METHODS FOR DEVELOPING FLASH FLOOD FORECASTING TABLES

By

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FLOOD FORECASTING TABLES

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CHAPTER I

INTRODUCTION

Background

Flash Flooding has become more prevalent during the early 1970's. The Floods of Bufflo Creek, West Virginia, Rapid Creek, Rapid City, South Dakota, and Boggy Creek, Enid, Oklahoma are a few of the disastrous floods that have occurred. It is not so much there are more floods, but where urban development has encroached into the flood plain more people are locating themselves in areas that are subject to flooding. What may seem to be an increase in Flash Flooding is in reality increased exposure.

A Flash Flood is a flood that takes place within four to six hours after the storm that caused it. A Flash Flood can be caused by heavy rain, dam failure, ice dam breakup, or an earthquake, or a combination of the above.

Flash Floods occur in such a short time that to be able to forecast the flood there must be pre-developed procedures that can be applied quickly and directly to the drainage basin affected.

Objectives

Based on new and the currently used methods for Flash Flood procedures the objectives of this study are:

1. To assemble and document all methods used in Flash Flood procedure development.
2. Organize the documentation of existing methods along with newly developed methods into a Flash Flood procedure design manual for the National Weather Service.

In Chapters II through VI a method is used whereby taking basic parameters of a stream basin a hydrologic forecasting tool is developed. This hydrologic tool will enable timely and accurate Flash Flood forecasting of a stream. The tables will also allow prior, real time, or after the fact information on if or will a community be affected by a local stream. Hydrologic parameters used in this study are presented in a way that when the controls are corrected along with being a hydrologic forecasting tool the methods can also be used for hydrologic design.

CHAPTER II

REVIEW OF LITERATURE

The basis of any hydrologic study is the unit hydrograph. A unit hydrograph is the hydrograph of one inch of direct runoff from a storm of specified duration. In development of a Flash Flood procedure the first control established is the unit hydrograph. Considerable literature has been written on the development and use of the unit hydrograph. The topic areas covered in this review are those used by the author.

Unit Hydrograph

In 1932, L. K. Sherman (1) advanced the theory of the unit hydrograph, or unit graph. The unit hydrograph procedure assumes that discharge at the time is proportional to the volume of runoff and that time factors affecting shape are constant.

The fundamental principles of invariance and superposition make the unit graph an extremely flexible tool for developing synthetic hydrographs: 1) the hydrograph of surface runoff from a watershed due to a given pattern of rainfall, is invariable, and 2) the hydrograph resulting from a given pattern of rainfall excess can be built by superimposing the unit hydrograph due to the separate amounts of rainfall excess occuring in each unit period, which includes the principle of proportionality by which the ordinates of the hydrograph are proportional to the volume of rainfall excess.

The unit time or unit graph duration is the optimum duration for the occurrence of the precipitation excess. In general this unit time is approximately 20 percent of the time interval between the beginning of runoff from a short high-intensity storm and the peak discharge of the corresponding runoff.

The storm duration is the actual duration of the precipitation excess. The duration varies with actual storms. The dimensionless unit hydrograph (Figure 1) was developed by Victor Mockus. It was derived from a large number of natural unit hydrographs from watersheds varying widely in size and geographical location. This dimensionless curvilinear hydrograph, Table I, has its ordinate values expressed in a dimensionless ratio discharge at time t (q)/peak discharge (qp) or accumulated volume at time t (Q_a)/total volume (Q) and its abscissa values as a selected time (t)/time from beginning of rise to peak (T_p). This unit hydrograph has a point of inflection approximately 1.70 times the time-to-peak (T_p) and the time-to-peak 0.2 of the time-of-base (T_b).

The dimensionless curvilinear unit hydrograph (Figure 1) has 37.5% of the total volume in the rising side, which is represented by one unit of time and one unit of discharge. This dimensionless unit hydrograph also can be represented by an equivalent triangular hydrograph having the same unit of time and discharge, thus having the same percent of volume in the rising side of the triangle (Figure 2).

This allows the base of the triangle to be solved in relation to the time to peak using the geometry of triangles. Solving for the base length (T_b) of the triangle, if one unit of time T_p equals .375 of volume and time of recession equals (T_r):

$$T_b = 1.00/.375 \pm 2.67 \text{ units of time,}$$

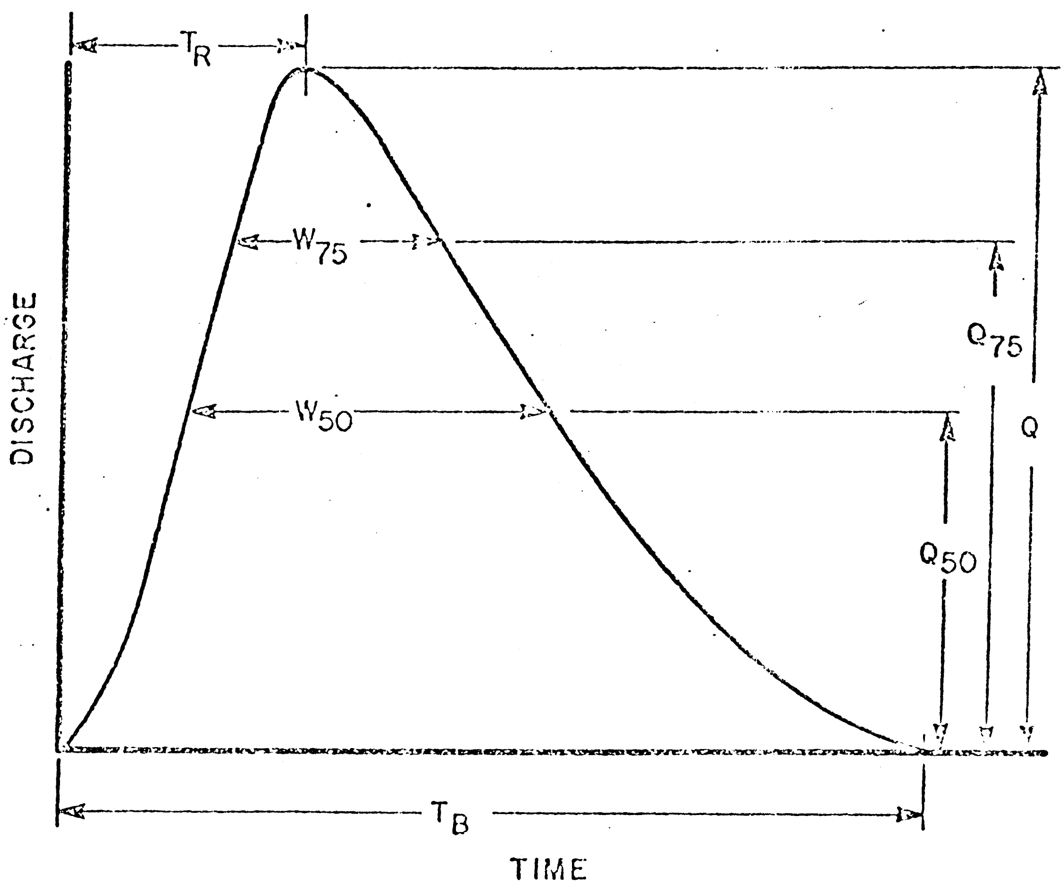

Figure 1. Dimensionless Unit Hydrograph and Mass Curve

TABLE I

RATIOS FOR DIMENSIONLESS UNIT HYDROGRAPH AND MASS CURVE

Time Ratios (t/T_p)	Discharge Ratios (q/q_p)	Mass Curve Ratios (Qa/Q)
0	.000	.000
.1	.030	.001
.2	.100	.006
.3	.190	.012
.4	.310	.035
.5	.470	.065
.6	.660	.107
.7	.820	.163
.8	.930	.228
.9	.990	.300
1.0	1.000	.375
1.1	.990	.450
1.2	.930	.522
1.3	.860	.589
1.4	.780	.650
1.5	.680	.700
1.6	.560	.751
1.7	.460	.790
1.8	.390	.822
1.9	.330	.849
2.0	.280	.871
2.2	.207	.908
2.4	.147	.934
2.6	.107	.953
2.8	.077	.967
3.0	.055	.977
3.2	.040	.984
3.4	.029	.989
3.6	.021	.993
3.8	.015	.995
4.0	.011	.997
4.5	.005	.999
5.0	.000	1.000

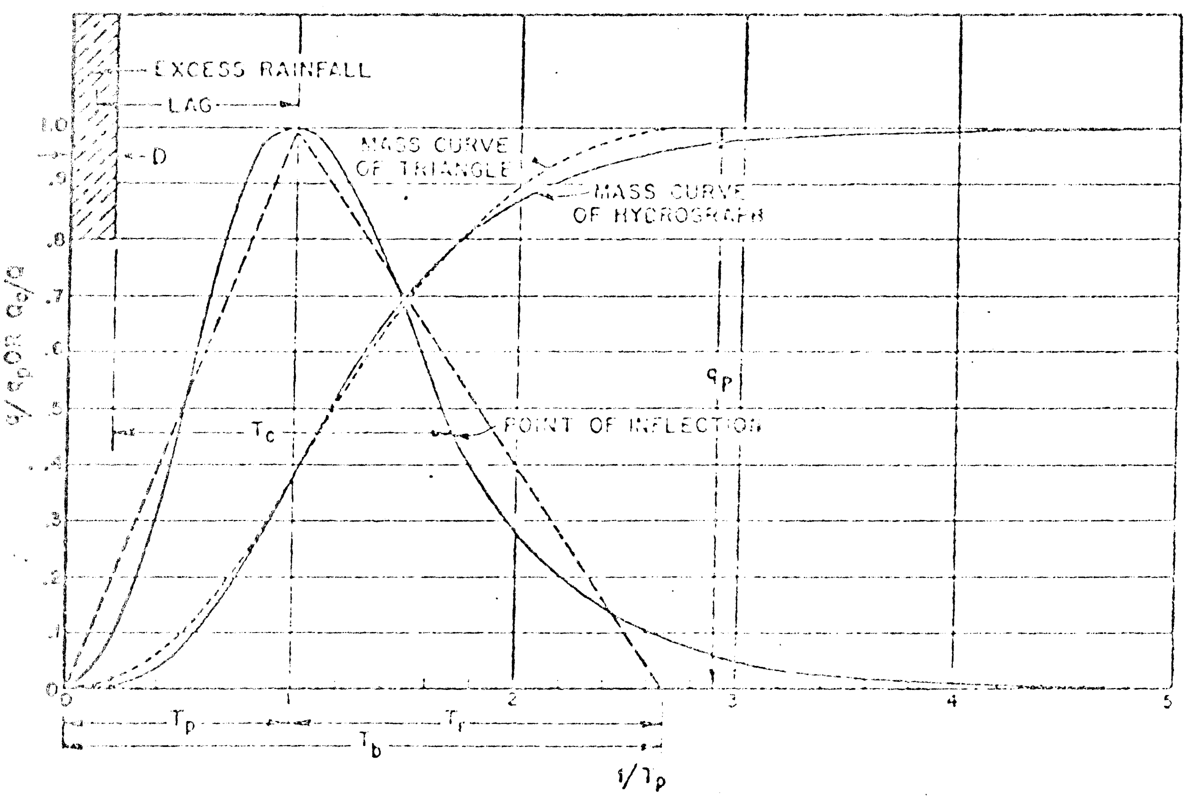

Figure 2. Dimensionless Unit Hydrograph and Equivalent Triangular Hydrograph

$T_r = T_b - T_p = 1.67$ units of time or 1.67 Tp.

These relationships are useful in developing the peak rate equation for use with the dimensionless unit hydrograph.

From Figure 2 the total volume under the trianglar unit hydrograph is:

$$Q = q_p \, T_p/2 + q_p \, T_r/2 = q_p/2 \, (T_p + T_r) \qquad (1)$$

With Q inches the T in hours, the peak rate Q_p in inches per hour would be:

$$q_p - 2Q/(T_p + T_r) \qquad (2)$$

$$\text{Let } K = 2/(1 + (T_r/T_p) \qquad (3)$$

$$\text{Therefore } q_p = KQ/T_p \qquad (4)$$

In making the conversion from inches per hour to cubic feet per second and putting the equation in terms ordinarily used, in drainage area A in square miles, and time T in hours, equation 4 becomes the general equation:

$$q_p = 645.33 \, KAQ/T_p \qquad (5)$$

Where q_p is peak discharge in cubic feet per second (cfs) and the conversion factor 645.33 is the rate required to discharge one inch from one square mile in one hour.

The relationship of the trianglar unit hydrograph, $T_r = 1.67 \, T_p$, gives $K = 0.75$. Then substituting into equation 5 gives:

$$q_p = 484 \, AQ/T_p \qquad (6)$$

Since the volume under the rising side of the trianglar unit hydrograph is equal to the volume under the rising side of the curvilinear dimensionless unit hydrograph in Figure 2, the constant 484, or peak rate factor, is valid for the dimensionless unit hydrograph in Figure 1.

Figure 2 shows that:

$$T_p = DX/2 + L \qquad (7)$$

Where DX is the duration of unit excess rainfall and L is the watershed lag in hours. The lag L of a watershed is defined as the time from the center of mass of excess rainfall DX to the time to peak T_p of a unit hydrograph. From equation 6:

$$q_p = 484\ AQ/(DX/20 + L) \qquad (8)$$

The average relationship of lag (L) to time of concentration (T_c) is $L = 0.6\ T_c$.

$$q_p = 484\ AQ/(DX/2 + 0.6\ T_c) \qquad (9)$$

Using the relationship shown on the dimensionless unit hydrograph, Figure 2 to complete the relationship of DX to T_c:

$$T_c + DX = 1.7\ T_p \qquad (10)$$

$$DX/2 + 0.6\ T_c = T_p \qquad (11)$$

$$T_c + DX = 1.7\ (DX/2 + 0.6\ T_c) \quad ,$$

where $.15\ DX = .2\ T_c$

$$DX = .133\ T_c \qquad (12)$$

The unit hydrograph can be constructed for any location on a uniformly shaped watershed, once the value of q_p and T_p are defined, see Figure 3, areas A and B. Area C in Figure 3 is an irregularly shaped watershed having two uniformly shaped areas with a big difference in their time of concentration.

Snyder's Synthetic Unit Hydrograph Relations

Synthetic Unit Hydrographs (3) are important in many hydrologic studies. The Snyder approach is intended primarily for use in estimating critical rates of runoff from major storms, although the general methods are adaptable to other problems. In developing unit hydrographs for use in estimating critical hydrographs of runoff, conservative determinations of the peak discharge, the degree of concentration of runoff near the peak, and the lag time are of primary importance. The empirical relations presented by Franklin F. Snyder (4) have proven to be particularly useful in the study of runoff characteristics of drainage areas where streamflow records are not available. The following terms are used in Snyder's method:

t_p = lag time

t_r = unit rainfall duration equal to $t_p/5.5$, in hours.

t_R = unit rainfall duration, other than standard, hours.

t_pR = lag time from mid point of rainfall to peak, hours.

q_p = peak rate of discharge in cfs/Sq. mile.

q_pR = peak rate of discharge in cfs/sq. mile.

Q_p = peak rate of discharge in cfs.

A = drainage area in square miles.

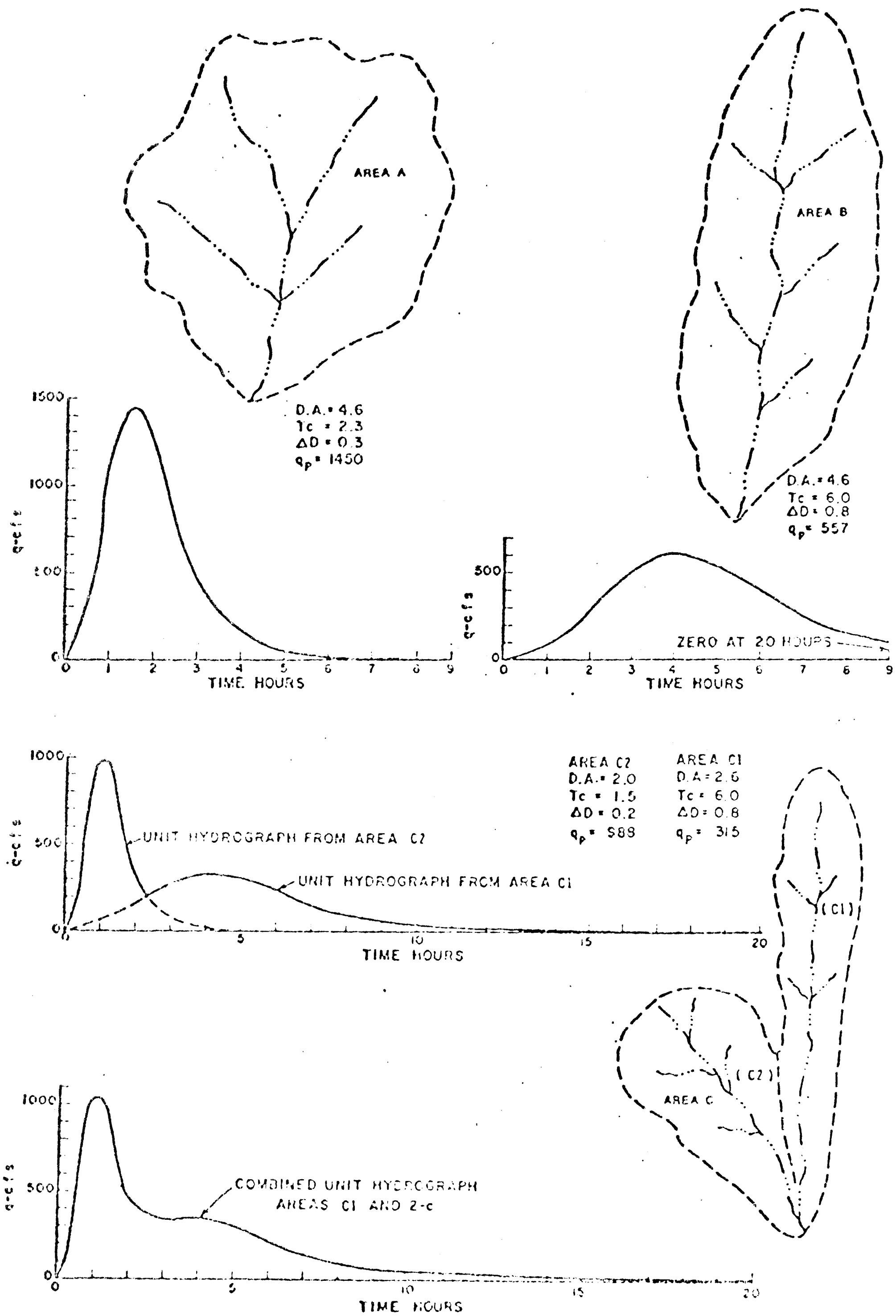

Figure 3. The Effect of Watershed Shape on the Peaks of Unit Hydrographs

L_{ca} = river miles from station to center of gravity, ml.

L = river milage from station to limit of basin, miles.

C_t and C_p are coefficients depending on basin.

The following are the Snyder equations:

$$t_p = C_t(LL_{ca})^{0.3} \quad (13)$$

$$t_r = t_p/5.5 \quad (14)$$

$$q_p = C_p 640/t_p \quad (15)$$

$$t_pR = t_p + 0.25(t_R - t_r) \quad (16)$$

$$q_p = 640C_p/t_pR \quad (17)$$

$$q_pR = q_p t_p/t_pR \quad (18)$$

$$Q_p = q_pA \quad (19)$$

The distance to the center of area may be taken as the mean distance off a cumulative area-distance curve or estimated as the distance to the center of gravity of the drainage area. The average value of the product 640 C_p is approximately 400, as determined by Snyder, for basins in the fairly mountainous Appalachian Highlands and the corresponding average value of C_t is 2.0. See Figure 4.

Rational Method

Most urban storm-drain systems are designed by the rational method.(5) Considerable judgment is involved when using this method because time of concentration affects the value of runoff coefficient (C), and many factors affecting C are difficult to evaluate. A common procedure is to select a C and assume it remains constant through the storm. Typical values of C from Table II are applicable for storms of 5 to 10 yr. frequencies. The time of concentration in the rational method is extremely difficult to

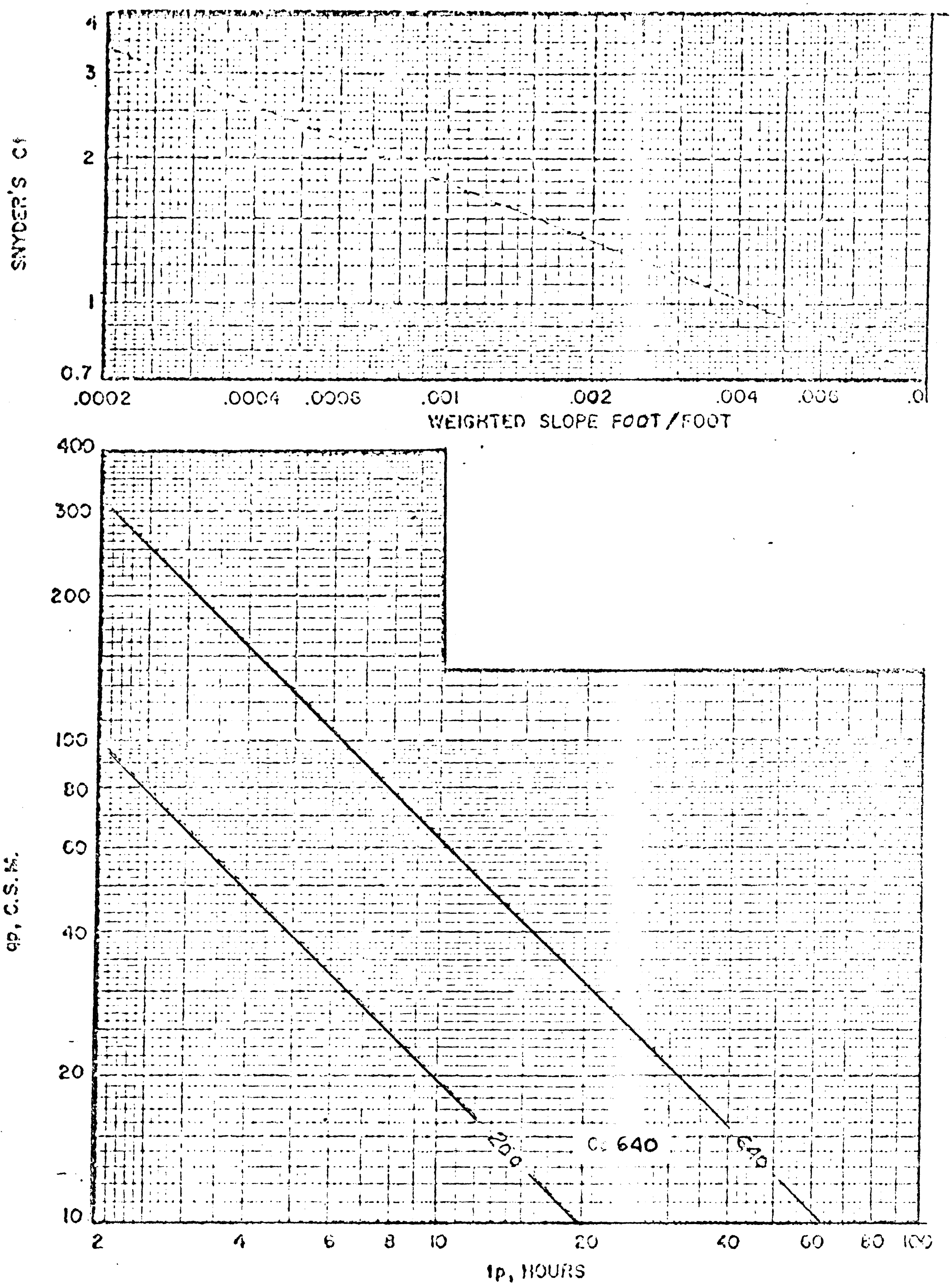

Figure 4. Snyder's Unit Hydrograph Coefficients

establish. The usual assumption accepts it as the interval required for water to flow from the most remote part of the watershed to a disignated point. The rational equation is:

$$Q = C\ I\ A \tag{20}$$

TABLE II

TYPICAL C VALUES

Description of Area	Runoff Coefficients
Business	
Downtown areas	0.70 to 0.95
Neighborhood areas	0.50 to 0.70
Residential	
Single family areas	0.30 to 0.50
Suburban	0.25 to 0.40
Multiunits	0.50 to 0.70
Industrial	
Light areas	0.50 to 0.80
Heavy areas	0.60 to 0.90
Streets	0.75 to 0.95
Lawns	
Flat	0.07 to 0.15
Average	0.15 to 0.20
Steep	0.20 to 0.30

Development of Peak Discharge Equations From a Triangular Hydrograph Study

The typical shape of flood hydrographs of small watersheds, as studies by I. Pai Wu (6), indicates the possibility of using a triangular hydrograph to design the size of Hawaiian hydrographs and determine the peak rate of flow of a small watershed.

The general form of the peak discharge is shown in Figure 5. The triangular hydrograph has been applied by Mockus (7), and Holtan and Overton (8), as an approach for the determination of peak discharge and may be expressed as:

$$Q_p = AR\ (2/(t_p + t_r)) \tag{20}$$

where Q_p is peak discharge, A is the area of the drainage in acres, R is the runoff or effective rainfall expressed as depth of water over the basin, t_p is time to peak, and t_r is the time from the peak rate to the end of the triangle. Since the typical hydrograph-shape is a steep triangle, t_r can be expressed by the recession constant, K_1.

