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# SUSITNA HYDROELECTRIC PROJECT

## REGIONAL FLOOD STUDIES

DECEMBER 1981

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SUSITNA HYDROELECTRIC PROJECT

TASK 3 - HYDROLOGY

REGIONAL FLOOD STUDIES

DECEMBER 1981

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TASK 3 - HYDROLOGY

REGIONAL FLOOD STUDIES

TABLE OF CONTENTS

|                                                                                | <u>Page</u> |
|--------------------------------------------------------------------------------|-------------|
| LIST OF TABLES                                                                 | iii         |
| LIST OF FIGURES                                                                | iv          |
| 1 - INTRODUCTION                                                               | 1-1         |
| 2 - SUMMARY                                                                    | 2-1         |
| 3 - FLOOD FREQUENCY ANALYSIS                                                   | 3-1         |
| 3.1 - Single Station Frequency Analysis                                        | 3-1         |
| 3.2 - Regionalization of Frequency Analyses                                    | 3-3         |
| 3.3 - Relative Standard Error of the Estimate for the<br>Index Method          | 3-8         |
| 3.4 - Comparison with Results of Previous Studies                              | 3-9         |
| 4 - EVALUATION OF DESIGN FLOODS                                                | 4-1         |
| 5 - EVALUATION OF TYPICAL FLOOD HYDROGRAPHS<br>FOR SUSITNA RIVER AT GOLD CREEK | 5-1         |
| 6 - FLOOD VOLUME DURATION FREQUENCY ANALYSIS                                   | 6-1         |
| 7 - REFERENCES                                                                 | 7-1         |

## TABLE OF CONTENTS (Cont'd)

- ATTACHMENT A - Flood Frequency Curves for Annual  
Instantaneous Flood Peak Series,  
Individual Stations
- ATTACHMENT B - Flood Frequency Curves for Maximum  
Annual October-May Mean, Individual  
Stations
- ATTACHMENT C - Comparison of Susitna Regional Flood  
Peak Estimates with USGS Methods
- ATTACHMENT D - Review of Flood Frequency Analysis,  
Conducted by Dr. Robert F. Carlson,  
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## LIST OF TABLES

| <u>Number</u> | <u>Title</u>                                                                                        | <u>Page</u> |
|---------------|-----------------------------------------------------------------------------------------------------|-------------|
| 3.1           | Ratio of Instantaneous Flood Peaks to Maximum Mean Daily Flow for Specific Stations                 | 3-10        |
| 3.2           | Distribution Statistics for Annual Instantaneous Peak and October-May Mean Daily Peak Flows         | 3-11        |
| 3.3           | Mean Distribution Statistics for Annual Instantaneous Peak and October-May Maximum Mean Daily Flows | 3-12        |
| 3.4           | Homogeneity Test, Annual Instantaneous Peaks                                                        | 3-13        |
| 3.5           | Homogeneity Test, October-May Instantaneous Peaks                                                   | 3-14        |
| 3.6           | Regional Annual Instantaneous Dimensionless Flood Values                                            | 3-15        |
| 3.7           | Regional October-May Instantaneous Dimensionless Flood Values                                       | 3-16        |
| 3.8           | Physiographic and Climatic Parameters                                                               | 3-17        |
| 3.9           | Comparison of Regression Equations                                                                  | 3-18        |
| 5.1           | Determination of Daily-Instantaneous Peak Ratio, Susitna River at Gold Creek                        | 5-3         |
| 5.2           | Tabulation and Statistics of Instantaneous Peaks versus Peak Volumes, Susitna River at Gold Creek   | 5-4         |
| 6.1           | Highest Mean Discharge of Consecutive Days from May through July, Susitna River at Gold Creek       | 6-2         |

## LIST OF FIGURES

| <u>Number</u> | <u>Title</u>                                                                         | <u>Page</u> |
|---------------|--------------------------------------------------------------------------------------|-------------|
| 3.1           | Design Dimensionless Regional Frequency Curve, Annual Instantaneous Flood Peaks      | 3-19        |
| 3.2           | Design Dimensionless Regional Frequency Curve, October-May Instantaneous Flood Peaks | 3-20        |
| 5.1           | Percent of Annual Maximum Floods, Susitna River at Gold Creek                        | 5-5         |
| 5.2           | Dimensionless Hydrographs, May-July                                                  | 5-6         |
| 5.3           | Dimensionless Hydrographs, August-October                                            | 5-7         |
| 5.4           | Seasonal Discharge Frequency Curves, Susitna River at Gold Creek                     | 5-8         |
| 5.5           | Flood Volume Frequency Curve, May-July, Susitna River at Gold Creek                  | 5-9         |
| 5.6           | Flood Volume Frequency Curve, August-October, Susitna River at Gold Creek            | 5-10        |
| 5.7           | Peak vs. Volume, May-July, Susitna River at Gold Creek                               | 5-11        |
| 5.8           | Peak vs. Volume, August-October, Susitna River at Gold Creek                         | 5-12        |
| 5.9           | Typical Flood Hydrographs, May-July, Susitna River at Gold Creek                     | 5-13        |
| 5.10          | Typical Flood Hydrographs, August-October, Susitna River at Gold Creek               | 5-14        |
| 6.1           | Volume-Duration Frequency Curves, May-July, Susitna River at Gold Creek              | 6-3         |

## 1 - INTRODUCTION

On January 1, 1980, Acres American, Inc., received notice to proceed with the feasibility analysis of the Susitna Hydroelectric Project. The analysis will consider the feasibility of constructing one or possibly two dams along the upper Susitna River. The two primary sites being considered are the Watana and the Devil Canyon sites.

The objective of this study is to provide design flood peak information for the design of the project and for assessing pre-project flood conditions in the Susitna River reaches located downstream and upstream from the proposed Watana and Devil Canyon dam sites. Within this context, two types of floods were studied: the largest annual floods and the largest annual floods during ice conditions (October-May). Procedures were developed to estimate the annual instantaneous peak and the October-May instantaneous peak for selected frequencies of occurrence on ungaged rivers within the upper Susitna River basin. Procedures were also developed to estimate the error associated with estimates made by the above mentioned procedures. Typical hydrographs were developed indicating flood shape, peak, and volume for selected frequencies of occurrence. Flow volume-duration frequency curves were also developed for the May-July and August-October periods on the Susitna River at Gold Creek.





## 2 - SUMMARY

This report describes the Susitna Regional Flood Peak Frequency Analysis conducted by R&M Consultants, Inc., for Acres American, Inc. Acres American, under contract with the State of Alaska, is conducting a study concerning the feasibility of developing a hydroelectric complex on the upper Susitna River.

The results of single station flood frequency analyses are presented for 12 stations having annual instantaneous flood peak data, and for 11 stations having maximum October-May mean daily flow data. Four frequency distributions were analyzed, from which the Three Parameter Log Normal Distribution was selected. Subsequently, the October-May maximum mean daily flows for selected frequencies of occurrence were converted to instantaneous peaks.

By using the index method of regionalizing the data, procedures were developed to estimate the annual instantaneous peak and the October-May instantaneous peak for selected frequencies of occurrence on ungaged rivers within the upper Susitna River basin. Procedures were also developed to estimate the error associated with estimates made by the above mentioned procedures. The results of this analysis are then compared to those of previous regional analyses.

Typical hydrographs for different frequency floods were developed for the Susitna River at Gold Creek. A flood volume-duration analysis was also conducted for May-July flows recorded at Susitna River at Gold Creek.



### 3 - FLOOD FREQUENCY ANALYSIS

The Susitna Regional Flood Frequency Analysis was conducted in the following four steps;

- a. Single station flood frequency analyses were conducted at stations thought to be hydrologically similar to the upper Susitna River basin.
- b. The single station flood frequency analyses were regionalized.
- c. An error analysis was conducted in order to estimate the amount of error associated with flood peak estimates in ungaged areas.
- d. The results of this analysis were compared with 2 regional analyses which have been conducted by the U.S. Geological Survey.

Each of these steps is explained fully in the report that follows:

#### 3.1 - Single Station Frequency Analysis

In order to select stream gaging stations that are hydrologically similar to the upper Susitna River basin, factors such as mean annual runoff volume, climate, and geology were examined for rivers with USGS stream gaging stations in southcentral Alaska. Of those stations identified, only those with 10 or more years of record and greater than 150 square miles in size were utilized. The basins finally selected were as follows:

Susitna River at Gold Creek  
Susitna River near Denali  
Maclaren River near Paxson  
Susitna River near Cantwell  
Chulitna River near Talkeetna  
Talkeetna River near Talkeetna  
Montana Creek near Montana  
Skwentna River near Skwentna  
Caribou Creek near Sutton  
Matanuska River at Palmer  
Tonsina River at Tonsina  
Copper River near Chitina

The last four stations are not as good as the first eight, due to their distance from the Susitna basin and their exposure to a maritime climate. However, these differences were not sufficient to warrant exclusion from the analysis.

Three types of floods were abstracted from the records: annual instantaneous peak discharge, annual maximum mean daily discharges, and annual maximum October-May mean daily discharges. Both the annual instantaneous peak discharge and the mean daily discharge data are available for each of the stations selected, with the exception of Montana Creek. Montana Creek is a crest gage station with only annual instantaneous peak discharge data available.

For each station with mean daily discharge data, a ratio was developed between the annual instantaneous peak discharge and the annual maximum mean daily discharge (Table 3.1). Where an occasional annual instantaneous peak discharge value was missing from the station record, the ratio was used to predict the annual instantaneous peak value.

A Fortran IV computer program (Condie et. al., 1977) was used to fit the Gumbel I, Log Normal, Three Parameter Log Normal and Log Pearson Type III distributions to both the annual instantaneous flood peaks and the annual maximum October-May mean daily discharges. The program ranks the annual flood peaks and fits the frequency curves by the method of maximum likelihood. When the maximum likelihood methods have no true solution, a moments fit is used. For the Log Pearson Type III distribution, both the maximum likelihood and the moment fits are calculated in the program. The ranked discharges are assigned plotting positions by the Weibull formula:

$$T = (N + 1) / M \quad (3.1)$$

Where:

T = return period in years  
N = record length in years  
M = the rank

Tables 3.2 and 3.3 illustrate the degree of fit achieved by fitting each of the distributions to both the annual instantaneous flood peak series and the annual maximum October-May mean daily discharge series. From the results shown in Table 3.3, the Three Parameter Log Normal Distribution provides the best fit of the data, although the Log Normal Distribution is also acceptable. The Three Parameter Log Normal Distribution is adopted almost exclusively throughout this study. At two stations in the annual maximum October-May mean daily discharge series it was not possible to fit the Three Parameter Log Normal Distribution to the data. At these two stations, Susitna River at Cantwell and Skwentna River near Skwentna, the Log Normal Distribution was

used. Plots of the flood frequency curves for each of the stations and flood series are exhibited in Attachments A and B.

Since the computer program only considers recurrence intervals of 1.005, 1.05, 1.25, 2, 5, 10, 20, 50, 100, 200 and 500 years, the graphs of the annual instantaneous flood peak frequency curves were extrapolated to the 10,000-year recurrence interval.

The annual maximum October-May mean daily discharge frequency curves were converted to October-May instantaneous peak discharge frequency curves using the ratios discussed earlier. Thus, the remainder of this study only considers the annual instantaneous flood peak frequencies and the October-May instantaneous flood peak frequencies.

### 3.2 - Regionalization of Frequency Analyses

Regionalization of the single-station frequency curves involves developing regional relationships which can be used to calculate design flood peaks within a "homogeneous flood region". Theoretically, the flood response of all catchments within a homogeneous flood region is the same. In practice, however, the term "homogeneous" implies that the response characteristics of the individual basins are not significantly different and that these differences, coupled with sampling errors associated with the discharge measurement, yield errors in the regional relationships which are within acceptable limits. The purpose of developing the regional relationships is to apply them to ungaged drainage basins as well as to gaged drainage basins for which discharge records are too short to yield accurate results.

To determine if the stations selected were homogeneous with regard to runoff, a standard Student's "t" test of homogeneity of the  $Q_{20}/Q_2 = Y_{20}$  variables was used. For each flood series within the region being analyzed, individual station  $Y_{20}$  values were computed (Tables 3.4 and 3.5) and were used to calculate the allowable range in  $Y_{20}$  by applying the following equation:

$$\bar{Y}_{20} - (t_{m-1}) \left[ S_{20}^2 \left( 1 + \frac{1}{(m-1)} \right) \right]^{\frac{1}{2}} < Y_{20} < \bar{Y}_{20} + (t_{m-1}) \left[ S_{20}^2 \left( 1 + \frac{1}{(m-1)} \right) \right]^{\frac{1}{2}} \quad (3.2)$$

Where:

- $Y_{20}$  = ratio of 20-year return flood to the mean annual flood for a single station
- $\bar{Y}_{20}$  = an average of the single station  $Y_{20}$  values for a particular flood series
- $t_{m-1}$  = "t" statistic for m-1 degrees of freedom at the 95 percent confidence level
- $S_{20}$  = standard deviation of the individual stations at the 20-year return period
- $m$  = number of stations in the region

As can be seen from Tables 3.4 and 3.5, all individual  $Y_{20}$  value are within the limits of the 95% confidence level. Therefore, all of the stations selected for use in the Susitna Regional Flood Frequency Analysis are homogeneous with respect to both annual instantaneous peak discharges and October-May instantaneous peak discharges.

Once it was determined that all of the stations selected for use in the analysis were homogeneous with respect to discharge, the index method was used to regionalize the single-station data. The index method consists of two parts (Dalrymple, 1960). The first involves the development of a regional dimensionless frequency curve representing the ratio of the flood of any given frequency to the mean annual flood. The second part requires the development of regression equations for relating the mean annual flood to the physiographic and climatic characteristics of the drainage basins. By combining the mean annual flood with the regional dimensionless frequency curve, a frequency curve for any ungaged location within the region can be developed.

This method assumes that throughout large regions that are considered to be homogeneous with respect to flood producing characteristics, individual basins with widely varying drainage areas will have frequency curves of equal shape and slope. Any differences in the shape and slopes of the individual curves are attributed to sampling error.

To produce a regional curve from single station curves, Dalrymple (1960) recommends that the dimensionless frequency curves for a homogeneous region be evaluated as the median of the individual frequency curves within the region. Since the weighted median has also been found to be useful in this type of analysis (Acres American, 1977), the dimensionless discharges at the 1.005, 1.05, 1.25, 2, 5, 10, 20, 50, 100, 200 and 500-year recurrence intervals were analyzed with regards to the mean, median and weighted median at each recurrence interval (Tables 3.6 and 3.7). The weighted median was determined by using the number of years of record at a station as the weight for that station. The dimensionless frequency curve was estimated from the median of the 12 stations used in the analysis. The median value had a better general fit than either the mean or the weighted median values. The mean value at the 10,000-year return period was abnormally high, while the weighted median values started decreasing after the 100-year return period.

The confidence limits for each of the regional curves are based on values computed at the 1.005, 1.05, 1.25, 2, 5, 10, 20, 50, 100, 200 and 500-year recurrence intervals from the standard deviation of the single station curves about the regional curves, using the following equations.

The standard deviation of single station curve values about the regional curve is given by

$$ST = \left[ \frac{\sum_{1}^m [(Y_T - \bar{Y}_T)^2]}{(m-1)} \right]^{\frac{1}{2}} \quad (3.3)$$

Where:

- ST = standard deviation at T-year return period
- $\bar{Y}_T$  = value of median dimensionless regional curve at T-year return period
- $Y_T$  = value of dimensionless single station curve at T-year return period
- m = number of single station curves

The standard error of the median (or regional curve in this case) as a proportion of the median is given by

$$SEM_T = \frac{ST}{\bar{Y}_T (m)^{\frac{1}{2}}} \quad (3.4)$$

Where:

$SEM_T$  = relative standard error of median, i.e.  
regional curve at T-year period.

The associated 95 percent confidence limits for the regional curve are derived from the standard error and the corresponding "t" statistic coefficients.

A stepwise multiple linear regression computer program (Dixon et al., 1977) was used to relate the mean annual instantaneous peak flow and the mean October-May instantaneous peak flow to the physiographic and climatic characteristics of the drainage basins. The program performs a forward stepping multiple linear regression analysis and tests the "significance" of variables, both those used in the equation and those remaining to be used, by their "F" ratio at each step of the analysis. The standard error of the estimate and the coefficient of determination are determined for each step. The physiographic and climatic parameters used and their values for each of the stations are presented in Table 3.8.

In order to test the effect of a log-transform on the flow data, the HEC Multiple Linear Regression computer program was used. Non-transform and log-transform regression analyses were conducted on the mean annual instantaneous peak flow and the mean October-May instantaneous peak flow. The non-transformed results obtained by HEC's stepwise backward program duplicated results obtained in the initial analysis. The following information indicates that the log-transform analysis did not improve the statistics. Consequently, the non-transform regression equations were selected.

|                    | <u>R<sup>2</sup></u> | <u>Standard Error of Estimate (s)</u> |       | <u>95% Error</u> |
|--------------------|----------------------|---------------------------------------|-------|------------------|
| Mean Annual Flood  |                      |                                       |       |                  |
| Non-Transform      | 0.9994               | +1465                                 | -1465 | 4%               |
| Log-Transform      | 0.9930               | +2612                                 | -2612 | 14.5%            |
| Oct-May Mean Flood |                      |                                       |       |                  |
| Non-Transform      | 0.9709               | +3081                                 | -3081 | 20%              |
| Log-Transform      | 0.9141               | +4425                                 | -4425 | 50%              |



The equations that were finally selected, including the coefficient of determination and the standard error of the estimate, are as follows:

Mean Annual Instantaneous Flood Peak

$$Q_A = 7.06(D.A) + 46.36(L) + 697.14(G) + 200.15(MAP) - 49.55(MAS) - 2594 \quad (3.5)$$

$$R^2 = 0.9994$$

$$S.E.E. = 1465$$

Mean October-May Instantaneous Flood Peak

$$Q_{o-m} = 1.56(D.A.) + 143.35(L) - 2894 \quad (3.6)$$

$$R^2 = 0.9853$$

$$S.E.E. = 3081$$

Where:

- $Q_A$  = Mean Annual Instantaneous Flood Peak, cfs.
- $Q_{o-m}$  = Mean October-May Instantaneous Flood Peak, cfs.
- $D.A.$  = Drainage Area, sq. mi.
- $L$  = Stream Length, mi.
- $G$  = Percent of Drainage Area Covered by Glaciers, %
- $MAP$  = Mean Annual Precipitation, in.
- $MAS$  = Mean Annual Snowfall, in.

Of the five parameters selected for computing the mean annual instantaneous flood peaks, drainage area explains over 98 percent of the variation between the regional mean annual flood and those of the individual stations. However, inclusion of the other four basin and climatic parameters (main channel length, percent of glacial area, mean annual precipitation, and mean annual snowfall) significantly reduced the standard error of estimate for the mean

annual flood peak. Since the regional mean annual flood is the basis from which all other recurrence intervals are estimated, the four other parameters were included.

Similar logic applies to the selection of parameters for the mean October-May instantaneous flood peak. Drainage area and main channel length explain over 97 percent of the variation. However, inclusion of additional parameters did not significantly decrease the standard error of estimate in this case, so only the above two parameters were used.

### 3.3 - Relative Standard Error of the Estimate for the Index Method

Equation (3.3) gives the standard deviation,  $S_T$ , of the dimensionless frequency curves about the regional curve. Equation (3.7) is then used to calculate the associated relative standard error of estimate,  $SE_T$ .

$$SE_T = \frac{S_T}{\bar{Y}_T} \quad (3.7)$$

Where:

$\bar{Y}_T$  = value of median dimensionless regional curve for the T-year return period

$SEM_T$  in Equation (3.4) represents the standard error of estimate of the median or regional curve.  $SE_T$  in Equation (3.7) represents the standard error of the individual station curves about the regional curve. Note that  $SEM_T = SE_T / (m)^2$ .

In order to combine the errors  $SE_T$  associated with the application of the index curve with the errors in the calculation of the mean annual flood, Equation (3.8) is applied. An outline of the derivation of this equation is presented in the report entitled "Regional Flood Frequency Analysis" (Acres American, 1977).

$$SEC_T = (SE_T^2 + SE_2^2)^{\frac{1}{2}} \quad (3.8)$$

Where:

$SEC_T$  = composite relative standard error of estimate of T-year event

$SE_2$  = relative standard error of estimate associated with the evaluation of the mean annual flood

Figures 3.1 and 3.2 present dimensionless flood frequency curves which can be used in conjunction with Equations (3.5) and (3.6) to predict the annual instantaneous and October-May instantaneous flood peaks at specific recurrence intervals. The figures also present curves for computing the associated composite 95 percent confidence limits for the estimate.

### 3.4 - Comparison with Results of Previous Studies

Previous regional flood studies carried out in the Susitna River basin and surrounding basins include:

(a) Lamke, R.D. (1979)

Multiple regression equations for different recurrence intervals were developed for two regions of the state. Area I consists of most areas of Alaska with a maritime climate, excluding the Aleutian Islands and the Pacific Ocean side of the Alaska Peninsula. Area II consists of those parts of Alaska with transitional, continental, and arctic climates, together with the Aleutian Islands and the Pacific Ocean side of the Alaskan Peninsula which have maritime climate. The Susitna River basin is included in Area II.

(b) Freethey, G.W. and D.R. Scully (1980)

Multiple regression equations for different recurrence intervals were developed using peak discharges from 50 Cook Inlet gaging stations with 10 years or more of data.

No regional flood studies in the area have used the index method.

Table 3.9 lists the parameters used in the regression analyses and compares the standard errors of estimate for the 2-, 5-, 10-, 50- and 100-year flood peaks. Values for the 100-year flood peaks were not derived by either of the USGS studies. It is evident from this table that the standard errors achieved in this study are lower than those in the other studies. Fewer stations were used in this study, but the stations were either within the transitional climate region or were on its borders. The USGS studies used gaging stations over much larger areas, with consequently larger differences in climate. Attachment C presents a comparison between the Susitna Regional Flood Peak estimates and estimates using the two USGS methods.

TABLE 3.1

RATIO OF INSTANTANEOUS FLOOD PEAKS TO MAXIMUM MEAN  
DAILY FLOW FOR SPECIFIC STATIONS

| <u>Station Name</u> | <u>Location</u> | <u>QP/QD<sup>1</sup></u> | <u>Standard<br/>Deviation</u> | <u>Number in<br/>Sample</u> |
|---------------------|-----------------|--------------------------|-------------------------------|-----------------------------|
| Susitna River       | at Gold Creek   | 1.060                    | 0.036                         | 31                          |
| Caribou Creek       | near Sutton     | 1.617                    | 0.365                         | 22                          |
| Matanuska River     | at Palmer       | 1.221                    | 0.168                         | 24                          |
| Susitna River       | near Denali     | 1.104                    | 0.049                         | 19                          |
| Maclaren River      | near Paxson     | 1.091                    | 0.077                         | 19                          |
| Susitna River       | near Cantwell   | 1.082                    | 0.059                         | 6                           |
| Chulitna River      | near Talkeetna  | 1.044                    | 0.032                         | 13                          |
| Talkeetna River     | near Talkeetna  | 1.219                    | 0.102                         | 16                          |
| Skwentna River      | near Skwentna   | 1.067                    | 0.044                         | 18                          |
| Tonsina River       | at Tonsina      | 1.031                    | 0.036                         | 28                          |
| Copper River        | near Chitina    | 1.043                    | 0.061                         | 23                          |

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<sup>1</sup> Mean Ratio of Annual Instantaneous Flood Peak to Annual Maximum Mean Daily Flow.

TABLE 3.2  
DISTRIBUTION STATISTICS FOR ANNUAL INSTANTANEOUS PEAK  
AND  
OCT-MAY MEAN DAILY PEAK FLOWS

| GUMBEL I                        |              |               |     |          |         |                   |                |          |         |                   |                | LOG NORMAL  |         |          |                   | 3 PARAMETER LOG NORMAL |                            |                   |                | LOG PEARSON TYPE III (moments) |                           |                |      | LOG PEARSON TYPE III (maximum likelihood) |  |  |  |
|---------------------------------|--------------|---------------|-----|----------|---------|-------------------|----------------|----------|---------|-------------------|----------------|-------------|---------|----------|-------------------|------------------------|----------------------------|-------------------|----------------|--------------------------------|---------------------------|----------------|------|-------------------------------------------|--|--|--|
| STATION NUMBER                  | RIVER NAME   | LOCATION      | N   | CS       | CK      | SUM OF DEVIATIONS | MEAN DEVIATION | CSL      | CKL     | SUM OF DEVIATIONS | MEAN DEVIATION | CSLA        | CKLA    | AVG. CV. | SUM OF DEVIATIONS | MEAN DEVIATION         | AVG. CV.                   | SUM OF DEVIATIONS | MEAN DEVIATION | AVG. CV.                       | SUM OF DEVIATIONS         | MEAN DEVIATION |      |                                           |  |  |  |
| ANNUAL INSTANTANEOUS PEAK FLOWS |              |               |     |          |         |                   |                |          |         |                   |                |             |         |          |                   |                        |                            |                   |                |                                |                           |                |      |                                           |  |  |  |
| 2920                            | Susitna R.   | at Gold Cr.   | 25  | 0.6830   | 2.9269  | -22.90            | 5.16           | 0.0664*  | 2.8362  | -19.28            | 4.23           | -0.0805     | 2.9638* | 15.01*   | -18.09*           | 4.11*                  | 15.39                      | -19.01            | 3.97           | 15.51                          | -20.67                    | 4.38           |      |                                           |  |  |  |
| 2820                            | Caribou Cr.  | nr. Sutton    | 21  | 0.9338   | 4.2274  | -22.03            | 7.14           | -0.0431  | 3.6494  | -19.39*           | 7.07*          | -0.0228*    | 3.6401* | 15.53*   | -19.56            | 7.11                   | 16.49                      | -19.57            | 7.15           | 16.16                          | -21.98                    | 7.31           |      |                                           |  |  |  |
| 2840                            | Matanuska R. | at Palmer     | 17  | 0.2193   | 3.6631  | 10.05             | 4.32           | -0.5370  | 3.9370  | 5.46              | 4.17*          | -0.0121*    | 3.5923* | 10.59    | 2.03*             | 5.53                   | Upper Boundary Is Too Low  |                   |                |                                | Upper Boundary Is Too Low |                |      |                                           |  |  |  |
| 2910                            | Susitna R.   | nr. Denali    | 20  | 2.4985   | 10.3480 | -49.50            | 12.95          | 1.8453   | 7.0725  | -33.19*           | 11.21          | 0.0613*     | 4.2263* | 23.59*   | -38.16            | 8.39*                  | 35.46                      | -38.81            | 8.39*          | No Solution                    |                           |                |      |                                           |  |  |  |
| 2912                            | MacLaren R.  | nr. Paxson    | 22  | 0.9062   | 3.4430  | -15.76            | 7.18           | 0.5539   | 2.6687* | - 8.75            | 6.14           | -0.3915*    | 2.6565  | 25.66    | 8.93              | 3.99*                  | 15.93*                     | - 8.18*           | 4.90           | No Solution                    |                           |                |      |                                           |  |  |  |
| 2915                            | Susitna R.   | nr. Cantwell  | 11  | 0.3325   | 3.1548  | - 0.90*           | 4.46           | -0.1474  | 3.2888  | 3.15              | 5.85*          | -0.1172*    | 3.2667* | 18.79*   | 1.32              | 6.01                   | 19.01                      | 1.92              | 6.21           | Upper Boundary Is Too Low      |                           |                |      |                                           |  |  |  |
| 2924                            | Chulitna R.  | nr. Talkeetna | 18  | 2.9054   | 11.7449 | -33.82            | 10.15          | 2.0596   | 10.0178 | -23.88*           | 10.58          | 0.3512*     | 6.8509* | 14.05    | -27.36            | 9.21*                  | Lower Boundary Is Too High |                   |                |                                | 12.82*                    | -29.93         | 9.45 |                                           |  |  |  |
| 2927                            | Talkeetna R. | nr. Talkeetna | 15  | 1.8140   | 6.6111  | - 1.99            | 8.16           | 1.0298   | 4.7599  | 5.39              | 8.80           | -0.0921*    | 4.0752* | 30.54*   | - 0.74*           | 5.27                   | 40.08                      | - 3.38            | 5.65           | 37.65                          | - 5.43                    | 5.97*          |      |                                           |  |  |  |
| 2928                            | Montana Cr.  | nr. Montana   | 10  | 0.9133   | 6.6962* | -26.31            | 9.59*          | -1.2149  | 7.5292  | -26.37            | 11.51          | 0.0324*     | 5.9398  | 22.31    | -25.50*           | 9.65                   | Upper Boundary Is Too Low  |                   |                |                                | Upper Boundary Is Too Low |                |      |                                           |  |  |  |
| 2943                            | Skwentna R.  | nr. Skwentna  | 20  | 1.0748   | 4.6668* | -20.21            | 5.42           | 0.4530   | 4.0757  | -19.07            | 6.23           | 0.0346*     | 4.2125  | 11.90*   | -18.27*           | 5.42                   | 13.81                      | -18.61            | 5.20*          | 12.23                          | -20.29                    | 5.53           |      |                                           |  |  |  |
| 2080                            | Tonsina R.   | at Tonsina    | 28  | 0.4969   | 3.3804  | -11.33            | -3.54          | 0.0305*  | 2.8533  | - 9.25            | 3.44           | -0.0817     | 2.8733* | 12.73*   | - 9.15*           | 3.09*                  | 12.88                      | - 9.98            | 3.38           | 12.83                          | -11.34                    | 3.65           |      |                                           |  |  |  |
| 2120                            | Copper R.    | nr. Chitina   | 25  | 1.6079   | 7.3832  | -16.95            | 3.39           | 0.9367   | 5.5081  | -15.77            | 3.71           | 0.1061*     | 4.8017* | 8.59     | -15.57*           | 3.11*                  | 11.98                      | -15.68            | 3.14           | 8.35*                          | -16.99                    | 3.40           |      |                                           |  |  |  |
| OCT-MAY MEAN DAILY PEAK FLOWS   |              |               |     |          |         |                   |                |          |         |                   |                |             |         |          |                   |                        |                            |                   |                |                                |                           |                |      |                                           |  |  |  |
| 2920                            | Susitna R.   | at Gold Cr.   | 30  | 0.2895   | 3.8267  | 9.19              | 6.04           | -0.9208  | 5.1200* | 4.47              | 5.98           | 0.0009*     | 3.6135  | 8.76     | - 3.39*           | 3.82*                  | Upper Boundary Is Too Low  |                   |                |                                | Upper Boundary Is Too Low |                |      |                                           |  |  |  |
| 2820                            | Caribou Cr.  | nr. Sutton    | 23  | 1.1847   | 4.6347  | -16.66            | 12.90          | -0.5297  | 4.3443  | -4.60*            | 2.82*          | 0.0363*     | 3.4587* | 22.25    | - 9.95            | 7.51                   | 24.25                      | - 9.34            | 7.36           | 20.36*                         | -12.39                    | 8.25           |      |                                           |  |  |  |
| 2840                            | Matanuska R. | at Palmer     | 24  | 1.7691   | 8.7422  | -16.47            | 6.90           | -0.0550  | 3.6148* | -10.60*           | 5.97           | -0.0449*    | 3.6202  | 19.25*   | -10.70            | 6.95                   | 20.73                      | -10.91            | 6.94           | 20.35                          | -13.76                    | 6.79*          |      |                                           |  |  |  |
| 2910                            | Susitna R.   | nr. Denali    | 16  | 1.3738   | 5.3382* | -10.57            | 9.09           | 0.1569   | 3.6358  | - 9.12*           | 7.30           | -0.0939*    | 3.6889  | 25.84*   | -10.81            | 6.56*                  | 27.98                      | -10.54            | 6.76           | 27.46                          | -12.55                    | 6.83           |      |                                           |  |  |  |
| 2912                            | MacLaren R.  | nr. Paxson    | 15  | 2.1811   | 9.2765  | 0.90              | 13.63          | 0.6728   | 4.3661  | 0.51*             | 10.37          | -0.1931*    | 3.8534* | 38.51*   | - 6.32            | 5.31*                  | 47.26                      | - 7.98            | 7.13           | 44.44                          | -11.66                    | 6.17           |      |                                           |  |  |  |
| 2915                            | Susitna R.   | nr. Cantwell  | 10  | -0.0092  | 3.7052  | 6.56              | 5.88*          | -0.9013* | 4.5940* | 5.33*             | 6.58           | NO SOLUTION |         |          |                   |                        | 29.00                      | 10.07             | 5.54           | No Solution                    |                           |                |      |                                           |  |  |  |
| 2924                            | Chulitna R.  | nr. Talkeetna | 11  | 0.5364   | 3.9480  | -3.16             | 7.93           | -0.1723  | 3.1067  | 0.39*             | 6.28           | -0.1638*    | 3.3051* | 24.41    | 0.45              | 6.29                   | 24.45                      | 1.52              | 6.22*          | 18.11*                         | 2.06                      | 7.66           |      |                                           |  |  |  |
| 2927                            | Talkeetna R. | nr. Talkeetna | 15  | 0.4151   | 3.1464  | 0.02*             | 11.90          | -0.2369  | 2.6070* | 0.14              | 11.01*         | -0.1968*    | 2.6042  | 22.46*   | 0.56              | 11.14                  | 22.83                      | 1.65              | 11.23          | Upper Boundary Is Too Low      |                           |                |      |                                           |  |  |  |
| 2928                            | Montana Cr.  | nr. Montana   | 0** |          |         |                   |                |          |         |                   |                | NO SOLUTION |         |          |                   |                        | 15.68                      | 1.10              | 7.95*          | No Solution                    |                           |                |      |                                           |  |  |  |
| 2943                            | Skwentna R.  | nr. Skwentna  | 15  | -0.1794* | 2.1487  | -0.72             | 9.03           | -0.4334  | 2.3244* | -0.58*            | 9.86           | NO SOLUTION |         |          |                   |                        | 24.10                      | 5.92              | 9.83           | 23.11                          | 3.76                      | 9.81*          |      |                                           |  |  |  |
| 2080                            | Tonsina R.   | at Tonsina    | 26  | 2.4301   | 12.2475 | -1.32*            | 10.02          | 0.2485   | 3.9367  | 5.01              | 9.98           | -0.0632*    | 3.6135* | 21.23*   | 7.76              | 9.92                   | 24.10                      | 5.92              | 9.83           | 23.11                          | 3.76                      | 9.81*          |      |                                           |  |  |  |
| 2120                            | Copper R.    | nr. Chitina   | 21  | 0.2134   | 3.0599  | -1.53*            | 3.47           | -0.3625  | 3.0558  | -5.10             | 3.21*          | -0.0281*    | 2.9764* | 9.73     | -7.64             | 3.61                   | 11.11                      | - 6.77            | 3.20*          | 7.96*                          | - 9.00                    | 4.02           |      |                                           |  |  |  |

N = record length in years  
CS = coefficient of skewness of natural data  
CK = coefficient of kurtosis of natural data  
CSL = coefficient of skewness of the natural logs of the data  
CKL = coefficient of kurtosis of the natural logs of the data  
CSLA = coefficient of skewness of the natural logs of the transformed data  
CKLS = coefficient of kurtosis of the natural logs of the transformed data

AVG. CV. = average coefficient of variation for all return periods estimated  
Sum of Deviations =  $\sum (Q - Q_0)/Q_0$  for 1.25, 2, 5, 10 and 20 year return periods  
Mean Deviation =  $\sum (Q - Q_0)/5$  for 1.25, 2, 5, 10 and 20 year return periods  
GI = Gumbel I  
LN = Log Normal  
3PLN = Three Parameter Log Normal  
LP-M = Log Pearson Type III (moments)  
LP-ML = Log Pearson Type III (maximum likelihood)

\* Distribution best fitting a given parameter  
\*\* A Great-Gage station only  
Upper boundary is too low - less than twice the magnitude of the largest flood on record.  
Lower boundary is too high - greater than the smallest flood on record.

