

FLOOD ANALYSIS OF THE LOWER NIGER RIVER BASIN, NIGERIA

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AGE 97/9618

AUGUST, 2006

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**A THESIS IN THE DEPARTMENT OF
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TECHNOLOGY, AKURE, NIGERIA**

AUGUST, 2006

CERTIFICATION

(a) (By the student)

This work has not been presented elsewhere for the award of a degree, or any other purpose.


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DEDICATION

This project is dedicated to the Almighty Allah for his sustenance over mankind. He has been my strength.

To Him alone must all glory be ascribed.

ACKNOWLEDGEMENT

My profound gratitude goes to Almighty Allah who spared my life throughout the programme.

However, "He who does not show gratitude to man is not grateful to Allah". To this end, I am highly indebted to a lot of people for success of this work. First and foremost, I gratefully acknowledge the numerous contributions of my able Head of Department and major supervisor, Prof. A. A. Olufayo for his keen interest of the Project. He did not only gave constructive criticism, constant advice and valuable suggestion but also made himself available and approachable at all time despite his tight schedule.

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T. A. AFFINNIH

ABSTRACT

The flood analysis of Lower Niger River Basin was carried out using hydrological data such as river discharges, water levels, (stages) and rainfall records for the assessment. The data were collected to various locations such as Jebba, Boro and Lokoja, and were subjected to various statistical test, frequency and return period of each magnitude were plotted using three models viz Hanzen, Gumbel and Weibul . The highest annual data of each location were used to predict the likely discharge that may occur at various points.

Seven villages were visited to carry out oral interview and examine the effect of flood water on the environment and properties. It was discovered from the studies that improper release of water from dams contribute mainly to frequent flooding of the basin and reduced the flood cycles from 10 years to 2 years various ways were suggested to reduce the effect of flood on environment and the study could be used for planning purposes.

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CHAPTER ONE

INTRODUCTION

1.0 Overview of Study Area

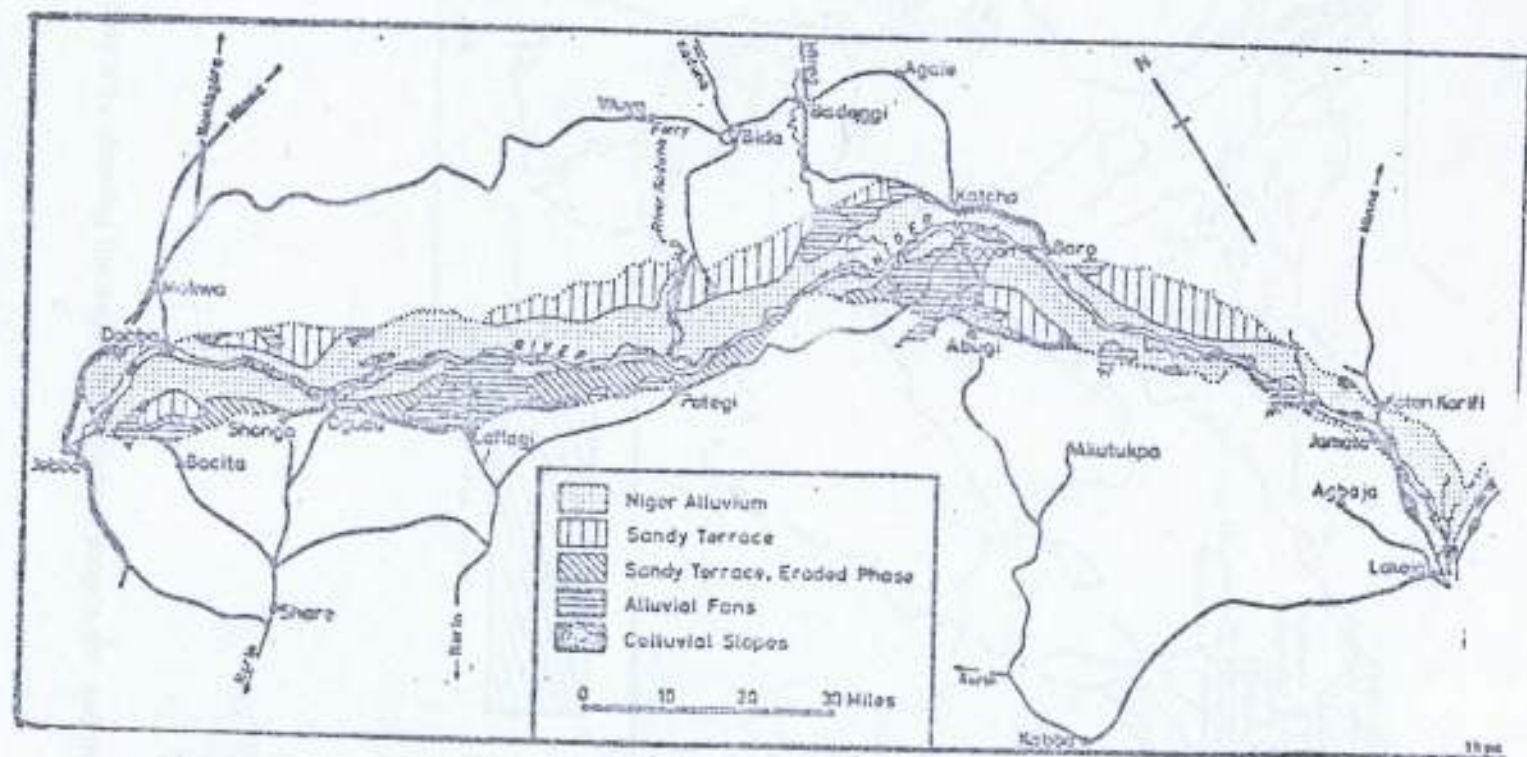
The Lower Basin of the River Niger Basin lies between long $7^{\circ} - 10^{\circ}$ North and Lat $5^{\circ} - 7^{\circ}$ East (Oguntoyinbo, 1970). The area covers the stretch between Jebba and Lokoja, a distance of about 300km with average basin width of 25km (NEDECO, 1962). The Northern and Southern limits of the basin fall within Kwara and Kogi States respectively, both in the Middle Belt zone of Nigeria (Figure 1.1).

The river with annual runoff of about 55,000 Millions Cubic Meter (MCM) flows on a gentle slope of 1:5000 to 1:7000 (JAICA, 1995). In this reach, Island and sandbars formed by transported sediments are common features. Transported sediment deposits are also found at the riverbanks forming flood plains that are suitable for cultivation of various crops like sugar cane, rice and varied vegetables.

River Niger has undergone notable eco-hydrological changes due to several developments along its course. This has influenced its flow pattern within the Nigerian border. Among these development projects are the Kainji Hydro-Electric Power dam constructed in 1969, the Bacita Sugar Cane irrigation project which commenced in 1969, the Tada-Shonga Irrigation Project in Kwara State started in 1977, the Raba, Sunti, and Lafiagi Sugar Companies and the Jebba Hydro-Electric Power dam constructed in 1984.

These developmental projects are designed on the basis of reliability of the Niger-River. The dependability or otherwise of the Niger River could be assessed by a thorough analysis of available weather parameters, which unfortunately are insufficient and inadequate. These have adversely affected the potential of predicting possible scenarios that could result from these operations. It has also been difficult to evaluate the effect of these different operations on the micro-climate of the basin.

Figure 1.2 Soil types in the Middle Niger valley flood plain
After Oguntinyinbo (1970)



maximum possible discharge from a particular river, and when will it occur? The only way to answer these questions will be to gather reliable data (both spatially and temporally), in adequate and effective resolution, and analyse the same, to provide the framework for interpretation and possible prediction.

Many hydrological processes are quite complex and can only be interpreted and explained in probabilistic sense. Hydrological events appear as uncertainties of nature and the information to investigate these processes are contained in records of hydrological observations. The hydrologist is interested in obtaining a quantitative understanding of hydrological variables. Such will allow for a proper interpretation and understanding of the inter-relationship between factors, such that the influence of exogenous factors like human activities can be predicted.

Hydrologists are also interested in understanding frequency with which extremes events may occur. For example, flow frequency analysis is often done by fitting the statistical model (s) of available data to estimate the flow magnitude corresponding to a return period, which is usually much longer than record length.

The importance of river flow analysis to the effective monitoring of flood occurrence can not be over emphasized. In preventing possible losses, it is imperative that the most adequate statistical model be determined to assist in the management of the Lower Niger River Basin.

In this study, an attempt is made to estimate flood frequency using discharge record of River Niger at Jebba, Baro and Lokoja. These three gauging stations have taken care of the tributaries of some of the major contributing rivers, like River Kaduna and River Gurara. Other weather data collected at Bacita, Jebba and Lokoja were also used in the analysis. The study will therefore consider river discharge from Jebba dam, and contribution from the tributaries, vis-à-vis the rainfall records at Jebba, Bacita and Lokoja.

1.1 Objectives of the Study

Flood analyses of the Niger River within the Lower Niger River Basin will assist in proposing a lasting solution to the problem of incessant flooding within the adjoining area, thus, the objectives of this study are:

- i. To establish the flood level of river Niger and their return periods;
- ii. To evaluate the environmental and economic impact of incessant flood in the study area and possibly recommend ways of using the flood water for economic purpose.

1.2 Justification

There is a dire need for improvement in the management of data on water resource in Nigeria, and specifically in the Niger Basin, which is the main drainage system for Nigeria. This will help to understand the mechanism of flooding in the river catchment and assist in reducing the effect of flooding within the basin. This study will also assist the authority of the Hydro-Power dams in safe release of water downstream to prevent human and properties losses.

1.3 Hydrology and Drainage of the study Area

The Niger River, which is the longest river in Nigeria and ranked 3rd in Africa, is the main drainage system, which always over flow its bank. The regular overflow of banks often causes serious damage to lives and properties. The river flows through the whole middle Niger valley, flowing in the West-East direction. It is bounded by low (more than 25km at both sides of the river) lands seasonally flooded twice a year. According to NEDECO (1961), these are called black flood and white flood respectively. The black flood originating from Mali reaches Nigeria during the dry season (Nov – March) while the white flood is due to run-off originating from the tributaries of river Niger in Nigeria, which occurs during the raining season (June – October). In this region, the river has water level fluctuation between 4m and 5m in the past but due to dry climate tendency, construction of two dams up-stream viz Kainji, in 1969, Jebba in 1984, and Shiroro Dam on river Kaduna which is tributary of river Niger, couple with erratic release of water from these dams, the level has fluctuated as the releases of water from the reservoir determine the height of flood level down stream.

River Kaduna is one of the major tributaries at the left bank of River Niger, joining the Niger at Muregi near Baro, which is the mid point between Jebba and Lokoja. While River Gurara joins at Gerinyan very close to Lokoja. Other tributaries at right bank of the river are, Oshin, Awon, Kampe and Oyun. These are minor tributaries forming drainage of roughly rectangular shape joining the main stream of the Niger at nearly perpendicular which rather causing flooding down stream quickly. See fig. 1.3

River Niger within Nigeria can be broadly divided into three reaches viz Upper, Middle and Lower reach and has a total catchments area of 74,240km² above Lokoja, which is about 300km from Jebba. The river flows with gentle slope 1:5000 to 1:7000. Many sandbars formed by transported sediments have been deposited and expanding along both riverbanks which is being used for Agricultural Activities called Fadama. The Niger River changes its flow direction at right angle to the south at Lokoja where it joins river Benue.

1.4 Scope of the Study

The scope of the study involves the collection, of relevant data that will be primarily useful for flood analysis. Among the data are discharge measurement at various gauging stations along River Niger, Rainfall Records, Water Level, Evaporation and Temperature records. These data will be analysed and subjected to various statistical test frequency and probability of occurrence

1.5 Climate

Generally, climate has a great influence on water resources of an area. Among the climate factors that play a significant role on water resources are rainfall intensity, sunshine intensity, temperature and Humidity.

The climate of the study area is generally representative of tropical Savannah type, which is commonly found in the Northern part of the Country. The mean annual rainfall data recorded at the three stations were Lokoja 130mm, at Jebba 137mm and at Bacita 139mm. While the average net evaporation and average maximum temperature at Jebba were 6.73mm and 34.3°C respectively.

CHAPTER TWO



LITERATURE REVIEW

2.1 Flood-Historical Perspectives

Floods are the major disaster affecting many countries in the world. It is an inevitable natural phenomenon occurring from time to time in all rivers and natural drainage systems, which not only damages natural resources and the environment, but often result in loss of lives and significant set-back in the economy. Besides fire, floods are the most common and widespread of all natural disasters.

Flood may be defined as a discharge which exceeds the capacity of a river channel, and then proceeds to inundate the adjacent flood plain. Such high flows are normally caused by either intense or prolonged rainfall. Flood menaces have also been defined as a danger or threat due to excessive flow (run-off) off within the drainage area (Sule, 1992).

History indicate it that civilisation has always developed along rivers courses, whose presence guarantees access to and from the seacoasts, irrigation for crops, water supply for urban communities and more recently power development and industrial water supply. These many advantages are often negated by the danger of flood (Wilson, 1979; Ray, et. al 1988). Civilisation of Egypt is traceable to the development of Nile River for irrigation purposes and navigation. Since men are unable to control the basic atmospheric processes which produce most floods, he has attempted to adjust to the hazards by means of flood alleviation projects concerned with the land based phase of hydrological cycle, through the application of technology and massive investment of capital i.e. structural method of flood mitigation. Geraghty et al (1973) estimated that annual death from flood in United State of America average more than 185 during the period 1831 – 1940. Whereas, Ward (1978) indicate that fatalities were reduced to less than 83 per year between 1925 and 1971.

Experience has shown that the construction of engineering structure like flood retention dam, dyke, etc can reduce flood flow in many years but the damage potential of these structures is more dangerous than the benefit, if they are not properly constructed.

Major flood disasters in modern times have been traced to the failure of some of these structures. In recent years much attention has therefore been given to the management of natural disaster.

In 1992, 42 people were killed in Vaisan – La – Romaine due to flash flood (Samuel, 1998). Human activities directly or indirectly interfere with the hydrological cycle therefore upsetting the natural balance and biodiversity. Floods have increased progressively both in height or stages and durations. The growing heights of flood stages on the other hand and the increasing value of properties and Agricultural lands has necessitated the progressive and strengthening of levees.

Flood frequency analysis involves the estimation of expedience probabilities corresponding to flood peaks of various magnitude or vice versa. Data used to support the estimation process usually consist of maximum instantaneous discharge, which is sometimes approximated by the annual maximum average daily discharge (Durran, 1995).