K_1, can be calculated as:

$$K_1 = dt/(2.3 \log\ (Q_p/0.5Q_p) \tag{21}$$

Since it can be replaced as 0.5 t_r according to the triangular shape then,

$$K_1 = 0.5t_r/2.3 \log 2,$$

or

$$K_1 = 0.724\ t_r$$

$$t_r = 1.38\ K_1$$

The peak discharge equation can be expressed as a function of the two hydrograph parameters, time to peak and recession constant,

$$Q_p = AR/t_p(2/1 + 1.38\ (K_1/t_p)) \tag{22}$$

$$Q_p = AR/t_p(2/1 + 1.5\ (K/t_p)) \tag{23}$$

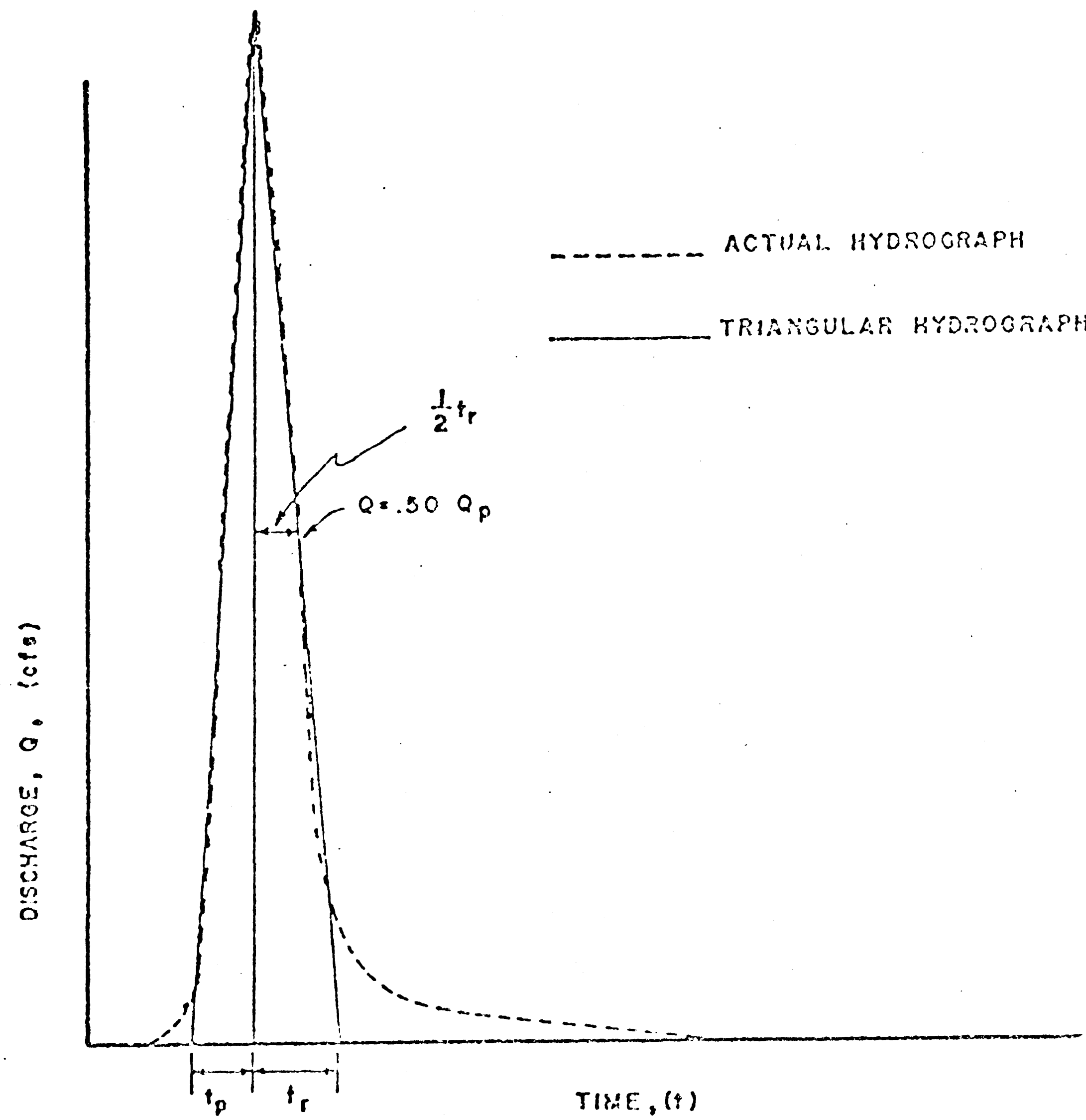

Figure 5. A Typical Triangular Hydrograph

The modified peak discharge equation (22), expresses a linear function for peak discharge and runoff if the two hydrograph time parameters of a watershed are constant. The assumption of linearity has been used since 1932 when Sherman (1) introduced the unit hydrograph concept that peak discharge is directly proportional to the volume of runoff for a given duration of unit hydrograph. The most important property of such a linear relationship is that of superposition which allows a flood hydrograph to be constructed if the duration of effective rainfall and its corresponding unit hydrograph are known.

Four empirical relations have been found and may be used for determining peak discharge and for verifying the dervied equations. They are:

a. For a watershed area of less than 1 square mile:

$$Q_p = 1.4 \text{ AR} \tag{24}$$

b. For a watershed area from 1 to 3 square miles:

$$Q_p = 0.9 \text{ AR} \tag{25}$$

c. For a watershed area from 3 to 6 square miles:

$$Q_p = 0.6 \text{ AR} \tag{26}$$

d. For a watershed area larger than 6 square miles:

$$Q_p = 0.32 \text{ AR} \tag{27}$$

The peak discharge equation, equation (22), can be further simplified if the time parameters, time to peak, and the recession constant are known. If they can be expressed by a linear line, then:

$$Q_p = 0.84 \text{ (AR}/K_1) \tag{28}$$

or,

$$Q_p = \text{CAR} \tag{29}$$

where C is a coefficient and a function of the hydrograph time parameters, time to peak and recession. A regression equation is obtained and may be expressed as:

$$K_1 = 0.43 + 0.0003A \tag{30}$$

where K_1 is in hours and the watershed area, A is in acres.

The Effects of Urbanization on Unit Hydrographs

A study was made to determine the past and future effects of urbanization on several watersheds in Houston, Texas (9), to obtain equations which describe the effects of urbanization on the unit hydrograph.

Average S-hydrographs and 30 minute hydrographs for 17 Houston watersheds, 11 classified as urban and 6 as rural, were obtained from basic data for 59 storms.

From the data, equations were derived which specifically predict the 30-minute hydrograph for Houston watersheds under urban and rural conditions. Combined data from 17 Houston watersheds and 33 watersheds studies previously by Espey, Morgan and Masch (10) were used to derive new equations which predict the 30-minute unit hydrograph for urban and rural watersheds.

In deriving the unit hydrograph for a particular storm the following steps were taken:

1. The rainfall pattern of the storm was checked as to uniform rate and uniformly distributed.
2. The base flow was separated from the surface runoff.
3. The surface runoff hydrograph is integrated to calculate the total inches of runoff.

4. The surface runoff hydrograph was reduced to a unit hydrograph.

5. The resulting unit hydrograph was reduced to a unit hydrograph of standard duration by the S-hydrograph method of superposition.

A detailed explanation of the above procedure is presented by Chow (11).

To describe the hydrograph the following parameters were used:

1. T_R, the time of rise, from beginning of runoff to peak.

2. Q, the discharge, in cfs.

3. T_B, the time base, from beginning to end of runoff.

4. W_{50}, the time in minutes at half the peak discharge.

5. W_{75}, the time in minutes at 3/4 the peak discharge.

TABLE III

URBANIZATION FACTORS

UF_1	Classification
0.6	Extensive channel improvement and storm sewer system, closed conduit channel.
0.8	Some channel improvement and storm sewers mainly cleaning and enlargement of existing channel.
1.0	Natural channel conditions.

UF_2	Classification
0.0	No channel vegetation.
0.1	Light channel vegetation.
0.2	Moderate channel vegetation.
0.3	Heavy channel vegetation.

See Figure 6 for definition of hydrograph properties.

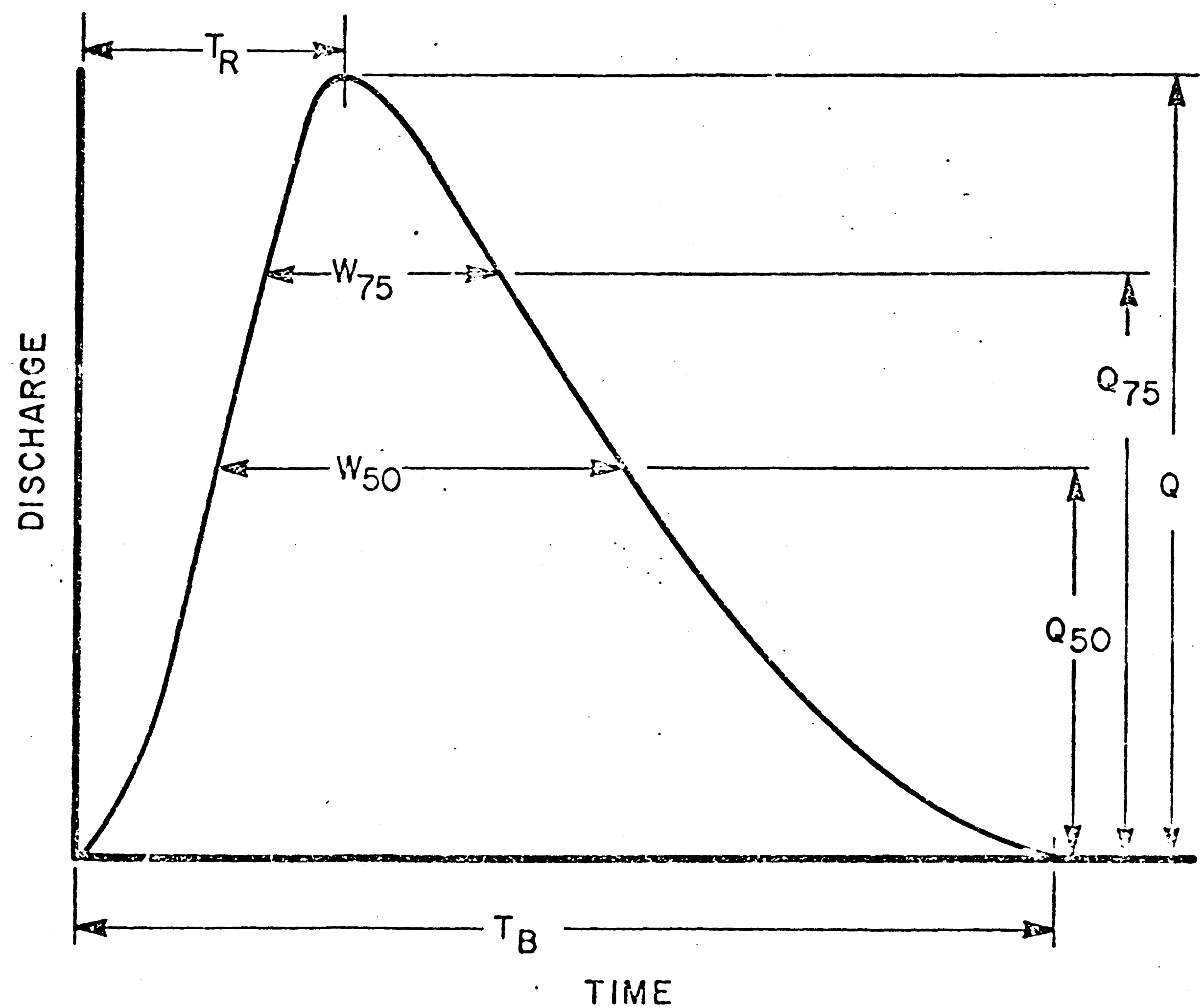

Figure 6. Definition of Hydrograph Properties

$$UF = UF_1 + UF_2 \tag{31}$$

The 30 minute unit hydrograph for rural watersheds can be determined by the following equations:

$$T_R = 2.68\ L^{0.223} S^{-0.302} \tag{32}$$

$$Q = 8.25 \times 10^4 A^{0.988} T_R^{-1.26} \tag{33}$$

$$T_B = 5.00 \times 10^4 A^{0.921} Q^{-0.834} \tag{34}$$

$$W_{50} = 2.9 \times 10^4 A^{0.959} Q^{00.83} \tag{35}$$

$$W_{75} = 1.15 \times 10^4 A^{0.857} Q^{-0.915} \tag{36}$$

The 30 minute unit hydrograph for urban watersheds are as follows:

$$T_R = 16.4\ UF\ L^{0.315}\ S^{-0.0488} I^{-0.490} \tag{37}$$

$$Q = 3.5 \times 10^4 T_R^{-1.10} A^{1.00} \tag{38}$$

$$T_B = 3.67 \times 10^5 A^{1.14} Q^{-1.15} \tag{39}$$

$$W_{50} = 4.14 \times 10^4 A^{1.03} Q^{-1.04} \tag{40}$$

$$W_{75} = 1.34 \times 10^4 A^{0.92} Q^{-0.94} \tag{41}$$

Where: A is the area of the watershed in square miles.

L is the length of the main channel in feet.

S is the slope of the main channel in FT/FT.

I is the percent of impervious cover for the area.

UF is the urbanization factor defined in Table VI.

Flow Through a Breached Dam

Many Flash Floods have been caused by the breaching of dams. (13) To provide the necessary equations to deal with the situation the following information is included. The amount of damage from the flood wave is proportional to the height, duration and speed of the propagation of the wave. These factors vary with the river channel characteristics and the rate of flow from the breached dam. In cases of complete breach:

$$B = 2\ V/Lh \qquad (42)$$

where,

B = Average reservoir width.

V = Initial storage above the breach lip.

L = Length of reservoir, miles.

h = Depth from the initial surface to bottom of breach, feet.

The average bottom slope of the reservoir can be computed as the initial depth of water at the dam divided by the reservoir length.

$$S_o = H_o/L \qquad (43)$$

where,

S_o = Average reservoir bottom slope

H_o = Specific head

For complete breach the following flow equation should be used:

$$Q\ max = (8/27)B(g)^{0.5}H_o^{1.5} \qquad (44)$$

The initial depth would be:

$$y = (4/9)H_o \qquad (45)$$

Maximum peak flow would be developed in the following time period:

$$t_k = V/Q \text{ max} \tag{46}$$

Many times there would not be enough time to find or calculate a true reservoir capacity, during those times the estimated capacity should be determined by the SCS method (14) where the surface area is multiplied by 0.4 times the maximum depth, in feet measured at the dam.

HEC-2 Water Surface Profiles

The HEC-2 program (14) computes and plots by printer the water surface profile for river channels of any cross section for either subcritical or supercritical flow conditions. The effects of various hydraulic structures such as bridges, culverts, weirs, embankments, and dams may be considered in the computation.

The basic theory is similar to Method 1, Backwater Curves in River Channels, Engineering Manual 1110-2-1409, U. S. Army Corps of Engineers, 7 December 1959.(16) This method applies Bernoulli's Theorem for the total energy at each cross section and Manning's formula for the friction head loss between cross sections. The computation begins at a control section in the river channel and proceeds upstream for subcritical flow or down stream for supercritical flow. The water surface elevation for the beginning may be specified in one of three ways: 1) as critical depth, 2) as a known elevation, or 3) by the slope area method. The river flow may be specified and altered in several ways. The starting flow is normally specified as variable Q on card J1 for one job. If it is desired to run different flows the QT card is used. Manning's "n" can either be specified or the program can develop an "n" to fit the conditions.

The water surface profile computations may be computed up both forks of a river or throughout a whole river basin for a single or multiple profile in a single computer run.

Cross sections are required at representative locations throughout the river reach. These are locations where changes occur in slope, cross sectional area, or channel roughness; locations where levees begin or end; and at bridges. In general for rivers of flat slope and fairly uniform section, cross sections should be taken at least every mile. The HEC-2 program will insert cross sections between those specified when the hydraulic gradient is too great. Expansion or contraction of flow due to changes in the channel cross section is a common cause of energy loss, when this occurs the program uses coefficients as variables. The HEC-2 program can investigate the complete hydrologic properties of a river basin.

CHAPTER III

METHODS OF ANALYSIS

Formal Development Analysis

The development of procedures for Flash Flood Forecasting design will be a combination of hydrologic studies and methods listed under Chapter II, along with forecast methods used by the River Forecast Center, National Weather Service, Tulsa, Oklahoma.

A Flash Flood Forecasting development program needs three basic input determinents: 1) Unit Graph, 2) Time to Peak, and 3) Stage Discharge Relationship.

The Formal development will use the unit graph methods of

1. Triangle Method (Equation 6)
2. Rational Method (5)
3. Honolulu Method (6)
4. Houston Method (9)

The input into the Flash Flood Basic Program will include requirements for all four methods with the final selection being a responsibility of the professional hydrologist, or the value of the unit graph may be an average of the four methods.

The Time to Peak will be the accompanying value of the selected unit graph value, or it may be the average of the out put data.

The calculations for the basic requirements will be done by a program compiled by the author named, BASIC, Appendix A.

The stage Discharge Relationship (Rating) will either be as: 1) Data from existing rating table or, 2) Stage Discharge values calculated using HEC-2, Appendix B.

The final product of this study, the Flash Flood Forecasting Tables will be calculated and developed by a program compiled by the author named, TABL, Appendix C.

Emergency Conditions

When the situation occurs that a Flash Flood Forecast must be developed for an unstudied area the nomography can be used. It is to be understood that the nomography is only an approximation and must be treated as such, see Figure 7.

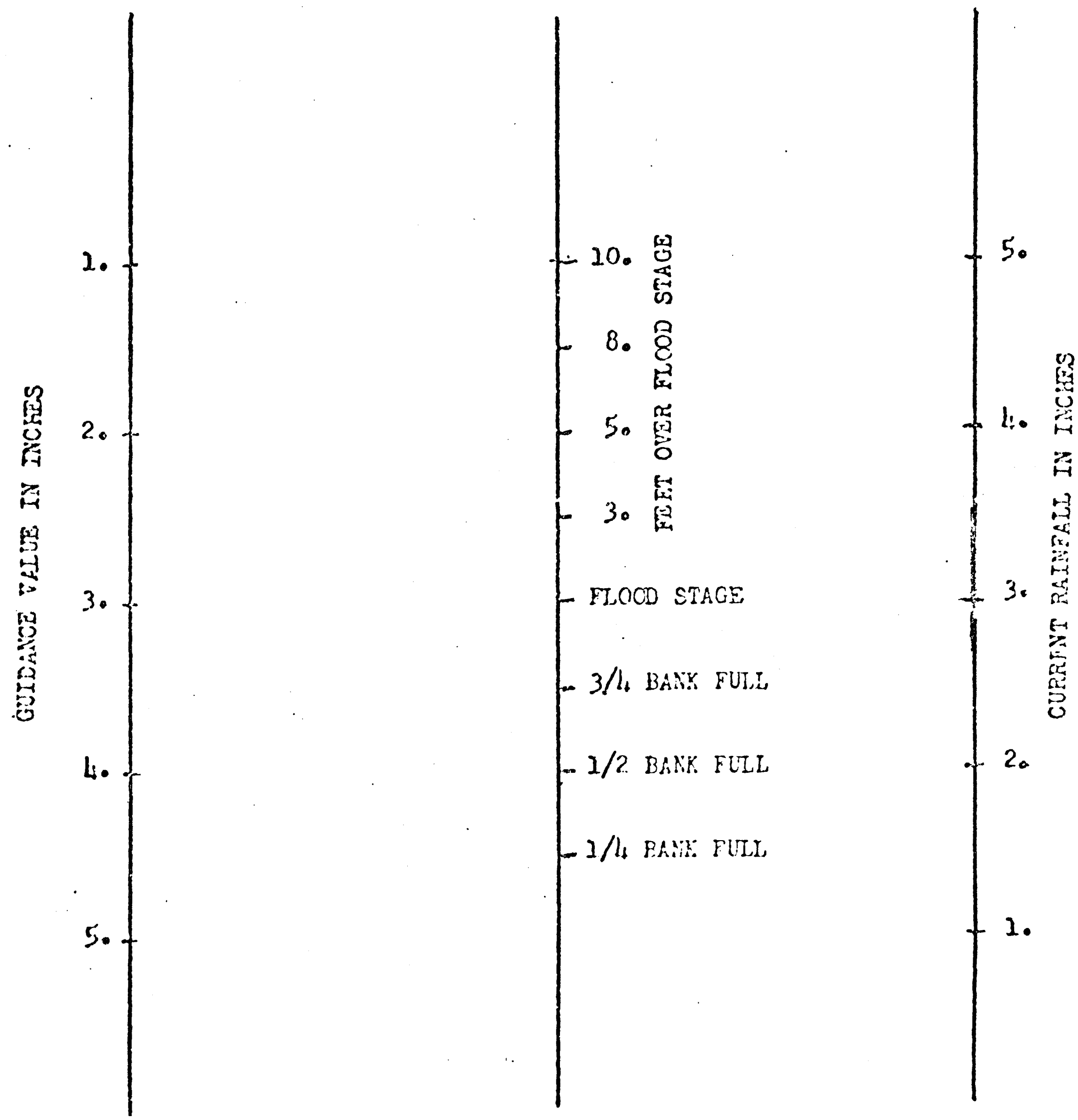

Figure 7. Nonograph of Guidance Value Vs Current Rainfall to Determine Possible Flood Stage

CHAPTER IV

PROCEDURE

Unit Graph Determination

The four methods for unit graph determination that were selected from the literature, namely the: 1) Triangle Method, 2) Rational Method, 3) Honolulu, and 4) the Houston Method were incorporated into a program called BASIC.

Basic Program

The Basic Program (BASIC) (Appendix A) is written in Fortran IV and is a collection of fundamental hydrologic parameters. BASIC is divided into two separate segments acting in series, but independent of each other. Part one computes the unit graph values and time to peak values. Part two of BASIC is for computing information related to Dam Breaks.

Data requirement for BASIC.

Part One

Card No.	Item	Format
B 1	Name	4A10
B 2	Drainage Area, Square Miles	F7.1
B 3	River Miles, Miles	F5.0
B 4	Maximum Height of Basin, MSL	F5.0
B 5	Zero of station, MSL	F7.2
B 6	Duration of Storm, Hours	F4.1

Card No.	Item	Format
B 7	Channel Slope between 20% & 80% feet/mile	F5.2
B 8	Annual Rainfall, Inches	F5.2
B 9	Channel Classification	F5.2
B10	Percent Imperyious Cover	F5.2

Part Two

Is investigation into Dam Break desired

B11	No = 1.0 (F1.0)	
B11	Yes = 2.0 (F1.0)	
B12	Name of Reservoir	4A10
B13	Surface Area, Acres	F7.2
B14	Maximum Depth, Feet	F7.2
B15	Reservoir Length, Miles	F5.2
B16	Width of Breach, Feet	F7.1
B17	Depth of Breach, Feet	F7.1
B18	Reservoir Capacity, if known, Acft	F12.1

If all data is not available for the running of BASIC then a blank card is to be used in lieu of data for continued operation of the program.

Stage Discharge Relationship

When possible, existing Stage Discharge Relationships (ratings) should be used particularly when there is a long historical record.

When no rating exists, then the HEC-2 program should be used to develop a rating. Data input into the program will consist of: 1) One or several cross sections at the station under study, 2) estimates of the slope, 3) estimation of the roughness factor, and 4) any maximum flows previously recorded. Data into cards for the HEC-2 program are shown in Table IV.

Flash Flood Forecasting
Table Program

The Flash Flood Forecasting Table program (TABL) (Appendix C) is the assembly of known and calculated data of a stream location to be used as data input for the product of a forecast scheme. The TABL will use the Flash Flood Guidance values that are calculated for our River Forecasting District each day. The Flash Flood Guidance values are representative values of the rainfall required to flood an average small basin within a State Zone forecasting area. The Guidance value is a representation of the soil moisture in terms of how much rainfall would be required to flood an average small creek basin within a particular geographic area. The Guidance value is calculated by analyzing the Antecedent Precipitation Index (API) model, backwards, to determine what rainfall is required, rather than what runoff will occur. The Guidance values are called from tape file as tape TS. These values are calculated by a separate program used in daily operation as they would be in other River Centers. Those River Centers not using the API model must have availability to call a value of equal areas (state zones) of runoff.

The Tulsa River Forecast Center uses four different values of runoff to cause flooding; 1) 0.25, 2) 0.50, 3) 0.75, and 4) 1.00 inches of rainfall. A map showing runoff estimates within the Unites States is shown in Figure 8.