**Theoretical Values**  
Gumbel I Log Normal 3PLN  
CS=1.14 CSL=0.0 CSLA=0.0  
CK=5.4 CKL=3.0 CKLS=3.0

TABLE 3.3

MEAN DISTRIBUTION STATISTICS FOR ANNUAL INSTANTANEOUS PEAK AND  
OCT. - MAY MAXIMUM MEAN DAILY FLOWS

| <u>ANNUAL INSTANTANEOUS PEAKS</u>            |             |                               |                                         | <u>OCT. - MAY MAXIMUM DAILY FLOWS</u> |                               |                                         |
|----------------------------------------------|-------------|-------------------------------|-----------------------------------------|---------------------------------------|-------------------------------|-----------------------------------------|
|                                              | <u>MEAN</u> | <u>STANDARD<br/>DEVIATION</u> | <u>COEFFICIENT OF<br/>VARIATION (%)</u> | <u>MEAN</u>                           | <u>STANDARD<br/>DEVIATION</u> | <u>COEFFICIENT OF<br/>VARIATION (%)</u> |
| Gumbel I                                     |             |                               |                                         |                                       |                               |                                         |
| Coefficient of Skew                          | 1.22        | 0.83                          | 68                                      | 0.92                                  | 0.91                          | 99                                      |
| Coefficient of Kurtosis                      | 5.86*       | 3.34                          | 57                                      | 5.46*                                 | 3.20                          | 59                                      |
| Sum of Deviations                            | -17.64      | 15.79                         | 90                                      | -2.86                                 | 8.43                          | 295                                     |
| Mean Deviation                               | 6.95        | 2.89                          | 42                                      | 8.80                                  | 3.17                          | 36                                      |
| Log Normal                                   |             |                               |                                         |                                       |                               |                                         |
| Coefficient of Skew                          | 0.42        | 0.92                          | 219                                     | 0.23                                  | 0.48                          | 209                                     |
| Coefficient of Kurtosis                      | 4.85        | 2.29                          | 47                                      | 3.73                                  | 0.87                          | 23                                      |
| Sum of Deviations                            | -13.59      | 12.61                         | 93                                      | -1.27*                                | 5.45                          | 429                                     |
| Mean Deviation                               | 6.91        | 2.95                          | 43                                      | 7.21                                  | 2.70                          | 37                                      |
| Three Parameter Log Normal                   |             |                               |                                         |                                       |                               |                                         |
| Coefficient of Skew                          | -0.02*      | 0.17                          | 850                                     | 0.09*                                 | 0.08                          | 89                                      |
| Coefficient of Kurtosis                      | 4.10        | 1.27                          | 31                                      | 3.41                                  | 0.40                          | 12                                      |
| Sum of Deviations                            | -13.34*     | 14.06                         | 105                                     | -4.45                                 | 6.32                          | 142                                     |
| Mean Deviation                               | 5.91        | 2.26                          | 38                                      | 6.79*                                 | 2.52                          | 37                                      |
| Log Pearson Type III<br>(moments)            |             |                               |                                         |                                       |                               |                                         |
| Sum of Deviations                            | -14.58      | 11.78                         | 81                                      | -2.53                                 | 7.50                          | 296                                     |
| Mean Deviation                               | 5.33        | 1.74                          | 33                                      | 7.22                                  | 2.21                          | 31                                      |
| Log Pearson Type III<br>(maximum likelihood) |             |                               |                                         |                                       |                               |                                         |
| Sum of Deviations                            | -18.09      | 7.89                          | 44                                      | -7.72                                 | 7.25                          | 94                                      |
| Mean Deviation                               | 5.09*       | 2.57                          | 50                                      | 7.08                                  | 1.80                          | 25                                      |

\* Distribution best fitting a given parameter.

TABLE 3.4  
HOMOGENEITY TEST  
ANNUAL INSTANTANEOUS PEAKS

| Station                        | $Q_{20}/Q_2 = Y_{20}$  |
|--------------------------------|------------------------|
| Susitna River at Gold Creek    | 1.83                   |
| Caribou Creek near Sutton      | 1.82                   |
| Matanuska River at Palmer      | 1.49                   |
| Susitna River near Denali      | 1.81                   |
| MacLaren River near Paxson     | 2.02                   |
| Susitna River near Cantwell    | 1.68                   |
| Chulitna River near Talkeetna  | 1.47                   |
| Talkeetna River near Talkeetna | 2.33                   |
| Montana Creek near Montana     | 1.96                   |
| Skwentna River near Skwentna   | 1.49                   |
| Tonsina River at Tonsina       | 1.72                   |
| Copper River near Chitina      | 1.35                   |
|                                | <hr/>                  |
|                                | $\bar{Y}_{20} = 1.748$ |
|                                | $S_{20} = 0.2776$      |

Limits of 95% Confidence Interval  
1.11 - 2.39

The stations selected for use in the Susitna Regional Flood Peak Frequency Analysis are homogenous with respect to the annual instantaneous peaks at the 95% confidence level.

TABLE 3.5  
HOMOGENEITY TEST  
OCTOBER - MAY INSTANTANEOUS PEAKS

| Station                        | $Q_{20}/Q_2 = Y_{20}$                             |
|--------------------------------|---------------------------------------------------|
| Susitna River at Gold Creek    | 1.57                                              |
| Caribou Creek near Sutton      | 2.63                                              |
| Matanuska River at Palmer      | 2.24                                              |
| Susitna River near Denali      | 2.35                                              |
| MacLaren River near Paxson     | 3.32                                              |
| Susitna River near Cantwell    | 2.33                                              |
| Chulitna River near Talkeetna  | 1.98                                              |
| Talkeetna River near Talkeetna | 2.12                                              |
| Skwentna River near Skwentna   | 1.76                                              |
| Tonsina River at Tonsins       | 2.45                                              |
| Copper River near Chitina      | 1.50                                              |
|                                | <hr/> $\bar{Y}_{20} = 2.205$<br>$S_{20} = 0.5175$ |

Limits of 95% Confidence Interval  
0.99 - 3.41

The stations selected for use in the Susitna Regional Flood Frequency Analysis are homogenous with respect to the October - May instantaneous peaks at the 95% confidence level.



TABLE 3.6  
REGIONAL ANNUAL INSTANTANEOUS  
DIMENSIONLESS FLOOD VALUES

| Return<br>Period | Susitna<br>River<br>at Gold<br>Creek | Caribou<br>Creek<br>near<br>Sutton | Matanuska<br>River at<br>Palmer | Susitna<br>River<br>near<br>Denali | MacLaren<br>River<br>near<br>Paxson | Susitna<br>River<br>near<br>Cantwell | Chulitna<br>River<br>near<br>Talkeetna | Talkeetna<br>River<br>near<br>Talkeetna | Skwentna<br>River<br>near<br>Skwentna | Tonsina<br>River<br>at<br>Tonsina | Copper<br>River<br>near<br>Chitina | Montana<br>Creek<br>near<br>Montana | Mean | Median | Weighted<br>Median |
|------------------|--------------------------------------|------------------------------------|---------------------------------|------------------------------------|-------------------------------------|--------------------------------------|----------------------------------------|-----------------------------------------|---------------------------------------|-----------------------------------|------------------------------------|-------------------------------------|------|--------|--------------------|
| 1.005            | 0.50                                 | 0.45                               | 0.45                            | 0.81                               | 0.79                                | 0.49                                 | 0.76                                   | 0.62                                    | 0.66                                  | 0.53                              | 0.76                               | 0.17                                | 0.58 | 0.52   | 0.58               |
| 1.050            | 0.58                                 | 0.55                               | 0.57                            | 0.83                               | 0.81                                | 0.59                                 | 0.80                                   | 0.66                                    | 0.72                                  | 0.61                              | 0.81                               | 0.34                                | 0.66 | 0.64   | 0.76               |
| 1.25             | 0.75                                 | 0.73                               | 0.77                            | 0.88                               | 0.86                                | 0.76                                 | 0.88                                   | 0.77                                    | 0.84                                  | 0.77                              | 0.89                               | 0.63                                | 0.79 | 0.77   | 0.86               |
| 2                | 1.00                                 | 1.00                               | 1.00                            | 1.00                               | 1.00                                | 1.00                                 | 1.00                                   | 1.00                                    | 1.00                                  | 1.00                              | 1.00                               | 1.00                                | 1.00 | 1.00   | 1.00               |
| 5                | 1.36                                 | 1.36                               | 1.24                            | 1.26                               | 1.32                                | 1.31                                 | 1.19                                   | 1.46                                    | 1.22                                  | 1.31                              | 1.15                               | 1.45                                | 1.30 | 1.31   | 1.24               |
| 10               | 1.60                                 | 1.59                               | 1.38                            | 1.51                               | 1.63                                | 1.50                                 | 1.33                                   | 1.86                                    | 1.36                                  | 1.52                              | 1.25                               | 1.72                                | 1.52 | 1.52   | 1.69               |
| 20               | 1.83                                 | 1.82                               | 1.49                            | 1.81                               | 2.02                                | 1.68                                 | 1.47                                   | 2.33                                    | 1.49                                  | 1.72                              | 1.35                               | 1.96                                | 1.75 | 1.77   | 1.84               |
| 50               | 2.14                                 | 2.10                               | 1.63                            | 2.29                               | 2.67                                | 1.91                                 | 1.67                                   | 3.04                                    | 1.66                                  | 1.98                              | 1.47                               | 2.26                                | 2.07 | 2.04   | 1.79               |
| 100              | 2.38                                 | 2.32                               | 1.72                            | 2.74                               | 3.27                                | 2.08                                 | 1.82                                   | 3.67                                    | 1.79                                  | 2.17                              | 1.56                               | 2.47                                | 2.33 | 2.25   | 1.94               |
| 200              | 2.63                                 | 2.54                               | 1.81                            | 3.26                               | 3.99                                | 2.25                                 | 1.98                                   | 4.39                                    | 1.92                                  | 2.37                              | 1.65                               | 2.68                                | 2.62 | 2.46   | 2.10               |
| 500              | 2.96                                 | 2.83                               | 1.92                            | 4.07                               | 5.15                                | 2.47                                 | 2.21                                   | 5.48                                    | 2.09                                  | 2.63                              | 1.78                               | 2.95                                | 3.05 | 2.73   | 2.46               |
| 10,000           | 3.84                                 | 3.64                               | 1.97                            | 9.97                               | 11.65                               | 3.10                                 | 2.99                                   | 11.54                                   | 2.75                                  | 3.39                              | 2.20                               | 3.62                                | 5.06 | 3.51   | 3.06               |

TABLE 3.7

REGIONAL OCTOBER - MAY INSTANTANEOUS  
DIMENSIONLESS FLOOD VALUES

| Return<br>Period | Susitna<br>River<br>at Gold<br>Creek | Caribou<br>Creek<br>near<br>Sutton | Matanuska<br>River at<br>Palmer | Susitna<br>River<br>near<br>Denali | MacLaren<br>River<br>near<br>Paxson | Susitna<br>River<br>near<br>Cantwell | Chulitna<br>River<br>near<br>Talkeetna | Talkeetna<br>River<br>near<br>Talkeetna | Skwentna<br>River<br>near<br>Skwentna | Tonsina<br>River<br>at<br>Tonsina | Copper<br>River<br>near<br>Chitina | Mean | Median | Weighted<br>Median |
|------------------|--------------------------------------|------------------------------------|---------------------------------|------------------------------------|-------------------------------------|--------------------------------------|----------------------------------------|-----------------------------------------|---------------------------------------|-----------------------------------|------------------------------------|------|--------|--------------------|
| 1.005            | 0.36                                 | 0.18                               | 0.34                            | 0.40                               | 0.45                                | 0.33                                 | 0.40                                   | 0.35                                    | 0.48                                  | 0.39                              | 0.48                               | 0.38 | 0.39   | 0.45               |
| 1.050            | 0.51                                 | 0.30                               | 0.44                            | 0.48                               | 0.50                                | 0.43                                 | 0.50                                   | 0.45                                    | 0.57                                  | 0.47                              | 0.59                               | 0.48 | 0.48   | 0.48               |
| 1.25             | 0.74                                 | 0.57                               | 0.66                            | 0.67                               | 0.65                                | 0.65                                 | 0.70                                   | 0.67                                    | 0.75                                  | 0.66                              | 0.78                               | 0.68 | 0.67   | 0.75               |
| 2                | 1.00                                 | 1.00                               | 1.00                            | 1.00                               | 1.00                                | 1.00                                 | 1.00                                   | 1.00                                    | 1.00                                  | 1.00                              | 1.00                               | 1.00 | 1.00   | 1.00               |
| 5                | 1.28                                 | 1.67                               | 1.51                            | 1.53                               | 1.76                                | 1.54                                 | 1.42                                   | 1.47                                    | 1.34                                  | 1.56                              | 1.24                               | 1.48 | 1.51   | 1.24               |
| 10               | 1.44                                 | 2.15                               | 1.88                            | 1.93                               | 2.47                                | 1.93                                 | 1.70                                   | 1.80                                    | 1.55                                  | 2.00                              | 1.38                               | 1.84 | 1.88   | 1.93               |
| 20               | 1.57                                 | 2.63                               | 2.24                            | 2.35                               | 3.32                                | 2.33                                 | 1.98                                   | 2.12                                    | 1.76                                  | 2.45                              | 1.50                               | 2.20 | 2.24   | 2.35               |
| 50               | 1.73                                 | 3.31                               | 2.74                            | 2.94                               | 4.70                                | 2.88                                 | 2.35                                   | 2.54                                    | 2.02                                  | 3.10                              | 1.63                               | 2.72 | 2.74   | 2.94               |
| 100              | 1.84                                 | 3.84                               | 3.13                            | 3.42                               | 5.96                                | 3.31                                 | 2.63                                   | 2.87                                    | 2.22                                  | 3.64                              | 1.73                               | 3.14 | 3.13   | 3.42               |
| 200              | 1.94                                 | 4.40                               | 3.53                            | 3.93                               | 7.43                                | 3.77                                 | 2.91                                   | 3.20                                    | 2.42                                  | 4.22                              | 1.82                               | 3.60 | 3.53   | 1.94               |
| 500              | 2.06                                 | 5.18                               | 4.10                            | 4.66                               | 9.76                                | 4.40                                 | 3.30                                   | 3.67                                    | 2.69                                  | 5.05                              | 1.93                               | 4.25 | 4.10   | 2.06               |

TABLE 3.8  
PHYSIOGRAPHIC AND CLIMATIC PARAMETERS<sup>1</sup>

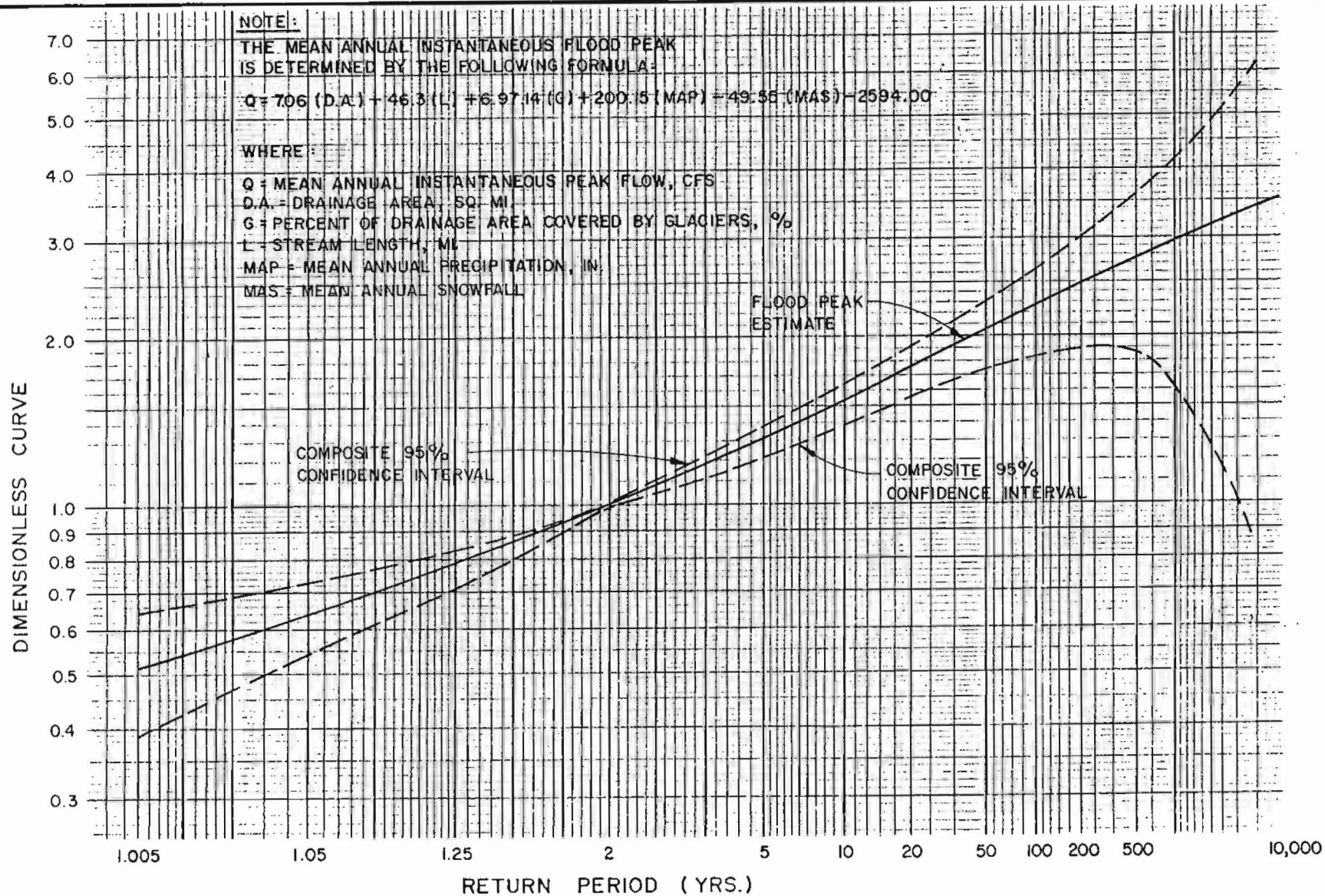
| Station Name | Location      | Drainage Area (sq. mi.) | Main Channel Slope (ft./mi.) | Stream Length (mi.) | Mean Basin Elevation (ft.) | Area of Lakes & Ponds (%) | Area of Forests (%) | Area of Glaciers (%) | Mean Annual Precipitation (in.) | Precipitation Intensity (in.) | Mean Annual Snowfall (in.) | Mean Minimum January Temperature (°F) |
|--------------|---------------|-------------------------|------------------------------|---------------------|----------------------------|---------------------------|---------------------|----------------------|---------------------------------|-------------------------------|----------------------------|---------------------------------------|
| Susitna R.   | at Gold Creek | 6,160                   | 10.2                         | 189.0               | 3420.0                     | 1.0                       | 7.0                 | 5.0                  | 29.0                            | 2.0                           | 200.0                      | -4.0                                  |
| Caribou Cr.  | nr. Sutton    | 289                     | 13.6                         | 30.0                | 4190.0                     | 0.0                       | 10.0                | 0.0                  | 28.0                            | 1.5                           | 80.0                       | 2.0                                   |
| Matanuska R. | at Palmer     | 2,070                   | 79.7                         | 77.0                | 4000.0                     | 0.0                       | 14.0                | 12.0                 | 35.0                            | 1.5                           | 80.0                       | 4.0                                   |
| Susitna R.   | nr. Denali    | 950                     | 56.6                         | 51.0                | 4510.0                     | 1.0                       | 1.0                 | 25.0                 | 60.0                            | 2.0                           | 400.0                      | -6.0                                  |
| MacLaren R.  | nr. Paxson    | 280                     | 133.0                        | 23.0                | 4520.0                     | 1.0                       | 0.0                 | 19.0                 | 55.0                            | 1.5                           | 400.0                      | -6.0                                  |
| Susitna R.   | nr. Cantwell  | 4,140                   | 10.0                         | 107.0               | 3560.0                     | 2.0                       | 5.0                 | 7.0                  | 32.0                            | 1.5                           | 200.0                      | -4.0                                  |
| Chulitna R.  | nr. Talkeetna | 2,570                   | 23.0                         | 87.0                | 3760.0                     | 1.0                       | 22.0                | 27.0                 | 55.0                            | 1.6                           | 250.0                      | -5.0                                  |
| Talkeetna R. | nr. Talkeetna | 2,006                   | 35.0                         | 90.3                | 3630.0                     | 0.0                       | 25.0                | 7.0                  | 70.0                            | 2.5                           | 150.0                      | -2.0                                  |
| Montana Cr.  | nr. Montana   | 164                     | 114.0                        | 25.0                | 1930.0                     | 3.0                       | 54.0                | 0.0                  | 40.0                            | 2.2                           | 90.0                       | 0.0                                   |
| Skwentna R.  | nr. Skwentna  | 2,250                   | 30.6                         | 98.0                | 2810.0                     | 5.0                       | 34.0                | 16.0                 | 43.0                            | 2.0                           | 140.0                      | -5.0                                  |
| Tonsina R.   | at Tonsina    | 420                     | 71.0                         | 46.0                | 3600.0                     | 4.0                       | 27.0                | 11.0                 | 25.0                            | 2.0                           | 180.0                      | -2.0                                  |
| Copper R.    | nr. Chitina   | 20,600                  | 14.4                         | 178.0               | 3620.0                     | 3.0                       | 22.0                | 17.0                 | 37.0                            | 2.0                           | 120.0                      | -4.0                                  |

<sup>1</sup> Values in this table are from the report entitled "Flood Characteristics of Alaska Streams" by Lanake (1979).

TABLE 3.9  
COMPARISON OF REGRESSION EQUATIONS

| <u>Study</u> | <u>Homogenous<br/>Flood Region</u>   | <u>Number of<br/>Hydrometric<br/>Stations Used</u> | <u>Physiographic<br/>Parameters<br/>Utilized</u> | <u>Recurrence<br/>Interval<br/>(Years)</u> | <u>SE of<br/>Estimate<br/>(Percent)</u> |
|--------------|--------------------------------------|----------------------------------------------------|--------------------------------------------------|--------------------------------------------|-----------------------------------------|
| Present      | Susitna &<br>Neighboring<br>Stations | 12                                                 | D.A., L, G,<br>MAP, MAS                          | 2                                          | ±18                                     |
|              |                                      |                                                    |                                                  | 5                                          | ±19                                     |
|              |                                      |                                                    |                                                  | 10                                         | ±21                                     |
|              |                                      |                                                    |                                                  | 50                                         | ±29                                     |
|              |                                      |                                                    |                                                  | 100                                        | ±34                                     |
| (a)          | Area II                              | 163                                                | D.A., MAP,<br>LP, F, T                           | 2                                          | ±77                                     |
|              |                                      | 163                                                |                                                  | 5                                          | ±78                                     |
|              |                                      | 132                                                |                                                  | 10                                         | ±79                                     |
|              |                                      | 26                                                 |                                                  | 50                                         | ±68                                     |
| (b)          | Cook Inlet                           | 50                                                 | D.A., LP,<br>MAP                                 | 2                                          | +56, -36                                |
|              |                                      |                                                    |                                                  | 5                                          | +51, -34                                |
|              |                                      |                                                    |                                                  | 10                                         | +52, -34                                |
|              |                                      |                                                    |                                                  | 50                                         | +61, -38                                |

D.A. = drainage area, mi<sup>2</sup>  
 L = stream length, miles  
 G = percent of basin as glaciers  
 MAP = mean annual precipitation, inches  
 MAS = mean annual snowfall, inches  
 LP = percent of area as lakes and ponds  
 F = percent of area forested  
 T = mean minimum January temperature, °F



Prepared by:

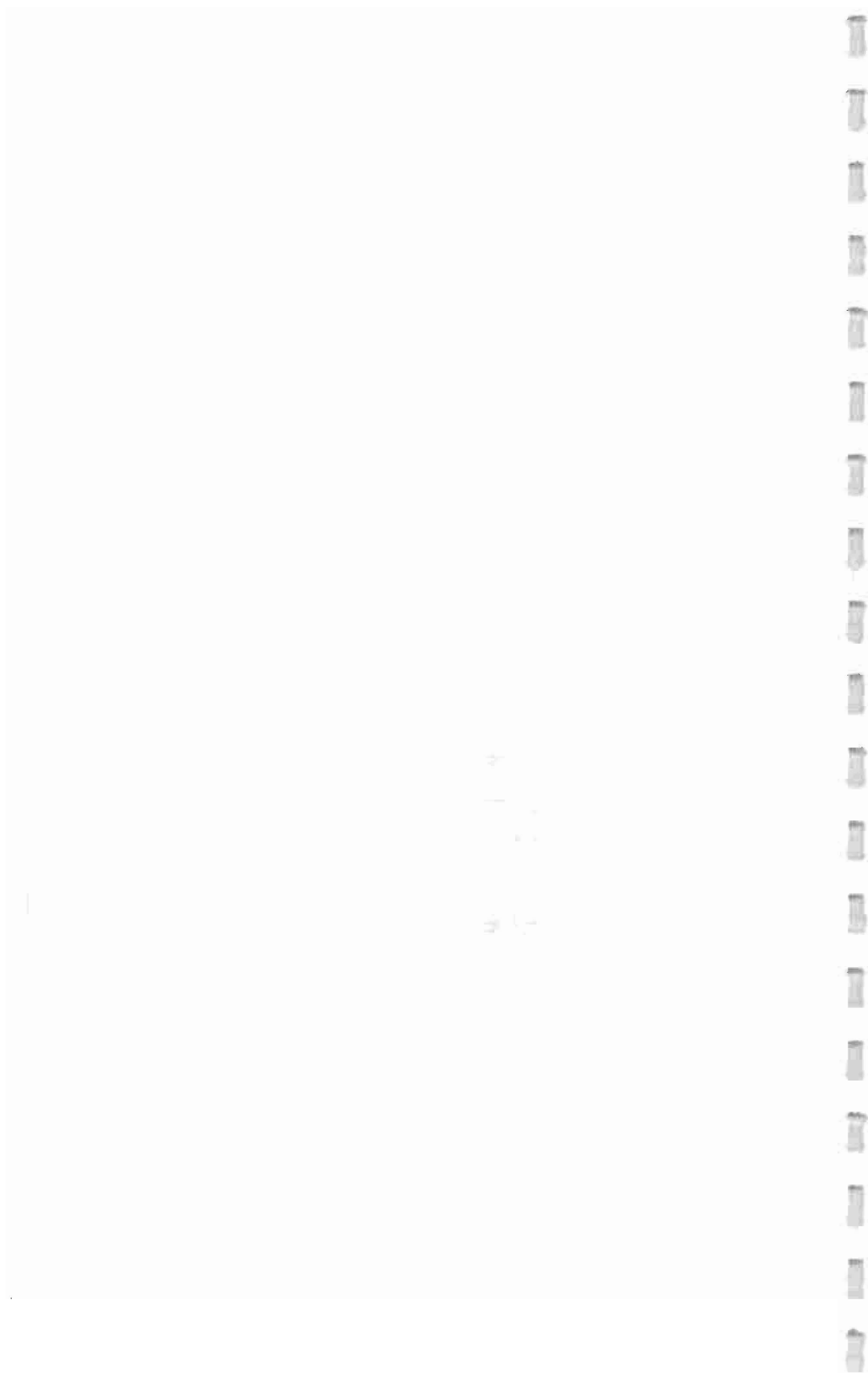
Prepared for:

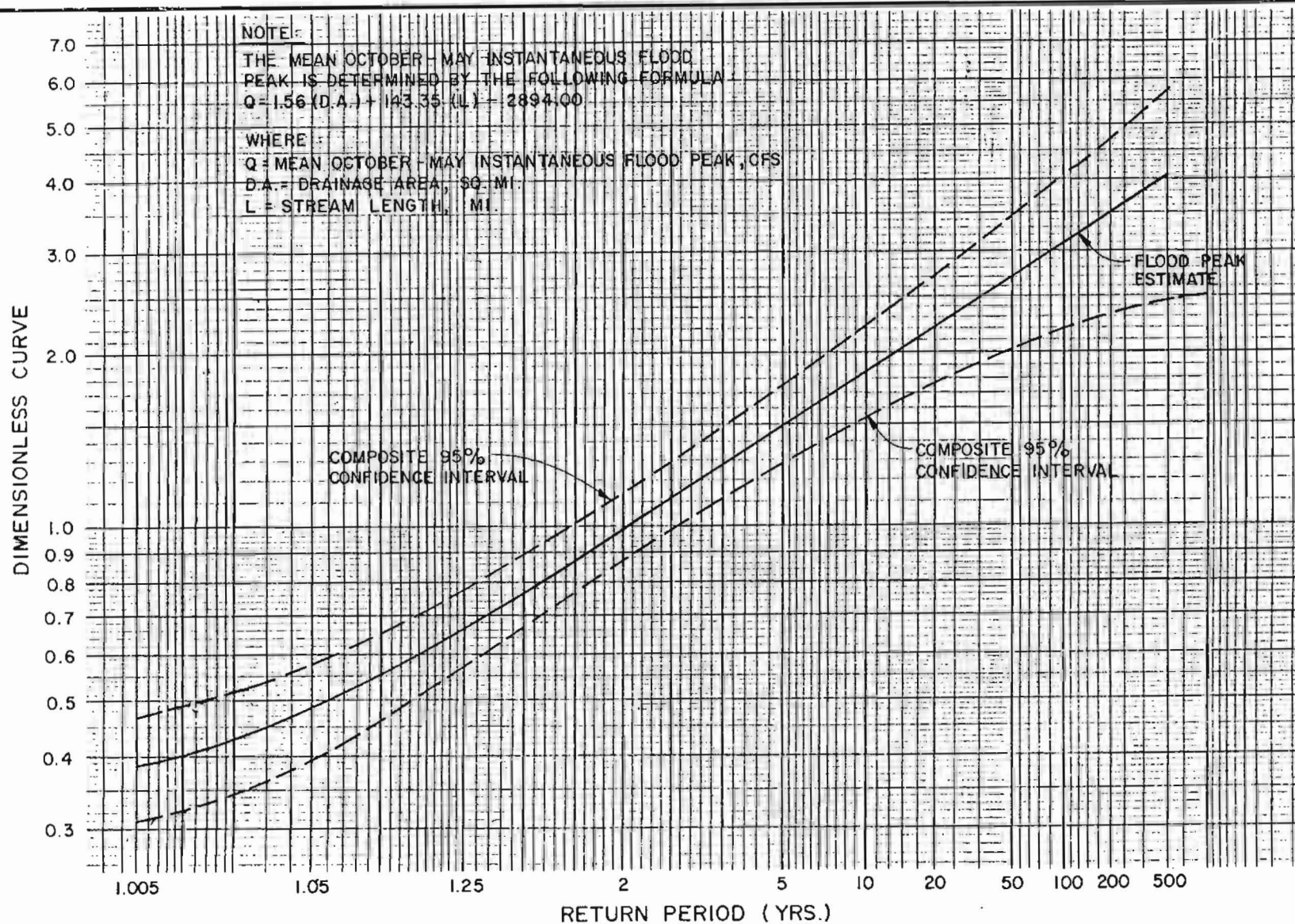


DESIGN DIMENSIONLESS REGIONAL FREQUENCY CURVE  
ANNUAL INSTANTANEOUS FLOOD PEAKS

FIGURE 3.1







Prepared by:

Prepared for:



DESIGN DIMENSIONLESS REGIONAL FREQUENCY CURVE  
OCTOBER - MAY INSTANTANEOUS FLOOD PEAKS

FIGURE 3.2







#### 4 - EVALUATION OF DESIGN FLOODS

Using Figures 3.1 and 3.2, annual instantaneous flood peaks and October-May instantaneous flood peaks can be predicted with a minimum of additional data. The figures will prove useful in assessing flood peaks at ungauged sites within the study area. The figures should not be used for basins with drainage areas smaller than 164 square miles, the smallest basin area included in the study. Use of the equations and figures for these smaller basins may result in unrealistic values. It is recommended that the regression equations developed by Freethy and Scully (1980) be used for determining flood peaks in these basins. Their analysis included basins as small as one square mile, and the equations have a smaller standard error than the regression equations developed by Lamke (1979), as seen in Table 3.9.

It is necessary to have information concerning the drainage area, the length of the main channel, the percent of the drainage area covered by glaciers, the mean annual precipitation, and the mean annual snowfall in order to predict the annual instantaneous flood peaks on drainage basins in the upper Susitna River region. It is also necessary to have information on drainage area and stream length to predict October-May instantaneous flood peaks in the upper Susitna region. When compiling this information, it is important that the information come from the same source, or at least represent the same precision, as the data used in the regression analyses.

Thus, the drainage area should be computed from U.S. Geological Survey topographic maps in the horizontal plane. Main channel slope is taken as the average slope between points 10% and 85% of the distance along the main stream from the lowest point of interest to the basin divide. The percent of glacial area is the total drainage area shown as glaciers on the topographic maps divided by the basin drainage area, as measured by the grid-sampling method or planimeters. The mean annual precipitation and mean annual snowfall are determined from isohyetal maps (NWS, 1972 or Lamke, 1979) using the grid sampling method. An example of the use of the figures for determining instantaneous flood peaks is given below.

Suppose it is desired to obtain the annual instantaneous flood peak with a 50-year recurrence interval on an ungauged basin in the upper Susitna River basin. The following drainage basin characteristics were determined.

Area of Drainage Basin = 164 sq. mi.  
Stream Length = 25.0 miles  
Percent Area of Glaciers = 0 percent  
Mean Annual Precipitation = 40 inches  
Mean Annual Snowfall = 90 inches

Using Equation (3.5), the mean annual instantaneous flood peak is determined to be 3269 cfs. Using Figure 3.1, the ratio of the 50-year peak to the mean annual peak is 2.04. Thus, the fifty year peak is

$$\begin{aligned}Q_{50} &= 2.04 (3,269 \text{ cfs}) \\Q_{50} &= 6,670 \text{ cfs}\end{aligned}$$

The confidence limits on this estimate could be found in the same manner by selecting the appropriate ratio from Figure 3.1. Thus the upper and lower 95% confidence interval are:

$$\begin{aligned}\text{Upper 95\% Confidence Interval} \\Q &= 3.11 \times 3269 = 10,170 \text{ cfs}\end{aligned}$$

$$\begin{aligned}\text{Lower 95\% Confidence Interval} \\Q &= 1.01 \times 3269 = 3,300 \text{ cfs}\end{aligned}$$

## 5 - EVALUATION OF TYPICAL FLOOD HYDROGRAPHS FOR SUSITNA RIVER AT GOLD CREEK

For the gaging station on the Susitna River at Gold Creek, typical flood hydrographs were developed from several measured hydrographs. The temporal distribution of annual maximum flood peaks was first determined, and is presented in Figure 5.1. The figure illustrates that the greatest frequency of floods (55%) occurs in June and the second highest frequency of floods (26%) occurs in August.

The five largest peak hydrographs were selected for two periods: May-July (rain-and-snowmelt floods), and August-October (rainfall floods). These were made dimensionless by dividing the flows by the peak daily mean discharge, centered about the peak with  $\pm 15$  days and plotted on the same graph. The mean hydrograph is the arithmetic average of the five floods selected for each period. The five dimensionless hydrographs and the corresponding mean curve for each time period are depicted in Figures 5.2 and 5.3. These figures illustrate that the mean curves are typical of the general shape of the snowmelt and rainfall hydrographs, but that there is considerable variation from year to year.

The seasonal discharge frequency curves depicted in Figure 5.4 were derived by assuming that all floods from May through July are rain and snowmelt floods and that all floods from August through October are rainfall floods with high-altitude snowmelt. The seasonal daily peak discharges for each period are tabulated in Table 5.1. The corresponding published annual instantaneous peaks are listed in the respective seasonal period. The average ratios between instantaneous peaks ( $Q_I$ ) and daily peaks ( $Q_D$ ) for the snowmelt and rainfall floods were calculated by averaging all the ratios ( $Q_I/Q_D$ ) for corresponding instantaneous and daily peaks. The calculated ratios ( $Q_I/Q_D$ ) are 1.063 for snowmelt events and 1.052 for rainfall events. The missing instantaneous peaks were then computed by multiplying the daily peak by the appropriate ( $Q_I/Q_D$ ) ratio. Using the three parameter log-normal frequency distribution and the instantaneous peaks from Table 5.1, the frequency curves for the May-July and August-October periods were computed. The annual instantaneous peak frequency curve is included on Figure 5.4 for comparison.

Fifty peak hydrographs were separated into the May-July and August-October periods and plotted. The base flows were estimated using standard techniques and subtracted from the hydrographs. The volume of each flood was estimated by planimetering the resulting hydrograph and tabulated in Table 5.2, together with the corresponding instantaneous peak. The flood volume frequency analysis for each period was conducted using the three parameter log-normal frequency distribution. The corresponding frequency curves with the 95% confidence levels are illustrated in Figures 5.5 and 5.6.

A power curve regression analysis was used to determine the correlation between the instantaneous peaks and the corresponding volumes. The correlation proved to be significant, with correlation coefficients of 0.794 and 0.825 for the May-July period and August-October period, respectively. The statistics are tabulated in Table 5.2 and illustrated graphically on Figures 5.7 and 5.8. As the correlation is acceptable, it allows for the development of the typical 100-, 500-, and 10,000-year flood hydrographs illustrated in Figures 5.9 and 5.10. These typical flood hydrographs were produced by using the general shape of the mean dimensionless hydrographs in Figures 5.2 and 5.3, and extrapolating the peaks and volumes for the 500- and 10,000-year floods from Figures 5.4, 5.5, and 5.6. The volumes beneath the flood hydrographs are those determined in the frequency analysis.

The typical hydrographs discussed here are qualitative indicators of flood hydrograph shapes. They should not be used for rigorous analytical calculations, but are intended to supplement them.

TABLE 5.1  
DETERMINATION OF DAILY INSTANTANEOUS PEAK RATIO  
SUSITNA RIVER AT GOLD CREEK

| Year | May - July<br>(Snowmelt Floods) |                                      |                    | August - October<br>(Rainfall Floods) |                                      |                    |
|------|---------------------------------|--------------------------------------|--------------------|---------------------------------------|--------------------------------------|--------------------|
|      | Daily<br>Peaks<br>(cfs)         | Instant-<br>aneous<br>Peaks<br>(cfs) | Ratio<br>$Q_I/Q_D$ | Daily<br>Peaks<br>(cfs)               | Instant-<br>aneous<br>Peaks<br>(cfs) | Ratio<br>$Q_I/Q_D$ |
| 49   | -                               | -                                    | -                  | 35,000                                | [38,700]                             |                    |
| 50   | 34,000                          | (37,300)                             | 1.097              | 27,600                                | [29,000]                             |                    |
| 51   | 35,800                          | (37,400)                             | 1.044              | 31,800                                | [33,500]                             |                    |
| 52   | 43,300                          | (44,700)                             | 1.032              | 41,900                                | [44,100]                             |                    |
| 53   | 37,700                          | (38,400)                             | 1.065              | 28,100                                | [29,600]                             |                    |
| 54   | 30,100                          | [32,000]                             |                    | 41,000                                | (42,400)                             | 1.034              |
| 55   | 39,000                          | [41,500]                             |                    | 56,900                                | (58,100)                             | 1.021              |
| 56   | 51,500                          | (51,700)                             | 1.004              | 31,000                                | [32,600]                             |                    |
| 57   | 40,600                          | (42,200)                             | 1.039              | 26,600                                | [28,000]                             |                    |
| 58   | 28,000                          | [29,800]                             |                    | 47,800                                | (49,600)                             | 1.038              |
| 59   | 39,600                          | [42,100]                             |                    | 59,700                                | (62,300)                             | 1.044              |
| 60   | 39,300                          | [41,800]                             |                    | 40,100                                | (41,900)                             | 1.045              |
| 61   | 54,000                          | (59,300)                             | 1.098              | 26,000                                | [27,400]                             |                    |
| 62   | 79,700                          | (80,600)                             | 1.011              | 31,000                                | [32,600]                             |                    |
| 63   | 49,000                          | (53,800)                             | 1.098              | 35,000                                | [36,800]                             |                    |
| 64   | 85,900                          | (90,700)                             | 1.056              | 21,600                                | [22,800]                             |                    |
| 65   | 39,900                          | (43,600)                             | 1.093              | 33,600                                | [35,400]                             |                    |
| 66   | 58,400                          | (63,600)                             | 1.089              | 33,500                                | [35,200]                             |                    |
| 67   | 50,000                          | [53,150]                             |                    | 76,000                                | (80,200)                             | 1.055              |
| 68   | 39,700                          | (41,800)                             | 1.053              | 21,800                                | [22,900]                             |                    |
| 69   | 26,500                          | (28,400)                             | 1.072              | 16,800                                | [17,700]                             |                    |
| 70   | 30,800                          | [32,740]                             |                    | 31,600                                | (33,400)                             | 1.057              |
| 71   | 66,300                          | [70,500]                             |                    | 77,700                                | (87,400)                             | 1.125              |
| 72   | 70,700                          | (82,600)                             | 1.168              | 26,400                                | [27,800]                             |                    |
| 73   | 52,800                          | (54,100)                             | 1.025              | 30,500                                | [32,100]                             |                    |
| 74   | 33,600                          | (37,200)                             | 1.107              | 22,300                                | [23,500]                             |                    |
| 75   | 44,000                          | (47,300)                             | 1.075              | 24,800                                | [26,100]                             |                    |
| 76   | 33,300                          | (35,700)                             | 1.072              | 32,000                                | [33,700]                             |                    |
| 77   | 52,600                          | (54,300)                             | 1.032              | 26,200                                | [27,600]                             |                    |
| 78   | 24,300                          | (25,000)                             | 1.029              | 20,800                                | [21,900]                             |                    |
| 79   | 39,300                          | (41,300)                             | 1.051              | 28,400                                | [29,900]                             |                    |
| 80   | 49,700                          | (52,000)                             | 1.046              | 31,100                                | [32,800]                             |                    |

$$Q_I/Q_D = X = 1.063$$

$$S.D. = .034$$

$$N = 23$$

$$Q_I/Q_D = X = 1.052$$

$$S.D. = .032$$

$$N = 8$$

Notes: ( ) Published instantaneous peaks

[ ] Instantaneous peaks computed by ratio.

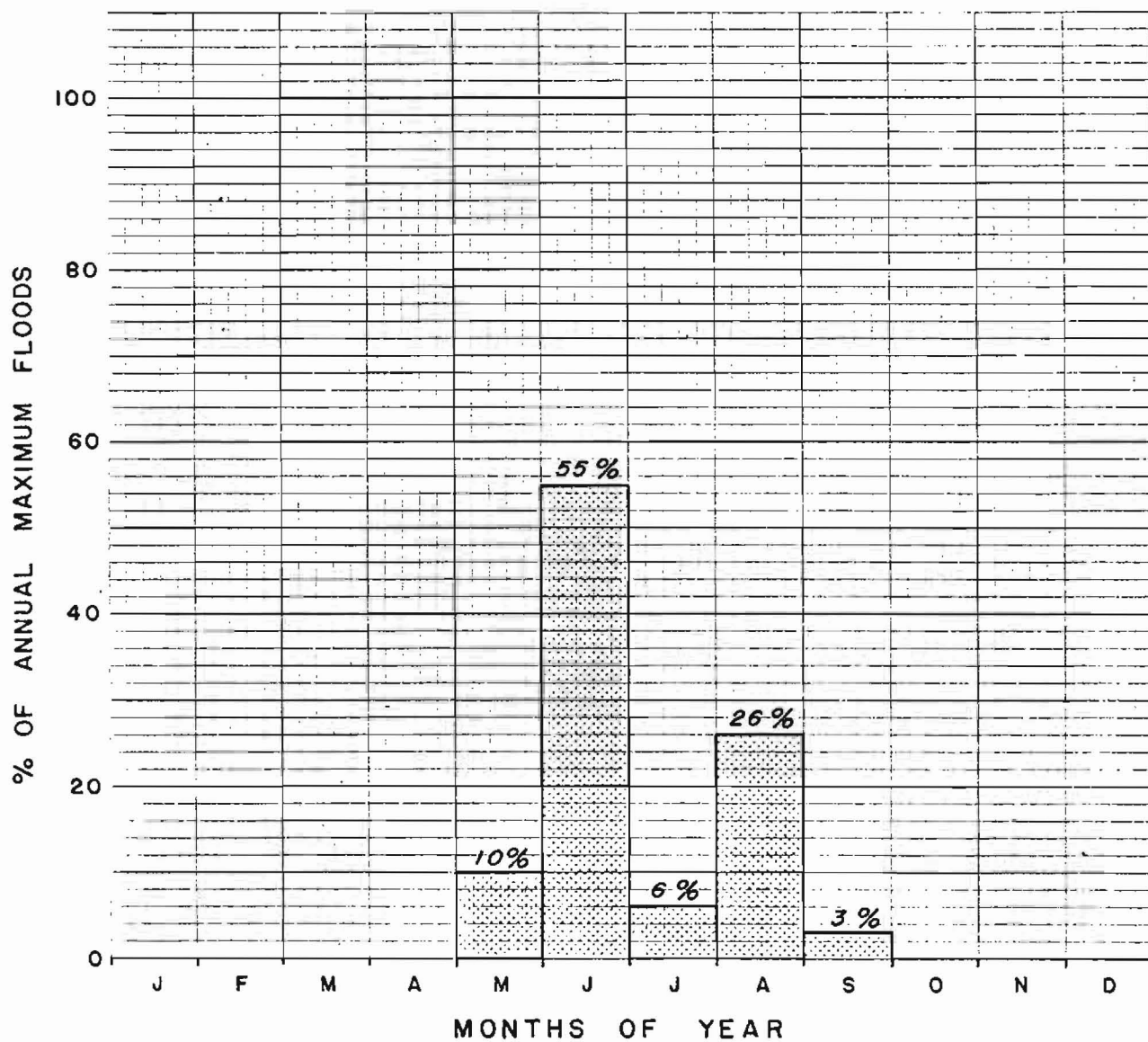
TABLE 5.2  
TABULATION AND STATISTICS OF INSTANTANEOUS PEAKS  
VERSUS PEAK VOLUMES  
SUSITNA RIVER AT GOLD CREEK

| Year | May - July<br>(Snowmelt Floods) |                        | August - October<br>(Rainfall Floods) |                        |
|------|---------------------------------|------------------------|---------------------------------------|------------------------|
|      | Instantaneous<br>Peak, $Q_p$    | Peak<br>Volume, $V$    | Instantaneous<br>Peak, $Q_p$          | Peak<br>Volume, $V$    |
|      | (cfs)                           | ( $ft^3 \times 10^9$ ) | (cfs)                                 | ( $ft^3 \times 10^9$ ) |
| 50   | 37,300                          | 10.6                   | 29,000                                | 8.2                    |
| 51   | 37,400                          | 23.0                   | 33,500                                | 16.4                   |
| 52   | 44,700                          | 69.9                   | 44,100                                | 12.9                   |
| 53   | 38,400                          | 33.6                   | 29,600                                | 8.4                    |
| 54   | 32,000                          | 9.7                    | 42,400                                | ND                     |
| 55   | 41,500                          | 38.0                   | 58,100                                | 19.0                   |
| 56   | 51,700                          | 33.8                   | 32,600                                | ND                     |
| 57   | 42,200                          | 27.0                   | 28,000                                | 6.1                    |
| 58   | 29,800                          | ND                     | 49,600                                | 19.0                   |
| 59   | 42,100                          | 28.4                   | 62,300                                | 37.6                   |
| 60   | 41,800                          | 18.4                   | 41,900                                | 10.3                   |
| 61   | 59,300                          | 30.8                   | 27,400                                | ND                     |
| 62   | 80,600                          | 63.7                   | 32,600                                | ND                     |
| 63   | 53,800                          | 26.7                   | 36,800                                | 5.7                    |
| 64   | 90,700                          | 83.4                   | 22,800                                | 6.5                    |
| 65   | 43,600                          | 35.6                   | 35,400                                | 17.7                   |
| 66   | 63,600                          | 30.8                   | 35,200                                | 12.5                   |
| 67   | 53,150                          | 19.9                   | 80,200                                | 30.3                   |
| 68   | 41,800                          | 32.2                   | 22,900                                | UPH                    |
| 69   | 28,400                          | 11.8                   | 17,700                                | 3.9                    |
| 70   | 32,740                          | 16.1                   | 33,400                                | 7.7                    |
| 71   | 70,500                          | 50.1                   | 87,400                                | 27.5                   |
| 72   | 82,600                          | 82.8                   | 27,800                                | UPH                    |
| 73   | 54,100                          | 36.8                   | 32,100                                | 14.9                   |
| 74   | 37,200                          | 23.9                   | 23,500                                | 9.3                    |
| 75   | 47,300                          | 28.0                   | 26,100                                | UPH                    |
| 76   | 35,700                          | 18.8                   | 33,700                                | 11.5                   |
| 77   | 54,300                          | 45.9                   | 27,600                                | 3.2                    |
| 78   | 25,000                          | 12.9                   | 21,900                                | UPH                    |
| 79   | 41,300                          | 12.6                   | 29,900                                | UPH                    |
| 80   | 52,000                          | NA                     | 31,100                                | NA                     |

### STATISTICS

|                         |                       |                    |                       |                    |
|-------------------------|-----------------------|--------------------|-----------------------|--------------------|
| Mean                    | 48,441                | $32.9 \times 10^9$ | 40,090                | $13.7 \times 10^9$ |
| Standard Deviation      | 16,104                | $20.1 \times 10^9$ | 18,214                | $9.0 \times 10^9$  |
| Regression Equation     | $V = 2820 Q_p^{1.50}$ |                    | $V = 9840 Q_p^{1.33}$ |                    |
| Correlation Coefficient | $r = 0.794$           |                    | $r = 0.825$           |                    |
| Sample Size             | $n = 29$              |                    | $n = 21$              |                    |

Notes: ND = No data  
UPH = Undefined peak hydrograph  
NA = Not available



SUSITNA RIVER AT GOLD CREEK  
PERIOD OF RECORD - 1950 - 1980

Prepared by:



PERCENT OF ANNUAL  
MAXIMUM FLOODS

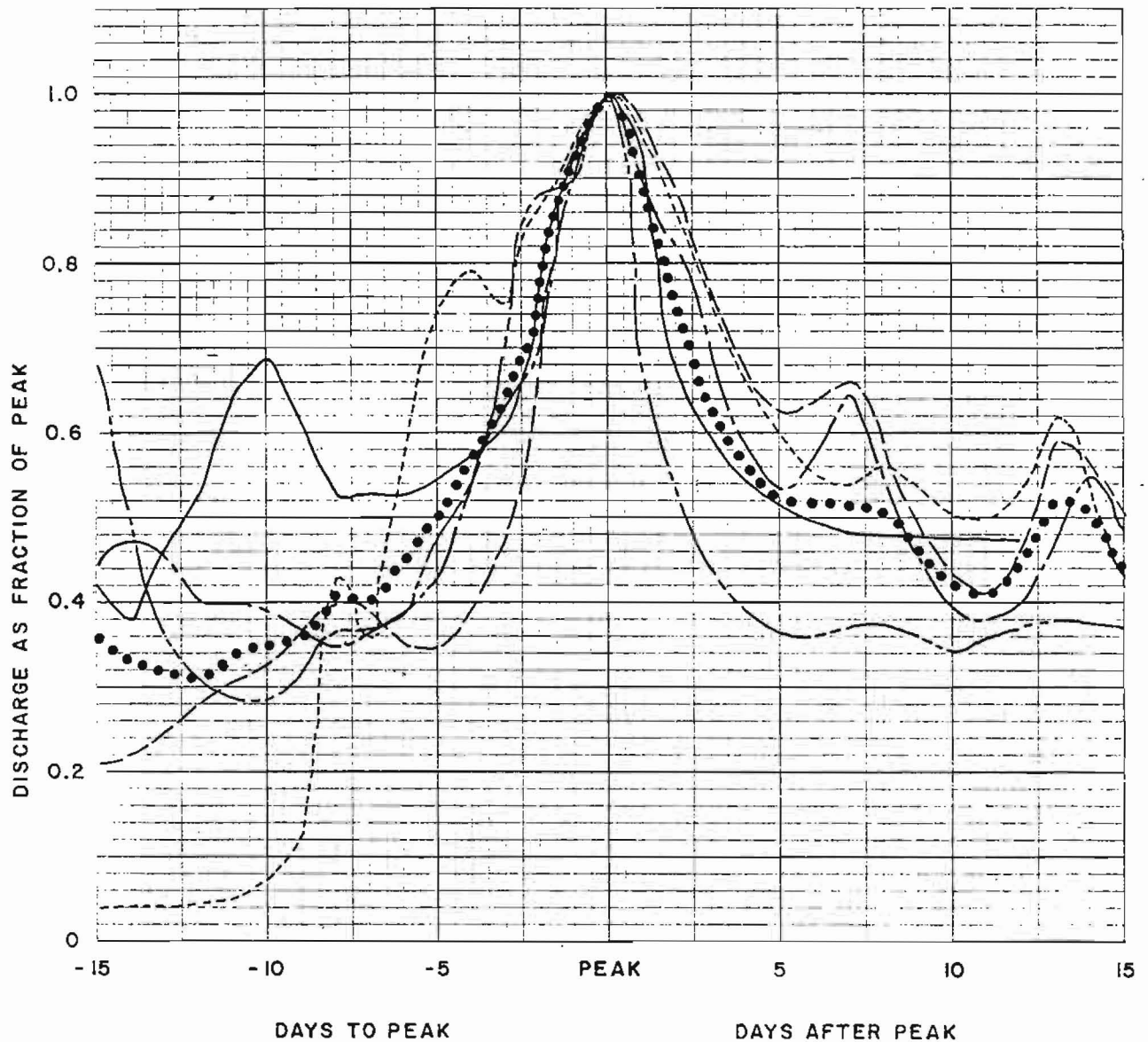
Prepared for:

FIGURE 5.1









## SUSITNA RIVER AT GOLD CREEK

### LEGEND

|           | Date          | Peak Discharge<br>(cfs) |
|-----------|---------------|-------------------------|
| .....     | Mean Curve    |                         |
| ————      | June 23, 1961 | 54,000                  |
| -----     | June 15, 1962 | 79,900                  |
| - - - - - | June 7, 1964  | 85,900                  |
| - . - . - | June 6, 1966  | 58,400                  |
| - - - . - | June 17, 1972 | 70,700                  |

Prepared by:

Prepared for:



DIMENSIONLESS HYDROGRAPHS

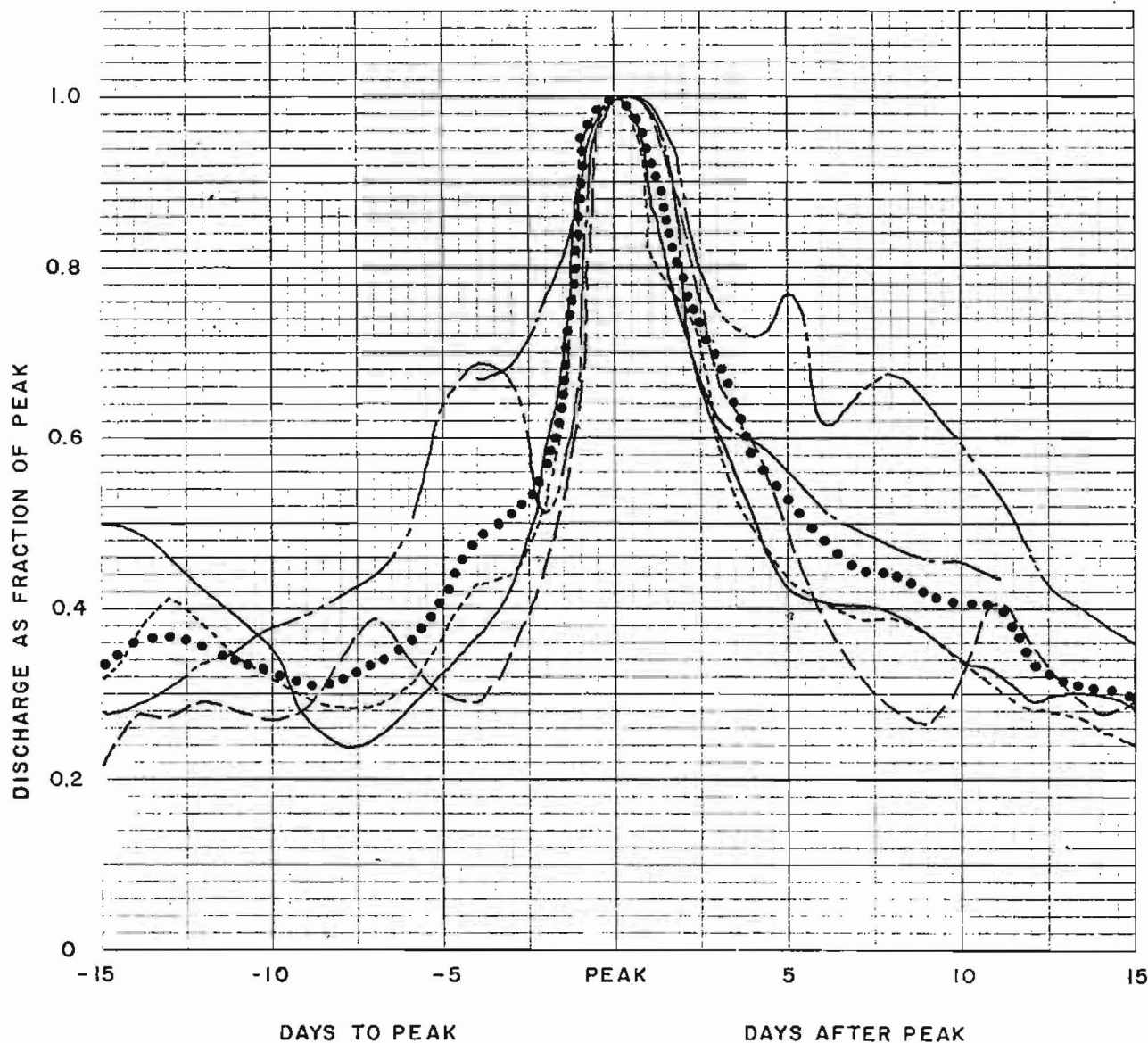
MAY - JULY

5-6

FIGURE 5.2

AGRES





# SUSITNA RIVER AT GOLD CREEK

## LEGEND

|           | Date         | Peak Discharge<br>(cfs) |
|-----------|--------------|-------------------------|
| .....     | Mean Curve   |                         |
| ————      | Aug 26, 1955 | 56,900                  |
| -----     | Aug 3, 1958  | 47,800                  |
| - - - - - | Aug 24, 1959 | 59,700                  |
| - . - . - | Aug 15, 1967 | 76,000                  |
| - - - - - | Aug 10, 1971 | 77,700                  |