The searches for the proper distribution functions have been subject of several studies. Onos and Bayazit (1994) worked on the best-fit distribution of largest available flood samples. Some of these were aimed at determining the distribution that best fit the observed flood. Although such studies shed light on how certain model behave for various flood like population distribution, they cannot answer the fundamental questions of which distribution should be chosen to represent the flood flows.

In one of the earliest studies in the search for the probability distribution of floods, Benson (1968) stated that, the Water Resources Council of United State of America showed that, out of the records (between 44 and 97 years) analysed, only two events exceeded 60 years.

There are many ways of developing probability distribution of flood occurrence magnitude (Frequency distribution), some of the methods used are Gamma, Gumbel, Extreme value, Log – Gumbel, Log Normal and Log Pearson Type III distributor. Considerable research on other estimation techniques has been carried out in the past 20 years, in China. Cong (1980) applied the Monte - Carlo method, to study the statistical performance of methods by optimization. His result showed that the curve fitting method, with the Weibull plotting position formula is the best of all estimation methods considered. Bobee and Askkar (1991) reviewed the performance of Gamma distribution methods, in particular, the Pearson III distribution, in parameter estimation methods for flood frequency analysis.

Bobee et al (1993) pointed out that researchers tend to spend much more efforts on development of new methods. A new evaluation standard - Expected Probability has been presented in recent years. Several researchers have worked with it in China, the results show that it is reasonable to use expected probability to evaluate the quantity of statistical performance. They recommended that more coherent and broadly accepted strategy for estimating flood should be adopted by international forum of experts (Chen Yuanfang et al, 2000).

The design of hydraulic structure, delineation of flood plains and flood prone areas, management of water supply are all activities that require estimation of frequency distribution of flood events (Benjamin et al 2001). A stream flow sample would lack homogeneity if a large storage reservoir constructed on the stream during the period for which the sample was taken.

2.2 Flood Data Sampling

For any statistical analysis, a sample is needed from the entire population, which comprises of all possible flood flows at a gauging station. The statistical sample is represented by past observation data. The data must be homogenous and independent.

Homogeneity means the sample elements belongs to the same Population. Two common tests are available to check homogeneity. They are Kolmogorou-Smirnov test and X-test. Homogeneity of data may be tested through the use of mass curve. Test for independence: Daily flows are typically non-dependent variable in Hydrology since yesterday's flow certainly influences today's flow. Only the yearly maximum can often be considered independent random variable others like daily and monthly are not (dependent).

The data in a sample, and therefore in the population, may follow one of several types of frequency distributions. One of the most important of these is the Normal or Gaussian distribution, which is the bell-shaped symmetrical curve Ω . Most hydrological data however, are not normally distributed although the data can be normalized by various methods, such as using Logarithms or cube root of random varieties of sample.

2.3 Statistical Treatment

2.3.1 Probability Distribution Function

There are many probability distribution models for flood analysis, they include, Normal, Gamma, Gumbel type I, Log Gumbel, Log Normal and Log Pearson III. Apart from Normal distribution, others are currently widely used in various countries (Cunnane, 1984). The normal distribution included for the sake of comparison in evaluating the power of the test, as it is known that flood flow distribution are in the short coming of statistical methods to the emphasis on the role of models for evaluating new policies in presence of dependencies and lack of data (Joanne, 2003) but needless to say, this uncertainty can be treated in a multiple of ways by studying the uncertainty explicitly by considering the flood related variables as stochastic variable in probability theory.

2.3.2 Correlation Coefficient Test (r)

Correlation coefficient analysis is used to determine the manner in which an independent variable affects another dependent variable. If there is only one independent variable involved, it is known as simple correlation but if there are two or more independent variables it is called multiple correlation. The value of dependent variable must be physically related to the independent variable. For example, the volume of annual run off from a river basin (dependent variable) might be correlated with the annual precipitation of the basin (independent variable).

The reliability of estimated data of the dependent variable based on the relation is a most important consideration in the use of the relation. In correlation analysis, the coefficient of correlation and standard error of estimate provide assessments of reliability.

In a simple correlation, the proportion of the variation of the dependent variation that is explained by the linear regression equation is the coefficient of determination r^2 which is square of the correlation coefficient r , the value of r^2 may range from Zero (no relation between the variables) to either -1 or $+1$.

These tests are more powerful than chi-square test. The probability correlation coefficient is test statistics between ordered observation and the inverse value of hypothesized cumulative function. It evaluates the linearity of the probability plot, so that the sample is expected to be close to 1.

The quantity r called coefficient of correlation is given by

$$r = \pm \sqrt{\frac{\sum (Y_{est} - Y)^2}{\sum (Y - \bar{Y})^2}}$$

and varies between -1 and $+1$, r is a good measure of the correlation between two variables. Where Y_{est} represents the value estimated from a given observed values and $\bar{Y}$ is the Average of the data.

Grade of Correlation:

Excellent	-	0.75 – 1.00
Good	-	0.50 – 0.75
Weak	-	Less than 0.50

2.3.3 Coefficient of Determination (r^2)

The ratio of explained variation to the total variation is called coefficient of determination (r^2). If there is zero explained variation i.e. the total variation in all, are unexplained, the ratio will be zero but there is zero unexplained variation i.e. the total variation in all are explained then the ratio is 1.

Therefore r^2 lies between zero and 1 ($0 < r^2 < 1$) since the ratio is non-negative.

2.4 Statistical Method of Predicting Flood Frequency

An estimate of the frequency with which a given magnitude of rainfall or stream flow may be exceeded in the future is based upon a study of the frequency with which it has been exceeded in the past. Frequency analysis techniques have been devised to draw the maximum information from the record and to evaluate the most probable nature of the distribution of the present population from which the sample has been drawn. The extreme events are of primary concern in predicting flood and the maximum value of event of a year may out-rank the highest of other years.

According to Sule (1992), the Probable Maximum Precipitation (PMP) is used in the design of flood control and storm drainage schemes where excessive storm runoff can cause damage to properties and loss of life.

The curve fitting method by eye estimation was widely used in practical flood frequency analysis because of its flexibility; however the weakness is obvious and serious. It is not

objective therefore other objective parameter estimation methods with good statistical performance in design flood calculation should be considered.

2.4.1 Gumbel (EVI) Type I

Gumbel was the first to employ extreme value theory of analysis of flood frequencies. Gumbel used extreme value theory (EVI) to show that in a series of extreme value:

$$X_1, X_2, \dots, X_n$$

where the samples are of equal size and X is an exponential distribution variable (for example, the maximum discharge observed in a year in gauge readings), then the cumulative probability (p) that any of the n value will be less than a particular value X (of returns period T) as approach the value.

$$p^1 = e^{-e^{-x}}$$

$$y = \ln \left\{ -I_n \left(1 - \frac{1}{T} \right) \right\}$$

where e is the natural logarithm and p^1 is the probability of non occurrence of an event X in T year or

$$T = \frac{1}{1 - p^1}$$

Q_T is expressed as

$$p = 1 - e^{-e^{-x}}$$

and

$$Y_T = -I_n \left(1 - \frac{1}{Tr} \right)$$

where

$$P = \frac{1}{Tr}$$

Tr years can be obtained using the expression

$$Q_i = Q_m + \sigma(0.78y - 0.45)$$

where Q_i is the flood magnitude with return period Tr and probability P . Q_m is the average of all values of annual maximum flood Q_{max} .

σ ; the standard deviation of the series and can be obtained using

$$\sigma = \frac{Q_{\max}^2 - Q_{\min}^2}{N-1}$$

where, N =Total number of years of record

Table 2.1: Shows value of reduced variant (Y) as a function of return period (T) and value of K for extreme value (Type 1 distribution).

Return (Yrs)	Period	Probability (P)	Reduced (Y)	Variance	K
1.58		0.63	0.000		-.450
2.00		0.50	0.367		-0.164
2.33		0.43	0.579		0.001
5		0.20	1.500		0.719
10		0.10	2.250		1.30
20		0.05	2.970		1.87
50		0.02	3.902		2.59
100		0.01	4.600		3.14
200		0.005	5.296		3.68
400		.0025	6.000		4.23

Source: Wilson, (1979) hydrology for Engineers 3rd Edition

The return period or re-occurrence interval T_r can now be computed for the different methods using appropriate relationship as described:

$$T_r = \frac{n+1}{m}$$

for Weibull's formula

$$T_r = \frac{2n}{2m}$$

for Hazen formula

$$T_r = \frac{n}{m}$$

for California formular

$$T_r = \frac{n+0.12}{m-0.44}$$

for Gringoten formular

where m = ranking order of magnitude of discharge

n = No of years of record

T_r = return period

Table 2.2: Theoretical Distribution of the Return Period

Average return period	Actual return period T_r exceeded various percentages of the time							
	Tr	1%	5%	25%	50%	75%	95%	99%
	2	8	5	3	1	0	0	0
	5	22	14	7	3	1	0	0
	10	45	28	14	7	3	0	0
	30	137	89	42	21	8	2	0
	100	459	300	139	69	29	5	1
	1,000	4,620	3,000	1,400	693	288	51	10
	10,000	46,200	30,000	14,000	6,932	2,880	513	100

Source: Wilson, (1979) hydrology for Engineers

The Gringorten plotting position gives longer return periods for the higher floods in a series. This recognizes that the true return period of the higher floods is probably longer than the value computed with Weibull equation

The probability j that the actual probability of the m th of n floods is less than p_0 can be obtained from.

$$j = \frac{n!}{m!(n-m)!} m \int_0^{1-p_0} p^{m-1} (1-p)^{n-m} dp$$

This probability equation can be used to compute the average return period for various level of probability. There are approximately 2 chances out of 3 that the true return period of the largest event in a data series is greater than the period of record.

2.4.2 Normal Distribution

This is a symmetrical, bell shaped frequency function, which is known as Gaussian distribution or Natural Law of Errors. It describes many processes that are subject to random and independent variations. It does not often perfectly fit sequences of Hydrological data, but has wide applications. For example, in dealing with transformed data, which subsequently follow the normal distribution, and in estimating sample reliability by virtue of central limit theorem.

The normal distribution (z) has the formula

$$z = \frac{x - m}{\sigma}$$

where m is the mean and σ = standard deviation.

The variable z is called standard unit, it is normally distributed with zero mean and unit standard deviation. It is necessary to compute the parameters of the Chow equation from the relationship:

$$Q_r = Q_{av} + K\sigma$$

Where Q_r = specific discharge associated with a particular probability or occurrence r in an annual series that is normally distributed.

Q_{av} is the average of all value of annual flood and σ is the standard deviation.

$$\sigma = \sqrt{\frac{\sum (Q_{max} - Q_{av})^2}{N}}$$

The value of K is shown in the table below.

Table 2.3: Value for the constant K for Normal and Log Normal distribution

Probability of Exceedence %	K	Probability of Exceedence %	K
0.1	3.09	50	-0.00
0.5	2.58	55	-0.13
1.0	2.23	60	-0.25
2.5	1.96	65	-0.385
5.0	1.645	70	-0.52
10	1.28	75	-0.67
15	1.04	80	-0.84
20	0.84	85	-1.04
25	0.67	90	-1.28
30	0.52	95	-1.645
35	0.385	97.5	-1.96
40	0.25	99	-2.33
45	0.13	99.5	-2.58
50	0.00	99.9	-3.69

Source: Wilson, (1979) hydrology for Engineers

The normal or Gaussian distribution is the best-known statistical model and the most frequently used. It provides reasonable approximation in central but is inadequate at one or both tail of distributed. If x is normally distributed with arbitrary mean (m) and standard deviation (σ), the random variable is normally distribution with $N = 0$ and $\sigma = 1$

2.4.3 Log-Normal Distribution

Many hydrological variables exhibit a marked right skewness, partly due to the influence of natural phenomena having value greater than zero or some other lower limit, and being unconstrained, theoretically, in the upper range. In such cases, frequencies will not follow the normal distribution.

The log normal distribution is especially useful, because the transformation opens the extensive body of theoretical and applied uses of the normal distribution since both the normal and log-normal are two parameter distributions. It is necessary only to compute the mean and variance of the untransformed variant x and solve simultaneously.

Log – Normal distribution method have also been found useful in many hydrological variable, which exhibit a marked right skewness, partly due to the influence of natural phenomenon. It is a model of a random variable whose logarithm follow the normal distribution with parameter (m) mean and σ standard deviation.

For Log-Normal distribution:

$$\log Q = \log \bar{Q} + K \sigma \log Q$$

where $\log \bar{Q}$ is the average of the observed discharge, K is given in the normal table.

$\sigma \log Q$ is the standard deviation of $\log Q$

2.4.4 Log Pearson Type III Distribution

This is the limiting model as “ n ” which is number of data approaches infinity for distribution of the minimum of “ n ” value from variables. Initial distribution bounded at the left. It has already been mentioned that annual flood series are rarely normally distributed. The histogram of such series is usually skewed, i.e. the means value does not coincides with the mode. Pearson devised a measure of skewness base on:

Mean – Mode/Standard deviation and developed a family of curve to describe degree of skewness.

The log-Pearson Type III is generally accepted in USA. n -year even can be calculated in a similar manner to normal distribution method. The additional complication of using logarithm of the variant and a skew coefficient G given by:

$$G = n \sum \frac{(\log x - \log \bar{x})^3}{(n-1)(n-2)(\sigma_x \log x)^3}$$

Where $x = \log Q$ and σ_x = standard deviation of n value.

Accordingly, to compute particular return period of flood Q from an annual series the following steps are required.

Transform all (n) value of Q in the series to their logarithm i.e. base 10. Find the mean of all value of X ,

$$X_{av} = \frac{\sum X}{n} = \log \bar{x} = \frac{\sum \log x}{n}$$

and the standard deviation. One can compute the skew of x values, G from equation above.