TABLE IV

DESCRIPTION OF CARD TYPES

Cards	Description of Card Type
C	Comment Cards for Data
T1-T3	Title Cards
J1	Job Card - Starting Conditions
J2	Job Card - Optional Features
J3	Job Card - Selection of Variables for Summary
J4	Job Card - Routing Reaches - Punching Cards for HEC-1
NC	Starting N Values & Shock Losses
QT	Table of Discharges for Multiple Profiles
NH	Horizontal Variations in Roughness "N"
NV	Vertical Variations in Roughness "N"
ET	Encroachment Width Table
SB	Special Bridge
X1	General Items for Each Cross Section
CI	Channel Improvement
X2	Optional Items for Each Cross Section (Bridge, Etc).
X3	Optional Items for Each Cross Section (Effective Area)
X4	Additional Points for Cross Section
X5	Use of Input Water Elevations
BT	Bridge Table of Elevations, Stations
GR	Ground Profile Elevations and Stations
EJ	End of Job Card for Each Profile
ER	End of Run Card for Last Profile

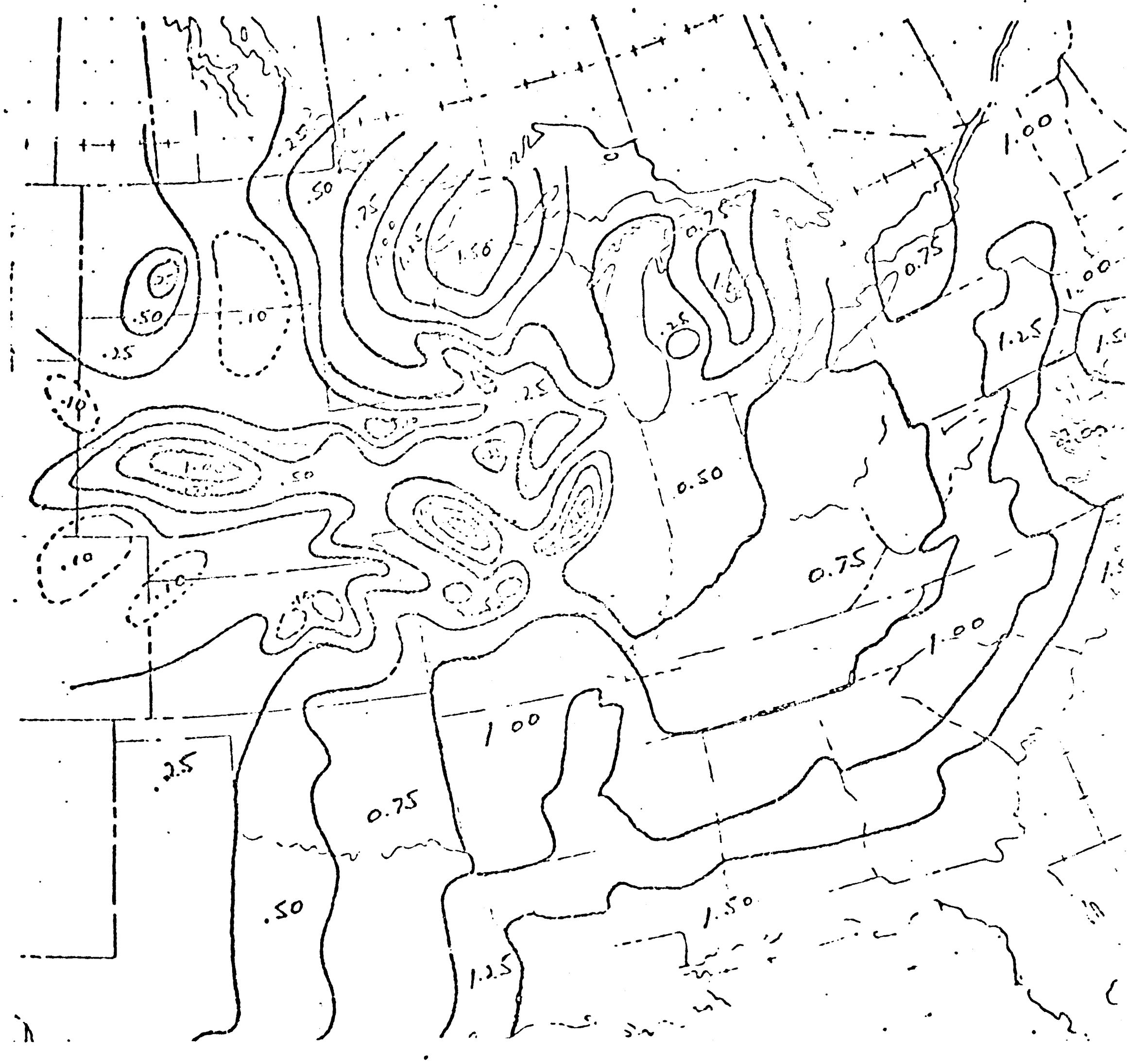

Figure 8. Runoff Areas in the Central and Eastern Portions of the United States in Terms of Inches of Runoff to Cause Flooding of Small Creek Basins

Data which the Tulsa River Forecast Center uses as generated by the API model runoff program for use in TABL is shown in Appendix C.

Outside of the call from files of the Guidance values, all other data necessary for calculation and printing of Flash Flood Forecasting Tables are as follows:

Data for TABL

Card No.	Item	Format
1	Name of Station (basin)	5A10
2	Limit of Reach (local headwater)	5A10
3	Date	A8
4	Name of State	A10
5	Number of State Forecasting Zone	I2
6	Time to Peak, Hours	F4.1
7	Unit Graph Peak, CFS	F6.0
8	Zero of gage, Feet MSL	F7.2
9-28	Rating cards, MSL vs CFS	F7.2,F7.0
29	Flood Stage, MSL	F7.2
30	Runoff values (Figure 8)	F4.2
31	Datum desired, MSL of Feet (blank = feet, 1.0 = MSL)	F4.0

CHAPTER V

PRESENTATION OF A BASIN STUDY

Location

The Mingo Creek Basin, Tulsa County, Oklahoma will be analyzed to develop Flash Flood Forecasting Tables. Mingo Creek is a tributary of Bird Creek which is a tributary of the Verdigris River. Mingo Creek drains a somewhat rectangular shaped watershed of about 7 miles wide and 12 miles long. Mingo Creek lies within a rapidly developing segment of Tulsa County. Numerous highways and city streets are in the flood plain and these highways would be inundated, somewhat by the 200 year flood. There would be major damage from the 100 year flood along with the high potential of loss of life.

Three approahces to the test basin study will be made, they are 1) Complete Basin Analysis, 2) Specific Station Analysis, and 3) Emergency Condition.

Complete Basin Analysis

The first step is the determination of the unit graph peak flow and the time to peak of the flow. The data requirements for BASIC were listed in Chapter IV and have been tabulated as follows;

Card No.	Data or Information
B 1	Mingo Creek at 11th Street (Name)
B 2	25.6 (Drainage Area, Sq. Mi.)

Card No.	Data or Information
B 3	8. (River Miles, Miles)
B 4	770. (Maximum Height of Basin, in MSL)
B 5	608. (Zero of Station, in MSL)
B 6	3. (Duration of Storm, in Hours)
B 7	10. (Channel Slope Between 20% to 80%)
B 8	36.0 (Annual Rainfall, in Inches)
B 9	1.0 (Channel Classification)
B 10	30 (Percent Impervious Cover)
B 11	2.0 (Dam Break Investigation, No.)

The above data is shown in Appendix A. On card 2 is shown the drainage area for a location approximately half way up Mingo Creek. Although the Complete Basin Analysis will study the flow throughout the entire 61.1 drainage, the forecast point will only be for the 25.6 square mile basin (11th Street and Mingo Creek). The shown data is then run in the BASIC program with the results shown in Appendix A.

The average unit graph peak and time to peak will be used as calculated by the Triangle method, the rational method, and the Houston method. Input data for the TABL program will be a unit graph value of 2890., cfs, and a time to peak of 3.5 hours.

The second step is the determination of a representative rating developed through multi flow profiles from the HEC-2 program. Cross section data is available for Mingo creek and to run the HEC-2 program, approximately 40 cross sections were used.

The complete basin analysis should only be used when there is good data (cross sections) available, and when the demand for the forecast location warrents an extensive analysis.

Input to the HEC-2 program is shown in Appendix B. As this is the Complete Basin Analysis all calculated values available through HEC-2 are printed out for future data requirements and for general knowledge. See Appendix B for the out put from HEC-2. The 11th Street and Mingo location is shown as Station 23 in the profile. The values as shown on the summary sheet will control the rating that will be used for 11th Street.

Specific Station Analysis

During the majority of Flash Flood Forecasting investigation the Specific Station Analysis will be used in lieu of the Complete Basin Analysis as there is seldom so great a data bank available.

Step 1 as outlined under the Complete Basin Analysis will be the same as the Specific Station Analysis.

Step 2 will require the data from only one cross section. This data may be obtained from formal survey, old historic data, or possibly from State Highway bridge profiles. Along with the one cross section there will need be an estimate of the Manning "n" value, an average channel sl slope, and there must also be an estimated rating developed on the following relation

$$FSQ = UGP \times ZRO \quad (42)$$

where,

FSQ = Flood Stage flow in cfs

UGP = Unit Graph Peak

ZRO = State Zone Runoff value

The first estimated rating will be developed from Table V

TABLE V

TYPICAL RATING TABLE FOR FIRST ESTIMATION FOR HEC-2

Elevation		
¼ Flood Stage	=	0.09 FSQ
½ Flood Stage	=	0.14 FSQ
3/4 Flood Stage	=	0.46 FSQ
Flood Stage	=	1.00 FSQ
Flood Stage + 2 Feet	=	1.80 FSQ
Flood Stage + 4 Feet	=	3.20 FSQ
Flood Stage + 6 Feet	=	4.80 FSQ
Flood Stage + 8 Feet	=	7.80 FSQ
Flood Stage + 10 Feet	=	14.00 FSQ

See Appendix B for first estimate for Mingo Creek. The estimates will then be coded into the J1 cards for the HEC-2 program. See Appendix B for estimated J1 cards. These original estimates will enable the HEC-2 program to satify the built-in capability to make 20 tries to balance the calculated flow with given conditions. If, after running the program it is found that the original estimates are off too far, then a re-run of the HEC-2 with the closest values the program found is required.

The data deck for the running of the Specific Station Analysis is shown in Appendix B. The out put from the HEC-2 is also shown in Appendix B.

Now, with the Complete Basin Study completed. the required input for the TABL program is available, namely: 1) Unit Graph Peak flow, 2) Time to Peak, 3) Initial Rating.

Flash Flood Forecasting Tables

The Flash Flood Forecasting Tables are the final products of this hydrologic study. The Flood Tables as developed by the TABL program will be in a group of ten. Limits of the grouping will be zero base flow on the lower limit to six times the flood flow as the upper limit.

Each Flash Flood Table will show the base flow and related stage as pertaining to that particular table. The left margin will contain the list of possible Flash Flood Guidance values, with the top reference line the possible rainfall. Although the tables are printed in tenths of feet, a forecast from the table should be specified to the next nearest whole foot below and the next nearest whole foot above the table value. A table value of flooding to 25.2 feet should be specified as 24 to 26 feet.

Input for the TABL program to develop forecast tables for Mingo Creek, 11th Street, Tulsa, Oklahoma is shown below:

Card No.	Data or Information
T 1	Mingo Creek, 11th Street, Tulsa
T 2	Total Basin above Station
T 3	09-01-67 (Date)
T 4	Oklahoma (State)
T 5	3 (Number of State Forecasting Zone)
T 6	3.5 (Time-to-Peak)
T 7	2890. (Unit Graph Peak)

Card No.	Data or Information
T 8	608. (Zero to Station)
T 9-28	Rating table (see Appendix B)
T 29	617.5 (Flood Stage)
T 30	0.75 (Run-off Values, Figure 9)
T 31	Blank card (Datum Required, Feet)

See Appendix C for printout of input data for TABL.

See Tables VI through XV for Mingo Creek Flash Flood Forecasting Tables.

Emergency Condition

The Emergency Condition nomograph should only be used when time will not allow any formal investigation of the basin and one must come up with a forecast immediately. Information requirements for the emergency procedure are: 1) State Zone Guidance value, 2) Rainfall of current storm.

Assuming that no formal procedures were available for Mingo Creek, then with a Zone Guidance value of 2.0 and a current rainfall of 4.50 inches, the resultant forecast should be a crest of near 3 to 5 feet over banks in the 11th Street area.

Dam Break

The Dam Break procedure, part 2 of the BASIC program will probably not be used too often, but when the need arises, it is available. The Dam Break study was made from Monument Lake located north of Colorado Springs, Colorado. The dam is an earth embankment, and like so many man made lakes, little or no pertinent data is known. Most times when a hydrologist has to make a Dam Break forecast it will be concerning such a no data situation and that is why this example was used. All information needed for the Dam Break program was estimated from the USGS Quadrangle, Monument Lake. Controls estimated were, 1) Surface area = 800 acres; 2) Maximum depth = 240 feet, 3) Reservoir length = 1.5 miles, and breach was set at 100 feet wide and 80 feet deep. See Appendix A for data input. See Appendix A for output from BASIC. The breach dimensions of any break probably will have to be estimated as the procedure should be run before the fact, or the actual dam break.

09-08-75

FLASH FLOOD FORECASTING TABLE

STATE OF OKLAHOMA

FORECAST ZONE 3

MINGO CREEK AT 11TH STREET, TULSA, OKLAHOMA

FOR TOTAL DRAINAGE ABOVE 11TH STREET
GAGE HEIGHT IN FEET

CURRENT FLOW = 21. CFS

CURRENT STAGE = .5 FT

FLOOD STAGE = 14.0 FT.
GAGE ZERO = 608.00 FT.-MSL
TIME TO PEAK = 3.5 HOURS

FLASH FLOOD GUIDANCE VALUES		INCHES OF RAINFALL IN 3 HOURS										
		.5	1.0	1.5	2.0	2.5	3.0	4.0	5.0	6.0	8.0	10.0
1.0	I	10.5	12.3	13.9	15.2	16.3	17.1	18.5	19.3	19.9	21.0	22.0
1.2	I	9.2	11.7	13.2	14.5	15.8	16.7	18.3	19.2	19.8	20.9	21.9
1.4	I	8.7	11.4	12.9	14.3	15.5	16.6	18.1	19.1	19.7	20.8	21.9
1.6	I	7.9	10.8	12.1	13.5	14.9	16.1	17.7	18.9	19.6	20.7	21.8
1.8	I	6.3	10.5	11.8	12.9	14.3	15.5	17.3	18.7	19.5	20.6	21.6
2.0	I	2.2	9.1	11.2	12.4	13.7	15.0	17.0	18.5	19.4	20.5	21.5
2.2	I	.5	7.7	10.7	11.9	13.1	14.5	16.7	18.3	19.2	20.4	21.4
2.4	I	.5	7.7	10.4	11.6	12.9	14.1	16.3	17.8	19.0	20.3	21.3
2.6	I	.5	3.9	8.8	10.9	12.2	13.5	15.7	17.4	18.7	20.1	21.1
2.8	I	.5	.9	7.8	10.5	11.6	13.0	15.3	17.1	18.5	20.0	21.0
3.0	I	.5	.5	5.8	9.2	11.1	12.3	14.5	16.5	18.0	19.8	20.7
3.2	I	.5	.5	3.9	8.7	10.8	12.0	14.4	16.5	18.0	19.7	20.7
3.4	I	.5	.5	.5	6.3	10.0	11.4	14.0	16.2	17.7	19.6	20.6
3.6	I	.5	.5	.5	2.9	8.8	11.0	13.5	15.8	17.4	19.5	20.5
3.8	I	.5	.5	.5	.5	7.6	10.5	13.0	15.4	17.1	19.4	20.3
4.0	I	.5	.5	.5	.5	4.0	9.3	12.3	14.9	16.8	19.2	20.2
4.2	I	.5	.5	.5	.5	.5	7.8	12.0	14.5	16.7	19.1	20.2
4.4	I	.5	.5	.5	.5	.5	5.1	11.4	13.9	16.2	18.9	20.0
4.6	I	.5	.5	.5	.5	.5	4.4	11.1	13.4	15.4	18.5	19.7
4.8	I	.5	.5	.5	.5	.5	1.9	10.8	13.1	15.1	18.3	19.5
5.0	I	.5	.5	.5	.5	.5	.5	10.4	12.6	14.7	17.9	19.4

RIVER FORECAST CENTER
TULSA OKLAHOMA

09-08-75

FLASH FLOOD FORECASTING TABLE

STATE OF OKLAHOMA

FORECAST ZONE 3

MINGO CREEK AT 11TH STREET, TULSA, OKLAHOMA

FOR TOTAL DRAINAGE ABOVE 11TH STREET
GAGE HEIGHT IN FEET

CURRENT FLOW = 150. CFS

CURRENT STAGE = 3.5 FT

FLOOD STAGE = 14.0 FT.
GAGE ZERO = 608.00 FT.-MSL
TIME TO PEAK = 3.5 HOURS

FLASH FLOOD GUIDANCE VALUES		INCHES OF RAINFALL IN 3 HOURS										
		.5	1.0	1.5	2.0	2.5	3.0	4.0	5.0	6.0	8.0	10.0
1.0	I	10.8	12.6	14.1	15.3	16.5	17.2	18.5	19.4	19.9	21.0	22.1
1.2	I	10.0	11.9	13.4	14.7	15.9	16.8	18.3	19.3	19.8	20.9	22.0
1.4	I	9.6	11.7	13.2	14.4	15.7	16.7	18.2	19.2	19.8	20.9	21.9
1.6	I	8.8	11.1	12.4	13.6	15.0	16.2	17.8	18.9	19.6	20.8	21.8
1.8	I	8.1	10.8	12.0	13.1	14.5	15.6	17.4	18.7	19.5	20.6	21.7
2.0	I	5.2	9.9	11.5	12.6	13.9	15.2	17.1	18.5	19.4	20.5	21.5
2.2	I	3.5	8.5	10.9	12.1	13.3	14.7	16.8	18.3	19.3	20.4	21.4
2.4	I	3.5	8.6	10.7	11.8	13.1	14.3	16.5	17.9	19.0	20.3	21.3
2.6	I	3.5	6.9	9.7	11.2	12.4	13.6	15.9	17.5	18.7	20.1	21.1
2.8	I	3.5	3.9	8.6	10.8	11.9	13.2	15.5	17.2	18.5	20.0	21.0
3.0	I	3.5	3.5	7.9	10.1	11.4	12.5	14.6	16.6	18.1	19.8	20.7
3.2	I	3.5	3.5	6.9	9.6	11.1	12.2	14.6	16.6	18.1	19.8	20.7
3.4	I	3.5	3.5	3.5	8.1	10.6	11.7	14.2	16.3	17.8	19.6	20.6
3.6	I	3.5	3.5	3.5	5.9	9.6	11.2	13.7	15.9	17.5	19.5	20.5
3.8	I	3.5	3.5	3.5	3.5	8.5	10.8	13.2	15.5	17.2	19.4	20.4
4.0	I	3.5	3.5	3.5	3.5	7.0	10.1	12.6	15.1	16.9	19.3	20.2
4.2	I	3.5	3.5	3.5	3.5	3.5	8.7	12.2	14.7	16.8	19.2	20.2
4.4	I	3.5	3.5	3.5	3.5	3.5	7.7	11.7	14.1	16.3	18.9	20.0
4.6	I	3.5	3.5	3.5	3.5	3.5	7.4	11.4	13.6	15.5	18.6	19.7
4.8	I	3.5	3.5	3.5	3.5	3.5	4.9	11.1	13.3	15.3	18.3	19.6
5.0	I	3.5	3.5	3.5	3.5	3.5	3.5	10.7	12.8	14.9	18.0	19.4

RIVER FORECAST CENTER
TULSA OKLAHOMA

09-08-75

FLASH FLOOD FORECASTING TABLE

STATE OF OKLAHOMA

FORECAST ZONE 3

MINGO CREEK AT 11TH STREET, TULSA, OKLAHOMA

FOR TOTAL DRAINAGE ABOVE 11TH STREET
GAGE HEIGHT IN FEET

CURRENT FLOW = 300. CFS

CURRENT STAGE = 7.0 FT

FLOOD STAGE = 14.0 FT.
GAGE ZERO = 608.00 FT.-MSL
TIME TO PEAK = 3.5 HOURS

FLASH FLOOD GUIDANCE VALUES		INCHES OF RAINFALL IN 3 HOURS										
		.5	1.0	1.5	2.0	2.5	3.0	4.0	5.0	6.0	8.0	10.0
1.0	I	11.1	12.8	14.3	15.5	16.6	17.3	18.6	19.4	20.0	21.0	22.1
1.2	I	10.7	12.2	13.6	14.9	16.1	16.9	18.4	19.3	19.9	20.9	22.0
1.4	I	10.5	12.0	13.4	14.6	15.8	16.8	18.3	19.2	19.8	20.9	22.0
1.6	I	9.8	11.4	12.6	13.9	15.2	16.4	17.9	19.0	19.7	20.8	21.8
1.8	I	9.1	11.1	12.2	13.4	14.6	15.8	17.5	18.8	19.5	20.7	21.7
2.0	I	7.9	10.6	11.8	12.9	14.1	15.3	17.2	18.6	19.4	20.6	21.6
2.2	I	7.0	9.5	11.3	12.4	13.5	14.8	16.9	18.4	19.3	20.4	21.5
2.4	I	7.0	9.6	11.1	12.1	13.4	14.5	16.6	18.0	19.1	20.3	21.3
2.6	I	7.0	8.4	10.5	11.5	12.6	13.9	16.0	17.6	18.8	20.2	21.2
2.8	I	7.0	7.4	9.7	11.1	12.1	13.4	15.6	17.3	18.6	20.0	21.0
3.0	I	7.0	7.0	8.9	10.7	11.7	12.8	14.8	16.7	18.2	19.8	20.8
3.2	I	7.0	7.0	8.4	10.5	11.4	12.5	14.7	16.7	18.2	19.8	20.8
3.4	I	7.0	7.0	7.0	9.1	10.9	12.0	14.4	16.5	17.9	19.7	20.7
3.6	I	7.0	7.0	7.0	8.1	10.5	11.6	13.9	16.1	17.6	19.6	20.5
3.8	I	7.0	7.0	7.0	7.0	9.5	11.1	13.4	15.7	17.3	19.4	20.4
4.0	I	7.0	7.0	7.0	7.0	8.4	10.7	12.8	15.2	17.0	19.3	20.3
4.2	I	7.0	7.0	7.0	7.0	7.0	9.7	12.4	14.8	16.9	19.3	20.2
4.4	I	7.0	7.0	7.0	7.0	7.0	8.7	12.0	14.3	16.4	19.0	20.0
4.6	I	7.0	7.0	7.0	7.0	7.0	8.5	11.7	13.8	15.7	18.6	19.7
4.8	I	7.0	7.0	7.0	7.0	7.0	7.8	11.4	13.5	15.4	18.4	19.6
5.0	I	7.0	7.0	7.0	7.0	7.0	7.0	11.0	13.1	15.0	18.1	19.4

RIVER FORECAST CENTER
TULSA OKLAHOMA

09-08-75

FLASH FLOOD FORECASTING TABLE

STATE OF OKLAHOMA

FORECAST ZONE 3

MINGO CREEK AT 11TH STREET, TULSA, OKLAHOMA

FOR TOTAL DRAINAGE ABOVE 11TH STREET
GAGE HEIGHT IN FEET

CURRENT FLOW = 767. CFS

CURRENT STAGE = 10.5 FT

FLOOD STAGE = 14.0 FT.
GAGE ZERO = 608.00 FT.-MSL
TIME TO PEAK = 3.5 HOURS

FLASH FLOOD GUIDANCE VALUES		INCHES OF RAINFALL IN 3 HOURS										
		.5	1.0	1.5	2.0	2.5	3.0	4.0	5.0	6.0	8.0	10.0
1.0	I	12.0	13.6	14.8	16.0	16.9	17.6	16.8	19.5	20.1	21.2	22.2
1.2	I	11.7	13.0	14.3	15.4	16.5	17.3	18.6	19.4	20.0	21.1	22.1
1.4	I	11.5	12.8	14.0	15.2	16.3	17.1	18.5	19.4	19.9	21.0	22.1
1.6	I	11.3	12.3	13.4	14.5	15.7	16.7	18.2	19.2	19.8	20.9	21.9
1.8	I	11.0	12.0	13.1	14.0	15.2	16.3	17.9	19.0	19.7	20.8	21.8
2.0	I	10.7	11.6	12.6	13.6	14.7	15.8	17.5	18.8	19.5	20.7	21.7
2.2	I	10.5	11.2	12.2	13.2	14.2	15.4	17.2	18.6	19.4	20.5	21.6
2.4	I	10.5	11.2	12.0	12.9	14.0	15.1	16.9	18.3	19.3	20.4	21.4
2.6	I	10.5	10.8	11.6	12.4	13.4	14.5	16.5	17.9	19.0	20.3	21.3
2.8	I	10.5	10.5	11.2	12.1	13.0	14.1	16.1	17.6	18.8	20.2	21.1
3.0	I	10.5	10.5	11.0	11.7	12.6	13.5	15.3	17.0	18.4	19.9	20.9
3.2	I	10.5	10.5	10.8	11.5	12.3	13.3	15.3	17.0	18.4	19.9	20.9
3.4	I	10.5	10.5	10.5	11.0	11.9	12.8	14.9	16.8	18.2	19.8	20.8
3.6	I	10.5	10.5	10.5	10.7	11.5	12.4	14.5	16.5	17.9	19.7	20.6
3.8	I	10.5	10.5	10.5	10.5	11.2	12.1	14.1	16.1	17.6	19.6	20.5
4.0	I	10.5	10.5	10.5	10.5	10.8	11.7	13.6	15.7	17.3	19.4	20.4
4.2	I	10.5	10.5	10.5	10.5	10.5	11.2	13.2	15.4	17.2	19.4	20.3
4.4	I	10.5	10.5	10.5	10.5	10.5	10.9	12.8	14.9	16.8	19.2	20.2
4.6	I	10.5	10.5	10.5	10.5	10.5	10.9	12.5	14.4	16.1	18.8	19.9
4.8	I	10.5	10.5	10.5	10.5	10.5	10.6	12.3	14.2	15.9	18.6	19.7
5.0	I	10.5	10.5	10.5	10.5	10.5	10.5	12.0	13.8	15.5	18.4	19.5

