR SAND-1 SCREENING AND FOR DISCHARGES CORRESPONDING TO THE 2 YEAR FLOOD

$$n/(DG50)^{0.167} = 0.0682 \cdot (DM/DG50)^{-0.114} \qquad \text{EQUATION 5.54}$$

and for the Gravel-3 screening is:

$$n/(DG50)^{0.167} = 0.111 \cdot (DM/DG50)^{-0.242} \qquad \text{EQUATION 5.55}$$

The analysis was also carried out by using $DM^{0.167}$ to form a dimensionless ratio with "n". The resulting equation for the 2 year flood and the Gravel-1 screening is:

$$n/DM^{0.167} = 0.0682 \cdot (DM/DG50)^{-0.281} \qquad \text{EQUATION 5.56}$$

and for the Gravel-3 screening is:

$$n/DM^{0.167} = 0.111 \cdot (DM/DG50)^{-0.409} \qquad \text{EQUATION 5.57}$$

An approximate equation obtained from data presented by Limerinos (1970) for relative depths between 4 and 100 is as follows:

$$n/DM^{0.167} = 0.055 \cdot (DM/DG)^{-0.23} \qquad \text{EQUATION 5.58}$$

The bed material size used in this case was a weighted size involving DG16, DG50 and DG84 sizes. The overall estimate of DG is not substantially different from the DG50 size when the relatively small exponent is considered. If the DG50 size is accepted to be equivalent to the value of DG used by Limerinos, the results are very similar to those obtained for the Gravel-1 screening. Based on the analysis of the Gravel-1 river reaches, the coefficient of determination for the $n/DM^{0.167}$ relation is 0.37 and for the $n/DG50^{0.167}$ relation is 0.09. Each relation has a standard error of 0.12.

5.5.7.2 Relations Involving More than One Independent Variable

When more than one parameter are introduced as independent variables for the estimation of "n", the results are generally better than when only one independent variable is used. For the Gravel-1 screening , the best estimate of "n" may be made by using field measurements of the average slope, and an estimate of the form factor. For the 2 year flood, the best fit relation is:

$$n = 0.208 \cdot S^{0.158} \cdot FF^{-0.213} \qquad \text{EQUATION 5.59}$$

where FF is the form factor. About 40 percent of the variance is explained by this best fit equation.

5.5.8 Comparison of Discharge Relations

The exponential form of the width-discharge, area-discharge, depth-discharge, form factor-discharge, velocity-discharge,and Manning "n"-discharge relations may be compared with the exponential forms given by Lacey (1929, 1933) and Blench (1969a) and with the exponential forms given by Leopold and Maddock (1953).

The basic exponents for the equations of Lacey and Blench are the same, however, the coefficients differ to some extent. It is to be noted that the Lacey-Blench equations should be applicable to duned sand bed channels, with a discharge equal to the formative or dominant discharge.

The exponents given by Leopold and Maddock (1953) were derived from an analysis of sand-bed and gravel rivers for which the characteristic discharge was selected to be the mean annual discharge or essentially the long term mean discharge.

All results are presented in TABLE 5.3. Based on this summary, the Lacey-Blench exponents are close to those derived from this study except for those of slope and Manning "n" when the discharge at the valley flat or the 2 year flood are used as estimates of the dominant discharge.

The reported Leopold and Maddock exponents do not compare

TABLE 5.3

COMPARISON OF THE FUNCTIONAL FORM OF THE DERIVED DISCHARGE EQUATIONS BASED ON THE GRAVEL-1 RIVER REACHES WITH THOSE OF THE LACEY-BLENCH EQUATIONS AND THE LEOPOLD AND MADDOCK EXPRESSIONS

Dependent Variable, Y	Lacey-Blench (Sand)	This Study			Leopold and Maddock All
		VF Gravel-1	2 YF Gravel-1	LTM Gravel-1	
Width	0.500	0.478	0.527[3.]	0.520	0.500
Area	0.833	0.838	0.860	0.799[4.]	0.900
Depth	0.333	0.361	0.333	0.279[4.]	0.400
Form Factor	0.167	0.117	0.194	0.240[4.]	0.100
Velocity	0.167	0.162	0.140	0.201[4.]	0.100
Slope	-0.167	-0.373[3.]	-0.342[3.]	-0.307[4.]	-0.490
Manning "n"	(-0.028)	-0.107[3.]	-0.089[3.]	-0.169[4.]	(-0.078)

NOTE:

1. All equations of the form: $Y = a \cdot Q^b$. Tabulated values are values of exponent, b.
2. Bracketed values for Manning "n" are based on published exponents for VM, DM and S.
3. Lacey-Blench exponent significantly different from the computed value for this study.
4. Leopold and Maddock exponent significantly different from the computed value for this study.
5. Characteristic discharges: VF = Valley Flat; 2YF = 2 year flood; LTM = Long-term mean.
6. Sample size for VF = 41, 2YF = 70, and LTM = 71.
7. Exponents for Lacey-Blench equations based on dominant discharge, and exponents for Leopold and Maddock (1953) expressions based on the mean annual discharge.

favorably with the exponents for the Gravel-1 reaches when the long term mean discharge is used as the characteristic discharge. Based on the data in TABLE 5.3, the Leopold and Maddock exponents are closer to the exponents obtained by using the discharge corresponding to the valley flat or the two year flood than to the exponents obtained by using the long term mean discharge.

5.6 Dimensional Analysis

5.6.1 The Statement of the Problem

Dimensional analysis provides a means of organizing the study of certain natural phenomena when a proper statement of the problem is made. When the relevant parameters are identified numerics or dimensionless variables are obtained and the data are analyzed according to the derived numerics. By using this approach it may be possible to identify different phases and a physical basis may be developed to explain the occurrance of these different phases. A further analysis may be carried out to determine functional relations for the different identified phases.

One statement of the problem adapted from Blench (1969a) for a class of natural channels is as follows:

A characteristic fluid discharge, Q, and wash load, Cw, with a composite kinematic viscosity, ν, and density, ρ, flows in a natural channel of deep alluvium with no lateral constraints and with a bed characterized by a size, DG, and a density, ρs. The shapes and distribution of the bed material are characterized by nondimensional factors represented by X.... Similarly the banks are characterized by DG', ρs', and X'.... The bed material transport supplied at the upper end of the reach is Cb. The motion takes place in the earth's field of body force,where the acceleration due to gravity is g.

When all of the above factors have been imposed the channel will adjust itself to have a unique space-mean width, WSM; depth, DM; and a unique dissipation of energy per unit mass per unit length along the flow, gS. There will also be a definite mean velocity, VM. In addition, bed forms and a characteristic channel plan will result.

The above statement of the problem assumes that the slope is free to adjust, since there are no geologic controls imposed on the channel. The case of an imposed slope is considered in SECTION 5.6.5.

The statement may be written in the following general functional form, omitting any aspects regarding bed forms or channel plan:

$$WSM,\ DM,\ gS,\ VM = \Phi\,(Q,\ Cw,\ \nu,\ \rho,\ DG,\ \rho s,\ X\ldots,\ DG',\ \rho s',\ X'\ldots, Cb,\ g)$$

EQUATION 5.60

The expression merely states that width, depth, energy degradation rate, or mean velocity is a function of the variables on the right.

Various assumptions and simplifications can be made to reduce the number of variables. For example, $\rho s' \approx \rho s$ and $X'\ldots \approx X\ldots$ for the case of sand and gravel banks. If the banks are cohesive, this simplification may not be made. The effect of Cw would primarily be noted in ν and ρ, although it may also change the turbulent structure of the flow at high concentrations. For many gravel rivers it is possible to neglect the effect of the wash load, Cw. Since DG' cannot be rejected, the above functional form must be written for a class of rivers with a similar type of bank material.

One major difficulty encountered in a study of natural channels is the evaluation of the term Cb. Little or no data are available and, consequently, it is necessary to adopt the results from flume experiments when considering the relative importance of the term.

If these assumptions are accepted, then the following simplified functional statement should apply for a given class of rivers:

$$WSM, DM, gS, VM = \phi\ (Q, \nu, \rho, DG, \rho s, X\ldots\ Cb, g)$$

EQUATION 5.6

Details concerning the development of dimensionless ratios, or numerics, are given in Streeter (1966), or Blench (1969a).

5.6.2 Numerics from the Adopted Functional Statement

This section considers some of the numerics which can be obtained from the statement of the problem represented in functional form by EQUATION 5.6. When developing the various numerics, the variables, ρ, ρs, X..., and Cb will not be replaced. There are nine variables in any particular evaluation, and consequently, six numerics will be required to describe the problem. Of these six, three of the numerics will be $\rho s/\rho$, X... and Cb. The other three will be given for the width, depth, area, slope, Froude number, and friction factor relations.

5.6.2.1 Width, Depth and Area Numerics

Three numerics in addition to $\rho s/\rho$, X... and Cb for the width relation may be stated as:

$$WSM\cdot g^{0.20}/Q^{0.40},\ DG\cdot g^{0.20}/Q^{0.40},\ (\nu\cdot g)^{0.333}\cdot DG/\nu$$

$$WSM\cdot g^{0.20}/Q^{0.40}, DG\cdot g^{0.20}/Q^{0.40}, S$$

For the case of gravel rivers, the value of $\rho s/\rho$ will be constant and the effect of ν should be small, since viscosity does not have a great influence on the fall velocity of gravel size particles. Studies from rigid boundary hydraulics also show that kinematic viscosity is unimportant for fully developed turbulent flows over rough boundaries. If a threshold type of analysis is considered, the term Cb goes to zero. The numeric $WSM \cdot g^{0.20}/Q^{0.40}$ was used by Kellerhals (1970) for a study of small mountain streams. The numeric $(\nu \cdot g)^{0.333} \cdot DG/\nu$ was introduced by Blench and Erb (1957) and is commonly called the Vig number.

Similar numerics may be obtained for evaluating the mean depth by replacing WSM by DM and for evaluating the mean area by replacing WSM by $AM^{0.500}$.

5.6.2.2 Numerics Involving Slope

The three numerics $\rho s/\rho$, X... and Cb are retained. By a suitable change of variables, the following numerics may be established:

$S, DM/DG, DG \cdot g^{0.20}/Q^{0.40}$

$S, WSM/DM, DG \cdot g^{0.20}/Q^{0.40}$

Of course other sets of numerics may also be developed.

The first two numerics in the first set above, along with that of charge, Cb, have been used by Cooper (1970) for a comprehensive analysis of world flume data.

5.6.2.3 Numerics Involving the Froude Number

By making certain substitutions in the adopted functional relation, various numerics involving the square of the Froude number may be developed. Three sets of three numerics for this case are:

$VM^2/(g \cdot DM), DM/DG, S$

$VM^2/(g \cdot DM), DM/DG, WSM/DM$

$\rho \cdot VM^2/(\gamma' \cdot DM), DM/DG, WSM/DM$

The first two numerics in the first set of three in this group are those used by Blench (1969b) to illustrate the different phases encountered in the study of river behaviour. Cooper (1970) used the first two in the third set of numerics along with charge for the analysis of flume data. The first numeric of this set is the square of the densiometric Froude number.

The numerics involving the square of the Froude Number in the above groupings are not extensively used in the literature. It is difficult to attach a physical meaning to the Froude Number as it is incorporated in some of the above forms; however, the numerics are valid based on the statement of the problem.

5.6.2.4 Numerics Involving the Friction Factor

The friction factor, f, may be defined for open channels as:

$$f = 8.0 \cdot g \cdot DM \cdot S/VM^2 \qquad \text{EQUATION 5.62}$$

The term $VM^2/g \cdot DM \cdot S$ is inversely proportional to the friction factor.

By a suitable replacement of variables in the adopted general functional relation, some of the possible sets of three resulting numerics are:

$VM^2/(g \cdot DM \cdot S)$, $VM \cdot WSM/\nu$, WSM/DM

$VM^2/(g \cdot DM \cdot S)$, $VM \cdot DM/\nu$, WSM/DM

$VM^2/(g \cdot DM \cdot S)$, $VM \cdot WSM/\nu$, DM/DG

$VM^2/(g \cdot DM \cdot S)$, $VM \cdot DM/\nu$, DM/DG

The first two numerics in the first set in this group are those used by

King (1943) to develop the slope equation for duned sand-bed canals. The square root of the first numeric and the third numeric in the third set were used by Kellerhals (1967) in the development of a set of regime equations for paved gravel channels.

The viscosity terms are introduced only to make comparisons with the results obtained from duned sand-bed canals. The viscosity term should have no physical significance for the fully developed turbulent flow prevailing in gravel rivers.

5.6.3 The Simplest Relations

The above sets of numerics were based on a relatively complete statement of the problem. If it is assumed that discharge and the gravitational effect are the only important imposed variables, or if all other variables are constant, the functional form may be stated as:

$$WSM, DM, gS, VM = \phi\,(Q,g) \qquad \text{EQUATION 5.63}$$

In such a case the width numeric may be stated as follows:

$$WSM \cdot g^{0.20}/Q^{0.40} = \text{constant} \qquad \text{EQUATION 5.64}$$

In a similar manner a depth numeric and an area numeric may be developed.

By making suitable replacements in the above shortened functional relation, the following Froude numeric results:

$$VM^2/(g \cdot DM) = \text{constant} \qquad \text{EQUATION 5.65}$$

and the friction factor numeric is given as:

$$VM\ /(g \cdot DM \cdot S) = \text{constant} \qquad \text{EQUATION 5.66}$$

Other sets of numerics may be developed by introducing more of the relevant variables into the functional form of EQUATION 5.63 until all of the relevant parameters are considered.

5.6.4 Threshold Case

For the threshold analysis the bed material transport approaches zero, so the functional form may be stated as follows:

$$WSM, DM, gS, VM = \phi(Q, \nu, \rho, DG, \rho s, X\ldots, g) \qquad \text{EQUATION 5.67}$$

By a suitable replacement of variables, the following two sets of five numerics may be obtained:

$$\rho \cdot VM^2/(\gamma' \, DG),\ DM/DG,\ (\nu g)^{0.333} \cdot DG/\nu,\ \rho s/\rho, X\ldots.$$

$$\gamma \cdot DM \cdot S/(\gamma' \cdot DG50), (g \cdot DM \cdot S)^{0.500} \cdot DG/\nu, DM/DG,\ \rho s/\rho,\ X\ldots$$

The first two numerics of the first set were those used by Neill (1968) and the first two numerics of the second set were used by Shields (1936) for an analysis of flume experiments related to the initiation of motion.

5.6.5 Slope as an Imposed Variable

The initial statement of the problem could have been made for the case where the slope was imposed; that is, for reaches with shallow alluvium and which are controlled by bedrock or by some other geologic control. In this case the initial statement would be:

$$WSM, DM, VM = \phi(Q, \nu, \rho, DG, \rho s, X\ldots, Cb, gS, g) \qquad \text{EQUATION 5.68}$$

This restatement of the problem results in seven numerics rather than six in the former statement with the slope being free to adjust.

If the first statement of the problem represented by EQUATION 5.60 is used as the basis for an analysis of river behavior, it is essential that river reaches which have their slope controlled by the presence of lag material, bedrock outcrops , etc., be omitted from the analysis. Only those reaches which definitely have their slope controlled by some local geologic control should be analyzed by using EQUATION 5.68 as a basis.

5.6.6 Summary

Several sets of numerics have been proposed for the statement of the problem expressed by EQUATION 5.60. Obviously, other sets of numerics could also have been considered for the same statement of the problem. The main numerics which are used in this analysis are as follows:

NUMERIC	NAME FOR NUMERIC
$WSM \cdot g^{0.20}/Q^{0.40}$	Width Numeric
$DM \cdot g^{0.20}/Q^{0.40}$	Depth Numeric
$AM \cdot g^{0.40}/Q^{0.80}$	Area Numeric
$DG \cdot g^{0.20}/Q^{0.40}$	Bed Material Size Numeric
WSM/DM	Form Factor
DM/DG50	Relative Depth
$VM^2/(g \cdot DM)$	$(\text{Froude No.})^2$
$VM^2/(g \cdot DM \cdot S)$	Friction Factor Numeric
S	Slope
$VM \cdot WSM/\nu$	King Parameter
$VM \cdot DM/\nu$	Reynolds Number
$\rho \cdot VM^2/(\gamma' \cdot DG50)$	Mobility Number
$\gamma DM \cdot S/(\gamma' \cdot DG50)$	Shields Parameter
$(g \cdot DM \cdot S)^{0.500} \cdot DG50/\nu$	Particle Reynolds Number

The names adopted for some numerics are not widely used, but have been employed to facilitate the discussion of the results.

5.7 Testing of Dimensionless Forms

The basic data were used to make plots and to develop equations of an exponential form by utilizing some of the dimensionless parameters presented in the last section.

For the plots, the values of a third numeric were printed by the plotted points for the gravel range. However, in most cases the data did not show any clear phases or groupings. In some cases, the data were close to one another and the third parameter was difficult to separate visually on the plots.

As an alternate approach, it was assumed that the most important numerics for the gravel range could be assumed to be of an exponential form. That is:

$$\text{NUMERIC 1} = a \cdot (\text{NUMERIC 2})^{b} \cdot (\text{NUMERIC 3})^{c} \qquad \text{EQUATION 5.69}$$

This assumption should be tested further, but it provides a framework for the analysis in this section.

All detailed results are presented in Appendix L for the Gravel-1 screening and for discharges corresponding to the 2 year flood or to the elevation of the valley flat. The following sections present some discussion related to the findings for this class of rivers.

5.7.1 Width, Area, and Depth Relations

The simplest dimensionless relation for evaluating width was:

$$WSM \cdot g^{0.20}/Q^{0.40} = \text{constant} \qquad \text{EQUATION 5.64}$$

For the 2 year flood the constant was 14.5. Consequently, the width numeric may be rewritten to give the following equation:

$$WSM = 7.25 \cdot Q^{0.40} \qquad \text{EQUATION 5.70}$$

The comparable best fit width-discharge relation obtained for this investigation of Alberta gravel rivers was:

$$WSM = 2.38 \cdot Q^{0.527} \qquad \text{EQUATION 5.38}$$

In a similar manner comparable expressions were developed for area and depth.

A comparison of the width, depth, and area values estimated by the appropriate numerics and by the best fit relations are presented in TABLE 5.4 for the case of the minimum 2 year flood and the maximum 2 year flood used in the analysis. The greatest deviation at the extreme end of the discharge range covered by the data was 67 percent.

Next a series of computations were carried out by considering two numerics. The first test was to determine if the slope numeric or the bed material size numeric were most closely associated with the width, area and depth numerics. For those cases where the bed material numeric is best, the DG50 size is as good as or better than the DG90 size.

The best fit equation involving the width numeric and bed material size numeric is:

$$WSM \cdot g^{0.20}/Q^{0.40} = (DG50 \cdot g^{0.20}/Q^{-0.241}) \qquad \text{EQUATION 5.71}$$

which transforms to:

$$WSM = 2.00 \cdot Q^{0.496} \cdot DG50^{-0.240} \qquad \text{EQUATION 5.72}$$

The best fit relation obtained by using the standard multiple linear regression without dimensional considerations was:

$$WSM = 2.08 \cdot Q^{0.528} \cdot DG50^{-0.070} \qquad \text{EQUATION 5.73}$$

The coefficient of determination was 0.96 for the best fit relation and was 0.48 for the case where the two numerics were used in the regression for EQUATION 5.72. The exponent for the bed material size resulting from the analysis based on the two numerics is over three times as large as that for the best fit relation in EQUATION 5.73.

TABLE 5.4

COMPARISON OF RESULTS FOR ESTIMATION OF WIDTH, AREA, AND DEPTH USING THE DIMENSIONLESS RATIO AND THE BEST FIT RELATION FOR GRAVEL RIVERS SATISFYING THE GRAVEL-1 SCREENING AND FOR A CHARACTERISTIC DISCHARGE CORRESPONDING TO THE 2 YEAR FLOOD

Parameter	Q [1] cfs.	Value of Parameter From Dimensionless Ratio	Value of Parameter From Best Fit Relation	% Deviation From Best Fit Relation	Discharge For Equivalence; [2] cfs.
Width	200	60	36	+ 67	6,500
Width	300,000	1,120	1,810	- 38	
Area	200	76.5	60.5	+ 26	8,500
Area	300,000	26,400	32,800	- 20	
Depth	200	1.31	1.55	- 16	2,100
Depth	300,000	24.0	17.8	+ 35	

1. The minimum 2 year flood in the analysis was about 200 cfs. and the maximum 2 year flood was 300,000 cfs.
2. The discharge for equivalence is the discharge for which the value of the parameter estimated from the dimensionless ratio (or numeric) is equal to the value of the parameter estimated from the best fit relation.

The correlation between the two numerics is a spurious correlation as pointed out by Benson (1965). EQUATION 5.71 is actually of the form:

$$\frac{Y}{A} = a \cdot \left[\frac{X}{A}\right]^{b}$$ EQUATION 5.74

where: $A = Q^{0.40}/g^{0.20}$

$Y = WSM$

$X = DG50$

The plot of the width numeric versus the bed material numeric is presented in FIGURE 5.30. No clear grouping of the data is apparent when the plotted symbols for the relation of the channel to the valley bottom are considered.

The best estimate of the area numeric is obtained when it is related to slope rather than when it is related to the bed material numeric. The best result is:

$$AM \cdot g^{0.40}/Q^{0.80} = 1.13 \cdot S^{-0.211}$$ EQUATION 5.75

which can be restated as:

$$AM = 0.282 \cdot Q^{0.800} \cdot S^{-0.211}$$ EQUATION 5.76

The comparable best fit line from a regression analysis of the individual parameters is:

$$AM = 0.290 \cdot Q^{0.780} \cdot S^{-0.234}$$ EQUATION 5.34

The coefficient of determination was 0.99 for the best fit relation and was 0.58 for the case where the two numerics were used in the regression for EQUATION 5.75. The form of the rewritten equation based on dimensional considerations is very similar to that obtained by the best fit multiple linear regression of the individual variables.

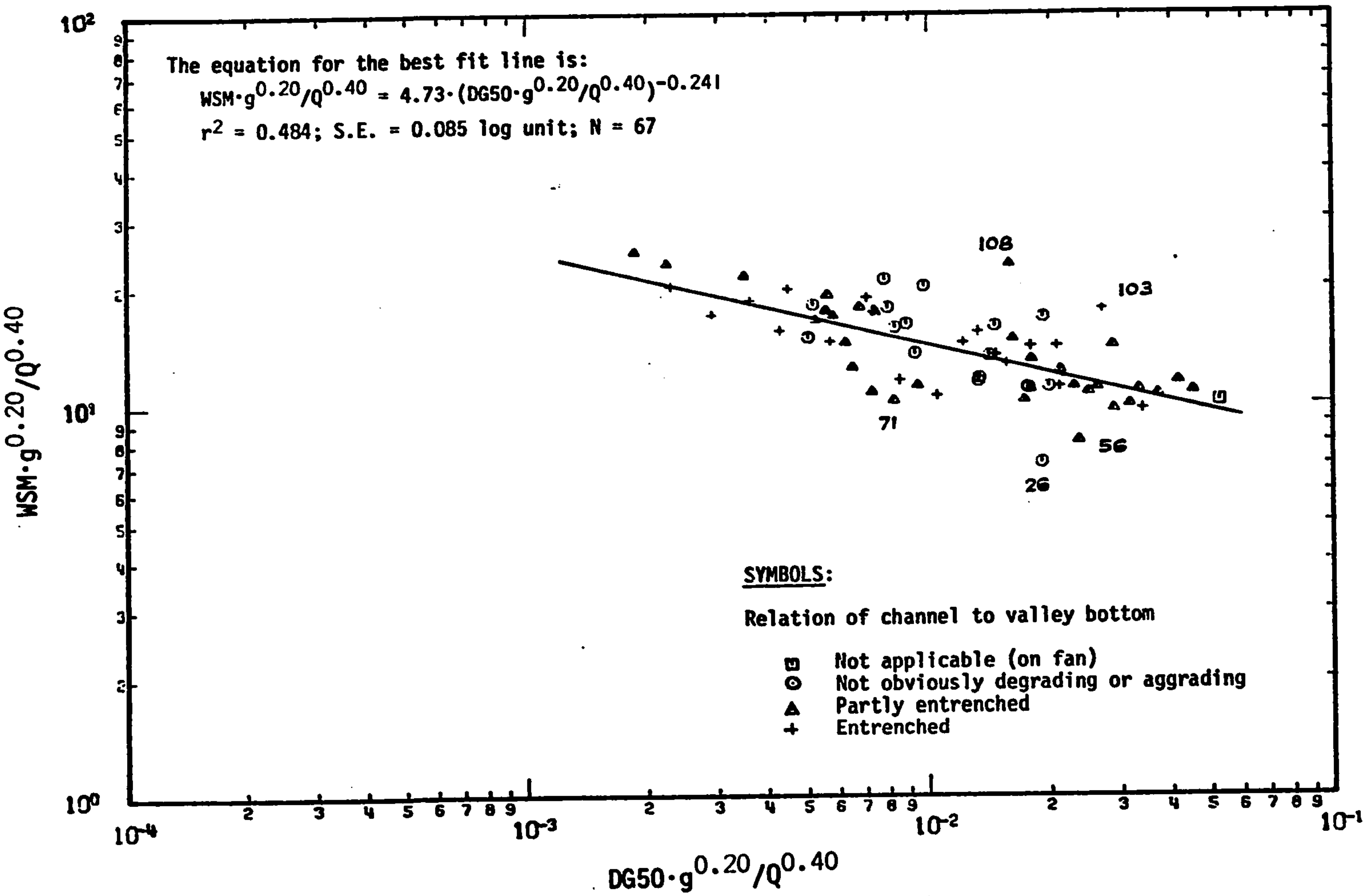


FIGURE 5.30 DIMENSIONLESS PLOT OF $WSM \cdot g^{0.20}/Q^{0.40}$ VERSUS $DG50 \cdot g^{0.20}/Q^{0.40}$ FOR RIVERS SATISFYING THE GRAVEL-1 SCREENING AND FOR DISCHARGES CORRESPONDING TO THE 2 YEAR FLOOD

This result implies that the discharge and slope are the independent variables which best define cross-sectional areas. If the value of the coefficient of determination, r^2, is considered to be a measure of best fit, the area is more highly related to discharge and slope than to discharge and bed material size as shown below:

Area is a function of	r^2
discharge	0.97
discharge and slope	0.99
discharge and bed material size	0.97

These results also show the dominant influence of discharge alone.

A plot of the area numeric versus slope is presented in FIGURE 5.31.

Finally a comparison is made for the mean depth relations. When only two numerics are used, the depth numeric and the bed material numeric give the best results for the discharge corresponding to the 2 year flood. However, even the best relation is poor for only about 10 percent of the variance is explained.

The plot of the depth numeric versus the bed material size numeric is presented in FIGURE 5.32.

If a third numeric is introduced, the regression equations involving the width, area, and depth numerics are improved somewhat.

5.7.2 Dimensionless Slope Equations

Several analyses were made to evaluate slope by considering the bed material numeric, or the form factor, or the relative depth as an independent variable. All coefficients of determination for the above relations were higher for the characteristic discharge corresponding to the valley flat than for the 2 year flood.

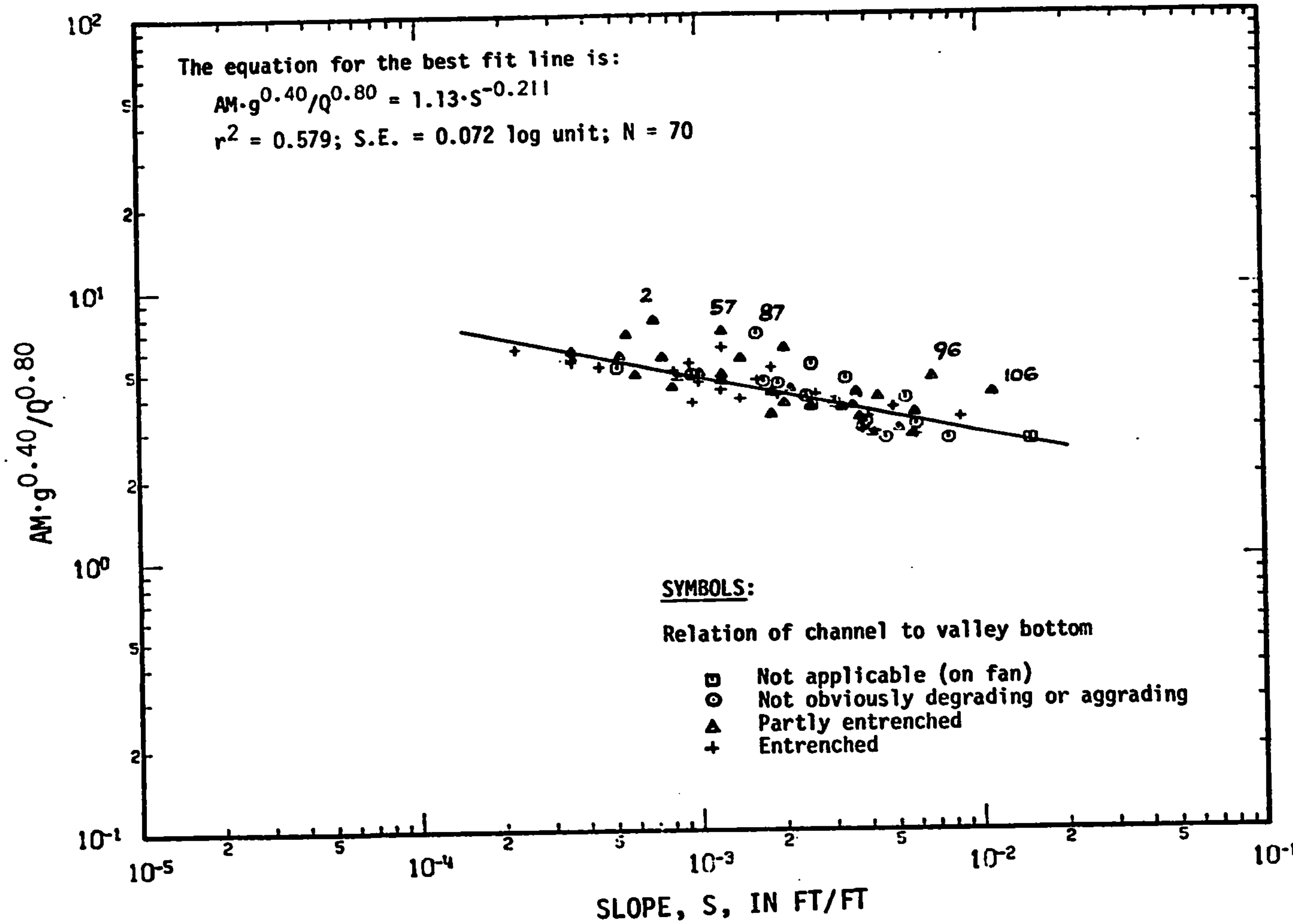


FIGURE 5.31 DIMENSIONLESS PLOT OF $AM \cdot g^{0.40}/Q^{0.80}$ VERSUS SLOPE FOR RIVERS SATISFYING THE GRAVEL-1 SCREENING AND FOR DISCHARGES CORRESPONDING TO THE 2 YEAR FLOOD

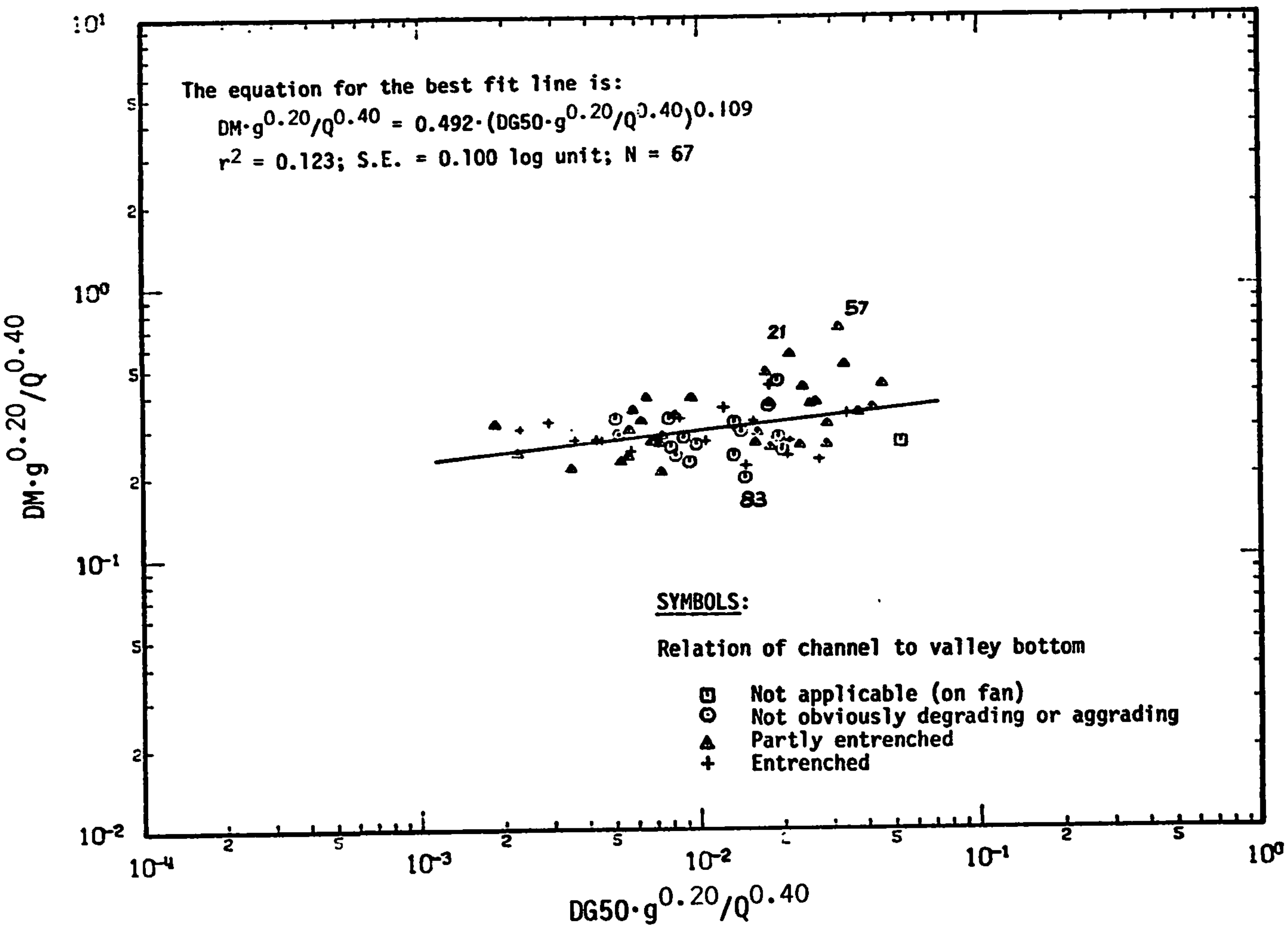


FIGURE 5.32 DIMENSIONLESS PLOT OF $DM \cdot g^{0.20}/Q^{0.40}$ VERSUS $DG50 \cdot g^{0.20}/Q^{0.40}$ FOR RIVERS SATISFYING THE GRAVEL-1 SCREENING AND FOR DISCHARGES CORRESPONDING TO THE 2 YEAR FLOOD

When only one numeric is used to predict the slope, the relative depth gives the most acceptable results. The expression for this relation for a discharge corresponding to the 2 year flood is:

$$S = 0.0449 \cdot (DM/DG50)^{-0.945} \qquad \text{EQUATION 5.77}$$

This relation implies that slope is almost inversely proportional to the relative depth.

If it is accepted that the above relation may be rewritten as:

$$S \propto (DM/DG50)^{-1.00}$$

then

$$DM \cdot S \propto DG50$$

and

$$\gamma \cdot DM \cdot S = c \cdot DG50 \qquad \text{EQUATION 5.78}$$

This result indicates that shear stress is directly proportional to the bed material size. The Shields initiation of motion criterion for fully developed turbulent flow is of the same form.

The plotted points and the best fit line for the slope-relative depth relation are shown in FIGURE 5.33 for the Gravel-1 rivers and for a discharge corresponding to the 2 year flood. The data points for the reaches which are not obviously aggrading or degrading fall above the best fit line in essentially all cases. A similar plot is shown in FIGURE 5.34a which includes Gravel-1 and Sand-1 river data superimposed on the generalized relations obtained by Cooper (1970). In FIGURE 5.34b the slope adjustment parameter, SCOR, has been applied to make the field slopes comparable to the flume slope.

The plots with the Cooper lines on them show that there is an overlap between flume experiments and field data for the case of rela-

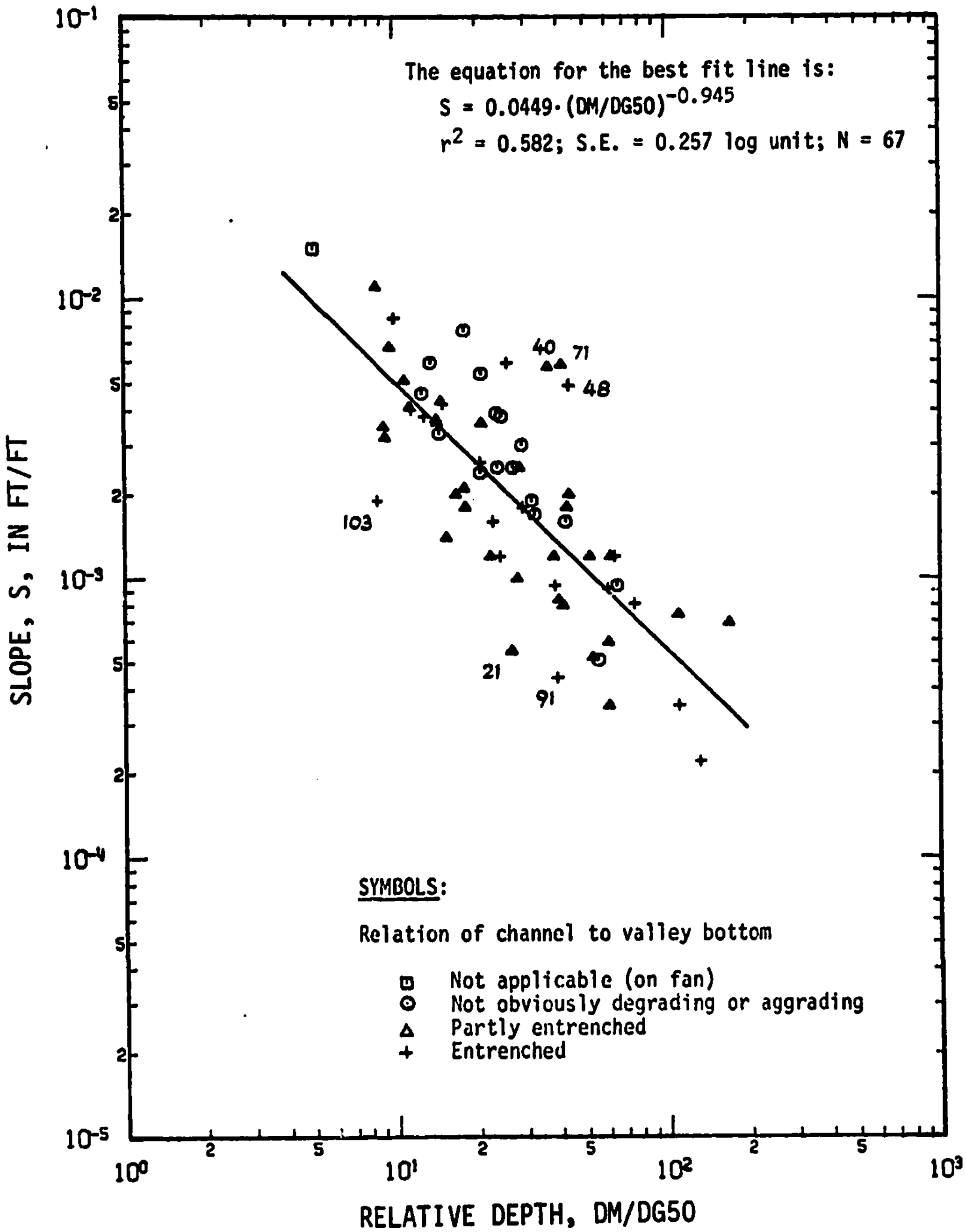
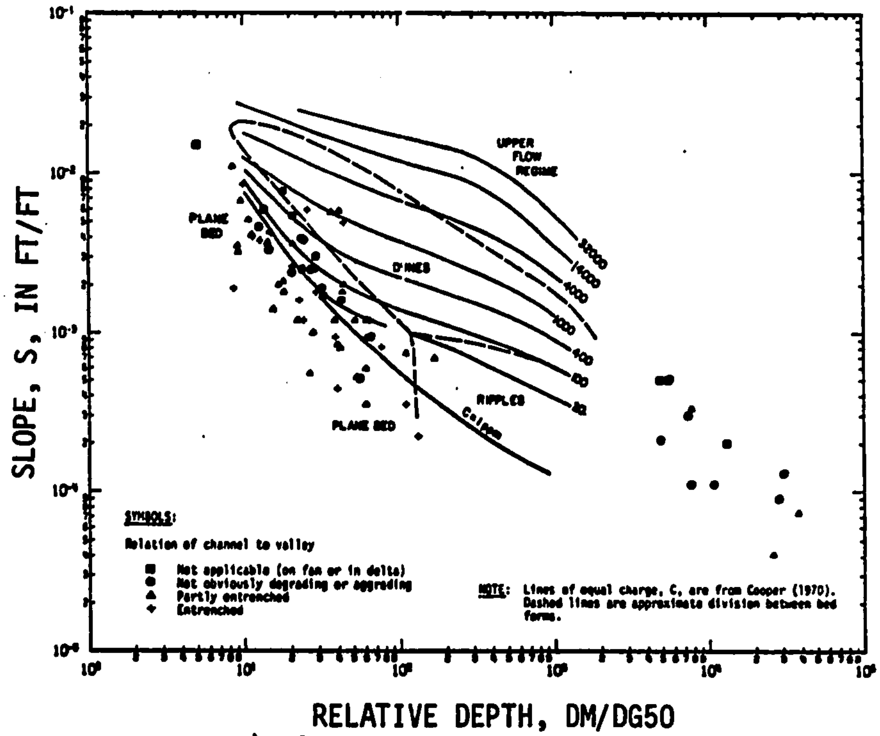
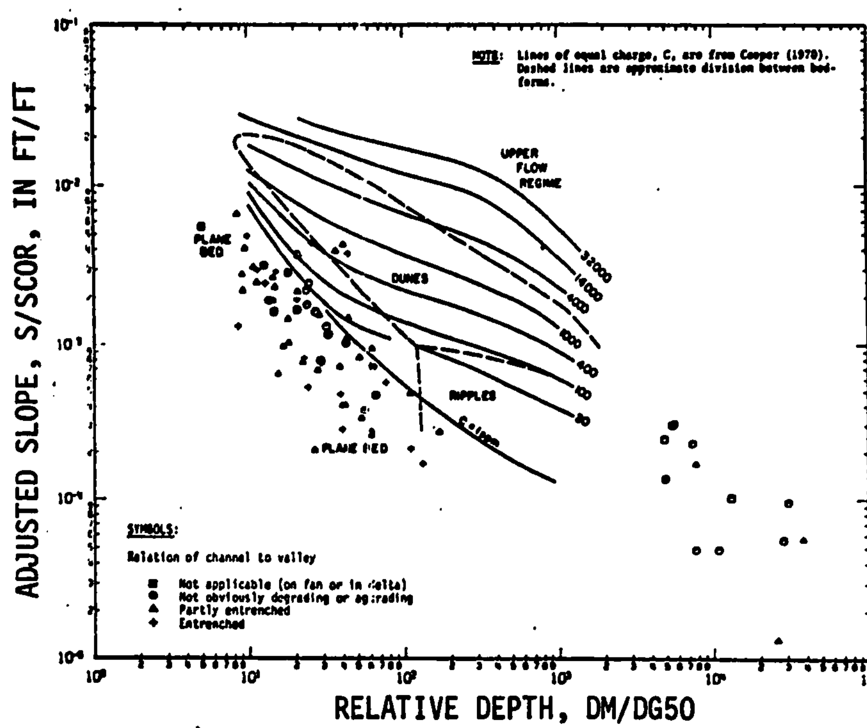


FIGURE 5.33 DIMENSIONLESS PLOT OF SLOPE VERSUS RELATIVE DEPTH FOR RIVERS SATISFYING THE GRAVEL-1 SCREENING AND FOR DISCHARGES CORRESPONDING TO THE 2 YEAR FLOOD



a) Slope versus relative depth



b) Adjusted slope versus relative depth

FIGURE 5.34 RELATIONS BETWEEN SLOPE AND RELATIVE DEPTH WITH COOPER LINES SUPERIMPOSED ON DATA FROM RIVERS SATISFYING THE SAND-1 OR GRAVEL-1 SCREENING AND FOR DISCHARGES CORRESPONDING TO THE 2 YEAR FLOOD tive depths less than 200. In all cases, the sand-bed channels are not within the range of relative depths considered in the flume experiments.

If initiation of motion is arbitrarily taken at a charge of approximately 1 ppm. for the gravel reaches, the location of the plotted points on the Cooper plot of adjusted slope versus relative depth indicates that nine of the 67 reaches have mobile beds. For the highly mobile cases, charges of up to 800 ppm. are indicated. For most of the gravel reaches, the bed form is shown to be a plane bed. The three reach numbers in FIGURE 5.34b with bed forms indicated to be dunes are #40, #71, and #48. These reach numbers are given in the order of increasing relative depth. No field confirmation of the presence of dunes is available for these cases; however, Galay (1967) has reported the formation of large dune-like bed forms on a gravel reach of the North Saskatchewan River, Alberta. The Cooper chart should be modified slightly with regard to the bed form division at relative depths between 100 and 200 for large gravel rivers, since ripples usually do not form if the bed material size is greater than approximately 0.6 mm. [Simons and Richardson (1965)].

In the sand-bed range the line separating the ripples from dunes should probably turn down at a value of the relative depth of approximately 5000. The sand-bed channels which could be readily observed during field visits had dunes on the bed at flows much lower than the 2 year flood. In other cases, evidence from aerial photographs indicate that dunes or sand waves are present at discharges less than the 2 year flood.

If two numerics are considered as independent variables for the estimation of slope, the combination of the bed material numeric with relative depth is better than that for the bed material numeric and the form factor.

5.7.3 Froude Number Equations

The results from this analysis indicate that the Froude number squared is more closely associated with slope than with relative depth. The best fit relation involving the Froude number squared and slope for the 2 year flood is:

$$VM^2/(g \cdot DM) = 2.49 \cdot S^{0.469} \qquad \text{EQUATION 5.79}$$

This expression may be rewritten in a form which is similar to the standard exponential velocity equation as follows:

$$VM = 9.22 \cdot DM^{0.500} \cdot S^{0.234} \qquad \text{EQUATION 5.80}$$

The coefficient and exponents for mean depth and slope are 12.6, 0.608 and 0.288 respectively, for the best fit relation for mean velocity as obtained in SECTION 5.5.5.

The plotted points and the best fit line for the Froude number squared versus slope relation are shown in FIGURE 5.35 for the Gravel-1 reaches and for the 2 year flood.

The relation between Froude number squared and relative depth is poor. Blench (1969a, 1971) has used a relation of this type extensively for the analysis of gravel river data with relative depths less than approximately 200.

A plot of Froude number squared versus the relative depth for the data for Gravel-1 and Sand-1 rivers is presented in FIGURE 5.36. The generalized curves obtained by Cooper (1970) are superimposed to indicate the type of agreement which is obtained between flume data and data from natural channels.

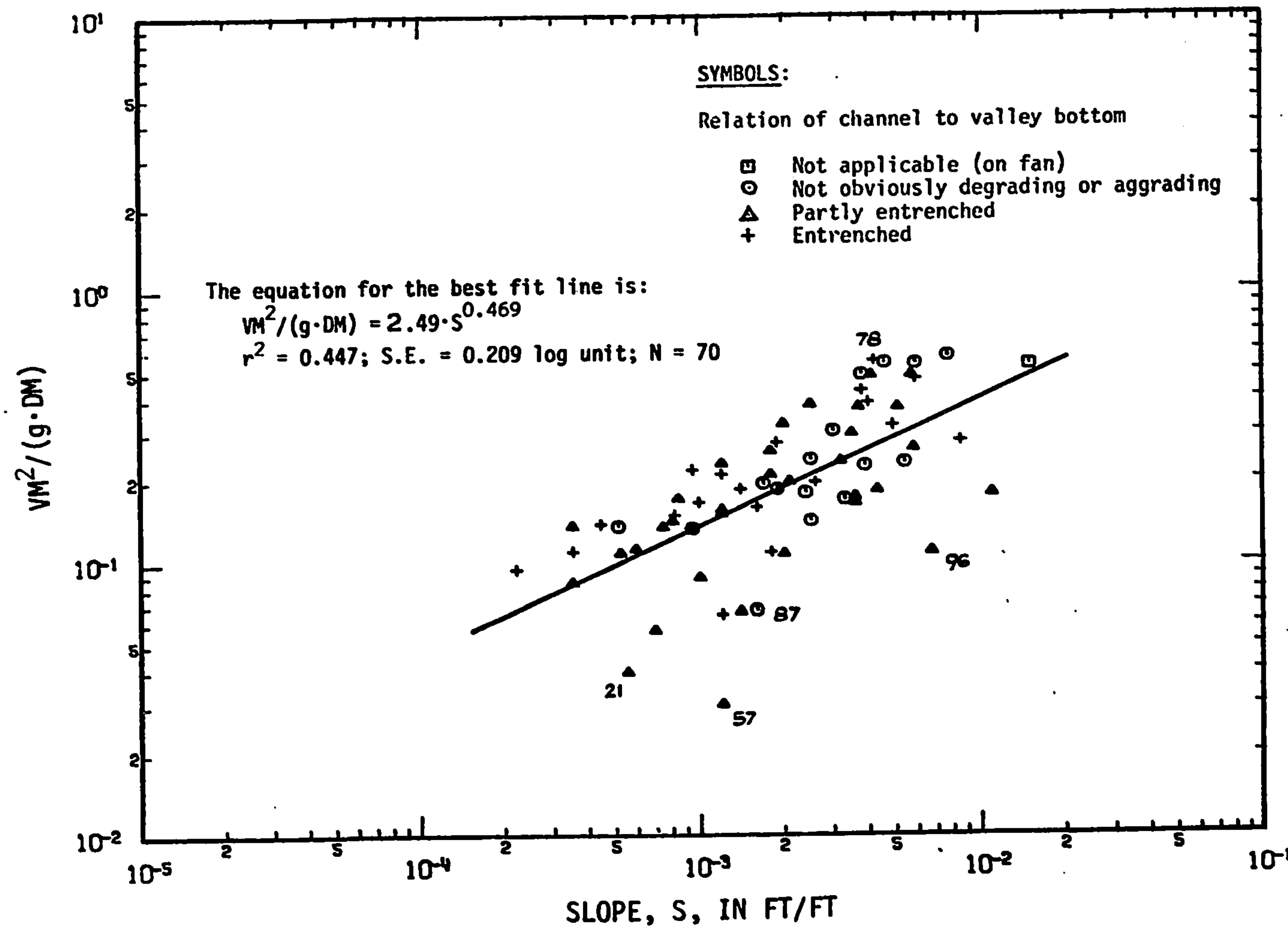


FIGURE 5.35 DIMENSIONLESS PLOT OF $VM^2/(g \cdot DM)$ VERSUS SLOPE FOR RIVERS SATISFYING THE GRAVEL-1 SCREENING AND FOR DISCHARGES CORRESPONDING TO THE 2 YEAR FLOOD

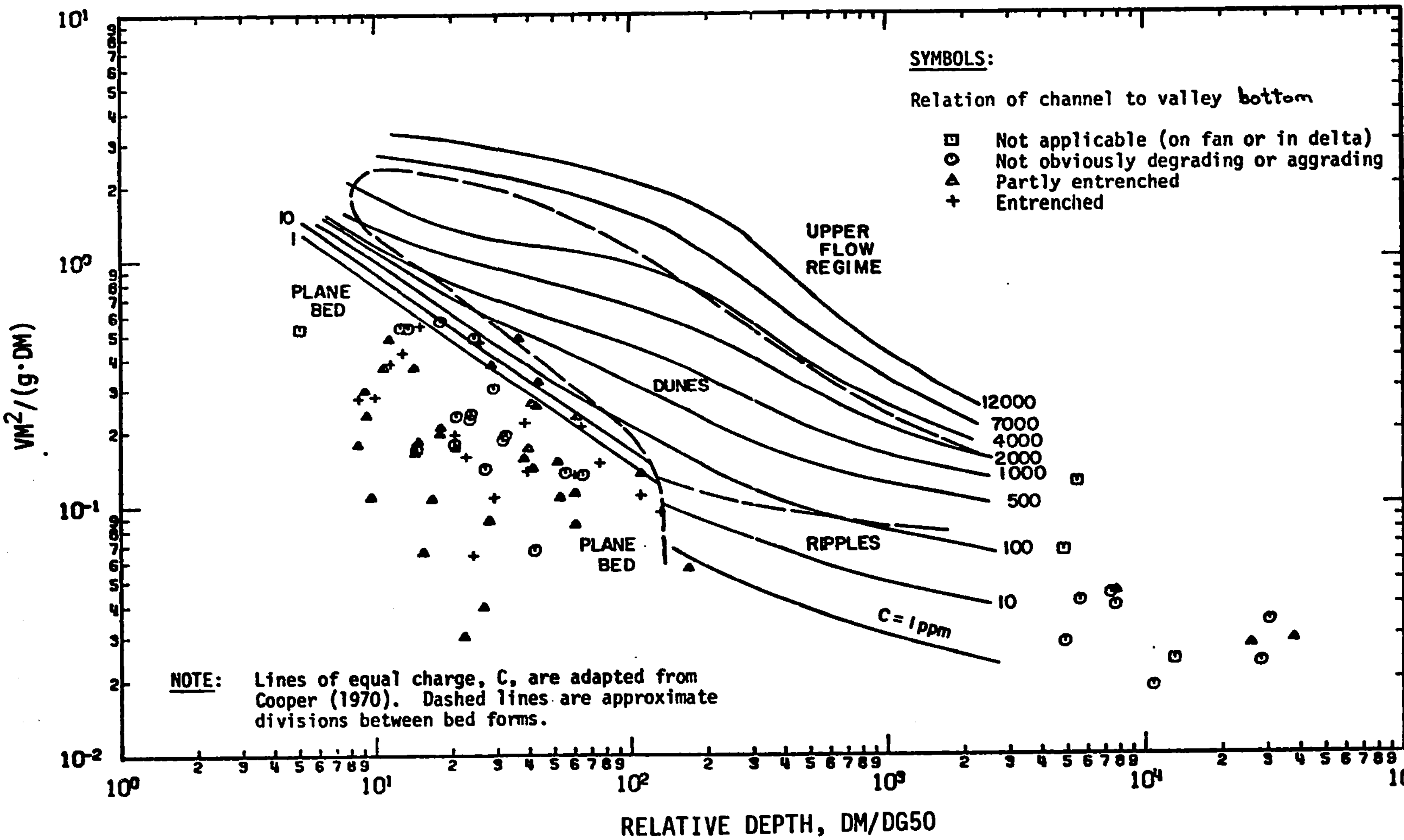


FIGURE 5.36 RELATION BETWEEN $VM^2/(g \cdot DM)$ AND RELATIVE DEPTH WITH COOPER LINES SUPERIMPOSED ON DATA FOR RIVERS SATISFYING THE SAND-1 OR GRAVEL-1 SCREENING AND FOR DISCHARGES CORRESPONDING TO THE 2 YEAR FLOOD

The number of reaches with indicated mobile beds in FIGURE 5.36 is less than the number indicated in the slope versus relative depth plot in FIGURE 5.34a. However, when FIGURE 5.36 is compared with the corrected slope versus relative depth plot in FIGURE 5.34b, the number of reaches with indicated movement in each case is similar. It is noted that the hydrophone data indicate that more reaches would be mobile than indicated in either FIGURE 5.34b or FIGURE 5.36.

If the transport lines of Cooper are accepted for the gravel range, they would imply that the functional form of $VM^2/(g \cdot DM)$ versus DM/DG50 relation would not be greatly altered if the charge is less than about 100 ppm. That is, the initiation of motion or threshold relation should only result in a change in the coefficient within the range of charges from 1 ppm. to 100 ppm. rather than a change in functional form.

The Cooper plot in FIGURE 5.36 shows a change in functional form at a relative depth of about 150. For relative depths above this value, the behaviour of the $VM^2/(g \cdot DM)$-relative depth relation is more like that for sand-bed channels.

5.7.4. Dimensionless Resistance Equations

An analysis was carried out for the case of the friction factor numeric equal to a constant; however, the variability was extreme.

Next several regression analyses were made to estimate the value of the numeric $VM^2/(g \cdot DM \cdot S)$ from one numeric. The best relations are the ones with a Reynolds number in terms of width (King numeric) or in terms of depth. The best fit relations for the Gravel-1 reaches and for the 2 year flood are:

$$VM^2/(g \cdot DM \cdot S) = 0.0398 \cdot (VM \cdot WSM/\nu)^{0.430} \qquad \text{EQUATION 5.81}$$

and:

$$VM^2/(g \cdot DM \cdot S) = 0.0194 \cdot (VM \cdot DM/\nu)^{0.597} \qquad \text{EQUATION 5.82}$$

Only about 50 percent of the variance is explained by each of the above equations.

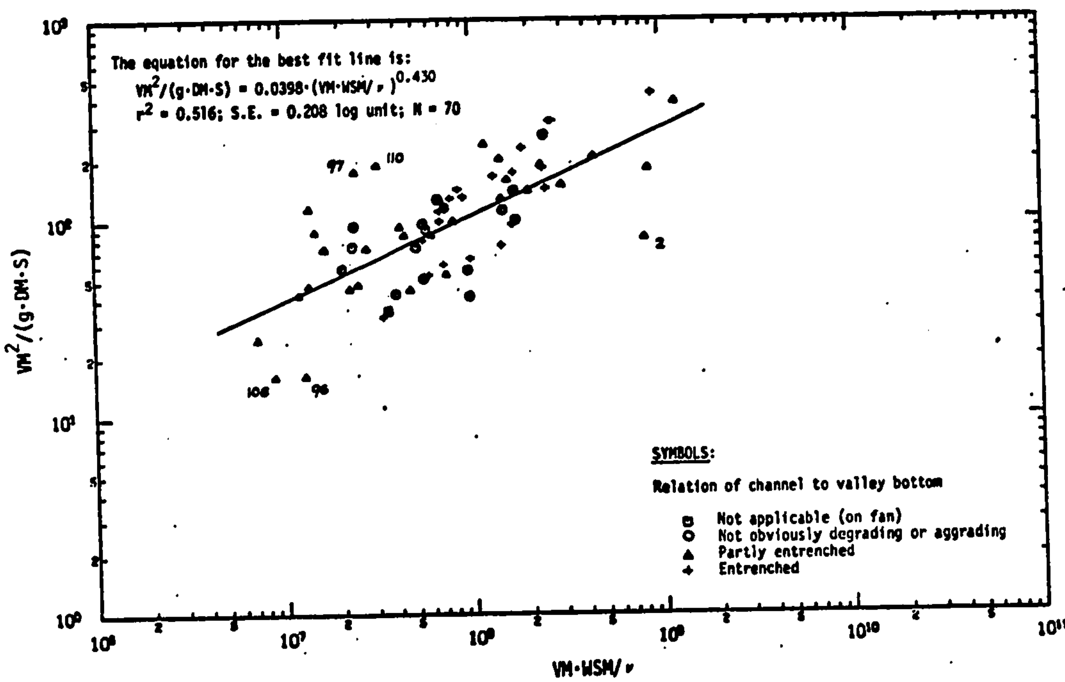
The regime theory for duned sand-bed channels places some significance on the numeric $VM \cdot WSM/\nu$ by applying it in analogy with the Reynolds number term in the Blasius (1911) equation for turbulent flow in smooth pipes. The exponent for the Reynolds number term obtained by Blasius was 0.25. This value does not compare favourably with the exponent for either the numeric $VM \cdot WSM/\nu$ or $VM \cdot DM/\nu$. From this result, it is concluded that for gravel rivers, the form of the friction factor equation is quite different from the form obtained for smooth pipes.

Plots of $VM^2/(g \cdot DM \cdot S)$ versus the King numeric $VM \cdot WSM/\nu$, and of $VM^2/(g \cdot DM \cdot S)$ versus the numeric $VM \cdot DM/\nu$ are presented in FIGURE 5.37 for the Gravel-1 reaches and for the 2 year flood.

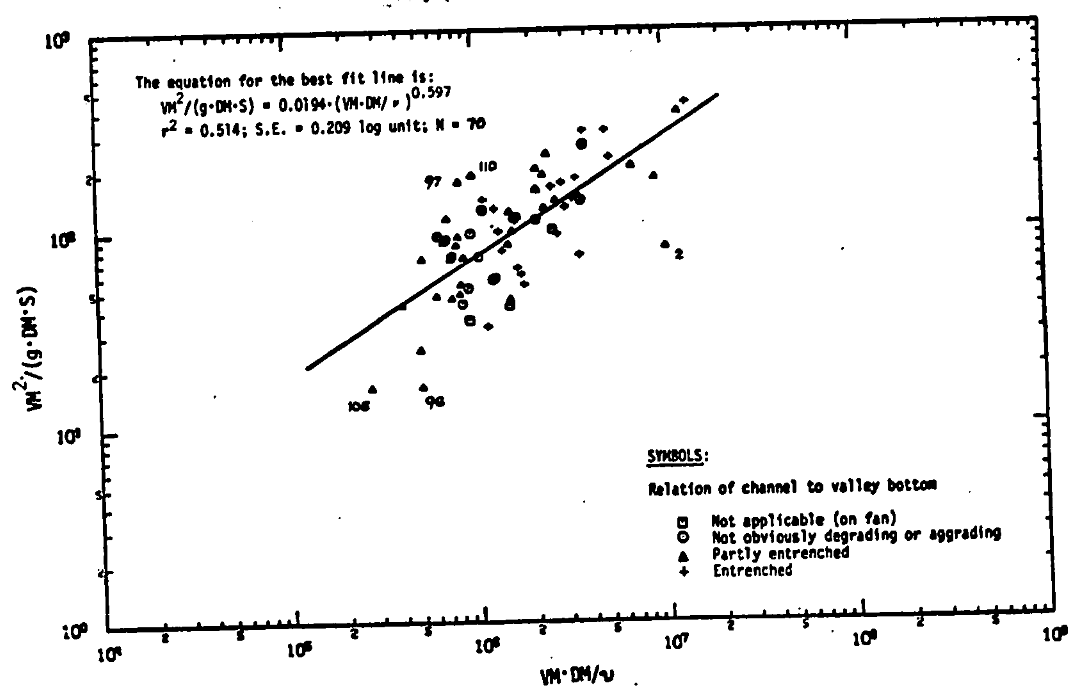
The results involving the friction factor numeric, $VM^2/(g \cdot DM \cdot S)$, and relative depth, DM/DG50, are not as good as those involving the friction factor numeric and a Reynolds number defined in terms of width or depth. The best fit relation for the friction factor versus relative depth for the 2 year flood is:

$$VM^2/(g \cdot DM \cdot S) = 14.8 \cdot (DM/DG50)^{0.562} \qquad \text{EQUATION 5.83}$$

About 40 percent of the variance is explained by this equation. This expression is similar to the one proposed by Kellerhals. (See SECTION 5.4.4).



a) Abscissa is King Numeric, VM·WSM/ν



b) Abscissa is the Numeris, VM·DM/ν

FIGURE 5.37 DIMENSIONLESS PLOTS OF $VM^2/(g \cdot DM \cdot S)$ VERSUS THE KING NUMERIC AND $VM^2/(g \cdot DM \cdot S)$ VERSUS THE NUMERIC $VM \cdot DM/\nu$ FOR RIVERS SATISFYING THE GRAVEL-1 SCREENING AND FOR DISCHARGES CORRESPONDING TO THE 2 YEAR FLOOD

5.8 Development of Regime Equations in Terms of Discharge and Bed Material Size

5.8.1. Introduction

The basic premise in this section is that channels adjust to a certain width, depth, and slope in response to the imposed discharge and bed material size. For each case presented, three independent equations involving the above variables are solved to give width, depth, and slope relations. The velocity is related to discharge through the continuity equation.

The slope-discharge relation presented in SECTION 5.5.6.1 was not well defined. This and other considerations such as the form of the area relation in SECTION 5.5.2 and SECTION 5.7.1 indicate that the slope is most probably imposed for several of the reaches. However, since there is no simple means of establishing the degree to which the slope is imposed, this analysis is carried out with the assumption that width, depth, and slope are free to adjust.

All comparisons are made with the best fit relations involving width, depth, velocity, and slope obtained in this analysis. The coefficients and exponents for all regime equations are presented in TABLE 5.5, but the basic equations and some discussion related to each set of equations are given in the following subsections.

The 2 year flood was accepted as the characteristic discharge for the following computations. Only gravel river reaches satisfying the Gravel-1 screening are used in the analysis. The median bed material size is used in all cases.

TABLE 5.5

REGIME TYPE EQUATIONS FOR WIDTH, DEPTH, MEAN VELOCITY AND SLOPE FOR GRAVEL RIVERS BASED ON VARIOUS SETS OF THREE INDEPENDENT EQUATIONS FOR A CHARACTERISTIC DISCHARGE CORRESPONDING TO THE 2 YEAR FLOOD

Best Fit

	a	b	c
WSM	2.38	0.527	
WSM	2.08	0.528	-0.070
DM	0.256	0.331	-0.025
VM	1.87	0.140	0.095
S	0.0965	-0.334	0.586

A Threshold Approach (No reference to this study)

	a	b	c
WSM	2.67	0.500	
DM	0.0585	0.428	-0.285
VM	6.40	0.0715	0.285
S	0.968	-0.428	1.285

Lacey Type Equations

	a	b	c
WSM	2.38	0.527	
DM	0.159	0.377	-0.082
VM	2.66	0.096	0.082
S	0.218	-0.463	0.459

Blench Type:All Banks Temperature: 45°F

	a	b	c
WSM	11.4	0.402	0.291
DM	0.0458	0.463	-0.387
VM	1.89	0.134	0.097
S	0.137 (0.430)	-0.425	0.414

Blench Type;Silt Banks Temperature: 45°F

	a	b	c
WSM	14.5	0.402	0.291
DM	0.0380	0.463	-0.387
VM	1.79	0.134	0.097
S	0.139 (0.430)	-0.425	0.414

Blench Type;Gravel Cobble Banks Temperature: 45°F

	a	b	c
WSM	9.68	0.402	0.291
DM	0.0518	0.463	-0.387
VM	1.96	0.134	0.097
S	0.138 (0.430)	-0.425	0.414

Modified Blench;Gravel Cobble Banks Temperature: 45°F

	a	b	c
WSM	2.39	0.519	-0.058
DM	0.155	0.372	-0.116
VM	2.69	0.109	0.174
S	0.139 (0.430)	-0.424	0.414

Kellerhals Type

	a	b	c
WSM	2.38	0.527	
DM	0.178	0.372	-0.080
VM	2.36	0.101	0.080
S	0.180	-0.368	0.849

Dimensionless No viscosity term

	a	b	c
WSM	2.00	0.496	-0.241
DM	0.185	0.394	0.015
VM	2.71	0.110	0.226
S	0.220	-0.372	0.931

NOTE:

1. All equations are for Gravel-1 reaches (unless a class of Gravel-1 reaches as noted) and for discharges corresponding to the 2 year flood.
2. All expressions are of the form:

$$Y = a \cdot Q^b \cdot DG50^c$$

If a viscosity term was in the regime equation for WSM, DM, VM, or S; it was evaluated for a temperature of 45°F (ν = 0.0000154 ft.^{2}/s.). The bracketed term under the value of the coefficient a, in some cases is the exponent of the kinematic viscosity term if it is present. By using this information it is possible to compute the coefficient, a, for temperatures other than 45°F.

Kinematic viscosity has been introduced into this analysis of gravel river reaches in a couple of instances in order to make comparisons with an extension of existing regime equations for sand-bed channels.

As a means of evaluating the relative importance of any basic equation used in the development of the regime equations, the coefficients of determination and the standard errors for all basic equations are presented in APPENDIX L.

5.8.2 The Best Fit Relations

The summary of the values of the coefficient, a, the exponent for the discharge, b, and the exponent for the median bed material size, c, for the best fit width, depth, and slope equations and also the mean velocity equation are given in TABLE 5.5. The width equation expressed in terms of discharge and median bed material size is accepted in this case as the best fit equation; however, the equation for width in terms of discharge alone is as good.

5.8.3 Regime Equations Derived Without Consideration of the Data from this Study

As a first approach, a set of regime equations for gravel are developed without reference to any of the results obtained for this study. The equations used are the Lacey width equation, the Manning - Strickler resistance equation and the Neill initiation of motion equation. These equations are expressed as follows:

$$WSM = 2.67 \cdot Q^{0.500} \qquad \text{EQUATION 5.3}$$

$$VM = 43.4 \cdot DM^{0.667} \cdot S^{0.500} \cdot DG50^{-0.167} \qquad \text{EQUATION 5.84}$$

$$VM = 10.3 \cdot DM^{0.167} \cdot DG50^{0.333} \qquad \text{EQUATION 5.85}$$

For the Manning-Strickler equation, the value of the Manning "n" was assumed to be expressed as:

$$n = 0.0342 \cdot DG50^{0.167} \qquad \text{EQUATION 5.53}$$

For the Neill equation the specific gravity of the bed material was assumed to be 2.65. Since the threshold equation is utilized in this set of equations, the results would be more applicable to the design of gravel canals rather than for the general class of natural gravel channels, although the results should be applicable to gravel rivers with vanishingly small charge.

5.8.4 Lacey Type Regime Equation

The regime type equations used in this subsection are those equations of the form presented by Lacey (1929, 1933), but with the coefficients and exponents obtained from the analysis of the Gravel-1 reaches. The basic equations are:

$$WSM = 2.38 \cdot Q^{0.527} \qquad \text{EQUATION 5.38}$$

$$VM = 12.6 \cdot DM^{0.608} \cdot S^{0.288} \qquad \text{EQUATION 5.45}$$

$$VM = 4.25 \cdot DM^{0.255} \cdot DG50^{0.103} \qquad \text{EQUATION 5.86}$$

The coefficients and exponents for these first two equations are quite similar to those given by Lacey. Those for the third equation are not very close to the Lacey values.

5.8.5 Blench Type Regime Equations

The Blench type analysis was then carried out using the following equations:

$VM^2/DM = 21.6 \cdot (DM/DG50)^{-0.418}$ EQUATION 5.10

$VM^3/WSM = Fs$ EQUATION 5.87

$VM^2/(g \cdot DM \cdot S) = 0.0398 \cdot (VM \cdot WSM/\nu)$ EQUATION 5.81

The first of these equations is the Blench bed factor as derived from the data for Alberta gravel rivers. This equation was obtained by rejecting all reaches with mobile beds as predicted by the Cooper-Neill criterion. Consequently, the value of VM^2/DM could be considered to be the zero bed factor for most practical cases.

The second equation is the Blench side factor. Three sets of regime equations are presented for different classes of gravel river banks; that is, for all cases (70), for cases with banks of gravel overlain by silt or cobbles overlain by silt (19), and for cases with banks of gravel or cobbles (44). The median value of the side factor as determined for these classes are 0.594, 0.399, and 0.778 respectively. The different side factors only affect the value of the derived coefficients and not the functional form.

The third equation is the form of the King equation as developed for gravel rivers. The values of the coefficients and exponents are derived for a value of the kinematic viscosity equal to 0.0000154 $ft.^2/sec.$ (corresponding to a temperature of 45°F). The value of the exponent of ν is indicated in TABLE 5.5 in order that the coefficients at other temperatures may be computed. It is to be noted that the range of values of the kinematic viscosity term is small. The term $VM \cdot WSM/\nu$ does not seem to be a reasonable numeric to use in an analysis involving fully developed turbulent flow over a rough boundary.

5.8.6 Modified Blench Type Equations

The next set of regime equations for gravel rivers with gravel or cobble banks were based on the main Blench equations, but posed in a slightly different manner. These three equations are presented as follows:

$$VM = 4.65 \cdot DM^{0.291} \cdot DG50^{0.209} \qquad \text{EQUATION 5.86}$$

$$WSM/DM = 15.0 \cdot VM^{0.500} \cdot DM^{0.250} \qquad \text{EQUATION 5.15}$$

$$VM^2/(g \cdot DM \cdot S) = 0.0398 \cdot (VM \cdot WSM/\nu)^{0.430} \qquad \text{EQUATION 5.81}$$

The first equation is a restatement of the bed factor equation with all highly mobile reaches rejected by the Cooper-Neill criterion. In the stated form it may be considered to be an initiation of motion expression.

The second equation is a form factor equation developed for the class of gravel rivers with gravel or cobble banks. This relation was obtained by assuming that the side factor, VM^3/WSM and the bed factor VM^2/DM must be related in some simple manner, since the bank and bed material are not greatly dissimilar. This approach has been suggested previously by Blench, but has not been incorporated into a form factor expression such as that used to derive this set of regime equations. As noted before, the relation between side factor and bed factor involves a spurious correlation.

The third equation is the resistance equation of the King type for duned sand-bed channels. No slope correction is used in this relation for gravel rivers. It has been assumed that the first and third equations are applicable for the class of gravel rivers considered, although they were derived from data for all of the Gravel-1 reaches.

5.8.7 Kellerhals Type Equations

The next set of equations are those of the form presented by Kellerhals for gravel rivers. The three equations are as follows:

$$WSM = 2.38 \cdot Q^{0.527} \qquad \text{EQUATION 5.38}$$

$$\gamma \cdot DM \cdot S = 2.02 \cdot DG50^{0.769} \qquad \text{EQUATION 5.36}$$

$$VM/(g \cdot DM \cdot S)^{0.500} = 3.84 \cdot (DM/DG50)^{0.281} \qquad \text{EQUATION 5.31}$$

The first equation is the standard width adjustment equation. The second equation is a shear stress relation involving the median bed material size. If the exponent of DG50 was 1.00, this expression is essentially a threshold type equation for fully developed turbulent flow. The coefficient and exponent for this equation were evaluated after all mobile reaches were rejected from the analysis by using the Cooper-Neill initiation of motion criterion. The third equation is a resistance equation of the exponential form. This equation conforms to the accepted view of a resistance equation for fully developed turbulent flow over a rough boundary because $VM/(g \cdot DM \cdot S)^{0.500}$ is a function of relative depth rather than a Reynolds Number.

5.8.8 Dimensionless Expressions

The following three dimensionless expressions were selected to obtain the last set of regime equations:

$$WSM \cdot g^{0.20}/Q^{0.40} = 4.73 \cdot (DG50 \cdot g^{0.20}/Q^{0.40})^{-0.241} \qquad \text{EQUATION 5.71}$$

$$S = 0.0449 \cdot (DM/DG50)^{-0.945} \qquad \text{EQUATION 5.77}$$

$$VM^2/(g \cdot DM) = 2.49 \cdot S^{0.469} \qquad \text{EQUATION 5.79}$$

The first equation is a width adjustment equation in terms of discharge and bed material size. The second is of the form of an initiation of motion equation for fully developed turbulent flow. The third expression is the relation between the square of the Froude number and slope. The form of this equation is not standard and is difficult to interpret from a fundamental point of view. However, when this third relation is rewritten, it is of the form of the Lacey velocity equation.

No expression involving viscosity is included in this set of three dimensionless relations, since it does not seem reasonable that viscosity can be a physically realistic parameter for the case of fully developed turbulent flow over a rough boundary.

5.8.9 Comparison of the Sets of Regime Equations

When evaluating the eight sets of regime equations developed in this section, it is assumed that the result of the most acceptable set of equations should compare favourably with the "best fit" equations for width, depth, velocity and slope as given in TABLE 5.5. The main reason for not accepting the best fit equations based on discharge and/or bed material size without further consideration is that only intuitive physical arguments are used in their development. For the other sets of regime equations a threshold equation, resistance equation, etc., are utilized or equations developed from the dimensional analysis of the relevant variables are utilized.

Some features of the best fit relations are that the exponent for the bed material size is small for the width equation, and the exponent for the discharge is about 10 times as large as that for the bed material size. In addition, the exponent for discharge is essentially unaltered by omitting bed material size from the relation. The best fit equations for mean depth and mean velocity are defined by discharge alone. For the slope equation, the exponent for the bed material size is dominant, with a magnitude of about 1.75 times that for the discharge. These details have been given to draw attention to the relation magnitudes of the exponents for the "best fit" regime equations in order to facilitate comparisons with the eight sets of regime equations which have been developed.

The set of equations for the threshold approach has relatively high exponents for the bed material size, especially with respect to the slope equation. The signs of all exponents are the same as those for the best fit relations. It is to be noted that for this case the regime equations were developed independently of the basic data used in this study.

The Lacey type coefficients and exponents are reasonably close to those for the best fit values. The signs of the exponents are also the same as those for the best fit equations.

The regime equations obtained by the Blench type analysis results in a relatively high exponent for the bed material size for the width and depth. The sign of this exponent for width is not the same as that obtained by the best fit relation. The range of the median side factor from 0.399 to 0.778 results in a change in the width coefficient of about 50 percent, the depth coefficient of about 30 percent, the mean velocity coefficient of about 10 percent, and the slope coefficient of about 1 percent. A change in the side factor does not result in a change of the exponents.

The exponents in the modified Blench equations for the width and depth are quite close to those for the best fit relations, although the modified Blench equations should only apply to the class of channels with gravel or cobble banks. When the exponents of the modified Blench equations for width and depth are compared with the Blench equations for the same class of rivers, it is noted that the exponents for the bed material size are much smaller for the modified Blench equations. The exponents for the mean velocity and slope relations are more comparable.

The exponents for the Kellerhals type equations for mean depth and mean velocity compare quite favourably with those for the best fit relations. The exponent for the bed material size in the slope equation is almost double that for the best fit equation for slope, but is comparable to that obtained for the threshold analysis. This result is not unexpected since a threshold type relation was used in the basic Kellerhals equations.

The regime equations developed from the dimensionless expressions have high exponents for the bed material size in comparison to the exponents for the bed material size in the best fit relations. This is partly attributed to the high exponent introduced from the basic relation between the width numeric and the bed material size numeric. The high exponent for the bed material size for the slope equation is primarily due to the basic relation between slope and relative depth which is similar to the Shields relation for the initiation of motion.

To provide a means of comparison, the mean widths, mean depths, mean velocities, and mean slopes for the best fit equations and for the eight sets of regime equations were computed for a median grain size of 50 mm.(0.164 ft.) and for discharges of 1,000 cfs., 10,000 cfs., and 100,000 cfs. A summary of the results is presented in TABLE 5.6 for the five sets of regime equations which are applicable to all types of channel banks. The results in this table indicate that the forms of the Lacey, Kellerhals, and Dimensionless Equations generally yield the most acceptable results for the range of discharges and bed material sizes used in the computations.

TABLE 5.6

RELATIONS WHICH GIVE MAXIMUM OVER AND UNDER ESTIMATES OF MEAN WIDTH, MEAN DEPTH, MEAN VELOCITY, AND SLOPE WHEN COMPARED TO THE BEST FIT RESULTS FOR GRAVEL-1 REACHES AND FOR THE 2 YEAR FLOOD.

Relation:	Maximum over estimate DG50 = 0.164 ft (50 mm)			Maximum under estimate DG50 = 0.164 ft (50 mm)		
	Q = 1,000 cfs	Q = 10,000 cfs	Q = 100,000 cfs	Q = 1,000 cfs	Q = 10,000 cfs	Q = 100,000 cfs
Threshold	VM, S (1.51) (1.47)	VM, S (1.29) (1.18)	VM (1.10)	WSM, DM (0.93) (0.71)	WSM, DM (0.88) (0.87)	
Lacey						S (0.65)
Blench (all Banks; 45°F)	WSM (1.19)		DM (1.52)			WSM (0.67)
Kellerhals				S (0.85)	S (0.76)	
Dimensionless	DM, (1.03)	DM, (1.14)		VM (0.93)	VM (0.86)	VM (0.80)

NOTES:
1. If WSM, DM, VM, or S not entered then not applicable.
2. Bracketed values are the values of the parameter WSM, DM, VM, or S obtained by a set of regime equations divided by the corresponding best fit value.
3. See Appendix L for detailed tabulations.

CHAPTER 6

CONCLUSIONS AND RECOMMENDATIONS

6.1 Conclusions

The basic conclusion resulting from this investigation is that the inductive approach to the study of river regime provides a means of determining the relative importance of variables and yields practical formulae or graphs to fit and coordinate the important aspects of river regime.

The Subsidiary conclusions based on the study of Alberta gravel rivers are:

1. The 2 year flood results in the statistically most consistent width-discharge, and area-discharge relations and is of such a magnitude that it is capable of moving the bed material in most cases. The 2 year flood is accepted as the hydrologically defined dominant discharge.
2. The discharge corresponding to the elevation of the valley flat results in statistically more consistent width-discharge, and area-discharge relations than the discharge corresponding to the elevation of the low level bench. The discharge corresponding to the valley flat is adopted as the dominant discharge defined by a geomorphic feature.
3. When evaluating the threshold condition for gravel rivers, the reaches which are not obviously aggrading or degrading tend to have relatively high mobility numbers. Those reaches which are entrenched tend to have a wide range of mobility numbers. This may indicate that some of the entrenched channels are paved and others are armoured.

4. Based on limited hydrophone data, the Shields (1936) criterion and the Neill (1968) criterion for the initiation of motion generally indicate no movement when there is observed movement over a part of the channel width. The predictions based on the Galay (1971) criterion for the initiation of motion compares quite favourably with the field measurements; however, the criterion has no sound physical basis.
5. The width-discharge, and area-discharge relations for a particular characteristic discharge are well defined; whereas, the slope-discharge relation is poorly defined. This result tends to confirm statements by Rubey (1952) and Chorley (1962) concerning the concept of grade.
6. When the bed material size is used as an independent variable for gravel rivers, the median bed material size (DG50) is as good a parameter as the DG90 size.
7. The best fit relation for width uses only discharge as the independent variable, whereas the best fit relations for area, depth, and mean velocity are improved if slope and discharge are used as the independent variables.
8. Stratification according to geomorphic criteria improves the slope-discharge relation; for example, the exponent for reaches which are not obviously aggrading or degrading is significantly different from the exponent for entrenched reaches.
9. The Lacey-Blench exponents for width-discharge, area-discharge, depth-discharge, and velocity-discharge relations fit the

the data for natural channels better than the exponents presented by Leopold and Maddock (1953). The exponent for the slope-discharge relation given by the Lacey-Blench form for duned sand-bed channels is significantly different from the exponent obtained for the gravel river reaches.

10. The product $DM \cdot S^{0.500}$ tends to be a constant for a given bed material size which is contrary to the Shields requirement that $DM \cdot S$ be a constant at threshold conditions.
11. The Manning "n" is more highly associated with the form factor than with bed material size.
12. The Lacey equation for mean velocity ($VM = 16.0 \cdot DM^{0.667} \cdot S^{0.333}$), which contains no roughness parameter, is as good as the Manning equation, if the discharge is relatively high.
13. The estimation of width from the single non-dimensional parameter, $WSM \cdot g^{0.20}/Q^{0.40}$, is quite close to the estimate of width obtained by a regression of width on discharge. Similar results were obtained for estimates of area and depth.
14. The relation between the square of the Froude number and the relative depth is poor compared to the relation between slope and the relative depth.
15. The slope correction parameter, SCOR, does not improve the overall relations involving slope; however, the use of the parameter does tend to make river data compatible with flume data on the generalized Cooper (1970) plots.

16. When various sets of relations are used to establish regime equations for width, depth, mean velocity, and slope in terms of discharge and bed material size, the results obtained by using the Lacey type equations, the Kellerhals type equations, or a set of three dimensionless equations (see SECTION 5.9.8) compare favourably with the results obtained by the best fit equations.

6.2 Recommendations

During the course of this investigation several problems or questions were encountered which should be considered in greater detail. The following topics recommend where further work is required.

1. Five to ten cross-sections were surveyed for each reach. More work should be carried out to determine the optimum number and location of the cross-sections. A comparison could also be made between the mean hydraulic properties of the reach and those computed for the one cross-section at the hydrometric station.
2. Cross-sections should be extended well above the high water line. The field surveys should also include a geomorphic description of the study reach.
3. The entire study was based on the premise that the water surface profile for any discharge was parallel to the water surface on the day of the survey. This assumption needs to be substantiated.

4. Based on the available data, non-dimensional rating curves should be constructed for different classes of rivers.

5. Several methods of sampling paved gravel surfaces have been evaluated. It is recommended that the grid-by-number procedure be used since this method of sampling and analyzing a surface of a population of bed material is shown to be equivalent to the bulk sieve analysis of the same population.

6. The surface of some gravel beds consist of a pavement with only the fines removed, while in other cases the surface is armoured and consists of material which is obviously coarser than the material under the top layer. Consideration should be given to the deviation of a grid-by-number analysis from a bulk sieve analysis of material coarser than 8 mm. as a measure of the degree of armouring.

7. If field measurements of the threshold condition are made, it is recommended that the distribution of the bed material in movement be compared with the distribution of the bed material forming the pavement in order to clearly determine if the movement is associated with a general threshold condition.

8. For practical design purposes, it is recommended that the best fit relations be used to estimate width, depth, and mean velocity. If there is no definite evidence that the slope is controlled by a geological feature, the best-fit slope equation may be used.

9. A detailed study should be carried out to determine the effect of geological structures on channel slope.

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APPENDIX A

SOME PRACTICAL ASPECTS OF RIVER SURVEYS

The aim of this appendix is to provide a basis for obtaining quantitative and qualitative data for a river reach. This outline does not attempt to be exhaustive, but does provide some practical points that should be kept in mind when carrying out a field survey.

It is assumed that the main purpose of the survey is to obtain information related to the hydraulic geometry of the reach. Planimetric control is of lesser importance than vertical control. This appendix will be presented in two main sections: preparation for the field survey, and the field work (quantitative and qualitative). A procedure similar to the one outlined in this section was used to obtain the data for most of the river reaches in the investigation.

A.1 Preparation for the Field Survey

Before going to the field, it is essential to obtain good topographic maps and aerial photographs of the reach under study and to make an evaluation of the hydrological regime of the river.

Topographic maps at a scale of 1:50,000 are available for a large part of Canada. When working with topographic maps it is important to note the date of the photography from which the maps were made. Key maps are available to quickly determine the required topographic maps.

Aerial photographs at a scale of about 1.0 in. = 2640 ft. are available for a large part of the country. When ordering aerial photographs sufficient stereo-pairs should be ordered to not only cover the study reach, but also some distance upstream and downstream from the reach. This will provide an opportunity to determine if the selected study reach is somewhat typical of the river on a larger scale. The stereo-pairs provide much more information than a single photograph, since it is possible to quickly evaluate relative steepness of banks, relative heights of terraces, etc. Key maps are available showing flight paths of the aircraft and the photograph numbers taken along the flight line. The approximate location of the cross-sections should be established on the air photo before going to the field. If possible, the sections should be established with reference to relatively fixed points, such as fence lines, or large isolated trees. A minor adjustment of the cross-section location may be necessary in the field.

An evaluation of the hydrology of the river at a study reach should be made before going to the field. The Water Survey of Canada publish key maps which give the location of all active and retired gauging stations in a region.

For those cases where a hydrometric station is not located near the study reach, it will be necessary to obtain a few discharge measurements to establish a rating curve for the reach. A dimensionless rating curve similar to that suggested by Leopold, Wolman and Miller (1964) or by Galay (1971) may be of assistance when attempting to establish a rating curve for an ungauged river. A regional analysis will have to be made to provide an estimate of the hydrologic regime.

If a hydrometric station is in the reach, it is essential to obtain the following information concerning the station from the District Office of the Water Survey of Canada:

1. The station history.
2. The station location with bench mark locations and elevation of gauge zero.
3. The current and past rating curves.

The "Surface Water Papers" related to the station must be consulted in order to obtain the long-term mean discharge, to construct the flood frequency curve and to establish the flow duration data for the station.

Any information concerning the location of additional bench marks should be obtained for the area near the study reach. Such data may be obtained from the Geodetic Survey of Canada, or the appropriate branch of the Provincial Government.

A final, but not unimportant point is that the field equipment should be checked and tested before leaving for the survey.

A.2 The Field Work

A.2.1 The Reach

The reach should be selected so that the hydrometric station is located near the middle of the reach. If the character of the channel is significantly different near the gauge, it may be necessary to place the gauging section near the upper or lower part of the reach. One difficulty often encountered is that the Water Survey of Canada gauging stations are situated at an atypical location (such as a bed rock outcrop) in order to provide a good "control".

The length of the reach should include at least one meander wave length or at least two pools and two riffles. The selected reach should begin and end at geomorphically similar locations. For example, if the survey begins at a cross-over, it should end at the head of a cross-over. A simple rule which seems to be quite adequate for most cases is that the length of the reach should be at least 20 river widths.

About 10 cross-sections in the reach quite adequately describes the hydraulic geometry. If the channel is very uniform, as few as five cross-sections may be satisfactory. Some thought must be given to the precise location of the cross-sections. It is suggested that about one-quarter of the cross-sections be located at cross-overs (or riffles), about one-quarter at pools (in sections of maximum depth), and about one-half at locations intermediate between cross-overs and pools.

A.2.2 Quantitative Data

The two main elements in the quantitative survey are the longitudinal profile and the cross-section data. Of these two aspects, the work related to the longitudinal profile must be of the highest degree of precision.

A.2.2.1 <u>Longitudinal Profile</u>

The longitudinal water surface profile should be carried out when the stage of the river is stable. It is important to consider the variability of the stage during the survey, especially on rivers with relatively low slopes. Several measurements of stage should be obtained at the gauging site during the course of the survey in order to make any necessary adjustments.

Distances along the longitudinal water surface profile may be obtained by stadia, if care is taken when selecting instrument set-up locations. If it is necessary to continually shoot across the channel due to dense vegetation, etc., the stadia distances are questionable. The survey notes should include sketches to show the approximate location of each instrument set-up. Distances obtained from the aerial photographs will usually be within five or ten percent of the correct distance for all but the smallest channels (less than 50 feet wide). If considered necessary, the distance along the profile and between cross-sections may be taped.

On large rivers two bench marks, located well above the high water stage, should be established at each cross-section. For smaller rivers, it is adequate to establish bench marks at the upper and lower ends of the reach, in addition to the bench mark at the gauge.

A procedure which might be used on a moderate sized river using a crew of three is as follows:

1. Observe the stage and time at the gauge.

2. Locate the cross-sections, bench marks (or reference elevations) and obtain all cross-section data while proceeding upstream. One shot must be taken on the bench mark, (or reference elevation) at each cross-section.

3. On the way down the river, the longitudinal profile data is obtained. The elevation of the water surface is recorded at frequent intervals. In shallow streams, the bed profile may be obtained at the same time the water surface profile is surveyed. All bench marks (or reference elevations) previously established are tied into the line of levels used to obtain the water surface profile. If the channel is deep, one bed profile may be obtained by a sonic sounder.

4. At the gauge the stage and time are again recorded.

5. The profile is continued downstream with the bench marks (or reference elevations) being set at the selected cross-sections.

6. After the profile is completed, the cross-section data is obtained in the upstream direction to the gauge.

7. Finally the stage and time are recorded at the gauge.

The advantage of this procedure is that the profile can be obtained by a small field crew with a minimum of interruption. This means that the stage will be relatively constant during the survey and it will probably be unnecessary to make adjustments due to a varying stage. Obviously, other procedures may be adopted for large rivers, or for special studies.

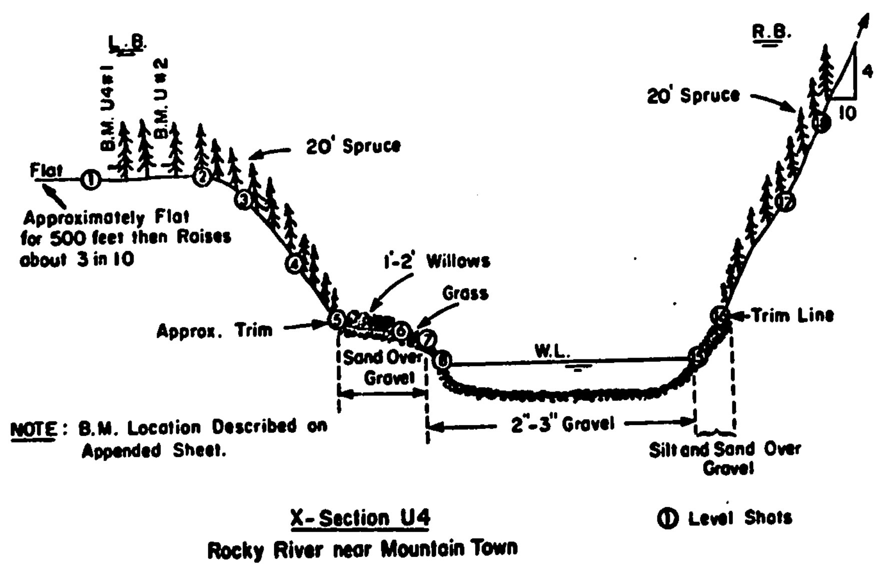
The longitudinal profile should be plotted in the field to ensure that no major errors have been made. It is also good practice to check the accuracy of the level before each survey. The simple two-peg test only takes about 15 minutes to execute, but it is worth the effort to know that the results of the survey are acceptable.

A.2.2.2 Cross-sections

Each cross-section must be tied into the bench marks (or reference elevations) established when surveying the longitudinal profile. The cross-section data must be taken in sufficient detail to provide a good representation of relatively small topographic features. Enough shots should be taken to clearly identify a low level bench, a trim line (the interface between limited or no vegetation and a vigorous growth of hearty shrubs and trees), and a valley flat. If a valley flat is encountered, one or two shots must be taken on the flat as well as at the break of slope. Hand level shots may be used for establishing the cross-section profile for any portion involving steep banks above the water surface unless a bench mark is being set. The field notes should clearly indicate the location of the shots by means of sketches and descriptive notes. A brief note describing the terrain beyond the last survey point in the cross-section is important. Is the terrain flat? Is it roughly sloping at "x" feet per foot? If the valley has a valley flat on one side and a valley wall on the other side of the channel, shots should be taken up the valley to a point which is above the valley flat. FIGURE A.1 illustrates the features which should be given in the sketch in the field notes.

The cross-section profile below the water surface may be obtained by wading in a shallow stream, or by hand sounding from a boat, or preferably by sonic sounding from a boat for water depths greater than two to three feet. FIGURE A.2 shows a typical sounding chart for a cross-section on a relatively large river.

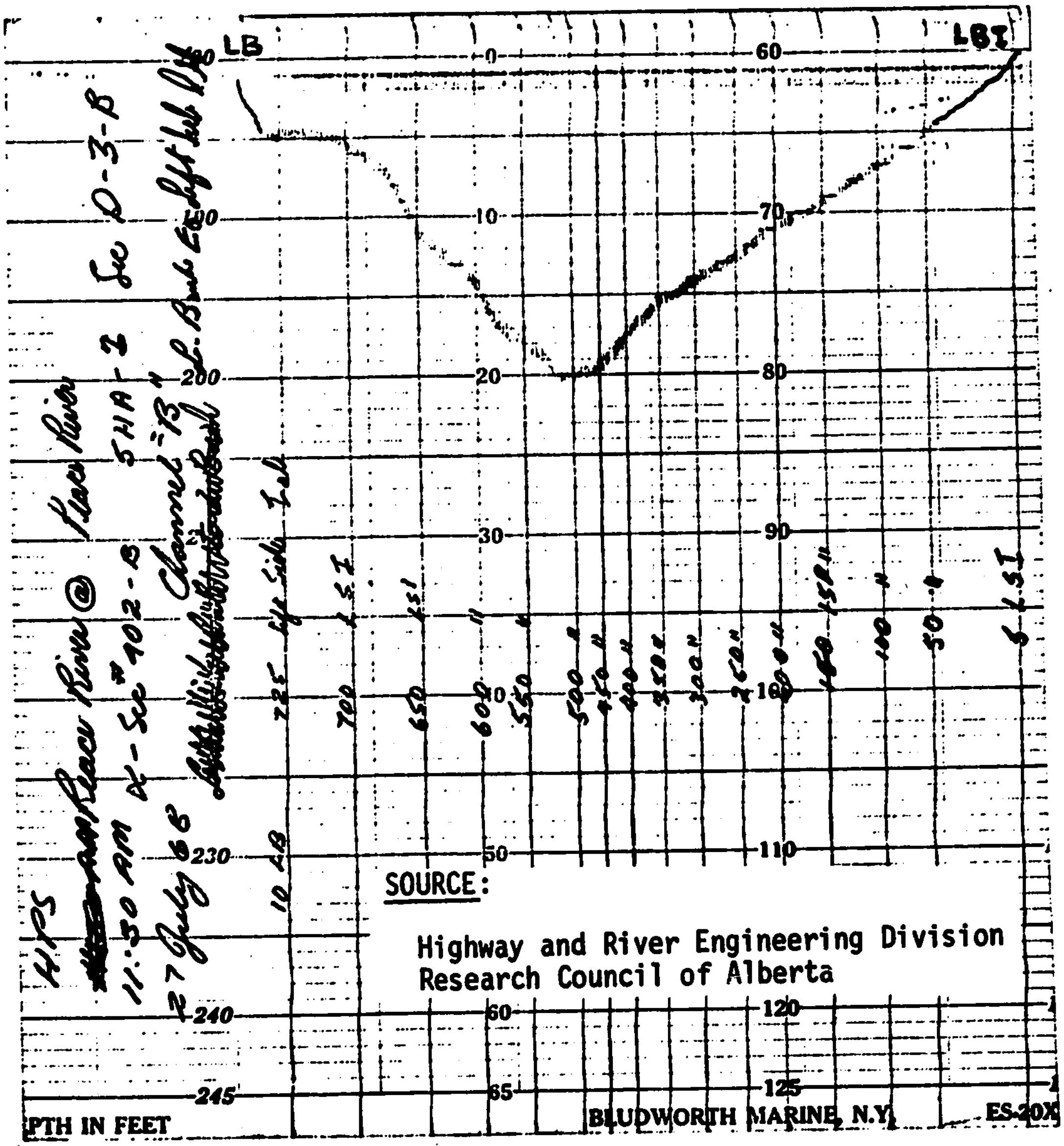
Distances along the cross-section may be measured by tape, stadia or a range finder depending upon the nature of the survey. Shields



NOTE:
1. Character of Terrain before First Shot (e.g. Flat, etc.) is Described
2. First Shot is Beyond Break in Slope
3. Bench Marks Set above High Water (if Used)
4. Low Level Bench Shown (if Present)
5. Trim Line Shot Taken
6. Character of Terrain after Last Shot (e.g. Rising at Approx. 4 Ft. in 10 Ft.)
7. Vegetation Shown
8. Bed and Bank Material Roughly Described (if Known)

CONVENTION: X-Section is Drawn as Observed when Looking Down Stream. Zero Distance on Left Bank.

FIGURE A.1 ILLUSTRATION OF CROSS-SECTION FIELD NOTES



SOURCE:

Highway and River Engineering Division
Research Council of Alberta

FIGURE A.2 TYPICAL SOUNDING OF A CROSS-SECTION ON A LARGE RIVER

(1971) and Welch (1971) pointed out that precise measurements for large rivers are expensive and time consuming, since a good horizontal and vertical control is necessary. In most cases a high degree of precision is not necessary unless small changes in section properties with time are of interest. FIGURE A.3 shows how a sounding may be tied into the total cross-section profile.

A.2.3 Qualitative Data

Qualitative data should also be recorded for each cross-section in the river reach. The character of the surface of the earth along the cross-section should be noted. For example, it should show where there is gravel, silt, rock outcrops, grass, shrubs, mature trees, etc. This is best done by making a sketch of the cross-section and showing the character of the surface in relation to the shots taken on the cross-section. Any evidence of high water marks should also be noted.

At each cross-section, one or more photographs should be taken to indicate the type of bank material and the general setting. It is best to have some rough scale in the picture such as a survey rod. It is also advisable to include a sign in the photograph to correctly identify the picture, or failing this, a detailed record of all photographs should be kept. It is important to say if the picture is taken from midstream, left bank, etc. A few photographs of the general character of the channel should be taken from the top of the river bank or a high point of land. It should be remembered that the pictures, which are relatively inexpensive, may yield valuable

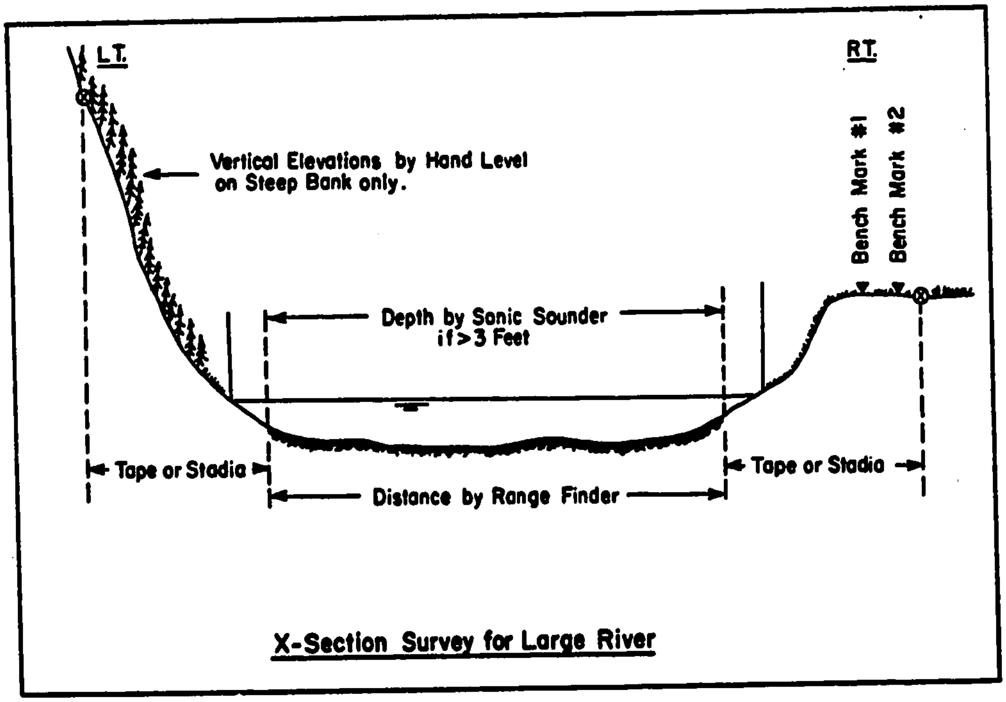


FIGURE A.3 ONE METHOD OF OBTAINING CROSS-SECTION DATA FOR LARGE RIVERS information at a later date.

The general character of the bed and bank material should be described, using a check list which can be quickly filled in during the field visit. A few minutes observing the setting, the plant growth, signs of high water marks, etc., may provide a useful supplement to the quantitative data.

In addition to the above noted data, some quantitative samples of the bed material should be obtained. If the banks of the channel consist of fine grained material, samples of bank material may also be obtained. The bed material can usually be adequately described by obtaining three or four "representative" samples in the reach. A sample should be taken near the center of the channel for the case of sand bed channels. For gravel channels, it is only possible to readily obtain samples under water if the stream can be waded. For large gravel channels, it is best to obtain samples from exposed bars during periods of low flow. The sampling sites should be in geomorphically similar locations, such as at point bars.

A grid-by-number sample of 50, or preferably 100, will yield an "equivalent" sieve sample of the surface material for studies related to resistance to flow. A photograph of a 10 x 10 grid (grid spacing of 50 mm.) on the gravel surface will also provide some information, especially if the material is less than 128 mm. The photograph will not only provide a means of obtaining a size distribution, but will also record the shape and appearance of the material. At least two grid photographs should be taken at each sample site.

When taking grid photographs of gravel surfaces, it is important to identify each picture in the field, preferably by using a title on the grid used. If some information is required concerning transport in a gravel river it will be necessary to obtain a customary bulk sieve sample of the subsurface material. The details concerning bed material sampling are given in APPENDIX D.

A qualitative description of each bed material site should be made. This is best accomplished by using data sheets which may be quickly completed during the field visit. A photograph of the general location of the site should also be taken.

A.3 Summary

This appendix has presented some of the points which should be considered when carrying out a field survey of a river reach. First, it outlines work which should be completed before going to the field, and secondly presents some of the quantitative and qualitative aspects of the field survey. This outline cannot be considered to be a complete coverage of surveying techniques related to river engineering problems, but it does attempt to provide some guidance to the person with limited field experience. The principles outlined in this appendix have generally been followed when obtaining the data for this investigation.

APPENDIX B

COMPUTER PROGRAM FOR QUANTITATIVE ANALYSIS OF A RIVER SURVEY

B.1 General

No computer program can provide "the results" from the analysis of a river reach, since qualitative evaluations must be made in addition to the quantitative analysis. However, a program which quickly summarizes and quantifies some of the standard parameters is a useful tool for the river engineer.

The program described in this appendix takes the basic field survey data and computes the cross-sectional area and water surface width for each given flow condition at each cross-section. The mean depth is then computed from these two basic parameters. Wetted perimeter and hydraulic radius are also computed and compared with water surface width and mean depth. In addition, the maximum depth is determined at each cross-section for each flow condition.

A summary is presented in which the average cross-sectional area and water surface width are computed for the reach for each flow condition. The coefficient of variation is also tabulated for these two basic parameters to indicate their variability within the reach. A mean depth and mean velocity are computed for the reach as well as the average form factor (average width divided by average depth) for each flow condition. Using the average properties for the reach, the shear velocity, the average shear stress, the Manning "n", the Blench bed and side factor, and the Lacey width coefficient are computed for each flow condition.

B.2 Main Assumptions

Several assumptions have been made in order to make the analysis of the river reach practical. The main assumptions which were used in the development of the program are as follows:

1. The longitudinal profile at any stage is assumed to be parallel to the profile on the date of survey. This is the most important assumption, but is necessary unless a much more refined analysis is considered. The assumption should not be too much in error unless there is a major break in slope in the reach, or the variability of the cross-section properties in the reach is extreme.

2. The average slope for the reach is assumed to be adequate for the computation of such parameters as shear velocity, average shear stress, etc. The average slope is defined by drawing a straight line through the longitudinal profile of the surveyed water surface such that the area between the profile and the line is balanced.

3. The water surface at each cross-section is assumed to be horizontal. This assumption may result in some error for the case of gravel rivers with multiple channels at low flow conditions. Super-elevated flows may be accommodated without too much error by using an average water surface elevation.

4. The rating curve adopted for the reach is assumed to be valid for all discharges up to the valley flat (or some high stage). In most cases the adopted rating curve must be extrapolated beyond the last observed data point.

5. A log-log interpolation is assumed to be valid for all flows within the range of the five data points supplied to the computer from the adopted rating curve for the reach. A second order log-log interpolation is made for the range of the first three data points, and a linear log-log interpolation is made for the range of the last two data points.

B.3 Advantages of the Program

Once the main assumptions are accepted, the cross-sectional properties and the average properties for the reach (consisting of up to 15 cross-sections) may be computed for any discharge within the range of data points on the rating curve supplied to the computer, provided the stage is lower than the valley flat. The properties may be computed for up to 14 different discharges in any given reach. A discharge may be coded as one of 19 characteristic discharges, such as long term mean, 2-year flood, etc. On the other hand, the flow condition does not have to be specified.

It is possible to compute cross-sectional properties with artificial confining walls imposed on the section. This option may be useful in the following cases:

1. If an average stage for the valley flat is determined for a reach and found to be a few tenths of a foot too high for one cross-section, a wall may be inserted at any location in the horizontal to confine the flow and generate more reasonable cross-section properties (see FIGURE B.1). The main advantage is that this may be accomplished without manipulating any of the original field data. An option is also provided which allows the walls to confine the flow for all discharges less than or equal to the stage corresponding to the low level bench.

2. The average flow properties may be evaluated for small imposed "artificial constrictions" in the reach. The same assumption concerning parallel water surface profiles must be considered to be valid.

3. If the first and/or last surveyed data points are lower than the computed water level, a wall is automatically inserted at the first and/or last data point.

B.4 Basic Data Required

An outline of the basic data required for the analysis is as follows:

1. The stage at the time of the survey, the average slope of the reach.

2. The limiting stage above which there is a valley flat; or there are no data points on the read-in rating curve; or there are inadequate survey data.

3. The rating curve for a station in the reach. It will usually consist of four actually observed discharges and stages and one estimated discharge and stage from an extrapolation.

4. The discharges and the type of flow for all cases for which

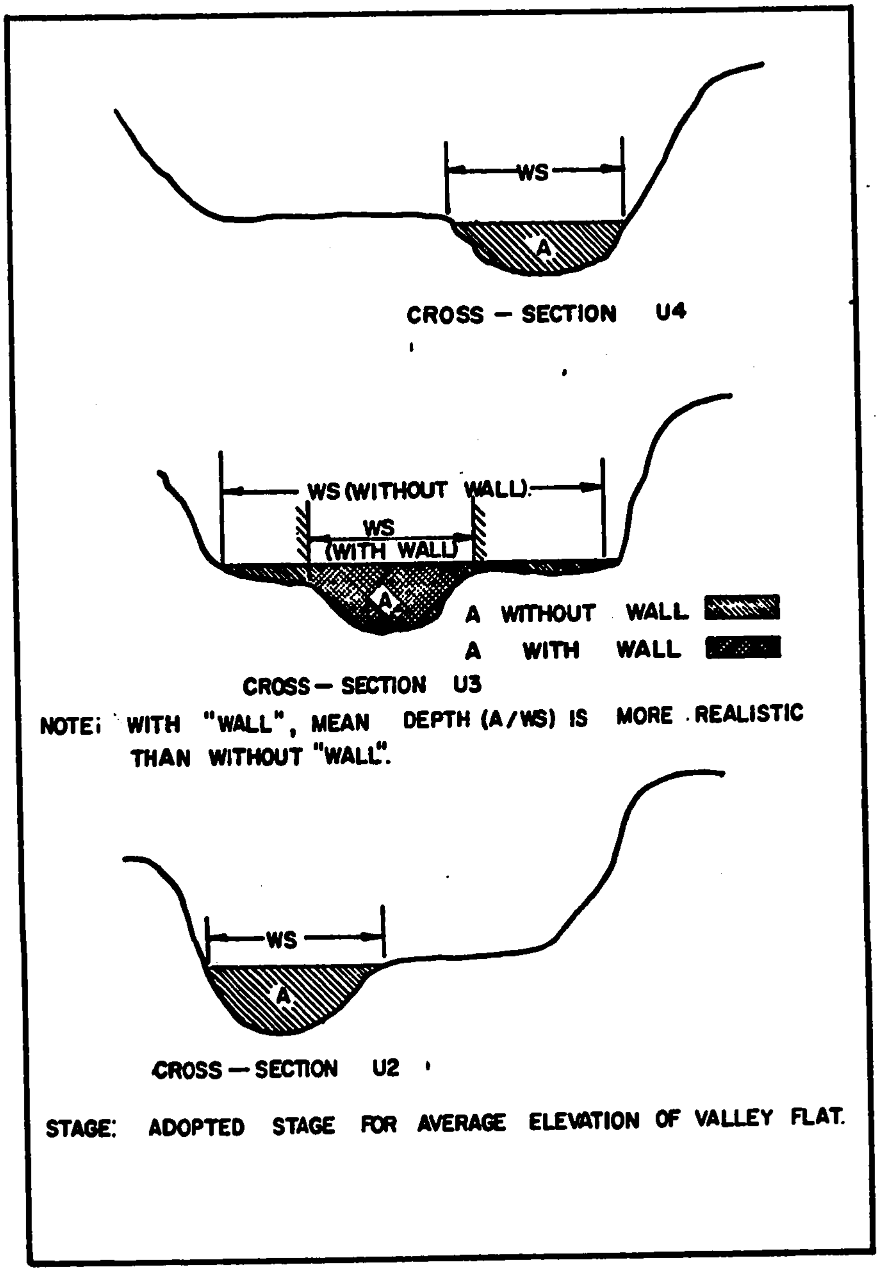


FIGURE B.1 ILLUSTRATION OF THE USE OF AN "ARTIFICIAL CONFINING WALL" TO GIVE MORE REALISTIC HYDRAULIC GEOMETRY DATA properties are to be computed.

5. The elevation of the water-surface at each cross-section on the date of the survey. The location of walls at each cross-section, if any, along with a code to indicate if the walls are to apply for all stages or only for stages below the low level bench.

6. The X and Y coordinates for the points on each cross-section.

B.5 Detailed Data Preparation

The detailed instructions for coding the input data for a reach are given in this section. The data preparation for the hydraulic geometry program falls under the following main headings:

1. General data for the reach
2. Cross-section data for the reach

The first set of numbers on the left are the column numbers and the second code is the format used to store the data on cards. The description of the data to be stored is given to the right of the format requirements.

B.5.1 General Data for the Reach

The general data for the reach are stored on the first six cards as follows:

FIRST CARD: TITLE CARD

1- 5	I5	Research Council of Alberta Number for Reach, Right Justified (R.J.).
6-45	10A4	Name of Reach, Left Justified (L.J.).
46-53	2A4	Water Survey of Canada Code (R.J.). eg. 11AA023.
54-61	2A4	Date of Survey (R.J.). Must be day for the reference stage and discharge for the Reach. The date is given as day, month (using 3 letter abbreviation), year (using last two digits). (e.g. 27SEP70)
62-63	2X	Blank (may be used for code at later date if program needs to be modified).
64-68	F5.2	Stage in feet at gauge on the date of survey. The stage must correspond to the discharge for the date of survey for the Reach.
69-76	F8.6	Slope for Reach in ft/ft.
77-80	A4	Must be "TITL" (code for title card).

SECOND CARD: FIRST RATING CURVE CARD

1- 5	I5	Research Council Number (R.J.).
6-45	10A4	Name of Reach (L.J.).
46-49	4X	Blank
50-57	F8.2	Gauge zero elevation in ft., use geodetic elevation if available. This <u>must</u> be the gauge zero applicable to the rating curve used in the Second Rating Curve Card. This information is not used in this computation.
58-63	F6.2	Limiting stage for analysis. This stage is necessary for one of the following reasons: 1. Major valley flat present 2. No data points to define geometry 3. Rating curve extrapolation not reasonable
64-67	A4	Curve (or table) number used for rating curve (R.J.).

68-69	A2	Day	for Rating Curve (e.g. 13NOV1967)
70-72	A3	Month	
73-76	A4	Year	
77-80	A4	Must be "RAT1" (code for First Rating Curve Card).	

THIRD CARD: SECOND RATING CURVE CARD

1- 5	I5	Research Council Number (R.J.).
6-11	F6.2	Stage in ft.
12-18	F7.0	Corresponding discharge in cfs.
		(continues as F6.2, F7.0)
58-63	F6.2	Stage in ft.
64-70	F7.0	Corresponding discharge in cfs.

NOTE:

1. Five stages and corresponding discharges <u>must</u> be used. If possible, the points should be observed stages and discharges. However, the last point is usually obtained by extrapolation.
2. The stage and discharges <u>must</u> be in ascending order.
3. The first data point read-in for the rating curve must be for a discharge which is smaller than the smallest discharge used in the analysis, and the last point must be for a stage which is equal to or greater than the limiting stage on the card "RAT1".
4. If possible, the Rating Curve should be the one used by the official government agency for the date of survey.

71-72 A2 Code for last points on Rating Curve.

1. Blank = No extrapolation for last point
2. * = Last point obtained by extrapolation
3. ** = Last two points obtained by extrapolation (usually this last code will not be used)

73-76 A4 Year of the Rating Curve. <u>Must</u> be same as year in Col. 73-76 of RAT1.

77-80 A4 Must be "RAT2" (code for Second Rating Curve).

FOURTH CARD: FIRST DISCHARGE CARD

1- 5	I5	Research Council Number (R.J.).	
6-12	F7.0	Characteristic Discharge in cfs	First for Card
13-14	I2	Code for characteristic discharge	
		(continues as F7.0, I2)	
60-66	F7.0	Characteristic Discharge in cfs.	Seventh and last for card
67-68	I2	Code for characteristic discharge	
69-76	8X	Blank	
77-80	A4	Must be "DIS1" (code for first discharge card).	

FIFTH CARD: SECOND DISCHARGE CARD

1-76		Same as for first discharge card
77-80	A4	Must be "DIS2" (code for second discharge card).

CODES FOR CHARACTERISTIC DISCHARGES

1 = Survey

2 = Long Term Mean; Full Year

3 = Long Term Mean; Mar - Oct

4 = Long Term Mean; Apr - Oct

5 = 1.5 Year Flood

6 = 2 Year Flood

7 = 5 Year Flood

8 = 10 Year Flood

9 = 25 Year Flood

10 = 50 Year Flood

11 = 100 Year Flood

12 = 0.5% Flow Duration Based on Year

13 = 1% Flow Duration Based on Year

14 = 5% Flow Duration Based on Year

15 = 10% Flow Duration Based on Year

16 = 50% Flow Duration Based on Year

17 = Flow for Stage at Low Level Bench

18 = Flow for Stage at Trim Line

19 = Flow for Stage at Valley Flat

20 = Not Specified

21 = See Note

Blank = Not Specified

NOTE: 1. The discharges in DIS1 and DIS2 may be in any order.

2. Codes from above table will be printed out with analysis.

3. Both DIS1 and DIS2 must be supplied even if there are no discharges (and codes) on DIS2.

4. Maximum number of discharges is 14.

SIXTH CARD: COMMENT CARD

This card must be blank if no comments are required. If comments are required use the following format:

1- 5	A1,A4	Research Council Number (R.J.).
6-80	18A4, A3	Comments.

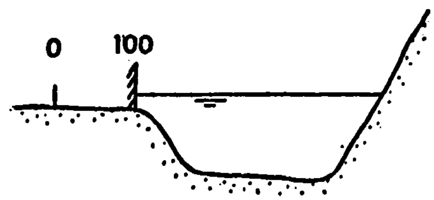
B.5.2 Cross-Section Data for the Reach

The cross-section data for the reach are stored on two to eleven data cards as follows:

FIRST CARD: GENERAL CROSS-SECTION DATA AND CODES

1- 5	I5	Research Council of Alberta Number (R.J.).
6-45	10A4	Reach Name (L.J.)
46-53	F8.2	Water Surface Elevation in feet at Cross-Section corresponding to discharge on date of survey. Use geodetic elevation if available. If possible, use the elevation to nearest 0.01 foot. (If the stage varied during the survey, attempt to use water surface elevations corresponding to the reference discharge for the date of survey.)
54-58	F5.0	Location of first left wall in feet.

NOTE: This only applies if the cross-section has to be controlled to give realistic bankfull properties. For example, in the following case a wall is inserted at a distance of 100 feet from origin. The distance for the wall may be in a negative direction if necessary.



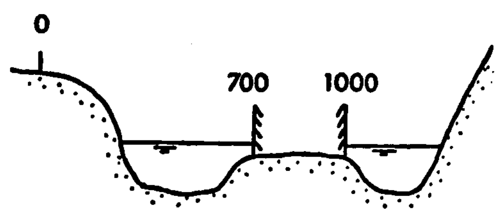
FIRST LEFT WALL AT 100 FT.

The distance for the location of the wall may be any value except 0.0 and -999. If a wall is required at 0.0 place it at 0.1. The value 0.0 is used as a test and the value -999 is printed out if no wall is used.

59-63 F5.0 Location of first right wall in feet.

64-68 F5.0 Location of second left wall in feet.

NOTE: This wall may only be used in there is a first right wall. For example:



FIRST RIGHT WALL AT 700 FT.

SECOND LEFT WALL AT 1000 FT.

69-73 F5.0 Location of second right wall in feet.

NOTE: This wall may only be used if there is a first right wall and a second left wall.

74 I1 Code for applicability of walls

BLANK = all flows

1 = only for flows equal or less than flow corresponding to low level bench.

75-80	A2,A4	Cross-section name (R.J.). eg. U4

SECOND CARD: CROSS-SECTION DATA

1- 5	I5	Research Council Number for Reach (R.J.).
6-11	F6.0	First X for card
12-18	F7.1	First Y for card
		(continues F6.0, F7.1)
58-63	F6.0	Fifth X for card
64-70	F7.1	Fifth Y for card
71-74	4X	Blank
75-80	A2,A4	Cross-section name (R.J.). Must be same as used for first cross-section card.

NOTE: 1. If possible, 0.0 should be the initial point on the left of the cross-section when looking downstream since this is a standard convention. However, it is not necessary to use this convention.

2. X values must increase or remain the same, they must never decrease.

3. X values may be negative.

4. Y values must not take the value 0.0 since this value is used as a test.

5. If no wall is inserted a "Y" on the left and right of the channel should be greater than the maximum water surface elevation for the analysis. This is not a necessary condition since the program automatically inserts a wall at the first and/or last data point under such circumstances.

THIRD (TO THE ELEVENTH) CARD: CROSS-SECTION DATA

Same format as second card.

NOTE: 1. Continue to put 5 data points on each card until all points are coded.

2. The last card with data for the cross-section may have from 1 to 5 data points.

3. It is possible to use up to and including 50 values of X and 50 values of Y for any cross-section.

LAST CARD FOR CROSS-SECTION

1-76	76X	Blank
77-80	A4	Must be "XEND" (code for end of cross-section).

NOTE: Each cross-section for the Reach is coded as outlined above. (Maximum number of cross-sections is 15.)

LAST CARD FOR REACH

1-76	76X	Blank
77-80	A4	Must be "REND" (code for end of Reach).

NOTE: Each Reach is coded as outlined above. If more than one Reach to be analysed continue as follows: (No limit on number of Reaches)

First card for next Reach

...

Last card for next Reach must be "REND".

LAST CARD FOR A SERIES OF REACHES

1-76	76X	Blank
77-80	A4	Must be "END" (R.J.)(code for end of job).

NOTE: The dimension statements may easily be changed to allow more than 50 points per cross-section, or more than 15 cross-sections in a reach. To compute hydraulic geometry properties for more than 14 discharges for a Reach it would be necessary to rerun the data for the Reach or make some minor modification to the read statements and dimension statements.

B.6 An Example

A sample computer print-out is presented in FIGURES B.2, B.3 and B.4 to illustrate a cross-sectional analysis with and without an "artificial confining wall" and a reach summary. A print-out of the data cards and control cards for this example is shown in FIGURE B.5.

B.7 Listing for Hydraulic Geometry Program

The hydraulic geometry program was written in Fortran IV and was processed by the Fortran IV compiler under the Michigan Terminal System on the IBM 360-67 computer at the University of Alberta Computing Center. The listings for the main program and subroutines are presented on the following pages.

 # 117 SWAN RIVER NEAR KINUSO WATER SURVEY CODE: 78J01

CROSS-SECTION DATA FOR X-SECTION U3 DATE OF SURVEY: 11JUN70

X	Y	X	Y	X	Y	X	Y	X	Y
-10.0	91.2	0.0	91.2	7.0	90.5	16.0	82.9	22.0	78.6
25.0	76.9	41.0	76.2	56.0	76.0	72.0	75.6	90.0	75.1
104.0	75.3	114.0	74.1	118.0	77.1	120.0	78.6	127.0	82.6
135.0	90.5	145.0	90.5						

SECTION PROPERTIES FOR X-SEC U3 : WALLS AT -999. 132. -999. -999. FOR ALL FLOWS

FLOW	WS.EL.	CODE	AREA	WS	WP	DM	RH	DMAX	VM	WS/WP	DM/RH	DMAX/DM	WS/DM
456.	78.55	LTM:YEAR	272.	98.	100.	2.78	2.72	4.45	1.68	0.98	1.02	1.60	35.2
747.	79.68	LTM:4-10	384.	101.	104.	3.78	3.69	5.58	1.95	0.97	1.03	1.47	26.8
3800.	87.91	1.5YR FL	1312.	122.	130.	10.76	10.07	13.81	2.90	0.94	1.07	1.28	11.3
4940.	90.30	0.5% DUR	1606.	125.	134.	12.87	11.99	16.20	3.08	0.93	1.07	1.26	9.7
3890.	88.11	1% DUR	1336.	122.	131.	10.94	10.23	14.01	2.91	0.94	1.07	1.28	11.2
2400.	84.60	5% DUR	919.	115.	121.	7.99	7.60	10.50	2.61	0.95	1.05	1.31	14.4
1400.	81.83	10% DUR	609.	108.	112.	5.63	5.44	7.73	2.30	0.96	1.04	1.37	19.2
5220.	90.90	VAL FLAT	1682.	129.	138.	13.04	12.16	16.80	3.10	0.93	1.07	1.29	9.9
470.	78.60	SURVEY	276.	98.	100.	2.82	2.76	4.50	1.70	0.98	1.02	1.60	34.8

1. All units are ft-lb-sec units.

FIGURE B.2 AN EXAMPLE OF A COMPUTER PRINT-OUT OF AN ANALYSIS FOR A CROSS-SECTION WITH A WALL

117 <u>SWAN RIVER NEAR KINUSO</u> WATER SURVEY CODE: 78J01

CROSS-SECTION DATA FOR X-SECTION G DATE OF SURVEY: 11JUN70

X	Y	X	Y	X	Y	X	Y	X	Y
-10.0	93.6	0.0	93.6	12.0	85.4	18.0	81.4	20.0	78.0
22.0	74.1	41.0	74.8	56.0	74.6	70.0	74.4	82.0	74.4
103.0	74.1	116.0	75.6	118.0	78.0	132.0	89.3	143.0	91.2
152.0	93.5	162.0	93.5						

SECTION PROPERTIES FOR X-SEC G

FLOW	WS.EL.	CODE	AREA	WS	WP	DM	RH	DMAX	VM	WS/WP	DM/RH	DMAX/DM	WS/DM
456.	77.95	LTM:YEAR	331.	98.	101.	3.38	3.26	3.85	1.38	0.96	1.04	1.14	29.0
747.	79.08	LTM:4-10	442.	100.	105.	4.42	4.22	4.98	1.69	0.96	1.05	1.13	22.6
3800.	87.31	1.5YR FL	1343.	120.	131.	11.16	10.25	13.21	2.83	0.92	1.09	1.18	10.8
4940.	89.70	0.5% DUP	1638.	129.	141.	12.74	11.64	15.60	3.02	0.91	1.09	1.22	10.1
3890.	87.51	1% DUP	1367.	121.	132.	11.31	10.38	13.41	2.85	0.92	1.09	1.19	10.7
2400.	84.00	5% DUR	959.	111.	120.	8.62	8.01	9.90	2.50	0.93	1.08	1.15	12.9
1400.	81.23	10% DUR	661.	104.	111.	6.37	5.98	7.13	2.12	0.94	1.06	1.12	16.3
5220.	90.30	VAL FLAT	1717.	133.	145.	12.91	11.81	16.20	3.04	0.91	1.09	1.25	10.3
470.	78.00	SURVEY	335.	98.	102.	3.42	3.30	3.90	1.40	0.96	1.04	1.14	28.7

1. All units are ft-lb-sec units.

FIGURE B.3 AN EXAMPLE OF A COMPUTER PRINT-OUT OF AN ANALYSIS FOR A CROSS-SECTION WITHOUT A WALL

117 SWAN RIVER NEAR KINUSO   WATER SURVEY CODE: 78J01

117 DATE OF SURVEY 11JUN70 STAGE FOR SURVEY = 3.05 FT.
LIMITING STAGE FOR ANALYSIS = 15.35 FT.

117 RATING CURVE: C8 1969: GAUGE ZERO = 74.95 FT.

STAGE	Q	STAGE	Q	STAGE	Q	STAGE	Q	STAGE	Q
1.00	70.	3.17	500.	5.00	1000.	12.80	4000.	16.80	6000.

SUMMARY FOR REACH: NUMBER OF X-SEC = 5 SLOPE FOR REACH = 0.000200 FT/FT.
X-SECTIONS USED: U3, U2, U1, G, D1.