The discharge Q can be calculated from the relationship:

$$Q_r = x_{av} + K \sigma_x$$

Table 2.4: Values for the log-Pearson Type III distribution

Recurrence interval, years								
	1.0101	1.2500	2	5	10	25	50	100
Percent Chance								
Skew	99	80	50	20	10	4	2	1
Coefficient G								
3.0	-0.667	-0.636	-0.396	0.420	1.180	2.278	3.152	4.051
2.8	-0.714	-0.666	-0.384	0.460	1.210	2.275	3.114	3.973
2.6	-0.769	-0.696	-0.368	0.499	1.238	2.267	3.071	3.889
2.4	-0.832	-0.725	-0.351	0.537	1.262	2.256	3.023	3.800
2.2	-0.905	-0.752	-0.330	0.574	1.284	2.240	2.970	3.705
2.0	-0.990	-0.777	-0.307	0.609	1.302	2.219	2.912	3.605
1.8	-1.087	-0.799	-0.282	0.643	1.318	2.193	2.848	3.499
1.6	-1.197	-0.817	-0.254	0.675	1.329	2.163	2.780	3.388
1.4	-1.318	-0.832	-0.225	0.705	1.337	2.128	2.706	3.271
1.2	-1.449	-0.844	-0.195	0.732	1.340	2.087	2.626	3.149
1.0	-1.588	-0.852	-0.164	0.758	1.340	2.043	2.542	3.022
0.8	-1.733	-0.856	-0.132	0.780	1.336	1.993	2.453	2.891
0.6	-1.880	-0.857	-0.099	0.800	1.328	1.939	2.359	2.755
0.4	-2.029	-0.855	-0.066	0.816	1.317	1.880	2.261	2.615

	Recurrence interval, years							
	1.0101	1.2500	2	5	10	25	50	100
Percent Chance Skew Coefficient ent G	99	80	50	20	10	4	2	1
0.2	-2.178	-0.850	-0.033	0.830	1.301	1.818	2.159	2.472
0	-2.326	-0.812	0.	0.842	1.282	1.751	2.054	2.326
-0.2	-2.472	-0.830	0.033	0.850	1.258	1.680	1.945	2.178
-0.4	-2.615	-0.816	0.066	0.855	1.231	1.606	1.834	2.029
-0.6	-2.755	-0.800	0.099	0.857	1.200	1.528	1.720	1.880
-0.8	-2.891	-0.780	0.132	0.856	1.166	1.448	1.606	1.733
-1.0	-3.022	-0.758	0.164	0.852	1.128	1.366	1.492	1.588
-1.2	-3.149	-0.732	0.195	0.844	1.086	1.282	1.379	1.449
-1.4	-3.271	-0.705	0.225	0.832	1.041	1.198	1.270	1.318
-1.6	-3.388	-0.675	0.254	0.817	0.994	1.116	1.166	1.197
-1.8	-3.499	-0.643	0.282	0.799	0.945	1.035	1.069	1.087
-2.0	-3.605	-0.609	0.307	0.777	0.895	0.959	0.980	0.990
-2.2	-3.705	-0.574	0.330	0.752	0.844	0.888	0.900	0.905
-2.4	-3.800	-0.537	0.351	0.725	0.795	0.823	830	0.832
-2.6	-3.889	-0.499	0.368	0.696	0.747	0.764	0.768	0.769
-2.8	-3.973	-0.460	0.384	0.666	0.702	0.712	0.714	0.714
-3.0	-4.051	-0.420	0.396	0.636	0.660	0.666	0.666	0.667

Source: Wilson, (1979) hydrology for Engineers.

Chen Yuanfang et al (2002) compared the parameter in estimation method for the Pearson III, in his result, he concluded that both probabilities weighted moments (PWM) and curve fitting are the parameter estimation methods for Pearson III distribution with good statistical performance and objectivity.



3.0 Data Collection

The need for reliable and adequate data for effective flood analysis can not be over emphasised. The important dataset required for flood analyses are rainfall total, river discharges, water levels and evaporation data. The catchments characteristics and general slope of the area also are very important in ensuring useful flood analyses.

River discharge measurement, water levels and other meteorological data were collected at various organisations as shown in table 3.1. The organisations are

- i. Jebba Hydropower station,
- ii. Nigeria Sugar Company Bacita,
- iii. Lower Niger River Basin Ilorin, and
- iv. Federal Ministry of Water resources Abuja.

Table 1.1: Data source, type and period.

Institutions	Rainfall	River Discharge	Net Evaporation	Max. Temperature	Water Level
Jebba Hydroelectric Power Dam	(19yrs)	(19yrs)	15yrs	12yrs	16yrs
Nigeria Sugar Company Bacita	(19yrs)		15yrs	10yrs	Belle-20yrs Yelwa 30yrs
Federal Ministry of Water Resources	Lokoja (19yrs)	River Niger at Lokoja 29yrs River		19yrs	

Institutions	Rainfall	River Discharge	Net Evaporation	Max. Temperature	Water Level
		Niger at Baro			
		28yrs River			
		Kaduna at			
		Wuya 19yrs			

Among the data collected from Jebba Hydro-power station were Average discharge of Reviver at Jebba (1984-2001), Average Net evaporation (1987-2003) monthly rainfall (1984-2003) and maximum temperature (1991-2003). Data collected from Nigeria Sugar Company Bacita were water level at Belle, (1980-2000) and Yelwa (1971-2000) gauging stations and rainfall data (1971-1990). While data collected from Federal Ministry of Water Resources were monthly run-off of River Niger at Lokoja (1960-1989), monthly discharges of River Niger at Baro (1961-1989), monthly run off of River Kaduna at Wuya and monthly rainfall data at Lokoja. The data collected were studied and analysed with various statistical methods. The probability distribution and plotting position were also determined. Seven towns were visited to assess the effect of flood on the environment and to be acquainted with the possible land use for agriculture and other productive sector of economy. The towns are Jebba, Bacita, Shonga, Patigi, Baro, Geriyan and Lokoja. (Fig 2).

Lastly, the profile of peak water levels and times taking from Jebba dam below reservoir was extracted from the study carried out by Babbie Group in association with Afremedev Constancy Services, for the defunct Petroleum Trust Fund (PTF). (1999)

3.1 Data Analysis

These data were subjected to three different analyses. The analyses that are frequently used are:

- (i) Statistical analysis
- (ii) Plotting position and
- (iii) Probability distribution analysis.

3.1.1 Statistical Analysis:

The statistical analyses carried out were mean ($\bar{x}$), the standard Deviation, (σ) and the skewness (g). These are presented at the end of each analysis.

Plotting Position:

Although there many formulae use for computing frequency of certain discharge that may occur but the following method are used.

Weibull Method

$$P = \frac{m}{n+1}$$

$$Tr = \frac{1}{P} = \frac{n+1}{m}$$

Hazen method

$$P = \frac{2m-1}{2n}$$

$$Tr = \frac{2n}{2m-1}$$

Gumbel method

$$P = \frac{m+c-1}{n+1}$$

$$Tr = \frac{n+1}{m+c-1}$$

P is the probability of occurrence and the inverse of it, is the Return period or Recurrence interval Tr i.e.

$$Tr = \frac{1}{P}$$

The monthly data (discharge and rainfall) were plotted against the recurrent intervals based on different plotting position. The lines of best fit were drawn, the equation and coefficient determination r^2 were determined. Annual and partial duration series events of data at various points of River Niger and River Kaduna were also plotted and presented in the figures. 4.26-4.48.

3.1.2 Probability Distribution

Four models were used for the probability distribution. The four models used are Gumbel, Log – Gumbel, Log-Pearson and Log Normal.

The yearly peak of the flow at each section of River Niger were selected and ranked in their order of magnitude. The sections considered for the analyses are Jebba (Inlet), Baro, (mid-point) and Lokoja (outlet). The peak discharge of River Kaduna at Wuya was also selected for the analyses. The results of the analyses for the four probability distribution models for the different points of observation are presented in chapter that deals with results and discussion.

The Predicted Discharge (Q_p) for each year was computed based on the mathematical formulae of each of the probability model. The observed and the predicted discharge were correlated and the correlation coefficients for all the models were determined. The probability model with the highest value of correlation coefficient close to one was selected as the best probability model for section.

3.1.3 Gumbel Distribution Model

Gumbel Extreme Value (type 1) model was adapted to analyse the maximum annual discharge for River Niger at the various gauging stations and River Kaduna at Wuya. The statistical parameters used in the Gumbel formula are

- ✦ peak annual discharge Q ,
- ✦ average of the peak annual discharges Q ,
- ✦ Standard deviation σ and
- ✦ reduce variate (Y_r).

The mathematical relationship in the Gumbel distribution method for predicting future discharge is given as:

$$Q_r = Q_m + \sigma (0.75Y_r - 0.45)$$

and this was used to estimate the yearly discharge.

3.1.4 Log-Gumbel Distribution:

In this model, all the parameters were converted to the logarithm form. The mathematical expression for the model is given as:

$$\log Q_p = \log X_{av} + \log \sigma (0.75Y_r - 0.45)$$

where

$\log Q_p$ is the Predicted Discharge in Logarithm 10

X_{av} is the Average discharges in Logarithm 10

σ Log is the standard deviation in Logarithm 10

$$Y_r = -\ln(-\ln(1-p))$$

3.1.5 Log Pearson Model:

In log Pearson Model, all the data were converted into Logarithm 10 similar to the Log Gumbel model. The mathematical expression for the model is given as:

$$\log X = \log \bar{X} + K\sigma \log x$$

where K is taken from the table on the values for the log-Pearson Type III distribution early mentioned.

3.1.6 Log Normal Model

The mathematical expression for model is given by

$$\log Q_p = \log \bar{Q} + K\sigma \log Q$$

The value of K used for each estimation point is selected from the normal distribution table.

$\log Q_p$ is the logarithm of the predicted discharge;

$\log \bar{Q}$ is the logarithm of the average discharge, and

σ is the standard deviation

3.2 Testing of the Developed Statistical Models

The acceptability and reliability of developed statistical models for all the analysed points were evaluated using two goodness of fit tests. These tests were used to evaluate the suitability or otherwise of the different probability distribution. The goodness of fit tests were:

- ♣ Correlation coefficient, and

The equation of each model was developed and used to predict the expected flood for each point of evaluation.

3.2.1 Probability Plot Correlation Coefficient (r)

This model evaluates the linearity of the probability plot of each of the test points. The hypothesized distribution r is expected to be close to one, if the plot describes the observation very well. Mathematically, the quantity r is called coefficient of correlation which is given by,

$$r = \pm \sqrt{\frac{\text{Explained Variation}}{\text{Total Variation}}} = \sqrt{\frac{(Y_{\text{est}} - Y^2)}{(Y)^2}}$$

The value varies between -1 and $+1$. Since the observed value and the predicted value are directly related, we will choose the positive sign, in the two decimal places.

The following table is used as a guide.

Table 3.2: r value interpretation in the study

r value	Interpretation
0.75 – 1.00	Excellent
0.50 – 0.74	Good
Less than 0.50	Weak

The model that gives a very close value to 1 is the best distribution model.

3.2.2 Coefficient Determination (r^2)

This is the square of coefficient of correlation. It is a measure of the proportion of the variance of dependent variable that is explained by regression equation.

3.3 Profile of flow along River Niger Channel

The data used for profile study along River Niger from Jebba to Lokoja were from Babtic group (1999). The data were used base on its reliability in terms of spatial coverage and the maximum flood level collected from Bacita Sugar Company and Tada Shonga Irrigation Project.

3.4 Environmental Impact

Seven towns were visited to assess the effect of flood on the environments, agriculture, industries, settlements and public utilities. Also to evaluate the vulnerability and proximity to flood, the present land use was critically assessed and in certain instance, safe land use were proposed. The towns visited are Jebba, Bacita, Shonga, Patigi, Baro, Geriyan and Lokoja.

Environmental impacts due to flooding can broadly be assessed under different broad classes, they are:

- ♣ Basic Infrastructures
- ♣ Settlements Damage
- ♣ Economic Damage

3.4.1 Basic Infrastructures

This includes damage to personal property such as building clothing, health institution, schools and historical monuments.

3.4.2 Settlements Damage

Most of the buildings along the plain were constructed with mud (earth materials) and collapse when soaked with floodwater. This may be as a result of differential statement of the foundation. Also many people from villages and towns along river bank migrate to higher elevation towns most of them were not use to the new environmental and hinder their economic and social lives.

3.4.3 Economic Damage

This represents damage to economic production sector. It is sub-classified according to the magnitude and importance, but may be broadly broken down into the following:

- ♣ Agriculture (include forestry and wild life)
- ♣ Transportation and Communication

Industries e.g. Bacita Sugar Company lost over 4,500 Ha of sugarcane to flood and used large sum of money in rehabilitating their machine and equipment during 1994 and 1998 flooding. While over 4000Ha of farmland were flooded in Shonga Irrigation Project.

3.5 Health Hazard

Another important environmental impact is health hazard. Various problems associated with occurrence of flood, among the health problems are infection and spreading of various water related diseases such as malaria, guinea worm, bilharzias and other skin diseases were investigated with questionnaires administered to the inhabitant of the area and the health personnel in the health centres at the study area.



RESULTS AND DISCUSSIONS

4.1 Return Periods for Annual Rainfall Events and its effect on Flood Events

The result of the plots of the return periods for the annual rainfall total between 1971 and 1990 for Lokoja using Weibull, Hazen and Gumbel models are presented in Figures 4.1 to 4.3. The plot showed that the average rainfall total for the Lokoja is between 200mm and 300mm. The return period for most of these event is in the neighbourhood of 20years, indicating that, if the annual rainfall total required to trigger flooding is low, the recurrence interval of flood will be high. Some extreme events were also recorded, within the annual total of between 300mm and 400mm. The recurrence interval of these events which often than not result in major flood events in the study area within 30 years.

There exists a general agreement in the three models on the recurrence interval of 20 year for the moderate event, but the Weibull method produce the best r^2 value. The implication of these is that the 3 models can be used to effectively predict the recurrence interval for the events.

The return period for the rainfall events at Bacita using the 3 models (Weibull, Hazen and Gumbel) are also presented in Figures 4.4 to 4.6. Also figures 4.7 to 4.9 highlights the return period for the annual rainfall total for Jebba. Similar to the Lokoja study site, most frequents events in Bacita has an average monthly total of between 300mm and 350mm. Weibull and Hazen model predicted the events better than the Gumbel which slightly under-predict it resulting in the lowest r^2 value. While the determination coefficient of the other two methods are strong and very close to 1.

A general observation in all the plots is that the annual rainfall total in the three selected study site is on the low side, whilst their recurrent interval is high. One would not naturally expect flooding due to these rainfall events, but oral interview results during the site visits and the records from most of the agency in charge of flood monitoring in the area is contrary.

The analysis clearly indicate that in recent past, flash flooding is experienced almost every two year, while major flood occur at least once in 5 years in all the area.