RIVER FORECAST CENTER
TULSA OKLAHOMA

09-08-75

FLASH FLOOD FORECASTING TABLE

STATE OF OKLAHOMA

FORECAST ZONE 3

MINGO CREEK AT 11TH STREET, TULSA, OKLAHOMA

FOR TOTAL DRAINAGE ABOVE 11TH STREET
GAGE HEIGHT IN FEET

CURRENT FLOW = 767. CFS

CURRENT STAGE = 10.5 FT

FLOOD STAGE = 14.0 FT.
GAGE ZERO = 606.00 FT.-MSL
TIME TO PEAK = 3.5 HOURS

FLASH FLOOD GUIDANCE VALUES		INCHES OF RAINFALL IN 3 HOURS										
		.5	1.0	1.5	2.0	2.5	3.0	4.0	5.0	6.0	8.0	10.0
1.0	I	12.0	13.6	14.8	16.0	16.9	17.6	18.8	19.5	20.1	21.2	22.2
1.2	I	11.7	13.0	14.3	15.4	16.5	17.3	18.6	19.4	20.0	21.1	22.1
1.4	I	11.5	12.8	14.0	15.2	16.3	17.1	18.5	19.4	19.9	21.0	22.1
1.6	I	11.3	12.3	13.4	14.5	15.7	16.7	18.2	19.2	19.8	20.9	21.9
1.8	I	11.0	12.0	13.1	14.0	15.2	16.3	17.9	19.0	19.7	20.8	21.8
2.0	I	10.7	11.6	12.6	13.6	14.7	15.8	17.5	18.8	19.5	20.7	21.7
2.2	I	10.5	11.2	12.2	13.2	14.2	15.4	17.2	18.6	19.4	20.5	21.6
2.4	I	10.5	11.2	12.0	12.9	14.0	15.1	16.9	18.3	19.3	20.4	21.4
2.6	I	10.5	10.8	11.6	12.4	13.4	14.5	16.5	17.9	19.0	20.3	21.3
2.8	I	10.5	10.5	11.2	12.1	13.0	14.1	16.1	17.6	18.8	20.2	21.1
3.0	I	10.5	10.5	11.0	11.7	12.6	13.5	15.3	17.0	18.4	19.9	20.9
3.2	I	10.5	10.5	10.8	11.5	12.3	13.3	15.3	17.0	18.4	19.9	20.9
3.4	I	10.5	10.5	10.5	11.0	11.9	12.8	14.9	16.8	18.2	19.8	20.8
3.6	I	10.5	10.5	10.5	10.7	11.5	12.4	14.5	16.5	17.9	19.7	20.6
3.8	I	10.5	10.5	10.5	10.5	11.2	12.1	14.1	16.1	17.6	19.6	20.5
4.0	I	10.5	10.5	10.5	10.5	10.8	11.7	13.6	15.7	17.3	19.4	20.4
4.2	I	10.5	10.5	10.5	10.5	10.5	11.2	13.2	15.4	17.2	19.4	20.3
4.4	I	10.5	10.5	10.5	10.5	10.5	10.9	12.8	14.9	16.8	19.2	20.2
4.6	I	10.5	10.5	10.5	10.5	10.5	10.9	12.5	14.4	16.1	18.8	19.9
4.8	I	10.5	10.5	10.5	10.5	10.5	10.6	12.3	14.2	15.9	18.6	19.7
5.0	I	10.5	10.5	10.5	10.5	10.5	10.5	12.0	13.8	15.5	18.4	19.5

RIVER FORECAST CENTER
TULSA OKLAHOMA

09-08-75

FLASH FLOOD FORECASTING TABLE

STATE OF OKLAHOMA

FORECAST ZONE 3

MINGO CREEK AT 11TH STREET, TULSA, OKLAHOMA

FOR TOTAL DRAINAGE ABOVE 11TH STREET
GAGE HEIGHT IN FEET

CURRENT FLOW = 5487. CFS

CURRENT STAGE = 16.8 FT

FLOOD STAGE = 14.0 FT.
GAGE ZERO = 608.00 FT.-MSL
TIME TO PEAK = 3.5 HOURS

FLASH FLOOD GUIDANCE VALUES		INCHES OF RAINFALL IN 3 HOURS										
		.5	1.0	1.5	2.0	2.5	3.0	4.0	5.0	6.0	8.0	10.0
1.0	I	17.3	17.9	18.5	18.9	19.3	19.6	20.1	20.7	21.2	22.3	23.4
1.2	I	17.2	17.7	18.3	18.7	19.1	19.5	20.0	20.6	21.1	22.2	23.3
1.4	I	17.1	17.6	18.2	18.6	19.0	19.4	20.0	20.5	21.1	22.2	23.2
1.6	I	17.1	17.4	17.9	18.3	18.8	19.3	19.8	20.4	20.9	22.1	23.1
1.8	I	17.0	17.3	17.7	18.2	18.6	19.0	19.7	20.2	20.8	22.0	23.0
2.0	I	16.9	17.2	17.5	18.0	18.4	18.8	19.6	20.1	20.7	21.8	22.8
2.2	I	16.8	17.0	17.4	17.8	18.2	18.7	19.4	20.0	20.6	21.7	22.7
2.4	I	16.8	17.0	17.3	17.7	18.2	18.5	19.3	19.9	20.4	21.6	22.6
2.6	I	16.8	16.9	17.2	17.5	17.9	18.3	19.1	19.7	20.3	21.4	22.4
2.8	I	16.8	16.8	17.0	17.3	17.7	18.2	19.0	19.6	20.1	21.3	22.3
3.0	I	16.8	16.8	17.0	17.2	17.5	17.9	18.6	19.4	19.9	21.1	22.0
3.2	I	16.8	16.8	16.9	17.1	17.4	17.8	18.6	19.4	19.9	21.1	22.0
3.4	I	16.8	16.8	16.8	17.0	17.3	17.6	18.5	19.3	19.8	20.9	21.9
3.6	I	16.8	16.8	16.8	16.9	17.1	17.5	18.4	19.1	19.7	20.8	21.8
3.8	I	16.8	16.8	16.8	16.8	17.0	17.3	18.2	19.0	19.6	20.7	21.7
4.0	I	16.8	16.8	16.8	16.8	16.9	17.2	17.9	18.8	19.5	20.6	21.5
4.2	I	16.8	16.8	16.8	16.8	16.8	17.0	17.8	18.7	19.4	20.5	21.5
4.4	I	16.8	16.8	16.8	16.8	16.8	17.0	17.6	18.5	19.3	20.3	21.3
4.6	I	16.8	16.8	16.8	16.8	16.8	16.9	17.5	18.3	19.0	20.1	21.0
4.8	I	16.8	16.8	16.8	16.8	16.8	16.9	17.4	18.2	18.9	20.0	20.9
5.0	I	16.8	16.8	16.8	16.8	16.8	16.8	17.3	18.0	18.7	19.9	20.7

RIVER FORECAST CENTER
TULSA OKLAHOMA

09-08-75

FLASH FLOOD FORECASTING TABLE

STATE OF OKLAHOMA

FORECAST ZONE 3

MINGO CREEK AT 11TH STREET, TULSA, OKLAHOMA

FOR TOTAL DRAINAGE ABOVE 11TH STREET
GAGE HEIGHT IN FEET

CURRENT FLOW = 8231. CFS

CURRENT STAGE = 18.5 FT

FLOOD STAGE = 14.0 FT.
GAGE ZERO = 608.00 FT.-MSL
TIME TO PEAK = 3.5 HOURS

FLASH FLOOD GUIDANCE VALUES		INCHES OF RAINFALL IN 3 HOURS										
		.5	1.0	1.5	2.0	2.5	3.0	4.0	5.0	6.0	8.0	10.0
1.0	I	18.8	19.2	19.5	19.7	20.0	20.3	20.8	21.4	21.9	23.0	24.0
1.2	I	18.7	19.1	19.3	19.6	19.9	20.1	20.7	21.2	21.8	22.9	23.9
1.4	I	18.7	19.0	19.3	19.5	19.8	20.1	20.6	21.2	21.7	22.8	23.9
1.6	I	18.7	18.9	19.2	19.4	19.7	19.9	20.5	21.0	21.6	22.7	23.8
1.8	I	18.6	18.8	19.1	19.3	19.5	19.8	20.3	20.9	21.5	22.6	23.6
2.0	I	18.5	18.7	19.0	19.2	19.4	19.7	20.2	20.8	21.4	22.5	23.5
2.2	I	18.5	18.6	18.9	19.1	19.3	19.6	20.1	20.7	21.2	22.4	23.4
2.4	I	18.5	18.6	18.8	19.0	19.3	19.5	20.0	20.5	21.1	22.3	23.3
2.6	I	18.5	18.6	18.7	18.9	19.2	19.4	19.8	20.4	20.9	22.1	23.1
2.8	I	18.5	18.5	18.7	18.8	19.0	19.3	19.8	20.3	20.8	22.0	23.0
3.0	I	18.5	18.5	18.6	18.7	18.9	19.2	19.6	20.0	20.6	21.8	22.7
3.2	I	18.5	18.5	18.6	18.7	18.9	19.1	19.6	20.0	20.6	21.7	22.7
3.4	I	18.5	18.5	18.5	18.6	18.8	19.0	19.5	20.0	20.5	21.6	22.6
3.6	I	18.5	18.5	18.5	18.6	18.7	18.9	19.4	19.9	20.4	21.5	22.5
3.8	I	18.5	18.5	18.5	18.5	18.6	18.8	19.3	19.8	20.3	21.4	22.3
4.0	I	18.5	18.5	18.5	18.5	18.6	18.7	19.2	19.7	20.2	21.3	22.2
4.2	I	18.5	18.5	18.5	18.5	18.5	18.7	19.1	19.6	20.1	21.2	22.2
4.4	I	18.5	18.5	18.5	18.5	18.5	18.6	19.0	19.5	19.9	21.0	22.0
4.6	I	18.5	18.5	18.5	18.5	18.5	18.6	18.9	19.4	19.8	20.8	21.7
4.8	I	18.5	18.5	18.5	18.5	18.5	18.5	18.9	19.3	19.7	20.7	21.5
5.0	I	18.5	18.5	18.5	18.5	18.5	18.5	18.8	19.3	19.6	20.6	21.4

RIVER FORECAST CENTER
TULSA OKLAHOMA

09-08-75

FLASH FLOOD FORECASTING TABLE

STATE OF OKLAHOMA

FORECAST ZONE 3

MINGO CREEK AT 11TH STREET, TULSA, OKLAHOMA

FOR TOTAL DRAINAGE ABOVE 11TH STREET
GAGE HEIGHT IN FEET

CURRENT FLOW = 10975. CFS

CURRENT STAGE = 14.5 FT

FLOOD STAGE = 14.0 FT.
GAGE ZERO = 608.00 FT.-MSL
TIME TO PEAK = 3.5 HOURS

FLASH FLOOD GUIDANCE .VALUES		INCHES OF RAINFALL IN 3 HOURS										
		.5	1.0	1.5	2.0	2.5	3.0	4.0	5.0	6.0	8.0	10.0
1.0	I	19.7	19.9	20.1	20.4	20.7	20.9	21.5	22.0	22.6	23.6	23.6
1.2	I	19.6	19.8	20.0	20.2	20.5	20.8	21.3	21.9	22.5	23.6	23.6
1.4	I	19.6	19.8	20.0	20.2	20.5	20.7	21.3	21.9	22.4	23.5	23.5
1.6	I	19.6	19.7	19.9	20.1	20.3	20.6	21.1	21.7	22.3	23.4	23.4
1.8	I	19.5	19.7	19.8	20.0	20.2	20.5	21.0	21.6	22.2	23.3	23.3
2.0	I	19.5	19.6	19.7	19.9	20.1	20.3	20.9	21.5	22.0	23.2	24.2
2.2	I	19.5	19.6	19.7	19.8	20.0	20.2	20.8	21.3	21.9	23.0	24.1
2.4	I	19.5	19.6	19.7	19.8	20.0	20.2	20.7	21.2	21.8	22.9	23.9
2.6	I	19.5	19.5	19.6	19.7	19.9	20.1	20.5	21.0	21.6	22.8	23.8
2.8	I	19.5	19.5	19.6	19.7	19.8	20.0	20.4	20.9	21.5	22.6	23.6
3.0	I	19.5	19.5	19.5	19.6	19.7	19.9	20.2	20.7	21.2	22.4	23.4
3.2	I	19.5	19.5	19.5	19.6	19.7	19.8	20.2	20.7	21.2	22.4	23.4
3.4	I	19.5	19.5	19.5	19.5	19.6	19.8	20.2	20.6	21.2	22.3	23.3
3.6	I	19.5	19.5	19.5	19.5	19.6	19.7	20.1	20.5	21.0	22.2	23.1
3.8	I	19.5	19.5	19.5	19.5	19.6	19.7	20.0	20.4	20.9	22.0	23.0
4.0	I	19.5	19.5	19.5	19.5	19.5	19.6	19.9	20.3	20.8	21.9	22.9
4.2	I	19.5	19.5	19.5	19.5	19.5	19.6	19.8	20.2	20.8	21.9	22.8
4.4	I	19.5	19.5	19.5	19.5	19.5	19.5	19.8	20.1	20.6	21.7	22.6
4.6	I	19.5	19.5	19.5	19.5	19.5	19.5	19.7	20.0	20.4	21.5	22.3
4.8	I	19.5	19.5	19.5	19.5	19.5	19.5	19.7	20.0	20.4	21.4	22.2
5.0	I	19.5	19.5	19.5	19.5	19.5	19.5	19.7	19.9	20.3	21.2	22.0

RIVER FORECAST CENTER
TULSA OKLAHOMA

09-08-75

FLASH FLOOD FORECASTING TABLE

STATE OF OKLAHOMA

FORECAST ZONE 3

MINGO CREEK AT 11TH STREET, TULSA, OKLAHOMA

FOR TOTAL DRAINAGE ABOVE 11TH STREET
GAGE HEIGHT IN FEET

CURRENT FLOW = 13718. CFS

CURRENT STAGE = 20.2 FT

FLOOD STAGE = 14.0 FT.
GAGE ZERO = 608.00 FT.-MSL
TIME TO PEAK = 3.5 HOURS

FLASH FLOOD GUIDANCE		INCHES OF RAINFALL IN 3 HOURS										
.VALUES		.5	1.0	1.5	2.0	2.5	3.0	4.0	5.0	6.0	8.0	10.0
1.0	I	20.3	20.6	20.8	21.1	21.3	21.6	22.1	22.7	23.2	23.2	23.2
1.2	I	20.3	20.5	20.7	20.9	21.2	21.5	22.0	22.6	23.1	23.1	23.1
1.4	I	20.3	20.4	20.6	20.9	21.1	21.4	22.0	22.5	23.1	24.2	24.2
1.6	I	20.2	20.4	20.5	20.7	21.0	21.3	21.8	22.4	22.9	24.1	24.1
1.8	I	20.2	20.3	20.5	20.6	20.9	21.1	21.7	22.2	22.8	24.0	24.0
2.0	I	20.2	20.3	20.4	20.6	20.8	21.0	21.6	22.1	22.7	23.8	23.8
2.2	I	20.2	20.2	20.4	20.5	20.7	20.9	21.5	22.0	22.6	23.7	23.7
2.4	I	20.2	20.2	20.3	20.5	20.6	20.8	21.3	21.9	22.4	23.6	23.6
2.6	I	20.2	20.2	20.3	20.4	20.5	20.7	21.2	21.7	22.3	23.4	23.4
2.8	I	20.2	20.2	20.2	20.3	20.5	20.6	21.1	21.6	22.2	23.3	23.3
3.0	I	20.2	20.2	20.2	20.3	20.4	20.6	20.9	21.4	21.9	23.1	24.1
3.2	I	20.2	20.2	20.2	20.3	20.4	20.5	20.9	21.4	21.9	23.1	24.0
3.4	I	20.2	20.2	20.2	20.2	20.3	20.4	20.8	21.3	21.8	23.0	23.9
3.6	I	20.2	20.2	20.2	20.2	20.3	20.4	20.7	21.2	21.7	22.8	23.8
3.8	I	20.2	20.2	20.2	20.2	20.2	20.3	20.6	21.1	21.6	22.7	23.7
4.0	I	20.2	20.2	20.2	20.2	20.2	20.3	20.6	21.0	21.5	22.6	23.6
4.2	I	20.2	20.2	20.2	20.2	20.2	20.2	20.5	20.9	21.4	22.5	23.5
4.4	I	20.2	20.2	20.2	20.2	20.2	20.2	20.4	20.8	21.3	22.4	23.3
4.6	I	20.2	20.2	20.2	20.2	20.2	20.2	20.4	20.7	21.1	22.2	23.0
4.8	I	20.2	20.2	20.2	20.2	20.2	20.2	20.4	20.7	21.0	22.0	22.9
5.0	I	20.2	20.2	20.2	20.2	20.2	20.2	20.3	20.6	21.0	21.9	22.7

RIVER FORECAST CENTER
TULSA OKLAHOMA

09-08-75

FLASH FLOOD FORECASTING TABLE

STATE OF OKLAHOMA

FORECAST ZONE 3

MINGO CREEK AT 11TH STREET, TULSA, OKLAHOMA

FOR TOTAL DRAINAGE ABOVE 11TH STREET
GAGE HEIGHT IN FEET

CURRENT FLOW = 16462. CFS

CURRENT STAGE = 20.8 FT

FLOOD STAGE = 14.0 FT.
GAGE ZERO = 608.00 FT.-MSL
TIME TO PEAK = 3.5 HOURS

FLASH FLOOD GUIDANCE VALUES		INCHES OF RAINFALL IN 3 HOURS										
		.5	1.0	1.5	2.0	2.5	3.0	4.0	5.0	6.0	8.0	10.0
1.0	I	21.0	21.2	21.5	21.7	22.0	22.3	22.8	23.4	23.9	23.9	23.9
1.2	I	21.0	21.1	21.4	21.6	21.9	22.1	22.7	23.2	23.8	23.8	23.8
1.4	I	20.9	21.1	21.3	21.5	21.8	22.1	22.6	23.2	23.8	23.8	23.8
1.6	I	20.9	21.0	21.2	21.4	21.7	21.9	22.5	23.1	23.6	23.6	23.6
1.8	I	20.9	21.0	21.2	21.3	21.5	21.8	22.4	22.9	23.5	23.5	23.5
2.0	I	20.8	21.0	21.1	21.2	21.4	21.7	22.2	22.8	23.4	23.4	23.4
2.2	I	20.8	20.9	21.0	21.2	21.3	21.6	22.1	22.7	23.2	23.2	23.2
2.4	I	20.8	20.9	21.0	21.1	21.3	21.5	22.0	22.5	23.1	23.1	23.1
2.6	I	20.8	20.9	20.9	21.1	21.2	21.4	21.9	22.4	22.9	24.1	24.1
2.8	I	20.8	20.8	20.9	21.0	21.1	21.3	21.8	22.3	22.8	24.0	24.0
3.0	I	20.8	20.8	20.9	21.0	21.1	21.2	21.6	22.0	22.6	23.8	23.8
3.2	I	20.8	20.8	20.9	20.9	21.0	21.2	21.6	22.0	22.6	23.7	23.7
3.4	I	20.8	20.8	20.8	20.9	21.0	21.1	21.5	22.0	22.5	23.6	23.6
3.6	I	20.8	20.8	20.8	20.9	20.9	21.1	21.4	21.9	22.4	23.5	23.5
3.8	I	20.8	20.8	20.8	20.8	20.9	21.0	21.3	21.8	22.3	23.4	23.4
4.0	I	20.8	20.8	20.8	20.8	20.9	21.0	21.2	21.7	22.2	23.3	23.3
4.2	I	20.8	20.8	20.8	20.8	20.8	20.9	21.2	21.6	22.1	23.2	24.2
4.4	I	20.8	20.8	20.8	20.8	20.8	20.9	21.1	21.5	22.0	23.0	24.0
4.6	I	20.8	20.8	20.8	20.8	20.8	20.9	21.1	21.4	21.8	22.8	23.7
4.8	I	20.8	20.8	20.8	20.8	20.8	20.8	21.0	21.3	21.7	22.7	23.5
5.0	I	20.8	20.8	20.8	20.8	20.8	20.8	21.0	21.3	21.6	22.6	23.4

RIVER FORECAST CENTER
TULSA OKLAHOMA

CHAPTER VI

SUMMARY AND CONCLUSIONS

Summary

The Flash Flood Forecasting Table has direct, immediate use to the National Weather Service, and to flood prone communities by enabling the professional, technician or layman to make use of the tables and actually forecast a flood. The data shown in this report is but a small measure of the actual development analysis that went into the final development procedure.

Once a hydrologist has become acquainted with the procedure the data could be set up and a set of tables run in 30 minutes. The literature, as listed in Chapter II, is not a complete library on the topic, unit graph, but is an insight into the material and thoughts used in this manual.

The printout from BASIC (Appendix A), gives a more complete tabulation than just unit graph peaks and times to peak. Values will be generated that indicate concentration time, basin slope, and six peak flow values for different flood frequencies. In the calculation of the Mingo Creek rating the value of the 100 year flood was used as one of the flow estimates for the HEC-2 program.

The Dam Break procedure was used, using data from Monument Lake, north of Colorado Springs, Colorado. The BASIC program indicates that a peak discharge of 89,000, cfs could be generated in 17 minutes. The

Dam Break procedure would be most useful when applied to the situation, what if the dam should break, what would happen? The time element is so important when a dam breaks that one must be able to warn the people and still leave them time enough to react. When the safety of a dam is in question, the National Weather Service (NWS) should be able to forecast what would happen to a downstream community. Keeping in mind that it is not NWS responsibility to say if a dam will break, but it is the responsibility of the NWS to forecast downstream flooding.

Conclusions

1. It is possible to prepare a standardized Flash Flood Forecasting table.
2. A reasonable, synethic rating can be developed at any cross section through use of the HEC-2 program.
3. To be able to better serve the community, state and nation the National Weather Service must have available in all its service offices the potential of being able to gage a Flash Flood, rather than a forecast in the general terms of slight, moderate or severe flooding. A flood forecast of near 14 feet over banks is more useful than a forecast of moderate flooding.
4. The potential now is available for the River Center to have an operational Dam Break procedure ready for immediate use.
5. Too often the thought of issuing a Flash Flood forecast is put off until after the storm has occurred. The tables that can be developed through this report now will allow a line forecaster, who may have good reason to believe that a heavy storm will occur over a certain location, to issue a Flash Flood Forecast before the rain has actually fallen over the community.

6. Let it be remembered that the National Weather Service is in business to forecast, not to observe a flood peak flow. A hydrologic tool such as the Flash Flood Forecasting table fills a gap in the forecasting system.

Suggestions for Future Study

1. A study to combine the BASIC, HEC-2 and TABL program into one program.
2. Research on the possibility of using Radar rainfall in the parameter of observed rainfall, thereby enabling real time Flash Flood Forecasting.

SELECTED BIBLIOGRAPHY

1. Sherman, L. K. "Streamflow from Rainfall by the Unit Graph Method." Engineering News Record, Vol. 108 (1932), pp. 501-505.

2. "Hydrology." SCS National Engineering Handbook. Washington, D.C.: USDA, 1972.

3. "Flood-Hydrograph Analysis and Computations." Manuals Corps of Engineers U. S. Army EM 1110-2-1405. Washington, D.C.: Government Printing Office, 1959.

4. Snyder, Franklin F. "Synthetic Unit Graphs." Trans. Am. Soc. Civ. Eng., Part I (1938), pp. 447-454.

5. Viessman, Jr., W., T. E. Harbaugh. Introduction to Hydrology. Place: Intext Educational Publishers, 1972.

6. Wu, I. Pai. "Hydrography Study and Peak Discharge Determination of Hawaiian Small Watersheds, Island of Oahu." Water Resources Research Center, Univ. of Honolulu, Hawaii, 1969.

7. Mockus, V. "Use of Storm and Watershed Characteristics in Synthetic Hydrograph Analysis and Application." Annual Meeting of AGU., Pacific Southwest Region, Sacramento, California, 1957.

8. Holtan, H. N. and D. E. Overton. "Analysis and Application of Simple Hydrograph." Journal of Hydrology, Vol. 1, No. 3 (1963) pp. 250-264.

9. Espey, Jr., W. H., and D. E. Winslow. "The Effects of Urbanization on Unit Hydrographs for Small Watersheds." Office of Water Resources Research USDI, 1968.

10. Espey, Jr., W. H., C. W. Morgan, and F. D. Masch. "A Study of Some Effects of Urbanization on Storm Runoff From a Small Watershed." Technical Report HY DO-7-6501 CRW-2. Place: Center for Research in Water Resources, Hydraulic Engineering Laboratory Dept., Civil Engineering, Univ. of Texas, 1965.

11. Chow, Ven Te. Handbook of Applied Hydrology. New York: McGraw-Hill, 1964.

12. "Flow Through a Breached Dam." Military Hydrology Bulletin 9. Washington, D.C.: Dept. of the Army, 1957.

13. "Ponds for Water Supply and Recreation." SCS Agriculture Handbook No. 387, Washington, D.C.: U.S. Government Printing Office, 1971.