FLOW	STAGE	CODE	AREA	CVA	WS	CVWS	DM	WS/DM	VM
456.	3.00	LTM:YEAR	302.	0.15	92.	0.09	3.29	27.9	1.51
747.	4.13	LTM:4-10	408.	0.13	96.	0.09	4.24	22.7	1.83
3800.	12.36	1.5YR FL	1315.	0.12	125.	0.11	10.56	11.8	2.89
4940.	14.75	0.5% DUR	1625.	0.11	135.	0.12	12.06	11.2	3.04
3890.	12.56	1% DUR	1340.	0.12	126.	0.10	10.66	11.8	2.90
2400.	9.05	5% DUR	924.	0.12	113.	0.13	8.17	13.8	2.60
1400.	6.28	10% DUR	623.	0.12	104.	0.12	6.02	17.2	2.25
5220.	15.35	VAL FLAT	1707.	0.11	138.	0.11	12.37	11.1	3.06
470.	3.05	SURVEY	306.	0.15	92.	0.09	3.33	27.6	1.53

FLOW	CODE	V*	V/V*	TAU	N	V**2/D	V**3/WS	WS/Q**.5
456.	LTM:YEAR	0.15	10.37	0.041	0.031	0.69	0.04	4.29
747.	LTM:4-10	0.17	11.08	0.053	0.030	0.79	0.06	3.52
3800.	1.5YR FL	0.26	11.08	0.132	0.035	0.79	0.19	2.02
4940.	0.5% DUR	0.28	10.91	0.151	0.036	0.77	0.21	1.92
3890.	1% DUR	0.26	11.08	0.133	0.035	0.79	0.19	2.01
2400.	5% DUR	0.23	11.32	0.102	0.033	0.82	0.15	2.31
1400.	10% DUR	0.20	11.40	0.075	0.031	0.84	0.11	2.77
5220.	VAL FLAT	0.28	10.83	0.154	0.037	0.76	0.21	1.91
470.	SURVEY	0.15	10.48	0.042	0.031	0.71	0.04	4.24

ALL UNITS ARE FT.-LB.-SEC. UNITS

FIGURE B.4 AN EXAMPLE OF A COMPUTER PRINT-OUT OF A REACH SUMMARY

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CCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCC
00000000000000000000000000000000000000000000000000000000000000000000000000000000
LLLLLLLLLLLLLLLLLLLLLLLLLLLLLLLLLLLLLLLLLLLLLLLLLLLLLLLLLLLLLLLLLLLLLLLLLLLLLLLL
         1111111111222222222233333333334444444444555555555566666666667777777778
12345678901234567890123456789012345678901234567890123456789012345678901234567890
C     LAST JOB CONTROL CARD BEFORE DATA
 117SWAN RIVER NEAR KINUSO                              78J01 11JUN70  3.05 0.00020TITL
 117SWAN RIVER NEAR KINUSO                                  74.95 15.35  C8     1969RAT1
 117  1.00      70  3.17     500  5.00   1000 12.80   4000 16.80   6000  1969RAT2
 117     456 2     747 4    3800 5    5300 6   494012   389013   240014        DIS1
 117    140015    522019     470 1                                             DIS2

 117SWAN RIVER NEAR KINUSO                      78.60          132              U3
 117    -10    91.2      C    91.2      7    90.5     16    82.9     22    78.6  U3
 117     25    76.9     41    76.2     56    76.0     72    75.6     90    75.1  U3
 117    104    75.3    114    74.1    118    77.1    120    78.6    127    82.6  U3
 117    135    90.5    145    90.5                                              U3
                                                                               XEND
 117SWAN RIVER NEAR KINUSO                      78.50     6                     U2
 117    -18    97.0     -8    97.0     -4    90.0      0    90.0      8    89.4  U2
 117     11    83.8     15    81.5     20    78.5     28    77.9     43    76.0  U2
 117     57    74.8     70    74.1     83    72.5    101    70.5    107    73.1  U2
 117    110    77.1    118    78.5    122    79.2    131    80.4    143    83.3  U2
 117    153    87.1    173    91.1    194    95.0    204    95.0                  U2
                                                                               XEND
 117SWAN RIVER NEAR KINUSO                      78.10                           U1
 117    -10    90.5      0    90.5      2    89.8     17    80.6     20    78.1  U1
 117     23    78.1     40    72.6     48    73.2     60    73.8     70    73.5  U1
 117     84    75.0     97    75.4    103    77.2    105    78.1    112    82.2  U1
 117    116    83.3    124    87.1    132    89.3    140    97.3    150    97.3  U1
                                                                               XEND
 117SWAN RIVER NEAR KINUSO                      78.00                            G
 117    -10    93.6      0    93.6     12    85.4     18    81.4     20    78.0   G
 117     22    74.1     41    74.8     56    74.6     70    74.4     82    74.4   G
 117    103    74.1    116    75.6    118    78.0    132    89.3    143    91.2   G
 117    152    93.5    162    93.5                                               G
                                                                               XEND
 117SWAN RIVER NEAR KINUSO                      77.40                           D1
 117    -10    91.9      0    91.9     12    87.4     18    81.3     22    77.4  D1
 117     23    75.0     28    72.4     44    72.8     66    74.2     70    75.2  D1
 117    104    75.9    106    77.4    107    80.4    110    81.6    117    85.9  D1
 117    133    87.3    135    89.4    137    91.4    147    91.4                  D1
                                                                               XEND
                                                                               REND
                                                                                END
C      FIRST JOB CONTROL CARD AFTER DATA
         1111111111222222222233333333334444444444555555555566666666667777777778
12345678901234567890123456789012345678901234567890123456789012345678901234567890
```

FIGURE B.5 A PRINT-OUT OF THE DATA CARDS AND CONTROL CARDS USED TO GENERATE THE RESULTS GIVEN IN THE EXAMPLE SHOWN IN FIGURES B.2, B.3 AND B.4

```
C
C     ******************************************************************
C
C     COMPUTATION OF HYDRAULIC GEOMETRY   - D. I. BRAY -  1970
C
C     ******************************************************************
C
C     THIS PROGRAM IS DESIGNED TO READ IN SOME GENERAL DATA FOR A RIVER
C        REACH AND THE CROSS-SECTIONAL DATA FOR THE REACH.  GEOMETRIC
C        AND HYDRAULIC PARAMETERS ARE COMPUTED AND PRINTED OUT FOR EACH
C        CROSS-SECTION.  FINALLY THE AVERAGE GEOMETRIC AND HYDRAULIC
C        PARAMETERS FOR THE REACH ARE COMPUTED AND PRINTED OUT.
C     THE DIMENSION STATEMENTS WILL HAVE TO BE CHANGED TO ACCOMODATE
C        MORE THAN 15 CROSS-SECTION IN THE REACH AND MORE THAN 14 OF THE
C        21 DIFFERENT FLOW CONDITIONS.  THE DIMENSIONS FOR THE X AND Y
C        COORDINATES WILL HAVE TO BE CHANGED IF THERE ARE MORE THAN
C        55 POINTS FOR ANY CROSS-SECTION.
C     A MORE DETAILED WRITE-UP OF THIS PROGRAM IS AVAILABLE FROM THE
C        AUTHOR.
C
      DIMENSION IREACH(10),IWSC(2),IDSUR(2),EWSS(12)
      DIMENSION SR(5),QR(5),SRL(5),QRL(5),Q(15),IQ(15),QL(15),SL(15)
      DIMENSION S(15),X(55),Y(55),CA(15),IQA(15)
      DIMENSION A(14,15),WS(14,15),WP(14,15),D(14,15),RH(14,15),V(14,15)
      DIMENSION DMAX(14,15)
      DIMENSION W(14)
      DIMENSION AA(14),AWS(14),CVA(14),CVWS(14),DA(14),VM(14),VSTAR(14)
      DIMENSION VBVST(14),TAU(14),AN(14),BEDF(14),SIDEF(14),WIDEF(14)
      DIMENSION FFACT(14)
      DIMENSION NAME1(21),NAME2(21)
      DIMENSION IXS(16),IXSEC(16),ICOM(18)
      DATA NAME1(1)/'  SU'/,NAME2(1)/'RVEY'/
      DATA NAME1(2)/'LTM:'/,NAME2(2)/'YEAR'/
      DATA NAME1(3)/'LTM:'/,NAME2(3)/'3-10'/
      DATA NAME1(4)/'LTM:'/,NAME2(4)/'4-10'/
      DATA NAME1(5)/'1.5Y'/,NAME2(5)/'R FL'/
      DATA NAME1(6)/' 2 Y'/,NAME2(6)/'R FL'/
      DATA NAME1(7)/' 5 Y'/,NAME2(7)/'R FL'/
      DATA NAME1(8)/'10 Y'/,NAME2(8)/'R FL'/
      DATA NAME1(9)/'25 Y'/,NAME2(9)/'R FL'/
      DATA NAME1(10)/'50 Y'/,NAME2(10)/'R FL'/
      DATA NAME1(11)/'100Y'/,NAME2(11)/'R FL'/
      DATA NAME1(12)/'0.5%'/,NAME2(12)/' DUR'/
      DATA NAME1(13)/'  1%'/,NAME2(13)/' DUR'/
      DATA NAME1(14)/'  5%'/,NAME2(14)/' DUR'/
      DATA NAME1(15)/' 10%'/,NAME2(15)/' DUR'/
      DATA NAME1(16)/' 50%'/,NAME2(16)/' DUR'/
      DATA NAME1(17)/'LL B'/,NAME2(17)/'ENCH'/
      DATA NAME1(18)/'TRIM'/,NAME2(18)/' LIN'/
      DATA NAME1(19)/'VAL '/,NAME2(19)/'FLAT'/
      DATA NAME1(20)/'NOT '/,NAME2(20)/'SPEC'/
      DATA NAME1(21)/'SEE '/,NAME2(21)/'NOTE'/
      INTEGER ITITT/'TITL'/,IRAT1T/'RAT1'/,IRAT2T/'RAT2'/
      INTEGER IDIS1T/'DIS1'/,IDIS2T/'DIS2'/
      INTEGER IXEND/'XEND'/,IREND/'REND'/,ISEND/' END'/
```

```
      IR=5
      IP=6
C     INITIATION FOR NEW REACH
  571 JDM=14
      KM=15
C     JDM = THE MAXIMUM NUMBER OF DISCHARGES ALLOWED
C     KM  = THE MAXIMUM NUMBER OF CROSS SECTIONS ALLOWED
      DO 1 J=1,JDM
      DO 2 K=1,KM
      WS(J,K)=0.0
      WP(J,K)=0.0
      A(J,K)=0.0
      D(J,K)=0.0
      RH(J,K)=0.0
      DMAX(J,K)=0.0
    2 CONTINUE
    1 CONTINUE
      READ(IR,600)INUM1,IREACH(1),IREACH(2),IREACH(3),IREACH(4),IREACH(5
     1),IREACH(6),IREACH(7),IREACH(8),IREACH(9),IREACH(10),IWSC(1),IWSC(
     12),IDSUR(1),IDSUR(2),SURVSG,SLOPE,ITITLE
      IF(ITITLE.EQ.ISEND) GO TO 454
      IF(ITITLE.NE.ITITT) GO TO 565
      READ(IR,601)INUM2,IREACH(1),IREACH(2),IREACH(3),IREACH(4),IREACH(5
     1),IREACH(6),IREACH(7),IREACH(8),IREACH(9),IREACH(10),GAGEZ,BANKSG,
     1INRC,IDAY,IMCN,IYYR,IRATE1
      IF(INUM2.NE.INUM1) GO TO 565
      IF(IRATE1.NE.IRAT1T) GO TO 565
      READ(IR,602)INUM3,SR(1),QR(1),SR(2),QR(2),SR(3),QR(3),SR(4),QR(4),
     1SR(5),QR(5),ICODER,IYYRC,IRATE2
      IF(IYYRC.NE.IYYR) GO TO 565
      IF(INUM3.NE.INUM1) GO TO 565
      IF(IRATE2.NE.IRAT2T) GO TO 565
      READ(IR,603)INUM4,Q(1),IQ(1),Q(2),IQ(2),Q(3),IQ(3),Q(4),IQ(4),Q(5)
     1,IQ(5),Q(6),IQ(6),Q(7),IQ(7),IDIS1
      IF(INUM4.NE.INUM1) GO TO 565
      IF(IDIS1.NE.IDIS1T) GO TO 565
      READ(IR,603)INUM5,Q(8),IQ(8),Q(9),IQ(9),Q(10),IQ(10),Q(11),IQ(11),
     1Q(12),IQ(12),Q(13),IQ(13),Q(14),IQ(14),IDIS2
      IF(INUM5.NE.INUM1) GO TO 565
      IF(IDIS2.NE.IDIS2T) GO TO 565
      READ(IR,869)INUMA,INUMB,(ICOM(I),I=1,18),ICOM19
  869 FORMAT(A1,A4,18A4,A3)
C     IPRITT IS USED AS A TEST FOR A PRINT OUT
      IPRITT=0
C     TEST TO ENSURE THAT STAGES AND DISCHARGES ARE IN INCREASING ORDER
      DO 72 M=1,4
      IF(SR(M+1).LT.SR(M)) GO TO 575
      IF(QR(M+1).LT.QR(M)) GO TO 575
   72 CONTINUE
C     DETERMINE DISCHARGES EQUAL TO OR LESS THAN BANKFULL
  393 DO 230 J=1,JDM
      IJVF=19
      IF(IQ(J).EQ.IJVF) GO TO 231
C     NOTE: IQ = IJVF IS THE CODE FOR BANKFULL DISCHARGE AT THE
C                   VALLEY FLAT.
```

```
  230 CONTINUE
      GO TO 293
  231 OBANK=Q(J)
      GO TO 299
C     ONLY GOES THROUGH THIS SECTION IF NO VALLEY FLAT
  293 DO 71 M=1,5
C     NOTE: ONLY 5 POINTS ON THE RATING CURVE, LAST PT. MUST BE GE.
C           BANKFULL.
      IF(SR(M).GE.BANKSG) GO TO 351
C     BANKSG = THE LIMITING STAGE FOR THE REACH, NOT NECESSARILY BANK-
C     FULL.  MAY BE LIMITED SURVEY DATA, ETC.
   71 CONTINUE
      GO TO 569
  351 M1=M-1
      SRL(M)=ALOG(SR(M))
      SRL(M1)=ALOG(SR(M1))
      QRL(M)=ALOG(QR(M))
      QRL(M1)=ALOG(QR(M1))
      BANKFL=ALOG(BANKSG)
      QBANKL=QRL(M1)+(QRL(M)-QRL(M1))/(SRL(M)-SRL(M1))*(BANKFL-SRL(M1))
      QBANK=EXP(QBANKL)
C     ADJUST DISCHARGES BY OMMITING ALL DISCHARGES GT. BANKFULL
  299 J=1
      JA=1
  360 IF(J.GT.JDM) GO TO 366
      IF(Q(J).GT.QBANK) GO TO 361
      IF(Q(J).LT.QR(1)) GO TO 361
      IF(Q(J).EQ.0.0) GO TO 361
      QA(JA)=Q(J)
      IQA(JA)=IQ(J)
      J=J+1
      JA=JA+1
      GO TO 360
  361 J=J+1
      GO TO 360
  366 JF=JA-1
      K=1
C     READ CROSS-SECTION DATA
  539 READ(IR,604)INUM6,EWSS(K),WL1T,WR1T,WL2T,WR2T,IWALLT,IXS(K),IXSEC(
     1K)
C     ALL WALLS SHOULD BE LOCATED AT A DISTANCE GREATER THAN 0.0
      IF(IXSEC(K).EQ.IREND) GO TO 537
      IF(INUM6.NE.INUM1) GO TO 565
      N=1
  451 READ(IR,605)INUM7,X(N),Y(N),X(N+1),Y(N+1),X(N+2),Y(N+2),X(N+3),Y(N
     1+3),X(N+4),Y(N+4),IXSECT
      IF(IXSECT.EQ.IREND) GO TO 565
      IF(IXSECT.EQ.IXEND) GO TO 452
      IF(INUM7.NE.INUM1) GO TO 452
      IF(IXSECT.NE.IXSEC(K)) GO TO 565
      N=N+5
      NT=N-1
      GO TO 451
  452 IF(INUM7.EQ.0) GO TO 453
      GO TO 565
```

```
  453 IF(IXSECT.EQ.ISEND) GO TO 565
C     TEST TO CHECK THAT X VALUES ARE IN ASCENDING ORDER
      N=1
      NF=1
  295 IF(X(N+1).GE.X(N)) GO TO 296
      IF(X(N+1).EQ.0.0) GO TO 297
      GC TO 566
  296 NF=NF+1
      N=N+1
      IF(N.EQ.NT) GO TO 297
      GC TO 295
C     CHECK TO ENSURE THAT VALUES OF Y ARE NOT EQ. TO ZERO
  297 DO 65 N=1,NF
      IF(Y(N).EQ.0.0) GO TO 568
   65 CCNTINUE
      NFY=NF+1
      Y(NFY)=0.0
C     DETERMINE STAGE FOR WALL TEST
C     IF WALL IS FOR ALL STAGES IWALLT = 0;  IF WALL IS FOR ALL STAGES
C     LE. TO THE LOW LEVEL BENCH  IWALLT = 1
      IF(IWALLT.EC.0) GO TO 468
      IJLL=17
C     IJLL IS THE VALUE CF IQA CORRESPONDING TO THE LOW LEVEL BENCH
      DC 238 J=1,JF
      IF(IQA(J).EQ.IJLL) GO TO 239
  238 CONTINUE
C     LOW LEVEL BENCH STAGE NOT AVAILABLE
      IWALLT=0
      GC TO 468
C     FIND STAGE CORRESPCNDING TO LOW LEVEL BENCH
C     INTERPOLATICN FOR DETERMINATION OF STAGE GIVEN A DISCHARGE
C     SECCND ORDER INTERPCLATICN FCR THE FIRST THREE POINTS, THEN
C     LINEAR INTERPOLATICN FOR LAST TWO POINTS.  ALL LCG-LOG
C        INTERPOLATICN.
  239 IF(QA(J).LT.QR(1)) GO TO 565
      IF(QA(J).LE.QR(3)) GO TO 520
      GC TO 521
  520 CL(J)=ALOG(QA(J))
      DC 524 M=1,3
      QRL(M)=ALCG(CR(M))
      SRL(M)=ALOG(SR(M))
  524 CONTINUE
      SLJ1=(QL(J)-QRL(2))/(CRL(1)-CRL(2))*(QL(J)-QRL(3))/(QRL(1)-QRL(3))
     1*SRL(1)
      SLJ2=(QL(J)-QRL(1))/(CRL(2)-QRL(1))*(QL(J)-QRL(3))/(QRL(2)-QRL(3))
     1*SRL(2)
      SLJ3=(QL(J)-QRL(1))/(QRL(3)-QRL(1))*(QL(J)-CRL(2))/(QRL(3)-QRL(2))
     1*SRL(3)
      SL(J)=SLJ1+SLJ2+SLJ3
      GC TO 523
  521 DC 250 M=4,5
      IF(QA(J).LE.QR(M)) GO TO 251
  250 CCNTINUE
  251 CL(J)=ALOG(CA(J))
      M1=M-1
```

```
      QRL(M1)=ALOG(QR(M1))
      SRL(M1)=ALOG(SR(M1))
      QRL(M)=ALOG(QR(M))
      SRL(M)=ALOG(SR(M))
      SL(J)=SRL(M1)+(SRL(M)-SRL(M1))/(QRL(M)-QRL(M1))*(QL(J)-QRL(M1))
  523 S(J)=EXP(SL(J))
      SLLB=S(J)+0.001
C     CARRY OUT COMPUTATIONS FOR THE FIRST CROSS-SECTION
C     DETERMINE WATER SURFACE ELEVATION FOR SPECIFIED DISCHARGE.
  468 J=1
      IPRIT=0
C     NOTE: THE STAGES AND DISCHARGES CORRESPONDING TO THE SURVEY AND
C     AND BANKFULL CASES ARE NOT OBTAINED BY INTERPOLATION, BUT ARE THE
C     VALUES READ IN.
   56 IF(IQA(J).EQ.IJVF) GO TO 67
      IF(IQA(J).EQ.1) GO TO 68
      IF(QA(J).LT.QR(1)) GO TO 567
      DO 50 M=2,5
      IF(QA(J).LE.QR(M)) GO TO 51
   50 CONTINUE
   51 QL(J)=ALOG(QA(J))
      M1=M-1
      QRL(M1)=ALOG(QR(M1))
      SRL(M1)=ALOG(SR(M1))
      QRL(M)=ALOG(QR(M))
      SRL(M)=ALOG(SR(M))
      SL(J)=SRL(M1)+(SRL(M)-SRL(M1))/(QRL(M)-QRL(M1))*(QL(J)-QRL(M1))
      S(J)=EXP(SL(J))
      GO TO 57
   67 S(J)=BANKSG
      GO TO 57
   68 S(J)=SURVSG
   57 DELTS=S(J)-SURVSG
      IF(IWALLT.EQ.0) GO TO 236
C     IF STAGE IS GREATER THAN THE LOW LEVEL BENCH THE WALLS ARE REMOVED
C     IF THE VALUE OF IWALLT .GT. 0.
      IF(S(J).GT.SLLB) GO TO 237
      GO TO 236
  237 WL1=0.0
      WL2=0.0
      WR1=0.0
      WR2=0.0
      GO TO 248
  236 WL1=WL1T
      WR1=WR1T
      WL2=WL2T
      WR2=WR2T
  248 EWS=EWSS(K)+DELTS
C     EWS IS THE ELEVATION OF THE WATER SURFACE
      W(J)=EWS
C     DETERMINE IF WALLS HAVE TO BE PUT IN AUTOMATICALLY
      IF(Y(1).LT.W(J)) GO TO 271
      GO TO 273
  271 IF(WL1T.NE.0.0) GO TO 273
C     ASSUMES THAT WR1T WILL ALWAYS BE GREATER THAN X = 0.0
```

```
      IF(X(1).EQ.0.0) GO TO 281
      WL1T=X(1)
      WL1=X(1)
      IPRIT=1
      IPRITT=1
      GO TO 273
C     WL1T SET EQ. TO 0.01 SO THAT TESTS WILL NOT HAVE TO BE ALTERED
  281 WL1T=0.01
      WL1=0.01
      IPRIT=1
      IPRITT=1
  273 IF(Y(NF).LT.W(J)) GO TO 274
      GO TO 275
  274 IF(WL2T.NE.0.0) GO TO 276
      IF(WR1T.NE.0.0) GO TO 275
      WR1=X(NF)
      WR1T=X(NF)
      IPRIT=1
      IPRITT=1
      GO TO 275
  276 IF(WR2T.NE.0.0) GO TO 275
      WR2=X(NF)
      WR2T=X(NF)
      IPRIT=1
      IPRITT=1
C     SET TEST FOR OCCURANCE OF RIGHT WALL
  275 IWRT=0
C     COMPUTE HYDRAULIC GEOMETRY FOR CROSS-SECTION FOR Q
      N=1
      IF(Y(1).GT.EWS) GO TO 14
      IF(Y(1).EQ.0.0) GO TO 568
      N=N+1
      IF(Y(2).EQ.0.0) GO TO 568
      GO TO 22
   14 IF(Y(N).EQ.0.0) GO TO 400
      IF(Y(N).LT.EWS) GO TO 22
      IF(N.LT.NF) GO TO 13
      GO TO 400
   13 N=N+1
      GO TO 14
   22 IF(WL1.EQ.0.0) GO TO 23
      IF(X(N-1).GT.WL1) GO TO 23
      GO TO 200
C     LEFT TRIANGLE COMPUTATION IF NO WALL INTERSECTING WATER SURFACE
   23 IF(Y(N).EQ.Y(N-1)) GO TO 28
      XNI=X(N-1)+((X(N)-X(N-1))/(Y(N)-Y(N-1)))*(EWS-Y(N-1))
      GO TO 29
   28 XNI=X(N)
   29 IF(Y(N).EQ.0.0) GO TO 400
      IF(Y(N).GT.EWS) GO TO 38
      IF(WR1.EQ.0.0) GO TO 24
      IF(X(N).GT.WR1) GO TO 300
   24 DX=X(N)-XNI
      DY=EWS-Y(N)
      DM=0.0
```

```
      DN=DY
      CALL XPROP(DX,DY,DM,DN,J,K,WS,WP,DMAX,A)
      N=N+1
C     COMPUTATION OF PROPERTIES FOR TRAPEZOIDAL SECTIONS
  100 IF(Y(N).EQ.0.0) GO TO 400
      IF(Y(N).GE.EWS) GO TO 38
      IF(WR1.EQ.0.0) GO TO 34
      IF(X(N).GT.WR1) GO TO 300
   34 DX=X(N)-X(N-1)
      DY=Y(N)-Y(N-1)
      DM=EWS-Y(N-1)
      DN=EWS-Y(N)
      CALL XPROP(DX,DY,DM,DN,J,K,WS,WP,DMAX,A)
      N=N+1
      GO TO 100
C     COMPUTATION OF RIGHT TRIANGLE IF NO WALL INTERSECTING WATER
C         SURFACE.
   38 IF(WR1.EQ.0.0) GO TO 39
      IF(Y(N).EQ.Y(N-1)) GO TO 41
      XNI=X(N-1)+((X(N)-X(N-1))/(Y(N)-Y(N-1)))*(EWS-Y(N-1))
      GO TO 43
   41 XNI=X(N-1)
   43 IF(XNI.GT.WR1) GO TO 300
   39 IF(Y(N).EQ.Y(N-1)) GO TO 45
      XNI=X(N-1)+((X(N)-X(N-1))/(Y(N)-Y(N-1)))*(EWS-Y(N-1))
      GO TO 47
   45 XNI=X(N-1)
   47 DX=XNI-X(N-1)
      DY=EWS-Y(N-1)
      DM=DY
      DN=0.0
      CALL XPROP(DX,DY,DM,DN,J,K,WS,WP,DMAX,A)
      IF(WR1.EQ.0.0) GO TO 14
      IF(IWRT.EQ.1) GO TO 400
      IF(X(N).GE.WR1) GO TO 76
      N=N+1
      GO TO 14
C     COMPUTATIONS IF LEFT WALL INTERSECTS WATER SURFACE
  200 IF(WL1.GE.X(N)) GO TO 201
      GO TO 202
  201 N=N+1
      GO TO 200
  202 IF(Y(N).EQ.0.0) GO TO 400
      IF(Y(N).GT.EWS) GO TO 14
      IF(WR1.EQ.0.0) GO TO 216
      IF(X(N).GT.WR1) GO TO 300
  216 IF(X(N).EQ.X(N-1)) GO TO 204
      GO TO 205
  204 YNI=Y(N-1)
      GO TO 206
  205 YNI=Y(N-1)+((Y(N)-Y(N-1))/(X(N)-X(N-1)))*(WL1-X(N-1))
  206 IF(YNI.GT.EWS) GO TO 23
      DX=X(N)-WL1
      DY=Y(N)-YNI
      DM=EWS-YNI
```

```
      DN=EWS-Y(N)
C     NC WETTED PERIMETER CCMPUTED FOR WATER AGAINST WALL
      CALL XPROP(DX,DY,DM,DN,J,K,WS,WP,DMAX,A)
      N=N+1
      GC TO 100
C     CCMPUTATICNS IF RIGHT WALL INTERSECTS WATER SURFACE
  300 IF(Y(N).EQ.0.0) GO TO 400
      IF(IWRT.EQ.1) GO TO 400
      IF(X(N-1).EQ.WR1) GC TO 76
      IF(X(N).EQ.X(N-1)) GO TO 304
      GO TO 305
  304 YNI=Y(N)
      GC TO 306
  3C5 YNI=Y(N-1)+((Y(N)-Y(N-1))/(X(N)-X(N-1)))*(WR1-X(N-1))
  3C6 IF(YNI.GT.EWS) GO TO 39
      DX=WR1-X(N-1)
      DY=YNI-Y(N-1)
      DM=EWS-Y(N-1)
      DN=EWS-YNI
C     NC WETTED PERIMETER CCMPUTED FOR WATER AGAINST WALL
      CALL XPROP(DX,DY,DM,DN,J,K,WS,WP,DMAX,A)
      N=N+1
   76 WL1=WL2
      WR1=WR2
      IWRT=1
      IF(WL1.EQ.0.0) GO TO 400
      GC TO 14
C     END OF COMPUTATIONS FOR FLOW
  4C0 IF(J.EQ.JF) GO TO 63
      J=J+1
      GC TO 56
C     END OF COMPUTATIONS FCR ALL FLOWS
C     PRINT OUT RESULTS FCR CRCSS-SECTICN
   63 WRITE(IP,700)
      WRITE(IP,701)
      WRITE(IP,800)INUM1,IREACH(1),IREACH(2),IREACH(3),IREACH(4),IREACH(
     15),IREACH(6),IREACH(7),IREACH(8),IREACH(9),IREACH(10),IWSC(1),IWSC
     1(2)
      WRITE(IP,801)IXS(K),IXSEC(K),IDSUR(1),IDSUR(2)
      WRITE(IP,802)
      NFTE=NF/5
      NB=1
      NE=NB+4
      DC 449 NK=1,NFTE
      WRITE(IP,803)(X(N),Y(N),N=NB,NE)
      NB=NB+5
      NE=NB+4
  449 CCNTINUE
      NFTES=NFTE*5
      IF(NF.EQ.NFTES) GO TO 551
      WRITE(IP,803)(X(N),Y(N),N=NB,NF)
  551 WRITE(IP,701)
C     IF NO WALLS USED SET LCCATICN TO TO -999.
      IF(WL1T.EQ.0.0.AND.WR1T.EQ.0.0) GC TO 719
      IF(WL1T.NE.0.0) GO TO 770
```

```
      WL1T=-999.
  770 IF(WR1T.NE.0.0) GO TO 771
      WR1T=-999.
  771 IF(WL2T.NE.0.0) GO TO 772
      WL2T=-999.
  772 IF(WR2T.NE.0.0) GO TO 773
      WR2T=-999.
  773 IF(IWALLT.EQ.1) GO TO 720
      WRITE(IP,804)IXS(K),IXSEC(K),WL1T,WR1T,WL2T,WR2T
  8C4 FCRMAT('0',9X,'SECTICN PROPERTIES FOR X-SEC ',A2,A4,1X,': WALLS AT
     1',4F7.0,' FOR ALL FLOWS')
      GC TO 721
  720 WRITE(IP,897)IXS(K),IXSEC(K),WL1T,WR1T,WL2T,WR2T
  897 FORMAT('0',9X,'SECTION PROPERTIES FOR X-SEC ',A2,A4,' ;WALLS AT ',
     14F7.0,' FCR FLOWS LE. LL BEACH')
      GC TO 721
  719 WRITE(IP,898)IXS(K),IXSEC(K)
  898 FCRMAT('0',9X,'SECTICN PROPERTIES FOR X-SEC ',A2,A4)
  721 WRITE(IP,8C5)
C     CCMPUTE PROPERTIES FOR X-SECTION USING AREA AND WIDTH
      DC 553 J=1,JF
      IF(A(J,K).LE.0.0) GC TO 345
      IF(WS(J,K).LE.0.0) GO TO 345
      D(J,K)=A(J,K)/WS(J,K)
      RH(J,K)=A(J,K)/WP(J,K)
      V(J,K)=QA(J)/A(J,K)
      WSBWP=WS(J,K)/WP(J,K)
      DBRH=D(J,K)/RH(J,K)
      DMAXD=DMAX(J,K)/D(J,K)
      F=WS(J,K)/D(J,K)
      GC TO 347
  345 WRITE(IP,346)
  346 FORMAT(' ',10X,'A OR WS = 0.0')
      GC TO 553
  347 IF(IQA(J).EQ.0)  GO TC 477
      IN=IQA(J)
      GC TO 478
  477 IN=20
  478 WRITE(IP,871)QA(J),W(J),NAME1(IN),NAME2(IN),A(J,K),WS(J,K),WP(J,K)
     1,D(J,K),RH(J,K),DMAX(J,K),V(J,K),WSBWP,DBRH,DMAXD,F
  871 FCRMAT(' ',7X,F8.0,F8.2,2X,2A4,2X,F8.0,2F6.0,6F6.2,F7.2,F7.1)
  553 CONTINUE
C     PRINT MESSAGE IF WALLS HAVE BEEN INSERTED AUTOMATICALLY
      IF(IPRIT.EQ.0) GO TO 450
      WRITE(IP,909)
  909 FCRMAT('0',10X,'NOTE: AT HIGH FLOWS WS. EL. WAS GT. FIRST AND/OR L
     1AST DATA POINTS IN X-SECT. DATA')
      WRITE(IP,910)
  910 FCRMAT(' ',16X,'WALLS HAVE BEEN AUTOMATICALLY PLACED AT BEGINNING
     1AND/OR END PCINTS')
  450 K=K+1
      GC TO 539
C     SUMMARY FOR THE REACH
  537 KNSEC=K-1
      CALL AANDCV(A,JF,KNSEC,AA,CVA)
```

```
      CALL AANDCV(WS,JF,KNSEC,AWS,CVWS)
      DO 560 J=1,JF
      IF(AA(J).LE.0.0) GO TO 560
      IF(AWS(J).LE.0.0) GO TO 560
      DA(J)=AA(J)/AWS(J)
      FFACT(J)=AWS(J)/DA(J)
      VM(J)=QA(J)/AA(J)
      VSTAR(J)=SQRT(32.2*DA(J)*SLOPE)
      VBVST(J)=VM(J)/VSTAR(J)
      TAU(J)=62.4*DA(J)*SLOPE
      AN(J)=1.49*DA(J)**0.667*SLOPE**0.50/VM(J)
      BEDF(J)=VM(J)**2/DA(J)
      SIDEF(J)=VM(J)**3/AWS(J)
      WIDEF(J)=AWS(J)/QA(J)**0.50
  560 CONTINUE
      WRITE(IP,700)
      WRITE(IP,701)
      WRITE(IP,807)INUM1,IREACH(1),IREACH(2),IREACH(3),IREACH(4),IREACH(
     15),IREACH(6),IREACH(7),IREACH(8),IREACH(9),IREACH(10),IWSC(1),IWSC
     1(2)
      WRITE(IP,820)INUM1,IDSUR(1),IDSUR(2),SURVSG
      WRITE(IP,823)BANKSG
      WRITE(IP,808)INUM1,INRC,IDAY,IMON,IYYRC,GAGEZ
C     GAGE ZERO IS NOT USED IN ANY OF THE COMPUTATIONS
      WRITE(IP,809)
      WRITE(IP,810)SR(1),QR(1),SR(2),QR(2),SR(3),QR(3),SR(4),QR(4),SR(5)
     1,QR(5),ICODER
      WRITE(IP,811)KNSEC,SLOPE
      IF(KNSEC.LE.10) GO TO 390
      WRITE(IP,898)(IXS(K),IXSEC(K),K=1,10)
  896 FORMAT(' ',10X,'X-SECTIONS USED: ',A2,A4,9(',',A2,A4))
      WRITE(IP,519)(IXS(K),IXSEC(K),K=11,KNSEC)
  519 FORMAT(' ',27X,A2,A4,9(',',A2,A4))
      GO TO 392
  390 WRITE(IP,896)(IXS(K),IXSEC(K),K=1,KNSEC)
  392 WRITE(IP,819)
      DO 171 J=1,JF
      IF(AA(J).LE.0.0) GO TO 438
      IF(AWS(J).LE.0.0) GO TO 438
      IF(IQA(J).EQ.0) GO TO 487
      IN=IQA(J)
      GO TO 488
  487 IN=20
  488 WRITE(IP,371) QA(J),S(J),NAME1(IN),NAME2(IN),AA(J),CVA(J),AWS(J),C
     1VWS(J),DA(J),FFACT(J),VM(J)
  371 FORMAT(' ',8X,F8.0,F7.2,2X,2A4,2X,F8.0,F7.2,F7.0,2F7.2,F7.1,F7.2)
      GO TO 171
  438 WRITE(IP,346)
  171 CONTINUE
      WRITE(IP,821)
      DO 87 J=1,JF
      IF(AA(J).LE.0.0) GO TO 439
      IF(AWS(J).LE.0.0) GO TO 439
      IF(IQA(J).EQ.0) GO TO 497
      IN=IQA(J)
```

```
      GC TO 498
  497 IN=20
  498 WRITE(IP,822)OA(J),NAME1(IN),NAME2(IN),VSTAR(J),VBVST(J),TAU(J),AN
     1(J),BEDF(J),SIDEF(J),WIDEF(J)
      GC TO 87
  439 WRITE(IP,346)
   87 CONTINUE
      WRITE(IP,870)(ICOM(I),I=1,18),ICOM19
  870 FCRMAT('0',10X,18A4,A3)
      IF(IPRITT.EQ.0) GO TO 907
      WRITE(IP,909)
      WRITE(IP,911)
  911 FORMAT(' ',16X,'WALLS HAVE BEEN AUTOMATICALLY PLACED FOR THE X-SEC
     1TIONS IN QUESTION')
  9C7 WRITE(IP,391)
  391 FCRMAT(' ',10X,'ALL UNITS ARE FT.-LB.-SEC. UNITS')
      GC TO 571
  565 WRITE(IP,815) J,K
  815 FCRMAT('1',10X,'ERRCR IN REACH OR X-SECT CODE:  J =',I3,' K =',I3)
      GC TO 475
  566 WRITE(IP,555)K,N
  555 FCRMAT('1',10X,'X VALUES ARE NOT IN ORDER:  K ='I3,' AND N =',I3)
      GC TO 475
  575 WRITE(IP,576)
  576 FCRMAT('1',10X,'RATING CURVE DATA ARE NOT IN ASCENDING ORDER')
      GC TO 475
  567 WRITE(IP,667)
  667 FCRMAT('1',10X,'DISCHARGE LESS THAN LOWEST POINT ON RATING CURVE')
      GC TO 475
  568 WRITE(IP,668) J,K,N
  668 FORMAT('1',10X,'ELEVATION OF Y = 0.0   J=',I3,'  K=',I3, ' N=',I3)
      GC TO 475
  569 WRITE(IP,669)
  669 FORMAT('1',10X,'NO STAGE GE. LIMITING STAGE (BANKSG)')
  475 READ(IR,427)ITEST
  427 FCRMAT(76X,A4)
      IF(ITEST.EQ.ISEND) GO TO 454
      IF(ITEST.EQ.IREND) GO TO 571
      GC TO 475
  6CC FCRMAT(I5,1CA4,2A4,2A4,2X,F5.2,F8.6,A4)
  6C1 FCRMAT(I5,10A4,4X,F8.2,F6.2,A4,A2,A3,I4,A4)
  6C2 FCRMAT(I5,5(F6.2,F7.0),A2,I4,A4)
  603 FCRMAT(I5,7(F7.0,I2),8X,A4)
  6C4 FCRMAT(I5,4CX,F8.2,4F5.0,I1,A2,A4)
  6C5 FCRMAT(I5,5(F6.0,F7.1),6X,A4)
  7C0 FORMAT('1')
  7C1 FCRMAT(//)
  8C0 FORMAT(' ',9X,'#',I5,2X,10A4,2X,'WATER SURVEY CODE: ',2A4)
  8C1 FCRMAT('0',9X,'CROSS-SECTION DATA FOR X-SECTION ',A2,A4,5X,'DATE O
     1F SURVEY:',1X,2A4)
  802 FORMAT(' ',9X,4X,'X',7X,'Y',1CX,'X',7X,'Y',10X,'X',7X,'Y',10X,'X',
     17X,'Y',10X,'X',7X,'Y')
  8C3 FCRMAT(' ',8X,5(F9.1,F8.1,2X))
  805 FCRMAT('0',9X,'FLOW    WS.EL.    CODE      AREA    WS    WP     DM
     1     RH  CMAX    VM    WS/WP DM/RH DMAX/DM WS/DM'/)
```

```
    807 FORMAT('0',9X,'#',I5,2X,10A4,2X,'WATER SURVEY CODE: ',2A4)
    808 FORMAT('0',9X,'#',I5,2X,'RATING CURVE: ',A4,2X,A2,A3,I4,': ','GAUG
       1E ZERO =',F8.2,' FT.')
    809 FORMAT('0',9X,'  STAGE     Q      STAGE     Q      STAGE     Q      S
       1TAGE     Q      STAGE     Q')
    810 FORMAT(' ',9X,5(F7.2,F8.0,1X),A2)
    811 FORMAT('0',9X,'SUMMARY FOR REACH: NUMBER OF X-SEC =',I5,5X,'SLOPE
       1FOR REACH =',F9.6,' FT/FT.')
    819 FORMAT('0',12X,'FLOW  STAGE      CODE       AREA    CVA     WS     CV
       1WS     DM    WS/DM     VM'/)
    820 FORMAT('0',9X,'#',I5,2X,'DATE OF SURVEY ',2A4,2X,'STAGE FOR SURVEY
       1 =',F8.2,' FT.')
    821 FORMAT('0',12X,'FLOW       CODE        V*      V/V*    TAU      N    V**2/
       1D V**3/WS WS/Q**.5'/)
    822 FORMAT(' ',8X,F8.0,2X,2A4,2X,2F7.2,2F7.3,2F7.2,F8.2)
    823 FORMAT(' ',24X,'        LIMITING STAGE FOR ANALYSIS =',F8.2,' FT.')
    454 WRITE(IP,700)
    455 STOP
        END
```

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```
      SUBROUTINE AANDCV(X,JT,KT,AX,CVX)
C     AANDCV = SUBROUTINE TO COMPUTE AVERAGE AND COEFFICIENT OF
C              VARIATION.
C     X      = INPUT MATRIX OF SIZE JT, KT.
C     JT     = TOTAL NUMBER OF DISCHARGES.
C     KT     = TOTAL NUMBER OF CROSS-SECTIONS9
C     AX     = OUTPUT VECTOR OF LENGTH JT.  EACH ELEMENT, J, IN AX CON-
C              TAINS THE AVERAGE OF THE VARIABLE X FOR THE KT CROSS-
C              SECTIONS FOR THE DISCHARGE J.
C     CVX    = OUTPUT VECTOR OF LENGTH JT.  EACH ELEMENT, J, IN AX CON-
C              TAINS THE COEFFICIENT OF VARIATION OF THE VARIABLE X FOR
C              THE DISCHARGE J.
      DIMENSION X(14,15),AX(14),CVX(14),SUMX(14),SUMXX(14)
      IF(KT.EQ.1) GO TO 2
      DO 1 J=1,JT
      SUMX(J)=0.0
      SUMXX(J)=0.0
    1 CONTINUE
      DO 3 J=1,JT
      DO 4 K=1,KT
      SUMX(J)=SUMX(J)+X(J,K)
      SUMXX(J)=SUMXX(J)+X(J,K)**2
    4 CONTINUE
    3 CONTINUE
      TK=KT
      DO 5 J=1,JT
      AX(J)=SUMX(J)/TK
      SDX=SQRT(ABS((SUMXX(J)-SUMX(J)*SUMX(J)/TK)/(TK-1.)))
      CVX(J)=SDX/AX(J)
    5 CONTINUE
      DO 8 J=1,JT
      DO 7 K=1,KT
      IF(X(J,K).LE.0.0) GO TO 9
    7 CONTINUE
      GO TO 8
    9 AX(J)=0.0
      CVX(J)=0.0
    8 CONTINUE
      GO TO 10
    2 AX(J)=X(J,K)
      CVX(J)=0.0
      IF(AX(J).GT.0.0) GO TO 10
      AX(J)=0.0
   10 RETURN
      END
```

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89 RC=0

```
      SUBROUTINE XPROP(DX,DY,DM,DN,J,K,WS,WP,DMAX,A)
C     XPROP = SUBROUTINE TO COMPUTE CROSS-SECTIONAL PROPERTIES.
C     DX    = INCREMENT IN  X  DIRECTION FOR ELEMENT CONSIDERED.
C     DY    = INCREMENT IN  Y  DIRECTION FOR ELEMENT CONSIDERED.
C     DM     = DEPTH FROM WATER SURFACE TO BED ON LEFT SIDE OF ELEMENT.
C     DN     = DEPTH FROM WATER SURFACE TO BED ON RIGHT SIDE OF ELEMENT.
C     J      = INDEX FOR DISCHARGE UNDER CONSIDERATION.
C     K      = INDEX FOR CROSS-SECTION UNDER CONSIDERATION.
C     WS     = WATER SURFACE WIDTH IN FEET.
C     WP     = WETTED PERIMETER IN FEET
C     DMAX  = MAXIMUM DEPTH IN FEET.
C     A      = CROSS-SECTIONAL AREA IN FT**2.
      DIMENSION WS(14,15),WP(14,15),DMAX(14,15),A(14,15)
      IF(DX.LE.0.0) GO TO 5
      WS(J,K)=DX+WS(J,K)
      WP(J,K)=SQRT(DX*DX+DY*DY)+WP(J,K)
      IF(DM.GT.DN) GO TO 1
      DMAXT=DN
      GO TO 2
    1 DMAXT=DM
    2 IF(DMAXT.GT.DMAX(J,K)) GO TO 3
      GO TO 4
    3 DMAX(J,K)=DMAXT
    4 A(J,K)=0.5*DX*(DM+DN)+A(J,K)
    5 RETURN
      END
```

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APPENDIX C

COMPARISON OF SURVEYED AND TOPOGRAPHIC SLOPES

C.1 Purpose

During the preparation of the data for this study, the following two questions were posed with regard to the measurement of the average slope of the water surface for a river reach:

1. How good an estimate is the topographic slope of the average field slope for the reach?
2. How good an estimate is the reach length as determined from an aerial photograph compared to the field measurement of the reach length?

These two questions were of importance, since in some cases there were no field measurements of slope and/or of reach length.

C.2 Relation between Topographic Slope and Average Field Slope

A topographic slope was obtained for all reaches which were not located on a local atypical feature, such as an old lake bottom or a small alluvial fan. When determining the topographic slope, the two contour intervals nearest the reach were used. In most cases the topographic slope was determined from a 1:50,000 map, and in a few cases a 1:250,000 map was used.

Average field slopes were obtained by drawing a line by eye through the surveyed water surface profile such that the area above and below the line were approximately equal. In some cases the water surface profile was adjusted to account for beaver dams or local atypical rapids.

The basic data for all reaches with topographic slopes and corresponding average field slopes are given in APPENDIX I. Only slopes less than 0.01 ft./ft. are presented, since the few higher slopes were associated with local atypical features such as small alluvial fans which could not be easily determined from topographic maps.

A plot of the field slope versus the topographic slope is presented in FIGURE C.1 for the 88 data points. No regression line is shown; however, the line for perfect agreement and the lines with a slope of 2.0 and of 0.50 are shown to give a visual impression of the magnitude of the deviations which might be expected when using the topographic slope when no field slope is available.

An analysis of the distribution of the percent differences between the topographic slopes and field slopes (based on the field slope) was carried out using three criteria:

1. All field slopes less than 0.010000 ft./ft.
2. All field slopes less than 0.002000 ft./ft.
3. All field slopes between 0.002001 and 0.010000 ft./ft.

The histograms of the distribution of the deviations are presented in FIGURE C.2. In all of the three categories over half of the deviations were in the range of ± 20 percent. From these results, the extreme deviations are primarily associated with the low slopes. For those cases where the percent difference was greater than 100 percent or less than -50 percent, slopes were smaller than 0.000550 ft./ft. From this simple analysis it is evident that topographic maps are probably less reliable for cases involving low slopes. One of the reasons for this is the great distance between contour lines on the

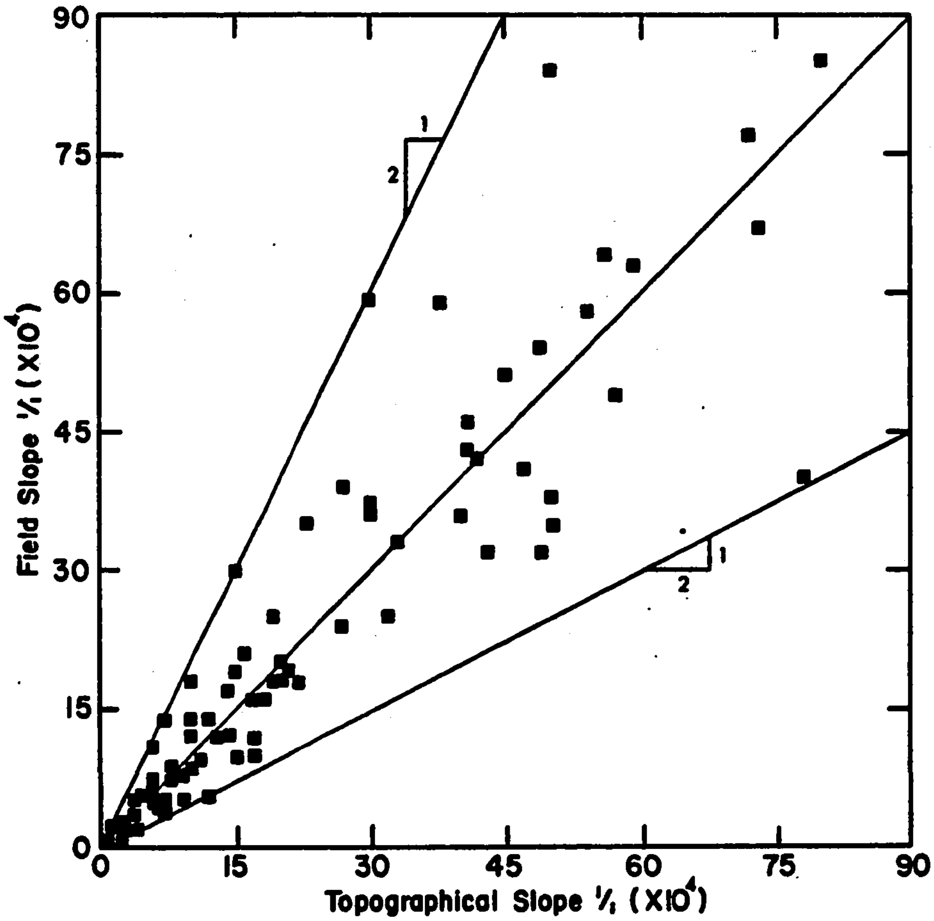


FIGURE C.1 FIELD SLOPE VERSUS TOPOGRAPHIC SLOPE

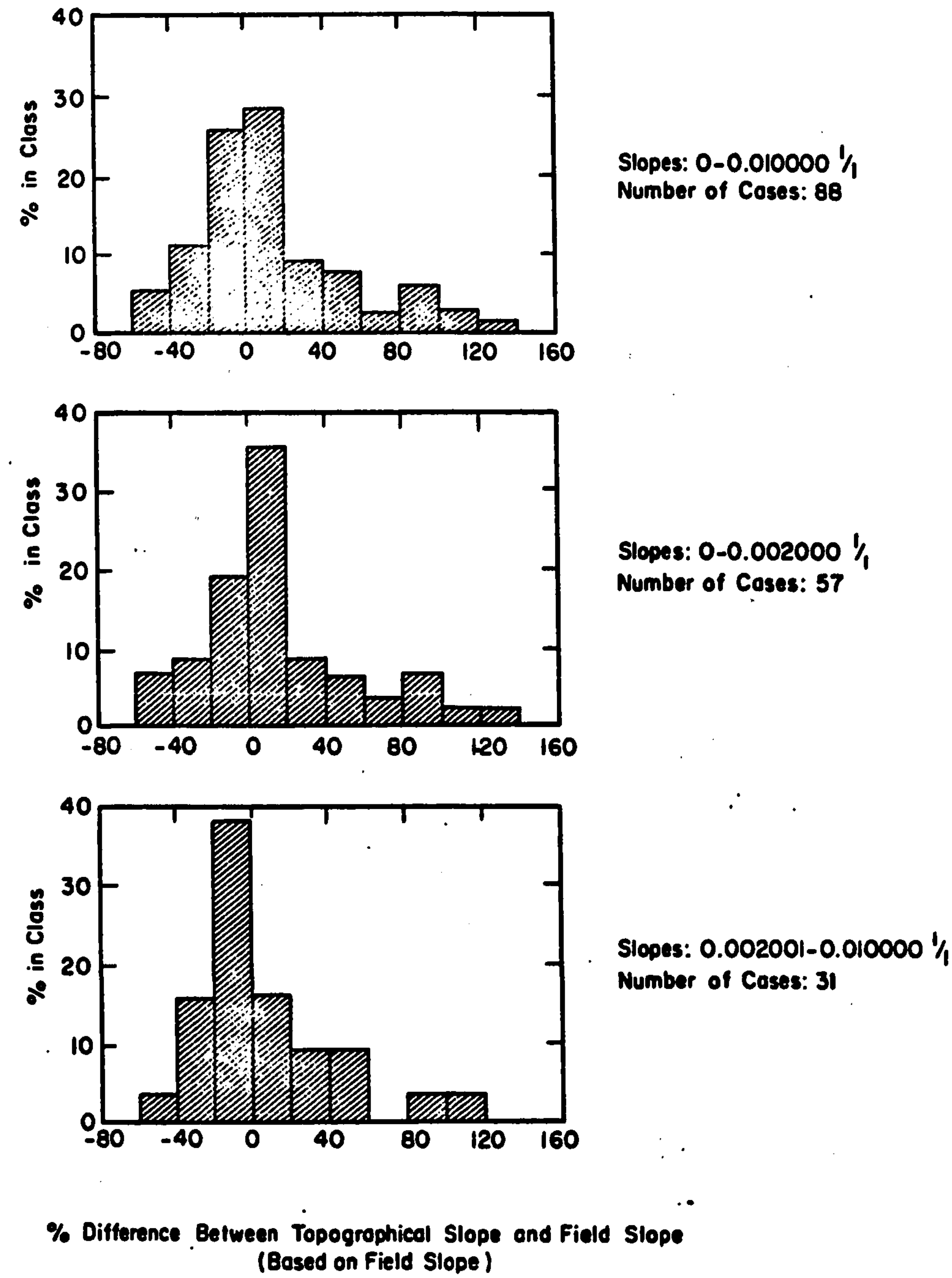


FIGURE C.2 DISTRIBUTION OF PERCENT DIFFERENCE BETWEEN TOPOGRAPHIC SLOPE AND FIELD SLOPE FOR THREE CLASSES OF SLOPES map. It is suggested that field slopes be taken in a closed-loop or by two independent sets of level lines, especially for those cases involving low slopes.

C.3 Comparison of Photo and Stadia Distances

Seventy-five reaches which had a stadia distance less than 36,000 feet were used to obtain a comparison between the reach length as determined by field measurements and as determined from aerial photographs. The length of the reach, that is, the distance between the first and last cross-section used in the slope analysis, were marked on the aerial photographs before or during the time of the field survey. All aerial photographs with the reach length marked on them were calibrated by using a 1:50,000 map. In most cases the photographs were of an approximate scale of 1" = 2640'. All data used in the analysis are presented in APPENDIX I.

When the field slopes were computed the stadia distance was used as the horizontal distance, since it was not known how precisely the first and last cross-sections in the field corresponded with the indicated locations on the aerial photographs. The purpose of this section is to investigate the maximum deviations which might be expected if the photo distance of the reach were used to compute the field slope.

FIGURE C.3 presents the results of a simple regression analysis between stadia distances in feet and photo distance in feet where the photo distance was considered to be the independent variable. The

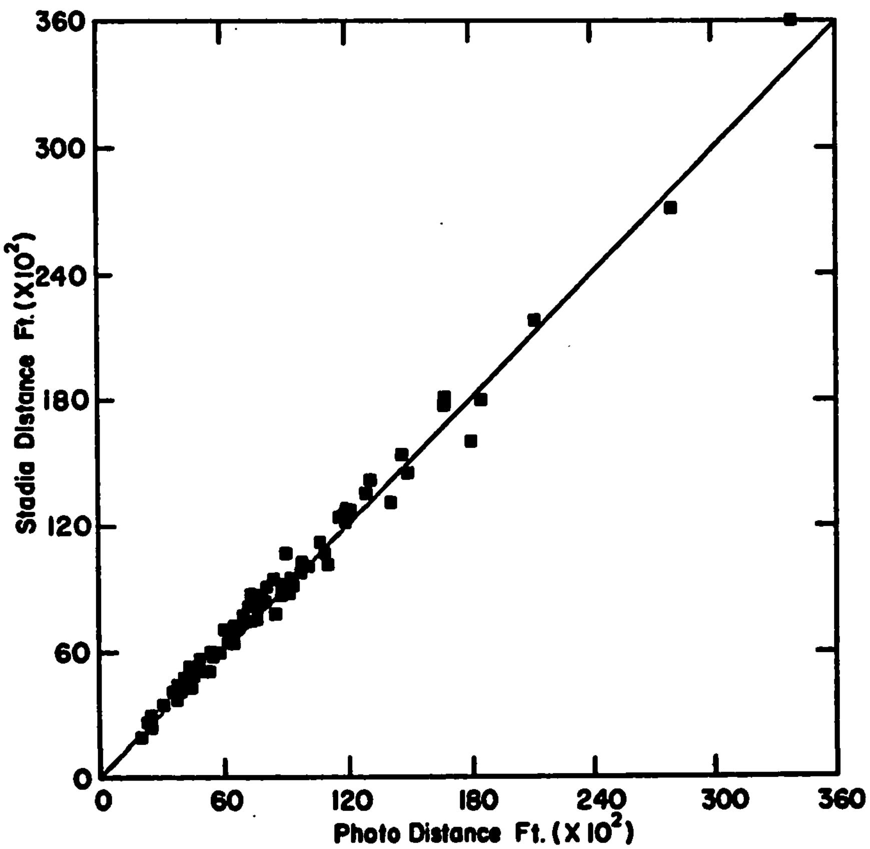


FIGURE C.3 STADIA DISTANCE VERSUS DISTANCE FROM AERIAL PHOTOGRAPHS resulting regression equation was:

$$\text{STADIA DIST. (ft.)} = 179 + 1.006 \ \text{PHOTO DIST. (ft.)}$$
$$r^2 = 0.99$$
$$\text{S.E.} = 606 \text{ ft.}$$

An analysis of the distribution of the percent deviations between photo distance and stadia distance based on stadia distances was carried out using three criteria:

1. All stadia distances less than 36,000 ft.
2. All stadia distances less than 7,500 ft.
3. All stadia distances between 7,500 and 36,000 ft.

The histograms of the distribution of the deviations are presented in FIGURE C.4. These histograms indicate that the greater deviations are associated with the shorter reaches. In all cases over one half of the deviations were less than ± 5 percent.

In the majority of cases, the stadia distances were greater than the photo distances. This is reasonable since it is often necessary to shoot diagonally across some channels, or at least to use a line of sight which is not exactly along the thalweg of the channel. Such a situation occurs quite often in the smaller meandering channels which are heavily vegetated on the banks. This observation is also in agreement with the results of the analysis, in that the maximum number of negative deviations occur for the shorter (smaller) reaches. Therefore, the slope for short reaches may be slightly underestimated by using the field stadia distance.

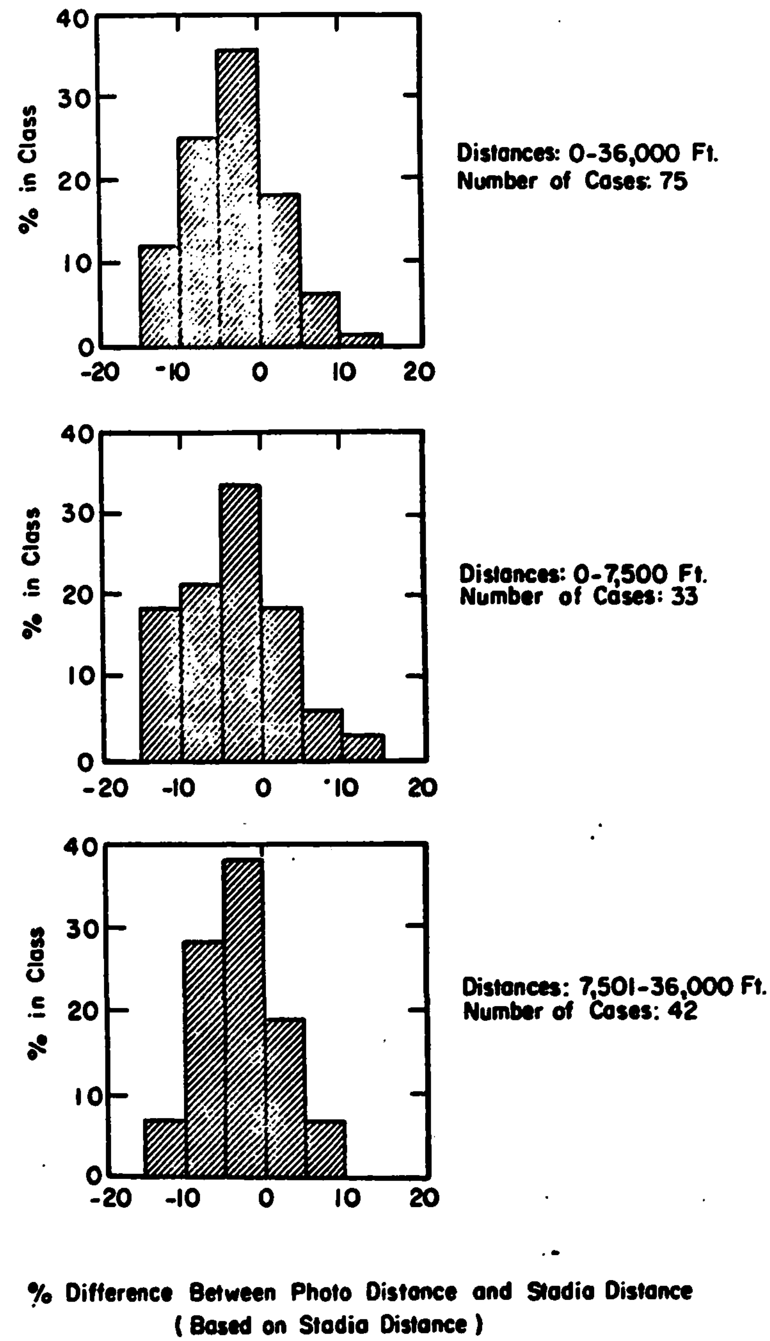


FIGURE C.4 COMPARISON OF PHOTO AND STADIA DISTANCES FOR THE DETERMINATION OF A REACH LENGTH FOR THREE CLASSES OF REACH LENGTHS

The cause for the random deviations is primarily due to the calibration of the photographs and the problem of precisely locating the cross-section in the field at the location indicated on the aerial photograph.

These results also indicate that the stadia distance may not be required for reaches in excess of two miles, if a deviation of less than 10 percent is acceptable.

C.4 <u>Summary</u>

This appendix has firstly evaluated the order of magnitude of deviations which might be expected if topographic slopes are used instead of field slopes. In this case, the maximum deviations occur for the smaller slopes and might be expected to be within the range of +100 percent and -50 percent (based on field slope). Secondly, the order of magnitude of the deviation which might be expected if calibrated aerial photograph distances are used instead of field measured stadia distances is in the range of ± 15 percent. The larger deviations were found to be associated with shorter reaches. Field slopes of short reaches based on stadia distance may be slightly underestimated in some cases.

APPENDIX D

BED MATERIAL SAMPLING AND ANALYSIS

This appendix outlines the procedure used to obtain bed material samples in the field, and indicates the type of analysis that was used in this investigation. A detailed example illustrating the documentation of a sampling site, and the computation and presentation of results for three sampling procedures is also given.

D.1 Location of the Sampling Site

D.1.1 Location of Sampling Sites for Gravel Rivers

The following order of priority was established for selecting sample sites for gravel rivers:

1. Near the upstream end of a mid-channel bar or island.
2. Near the upstream end of a point bar.
3. Near the upstream end of a side bar.
4. At the head of a riffle.

If a sample was not exposed or could not be readily obtained at the location of the highest priority, a sample site was selected at the location corresponding to the next highest priority.

One of the reasons for selecting the above four locations was that they contain material associated with the channel-forming process. It might be argued that the sample taken at the head of a riffle does not belong to this general class, since the riffle is a major factor controlling the slope. This may be true at low flows when the sample is usually taken, but at high flows the material is often transported over the riffle and becomes involved in the channel-forming process.

Another reason for establishing this order of priority was an attempt to sample from geomorphically similar locations. For example, rivers with pronounced point bars would be sampled at point bars, and channels with a distinct pool-and-riffle sequence would be sampled at the head of riffles.

The average to coarser material for the reach is found at these four locations. Therefore, the obviously finer material, usually associated with deposition during the recession of a flood, was not sampled.

The listed sampling locations were chosen because they were normally accessible during a field visit. It is almost impossible to sample gravel from a river bed if there is more than two feet of water over the surface to be sampled.

D.1.2 <u>Location of Sampling Sites for Sand-Bed Rivers</u>

In the same manner a priority for selecting sampling sites was established for sand-bed channels. The following order was used:

1. Near the center of the channel at a cross-over.
2. Near the upstream end of a point bar.

A sample at the cross-over gives a good indication of the material that is being transported at relatively low flows. Emphasis was placed on sampling near the center of the channel, since bank material is sometimes incorporated with the bed material near the edge of the channel. The material near the upstream end of the point bar often is somewhat coarser than that near the center of the channel, but it is relatively free of any local bank material.

D.2 Number and Type of Samples in the Reach

The number and type of samples for a given reach could not be rigidly defined in all cases. Criteria were established for this study, in order to provide reasonable guidelines for field work considering the time available and the necessity of obtaining an adequate evaluation of the bed material in the reach.

The reach referred to in this appendix varied in length from 10 to 50 channel widths. In most cases a hydrometric station was located near the center of the reach.

In many cases the best sampling sites could be located on the aerial photographs of the reach. Limited access or a limited number of acceptable sampling sites would often result in a compromise of the number and type of samples taken.

D.2.1 For Gravel Rivers with Exposed Bars

At least three acceptable sample sites were sought in the reach. If possible, these sites were located near the upper end, near the center, and near the downstream end of the reach. The following samples were taken depending upon the time available:

1. If the time was limited, one line grid sample was taken at each of the three or more sample sites in the reach. Two grid photographs were taken along each line grid.

2. If more time was available a volumetric sample was taken at one or two sample sites in order to provide data for the comparison of sampling methods. A second line grid sample was also taken at this site.

A detailed explanation of the complete sampling process for case 2 above is given in Section D.3.

D.2.2 For Gravel Rivers Without Exposed Bars

Gravel rivers without exposed bars usually implies a pool-and-riffle sequence with well-vegetated banks consisting of sand and silt. In such a case, three or more samples were obtained at the head of riffles by a stepping grid method. In a small stream it may be necessary to traverse the head of a riffle several times in order to obtain the required sample size. In a larger river it may not be possible to wade across the head of a riffle, in such a case the sample was taken over a portion of the riffle.

When obtaining a stepping grid sample, the particle selected was the one immediately under the big toe of the foot used to make the last step. The stone was located by moving the index finger vertically over the end of the boot at the big toe. Wolman (1954) discusses this technique in more detail. One stepping grid sample consisted of 50 stones.

D.2.3 For Sand-Bed Rivers

At least two bed material samples were taken at sites near the third points of the reach. If possible, the samples were taken near the center of the channel at a cross-over by using a Straub sampler. About two pounds of sand was obtained at each sampling site.

In addition to the bed material samples, one or more bank material samples were obtained for those cases where the bank was being built from the fines transported through the channel.

D.3 General Sampling Procedure in the Field

The detailed sampling procedure is given for the case of a gravel river with an exposed bar. The procedure along with the accompanying explanation is presented as follows:

1. A line grid sample was taken by stretching a survey tape out parallel to the direction of flow about five feet from the edge of the water on the exposed bar. Usually a 1 foot spacing was used to obtain the b-axes of 50 stones falling directly under the grid points. If two grid points fall on the same rock, the size was recorded twice. In most cases, however, the grid spacing was such that a rock would only be intersected by one grid point.

   If a sample point fell on sand that was more than a few millimeters deep or on a particle whose b-axis was less than 8 mm., the b-axis of the stone immediately under the sand or small particle was used. A note was made to indicate that such a procedure was followed (This situation occurred infrequently.)

   A record was made to indicate if a rock was angular or flat. A note was also made of any anomalous features observed during the sampling.

   If a bar was relatively small, more than one line was used in order to obtain the sample of 50.

   Figure D.1a illustrates a line grid on a bar, and Figure D.1b shows a measurement of the b-axis of a stone by means of a pair of calipers.

2. A photograph of the general area was taken to show the locality of the line grid sample. A sketch of the location of the site in the reach as well as a sketch of the cross-section at the sample site were made. A detailed sample description form was also filled out in the field.

3. Two grid photographs were taken along the line grid established in 1. The size of the grid spacing, the sample number, and the flow direction were indicated on each photograph. (A fifty millimeter square grid with 100 intersections was used in this study.)

a) Line grid on bar. Tape establishes the grid.

b) Measurement of the b-axis of a rock.

FIGURE D.1 ILLUSTRATIONS OF A LINE GRID ON A BAR AND OF THE MEASUREMENT OF A b-AXIS

The grid was placed to give a fair representation of the material along the line established in 1. The grid was placed with the bottom nearest to the water and parallel to the direction of flow. FIGURE D.2 illustrates the square grid in place on a gravel surface.

If a sieve analysis was to be carried out at the site, the boundary of the square grid was marked off at one of the locations along the line grid.

4. A volumetric sample of the surface and subsurface material was obtained from the location established in 3.

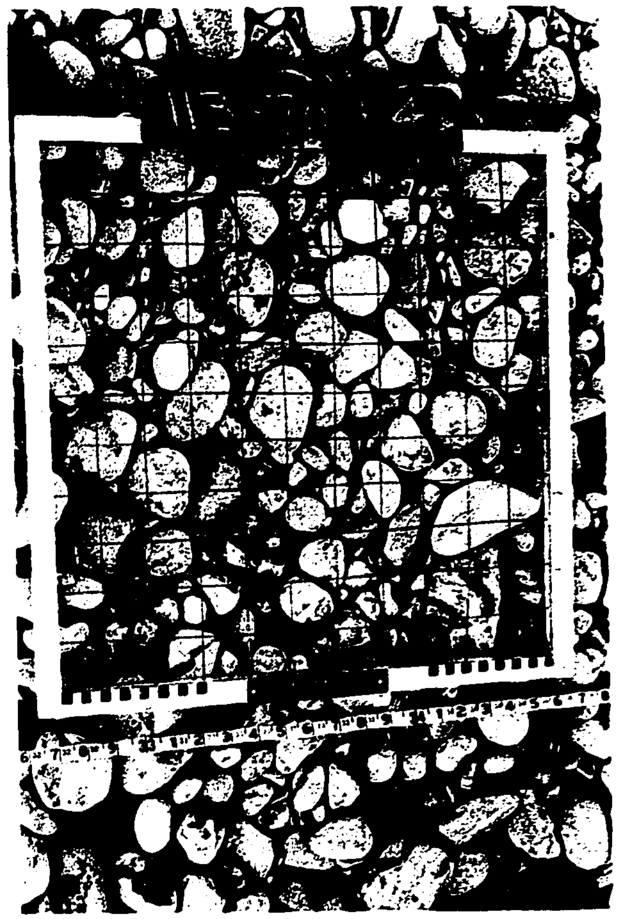
   The minimum size of the sample was dictated by the largest stone size in the material making up the sample. Approximate limits are given as follows:

Largest b-axis, mm.	Approx. size of sample hole, in.	Approx. weight, lb.
8	6 x 6 x 3	6
16	8 x 8 x 4	16
32	10 x 10 x 5	43
64	16 x 16 x 8	120
128	20 x 20 x 10	330
256	40 x 40 x 20	1860

The criteria for establishing the limits in the above table were:

1. The minimum weight for a sample of 8 mm. material should be 5 pounds.
2. The depth of the square sample hole should be at least twice the b-axis of the largest stone, and the width should be at least twice the depth of the hole.
3. The weight of the largest particle should not be more than about three percent of the total sample.

FIGURE D.3 shows the plotted data corresponding to these three criteria along with the enveloping line up to the 150 mm. size. The criteria established by the American Society for Testing and Materials (1967) for obtaining gravel samples for concrete aggregate (Test C136-67) is also shown on the plot. It is not practical to sieve gravel



NOTE:

- Sample number is 113-70-P4
- Direction of flow to right
- Bottom of grid closest to water edge

FIGURE D.2 GRID IN PLACE ON GRAVEL SURFACE FOR OBTAINING A GRID PHOTOGRAPH SAMPLE

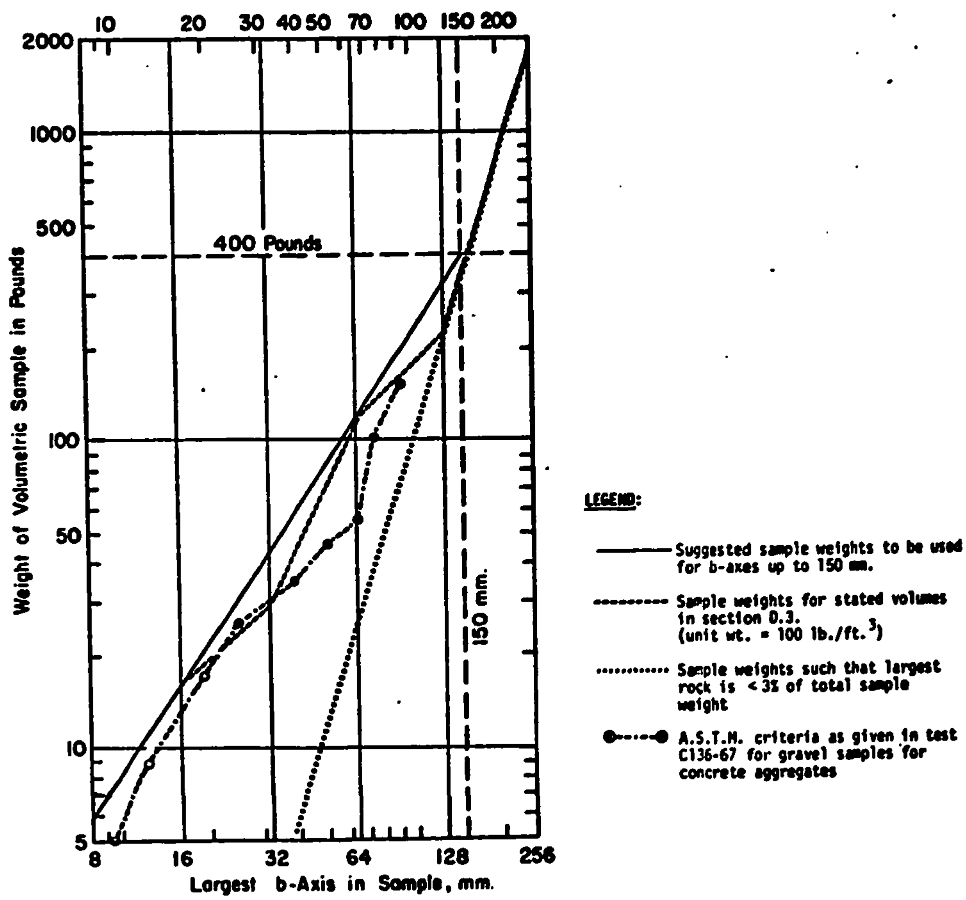


FIGURE D.3 GRAPH FOR ESTIMATION OF VOLUMETRIC SAMPLE SIZE in the field if the largest b-axis is in excess of 150 mm., since this requires a sample of over 400 pounds according to the above criteria.

D.4 Field Sieving Procedure for Gravels

The detailed procedure used in the field for sieving gravels was as follows:

1. One or more tarps or reinforced plastic sheets were placed on the gravel surface near the sample area. (All tarps were pre-weighed.)

2. The predetermined volume as given in Section D.3, was shovelled onto the tarps and allowed to air dry for ten or fifteen minutes. (A second line grid sample was usually taken parallel to and a couple of feet from the first line grid while the material was air drying.)

3. The tarp and the sample of material were weighed on a set of precalibrated spring scales to the nearest pound, or to at least two significant figures, whichever was more precise. (Three sets of scales with varying capacities were available in the field.)

4. As soon as the material was weighed, some of it was passed through the 8 mm. sieve onto another tarp. This material was representative of all fine material in the sample. About 5 pounds of the "pass 8 mm." material was placed in a marked plastic sample bag and tied. The sample bag and sample were weighed on a set of spring scales which would yield three significant figures.

   This sample was later used in the laboratory for the analysis of the "pass 8 mm." material. It also provided a means of computing the amount of water in the sample, since all the water was assumed to be associated with the material passing the 8 mm. sieve.

5. After the sample of the "pass 8 mm." material was obtained, all of the material on the tarps was passed through the 128, 64, 32, 16, and 8 mm. sieves.

   The sieving was best accomplished by placing the nest of sieves next to the stream and pouring water through the sieves while shaking. For large samples the sieving was done in stages.

After the sieving was complete, the material on each sieve was allowed to air dry.

6. While the material was drying, the b-axis of the largest stone was measured. The number of stones on the top one or two sieves was also recorded. The average lithology and shape of the material in each sieve size were noted.

7. After the sieved material was surface dry, the weight retained on each sieve was obtained to the nearest pound, or to at least two significant figures, whichever was the most precise.

8. The basic computations were checked in the field to ensure that the measured values were reasonable.

FIGURE D.4 shows six photographs depicting different aspects of the field sieving procedure used for gravels on exposed bars.

D.5 Laboratory Procedure for Sieving

The following laboratory procedure was used when sieving the material passing the 8 mm. sieve for gravels and is essentially the same as that used for sands:

1. If it was obvious that no moisture was lost from the sample bag, the "pass 8 mm." material was reweighed in the laboratory before the sample was opened. This served as a check on the field measurement.

2. The sample was allowed to air dry for a period of at least five days. At the end of this period, the entire sample was reweighed. The water content based on the air-dried weight of the sample was then computed.

3. The air-dried sample was prepared for sieving by breaking the material into individual particles. After this preparation, the sample was split to obtain a representative sample of about 500 grams for sieving (only about 200 grams was used for sands). The remainder of the sample was retained for future analysis, if necessary.

4. The sieve sample was weighed to the nearest 0.1 gram. The material was sieved on the following sieves for a period of 10 minutes: 5.66, 4.00, 2.83, 2.00, 1.41, 1.00, and 0.707 mm. The material passing the 0.707 mm. sieve was then sieved on the following sieves for a period of 10 minutes: 0.500, 0.354, 0.250, 0.177, 0.125, 0.088, and 0.063 mm. (These sieves have

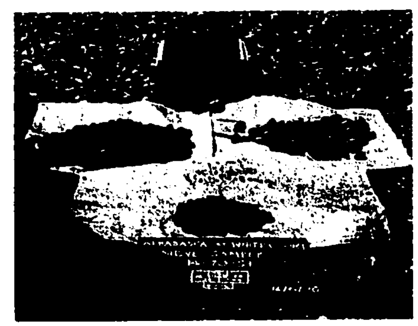
a) Sample placed on tarp(s)

b) Total sample weighed after some air-drying

c) Obtaining representative sample of pass 8 mm. material immediately after weighing total sample.

d) Weighing sample of pass 8 mm. material for laboratory analysis. (sample approximately 2500 gms.)

e) Field sieving material retained on the 8 mm. sieve.



f) Air-drying material retained on 8, 16, 32, and 64 mm. sieves before weighing in field.

FIGURE D.4 ILLUSTRATIONS OF THE FIELD PROCEDURE USED TO OBTAIN AND SIEVE A VOLUMETRIC SAMPLE square meshes at 1/2-phi intervals.) After sieving, the weight retained on each sieve was determined to the nearest 0.1 grams. The total weight of the material after sieving was determined as a check.

D.6 Analysis of Bed Material

After the bed material samples were obtained in the field, a linear dimension had to be assigned to each grain and the frequency distribution of the particles had to be determined. The distribution of the particles was usually established by weight or by number. The following sections outline the analysis used for the bulk sieve sample (surface and subsurface material), the line grid and stepping grid sample, and the grid photograph sample.

D.6.1 Bulk Sieve Analysis

The bulk sieve analysis used for a gravel sample is outlined as follows:

1. The moisture content of the "pass 8 mm." material obtained from the laboratory sample was used to determine the adjusted weight of the pass 8 mm. portion of the entire field sample. The assumption was made that the material greater than 8 mm. in the field sample was air dry.

2. The percent by weight of the material passing each "phi diameter" was computed. (That is the percent passing 256, 128, 64, 32, 16, 8, 4, 2, 1, 0.5, 0.25. 0.125, and 0.063 mm. sieves.)

3. The sample was analytically split at the 8 mm. size. The percent by weight finer than each "phi diameter" was computed for the "retain 8 mm." material. (That is, 256, 128, 64, 32, 16, 8 mm.) In a similar manner, the percent by weight finer than each "phi diameter" was computed for the "pass 8 mm." material. (That is, 8, 4, 2, 1, 0.5, 0.25, 0.125, and 0.063 mm.)

4. A grain size curve was plotted for each of the following cases: the entire sample, the material greater than 8 mm., the material finer than 8 mm. The D90, D84, D65, D50, D35, D16, and D10 sizes were obtained for each of the sieve curves and tabulated for the sample. (For sands, the same data was

obtained from a grain size curve using 1/2-phi plotting positions.)

D.6.2 Line Grid and Stepping Grid Analysis

Each line grid or stepping grid sample consisted of 50 stones whose b-axes were measured to the nearest millimeter in the field with a pair of calipers.

A computer program was written to analyse each sample by determining the largest and smallest stone size and the number of stones falling into "1/2 phi diameter" classes. The percent finer than any particular "1/2 phi diameter" was determined. By means of a linear interpolation using "phi units" the B90, B84, B85, B50, B35, B16, and B10 sizes were evaluated in "phi diameters" and converted to the nearest millimeter. The detailed write-up of the computer program used to carry out these computations is presented in APPENDIX E. This type of analysis was referred to as a grid-by-number analysis.

D.6.3 Grid Photograph Analysis

The photograph of the grid on the gravel surface was considered to be the field sample. After the field trip, it was necessary to assign a linear dimension to the stones in the grid photograph and to determine the frequency distribution of the stones. The detailed procedure that was used is given as follows:

1. The scale of the photograph was first computed. Any distortion in the photograph was accounted for by using the average dimension of the grid frame when determining the scale. Each grid intersection was assigned a number. (The grid used for this study had 100 grid intersections.)

2. A regular pattern was established for selecting the grid

intersections to be used when measuring the stones on the photographs. Twenty-five intersections were used from each of the two grid photographs taken at the sample site. The b-axis (assumed to be the smallest axis in the photograph) for each of the 50 stones under the assigned grid intersections were scaled from the photographs and converted to the actual size. (If the transparencies were used, the b-axes were determined from the projection of the transparency. In this case a scale of 1 to 1 or 2 to 1 was adopted.)

The following three cases were sometimes encountered when evaluating a grid photograph:

1. More than one assigned intersection occurred on one stone.

2. An assigned intersection was such that no particle was visible under the intersection because of a shadow or some other cause.

3. An assigned intersection was on sand or a particle with an actual b-axis less than (approx.) 8 mm.

In the first case, the stone diameter was repeated each time an assigned grid intersection fell on it. In the second case, a random number between 1 and 100 was selected. The b-axis used was the one under the grid intersection corresponding to the random number. The next stone to be scaled off the photograph was at the next assigned grid intersection. In the third case, the b-axis used was that for the first stone encountered by moving away from the grid point in a random direction. The next stone to be scaled off the photograph was at the next assigned grid intersection.

A note was made each time a random number or a random direction was used to determine the particle to be measured. (If too many such occurances were noted, the analysis was questioned or rejected.)

The sample obtained from the grid photograph in the above manner is theoretically identical to that obtained from the line grid.

3. The analysis was completed in the same manner as that used for the line grid sample, but was referred to as "grid-by-number from photograph".

D.7 An Example

The detailed presentation of the bed material analysis for one bar on the Crowsnest River near Frank, Alberta is given in this section. The order of presentation is as follows:

1. Description of Sample Site

    1. Sketch of site in plan and cross-section.
    2. Coding sheet for description of sample site and samples taken at site.
    3. A photograph of the bar that was sampled.

2. Grid-by-number Analysis

    1. Field data sheet for a sample of 50 b-axes.
    2. The analysis of the sample.

3. Grid-by-number from Photograph Analysis

    1. Grid photographs taken along the line grid used to obtain the line grid sample.
    2. Determination of the b-axes of the material from the two grid photographs.
    3. The analysis of the sample.

4. Bulk Sieve Analysis

    1. Field data sheet for the field sieving.
    2. Laboratory analysis of entire sample.
    3. Laboratory analysis of the portion finer than 8 mm.
    4. Grain size distribution.
    5. Summary giving the characteristic sizes for the entire sample, the portion < 8 mm., and the portion > 8 mm.

The following example is typical of the most complete analysis for one sampling site. In many cases the only data obtained were the field description of the sample site, and the grid-by-number analysis for gravel rivers. For sand-bed rivers, the data consisted of the description of the sample site and a bulk sieve analysis.

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RIVER DATA SHEET No.
DES 1/71

DESCRIPTION OF BED MATERIAL SAMPLING SITE, LOCATION IN CHANNEL

Reach Name: CROWSNEST RIVER AT FRANK, ALTA Reach No: 92

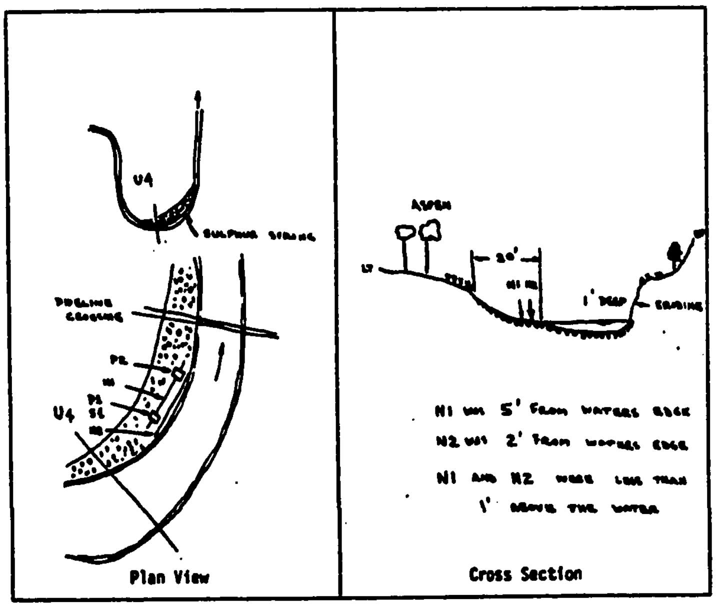
Description by: D. BRAY Date: 13, AUG, 1970

Samples obtained at site:

Sample numbers 92-70-N1*, 92-70-N2, 92-70-P1*, 92-70-S1*, ________

Note: Place an asterisk (*) by samples that are most compatible.

Sketch of sampling site



Comments: SAMPLES LOCATED ABOUT 100' D/S OF U4

FIGURE D.5 DESCRIPTION OF BED MATERIAL SAMPLING SITE

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RIVER DATA SHEET No. DES 2/71

DESCRIPTION OF BED-MATERIAL SAMPLING SITE, CODES

Sample No.	Type	Location to W.S.	Geomorphic Unit	Loc. on Geo. Unit	Lateral Location	Longitudinal Location	Direction	Pavement	Activity	Representa-tiveness	Particle Shape	Particle Lithology
92-70-N1	1	1 (1)	2	1	1	2	1	1	1	1	2	6,3
92-70-N2	1	1 (1)	2	1	1	2	1	1	1	1	2	6,3
92-70-P1	3	1 (1)	2	1	1	2	0	1	1	1	2	6,3
92-70-S1	4	1 (1)	2	1	1	2	0	1	1	1	2	6,3

NOTE: Use -1 for "unknown" and use multiple codes where necessary.

SAMPLE NO: Station - Year - Type - No.
(e.g.) 10 70 N 3
(10-70-N3)

TYPE: Grid-by-number = N
Photo = P
Sieve = S

Sample Type
1 tape grid
2 stepping (toe) grid
3 grid photo
4 sieve, including surface
5 sieve, excluding surface

Location in Relation to Water Surface
0 at edge of water
1 (n) n ft above water surface
2 (n) n ft below water surface

Geomorphic Unit
0 no particular feature
1 side bar
2 point bar
3 mid-channel bar
4 island
5 in pool
6 at riffle
7 at cross-over

Location on Geomorphic Unit
0 not applicable
1 near upstream end
2 near centre
3 near downstream end

Lateral Location in Channel
0 not applicable
1 near left bank
2 near left quarter point
3 near centre
4 near right quarter point
5 near right bank

Longitudinal Location
1 relatively straight reach
2 bend to left
3 bend to right

Direction of Linear Grid Samples
0 not applicable
1 parallel to flow
2 perpendicular to flow
3 (ϕ) at ϕ degrees to flow

Pavement Code
0 no apparent pavement
1 only fines removed from surface
2 obviously larger material at surface

Activity Code
0 no indication of recent movement
1 indication of recent minor movement
2 indication of recent major movement

Representativeness Code
0 not representative of site
1 estimated average for site
2 coarsest material at site
3 finer than average

Predominant Particle Shape
1 spherical and rounded
2 elongate and rounded
3 angular
4 platy

Predominant Particle Lithology
1 granite
2 gneiss
3 basalt
4 quartzite
5 slate
6 schist
7 limestone
8 dolomite
9 conglomerate
10 sandstone
11 shale
12

FIGURE D.6 CODES TO DESCRIBE BED MATERIAL SAMPLE AT A SAMPLING SITE

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RIVER DATA SHEET No.
DES 3/71

DESCRIPTION OF BED MATERIAL SAMPLING SITE, PHOTOGRAPHS

Reach Name: CROWSNEST RIVER AT FRANK, ALTA Reach No. 92

Photo by: D.I. BRAY Date 13 AUG, 1970

Photo Ref. No: RS-70-12-2

Comments: LOOKING DOWNSTREAM AT SAMPLE SITE.
NOTE: SCAR ON MOUNTAIN AT UPPER RIGHT DUE TO
"FRANK SLIDE"

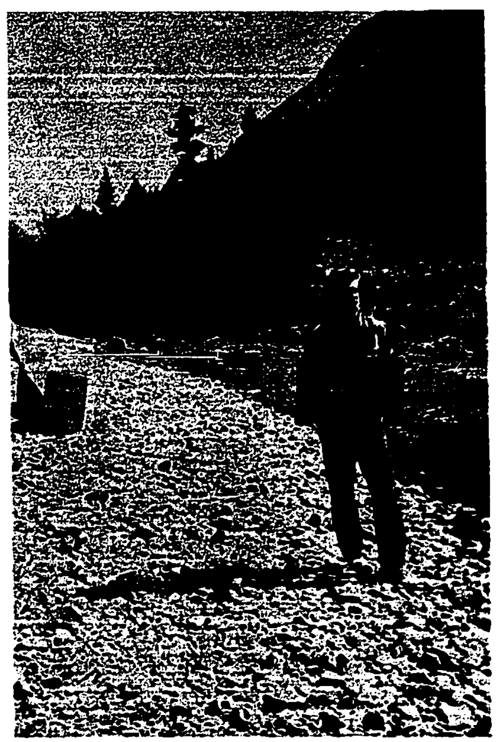

FIGURE D.7 PHOTOGRAPH OF BED MATERIAL SAMPLING SITE

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DEPARTMENT OF CIVIL ENGINEERING

RIVER DATA SHEET No: GBN 1/70

BED-MATERIAL DATA: GRID-BY-NUMBER

Reach Name: Crowsnest River at Frank, Alta Reach No: 92

Sample No: 92-70-M1 Date: 13 ; Aug ; 19 70

Sampled By: D. I. Bray Sample Method: Line Grid with Tape

Spacing: 1.0 ft. Minimum b-Axis: 8 mm.

Location: At head of point bar on left just D/S from U4

No.	b-Axis mm	Lithology and/or shape	No.	b-Axis mm	Lithology and/or shape
1	34	SS sandstone	26	32	LS
2	18	LS limestone	27	91	SS
3	12	SS	28	18	
4	70	SS	29	45	
5	39		30	78	
6	65		31	103	
7	15	LS	32	202	SS flat
8	11	flat	33	34	
9	40		34	17	
10	45	SS	35	20	SS
11	24	LS	36	71	
12	83	SS	37	13	
13	26	flat	38	64	
14	20	SS	39	16	LS
15	45	LS	40	94	
16	57	SS flat	41	8	
17	33	LS	42	57	LS
18	31		43	17	LS
19	53		44	26	
20	56	SS	45	8	
21	67		46	43	
22	19		47	64	
23	48		48	29	SS
24	23		49	35	LS
25	[illegible]		50	9	

Comments:

FIGURE D.8 DATA SHEET FOR A GRID-BY-NUMBER SAMPLE

SUMMARY OF GRID-BY-NUMBER ANALYSIS FOR BED MATERIAL SAMPLE 92-70-N1

SAMPLE SIZE = 50 (ALL VALUES ARE FOR B-AXIS MEASURED TO NEAREST MILLIMETER)

34.	18.	12.	70.	39.	65.	15.	11.	40.	45.	24.	82.	26.	90.	45.
57.	33.	31.	53.	56.	67.	19.	48.	23.	88.	39.	91.	18.	45.	78.
103.	202.	34.	17.	20.	71.	13.	64.	16.	94.	8.	57.	17.	26.	8.
43.	64.	29.	25.	9.										

CHARACTERISTIC SIZES

SIZE	PHI	B-AXIS
MINIMUM	3.00	8.
B10	3.67	13.
B16	4.07	17.
B25	4.39	21.
B35	4.75	27.
B50	5.20	37.
B65	5.65	50.
B75	6.08	67.
B84	6.30	79.
B90	6.45	87.
MAXIMUM	7.66	202.

SUMMARY OF STATISTICAL MEASURES BASED ON PHI VALUES

		PHI	(B-AXIS)
ARITHMETIC MEAN	=	5.14	(35.3)
MEDIAN (B50)	=	5.20	(36.8)
MODE	=	5.19	(36.4)
STANDARD DEVIATION	=	1.08	(2**PHI= 2.11)
(PHI84 - PHI16)/2	=	1.11	(2**PHI= 2.16)
COEF. OF SKEWNESS	=	-0.15	
COEF. OF KURTOSIS	=	2.60	

GRADATION COEF. BASED ON B-AXIS
TRASK SORTING COEF. = 1.79
GRADATION COEF.(SIGMA) = 2.16

SUMMARY OF DATA BY CLASS BOUNDS WHERE BOUNDS ARE IN MILLIMETERS

CLASS-LB	5.7	8.0	11.3	16.0	22.6	32.0	45.3	64.0
CLASS-UB	7.9	11.2	15.9	22.5	31.9	45.2	63.9	90.4
NC IN CL	0	4	3	7	7	10	5	10
NC LE UB	0	4	7	14	21	31	36	46
% LE UB	0.0	8.0	14.0	28.0	42.0	62.0	72.0	92.0

CLASS-LB	90.5	128.0	181.0
CLASS-UB	127.9	180.9	255.9
NC IN CL	3	0	1
NC LE UB	49	49	50
% LE UB	98.0	98.0	100.0

FIGURE D.9 GRID-BY-NUMBER ANALYSIS OF A BED MATERIAL SAMPLE

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RIVER DATA SHEET No.
GBN P1/70

BED MATERIAL ANALYSIS FROM PHOTOGRAPH

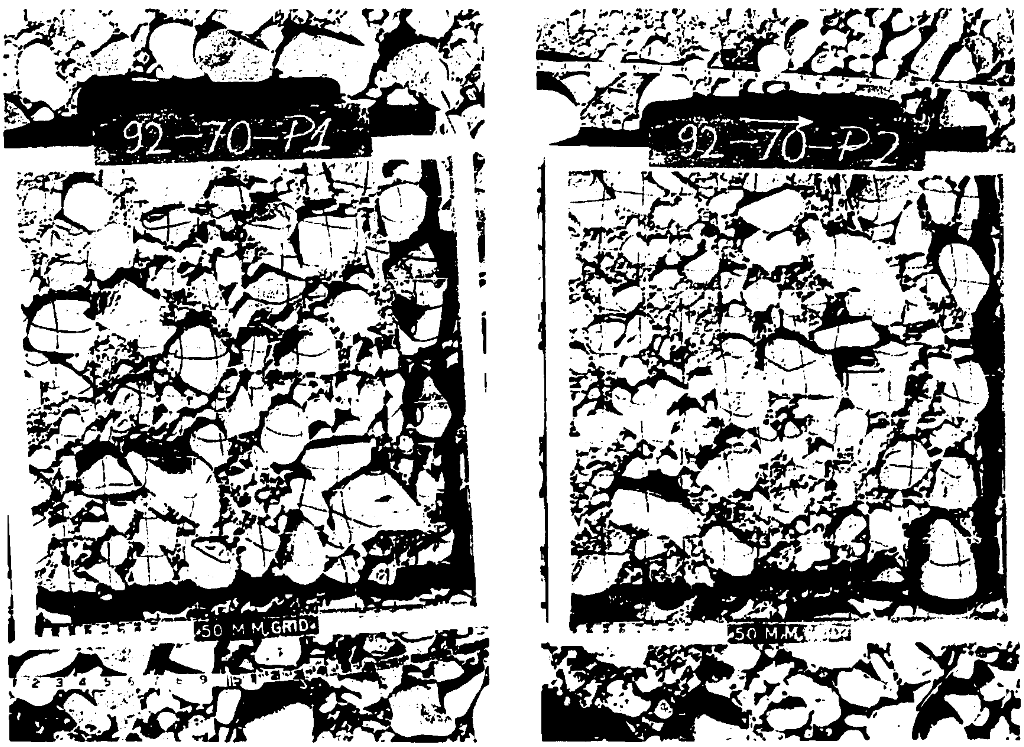
Reach Name CROWSNEST RIVER AT FRANK, ALTA Reach No. 92

Sample No. 92-70-P1\P2 Date 13 AUG 1970

Photo By D.I. GRAY Photo Ref. No. RS-70-12-3&4

Photo Grid 50 MILLIMETERS

Location AT HEAD OF POINT BAR ON LEFT JUST BELOW U4



Comments: SAMPLE 92-70-S1 TAKEN UNDER 92-70-P1

FIGURE D.10 PHOTOGRAPHS OF A GRAVEL SURFACE USED TO OBTAIN A GRID PHOTOGRAPH SAMPLE

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RIVER DATA SHEET No.
GBN P2/70

BED MATERIAL ANALYSIS: GRID-BY-NUMBER FROM PHOTOGRAPH

Sample No. 92-70-P1
450 mm in Field = 61.8 mm on Photo.
1 mm on Photo = 7.28 mm in Field.
No. 1 to 25 obtained from Sample.
Largest b-axis in Photograph
13.0 mm photo; 95 mm (actual)

No.	b-axis, mm Photo	b-axis, mm Actual	Rand. Code
1	2.0	15	
2	2.1	15	
3	4.0	29	
4	1.3	9	
5	1.5	11	
6	6.5	47	
7	8.8	64	
8	4.2	31	
9	7.8	57	
10	4.3	31	
11	3.8	28	
12	6.9	50	
13	9.0	66	
14	10.0	73	
15	2.8	20	
16	2.0	15	
17	10.0	73	
18	5.8	42	
19	9.0	66	
20	1.0	7	
21	2.6	19	
22	6.6	48	
23	1.3	9	
24	7.0	51	
25	10.5	77	

Sample No. 92-70-P2
450 mm in Field = 61.4 mm on Photo.
1 mm on Photo = 7.34 mm in Field.
No. 26 to 50 obtained from Sample.
Largest b-axis in Photograph
10.5 mm photo; 77 mm (actual).

No.	b-axis, mm Photo	b-axis, mm Actual	Rand. Code
1 (26)	7.2	53	
2 (27)	4.1	30	
3 (28)	6.1	45	
4 (29)	1.1	8	
5 (30)	5.0	37	↓
6 (31)	2.8	20	
7 (32)	1.2	9	←
8 (33)	5.9	43	
9 (34)	4.0	29	
10 (35)	3.2	23	
11 (36)	1.1	8	
12 (37)	3.2	23	↓
13 (38)	9.1	67	
14 (39)	7.3	54	
15 (40)	1.8	13	
16 (41)	1.6	12	→
17 (42)	2.0	15	
18 (43)	3.8	28	
19 (44)	1.0	7	←
20 (45)	7.6	56	
21 (46)	7.2	53	
22 (47)	2.0	15	
23 (48)	2.0	15	
24 (49)	3.8	28	
25 (50)	10.5	77	

Random Code: Give random direction used if predetermined intersection on sand (→)
Give random intersection used if rock at predetermined intersection is not visible

(Δ^{35})

FIGURE D.11 DATA SHEET FOR A GRID-BY-NUMBER FROM PHOTOGRAPH ANALYSIS

SUMMARY OF GRID-BY-NUMBER ANALYSIS FOR BED MATERIAL SAMPLE 92-70-P1&2

SAMPLE SIZE = 50 (ALL VALUES ARE FOR B-AXIS MEASURED TO NEAREST MILLIMETER)

15.	15.	29.	9.	11.	47.	64.	31.	57.	31.	28.	50.	66.	73.	20.
15.	73.	42.	66.	7.	19.	48.	9.	51.	77.	53.	30.	45.	8.	37.
20.	9.	43.	29.	23.	8.	23.	67.	54.	13.	12.	15.	28.	7.	56.
53.	15.	15.	28.	77.										

CHARACTERISTIC SIZES

SIZE	PHI	B-AXIS
MINIMUM	2.81	7.
B10	3.25	10.
B16	3.50	11.
B25	3.78	14.
B35	4.25	19.
B50	4.80	28.
B65	5.44	43.
B75	5.75	54.
B84	6.00	64.
B90	6.10	69.
MAXIMUM	6.27	77.

SUMMARY OF STATISTICAL MEASURES BASED ON PHI VALUES

	PHI	(B-AXIS)
ARITHMETIC MEAN =	4.76	(27.1)
MEDIAN (B50) =	4.80	(27.9)
MODE =	4.77	(27.3)
STANDARD DEVIATION =	1.07	(2**PHI= 2.09)
(PHI84 - PHI16)/2 =	1.25	(2**PHI= 2.38)
COEF. OF SKEWNESS =	-0.31	
COEF. OF KURTOSIS =	2.01	

GRADATION COEF. BASED ON B-AXIS
TRASK SORTING COEF. = 1.98
GRADATION COEF.(SIGMA) = 2.38

SUMMARY OF DATA BY CLASS BOUNDS WHERE BOUNDS ARE IN MILLIMETERS

CLASS-LB	5.7	8.0	11.3	16.0	22.6	32.0	45.3	64.0
CLASS-UB	7.9	11.2	15.9	22.5	31.9	45.2	63.9	90.4
NC IN CL	2	6	8	3	10	4	9	8
NC LE UB	2	8	16	19	29	33	42	50
% LE UB	4.0	16.0	32.0	38.0	58.0	66.0	84.0	100.0

FIGURE D.12 GRID-BY-NUMBER FROM PHOTOGRAPH ANALYSIS OF A BED MATERIAL SAMPLE

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RIVER DATA SHEET No. S1/70

SIEVE ANALYSIS OF BED MATERIAL IN FIELD

Reach Name: CROWSNEST RIVER AT FRANK, ALTA Reach No. 116
Sample No. 92-70-S1 Date: 13 ; AUG ; 1970 ; Sampled By: D.I. BRAY
Sample: Surface and Subsurface ✓ ; Surface ____ ; Subsurface ____.
Sample Condition: Submerged ____ ; Moist ✓ ; Dry ____.
Sample Size: Depth ≃ 10 ins.; Width ≃ 18 ins.; Length ≃ 18 ins.
Location: ON POINT BAR ON LEFT JUST D/S OF U4

Field Measurements
Total Weight of Sample + Tare: 105 + 133 = 238 lbs.
Weight of Tare: 1.6 + 1.6 = 3 lbs.
Total Weight of Sample: 235 lbs. (1)

Size Range, mm.	Material + Tare, lbs.	Tare, lbs.	Material, lbs.	Scale Used
> 256	–	–	–	–
128-256	–	–	–	–
64-128	49	1.6	47	LL
32- 64	67	1.6	65	LL
16- 32	43	0.8	42	LL
8- 16	27	0.8	26	LL
		Σ	180	(2)

Size Range, mm.	Lithology	Shape	Comment
> 256	–	–	–
128-256	–	–	–
64-128	S.S. and Conglomerate	Rounded	
32- 64	S.S. and Conglomerate	Rounded	
16- 32	S.S. and Limestone	Elongate & Rounded	Slightly Flattened
8- 16	Limestone	Elongate & Rounded	

Largest b-axis in Sample: = 118 mm.; No. of Rocks on Top Sieve = 27
Wt. of Total Sample: = 235 lbs. (1)
Wt. of Sample Retained on 8 mm.: = 180 lbs. (2)
Wt. of Sample Pass 8 mm. in Total Sample: = 55 lbs.
Wt. of Sample Pass 8 mm. for Laboratory: = 2310 gms.
(at least 2,500 gms.) = 5.1 lbs.
% of Pass 8 mm. Material in Sample for Laboratory: = 9.3 %

Comments: TAKEN UNDER 92-70-P1

FIGURE D.13 DATA SHEET FOR A BULK SIEVE ANALYSIS OF BED MATERIAL IN THE FIELD

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DEPARTMENT OF CIVIL ENGINEERING

RIVER DATA SHEET No. S3/70

LABORATORY ANALYSIS OF BED MATERIAL SAMPLE: PASS 8 MM MATERIAL

Sample No. 92-70-51 Site No. 92

Weight of Air-Dried Sample + Tare = 850.5 gms.
Weight of Tare # PC-20 = 88.3 gms.
Weight of Air-Dried Sample for Analysis = 762.2 gms.
(Minimum = 500 gms for gravels; 200 gms for sands.)

RESULTS OF SIEVING FOR PASS 8 MM MATERIAL ONLY

Sieve size mm.	Air-dry wt. retained + tare gms.	Weight of tare gms.	Air-dry weight retained gms.	% Total pass 8 mm retained	% Total pass 8 mm retained
5.66 *					
4.00	636.3	464.4	171.9	22.5	22.5
2.83	585.6	497.1	88.5	11.6	
2.00	523.6	457.5	66.1	8.7	20.3
1.41	474.6	422.8	51.8	6.8	
1.00	551.8	487.4	64.4	8.5	15.3
0.707	492.3	424.3	68.0	8.9	
0.500	490.9	414.3	76.6	10.1	19.0
0.354	470.4	387.6	82.8	10.9	
0.250	420.0	376.1	43.9	5.8	16.7
0.177	382.0	360.4	21.6	2.8	
0.125	355.1	346.6	8.5	1.1	3.9
0.088	356.1	351.0	5.1	0.7	
0.063	344.8	340.8	4.0	0.5	1.2
<0.063	380.0	372.7	7.3	1.0	1.0
Σ			760.5	99.9	

Check:

Total Air-Dry Weight After Sieving + Tare = 872.7 gms.
Weight of Tare # ________ = 111.6 gms.
Total Air-Dry Weight After Sieving = 761.1 gms.

* THE 5.66 MM SIEVE WAS NOT USED IN THIS ANALYSIS.

FIGURE D.15 DATA SHEET FOR THE SIEVE ANALYSIS OF A BED MATERIAL SAMPLE IN THE LABORATORY

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RIVER DATA SHEET No. S2/70

LABORATORY ANALYSIS OF BED-MATERIAL SAMPLE

Sample No.: 92-70-S1 Site No. 92

Analysis By: D. Gary, L. [illegible], C. [illegible] Date 26 Aug, 1970

If any Material Greater than 8 mm in Total Sample:

Weight of Sample of Pass 8 mm from Field = 2310 gms. (1)

Weight of Air-Dried Sample + Tare = 2174 gms.

Weight of Tare # = 0 gms.

Weight of Air-Dried Sample = 2174 gms. = 2174 gms. (2)

Weight of Water in Field Sample of Pass 8 mm = 136 gms. (3)

% Moisture in Pass 8 mm Material Based on Air-Dried Weight

$$= \frac{(3)}{(2)} \times 100\% = \frac{136}{2174} \times 100\% = 16.0\ \% \quad (4)$$

Total Dry Weight of Pass 8 mm Material in Total Field Sample

$$= \frac{(1) \times 100}{100 + (4)} = \frac{5500}{116} = 47.4 \text{ LB.} \quad (5)$$

Total Dry-Weight of Entire Sample

= Total Weight of Material Greater than 8 mm + (5)

= 180 LB + 47 LB = 227 LB. (6)

Distribution of Sizes:

Size range mm.	Wt. in range lb.	% based on total sample
128-256	—	—
64-128	47	20.7
32- 64	65	28.6
16- 32	42	18.5
8- 16	26	11.5
Σ	180	79.3 (7)

Size range mm.	% of Pass 8 mm. in range (a)	% based on total sample (b)
4 - 8	22.5	4.7
2 - 4	20.3	4.2
1 - 2	15.3	3.2
0.5 - 1	19.0	3.8
0.25 -0.5	16.7	3.5
0.125-0.25	3.9	0.8
0.063-0.125	1.2	0.3
< 0.063	1.0	0.2
Σ	99.9	20.7 (8)

(a) Copy last column of table on data sheet S3/70.
(b) Multiply the column to left with (5)/(6).

NOTE: Check computations as follows:

(8) = 100 x (5)/(6) 20.7 = 20.8 o.k.

(7) + (8) = 100 79.3 + 20.7 = 100 o.k.

FIGURE D.14 DATA SHEET FOR BULK SIEVE ANALYSIS OF BED MATERIAL

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RIVER DATA SHEET No: S4/70

SIEVE ANALYSIS OF BED MATERIAL

Reach: CROWSNEST RIVER AT FRANK, ALTA Station No: 92 Sample No: 92-70-S1

Location: NEAR HEAD OF POINT BAR JUST D/S OF X-SECTION U4

Comments:

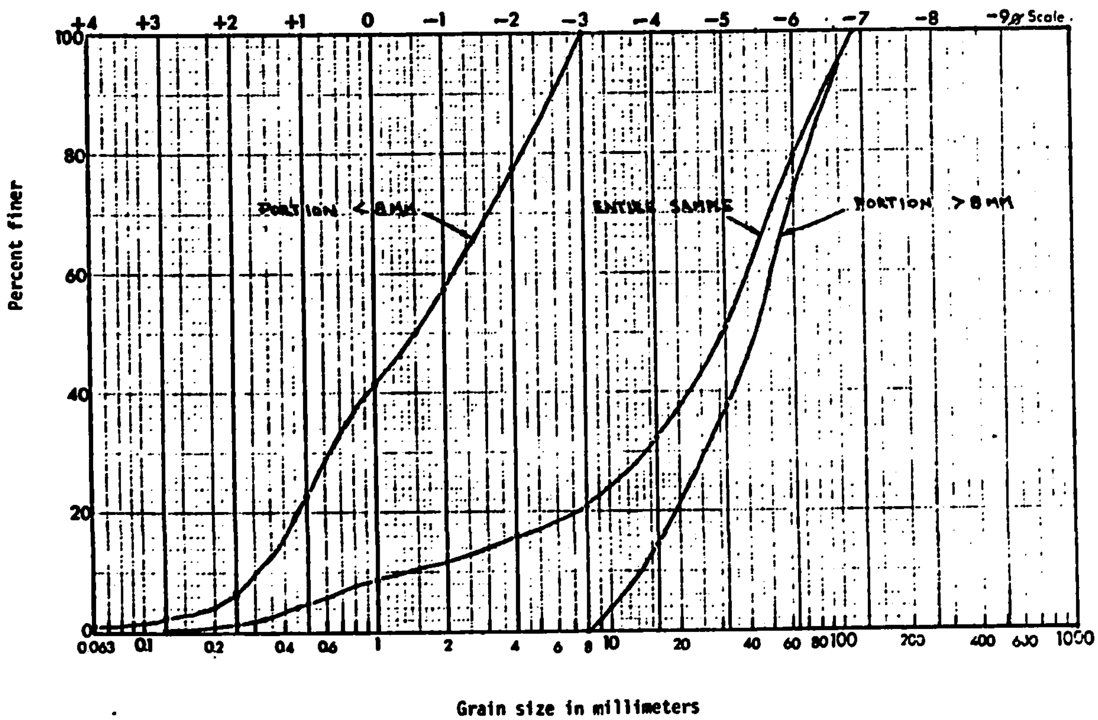

FIGURE D.16 GRAIN SIZE CURVE FOR THE ENTIRE SAMPLE, THE PORTION GREATER THAN 8 MM., AND THE PORTION LESS THAN 8 MM.

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RIVER DATA SHEET No. S5/70

SIEVE ANALYSIS OF BED MATERIAL SAMPLE, SUMMARY

Reach Name CROWSNEST RIVER AT FRANK Reach No. 92
Sample No. 92-70-SL

1. Entire Sample:

Range mm	% in Range	% Finer Than First #
512-1024	–	–
256- 512	–	–
128- 256	-	100.0
64- 128	20.7	79.3
32- 64	28.6	50.7
16- 32	18.5	32.2
8- 16	11.5	20.7

Range mm	% in Range	% Finer Than First #
4 - 8	4.7	16.0
2 - 4	4.2	11.8
1 - 2	3.2	8.6
0.5 - 1	3.8	4.8
0.25-0.5	3.5	1.3
0.125-0.25	0.8	0.5
0.0625-0.125	0.3	0.2
< 0.0625	0.2	Error= 0.0

2. Portion Greater Than 8 mm.

Range mm	% in Range	% Finer Than First #
512-1024	–	-
256- 512	–	-
128- 256	–	100.0
64- 128	26.2	73.8
32- 64	36.1	37.7
16- 32	23.3	14.4
8- 16	14.4	0.0
< 8	0.0	Error= 0.0

3. Portion Less Than 8 mm.

Range mm	% in Range	% Finer Than First #
4 - 8	22.5	77.5
2 - 4	20.3	57.2
1 - 2	15.3	41.9
0.5 - 1	19.0	22.9
0.25-0.5	16.7	6.2
0.125-0.25	3.9	2.3
0.0625-0.125	1.2	1.1
< 0.0625	1.0	Error= 0.1

Characteristic Sizes in Millimeters

Size	Portion < 8 mm	Entire Sample	Portion > 8 mm
d_{90}	6.0	86	90
d_{84}	5.0	72	80
d_{65}	2.6	44	54
d_{50}	1.5	31	43
d_{35}	0.74	18	30
d_{16}	0.40	4.1	17
d_{10}	0.30	1.2	13

FIGURE D.17 SUMMARY OF A FIELD AND LABORATORY SIEVE ANALYSIS OF A VOLUMETRIC BED MATERIAL SAMPLE

APPENDIX E

COMPUTER PROGRAM FOR GRID-BY-NUMBER ANALYSIS

E.1 Purpose

The grid-by-number analysis has been shown to be equivalent to a bulk sieve analysis of the surface population of a gravel river bed in CHAPTER 3 and also by Kellerhals and Bray (1971). Consequently, emphasis should be placed on the grid-by-number analysis when studying phenomenon related to the surface material in gravel rivers. A computer program has been written to provide a standard and objective grid-by-number analysis of a line grid sample, a stepping grid sample, or a grid photograph sample.

One indirect advantage of using a computer analysis is that all data obtained in the field are stored in a readily accessible manner. This provides an opportunity for easily analysing the data in one or more ways. For example, individual samples from one site may be analysed or several samples at one site may be combined for the analysis. It is even possible to obtain a "pooled sample" for a given river reach by combining all "representative" samples in the reach.

E.2 Parameters Computed

All bed material data obtained in the field are in millimeters. The analysis is based on "phi units" defined as the log to the base 2 of the b-axis in millimeters. (Conventionally, the "phi unit" is the negative value of the log, but in this analysis the positive value is used. No confusion should arise since the equivalent b-axis in millimeters is also given.) The b-axis in millimeters is referred to as "B" and after conversion to "phi units" the b-axis is referred to as "PHI".

A print-out of the analysis of a single bed material sample is presented in FIGURE E.1 and the analysis of a "pooled" sample is given in FIGURE E.2. A detailed explanation of all computed values in the analysis is given as follows:

1. Nine characteristic b-axes are given in "phi units" and in millimeters. In each case PHI(i) is the b-axis in "phi units" computed such that "i" percent of the stones in the sample are finer than this size. All characteristic sizes computed in this manner are also expressed in millimeters as B(i).

2. Three measures of central tendancy based on the "phi units" are computed.

    1. The arithmetic mean in "phi units". When the arithmetic mean is transformed to millimeters, it corresponds to the geometric mean of the sample.

    2. The median or PHI50 in "phi units". The equivalent b-axis, B50, in millimeters is also computed.

    3. The mode in "phi units". The mode is computed by fitting a parabola through the center of the peak of the histogram. The corresponding b-axis in millimeters is also computed.

3. Two measures of dispersion based on "phi units" are computed.

    1. The unbiased estimate of the standard deviation, s, in "phi units" based on the entire sample.

       A second form of dispersion based on the unbiased estimate of the standard deviation, s, is expressed as 2^s.

    2. The parameter σ defined as follows:

       $$\sigma = (PHI84 - PHI16)/2 \qquad \text{EQUATION E-1}$$

       This parameter is equivalent to the standard deviation for a phi-normal (log-normal) distribution (see FIGURE E.3). If the distribution of the sample is phi-normal, the unbiased estimate of the standard deviation is essentially

SUMMARY OF GRID-BY-NUMBER ANALYSIS FOR BED MATERIAL SAMPLE 12-70-N3

SAMPLE SIZE = 50 (ALL VALUES ARE FOR B-AXIS MEASURED TO NEAREST MILLIMETER)

59.	38.	19.	53.	52.	99.	76.	110.	143.	147.	107.	60.	41.	50.	70.
107.	34.	19.	34.	110.	15.	167.	36.	25.	163.	21.	20.	19.	36.	59.
77.	51.	126.	52.	81.	134.	120.	50.	89.	35.	73.	129.	102.	89.	75.
41.	42.	105.	33.	50.										

CHARACTERISTIC SIZES

SIZE	PHI	B-AXIS
MINIMUM	3.91	15.
B10	4.40	21.
B16	5.05	33.
B25	5.27	39.
B35	5.53	46.
B50	5.90	60.
B65	6.34	81.
B75	6.64	100.
B84	6.89	119.
B90	7.06	134.
MAXIMUM	7.38	167.

SUMMARY OF STATISTICAL MEASURES BASED ON PHI VALUES

		PHI	(B-AXIS)
ARITHMETIC MEAN	=	5.88	(58.8)
MEDIAN (B50)	=	5.90	(59.7)
MODE	=	5.50	(45.3)
STANDARD DEVIATION	=	0.93	(2**PHI= 1.90)
(PHI84 - PHI16)/2	=	0.92	(2**PHI= 1.89)
COEF. OF SKEWNESS	=	-0.31	
COEF. OF KURTOSIS	=	2.40	

GRADATION COEF. BASED ON B-AXIS
TRASK SORTING COEF. = 1.60
GRADATION COEF.(SIGMA) = 1.89

SUMMARY OF DATA BY CLASS BOUNDS WHERE BOUNDS ARE IN MILLIMETERS

CLASS-LB	11.3	16.0	22.6	32.0	45.3	64.0	90.5	128.0
CLASS-UB	15.9	22.5	31.9	45.2	63.9	90.4	127.9	180.9
NC IN CL	1	5	1	10	10	8	9	6
NC LE UB	1	6	7	17	27	35	44	50
% LE UB	2.0	12.0	14.0	34.0	54.0	70.0	88.0	100.0

FIGURE E.1 EXAMPLE OF THE COMPUTER PRINT-OUT FOR THE GRID-BY-NUMBER ANALYSIS OF A SINGLE SAMPLE OF 50

SUMMARY OF GRID-BY-NUMBER ANALYSIS FOR THE FOLLOWING 3 BED MATERIAL SAMPLES

21-70-N3. 21-70-N4. 21-70-N5.

SAMPLE SIZE = 150 (ALL VALUES ARE FOR B-AXIS MEASURED TO NEAREST MILLIMETER)

55.	41.	40.	67.	42.	40.	138.	92.	23.	13.	63.	37.	18.	13.	47.
66.	76.	117.	43.	61.	53.	122.	138.	11.	49.	59.	51.	38.	14.	29.
27.	103.	100.	58.	78.	18.	24.	57.	113.	60.	34.	64.	97.	47.	69.
52.	29.	52.	72.	64.	50.	54.	16.	41.	17.	22.	15.	61.	19.	61.
26.	19.	23.	48.	46.	12.	19.	31.	26.	27.	27.	13.	53.	34.	41.
34.	27.	24.	18.	19.	17.	26.	20.	22.	19.	19.	14.	21.	34.	31.
11.	40.	10.	16.	10.	34.	39.	12.	14.	29.	20.	34.	45.	52.	28.
40.	49.	37.	26.	31.	61.	71.	26.	26.	44.	24.	49.	38.	96.	39.
45.	22.	83.	49.	66.	65.	69.	41.	23.	69.	30.	37.	83.	55.	26.
69.	39.	16.	48.	41.	73.	92.	76.	33.	48.	89.	33.	39.	106.	77.

CHARACTERISTIC SIZES

SIZE	PHI	B-AXIS
MINIMUM	3.32	10.
B10	4.05	17.
B16	4.27	19.
B25	4.59	24.
B35	4.89	30.
B50	5.27	39.
B65	5.65	50.
B75	5.91	60.
B84	6.20	74.
B90	6.43	86.
MAXIMUM	7.11	138.

SUMMARY OF STATISTICAL MEASURES BASED ON PHI VALUES

		PHI	(B-AXIS)
ARITHMETIC MEAN	=	5.23	(37.5)
MEDIAN (B50)	=	5.27	(38.7)
MODE	=	5.37	(41.5)
STANDARD DEVIATION	=	0.88	(2**PHI= 1.84)
(PHI84 - PHI16)/2	=	0.96	(2**PHI= 1.95)
COEF. OF SKEWNESS	=	-0.13	
COEF. OF KURTOSIS	=	2.47	

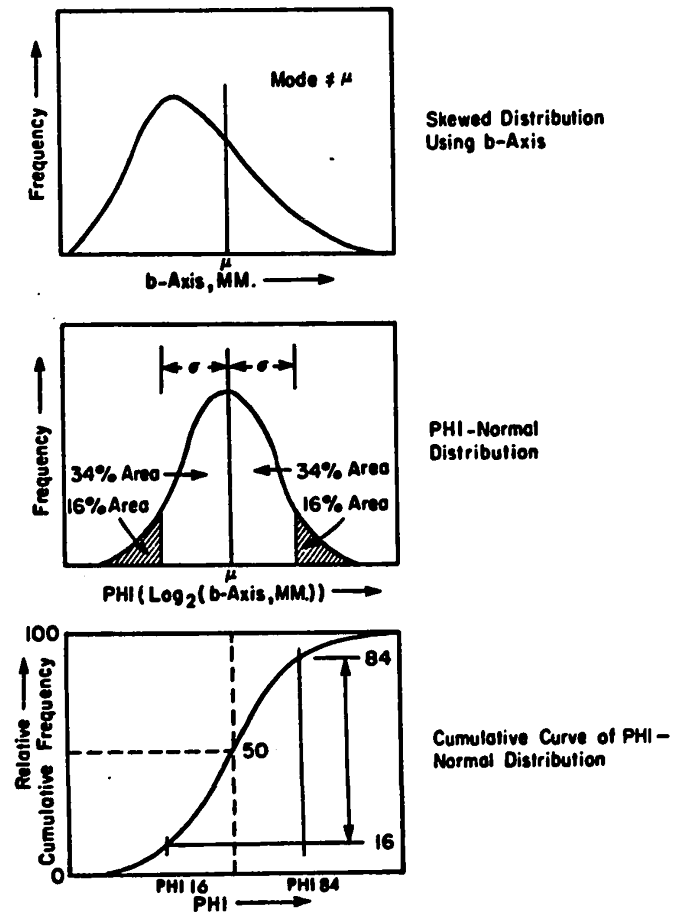
GRADATION COEF. BASED ON B-AXIS
TRASK SORTING COEF. = 1.58
GRADATION COEF.(SIGMA) = 1.95

SUMMARY OF DATA BY CLASS BOUNDS WHERE BOUNDS ARE IN MILLIMETERS

CLASS-LB	8.0	11.3	16.0	22.6	32.0	45.3	64.0	90.5
CLASS-UB	11.2	15.9	22.5	31.9	45.2	63.9	90.4	127.9
NC IN CL	4	9	20	25	31	29	20	10
NC LE UB	4	13	33	58	89	118	138	148
% LE UB	2.7	8.7	22.0	38.7	59.3	78.7	92.0	98.7

CLASS-LB	128.0
CLASS-UB	180.9
NC IN CL	2
NC LE UB	150
% LE UB	100.0

FIGURE E.2 EXAMPLE OF THE COMPUTER PRINT-OUT FOR THE GRID-BY-NUMBER ANALYSIS OF THREE "POOLED" SAMPLES OF 50 EACH



σ = Standard Deviation = (PHI 84 - PHI 16)/2

Note: $\sqrt{\frac{B84}{B16}} = 2^{\sigma}$

FIGURE E.3 MEASURES OF SAMPLE DISPERSION identical to this parameter.

A second form of this parameter based on b-axes in millimeters is computed as: $(B84/B16)^{0.500}$. This is equal to 2^{σ} for a phi-normal distribution.

4. The unbiased estimate of the coefficient of skewness is computed from the "phi" diameters. If the sample is distributed as phi-normal, the value of this coefficient is 0.0. Therefore, this parameter provides a measure of the deviation of the sample distribution from phi-normal.

5. The unbiased estimate of the coefficient of kurtosis is computed from the "phi" diameters. If the sample is distributed as phi-normal, the value of this coefficient is 3.0. This parameter is a measure of the peakedness of the distribution. Since the computation of this coefficient involves the fourth moment, the computed value should be interpreted with caution.

6. Two widely accepted gradation coefficients are computed. Both coefficients are based on characteristic b-axes in millimeters.

   1. The Trask Sorting Coefficient.
   This coefficient has been commonly used by geologists to describe the gradation of a sample and is defined as:

   $$\tau = (B75/B25)^{0.500} \qquad \text{EQUATION E-2}$$

   It would be more meaningful if this parameter were called a gradation coefficient, because a sorting coefficient should imply that good sorting is associated with a high value. In this case good sorting is associated with a low value of the coefficient.

   If the "phi diameters" are used, the coefficient is defined as:

   $$\tau \, PHI = (PHI75 - PHI25)/2 \qquad \text{EQUATION E-3}$$

   This form of the coefficient is similar to that used for the sample dispersion. However, the PHI25 and PHI75 sizes do not have the statistical significance of the PHI16 and PHI84 sizes. This later form, τ PHI is not computed.

   2. The Gradation Coefficient, σ_g .
   This coefficient has been used extensively in recent engineering literature (Simons and Richardson (1965)). The coefficient is defined as:

   $$\sigma_g = \frac{1}{2}\left[\frac{B84}{B50} + \frac{B50}{B16}\right] \qquad \text{EQUATION E-4}$$

If a sample is distributed as phi-normal, the value of this parameter is identical to the dispersion coefficient, 2^{σ} , where σ is defined by EQUATION E-1. If the distribution is skewed, the value of σ_g is a slightly better measure of the dispersion than 2^{σ}, since it is a weighted value by considering B50 as well as B16 and B84.

The log of σ_g to the base 2 is equivalent to the standard deviation of the sample in "phi units" if the sample is distributed as phi-normal.

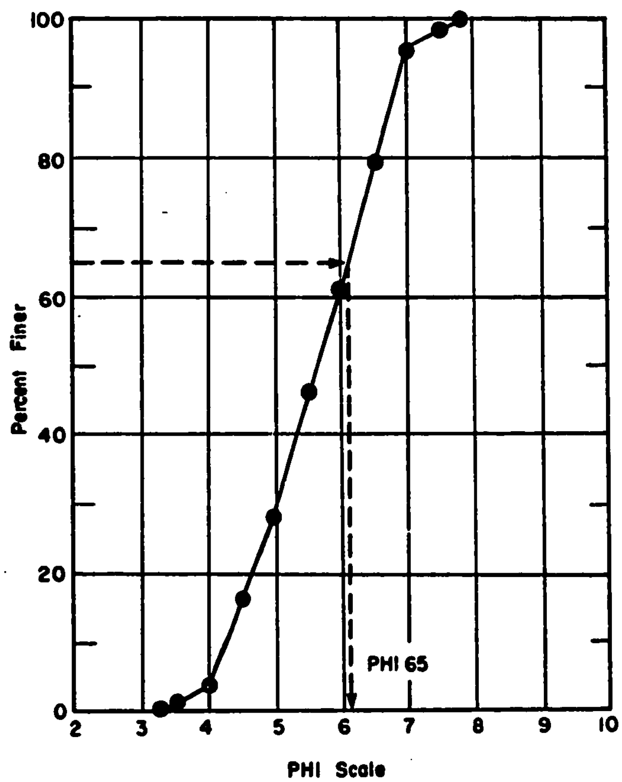
7. A summary of the number of stones falling into one-half phi class intervals is presented along with the cumulative number and cumulative percent of the stones finer than the lower bound of each class interval.

Using this analysis, most of the parameters required to characterize the sample may be obtained.

E.3 Method of Computation

This section will only consider the method used to compute the characteristic sizes which are determined from the sample. The procedure that was used is given as follows:

1. All b-axes were transformed from the millimeter to "phi units".
2. The maximum and minimum phi sizes were determined.
3. The cell sizes were computed using an interval of one-half phi unit. (e.g. 2.000 - 2.4999, 2.500 - 2.999, etc.).
4. The transformed b-axes were sorted into the correct class interval.
5. The number and percent of stones finer than the lower class bound of each size interval were determined.
6. The nine characteristic sizes PHI90, PHI84, PHI75, PHI65, PHI 50, PHI35, PHI25, PHI16 and PHI10 were obtained by linear interpolation. The smallest and the largest stones were used as the zero and 100 percent finer sizes. FIGURE E.4 illustrates the interpolation technique.
7. The b-axes in millimeters, B, corresponding to the characteristic PHI sizes were computed.



Note: PHI = Log (b-Axis in Millimeters)

Example: PHI 65 = 6.12 (from Linear Interpolation)

B 65 = $2^{6.12}$

= 69 Millimeters

FIGURE E.4 METHOD USED TO OBTAIN A CHARACTERISTIC SIZE

E.5 The Program and an Example of the Data Card Set-Up

The program was written in Fortran IV and processed by Michigan Terminal System (MTS) by using the Fortran IVG Compiler on the IBM 360-67 computer at the University of Alberta Computing Center. The listing of the program is presented on the following pages.

A listing of the control cards and data cards are presented at the end of the listing. It is noted that the sample data should be coded in a continuous sequence. The first number (col 1-4) on any sample card should never be zero. The data for a run are arranged in the following order:

1. First data set. A data set may consist of a maximum of 15 cards of data using from 1 to 5 samples. Each sample must have at least 18 b-axes.
2. One blank card at the end of first data set.
3. Second data set.
4. One blank card at the end of second data set, etc. ...
5. Last data set.
6. Two blank cards at the end of last data set.

A larger number of samples or a larger sample size in a data set may easily be accomodated by changing the appropriate dimension statements.

```
C
C     ******************************************************************
C
C     GRID-BY-NUMBER ANALYSIS FOR BED MATERIAL DATA  - D. I. BRAY - 1970
C
C     ******************************************************************
C
C     THIS PROGRAM WAS DESIGNED TO READ IN DATA FOR A GRID-BY-NUMBER
C        ANALYSIS.  THE BASIC INPUT DATA IS ANALYSED, SUMMARIZED AND
C        PRINTED OUT IN TABULAR FORM.
C
C     THE DIMENSION STATEMENT FOR AN INDIVIDUAL SAMPLE WILL HAVE TO BE
C        CHANGED TO ACCOMODATE A SAMPLE LARGER THAN 255.
C
C     NOTE: THE READ IN FORMAT IS FIXED AS OUTLINED IN THE SUBROUTINE
C        READD.
C     MAIN PROGRAM
      DIMENSION D(280)
      IP=6
      DIMENSION NAME1(6),NAME2(6),NAME3(6)
      DIMENSION ECF(16),ECLF(16),CUB(16),TNCUB(16),NCUB(16)
      DIMENSION PHI(17),CPF(17),PC(16),PHIU(16),BAXIS(16)
      DIMENSION CPL(16),CMML(16),CMMU(16),NCUM(16)
  561 CALL READD(D,NT,NAME1,NAME2,NAME3,NSAMP,IENDT)
      IF(IENDT.EQ.1) GO TO 503
C     D     = THE B-AXIS IN MILLIMETERS
      WRITE(IP,998)
  998 FORMAT('1',///)
      IF(NSAMP.EQ.1) GO TO 901
      GO TO 902
  901 WRITE(IP,755)NAME1(1),NAME2(1),NAME3(1)
  755 FORMAT('0',20X,'SUMMARY OF GRID-BY-NUMBER ANALYSIS FOR BED MATERIA
     1L SAMPLE ',3A4)
      GO TO 903
  902 WRITE(IP,347)NSAMP
  347 FORMAT('0',10X,'SUMMARY OF GRID-BY-NUMBER ANALYSIS FOR THE FOLLOWI
     1NG',I4,'  BED MATERIAL SAMPLES')
      WRITE(IP,756)(NAME1(IN),NAME2(IN),NAME3(IN),IN=1,NSAMP)
  756 FORMAT('0',20X,5(3A4,',  '))
  903 WRITE(IP,780) NT
  780 FORMAT('0',10X,'SAMPLE SIZE =',I5,'    (ALL VALUES ARE FOR B-AXIS
     1MEASURED TO NEAREST MILLIMETER)')
      WRITE(IP,781)(D(I),I=1,NT)
  781 FORMAT(' ',6X,15F6.0)
C     TRANSFORM B-AXIS TO LOG TO THE BASE 2
      DO 1 I=1,NT
      D(I)=ALOG10(D(I))/0.30103
    1 CONTINUE
      CALL FLAS(D,NT,AL,AS)
      CELL=0.50
C     DETERMINE LOWEST UPPER BOUND TO BE USED
   15 ALB=2.00**AL
      ASB=2.00**AS
      CUBT=0.0+CELL
   32 IF(CUBT.GT.AS) GO TO 35
```

```
      CUBT=CUBT+CELL
      GC TO 32
   35 CUB(1)=CUBT
      IC=2
   20 CUB(IC)=CUB(IC-1)+CELL
      IF(CUB(IC).LE.AL) GO TO 5
      ICF=IC
      IF(ICF.LE.16) GO TO 6
      CELL=1.00
      GC TO 15
    5 IC=IC+1
      GC TO 20
C     DETERMINE THE NUMBER CF DATA POINTS IN EACH CELL
    6 DC 60 K=1,ICF
      TNCUB(K)=0.0
      NCUB(K)=0
      DO 70 I=1,NT
      CUBT1=CUB(K)-0.0001
      IF (D(I).GT.CUBT1) GO TO 70
      CUBT2=CUB(K)-CELL-0.0001
      IF(D(I).GE.CUBT2) GO TO 72
      GC TO 70
   72 TNCUB(K)=TNCUB(K)+1.
      NCUB(K)=TNCUB(K)
C     TNCUB = THE TOTAL NUMBER IN CLASS INTERVAL
   70 CONTINUE
   60 CONTINUE
      DC 71 K=1,ICF
C     ASSUMES MEASUREMENTS ARE TO NEAREST 0.1 MILLIMETER OR GREATER
      CPL(K)=CUB(K)-CELL
      CPML(K)=2.CO**CPL(K)
      CPMU(K)=2.00**CUB(K)-0.1
   71 CONTINUE
      NCUM(1)=NCUB(1)
      CO 172 K=2,ICF
      NCUM(K)=NCUM(K-1)+NCUB(K)
  172 CONTINUE
      CALL STATP(D,NT,SM,SSD,UCOV,UCOSK,UCOKU)
      SSCB=2.00**SSD
      SMB=2.00**SM
C     DETERMINE SIZES CORRESPONDING TO GIVEN PERCENTAGES
      CPF(1)=0.0
C     CPF   =CUMULATIVE PERCENT FINER
      PHI(1)=AS
C     ICF   = TOTAL NUMBER CF CELLS
      TN=NT
      DC 11 K=2,ICF
      CPF(K)=CPF(K-1)+TNCUB(K-1)/TN*100.
      PHI(K)=CUB(K-1)
   11 CCNTINUE
      ICFF=ICF+1
      CPF(ICFF)=100.0
      PHI(ICFF)=AL
      PC(2)=10.
      PC(3)=16.
```

```
      PC(4)=25.
      PC(5)=35.
      PC(6)=50.
      PC(7)=65.
      PC(8)=75.
      PC(9)=84.
      PC(10)=90.
      ICB=2
      DO 13 I=2,10
      DO 12 K=ICB,ICFF
      IF(PC(I).LE.CPF(K)) GO TO 75
      GO TO 12
   75 IF(PC(I).GT.CPF(K-1)) GO TO 85
      GO TO 12
   85 PHIU(I)=PHI(K-1)+(PHI(K)-PHI(K-1))/(CPF(K)-CPF(K-1))*(PC(I)-CPF(K-
     11))
      BAXIS(I)=2.00**PHIU(I)
   12 CONTINUE
   13 CONTINUE
C     FIND MAXIMUM NUMBER IN CELL FOR COMPUTING MODE
      ABMAX=0.0
      DO 17 I=1,ICF
      IF(TNCUB(I).GT.ABMAX) GO TO 113
      GO TO 17
  113 ABMAX=TNCUB(I)
      MAX=I
   17 CONTINUE
      ICFP=ICF+1
      TNCUB(ICFP)=0.0
      DELTA1=TNCUB(MAX)-TNCUB(MAX-1)
      DELTA2=TNCUB(MAX)-TNCUB(MAX+1)
      DMODE=CUB(MAX-1)+DELTA1*CELL/(DELTA1+DELTA2)
      DMODEB=2.00**DMODE
      GRADP=(PHIU(9)-PHIU(3))/2.
      GRADPB=2.00**GRADP
      TRASK=SORT(BAXIS(8)/BAXIS(4))
      SIGMA=0.5*((BAXIS(6)/BAXIS(3)+BAXIS(9)/BAXIS(6)))
  786 WRITE(IP,758)
  758 FORMAT('0',10X,'CHARACTERISTIC SIZES',10X,'SUMMARY OF STATISTICAL
     1MEASURES BASED ON PHI VALUES')
      WRITE(IP,759)
  759 FORMAT(' ',10X,'SIZE    PHI   B-AXIS',38X,'PHI  (B-AXIS)')
      WRITE(IP,760)AS,ASB,SM,SMB
  760 FORMAT(' ',9X,'MINIMUM',F6.2,F8.0,15X,'ARITHMETIC MEAN    =',F7.2,
     1' (',F5.1,' )')
      WRITE(IP,761)PHIU(2),BAXIS(2),PHIU(6),BAXIS(6)
  761 FORMAT(' ',11X,'B10',F8.2,F8.0,15X,'MEDIAN (B50)       =',F7.2,' (
     1',F5.1,' )')
      WRITE(IP,762)PHIU(3),BAXIS(3),DMODE,DMODEB
  762 FORMAT(' ',11X,'B16',F8.2,F8.0,15X,'MODE               =',F7.2,' (
     1',F5.1,' )')
      WRITE(IP,763)PHIU(4),BAXIS(4),SSD ,SSDB
  763 FORMAT(' ',11X,'B25',F8.2,F8.0,15X,'STANDARD DEVIATION =',F7.2,' (
     1 2**PHI=',F6.2,' )')
      WRITE(IP,764)PHIU(5),BAXIS(5),GRADP,GRADPB
```

```
  764 FORMAT(' ',11X,'B35',F8.2,F8.0,15X,'(PHI84 - PHI16)/2  =',F7.2,' (
     1 2**PHI=',F6.2,' )')
      WRITE(IP,765)PHIU(6),BAXIS(6),UCOSK
  765 FORMAT(' ',11X,'B50',F8.2,F8.0,15X,'COEF. OF SKEWNESS  =',F7.2)
      WRITE(IP,766)PHIU(7),BAXIS(7),UCOKU
  766 FORMAT(' ',11X,'B65',F8.2,F8.0,15X,'COEF. OF KURTOSIS  =',F7.2)
      WRITE(IP,767)PHIU(8),BAXIS(8)
  767 FORMAT(' ',11X,'B75',F8.2,F8.0)
      WRITE(IP,768)PHIU(9),BAXIS(9)
  768 FORMAT(' ',11X,'B84',F8.2,F8.0,10X,'GRADATION COEF. BASED ON B-AXI
     1S')
      WRITE(IP,769)PHIU(10),BAXIS(10),TRASK
  769 FORMAT(' ',11X,'B90',F8.2,F8.0,15X,'TRASK SORTING COEF.    =',F5.2
     1)
      WRITE(IP,770)AL,ALB,SIGMA
  770 FORMAT(' ',9X,'MAXIMUM',F6.2,F8.0,15X,'GRADATION COEF.(SIGMA) =',F
     15.2)
      WRITE(IP,801)
  801 FORMAT('0',9X,'SUMMARY OF DATA BY CLASS BOUNDS WHERE BOUNDS ARE IN
     1 MILLIMETERS'/)
      IF(ICF.GT.8) GO TO 777
      WRITE(IP,803)(CMML(K),K=1,ICF)
  803 FORMAT(' ',9X,'CLASS-LB',F7.1,7F10.1)
      WRITE(IP,802)(CMMU(K),K=1,ICF)
  802 FORMAT(' ',9X,'CLASS-UB  ',F7.1,7F10.1)
      WRITE(IP,804)(NCUB(K),K=1,ICF)
  804 FORMAT(' ',9X,'NO IN CL',I7,7I10)
      WRITE(IP,805)(NCUM(K),K=1,ICF)
  805 FORMAT(' ',9X,'NO LE UB',I7,7I10)
      WRITE(IP,806)(CPF(K),K=2,ICFF)
  806 FORMAT(' ',9X,' % LE UB',F7.1,7F10.1)
      GO TO 561
  777 WRITE(IP,803)(CMML(K),K=1,8)
      WRITE(IP,802)(CMMU(K),K=1,8)
      WRITE(IP,804)(NCUB(K),K=1,8)
      WRITE(IP,805)(NCUM(K),K=1,8)
      WRITE(IP,806)(CPF(K),K=2,9)
      WRITE(IP,807)(CMML(K),K=9,ICF)
  807 FORMAT('0',9X,'CLASS-LB',F7.1,7F10.1)
      WRITE(IP,802)(CMMU(K),K=9,ICF)
      WRITE(IP,804)(NCUB(K),K=9,ICF)
      WRITE(IP,805)(NCUM(K),K=9,ICF)
      WRITE(IP,806)(CPF(K),K=10,ICFF)
      GO TO 561
  503 WRITE(IP,507)
  507 FORMAT('1')
      GO TO 504
  504 STOP
      END

CRY RECUIREMENTS 001E14 BYTES
```

```
      SUBROUTINE READD(D,NT,NAME1,NAME2,NAME3,NSAMP,IENDT)
C     READD = A SUBROUTINE TO READ IN THE DATA FOR AN INDIVIDUAL SAMPLE.
C     D     = VECTOR CONTAINING THE VALUES OF THE B-AXES OF THE ROCKS
C             IN THE SAMPLE OR GROUPED SAMPLES.
C     NT    = THE TOTAL NUMBER OF B-AXES IN THE SAMPLE OR GROUPED
C             SAMPLES.
C     NAME1, NAME2, NAME3 CONTAIN THE IDENTIFICATION OF THE SAMPLE(S).
C     NSAMP  = THE NUMBER OF INDIVIDUAL SAMPLES GROUPED TO FORM ONE
C             SAMPLE FOR ANALYSIS.  ( THIS MAY BE ONE )
C     IENDT  = CODE TO DETERMINE IF ALL ANALYSIS IN THE RUN HAVE BE
C             CARRIED OUT.
C
C     DATA CARDS MUST BE SET UP AS FOLLOWS
C     1. FIRST DATA SET ( MAY CONSIST OF FROM 1 TO 5 SAMPLES, TOTAL NUMBER
C          OF VALUES IN SET NOT TO EXCEED 255; THAT IS 15 CARDS OF DATA)
C     2. BLANK CARD
C     3. SECOND DATA SET
C     LAST CARD -1  BLANK
C     LAST CARD  BLANK
      DIMENSION D(280),NAME1(6),NAME2(6),NAME3(6)
      IR=5
      IP=6
      IENDT=0
      READ(IR,700)(D(I),I=1,17),NAME1(1),NAME2(1),NAME3(1)
  700 FORMAT(17F4.0,3A4)
      IF(D(1).EQ.0.0) GO TO 27
      IN=2
      INI=IN-1
      IB=18
      IE=34
      NSAMP=1
    6 READ(IR,700)(D(I),I=IB,IE),NAME1(IN),NAME2(IN),NAME3(IN)
      IF(D(IB).EQ.0.0) GO TO 7
      IF(NAME1(IN).EQ.NAME1(INI).AND.NAME2(IN).EQ.NAME2(INI).AND.NAME3(I
     1N).EQ.NAME3(INI)) GO TO 5
      IN=IN+1
      INI=INI+1
      NSAMP=NSAMP+1
    5 IB=IB+17
      IE=IE+17
      GO TO 6
    7 IN=IN-1
C     DETERMINE TOTAL SAMPLE SIZE
      IT=IE-1
      I=1
   17 IF(D(I).EQ.0.0) GO TO 21
      GO TO 8
   21 IF(I.EQ.IE) GO TO 23
      DO 9 J=I,IT
      D(J)=D(J+1)
    9 CONTINUE
      IE=IE-1
      IT=IT-1
      I=I-1
    8 IF(I.EQ.IE) GO TO 24
```

```
      I=I+1
      GC TO 17
   23 NT=IE-1
      GC TO 25
   24 NT=IE
   25 IENDT=0
      GO TO 15
   27 IENDT=1
   15 RETURN
      END
```

MCRY REQUIREMENTS 000560 BYTES

```
G COMPILER          FLAS              06-30-71         21:17.41         PAGE 0001

         SUBROUTINE FLAS(X,NT,AL,AS)
   C     FLAS = SUBROUTINE TO DETERMINE THE LARGEST AND SMALLEST VALUES
   C            IN A VECTOR.
   C     X    = INPUT VECTOR OF LENGTH NT.
   C     NT   = LENGTH OF VECTOR X
   C     AL   = THE LARGEST VALUE IN THE VECTOR X.
   C     AS   = THE SMALLEST VALUE IN THE VECTOR X.
         DIMENSION X(280)
         AL=X(1)
         J=1
         IF(NT.EQ.1) GO TO 7
         DO 6 I=2,NT
         IF(X(I).LE.AL) GO TO 6
         AL=X(I)
         J=I
       6 CONTINUE
         AS=X(1)
         J=1
         IF(NT.EQ.1) GO TO 7
         DO 8 I=2,NT
         IF(X(I).GE.AS) GO TO 8
         AS=X(I)
         J=I
       8 CONTINUE
       7 RETURN
         END

MORY REQUIREMENTS 000264 BYTES
```

```
      SUBROUTINE STATP(X,NDATA,VMEAN,USTDEV,UCOV,UCOSK,UCOKU)
C     STATP = SUBROUTINE TO COMPUTE SOME COMMON STATISTICAL PARAMETERS.
C     X     = INPUT VECTOR CF LENGTH NDATA.
C     NCATA = THE LENGTH OF THE INPUT VECTOR X
C     VMEAN = MEAN OF THE VALUES IN THE INPUT VECTOR X.
C     USTDEV= THE UNBIASED ESTIMATE OF THE STANDARD DEVIATION.
C     UCOV  = THE UNBIASED ESTIMATE OF THE COEFFICIENT OF VARIATION.
C     UCOSK = THE UNBIASED ESTIMATE OF THE COEFFICIENT OF SKEWNESS.
C     UCOKU = THE UNBIASED ESTIMATE OF THE COEFFICIENT OF KURTOSIS.
C
      DIMENSION X(280)
      VM1P=0.0
      VM2P=0.0
      VM3P=0.0
      VM4P=0.0
      DO 1 I=1,NDATA
      VM1P=X(I)+VM1P
      VM2P=X(I)**2+VM2P
      VM3P=X(I)**3+VM3P
      VM4P=X(I)**4+VM4P
    1 CONTINUE
      DN=NDATA
      VM1P=VM1P/DN
      VM2P=VM2P/DN
      VM3P=VM3P/DN
      VM4P=VM4P/DN
      VM2=VM2P-VM1P**2
      VM3=VM3P-3.0*VM1P*VM2P+2.0*VM1P**3
      VM4=VM4P-4.0*VM1P*VM3P+6.0*VM1P**2*VM2P-3.0*VM1P**4
      VMEAN=VM1P
C     IF THERE IS AN 'U' BEFORE A NAME IT IS AN UNBIASED ESTIMATE.
      VAR=VM2
      UVAR=DN/(DN-1.0)*VM2
      STDEV=SQRT(ABS(VAR))
      USTDEV=SQRT(ABS(UVAR))
      COV=STDEV/VMEAN
      UCOV=USTDEV/VMEAN
      COSK=VM3/VM2**1.5
      UCOSK=(DN*DN/((DN-1.0)*(DN-2.0)))*VM3/UVAR**1.5
      COKU=VM4/VM2**2
      UCOKU=(DN*DN*DN/((DN-1.0)*(DN-2.0)*(DN-3.0)))*VM4/UVAR**2
      RETURN
      END
```

ORY REQUIREMENTS 000466 BYTES
35 RC=0

```
C
C      EXAMPLE OF CATA AND CONTROL CARDS FOR A RUN USING THE PROGRAM
C         FOR A GRID-BY NUMBER ANALYSIS FOR BED MATERIAL.
C


CCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCC
OOOOOOOOOOOOOOOOOOOOOOOOOOOOOOOOOOOOOOOOOOOOOOOOOOOOOOOOOOOOOOOOOOOOOOOOOOOOOOOO
LLLLLLLLLLLLLLLLLLLLLLLLLLLLLLLLLLLLLLLLLLLLLLLLLLLLLLLLLLLLLLLLLLLLLLLLLLLLLLLL
         11111111112222222222333333333344444444445555555555666666666677777777778
12345678901234567890123456789012345678901234567890123456789012345678901234567890
C      LAST JOB CONTROL CARD BEFORE DATA.
  59  38  19  53  52  99  76 110 143 147 1C7  60  41  50  70 107  34    12-70-N3
  19  34 110  15 167  36  25 163  21  20  19  36  59  77  51 126  52    12-70-N3
  81 134 120  50  89  35  73 129 102  89,  75  41  42 105  33  50        12-70-N3

  55  41  40  67  42  40 138  92  23  13  63  37  18  13  47  66  76    21-70-N3
 117  43  61  53 122 138  11  49  59  51  38  14  29  27 103 100  58    21-70-N3
  78  18  24  57 113  60  34  64  97  47  69  52  29  52  72  64        21-70-N3
  50  54  16  41  17  22  15  61  19  61  26  19  23  48  46  12  19    21-70-N4
  31  26  27  27  13  53  34  41  34  27  24  18  19  17  26  20  22    21-70-N4
  19  19  14  21  34  31  11  40  10  16  10  34  39  12  14  29        21-70-N4
  20  34  45  52  28  40  49  37  26  31  61  71  26  26  44  24  49    21-70-N5
  38  96  39  45  22  83  49  66  65  69  41  23  69  30  37  83  55    21-70-N5
  26  69  39  16  48  41  73  92  76  33  48  89  33  39 106  77        21-70-N5

C      FIRST JOB CONTROL CARD AFTER DATA.
         11111111112222222222333333333344444444445555555555666666666677777777778
12345678901234567890123456789012345678901234567890123456789012345678901234567890
```

APPENDIX F

COMPARISON OF BED MATERIAL SAMPLING PROCEDURES

F.1 Purpose

In CHAPTER 3, a simple geometrical model was used to show that the grid-by-number procedure is the most acceptable manner in which to analyse a gravel surface, since it is equivalent to a customary bulk sieve analysis of the surface population. Consequently, the grid-by-number procedure was adapted as the basic form of presentation for this study.

In order to provide a means of adjusting currently available grid-by-number from photograph data, and customary bulk sieve analysis data to grid-by-number data, a field program was designed to obtain the three types of data from the same gravel bar at several different river reaches. This appendix establishes the relations between these three equivalent types of analyses.

F.2 The Data

The following data were obtained at a gravel bar:

1. One or two line grid samples of (50).
2. One or two grid photographs along the first line grid sample of (50).
3. One volumetric sample (including both surface and subsurface material) from under one of the grid photographs.

All samples were obtained and analysed according to the detailed procedure given in APPENDIX D. The volumetric sample was passed through an 8 mm. square mesh sieve, and the grain size analysis was carried out on the coarser fraction. Since very little material finer than 8 mm. was present on the gravel surface, it was assumed that if all the finer material was removed from the volumetric sample, the surface and subsurface sample would approximate the surface population. This assumption does not seem to be unreasonable unless the gravel surface is highly armored. (An armored surface consists of "lag" material which is obviously larger than the coarser material under the surface layer.)

All data for this analysis are presented in TABLE F.1. Each entry in the table is identified by a reach number, year and sample number. All data were obtained by the author during the summer of 1970, except at reach numbers 77 to 84. These samples were obtained by R. McGinn, Department of Geography, University of Alberta in 1970.

Only the B90, B65, and B50 sizes are used, since the finer sizes seldom enter into the standard equations related to river engineering. Another reason for using the B90, B65, and B50 sizes was that some of the bed material data obtained prior to 1970 were only described by these three sizes [Van der Giessen (1966)]. If necessary, the B35 size may be closely approximated by assuming that the grain size curve is linear between the B65 and the B35 sizes when plotted on semi-log paper. Using this assumption the resulting estimate for the B35 size is as follows:

$$B35 = B50^2/B65 \qquad \text{EQUATION F.1}$$

It is apparent from TABLE F.1 that the three types of samples were not always obtained for each site presented in the table. Normally, a volumetric sample was not taken in the field if the larger material

TABLE F.1

SUMMARY OF BED MATERIAL DATA USED TO DETERMINE RELATIONS BETWEEN DIFFERENT METHODS

SEQ NO	REA-CH # RCA	YP	GRID-BY-NUMBER (50 IN SAMPLE) B90	B65	B50	#	GRID-BY-NUMBER (100 IN SAMPLE) B90	B65	B50	#	GRID-BY-NUMBER FROM PHOTO(50 IN SAMPLE) B90	B65	B50	#	SIEVE FOR MATERIAL GREATER THAN 8 MM. D90	D65	D50	#
1	10	70	244	141	82	N1	276	141	83	N1&2	161	92	69	P1&2	106	72	56	S1
2	10	70	166	108	87	N3	164	104	84	N3&4	84	55	45	P3&4	130	95	67	S1
3	12	70	99	71	58	N1	121	79	64	N1&2	104	73	56	P5&6	60	40	29	S2
4	12	70	60	36	27	N4	68	41	30	N4&5	59	39	27	P1&2	92	60	45	S1
5	13	70	81	51	41	N1	88	51	39	N1&2	78	49	38	P1&2				
6	13	70	80	47	35	N3					45	27	22	P4&5	54	35	28	S1
7	14	70	53	37	31	N1	55	39	33	N1&2					108	68	52	S2
8	14	70	111	70	57	N3	111	68	57	N3&4								
9	19	70	362	192	128	N1	362	172	114	N1&2	263	140	91	P1&2				
10	19	70	512	134	44	N3	388	134	57	N3&4	204	123	54	P3&4	32	19	16	S1
11	19	70	51	23	20	N5					25	17	11	P5				
12	20	70	79	54	44	N1	78	51	41	N1&2	61	37	30	P1&2	110	76	60	S1
13	21	70	108	76	65	N1	109	78	67	N1&2	89	68	54	P1&2	50	30	24	S2
14	21	70	49	30	23	N4					38	22	19	P3&4	115	84	70	S1
15	24	70	156	100	80	N1	172	112	88	N1&2	121	86	66	P1&2	120	74	56	S2
16	24	70	148	87	71	N3	148	89	74	N3&4	128	71	56	P4&5	43	29	25	S1
17	26	70	61	44	36	N3					44	31	25	P1&2	31	24	20	S1
18	34	70	37	24	20	N1	35	24	20	N1&2	32	23	18	P1&2				
19	34	70	270	168	116	N3	252	170	123	N3&4	168	123	102	P3&4				
20	34	70	168	113	95	N5					171	88	76	P5&6	74	40	30	S1
21	37	70	82	49	37	N1					61	38	31	P1&2	56	30	23	S2
22	37	70	43	27	22	N2					41	28	23	P3&4				
23	37	70	81	43	33	N3	77	39	31	N3&4	70	34	28	P5&6	15	12	11	S1
24	39	70									15	10	8	P1				
25	39	70	191	126	99	N1					181	116	87	P2&3				
26	39	70	338	215	161	N2					256	167	147	P4&5	106	68	52	S1
27	50	70	133	82	56	N2					81	55	42	P1&2	74	44	35	S1
28	56	70	91	41	34	N3					68	44	30	P1&2	84	44	35	S1
29	57	70	76	50	40	N2					74	46	33	P1&2				
30	62	70	318	192	140	N1					181	153	139	P1&2				
31	67	70	335	195	124	N1	347	175	115	N1&2	208	113	84	P1&2				

1. Grid-by-number sizes based on interpolation using values plotted at 0.5 PHI intervals.
2. Sizes are in millimeters.

TABLE F.1 (continued)

SUMMARY OF BED MATERIAL DATA USED TO DETERMINE RELATIONS BETWEEN DIFFERENT METHODS

SEC NO	REACH # RCA	YR	GRID-BY-NUMBER (50 IN SAMPLE) B90	B65	B50	#	GRID-BY-NUMBER (100 IN SAMPLE) B90	B65	B50	#	GRID-BY-NUMBER FROM PHOTO (50 IN SAMPLE) B90	B65	B50	#	SIEVE FOR MATERIAL GREATER THAN 8 MM. D90	D65	D50	#
32	67	70	330	243	187	N3	334	234	178	N3&4	209	159	128	P3&4				
33	67	70	291	190	147	N5	290	189	142	N5&6	197	146	115	P5&6				
34	68	70	215	134	108	N1	221	130	99	N1&2	140	101	82	P1&2				
35	68	70	128	89	70	N3	132	93	72	N3&4	91	60	51	P3&4				
36	68	70	161	92	78	N5	175	94	75	N5&6	128	101	84	P5&6				
37	77	70	63	49	40	N1					61	38	29	P1&2	45	29	24	S1
38	78	70	109	72	58	N1	104	70	57	N1&2	87	52	40	P1&2	91	60	47	S1
39	80	70	94	52	36	N1					76	43	32	P2&3	64	37	27	S1
40	81	70									53	29	20	P1	48	31	25	S1
41	82	70	91	46	32	N1					79	48	35	P1&2	68	36	28	S1
42	83	70	76	49	38	N1	88	58	43	N1&2	82	53	44	P1&2	89	57	47	S1
43	84	70									49	25	20	P1&2	42	26	22	S1
44	85	70	97	59	45	N1					94	63	49	P2				
45	85	70	215	126	94	N2					147	102	84	P3&4				
46	85	70	247	160	119	N3					209	150	119	P5&6				
47	92	70	87	50	37	N1	97	65	49	N1&2	69	43	28	P1&2	90	54	43	S1
48	92	70	84	63	47	N3	82	60	47	N3&4	76	45	35	P3&4	78	45	35	S2
49	95	70	256	142	85	N1					181	108	74	P1&2				
50	95	70	166	100	75	N2	174	105	78	N2&3	108	61	47	P3&4	137	85	60	S1
51	95	70	189	73	49	N5					111	66	47	P5&6				
52	96	70	181	105	71	N1					192	84	58	P1&2				
53	96	70	279	163	91	N2					161	81	64	P3&4				
54	100	70	181	92	76	N1	228	119	89	N1&2	165	102	77	P1&2	195	100	76	S1
55	100	70	312	164	132	N3					169	99	76	P3&4				
56	100	70	310	171	109	N5					188	126	97	P5&6				
57	113	70	224	161	131	N1	231	163	133	N1&2	175	139	110	P1&2				
58	113	70	97	65	50	N3	91	58	46	N3&4	79	53	41	P3&4				
59	113	70	181	110	76	N5	181	123	87	N5&6	161	92	76	P5&6				
60	115	70	76	47	39	N4									86	41	29	S1
61	116	70	91	69	55	N5					67	36	26	P1&2	92	48	33	S1

1. Grid-by-number sizes based on interpolation using values plotted at 0.5 PHI intervals.
2. Sizes are in millimeters.

had a b-axis greater than 150 mm.

F.3 The Analysis

The analysis was carried out for the following four cases using the data presented in TABLE F.1.

1. Comparisons between grid-by-number analysis and grid-by-number from photograph analysis.
2. Comparisons between grid-by-number analysis and bulk sieve analysis.
3. Comparisons between bulk sieve analysis and grid-by-number from photograph analysis.
4. Comparison of grid-by-number samples of 50 and 100.

Only those samples with the b-axis less than 512 mm. (9 phi units) were considered in any analysis. This criterion resulted in the rejection of one B90 size for a grid-by-number analysis (sequence #10, reach #19).

In the first three cases, a standard simple linear regression analysis (of the form $Y = a + bX$) was carried out between a stated dependent and independent variable. In addition a regression analysis (of the form $Y = bX$) was also carried out for each case by forcing the regression line to pass through the origin. A computer program was written to summarize the analyses and to plot the resulting graphical relations.

F.3.1 Grid-by-Number Sizes Estimated from Grid-by-Number from Photograph Sizes

The results summarized in TABLE F.2 indicate that the grid-by-number sizes are approximately 20 to 40 percent larger than the grid-by-number from photograph sizes for each of the

TABLE F.2

SUMMARY OF RELATIONS FOR THE ESTIMATION OF GRID-BY-NUMBER SIZES FROM PHOTOGRAPH SIZES

Form	Size	a in mm.	b	r	S.E. in mm.	N
Y = a + bX	B90	-10.2 (-30.5,10.2)	1.44 (1.29,1.59)	0.93 (0.89,0.96)	33.6	54
Y = bX	B90	0.0	1.37 (0.87,1.88)		33.6	54
Y = a + bX	B65	-0.5 (-12.1,11.0)	1.29 (1.16,1.42)	0.94 (0.89,0.96)	19.9	55
Y = bX	B65	0.0	1.29 (0.83,1.74)		19.7	55
Y = a + bX	B50	4.8 (-2.9,12.5)	1.14 (1.02,1.25)	0.94 (0.90,0.96)	13.9	55
Y = bX	B50	0.0	1.20 (0.79,1.61)		13.9	55

1. Y = GBN(50) = Grid-by-number analysis (50 in sample).
2. X = GBNP(50) = Grid-by-number from photograph (50 in sample).
3. Values in brackets are 95% confidence limits assuming a normal distribution.

relations. All data points used to obtain the relations between the characteristic sizes are presented in FIGURE F.1 for the simple linear regression (of the form Y = a + bX). The regression line and the 95 percent confidence limits are also presented in this figure.

According to the simple cube model developed by Kellerhals and Bray (1971) the results for these two methods should be the same. The reasons for the differences are:

1. The actual b-axis was measured in the grid-by-number analysis, but the smallest visible axis was measured in the grid-by-number from photograph analysis. If the rock measured from the photograph was tilted or embricated, then the b-axis would be foreshortened.

2. In some cases a stone in the photograph might be partially obscured and, consequently, a smaller b-axis would be measured.

The three regression lines (of the form Y = a + bX) show significant differences in slope at the five percent level. Therefore, it is not possible to use only one equation for the adjustment of all characteristic sizes. The slope of the regression line becomes closer to 1.00 as the characteristic size becomes closer to the B50 size. This suggests that the amount of tilting of the stones in the photograph may be primarily associated with the larger sizes.