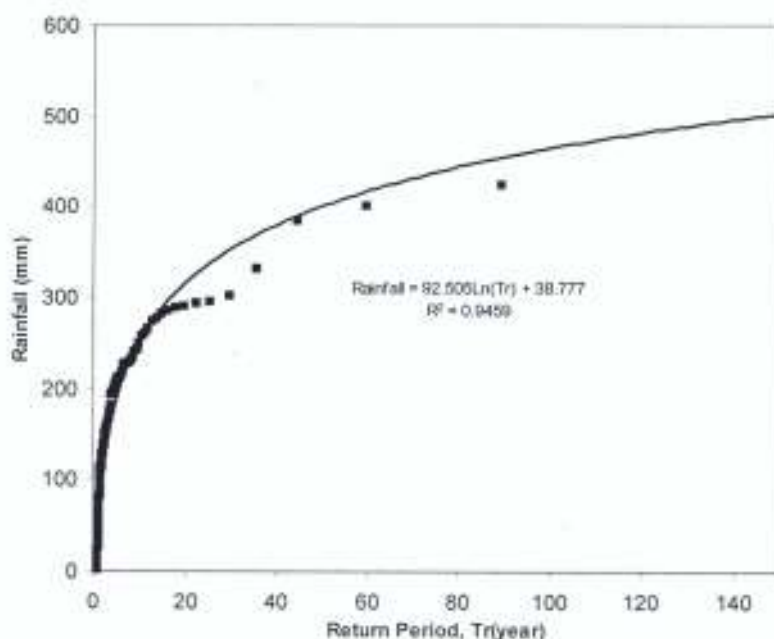


Figure 4.1: Return period for annual rainfall total (1971-1990), Lokoja Weibull model

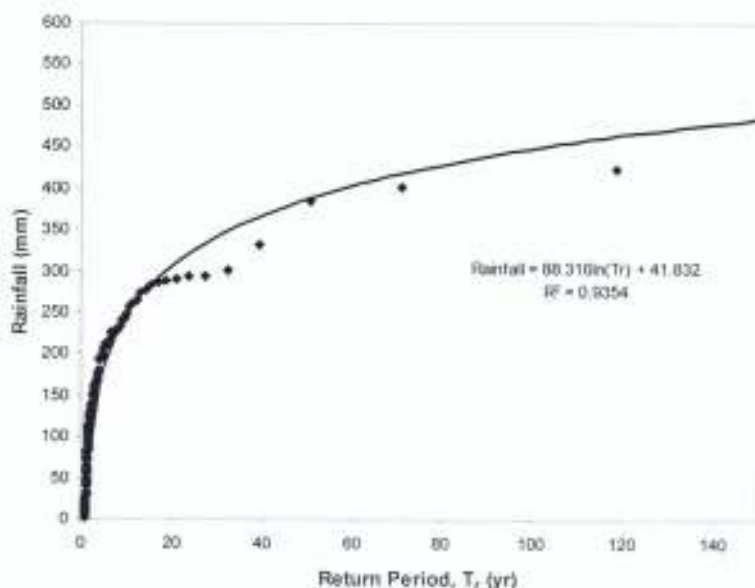


Figure 4.2: Return period for annual rainfall total (1971-1990), Lokoja Hazen model

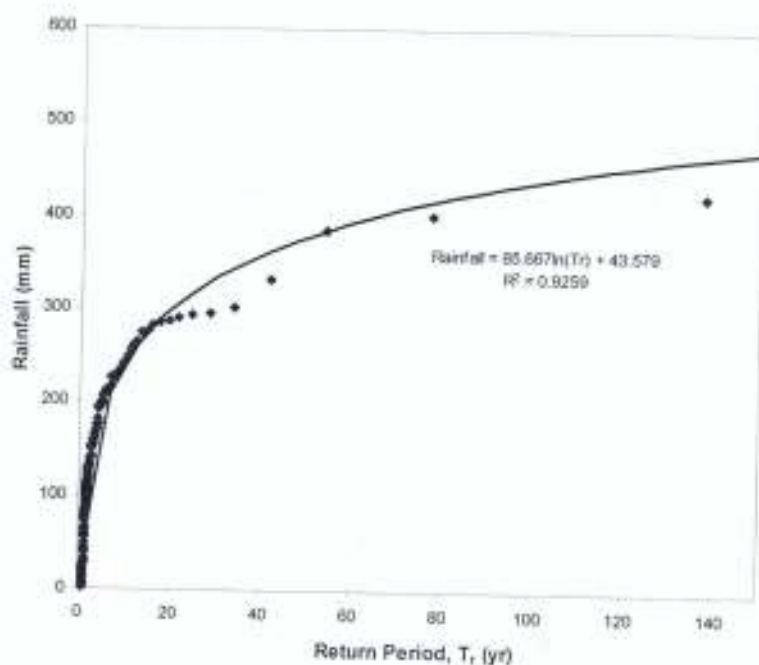


Figure 4.3: Return period for annual rainfall total (1971-1990), Lokoja Gumbel model

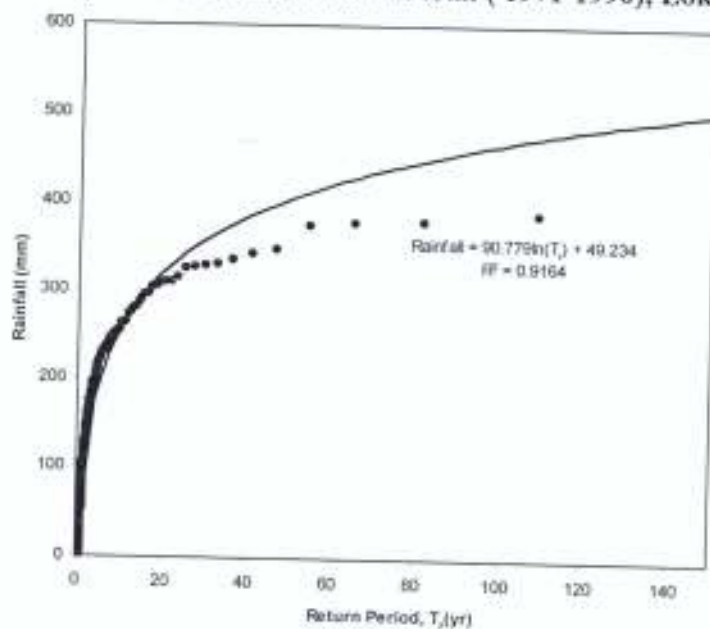


Figure 4.4: Return period for annual rainfall total (1971-1990), Bacita, Weibull model

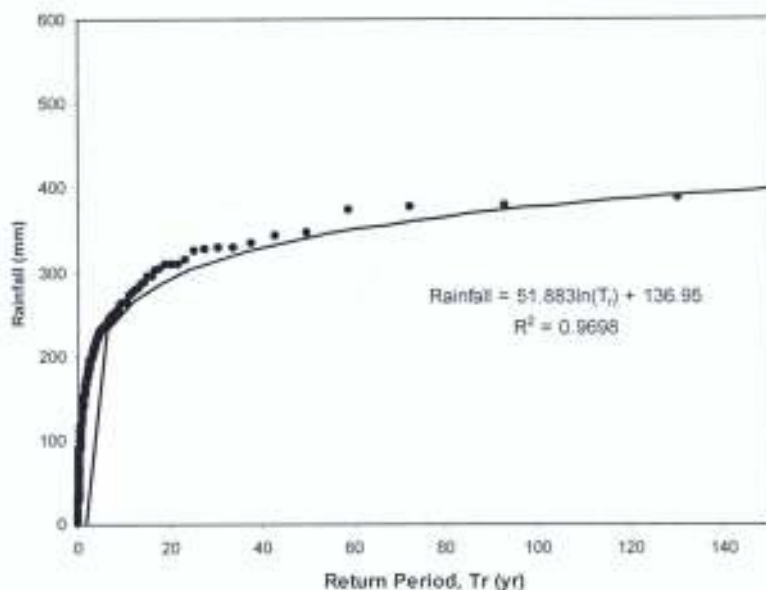


Figure 4.5: Return period for annual rainfall total (1971-1990), Bacita, Hazen model

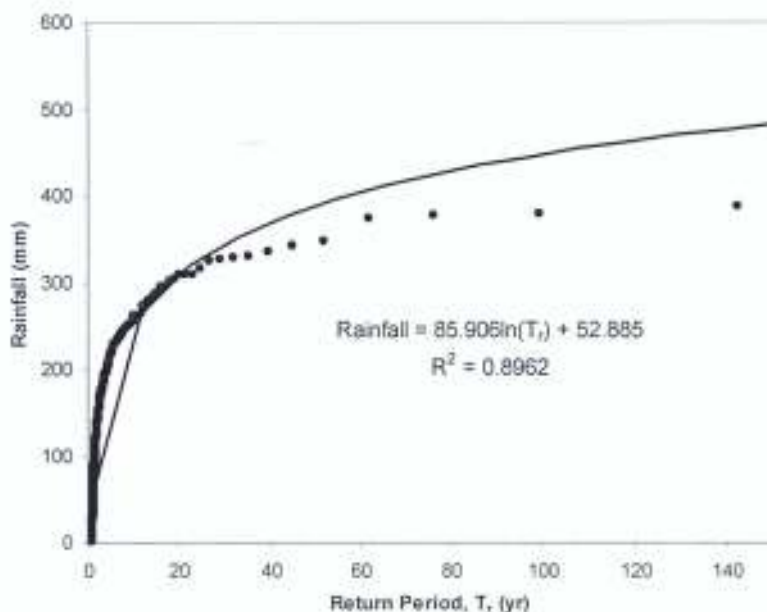


Figure 4.6: Return period for annual rainfall total (1971-1990), Bacita, Gumbel model

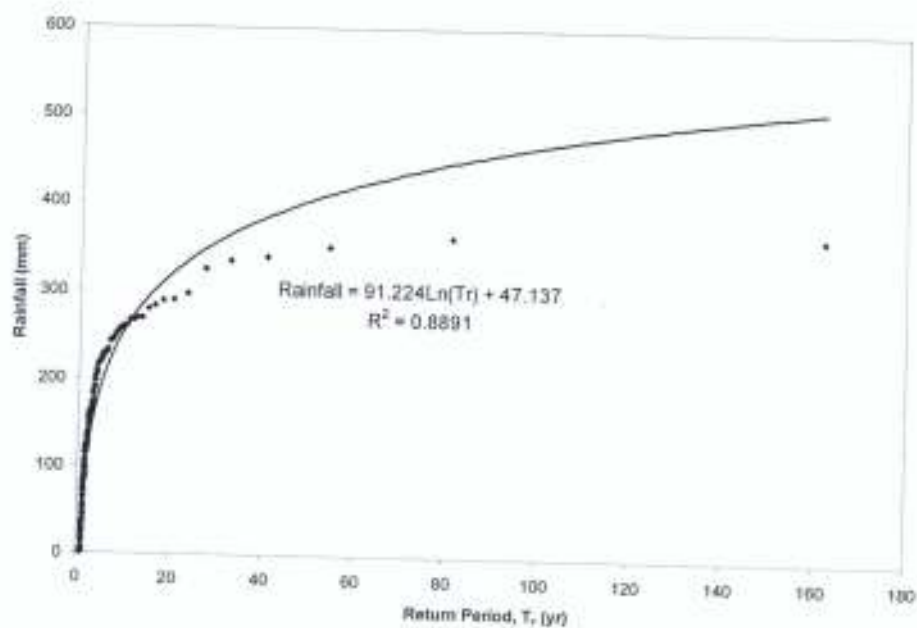


Figure 4.7: Return period for annual rainfall total (1971-1990), Jebba, Webull model

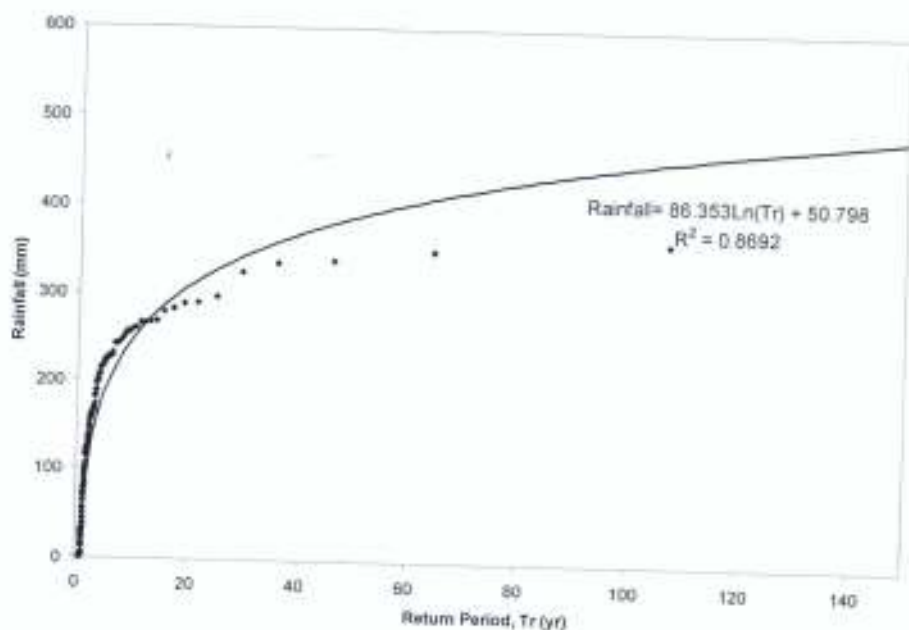


Figure 4.8: Return period for annual rainfall total (1971-1990), Jebba, Hazen model

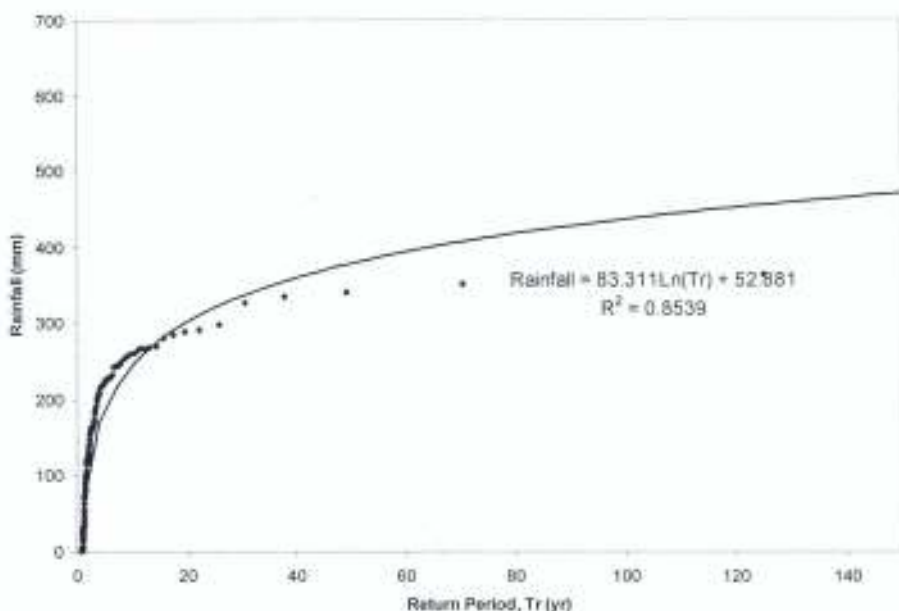


Figure 4.9: Return period for annual rainfall total (1971-1990), Jebba, Gumbel model

This observation from figures above clearly showed that most of the flood event are not directly resulting from high rainfall total, but are rather influenced by other factors including high level of bed siltation resulting from uncontrolled erosion and the accompanying soil wash and deposition from the upstream into the different rivers. Thus, the capacities of the river channels are easily exceeded due to reduce flow area, particularly during the short but intense rainfall events.