APPENDIX A

BASIC PROGRAM

TABULATION OF BASIC PROGRAM

```
TJ100,CM60000.                SHERIDAN-TULSA
RFL,60000.
FTN(LR,A)
MAP OFF.
REWIND OUTPUT.
SETCORE(INDEF,ADDR)
LGO.
0000000000000000000000
      PROGRAM BASIC(INPUT,OUTPUT,TAPE2=INPUT,TAPE5=OUTPUT)
      DIMENSION XNAME(4), YNAME(4)
      READ(2,100)XNAME
100   FORMAT(4A10)
      READ(2,1)DA
1     FORMAT(F7.1)
C  DA = DRAINAGE AREA IN MILES
C  DAA = DRAINAGE ARE IN ACREA.
      DAA = DA*640.
C  RM = RIVER MILES
      READ(2,2)RM
2     FORMAT(F4.1)
C  RMFT = RIVER DISTANCE IN FEET
      RMFT = RM*5280.
C  HIGH = MAX BASIN ELEVATION
      READ(2,3)HIGH
3     FORMAT(F5.0)
      READ(2,4)ZERO
C  ZERO = ZERO OF GAGE OR STATION
4     FORMAT(F7.2)
C  DIFF = DIFFERENTIAL ELEVATION
      DIFF = HIGH-ZERO
      READ(2,5)DUR
C  DUR = DURATION IN HOURS
5     FORMAT(F4.1)
      XK = 0.43 + 0.0003*DAA
C  TR = TIME FROM PEAK RATE TO END OF TRIANGLE
      TR = 1.38*XK
C  TC = TIME OF CONCENTRATION
      TC = ((11.9*RM**3.)/DIFF)**0.385
C  TP = TIME TO PEAK
      TP = ((DUR/2.)+(0.6*TC))
      QP = DAA*1.0*(2./(TP+TR))
C  QP = TRIANGLE METHOD
      QQP = (484.*DA*1.0)/TC
C  QQP = GENERAL EQUATION
C  QQQP = EMPERICAL
      IF(DA-6.)6,7,7
7     QQQP = 0.32*DAA
      GO TO 14
6     IF(DA-3.0)8,9,9
9     QQQP = 0.6*DAA
```

TABULATION OF BASIC PROGRAM (CONTINUED)

```
      GO TO 14
8     IF (DA-1.0)10,11,11
11    QQQP= 0.9*DAA
10    IF(DA-.01)14,13,13
13    QQQP = 1.4*DAA
      GO TO 14
14    CONTINUE
C  XLAG = EMPERICAL RATIONAL FOR FOR LAG
      XLAG = 0.6*TC
      S = DIFF/RMFT
C  S = SLOPE OF MAX ELEVATION TO GAGE
C  SS = CHANNEL SLOPE
      READ(2,15)SS
C  SS = CHANNEL SLOPE OF 10 TO 85 PERCENT OF BASIN
15    FORMAT(F5.3)
      READ(2,16)ANRF
16    FORMAT(F5.2)
      READ(2,201)URBAN
201   FORMAT(F5.2)
      READ(2,202)XIMP
202   FORMAT(F5.2)
      TRR = (2.68*RMFT**0.223)/( SS/5280.)**0.302
      TRRH = TRR/60.
      QRR= (82500.*DA**0.988)/TRR**1.26
      TRU = (16.4*URBAN*RMFT**0.315)/((( SS/5280.)**0.0488)*
      TRUH = TRU/60.                                XIMP**0.490)
      QRU = (35400.*DA)/TRU**1.10
      Q2 = 0.0568 *DA**0.67*SS**0.37*ANRF**2.0
      Q5 = 0.498*DA**0.66*SS**0.4*ANRF**1.58
      Q10 = 1.081*DA**0.67*SS**0.42*ANRF**1.44
      Q25 = 2.56*DA**0.68*SS**0.44*ANRF**1.27
      Q50 = 5.40*DA**0.69*SS**0.47*ANRF**1.12
      Q100 = 9.14*DA**0.70*SS**0.48*ANRF**1.01
C  PROGRAM FOR RESERVOIR FAULARE
      READ(2,101)DAM
101   FORMAT(F1.0)
      READ(2,49)YNAME
49    FORMAT(4A10)
      IF(DAM-1.)102,102,103
C  SRDAA = SURFACE ACRES
102   READ(2,17)SRDAA
17    FORMAT(F7.2)
C  DEPTH = MAX DEPTH OF RESERVOIR AT DAM
      READ(2,18)DEPTM
18    FORMAT(F7.2)
C  CAP = RESERVOIR CAPACITY
      CAP = SRDAA*0.4*DEPTM
      READ(2,19)RESLN
C  RESLN = RESERVOIR LENGTH
19    FORMAT(F5.2)
      B = 2.*CAP/DEPTM*RESLN
C  QRES = PEAK OUTFLOW OF RESERVOIR
```

TABULATION OF BASIC PROGRAM (CONTINUED)

```
      QRES = (8./27.)*B*32.2**.5*DEPTM**1.5
      TK = CAP/QRES*60.
C   TK = TIME IN MINUTES
      READ(2,60)TW
60    FORMAT(F7.1)
      READ(2,61)DEPTH
61    FORMAT(F7.1)
      CP = (TW/(2.*DEPTH))**2.
      QPQ = CP*4.*(DEPTH**2.5)
      CAPB = SRDAA*0.4*DEPTH
      READ(2,70)CAPBB
70    FORMAT(F12.1)
      IF(CAPBB-1)71,72,72
72    CAPB = CAPBB
71    CONTINUE
      TKK = CAPB/QPQ*60.
      WRITE(5,50)YNAME
50    FORMAT( H1,22X,4A10)
      WRITE(5,62)
62    FORMAT(/,1H ,*TOTAL DAM FAILURE*)
      WRITE(5,42)SRDAA
42    FORMAT(/,1H ,*SURFACE AREA IN ACRES = *,F10.1)
      WRITE(5,43)DEPTM
43    FORMAT(1H ,*MAXIMUN DEPTH AT DAM IN FEET = *,F6.2)
      WRITE(5,44)CAP
44    FORMAT(1H ,*RESERVOIR CAPACITY IN ACFT = *,F11.1)
      WRITE(5,45)RESLN
45    FORMAT(1H , *RESERVOIR LENGTH IN MILES = *,F5.1)
      WRITE(5,47)QRES
47    FORMAT(1H ,*PEAK FLOW AT DAM BREAK IN CFS = *,F11.1)
      WRITE(5,48)TK
48    FORMAT(1H , *RESERVOIR PEAK TIME IN MINUTES = *,F5.2)
      WRITE(5,63)                                            E*)
63    FORMAT(/,1H ,*WEIR BREACH*)
      WRITE(5,64)
64    FORMAT(1H ,*MORE THAN PARABOLIC - LESS THAN RECTANGL
      WRITE(5,65)TW
65    FORMAT(/,1H ,*BREACH WIDTH IN FEET = *,F7.1)
      WRITE(5,66)DEPTH
66    FORMAT(1H ,*BREACH DEPTH IN FEET = *,F7.1)
      WRITE(5,67)QPQ
67    FORMAT(1H ,*PEAK FLOW AT BREACH IN CFS = *,F12.1)
      WRITE(5,68)TKK
68    FORMAT(1H ,*PEAK TIME IN MINUTES AT BREACH = *,F10.2)
103   CONTINUE
      WRITE(5,20)XNAME
20    FORMAT(/////,22X,4A10)
      WRITE(5,21)DA
21    FORMAT(1H0,*DRAINAGE AREA IN SQUARE MILES = *,F7.1)
      WRITE(5,22)RM
22    FORMAT(1H ,*RIVER MILES = *,F4.1)
      WRITE(5,23)HIGH
23    FORMAT(1H ,*MAXIMUM ELEVATION = *,F5.0)
```

TABULATION OF BASIC PROGRAM (CONTINUED)

```
      WRITE(5,24)ZERO
24    FORMAT(1H ,*ZERO OF GAGE = *,F7.2)
      WRITE(5,25) DUR
25    FORMAT (1H ,*STORM DURATION IN HOURS = *,F4.1)
      WRITE(5,26)XK
26    FORMAT(1H ,*RECESSION CONSTANT = *,F5.2)
      WRITE(5,27)TC
27    FORMAT(1H , *TIME OF CONCENTRATION = *,F5.2)
      WRITE (5,28)TP
28    FORMAT(1H , *TIME TO PEAK IN HOURS = *,F5.2)
      WRITE(5,29)QP
29    FORMAT(1H ,*MAXIMUM FLOW(TRIANGLE METHOD) IN CFS = *,F11.1)
      WRITE (5,30)QQP
30    FORMAT(1H ,*MAXIMUM FLOW (GENERAL EQUATION) IN CFS = *,F11.1)
      WRITE(5,31)QQQP
31    FORMAT(1H ,*MAXIMUN BY HONOLULU METHOD IN CFS = *,F11.1)
      WRITE(5,203)TRRH
203   FORMAT(1H ,*TIME TO PEAK (HOUSTON RURAL METHOD) IN HOURS = *,F5.2)
      WRITE(5,204)QRR
204   FORMAT(1H ,*UNIT FLOW (HOUSTON RURAL METHOD) IN CFS = *,F11.1)
      WRITE(5,205)TRUH
205   FORMAT(1H ,*TIME TO PEAK (HOUSTON URBAN METHOD) IN HOURS = *,F5.2)
      WRITE(5,206)QRU
206   FORMAT(1H ,*UNIT FLOW (HOUSTON URBAN METHOD) IN CFS = *,F11.1)
      WRITE(5,32)XLAG
32    FORMAT(1H ,*EMPERICAL LAG = *, F5.2)
      WRITE(5,33)S
33    FORMAT(1H , *BASIN SLOPE = *,F5.4)
      WRITE(5,35)ANRF
35    FORMAT(1H ,*MEAN ANNUAL RAINFALL FOR BASIN = *, F5.2)
      WRITE(5,36)Q2
36    FORMAT(1H ,*TWO YEAR FLOOD FREQUENCY IN YEARS = *,F7.1)
      WRITE(5,37)Q5
37    FORMAT(1H ,*FIVE YEAR FLOOD FREQUENCY IN CFS = *, F7.1)
      WRITE(5,38)Q10
38    FORMAT(1H ,*TEN YEAR FLOOD FREQYENCY IN CFS = *, F7.1)
      WRITE(5,39)Q25
39    FORMAT(1H ,*TWENTY FIVE YEAR FLOOD FREQUENCY IN CFS = *, F7.1)
      WRITE(5,40)Q50
40    FORMAT(1H ,*FIFTY UEAR FLOOD FREQUENCY IN CFS = *,F7.1)
      WRITE(5,41)Q100
41    FORMAT(1H ,*100 YEAR FLOOD FREQUENCY IN CFS = *,F7.1)
      END
```

BASIC INPUT DATA

```
MINGO CREEK AT 11TH STREET
25.6
8.
770.
603.
3.
10.
20.
1.
30.
1.
```

```
MONUMENT LAKE  MONUMENT CREEK  COLORADO
800.
240.
1.5
100.
80.
0.0
```

BASIC OUTPUT

MONUMENT LAKE MONUMENT CREEK COLORADO

TOTAL DAM FAILURE

SURFACE AREA IN ACRES = 800.0
MAXIMUN DEPTH AT DAM IN FEET = 240.00
RESERVOIR CAPACITY IN ACFT = 76800.0
RESERVOIR LENGTH IN MILES = 1.5
PEAK FLOW AT DAM BREAK IN CFS = 6001257.4
RESERVOIR PEAK TIME IN MINUTES = .77

WEIR BREACH
MORE THAN PARABOLIC - LESS THAN RECTANGLE

BREACH WIDTH IN FEET = 100.0
BREACH DEPTH IN FEET = 80.0
PEAK FLOW AT BREACH IN CFS = 89442.7
PEAK TIME IN MINUTES AT BREACH = 17.17

MINGO CREEK AT 11TH STREET

DRAINAGE AREA IN SQUARE MILES = 25.6
RIVER MILES = 8.0
MAXIMUM ELEVATION = 770.
ZERO OF GAGE = 608.00
STORM DURATION IN HOURS = 3.0
RECESSION CONSTANT = 5.35
TIME OF CONCENTRATION = 4.04
TIME TO PEAK IN HOURS = 3.92
MAXIMUM FLOW(TRIANGLE METHOD) IN CFS = 2899.6
MAXIMUM FLOW (GENERAL EQUATION) IN CFS = 3066.2
MAXIMUN BY HONOLULU METHOD IN CFS = 5242.9
TIME TO PEAK (HOUSTON RURAL METHOD) IN HOURS = 3.19
UNIT FLOW (HOUSTON RURAL METHOD) IN CFS = 2707.7
TIME TO PEAK (HOUSTON URBAN METHOD) IN HOURS = 2.01
UNIT FLOW (HOUSTON URBAN METHOD) IN CFS = 4657.1
EMPERICAL LAG = 2.42
BASIN SLOPE = .0038
MEAN ANNUAL RAINFALL FOR BASIN = 36.00
TWO YEAR FLOOD FREQUENCY IN YEARS = 1515.2
FIVE YEAR FLOOD FREQUENCY IN CFS = 3059.3
TEN YEAR FLOOD FREQYENCY IN CFS = 4349.3
TWENTY FIVE YEAR FLOOD FREQUENCY IN CFS = 6058.3
FIFTY UEAR FLOOD FREQUENCY IN CFS = 8263.0
100 YEAR FLOOD FREQUENCY IN CFS = 9967.3

APPENDIX B

HEC-2 PROGRAM

FILE TS FOR 0.25 INCHES OF RUNOFF TO FLOOD

.07	.28	.52	.81	1.21	1.66	2.64	3.71	4.80	6.98	8.90
.03	.21	.43	.69	1.06	1.48	2.42	3.45	4/55	6/75	9/66
.00	.15	.34	.57	.92	1.30	2.21	3.22	4.30	6.52	8.41
0.00	.12	.28	.49	.81	1.17	2.05	3.05	4.11	6.35	8.23
0.00	.05	.19	.37	.63	.92	1.71	2.67	3.72	5.96	7.81
0.00	.01	.13	.29	.52	.80	1.48	2.40	3.43	5.68	7.50
0.00	0.00	.07	.22	.40	.67	1.39	2.29	3.30	5.49	7.31
0.00	0.00	0.00	.11	.33	.58	1.30	2.25	3.28	5.40	7.27
0.00	0.00	0.00	.10	.28	.49	1.08	1.82	2.70	4.95	6.70
0.00	0.00	0.00	.01	.18	.38	.88	1.58	2.42	4.56	6.28
0.00	0.00	0.00	0.00	.10	.29	.76	1.42	2.23	4.31	5.99
0.00	0.00	0.00	0.00	.04	.21	.65	1.25	2.03	4.02	5.67
0.00	0.00	0.00	0.00	0.00	.15	.56	1.10	1.84	3.78	5.35
0.00	0.00	0.00	0.00	0.00	.08	.47	1.06	1.78	3.77	5.40
0.00	0.00	0.00	0.00	0.00	.03	.38	.94	1.63	3.58	5.19
0.00	0.00	0.00	0.00	0.00	0.00	.29	.82	1.49	3.39	4.98
0.00	0.00	0.00	0.00	0.00	0.00	.21	.69	1.47	3.34	5.05
0.00	0.00	0.00	0.00	0.00	0.00	.11	.55	1.15	2.76	4.22
0.00	0.00	0.00	0.00	0.00	0.00	.07	.46	1.03	2.65	4.11
0.00	0.00	0.00	0.00	0.00	0.00	.02	.38	.92	2.42	3.83
0.00	0.00	0.00	0.00	0.00	0.00	0.00	.28	.80	2.31	3.73

FILE TS FOR 0.50 INCHES OF RUNOFF TO FLOOD

.21	.52	.89	1.31	1.82	2.33	3.38	4.44	5.49	7.58	9.55
.17	.43	.74	1.12	1.62	2.13	3.18	4.25	5.31	7.43	9.39
.1	.32	.59	.89	1.32	1.78	2.81	3.89	4.97	4.13	9.06
.06	.26	.49	.77	1.17	1.61	2.57	3.64	4.73	6.92	8.84
.82	.18	.39	.65	1.01	1.41	2.34	3.37	4.46	6.67	8.57
0.00	.13	.30	.52	.85	1.23	2.12	3.12	4.19	6.42	8.31
0.00	.08	.23	.42	.69	1.01	1.85	2.83	3.89	6.13	7.99
0.00	.04	.17	.34	.59	.88	1.63	2.58	3.62	5.87	7.71
0.00	0.00	.10	.25	.48	.75	1.41	2.28	3.31	5.56	7.37
0.00	0.00	.08	.22	.44	.70	1.35	2.18	3.21	5.46	7.26
0.00	0.00	.01	.13	.31	.54	1.15	1.90	2.82	5.07	6.83
0.00	0.00	0.00	.07	.25	.45	1.01	1.74	2.61	4.82	6.55
0.00	0.00	0.00	.00	.17	.36	.85	1.54	2.38	4.51	6.21
0.00	0.00	0.00	0.00	.10	.28	.74	1.36	2.17	4.22	5.89
0.00	0.00	0.00	0.00	.05	.21	.63	1.20	1.96	3.96	5.56
0.00	0.00	0.00	0.00	.00	.15	.53	1.07	1.76	3.71	5.22
0.00	0.00	0.00	0.00	0.00	.06	.41	1.02	1.83	3.79	5.45
0.00	0.00	0.00	0.00	0.00	0.00	.33	.87	1.73	3.72	5.51
0.00	0.00	0.00	0.00	0.00	0.00	.26	.76	1.51	3.39	5.03
0.00	0.00	0.00	0.00	0.00	0.00	.21	.69	1.47	3.34	5.05
0.00	0.00	0.00	0.00	0.00	0.00	.16	.60	1.22	3.02	4.57

FILE TS FOR 0.75 INCHES OF RUNOFF TO FLOOD

.34	.77	1.22	1.70	2.21	2.73	3.76	4.79	5.82	7.86	9.85
.25	.60	1.00	1.44	1.96	2.47	3.52	4.57	5.61	7.69	9.66
.22	.54	.92	1.34	1.85	2.37	3.42	4.47	5.53	7.61	9.59
.16	.42	.71	1.08	1.58	2.09	3.14	4.21	5.27	7.40	9.35
.12	.34	.61	.92	1.36	1.83	2.88	3.95	4.03	7.18	9.12
.08	.24	.49	.78	1.16	1.63	2.67	3.73	4.80	6.94	8.88
0.00	.15	.38	.66	.97	1.43	2.45	3.51	4.57	6.70	8.64
0.00	.15	.34	.57	.92	1.30	2.21	3.22	4.30	6.52	8.41
0.00	.07	.23	.43	.72	1.08	1.94	2.92	3.98	6.19	8.07
0.00	.01	.15	.35	.59	.93	1.77	2.73	3.77	5.96	7.83
0.00	0.00	.10	.25	.48	.75	1.41	2.28	3.31	5.56	7.37
0.00	0.00	.07	.22	.40	.67	1.39	2.29	3.30	5.49	7.31
0.00	0.00	0.00	.11	.30	.54	1.26	2.15	3.14	5.28	7.12
0.00	0.00	0.00	.05	.22	.44	1.09	1.96	2.94	5.05	6.89
0.00	0.00	0.00	0.00	.14	.35	.93	1.78	2.73	4.83	6.65
0.00	0.00	0.00	0.00	.07	.26	.77	1.59	2.53	4.61	6.42
0.00	0.00	0.00	0.00	0.00	.16	.66	1.43	2.43	4.48	6.33
0.00	0.00	0.00	0.00	0.00	.09	.54	1.23	2.13	4.16	5.96
0.00	0.00	0.00	0.00	0.00	.08	.47	1.06	1.78	3.77	5.40
0.00	0.00	0.00	0.00	0.00	.03	.41	.97	1.67	3.54	5.12
0.00	0.00	0.00	0.00	0.00	0.00	.33	.84	1.51	3.28	4.82

FILE TS FOR 1.00 INCHES OF RUNOFF TO FLOOD

.50	1.00	1.50	2.00	2.50	3.00	4.00	5.00	6.00	8.00	10.00
.38	.83	1.30	1.79	2.31	2.82	3.85	4.87	4.89	7.91	9.91
.30	.69	1.12	1.58	2.10	2.61	3.65	4.69	5.73	7.78	9.77
.22	.54	.92	1.34	1.85	2.37	3.42	4.47	5.53	7.61	9.59
.9	.46	.81	1.21	1.71	2.23	3.28	4.34	5.40	7.50	9.47
.15	.41	.70	1.04	1.54	2.05	3.10	4.16	5.23	7.36	9.31
.13	.36	.64	.95	1.40	1.90	2.96	4.03	5.10	7.25	9.19
.04	.22	.45	.71	1.09	1.51	2.47	3.51	4.60	6.80	8.71
.01	.16	.36	.61	.96	1.35	2.27	3.29	4.37	6.59	8.48
0.00	.14	.31	.54	.88	1.26	2.15	3.16	4.23	6.46	8.35
0.00	.08	.23	.42	.69	1.01	1.85	2.83	3.89	6.13	7.99
0.00	.04	.18	.35	.61	.90	1.66	2.61	3.66	5.91	7.75
0.00	0.00	.13	.29	.51	.79	1.54	2.47	3.50	5.71	7.55
0.00	0.00	0.00	.09	.32	.61	1.40	2.40	3.43	5.52	7.42
0.00	0.00	0.00	0.00	.21	.47	1.19	2.18	3.21	5.28	7.18
0.00	0.00	0.00	.10	.29	.50	1.10	1.84	2.73	4.98	6.73
0.00	0.00	0.00	0.00	0.00	.23	.87	1.75	2.76	4.81	6.70
0.00	0.00	0.00	0.00	.15	.35	.83	1.51	2.35	4.46	6.16
0.00	0.00	0.00	0.00	.03	.21	.66	1.30	2.09	4.11	5.77
0.00	0.00	0.00	0.00	0.00	.14	.57	1.14	1.90	3.83	5.45
0.00	0.00	0.00	0.00	0.00	.06	.41	1.02	1.83	3.79	5.46

INPUT FOR COMPLETE BASIN ANALYSIS

```
T1       RIVER FORECAST CENTER  TULSA OKLAHOMA
T2       MINGO CREEK  TULSA CITY-COUNTY  OKLAHOMA
T3       COMPLETE BASIN ANALYSIS
J1                2                                                      590.
J2        1       1
J3        1      34        3        4       27       28        9
QT       11    9967      325      758     1366     2168     2516     3035     3764     4878
QT     7588   30355
FT        3       0     10.4      5.4
NC      .06     .12      .15
X1      1.0      32     1545     1693        0        0        0
GR    591.5       0    581.3       30    579.1       55    579.2      360    581.8      385
GR    582.5     490    582.5      590    582.2      695    582.3      800    582.4      900
GR    582.1    1000    581.9     1090    578.6     1115    578.2     1140    578.6     1230
GR    578.9    1340    578.9     1405    579.8     1470    579.5     1545    574.1     1568
GR    568.5    1585    556.9     1610    553.9     1615    551.5     1625    551.5     1633
GR    553.9    1654    556.6     1652    575.6     1672    580.0     1693    579.5     1715
GR    579.1    1745    596.0     1805
X1      1.1      37     1805     1960      575      575      825        0        0        0
X3       10
GR    597.5       0    590.2      120    587.2      225    586.0      335    581.8      445
GR    579.9     550    579.7      685    578.0      820    577.8     1040    577.6     1160
GR    577.8    1355    576.8     1455    577.1     1565    578.0     1665    579.7     1805
GR    578.8    1820    575.9     1840    572.5     1860    560.2     1880    553.2     1895
GR    551.0    1910    557.2     1920    560.2     1930    570.7     1945    576.2     1950
GR    576.2    1960    573.5     1970    573.1     1990    579.2     2025    579.4     2040
GR    576.6    2160    576.5     2210    574.2     2265    576.9     2300    577.2     2340
GR    589.3    2410    597.5     2420
NC      .04     .04      .08       .3       .5
X1      1.9      52     2700     2883       50       50       50
X2                                590    593.3
GR    601.2       0    600.8       80    600.7      170    601.0      340    600.2      630
GR    600.2     510    601.0      600    600.3      680    600.0      770    559.0      860
GR    593.3    1160    591.7     1260    590.4     1360    589.2     1460    588.1     1550
GR    587.5    1650    587.3     1750    587.2     1850    589.1     2150    587.8     2250
GR    593.3    2700    590.0     2701    571.0     2738    571.0     2748    570.0     2755
GR    564.5    2759    590.0     2759    590.0     2763    566.0     2763    561.0     2773
GR    556.0    2788    556.0     2805    559.0     2817    560.5     2819    590.0     2819
GR    590.0    2823    563.5     2823    566.5     2827    571.0     2837    580.0     2862
GR    580.0    2864    590.0     2882    593.3     2883    592.2     2980    590.5     3090
GR    589.3    3200    587.4     3300    589.3     3350    588.9     3460    588.2     3560
GR    587.5    3630    601.0     3640
X1      2.0       0        0        0       50       50       50        0       .1        0
NC      .04     .07      .15
X1      2.1      37     1805     1960       50       50       50        0        0        0
X3       10
GR    597.9       0    590.6      120    587.6      225    586.4      335    582.3      445
GR    580.4     550    580.1      685    578.4      820    578.2     1040    578.0     1160
GR    578.3    1355    577.2     1455    577.5     1565    578.4     1665    580.1     1805
GR    579.2    1820    576.3     1840    572.9     1860    560.6     1880    553.6     1895
GR    551.4    1910    557.6     1920    560.6     1930    571.1     1945    576.6     1950
GR    574.6    1960    574.0     1970    573.5     1990    579.6     2025    579.8     2040
GR    577.0    2160    576.9     2210    574.6     2265    576.8     2300    577.6     2340
GR    583.7    2410    597.3     2420
X1      3.0       0        0        0      125      125      125        0       .1        0
NC      .07     .08      .15
X1      4.0      36     3400     3620     2000     2000     3340
X2
GR    601.7     460    597.2      800    594.6      900    594.7     1240    590.2     1540
GR    591.2    1640    590.0     1750    585.4     1960    585.5     2070    584.8     2180
GR    583.5    2280    583.0     2390    581.2     2490    580.1     2600    580.7     2710
GR    580.3    2820    580.2     2920    579.7     3030    579.5     3140    580.0     3190
GR    579.6    3290    580.1       34    572.0     3500    567.4     3540    561.2     3550
GR    561.0    3590    578.8     3620    579.9     3740    579.8     3770    578.7     3880
GR    578.2    3990    580.5     4090    586.9     4190    589.6     4290    598.0     4590
GR    600.0    5120
NC      .10     .12      .15
X1      4.9      30     1795     1935     2800     2800     5040        0        0        0
X3      10.
GR    598.0       0    597.3      100    596.5      210    595.6      320    594.1      640
GR    589.7     640    587.9      740    587.2      850    586.5      960    586.1     1075
GR    585.6    1180    585.7     1300    585.0     1410    586.1     1520    583.6     1630
GR    581.8    1650    583.0     1795    576.8     1820    568.8     1835    568.2     1840
GR    568.8    1850    569.6     1857    579.7     1863    577.2     1900    582.6     1935
GR    583.4    2030    581.7     2130    583.9     2240    589.0     2310    602.0     3080
X1     4.95       0        0        0      130      130      130        0       .1        0
X3       10
NC      .04     .04      .12       .3       .5
X1      5.0      28     1840     1900        1        1        1
X2                              583.9    586.6
GR    598.0       0    597.3      100    596.5      210    595.6      320    594.1      440
GR    589.7     640    587.9      740    587.2      650    586.5      960    586.1     1065
GR    585.6    1180    585.7     1300    586.0     1410    586.1     1520    586.3     1630
GR    587.5    1770    586.6     1840    572.1     1841    571.2     1855    565.9     1870
GR    562.2    1876    568.9     1898    586.5     1900    586.5     2000    586.9     2100
GR    587.5    2230    589.0     2300    602.0     3080
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INPUT FOR COMPLETE BASIN ANALYSIS (CONTINUED)