Prepared by:

Prepared for:



DIMENSIONLESS HYDROGRAPHS

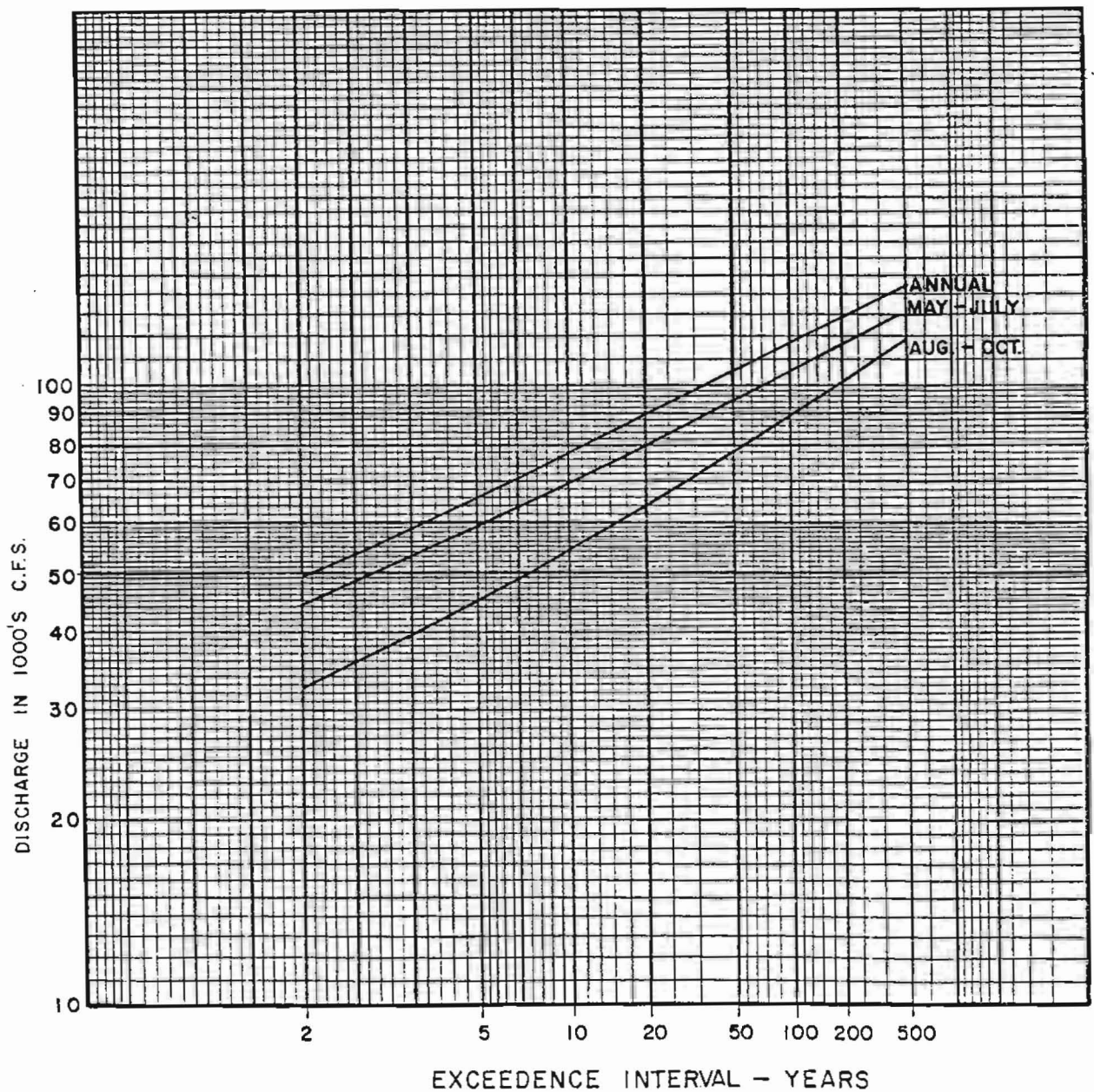
AUG - OCT

5-7

FIGURE 5.3







### SUSITNA RIVER AT GOLD CREEK

PERIOD OF RECORD - 1950-1980

ANNUAL SKEW IS 0.6830

MAY-JULY SKEW IS 1.130

AUG-OCT SKEW IS 1.134

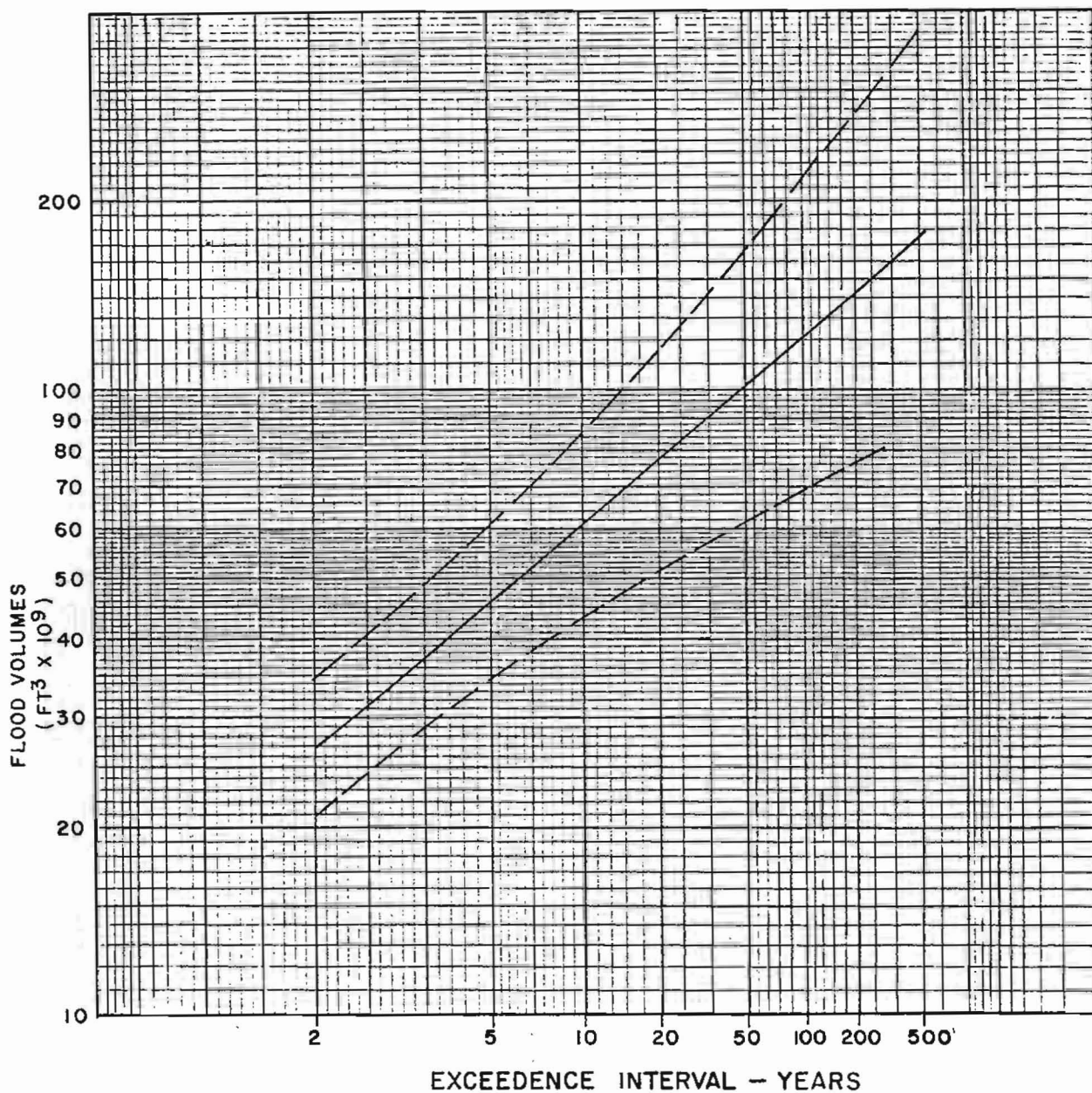
Prepared by:

Prepared for:



SEASONAL DISCHARGE  
FREQUENCY CURVES





# SUSITNA RIVER AT GOLD CREEK

PERIOD OF RECORD - 29 yrs.

## LEGEND

- 95% CONFIDENCE LIMITS
- VOLUME FREQUENCY CURVE

Prepared by:

Prepared for:



FLOOD VOLUME FREQUENCY CURVE

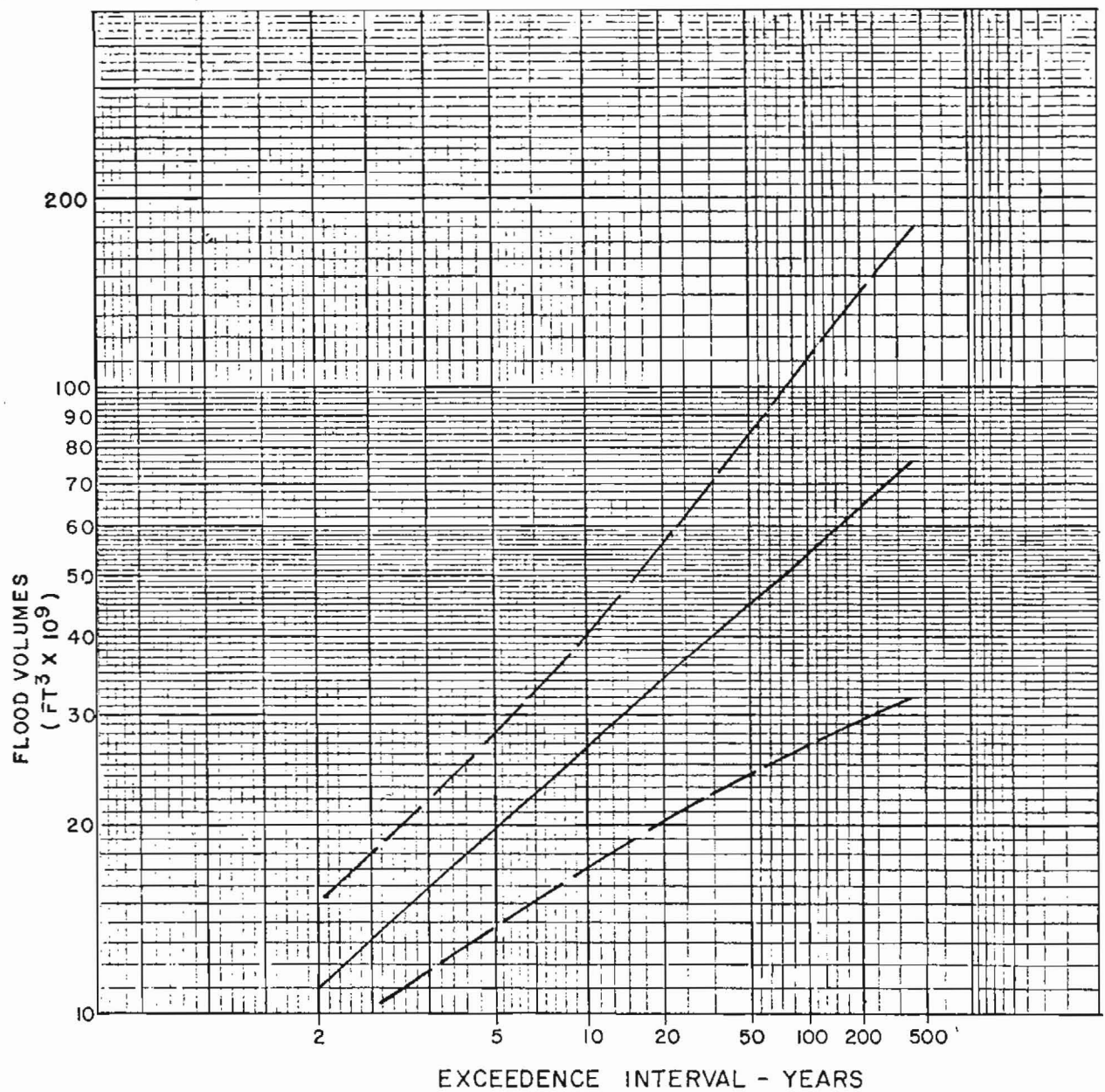
MAY-JULY

FIGURE 5.5

ACRES







# SUSITNA RIVER AT GOLD CREEK

PERIOD OF RECORD - 21 yrs.

## LEGEND

- 95 % CONFIDENCE LIMITS
- VOLUME FREQUENCY CURVE

Prepared by:

Prepared for:



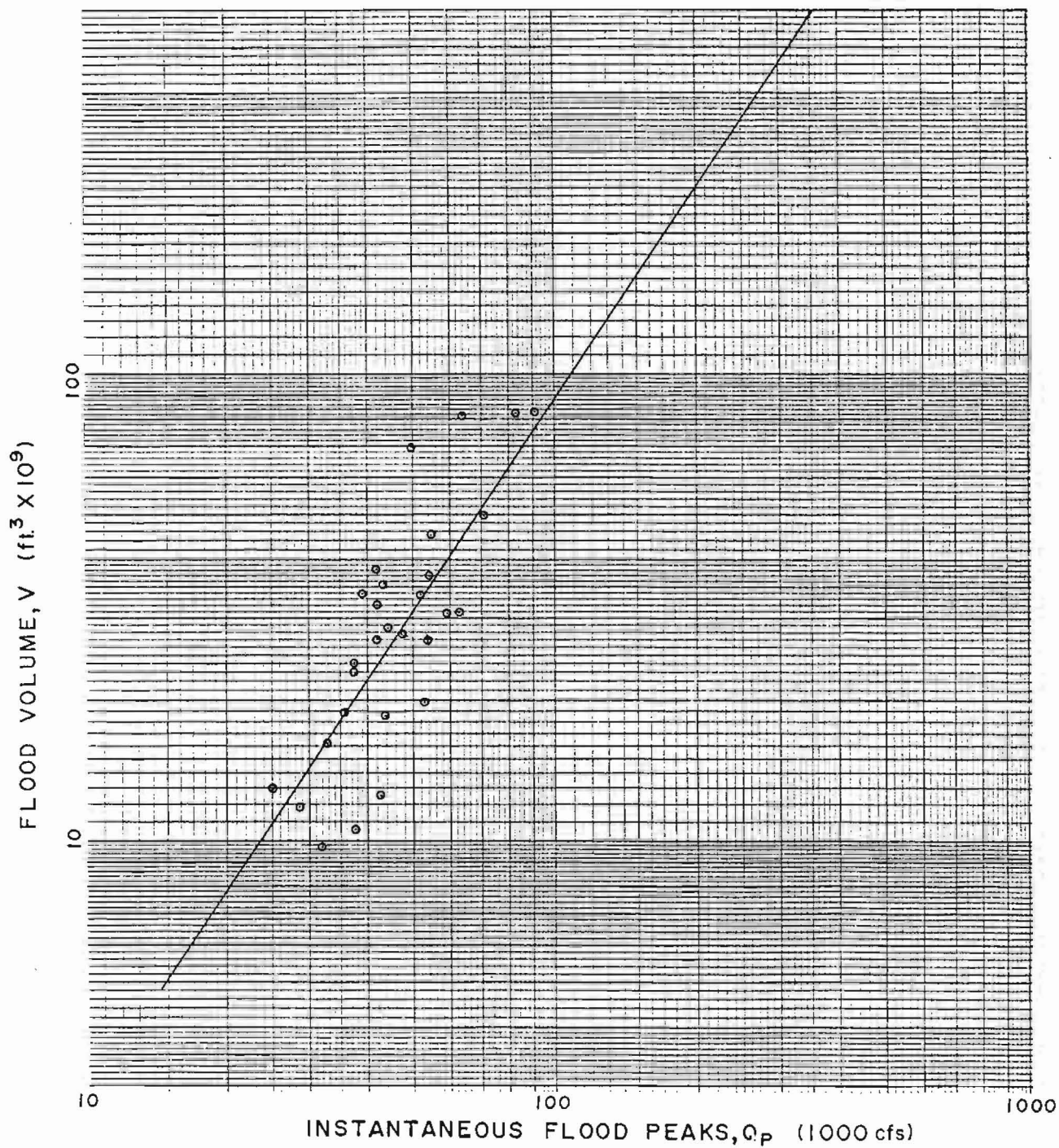
FLOOD VOLUME FREQUENCY CURVE

AUG - OCT

FIGURE 5.6

ACRES





SUSITNA RIVER AT GOLD CREEK  
PERIOD OF RECORD - 29 YEARS

$$V = 2820 Q_p^{1.50}$$

$$r^2 = 0.63$$

$$n = 29$$

Prepared by:

Prepared for:



VOLUME vs. PEAK

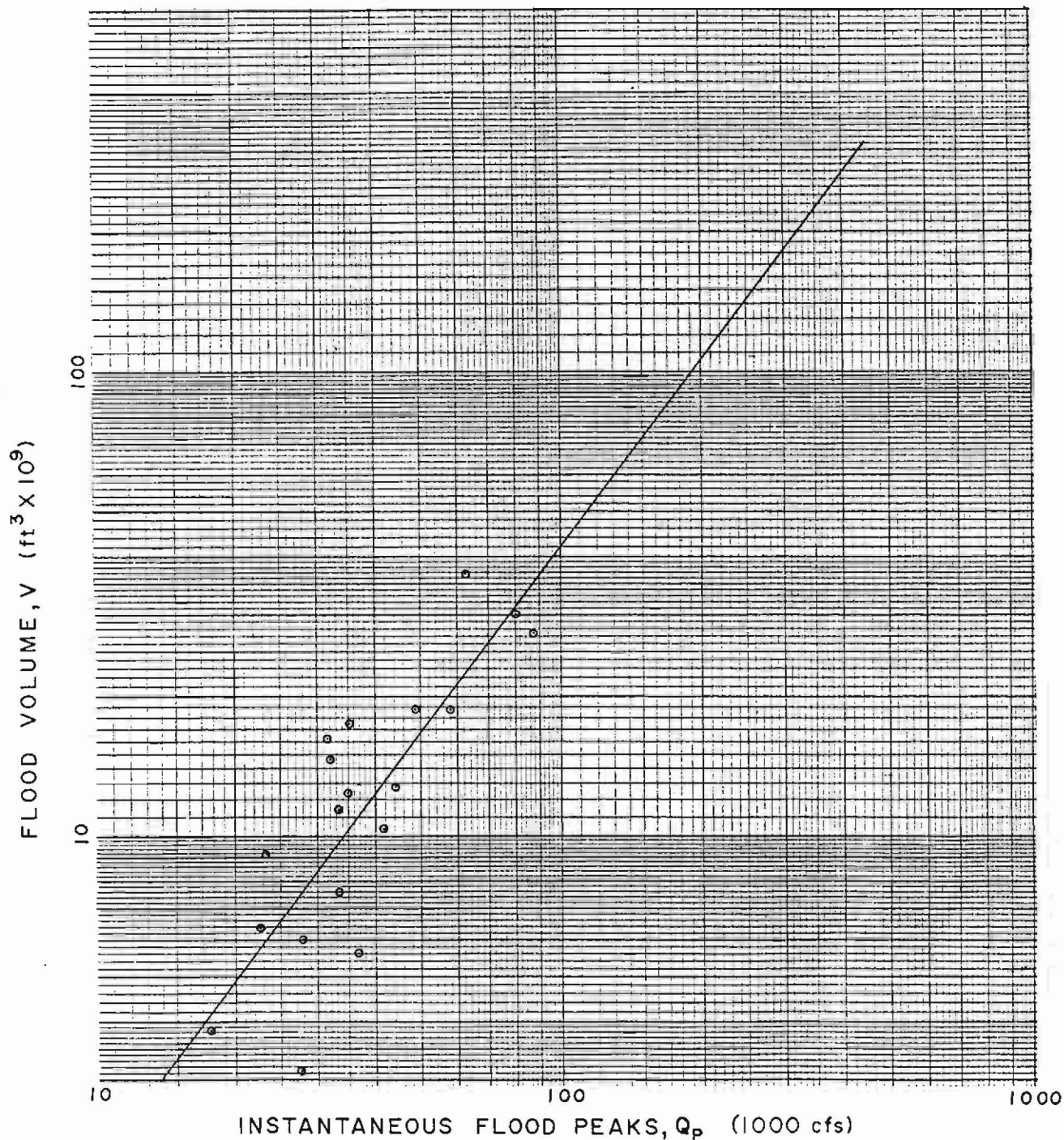
MAY - JULY

5-11

FIGURE 5.7

AGRES





SUSITNA RIVER AT GOLD CREEK  
PERIOD OF RECORD - 29 YEARS.

$$V = 9840 Q^{1.33}$$

$$r^2 = 0.68$$

$$n = 21$$

Prepared by:

Prepared for:



VOLUME VS. PEAK

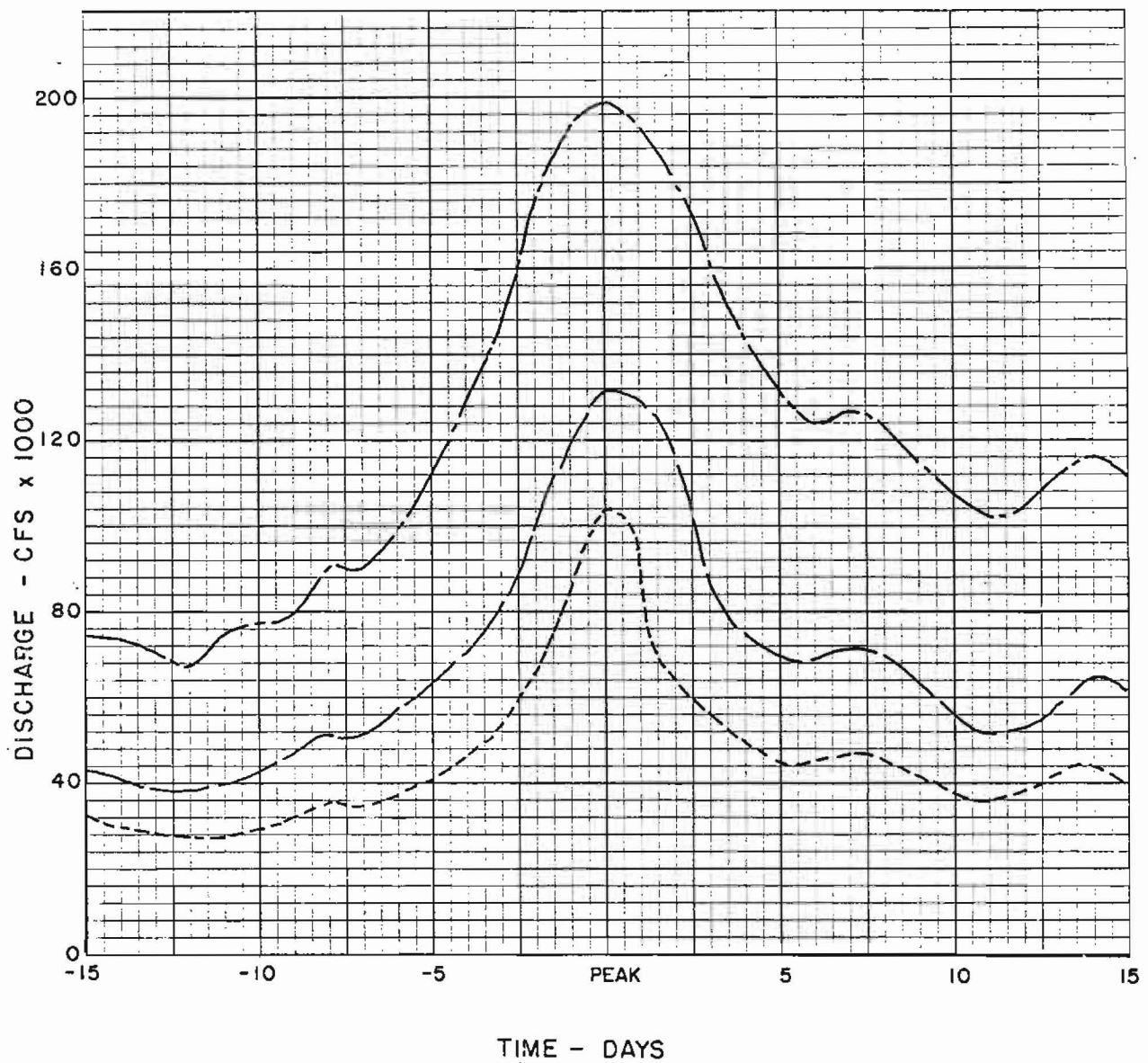
AUG. - OCT.

5-12

FIGURE 5.8

ACRES





# SUSITNA RIVER AT GOLD CREEK

100, 500, 10000 yr. FLOOD VOLUMES

## LEGEND

|               | Flood Volume<br>ft <sup>3</sup> | Peak Discharge<br>(cfs) |
|---------------|---------------------------------|-------------------------|
| -----100 yr   | 122.3 X 10 <sup>9</sup>         | 104,550                 |
| -----500 yr   | 178.2 X 10 <sup>9</sup>         | 131,870                 |
| -----10,000 y | 310.0 X 10 <sup>9</sup>         | 198,000                 |

Prepared by:

Prepared f



FLOOD HYDROGRAPHS

MAY - JULY

5-13

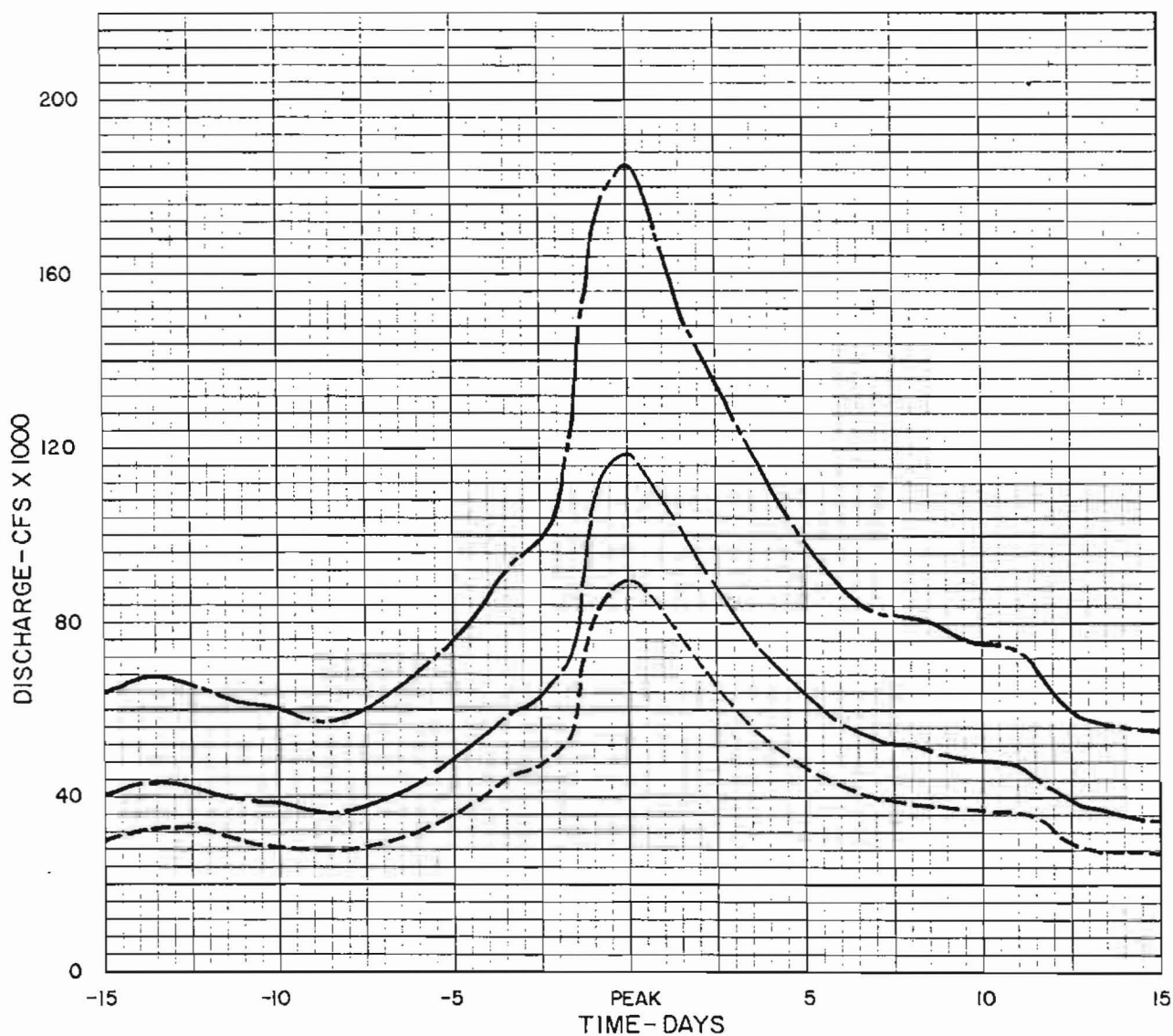
FIGURE 5.9

ACRE



100





## SUSITNA RIVER AT GOLD CREEK

### LEGEND

|                 | Flood Volume<br>ft <sup>3</sup> | Peak Discharge<br>(cfs) |
|-----------------|---------------------------------|-------------------------|
| ----- 100 yr    | 53.8 X 10 <sup>9</sup>          | 90,140                  |
| ----- 500 yr    | 78.8 X 10 <sup>9</sup>          | 119,430                 |
| ----- 10,000 yr | 140.0 X 10 <sup>9</sup>         | 185,000                 |

PREPARED BY:

PREPARED FOR:



FLOOD HYDROGRAPHS

AUG - OCT

5-14

FIGURE 5.10



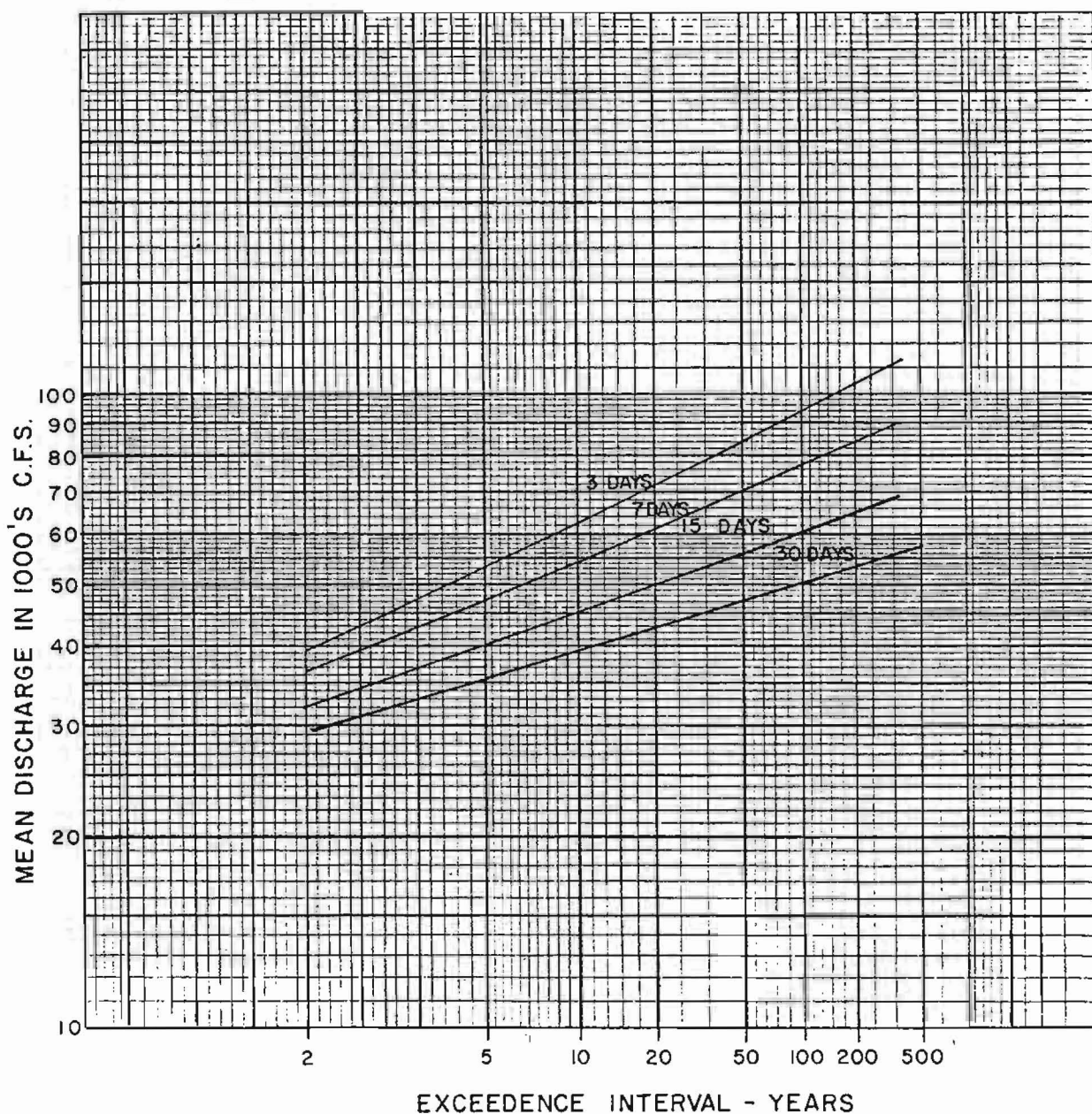


## 6 - FLOOD VOLUME-DURATION FREQUENCY ANALYSIS

To assist in designing temporary diversion structures and determining reservoir filling sequences, a flood volume-duration frequency analysis was conducted for May-July flows of the Susitna River at Gold Creek. Table 6.1 is a computer tabulation of May through July volume durations computed by the U.S. Geological Survey. The mean discharge for the 3-, 7-, 15- and 30-day durations were utilized with the three parameter log-normal frequency distribution to compute the volume-duration frequency curves illustrated on Figure 6.1.