Another reason for the increase in the frequency of flood events may be the different developmental project located in the study area. The process of construction of these various dams and irrigation project often require massive distortion of the eco-system balance due to massive earth work (land levelling and grading), deforestation, and reengineering of river courses. All these various processes increase the susceptibility of the area to degradation effect due to significant changes in infiltration capacity of soil, water retention characteristics, and soil bearing capacity among others.

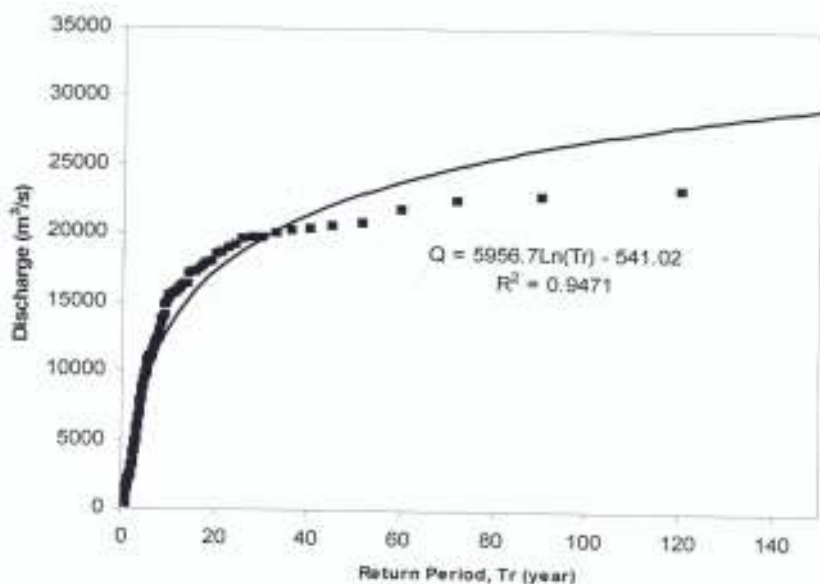


Figure 4.10: Recurrence Interval of total annual discharge for Lokoja using Weibull model (1960-1989)

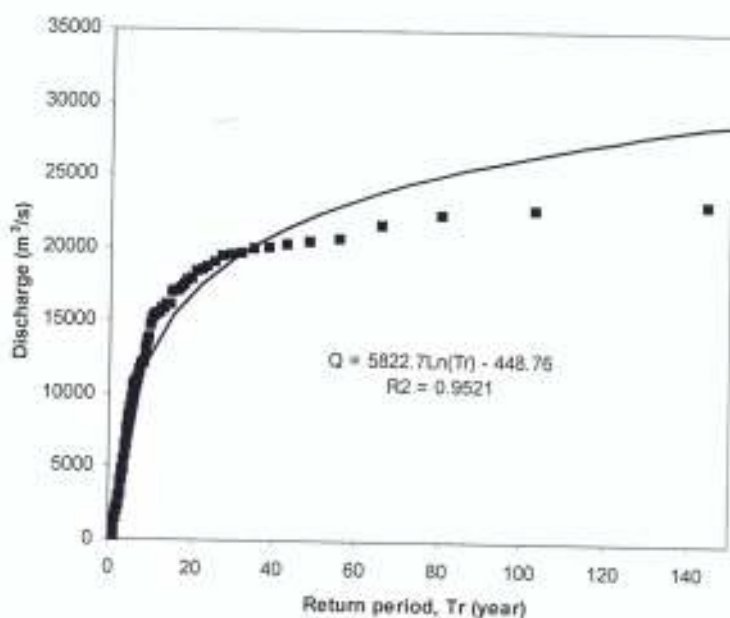


Figure 4.11: Recurrence Interval of total annual discharge for Lokoja using Hazen model (1960-1989)

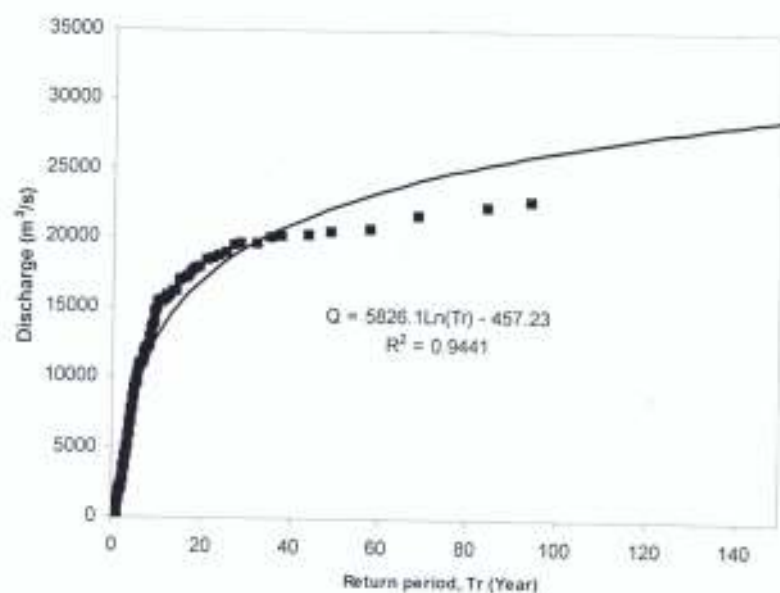


Figure 4.12: Recurrence Interval of total annual discharge for Lokoja using Gumbel model (1960-1989)

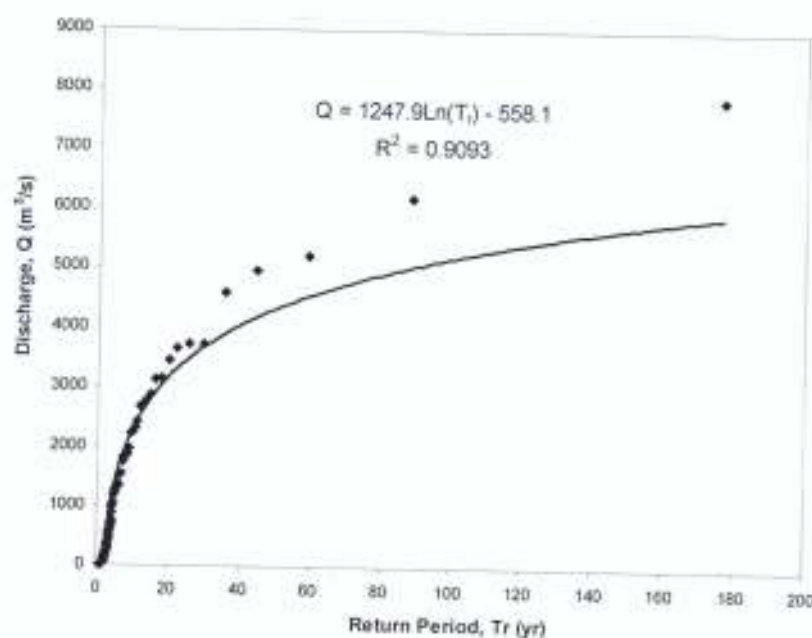


Figure 4.13: Recurrence Interval of total annual discharge for Wuya Gauging station using Weibull model

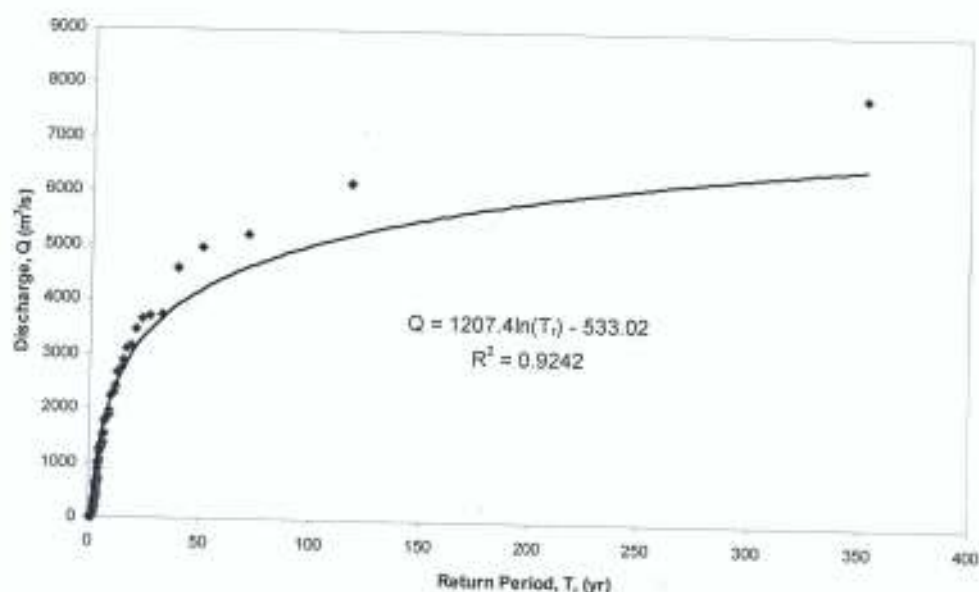


Figure 4.14: Recurrence Interval of total annual discharge for Wuya Gauging station using Hazen model

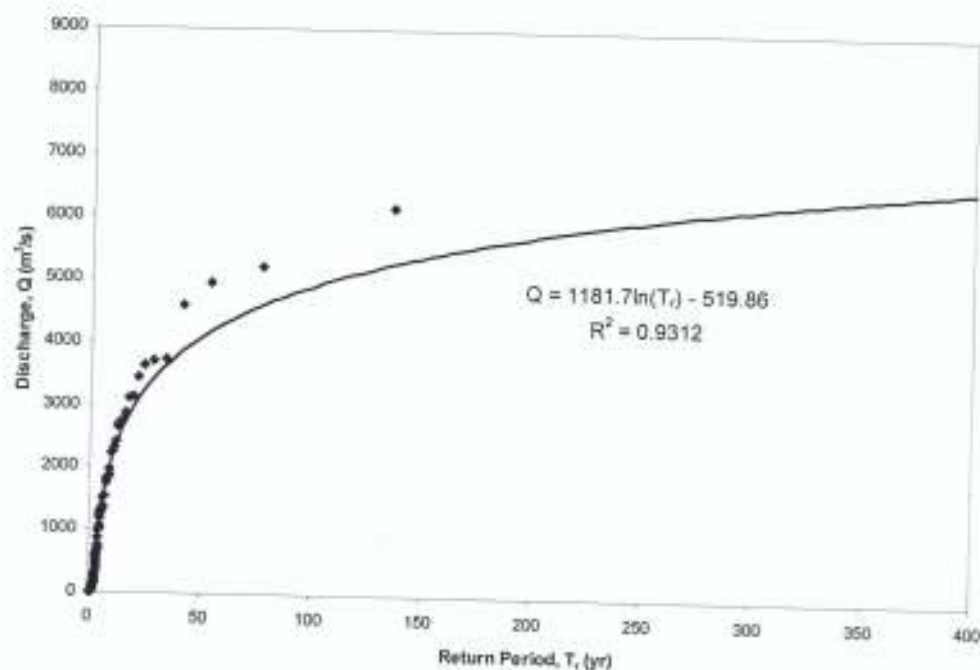


Figure 4.15: Recurrence Interval of total annual discharge for Wuya Gauging station using Gumbel model

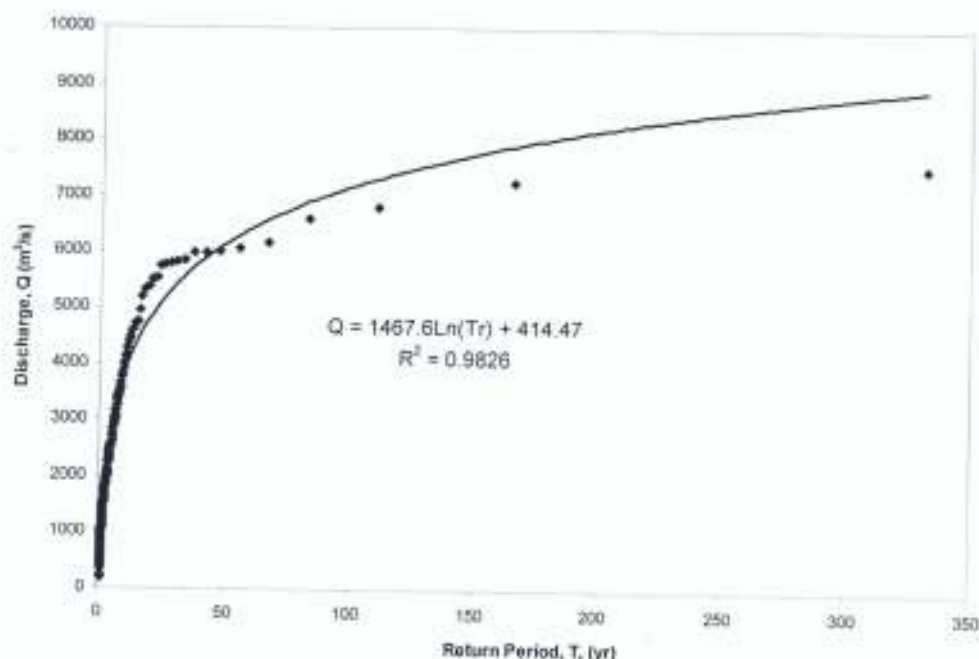


Figure 4.16: Recurrence Interval of total annual discharge for Baro Gauging station using Weibull model