```
NC   .08     .12     .15
X1  5.05       0       0       0      98      98      98       0      .1
X1   5.1      28    1840    1955       1       1       1
X3    10
GR 598.0       0   597.3     100   596.5     210   595.6     320   594.1     640
GR 589.7     640   587.9     760   587.2     850   586.5     960   586.1    1075
GR 585.6    1180   585.7    1300   586.0    1410   586.1    1600   581.7    1630
GR 580.7    1725   582.5    1840   579.5    1850   569.2    1868   567.2    1876
GR 569.5    1890   570.5    1930   580.8    1955   584.0    2050   582.7    2145
GR 583.9    2240   589.0    2310   602.0    3080
NC   .08     .12     .15
X1   6.0      23    1240    1420    2500    2500    2910
GR 608.6       0   608.4     120   608.1     220   607.8     310   606.8     420
GR 605.0     530   602.1     610   597.9     710   588.7     830   585.7     940
GR 586.0    1140   585.9    1220   585.3    1240   576.5    1250   572.0    1260
GR 571.6    1270   574.8    1310   577.0    1311   580.3    1370   597.7    1415
GR 600.8    1420   604.4    1530   609.5    1740
NC  .100    .100    .150
X1   6.9      21     380     520    2500    2500    3200
X3   10.
GR   614       0   613.9      70   612.8      95   591.8     200   590.0     260
GR 587.1     340   584.5     380   578.5     420   574.5     450   574.5     460
GR 574.9     490   591.5     520   600.0     600   605.1     700   608.0     790
GR 610.3   890.0   612.1    1000   611.2    1210   611.4    1420   612.6    1520
GR 614.5    1620
NC   .04     .04     .04
X1     7      29     460     580     100     100     100
X3   10.
GR   614       0   613.7      20   606.1     120   599.2     220   597.1     330
GR 597.3     420   598.2     460   581.2     464   581.2     475   574.1     490
GR 595.0     490     595     492   574.1     492   574.1   545.0   595.0     545
GR   595     547   574.1   547.0   578.4   551.0   584.8   564.0   595.0   580.0
GR 598.2   580.0   600.3   670.0   605.5   780.0   610.3   890.0   612.1  1000.0
GR 611.2  1210.0   611.4  1420.0   612.6  1520.0   614.5  1620.0
NC   .10     .10     .15
X1   7.1      26     565     705     100     100     100                       1
X3   10.
GR 614.0       0   612.9   160.0   607.3   230.0   603.1   260.0   598.8   280.0
GR 592.8   320.0   589.9   405.0   584.0   470.0   585.2   520.0   586.7   565.0
GR 577.7   575.0   576.6   620.0   577.6   650.0   578.6   660.0   585.7   660.0
GR 589.3   680.0   594.1   705.0   601.2   785.0   607.1   885.0   609.3   955.0
GR 610.8  1045.0   611.6  1120.0   611.2  1210.0   611.4  1420.0   612.6  1520.0
GR 614.5  1620.0
NC   .12     .12     .15
X1     8      37    2583    2730    1200    1200    1430       0       0       1
X3   10.
GR 618.9       0   616.7     190   613.5     285   609.8     475   615.4     710
GR 615.0     735   615.4     770   616.4     830   616.2     925   614.2    1025
GR 611.9    1120   610.6    1310   611.5    1405   613.3    1495   614.8    1590
GR 614.5    1685   613.1    1775   611.1    1885   610.4    1985   609.8    2010
GR 606.1    2105   598.6    2225   596.6    2250   597.8    2280   593.9    2310
GR 594.0    2400   592.7    2450   590.5    2555   590.4    2583   584.7    2608
GR 581.9    2615   577.9    2620   576.4    2630   576.6    2640   581.9    2650
GR 609.6    2730   615.9    2835
NC   .10     .08     .15
X1     9      59    3260    3400    2600    2600    6890                       1
X3   10.
GR 622.0       0   622.0      70   620.9     120   616.5     220   612.5     320
GR 609.0     420   608.6     490   605.8     590   603.3     790   603.0     890
GR 603.6     990   601.9    1100   602.5    1200   600.1    1290   600.0    1400
GR 598.0    1500   597.4    1600   595.5    1700   594.8    1720   595.9    1740
GR 595.6    1790   599.7    1810   594.0    1830   594.0    1900   600.0    1920
GR 596.0    1940   596.3    2060   597.4    2230   598.0    2430   597.3    2510
GR 597.9    2560   596.9    2670   594.4    3080   596.6    3170   597.7    3260
GR 593.9    3280   593.7    3290   586.1    3310   585.1    3315   588.0    3350
GR 597.5    3360   600.0    3400   604.2    3550   604.4    3650   602.0    3750
GR 601.0    3890   601.3    3990   601.2    4080   602.9    4270   602.7    4400
GR 603.7    4500   604.0    4600   605.6    4800   606.8    4870   608.1    4900
GR 608.5    4940   613.5    4980   614.2    5000   616.0    5001
NC   .10     .06     .15
X1   9.9      40    2200    2335    1300    1300    2560                       1
X3   10.
GR 622.3       0   617.7     250   612.1     290   606.7     420   603.5     520
GR 601.2     690   600.2     850   599.7    1050   596.3    1280   578.2    1450
GR 598.0    1620   597.9    1790   597.8    2000   598.4    2200   595.7    2220
GR 596.4    2250   586.2    2255   583.2    2275   586.2    2290   598.0    2305
GR 598.4    2335   598.5    2480   598.6    2680   598.9    2840   599.1    2970
GR 600.3    3300   601.5    3420   606.0    3620   609.5    3760   611.5    3920
GR 612.8    4060   613.5    4200   613.8    4360   614.8    4610   614.7    4700
GR 614.4    4800   614.4    4900   613.8    4930   616.1    4960   620.0    5000
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INPUT FOR COMPLETE BASIN ANALYSIS (CONTINUED)

```
NC.04    .04      .04
X1    10       41     2250     2335      100      100      100                        1
X3    10.
GR 622.3        0    617.7    250.0    612.1    290.0    606.7    420.0    603.5    520.0
GR 601.2    690.0    600.2    850.0    599.7   1050.0    598.3   1280.0    598.2   1450.0
GR 598.0   1620.0    597.9   1790.0    597.8   2000.0    598.4   2200.0    600.4   2250.0
GR 586.1   2250.0    586.1   2274.0    585.1   2293.0    586.1   2318.0    686.1   2335.0
GR 600.4   2335.0    599.0   2400.0    598.5   2480.0    598.6   2680.0    599.9   2840.0
GR 599.1   2970.0    600.3   3200.0    601.5   3420.0    606.0   3620.0    609.5   3760.0
GR 611.5   3920.0    611.8   4060.0    613.5   4200.0    613.8   4360.0    614.8   4610.0
GR 614.7   4700.0    614.4   4800.0    614.4   4900.0    613.8   4930.0    616.1     4960
GR 620.0   5000.0
NC.10    .08      .15
X1    10.1     39     2200     2335      100      100      100                        1
X3    10.
GR 622.3        0    617.7    250.0    612.1    290.0    606.7    420.0    603.5    520.0
GR 601.2    690.0    600.2    850.0    599.7   1050.0    598.3   1280.0    598.2   1450.0
GR 598.0   1620.0    597.9   1790.0    597.8   2000.0    597.9   2200.0    597.5   2250.0
GR 594.8   2265.0    586.2   2270.0    584.9   2315.0    598.7   2335.0    598.6   2365.0
GR 598.5   2480.0    598.6   2680.0    598.9   2840.0    599.1   2970.0    600.3   3200.0
GR 601.5   3420.0    606.0   3620.0    609.5     3760    611.5   3920.0    612.8   4060.0
GR 613.5   4200.0    613.8   4360.0    614.8   4610.0    614.7   4700.0    614.4   4800.0
GR 614.4   4900.0    613.8     4930    616.1     4960    620.0     5000
NC    .12     .12      .15
X1    11       36     1820     2010     2550     2350     3150                        1
X3    10.
GR 622.0        0    607.1     60.0    604.5    110.0    603.7    190.0    600.7    290.0
GR 602.2    390.0    602.6    580.0    601.8    680.0    600.5    780.0    602.0    880.0
GR 601.0   1090.0    601.1   1190.0    600.1   1290.0    599.2   1420.0    599.4   1510.0
GR 598.5   1600.0    598.4   1720.0    599.2   1810.0    603.1   1820.0    599.3   1830.0
GR 594.8   1960.0    586.1   2000.0    597.9   2010.0    597.0   2030.0    600.3   2150.0
GR 598.5   2250.0    600.6   2350.0    600.8   2550.0    602.2   3000.0    603.1   3100.0
GR 603.2   3200.0    606.6   3500.0    614.7   3800.0    616.1   3910.0    619.8   4480.0
GR 623.5   4560.0
NC.05    .05      .08
X112.    67.      4155.    4350.    100.     100.     100.
X3    10.
GR621.   0.       618.4    800.     613.3    1300.    612.5    1400.    612.00   1500.
GR611.7 1620.     611.3    1710.    611.     1810.    610.8    1910.    610.8    2010.
GR610.7 2110.     609.5    2480.    609.7    2570.    609.5    2660.    609.6    2880.
GR608.2 4155.     600.2    4156.    598.5    4164.    604.1    4164.    604.1    4166.
GR597.9 4166.     594.7    4175.    604.1    4175.    604.1    4177.    594.     4177.
GR592.4 4189.     604.1    4189.    604.1    4191.    592.2    4191.    591.7    4203.
GR604.1 4203.     604.1    4205.    591.6    4205.    591.2    4218.    604.1    4218.
GR604.1 4220.     591.8    4220.    589.2    4233.    604.1    4233.    604.1    4236.
GR588.7 4238.     588.7    4250.    586.9    4270.    586.9    4280.    588.7    4289.
GR592.2 4293.     604.1    4293.    604.1    4298.    594.5    4298.    596.3    4310.
GR604.1 4310.     604.1    4312.    596.5    4312.    597.0    4323.    604.1    4323.
GR604.1 4325.     597.2    4325.    598.6    4337.    604.1    4337.    604.1    4339.
GR599.0 4339.     602.8    4347.    608.2    4350.    609.4    5240.    611.7    5630.
GR615.6 6040.     620.0    6300.
NC.10    .10      .12
X113.    27.      2720.    2930.    400.     400.     400.
X3    10.
GR620.0           612.0    1.0      612.0    2500.    601.9    2630.    601.9    2720.
GR590.8 2780.     587.9    2810.    588.7    2840.    596.7    2850.    596.4    2880.
GR601.9 2930.     602.5    3040.    601.6    3120.    601.3    3260.    602.3    3320.
GR604.7 3750.     604.8    3850.    605.8    3950.    606.4    4150.    607.7    4260.
GR608.2 4380.     607.8    4480.    608.5    4590.    605.0    4700.    598.8    5310.
GR597.8 5350.     620.0    5400.
NC.08    .10      .15
X114.    32.      1940.    2150.    2000.    1900.    2920.
X218500.
X3    10.
GR620.0           607.7    30.      606.9    40.0     608.6    60.0     616.4    170.
GR609.2 420.      607.5    520.0    607.2    620.0    605.9    700.0    605.4    810.0
GR604.3 920.0     604.0    1010.    604.5    1140.    604.6    1230.    604.2    1260.
GR605.5 1360.     605.1    1480.    605.4    1580.    606.4    1880.    605.6    1940.
GR594.7 1960.     591.0    1980.    595.0    2010.    597.9    2090.    605.6    2150.
GR604.4 2270.     604.5    2380.    603.8    2480.    604.8    2580.    606.5    2850.
GR612.9 3060.     620.2    3250.
NC.04    .04      .10
X115.    35.      1640.    1822.    400.     400.     400.
X3    10.
GR620.0           617.6    1.000    616.6    100.0    613.7    270.0    611.9    390.
GR610.5 560.0     610.3    710.0    610.7    850.0    611.6    1030.    614.2    1490.
GR615.3 1640.     610.0    1641.    593.0    1694.    593.0    1699.    611.6    1699.
GR611.6 1702.     591.0    1702.    593.0    1759.    611.6    1759.    611.6    1762.
GR593.0 1762.     591.8    1768.    610.0    1820.    615.8    1822.    614.7    1960.
GR613.6 2170.     611.1    2230.    617.1    2470.    611.5    2600.    610.9    2760.
GR610.8 2840.     612.2    3070.    612.5    3150.    614.3    3440.    620.0    4000.
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INPUT FOR COMPLETE BASIN ANALYSIS (CONTINUED)

```
NC.08   .12     .15
X115.1  39.     1940.   2100.   220.    220.    220.
X3   10.
GR630.0         607.7   30.00   606.9   40.0    608.6   60.     618.4   170.0
GR609.2 420.0   607.5   520.0   607.2   620.0   605.9   700.0   605.4   810.0
GR604.3 920.0   604.0   1010.   604.5   1140.   604.6   1230.   604.2   1250.
GR605.5 1360.   605.1   1480.   605.4   1580.   604.7   1650.   595.9   1690.
GR596.1 1820.   606.4   1880.   605.6   1940.   598.8   1994.   597.5   2030.
GR593.7 2040.   592.7   2050.   592.9   2070.   599.1   2080.   599.1   2090.
GR606.9 2100.   606.9   2150.   604.4   2270.   604.4   2270.   603.9   2480.
GR606.5 2850.   612.9   3060.   620.2   3249.   630.0   3250.
NC.10   .15     .10
X116.   59.     3890.   4015.   2400.   2400.   3010,
X3   10.
GR633.          632.4   50.0    628.9   270.0   627.0   490.0   625.9   630.0
GR627.4 710.0   624.0   800.0   622.6   1100.   623.1   1180.   622.8   1240.
GR619.5 1550.   618.7   1450.   617.5   1860.   616.6   1960.   612.3   2170.
GR611.3 2260.   610.8   2360.   610.8   2560.   612.4   2600.   612.6   2630.
GR612.1 2660.   609.1   2680.   608.8   2775.   605.2   2790.   608.4   2800.
GR608.7 2860.   611.2   2900.   611.3   3100.   610.1   3210.   609.9   3310.
GR610.8 3410.   610.7   3460.   609.6   3540.   610.8   3630.   611.4   3720.
GR611.6 3850.   611.4   3890.   595.0   3920.   593.0   3940.   593.0   3960.
GR611.6 4015.   610.0   4120.   610.4   4220.   613.1   4320.   610.5   4420.
GR609.5 4520.   610.7   4610.   610.6   4670.   615.0   4720.   604.4   4760.
GR608.8 4780.   611.3   4840.   611.5   4930.   611.2   5000.   608.4   5010.
GR615.4 5030.   617.8   5060.   617.6   5100.   633.2   5600.
NC.06   .10     .15
X117.   24.     690.    890.    2000.   1800.   2710.
X3   10.
GR630.0         614.9   1.0     614.8   100.0   613.4   120.0   612.7   200.0
GR612.9 300.0   613.2   390.0   613.2   480.0   613.1   580.0   613.9   690.0
GR610,8 720.0   606.5   750.0   599.2   760.0   599.0   780.0   603.8   840.0
GR610.8 890.0   613.7   1020.   613.4   1120.   613.6   1220.   611.6   1310.
GR607.4 1400.   613.7   1500.   609.1   1590.   630.0   1600.
NC   .04   .04     .05
X1  18.   40.    3330.    3540.   150.     150.    150.                 1.
X3    10.
GR  640.   0.     640.    290.    634.5   570.     632.8  730.    629.4   880.
GR  627.  1070.   625.9  1140.    624.2  1430.     624.5 1570.    625.    1720.
GR 626.3  1880.   630.4  2180.    632.6  2350.     634.  2490.    635.   2550.
GR 636.3  2650.   636.3  2750.    635.8  2860.     633.  2990.    630.9   3140.
GR 627.   3330.   618.7  3331.    618.7  3339.     598.  3380.    598.    3390.5
GR 623.   3390.5  623.   3393.    598.   3393.    598.  3477.   623.     3477.
GR 623.   3479.5  592.   3479.5   598.   3490.     615.7 3526.    615.7   3539.
GR 627.   3540.   624.6  3780.    626.1  3910.     628.1 4050.    640.7   4700.
NC .06    .19      .15
X1 19.    52.    3760.    3960.   550.     550.    550.                 1.
X3    10.
GR 630.    0.    620.    1000.    616.    1200.  . 616.  1300.    618.6   1400.
GR 617.4  1500.  617.8   1600.    617.5   1800.   617.2 1880.   617.1   2080.
GR 615.9  2280.  616.6   2380.    616.4   2480.    615.5 2580.    615.9   2680.
GR 615.   2880.  615.3   2920.    614.6   3040.   614.7  3150.    613.9   3160.
GR 617.3  3180.  616.8   3240.    614.8   3270.    614.1 3360.    613.9   3460.
GR 614.5  3540.  613.8   3680.    610.3   3720.    610.2 3740.    614.4   3760.
GR 597.5  3780.  598.9   3800.    608.1   3810.    605.1 3840.    611.4    3900.
GR 615.3  3960.  614.3   4100.    614.6   4140.    605.6 4150.    607.6   4180.
GR 614.7  4230.  614.0   4380.    614.2   4480.    613.4 4580.    612.8   4750.
GR 616.0  4880.  616.4   4990.    607.0   5000.      604.  5040.   618.8    5080.
GR 619.2  5120.  631.    5180.
NC .04    .04     .12
X1 20.    54.    3150.    3330.    800.    800.    800.                  1.
X3    10.
GR 632.   0.     627.6    1.       627.    100.    625.7   200.    625.4   290.
GR 624.6  400.   619.9   900.      619.4   1000.   619.5   1100.   619.3   1160.
GR 619.6  1260.  619.4   1700.     619.6   2040.   619.8   2140.   621.2   2350.
GR 621.4  2450.  620.8   2580.     621.    2800.   622.3   2870.   623.7   3070.
GR 624.1  3150.  620.1   3151.     607.2   3178.   607.2   3203.   620.1   3203.
GR 620.1  3206.  607.2   3206.     607.2   3223.   601.4   3231.   601.4   3251.
GR 607.2  3263.  607.2   3271.     620.1   3271.   620.1   3271.   620.1   3274.
GR 607.2  3304.  618.2   3326.     620.1   3327.   624.1   3330.   623.9   3430.
GR 623.1  3510.  622.4   3610.     621.5   3710.   620.7   3820.   620.3   3920.
GR 620.1  4020.  620.5   4120.     620.9   4220.   621.1   4330.   621.9   4420.
GR 622.9  4520.  623.5   4630.     628.6   4840.   629.8   4940.
NC .06    .08     .15
X1 21.    22.    380.     585.     250.    1100.   600.                  1.
X3    10.
GR 634.   0.     621.9    1.0      621.8   46.     621.4   60.     614.5   95.
GR 614.4  205.   615.4   315.       615.4   380.    607.7   415.    609.4   465.
GR 599.7  475.   599.7   495.       609.4   500.    608.4   555.    617.7   585.
GR 619.9  690.    620.3  795.      622.    895.    623.8   995.    625.4   1060.
GR 630.   1240.  634.    1250.
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INPUT FOR COMPLETE BASIN ANALYSIS (CONTINUED)

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GR 635.   0.     630.2  100.   628.3  460.   628.2  560.   635.   560.
GR 635.   620.   627.8  620.   627.3  730.   639.   730.   635.   780.
GR 627.2  780.   627.1  890.   635.   890.   635.   940.   626.9  940.
GR 626.6  1050.  635.   1050.  635.   1100.  626.5  1100.  625.3  1210.
GR 635.   1210.  635.   1260.  626.2  1260.  625.9  1370.  635.   1370.
GR 635.   1420.  625.7  1420.  625.4  1530.  635.   1530.  635.   1580.
GR 625.2  1580.  625.1  1690.  635.   1690.  635.   1740.  625.1  1740.
GR 625.   1850.  635.   1850.  635.   1900.  625.   1900.  624.9  1980.
GR 616.8  2000.  613.4  2050.  609.9  2070.  611.2  2080.  613.6  2090.
GR 615.   2130.  624.7  2160.  624.5  2240.  635.   2240.  635.   2300.
GR 624.6  2300.  624.6  2380.  635.   2380.  635.   2440.  624.5  2440.
GR 624.4  2520.  635.   2520.  635.   2580.  624.   2660.  635.   2660.
GR 635.   2720.  624.   2720.  624.   2800.  635.   2800.  635.   2860.
GR 624.5  2860.  625.   2940.  635.   2940.  635.   3030.  625.7  3000.
GR 626.6  3090.  626.7  3190.  627.5  3300.  629.9  3400.  630.4  3480.
GR635.0 3500.
NC    .04      .04      .06       .3       .5
X1     23       40     1990     2170      100      100      100
X3     10.
GR 635.0             629.5      210    630.1      330    629.0      360    628.3      460
GR 628.2      560    627.6      660    627.2      770    627.2      870    625.2     1590
GR 626.0     1720    627.2     1820    630.1     1990    624.9     1991    615.0     2009
GR 611.6     2035    626.2     2035    626.2     2038    611.2     2038    608.0     2043
GR 608.0     2074    611.0     2092    611.0     2120    626.2     2120    626.2     2123
GR 611.0     2141    625.0     2168    630.1     2170    627.4     2280    625.6     2390
GR 624.5     2490    623.9     2700    624.3     2810    624.8     2910    626.6     3090
GR 626.7     3190    627.5     3300    629.9     3400    630.4     3478    635.0     3480
NC    .12      .12      .15
X1     24       58     1320     1450      720      720      720
X3     10.
GR 636.0        0    631.3      100    629.9      210    630.0      300    629.7      419
GR 628.7      540    640.0      540    640.0      600    626.1      600    626.9      740
GR 640.0      740    640.0      800    626.2      800    625.3      880    640.0      880
NC  .04    .04     .12
X1 21.5   22.    600.   801.   250.   800.   410.                        1.
X3     10.
GR 634.   0.     622.   1.     622.   608.   614.5  601.   606.   625.
GR 606.   664.   618.   684.   618.   657.   606.   667.   606.   675.
GR 600.   690.   608.   705.   606.   718.   606.   733.   618.   733.
GR 618.   736.   606.   736.   606.   784.   618.   800.   622.   801.
GR 622.   2001.  634.   2002.
NC  .12    .10     .08
X1 22.    92.    2214.  2470.  2200.  380.   1400.                       1.
X3     10.
GR 635.   0.     626.9  130.   626.   270.   624.4  440.   623.6  520.
GR 630.   520.   630.   570.   623.   570.   622.7  600.   630.   600.
GR 630.   650.   622.1  650.   621.8  680.   630.   680.   630.   730.
GR 622.3  730.   622.7  760.   630.   760.   630.   810.   622.8  810.
GR 622.3  840.   630.   840.   630.   890.   621.4  890.   620.8  920.
GR 630.   920.   630.   970.   620.3  970.   620.4  1080.  630.   1000.
GR 630.   1050.  626.6  1050.  620.6  1080.  630.   1080.  630.   1130.
GR 620.7  1130.  620.9  1160.  630.   1160.  630.   1210.  621.   1210.
GR 621.1  1240.  630.   1240.  630.   1290.  621.   1290.  620.9  1320.
GR 630.   1320.  630.   1370.  620.8  1370.  620.8  1400.  630.   1400.
GR 630.   1450.  620.8  1450.  620.8  1480.  630.   1480.  630.   1530.
GR 620.8  1530.  620.8  1560.  630.   1560.  630.   1610.  620.9  1610.
GR 620.9  1640.  630.   1640.  630.   1690.  620.9  1690.  621.   1720.
GR 630.   1720.  630.   1770.  621.1  1770.  621.2  1800.  630.   1800.
GR 630.   1850.  621.3  1850.  621.2  1880.  630.   1880.  630.   1930.
GR 621.   1930.  621.5  1975.  621.4  2090.  619.1  2214.  612.9  2250.
GR 607.9  2257.  605.8  2260.  608.1  2275.  611.9  2280.  618.4  2295.
GR 611.2  2319.  612.1  2380.  618.2  2470.  620.8  2560.  622.9  2625.
GR 625.   2700.  635.   2701.
NC .12    .12    .10
X1 22.8   78.    1980.  2160.  2600.  2600.  2700.                       1.
X3     10.
GR 640.0      940    626.5      940    623.4     1020    640.0     1020    640.0     1080
GR 622.7     1080    622.2     1130    622.2     1180    640.0     1180    640.0     1240
GR 622.2     1240    624.1     1320    623.4     1330    617.9     1340    625.1     1350
GR 621.7     1380    610.7     1400    608.1     1410    610.7     1430    615.2     1440
GR 619.0     1450    618.0     2040    620.0     2190    640.0     2190    640.0     2200
GR 621.0     2200    623.5     2300    624.0     2460    624.0     2550    626.1     2630
GR 625.8     2640    626.2     2650    625.5     2750    625.5     2860    625.7     2950
GR 627.7     2990    628.8     3200    628.5     3300    630.0     3500    630.0     3610
GR 630.5     3720    631.6     3820    636.0     3870
NC    .12      .12      .15       .3       .5
X1     25       65     2590     2680     1850     1850     2750
X3     10.
GR 642.4        0    641.2      200    640.1      300    639.3      400    638.8      500
GR 638.1      590    638.1      690    638.9      800    637.6      900    635.8     1000
GR 635.4     1100    634.2     1200    630.7     1300    628.7     1380    650.0     1380
GR 650.0     1440    627.3     1440    626.0     1500    626.3     1600    650.0     1600
GR 650.0     1660    627.7     1660    627.9     1580    620.9     1700    627.0     1710
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INPUT FOR COMPLETE BASIN ANALYSIS (CONTINUED)