SUSITNA RIVER AT GOLD CREEK  
HIGHEST MEAN DISCHARGE (CFS) OF CONSECUTIVE DAYS FROM MAY THROUGH JULY  
VOLUME DURATIONS COMPUTED BY U.S. GEOLOGICAL SURVEY

| YEAR | 1          | 3          | 7          | 15         | 30         |
|------|------------|------------|------------|------------|------------|
| 1950 | 34000.0 23 | 32100.0 24 | 27000.0 28 | 24500.0 28 | 22700.0 27 |
| 1951 | 35800.0 22 | 32100.0 25 | 29800.0 24 | 25200.0 27 | 22700.0 28 |
| 1952 | 43300.0 13 | 42300.0 12 | 39500.0 11 | 37000.0 9  | 33000.0 10 |
| 1953 | 37700.0 21 | 37200.0 18 | 35500.0 17 | 31000.0 19 | 27400.0 19 |
| 1954 | 30100.0 28 | 29500.0 28 | 28800.0 25 | 26900.0 24 | 25700.0 22 |
| 1955 | 39000.0 20 | 38700.0 16 | 36600.0 16 | 35500.0 12 | 33800.0 8  |
| 1956 | 51500.0 9  | 49900.0 8  | 46800.0 7  | 40300.0 4  | 34500.0 7  |
| 1957 | 40600.0 14 | 39900.0 14 | 38400.0 13 | 35500.0 13 | 32300.0 13 |
| 1958 | 32400.0 26 | 32100.0 26 | 28000.0 26 | 28000.0 22 | 25800.0 21 |
| 1959 | 39600.0 18 | 37200.0 19 | 30700.0 22 | 27300.0 23 | 26200.0 20 |
| 1960 | 40000.0 15 | 36100.0 20 | 32900.0 19 | 26100.0 25 | 23100.0 26 |
| 1961 | 54000.0 6  | 52000.0 7  | 42700.0 9  | 36800.0 10 | 30800.0 14 |
| 1962 | 79900.0 2  | 75200.0 2  | 64700.0 2  | 53200.0 2  | 43300.0 2  |
| 1963 | 49000.0 11 | 46300.0 9  | 42900.0 8  | 39200.0 7  | 34900.0 6  |
| 1964 | 85900.0 1  | 81900.0 1  | 75000.0 1  | 63500.0 1  | 50700.0 1  |
| 1965 | 39900.0 16 | 37400.0 17 | 34100.0 18 | 31300.0 18 | 30500.0 15 |
| 1966 | 58400.0 5  | 56600.0 5  | 49200.0 4  | 39800.0 5  | 33000.0 9  |
| 1967 | 50000.0 10 | 46300.0 10 | 38900.0 12 | 32500.0 16 | 29900.0 16 |
| 1968 | 39700.0 17 | 38900.0 15 | 38100.0 14 | 36500.0 11 | 32400.0 11 |
| 1969 | 26500.0 29 | 24400.0 29 | 20500.0 30 | 17700.0 30 | 16700.0 30 |
| 1970 | 30800.0 27 | 30100.0 27 | 27100.0 27 | 25700.0 26 | 23800.0 24 |
| 1971 | 66300.0 4  | 59000.0 4  | 48300.0 5  | 38200.0 8  | 35400.0 5  |
| 1972 | 70700.0 3  | 65600.0 3  | 53500.0 3  | 39800.0 6  | 37300.0 4  |
| 1973 | 52800.0 7  | 45300.0 11 | 40900.0 10 | 34600.0 14 | 28600.0 18 |
| 1974 | 33600.0 24 | 33200.0 22 | 32400.0 21 | 29300.0 20 | 23200.0 25 |
| 1975 | 44000.0 12 | 42200.0 13 | 37100.0 15 | 33300.0 15 | 32300.0 12 |
| 1976 | 33300.0 25 | 32100.0 23 | 29800.0 23 | 28600.0 21 | 24500.0 23 |
| 1977 | 52600.0 8  | 52200.0 6  | 48300.0 6  | 41500.0 3  | 38000.0 3  |
| 1978 | 24300.0 30 | 23800.0 30 | 23100.0 29 | 22600.0 29 | 21700.0 29 |
| 1979 | 39300.0 19 | 34800.0 21 | 32600.0 20 | 31700.0 17 | 29100.0 17 |



SUSITNA RIVER AT GOLD CREEK  
PERIOD OF RECORD - 1950 - 1979

Prepared by:

Prepared for:



VOLUME DURATION  
FREQUENCY CURVES  
MAY - JULY  
6-3

FIGURE 6.1





## 7 - REFERENCES

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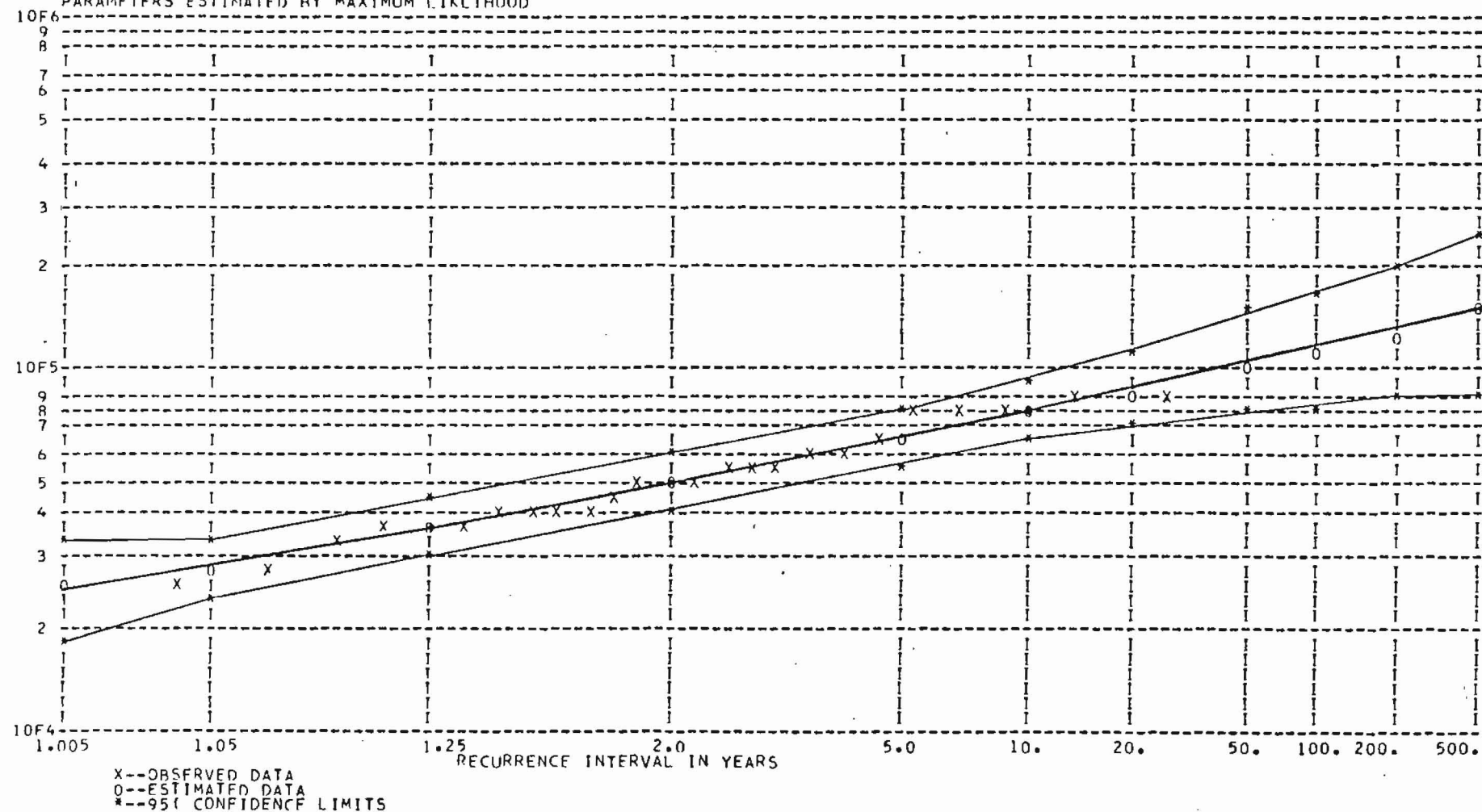


ATTACHMENT A

FLOOD FREQUENCY CURVES FOR ANNUAL  
INSTANTANEOUS FLOOD PEAK SERIES,  
INDIVIDUAL STATIONS



Susitna R. at Gold Creek  
THREE PARAMETER LOG-NORMAL DISTRIBUTION-WITH 95 PCT CL  
PARAMETERS ESTIMATED BY MAXIMUM LIKLIHOOD



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ANNUAL FLOOD FREQUENCY CURVE  
SUSITNA RIVER AT GOLD CREEK

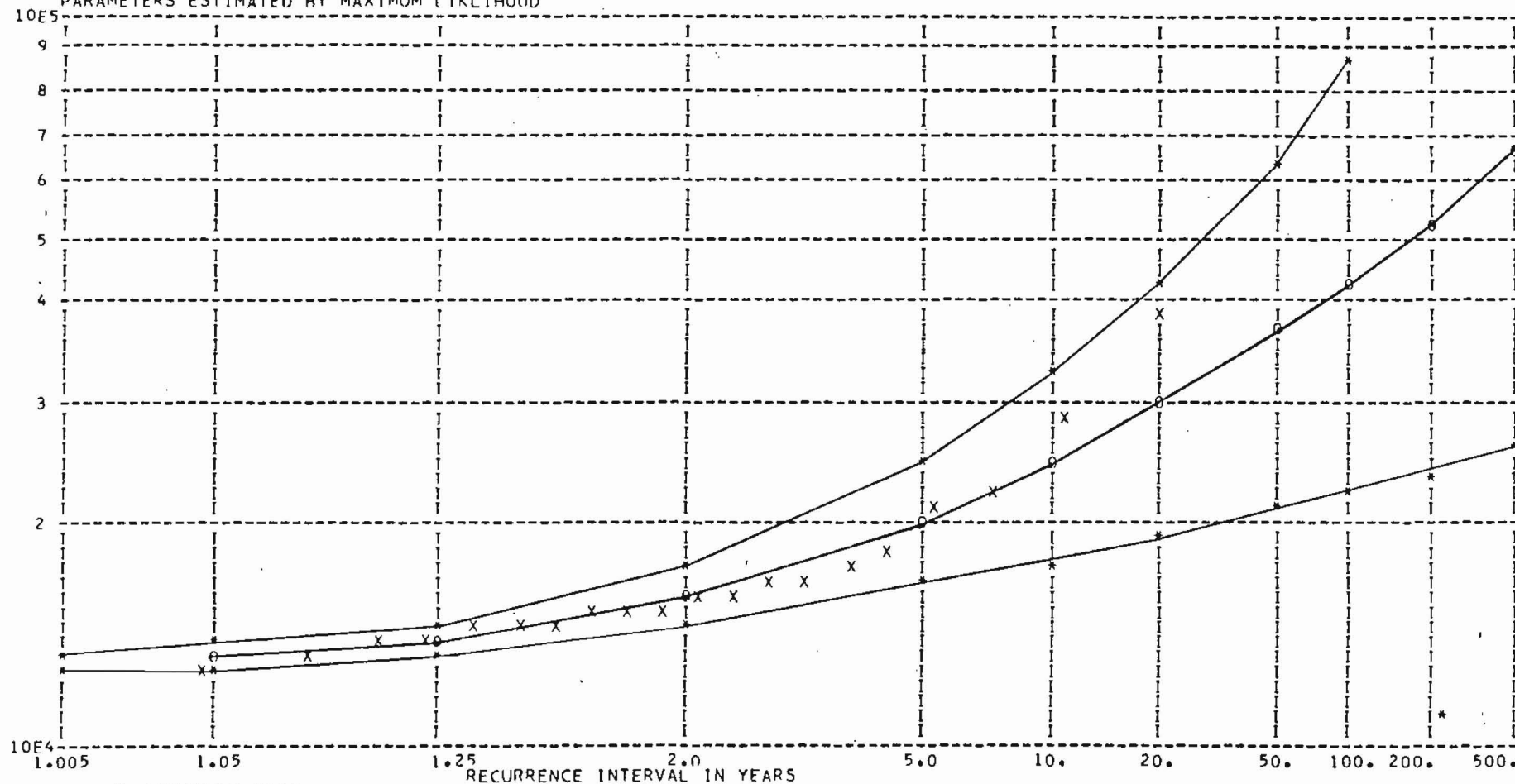
Prepared for:



FIGURE: A.1



Susitna R. near Denali  
 THREE PARAMETER LOG-NORMAL DISTRIBUTION-WITH 95 PCT CI  
 PARAMETERS ESTIMATED BY MAXIMUM LIKLIHOOD



X--OBSERVED DATA  
 O--ESTIMATED DATA  
 \*--95% CONFIDENCE LIMITS

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ANNUAL FLOOD FREQUENCY CURVE  
 SUSITNA RIVER NEAR DENALI

Prepared for:

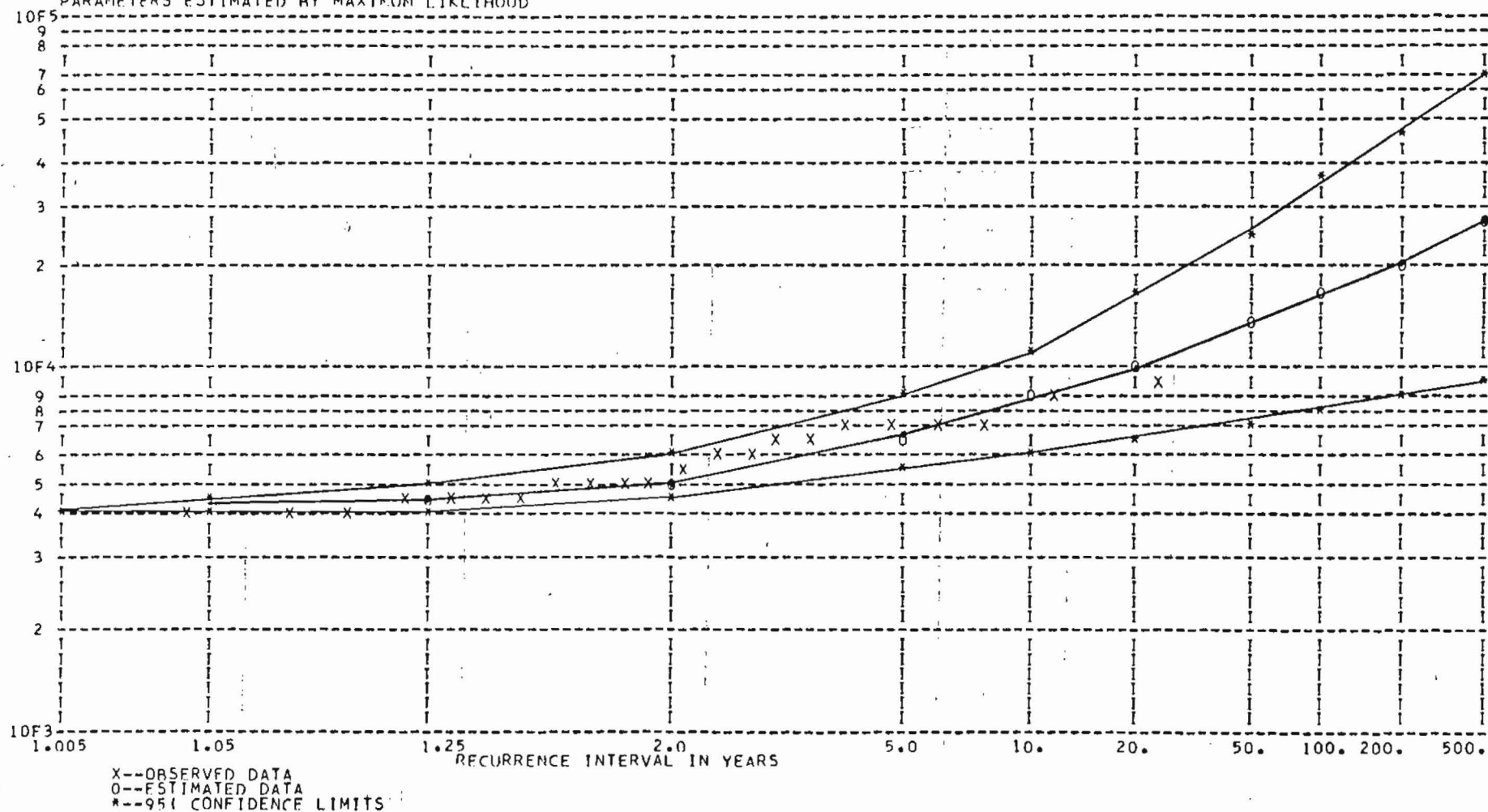


FIGURE: A.2



Maclaren R. near Paxson

THREE PARAMETER LOG-NORMAL DISTRIBUTION-WITH 95 PCT CL  
PARAMETERS ESTIMATED BY MAXIMUM LIKLIHOOD



Prepared by:

Prepared for:



ANNUAL FLOOD FREQUENCY CURVE  
MACLAREN RIVER NEAR PAXSON

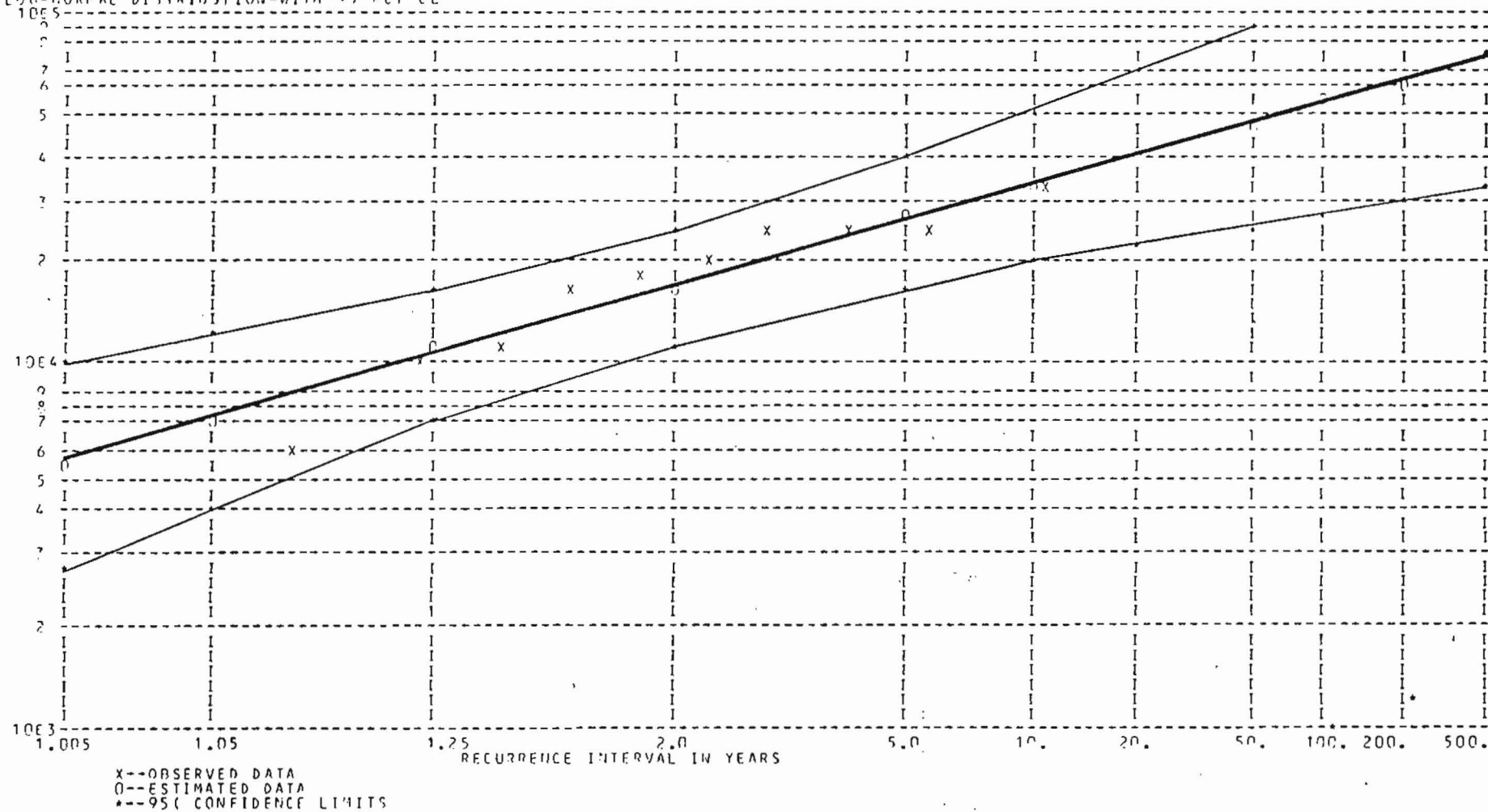


FIGURE: A.3





Susitna R. near Cantwell  
LOG-NORMAL DISTRIBUTION-WITH 25 PCT CL



Prepared by:



ANNUAL FLOOD FREQUENCY CURVE  
SUSITNA RIVER NEAR CANTWELL

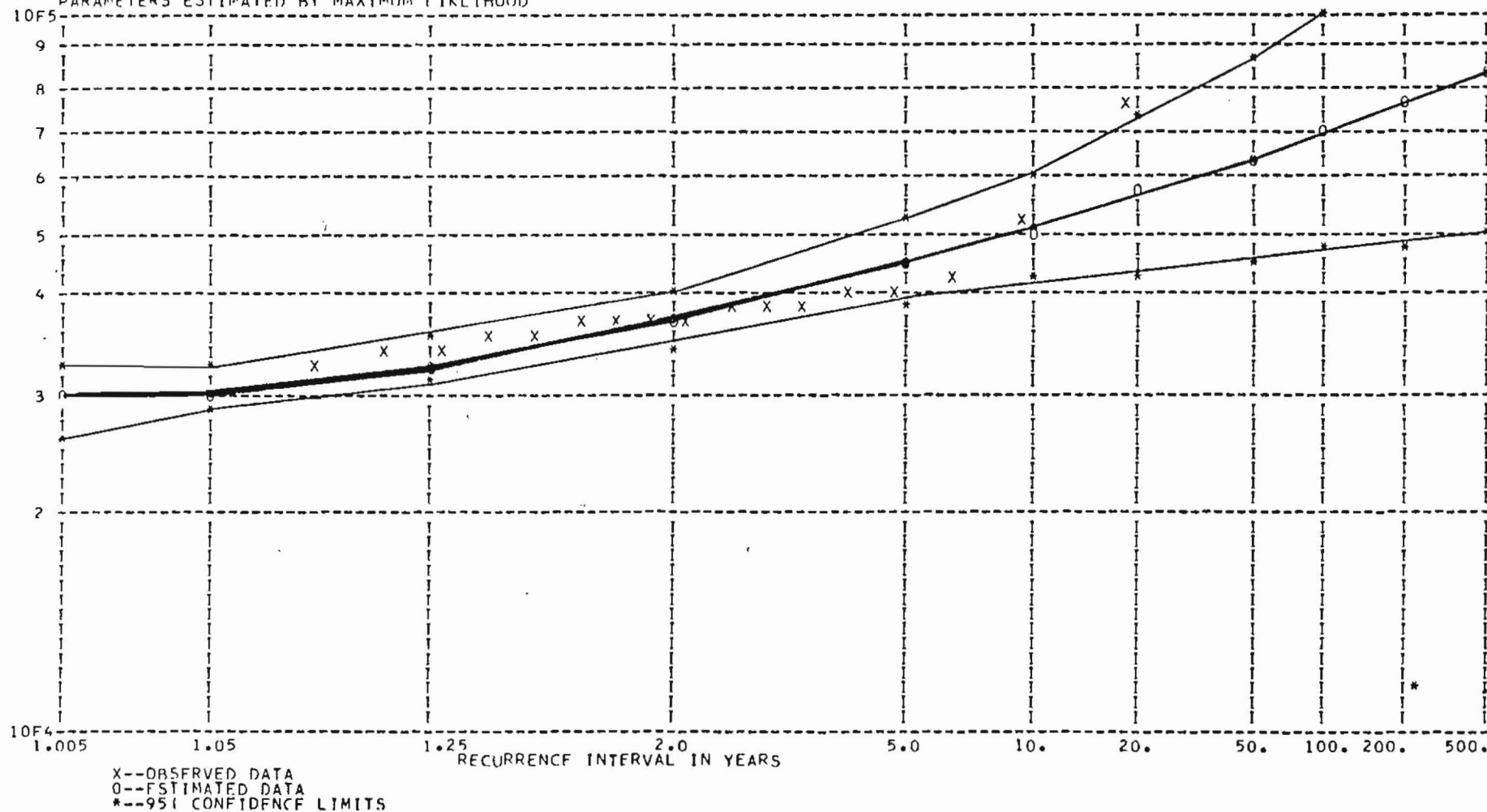
Prepared for:



FIGURE: A.4



Chulitna R. near Talkeetna  
THREE PARAMETER LOG-NORMAL DISTRIBUTION-WITH 95 PCT CL  
PARAMETERS ESTIMATED BY MAXIMUM LIKLIHOOD



Prepared by:



ANNUAL FLOOD FREQUENCY CURVE  
CHULITNA RIVER NEAR TALKEETNA

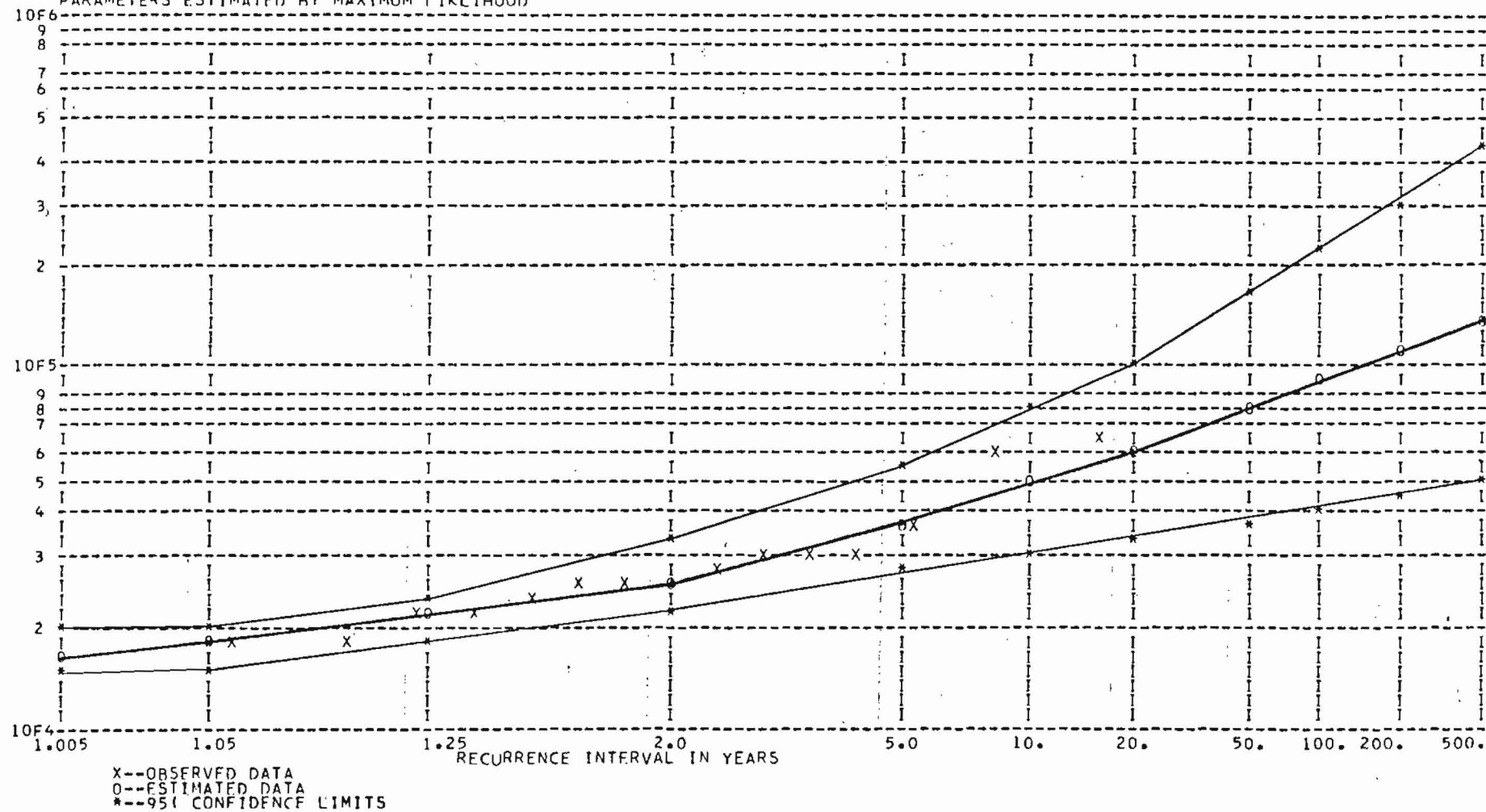
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FIGURE: A.5