F.3.2 <u>Grid-by-Number Sizes Estimated from Sieve Analysis Sizes</u>

A summary of the results of the analysis are presented in TABLE F.3. The slope of the regression line is quite close to one in each case. The result for the B50 size is almost a one-to-one relation. The regression line and the 95 percent confidence limits for the three relations (of the form Y = a + bX) are presented in

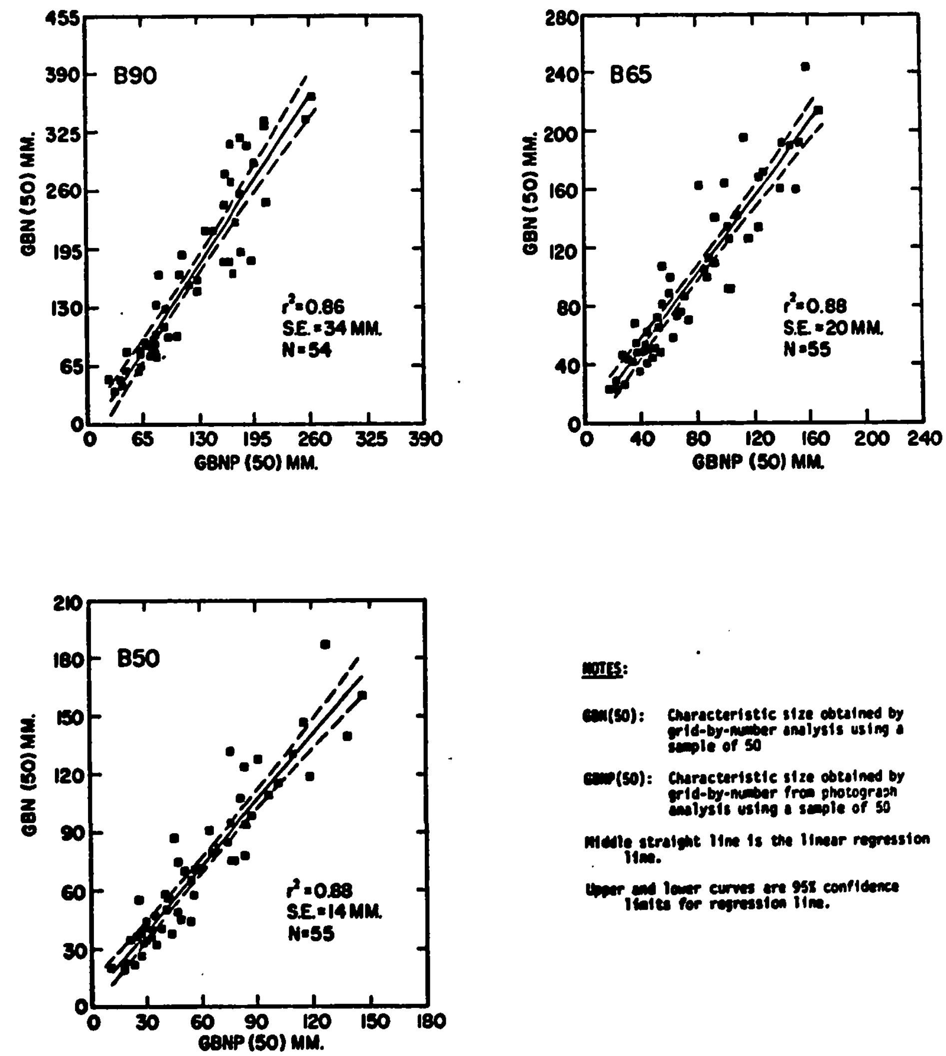


FIGURE F.1 ESTIMATION OF GRID-BY-NUMBER SIZES FROM GRID-BY-NUMBER PHOTOGRAPH SIZES

TABLE F.3

SUMMARY OF RELATIONS FOR THE ESTIMATION OF GRID-BY-NUMBER SIZES FROM SIZES OBTAINED FROM A BULK SIEVE ANALYSIS OF MATERIAL GREATER THAN 8 MM.

Form	Size	a in mm.	b	r	S.E. in mm.	N
Y = a + bX	B90	11.4 (-8.6,31.4)	0.96 (0.75,1.18)	0.87 (0.74,0.94)	19.8	29
Y = bX	B90	0.0	1.08 (0.65,1.51)		19.9	29
Y = a + bX	B65	9.4 (-2.6,21.5)	0.93 (0.72,1.14)	0.87 (0.73,0.94)	12.1	29
Y = bX	B65	0.0	1.09 (0.65,1.53)		12.4	29
Y = a + bX	B50	5.0 (-4.4,14.4)	1.02 (0.80,1.23)	0.88 (0.76,0.94)	9.2	29
Y = bX	B50	0.0	1.12 (0.70,1.55)		9.2	29

1. Y = GBN(50) = Grid-by-number analysis (50 in sample).
2. X = S(>8 mm.) = Bulk sieve analysis of surface and subsurface material. (for material greater than 8 mm.)
3. Values in brackets are 95% confidence limits assuming a normal distribution.

FIGURE F.2. Perhaps a slightly better relation could be obtained if the volumetric sample was separated on a sieve size slightly larger than the 8 mm. sieve. For convenience, however, it is recommended that the 8 mm. sieve be used to separate the volumetric sample.

The cube model referred to earlier in this appendix should not apply unless the volumetric sample consists of a population similar to that of the surface material. If this condition is satisfied, the results from the grid-by-number and the sieve analysis should be "equivalent". Since the slope of the regression line is close to one, it is concluded that a volumetric sample with the material finer than 8 mm. removed, is essentially of the same population as the surface material. Of course, this would not apply in cases where the surface is obviously armored. The presence of platy material would also result in some bias, since the sieve size and the b-axis deviate the most for this type of material.

Part of the random scatter may be explained by the fact that the volumetric sample for sieving is from a relatively small portion of the exposed gravel bar in comparison with that of the line grid. This aspect of the sampling problem may be studied by taking several volumetric samples along a line grid on a bar.

For practical purposes, the three equations presented in TABLE F.3 for the simple linear regression (of the form $Y = a + bX$), may be expressed in terms of the approximate average line:

$$Bi(GBN) = 5.0 + 1.00\ Di(S) \qquad \text{EQUATION F.2}$$

where: Bi(GBN) = the characteristic size of grid-by-number for i between 50 and 90.

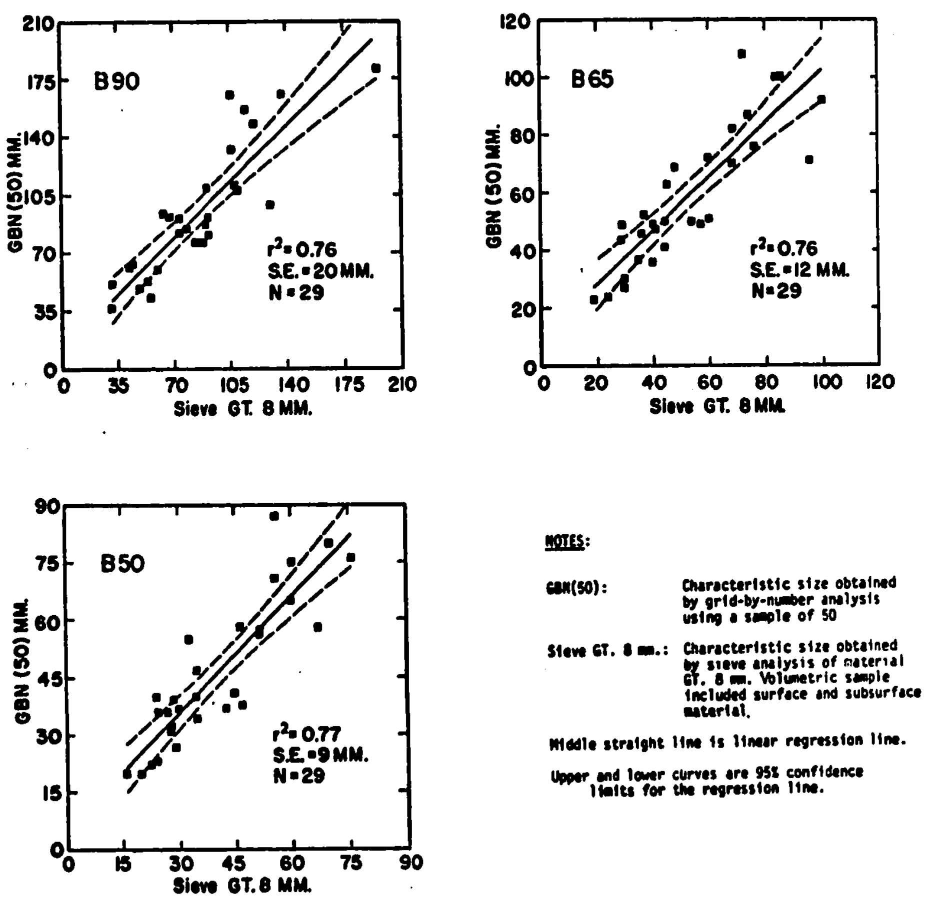


FIGURE F.2 ESTIMATION OF GRID-BY-NUMBER SIZES FROM SIEVE ANALYSIS SIZES FOR MATERIAL GREATER THAN 8 MM.

Di(S) = the characteristic size of the sieve analysis of the material greater than 8 mm. for the same i as used for Bi(GBN).

If the results of the simple linear regression (of the form Y = bX) are used, the approximate average relation may be expressed as:

Bi(GBN) = 1.1 Di(S) EQUATION F.3

EQUATIONS F.2 and F.3 are quite similar over the range of data used to obtain the relations.

The maximum value of D90 was 195 mm. and the minimum value of D50 was 16 mm. for the bulk sieve analyses used in this study. The sieve analysis should be based on a volumetric sample at least as large as that recommended in APPENDIX D.

F.3.3 Sieve Analysis Sizes Estimated from Grid-by-Number from Photograph Sizes

Since the basic data were available, an additional set of linear equations were established to determine the relation between the sieve analysis sizes for material greater than 8 mm. and the grid-by-number from photograph sizes. Twenty-nine data points were used in the analysis. A summary of the results of the analysis is presented in TABLE F.4.

The relations indicate that the characteristic sizes for the sieve analysis are about 10 percent greater than the grid-by-number from photograph. The reasons for this difference are primarily due to the tilting of rocks in the grid photograph analysis.

TABLE F.4

SUMMARY OF RELATIONS FOR THE ESTIMATION OF SIZES OBTAINED FROM A BULK SIEVE ANALYSIS OF MATERIAL GREATER THAN 8 MM. FROM GRID-BY-NUMBER FROM PHOTOGRAPH SIZES

Form	Size	a in mm.	b	r	S.E. in mm.	N
Y = a + bX	B90	-1.5 (-14.0,11.0)	1.12 (0.97,1.28)	0.94 (0.88,0.97)	13.0	29
Y = bX	B90	0.0	1.11 (0.78,1.43)		12.7	29
Y = a + bX	B65	0.7 (-7.2,8.5)	1.08 (0.92,1.23)	0.94 (0.87,0.97)	8.3	29
Y = bX	B65	0.0	1.09 (0.76,1.41)		8.2	29
Y = a + bX	B50	2.4 (-2.6,7.4)	1.04 (0.91,1.17)	0.95 (0.90,0.98)	5.4	29
Y = bX	B50	0.0	1.09 (0.81,1.38)		5.3	29

1. Y = S(>8 mm.) = Bulk sieve analysis of surface and subsurface material (for material greater than 8 mm.).
2. X = GBNP(50) = Grid-by-number from photograph analysis (50 in sample).
3. Values in brackets are 95% confidence limits.

The scatter is smaller than in the case of the grid-by-number analysis, since one of the grid photograph samples was obtained from the same locality as the volumetric sample for the sieve analysis. All data points used to obtain the relations are presented in FIGURE F.3 along with the computed regression lines.

F.3.4 Comparison of Grid-by-Number Analysis of 50 and 100

In all of the grid-by-number analyses up to this point, a sample size of 50 has been used. A sample size of 50 was chosen as a convenient module for the field data obtained in 1970 for this study. To justify the sample size of 50, two line grid samples of 50 were taken within a few feet of one another on the same gravel bar.

A program was written to test the ratio of the variances and the difference of the means of two samples of 50. Since the "F" test and the "t" test are based on samples from the normal distribution, the b-axes were transformed to the equivalent "phi" sizes. Many of the individual sample analyses of 50 based on "phi" units indicated that the distribution was approximately normal, since the coefficient of skewness was nearly zero and the coefficient of kurtosis was nearly three. The standard deviation for a log-normal distribution was also close to the unbiased estimate of the standard deviation computed from the sample. No further detailed tests of normality were carried out.

The ratio of the variances were tested at the 5% and 1% levels

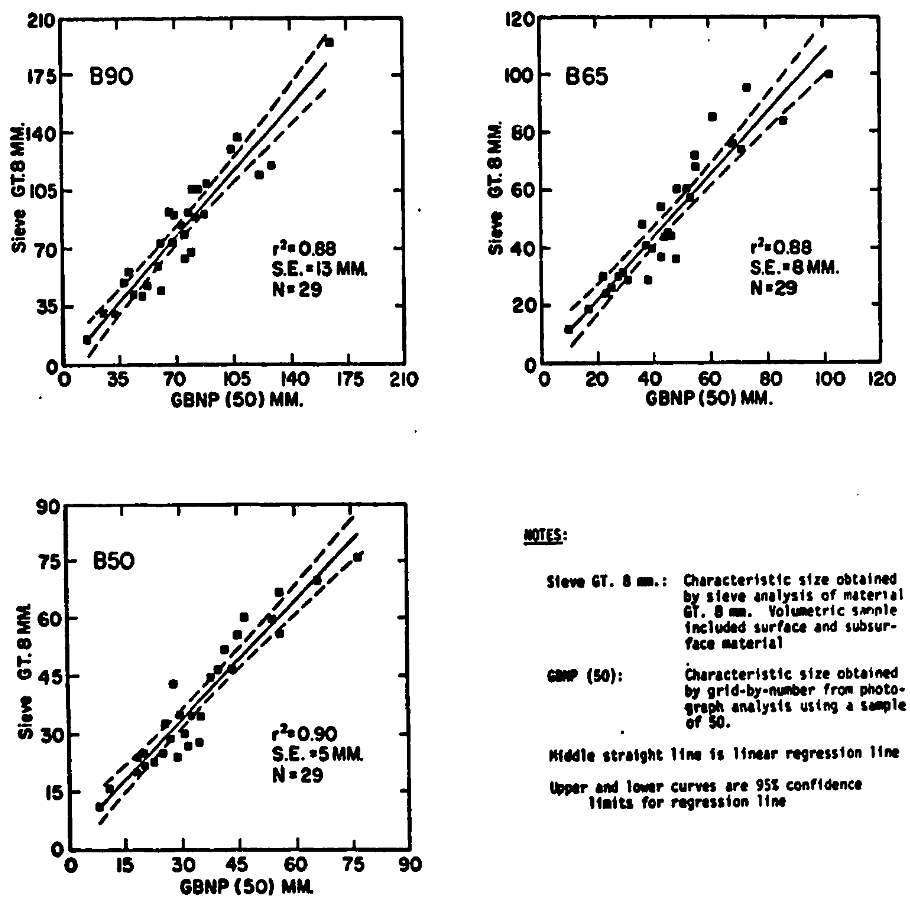


FIGURE F.3 ESTIMATION OF SIEVE ANALYSIS SIZES FOR MATERIAL GREATER THAN 8 MM. FROM GRID-BY-NUMBER FROM PHOTOGRAPH SIZES and the difference of the means were tested at the same levels. A sample print-out of one such analysis is presented in FIGURE F.4.

Thirty-one pairs of samples obtained from 18 different river reaches were tested in this manner. In all cases the ratio of the variances between the two samples was not significantly different from 1.00 at the 5 percent level. In two cases the means differed significantly at the 5 percent level, but in no cases were they significantly different at the 1 percent level. For one of the cases where the difference of the means was significant, the sample was obtained at a site (Belly River near Mountain View #100) where the gravel was large (up to 495 mm.).

At one large bar in the North Saskatchewan River at Edmonton, four samples of 50 were taken along four line grids, displaced about two feet from each other. A summary of the results of the grid-by-number analyses is presented in TABLE F.5.

These results give an indication of the type of variability of the characteristic sizes that may be expected at a sampling site. The B50 and B65 sizes are less variable than the B90 size, indicating that the central part of the distribution is more stable than that near the tails of the distribution. The arithmetic mean of the individual samples is essentially the same as that obtained from an analysis of a pooled sample, or the geometric mean of the individual samples.

From this rather elementary analysis, it is concluded that a

SIGNIFICANCE TESTS FOR DIFFERENCES OF MEANS AND RATIO OF VARIANCES
FOR TWO BED-MATERIAL SAMPLES OBTAINED BY GRID-BY-NUMBER

SAMPLE # 20-70-N1

#	B-AXIS	PHI	#	B-AXIS	PHI
1	71.	6.15	26	103.	6.69
2	37.	5.21	27	70.	6.13
3	27.	4.75	28	43.	5.43
4	55.	5.78	29	34.	5.09
5	63.	5.98	30	56.	5.81
6	38.	5.25	31	50.	5.64
7	39.	5.29	32	39.	5.29
8	14.	3.81	33	25.	4.64
9	55.	5.78	34	12.	3.58
10	21.	4.39	35	59.	5.88
11	63.	5.98	36	27.	4.75
12	88.	6.46	37	24.	4.58
13	56.	5.81	38	40.	5.32
14	57.	5.83	39	60.	5.91
15	72.	6.17	40	71.	6.15
16	16.	4.00	41	28.	4.81
17	34.	5.09	42	66.	6.04
18	34.	5.09	43	67.	6.07
19	29.	4.86	44	73.	6.19
20	48.	5.58	45	20.	4.32
21	13.	3.70	46	23.	4.52
22	54.	5.75	47	14.	3.81
23	73.	6.19	48	69.	6.11
24	47.	5.55	49	17.	4.09
25	31.	4.95	50	15.	3.91

MEAN PHI = 5.28
ST.DEV PHI = 0.82

SAMPLE # 20-70-N2

#	B-AXIS	PHI	#	B-AXIS	PHI
1	56.	5.81	26	35.	5.13
2	57.	5.83	27	39.	5.29
3	44.	5.46	28	46.	5.52
4	37.	5.21	29	20.	4.32
5	17.	4.09	30	68.	6.09
6	25.	4.64	31	36.	5.17
7	77.	6.27	32	65.	6.02
8	104.	6.70	33	38.	5.25
9	31.	4.95	34	14.	3.81
10	16.	4.00	35	68.	6.09
11	70.	6.13	36	71.	6.15
12	33.	5.04	37	15.	3.91
13	40.	5.32	38	42.	5.39
14	54.	5.75	39	26.	4.70
15	78.	6.29	40	24.	4.58
16	59.	5.88	41	59.	5.88
17	39.	5.29	42	24.	4.58
18	26.	4.70	43	41.	5.36
19	40.	5.32	44	64.	6.00
20	48.	5.58	45	60.	5.91
21	85.	6.41	46	41.	5.36
22	53.	5.73	47	22.	4.46
23	17.	4.09	48	21.	4.39
24	35.	5.13	49	30.	4.91
25	14.	3.81	50	22.	4.46

MEAN PHI = 5.24
ST.DEV PHI = 0.75

T(COMPUTED)= 0.256 F(COMPUTED)= 1.182

THE DIFFERENCE OF THE MEANS DOES NOT DIFFER SIGNIFICANTLY AT THE 5% LEVEL
THE DIFFERENCE OF THE MEANS DOES NOT DIFFER SIGNIFICANTLY AT THE 1% LEVEL
THE RATIO OF THE VARIANCES DOES NOT DIFFER SIGNIFICANTLY FROM 1.00 AT THE 5% LEVEL
THE RATIO OF THE VARIANCES DOES NOT DIFFER SIGNIFICANTLY FROM 1.00 AT THE 1% LEVEL

NOTE: 1. ALL TESTS MADE WITH THE ASSUMPTION THAT THE DATA ARE DISTRIBUTED AS PHI-NORMAL
2. UNITS FOR THE B-AXIS ARE IN MILLIMETERS
3. PHI VALUES ARE TAKEN TO BE POSITIVE FOR GRAVEL SIZE MATERIAL.

FIGURE F.4 EXAMPLE OF A COMPUTER PRINT-OUT FOR THE COMPARISON OF THE VARIANCES AND THE DIFFERENCE OF THE MEANS OF TWO LINE GRID SAMPLES

TABLE F.5

CHARACTERISTIC SIZES BASED ON GRID-BY-NUMBER ANALYSIS OF FOUR SAMPLES OBTAINED FROM A GRAVEL BAR ON THE NORTH SASKATCHEWAN RIVER AT EDMONTON [1].

Sample number(s)	Method	Sample size	B90 mm.	B65 mm.	B50 mm.	σ
37-70-N3	Basic	50	81	43	33	0.84
37-70-N4	Basic	50	74	36	29	0.82
37-70-N5	Basic	50	51	32	25	0.71
37-70-N6	Basic	50	102	40	30	1.08
37-70-N3, N4	Pooled	100	77	39	31	0.90
	Arithmetic mean		78	40	31	
	Geometric mean		78	39	31	
37-70-N3, N4, N5	Pooled	150	71	37	29	0.84
	Arithmetic mean		69	37	29	
	Geometric mean		67	37	29	
37-70-N3, N4, N5, N6	Pooled	200	76	37	29	0.90
	Arithmetic mean		76	38	29	
	Geometric mean		77	37	29	

1. Each of the four samples were taken on a line grid located two or three feet from one another.
2. σ is the measure of dispersion defined by:

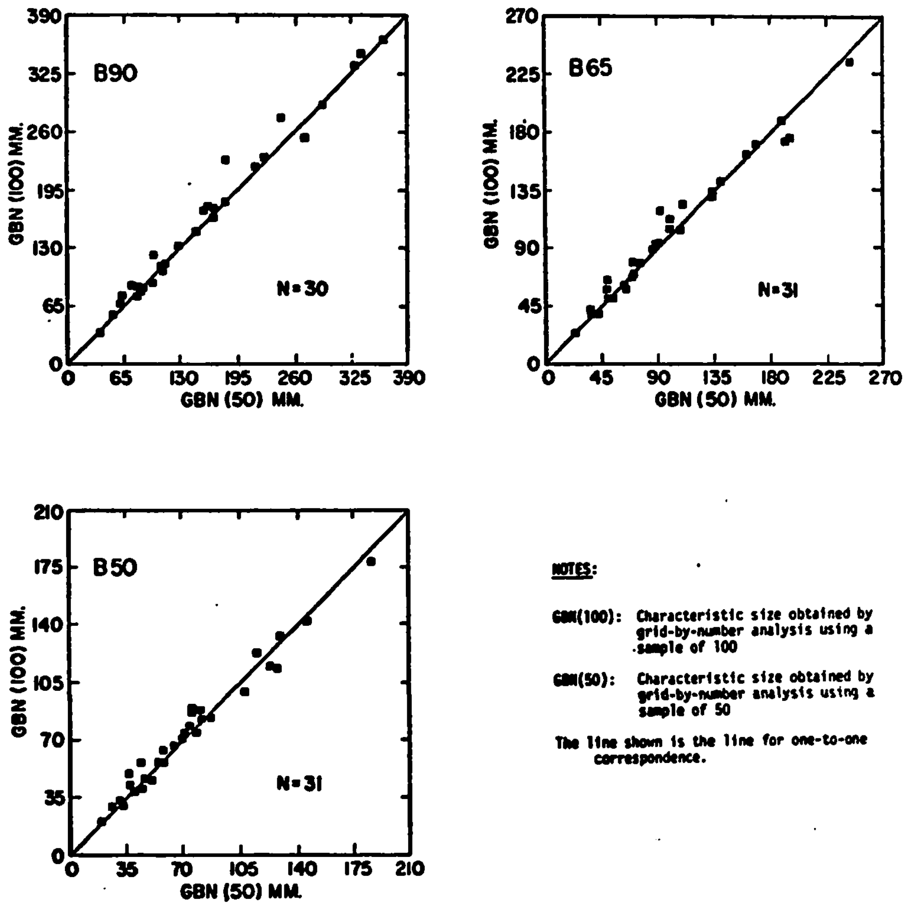
$$\sigma = (PHI84 - PHI16)/2$$

3. The pooled sample is formed by combining the basic samples of 50.
4. The arithmetic mean is the arithmetic mean of the particular characteristic size for the results obtained from the analysis of the basic samples of 50.

sample of 50 is adequate for practical purposes. If time is available, a sample of 100 should be taken in the field. It should be noted that Wolman (1954) used a sample size of 60 and Miller (1958) used a sample size of 50 when obtaining a line grid sample from a gravel surface.

As a visual means of comparison, the three characteristic sizes were plotted for sample sizes of 100 and 50 in Figure F.5. In all cases the data points fall very close to the line of one-to-one correspondence. No regression line was fitted through the data points since the two samples were not independent.

It is apparent that more work should be carried out to rigorously test the distribution of gravel sizes and to more adequately determine the optimum sample size required to define the B90, B65 and B50 sizes.



NOTES:

GBN(100): Characteristic size obtained by grid-by-number analysis using a sample of 100

GBN(50): Characteristic size obtained by grid-by-number analysis using a sample of 50

The line shown is the line for one-to-one correspondence.

FIGURE F.5 COMPARISON OF GRID-BY-NUMBER SIZES USING SAMPLES OF 100 AND OF 50

APPENDIX G

CODING OF THE MAJOR GEOMORPHIC AND PHYSIOGRAPHIC CHARACTERISTICS OF A RIVER REACH

G.1 Introduction

The system of numeric codes described in this appendix was developed to permit the stratification of river data on the basis of geomorphic and physiographic factors. The coding system can also be used as a check list for preliminary river surveys. The length of river which can be considered a "reach" for the present codes is variable. The main criterion is that the reach should be geomorphologically homogeneous. Non-homogeneous reaches should be divided into homogeneous elements for separate coding.

The general principles on which the coding system is based are as follows:

1. The coding proceeds from a broad view of the general setting of the reach to a relatively detailed description of the channel banks and bed;
2. The codes are based on data that may be obtained from maps, air photos and from field surveys;
3. The codes incorporate relatively standard terminology;
4. The codes are quantitatively defined wherever possible;
5. The range of codes for any specific classification is as small as possible;
6. The codes are supplemented by comments in situations that are not readily described numerically. The extent to which the coded features are typical for the particular river is also noted in comments;
7. Multiple codes are used in cases where one code is not adequate. Multiple codes are arranged in decreasing order of dominance or importance.

Many of the codes are open to subjective and inconsistent application. For example, the channel patterns "irregular" and "irregular meanders" may be difficult to separate consistently; however, no matter which code is selected, the reach is definitely different from those classified as "straight", or "tortuous".

The major headings used for the coding are as follows:

1. General description of the terrain in the vicinity of the surveyed reach above valley.
2. Valley characteristics above valley flat.
3. Terraces.
4. Relation of channel to valley.
5. Description of valley flat.
6. Description of channel.
7. Lateral channel activity.
8. Channel banks and bed.
9. Bed rock below channel.

In the following section the codes are outlined in detail. Examples are provided in cases where the code may be difficult to interpret. In all codes a "-1" is used to mean "unknown", and a "blank" or a "0" means that the code is not applicable.

Special coding sheets GEOG1 and GEOG2 shown in FIGURE G.1 and G.2 have been constructed to facilitate the coding of a river reach. The codes presented in this appendix have been developed jointly by the writer and Dr. R. Kellerhals, Department of Civil Engineering, University of Alberta.

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UNIVERSITY OF ALBERTA
DEPARTMENT OF CIVIL ENGINEERING

RIVER DATA SHEET No. Geog. 1/71

GEOGRAPHIC FEATURES

Reach Name:______________ Reach No:________ Date of Analysis:__________ Analysis By:______________
Scale of Air Photos:______________ Scale of Map:______________

NOTE: Complete codes by circling the appropriate number(s). Use "-1" for "unknown" and "0" for "not applicable".

General Description of the Terrain in the Vicinity of the Surveyed Reach, above Valley

Terrain:
1 mountainous
2 foothills
3 uplands
4 hills
5 plains
6 lowlands

Vegetation:
0 0 0 not applicable
1 1 1 almost none
2 2 2 grass
3 3 3 shrubs
4 4 4 sparsely forested, 0-25%
5 5 5 moderately forested, 25-75%
6 6 6 heavily forested, 75-100%
7 7 7 swamp or muskeg

Forest type:
0 0 0 not applicable
1 1 1 deciduous
2 2 2 coniferous

Comments:______________

Land use:
0 0 no cultivation or built-up area
1 1 partly cultivated
2 2 mainly cultivated
3 3 partly built-up
4 4 urbanized

Surficial geology:
1 1 1 bedrock
2 2 2 ground moraine
3 3 3 hummocky moraine
4 4 4 lacustrine deposits
5 5 5 glacio-fluvial dep.
6 6 6 fluvial deposits
7 7 7 aeolian deposits

Valley Characteristics above Valley Flat

Valley measurements:
____within reach
____within reach and immediate vicinity
depth:________ft.
top width:______mi.
bottom width:______mi.

Slumping of valley walls:
0 none
1 occasional
2 frequent

Length of reach with slumping valley walls (contact length in percent of total length of banks):__________

Vegetation on valley wall:
0 0 not applicable
1 1 almost none
2 2 grass
3 3 shrubs
4 4 sparsely forested
5 5 moderately forested
6 6 heavily forested
7 7 swamp or muskeg

Forest type on valley wall:
0 0 not applicable
1 1 deciduous
2 2 coniferous

Comments:______________

Terraces

Terrace presence:
0 none
1 indefinite
2 fragmentary
3 continuous

Number of levels:
0 not applicable
1 one level
2 two levels
_ __ levels
9 several levels

Comments (in particular land use and vegetation):______________

Relation of Channel to Valley

Valley type:
0 not applicable
1 stream cut valley
2 stream cut valley in wide valley
3 wide mountainous valley

If no valley:
0 valley present
1 on alluvial fan
2 on alluvial plain
3 in delta
4 in old lake

Underfit:
0 not applicable or not obviously underfit
1 obviously underfit

Local lateral constriction:
0 none
1 one
2 two
_ ______ cases
9 several cases

Relation of channel to valley bottom (vertical):
0 not applicable
1 not obviously degrading or aggrading
2 partly entrenched
3 entrenched
4 aggrading

Relation of channel to valley walls or to high, resistant terraces (lateral):
0 not applicable (no valley or free)
1 occasionally confined
2 frequently confined
3 confined
4 entrenched

Comments:______________

FIGURE G.1 SAMPLE COPY OF CODING SHEET GEOG1

RESEARCH COUNCIL OF ALBERTA
HIGHWAY AND RIVER ENGINEERING DIVISION
UNIVERSITY OF ALBERTA
DEPARTMENT OF CIVIL ENGINEERING

RIVER DATA SHEET No. Geog. 2/71

GEOGRAPHIC FEATURES - (Cont'd.)

Reach Name: ______________________ Reach No: __________

Description of Valley Flat

Presence:
0 none
1 indefinite
2 fragmentary
3 continuous

Extent:
0 none
1 narrow (< 1 W_s)
2 moderate (1-5 W_s)
3 wide (> 5 W_s)

Average width ______ mi.
Maximum width ______ mi.
Channel length with valley
flat on left ______ %
on right ______ %

Vegetation:
0 0 not applicable
1 1 almost none or bare
2 2 grass
3 3 shrubs
4 4 sparsely forested
5 5 moderately forested
6 6 heavily forested
7 7 swamp or muskeg

Forest type:
0 0 not applicable
1 1 deciduous
2 2 coniferous

Land use:
0 0 not cultivated, not built-up
1 1 partly cultivated
2 2 mainly cultivated
3 3 partly built-up
4 4 mainly built-up

Comments: ______________________

Channel Description (near long-term mean)

Channel pattern:
1 straight
2 sinuous
3 irregular
4 regular meanders
5 irregular meanders
6 tortuous meanders

Islands:
0 none
1 occasional
2 frequent
3 split
4 braided

Type of flow:
1 uniform water surface
2 uniform with rapid in reach
3 uniform with boils and irregularities
4 pool and riffle sequence
5 tumbling flow

Bar type:
0 0 0 none
1 1 1 point bars
2 2 2 side bars
3 3 3 mid-channel bars
4 4 4 diagonal bars
5 5 5 large dunes

Meander dimensions:
belt width ______ mi.
wave length ______ mi.
sinuosity ______

Natural obstructions:
0 0 none
1 1 logs
2 2 beaver dams
3 3 boulders (lag material)
4 4 vegetation

Degree of obstruction:
0 0 none
1 1 occ. minor
2 2 occ. major
3 3 frequent minor
4 4 frequent major

Comments: ______________________

Lateral Channel Activity

Lateral activity:
0 not detectable
1 downstream progression
2 progression and cut-offs
3 mainly cut-offs
4 entrenched loop development
5 laterally active but not 1-4

Lateral stability:
0 stable
1 slightly unstable
2 moderately unstable
3 highly unstable

Comments: ______________________

Channel Banks and Bed

Alluvial bank material:
0 0 0 no alluvial banks
1 1 1 clay and silt (cohesive)
2 2 2 silt and sand (non-cohesive)
3 3 3 sand and gravel (< 64 mm)
4 4 4 sand to cobbles
5 5 5 sand overlain by silt
6 6 6 gravel overlain by silt
7 7 7 cobbles overlain by silt

Non-alluvial bank material:
0 0 0 alluvial bank material
1 1 1 lacustrine deposits
2 2 2 till
3 3 3 easily erodible rock
4 4 4 moderately erodible rock
5 5 5 resistant rock
6 6 6 boulders

Percentage of left bank in alluvium ______ %
Percentage of right bank in alluvium ______ %

Bank vegetation:
0 none
1 weak
2 good
3 very strong

Predominant bed material:
1 sand
2 sand with local gravel
3 gravel
4 gravel with local sand
5 sand and gravel

Depth of alluvium:
0 no alluvium
1 shallow
2 moderate
3 deep

Estimated depth of alluvium ______ ft.

Reference or comments: ______________________

Bed Rock Below Channel

Presence of rock outcrops in channel bed:
0 none
1 one occurrence
2 two occurrences
______ occurrences
9 several occurrences

Rock type at channel base:
0 0 0 not applicable (none for great depth)
1 1 1 compact clay
2 2 2 shale
3 3 3 limestone
4 4 4 sandstone
5 5 5 conglomerate
6 6 6 granite
7 7 7 ______

Erodibility:
0 0 0 not applicable
1 1 1 soft cohesive
2 2 2 easily erodible
3 3 3 moderately erodible
4 4 4 resistant

Comments: ______________________

FIGURE G.2 SAMPLE COPY OF CODING SHEET GEOG2

G.2 Codes for the General Description of the Terrain in the Vicinity of the Surveyed Reach Above Valley

The codes give a rough description of the terrain within approximately 3 mi. radius of the study reach. Normally, a few aerial photographs at and near the reach and a topographic map provide all the data for this code. In the case of normal prairie rivers with well defined valleys cut into the surrounding plains, it is important to apply these "terrain" codes to the area outside the river valley, since other codes will describe the river valley. In mountainous areas the use of these codes is somewhat questionable as the valleys cover essentially the entire area. One can either consider this coding to apply to the higher regions of mountainous valleys or use not applicable ("0") codes.

Terrain: This code corresponds to the physiographic regions given in Atlas of Alberta (1969) and can be obtained there.

Code: 1 mountainous
2 foothills
3 uplands
4 hills
5 plains
6 lowlands

Vegetation: Multiple coding is generally necessary with the most dominant vegetation type being coded first.

Code: 0 not applicable
1 almost none

2 grass

3 shrubs

4 sparsely forested, 0 - 25% of area in forested portion

5 moderately forested, 25 - 75% of area in forested portion

6 heavily forested, 75 - 100% of area in forested portion

7 swamp of muskeg

Forest type: This code is used to describe the forest type in the vegetation code. In most cases it is associated with codes 4, 5, 6, or 7 in the vegetation code.

Code: 0 not applicable

1 deciduous

2 coniferous

Land use: This is a multiple code used to indicate the relative influence of man on the area near the study reach.

Code: 0 no cultivation or built-up areas

1 partly cultivated

2 mainly cultivated

3 partly built-up

4 urbanized

Surficial geology: This code refers mainly to glacial or preglacial deposits, as they dominate the Alberta landscape.

Code: 1 bedrock

2 ground moraine

3 hummocky moraine

4 lacustrine deposits

5 glacio-fluvial deposits

6 fluvial deposits

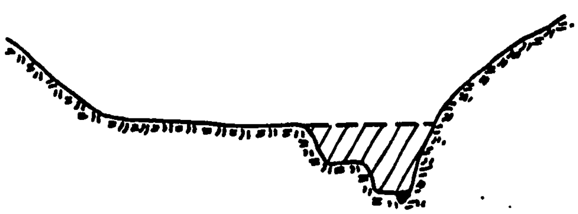
7 aeolian deposits

Comments: Comments should be used liberally to supplement the codes by describing characteristic features of the area.

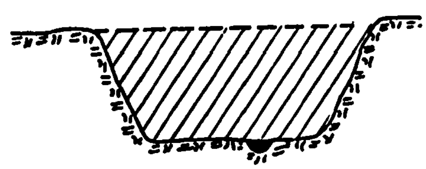
G.3 Valley Characteristics Above Valley Flat

The following codes describe the valley above the valley flat. Valley measurements are made with reference to a major plain area. In situations where the stream has no valley (fans, deltas) or where the valley is not stream cut, "0" codes may be unavoidable.

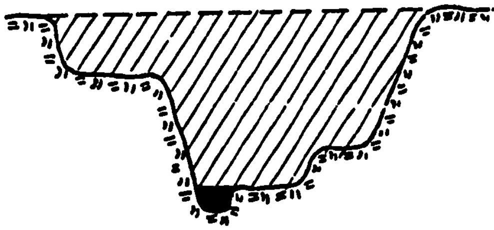
The shaded portions in the following sketches define the valley to which these codes refer. These illustrations show that the major plain is considered to be the upper limit of the defined valley.



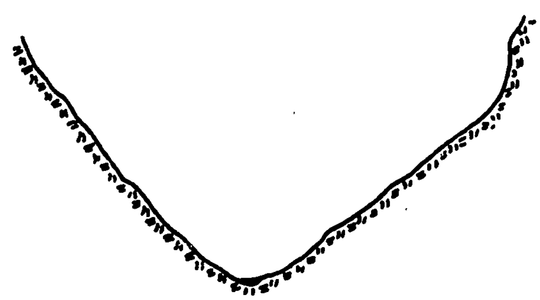
Valley in wide glaciated valley



Trench like valley

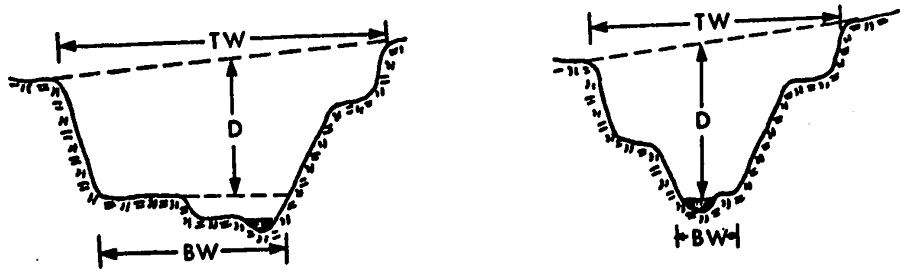


Valley with terraces



Not applicable (mountainous)

Valley measurements: The valley measurements consist of roughly estimated averages for the reach or for the reach and its immediate vicinity. The measurements are defined in the following sketches.



where: D = depth in feet usually to the nearest contour interval on a topographic map unless more detailed data are available

TW = top width of the valley in miles

BW = bottom width of valley in miles

A zero may be used for any of the above three parameters, if there is no valley, or if the measurement is not applicable (e.g. TW for some large mountain valleys).

With the above parameters a rough estimate of the volume of material removed per lineal foot along the channel may easily be computed and the average slope of the valley walls may be estimated as:

$$V_{slope} = \frac{2D}{TW - BW}$$

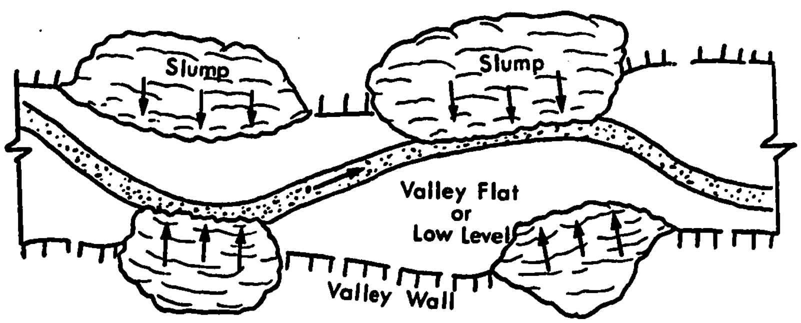
Slumping of valley walls: This code describes the presence of massive slumping of the valley walls in a qualitative manner. The code is not to refer to the small local failures which often occur at bends.

Code: 0 none

1 occasional

2 frequent

Length of reach with slumping valley walls: The massive slumps in contact with the channel impose a control on channel development. It is therefore, important to estimate the length of contact of massive slumps with the channel of the present river. A quantitative code in percent is used to express the total length of massive slump contact with the channel banks in the reach.



For the above case the code would be 15 percent. (Approximately 20 percent of the left bank and 10 percent of the right bank are in contact with massive slumps.)

Vegetation on valley walls: The type of vegetation on the valley walls gives an indication of the general environment and of the ease with which material may be transported from the valley walls to the valley flat or to the channel. This code only applies to the valley wall above the valley flat or above the high water line. Another code will deal with the influence of vegetation on the banks of the channel below the high water line.

Code: 0 not applicable

1 essentially bare

2 grass

3 shrubs

4 sparsely forested

5 moderately forested

6 heavily forested

7 swamp or muskeg

Forest type above valley flat:

Code: 0 not applicable

1 deciduous

2 coniferous

Comments: Additional information such as the difference between north-exposed and south-exposed valley sides, etc., should be noted here. The representativeness of the study reach for longer reaches of the river should also be noted.

G.4 Coding for Terraces

The study of terraces along a river reach can generally provide some information concerning the geologic history of the river and of the valley. At the very least the presence of terraces indicates that the river has had an opportunity for lateral development at some earlier time.

One difficulty of dealing with terraces is the definition of the term. What is a low terrace to some may be a flood plain to others as it is difficult to distinguish between the two without very extensive analysis. Here, the lowest terrace is defined as the first flat area in the valley above the present river which appears to be subject to infrequent flooding only (return periods in the order of 10 years or greater). The lowest terrace is often identical with the valley flat (see Section G.6).

Terrace presence:

Code: 0 none

1 indefinite: small flat areas that may be terraces

2 fragmentary: well defined, but small and discontinuous

3 continuous: terraces are present almost continuously along the valley. Any particular terrace level need not be continuous.

Number of levels: The number of terrace levels may give an indication of the relative frequency of lateral traverses of the valley made by the channel during the valley development. Only a detailed analysis could lead to a truly quantitative evaluation of this code.

Code: 0 not applicable

1 one level

2 two levels

(n) (n) levels

9 several levels

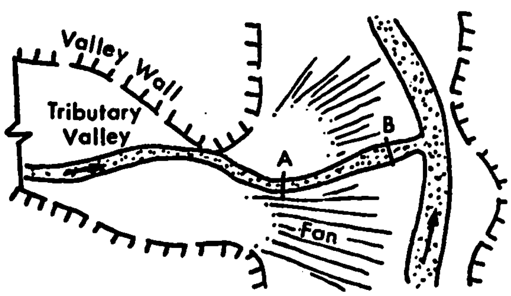
Comments: A brief note on land use and vegetation on the terraces should be added. The representativeness of the coded reach for the river valley in general is also of interest. A note should be made to indicate if the lowest terrace corresponds to the valley flat.

G.5 Coding for Relation of Channel to Valley

This code deals with the relation of the present river to the valley in which it is flowing.

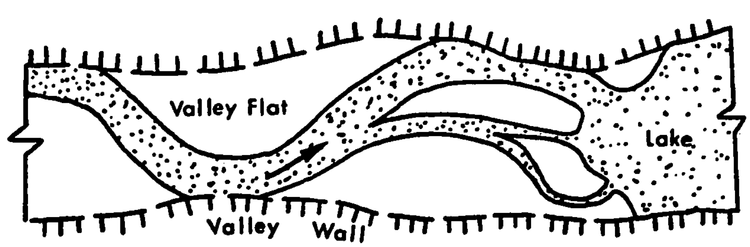
Valley type:

Code: 0 not applicable: mainly situations where the river has no valley of its own, e.g. deltas and fans. Note that this code applies to fans in valleys, if the fan is associated with a tributary valley.



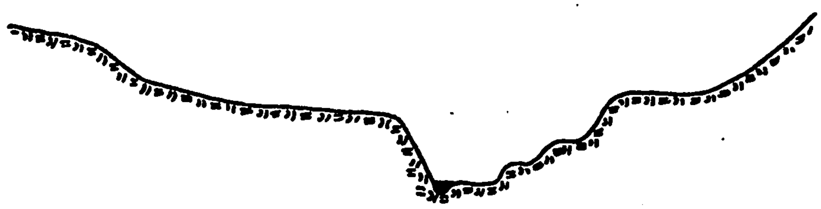
The reach $\overline{AB}$ has no valley

Rivers may flow on deltaic or fan deposits inside their own valley, in which case another code would apply.



1 stream cut valley: most valleys on the plains and narrow mountainous valleys fall into this category. The valley may not have been cut by the present rivers.

2 stream-cut valley in wide valley: a common situation in the foothills of Alberta. The wide valleys are the result of glacial processes.



3 wide mountainous valley: streams in valleys between mountains where the present valley shape is mainly the result of glacial processes.

If no valley: This code gives the reason why the river may not have a valley.

Code: 0 valley present

1 on alluvial fan

2 on alluvial plain

3 in delta

4 in old lake

Underfit: This code is used to point out those channels which are obviously flowing in valleys that have been excavated by larger, earlier rivers.

Code: 0 not applicable or not obviously underfit

1 obviously underfit

Local lateral constriction: Local constrictions of the valley by rock spurs, lava flows, moraines, tributary fans, etc. are listed.

Code: 0 none

1 one case

2 two cases

3 three cases

(n) (n) cases

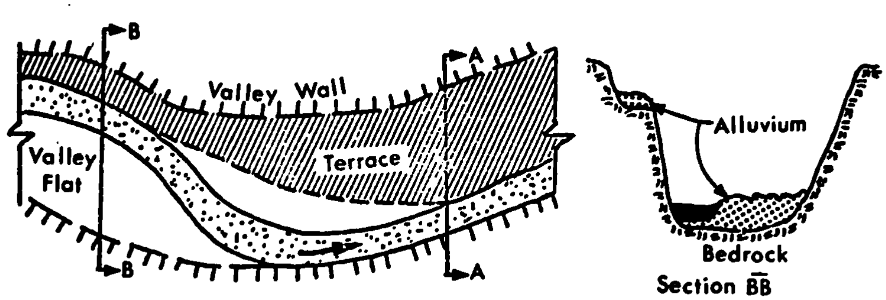
9 several cases

Relation of channel to valley bottom (vertical): This code indicates the state of the vertical activity of the channel with reference to the valley bottom. For this code the valley bottom is that observed on aerial photographs.

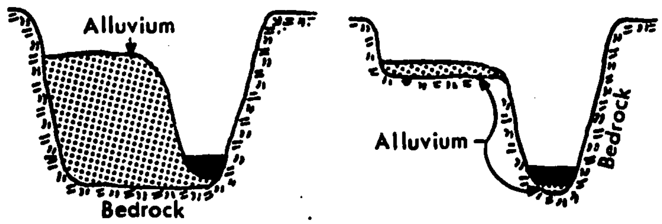
Code: 0 not applicable: situation with no valley

1 not obviously degrading or aggrading: mainly river reaches associated with a prominent and frequently flooded valley flat, which appears to be a flood plain in the geomorphic sense.

2 partly entrenched: some segments of the study reach are entrenched, either in non-alluvial material (bedrock, till, etc.) or in major alluvial terrace deposits.



(continued)



Two Possible Situations at Section $\overline{AA}$

The river is entrenched at Section $\overline{AA}$ (in both situations shown), but not entrenched at Section $\overline{BB}$.

3 entrenched

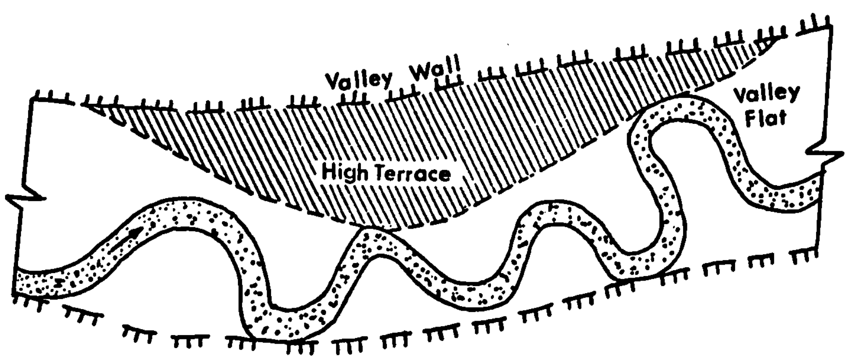
4 aggrading

Relation of channel to valley walls or to high, resistant terraces: This code deals with the restraints on lateral development (meandering) of the channel imposed by valley walls or high terraces.

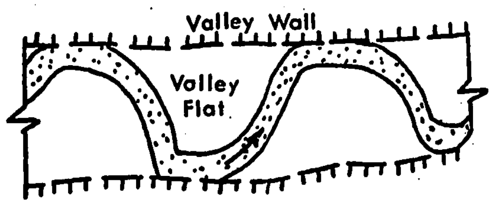
Code: 0 not applicable (no valley or free)

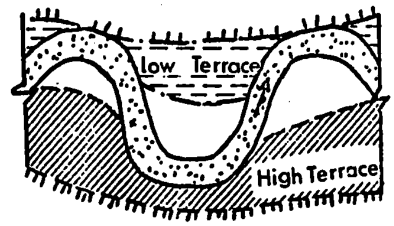
1 occasionally confined: the river is occasionally deflected by the valley wall or by a terrace

2 frequently confined: the river is frequently deflected by the valley wall or by a terrace



3 confined: the river is regularly deflected by the valley walls or by terraces.





4 entrenched

Comments: The subject matter of the above codes is open to widely differing interpretations. The situation should always be described verbally, even if the codes seem to fit well. As before, the representativeness of the coded reach should also be noted.

G.6 Codes for Description of Valley Flat

In the context of this code, the valley flat is the lowest flat associated with the present river and is subject to frequent or occasional flooding. In geomorphological terms it may be a flood plain or a low terrace. In engineering terms it is always a flood plain. The use of the term valley flat implies that no specific genetic meaning is intended, but it is to be considered as a readily observable physical feature. In some cases it is difficult to assure that the selected valley flat is at a constant genetic level along the river reach.

The valley flat codes also apply to cases where there is no valley. The flat associated with an alluvial fan, for example, should be considered to be the valley flat for the purposes of coding.

Presence:

Code: 0 none: this applies to entrenched channels

1 indefinite: small flat areas

2 fragmentary: a definite valley flat is present for some distance along the reach.

3 continuous: a well defined valley flat is present on at least one side of the channel along most of the length of the reach.

Lateral extent: The purpose of this code is to evaluate the approximate extent of the valley flat.

Code: 0 none

1 narrow (less than 1 river width at bankfull stage)

2 moderate (between 1 and 5 river widths at bankfull stage)

3 wide (greater than 5 river widths at bankfull stage).

Average width of valley flat, in mi.: The average width is based on the width of a rectangle of area equal to that of the valley flat and with the length of the rectangle approximately equal to the length of valley flat in contact with the river. The flat on both sides of the channel is considered when making an estimate of the average width of valley flat.

Maximum width of valley flat, in mi.

Channel length with valley flat on left, percent

Channel length with valley flat on right, percent

Vegetation for valley flat: The type of vegetation on the valley flat may indicate the relative resistance offered to overbank flow.

Code: 0 not applicable

1 almost none or bare

2 grass

3 shrubs

4 sparsely forested

5 moderately forested

6 heavily forested

7 swamp or muskeg

Forest type:

Code: 0 not applicable

1 deciduous

2 coniferous

Valley flat land use:

Code: 0 not cultivated, not built-up

1 partly cultivated

2 mainly cultivated

3 partly built-up

4 urbanized

Comments: At least a note on representativeness.

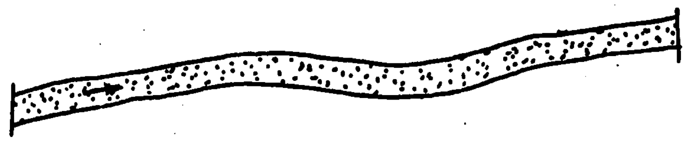
Some additional information concerning the presence of a low level bench, a vegetation trim line, or a valley flat is noted in the hydraulic geometry data. The approximate return period, at which the river stage reaches these features is also given there.

G.7 Coding for Channel Description

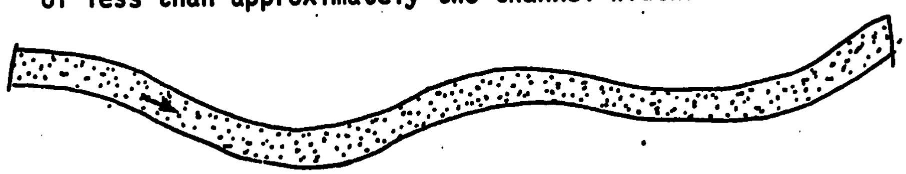
This section deals primarily with the planimetric aspects of the reach, as it appears near long-term-mean stage. This rather low stage is used here because air photos rarely show the channels at flows near bankfull.

Channel pattern:

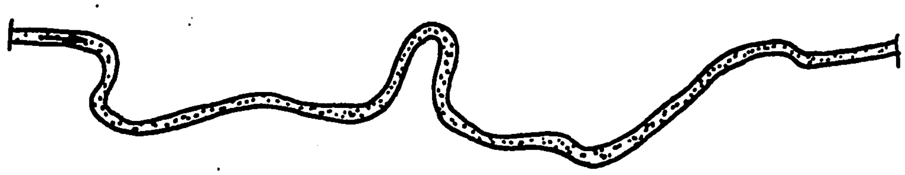
Code: 1 straight: very little curvature within reach.



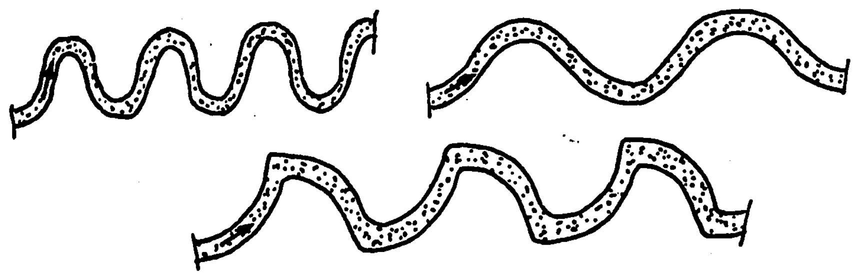
2 sinuous: slight curvature with a belt width or deviation of less than approximately two channel widths.



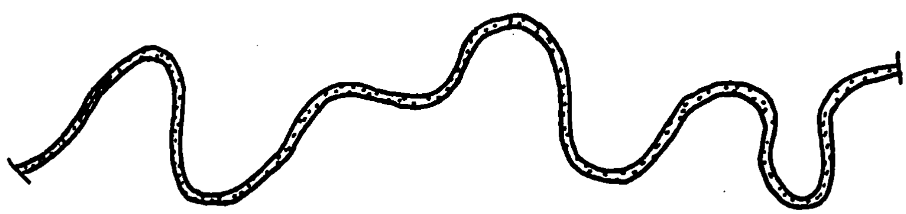
3 irregular: a channel pattern which cannot be considered straight or sinuous and does not have a repeatable pattern. This code also applies to structurally controlled, geometric patterns (add appropriate comments).



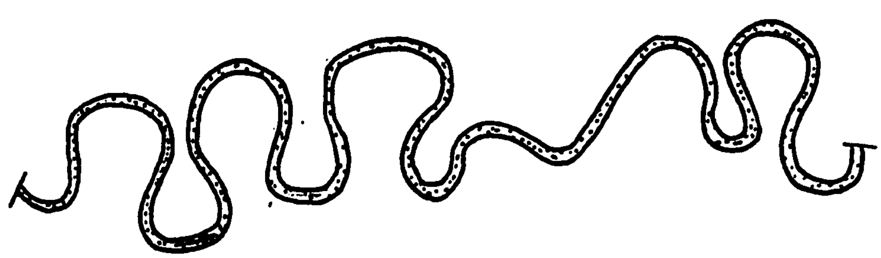
4 regular meanders: this channel pattern is characterized by a repeatable pattern. The angle that the channel makes with the valley axis at the cross-over is less than, or equal to 90°.



5 irregular meanders: a repeatable pattern is detectable in the channel plan but it cannot be considered regular.



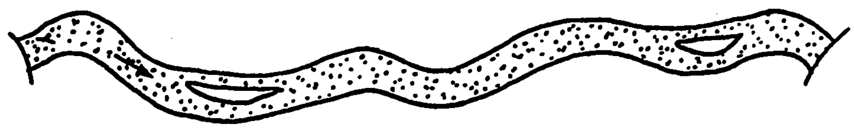
6 tortuous meanders: the channel plan is more or less repeatable but is different from the regular meander in that the angle between the channel and the valley axis at cross-overs is frequently greater than 90°.



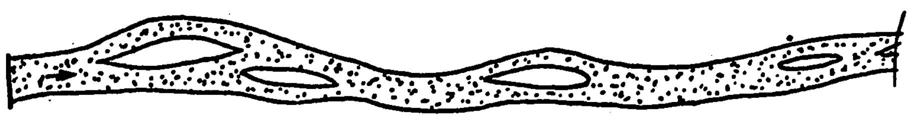
Islands:

Code: 0 none

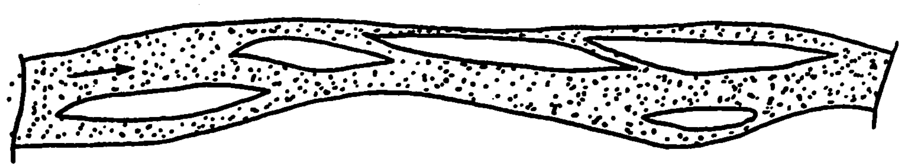
1 occasional: the islands should be relatively stable and have some vegetation. It should generally be possible to consider the surface of the islands as part of the valley flat. No overlapping of islands, the average spacing being 10 or more river widths.



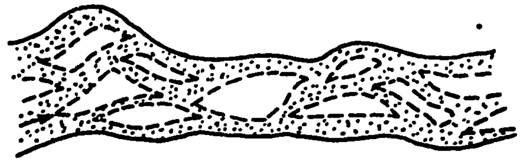
2 frequent: in appearance the islands should be as above, but there may be infrequent overlapping, with the average spacing being less than 10 river widths.



3 split: the islands are stable, as above and overlap frequently or continuously. The number of flow channels is usually two or three.



4 braided: in this case the islands are characterized by being unstable and overlapping. They may have some vegetation. The number of flow channels is greater than two.



Type of flow: This code classifies the river reach according to the type of energy dissipation indicated by the water surface.

Code: 1 uniform water surface

2 uniform with rapid in reach: this is not a pool and riffle sequence but is indicative of a non-uniformity in the reach.

3 uniform with boils and irregularities: irregular water surface indicating a channel with high velocities and generally high Froude number.

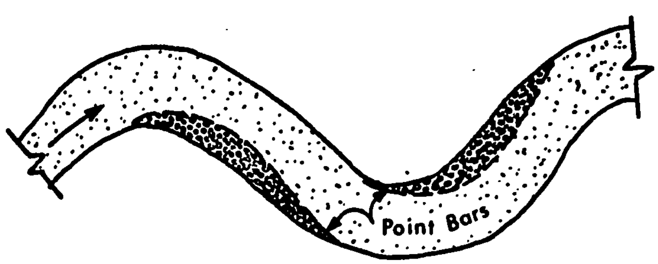
4 pool and riffle sequence: pools and riffles (rapids) at relatively uniform spacing. Most of the energy is lost in the riffles.

5 tumbling flow: most mountainous streams are characterized by this type of flow. Jets, wakes and hydraulic jumps account for part of the energy loss.

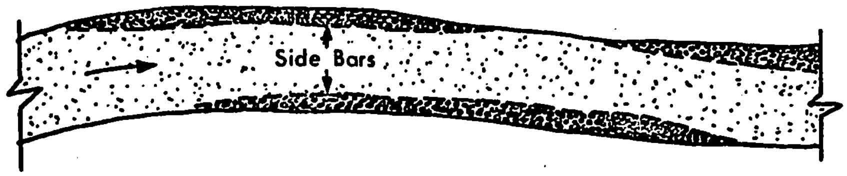
Bar type: Bars differ from islands (considered above) by being largely unvegetated and submerged at or below bankfull stage.

Code: 0 none

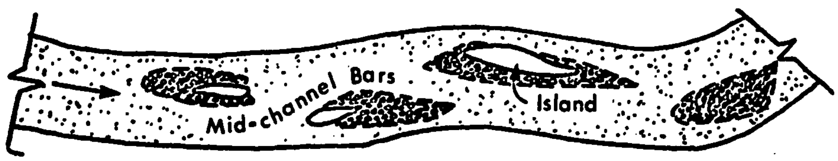
1 point bars



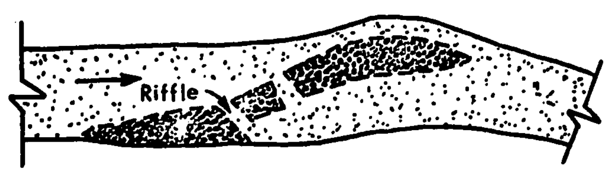
2 side bars



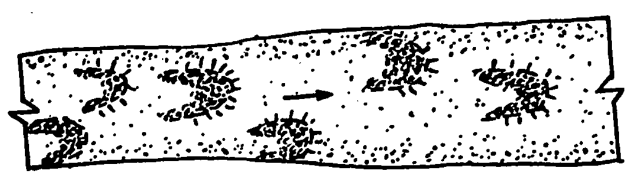
3 mid-channel bars



4 diagonal bars (mainly gravel): this applies to bars which extend part way across or all the way across the channel. A riffle may sometimes be considered a diagonal bar.



5 large dunes: a feature occurring in certain sand-bed rivers. Lingoid bars with gentle up-stream slope and steep downstream slope (at angle of repose).



Meander dimensions: If the channel plan is classified as meandering, it should be possible to obtain an estimate of the average meander dimensions. A somewhat longer portion of the river than the study reach may have to be used to make the necessary measurements. If several wavelengths and belt widths are measured, present the average for the reach. If the channel plan is not considered to have a repeatable pattern, enter "0" for the meander dimensions.

Meander wavelength (mi.)

Meander belt width (mi.)

Sinuosity: the definition of sinuousity used is the thalweg length divided by the valley axis length between two points on the channel. This definition is satisfactory except for those cases where the valley is entrenched. In such cases, the sinuosity as defined above may be approximately 1.00, although the channel is not straight in plan.

If the reach is similar to the channel upstream and downstream of the surveyed reach, the sinuosity is usually determined between the contour lines used to establish the topographic slope. In cases where the study reach is not typical of a longer portion of the river, the sinuosity is presented for the reach only and a note is made to indicate the variability of channel plan shape. The value for sinuosity is presented to three significant digits but only two are justified in most cases.

Natural obstructions: Certain natural obstructions can have far-reaching effects on channel slope, type of flow, and channel pattern. This code attempts to recognize and identify them. Man-made obstructions are given in the coding related to the surveyed reach.

Code: 0 none

1 logs

2 beaver dams

3 boulders (lag material)

4 vegetation

Degree of obstruction:

Code: 0 none

1 occasional minor

2 occasional major

3 frequent minor

4 frequent major

Comments: The extent to which the study reach described here is typical of the river beyond the study reach should always be noted. If the channel pattern is stage dependent, this should also be noted.

G.8 Codes for Lateral Channel Activity

This code attempts to describe the predominant type of lateral channel activity in the reach. One difficulty of using this code is that it may not be possible to distinguish the presently active process from processes which may have been active at earlier periods.

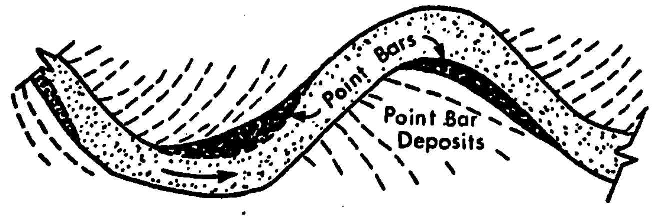
Some common features which assist in the evaluation of this code are meander scrolls (point bar deposits), meander scars, lineated vegetation, cut-offs, etc.

Lateral activity

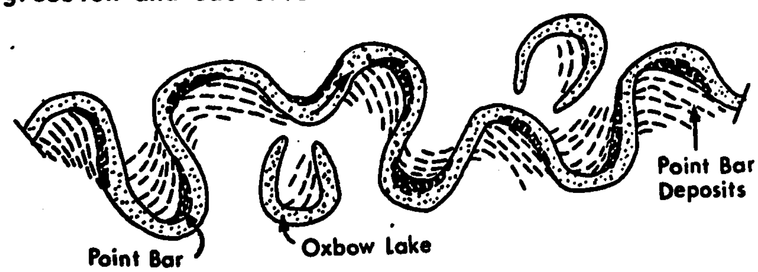
Code: 0 not detectable: this code is used if no signs of lateral channel activity are noted.

1 downstream progression: the whole meander pattern moves

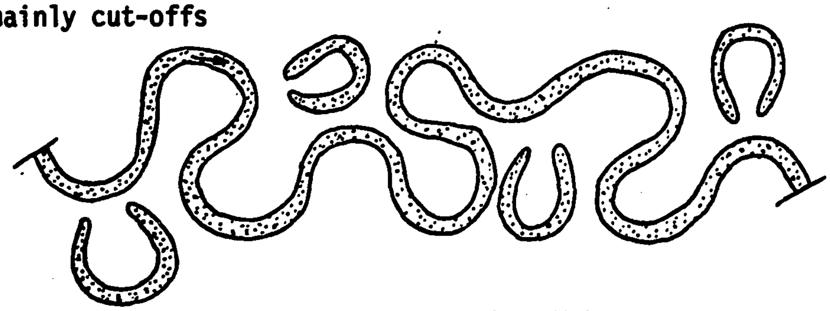
down-valley without forming cut-offs. Frequently associated with regular, confined meanders.



2 progression and cut-offs

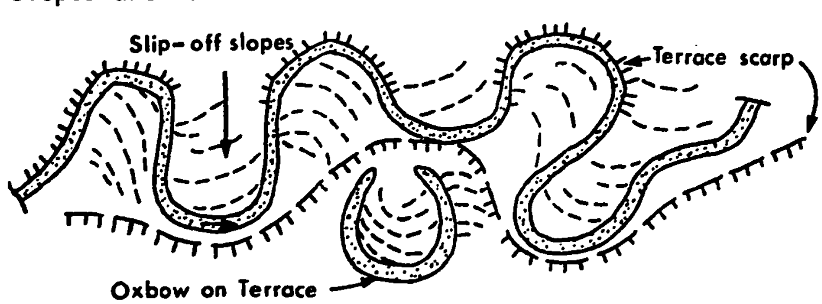


3 mainly cut-offs



Mainly Suspended Load Deposits on Valley Flat

4 entrenched loop development: occurs with rivers entrenched in relatively easily erodible materials. Generally associated with irregular or contorted meanders. Slip-off slopes are formed on the inside of the meander bends.



5 laterally active but not 1-4: this code is used for gravel rivers which exhibit irregular lateral activity.

Lateral stability: The degree of lateral stability may be estimated from air photos on the basis of plant growth, occurrence of vertical but banks, eroded fields, etc. The conclusions may be somewhat biased if the air photos were taken shortly after a major flood.

This code is to apply to activity of the present river.

Code: 0 stable: bank vegetation is well developed with no evidence of recent bank erosion.

1 slightly unstable: localized bank erosion.

2 moderately unstable: a considerable part of the total length of either bank is subject to erosion or is being newly formed. Vegetation (if present) also indicates channel shift. Presence of vertical alluvial banks or very steep non-alluvial banks.

3 highly unstable: clear evidence that the channel has changed position in recent past. Little opportunity for growth of well established vegetation on the valley flat.

An indication of vertical stability in the reach may be obtained from the stability of a stage-discharge relation if there is one available in the reach.

Comments: Note the rate of lateral movement if it can be estimated from comparison between old and new photos or maps. Comment on representativeness of coding.

G.9 Codes for Channel Banks and Bed

This code applies to the channel bed and to those banks which are subject to attack by the river; that is, the banks below the valley flat or below the estimated two-year flood.

Alluvial bank material:

Code: 0 no alluvial bank material

1 clay and silt (cohesive)

2 silt and sand (non-cohesive)

3 sand to gravel (< 64 mm.)

4 sand to cobbles

5 sand overlain by silt

6 gravel overlain by silt

7 cobbles overlain by silt

Non-alluvial bank material: Rock types are not used, since one rock type may not always fall into the same category concerning erodibility.

Code: 0 alluvial bank material

1 lacustrine deposits

2 till

3 easily erodible rock: this code applies to rock types that weather into fine material and are relatively easily eroded. Weathered shale usually fits into this category.

4 moderately erodible rock

5 resistant rock: granites or hard sandstones fall into this category.

6 boulders

Length of river bank on left with alluvial banks (percent)

Length of river bank on right with alluvial banks (percent)

These estimates are best made during a field visit but rough estimates may be made from aerial photographs. The greatest difficulty arises with channels in the early stages of entrenchment. The appearance of the banks may not indicate that the base of the channel is cut in bed rock.

Bank vegetation: As above, this code also applies to the banks below the valley flat or below the level corresponding to the two-year flood. The code evaluates the importance of bank vegetation on the stability of the bank. No vegetation type is noted since there may be considerable variation in the vertical and between sections. Most emphasis should be placed on banks which are subject to some attack by the river.

Code: 0 none: no vegetation or no effective vegetation. Vegetation on the valley flat may offer little resistance to lateral development, unless it is deep-rooted.

1 weak: this could apply to sparse shrubs.

2 good

3 very strong: e.g. a dense growth of willows, or alders overhanging the channel. A well sodded bank may also fit here.

Predominant bed material type: This code categorizes the channels by the bed material type.

Code: 1 sand

2 sand with local gravel

3 gravel

4 gravel with local sand

5 sand and gravel

Depth of alluvium: In some cases a rough estimate of the depth of alluvium may be available from field observations or from test holes shown on bridge plans, etc. The depths are expressed in terms of the mean depth associated with a high flow (say bankfull discharge or a 10 year flood). The high flow does not have to be precisely defined for this evaluation.

Code: 0 no alluvium: stream essentially on bed rock through entire reach.

1 shallow: less than 1/2 times the estimated flood depth.

2 moderate: between 1/2 and 1-1/2 times the estimated flood depth.

3 deep: greater than 1-1/2 times the estimated flood depth.

Estimated depth of alluvium (feet):

Comments: The reference for the depth of alluvium should be noted along with any necessary qualifying statement.

G.10 Codes for Bed Rock Below Channel

Presence of rock outcrops in channel bed: The number of observed bedrock outcrops is coded. There may naturally be more outcrops than those noted.

Code: 0 none

1 one occurrence

2 two occurrences

(n) (n) occurrences

9 several occurrences

Bedrock type at channel base or below alluvium: This is a multiple code, with the dominant or first code applying to the actual outcrops if any. Otherwise, the codes apply to the bedrock under the alluvium if it is known.

Code: 0 not applicable: in this case the depth of alluvium is greater than about three times the 25-year flood depth.

1 compact clay

2 shale

3 limestone

4 sandstone

5 conglomerate

6 granite

Bedrock erodibility: This code describes the bedrock type in the above code.

Code: 0 not applicable

1 soft cohesive: this would apply to compact clays and to some types of shale.

2 easily erodible

3 moderately erodible

4 resistant

Comments: If the reach has been inspected in the field it should be possible to expand considerably on the above codes.

APPENDIX H

EXAMPLE OF DATA FOR A TYPICAL REACH

H.1 General

The purpose of this appendix is to present an example of the general type of data available for a typical study reach used in this investigation. No discussion is presented to amplify the figures which are presented in this example. Additional information concerning some of the figures may be obtained by consulting other relevant appendices.

Only one example of each type of data is given, for instance, only one cross-section plot is shown. Not all reaches have exactly the same data available, but the example presented is typical.

H.2 Typical Data for a Reach

The reach used for this example is the Lobstick River near Styal. This reach was surveyed by the writer during the summer of 1970. The data for the reach are presented in the following order:

1. General Reach Data
    1. General data for reach.
    2. Topographic map of the reach and vicinity.
    3. Stereo-pair for reach (1" = 1320').
    4. Geographical description of reach and vicinity (2 coded sheets).
    5. Sketch map to show location of cross-sections, photographs, bed material samples, and geomorphic features.
2. Hydrologic Data
    1. Hydrometric station description (Water Survey of Canada).

2. Rating curve applicable for the date of survey (Water Survey of Canada).

3. Long-term mean discharges and flow duration data (Hydrology Branch, Water Resources Division, Alberta Department of the Environment).

4. Flood frequency data for hydrometric station.

5. Flood frequency plot.

3. Slope Data

1. Comparison of photo distances and field distances.

2. Data for water surface profile on date of survey.

3. Plot of longitudinal water surface profile.

4. Determination of topographic slope and summary of field slope data.

4. Hydraulic Geometry Data

1. Typical cross-section plot.

2. Estimation of average elevation of the low level bench.

3. Estimation of average elevation of the valley flat.

4. Extrapolation of the rating curve to the adopted elevation of the valley flat.

5. Summary of stage-discharge relations for various characteristic discharges.

6. Computer print-out of the hydraulic geometry data for a cross-section.

7. Computer print-out of the average hydraulic geometry and characteristic flow parameters for the reach.

5. Supplementary Data

1. Field check sheet for valley and channel data.

2. Field check sheet for bank characteristics.

3. Field notes, comments and further description of each cross-section.

4. Typical field photographs on date of survey.

No bed material data are presented since a complete example of the method of recording and storing bed material data is given in APPENDIX D.

General Data for Reach

Reach Name: Lobstick River near Styal, Alberta

Research Council of Alberta Number: 116

Water Survey of Canada Code: 7BB003

Date of Survey:

Water Surface Profile 5 Jun. 1970
Stage: 1.66 ft.; Discharge: 50 cfs.

Cross-section: 8 Jun. 1970
Stage: 1.48 ft.; Discharge: 38 cfs.

Length of reach:	4491 ft.
Length below gauge:	2314 ft.
Number of cross-sections:	10
Drainage area above reach:	671 square miles
Long term mean discharge:	137 cfs. (11 yrs.)

Comments: The reach is located about 5 valley miles upstream from its confluence with the Pembina River. There is natural storage upstream, as the river is the outlet from Chip Lake.

FIGURE H.1 GENERAL DATA FOR REACH

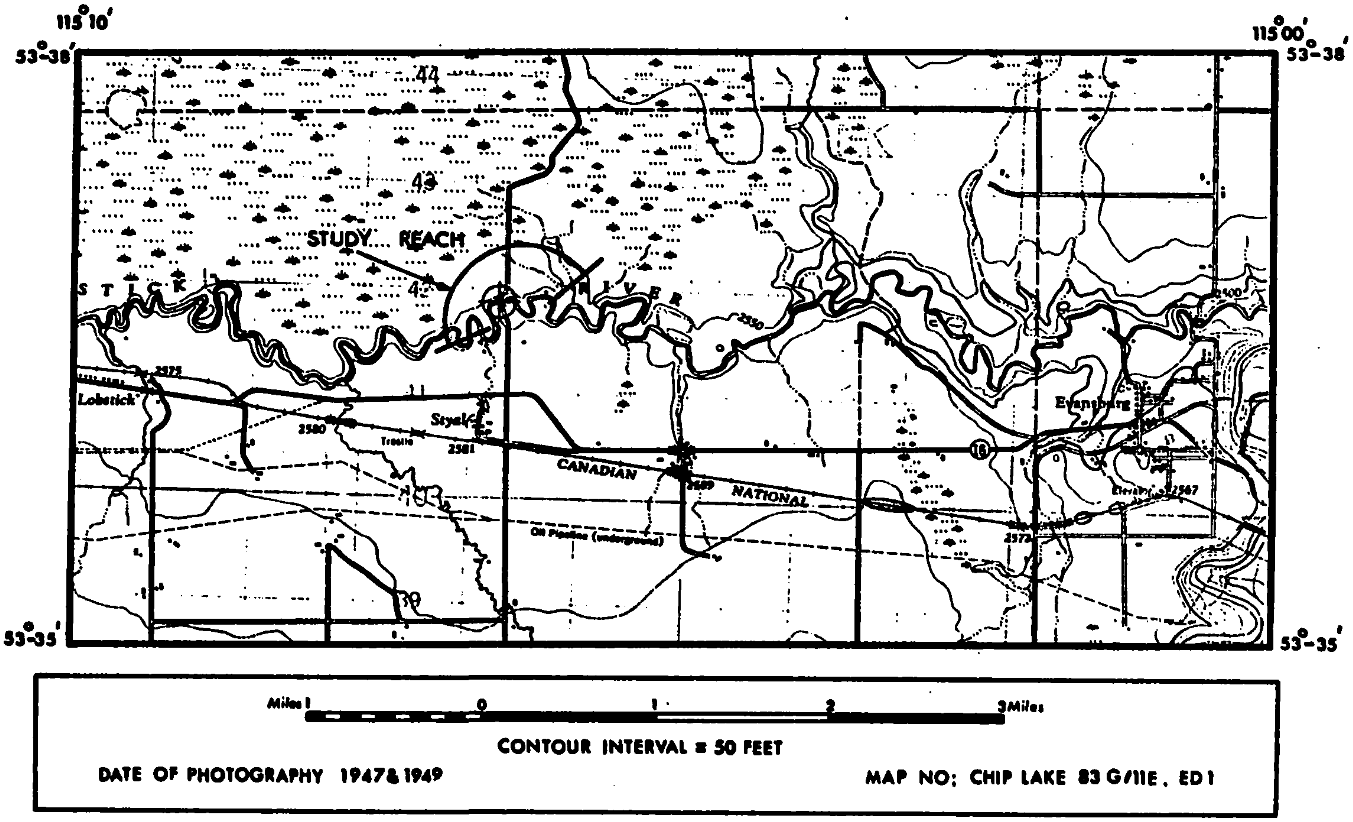
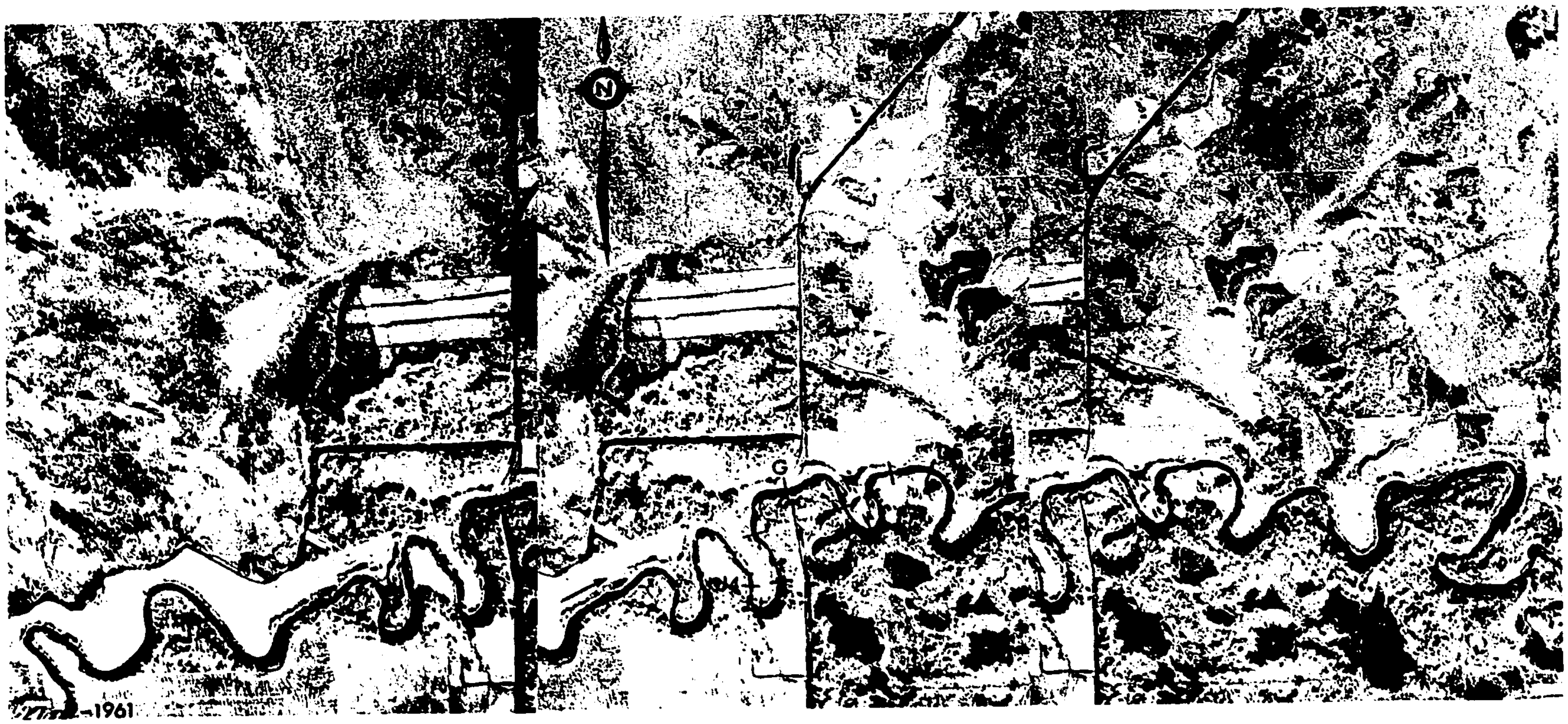


FIGURE H.2 TOPOGRAPHIC MAP OF REACH AND VICINITY



SCALE: 0 1320 2640 3960 5280 ft.

REACH: LOBSTICK RIVER NEAR STYAL RCA # 116

FIGURE H.3 STEREO TRIPLET OF STUDY REACH AND VICINITY.

RESEARCH COUNCIL OF ALBERTA
HIGHWAY AND RIVER ENGINEERING DIVISION
UNIVERSITY OF ALBERTA
DEPARTMENT OF CIVIL ENGINEERING

RIVER DATA SHEET No. Geog. 1/71

GEOGRAPHIC FEATURES

Reach Name: LOBSTICK R. NE. STYAL Reach No: 116 Date of Analysis: 9 MAR 1971 Analysis By: D.I.Bray
Scale of Air Photos: 1" = 1320' Scale of Map: 1:50,000

NOTE: Complete codes by circling the appropriate number(s). Use "-1" for "unknown" and "0" for "not applicable".

General Description of the Terrain in the Vicinity of the Surveyed Reach, above Valley

Terrain:
1 mountainous
2 foothills
3 uplands
4 hills
5 plains
6 lowlands

Vegetation:
0 0 0 not applicable
1 1 1 almost none
2 2 2 grass
3 3 3 shrubs
4 4 4 sparsely forested, 0-25%
5 5 5 moderately forested, 25-75%
6 6 6 heavily forested, 75-100%
7 7 7 swamp or muskeg

Forest type:
0 0 0 not applicable
1 1 1 deciduous
2 2 2 coniferous

Comments: ______

Land use:
0 0 no cultivation or built-up area
1 1 partly cultivated
2 2 mainly cultivated
3 3 partly built-up
4 4 urbanized

Surficial geology:
1 1 1 bedrock
2 2 2 ground moraine
3 3 3 hummocky moraine
4 4 4 lacustrine deposits
5 5 5 glacio-fluvial dep.
6 6 6 fluvial deposits
7 7 7 aeolian deposits

Valley Characteristics above Valley Flat

Valley measurements:
✓ within reach
___ within reach and immediate vicinity
depth: 50 ft.
top width: 0.20 mi.
bottom width: 0.04 mi.

Slumping of valley walls:
0 none
1 occasional
2 frequent

Length of reach with slumping valley walls (contact length in percent of total length of banks): 0

Vegetation on valley wall:
0 0 not applicable
1 1 almost none
2 2 grass
3 3 shrubs
4 4 sparsely forested
5 5 moderately forested
6 6 heavily forested
7 7 swamp or muskeg

Forest type on valley wall:
0 0 not applicable
1 1 deciduous
2 2 coniferous

Comments: ______

Terraces

Terrace presence:
0 none
1 indefinite
2 fragmentary
3 continuous

Number of levels:
0 not applicable
1 one level
2 two levels
__ __ levels
3 several levels

Comments (in particular land use and vegetation): ______

Relation of Channel to Valley

Valley type:
0 not applicable
1 stream cut valley
2 stream cut valley in wide valley
3 wide mountainous valley

If no valley:
0 valley present
1 on alluvial fan
2 on alluvial plain
3 in delta
4 in old lake

Underfit:
0 not applicable or not obviously underfit
1 obviously underfit

Local lateral constriction:
0 none
1 one
2 two
__ cases
3 several cases

Relation of channel to valley bottom (vertical):
0 not applicable
1 not obviously degrading or aggrading
2 partly entrenched
3 entrenched
4 aggrading

Relation of channel to valley walls or to high, resistant terraces (lateral):
0 not applicable (no valley or free)
1 occasionally confined
2 frequently confined
3 confined
4 entrenched

Comments: ______

FIGURE H.4 GEOGRAPHICAL DESCRIPTION OF TERRAIN AND RELATION OF CHANNEL TO VALLEY

RESEARCH COUNCIL OF ALBERTA
HIGHWAY AND RIVER ENGINEERING DIVISION
UNIVERSITY OF ALBERTA
DEPARTMENT OF CIVIL ENGINEERING

RIVER DATA SHEET No. Geog. 2/71

GEOGRAPHIC FEATURES - (Cont'd.)

Reach Name: LOBSTICK RIVER NEAR STYAL, ALTA. Reach No: 116

Description of Valley Flat

Presence:
0 none
1 indefinite
2 fragmentary
3 continuous

Extent:
0 none
1 narrow (< 1 W_s)
2 moderate (1-5 W_s)
3 wide (> 5 W_s)

Average width 0.02 mi.
Maximum width 0.04 mi.
Channel length with valley flat on left 30 %
on right 50 %

Vegetation:
0 0 not applicable
1 1 almost none or bare
2 2 grass
3 3 shrubs
4 4 sparsely forested
5 5 moderately forested
6 6 heavily forested
7 7 swamp or muskeg

Forest type:
0 0 not applicable
1 1 deciduous
2 2 coniferous

Land use:
0 0 not cultivated, not built-up
1 1 partly cultivated
2 2 mainly cultivated
3 3 partly built-up
4 4 mainly built-up

Comments: VALLEY FLAT OF LIMITED EXTENT

Channel Description (near long-term mean)

Channel pattern:
1 straight
2 sinuous
3 irregular
4 regular meanders
5 irregular meanders
6 tortuous meanders

Islands:
0 none
1 occasional
2 frequent
3 split
4 braided

Type of flow:
1 uniform water surface
2 uniform with rapid in reach
3 uniform with boils and irregularities
4 pool and riffle sequence
5 tumbling flow

Bar type:
0 0 0 none
1 1 1 point bars
2 2 2 side bars
3 3 3 mid-channel bars
4 4 4 diagonal bars
5 5 5 large dunes

Meander dimensions:
belt width 0.15 mi.
wave length 0.20 mi.
sinuosity 1.90

Natural obstructions:
0 0 none
1 1 logs
2 2 beaver dams
3 3 boulders (log material)
4 4 vegetation

Degree of obstruction:
0 0 none
1 1 acc. minor
2 2 acc. major
3 3 frequent minor
4 4 frequent major

Comments:

Lateral Channel Activity

Lateral activity:
0 not detectable
1 downstream progression
2 progression and cut-offs
3 mainly cut-offs
4 entrenched loop development
5 laterally active but not 1-4

Lateral stability:
0 stable
1 slightly unstable
2 moderately unstable
3 highly unstable

Comments:

Channel Banks and Bed

Alluvial bank material:
0 0 0 no alluvial banks
1 1 1 clay and silt (cohesive)
2 2 2 silt and sand (non-cohesive)
3 3 3 sand and gravel (< 64 mm)
4 4 4 sand to cobbles
5 5 5 sand overlain by silt
6 6 6 gravel overlain by silt
7 7 7 cobbles overlain by silt

Non-alluvial bank material:
0 0 0 alluvial bank material
1 1 1 lacustrine deposits
2 2 2 till
3 3 3 easily erodible rock
4 4 4 moderately erodible rock
5 5 5 resistant rock
6 6 6 boulders

Percentage of left bank in alluvium 80 %
Percentage of right bank in alluvium 80 %

Bank vegetation:
0 none
1 weak
2 good
3 very strong

Predominant bed material:
1 sand
2 sand with local gravel
3 gravel
4 gravel with local sand
5 sand and gravel

Depth of alluvium:
0 no alluvium
1 shallow
2 moderate
3 deep
-1

Estimated depth of alluvium — ft.

Reference or comments:

Bed Rock Below Channel

Presence of rock outcrops in channel bed:
0 none
1 one occurrence
2 two occurrences
___ occurrences
5 several occurrences

Rock type at channel base:
0 0 0 not applicable (none for great depth)
1 1 1 compact clay
2 2 2 shale
3 3 3 limestone
4 4 4 sandstone
5 5 5 conglomerate
6 6 6 granite
7 7 7 ______
-1

Erodibility:
0 0 0 not applicable
1 1 1 soft cohesive
2 2 2 easily erodible
3 3 3 moderately erodible
4 4 4 resistant
-1

Comments:

FIGURE H.5 GEOGRAPHIC FEATURES RELATED TO THE VALLEY FLAT AND THE CHANNEL BED AND BANKS

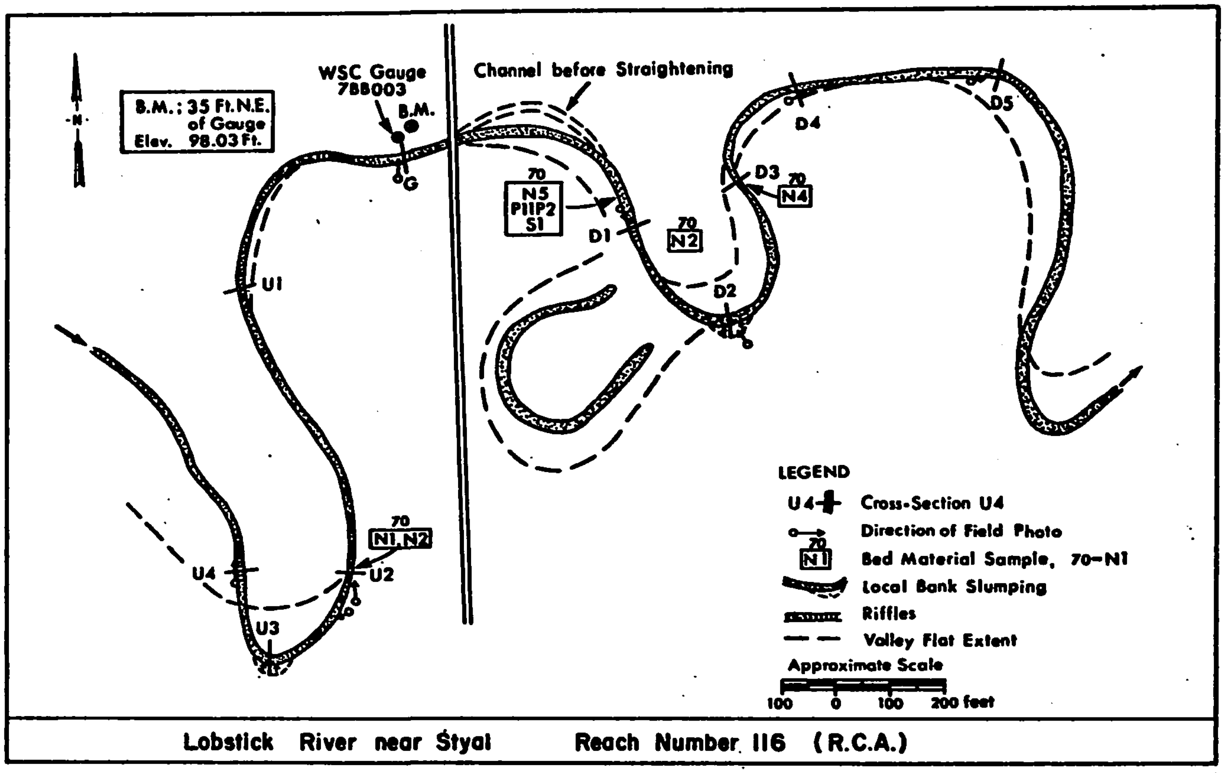


FIGURE H.6 SKETCH MAP SHOWING LOCATION OF CROSS-SECTIONS, FIELD PHOTOGRAPHS, BED-MATERIAL SAMPLE SITES, AND GEOMORPHIC FEATURES

DEPARTMENT OF NORTH. AFFAIRS AND NATIONAL RESOURCES - WATER RESOURCES BRANCH

1968 STATION DESCRIPTION FOR PUBLICATION

Station No.

Lobstick River near Styal 07BB003

Location: Lat. 53° 36' 45", long. 115° 06' 20", Alberta, in NE. ¼ sec. 28, tp. 53, rge. 8, W. 5th Mer., about four miles above confluence with Pembina River twelve miles downstream from Chip Lake and one mile north of Styal.

Drainage Area: 671 square miles.

Gauge: Recording installed November, 1966, about twenty feet below former manual gauge location.

Period of Record: Continuous January, 1955, to December, 1968; miscellaneous measurements in 1954.

Mean Discharge: (12 years) 133 cfs.

Extremes Recorded:

Maximum	[redacted] Daily	June 29, 1965 (g.h. 9.22)	3,380 cfs.
Minimum	[redacted] Daily	At various times	0 cfs.

Revisions:

Remarks: Records good. During the period 1913 to 1923, data were collected at a site near the confluence with Pembina River, about four miles downstream, and published under the title "Lobstick River near Entwistle".

FIGURE H.7 HYDROMETRIC STATION DESCRIPTION

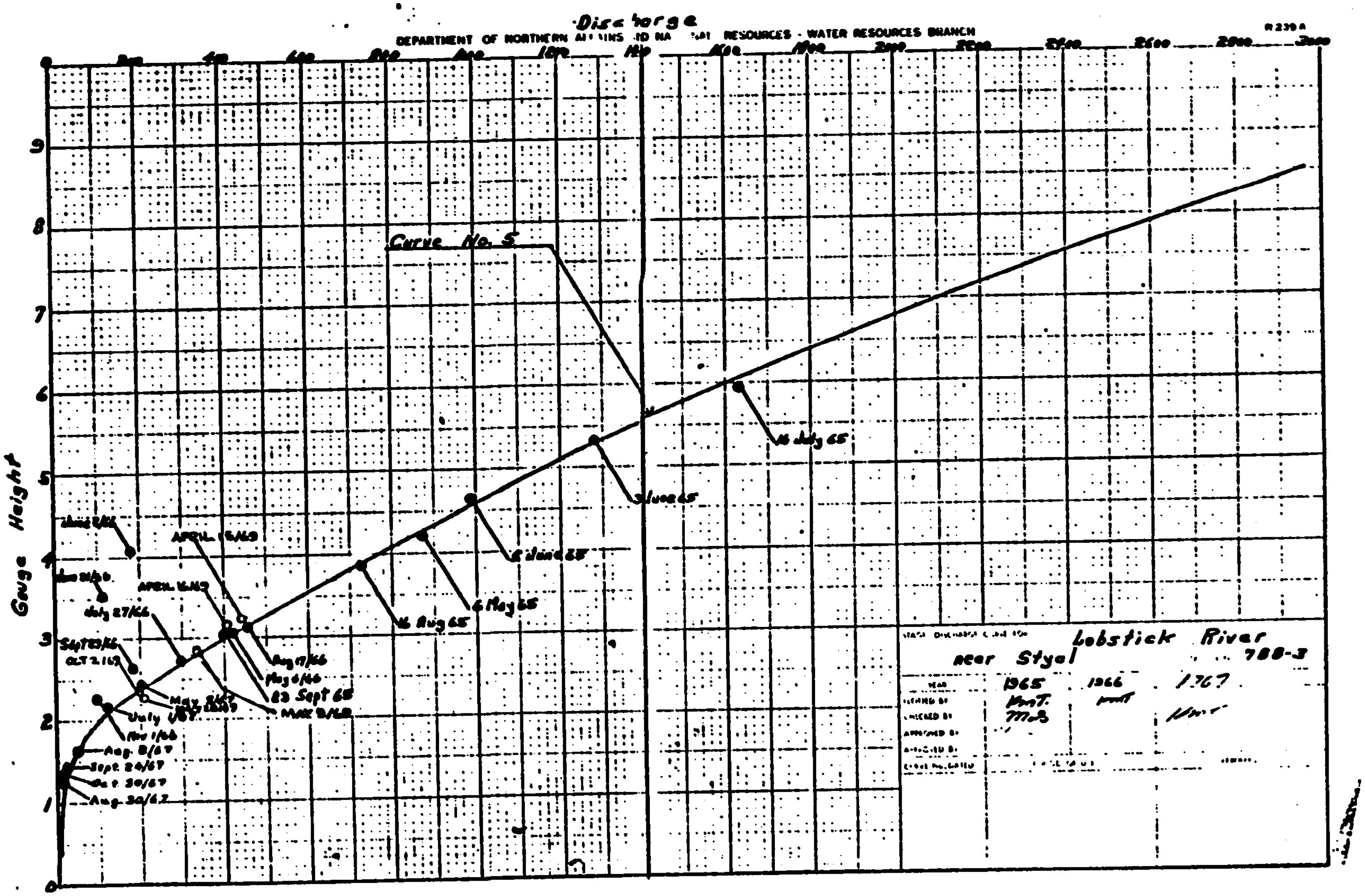


FIGURE H.8 RATING CURVE APPLICABLE FOR DATE OF SURVEY

FLOW DURATIONS FOR STATION 07BB003

LOBSTICK RIVER NEAR STYAL
NO. OF YEARS OF RECORD 14
DRAINAGE AREA 671.0 SQ.MS.

	COMPLETE PERIODS	MEAN	FREQUENCIES .0010	.0050	.0100	.0200	.0500	.1000	.2000	.5000	.9000	.9500	.9900
JAN-DEC CFS	11	136.5	1880.0	1280.0	1050.0	778.0	532.0	338.0	167.0	74.0	6.3	0.0	0.0
% OF MEAN			1377.6	937.9	769.4	570.1	389.8	247.7	122.4	54.2	4.6	0.0	0.0
MAR-OCT CFS	12	171.6	1880.0	1260.0	1010.0	732.0	505.0	323.0	156.0	51.0			
% OF MEAN			1095.5	734.2	588.6	426.6	294.3	188.2	90.9	29.7			
APR-OCT CFS	12	189.1	1880.0	1260.0	1010.0	732.0	505.0	322.0	154.0	41.3			
% OF MEAN			994.0	666.2	534.0	387.0	267.0	170.2	81.4	21.8			
MAY-SEP CFS	13	193.0	1760.0	1190.0	927.0	684.0	422.0	248.0	108.0				
% OF MEAN			911.7	616.4	480.2	354.3	218.6	128.5	55.9				
JUN-SEP CFS	13	165.6	1760.0	1190.0	884.0	525.0	282.0	140.0	65.4				
% OF MEAN			1063.0	718.7	533.9	317.1	170.3	84.6	39.5				

Source: Water Resources Division,
Alberta Department of the Environment

FIGURE H.9 LONG-TERM MEAN DISCHARGES AND FLOW DURATION DATA

#116 LOBSTICK RIVER NEAR STYAL 7BB003

ANALYSIS USES ANNUAL MAXIMUM DAILY MEAN DISCHARGES

BASIC DATA AND TRANSFORMATICNS OF ORDERED DATA

YEAR	FLOW,CFS	CODE	**	ORD	YEAR	PROB	TR,YRS	X	LOG10(X)	X**0.33
1915	723.0	0	**	1	1965	0.048	21.00	3380.0	3.529	15.007
1916	1071.0	0	**	2	1920	0.095	10.50	2690.0	3.430	13.907
1917	2014.0	0	**	3	1917	0.143	7.00	2014.0	3.304	12.628
1918	373.0	0	**	4	1916	0.190	5.25	1071.0	3.030	10.231
1919	283.0	0	**	5	1921	0.238	4.20	874.0	2.942	9.561
1920	2690.0	0	**	6	1963	0.286	3.50	840.0	2.924	9.435
1921	874.0	0	**	7	1915	0.333	3.00	723.0	2.859	8.975
1922	294.0	0	**	8	1962	0.381	2.62	686.0	2.836	8.819
1956	662.0	0	**	9	1956	0.429	2.33	662.0	2.821	8.715
1957	239.0	0	**	10	1967	0.476	2.10	662.0	2.821	8.715
1958	510.0	0	**	11	1966	0.524	1.91	620.0	2.792	8.527
1959	151.0	0	**	12	1964	0.571	1.75	559.0	2.747	8.237
1960	427.0	0	**	13	1958	0.619	1.62	510.0	2.708	7.989
1961	170.0	0	**	14	1960	0.667	1.50	427.0	2.630	7.530
1962	686.0	0	**	15	1918	0.714	1.40	373.0	2.572	7.198
1963	840.0	0	**	16	1922	0.762	1.31	294.0	2.468	6.649
1964	559.0	0	**	17	1919	0.810	1.24	283.0	2.452	6.565
1965	3380.0	0	**	18	1957	0.857	1.17	239.0	2.378	6.206
1966	620.0	0	**	19	1961	0.905	1.11	170.0	2.230	5.540
1967	662.0	0	**	20	1959	0.952	1.05	151.0	2.179	5.325
							MEAN =	861.4	2.783	8.788

FIGURE H.10 FLOOD REQUENCY DATA FOR HYDROMETRIC STATION

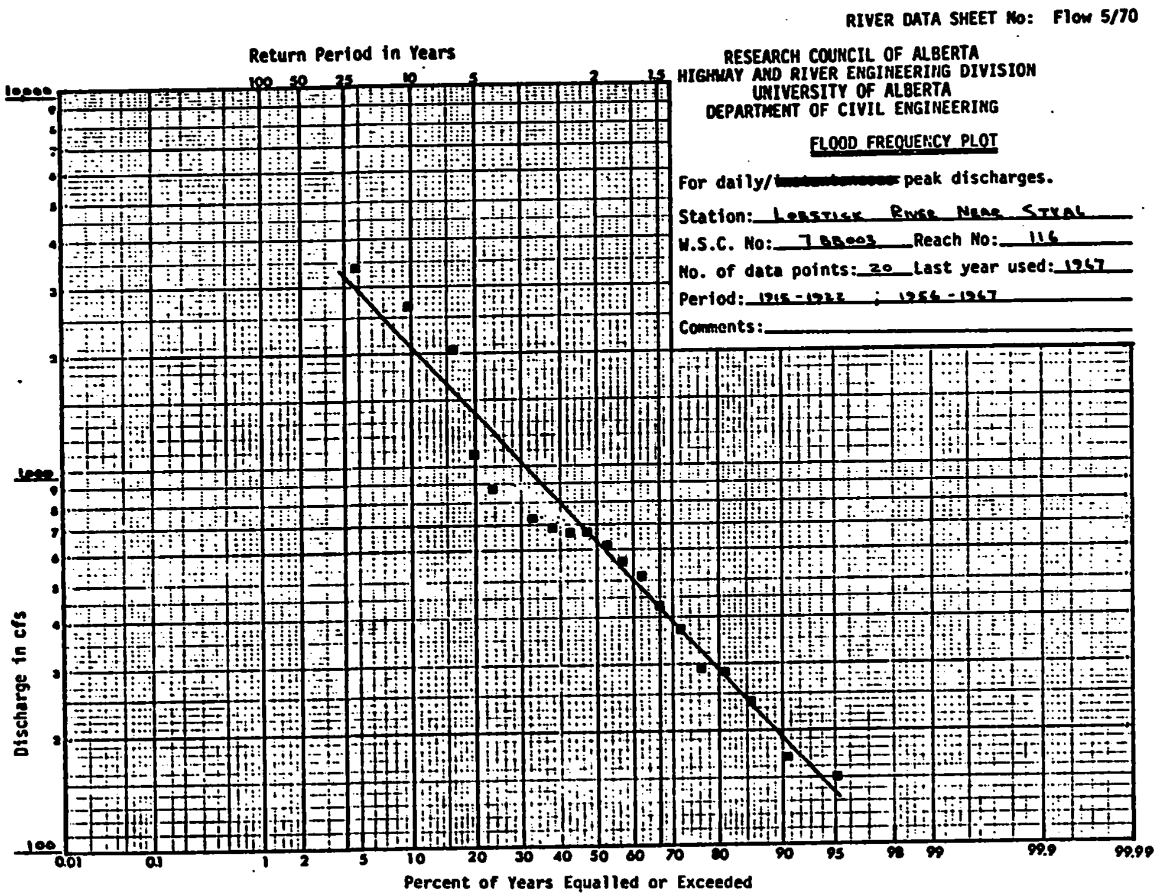


FIGURE H.11 LOG-NORMAL FLOOD FREQUENCY PLOT

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RIVER DATA SHEET No.
Slope 1/70

DATA FOR SLOPE DETERMINATION

Reach Name: Lobstick River near Styal Reach No. 116

Date of Survey: 5 June 1970 Analysis By: D.I. Gray

COMPARISON OF PHOTO DISTANCES AND FIELD DISTANCES

Photograph No.: C 61.22.610 - 5324 YC 446A - 63

Map Name: Chip Lake Scale: 1:50000 Date of Map: 1960

Distance on Map Between Reference Points = 1.52 ins. (6320 ft.)

Distance on Photo Between Reference Points = 4.70 ins.

Scale for Photograph: 1.00 inch on Photo = 1345 ft. on Ground

0.10 inch on Photo = 134 ft. on Ground

Stations	Distance on photo in 0.10" units	Distance from photo, ft.	Distance from stadia, ft.	Comment
U5-U4				
U4-U3	2.4	322	474	
U3-U2	3.1	415	372	
U2-U1	4.5	603	512	
U1-G	4.6	616	819	
G-D1	6.3	845	639	
D1-D2	3.1	415	404	
D2-D3	3.6	482	484	
D3-D4	2.9	388	314	
D4-D5	3.1	415	473	
	Σ	4501	4491	

Percent Difference in Distance (Stadia Basis)

$$= \frac{4501 - 4491}{4491} \times 100 = \frac{1000}{4491}$$

$$= 0.2\ \%$$

Comments:

FIGURE H.12 COMPARISON OF PHOTO AND FIELD DISTANCES

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RIVER DATA SHEET No.
Slope 2/70

DATA FOR WATER SURFACE PROFILE ON DATE OF SURVEY

Reach Name: Lossticx River near Styal Reach No. 116

Date of Survey: 5 June 1970 Surveyed By: D.I. Bray

Stage: 1.66 ft. Discharge: 50 cfs.

Cross-section	Elevation of W.S. ft.	Stadia distance ft.	Accumulated distance ft.	Accumulated distance from gauge	Comments
U4	89.50		0	2177	IN RAPID
	89.18	120	120	2057	BOT. RAPID
U3	89.10	354	474	1703	
U2	88.95	372	846	1331	20' U/S OF TOP OF RAPID
	88.57	120	966	1211	BOT. RAPID
U1	88.10	392	1358	819	
	88.10	100	1458	719	TOP. RAPID
	86.77	100	1558	619	BOT. RAPID
	86.76	429	1987	190	TOP RAPID
	86.42	50	2037	140	BOT. RAPID
G	86.41	140	2177	0	
	86.07	619	2796	619	TOP RAPID
D1	85.85	20	2816	639	IN RAPID
	85.39	60	2876	699	BOT. RAPID
D2	84.97	344	3220	1043	
	84.71	444	3664	1487	TOP RAPID
D3	84.24	40	3704	1527	BOT. RAPID
D4	84.22	314	4018	1841	
D5	83.75	473	4491	2314	

Comments: Pool and Riffle Sequence

FIGURE H.13 DATA FOR WATER SURFACE PROFILE

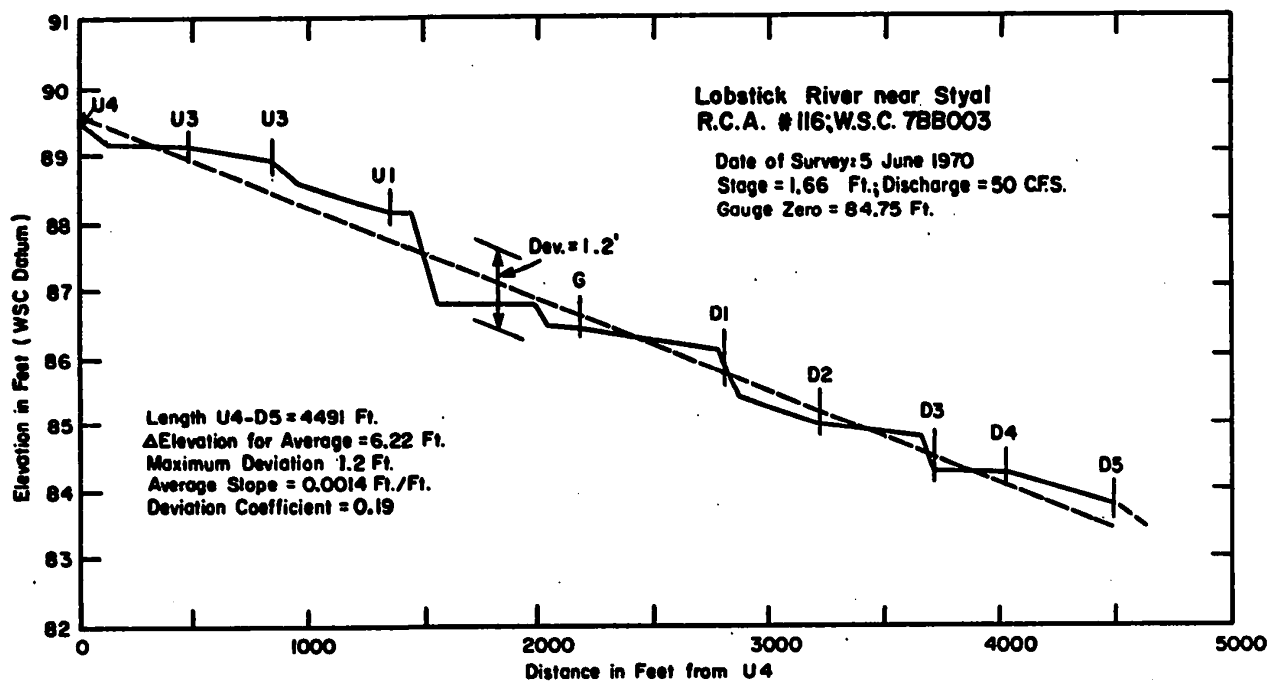

FIGURE H.14 PLOT OF LONGITUDINAL WATER SURFACE PROFILE

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RIVER DATA SHEET No.
Slope 3/70

DETERMINATION OF TOPOGRAPHIC SLOPE

Reach Name: LOBSTICK RIVER NEAR STYAL Reach No. 116

Analysis By: D.I. BRAY Date: 2 SEP 1970

Map Name(s) CHIP LAKE Number 83G/11E Scale 1:50000 Date 1960

Number ____ Scale ____ Date ____

Contour ft.		River distance ft.		Valley distance ft.
2250				
2200		69,900		

Topographic Slope = $\frac{2250 - 2200}{69,900}$ = 0.00072 %; Sinuosity (for reach) = $\frac{4491}{2370}$ = 1.90

SUMMARY OF FIELD SLOPE DATA

Field Distance: 1. By Tape ② By Stadia

Vertical Control: ① Levelling 2. Photogrammetry 3. Maps

Shape of Water Surface Profile:

1. Very close to average ② Moderately close to average
3. Not very close to average but acceptable

First and Last X-sections in Reach Used to Obtain Slope = U4 - D5
Distance Between First and Last X-sections = 4491 FT.
Vertical Difference for Average Slope = 6.22 FT.
Maximum Deviation from Average Slope = 2.2 FT
Average Slope for Reach = 0.0014 FT/FT

Comments: SLOPE IS FLATTER ABOVE REACH. GREATEST PORTION OF LENGTH USED TO DETERMINE SLOPE WAS ABOVE REACH. SINUOSITY IS FOR REACH.

FIGURE H.15 DETERMINATION OF TOPOGRAPHICS SLOPE AND SUMMARY OF FIELD SLOPE DATA

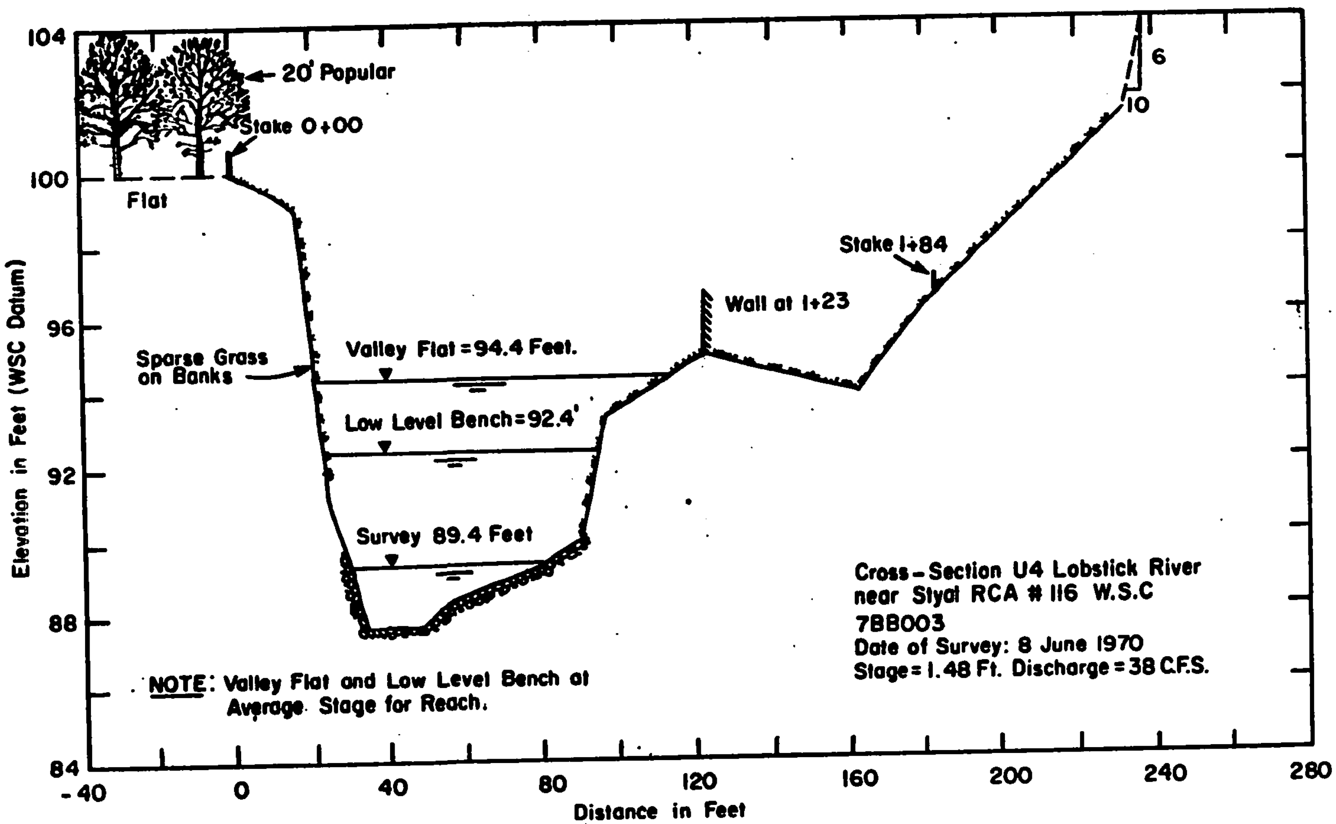

FIGURE H.16 TYPICAL CROSS-SECTION PLOT

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RIVER DATA SHEET No.
Flow 1/70

ESTIMATION OF BANKFULL DISCHARGE FOR REACH

Reach Name: Lobstick River near Styal   Reach No.: 116

Date of Survey of X-Sections: 8 Jun 1970

Analysis: By D.I. Bray   Date: 3 Sep 1970

Bankfull: (1) Low level bench   2. Trim line   3. Major valley flat

Section	Elevation at bankfull ft.	W.S. elev. on day of survey ft.	Difference in elevation ft.	W.S. elevation for estimated bankfull ft.	Comment
U4	—	89.4	—	92.4	No LL bench
U3	—	89.0	—	92.0	"
U2	—	88.8	—	91.8	"
U1	91.2	87.9	3.3	90.9	
C	89.3	86.2	3.1	89.2	
D1	88.8	85.6	3.2	88.6	
D2	—	84.7	—	87.7	No LL bench
D3	86.4	84.1	2.3	87.1	
D4	86.6	84.1	2.5	87.1	
D5	86.8	83.7	3.1	86.7	
		Σ	17.5		

Average Difference in Elevation 2.91 ft.

Accepted Difference in Elevation for Bankfull 3.00 ft.

Stage at Gauge on Date of Survey 1.48 ft.

Stage at Gauge Corresponding to Bankfull 4.48 ft.

Discharge Corresponding to Bankfull 960 cfs.

Return Period Associated with Bankfull Discharge 3.1 yrs.

Rating Curve: Curve No. 5 ; Most recent point 1969 ; Max. stage obs. 5.96 ft.

Frequency Curve: No. of years of data 20 ; Last year used 1967

Comments:

FIGURE H.17 ESTIMATION OF AVERAGE ELEVATION OF THE LOW LEVEL BENCH

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RIVER DATA SHEET No.
Flow 1/70

ESTIMATION OF BANKFULL DISCHARGE FOR REACH

Reach Name: LOBSTICK RIVER NEAR STYAL Reach No.: 116

Date of Survey of X-Sections: 8 JUN 1970

Analysis: By D.I. BRAY Date: 4 DEC 1970

Bankfull: 1. Low level bench 2. Trim line ③ Major Valley flat

Section	Elevation at bankfull ft.	W.S. elev. on day of survey ft.	Difference in elevation ft.	W.S. elevation for estimated bankfull ft.	Comment
U4	94.0	89.4	4.6	94.4	WALL @ 1+23
U3	—	89.0	—	94.0	WALL @ 0+15
U2	94.6	88.8	5.8	93.8	
U1	93.2	87.9	5.3	92.9	
6	—	86.2	—	91.2	
D1	92.2	85.6	6.6	90.6	
D2	—	84.7	—	89.7	WALL @ 0+44
D3	88.4	84.1	4.3	89.1	WALL @ 0+48
D4	89.4	84.1	5.3	89.1	
D5	90.0	83.7	6.3	88.7	
		Σ	38.2		

Average Difference in Elevation 5.46 ft.

Accepted Difference in Elevation for Bankfull 5.00 ft.

Stage at Gauge on Date of Survey 1.48 ft.

Stage at Gauge Corresponding to Bankfull 6.48 ft.

Discharge Corresponding to Bankfull 1950 cfs.

Return Period Associated with Bankfull Discharge 91 yrs.

Rating Curve: Curve No. 5 ; Most recent point 1969; Max. stage obs. 5.95 ft.

Frequency Curve: No. of years of data 20 ; Last year used 1967

Comments: MAXIMUM DEPTH OF WATER AT ANY WALL = 0.3 FT.

FIGURE H.18 ESTIMATION OF THE AVERAGE ELEVATION OF THE VALLEY FLAT

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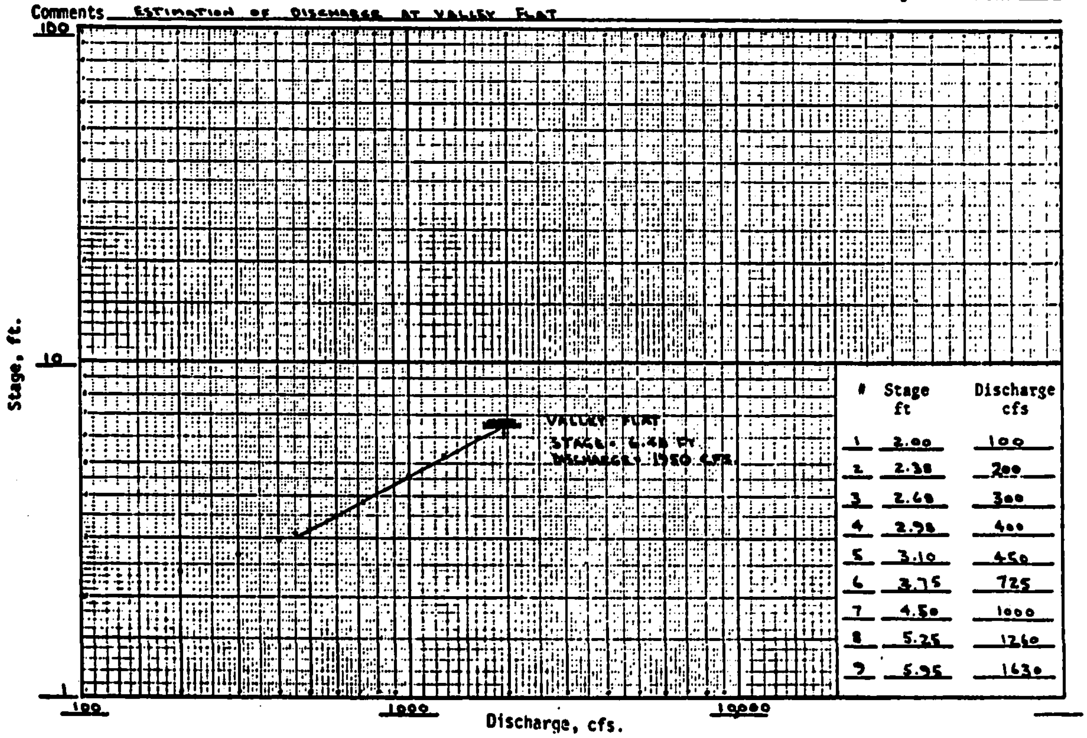
RIVER DATA SHEET No: Flow 4/70

STAGE-DISCHARGE CURVE

Station: Lobstick River near Styal W.S.C. No: 7BB 003 Reach No: 116

Rate Curve No: 5 ; Date of Most Recent Measurement 1962 ; Max. Observed Discharge: 1630 cfs.

Comments Estimation of discharge at valley flat



#	Stage ft	Discharge cfs
1	2.00	100
2	2.38	200
3	2.60	300
4	2.98	400
5	3.10	450
6	3.75	725
7	4.50	1000
8	5.25	1260
9	5.95	1630

FIGURE H.19 EXTRAPOLATION OF THE RATING CURVE TO THE ADOPTED ELEVATION OF THE VALLEY FLAT

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RIVER DATA SHEET No.
Flow 2/70

STAGE-DISCHARGE RELATIONSHIPS FOR REACH

River Reach: Lobstick River near Styal, Alta Reach No. 116

Date of Survey: 8 Jun 1970 Analysis By: D.I. Bray

Date of Rating Curve: 1967 - 1970 Curve No. C5
(Date Closest to Survey)

Stability of Rating Curve:
1. Stable for entire range of flows (circled)
2. Unstable for low flows only
3. Unstable for high flows only
4. Unstable for all flows

Degree of Stability:
1. Highly stable
2. Slightly unstable (circled)
3. Moderately unstable
4. Highly unstable

Elevation of Gauge Zero = 84.75 ft.; approximate Gauge at Zero Flow = 0.1 ft.

Discharge level	Discharge (cfs)	Stage (ft.)	Elevation (ft.)	Comment
Date of survey of X-sect.	38	1.48	86.23	
Long-term mean (full year)	137	2.16	86.91	
Long-term mean (Mar.-Oct.)	172			
Long-term mean (Apr.-Oct.)	189	2.36	87.11	
1.5 year flood (Daily)	420	3.05	87.80	
2 year flood (Daily)	620	3.71	88.46	
5 year flood (Daily)	1360	5.53	90.28	
10 year flood (Daily)	2060	—	—	Above valley fl.
25 year flood (Daily)	3200	—	—	Above valley fl.
50 year flood ( )	—	—	—	
100 year flood ( )	—	—	—	
0.5% flow dur. (Apr.-Oct.)	1260	5.32	90.07	
1% flow dur. (Apr.-Oct.)	1010	4.75	89.50	
5% flow dur. (Apr.-Oct.)	505	3.35	88.10	
10% flow dur. (Apr.-Oct.)	322	2.80	87.55	
50% flow dur. (Apr.-Oct.)	41			Return Period
Low Level Bench	960	4.63	89.38	3.7 yrs.
Trim Line	—	—	—	— yrs.
Major Valley Flat	1950	6.48	91.23	9.1 yrs.

Comments:

FIGURE H.20 SUMMARY OF STAGE-DISCHARGE RELATIONS FOR VARIOUS CHARACTERISTIC DISCHARGES

116 LCBSTICK RIVER NEAR STYAL   WATER SURVEY CODE: 7BB03

CROSS-SECTION DATA FOR X-SECTION U4   DATE OF SURVEY: 8JUN70

X	Y	X	Y	X	Y	X	Y	X	Y
0.0	100.1	11.0	99.1	23.0	92.3	25.0	91.2	31.0	89.4
35.0	87.7	49.0	87.8	58.0	88.5	81.0	89.4	91.0	90.1
98.0	93.4	123.0	95.0	165.0	93.9	184.0	96.5		

SECTION PROPERTIES FOR X-SEC U4 : WALLS AT -999. 123. -999. -999. FOR ALL FLOWS

FLOW	WS.EL.	CODE	AREA	WS	WP	DM	RH	DMAX	VM	WS/WP	DM/RH	DMAX/DM	WS/DM
38.	89.40	SURVEY	48.	50.	50.	0.96	0.95	1.70	0.79	0.99	1.01	1.77	52.0
137.	90.08	LTM:YEAR	86.	62.	62.	1.39	1.38	2.38	1.59	0.99	1.01	1.71	44.6
185.	90.28	LTM:4-10	99.	63.	64.	1.56	1.55	2.58	1.91	0.99	1.01	1.65	40.6
420.	90.97	1.5YR FL	144.	67.	68.	2.14	2.12	3.27	2.92	0.99	1.01	1.53	31.3
620.	91.63	2 YR FL	189.	70.	71.	2.70	2.66	3.93	3.27	0.98	1.02	1.46	25.9
1360.	93.45	5 YR FL	323.	78.	80.	4.15	4.05	5.75	4.21	0.97	1.03	1.38	18.7
1260.	93.24	0.5% DUR	307.	76.	78.	4.02	3.92	5.54	4.11	0.98	1.03	1.38	19.0
1010.	92.67	1% DUR	264.	74.	76.	3.57	3.49	4.97	3.82	0.98	1.02	1.39	20.8
505.	91.27	5% DUR	164.	69.	70.	2.39	2.36	3.57	3.08	0.99	1.01	1.49	28.7
322.	90.72	10% DUR	127.	66.	66.	1.93	1.91	3.02	2.53	0.99	1.01	1.56	34.0
960.	92.55	LL BENCH	255.	74.	75.	3.47	3.39	4.85	3.76	0.98	1.02	1.40	21.2
1950.	94.40	VAL FLAT	405.	94.	97.	4.29	4.19	6.70	4.82	0.98	1.02	1.56	22.0

1. All units are ft-lb-sec units.

Note: This cross-section (U4) is the same as that used for the typical cross-section plot in FIGURE H.16.

FIGURE H.21 COMPUTER PRINT-OUT OF THE HYDRAULIC GEOMETRY FOR A CROSS-SECTION

\# 116 LCASTICK RIVER NEAR STYAL WATER SURVEY CODE: 7R803

\# 116 DATE OF SURVEY 8JUN70 STAGE FOR SURVEY = 1.48 FT.
LIMITING STAGE FOR ANALYSIS = 6.48 FT.

\# 116 RATING CURVE: C5 1967; GAUGE ZERO = 84.75 FT.

STAGE	Q	STAGE	Q	STAGE	Q	STAGE	Q	STAGE	Q
1.25	20.	2.40	200.	3.05	420.	6.00	1600.	6.48	1950. *

SUMMARY FOR REACH: NUMBER OF X-SEC = 10 SLOPE FOR REACH = 0.001400 FT/FT.
X-SECTIONS USED: U4, U3, U2, U1, G, D1, D2, D3, D4, D5

FLOW	STAGE	CODE	AREA	CVA	WS	CVWS	DM	WS/DM	VM
38.	1.48	SURVEY	91.	0.44	56.	0.12	1.62	34.7	0.42
137.	2.16	LTM:YEAR	131.	0.30	62.	0.10	2.12	29.2	1.05
189.	2.36	LTM:4-10	144.	0.27	63.	0.10	2.28	27.8	1.31
420.	3.05	1.5YR FL	189.	0.21	67.	0.10	2.80	24.0	2.22
620.	3.71	2 YR FL	235.	0.17	71.	0.10	3.30	21.6	2.64
1360.	5.53	5 YR FL	377.	0.13	87.	0.15	4.34	20.0	3.61
1260.	5.32	0.5% DUR	359.	0.13	85.	0.15	4.23	20.1	3.51
1010.	4.75	1% DUR	313.	0.14	79.	0.14	3.96	20.0	3.23
505.	3.35	5% DUR	209.	0.19	69.	0.10	3.03	22.8	2.41
322.	2.80	10% DUR	172.	0.23	66.	0.10	2.61	25.2	1.87
960.	4.63	LL BENCH	303.	0.14	78.	0.14	3.90	19.9	3.17
1950.	6.48	VAL FLAT	464.	0.12	96.	0.13	4.82	20.0	4.20

FLOW	CODE	V*	V/V*	TAU	N	V**2/D	V**3/WS	WS/Q**.5
38.	SURVEY	0.27	1.54	0.142	0.184	0.11	0.00	9.12
137.	LTM:YEAR	0.31	3.38	0.185	0.088	0.52	0.02	5.29
189.	LTM:4-10	0.32	4.10	0.199	0.074	0.76	0.04	4.60
420.	1.5YR FL	0.36	6.25	0.245	0.050	1.76	0.16	3.29
620.	2 YR FL	0.39	6.84	0.288	0.047	2.11	0.26	2.86
1360.	5 YR FL	0.44	8.16	0.379	0.041	3.00	0.54	2.35
1260.	0.5% DUR	0.44	8.04	0.369	0.042	2.92	0.51	2.39
1010.	1% DUR	0.42	7.65	0.346	0.043	2.64	0.43	2.49
505.	5% DUR	0.37	6.53	0.264	0.048	1.92	0.20	3.08
322.	10% DUR	0.34	5.45	0.228	0.057	1.34	0.10	3.67
960.	LL BENCH	0.42	7.55	0.341	0.044	2.57	0.41	2.51
1950.	VAL FLAT	0.47	9.01	0.421	0.038	3.66	0.77	2.18

ALL UNITS ARE FT.-LB.-SEC. UNITS

FIGURE H.22 COMPUTER PRINT-OUT OF THE AVERAGE HYDRAULIC GEOMETRY AND CHARACTERISTIC FLOW PARAMETERS FOR THE REACH

RIVER DATA TABLES - CROSS SECTION DESCRIPTION - TABLE 1

LOCATION Lobstick River near Styal, Alta | DISCHARGE 38 cfs | DATE 8 Jun 1970 | RECORDER D.I. Bray

	X-SECTION CODE	U4	U3	U2	U1	G	D1	D2	D3	D4	D5
VALLEY DATA	**VALLEY LANDFORM**										
	- Narrow	✓	✓	✓	✓	✓	✓	✓			
	- Medium	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓
	- Wide										
	- Wide Terrace										
	- Alluvial Plain										
	- Delta										
	- Alluvial Fan										
	- Irregular Bedrock										
	VALLEY PATTERN										
	- Straight										
	- Meander	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓
	- Irregular										
	SUDDEN VALLEY VARIATION (Constriction, Direction)										
	- Upstream										
	- Downstream										
CHANNEL DATA	**NUMBER OF CHANNELS**										
	- Low Water	1	1	1	1	1	1	1	1	1	1
	- High Water	1	1	1	1	1	1	1	1	1	1
	CHANNEL PATTERN (local)										
	- Straight	✓		✓	✓	✓	✓		✓		
	- Regular Meander										✓
	- Tortuous Meander										
	- U-Shape Meander		✓					✓		✓	
	- Irregular Meander										
	- Confined Meander										
	- Split										
	- Braided										
	CHANNEL BED										
	- Boulders		✓	✓	✓	✓	✓	✓	✓		✓
	- Cobbles	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓
	- Pebbles										
	- Gravel	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓
	- Sandy										
	- Silty					✓		✓		✓	
	- Rounded	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓
	- Angular										
	APPROXIMATE WATER										
	- Depth (ft)	1	2½	1½	2	2	1	3	1	3	1
	- Speed (ft/sec)	-	-	-	-	-	-	-	-	-	1.4
	- Colour	←			LIGHT	BROWN					→
	SLOPE VARIATION										
	- Rapids										
	- Falls										
	- Pools		✓		✓	✓		✓		✓	
	- Riffles	✓		✓ Top of riffle			✓		✓		✓

FIGURE H.23 FIELD CHECK SHEET FOR VALLEY AND CHANNEL DATA

RIVER DATA TABLES - CROSS SECTION DESCRIPTION - TABLE 2

LOCATION Lobstick River near Styal, Alta | DISCHARGE 38 cfs | DATE 8 Jun 1970 | RECORDER D.I. Bray

BANK CHARACTERISTICS

X-SECTION CODE	U4 L	U4 R	U3 L	U3 R	U2 L	U2 R	U1 L	U1 R	G L	G R	D1 L	D1 R	D2 L	D2 R	D3 L	D3 R	D4 L	D4 R	D5 L	D5 R
SHAPE																				
- Concave	✓			✓	✓	✓	✓							✓		✓	✓		✓	
- Convex			✓					✓	✓	✓	✓	✓	✓		✓			✓		✓
- Complex		✓																		
GRADIENT																				
- Cliffed (vertical)	✓																		✓	
- Steep				✓		✓	✓		✓					✓		✓	✓			
- Mild		✓	✓		✓			✓		✓	✓	✓	✓		✓			✓		✓
APPROXIMATE HEIGHT (ft)	7	3	3	30	2	7	5	3	20	20	5	5	2	50	2	5	30	2	10	3
BANK MATERIAL																				
- Stable		✓	✓		✓				✓	✓	✓	✓	✓		✓			✓		✓
- Intermediate	✓					✓	✓	✓								✓			✓	
- Unstable				✓										✓			✓			
- Bedrock																				
- Coarse	✓																			
- Silt Clay	✓	✓	✓	✓	✓?	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓
- Sand																				
- Glacial Till																				
- Boulders																				
- Cobbles																				
- Pebbles																				
- Rounded																				
- Angular																				
OVERFLOW																				
- Liable		✓	✓		✓			✓					✓		✓		✓		✓	
- Not Liable	✓			✓		✓	✓		✓	✓	✓	✓		✓		✓		✓		✓
CHANNEL SHIFT																				
- Point Bars			✓										✓		?			✓		?
- Bank Erosion	✓			✓		✓	✓	✓	✓ ?	✓	✓ ?	✓		✓		✓	✓		✓	
- Abandoned Channels											✓	✓								
- Oxbow Lakes																				
- Flats																				
- Islands																				
VEGETATION AMOUNT																				
- Absent		✓							✓	✓						✓		✓	✓	✓
- Sparse	✓		✓	✓	✓	✓	✓	✓			✓	✓	✓	✓	✓		✓			
- Dense																				
- Over-hanging																				
TYPE																				
- Grass		✓	✓		✓				✓	✓						✓		✓	✓	✓
- Weed			✓																	
- Brush					✓	✓	✓	✓			✓	✓	✓		✓					
- Willow																				
- Tree (1) poplar	✓											✓					✓			
(2) spruce				✓										✓						
(3)																				

FIGURE H.24 FIELD CHECK SHEET FOR BANK CHARACTERISTICS

RIVER DATA TABLES - CROSS SECTION DESCRIPTION

LOCATION LOBSTICK RIVER NEAR STYAL, ALTA	DISCHARGE 38 cfs	DATE 8 Jan 1970	RECORDER D.I. BRAY

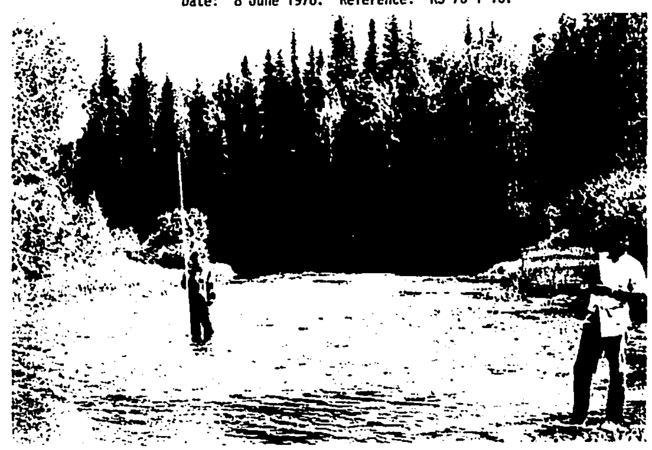
X-SECTION CODE	COMMENTS - FURTHER DESCRIPTION
U4	AT HEAD OF RAPIDS HIGH TERRACE ON LEFT BOULDERS AND GRAVEL HALF WAY UP LEFT BANK
U3	BANK EROSION ON OUTSIDE OF BEND. SOME LOCAL SLUMPING EVIDENT POINT BAR OF SANDY SILT LARGE BOULDERS (1' Ø) AT BOTTOM OF POOL.
U2	15' ABOVE HEAD OF RIFFLE RAPID ABOUT 100' LONG LEFT BANK COULD EASILY BE FLOODED
U1	ABOUT 160' u/s OF RAPID POOL WITH FLAT BOTTOM AND STEEP
G	BRIDGE DOES NOT AFFECT FLOWS SECTION IN POOL, RAPID ENDS ABOUT 150' u/s RECORDING GAUGE AT SECTION SOME ARTIFICIAL STRAIGHTENING BETWEEN G AND D1
D1	ABOUT 20' D/S FROM HEAD OF RAPID RIGHT BANK LOW, LEFT BANK HIGHER
D2	STEEP BANK ON OUTSIDE OF BEND, SOME LOCAL SLUMPING DEEPEST CROSS-SECTION IN REACH
D3	30' BELOW TOP OF RAPID
D4	EVIDENCE OF FAILURE ON LEFT BANK (LOCAL) CAN SEE POINT BAR DEVELOPMENT ON RIGHT
D5	ABOUT 20' ABOVE RAPID (RIFFLE) TERRACE ON LEFT; LOWER FLAT ON RIGHT

FIGURE H.25 FIELD NOTES, COMMENTS AND FURTHER DESCRIPTIONS OF EACH CROSS-SECTION

a) Lobstick river near Styal. Looking upstream from a point near cross-section U4.
Date: 8 June 1970. Reference: RS-70-1-9.

b) Lobstick river near Styal. Looking upstream toward cross-section U3 at the bend. Note active erosion at outside of bend. The trees are tilted toward channel.
Date: 8 June 1970. Reference: RS-70-1-10.

c) Lobstick river near Styal. Looking downstream towards cross-section U2. Man at center of channel on line of cross-section U2. Note the riffle just below cross-section U2. Pool and riffle sequence typical for reach.
Date: 8 June 1970. Reference: RS-70-1-11.



d) Lobstick river near Styal. Looking downstream toward cross-section D2 at bend from cross-section D1.
Date: 8 June 1970. Reference: RS-70-1-13.

FIGURE H.26 TYPICAL FIELD PHOTOGRAPHS ON DATE OF SURVEY

APPENDIX I

BASIC DATA

I.1 Tables Containing Basic Data

A data storage system has been developed whereby the data for a river reach is stored in 37 tables. The list of the tables containing the basic data for this investigation are given in the following sub-section.

I.1.1 Station Description

I.1.2 Discharge Summaries

I.1.3 General Reach Data

I.1.6 Bed Material Data

I.1.7 Numbering of Tables

The numbering of the tables of basic data in this appendix is the same as that given in the previous sub-sections. The table numbering is not consecutive in order that more data tables may be added at appropriate locations as the data acquisition expands. The basic system is set up to store the data from any number of reaches in any number of tables. At present 37 tables are used to store the data related to 120 river reaches.

I.2 Use of Basic Data

The data in the tables have been assembled from many sources to carry out a generalized regime type analysis of Alberta rivers. All data have been checked at least once and have been found to be essentially correct. No major errors have been detected during the analysis due to incorrect data. However, the data should be studied

I.1.4 Hydraulic Geometry Data

I.1.5 Geomorphological and Geographical Data with caution when considering the use of the data for a specialized application. This warning is particularly important when considering the estimated discharges. All estimates have been carefully made, but the estimations are not the results of a rigorous analysis. In summary, it may be stated that the data are of particular value for generalized analyses.

I.3 Introduction to the River Data Tables

The data compiled in the following river data tables describe the hydrologic, hydraulic, and geomorphic characteristics of all river reaches in this investigation. A print-out giving the definitions of parameters and codes and additional explanatory notes preceed each table.

The following explanations are valid for all tables:

1. A blank in a table indicates that there is no information available or that the code is not applicable. A blank only occurs for those cases that are printed as integer values.
2. A -1 for a coded integer value indicates that the value is unknown. In this case an effort had been made to obtain the data, but no acceptable data could be found.
3. A 0.0 for a floating point value indicates that there is no information available. If the actual value is 0.0 it is recorded as 0.01 or 0.1, etc.
4. A -1.00 for a floating point value indicates that the value is unknown. In this case an effort had been made to obtain the data, but no acceptable data could be found.

The values -1, 0.0 and -1.0 may be used as test values when working with the data. A blank for an integer value may be set to -1 for analysis purposes.

No more than three significant figures should be accepted.

TABLE #1

*** STATICN INFORMATION ***

EXPLANATICNS:

1. A STUCY REACH IS LOCATED ON THE LISTED RIVER. THE HYDROMETRIC STATICN IS IN THE STUDY REACH OR VERY NEAR THE STUDY REACH.

2. NAME CF RIVER CR CREEK
   THIS IS THE NAME OF THE RIVER OR CREEK ON WHICH THE HYDROMETRIC STATICN IS LCCATED.

3. NAME CF HYCROMETRIC STATION(S)
   THE NAME OF HYDROMETRIC STATION IS THAT USED BY THE WATER SURVEY OF CANADA. THE MOST RECENT STATION IS LISTED FIRST. IF OTHER STATICNS WERE LOCATED AT OR NEAR THE PRESENT STATION, THEY ARE LISTED IN CHRCNCLOGICAL ORDER SUCH THAT THE EARLIEST STATION IS LISTED LAST.