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GR 627.5     1840   650.0    1840   650.0    1900   627.5    1900   626.9    2010
GR 627.2     2060   650.0    2060   650.0    2120   627.6    2120   626.8    2230
GR 624.2     2300   627.7    2400   618.7    2590   612.7    2620   617.9    2640
GR 621.6     2660   625.0    2680   625.1    2780   625.3    2800   650.0    2800
GR 650.0     2860   626.0    2860   626.4    2890   626.7    2960   650.0    2960
GR 650.0     3020   627.4    3020   628.6    3080   629.2    3140   650.0    3140
GR 650.0     3200   629.7    3200   630.9    3340   650.0    3340   650.0    3400
GR 631.4     3400   632.4    3540   632.8    3610   633.7    3860   650.0    3865
NC   .12      .12     .15      .3      .5
X1    26       30 3400.    3540.   1500.    1500.   2050.
X2 12300
X3    10.
GR 650.0        0   640.0    1600   637.8    1820   650.0    1820   650.0    1900
GR 637.0     1900   633.1    2300   650.0    2300   650.0    2400   632.0    2400
GR 630.0     2600   630.6    3100   629.8    3200   630.7    3310   630.1    3400
GR 626.9     3445   622.5    3460   621.7    3470   617.4    3475   617.0    3480
GR 615.9     3482   616.5    3485   617.0    3490   619.6    3500   629.3    3540
GR 630.9     3640   630.4    3745   621.0    4250   623.5    5100   650.0    5100
NC   .04      .04     .06      .3      .5
X1    27       58    2340    2443    1300     1300    1520
X3    10.
GR 650.7        0   650.3      60   648.8     160   647.8     360   646.5     470
GR 645.9      550   643.4     760   641.5     870   640.3     970   640.2    1000
GR 656.0     1000   656.0    1080   639.2    1180   639.0    1280   628.7    1370
GR 638.7     1400   656.0    1400   656.0    1480   638.6    1490   637.6    1580
GR 637.5     1650   656.0    1650   656.0    1730   637.4    1780  637.96    1880
GR 637.2     1980   637.2    2150   656.0    2150   656.0    2250   637.2    2250
GR 637.2     2340   630.0    2341   621.5  2341.5   621.8    2359   617.5    2370
GR 630.0     2370   630.0    2374   615.9    2374   615.2    2376   614.2    2385
GR 615.2     2393   619.7    2401   620.2    2410   630.0    2410   630.0    2414
GR 620.5     2414   622.0    2440   630.0    2442   637.2    2443   637.0    2500
GR 656.0     2500   656.0    2600   636.5    2600   636.3    2640   634.2    2770
GR 633.5     2890   633.4    3000   656.0    3001
NC   .04      .04     .06      .3      .5
X1  27.9       21     600     780     200      600     500
X3    10.
GR 650.0        0   645.0     600   634.5     601   634.5     616   621.0     647
GR 621.0      653   645.0     653   645.0     657   621.0     657   621.0     674
GR 619.0      679   619.0     687   621.0     695   621.0     721   645.0     721
GR 645.8      725   621.0     725   621.0     729   642.0     778   648.0     780
GR 650.0      900
NC   .06      .12     .12      .3      .5
X1    28       35     190     290     200      200     200
X3    10.
GR 648.0        0   643.6       1   640.5      22   641.3      80   642.6     150
GR 636.7      170   636.7     190   626.8     200   624.7     220   619.7     225
GR 622.7      235   623.8     240   625.2     270   634.9     290   634.4     390
GR 634.9      470   634.1     560   634.3     550   634.1     660   634.3     670
GR 633.5      760   632.9     860   633.7     960   634.4    1070   635.1     090
GR 632.4     1100   631.0    1120   629.1    1130   636.5    1280   639.[illegible]    1370
GR 640.4     1480   643.2    1580   645.3    1690   646.6    1800   648.[illegible]    1950
NC  0.04     0.12    0.04
X1 29.00     63.0  1850.0  2100.0  2000.0   2000.0  2000.0     0.0     0.0     1.0
X3    10.
GR651.60      0.0  649.50    10.0  648.70    110.0  644.50   220.0  645.00   320.0
GR642.70    430.0  641.30   510.0  640.10    610.0  639.50   740.0  638.10   840.0
GR638.40    940.0  636.40   950.0  637.00    960.0  637.30   980.0  636.90   990.0
GR636.20   1120.0  655.00  1120.0  655.00   1200.0  635.70  1200.0  636.00  1300.0
GR635.60   1400.0  636.20  1520.0  655.00   1520.0  655.00  1600.0  636.80  1600.0
GR636.20   1720.0  635.70  1850.0  633.80   1900.0  626.70  1920.0  624.90  1950.0
GR624.00   2010.0  622.60  2020.0  622.10   2030.0  622.90  2050.0  624.60  2050.0
GR624.60   2070.0  625.10  2080.0  637.50   2100.0  637.00  2200.0  636.40  2290.0
GR636.80   2320.0  637.00  2410.0  637.40   2450.0  630.20  2485.0  625.20  2485.0
GR624.20   2510.0  634.90  2570.0  635.80   2580.0  637.70  2600.0  636.90  2630.0
GR635.30   2710.0  635.30  2830.0  636.40   2940.0  637.80  3040.0  637.80  3130.0
GR638.70   3250.0  639.30  3310.0  639.30   3430.0  637.30  3440.0  637.30  3450.0
GR639.00   3460.0  640.90  3510.0  650.00   3800.0
NC.12
X1    30       83    1310    1510    1840     1840    1840       0       0       0
X3    10.
GR 650.0        0   646.1       1   644.8     100   644.7     140   660.0     140
GR 660.0      190   644.7     190   644.1     220   660.0     220   660.0     270
GR 642.7      270   641.9     300   660.0     300   660.0     350   641.1     350
GR 640.6      380   660.0     380   660.0     430   639.9     430   639.6     460
GR 660.0      460   660.0     510   639.0     510   638.8     540   660.0     540
GR 660.0      590   638.7     590   638.7     620   660.0     620   660.0     670
GR 639.0      670   639.1     700   660.0     700   660.0     750   639.4     750
GR 639.6      780   660.0     780   660.0     830   639.6     830   639.5     860
GR 660.0      860   660.0     910   639.2     910   639.0     940   660.0     940
GR 660.0      990   638.8     990   638.7    1020   660.0    1020   660.0    1070
GR 638.5     1070   638.1    1150   639.6    1170   660.0    1170   660.0    1220
GR 639.8     1220   640.6    1250   641.3    1310   637.1    1330   632.8    1340
GR 624.1     1350   623.5    1460   624.1    1480   626.3    1485   642.1    1510
```

INPUT FOR COMPLETE BASIN ANALYSIS (CONTINUED)

```
GR 640.5     1610    638.3     1650    641.3     1710    641.2     1730    640.7     1745
GR 635.5     1780    633.3     1910    634.9     1820    641.0     1880    641.1     1940
GR 638.7     2020    640.4     2120    640.7     2190    644.1     2310    647.7     2410
GR 645.0     2510    648.5     2610    650.1     2710
NC  0.06     0.06     0.06
X1  31.0     82.0   1370.0   1476.0    850.0    850.0    850.0      0.0      0.0      1.0
X3    10.
GR656.60      0.0   655.20    100.0   648.00    400.0   560.00    400.0   660.00    460.0
GR647.00    460.0   646.20    500.0   660.00    500.0   660.00    560.0   645.70    560.0
GR645.70    600.0   660.00    600.0   660.00    660.0   645.00    660.0   644.90    700.0
GR660.00    700.0   660.00    760.0   644.20    760.0   643.70    800.0   660.00    800.0
GR660.00    860.0   643.10    860.0   643.00    900.0   660.00    900.0   660.00    960.0
GR643.10    960.0   643.20   1000.0   640.00   1000.0   660.00   1060.0   643.70   1060.0
GR644.20   1100.0   660.00   1100.0   660.00   1280.0   646.90   1280.0   645.20   1370.0
GR637.80   1370.1   627.30   1372.0   625.70   1420.5   637.80   1420.5   637.80   1423.5
GR625.50   1423.5   624.30   1458.0   624.50   1471.0   624.80   1475.0   645.20   1476.0
GR644.40   1580.0   660.00   1580.0   660.00   1640.0   643.80   1640.0   643.00   1700.0
GR660.00   1700.0   660.00   1760.0   642.00   1760.0   641.50   1820.0   660.00   1820.0
GR660.00   1880.0   641.30   1880.0   641.10   1940.0   660.00   1940.0   660.00   2000.0
GR641.20   2000.0   641.40   2160.0   642.10   2280.0   660.00   2280.0   660.00   2340.0
GR642.40   2340.0   642.40   2440.0   643.60   2600.0   660.00   2600.0   660.00   2660.0
GR644.30   2660.0   646.20   2840.0   660.00   2840.0   640.00   2900.0   646.40   2900.0
GR646.80   3099.0   648.90   3340.0   649.30   3450.0   650.00   3550.0   649.90   3650.0
GR650.10   3740.0   654.00   6000.0
X1  31.5     14.0   1000.0   1091.0   2300.0   1400.0   1850.0      0.0      0.0      1.0
X3    10.
GR660.00      0.0   654.00      1.0   649.00   1000.0   635.10   1001.0   634.50   1017.0
GR633.70   1035.0   632.60   1045.0   632.00   1057.0   632.00   1071.0   633.90   1087.0
GR634.10   1090.0   649.10   1091.0   651.00   1600.0   660.00   1601.0
X1  31.6     17.0   1000.0   1091.0    100.0    100.0    100.0      0.0      0.0      1.0
X3    10
GR660.00      0.0   654.00      1.0   649.00   1000.0   635.10   1001.0   634.50   1017.0
GR633.70   1035.0   632.60   1045.0   644.50   1045.0   644.50   1047.0   632.50   1047.0
GR632.00   1057.0   632.00   1071.0   633.90   1087.0   634.10   1090.0   649.10   1091.0
GR651.00   1600.0   660.00   1601.0
X1  31.7     14.0   1000.0   1091.0    100.0    100.0    100.0      0.0      0.0      1.0
X3    10.
GR660.00      0.0   654.00      1.0   649.00   1000.0   635.10   1001.0   634.50   1017.0
GR633.70   1035.0   632.60   1045.0   632.00   1057.0   632.00   1057.0   632.00   1071.0
GR633.90   1087.0   634.10   1090.0   649.10   1091.0   651.00   1600.0   660.00   1601.0
NC  0.08     0.08     0.21
X132.0  37.0     1400.    1580.    1000.    2600.    1700.
X2 300.0
X3    10.
GR657.00      0.0   654.40    220.0   654.20    320.0   651.90    360.0   653.50    370.0
GR651.70    470.0   651.10    580.0   651.10    660.0   650.60    780.0   650.00    890.0
GR648.70    980.0   645.60   1090.0   646.30   1180.0   646.20   1280.0   648.40   1400.0
GR644.60   1420.0   643.50   1470.0   640.30   1500.0   634.80   1520.0   634.90   1525.0
GR635.65   1530.0   640.20   1550.0   642.10   1560.0   647.70   1580.0   646.60   1680.0
GR645.70   1780.0   644.00   1880.0   644.90   1980.0   645.00   2050.0   646.00   2180.0
GR646.00   2300.0   647.30   2400.0   648.10   2500.0   649.40   2620.0   652.70   2740.0
GR654.90   2840.0   657.00   2900.0
NC   .08      .10      .21        0        0
X1  32.0       36     2000     2100     2600     2600     3300        0        0        1
X3    10.
GR 663.2        0    662.5      100    662.3      200    661.3      300    660.4      400
GR 660.4      520    658.8      610    658.3      660    657.2      760    656.6      860
GR 655.9      960    655.1     1060    654.3     1180    652.4     1500    651.9     1600
GR 651.5     1700    651.2     1800    650.8     1900    650.7     2000    632.0     2040
GR 632.0     2080    650.7     2100    650.7     2200    650.9     2300    651.2     2400
GR 651.8     2500    652.6     2600    653.7     2720    654.8     2820    655.7     2920
GR 656.9     3020    658.5     3130    661.0     3330    662.2     3430    663.0     3530
GR 664.5     3740
NC   .04      .04      .06        0        0
X1  33.0       39     1580     1707      100      100      100        0        0        1
X3    10.
GR 663.2        0    662.5      100    662.3      200    661.3      300    660.4      400
GR 660.4      510    658.8      610    657.2      750    656.6      860    655.9      960
GR 655.1     1060    654.3     1180    653.7     1280    653.2     1380    652.8     1500
GR 652.8     1600    653.0     1680    634.9   1680.1    632.7     1697    632.2     1698
GR 632.7     1703    633.9   1706.9    653.0     1707    651.6     1900    651.5     2020
GR 651.2     2120    651.2     2220    651.9     2430    652.4     2540    653.0     2640
GR 653.7     2720    654.8     2820    655.7     2920    656.9     3020    658.5     3130
GR 661.0     3330    662.2     3430    663.0     3530    664.5     3740
NC   .10      .10      .15        0        0
X1  33.5        8      550      650      800      800      800        0        0        1
X3    10.
GR 663.0        0    660.0      350    650.0      550    644.0      570    644.0      680
GR 650.0      650    660.0     2250    665.0     3300
NC   .04      .04      .08        0        0
X1  34.0       36     2100   2155.1      800     1800     1450        0        0        1
X3    10.
GR 682.0        0    679.9      100    678.0      200    676.2      290    673.1      380
```

INPUT FOR COMPLETE BASIN ANALYSIS (CONTINUED)

```
GR 670.4     680    669.1     530    667.6     640    666.5     730    665.6     810
GR 665.3     910    664.8    1000    664.3    1120    664.5    1200    663.4    1300
GR 663.1    1390    662.1    1480    661.9    1580    661.3    1660    660.0    1960
GR 660.0    2100    643.0    2100    643.0    2113    658.0    2113    658.0    2114
GR 643.0    2114    643.0    2141    658.8    2141    658.0    2142    643.0    2142
GR 643.0    2155    660.0  2155.1    660.0    4200    660.7    4280    661.8    4370
GR 680.0    5050
NC   .10     .06      .10       0        0
X1  34.5       9     1658    1750     2200     400      900       0        0       1
X3    10.
GR 670.0       0    660.0    1350    656.3    1658    645.0    1680    645.0    1730
GR 655.2    1750    656.0    2320    660.0    2400    670.0    2401
NC   .08     .08      .10       0        0
X1  35.0      12      540     620      720    2000     2750       0        0       1
X3    10.
GR 670.0       0    661.8     400    659.6     500    660.2     540    668.2     570
GR 658.8     620    659.9     720    659.7     870    659.6     880    659.3    1000
GR 659.8    1100    670.0    1400
X1  36.0      24     1680  1731,1     1100    1100     1600       0        0       1
X3    10.
GR 670.9       0    670.4     100    670.3     200    669.5     340    669.0     610
GR 668.4     700    665.6    1000    665.2    1120    664.6    1200    664.7    1330
GR 667.2    1480    664.8    1540    663.2    1680    655.0  1680.1    655.0    1705
GR 657.5    1706    655.0    1706    655.0    1731    663.2  1731.1    663.2    1780
GR 662.6    1880    663.1    1980    667.0    2280    670.3    2680
NC  0.06    0.06     0.10
X1   37.     29.     318.    366.     150.    500.     220.                         6
X3    10.
GR  680.      0.    665.5      1.    665.7     80.    665.5    170.    665.4    250.
GR 665.6    318.    654.4   318.1    654.4    324.    662.     324.    662.   325.5
GR 654.4   325.5    654.4    340.    662.     340.    662.   341.5    654.4    350.
GR  662.    350.    662.    351.5    654.4   365.9    665.6    366.    665.     450.
GR 666.3    540.    666.7    620.    667.     710.    667.5    790.    668.1    870.
GR 668.9    970.    669.4   1060.    670.1   1150.    680.    1160.
NC  0.10    0.10     0.04
X1  37.1      8.    1700.   1764.     100.    100.     100.                         6
X3    10.
GR  680.      0.    670.       .1    664.3   1700.    655.3   1722.    655.3   1742.
GR 664.3   1764.    670.    2800.    680.    2801.
NC  0.10    0.10     0.10
X1  37.5     15.     967.   1080.    1400.   1800.    2000.                         6
X3    10.
GR  675.      0.    670.     900.    667.9    967.    659.2    989.    659.1   1040.
GR  668.   1080.    667.4   1124.    669.6   1145.    668.7   1203.    664.2   1215.
GR 663.5   1275.    667.7   1290.    668.4   1300.    670.    1395.    675.    2495.
NC  0.10    0.10     0.15
X1   38.     25.    1660.   1700.    1400.   1400.    2400.                         6
X3    10.
GR  690.      0.    679.2    115.    679.7    430.    678.4    540.    678.2    635.
GR 677.7    770.    672.4   1030.    673.9   1105.    673.8   1120.    673.3   1190.
GR 672.6   1270.    672.9   1310.    671.2   1390.    672.3   1430.    672.2   1520.
GR 671.2   1600.    669.1   1660.    664.    1665.    669.7   1700.    669.3   1820.
GR 670.6   1935.    676.6   1985.    677.    2075.    677.8   2114.    690.    2115.
NC  0.10    0.10     0.20
X1  38.7     13.     608.    740.    1400.   1500.    2370.                         6
X3    10.
GR  690.      0.    680.3    600.    679.6    608.    677.2    617.    675.4    693.
GR 672.8    698.    671.6    704.    672.6    708.    675.6    714.    676.4    725.
GR 680.1    740.    680.7    760.    690.    1300.
NC  0.10    0.10     0.06
X1  38.8      7.     500.    543.     100.    100.     100.                         6
X3    10.
GR  690.      0.    680.5    500.    672.5    507.    672.5    536.    680.4    543.
GR  690.   1100.    700.    1102.
NC  0.12    0.12     0.15
X1   39.     19.     840.    860.     700.    400.     970.                         6
X3    10.
GR 691.4      0.    687.2     40.    687.8    120.    687.6    210.    687.4    300.
GR 686.2    390.    686.3    470.    685.9    560.    685.2    660.    683.1    740.
GR 678.3    840.    674.3    845.    674.6    855.    677.9    860.    678.7    960.
GR 680.6   1220.    681.1   1240.    681.6   1310.    689.4   1770.
```

INPUT FOR COMPLETE BASIN ANALYSIS (CONTINUED)

```
FJ
T1     RIVER FORECAST CENTER  TULSA OKLAHOMA
T2     MINGO CREEK  TULSA CITY-COUNTY  OKLAHOMA
T3     COMPLETE BASIN ANALYSIS
J1   -10       3                                                   590.
J2     2
T1     RIVER FORECAST CENTER  TULSA OKLAHOMA
T2     MINGO CREEK  TULSA CITY-COUNTY  OKLAHOMA
T3     COMPLETE BASIN ANALYSIS
J1   -10       4                                                   590.
J2     3
T1     RIVER FORECAST CENTER  TULSA OKLAHOMA
T2     MINGO CREEK  TULSA CITY-COUNTY  OKLAHOMA
T3     COMPLETE BASIN ANALYSIS
J1   -10       5                                                   590.
J2     4
T1     RIVER FORECAST CENTER  TULSA OKLAHOMA
T2     MINGO CREEK  TULSA CITY-COUNTY  OKLAHOMA
T3     COMPLETE BASIN ANALYSIS
J1   -10       6                                                   590.
J2     5
T1     RIVER FORECAST CENTER  TULSA OKLAHOMA
T2     MINGO CREEK  TULSA CITY-COUNTY  OKLAHOMA
T3     COMPLETE BASIN ANALYSIS
J1   -10       7                                                   590.
J2     6
T1     RIVER FORECAST CENTER  TULSA OKLAHOMA
T2     MINGO CREEK  TULSA CITY-COUNTY  OKLAHOMA
T3     COMPLETE BASIN ANALYSIS
J1   -10       8                                                   590.
J2     7
T1     RIVER FORECAST CENTER  TULSA OKLAHOMA
T2     MINGO CREEK  TULSA CITY-COUNTY  OKLAHOMA
T3     COMPLETE BASIN ANALYSIS
J1   -10       9                                                   590.
J2     8
T1     RIVER FORECAST CENTER  TULSA OKLAHOMA
T2     MINGO CREEK  TULSA CITY-COUNTY  OKLAHOMA
T3     COMPLETE BASIN ANALYSIS
J1   -10      10                                                   590.
J2     9
T1     RIVER FORECAST CENTER  TULSA OKLAHOMA
T2     MINGO CREEK  TULSA CITY-COUNTY  OKLAHOMA
T3     COMPLETE BASIN ANALYSIS
J1   -10      11                                                   590.
J2    10
T1     RIVER FORECAST CENTER  TULSA OKLAHOMA
T2     MINGO CREEK  TULSA CITY-COUNTY  OKLAHOMA
T3     COMPLETE BASIN ANALYSIS
J1   -10      12                                                   590.
J2    15
```

SUMMARY OUTPUT FOR STATION 23

SECTION NUMBER	CHANNEL LENGTH	MIN EL OF ROADWAY	MAX EL OF LOW CHORD	MIN EL GROUND	DISCHARGE (CFS)	CWSEL	TQ	EG	TOPWID
23.00	100.00	0.00	0.00	608.00	9967.00	627.24	2641.47	627.52	178.33
23.00	100.00	0.00	0.00	608.00	325.00	616.59	474.24	616.59	128.26
23.00	100.00	0.00	0.00	608.00	758.00	618.48	741.83	618.49	137.57
23.00	100.00	0.00	0.00	608.00	1366.00	619.79	955.62	619.81	144.05
23.00	100.00	0.00	0.00	608.00	2168.00	621.16	1206.24	621.20	150.82
23.00	100.00	0.00	0.00	608.00	2516.00	621.70	1312.14	621.75	153.51
23.00	100.00	0.00	0.00	608.00	3035.00	622.41	1455.94	622.47	157.00
23.00	100.00	0.00	0.00	608.00	3764.00	623.25	1635.92	623.33	161.15
23.00	100.00	0.00	0.00	608.00	4878.00	624.41	1896.79	624.52	166.82
23.00	100.00	0.00	0.00	608.00	7588.00	626.24	2328.57	626.44	177.75
23.00	100.00	0.00	0.00	608.00	30355.00	632.22	24860.71	632.25	3367.96

STENCL	STENCR	WSELK
0.00	0.00	0.00
1990.00	2170.00	627.24
1990.00	2170.00	627.24
0.00	0.00	0.00
0.00	0.00	0.00
0.00	0.00	0.00
0.00	0.00	0.00
0.00	0.00	0.00
0.00	0.00	0.00
0.00	0.00	0.00
0.00	0.00	0.00

FIRST ESTIMATES FOR 11th STREET RATING

Elevations MSL	Discharge CFS
611.50	195.
615.00	303.
618.50	996.
622.00	2168.
624.00	2516.
626.00	3035.
628.00	3794.
630.00	4878.
632.00	7588.
637.00	30355.

INPUT FOR SPECIFIC STATION ANALYSIS

```
TJ100,CM230000,T100.      SHERIDAN/TULSA RFC
ATTACH(HEC2,WRAPI,CY=61)
RFL,230000.
SETCORE.
MAP(OFF)
HEC2.
REWIND(TAPE92)
COPYCF(TAPE92,OUTPUT)
0000000000000000000000
T1      RIVER FORECAST CENTER   TULSA OKLAHOMA
T2      MINGO CREEK AT 11 TH STREET   TULSA OKLAHOMA
T3      SPECIFIC STATION ANALYSIS
J1    -10                              .00070                         30355  632.00
J2      1
NC    .04       .04       .06       .3        .5
X1     23        40      1990      2170       100       100       100
X3     10.
GR 635.0                629.5       210     630.1       330     629.0       360     628.3      460
GR 628.2        560     627.6       660     627.2       770     627.2       870     625.2     1590
GR 626.0       1720     627.2      1820     630.1      1990     624.9      1991     615.0     2099
GR 611.6       2035     626.2      2035     626.2      2038     611.2      2038     608.0     2063
GR 608.0       2074     611.0      2092     611.0      2120     626.2      2120     626.2     2123
GR 611.0       2141     625.0      2168     630.1      2170     627.4      2280     625.6     2390
GR 624.5       2490     623.9      2700     624.3      2810     624.8      2910     626.6     3090
GR 626.7       3190     627.5      3300     629.9      3400     630.4      3470     635.0     3480
EJ
T1      RIVER FORECAST CENTER   TULSA OKLAHOMA
T2      MINGO CREEK AT 11 TH STREET   TULSA OKLAHOMA
T3      SPECIFIC STATION ANALYSIS
J1    -10                              .00070                           195  611.50
J2      2
T1      RIVER FORECAST CENTER   TULSA OKLAHOMA
T2      MINGO CREEK AT 11 TH STREET   TULSA OKLAHOMA
T3      SPECIFIC STATION ANALYSIS
J1    -10                              .00070                           303  615.00
J2      3
T1      RIVER FORECAST CENTER   TULSA OKLAHOMA
T2      MINGO CREEK AT 11 TH STREET   TULSA OKLAHOMA
T3      SPECIFIC STATION ANALYSIS
J1    -10                              .00070                           996  618.50
J2      4
T1      RIVER FORECAST CENTER   TULSA OKLAHOMA
T2      MINGO CREEK AT 11 TH STREET   TULSA OKLAHOMA
T3      SPECIFIC STATION ANALYSIS
J1    -10                              .00070                          2168  622.00
J2      5
T1      RIVER FORECAST CENTER   TULSA OKLAHOMA
T2      MINGO CREEK AT 11 TH STREET   TULSA OKLAHOMA
T3      SPECIFIC STATION ANALYSIS
J1    -10                              .00070                          4000  624.00
J2      6
T1      RIVER FORECAST CENTER   TULSA OKLAHOMA
T2      MINGO CREEK AT 11 TH STREET   TULSA OKLAHOMA
T3      SPECIFIC STATION ANALYSIS
J1    -10                              .00070                          7000  626.00
J2      7
T1      RIVER FORECAST CENTER   TULSA OKLAHOMA
T2      MINGO CREEK AT 11 TH STREET   TULSA OKLAHOMA
T3      SPECIFIC STATION ANALYSIS
J1    -10                              .00070                         10500  628.00
J2      8
T1      RIVER FORECAST CENTER   TULSA OKLAHOMA
T2      MINGO CREEK AT 11 TH STREET   TULSA OKLAHOMA
T3      SPECIFIC STATION ANALYSIS
J1    -10                              .00070                         17000  630.00
J2      9
T1      RIVER FORECAST CENTER   TULSA OKLAHOMA
T2      MINGO CREEK AT 11 TH STREET   TULSA OKLAHOMA
T3      SPECIFIC STATION ANALYSIS
J1    -10                              .00070                        100000  637.00
J2     15
EJ