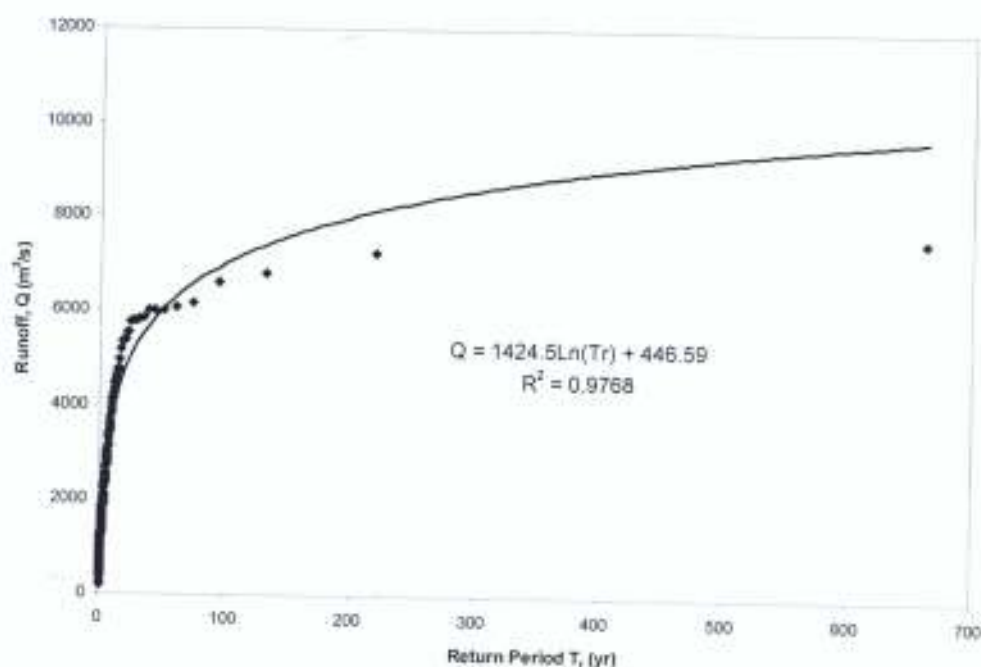


Figure 4.17: Recurrence Interval of total annual discharge for Baro Gauging station using Hazen model

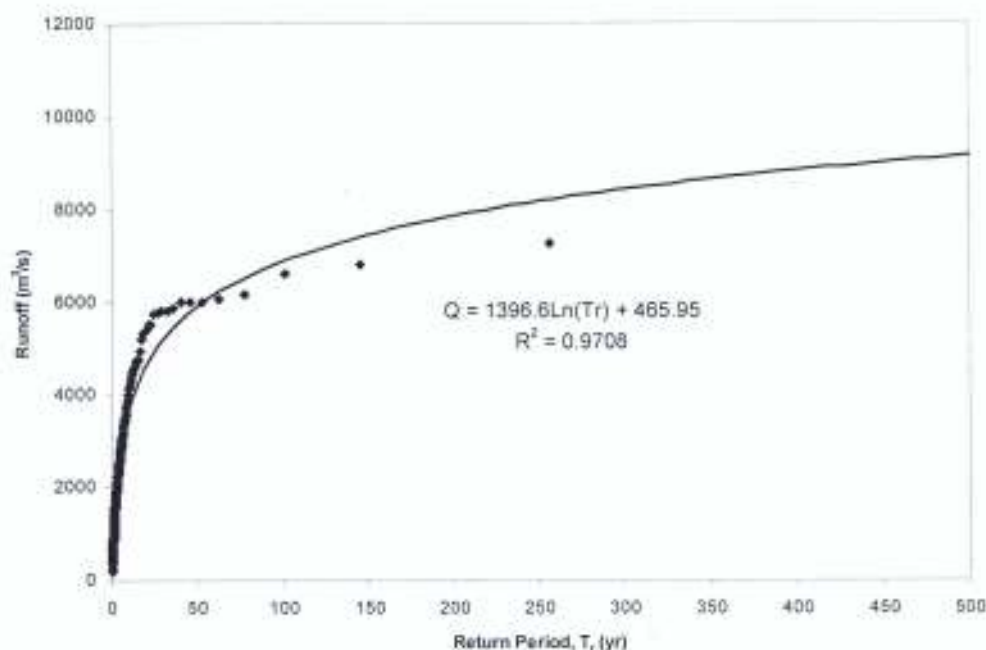
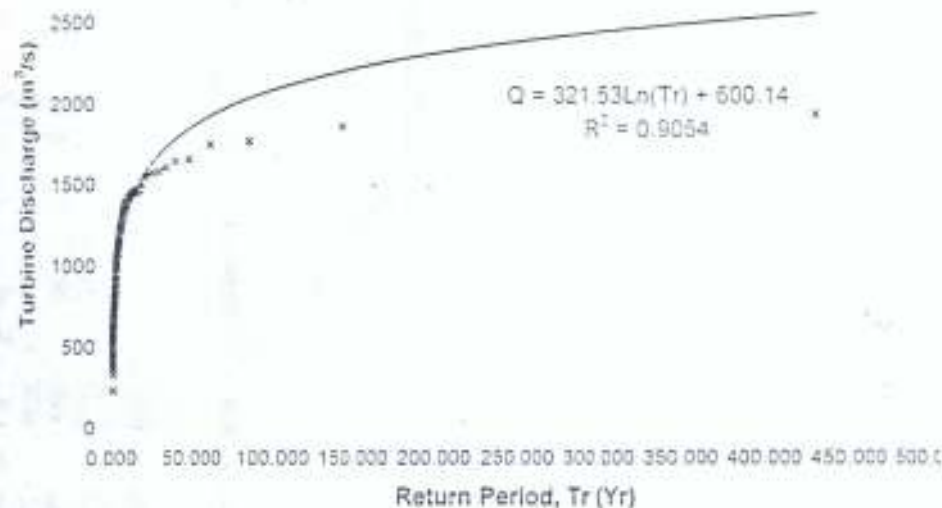


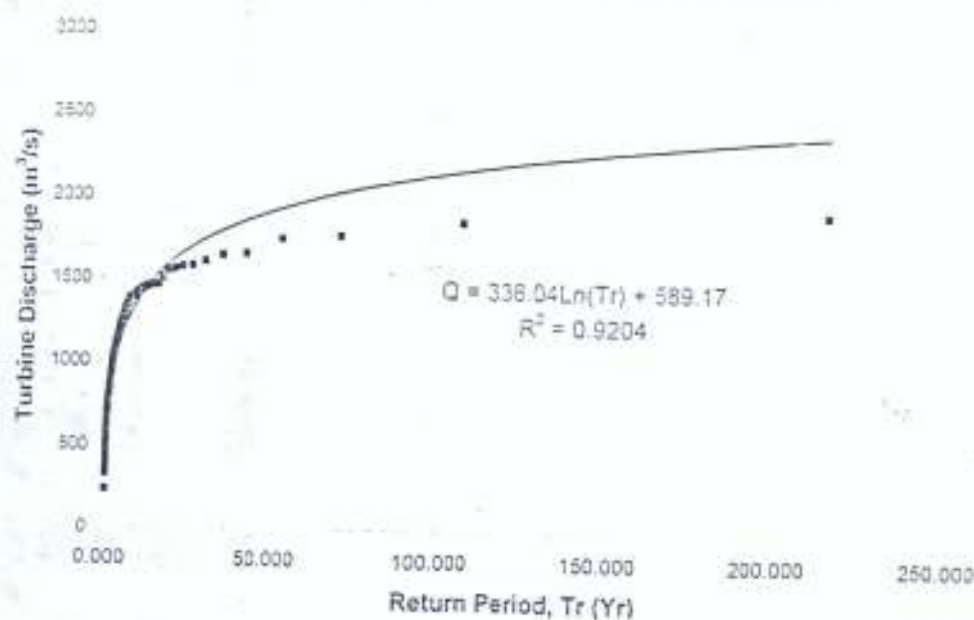
Figure 4.18: Recurrence Interval of total annual discharge for Baro Gauging station using Gumbel model

4.2 Recurrence Periods for Annual Discharge and Maximum Discharge at Selected Gauging site using the different models

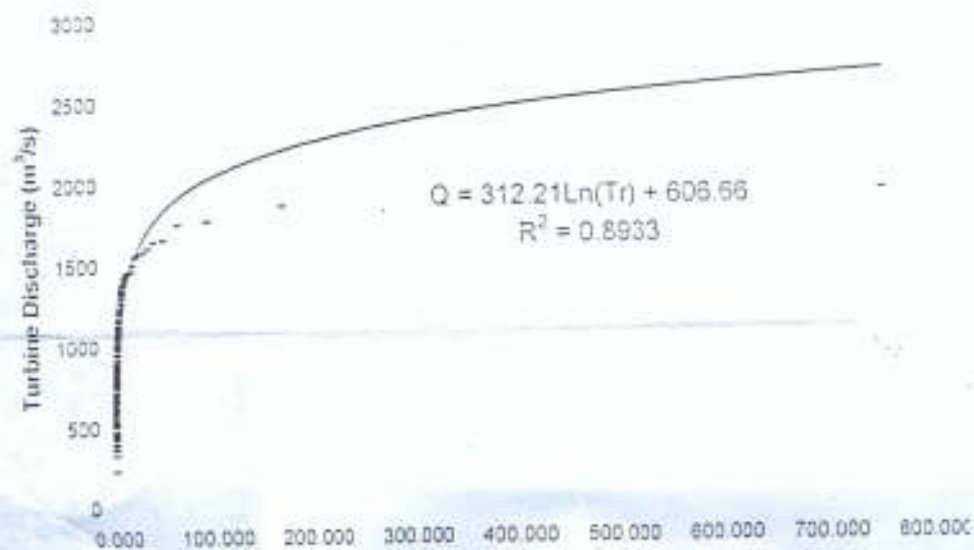
The recurrence intervals for the maximum discharge at Jebba (a common gauging station in the study area) using the 3 models are presented in figures 4.19 to 4.21, while those of the annual discharge for Lokoja, Wuya and Baro are presented in figures 4.10 through 4.18. The result clearly showed that discharge in Lokoja is much higher than those at Wuya and Baro. This is possibly due to the release from the dam upstream the point of measurement. It could also be observed from all the model fittings of the annual discharge record, that the recurrence interval for the discharges value of about 20000m³/sec at Lokoja is within 10years. Those for a quarter of that magnitude are also observed at Wuya and Baro over the same period. Discharge of about 1500m³/s which has been noted to stimulate flash flooding during wet years have a recurrence interval of about between 2 and 5 years in all the study sites. These explain why flash flooding is a common phenomenon in the study area. The flash flood occurred as a result of the over flow of the River Niger which has reached its full capacity, therefore the smaller tributaries found it difficult to enter the channel therefore there will be back flow of water in their channels. For the annual discharge, it could be observed that most of the events have a recurrence interval of less than 50years. The implications of these results are discussed in detail in the section of general observation.



Turbine Discharge/ Return Period at Jebba - Weibull



Turbine discharge/Return Period at Jebba (Gumbel)



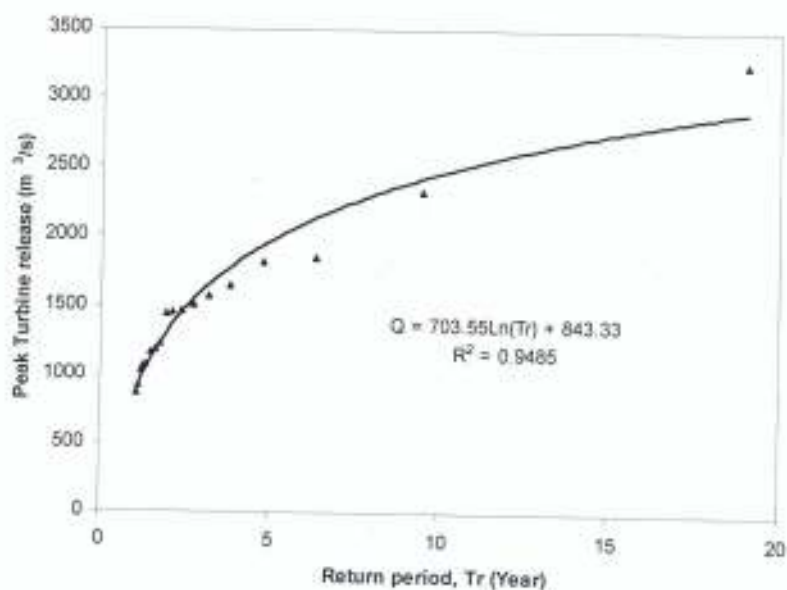


Figure 4.19: Recurrence Interval of Peak Annual Discharge for Jebba using Weibull model (1984 – 2001)

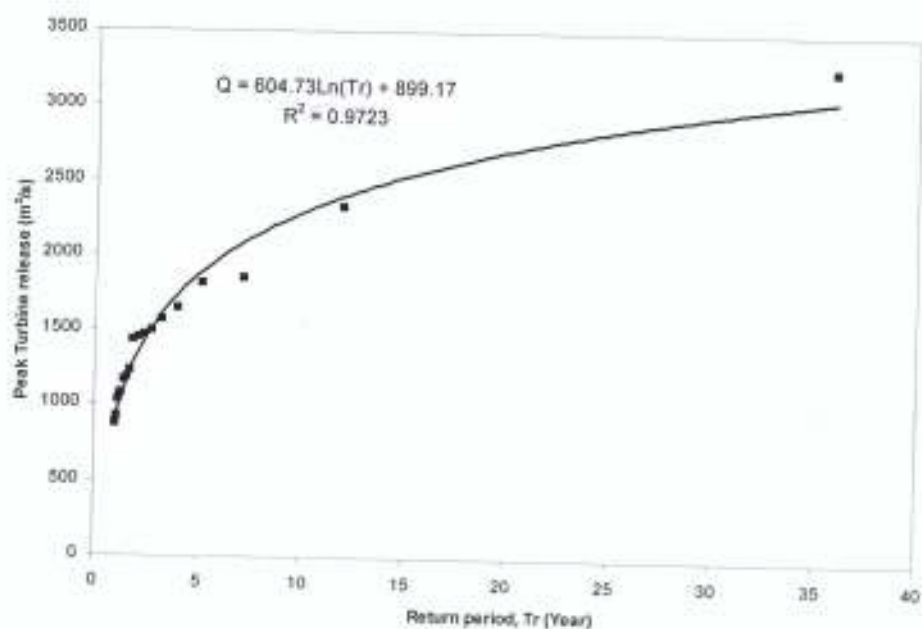


Figure 4.20: Recurrence Interval of Peak Annual Discharge for Jebba using Hazen model (1984 – 2001)

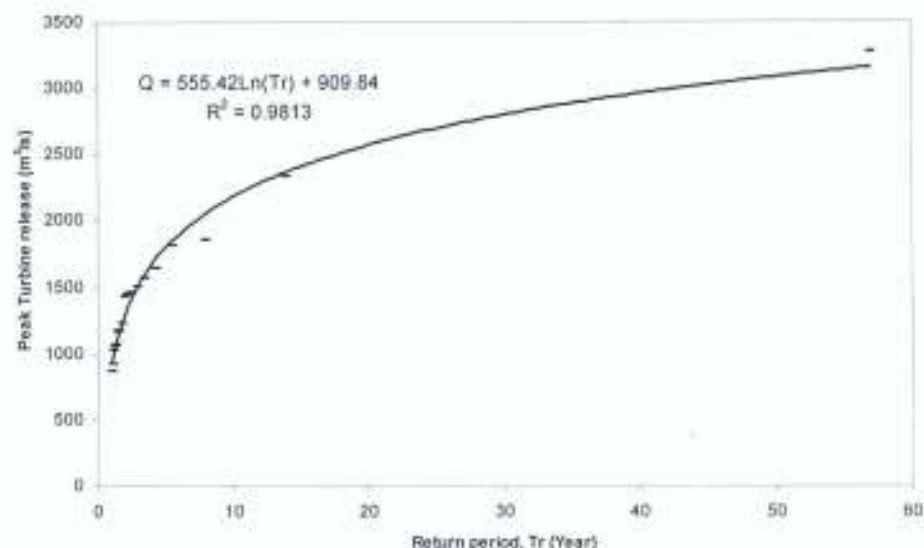


Figure 4.21: Recurrence Interval of Peak Annual Discharge for Jebba using Gumbel model (1984 – 2001)

4.3 Summary of Parameter for the Statistical model for the analysed hydrological data

Table 4.1 show the result of the statistical analysis of collected weather and hydrological data for the study area.