Talkeetna R. near Talkeetna  
THREE PARAMETER LOG-NORMAL DISTRIBUTION-WITH 95 PCT CL  
PARAMETERS ESTIMATED BY MAXIMUM LIKLIHOOD



Prepared by:



ANNUAL FLOOD FREQUENCY CURVE  
TALKEETNA RIVER NEAR TALKEETNA

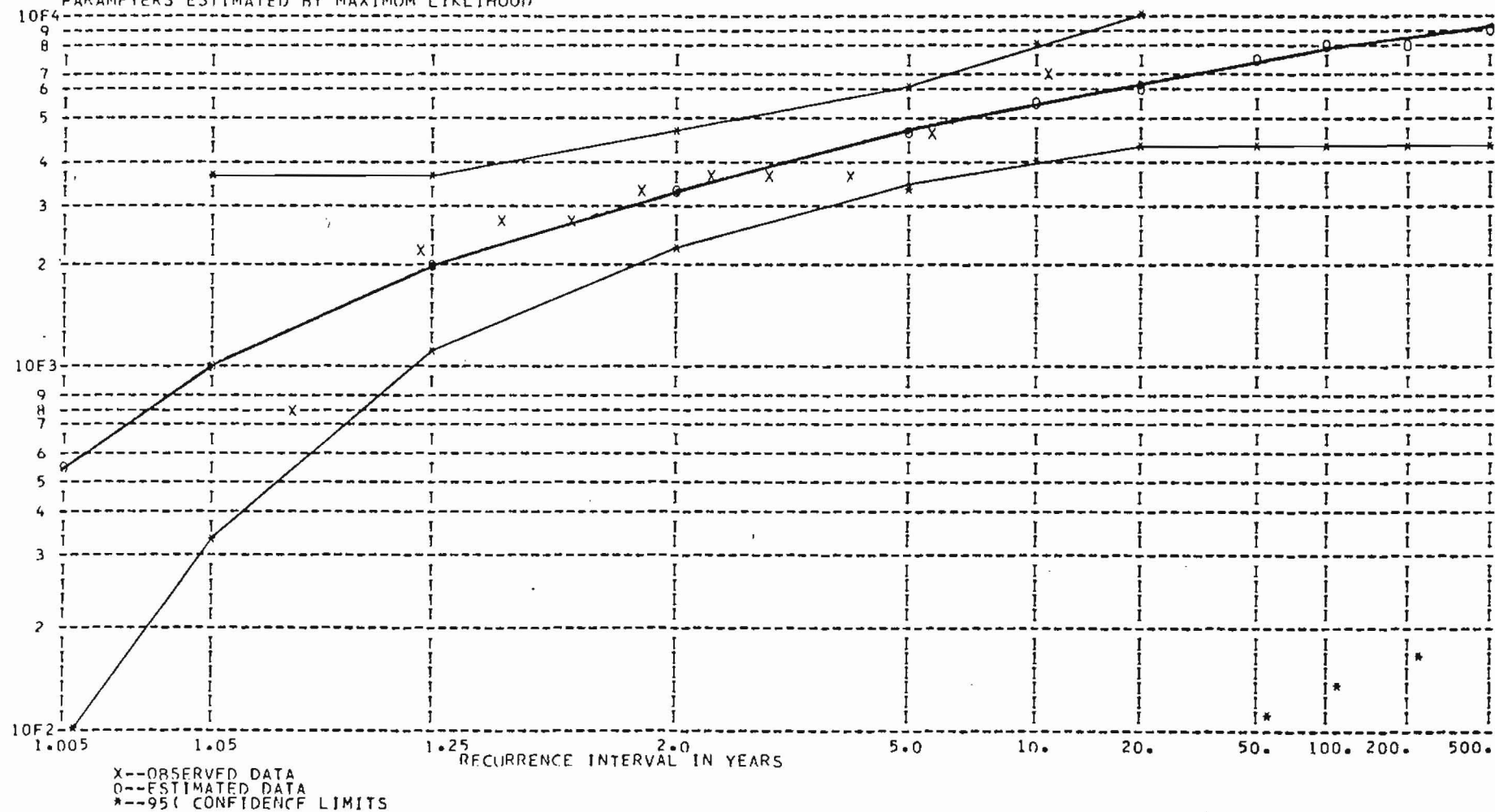
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FIGURE: A.6



Montana Cr. near Montana  
THREE PARAMETER LOG-NORMAL DISTRIBUTION-WITH 95 PCT CL  
PARAMETERS ESTIMATED BY MAXIMUM LIKLIHOOD



Prepared by:

Prepared for:



ANNUAL FLOOD FREQUENCY CURVE  
MONTANA CREEK NEAR MONTANA

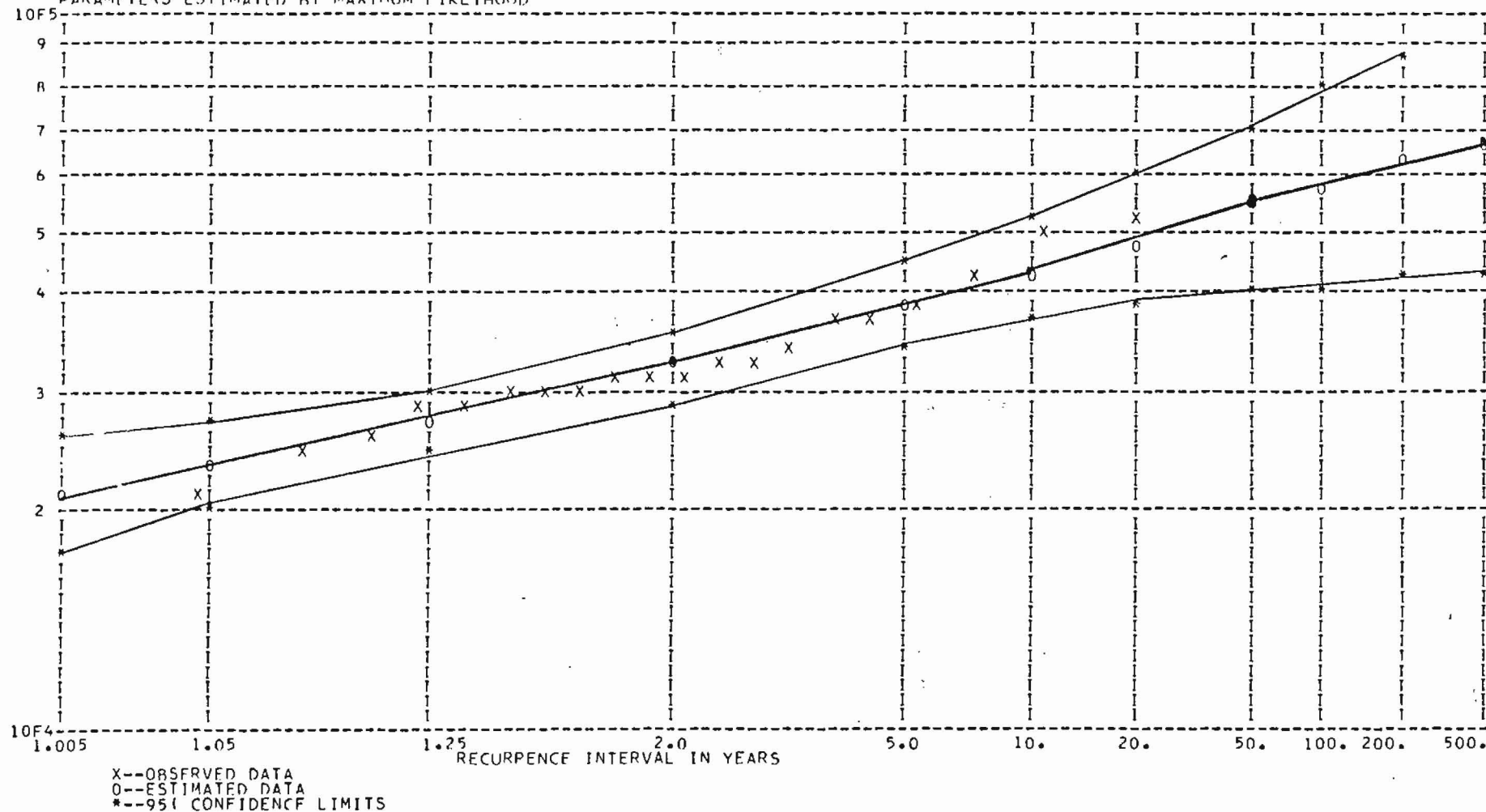


FIGURE: A.7





Skwentna R. near Skwentna  
THREE PARAMETER LOG-NORMAL DISTRIBUTION-WITH 95 PCT CI  
PARAMETERS ESTIMATED BY MAXIMUM LIKLIHOOD



Prepared by:



ANNUAL FLOOD FREQUENCY CURVE  
SKWENTNA RIVER NEAR SKWENTNA

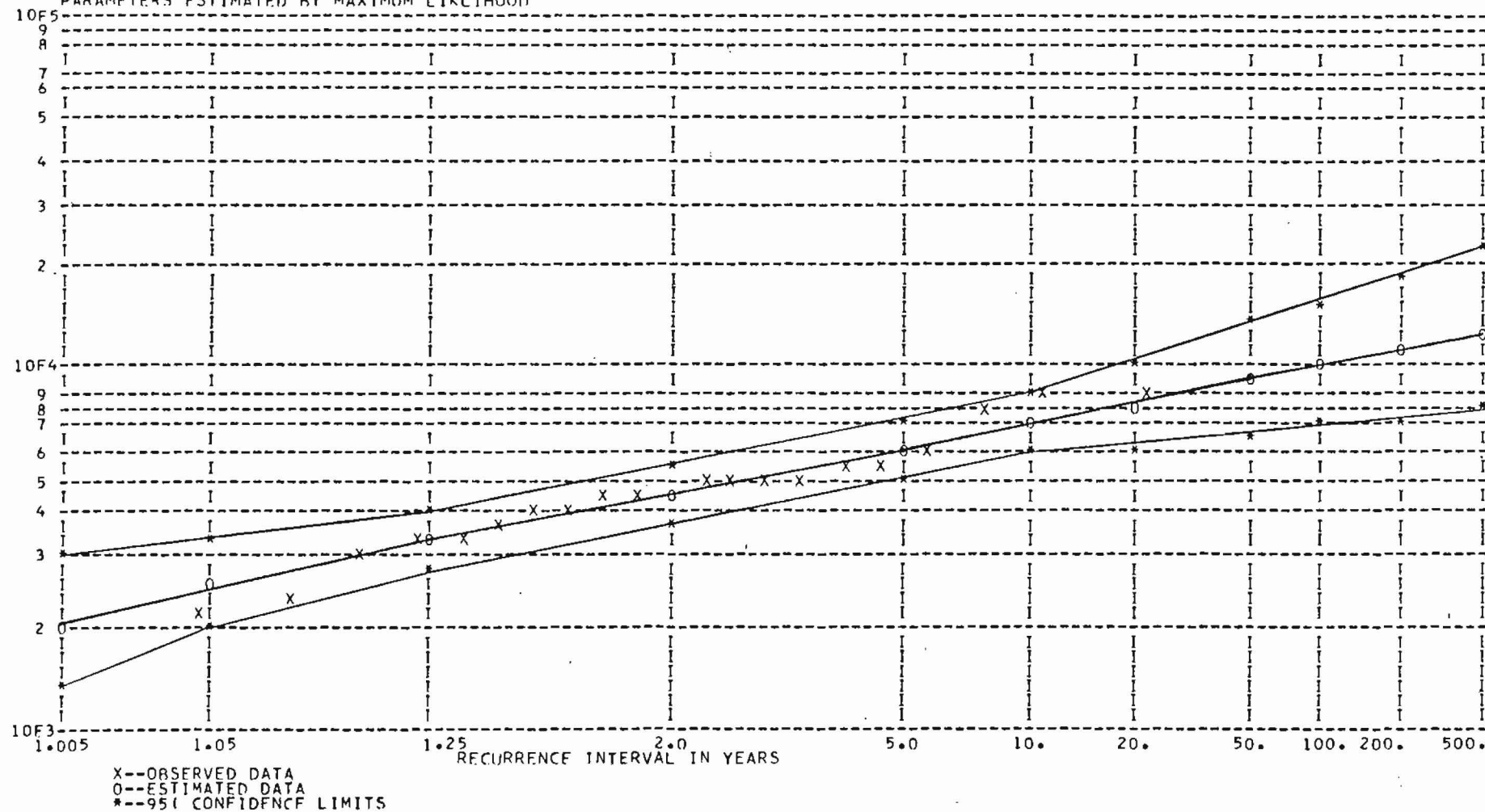
Prepared for:



FIGURE: A.8



Caribou Cr. near Sutton  
THREE PARAMETER LOG-NORMAL DISTRIBUTION-WITH 95 PCT CL  
PARAMETERS ESTIMATED BY MAXIMUM LIKLIHOOD



Prepared by:

Prepared for:



ANNUAL FLOOD FREQUENCY CURVE  
CARIBOU CREEK NEAR SUTTON

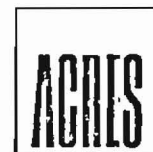
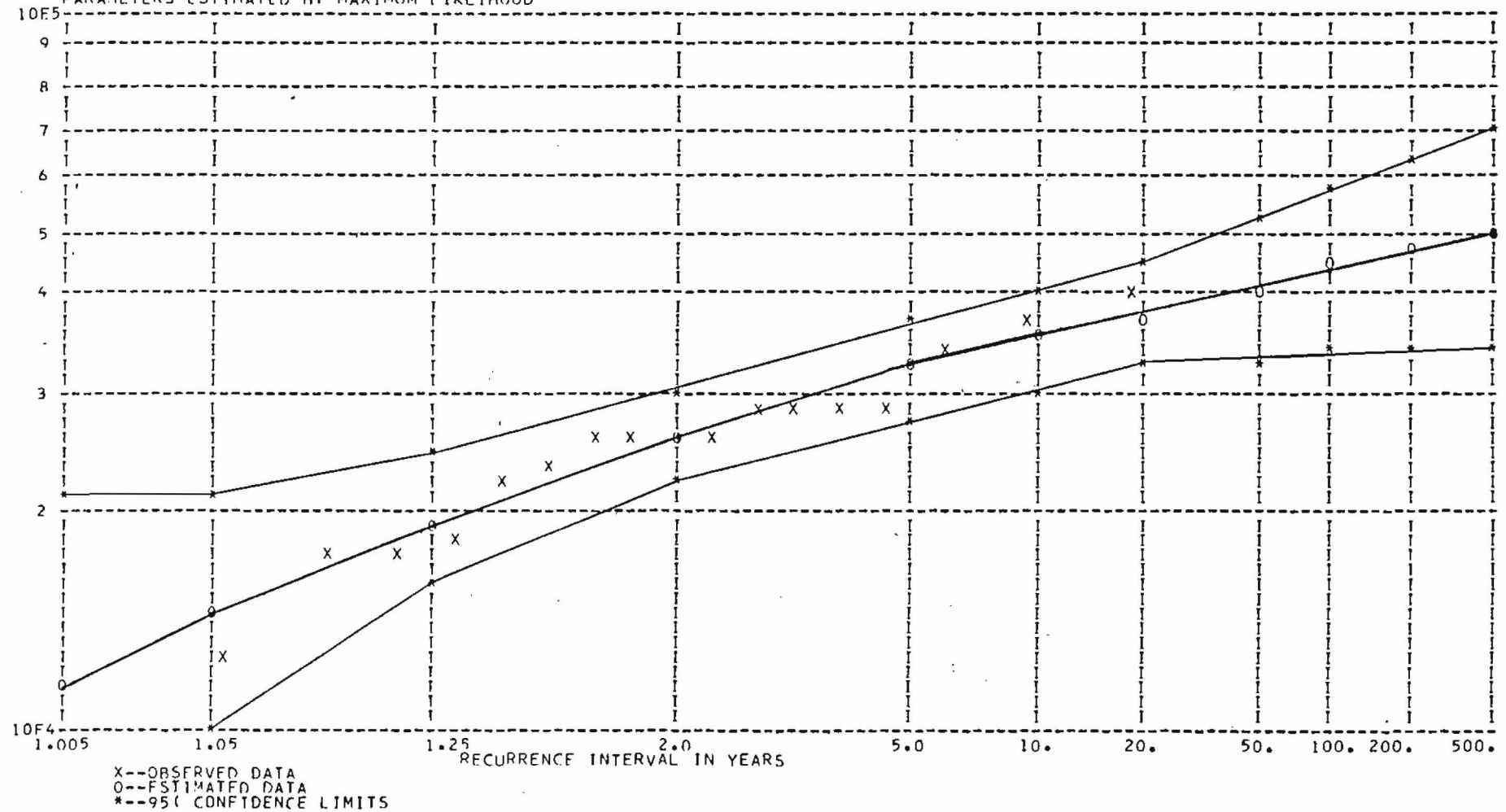


FIGURE: A.9



Matanuska R. at Palmer  
THREE PARAMETER LOG-NORMAL DISTRIBUTION-WITH 95 PCT CL  
PARAMETERS ESTIMATED BY MAXIMUM LIKLIHOOD



Prepared by:

Prepared for:



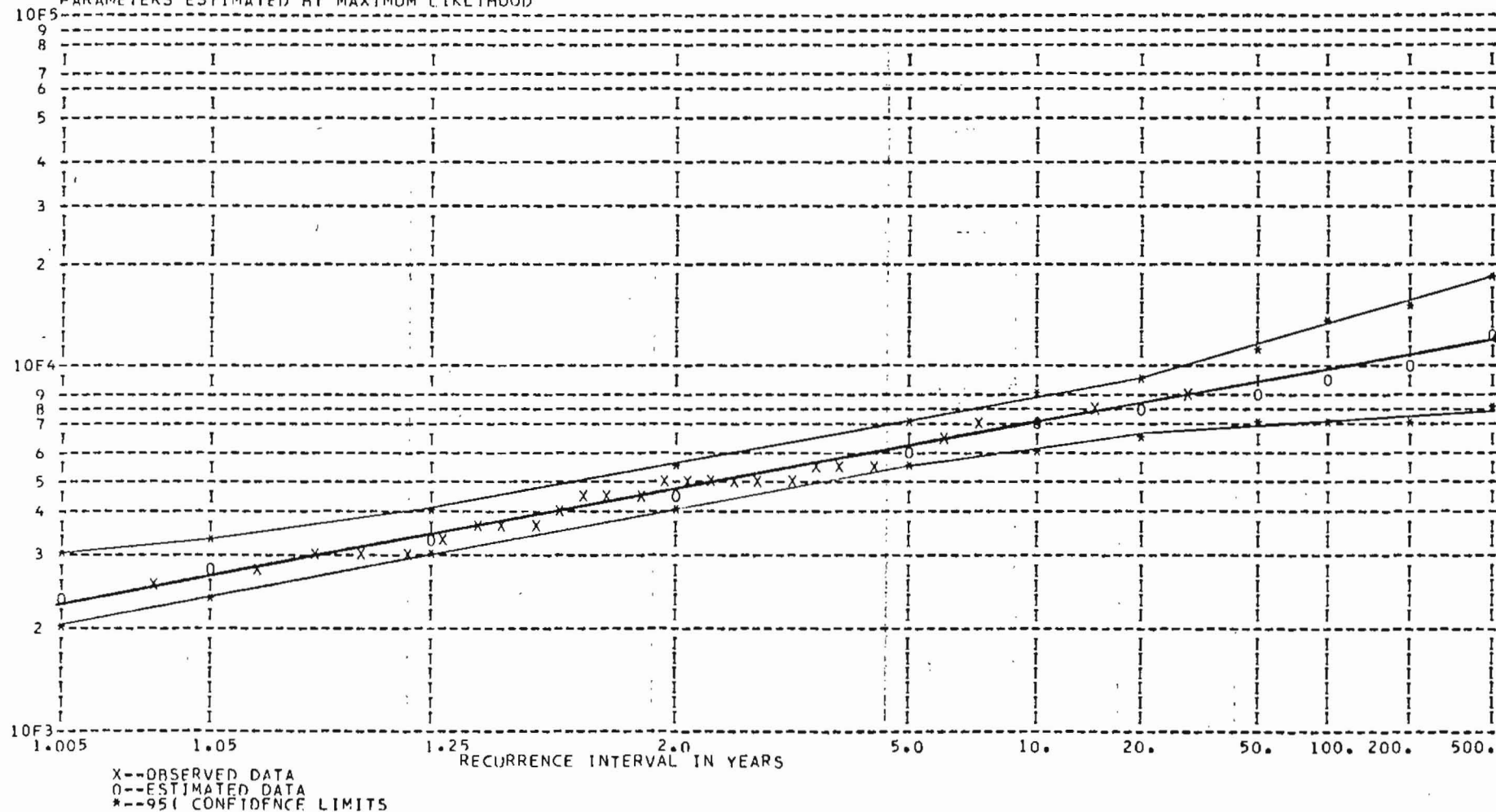
ANNUAL FLOOD FREQUENCY CURVE  
MATANUSKA RIVER AT PALMER



FIGURE: A.10



Tonsina R. at Tonsina  
THREE PARAMETER LOG-NORMAL DISTRIBUTION-WITH 95 PCT CL  
PARAMETERS ESTIMATED BY MAXIMUM LIKLIHOOD



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ANNUAL FLOOD FREQUENCY CURVE  
TONSINA RIVER AT TONSINA

Prepared for:

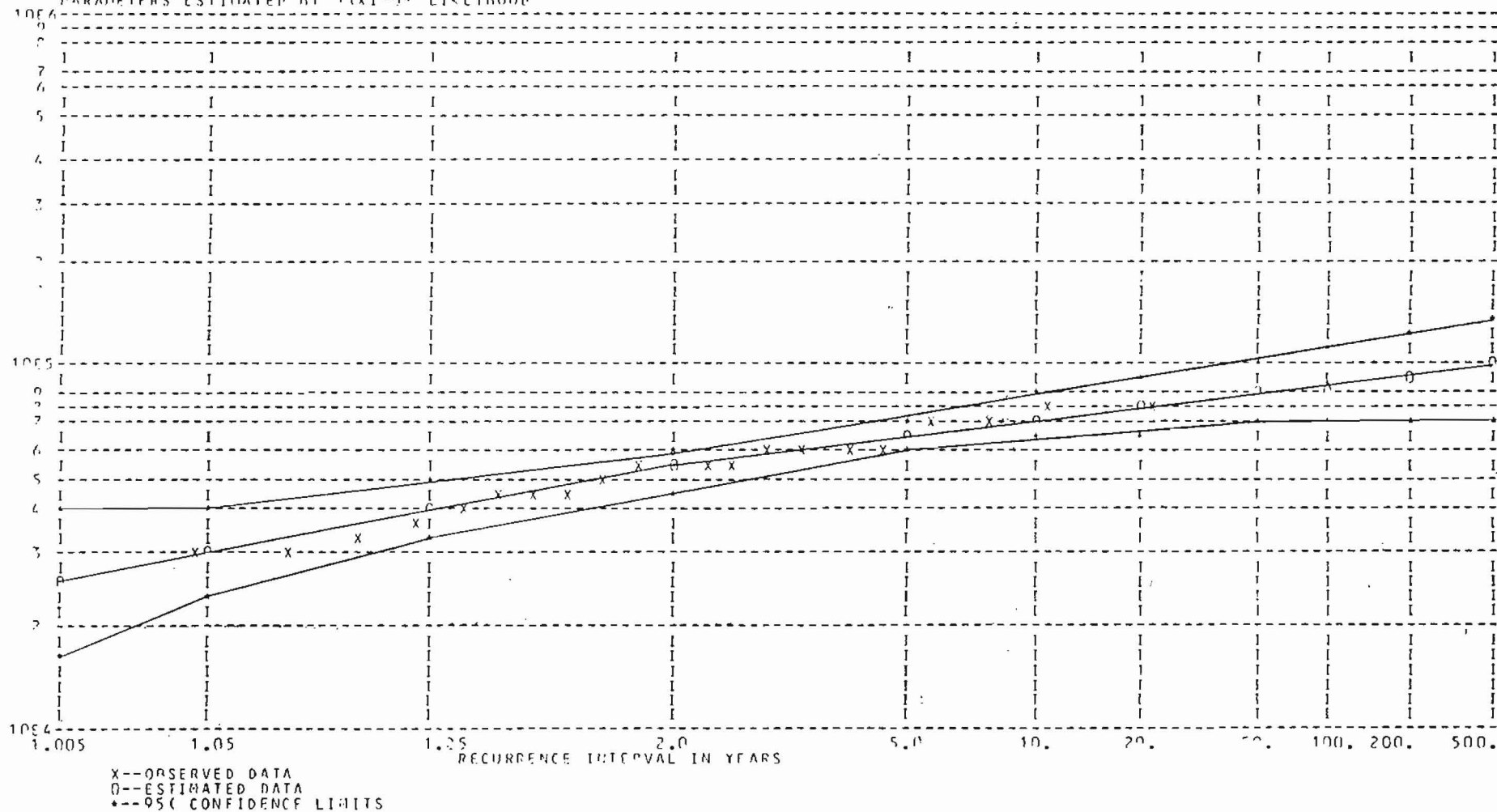


FIGURE: A.11





Copper R. near Chitina  
 THREE PARAMETER LOG-NORMAL DISTRIBUTION WITH 25 PER CENT  
 PARAMETERS ESTIMATED BY "MAXIMUM LIKELIHOOD"



Prepared by:

Prepared for:



ANNUAL FLOOD FREQUENCY CURVE  
 COPPER RIVER NEAR CHITINA



FIGURE: A.12

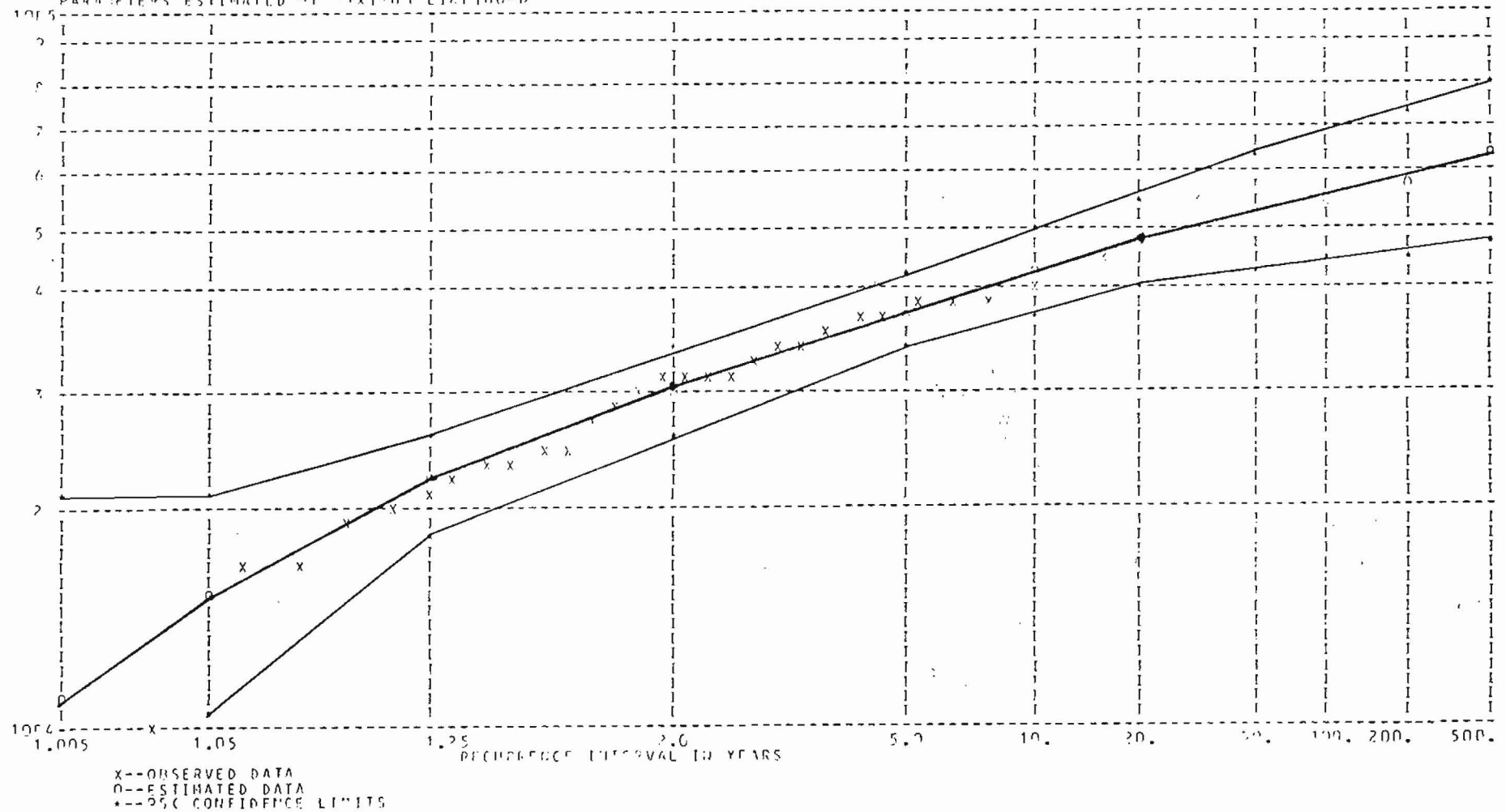


ATTACHMENT B

FLOOD FREQUENCY CURVES FOR  
MAXIMUM ANNUAL OCTOBER-MAY MEAN,  
INDIVIDUAL STATION



Susitna R. at Gold Creek  
THREE PARAMETER LOG-NORMAL DISTRIBUTION WITH 95 PER C  
PARAMETERS ESTIMATED BY MAXIMUM LIKELIHOOD