ER
```

OUTPUT SUMMARY FOR SPECIFIC STATION ANALYSIS

SUMMARY PRINTOUT FOR MULTIPLE PROFILES

PECIFIC STATION ANALYSIS

SECTION NUMBER	CHANNEL LENGTH	MIN EL OF ROADWAY	MAX EL OF LOW CHORD	MIN EL GROUND	DISCHARGE (CFS)	CWSEL	CRIWS	EG	TOPWID	10K*S	TIME	VOL
23.00	100.00	0.00	0.00	608.00	30355.00	652.07	0.00	652.07	3480.00	.01	0.00	0.00
23.00	100.00	0.00	0.00	608.00	195.00	612.08	0.00	612.10	89.08	7.00	0.00	0.00
23.00	100.00	0.00	0.00	608.00	303.00	612.81	0.00	612.83	96.85	6.99	0.00	0.00
23.00	100.00	0.00	0.00	608.00	996.00	615.79	0.00	615.83	124.35	6.94	0.00	0.00
23.00	100.00	0.00	0.00	608.00	2168.00	618.97	0.00	619.04	140.02	6.99	0.00	0.00
23.00	100.00	0.00	0.00	608.00	4000.00	622.65	0.00	622.75	158.17	7.06	0.00	0.00
23.00	100.00	0.00	0.00	608.00	7000.00	627.25	0.00	627.39	178.34	7.00	0.00	0.00
23.00	100.00	0.00	0.00	608.00	10500.00	630.09	0.00	630.20	179.99	8.45	0.00	0.00
23.00	100.00	0.00	0.00	608.00	17000.00	630.10	0.00	630.13	3241.13	1.65	0.00	0.00
23.00	100.00	0.00	0.00	608.00	100000.00	634.07	0.00	634.29	3442.27	6.99	0.00	0.00

SECTION NUMBER	DISCHARGE CFS	CWSEL	CWSEL DIFF EACH Q	CWSEL DIFF EACH SECTION	CWSEL-WSELK	TOPWID	T.W. DIFF	LENGTH
23.000	30355.001	652.066	0.000	0.000	0.000	3480.003	0.000	100.000
23.000	195.001	612.084	-39.982	0.000	0.000	89.079	3390.924	100.000
23.000	302.001	612.806	.722	0.000	0.000	96.849	3383.154	100.000
23.000	996.001	615.790	2.984	0.000	0.000	124.348	3355.656	100.000
23.000	2168.001	618.968	3.178	0.000	0.000	140.019	3339.985	100.000
23.000	4000.001	622.650	3.682	0.000	0.000	158.174	3321.829	100.000
23.000	7000.001	627.253	4.603	0.000	0.000	178.336	3301.667	100.000
23.000	10500.001	630.089	2.836	0.000	0.000	179.993	3300.010	100.000
23.000	17000.001	630.101	.012	0.000	0.000	3241.130	238.873	100.000
23.000	100000.001	634.065	3.964	0.000	0.000	3442.270	37.733	100.000

DATA FOR LAST CROSS SECTION

PROFILE	TYPE ENC	TARGET	TOP WIDTH AREA-ACRES	TOP WIDTH AREA-DIFF
1	0.000	0.000	0.000	0.000
2	0.000	0.000	0.000	0.000
3	0.000	0.000	0.000	0.000
4	0.000	0.000	0.000	0.000
5	0.000	0.000	0.000	0.000
6	0.000	0.000	0.000	0.000
7	0.000	0.000	0.000	0.000
8	0.000	0.000	0.000	0.000
9	0.000	0.000	0.000	0.000
10	0.000	0.000	0.000	0.000

APPENDIX C

TABL PROGRAM

TABL PROGRAM

```
TJ100, CM60000, T15.     SHERIDAN-TULSA
REQUFST JHS,*PF.
RFL,60000.
FTN(LR,B=JHS)
ATTACH(TS,WTUL2, CY=60)
PURGE(TS,WTUL2, CY=60)
CATALOG(JHS,WTUL2, CY=60)
0000000000000000000000
      PROGRAM TABL(INPUT,OUTPUT,TAPE2=INPUT,TAPE5=OUTPUT,TSS,TAPE8=TSS)
      DIMENSION ZB(231), TS(924),ZEELV(2310),ZA(2310)
      COMMON STAGE(20),EV(5),Q(20),QX(10),DATUM
      COMMON BASIN(5),REACH(5)
      COMMON RF(11),FF(21),EELV(21,11)
      READ(8)TS,RF,FF
5559  READ(2,104)BASIN
104   FORMAT(5A10)
      IF(EOF(2))5560,5561
5561  READ(2,54)REACH
54    FORMAT(5A10)
      READ(2,103)DATE
103   FORMAT(A6)
      READ(2,1300)STATE
1300  FORMAT(A10)
      READ(2,1301)ZONE
1301  FORMAT(I2)
      READ(2,5023)TP
5023  FORMAT(F4.1)
      READ(2,1) (UNIT)
1     FORMAT(F6.0)
      READ(2,11) ZERO
11    FORMAT(F7.2)
      READ(2,4)(STAGE(I),Q(I), I=1,20)
4     FORMAT(F7.2,F7.0)
      READ(2,5)(FS)
5     FORMAT(F7.2)
      FSS = FS-ZFRO
      EV(1) = .5+ZERO
      FV(2) = (FSS*.25)+ZERO
      FV(3) = (FSS*.5)+ZERO
      FV(4) = (FSS*.75)+ZERO
      FV(5) = FSS + ZERO
      CALL RATING
      QX(6) = QX(5)*2.
      QX(7) = QX(5)*3.
      QX(8) = QX(5)*4.
      QX(9) = QX(5)*5.
      QX(10) = QX(5)*6.
      READ(2,31)TZ
31    FORMAT(F4.2)
```

TABL PROGRAM (CONTINUED)

```
      READ(2,59)DATUM
59    FORMAT(F4.0)
      IF(TZ-.25)34,33,34
33    K = 1
      DO 35 I = 1,231
      ZB(I)=TS(K)*UNIT*TZ
35    K = K+ 1
      GO TO 301
34    IF(TZ-.50) 40,39,40
39    K = 232
      DO 41 I = 1,231
      ZB(I)=TS(K)*UNIT*TZ
41    K = K + 1
      GO TO 301
40    IF(TZ - .75)44,43,44
43    K = 463
      DO 45 I = 1,231
      ZB(I)=TS(K)*UNIT*TZ
45    K = K + 1
      GO TO 301
44    K = 694
      DO 46 I = 1,231
      ZB(I)=TS(K)*UNIT*TZ
46    K = K + 1
301   CONTINUE
      J = 1
      DO 3501 K = 1,10
      DO 3501 I = 1,231
      ZA(J) = ZB(I)+QX(K)
      J = J + 1
3501  CONTINUE
      DO 803 I=1,2310
      DO 8033 K = 2,20
      IF(Q(K)-ZA(I))8033,345,306
306   ZZHIG = Q(K)
      ZZLOW = Q(K-1)
      ZZELE = STAGE(K-1)
      ZZZEL = STAGE(K)
      ZZXZ = ZZZEL - ZZELE
      ZQQX = (ZA(I)-ZZLOW)/(ZZHIG-ZZLOW)
      ZZXXZ = ZZXZ*ZQQX
      ZSSS = ZZELE + ZZXXZ
      GO TO 307
345   ZSSS = (STAGE(K))
      GO TO 307
8033  CONTINUE
307   ZEELV(I) = (ZSSS - ZERO)
803   CONTINUE
      IF (DATUM-1.0)50,51,51
51    DO 52 I = 1,2310
```

TABL PROGRAM (CONTINUED)

```
52      ZEELV(I) = ZEELV(I) + ZERO
        FSS = FS
50      K = 1
        DO 6677 I = 1,21
        DO 6677 J = 1,11
        EELV(I,J) = ZEELV(K)
6677    K=K+1
        BASEQ = QX(1)
        CALL STAGG (BASEQ,ZERO,BASEF)
        CALL TABLE (DATE,STATE,ZONE,        BASEQ,BASEF,FSS,ZERO,TP,RF)
        K = 232
        DO 5312 I = 1,21
        DO 5312 J = 1,11
        EELV(I,J) = ZEELV(K)
5312    K = K+1
        BASEQ = QX(2)
        CALL STAGG (BASEQ,ZERO,BASEF)
        CALL TABLE (DATE,STATE,ZONE,        BASEQ,BASEF,FSS,ZERO,TP,RF)
        K = 463
        DO 5313 I =1,21
        DO 5313 J = 1,11
        EELV(I,J) = ZEELV(K)
5313    K = K+1
        BASEQ = QX(3)
        CALL STAGG (BASEQ,ZERO,BASEF)
        CALL TABLE (DATE,STATE,ZONE,        BASEQ,BASEF,FSS,ZERO,TP,RF)
        K = 694
        DO 5314 I = 1,21
        DO 5314 J = 1,11
        EELV(I,J) = ZEELV(K)
5314    K = K+1
        BASEQ = QX(4)
        CALL STAGG (BASEQ,ZERO,BASEF)
        CALL TABLE (DATE,STATE,ZONE,        BASEQ,BASEF,FSS,ZERO,TP,RF)
        K = 925
        DO 5315 I = 1,21
        DO 5315 J = 1,11
        EELV(I,J) = ZEELV(K)
5315    K = K+1
        BASEQ = QX(5)
        CALL STAGG (BASEQ,ZERO,BASEF)
        CALL TABLE (DATE,STATE,ZONE,        BASEQ,BASEF,FSS,ZERO,TP,RF)
        K = 1156
        DO 5316 I = 1,21
        DO 5316 J = 1,11
        EELV(I,J) = ZEELV(K)
5316    K = K+1
        BASEQ = QX(6)
        CALL STAGG (BASEQ,ZERO,BASEF)
        CALL TABLE (DATE,STATE,ZONE,        BASEQ,BASEF,FSS,ZERO,TP,RF)
        K = 1387
```

TABL PROGRAM (CONTINUED)

```
      DO 5317 I = 1,21
      DO 5317 J = 1,11
      EELV(I,J) = ZEELV(K)
5317  K = K+1
      BASEQ = QX(7)
      CALL STAGG (BASEQ,ZERO,BASEF)
      CALL TABLE (DATE,STATE,ZONE,        BASEQ,BASEF,FSS,ZERO,TP,RF)
      K = 1618
      DO 5318 I = 1,21
      DO 5318 J = 1,11
      EELV(I,J) = ZEELV(K)
5318  K = K +1
      BASEQ = QX(8)
      CALL STAGG (BASEQ,ZERO,BASEF)
      CALL TABLE (DATE,STATE,ZONE,        BASEQ,BASEF,FSS,ZERO,TP,RF)
      K = 1849
      DO 5319 I = 1,21
      DO 5319 J = 1,11
      EELV(I,J) = ZEELV(K)
5319  K = K+1
      BASEQ = QX(9)
      CALL STAGG (BASEQ,ZERO,BASEF)
      CALL TABLE (DATE,STATE,ZONE,        BASEQ,BASEF,FSS,ZERO,TP,RF)
      K = 2080
      DO 5320 I = 1,21
      DO 5320 J = 1,11
      EELV(I,J) = ZEELV(K)
5320  K = K +1
      BASEQ = QX(10)
      CALL STAGG (BASEQ,ZERO,BASEF)
      CALL TABLE (DATE,STATE,ZONE,        BASEQ,BASEF,FSS,ZERO,TP,RF)
      GO TO 5559
5560  CONTINUE
      END
      SUBROUTINE RATING
      COMMON STAGE(20),EV(5),Q(20),QX(10),DATUM
      DO 144 I = 1,5
      DO 14 K =2,20
      IF (STAGE(K)-EV(I))14,12,13
13    HIGH = Q(K)
      XLOW = Q(K-1)
      DIFF = HIGH-XLOW
      HHI = STAGE(K)
      HHL = STAGE(K-1)
      HHH = HHI-HHL
      HA = (EV(I)-HHL)/HHH
      AFLOW = HA*DIFF
      QX(I) = AFLOW + XLOW
      GO TO 144
12    QX(I) = Q(K)
      GO TO 144
14    CONTINUE
```

TABL PROGRAM (CONTINUED)

```
144   CONTINUE
      RETURN
      END
      SUBROUTINE STAGG (BASEQ,ZERO,BASEF)
      COMMON STAGE(20),EV(5),Q(20),QX(10),DATUM
      DO 8033 K = 2,20
      IF(Q(K)-BASEQ)8033,345,306
306   ZZHIG = Q(K)
      ZZLOW = Q(K-1)
      ZZELE = STAGE(K-1)
      ZZZEL = STAGE(K)
      ZZXZ = ZZZEL - ZZELE
      ZQQX = (BASEQ-ZZLOW)/(ZZHIG-ZZLOW)
      ZZXXZ = ZZXZ*ZQQX
      ZSSS = ZZELE + ZZXXZ
      GO TO 307
345   ZSSS = (STAGE(K))
      GO TO 307
8033  CONTINUE
307   BASEF = (ZSSS-ZERO)
      IF(DATUM-1.0)55,56,56
56    BASEF = BASEF + ZERO
55    CONTINUE
      RETURN
      END
      SUBROUTINE TABLE (DATE,STATE,ZONE,      BASEQ,BASEF,FSS,ZERO,
     1TP)
      COMMON STAGE(20),EV(5),Q(20),QX(10),DATUM
      COMMON BASIN(5),REACH(5)
      COMMON RF(11),FF(21),EELV(21,11)
      WRITE(5,1033)DATE
1033  FORMAT( H1,66X,A8)
      IF(TP-13.)56,57,57
56    WRITE(5,4700)
4700  FORMAT(1H ,24X,*FLASH FLOOD FORECASTING TABLE*)
      GO TO 58
57    WRITE(5,4701)
4701  FORMAT(1H ,27X,*FLOOD FORECASTING TABLE*)
58    CONTINUE
      WRITE(5,1302)STATE
1302  FORMAT(//,55X,*STATE OF   *,A10)
      WRITE(5,1303)ZONE
1303  FORMAT(/,55X,*FORECAST ZONE   *,I2)
      WRITE(5,1044)BASIN
1044  FORMAT(/////,12X,5A10)
      WRITE(5,53)REACH
53    FORMAT(/,12X,5A10)
      WRITE(5,2001)
2001  FORMAT(1H ,29X,*GAGE HEIGHT IN FEET*)
5303  FORMAT(///,25X,*CURRENT FLOW = *,F7.0,* CFS*)
5304  FORMAT(/,25X,*CURRENT STAGE = *,F7.1,* FT*)
      WRITE(5,5303)BASEQ
```

TABL PROGRAM (CONTINUED)

```
      WRITE(5,5304)BASEF
      WRITE(5,107)
107   FORMAT(1H ,)
      WRITE(5,113)FSS
113   FORMAT(1H ,46X,*FLOOD STAGE =      *,F5.1,* FT.*)
      WRITE(5,108) ZERO
108   FORMAT(1H ,45X,*GAGE ZERO = *,F7.2,* FT.-MSL*)
      WRITE(5,5024)TP
5024  FORMAT(1H ,46X,*TIME TO PEAK =  *,F4.1,* HOURS*)
      WRITE(5,59)
59    FORMAT(1H ,*FLASH FLOOD*)
      WRITE(5,109)
109   FORMAT(1H ,*GUIDANCE*,19X,*INCHES OF RAINFALL IN 3 HOURS*)
      WRITE(5,106) RF
106   FORMAT(2H ,*VALUES*,11F6.1)
      WRITE(5,63)
63    FORMAT(1H ,10X,*------------------------------------------------------------
     1-------------*)
      WRITE(5,305)(FF(I),(EELV(I,J),J=1,11),I=1,21)
305   FORMAT(1X,F4.1,*  I*,11F6.1)
1112  FORMAT(1H0,)
      WRITE(5,1112)
      WRITE(5,110)
110   FORMAT(1H0,28X,*RIVER FORECAST CENTER*)
      WRITE(5,112)
112   FORMAT(1H ,31X,*TULSA OKLAHOMA*)
      RETURN
      END
000000000000000000000
000000000000000000000
```

INPUT FOR MINGO CREEK 11th STREET TABLES

```
TJ100.CM60000.T20.              SHERIDAN  TULSA
RFL.60000.
ATTACH(TSS.WTUL2,CY=62)
ATTACH(JHS,WTUL2, CY=60)
MAP OFF.
SETCORE(INDEF,ADDR)
JHS.
RFL,10000.
REWIND(OUTPUT)
COPYBF(OUTPUT.X)
REWIND(X)
COPYBF(X.OUTPUT)
0000000000000000000000
   MINGO CREEK AT 11TH STREET. TULSA, OKLAHOMA
        FOR TOTAL DRAINAGE ABOVE 11TH STREET
09-08-75
OKLAHOMA
 3
 3.5
 2891.
 608.00
 608.00       0
 615.59     325
 618.48     758
 619.79    1366
 621.19    2168
 622.41    3035
 623.25    3764
 624.41    4878
 626.24    7588
 627.24    9967
 632.22   30355






 622.
 .75
```

VITA

John Francis Sheridan

Candidate for the Degree of

Master of Science

Thesis: METHODS FOR DEVELOPING FLASH FLOOD FORECASTING TABLES

Major Field: Civil Engineering

Biographical:

Personal Data: Born in Natick, Massachusetts, April 23, 1929, the son of Thomas J. and Margaret L. Sheridan. Married to Jo Ann Dearston 1953, two sons, John H. T. and Jeffery J. Sheridan.

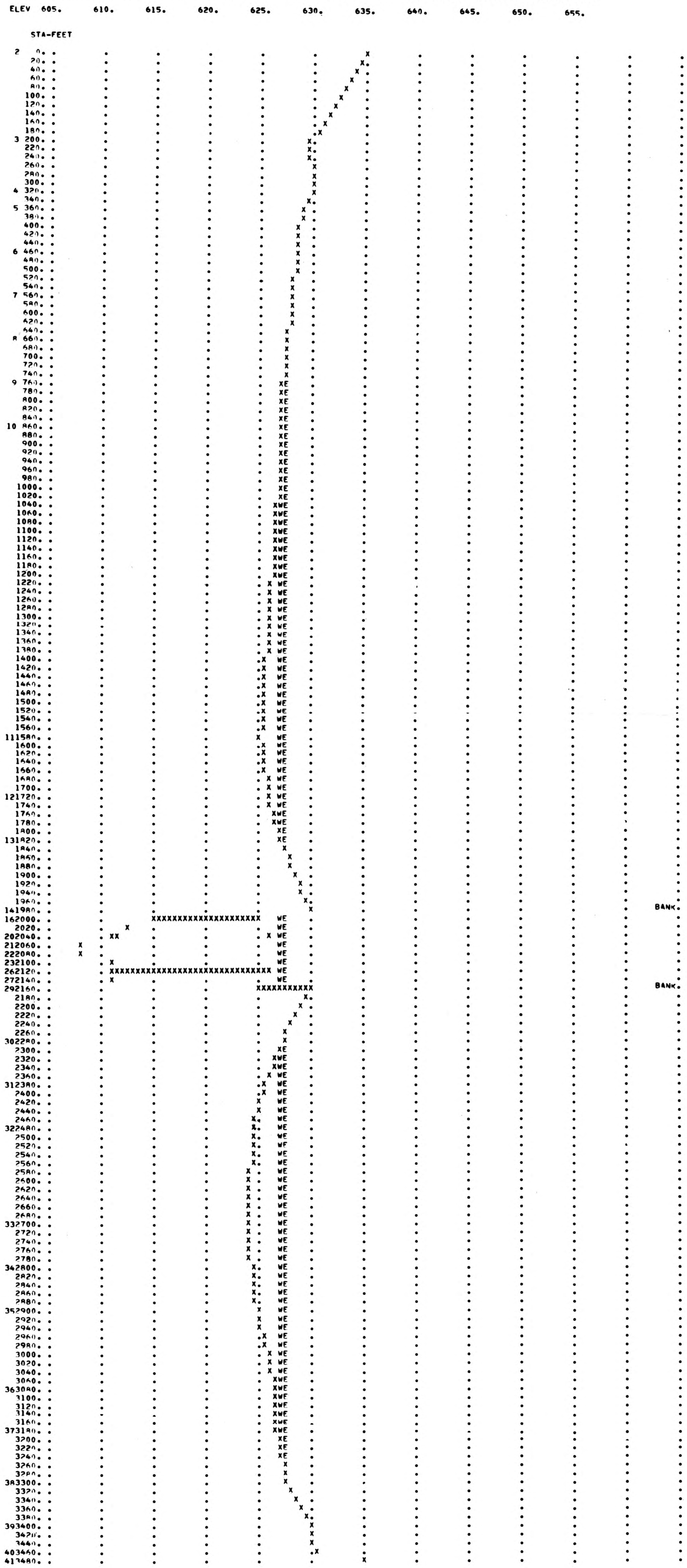
Education: Graduated from Natick High School, Natick, Massachusetts, in 1946; received a Bachelor of Science degree in Petroleum Engineering from the University of Tulsa, 1953; completed the requirements for the Master of Science degree December, 1975.

Professional Experience: For the period 1953 through 1961 worked in the fields of Petroleum, Mechanical and Civil Engineering. Since 1961 have worked as a Hydrologist with the National Weather Service, River Forecast Center, Tulsa, Oklahoma.

Professional Organizations: Student member of American Society of Petroleum Engineers; Registered Engineer, State of Oklahoma, Registered Land Surveyor, State of Oklahoma.

CROSS SECTION 23.00
RIVER OMPLETE BASIN ANALYSIS
DISCHARGE= 9967.

PLOTTED POINTS (BY PRIORITY)-B=BOTTOM BRIDGE,T=TOP BRIDGE,X=GROUND,W=WATER SUR,E=ENERGY GRADIENT,C=CRITICAL WSEL



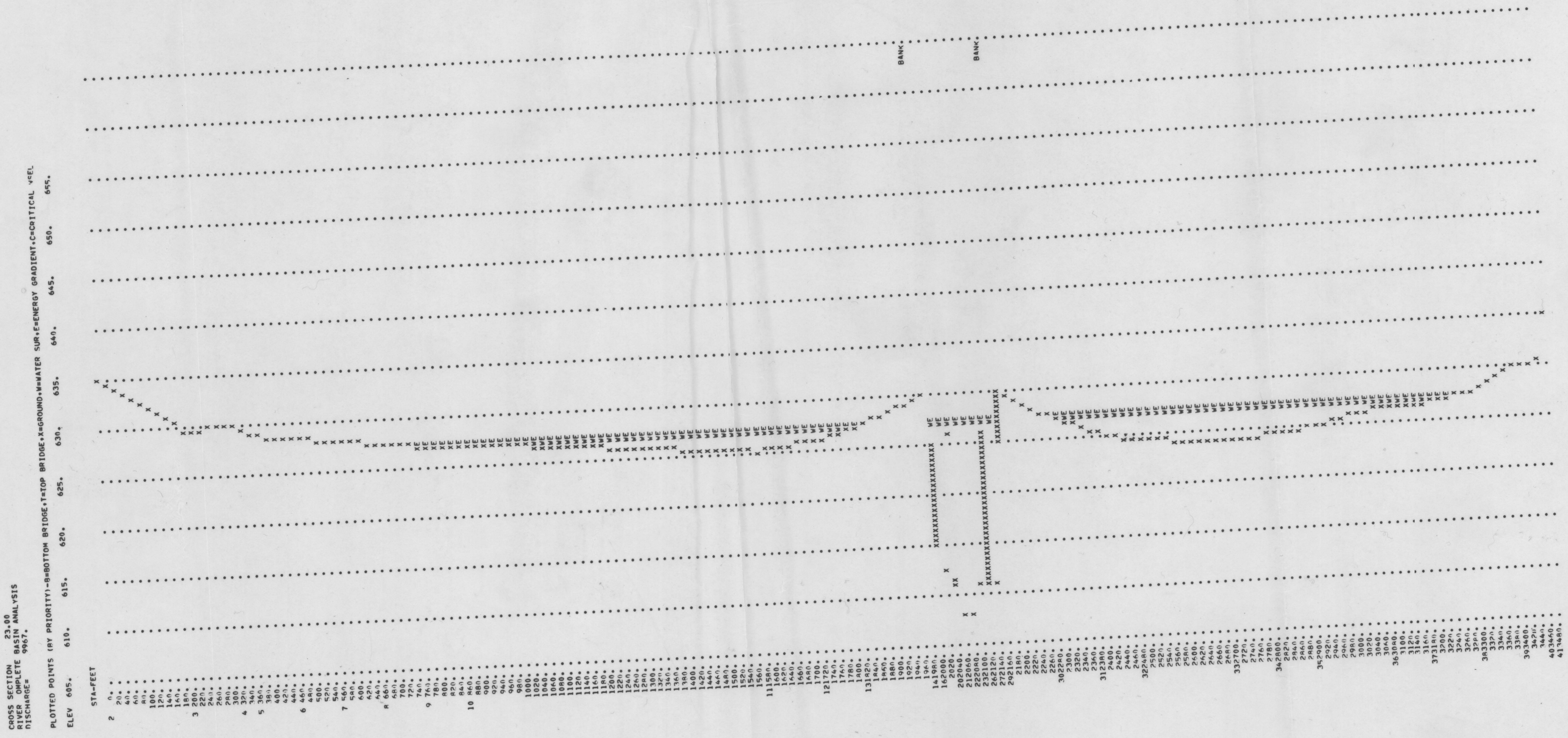
CROSS SECTION AT STATION 23 (11th STREET)

PROFILE FOR RIVER OMPLETE BASIN ANALYSIS

PLOTTED POINTS (BY PRIORITY)-E-ENERGY,W-WATER SURFACE,I-INVERT,C-CRITICAL W.S.,L-LEFT BANK,R-RIGHT BANK,M-LOWER END STA

OUTPUT BASIN PROFILE FOR 100 YEAR FLOOD

CROSS SECTION AT STATION 23 (11th STREET)



OUTPUT BASIN PROFILE FOR 100 YEAR FLOOD