4. HYDRCMETRIC STATICN CODE
   THE CODES ARE THOSE CORRESPONDING TO THE HYDORMETRIC STATIONS LISTED IN 2. THESE CODES ARE USED FOR STATION IDENTIFICATION BY THE WATER SURVEY OF CANADA. THE FIRST NUMBER IDENTIFIES THE MAJOR DRAINAGE BASIN. THE TWO LETTERS IDENTIFY THE SUB-BASIN IN THE MAJOR DRAINAGE BASIN. THE LAST NUMBER IDENTIFIES THE HYDRCMETRIC STATICN IN THE SUB-BASIN. THE CODES FOR THE MAJOR BASINS ARE:

   5 SASKATCHEWAN/NELSON
   6 CHURCHILL
   7 PEACE/MACKENZIE
   11 MISSISSIPPI

TABLE # 1
STATION INFORMATION

SITE #	RIVER/CREEK	STATION NAME	STATION CODES (W.S.C.)	STATION CODES (W.S.C.)	STATION CODES (W.S.C.)
1	PEACE R.	AT HUDSON HOPE (B.C.)	07EF001		
2	PEACE R.	NEAR TAYLOR (B.C.)	07FD002		
3	PEACE R.	AT DUNVEGAN	07FD003		
4	PEACE R.	AT PEACE RIVER	07HA001		
5	PEACE R.	NEAR CARCAJOU	07HD001		
6	PEACE R.	AT FORT VERMILION	07HF001		
7	PEACE R.	AT PEACE POINT	07KC001		
8	SMOKY R.	AT WATINO/AT SMOKY/AT PRUDENT'S RA.	07GJ001		
9	WAPITI R.	NEAR GRANDE PRAIRIE	07GE001		
10	LITTLE SMOKY R.	NEAR GUY	07GH002		
11	NOTIKEWIN R.	AT MANNING	07HC001		
12	ATHABASCA R.	AT JASPER	07AA002		
13	ATHABASCA R.	AT HINTON/AT ENTRANCE	07AD002	07AD001	
14	ATHABASCA R.	NEAR WHITECOURT	07AE001		
15	ATHABASCA R.	AT ATHABASCA	07BE001		
16	ATHABASCA R.	BELOW MCMURRAY	07DA001		
17	ATHABASCA R.	AT EMBARRAS AIRPORT	07DD001		
18	WILDHAY R.	NEAR HINTON	07AC001		
19	MCLEOD R.	ABOVE EMBARRAS RIVER	07AF002		
20	MCLEOD R.	NEAR WOLF CK/EDSON/WOLF CR.	07AG001	07AG002	07AG001
21	WOLF CR.	AT HIGHWAY NO.16	07AG003		
22	FREEMAN R.	NEAR FORT ASSINIBOINE	07AH001		
23	PEMBINA R.	BELOW PADDY CR.	07BA001		
24	PEMBINA R.	NEAR ENTWISTLE	07BB002		
25	PEMBINA R.	AT JARVIE	07BC002		
26	PADDLE R.	NEAR ROCHFORT BRIDGE	07BB004		
27	LITTLE PADDLE R.	NEAR MAYERTHORPE	07BB005		
28	LESSER SLAVE R.	AT HIGHWAY NO.2/SLAVE LAKE	07BK006	07BK001	
29	WEST PRAIRIE R.	NEAR HIGH PRAIRIE	07BF002		
30	EAST PRAIRIE	NEAR ENILDA	07BF001		
31	CLEARWATER R.	AT DRAPER	07CD001		
32	BEAVER R.	AT COLD LAKE RESERVE	06AD006		
33	BEAVER R.	NEAR DORINTOSH,SASK./BARNES CROSSING	06AD001	06AD001	
34	N. SASK. R.	AT SASKATCHEWAN CROSSING	05DA006		
35	N. SASK. R.	AT SAUNDERS	05DC002		
36	N. SASK. R.	NEAR ROCKY MOUNTAIN HOUSE	05DC001		
37	N. SASK. R.	AT EDMONTON	05DF001		
38	N. SASK. R.	AT LEA PARK/FRENCHMAN BUTTE/FT. PITT	05EF003	05EF001	05EF001
39	MISTAYA R.	NEAR SASKATCHEWAN CROSSING	05DA007		
40	CLEARWATER R.	ABOVE LIMESTONE CR.	05DB003		

TABLE # 1
STATION INFORMATION

SITE #	RIVER/CREEK	STATION NAME	STATION CODES (W.S.C.)	STATION CODES (W.S.C.)	STATION CODES (W.S.C.)
41	CLEARWATER R.	NEAR ROCKY MOUNTAIN HOUSE	05DB001		
42	PRAIRIE CR.	NEAR ROCKY MOUNTAIN HOUSE	05DB002		
43	BRAZEAU R.	BELOW CARDINAL RIVER	05DD007		
44	BRAZEAU R.	BELOW BIG BEND PLANT/BRAZEAU DAM/BEND	05DD005	05DD005	05DD005
45	VERMILION R.	NEAR MANNVILLE	05EE001		
46	BATTLE R.	AT PONOKA	05FA001		
47	BATTLE R.	NEAR UNWIN, SASKATCHEWAN	05FE001		
48	RED DEER R.	NEAR SUNDRE	05CA001		
49	RED DEER R.	AT RED DEER	05CC002		
50	RED DEER R.	AT DRUMHELLER	05CE001		
51	RED DEER R.	NEAR BINDLOSS/EMPRESS	05CK004	05CK002	
52	L. RED DEER R.	NEAR WATER VALLEY	05CB002		
53	L. RED DEER R.	NEAR THE MOUTH	05CB001		
54	MEDICINE R.	NEAR ECKVILLE	05CC007		
55	BLINDMAN R.	NEAR BLACKFALDS	05CC001		
56	KNEEHILLS CR.	NEAR DRUMHELLER	05CE002		
57	ROSEBUD R.	AT REDLAND	05CE005		
58	S. SASK. R.	AT MEDICINE HAT	05AJ001		
59	S. SASK. R.	NEAR LEMSFORD, SASK.	05HB001		
60	BOW R.	AT BANFF	05BB001		
61	BOW R.	AT KANANASKIS	05BE003		
62	BOW R.	NEAR SEEBE	05BE004		
63	BOW R.	BELOW GHOST DAM	05BE006		
64	BOW R.	AT CALGARY	05BH004		
65	BOW R.	BELOW CARSELAND DAM	05BM002		
66	BOW R.	BELOW BASSANO DAM	05BM004		
67	PIPESTONE R.	NEAR LAKE LOUISE	05BA002		
68	FORTY MILES CR.	NEAR BANFF	05BB003		
69	SPRAY R.	NEAR SPRAY LAKES	05BC002		
70	SPRAY R.	AT BANFF	05BC001		
71	KANANASKIS R.	NEAR SEEBE	05BF001		
72	GHOST R.	NEAR COCHRANE	05BG001		
73	JUMPINGPOUND CR.	NEAR JUMPINGPOUND	05BH006		
74	ELBOW R.	AT BRAGG CREEK/FULLERTON RANCH	05BJ004	05BJ003	
75	ELBOW R.	ABOVE GLENMORE DAM	05BJ005		
76	ELBOW R.	BELOW GLENMORE DAM	05BJ001		
77	HIGHWOOD R.	AT DIEBEL'S RANCH	05BL019		
78	HIGHWOOD R.	AT BROWN'S RANCH	05BL008		
79	HIGHWOOD R.	NEAR ALDERSYDE	05BL009		
80	PEKISKO CR.	AT PEKISKO	05BL006		

TABLE # 1
STATION INFORMATION

SITE #	RIVER/CREEK	STATION NAME	STATION CODES (W.S.C.)	STATION CODES (W.S.C.)	STATION CODES (W.S.C.)
81	STIMSON CR.	NEAR PEKISKO	05BL007		
82	SHEEP R.	AT BUCK RANCH	05BL018		
83	SHEEP R.	AT BLACK DIAMOND	05BL014		
84	SHEEP R.	AT OKOTOKS/ALDERSYDE/OKOTOKS	05BL012	05BL020	05BL012
85	OLDMAN R.	NEAR WALDRON'S CORNER	05AA023		
86	OLDMAN R.	NEAR COWLEY	05AA001		
87	OLDMAN R.	NEAR BROCKET	05AA024		
88	OLDMAN R.	NEAR FORT MCLEOD	05AB007		
89	OLDMAN R.	NEAR MONARCH	05AD019		
90	OLDMAN R.	NEAR LETHBRIDGE	05AD007		
91	OLDMAN R.	NEAR THE MOUTH	05AG006		
92	CROWSNEST R.	AT FRANK	05AA009		
93	CROWSNEST R.	NEAR LUNDBRECK	05AA002		
94	CASTLE R.	NEAR BEAVER MINES	05AA022		
95	CASTLE R.	NEAR COWLEY	05AA003		
96	PINCHER CR.	AT PINCHER CREEK	05AA004		
97	WILLOW CR.	NEAR CLARESHOLM	05AB021		
98	WILLOW CR.	NEAR NOLAN	05AB002		
99	BELLY R.	AT INTERNATIONAL BOUNDARY (U.S.A.)	05AD032		
100	BELLY R.	NEAR MOUNTAIN VIEW	05AD005		
101	BELLY R.	NEAR STAND OFF	05AD002		
102	WATERTON R.	NEAR INTERNATIONAL BOUNDARY (U.S.A.)	05AD029		
103	WATERTON R.	NEAR WATERTON PARK	05AD003		
104	WATERTON R.	NEAR STAND OFF	05AD008		
105	BOUNDARY CR.	NEAR INTERNATIONAL BOUNDARY (U.S.A.)	05AD030		
106	DRYWOOD CR	NEAR TWIN BUTTE	05AD016		
107	ST. MARY R.	INTERNATIONAL BOUNDARY/COOK'S RANCH	05AE027	05AE001	
108	ST. MARY R.	NEAR LETHBRIDGE	05AE006		
109	LEE CR.	AT CARDSTON	05AE002		
110	MILK R.	AT MILK RIVER	11AA005		
111	SMOKY R.	ABOVE HELLS CREEK	07GA001		
112	S. SASK. R.	AT HIGHWAY NO.41	05AK001		
113	BOW R.	AT LAKE LOUISE	05BA001		
114	PEACE R.	AT FIFTH MERIDIAN	07KA002		
115	STURGEON R.	NEAR FORT SASKATCHEWAN	05EA001		
116	LOBSTICK R.	NEAR STYAL	07BB003	07BB001	
117	SWAN R.	NEAR KINUSO	07BJ001		
118	RIBSTONE CR.	NEAR EDGERTON	05FD001		
119	ROSEBUD R.	BELOW CARSTAIRS CREEK	05CE006		
120	CLEARWATER R.	ABOVE CHRISTINA RIVER	07CD005		

TABLE #2

*** RIVER ***

EXPLANATIONS:

1. MAJOR DRAINAGE BASIN
   THIS IS THE MAJOR BASIN TO WHICH THE RIVER OR CREEK (ALSO GIVEN IN TABLE #1) IS A TRIBUTARY. THE FIRST BASIN NAME IS THE LARGEST ALBERTA BASIN, AND THE SECOND BASIN IS THE LARGEST SCALE BASIN.

2. RIVER OR CREEK
   THIS IS THE NAME OF THE RIVER OR CREEK ON WHICH THE HYDROMETRIC STATION AND THE STUDY REACH ARE LOCATED.

3. CHANNEL CODE
   THIS IS A CODE DEVELOPED FOR ALBERTA RIVERS BY THE HIGHWAY AND RIVER ENGINEERING DIVISION, RESEARCH COUNCIL OF ALBERTA.

TABLE # 2
RIVER

SITE #	BASIN	RIVER/CREEK	CODE (R.C.A.)
1	PEACE / MACKENZIE	PEACE R.	03000000
2	PEACE / MACKENZIE	PEACE R.	03000000
3	PEACE / MACKENZIE	PEACE R.	03000000
4	PEACE / MACKENZIE	PEACE R.	03000000
5	PEACE / MACKENZIE	PEACE R.	03000000
6	PEACE / MACKENZIE	PEACE R.	03000000
7	PEACE / MACKENZIE	PEACE R.	03000000
8	PEACE / MACKENZIE	SMOKY R.	03700000
9	PEACE / MACKENZIE	WAPITI R.	03730000
10	PEACE / MACKENZIE	LITTLE SMOKY R.	03710000
11	PEACE / MACKENZIE	NOTIKEWIN R.	03400000
12	ATHABASCA / MACKENZIE	ATHABASCA R.	04000000
13	ATHABASCA / MACKENZIE	ATHABASCA R.	04000000
14	ATHABASCA / MACKENZIE	ATHABASCA R.	04000000
15	ATHABASCA / MACKENZIE	ATHABASCA R.	04000000
16	ATHABASCA / MACKENZIE	ATHABASCA R.	04000000
17	ATHABASCA / MACKENZIE	ATHABASCA R.	04000000
18	ATHABASCA / MACKENZIE	WILDHAY R.	04910000
19	ATHABASCA / MACKENZIE	MCLEOD R.	04800000
20	ATHABASCA / MACKENZIE	MCLEOD R.	04800000
21	ATHABASCA / MACKENZIE	WOLF CR.	04820000
22	ATHABASCA / MACKENZIE	FREEMAN R.	04700000
23	ATHABASCA / MACKENZIE	PEMBINA R.	04600000
24	ATHABASCA / MACKENZIE	PEMBINA R.	04600000
25	ATHABASCA / MACKENZIE	PEMBINA R.	04600000
26	ATHABASCA / MACKENZIE	PADDLE R.	04610000
27	ATHABASCA / MACKENZIE	LITTLE PADDLE R.	04610100
28	ATHABASCA / MACKENZIE	LESSER SLAVE R.	04500000
29	ATHABASCA / MACKENZIE	WEST PRAIRIE R.	04560200
30	ATHABASCA / MACKENZIE	EAST PRAIRIE R.	04560100
31	ATHABASCA / MACKENZIE	CLEARWATER R.	04300000
32	BEAVER / CHURCHILL	BEAVER R.	05000000
33	BEAVER / CHURCHILL	BEAVER R.	05000000
34	NORTH SASKATCHEWAN / NELSON	NORTH SASKATCHEWAN R	06090000
35	NORTH SASKATCHEWAN / NELSON	NORTH SASKATCHEWAN R	06090000
36	NORTH SASKATCHEWAN / NELSON	NORTH SASKATCHEWAN R	06090000
37	NORTH SASKATCHEWAN / NELSON	NORTH SASKATCHEWAN R	06090000
38	NORTH SASKATCHEWAN / NELSON	NORTH SASKATCHEWAN R	06090000
39	NORTH SASKATCHEWAN / NELSON	MISTAYA R.	06085000
40	NORTH SASKATCHEWAN / NELSON	CLEARWATER R.	06300000

TABLE # 2
RIVER

SITE #	BASIN	RIVER/CREEK	CODE (R.C.A.)
41	NORTH SASKATCHEWAN / NELSON	CLEARWATER R.	06300000
42	NORTH SASKATCHEWAN / NELSON	PRAIRIE CR.	06310000
43	NORTH SASKATCHEWAN / NELSON	BRAZEAU R.	06200000
44	NORTH SASKATCHEWAN / NELSON	BRAZEAU R.	06220000
45	NORTH SASKATCHEWAN / NELSON	VERMILION R.	06100000
46	NORTH SASKATCHEWAN / NELSON	BATTLE R.	07000000
47	NORTH SASKATCHEWAN / NELSON	BATTLE R.	07000000
48	RED DEER / NELSON	RED DEER R.	09000000
49	RED DEER / NELSON	RED DEER R.	09000000
50	RED DEER / NELSON	RED DEER R.	09000000
51	RED DEER / NELSON	RED DEER R.	09000000
52	RED DEER / NELSON	LITTLE RED DEER R.	09400000
53	RED DEER / NELSON	LITTLE RED DEER R.	09400000
54	RED DEER / NELSON	MEDICINE R.	09300000
55	RED DEER / NELSON	BLINDMAN R.	09200000
56	RED DEER / NELSON	KNEEHILLS CR.	09025000
57	RED DEER / NELSON	ROSEBUD R.	09100000
58	SOUTH SASKATCHEWAN / NELSON	SOUTH SASKATCHEWAN R	10000000
59	SOUTH SASKATCHEWAN / NELSON	SOUTH SASKATCHEWAN R	10000000
60	BOW / NELSON	BOW R.	10100000
61	BOW / NELSON	BOW R.	10100000
62	BOW / NELSON	BOW R.	10100000
63	BOW / NELSON	BOW R.	10100000
64	BOW / NELSON	BOW R.	10100000
65	BOW / NELSON	BOW R.	10100000
66	BOW / NELSON	BOW R.	10100000
67	BOW / NELSON	PIPESTONE R.	10190000
68	BOW / NELSON	FORTY MILE CR.	10170100
69	BOW / NELSON	SPRAY R.	10180000
70	BOW / NELSON	SPRAY R.	10180000
71	BOW / NELSON	KANANASKIS R.	10160000
72	BOW / NELSON	GHOST R.	10150000
73	BOW / NELSON	JUMPINGPOUND CR.	10140000
74	BOW / NELSON	ELBOW R.	10130000
75	BOW / NELSON	ELBOW R.	10130000
76	BOW / NELSON	ELBOW R.	10130000
77	BOW / NELSON	HIGHWOOD R.	10110000
78	BOW / NELSON	HIGHWOOD R.	10110000
79	BOW / NELSON	HIGHWOOD R.	10110000
80	BOW / NELSON	PEKISKO CR.	10110210

TABLE # 2
RIVER

SITE #	BASIN	RIVER/CREEK	CODE (R.C.A.)
81	BOW / NELSON	STIMSON CR.	10110200
82	BOW / NELSON	SHEEP R.	10110100
83	BOW / NELSON	SHEEP R.	10110100
84	BOW / NELSON	SHEEP R.	10110100
85	OLDMAN / NELSON	OLDMAN R.	10200000
86	OLDMAN / NELSON	OLDMAN R.	10200000
87	OLDMAN / NELSON	OLDMAN R.	10200000
88	OLDMAN / NELSON	OLDMAN R.	10200000
89	OLDMAN / NELSON	OLDMAN R.	10200000
90	OLDMAN / NELSON	OLDMAN R.	10200000
91	OLDMAN / NELSON	OLDMAN R.	10200000
92	OLDMAN / NELSON	CROWSNEST R.	10270000
93	OLDMAN / NELSON	CROWSNEST R.	10270000
94	OLDMAN / NELSON	CASTLE R.	10260000
95	OLDMAN / NELSON	CASTLE R.	10260000
96	OLDMAN / NELSON	PINCHER CR.	10250000
97	OLDMAN / NELSON	WILLOW CR.	10240000
98	OLDMAN / NELSON	WILLOW CR.	10240000
99	OLDMAN / NELSON	BELLY R.	10230000
100	OLDMAN / NELSON	BELLY R.	10230000
101	OLDMAN / NELSON	BELLY R.	10230000
102	OLDMAN / NELSON	WATERTON R.	10230100
103	OLDMAN / NELSON	WATERTON R.	10230100
104	OLDMAN / NELSON	WATERTON R.	10230100
105	OLDMAN / NELSON	BOUNDARY CR.	10230130
106	OLDMAN / NELSON	DRYWOOD CR.	10230150
107	OLDMAN / NELSON	ST. MARY R.	10220000
108	OLDMAN / NELSON	ST. MARY R.	10220000
109	OLDMAN / NELSON	LEE CREEK	10220500
110	MILK / MISSISSIPPI	MILK R.	11000000
111	PEACE / MACKENZIE	SMOKY R.	03700000
112	SOUTH SASKATCHEWAN / NELSON	SOUTH SASKATCHEWAN R	10000000
113	BOW / NELSON	BOW R.	10100000
114	PEACE / MACKENZIE	PEACE R.	03000000
115	NORTH SASKATCHEWAN / NELSON	STURGEON R.	06030000
116	ATHABASCA / MACKENZIE	LOBSTICK R.	04620000
117	ATHABASCA / MACKENZIE	SWAN R.	04540000
118	NORTH SASKATCHEWAN / NELSON	RIBSTONE CR.	07100000
119	RED DEER / NELSON	ROSEBUD R.	09100000
120	ATHABASCA / MACKENZIE	CLEARWATER R.	04300000

TABLE #4

*** STATICN LOCATION ***

(ELEVATICNS IN FT., AREAS IN SQ.MI., AND DISTANCE IN MILES)

EXPLANATICNS:

1. LOCATION OF HYDRCMETRIC STATION
   THE CCORDINATES OF THE LATEST HYDROMETRIC STATION ARE GIVEN IN LATITUDE AND LONGITUDE.

2. LOCATION OF HYDRCMETRIC STATICN USING SURVEY GRID
   THE LOCATION OF THE LATEST HYDROMETRIC STATION IS GIVEN USING THE LEGAL SURVEY GRID. THE SMALLEST UNIT IS GIVEN FIRST, (THE SECTICN NUMBER), THEN THE NEXT LARGEST UNIT IS GIVEN (THE TOWNSHIP). FINALLY THE RANGE AND THE MERIDIAN ARE GIVEN.

3. ELEVATICN CF GAUGE ZERO
   THIS IS THE REFERENCE ELEVATION FROM WHICH THE STAGE IS MEASURED. THE STAGE EQUALS ZERO AT THIS ELEVATICN AT THE HYDROMETRIC STATION, UNLESS THE DATUM USED FOR THE GAUGE ZERO IS APPROXIMATE (2).

4. CODE FCR CATUM USED FOR GAUGE ZERO
   0 GEODETIC ELEVATICN OF GAUGE ZERO
   1 NCT TIED TO GEODETIC ELEVATION
   2 APPROXIMATE ELEVATICN OBTAINED FROM TOPOGRAPHIC MAPS OR BY OTHER MEANS. THIS ELEVATION MAY DEVIATE 10 OR MORE FEET FROM THE ACTUAL GAUGE ZERO, BUT GIVES AN INDICATION OF THE ELEVATION CF THE HYDRCMETRIC STATION.

5. GAUGE HEIGHT FOR ZERO DISCHARGE
   THIS IS THE APPROXIMATE GAUGE HEIGHT CORRESPONDING TO ZERO DISCHARGE AS DETERMINED FROM THE RATING CURVE THAT WAS APPLICABLE FOR THE HYCROMETRIC STATION AT THE TIME OF THE SURVEY OF THE STUDY REACH. THIS STAGE MUST BE ACCEPTED AS BEING APPRCXIMATE. IF THE GAUCE HEIGHT FOR ZERO DISCHARGE IS 0.0, THE VALUE 0.01 IS RECORDED SINCE 0.0 IS USED AS A TEST. IF THE GAUGE HEIGHT FOR ZERO DISCHARGE IS -1.0, THE VALUE -1.01 IS RECCRDED SINCE -1.C IS USED AS A TEST.

6. CODE FOR THE STABILITY OF THE RATING CURVE
   0 NCT APPLICABLE
   1 STABLE
   2 SLIGHTLY UNSTABLE
   3 MCDERATELY UNSTABLE
   4 HIGHLY UNSTABLE

   THE CODE FOR THE STABILITY OF THE RATING CURVE WAS EVALUATED BY THE CALGARY OFFICE OF THE WATER SURVEY OF CANADA.

TABLE # 4 (CONTINUED)

THE EVALUATION OF THE RATING CURVE STABILITY WAS MADE BY THE WATER SURVEY OF CANADA. MORE DATA RELATED TO RATING CURVE STABILITY IS GIVEN IN TABLE #20.

7. YEAR OF THE RATING CURVE
THIS IS THE YEAR OF THE RATING CURVE USED TO MAKE AN ESTIMATE OF THE GAUGE HEIGHT CORRESPONDING TO ZERO DISCHARGE.

8. DRAINAGE AREA
THIS IS THE DRAINAGE AREA OF THE BASIN ABOVE THE HYDROMETRIC STATION. THE DRAINAGE AREA IS THAT PUBLISHED BY THE WATER SURVEY OF CANADA UNLESS OTHERWISE NOTED.

9. DISTANCE FROM SOURCE
THIS IS THE (APPROXIMATE) DISTANCE FROM THE BEGINNING OF THE CHANNEL ON WHICH THE HYDROMETRIC STATION IS LOCATED TO THE HYDROMETRIC STATION. THE BEGINNING POINT IS CONSIDERED TO BE THE END OF THE CHANNEL AS SHOWN ON TOPOGRAPHIC MAPS.

10. DISTANCE FROM MOUTH
THIS IS THE (APPROXIMATE) DISTANCE FROM THE MOUTH OF THE CHANNEL ON WHICH THE HYDROMETRIC STATION IS LOCATED TO THE HYDROMETRIC STATION. THE MOUTH OF A CHANNEL IS CONSIDERED TO BE AT THE CONFLUENCE WITH THE FIRST LARGER CHANNEL OR WHERE THE CHANNEL TAKES A NEW NAME (E.G. PEACE R. - SLAVE R.)

TABLE # 4
STATION LOCATION

(ALL ELEVATIONS IN FT.: ALL DISTANCES IN MILES AND ALL AREAS IN SQ. MILES)

SITE #	LATITUDE DEG MIN SEC	LONGITUDE DEG MIN SEC	LEGAL SURVEY SEC # TS R M	ELEV. OF GAUGE ZERO	CODE	GAUGE FOR ZERO FLOW	CODE	YR	DRAIN. AREA	DIST. FROM SOURCE	DIST. FROM MOUTH	COMMENTS
1	56 01 39	121 53 56	80 25 6	1468.96	0	2.0	2	68	27800.0	333.0	755.0	THUTADE L.
2	56 08 09	120 40 13	82 17 6	1313.23	0	-2.0	3	68	38300.0	393.0	698.0	
3	55 55 00	118 37 00	7 80 4 6	1104.50	0	4.0	1	68	50200.0	506.0	585.0	
4	56 14 41	117 18 46	31 83 21 5	1000.52	0	17.0	2	68	72000.0	570.0	521.0	
5	57 44 30	117 01 55	3 101 19 5	860.00	2	-7.0	3	66	81000.0	735.0	356.0	
6	58 23 15	115 02 05	24 108 12 5	798.91	0	1.0	3	65	86000.0	836.0	255.0	
7	59 06 50	112 25 35	35 116 15 4	680.28	0	3.0	2	70	113000.0	1029.0	62.0	
8	55 24 56	117 37 19	34 77 24 5	1226.17	0	1.0	2	68	18500.0	304.0	41.0	
9	55 04 20	118 48 10	23 70 6 6	1680.00	2	-0.8	1	68	4350.0	147.0	25.0	
10	55 27 55	117 09 40	33 74 21 5	1580.00	2	6.0	2	67	4130.0	327.0	39.0	
11	56 55 25	117 37 35	28 91 23 5	1480.19	0	2.1	3	65	1810.0	166.0	56.0	
12	52 52 35	118 04 08	15 45 01 6	3370.00	2	-1.0	2	-1	1576.0	65.0	836.0	
13	53 24 45	117 35 15	22 51 25 5	3128.51	0	3.0	1	68	4000.0	128.0	773.0	
14	54 09 10	115 43 15	34 59 12 5	2255.67	0	2.0	-1	68	7300.0	254.0	647.0	
15	54 43 20	113 17 10	20 66 22 4	1662.97	0	-2.0	1	65	29600.0	467.0	434.0	
16	56 43 53	111 24 09	05 90 09 4	774.17	0	-1.0	2	-1	50000.0	717.0	184.0	
17	58 12 15	111 23 32	15 106 09 4	700.40	0	-1.0	-1	-1	58700.0	830.0	71.0	DA NOT WSC
18	53 31 24	117 56 49	29 52 27 5	4100.00	2	1.0	2	67	373.0	0.0	47.0	
19	54 28 10	116 37 45	07 52 18 5	3050.00	2	3.0	2	65	1000.0	104.0	0.0	
20	53 39 15	116 16 50	10 54 16 5	2737.00	2	0.5	1	65	2510.0	149.0	0.0	
21	53 35 55	116 16 15	22 53 16 5	2800.00	2	2.8	1	69	350.0	62.0	0.0	
22	54 21 53	114 54 17	13 62 07 5	2240.00	2	1.5	3	67	662.0	0.0	11.0	
23	53 07 55	115 18 45	07 48 09 5	2770.00	2	-1.0	1	-1	1110.0	148.0	315.0	
24	53 36 00	115 00 14	29 53 07 5	2330.00	2	1.6	2	67	1710.0	235.0	230.0	
25	54 27 05	113 59 30	15 63 27 4	1960.00	2	1.9	3	67	4550.0	407.0	53.0	
26	53 53 50	115 02 20	06 57 07 5	2200.00	2	1.6	3	67	341.0	0.0	80.0	
27	53 57 40	115 08 55	29 57 08 5	2250.00	2	1.2	2	67	124.0	0.0	20.0	
28	55 17 39	114 35 26	06 73 04 5	1888.00	2	1.0	4	68	5690.0	16.0	0.0	
29	55 26 00	116 29 50	26 74 17 5	1930.00	2	1.3	3	58	430.0	107.0	0.0	
30	55 25 00	116 20 20	14 74 16 5	1930.00	2	0.5	4	68	500.0	114.0	0.0	
31	56 40 50	111 15 00	32 88 08 4	789.95	0	4.0	2	65	9390.0	10.0	0.0	
32	54 21 20	110 13 00	15 62 02 4	1608.00	2	18.0	2	66	5460.0	137.0	0.0	
33	54 17 46	108 36 18		0.0		2.0	-1	65	7830.0	0.0	0.0	
34	51 58 00	116 43 30		4548.81	0	1.0	-1	67	492.0	25.0	515.0	A-S BORDER
35	52 27 10	115 45 20	23 40 13 5	3673.60	0	-1.3	1	63	1980.0	96.0	444.0	A-S BORDER
36	52 22 51	114 56 21	21 39 07 5	3125.35	0	3.0	3	64	4220.0	143.0	397.0	A-S BORDER
37	53 32 20	113 29 10	33 52 24 4	1999.41	0	4.0	1	65	10500.0	330.0	210.0	A-S BORDER
38	53 39 30	110 20 20	14 54 03 4	1643.05	0	6.0	1	65	21300.0	521.0	19.0	A-S BORDER
39	51 53 00	116 41 20	06 34 19 5	5331.32	0	-1.0	3	-1	94.0	19.0	0.0	
40	51 59 30	115 26 00	12 35 11 5	4451.51	0	1.0	3	64	500.0	59.0	0.0	

TABLE # 4

STATION LOCATION

(ALL ELEVATIONS IN FT.: ALL DISTANCES IN MILES AND ALL AREAS IN SQ. MILES)

SITE #	LATITUDE DEG	MIN	SEC	LONGITUDE DEG	MIN	SEC	LEGAL SURVEY SEC #	TS	R	M	ELEV. OF GAUGE ZERO	CODE	GAUGE FOR ZERO FLOW	CODE	YR	DRAIN. AREA	DIST. FROM SOURCE	DIST. FROM MOUTH	COMMENTS
41	52	20	40	114	56	10	09	29	07	4	3143.38	0	1.5	2	65	1210.0	120.0	0.0	
42	52	16	20	114	55	50	15	38	07	4	3235.00	2	-1.0	2	-1	318.0	55.0	0.0	
43	52	52	50	116	34	40	16	45	18	5	4117.35	0	-1.0	-1	-1	1000.0	0.0	80.0	
44	52	57	45	115	32	40	16	46	11	5	2745.00	0	0.3	2	69	2190.0	0.0	14.0	
45	53	22	30	111	10	30	06	51	08	4	1900.00	2	2.0	4	66	2200.0	0.0	100.0	
46	52	39	34	113	36	15	36	42	26	4	2625.00	2	3.0	1	66	730.0	50.0	0.0	
47	52	57		109	53		05	46	27	3	0.0		5.0	-1	66	9820.0	0.0	0.0	
48	51	42	00	114	51	20	36	31	07	5	3940.00	2	-1.0	3	-1	954.0	89.0	394.0	
49	52	16	35	113	48	45	20	38	27	4	2781.99	0	2.0	2	60	4420.0	161.0	321.0	
50	51	28	08	112	42	30	11	29	20	4	2220.45	0	0.5	2	64	9660.0	288.0	195.0	
51	50	54	10	110	17	50	25	22	03	4	1934.30	0	0.5	2	64	16800.0	453.0	29.0	
52	51	30	45	114	40	20	29	29	05	5	3870.00	2	3.1	2	66	178.0	27.0	88.0	
53	52	01	40	114	08	20	30	35	01	5	2980.00	2	1.0	2	65	924.0	109.0	6.0	
54	52	19	08	114	20	33	34	38	03	5	3000.00	2	3.5	2	65	754.0	66.0	0.0	
55	52	51	23	113	47	39	15	39	27	4	2760.00	2	0.5	2	65	687.0	77.0	0.0	
56	51	28	50	112	50	50	23	29	21	4	2220.00	2	1.7	4	67	950.0	81.0	2.0	
57	51	17	35	113	00	10	10	27	22	4	2605.00	2	0.7	3	66	1400.0	96.0	36.0	
58	50	02	35	110	40	40	31	12	05	4	2139.24	0	4.5	1	67	22500.0	343.0	0.0	
59	50	01	20	109	07	30	10	24	23	3	0.0		-1.0	-1	-1	45000.0	0.0	0.0	
60	51	10	30	115	34	10	35	25	12	5	4514.57	0	4.0	1	68	858.0	66.0	321.0	
61	51	05	25	115	5	20	32	24	08	5	4195.52	0	0.5	1	22	1614.0	98.0	289.0	
62	51	07	10	115	02	00	10	25	08	5	4047.85	0	-1.0	1	-1	1960.0	101.0	286.0	
63	51	12	50	114	36	40	15	26	05	4	3743.49	0	1.0	1	68	2500.0	125.0	262.0	
64	51	03	00	114	03	00	15	24	01	5	3405.61	0	1.0	2	66	3009.0	160.0	227.0	
65	50	49	50	113	25	00	33	21	25	4	2955.53	0	0.3	3	67	6000.0	208.0	179.0	
66	50	45	00	112	32	20	02	21	19	4	2540.00	0	2.5	3	67	7610.0	281.0	106.0	
67	51	25	30	116	10	40	28	28	16	5	5025.29	0	3.5	3	20	136.0	28.0	1.0	
68	51	11	40	115	33	40	2	26	12	5	4522.90	0	0.5	3	48	54.0	19.0	0.0	
69	50	53	10	115	22	30	31	22	10	5	5418.17	0	1.5	-1	39	143.0	15.0	24.0	
70	51	09	30	115	33	00	25	25	12	5	4467.95	0	2.4	1	68	276.0	38.0	1.0	
71	51	02	50	115	01	40	15	24	08	5	4329.80	0	-1.0	1	-1	362.0	0.0	5.0	
72	51	15	40	114	45	50	34	26	06	5	3960.00	2	0.5	4	68	346.0	0.0	4.0	
73	51	04	10	114	32	40	30	24	4	5	4048.00	2	1.0	3	15	187.0	0.0	19.0	
74	50	56	40	114	34	30	13	23	05	5	4242.96	0	0.1	4	67	306.0	41.0	38.0	
75	51	00		114	06		32	23	01	5	0.0	-1	-1.0	-1	-1	471.0	72.0	7.0	
76	51	00		114	06		32	23	01	5	0.0	-1	-1.0	-1	-1	471.0	72.0	7.0	
77	50	24	40	114	28	30	10	17	04	5	4550.00	2	0.5	2	67	300.0	40.0	69.0	
78	50	31	50	114	14	15	20	18	02	5	3980.00	2	-1.0	2	19	421.0	59.0	50.0	
79	50	42	00	113	51	10	17	20	28	4	3355.00	2	2.5	2	65	906.0	95.0	14.0	
80	50	25	10	114	14	55	8	17	02	5	3900.00	2	1.0	-1	31	99.0	25.0	0.0	

TABLE # 4
STATION LOCATION

(ALL ELEVATIONS IN FT.; ALL DISTANCES IN MILES AND ALL AREAS IN SQ. MILES)

SITE #	LATITUDE DEG	MIN	SEC	LONGITUDE DEG	MIN	SEC	LEGAL SURVEY SEC #	TS	R	M	ELEV. OF GAUGE ZERO	CODE	GAUGE FOR ZERO FLOW	CODE	YR	DRAIN. AREA	DIST. FROM SOURCE	DIST. FROM MOUTH	COMMENTS
81	50	25	50	114	09	55	14	17	02	5	3900.00	2	2.6	3	67	96.0	28.0	0.0	
82	50	37	20	114	25	40	24	19	04	5	4200.00	2	3.0	4	65	176.0	33.0	0.0	
83	50	41	20	114	14	35	17	20	02	5	3850.00	2	-1.0	4	-1	232.0	46.0	0.0	
84	50	43	17	113	58	51	29	20	29	4	3441.70	0	5.3	4	66	628.0	69.0	0.0	
85	49	48	50	114	11	00	10	10	02	5	4141.32	0	1.5	2	65	551.0	41.0	239.0	
86	49	36	30	114	03	40	34	07	01	5	3580.00	2	2.0	2	25	730.0	62.0	218.0	
87	49	33	27	113	49	20	14	07	29	4	3400.49	0	-1.0	2	-1	1700.0	76.0	204.0	
88	49	43	15	113	27	00	10	09	26	4	3089.97	0	-1.0	3	-1	2230.0	112.0	168.0	
89	49	47	25	113	07	25	01	10	24	4	2897.25	0	5.0	2	65	3450.0	141.0	139.0	
90	49	42	30	112	52	30	01	09	22	4	2686.90	0	1.0	1	65	6630.0	162.0	98.0	
91	49	55	08	111	48	00	24	11	14	4	2314.92	0	6.4	1	65	11000.0	272.0	9.0	DA NOT WSC
92	49	35	33	114	24	20	30	07	03	5	4166.58	0	3.0	2	67	162.0	27.0	25.0	
93	49	35	35	114	10	20	26	07	02	5	3720.00	2	1.0	1	30	268.0	44.0	8.0	
94	49	29	20	114	08	40	24	06	02	5	3900.00	2	-1.0	2	-1	319.0	43.0	20.0	
95	49	31	30	114	01	27	02	07	01	5	3650.00	2	2.5	1	30	435.0	55.0	9.0	
96	49	29	12	113	56	49	23	06	30	4	3700.00	2	1.5	3	68	57.0	29.0	0.0	
97	50	01	05	113	42	50	23	12	28	4	3260.00	2	1.5	2	58	446.0	68.0	0.0	
98	49	47	40	113	31	30	01	10	27	4	3140.00	2	1.5	3	67	900.0	103.0	0.0	
99	48	59	50	113	40	50	02	37	16	0	4500.00	2	1.0	1	64	75.0	75.0	0.0	
100	49	06	00	113	41	48	05	02	28	4	4344.90	0	1.0	2	62	121.0	27.0	0.0	
101	49	29	20	113	18	10	21	06	25	4	3200.00	2	0.5	3	61	476.0	81.0	0.0	
102	48	57	20	113	54	00	23	37	18	0	0.0	-1	1.5	-1	64	61.0	16.0	76.0	
103	49	06	50	113	50	20	08	02	29	4	4186.37	0	0.5	1	66	238.0	29.0	63.0	
104	49	30	07	113	19	34	10	06	25	4	3207.83	0	-1.0	2	-1	674.0	87.0	5.0	
105	48	59	50	113	54	20	03	37	18	0	0.0	-1	1.0	-1	64	21.0	9.0	0.0	
106	49	19	00	114	00	20	13	04	01	5	4793.98	0	1.5	4	65	12.0	11.0	0.0	
107	49	00	10	113	18	50	05	01	25	4	3917.00	2	3.0	1	67	469.0	42.0	101.0	
108	49	34	10	112	50	00	19	07	21	4	2780.00	2	1.0	2	65	1410.0	135.0	8.0	
109	49	12	00	113	17	45	10	03	25	4	3699.64	0	3.0	4	62	117.0	41.0	4.0	
110	49	08	45	112	04	44	28	02	16	4	3402.75	0	1.0	3	65	1040.0	122.0	0.0	
111	53	57		119	09			57	8	6	0.0	-1	-1.5	3	67	1460.0	72.0	273.0	DA NOT WSC
112	50	44	15	110	05	45	33	20	1	4	1913.05	0	2.0	1	66	25600.0	443.0	0.0	
113	51	25	42	116	11	15	28	28	16	5	5033.47	0	2.0	1	67	165.0	24.0	363.0	
114	58	39	00	114	01	20	24	111	1	5	0.0	2	0.0			109000.0	921.0	167.0	
115	53	47	15	113	13	20	28	55	22	4	2000.00	2	1.0	3		1310.0	0.0	0.0	
116	53	36	45	115	06	20	28	53	8	5	2520.00	2	0.5	2		671.0	0.0	0.0	
117	55	19	45	115	24	50	14	73	10	5	1928.00	2	2.5	3	69	742.0	0.0	0.0	
118	52	45	10	110	29	00	35	43	4	4	2063.00	2	4.8	4	70	990.0	0.0	0.0	
119	51	25	00	113	43	35	22	28	27	4	3038.00	2	2.4	2		316.0	0.0	0.0	
120	56	40	10	111	03	00	33	88	7	4	815.00	2	-1.0	3	69	6144.0	0.0	0.0	DA NOT WSC

TABLE #6

*** ENGINEERING WORKS ABOVE STATION ***

EXPLANATIONS:

1. THIS TABLE GIVES INFORMATION CONCERNING THE ENGINEERING WORKS AFFECTING THE FLOWS AT THE HYDROMETRIC STATION. THE FOLLOWING CODES APPLY TO EACH OF THE MAJOR UPSTREAM WORKS.

2. CODE FOR PURPOSE OF ENGINEERING WORKS
   - 0 NO UPSTREAM WORKS
   - 1 STORAGE
   - 2 DIVERSION (OUT)
   - 3 DIVERSION (IN)

   THIS CODE APPLIES TO THE PRINCIPAL PURPOSE IF THE PROJECT IS A MULTIPURPOSE PROJECT

3. CODE FOR SEVERITY OF WORKS
   - 0 NO UPSTREAM WORKS
   - 1 MINOR
   - 2 MAJOR

   THIS EVALUATION IS QUALITATIVE BUT GIVES AN INDICATION OF THE RELATIVE IMPORTANCE OF THE PROJECT REGARDING THE HYDROLOGICAL REGIME AT THE STUDY REACH. CODES ARE USED IN TABLES 13, 14 AND 18 TO FURTHER QUALIFY THE EFFECTS OF UPSTREAM WORKS.

4. CODE FOR AGENCY CONTROLLING WORKS
   - 1 FEDERAL GOVERNMENT
   - 2 PROVINCIAL GOVERNMENT
   - 3 IRRIGATION DISTRICT
   - 4 PRIVATE
   - 5 POWER COMPANY
   - 6 MUNICIPAL GOVERNMENT

5. STARTING DATE FOR WORKS
   THIS IS THE MONTH AND YEAR FOR WHICH THE U/S ENGINEERING WORKS BEGAN TO AFFECT THE HYDROLOGIC REGIME AT THE HYDROMETRIC STATION.

6. STOPPING DATE FOR WORKS
   THIS IS THE MONTH AND YEAR FOR WHICH THE U/S ENGINEERING WORKS NO LONGER AFFECTED THE HYDROLOGICAL REGIME AT THE HYDROMETRIC STATION.

7. COMMENTS
   THE COMMENTS GIVE SOME ADDITIONAL INFORMATION CONCERNING THE U/S ENGINEERING WORKS IN A VERY ABBREVIATED MANNER.

TABLE # 6
ENGINEERING WORKS ABOVE STATION

SITE #	TYPE	SEVER.	AGENCY	START MCN YR	STOP MCN YR	COMMENTS	TYPE	SEVER.	AGENCY	START MON YR	STOP MON YR	COMMENTS
1	1	2	5	10 67		PMD, BCHPA						
2	1	2	5	10 67		PMD, BCHPA						
3	1	2	5	10 67		PMD, BCHPA						
4	1	2	5	10 67		PMD, BCHPA						
5	1	2	5	10 67		PMD, BCHPA						
6	1	2	5	10 67		PMD, BCHPA						
7	1	2	5	10 67		PMD, BCHPA						
8												
9												
10												
11												
12	0											
13	0											
14	0											
15	0											
16	0											
17	0											
18	0											
19	0											
20	0											
21	0											
22	0											
23	0											
24	0											
25	0											
26	0											
27	0											
28	0											
29	0											
30	0											
31	0											
32	0											
33	0											
34	0											
35	0											
36	1	2	5	72		BIGHORN DAM CPL		1 1	5		63	BRAZEAU DAM CPL
37	1	2	5	72		BIGHORN DAM CPL		1 1	5		63	BRAZEAU DAM CPL
38	1	1	5	72		BIGHORN DAM CPL						
39	0											
40	0											

TABLE # 6
ENGINEERING WORKS ABOVE STATION

SITE #	TYPE	SEVER.	AGENCY	START MON YR	STOP MON YR	COMMENTS	TYPE	SEVER.	AGENCY	START MON YR	STOP MON YR	COMMENTS
41	0											
42	0											
43	0											
44	1	2	5	63		BRAZEAU DAM CPL						
45	0											
46	0											
47	1	1		55		BATTLE RESERVOIR						
48	0											
49	0											
50	0											
51	3	1	3			IRRIGATION RETURN						
52	0											
53	0											
54	0											
55	0											
56	0											
57	3	1	3			IRRIGATION RETURN	2	1	3			NUMEROUS
58	1	1	5	11		BOW RIVER CPL ETC	2	1	3			NUMEROUS
59	1	1	5	11		BOW RIVER CPL ETC						
60	0						3	1	5		42	CPL CASCADE
61	2	2	5	50		SPPAY RESERVOIR	2	1	5		50	CPL
62	1	1	5	42		CPL	1	1	5		11	CPL
63	1	1	5	29		CPL						
64	1	1	5	29		CPL	1	1	5		29	CPL
65	2	2	1	15		PFRA	1	1	5		29	CPL
66	2	2	1	14		PFRA						
67	0											
68	2	1	6			WATER SUPPLY						
69	2	2	5	50		CPL						
70	2	2	5	50		CPL	1	2	5		47	CPL BARRIER DAM
71	1	2	5	32		CPL						
72	2	2	5	42		CPL MINNEWANKA						
73	0											
74	0											
75	0											
76	2	2	6	32		WATER SUPPLY						
77	0											
78	0											
79	0											
80	0											

TABLE # 6

ENGINEERING WORKS ABOVE STATION

SITE #	TYPE	SEVER.	AGENCY	START MON YR	STOP MON YR	COMMENTS	TYPE	SEVER.	AGENCY	START MON YR	STOP MON YR	COMMENTS
81	1	1	-1	66		CHAIN LAKES RES.						
82	0											
83	0											
84	0											
85	C											
86	0											
87	0											
88	2	2	3	23		LNID						
89	2	2	3	23		LNID		1 1	3			WATERTON ST MARY
90	2	1	3	23		LNID		1 1	3			WATERTON ST MARY
91	2	1	3	23		LNID						
92	0											
93	0											
94	0											
95	0											
96	0											
97	1	1	-1	66		CHAIN LAKES RES.						
98	1	1	-1	66		CHAIN LAKES RES.						
99	0											
100	2	1	3	30		MVID UID						
101	2	1	3	23		TO ST MARY ID						
102	0											
103	0							2 1	3		64	UID
104	1	2	3	64		UID						
105	0											
106	0											
107	2	-1		17				2 -1			17	
108	1	2	3									
109	0											
110	3	1	3	17								
111								2 1	3			NUMEROUS
112	1	1	5	11		BCW RIVER CPL ETC						
113	0											
114	1	2		10 67		PMD DEV.,BCHPA						
115	0											
116	0											
117	0											
118	0											
119	0											
120	0											

TABLE #8

*** STATION OPERATING PERIODS ***

EXPLANATIONS:

1. THE DATA IN THIS TABLE ARE NOT ABSOLUTELY CORRECT IN ALL CASES, BUT ARE SUFFICIENTLY ACCURATE TO GIVE A GOOD ESTIMATE OF THE OPERATING PERIOD FOR THE HYDROMETRIC STATION. THE DATA ARE OBTAINED FROM PUBLICATIONS OF THE WATER SURVEY OF CANADA.

2. THE FOLLOWING CODING APPLIES TO EACH OPERATING PERIOD. IF THERE ARE MORE THAN FOUR DISTINCT OPERATING PERIODS, INDICATE BY GIVING A COMMENT.

3. BEGINNING AND ENDING MONTH FOR STATION IN AN OPERATING YEAR
   THIS APPLIES TO THE NORMAL OPERATING PERIOD FOR THE STATION. THE DATA ARE NOT NECESSARILY THE MONTH IN WHICH THE STATION STARTED AND THE MONTH IN WHICH THE STATION STOPPED OPERATION. FOR EXAMPLE, A STATION MAY OPERATE FROM APRIL TO OCTOBER EACH YEAR, BUT IT MAY HAVE BEEN INITIATED IN JUNE FOR THE FIRST YEAR OF OPERATION AND MAY HAVE BEEN SHUT DOWN IN SEPTEMBER ON THE LAST YEAR OF OPERATION. THE BEGINNING AND ENDING MONTHS IN THIS CASE ARE APRIL (4) AND OCTOBER (10).

4. BEGINNING AND ENDING YEAR FOR STATION IN AN OPERATING PERIOD
   THIS IS THE FIRST YEAR AND FINAL YEAR OF OPERATION IN ANY ONE OPERATING PERIOD.

5. CODE FOR TYPE OF RECORD (D-CODE)
   0 DISCHARGE
   1 STAGE ONLY

6. CODE FOR COMPLETENESS OF RECORD IN OPERATING PERIOD (P-CODE)
   0 ESSENTIALLY COMPLETE PERIOD EXCEPT AT BEGINNG AND END.
   1 EXACT PERIOD
   2 INTERMITTENT PERIOD

7. AN EXAMPLE OF THE CODING FOR ONE PERIOD IS AS FOLLOWS:
   3 10 15 28 0 0
   THIS WOULD MEAN: THE OPERATION PERIOD FOR EACH YEAR IS MARCH TO OCTOBER; THE FIRST YEAR OF OPERATION WAS 1915 AND THE FINAL YEAR WAS 1928; THE STATION WAS USED TO OBTAIN DISCHARGE DATA; THE RECORD IS ESSENTIALLY COMPLETE EXCEPT AT THE ENDS. (THE STATION ACTUALLY STARTED IN MAY 1915 AND SHUT DOWN AT THE END OF OCTOBER 1928)

TABLE # 9
STATION OPERATING PERIODS

SITE #	MONTH FROM	MONTH TO	YEAR FROM	YEAR TO	D CODE	P CODE	MONTH FROM	MONTH TO	YEAR FROM	YEAR TO	D CODE	P CODE	MONTH FROM	MONTH TO	YEAR FROM	YEAR TO	D CODE	P CODE	MONTH FROM	MONTH TO	YEAR FROM	YEAR TO	D CODE	P CODE
1	5	11	17	22	0	0	1	12	50		0	1												
2	5	10	44	50	0	0	1	12	52		0	0												
3	5	10	60		0	0																		
4	1	12	15	32	0	0	11	12	57	57	0	1	1	12	58		0	1						
5	5	10	60	67	0	0																		
6	5	11	15	22	0	0	1	12	60	60	1	1	5	12	61	61	0	1	1	12	62		0	1
7	6	12	59	59	0	1	1	12	60		0	0												
8	1	12	15	22	0	0	5	12	55	55	0	1	1	12	56		0	1						
9	12	4	17	18	0	0	10	12	60	60	0	1	1	12	61		0	1						
10	10	12	59	59	0	1	1	12	60		0	1												
11	5	12	61	61	0	1	1	12	62		0	1												
12	1	12	13	31	0	0																		
13	1	12	15	39	0	0	1	12	55	61	0	0	1	12	61		0	0						
14	1	12	60		0	0																		
15	1	12	13	31	0	0	5	10	38	50	0	1	1	12	51		0	0						
16	1	12	57		0	0																		
17	5	10	59	60	1	2	5	10	64		1	2												
18	5	10	65		0	0																		
19	1	12	54		0	0																		
20	1	12	14	23	0	0	3	10	24	31	0	1	1	12	55	57	0	0	1	12	57		0	0
21	1	12	54		0	0																		
22	3	10	65		0	1																		
23	3	10	56		0	1																		
24	1	12	14	23	0	0	1	12	55		0	0												
25	3	10	57	60	0	1	1	12	61		0	0												
26	3	10	63		0	1																		
27	3	10	63		0	1																		
28	1	12	15	31	0	0	1	12	35	40	0	0	1	12	60	62	0	0	1	12	64		0	0
29	3	10	15	17	0	2	4	10	21	31	0	1	3	10	58		0	1						
30	3	10	15	17	0	1	4	10	21	31	0	1	3	10	58		0	1						
31	1	12	30	31	0	0	1	12	57		0	0												
32	1	12	55		0	0																		
33	5	10	33	40	0	1	5	10	60		0	1												
34	6	10	50	65	0	2	1	12	66		0	0												
35	1	12	15	21	0	0	5	10	21	23	0	2	3	10	52	56	0	1	5	10	56		0	1
36	1	12	13	31	0	0	3	10	44	52	0	1	1	12	53		0	0						
37	1	12	11		0	0																		
38	1	12	17	21	0	0	3	10	21	22	0	1	3	10	44	48	0	1	1	12	48		0	1
39	5	10	50	65	0	1	1	12	56		0	0												
40	5	10	59		0	2																		

TABLE # 8
STATICN OPERATING PERIODS

SITE #	MONTH FROM / TC	YEAR FROM / TO	D CODE	P CODE	MONTH FROM / TO	YEAR FROM / TO	D CODE	P CODE	MCNTH FROM / TO	YEAR FROM / TC	D CODE	P CODE	MCNTH FROM / TO	YEAR FROM / TO	D CODE	P CODE
81	3 10	11 19	0	2	3 10	38	0	1								
82	3 10	50	0	1												
83	3 10	9 16	0	1												
84	4 10	8 15	0	1	1 12	16 20	0	0	1 12	57	0	0				
85	1 12	49	0	0												
86	3 10	08 09	0	1	1 12	10 31	0	0	1 14	44 49	0	1				
87	3 10	66	0	1												
88	1 12	11 31	0	0	3 10	32 34	0	1	1 12	35 48	0	0				
89	1 12	48	0	0												
90	1 12	11 31	0	0	1 12	32 48	0	0	1 12	57	0	0				
91	1 12	64	0	0												
92	1 12	11 20	0	0	3 10	49 63	0	1	1 12	64	0	0				
93	3 10	08 10	0	1	1 12	11 31	0	0								
94	1 12	45 49	0	0	1 12	50	0	0								
95	3 10	10 10	0	1	1 12	11 31	0	0								
96	3 10	10 31	0	1	3 10	35 36	0	1	3 10	65	0	1				
97	1 12	44	0	1												
98	3 10	09 14	0	2	1 12	15 23	0	0	3 10	42 61	0	1	1 12	62	0	0
99	1 12	47 57	0	0	5 10	58 64	0	1								
100	1 12	11	0	0												
101	3 10	09 11	0	2	1 12	12 24	0	0	3 10	25 31	0	1	1 12	48	0	0
102	1 12	47 57	0	0	3 10	58 64	0	1								
103	3 10	08 12	0	2	1 12	13 30	0	0	3 10	31 33	0	1	1 12	48	0	0
104	1 12	15 24	0	0	3 10	25 31	0	1	3 10	35 48	0	1	1 12	49 66	0	0
105	1 12	48 57	0	0	5 10	58 64	0	1								
106	4 10	35	0	1												
107	1 12	02	0	0												
108	1 12	11	0	0												
109	5 10	09 14	0	1	1 12	20	0	0								
110	3 10	09 10	0	1	1 12	11	0	0								
111	10 12	66 67	0	0	4 8	68	0	0								
112	1 12	66	0	0												
113	1 12	10 20	0	0	4 10	23 30	1	2	1 12	64	0	0				
114	1 12	60 64	0	0	1 12	65 65	0	2	5 10	66 67	0	0				
115	1 5	14 23	0	1	3 10	27 31	0	0	3 10	35	0	0				
116	1 12	15 23	0	0	1 12	55	0	1								
117	5 10	15 17	0	0	7 10	61 61	0	0		64 64	0	2	3 10	62	0	0
118	3 10	24 30	0	0	3 10	35 36	0	0	3 10	62	0	0				
119	5 10	57 58	0	0	3 10	59	0	0								
120		66	0	0												

TABLE # 8
STATION OPERATING PERIODS

SITE #	MONTH FROM TO	YEAR FROM TO	D CODE	P CODE	MONTH FROM TO	YEAR FROM TO	D CODE	P CODE	MONTH FROM TO	YEAR FROM TO	D CODE	P CODE	MONTH FROM TO	YEAR FROM TO	D CODE	P CODE
41	1 12	14 31	0	0	3 10	44 52	0	1	1 12	53	0	0				
42	5 10	22 25	0	2	3 10	51 60	0	1	1 12	61	0	0				
43	5 10	61 65	0	1												
44	5 1C	57 60	0	2	1 12	61 66	0	C								
45.	1 12	58	0	0												
46	1 12	13 23	0	C	1 12	24 31	0	0	6 10	66	0	1				
47	3 10	44 48	0	1	1 12	49	0	0								
48	3 10	50	0	1												
49	1 12	12 31	0	0	1 12	32 33	0	0	1 12	35	0	0				
50	1 12	15 23	0	C	3 7	24 31	0	1	1 12	59	0	0				
51	1 12	18 31	0	C	3 10	44 48	0	1	1 12	49	0	0				
52	3 10	61 63	0	2	3 10	64	0	1								
53	1 12	60	0	C												
54	3 10	62 63	0	2	3 10	64	0	1								
55	1 12	16 22	0	0	5 10	23 62	0	1	3 10	63	0	1				
56	3 10	21 31	0	1	3 10	35 36	0	1	3 10	57	0	1				
57	5 10	51	0	1												
58	1 12	11	0	0												
59	1 12	58	0	0												
6C	1 12	09 10	0	0	1 12	10	0	0								
61	1 12	12 22	0	C												
62	1 12	23 62	0	0	1 12	63	0	0								
63	5 10	33 36	0	2	1 12	37	0	0								
64	1 12	10 50	0	C	5 10	52 53	0	1	1 12	53	0	0				
65	5 10	10 10	0	1	5 10	13 15	0	1	5 10	56	0	1				
66	5 10	10 11	0	2	5 10	13 13	0	1	1 12	14 33	0	0	5 10	64	0	1
67	1 12	11 20	0	0												
68	1 12	13 19	0	C	1 12	46 47	0	0								
69	5 10	15 19	0	2	5 10	21 23	0	2	1 12	24 39	0	0				
7C	1 12	10	0	0												
71	1 12	11 62	0	0												
72	1 12	11 20	0	0	1 12	29	0	0								
73	5 10	08 19	0	1	5 10	24 26	1	1	5 10	28 29	1	1	5 10	33 36	1	2
74	1 12	14 23	0	0	5 10	23 34	1	1	5 10	35 51	0	2	3 10	52	0	1
75	1 12	33	0	0												
76	1 12	10 32	0	C	1 12	33	0	0								
77	3 10	50	0	1												
78	3 10	12 16	0	1	1 12	17 20	0	0								
79	3 10	12 16	0	2	1 12	16 31	0	0	3 10	33 57	0	2	1 12	57	0	0
80	4 10	11 19	0	1	3 10	23 31	0	1								

TABLE #10

*** HYDROMETRIC INSTRUMENTATION ***

EXPLANATIONS:

1. THE DATA PRESENTED IN THIS TABLE ARE OBTAINED FROM PUBLICATIONS OF THE WATER SURVEY OF CANADA.

2. THE FOLLOWING CODES APPLY FOR EACH PERIOD OF OPERATION OF A SPECIFIC TYPE OF INSTRUMENTATION.

3. BEGINNING AND ENDING YEAR OF A TYPE OF INSTRUMENTATION.
   THIS IS THE FIRST YEAR AND FINAL YEAR OF OPERATION FOR A PARTICULAR TYPE OF INSTRUMENTATION. IN SOME CASES TWO TYPES OF INSTRUMENTATION WILL BE USED DURING THE SAME YEAR.

4. CODE FOR TYPE OF INSTRUMENTATION
   0 NOT APPLICABLE
   1 MANUAL
   2 RECORDING
   3 COMPUTED FROM POWERHOUSE AND/OR SPILLWAY RATINGS.

TABLE # 10
HYDROMETRIC INSTRUMENTATION

SITE #	YEAR FROM	YEAR TO	CODE	YEAR FROM	YEAR TO	CODE	YEAR FROM	YEAR TO	CODE
1	17		1						
2	44		2						
3	60		1						
4	15	62	1	63		2			
5	60	65	1	66	67	2			
6	15	62	1	63		2			
7	59	60	1	61		2			
8	15	22	1	55		2			
9	17		1						
10	59	62	1	63		2			
11	61		1						
12	13	31	1						
13	15	61	1	61		2			
14	60	67	1	68		2			
15	13	59	1	59		2			
16	57		2						
17	59		2						
18	65		2						
19	54		1						
20	14	57	1	57		2			
21	55		1						
22	65		1						
23	56		1						
24	14	64	1	65		2			
25	57	60	1	61		2			
26	63		1						
27	63		1						
28	15	62	1	63		2			
29	15		1						
30	15		1						
31	30	31	1	57		2			
32	55		1						
33	33		1						
34	50		2						
35	15	23	1	52		2			
36	13	52	1	53		2			
37	11	49	1	50		2			
38	17	62	1	62		2			
39	50		2						
40	59		2						
41	14	52	1	53		2			
42	22	62	1	63		2			
43	61	65	2						
44	57	66	2						
45	58		1						
46	13	31	1	66		2			
47	44	64	1	65		2			
48	50		2						
49	12	66	1	67		2			
50	15	63	1	64		2			
51	18	60	1	60		2			
52	61		1						
53	60		1						
54	62		1						
55	16		1						
56	21	58	1	59		2			
57	51		1						
58	11	63	1	63		2			
59	58	59	1	59		2			
60	9	54	1	54		2			
61	12	22	2						
62	23		2						
63	33		2						
64	10	13	1	14		2			
65	10	15	1	56		2			
66	10	19	1	19		2			
67	11	20	1						
68	12	48	1						
69	15	39	1						
70	10	48	1	49		2			
71	11	18	1	19	62	2			
72	11	15	1	16		2			
73	08	19	1						
74	14	48	1	48		2			
75	33		3						
76	10	32	1	33		3			
77	50		2						
78	12	20	1						
79	12	62	1	63		2			
80	11	31	1						
81	11	59	1	60		2			
82	50		2						
83	09	16	1						
84	08	61	1	62	65	2	65		1
85	49		2						
86	08	49	1						
87	21	25	-1	66		2			
88	11	48	1						
89	48		1						
90	11	63	1	63		2			
91	64		2						
92	11	20	1	49		2			
93	08	31	1						
94	45	49	1	50		2			
95	10	31	1						
96	10	36	1	65		2			
97	44		1						
98	09	60	1	61		2			
99	47	64	2						
100	11	48	1	48		2			
101	09	49	1	50		2			
102	47	64	2						
103	08	48	1	49		2			
104	15	66	1						
105	48	64	2						
106	35	49	1	50		2			
107	02	12	1	13		2			
108	11		2						
109	09	56	1	56		2			
110	09	16	1	17		2			
111	66	61	1	68		2			
112	66		2						
113	10	30	1	64		2			
114	60	64	1	65	65	-1	66	67	2
115	14	23	1	27	31	1	35		1
116	54	54	-1	55	65	1	66		2
117	15	17	1	61	66	1	67		2
118	24	30	1	35	36	1	62		1
119	57	60	1	61		2			
120	66		2						

TABLE #12

*** EXTREME DISCHARGES AND MAXIMUM RECORDED GAUGE HEIGHTS ***

(ALL DISCHARGES IN CFS. AND ALL HEIGHTS IN FT.)

EXPLANATIONS:

1. MINIMUM DISCHARGE
   IF THE MINIMUM DISCHARGE IS ZERO ON MORE THAN ONE OCCASION, NO DATE IS GIVEN. IF THE MINIMUM DISCHARGE IS 0.0, THE VALUE 0.01 IS RECORDED SINCE 0.0 IS USED AS ATEST.

2. CODE FOR MAXIMUM DAILY MEAN DISCHARGE
   0 NOT APPLICABLE
   1 DAILY MEAN DISCHARGE OBTAINED FROM A RECORDING GAUGE.
   2 DAILY MEAN DISCHARGE OBTAINED FROM MANUAL OBSERVATION OF STAGE.

3. CODE FOR MAXIMUM INSTANTANEOUS DISCHARGE
   0 NOT APPLICABLE
   1 ESTIMATED FROM RECORDING
   1 ESTIMATED FROM RECORDED MAXIMUM STAGE WITH AN EXTENSION OF THE RATING CURVE.
   2 ESTIMATED FROM MANUAL OBSERVATION OF STAGE WITH AN EXTENSION OF THE RATING CURVE.
   3 ESTIMATED FROM SLOPE AREA COMPUTATIONS.
   4 DISCHARGE MEASURED AT OR VERY NEAR THE MAXIMUM STAGE.

4. CODE FOR MAXIMUM GAUGE HEIGHT
   0 NOT APPLICABLE
   1 DUE TO PEAK DISCHARGE
   2 DUE TO ICE JAM
   3 DUE TO LOG (OR DEBRIS) JAM

TABLE # 12
EXTREME DISCHARGES AND MAXIMUM RECORDED GAUGE HEIGHTS

(ALL DISCHARGES IN CFS. AND ALL HEIGHTS IN FT.)

SITE #	MINIMUM FLOW,C	DATE DAY	MON.	YEAR	MAXIMUM DAILY MEAN FLOW,C	CODE	DATE DAY	MON.	YEAR	MAXIMUM INST. FLOW,Q	CODE	DATE DAY	MON.	YEAR	MAXIMUM GAUGE HEIGHT	CODE	DATE DAY	MON.	YEAR
1	348C.	28	11	1952	311000.	2	14	6	1964	0.					21.30	-1			
2	60CC.	24	3	1952	407000.	2	31	5	1948	410C00.		14	6	1964	21.10	-1			
3	1902C.	30	8	1961	391000.	2	14	6	1964	0.					35.20	-1			
4	635C.	28	3	1919	514C0C.	1	11	7	1965	549C00.		11	7	1965	40.50	1			
5	2589C.	2	9	1961	429C00.	2	18	6	1954	0.					39.00	-1			
6	682C.	8	12	1964	421000.	1	16	6	1964	0.					34.00	-1			
7	960C.	7	4	1962	42100C.	1	20	6	1954	0.					-1.00	-1			
8	494.	12	12	1956	18400C.	1	10	7	1965	195C00.		10	7	1965	24.90	1			
9	142.	19	2	1961	8060C.	2	9	7	1965	96400.		9	7	1965	20.45	1			
10	23.	13	2	1962	36900.	1	29	4	1965	37500.		29	4	1965	19.20	1			
11	C.				17800.	1	23	5	1964	0.					8.50	-1			
12	130.	30	1	1929	21800.	2	13	7	1916	21800.		13	7	1916	10.00	-1			
13	250.	26	4	1937	53000.	2	17	6	1933	0.					19.00	-1			
14	828.	30	3	1964	75200.	2	10	7	1965	0.					17.40	-1			
15	1610.	14	12	1956	192300.	2	10	6	1954	199600.		10	6	1954	25.80	1			
16	3410.	4	2	1964	147000.	1	30	6	1960	150600.		30	6	1960	13.70	1			
17	0.				0.					0.					52.80	-1			
18	29.	17	3	1965	3280.	1	12	7	1965	3870.		11	7	1965	9.00	1			
19	36.	24	2	1959	14600.	2	1	6	1965	0.					13.30	-1			
20	3.	7	3	1923	29600.	1	1	6	1965	80C00.		8	6	1954	-1.00	-1			
21	1.	29	3	1963	307C.	2	10	7	1965	0.					9.60	-1			
22	2.	11	3	1966	14100.	2	29	6	1965	0.					10.70	-1			
23	22.	10	3	1959	13200.	2	10	6	1965	0.					16.50	-1			
24	0.				19900.	2	12	7	1965	0.					13.40	-1			
25	28.	20	4	1962	1940C.	1	4	7	1965	19400.		4	7	1965	19.30	-1			
26	0.				4310.	2	28	8	1965	0.					16.20	-1			
27	0.				2340.	2	28	8	1965	0.					9.60	-1			
28	190.	17	1	1923	8500.	2	15	7	1935	0.					11.10	-1			
29	0.				627C.	2	29	6	1965	0.					15.20	-1			
30	C.				867C.	2	25	6	1927	0.					19.00	-1			
31	1150.	13	2	1962	25100.	1	12	6	1962	25200.		12	6	1962	12.60	1			
32	13.	15	2	1964	2160C.	2	13	6	1962	21800.		13	6	1962	41.60	-1			
33	64.	5	10	1940	23050.	2	18	6	1962	0.					15.30	-1			
34	92.	2	5	1966	1002C.	1	15	7	1953	11130.		15	7	1953	10.80	1			
35	235.	9	3	1921	27400.	2	15	6	1918	43840.		27	6	1915	15.60	-1			
36	404.	21	12	1921	130000.	2	27	6	1915	145C00.		27	6	1915	23.40	-1			
37	220.	1	1	1940	164000.	2	28	6	1915	204500.		28	6	1915	45.00	1			
38	400.	28	12	1941	120000.	2	17	6	1944	0.					23.00	1			
39	5.	20	4	1966	2070.	1	15	7	1953	2310.		15	7	1953	6.30	1			
40	139.	14	4	1964	10000.	1	18	6	1965	18000.		18	6	1965	10.20	1			

TABLE # 12

EXTREME DISCHARGES AND MAXIMUM RECORDED GAUGE HEIGHTS

(ALL DISCHARGES IN CFS. AND ALL HEIGHTS IN FT.)

SITE #	MINIMUM FLOW.Q	DATE DAY	MON.	YEAR	MAXIMUM DAILY MEAN FLOW.Q	CODE	DATE DAY	MON.	YEAR	MAXIMUM INST. FLOW.Q	CODE	DATE DAY	MON.	YEAR	MAXIMUM GAUGE HEIGHT	CODE	DATE DAY	MON.	YEAR
41	66.	21	12	1963	39100.	2	27	6	1915	0.					18.10	-1			
42	6.	1	4	1924	3180.	1	8	5	1964	3860.		8	5	1964	7.50	1			
43	375.	9	5	1961	8600.	1	19	6	1964	9590.		19	6	1964	5.30	1			
44	0.				8120.	1	5	7	1966	24000.		5	7	1966	12.70	1			
45	0.				1490.	2	22	4	1963	0.					11.00	-1			
46	0.				3205.	2	9	5	1920	0.					15.20	-1			
47	0.				9970.	2	8	5	1948	0.					19.60	-1			
48	104.	2	3	1964	20400.	1	18	6	1965	23100.		18	6	1965	8.70	1			
49	64.	7	12	1922	56000.	2	27	6	1915	68250.		27	6	1915	19.00	1			
50	54.	13	12	1922	-1.	-1				43000.		3	6	1923	-1.00	-1			
51	16.	24	1	1922	46200.	2	27	4	1948	0.					11.60	-1			
52	0.				1540.	2	22	7	1965	2580.		31	5	1967	5.30	1			
53	0.				4140.	2	7	5	1964	0.					7.90	-1			
54	0.				4810.	2	14	7	1955	0.					19.60	-1			
55	0.				7400.	2	9	5	1920	0.					10.60	-1			
56	0.				3090.	1	29	3	1956	0.					-1.00	-1			
57	0.				2130.	2	29	3	1966	0.					10.00	-1			
58	360.	22	11	1929	144000.	2	11	6	1953	151800.		11	6	1953	24.40	-1			
59	820.	27	12	1962	86300.	1	4	6	1947	0.					-1.00	-1			
60	128.	5	1	1932	-1.	-1				14100.		14	6	1923	11.90	-1			
61	300.	10	12	1912	21210.	1	21	6	1916	0.					6.10	-1			
62	242.	29	12	1941	26900.	1	3	6	1932	31900.		2	6	1932	10.00	1			
63	143.	11	2	1940	20300.	1	18	6	1933	21400.		17	6	1933	6.30	1			
64	123.	24	2	1930	41100.	1	3	6	1932	53600.		3	6	1932	12.50	1			
65	801.	8	9	1964	37800.	1	1	7	1963	44100.		1	7	1963	9.70	1			
66	109.	18	9	1964	78800.	1	4	6	1929	89700.		4	6	1929	17.30	1			
67	7.	22	3	1912	2860.	2	14	6	1918	0.					8.60	-1			
68	5.	4	3	1919	710.	2	19	6	1916	0.					7.90	-1			
69	25.	12	2	1936	3570.	2	3	6	1932	0.					7.30	-1			
70	10.	27	2	1958	5040.	2	3	6	1932	0.					9.20	-1			
71	0.				10000.	1	3	6	1932	11900.		20	6	1932	7.10	1			
72	25.	18	12	1964	10200.	1	2	6	1932	13900.		20	6	1932	8.00	1			
73	0.				-1.	-1				10300.		20	6	1932	8.60	-1			
74	28.	11	3	1960	8980.	1	31	5	1967	15200.		31	5	1967	-1.00	-1			
75	7.	5	2	1956	7020.	2	31	5	1967	25200.		2	6	1932	-1.00	-1			
76	10.	26	2	1963	13500.	2	3	6	1929	15300.		3	6	1929	-1.00	-1			
77	18.		3	1957	7570.	1	9	6	1953	10000.		9	6	1953	8.00	-1			
78	2.	7	3	1918	8000.	2	28	6	1916	0.					6.50	-1			
79	10.	2	3	1936	15800.	2	12	5	1942	25010.		12	5	1942	13.40	-1			
80	1.				4500.	2	2	6	1929	0.					7.40	-1			

TABLE # 12

EXTREME DISCHARGES AND MAXIMUM RECORDED GAUGE HEIGHTS

(ALL DISCHARGES IN CFS. AND ALL HEIGHTS IN FT.)

SITE #	MINIMUM FLOW,C	DATE DAY	MON.	YEAR	MAXIMUM DAILY MEAN FLOW,Q	CODE	DATE DAY	MON.	YEAR	MAXIMUM INST. FLOW,Q	CODE	DATE DAY	MON.	YEAR	MAXIMUM GAUGE HEIGHT	CODE	DATE DAY	MON.	YEAR
81	0.				2030.	2	11	5	1942	0.					9.20	-1			
82	10.	11	3	1954	4360.	1	29	6	1963	12000.		29	6	1963	11.20	-1			
83	0.				-1.	-1				5125.		26	6	1915	5.50	-1			
84	3.				21400.	2	26	6	1915	0.					10.80	-1			
85	39.	18	1	1950	11850.	1	9	6	1953	16000.		8	6	1953	12.70	-1			
86	28.	17	1	1918	27300.	2	31	5	1923	0.					0.0				
87	159.	2	12	1967	22400.	1	31	5	1967	26100.		30	5	1967	9.30	1			
88	6.	17	9	1939	78500.	2	2	6	1923	0.					0.0				
89	4.	9	9	1961	54620.	2	10	6	1953	67500.		9	6	1953	23.80	-1			
90	134.	31	8	1936	135000.	2	10	6	1953	149000.		10	6	1953	23.10	-1			
91	350.	7	1	1967	64900.	1	11	6	1964	68200.		11	6	1964	21.20	1			
92	21.	11	12	1919	2320.	1	9	6	1953	2610.		9	6	1953	8.60	1			
93	19.	20	1	1920	8000.	2	31	5	1923	0.					9.20	-1			
94	36.	19	1	1953	12700.	1	8	6	1964	18000.		8	6	1964	11.00	1			
95	34.	21	1	1920	44000.	2	31	5	1923	0.					8.60	-1			
96	0.				1560.	2	1	6	1923	2350.		1	6	1923	7.20	-1			
97	1.	13	2	1950	8250.	2	9	6	1953	10000.		9	6	1953	15.00	-1			
98	0.				14690.	2	9	6	1953	20920.		9	6	1953	19.00	-1			
99	12.	12	2	1949	8200.	1	8	6	1964	12000.		8	6	1964	10.20	-1			
100	1.	22	10	1963	10700.	1	8	6	1964	16400.		8	6	1964	11.40	1			
101	6.	5	11	1960	10300.	1	9	6	1964	11700.		9	6	1964	11.60	-1			
102	9.	7	1	1953	7280.	1	8	6	1964	12400.		8	6	1964	11.50	-1			
103	28.	21	3	1966	22700.	1	9	6	1964	25700.		9	6	1964	12.00	-1			
104	25.	28	12	1963	16500.	2	10	6	1964	0.					9.70	-1			
105	4.				-1.	-1				5930.		8	6	1964	-1.00	-1			
106	2.				892.	1	8	6	1964	1180.		8	6	1964	6.00	-1			
107	16.	29	11	1936	18000.	2	5	6	1908	40000.		5	6	1908	12.80	-1			
108	0.				15800.	1	11	6	1964	16200.		11	6	1964	8.50	1			
109	0.				5340.	1	8	6	1964	11400.		8	6	1964	12.60	-1			
110	0.				4250.	1	22	5	1927	8730.		22	5	1927	11.00	1			
111	96.	16		1967	9820.	1	23	5	1958	0.					6.80	-1			
112	1940.	11	9	1967	71100.	1	3	6	1967	75100.		3	6	1967	16.50	1			
113	24.	4	10	1966	-1.	-1				4360.		14	6	1918	-1.00	-1			
114	29240.	3	9	1961	371000.	1	19	6	1964	0.					0.0				
115	0.				3170.	2	7	5	1948	0.					0.0				
116	0.				3380.	2	29	6	1965	0.					0.0				
117	8.				17360.	1	17	5	1917	0.					0.0				
118	0.				195.	2	28	4	1928	0.					0.0				
119	0.				943.	1	20	3	1960	0.					0.0				
120	2230.	29	11	1966	7340.	2	18	5	1967	0.					0.0				

TABLE #13

*** LONG TERM MEAN DISCHARGES ***

(ALL DISCHARGES IN CFS.)

EXPLANATIONS:

1. ALL LONG-TERM DISCHARGES ARE OBTAINED FOR STATIONS WITH COMPLETE YEARS OF DATA UNLESS AN ESTIMATION IS MADE. COMPUTED MEAN DISCHARGES FOR COMPLETE PERIODS SUPPLIED BY THE HYDROLOGY BRANCH, WATER RESOURCES DIVISION, ALBERTA DEPARTMENT OF AGRICULTURE.

2. CODE FOR ESTIMATION (SAME CODE FOR DIFFERENT PERIODS)
   0 NO ESTIMATION
   1 ESTIMATION BY USING U/S OR D/S STATION ON SAME RIVER.
   2 ESTIMATION BY USING STATION(S) IN ADJOINING BASIN(S).
   3 ESTIMATION BY USING STATION(S) IN BASIN(S) NOT ADJOINING THE BASIN UNDER CONSIDERATION.
   4 ESTIMATION BY ASSUMING WINTER DISCHARGE TO BE ZERO.
   5 ESTIMATION BY USING DATA FOR SOME YEARS WITH INCOMPLETE DATA

3. NUMBER OF YEARS
   NUMBER OF YEARS USED TO DETERMINE MEAN DISCHARGE. IF THE MEAN DISCHARGE IS OBTAINED BY ESTIMATION, THE NUMBER OF YEARS IS APPROXIMATE. THE NUMBER OF YEARS GIVEN IN SUCH A CASE IS GENERALLY THE NUMBER OF YEARS OF DATA FOR THE STATION ON WHICH THE ESTIMATE IS BASED.

4. LAST YEAR
   LAST YEAR OF DATA USED TO OBTAIN THE MEAN DISCHARGE.

5. CODE FOR U/S EFFECTS OF ENGINEERING WORKS ON MEAN DISCHARGES
   0 NO UPSTREAM EFFECTS
   1 SLIGHT EFFECT
   2 SOME INCREASE IN DISCHARGE
   4 APPRECIABLE INCREASE IN DISCHARGE
   5 APPRECIABLE DECREASE IN DISCHARGE

   THIS CODE ONLY GIVES AN ESTIMATE OF THE PROBABLE EFFECT OF WORKS ON THE MEAN DISCHARGES. THE CODE PRIMARILY APPLIES TO THE EFFECT ON THE LONG-TERM MEAN FOR THE YEAR. NO QUANTITATIVE LIMITS HAVE BEEN ESTABLISHED; THE CODE IS QUALITATIVE.

6. EFFECTIVE YEAR OF BEGINNING OF ENGINEERING WORKS.
   THE YEAR USED IS NOT NECESSARILY THE FIRST YEAR IN WHICH A STRUCTURE IS BUILT U/S OF THE REACH, BUT THE FIRST YEAR IN WHICH A STRUCTURE IMPOSES THE CODED EFFECT.

TABLE # 13
LONG-TERM MEAN DISCHARGES
(ALL DISCHARGES IN CFS.)

SITE #	LTM FOR YEAR FLOW	EST. CODE	# YRS	LTM FOR MAR-OCT FLOW	EST. CODE	# YRS	LTM FOR APR-OCT FLOW	EST. CODE	# YRS	LTM FOR MAY-SEP FLOW	EST. CODE	# YRS	LAST YEAR	U/S EFFECTS CODE	BEGIN. YEAR
1	39600.	0	14	0.			56500.	1	14	0.			1966	0	
2	51700.	0	14	0.			79300.	1	14	0.			1965	0	
3	56000.	1	8	0.			105000.	1	8	133000.	0	8	1967	0	
4	63700.	0	25	86500.	0	26	97400.	0	26	120000.	0	26	1967	0	
5	66600.	1	8	90800.	1	8	102000.	1	8	125000.	1	8	1967	0	
6	75300.	1	8	101000.	1	8	114000.	0	7	140000.	1	8	1967	0	
7	80500.	0	7	108000.	0	7	122000.	0	7	153000.	0	7	1967	0	
8	13400.	0	16	18700.	0	17	21100.	0	17	25400.	0	19	1967	0	
9	4100.	0	6	5660.	0	6	6410.	0	5	7840.	0	7	1967	0	
10	1980.	0	6	2850.	0	6	3230.	0	6	3150.	0	7	1967	0	
11	593.	0	5	871.	0	5	995.	0	5	1030.	0	7	1967	0	
12	3190.	0	14	4540.	0	16	5150.	0	16	4710.	0	17	1931	0	
13	6600.	0	26	9100.	0	27	10200.	0	27	13000.	0	30	1967	0	
14	0.			0.			0.			0.					
15	15200.	0	30	20600.	0	30	23200.	0	31	27100.	0	47	1967	0	
16	22800.	0	8	30800.	0	9	34400.	0	9	39700.	0	10	1967	0	
17	27100.	1	8	0.			40400.	1	8	0.			1967	0	
18	283.	3	12	389.	5	6	425.	5	6	0.			1970	0	
19	721.	0	12	991.	0	12	1120.	0	12	1340.	0	13	1967	0	
20	1370.	0	17	1890.	0	22	2130.	0	23	2530.	0	25	1967	0	
21	116.	0	12	0.			140.	3	5	0.			1967	0	
22	302.	2	11	380.	5	6	431.	5	6	534.	0	6	1970	0	
23	537.	1	10	756.	0	10	855.	1	10	0.			1967	0	
24	662.	0	20	931.	0	20	1050.	0	20	1220.	0	21	1967	0	
25	1460.	0	5	1550.	0	9	1740.	0	9	1770.	0	10	1967	0	
26	79.	2	5	98.	1	5	111.	0	5	84.	0	5	1967	0	
27	37.	2	5	46.	0	5	52.	0	5	41.	0	5	1967	0	
28	1550.	0	20	1760.	0	21	1850.	0	21	1940.	0	23	1967	0	
29	163.	3	10	235.	0	10	296.	0	16	286.	0	19	1967	0	
30	230.	3	10	328.	0	10	442.	0	16	465.	0	19	1967	0	
31	4770.	0	8	5950.	0	8	6550.	0	8	7120.	0	10	1967	0	
32	986.	0	11	1350.	0	11	1530.	0	11	1580.	0	12	1967	0	
33	0.			0.			0.			0.					
34	0.			0.			0.			0.					
35	3490.	0	6	4700.	0	8	5350.	0	10	6900.	0	20	1967	0	
36	5080.	0	30	6960.	0	40	7840.	0	40	9930.	0	41	1967	0	
37	7770.	0	55	10700.	0	55	12100.	0	55	14900.	0	57	1967	0	
38	8180.	0	20	11500.	0	27	12300.	0	27	15200.	0	29	1967	0	
39	254.	2	7	352.	2	7	399.	2	7	516.	0	7	1967	0	
40	502.	1	7	665.	1	7	735.	1	7	899.	0	7	1967	0	

TABLE # 13
LONG-TERM MEAN DISCHARGES

(ALL DISCHARGES IN CFS.)

SITE #	LTM FOR YEAR FLOW	EST. CODE	# YRS	LTM FOR MAR-OCT FLOW	EST. CODE	# YRS	LTM FOR APR-OCT FLOW	EST. CODE	# YRS	LTM FOR MAY-SEP FLOW	EST. CODE	# YRS	LAST YEAR	U/S EFFECTS CODE	U/S EFFECTS BEGIN. YEAR
41	920.	0	31	1220.	0	41	1350.	0	41	1620.	0	41	1967	0	
42	172.	0	5	220.	0	15	238.	0	18	271.	0	19	1967	0	
43	C.			0.			0.			0.					
44	206C.	0	5	2330.	0	5	2440.	0	5	3160.	0	10	1966	0	
45	5C.	0	8	72.	0	8	82.	0	5	68.	0	9	1967	0	
46	C.			0.			0.			0.					
47	C.			0.			0.			0.					
48	88C.	1	12	1210.	0	12	1370.	0	13	1740.	0	16	1967	0	
49	1810.	0	49	2500.	0	49	2790.	0	51	3211.	0	53	1967	0	
50	2120.	0	14	2970.	0	14	3190.	0	15	3500.	0	16	1967	0	
51	2440.	0	29	3390.	0	35	3710.	0	36	3930.	0	38	1967	1	15
52	88.	1	6	116.	0	6	135.	0	6	172.	0	6	1967	0	
53	172.	0	6	240.	0	6	257.	0	6	274.	0	7	1967	0	
54	217.	4	5	326.	0	4	331.	0	5	253.	0	6	1967	0	
55	144.	0	5	167.	0	11	176.	0	12	170.	0	13	1967	0	
56	34.	4	18	50.	0	18	36.	0	18	16.	0	20	1967	0	
57	6C.	4	15	0.			88.	0	15	97.	0	15	1967	2	15
58	747C.	0	50	9690.	0	51	10500.	0	52	12300.	0	54	1967	3	15
59	C.			0.			0.			0.					
60	1410.	0	56	1920.	0	56	2170.	0	56	2815.	0	58	1967	0	
61	2540.	0	10	3320.	C	10	3700.	0	11	4640.	0	11	1922	0	
62	283C.	0	39	3510.	C	39	3850.	0	39	4730.	0	40	1967	0	
63	3C2C.	0	24	3650.	0	25	3930.	0	28	4640.	0	29	1967	0	
64	327C.	0	51	4150.	0	52	4540.	0	52	5580.	0	57	1967	0	
65	3520.	1	11	4580.	1	11	4870.	1	11	6040.	0	11	1967	5	15
66	441C.	0	12	5670.	0	14	6000.	0	16	7670.	0	22	1967	5	15
67	203.	0	6	282.	0	8	323.	0	9	420.	0	9	1920	0	
68	75.	0	8	100.	0	8	112.	0	8	141.	0	8	1947	0	
69	C.			0.			0.			0.					
70	391.	0	56	514.	0	56	571.	0	56	708.	0	57	1967	1	50
71	543.	0	40	657.	0	43	721.	0	46	886.	0	48	1962	0	
72	235.	C	46	287.	0	46	314.	0	46	362.	0	48	1967	2	42
73	131.	2	11	168.	2	11	193.	2	11	229.	0	11	1919	0	
74	313.	1	16	405.	0	16	466.	0	18	551.	0	19	1967	0	
75	C.			0.			0.			0.					
76	C.			0.			0.			0.					
77	325.	1	16	470.	0	16	528.	0	16	715.	0	17	1967	0	
78	512.	1	5	767.	1	5	863.	0	5	994.	0	7	1920	0	
79	507.	0	23	732.	0	41	824.	0	48	1000.	0	52	1967	0	
80	C.			0.			0.			0.					

TABLE # 13
LONG-TERM MEAN DISCHARGES

(ALL DISCHARGES IN CFS.)

SITE #	LTM FOR YEAR FLOW	EST. CODE	# YRS	LTM FOR MAR-OCT FLOW	EST. CODE	# YRS	LTM FOR APR-OCT FLOW	EST. CODE	# YRS	LTM FOR MAY-SEP FLOW	EST. CODE	# YRS	LAST YEAR	U/S EFFECTS CODE	BEGIN. YEAR
81	26.	2	23	37.	0	26	42.	0	30	52.	0	33	1967	1	66
82	187.	1	15	260.	0	15	296.	0	16	380.	0	17	1967	0	
83	220.	1	6	307.	1	6	405.	1	6	520.	0	6	1916	0	
84	249.	0	11	346.	0	11	497.	0	16	637.	0	21	1967	0	
85	491.	0	15	675.	0	16	755.	0	16	969.	0	17	1967	0	
86	562.	0	20	768.	0	20	858.	0	20	1050.	0	20	1949	0	
87	1100.	1	20	0.			1650.	1	20	0.			1967	0	
88	1350.	0	32	1820.	0	32	2060.	0	33	2540.	0	35	1948	3	23
89	1610.	0	18	2200.	0	18	2420.	0	18	3070.	0	19	1967	3	23
90	3230.	0	42	4330.	0	43	4750.	0	43	5860.	0	46	1967	5	51
91	3233.	1	42	0.			4750.	1	43	0.			1967	5	51
92	198.	0	11	250.	0	25	266.	0	26	349.	0	27	1967	0	
93	254.	0	20	331.	0	20	364.	0	21	432.	0	22	1931	0	
94	614.	0	19	825.	0	21	929.	0	21	1170.	0	23	1967	0	
95	684.	0	20	937.	0	20	1040.	0	21	1270.	0	21	1931	0	
96	51.	2	14	69.	0	14	77.	0	22	89.	0	23	1967	0	
97	123.	0	23	173.	0	23	186.	0	23	219.	0	24	1967	1	66
98	173.	0	13	239.	1	11	244.	1	12	0.			1967	1	66
99	0.			0.			0.			0.					
100	313.	0	54	424.	0	54	474.	0	55	584.	0	56	1967	3	53
101	339.	0	29	467.	0	36	521.	0	38	626.	0	40	1967	3	23
102	0.			0.			0.			0.					
103	672.	0	35	911.	0	35	1030.	0	37	1310.	0	41	1967	0	
104	943.	0	23	1210.	0	40	1370.	0	43	1680.	0	45	1967	5	64
105	0.			0.			0.			0.					
106	23.	2	7	31.	0	7	35.	0	29	44.	0	33	1967	0	
107	764.	0	63	1040.	0	64	1160.	0	64	1330.	0	65	1967	1	17
108	593.	0	50	766.	0	52	831.	0	52	1010.	0	55	1967	5	51
109	62.	0	46	85.	0	47	90.	0	48	106.	0	50	1967	0	
110	303.	0	55	428.	0	55	452.	0	57	520.	0	59	1967	1	17
111	0.			0.			0.			0.					
112	7540.	1	50	0.			10600.	1	50	0.			1970	3	15
113	402.	0	9	556.	0	11	631.	0	11	816.	0	14	1967	0	
114	0.			0.			0.			0.					
115	114.	0	11	148.	0	42	169.	0	44	161.	0	45	1967	0	
116	137.	0	11	172.	0	12	189.	0	12	193.	0	13	1967	0	
117	456.	3	5	655.	0	5	747.	0	5	896.	0	7	1967	0	
118	17.	2	8	24.	0	8	22.	0	12	22.	0	12	1967	0	
119	13.	4	9	20.	0	9	13.	0	9	6.	0	11	1967	0	
120	2850.	1	8	3550.	1	8	3930.	1	8	4300.	1	8	1970	0	

TABLE #14

*** FLOOD DISCHARGES CORRESPONDING TO SPECIFIED RETURN PERIODS ***

(ALL DISCHARGES IN CFS.)

EXPLANATIONS:

1. ANALYSIS BASED ON MAXIMUM ANNUAL DAILY MEAN DISCHARGES

2. DISCHARGES DETERMINED BY FITTING A STRAIGHT LINE THROUGH DATA POINTS BY EYE WHEN PLOTTED ON LOG-NORMAL PROBABILITY PAPER.

3. DISCHARGES ARE ONLY GIVEN IF THE NUMBER OF DATA POINTS USED TO ESTABLISH THE FLOOD FREQUENCY PLOT MEETS A SPECIFIED CRITERIA.

YEARS OF DATA	RETURN PERIODS,YRS.
LT. 5	NONE GIVEN
5- 7	1.5, 2, 5
8-12	1.5, 2, 5, 10
13-25	1.5, 2, 5, 10, 25
26-50	1.5, 2, 5, 10, 25, 50
GT 50	1.5, 2, 5, 10, 25, 50, 100

4. CODE FOR ESTIMATION
   - 0 NO ESTIMATION
   - 1 ESTIMATION BY USING U/S AND OR D/S STATION ON SAME RIVER
   - 2 ESTIMATION BY USING STATION(S) IN ADJOINING BASIN(S)
   - 3 ESTIMATION BY USING STATION(S) IN BASIN(S) NOT ADJOINING THE BASIN UNDER CONSIDERATION

5. NUMBER OF YEARS
   NUMBER OF MAXIMUM ANNUAL DAILY MEAN DISCHARGES USED IN ANALYSIS. CORRESPONDS TO NUMBER OF DATA POINTS DEFINING FLOOD FREQUENCY CURVE

6. LAST YEAR
   LAST YEAR OF DATA USED TO DEFINE THE FLOOD FREQUENCY CURVE.

7. CODE FOR U/S EFFECTS OF ENGINEERING WORKS ON FLOOD DISCHARGES
   - 0 NO UPSTREAM EFFECTS
   - 1 SLIGHT EFFECT
   - 2 SOME EFFECT
   - 3 APPRECIABLE REDUCTION OF SMALLER FLOOD PEAKS
   - 4 APPRECIABLE REDUCTION OF ALL FLOOD PEAKS
   - 5 APPRECIABLE INCREASE OF SMALLER FLOOD PEAKS
   - 6 APPRECIABLE INCREASE OF ALL FLOOD PEAKS

   THIS CODE ONLY GIVES AN ESTIMATE OF THE PROBABLE EFFECT OF WORKS ON THE FLOOD PEAKS. NO QUANTITATIVE LIMITS HAVE BEEN ESTABLISHED, THE CODE IS QUALITATIVE.

8. EFFECTIVE YEAR OF BEGINNING OF ENGINEERING WORKS
   THE YEAR USED IS NOT NECESSARILY THE FIRST YEAR IN WHICH A STRUCTURE IS BUILT U/S OF THE REACH, BUT THE FIRST YEAR IN WHICH A STRUCTURE IMPOSED THE CODED EFFECT.

TABLE # 14
FLOOD DISCHARGES CORRESPONDING TO SPECIFIED RETURN PERIODS

(ALL DISCHARGES IN CFS.)

SITE #	1.5-YEAR FLOOD	2-YEAR FLOOD	5-YEAR FLOOD	10-YEAR FLOOD	25-YEAR FLOOD	50-YEAR FLOOD	100-YEAR FLOOD	EST. CODE	NO. YRS	LAST YEAR	U/S EFFECTS CODE	U/S EFFECTS BEGIN.
1	203000.	215000.	245000.	260000.	280000.	290000.	0.	0	26	1970	4	1967
2	240000.	255000.	290000.	310000.	335000.	0.	0.	0	22	1967	4	1967
3	265000.	290000.	345000.	375000.	0.	0.	0.	0	9	1967	4	1967
4	295000.	315000.	390000.	435000.	490000.	530000.	0.	0	29	1970	4	1967
5	305000.	340000.	410000.	455000.	0.	0.	0.	0	8	1967	4	1967
6	315000.	340000.	385000.	410000.	0.	0.	0.	0	12	1967	4	1967
7	295000.	320000.	380000.	410000.	0.	0.	0.	0	11	1967	4	1967
8	70000.	85000.	120000.	145000.	0.	0.	0.	0	21	1967	0	
9	21300.	29500.	56000.	79000.	0.	0.	0.	0	8	1967	0	
10	20600.	24000.	32500.	38000.	0.	0.	0.	0	7	1967	0	
11	6300.	8500.	15200.	20800.	0.	0.	0.	0	7	1967	0	
12	14800.	16000.	19200.	21000.	0.	0.	0.	0	17	1931	0	
13	29000.	32000.	38000.	42000.	46500.	49000.	0.	0	34	1964	0	
14	0.	0.	0.	0.	0.	0.	0.					
15	54000.	66000.	98000.	120000.	150000.	172000.	196000.	0	50	1970	0	
16	70000.	78000.	102000.	119000.	0.	0.	0.	0	12	1970	0	
17	81800.	92000.	120900.	141200.	0.	0.	0.	1	12	1970	0	
18	1260.	1700.	3000.	0.	0.	0.	0.	0	6	1970	0	
19	4200.	5600.	9800.	13000.	0.	0.	0.	0	9	1964	0	
20	8000.	10800.	19200.	26000.	36400.	44000.	0.	0	26	1964	0	
21	600.	1000.	2000.	2800.	0.	0.	0.	0	10	1964	0	
22	1850.	2800.	5900.	0.	0.	0.	0.	0	6	1970	0	
23	2700.	3400.	5400.	6900.	0.	0.	0.	0	9	1964	0	
24	3900.	5500.	10200.	11200.	25000.	0.	0.	0	21	1965	0	
25	4700.	6700.	13000.	18500.	0.	0.	0.	0	12	1969	0	
26	630.	1000.	2400.	4500.	0.	0.	0.	0	7	1969	0	
27	250.	450.	1040.	2500.	0.	0.	0.	0	7	1969	0	
28	2000.	2430.	3570.	4370.	5420.	6200.	0.	0	28	1964	0	
29	1700.	2200.	3600.	4800.	6400.	0.	0.	0	15	1964	0	
30	2100.	2800.	5000.	6700.	9200.	0.	0.	0	16	1964	0	
31	12800.	15000.	20500.	24000.	0.	0.	0.	0	12	1959	0	
32	3200.	4500.	8600.	12000.	17200.	0.	0.	0	13	1968	0	
33	0.	0.	0.	0.	0.	0.	0.					
34	0.	0.	0.	0.	0.	0.	0.					
35	15700.	17000.	21000.	23300.	26000.	0.	0.	0	20	1964	0	
36	21000.	24400.	33000.	39000.	46000.	52000.	0.	0	39	1964	0	
37	35000.	42000.	62000.	76000.	96000.	110000.	125000.	0	54	1964	3	1963
38	37000.	45000.	67000.	82000.	102000.	0.	0.	0	24	1967	2	1963
39	1100.	1200.	1700.	2000.	2400.	0.	0.	0	13	1964	0	
40	2150.	3000.	5500.	7500.	0.	0.	0.	0	11	1969	0	

TABLE # 14
FLOOD DISCHARGES CORRESPONDING TO SPECIFIED RETURN PERIODS

(ALL DISCHARGES IN CFS.)

SITE #	1.5-YEAR FLOOD	2-YEAR FLOOD	5-YEAR FLOOD	10-YEAR FLOOD	25-YEAR FLOOD	50-YEAR FLOOD	100-YEAR FLOOD	EST. CODE	NO. YRS	LAST YEAR	U/S EFFECTS CODE	U/S EFFECTS BEGIN.
41	3300.	4400.	8300.	11300.	16000.	20000.	0.	0	38	1964	0	
42	650.	1000.	2100.	3000.	0.	0.	0.	0	12	1961	0	
43	0.	0.	0.	0.	0.	0.	0.					
44	9500.	11500.	16500.	0.	0.	0.	0.	0	5	1963	3	1963
45	230.	380.	1000.	1600.	0.	0.	0.	0	11	1958	0	
46	0.	0.	0.	0.	0.	0.	0.					
47	0.	0.	0.	0.	0.	0.	0.					
48	4000.	6000.	11000.	15000.	21000.	0.	0.	0	14	1964	0	
49	8800.	12000.	23000.	32500.	47000.	59000.	71000.	0	52	1964	0	
50	8700.	12400.	24500.	35000.	52000.	0.	0.	0	21	1964	0	
51	10000.	14000.	24000.	32500.	45000.	55000.	0.	0	28	1961	1	1959
52	680.	1000.	2100.	0.	0.	0.	0.	0	6	1969	0	
53	890.	1600.	5050.	9300.	0.	0.	0.	0	9	1969	0	
54	830.	1700.	4300.	6900.	0.	0.	0.	0	8	1969	0	
55	710.	1150.	3000.	5000.	0.	0.	0.	0	12	1965	0	
56	270.	470.	1060.	2250.	4000.	0.	0.	0	19	1964	0	
57	275.	370.	640.	850.	1700.	0.	0.	0	14	1964	1	-1
58	26000.	35000.	75000.	86000.	120000.	140000.	165000.	0	54	1964	4	1951
59	0.	0.	0.	0.	0.	0.	0.					
60	6400.	7300.	9200.	10500.	12000.	13200.	14200.	0	55	1964	0	
61	9600.	11200.	15000.	17700.	0.	0.	0.	0	11	1922	2	1950
62	11100.	13000.	18000.	21300.	25300.	0.	0.	0	20	1943	2	1942
63	9700.	11100.	14300.	16400.	0.	0.	0.	0	31	1963	2	1929
64	13200.	15500.	21000.	25000.	30000.	0.	0.	0	23	1933	2	1929
65	13000.	17000.	28000.	37000.	0.	0.	0.	0	12	1967	2	1929
66	19400.	26500.	48000.	66000.	0.	0.	0.	0	21	1933	2	1929
67	1100.	1400.	2200.	2800.	0.	0.	0.	0	9	1920	0	
68	370.	450.	720.	900.	0.	0.	0.	0	9	1920	0	
69	0.	0.	0.	0.	0.	0.	0.					
70	2300.	2700.	3700.	4400.	5300.	5900.	0.	0	37	1959	4	1951
71	2100.	2850.	4600.	6900.	10000.	0.	0.	0	21	1932	2	1932
72	800.	1270.	3150.	5000.	8500.	0.	0.	0	20	1956	2	1942
73	430.	840.	2800.	5800.	0.	0.	0.	0	11	1919	0	
74	1400.	1860.	3600.	4500.	6200.	7600.	0.	0	29	1964	0	
75	0.	0.	0.	0.	0.	0.	0.					
76	0.	0.	0.	0.	0.	0.	0.					
77	2000.	2600.	4400.	5800.	7800.	0.	0.	0	14	1964	0	
78	2500.	3300.	5800.	7800.	0.	0.	0.	0	7	1920	0	
79	2700.	3900.	7800.	11200.	16500.	21100.	26500.	0	50	1964	0	
80	0.	0.	0.	0.	0.	0.	0.					

TABLE # 14
FLOOD DISCHARGES CORRESPONDING TO SPECIFIED RETURN PERIODS

(ALL DISCHARGES IN CFS.)

SITE #	1.5-YEAR FLOOD	2-YEAR FLOOD	5-YEAR FLOOD	10-YEAR FLOOD	25-YEAR FLOOD	50-YEAR FLOOD	100-YEAR FLOOD	EST. CODE	NO. YRS	LAST YEAR	U/S EFFECTS CODE	U/S EFFECTS BEGIN.
81	230.	340.	900.	1100.	1240.	2200.	0.	0	34	1964	0	
82	1150.	1500.	2500.	3200.	4200.	0.	0.	0	14	1964	0	
83	1120.	1650.	3700.	0.	0.	0.	0.	0	6	1916	0	
84	1400.	2300.	6400.	10100.	0.	0.	0.	0	12	1956	0	
85	2800.	3700.	6000.	7900.	10300.	0.	0.	0	16	1964	0	
86	2700.	3600.	6150.	8100.	11000.	0.	0.	0	18	1949	0	
87	6000.	8000.	13500.	20000.	0.	0.	0.	1	18	1959	0	
88	7700.	10600.	20400.	27000.	41000.	53000.	0.	0	35	1948	1	1923
89	12200.	14600.	19400.	24000.	30000.	0.	0.	0	17	1965	1	1923
90	13000.	20000.	40000.	63000.	100000.	130000.	0.	0	45	1964	3	1951
91	13500.	31500.	56000.	0.	0.	0.	0.	0	5	1968	3	1951
92	940.	1150.	1650.	2000.	2500.	0.	0.	0	23	1959	0	
93	900.	1200.	2030.	2680.	3600.	0.	0.	0	20	1931	0	
94	3800.	4900.	7800.	10000.	12800.	0.	0.	0	20	1964	0	
95	3500.	4500.	7200.	9100.	10200.	0.	0.	0	20	1931	0	
96	285.	435.	980.	1500.	2400.	0.	0.	0	20	1936	0	
97	700.	1050.	2300.	3500.	5350.	0.	0.	0	22	1960	1	1966
98	980.	1500.	3400.	5200.	7400.	11000.	14500.	0	53	1964	1	1966
99	0.	0.	0.	0.	0.	0.	0.					
100	1350.	1650.	2400.	3140.	3600.	4100.	4600.	0	53	1964	1	1930
101	2000.	2400.	3550.	4300.	5300.	6000.	0.	0	31	1964	1	1923
102	0.	0.	0.	0.	0.	0.	0.					
103	3600.	4200.	5700.	6600.	7800.	8600.	0.	0	41	1965	0	
104	4200.	5400.	8700.	11200.	14700.	17500.	0.	0	44	1964	2	1964
105	0.	0.	0.	0.	0.	0.	0.					
106	160.	195.	290.	355.	455.	500.	0.	0	30	1964	0	
107	3200.	3900.	5700.	7000.	8600.	9800.	11000.	0	50	1965	2	1917
108	2600.	3500.	6200.	8300.	11500.	14000.	17000.	0	56	1967	3	1951
109	220.	380.	1400.	2200.	4200.	6000.	0.	0	46	1964	0	
110	1250.	1650.	2750.	3550.	4750.	5700.	6700.	0	58	1967	1	1917
111	0.	0.	0.	0.	0.	0.	0.					
112	27800.	37400.	80000.	92000.	0.	0.	0.	1	54	1964	3	1951
113	1650.	1900.	2850.	3450.	0.	0.	0.	0	16	1969	0	
114	0.	0.	0.	0.	0.	0.	0.					
115	440.	650.	1320.	1900.	2850.	3700.	0.	0	44	1967	0	
116	420.	620.	1360.	2060.	3200.	0.	0.	0	20	1967	0	
117	3800.	5250.	9600.	13300.	0.	0.	0.	0	9	1967	0	
118	54.	74.	130.	180.	250.	0.	0.	0	13	1967	0	
119	57.	130.	580.	1250.	0.	0.	0.	0	11	1967	0	
120	5700.	6100.	6900.	0.	0.	0.	0.	0	5	1970	0	

TABLE #18

*** DISCHARGES WHICH ARE EXCEEDED A SPECIFIED PERCENT OF THE TIME ***

(ALL DISCHARGES IN CFS.)

EXPLANATIONS:

1. THE DATA USED ARE THE APRIL TO OCTOBER DAILY MEAN DISCHARGES. THE TIME BASE IS ONE YEAR EVEN THOUGH ONLY SEVEN MONTHS DATA ARE USED. IT IS ASSUMED THAT ALL NOVEMBER TO MARCH FLOWS ARE LESS THAN THE DISCHARGE WHICH OCCURS 50 PERCENT OF THE YEAR.

2. ALL CASES INVOLVING NO ESTIMATION WERE BASED ON COMPLETE PERIODS OF APRIL TO OCTOBER. THE COMPUTED FLOW DURATION DATA WERE SUPPLIED BY THE HYDROLOGY BRANCH, WATER RESOURCES DIVISION, ALBERTA DEPARTMENT OF AGRICULTURE.

3. CODE FOR ESTIMATION
   - 0 NO ESTIMATION
   - 1 ESTIMATION BY USING U/S AND/OR D/S STATION ON SAME RIVER
   - 2 ESTIMATION BY USING STATION(S) IN ADJOINING BASIN(S)
   - 3 ESTIMATION BY USING STATION(S) IN BASIN(S) NOT ADJOINING THE BASIN UNDER CONSIDERATION
   - 4 ESTIMATION BASED ON ASSUMPTION THAT MAY-SEPTEMBER DURATION DATA IS THE SAME AS THE APRIL-OCTOBER DATA. (IN THIS CASE NO ESTIMATE FOR THE DISCHARGE WHICH IS EXCEEDED 50 PERCENT OF THE TIME IS GIVEN)

4. NUMBER OF YEARS
   NUMBER OF YEARS USED TO DETERMINE FLOW DURATION DATA. IF THE DATA ARE OBTAINED BY ESTIMATION, THE NUMBER OF YEARS IS APPROXIMATE. THE NUMBER OF YEARS GIVEN IN SUCH A CASE IS GENERALLY THE NUMBER OF YEARS OF DATA FOR THE STATION ON WHICH THE ESTIMATE IS BASED.

5. LAST YEAR
   LAST YEAR OF DATA USED TO DETERMINE THE FLOW DURATION DATA

6. CODE FOR U/S EFFECTS OF ENGINEERING WORKS ON FLOW DURATION DATA
   - 0 NO UPSTREAM EFFECTS
   - 1 SLIGHT UPSTREAM EFFECTS
   - 2 SOME DECREASE OF LOW FLOWS
   - 3 SOME INCREASE OF LOW FLOWS
   - 4 APPRECIABLE DECREASE OF LOW FLOWS
   - 5 APPRECIABLE INCREASE OF LOW FLOWS

   THIS CODE ONLY GIVES AN ESTIMATE OF THE PROBABLE EFFECT OF WORKS ON THE FLOW DURATION DATA. NO QUNATITATIVE LIMITS HAVE BEEN ESTABLISHED, THE CODE IS QUALITATIVE.

7. EFFECTIVE YEAR OF BEGINNING OF ENGINEERING WORKS
   THE YEAR USED IS NOT NECESSARILY THE FIRST YEAR IN WHICH A STRUCTURE WAS BUILT U/S OF THE REACH, BUT THE FIRST YEAR IN WHICH A STRUCTURE IMPOSED THE CODED EFFECT.

TABLE # 18
DISCHARGES WHICH ARE EXCEEDED A SPECIFIC PERCENT OF THE TIME

(ALL DISCHARGES IN CFS.)

SITE #	DISCHARGE EXCEEDED .5% OF TIME	DISCHARGE EXCEEDED 1% OF TIME	DISCHARGE EXCEEDED 5% OF TIME	DISCHARGE EXCEEDED 10% OF TIME	DISCHARGE EXCEEDED 50% OF TIME	EST. CODE	NO. YRS	LAST YEAR	U/S EFFECTS CODE	U/S EFFECTS BEGIN. YEAR
1	300000.	277000.	170000.	110000.	28000.	0	5	1964	5	1957
2	340000.	325000.	195000.	152000.	29000.	0	5	1964	5	1957
3	350000.	320000.	210000.	160000.	0.	1	5	1967	5	1967
4	377000.	320000.	229000.	172000.	29500.	0	26	1967	5	1967
5	434000.	364000.	244000.	180000.	28800.	1	5	1967	5	1967
6	363000.	343000.	260000.	213000.	39600.	1	7	1967	5	1967
7	386000.	360000.	275000.	223000.	40700.	0	7	1967	5	1967
8	53700.	77600.	46200.	36000.	6300.	0	17	1967	0	
9	30900.	22800.	14500.	11000.	1520.	0	6	1967	0	
10	24200.	20200.	8740.	5510.	368.	0	6	1967	0	
11	11400.	8990.	3040.	1590.	58.	0	5	1967	0	
12	16500.	15400.	11400.	9450.	895.	0	16	1931	0	
13	32200.	29900.	21400.	17600.	2290.	0	33	1967	0	
14	44400.	37900.	27800.	24100.	5330.	0	6	1967	0	
15	80000.	70400.	43900.	35000.	8960.	0	31	1967	0	
16	101000.	82100.	60000.	50100.	15000.	0	9	1967	0	
17	120400.	99800.	72600.	59400.	0.	1	9	1967	0	
18	2040.	1800.	1220.	937.	131.	2	12	1967	0	
19	7480.	5200.	2500.	1740.	277.	0	12	1967	0	
20	13200.	10000.	4850.	3360.	535.	0	23	1967	0	
21	2000.	1000.	380.	227.	0.	2	5	1967	0	
22	4400.	3700.	700.	450.	0.	2	5	1967	0	
23	7500.	5230.	2080.	1330.	164.	1	20	1967	0	
24	9240.	6440.	2570.	1640.	202.	0	20	1967	0	
25	14200.	11600.	4210.	2630.	302.	0	9	1967	0	
26	2030.	1200.	274.	161.	1.	0	5	1967	0	
27	971.	502.	126.	70.	0.	0	5	1967	0	
28	4200.	4010.	3240.	2630.	1080.	0	24	1967	0	
29	3320.	2340.	895.	458.	12.	0	16	1967	0	
30	4340.	2940.	1180.	684.	42.	0	16	1967	0	
31	21100.	19100.	13700.	10100.	2620.	0	8	1967	0	
32	7540.	6480.	3770.	2660.	310.	0	11	1967	0	
33	0.	0.	0.	0.	0.					
34	0.	0.	0.	0.	0.					
35	17400.	16600.	12300.	9750.	940.	0	10	1967	0	
36	26600.	23000.	16000.	13200.	2200.	0	40	1967	0	
37	48200.	39100.	24400.	19000.	3920.	0	55	1967	3	1963
38	47600.	41600.	24400.	17400.	4320.	0	27	1967	3	1963
39	1150.	1090.	883.	756.	68.	0	7	1967	0	
40	2770.	2360.	1460.	1140.	278.	0	7	1967	0	

TABLE # 18
DISCHARGES WHICH ARE EXCEEDED A SPECIFIC PERCENT OF THE TIME

(ALL DISCHARGES IN CFS.)

SITE #	DISCHARGE EXCEEDED .5% OF TIME	DISCHARGE EXCEEDED 1% OF TIME	DISCHARGE EXCEEDED 5% OF TIME	DISCHARGE EXCEEDED 10% OF TIME	DISCHARGE EXCEEDED 50% OF TIME	EST. CODE	NO. YRS	LAST YEAR	U/S EFFECTS CODE	U/S EFFECTS BEGIN. YEAR
41	6660.	5190.	2730.	2000.	520.	0	41	1967		
42	1450.	1040.	484.	351.	89.	0	18	1967	0	
43	0.	0.	0.	0.	0.					
44	14500.	12030.	7290.	4530.	3.	0	5	1966	5	1963
45	1030.	667.	243.	132.	1.	0	8	1967	0	
46	0.	0.	0.	0.	0.					
47	0.	0.	0.	0.	0.					
48	5420.	4610.	2950.	2190.	411.	0	13	1967	0	
49	16600.	13500.	6120.	4170.	840.	0	51	1967	0	
50	22500.	19000.	6820.	4320.	930.	0	15	1967	0	
51	21900.	17300.	7800.	5280.	1330.	0	36	1967	1	1915
52	1200.	700.	358.	238.	23.	0	4	1967	0	
53	2230.	1800.	561.	372.	39.	0	6	1967	0	
54	3760.	2970.	959.	510.	16.	0	5	1967	0	
55	2610.	1770.	442.	197.	15.	0	12	1967	0	
56	899.	481.	66.	28.	0.	0	18	1967	0	
57	481.	359.	159.	104.	0.	0	15	1967	5	1915
58	52700.	43400.	25100.	18100.	2630.	0	52	1967	2	1915
59	0.	0.	0.	0.	0.					
60	8010.	7220.	4850.	3710.	515.	0	56	1967	0	
61	13200.	12300.	7900.	6200.	1120.	0	11	1922	0	
62	13600.	11800.	8000.	6090.	1490.	0	39	1967	3	1950
63	12500.	11200.	7620.	6050.	1800.	0	28	1967	3	1942
64	16800.	14505.	9440.	7100.	1790.	0	57	1967	3	1929
65	21400.	18800.	9920.	7680.	0.	0	11	1967	2	1915
66	32400.	26800.	13900.	9500.	1820.	0	16	1967	2	1915
67	1400.	1140.	726.	546.	59.	0	9	1920	0	
68	491.	446.	268.	185.	37.	0	8	1947	0	
69	0.	0.	0.	0.	0.					
70	2660.	2350.	1460.	997.	132.	0	56	1967	3	1950
71	3000.	2520.	1610.	1190.	207.	0	46	1962	0	
72	1570.	1210.	580.	424.	143.	0	46	1967	5	1942
73	2020.	1510.	440.	220.	0.	0	11	1919	0	
74	2250.	1720.	962.	701.	184.	0	18	1967	0	
75	0.	0.	0.	0.	0.					
76	0.	0.	0.	0.	0.					
77	3220.	2550.	1400.	1030.	110.	0	16	1967	0	
78	4600.	3820.	2550.	1640.	201.	0	51	1920	0	
79	4850.	4000.	2150.	1450.	157.	0	48	1967	0	
80	0.	0.	0.	0.	0.					

TABLE # 18
DISCHARGES WHICH ARE EXCEEDED A SPECIFIC PERCENT OF THE TIME

(ALL DISCHARGES IN CFS.)

SITE #	DISCHARGE EXCEEDED .5% OF TIME	DISCHARGE EXCEEDED 1% OF TIME	DISCHARGE EXCEEDED 5% OF TIME	DISCHARGE EXCEEDED 10% OF TIME	DISCHARGE EXCEEDED 50% OF TIME	EST. CODE	NO. YRS	LAST YEAR	U/S EFFECTS CODE	U/S EFFECTS BEGIN. YEAR
81	479.	337.	127.	63.	0.	0	30	1967	2	1966
82	1590.	1330.	724.	520.	77.	0	16	1967	0	
83	1810.	1640.	1061.	635.	114.	0	4	1916	0	
84	3500.	2710.	1210.	730.	102.	0	16	1967	0	
85	4110.	3340.	2000.	1450.	153.	0	16	1967	0	
86	4680.	3650.	2270.	1525.	177.	0	20	1949	0	
87	9800.	8000.	4500.	2900.	0.	1	20	1967	0	
88	12800.	10400.	5660.	3730.	187.	0	33	1948	2	1923
89	14000.	11500.	6990.	4640.	162.	0	18	1967	2	1923
90	27700.	21700.	12600.	8730.	665.	0	43	1967	2	1951
91	23700.	19200.	12000.	8700.	0.	1	16	1967	2	1951
92	1380.	1140.	694.	486.	79.	0	26	1967	0	
93	1460.	1220.	831.	625.	108.	0	21	1931	0	
94	5040.	4380.	2660.	1870.	135.	0	21	1967	0	
95	5080.	4580.	2770.	1920.	188.	0	21	1931	0	
96	679.	514.	207.	120.	7.	0	22	1967	0	
97	1580.	1190.	486.	299.	19.	0	23	1967	1	1966
98	3050.	1860.	660.	398.	0.	1	12	1967	1	1966
99	0.	0.	0.	0.	0.					
100	2010.	1740.	1180.	866.	115.	0	55	1967	2	1953
101	2390.	2010.	1310.	954.	92.	0	38	1967	2	1923
102	0.	0.	0.	0.	0.					
103	4810.	4320.	2850.	2020.	188.	0	37	1967	0	
104	6800.	5760.	3740.	2610.	250.	0	43	1967	2	1964
105	0.	0.	0.	0.	0.					
106	190.	171.	104.	66.	6.	0	29	1967	0	
107	5420.	4780.	2860.	2020.	307.	0	64	1967	1	1917
108	5670.	4510.	2560.	1590.	39.	0	52	1967	4	1951
109	732.	511.	238.	158.	10.	0	48	1967	0	
110	1730.	1310.	802.	715.	73.	0	57	1967	1	1917
111	0.	0.	0.	0.	0.					
112	56700.	46400.	28100.	19400.	0.	1	52	1967	2	1915
113	2310.	1950.	1380.	1150.	106.	0	11	1967	0	
114	0.	0.	0.	0.	0.					
115	1620.	1280.	540.	280.	9.	0	44	1967	0	
116	1260.	1010.	505.	322.	41.	0	12	1967	0	
117	4940.	3890.	2400.	1400.	80.	0	5	1967	0	
118	157.	126.	70.	44.	1.	0	12	1967	0	
119	305.	210.	25.	12.	0.	0	9	1967	0	
120	14000.	13000.	9100.	6450.	0.	1	8	1967	0	

TABLE #20

*** BASIC REACH DATA ***

(ALL LENGTHS IN FT.)

EXPLANATIONS:

1. LENGTH OF REACH
   THIS IS THE DISTANCE BETWEEN THE UPPERMOST AND LOWERMOST CROSS-SECTIONS USED TO COMPUTE THE AVERAGE HYDRAULIC GEOMETRY PROPERTIES.

2. LENGTH OF REACH BELOW GAUGE
   THIS IS THE DISTANCE BETWEEN THE HYDROMETRIC STATION (OR CROSS-SECTION AT THE GAUGE) TO THE LOWERMOST CROSS-SECTION IN THE REACH. IF THE HYDROMETRIC STATION IS ABOVE THE REACH, THIS DISTANCE WILL BE GT. THE LENGTH OF REACH. IF THE HYDROMETRIC STATION IS BELOW THE REACH,THE DISTANCE WILL BE NEGATIVE WITH AN ABSOLUTE VALUE EQUAL TO THE DISTANCE FROM THE LOWERMOST CROSS-SECTION TO THE HYDROMETRIC STATION.

3. CODE FOR METHOD OF MEASUREMENT OF DISTANCE
   0 NOT APPLICABLE
   1 TAPE
   2 STADIA
   3 SCALE FROM AERIAL PHOTOGRAPHS
   4 SCALE FROM MAPS

4. NUMBER OF CROSS-SECTIONS
   NUMBER OF CROSS-SECTIONS USED TO COMPUTE THE AVERAGE HYDRAULIC GEOMETRY PROPERTIES FOR THE REACH.

5. CODE FOR STABILITY OF RATING CURVE
   0 NOT APPLICABLE
   1 STABLE
   2 SLIGHTLY UNSTABLE
   3 MODERATLY UNSTABLE
   4 HIGHLY UNSTABLE

   THE CODE FOR STABILITY OF RATING CURVE WAS EVALUATED BY THE CALGARY OFFICE OF THE WATER SURVEY OF CANADA.

6. CODE FOR THE TYPE OF ENGINEERING WORKS IN AND CLOSE TO THE REACH
   0 NO ENGINEERING WORKS IN OR NEAR REACH
   1 OBSTRUCTION JUST U/S OF REACH
   2 OBSTRUCTION IN REACH (EG. A WEIR)
   3 OBSTRUCTION JUST D/S OF REACH
   4 SOME DYKING
   5 EXTENSIVE DYKING
   6 SOME BANK PROTECTION

TABLE #20 (CONTINUED)

7 EXTENSIVE BANK PROTECTION
8 SOME CONSTRICTIONS (LOCAL)
9 EXTENSIVE CONSTRICTIONS
10 BRIDGE, NOT AFFECTING RIVER SERIOUSLY
11 ARTIFICIAL STRAIGHTENING

7. YEAR THE ENGINEERING WORKS BECAME EFFECTIVE

CODES 6 AND 7 ARE MULTIPLE CODES. THE FIRST CODE INDICATES THE WORKS WHICH HAVE THE GREATEST EFFECT ON THE REACH. THE SECOND AND THIRD PAIRS OF CODES ARE OF DECREASING IMPORTANCE.

TABLE # 20
BASIC REACH DATA

(ALL LENGTHS IN FT.)

SITE #	LENGTH OF REACH	LENGTH BELOW GAUGE	METH. OF MEAS.	# X-SEC	STABIL. OF R.CURVE	ENGR. WORK	YEAR STRT	ENGR. WORK	YEAR STRT	ENGR. WORK	YEAR STRT	COMMENTS
1	64900.	77000.	4	5	2	0	0	0	0	0	0	
2	58100.	58100.	4	3	3	10	45	10	58	0	0	
3	12319.	5987.	2	6	1	10	56	0	0	0	0	
4	10890.	6905.	3	6	2	10	-1	10	65	0	0	
5	10611.	6256.	2	8	3	0	0	0	0	0	0	
6	35956.	14909.	2	8	3	0	0	0	0	0	0	
7	27065.	10100.	2	6	2	0	0	0	0	0	0	
8	25368.	11555.	3	8	2	10	-1	10	53	0	0	
9	15427.	8011.	3	9	1	10	64	0	0	0	0	
10	9750.	5116.	2	7	2	10	-1	0	0	0	0	
11	7473.	3689.	2	10	3	10	-1	0	0	0	0	
12	16009.	16009.	2	5	2	10	-1	10	-1	0	0	
13	17555.	6913.	2	7	1	0	0	0	0	0	0	
14	31360.	24740.	3	9	-1	10	-1	0	0	0	0	
15	17792.	14984.	2	7	1	10	51	0	0	0	0	
16	8783.	3125.	2	7	2	0	0	0	0	0	0	
17	34761.	31005.	2	7	-1	0	0	0	0	0	0	
18	4057.	2207.	2	7	2	10	-1	0	0	0	0	
19	10215.	5241.	2	7	2	10	-1	10	55	0	0	
20	12739.	7226.	2	7	1	0	0	0	0	0	0	
21	2862.	1475.	2	7	1	10	55	0	0	0	0	
22	6542.	4135.	2	8	3	10	-1	0	0	0	0	
23	9052.	3428.	3	10	1	10	-1	0	0	0	0	
24	8656.	3059.	2	9	2	10	-1	10	62	0	0	STRAIGHTENING U/S OF REACH
25	11710.	7890.	2	7	3	10	-1	11	-1	0	0	SOME STRAIGHTENING RECENTLY
26	2626.	1102.	2	8	3	10	-1	11	-1	0	0	
27	4367.	1815.	2	7	2	10	-1	10	-1	3	-1	
28	14158.	8222.	2	7	4	10	-1	0	0	0	0	
29	8385.	3945.	2	9	3	10	-1	4	-1	11	-1	RECENT STRAIGHTENING DOWNSTREAM
30	9931.	4732.	2	10	4	10	-1	10	-1	11	-1	
31	8114.	7153.	2	7	2	0	0	0	0	0	0	
32	8747.	1775.	2	8	2	10	62	0	0	0	0	
33	0.	0.										
34	3407.	3407.	2	3	-1	10	-1	0	0	0	0	
35	5285.	3615.	3	6	1	0	0	0	0	0	0	
36	26824.	16124.	3	8	3	10	-1	10	-1	0	0	
37	100000.	38600.	2	10	1	10	-1	10	-1	10	-1	
38	85035.	50221.	3	9	1	0	0	0	0	0	0	
39	3456.	254.	2	5	3	0	0	0	0	0	0	
40	12630.	9600.	1	10	3	10	-1	0	0	0	0	

TABLE # 20
BASIC REACH DATA

(ALL LENGTHS IN FT.)

SITE #	LENGTH OF REACH	LENGTH BELOW GAUGE	METH. OF MEAS.	# X-SEC	STABIL. OF R.CURVE	ENGR. WORK	YEAR STRT	ENGR. WORK	YEAR STRT	ENGR. WORK	YEAR STRT	COMMENTS
41	7452.	2135.	2	7	2	10	-1	0	0	0	0	
42	3705.	2005.	1	10	2	10	59	0	0	0	0	
43	5203.	2904.	2	8	-1	10	-1	0	0	0	0	
44	7808.	7190.	2	7	2	1	65	0	0	0	0	
45	4105.	2128.	2	8	4	10	-1	0	0	0	0	
46	0.	0.										
47	0.	0.										
48	1920.	1920.	1	4	3	0	0	0	0	0	0	
49	52650.	24376.	-1	10	2	10	-1	10	-1	0	0	
50	18055.	7557.	2	11	2	10	-1	10	-1	0	0	
51	130500.	5110.	4	10	4	10	-1	0	0	0	0	
52	2654.	854.	1	10	2	10	-1	0	0	0	0	
53	11151.	5064.	2	9	2	10	-1	0	0	0	0	
54	6375.	3147.	2	9	2	10	-1	0	0	0	0	
55	15317.	5724.	2	8	2	2	-1	10	-1	10	-1	SMALL WEIR AT OLD FORD
56	5603.	5603.	2	9	4	10	-1	10	-1	0	0	
57	4426.	2943.	2	8	3	10	-1	11	-1	0	0	
58	21758.	17667.	2	7	1	10	-1	10	-1	10	-1	
59	0.	0.										
60	15986.	0.	2	6	1	10	-1	6	-1	0	0	
61	3467.	0.	2	3	1	3	-1	10	-1	0	0	
62	4295.	4299.	2	4	1	1	-1	0	0	0	0	
63	9363.	4443.	2	7	2	1	-1	0	0	0	0	
64	12089.	4996.	2	8	2	10	-1	4	-1	6	-1	ALSO WEIR JUST BELOW REACH
65	8402.	5036.	2	6	3	1	-1	10	-1	0	0	
66	9152.	5162.	2	9	3	1	-1	0	0	0	0	
67	2352.	68.	2	5	3	10	-1	6	-1	10	-1	
68	2536.	1634.	2	6	3	10	-1	11	-1	0	0	
69	0.	0.										
70	5013.	1923.	2	7	1	10	-1	0	0	0	0	
71	5087.	2362.	2	8	1	1	-1	0	0	0	0	
72	9239.	6482.	2	7	4	3	-1	0	0	0	0	NOT AFFECTING REACH
73	1978.	466.	2	7	3	10	-1	0	0	0	0	
74	3008.	1006.	1	8	4	10	-1	0	0	0	0	
75	0.	0.										
76	0.	0.										
77	7000.	6106.	2	7	2	0	0	0	0	0	0	
78	8597.	6088.	2	9	2	10	-1	0	0	0	0	
79	5600.	3000.	1	9	2	10	56	0	0	0	0	
80	4583.	2144.	1	9	-1	10	-1	0	0	0	0	

TABLE # 20

BASIC REACH DATA

(ALL LENGTHS IN FT.)

SITE #	LENGTH OF REACH	LENGTH BELOW GAUGE	METH. OF MEAS.	# X-SEC	STABIL. OF R.CURVE	ENGR. WORK	YEAR STRT	ENGR. WORK	YEAR STRT	ENGR. WORK	YEAR STRT	COMMENTS
81	7275.	4521.	2	8	3	10	-1	0	0	0	0	
82	9450.	3986.	1	9	4	0	0	0	0	0	0	
83	12735.	1324.	2	9	4	10	-1	6	-1	0	0	
84	6740.	1665.	1	9	4	10	-1	0	0	0	0	
85	7089.	3369.	2	8	2	0	0	0	0	0	0	
86	4630.	1050.	2	5	2	0	0	0	0	0	0	
87	7716.	4241.	2	8	2	10	54	0	0	0	0	
88	9000.	5000.	1	10	3	10	-1	10	-1	0	0	
89	8300.	-13230.	3	10	2	0	0	0	0	0	0	
90	25169.	6521.	3	8	1	10	-1	2	-1	4	-1	ALL HAVE MINOR AFFECT ON GEOMET.
91	9754.	5110.	2	8	1	0	0	0	0	0	0	
92	5103.	2560.	2	6	2	10	-1	0	0	0	0	
93	7961.	4445.	2	8	1	10	-1	0	0	0	0	
94	9200.	-8351.	1	10	2	0	0	0	0	0	0	
95	10150.	4200.	2	7	2	10	-1	0	0	0	0	
96	7219.	5360.	2	7	3	10	-1	10	-1	10	-1	
97	5000.	2060.	1	10	2	10	-1	0	0	0	0	
98	10626.	6560.	2	8	3	10	-1	10	57	0	0	
99	0.	0.										
100	4800.	16133.	1	10	2	10	-1	10	56	0	0	
101	4500.	-4396.	1	10	3	10	-1	4	-1	0	0	POSSIBLY STRAIGHTENED AT BRIDGE
102	0.	0.										
103	6193.	6193.	2	6	1	10	-1	0	0	0	0	
104	9000.	8200.	1	10	2	10	-1	0	0	0	0	
105	0.	0.										
106	2640.	-5559.	1	7	4	10	-1	3	-1	0	0	
107	12252.	5700.	2	7	1	0	0	0	0	0	0	
108	9427.	5399.	2	9	2	0	0	0	0	0	0	
109	4500.	-1740.	1	10	4	10	-1	0	0	0	0	
110	4920.	2529.	3	9	3	10	-1	10	-1	11	-1	RIVER STRAIGHTENED AT U/S REACH
111	2433.	1895.	2	5	3							
112	17104.	3069.	3	6	1	0	0	0	0	0	0	
113	9029.	2767.	2	6	1	10	-1	0	0	0	0	
114	0.	0.										
115	1940.	1000.	1	9	3	10	-1	0	0	0	0	
116	4491.	2314.	2	10	2	10	-1	11	-1	0	0	LOCAL STRAIGHTENING AT BRIDGE
117	5718.	1592.	2	5	3	0	0	0	0	0	0	
118	2947.	1381.	1	9	4	10	-1	11	69	0	0	STRAIGHTENING EFFECT IMPORTANT
119	4597.	2378.	1	9	2	10	-1	0	0	0	0	
120	7740.	3710.	2	6	3	0	0	0	0	0	0	

TABLE #22

*** REPRESENTATIVENESS OF REACH ***

EXPLANATIONS:

1. CODE FOR REPRESENTATIVENESS OF REACH
   - 0 NOT REPRESENTATIVE
   - 1 REPRESENTATIVE
   - 2 QUITE REPRESENTATIVE
   - 3 QUESTIONABLE

   THIS CODE IS APPLIED TO THE REACH AND SOME DISTANCE BOTH U/S AND D/S FROM THE REACH. REASONS ARE GIVEN IF THE REACH IS NOT REPRESENTATIVE.

2. CODE FOR CONFLUENCES
   - 0 NO CONFLUENCE IN OR NEAR REACH
   - 1 CONFLUENCE JUST U/S OF REACH
   - 2 CONFLUENCE IN REACH
   - 3 CONFLUENCE JUST D/S OF REACH

   ONLY SIGNIFICANT CONFLUENCES ARE CONSIDERED.

3. COMMENTS

   THE COMMENTS GIVE A REASON FOR THE UNREPRESENTATIVENESS OF THE REACH, OR THE NAME OF THE CONFLUENCE IN OR NEAR THE REACH, OR SIMPLY SOME INFORMATION RELATED TO THE REACH.

TABLE # 22
REPRESENTATIVENESS OF REACH

SITE #	REPRES. CODE	CONF. CODE	COMMENTS
1	1	0	
2	1	0	
3	1	0	TWO SMALL STREAMS ENTER IN REACH
4	1	1	SMOKY RIVER CONFLUENCE
5	1	0	
6	1	0	
7	1	0	
8	1	1	LITTLE SMOKY CONFLUENCE
9	1	0	
10	1	0	
11	1	0	
12	2	1	MIETTE CONFLUENCE: NOT REPRESENTATIVE OF CHANNEL ABOVE REACH
13	1	0	VERY STRAIGHT REACH; PERHAPS CONTROLLED BY GEOLOGY
14	0	2	MCLEOD CONFLUENCE: LOCAL GRAVEL STORAGE AT CONFLUENCE
15	1	0	
16	1	1	CLEARWATER CONFLUENCE
17	2	0	PATTERN IN REACH SOMEWHAT DIFFERENT THAN OUTSIDE OF REACH
18	1	0	
19	2	0	MAJOR RAPIDS IN REACH
20	1	1	WOLF CREEK CONFLUENCE
21	1	0	
22	2	0	GEOMETRY HIGHLY VARIABLE IN REACH
23	1	0	
24	1	0	
25	1	0	AN ATYPICAL GRAVEL RAPID NEAR GAUGE
26	1	0	
27	3	0	BEAVER DAMS IN REACH; LARGE CULVERT AT D/S END OF REACH
28	1	0	
29	1	0	
30	2	0	MEANDERS MORE TORTUOUS U/S; SWAMP D/S
31	1	0	
32	1	0	AN ATYPICAL GRAVEL BAR AT U/S END OF REACH
33	0	0	NO SURVEY
34	0	2	MISTAYA CONFLUENCE; SUDDEN VARIATION IN VALLEY
35	1	0	
36	1	1	CLEARWATER CONFLUENCE
37	1	0	
38	1	0	
39	3	0	MAINLY IN OLD LAKE BED; NOT REPRESENTATIVE OF CHANNEL D/S REACH
40	1	0	

TABLE # 22
REPRESENTATIVENESS OF REACH

SITE #	REPRES. CODE	CONF. CODE	COMMENTS
81	1	0	
82	3	0	SOME OF THE SURVEY DATA IN QUESTION
83	1	0	
84	1	0	
85	1	0	
86	1	3	CROWNEST CONFLUENCE
87	2	3	PINCHER CREEK CONFLUENCE. PATTERN MORE SINUOUS AT D/S END OF RCH
88	2	0	PATTERN MORE SINUOUS AND LESS CONFINED D/S OF REACH
89	2	0	REACH AT BEND. CHANNEL IS STRAIGHTER U/S AND D/S OF REACH
90	1	0	ST. MARY CONFLUENCE ABOUT 5 MILES U/S OF REACH
91	1	0	
92	1	0	LARGE ROCK SLIDE JUST D/S OF REACH
93	1	0	
94	2	0	MORE CONFINED U/S AND D/S OF REACH
95	1	0	
96	1	0	MORE ENTRENCHED U/S OF REACH
97	1	0	
98	1	0	
99	0	0	NO SURVEY
100	1	0	SOME DIVERSION FROM CHANNEL U/S OF REACH
101	2	0	STRAIGHTER THAN SECTIONS U/S OR D/S OF REACH
102	0	0	NO SURVEY
103	1	0	
104	2	0	LESS SINUCUS THAN U/S OF REACH
105	0	0	NO SURVEY
106	2	0	GEOMETRY HIGHLY VARIABLE IN REACH
107	1	0	
108	1	0	
109	1	0	
110	1	0	
111	0	3	HELL'S CREEK CONFLUENCE; POOR HYDRCLOGY
112	1	0	
113	1	3	PIPESTONE CONFLUENCE
114	0	0	NO SURVEY
115	2	0	STRAIGHTER THAN SECTIONS U/S OR D/S OF REACH
116	1	0	
117	2	0	STRAIGHTER THAN SECTIONS U/S OR D/S OF REACH
118	3	0	GREAT ADJUSTMENT DUE TO RECENT STRAIGHTENING
119	1	0	
120	1	3	CHRISTINA CONFLUENCE

TABLE # 22
REPRESENTATIVENESS OF REACH

SITE #	REPRES. CODE	CONF. CODE	COMMENTS
41	1	0	
42	1	0	
43	C	0	POOR HYDROLOGY
44	1	0	LARGE POWERHOUSE AND DAM U/S OF REACH; REACH HIGHLY CONTROLLED
45	1	0	
46	0	0	SEVERAL WEIRS IN REACH; CHARACTER OF CHANNEL CHANGES RAPIDLY
47	C	0	NO SURVEY
48	2	0	PORTION OF RIVER D/S FROM REACH NOT REPRESENTATIVE
49	1	0	
50	1	0	
51	1	0	
52	2	0	ALL CROSS-SECTIONS IN A STRAIGHT REACH
53	1	0	
54	1	C	A SMALL ATYPICAL GRAVEL RAPID NEAR U/S END OF REACH
55	3	0	REACH AT HEAD OF STEEP PART OF RIVER;JOINS RED DEER D/S OF REACH
56	1	0	
57	1	1	IRRIGATION RETURN FLOW; RETURN FLOW QUITE APPRECIABLE
58	1	0	
59	C	0	NO SURVEY
60	2	0	ONLY REPRESENTATIVE OF REACH; REACH IN OLD LAKE BED
61	3	3	REACH IN BACKWATER OF DAM; KANANASKIS CONFLUENCE
62	1	0	REPRESENTATIVE OF REACH IN GORGE
63	1	C	
64	1	3	ELBOW CONFLUENCE
65	2	0	CHANNEL IS SPLIT D/S FROM REACH; LARGE WEIR JUST U/S OF REACH
66	1	0	
67	2	0	ONLY REPRESENTATIVE OF REACH; GORGE U/S OF REACH; REACH ON FAN.
68	3	0	CHARACTER OF RIVER CHANGES IN REACH; REACH ON FAN.
69	0	0	NO SURVEY
70	3	3	BOW CONFLUENCE
71	2	C	REPRESENTATIVE FOR SHORT DISTANCE
72	3	0	REPRESENTATIVE FOR SHORT DISTANCE
73	2	0	MORE SINUOUS U/S AND D/S
74	2	C	MORE UNSTABLE U/S AND D/S
75	0	0	NO SURVEY
76	0	0	NO SURVEY
77	1	0	
78	1	0	
79	1	0	
80	C	0	POOR HYDROLOGY; OLD STATION NOT OPERATIVE

TABLE #23

*** SLOPE FCR REACH ***

(ALL SLCPES IN FT/FT. AND ALL LENGTHS IN FT.)

EXPLANATIONS:

1. AVERAGE FIELD SLOPE IS THE SLOPE OF AVERAGE LINE THROUGH THE WATER SURFACE PROFILE CN THE DAY OF SURVEY. IF ADJUSTMENTS WERE MADE DUE TC LCCAL FEATURES SUCH AS A BEAVER DAM, A NOTE IS PRCVIDED. (THE ACTUAL CATE OF THE SURVEY OF THE PROFILE MAY DIFFER BY 1 OR 2 DAYS FROM THE DATE OF THE SURVEY OF THE CROSS-SECTICNS AS GIVEN IN TABLE #27)

2. LENGTH USED TO DETERMINE FIELD SLOPE
   THIS IS THE SAME AS THE LENGTH OF THE REACH UNLESS SOME ADJUSTMENT WAS MADE IN CRDER TO CBTAIN A BETTER MEASURE OF SLOPE. A NOTE IS GIVEN FOR CASES WHERE THIS LENGTH DIFFERS FROM THE LENGTH OF THE REACH.

3. CODE FCR METHOD OF MEASUREMENT OF HORIZONTAL DISTANCE FOR FIELD SLOPE
   - 0 NO FIELD SLCPE
   - 1 TAPE
   - 2 STADIA
   - 3 SCALED FROM AERIAL PHCTOGRAPHS
   - 4 SCALED FRCM MAPS

   ALL VERTICAL MEASUREMENTS OBTAINED BY FIELD LEVELING

4. CODE FOR SHAPE OF WATER SURFACE PROFILE
   - 0 NCT APPLICABLE
   - 1 CLOSE FIT TO AVERAGE
   - 2 SCME RELATIVELY SMALL DEVIATIONS ABOVE AND BELOW AVERAGE (E.G. POOL AND RIFFLE SEQUENCES)
   - 3 ACCEPTABLE DEVIATION(S) FROM AVERAGE BUT NOT OF TYPE 1 OR 2
   - 4 UNACCEPTABLE DEVIATION(S) FROM AVERAGE.

5. RELATIVE CEVIATION IN PERCENT
   THIS PARAMETER IS DEFINED AS THE MAXIMUM DEVIATION OF THE WATER SURFACE PROFILE FROM THE AVERAGE SLOPE LINE DIVIDED BY THE FALL OF THE AVERAGE SLOPE LINE OVER THE SLOPE LENGTH.

6. CODE FOR SLCPE ADJUSTMENT
   - 0 NO REASCN FOR ADJUSTMENT
   - 1 MAJOR RAPID (CR LOCAL FALL) IN ORIGINAL SURVEYED REACH, RAPID CMITTED WHEN DETERMINING SLOPE.
   - 2 OBSTRUCTION IN REACH (EG. BEAVER DAM).SLOPE ADJUSTED
   - 3 BACKWATER (EG. REACH NEAR UPPER END OF RESERVOIR), NO SLOPE ADJUSTMENT

TABLE #23 (CONTINUED)

4 MAJOR CONFLUENCE IN CR NEAR REACH, NO SLOPE ADJUSTMENT
5 QUESTIONABLE VARIATION IN SLOPE, NO SLOPE ADJUSTMENT.

THIS CODE INDICATES THE SLOPE ADJUSTMENTS ACTUALLY MADE AND ALSO INDICATES THOSE CASES WHERE SLOPE IS NOT CONSIDERED TO BE TYPICAL BUT FOR WHICH NO ADJUSTMENTS WERE MADE.

7. TOPOGRAPHIC SLOPE
THIS SLOPE IS DETERMINED FROM TOPOGRAPHIC MAPS BY USING THE TWO (OR THREE) CONTOURS NEAREST THE REACH.

8. MAP SCALE
THIS IS THE MULTIPLYING FACTOR OF THE MAP. (E.G. 1: 50,000 HAS A MULTIPLYING FACTOR OF 50,000)

TABLE # 23
SLOPE FOR REACH

(ALL SLOPES IN FT./FT. AND ALL LENGTHS IN FT.)

SITE #	AVG.FIELD SLOPE	LENGTH USED	DISTANCE MEASURE CODE	SHAPE CODE	RELAT. DEV.	ADJUST. CODE	TOPOGRAPHIC SLOPE	MAP SCALE	COMMENTS
1	0.0007400	77000.	4	1	10.	0	0.0005800	50000.	
2	0.0006900	58000.	4	-1	-1.	0	0.0005900	50000.	
3	0.0002200	12319.	2	3	36.	0	0.0002500	50000.	
4	0.0	0.		-1	-1.	-1	0.0002500	50000.	
5	0.0000740	10611.	2	2	24.	0	0.0000940	50000.	
6	0.0000410	35995.	2	2	28.	0	0.0000940	50000.	
7	0.0000740	27065.	2	1	16.	0	0.0001000	250000.	
8	0.0	0.		-1	-1.	-1	0.0005200	50000.	
9	0.0	0.		-1	-1.	-1	0.0005100	50000.	
10	0.0009400	8750.	2	2	40.	0	0.0011000	50000.	
11	0.0014000	7473.	2	2	26.	0	0.0012000	50000.	
12	0.0030000	13504.	2	1	13.	0	0.0015000	50000.	
13	0.0009200	17999.	2	1	6.	0	0.0010000	50000.	
14	0.0	0.		-1	-1.	-1	0.0012000	50000.	
15	0.0002900	17796.	2	2	10.	0	0.0002400	50000.	
16	0.0002300	8793.	2	2	22.	0	0.0001100	50000.	
17	0.0000900	36090.	2	1	13.	0	0.0001800	50000.	
18	0.0054000	4057.	2	2	16.	0	0.0049000	50000.	
19	0.0012000	10215.	2	2	23.	0	0.0009700	50000.	
20	0.0008400	12739.	2	1	14.	0	0.0010000	50000.	
21	0.0005500	2862.	2	3	25.	0	0.0012000	50000.	
22	0.0033000	6542.	2	1	12.	0	0.0033000	50000.	
23	0.0	0.		-1	-1.	-1	0.0003300	50000.	
24	0.0018000	8696.	2	2	17.	0	0.0020000	50000.	
25	0.0001100	9873.	2	3	35.	1	0.0002200	50000.	
26	0.0039000	2626.	2	1	11.	0	0.0027000	50000.	
27	0.0020000	5855.	2	2	32.	0	0.0020000	50000.	
28	0.0001100	14158.	2	3	24.	0	0.0002200	50000.	
29	0.0005000	8385.	2	1	12.	0	0.0006900	50000.	
30	0.0005000	9831.	2	1	15.	0	0.0005800	50000.	
31	0.0002000	8114.	2	2	22.	0	0.0004100	50000.	
32	0.0002100	8108.	2	1	15.	1	0.0002800	50000.	
33	0.0	0.			0.		0.0	0.	
34	0.0	0.			0.		0.0	0.	
35	0.0	0.		-1	-1.	-1	0.0026000	50000.	
36	0.0	0.		-1	-1.	-1	0.0025000	50000.	
37	0.0003500	100000.	2	1	8.	0	0.0003500	50000.	
38	0.0	0.		-1	-1.	-1	0.0001900	50000.	
39	0.0002300	3125.	2	2	35.	0	0.0	0.	IN LOCAL FLAT (LAKE)
40	0.0057000	12430.	1	1	5.	0	0.0061000	50000.	

TABLE # 23
SLOPE FOR REACH

(ALL SLOPES IN FT./FT. AND ALL LENGTHS IN FT.)