Table 4.1: Summary of Statistical Parameter of analysed hydro-meteorological data

Data Points	Mean	Standard Deviation	Skewness
Discharge from Jebba	921.59m ³ /sec	335.16m ³ /sec	0.56
Discharge of River Niger at Lokoja	5369.66m ³ /sec	5934.56m ³ /sec	2.29
Discharge of River Niger at Baro	1869.56m ³ /sec	1432.85m ³ /sec	1.68
Discharge of River Kaduna at Wuya	672 m ³ /sec	1243.68m ³ /sec	2.84
Net Evaporation at Jebba Dam	6.73mm	1.76mm	0.56mm
Rainfall Data at Lokoja	130mm	90.4mm	0.80mm
Rainfall Data at Jebba	136.96mm	91.65mm	0.35mm
Rainfall Data at Bacita	139.23mm	91.74mm	0.54mm

Table 4.2: Summary of Coefficient of Determination for the Statistical model used to fit the hydro-meteorological data

Data Points	Coefficient of Determination			Remark Preference
	Weibull	Hazen	Gumbel	
Average Reservoir inflow m^3/sec	0.9293	0.9418	0.7929	Hazen
Average Discharge at Jebba m^3/sec	0.9204	0.9054	0.8933	Weibull
Monthly Discharge of River Niger at Baro m^3/sec	0.9826	0.9768	0.9708	Weibull
Monthly runoff of River Niger at Lokoja m^3/sec	0.9485	0.9723	0.9813	Hazen
Peak Turbine Discharge at Jebba m^3/sec	0.9485	0.9723	0.9813	Gumbel
Monthly runoff of River Kaduna at Wuya m^3/sec	0.9093	0.9242	0.9312	Gumbel



Table 4.3: Summary of Coefficient of Determination for the Probability distribution Test for the hydro-meteorological data

	Coefficient of determination for Probability				Remark Preference
	Gumbel	Log Gumbel	Log Pearson	Log Normal	
Peak average reservoir Flow (m^3/sec)	0.9474	0.9191	0.7824	0.9339	Gumbel
Peak turbine release at Jebba (m^3/sec)	0.9424	0.9710	0.9596	0.8343	Log Gumbel
Peak discharge of Niger at Baro (m^3/sec)	0.9585	0.9168	0.9457	0.9625	Log Normal
Peak monthly runoff of River Niger at Lokoja (m^3/sec)	0.9548	0.8485	0.7619	0.9648	Log Normal
Peak discharge of River Kaduna at Wuya (m^3/sec)	0.9880	0.9499	0.5049	0.2298	Gumbel

4.4 Flood Years

From the analyses of the hydro-meteorological data used for this study and the oral interview carried out administered on the inhabitant of the study area, the following flood years between 1990 and 2005 were identified. They are 1994, 1995, 1998, 1999, 2001 and 2003. The equivalent river discharges both at the inflow points and the turbine discharges, and the corresponding rainfall amount for the flood days are given in table 4.4.

Table 4.4: Summary of flood events, corresponding rainfall, and river discharge at various stations

Date	Reservoir Inflow	Peak Discharge	Rainfall Data at Jebba	Rainfall Data at Bacita
Oct, 1994	3275 m^3/sec	3275 m^3/sec	July 1994 22.6mm	July 265mm 275mm
Feb. 1998	1413 m^3/sec	1643 m^3/sec	June 1995 268.3mm	July 241mm Sept. 287mm
Sept. 1998	1289 m^3/sec	1451 m^3/sec	June 1998 366.4mm	June 265mm Sept. 312mm
Oct. 1999		1856 m^3/sec	Sept. 1999 283.5mm	June 241mm Aug. 228mm
Jan. 2001		1426 m^3/sec	Sept. 2001 325.6mm	

4.5 General Observation

4.5.1 Coefficient of Determination r^2

The coefficient of determination r^2 of all the three models used for calculating the return periods are acceptable. This is because they are all very strong and close to one but the best of the three models in each situation is presented in the column on remarks in table 4.2.

4.5.2 Plotting Position

Weibull method is preferred for average Turbine discharge of river Niger at Jebba, and monthly discharge of the river at Baro. Gumbel method is preferred for peak turbine discharge at Jebba and monthly runoff of river Kaduna at Wuya while Hazen is good for only monthly runoff of - River Niger at Lokoja. Also from figure 4.1 to 4.18, the graph is linear i.e. the discharge is more proportional to the return period. This may be due to controlled release of water from the dams.

The equation to predict the discharge from each figure varies from one and other; it decreases from Weibull to Hazen and to Gumbel. The extreme discharges recorded during the years are well pronounced in Annual and partial series graph. These could be during the flood years and rainfall are higher. The result of the plots of the annual discharge against the return period of the three gauging stations along the river Niger i.e. Jebba, Baro and Lokoja and that of River Kaduna at Wuya using the three plotting positions, the return period of total annual discharge are in agreement with annual discharges.

The discharges of the river Niger at the three gauging stations are linearly progressing between 0 year and 10 years which agree with the historical information of 10 years flood circle. However, the simulated curve has changed to deviate from the actual discharge, this may be due to construction of Jebba Dam in 1984. From year 10 to 30 the simulated curve is below the actual discharge curve, this may result to flooding and is more frequent which can also be used to confirm the unregulated release of water from the dam.

There exists a general agreement in the 3 models on the recurrence interval of 10 years cycle but Hazen model produces the best r^2 value for total annual discharge at Lokoja. The implication is that the 3 models are good for predicting recurrence interval for the event.

For recurrence interval of total annual discharge of river Kaduna at Wuya, the relationship between discharge and the return period is linear within 0 and 20 years but from year 20, the simulated curve is below the actual discharge, which implies that the basin is always flooded despite the construction of Shiroro Dam.

The three plotting positions are good for predicting the discharges but Gumbel model is the best. In case of peak Turbine discharge against return period the Turbine discharge is co-linear with the time until year 4 when the discharge is about $1500 \text{ m}^3/\text{sec}$, the simulated discharge rose above the Turbine discharge of $3250 \text{ m}^3/\text{sec}$ to above the simulated curve. The

implication is that the peak Turbine discharge is dependent on release of water from the reservoir.

All the three models used for predicting are acceptable but Gumbel model is the best.

4.5.3 Probability Distributions

The results of the four models used are shown in Table 4.3. The four models used to estimate the peak discharges at various locations of River Niger within the Lower Basin are favourable and considered to be good because the correlation coefficients obtained are very high and close to one. Gumbel method is good for estimating peak discharge of River Kaduna at Wuya. Log-Normal is good for estimating peak discharges of River Niger at Lokoja and Baro while log Gumbel is only suitable for peak Turbine discharge of River Niger at Jebba.

4.5.4 Flood Years

The flood years were 1994, 1995, 1998, 1999, 2001 and 2003. The equivalent River Niger discharge (both inflow and outflow) at Jebba and rainfall data at Jebba and Bacita are recorded as shown in the Table 4.4.

The rainfall data showed that the rainfall total are generally high during the recorded flood year periods, which led to high river discharges. The highest discharge recorded at Jebba during the year was 3275m³/sec, which was in 1994 while the lowest was 1436 m³/sec in 2001.

The profile of maximum water level and maximum flow were plotted against distance. The rating curve (figure 4.22) of river Niger was drawn and the equation for the rating curve is given as

$$Q = 0.0048H^{3.8345}$$

The profile of maximum water level of river Niger below Jebba reservoir was plotted against distance (fig. 4.23). The water level at Jebba is higher and gently decreasing as moving toward Lokoja which is almost 319Km.

The difference in water elevation of 32m could be as a result of closeness to Jebba Dam or difference in topography. The maximum water level profile could be useful for predicting flood frequency behaviour of the entire location from Jebba to Lokoja, the differences in flood frequency curve from one location to another are due to the differences in the catchments and not in the Agro-meteorology but if the Agro-meteorological variable could be regionalized, then run-off models could be used to account for the runoff differences due to the catchments properties.

The maximum flow were plotted against distance with equation (Figure 4.24)

$$Q = -36607 \ln(D) + 218068$$

It showed that the maximum flow of $190000 \text{ m}^3/\text{sec}$ was recorded at Jebba while $10000 \text{ m}^3/\text{sec}$ was recorded at Lokoja. The difference could also be due to the difference in distance and catchment characteristics.

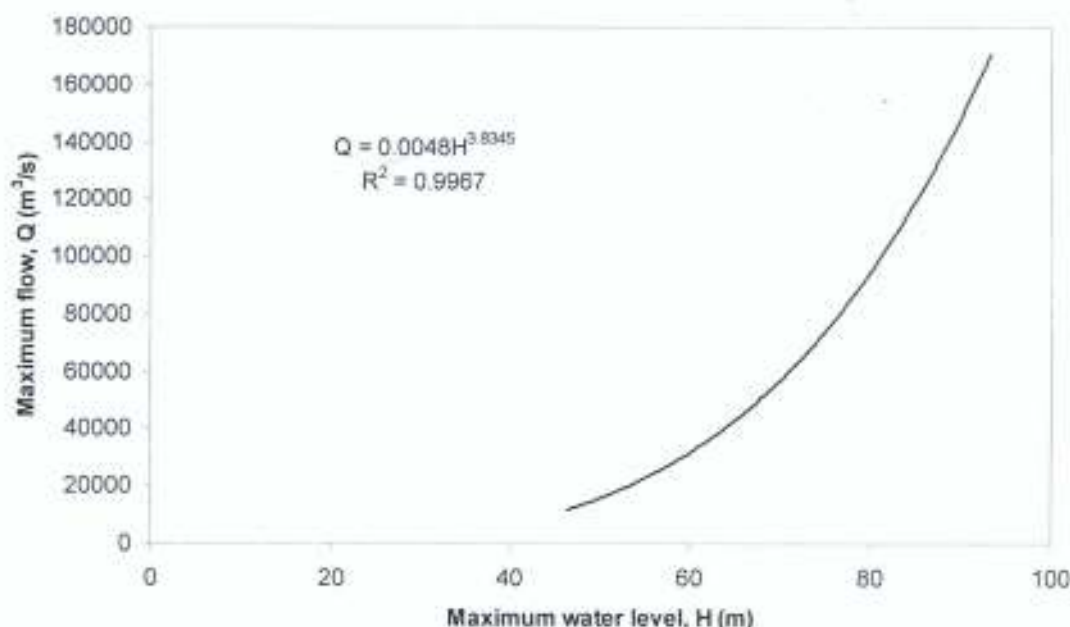


Figure 4.22: Rating curve of River Niger below Jebba Reservoir

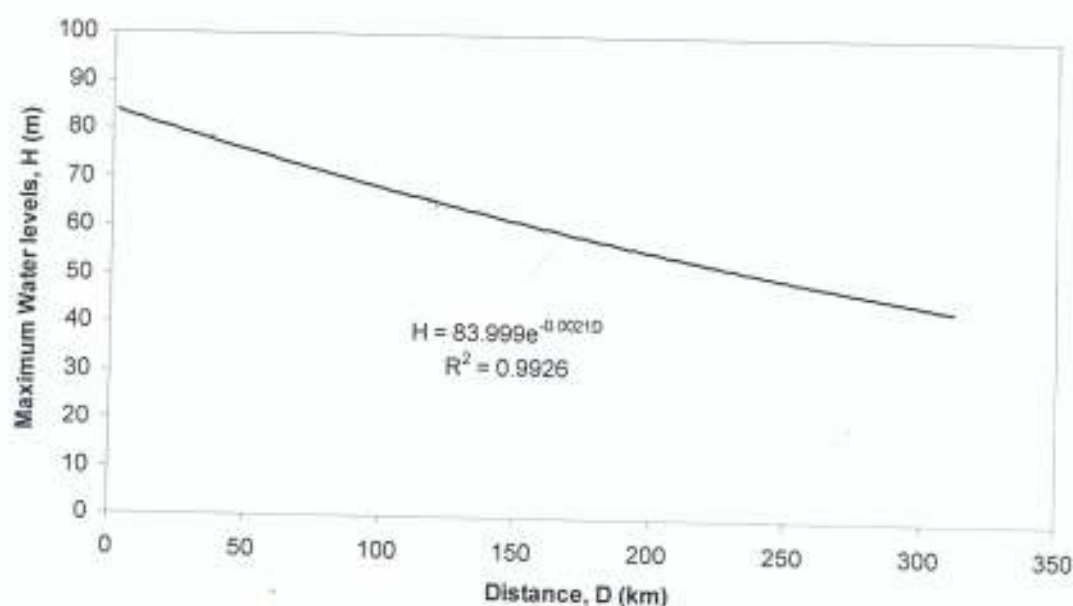


Figure 4.23: Profile of Maximum Water Levels along River Niger below Jebba Reservoir