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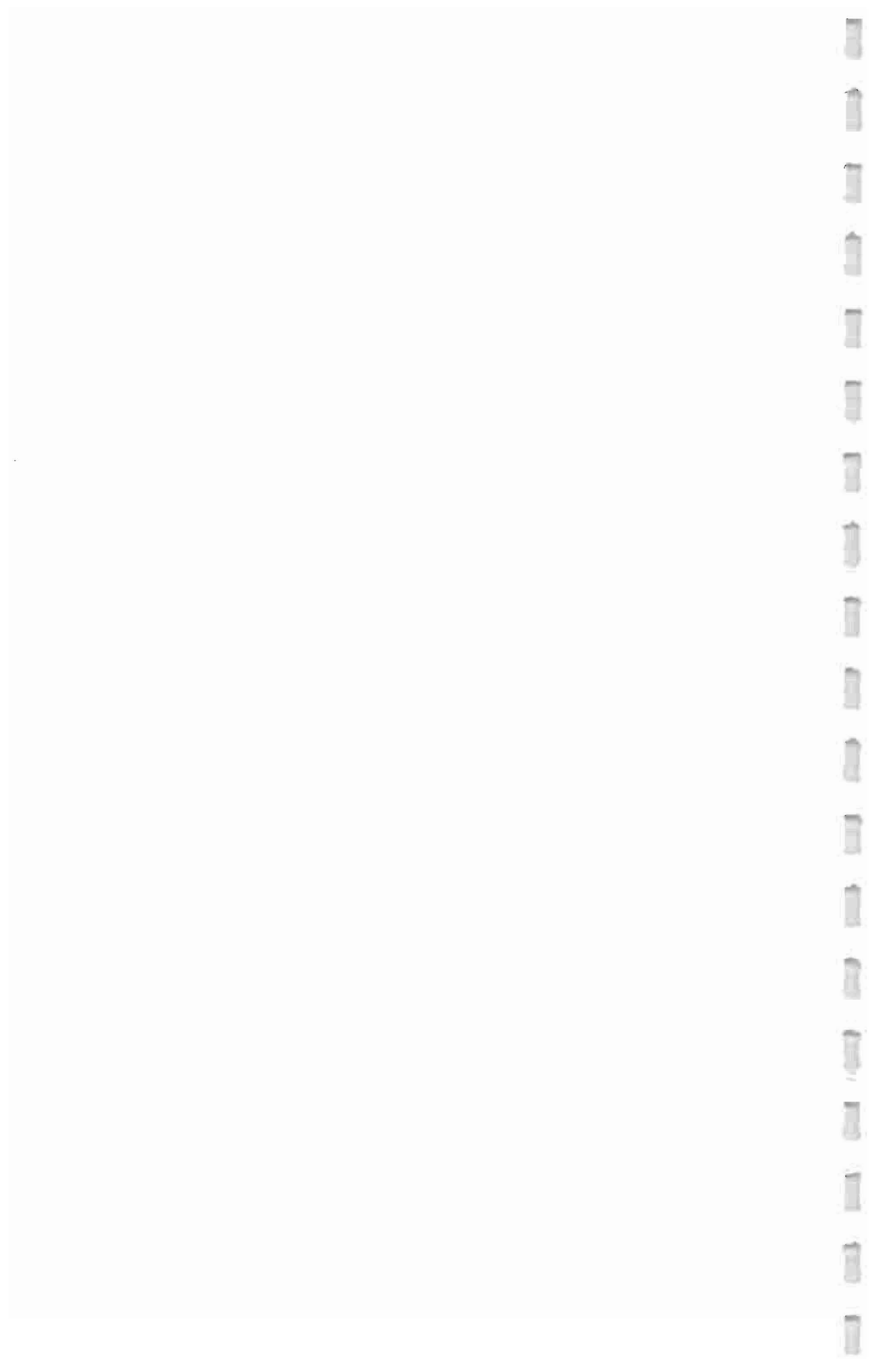
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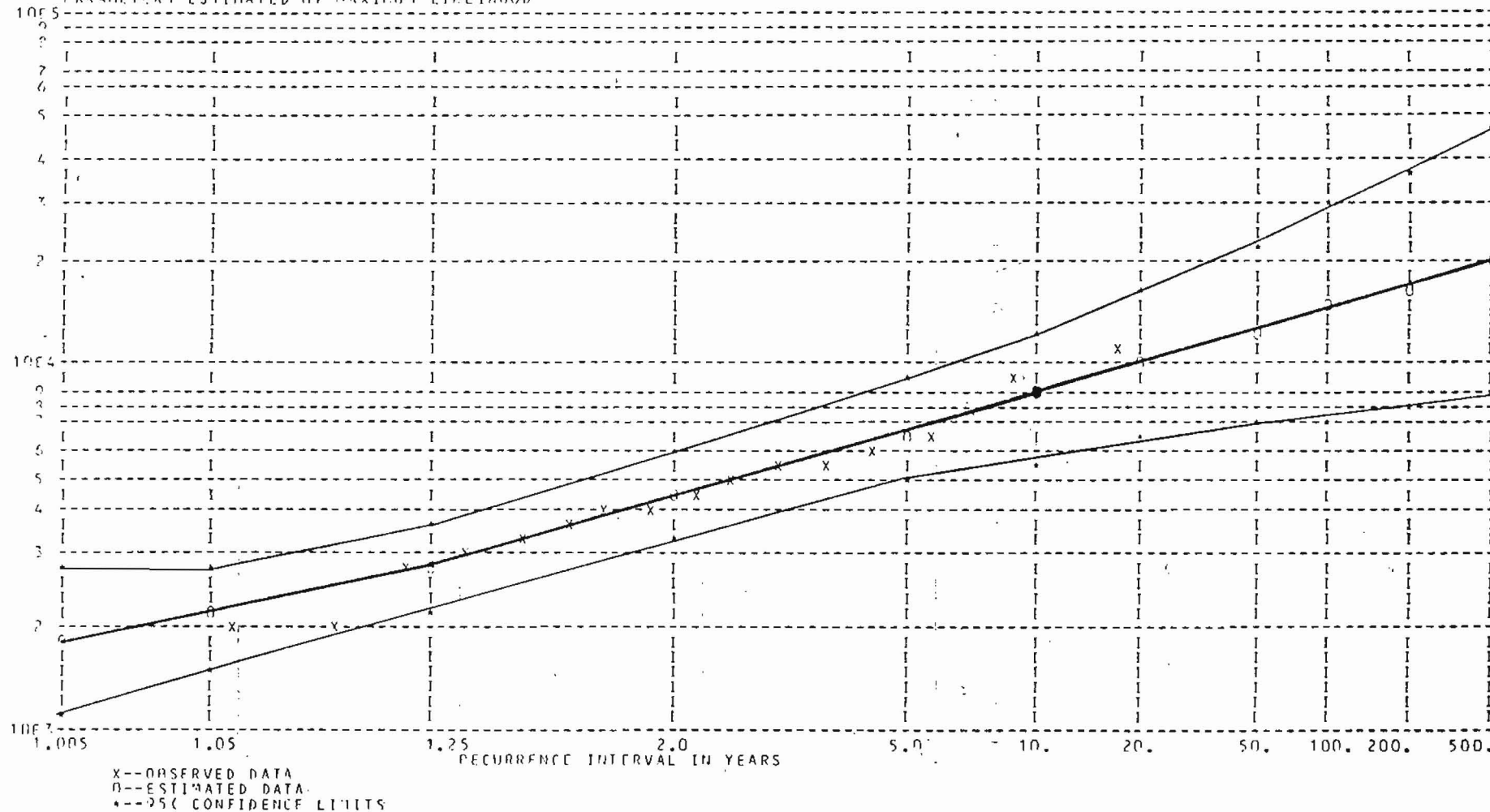
OCT-MAY FLOOD FREQUENCY CURVE  
SUSITNA RIVER AT GOLD CREEK



FIGURE: B.1



Susitna R. near Denali  
 TYPE I PARAMETER LOG-NORMAL DISTRIBUTION-WITH 95 PCT CL  
 PARAMETERS ESTIMATED BY MAXIMUM LIKLIHOOD



Prepared by:

Prepared for:



OCT-MAY FLOOD FREQUENCY CURVE  
 SUSITNA RIVER NEAR DENALI

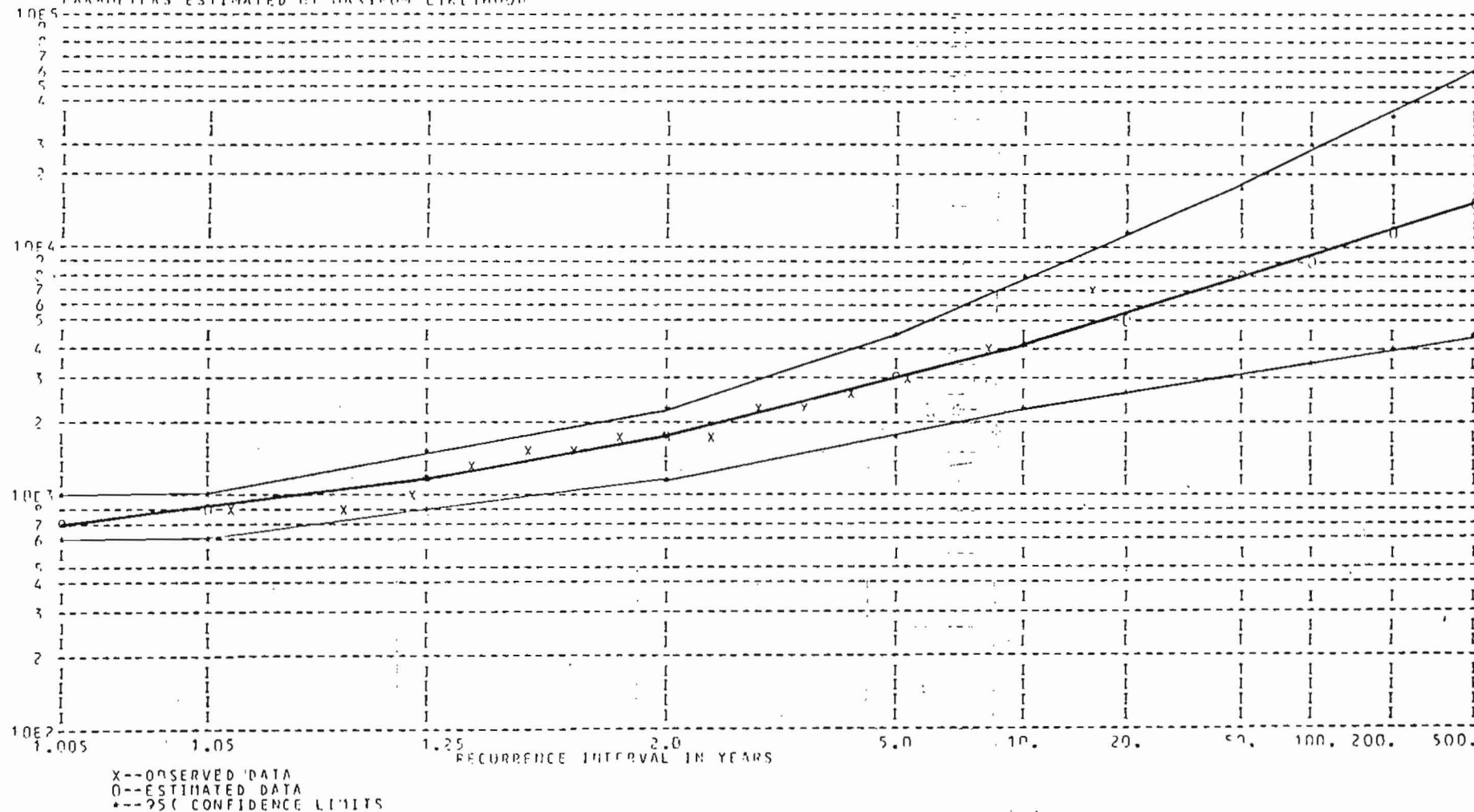


FIGURE: B.2





Maclaren R. near Paxson  
THREE PARAMETER LOG-NORMAL DISTRIBUTION WITH 95 PCT CI  
PARAMETERS ESTIMATED BY MAXIMUM LIKELIHOOD



Prepared by:

Prepared for:



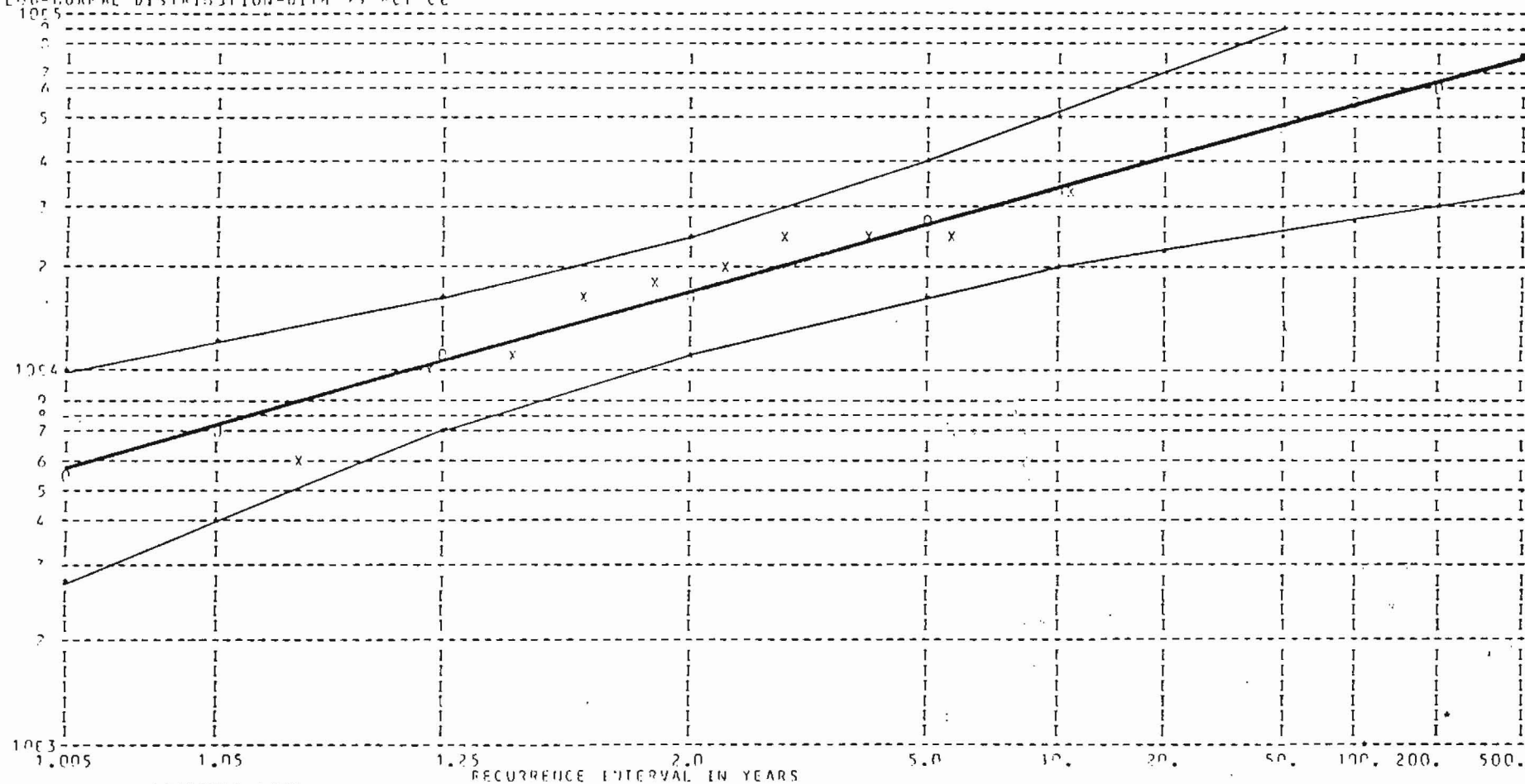
OCT-MAY FLOOD FREQUENCY CURVE  
MACLAREN RIVER NEAR PAXSON



FIGURE: B.3



Susitna R. near Cantwell  
LOG-NORMAL DISTRIBUTION-WITH 25 PCT CL



x--OBSERVED DATA  
o--ESTIMATED DATA  
---95% CONFIDENCE LIMITS

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Prepared for:



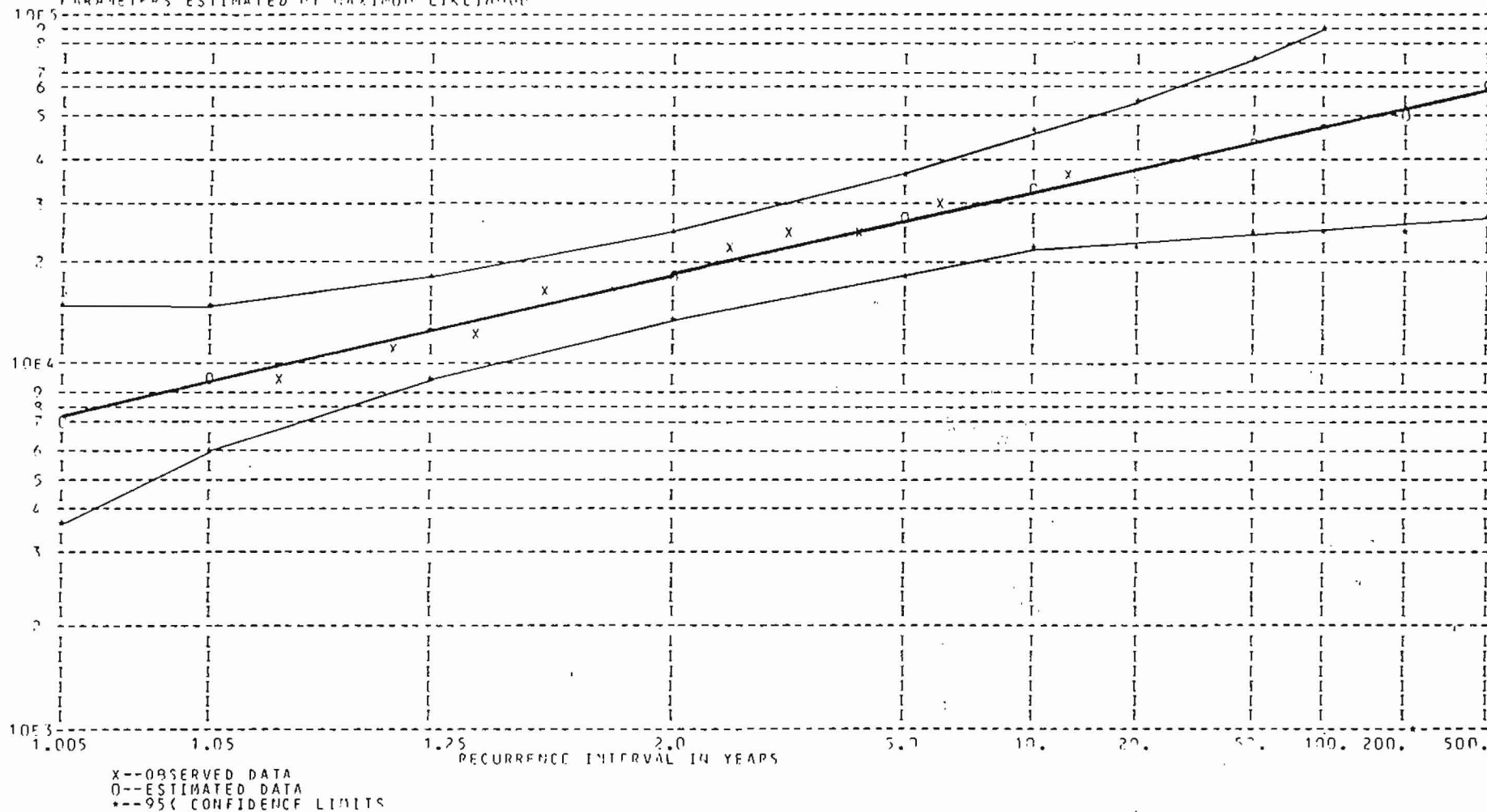
OCT-MAY FLOOD FREQUENCY CURVE  
SUSITNA RIVER NEAR CANTWELL



FIGURE: B.4



Chulitna R. near Talkeetna  
 THREE PARAMETER LOG-NORMAL DISTRIBUTION WITH 95% C.I.  
 PARAMETERS ESTIMATED BY MAXIMUM LIKELIHOOD



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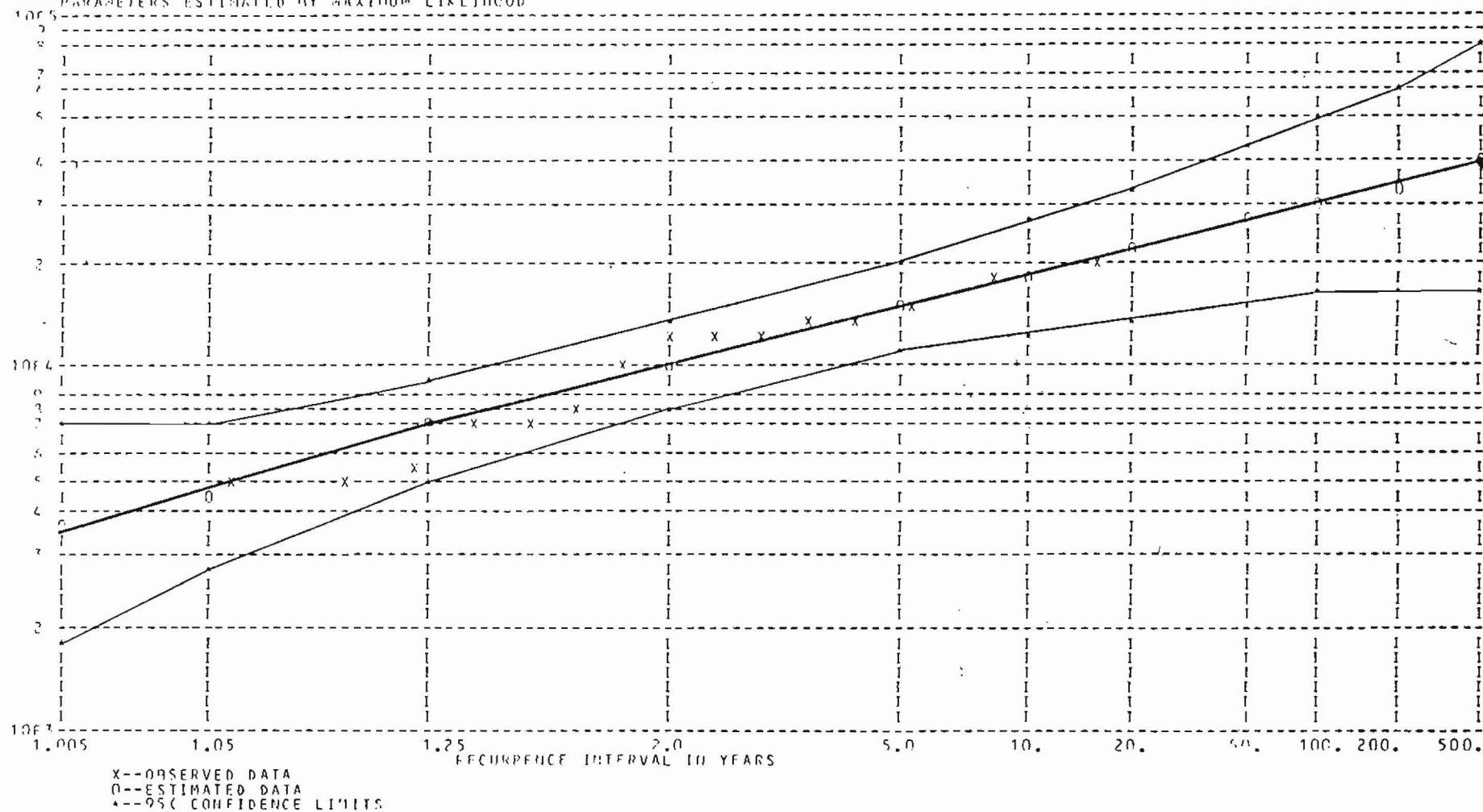
OCT-MAY FLOOD FREQUENCY CURVE  
 CHULITNA RIVER NEAR TALKEETNA



FIGURE: B.5



Talkeetna R. near Talkeetna  
 THREE PARAMETER LOG-NORMAL DISTRIBUTION-WITH 95 PCT CL  
 PARAMETERS ESTIMATED BY MAXIMUM LIKELIHOOD



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Prepared for:



OCT-MAY FLOOD FREQUENCY CURVE  
 TALKEETNA RIVER NEAR TALKEETNA

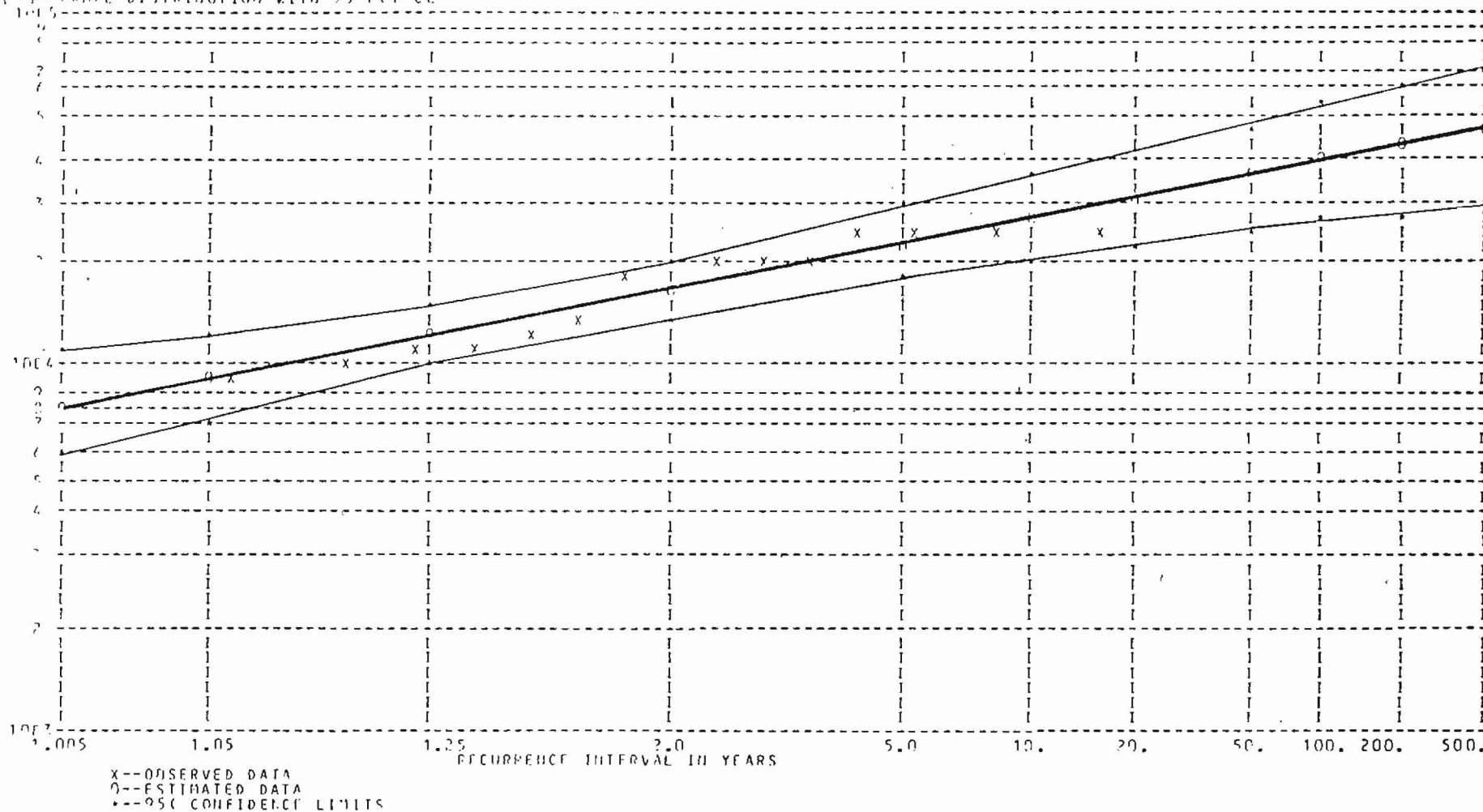


FIGURE: B.6





Skwentna R. near Skwentna  
LOG-NORMAL DISTRIBUTION-WITH 95 PCT CL



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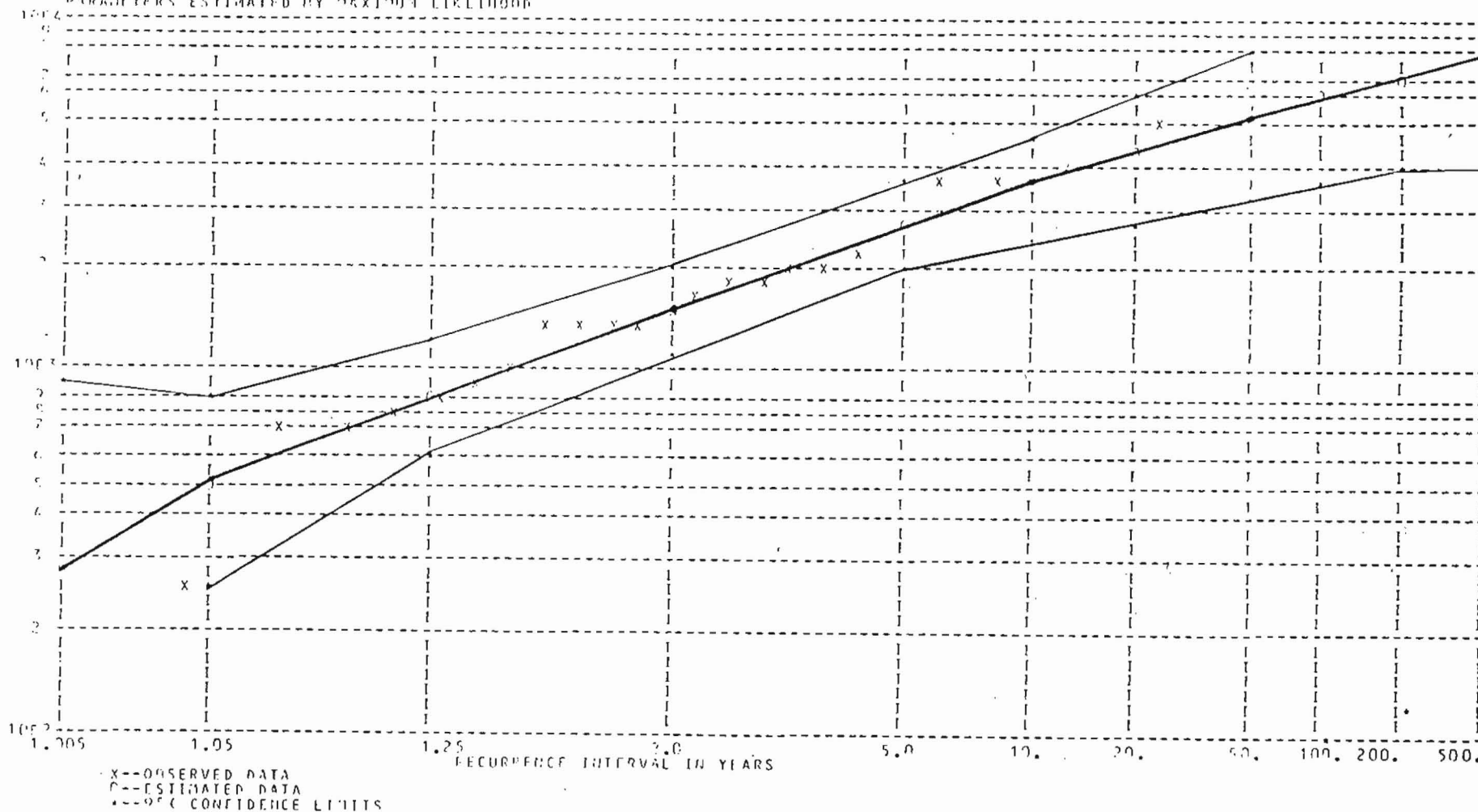
OCT-MAY FLOOD FREQUENCY CURVE  
SKWENTNA RIVER NEAR SKWENTNA