SITE #	AVG.FIELD SLOPE	LENGTH USED	DISTANCE MEASURE CODE	SHAPE CODE	RELAT. DEV.	ADJUST. CODE	TOPOGRAPHIC SLOPE	MAP SCALE	COMMENTS
41	0.0012000	7452.	2	2	14.	0	0.0010000	50000.	
42	0.0036000	3705.	1	3	27.	0	0.0030000	50000.	
43	0.0	0.			0.		0.0	0.	
44	0.0009900	7808.	2	1	12.	0	0.0015000	50000.	
45	0.0003700	4105.	2	2	18.	0	0.0003600	50000.	
46	0.0	0.			0.		0.0	0.	
47	0.0	0.			0.		0.0	0.	
48	0.0049000	1920.	1	1	9.	0	0.0057000	50000.	
49	0.0012000	52650.	1	1	6.	0	0.0013000	50000.	
50	0.0003500	18055.	2	2	16.	0	0.0003700	50000.	
51	0.0003000	90816.	4	-1	-1.	-1	0.0003300	50000.	
52	0.0036000	2375.	1	3	21.	0	0.0040000	50000.	
53	0.0021000	11151.	2	2	12.	0	0.0016000	50000.	
54	0.0005100	6375.	2	3	48.	0	0.0003800	50000.	
55	0.0008700	15317.	2	3	50.	0	0.0007900	50000.	
56	0.0018000	5603.	2	2	23.	0	0.0019000	50000.	
57	0.0012000	4426.	2	3	28.	0	0.0014000	50000.	
58	0.0004100	21758.	2	3	34.	0	0.0007100	50000.	
59	0.0	0.			0.		0.0	0.	
60	0.0001300	15936.	2	1	21.		0.0	0.	IN LOCAL FLAT (LAKE)
61	0.0018000	3467.	2	3	27.	3	0.0009900	50000.	
62	0.0040000	4299.	2	1	8.	0	0.0078000	50000.	
63	0.0029000	9363.	2	2	9.	0	0.0020000	50000.	
64	0.0018000	17089.	2	1	11.	0	0.0022000	50000.	
65	0.0012000	8402.	2	1	9.	0	0.0017000	250000.	
66	0.0098100	9152.	2	2	29.	0	0.0008000	250000.	
67	0.0150000	2352.	2	1	9.	0	0.0160000	50000.	
68	0.0190000	2536.	2	2	14.	0	0.0	0.	ON LOCAL FAN
69	0.0	0.			0.		0.0	0.	
70	0.0068000	5013.	2	1	6.	0	0.0120000	50000.	
71	0.0058000	5087.	2	1	12.	0	0.0054000	50000.	
72	0.0064000	9239.	2	1	7.	0	0.0032000	50000.	
73	0.0025000	3426.	2	2	30.	0	0.0032000	50000.	
74	0.0077000	2808.	1	1	11.	0	0.0072000	50000.	
75	0.0	0.			0.		0.0	0.	
76	0.0	0.			0.		0.0	0.	
77	0.0059000	7000.	2	2	30.	0	0.0030000	50000.	
78	0.0042000	8597.	2	2	14.	0	0.0042000	50000.	
79	0.0016000	5600.	1	2	19.	0	0.0017000	250000.	
80	0.0	0.			0.		0.0	0.	

TABLE # 23
SLOPE FOR REACH

(ALL SLOPES IN FT./FT. AND ALL LENGTHS IN FT.)

SITE #	AVG.FIELD SLOPE	LENGTH USED	DISTANCE MEASURE CODE	SHAPE CODE	RELAT. DEV.	ADJUST. CODE	TOPOGRAPHIC SLOPE	MAP SCALE	COMMENTS
81	C.CC43000	7275.	2	2	9.	0	C.0041000	50000.	
82	0.0063000	9450.	1	1	7.	0	0.0059000	50000.	
83	C.0059000	12735.	2	1	8.	0	0.0038C00	50000.	
84	C.CC38C00	6740.	1	1	6.	0	C.C050000	50000.	
85	C.0039C0C	7C89.	2	2	15.	0	C.0050000	50000.	
86	C.0C46000	4632.	2	2	20.	4	C.0041000	50000.	
87	C.C016000	7716.	2	2	35.	0	C.0018000	50000.	
88	C.C017000	10000.	1	2	12.	0	0.0014000	50000.	
89	C.0012C00	13100.	1	2	16.	0	0.0010000	50000.	
90	C.0	0.		-1	-1.	0	0.C009400	50000.	
91	0.0004400	7000.	2	2	22.	1	0.0006200	50000.	
92	C.0024000	5103.	2	2	19.	0	0.0027000	50000.	
93	C.0032000	7561.	2	1	11.	0	0.0049000	50000.	
94	0.0032000	14500.	1	1	7.	0	0.C043000	50000.	
95	C.0037100	10150.	2	1	9.	0	0.0030000	50000.	
96	C.0067000	7219.	2	1	5.	0	0.CC73000	50000.	
97	C.0008000	5000.	1	2	21.	0	C.C009200	50000.	
98	C.CC0790C	10626.	2	3	46.	0	0.C009100	50000.	
99	C.C	0.			0.		0.0	0.	
100	C.0065000	5000.	1	2	10.	0	0.C080000	50000.	
101	C.0019000	5000.	1	3	16.	0	0.0015000	50000.	
102	C.C	0.			0.		0.0	0.	
103	C.0015000	5873.	2	3	35.	0	0.C021000	50000.	
104	0.0025000	28500.	1	1	4.	0	0.C019000	50000.	
105	C.C	0.			0.		0.0	0.	
106	C.C11C000	3540.	1	2	12.	0	0.0120000	50000.	
107	0.0041C0C	12252.	2	1	7.	0	0.C047000	50000.	
108	C.CC2C000	9427.	2	2	16.	0	0.C020000	50000.	
109	C.0051030	4590.	1	1	12.	0	0.C045000	50000.	
110	C.0	0.		-1	-1.	-1	0.C005900	5000.	
111	C.C011000	2443.	2	1	18.	1	0.C023000	50000.	
112	0.0	0.		-1	-1.	-1	0.C003600	50000.	
113	C.0035000	9029.	2	1	8.	0	0.CC48000	50000.	
114	C.C	0.			0.		0.0	0.	
115	0.001C000	1940.	1	3	42.	0	0.0017000	50000.	
116	C.0C14C00	4491.	2	2	19.	0	0.C007200	50000.	
117	C.CC02000	5718.	2	2	12.	0	0.C003200	50000.	
118	C.0CC4600	2947.	1	1	13.	0	0.0	0.	CHANNEL STRAIGHTENED
119	0.0005100	4597.	1	2	26.	0	0.C009300	50000.	
120	C.0005800	7740.	2	2	24.	0	0.0004400	250000.	

TABLE #27

*** HYCRAULIC GECMETRY FCR DATE OF SURVEY ***

(ALL DISCHARGES IN CFS. ; DISTANCES IN FT.)

EXPLANATICNS:

1. RETURN PERIOD IN YEARS
   THIS IS ONLY GIVEN IF THE DISCHARGE ON THE DATE OF THE SURVEY OF THE CROSS-SECTIONS IS GE. THE DISCHARGE HAVING A RETURN PERIOD OF TWO YEARS.

2. DISCHARGE ON DATE OF SURVEY
   THIS DISCHARGE CORRESPCNDS TO THE STAGE ON THE DATE OF SURVEY GIVEN IN THIS TABLE

3. AVERAGE CROSS-SECTICNAL AREA
   THIS IS THE AVERAGE WATER AREA CORRESPONDING TO THE STATED DISCHARGE. THE NUMBER CF CROSS-SECTIONS USED FOR THE COMPUTATION IS GIVEN IN THIS TABLE.

4. COEFFICIENT OF VARIATION OF THE CROSS-SECTIONAL AREAS
   THIS IS DEFINED AS THE STANDARD DEVIATION OF THE AREAS DIVIDED BY THE AVERAGE AREA AND EXPRESSED AS A PERCENTAGE. THE COMPUTED STANCARD DEVIATICN IS BASED ON N-1 DEGREES OF FREEDOM, WHERE N IS THE NUMBER OF CROSS-SECTIONS IN THE REACH.

5. AVERAGE WATER SURFACE WICTH
   NOTES FOR AVERAGE CROSS-SECTIONAL AREA APPLY.

6. COEFFICIENT OF VARIATION CF THE WATER SURFACE WIDTHS
   NOTES FOR COEFFICIENT OF VARIATION OF THE CROSS-SECTIONAL AREAS APPLY.

7. NUMBER OF CROSS-SECTIONS
   THIS IS THE NUMBER OF CROSS-SECTIONS USED TO COMPUTE THE AVERAGE HYCRAULIC GECMETRY FOR THE REACH.

8. CODE FOR AGENCY WHICH SURVEYED REACH
   0 NC SURVEY
   1 HIGHWAY AND RIVER ENGINEERING DIVISION, RESEARCH COUNCIL OF ALBERTA
   2 HYCROLOGY BRANCH, WATER RESOURCES DIVISION, ALBERTA DEPARTMENT OF AGRICULTURE
   3 DEPARTMENT OF CIVIL ENGINEERING, UNIVERSITY OF ALBERTA
   4 WATER SURVEY CF CANADA
   5 CCNSULTING ENGINEERING FIRM

9. CODE FOR TYPE OF SURVEY FCR CROSS-SECTIONS

TABLE #27 (CONTINUED)

0 NC SURVEY
1 FIELC SURVEY TO VALLEY FLAT AND/OR TO AN ELEVATION ABOVE EXTREME HIGH WATER
2 SCUNDING FOR PORTION CF CHANNEL BELCW WATER WITH LIMITED FIELD NOTES FOR PCRTICN ABCVE WATER SURFACE AND/OR PHOTOGRAMMETRIC PLOTS OF VALLEY CROSS-SECTION.
3 SCUNDING ONLY. GECMETRY FOR MODERATE TO HIGH FLOWS QUESTIONABLE
4 FIELD SURVEY BUT NOT TO VALLEY FLAT, GEOMETRY FOR HIGH FLOWS QUESTICNABLE.

10. RATING CURVE NUMBER
THIS IS THE NUMBER OF THE RATING CURVE WHICH WAS USED BY THE WATER SURVEY CF CANADA FOR THE DATE OF SURVEY. SOME OF THE INOPERATIVE STATIONS DC NOT HAVE A NUMBER ASSOCIATED WITH THE APPROPRIATE RATING CURVE.

11. DATE CF RATING CURVE
THIS IS THE CATE OF APPROVAL OF THE RATING CURVE. IF THE DAY AND THE MCNTH ARE UNKNCWN, THE FXACT DATE OF APPROVAL IS NOT KNOWN.

12. STAGE ON DATE OF SURVEY
THIS IS THE STAGE USED FOR THE DATE OF SURVEY OF THE CROSS-SECTIONS.

13. CODE FOR ESTIMATING STAGE (OR DISCHARGE) FCR INOPERATIVE STATIONS
0 STATION OPERATING AT DATE OF SURVEY
1 DISCHARGE ESTIMATED BY USING U/S AND/OR D/S OPERATING STATIONS. THE LAST RATING CURVE FOR THE INOPERATIVE STATION WAS CONSIDERED TO BE VALID FOR CCMPUTATICN OF THE HYDRAULIC GEOMETRY.
2 ONE OR TWO DISCHARGE AND STAGE MEASUREMENTS WERE MADE AFTER THE STATION BECAME INOPERATIVE. THESE DATA WERE USED IN CONJUNCTION WITH THE LAST RATING CURVE CONSIDERED TO BE VALID FOR THE INOPERATIVE STATION.
3 DISCHARGE ESTIMATED BY USING THE GAUGE ZERO FOR THE INOPERATIVE STATION AND ASSUMING THAT THE LAST RATING CURVE FOR THE INOPERATIVE STATICN IS VALID.

TABLE # 27
HYDRAULIC GEOMETRY FOR DATE OF SURVEY

(ALL DISCHARGES IN CFS.;DISTANCES IN FT.)

SITE #	R.P. IF> 2 YR	DISCHARGE AT SURVEY	X-SEC. AREA	COEF. OF VAR.%	WATER SURF. WIDTH	COEF. OF VAR.%	# X-SEC	DATE OF SURV. DAY	MON.	YEAR	SURV. BY	TYPE OF SUR.	RATING CURVE #	DATE OF R.CURVE DAY	MON.	YEAR	STAGE	EST. CODE
41	0.0	1690.	621.	18.	177.	17.	7	13	8	1966	1	1	10	15	11	1965	3.70	0
42	0.0	144.	88.	34.	70.	18.	10	22	6	1966	2	4	6	-1	-1	1966	1.48	0
43	0.0	3200.	0.	0.	0.	0.	8	20	8	1969	1	1	-1	23	3	1965	2.92	3
44	0.0	5350.	1156.	18.	296.	27.	7	19	8	1969	1	1	3	25	3	1969	5.43	0
45	0.0	12.	54.	31.	34.	14.	8	4	6	1968	1	1	3	23	12	1966	3.07	0
46	0.0	0.	0.	0.	0.	0.	-1	9	8	1966	1	2					0.0	
47	0.0	0.	0.	0.	0.	0.											0.0	
48	0.0	640.	246.	21.	152.	18.	4	22	9	1961	2	1	-1	-1	-1	1962	1.60	0
49	0.0	1140.	538.	40.	279.	28.	10	1	9	1961	2	4	-1	-1	-1	1960	4.40	0
50	0.0	2930.	1200.	13.	332.	11.	11	9	6	1968	1	1	4	18	9	1964	3.86	0
51	0.0	2500.	1580.	23.	562.	24.	10	-1	-1	1963	1	1	3	25	9	1964	5.78	0
52	0.0	339.	137.	14.	79.	18.	10	12	6	1966	2	1	4	15	11	1966	4.70	0
53	0.0	296.	153.	29.	101.	30.	9	10	8	1966	1	1	3	27	7	1965	3.45	0
54	0.0	222.	110.	40.	55.	18.	9	13	8	1966	1	1	4	29	12	1965	5.27	0
55	0.0	131.	165.	32.	74.	21.	8	10	8	1966	1	1	2	1	12	1965	2.00	0
56	0.0	3.	22.	97.	23.	36.	9	5	6	1968	1	1	8	16	10	1967	1.67	0
57	0.0	179.	117.	30.	45.	26.	8	9	6	1968	1	1	7	10	12	1966	2.44	0
58	0.0	15900.	4470.	13.	635.	24.	9	1	6	1968	1	1	6	15	11	1967	11.30	0
59	0.0	0.	0.	0.	0.	0.											0.0	
60	0.0	5600.	2163.	32.	253.	17.	6	10	6	1969	1	1	9	6	5	1968	9.96	0
61	0.0	2800.	1319.	24.	533.	15.	3	24	6	1969	1	1	-1	-1	-1	1922	2.70	-1
62	0.0	3250.	665.	25.	219.	34.	4	23	5	1969	1	1	5	5	12	1968	5.00	0
63	0.0	6000.	1112.	7.	321.	9.	7	20	5	1969	1	1	3	3	12	1968	4.50	0
64	0.0	5000.	1268.	37.	360.	23.	8	5	5	1969	1	1	6	24	10	1966	4.70	0
65	0.0	9500.	2052.	8.	507.	13.	6	12	5	1969	1	1	5	24	11	1967	4.62	0
66	0.0	6100.	2008.	17.	477.	13.	9	9	5	1969	1	1	2	14	9	1967	5.80	0
67	0.0	700.	149.	24.	75.	33.	5	17	6	1969	1	1	-1	-1	-1	1920	6.00	-1
68	0.0	30.	64.	61.	49.	51.	6	11	6	1969	1	1	-1	-1	-1	1948	1.36	3
69	0.0	0.	0.	0.	0.	0.											0.0	
70	0.0	240.	69.	14.	54.	32.	7	28	5	1969	1	1	6	16	9	1968	3.84	0
71	0.0	34.	46.	38.	59.	30.	8	26	8	1969	1	1	2	4	4	1968	0.43	0
72	0.0	345.	117.	8.	81.	18.	7	14	5	1969	1	1	10	27	11	1968	1.91	0
73	0.0	10.	70.	44.	50.	22.	7	27	8	1969	1	1	-1	-1	-1	1915	1.50	-1
74	0.0	410.	152.	28.	89.	32.	8	10	8	1967	1	1	10	-1	-1	1967	3.67	0
75	0.0	0.	0.	0.	0.	0.											0.0	
76	0.0	0.	0.	0.	0.	0.											0.0	
77	0.0	260.	96.	19.	81.	30.	7	1	9	1969	1	1	7	21	12	1967	1.95	0
78	0.0	240.	109.	27.	97.	29.	9	31	3	1969	1	1	-1	-1	-1	1919	1.30	1
79	0.0	594.	337.	27.	168.	27.	9	21	7	1966	2	4	5	21	9	1965	4.35	0
80	0.0	10.	0.	0.	0.	0.	9	29	8	1969	1	1	-1	-1	-1	1931	1.40	-1

TABLE # 27

HYDRAULIC GEOMETRY FOR DATE OF SURVEY

(ALL DISCHARGES IN CFS.;DISTANCES IN FT.)

SITE #	R.P. IF> 2 YR	DISCHARGE AT SURVEY	X-SEC. AREA	COEF. OF VAR.%	WATER SURF. WIDTH	COEF. OF VAR.%	# X-SEC	DATE OF SURV. DAY	MON.	YEAR	SURV. BY	TYPE OF SUR.	RATING CURVE #	DATE OF R.CURVE DAY	MON.	YEAR	STAGE	EST. CODE
1	0.0	28000.	6561.	28.	580.	9.	5	-1	5	1968	5	1	3	28	4	1968	13.41	0
2	0.0	29000.	14957.	40.	1700.	34.	3	-1	5	1968	5	1	3	25	7	1969	5.03	0
3	0.0	15700.	4800.	16.	1310.	16.	6	7	8	1968	1	1	4	13	11	1968	7.34	0
4	0.0	34000.	13920.	37.	1376.	33.	6	27	7	1968	1	1	4	13	11	1968	21.28	0
5	0.0	40000.	15059.	9.	1537.	18.	8	5	8	1968	1	1	4	16	3	1966	11.60	0
6	0.0	37500.	24000.	9.	1830.	27.	8	12	8	1969	1	1	5	9	12	1965	9.66	0
7	0.0	41500.	19021.	7.	1889.	24.	6	15	8	1970	1	1	6	22	5	1970	12.20	0
8	0.0	18200.	5240.	36.	772.	20.	8	31	7	1968	1	1	10	-1	-1	1968	8.30	0
9	0.0	6350.	2170.	12.	406.	16.	9	13	7	1968	1	1	6	19	12	1968	5.14	0
10	0.0	860.	810.	39.	251.	28.	7	1	8	1968	1	1	6	12	12	1967	9.51	0
11	0.0	2280.	640.	9.	146.	12.	10	3	8	1968	1	1	1	2	12	1965	6.14	0
12	0.0	13500.	1849.	17.	345.	46.	5	15	7	1968	1	1	-1	-1	-1	1931	7.76	2
13	0.0	27200.	4820.	17.	620.	32.	7	5	7	1968	1	1	2	16	8	1968	14.50	0
14	0.0	19000.	0.	0.	0.	0.	10	8	8	1967	1	1	7	11	9	1968	11.73	0
15	0.0	16500.	5520.	9.	936.	26.	7	29	7	1969	1	1	6	28	12	1965	5.23	0
16	0.0	24000.	6840.	22.	1480.	33.	7	25	7	1959	1	1	5	29	11	1965	6.86	0
17	0.0	29800.	11552.	18.	1301.	17.	7	23	8	1970	1	1	-1	-1	-1	1970	6.12	1
18	0.0	485.	179.	24.	92.	14.	7	24	6	1968	1	1	2	20	11	1967	5.22	0
19	0.0	773.	685.	25.	190.	5.	7	23	6	1968	1	1	4	16	6	1965	5.52	0
20	0.0	1800.	820.	20.	287.	20.	7	21	6	1968	1	1	5	27	7	1965	2.62	0
21	0.0	85.	151.	35.	75.	19.	7	21	6	1968	1	1	6	14	1	1969	3.90	0
22	0.0	102.	102.	35.	72.	19.	8	23	7	1968	1	2	3	12	9	1967	2.39	0
23	0.0	1860.	714.	15.	156.	20.	10	17	8	1966	1	1	7	22	10	1965	6.38	0
24	0.0	1150.	560.	49.	174.	10.	9	17	6	1968	1	1	11	25	10	1967	4.33	0
25	0.0	327.	500.	37.	207.	25.	7	27	7	1968	1	1	8	28	11	1967	2.64	0
26	0.0	12.	40.	47.	27.	21.	8	19	6	1968	1	1	6	23	10	1967	2.46	0
27	0.0	1.	100.	73.	35.	26.	7	20	6	1968	1	1	3	20	10	1967	1.74	0
28	0.0	1240.	766.	14.	147.	23.	7	25	7	1968	1	1	3	10	12	1968	4.26	0
29	0.0	18.	22.	40.	46.	26.	9	31	7	1968	1	1	8	12	1	1968	1.92	0
30	0.0	99.	57.	26.	62.	20.	10	30	7	1968	1	1	8	14	3	1968	1.11	0
31	0.0	2900.	1420.	14.	402.	21.	7	22	7	1969	1	1	4	28	5	1965	7.16	0
32	0.0	284.	250.	18.	125.	25.	8	22	5	1968	1	1	9	5	12	1966	20.67	0
33	0.0	0.	0.	0.	0.	0.											0.0	
34	0.0	4300.	0.	0.	0.	0.	-1	25	6	1969	1	1	6	7	12	1967	7.80	0
35	0.0	7800.	1630.	42.	283.	12.	6	16	8	1966	1	2	4	11	2	1963	4.91	0
36	0.0	10100.	1540.	10.	379.	12.	8	15	8	1966	1	2	6	29	7	1964	8.76	0
37	0.0	16700.	3800.	26.	514.	26.	10	1	9	1966	3	1	6	5	10	1965	14.20	0
38	0.0	14500.	6040.	7.	953.	34.	9	14	7	1967	1	1	4	6	10	1965	11.04	0
39	0.0	508.	333.	16.	99.	21.	5	26	8	1968	1	1	8	8	12	1967	4.70	0
40	0.0	667.	175.	12.	108.	15.	10	17	8	1964	2	1	5	16	11	1964	3.20	0

TABLE #31

*** HYDRAULIC GEOMETRY BASED ON LONG-TERM MEAN DISCHARGE FOR YEAR ***

(ALL DISCHARGES IN CFS.; DISTANCES IN FT.)

EXPLANATIONS:

1. NO DATA IS PRESENTED IF THE DISCHARGE IS GREATER THAN THE BANKFULL CORRESPONDING TO THE RECOGNIZED VALLEY FLAT ,OR IF THE DISCHARGE CORRESPONDS TO A STAGE BEYOND THE LIMIT OF THE SURVEY DATA OR BEYOND A REASONABLE EXTENSION OF THE RATING CURVE.

2. YEAR OF SURVEY
   THIS IS THE YEAR OF SURVEY OF THE CROSS-SECTIONS. CORRESPONDS TO DATE OF SURVEY IN TABLE #27.

3. DISCHARGE
   THIS CORRESPONDS TO THE DISCHARGE SPECIFIED IN THE TABLE TITLE. IF THIS DISCHARGE HAS BEEN ESTIMATED, A NOTE IS GIVEN IN TABLE #13.

4. AVERAGE CROSS-SECTIONAL AREA

5. COEFFICIENT OF VARIATION OF THE CROSS-SECTIONAL AREA IN PERCENT

6. AVERAGE WATER SURFACE WIDTH

7. COEFFICIENT OF VARIATION OF THE WATER SURFACE WIDTH IN PERCENT

   (SEE EXPLANATORY NOTES FOR TABLE #27 FOR MORE DETAILS RELATED TO ITEMS 4,5,6, AND 7)

8. CODE FOR INTERPOLATION FOR ELEMENTS OF HYDRAULIC GEOMETRY
   0 NO INTERPOLATION, ALL VALUES COMPUTED FOR SPECIFIED DISCHARGE
   1 GOOD INTERPOLATION (OR EXTRAPOLATION) BASED ON COMPUTED VALUES FOR 3 OR 4 DIFFERENT DISCHARGES
   2 POOR INTERPOLATION (OR EXTRAPOLATION) BASED ON COMPUTED VALUES FOR 3 OR 4 DIFFERENT DISCHARGES.
   3 UNACCEPTABLE INTERPOLATION (OR EXTRAPOLATION)

   THE 3 OR 4 DISCHARGES USED FOR THE INTERPOLATION (OR EXTRAPOLATION) WERE USUALLY THOSE CORRESPONDING TO THE DATE OF SURVEY, THE APPROXIMATE LONG-TERM MEAN, THE APPROXIMATE 2 YEAR FLOOD, AND THE APPROXIMATE BANKFULL (OR HIGH DISCHARGE IF BANKFULL NOT EVIDENT).

TABLE # 27
HYDRAULIC GEOMETRY FOR DATE OF SURVEY

(ALL DISCHARGES IN CFS.;DISTANCES IN FT.)

SITE #	R.P. IF> 2 YR	DISCHARGE AT SURVEY	X-SEC. AREA	COEF. OF VAR.%	WATER SURF. WIDTH	COEF. OF VAR.%	# X-SEC	DATE OF SURV. DAY	MON.	YEAR	SURV. BY	TYPE OF SUR.	RATING CURVE #	DATE OF R.CURVE DAY	MON.	YEAR	STAGE	EST. CODE
81	0.0	4.	18.	61.	30.	17.	8	29	8	1969	1	1	7	29	12	1967	2.93	0
82	0.0	350.	70.	19.	54.	30.	9	27	7	1965	2	1	7	26	7	1965	0.0	0
83	0.0	165.	65.	60.	57.	51.	9	30	8	1969	1	1	-1	-1	-1	1916	0.62	1
84	0.0	614.	191.	32.	110.	44.	9	9	7	1966	2	1	1	12	7	1966	7.40	0
85	0.0	200.	141.	21.	93.	22.	8	23	8	1967	1	1	6	26	8	1965	3.19	0
86	0.0	250.	146.	35.	88.	15.	5	24	8	1967	1	2	-1	-1	-1	1925	2.90	1
87	0.0	537.	425.	27.	140.	33.	8	25	8	1967	1	1	2	-1	-1	1967	3.38	0
88	0.0	75.	135.	50.	140.	35.	10	28	8	1962	2	4	-1	-1	-1	1948	1.20	1
89	0.0	845.	460.	32.	265.	21.	10	12	9	1965	2	4	8	30	8	1965	6.51	0
90	0.0	1460.	790.	41.	243.	31.	8	7	9	1966	1	2	6	23	8	1965	3.39	0
91	0.0	1170.	898.	4.	353.	21.	8	16	8	1967	1	2	2	12	10	1965	7.97	0
92	0.0	149.	104.	26.	62.	29.	6	21	8	1967	1	1	10	28	11	1967	4.70	0
93	0.0	225.	108.	16.	69.	15.	8	22	8	1967	1	1	-1	-1	-1	1930	2.36	1
94	0.0	198.	98.	36.	55.	24.	10	31	8	1965	2	1	6	5	10	1965	2.27	0
95	0.0	190.	155.	41.	83.	28.	7	1	8	1967	1	1	-1	-1	-1	1930	4.35	1
96	0.0	2.	8.	49.	24.	46.	7	18	8	1967	1	1	2	4	1	1968	1.35	0
97	0.0	4.	25.	90.	22.	21.	10	31	8	1962	2	4	2	15	12	1958	0.86	0
98	0.0	62.	135.	50.	86.	10.	8	26	8	1967	1	1	10	27	6	1967	2.47	0
99	0.0	0.	0.	0.	0.	0.											0.0	
100	0.0	194.	89.	20.	68.	22.	10	20	10	1962	2	1	5	-1	-1	1962	2.10	0
101	0.0	28.	45.	51.	53.	26.	10	28	9	1962	2	1	3	-1	-1	1961	0.80	0
102	0.0	0.	0.	0.	0.	0.											0.0	
103	0.0	311.	269.	42.	183.	44.	6	6	9	1966	1	2	9	21	11	1966	1.66	0
104	0.0	272.	321.	15.	174.	17.	10	21	9	1962	2	4	3	16	12	1961	2.51	0
105	0.0	0.	0.	0.	0.	0.											0.0	
106	0.0	43.	25.	36.	30.	32.	7	12	7	1965	2	1	8	26	3	1965	2.63	0
107	0.0	530.	236.	23.	95.	20.	7	17	8	1967	1	1	8	15	11	1967	4.64	0
108	0.0	168.	167.	25.	140.	51.	9	8	9	1966	1	1	6	30	8	1965	2.29	0
109	0.0	14.	25.	68.	35.	37.	10	10	10	1962	2	1	5	-1	-1	1962	3.50	0
110	0.0	720.	217.	23.	99.	20.	9	7	9	1966	1	2	7	3	12	1965	3.10	0
111	0.0	5470.	0.	0.	0.	0.	5	14	8	1968	1	1	1	14	11	1967	4.18	0
112	0.0	15800.	5580.	18.	709.	20.	6	4	6	1968	1	1	1	16	11	1966	9.90	0
113	0.0	1180.	264.	15.	109.	31.	6	18	6	1969	1	1	3	19	10	1967	5.80	0
114	0.0	0.	0.	0.	0.	0.											0.0	
115	0.0	75.	94.	16.	55.	8.	9	29	5	1970	1	1	4	18	11	1966	2.16	0
116	0.0	38.	91.	44.	56.	12.	10	8	6	1970	1	1	5	-1	-1	1967	1.48	0
117	0.0	470.	306.	15.	92.	9.	5	11	6	1970	1	1	8	-1	-1	1970	3.05	0
118	0.0	47.	35.	15.	23.	22.	9	18	7	1970	1	1	-1	-1	-1	1970	6.54	0
119	0.0	10.	41.	79.	23.	35.	9	23	7	1970	1	1	9	18	8	1969	2.97	0
120	0.0	3415.	1279.	14.	364.	28.	6	1	9	1970	1	1	2	29	11	1967	10.43	0

TABLE # 31
HYDRAULIC GEOMETRY BASED ON LONG-TERM MEAN DISCHARGE FOR YEAR

(ALL DISCHARGES IN CFS.;DISTANCES IN FT.)

SITE #	YEAR OF SURVEY	DISCHARGE	X-SEC. AREA	COEF. OF VAR.%	WATER SURF. WIDTH	COEF. OF VAR.%	INTER-POLATION CODE
1	1968	39600.	8328.	23.	1118.	13.	0
2	1968	51700.	18922.	39.	1718.	33.	0
3	1969	56000.	11000.	16.	1310.	18.	1
4	1968	63700.	17504.	31.	1535.	35.	0
5	1968	66600.	21639.	10.	1834.	15.	0
6	1969	75300.	32000.	9.	2020.	30.	1
7	1970	80500.	29940.	9.	2109.	30.	0
8	1968	13420.	4600.	42.	740.	42.	1
9	1968	4100.	1730.	14.	386.	43.	1
10	1968	1984.	1030.	36.	263.	26.	1
11	1968	593.	375.	17.	131.	15.	1
12	1968	3188.	670.	42.	195.	28.	1
13	1966	6600.	1820.	12.	405.	21.	1
14	1967	0.	0.	0.	0.	0.	
15	1969	15240.	5250.	9.	930.	27.	1
16	1969	22800.	6600.	22.	1470.	34.	1
17	1970	27100.	10944.	19.	1255.	19.	0
18	1968	283.	130.	30.	79.	14.	1
19	1968	721.	670.	26.	189.	6.	1
20	1968	1366.	760.	21.	281.	20.	1
21	1968	116.	204.	28.	79.	14.	0
22	1968	302.	167.	23.	100.	37.	0
23	1966	537.	374.	19.	143.	21.	0
24	1968	662.	500.	56.	166.	9.	1
25	1968	1461.	775.	21.	232.	24.	1
26	1968	79.	57.	35.	30.	19.	0
27	1968	37.	129.	66.	38.	21.	0
28	1968	1550.	880.	15.	151.	23.	1
29	1968	163.	98.	17.	61.	16.	1
30	1968	230.	100.	20.	72.	20.	1
31	1969	4769.	1970.	11.	424.	15.	1
32	1969	986.	560.	15.	151.	19.	1
33		0.	0.	0.	0.	0.	
34	1969	0.	0.	0.	0.	0.	
35	1966	3491.	1160.	64.	243.	13.	1
36	1966	5283.	1120.	30.	347.	13.	1
37	1966	7771.	2050.	58.	447.	15.	1
38	1967	8180.	5000.	22.	808.	33.	1
39	1968	254.	244.	21.	96.	20.	0
40	1964	502.	153.	18.	105.	11.	1

TABLE # 31
HYDRAULIC GEOMETRY BASED ON LONG-TERM MEAN DISCHARGE FOR YEAR

(ALL DISCHARGES IN CFS.;DISTANCES IN FT.)

SITE #	YEAR OF SURVEY	DISCHARGE	X-SEC. AREA	COEF. OF VAR.%	WATER SURF. WIDTH	COEF. OF VAR.%	INTER-POLATION CODE
41	1966	920.	474.	28.	177.	16.	1
42	1966	172.	95.	28.	73.	17.	1
43	1969	0.	0.	0.	0.	0.	
44	1969	2056.	600.	32.	237.	12.	1
45	1968	50.	73.	23.	38.	15.	1
46	1966	0.	0.	0.	0.	0.	
47		0.	0.	0.	0.	0.	
48	1961	880.	305.	18.	168.	16.	1
49	1961	1811.	805.	33.	293.	30.	1
50	1968	2122.	1000.	15.	314.	11.	1
51	1963	2440.	1550.	24.	560.	24.	1
52	1966	88.	76.	20.	71.	18.	0
53	1966	172.	127.	33.	96.	31.	1
54	1966	217.	108.	40.	55.	18.	1
55	1966	144.	168.	31.	75.	20.	1
56	1968	34.	37.	68.	28.	34.	1
57	1968	65.	103.	34.	43.	24.	1
58	1968	7473.	3030.	28.	585.	27.	1
59		0.	0.	0.	0.	0.	
60	1969	1414.	1600.	28.	228.	19.	1
61	1969	2535.	1282.	25.	532.	15.	0
62	1969	2828.	600.	39.	207.	31.	1
63	1969	3025.	758.	9.	297.	8.	1
64	1969	3269.	1030.	43.	332.	23.	1
65	1969	3523.	1150.	10.	478.	15.	1
66	1969	4407.	1740.	20.	468.	13.	1
67	1969	203.	83.	34.	55.	27.	1
68	1969	75.	90.	56.	65.	45.	1
69		0.	0.	0.	0.	0.	
70	1969	391.	90.	18.	66.	30.	1
71	1969	543.	213.	31.	106.	31.	0
72	1969	235.	103.	9.	78.	18.	1
73	1969	131.	122.	30.	63.	18.	1
74	1967	313.	142.	28.	86.	32.	0
75		0.	0.	0.	0.	0.	
76		0.	0.	0.	0.	0.	
77	1969	325.	112.	20.	85.	28.	1
78	1969	512.	170.	18.	122.	24.	1
79	1966	507.	313.	32.	165.	24.	1
80	1969	0.	0.	0.	0.	0.	

TABLE #32

*** HYDRAULIC GEOMETRY BASED ON LONG-TERM MEAN DISCHARGE FOR APR-OCT ***

(ALL DISCHARGES IN CFS.; DISTANCES IN FT.)

EXPLANATIONS:

1. NO DATA IS PRESENTED IF THE DISCHARGE IS GREATER THAN THE BANKFULL CORRESPONDING TO THE RECOGNIZED VALLEY FLAT ,OR IF THE DISCHARGE CORRESPONDS TO A STAGE BEYOND THE LIMIT OF THE SURVEY DATA OR BEYOND A REASONABLE EXTENSION OF THE RATING CURVE.

2. YEAR OF SURVEY
   THIS IS THE YEAR OF SURVEY OF THE CROSS-SECTIONS. CORRESPONDS TO DATE OF SURVEY IN TABLE #27.

3. DISCHARGE
   THIS CORRESPONDS TO THE DISCHARGE SPECIFIED IN THE TABLE TITLE.
   IF THIS DISCHARGE HAS BEEN ESTIMATED, A NOTE IS GIVEN IN TABLE #13.

4. AVERAGE CROSS-SECTIONAL AREA

5. COEFFICIENT OF VARIATION OF THE CROSS-SECTIONAL AREA IN PERCENT

6. AVERAGE WATER SURFACE WIDTH

7. COEFFICIENT OF VARIATION OF THE WATER SURFACE WIDTH IN PERCENT

   (SEE EXPLANATORY NOTES FOR TABLE #27 FOR MORE DETAILS RELATED TO ITEMS 4,5,6, AND 7)

8. CODE FOR INTERPOLATION FOR ELEMENTS OF HYDRAULIC GEOMETRY
   0 NO INTERPOLATION, ALL VALUES COMPUTED FOR SPECIFIED DISCHARGE
   1 GOOD INTERPOLATION (OR EXTRAPOLATION) BASED ON COMPUTED VALUES FOR 3 OR 4 DIFFERENT DISCHARGES
   2 POOR INTERPOLATION (OR EXTRAPOLATION) BASED ON COMPUTED VALUES FOR 3 OR 4 DIFFERENT DISCHARGES.
   3 UNACCEPTABLE INTERPOLATION (OR EXTRAPOLATION)

   THE 3 OR 4 DISCHARGES USED FOR THE INTERPOLATION (OR EXTRAPOLATION) WERE USUALLY THOSE CORRESPONDING TO THE DATE OF SURVEY, THE APPROXIMATE LONG-TERM MEAN, THE APPROXIMATE 2 YEAR FLOOD, AND THE APPROXIMATE BANKFULL (OR HIGH DISCHARGE IF BANKFULL NOT EVIDENT).

TABLE # 31
HYDRAULIC GEOMETRY BASED ON LONG-TERM MEAN DISCHARGE FOR YEAR

(ALL DISCHARGES IN CFS.;DISTANCES IN FT.)

SITE #	YEAR OF SURVEY	DISCHARGE	X-SEC. AREA	COEF. OF VAR.%	WATER SURF. WIDTH	COEF. OF VAR.%	INTER-POLATION CODE
81	1969	26.	33.	39.	38.	18.	1
82	1965	187.	50.	17.	43.	33.	1
83	1969	220.	78.	59.	65.	52.	1
84	1966	249.	125.	35.	93.	44.	1
85	1967	491.	193.	15.	107.	29.	1
86	1967	562.	190.	29.	96.	15.	0
87	1967	1100.	550.	29.	240.	30.	1
88	1962	1354.	433.	31.	219.	38.	1
89	1965	1612.	620.	26.	290.	19.	1
90	1966	3233.	1350.	38.	292.	19.	1
91	1967	3233.	1460.	21.	405.	12.	1
92	1967	188.	119.	24.	68.	42.	1
93	1967	254.	114.	16.	71.	13.	1
94	1965	614.	201.	29.	114.	24.	1
95	1967	684.	260.	30.	115.	24.	1
96	1967	51.	55.	21.	45.	20.	1
97	1962	123.	108.	38.	63.	17.	1
98	1967	173.	195.	40.	93.	14.	1
99		0.	0.	0.	0.	0.	
100	1962	313.	145.	21.	76.	26.	1
101	1962	339.	131.	23.	86.	34.	1
102		0.	0.	0.	0.	0.	
103	1966	672.	354.	39.	195.	43.	0
104	1962	943.	570.	15.	220.	21.	1
105		0.	0.	0.	0.	0.	
106	1965	23.	16.	34.	21.	21.	1
107	1967	764.	240.	18.	105.	22.	1
108	1966	593.	370.	27.	187.	32.	1
109	1962	62.	44.	34.	41.	32.	1
110	1966	303.	151.	27.	90.	17.	1
111	1968	0.	0.	0.	0.	0.	
112	1968	7540.	3790.	23.	658.	21.	1
113	1969	402.	136.	30.	84.	25.	1
114		0.	0.	0.	0.	0.	
115	1970	114.	108.	14.	57.	7.	0
116	1970	137.	131.	30.	62.	10.	0
117	1970	456.	302.	15.	92.	9.	0
118	1970	17.	16.	37.	20.	23.	0
119	1970	13.	46.	73.	25.	30.	0
120	1970	2850.	1140.	14.	355.	28.	0

TABLE # 32

HYDRAULIC GEOMETRY BASED ON LONG-TERM MEAN DISCHARGE(APR-OCT)

(ALL DISCHARGES IN CFS.;DISTANCES IN FT.)

SITE #	YEAR OF SURVEY	DISCHARGE	X-SEC. AREA	COEF. OF VAR.%	WATER SURF. WIDTH	COEF. OF VAR.%	INTER-POLATION CODE
1	1968	54500.	10655.	16.	1290.	10.	0
2	1968	79300.	23539.	38.	1740.	32.	0
3	1968	105000.	16500.	10.	1455.	14.	1
4	1968	97400.	20318.	29.	1612.	37.	0
5	1968	102000.	29290.	11.	1936.	12.	0
6	1965	114400.	41500.	10.	2270.	33.	1
7	1970	122300.	38829.	13.	2236.	28.	0
8	1968	21145.	5800.	34.	780.	43.	1
9	1968	6408.	2180.	12.	407.	41.	1
10	1968	3229.	1270.	34.	275.	26.	1
11	1968	995.	460.	14.	137.	14.	1
12	1968	5150.	1120.	34.	235.	34.	1
13	1968	10200.	2450.	15.	472.	26.	1
14	1967	0.	0.	0.	0.	0.	
15	1969	23166.	6800.	10.	960.	25.	1
16	1969	34395.	9200.	26.	1570.	28.	1
17	1970	40400.	13913.	14.	1381.	18.	0
18	1968	425.	165.	26.	85.	14.	1
19	1968	1119.	790.	22.	196.	5.	1
20	1968	2130.	890.	19.	294.	20.	1
21	1968	140.	220.	27.	80.	14.	0
22	1968	431.	195.	22.	109.	38.	0
23	1966	855.	467.	17.	148.	20.	0
24	1968	1052.	550.	50.	173.	10.	1
25	1968	1742.	870.	20.	236.	23.	1
26	1968	111.	65.	31.	31.	18.	0
27	1968	52.	135.	64.	39.	21.	0
28	1969	1850.	990.	15.	157.	23.	1
29	1968	296.	147.	13.	65.	14.	1
30	1968	442.	158.	17.	79.	19.	1
31	1969	6551.	2450.	10.	433.	14.	1
32	1968	1528.	750.	14.	158.	17.	1
33		0.	0.	0.	0.	0.	
34	1969	0.	0.	0.	0.	0.	
35	1966	5353.	1400.	56.	264.	13.	1
36	1966	7835.	1380.	27.	368.	12.	1
37	1966	12089.	2950.	39.	485.	22.	1
38	1967	12300.	5700.	11.	840.	34.	1
39	1968	399.	299.	17.	98.	21.	0
40	1964	735.	183.	10.	109.	15.	1

TABLE # 32

HYDRAULIC GEOMETRY BASED ON LONG-TERM MEAN DISCHARGE(APR-OCT)

(ALL DISCHARGES IN CFS.;DISTANCES IN FT.)

SITE #	YEAR OF SURVEY	DISCHARGE	X-SEC. AREA	COEF. OF VAR.%	WATER SURF. WIDTH	COEF. OF VAR.%	INTER-POLATION CODE
41	1966	1349.	560.	22.	177.	17.	1
42	1966	238.	110.	19.	77.	17.	1
43	1969	0.	0.	0.	0.	0.	
44	1969	2440.	670.	29.	248.	14.	1
45	1968	82.	100.	23.	45.	18.	1
46	1966	0.	0.	0.	0.	0.	
47		0.	0.	0.	0.	0.	
48	1961	1367.	395.	17.	180.	16.	1
49	1961	2794.	1010.	19.	310.	18.	1
50	1968	3190.	1260.	13.	334.	11.	1
51	1963	3710.	2000.	22.	585.	23.	1
52	1966	135.	91.	17.	74.	18.	0
53	1966	251.	145.	30.	100.	30.	1
54	1966	331.	140.	36.	60.	16.	1
55	1966	176.	180.	30.	76.	20.	1
56	1968	36.	37.	63.	28.	34.	1
57	1968	88.	113.	31.	45.	25.	1
58	1968	10512.	3600.	21.	607.	26.	1
59		0.	0.	0.	0.	0.	
60	1969	2170.	1750.	29.	236.	18.	1
61	1969	3696.	1459.	22.	536.	15.	0
62	1969	3847.	740.	24.	230.	35.	1
63	1969	3927.	880.	8.	306.	8.	1
64	1969	4541.	1200.	38.	353.	23.	1
65	1969	4866.	1385.	10.	487.	14.	1
66	1969	6000.	1985.	17.	476.	13.	1
67	1969	323.	103.	30.	63.	29.	1
68	1969	112.	98.	54.	67.	43.	1
69		0.	0.	0.	0.	0.	
70	1969	571.	113.	18.	76.	29.	1
71	1969	721.	246.	31.	110.	29.	0
72	1969	314.	114.	8.	80.	18.	1
73	1969	193.	133.	28.	66.	17.	1
74	1967	466.	162.	28.	92.	32.	0
75		0.	0.	0.	0.	0.	
76		0.	0.	0.	0.	0.	
77	1969	528.	152.	21.	94.	25.	1
78	1969	863.	227.	18.	136.	24.	1
79	1966	824.	400.	25.	175.	26.	1
80	1969	0.	0.	0.	0.	0.	

TABLE # 32
HYDRAULIC GEOMETRY BASED ON LONG-TERM MEAN DISCHARGE(APR-OCT)

(ALL DISCHARGES IN CFS.;DISTANCES IN FT.)

SITE #	YEAR OF SURVEY	DISCHARGE	X-SEC. AREA	COEF. OF VAR.%	WATER SURF. WIDTH	COEF. OF VAR.%	INTER-POLATION CODE
81	1969	42.	39.	34.	40.	18.	1
82	1965	296.	64.	18.	51.	31.	1
83	1969	405.	113.	56.	84.	44.	1
84	1966	497.	174.	32.	106.	44.	1
85	1967	755.	238.	15.	116.	28.	1
86	1967	858.	221.	24.	102.	15.	0
87	1967	1650.	760.	28.	270.	32.	1
88	1962	2060.	580.	30.	247.	37.	1
89	1965	2422.	785.	24.	303.	18.	1
90	1966	4746.	1650.	34.	313.	19.	1
91	1967	4750.	1850.	20.	430.	10.	1
92	1967	286.	145.	26.	73.	39.	1
93	1967	364.	137.	15.	75.	12.	1
94	1965	929.	270.	27.	137.	24.	1
95	1967	1045.	325.	29.	132.	24.	1
96	1967	77.	71.	20.	49.	16.	1
97	1962	186.	130.	34.	68.	18.	1
98	1967	244.	230.	36.	95.	15.	1
99		0.	0.	0.	0.	0.	
100	1962	474.	225.	21.	81.	28.	1
.101	1962	521.	178.	23.	102.	33.	1
102		0.	0.	0.	0.	0.	
103	1966	1032.	417.	38.	203.	42.	0
104	1962	1367.	670.	14.	235.	22.	1
105		0.	0.	0.	0.	0.	
106	1965	35.	21.	35.	27.	28.	1
107	1967	1159.	300.	19.	117.	72.	1
108	1966	831.	440.	27.	208.	32.	1
109	1962	90.	51.	32.	43.	31.	1
110	1966	452.	179.	25.	94.	18.	1
111	1969	0.	0.	0.	0.	0.	
112	1968	10600.	4600.	21.	690.	20.	1
113	1969	631.	180.	24.	95.	28.	1
114		0.	0.	0.	0.	0.	
115	1970	169.	126.	12.	58.	7.	0
116	1970	189.	144.	27.	63.	10.	0
117	1970	747.	408.	13.	96.	9.	0
118	1970	22.	20.	27.	21.	98.	0
119	1970	13.	46.	73.	25.	30.	0
120	1970	3930.	1439.	15.	368.	28.	0

TABLE #36

*** HYDRAULIC GEOMETRY BASED ON 1.5 YEAR FLOOD **

(ALL DISCHARGES IN CFS.; DISTANCES IN FT.)

EXPLANATIONS:

1. NO DATA IS PRESENTED IF THE DISCHARGE IS GREATER THAN THE BANKFULL CORRESPONDING TO THE RECOGNIZED VALLEY FLAT ,OR IF THE DISCHARGE CORRESPONDS TO A STAGE BEYOND THE LIMIT OF THE SURVEY DATA OR BEYOND A REASONABLE EXTENSION OF THE RATING CURVE.

2. YEAR OF SURVEY
   THIS IS THE YEAR OF SURVEY OF THE CROSS-SECTIONS. CORRESPONDS TO DATE OF SURVEY IN TABLE #27.

3. DISCHARGE
   THIS CORRESPONDS TO THE DISCHARGE SPECIFIED IN THE TABLE TITLE. IF THIS DISCHARGE HAS BEEN ESTIMATED, A NOTE IS GIVEN IN TABLE #14.

4. AVERAGE CROSS-SECTIONAL AREA

5. COEFFICIENT OF VARIATION OF THE CROSS-SECTIONAL AREA IN PERCENT

6. AVERAGE WATER SURFACE WIDTH

7. COEFFICIENT OF VARIATION OF THE WATER SURFACE WIDTH IN PERCENT

   (SEE EXPLANATORY NOTES FOR TABLE #27 FOR MORE DETAILS RELATED TO ITEMS 4,5,6, AND 7)

8. CODE FOR INTERPOLATION FOR ELEMENTS OF HYDRAULIC GEOMETRY
   0 NO INTERPOLATION, ALL VALUES COMPUTED FOR SPECIFIED DISCHARGE
   1 GOOD INTERPOLATION (OR EXTRAPOLATION) BASED ON COMPUTED VALUES FOR 3 OR 4 DIFFERENT DISCHARGES
   2 POOR INTERPOLATION (OR EXTRAPOLATION) BASED ON COMPUTED VALUES FOR 3 OR 4 DIFFERENT DISCHARGES.
   3 UNACCEPTABLE INTERPOLATION (OR EXTRAPOLATION)

   THE 3 OR 4 DISCHARGES USED FOR THE INTERPOLATION (OR EXTRAPOLATION) WERE USUALLY THOSE CORRESPONDING TO THE DATE OF SURVEY, THE APPROXIMATE LONG-TERM MEAN, THE APPROXIMATE 2 YEAR FLOOD, AND THE APPROXIMATE BANKFULL (OR HIGH DISCHARGE IF BANKFULL NOT EVIDENT).

TABLE # 36

HYDRAULIC GEOMETRY BASED ON 1.5 YR FLOOD

(ALL DISCHARGES IN CFS.;DISTANCES IN FT.)

SITE #	YEAR OF SURVEY	DISCHARGE	X-SEC. AREA	COEF. OF VAR.%	WATER SURF. WIDTH	COEF. OF VAR.%	INTER-POLATION CODE
1	1968	203000.	24747.	9.	1556.	10.	0
2	1968	240000.	38897.	35.	1783.	31.	0
3	1968	265000.	32500.	6.	1535.	17.	1
4	1968	285000.	33430.	24.	1823.	30.	0
5	1968	305000.	58286.	11.	2028.	11.	0
6	1969	315000.	67500.	19.	2640.	31.	1
7	1970	295000.	61785.	17.	2370.	25.	0
8	1968	70000.	11000.	14.	880.	20.	1
9	1968	21300.	4050.	11.	520.	34.	1
10	1968	20600.	2800.	27.	322.	24.	1
11	1968	6300.	1150.	8.	188.	16.	1
12	1968	14800.	2030.	17.	365.	48.	1
13	1968	29000.	5000.	18.	623.	32.	1
14	1967	0.	0.	0.	0.	0.	
15	1969	54000.	11400.	14.	1014.	24.	1
16	1969	70000.	16500.	20.	1745.	18.	1
17	1970	81800.	22721.	10.	1433.	18.	0
18	1968	1260.	315.	20.	120.	20.	1
19	1968	4200.	1300.	13.	217.	12.	1
20	1968	8000.	1670.	13.	350.	17.	1
21	1968	900.	383.	19.	93.	11.	0
22	1968	1850.	493.	37.	175.	59.	0
23	1966	2700.	957.	16.	164.	20.	0
24	1968	3900.	1050.	26.	214.	15.	1
25	1968	4700.	1650.	14.	253.	19.	1
26	1968	630.	154.	14.	52.	28.	0
27	1968	250.	192.	50.	47.	17.	0
28	1968	2000.	1040.	15.	159.	23.	1
29	1968	1700.	485.	12.	80.	14.	1
30	1968	2100.	460.	16.	94.	13.	1
31	1969	12800.	3900.	10.	449.	12.	1
32	1968	3200.	1250.	13.	170.	14.	1
33		0.	0.	0.	0.	0.	
34	1969	0.	0.	0.	0.	0.	
35	1966	15700.	2300.	30.	308.	12.	1
36	1966	21000.	2600.	14.	474.	15.	1
37	1966	35000.	6050.	11.	582.	22.	1
38	1967	37000.	10000.	21.	859.	33.	1
39	1968	1100.	469.	12.	124.	11.	0
40	1964	2150.	345.	17.	126.	15.	1

TABLE # 36
HYDRAULIC GEOMETRY BASED ON 1.5 YR FLOOD

(ALL DISCHARGES IN CFS.:DISTANCES IN FT.)

SITE #	YEAR OF SURVEY	DISCHARGE	X-SEC. AREA	COEF. OF VAR.%	WATER SURF. WIDTH	COEF. OF VAR.%	INTER-POLATION CODE
41	1966	3300.	830.	12.	197.	15.	1
42	1966	650.	195.	16.	83.	14.	1
43	1969	0.	0.	0.	0.	0.	
44	1969	9500.	1750.	17.	314.	26.	1
45	1968	230.	193.	23.	58.	30.	1
46	1966	0.	0.	0.	0.	0.	
47		0.	0.	0.	0.	0.	
48	1961	4000.	750.	15.	222.	15.	1
49	1961	8800.	1860.	19.	355.	21.	1
50	1968	8700.	2250.	9.	357.	9.	1
51	1963	10000.	3650.	18.	645.	22.	1
52	1966	680.	207.	13.	84.	15.	0
53	1966	890.	280.	23.	125.	30.	1
54	1966	830.	320.	25.	87.	18.	1
55	1966	710.	303.	22.	86.	22.	1
56	1968	270.	90.	40.	43.	31.	1
57	1968	275.	160.	23.	49.	29.	1
58	1968	26000.	5800.	7.	663.	22.	1
59		0.	0.	0.	0.	0.	
60	1969	6400.	2240.	25.	257.	17.	1
61	1969	9600.	2103.	17.	573.	18.	0
62	1969	11100.	1450.	16.	300.	39.	1
63	1969	9700.	1480.	7.	337.	7.	1
64	1969	13200.	2100.	28.	404.	19.	1
65	1969	13000.	2370.	8.	517.	11.	1
66	1969	19400.	3595.	11.	528.	10.	1
67	1969	1100.	192.	24.	86.	28.	1
68	1969	370.	128.	46.	75.	38.	
69		0.	0.	0.	0.	0.	
70	1969	2300.	206.	18.	100.	28.	1
71	1969	2100.	413.	28.	119.	25.	0
72	1969	800.	168.	9.	92.	19.	1
73	1969	430.	167.	25.	77.	24.	1
74	1967	1400.	249.	28.	111.	29.	0
75		0.	0.	0.	0.	0.	
76		0.	0.	0.	0.	0.	
77	1969	2000.	325.	19.	117.	20.	1
78	1969	2500.	406.	17.	162.	25.	1
79	1966	2700.	710.	19.	199.	21.	1
80	1969	0.	0.	0.	0.	0.	

TABLE # 36
HYDRAULIC GEOMETRY BASED ON 1.5 YR FLOOD

(ALL DISCHARGES IN CFS.;DISTANCES IN FT.)

SITE #	YEAR OF SURVEY	DISCHARGE	X-SEC. AREA	COEF. OF VAR.%	WATER SURF. WIDTH	COEF. OF VAR.%	INTER-POLATION CODE
81	1969	230.	83.	22.	50.	21.	1
82	1965	1150.	130.	21.	75.	26.	1
83	1969	1120.	225.	41.	131.	40.	1
84	1966	1400.	290.	34.	134.	41.	1
85	1967	2800.	455.	15.	142.	25.	1
86	1967	2700.	387.	13.	128.	20.	0
87	1967	6000.	1950.	28.	370.	42.	1
88	1962	7700.	1480.	27.	345.	31.	1
89	1965	12200.	2020.	15.	353.	15.	1
90	1966	13000.	2700.	23.	367.	18.	1
91	1967	13500.	3200.	12.	520.	6.	1
92	1967	940.	250.	30.	86.	33.	1
93	1967	900.	222.	12.	86.	9.	1
94	1965	3900.	650.	18.	209.	24.	1
95	1967	3500.	610.	27.	177.	24.	1
96	1967	285.	124.	19.	58.	18.	1
97	1962	700.	230.	26.	83.	17.	1
98	1967	980.	363.	21.	106.	20.	1
99		0.	0.	0.	0.	0.	
100	1962	1350.	290.	20.	91.	32.	1
101	1962	2000.	482.	22.	170.	30.	1
102		0.	0.	0.	0.	0.	
103	1966	3600.	734.	32.	244.	27.	0
104	1962	4200.	1100.	14.	300.	25.	1
105		0.	0.	0.	0.	0.	
106	1965	160.	59.	40.	44.	52.	1
107	1967	3200.	485.	19.	144.	23.	1
108	1966	2600.	850.	27.	279.	31.	1
109	1962	222.	71.	27.	48.	28.	1
110	1966	1250.	355.	21.	113.	20.	1
111	1968	0.	0.	0.	0.	0.	
112	1968	27800.	7700.	17.	760.	20.	1
113	1969	1650.	340.	17.	132.	38.	1
114		0.	0.	0.	0.	0.	
115	1970	440.	182.	9.	64.	6.	0
116	1970	420.	189.	21.	67.	10.	0
117	1970	3800.	1315.	12.	125.	11.	0
118	1970	54.	38.	15.	24.	21.	0
119	1970	57.	70.	54.	31.	20.	0
120	1970	5700.	1824.	17.	377.	29.	0

TABLE #37

*** HYCRAULIC GECMETRY BASEC ON 2.0 YEAR FLCOD ***

(ALL DISCHARGES IN CFS.; DISTANCES IN FT.)

EXPLANATIONS:

1. NO DATA IS PRESENTED IF THE DISCHARGE IS GREATER THAN THE BANKFULL CORRESPCNDING TO THE RECCGNIZED VALLEY FLAT ,OR IF THE DISCHARGE CORRFSPCNDS TO A STAGE BEYOND THE LIMIT OF THE SURVEY DATA OR BEYOND A REASONABLE EXTENSICN CF THE RATING CURVE.

2. YEAR OF SURVEY
   THIS IS THE YEAR OF SURVEY OF THE CROSS-SECTIONS. CORRESPONDS TO DATE CF SURVEY IN TABLE #27.

3. DISCHARGE
   THIS CORRESPONDS TO THE DISCHARGE SPECIFIED IN THE TABLE TITLE.
   IF THIS DISCHARGE HAS BEEN ESTIMATED, A NOTE IS GIVEN IN TABLE #14.

4. AVERAGE CROSS-SECTIONAL AREA

5. COEFFICIENT OF VARIATION CF THE CROSS-SECTIONAL AREA IN PERCENT

6. AVERAGE WATER SURFACE WIDTH

7. COEFFICIENT OF VARIATION OF THE WATER SURFACE WIDTH IN PERCENT

   (SEE EXPLANATORY NOTES FOR TABLE #27 FOR MORE DETAILS RELATED TO ITEMS 4,5,6, AND 7)

8. CODE FOR INTERPCLATICN FCR ELEMENTS OF HYDRAULIC GEOMETRY
   0 NG INTERPOLATICN. ALL VALUES CGMPUTED FOR SPECIFIED DISCHARGE
   1 GCOD INTERPCLATION (OR EXTRAPOLATION) BASED ON COMPUTED VALUES FCR 3 OR 4 DIFFERENT DISCHARGES
   2 POOR INTERPOLATICN (CR EXTRAPOLATION) BASED ON COMPUTED VALUES FCR 3 OR 4 DIFFERENT DISCHARGES.
   3 UNACCEPTABLE INTERPCLATICN (OR EXTRAPOLATION)

   THE 3 CR 4 DISCHARGES USED FOR THE INTERPOLATION (OR EXTRAPOLATION) WERE USUALLY THOSE CORRESPONDING TO THE DATE OF SURVEY, THE APPRCXIMATE LCNG-TERM MEAN, THE APPROXIMATE 2 YEAR FLOOD, AND THE APPROXIMATE BANKFULL (OR HIGH DISCHARGE IF BANKFULL NOT EVIDENT).

TABLE # 37
HYDRAULIC GEOMETRY BASED ON 2 YR FLOOD

(ALL DISCHARGES IN CFS.;DISTANCES IN FT.)

SITE #	YEAR OF SURVEY	DISCHARGE	X-SEC. AREA	COEF. OF VAR.%	WATER SURF. WIDTH	COEF. OF VAR.%	INTER-POLATION CODE
1	1968	215000.	25582.	9.	1559.	10.	0
2	1968	255000.	40101.	35.	1787.	31.	0
3	1968	290000.	35000.	6.	1540.	17.	1
4	1968	315000.	34839.	24.	1855.	30.	0
5	1968	340000.	62058.	11.	2030.	11.	0
6	1969	340000.	71000.	19.	2730.	31.	1
7	1970	320000.	64208.	17.	2375.	25.	0
8	1968	85000.	12300.	12.	890.	18.	1
9	1968	29500.	4800.	11.	552.	39.	1
10	1968	24000.	3000.	26.	326.	24.	1
11	1968	8500.	1350.	8.	201.	17.	1
12	1968	16000.	2150.	17.	377.	49.	1
13	1968	32000.	5320.	19.	627.	31.	1
14	1967	0.	0.	0.	0.	0.	
15	1969	66000.	13000.	14.	1035.	24.	1
16	1969	78000.	18200.	19.	1770.	17.	1
17	1970	92000.	25388.	10.	1447.	18.	0
18	1968	1700.	370.	18.	130.	22.	1
19	1968	5500.	1500.	11.	221.	7.	1
20	1968	10800.	1980.	12.	363.	17.	1
21	1968	1000.	423.	18.	96.	10.	0
22	1968	2900.	660.	43.	199.	61.	0
23	1966	3400.	1104.	16.	168.	19.	0
24	1968	5500.	1250.	20.	225.	16.	1
25	1968	6700.	2100.	12.	261.	18.	1
26	1968	1000.	198.	14.	56.	28.	0
27	1968	450.	233.	43.	53.	19.	0
28	1968	2430.	1180.	16.	167.	23.	1
29	1968	2200.	580.	12.	85.	15.	1
30	1968	2800.	580.	15.	98.	11.	1
31	1969	15000.	4350.	9.	452.	11.	1
32	1968	4500.	1580.	13.	176.	13.	1
33		0.	0.	0.	0.	0.	
34	1969	0.	0.	0.	0.	0.	
35	1966	17000.	2430.	29.	311.	12.	1
36	1966	24400.	2900.	15.	495.	16.	1
37	1966	42000.	6700.	11.	601.	20.	1
38	1967	45000.	11100.	22.	914.	33.	1
39	1968	0.	0.	0.	0.	0.	
40	1964	3000.	425.	14.	132.	15.	1

TABLE # 37
HYDRAULIC GEOMETRY BASED ON 2 YR FLOOD

(ALL DISCHARGES IN CFS.;DISTANCES IN FT.)

SITE #	YEAR OF SURVEY	DISCHARGE	X-SEC. AREA	COEF. OF VAR.%	WATER SURF. WIDTH	COEF. OF VAR.%	INTER-POLATION CODE
81	1969	340.	103.	20.	55.	21.	1
82	1965	1500.	150.	22.	80.	25.	1
83	1965	1650.	290.	35.	153.	39.	1
84	1966	2300.	370.	34.	149.	38.	1
85	1967	3700.	530.	15.	148.	34.	1
86	1967	3600.	479.	13.	146.	27.	0
87	1967	8000.	2250.	33.	380.	50.	1
88	1962	10600.	1870.	26.	360.	29.	1
89	1965	14600.	2250.	15.	358.	15.	1
90	1966	20000.	3320.	18.	390.	17.	1
91	1967	31500.	5100.	13.	590.	5.	1
92	1967	1150.	277.	29.	92.	31.	1
93	1967	1200.	259.	11.	90.	8.	1
94	1965	0.	0.	0.	0.	0.	
95	1967	4500.	685.	27.	187.	24.	1
96	1967	435.	149.	19.	61.	18.	1
97	1962	1050.	280.	13.	90.	28.	1
98	1967	1500.	440.	18.	111.	22.	1
99		0.	0.	0.	0.	0.	
100	1967	1650.	306.	19.	94.	32.	1
101	1962	2400.	560.	23.	180.	33.	1
102		0.	0.	0.	0.	0.	
103	1966	4200.	791.	31.	246.	27.	0
104	1962	5400.	1260.	14.	311.	26.	1
105		0.	0.	0.	0.	0.	
106	1965	195.	68.	40.	47.	55.	1
107	1967	3900.	530.	19.	151.	23.	1
108	1966	3500.	1020.	27.	297.	30.	1
109	1962	380.	86.	24.	52.	27.	1
110	1966	1650.	450.	20.	120.	21.	1
111	1968	0.	0.	0.	0.	0.	
112	1968	37400.	8900.	17.	770.	20.	1
113	1969	1900.	380.	18.	144.	41.	1
114		0.	0.	0.	0.	0.	
115	1970	650.	217.	8.	68.	6.	0
116	1970	620.	235.	17.	71.	10.	0
117	1970	5250.	1705.	11.	138.	11.	0
118	1970	74.	46.	14.	25.	20.	0
119	1970	130.	114.	35.	40.	24.	0
120	1970	6100.	1902.	17.	380.	29.	0

TABLE # 37
HYDRAULIC GEOMETRY BASED ON 2 YR FLOOD

(ALL DISCHARGES IN CFS.;DISTANCES IN FT.)

SITE #	YEAR OF SURVEY	DISCHARGE	X-SEC. AREA	COEF. OF VAR.%	WATER SURF. WIDTH	COEF. OF VAR.%	INTER-POLATION CODE
41	1966	4400.	940.	10.	206.	14.	1
42	1966	1000.	250.	14.	86.	14.	1
43	1969	0.	0.	0.	0.	0.	
44	1969	11500.	2000.	16.	320.	25.	1
45	1968	0.	0.	0.	0.	0.	
46	1966	0.	0.	0.	0.	0.	
47		0.	0.	0.	0.	0.	
48	1961	6000.	940.	15.	235.	16.	1
49	1961	12000.	2200.	17.	367.	19.	1
50	1968	12400.	2750.	8.	365.	9.	1
51	1963	14000.	4520.	17.	667.	21.	1
52	1966	1300.	255.	13.	87.	15.	0
53	1966	1600.	385.	20.	140.	29.	1
54	1966	1700.	620.	16.	109.	20.	1
55	1966	1150.	377.	21.	95.	24.	1
56	1968	470.	116.	32.	47.	30.	1
57	1968	370.	196.	19.	53.	31.	1
58	1968	35000.	6790.	6.	680.	21.	1
59		0.	0.	0.	0.	0.	
60	1969	7300.	2330.	19.	260.	17.	1
61	1969	11200.	2247.	17.	577.	19.	0
62	1969	13000.	1621.	15.	310.	40.	1
63	1969	11100.	1600.	7.	341.	7.	1
64	1969	15500.	2300.	27.	412.	18.	1
65	1969	17000.	2750.	8.	526.	10.	1
66	1969	26500.	4310.	10.	543.	10.	1
67	1969	1400.	220.	24.	92.	26.	1
68	1969	450.	134.	45.	76.	37.	1
69		0.	0.	0.	0.	0.	
70	1969	2700.	225.	18.	104.	28.	1
71	1969	2850.	493.	27.	123.	21.	0
72	1969	1270.	204.	10.	98.	20.	1
73	1969	840.	200.	22.	86.	30.	1
74	1967	1860.	280.	27.	116.	29.	0
75		0.	0.	0.	0.	0.	
76		0.	0.	0.	0.	0.	
77	1969	2600.	380.	19.	122.	19.	1
78	1969	3300.	473.	17.	170.	25.	1
79	1966	3900.	855.	18.	209.	19.	1
80	1969	0.	0.	0.	0.	0.	

TABLE #38

*** HYDRAULIC GEOMETRY BASED ON 5.0 YEAR FLOOD ***

(ALL DISCHARGES IN CFS.; DISTANCES IN FT.)

EXPLANATIONS:

1. NO DATA IS PRESENTED IF THE DISCHARGE IS GREATER THAN THE BANKFULL CORRESPONDING TO THE RECOGNIZED VALLEY FLAT ,OR IF THE DISCHARGE CORRESPONDS TO A STAGE BEYOND THE LIMIT OF THE SURVEY DATA OR BEYOND A REASONABLE EXTENSION OF THE RATING CURVE.

2. YEAR OF SURVEY
   THIS IS THE YEAR OF SURVEY OF THE CROSS-SECTIONS. CORRESPONDS TO DATE OF SURVEY IN TABLE #27.

3. DISCHARGE
   THIS CORRESPONDS TO THE DISCHARGE SPECIFIED IN THE TABLE TITLE. IF THIS DISCHARGE HAS BEEN ESTIMATED, A NOTE IS GIVEN IN TABLE #14.

4. AVERAGE CROSS-SECTIONAL AREA

5. COEFFICIENT OF VARIATION OF THE CROSS-SECTIONAL AREA IN PERCENT

6. AVERAGE WATER SURFACE WIDTH

7. COEFFICIENT OF VARIATION OF THE WATER SURFACE WIDTH IN PERCENT

   (SEE EXPLANATORY NOTES FOR TABLE #27 FOR MORE DETAILS RELATED TO ITEMS 4,5,6, AND 7)

8. CODE FOR INTERPOLATION FOR ELEMENTS OF HYDRAULIC GEOMETRY
   0 NO INTERPOLATION, ALL VALUES COMPUTED FOR SPECIFIED DISCHARGE
   1 GOOD INTERPOLATION (OR EXTRAPOLATION) BASED ON COMPUTED VALUES FOR 3 OR 4 DIFFERENT DISCHARGES
   2 POOR INTERPOLATION (OR EXTRAPOLATION) BASED ON COMPUTED VALUES FOR 3 OR 4 DIFFERENT DISCHARGES.
   3 UNACCEPTABLE INTERPOLATION (OR EXTRAPOLATION)

   THE 3 OR 4 DISCHARGES USED FOR THE INTERPOLATION (OR EXTRAPOLATION) WERE USUALLY THOSE CORRESPONDING TO THE DATE OF SURVEY, THE APPROXIMATE LONG-TERM MEAN, THE APPROXIMATE 2 YEAR FLOOD, AND THE APPROXIMATE BANKFULL (OR HIGH DISCHARGE IF BANKFULL NOT EVIDENT).

TABLE # 38
HYDRAULIC GEOMETRY BASED ON 5 YR FLOOD

(ALL DISCHARGES IN CFS.;DISTANCES IN FT.)

SITE #	YEAR OF SURVEY	DISCHARGE	X-SEC. AREA	COEF. OF VAR.%	WATER SURF. WIDTH	COEF. OF VAR.%	INTER-POLATION CODE
1	1968	245000.	27549.	9.	1563.	10.	0
2	1968	290000.	42821.	35.	1803.	30.	0
3	1968	345000.	40000.	8.	1545.	17.	1
4	1968	390000.	37800.	23.	1901.	30.	0
5	1968	0.	0.	0.	0.	0.	
6	1969	385000.	77000.	20.	2890.	30.	1
7	1970	380000.	69617.	18.	2389.	25.	0
8	1968	120000.	15300.	11.	909.	17.	1
9	1968	56000.	6900.	15.	597.	41.	1
10	1968	32500.	3400.	26.	337.	24.	1
11	1968	15200.	2000.	9.	224.	18.	1
12	1968	19200.	2490.	20.	405.	49.	1
13	1968	38000.	5900.	20.	637.	30.	1
14	1967	0.	0.	0.	0.	0.	
15	1969	98000.	17000.	16.	1100.	23.	1
16	1969	102000.	22000.	18.	1825.	14.	1
17	1970	0.	0.	0.	0.	0.	
18	1968	3000.	520.	16.	153.	26.	1
19	1968	9800.	1950.	8.	234.	6.	1
20	1968	19200.	2750.	12.	383.	16.	1
21	1968	2000.	574.	15.	105.	11.	0
22	1968	5900.	1057.	52.	256.	76.	0
23	1966	5400.	1475.	16.	181.	18.	0
24	1968	10200.	1870.	13.	246.	18.	1
25	1968	13000.	3500.	12.	290.	14.	1
26	1968	0.	0.	0.	0.	0.	
27	1968	1040.	356.	31.	77.	32.	0
28	1968	3570.	1580.	17.	191.	20.	1
29	1968	3600.	800.	13.	93.	18.	1
30	1968	5005.	1050.	13.	109.	9.	1
31	1969	20500.	5400.	9.	458.	11.	1
32	1968	0.	0.	0.	0.	0.	
33		0.	0.	0.	0.	0.	
34	1969	0.	0.	0.	0.	0.	
35	1966	21000.	2700.	27.	321.	12.	1
36	1966	33000.	3500.	16.	530.	20.	1
37	1966	62000.	9300.	12.	662.	20.	1
38	1967	67000.	13700.	27.	945.	32.	1
39	1968	0.	0.	0.	0.	0.	
40	1964	5500.	575.	17.	159.	17.	1

TABLE # 38
HYDRAULIC GEOMETRY BASED ON 5 YR FLOOD

(ALL DISCHARGES IN CFS.;DISTANCES IN FT.)

SITE #	YEAR OF SURVEY	DISCHARGE	X-SEC. AREA	COEF. OF VAR.%	WATER SURF. WIDTH	COEF. OF VAR.%	INTER-POLATION CODE
81	1969	900.	217.	19.	82.	25.	1
82	1965	2500.	197.	29.	88.	22.	1
83	1969	3700.	495.	34.	187.	40.	1
84	1966	6400.	700.	32.	203.	32.	1
85	1967	6000.	745.	17.	162.	22.	1
86	1967	6150.	725.	18.	186.	39.	0
87	1967	13500.	2850.	42.	400.	65.	1
88	1962	0.	0.	0.	0.	0.	
89	1965	19400.	2650.	15.	365.	14.	1
90	1966	40000.	5100.	15.	442.	18.	1
91	1967	56000.	7350.	6.	630.	8.	1
92	1967	0.	0.	0.	0.	0.	
93	1967	2030.	380.	9.	100.	9.	1
94	1965	0.	0.	0.	0.	0.	
95	1967	7200.	990.	23.	227.	20.	1
96	1967	980.	215.	19.	72.	18.	1
97	1962	2300.	530.	16.	118.	25.	1
98	1967	3400.	710.	17.	137.	24.	1
99		0.	0.	0.	0.	0.	
100	1962	2400.	400.	24.	98.	38.	1
101	1962	3550.	810.	23.	205.	34.	1
102		0.	0.	0.	0.	0.	
103	1966	5700.	916.	30.	250.	27.	0
104	1962	0.	0.	0.	0.	0.	
105		0.	0.	0.	0.	0.	
106	1965	290.	88.	41.	55.	58.	1
107	1967	5700.	640.	18.	163.	24.	1
108	1966	6200.	1500.	27.	330.	28.	1
109	1962	1400.	178.	19.	71.	19.	1
110	1966	2750.	640.	19.	135.	19.	1
111	1968	0.	0.	0.	0.	0.	
112	1968	80000.	13000.	16.	830.	19.	1
113	1969	0.	0.	0.	0.	0.	
114		0.	0.	0.	0.	0.	
115	1970	1320.	295.	7.	81.	14.	0
116	1970	1360.	377.	13.	87.	15.	0
117	1970	0.	0.	0.	0.	0.	
118	1970	130.	62.	15.	28.	19.	0
119	1970	580.	288.	19.	64.	30.	0
120	1970	6900.	2054.	18.	383.	29.	0

TABLE # 38
HYDRAULIC GEOMETRY BASED ON 5 YR FLOOD

(ALL DISCHARGES IN CFS.;DISTANCES IN FT.)

SITE #	YEAR OF SURVEY	DISCHARGE	X-SEC. AREA	COEF. OF VAR.%	WATER SURF. WIDTH	COEF. OF VAR.%	INTER-POLATION CODE
41	1966	8300.	1350.	12.	228.	13.	1
42	1966	2100.	395.	11.	101.	14.	1
43	1969	0.	0.	0.	0.	0.	
44	1969	16500.	2650.	11.	332.	23.	1
45	1968	0.	0.	0.	0.	0.	
46	1966	0.	0.	0.	0.	0.	
47		0.	0.	0.	0.	0.	
48	1961	11000.	1300.	15.	240.	15.	1
49	1961	23000.	3450.	15.	428.	17.	1
50	1968	24500.	4100.	8.	390.	9.	1
51	1963	24000.	5950.	17.	718.	22.	1
52	1966	2100.	424.	13.	99.	19.	0
53	1966	5050.	710.	19.	184.	20.	1
54	1966	4300.	1500.	19.	150.	33.	1
55	1966	3000.	720.	24.	133.	33.	1
56	1968	1060.	170.	27.	53.	27.	1
57	1968	640.	283.	20.	62.	29.	1
58	1968	62000.	9950.	9.	730.	20.	1
59		0.	0.	0.	0.	0.	
60	1969	9200.	2470.	15.	266.	12.	1
61	1969	15000.	2618.	16.	587.	20.	0
62	1969	18000.	1770.	17.	318.	39.	1
63	1969	14300.	1840.	7.	350.	8.	1
64	1969	21000.	2700.	25.	426.	18.	1
65	1969	28000.	3700.	7.	541.	10.	1
66	1969	48000.	6080.	9.	572.	10.	1
67	1969	0.	0.	0.	0.	0.	
68	1969	0.	0.	0.	0.	0.	
69		0.	0.	0.	0.	0.	
70	1969	3700.	260.	18.	112.	27.	1
71	1969	4600.	654.	25.	131.	18.	0
72	1969	3150.	357.	15.	117.	25.	1
73	1969	2800.	285.	22.	102.	29.	1
74	1967	3600.	368.	26.	134.	27.	0
75		0.	0.	0.	0.	0.	
76		0.	0.	0.	0.	0.	
77	1969	4400.	495.	18.	140.	24.	1
78	1969	5800.	740.	19.	188.	22.	1
79	1966	7800.	1250.	16.	230.	16.	1
80	1969	0.	0.	0.	0.	0.	

TABLE # 39
HYDRAULIC GECMETRY BASED CN 10 YR FLOOD

(ALL DISCHARGES IN CFS.;DISTANCES IN FT.)

SITE #	YEAR CF SURVEY	DISCHARGE	X-SEC. AREA	COEF. OF VAR.%	WATER SURF. WIDTH	COEF. OF VAR.%	INTER-POLATION CODE
1	1968	260000.	28476.	9.	1565.	10.	0
2	1968	310000.	44319.	35.	1806.	30.	0
3	1968	375000.	42500.	8.	1550.	17.	1
4	1968	435000.	39412.	23.	1970.	35.	0
5	1968	0.	0.	0.	0.	0.	
6	1969	410000.	80000.	20.	2970.	30.	1
7	1970	410000.	72287.	18.	2393.	25.	0
8	1968	145000.	17500.	10.	910.	17.	1
9	1968	79000.	8500.	21.	615.	40.	1
10	1968	38000.	3650.	26.	343.	24.	1
11	1968	20800.	2450.	11.	236.	18.	1
12	1968	21000.	2600.	21.	415.	49.	1
13	1968	42000.	6300.	21.	643.	30.	1
14	1967	0.	0.	0.	0.	0.	
15	1969	120000.	19400.	16.	1135.	23.	1
16	1969	119000.	24500.	18.	1860.	13.	1
17	1970	0.	0.	0.	0.	0.	
18	1968	0.	0.	0.	0.	0.	
19	1968	13000.	2250.	7.	241.	6.	1
20	1968	26000.	3600.	12.	401.	16.	1
21	1968	2800.	687.	15.	116.	12.	0
22	1968	0.	0.	0.	0.	0.	
23	1966	6900.	1725.	16.	189.	18.	0
24	1968	11200.	2000.	12.	250.	19.	1
25	1968	18500.	4600.	12.	305.	12.	1
26	1968	0.	0.	0.	0.	0.	
27	1968	0.	0.	0.	0.	0.	
28	1968	0.	0.	0.	0.	0.	
29	1968	4800.	980.	14.	98.	20.	1
30	1968	6700.	1420.	11.	114.	8.	1
31	1969	24000.	6000.	9.	460.	11.	1
32	1968	0.	0.	0.	0.	0.	
33		0.	0.	0.	0.	0.	
34	1969	0.	0.	0.	0.	0.	
35	1966	23300.	2870.	25.	326.	12.	1
36	1966	39000.	3950.	16.	550.	22.	1
37	1966	76000.	11000.	12.	694.	21.	1
38	1967	82000.	15300.	24.	940.	32.	1
39	1968	0.	0.	0.	0.	0.	
40	1964	0.	0.	0.	0.	0.	

TABLE #39

*** HYDRAULIC GEOMETRY BASED ON 10 YEAR FLOOD ***

(ALL DISCHARGES IN CFS.; DISTANCES IN FT.)

EXPLANATIONS:

1. NO DATA IS PRESENTED IF THE DISCHARGE IS GREATER THAN THE BANKFULL CORRESPONDING TO THE RECOGNIZED VALLEY FLAT ,OR IF THE DISCHARGE CORRESPONDS TO A STAGE BEYOND THE LIMIT OF THE SURVEY DATA OR BEYOND A REASONABLE EXTENSION OF THE RATING CURVE.

2. YEAR OF SURVEY
   THIS IS THE YEAR OF SURVEY OF THE CROSS-SECTIONS. CORRESPONDS TO DATE OF SURVEY IN TABLE #27.

3. DISCHARGE
   THIS CORRESPONDS TO THE DISCHARGE SPECIFIED IN THE TABLE TITLE.
   IF THIS DISCHARGE HAS BEEN ESTIMATED, A NOTE IS GIVEN IN TABLE #14.

4. AVERAGE CROSS-SECTIONAL AREA

5. COEFFICIENT OF VARIATION OF THE CROSS-SECTIONAL AREA IN PERCENT

6. AVERAGE WATER SURFACE WIDTH

7. COEFFICIENT OF VARIATION OF THE WATER SURFACE WIDTH IN PERCENT

   (SEE EXPLANATORY NOTES FOR TABLE #27 FOR MORE DETAILS RELATED TO ITEMS 4,5,6, AND 7)

8. CODE FOR INTERPOLATION FOR ELEMENTS OF HYDRAULIC GEOMETRY
   0 NO INTERPOLATION. ALL VALUES COMPUTED FOR SPECIFIED DISCHARGE
   1 GOOD INTERPOLATION (OR EXTRAPOLATION) BASED ON COMPUTED VALUES FOR 3 OR 4 DIFFERENT DISCHARGES
   2 POOR INTERPOLATION (OR EXTRAPOLATION) BASED ON COMPUTED VALUES FOR 3 OR 4 DIFFERENT DISCHARGES.
   3 UNACCEPTABLE INTERPOLATION (OR EXTRAPOLATION)

   THE 3 OR 4 DISCHARGES USED FOR THE INTERPOLATION (OR EXTRAPOLATION) WERE USUALLY THOSE CORRESPONDING TO THE DATE OF SURVEY, THE APPROXIMATE LONG-TERM MEAN, THE APPROXIMATE 2 YEAR FLOOD, AND THE APPROXIMATE BANKFULL (OR HIGH DISCHARGE IF BANKFULL NOT EVIDENT).

TABLE # 39
HYDRAULIC GEOMETRY BASED ON 10 YR FLOOD

(ALL DISCHARGES IN CFS.;DISTANCES IN FT.)

SITE #	YEAR OF SURVEY	DISCHARGE	X-SEC. AREA	COEF. OF VAR.%	WATER SURF. WIDTH	COEF. OF VAR.%	INTER-POLATION CODE
41	1966	11300.	1610.	13.	240.	13.	1
42	1966	0.	0.	0.	0.	0.	
43	1969	0.	0.	0.	0.	0.	
44	1969	0.	0.	0.	0.	0.	
45	1968	0.	0.	0.	0.	0.	
46	1966	0.	0.	0.	0.	0.	
47		0.	0.	0.	0.	0.	
48	1961	15000.	1570.	15.	243.	15.	1
49	1961	32500.	4400.	15.	463.	15.	1
50	1968	35000.	5040.	8.	404.	9.	1
51	1963	0.	0.	0.	0.	0.	
52	1966	0.	0.	0.	0.	0.	
53	1966	0.	0.	0.	0.	0.	
54	1966	0.	0.	0.	0.	0.	
55	1966	5000.	1020.	26.	154.	37.	1
56	1968	2250.	238.	15.	58.	14.	1
57	1968	850.	340.	20.	66.	28.	1
58	1968	86000.	12200.	10.	766.	20.	1
59		0.	0.	0.	0.	0.	
60	1969	0.	0.	0.	0.	0.	
61	1969	17700.	2880.	16.	593.	20.	0
62	1969	21300.	1850.	18.	321.	39.	1
63	1969	16400.	1980.	7.	355.	8.	1
64	1969	25000.	2940.	24.	434.	18.	1
65	1969	37000.	4360.	7.	550.	9.	1
66	1969	66000.	7420.	8.	588.	10.	1
67	1969	0.	0.	0.	0.	0.	
68	1969	0.	0.	0.	0.	0.	
69		0.	0.	0.	0.	0.	
70	1969	4400.	282.	18.	116.	27.	1
71	1969	0.	0.	0.	0.	0.	
72	1969	5000.	475.	18.	128.	28.	1
73	1969	5800.	355.	22.	113.	27.	1
74	1967	4500.	405.	26.	142.	26.	0
75		0.	0.	0.	0.	0.	
76		0.	0.	0.	0.	0.	
77	1969	5800.	570.	18.	149.	27.	1
78	1969	7800.	945.	20.	197.	20.	1
79	1966	11200.	1530.	14.	241.	16.	1
80	1969	0.	0.	0.	0.	0.	

TABLE # 39
HYDRAULIC GEOMETRY BASED ON 10 YR FLOOD

(ALL DISCHARGES IN CFS.;DISTANCES IN FT.)

SITE #	YEAR OF SURVEY	DISCHARGE	X-SEC. AREA	COEF. OF VAR.%	WATER SURF. WIDTH	COEF. OF VAR.%	INTER-POLATION CODE
81	1969	1100.	252.	19.	89.	26.	1
82	1965	3200.	226.	34.	92.	21.	1
83	1969	0.	0.	0.	0.	0.	
84	1966	10120.	945.	30.	230.	30.	1
85	1967	7900.	910.	18.	170.	22.	1
86	1967	0.	0.	0.	0.	0.	
87	1967	0.	0.	0.	0.	0.	
88	1962	0.	0.	0.	0.	0.	
89	1965	0.	0.	0.	0.	0.	
90	1966	0.	0.	0.	0.	0.	
91	1967	0.	0.	0.	0.	0.	
92	1967	0.	0.	0.	0.	0.	
93	1967	0.	0.	0.	0.	0.	
94	1965	0.	0.	0.	0.	0.	
95	1967	9100.	1160.	22.	246.	18.	1
96	1967	1500.	260.	20.	77.	17.	1
97	1962	3500.	750.	18.	134.	23.	1
98	1967	5200.	930.	17.	158.	24.	1
99		0.	0.	0.	0.	0.	
100	1962	3140.	500.	28.	105.	43.	1
101	1962	4300.	980.	23.	220.	34.	1
102		0.	0.	0.	0.	0.	
103	1966	6600.	985.	29.	253.	28.	0
104	1962	0.	0.	0.	0.	0.	
105		0.	0.	0.	0.	0.	
106	1965	355.	100.	41.	56.	56.	1
107	1967	7000.	710.	17.	170.	24.	1
108	1966	8300.	1840.	26.	347.	26.	1
109	1962	2200.	233.	16.	78.	17.	1
110	1966	3550.	730.	18.	142.	17.	1
111	1968	0.	0.	0.	0.	0.	
112	1968	92000.	13900.	16.	840.	19.	1
113	1969	0.	0.	0.	0.	0.	
114		0.	0.	0.	0.	0.	
115	1970	1900.	345.	6.	91.	21.	0
116	1970	0.	0.	0.	0.	0.	
117	1970	0.	0.	0.	0.	0.	
118	1970	180.	73.	15.	30.	20.	0
119	1970	1250.	422.	21.	84.	30.	0
120	1970	0.	0.	0.	0.	0.	

TABLE #41

*** HYDRAULIC GEOMETRY BASED ON DISCHARGE EXCEEDED 0.5 % OF THE TIME ***

(ALL DISCHARGES IN CFS.; DISTANCES IN FT.)

EXPLANATIONS:

1. NO DATA IS PRESENTED IF THE DISCHARGE IS GREATER THAN THE BANKFULL CORRESPONDING TO THE RECOGNIZED VALLEY FLAT ,OR IF THE DISCHARGE CORRESPONDS TO A STAGE BEYOND THE LIMIT OF THE SURVEY DATA OR BEYOND A REASONABLE EXTENSION OF THE RATING CURVE.

2. YEAR OF SURVEY
   THIS IS THE YEAR OF SURVEY OF THE CROSS-SECTIONS. CORRESPONDS TO DATE OF SURVEY IN TABLE #27.

3. DISCHARGE
   THIS CORRESPONDS TO THE DISCHARGE SPECIFIED IN THE TABLE TITLE. IF THIS DISCHARGE HAS BEEN ESTIMATED, A NOTE IS GIVEN IN TABLE #18.

4. AVERAGE CROSS-SECTIONAL AREA

5. COEFFICIENT OF VARIATION OF THE CROSS-SECTIONAL AREA IN PERCENT

6. AVERAGE WATER SURFACE WIDTH

7. COEFFICIENT OF VARIATION OF THE WATER SURFACE WIDTH IN PERCENT

   (SEE EXPLANATORY NOTES FOR TABLE #27 FOR MORE DETAILS RELATED TO ITEMS 4,5,6, AND 7)

8. CODE FOR INTERPOLATION FOR ELEMENTS OF HYDRAULIC GEOMETRY
   - 0 NO INTERPOLATION, ALL VALUES COMPUTED FOR SPECIFIED DISCHARGE
   - 1 GOOD INTERPOLATION (OR EXTRAPOLATION) BASED ON COMPUTED VALUES FOR 3 OR 4 DIFFERENT DISCHARGES
   - 2 POOR INTERPOLATION (OR EXTRAPOLATION) BASED ON COMPUTED VALUES FOR 3 OR 4 DIFFERENT DISCHARGES.
   - 3 UNACCEPTABLE INTERPOLATION (OR EXTRAPOLATION)

   THE 3 OR 4 DISCHARGES USED FOR THE INTERPOLATION (OR EXTRAPOLATION) WERE USUALLY THOSE CORRESPONDING TO THE DATE OF SURVEY, THE APPROXIMATE LONG-TERM MEAN, THE APPROXIMATE 2 YEAR FLOOD, AND THE APPROXIMATE BANKFULL (OR HIGH DISCHARGE IF BANKFULL NOT EVIDENT).

TABLE #41

*** HYDRAULIC GEOMETRY BASED ON DISCHARGE EXCEEDED 0.5 % OF THE TIME ***

(ALL DISCHARGES IN CFS.; DISTANCES IN FT.)

EXPLANATIONS:

1. NO DATA IS PRESENTED IF THE DISCHARGE IS GREATER THAN THE BANKFULL CORRESPONDING TO THE RECOGNIZED VALLEY FLAT ,OR IF THE DISCHARGE CORRESPONDS TO A STAGE BEYOND THE LIMIT OF THE SURVEY DATA OR BEYOND A REASONABLE EXTENSION OF THE RATING CURVE.

2. YEAR OF SURVEY
   THIS IS THE YEAR OF SURVEY OF THE CROSS-SECTIONS. CORRESPONDS TO DATE OF SURVEY IN TABLE #27.

3. DISCHARGE
   THIS CORRESPONDS TO THE DISCHARGE SPECIFIED IN THE TABLE TITLE. IF THIS DISCHARGE HAS BEEN ESTIMATED, A NOTE IS GIVEN IN TABLE #18.

4. AVERAGE CROSS-SECTIONAL AREA

5. COEFFICIENT OF VARIATION OF THE CROSS-SECTIONAL AREA IN PERCENT

6. AVERAGE WATER SURFACE WIDTH

7. COEFFICIENT OF VARIATION OF THE WATER SURFACE WIDTH IN PERCENT

   (SEE EXPLANATORY NOTES FOR TABLE #27 FOR MORE DETAILS RELATED TO ITEMS 4,5,6, AND 7)

8. CODE FOR INTERPOLATION FOR ELEMENTS OF HYDRAULIC GEOMETRY
   0 NO INTERPOLATION, ALL VALUES COMPUTED FOR SPECIFIED DISCHARGE
   1 GOOD INTERPOLATION (OR EXTRAPOLATION) BASED ON COMPUTED VALUES FOR 3 OR 4 DIFFERENT DISCHARGES
   2 POOR INTERPOLATION (OR EXTRAPOLATION) BASED ON COMPUTED VALUES FOR 3 OR 4 DIFFERENT DISCHARGES.
   3 UNACCEPTABLE INTERPOLATION (OR EXTRAPOLATION)

   THE 3 OR 4 DISCHARGES USED FOR THE INTERPOLATION (OR EXTRAPOLATION) WERE USUALLY THOSE CORRESPONDING TO THE DATE OF SURVEY, THE APPROXIMATE LONG-TERM MEAN, THE APPROXIMATE 2 YEAR FLOOD, AND THE APPROXIMATE BANKFULL (OR HIGH DISCHARGE IF BANKFULL NOT EVIDENT).

TABLE # 41
HYDRAULIC GEOMETRY BASED ON DISCHARGE EXCEEDED 0.5% OF THE TIME

(ALL DISCHARGES IN CFS.;DISTANCES IN FT.)

SITE #	YEAR OF SURVEY	DISCHARGE	X-SEC. AREA	COEF. OF VAR.%	WATER SURF. WIDTH	COEF. OF VAR.%	INTER-POLATION CODE
1	1968	0.	0.	0.	0.	0.	
2	1968	0.	0.	0.	0.	0.	
3	1968	350000.	40500.	8.	1546.	17.	1
4	1968	377000.	37316.	23.	1894.	30.	0
5	1968	0.	0.	0.	0.	0.	
6	1969	363000.	74700.	20.	2820.	30.	1
7	1970	396000.	70124.	18.	2390.	25.	0
8	1968	93720.	13000.	12.	890.	18.	1
9	1968	30900.	4900.	11.	555.	40.	1
10	1968	24200.	3000.	26.	326.	24.	1
11	1968	11400.	1650.	8.	213.	18.	1
12	1969	16512.	2200.	17.	380.	49.	1
13	1968	32200.	5330.	18.	627.	32.	1
14	1967	0.	0.	0.	0.	0.	
15	1969	80000.	14600.	15.	1067.	24.	1
16	1969	101000.	22000.	18.	1825.	14.	1
17	1970	0.	0.	0.	0.	0.	
18	1968	2040.	487.	18.	143.	23.	1
19	1968	7480.	1700.	10.	228.	7.	1
20	1968	13170.	2250.	12.	370.	17.	1
21	1968	2000.	574.	15.	105.	11.	0
22	1968	4400.	875.	47.	231.	67.	0
23	1966	7500.	1820.	16.	192.	19.	0
24	1968	9240.	1770.	14.	243.	18.	1
25	1968	14200.	3750.	12.	294.	13.	1
26	1968	0.	0.	0.	0.	0.	
27	1968	971.	341.	31.	73.	33.	0
28	1968	0.	0.	0.	0.	0.	
29	1968	3320.	760.	13.	92.	17.	1
30	1968	4340.	910.	14.	106.	10.	1
31	1969	21060.	5509.	9.	459.	11.	1
32	1968	0.	0.	0.	0.	0.	
33		0.	0.	0.	0.	0.	
34	1969	0.	0.	0.	0.	0.	
35	1966	17400.	2460.	29.	312.	12.	1
36	1966	26610.	3040.	15.	505.	17.	1
37	1966	48200.	7600.	11.	624.	20.	1
38	1967	47600.	11400.	22.	918.	33.	1
39	1968	0.	0.	0.	0.	0.	
40	1964	2770.	405.	16.	131.	14.	1

TABLE # 41
HYDRAULIC GEOMETRY BASED ON DISCHARGE EXCEEDED 0.5% OF THE TIME

(ALL DISCHARGES IN CFS.;DISTANCES IN FT.)

SITE #	YEAR OF SURVEY	DISCHARGE	X-SEC. AREA	COEF. OF VAR.%	WATER SURF. WIDTH	COEF. OF VAR.%	INTER-POLATION CODE
41	1966	6664.	1180.	11.	220.	14.	1
42	1966	1450.	310.	12.	94.	13.	1
43	1969	0.	0.	0.	0.	0.	
44	1969	14500.	2380.	16.	327.	25.	1
45	1968	0.	0.	0.	0.	0.	
46	1966	0.	0.	0.	0.	0.	
47		0.	0.	0.	0.	0.	
48	1961	5420.	890.	15.	232.	16.	1
49	1961	16580.	2750.	16.	395.	18.	1
50	1968	22495.	3900.	9.	387.	9.	1
51	1963	21900.	5650.	18.	709.	22.	1
52	1966	1200.	291.	13.	89.	15.	0
53	1966	2230.	460.	20.	153.	26.	1
54	1966	3760.	1330.	18.	143.	31.	1
55	1966	2610.	650.	23.	128.	32.	1
56	1968	899.	157.	28.	52.	27.	1
57	1968	481.	233.	29.	57.	30.	1
58	1968	52680.	8800.	6.	720.	21.	1
59		0.	0.	0.	0.	0.	
60	1969	8010.	2380.	17.	263.	15.	1
61	1969	13240.	2435.	17.	582.	19.	0
62	1969	13570.	1640.	15.	311.	40.	1
63	1969	12500.	1710.	7.	346.	7.	1
64	1969	16800.	2400.	26.	415.	18.	1
65	1969	21400.	3140.	8.	533.	10.	1
66	1969	32418.	4890.	10.	553.	10.	1
67	1969	1397.	220.	24.	92.	26.	1
68	1969	491.	136.	44.	77.	36.	1
69		0.	0.	0.	0.	0.	
70	1969	2660.	221.	18.	103.	28.	1
71	1969	3000.	508.	27.	124.	20.	0
72	1969	1572.	230.	11.	102.	21.	1
73	1969	2024.	260.	22.	99.	29.	1
74	1967	2250.	303.	27.	120.	28.	0
75		0.	0.	0.	0.	0.	
76		0.	0.	0.	0.	0.	
77	1969	3220.	425.	19.	130.	21.	1
78	1969	4600.	615.	18.	180.	23.	1
79	1966	4850.	960.	17.	214.	18.	1
80	1969	0.	0.	0.	0.	0.	

TABLE # 41

HYDRAULIC GECMETRY BASED ON DISCHARGE EXCEEDED 0.5% OF THE TIME

(ALL DISCHARGES IN CFS.;DISTANCES IN FT.)

SITE #	YEAR OF SURVEY	DISCHARGE	X-SEC. AREA	COEF. OF VAR.%	WATER SURF. WIDTH	COEF. OF VAR.%	INTER-POLATION CODE
81	1969	479.	134.	20.	63.	23.	1
82	1965	1590.	155.	22.	81.	24.	1
83	1969	1810.	305.	38.	158.	42.	1
84	1966	3500.	473.	34.	166.	36.	1
85	1967	4110.	570.	16.	151.	23.	1
86	1967	4680.	584.	14.	163.	30.	0
87	1967	9800.	2450.	37.	390.	56.	1
88	1962	12760.	2130.	25.	376.	28.	1
89	1965	14000.	2200.	15.	357.	15.	1
90	1966	27670.	4050.	17.	414.	17.	1
91	1967	23700.	4350.	4.	570.	8.	1
92	1967	1385.	303.	28.	97.	30.	1
93	1967	1460.	297.	10.	94.	9.	1
94	1965	0.	0.	0.	0.	0.	
95	1967	5080.	770.	26.	198.	23.	1
96	1967	679.	182.	19.	66.	18.	1
97	1962	1580.	390.	15.	105.	26.	1
98	1967	3050.	685.	17.	134.	24.	1
99		0.	0.	0.	0.	0.	
100	1962	2010.	340.	21.	100.	35.	1
101	1962	2390.	560.	27.	180.	33.	1
102		0.	0.	0.	0.	0.	
103	1966	4810.	845.	31.	248.	27.	0
104	1962	0.	0.	0.	0.	0.	
105		0.	0.	0.	0.	0.	
106	1965	190.	67.	40.	39.	54.	1
107	1967	5425.	630.	18.	161.	24.	1
108	1966	5670.	1420.	27.	325.	28.	1
109	1962	732.	120.	21.	60.	24.	1
110	1966	1731.	466.	10.	132.	11.	1
111	1968	0.	0.	0.	0.	0.	
112	1968	56700.	11000.	17.	800.	19.	1
113	1969	0.	0.	0.	0.	0.	
114		0.	0.	0.	0.	0.	
115	1970	1624.	322.	6.	84.	13.	0
116	1970	1260.	359.	13.	85.	15.	0
117	1970	4940.	1625.	11.	135.	12.	0
118	1970	157.	68.	15.	29.	19.	0
119	1970	305.	192.	22.	52.	22.	0
120	1970	14000.	3110.	21.	413.	27.	0

TABLE #42

*** HYDRAULIC GEOMETRY BASED ON DISCHARGE EXCEEDED 1.0 % OF THE TIME ***

(ALL DISCHARGES IN CFS.; DISTANCES IN FT.)

EXPLANATIONS:

1. NO DATA IS PRESENTED IF THE DISCHARGE IS GREATER THAN THE BANKFULL CORRESPONDING TO THE RECOGNIZED VALLEY FLAT ,OR IF THE DISCHARGE CORRESPONDS TO A STAGE BEYOND THE LIMIT OF THE SURVEY DATA OR BEYOND A REASONABLE EXTENSION OF THE RATING CURVE.

2. YEAR OF SURVEY
   THIS IS THE YEAR OF SURVEY OF THE CROSS-SECTIONS. CORRESPONDS TO DATE OF SURVEY IN TABLE #27.

3. DISCHARGE
   THIS CORRESPONDS TO THE DISCHARGE SPECIFIED IN THE TABLE TITLE. IF THIS DISCHARGE HAS BEEN ESTIMATED, A NOTE IS GIVEN IN TABLE #18.

4. AVERAGE CROSS-SECTIONAL AREA

5. COEFFICIENT OF VARIATION OF THE CROSS-SECTIONAL AREA IN PERCENT

6. AVERAGE WATER SURFACE WIDTH

7. COEFFICIENT OF VARIATION OF THE WATER SURFACE WIDTH IN PERCENT

   (SEE EXPLANATORY NOTES FOR TABLE #27 FOR MORE DETAILS RELATED TO ITEMS 4,5,6, AND 7)

8. CODE FOR INTERPOLATION FOR ELEMENTS OF HYDRAULIC GEOMETRY
   0 NO INTERPOLATION, ALL VALUES COMPUTED FOR SPECIFIED DISCHARGE
   1 GOOD INTERPOLATION (OR EXTRAPOLATION) BASED ON COMPUTED VALUES FOR 3 OR 4 DIFFERENT DISCHARGES
   2 POOR INTERPOLATION (OR EXTRAPOLATION) BASED ON COMPUTED VALUES FOR 3 OR 4 DIFFERENT DISCHARGES.
   3 UNACCEPTABLE INTERPOLATION (OR EXTRAPOLATION)

   THE 3 OR 4 DISCHARGES USED FOR THE INTERPOLATION (OR EXTRAPOLATION) WERE USUALLY THOSE CORRESPONDING TO THE DATE OF SURVEY, THE APPROXIMATE LONG-TERM MEAN, THE APPROXIMATE 2 YEAR FLOOD, AND THE APPROXIMATE BANKFULL (OR HIGH DISCHARGE IF BANKFULL NOT EVIDENT).

TABLE # 42

HYDRAULIC GEOMETRY BASED ON DISCHARGE EXCEEDED 1.0% OF THE TIME

(ALL DISCHARGES IN CFS.;DISTANCES IN FT.)

SITE #	YEAR OF SURVEY	DISCHARGE	X-SEC. AREA	COEF. OF VAR.%	WATER SURF. WIDTH	COEF. OF VAR.%	INTER-POLATION CODE
1	1968	0.	0.	0.	0.	0.	
2	1968	0.	0.	0.	0.	0.	
3	1968	320000.	37500.	7.	1544.	17.	1
4	1968	320000.	35051.	24.	1859.	30.	0
5	1968	0.	0.	0.	0.	0.	
6	1969	343000.	72000.	19.	2740.	31.	1
7	1970	360000.	67869.	18.	2386.	25.	0
8	1968	77646.	11706.	13.	880.	19.	1
9	1968	22800.	4160.	11.	527.	35.	1
10	1968	20200.	2770.	27.	321.	24.	1
11	1968	8990.	1400.	8.	203.	17.	1
12	1968	15360.	2100.	17.	370.	49.	1
13	1968	29900.	5050.	16.	625.	30.	1
14	1967	0.	0.	0.	0.	0.	
15	1969	70400.	13500.	15.	1047.	24.	1
16	1969	82100.	19000.	19.	1780.	16.	1
17	1970	0.	0.	0.	0.	0.	
18	1968	1800.	460.	18.	138.	23.	1
19	1968	5200.	1450.	12.	220.	7.	1
20	1968	10012.	1890.	12.	359.	17.	1
21	1968	1000.	423.	18.	96.	10.	0
22	1968	3700.	786.	46.	218.	63.	0
23	1966	5230.	1445.	16.	181.	18.	0
24	1968	6440.	1400.	18.	230.	17.	1
25	1968	11600.	3200.	12.	285.	14.	1
26	1968	1200.	219.	14.	58.	28.	0
27	1968	502.	243.	42.	55.	19.	0
28	1968	0.	0.	0.	0.	0.	
29	1968	2340.	600.	12.	86.	15.	1
30	1968	2940.	610.	15.	99.	11.	1
31	1969	19140.	5200.	9.	457.	11.	1
32	1968	0.	0.	0.	0.	0.	
33		0.	0.	0.	0.	0.	
34	1969	0.	0.	0.	0.	0.	
35	1966	16650.	2400.	29.	310.	12.	1
36	1966	22998.	2770.	15.	487.	15.	1
37	1966	39096.	6350.	11.	593.	20.	1
38	1967	41600.	10600.	21.	908.	33.	1
39	1968	1090.	467.	12.	124.	11.	0
40	1964	2360.	365.	17.	129.	15.	1

TABLE # 42
HYDRAULIC GEOMETRY BASED ON DISCHARGE EXCEEDED 1.0% OF THE TIME

(ALL DISCHARGES IN CFS.:DISTANCES IN FT.)

SITE #	YEAR OF SURVEY	DISCHARGE	X-SEC. AREA	COEF. OF VAR.%	WATER SURF. WIDTH	COEF. OF VAR.%	INTER-POLATION CODE
41	1966	5180.	1040.	11.	211.	14.	1
42	1966	1040.	255.	14.	87.	13.	1
43	1969	0.	0.	0.	0.	0.	
44	1969	12030.	2080.	16.	322.	25.	1
45	1968	0.	0.	0.	0.	0.	
46	1966	0.	0.	0.	0.	0.	
47		0.	0.	0.	0.	0.	
48	1961	4610.	810.	15.	226.	15.	1
49	1961	13500.	2350.	16.	375.	19.	1
50	1968	19000.	3500.	8.	380.	9.	1
51	1963	17300.	5000.	18.	687.	22.	1
52	1966	770.	222.	13.	85.	15.	0
53	1966	1800.	410.	20.	145.	28.	1
54	1966	2970.	1050.	17.	132.	27.	1
55	1966	1771.	500.	22.	112.	28.	1
56	1968	461.	115.	33.	47.	30.	1
57	1968	359.	193.	19.	52.	31.	1
58	1968	43400.	7800.	5.	700.	21.	1
59		0.	0.	0.	0.	0.	
60	1969	7220.	2300.	19.	260.	17.	1
61	1969	12266.	2337.	17.	579.	19.	0
62	1969	11800.	1520.	16.	304.	40.	1
63	1969	11150.	1600.	7.	342.	7.	1
64	1969	14505.	2220.	27.	408.	19.	1
65	1969	18800.	2910.	8.	529.	10.	1
66	1969	26766.	4270.	10.	544.	10.	1
67	1969	1135.	194.	24.	87.	28.	1
68	1969	446.	133.	45.	76.	37.	1
69		0.	0.	0.	0.	0.	
70	1969	2350.	210.	18.	100.	28.	1
71	1969	2520.	459.	28.	121.	24.	0
72	1969	1210.	200.	10.	97.	20.	1
73	1969	1506.	237.	22.	94.	30.	1
74	1967	1720.	271.	28.	115.	29.	0
75		0.	0.	0.	0.	0.	
76		0.	0.	0.	0.	0.	
77	1969	2550.	375.	19.	122.	19.	1
78	1969	3816.	525.	17.	174.	24.	1
79	1966	4000.	870.	18.	208.	19.	1
80	1969	0.	0.	0.	0.	0.	

TABLE # 42
HYDRAULIC GEOMETRY BASED ON DISCHARGE EXCEEDED 1.0% OF THE TIME

(ALL DISCHARGES IN CFS.;DISTANCES IN FT.)

SITE #	YEAR OF SURVEY	DISCHARGE	X-SEC. AREA	COEF. OF VAR.%	WATER SURF. WIDTH	COEF. OF VAR.%	INTER-POLATION CODE
81	1969	337.	102.	20.	54.	21.	1
82	1965	1330.	140.	21.	78.	25.	1
83	1969	1640.	288.	39.	153.	42.	1
84	1966	2710.	403.	35.	154.	37.	1
85	1967	3340.	500.	15.	146.	24.	1
86	1967	3690.	498.	13.	148.	27.	0
87	1967	8000.	2250.	33.	380.	50.	1
88	1962	10400.	1940.	26.	362.	30.	1
89	1965	11520.	1960.	16.	351.	15.	1
90	1966	21700.	3500.	18.	396.	17.	1
91	1967	19200.	3950.	10.	550.	5.	1
92	1967	1140.	275.	29.	92.	31.	1
93	1967	1220.	262.	11.	90.	8.	1
94	1965	0.	0.	0.	0.	0.	
95	1967	4583.	705.	27.	189.	24.	1
96	1967	514.	163.	19.	63.	18.	1
97	1962	1190.	310.	14.	95.	27.	1
98	1967	1860.	517.	18.	118.	22.	1
99		0.	0.	0.	0.	0.	
100	1962	1740.	310.	19.	94.	33.	1
101	1962	2010.	482.	29.	170.	32.	1
102		0.	0.	0.	0.	0.	
103	1966	4320.	802.	31.	246.	27.	0
104	1962	5760.	1300.	14.	314.	26.	1
105		0.	0.	0.	0.	0.	
106	1965	171.	62.	40.	45.	53.	1
107	1967	4780.	590.	18.	157.	23.	1
108	1966	4510.	1220.	27.	311.	29.	1
109	1962	511.	97.	22.	54.	26.	1
110	1966	1310.	369.	11.	125.	11.	1
111	1968	0.	0.	0.	0.	0.	
112	1968	46400.	10000.	17.	790.	19.	1
113	1969	0.	0.	0.	0.	0.	
114		0.	0.	0.	0.	0.	
115	1970	1280.	292.	7.	79.	7.	0
116	1970	1010.	313.	14.	79.	14.	0
117	1970	3890.	1340.	12.	126.	10.	0
118	1970	126.	61.	15.	28.	13.	0
119	1970	210.	153.	27.	45.	21.	0
120	1970	13000.	3005.	21.	403.	24.	0

TABLE #43

*** HYDRAULIC GEOMETRY BASED ON DISCHARGE EXCEEDED 5.0 % OF THE TIME ***

(ALL DISCHARGES IN CFS.; DISTANCES IN FT.)

EXPLANATIONS:

1. NO DATA IS PRESENTED IF THE DISCHARGE IS GREATER THAN THE BANKFULL CORRESPONDING TO THE RECOGNIZED VALLEY FLAT ,OR IF THE DISCHARGE CORRESPONDS TO A STAGE BEYOND THE LIMIT OF THE SURVEY DATA OR BEYOND A REASONABLE EXTENSION OF THE RATING CURVE.

2. YEAR OF SURVEY
   THIS IS THE YEAR OF SURVEY OF THE CROSS-SECTIONS. CORRESPONDS TO DATE OF SURVEY IN TABLE #27.

3. DISCHARGE
   THIS CORRESPONDS TO THE DISCHARGE SPECIFIED IN THE TABLE TITLE. IF THIS DISCHARGE HAS BEEN ESTIMATED, A NOTE IS GIVEN IN TABLE #18.

4. AVERAGE CROSS-SECTIONAL AREA

5. COEFFICIENT OF VARIATION OF THE CROSS-SECTIONAL AREA IN PERCENT

6. AVERAGE WATER SURFACE WIDTH

7. COEFFICIENT OF VARIATION OF THE WATER SURFACE WIDTH IN PERCENT

   (SEE EXPLANATORY NOTES FOR TABLE #27 FOR MORE DETAILS RELATED TO ITEMS 4,5,6, AND 7)

8. CODE FOR INTERPOLATION FOR ELEMENTS OF HYDRAULIC GEOMETRY
   0 NO INTERPOLATION, ALL VALUES COMPUTED FOR SPECIFIED DISCHARGE
   1 GOOD INTERPOLATION (OR EXTRAPOLATION) BASED ON COMPUTED VALUES FOR 3 OR 4 DIFFERENT DISCHARGES
   2 POOR INTERPOLATION (OR EXTRAPOLATION) BASED ON COMPUTED VALUES FOR 3 OR 4 DIFFERENT DISCHARGES.
   3 UNACCEPTABLE INTERPOLATION (OR EXTRAPOLATION)

   THE 3 OR 4 DISCHARGES USED FOR THE INTERPOLATION (OR EXTRAPOLATION) WERE USUALLY THOSE CORRESPONDING TO THE DATE OF SURVEY, THE APPROXIMATE LONG-TERM MEAN, THE APPROXIMATE 2 YEAR FLOOD, AND THE APPROXIMATE BANKFULL (OR HIGH DISCHARGE IF BANKFULL NOT EVIDENT).

TABLE # 43
HYDRAULIC GEOMETRY BASED ON DISCHARGE EXCEEDED 5.0% OF THE TIME

(ALL DISCHARGES IN CFS.;DISTANCES IN FT.)

SITE #	YEAR OF SURVEY	DISCHARGE	X-SEC. AREA	COEF. OF VAR.%	WATER SURF. WIDTH	COEF. OF VAR.%	INTER-POLATION CODE
41	1966	2734.	760.	14.	191.	15.	1
42	1966	484.	165.	17.	81.	15.	1
43	1969	0.	0.	0.	0.	0.	
44	1969	7290.	1450.	17.	306.	26.	1
45	1968	243.	200.	23.	59.	30.	1
46	1966	0.	0.	0.	0.	0.	
47		0.	0.	0.	0.	0.	
48	1961	2950.	630.	15.	213.	15.	1
49	1961	6120.	1530.	17.	340.	18.	1
50	1968	6820.	1950.	10.	352.	10.	1
51	1963	7800.	3150.	19.	630.	22.	1
52	1966	358.	146.	14.	80.	18.	0
53	1966	561.	217.	25.	115.	30.	1
54	1966	959.	370.	22.	91.	19.	1
55	1966	442.	253.	25.	83.	22.	1
56	1968	66.	47.	59.	32.	33.	1
57	1968	159.	114.	31.	45.	25.	1
58	1968	25140.	5700.	8.	660.	22.	1
59		0.	0.	0.	0.	0.	
60	1969	4848.	2080.	32.	250.	17.	1
61	1969	7896.	1934.	18.	567.	18.	0
62	1969	8000.	1180.	19.	286.	38.	1
63	1969	7620.	1295.	7.	329.	8.	1
64	1969	9440.	1760.	31.	389.	20.	1
65	1969	9918.	2090.	8.	508.	13.	1
66	1969	13900.	2960.	12.	513.	10.	1
67	1969	726.	150.	24.	78.	33.	1
68	1969	268.	119.	48.	73.	39.	1
69		0.	0.	0.	0.	0.	
70	1969	1460.	167.	18.	90.	28.	1
71	1969	1608.	361.	29.	117.	26.	0
72	1969	580.	147.	9.	88.	29.	1
73	1969	440.	168.	25.	77.	24.	1
74	1967	962.	212.	28.	105.	31.	0
75		0.	0.	0.	0.	0.	
76		0.	0.	0.	0.	0.	
77	1969	1400.	265.	20.	111.	21.	1
78	1969	2552.	410.	17.	163.	25.	1
79	1966	2150.	630.	20.	194.	22.	1
80	1969	0.	0.	0.	0.	0.	

TABLE # 43

HYDRAULIC GEOMETRY BASED ON DISCHARGE EXCEEDED 5.0% OF THE TIME

(ALL DISCHARGES IN CFS.;DISTANCES IN FT.)

SITE #	YEAR OF SURVEY	DISCHARGE	X-SEC. AREA	COEF. OF VAR.%	WATER SURF. WIDTH	COEF. OF VAR.%	INTER-POLATION CODE
1	1968	170000.	22286.	9.	1541.	10.	0
2	1968	195000.	35097.	35.	1772.	31.	0
3	1968	210000.	27500.	7.	1516.	16.	1
4	1968	229000.	30042.	25.	1772.	31.	0
5	1968	244000.	51158.	11.	2017.	11.	0
6	1969	260000.	63300.	18.	2570.	31.	1
7	1970	275000.	59759.	17.	2365.	25.	0
8	1968	46180.	8700.	21.	840.	26.	1
9	1968	14500.	3300.	12.	485.	28.	1
10	1968	8740.	1960.	30.	300.	25.	1
11	1968	3040.	750.	9.	158.	13.	1
12	1968	11400.	1700.	20.	325.	44.	1
13	1968	21450.	4100.	16.	585.	30.	1
14	1967	0.	0.	0.	0.	0.	
15	1968	43900.	10000.	13.	1000.	25.	1
16	1968	60000.	14500.	20.	1705.	20.	1
17	1970	72600.	20819.	10.	1419.	18.	0
18	1968	1220.	377.	20.	124.	20.	1
19	1968	2500.	1100.	17.	208.	7.	1
20	1968	4950.	1330.	15.	329.	18.	1
21	1968	380.	325.	22.	88.	12.	0
22	1968	700.	242.	23.	127.	48.	0
23	1966	2080.	813.	15.	159.	20.	0
24	1968	2568.	840.	34.	200.	13.	1
25	1968	4210.	1530.	15.	251.	20.	1
26	1968	274.	97.	21.	40.	22.	0
27	1968	126.	158.	58.	41.	20.	0
28	1968	3240.	1470.	17.	185.	21.	1
29	1968	895.	315.	12.	75.	12.	1
30	1968	1180.	310.	16.	89.	15.	1
31	1969	13740.	4100.	9.	450.	12.	1
32	1968	3770.	1400.	13.	173.	14.	1
33		0.	0.	0.	0.	0.	
34	1969	0.	0.	0.	0.	0.	
35	1966	12340.	2040.	34.	299.	12.	1
36	1966	16000.	2150.	13.	440.	14.	1
37	1966	24380.	5100.	13.	546.	30.	1
38	1967	24400.	8000.	15.	877.	33.	1
39	1968	883.	423.	13.	111.	14.	0
40	1964	1460.	275.	13.	120.	16.	1

TABLE #44

*** HYDRAULIC GEOMETRY BASED ON DISCHARGE EXCEEDED 10.0 % OF THE TIME ***

(ALL DISCHARGES IN CFS.; DISTANCES IN FT.)

EXPLANATIONS:

1. NO DATA IS PRESENTED IF THE DISCHARGE IS GREATER THAN THE BANKFULL CORRESPONDING TO THE RECOGNIZED VALLEY FLAT ,OR IF THE DISCHARGE CORRESPONDS TO A STAGE BEYOND THE LIMIT OF THE SURVEY DATA OR BEYOND A REASONABLE EXTENSION OF THE RATING CURVE.

2. YEAR OF SURVEY
   THIS IS THE YEAR OF SURVEY OF THE CROSS-SECTIONS. CORRESPONDS TO DATE OF SURVEY IN TABLE #27.

3. DISCHARGE
   THIS CORRESPONDS TO THE DISCHARGE SPECIFIED IN THE TABLE TITLE. IF THIS DISCHARGE HAS BEEN ESTIMATED, A NOTE IS GIVEN IN TABLE #18.

4. AVERAGE CROSS-SECTIONAL

5. COEFFICIENT OF VARIATION OF THE CROSS-SECTIONAL AREA IN PERCENT

6. AVERAGE WATER SURFACE WIDTH

7. COEFFICIENT OF VARIATION OF THE WATER SURFACE WIDTH IN PERCENT

   (SEE EXPLANATORY NOTES FOR TABLE #27 FOR MORE DETAILS RELATED TO ITEMS 4,5,6, AND 7)

8. CODE FOR INTERPOLATION FOR ELEMENTS OF HYDRAULIC GEOMETRY
   0 NO INTERPOLATION, ALL VALUES COMPUTED FOR SPECIFIED DISCHARGE
   1 GOOD INTERPOLATION (OR EXTRAPOLATION) BASED ON COMPUTED VALUES FOR 3 OR 4 DIFFERENT DISCHARGES
   2 POOR INTERPOLATION (OR EXTRAPOLATION) BASED ON COMPUTED VALUES FOR 3 OR 4 DIFFERENT DISCHARGES.
   3 UNACCEPTABLE INTERPOLATION (OR EXTRAPOLATION)

   THE 3 OR 4 DISCHARGES USED FOR THE INTERPOLATION (OR EXTRAPOLATION) WERE USUALLY THOSE CORRESPONDING TO THE DATE OF SURVEY, THE APPROXIMATE LONG-TERM MEAN, THE APPROXIMATE 2 YEAR FLOOD, AND THE APPROXIMATE BANKFULL (OR HIGH DISCHARGE IF BANKFULL NOT EVIDENT).

TABLE # 43
HYDRAULIC GEOMETRY BASED ON DISCHARGE EXCEEDED 5.0% OF THE TIME

(ALL DISCHARGES IN CFS.;DISTANCES IN FT.)

SITE #	YEAR OF SURVEY	DISCHARGE	X-SEC. AREA	COEF. OF VAR.%	WATER SURF. WIDTH	COEF. OF VAR.%	INTER-POLATION CODE
81	1969	127.	64.	26.	46.	20.	1
82	1965	724.	103.	20.	67.	26.	1
83	1969	1061.	215.	42.	132.	44.	1
84	1966	1210.	270.	33.	130.	41.	1
85	1967	2000.	385.	15.	135.	25.	1
86	1967	2270.	341.	15.	122.	18.	0
87	1967	4500.	1650.	25.	350.	36.	1
88	1962	5660.	1190.	27.	319.	32.	1
89	1965	6990.	1470.	18.	336.	16.	1
90	1966	12578.	2650.	23.	366.	18.	1
91	1967	12000.	3000.	13.	505.	7.	1
92	1967	694.	217.	29.	82.	34.	1
93	1967	831.	214.	12.	85.	9.	1
94	1965	2660.	520.	20.	190.	24.	1
95	1967	2770.	535.	29.	168.	24.	1
96	1967	207.	108.	20.	56.	17.	1
97	1962	486.	198.	22.	80.	24.	1
98	1967	660.	337.	25.	102.	19.	1
99		0.	0.	0.	0.	0.	
100	1962	1180.	280.	20.	90.	31.	1
101	1962	1308.	350.	34.	145.	31.	1
102		0.	0.	0.	0.	0.	
103	1966	2850.	654.	34.	240.	28.	0
104	1962	3740.	1050.	14.	295.	25.	1
105		0.	0.	0.	0.	0.	
106	1965	104.	44.	38.	38.	45.	1
107	1967	2860.	460.	19.	142.	23.	1
108	1966	2565.	840.	27.	278.	31.	1
109	1962	238.	73.	26.	49.	28.	1
110	1966	802.	239.	23.	102.	20.	1
111	1968	0.	0.	0.	0.	0.	
112	1968	28100.	7750.	17.	765.	20.	1.
113	1969	1376.	296.	16.	120.	33.	1
114		0.	0.	0.	0.	0.	
115	1970	540.	198.	9.	66.	6.	0
116	1970	505.	209.	19.	69.	10.	0
117	1970	2400.	924.	12.	113.	13.	0
118	1970	70.	44.	14.	25.	20.	0
119	1970	25.	55.	65.	28.	24.	0
120	1970	9100.	2408.	19.	388.	29.	0

TABLE # 44
HYDRAULIC GEOMETRY BASED ON DISCHARGE EXCEEDED 10.0% OF THE TIME

(ALL DISCHARGES IN CFS.;DISTANCES IN FT.)

SITE #	YEAR OF SURVEY	DISCHARGE	X-SEC. AREA	COEF. OF VAR.%	WATER SURF. WIDTH	COEF. OF VAR.%	INTER-POLATION CODE
1	1968	110000.	17000.	10.	1503.	11.	0
2	1968	152000.	31200.	35.	1760.	30.	0
3	1968	160000.	22500.	8.	1490.	15.	1
4	1968	172000.	26000.	27.	1680.	37.	0
5	1968	180000.	42600.	11.	2000.	11.	0
6	1969	213000.	58000.	16.	2490.	32.	1
7	1970	223000.	54100.	16.	2350.	25.	0
8	1968	35900.	7600.	25.	820.	30.	1
9	1968	11000.	2860.	12.	455.	24.	1
10	1968	5510.	1600.	32.	289.	25.	1
11	1968	1590.	550.	8.	142.	13.	1
12	1968	9450.	1530.	23.	305.	41.	1
13	1968	17600.	3550.	16.	555.	29.	1
14	1967	0.	0.	0.	0.	0.	
15	1968	35000.	8800.	12.	985.	25.	1
16	1968	50100.	12500.	20.	1660.	23.	1
17	1970	59400.	18000.	11.	1410.	19.	0
18	1968	937.	320.	21.	115.	18.	1
19	1968	1740.	940.	19.	203.	6.	1
20	1968	3360.	1100.	17.	313.	19.	1
21	1968	227.	273.	25.	84.	13.	0
22	1968	450.	199.	22.	110.	39.	0
23	1966	1330.	609.	15.	153.	20.	0
24	1968	1640.	660.	42.	185.	11.	1
25	1968	2630.	1150.	17.	243.	21.	1
26	1968	161.	76.	27.	33.	17.	0
27	1968	70.	141.	62.	40.	28.	0
28	1968	2630.	1260.	16.	171.	23.	1
29	1968	458.	200.	13.	69.	14.	1
30	1968	684.	210.	17.	84.	17.	1
31	1969	10100.	3300.	10.	443.	13.	1
32	1968	2660.	1100.	14.	167.	15.	1
33		0.	0.	0.	0.	0.	
34	1969	0.	0.	0.	0.	0.	
35	1966	9750.	1800.	39.	291.	12.	1
36	1966	13200.	1870.	11.	413.	13.	1
37	1966	19000.	4250.	20.	524.	28.	1
38	1967	17400.	6700.	10.	862.	34.	1
39	1968	756.	395.	14.	108.	16.	0
40	1964	1140.	237.	21.	116.	17.	1

TABLE # 44

HYDRAULIC GEOMETRY BASED ON DISCHARGE EXCEEDED 10.0% OF THE TIME

(ALL DISCHARGES IN CFS.;DISTANCES IN FT.)

SITE #	YEAR OF SURVEY	DISCHARGE	X-SEC. AREA	COEF. OF VAR.%	WATER SURF. WIDTH	COEF. OF VAR.%	INTER-POLATION CODE
41	1966	2000.	670.	17.	182.	16.	1
42	1966	351.	138.	18.	79.	16.	1
43	1969	0.	0.	0.	0.	0.	
44	1969	4530.	1020.	20.	285.	24.	1
45	1968	132.	135.	23.	51.	24.	1
46	1966	0.	0.	0.	0.	0.	
47		0.	0.	0.	0.	0.	
48	1961	2180.	540.	14.	204.	14.	1
49	1961	4170.	1250.	25.	325.	25.	1
50	1968	4320.	1500.	12.	341.	10.	1
51	1963	5280.	2500.	20.	792.	23.	1
52	1966	238.	121.	15.	77.	19.	0
53	1966	372.	175.	28.	106.	30.	1
54	1966	510.	205.	31.	72.	17.	1
55	1966	197.	187.	30.	77.	33.	1
56	1968	28.	35.	70.	27.	34.	1
57	1968	104.	103.	34.	43.	24.	1
58	1968	18100.	4750.	12.	643.	14.	1
59		0.	0.	0.	0.	0.	
60	1969	3710.	1970.	31.	245.	18.	1
61	1969	6190.	1750.	19.	542.	16.	0
62	1969	6090.	1000.	21.	260.	37.	1
63	1969	6050.	1120.	7.	322.	9.	1
64	1969	7100.	1520.	34.	376.	22.	1
65	1969	7680.	1800.	8.	500.	13.	1
66	1969	9500.	2470.	15.	496.	11.	1
67	1969	546.	132.	26.	71.	32.	1
68	1969	185.	110.	50.	71.	41.	1
69		0.	0.	0.	0.	0.	
70	1969	997.	140.	18.	82.	29.	1
71	1969	1190.	313.	30.	115.	27.	0
72	1969	424.	128.	8.	94.	27.	1
73	1969	220.	138.	27.	68.	18.	1
74	1967	701.	184.	28.	69.	32.	0
75		0.	0.	0.	0.	0.	
76		0.	0.	0.	0.	0.	
77	1969	1030.	220.	20.	105.	22.	1
78	1969	1640.	325.	18.	152.	25.	1
79	1966	1450.	515.	22.	186.	24.	1
80	1969	0.	0.	0.	0.	0.	

TABLE # 44
HYDRAULIC GEOMETRY BASED ON DISCHARGE EXCEEDED 10.0% OF THE TIME

(ALL DISCHARGES IN CFS.;DISTANCES IN FT.)

SITE #	YEAR OF SURVEY	DISCHARGE	X-SEC. AREA	COEF. OF VAR.%	WATER SURF. WIDTH	COEF. OF VAR.%	INTER-POLATION CODE
81	1969	63.	47.	31.	42.	19.	1
82	1965	520.	86.	20.	61.	29.	1
83	1969	635.	153.	50.	107.	50.	1
84	1966	730.	205.	32.	115.	43.	1
85	1967	1450.	330.	15.	129.	26.	1
86	1967	1530.	278.	19.	114.	16.	0
87	1967	2900.	1180.	26.	310.	34.	1
88	1962	3730.	890.	29.	288.	34.	1
89	1965	4640.	1150.	20.	323.	17.	1
90	1966	8730.	2220.	27.	336.	18.	1
91	1967	8700.	2500.	16.	480.	8.	1
92	1967	486.	183.	29.	78.	36.	1
93	1967	625.	183.	13.	82.	10.	1
94	1965	1870.	415.	22.	172.	24.	1
95	1967	1920.	440.	28.	154.	24.	1
96	1967	120.	86.	21.	52.	17.	1
97	1962	299.	160.	28.	74.	21.	1
98	1967	398.	275.	29.	97.	17.	1
99		0.	0.	0.	0.	0.	
100	1962	866.	260.	20.	87.	30.	1
101	1962	954.	280.	37.	128.	30.	1
102		0.	0.	0.	0.	0.	
103	1966	2020.	555.	36.	224.	32.	0
104	1962	2610.	890.	14.	278.	24.	1
105		0.	0.	0.	0.	0.	
106	1965	66.	32.	37.	32.	38.	1
107	1967	2020.	390.	19.	112.	23.	1
108	1966	1590.	640.	27.	249.	31.	1
109	1962	158.	63.	29.	47.	29.	1
110	1966	715.	217.	23.	49.	20.	1
111	1968	0.	0.	0.	0.	0.	
112	1968	19400.	6400.	18.	730.	20.	1
113	1969	1150.	260.	15.	108.	31.	1
114		0.	0.	0.	0.	0.	
115	1970	280.	153.	11.	61.	6.	0
116	1970	322.	172.	23.	66.	10.	0
117	1970	1400.	623.	12.	104.	12.	0
118	1970	44.	34.	16.	23.	27.	0
119	1970	12.	45.	74.	25.	31.	0
120	1970	6450.	1970.	17.	352.	29.	0

TABLE #46

*** HYDRAULIC GEOMETRY BASED ON LOW LEVEL BENCH OR TRIM LINE ***

(ALL DISCHARGES IN CFS., DISTANCES IN FT.)

EXPLANATIONS:

1. THE LOW LEVEL BENCH IS A MINOR FEATURE ASSOCIATED WITH THE PRESENT CHANNEL. THE TRIM LINE IS DEFINED BY AN ABRUPT CHANGE IN THE VEGETATION NEXT TO THE PRESENT CHANNEL. THESE MINOR FEATURES BOTH BE PRESENT AT A GIVEN CROSS-SECTION BUT BOTH MAY BE ABSENT AT ANOTHER CROSS-SECTION. SOME SURVEY DATA ARE NOT DETAILED ENOUGH TO DISTINGUISH THESE FEATURES EVEN IF THEY WERE PRESENT.

2. YEAR OF SURVEY
   THIS IS THE YEAR OF SURVEY OF THE CROSS-SECTIONS. CORRESPONDS TO DATE OF SURVEY IN TABLE #27.

3. DISCHARGE
   THIS IS THE DISCHARGE THAT CORRESPONDS TO THE STAGE AT THE ACCEPTED ELEVATION OF THE LOW LEVEL BRANCH (OR TRIM LINE) ABOVE GAUGE ZERO. THE ACCEPTED ELEVATION IS BASED ON THE APPROXIMATE AVERAGE DIFFERENCE BETWEEN THE LOW LEVEL BENCH (OR TRIM LINE) AND THE WATER SURFACE ELEVATION ON THE DAY OF SURVEY.

4. AVERAGE CROSS-SECTION AREA

5. COEFFICIENT OF VARIATION OF THE CROSS-SECTIONAL AREA IN PERCENT

6. AVERAGE WATER SURFACE WIDTH

7. COEFFICIENT OF VARIATION OF THE WATER SURFACE WIDTH IN PERCENT

   (SEE EXPLANATORY NOTES FOR TABLE #27 FOR MORE DETAILS RELATED TO ITEMS 4,5,6, AND 7)

8. CODE FOR INTERPOLATION FOR ELEMENTS OF HYDRAULIC GEOMETRY
   0 NO INTERPOLATION, ALL VALUES COMPUTED FOR SPECIFIED DISCHARGE
   1 GOOD INTERPOLATION (OR EXTRAPOLATION) BASED ON COMPUTED VALUES FOR 3 OR 4 DIFFERENT DISCHARGES
   2 POOR INTERPOLATION (OR EXTRAPOLATION) BASED ON COMPUTED VALUES FOR 3 OR 4 DIFFERENT DISCHARGES
   3 UNACCEPTABLE INTERPOLATION (OR EXTRAPOLATION)

   THE 3 OR 4 DISCHARGES USED FOR THE INTERPOLATION (OR EXTRAPOLATION) WERE USUALLY THOSE CORRESPONDING TO THE DATE OF SURVEY, THE APPROXIMATE LONG-TERM MEAN, THE APPOXIMATE 2 YEAR FLOOD, AND THE APPROXIMATE BANKFULL (OR HIGH DISCHARGE IF BANKFULL NOT EVIDENT).

TABLE #46 (CONTINUED)

9. STAGE
THIS IS THE STAGE CORRESPONDING TO THE ACCEPTED LOW LEVEL BENCH (OR TRIM LINE)

10. RETURN PERIOD IN YEARS
THIS IS THE RETURN PERIOD (FROM ANALYSIS OF DAILY MEAN DISCHARGES) WHICH CORRESPONDS TO THE DISCHARGE AT THE LEVEL OF THE LOW LEVEL BENCH (OR TRIM LINE). THE MAXIMUM RETURN PERIOD GIVEN IS 100 YEARS. A RETURN PERIOD OF -100 YRS IMPLIES GREATER THAN 100 YEARS.

11. PERCENT OF TIME
THIS IS THE PERCENT OF TIME THAT THE DISCHARGE AT THE LEVEL OF THE LOW LEVEL BENCH (OR TRIM LINE) IS EXCEEDED. THE MINIMUM PERCENT GIVEN IS 0.1%. A VALUE OF -0.1% IMPLIES LESS THAN 0.1%. THE DURATION DATA IS BASED ON APR.-OCT. DISCHARGES.

12. CODE FOR ACCEPTED LEVEL
0 NOT APPLICABLE
1 LOW LEVEL BENCH
2 TRIM LINE
3 LOW LEVEL BENCH AND TRIM LINE

13. CODE FOR QUALITY OF DATA FOR OBTAINING LOW LEVEL BENCH (OR TRIM LINE)
0 NOT APPLICABLE
1 GOOD DATA
2 SATISFACTORY DATA
3 LIMITED DATA
4 UNACCEPTABLE DATA

14. COMMENTS
THE COMMENTS GIVE SOME ADDITIONAL INFORMATION CONCERNING THE HYDRAULIC GEOMETRY AT THE LOW LEVEL BENCH (OR TRIM LINE).

TABLE # 46
HYDRAULIC GEOMETRY BASED ON LOW LEVEL BENCH OR TRIM LINE

(ALL DISCHARGES IN CFS.;DISTANCES IN FT.)

SITE #	YEAR OF SURVEY	DISCHARGE	X-SEC. AREA	COEF. OF VAR.%	WATER SURF. WIDTH	COEF. OF VAR.%	INTER-POLATION CODE	STAGE	RETURN PERIOD YR	% OF TIME	TYPE	QUAL CODE	COMMENTS
1	1968	0.	0.	0.	0.	0.		0.0	0.0	0.0			
2	1968	0.	0.	0.	0.	0.		0.0	0.0	0.0			
3	1968	247000.	31000.	6.	1528.	16.	1	26.30	1.3	2.8	2	1	
4	1968	330000.	35500.	24.	1870.	30.	0	34.28	2.5	3.4	2	1	
5	1969	0.	0.	0.	0.	0.		0.0	0.0	0.0			
6	1969	380000.	76500.	20.	2880.	30.	1	31.16	4.5	0.3	1	1	
7	1970	218000.	53464.	16.	2350.	25.	0	28.20	1.0	10.3	1	3	
8	1968	0.	0.	0.	0.	0.		0.0	0.0	0.0			
9	1968	27000.	4550.	11.	543.	31.	1	10.14	1.8	6.8	1	2	
10	1968	23680.	2970.	27.	325.	24.	1	16.83	1.9	0.5	1	1	
11	1968	7760.	1300.	8.	197.	17.	1	9.87	1.8	1.3	1	2	
12	1968	0.	0.	0.	0.	0.		0.0	0.0	0.0			
13	1968	32800.	5350.	19.	630.	31.	1	15.47	2.1	0.4	1	2	
14	1967	0.	0.	0.	0.	0.		0.0	0.0	0.0			
15	1969	40000.	9500.	12.	994.	25.	1	9.23	1.2	6.6	1	2	
16	1969	92000.	20500.	18.	1810.	15.	1	14.90	3.0	0.7	2	2	
17	1970	0.	0.	0.	0.	0.		0.0	0.0	0.0			
18	1968	0.	0.	0.	0.	0.		0.0	0.0	0.0			
19	1968	4660.	1370.	12.	218.	7.	1	8.83	1.6	1.3	2	2	
20	1968	19700.	2950.	12.	388.	16.	1	8.65	5.0	0.2	1	1	
21	1968	660.	355.	20.	91.	11.	0	5.90	1.4	2.2	1	2	
22	1968	0.	0.	0.	0.	0.		0.0	0.0	0.0			
23	1966	0.	0.	0.	0.	0.		0.0	0.0	0.0			
24	1968	8020.	1600.	16.	238.	18.	1	9.26	4.0	0.7	3	2	
25	1968	5070.	1730.	13.	255.	19.	1	7.64	1.6	3.8	3	2	
26	1968	280.	99.	20.	40.	22.	0	4.87	1.3	4.9	1	2	
27	1968	0.	0.	0.	0.	0.		0.0	0.0	0.0			
28	1968	2540.	1230.	16.	169.	23.	1	7.30	2.0	10.6	1	1	
29	1968	1390.	420.	12.	79.	14.	1	7.90	1.2	2.5	1	3	
30	1968	2800.	580.	15.	98.	12.	1	7.10	2.0	1.1	1	3	
31	1969	13180.	3950.	9.	449.	12.	1	13.16	1.6	5.5	2	1	
32	1968	0.	0.	0.	0.	0.		0.0	0.0	0.0			
33		0.	0.	0.	0.	0.		0.0	0.0	0.0			
34	1969	0.	0.	0.	0.	0.		0.0	0.0	0.0			
35	1966	16300.	2350.	30.	310.	12.	1	7.21	1.8	1.1	1	3	
36	1966	0.	0.	0.	0.	0.		0.0	0.0	0.0			
37	1966	0.	0.	0.	0.	0.		0.0	0.0	0.0			
38	1967	0.	0.	0.	0.	0.		0.0	0.0	0.0			
39	1968	0.	0.	0.	0.	0.		0.0	0.0	0.0			
40	1964	2950.	420.	15.	132.	14.	1	5.20	2.0	0.4	1	2	

TABLE # 46
HYDRAULIC GEOMETRY BASED ON LOW LEVEL BENCH OR TRIM LINE

(ALL DISCHARGES IN CFS.;DISTANCES IN FT.)

SITE #	YEAR OF SURVEY	DISCHARGE	X-SEC. AREA	COEF. OF VAR.%	WATER SURF. WIDTH	COEF. OF VAR.%	INTER-POLATION CODE	STAGE	RETURN PERIOD YR	% OF TIME	TYPE	QUAL CODE	COMMENTS
41	1966	8500.	1360.	11.	230.	13.	1	7.70	5.3	0.2	1	2	
42	1966	0.	0.	0.	0.	0.		0.0	0.0	0.0			
43	1969	0.	0.	0.	0.	0.		0.0	0.0	0.0			
44	1969	14800.	2420.	16.	328.	25.	1	9.43	3.4	0.5	2	3	
45	1968	0.	0.	0.	0.	0.		0.0	0.0	0.0			
46	1966	0.	0.	0.	0.	0.		0.0	0.0	0.0			
47		0.	0.	0.	0.	0.		0.0	0.0	0.0			
48	1961	0.	0.	0.	0.	0.		0.0	0.0	0.0			
49	1961	14000.	2430.	16.	378.	19.	1	9.50	2.4	0.9	1	3	
50	1968	14000.	2950.	8.	368.	9.	1	8.90	2.2	1.7	1	2	
51	1963	0.	0.	0.	0.	0.		0.0	0.0	0.0			
52	1966	2860.	520.	14.	112.	23.	0	8.70	9.0	0.1	1	3	
53	1966	1500.	370.	20.	138.	29.	1	5.40	1.8	1.3	1	3	
54	1966	0.	0.	0.	0.	0.		0.0	0.0	0.0			
55	1956	0.	0.	0.	0.	0.		0.0	0.0	0.0			
56	1958	3800.	303.	23.	61.	21.	1	7.70	22.0	0.1	1	3	
57	1958	676.	293.	20.	63.	29.	1	5.40	6.0	0.2	1	2	
58	1968	49500.	8450.	6.	715.	21.	1	17.30	3.2	0.6	1	2	
59		0.	0.	0.	0.	0.		0.0	0.0	0.0			
60	1969	0.	0.	0.	0.	0.		0.0	0.0	0.0			
61	1969	10200.	2159.	17.	575.	19.	0	4.20	1.6	2.2	3	3	
62	1969	0.	0.	0.	0.	0.		0.0	0.0	0.0			
63	1969	17000.	2020.	7.	357.	8.	1	6.50	12.5	-0.1	2	2	
64	1969	12200.	2000.	29.	400.	19.	1	6.70	1.2	2.0	3	3	
65	1969	19600.	3000.	8.	530.	10.	1	6.62	2.4	0.8	1	2	
66	1969	14000.	2970.	12.	513.	10.	1	7.80	1.2	4.8	1	2	
67	1969	0.	0.	0.	0.	0.		0.0	0.0	0.0			
68	1969	0.	0.	0.	0.	0.		0.0	0.0	0.0			
69		0.	0.	0.	0.	0.		0.0	0.0	0.0			
70	1969	4500.	283.	18.	117.	27.	1	6.34	11.0	-0.1	1	2	
71	1969	2275.	433.	28.	120.	24.	0	4.43	1.6	1.5	2	3	
72	1969	2050.	275.	13.	108.	23.	1	3.41	3.0	0.2	1	2	
73	1969	1800.	250.	22.	96.	30.	1	4.00	3.2	0.7	1	2	
74	1967	5700.	450.	25.	153.	25.	0	6.17	19.0	-0.1	1	3	
75		0.	0.	0.	0.	0.		0.0	0.0	0.0			
76		0.	0.	0.	0.	0.		0.0	0.0	0.0			
77	1969	4290.	490.	18.	139.	24.	1	5.45	4.8	0.2	3	1	
78	1969	3800.	525.	17.	174.	24.	1	4.30	2.4	1.0	1	3	
79	1966	3500.	810.	18.	204.	20.	1	6.85	1.8	1.4	1	3	
80	1969	0.	0.	0.	0.	0.		0.0	0.0	0.0			

TABLE #48

*** HYDRAULIC GEOMETRY BASED ON VALLEY FLAT ***

(ALL DISCHARGES IN CFS.; DISTANCES IN FT.)

EXPLANATIONS:

1. THE VALLEY FLAT IS A RELATIVELY LARGE FLAT AREA NEXT TO THE PRESENT CHANNEL. IN SOME CASES IT IS LOCAL AND OF LIMITED LATERAL EXTENT. MORE DATA ARE AVAILABLE IN TABLE #56 TO DESCRIBE THE VALLEY FLAT.

2. YEAR OF SURVEY
   THIS IS THE YEAR OF SURVEY OF THE CROSS-SECTIONS. IT CORRESPONDS TO THE DATE OF SURVEY IN TABLE #27.

3. DISCHARGE
   THIS IS THE DISCHARGE THAT CORRESPONDS TO THE STAGE AT THE ACCEPTED ELEVATION OF THE VALLEY FLAT ABOVE THE GAUGE ZERO. THE ACCEPTED ELEVATION IS BASED ON THE AVERAGE (OR SLIGHTLY LESS THAN AVERAGE) DIFFERENCE BETWEEN THE VALLEY FLAT AND THE WATER SURFACE ELEVATION ON THE DAY OF SURVEY. THIS DISCHARGE MUST BE ACCEPTED AS APPROXIMATE IN MANY CASES BECAUSE OF THE EXTRAPOLATION OF THE RATING CURVE.

4. AVERAGE CROSS-SECTIONAL AREA

5. COEFFICIENT OF VARIATION OF THE CROSS-SECTIONAL AREAS IN PERCENT

6. AVERAGE WATER SURFACE WIDTH

7. COEFFICIENT OF VARIATION OF THE CROSS-SECTIONAL AREAS

   (SEE EXPLANATORY NOTES FOR TABLE #27 FOR MORE DETAILS RELATED TO ITEMS 4,5,6, AND 7)

8. CODE FOR INTERPOLATION FOR ELEMENTS OF HYDRAULIC GEOMETRY
   0 NO INTERPOLATION, ALL VALUES COMPUTED FOR SPECIFIED DISCHARGE
   1 GOOD INTERPOLATION (OR EXTRAPOLATION) BASED ON COMPUTED VALUES FOR 3 OR 4 DIFFERENT DISCHARGES
   2 POOR INTERPOLATION (OR EXTRAPOLATION) BASED ON COMPUTED VALUES FOR 3 OR 4 DIFFERENT DISCHARGES

   THE 3 OR 4 DISCHARGES USED FOR THE INTERPOLATION (OR EXTRAPOLATION) WERE USUALLY THOSE CORRESPONDING TO THE DATE OF SURVEY, THE APPROXIMATE LONG-TERM MEAN, THE APPROXIMATE 2 YEAR FLOOD, AND THE APPROXIMATE BANKFULL (OR HIGH DISCHARGE IF BANKFULL NOT EVIDENT)

9. STAGE

TABLE # 46
HYDRAULIC GEOMETRY BASED ON LOW LEVEL BENCH OR TRIM LINE
(ALL DISCHARGES IN CFS.:DISTANCES IN FT.)

SITE #	YEAR OF SURVEY	DISCHARGE	X-SEC. AREA	COEF. OF VAR.%	WATER SURF. WIDTH	COEF. OF VAR.%	INTER-POLATION CODE	STAGE	RETURN PERIOD YR	% OF TIME	TYPE	QUAL CODE	COMMENTS
81	1969	560.	150.	20.	69.	23.	1	5.43	3.4	0.4	1	1	
82	1965	1580.	154.	22.	81.	24.	1	6.10	2.1	0.5	1	3	
83	1969	0.	0.	0.	0.	0.		0.0	0.0	0.0			
84	1966	3470.	470.	35.	165.	36.	1	8.70	2.7	0.5	1	2	
85	1967	4500.	610.	16.	154.	23.	1	6.59	2.7	0.4	1	2	
86	1967	4000.	518.	13.	151.	26.	0	5.75	2.3	0.8	1	2	
87	1967	4550.	1700.	25.	360.	3[illegible]	1	5.38	1.2	4.9	1	3	
88	1962	0.	0.	0.	0.	0.		0.0	0.0	0.0			
89	1965	19400.	2650.	15.	365.	14.	1	13.10	5.0	0.2	1	3	
90	1966	21000.	3450.	18.	393.	17.	1	10.14	2.1	1.1	1	2	
91	1967	0.	0.	0.	0.	0.		0.0	0.0	0.0			
92	1967	0.	0.	0.	0.	0.		0.0	0.0	0.0			
93	1967	0.	0.	0.	0.	0.		0.0	0.0	0.0			
94	1965	0.	0.	0.	0.	0.		0.0	0.0	0.0			
95	1967	4400.	680.	27.	186.	24.	1	7.85	1.9	1.1	1	2	
96	1967	1035.	219.	19.	72.	18.	1	4.85	5.5	0.2	1	2	
97	1962	0.	0.	0.	0.	0.		0.0	0.0	0.0			
98	1967	0.	0.	0.	0.	0.		0.0	0.0	0.0			
99		0.	0.	0.	0.	0.		0.0	0.0	0.0			
100	1962	2150.	363.	22.	96.	36.	1	4.60	3.3	0.4	1	3	
101	1962	0.	0.	0.	0.	0.		0.0	0.0	0.0			
102		0.	0.	0.	0.	0.		0.0	0.0	0.0			
103	1966	3570.	731.	32.	243.	27.	0	3.76	1.6	2.2	1	3	
104	1962	0.	0.	0.	0.	0.		0.0	0.0	0.0			
105		0.	0.	0.	0.	0.		0.0	0.0	0.0			
106	1965	0.	0.	0.	0.	0.		0.0	0.0	0.0			
107	1967	4800.	590.	18.	158.	23.	1	6.80	3.1	1.0	1	3	
108	1966	0.	0.	0.	0.	0.		0.0	0.0	0.0			
109	1962	0.	0.	0.	0.	0.		0.0	0.0	0.0			
110	1966	0.	0.	0.	0.	0.		0.0	0.0	0.0			
111	1968	0.	0.	0.	0.	0.		0.0	0.0	0.0			
112	1968	0.	0.	0.	0.	0.		0.0	0.0	0.0			
113	1969	0.	0.	0.	0.	0.		0.0	0.0	0.0			
114		0.	0.	0.	0.	0.		0.0	0.0	0.0			
115	1970	1110.	272.	7.	77.	12.	0	5.16	3.8	1.4	1	2	
116	1970	960.	303.	14.	78.	14.	0	4.63	3.7	1.1	1	2	
117	1970	0.	0.	0.	0.	0.		0.0	0.0	0.0			
118	1970	0.	0.	0.	0.	0.		0.0	0.0	0.0			
119	1970	0.	0.	0.	0.	0.		0.0	0.0	0.0			
120	1970	0.	0.	0.	0.	0.		0.0	0.0	0.0			

TABLE #48 (CONTINUED)

THIS IS THE STAGE CORRESPONDING TO THE ACCEPTED VALLEY FLAT.

10. RETURN PERIOD IN YEARS
THIS IS THE RETURN PERIOD (FROM ANALYSIS OF DAILY MEAN DISCHARGES) WHICH CORRESPONDS TO THE DISCHARGE AT THE LEVEL OF THE VALLEY FLAT. THE MAXIMUM RETURN PERIOD GIVEN IS 100 YEARS. A RETURN PERIOD OF -100 YEARS IMPLIES GEATER THAN 100 YEARS.

11. PERCENT OF TIME
THIS IS THE PERCENT OF TIME THAT THE DISCHARGE AT THE LEVEL OF THE VALLEY FLAT IS EXCEEDED. THE MINIMUM PERCENT GIVEN IS 0.1%. A VALUE OF -0.1% IMPLIES LESS THAN 0.1%. THE DURATION IS BASED ON APR.-OCT. DISCHARGES.

12. CODE FOR QUALITY OF DATA FOR OBTAINING VALLEY FLAT ELEVATION.
0 NOT ACCEPTABLE
1 GOOD DATA
2 SATISFACTORY DATA
3 LIMITED DATA
4 UNACCEPTABLE DATA

13. COMMENTS
THE COMMENTS MAY GIVE SOME ADDITIONAL INFORMATION CONCERNING THE HYDRAULIC GEOMETRY AT THE VALLEY FLAT.

TABLE # 48
HYDRAULIC GEOMETRY BASED ON VALLEY FLAT

(ALL DISCHARGES IN CFS.;DISTANCES IN FT.)

SITE #	YEAR OF SURVEY	DISCHARGE	X-SEC. AREA	COEF. OF VAR.%	WATER SURF. WIDTH	COEF. OF VAR.%	INTER-POLATION CODE	STAGE	RETURN PERIOD YR	% OF TIME	QUAL CODE	COMMENTS
1	1968	275000.	29854.	9.	1567.	10.	0	29.40	22.0	4.5	2	
2	1968	318000.	44807.	35.	1807.	30.	0	22.03	13.0	1.4	3	
3	1968	530000.	57000.	11.	1557.	17.	1	38.40	-100.0	-0.1	1	
4	1968	1000000.	58939.	17.	2320.	40.	0	43.28	-100.0	-0.1	1	
5	1968	352000.	64023.	11.	2030.	11.	0	36.96	2.5	1.8	1	
6	1969	0.	0.	0.	0.	0.		0.0	0.0	0.0		
7	1970	590000.	88879.	19.	2421.	25.	0	42.90	-100.0	-0.1	1	
8	1968	192000.	21000.	10.	920.	16.	1	25.10	25.5	-0.1	2	
9	1968	0.	0.	0.	0.	0.		0.0	0.0	0.0		
10	1968	65000.	4600.	30.	365.	24.	1	19.93	-100.0	-0.1	3	
11	1968	25000.	2750.	11.	242.	18.	1	16.87	17.0	-0.1	2	
12	1968	31000.	3550.	27.	480.	48.	1	11.06	-100.0	-0.1	2	
13	1968	0.	0.	0.	0.	0.		0.0	0.0	0.0		
14	1967	0.	0.	0.	0.	0.		0.0	0.0	0.0		
15	1969	300000.	36000.	19.	1286.	21.	1	33.03	-100.0	-0.1	3	
16	1969	420000.	59000.	13.	2110.	2.	1	34.90	-100.0	-0.1	1	
17	1970	92000.	25398.	10.	1447.	18.	0	15.98	2.0	1.5	2	
18	1968	4300.	640.	14.	169.	29.	1	8.89	12.0	-0.1	2	
19	1968	50000.	4400.	1.	2706	5.	1	20.83	-100.0	-0.1	2	
20	1968	64000.	6600.	12.	440.	15.	1	16.65	-100.0	-0.1	2	
21	1968	4000.	833.	14.	125.	12.	0	10.40	23.0	0.2	2	
22	1968	7180.	1192.	55.	262.	76.	0	8.60	8.0	-0.1	2	
23	1966	20000.	3526.	17.	260.	23.	0	20.38	-100.0	-0.1	3	
24	1968	0.	0.	0.	0.	0.		0.0	0.0	0.0		
25	1968	21500.	5100.	12.	212.	10.	1	19.60	14.0	0.1	2	
26	1969	1630.	499.	21.	75.	27.	0	10.87	2.9	0.7	1	
27	1968	1040.	355.	31.	77.	32.	0	6.75	5.0	0.4	1	
28	1968	3790.	1670.	17.	195.	20.	1	9.80	5.0	1.8	2	
29	1968	5790.	1100.	14.	102.	21.	1	15.90	18.0	0.2	1	
30	1968	14000.	3000.	8.	127.	6.	1	18.10	-100.0	-0.1	1	
31	1969	28000.	6800.	9.	463.	11.	1	19.16	22.0	-0.1	1	
32	1968	5000.	1700.	13.	178.	13.	1	29.70	2.2	2.3	2	
33		0.	0.	0.	0.	0.		0.0	0.0	0.0		
34	1969	0.	0.	0.	0.	0.		0.0	0.0	0.0		
35	1965	0.	0.	0.	0.	0.		0.0	0.0	0.0		
36	1966	100000.	7490.	18.	659.	35.	1	18.97	-100.0	-0.1	2	
37	1966	155000.	20000.	14.	800.	16.	1	38.20	-100.0	-0.1	2	
38	1967	0.	0.	0.	0.	0.		0.0	0.0	0.0		
39	1968	983.	444.	13.	121.	12.	0	5.70	1.4	2.3	1	
40	1964	5850.	590.	17.	162.	17.	1	6.20	5.2	-0.1	3	

TABLE # 48
HYDRAULIC GEOMETRY BASED ON VALLEY FLAT

(ALL DISCHARGES IN CFS.;DISTANCES IN FT.)

SITE #	YEAR OF SURVEY	DISCHARGE	X-SEC. AREA	COEF. OF VAR.%	WATER SURF. WIDTH	COEF. OF VAR.%	INTER-POLATION CODE	STAGE	RETURN PERIOD YR	% OF TIME	QUAL CODE	COMMENTS
41	1966	33000.	3000.	14.	279.	12.	1	15.70	-100.0	-0.1	2	
42	1966	2200.	405.	10.	102.	14.	1	4.98	5.6	0.2	2	
43	1969	0.	0.	0.	0.	0.		0.0	0.0	0.0		
44	1969	0.	0.	0.	0.	0.		0.0	0.0	0.0		
45	1968	280.	220.	23.	61.	32.	1	6.60	1.6	4.2	1	
46	1966	0.	0.	0.	0.	0.		0.0	0.0	0.0		
47		0.	0.	0.	0.	0.		0.0	0.0	0.0		
48	1961	0.	0.	0.	0.	0.		0.0	0.0	0.0		
49	1961	0.	0.	0.	0.	0.		0.0	0.0	0.0		
50	1968	36000.	5100.	8.	405.	9.	1	13.90	10.5	-0.1	3	
51	1963	30000.	6670.	19.	739.	23.	1	-1.00	8.0	0.2	2	
52	1966	5000.	754.	16.	136.	23.	0	10.70	29.0	-0.1	2	
53	1966	6600.	820.	18.	195.	19.	1	9.40	7.0	-0.1	3	
54	1966	4600.	1600.	19.	152.	35.	1	19.15	6.0	0.3	2	
55	1966	6500.	1210.	27.	164.	40.	1	11.20	15.0	-0.1	2	
56	1968	0.	0.	0.	0.	0.		0.0	0.0	0.0		
57	1968	4600.	1040.	21.	93.	22.	1	15.40	-100.0	-0.1	2	
58	1968	150000.	17600.	13.	818.	20.	1	26.30	53.0	-0.1	2	
59		0.	0.	0.	0.	0.		0.0	0.0	0.0		
60	1969	10000.	2520.	15.	268.	10.	1	11.46	9.0	0.1	3	
61	1969	0.	0.	0.	0.	0.		0.0	0.0	0.0		
62	1969	0.	0.	0.	0.	0.		0.0	0.0	0.0		
63	1969	0.	0.	0.	0.	0.		0.0	0.0	0.0		
64	1969	84000.	5500.	17.	488.	19.	1	14.70	-100.0	-0.1	2	
65	1969	38000.	4440.	7.	551.	9.	1	10.32	11.0	-0.1	2	
66	1969	0.	0.	0.	0.	0.		0.0	0.0	0.0		
67	1969	1850.	285.	22.	115.	28.	1	7.50	3.3	0.2	2	
68	1969	700.	149.	42.	79.	34.	1	2.61	4.9	-0.1	3	
69		0.	0.	0.	0.	0.		0.0	0.0	0.0		
70	1969	0.	0.	0.	0.	0.		0.0	0.0	0.0		
71	1969	0.	0.	0.	0.	0.		0.0	0.0	0.0		
72	1969	6900.	580.	20.	135.	30.	1	5.91	18.0	-0.1	3	
73	1969	0.	0.	0.	0.	0.		0.0	0.0	0.0		
74	1967	0.	0.	0.	0.	0.		0.0	0.0	0.0		
75		0.	0.	0.	0.	0.		0.0	0.0	0.0		
76		0.	0.	0.	0.	0.		0.0	0.0	0.0		
77	1969	0.	0.	0.	0.	0.		0.0	0.0	0.0		
78	1969	0.	0.	0.	0.	0.		0.0	0.0	0.0		
79	1966	0.	0.	0.	0.	0.		0.0	0.0	0.0		
80	1969	0.	0.	0.	0.	0.		0.0	0.0	0.0		

TABLE # 50
GENERAL TERRAIN

SITE #	TER. TYPE	VEG.	FOR. TYPE	VEG.	FOR. TYPE	VEG.	FOR. TYPE	LAND USE	LAND USE	COMMENTS
1	2	5	1	5	2	0	0	0	0	
2	5	5	1	2	0	0	0	1	0	
3	6	2	0	5	1	0	0	1	0	TILL PLAIN
4	6	2	0	5	1	0	0	2	3	HUMMOCKY PLAIN
5	6	5	1	7	0	0	0	0	0	
6	6	4	1	7	0	0	0	1	0	HUMMOCKY PLAIN
7	5	5	1	7	0	0	0	0	0	
8	6	2	0	5	1	0	0	2	0	HUMMOCKY PLAIN
9	5	4	2	7	2	0	0	1	0	
10	5	2	0	4	1	0	0	2	0	THIN LACUSTRINE DEP.OVERLYING TILL
11	5	2	0	0	0	0	0	2	0	
12	1	5	2	0	0	0	0	3	0	MOUNTAINOUS AREA
13	2	6	1	6	2	0	0	3	0	
14	5	5	2	5	1	0	0	1	4	
15	5	2	0	5	1	5	2	1	3	
16	6	5	1	C	0	0	0	0	0	
17	5	5	1	5	2	7	0	0	0	
18	2	6	2	0	0	0	0	0	0	
19	5	7	2	5	1	0	0	0	0	
20	5	5	2	7	0	0	0	0	0	
21	5	5	1	5	2	7	0	0	0	
22	3	2	0	5	1	7	0	1	0	TILL PLAIN
23	5	5	1	5	2	0	0	0	0	
24	5	4	1	2	0	0	0	1	3	TILL PLAIN
25	6	2	0	7	1	0	0	2	0	
26	5	2	0	5	1	0	0	2	0	TILL PLAIN
27	5	2	0	0	0	0	0	2	3	TILL PLAIN
28	6	7	2	4	1	0	0	0	0	OLD LAKE BOTTOM
29	6	2	0	4	1	7	2	2	3	PROB. OLD DELTA RIV.DISAPPEARS D/S
30	6	2	0	5	1	7	2	2	0	RIVER ENTERS LOGJAM BELOW REACH
31	6	5	1	7	2	0	0	0	0	TILL PLAIN
32	5	5	1	2	0	0	0	1	0	
33										
34	1	5	2	1	0	0	0	0	0	MOUNTAINOUS VALLEY
35	2	5	1	5	2	7	0	0	0	
36	5	7	0	2	C	5	1	1	3	
37	5	2	0	0	0	0	0	4	1	LAKE BED AND TILL PLAIN
38	5	2	0	4	1	0	0	2	0	HUMMOCKY TILL PLAIN
39	1	5	1	1	C	C	0	0	0	MOUNTAINOUS
40	2	5	2	4	1	0	0	0	0	

TABLE # 48
HYDRAULIC GEOMETRY BASED ON VALLEY FLAT

(ALL DISCHARGES IN CFS.;DISTANCES IN FT.)

SITE #	YEAR OF SURVEY	DISCHARGE	X-SEC. AREA	COEF. OF VAR.%	WATER SURF. WIDTH	COEF. OF VAR.%	INTER-POLATION CODE	STAGE	RETURN PERIOD YR	% OF TIME	QUAL CODE	COMMENTS
81	1969	0.	0.	0.	0.	0.		0.0	0.0	0.0		
82	1965	0.	0.	0.	0.	0.		0.0	0.0	0.0		
83	1969	9200.	920.	33.	225.	42.	1	6.12	30.0	-0.1	1	
84	1966	0.	0.	0.	0.	0.		0.0	0.0	0.0		
85	1967	0.	0.	0.	0.	0.		0.0	0.0	0.0		
86	1967	0.	0.	0.	0.	0.		0.0	0.0	0.0		
87	1967	18000.	3220.	48.	415.	72.	1	8.38	8.6	-0.1	2	
88	1962	17200.	2570.	24.	396.	25.	1	9.20	3.7	-0.1	3	
89	1965	0.	0.	0.	0.	0.		0.0	0.0	0.0		
90	1966	61000.	6650.	14.	473.	19.	1	17.14	9.1	-0.1	1	
91	1967	0.	0.	0.	0.	0.		0.0	0.0	0.0		
92	1967	1500.	315.	28.	100.	29.	1	7.17	3.7	0.4	1	
93	1967	2310.	420.	9.	102.	9.	1	5.87	7.0	-0.1	1	
94	1965	4000.	680.	18.	211.	24.	1	6.20	1.6	1.4	1	
95	1967	9800.	1235.	21.	252.	17.	1	10.40	14.0	-0.1	2	
96	1967	0.	0.	0.	0.	0.		0.0	0.0	0.0		
97	1962	3540.	760.	18.	114.	23.	1	9.10	10.0	-0.1	3	
98	1967	7200.	1150.	16.	163.	25.	1	11.03	22.0	-0.1	3	
99		0.	0.	0.	0.	0.		0.0	0.0	0.0		
100	1962	0.	0.	0.	0.	0.		0.0	0.0	0.0		
101	1962	6300.	1400.	33.	250.	43.	1	8.30	59.0	-0.1	2	
102		0.	0.	0.	0.	0.		0.0	0.0	0.0		
103	1966	0.	0.	0.	0.	0.		0.0	0.0	0.0		
104	1962	0.	0.	0.	0.	0.		0.0	0.0	0.0		
105		0.	0.	0.	0.	0.		0.0	0.0	0.0		
106	1965	420.	110.	42.	59.	55.	1	4.70	18.0	-0.1	2	
107	1967	0.	0.	0.	0.	0.		0.0	0.0	0.0		
108	1966	17300.	2950.	26.	389.	23.	1	10.14	-100.0	-0.1	2	
109	1962	0.	0.	0.	0.	0.		0.0	0.0	0.0		
110	1966	9500.	1260.	11.	173.	11.	1	9.99	-100.0	-0.1	2	
111	1968	0.	0.	0.	0.	0.		0.0	0.0	0.0		
112	1968	0.	0.	0.	0.	0.		0.0	0.0	0.0		
113	1969	1900.	380.	18.	144.	41.	1	6.72	2.0	1.1	2	
114		0.	0.	0.	0.	0.		0.0	0.0	0.0		
115	1970	0.	0.	0.	0.	0.		0.0	0.0	0.0		
116	1970	1950.	464.	12.	96.	13.	0	6.48	9.5	0.1	2	
117	1970	5260.	1707.	11.	138.	11.	0	15.35	2.0	0.4	2	
118	1970	268.	86.	16.	36.	36.	0	8.44	31.0	-0.1	2	
119	1970	1500.	469.	22.	90.	31.	0	10.97	12.0	-0.1	2	
120	1970	53500.	5610.	20.	459.	19.	0	20.90	-100.0	-0.1	2	

TABLE #50

*** GENERAL TERRAIN ***

EXPLANATIONS:

1. ALL INFORMATION IN THIS TABLE IS BASED ON THE TERRAIN ABOVE THE VALLEY AND INCLUDES AN AREA WITH A RADIUS OF ABOUT 2 OR 3 MILES.

2. CODE FOR TERRAIN DESCRIPTION
   0 NOT APPLICABLE
   1 MOUNTAINOUS
   2 FOOTHILLS
   3 UPLANDS
   4 HILLS
   5 PLAINS
   6 LOWLANDS

   THIS CODE WAS EVALUATED FROM DATA IN THE ATLAS OF ALBERTA (1969)

3. CODE FOR VEGETATION TYPE
   0 NOT APPLICABLE
   1 ALMOST NONE
   2 GRASS
   3 SHRUBS
   4 SPARSELY FORESTED (0-25. FOREST COVER IN FORESTED AREA)
   5 MODERATELY FORESTED (25-75% FOREST COVER IN FORESTED AREA)
   6 HEAVILY FORESTED (75-100% FOREST COVER IN FORESTED AREA)
   7 SWAMP OR MUSKEG

4. CODE FOR FOREST TYPE
   0 NOT APPLICABLE
   1 DECIDUOUS
   2 CONIFEROUS

   CODES 3 AND 4 ARE MULTIPLE CODES WHICH ARE USED AS COMPLIMENTARY PAIRS. THE FIRST PAIR OF CODES 3 AND 4 ARE OF PRIMARY IMPORTANCE. THE SECOND AND THIRD PAIRS ARE OF DECREASING IMPORTANCE.

5. CODE FOR LAND USE
   0 NO CULTIVATION OR BUILT-UP AREAS
   1 PARTLY CULTIVATED
   2 MAINLY CULTIVATED
   3 PARTLY BUILT-UP
   4 URBANIZED

   THIS CODE IS MULTIPLE CODE. THE FIRST CODE IS OF PRIMARY IMPORTANCE AND THE SECOND IS OF SECONDARY IMPORTANCE.

6. COMMENTS

   THE COMMENTS PROVIDE SOME ADDITIONAL INFORMATION RELATED TO THE TERRAIN ABOVE THE VALLEY.

TABLE # 5C
GENERAL TERRAIN

SITE #	TER. TYPE	VEG.	FOR. TYPE	VEG.	FOR. TYPE	VEG.	FOR. TYPE	LAND USE	LAND USE	COMMENTS
41	5	2	0	5	1	7	0	2	0	
42	5	7	0	5	1	2	0	1	0	
43	2	5	2	0	0	0	0	0	0	
44	5	6	2	5	1	7	0	0	0	
45	5	2	0	3	0	0	0	2	0	TILL PLAIN
46	5									
47										
48	2	5	1	0	0	0	0	0	0	
49	5	2	0	0	0	0	0	2	3	TILL PLAIN
50	5	2	0	0	0	0	0	2	0	TILL PLAIN
51	5	2	0	0	0	0	0	1	0	HUMMOCKY PLAIN
52	2	5	2	5	1	0	0	0	0	
53	5	2	0	0	0	0	0	2	0	
94	5	2	0	0	0	0	0	2	0	TILL PLAIN
55	5	2	0	5	1	0	0	2	0	
56	5	2	0	0	0	0	0	2	0	TILL PLAIN
57	5	2	0	0	0	0	0	2	0	TILL PLAIN
58	5	2	0	0	0	0	0	1	3	
59										
60	1	1	0	5	2	0	0	0	0	
61	1	4	2	3	0	1	0	0	0	
62	2	1	0	4	2	0	0	0	0	LARGE OUTWASH PLAIN NEAR REACH
63	2	2	0	4	1	0	0	1	0	
64	5	2	0	0	0	0	0	4	0	
65	5	2	0	0	0	0	0	2	0	TILL PLAIN
66	5	2	0	0	0	0	0	3	0	GROUND MORAINE
67	1	5	2	0	0	0	0	3	0	
68	1	4	2	1	0	0	0	0	0	
69										
70	1	5	2	1	0	0	0	0	0	
71	2	5	2	5	1	0	0	0	0	MOUNTAINOUS
72	2	2	1	4	2	4	0	0	0	
73	2	2	1	4	0	1	0	1	0	
74	2	5	2	4	1	1	0	1	0	
75										
76										
77	2	5	1	2	0	0	0	0	0	
78	2	2	0	0	0	0	0	2	0	
79	5	2	0	0	0	0	0	2	0	
8C	2	2	0	3	0	0	0	1	0	

TABLE # 5C
GENERAL TERRAIN

SITE #	TER. TYPE	VEG.	FOR. TYPE	VEG.	FOR. TYPE	VEG.	FOR. TYPE	LAND USE	LAND USE	COMMENTS
81	2	2	0	3	0	0	0	2	0	
82	2	5	1	2	0	0	0	1	0	
83	2	2	0	0	0	0	0	2	0	
84	4	2	0	0	0	0	0	2	0	
85	2	2	0	0	0	0	0	1	0	
86	2	2	0	0	0	0	0	2	0	
87	5	2	0	0	0	0	0	1	0	FLOOR OF PRE-GLAC VAL.TILL&LAC DEP
88	5	2	0	0	0	0	0	2	1	
89	5	2	0	0	0	0	0	2	0	TILL PLAIN
90	5	2	0	0	0	0	0	2	4	
91	5	2	0	0	0	0	0	1	0	IRRIGATION
92	1	5	1	0	0	0	0	3	0	SHORTLY U/S OF SLIDE
93	2	2	0	0	0	0	0	1	0	
94	2	2	0	0	0	0	0	1	0	
95	2	2	0	0	0	0	0	2	0	
96	5	2	0	0	0	0	0	2	1	
97	5	2	0	0	0	0	0	2	0	
98	5	2	0	7	0	0	0	2	0	
99										
100	2	2	0	5	1	0	0	0	0	
101	5	2	0	0	0	0	0	1	0	
102										
103	2	2	0	5	1	0	0	0	0	UPPER FOOTHILLS
104	5	2	0	0	0	0	0	2	0	
105										
106	2	5	1	2	0	1	0	0	0	
107	2	2	0	0	0	0	0	1	0	
108	5	2	0	0	0	0	0	1	0	
109	5	2	0	0	0	0	0	2	1	
110	5	2	0	0	0	0	0	1	3	
111										
112	5	2	0	0	0	0	0	1	0	
113	1	5	2	1	0	0	0	0	0	MOUNTAINOUS
114										
115	5	2	0	0	0	0	0	2	0	
116	5	5	1	7	0	2	0	1	0	
117	3	5	1	2	0	0	0	1	0	HUMMOCKY PLAIN
118	5	2	0	3	0	0	0	1	0	TILL PLAIN
119	5	2	0	0	0	0	0	2	0	
120	6	5	1	5	2	1	0	0	0	

TABLE #51

*** CLIMATE OVER THE BASIN ***

(ALL PRECIPITATION IN IN.,AND TEMPERATURES IN DEG. F.)

EXPLANATIONS:

1. THE SOURCES OF ALL DATA FOR THIS TABLE ARE:
   1.ATLAS OF ALBERTA (1969): GOVERNMENT OF ALBERTA AND UNIVERSITY OF ALBERTA.
   2.LONGLEY, R.W. (1968): CLIMATIC MAPS FOR ALBERTA: DEPARTMENT OF GEOGRAPHY, UNIVERSITY OF ALBERTA

2. ANNUAL SNOWFALL
   THIS IS THE AVERAGE ANNUAL SNOWFALL EXPRESSED AS WATER EQUIVALENT.
   (NOT PRESENTED IN TABLE)

3. APRIL TO SEPTEMBER PRECIPITATION

4. ANNUAL PRECIPITATION
   THE ANNUAL PRECIPITATION MINUS THE APRIL TO SEPTEMBER PRECIPITATION SHOULD BE APPROXIMATELY EQUAL TO THE ANNUAL SNOW WATER EQUIVALENT.

5. MEAN JANUARY TEMPERATURE
   IF TEMPERATURE IS 0.0 USE 0.1 SINCE 0.0 IS USED FOR A TEST.
   IF TEMPERATURE IS -1.0 USE -1.1 SINCE -1.0 IS USED FOR A TEST.

6. MEAN JULY TEMPERATURE

7. MEAN ANNUAL TEMPERATURE
   THIS WAS NOT AVAILABLE IN THE PUBLISHED CHARTS BUT WAS ASSUMED TO BE THE AVERAGE OF THE MEAN JANUARY AND MEAN JULY TEMPERATURES.

TABLE # 51
CLIMATE OVER THE BASIN

(PRECIP. IN IN. AND TEMP. IN DEG. F.)

SITE #	PRECIPITATION SNOW	PRECIPITATION APR-SEP	PRECIPITATION ANNUAL	TEMPERATURE JAN.	TEMPERATURE JULY	TEMPERATURE ANNUAL
1	0.	-1.	-1.	-1.	-1.	-1.
2	0.	-1.	-1.	-1.	-1.	-1.
3	0.	-1.	-1.	-1.	-1.	-1.
4	0.	-1.	-1.	-1.	-1.	-1.
5	0.	-1.	-1.	-1.	-1.	-1.
6	0.	-1.	-1.	-1.	-1.	-1.
7	0.	-1.	-1.	-1.	-1.	-1.
8	0.	14.	17.	8.	56.	32.
9	0.	12.	17.	5.	59.	32.
10	0.	16.	19.	8.	55.	32.
11	0.	12.	17.	0.	59.	30.
12	0.	-1.	-1.	-1.	-1.	-1.
13	0.	17.	21.	12.	56.	34.
14	0.	16.	21.	9.	59.	34.
15	0.	16.	20.	7.	59.	33.
16	0.	14.	19.	3.	60.	32.
17	0.	14.	19.	3.	60.	32.
18	0.	16.	20.	11.	52.	32.
19	0.	16.	21.	11.	58.	34.
20	0.	16.	21.	9.	58.	34.
21	0.	16.	21.	11.	58.	34.
22	0.	15.	20.	3.	59.	31.
23	0.	16.	21.	10.	58.	34.
24	0.	16.	21.	9.	59.	34.
25	0.	15.	20.	7.	60.	34.
26	0.	15.	20.	3.	60.	32.
27	0.	15.	20.	3.	60.	32.
28	0.	12.	18.	3.	60.	32.
29	0.	15.	19.	3.	59.	31.
30	0.	15.	19.	3.	60.	32.
31	0.	14.	17.	-3.	60.	28.
32	0.	13.	17.	0.	61.	30.
33	0.	0.	0.	0.	0.	0.
34	0.	-1.	-1.	-1.	-1.	-1.
35	0.	-1.	-1.	-1.	-1.	-1.
36	0.	17.	21.	12.	56.	34.
37	0.	16.	21.	10.	59.	34.
38	0.	13.	17.	7.	61.	34.
39	0.	-1.	-1.	-1.	-1.	-1.
40	0.	-1.	-1.	-1.	-1.	-1.

(PRECIP. IN IN. AND TEMP. IN DEG. F.)

SITE #	PRECIPITATION SNOW	PRECIPITATION APR-SEP	PRECIPITATION ANNUAL	TEMPERATURE JAN.	TEMPERATURE JULY	TEMPERATURE ANNUAL
41	0.	17.	22.	12.	58.	35.
42	0.	16.	21.	11.	59.	35.
43	0.	-1.	-1.	-1.	-1.	-1.
44	0.	17.	21.	11.	56.	34.
45	0.	11.	15.	1.	62.	32.
46	0.	15.	15.	7.	60.	34.
47	0.	0.	0.	0.	0.	0.
48	0.	17.	21.	11.	56.	34.
49	0.	15.	21.	11.	58.	34.
50	0.	13.	17.	9.	60.	34.
51	0.	11.	16.	7.	63.	35.
52	0.	16.	21.	11.	56.	34.
53	0.	15.	20.	11.	58.	34.
54	0.	14.	20.	7.	60.	34.
55	0.	13.	19.	7.	62.	34.
56	0.	11.	18.	6.	62.	34.
57	0.	11.	18.	7.	62.	34.
58	0.	11.	16.	17.	66.	42.
59	0.	0.	0.	0.	0.	0.
60	0.	-1.	-1.	-1.	-1.	-1.
61	0.	-1.	-1.	-1.	-1.	-1.
62	0.	-1.	-1.	-1.	-1.	-1.
63	0.	-1.	-1.	-1.	-1.	-1.
64	0.	-1.	-1.	-1.	-1.	-1.
65	0.	-1.	-1.	-1.	-1.	-1.
66	0.	-1.	-1.	-1.	-1.	-1.
67	0.	-1.	-1.	-1.	-1.	-1.
68	0.	-1.	-1.	-1.	-1.	-1.
69	0.	0.	0.	0.	0.	0.
70	0.	-1.	-1.	-1.	-1.	-1.
71	0.	-1.	-1.	-1.	-1.	-1.
72	0.	-1.	-1.	-1.	-1.	-1.
73	0.	-1.	-1.	-1.	-1.	-1.
74	0.	16.	21.	16.	58.	37.
75	0.	-1.	-1.	-1.	-1.	-1.
76	0.	0.	0.	0.	0.	0.
77	0.	0.	0.	0.	0.	0.
78	0.	-1.	-1.	-1.	-1.	-1.
79	0.	13.	21.	16.	60.	38.
80	0.	-1.	-1.	-1.	-1.	-1.

(PRECIP. IN IN. AND TEMP. IN DEG. F.)

SITE #	PRECIPITATION SNOW	PRECIPITATION APR-SEP	PRECIPITATION ANNUAL	TEMPERATURE JAN.	TEMPERATURE JULY	TEMPERATURE ANNUAL
81	0.	14.	21.	17.	61.	39.
82	0.	-1.	-1.	-1.	-1.	-1.
83	0.	-1.	-1.	-1.	-1.	-1.
84	0.	14.	21.	16.	62.	39.
85	0.	-1.	-1.	-1.	-1.	-1.
86	0.	-1.	-1.	-1.	-1.	-1.
87	0.	-1.	-1.	-1.	-1.	-1.
88	0.	-1.	-1.	-1.	-1.	-1.
89	0.	-1.	-1.	-1.	-1.	-1.
90	0.	13.	20.	18.	64.	41.
91	0.	12.	20.	18.	66.	42.
92	0.	-1.	-1.	-1.	-1.	-1.
93	0.	-1.	-1.	-1.	-1.	-1.
94	0.	-1.	-1.	-1.	-1.	-1.
95	0.	-1.	-1.	-1.	-1.	-1.
96	0.	-1.	-1.	-1.	-1.	-1.
97	0.	12.	20.	17.	64.	40.
98	0.	12.	20.	18.	64.	41.
99	0.	0.	0.	0.	0.	0.
100	0.	-1.	-1.	-1.	-1.	-1.
101	0.	12.	21.	18.	64.	41.
102	0.	0.	0.	0.	0.	0.
103	0.	-1.	-1.	-1.	-1.	-1.
104	0.	-1.	-1.	-1.	-1.	-1.
105	0.	-1.	-1.	-1.	-1.	-1.
106	0.	-1.	-1.	-1.	-1.	-1.
107	0.	13.	19.	18.	64.	41.
108	0.	12.	17.	18.	63.	40.
109	0.	12.	20.	18.	64.	41.
110	0.	10.	17.	16.	66.	41.
111	0.	0.	0.	0.	0.	0.
112	0.	11.	16.	16.	67.	42.
113	0.	-1.	-1.	-1.	-1.	-1.
114	0.	0.	0.	0.	0.	0.
115	0.	13.	17.	5.	61.	33.
116	0.	15.	21.	7.	60.	34.
117	0.	14.	20.	3.	59.	31.
118	0.	11.	14.	1.	63.	32.
119	0.	12.	15.	6.	62.	34.
120	0.	13.	18.	-3.	60.	28.

TABLE #52

*** VALLEY CHARACTERISTICS WITHIN AND IN VICINITY OF REACH ***

(DEPTHS IN FT. AND WIDTHS IN MI.)

EXPLANATIONS:

1. FOR DETAILED EXPLANATIONS SEE WRITE-UP RELATED TO GEOGRAPHICAL DESCRIPTION OF THE REACH.

2. VALLEY MEASUREMENTS
   THESE MEASUREMENTS INCLUDE VALLEY DEPTH, VALLEY TOP WIDTH, AND VALLEY BOTTOM WIDTH.

3. SLUMPING OF VALLEY WALLS
   0 NONE
   1 OCCASIONAL
   2 FREQUENT

   THE SLUMPING DOES NOT HAVE TO BE IN CONTACT WITH THE RIVER.

4. LENGTH OF REACH WITH SLUMPING VALLEY WALLS IN CONTACT WITH CHANNEL.
   THE CODE IS THE PERCENT OF SLUMP CONTACT WITH CHANNEL BANKS IN THE REACH; THAT IS, THE AVERAGE OF THE PERCENT CONTACT ON THE LEFT BANK AND THE PERCENT CONTACT ON THE RIGHT BANK.

5. CODE FOR VEGETATION ON VALLEY WALL
   0 NOT APPLICABLE
   1 ALMOST NONE
   2 GRASS
   3 SHRUBS
   4 SPARSELY FORESTED (0-25% FOREST COVER IN FORESTED AREA)
   5 MODERATELY FORESTED (25-75% FOREST COVER IN FORESTED AREA)
   6 HEAVILY FORESTED (75-100% FOREST COVER IN FORESTED AREA)
   7 SWAMP OR MUSKEG

6. CODE FOR FOREST TYPE
   0 NOT APPLICABLE
   1 DECIDUOUS
   2 CONIFEROUS

   CODES 5 AND 6 ARE MULTIPLE CODES AND ARE USED AS COMPLIMENTARY PAIRS. CODES 5 AND 6 ARE OF PRIMARY IMPORTANCE, AND THE SECOND PAIR IS OF SECONDARY IMPORTANCE.

7. COMMENTS
   COMMENTS ARE USED TO AMPLIFY DATA PRESENTED IN THE TABLE.

TABLE # 52
VALLEY CHARACTERISTICS WITHIN AND IN VICINITY OF REACH

(ALL DEPTHS IN FT.;WIDTHS IN MILES)

SITE #	VALLEY MEASURE DEPTH	T/WIDTH	B/WIDTH	SLUMP CODE	SLUMP LENGTH %	VEG. V.W.	FOR. TYPE	VEG. V.W.	FOR. TYPE	COMMENTS
1	-1.	2.00	0.70	0	0	4	2	2	0	
2	600.	2.50	0.80	1	10	2	0	4	2	
3	650.	0.85	0.35	0	0	4	1	1	0	CLD SLUMP, PROBABLY INACTIVE
4	650.	3.00	0.80	1	5	4	1	4	2	SLUMPING BEYOND STUDY REACH
5	250.	2.50	1.25	1	15	5	1	1	0	SLUMPING RELATIVELY STABILIZED
6	100.	1.30	1.00	0	0	1	0	3	0	
7	75.	1.00	0.50	0	0	5	1	0	0	
8	500.	3.00	1.20	2	10	5	1	3	0	
9	450.	1.00	0.35	1	5	4	1	1	0	VALLEY DIMENSIONS QUITE VARIABLE
10	300.	1.20	0.15	2	90	3	0	4	1	CUT IN SHALES OF SMOKY GROUP
11	100.	1.00	0.15	1	10	5	1	2	0	WIDE SHALLOW VALLEY
12	-1.	-0.01	1.25	0	0	5	2	0	0	WIDE MOUNTAINOUS VALLEY
13	500.	2.50	0.30	0	0	5	2	5	1	VALLEY NOT WELL DEFINED
14	250.	2.50	1.50	1	0	4	2	4	1	SOME BED ROCK CLIFFS
15	250.	1.50	0.20	1	20	5	1	0	0	SLUMP CONSTRICTING RIVER AT 1 PT
16	250.	2.00	0.80	0	0	5	1	0	0	
17	50.	2.10	2.00	0	0	5	2	5	1	NEAR DELTA;LT. VAL. WALL UNCERT.
18	250.	0.80	0.40	0	0	5	1	0	0	
19	100.	0.30	0.05	0	0	4	1	0	0	
20	100.	1.20	0.40	0	0	5	2	0	0	
21	75.	0.60	0.30	0	0	5	1	1	0	
22	100.	0.70	0.50	0	0	4	1	1	0	
23	200.	1.50	0.60	0	0	5	1	0	0	
24	200.	0.20	0.05	0	0	1	0	5	1	
25	50.	1.50	1.20	0	0	1	0	0	0	VALLEY VERY WIDE AND SHALLOW
26	100.	0.55	0.35	1	0	5	1	0	0	
27	60.	0.25	0.10	0	0	1	0	5	1	CHAR.OF V.DIFF.U/S OF R.R.BR./U1
28	0.	0.0	0.0	0	0	0	0	0	0	NO VALLEY,IN OLD LAKE BOTTOM
29	0.	0.0	0.0	0	0	0	0	0	0	NO VALLEY,IN ALLUVIAL PL OR DELT
30	0.	0.0	0.0	0	0	0	0	0	0	NO VALLEY,IN ALLUVIAL PL OR DELT
31	350.	2.00	1.00	0	5	5	1	2	0	
32	150.	0.35	0.20	0	0	5	1	1	0	
33	0.	0.0	0.0							
34	-1.	-0.01	0.70	0	0	5	2	1	0	
35	300.	1.40	0.40	0	0	5	2	1	0	
36	75.	0.50	0.30	0	0	5	1	1	0	
37	175.	0.70	0.30	0	0	5	1	1	0	
38	225.	1.00	0.40	0	0	2	0	5	1	
39	-1.	-0.01	0.50	0	0	4	2	0	0	
40	-1.	-0.01	0.20	0	0	5	1	5	2	VALLEY MEASUREMENTS VERY APPROX.

TABLE # 52
VALLEY CHARACTERISTICS WITHIN AND IN VICINITY OF REACH

(ALL DEPTHS IN FT.;WIDTHS IN MILES)

SITE #	VALLEY MEASURE DEPTH	T/WIDTH	B/WIDTH	SLUMP CODE	SLUMP LENGTH %	VEG. V.W.	FOR. TYPE	VEG. V.W.	FOR. TYPE	COMMENTS
41	75.	1.00	0.25	0	0	2	0	5	1	
42	50.	0.50	0.15	0	0	5	1	0	0	
43	200.	0.50	0.05	0	0	1	0	4	2	
44	150.	0.40	0.05	0	0	1	0	5	2	
45	50.	0.40	0.25	0	0	2	0	3	0	POSSIBLY OLD SLUMPS ON V. WALL
46	0.	0.0	0.0							
47	0.	0.0	0.0							
48	150.	1.00	0.20	0	0	5	1	5	2	
49	100.	1.50	0.50	1	5	5	1	3	0	
50	400.	1.50	0.30	0	0	1	0	2	0	BADLANDS TOPOGRAPHY
51	250.	2.00	1.00	0	0	1	0	2	0	VAL WIDENS IN RCH
52	200.	0.40	0.15	0	0	5	1	0	0	
53	100.	0.30	0.15	0	0	5	1	1	0	
54	50.	0.30	0.15	0	0	3	0	2	0	
55	100.	0.79	0.30	0	0	2	0	5	1	
56	300.	0.40	0.10	0	0	1	0	0	0	
57	125.	0.50	0.30	1	0	2	0	1	0	
58	300.	1.80	1.20	1	10	4	1	1	0	
59	0.	0.0	0.0							
60	0.	0.0	0.80	0	0	0	0	0	0	
61	0.	0.0	0.25	0	0	0	0	0	0	REACH LIES EAST EDGE OF ROCKIES
62	200.	0.10	0.05	0	0	1	0	4	2	IN GORGE
63	100.	0.20	0.10	0	0	2	0	4	1	
64	200.	1.20	0.40	0	0	2	0	4	1	SMALL VALLEY IN WIDE VALLEY
65	120.	0.80	0.65	0	0	1	0	4	1	
66	130.	1.00	0.40	2	30	1	2	0	0	
67	0.	0.0	0.0	0	0	0	0	0	0	
68	0.	0.0	0.0	0	0	0	0	0	0	
69	0.	0.0	0.0							
70	0.	0.0	0.15	0	0	0	0	0	0	
71	75.	0.25	0.03	0	0	5	2	4	1	
72	200.	0.40	0.08	0	0	1	0	5	2	SMALL VALLEY IN LARGE VALLEY
73	65.	0.25	0.15	0	0	2	0	4	1	
74	100.	0.50	0.35	0	0	5	2	5	1	
75	0.	0.0	0.0							
76	0.	0.0	0.0							
77	100.	0.80	0.30	0	0	5	1	2	0	
78	100.	0.50	0.20	0	0	2	0	0	0	
79	120.	0.40	0.35	0	0	2	0	1	0	
80	75.	0.40	0.25	0	0	2	0	0	0	

TABLE # 52
VALLEY CHARACTERISTICS WITHIN AND IN VICINITY OF REACH

(ALL DEPTHS IN FT.;WIDTHS IN MILES)

SITE #	VALLEY MEASURE DEPTH	T/WIDTH	B/WIDTH	SLUMP CODE	SLUMP LENGTH %	VEG. V.W.	FOR. TYPE	VEG. V.W.	FOR. TYPE	COMMENTS
81	75.	0.30	0.15	0	0	1	0	2	0	
82	250.	0.30	0.03	1	10	1	0	5	1	
83	75.	0.60	0.20	0	0	2	0	3	0	
84	35.	0.40	0.30	0	0	2	0	4	1	
85	100.	0.60	0.40	0	0	2	0	3	0	SMALL VALLEY CUT IN WIDE VALLEY
86	150.	0.35	0.15	0	0	2	0	3	0	
87	150.	0.50	0.35	0	0	2	0	4	1	VALLEY WIDENS AT REACH
88	50.	0.70	0.35	0	0	3	0	2	0	
89	175.	0.30	0.20	0	0	1	0	2	0	
90	300.	0.80	0.40	1	5	2	0	0	0	DISSECTED VALLEY SLOPES
91	200.	1.00	0.60	1	5	2	0	0	0	
92	-1.	-0.01	0.40	0	0	1	0	4	2	
93	175.	0.40	0.20	0	0	2	0	1	0	
94	150.	0.50	0.35	0	0	2	0	5	1	
95	200.	0.40	0.25	0	0	2	0	1	0	
96	75.	0.50	0.40	0	0	2	0	4	1	
97	50.	0.35	0.25	0	0	2	0	0	0	
98	50.	0.20	0.15	0	0	2	0	1	0	VALLEY NOT WELL DEFINED
99	100.	0.20	0.30	0	0	2	0	1	0	
100	100.	0.25	0.10	0	0	2	0	5	1	
101	100.	0.70	0.55	0	0	2	0	1	0	
102	0.	0.0	0.0							
103	-1.	-0.01	0.10	0	0	2	0	3	0	FOR LOWER PART OF VALLEY
104	50.	0.35	0.20	0	0	3	0	2	0	VALLEY NOT WELL DEFINED;NR CONFL
105	0.	0.0	0.0							
106	50.	0.20	0.10	0	0	3	0	5	1	
107	100.	0.40	0.10	0	0	2	0	4	1	
108	200.	0.50	0.10	1	5	2	0	1	0	
109	100.	0.40	0.20	0	0	2	0	4	1	
110	25.	0.30	0.15	0	0	2	0	1	0	
111	0.	0.0	0.0							
112	400.	1.50	0.15	2	20	2	0	1	0	
113	-1.	-0.01	0.25	0	0	0	0	0	0	IN MOUNTAINOUS VALLEY
114	0.	0.0	0.0							
115	100.	0.35	0.08	0	0	5	1	5	2	
116	50.	0.20	0.04	0	0	5	2	5	1	
117	0.	0.0	0.0	0	0	0	0	0	0	
118	50.	0.20	0.10	0	0	2	0	3	0	
119	75.	0.35	0.20	0	0	2	0	0	0	
120	300.	1.20	0.70	1	15	5	1	0	0	

TABLE #54

*** TERRACES ***

EXPLANATIONS:

1. A TERRACE IS DEFINED AS A FLAT ASSOCIATED WITH THE RIVER, BUT WHICH IS NEVER FLOODED OR ONLY FLOODED INFREQUENTLY. IN MOST CASES THE DISCHARGE REQUIRED TO FLOOD ANY TERRACE HAS A RETURN PERIOD GT. TEN YEARS.
2. CODE FOR TERRACE PRESENCE
   - 0 NONE
   - 1 INDEFINITE
   - 2 FRAGMENTARY
   - 3 CONTINUOUS

   CONTINUOUS MEANS THAT THERE ARE CONTINUOUS TERRACES. EACH TERRACE LEVEL DOES NOT HAVE TO BE CONTINUOUS.
3. CODE FOR NUMBER OF LEVELS
   - 0 NONE
   - 1 ONE LEVEL
   - 2 TWO LEVELS
   - N N LEVELS
   - . .....
   - 9 SEVERAL LEVELS.
4. COMMENTS
   THE COMMENTS GIVE ADDITIONAL INFORMATION CONCERNING LAND-USE, AND VEGETATION IF THE DATA ARE CONSIDERED TO BE IMPORTANT. STATEMENTS ARE MADE TO INDICATE IF THE LOWEST TERRACE CORRESPONDS TO THE VALLEY FLAT.

TABLE # 54
TERRACES

SITF #	TERRACE CODE	# LEVELS	CCPMENTS
41	3	3	VALLEY FLAT CORRESPCNDS TO LOWEST TERRACE
42	3	3	VALLEY FLAT COPRESPCNDS TO LOWEST TERRACE
43	2	2	
44	2	1	
45	1	1	
46			
47			
48	3	9	SEVERAL TERRACE LEVELS.CN PREDOMINANT TERR.
49	3	9	
50	3	2	MAIN LOW TERRACE: UPPER DISSECTED TERRACE
51	3	2	AT LEAST ONE WELL-DEFINED TERRACE
52	2	9	SEVERAL CF LIMITED EXTENT.LOWEST CORR TO VF
53	3	2	
54	0	1	
55	3	9	LCWEST TERRACE CCRRESPONDS TO VALLEY FLAT
56	3	1	CORRESPONDS TO VALLEY FLAT
57	3	9	LCWEST TERRACE CORRESPCNDS TO VALLEY FLAT
58	2	9	SCME BUILT UP,MED.HAT CN TERR.VF IS LO TER
59			
60	0	0	IN OLD LAKE BOTTCM
61	2	1	CORRESPCNCS TO VALLEY FLAT
62	1	9	SMALL FEATURES
63	2	1	
64	3	3	LCWEST TERRACE CORRESPONCS TO VALLEY FLAT
65	3	1	
66	3	1	RANGELAND
67	C	0	
68	0	0	
69			
70	0	0	
71	2	2	
72	1	9	
73	3	1	
74	3	1	CCRRESPCNDS TO VALLEY FLAT
75			
76			
77	2	9	
78	3	9	
79	3	9	SLIP-OFF SLCPES
80	3	1	ALSO SLIP-OFF SLOPES

TABLE # 54
TERRACES

SITE #	TERRACE CODE	# LEVELS	COMMENTS
1	3	9	
2	2	9	
3	2	1	LOWEST LEVEL CORRESPONDS TO VALLEY FLAT
4	2	2	LOWEST LEVEL CORRESPONDS TO VALLEY FLAT
5	2	1	LOWEST LEVEL CORRESPONDS TO VALLEY FLAT
6	2	2	LOWEST LEVEL CORRESPONDS TO VALLEY FLAT
7	2	2	LOW TERRACE IS VALLEY FLAT
8	3	9	
9	2	2	ONE HIGH TERRACE
10	2	9	LOWEST ONE MAY BE FLOODED & CORR.TO VAL.FLAT
11	3	9	
12	3	9	ONE LOW TERRACE ABOVE VALLEY FLAT
13	3	3	LOWEST LEVEL CORRESPONDS TO VALLEY FLAT
14	3	2	
15	2	2	ONE HIGH LEVLE
16	3	1	LIMESTONE BENCH
17	2	1	
18	3	2	
19	2	2	LOWEST LEVEL CORR. TO VALLEY FLAT
20	3	2	LOWEST LEVEL CORR. TO VALLEY FLAT
21	2	1	LOW TERRACE CORRESPONDS TO VALLEY FLAT
22	3	2	
23	3	2	BOTH CORRESPOND TO VALLEY FLAT
24	2	9	SLIP-OFF SLOPES
25	3	2	
26	0	0	PARTS OF V. FLAT MAY BE LOW TERRACE
27	2	9	NOT TOO EXTENSIVELY DEVELOPED
28	2	1	
29	3	1	MAY BE FLOODED AT TIMES CORR.TO VALLEY FLAT
30	3	1	MAY BE FLOODED AT TIMES CORR.TO VALLEY FLAT
31	0	0	
32	0	0	
33			
34	1	1	
35	2	9	
36	2	3	LOWEST TERRACE IS PART OF VALLEY FLAT
37	2	4	LOWEST LEVEL CORRESP. TO VALLEY FLAT
38	2	9	
39	1	1	NOT TOO WELL DEFINED
40	3	3	

TABLE # 54
TERRACES

SITE #	TERRACE CODE	# LEVELS	COMMENTS
81	3	9	
82	1	9	SMALL,HIGH TERRACE
83	3	9	PARTLY BUILT-UP
84	2	1	PARTLY BUILT-UP
85	2	9	
86	3	1	VALLEY FLAT MAY BE LOW TERRACE
87	2	9	LOW TERRACE MAY BE FLOODED BUT ISNT VAL FLAT
88	3	9	
89	3	9	
90	2	1	
91	3	9	SOME HIGH TERRACES ON SLIP-OFF SLOPE
92	2	1	PARTLY BUILT-UP
93	2	9	
94	2	9	
95	2	9	
96	2	9	BUILT-UP(PINCHER CK).LOWEST TER CORR. TO VF
97	3	9	ONE PROMINENT LOW LEVLEL
98	3	1	
99			
100	3	2	
101	3	2	LOW LEVEL CORRESPONDS TO VALLEY FLAT
102			
103	2	9	NOT TOO WELL DEFINED
104	3	9	EXTENSIVE LATERAL DEVELOPMENT
105			
106	1	9	LOWEST LEVEL CORRESPONDS TO VALLEY FLAT
107	3	9	
108	3	9	
109	3	2	
110	3	2	
111			
112	2	2	ONE HIGH LEVEL TERRACE
113	2	1	
114			
115	2	1	
116	2	9	
117	0	0	
118	0	0	
119	3	9	ONE MAIN LEVEL AT BOTTOM OF MELT CHANNEL
120	2	2	ONE HIGH ON RIGHT

TABLE #55

*** RELATION OF CHANNEL TO VALLEY ***

EXPLANATIONS:

1. ADDITIONAL INFORMATION RELATED TO THIS TABLE IS GIVEN IN THE DETAILED WRITE-UP FOR THE GEOGRAPHICAL DESCRIPTION OF A RIVER REACH.

2. CODE FOR VALLEY TYPE
   - 0 NOT APPLICABLE
   - 1 STREAM CUT VALLEY
   - 2 STREAM CUT VALLEY IN WIDE VALLEY
   - 3 WIDE MOUNTAINOUS VALLEY

3. CODE IF NO VALLEY PRESENT
   - 0 VALLEY PRESENT
   - 1 ON ALLUVIAL FAN
   - 2 ON ALLUVIAL PLAIN
   - 3 IN DELTA
   - 4 IN OLD LAKE

4. CODE FOR UNDERFIT RIVER
   - 0 NOT APPLICABLE OR NOT OBVIOUSLY UNDERFIT
   - 1 OBVIOUSLY UNDERFIT

5. CODE FOR LOCAL LATERAL CONSTRICTION
   - 0 NONE
   - 1 ONE LOCAL LATERAL CONSTRICTION
   - 2 TWO LOCAL LATERAL CONSTRICTIONS
   - N N LOCAL LATERAL CONSTRICTIONS
   - ....
   - 9 SEVERAL LOCAL LATERAL CONSTRICTIONS

6. CODE FOR RELATION OF CHANNEL TO VALLEY BOTTOM (VERTICAL)
   - 0 NOT APPLICABLE
   - 1 NOT OBVIOUSLY DEGRADING OR AGGRADING
   - 2 PARTLY ENTRENCHED
   - 3 ENTRENCHED
   - 4 AGGRADING

7. CODE FOR RELATION OF CHANNEL TO VALLEY WALLS AND/OR HIGH,RESISTANT TERRACES (LATERAL)
   - 0 NOT APPLICABLE (NO VALLEY OR FREE)
   - 1 OCCASIONALLY CONFINED
   - 2 FREQUENTLY CONFINED
   - 3 CONFINED
   - 4 ENTRENCHED

8. COMMENTS

   THE COMMENTS GIVE SOME ADDITIONAL INFORMATION CONCERNING THE RELATION OF THE CHANNEL TO THE VALLEY.

TABLE # 55
RELATION OF CHANNEL TO VALLEY

SITE #	VAL. TYPE	IF NC VALLEY	UNDER-FIT	LOC. LAT. CONST.	CHAN. TO VAL. BOT.	CHAN. TO VAL. WALL	COMMENTS
1	1	0	0	0	2	3	
2	1	0	0	0	2	3	TYPICAL FOR LONG REACH
3	1	0	0	0	3	4	
4	1	0	0	0	2	3	
5	1	0	0	0	2	2	
6	2	0	0	0	2	3	
7	1	0	0	0	2	3	CONSTRICTED BY SLUMP; ENTRENCHED U/S
8	1	0	0	1	2	2	
9	1	0	0	0	1	3	VERY PROMINENT SLUMPS
10	1	0	0	0	3	4	
11	1	0	0	0	3	4	CONSTRICTION AT UPPER END.CONFINED BY HI TERRACE
12	3	0	0	1	1	2	CONFINED BY TERRACES
13	2	0	0	0	3	4	
14	1	0	0	0	1	1	
15	1	0	0	0	3	4	
16	1	0	0	0	3	4	NEAR DELTA
17	1	0	0	0	1	1	CONFINED BY BEDROCK
18	2	0	0	0	1	3	
19	1	0	0	0	3	4	
20	1	0	0	0	2	2	
21	2	0	0	0	2	3	
22	1	0	0	0	1	1	
23	1	0	0	0	2	1	
24	1	0	0	0	3	4	
25	1	0	0	0	1	1	POSSIBLY IN EARLY STAGE OF ENTRENCHMENT
26	1	0	0	0	1	1	ENTRENCHED U/S OF U1
27	1	0	0	0	1	1	OCC. CONFINED BY TERRACE (OLD ISLAND)
28	0	4	0	0	1	0	MAY BE IN DELTA AREA OF FORMER LAKE
29	0	2	0	0	0	0	RIVER DEGRADING NOW DUE TO STRAIGHTENING D/S
30	0	2	0	0	0	0	
31	1	0	0	0	1	2	GLACIAL SPILLWAY
32	1	0	0	0	1	3	
33							CONSTRICTED BY FAN AND END MORAINE AT GAUGE
34	3	0	0	1	1	2	
35	2	0	0	0	3	4	
36	2	0	0	0	2	2	
37	1	0	0	0	3	4	
38	1	0	0	0	3	4	PROBABLY OLD LAKE
39	3	0	0	1	1	1	
40	3	0	0	0	2	1	

TABLE # 55
RELATION OF CHANNEL TO VALLEY

SITE #	VAL. TYPE	IF NO VALLEY	UNDER-FIT	LOC. LAT. CONST.	CHAN. TO VAL. BOT.	CHAN. TO VAL. WALL	COMMENTS
41	1	0	0	0	2	3	ALMOST ENTRENCHED
42	1	0	0	0	2	3	ALMOST ENTRENCHED
43	1	0	0	0	1	3	
44	1	0	0	0	3	4	
45	1	0	1	0	1	1	IN OLD MELT CHANNEL
46							
47							
48	2	0	0	0	3	3	BRAIDED WITH BROAD VALLEY FLAT BELOW
49	1	0	0	0	2	2	
50	1	0	0	0	2	3	
51	1	0	0	0	1	2	CONTINUOUSLY CONFINED BY LOW TERRACE
52	2	0	0	0	2	3	
53	1	0	0	0	2	2	
54	1	0	0	0	1	1	
55	1	0	0	0	2	3	ENTRENCHMENT DEEPENS OVER REACH
56	1	0	0	0	2	3	
57	1	0	0	0	2	2	
58	1	0	0	0	2	3	
59							
60	3	0	0	0	1	1	OLD,FILLED-IN LAKE
61	3	0	0	0	3	4	IN BACKWATER OF DAM
62	2	0	0	3	3	4	GORGE CONTRICTED LOCALLY
63	2	0	0	1	2	3	
64	2	0	0	0	2	2	
65	1	0	0	0	2	2	LESS CONFINED D/S OF REACH
66	1	0	0	0	3	4	ON FAN BELOW GORGE
67	0	1	0	0	0	0	ON FAN BELOW GORGE
68	0	1	0	0	0	0	
69							
70	3	0	0	0	2	3	
71	2	0	0	1	2	3	
72	2	0	0	0	2	3	
73	1	0	0	0	1	3	
74	2	0	0	1	1	2	
75							
76							
77	2	0	0	1	3	4	BEING ENTRENCHED
78	2	0	0	1	3	4	
79	1	0	0	0	3	4	
80	1	0	1	0	1	1	

TABLE # 55
RELATION OF CHANNEL TO VALLEY

SITE #	VAL. TYPE	IF NO VALLEY	UNDER-FIT	LOC. LAT. CONST.	CHAN. TO VAL. BOT.	CHAN. TO VAL. WALL	COMMENTS
81	1	0	0	0	2	3	
82	2	0	0	0	3	4	
83	1	0	0	0	1	1	
84	1	0	0	0	1	2	
85	2	0	0	0	3	4	
86	1	0	0	0	1	3	
87	1	0	0	0	1	2	
88	1	0	0	0	1	1	
89	1	0	0	0	3	4	
90	1	0	0	0	1	3	
91	2	0	0	0	3	4	
92	3	0	0	0	1	3	
93	1	0	0	0	2	3	REACH ATYPICAL ENTRENCHED U/S&D/S. OLD LAKE?
94	1	0	0	0	1	2	
95	1	0	0	0	2	3	
96	1	0	0	0	2	3	
97	1	0	0	0	2	2	
98	1	0	0	0	2	3	
99							
100	1	0	0	0	3	3	
101	1	0	0	0	1	1	
102							
103	2	0	0	0	3	4	NOT DEEPLY ENTRENCHED
104	2	0	0	0	1	2	LARGE GLACIAL SPILLWAY
105							
106	2	0	0	0	2	2	
107	1	0	0	0	2	3	
108	1	0	0	0	2	3	RECENTLY ENTRENCHED IN VALLEY BOTTOM
109	1	0	0	0	2	2	
110	1	0	0	0	2	2	
111							
112	1	0	0	0	3	4	LITTLE LATERAL DEVELOPMENT
113	3	0	0	0	2	3	
114							
115	1	0	0	0	2	2	
116	1	0	0	0	2	3	
117	0	2	0	0	0	0	MIGHT BE UNDERFIT
118	1	0	1	0	1	1	ENTRENCHED IN MELT WATER CHANNEL
119	1	0	1	0	2	2	
120	1	0	0	0	2	2	

TABLE #56

*** VALLEY FLAT (LOWEST FLAT ASSOCIATED WITH PRESENT RIVER) ***

(ALL WIDTHS IN MILES)

EXPLANATIONS:

1. ADDITIONAL INFORMATION RELATED TO THIS TABLE IS GIVEN IN THE DETAILED WRITE-UP FOR THE GEOGRAPHICAL DESCRIPTION OF A RIVER REACH.

2. THE VALLEY FLAT IS THE LOWEST FLAT ADJOINING THE RIVER. IT MAY BE A FLOOD PLAIN OR THE LOWEST TERRACE.

3. CODE FOR VALLEY FLAT PRESENCE
   - 0 NONE
   - 1 INDEFINITE
   - 2 FRAGMENTARY
   - 3 CONTINUOUS

4. CODE FOR LATERAL EXTENT OF VALLEY FLAT
   - 0 NO VALLEY FLAT
   - 1 NARROW (LT. ONE CHANNEL WIDTH)
   - 2 MODERATE (BETWEEN ONE AND FIVE CHANNEL WIDTHS)
   - 3 WIDE (GT. FIVE CHANNEL WIDTHS)

5. AVERAGE WIDTH AND MAXIMUM WIDTH OF THE VALLEY FLAT IN THE REACH.

6. CHANNEL LENGTH IN THE REACH WITH VALLEY FLAT ON THE LEFT IN PERCENT

7. CHANNEL LENGTH IN THE REACH WITH VALLEY FLAT ON THE RIGHT IN PERCENT

8. CODE FOR VEGETATION TYPE ON THE VALLEY FLAT.
   - 0 NOT APPLICABLE OR NO VALLEY FLAT
   - 1 ALMOST NONE
   - 2 GRASS
   - 3 SHRUB
   - 4 SPARSELY FORESTED (0-25% FOREST COVER OVER FORESTED AREA)
   - 5 MODERATELY FORESTED (25-75% FORESTED COVER OVER FORESTED AREA)
   - 6 HEAVILY FORESTED (75-100% FOREST COVER OVER FORESTED AREA)
   - 7 SWAMP OR MUSKEG

9. CODE FOR FOREST TYPE
   - 0 NOT APPLICABLE OR NO VALLEY FLAT
   - 1 DECIDUOUS
   - 2 CONIFEROUS

   CODES 8 AND 9 ARE USED AS A PAIR, AND EACH PAIR IS A MULTIPLE CODE. THE FIRST PAIR OF 8 AND 9 CODES ARE MOST IMPORTANT. THE SECOND AND THIRD PAIRS ARE OF DECREASING IMPORTANCE.

TABLE #56 (CONTINUED)

10. CODE FOR LAND USE OF THE VALLEY FLAT
    0 NOT CULTIVATED, AND NOT BUILT-UP, OR NO VALLEY FLAT
    1 PARTLY CULTIVATED
    2 MAINLY CULTIVATED
    3 PARTLY BUILT-UP
    4 MAINLY BUILT-UP

    THIS IS A MULTIPLE CODE. THE FIRST USE OF THE CODE IS THE MOST IMPORTANT.

11. COMMENTS
    THE COMMENTS GIVE SOME ADDITIONAL INFORMATION CONCERNING THE VALLEY FLAT.

TABLE # 56

VALLEY FLAT(LOWEST FLAT ASSCCIATED WITH PRESENT RIVER)

(ALL WIDTHS IN MILES)

SITE #	PRE-SENCE	LAT. EXT.	AVG. WIDTH	MAX. WIDTH	LENGTH VF.LT. %	LENGTH VF.RT. %	VEG. VF.	FOR. TYPE	VEG. VF.	FOR. TYPE	LAND USE	LAND USE	COMMENTS
1	2	1	0.20	0.40	10	10	5	1	2	0	0	1	
2	2	1	0.30	0.50	30	40	5	0	1	0	0	0	LOW TERRACE WITH CHANNEL SCAR
3	2	1	0.10	0.18	90	0	2	0	0	0	2	0	TOWN OF PEACE R. ON VALLEY FLAT
4	2	1	0.50	0.80	0	100	2	0	0	0	3	1	MAY BE A TERRACE
5	2	1	0.70	1.00	40	60	5	1	7	0	0	0	
6	2	1	0.30	0.50	40	20	3	0	7	0	0	0	
7	2	1	0.30	0.60	80	20	5	1	0	0	0	0	FLATS OF LIMITED EXTENT
8	2	1	0.08	0.10	20	30	4	1	0	0	0	0	
9	2	1	0.10	0.13	30	60	3	0	4	1	0	0	INFREQUENTLY FLOODED
10	2	1	0.09	0.10	20	20	5	1	0	0	0	0	GENTLE SLIP-OFF SLOPE
11	2	1	0.05	0.07	10	40	5	1	3	0	0	0	
12	2	2	0.10	0.15	20	50	5	2	0	0	0	0	
13	1	1	0.15	0.20	20	10	5	1	5	2	0	0	
14	2	1	0.30	0.50	90	90	4	1	3	0	0	0	RARELY FLOODED
15	2	1	0.10	0.12	0	70	5	1	0	0	3	0	HIGH LIMESTONE BENCH PRESENT
16	0	0	0.0	0.0	0	0	0	0	0	0	0	0	
17	3	3	2.00	3.00	100	40	5	2	3	0	0	0	
18	2	2	0.09	0.20	80	80	5	1	4	2	0	0	INFREQ. FLOODED
19	2	1	0.03	0.05	10	50	2	0	4	2	0	0	INFREQ. FLOODED
20	2	2	0.25	0.30	50	50	2	0	0	0	2	0	
21	2	2	0.25	0.30	10	90	2	0	3	0	1	0	FAIRLY FREQUENTLY FLOODED.
22	2	2	0.15	0.30	80	90	4	2	0	0	0	0	VALLEY FLAT RARELY FLOODED
23	3	3	0.50	0.60	90	90	2	0	0	0	0	0	
24	0	0	0.0	0.0	0	0	0	0	0	0	0	0	NARROW STRIP NEXT TO RIVER.
25	2	2	0.05	0.08	30	50	2	0	3	0	1	0	
26	3	3	0.30	0.40	80	100	3	0	2	0	1	0	
27	2	2	0.06	0.10	60	60	4	1	3	0	0	0	
28	2	2	0.08	0.20	80	80	2	0	3	0	0	0	WIDE FLAT AREA
29	3	3	2.00	2.00	100	100	2	0	3	0	2	3	WIDE FLAT AREA,FLOODED INFREQ.
30	3	3	2.00	2.00	100	100	2	0	3	0	2	0	COULD BE VERY LOW TERRACE
31	3	2	0.15	0.35	80	70	5	1	3	0	0	0	MAY BE A TERRACE
32	3	2	0.18	0.20	80	80	5	1	0	0	0	0	
33			0.0	0.0									
34	2	2	0.25	0.30	40	30	3	0	1	0	0	0	
35	0	0	0.0	0.0	0	0	0	0	0	0	0	0	INCLUDES TWO LEVELS
36	2	2	0.10	0.25	90	50	5	1	2	0	1	0	
37	2	2	0.20	0.40	50	50	2	0	5	1	3	0	
38	0	0	0.0	0.0	0	0	0	0	0	0	0	0	
39	2	2	0.05	0.10	40	50	7	0	3	0	0	0	VALLEY FLAT FREQUENTLY FLOODED
40	3	1	0.02	0.03	30	30	1	0	3	0	0	0	

TABLE # 56
VALLEY FLAT(LOWEST FLAT ASSOCIATED WITH PRESENT RIVER)

(ALL WIDTHS IN MILES)

SITE #	PRE-SENCE	LAT. EXT.	AVG. WIDTH	MAX. WIDTH	LENGTH VF.LT. %	LENGTH VF.RT. %	VEG. VF.	FOR. TYPE	VEG. VF.	FOR. TYPE	LAND USE	LAND USE	COMMENTS
41	2	2	0.10	0.25	40	10	2	0	5	1	1	0	
42	3	2	0.03	0.05	100	70	5	1	2	0	1	0	ELEVATION UNCERTAIN
43	2	2	0.10	0.20	10	40	3	0	4	2	0	0	
44	0	0	0.0	0.0	0	0	0	0	0	0	0	0	
45	3	3	0.10	0.20	50	60	2	0	3	0	2	0	PART OF FLAT MAYBE TERRACE
46			0.0	0.0									
47			0.0	0.0									
48	1	1	0.02	0.03	20	20	3	0	0	0	0	0	VERY SMALL FLAT
49	2	1	0.05	0.10	20	20	3	0	0	0	0	0	
50	2	1	0.07	0.10	30	30	3	0	0	0	0	0	VERY LIMITED
51	2	1	0.20	0.25	60	60	3	0	0	0	0	0	EXTENT OF FLAT NOT WELL DEFINED
52	2	1	0.03	0.05	100	40	3	0	0	0	0	0	
53	2	2	0.05	0.15	20	20	5	1	3	0	1	0	MAINLY AT LOWER END
54	3	3	0.15	0.25	60	60	2	0	5	1	1	0	MAYBE A TERRACE
55	2	2	0.06	0.15	30	20	3	0	2	0	0	0	VERY LIMITED
56	2	3	0.10	0.10	80	80	3	0	0	0	0	0	
57	2	2	0.10	0.15	80	80	2	0	0	0	2	0	MAY BE A TERRACE
58	2	1	0.10	0.15	40	40	3	0	0	0	0	0	VERY LIMITED
59			0.0	0.0									
60	3	3	0.70	0.80	100	90	7	0	3	0	0	0	NATURAL LEVEES FORESTED
61	2	1	0.10	0.12	80	0	5	1	5	2	0	0	
62	0	0	0.0	0.0	0	0	0	0	0	0	0	0	IN GORGE
63	2	1	0.05	0.07	10	20	3	0	0	0	0	0	VERY LIMITED EXTENT
64	2	1	0.10	0.15	30	30	2	0	4	1	0	0	AT EXTREME FLOOD,EXTENT LARGER
65	3	2	0.20	0.30	50	90	4	1	3	0	0	0	
66	0	0	0.0	0.0	0	0	0	0	0	0	0	0	
67	3	3	0.60	1.00	100	90	4	1	0	0	3	0	
68	3	3	0.50	0.80	100	90	4	1	3	0	0	0	EXTENT APPROXIMATE
69			0.0	0.0									
70	2	1	0.04	0.08	20	50	4	2	2	0	0	0	LIMITED EXTENT
71	2	1	0.01	0.01	20	0	4	2	0	0	0	0	VERY LIMITED
72	2	1	0.03	0.05	20	40	4	2	0	0	0	0	VERY LIMITED
73	2	2	0.05	0.07	60	30	4	1	3	0	0	0	
74	3	3	0.20	0.30	50	100	4	1	0	0	0	0	
75			0.0	0.0									
76			0.0	0.0									
77	0	0	0.0	0.0	0	0	0	0	0	0	0	0	
78	0	0	0.0	0.0	0	0	0	0	0	0	0	0	
79	0	0	0.0	0.0	0	0	0	0	0	0	0	0	
80	3	2	0.05	0.07	80	80	4	1	2	0	1	0	

TABLE # 56
VALLEY FLAT(LOWEST FLAT ASSOCIATED WITH PRESENT RIVER)

(ALL WIDTHS IN MILES)

SITE #	PRE-SENCE	LAT. EXT.	AVG. WIDTH	MAX. WIDTH	LENGTH VF.LT. %	LENGTH VF.RT. %	VEG. VF.	FOR. TYPE	VEG. VF.	FOR. TYPE	LAND USE	LAND USE	COMMENTS
81	0	C	0.0	C.0	0	0	0	0	0	0	0	0	
82	0	0	0.0	0.0	0	0	0	0	0	0	0	0	GORGE-LIKE
83	3	2	0.20	0.30	80	90	5	1	3	0	0	0	
84	3	2	0.20	0.20	90	80	5	1	3	0	0	0	
85	C	C	0.0	0.0	0	0	0	0	0	0	0	0	GORGE-LIKE
86	2	2	0.08	0.15	30	70	2	0	4	2	0	0	
87	3	2	0.20	C.40	100	80	4	1	3	0	0	0	
88	3	2	0.20	0.30	70	80	4	1	3	0	0	0	
89	0	C	0.0	0.0	0	0	0	0	0	0	0	0	
90	3	2	0.25	C.35	30	80	4	1	0	0	0	0	
91	0	C	0.0	0.0	0	0	0	0	0	0	0	0	
92	2	2	0.10	0.15	80	10	4	1	2	0	0	0	
93	2	2	0.05	C.10	30	0	4	1	0	0	0	0	
94	3	2	0.20	0.25	90	50	4	1	3	0	0	0	
95	3	2	0.05	C.10	70	60	4	1	3	0	0	0	
96	2	2	0.03	0.05	30	50	3	C	0	0	0	0	MAINLY IN D/S END OF THE REACH
97	1	1	0.04	0.10	40	30	3	0	2	0	0	0	VERY LIMITED EXTENT
98	2	1	0.03	C.05	10	10	3	0	0	0	0	0	
99			0.0	C.0									
100	2	1	0.04	0.06	30	20	3	0	0	0	0	0	
101	3	2	0.08	C.15	70	80	5	1	3	0	0	0	
102			0.0	C.0									
103	0	0	C.0	0.0	0	0	0	0	0	0	0	0	
104	3	2	0.10	0.20	80	50	4	1	3	0	0	0	
105			C.0	C.0									
106	2	2	0.05	C.10	-1	-1	0	0	0	0	0	0	
107	2	1	0.05	0.06	20	20	4	1	0	0	0	0	
108	2	2	0.08	0.12	60	0	2	0	0	0	0	0	
109	2	2	0.03	C.05	80	60	3	0	4	1	0	0	
110	2	1	0.05	0.08	0	60	2	0	0	0	0	0	LIMITED EXTENT
111			0.0	0.0									
112	0	0	0.0	0.0	0	0	0	0	0	0	0	0	NO FLAT
113	2	1	0.06	0.08	30	0	4	2	2	0	0	0	VERY LIMITED EXTENT
114			C.0	0.0									
115	2	1	0.02	0.04	20	60	4	1	3	0	0	0	
116	2	1	0.02	0.04	30	50	3	0	0	0	0	0	LIMITED EXTENT
117	3	3	1.00	1.00	100	100	5	1	3	1	0	0	
118	3	3	C.10	0.10	80	90	2	0	3	0	0	0	
119	2	1	0.02	0.03	20	10	2	C	2	C	0	0	VERY LIMITED EXTENT
120	2	2	0.06	0.10	60	0	4	1	3	0	0	0	LIMITED TO LOWER END OF REACH

TABLE #60

*** CHANNEL PLAN ***

(ALL DIMENSIONS IN MILES)

EXPLANATIONS:

1. SINCE SOME OF THE FEATURES IN THIS TABLE ARE STAGE DEPENDENT, THE THE CODING APPLIES TO A DISCHARGE NEAR THE LONG-TERM MEAN DISCHARGE. ADDITIONAL INFORMATION RELATED TO THIS TABLE IS GIVEN IN THE DETAILED WRITE-UP FOR THE GEOGRAPHICAL DESCRIPTION OF A RIVER REACH.

2. CODE FOR CHANNEL PATTERN
   1 STRAIGHT
   2 SINUOUS
   3 IRREGULAR
   4 REGULAR MEANDERS
   5 IRREGULAR MEANDERS
   6 TORTUOUS MEANDERS

3. CODE FOR ISLANDS IN CHANNEL
   0 NONE
   1 OCCASIONAL (SPACING GT. 10 CHANNEL WIDTHS)
   2 FREQUENT (SPACING LT. 10 CHANNEL WIDTHS)
   3 SPLIT
   4 BRAIDED

4. CODE FOR TYPE OF FLOW AS INDICATED BY WATER SURFACE.
   1 UNIFORM
   2 UNIFORM WITH ISOLATED RAPIDS
   3 UNIFORM WITH BOILS AND/OR IRREGULARITIES
   4 POOL AND RIFFLE SEQUENCE
   5 TUMBLING FLOW

5. CODE FOR BAR TYPE
   0 NOT APPLICABLE OR NOT DETECTABLE
   1 POINT BARS
   2 SIDE BARS
   3 MID-CHANNEL BARS
   4 DIAGONAL BARS
   5 LARGE DUNES

   THIS IS A MULTIPLE CODE, THE FIRST USE OF THE CODE IS MOST IMPORTANT AND THE SECOND AND THIRD USES OF THE CODE ARE OF DECREASING IMPORTANCE.

6. MEANDER DIMENSIONS
   MEANDER WAVE LENGTH
   MEANDER BELT WIDTH

TABLE #60 (CONTINUED)

THESE DIMENSIONS ARE CNLY GIVEN IF THE CHANNEL PATTERN IS CONSIDERED TO HAVE A SCMEWHAT REPEATABLE PATTERN. THAT IS, THE CHANNEL PLAN MUST BE CODED AS REGULAR, IRREGULAR, OR TORTUOUS MEANDERS. THE AVERAGE CF TWO OR THREE MEANDER WAVE LENGTHS IN AND ACJACENT TO THE STUDY REACH ARE USED. THE MEANDER BELT WIDTH IS THE AVERAGE OVER THE DISTANCE USED TO DETERMINE THE MEANDER WAVE LENGTH.

7. SINUOSITY
THE DEFINITION USED FCR SINUOSITY IS CHANNEL LENGTH DIVIDED BY VALLEY LENGTH. THIS DEFINITION IS SATISFACTORY FOR MOST CASES EXCEPT FCR THOSE INVOLVING DEEPLY INCISED MEANDERING VALLEYS. THE QUANTITATIVE VALUE OF SINUSITY MUST BE ACCEPTED WITH SOME RESERVATION SINCE THE SINUOSITY IS QUITE VARIABLE IN AND NEAR THE STUDY REACH. A NCTE IS GIVEN IF THE SINUOSITY HAS BEEN DETERMINED FOR THE PORTION OF THE RIVER IN THE REACH ONLY. NORMALLY THE SINUOSITY WAS DETERMINED BETWEEN THE CONTOUR LINES LINES USED TO OBTAIN THE TOPOGRAPHIC SLOPE.

8. CODE FCR NATURAL CBSTRUCTIONS IN CHANNEL
0 NCNE
1 LOGS
2 BEAVER DAMS
3 BCULCERS (LAG MATERIAL)
4 VEGETATION (IN CHANNEL BED)

9. CODE FOR DEGREE OF OBTRUCTION
0 NOT APPLICABLE OR NCNE
1 OCCASICNAL CCCURENCE, MINOR EFFECT
2 OCCASICNAL CCCURENCE, MAJOR EFFECT
3 FRECUENT OCCURANCE, MINOR EFFECT
3 FREQUENT OCCURANCE, MAJOR EFFECT

CODES 6 AND 7 ARE MULTIPLE CODES WHICH ARE USED AS CCMPLIMENTARY PAIRS. THE FIRST PAIR OF CODES 6 AND 7 ARE OF PRIMARY IMPORTANCE. THE SECCND PAIR IS OF SECCNDARY IMPORTANCE.

10. COMMENTS
THE CCMMENTS GIVE SCME ADDITIONAL INFORMATION CONCERNING THE CHANNEL DESCRIPTICN.

TABLE # 60
CHANNEL PLAN

(ALL DISTANCES IN MILES)

SITE #	CHAN. PATT.	ISL.	CHAN. TYPE	BAR	BAR	BAR	MEANDER GEOM. WAVE L.	MEANDER GEOM. BELT W.	SINU-OSITY	NAT. OBS.	EF-FECT	NAT. OBS.	EF-FECT	COMMENTS
1	1	2	1	3	0	0	-1.00	-1.00	1.01	1	1	0	0	
2	1	3	1	3	0	0	-1.00	-1.00	1.01	1	1	0	0	
3	2	0	1	1	0	0	0.0	0.0	1.04	0	0	0	0	BAR AT MOUTH OF TRIB
4	2	1	1	3	0	0	0.0	0.0	1.10	0	0	0	0	ISL. U/S OF REACH
5	5	2	1	1	5	0	6.20	6.00	1.80	0	0	0	0	2.REG MEAND.AT REACH
6	3	3	1	3	1	0	0.0	0.0	1.30	0	0	0	0	
7	3	1	1	3	1	0	0.0	0.0	1.05	0	0	0	0	TORT.BENDS D/S
8	5	1	1	1	3	0	2.20	1.50	1.30	0	0	0	0	IRREG.ABOVE L.SMOKY
9	2	1	1	3	1	0	0.0	0.0	1.10					
10	5	1	3	1	3	0	1.20	0.90	1.70	3	1	0	0	
11	5	0	4	4	2	0	0.90	0.80	2.10	0	0	0	0	ALMOST TORTUOUS
12	2	4	3	3	4	0	0.0	0.0	1.10	0	0	0	0	
13	1	1	3	3	0	0	0.0	0.0	1.00	0	0	0	0	
14	2	3	3	3	1	0	0.0	0.0	1.20	0	0	0	0	
15	3	1	1	0	0	0	0.0	0.0	1.20	0	0	0	0	NO ISL IN SURV REACH
16	1	1	1	3	0	0	0.0	0.0	1.00	0	0	0	0	
17	5	1	1	1	3	0	3.50	1.50	1.35	0	0	0	0	IRREGULAR U/S.D/S.
18	3	1	4	3	4	0	0.0	0.0	1.20	1	1	0	0	
19	5	0	4	0	0	0	0.60	0.50	2.00	3	2	0	0	BOULDER RAPIDS
20	5	1	1	1	0	0	2.00	1.10	1.80	0	0	0	0	RELATIVELY STABLE
21	5	0	4	1	0	0	0.35	0.30	2.40	0	0	0	0	
22	6	0	4	3	4	0	0.30	0.15	1.90	1	2	0	0	
23	5	0	1	1	0	0	0.45	0.50	1.70	0	0	0	0	
24	5	0	4	1	0	0	0.60	0.60	2.10	0	0	0	0	
25	5	1	1	1	0	0	0.90	0.50	2.00	3	0	2	0	
26	3	0	4	4	0	0	0.0	0.0	1.50	0	0	0	0	IRREG. TO TORTUOUS
27	3	0	4	4	0	0	0.0	0.0	1.60	2	3	0	0	MEAND.NO WEL DEFINED
28	5	0	1	0	0	0	0.60	0.50	2.00	0	0	0	0	
29	3	0	1	5	0	0	0.0	0.0	1.80	0	0	0	0	ARTIF.STRAIGHTENED
30	3	1	1	1	5	0	0.0	0.0	1.40	1	2	0	0	TORTUOUS MEANDERSU/S
31	4	1	1	1	5	0	1.20	0.60	1.50	0	0	0	0	
32	4	0	2	1	5	0	0.50	0.20	1.30	1	1	3	2	
33							0.0	0.0	0.0					
34	2	4	3	3	0	0	0.0	0.0	1.10	3	2	0	0	CHANN TYPE NON-UNIFO
35	3	1	3	3	4	0	0.0	0.0	1.10	0	0	0	0	
36	2	2	4	3	4	0	0.0	0.0	1.10	0	0	0	0	
37	5	0	1	1	2	0	2.00	1.50	1.40	0	0	0	0	
38	2	1	1	3	0	0	0.0	0.0	1.10	3	2	0	0	
39	5	0	2	1	0	0	0.25	0.20	1.40	0	0	0	0	BOULD.RAPIDS BELOW G
40	3	1	4	4	0	0	0.0	0.0	1.20	1	3	0	0	

TABLE # 60
CHANNEL PLAN

(ALL DISTANCES IN MILES)

SITE #	CHAN. PATT.	ISL.	CHAN. TYPE	BAR	BAR	BAR	MEANDER GEOM.		SINU-OSITY	NAT. OBS.	EF-FECT	NAT. OBS.	EF-FECT	COMMENTS
							WAVE L.	BELT W.						
41	3	1	-1	3	0	0	0.0	0.0	1.20	0	0	0	0	
42	3	0	4	4	0	0	0.0	0.0	1.40	1	1	3	1	
43	3	0	3	1	3	0	0.0	0.0	1.40	3	3	0	0	
44	5	0	4	4	2	0	0.90	0.40	1.40	0	0	0	0	
45	6	0	1	0	0	0	0.12	0.07	2.20	4	4	0	0	
46							0.0	0.0	0.0					
47							0.0	0.0	0.0					
48	2	0	5	3	0	0	0.0	0.0	1.04	0	0	0	0	
49	5	0	4	4	3	0	1.40	0.50	1.40	0	0	0	0	
50	2	1	2	2	0	0	0.0	0.0	1.10	0	0	0	0	SOME MEAND.SPLIT CHA
51	2	1	1	3	5	0	0.0	0.0	1.06	0	0	0	0	LONG STRAIGHT REACH
52	3	1	3	4	3	0	0.0	0.0	1.10	1	1	0	0	
53	3	1	4	4	0	0	0.0	0.0	1.20	0	0	0	0	ALMOST STRT.IN REACH
54	3	0	2	0	0	0	0.0	0.0	1.40	2	2	0	0	PAT.CHANGES IN REACH
55	3	0	4	4	0	0	0.0	0.0	1.40	3	2	0	0	
56	5	0	4	4	0	0	0.25	0.10	1.50	2	1	0	0	TORT.MEAND.OUT REACH
57	3	0	4	4	0	0	0.0	0.0	1.30	3	1	0	0	
58	5	1	1	3	1	0	2.00	1.30	1.50	0	0	0	0	
59							0.0	0.0	0.0					
60	3	0	1	1	0	0	0.0	0.0	1.10	0	0	0	0	
61	2	1	3	3	0	0	0.0	0.0	1.10	0	0	0	0	BED ROCK & BOULD.RAP
62	3	0	5	3	4	0	0.0	0.0	1.10	3	4	0	0	
63	2	1	3	2	3	0	0.0	0.0	1.10	0	0	0	0	
64	2	2	3	3	4	0	0.0	0.0	1.10	0	0	0	0	SPLIT D/S OF REACH
65	3	1	1	4	0	0	0.0	0.0	1.02	0	0	0	0	
66	3	1	2	2	3	0	0.0	0.0	1.16	3	1	0	0	
67	2	3	5	3	4	0	0.0	0.0	1.10	3	3	0	0	STRAIGHTENED ARTIFIC
68	2	1	5	3	4	0	0.0	0.0	1.10	3	1	0	0	
69							0.0	0.0	0.0					
70	2	1	5	4	3	0	0.0	0.0	1.08	0	0	0	0	
71	2	1	5	3	0	0	0.0	0.0	1.10	0	0	0	0	
72	5	0	5	4	3	0	0.50	0.20	1.09	3	3	0	0	
73	3	0	4	3	4	0	0.0	0.0	1.15	0	0	0	0	BRAIDED D/S
74	2	3	4	4	3	0	0.0	0.0	1.10	3	3	0	0	
75							0.0	0.0	0.0					
76							0.0	0.0	0.0					
77	3	1	5	4	3	0	0.0	0.0	1.09	3	3	1	1	
78	5	0	4	4	1	2	0.80	0.25	1.20	3	3	0	0	
79	5	0	4	4	3	0	0.70	0.40	1.70	0	0	0	0	
80	3	1	4	4	3	0	0.0	0.0	1.40	0	0	0	0	

TABLE # 60
CHANNEL PLAN

(ALL DISTANCES IN MILES)

SITE #	CHAN. PATT.	ISL.	CHAN. TYPE	BAR	BAR	BAR	MEANDER GEOM. WAVE L.	MEANDER GEOM. BELT W.	SINU-OSITY	NAT. OBS.	EF-FECT	NAT. OBS.	EF-FECT	COMMENTS
81	3	0	4	-1	0	0	0.0	0.0	1.60	3	4	0	0	
82	3	0	-1	4	3	0	0.0	0.0	1.30	3	4	0	0	
83	3	3	4	4	3	0	0.0	0.0	1.30	1	1	0	0	SOME RIP-RAP ON LEFT
84	3	1	4	4	3	0	0.0	0.0	1.30	0	0	0	0	
85	3	0	5	4	3	0	0.0	0.0	1.30	3	4	0	0	
86	3	0	5	4	2	0	0.0	0.0	1.20	3	2	0	0	
87	2	1	4	3	4	0	0.0	0.0	1.30	0	0	0	0	TO IRREG.MEAND. D/S
88	2	1	4	4	2	0	0.0	0.0	1.20	0	0	0	0	
89	3	1	-1	4	3	0	0.0	0.0	1.40	0	0	0	0	LONG STRAIGHTS
90	3	2	4	4	2	0	0.0	0.0	1.40	0	0	0	0	
91	5	1	4	3	2	0	1.80	0.50	1.30	3	3	0	0	
92	2	0	4	4	1	0	0.0	0.0	1.20	3	1	0	0	
93	3	0	4	1	4	0	0.0	0.0	1.20	3	1	0	0	
94	3	0	-1	3	2	0	0.0	0.0	1.40	0	0	0	0	
95	5	0	4	4	1	0	0.70	0.40	1.70	3	1	0	0	
96	3	0	5	0	0	0	0.0	0.0	1.40	0	0	0	0	
97	5	0	-1	1	4	0	0.30	0.25	1.70	3	1	0	0	
98	3	1	4	4	0	0	0.0	0.0	1.70	3	3	0	0	
99							0.0	0.0	0.0					
100	3	1	5	4	3	0	0.0	0.0	1.50	0	0	0	0	
101	3	0	4	4	1	0	0.0	0.0	1.20	0	0	0	0	ALMOST TORT. BEYOND
102							0.0	0.0	0.0					
103	2	1	5	2	0	0	0.0	0.0	1.20	3	2	0	0	
104	3	1	4	4	1	0	0.0	0.0	1.30	0	0	0	0	
105							0.0	0.0	0.0					
106	3	0	5	4	0	0	0.0	0.0	1.40	-1	-1	0	0	
107	3	1	4	4	3	0	0.0	0.0	1.40	3	1	0	0	
108	5	1	4	4	2	0	1.00	0.40	1.80	3	1	0	0	
109	3	0	4	4	2	0	0.0	0.0	1.40	-1	-1	0	0	
110	3	0	2	4	0	0	0.0	0.0	1.90	0	0	0	0	ART.CUTOFFS ABOVE G
111							0.0	0.0	0.0					
112	2	1	1	1	0	0	0.0	0.0	1.01	0	0	0	0	
113	2	1	5	4	2	0	0.0	0.0	1.01	3	3	0	0	
114							0.0	0.0	0.0					
115	3	0	4	4	0	0	0.0	0.0	1.20	0	0	0	0	
116	5	0	4	4	0	0	0.20	0.15	1.90	3	1	0	0	
117	6	0	1	1	0	0	0.50	0.25	1.70	1	1	0	0	SINUOSITY FOR REACH
118	3	0	1	0	0	0	-1.00	-1.00	1.20	3	1	0	0	ART.STRAIGHTENED
119	3	0	4	0	0	0	0.0	0.0	1.45	3	3	0	0	RIFFLES CONTROL SLOP
120	2	1	1	5	0	0	0.0	0.0	1.04	3	3	0	0	ONE LOOP U/S REACH

TABLE #61

*** CHANNEL SHIFT ***

EXPLANATIONS:

1. ADDITIONAL INFORMATION RELATED TO THIS TABLE IS GIVEN IN THE DETAILED WRITE-UP FOR GEOGRAPHICAL DESCRIPTION OF A RIVER REACH.

2. CODE FOR TYPE OF LATERAL ACTIVITY
   0 NOT DETECTABLE
   1 DOWNSTREAM PROGRESSION
   2 PROGRESSION AND CUT-OFFS
   3 MAINLY CUT-OFFS
   4 ENTRENCHED LOOP DEVELOPMENT
   5 LATERALLY ACTIVE BUT NOT IN CATEGORIES 1 TO 4

3. CODE FOR DEGREE OF LATERAL STABILITY
   0 STABLE
   1 SLIGHTLY UNSTABLE
   2 MODERATELY UNSTABLE
   3 HIGHLY UNSTABLE

4. COMMENTS
   THE COMMENTS GIVE SOME ADDITIONAL INFORMATION CONCERNING THE LATERAL STABILITY.

TABLE # 61
CHANNEL SHIFT

SITE #	LATERAL ACTIVITY	RELATIVE ACTIVITY
1	0	0
2	5	1
3	0	0
4	0	0
5	4	0
6	1	0
7	0	0
8	1	1
9	1	0
10	4	1
11	4	2
12	5	2
13	0	0
14	5	1
15	0	0
16	0	0
17	1	2
18	5	2
19	0	0
20	4	0
21	2	0
22	2	2
23	2	1
24	4	1
25	2	0
26	3	2
27	3	0
28	2	1
29	3	1
30	3	1
31	1	1
32	1	1
33		
34	5	2
35	5	1
36	5	1
37	4	1
38	0	0
39	5	1
40	5	2

SITE #	LATERAL ACTIVITY	RELATIVE ACTIVITY
41	0	0
42	4	0
43	5	1
44	4	0
45	3	1
46		
47		
48	5	1
49	1	1
50	1	1
51	1	2
52	4	0
53	5	1
54	3	0
55	4	0
56	1	2
57	3	2
58	4	1
59		
60	5	1
61	0	0
62	0	0
63	0	0
64	0	1
65	0	0
66	0	0
67	5	2
68	5	3
69		
70	5	1
71	5	0
72	4	1
73	5	1
74	5	2
75		
76		
77	5	1
78	4	1
79	4	0
80	5	2

SITE #	LATERAL ACTIVITY	RELATIVE ACTIVITY
81	4	1
82	4	0
83	5	3
84	5	3
85	4	1
86	5	1
87	5	1
88	5	2
89	4	0
90	5	1
91	4	0
92	5	1
93	1	1
94	5	2
95	4	2
96	5	1
97	3	1
98	4	0
99		
100	5	2
101	3	2
102		
103	0	0
104	1	2
105		
106	5	1
107	4	2
108	4	1
109	1	1
110	2	2
111		
112	4	0
113	5	1
114		
115	3	1
116	4	1
117	3	2
118	3	2
119	4	0
120	5	1

TABLE #62

*** CHANNEL BANKS AND BED BELOW VALLEY FLAT ***

(DEPTH IN FT.)

EXPLANATIONS:

1. CODE FOR ALLUVIAL BANK MATERIAL
   0 NO ALLUVIAL BANKS
   1 CLAY AND SILT (COHESIVE)
   2 SILT AND SAND (NON-COHESIVE)
   3 SAND AND GRAVEL (< 64 MM)
   4 SAND AND COBBLES (> 64 MM)
   5 SAND OVERLAIN BY SILT
   6 GRAVEL OVERLAIN BY SILT

   THIS IS A MULTIPLE CODE. THE FIRST CODED NUMBER IS OF PRIMARY IMPORTANCE, THE SECOND AND THIRD NUMBERS ARE OF DECREASING IMPORTANCE.

2. CODE FOR NON-ALLUVIAL BANK MATERIAL
   0 ALL ALLUVIAL BANK MATERIAL
   1 LACUSTRINE DEPOSITS
   2 TILL
   3 EASILY ERODIBLE ROCK
   4 MODERATELY ERODIBLE ROCK
   5 RESISTANT ROCK
   6 BOULDERS

   THIS IS A MULTIPLE CODE. THE FIRST CODED NUMBER IS OF PRIMARY IMPORTANCE, THE SECOND AND THIRD NUMBERS ARE OF DECREASING IMPORTANCE.

3. CHANNEL LENGTH IN THE REACH WITH ALLUVIUM ON THE LEFT IN PERCENT.

4. CHANNEL LENGTH IN THE REACH WITH ALLUVIUM ON THE RIGHT IN PERCENT.

5. CODE FOR BANK VEGETATION BELOW VALLEY FLAT OR 2 YEAR FLOOD STAGE.
   0 NONE
   1 WEAK
   2 GOOD
   3 VERY STRONG

   THIS CODE IS AN AVERAGE EVALUATION FOR THE REACH WITH MOST EMPHASIS GIVEN TO THE BANKS UNDER SOME ATTACK.

6. CODE FOR PREDOMINANT BED MATERIAL
   1 SAND
   2 SAND WITH LOCAL GRAVEL

TABLE #62 (CONTINUED)

3 GRAVEL
4 GRAVEL WITH LCCAL SAND
5 SAND AND GRAVEL

7. CODE FOR DEPTH OF ALLUVIUM AT CHANNEL BASE
0 NO ALLUVIUM
1 SHALLOW (< 0.5 TIMES THE 25 YEAR FLOOD DEPTH)
2 MCDERATE (BETWEEN 0.5 AND 1.5 TIMES THE 25 YEAR FLOOD DEPTH)
3 DEEP (> 1.5 TIMES THE 25 YEAR FLOOD DEPTH)

8. ESTIMATED DEPTH OF ALLUVIUM
THIS DEPTH IS DETERMINED FRCM SOME TEST HOLE DATA IN OR NEAR THE REACH

9. REFERENCE OR COMMENT
THE REFERENCE USED FOR ESTIMATE OF ALLUVIUM DEPTH IS GIVEN HERE. THE COMMENTS GIVE SOME ADDITIONAL INFORMATION CCNCERNING THE BANK AND BED MATERIAL.

TABLE # 62
CHANNEL BANKS AND BED BELOW VALLEY FLAT
(ALL DEPTHS IN FT.)

SITE #	BANK MATERIAL ALL	ALL	ALL	NCN ALL	NON ALL	NCN ALL	LEN ALL LT. %	LEN ALL RT. %	VEG STA	PRED BM TYPE	DEP ALL	EST. DEPTH	REFERENCE OR COMMENT
1	6	0	0	3	0	0	40	4C	0	3	1	-1.	
2	6	0	0	3	0	0	30	40	0	3	2	20.	TAYLOR BRIDGE DRAWING
3	6	0	0	4	0	0	90	C	0	3	2	65.	BRIDGE PLAN 6 MAY 57
4	6	0	0	4	0	C	0	100	0	3	1	15.	BRIDGE PLAN 23 OCT 64
5	2	3	0	3	0	0	40	60	1	2	-1	-1.	SOME GRAVEL AT BANKS
6	6	2	0	3	0	0	70	40	1	1	-1	-1.	SOME BEDROCK BANKS
7	2	0	0	3	0	0	80	20	2	1	1	-1.	
8	6	3	0	3	0	0	80	70	0	3	2	35.	VERY ROUGH EST.BRIDGE PLAN 16 NOV 53
9	3	0	0	3	2	0	50	80	0	3	1	15.	BRIDGE PLAN 16 NOV 64
10	6	3	0	3	2	0	20	20	1	3	-1	-1.	PROBABLY SHALLOW ALLUVIUM
11	2	C	0	3	0	0	40	40	1	3	1	-1.	EXTENT OF ALLUVIAL BANKS DOUBTFUL
12	4	3	0	5	0	0	100	95	C	3	-1	-1.	DEPTH OF BED MATERIAL PROBABLY GREAT
13	3	0	0	4	0	0	80	100	0	3	-1	-1.	THICKNESS OF ALLUVIAL BANK PROB.SMAL
14	3	0	0	-1	0	0	90	10C	0	3	1	-1.	BRIDGE PLAN 12 JUN 63
15	3	0	0	-1	0	0	70	7C	1	-1	1	8.	BRIDGE PLAN 6 JAN 51;NON-ALL BANK?
16	1	0	0	3	0	0	30	10	1	2	-1	-1.	DEPTH ALLUVIUM PROB. SMALL
17	2	1	0	0	0	0	1C0	100	1	1	3	-1.	
18	3	0	0	4	0	0	100	80	1	3	-1	-1.	
19	3	0	0	4	0	0	50	50	2	3	1	8.	BRIDGE PLAN 9 FEB 55
20	3	0	0	3	0	0	50	80	2	3	1	-1.	
21	3	0	0	3	2	4	50	90	1	3	1	2.	BRIDGE PLAN AUG 54
22	4	0	0	0	0	0	100	100	0	3	-1	-1.	PROBABLY DEEP ALLUVIUM
23	2	0	0	2	0	0	90	9C	1	2	-1	-1.	SOME GRAVEL ABOVE BRIDGE
24	4	3	0	4	3	0	40	70	1	3	1	4.	BRIDGE PLAN 9 JAN 62
25	2	0	0	0	0	0	1C0	100	2	2	3	75.	BRIDGE PLAN DEC 61
26	2	3	0	2	-1	0	80	100	1	3	1	-1.	
27	6	0	0	2	0	0	70	70	2	3	-1	-1.	
28	2	1	0	0	0	0	1C0	100	1	1	-1	-1.	PROBABLY DEEP ALLUVIUM
29	2	1	0	0	0	0	100	100	2	1	-1	-1.	PROBABLY NOT TOO DEEP
30	2	1	0	3	0	0	50	50	2	1	1	-1.	DEG. INTO SHALE/OR CLAY AT D/S END
31	2	0	0	4	0	0	80	70	1	1	-1	-1.	SOME LIMESTONE EXPOSED ON BANKS
32	2	0	0	3	0	0	80	80	1	2	2	20.	BRIDGE PLAN APR 62
33												0.	
34	3	4	0	2	0	0	60	90	0	3	-1	-1.	PROBABLY DEEP ALLUVIUM
35	4	0	0	4	0	0	60	20	0	3	-1	-1.	LENGTH OF ALLUVIUM APPROX.
36	3	0	0	4	0	0	100	50	C	3	-1	-1.	
37	6	C	0	3	0	0	50	5C	1	3	1	10.	LEA PARK BRIDGE DRWG JAN 2/64
38	2	0	0	3	0	0	-1	-1	1	4	1	10.	SOME CLAY ON CHANNEL BOTTOM
39	2	3	0	1	2	4	40	80	0	-1	1	-1.	
40	3	C	0	4	0	0	1C0	7C	C	3	3	-1.	

TABLE # 62
CHANNEL BANKS AND BED BELOW VALLEY FLAT

(ALL DEPTHS IN FT.)

SITE #	BANK MATERIAL ALL	ALL	ALL	NON ALL	NON ALL	NON ALL	LEN ALL LT. %	LEN ALL RT. %	VEG STA	PRED BY TYPE	DEP ALL	EST. DEPTH	REFERENCE OR COMMENT
41	6	0	0	-1	0	0	70	70	1	3	-1	-1.	NO BEDROCK EVIDENT
42	6	0	0	2	0	0	100	70	2	3	-1	-1.	
43	6	0	0	3	4	0	30	70	0	3	-1	-1.	
44	3	0	0	4	0	0	70	30	0	3	-1	-1.	
45	2	0	0	4	0	0	90	90	1	1	-1	-1.	
46												0.	
47												0.	
48	3	0	0	4	6	0	100	30	0	3	1	-1.	
49	3	0	0	-1	0	0	100	80	1	3	-1	-1.	
50	6	2	0	3	0	0	50	50	1	3	1	-1.	
51	2	6	0	3	0	0	80	90	0	2	3	50.	
52	3	0	0	4	0	0	100	80	0	3	-1	-1.	
53	6	2	0	4	0	0	80	50	1	3	-1	-1.	
54	2	6	0	0	0	0	100	100	3	2	-1	-1.	
55	6	2	0	-1	0	0	70	80	2	3	1	10.	BRIDGE PLAN NOV 61,JUST U/S OF REACH
56	6	2	0	3	0	0	80	80	1	3	-1	-1.	
57	6	2	0	4	0	0	80	100	1	3	-1	-1.	
58	6	2	0	2	-1	0	50	80	0	-1	-1	-1.	
59												0.	
60	2	0	0	6	0	0	100	90	1	1	-1	-1.	
61	3	0	0	3	0	0	80	60	1	3	-1	-1.	ONLY UPPER PART OF REACH CONSIDERED
62	3	0	0	4	3	0	10	30	0	3	1	-1.	
63	3	0	0	4	3	0	60	60	1	3	1	-1.	
64	3	0	0	-1	0	0	80	100	1	3	-1	-1.	
65	3	0	0	3	0	0	50	100	1	3	-1	-1.	
66	3	0	0	3	0	0	40	40	1	3	1	-1.	
67	3	4	0	2	-1	0	80	80	0	3	3	-1.	DEPTH OF ALLUVIUM GT. 40 FT BR. PLAN
68	3	0	0	5	0	0	100	80	1	3	3	-1.	
69												0.	
70	3	0	0	4	0	0	80	80	1	3	-1	-1.	
71	3	4	0	4	5	0	60	70	1	3	1	-1.	
72	3	0	0	4	0	0	60	60	1	3	-1	-1.	
73	3	0	0	2	4	0	100	80	1	3	1	6.	BR. PLAN JUN 64(OUTSIDE REACH)
74	3	0	0	-1	0	0	70	100	0	3	1	-1.	
75												0.	
76												0.	
77	4	3	0	4	0	0	70	70	1	3	1	-1.	
78	3	0	0	3	4	0	40	30	1	3	1	-1.	
79	5	0	0	3	4	0	20	30	2	3	1	0.	BRIDGE PLAN 19 NOV 57 JUST U/S REACH
80	5	0	0	3	4	0	90	90	0	3	1	0.	

TABLE # 62
CHANNEL BANKS AND BED BELOW VALLEY FLAT

(ALL DEPTHS IN FT.)

SITE #	BANK MATERIAL ALL	ALL	ALL	NCN ALL	NON ALL	NON ALL	LEN ALL LT. %	LEN ALL RT. %	VEG STA	PRED BM TYPE	DEP ALL	EST. DEPTH	REFERENCE OR COMMENT
81	3	6	0	3	4	0	70	70	1	3	1	-1.	
82	4	0	0	-1	0	0	10	20	0	3	1	-1.	
83	3	0	0	6	5	0	80	90	0	3	2	8.	BRIDGE PLAN JAN 62
84	3	6	0	3	0	0	90	90	1	3	-1	-1.	
85	4	0	0	3	4	0	10	50	1	3	1	-1.	
86	4	2	0	4	3	0	70	70	0	3	-1	-1.	
87	3	0	0	3	2	0	100	80	0	3	-1	-1.	NO BEDROCK EXPOSURES
88	3	0	0	-1	0	0	70	100	0	3	-1	6.	BRIDGE PLAN 27 APR 56
89	3	0	0	3	-1	0	40	40	1	3	1	-1.	
90	6	0	0	3	2	0	60	90	1	3	-1	-1.	
91	6	0	0	3	2	0	70	90	1	3	-1	-1.	
92	3	0	0	-1	0	0	90	30	2	3	-1	4.	BRIDGE PLAN NOV 65 JUST U/S OF REACH
93	3	0	0	4	3	0	60	80	1	3	1	-1.	
94	3	0	0	3	-1	0	90	80	1	3	-1	12.	BRIDGE PLAN MAR 65 D/S OF REACH
95	3	0	0	3	0	4	70	70	0	3	2	-1.	
96	2	3	0	4	0	0	80	100	2	3	-1	-1.	
97	2	-1	0	3	0	0	80	80	0	3	-1	1.	BRIDGE PLAN 7 MAR 57
98	2	3	0	3	4	0	50	80	2	4	1	0.	
99												2.	BRIDGE PLAN 31 AUG 56
100	3	0	0	3	4	0	60	60	1	3	1	12.	BRIDGE PLAN DEC 65
101	2	3	0	2	0	0	90	90	1	3	2	0.	
102												-1.	
103	3	-1	0	2	-1	0	50	50	2	3	-1	10.	BRIDGE PLAN DEC 64
104	6	0	0	2	-1	0	90	90	1	3	2	0.	
105												-1.	
106	3	-1	0	2	-1	0	70	70	2	3	-1	-1.	
107	3	6	0	4	-1	0	70	60	1	3	1	-1.	
108	3	0	0	2	3	4	80	70	1	3	-1	-1.	
109	6	-1	0	-1	0	0	80	70	-1	3	-1	-1.	
110	6	0	0	2	3	4	60	100	1	3	-1	0.	
111												-1.	
112	6	-1	0	3	0	0	20	60	1	5	-1	-1.	
113	4	0	0	4	-1	0	90	20	1	3	-1	0.	
114												-1.	
115	6	2	0	4	2	0	40	90	1	3	1	-1.	
116	2	3	0	2	0	0	80	80	1	3	-1	-1.	
117	1	0	0	0	0	0	100	100	1	1	3	-1.	
118	2	1	0	2	0	0	80	90	0	1	-1	-1.	
119	2	0	0	2	-1	0	80	80	2	4	-1	-1.	
120	2	6	0	2	4	0	90	30	2	2	-1	-1.	

TABLE #63

*** BED ROCK AT CHANNEL BASE OR UNDER CHANNEL ***

```
EXPLANATIONS:
 1. CODE FOR PRESENCE OF ROCK OUTCROPS IN CHANNEL BED
      0 NONE DETECTABLE
      1 ONE BEDROCK OUTCROP IN CHANNEL BED
      2 TWO BEDROCK OUTCROPS IN CHANNEL BED
      N N  BEDROCK OUTCROPS IN CHANNEL BED
      . ....
      9 SEVERAL BEDROCK OUTCROPS IN CHANNEL BED

 2. CODE FOR ROCK TYPE UNDER CHANNEL
      0 NOT APPLICABLE OR NONE FOR GREAT DEPTH
      1 COMPACT CLAY
      2 SHALE
      3 LIMESTONE
      4 SANDSTONE
      5 CONGLOMERATE
      6 GRANITE

 3. CODE FOR ERODIBILITY OF BEDROCK UNDER CHANNEL
      0 NOT APPLICABLE
      1 SOFT COHESIVE
      2 EASILY ERODIBLE
      3 MODERATELY ERODIBLE
      4 RESISTANT

      CODES 2 AND 3 ARE USED AS A PAIR, AND EACH PAIR IS A MULTIPLE CODE.
      THE FIRST PAIR OF 2 AND 3 CODES ARE MOST IMPORTANT.  THE SECOND
      AND THIRD PAIRS ARE OF DECREASING IMPORTANCE.

 4. COMMENTS
      THE COMMENTS GIVE SOME ADDITIONAL INFORMATION CONCERNING THE
      BEDROCK BELOW THE CHANNEL.  THE SOURCE OF THE DATA USED IN THE
      TABLE IS GIVEN IN THE COMMENTS.
```

TABLE # 63
BED ROCK AT CHANNEL BASE OR UNDER CHANNEL

SITE #	PRE-SENCE	BR. TYPE	BR. ERO.	BR. TYPE	BR. FRC.	BR. TYPE	BR. ERO.	COMMENTS AND REFERENCES
1	1	2	1	4	3	0	0	
2	0	2	1	0	0	0	0	
3	0	2	1	3	2	0	0	BRIDGE PLAN 6 MAY 57
4	0	2	1	0	0	0	0	BRIDGE PLAN 23 OCT 64
5	0	-1	-1	0	0	0	0	
6	0	-1	-1	0	0	0	0	
7	0	2	2	0	0	0	0	GYPSUM ARCH DISECTED BY RIVER
8	0	1	1	0	0	0	0	BRIDGE PLAN 16 NOV 53
9	0	1	1	0	0	0	0	BRIDGE PLAN 16 NOV 64
10	0	-1	-1	0	0	0	0	
11	-1	2	1	0	0	0	0	
12	0	-1	-1	0	0	0	0	
13	-1	-1	-1	0	0	0	0	
14	-1	-1	-1	0	0	0	0	
15	-1	1	1	0	0	0	0	BRIDGE PLAN 6 JAN 51
16	-1	3	2	0	0	0	0	
17	0	-1	-1	0	0	0	0	
18	-1	4	2	0	0	0	0	
19	2	4	3	0	0	0	0	BOULDER RAPIDS AT OUTCROP LOCATIONS
20	-1	2	2	0	0	0	0	
21	-1	2	2	4	3	0	0	BRIDGE PLAN AUG 54
22	-1	-1	-1	0	0	0	0	
23	-1	2	2	0	0	0	0	
24	0	4	2	2	1	0	0	BRIDGE PLAN 9 JAN 62
25	0	1	1	0	0	0	0	BRIDGE PLAN DEC 61
26	1	-1	-1	0	0	0	0	
27	-1	-1	-1	0	0	0	0	
28	-1	-1	-1	0	0	0	0	
29	-1	-1	-1	0	0	0	0	
30	2	2	1	0	0	0	0	EXPOSED FOR SOME DISTANCE BELOW BRIDGE
31	-1	-1	-1	0	0	0	0	
32	0	2	2	0	0	0	0	BRIDGE PLAN APR 62
33								
34	-1	-1	-1	0	0	0	0	
35	-1	-1	-1	0	0	0	0	
36	-1	-1	-1	0	0	0	0	
37	-1	2	2	0	0	0	0	
38	-1	2	2	0	0	0	0	
39	1	2	3	0	0	0	0	
40	-1	-1	-1	0	0	0	0	

TABLE # 63

REC RCCK AT CHANNEL BASE OR UNDER CHANNEL

SITE #	PRE-SENCE	BR. TYPE	BR. ERO.	PR. TYPE	BR. ERO.	BR. TYPE	BR. ERO.	COMMENTS AND REFERENCES
41	0	-1	-1	0	0	0	0	
42	-1	-1	-1	0	0	0	0	
43	-1	3	2	4	3	0	0	
44	-1	4	3	0	0	0	0	
45	-1	-1	-1	0	0	0	0	
46								
47								
48	2	-1	-1	0	0	0	0	
49	-1	-1	-1	0	0	0	0	
50	0	2	2	0	0	0	0	
51	0	2	2	0	0	0	0	
52	-1	-1	-1	0	0	0	0	
53	0	-1	-1	0	0	0	0	
54	0	-1	-1	0	0	0	0	BRIDGE PLAN NOV 61,JUST U/S OF REACH
55	0	2	3	0	0	0	0	
56	0	-1	-1	0	0	0	0	
57	0	-1	-1	0	0	0	0	
58	0	-1	-1	0	0	0	0	
59								
60	0	-1	-1	0	0	0	0	
61	0	-1	-1	0	0	0	0	
62	2	4	3	2	2	0	0	
63	-1	4	3	0	0	0	0	
64	0	-1	-1	0	0	0	0	
65	0	-1	-1	0	0	0	0	
66	-1	-1	-1	0	0	0	0	
67	0	-1	-1	0	0	0	0	
68	0	-1	-1	0	0	0	0	
69								
70	0	-1	-1	0	0	0	0	
71	1	3	3	0	0	0	0	
72	-1	4	3	0	0	0	0	BR. PLAN JUN 64.BR. LOCATED OUTSIDE OF REACH
73	-1	2	3	0	0	0	0	
74	1	-1	-1	0	0	0	0	
75								
76								
77	5	-1	3	0	0	0	0	
78	-1	-1	-1	0	0	0	0	BRIDGE PLAN 19 NOV 57 JUST U/S OF REACH
79	1	1	1	0	0	0	0	
80	0	-1	-1	0	0	0	0	

TABLE # 63
BED ROCK AT CHANNEL BASE OR UNDER CHANNEL

SITE #	PRE-SENCE	BR. TYPE	BR. ERO.	BR. TYPE	BR. ERO.	BR. TYPE	BR. ERO.	COMMENTS AND REFERENCES
81	3	4	3	0	0	0	0	
82	-1	-1	-1	0	0	0	0	
83	-1	2	2	4	3	0	0	
84	-1	-1	-1	0	0	0	0	
85	1	-1	4	-1	-1	0	0	RAPIDS AT OUTCROP
86	-1	-1	-1	0	0	0	0	
87	-1	-1	-1	0	0	0	0	
88	-1	-1	-1	0	0	0	0	
89	-1	2	2	4	3	0	0	BRIDGE PLAN 27 APR 56
90	-1	-1	-1	0	0	0	0	
91	-1	-1	-1	0	0	0	0	
92	0	-1	-1	0	0	0	0	
93	2	2	2	4	3	0	0	BRIDGE PLAN NOV 65 JUST U/S FROM REACH
94	-1	-1	-1	0	0	0	0	
95	1	2	2	-1	-1	0	0	
96	0	-1	-1	0	0	0	0	
97	-1	-1	-1	0	0	0	0	
98	1	2	1	4	3	0	0	BRIDGE PLAN 7 MAR 57
99								
100	1	4	4	2	2	0	0	BRIDGE PLAN 31 AUG 56
101	0	1	1	0	0	0	0	BRIDGE PLAN SEP 65
102								
103	0	-1	-1	0	0	0	0	
104	0	2	2	0	0	0	0	BRIDGE PLAN DEC 64
105								
106	1	-1	4	0	-1	0	0	
107	1	2	4	-1	-1	0	0	
108	0	-1	-1	0	0	0	0	
109	-1	-1	-1	0	0	0	0	
110	-1	-1	-1	0	0	0	0	
111								
112	0	-1	-1	0	0	0	0	
113	0	-1	-1	0	0	0	0	
114								
115	0	4	3	-1	-1	0	0	
116	0	-1	-1	0	0	0	0	
117	0	-1	-1	0	0	0	0	
118	0	-1	-1	0	0	0	0	
119	0	-1	-1	0	0	0	0	
120	0	-1	-1	0	0	0	0	

TABLE #71

*** AVERAGE CHARACTERISTIC BED MATERIAL SIZES FOR REACH ***

(ALL SIZES IN MILLIMETERS)

EXPLANATIONS:

1. ALL GRAVEL DATA ARE ADJUSTED TO BE EQUIVALENT TO THE RESULTS OBTAINED BY THE GRID-BY-NUMBER PROCEDURE.(GBN)

2. ONLY ONE SAMPLE PER SITE WAS USED TO OBTAIN THE AVERAGE FOR THE REACH; THAT IS, IF MORE THAN ONE SAMPLE TYPE WAS OBTAINED AT ANY ONE SAMPLE SITE, ONLY ONE SAMPLE TYPE WAS UTILIZED FOR THAT SITE. THE AVERAGE CHARACTERISTIC SIZE FOR THE REACH IS THE AVERAGE OF ALL ADJUSTED SIZES CORRESPONDING TO A PARTICULAR CHARACTERISTIC SIZE BEING EVALUATED. THE ONLY CHARACTERISTIC SIZES PRESENTED ARE B90, B65, AND B50.

3. YEAR OF ANALYSIS
   THIS IS THE YEAR DURING WHICH THE DETERMINATION OF THE AVERAGE CHARACTERISTIC SIZES WAS MADE. IT IS IMPLIED THAT ESSENTIALLY ALL RELEVANT DATA PRIOR TO AND INCLUDING THE YEAR OF ANALYSIS HAVE BEEN CONSIDERED.

4. NUMBER OF SITES IN AND NEAR REACH WITH GRID-BY-NUMBER DATA. (GBN)

5. NUMBER OF SITES IN AND NEAR REACH WITH GRID-BY-NUMBER FROM PHOTOGRAPH DATA.(GBNP)

6. NUMBER OF SITES IN AND NEAR REACH WITH BULK SIEVE ANALYSIS DATA.(S)

   THE TOTAL NUMBER OF SAMPLING SITES FROM 4, 5, AND 6 WERE THE NUMBER OF SITES USED TO EVALUATE THE AVERAGE CHARACTERISTIC SIZES FOR THE REACH.

7. CODE FOR SOURCE OF DATA
   - 0 NO DATA
   - 1 HIGHWAYS AND RIVER ENGINEERING DIVISION, RESEARCH COUNCIL OF ALBERTA.
   - 2 HYDROLOGY BRANCH, WATER RESOURCES DIVISION, ALBERTA DEPARTMENT OF AGRICULTURE
   - 3 DEPARTMENT OF CIVIL ENGINEERING, UNIVERSITY OF ALBERTA
   - 4 GEOLOGY DIVISION, RESEARCH COUNCIL OF ALBERTA
   - 5 CONSULTING ENGINEERING FIRM
   - 6 WATER SURVEY OF CANADA

   THIS IS A MULTIPLE CODE. THE FIRST CODED SOURCE IS THE MOST IMPORTANT SOURCE, THE OTHERS ARE OF DECREASING IMPORTANCE.

TABLE #71 (CONTINUED)

8. CODE FCR LOCATICN OF SAMPLE SITES
   0 NC SAMPLES FOR REACH
   1 ALL SAMPLE SITES IN REACH
   2 MCST SAMPLE SITES IN REACH
   3 MCST SAMPLE SITES OUT OF REACH
   4 MCST SAMPLE SITES A SHORT DISTANCE CUT OF REACH
   5 ALL SAMPLE SITES AN APPRECIABLE DISTANCE OUT OF REACH

9. CCDE FCR BED-MATERIAL TYPE IN REACH
   0 NCT APPLICABLE
   1 SAND
   2 SAND WITH LOCAL GRAVEL
   3 GRAVEL
   4 GRAVEL WITH LCCAL SAND
   5 SAND AND GRAVEL

10. CODE FOR REPRESENTATIVENESS OF ADOPTED SIZES
   0 NCT REPRESENTATIVE CF 1, 2, OR 3
   1 REPRESENTATIVE OF THE AVERAGE MATERIAL IN THE REACH
   2 REPRESENTATIVE OF THE OBVIOUSLY COARSER MATERIAL IN THE REACH
   3 REPRESENTATIVE OF THE OBVIOUSLY FINER MATERIAL IN THE REACH

11. AVERAGE B90 (OR D90) SIZE FOR REACH

12. AVERAGE B65 (OR D65) SIZE FOR THE REACH

13. AVERAGE B50 (OR D65) SIZE FOR THE REACH

TABLE # 71
AVERAGE CHARACTERISTIC BED-MATERIAL SIZES FOR REACH

(ALL SIZES IN MILLIMETERS)

SITE #	YEAR OF ANALY-SIS	# SITES GBN	# SITES GBNP	# SITES SIEVE	SOURCES OF DATA 1	2	3	LOC. CODE	BED TYPE CODE	REP. CODE	D90 ADJUSTED	D65 ADJUSTED	D50 ADJUSTED
1	1970	22	0	0	5	0	0	2	3	1	81.00	53.00	46.00
2	1970	4	0	0	5	0	0	2	3	1	81.00	57.00	41.00
3	1970	0	3	0	1	0	0	1	3	1	127.00	70.00	53.00
4	1970	0	0	0	0	0	0	0	3		0.0	0.0	0.0
5	1970	0	0	0	0	0	0	0	2		0.0	0.0	0.0
6	1970	0	0	4	1	4	0	2	1	1	0.51	0.34	0.31
7	1970	0	0	3	1	0	0	1	1	1	0.27	0.23	0.22
8	1970	0	8	1	1	4	0	2	3	1	171.00	112.00	80.00
9	1970	1	6	1	1	2	4	2	3	1	94.00	62.00	48.00
10	1970	2	1	1	1	4	0	1	3	1	183.00	100.00	73.00
11	1970	0	0	0	0	0	0	0	3		0.0	0.0	0.0
12	1970	2	2	0	1	0	0	1	3	1	132.00	82.00	60.00
13	1970	1	0	0	1	0	0	1	3	1	86.00	56.00	43.00
14	1970	2	1	1	1	2	0	2	3	1	100.00	61.00	52.00
15	1970	0	0	0	0	0	0	0	-1		0.0	0.0	0.0
16	1970	0	0	0	0	0	0	0	2		0.0	0.0	0.0
17	1970	0	0	2	1	0	0	1	1	1	0.37	0.23	0.19
18	1970	1	0	2	2	1	0	1	3	1	78.00	51.00	42.00
19	1970	2	0	0	1	0	0	1	3	2	375.00	153.00	86.00
20	1970	2	0	1	1	2	4	2	3	1	83.00	51.00	42.00
21	1970	3	0	0	1	0	0	1	3	1	95.00	62.00	51.00
22	1970	0	0	3	1	0	0	1	3	1	138.00	83.00	70.00
23	1970	0	0	3	1	0	0	1	2	1	0.39	0.29	0.26
24	1970	3	0	1	1	2	0	1	3	1	125.00	79.00	58.00
25	1970	0	0	3	1	0	0	1	2	1	0.63	0.35	0.32
26	1970	3	0	0	1	0	0	1	3	1	76.00	54.00	46.00
27	1970	4	0	0	1	0	0	1	3	1	103.00	67.00	54.00
28	1970	0	0	2	1	0	0	1	1	1	0.29	0.22	0.20
29	1970	0	0	3	1	0	0	1	1	1	0.72	0.49	0.43
30	1970	0	0	3	1	0	0	1	1	1	0.79	0.37	0.33
31	1970	0	0	0	0	0	0	0	1		0.0	0.0	0.0
32	1970	0	0	4	1	0	0	1	2	1	0.83	0.64	0.56
33	1970	0	0	0	0	0	0	0	-1		0.0	0.0	0.0
34	1970	0	0	0	0	0	0	0	3		0.0	0.0	0.0
35	1970	0	3	1	1	4	0	1	3	1	319.00	191.00	117.00
36	1970	0	7	2	1	4	2	1	3	1	127.00	79.00	63.00
37	1970	3	0	2	1	4	0	2	3	1	70.00	40.00	31.00
38	1970	0	0	1	4	0	0	1	4	1	53.00	32.00	24.00
39	1970	0	0	0	0	0	0	0	-1		0.0	0.0	0.0
40	1970	12	0	0	2	0	0	1	3	1	100.00	37.00	27.00

TABLE # 71
AVERAGE CHARACTERISTIC BED-MATERIAL SIZES FOR REACH

(ALL SIZES IN MILLIMETERS)

SITE #	YEAR OF ANALY-SIS	# SITES GBN	# SITES GBNP	# SITES SIEVE	SOURCES OF DATA			LOC. CODE	BED TYPE CODE	REP. CODE	D90 ADJUSTED	D65 ADJUSTED	D50 ADJUSTED
					1	2	3						
41	1970	0	4	1	1	2	0	1	3	1	49.00	31.00	27.00
42	1970	35	0	0	2	0	0	1	3	1	66.00	51.00	43.00
43	1970	0	0	0	0	0	0	0	3		0.0	0.0	0.0
44	1970	0	0	0	0	0	0	0	3		0.0	0.0	0.0
45	1970	0	0	3	1	0	0	1	1	1	0.54	0.32	0.26
46	1970	0	0	0	0	0	0	0	-1		0.0	0.0	0.0
47	1970	0	0	0	0	0	0	0	-1		0.0	0.0	0.0
48	1970	1	0	1	2	0	0	1	3	1	60.00	34.00	28.00
49	1970	7	0	2	2	1	4	2	3	1	95.00	60.00	48.00
50	1970	4	0	1	1	4	0	2	3	1	83.00	49.00	38.00
51	1970	0	0	6	1	4	0	2	2	1	0.43	0.32	0.28
52	1970	30	0	0	2	0	0	2	3	1	127.00	77.00	63.00
53	1970	4	0	0	1	0	0	1	3	1	105.00	58.00	47.00
54	1970	0	0	3	1	0	0	1	2	1	1.35	0.40	0.31
55	1970	3	0	0	1	0	0	1	3	1	239.00	124.00	92.00
56	1970	3	0	0	1	0	0	1	3	1	89.00	50.00	42.00
57	1970	3	0	0	1	0	0	1	3	1	147.00	70.00	51.00
58	1970	0	0	0	0	0	0	0	-1		0.0	0.0	0.0
59	1970	0	0	0	0	0	0	0	-1		0.0	0.0	0.0
60	1970	0	0	2	1	0	0	1	1	1	0.16	0.11	0.09
61	1970	1	0	0	2	0	0	4	3	-1	48.00	38.00	33.00
62	1970	1	0	0	1	0	0	1	3	-1	318.00	192.00	140.00
63	1970	2	0	0	2	0	0	2	3	-1	56.00	39.00	33.00
64	1970	3	0	1	2	0	0	1	3	1	65.00	47.00	40.00
65	1970	0	0	1	4	0	0	1	3	-1	72.00	35.00	26.00
66	1970	0	0	1	4	0	0	2	3	-1	73.00	42.00	32.00
67	1970	3	0	0	1	0	0	1	3	1	323.00	200.00	145.00
68	1970	3	0	1	1	0	0	1	3	1	162.00	100.00	78.00
69	1970	0	0	0	0	0	0	0	-1		0.0	0.0	0.0
70	1970	0	1	0	1	0	0	1	3	-1	115.00	62.00	47.00
71	1970	0	0	1	2	0	0	1	3	-1	60.00	38.00	30.00
72	1970	0	0	1	1	0	0	1	3	1	165.00	100.00	76.00
73	1970	0	0	1	1	0	0	1	3	1	80.00	40.00	30.00
74	1970	27	0	0	1	0	0	1	3	1	160.00	53.00	41.00
75	1970	0	0	0	0	0	0	0	-1		0.0	0.0	0.0
76	1970	0	0	0	0	0	0	0	-1		0.0	0.0	0.0
77	1970	1	0	1	1	2	0	1	3	1	75.00	48.00	37.00
78	1970	1	0	0	1	0	0	1	3	-1	104.00	70.00	57.00
79	1970	39	0	0	2	1	0	2	3	1	101.00	62.00	55.00
80	1970	1	0	1	1	0	0	1	3	1	114.00	78.00	60.00

TABLE # 71
AVERAGE CHARACTERISTIC BED-MATERIAL SIZES FOR REACH

(ALL SIZES IN MILLIMETERS)

SITE #	YEAR OF ANALY-SIS	# SITES GBN	# SITES GRNP	# SITES SIEVE	SOURCES OF DATA 1	2	3	LOC. CODE	BED TYPE CODE	REP. CODE	D90 ADJUSTED	D65 ADJUSTED	D50 ADJUSTED
81	1970	8	0	0	2	1	0	3	3	1	72.00	47.00	39.00
82	1970	13	0	0	2	1	0	1	3	1	88.00	55.00	43.00
83	1970	2	0	1	1	2	0	1	3	1	105.00	59.00	43.00
84	1970	22	0	0	2	1	0	1	3	1	67.00	37.00	31.00
85	1970	3	0	0	1	0	0	1	3	1	189.00	115.00	86.00
86	1970	0	3	0	1	0	0	1	3	1	216.00	121.00	80.00
87	1970	1	2	1	1	2	4	2	3	1	87.00	52.00	43.00
88	1970	1	2	2	1	2	4	2	3	1	101.00	61.00	49.00
89	1970	24	0	0	2	0	0	2	3	1	60.00	34.00	30.00
90	1970	0	2	2	1	2	4	1	3	-1	90.00	53.00	40.00
91	1970	0	1	1	1	4	0	2	3	1	148.00	93.00	67.00
92	1970	2	0	1	1	2	0	1	3	1	84.00	58.00	45.00
93	1970	3	0	0	1	0	0	1	3	1	177.00	118.00	96.00
94	1970	14	0	0	2	0	0	1	3	1	124.00	69.00	56.00
95	1970	4	0	0	1	0	0	1	3	1	202.00	113.00	79.00
96	1970	3	0	0	1	0	0	1	3	1	202.00	119.00	78.00
97	1970	2	0	1	2	0	0	1	3	1	45.00	29.00	23.00
98	1970	3	0	0	1	0	0	1	4	1	73.00	49.00	38.00
99	1970	0	0	0	0	0	0	0	-1		0.0	0.0	0.0
100	1970	5	0	0	1	2	0	1	3	1	232.00	124.00	100.00
101	1970	4	0	9	2	0	0	1	3	1	51.00	35.00	30.00
102	1970	0	0	0	0	0	0	0	-1		0.0	0.0	0.0
103	1970	3	0	0	1	0	0	1	3	1	248.00	143.00	115.00
104	1970	7	0	0	2	0	0	1	3	1	77.00	53.00	46.00
105	1970	0	0	0	0	0	0	0	-1		0.0	0.0	0.0
106	1970	8	0	0	2	0	0	3	3	1	138.00	86.00	52.00
107	1970	0	2	0	1	0	0	1	3	1	208.00	128.00	95.00
108	1970	0	3	0	1	0	0	1	3	1	171.00	98.00	63.00
109	1970	3	0	0	2	0	0	1	3	1	79.00	54.00	47.00
110	1970	0	0	1	4	0	0	1	3	1	36.00	25.00	19.00
111	1970	0	0	0	0	0	0	0	-1		0.0	0.0	0.0
112	1970	0	0	6	6	0	0	1	5	1	3.00	0.42	0.25
113	1970	3	0	0	1	0	0	1	3	1	168.00	115.00	89.00
114	1970	0	0	0	0	0	0	0	-1		0.0	0.0	0.0
115	1970	4	0	0	1	0	0	1	3	1	103.00	46.00	35.00
116	1970	4	0	0	1	0	0	1	3	1	109.00	80.00	66.00
117	1970	3	0	0	1	0	0	1	1	1	0.45	0.33	0.29
118	1970	3	0	0	1	0	0	1	1	1	0.36	0.21	0.18
119	1970	3	0	0	1	0	0	1	4	2	194.00	94.00	51.00
120	1970	0	0	0	0	0	0	0	2		0.0	0.0	0.0

APPENDIX J

PROGRAM FOR GENERAL REGIME TYPE ANALYSIS WITH AN EXAMPLE

J.1 General

The main program and associated subroutines presented in this appendix have been developed to facilitate a generalized regime type analysis of Alberta rivers. All programs were written in Fortran IV and have been processed by the Michigan Terminal System using the Fortran IV G compiler on the IBM 360-67 computer at the University of Alberta Computing Center.

J.2 Files Used

J.2.1 System Files

The file names of the system files used by the main program and the subroutines presented in this appendix are:

1. SSPLIB, the IBM Scientific Subroutine Package Library
2. GPLIB, a general program for plotting on the Calcomp Plotter. This program makes extensive use of the subroutines in the file CALCOMPLIB. GPLIB was developed by Cooper and Howells (1969).
3. CALCOMPLIB, the library containing the detail subroutines for plotting.

Details concerning these files are available from the Computing Center, University of Alberta.

J.2.2 Data File for Analysis

One other file called RIVFILE contained the selected data for the general analysis. For this investigation RIVFILE stored 80 variables for 120 river reaches. Arora (1971) has documented the program used to construct RIVFILE from the tape containing all the basic data from the River Data Tables given in APPENDIX I.

J.2.3 Files with Subroutines Written for this Analysis

The following files were constructed to store the subroutines especially written for this analysis:

1. HYDPFILE, a file with one subroutine to compute and print out standard hydraulic parameters, initiation of motion data and bed-load transport data. The subroutine name in the file was HYDPAR.

2. ANALFILE, a file with fourteen subroutines to define variable names of data stored in RIVFILE, to carry out screening, to construct working vectors, to determine the distribution of a single variable, to carry out simple linear and multiple linear regression. This file had to be in core for all analysis and/or plotting. The subroutines in this file were: DEFEL, GSCRN, FWORKV, SCRN, PRMA, COEFV, FLAS, PHIST, SORTD, PRLS, LSQFT, PRMR, REGRE, and DATA.

3. PLOTFILE, a file with two subroutines to carry out the desired plotting and to print out the plotted data. The subroutine names in this file were: PLOTR, and PLOTVA.

Obviously all of the subroutines could have been stored on one file, but three separate files were used to reduce the amount of core storage required when carrying out certain analyses. This procedure meant that a "C" had to be placed in one or two call statements in the main program when the called subroutines were not in core. The documentation of the main program indicates these changes at CALL HYDPAR and at CALL GPL.

J.3 Listing of the Input Data Cards and Control Cards for an Analysis

An example of the input data cards and control cards for the example of Section J.4 are presented in FIGURE J.1. In the three screenings in this example the computations are carried out for four characteristic discharges: the 2 year flood, low level bench, valley flat, and valley flat if return period is LE. 20 years.

A more detailed explanation of the input data and control cards used in this example are as follows:

1. The element numbers and the corresponding abbreviated names are first read in as data.

2. The main control card is next. The codes on this card are explained as follows:

   2 means detailed print out of data in working vectors
   1 means detailed print out of hydraulic parameters, etc.
   1 means analysis from program segment(s) to follow
   1 means plotting from program segment(s) to follow

3. The general screening for the first run in the analysis is next. This consists of a control card, followed by an explanation of the particular screening. This is continued until all desired general screening for the run are carried out. At the end of the general screening there is a control to indicate the end of the screen.

4. The element numbers for the desired discharge, area, and width are next read in with a description of the discharge being used in the run.

5. This is followed by a control card to indicate if there is to be further screening on the desired discharge.

6. After all screening is completed for the desired discharge the printing of the basic data in the working vectors and/or printing of the hydraulic parameters and/or analysis, and/or plotting are carried out for the stated screenings and the stated discharge.

7. A control card then follows to indicate if another screening, or discharge is to follow, or if the analysis is at an end. The controls used are defined as follows:

   2 further screening of stated discharge to follow
   3 new general screening to follow
   4 new discharge to follow (no computed screening)
   5 new discharge to follow (computed screening)
   6 end of all runs in analysis

More detail concerning the control cards used for an analysis is found in the write up of the main program and the subroutines.

J.4 Listing of Main Program, Computed Results, and Subroutines

The listing of the main program is presented first. In this listing four program segments have been inserted to illustrate the following three basic types of analysis and the type of plotting used in the investigation:

1. variation of a single variable

   e.g. $WSM = a \cdot Q^{0.50}$

2. simple linear regression

   e.g. of the form $WSM = a \cdot Q^{b}$; that is,

   $\log(WSM) = \log(a) + b \log(Q)$

3. multiple linear regression

   e.g. of the form $WSM = a \cdot Q^{b} \cdot S^{c}$; that is,

   $\log(WSM) = \log(a) + b \log(Q) + c \log(S)$

4. a plot

   e.g. WSM versus Q

A print out of the results for the first discharge (2 year flood) and for the first screening (Gravel-1) given in Section J.3 are presented after the main program used for the computations.

After the sample print out an example of the modification of a value in ARRAY is given. An example of a computed screening is also provided. The documentation of the main program indicates where these modifications would be inserted in the main program if required.