FIGURE: B.7



Caribou Cr. near Sutton  
 THREE PARAMETER LOG-NORMAL DISTRIBUTION-WITH 95 PCT CI  
 PARAMETERS ESTIMATED BY MAXIMUM LIKELIHOOD



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Prepared for:



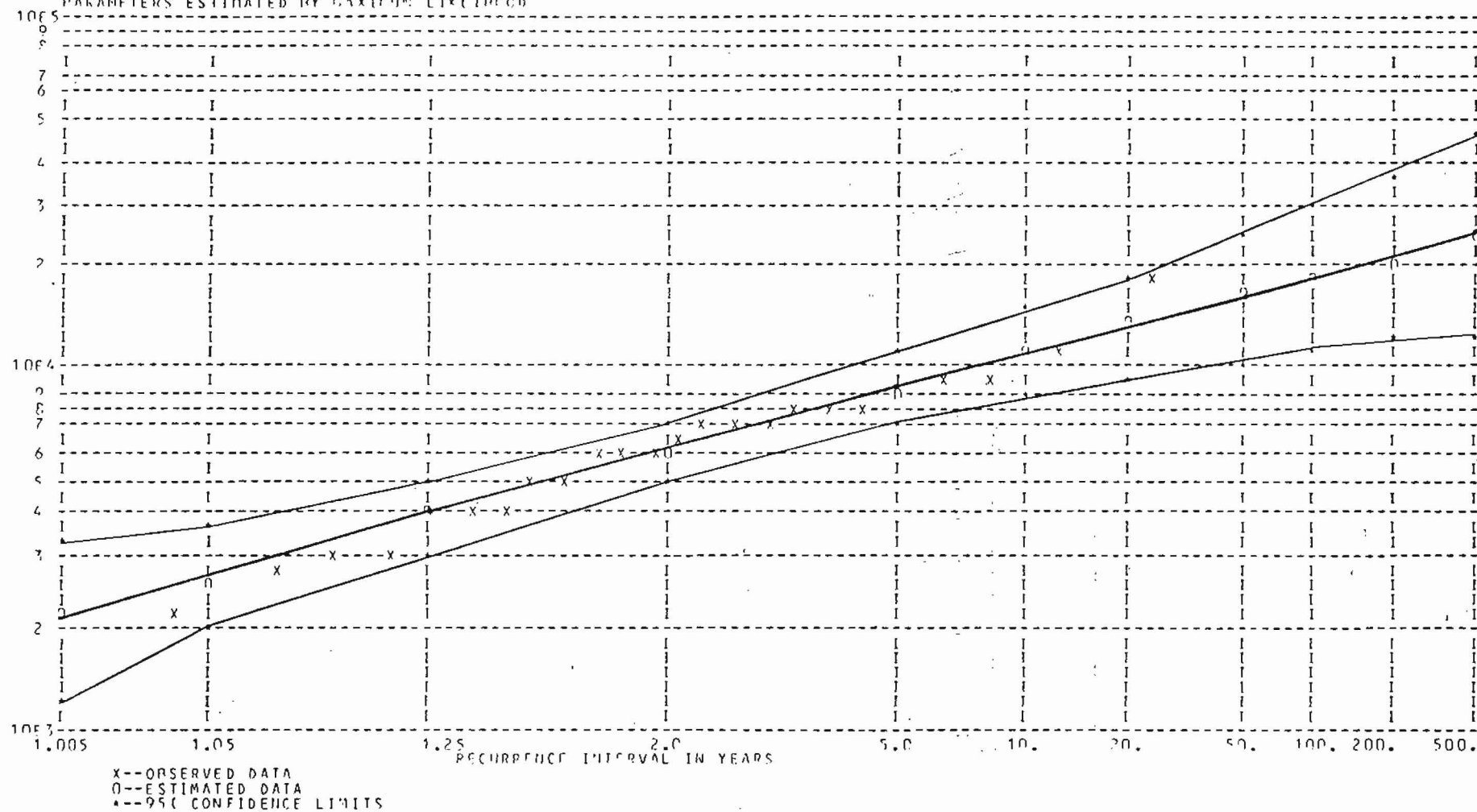
OCT-MAY FLOOD FREQUENCY CURVE  
 CARIBOU CREEK NEAR SUTTON

FIGURE: B.8





Matanuska R. at Palmer  
THREE PARAMETER LOG-NORMAL DISTRIBUTION-WITH 95 PCT CL  
PARAMETERS ESTIMATED BY MAXIMUM LIKELIHOOD



Prepared by:

Prepared for:



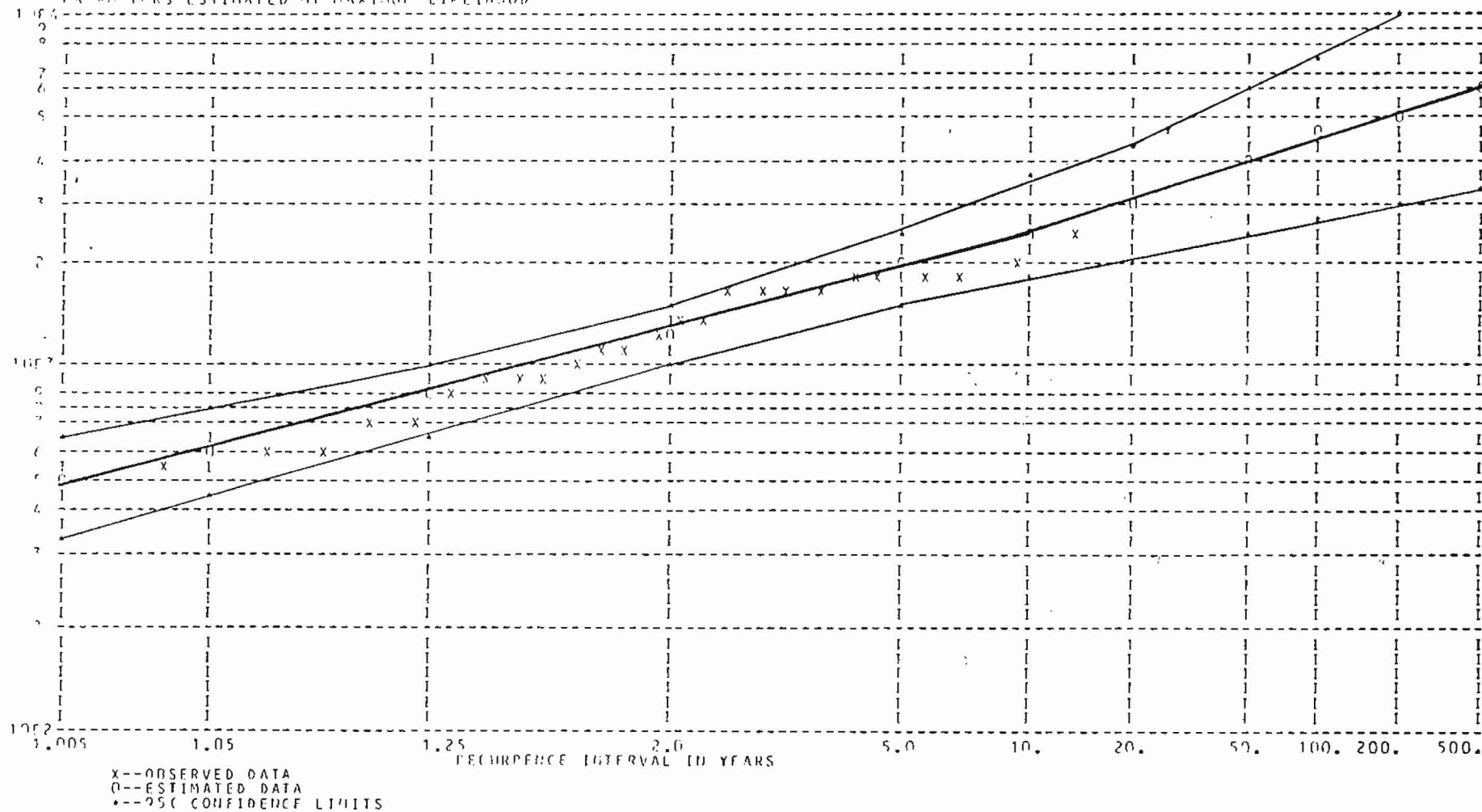
OCT-MAY FLOOD FREQUENCY CURVE  
MATANUSKA RIVER AT PALMER



FIGURE: B.9



Tonsina R. at Tonsina  
 THREE PARAMETER LOG-NORMAL DISTRIBUTION-WITH 95 PCT CI  
 PARAMETERS ESTIMATED BY MAXIMUM LIKELIHOOD



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Prepared for:



OCT-MAY FLOOD FREQUENCY CURVE  
 TONSINA RIVER AT TONSINA

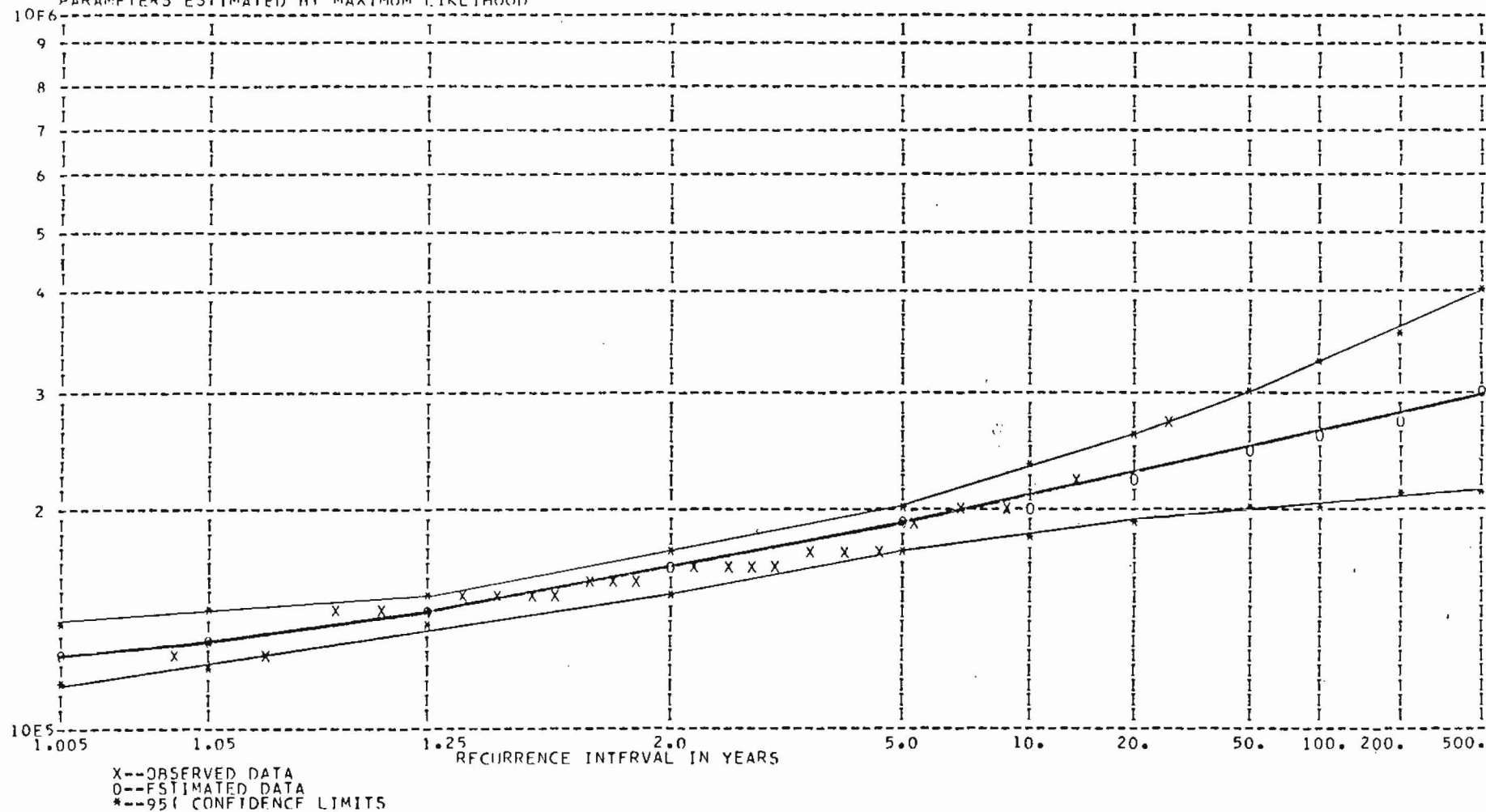


FIGURE: B.10





Copper R. near Chitna  
THREE PARAMETER LOG-NORMAL DISTRIBUTION-WITH 95 PCT CL  
PARAMETERS ESTIMATED BY MAXIMUM LIKLIHOOD



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OCT-MAY FLOOD FREQUENCY CURVE  
COPPER RIVER NEAR CHITINA

Prepared for:



FIGURE: B.11



## ATTACHMENT C:

COMPARISON OF SUSITNA REGIONAL FLOOD PEAK  
ESTIMATES WITH USGS METHODS

| Station Location            | Return<br>Period<br>(Yrs.) | Single <sup>1</sup><br>Station<br>Estimate<br>(CFS) | Susitna<br>Regional<br>Estimate<br>(CFS) | USGS <sup>2</sup><br>Area II<br>Regional<br>Estimate<br>(CFS) | USGS <sup>3</sup><br>Cook Inlet<br>Regional<br>Estimate<br>(CFS) |
|-----------------------------|----------------------------|-----------------------------------------------------|------------------------------------------|---------------------------------------------------------------|------------------------------------------------------------------|
| Susitna River at Gold Creek | 1.25                       | 37,100                                              | 37,700                                   | 48,700                                                        | -                                                                |
|                             | 2                          | 49,500                                              | 49,000                                   | 59,200                                                        | 43,800                                                           |
|                             | 5                          | 67,000                                              | 64,200                                   | 73,000                                                        | 53,400                                                           |
|                             | 10                         | 79,000                                              | 74,500                                   | 83,400                                                        | 55,300                                                           |
|                             | 50                         | 106,000                                             | 100,000                                  | 104,000                                                       | 71,600                                                           |
|                             | 100                        | 118,000                                             | 110,000                                  | 115,000                                                       | -                                                                |
| Caribou Creek near Sutton   | 1.25                       | 3,310                                               | 1,910                                    | 2,510                                                         | -                                                                |
|                             | 2                          | 4,500                                               | 2,480                                    | 3,620                                                         | 2,670                                                            |
|                             | 5                          | 6,120                                               | 3,240                                    | 5,130                                                         | 3,680                                                            |
|                             | 10                         | 7,170                                               | 3,760                                    | 6,280                                                         | 4,200                                                            |
|                             | 50                         | 9,480                                               | 5,050                                    | 8,810                                                         | 6,210                                                            |
|                             | 100                        | 10,500                                              | 5,570                                    | 10,500                                                        | -                                                                |
| Matanuska River at Palmer   | 1.25                       | 19,700                                              | 20,800                                   | 20,400                                                        | -                                                                |
|                             | 2                          | 25,500                                              | 27,000                                   | 25,700                                                        | 24,000                                                           |
|                             | 5                          | 31,800                                              | 35,400                                   | 32,500                                                        | 30,500                                                           |
|                             | 10                         | 35,200                                              | 41,000                                   | 37,400                                                        | 32,800                                                           |
|                             | 50                         | 41,600                                              | 55,100                                   | 47,300                                                        | 44,600                                                           |
|                             | 100                        | 43,900                                              | 60,700                                   | 53,300                                                        | -                                                                |
| Susitna River at Denali     | 1.25                       | 14,000                                              | 12,400                                   | 15,900                                                        | -                                                                |
|                             | 2                          | 15,900                                              | 16,100                                   | 21,700                                                        | 18,100                                                           |
|                             | 5                          | 20,200                                              | 21,100                                   | 30,000                                                        | 23,600                                                           |
|                             | 10                         | 24,100                                              | 24,500                                   | 36,500                                                        | 25,700                                                           |
|                             | 50                         | 36,600                                              | 32,800                                   | 50,900                                                        | 35,600                                                           |
|                             | 100                        | 43,600                                              | 36,200                                   | 59,700                                                        | -                                                                |

## ATTACHMENT C (Continued)

| Station Location               | Return<br>Period<br>(Yrs.) | Single <sup>1</sup><br>Station<br>Estimate<br>(CFS) | Susitna<br>Regional<br>Estimate<br>(CFS) | USGS <sup>2</sup><br>Area II<br>Regional<br>Estimate<br>(CFS) | USGS <sup>3</sup><br>Cook Inlet<br>Regional<br>Estimate<br>(CFS) |
|--------------------------------|----------------------------|-----------------------------------------------------|------------------------------------------|---------------------------------------------------------------|------------------------------------------------------------------|
| MacLaren River near Paxson     | 1.25                       | 4,450                                               | 3,760                                    | 4,880                                                         | -                                                                |
|                                | 2                          | 5,150                                               | 4,880                                    | 7,180                                                         | 4,960                                                            |
|                                | 5                          | 6,800                                               | 6,390                                    | 10,600                                                        | 6,790                                                            |
|                                | 10                         | 8,420                                               | 7,420                                    | 13,300                                                        | 7,660                                                            |
|                                | 50                         | 13,700                                              | 9,960                                    | 19,800                                                        | 11,200                                                           |
|                                | 100                        | 16,800                                              | 11,000                                   | 24,000                                                        | -                                                                |
| Susitna River near Cantwell    | 1.25                       | 24,600                                              | 25,400                                   | 34,000                                                        | -                                                                |
|                                | 2                          | 32,300                                              | 33,000                                   | 42,500                                                        | 29,800                                                           |
|                                | 5                          | 42,200                                              | 43,200                                   | 53,600                                                        | 36,900                                                           |
|                                | 10                         | 48,400                                              | 50,100                                   | 61,900                                                        | 38,400                                                           |
|                                | 50                         | 61,700                                              | 67,200                                   | 78,700                                                        | 50,400                                                           |
|                                | 100                        | 67,100                                              | 74,200                                   | 88,500                                                        | -                                                                |
| Chulitna River near Talkeetna  | 1.25                       | 33,100                                              | 28,500                                   | 28,200                                                        | -                                                                |
|                                | 2                          | 37,800                                              | 37,000                                   | 36,200                                                        | 42,600                                                           |
|                                | 5                          | 45,100                                              | 48,500                                   | 47,100                                                        | 53,400                                                           |
|                                | 10                         | 50,400                                              | 56,300                                   | 55,300                                                        | 56,400                                                           |
|                                | 50                         | 63,100                                              | 75,500                                   | 72,600                                                        | 75,200                                                           |
|                                | 100                        | 69,000                                              | 83,300                                   | 82,700                                                        | -                                                                |
| Talkeetna River near Talkeetna | 1.25                       | 20,300                                              | 20,900                                   | 30,000                                                        | -                                                                |
|                                | 2                          | 26,300                                              | 27,200                                   | 38,500                                                        | 56,600                                                           |
|                                | 5                          | 38,500                                              | 35,600                                   | 50,100                                                        | 71,400                                                           |
|                                | 10                         | 49,100                                              | 41,400                                   | 58,900                                                        | 76,300                                                           |
|                                | 50                         | 80,100                                              | 55,500                                   | 77,400                                                        | 103,000                                                          |
|                                | 100                        | 96,700                                              | 61,200                                   | 88,300                                                        | -                                                                |

## ATTACHMENT C (Continued)

| Station Location             | Return<br>Period<br>(Yrs.) | Single <sup>1</sup><br>Station<br>Estimate<br>(CFS) | Susitna<br>Regional<br>Estimate<br>(CFS) | USGS <sup>2</sup><br>Area II<br>Regional<br>Estimate<br>(CFS) | USGS <sup>3</sup><br>Cook Inlet<br>Regional<br>Estimate<br>(CFS) |
|------------------------------|----------------------------|-----------------------------------------------------|------------------------------------------|---------------------------------------------------------------|------------------------------------------------------------------|
| Montana Creek near Montana   | 1.25                       | 2,040                                               | 2,520                                    | 1,130                                                         | -                                                                |
|                              | 2                          | 3,230                                               | 3,270                                    | 1,700                                                         | 1,580                                                            |
|                              | 5                          | 4,670                                               | 4,280                                    | 2,500                                                         | 2,220                                                            |
|                              | 10                         | 5,540                                               | 4,970                                    | 3,100                                                         | 2,540                                                            |
|                              | 50                         | 7,290                                               | 6,670                                    | 4,490                                                         | 3,770                                                            |
|                              | 100                        | 7,990                                               | 7,350                                    | 5,470                                                         | -                                                                |
| Skwentna River near Skwentna | 1.25                       | 26,800                                              | 23,600                                   | 15,700                                                        | -                                                                |
|                              | 2                          | 32,000                                              | 30,700                                   | 20,400                                                        | 19,400                                                           |
|                              | 5                          | 38,900                                              | 40,200                                   | 26,500                                                        | 24,600                                                           |
|                              | 10                         | 43,400                                              | 46,600                                   | 31,100                                                        | 25,800                                                           |
|                              | 50                         | 53,200                                              | 62,500                                   | 40,400                                                        | 34,300                                                           |
|                              | 100                        | 57,300                                              | 69,000                                   | 46,200                                                        | -                                                                |
| Tonsina River at Tonsina     | 1.25                       | 3,540                                               | 4,820                                    | 2,130                                                         | -                                                                |
|                              | 2                          | 4,600                                               | 6,250                                    | 3,040                                                         | -                                                                |
|                              | 5                          | 6,040                                               | 8,190                                    | 4,260                                                         | -                                                                |
|                              | 10                         | 6,990                                               | 9,510                                    | 5,160                                                         | -                                                                |
|                              | 50                         | 9,090                                               | 12,800                                   | 7,130                                                         | -                                                                |
|                              | 100                        | 9,980                                               | 14,100                                   | 8,490                                                         | -                                                                |
| Copper River at Chitna       | 1.25                       | 146,000                                             | 127,000                                  | 146,000                                                       | -                                                                |
|                              | 2                          | 164,000                                             | 164,000                                  | 165,000                                                       | -                                                                |
|                              | 5                          | 189,000                                             | 215,000                                  | 191,000                                                       | -                                                                |
|                              | 10                         | 206,000                                             | 250,000                                  | 210,000                                                       | -                                                                |
|                              | 50                         | 242,000                                             | 335,000                                  | 246,000                                                       | -                                                                |
|                              | 100                        | 257,000                                             | 370,000                                  | 265,000                                                       | -                                                                |

<sup>1</sup> Based on three parameter log normal distribution and shown to three significant figures

<sup>2</sup> Lamke, R.D. (1979) Flood Characteristics of Alaskan Streams, USGS, Water Resources Investigation, 78-129

<sup>3</sup> Freethy G.W. and D.R. Scully (1980) Water Resources of the Cook Inlet Basin, Alaska, USGS, Hydrological Investigations Atlas HA-620



ATTACHMENT D

REVIEW OF FLOOD FREQUENCY ANALYSIS,  
CONDUCTED BY DR. ROBERT F. CARLSON,  
UNIVERSITY OF ALASKA, FAIRBANKS





UNIVERSITY OF ALASKA  
FAIRBANKS, ALASKA 99701

MEMORANDUM REPORT

To: John Lawrence, Acres American Inc.  
Steve Bredthauer, R&M Consultants, Inc.

From: Robert F. Carlson *RFC*

Date: June 11, 1981

Subject: Susitna Hydroelectric Project

This report is in response to John D. Lawrence's letter of April 3, 1981, asking me to review the regional flood analysis conducted by R&M Consultants. The review is meant to include:

- a) Validity of gaging stations selected for the regional analysis and their representation of the hydrologic region analyzed.
- b) Adequacy and limitations of the analysis in development of regression expressions and the assumed 3-parameter log normal distribution.
- c) Validity of the shape, peak, and volume of the design flood hydrographs as developed.
- d) Discussion of review findings with Acres and R&M.

The review is based on three reports which have been transmitted from R&M to Acres:

- a) Two letters from James Aldrich to Ian Hutchinson, Re: Susitna Regional Flood Peak Analysis, Project No. 052305, dated October 27, and December 22, 1980.

- b) A letter from Brent Drage to Ian Hutchison, Re: Susitna Regional Flood Analysis, Subtask 3.05, dated March 9, 1981.

The time and budget constraints of the review contract did not permit me to conduct an independent computation and verification of the values contained in the report. Therefore, the review is based on the material as presented by R&M. Nevertheless, several key values could be checked by comparison with published information.

✓ Part (a). Validity of selected gaging stations.

The stations selected for regional analysis represent the transitional-continental climate zone of the Susitna basin. The Susitna basin's outstanding geographic characteristic is the combination of drainage from the south side of the Alaska range, the north side of the Talkeetna mountains and the large flat boggy sub-basin north of Lake Louise. It is doubtful whether any other basin faithfully represents this type of hydrologic region. Of the twelve stations chosen for the regional analysis, the Susitna's hydrologic regime is best represented by:

1. Susitna at Gold Creek.
2. Susitna near Denali.
3. Maclaren near Paxson.
4. Susitna near Cantwell.
5. Chulitna near Talkeetna.
6. Skewnta near Skewnta.
7. Montana near Montana.
8. Talkeetna near Talkeetna.

Stations that are not as closely representative are:

1. Matanuska at Palmer.
2. Tonsina at Tonsina.
3. Copper near Chitina.
4. Caribou near Sutton.

The second group has been selected primarily on the basis of station distance from the Susitna basin and a different exposure to the coastal maritime climate. I do not feel the differences are great enough to warrant their exclusion from the regional analysis.

Part (b). Adequacy of the regression expressions and the assumed 3-parameter log normal distribution.

The assumed 3-parameter log normal distribution: Given the very sparse data base of the Susitna area streamflow records in combination with the great variability of extreme values, an attempt should be made to model or fit the sample data with a theoretical distribution of simple construction and few parameters. The analysis indicates that either the log-normal (LN) or the three-parameter log-normal (3PLN) distributions are nearly equally satisfactory. The 3PLN distribution has the advantage of further adjusting for the skew by inserting a lower truncation limit. I feel that, in view of the slight difference in predictability between the two distributions, the LN is preferred because of its simplicity. The analysis is not greatly compromised by using a 3PLN distribution, but the small reduction of the total deviation does

not seem to warrant the additional complexity. An inspection of rough frequency plots shows a good agreement between the fitted distribution and the sample points for both the LN and the 3PLN distributions. In summary, my preference for a frequency distribution would be the LN, but I do not see any great disadvantage in using the 3PLN.

The regression analysis: The regression analysis which attempts to predict the mean annual peak flow from watershed parameters has been carried out in a standard manner. A standard step-wise regression program has been used with up to twelve watershed parameters. Of the twelve, five parameters (drainage area, stream length, glacier area, mean annual precipitation, and mean annual snowfall) were shown to be statistically significant predictors of the mean annual instantaneous peak flow. Of these five, only the first three are directly related to basin parameters. The last two are estimated values and must be calculated from nearby gages or yet other basin parameters. Of the first three, the stream length and glacier area are potentially strongly related to drainage area. Larger areas are expected to be longer and, in the Susitna area, they should be strongly related to higher elevations and glaciers. Therefore, since drainage area is the most obvious predictor and far outweighs the others, it should be retained as the only independent predictor. The same reasoning holds for predicting the mean October-May peak flow.

There is one aspect of the regression analysis which is puzzling. The usual reason for an analysis of mean annual flood versus drainage

basin characteristics is to allow a regional estimation equation to be developed. Yet I can find no evidence of the completion of this equation or of its intended use. When using the 3PLN frequency model, three values of the sample must somehow be estimated (the mean, standard deviation, and skewness of the sample) or the three parameters of the distribution must be calculated (in this case the truncation level, the mean of the logs, and the standard deviation of the logs). I can find no estimates of the other two and only the Susitna at Gold Creek is used in the third memorandum.

My recommendation would be to estimate the mean annual flood (or May-October flood) from the drainage area and to use a pooled regional standard deviation and skewness to complete the description of the regional curve. The great sparseness of the data base must be constantly kept in mind and the most variable parameters pooled whenever possible.

- ✓ In summary, unless some use is made of the regression exercise, which is not apparent in the three memorandums, I would not recommend its inclusion in the final report.

Part (c). Validity of the shape, peak, and volume of the design flood hydrograph.

The first step, a dimensionless comparison of the five largest hydrographs, seems to be straightforward and correct. I think the mean curve should be smoothed out a bit more, perhaps with a moving average method.

The time base (which determines the volume) is not clear. Also, whether the base flow was removed from the peak prior to the plot is not clearly indicated. I was not furnished with Enclosure 3 (the fifty peak hydrographs), so it is difficult for me to make an accurate assessment.

✓ Although a flood peak versus volume relationship was established in Figure 7 of Memorandum 3, it is not clear whether the flood volumes were estimated from this graph or established independently through a separate frequency analysis. I assume a separate analysis has been made and the peaks and volumes, say for a 50-year return period, are matched to form the hydrograph. That seems to be a logical procedure, but the volume under the stated flood peak hydrograph should equal the corresponding estimated flood volume. There is no clear indication that this comparison has been made.

In summary, the flood peak-volume analysis has been carried out in a satisfactory way, but the several points mentioned above should be cleared up for the final report.

Part (d). Discussion of review findings with Acres and R&M.

I had preliminary discussions with Brent Drage and Tim Renschler of R&M Consultants about the analysis. My comments were essentially the same as those I have presented here. In late May, I had a meeting with Steve Bredthauer of R&M Consultants during which we discussed the three memorandum reports in some detail. Again, the substance of my remarks has been presented here.

Part (e). Some additional items for discussion.

The instantaneous-daily flow ratio analysis seems to be logical and consistent. An average value of 1.1 for all stations would seem to be appropriate. The mean daily values should be used for the frequency analysis since they are stable and available in every case. Then the calculated ratio should be used when required.

A comparison of the predicted values of mean daily floods for the 100-year return period from four sources compares reasonably well. The values are:

|                                        |             |
|----------------------------------------|-------------|
| Lamke's U.S.G.S. Report                | 120,000 cfs |
| U.S. Corp's Interim Feasibility Report | 110,000 cfs |
| R&M's Lognormal Estimate               | 112,625 cfs |
| R&M's 3-Parameter Lognormal            | 117,782 cfs |

These values are reasonably close, given the general vagueness which is a part of every flood frequency analysis. One can be fairly sure that the flood frequency analysis has been carried out correctly.

Part (f). Concluding remarks.

This memorandum report completes my review of the Susitna flood frequency report. I hope the comments will be useful for understanding the application of the frequency analysis and for preparation of this final report. I will be willing to assist in any additional analysis which may be required or to answer questions about my comments.