Finally a listing of all the subroutines are given. The subroutines are listed in the same order as given in Section J.2.3

```
CCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCC
OOOOOOOOOOOOOOOOOOOOOOOOOOOOOOOOOOOOOOOOOOOOOOOOOOOOOOOOOOOOOOOOOOOOOOOOOOOOOOOO
LLLLLLLLLLLLLLLLLLLLLLLLLLLLLLLLLLLLLLLLLLLLLLLLLLLLLLLLLLLLLLLLLLLLLLLLLLLLLLLL
         11111111112222222222333333333344444444445555555555666666666677777777778
12345678901234567890123456789012345678901234567890123456789012345678901234567890
C     LAST JOB CONTROL CARD BEFORE DATA.
--------------------------------------------------------------------------------
  1   2   3   4   5   6   7   8   9  10
IRCA     IBASIN  IDA      IESFAO  IYRFAO  ISRC     IREP     ISF      IRDS     IST
  11  12  13  14  15  16  17  18  19  20
IINOP    IQLM    IALM     IWSLM   IQF1    IAF1     IWSF1    IQF2     IAF2     IWSF2
  21  22  23  24  25  26  27  28  29  30
IQF3     IAF3    IWSF3    IQF4    IAF4    IWSF4    IQD1     IAD1     IWSD1    IQD2
  31  32  33  34  35  36  37  38  39  40
IAD2     IWSD2   IQD3     IAD3    IWSD3   IQD4     IAD4     IWSD4    IQLLB    IALLB
  41  42  43  44  45  46  47  48  49  50
IWSLLB  IRPLLB  IDLLB    IQDLLB  IQVF    IAVF     IWSVF    IRPVF    IDVF     IQDVF
  51  52  53  54  55  56  57  58  59  60
ITERR    IPSLU   IVT      IUNFIT  IRCVB   IRCVW    IVFP     IVFE     ICPAT    IISL
  61  62  63  64  65  66  67  68  69  70
ITYFL    IBAR    ISIN     ITLA    IDLA    IBANKA   IBANKN   IPABLT   IPABRT   IVBANK
  71  72  73  74  75  76  77  78  79  80
IPBEDM  IRCA     INGBN    INGBNP  INS     ILSAM    IRSAM    IDG90    IDG65    IGD50
    2     1       1     1
 0 1    7       0.99       2.01
 ACCEPT IF REPRESENTATIVE OR QUITE REPRESENTATIVE
 0 1   71       2.99       3.01
 ACCEPT IF BED-MATERIAL IS GRAVEL
 1 1
 END OF SCREEN
   18    19    20 2.0 YEAR FLOOD
 1 1
 END OF SCREEN
 4
   39    40    41  DISCHARGE AT LOW LEVEL BENCH AND/OR TRIM LINE
 1 1
 END OF SCREEN
 4
   45    46    47  DISCHARGE AT VALLEY FLAT
 1 1
 END OF SCREEN
 2
 0 1   48         1.0        20.
 ACCEPT IF RETURN PERIOD AT VALLEY FLAT IS GE. 1 AND LE. 20 YEARS.
 1 1
 END OF SCREEN
 3
 0 1    7       0.99       2.01
 ACCEPT IF REPRESENTATIVE, OR QUITE REPRESENTATIVE
 0 1   71       2.99       3.01
 ACCEPT IF BED-MATERIAL IS GRAVEL
 0 1    6       0.99       3.01
 ACCEPT IF THE RATING CURVE IS STABLE, SLIGHTLY UNSTABLE , OR MOD. UNSTABLE
 0 1   11      -0.01       0.01
 ACCEPT IF HYDROMETRIC STATION OPERATIONAL AT TIME OF SURVEY
 0 1   77       0.99       1.01
 ACCEPT IF BED-MATERIAL SAMPLES ARE REPRESENTATIVE
 0 1   80       8.00      152.2
 ACCEPT IF DG50 IS GE. 8 MM AND LE. 152.2MM.( PHI RANGE 3 TO 7.25)
 1 1
 END OF SCREEN
--------------------------------------------------------------------------------
         11111111112222222222333333333344444444445555555555666666666677777777778
12345678901234567890123456789012345678901234567890123456789012345678901234567890
```

FIGURE J.1 EXAMPLE OF INPUT DATA AND CONTROL CARDS FOR AN ANALYSIS

```
CCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCC
COCCOCCCCCOOCCCOOCCOCOCOOCCCOOCCOOOOOOOOOOOOOOOOOOOOOOCOOOOOOOOOOOOOOCCOOOOOOOOO
LLLLLLLLLLLLLLLLLLLLLLLLLLLLLLLLLLLLLLLLLLLLLLLLLLLLLLLLLLLLLLLLLLLLLLLLLLLLLLLL
         1111111111222222222233333333334444444444555555555566666666667777777778
12345678901234567890123456789012345678901234567890123456789012345678901234567890
   18   19   20  2 YR FLOOD
 1 1
 END OF SCREEN
 4
   39   40   41  DISCHARGE AT LOW LEVEL BENCH AND/OR TRIM LINE
 1 1
 END OF SCREEN
 4
   45   46   47  DISCHARGE AT VALLEY FLAT
 1 1
 END OF SCREEN
 2
 0 1   48       1.0       20.
 ACCEPT IF RETURN PERIOD AT VALLEY FLAT IS GE. 1 AND LE. 20 YEARS.
 1 1
 END OF SCREEN
 3
 0 1    7      0.99      2.01
 ACCEPT IF REPRESENTATIVE, OR QUITE REPRESENTATIVE
 0 1   71      2.99      3.01
 ACCEPT IF BED-MATERIAL IS GRAVEL
 0 1    6      0.99      3.01
 ACCEPT IF THE RATING CURVE IS STABLE, SLIGHTLY UNSTABLE , OR MOD. UNSTABLE
 0 1   11     -0.01      0.01
 ACCEPT IF HYDROMETRIC STATICN OPERATIONAL AT TIME OF SURVEY
 0 1   77      0.99      1.01
 ACCEPT IF BED-MATERIAL SAMPLES ARE CONSIDERED REPRESENTATIVE OF REACH
 0 1   80      8.00     152.2
 ACCEPT IF DG50 IS GE. 8 MM AND LE. 152.2MM.( PHI RANGE 3 TO 7.25)
 0 1    9      0.01     33.33
 ACCEPT IF RELATIVE DEVIATION OF WATER SURFACE PROFILE IS GE. 0.01 AND LE.33.33%
 0 1   65     -0.01      2.01
 ACCEPT IF LATERALLY STABLE, SLIGHTLY UNSTABLE, OR MODERATELY UNSTABLE
 0 5   73      2.99     1000.   74       2.99     1000.   75       2.99     1000.
 ACCEPT IF NUMBER OF BED-MATERIAL SITES GE. 3.0
 0 1   76      0.99      2.01
 ACCEPT IF BED MATERIAL SAMPLES ARE FROM REACH OR ARE MOSTLY FROM THE REACH
 1 1
 END OF SCREEN
   18   19   20 2.0 YEAR FLOOD
 1 1
 END OF SCREEN
 4
   39   40   41  DISCHARGE AT LOW LEVEL BENCH AND/OR TRIM LINE
 1 1
 END OF SCREEN
 4
   45   46   47  DISCHARGE AT VALLEY FLAT
 1 1
 END OF SCREEN
 2
 0 1   48       1.0       20.
 ACCEPT IF RETURN PERIOD AT VALLEY FLAT IS GE. 1 AND LE. 20 YEARS.
 1 1
 END OF SCREEN
 6
C     FIRST JOB CONTROL CARD AFTER DATA.
         1111111111222222222233333333334444444444555555555566666666667777777778
12345678901234567890123456789012345678901234567890123456789012345678901234567890
```

FIGURE J.1 (continued) EXAMPLE OF INPUT DATA AND CONTROL CARDS FOR AN ANALYSIS

```
C
C     ******************************************************************
C
C     GENERAL REGIME TYPE ANALYSIS FOR ALBERTA RIVERS  - D. I. BRAY -
C
C     ******************************************************************
C
C     THIS PROGRAM IS DESIGNED TO:
C          1.  PRINT OUT BASIC DATA
C          2.  COMPUTE AND PRINT OUT COMMON HYDRAULIC PARAMETERS,
C              INITIATION OF MOTION DATA, AND BED-LOAD TRANSPORT DATA.
C          3.  CARRY OUT ANY OF THE FOLLOWING THREE STANDARD TYPES
C              OF ANALYSIS:
C                   - VARAIBILITY OF A SINGLE VARIABLE
C                   - SIMPLE LINEAR REGRESSION FOR A DEPENDENT VARIABLE
C                     AND ONE INDEPENDENT VARIABLE.
C                   - MULTIPLE LINEAR REGRESSION FOR A DEPENDENT
C                     VARIABLE AND TWO, OR THREE INDEPENDENT VARIABLES.
C          4.  PLOT DATA ON AN  X-Y  PLOT WITH THE POSSIBILITY OF
C              PRINTING A THIRD PARAMETER BY THE PLOTTED POINT AND THE
C              POSSIBILITY OF SELECTING UP TO 13 DIFFERENT SYMBOLS PER
C              PLOT.  THIS OPTION MAKES USE OF THE SUBROUTINE GPL
C              (AVAILABLE AT U. OF. ALBERTA) PLUS THE CALCOMP PLOTTER.
C     ******************************************************************
C     THIS PROGRAM MAINLY PROVIDES A CONTROL OVER THE VARIOUS SUB-
C        ROUTINES WHICH ARE CALLED DURING THE EXECUTION.  IT ALSO
C        PROVIDES FOR THE INSERTION OF ANY NUMBER OF SELF-CONTAINED
C        PROGRAM SEGMENTS FOR ANALYSIS OR PLOTTING.
C     ******************************************************************
C     THE GENERAL PROCEDURE USED IN ANY ANALYSIS IS TO:
C          1.  READ THE BASIC DATA FROM A FILE ( CRNE:RIVFILE ) INTO
C              ARRAY(I,IELEM).  ( THIS PART HAS TO BE CHANGED WHEN A
C              NEW ARRAY IS ESTABLISHED:  FOR THIS CASE  I(MAX)= 120;
C              IELEM(MAX)= 80 )
C          2.  READ IN THE NAMES OF THE VARIABLES ASSOCIATED WITH EACH
C              ELEMENT NUMBER IN ARRAY.  (THIS HAS TO BE CHANGED WHEN
C              A NEW ARRAY IS ESTABLISHED )
C          3.  READ IN A CONTROL CARD TO INDICATE IF:
C                   - THE BASIC DATA IS TO BE PRINTED OUT
C                   - THE ANALYSIS FOR THE HYDRAULIC PARAMETERS
C                     IS TO BE CARRIED OUT
C                   - ANY ANALYSIS OF PROGRAM SEGMENTS IS TO BE
C                     CARRIED OUT
C                   - ANY PLOTTING FROM PROGRAM SEGMENTS IS TO BE
C                     CARRIED OUT
C          4.  READ IN THE GENERAL SCREENING CRITERIA TO BE USED BEFORE
C              ANY ANALYSIS OR PLOTTING.
C          5.  READ IN THE ELEMENT NUMBERS FOR THE DISCHARGE, AREA, AND
C              WATER SURFACE WIDTH WHICH ARE TO BE USED IN THE ANALYSIS
C              AND/OR PLOTTING.
C          6.  READ IN CONTROL CARDS WHICH INDICATE IF A NEW SCREENING
C              IS TO FOLLOW, AN ADDITIONAL SCREENING IS TO FOLLOW, OR
C              A NEW DISCHARGE IS TO FOLLOW.
C          7.  DO THE DESIRED PRINTING, ANALYSIS, AND/OR PLOTTING
C
```

```
C     THIS PROCEDURE CONTINUES UNTIL ALL DESIRED SCREENINGS ARE CARRIED
C        OUT  AND ALL DESIRED DISCHARGES ARE EVALUATED FOR THE BASIC
C        DATA PRINT OUT, AND/OR THE COMPUTATION AND PRINT OUT OF THE
C        HYDRAULIC PARAMETERS, AND/OR THE ANALYSIS OF THE PROGRAM
C        SEGMENTS, AND/OR THE PLOTTING FROM PROGRAM SEGMENTS.
C     *****************************************************************
C     SEE WRITE UP AT THE BEGINNING OF THE SUBROUTINES FOR FURTHER
C        EXPLANATICNS.
C     *****************************************************************
C     THIS PROGRAM IS SET UP FOR A TOTAL OF 120 RIVER REACHES.  ALL
C            APPROPRIATE DIMENSION STATEMENTS MUST BE CHANGED TO
C            ACCOMCDATE MCRE REACHES.
C     *****************************************************************
      COMMON/SUB1/ARRAY(120,80)
      COMMON RCA(120),Q(120),AM(120),WSM(120),DM(120),VM(120),S(120)
      COMMON DG90(120),DG65(120),DG50(120),VISK(120),THRES(120)
      COMMON SCOR(120),T(120)
      DIMENSION Y(120),X1(120),X2(120),X3(120),XX(120,4)
      DIMENSION ITITLE(20),IDISCH(16),TTEMP(120)
C     ********      IF USING PRINT OUT FOR HYDRAULIC PARAMETERS PUT
C                   THE FOLLOWING FILES IN CORE
C     ********           ANALFILE+*SSPLIB+HYDPFILE
C     ********           3=CRNE:RIVFILE
C     ********      IF USING ANALYSIS ONLY PUT FOLLOWING FILES IN CORE
C     ********           ANALFILE+*SSPLIB
C     ********           3=CRNE:RIVFILE
C     ********      IF USING PLOT ONLY PUT FOLLOWING FILES IN CORE
C     ********           ANALFILE+*SSPLIB+PLOTFILE+CC:GPLIB+CC:CALCOMPLIB
C     ********           3=CRNE:RIVFILE 8=*SINK* 9=*DUMMY* (FOR TEST)
C     ********           3=CRNE:RIVFILE 8=*SINK* 9=*PLOTXY* (FOR RUN)
C     ANY COMBINATION OF THE ABOVE MAY BE CARRIED OUT IF THE APPROPRIATE
C            FILES ARE PUT IN CORE.
C     IF ALL FILES ARE PUT INTO CORE WITH EACH RUN, IT IS UNNECESSARY TO
C            PLACE THE   C  IN COL. ONE  FOR CALL HYDPAR AND CALL GPL.
      IR=5
      IP=6
      NELEM=80
      NSTAT=120
      NA=NSTAT
      ISCRE=0
C     NELEM = NO. OF ELEMENTS IN MAJOR ARRAY
C     NSTAT = NO. OF STATIONS IN MAJOR ARRAY
      WRITE(IP,1069)
 1069 FORMAT('1',///)
      WRITE(IP,1070)
 1070 FORMAT('0',30X,'GENERALIZED REGIME TYPE ANALYSIS OF ALBERTA RIVERS
     1'//)
C     ?????????????????????????????????
C     READ ARRAY FROM DISK FILE  3=CRNE:RIVFILE
C     FORMAT(8F16.7)
      DO 1 I=1,120
      JB=1
      JE=8
    3 READ(3,2) (ARRAY(I,J),J=JB,JE)
    2 FORMAT(8F16.7)
```

```
      JB=JB+8
      JE=JE+8
      IF(JE.LE.80) GO TO 3
    1 CONTINUE
C     ??????????????????????????????????
C     aaaaaaaaaaaaaaa  TEMPORARY MODIFICATION OF BASIC DATA  aaaaaaaaaaa
C     aaaa  CHANGE THE FOLLOWING IF THE MASTER ARRAY IS CHANGED  aaaaaaa
C     aaaa  REMOVE THE FOLLOWING IF THE ERROR HAS BEEN CORRECTED IN THE
C     BASIC DATA; THAT IS IN  RIVFILE   aaaaaaaaaaaaaaaaaaaaaaaaaaaaaaaaa
C     aaaaaaaaaa  BEGINNING OT TEMPORARY MODIFICATION OF BASIC DATA   aa
C     aaaaaaaaaaaaaaaaa   END OF TEMPORARY MODIFICATIONS   aaaaaaaaaaaaa
C     ***********************************
C     READ IN THE ELEMENT NUMBERS AND DESCRIPTIONS OF ELEMENT CODES.
      CALL DEFEL(IRCA,IDA,ISF,IST,ITERR,IRCVB,IRCVW,IVFE,ICPAT,IISL,ITYF
     1L,IBAR,ISIN,IDLA,IBANKA,IPABLT,IPABRT,IRDA,IDG90,IDG65,IDG50,IELEM
     2T)
C     SYMBOLS FOR ELEMENT NUMBERS CANNOT BE USED UNLES THEY APPEAR IN
C     THE ABOVE CALL STATEMENT; WITH THE FOLLOWING EXCEPTION FOR Q,A,WS.
C     ***********************************
C     ***************************************
C     PRINT OUT VALUES IN THE ELEMENTS FOR THE FIRST REACH
      WRITE(IP,1971)
 1971 FORMAT('0',10X,'VALUES FOR THE ELEMENTS IN THE FIRST REACH'/)
      WRITE(IP,1972) (ARRAY(1,LELEM),LELEM=1,IELEMT)
 1972 FORMAT(' ',8F16.7)
C     ***************************************
C     *************************************
C     DEFINITION OF CONTROL PARAMETERS FOR TYPE OF ANALYSIS
      READ(IR,3640) IPWV,IPTRAN,IANAL,IPLOTT
 3640 FORMAT(4I5)
C     IPWV IS CODE FOR PRINT OUT OF WORKING VECTORS
C        IF IPWV = 0 NO PRINT OUT
C        IF IPWV = 1 THE FIRST VALUES OF THE WORKING VECTORS ARE
C                PRINTED.
C        IPWV = 2 ALL OF THE VALUES IN THE WORKING VECTORS ARE
C                PRINTED.
C     IPTRAN IS THE CODE FOR THE PRINT OUT OF THE HYDRAULIC PARAMETERS,
C        THE INITIATION OF MOTION DATA, AND THE BED-LOAD TRANSPORT DATA.
C        IF IPTRAN = 0 NOTHING IS PRINTED
C        IF IPTRAN = 1 ALL OF THE RESULTS FOR THE HYDRAULIC PARAMETERS,
C           ETC. ARE PRINTED OUT.
C     IANAL IS THE CODE TO DETERMINE IF THE ANALYTIC COMPUTATIONS WILL
C        BE EXECUTED.
C        IF IANAL = 0 NO ANALYSIS WILL BE EXECUTED.
C        IF IANAL = 1 THE DETAILED ANALYSIS WILL BE EXECUTED.
C     IPLOTT IS THE CODE TO DETERMINE IF ANY PLOTTING IS TO BE DONE.
C        IF IPLOTT = 0 NO PLOTTING WILL BE DONE
C        IF IPLOTT = 1 THE PLOTTING WILL BE DONE.
C     ***********************************
C     ***************************************
C     FILL TEST VECTOR TO 0.0
      DO 47 I=1,NA
      T(I)=0.0
   47 CONTINUE
C     ***************************************
```

```
  6C9 DUMMY=609.
C     PRINT HEADINGS FOR GENERAL SCREENING
      WRITE(IP,1052)
 1052 FORMAT('1',////,20X,'DESCRIPTION OF GENERAL SCREENING USED FOR MAJ
     1OR DATA SET'/)
      CALL GSCRN(NA,ISCRE,IT,ITT)
      IF(IT.LT.0.OR.IT.GT.1) GO TO 900
      IF(ITT.LT.1.OR.ITT.GT.8) GO TO 900
C     **********************************
C     DEFINITION OF THE DISCHARGE TO BE USED IN THE ANALYSES
  196 WRITE(IP,906)
  906 FORMAT('0','$$$$$$$$$$$$$$$$$$$$$$$$$$$$$$$$$$$$$$$$$$$$$$$$$$$$$$$$$
     1$$$$$$$$$$$$$$$$$$$$$$$$$$$$$$$$$$$$'/)
      IPTEST=IPTRAN
      IPWVT=IPWV
      WRITE(IP,199)
      WRITE(IP,195)
  195 FORMAT('0',10X,'THE FOLLOWING ANALYSES ARE BASED ON THE STATED DIS
     1CHARGE AFTER GENERAL SCREENING AND OTHER SCREENINGS TO THIS POINT'
     2/)
      READ(IR,1080) IQ,IAM,IWSM,(IDISCH(IDS),IDS=1,16)
 1080 FORMAT(3I5,16A4,1X)
      WRITE(IP,1078) (IDISCH(IDS),IDS=1,16)
 1078 FORMAT('0',10X,'DISCHARGE USED: ',16A4)
      WRITE(IP,1081)
 1081 FORMAT('0',20X,'ELEMENT NUMBERS USED FOR WORKING VECTORS')
      WRITE(IP,1082) IQ,IAM,IWSM
 1082 FORMAT('0',10X,'DISCHARGE:',I4,' ; AREA     :',I4,' ; WIDTH    :',
     1I4)
      WRITE(IP,1083) IRCA,ISF,IST,ITERR,IRCVB
 1083 FORMAT('0',10X,'REACH #  :',I4,' ; SLOPE FIE:',I4,' ; SLOPE TOP:',
     1I4,' ; TERRAIN  :',I4,' ; CHA TO VB:',I4)
      WRITE(IP,1084) IISL,ISIN,IBANKA
 1084 FORMAT('0',10X,'ISLANDS  :',I4,' ; SINUOSITY:',I4,' ; ALLU BANK:',
     1I4)
      WRITE(IP,1085) IDG90,IDG65,IDG50
 1085 FORMAT('0',10X,'BEDMAT 90:',I4,' ; BEDMAT 65:',I4,' ; BEDMAT 50:',
     1I4)
C     **************************************
      CALL FWORKV(IRCA,IQ,IAM,IWSM,ISF,IST,IDG90,IDG65,IDG50,ITERR,IISL,
     1ISIN,NA)
C     **************************************
C     @@@@@@@  ADDITIONAL GENERAL SCREENING,IF DESIRED  @@@@@@@@@@@@@@@@
C     @@@@@@@  EXPLANATION MUST BE PRINTED OUT IF THIS OPTION IS USED  @
C     @@@@@@@  IT = 4 MUST NOT BE USED AS A CONTROL IF THIS OPTION IS
C     @@@@@@@  USED:  USE  IT = 5 IN THIS CASE.    @@@@@@@@@@@@@@@@@@@@@
C     @@@@@@@@@@@   OPTIONAL COMPUTED SCREENIN TO FOLLOW IF DESIRED @@@@
C     @@@@@@@@@@@   END OF OPTIONAL COMPUTED SCREENING   @@@@@@@@@@@@@@@
C     **************************************
C     PRINT OUT WORKING VECTORS IF DESIRED
      IF(IPWVT.LE.0) GO TO 3613
      IF(IPWV.LE.0) GO TO 3613
      WRITE(IP,199)
      WRITE(IP,1089)
 1089 FORMAT('1',////)
```

```
      WRITE(IP,1090) (IDISCH(II),II=1,16)
 1090 FORMAT('0',20X,'BASIC DATA FOR REACHES FOR: ',16A4/)
      WRITE(IP,1091)
 1091 FORMAT(' ',8X,'  REACH   DISCHARGE  AREA     WIDTH    DEPTH  VEL.
     1 SLOPE    DG90    DG65    DG50    VISCOSITY   SCOR  WSM/DM DM/DG5
     10 ')
      WRITE(IP,1092)
 1092 FORMAT(' ',8X,'     #        FT**3/S    FT**2     FT       FT     FT/S
     1  FT/FT     MM      MM       MM      FT**2/S'/)
      IF(IPWV.EC.1) GO TC 3614
      IF(IPWV.GE.2) GO TO 3615
 3614 NAPR=1
      K=1
      GC TO 3616
 3615 NAPR=NA
      K=1
 3616 DC 413 I=1,NAPR
      IF(T(I).LE.0.0) GO TO 413
      IF(WSM(I).LE.0.0.OR.DM(I).LE.0.0) GO TO 3620
      FORMF=WSM(I)/DM(I)
      GC TO 3623
 3620 FORMF=-1.0
 3623 IF(DM(I).LE.0.0.OR.DG50(I).LE.0.0) GO TO 3621
      DMODG=DM(I)*305./DG50(I)
      GO TO 3622
 3621 DMODG=-1.0
 3622 WRITE(IP,1093)   RCA(I),Q(I),AM(I),WSM(I),DM(I),VM(I),S(I),DG90(I)
     1,CG65(I),DG50(I),VISK(I),SCOR(I),FORMF,DMODG
 1093 FORMAT(' ',9X,   F5.0,F12.0,F9.0,F8.0,F8.2,F7.2,F10.6,3F8.2,F12.7,
     1F7.2,2F7.0)
      IF(K.EQ.40) GO TO 421
      IF(K.EQ.80) GO TO 421
      GC TO 411
  421 WRITE(IP,1089)
      WRITE(IP,1090) (IDISCH(II),II=1,16)
      WRITE(IP,1091)
      WRITE(IP,1092)
  411 K=K+1
  413 CONTINUE
      WRITE(IP,1089)
      IPWVT=0
C     ************************************
C     ************************************
  608 DUMMY=608.
C     SCREENING OF WORKING VECTORS
 3613 WRITE(IR,1999)
 1999 FORMAT('0',10X,'SCREENING AFTER WORKING VECTORS FORMED FOR SPECIFI
     1ED DISCHARGE'/)
      ISCRE=0
      CALL GSCRN(NA,ISCRE,IT,ITT)
      IF(IT.LT.0.CR.IT.GT.1) GO TO 900
      IF(ITT.LT.1.OR.ITT.GT.8) GO TO 900
C     ***************************************
C     ************************************
C     *****  PLACE A C IN CCL. ONE IF HYDRAULIC PARAMETERS NOT DESIRED
```

```
      CALL HYDPAR(IPTRAN,NA,IPTEST,IDISCH)
      WRITE(IP,1089)
C     *****  REMOVE THE C IN COL. ONE IF HYDRAULIC PARAMETERS DESIRED.
C     ********************
C     BEGINNING OF DETAILED ANALYSES
      WRITE(IP,199)
  199 FORMAT('0',10X,'--------------------------------------------------
     1--------------------------------')
      IF(IANAL.LE.0) GO TO 3632
      IF(IANAL.GE.1) GO TO 3631
 3631 DUMMY=3631.0
C     ********** FIRST ANALYSIS TO FOLLOW ******************************
C     AAAAAAAAAAAAAAAAAAAAAAAA    L- 1     AAAAAAAAAAAAAAAAAAAAAAAAAAAAA
C     LACEY ANALYSIS   WSM=A * Q**0.50
      DO 750 I=1,NA
      IF(T(I).LE.0.0) GO TO 751
      IF(WSM(I).LE.0.0.OR.Q(I).LE.0.0) GO TO 751
      Y(I)=WSM(I)/Q(I)**0.5
      GO TO 750
  751 Y(I)=0.0
  750 CONTINUE
      WRITE(IP,1750)
 1750 FORMAT('0',10X,'LACEY TYPE RELATION:  WSM=A*Q**0.5')
      CALL PRMA(Y,NA,NAS,AMAX,AMIN)
      CALL PHIST(Y,NAS,AMAX,AMIN)
C     %%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%
C     AAAAAAAAAAAAAAAAAAAAAAAA    WSM- 1   AAAAAAAAAAAAAAAAAAAAAAAAAAAAA
C     WIDTH RELATION:  WSM=A*Q**B
      DO 950 I=1,NA
      IF(T(I).LE.C.0) GO TO 951
      IF(WSM(I).LF.0.0.OR.Q(I).LE.0.0) GO TO 951
      Y(I)=ALOG10(WSM(I))
      X1(I)=ALOG10(Q(I))
      GO TO 950
  951 Y(I)=0.0
      X1(I)=0.0
  950 CONTINUE
      WRITE(IP,1950)
 1950 FORMAT('0',10X,'WIDTH RELATION:  WSM=A*Q**B ')
      ITYPE=1
      CALL PRLS(Y,X1,NA,ITYPE,0)
C     %%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%
C     AAAAAAAAAAAAAAAAAAAAAAAA    WSM- 2   AAAAAAAAAAAAAAAAAAAAAAAAAAAAA
C     WIDTH RELATION:  WSM=A*Q**B*S**C
      DO 3105 I=1,NA
      IF(T(I).LE.0.0) GO TO 3106
      IF(WSM(I).LE.0.0.OR.Q(I).LE.0.0.OR.S(I).LE.0.0) GO TO 3106
      Y(I)=ALOG10(WSM(I))
      X1(I)=ALOG10(Q(I))
      X2(I)=ALOG10(S(I))
      X3(I)=0.0
      GO TO 3105
 3106 Y(I)=0.0
      X1(I)=0.0
      X2(I)=0.0
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      X3(I)=0.0
 3105 CONTINUE
      WRITE(IP,3107)
 3107 FORMAT('0',10X,'WIDTH RELATION: WSM= A*Q**B*S**C')
      WRITE(IP,3108)
 3108 FORMAT('0',10X,'INTERCEPT= LOG(A); LOG(WSM)= VAR1; LOG(Q)= VAR2;
     1LOG(S)= VAR3 ')
      NVAR=3
      CALL PRMR(Y,X1,X2,X3,NA,NVAR,NSTAT,0)
C     $$$$$$$$$$$$$$$$$$$$$$$$$$$$$$$$$$$$$
C     *********************  END OF ANALYSIS  ***************************
C     BEGINNING OF PLOTTING ROUTINES
 3632 IF(IPLOTT.LE.0) GO TO 901
      IF(IPLOTT.GE.1) GO TO 3634
 3634 DUMMY=3634.0
C     ********** FIRST PLOTTING PROGRAM TO FOLLOW **********************
C     PPPPPPPPPPPPPPPPPPPPPPPPP    Q- 1    PPPPPPPPPPPPPPPPPPPPPPPPPPPPPP
C     PLOT WSM VS Q  FOR Z = DG50 IN MM.; AND SYMBOLS AS RELATION OF
C     CHANNEL TO VALLEY BOTTOM.
      DO 2020 I=1,NA
      IF(T(I).LE.0.0) GO TO 2025
      IF(DG50(I).LE.0.0) GO TO 2021
      GO TO 2022
 2021 DG50(I)=-1.0
 2022 IF(ARRAY(I,IRCVB).GT.4.01) GO TO 2023
      GO TO 2024
 2023 ARRAY(I,IRCVB)=-1.0
 2024 IF(WSM(I).LE.0.0.OR.Q(I).LE.0.0) GO TO 2025
      XX(I,1)=Q(I)
      XX(I,2)=WSM(I)
      XX(I,3)=DG50(I)
      XX(I,4)=ARRAY(I,IRCVB)
      GO TO 2020
 2025 XX(I,1)=0.0
      XX(I,2)=0.0
      XX(I,3)=0.0
      XX(I,4)=-9.0
 2020 CONTINUE
      DIMENSION ALPHW(20)
      DATA ALPHW/'WSM ','V Q ','(Z=D','G50 ','IN M','M)(S','YMBO','LS=R'
     1,'EL. ','TO V','AL. ','BOT)','Q IN',' CFS','    ','    ','WSM ','I
     2N F','T.  ','    '/
      CALL PLOTR(XX,NA,5,2,2, 1,0,1.0,5.0,10.0,1.0,3.0,6.0,ALPHW)
      CALL PLOTVA(XX,NA)
C     @@@@@@@@@@@@@@@@@@@@@@@@@@@@@@@@@@@@@@@@@@@@@@@@@@@@@@@@@@@@
C     *************  END OF PLOTTING PROGRAM SEGMENTS    ***************
C     NOW AT END OF ANALYSIS AND PLOTTING FOR ONE CASE
C     TEST TO SEE IF ANOTHER SET  OF ANALYSIS IS TO BE EXECUTED
  901 READ(IR,1300) IT
 1300 FORMAT(I2)
      WRITE(IP,915) IT
  915 FORMAT('0',10X,'IT = ',I3)
      ISCRE=0
      IF(IT.LE.1) GO TO 900
      IF(IT.EQ.2) GO TO 608
```

```
      IF(IT.EQ.3) GO TO 800
      IF(IT.EQ.4) GO TO 196
      IF(IT.EQ.5) GO TO 811
      IF(IT.GE.6) GO TO 902
C     IT LE. 1 WILL CAUSE AN EXIT AFTER RECOGNITION OF ERROR IN THE
C              ORDER OF THE CONTROL CARDS FOR SCREENING.
C     IT = 2 WILL CAUSE  NEW SCREENING OF THE WORKING VECTORS.
C              THE TEST VECTOR IS UNALTERED
C              (SCREENING CRITERIA TO FOLLOW)
C     IT = 3 WILL CAUSE NEW SCREENING ( CONSIDER AS A NEW PROBLEM)
C              THE TEST VECTOR WILL BE INITIALIZED TO 0.0.
C              (GENERAL SCREENING CRITERIA TO FOLLOW)
C     IT = 4 WILL CAUSE NEW WORKING VECTOR TO BE FORMED FOR Q, AM,&WSM.
C              GENERAL SCREEENING UNALTERED
C              (ELEMENT NUMBERS FOR Q, AM, AND WSM TO FOLLOW)
C               NOTE: IT = 4 MUST NOT BE USED IF THE TEST PARAMETER T
C               IS SET BY MEANS OF THE COMPUTATION OPTION
C     IT = 5 WILL CAUSE A NEW WORKING VECTOR TO BE FORMED FOR Q, AM, AND
C              WSM AND WILL CAUSE THE TEST VECTOR TO BE SET TO 0.0 FOR
C              CASES WHICH DID NOT MEET THE COMPUTED SCREENING CRITERIA.
C              GENERAL SCREENING REMAINS UNALTERED
C              (ELEMENT NUMBERS FOR Q,AM,AND WSM TO FOLLOW)
C     IT GE. 6  WILL CAUSE A PLANNED EXIT.
  800 DO 801 I=1,NA
      T(I)=0.0
  801 CONTINUE
      WRITE(IP,804)
  804 FORMAT('0',10X,'TEST VECTOR SET TO  0.0: GENERAL SCREENING TO FOLL
     1OW ( CONSIDER AS A NEW PROBLEM)'/)
      GO TO 609
  811 DO 812 I=1,NA
      IF(TTEMP(I).LE.0.0) GO TO 813
      GO TO 812
  813 T(I)=1.0
  812 CONTINUE
      WRITE(IP,815)
  815 FORMAT('0',10X,'TEST VECTOR SET TO 0.0 FOR CASES WHICH DID NOT MEE
     1T COMPUTED SCREENING CRITERIA')
      GO TO 196
  900 WRITE(IP,1301)
 1301 FORMAT('1',20X,'ERROR IN ORDER OF CONTROL CARDS USED FOR SCREENING
     1')
  902 IF(IPLOTT.EQ.0) GO TO 903
C     ********  PLACE A C IN COL. ONE IF NO PLOTS DESIRED  *************
      CALL GPL(X1,Y,X2,NA,0,2,2,-1,1,2.0,4.0,12.0,1.0,3.0,9.0,ITITLE,8)
C     ********  REMOVE THE C IN COL. ONE IF PLOTS ARE DESIRED  *********
  903 WRITE(IP,911)
  911 FORMAT('1',10X,'END OF THIS ANALYSIS'/)
      STOP
      END

IORY REQUIREMENTS 002CE6 BYTES
'81 RC=0
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GENERALIZED REGIME TYPE ANALYSIS OF ALBERTA RIVERS

DEFINITION OF VARIABLES CORRESPONDING TO THE ELEMENTS IN THE MAJOR DATA SET

ELEM. #:	1	2	3	4	5	6	7	8	9	10
ELEM. NAME:	IRCA	IBASIN	IDA	IESFAO	IYRFAO	ISRC	IREP	ISF	IRDS	IST
ELEM. #:	11	12	13	14	15	16	17	18	19	20
ELEM. NAME:	IINOP	IQLM	IALM	IWSLM	IQF1	IAF1	IWSF1	IQF2	IAF2	IWSF2
ELEM. #:	21	22	23	24	25	26	27	28	29	30
ELEM. NAME:	IQF3	IAF3	IWSF3	IQF4	IAF4	IWSF4	IQD1	IAD1	IWSD1	IQD2
ELEM. #:	31	32	33	34	35	36	37	38	39	40
ELEM. NAME:	IAD2	IWSD2	IQD3	IAD3	IWSD3	IQD4	IAD4	IWSD4	IQLLB	IALLB
ELEM. #:	41	42	43	44	45	46	47	48	49	50
ELEM. NAME:	IWSLLB	IRPLLB	IDLLB	IQDLLB	IQVF	IAVF	IWSVF	IRPVF	IDVF	IQDVF
ELEM. #:	51	52	53	54	55	56	57	58	59	60
ELEM. NAME:	ITERR	IPSLU	IVT	IUNFIT	IRCVB	IRCVW	IVFP	IVFE	ICPAT	IISL
ELEM. #:	61	62	63	64	65	66	67	68	69	70
ELEM. NAME:	ITYFL	IBAR	ISIN	ITLA	IDLA	IBANKA	IBANKN	IPABLT	IPABRT	IVBANK
ELEM. #:	71	72	73	74	75	76	77	78	79	80
ELEM. NAME:	IPREDM	IROA	INGBN	INGBNP	INS	ILSAM	IRSAM	IDG90	IDG65	IGD50

VALUES FOR THE ELEMENTS IN THE FIRST REACH

1.0000000	3000000.0000000	27800.0000000	1.0000000	14.0000000	2.0000000	1.0000000	0.0007400
10.0000000	0.0005800	0.0	39600.0000000	8328.0000000	1118.0000000	203000.0000000	24747.0000000
1556.0000000	215000.0000000	25582.0000000	1559.0000000	245000.0000000	27549.0000000	1563.0000000	260000.0000000
28476.0000000	1565.0000000	0.0	0.0	0.0	0.0	0.0	0.0
170000.0000000	22286.0000000	1541.0000000	110000.0000000	17000.0000000	1503.0000000	0.0	0.0
0.0	0.0	0.0	-1.0000000	275000.0000000	29854.0000000	1567.0000000	22.0000000
4.5000000	2.0000000	2.0000000	0.0	1.0000000	0.0	2.0000000	3.0000000
2.0000000	1.0000000	1.0000000	2.0000000	1.0000000	3.0000000	1.0099993	0.0
0.0	6.0000000	3.0000000	40.0000000	40.0000000	0.0	3.0000000	1.0000000
22.0000000	0.0	0.0	2.0000000	1.0000000	81.0000000	53.0000000	46.0000000

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        DESCRIPTION OF GENERAL SCREENING USED FOR MAJOR DATA SET

SCREENING ON ELEM #    7 : LOWER BOUND =       0.990 : UPPER BOUND =       2.010 : TEST TYPE =   1
DESCRIPTION:  ACCEPT IF REPRESENTATIVE, OR QUITE REPRESENTATIVE.

SCREENING ON ELEM #   71 : LOWER BOUND =       2.990 : UPPER BOUND =       3.010 : TEST TYPE =   1
DESCRIPTION:  ACCEPT IF BED-MATERIAL IS GRAVEL.

CODE NUMBERS REMAINING AFTER ALL SCREENING TO THIS POINT

   1.   2.   3.   4.   8.   9.  10.  11.  12.  13.  18.  19.  20.  21.  22.  24.  26.  35.  36.  37.
  40.  41.  42.  44.  48.  49.  50.  52.  53.  56.  57.  62.  63.  64.  65.  66.  67.  71.  73.  74.
  77.  78.  79.  81.  83.  84.  85.  86.  87.  88.  89.  90.  91.  92.  93.  94.  95.  96.  97. 100.
 101. 103. 104. 106. 107. 108. 109. 110. 113. 115. 116.
TOTAL NUMBER SATISFYING TESTS =  71

$$$$$$$$$$$$$$$$$$$$$$$$$$$$$$$$$$$$$$$$$$$$$$$$$$$$$$$$$$$$$$$$$$$$$$$$$$$$$$$$$$$$$$$$$$$$$$$$$$$

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THE FOLLOWING ANALYSES ARE BASED ON THE STATED DISCHARGE AFTER GENERAL SCREENING AND OTHER SCREENINGS TO THIS POINT

DISCHARGE USED:  2.0 YEAR FLOOD

          ELEMENT NUMBERS USED FOR WORKING VECTORS

DISCHARGE:  18 : AREA      :  19 : WIDTH     :  20

REACH #   :   1 : SLOPE FIE:   8 : SLOPE TOP:  10 : TERRAIN   :  51 : CHA TO VB:  55

ISLANDS   :  60 : SINUOSITY:  63 : ALLU BANK:  66

BEDMAT 90:  78 : BEDMAT 65:  79 : BEDMAT 50:  80

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BASIC DATA FOR REACHES FOR: 2.0 YEAR FLOOD

REACH #	DISCHARGE FT**3/S	AREA FT**2	WIDTH FT	DEPTH FT	VEL. FT/S	SLOPE FT/FT	DG90 MM	DG65 MM	DG50 MM	VISCOSITY FT**2/S	SCOR	WSM/DM	DM/DG50
1.	215000.	25582.	1559.	16.41	8.40	0.000740	81.00	53.00	46.00	0.0000154	1.51	95.	109.
2.	255000.	40101.	1787.	22.44	6.36	0.000690	81.00	57.00	41.00	0.0000141	2.52	80.	167.
3.	290000.	35000.	1540.	22.73	8.29	0.000220	127.00	70.00	53.00	0.0000141	1.29	68.	131.
4.	315000.	34839.	1855.	18.78	9.04	0.000350	0.0	0.0	0.0	0.0000141	1.35	99.	-1.
8.	85000.	12300.	890.	13.82	6.91	0.000520	171.00	112.00	80.00	0.0000141	1.55	64.	53.
9.	29500.	4800.	552.	8.70	6.15	0.000510	94.00	62.00	48.00	0.0000141	1.35	63.	55.
10.	24000.	3000.	326.	9.20	8.00	0.000949	183.00	100.00	73.00	0.0000141	1.95	35.	38.
11.	8500.	1350.	201.	6.72	6.30	0.001402	0.0	0.0	0.0	0.0000141	2.35	30.	-1.
12.	16000.	2150.	377.	5.70	7.44	0.003000	132.00	82.00	60.00	0.0000166	3.78	66.	29.
13.	32000.	5320.	627.	8.48	6.02	0.000920	86.00	56.00	43.00	0.0000154	1.25	74.	60.
18.	1700.	370.	130.	2.85	4.59	0.005409	78.00	51.00	42.00	0.0000154	1.45	46.	21.
19.	5600.	1500.	221.	6.79	3.73	0.001200	375.00	153.00	86.00	0.0000141	2.25	33.	24.
20.	10800.	1980.	363.	5.45	5.45	0.000840	83.00	51.00	42.00	0.0000141	2.05	67.	40.
21.	1000.	423.	96.	4.41	2.36	0.000550	95.00	62.00	51.00	0.0000141	2.65	22.	26.
22.	2800.	660.	199.	3.32	4.24	0.003300	138.00	83.00	70.00	0.0000154	2.05	60.	14.
24.	5500.	1250.	225.	5.56	4.40	0.001800	125.00	79.00	58.00	0.0000141	2.35	40.	29.
26.	1000.	198.	56.	3.54	5.05	0.003900	76.00	54.00	46.00	0.0000141	1.75	16.	23.
35.	17000.	2430.	311.	7.81	7.00	0.002600	319.00	191.00	117.00	0.0000154	1.35	40.	20.
36.	24400.	2900.	495.	5.86	8.41	0.002500	127.00	79.00	63.00	0.0000141	1.62	84.	28.
37.	42000.	6700.	601.	11.15	6.27	0.000350	70.00	40.00	31.00	0.0000141	1.65	54.	110.
40.	3000.	425.	132.	3.22	7.06	0.005700	100.00	37.00	27.00	0.0000154	1.45	41.	36.
41.	4400.	940.	206.	4.56	4.68	0.001200	49.00	31.00	27.00	0.0000141	1.45	45.	52.
42.	1000.	250.	86.	2.91	4.00	0.003600	66.00	51.00	43.00	0.0000141	1.65	30.	21.
44.	11500.	2000.	320.	6.25	5.75	0.000990	0.0	0.0	0.0	0.0000141	1.65	51.	-1.
48.	6000.	940.	235.	4.00	6.38	0.004900	60.00	34.00	28.00	0.0000154	1.29	59.	44.
49.	12000.	2200.	367.	5.99	5.45	0.001200	95.00	60.00	48.00	0.0000141	1.65	61.	38.
50.	12400.	2750.	365.	7.53	4.51	0.000350	83.00	49.00	38.00	0.0000141	1.35	48.	60.
52.	1000.	255.	87.	2.93	3.92	0.003600	127.00	77.00	63.00	0.0000154	1.35	30.	14.
53.	1600.	385.	140.	2.75	4.16	0.002100	105.00	58.00	47.00	0.0000141	1.45	51.	18.
56.	470.	116.	47.	2.47	4.05	0.001800	89.00	50.00	42.00	0.0000141	1.75	19.	18.
57.	370.	196.	53.	3.70	1.89	0.001200	147.00	70.00	51.00	0.0000141	1.55	14.	22.
62.	13000.	1621.	310.	5.23	8.02	0.004000	318.00	192.00	140.00	0.0000154	1.35	59.	11.
63.	11100.	1600.	341.	4.69	6.94	0.002000	56.00	39.00	33.00	0.0000154	1.35	73.	43.
64.	15500.	2300.	412.	5.58	6.74	0.001800	65.00	47.00	40.00	0.0000141	1.62	74.	43.
65.	17000.	2750.	526.	5.23	6.18	0.001200	72.00	35.00	26.00	0.0000141	1.27	101.	61.
66.	26500.	4310.	543.	7.94	6.15	0.000810	73.00	42.00	32.00	0.0000141	1.41	68.	76.
67.	1400.	220.	92.	2.39	6.36	0.015000	323.00	200.00	145.00	0.0000166	2.70	38.	5.
71.	2850.	493.	123.	4.01	5.78	0.005800	60.00	38.00	30.00	0.0000154	1.35	31.	41.
73.	840.	200.	86.	2.33	4.20	0.002500	80.00	40.00	30.00	0.0000154	1.40	37.	24.
74.	1860.	280.	116.	2.41	6.64	0.007700	160.00	53.00	41.00	0.0000154	2.70	48.	18.

BASIC DATA FOR REACHES FOR: 2.0 YEAR FLOOD

REACH #	DISCHARGE FT**3/S	AREA FT**2	WIDTH FT	DEPTH FT	VEL. FT/S	SLOPE FT/FT	DG90 MM	DG65 MM	DG50 MM	VISCOSITY FT**2/S	SCOR	WSM/DM	DM/DG50
77.	2600.	380.	122.	3.11	6.84	0.005900	75.00	48.00	37.00	0.0000154	1.34	39.	26.
78.	3300.	473.	170.	2.78	6.98	0.004200	104.00	70.00	57.00	0.0000154	1.45	61.	15.
79.	3900.	855.	209.	4.09	4.56	0.001600	101.00	62.00	55.00	0.0000141	1.95	51.	23.
81.	340.	103.	55.	1.87	3.30	0.004300	72.00	47.00	39.00	0.0000154	1.85	29.	15.
83.	1650.	290.	153.	1.90	5.69	0.005900	105.00	59.00	43.00	0.0000154	3.10	81.	13.
84.	2300.	370.	149.	2.48	6.22	0.003900	67.00	37.00	31.00	0.0000141	1.55	60.	24.
85.	3700.	530.	148.	3.58	6.98	0.003800	189.00	115.00	86.00	0.0000154	1.55	41.	13.
86.	3600.	479.	146.	3.28	7.52	0.004600	216.00	121.00	80.00	0.0000154	1.45	45.	13.
87.	8000.	2250.	380.	5.92	3.56	0.001600	87.00	52.00	43.00	0.0000141	1.55	64.	42.
88.	10600.	1870.	360.	5.19	5.67	0.001700	101.00	61.00	49.00	0.0000141	1.45	69.	32.
89.	14600.	2250.	358.	6.28	6.49	0.001200	60.00	34.00	30.00	0.0000141	1.65	57.	64.
90.	20000.	3320.	390.	8.51	6.02	0.000940	90.00	53.00	40.00	0.0000141	1.98	46.	65.
91.	31500.	5100.	590.	8.64	6.18	0.000440	148.00	93.00	67.00	0.0000141	1.55	68.	39.
92.	1150.	277.	92.	3.01	4.15	0.002400	84.00	58.00	45.00	0.0000166	1.45	31.	20.
93.	1200.	259.	90.	2.88	4.63	0.003200	177.00	118.00	96.00	0.0000154	1.45	31.	9.
94.	0.	0.	0.	-1.00	-1.00	0.003200	124.00	69.00	56.00	0.0000154	1.65	-1.	-1.
95.	4500.	685.	187.	3.66	6.57	0.003700	202.00	113.00	79.00	0.0000154	1.95	51.	14.
96.	435.	149.	61.	2.44	2.92	0.006700	202.00	119.00	78.00	0.0000141	1.65	25.	10.
97.	1050.	280.	90.	3.11	3.75	0.000800	45.00	29.00	23.00	0.0000141	1.95	29.	41.
100.	1650.	306.	94.	3.26	5.39	0.008500	232.00	124.00	100.00	0.0000154	1.75	29.	10.
101.	2400.	560.	180.	3.11	4.29	0.001900	51.00	35.00	30.00	0.0000141	1.45	58.	32.
103.	4200.	791.	246.	3.22	5.31	0.001900	248.00	143.00	115.00	0.0000154	1.45	77.	9.
104.	5400.	1260.	311.	4.05	4.29	0.002500	77.00	53.00	46.00	0.0000141	1.55	77.	27.
106.	195.	68.	47.	1.45	2.87	0.011000	138.00	86.00	52.00	0.0000154	1.65	32.	8.
107.	3900.	530.	151.	3.51	7.36	0.004100	208.00	128.00	95.00	0.0000154	1.65	43.	11.
108.	3500.	1020.	297.	3.43	3.43	0.002000	171.00	98.00	63.00	0.0000141	2.05	86.	17.
109.	380.	86.	52.	1.65	4.42	0.005100	79.00	54.00	47.00	0.0000141	1.65	31.	11.
110.	1650.	450.	120.	3.75	3.67	0.000590	36.00	25.00	19.00	0.0000141	2.15	32.	60.
113.	1900.	380.	144.	2.64	5.00	0.003500	168.00	115.00	89.00	0.0000166	1.26	55.	9.
115.	650.	217.	68.	3.19	3.00	0.001000	103.00	46.00	35.00	0.0000141	1.45	21.	28.
116.	620.	235.	71.	3.31	2.64	0.001400	109.00	80.00	66.00	0.0000141	2.15	21.	15.

HYDRAULIC PARAMETERS FOR: 2.0 YEAR FLOOD

REACH #	CHEZY C	FRICT. FACTOR	MANN-ING.N	STRICK-LER.N	BLENCH FB	BLENCH FS	VM FT/S	VM/V*	TAU #/FT**2	INITIATION OF MOTION SHIELDS TAU/TAUC	NEILL VM/VMC	COOPER VM/VMC	BED-LOAD TRANSPORT SCHOK #/S/FT	STRAUB #/S/FT	MPM #/S/FT	BLENCH #/S/FT
1.	76.	0.044	0.031	0.025	4.30	0.38	8.40	13.4	0.76	0.81	-1.00	0.96	0.0	0.0	0.0	0.97
2.	51.	0.099	0.049	0.025	1.80	0.14	6.36	9.0	0.97	1.16	-1.00	0.95	0.01	0.31	0.41	0.51
3.	117.	0.019	0.021	0.026	3.02	0.37	8.29	20.6	0.31	0.29	-1.00	0.86	0.0	0.0	0.0	0.0
4.	112.	0.021	0.022	-1.000	4.35	0.40	9.04	19.7	0.41	-1.00	-1.00	-1.00	-1.00	-1.00	-1.00	-1.00
8.	82.	0.039	0.028	0.028	3.46	0.37	6.91	14.4	0.45	0.28	0.67	0.66	0.0	0.0	0.0	0.0
9.	92.	0.030	0.023	0.025	4.34	0.42	6.15	16.3	0.28	0.28	0.77	0.75	0.0	0.0	0.0	0.0
10.	86.	0.035	0.025	0.027	6.95	1.57	8.00	15.2	0.54	0.36	0.86	0.83	0.0	0.0	0.0	0.0
11.	65.	0.061	0.032	-1.000	5.90	1.24	6.30	11.4	0.59	-1.00	-1.00	-1.00	-1.00	-1.00	-1.00	-1.00
12.	57.	0.080	0.035	0.026	9.71	1.09	7.44	10.0	1.07	0.88	0.92	0.89	0.13	0.0	0.0	0.03
13.	68.	0.056	0.031	0.025	4.26	0.35	6.02	12.0	0.49	0.56	0.78	0.77	0.0	0.0	0.0	0.25
18.	37.	0.188	0.048	0.025	7.42	0.75	4.59	6.5	0.96	1.12	0.72	0.69	0.11	0.26	0.31	0.22
19.	41.	0.151	0.050	0.028	2.05	0.24	3.73	7.3	0.51	0.29	0.40	0.38	0.0	0.0	0.0	0.0
20.	81.	0.040	0.025	0.025	5.45	0.45	5.45	14.2	0.29	0.34	0.77	0.75	0.0	0.0	0.0	0.0
21.	48.	0.112	0.040	0.026	1.27	0.14	2.36	8.5	0.15	0.15	0.32	0.31	0.0	0.0	0.0	0.0
22.	41.	0.157	0.045	0.027	5.43	0.38	4.24	7.1	0.68	0.48	0.55	0.51	0.0	0.0	0.0	0.03
24.	44.	0.133	0.045	0.026	3.48	0.38	4.40	7.8	0.62	0.53	0.56	0.53	0.0	0.0	0.0	0.00
26.	43.	0.139	0.043	0.025	7.21	2.30	5.05	7.6	0.86	0.92	0.74	0.71	0.04	0.0	0.0	0.09
35.	49.	0.107	0.043	0.029	6.26	1.10	7.00	8.6	1.27	0.53	0.66	0.63	0.0	0.0	0.0	0.50
36.	70.	0.053	0.029	0.027	12.08	1.20	8.41	12.3	0.91	0.71	1.02	0.98	0.08	0.0	0.0	0.51
37.	100.	0.026	0.022	0.024	3.52	0.41	6.27	17.7	0.24	0.39	-1.00	0.87	0.0	0.0	0.0	0.0
40.	52.	0.095	0.035	0.023	15.48	2.66	7.06	9.2	1.15	2.09	1.26	1.22	0.63	1.73	3.16	-1.00
41.	63.	0.064	0.030	0.023	4.80	0.50	4.68	11.1	0.34	0.62	0.79	0.77	0.0	0.0	0.0	0.04
42.	39.	0.168	0.046	0.025	5.50	0.74	4.00	6.9	0.65	0.75	0.62	0.59	0.0	0.0	0.0	0.06
44.	73.	0.048	0.028	-1.000	5.29	0.59	5.75	12.9	0.39	-1.00	-1.00	-1.00	-1.00	-1.00	-1.00	-1.00
48.	46.	0.124	0.041	0.023	10.19	1.11	6.38	8.0	1.22	2.15	1.08	1.06	0.53	1.97	3.62	-1.00
49.	64.	0.062	0.031	0.025	4.96	0.44	5.45	11.3	0.45	0.46	0.72	0.70	0.0	0.0	0.0	0.04
50.	88.	0.033	0.024	0.024	2.70	0.25	4.51	15.5	0.16	0.21	0.62	0.61	0.0	0.0	0.0	0.0
52.	38.	0.177	0.047	0.027	5.25	0.69	3.92	6.7	0.66	0.51	0.54	0.50	0.0	0.0	0.0	0.06
53.	55.	0.086	0.032	0.025	6.28	0.51	4.16	9.6	0.36	0.38	0.63	0.60	0.0	0.0	0.0	0.01
56.	61.	0.070	0.029	0.025	6.65	1.42	4.05	10.7	0.28	0.33	0.65	0.62	0.0	0.0	0.0	0.0
57.	28.	0.321	0.065	0.026	0.96	0.13	1.89	5.0	0.28	0.27	0.27	0.25	0.0	0.0	0.0	0.0
62.	55.	0.084	0.035	0.030	12.30	1.66	8.02	9.8	1.31	0.46	0.76	0.71	0.0	0.0	0.0	0.50
63.	72.	0.050	0.027	0.024	10.26	0.98	6.94	12.6	0.59	0.87	1.09	1.06	0.04	0.0	0.0	0.34
64.	67.	0.057	0.030	0.025	8.14	0.74	6.74	11.8	0.63	0.77	0.96	0.94	0.00	0.0	0.0	0.25
65.	78.	0.042	0.025	0.023	7.31	0.45	6.18	13.8	0.39	0.74	1.03	1.01	0.0	0.0	0.0	0.24
66.	77.	0.044	0.027	0.024	4.76	0.43	6.15	13.5	0.40	0.62	0.89	0.88	0.0	0.0	0.0	0.17
67.	34.	0.228	0.051	0.031	16.93	2.80	6.36	5.9	2.24	0.76	0.68	0.62	0.48	0.0	0.0	0.14
71.	38.	0.179	0.050	0.023	8.34	1.57	5.78	6.7	1.45	2.38	0.96	0.93	0.61	2.83	5.25	-1.00
73.	55.	0.085	0.031	0.023	7.55	0.86	4.20	9.7	0.36	0.60	0.76	0.73	0.0	0.0	0.0	0.03
74.	49.	0.108	0.035	0.025	18.28	2.53	6.64	8.6	1.16	1.39	1.08	1.02	0.48	0.77	1.37	0.14

HYDRAULIC PARAMETERS FOR: 2.0 YEAR FLOOD

REACH #	CHEZY C	FRICT. FACTOR	MANN-ING.N	STRICK-LER.N	BLENCH FB	BLENCH FS	VM FT/S	VM/V*	TAU #/FT**2	INITIATION OF MOTION: SHIELDS TAU/TAUC	INITIATION OF MOTION: NEILL VM/VMC	INITIATION OF MOTION: COOPER VM/VMC	BED-LOAD TRANSPORT: SCHOK #/S/FT	BED-LOAD TRANSPORT: STRAUB #/S/FT	BED-LOAD TRANSPORT: MPM #/S/FT	BED-LOAD TRANSPORT: BLENCH #/S/FT
77.	50.	0.101	0.036	0.024	15.03	2.63	6.84	8.9	1.15	1.53	1.10	1.06	0.46	0.96	1.77	-1.00
78.	65.	0.062	0.027	0.026	17.49	2.00	6.98	11.4	0.73	0.63	0.99	0.93	0.03	0.0	0.0	0.19
79.	56.	0.081	0.033	0.026	5.05	0.45	4.56	9.9	0.41	0.37	0.62	0.59	0.0	0.0	0.0	0.0
81.	37.	0.190	0.045	0.025	5.82	0.65	3.30	6.5	0.50	0.63	0.57	0.53	0.0	0.0	0.0	0.01
83.	54.	0.089	0.031	0.025	17.08	1.20	5.69	9.5	0.70	0.80	0.95	0.89	0.08	0.0	0.0	0.03
84.	64.	0.063	0.027	0.024	15.56	1.61	6.22	11.3	0.59	0.94	1.11	1.06	0.09	0.0	0.0	0.16
85.	60.	0.072	0.031	0.028	13.61	2.30	6.98	10.5	0.85	0.49	0.83	0.78	0.0	0.0	0.0	0.14
86.	61.	0.069	0.030	0.028	17.22	2.91	7.52	10.8	0.94	0.58	0.93	0.87	0.05	0.0	0.0	0.24
87.	37.	0.193	0.055	0.025	2.14	0.12	3.56	6.4	0.59	0.68	0.49	0.48	0.0	0.0	0.0	0.10
88.	60.	0.071	0.033	0.025	6.15	0.51	5.67	10.6	0.55	0.55	0.76	0.74	0.0	0.0	0.0	0.15
89.	75.	0.046	0.027	0.023	6.70	0.76	6.49	13.2	0.47	0.77	1.00	0.99	0.0	0.0	0.0	0.16
90.	67.	0.057	0.032	0.025	4.26	0.56	6.02	11.9	0.50	0.61	0.80	0.79	0.0	0.0	0.0	0.02
91.	100.	0.026	0.021	0.027	4.41	0.40	6.18	17.6	0.24	0.17	0.69	0.67	0.0	0.0	0.0	0.0
92.	49.	0.108	0.037	0.025	5.72	0.78	4.15	8.6	0.45	0.49	0.63	0.60	0.0	0.0	0.0	0.02
93.	48.	0.111	0.037	0.029	7.46	1.11	4.63	8.5	0.57	0.29	0.55	0.51	0.0	0.0	0.0	0.02
94.	-1.	-1.000	-1.000	0.026	-1.00	-1.00	-1.00	-1.0	-1.00	-1.00	-1.00	-1.00	-1.00	-1.00	-1.00	-1.00
95.	56.	0.081	0.033	0.028	11.78	1.52	6.57	9.9	0.85	0.53	0.80	0.75	0.0	0.0	0.0	0.10
96.	23.	0.495	0.076	0.028	3.49	0.41	2.92	4.0	1.02	0.64	0.38	0.35	0.0	0.0	0.0	0.05
97.	75.	0.046	0.024	0.022	4.52	0.59	3.75	13.2	0.16	0.33	0.71	0.69	0.0	0.0	0.0	0.0
100.	32.	0.245	0.056	0.029	8.93	1.67	5.39	5.7	1.73	0.85	0.62	0.57	0.20	0.0	0.0	0.24
101.	56.	0.083	0.032	0.023	5.90	0.44	4.29	9.8	0.37	0.61	0.74	0.71	0.0	0.0	0.0	0.05
103.	68.	0.056	0.027	0.029	8.77	0.61	5.31	12.0	0.38	0.16	0.58	0.54	0.0	0.0	0.0	0.0
104.	43.	0.142	0.044	0.025	4.53	0.25	4.29	7.5	0.63	0.68	0.62	0.59	0.0	0.0	0.0	0.12
106.	23.	0.499	0.070	0.026	5.68	0.50	2.87	4.0	0.99	0.94	0.47	0.43	0.0	0.0	0.0	0.05
107.	61.	0.068	0.030	0.028	15.43	2.64	7.36	10.8	0.90	0.47	0.85	0.79	0.0	0.0	0.0	0.14
108.	41.	0.150	0.044	0.027	3.43	0.14	3.43	7.3	0.43	0.34	0.46	0.43	0.0	0.0	0.0	0.0
109.	48.	0.111	0.034	0.025	11.81	1.66	4.42	8.5	0.53	0.55	0.73	0.68	0.0	0.0	0.0	0.03
110.	78.	0.042	0.024	0.022	3.59	0.41	3.67	13.7	0.14	0.36	0.72	0.71	0.0	0.0	0.0	0.0
113.	52.	0.095	0.034	0.028	9.47	0.87	5.00	9.2	0.58	0.32	0.62	0.57	0.0	0.0	0.0	0.06
115.	53.	0.092	0.034	0.024	2.81	0.40	3.00	9.3	0.20	0.28	0.49	0.47	0.0	0.0	0.0	0.0
116.	39.	0.171	0.047	0.027	2.10	0.26	2.64	6.8	0.29	0.22	0.35	0.33	0.0	0.0	0.0	0.0

LACEY TYPE RELATION: WSM=A*Q**0.5

REACH NUMBERS USED IN THIS ANALYSIS

1.	2.	3.	4.	8.	9.	10.	11.	12.	13.	18.	19.	20.	21.	22.	24.	26.	35.	36.	37.
40.	41.	42.	44.	48.	49.	50.	52.	53.	56.	57.	62.	63.	64.	65.	66.	67.	71.	73.	74.
77.	78.	79.	81.	83.	84.	85.	86.	87.	88.	89.	90.	91.	92.	93.	95.	96.	97.	100.	101.
103.	104.	106.	107.	108.	109.	110.	113.	115.	116.										

TOTAL NUMBER OF REACHES USED IN THIS ANALYSIS = 70

MEAN A = 3.031 ; 95% C.L. FOR MEAN = 2.899 , 3.163 ; N = 70

MEAN A = 3.031 ; ST. DEV. = 0.552 ; COEF. OF VAR. =0.182 ; MIN.&MAX. = 1.771 , 5.020

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FREQUENCY DISTRIBUTION OF ONE VARIABLE

NUMBER OF DATA POINTS = 70

DATA USED IN THE ANALYSIS

3.3622	3.5388	2.8597	3.3051	3.0527	3.2139	2.1043	2.1802
2.9804	3.5050	3.1530	2.9532	3.4930	3.0358	3.7607	3.0339
1.7709	2.3853	3.1689	2.9326	2.4100	3.1056	2.7196	2.9840
3.0338	3.3502	3.2778	2.7512	3.5000	2.1679	2.7553	2.7189
3.2366	3.3093	4.0342	3.3356	2.4588	2.3040	2.9673	2.6897
2.3926	2.9593	3.3467	2.9828	3.7666	3.1069	2.4331	2.4333
4.2485	3.4966	2.9628	2.7577	3.3243	2.7129	2.5981	2.7876
2.9247	2.7775	2.3141	3.6742	3.7959	4.2322	3.3657	2.4179
5.0202	2.6675	2.9542	3.3036	2.6672	2.8514		

BOUNDS		MID-POINT	FREQ.F	REL.FREQ.	CUM. FREQ.	CUM.REL. FREQ.
1.5000-	2.0000	1.7500	1.	0.0143	1.	0.0143
2.0000-	2.5000	2.2500	12.	0.1714	13.	0.1857
2.5000-	3.0000	2.7500	24.	0.3429	37.	0.5286
3.0000-	3.5000	3.2500	22.	0.3143	59.	0.8429
3.5000-	4.0000	3.7500	7.	0.1000	66.	0.9429
4.0000-	4.5000	4.2500	3.	0.0429	69.	0.9857
4.5000-	5.0000	4.7500	0.	0.0	69.	0.9857
5.0000-	5.5000	5.2500	1.	0.0143	70.	1.0000
TOTALS			70.	1.0000		

MEDIAN = 2.9804

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AVERAGE CF GRCUPED DATA                  =          3.0071
VARIANCE CF GROUPED DATA                 =          0.3605
STANDARD CEVIATION OF GROUPED DATA =                0.6004
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WIDTH RELATICN:  WSM=A*Q**B

REACH NUMBERS USED IN THIS ANALYSIS

   1.    2.    3.    4.    8.    9.   10.   11.   12.   13.   18.   19.   20.   21.   22.   24.   26.   35.   36.   37.
  40.   41.   42.   44.   48.   49.   50.   52.   53.   56.   57.   62.   63.   64.   65.   66.   67.   71.   73.   74.
  77.   78.   79.   81.   83.   84.   85.   86.   87.   88.   89.   90.   91.   92.   93.   95.   96.   97.  100.  101.
 103.  104.  106.  107.  108.  109.  110.  113.  115.  116.

TOTAL NUMBER OF REACHES USED IN THIS ANALYSIS =  70

ANALYSIS OF VARIANCE

  SOURCE              D.F.  SUM OF SQUARES   MEAN SQUARE    MEAN SQUARE RATIO

LINEAR REGRESSION      1    0.1004715E 02    0.1004715E 02      1724.368
RESIDUAL ABOUT L.R.   68    0.3962069E 00    0.5826570E-02
TOTAL                 69    0.1044336E 02

LOG(A)=  0.3761 : 95% C.L. FOR LOG(A)=  0.2810 ,  0.4713 : B=  0.5267 : 95% C.L. FOR B=  0.5014 ,  0.5521

R= 0.981 : 95% C.L. FCR R= 0.969 , 0.988 : R**2 = 0.962 : STANDARD ERROR(LOG UNITS)=  0.0763 : N =  70

CF THE FCRM  Y =      2.378 * X**  0.5267
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WIDTH RELATICN: WSM= A*Q**B*S**C

INTERCEPT= LCG(A): LCG(WSM)= VAR1: LOG(Q)= VAR2:  LOG(S)= VAR3

REACH NUMBERS USED IN THIS ANALYSIS

   1.    2.    3.    4.    8.    9.   10.   11.   12.   13.   18.   19.   20.   21.   22.   24.   26.   35.   36.   37.
  40.   41.   42.   44.   48.   49.   50.   52.   53.   56.   57.   62.   63.   64.   65.   66.   67.   71.   73.   74.
  77.   78.   79.   81.   83.   84.   85.   86.   87.   88.   89.   90.   91.   92.   93.   95.   96.   97.  100.  101.
 103.  104.  106.  107.  108.  109.  110.  113.  115.  116.

TOTAL NUMBER OF REACHES USED IN THIS ANALYSIS =  70

VARIABLE      MEAN       STANDARD     CORRELATION    REGRESSION    STD. ERROR    COMPUTED
  NO.                    DEVIATICN      X VS Y       COEFFICIENT   OF REG.COEF.   T VALUE
   2        3.68710       0.72449      C.98081        0.51474       0.01615     31.87903
   3       -2.71133       0.39899     -0.63104       -0.03500       0.02932     -1.19388
DEPENDENT
   1        2.31819       0.38906
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INTERCEPT                  0.32539
MULTIPLE CORRELATION       0.98121
STD. ERROR OF ESTIMATE     0.07617
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ANALYSIS OF VARIANCE FOR THE REGRESSION

SOURCE OF VARIATION	DEGREES OF FREEDOM	SUM OF SQUARES	MEAN SQUARES	F VALUE
ATTRIBUTABLE TO REGRESSION	2	10.05572	5.02786	866.55029
DEVIATION FROM REGRESSION	67	0.38874	0.00580	
TOTAL	69	10.44446		

DATA SUPPLIED TO THE CALCOMP PLOTTER FOR THIS ANALYSIS

WSM V Q (Z=DG50 IN MM)(SYMBOLS=REL. TO VAL. BOT)Q IN CFS   WSM IN FT.

X = Q IN CFS

Y = WSM IN FT.

REACH NUMBERS USED IN THIS PLOT

1	2	3	4	8	9	10	11	12	13	18	19	20	21	22	24	26	35	36	37
40	41	42	44	48	49	50	52	53	56	57	62	63	64	65	66	67	71	73	74
77	78	79	81	83	84	85	86	87	88	89	90	91	92	93	95	96	97	100	101
103	104	106	107	108	109	110	113	115	116										

TOTAL NUMBER OF REACHES USED IN THIS ANALYSIS = 70

GPL SYMBOL CODE	VALUE FOR SYMBOL	NO. POINTS
1	0.0	1
2	1.0	16
3	2.0	33
4	3.0	20

PRINT OUT VALUES USED IN PLOT

#	X	Y	Z	SYMBOL
1	215000.0000000	1559.0000000	46.0000000	2.
2	255000.0000000	1787.0000000	41.0000000	2.
3	290000.0000000	1540.0000000	53.0000000	3.
4	315000.0000000	1855.0000000	-1.0000000	2.
8	85000.0000000	890.0000000	80.0000000	2.
9	29500.0000000	552.0000000	48.0000000	1.
10	24000.0000000	326.0000000	73.0000000	3.
11	8500.0000000	201.0000000	-1.0000000	3.
12	16000.0000000	377.0000000	60.0000000	1.
13	32000.0000000	627.0000000	43.0000000	3.
18	1700.0000000	130.0000000	42.0000000	1.
19	5600.0000000	221.0000000	86.0000000	3.
20	10800.0000000	363.0000000	42.0000000	2.
21	1000.0000000	96.0000000	51.0000000	2.
22	2800.0000000	199.0000000	70.0000000	1.
24	5500.0000000	225.0000000	58.0000000	3.
26	1000.0000000	56.0000000	46.0000000	1.
35	17000.0000000	311.0000000	117.0000000	3.
36	24400.0000000	495.0000000	63.0000000	2.
37	42000.0000000	601.0000000	31.0000000	3.
40	3000.0000000	132.0000000	27.0000000	2.
41	4400.0000000	206.0000000	27.0000000	2.
42	1000.0000000	86.0000000	43.0000000	2.
44	11500.0000000	320.0000000	-1.0000000	3.
48	6000.0000000	235.0000000	28.0000000	3.
49	12000.0000000	367.0000000	48.0000000	2.
50	12400.0000000	365.0000000	38.0000000	2.
52	1000.0000000	87.0000000	63.0000000	2.
53	1600.0000000	140.0000000	47.0000000	2.
56	470.0000000	47.0000000	42.0000000	2.
57	370.0000000	53.0000000	51.0000000	2.
62	13000.0000000	310.0000000	140.0000000	3.
63	11100.0000000	341.0000000	33.0000000	2.
64	15500.0000000	412.0000000	40.0000000	2.
65	17000.0000000	526.0000000	26.0000000	2.
66	26500.0000000	543.0000000	32.0000000	3.
67	1400.0000000	92.0000000	145.0000000	0.
71	2850.0000000	123.0000000	30.0000000	2.
73	840.0000000	86.0000000	30.0000000	1.
74	1860.0000000	116.0000000	41.0000000	1.
77	2600.0000000	122.0000000	37.0000000	3.
78	3300.0000000	170.0000000	57.0000000	3.
79	3900.0000000	209.0000000	55.0000000	3.
81	340.0000000	55.0000000	39.0000000	2.
83	1650.0000000	153.0000000	43.0000000	1.
84	2300.0000000	149.0000000	31.0000000	1.
85	3700.0000000	148.0000000	86.0000000	3.
86	3600.0000000	146.0000000	80.0000000	1.
87	8000.0000000	380.0000000	43.0000000	1.
88	10600.0000000	360.0000000	49.0000000	1.
89	14600.0000000	358.0000000	30.0000000	3.
90	20000.0000000	390.0000000	40.0000000	1.
91	31500.0000000	590.0000000	67.0000000	3.
92	1150.0000000	92.0000000	45.0000000	1.
93	1200.0000000	90.0000000	96.0000000	2.
95	4500.0000000	187.0000000	79.0000000	2.
96	435.0000000	61.0000000	78.0000000	2.
97	1050.0000000	90.0000000	23.0000000	2.
100	1650.0000000	94.0000000	100.0000000	3.
101	2400.0000000	180.0000000	30.0000000	1.
103	4200.0000000	246.0000000	115.0000000	3.
104	5400.0000000	311.0000000	46.0000000	1.
106	195.0000000	47.0000000	52.0000000	2.
107	3900.0000000	151.0000000	95.0000000	2.
108	3500.0000000	257.0000000	63.0000000	2.
109	380.0000000	52.0000000	47.0000000	2.
110	1650.0000000	120.0000000	19.0000000	2.
113	1500.0000000	144.0000000	89.0000000	2.
115	650.0000000	68.0000000	35.0000000	2.
116	620.0000000	71.0000000	66.0000000	2.

IT = 6
PLOTTER TIME REQUIRED = 000 HRS 004 MINS LAST BLK= 003

TOTAL NUMBER OF PLOTS = 1, PLOTTAPE CLOSED.
GPL MOD 5/25/71

SUMMARY OF GPL USAGE

GPL WAS CALLED 4 TIME(S), FOR A TOTAL OF 1 PLOT(S) TO BE DRAWN.

PLOT NUMBER: 1 TITLE, WSM V Q (Z=DG50 IN MM)(SYMBOLS=REL. TO VAL. BOT)

	LABEL	TYPE	ORIGIN	SCALE	SIZE
Y-AXIS:	WSM IN FT.	LOG	0.10000E 01	0.30000E 01	6.0
X-AXIS:	Q IN CFS	LOG	0.10000E 01	0.50000E 01	10.0

CURVE NUMBER	PLOT TYPE	DATA SYMBOL	NO. DATA POINTS	POINTS OFF-SCALE
1	1	1	1	0
2	1	2	16	0
3	1	3	33	0
4	1	4	20	0

```
C     EXAMPLE OF MODIFICATION OF A VALUE IN ARRAY.
C
      ARRAY(17,56)=3.00
C
C     THE ABOVE STATEMENT CHANGES THE PREVIOUS VALUE OF ELEMENT 56
C        FOR REACH 17 TO  3.00
```

```
C
C     EXAMPLE OF A COMPUTED SCREENING OPTION.
C
C     ACCEPT IF THE FROUDE NUMBER IS LT. 1.00
C     ACCEPT IF THE RELATIVE DEPTH (DM/DG50*305) IS GE. 4.0 AND LE. 100.
      DO 422 I=1,NA
      IF(T(I).LE.0.0) GO TO 417
      IF(DM(I).LE.0.0.OR.DG50(I).LE.0.0) GO TO 425
      IF(VM(I).LE.0.0) GO TO 425
  417 TTEMP(I)=1.0
      GO TO 422
      TESTFR=VM(I)/((32.2*DM(I))**0.50)
      IF(TESTFR.GE.1.00) GO TO 425
      TESTRD=DM(I)/DG50(I)*305.
      IF(TESTRD.LT.4.0.OR.TESTRD.GT.100.) GO TO 425
  425 T(I)=-1.0
C     TTEMP IS SET TO -1.0 ONLY IF THIS SPECIFIC TEST IS NOT SATISFIED
      TTEMP(I)=-1.0
  422 CONTINUE
      WRITE(IP,423)
  423 FORMAT('0',10X,'**ADDITIONAL SCREENING BASED ON COMPUTATION*******
     1************* ')
      WRITE(IP,416)
  416 FORMAT('0',10X,'ACCEPT IF THE FROUDE NUMBER IS LT. 1.00')
      WRITE(IP,424)
  424 FORMAT('0',10X,'ACCEPT IF DM/DG50*305 IS GE. 4.0 AND LE. 100.'/)
C
```

```
      SUBROUTINE HYDPAR(IPTRAN,NA,IPTEST,IDISCH)
C     HYDPAR = SUBROUTINE TO COMPUTE HYDRAULIC PARAMETERS, INITIATION
C              OF MOTION DATA, AND BED-LOAD TRANSPORT DATA.
C     IPTRAN = CODE TO DETERMINE IF A FULL ANALYSIS IS REQUIRED.
C              IPTRAN = 0 NO ANALYSIS
C              IPTRAN = 1 RESULTS PRINTED FOR ONE REACH ONLY.
C              IPTRAN = 2 PRINT OUT OF THE RESULTS OF THE ANALYSIS FOR
C                         ALL REACHES THAT HAVE MET THE SCREENING
C                         CRITERIA.
C     NA     = THE TOTAL NUMBER OF REACHES IN THE ANALYSIS.
C     IPTEST = A TEST VALUE TO INDICATE IF A PRINT OUT OF THE RESULTS IS
C              REQUIRED MORE THAN ONCE.  THIS IS SUPPLIED INTERNALLY.
C     IDISCH = VECTOR OF LENGTH 16 CONTAINING THE TYPE OF DISCHARGE
C              FOR THE ANALYSIS.
      COMMON/SUB1/ARRAY(120,80)
      COMMON RCA(120),Q(120),AM(120),WSM(120),DM(120),VM(120),S(120)
      COMMON DG90(120),DG65(120),DG50(120),VISK(120),THRES(120)
      COMMON SCOR(120),T(120)
      DIMENSION IDISCH(16)
      IF(IPTEST.LE.0) GO TO 3630
      IF(IPTRAN.LE.0) GO TO 3630
      IP=6
      WRITE(IP,700)
  700 FORMAT('1',//)
      WRITE(IP,1101) (IDISCH(II),II=1,16)
 1101 FORMAT('0',10X,'HYDRAULIC PARAMETERS FOR: ',16A4/)
      WRITE(IP,1102)
 1102 FORMAT('0',73X,'INITIATION OF MOTION        BED-LOAD TRANSPORT')
      WRITE(IP,1103)
 1103 FORMAT(' ',1X,' REACH   CHEZY  FRICT. MANN- STRICK- BLENCH BLENCH
     1 VM    VM/V*    TAU    SHIELDS NEILL   COOPER   SCHOK  STRAUB  MPM
     2 BLENCH')
      WRITE(IP,1104)
 1104 FORMAT(' ',2X,'   #      C     FACTOR ING,N  LER,N    FB     FS    F
     1T/S          #/FT**2 TAU/TAUC VM/VMC  VM/VMC   #/S/FT #/S/FT #/S/FT
     2#/S/FT'/)
      K=1
 3630 DO 1 I=1,NA
      IF(T(I).LE.0.0) GO TO 1
      IF(IPTEST.LE.0) GO TO 31
      IF(IPTRAN.LE.0) GO TO 31
      IF(VM(I).LE.0.0) GO TO 2
      VMT=VM(I)
      IF(DM(I).LE.0.0) GO TO 3
      FB=VM(I)**2/DM(I)
      IF(S(I).LE.0.0) GO TO 4
      CHEZY=VM(I)/((DM(I)*S(I))**0.50)
      FF=32.2*DM(I)*S(I)/VM(I)**2*8.0
      CMANN=1.49*DM(I)**0.667*S(I)**0.50/VM(I)
      TAU=62.4*DM(I)*S(I)
      VSTAR=(32.2*DM(I)*S(I))**0.50
      VMOVS=VMT/VSTAR
      GO TO 5
    2 VMT=-1.0
    3 FB=-1.0
```

```
    4 CHEZY=-1.0
      FF=-1.0
      CMANN=-1.0
      TAU=-1.0
      VMOVS=-1.0
    5 IF(WSM(I).LE.0.0.OR.VM(I).LE.0.0) GO TO 6
      FS=VM(I)**3/WSM(I)
      GO TO 7
    6 FS=-1.0
    7 IF(DG50(I).LE.0.0) GO TO 8
      CSTRIC=0.0133*DG50(I)**0.167
      GO TO 9
    8 CSTRIC=-1.0
    9 DUMMY=9.0
C     *************************************
C     THRESHOLD COMPUTATIONS
C     IIIIIIIIIIIIIIIIIIIIIIIIIIIIIIIIIII
C     THRESHOLD - SHIELDS (1936)
C     AFTER SHULITS AND HILL (1968)
      IF(DG50(I).LT.0.09) GO TO 20
      IF(DG50(I).GE.0.09.AND.DG50(I).LT.0.27) GO TO 21
      IF(DG50(I).GE.0.27.AND.DG50(I).LT.0.55) GO TO 22
      IF(DG50(I).GE.0.55.AND.DG50(I).LT.6.70) GO TO 23
      IF(DG50(I).GE.6.70.AND.DG50(I).LT.256.) GO TO 24
      GO TO 20
   21 TAUCS=0.00514*DG50(I)**0.25
      GO TO 25
   22 TAUCS=0.00842*DG50(I)**0.633
      GO TO 25
   23 TAUCS=0.01210*DG50(I)**1.26
      GO TO 25
   24 TAUCS=0.02030*DG50(I)
      GO TO 25
   20 TAUCS=-1.00
   25 DUMMY=25.0
C     IIIIIIIIIIIIIIIIIIIIIIIIIIIIIIIIIII
C     IIIIIIIIIIIIIIIIIIIIIIIIIIIIIIIIIII
C     THRESHOLD - NEILL (1969)
      IF(DM(I).LE.0.0.OR.DG50(I).LE.0.0) GO TO 30
      RATN=305.*DM(I)/DG50(I)
      IF(RATN.GT.100.0.OR.RATN.LT.2.0) GO TO 30
      VMCN=1.54*DM(I)**0.167*DG50(I)**0.333
      GO TO 31
   30 VMCN=-1.00
   31 DUMMY=31.0
C     IIIIIIIIIIIIIIIIIIIIIIIIIIIIIIIIIII
C     IIIIIIIIIIIIIIIIIIIIIIIIIIIIIIIIIII
C     THRESHOLD - COOPER (1970)
      IF(DM(I).LE.0.0.OR.DG50(I).LE.0.0) GO TO 40
      RATC=305.*DM(I)/DG50(I)
      IF(RATC.LT.4.0) GO TO 40
      IF(RATC.GE.4.0.AND.RATC.LT.150.) GO TO 41
      IF(RATC.GE.150.0.AND.RATC.LT.1000.) GO TO 42
      IF(RATC.GE.1000.0.AND.RATC.LT.3000.) GO TO 43
      IF(RATC.GE.3000.) GO TO 40
```

```
   41 VMCC=1.48*DM(I)**0.133*DG50(I)**0.367
      GO TO 44
   42 VMCC=1.26*DM(I)**0.304*DG50(I)**0.196
      GO TO 44
   43 VMCC=1.17*DM(I)**0.377*DG50(I)**0.123
      GO TO 44
   40 VMCC=-1.00
   44 IF(IPTEST.LE.0) GO TO 3677
      IF(IPTRAN.LE.0) GO TO 3677
C     IIIIIIIIIIIIIIIIIIIIIIIIIIIIIIIIIII
C     ************************************
C     BED-LOAD TRANSPORT COMPUTATIONS
C     TTTTTTTTTTTTTTTTTTTTTTTTTTTTTTTTTTTTT
C     BED-LOAD TRANSPORT SCHOKLITSCH (1934)
C     AFTER SHULITS AND HILL (1968)
      IF(WSM(I).LE.0.0) GO TO 50
      IF(S(I).LE.0.0.OR.Q(I).LE.0.0) GO TO 50
      IF(DG50(I).LE.0.0.OR.DG50(I).GT.256) GO TO 50
      DG=DG50(I)
      QBS34=437.*S(I)**1.5/DG**0.50*(Q(I)/WSM(I)-0.000209*DG/(S(I)**1.33
     1))
      IF(QBS34.GT.0.0) GO TO 51
      QBS34=0.0
      GO TO 51
   50 QBS34=-1.00
   51 DUMMY=51.0
C     TTTTTTTTTTTTTTTTTTTTTTTTTTTTTTTTTTTTTT
C     TTTTTTTTTTTTTTTTTTTTTTTTTTTTTTTTTTTTTT
C     BED-LOAD TRANSPORT STRAUB-DUBOUYS (1936)
C     AFTER SHULITS AND HILL (1968) AND HENDERSON (1966)
      IF(DM(I).LE.0.0.OR.S(I).LE.0.0) GO TO 60
      DG=DG50(I)
      IF(DG.LT.0.125.OR.DG.GE.256.) GO TO 60
      GAMMA=62.4
      TAUSD=GAMMA*DM(I)*S(I)
      CHI=111000./DG**0.75
      CONST=CHI/GAMMA**2*TAUSD
      IF(DG.GE.0.125.AND.DG.LT.0.250) GO TO 61
      IF(DG.GE.0.250.AND.DG.LT.1.00) GO TO 62
      IF(DG.GE.1.00.AND.DG.LT.4.00) GO TO 63
      IF(DG.GE.4.00.AND.DG.LT.16.0) GO TO 64
      IF(DG.GE.16.0.AND.DG.LT.256.) GO TO 65
      GO TO 60
   61 QBSD35=CONST*(TAUSD-0.0193*DG**0.0854)
      GO TO 66
   62 QBSD35=CONST*(TAUSD-0.0316*DG**0.440)
      GO TO 66
   63 QBSD35=CONST*(TAUSD-0.0316*DG**0.745)
      GO TO 66
   64 QBSD35=CONST*(TAUSD-0.0260*DG**0.890)
      GO TO 66
   65 QBSD35=CONST*(TAUSD-0.0191*DG)
   66 IF(QBSD35.GT.0.0) GO TO 69
      QBSD35=0.0
      GO TO 69
```

```
   60 OBSD35=-1.00
   69 DUMMY=69.0
C     TTTTTTTTTTTTTTTTTTTTTTTTTTTTTTTTTTTTTTTTT
C     TTTTTTTTTTTTTTTTTTTTTTTTTTTTTTTTTTTTTTTTT
C     BED-LOAD TRANSPORT MEYER-PETER AND MULLER (1948)
C     AFTER SHULITS AND HILL (1968)
      IF(DM(I).LE.0.0.OR.S(I).LE.0.0) GO TO 70
      DG=DG50(I)
      IF(DG.LE.0.0.OR.DG.GE.256.) GO TO 70
      TAUMPM=62.4*S(I)*DM(I)
      CTERM=0.8*TAUMPM-0.0158*DG
      IF(CTERM.LE.0.0) GO TO 72
      QBMPM=9.23*CTERM**1.5
      GO TO 71
   70 QBMPM=-1.00
      GO TO 71
   72 QBMPM=0.0
   71 DUMMY=71.0
C     TTTTTTTTTTTTTTTTTTTTTTTTTTTTTTTTTTTTTTTTT
C     TTTTTTTTTTTTTTTTTTTTTTTTTTTTTTTTTTTTTTTTT
C     BED-LOAD TRANSPORT BLENCH (1957)
      IF(SCOR(I).LE.0.0) GO TO 80
      IF(S(I).LE.0.0.OR.WSM(I).LE.0.0) GO TO 80
      IF(Q(I).LE.0.0.OR.VISK(I).LE.0.0)GO TO 80
      DG=DG50(I)
      IF(DG.LT.0.07) GO TO 80
      IF(DG.GE.0.07.AND.DG.LT.2.00) GO TO 81
      IF(DG.GE.2.00.AND.DG.LT.56.0) GO TO 82
      IF(DG.GE.56.0.AND.DG.LT.256.) GO TO 83
      GO TO 80
   81 FBO=1.9*DG**0.50
      GO TO 84
   82 FBO=1.75*DG**0.25
   84 DTES =DG/(305.*DM(I))        <------- DTEST = 1.0/DTES
      IF(DTEST.GT.1000.) GO TO 91
      IF(DTEST.LT.100.) GO TO 83
      FBOT=442.4*DTES **0.982
      IF(FBO.LT.FBOT) GO TO 85
      GO TO 91
   85 FBO=FBOT
      GO TO 91
C     NOTE THE CONSTANT WAS 38 IN THE ORIGINAL BOOK BUT HAS BEEN
C     CHANGED TO 48
   83 FBO=48.0*(DG/(305.*DM(I)))**0.50
      IF(FBO.GT.32.2) GO TO 80
   91 F3C=S(I)*117.*WSM(I)**0.167*Q(I)**0.0833/(SCOR(I)*VISK(I)**0.25*FB
     1O**0.916)
      IF(F3C.LE.1.00) GO TO 92
      IF(F3C.LT.1.15.AND.F3C.GT.1.00) GO TO 93
      IF(F3C.LT.1.45.AND.F3C.GE.1.15) GO TO 94
      IF(F3C.LT.2.45.AND.F3C.GE.1.45) GO TO 95
      IF(F3C.LT.3.55.AND.F3C.GE.2.45) GO TO 96
      GO TO 80
   92 C=0.00
      GO TO 98
```

```
   93 C=(F3C-1.00)*6.67
 C      THIS IS AN APPROXIMATION FOR F3C TENDS TO 1.00
        GO TO 98
   94 C=0.378*F3C**6.95
        GO TO 98
   95 C=2.30*F3C**2.09
        GO TO 98
   96 C=2.82*F3C**1.87
        GO TO 98
   80 QBB57=-1.00
        GO TO 99
   98 QBB57=C*Q(I)*62.4/(WSM(I)*100000.)
   99 DUMMY=99.0
 C      TTTTTTTTTTTTTTTTTTTTTTTTTTTTTTTTTTTTTTTT
 C      PRINT OUT OF RESULTS
        IF(TAUCS.LT.0.0.OR.TAU.LT.0.0) GO TO 100
        TRS=TAU/TAUCS
        GO TO 101
  100 TRS=-1.00
  101 IF(VMCN.LT.0.0.OR.VMT.LT.0.0) GO TO 103
        VRN=VMT/VMCN
        GO TO 3677
  103 VRN=-1.00
 3677 VMT=VM(I)
        IF(VMCC.LT.0.0.OR.VMT.LT.0.0) GO TO 104
        VRC=VMT/VMCC
        GO TO 102
  104 VRC=-1.00
  102 IF(VRC.GT.0.00) GO TO 105
        THRES(I)=-1.00
        GO TO 106
  105 THRES(I)=VRC
  106 IF(IPTEST.LE.0) GO TO 1
        IF(IPTRAN.LE.0) GO TO 1
        IF(IPTRAN.GE.1) GO TO 3626
 3626 WRITE(IP,1105)   RCA(I),CHEZY,FF,CMANN,CSTRIC,FB,FS,VMT,VMOVS,TAU,
     1TRS,VRN,VRC,QBS34,QBSD35,QBMPM,QBB57
 1105 FORMAT(' ',1X,F5.0,F9.0,3F7.3,F7.2,F7.2,F6.2,F7.1,F7.2,F9.2,F7.2,F
     18.2,F9.2,F8.2,F7.2,F7.2)
        IF(K.EQ.40) GO TO 705
        IF(K.EQ.80) GO TO 705
        GO TO 1903
  705 WRITE(IP,700)
        WRITE(IP,1101) (IDISCH(II),II=1,16)
        WRITE(IP,1102)
        WRITE(IP,1103)
        WRITE(IP,1104)
 1903 K=K+1
    1 CONTINUE
        IPTEST=0
        RETURN
        END
```

ORY REQUIREMENTS 001AF8 BYTES
5 RC=0

```
      SUBROUTINE DEFEL(IRCA,IDA,ISF,IST,ITERR,IRCVB,IRCVW,IVFE,ICPAT,IIS
     1L,ITYFL,IBAR,ISIN,IDLA,IBANKA,IPABLT,IPABRT,IRDA,IDG90,IDG65,IDG50
     2,IELEMT)
C     THIS SUBROUTINE MUST BE CHANGED WHEN SETTING UP A NEW MASTER ARRAY
C     USUALLY ONE MASTER ARRAY WILL BE SUFFICIENT FOR ANY PROJECT.
C     DEFEL = SUBROUTINE TO DEFINE THE ELEMENT NUMBERS ASSOCIATED WITH
C             THE VARIABLES IN THE MASTER ARRAY.   THE ELEMENT NUMBERS
C             FOR VARIABLES  IRCA TO IDG50 IN THE PARAMETER LIST ARE
C             PASSED TO THE MAIN PROGRAM, SINCE THEY ARE FREQUENTLY
C             USED.
C     IELEMT= TOTAL NUMBER OF ELEMENTS ( COLUMNS ) IN ARRAY
      DIMENSION ITITLE(20)
      IR=5
      IP=6
      WRITE(IP,1071)
 1071 FORMAT(' ',10X,'DEFINITION OF VARIABLES CORRESPONDING TO THE ELEME
     1NTS IN THE MAJOR DATA SET'/)
      READ(IR,1000) IRCA,IBASIN,IDA,IESFAO,IYRFAO,ISRC,IREP,ISF,IRDS,IST
      WRITE(IP,100) IRCA,IBASIN,IDA,IESFAO,IYRFAO,ISRC,IREP,ISF,IRDS,IST
      READ(IR,2000) (ITITLE(I),I=1,20)
      WRITE(IP,200) (ITITLE(I),I=1,20)
      READ(IR,1000) IINOP,IQLM,IALM,IWSLM,IQF1,IAF1,IWSF1,IQF2,IAF2,IWSF
     12
      WRITE(IP,100) IINOP,IQLM,IALM,IWSLM,IQF1,IAF1,IWSF1,IQF2,IAF2,IWSF
     12
      READ(IR,2000) (ITITLE(I),I=1,20)
      WRITE(IP,200) (ITITLE(I),I=1,20)
      READ(IR,1000) IQF3,IAF3,IWSF3,IQF4,IAF4,IWSF4,IQD1,IAD1,IWSD1,IQD2
      WRITE(IP,100) IQF3,IAF3,IWSF3,IQF4,IAF4,IWSF4,IQD1,IAD1,IWSD1,IQD2
      READ(IR,2000) (ITITLE(I),I=1,20)
      WRITE(IP,200) (ITITLE(I),I=1,20)
      READ(IR,1000) IAD2,IWSD2,IQD3,IAD3,IWSD3,IQD4,IAD4,IWSD4,IQLLB,IAL
     1LB
      WRITE(IP,100) IAD2,IWSD2,IQD3,IAD3,IWSD3,IQD4,IAD4,IWSD4,IQLLB,IAL
     1LB
      READ(IR,2000) (ITITLE(I),I=1,20)
      WRITE(IP,200) (ITITLE(I),I=1,20)
      READ(IR,1000) IWSLLB,IRPLLB,IDLLB,IQDLLB,IQVF,IAVF,IWSVF,IRPVF,IDV
     1F,IQDVF
      WRITE(IP,100) IWSLLB,IRPLLB,IDLLB,IQDLLB,IQVF,IAVF,IWSVF,IRPVF,IDV
     1F,IQDVF
      READ(IR,2000) (ITITLE(I),I=1,20)
      WRITE(IP,200) (ITITLE(I),I=1,20)
      READ(IR,1000) ITERR,IPSLUM,IVT,IUNFIT,IRCVB,IRCVW,IVFP,IVFE,ICPAT,
     1IISL
      WRITE(IP,100) ITERR,IPSLUM,IVT,IUNFIT,IRCVB,IRCVW,IVFP,IVFE,ICPAT,
     1IISL
      READ(IR,2000) (ITITLE(I),I=1,20)
      WRITE(IP,200) (ITITLE(I),I=1,20)
      READ(IR,1000) ITYFL,IBAR,ISIN,ITLA,IDLA,IBANKA,IBANKN,IPABLT,IPABR
     1T,IVBANK
      WRITE(IP,100) ITYFL,IBAR,ISIN,ITLA,IDLA,IBANKA,IBANKN,IPABLT,IPABR
     1T,IVBANK
      READ(IR,2000) (ITITLE(I),I=1,20)
      WRITE(IP,200) (ITITLE(I),I=1,20)
```

```
      READ(IR,1000) IPBEDM,IRDA,INGBN,INGBNP,INS,ILSAM,IRSAM,IDG90,IDG65
     1,IDG50
      WRITE(IP,100) IPBEDM,IRDA,INGBN,INGBNP,INS,ILSAM,IRSAM,IDG90,IDG65
     1,IDG50
      READ(IR,2000) (ITITLE(I),I=1,20)
      WRITE(IP,200) (ITITLE(I),I=1,20)
      IELEMT=IDG50
 1000 FORMAT(10I4)
 2000 FORMAT(20A4)
  100 FORMAT(' ',10X,'ELEM. #:',1X,10I8)
  200 FORMAT(' ',10X,'ELEM. NAME:  ',20A4/)
      RETURN
      END
```

ORY REQUIREMENTS 000FA0 BYTES

```
      SUBROUTINE GSCRN(NA,ISCRE,IT,ITT)
C     GSCRN = SUBROUTINE FOR SCREENING OF DATA.  A TEST VECTOR T(I) IS
C             INITIALLY SET TO 0.0.  IF A VARIABLE BEING SCREENED IS
C             ACCEPTABLE, T(I)= 1.0, AND IF THE VARIABLE IS NOT
C             ACCEPTABLE T(I)= -1.0.
C     NA    = TOTAL NUMBER OF REACHES IN ANALYSIS.
C     ISCRE = A TEST PARAMETER TO INDICATE IF A PRINT OUT OF THE
C             ACCEPTED REACHES IS NECESSARY.  THIS IS SET INTERNALLY
C             SUCH THAT ONLY ONE PRINT OUT OF THE SAME CHARACTERISTIC
C             DISCHARGE IS GIVEN.
C     IT AND ITT ARE DEFINED BELOW.
      COMMON/SUB1/ARRAY(120,80)
      COMMON RCA(120),Q(120),AM(120),WSM(120),DM(120),VM(120),S(120)
      COMMON DG90(120),DG65(120),DG50(120),VISK(120),THRES(120)
      COMMON SCOR(120),T(120)
      DIMENSION ITITLE(20),Y(120)
      IR=5
      IP=6
  604 READ(IR,1001) IT,ITT,IELEM1,BL1,UL1,IELEM2,BL2,UL2,IELEM3,BL3,UL3
 1001 FORMAT(2I2,I5,2F10.0,I5,2F10.0,I5,2F10.0)
C     READ DESCRIPTION OF SCREENING
      READ(IR,1201)(ITITLE(I),I=1,20)
 1201 FORMAT(20A4)
C     IT=  TEST TO DETERMINE IF SCREENING IS TO BE CARRIED OUT.
C     IT=0 SCREEN
C     IT=1 END OF SCREEN
C     ONLY VALUES OF IT = 0 AND 1 SHOULD REACH THIS POINT.
C     IT LT. 0 NOT ALLOWED; WILL CAUSE EXIT AFTER AN ERROR MESSAGE
C             IS PRINTED.  THIS ALSO HOLDS IF  IT  GT. 1.
C     ITT = TEST FOR TYPE OF SCREENING
C     ITT = 1 SCREEN ON ONE ELEMENT ONLY (ELEM1)
C     ITT = 2 MUST MEET SCREENING CRITERIA FOR FOR IELEM1 AND IELEM2
C     ITT = 3 MUST MEET SCREENING CRITERIA FOR IELEM1, IELEM2 AND IELEM3
C     ITT = 4 MUST MEET SCREENING CRITERIA OF BL1 AND UL1 WHEN THE VALUE
C             IN THE TWO ELEMENTS (IELEM1 AND IELEM2) ARE ADDED.
C     ITT = 5 MUST MEET SCREENING CRITERIA OF BL1 AND UL1 WHEN THE VALUE
C             IN THE THREE ELEMENTS (IELEM1,IELEM2,IELEM3) ARE ADDED.
C     ITT = 6 REJECT IF SCREENING CRITERIA FOR IELEM1 IS SATISFIED
C     ITT = 7 REJECT IF SCREENING CRITERIA FOR IELEM1 AND IELEM2
C             IS SATISFIED.
C     ITT = 8 REJECT IF SCREENING CRITERIA FOR IELEM1, IELEM2 AND IELEM3
C             IS SATISFIED
      IF(IT.LT.0.OR.IT.GT.1) GO TO 900
      IF(ITT.LT.1.OR.ITT.GT.8) GO TO 900
      IF(IT.EQ.1.AND.ISCRE.EQ.0) GO TO 603
      IF(IT.EQ.0) GO TO 602
      IF(IT.EQ.1) GO TO 605
  602 WRITE(IP,1003) IELEM1,BL1,UL1,ITT
 1003 FORMAT(' ',10X,'SCREENING ON ELEM # ',I4,' ; LOWER BOUND =',F12.3,
     1' ; UPPER BOUND =',F12.3,' ; TEST TYPE =',I4)
      IF(ITT.EQ.1.OR.ITT.EQ.6) GO TO 300
      IF(ITT.EQ.2.OR.ITT.EQ.4.OR.ITT.EQ.7) GO TO 303
      GO TO 301
  303 WRITE(IP,1003) IELEM2,BL2,UL2,ITT
  301 IF(ITT.EQ.3.OR.ITT.EQ.5.OR.ITT.EQ.8) GO TO 304
```

```
      GO TO 300
  304 WRITE(IP,1003) IELEM2,BL2,UL2,ITT
    . WRITE(IP,1003) IELEM3,BL3,UL3,ITT
  300 WRITE(IP,1004) (ITITLE(I),I=1,20)
 1004 FORMAT(' ',10X,'DESCRIPTION: ',20A4/)
C     ACCEPT IF WITHIN BOUNDS BL AND UL (INCLUDES BL AND UL)
C              FOR ITT= 1,2,3,4,5
C     REJECT IF WITHIN BOUNDS BL AND UL (INCLUDES BL AND UL)
C              FOR ITT= 6,7,8
      ISCRE=1
      DO 601 I=1,NA
      IF(T(I).LT.0.0) GO TO 80
      IF(ITT.EQ.1) GO TO 70
      IF(ITT.EQ.2) GO TO 71
      IF(ITT.EQ.3) GO TO 72
      IF(ITT.EQ.4) GO TO 73
      IF(ITT.EQ.5) GO TO 74
      IF(ITT.EQ.6) GO TO 75
      IF(ITT.EQ.7) GO TO 76
      IF(ITT.EQ.8) GO TO 77
   70 IF(ARRAY(I,IELEM1).GE.BL1.AND.ARRAY(I,IELEM1).LE.UL1) GO TO 207
      GO TO 80
   71 IF(ARRAY(I,IELEM1).GE.BL1.AND.ARRAY(I,IELEM1).LE.UL1.AND.ARRAY(I,I
     1ELEM2).GE.BL2.AND.ARRAY(I,IELEM2).LE.UL2) GO TO 207
      GO TO 80
   72 IF(ARRAY(I,IELEM1).GE.BL1.AND.ARRAY(I,IELEM1).LE.UL1.AND.ARRAY(I,I
     1ELEM2).GE.BL2.AND.ARRAY(I,IELEM2).LE.UL2.AND.ARRAY(I,IELEM3).GE.BL
     13.AND.ARRAY(I,IELEM3).LE.UL3) GO TO 207
      GO TO 80
   73 CTEST2=ARRAY(I,IELEM1)+ARRAY(I,IELEM2)
      IF(CTEST2.GE.BL1.AND.CTEST2.LE.UL1) GO TO 207
      GO TO 80
   74 CTEST3=ARRAY(I,IELEM1)+ARRAY(I,IELEM2)+ARRAY(I,IELEM3)
      IF(CTEST3.GE.BL1.AND.CTEST3.LE.UL1) GO TO 207
      GO TO 80
   75 IF(ARRAY(I,IELEM1).GE.BL1.AND.ARRAY(I,IELEM1).LE.UL1) GO TO 80
      GO TO 207
   76 IF(ARRAY(I,IELEM1).GE.BL1.AND.ARRAY(I,IELEM1).LE.UL1.AND.ARRAY(I,I
     1ELEM2).GE.BL2.AND.ARRAY(I,IELEM2).LE.UL2) GO TO 80
      GO TO 207
   77 IF(ARRAY(I,IELEM1).GE.BL1.AND.ARRAY(I,IELEM1).LE.UL1.AND.ARRAY(I,I
     1ELEM2).GE.BL2.AND.ARRAY(I,IELEM2).LE.UL2.AND.ARRAY(I,IELEM3).GE.BL
     13.AND.ARRAY(I,IELEM3).LE.UL3) GO TO 80
  207 T(I)=1.00
      GO TO 601
   80 T(I)=-1.00
  601 CONTINUE
C     T SHOULD ONLY HAVE VALUES OF -1.00 OR 1.00 AT THIS POINT.
      GO TO 604
  603 WRITE(IP,1206)
 1206 FORMAT('0',10X,'NO FURTHER SCREENING USED'/)
      GO TO 900
  605 WRITE(IP,1202)
 1202 FORMAT('0',10X,'CODE NUMBERS REMAINING AFTER ALL SCREENING TO THIS
     1 POINT'/)
```

```
      ICNT=1
      DO 700 I=1,NA
      IF(T(I).GT.0.0) GO TO 701
      GO TO 700
  701 Y(ICNT)=I
      ICNT=ICNT+1
  700 CONTINUE
      ITST=ICNT-1
      ITSTB=1
      ITSTE=20
  705 IF(ITST.GT.ITSTE) GO TO 703
      WRITE(IP,1203) (Y(I),I=ITSTB,ITST)
 1203 FORMAT(' ',10X,20F5.0)
      GO TO 704
  703 WRITE(IP,1203) (Y(I),I=ITSTB,ITSTE)
      ITSTB=ITSTB+20
      ITSTE=ITSTE+20
      GO TO 705
  704 WRITE(IP,1204) ITST
 1204 FORMAT(' ',10X,'TOTAL NUMBER SATISFYING TESTS =',I4)
  900 RETURN
      END
```

)RY REQUIREMENTS 0010E8 BYTES

```
      SUBROUTINE FWORKV(IRCA,IQ,IAM,IWSM,ISF,IST,IDG90,IDG65,IDG50,ITERR
     1,IISL,ISIN,NA)
C     FWORKV = SUBROUTINE USED TO FILL WORKING VECTORS.
C     IRCA   = THE ELEMENT NUMBER IN THE MASTER ARRAY WITH THE REACH
C              NUMBER.
C     IQ     = THE ELEMENT NUMBER IN THE MASTER ARRAY WITH THE SPECIFIED
C              DISCHARGE.
C     IAM    = THE ELEMENT NUMBER IN THE MASTER ARRAY WITH THE SPECIFIED
C              X-SECTIONAL AREA.
C     IWSM   = THE ELEMENT NUMBER IN THE MASTER ARRAY WITH THE SPECIFIED
C              WATER SURFACE WIDTH.
C     ISF  TO  ISIN  ARE THE ELEMENT NUMBERS IN THE MASTER ARRAY AS
C              DEFINED IN THE SUBROUTINE DEFEL.
C     NA     = THE TOTAL NUMBER OF REACHES IN THE ANALYSIS.
      COMMON/SUP1/ARRAY(120,80)
      COMMON RCA(120),Q(120),AM(120),WSM(120),DM(120),VM(120),S(120)
      COMMON DG90(120),DG65(120),DG50(120),VISK(120),THRES(120)
      COMMON SCOR(120),T(120)
C     FILL UP WORKING VECTORS
      DO 499 I=1,NA
      IF(T(I).LE.0.0) GO TO 420
      RCA(I)=ARRAY(I,IRCA)
      Q(I)=ARRAY(I,IQ)
      AM(I)=ARRAY(I,IAM)
      WSM(I)=ARRAY(I,IWSM)
      IF(ARRAY(I,ISF).GT.0.0) GO TO 402
      IF(ARRAY(I,IST).GT.0.0) GO TO 403
      S(I)=-1.0
      GO TO 404
  402 S(I)=ARRAY(I,ISF)
      GO TO 404
  403 S(I)=ARRAY(I,IST)
  404 DG90(I)=ARRAY(I,IDG90)
      DG65(I)=ARRAY(I,IDG65)
      DG50(I)=ARRAY(I,IDG50)
C     COMPUTE VISCOSITY BASED ON AVERAGE WATER TEMPERATURES IN DIFFERENT
C     TERRAIN
      IF(ARRAY(I,ITERR).LT.-0.1.AND.ARRAY(I,ITERR).GT.6.01) GO TO 405
      IF(ARRAY(I,ITERR).LT.1.01.AND.ARRAY(I,ITERR).GT.0.99) GO TO 406
      IF(ARRAY(I,ITERR).LT.3.01.AND.ARRAY(I,ITERR).GT.1.99) GO TO 407
      IF(ARRAY(I,ITERR).LT.6.01.AND.ARRAY(I,ITERR).GT.3.99) GO TO 408
  405 VISK(I)=-1.0
      GO TO 409
  406 VISK(I)=0.0000166
      GO TO 409
  407 VISK(I)=0.0000154
      GO TO 409
  408 VISK(I)=0.0000141
  409 IF(WSM(I).LE.0.0.OR.AM(I).LE.0.0) GO TO 410
      DM(I)=AM(I)/WSM(I)
      GO TO 411
  410 DM(I)=-1.0
  411 IF(AM(I).LE.0.0.OR.Q(I).LE.0.0) GO TO 412
      VM(I)=Q(I)/AM(I)
      GO TO 4114
```

```
  412 VM(I)=-1.0
 4114 IF(ARRAY(I,IISL).LT.-0.01.OR.ARRAY(I,IISL).GT.4.01) GO TO 86
      IF(ARRAY(I,ISIN).LE.0.0.OR.ARRAY(I,ISIN).GT.4.00) GO TO 86
      IF(ARRAY(I,IISL).LT.1.01.AND.ARRAY(I,IISL).GT.-0.01) GO TO 87
      IF(ARRAY(I,IISL).LT.2.01.AND.ARRAY(I,IISL).GT.1.99) GO TO 88
      IF(ARRAY(I,IISL).LT.3.01.AND.ARRAY(I,IISL).GT.2.99) GO TO 89
      IF(ARRAY(I,IISL).LT.4.01.AND.ARRAY(I,IISL).GT.3.99) GO TO 90
   87 SCOR(I)=0.25+ARRAY(I,ISIN)
      GO TO 400
   88 SCOR(I)=1.2*(0.25+ARRAY(I,ISIN))
      GO TO 400
   89 SCOR(I)=2.0*(0.25+ARRAY(I,ISIN))
      GO TO 400
   90 SCOR(I)=2.8*(0.25+ARRAY(I,ISIN))
      GO TO 400
   86 SCOR(I)=-1.0
C     IIIIIIIIIIIIIIIIIIIIIIIIIIIIIIIIIII
C     THRESHOLD - COOPER (1970)
  400 IF(DM(I).LE.0.0.OR.DG50(I).LE.0.0) GO TO 40
      RATC=305.*DM(I)/DG50(I)
      IF(RATC.LT.4.0) GO TO 40
      IF(RATC.GE.4.0.AND.RATC.LT.150.) GO TO 41
      IF(RATC.GE.150.0.AND.RATC.LT.1000.) GO TO 42
      IF(RATC.GE.1000.0.AND.RATC.LT.3000.) GO TO 43
      IF(RATC.GE.3000.) GO TO 40
   41 VMCC=1.48*DM(I)**0.133*DG50(I)**0.367
      GO TO 44
   42 VMCC=1.26*DM(I)**0.304*DG50(I)**0.196
      GO TO 44
   43 VMCC=1.17*DM(I)**0.377*DG50(I)**0.123
      GO TO 44
   40 VMCC=-1.00
   44 IF(VMCC.LE.0.0.OR.VM(I).LE.0.0) GO TO 104
      VRC=VM(I)/VMCC
      GO TO 102
  104 VRC=-1.00
  102 IF(VRC.GT.0.00) GO TO 105
      THRES(I)=-1.0
      GO TO 106
  105 THRES(I)=VRC
C     IIIIIIIIIIIIIIIIIIIIIIIIIIIIIIIIIIIIIIIIIIIIIII
  106 GO TO 499
  420 O(I)=-1.0
      AM(I)=-1.0
      WSM(I)=-1.0
      S(I)=-1.0
      DG90(I)=-1.0
      DG65(I)=-1.0
      DG50(I)=-1.0
      VISK(I)=-1.0
      DM(I)=-1.0
      VM(I)=-1.0
      SCOR(I)=-1.0
      THRES(I)=-1.0
  499 CONTINUE
```



```
      RETURN
      END
```

IORY REQUIREMENTS 000CDE BYTES

```
      SUBROUTINE SCRN(N,CODE,Y,X1,X2,X3,NA,NAS)
C     SCRN = SUBROUTINE FOR SCREENING DATA IN PREPARATION FOR USING
C            SUBROUTINES  COEFV,FLAS,PHIST,SORTD,LSOFT,REGRE.
C            ALL DATA TO BE SCREENED MUST BE SET TO 0.0 BEFORE CALLING
C            THIS SUBROUTINE.  THIS WILL BE DONE BEFORE CALLING
C            SUBROUTINE PRMA, PRLS, PRMR SINCE SCRN IS CALLED BY THESE
C            SUBROUTINES.
C     N    = NUMBER OF VARIABLES TO BE SCREENED.
C            N = 1                FOR COEFV
C            N = 2                FOR LSOFT
C            N = 3 OR 4           FOR REGRE
C     CODE = OUTPUT VECTOR FOR REACH NUMBERS AFTER SCREENING
C     Y    = INPUT VECTOR BEFORE SCREENING AND OUTPUT VECTOR AFTER
C            SCREENING.
C     X1   = INPUT VECTOR BEFORE SCREENING AND OUTPUT VECTOR AFTER
C            SCREENING.
C     X2   = INPUT VECTOR BEFORE SCREENING AND OUTPUT VECTOR AFTER
C            SCREENING.
C     X3   = INPUT VECTOR BEFORE SCREENING AND OUTPUT VECTOR AFTER
C            SCREENING.
C     NA   = LENGTH OF VECTORS Y,X1,X2,X3, BEFORE SCREENING
C     NAS  = LENGTH OF VECTORS Y,X1,X2,X3, AFTER SCREENING
      COMMON RCA(120)
      DIMENSION CODE(120),Y(120),X1(120),X2(120),X3(120)
      DIMENSION YA(120),X1A(120),X2A(120),X3A(120)
      IP=6
      IF(N.LT.1) GO TO 5
      IF(N.EQ.1) GO TO 6
      IF(N.EQ.2) GO TO 7
      IF(N.EQ.3) GO TO 8
      IF(N.EQ.4) GO TO 13
      GO TO 9
    6 DO 10 I=1,NA
      X1(I)=1.0
      X2(I)=1.0
      X3(I)=1.0
   10 CONTINUE
      GO TO 13
    7 DO 11 I=1,NA
      X2(I)=1.0
      X3(I)=1.0
   11 CONTINUE
      GO TO 13
    8 DO 12 I=1,NA
      X3(I)=1.0
   12 CONTINUE
   13 K=1
      DO 2 I=1,NA
      IF(N.EQ.1) GO TO 41
      IF(N.EQ.2) GO TO 42
      IF(N.EQ.3) GO TO 43
      IF(N.GE.4) GO TO 44
   41 IF(Y(I).EQ.0.0) GO TO 2
      GO TO 1
   42 IF(Y(I).EQ.0.0.AND.X1(I).EQ.0.0) GO TO 2
```

```
      GO TO 1
   43 IF(Y(I).EQ.0.0.AND.X1(I).EQ.0.0.AND.X2(I).EQ.0.0) GO TO 2
      GO TO 1
   44 IF(Y(I).EQ.0.0.AND.X1(I).EQ.0.0.AND.X2(I).EQ.0.0.AND.X3(I).EQ.0.0)
     1GO TO 2
    1 YA(K)=Y(I)
      X1A(K)=X1(I)
      X2A(K)=X2(I)
      X3A(K)=X3(I)
      CODE(K)=RCA(I)
      K=K+1
    2 CONTINUE
      NAS=K-1
      DO 47 I=1,NAS
      Y(I)=YA(I)
      X1(I)=X1A(I)
      X2(I)=X2A(I)
      X3(I)=X3A(I)
   47 CONTINUE
C     PRINT OUT THE NUMBERS OF REACHES MEETING SCREENING CRITERIA
      IB=1
      IE=20
      IF(NAS.EQ.0) GO TO 21
   22 IF(NAS.GT.IE) GO TO 20
      WRITE(IP,30) (CODE(I),I=IB,NAS)
   30 FORMAT(' ',10X,20F6.0)
      GO TO 21
   20 WRITE(IP,30) (CODE(I),I=IB,IE)
      IB=IB+20
      IE=IE+20
      GO TO 22
   21 WRITE(IP,31) NAS
   31 FORMAT('0',10X,'TOTAL NUMBER OF REACHES USED IN THIS ANALYSIS =',I
     14)
      GO TO 33
    5 NAS=-1
      GO TO 33
    9 NAS=-1
      WRITE(IP,32)
   32 FORMAT('0',10X,'N IS GREATER THAN THE MAX. NO OF VARIABLES (4) ')
   33 RETURN
      END
```

IORY REQUIREMENTS 000F88 BYTES

```
      SUBROUTINE PRMA(Y,NA,NAS,AMAX,AMIN)
C     PRMA = SUBROUTINE TO SCREEN DATA, TO DETERMINE MEAN, STANDARD
C            DEVIATION, COEFFICIENT OF VARIATION, CONFIDENCE LIMITS
C            AND THE MAXIMUM AND MINIMUM VALUES OF THE VARIABLE Y AFTER
C            SCREENING, AND FINALLY TO PRINT OUT THE RESULTS.
C     Y = INPUT VECTOR OF LENGTH NA
C     NA= THE LENGTH OF VECTOR Y BEFORE SCREENING
C     NAS= LENGTH OF VECTOR Y AFTER SCREENING
C     AMAX= MAXIMUM VALUE IN VECTOR Y AFTER SCREENING
C     AMIN= MINIMUM VALUE IN VECTOR Y AFTER SCREENING
      COMMON RCA(120)
      DIMENSION CODE(120),Y(120),X1(120),X2(120),X3(120)
      IP=6
      WRITE(IP,100)
  100 FORMAT('0',10X,'REACH NUMBERS USED IN THIS ANALYSIS'/)
      NVAR=1
      CALL SCRN(NVAR,CODE,Y,X1,X2,X3,NA,NAS)
      IF(NAS.LT.3) GO TO 1
      CALL COFFV(Y,NAS,YM,SDY,YCOV,B95CL,U95CL)
      CALL FLAS(Y,NAS,AMAX,AMIN)
      WRITE(IP,101) YM,B95CL,U95CL,NAS
  101 FORMAT('0',10X,'MEAN A =',F8.3,' ; 95% C.L. FOR MEAN =',F8.3,' ,',
     1F8.3,' ; N =',I4)
      WRITE(IP,102) YM,SDY,YCOV,AMIN,AMAX
  102 FORMAT('0',10X,'MEAN A =',F8.3,' ; ST. DEV. =',F8.3,' ; COEF. OF V
     1AR. =',F5.3,' ; MIN.&MAX. =',F8.3,' ,',F8.3)
    1 WRITE(IP,103)
  103 FORMAT('0',10X,'-----------------------------------------------------
     1---------------------------------')
      WRITE(IP,109)
  109 FORMAT(' ',10X,'*****************************************************
     1*********************************')
      WRITE(IP,110)
  110 FORMAT(' ',10X,'-----------------------------------------------------
     1---------------------------------'//)
      RETURN
      END
```

ORY REQUIREMENTS 000C6C BYTES

```
      SUBROUTINE COEFV(X,NT,XM,SDX,COVX,B95CLM,U95CLM)
C     COEFV = SUBROUTINE TO COMPUTE MEAN, STANDARD DEVIATION, COEF-
C             FICIENT OF VARIATION, AND THE 95% CONFIDENCE LIMITS FOR
C             THE VARIABLE X.
C     X     = INPUT VECTOR OF LENGTH NT.
C     NT    = LENGTH OF VECTOR X  ( AFTER ALL SCREENING )
C     XM    = MEAN OF VECTOR X
C     SDX   = STANDARD DEVIATION OF VECTOR X  ( UNBIASED EST. )
C     COVX  = COEF. OF VARIATION OF X
C     B95CLM= LOWER 95% CONF. LIM. FOR MEAN XM
C     U95CLM= UPPER 95% CONF. LIM. FOR MEAN XM
      DIMENSION X(120)
      DIMENSION TT(34),NDFT(34)
      DATA TT/12.706,4.303,3.182,2.776,2.571,2.447,2.365,2.306,2.262,2.2
     128,2.201,2.179,2.160,2.145,2.131,2.120,2.110,2.101,2.093,2.086,2.0
     280,2.074,2.069,2.064,2.060,2.056,2.052,2.048,2.045,2.042,2.021,2.0
     300,1.980,1.960/
      DATA NDFT/1,2,3,4,5,6,7,8,9,10,11,12,13,14,15,16,17,18,19,20,21,22
     1,23,24,25,26,27,28,29,30,40,60,120,100000/
      XM=0.0
      XMM=0.0
      DO 1 I=1,NT
      XM=XM+X(I)
      XMM=XMM+X(I)*X(I)
    1 CONTINUE
      ANT=NT
      CTEST=ANT*XMM-XM*XM
      IF(CTEST.GT.-0.00000001.AND.CTEST.LT.0.00000001) GO TO 17
      SDU=1./ANT*SQRT(ABS(ANT*XMM-XM*XM))
      SDX=SDU*SQRT(ANT/(ANT-1.0))
      XM=XM/ANT
      COVX=SDX/XM
      NDF=NT-1
      IF(NDF.LE.0) GO TO 10
      K=1
   14 IF(NDF.GT.NDFT(K)) GO TO 15
      DF=NDF
      DFTU=NDFT(K)
      DFTL=NDFT(K-1)
      T=TT(K-1)+(TT(K)-TT(K-1))/(DFTU-DFTL)*(DF-DFTL)
      GO TO 16
   15 K=K+1
      GO TO 14
   16 B95CLM=XM-T*SDX/SQRT(ANT)
      U95CLM=XM+T*SDX/SQRT(ANT)
      GO TO 11
   17 SDX=0.0
      COVX=0.0
   10 B95CLM=-1.0
      U95CLM=-1.0
   11 RETURN
      END
```

ORY REQUIREMENTS 0005CC BYTES

```
      SUBROUTINE FLAS(X,NT,AL,AS)
C     FLAS = SUBROUTINE TO DETERMINE THE LARGEST AND SMALLEST VALUES
C            OF THE VECTOR X.
C     NT   = LENGTH OF THE VECTOR X.
C     X    = INPUT VECTOR OF LENGTH NT  ( AFTER ALL SCREENING )
C     AL   = LARGEST VALUE IN VECTOR X
C     AS   = SMALLEST VALUE IN VECTOR X
      DIMENSION X(120)
      AL=X(1)
      J=1
      IF(NT.EQ.1) GO TO 7
      DO 6 I=2,NT
      IF(X(I).LE.AL) GO TO 6
      AL=X(I)
      J=I
    6 CONTINUE
      AS=X(1)
      J=1
      IF(NT.EQ.1) GO TO 7
      DO 8 I=2,NT
      IF(X(I).GE.AS) GO TO 8
      AS=X(I)
      J=I
    8 CONTINUE
    7 RETURN
      END
```

ORY REQUIREMENTS 000264 BYTES

```
      SUBROUTINE PHIST(X,N,XMAX,XMIN)
C     PHIST= SUBROUTINE TO GIVE FREQUENCY DISTRIBUTION OF ONE VARIABLE
C     X= INPUT VECTOR OF LENGTH  N
C     N = LENGTH OF THE VECTOR X
C     XMAX= LARGEST VALUE IN THE VECTOR X
C     XMIN= SMALLEST VALUE IN THE VECTOR X
      DIMENSION X(120),FREQ(20),BOUNDL(20),BOUNDU(20),XMID(20),FXMID(20)
      DIMENSION FXMSQ(20),RELF(20),CUMF(20),CRFRE(20),XO(120)
      IEND=N
      IF(IEND.EQ.0) GO TO 299
      TEND=N
      IF(IEND.LE.9) GO TO 670
C     FIND APPROXIMATE NUMBER OF DIVISIONS
      DIVN=SQRT(TEND)
      IF(DIVN-5.1)20,20,21
   20 DIVN=5.0
      GO TO 22
   21 IF(DIVN-15.0)22,22,23
   23 DIVN=15.
C     DIVISION INCREMENT
   22 DIVI=(XMAX-XMIN)/DIVN
C     FIND EVEN LIMITS FOR THE BOUNDS
      NT=7
   30 TEST=10.0**NT
      IF(DIVI-TEST)31,32,32
   31 NT=NT-1
      GO TO 30
   32 IF(DIVI-7.5*TEST)35,36,36
   36 DIVI=10.0*TEST
      GO TO 40
   35 IF(DIVI-2.5*TEST)37,38,38
   38 DIVI=5.0*TEST
      GO TO 40
   37 DIVI=TEST
C     FIND STARTING POINT
   40 STAR=XMIN/DIVI
      ISTAR=STAR
      STA=ISTAR
      START=STA*DIVI
      BOUNDL(1)=START
  131 BOUNDU(1)=START+DIVI
      XMID(1)=(BOUNDL(1)+BOUNDU(1))/2.0
      N=1
   52 IF(XMAX-BOUNDL(N))50,51,51
   51 N=N+1
      IF(N.GT.19) GO TO 130
      GO TO 152
  130 DIVI=2.0*DIVI
      GO TO 131
  152 NUP=N-1
      BOUNDL(N)=BOUNDU(NUP)
      BOUNDU(N)=BOUNDU(NUP)+DIVI
      XMID(N)=(BOUNDL(N)+BOUNDU(N))/2.0
      GO TO 52
   50 NI=N-1
```

```
C     SORT DATA INTO INTERVALS
      DO 58 N=1,NI
      FREQ(N)=0.0
   58 CONTINUE
      DO 60 N=1,NI
      DO 70 I=1,IEND
      IF(X(I)-BOUNDL(N))70,81,81
   81 IF(X(I)-BOUNDU(N))82,70,70
   82 FREQ(N)=FREQ(N)+1.0
   70 CONTINUE
   60 CONTINUE
C     SUM ALL TERMS FOR COMPUTING MEAN AND VARIANCE
      SFREQ=0.0
      SFXMID=0.0
      SFXMSQ=0.0
      DO 80 N=1,NI
      SFREQ=SFREQ+FREQ(N)
      FXMID(N)=FREQ(N)*XMID(N)
      SFXMID=SFXMID+FXMID(N)
      FXMSQ(N)=FREQ(N)*XMID(N)*XMID(N)
      SFXMSQ=SFXMSQ+FXMSQ(N)
   80 CONTINUE
      RELF(1)=FREQ(1)/SFREQ
      SUMREF=RELF(1)
      CUMF(1)=FREQ(1)
      CRFRF(1)=FREQ(1)/SFREQ
      DO 90 N=2,NI
      RELF(N)=FREQ(N)/SFREQ
      SUMREF=SUMREF+RELF(N)
      NZ=N-1
      CUMF(N)=CUMF(NZ)+FREQ(N)
      CRFRE(N)=CUMF(N)/SFREQ
   90 CONTINUE
C     COMPUTE MEAN AND VARIANCE
      XMEAN=SFXMID/SFREQ
      VAR=(SFXMSQ-(SFXMID*SFXMID)/SFREQ)/(SFREQ-1.0)
      SVAR=ABS(VAR)
      SDEV=SQRT(SVAR)
C     PRINT OUT RESULTS
  670 WRITE (6,601)
  601 FORMAT('0',10X,'FREQUENCY DISTRIBUTION OF ONE VARIABLE'/)
      WRITE (6,603) IEND
  603 FORMAT(10X,'NUMBER OF DATA POINTS =',I5/)
      WRITE (6,604)
  604 FORMAT(10X,'DATA USED IN THE ANALYSIS'/)
      WRITE (6,605)(X(I),I=1,IEND)
  605 FORMAT(' ',10X,8F15.4)
      IF(IEND.LE.9) GO TO 199
      WRITE(6,607)
  607 FORMAT('0',18X,'    BOUNDS                       MID-POINT     FREQ.F
     1  REL.FREQ.     CUM. FREQ. CUM.REL. FREQ.')
      DO 100 N=1,NI
      WRITE (6,608) BOUNDL(N),BOUNDU(N),XMID(N),FREQ(N),RELF(N),CUMF(N),
     1CRFRE(N)
  608 FORMAT(10X,F15.4,'-',2F15.4,F10.0,F15.4,F10.0,F15.4)
```

```
    100 CONTINUE
        WRITE(6,609) SFREQ,SUMREF
    609 FORMAT('0',23X,'TOTALS',26X,F10.0,F15.4//)
    199 N=IEND
        CALL SORTD(N,X,XO)
        NMED=N/2+1
        XMED=XO(NMED)
        WRITE(6,700) XMED
    700 FORMAT('0', 9X,'MEDIAN                              =',F15.4)
        IF(IEND.LE.9) GO TO 195
        WRITE (6,610) XMEAN
    610 FORMAT(10X,'AVERAGE OF GROUPED DATA            =',F15.4)
        WRITE(6,611) VAR
    611 FORMAT(10X,'VARIANCE OF GROUPED DATA           =',F15.4)
        WRITE (6,612) SDEV
    612 FORMAT(10X,'STANDARD DEVIATION OF GROUPED DATA =',F15.4/)
    195 WRITE(6,650)
    650 FORMAT(' ',10X,'--------------------------------------------------
       1-------------------------')
        WRITE(6,651)
    651 FORMAT(' ',10X,'**************************************************
       1**************************')
        WRITE(6,650)
    299 RETURN
        END
```

MORY REQUIREMENTS 0010BC BYTES

```
      SUBROUTINE SORTD(N,X,XD)
C     SORTD  = SUBROUTINE TO SORT VALUES IN DESCENDING ORDER.
C     N      = LENGTH OF VECTOR X
C     X      = INPUT VECTOR OF LENGTH N
C     XD     = OUTPUT VECTOR OF LENGTH N WITH VALUES OF THE VECTOR
C                ARRANGED IN DESCENDING ORDER.
      LOGICAL CHANGE
      DIMENSION X(120),XD(120)
      DO 10 I=1,N
      XD(I)=X(I)
   10 CONTINUE
      MD=N-1
      IF(MD.LT.1) RETURN
    1 CHANGE=.FALSE.
    2 DO 3 I=1,MD
      J=I+1
      IF(XD(I).GE.XD(J)) GO TO 3
      CHANGE=.TRUE.
      TMPXD=XD(I)
      XD(I)=XD(J)
      XD(J)=TMPXD
    3 CONTINUE
      IF(CHANGE) GO TO 1
      RETURN
      END
```

ORY REQUIREMENTS 00025C BYTES

```
      SUBROUTINE PRLS(Y,X1,NA,ITYPE,IRES)
C     PRLS = SUBROUTINE TO SCREEN DATA,TO DETERMINE LINEAR REGRESSION OF
C             SCREENED DATA; TO PRINT OUT RESULTS.
C     Y    = INPUT VECTOR OF LENGTH NA WITH DEPENDENT VARIABLE.
C     X1   = INPUT VECTOR OF LENGTH NA WITH INDEPENDENT VARIABLE.
C     NA= THE LENGTH OF VECTOR Y BEFORE ANY SCREENING
C     ITYPE= TYPE OF ANALYSIS.
C     ITYPE= 0 ARITH VS ARITH
C     ITYPE= 1 LOG VS LOG
C     IRES= CODE FOR RESIDUALS.
C     IRES=0  NO RESIDUALS PRINTED OUT
C     IRES=1  ONLY THE RESIDUALS ARE PRINTED OUT
C     IRES=2 ALL VALUES OF Y, X, COMPUTED Y, AND RESIDUALS ARE
C             PRINTED OUT.
      COMMON RCA(120)
      DIMENSION CODE(120),Y(120),X1(120),X2(120),X3(120),RES(120)
      IP=6
      NVAR=2
      WRITE(IP,100)
  100 FORMAT('0',10X,'REACH NUMBERS USED IN THIS ANALYSIS'/)
      CALL SCRN(NVAR,CODE,Y,X1,X2,X3,NA,NAS)
      IF(NAS.LT.4) GO TO 1
      CALL LSOFT(Y,X1,NAS,A,B95A,U95A,B,B95B,U95B,R,B95R,U95R,RSQ,SE,SSL
     1R,SSRES,SSTOT,ASRES,ASRAT)
      NDFLR=1
      NDFRES=NAS-2
      NDFTOT=NAS-1
      WRITE(IP,120)
  120 FORMAT('0',10X,'ANALYSIS OF VARIANCE')
      WRITE(IP,121)
  121 FORMAT('0',10X,'  SOURCE               D.F.  SUM OF SQUARES   MEAN SQ
     1UARE    MEAN SQUARE RATIO'/)
      WRITE(IP,122) NDFLR,SSLR,SSLR,ASRAT
  122 FORMAT(' ',10X,'LINEAR REGRESSION   ',I4,E16.7,E16.7,F12.3)
      WRITE(IP,123) NDFRES,SSRES,ASRES
  123 FORMAT(' ',10X,'RESIDUAL ABOUT L.R. ',I4,E16.7,E16.7)
      WRITE(IP,124) NDFTOT,SSTOT
  124 FORMAT(' ',10X,'TOTAL               ',I4,E16.7)
      IF(ITYPE.EQ.0) GO TO 12
      IF(ITYPE.EQ.1) GO TO 13
   13 WRITE(IP,101) A,B95A,U95A,B,B95B,U95B
  101 FORMAT('0',10X,'LOG(A)=',F8.4,' ; 95% C.L. FOR LOG(A)=',F8.4,' ,',
     1F8.4,' ; B=',F8.4,' ; 95% C.L. FOR B=',F8.4,' ,',F8.4)
      WRITE(IP,102) R,B95R,U95R,RSQ,SE,NAS
  102 FORMAT('0',10X,'R=',F6.3,' ; 95% C.L. FOR R=',F6.3,' ,',F6.3,' ; R
     1**2 =',F6.3,' ; STANDARD ERROR(LOG UNITS)=',F8.4,' ; N =',I4)
      ANTIL=10.0**A
      WRITE(IP,103) ANTIL,B
  103 FORMAT('0',10X,'OF THE FORM  Y =',F10.3,' * X**',F8.4)
      GO TO 477
   12 AT = ABS(A)
      IF(AT.GT.100000..OR.AT.LT.1.0) GO TO 15
      BT = ABS(B)
      IF(BT.GT.10000..OR.BT.LT.0.1) GO TO 15
      WRITE(IP,108) A,B95A,U95A
```

```
108 FORMAT('0',10X,'A =',F12.3,' ; 95% C.L. FOR A =',F12.3,',',F12.3)
    WRITE(IP,115) B,B95B,U95B
115 FORMAT('0',10X,'B =',F12.4,' ; 95% C.L. FOR B =',F12.4,',',F12.4)
    GO TO 17
 15 WRITE(IP,116) A,B95A,U95A
116 FORMAT('0',10X,'A =',E15.7,' ; 95% C.L. FOR A =',E15.7,',',E15.7)
    WRITE(IP,117) B,B95B,U95B
117 FORMAT('0',10X,'B =',E15.7,' ; 95% C.L. FOR B =',E15.7,',',E15.7)
 17 WRITE(IP,109) R,B95R,U95R,RSQ,SE,NAS
109 FORMAT('0',10X,'R =',F6.3,' ; 95% C.L. FOR R =',F6.3,' ,',F6.3,' ;
   1 R**2 =',F6.3,' ; STANDARD ERROR =',F20.9,' ; N =',I4)
    WRITE(IP,110) A,B
110 FORMAT('0',10X,'OF THE FORM Y =',F20.8,' + ',F20.8,'*X')
477 IF(IRES.LE.0) GO TO 1
    IF(IRES.GE.3) GO TO 1
    IF(IRES.EQ.1) GO TO 481
    IF(IRES.EQ.2) GO TO 482
481 DO 111 I=1,NAS
    RES(I)=Y(I)-(A+B*X1(I))
111 CONTINUE
    WRITE(IP,200)
200 FORMAT('0',10X,'RESIDUALS ( OBSERVED - COMPUTED VALUE )'/)
    WRITE(IP,201) (RES(I),I=1,NAS)
201 FORMAT(' ',10X,8F15.4)
    GO TO 1
482 WRITE(IP,300)
300 FORMAT('0',20X,'TABULATION OF DATA USED IN ANALYSIS WITH RESIDUALS
   1 '/)
    WRITE(IP,301)
301 FORMAT('0',10X,'CASE CODE           Y                   Y COMPUTED
   1       RESIDUAL              X '/)
    DO 320 I=1,NAS
    YC=A+B*X1(I)
    RESID=Y(I)-YC
    WRITE(IP,302) I,CODE(I),Y(I),YC,RESID,X1(I)
302 FORMAT(' ',10X,I5,F5.0,4F20.8)
320 CONTINUE
  1 WRITE(IP,104)
104 FORMAT('0',10X,'-----------------------------------------------
   1------------------------------')
    WRITE(IP,125)
125 FORMAT(' ',10X,'***********************************************
   1*********************************')
    WRITE(IP,126)
126 FORMAT(' ',10X,'-----------------------------------------------
   1------------------------------'//)
    RETURN
    END
```

ORY REQUIREMENTS 00153C BYTES

```
      SUBROUTINE LSOFT(Y,X,KT,A,A95L,A95U,B,B95L,B95U,R,R95L,R95U,RSQ,SE
     1,SSLR,SSRES,SSTOT,ASRES,ASRAT)
C     LSOFT = SUBROUTINE FOR OBTAINING LINEAR REGRESSION, CONFIDENCE
C             LIMITS, CORRELATION COEFFICIENT, STANDARD ERROR, AND DATA
C             FOR THE ANALYSIS OF VARIANCE.
C     Y     = VECTOR OF LENGTH KT FOR DEPENDENT VARIABLE
C     X     = VECTOR OF LENGTH KT FOR INDEPENDENT VARIABLE
C     KT    = LENGTH OF VECTORS Y AND X ( AFTER ALL SCREENING )
C     A     = CONSTANT TERM ( Y INTERCEPT )
C     A95L  = LOWER 95% CONF. LIM. FOR A
C     A95U  = UPPER 95% CONF. LIM. FOR A
C     B     = SLOPE OF REGRESSION LINE
C     B95L  = LOWER 95% CONF. LIM. FOR B
C     B95U  = UPPER 95% CONF. LIM. FOR B
C     R     = CORRELATION COEF.
C     R95L  = LOWER 95% CONF. LIM. FOR R
C     R95U  = UPPER 95% CONF. LIM. FOR R
C     RSQ   = R**2
C     SE    = STANDARD ERROR OF ESTIMATE OF Y ON X
C     SSLR TO ASRAT ARE PARAMETERS USED IN THE ANALYSIS OF VARIANCE
      DIMENSION X(120),Y(120)
      DIMENSION TT(34),NDFT(34),GT(32),RGT(32)
      DATA TT/12.706,4.303,3.182,2.776,2.571,2.447,2.365,2.306,2.262,2.2
     128,2.201,2.179,2.160,2.145,2.131,2.120,2.110,2.101,2.093,2.086,2.0
     280,2.074,2.069,2.064,2.060,2.056,2.052,2.048,2.045,2.042,2.021,2.0
     300,1.980,1.960/
      DATA NDFT/1,2,3,4,5,6,7,8,9,10,11,12,13,14,15,16,17,18,19,20,21,22
     1,23,24,25,26,27,28,29,30,40,60,120,100000/
      DATA GT/0.00,0.100,0.203,0.310,0.424,0.549,0.693,0.758,0.829,0.908
     1,0.996,1.099,1.188,1.293,1.376,1.472,1.528,1.589,1.658,1.738,1.832
     2,1.886,1.946,2.014,2.092,2.185,2.298,2.443,2.647,2.994,3.80,
     3100000./
      DATA RGT/0.00,0.10,0.20,0.30,0.40,0.50,0.60,0.64,0.68,0.72,0.76,0.
     180,0.83,0.86,0.88,0.90,0.91,0.92,0.93,0.94,0.95,0.955,0.96,0.965,0
     2.97,0.975,0.98,0.985,0.99,0.995,0.999,1.000/
      SX=0.0
      SY=0.0
      SXX=0.0
      SYY=0.0
      SXY=0.0
      DO 100 K=1,KT
      SX=SX+X(K)
      SY=SY+Y(K)
      SXX=SXX+X(K)**2
      SYY=SYY+Y(K)**2
      SXY=SXY+X(K)*Y(K)
  100 CONTINUE
      TK=KT
      XM=SX/TK
      YM=SY/TK
      STEST=SXX-TK*XM*XM
      IF(STEST.GT.-0.00000001.AND.STEST.LT.0.00000001) GO TO 75
      B=(SXY-TK*XM*YM)/(SXX-TK*XM**2)
      A=YM-B*XM
      VARX=(SXX-TK*XM**2)/(TK-1.)
```

```
      VARY=(SYY-TK*YM**2)/(TK-1.)
      STDX=SQRT(VARX)
      STDY=SQRT(VARY)
      SSLR=VARX*(TK-1.)*B**2
      SSTOT=VARY*(TK-1.)
      SSRES=SSTOT-SSLR
      ASRES=SSRES/(TK-2.)
      ASRAT=SSLR/ASRES
      COVAR=B*VARX
      R=B*SQRT(VARX)/SQRT(VARY)
      RSQ=R**2
      SESQ=(SYY-A*SY-B*SXY)/(TK-2.)
      SE=SQRT(SESQ)
      NDF=KT-2
      IF(NDF.EQ.0) GO TO 75
      I=2
   14 IF(NDF.GT.NDFT(I)) GO TO 15
      DF=NDF
      DFTU=NDFT(I)
      DFTL=NDFT(I-1)
      T=TT(I-1)+(TT(I)-TT(I-1))/(DFTU-DFTL)*(DF-DFTL)
      GO TO 16
   15 I=I+1
      GO TO 14
   16 CONST=ABS(SXX-TK*XM*XM)
      CONST1=T*SE*SQRT(1./TK+XM**2/CONST)
      A95U=A+CONST1
      A95L=A-CONST1
      CONST2=T*SE*SQRT(1./CONST)
      B95U=B+CONST2
      B95L=B-CONST2
      ABR=ABS(R)
      IF(ABR.GT.0.9999) GO TO 320
      GU=0.5*ALOG((1.+R)/(1.-R))+1.96/SQRT(TK-3.)
      GL=0.5*ALOG((1.+R)/(1.-R))-1.96/SQRT(TK-3.)
      SIGNRL=+1.
      SIGNRU=+1.
      IF(GL.GE.0.0) GO TO 180
      SIGNRL=-1.
      GL=-GL
      IF(GL.GT.100000.) GO TO 320
  180 IF(GU.GE.0.0) GO TO 181
      SIGNRU=-1.
      GU=-GU
  181 M=2
   81 IF(GL.LE.GT(M)) GO TO 82
      M=M+1
      GO TO 81
   82 R95L=RGT(M-1)+(RGT(M)-RGT(M-1))/(GT(M)-GT(M-1))*(GL-GT(M-1))
      IF(GU.GT.100000.) GO TO 320
      M=2
   84 IF(GU.LT.GT(M)) GO TO 83
      M=M+1
      GO TO 84
   83 R95U=RGT(M-1)+(RGT(M)-RGT(M-1))/(GT(M)-GT(M-1))*(GU-GT(M-1))
```

```
      R95L=R95L*SIGNRL
      R95U=R95U*SIGNRU
      GO TO 76
   75 A=-1.0
      A95L=-1.0
      A95U=-1.0
      B=-1.0
      B95L=-1.0
      B95U=-1.0
      R=-1.0
      RSQ=-1.0
      SE=-1.0
      SSLR=-1.0
      SSTOT=-1.0
      SSRES=-1.0
      ASRES=-1.0
      ASRAT=-1.0
  320 R95L=-1.0
      R95U=-1.0
   76 RETURN
      END
```

IORY REQUIREMENTS 000CB0 BYTES

```
      SUBROUTINE PRMR(Y,X1,X2,X3,NA,NVAR,NSTAT,NRESI)
C     PRMR = SUBROUTINE FOR SCREENING DATA, CONTROLLING THE MULTIPLE
C            LINEAR REGRESSION, AND PRINTING OUT THE RESULTS.
C     Y    = INPUT VECTOR OF LENGTH NA CONTAINING THE DEPENDENT VARIABLE
C     X1   = INPUT VECTOR OF LENGTH NA CONTAINING THE FIRST IND. VAR.
C     X2   = INPUT VECTOR OF LENGTH NA CONTAINING THE SECOND IND. VAR.
C     X3   = INPUT VECTOR OF LENGTH NA CONTAINING THE THIRD IND. VAR.
C     NA   = TOTAL NUMBER OF OBSERVATIONS SENT TO SUBROUTINE PRMR FOR
C            ANY ONE OF THE ABOVE VECTORS.
C     NVAR = NUMBER OF VARIABLES DIMENSIONED IN SUBROUTINE REGRE
C     NSTAT= NUMBER OF OBSERVATIONS DIMENSIONED IN SUBROUTINE REGRE
C     NRESI= 0 FOR NO TABLE OF RESIDUALS;  NRESI = A POSITIVE INTEGER
C     FOR A PRINT OUT OF THE TABLE OF RESIDUALS AND THE BASIC DATA
C     USED IN THE ANALYSIS.
C     THE SUBROUTINE PRMR IS SET UP TO HANDLE ONE DEPENDENT VARIABLE
C            AND THREE INDEPENDENT VARIABLES.  IN ORDER TO INCREASE
C            THE NUMBER OF INDEPENDENT VARIABLES IT IS NECESSARY
C            TO CHANGE THE DIMENSIONS OF XX , AND OTHER VARIABLES IN
C            SUBROUTINES SCRN, AND REGRE.
      COMMON PCA(120)
      DIMENSION CODE(120),Y(120),X1(120),X2(120),X3(120),XX(120,4)
      IP=6
      WRITE(IP,100)
  100 FORMAT('0',10X,'REACH NUMBERS USED IN THIS ANALYSIS'/)
      CALL SCRN(NVAR,CODE,Y,X1,X2,X3,NA,NAS)
      NTEST=NVAR+1
      IF(NAS.LT.NTEST) GO TO 1
      DO 2 I=1,NA
      XX(I,1)=Y(I)
      XX(I,2)=X1(I)
      XX(I,3)=X2(I)
      XX(I,4)=X3(I)
    2 CONTINUE
      NVART=4
      CALL REGRE(NAS,NVAR,NSTAT,NVART,XX,NRESI,CODE)
    1 WRITE(IP,104)
  104 FORMAT('0',10X,'--------------------------------------------------------
     1-------------------------------')
      WRITE(IP,109)
  109 FORMAT(' ',10X,'********************************************************
     1*********************************')
      WRITE(IP,110)
  110 FORMAT(' ',10X,'--------------------------------------------------------
     1-------------------------------'//)
      RETURN
      END
```

ORY REQUIREMENTS 000DF0 BYTES

```
      SUBROUTINE REGRE(N,M,ND,MD,XX,NRESI,CODE)
C     REGRE= SUBROUTINE TO DETERMINE THE COEFFICIENTS, THE CORRELATION
C            COEFFICIENTS, THE ANALYSIS OF VARIANCE, ETC. FOR A
C            MULTIPLE LINEAR REGRESSION.
C     N   = ACTUAL NO. OF OBSERVATIONS
C     M   = ACTUAL NO. OF VARIABLES
C     ND = NO. OF OBSERVATIONS DIMENSIONED IN XX
C     MD = NO. OF VARIABLES DIMENSIONED IN XX
C     XX = MATRIX DIMENSIONED AS (ND,MD)
C     NRESI= 0 FOR NO TABLE OF RESIDUALS;  NRESI = A POSITIVE INTEGER
C     FOR A PRINT OUT OF THE TABLE OF RESIDUALS AND THE BASIC DATA
C     USED IN THE& ANALYSIS.
C     CODE = A VECTOR OF LENGTH  N  CONTAINING THE CODE NUMBERS OF THE
C            ACCEPTED REACHES.
C     SEE THE IBM MANUAL FOR THE WRITE UP OF SSP PROGRAMS, THIS
C            SUBROUTINE IS TAKEN FROM THE EXAMPLES PROVIDED IN THE BACK
C            OF THE REFERENCE.
C     SUBROUTINES ARRAY, CORRE, ORDER, MINV, AND MULTR ARE FROM THE
C            SCIENTIFIC SUBROUTINES PACKAGE  *SSPLIB.
      DIMENSION XBAR(4),STD(4),D(4),RY(4),ISAVE(4),B(4),SB(4),T(4),W(4)
      DIMENSION RX(16),R(10),ANS(10),XX(120,4),X(480)
      DIMENSION CODE(120)
      NS=1
      NDEP=1
C     NDEP = THE VARIABLE NUMBER IN  XX(I,NVAR)  WHICH CORRESPONDS TO
C            TO THE DEPENDENT VARIABLE. IF NDEP IS NE.  1 , THE
C            SUBROUTINE REGRE MUST BE MODIFIED.
      K=M-1
      DO 131 IDV=1,K
      ISAVE(IDV)=IDV+1
  131 CONTINUE
      MODE=2
      CALL ARRAY(MODE,N,M,ND,MD,X,XX)
      IO=1
      CALL CORRE(N,M,IO,X,XBAR,STD,RX,R,D,B,T)
      IF(NS) 108, 108, 109
  108 WRITE(6,13)
      GO TO 300
  109 DO 200 I=1,NS
      CALL ORDER(M,R,NDEP,K,ISAVE,RX,RY)
      CALL MINV(RX,K,DET,B,T)
      IF(DET) 112,110,112
  110 WRITE(6,14)
      GO TO 200
  112 CALL MULTR(N,K,XBAR,STD,D,RX,RY,ISAVE,B,SB,T,ANS)
      MM=K+1
      WRITE(6,3)
      DO 115 J=1,K
      L=ISAVE(J)
  115 WRITE(6,4) L,XBAR(L),STD(L),RY(J),B(J),SB(J),T(J)
      WRITE(6,5)
      L=ISAVE(MM)
      WRITE(6,4) L,XBAR(L),STD(L)
      WRITE(6,6) ANS(1),ANS(2),ANS(3)
      WRITE(6,7)
```

```
      L=ANS(8)
      WRITE(6,8) K,ANS(4),ANS(6),ANS(10),L,ANS(7),ANS(9)
      L=N-1
      SUM=ANS(4)+ANS(7)
      WRITE(6,9) L,SUM
      IF(NRESI) 200,200,120
  120 WRITE(6,11)
      WRITE(6,199)
      MM=ISAVE(K+1)
      DO 140 II=1,N
      SUM=ANS(1)
      DO 130 J=1,K
      L=ISAVE(J)
  130 SUM=SUM+XX(II,L)*B(J)
      RESI=XX(II,1)-SUM
      IF(K.EQ.1) GO TO 400
      IF(K.EQ.2) GO TO 401
      IF(K.EQ.3) GO TO 402
  400 WRITE(6,12)  II,CODE(II),XX(II,1),SUM,RESI,XX(II,2)
      GO TO 140
  401 WRITE(6,410) II,CODE(II),XX(II,1),SUM,RESI,XX(II,2),XX(II,3)
      GO TO 140
  402 WRITE(6,411) II,CODE(II),XX(II,1),SUM,RESI,XX(II,2),XX(II,3),XX(II
     1,4)
  140 CONTINUE
  200 CONTINUE
    3 FORMAT(19H0          VARIABLE,5X,4HMEAN,6X,8HSTANDARD,6X,11HCORREL
     1ATION,4X,10HREGRESSION,4X,10HSTD. ERROR,5X,8HCOMPUTED/16H
     2    NO.,18X,9HDEVIATION,7X,6HX VS Y,7X,11HCOEFFICIENT,3X,12HOF REG
     3.COEF.,3X,7HT VALUE)
    4 FORMAT(' ',10X,I4,6F14.5)
    5 FORMAT(20H          DEPENDENT)
    6 FORMAT(1H0/20H             INTERCEPT,10X,F16.5//33H          MULTIP
     1LE CORRELATION   ,F13.5//33H          STD. ERROR OF ESTIMATE,F13.5
     2//)
    7 FORMAT(1H0,21X,39HANALYSIS OF VARIANCE FOR THE REGRESSION//15X,19H
     1SOURCE OF VARIATION,7X,7HDEGREES,7X,6HSUM OF,10X,4HMEAN,12X,7HF VA
     2LUE/40X,10HOF FREEDOM,4X,7HSQUARES,9X,7HSQUARES)
    8 FORMAT(40H          ATTRIBUTABLE TO REGRESSION    ,I6,3F16.5/40H
     1          DEVIATION FROM REGRESSION    ,I6,2F16.5)
    9 FORMAT(' ',15X,5HTOTAL,19X,I6,F16.5)
   11 FORMAT('0',30X,'TABLE OF RESIDUALS  -- DEPENDENT VARIABLE " Y" IS
     1VAR 1'/)
   12 FORMAT(' ',10X,I6,F5.0,4F15.5)
  410 FORMAT(' ',10X,I6,F5.0,5F15.5)
  411 FORMAT(' ',10X,I6,F5.0,6F15.5)
  199 FORMAT('0',10X,'CASE CODE        Y VALUE        Y ESTIMATE      RESIDU
     1AL          VAR 2          VAR 3          VAR 4'/)
   13 FORMAT(53H1NUMBER OF SELECTIONS NOT SPECIFIED.  JOB TERMINATED.)
   14 FORMAT(52H0THE MATRIX IS SINGULAR.  THIS SELECTION IS SKIPPED.)
  300 RETURN
      END
```

MORY REQUIREMENTS 0014B8 BYTES

```
G COMPILER         DATA              07-12-71          21:44.38        PAGE 0001

          SUBROUTINE DATA
  C       DATA = SUBROUTINE REQUIRED BY THE SSP LIBRARY WHEN USING THE
  C              MULTIPLE LINEAR REGRESSION PROGRAM.
          RETURN
          END

ORY REQUIREMENTS 0000F6 BYTES
884 RC=0
```

```
      SUBROUTINE PLOTR(XX,NA,KT,KA,KB,KC,KD,HA,HB,HC,VA,VB,VC,ALPH)
C     PLOTR = SUBROUTINE FOR PLOTTING
C     XX    = INPUT MATRIX OF (NA*4).  THIS MATRIX IS SCREENED WITH
C             TEST VALUES ESTABLISHED  FOR CASES NOT MEETING THE
C             SCREENING CRITERIA.  XX(I,4)= -9.0 IN SUCH CASES.
C     KT    = TOTAL NUMBER OF CURVES TO BE CALLED FOR A GIVEN PLOT.
C             KT SHOULD BE LE. 13.  THE FIRST CURVE IS DRAWN FOR XX(I,4)
C             = -1.0 (IF  XX(I,4) CONTAINS ANY VALUES OF -1.0)
C             A SECOND CURVE IS DRAWN FOR  XX(I,4)= 0.0, ETC.
C     SEE THE WRITE UP FOR SUBROUTINE GPL FOR MORE DETAILS CONCERNING
C            THE PARAMETERS KA TO ALPH.
C     KA    = TYPE OF ABSCISSA AXIS.
C     KB    = TYPE OF ORDINATE AXIS.
C     KC    = A NEGATIVE VALUE IF THE THIRD PARAMETER IS TO BE
C             PRINTED ON THE PLOT.
C     KD    = NUMBER OF DIGITS AFTER THE DECIMAL IF THE THIRD PARAMETER
C             IS USED.
C     HA    = ORIGIN OF THE ABSCISSA.
C     HB    = SCALE FOR THE ABSCISSA.
C     HC    = LENGTH OF THE ABSCISSA IN INCHES.
C     VA    = ORIGIN OF THE ORDINATE.
C     VB    = SCALE FOR THE ORDINATE.
C     VC    = LENGTH OF THE ORDINATE IN INCHES.
C     ALPH  = THE TITLE OF THE PLOT ( CLOS 1 - 48): THE TITLE OF THE
C             ABSCISSA ( COLS 49-64): THE TITLE OF THE ORDINATE ( COLS
C             65-80)
      DIMENSION XX(120,4),X(120),Y(120),Z(120)
      DIMENSION ALPH(20),KODE(120)
      IP=6
      WRITE(IP,20)
   20 FORMAT('0',10X,'DATA SUPPLIED TO THE CALCOMP PLOTTER FOR THIS ANAL
     1YSIS')
      WRITE(IP,9) (ALPH(I),I=1,20)
    9 FORMAT('0',10X,20A4)
      WRITE(IP,777) (ALPH(I),I=13,16)
  777 FORMAT('0',20X,'X =  ',4A4)
      WRITE(IP,778) (ALPH(I),I=17,20)
  778 FORMAT('0',20X,'Y =  ',4A4)
      WRITE(IP,75)
   75 FORMAT('0',10X,'REACH NUMBERS USED IN THIS PLOT'/)
      NCOUNT=1
      DO 70 I=1,NA
      IF(XX(I,4).LE.-1.01) GO TO 70
      KODE(NCOUNT)=I
      NCOUNT=NCOUNT+1
   70 CONTINUE
      NCOUNT=NCOUNT-1
      IB=1
      IE=20
      IF(NCOUNT.EQ.0) GO TO 78
   77 IF(NCOUNT.GT.IE) GO TO 79
      WRITE(IP,76) (KODE(I),I=IB,NCOUNT)
   76 FORMAT(' ',10X,20I6)
      GO TO 78
   79 WRITE(IP,76) (KODE(I),I=IB,IE)
```

```
      IB=IB+20
      IE=IE+20
      GO TO 77
   78 WRITE(IP,80) NCOUNT
   80 FORMAT('0',10X,'TOTAL NUMBER OF REACHES USED IN THIS ANALYSIS =',I
     14/)
      WRITE(IP,10)
   10 FORMAT('0',10X,'GPL SYMBOL CODE     VALUE FOR SYMBOL      NO. POIN
     1TS'/)
      KP=1
      K=1
    4 J=1
      IF(KP.GT.13) GO TO 6
      TEST=K-2
      UP=TEST+0.01
      BOTTOM=TEST-0.01
C     XX(I,1) HAS VALUES OF THE X AXIS (ABSCISSA)
C     XX(I,2) HAS VALUES OF THE Y AXIS  ( ORDINATE )
C     XX(I,3) HAS VALUES OF Z THE THIRD PARAMETER ASSOCIATED WITH
C             THE VARIABLES  X  AND  Y.
C     XX(I,4) HAS VALUES USED TO DETERMINE THE SYMBOL TO BE USED FOR
C             PLOTTING.  THE VALUES IN  XX(I,4)  MUST BE WHOLE NUMBERS
C             RANGING FROM  -1.0  TO  11.0
      DO 1 I=1,NA
      IF(XX(I,4).LT.-1.01) GO TO 1
      IF(XX(I,4).GT.BOTTOM.AND.XX(I,4).LT.UP) GO TO 3
      GO TO 1
    3 X(J)=XX(I,1)
      Y(J)=XX(I,2)
      Z(J)=XX(I,3)
      J=J+1
    1 CONTINUE
      JT=J-1
      IF(JT.EQ.0) GO TO 7
      WRITE(IP,11) KP,TEST,JT
   11 FORMAT(' ',15X,I3,16X,F5.1,16X,I3)
      IOU=8
      CALL GPL( X,Y,Z ,JT,KP,KA,KB,KC,KD,HA,HB,HC,VA,VB,VC,ALPH,IOU)
      KP=KP+1
    7 IF(K.EQ.KT) GO TO 8
      K=K+1
      GO TO 4
    6 IP=6
      WRITE(IP,101)
  101 FORMAT('0',10X,'MORE THAN 13 PLOTS REQUESTED')
    8 WRITE(IP,108)
  108 FORMAT('0',10X,'-----------------------------------------------------
     1--------------------------------')
      WRITE(IP,109)
  109 FORMAT(' ',10X,'*****************************************************
     1********************************')
      WRITE(IP,110)
  110 FORMAT(' ',10X,'-----------------------------------------------------
     1--------------------------------'//)
      RETURN
```



```
      END
```

ORY REQUIREMENTS 0011B4 BYTES

```
      SUBROUTINE PLOTVA(XX,NA)
C     SUBROUTINE PLOTVA IS USED TO PRINT THE VALUES USED IN THE PLOT.
C     XX IS AN INPUT MATRIX (NA*4) SUPPLIED  TO THE SUBROUTINE PLOTR
C     NA IS THE TOTAL NUMBER OF REACHES BEFORE ANY SCREENING.
      DIMENSION XX(120,4),X(120),Y(120),Z(120),S(120),KODE(120)
      IP=6
      IC=1
      DO 1 I=1,NA
      IF(XX(I,4).LE.-1.01) GO TO 1
      X(IC)=XX(I,1)
      Y(IC)=XX(I,2)
      Z(IC)=XX(I,3)
      S(IC)=XX(I,4)
      KODE(IC)=I
      IC=IC+1
    1 CONTINUE
      ICT=IC-1
      WRITE(IP,2)
    2 FORMAT('0',10X,'PRINT OUT VALUES USED IN PLOT'/)
      WRITE(IP,3)
    3 FORMAT('0',12X,'#',10X,'X',19X,'Y',19X,'Z',10X,'VALUE FOR SYMBOL'/
     1)
      DO 4 I=1,ICT
      WRITE(IP,5) KODE(I),X(I),Y(I),Z(I),S(I)
    5 FORMAT(10X,I4,3F20.7,F10.0)
    4 CONTINUE
      WRITE(108)
  108 FORMAT('0',10X,'-----------------------------------------------------
     1--------------------------------')
  109 FORMAT(' ',10X,'*****************************************************
     1********************************')
      WRITE(IP,110)
  110 FORMAT(' ',10X,'-----------------------------------------------------
     1--------------------------------'//)
      RETURN
      END
```

ORY REQUIREMENTS 000D70 BYTES
5 RC=0

APPENDIX K

LIST OF PROGRAM SEGMENTS FOR ANALYSIS AND PLOTTING

K.1 General

Since there are many possibilities for establishing regime type relations or for establishing hydrological relations, the concept of using program segments (or components) for analysis or plotting was adopted for this investigation. A program segment (consisting of from 15 to 20 cards) for a desired equation or relation is simply inserted in the main program at the appropriate place, since all segments are independent of each other. They were designed to ensure that the screening test vector "T" was not -1 for any river reach used in the desired analysis. Tests are made to ensure that the values involved in the computation will not result in division by zero, etc. The desired computations are then carried out and the appropriate subroutines are called. Some examples of program segments are given in the listing of the main program in APPENDIX J.

If the master ARRAY containing the basic data is changed, some modification is required in a few program segments where variable names are defined in the segment. In these cases the new element number in ARRAY for the particular variable name must be used in the program segment.

This appendix lists the more than 200 program segments available. The segments are grouped as follows:

1. Regime type analysis
2. Hydrologic type analysis; this is a broad category which also includes relations which may not be clearly classed as

hydrologic or regime.

3. Regime type plotting
4. Hydrologic type plotting

In the following lists the identification code assigned to each equation or relation is given, followed by the relation to be evaluated. All variables and abbreviations used in the expressions are defined in the list of symbols and the list of abbreviations. All units are ft.-lb.-sec. units. One exception should be noted: the characteristic bed material sizes (DG90 and DG50) are expressed in feet in this listing, but they are in millimeters in the program segments. Consequently, all bed material sizes in the program segments are divided by 305 to convert them to feet. All parameters involved in the computations are average values for the reach.

It is assumed that the proper screening is to be carried out before any analysis is executed. For example, equations pertaining to gravel rivers, should only be used after all non-gravel rivers are screened out of the analysis.

Other program segments may be written for special requirements. A program segment can be prepared in about 10 or 15 minutes. All statement numbers above 10,000 may be used when writing new segments.

K.2 <u>Program Segments for Regime Type Analysis</u>

Lacey type relation

L - 1 $WSM = a \cdot Q^{0.500}$

L - 2 $VM = a \cdot DM^{0.667} \cdot S^{0.333}$

L - 3 $VM = a \cdot DM^{0.500} \cdot DG90^{0.250}$

L - 4 $VM = a \cdot DM^{0.500} \cdot DG50^{0.250}$

L - 5 $S = 1/a \cdot DG90^{0.833}/Q^{0.167}$

L - 6 $S = 1/a \cdot DG50^{0.833}/Q^{0.167}$

Blench type relations

B - 1 $VM^2/DM = a \cdot [1/(DM/DG90)]^{0.500}$

B - 2 $VM^2/DM = a \cdot [1/(DM/DG50)]^{0.500}$

B - 3 $VM^2/DM = a \cdot (DM/DG90)^b$

B - 4 $VM^2/DM = a \cdot (DM/DG50)^b$

B - 5 $VM^2/DM = a \cdot (DM/DG50)^b$ No movement: Cooper-Neill

B - 6 $VM^2/DM = a \cdot (DM/DG50)^b$ No movement: Galay

B - 7 $VM^2/DM = a \cdot (DG50)^{0.250}$

B - 8 $VM^2/DM = a \cdot (DG50)^{0.500}$

B - 9 $VM^2/DM = a \cdot (DG90)^b$

B - 10 $VM^2/DM = a \cdot (DG50)^b$

B - 11 $VM^3/WSM = a$

B - 12 $VM^3/WSM = a \cdot (VM^2/DM)^{2.00}$; Banks: gravel and cobbles

B - 13 $VM^3/WSM = a \cdot (VM^2/DM)^b$; Banks: gravel and cobbles

B - 14 $VM^2/(g \cdot DM \cdot S) = a \cdot (VM \cdot WSM/\nu)^{0.250}$

B - 15 $VM^2/(g \cdot DM \cdot S) \cdot SCOR = a \cdot (VM \cdot WSM/\nu)^{0.250}$

B - 16 $VM^2/(g \cdot DM \cdot S) = a \cdot (VM \cdot WSM/\nu)^b$

B - 17 $VM^2/(g \cdot DM \cdot S) \cdot SCOR = a \cdot (VM \cdot WSM/\nu)^b$

Henderson type relations

H - 1 $WSM = a \cdot Q \cdot S^{1.167}/DG90^{1.50}$

H - 2 $WSM = a \cdot Q \cdot S^{1.167}/DG50^{1.50}$

H - 3 $WSM = a \cdot (Q \cdot S^{1.167}/DG50^{1.50})^b$

H - 4 $DM = a \cdot DG90/S$

H - 5 $DM = a \cdot DG50/S$

H - 6 $DM = a \cdot (DG90/S)^b$

H - 7 $DM = a \cdot (DG50/S)^b$

H - 8 $VM = a \cdot DM^{0.500} S^{0.333}$

Kellerhals type relations

K - 1 $VM/(g \cdot DM \cdot S)^{0.500} = a \cdot (DM/DG90)^{0.250}$

K - 2 $VM/(g \cdot DM \cdot S)^{0.500} = a \cdot (DM/DG50)^{0.250}$

K - 3 $VM/(g \cdot DM \cdot S)^{0.500} = a \cdot (DM/DG90)^b$

K - 4 $VM/(g \cdot DM \cdot S)^{0.500} = a \cdot (DM/DG50)^b$

K - 5 $\gamma \cdot DM \cdot S = a \cdot DG90^{0.800}$

K - 6 $\gamma \cdot DM \cdot S = a \cdot DG50$

K - 7 $\gamma \cdot DM \cdot S = a \cdot DG90^b$

K - 8 $\gamma \cdot DM \cdot S = a \cdot DG50^b$

Width relations

WSM - 1 $WSM = a \cdot Q^b$

WSM - 2 $WSM = a \cdot Q^b \cdot S^c$

WSM - 3 $WSM = a \cdot Q^b \cdot DG90^c$

WSM - 4 $WSM = a \cdot Q^b \cdot DG50^c$

WSM - 5 $WSM = a \cdot Q^b \cdot DG90^c \cdot S^d$

WSM - 6 $WSM = a \cdot Q^b \cdot DG50^c \cdot S^d$

Area relations

AM - 1 $AM = a \cdot Q^b$

AM - 2 $AM = a \cdot Q^b \cdot S^c$

AM - 3 $AM = a \cdot Q^b \cdot DG90^c$

AM - 4 $AM = a \cdot Q^b \cdot DG50^c$

AM - 5 $AM = a \cdot Q^b \cdot DG90^c \cdot S^d$

AM - 6 $AM = a \cdot Q^b \cdot DG50^c \cdot S^d$

Depth relations

DM - 1 $DM = a \cdot Q^b$

DM - 2 $DM = a \cdot Q^b \cdot S$

DM - 3 $DM = a \cdot Q^b \cdot DG90^c$

DM - 4 $DM = a \cdot Q^b \cdot DG50^c$

DM - 5 $DM = a \cdot Q^b \cdot DG90^c \cdot S^d$

DM - 6 $DM = a \cdot Q^b \cdot DG50^c \cdot S^d$

Form Factor (FF = WSM/DM) relations

FF - 1 $FF = a$

FF - 2 $FF = a \cdot Q^b$

FF - 3 $FF = a \cdot DG90^b$

FF - 4 $FF = a \cdot DG50^b$

FF - 5 $FF = a \cdot Q^b \cdot S^c$

FF - 6 $FF = a \cdot Q^b \cdot DG90^c$

FF - 7 $FF = a \cdot Q^b \cdot DG50^c$

FF - 8 $FF = a \cdot Q^b \cdot DG90^c \cdot S^d$

FF - 9 $FF = a \cdot Q^b \cdot DG50^c \cdot S^d$

Mean velocity relations

VM - 1 $VM = a \cdot Q^b$

VM - 2 $VM = a \cdot Q^b \cdot S^c$

VM - 3 $VM = a \cdot Q^b \cdot DG90^c$

VM - 4 $VM = a \cdot Q^b \cdot DG50^c$

VM - 5 $VM = a \cdot Q^b \cdot DG90^c \cdot S^d$

VM - 6 $VM = a \cdot Q^b \cdot DG50^c \cdot S^d$

VM - 7 $VM = a \cdot DM^b \cdot S^c$

VM - 8 $VM = a \cdot DM^b \cdot DG90^c$

VM - 9 $VM = a \cdot DM^b \cdot DG50^c$

VM - 10 $VM = a \cdot DM^b \cdot DG90^c \cdot S^d$

VM - 11 $VM = a \cdot DM^b \cdot DG50^c \cdot S^d$

Slope relations

S - 1 $S = a \cdot Q^b$

S - 2 $S = a \cdot DG90^b$

S - 3 $S = a \cdot DG50^b$

S - 4 $S = a \cdot Q^b \cdot DG90^c$

S - 5 $S = a \cdot Q^b \cdot DG50^c$

S - 6 $S/SCOR = a \cdot Q^b \cdot DG50^c$

S - 7 $S = a \cdot Q^b \cdot DG90^c \cdot WSM^d$

S - 8 $S = a \cdot Q^b \cdot DG50^c \cdot WSM^d$

S - 9 $S/SCOR = a \cdot Q^b \cdot DG50^c \cdot WSM^d$

Manning "n" relations

$n = 1.486 \cdot DM^{0.667} \cdot S^{0.500}/VM$

n - 1 $n = a \cdot Q^b$

n - 2 $n = a \cdot DG90^b$

n - 3 $n = a \cdot DG50^b$

n - 4 $n = a \cdot S^b$

n - 5 $n = a \cdot FF^b$

n - 6 $n = a \cdot Q^{b} \cdot S^{c}$

n - 7 $n = a \cdot Q^{b} \cdot DG90^{c}$

n - 8 $n = a \cdot Q^{b} \cdot DG50^{c}$

n - 9 $n = a \cdot Q^{b} \cdot DG90^{c} \cdot S^{d}$

n - 10 $n = a \cdot Q^{b} \cdot DG50^{c} \cdot S^{d}$

n - 11 $n = a \cdot DG90^{b} \cdot S^{c}$

n - 12 $n = a \cdot DG50^{b} \cdot S^{c}$

n - 13 $n = a \cdot DG90^{b} \cdot FF^{c}$

n - 14 $n = a \cdot DG50^{b} \cdot FF^{c}$

n - 15 $n = a \cdot S^{b} \cdot FF^{c}$

n - 16 $n = a \cdot DG90^{b} \cdot FF^{c} \cdot S^{d}$

n - 17 $n = a \cdot DG50^{b} \cdot FF^{c} \cdot S^{d}$

Dimensionless relations

DIM - 1 $WSM \cdot g^{0.20}/Q^{0.40} = a$

DIM - 2 $WSM \cdot g^{0.20}/Q^{0.40} = a \cdot S^{b}$

DIM - 3 $WSM \cdot g^{0.20}/Q^{0.40} = a \cdot (DG90 \cdot g^{0.20}/Q^{0.40})^{b}$

DIM - 4 $WSM \cdot g^{0.20}/Q^{0.40} = a \cdot (DG50 \cdot g^{0.20}/Q^{0.40})^{b}$

DIM - 5 $WSM \cdot g^{0.20}/Q^{0.40} = a \cdot (DG50 \cdot g^{0.20}/Q^{0.40})^{b} \cdot S^{c}$

DIM - 6 $AM \cdot g^{0.40}/Q^{0.80} = a$

DIM - 7 $AM \cdot g^{0.40}/Q^{0.80} = a \cdot S^{b}$

DIM - 8 $AM \cdot g^{0.40}/Q^{0.80} = a \cdot (DG90 \cdot g^{0.20}/Q^{0.40})^{b}$

DIM - 9 $AM \cdot g^{0.40}/Q^{0.80} = a \cdot (DG50 \cdot g^{0.20}/Q^{0.40})^{b}$

DIM - 10 $AM \cdot g^{0.40}/Q^{0.80} = a \cdot (DG50 \cdot g^{0.20}/Q^{0.40})^{b} \cdot S^{c}$

DIM - 11 $DM \cdot g^{0.20}/Q^{0.40} = a$

DIM - 12 $DM \cdot g^{0.20}/Q^{0.40} = a \cdot S$

DIM - 13 $DM \cdot g^{0.20}/Q^{0.40} = a \cdot (DG90 \cdot g^{0.20}/Q^{0.40})^{b}$

DIM - 14 $DM \cdot g^{0.20}/Q^{0.40} = a \cdot (DG50 \cdot g^{0.20}/Q^{0.40})^{b}$

DIM - 15 $DM \cdot g^{0.20}/Q^{0.40} = a \cdot (DG50 \cdot g^{0.20}/Q^{0.40})^{b} \cdot S^{c}$

DIM - 16 $S = a \cdot (DG90 \cdot g^{0.20}/Q^{0.40})^{b}$

DIM - 17 $S = a \cdot (DG50 \cdot g^{0.20}/Q^{0.40})^{b}$

DIM - 18 $S = a \cdot (DG50 \cdot g^{0.20}/Q^{0.40})^{b} \cdot FF^{c}$

DIM - 19 $S = a \cdot (DM/DG50)^{b}$

DIM - 20 $VM^{2}/(g \cdot DM) = a \cdot (DM/DG50)^{b}$

DIM - 21 $VM^{2}/(g \cdot DM) = a \cdot S^{b}$

DIM - 22 $VM^{2}/(g \cdot DM) = a \cdot (DM/DG50)^{b} \cdot S^{c}$

DIM - 23 $VM^{2}/(g \cdot DM \cdot S) = a \cdot (DM/DG50)^{b}$

DIM - 24 $VM^{2}/(g \cdot DM \cdot S) = a \cdot (DM/DG50)^{b} \cdot FF^{c}$

DIM - 25 $VM^{2}/(g \cdot DM \cdot S) = a \cdot (VM \cdot DM/\nu)^{b}$

DIM - 26 $VM^{2}/(g \cdot DM \cdot S) = a \cdot (VM \cdot DM/\nu)^{b} \cdot FF^{c}$

Stream power relations

SP - 1 $\gamma \cdot DM \cdot S \cdot VM = a \cdot DG90^{b}$

SP - 2 $\gamma \cdot DM \cdot S \cdot VM = a \cdot DG50^{b}$

Threshold relations

T - 1 $VM/VMCRIT = a$; Neill

where $VMCRIT = 1.41 \cdot (\gamma' / \rho)^{0.500} \cdot DG50^{0.333} DM^{0.167}$

T - 2 $VM/VMCRIT = a$; Galay

where $VMCRIT = 8.0 \cdot DG50^{0.333}$

T - 3 $\rho \cdot (g \cdot DM \cdot S)/(\gamma' \cdot DG50) = a$; Shields

K.3 Program Segments for Hydrologic and Miscellaneous Types of Analysis

Discharge estimation relations

QE - 1 $Q = a \cdot WSM@VF^{b}$

QE - 2 $Q = a \cdot DA^{b}$

QE - 3 $Q = a \cdot DA^{b} \cdot WSM@VF^{c}$

QE - 4 $Q = a \cdot DA^{b} \cdot WSM@VF^{c} \cdot S^{d}$

QE - 5 $Q = a \cdot DA^{b} \cdot WSM@VF^{c} \cdot DG50^{d}$

Discharge at low level bench or valley flat if no low level bench and if return period LE. 20 years

QBF - 1 $Q = a \cdot DA^{b} \cdot RP^{c}$

QBF - 2 $Q = a \cdot DA^{b} \cdot DUR^{c}$

Return period at bankfull relations

RP - 1 RP (at low level bench) = a

RP - 2 RP (at valley flat) = a if return period LE. 100 years

RP - 3 RP (at valley flat) = a if return period LE. 20 years

Percent duration at bankfull relations

DUR - 1 DUR (at low level bench) = a if percent duration GE. 0.1%

DUR - 2 DUR (at valley flat) = a if percent duration GE. 0.1%

Discharge-discharge relations

QQ - 1 $Q@0.5\%DUR = a \cdot Q@2YF^{b}$

QQ - 2 $Q@1\%DUR = a \cdot Q@2YF^{b}$

QQ - 3 $Q@5\%DUR = a \cdot Q@2YF^{b}$

QQ - 4 $Q@10\%DUR = a \cdot Q@2YF^{b}$

Width-width relations

WW - 1 $WSM@LTM = a \cdot WSM@2YF^{b}$

WW - 2 $WSM@1.5YF = a \cdot WSM@2YF^{b}$

WW - 3 $WSM@5YF = a \cdot WSM@2YF^{b}$

WW - 4 $WSM@10YF = a \cdot WSM@2YF^{b}$

WW - 5 $WSM@LLB = a \cdot WSM@2YF^{b}$

WW - 6 $WSM@VF = a \cdot WSM@2YF^{b}$

WW - 7 $WSM@VF = a \cdot WSM@2YF^{b}$; if return period LE. 20 years

Slope-slope relation

SS - 1 $S(field) = a \cdot [S(topographic)]^{b}$

K.4 <u>Program Segments for Regime Type Plotting</u>

Each plot may have a third parameter, Z, printed by each plotted position. This option is available for most plots but is not utilized since the plots are usually too cluttered when the Z values are plotted. Up to 13 symbols may be used on any one plot. Usually the selected symbols correspond to codes related to the terrain at the reach, or the relation of the channel to the valley bottom (RCVB).

Blench plots

B - 1 VM^2/DM versus DM/DG50
Z = DG50 Symbols = RCVB (relation of channel to valley bottom)

B - 2 VM^3/WSM versus DM/DG50
Z = RCVB Symbols = Alluvial bank type

B - 3 VM^3/WSM versus VM^2/DM
Z = RCVB Symbols = Alluvial bank type

B - 4 $VM^2/(g \cdot DM \cdot S)$ versus $VM \cdot WSM/\nu$
Z = None Symbols = RCVB

B - 5 $WSM^{0.167} \cdot S/(VM^2/DM)^{0.917}$ versus Q
Z = SCOR Symbols = RCVB

Henderson plot

H - 1 WSM versus $Q \cdot S^{1.167}/DG50^{1.50}$
Z = RCVB Symbols = Islands

Kellerhals plots

K - 1 $VM/(g \cdot DM \cdot S)^{0.500}$ versus DM/DG50
Z = DG50 Symbols = RCVB

K - 2 $\gamma \cdot DM \cdot S$ versus DG90
Z = DM/DG50 Symbols = RCVB

Depth-slope plots

DS - 1 $DM^{0.500} \cdot S$ versus DG50
Z = DM/DG50 Symbols = RCVB

DS - 2 $DM \cdot S$ versus DG50
Z = DM/DG50 Symbols = RCVB

Power plots

P - 1 $VM \cdot S$ versus DG50
Z = DM/DG50 Symbols = RCVB

P - 2 $\gamma \cdot DM \cdot S$ versus DG50
Z = DM/DG50 Symbols = RCVB

P - 3 $\gamma \cdot DM \cdot S \cdot VM$ versus DG50
Z = DM/DG50 Symbols = RCVB

P - 4 S versus DG50
Z = DM/DG50 Symbols = RCVB

P - 5 $Q \cdot S$ versus DG50
Z = DM/DG50 Symbols = RCVB

Manning "n" plots

n - 1 $n/DG90^{0.167}$ versus DM/DG50
Z = Form Factor Symbols = RCVB

n - 2 $n/DG50^{0.167}$ versus DM/DG50
Z = Form Factor Symbols = RCVB

n - 3 n versus DG90
Z = None Symbols = RCVB

n - 4 n versus DG50
Z = None Symbols = RCVB

Threshold plots

T - 1 $\rho \cdot VM^2/(\gamma' \cdot DG50)$ versus DM/DG50; Neill
Z = THRES Symbols = RCVB

T - 2 VM/VMCRIT versus DM/DG50; Galay
$VMCRIT = 8.0 \cdot DG50^{0.333}$
Z = None Symbols = RCVB

T - 3 $\rho \cdot (g \cdot DM \cdot S)/(\gamma' \cdot DG50)$ versus $(g \cdot DM \cdot S)^{0.500} \cdot DG50/\nu$; Shields
Z = None Symbols = RCVB

Discharge plots

Q - 1 WSM versus Q
Z = DG50 Symbols = RCVB

Q - 2 AM versus Q
Z = DG50 Symbols = RCVB

Q - 3 DM versus Q
Z = DG50 Symbols = RCVB

Q - 4 FF versus Q
Z = DG50 Symbols = RCVB

Q - 5 VM versus Q
Z = DG50 Symbols = RCVB

Q - 6 S versus Q
Z = DG50 Symbols = RCVB

Q - 7 Manning "n" versus Q
Z = DG50 Symbols = RCVB

Dimensionless plots

DIM - 1 $WSM \cdot g^{0.20}/Q^{0.40}$ versus S
Z = None Symbols = RCVB

DIM - 2 $AM \cdot g^{0.40}/Q^{0.80}$ versus S
Z = None Symbols = RCVB

DIM - 3 $DM \cdot g^{0.20}/Q^{0.40}$ versus S
Z = None Symbols = RCVB

DIM - 4 $WSM \cdot g^{0.20}/Q^{0.40}$ versus $DG50 \cdot g^{0.20}/Q^{0.40}$
Z = Slope Symbols = RCVB

DIM - 5 $AM \cdot g^{0.40}/Q^{0.80}$ versus $DG50 \cdot g^{0.20}/Q^{0.40}$
Z = Slope Symbols = RCVB

DIM - 6 $DM \cdot g^{0.20}/Q^{0.40}$ versus $DG50 \cdot g^{0.20}/Q^{0.40}$
Z = Slope Symbols = RCVB

DIM - 7 FF versus $DG50 \cdot g^{0.20}/Q^{0.40}$
Z = Slope Symbols = RCVB

DIM - 8 S versus $DG90 \cdot g^{0.20}/Q^{0.40}$
Z = Form Factor Symbols = RCVB

DIM - 9 S versus $DG50 \cdot g^{0.20}/Q^{0.40}$
Z = Form Factor Symbols = RCVB

DIM - 10 S versus DM/DG50
Z = Form Factor Symbols = RCVB

DIM - 11 $VM^2/(g \cdot DM)$ versus DM/DG50
Z = None Symbols = RCVB

DIM - 12 $VM^2/(g \cdot DM)$ versus S
Z = Form Factor Symbols = RCVB

DIM - 13 $VM^2/(g \cdot DM \cdot S)$ versus $VM \cdot DM/\nu$
Z = None Symbols = RCVB

K.5 Program Segments for Hydrologic and Miscellaneous Plots

Discharge-drainage area plots

QDA - 1 Q versus DA
Z = Bed material type Symbols = Terrain type

QDA - 2 Q@LLB versus DA
Z = Return period Symbols = Terrain type

QDA - 3 Q@VF versus DA
Z = Return period Symbols = Terrain type

QDA - 4 Q@LLB or VF if no LLB versus DA (RP@VF LE. 20 years)
Z = Return period Symbols = Terrain type

QDA - 5 Q@LLB or VF if no LLB versus DA (RP@VF LE. 20 years)
Z = % Duration Symbols = Terrain type

Discharge-bankfull plots

QBF - 1	Q@LLB versus RP Z = 10YF/2YF	Symbols = RCVB
QBF - 2	Q@LLB versus DUR Z = 1%FD/10%FD	Symbols = RCVB
QBF - 3	Q@VF versus RP Z = 10YF/2YF	Symbols = RCVB
QBF - 4	Q@VF versus DUR Z = 1%FD/10%FD	Symbols = RCVB

Discharge-discharge plots

QQ - 1	Q@1%FD versus Q@2YF Z = Reach No.	Symbols = Terrain type
QQ - 2	Q@5%FD versus Q@2YF Z = Reach No.	Symbols = Terrain type

Width-width plots

WW - 1	WSM@5YF versus WSM@2YF Z = None	Symbols = Terrain type
WW - 2	WSM@VF versus WSM@2YF Z = None	Symbols = Terrain type

Slope-slope plot

SS - 1	Slope (field) versus Slope (topographic) Z = None	Symbols = RCVB

APPENDIX L

TABLES CONTAINING DETAILED RESULTS OF ANALYSIS

This appendix contains 60 tables with the detailed results of many of the analyses related to this investigation. The tables have been incorporated into this appendix so that the text would not be too disjointed.

TABLE L.1

BASIC DATA FOR 25 GRAVEL RIVER REACHES FOR THE DATE OF HYDROPHONE MEASUREMENTS, AND FOR COMPUTED CONDITIONS AT A DISCHARGE CORRESPONDING TO THE 2 YEAR FLOOD

		Data obtained for date of hydrophone observations [1.]				Data based on average properties for reach for 2 year flood				
RCA #	Reach name	Q c.f.s.	Return Period Yrs.	Flow Duration %	Width of Movement %	Q 2 YF c.f.s.	VM / VMCRIT (Neill) [2.]	VM / VMCRIT (Galay) [3.]	Bed-load lb/ft/s (Blench) [4.]	Notes
9	Waipiti River near Grande Prairie	5,340	1.01	21	0	29,500	0.77	1.42	0.00	
10	Little Smoky River near Guy	253	1.00	> 50	0	24,000	0.86	1.61	0.00	
18	Wildhay River near Hinton	613	1.07	15	80	1,760	0.72	1.11	0.22	
20	McLeod River near Wolf Creek	1,780	1.01	20	40	10,800	0.77	1.32	0.00	
24	Pembina River near Entwistle	624	1.00	24	0	5,500	0.56	0.96	0.00	
36	North Saskatchewan River near Rocky Mountain House	14,000	1.06	8.2	45	24,400	1.02	1.78	0.51	
41	Clearwater River near Rocky Mountain House	1,850 1,230	1.11 1.03	11 21	0 0	4,400	0.79	1.32	0.04	
48	Red Deer River near Sundre	1,730 5,400	1.11 1.8	13 0.5	0 35	6,000	1.08	1.77	>0.46	5.
64	Bow River at Calgary	12,350	1.4	1.9	90	15,500	0.96	1.66	0.25	
71	Kananaskis River near Seebe	1,160	1.12	10.	70	2,850	0.96	1.56	>0.42	5.
74	Elbow River at Bragg Creek	800 1,200 3,290	1.10 1.3 4.2	8 4 < 0.5	1 20 50	1,860	1.03	1.62	0.14	6. 6. 7.
77	Highwood River at Diebel's Ranch	1,100 810	1.10 1.04	10 14	95 0	2,600	1.10	1.73	>0.39	5.
82	Sheep River at Buck Ranch	1,520 355	2.00 1.01	0.6 15	50 0	1,500				
84	Sheep River at Okotoks	1,620	1.6	2.8	65	2,300	1.10	1.66	0.16	

TABLE L.1 (cont'd.)

RCA #	Reach name	Data obtained for date of hydrophone observations [1]				Data based on average properties for reach for 2 year flood				
		Q c.f.s.	Return Period Yrs.	Flow Duration %	Width of Movement %	Q 2 YF c.f.s.	VM/VMCRIT (Neill) [2]	VM/VMCRIT (Galay) [3]	Bed-load lb/ft/s (Blench) [4]	Notes
85	Oldman River near Waldron's Corner	2,030	1.19	4.8	0	3,700	0.83	1.33	0.14	
87	Oldman River near Brocket	4,000 3,430 14,360	1.18 1.11 5.8	6.0 7.7 < 0.5	65 55 75	8,000	0.49	0.85	0.10	
89	Oldman River near Monarch	3,640	1.00	12	0	14,600	1.00	1.76	0.16	
90	Oldman River near Lethbridge	9,000	1.20	9.4	0	20,000	0.80	1.48	0.02	
92	Crowsnest River near Frank	399 720 986	1.01 1.18 1.6	11 4.5 1.7	0 0 75	1,150	0.63	0.98	0.02	
94	Castle River near Beaver Mines	1,260 4,200	1.01 1.6	13 1.1	0 70	4,900				9.
97	Willow Creek near Claresholm	1,780	3.5	< 0.5	0	1,050	0.71	1.11	0.00	
100	Belly River near Mountain View	910 572	1.10 1.01	8.8 15	0 30	1,650	0.62	0.98	0.24	
101	Belly River near Stand Off	154 381 565	1.00 1.00 1.00	39 22 16	0 0 0	2,400	0.74	1.16	0.05	
106	Drywood Creek near Twin Butte	37 83 49	1.00 1.04 1.00	16 7.0 13	0 0 0	195	0.47	0.65	0.05	
109	Lee Creek near Cardston	120 105	1.24 1.20	12 14	0 0	380	0.73	1.03	0.03	

1. Primary source of data for width of moving strip at channel base was obtained from hydrophone measurements made during the summers of 1968 and 1969 by the Water Resources Division, Alberta Department of the Environment.
2. VMCRIT was computed from initiation of motion criteria by Neill (1968). (See Section 5.2.3)
3. VMCRIT was computed from initiation of motion criteria by Galay (1971). (See Section 5.2.3)
4. Qb was estimated bed-load transport obtained by a Blench (1957) type transport equation. (See APPENDIX J for expressions used.)
5. Estimated transport was greater than upper limit accepted for Blench method; that is, a charge of 300 ppm.
6. Source Hollingshead (1968).
7. Source Samide (1971).
8. Reach properties considered to be questionable for this investigation.
9. Estimated bankfull discharge was 4000 cfs. with a return period of approximately 1.6 years.

TABLE L.2

ESTIMATION OF THRESHOLD CONDITIONS USING METHODS OF NEILL, GALAY, AND SHIELDS FOR GRAVEL RIVERS SATISFYING THE GRAVEL-1, AND GRAVEL-3 SCREENINGS AND FOR DISCHARGES CORRESPONDING TO THE 2 YEAR FLOOD AND THE VALLEY FLAT

Investigator	Screening	Q	a	95% confidence limits for a		c.v. of a	min. a	a_{50}	max. a	N
Neill (1968) VM/VMCRIT = a	Gravel-1	2 YF	0.742	0.690	0.793	0.285	0.266	0.732	1.258	67
	Gravel-3	2 YF	0.671	0.589	0.753	0.322	0.266	0.631	1.258	29
	Gravel-1	VF	0.957	0.842	1.072	0.370	0.432	0.870	1.937	39
	Gravel-3	VF	0.918	0.743	1.092	0.394	0.432	0.801	1.937	22
Galay (1971) VM/VMCRIT = a	Gravel-1	2 YF	1.24	1.14	1.33	0.309	0.428	1.262	1.978	67
	Gravel-3	2 YF	1.11	0.960	1.27	0.362	0.428	1.009	1.978	29
	Gravel-1	VF	1.76	1.52	1.98	0.403	0.767	1.625	3.76	39
	Gravel-3	VF	1.65	1.31	1.99	0.468	0.767	1.30	3.76	22
Shields (1935) (γ·DM·S)/(γ'·DG50) = a	Gravel-1	2 YF	0.039	0.032	0.045	0.684	0.009	0.033	0.143	67
	Gravel-3	2 YF	0.035	0.027	0.044	0.641	0.009	0.030	0.126	29
	Gravel-1	VF	0.055	0.046	0.064	0.510	0.013	0.049	0.142	39
	Gravel-3	VF	0.055	0.041	0.070	0.578	0.013	0.049	0.140	22

1. Critical velocity by Neill is: $VMCRIT = 1.41 \cdot (\gamma'/\rho)^{0.500} \cdot DG50^{0.333} \cdot DM^{0.167}$
2. Critical velocity by Galay is: $VMCRIT = 8.0 \cdot DG50^{0.333}$
3. Critical value of Shields parameter for fully developed turbulent flow (gravel range) is 0.056.

TABLE L.3

COEFFICIENTS, EXPONENTS, AND STATISTICAL PARAMETERS FOR THE WIDTH-DISCHARGE EQUATION FOR 12 CHARACTERISTIC DISCHARGES FOR GRAVEL RIVERS SATISFYING THE GRAVEL-1 SCREENING

Q	a	b	95% confidence limits for b		r^2	S.E.	F	N
LTM	4.84	0.520	0.491	0.548	0.949	0.093	1293	71
1.5 YF	2.92	0.514	0.489	0.539	0.960	0.079	1656	71
2 YF	2.38	0.527	0.501	0.552	0.962	0.076	1724	70
5 YF	1.82	0.536	0.508	0.565	0.959	0.076	1438	64
10 YF	1.57	0.542	0.503	0.581	0.945	0.092	788	48
0.5% FD	2.07	0.534	0.504	0.563	0.954	0.076	1315	65
1 % FD	2.25	0.532	0.502	0.562	0.951	0.080	1259	67
5 % FD	3.33	0.512	0.487	0.536	0.961	0.079	1722	71
10 % FD	4.10	0.501	0.475	0.526	0.957	0.086	1522	71
LLB	1.89	0.542	0.486	0.598	0.900	0.114	387	45
VF	2.78	0.478	0.432	0.524	0.920	0.114	446	41
VF LE. 20 YF.	2.40	0.503	0.438	0.561	0.928	0.096	256	22

1. The width-discharge equation is of the form: $WSM = a \cdot Q^b$

TABLE L.4

COEFFICIENTS, EXPONENTS, AND STATISTICAL PARAMETERS FOR THE AREA-DISCHARGE EQUATION FOR 12 CHARACTERISTIC DISCHARGES FOR GRAVEL RIVERS SATISFYING THE GRAVEL-1 SCREENING

Q	a	b	95% confidence limits for b		r^2	S.E.	F	N
LTM	1.78	0.799	0.754	0.843	0.950	0.142	1310	71
1.5 YF	0.808	0.841	0.807	0.874	0.973	0.106	2471	71
2 YF	0.632	0.860	0.826	0.894	0.974	0.102	2551	70
5 YF	0.451	0.881	0.840	0.923	0.966	0.112	1782	64
10 YF	0.381	0.891	0.835	0.948	0.956	0.134	1011	48
0.5% FD	0.534	0.871	0.832	0.910	0.970	0.100	2028	65
1 % FD	0.618	0.861	0.823	0.899	0.969	0.103	2016	67
5 % FD	0.992	0.827	0.790	0.864	0.967	0.119	2010	71
10 % FD	1.38	0.798	0.759	0.838	0.959	0.133	1618	71
LLB	0.677	0.844	0.772	0.916	0.929	0.147	562	45
VF	0.655	0.838	0.794	0.883	0.974	0.110	1452	41
VF LE. 20 YF	0.513	0.869	0.803	0.936	0.974	0.097	749	22

1. The area-discharge equation is of the form: $AM = a \cdot Q^b$

TABLE L.5

COEFFICIENTS, EXPONENTS, AND STATISTICAL PARAMETERS FOR THE DEPTH-DISCHARGE EQUATION FOR 12 CHARACTERISTIC DISCHARGES FOR GRAVEL RIVERS SATISFYING THE GRAVEL-1 SCREENING

Q	a	b	95% confidence limits for b		r^2	S.E.	F	N
LTM	0.368	0.279	0.246	0.312	0.805	0.106	284	71
1.5 YF	0.276	0.327	0.297	0.356	0.876	0.093	489	71
2 YF	0.266	0.333	0.302	0.364	0.871	0.094	458	70
5 YF	0.248	0.345	0.308	0.382	0.846	0.100	340	64
10 YF	0.243	0.349	0.304	0.394	0.841	0.107	244	48
0.5% FD	0.258	0.338	0.301	0.374	0.841	0.095	334	65
1 % FD	0.275	0.328	0.293	0.364	0.842	0.094	347	67
5 % FD	0.298	0.315	0.285	0.346	0.864	0.097	437	71
10 % FD	0.337	0.298	0.267	0.328	0.848	0.101	386	71
LLB	0.358	0.302	0.252	0.353	0.774	0.103	147	45
VF	0.236	0.361	0.309	0.413	0.835	0.129	197	41
VF LE. 20 YF	0.214	0.366	0.280	0.452	0.797	0.126	79	22

1. The depth-discharge equation is of the form: $DM = a \cdot Q^b$

TABLE L.6

COEFFICIENTS, EXPONENTS, AND STATISTICAL PARAMETERS FOR THE FORM FACTOR-DISCHARGE EQUATION FOR 12 CHARACTERISTIC DISCHARGES FOR GRAVEL RIVERS SATISFYING THE GRAVEL-1 SCREENING

Q	a	b	95% confidence limits for b		r^2	S.E.	F	N
LTM	13.2	0.240	0.196	0.284	0.635	0.141	120.2	71
1.5 YF	10.6	0.188	0.144	0.231	0.520	0.136	74.9	71
2 YF	8.95	0.194	0.148	0.239	0.515	0.137	72.3	70
5 YF	7.34	0.192	0.140	0.243	0.470	0.138	54.9	64
10 YF	6.43	0.193	0.131	0.256	0.458	0.148	37.8	48
0.5% FD	8.03	0.196	0.142	0.250	0.451	0.141	51.7	65
1 % FD	8.18	0.204	0.151	0.257	0.476	0.142	59.0	67
5 % FD	11.2	0.196	0.155	0.237	0.570	0.132	91.6	71
10 % FD	12.2	0.203	0.163	0.243	0.602	0.133	104	71
LLB	5.27	0.240	0.162	0.318	0.472	0.160	38.5	45
VF	11.8	0.117	0.030	0.204	0.159	0.216	7.4	41
VF LE. 20 YF	11.2	0.137	-0.001	0.275	0.177	0.202	4.3[2]	22

1. The form factor-discharge equation is of the form: $FF = WSM/DM = a \cdot Q^b$
2. Not significant at the 5% level

TABLE L.7

COEFFICIENTS, EXPONENTS, AND STATISTICAL PARAMETERS FOR THE VELOCITY-DISCHARGE EQUATION FOR 12 CHARACTERISTIC DISCHARGES FOR GRAVEL RIVERS SATISFYING THE GRAVEL-1 SCREENING

Q	a	b	95% confidence limits for b		r^2	S.E.	F	N
LTM	0.561	0.201	0.157	0.245	0.547	0.142	83.4	71
1.5 YF	1.24	0.159	0.126	0.193	0.563	0.106	88.8	71
2 YF	1.58	0.140	0.106	0.174	0.499	0.102	67.8	70
5 YF	2.21	0.119	0.077	0.160	0.344	0.112	32.4	64
10 YF	2.62	0.109	0.052	0.165	0.247	0.133	15.1	48
0.5% FD	1.87	0.129	0.090	0.168	0.414	0.100	44.5	65
1 % FD	1.62	0.139	0.101	0.178	0.448	0.103	52.6	67
5 % FD	1.01	0.173	0.136	0.210	0.561	0.119	88.2	71
10 % FD	0.722	0.202	0.162	0.241	0.600	0.133	103	71
LLB	1.48	0.156	0.084	0.228	0.308	0.147	19.1	45
VF	1.53	0.162	0.117	0.206	0.580	0.110	53.9	41
VF LE. 20 YF	1.95	0.131	0.064	0.197	0.457	0.097	16.8	22

1. The velocity-discharge equation is of the form: $VM = a \cdot Q^b$

TABLE L.8

COEFFICIENTS, EXPONENTS, AND STATISTICAL PARAMETERS FOR THE SLOPE-DISCHARGE EQUATION FOR 12 CHARACTERISTIC DISCHARGES FOR GRAVEL RIVERS SATISFYING THE GRAVEL-1 SCREENING

Q	a	b	95% confidence limits for b		r^2	S.E.	F	N
LTM	0.015	-0.307	-0.407	-0.208	0.355	0.321	37.9	71
1.5 YF	0.027	-0.319	-0.420	-0.217	0.363	0.319	39.4	71
2 YF	0.035	-0.342	-0.446	-0.237	0.385	0.315	42.6	70
5 YF	0.056	-0.375	-0.491	-0.259	0.404	0.310	42.1	64
10 YF	0.056	-0.371	-0.506	-0.235	0.396	0.322	30.2	48
0.5% FD	0.065	-0.405	-0.525	-0.286	0.421	0.310	45.7	65
1 % FD	0.048	-0.378	-0.495	-0.260	0.389	0.315	41.3	67
5 % FD	0.021	-0.300	-0.401	-0.199	0.337	0.326	35.1	71
10 % FD	0.016	-0.279	-0.378	-0.181	0.317	0.330	32.0	71
LLB	0.039	-0.355	-0.507	-0.203	0.341	0.311	22.2	45
VF	0.060	-0.373	-0.492	-0.253	0.505	0.296	39.8	41
VF LE. 20 YF	0.089	-0.412	-0.605	-0.220	0.499	0.282	19.9	22

1. The slope-discharge equation is of the form: $S = a \cdot Q^b$

TABLE L.9

COEFFICIENTS, EXPONENTS, AND STATISTICAL PARAMETERS FOR THE MANNING "n"-DISCHARGE EQUATION FOR 12 CHARACTERISTIC DISCHARGES FOR GRAVEL RIVERS SATISFYING THE GRAVEL-1 SCREENING

Q	a	b	95% confidence limits for b		r^2	S.E.	F	N
LTM	0.166	-0.169	-0.216	-0.122	0.428	0.151	51.6	71
1.5 YF	0.083	-0.101	-0.135	-0.067	0.335	0.108	34.7	71
2 YF	0.073	-0.089	-0.125	-0.053	0.262	0.109	24.1	70
5 YF	0.063	-0.076	-0.122	-0.031	0.152	0.122	11.1	64
10 YF	0.052	-0.061	-0.124	0.002	0.077	0.149	3.8 [2]	48
0.5% FD	0.082	-0.107	-0.152	-0.062	0.264	0.116	22.6	65
1 % FD	0.085	-0.109	-0.151	-0.067	0.290	0.113	26.6	67
5 % FD	0.095	-0.113	-0.150	-0.076	0.350	0.119	37.2	71
10 % FD	0.126	-0.143	-0.182	-0.104	0.440	0.130	54.1	71
LLB	0.101	-0.131	0.192	-0.071	0.310	0.124	19.3	45
VF	0.091	-0.107	-0.162	-0.053	0.290	0.135	15.9	41
VF LE. 20 YF	0.082	-0.093	-0.189	0.003	0.169	0.140	4.1 [2]	22

1. The Manning "n"-discharge equation is of the form:

$$n = 1.486 \cdot DM^{0.667} \cdot S^{0.500} / VM = a \cdot Q^{b}$$

2. Not significant at the 5% level.

TABLE L.10

COEFFICIENTS, EXPONENTS, AND STATISTICAL PARAMETERS FOR THE WIDTH-DISCHARGE EQUATION FOR THREE CHARACTERISTIC DISCHARGES AND SIX SCREENINGS

Q	Screening	a	b	95% confidence limits for b		r^2	S.E.	F	N
LTM	All	4.34	0.540	0.516	0.563	0.957	0.099	2072	95
LTM	Sand-1	3.13	0.585	0.531	0.639	0.970	0.103	525	18
LTM	Sand-2	3.29	0.570	0.521	0.620	0.988	0.074	688	10
LTM	Gravel-1	4.84	0.520	0.491	0.548	0.949	0.093	1293	71
LTM	Gravel-2	5.44	0.507	0.472	0.542	0.950	0.092	852	47
LTM	Gravel-3	5.04	0.521	0.466	0.577	0.929	0.094	369	30
2 YF	All	1.96	0.552	0.528	0.577	0.955	0.094	1950	93
2 YF	Sand-1	1.01	0.626	0.538	0.714	0.939	0.134	232	17
2 YF	Sand-2	0.671	0.656	0.553	0.760	0.970	0.110	225	9
2 YF	Gravel-1	2.38	0.527	0.501	0.552	0.962	0.076	1724	70
2 YF	Gravel-2	2.50	0.522	0.489	0.555	0.958	0.081	1007	46
2 YF	Gravel-3	2.13	0.544	0.493	0.596	0.946	0.082	469	29
VF	All	2.27	0.502	0.461	0.543	0.909	0.131	598	62
VF	Sand-1	1.56	0.549	0.442	0.657	0.888	0.172	118	17
VF	Sand-2	1.84	0.531	0.332	0.731	0.850	0.222	40	9
VF	Gravel-1	2.78	0.478	0.432	0.524	0.920	0.114	446	41
VF	Gravel-2	2.55	0.486	0.430	0.541	0.920	0.112	322	30
VF	Gravel-3	2.80	0.476	0.399	0.553	0.893	0.113	167	22

1. The width-discharge equation is of the form: $WSM = a \cdot Q^b$

TABLE L.11

COEFFICIENTS, EXPONENTS, AND STATISTICAL PARAMETERS FOR THE AREA-DISCHARGE EQUATION FOR THREE CHARACTERISTIC DISCHARGES AND SIX SCREENINGS

Q	Screening	a	b	95% confidence limits for b		r^2	S.E.	F	N
LTM	All	1.64	0.826	0.787	0.865	0.951	0.162	1792	95
LTM	Sand-1	1.39	0.876	0.806	0.945	0.978	0.132	718	18
LTM	Sand-2	1.44	0.881	0.773	0.989	0.978	0.159	355	10
LTM	Gravel-1	1.78	0.799	0.754	0.843	0.950	0.142	1310	71
LTM	Gravel-2	2.11	0.782	0.729	0.835	0.952	0.138	895	47
LTM	Gravel-3	2.70	0.742	0.659	0.826	0.922	0.140	363	30
2 YF	All	0.551	0.890	0.854	0.928	0.962	0.139	2286	93
2 YF	Sand-1	0.723	0.902	0.850	0.954	0.989	0.079	1372	17
2 YF	Sand-2	0.579	0.924	0.822	1.02	0.985	0.108	462	9
2 YF	Gravel-1	0.632	0.860	0.826	0.894	0.974	0.102	2551	70
2 YF	Gravel-2	0.767	0.844	0.803	0.886	0.975	0.101	1696	46
2 YF	Gravel-3	0.929	0.823	0.761	0.885	0.965	0.098	737	29
VF	All	0.786	0.838	0.787	0.890	0.947	0.163	1078	62
VF	Sand-1	1.63	0.808	0.728	0.888	0.969	0.128	462	17
VF	Sand-2	1.63	0.814	0.694	0.934	0.974	0.133	258	9
VF	Gravel-1	0.655	0.838	0.794	0.883	0.974	0.110	1452	41
VF	Gravel-2	0.651	0.844	0.786	0.902	0.969	0.118	882	30
VF	Gravel-3	0.812	0.820	0.744	0.895	0.962	0.111	510	22

1. The area-discharge equation is of the form: $AM = a \cdot Q^b$

TABLE L.12

COEFFICIENTS, EXPONENTS, AND STATISTICAL PARAMETERS FOR THE DEPTH-DISCHARGE EQUATION FOR THREE CHARACTERISTIC DISCHARGES AND SIX SCREENINGS

Q	Screening	a	b	95% confidence limits for b		r^2	S.E.	F	N
LTM	All	0.377	0.286	0.256	0.316	0.791	0.127	353	95
LTM	Sand-1	0.443	0.291	0.213	0.368	0.798	0.148	63.3	18
LTM	Sand-2	0.437	0.311	0.211	0.411	0.864	0.148	51.0	10
LTM	Gravel-1	0.368	0.279	0.246	0.312	0.805	0.106	284	71
LTM	Gravel-2	0.387	0.275	0.235	0.316	0.806	0.106	187	47
LTM	Gravel-3	0.535	0.221	0.158	0.284	0.651	0.106	52.1	30
2 YF	All	0.282	0.338	0.304	0.371	0.816	0.126	405	93
2 YF	Sand-1	0.717	0.276	0.204	0.349	0.815	0.110	66.1	17
2 YF	Sand-2	0.864	0.268	0.197	0.338	0.920	0.075	81.0	9
2 YF	Gravel-1	0.266	0.333	0.302	0.364	0.871	0.094	458	70
2 YF	Gravel-2	0.307	0.322	0.286	0.359	0.878	0.090	316	46
2 YF	Gravel-3	0.435	0.278	0.223	0.334	0.796	0.088	105	29
VF	All	0.346	0.337	0.287	0.386	0.756	0.158	186	62
VF	Sand-1	1.05	0.258	0.186	0.331	0.795	0.115	58.2	17
VF	Sand-2	0.885	0.283	0.173	0.393	0.841	0.122	37.0	9
VF	Gravel-1	0.236	0.361	0.309	0.413	0.835	0.129	197	41
VF	Gravel-2	0.255	0.358	0.294	0.422	0.825	0.129	132	30
VF	Gravel-3	0.290	0.344	0.244	0.444	0.721	0.146	51.7	22

1. The depth-discharge equation is of the form: $DM = a \cdot Q^b$

TABLE L.13

COEFFICIENTS, EXPONENTS, AND STATISTICAL PARAMETERS FOR THE FORM FACTOR-DISCHARGE EQUATION FOR THREE CHARACTERISTIC DISCHARGES AND SIX SCREENINGS

Q	Screening	a	b	95% confidence limits for b		r^2	S.E.	F	N
LTM	All	11.5	0.254	0.216	0.292	0.654	0.159	176.	95
LTM	Sand-1	7.06	0.294	0.180	0.408	0.651	0.218	29.8	18
LTM	Sand-2	7.53	0.259	0.143	0.375	0.767	0.172	26.3	10
LTM	Gravel-1	13.2	0.240	0.196	0.284	0.635	0.141	120.2	71
LTM	Gravel-2	14.0	0.232	0.177	0.286	0.620	0.142	73.5	47
LTM	Gravel-3	9.42	0.300	0.216	0.384	0.655	0.142	53.1	30
2 YF	All	6.93	0.215	0.169	0.260	0.488	0.172	86.7	93
2 YF	Sand-1	1.04	0.350	0.198	0.502	0.615	0.232	24.0	17
2 YF	Sand-2	0.777	0.388	0.244	0.533	0.852	0.155	40.2	9
2 YF	Gravel-1	8.95	0.194	0.148	0.239	0.515	0.137	72.3	70
2 YF	Gravel-2	8.15	0.200	0.144	0.256	0.538	0.138	51.3	46
2 YF	Gravel-3	4.90	0.266	0.178	0.354	0.590	0.138	38.8	29
VF	All	6.55	0.166	0.090	0.241	0.244	0.240	19.4	62
VF	Sand-1	1.48	0.291	0.126	0.455	0.485	0.263	14.1	17
VF	Sand-2	2.08	0.249	-0.050	0.547	0.356	0.332	3.9 [2]	9
VF	Gravel-1	11.8	0.117	0.030	0.204	0.159	0.216	7.4	41
VF	Gravel-2	9.97	0.128	0.024	0.232	0.184	0.212	6.3	30
VF	Gravel-3	9.67	0.132	-0.029	0.293	0.127	0.236	2.9 [2]	22

1. The form factor-discharge equation is of the form: $FF = WSM/DM = a \cdot Q^b$
2. Not significant at the 5% level

TABLE L.14

COEFFICIENTS, EXPONENTS, AND STATISTICAL PARAMETERS FOR THE VELOCITY-DISCHARGE EQUATION FOR THREE CHARACTERISTIC DISCHARGES AND SIX SCREENINGS

Q	Screening	a	b	95% confidence limits for b		r^2	S.E.	F	N
LTM	All	0.610	0.174	0.135	0.213	0.461	0.162	79.6	95
LTM	Sand-1	0.722	0.124	0.055	0.194	0.476	0.132	14.5	18
LTM	Sand-2	0.695	0.119	0.011	0.227	0.448	0.159	6.50	10
LTM	Gravel-1	0.561	0.201	0.157	0.245	0.547	0.142	83.4	71
LTM	Gravel-2	0.475	0.218	0.165	0.270	0.607	0.138	69.5	47
LTM	Gravel-3	0.371	0.258	0.174	0.341	0.589	0.140	40.1	30
2 YF	All	1.82	0.109	0.072	0.146	0.275	0.139	34.5	93
2 YF	Sand-1	1.38	0.098	0.046	0.150	0.517	0.079	16.0	17
2 YF	Sand-2	1.73	0.076	-0.025	0.178	0.311	0.104	3.17	9
2 YF	Gravel-1	1.58	0.140	0.106	0.174	0.499	0.102	67.8	70
2 YF	Gravel-2	1.30	0.156	0.114	0.197	0.567	0.101	57.6	46
2 YF	Gravel-3	1.08	0.178	0.115	0.239	0.558	0.098	34.0	29
VF	All	1.27	0.162	0.110	0.213	0.400	0.163	40.0	62
VF	Sand-1	0.612	0.192	0.112	0.272	0.636	0.128	26.2	17
VF	Sand-2	0.613	0.186	0.066	0.306	0.658	0.133	13.5	9
VF	Gravel-1	1.53	0.162	0.117	0.206	0.580	0.110	53.9	41
VF	Gravel-2	1.54	0.156	0.098	0.214	0.519	0.118	30.2	30
VF	Gravel-3	1.23	0.180	0.105	0.256	0.553	0.111	24.7	22

1. The velocity-discharge equation is of the form: $VM = a \cdot Q^b$

TABLE L.15

COEFFICIENT, EXPONENTS, AND STATISTICAL PARAMETERS FOR THE SLOPE-DISCHARGE EQUATION FOR THREE CHARACTERISTIC DISCHARGES AND SIX SCREENINGS

Q	Screening	a	b	95% confidence limits for b		r^2	S.E.	F	N
LTM	All	0.015	-0.371	-0.481	-0.262	0.328	0.458	45.5	95
LTM	Sand-1	0.0015	-0.265	-0.385	-0.145	0.579	0.229	22.0	18
LTM	Sand-2	0.0015	-0.288	-0.405	-0.172	0.803	0.172	32.5	10
LTM	Gravel-1	0.015	-0.307	-0.407	-0.208	0.355	0.321	37.9	71
LTM	Gravel-2	0.010	-0.272	-0.394	-0.151	0.312	0.318	20.4	47
LTM	Gravel-3	0.010	-0.269	-0.458	-0.080	0.233	0.318	8.51	30
2 YF	All	0.045	-0.420	-0.541	-0.299	0.345	0.454	47.9	93
2 YF	Sand-1	0.0038	-0.314	-0.471	-0.158	0.549	0.239	18.2	17
2 YF	Sand-2	0.0037	-0.329	-0.545	-0.113	0.650	0.230	13.0	9
2 YF	Gravel-1	0.035	-0.342	-0.446	-0.237	0.385	0.315	42.6	70
2 YF	Gravel-2	0.020	-0.292	-0.421	-0.162	0.319	0.318	20.6	46
2 YF	Gravel-3	0.020	-0.293	-0.495	-0.092	0.248	0.318	8.91	29
VF	All	0.020	-0.324	-0.475	-0.172	0.232	0.484	18.1	62
VF	Sand-1	0.0011	-0.164	-0.340	0.012	0.209	0.281	3.95	17
VF	Sand-2	0.0013	-0.206	-0.446	0.035	0.369	0.268	4.10	9
VF	Gravel-1	0.060	-0.373	-0.492	-0.253	0.505	0.296	39.8	41
VF	Gravel-2	0.030	-0.316	-0.459	-0.173	0.421	0.291	20.4	30
VF	Gravel-3	0.031	-0.319	-0.523	-0.115	0.347	0.299	10.6	22

1. The slope-discharge equation is of the form: $S = a \cdot Q^b$

TABLE L.16

COEFFICIENTS, EXPONENTS, AND STATISTICAL PARAMETERS FOR MANNING "n"-DISCHARGE EQUATION FOR THREE CHARACTERISTIC DISCHARGES AND SIX SCREENINGS

Q	Screening	a	b	95% confidence limits for b		r^2	S.E.	F	N
LTM	All	0.153	-0.169	-0.210	-0.127	0.413	0.174	62.5	95
LTM	Sand-1	0.047	-0.063	-0.144	0.017	0.148	0.153	2.8 [2]	18
LTM	Sand-2	0.048	-0.056	-0.184	0.072	0.113	0.188	1.0 [2]	10
LTM	Gravel-1	0.166	-0.169	-0.216	-0.122	0.428	0.151	51.7	71
LTM	Gravel-2	0.169	-0.170	-0.231	-0.110	0.421	0.157	32.7	47
LTM	Gravel-3	0.265	-0.245	-0.330	-0.160	0.555	0.143	34.9	30
2 YF	All	0.074	-0.094	-0.122	-0.066	0.334	0.104	45.6	93
2 YF	Sand-1	0.053	-0.070	-0.121	-0.020	0.368	0.078	8.8	17
2 YF	Sand-2	0.047	-0.062	-0.137	0.012	0.362	0.079	4.0 [2]	9
2 YF	Gravel-1	0.073	-0.089	-0.125	-0.053	0.262	0.109	24.1	70
2 YF	Gravel-2	0.074	-0.086	-0.133	-0.040	0.245	0.113	14.3	46
2 YF	Gravel-3	0.122	-0.138	-0.203	-0.073	0.416	0.102	19.2	29
VF	All	0.082	-0.099	-0.139	-0.058	0.285	0.129	23.9	62
VF	Sand-1	0.083	-0.102	-0.18	-0.024	0.340	0.125	7.7	17
VF	Sand-2	0.082	-0.100	-0.228	0.028	0.327	0.143	3.4 [2]	9
VF	Gravel-1	0.091	-0.107	-0.162	-0.053	0.290	0.135	15.9	41
VF	Gravel-2	0.067	-0.075	-0.149	-0.002	0.135	0.150	4.4	30
VF	Gravel-3	0.093	-0.111	-0.208	-0.013	0.218	0.143	5.6	22

1. The Manning's "n"-discharge equation is of the form: $n = 1.486 \cdot DM^{0.667} S^{0.500} / VM = a \cdot Q^{b}$
2. Not significant at the 5% level

TABLE L.17

EVALUATION OF LACEY TYPE EQUATIONS FOR GRAVEL RIVERS SATISFYING THE GRAVEL-1 SCREENING AND FOR A CHARACTERISTIC DISCHARGE CORRESPONDING TO THE 2 YEAR FLOOD

Equation	a	b	c	c.v. for a	S.E.	r^2	N	Note
$WSM = a \cdot Q^b$	2.67	0.500						2.
	3.03 (2.98)	0.500		0.182			70	3.
	2.38	0.527			0.076	0.962	70	4.
$VM = a \cdot DM^b \cdot S^c$	16.0	0.667	0.333					
	15.7 (16.1)	0.667	0.333	0.213			70	
	12.6	0.608	0.288		0.104	0.495	70	
$VM = a \cdot DM^b \cdot DG90^c$		0.500	0.250					5.
	3.36 (3.27)	0.500	0.250	0.311			67	
	3.86	0.255	0.084		0.129	0.210	67	
$VM = a \cdot DM^b \cdot DG50^c$	6.18	0.500	0.250					5.
	4.08 (3.86)	0.500	0.250	0.255			67	
	4.25	0.255	0.103		0.129	0.212	67	
$S = \frac{DG90^b/Q^c}{a}$		0.833	0.167					5.
	68.6 (49.0)	0.833	0.167	0.858			67	
	18.1	0.499	0.332		0.303	0.430	67	
$S = \frac{DG50^b/Q^c}{a}$	6.85	0.833	0.167					5.
	35.4 (26.9)	0.833	0.167	0.809			67	
	10.4	0.586	0.334		0.302	0.432	67	

1. These equations were not specifically developed for gravel rivers. See text for further explanation and qualification of equations used in this TABLE.
2. If neither the coefficient of variation (c.v.), nor the coefficient of determination (r^2) are filled in, the values of the coefficient, and the exponent(s) are those given by Lacey.
3. If the coefficient of variation (c.v.) is filled in, the exponent(s) was fixed at those given by Lacey and the coefficient was evaluated. The bracketed value under "a" in this case is the value of the median for "a".
4. If the standard error (S.E.) and the coefficient of determination (r^2) are filled in, the coefficient and the exponent(s) were evaluated by linear regression using a logarithmic transformation.
5. The original equations used a silt factor which was a constant times the square root of the median grain size in inches. In this analysis all grain sizes are in feet unless otherwise noted.

TABLE L.18

EVALUATION OF LACEY TYPE EQUATIONS FOR GRAVEL RIVERS SATISFYING THE GRAVEL-1 SCREENING AND FOR A CHARACTERISTIC DISCHARGE CORRESPONDING TO THE ELEVATION OF THE VALLEY FLAT

Equation	a	b	c	c.v. for a	S.E.	r^2	N	Note
$WSM = a \cdot Q^b$	2.67	0.500						2.
	2.32 (2.17)	0.500		0.250				3.
	2.78	0.478			0.114	0.920	41	4.
$VM = a \cdot DM^b \cdot S^c$	16.0	0.667	0.333					
	16.5 (16.0)	0.667	0.333	0.293			41	
	9.65	0.535	0.215		0.136	0.381	41	
$VM = a \cdot DM^b \cdot DG90^c$		0.500	0.250					5.
	3.62 (3.46)	0.500	0.250	0.361			39	
	4.67	0.269	0.114		0.141	0.271	39	
$VM = a \cdot DM^b \cdot DG50^c$	6.18	0.500	0.250					5.
	4.39 (4.15)	0.500	0.250	0.377			39	
	4.55	0.265	0.049		0.143	0.251	39	
$S = \frac{DG90^b/Q^c}{a}$		0.833	0.167					5.
	63.6 (45.1)	0.833	0.167	0.831			39	
	10.0	0.549	0.364		0.284	0.550	39	
$S = \frac{DG50^b/Q^c}{a}$	6.85	0.833	0.167					5.
	23.0 (24.9)	0.833	0.167	0.788			39	
	6.50	0.612	0.353		0.286	0.540	39	

1. These equations were not specifically developed for gravel rivers. See text for further explanation and qualification of equations used in this TABLE.
2. If neither the coefficient of variation (c.v.), nor the coefficient of determination (r^2) are filled in, the values of the coefficient, and the exponent(s) are those given by Lacey.
3. If the coefficient of variation (c.v.) is filled in, the exponent(s) was fixed at those given by Lacey and the coefficient was evaluated. The bracketed value under "a" in this case is the value of the median for "a".
4. If the standard error (S.E.) and the coefficient of determination (r^2) are filled in, the coefficient and the exponent(s) were evaluated by linear regression using a logarithmic transformation.
5. The original equations used a silt factor which was a constant times the square root of the median grain size in inches. In this analysis all grain sizes are in feet unless otherwise noted.

TABLE L.19

EVALUATION OF BLENCH TYPE EQUATIONS FOR GRAVEL RIVERS SATISFYING THE GRAVEL-1 SCREENING AND FOR A CHARACTERISTIC DISCHARGE CORRESPONDING TO THE 2 YEAR FLOOD [1].

Equation	a	b	c.v. for a	S.E.	r^2	N	Note
$VM^2/DM = a\cdot(DM/DG90)^b$		-0.500					2.
	24.8	-0.500	0.503			67	3.
	(22.9)						
	14.5	-0.374		0.262	0.170	67	4.
$VM^2/DM = a\cdot(DM/DG50)^b$	48.0	-0.500					
	36.4	-0.500	0.527			67	
	(33.2)						
	21.3	-0.384		0.260	0.184	67	
No movement: Cooper-Neill	21.6	-0.418		0.240	0.251	60	
No movement: Galay	53.2	-0.915		0.217	0.428	21	
$VM^2/DM = a\cdot(DG50)^b$	7.30	0.250					5.
	11.5	0.250	0.613			67	
	(9.73)						
	8.92	0.213		0.284	0.021	67	6.
No movement: Cooper-Neill	12.6	0.467		0.263	0.103	60	
No movement: Galay	10.8	0.590		0.272	0.098	21	6.
$VM^3/WSM = a$ Banks: gravel, or cobble overlain by silt for this equation	0.572		0.801			19	
	(0.399)						
$VM^3/WSM = a$ Banks: gravel, or cobble for this equation	1.10		0.737			44	
	(0.778)						
$VM^3/WSM = a\cdot(VM^2/DM)^b$ Banks: gravel, or cobble for this equation	0.125	2.00					
	0.017	2.00	0.795			44	
	(0.013)						
	0.066	1.25		0.137	0.858	44	
$VM^2/(g\cdot DM\cdot S) = a\cdot(VM\cdot WSM/\nu)^b$		0.250					7.
	1.18	0.250	0.489			70	
	(1.12)						
	0.0398	0.430		0.208	0.515	70	
No movement: Cooper-Neill	0.050	0.417		0.220	0.303	60	
No movement: Galay	0.270	0.308		0.229	0.181	21	6.
$VM^2/(g\cdot DM\cdot S)\cdot SCOR = a\cdot(VM\cdot WSM/\nu)^b$	3.63	0.250					
	1.99	0.250	0.516			70	
	(1.87)						
	0.110	0.403		0.219	0.457	70	

1. See text for further explanation and qualification of equations used in this TABLE.
2. If neither the coefficient of variation (c.v.), nor the coefficient of determination (r^2) are filled in, the values of the coefficient, and the exponent are those given by Blench.
3. If the coefficient of variation (c.v.) is filled in, the exponent was fixed as that given by Blench and the coefficient was evaluated. The bracketed value under "a" in this case is the value of the median for "a".
4. If the standard error (S.E.) and the coefficient of determination (r^2) are filled in, the coefficient and the exponent were evaluated by linear regression using a logarithmic transformation.
5. This expression is stated to be valid for DM/DG50 GT. about 500, for all rivers used in this analysis, DM/DG50 was LT. about 200.
6. Not significant at 5% level using the F-ratio.
7. This expression was developed for duned sand-bed channels.

TABLE L.20

EVALUATION OF BLENCH TYPE EQUATIONS FOR GRAVEL RIVERS SATISFYING THE GRAVEL-1 SCREENING AND FOR A CHARACTERISTIC DISCHARGE CORRESPONDING TO THE ELEVATION OF THE VALLEY FLAT[1].

Equation	a	b	c.v. for a	S.E.	r^2	N	Note
$VM^2/DM = a\cdot(DM/DG90)^b$		-0.500					2.
	38.8 (28.8)	-0.500	0.746			39	3.
	21.8	-0.382		0.281	0.229	39	4.
$VM^2/DM = a\cdot(DM/DG50)^b$	48.0	-0.500					
	57.3 (39.8)	-0.500	0.742			39	
	27.0	-0.361		0.195	0.195	39	
No movement: Cooper-Neill	42.7	-0.597		0.183	0.559	22	
No movement: Galay	113.	-1.12		0.015	0.998	4	
$VM^2/DM = a\cdot(DG50)^b$	7.30	0.250					5.
	13.7 (11.5)	0.250	0.749			39	
	10.5	0.242		0.317	0.020	39	6.
No movement: Cooper-Neill	20.5	0.753		0.240	0.241	22	
No movement: Galay	87.7	1.84		0.323	0.438	4	6.
$VM^3/WSM = a$ Banks: gravel or cobble overlain by silt for this equation	1.96 (0.930)		1.05			14	
$VM^3/WSM = a$ Banks: gravel or cobble for this equation	2.21 (1.39)		0.873			22	
$VM^3/WSM = a\cdot(VM^2/DM)^b$ Banks: gravel or cobble for this equation	0.125	2.00					
	0.024 (0.015)	2.00	0.901			22	
	0.130	1.12		0.226	0.591	22	
$VM^2/(g\cdot DM\cdot S) = a\cdot(VM\cdot WSM/\nu)^b$		0.250					7.
	1.45 (1.17)	0.250	0.673			41	
	0.0086	0.513		0.251	0.547	41	
No movement: Cooper-Neill	0.0068	0.520		0.242	0.428	22	
No movement: Galay	0.000	1.67		0.246	0.762	4	8.
$VM^2/(g\cdot DM\cdot S)\cdot SCOR = a\cdot(VM\cdot WSM/\nu)^b$	3.63	0.250					
	2.60 (2.11)	0.250	0.760			41	
	0.019	0.502		0.264	0.510	41	

1. See text for further explanation and qualification of equations used in this TABLE.
2. If neither the coefficient of variation (c.v.), nor the coefficient of determination (r^2) are filled in, the values of the coefficient, and the exponent are those given by Blench.
3. If the coefficient of variation (c.v.) is filled in, the exponent was fixed as that given by Blench and the coefficient was evaluated. The bracketed value under "a" in this case is the value of the median for "a".
4. If the standard error (S.E.) and the coefficient of determination (r^2) are filled in, the coefficient and the exponent were evaluated by linear regression using a logarithmic transformation.
5. This expression is stated to be valid for DM/DG50 GT. about 500, for all rivers used in this analysis, DM/DG50 was LT. about 200.
6. Not significant at 5% level using the F-ratio.
7. This expression was developed for duned sand-bed channels.
8. Log(a) = -10.769

TABLE L.21

EVALUATION OF HENDERSON TYPE EQUATIONS FOR GRAVEL RIVERS SATISFYING THE GRAVEL-1 SCREENING AND FOR A CHARACTERISTIC DISCHARGE CORRESPONDING TO THE 2 YEAR FLOOD[1].

Equation	a	b	c	d	c.v. for a	S.E.	r^2	N	Note
$WSM = a \cdot Q^b \cdot S^c / DG90^d$		1.00	1.167	1.50					2.
	21.2	1.00	1.167	1.50	1.24			67	3.
	(13.2)								
	2.08	0.520	-0.024	0.055		0.075	0.961	67	4.
$WSM = a \cdot Q^b \cdot S^c / DG50^d$	1.14	1.00	1.167	1.50					
	6.22	1.00	1.167	1.50	1.10			67	
	(4.00)								
	1.96	0.520	-0.025	0.055		0.076	0.961	67	
$DM = a \cdot (DG90/S)^b$		1.00							
	0.030	1.00			0.675			67	
	(0.025)								
	0.378	0.473				0.169	0.553	67	
$DM = a \cdot (DG50/S)^b$	0.091	1.00							
	0.064	1.00			0.684			67	
	(0.055)								
	0.501	0.492				0.165	0.576	67	
No movement: Cooper-Neill	0.351	0.563				0.162	0.616	60	
No movement: Galay	0.663	0.359				0.109	0.525	21	
$VM = a \cdot DM^b \cdot S^c$	32.0	0.500	0.333						
	20.2	0.500	0.333		0.231			70	
	(21.0)								
	12.6	0.608	0.288			0.104	0.495	70	
No movement: Cooper-Neill	11.2	0.593	0.270			0.106	0.495	60	
No movement: Galay	10.3	0.322	0.235			0.108	0.231	21	5.

1. See text for further explanation and qualification of equations used in this TABLE.
2. If neither the coefficient of variation (c.v.), nor the coefficient of determination (r^2) are filled in, the values of the coefficient, and the exponent(s) are those given by Henderson.
3. If the coefficient of variation (c.v.) is filled in, the exponent(s) was fixed as that given by Henderson and the coefficient was evaluated. The bracketed value under "a" in this case is the value of the median for "a".
4. If the standard error (S.E.) and the coefficient of determination (r^2) are filled in, the coefficient and the exponent(s) were evaluated by linear regression using a logarithmic transformation.
5. Not significant at the 5% level using the F-ratio.

TABLE L.22

EVALUATION OF HENDERSON TYPE EQUATIONS FOR GRAVEL RIVERS SATISFYING THE GRAVEL-1 SCREENING AND FOR A CHARACTERISTIC DISCHARGE CORRESPONDING TO THE ELEVATION OF THE VALLEY FLAT[1].

Equation	a	b	c	d	c.v. for a	S.E.	r^2	N	Note
$WSM = a \cdot Q^b \cdot S^c / DG90^d$		1.00	1.167	1.50					2.
	8.92	1.00	1.167	1.50	0.814			39	3.
	(7.49)								
	3.84	0.523	0.131	0.083		0.110	0.921	39	4.
$WSM = a \cdot Q^b \cdot S^c / DG50^d$	1.14	1.00	1.167	1.50					
	2.90	1.00	1.167	1.50	0.956			39	
	(2.07)								
	3.82	0.516	0.112	0.021		0.111	0.920	39	
$DM = a \cdot (DG90/S)^b$		1.00							
	0.043	1.00			0.542			39	
	(0.036)								
	0.275	0.621				0.187	0.642	39	
$DM = a \cdot (DG50/S)^b$	0.091	1.00							
	0.090	1.00			0.510			39	
	(0.080)								
	0.402	0.642				0.186	0.646	39	
No movement: Cooper-Neill	0.509	0.536				0.158	0.614	22	
No movement: Galay	1.23	0.267				0.272	0.212	4	5.
$VM = a \cdot DM^b \cdot S^c$	32.0	0.500	0.333						
	23.3	0.500	0.333		0.330			41	
	(22.2)								
	9.65	0.535	0.215			0.136	0.381	41	
No movement: Cooper-Neill	6.15	0.256	0.089			0.103	0.143	22	5.
No movement: Galay	1.99	-0.357	-0.217			0.055	0.835	4	5.

1. See text for further explanation and qualification of equations used in this TABLE.
2. If neither the coefficient of variation (c.v.), nor the coefficient of determination (r^2) are filled in, the values of the coefficient, and the exponent(s) are those given by Henderson.
3. If the coefficient of variation (c.v.) is filled in, the exponent(s) was fixed as that given by Henderson and the coefficient was evaluated. The bracketed value under "a" in this case is the value of the median for "a".
4. If the standard error (S.E.) and the coefficient of determination (r^2) are filled in, the coefficient and the exponent(s) were evaluated by linear regression using a logarithmic transformation.
5. Not significant at the 5% level using the F-ratio.

TABLE L.23

EVALUATION OF KELLERHALS TYPE EQUATIONS FOR GRAVEL RIVERS SATISFYING THE GRAVEL-1 SCREENING AND FOR A CHARACTERISTIC DISCHARGE CORRESPONDING TO THE 2 YEAR FLOOD[1].

Equation	a	b	c	c.v. for a	S.E.	r^2	N	Note
$WSM = a \cdot Q^b$	1.80	0.500						2.
	3.03	0.500		0.182			70	3.
	(2.98)							
	2.38	0.527			0.076	0.962	70	4.
$VM/(g \cdot DM \cdot S)^{0.500} = a \cdot (DM/DG90)^b$	6.50	0.250					42	
	5.33	0.250		0.255			67	
	(5.33)							
	5.02	0.261			0.117	0.365	67	
$VM/(g \cdot DM \cdot S)^{0.500} = a \cdot (DM/DG50)^b$		0.250						
	4.40	0.250		0.251			67	
	(4.40)							
	3.84	0.281			0.116	0.376	67	
No movement: Cooper-Neill	3.83	0.282			0.121	0.378	60	
No movement: Galay	5.54	0.096			0.125	0.024	21	5.
$\gamma \cdot DM \cdot S = a \cdot (DG90)^b$	1.25	0.800					42	
	1.48	0.800		0.616			67	
	(1.27)							
	0.909	0.485			0.244	0.167	67	
No movement: Cooper-Neill	0.975	0.566			0.235	0.231	60	
No movement: Galay	0.700	0.432			0.237	0.113	21	5.
$\gamma \cdot DM \cdot S = a \cdot (DG50)^b$	2.00	1.00					42	
	4.00	1.00		0.684			67	
	(3.43)							
	1.51	0.561			0.244	0.189	67	
No movement: Cooper-Neill	2.02	0.769			0.224	0.301	60	
No movement: Galay	1.51	0.695			0.228	0.178	21	5.
$DM = aQ^b DG90^c$	0.166	0.400	-0.120				42	
	0.266	0.331	-0.014		0.096	0.860	67	
$DM = aQ^b DG50^c$	0.256	0.331	-0.025		0.096	0.860	67	
$VM = aQ^b DG90^c$	3.34	0.100	0.120				42	
	1.67	0.141	0.080		0.104	0.490	67	
$VM = aQ^b DG50^c$	1.87	0.140	0.095		0.104	0.490	67	
$S = aQ^b DG90^c$	0.120	-0.400	0.920				42	
	0.055	-0.332	0.499		0.303	0.430	67	
$S = aQ^b DG50^c$	0.096	-0.334	0.586		0.302	0.432	67	

1. See text for further explanation and qualification of equations used in this TABLE. The total sample size used by Kellerhals was 42 of which 18 were from 10 different natural channels. Nineteen cases were from canal data and five cases were from laboratory data.
2. If neither the coefficient of variation (c.v.), nor the coefficient of determination (r^2) are filled in, the values of the coefficient, and the exponent(s) are those given by Kellerhals.
3. If the coefficient of variation (c.v.) is filled in, the exponent(s) was fixed as that given by Kellerhals and the coefficient was evaluated. The bracketed value under "a" in this case is the value of the median for "a".
4. If the standard error (S.E.) and the coefficient of determination (r^2) are filled in, the coefficient and the exponent(s) were evaluated by linear regression using a logarithmic transformation.
5. Not significant at the 5% level using the F-ratio.

TABLE L.24

EVALUATION OF KELLERHALS TYPE EQUATIONS FOR GRAVEL RIVERS SATISFYING THE GRAVEL-1 SCREENING AND FOR A CHARACTERISTIC DISCHARGE CORRESPONDING TO THE ELEVATION OF THE VALLEY FLAT[1].

Equation	a	b	c	c.v. for a	S.E.	r^2	N	Note
$WSM = a \cdot Q^b$	1.80	0.500					42	2.
	2.32	0.500		0.250				3.
	(2.17)							
	2.78	0.478			0.114	0.920	41	4.
$VM/(g \cdot DM \cdot S)^{0.500}$	6.50	0.250					42	
$= a \cdot (DM/DG90)^b$	5.39	0.250		0.305			41	
	(5.34)							
	5.30	0.239			0.148	0.297	39	
$VM/(g \cdot DM \cdot S)^{0.500}$		0.250						
$= a \cdot (DM/DG50)^b$	4.44	0.250		0.293			39	
	(4.45)							
	4.00	0.266			0.142	0.347	39	
No movement: Cooper-Neill	4.62	0.192			0.145	0.172	22	5.
No movement: Galay	16.5	-0.347			0.213	0.282	4	5.
$\gamma \cdot DM \cdot S = a \cdot (DG90)^b$	1.25	0.800					42	
	2.11	0.800		0.499			39	
	(1.77)							
	1.30	0.458			0.211	0.183	39	
No movement: Cooper-Neill	1.31	0.556			0.224	0.214	22	
No movement: Galay	0.371	-0.863			0.301	0.213	4	5.
$\gamma \cdot DM \cdot S = a \cdot (DG50)^b$	2.00	1.00					42	
	5.63	1.00		0.510			39	
	(5.00)							
	1.99	0.502			0.214	0.159	39	
No movement: Cooper-Neill	2.22	0.635			0.225	0.205	22	
No movement: Galay	0.049	-1.77			0.201	0.649	4	5.
$DM = a \cdot Q^b \cdot DG90^c$	0.166	0.400	-0.120				42	
	0.198	0.369	-0.090		0.130	0.830	39	
$DM = a \cdot Q^b \cdot DG50^c$	0.183	0.368	-0.102		0.129	0.830	39	
$VM = a \cdot Q^b \cdot DG90^c$	3.34	0.100	0.120				42	
	1.78	0.156	0.102		0.111	0.534	39	
$VM = a \cdot Q^b \cdot DG50^c$	1.76	0.156	0.055		0.113	0.531	39	
$S = a \cdot Q^b \cdot DG90^c$	0.120	-0.400	0.920				42	
	0.100	-0.364	0.549		0.284	0.555	39	
$S = a \cdot Q^b \cdot DG50^c$	0.153	-0.353	0.612		0.286	0.540	39	

1. See text for further explanation and qualification of equations used in this TABLE. The total sample size used by Kellerhals was 42 of which 18 were from 10 different natural channels. Nineteen cases were from canal data and five cases were from laboratory data.
2. If neither the coefficient of variation (c.v.), nor the coefficient of determination (r^2) are filled in, the values of the coefficient, and the exponent(s) are those given by Kellerhals.
3. If the coefficient of variation (c.v.) is filled in, the exponent(s) was fixed as that given by Kellerhals and the coefficient was evaluated. The bracketed value under "a" in this case is the value of the median for "a".
4. If the standard error (S.E.) and the coefficient of determination (r^2) are filled in, the coefficient and the exponent(s) were evaluated by linear regression using a logarithmic transformation.
5. Not significant at the 5% level using the F-ratio.

TABLE L.25

RELATIONS BETWEEN WIDTH AND DISCHARGE, BED MATERIAL SIZE, AND SLOPE FOR GRAVEL RIVERS SATISFYING THE GRAVEL-1 SCREENING AND FOR A CHARACTERISTIC DISCHARGE CORRESPONDING TO THE 2 YEAR FLOOD

Equation	a	b	c	d	r^2	S.E.	F
$WSM = a \cdot Q^b$	2.38	0.527			0.962	0.076	1724
$WSM = a \cdot Q^b \cdot S^c$	2.12	0.515	-0.035		0.963	0.076	866
$WSM = a \cdot Q^b \cdot DG90^c$	2.20	0.528	-0.067		0.963	0.075	807
$WSM = a \cdot Q^b \cdot DG50^c$	2.08	0.528	-0.070		0.963	0.075	801
$WSM = a \cdot Q^b \cdot DG90^c \cdot S^d$	2.06	0.520	-0.055	-0.024	0.963	0.075	535
$WSM = a \cdot Q^b \cdot DG50^c \cdot S^d$	1.96	0.520	-0.055	-0.025	0.963	0.076	531

1. The sample size for first two equations was 70 and sample size for other four equations was 67.
2. Correlation coefficients between the dependent variable and the individual independent variables based on the sample of 67 were:

   r(WSM-S) = -0.605; r(WSM-DG90) = -0.040; r(WSM-DG50) = -0.028

TABLE L.26

RELATIONS BETWEEN WIDTH AND DISCHARGE, BED MATERIAL, AND SLOPE FOR GRAVEL RIVERS SATISFYING THE GRAVEL-1 SCREENING AND FOR A CHARACTERISTIC DISCHARGE CORRESPONDING TO ELEVATION OF THE VALLEY FLAT

Equation	a	b	c	d	r^2	S.E.	F
$WSM = a \cdot Q^b$	2.78	0.478			0.920	0.114	446
$WSM = a \cdot Q^b \cdot S^c$	3.77	0.518	0.108		0.922	0.110	238
$WSM = a \cdot Q^b \cdot DG90^c$	3.57	0.475	-0.0114		0.910	0.114	188
$WSM = a \cdot Q^b \cdot DG50^c$	3.08	0.477	0.0476		0.910	0.114	189
$WSM = a \cdot Q^b \cdot DG90^c \cdot S^d$	3.85	0.523	-0.0834	0.131	0.920	0.110	137
$WSM = a \cdot Q^b \cdot DG50^c \cdot S^d$	3.81	0.516	-0.0212	0.112	0.920	0.111	134

1. The sample size for the first two equations was 41 and the sample size for the other equations was 39.
2. Correlation coefficients between the dependent variable and the individual independent variables based on the sample size of 39 were:

   r(WSM-S) = -0.592; r(WSM-DG90) = -0.061; r(WSM-DG50) = -0.105

TABLE L.27

RELATIONS BETWEEN AREA AND DISCHARGE, BED MATERIAL SIZE, AND SLOPE FOR GRAVEL RIVERS SATISFYING THE GRAVEL-1 SCREENING AND FOR A CHARACTERISTIC DISCHARGE CORRESPONDING TO THE 2 YEAR FLOOD

Equation	a	b	c	d	r^2	S.E.	F
$AM = a \cdot Q^b$	0.632	0.860			0.974	0.102	2551
$AM = a \cdot Q^b \cdot S^c$	0.290	0.780	-0.234		0.988	0.072	2622
$AM = a \cdot Q^b \cdot DG90^c$	0.585	0.859	-0.080		0.972	0.104	1118
$AM = a \cdot Q^b \cdot DG50^c$	0.534	0.859	-0.095		0.972	0.104	1119
$AM = a \cdot Q^b \cdot DG90^c \cdot S^d$	0.287	0.778	0.042	-0.246	0.986	0.073	1529
$AM = a \cdot Q^b \cdot DG50^c \cdot S^d$	0.300	0.777	0.050	-0.246	0.986	0.073	1530

1. The sample size for first two equations was 70 and sample size for the other four equations was 67.
2. Correlation coefficients between the dependent variable and the individual independent variables based on the sample size of 67 were:

r(AM-S) = -0.682; r(AM-DG90) = -0.030; r(AM-DG50) = -0.022

TABLE L.28

RELATIONS BETWEEN AREA AND DISCHARGE, BED MATERIAL SIZE, AND SLOPE FOR GRAVEL RIVERS SATISFYING THE GRAVEL-1 SCREENING AND FOR A CHARACTERISTIC DISCHARGE CORRESPONDING TO THE ELEVATION OF THE VALLEY FLAT

Equation	a	b	c	d	r^2	S.E.	F
$AM = a \cdot Q^b$	0.655	0.838			0.974	0.110	1452
$AM = a \cdot Q^b \cdot S$	0.385	0.768	-0.189		0.980	0.096	959
$AM = a \cdot Q^b \cdot DG90^c$	0.561	0.844	-0.101		0.971	0.111	630
$AM = a \cdot Q^b \cdot DG50^c$	0.567	0.844	-0.0546		0.971	0.113	610
$AM = a \cdot Q^b \cdot DG90^c \cdot S^d$	0.363	0.775	0.00297	-0.188	0.980	0.099	536
$AM = a \cdot Q^b \cdot DG50^c \cdot S^d$	0.386	0.772	0.0706	-0.205	0.980	0.098	546

1. The sample size for the first two equations was 41 and the sample size for the other equations was 39.
2. Correlation coefficients between the dependent variable and the individual independent variables based on the sample size of 39 were:

   r(AM-S) = -0.738; r(AM-DG90) = -0.089; r(AM-DG50) = -0.147

TABLE L.29

RELATIONS BETWEEN DEPTH AND DISCHARGE, BED MATERIAL SIZE AND SLOPE FOR GRAVEL RIVERS SATISFYING THE GRAVEL-1 SCREENING AND FOR A CHARACTERISTIC DISCHARGE CORRESPONDING TO THE 2 YEAR FLOOD

Equation	a	b	c	d	r^2	S.E.	F
$DM = a \cdot Q^b$	0.266	0.333			0.871	0.094	457
$DM = a \cdot Q^b \cdot S^c$	0.137	0.265	-0.199		0.928	0.070	432
$DM = a \cdot Q^b \cdot DG90^c$	0.266	0.331	-0.014		0.860	0.096	194
$DM = a \cdot Q^b \cdot DG50^c$	0.256	0.331	-0.025		0.860	0.096	195
$DM = a \cdot Q^b \cdot DG90^c \cdot S^d$	0.140	0.257	-0.097	-0.222	0.928	0.069	273
$DM = a \cdot Q^b \cdot DG50^c \cdot S^d$	0.153	0.257	-0.104	-0.221	0.928	0.069	269
$DM = a \cdot DG90^b \cdot S^c$	0.228	0.243	-0.516		0.607	0.160	49.4
$DM = a \cdot DG50^b \cdot S^c$	0.294	0.283	-0.516		0.607	0.160	49.4

1. The sample size for the first two equations was 70 and the sample size for the other equations was 67.
2. Correlation coefficients between the dependent variable and the individual independent variables based on the sample size of 67 were:

   r(DM-S) = -0.751; r(DM-DG90) = -0.014; r(DM-DG50) = -0.012

TABLE L.30

RELATIONS BETWEEN DEPTH AND DISCHARGE, BED MATERIAL SIZE, AND SLOPE FOR GRAVEL RIVERS SATISFYING THE GRAVEL-1 SCREENING AND FOR A DISCHARGE CORRESPONDING TO THE ELEVATION OF THE VALLEY FLAT

Equation	a	b	c	d	r^2	S.E.	F
$DM = a \cdot Q^b$	0.236	0.361			0.835	0.129	197
$DM = a \cdot Q^b \cdot S^c$	0.103	0.250	-0.296		0.910	0.096	195
$DM = a \cdot Q^b \cdot DG90^c$	0.198	0.369	-0.0897		0.831	0.130	89.4
$DM = a \cdot Q^b \cdot DG50^c$	0.184	0.368	-0.102		0.831	0.129	89.2
$DM = a \cdot Q^b \cdot DG90^c \cdot S^d$	0.0944	0.253	0.0864	-0.321	0.913	0.094	125
$DM = a \cdot Q^b \cdot DG50^c \cdot S^d$	0.101	0.255	0.0918	-0.317	0.913	0.094	124
$DM = a \cdot DG90^b \cdot S^c$	0.139	0.251	-0.667		0.722	0.167	46.9
$DM = a \cdot DG50^b \cdot S^c$	0.167	0.228	-0.660		0.710	0.170	44.3

1. The sample size for the first two equations was 41 and the sample size for the other equations was 39.
2. Correlation coefficients between the dependent variables and the individual independent variables based on the sample size of 39 were:

   r(DM-S) = -0.834; r(DM-DG90) = -0.114; r(DM-DG50) = -0.181

TABLE L.31

RELATIONS BETWEEN FORM FACTOR AND DISCHARGE, BED MATERIAL SIZE AND SLOPE FOR GRAVEL RIVERS SATISFYING THE GRAVEL-1 SCREENING AND FOR A CHARACTERISTIC DISCHARGE CORRESPONDING TO THE 2 YEAR FLOOD

Equation	a	b	c	d	r^2	S.E.	F
$FF = a \cdot Q^b$	8.95	0.194			0.515	0.137	72.
$FF = a \cdot DG90^b$	43.5	-0.053			0.004	0.195	0.2 [4.]
$FF = a \cdot DG50^b$	42.9	-0.039			0.002	0.196	0.1 [4.]
$FF = a \cdot Q^b \cdot S^c$	15.5	0.250	0.164		0.584	0.128	47.
$FF = a \cdot Q^b \cdot DG90^c$	8.30	0.197	-0.052		0.513	0.137	34.
$FF = a \cdot Q^b \cdot DG50^c$	8.10	0.197	-0.044		0.512	0.138	34.
$FF = a \cdot Q^b \cdot DG90^c \cdot S^d$	14.7	0.263	-0.152	0.198	0.606	0.124	32.
$FF = a \cdot Q^b \cdot DG50^c \cdot S^d$	12.8	0.263	-0.159	0.196	0.602	0.125	32.

1. The Form Factor (FF) is defined as: WSM/DM.
2. The sample size for the first and fourth equations was 70 and the sample size for the other equations was 67.
3. Correlation coefficients between the dependent variable and the individual independent variables based on the sample size of 67 were:

   r(FF-S) = -0.209; r(FF-DG90) = -0.061; r(FF-DG50) = -0.039
4. Not significant at the 5% level.

TABLE L.32

RELATIONS BETWEEN FORM FACTOR AND DISCHARGE, BED MATERIAL SIZE, AND SLOPE FOR GRAVEL RIVERS SATISFYING THE GRAVEL-1 SCREENING AND FOR A CHARACTERISTIC DISCHARGE CORRESPONDING TO THE ELEVATION OF THE VALLEY FLAT

Equation	a	b	c	d	r^2	S.E.	F
$FF = a \cdot Q^b$	11.8	0.117			0.003	0.216	7.39
$FF = a \cdot DG90^b$	38.4	0.0573			0.003	0.229	0.109 [4.]
$FF = a \cdot DG50^b$	42.6	0.0894			0.005	0.229	0.192
$FF = a \cdot Q^b \cdot S^c$	36.6	0.268	0.404		0.416	0.183	13.6
$FF = a \cdot Q^b \cdot DG90^c$	14.4	0.106	0.0783		0.126	0.218	2.61 [4.]
$FF = a \cdot Q^b \cdot DG50^c$	16.8	0.109	0.150		0.135	0.217	2.82 [4.]
$FF = a \cdot Q^b \cdot DG90^c \cdot S^d$	40.7	0.270	-0.170	0.452	0.429	0.178	8.76
$FF = a \cdot Q^b \cdot DG50^c \cdot S^d$	37.6	0.261	-0.113	0.430	0.414	0.181	8.25

1. The form factor, FF, is defined as: WSM/DM
2. The sample size for the first and fourth equations was 41 and the sample size for the other equation was 39.
3. Correlation coefficients between the dependent variables and the individual independent variables based on the sample size of 39 were:

   r(FF-S) = 0.073; r(FF-DG90) = 0.054; r(FF-DG50) = 0.072
4. Not significant at the 5% level.

TABLE L.33

RELATIONS BETWEEN VELOCITY AND DISCHARGE, BED MATERIAL SIZE AND SLOPE FOR GRAVEL RIVERS SATISFYING THE GRAVEL-1 SCREENING AND FOR A CHARACTERISTIC DISCHARGE CORRESPONDING TO THE 2 YEAR FLOOD

Equation	a	b	c	d	r^2	S.E.	F
$VM = a \cdot Q^b$	1.58	0.140			0.499	0.102	68
$VM = a \cdot Q^b \cdot S^c$	4.52	0.220	0.234		0.757	0.072	33
$VM = a \cdot Q^b \cdot DG90^c$	1.71	0.141	0.080		0.492	0.104	31
$VM = a \cdot Q^b \cdot DG50^c$	1.87	0.140	0.095		0.492	0.104	31
$VM = a \cdot Q^b \cdot DG90^c \cdot S^d$	3.48	0.222	-0.042	0.246	0.753	0.073	64
$VM = a \cdot Q^b \cdot DG50^c \cdot S^d$	3.34	0.223	-0.050	0.246	0.753	0.073	64
$VM = a \cdot DM^b \cdot S^c$	12.6	0.608	0.288		0.494	0.104	33
$VM = a \cdot DM^b \cdot DG90^c$	3.86	0.255	0.084		0.215	0.129	8.8
$VM = a \cdot DM^b \cdot DG50^c$	4.25	0.255	0.103		0.217	0.129	8.8
$VM = a \cdot DM^b \cdot DG90^c \cdot S^d$	13.3	0.623	-0.067	0.313	0.482	0.106	20
$VM = a \cdot DM^b \cdot DG50^c \cdot S^d$	12.5	0.621	-0.071	0.311	0.481	0.106	20

1. The sample size for the first, second and seventh equations was 70, the sample size for the other equations was 67.
2. Correlation coefficients between the dependent variable and the individual independent variables for equations based on the sample size of 67 were:
   r(VM-S) = 0.013; r(VM-DG90) = 0.124; r(VM-DG50) = 0.133

TABLE L.34

RELATIONS BETWEEN MEAN VELOCITY AND DISCHARGE, BED MATERIAL SIZE, AND SLOPE FOR GRAVEL RIVERS SATISFYING THE GRAVEL-1 SCREENING AND FOR A CHARACTERISTIC DISCHARGE CORRESPONDING TO THE ELEVATION OF THE VALLEY FLAT

Equation	a	b	c	d	r^2	S.E.	F
$VM = a \cdot Q^b$	1.53	0.162			0.580	0.110	53.9
$VM = a \cdot Q^b \cdot S^c$	2.60	0.232	0.189		0.687	0.096	41.9
$VM = a \cdot Q^b \cdot DG90^c$	1.78	0.156	0.102		0.545	0.111	21.6
$VM = a \cdot Q^b \cdot DG50^c$	1.76	0.156	0.0546		0.530	0.113	20.4
$VM = a \cdot Q^b \cdot DG90^c \cdot S^d$	2.76	0.225	-0.00298	0.190	0.650	0.099	21.9
$VM = a \cdot Q^b \cdot DG50^c \cdot S^d$	2.59	0.228	-0.0706	0.205	0.656	0.098	22.4
$VM = a \cdot DM^b \cdot S^c$	9.65	0.535	0.215		0.382	0.136	11.7
$VM = a \cdot DM^b \cdot DG90^c$	4.65	0.269	0.114		0.271	0.141	6.71
$VM = a \cdot DM^b \cdot DG50^c$	4.55	0.265	0.0494		0.251	0.143	6.06
$VM = a \cdot DM^b \cdot DG90^c \cdot S^d$	10.5	0.504	0.0170	0.218	0.350	0.135	6.29
$VM = a \cdot DM^b \cdot DG50^c \cdot S^d$	10.4	0.526	-0.069	0.245	0.355	0.134	6.42

1. The sample size for the first, second, and seventh equations was 41 and the sample size for the other equations was 39.
2. Correlation coefficients between the dependent variables and the individual independent variables based on the sample size of 39 were:

   r(VM-S) = -0.240; r(VM-DG90) = 0.094; r(VM-DG50) = -0.036

TABLE L.35

RELATIONS INVOLVING SLOPE AND DISCHARGE, BED MATERIAL SIZE, AND WIDTH FOR GRAVEL RIVERS SATISFYING THE GRAVEL-1 SCREENING AND FOR A CHARACTERISTIC DISCHARGE CORRESPONDING TO THE 2 YEAR FLOOD

Equation	a	b	c	d	r^2	S.E.	F	N
$S = a \cdot Q^b$	0.035	-0.342			0.385	0.315	42.6	70
$S = a \cdot DG90^b$	0.0034	0.500			0.080	0.382	5.6	67
$S = a \cdot DG50^b$	0.0057	0.577			0.080	0.382	5.6	67
$S = a \cdot Q^b \cdot DG90^c$	0.0555	-0.332	0.499		0.429	0.303	24.1	67
$S = a \cdot Q^b \cdot DG50^c$	0.0965	-0.334	0.586		0.432	0.302	24.3	67
$S = a \cdot Q^b \cdot DG90^c \cdot WSM^d$	0.0751	-0.129	0.473	-0.385	0.434	0.304	16.1	67
$S = a \cdot Q^b \cdot DG50^c \cdot WSM^d$	0.130	-0.119	0.558	-0.406	0.438	0.303	16.4	67
$S/SCOR = a \cdot Q^b \cdot DG50^c$	0.0457	-0.319	0.528		0.377	0.321	19.3	67
$S/SCOR = a \cdot Q^b \cdot DG90^c \cdot WSM^d$	0.0650	-0.063	0.494	-0.484	0.384	0.321	13.1	67

1. SCOR is a slope correction factor ranging from 1.25 to about 4.00.
2. Correlation coefficients for relations between S and individual independent variables for the sample of 67 are:

r(S-Q)	= -0.592	r(S/SCOR-Q)	= -0.558
r(S-DG90)	= 0.283	r(S/SCOR-DG50)	= 0.250
r(S-DG50)	= 0.282	r(S/SCOR-WSM)	= -0.574
r(S-WSM)	= -0.605		

TABLE L.36

RELATIONS INVOLVING SLOPE AND DISCHARGE, BED MATERIAL SIZE, AND WIDTH FOR GRAVEL RIVERS SATISFYING THE GRAVEL-3 SCREENING AND FOR A CHARACTERISTIC DISCHARGE CORRESPONDING TO THE 2 YEAR FLOOD

Equation	a	b	c	d	r^2	S.E.	F
$S = a \cdot Q^b$	0.020	-0.293			0.248	0.318	8.9
$S = a \cdot DG90^b$	0.0055	0.931			0.233	0.322	8.2
$S = a \cdot DG50^b$	0.0134	1.06			0.240	0.323	8.0
$S = a \cdot Q^b \cdot DG90^c$	0.027	-0.228	0.704		0.369	0.297	7.6
$S = a \cdot Q^b \cdot DG50^c$	0.054	-0.231	0.807		0.370	0.297	7.6
$S = a \cdot Q^b \cdot DG90^c \cdot WSM^d$	0.045	0.141	0.722	-0.674	0.391	0.298	5.4
$S = a \cdot Q^b \cdot DG50^c \cdot WSM^d$	0.098	0.162	0.839	-0.717	0.394	0.297	5.4
$S/SCOR = a \cdot Q^b \cdot DG50^c$	0.027	-0.223	0.748		0.289	0.337	5.3
$S/SCOR = a \cdot Q^b \cdot DG50^c \cdot WSM^d$	0.053	0.230	0.785	-0.828	0.320	0.336	3.9

1. The sample size for the above analysis was 29.
2. SCOR is a slope correction factor ranging from 1.25 to about 4.00.
3. Correlation coefficients for relations between S and individual independent variables are:

r(S-Q) = -0.498
r(S-DG90) = -0.483
r(S-DG50) = -0.478
r(S-WSM) = -0.514

r(S/SCOR-Q) = -0.446
r(S/SCOR-DG50) = 0.418
r(S/SCOR-WSM) = -0.468

TABLE L.37

RELATIONS INVOLVING SLOPE AND DISCHARGE, BED MATERIAL SIZE, AND WIDTH FOR GRAVEL RIVERS SATISFYING THE GRAVEL-1 SCREENING AND FOR A CHARACTERISTIC DISCHARGE CORRESPONDING TO THE ELEVATION OF THE VALLEY FLAT

Equation	a	b	c	d	r^2	S.E.	F	N
$S = a \cdot Q^b$	0.060	-0.373			0.505	0.296	39.8	41
$S = a \cdot DG90^b$	0.0034	0.622			0.105	0.395	4.4	39
$S = a \cdot DG50^b$	0.0076	0.807			0.128	0.390	5.4	39
$S = a \cdot Q^b \cdot DG90^c$	0.100	-0.364	0.549		0.550	0.284	22.1	39
$S = a \cdot Q^b \cdot DG50^c$	0.153	-0.353	0.612		0.540	0.286	21.3	39
$S = a \cdot Q^b \cdot DG90^c \cdot WSM^d$	0.0430	-0.746	0.558	0.805	0.596	0.272	17.4	39
$S = a \cdot Q^b \cdot DG50^c \cdot WSM^d$	0.0690	-0.691	0.578	0.709	0.576	0.278	16.0	39
$S/SCOR = a \cdot Q^b \cdot DG50^c$	0.073	-0.357	0.494		0.512	0.296	19.0	39
$S/SCOR = a \cdot Q^b \cdot DG50^c \cdot WSM^d$	0.069	-0.729	0.457	0.780	0.556	0.287	14.7	39

1. SCOR is a slope correction factor ranging from 1.25 to about 4.00.
2. Correlation coefficients for relations between S and individual independent variables for the sample of 39 are:

r(S-Q) = -0.684
r(S-DG90) = 0.324
r(S-DG50) = 0.358
r(S-WSM) = -0.592

r(S/SCOR-Q) = -0.683
r(S/SCOR-DG50) = 0.305
r(S/SCOR-WSM) = -0.586

TABLE L.38

EVALUATION OF MANNING "n" BY CONSIDERING ONE INDEPENDENT VARIABLE FOR GRAVEL RIVERS SATISFYING THE GRAVEL-1 SCREENING AND FOR A CHARACTERISTIC DISCHARGE CORRESPONDING TO THE 2 YEAR FLOOD

Equation	a	b	95% confidence limits for b		r^2	S.E.	F	N
$n = a \cdot Q^b$	0.073	-0.089	-0.125	-0.053	0.262	0.109	24.1	70
$n = a \cdot DG90^b$	0.041	0.160	0.026	0.294	0.081	0.122	5.7	67
$n = a \cdot DG50^b$	0.048	0.180	0.024	0.335	0.076	0.122	5.4	67
$n = a \cdot S^b$	0.107	0.183	0.120	0.245	0.335	0.104	34.2	70
$n = a \cdot (WSM/DM)^b$	0.105	-0.291	-0.431	-0.152	0.204	0.113	17.4	70

1. Manning "n" is defined by: $n = 1.486 \cdot DM^{0.667} \cdot S^{0.500} / VM$

TABLE L.39

EVALUATION OF MANNING "n" BY CONSIDERING ONE INDEPENDENT VARIABLE FOR GRAVEL RIVERS SATISFYING THE GRAVEL-1 SCREENING AND FOR A CHARACTERISTIC DISCHARGE CORRESPONDING TO THE ELEVATION OF THE VALLEY FLAT

Equation	a	b	95% confidence limits for b		r^2	S.E.	F	N
$n = a \cdot Q^b$	0.091	-0.107	-0.162	-0.053	0.290	0.135	15.9	41
$n = a \cdot DG90^b$	0.038	0.132	-0.099	0.362	0.035	0.150	1.3 [2.]	39
$n = a \cdot DG50^b$	0.051	0.231	-0.033	0.496	0.078	0.147	3.1 [2.]	39
$n = a \cdot S^b$	0.118	0.202	0.097	0.306	0.281	0.136	15.2	41
$n = a \cdot (WSM/DM)^b$	0.066	-0.198	-0.409	0.012	0.085	0.153	3.6 [2.]	41

1. Manning "n" is defined by: $n = 1.486 \cdot DM^{0.667} \cdot S^{0.500} / VM$
2. Not significant at the 5% level.

TABLE L.40

EVALUATION OF MANNING "n" BY CONSIDERING ONE INDEPENDENT VARIABLE FOR GRAVEL RIVERS SATISFYING THE GRAVEL-3 SCREENING AND FOR A CHARACTERISTIC DISCHARGE CORRESPONDING TO THE 2 YEAR FLOOD[1].

Equation	a	b	95% confidence limits for b		r^2	S.E.	F	N
$n = a \cdot Q^b$	0.112	-0.138	-0.203	-0.073	0.416	0.102	19.2	29
$n = a \cdot DG90^b$	0.059	0.415	0.193	0.638	0.352	0.108	14.6	29
$n = a \cdot DG50^b$	0.088	0.471	0.213	0.729	0.342	0.108	14.0	29
$n = a \cdot S^b$	0.158	0.232	0.121	0.342	0.406	0.103	18.4	29
$n = a \cdot (WSM/DM)^b$	0.119	-0.313	-0.524	-0.103	0.257	0.115	9.3	29

1. Manning "n" is defined by: $n = 1.486 \cdot DM^{0.667} \cdot S^{0.500} / VM$

TABLE L.41

EVALUATION OF MANNING "n" BY CONSIDERING MORE THAN ONE INDEPENDENT VARIABLE FOR GRAVEL RIVERS SATISFYING THE GRAVEL-1 SCREENING AND FOR A CHARACTERISTIC DISCHARGE CORRESPONDING TO THE 2 YEAR FLOOD

Equation	a	b	c	d	r^2	S.E.	F	N
$n = a \cdot Q^b \cdot S^c$	0.114	-0.043	0.134		0.372	0.101	19.9	70
$n = a \cdot Q^b \cdot DG90^c$	0.084	-0.086	0.160		0.312	0.106	14.5	67
$n = a \cdot Q^b \cdot DG50^c$	0.100	-0.086	0.182		0.309	0.106	14.3	67
$n = a \cdot Q^b \cdot DG90^c \cdot S^d$	0.115	-0.051	0.107	0.106	0.374	0.102	12.6	67
$n = a \cdot Q^b \cdot DG50^c \cdot S^d$	0.128	-0.051	0.119	0.107	0.373	0.102	12.5	67
$n = a \cdot DG90^b \cdot S^c$	0.104	0.078	0.164		0.326	0.105	15.4	67
$n = a \cdot DG50^b \cdot S^c$	0.112	0.084	0.165		0.324	0.105	15.3	67
$n = a \cdot DG90 \cdot FF^c$	0.115	0.146	-0.272		0.256	0.110	11.0	67
$n = a \cdot DG50^b \cdot FF^c$	0.136	0.169	-0.276		0.256	0.110	11.1	67
$n = a \cdot S^b \cdot FF^c$	0.208	0.158	-0.213		0.438	0.096	26.1	70
$n = a \cdot DG90^b \cdot FF^c \cdot S^d$	0.208	0.077	-0.217	0.142	0.433	0.097	16.0	67
$n = a \cdot DG50^b \cdot FF^c \cdot S^d$	0.227	0.089	-0.219	0.142	0.432	0.097	16.0	67

1. Manning "n" is defined by: $n = 1.486 \cdot DM^{0.667} \cdot S^{0.500} / VM$
2. FF is the average form factor defined by: WSM/DM
3. Correlation coefficients for relations between "n" and individual independent variables for the sample of 67 are:

r(n-Q) = -0.481
r(n-S) = 0.555
r(n-FF) = -0.436

r(n-DG90) = 0.284
r(n-DG50) = 0.275

TABLE L.42

EVALUATION OF MANNING "n" BY CONSIDERING MORE THAN ONE INDEPENDENT VARIABLE FOR GRAVEL RIVERS SATISFYING THE GRAVEL-1 SCREENING AND FOR A CHARACTERISTIC DISCHARGE CORRESPONDING TO THE ELEVATION OF THE VALLEY FLAT

Equation	a	b	c	d	r^2	S.E.	F	N
$n = a \cdot Q^b \cdot S^c$	0.125	-0.065	0.113		0.332	0.132	9.5	41
$n = a \cdot Q^b \cdot DG90^c$	0.091	-0.091	0.113		0.244	0.135	5.8	39
$n = a \cdot Q^b \cdot DG50^c$	0.106	-0.087	0.183		0.266	0.133	6.5	39
$n = a \cdot Q^b \cdot DG90^c \cdot S^d$	0.111	-0.056	0.061	0.096	0.274	0.134	4.4	39
$n = a \cdot Q^b \cdot DG50^c \cdot S^d$	0.124	-0.058	0.132	0.084	0.290	0.133	4.8	39
$n = a \cdot DG90^b \cdot S^c$	0.102	0.024	0.173		0.234	0.136	5.5	39
$n = a \cdot DG50^b \cdot S^c$	0.110	0.101	0.161		0.246	0.135	5.9	39
$n = a \cdot DG90^b \cdot FF^c$	0.067	0.140	-0.156		0.090	0.148	1.8[4.]	39
$n = a \cdot DG50^b \cdot FF^c$	0.093	0.246	-0.163		0.138	0.144	2.9[4.]	39
$n = a \cdot S^b \cdot FF^c$	0.282	0.158	-0.213		0.438	0.096	12.2	41
$n = a \cdot DG90^b \cdot FF^c \cdot S^d$	0.235	0.025	-0.202	0.190	0.325	0.129	5.6	39
$n = a \cdot DG50^b \cdot FF^c \cdot S^d$	0.258	0.106	-0.203	0.177	0.338	0.128	6.0	39

1. Manning "n" is defined by: $n = 1.486 \cdot DM^{0.667} \cdot S^{0.500} / VM$
2. FF is the average form factor defined by: WSM/DM
3. Correlation coefficients for relations between "n" and individual independent variables for the sample of 39 are:

   r(n-Q) = -0.467 r(n-DG90) = 0.187
   r(n-S) = 0.482 r(n-DG50) = 0.280
   r(n-FF) = -0.223

4. Not significant at the 5% level.

TABLE L.43

EVALUATION OF MANNING "n" BY CONSIDERING MORE THAN ONE INDEPENDENT VARIABLE FOR GRAVEL RIVERS SATISFYING THE GRAVEL-3 SCREENING AND FOR A CHARACTERISTIC DISCHARGE CORRESPONDING TO THE 2 YEAR FLOOD

Equation	a	b	c	d	r^2	S.E.	F
$n = a \cdot Q^b \cdot S^c$	0.202	-0.093	0.153		0.548	0.091	15.7
$n = a \cdot Q^b \cdot DG90^c$	0.127	-0.109	0.306		0.587	0.087	18.6
$n = a \cdot Q^b \cdot DG50^c$	0.173	-0.111	0.350		0.587	0.087	18.6
$n = a \cdot Q^b \cdot DG90^c \cdot S^d$	0.182	-0.087	0.238	0.098	0.635	0.084	14.5
$n = a \cdot Q^b \cdot DG50^c \cdot S^d$	0.230	-0.088	0.271	0.098	0.635	0.084	14.5
$n = a \cdot DG90^b \cdot S^c$	0.141	0.261	0.166		0.512	0.095	13.6
$n = a \cdot DG50^b \cdot S^c$	0.183	0.293	0.168		0.508	0.095	13.4
$n = a \cdot DG90^b \cdot FF^c$	0.146	0.364	-0.256		0.518	0.094	14.0
$n = a \cdot DG50^b \cdot FF^c$	0.216	0.420	-0.265		0.521	0.094	14.2
$n = a \cdot S^b \cdot FF^c$	0.332	0.203	-0.246		0.557	0.090	16.4
$n = a \cdot DG90^b \cdot FF^c \cdot S^d$	0.285	0.233	-0.228	0.147	0.642	0.083	14.9
$n = a \cdot DG50^b \cdot FF^c \cdot S^d$	0.366	0.270	-0.234	0.147	0.645	0.083	15.1

1. Manning "n" is defined by: $n = 1.486 \cdot DM^{0.667} S^{0.500} / VM$
2. FF is the form factor which is defined by: WSM/DM
3. Sample size is equal to 29
4. Correlation coefficient for relations between "n" and individual independent variables are:

r(n-Q) = -0.645   r(n-DG90) = 0.593
r(n-S) = 0.637   r(n-DG50) = 0.585
r(n-FF) = -0.506

TABLE L.44

VARIABILITY OF SEVERAL DIMENSIONLESS PARAMETERS FOR GRAVEL RIVERS SATISFYING THE GRAVEL-1 SCREENING AND FOR A CHARACTERISTIC DISCHARGE CORRESPONDING TO THE 2 YEAR FLOOD

Dimensionless parameter	a	95% confidence limits for a		c.v.	a_{min}	a_{50}	a_{max}	N
$WSM \cdot g^{0.20}/Q^{0.400} = a$	14.5	13.5	15.4	0.277	7.08	14.0	24.6	70
$AM \cdot g^{0.40}/Q^{0.80} = a$	4.35	4.08	4.62	0.260	2.68	4.10	7.60	70
$DM \cdot g^{0.20}/Q^{0.40} = a$	0.311	0.290	0.332	0.277	0.196	0.288	0.695	70
$FF = WSM/DM = a$	50.8	45.8	55.7	0.411	14.3	48.4	101.	70
$VM^2/(g \cdot DM) = a$	0.226	0.193	0.260	0.617	0.030	0.181	0.568	70
$VM^2/(g \cdot DM \cdot S) = a$	119.7	100.0	139.3	0.689	16.0	96.5	426.1	70

TABLE L.45

VARIABILITY OF SEVERAL DIMENSIONLESS PARAMETERS FOR GRAVEL RIVERS SATISFYING THE GRAVEL-1 SCREENING AND FOR A CHARACTERISTIC DISCHARGE CORRESPONDING TO THE ELEVATION OF THE VALLEY FLAT

Dimensionless parameter	a	95% confidence limits for a		c.v.	a_{min}	a_{50}	a_{max}	N
$WSM \cdot g^{0.20}/Q^{0.40} = a$	12.3	11.1	13.5	0.302	6.38	11.6	22.8	41
$AM \cdot g^{0.40}/Q^{0.80} = a$	3.94	3.60	4.28	0.270	2.29	3.63	7.12	41
$DM \cdot g^{0.20}/Q^{0.40} = a$	0.339	0.302	0.376	0.349	0.203	0.333	0.767	41
FF = WSM/DM = a	41.4	35.2	47.6	0.474	13.3	42.5	91.3	41
$VM^2/(g \cdot DM) = a$	0.269	0.210	0.328	0.695	0.050	0.231	0.838	41
$VM^2/(g \cdot DM \cdot S) = a$	180.7	125.8	235.6	0.963	12.8	126.3	1005.	41

TABLE L.46

COMPARISON OF VARIOUS DIMENSIONLESS RELATIONS INVOLVING WIDTH FOR GRAVEL RIVERS SATISFYING THE GRAVEL-1 SCREENING AND FOR A CHARACTERISTIC DISCHARGE CORRESPONDING TO THE 2 YEAR FLOOD

Equation	a	b	c	r^2	S.E.	F	N
$WSM \cdot g^{0.20}/Q^{0.40} = a \cdot S^b$	5.00	-0.164		0.304	0.100	29.6	70
$WSM \cdot g^{0.20}/Q^{0.40} = a \cdot (DG90 \cdot g^{0.20}/Q^{0.40})^b$	6.09	-0.222		0.462	0.087	55.7	67
$WSM \cdot g^{0.20}/Q^{0.40} = a \cdot (DG50 \cdot g^{0.20}/Q^{0.40})^b$	4.73	-0.241		0.484	0.085	61.1	67
$WSM \cdot g^{0.20}/Q^{0.40} = a \cdot (DG50 \cdot g^{0.20}/Q^{0.40})^b \cdot S^c$	4.20	-0.209	-0.042	0.493	0.085	31.5	67

TABLE L.47

COMPARISON OF VARIOUS DIMENSIONLESS RELATIONS INVOLVING WIDTH FOR GRAVEL RIVERS SATISFYING THE GRAVEL-1 SCREENING AND FOR A CHARACTERISTIC DISCHARGE CORRESPONDING TO THE ELEVATION OF THE VALLEY FLAT

Relation	a	b	c	r^2	S.E.	F	N
$WSM \cdot g^{0.20}/Q^{0.40} = a \cdot S^b$	0.426	-0.052		0.029	0.128	1.1 [1]	41
$WSM \cdot g^{0.20}/Q^{0.40} = a \cdot (DG90 \cdot g^{0.20}/Q^{0.40})^b$	6.91	-0.127		0.149	0.117	6.5	39
$WSM \cdot g^{0.20}/Q^{0.40} = a \cdot (DG50 \cdot g^{0.20}/Q^{0.40})^b$	6.43	-0.122		0.133	0.118	5.6	39
$WSM \cdot g^{0.20}/Q^{0.40} = a \cdot (DG50 \cdot g^{0.20}/Q^{0.40})^b \cdot S^c$	8.03	-0.196	0.093	0.176	0.117	3.8	39

1. Not significant at the 5% level.

TABLE L.48

COMPARISON OF VARIOUS DIMENSIONLESS RELATIONS INVOLVING AREA FOR GRAVEL RIVERS SATISFYING THE GRAVEL-1 SCREENING AND FOR A CHARACTERISTIC DISCHARGE CORRESPONDING TO THE 2 YEAR FLOOD

Relation	a	b	c	r^2	S.E.	F	N
$AM \cdot g^{0.40}/Q^{0.80} = a \cdot S^b$	1.13	-0.211		0.579	0.072	93.6	70
$AM \cdot g^{0.40}/Q^{0.80} = a \cdot (DG90 \cdot g^{0.20}/Q^{0.40})^b$	2.67	-0.122		0.153	0.104	11.8	67
$AM \cdot g^{0.40}/Q^{0.80} = a \cdot (DG50 \cdot g^{0.20}/Q^{0.40})^b$	2.33	-0.132		0.160	0.103	12.3	67
$AM \cdot g^{0.40}/Q^{0.80} = a \cdot (DG50 \cdot g^{0.20}/Q^{0.40})^b \cdot S^c$	1.16	0.054	-0.246	0.593	0.072	46.7	67

TABLE L.49

COMPARISON OF VARIOUS DIMENSIONLESS RELATIONS INVOLVING AREA FOR GRAVEL RIVERS SATISFYING THE GRAVEL-1 SCREENING AND FOR A CHARACTERISTIC DISCHARGE CORRESPONDING TO THE ELEVATION OF THE VALLEY FLAT

Relation	a	b	c	r^2	S.E.	F	N
$AM \cdot g^{0.40}/Q^{0.80} = a \cdot S^b$	1.50	-0.146		0.287	0.097	11.8	41
$AM \cdot g^{0.40}/Q^{0.80} = a \cdot (DG90 \cdot g^{0.20}/Q^{0.40})^b$	2.44	-0.107		0.125	0.110	5.3	39
$AM \cdot g^{0.40}/Q^{0.80} = a \cdot (DG50 \cdot g^{0.20}/Q^{0.40})^b$	2.40	-0.094		0.092	0.112	3.7[1]	39
$AM \cdot g^{0.40}/Q^{0.80} = a \cdot (DG50 \cdot g^{0.20}/Q^{0.40})^b \cdot S^c$	1.47	0.070	-0.205	0.340	0.097	9.3	39

1. Not significant at the 5% level.

TABLE L.50

COMPARISON OF VARIOUS DIMENSIONLESS RELATIONS INVOLVING DEPTH FOR GRAVEL RIVERS SATISFYING THE GRAVEL-1 SCREENING AND FOR A CHARACTERISTIC DISCHARGE CORRESPONDING TO THE 2 YEAR FLOOD

Relation	a	b	c	r^2	S.E.	F	N
$DM \cdot g^{0.20}/Q^{0.40} = a \cdot S^b$	0.226	-0.046		0.031	0.104	2.2 [1]	70
$DM \cdot g^{0.20}/Q^{0.40} = a \cdot (DG90 \cdot g^{0.20}/Q^{0.40})^b$	0.438	0.100		0.116	0.101	8.5	67
$DM \cdot g^{0.20}/Q^{0.40} = a \cdot (DG50 \cdot g^{0.20}/Q^{0.40})^b$	0.492	0.109		0.123	0.100	9.1	67
$DM \cdot g^{0.20}/Q^{0.40} = a \cdot (DG50 \cdot g^{0.20}/Q^{0.40})^b \cdot S^c$	0.278	0.263	-0.203	0.452	0.080	26.5	67

1. Not significant at the 5% level.

TABLE L.51

COMPARISON OF VARIOUS DIMENSIONLESS RELATIONS INVOLVING DEPTH FOR GRAVEL RIVERS SATISFYING THE GRAVEL-1 SCREENING AND FOR A CHARACTERISTIC DISCHARGE CORRESPONDING TO THE ELEVATION OF THE VALLEY FLAT

Relation	a	b	c	r^2	S.E.	F	N
$DM \cdot g^{0.20}/Q^{0.40} = a \cdot S^b$	0.178	-0.093		0.088	0.127	2.0 [1]	41
$DM \cdot g^{0.20}/Q^{0.40} = a \cdot (DG90 \cdot g^{0.20}/Q^{0.40})^b$	0.353	0.020		0.003	0.131	0.12 [1]	39
$DM \cdot g^{0.20}/Q^{0.40} = a \cdot (DG50 \cdot g^{0.20}/Q^{0.40})^b$	0.373	0.028		0.006	0.131	0.24 [1]	39
$DM \cdot g^{0.20}/Q^{0.40} = a \cdot (DG50 \cdot g^{0.20}/Q^{0.40})^b \cdot S^c$	0.183	0.267	-0.297	0.424	0.101	13.3	39

1. Not significant at the 5% level.

TABLE L.52

COMPARISON OF VARIOUS DIMENSIONLESS RELATIONS INVOLVING SLOPE FOR GRAVEL RIVERS SATISFYING THE GRAVEL-1 SCREENING AND FOR A CHARACTERISTIC DISCHARGE CORRESPONDING TO THE 2 YEAR FLOOD

Relation	a	b	c	r^2	S.E.	F	N
$S = a\cdot(DG90\cdot g^{0.20}/Q^{0.40})^b$	0.0273	0.702		0.408	0.306	44.8	67
$S = a\cdot(DG50\cdot g^{0.20}/Q^{0.40})^b$	0.0593	0.755		0.422	0.303	47.4	67
$S = a\cdot(DG50\cdot g^{0.20}/Q^{0.40})^b\cdot FF^c$	0.0147	0.971	0.617	0.478	0.290	29.4	67
$S = a\cdot(DM/DG50)^b$	0.0449	-0.945		0.582	0.257	90.5	67
$S = a\cdot(DG50\cdot g^{0.20}/Q^{0.40})^b\cdot(DM/DG50)^c$	0.0160	-0.895	-1.85	0.640	0.241	56.8	67

TABLE L.53

COMPARISON OF VARIOUS DIMENSIONLESS RELATIONS INVOLVING SLOPE FOR GRAVEL RIVERS SATISFYING THE GRAVEL-1 SCREENING AND FOR A CHARACTERISTIC DISCHARGE CORRESPONDING TO THE ELEVATION OF THE VALLEY FLAT

Relation	a	b	c	r^2	S.E.	F	N
$S = a\cdot(DG90\cdot g^{0.20}/Q^{0.40})^b$	0.0464	0.786		0.529	0.287	41.5	39
$S = a\cdot(DG50\cdot g^{0.20}/Q^{0.40})^b$	0.0922	0.804		0.532	0.286	42.1	39
$S = a\cdot(DG50\cdot g^{0.20}/Q^{0.40})^b\cdot FF^c$	0.0149	0.899	0.640	0.650	0.251	33.3	39
$S = a\cdot(DM/DG50)^b$	0.0525	-0.892		0.699	0.229	85.9	39
$S = a\cdot(DG50\cdot g^{0.20}/Q^{0.40})^b\cdot(DM/DG50)^c$	0.0229	-0.571	-1.41	0.729	0.220	48.4	39

TABLE L.54

COMPARISON OF VARIOUS DIMENSIONLESS RELATIONS INVOLVING THE FROUDE NUMBER FOR GRAVEL RIVERS SATISFYING THE GRAVEL-1 SCREENING AND FOR A CHARACTERISTIC DISCHARGE CORRESPONDING TO THE 2 YEAR FLOOD

Relation	a	b	c	r^2	S.E.	F	N
$VM^2/(g \cdot DM) = a \cdot (DM/DG50)^b$	0.663	-0.384		0.184	0.260	14.6	67
$VM^2/(g \cdot DM) = a \cdot S^b$	2.49	0.469		0.447	0.209	55.0	70
$VM^2/(g \cdot DM) = a \cdot (DM/DG50)^b \cdot S^c$	4.27	0.184	0.600	0.473	0.210	28.7	67
$VM^2/(g \cdot DM) = a \cdot (DM/DG50)^b \cdot (WSM/DM)^c$	0.0890	-0.537	0.652	0.354	0.233	17.5	67

TABLE L.55

COMPARISON OF VARIOUS DIMENSIONLESS RELATIONS INVOLVING THE FROUDE NUMBER FOR GRAVEL RIVERS SATISFYING THE GRAVEL-1 SCREENING AND FOR A CHARACTERISTIC DISCHARGE CORRESPONDING TO THE ELEVATION OF THE VALLEY FLAT

Relation	a	b	c	r^2	S.E.	F	N
$VM^2/(g \cdot DM) = a \cdot (DM/DG50)^b$	0.838	-0.361		0.195	0.287	8.9	39
$VM^2/(g \cdot DM) = a \cdot S^b$	2.51	0.385		0.268	0.268	14.2	41
$VM^2/(g \cdot DM) = a \cdot (DM/DG50)^b \cdot S^c$	3.78	0.095	0.511	0.339	0.265	8.8	39
$VM^2/(g \cdot DM) = a \cdot (DM/DG50)^b \cdot (WSM/DM)^c$	0.121	-0.342	0.520	0.334	0.264	9.05	39

TABLE L.56

COMPARISON OF VARIOUS DIMENSIONLESS RELATIONS INVOLVING THE PARAMETER $VM^2/(g\cdot DM\cdot S)$ FOR GRAVEL RIVERS SATISFYING THE GRAVEL-1 SCREENING AND FOR A CHARACTERISTIC DISCHARGE CORRESPONDING TO THE 2 YEAR FLOOD

Relation	a	b	c	r^2	S.E.	F	N
$VM^2/(g\cdot DM\cdot S) = a\cdot(DM/DG50)^b$	14.8	0.562		0.376	0.233	39.1	67
$VM^2/(g\cdot DM\cdot S) = a\cdot(DM/DG50)^b\cdot(WSM/DM)^c$	3.36	0.454	0.480	0.463	0.217	27.6	67
$VM^2/(g\cdot DM\cdot S) = a\cdot(VM\cdot WSM/\nu)^b$	0.0398	0.430		0.516	0.208	72.5	70
$VM^2/(g\cdot DM\cdot S) = a\cdot(VM\cdot WSM/\nu)^b\cdot(WSM/DM)^c$	0.0218	0.526	-0.297	0.530	0.208	37.8	70
$VM^2/(g\cdot DM\cdot S) = a\cdot(VM\cdot DM/\nu)^b$	0.0194	0.597		0.514	0.209	71.8	70
$VM^2/(g\cdot DM\cdot S) = a\cdot(VM\cdot DM/\nu)^b\cdot(DM/DG50)^c$	0.0825	0.444	0.214	0.506	0.208	32.8	67
$VM^2/(g\cdot DM\cdot S) = a\cdot(VM\cdot DM/\nu)^b\cdot(WSM/DM)^c$	0.0218	0.526	0.229	0.530	0.207	37.8	70

1. The third equation is the form of the King equation.

TABLE L.57

COMPARISON OF VARIOUS DIMENSIONLESS RELATIONS INVOLVING THE PARAMETER $VM^2/(g \cdot DM \cdot S)$ FOR GRAVEL RIVERS SATISFYING THE GRAVEL-1 SCREENING AND FOR A CHARACTERISTIC DISCHARGE CORRESPONDING TO THE ELEVATION OF THE VALLEY FLAT

Relation	a	b	c	r^2	S.E.	F	N
$VM^2/(g \cdot DM \cdot S) = a \cdot (DM/DG50)^b$	16.0	0.531		0.347	0.285	19.7	39
$VM^2/(g \cdot DM \cdot S) = a \cdot (DM/DG50)^b \cdot (WSM/DM)^c$	4.52	0.543	0.338	0.395	0.278	11.8	39
$VM^2/(g \cdot DM \cdot S) = a \cdot (VM \cdot WSM/\nu)^b$	0.00860	0.513		0.588	0.251	47.1	41
$VM^2/(g \cdot DM \cdot S) = a \cdot (VM \cdot WSM/\nu)^b \cdot (WSM/DM)^c$	0.00566	0.607	-0.376	0.587	0.243	26.9	41
$VM^2/(g \cdot DM \cdot S) = a \cdot (VM \cdot DM/\nu)^b$	0.00982	0.626		0.565	0.246	50.7	41
$VM^2/(g \cdot DM \cdot S) = a \cdot (VM \cdot DM/\nu)^b \cdot (DM/DG50)^c$	0.0138	0.611	-0.033	0.514	0.249	19.1	39
$VM^2/(g \cdot DM \cdot S) = a \cdot (VM \cdot DM/\nu)^b \cdot (WSM/DM)^c$	0.00566	0.607	0.231	0.586	0.243	26.9	41

1. The third equation is the form of the King equation.

TABLE L.58

COEFFICIENTS OF DETERMINATION AND STANDARD ERRORS OF ESTIMATE FOR BASIC EQUATIONS USED FOR DEVELOPMENT OF REGIME EQUATIONS FOR GRAVEL RIVERS

Type	Basic Equations	r^2	S.E.	N
Best Fit	$WSM = 2.08 \cdot Q^{0.528} \cdot DG50^{-0.070}$	0.963	0.075	67
	$DM = 0.266 \cdot Q^{0.333}$	0.871	0.094	70
	$VM = 1.58 \cdot Q^{0.140}$	0.499	0.102	70
	$S = 0.0965 \cdot Q^{-0.334} \cdot DG50^{0.586}$	0.432	0.302	67
Lacey	$WSM = 2.38 \cdot Q^{0.527}$	0.962	0.076	70
	$VM = 12.6 \cdot DM^{0.608} S^{0.288}$	0.495	0.104	70
	$VM = 4.25 \cdot DM^{\text{[illegible]}255} DG50^{0.103}$	0.212	0.129	67
Blench	$VM^2/DM = 21.6 \cdot (DM/DG50)^{-0.418}$	0.251	0.240	60
	$VM^3/WSM = 0.594$ (median); Mean = 0.930; c.v. = 0.811. for All Gravel-1 Reaches			70
	$VM^3/WSM = 0.399$ (median); Mean = 0.572; c.v. = 0.801 for reaches with silt banks			19
	$VM^3/WSM = 0.778$ (median); Mean = 1.10; c.v. = 0.737 for reaches with gravel or cobble banks			44
	$VM^2/(g \cdot DM \cdot S) = 0.0398 \cdot (VM \cdot WSM/\nu)^{0.430}$	0.515	0.208	70

Type	Basic Equations	r^2	S.E.	N
Modified Blench	$VM^2/DM = 21.6 \cdot (DM/DG50)^{-0.418}$	0.251	0.240	60
	$VM^3/WSM = 0.066 \cdot (VM^2/DM)^{1.25}$	0.858	0.137	44
	$VM^2/(g \cdot DM \cdot S) = 0.0398 \cdot (VM \cdot WSM/\ )^{0.430}$	0.515	0.208	70
Kellerhals	$WSM = 2.38 \cdot Q^{0.527}$	0.962	0.076	70
	$\gamma \cdot DM \cdot S = 2.02 \cdot DG50^{0.769}$	0.301	0.224	60
	$VM/(g \cdot DM \cdot S)^{0.500} = 3.84 \cdot (DM/DG50)^{0.281}$	0.376	0.116	67
Dimensionless	$WSM \cdot g^{0.20}/Q^{0.40} = 4.73 \cdot (DG50 \cdot g^{0.20}/Q^{0.40})^{-0.241}$	0.484	0.085	67
	$S = 0.0449 \cdot (DM/DG50)^{-0.945}$	0.582	0.257	67
	$VM^2/(g \cdot DM) = 2.49 \cdot S^{0.469}$	0.447	0.210	70

NOTES:

1. All data for reaches satisfying the Gravel-1 screening and for a characteristic discharge corresponding to the 2 year flood.
2. Equations based on a sample size of 60 had reaches with highly mobile beds rejected using the Cooper-Neill criterion.

TABLE L.59

RATIOS OF MEAN WIDTH AND MEAN DEPTH AS ESTIMATED FROM VARIOUS REGIME EQUATIONS TO THOSE ESTIMATED FROM THE BEST FIT RELATIONS USING THE GRAVEL-1 REACHES AND THE 2 YEAR FLOOD.

Relation used	Mean width, ft. DG50 = 0.164 ft (50 mm)			Mean depth, ft. DG50 = 0.164 ft (50 mm)		
	Q = 1,000 cfs	Q = 10,000 cfs	Q = 100,000 cfs	Q = 1000 cfs	Q = 10,000 cfs	Q = 100,000 cfs
Best fit	90.0	304	1020	2.66	5.71	12.3
Threshold	0.93	0.88	0.83	0.71	0.87	1.09
Lacey	1.00	1.00	1.00	1.02	1.04	1.15
Blench (all)	1.19	0.90	0.67	0.85	1.13	1.52
Blench (silt banks)	1.52	1.14	0.85	0.70	0.94	1.27
Blench (gravel and cobble banks)	1.02	0.76	0.57	0.98	1.30	1.76
Modified Blench (gravel and cobble banks)	1.05	1.04	1.02	0.94	1.04	1.13
Kellerhals	1.00	1.00	1.00	1.02	1.13	1.22
Dimensionless	1.05	0.97	0.92	1.03	1.14	1.28

1. Equations used for computing values in this table are given in Table 5.5.
2. All tabulated values below the best fit value are ratio of indicated relations to best fit.

TABLE L.60

RATIOS OF MEAN VELOCITY AND SLOPE AS ESTIMATED FROM VARIOUS REGIME EQUATIONS TO THOSE ESTIMATED FROM THE BEST FIT RELATIONS USING GRAVEL-1 REACHES AND THE 2 YEAR FLOOD.

Relation used	Mean velocity, ft/sec DG50 = 0.164 ft (50 mm)			Slope, ft/ft DG50 = 0.164 ft (50 mm)		
	Q = 1,000 cfs	Q = 10,000 cfs	Q = 100,000 cfs	Q = 1,000 cfs	Q = 10,000 cfs	Q = 100,000 cfs
Best fit	4.15	5.75	7.92	0.00334	0.00154	0.000710
Threshold	1.51	1.29	1.10	1.47	1.18	0.94
Lacey	1.07	0.97	0.90	1.17	0.86	0.65
Blench (all)	0.97	0.95	0.94	1.03	0.84	0.66
Blench (silt banks)	0.92	0.90	0.89	1.05	0.85	0.67
Blench (gravel and cobble banks)	1.01	0.98	0.97	1.04	0.85	0.67
Modified Blench (Gravel and cobble banks)	1.02	0.93	0.87	1.05	0.86	0.68
Kellerhals	0.99	0.90	0.83	0.85	0.76	0.70
Dimensionless	0.93	0.86	0.80	0.93	0.87	0.79

1. Equations used for computing values in this table are given in Table 5.5.
2. All tabulated values below the best fit value are ratios of indicated relations to best fit.