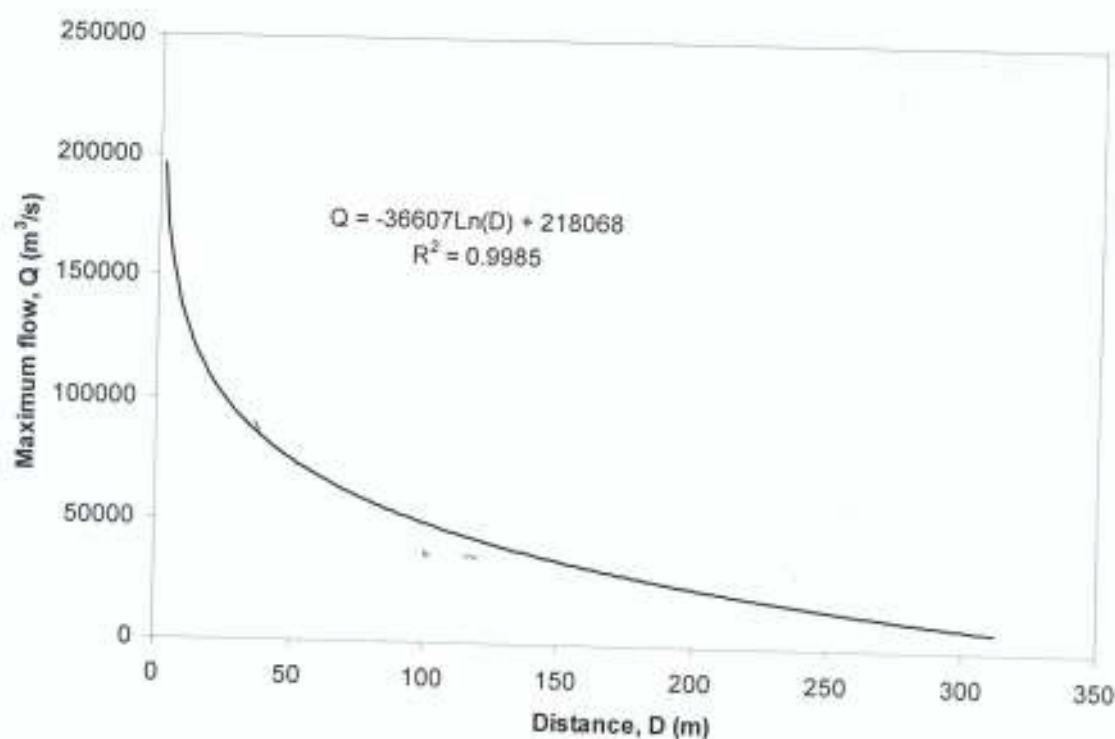


Figure 4.24: Profile of Maximum Flow along River Niger below Jebba Reservoir

From the assessment of environmental impact carried out, it was observed that the flow fluctuation of river Niger within the Lower Niger River Basin has a great impact on the people living within the flood plain of the River from Jebba to Lokoja and causes a lot of damages to the environments, Agriculture, industries, settlements and public utilities.

The flood plains experiences the problem of perennial flooding emanating from erratic water releases from the three dams namely Jebba and Kainji on River Niger and Shiroro on River Kaduna. This water over flows the riverbanks due to topography of the flood plain and this is more pronounced in the area close to Jebba with flat topography while away from Jebba, the river channel becomes narrower and hilly from Abugi to Lokoja.

4.6 Evaluation of Model Prediction against Observed Discharge

Based on the observation that the Gumbel model gave the best result, among the 3 models used for this study, it was applied to simulating the peak reservoir inflow for the study site and the results are presented in figures available data to generate a model

$$Q_p = Q_w + SD(0.78Y_T - 0.45)$$

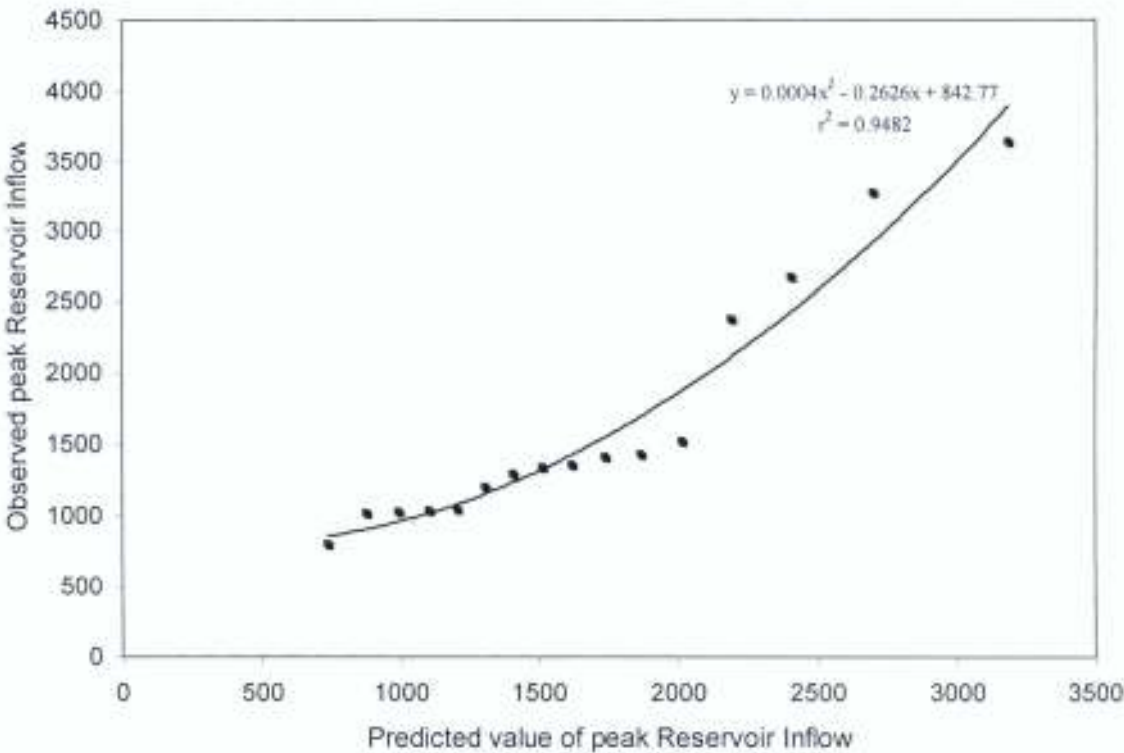


Figure 4.25: Observed Peak Reservoir Inflow against the predicted value using Gumbel model

4.7 Annual and partial duration series for runoff (discharge) events at Lokoja

From table 4.4, the highest discharge of 3275m³/sec was recorded in 1994 flood year, taking this discharge as datum level it would be observed that at Baro, flood occurred in many years, this may be due to water from River Kaduna.

In case of Lokoja, the only period is 1980; this may be due to terrene which can accommodate more flood water as storage.

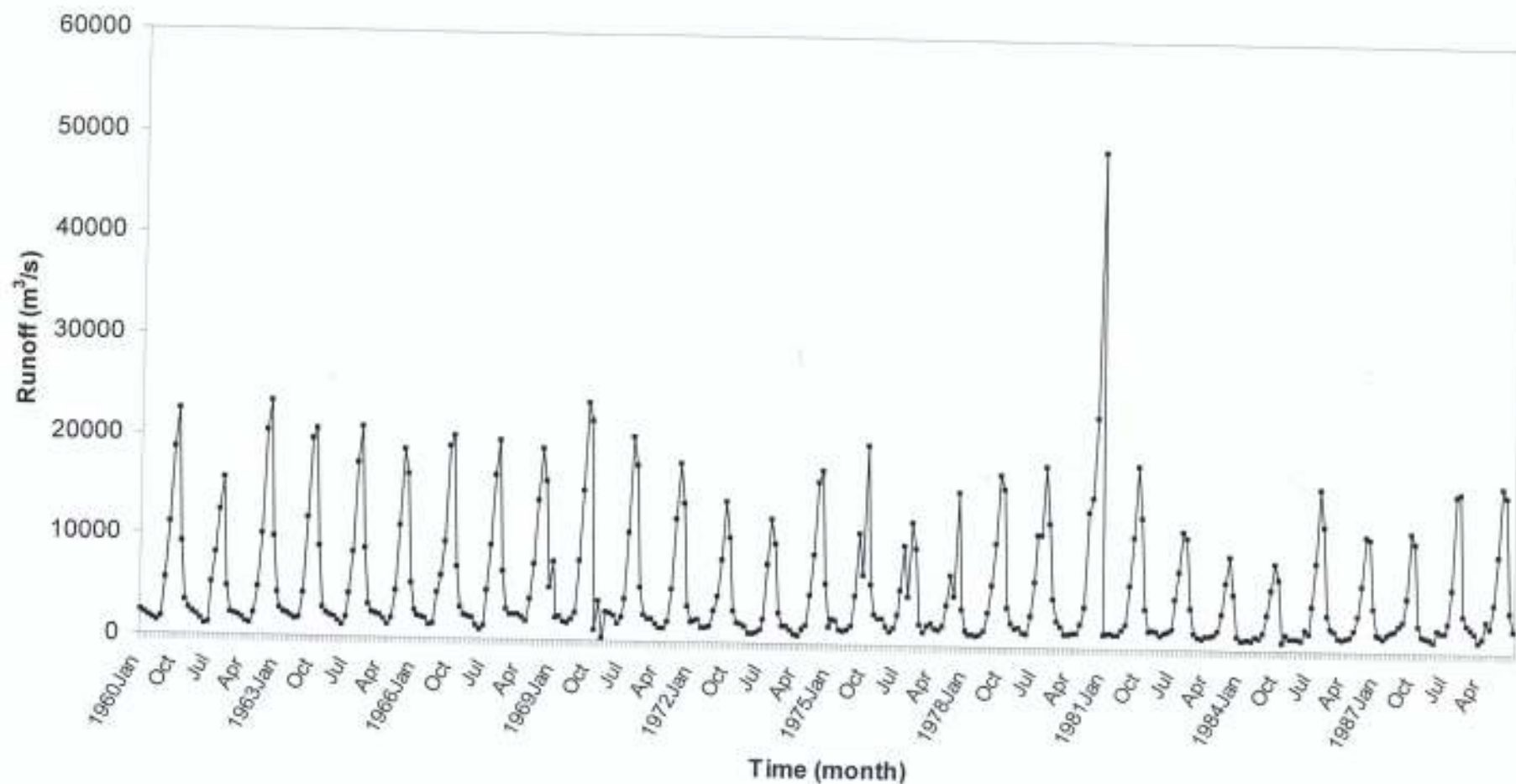


Figure 4.26: Annual and partial duration series for runoff (discharge) events at Lokoja

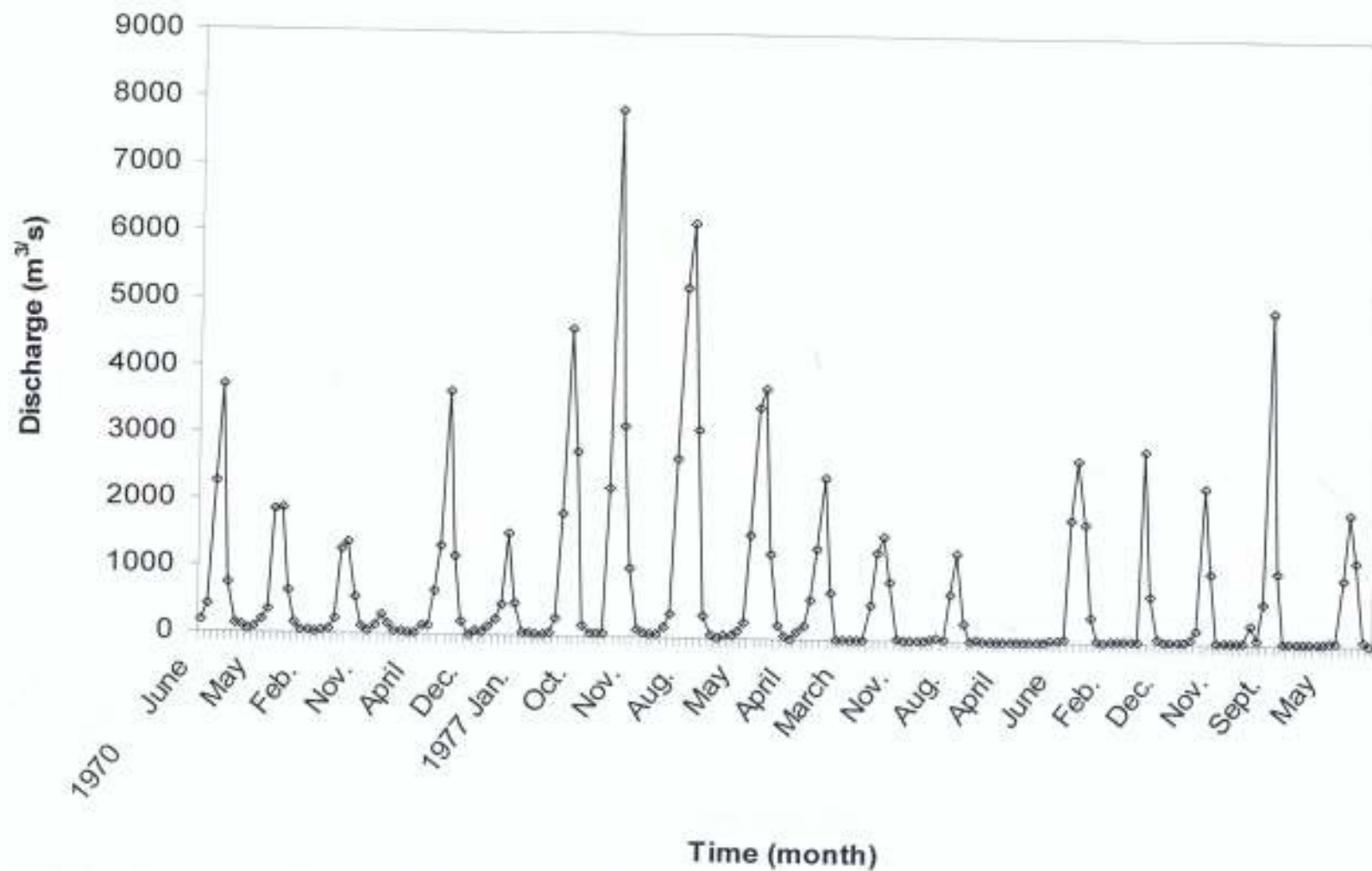


Figure 4.27: Annual and partial duration series for runoff (discharge) events at Wuya

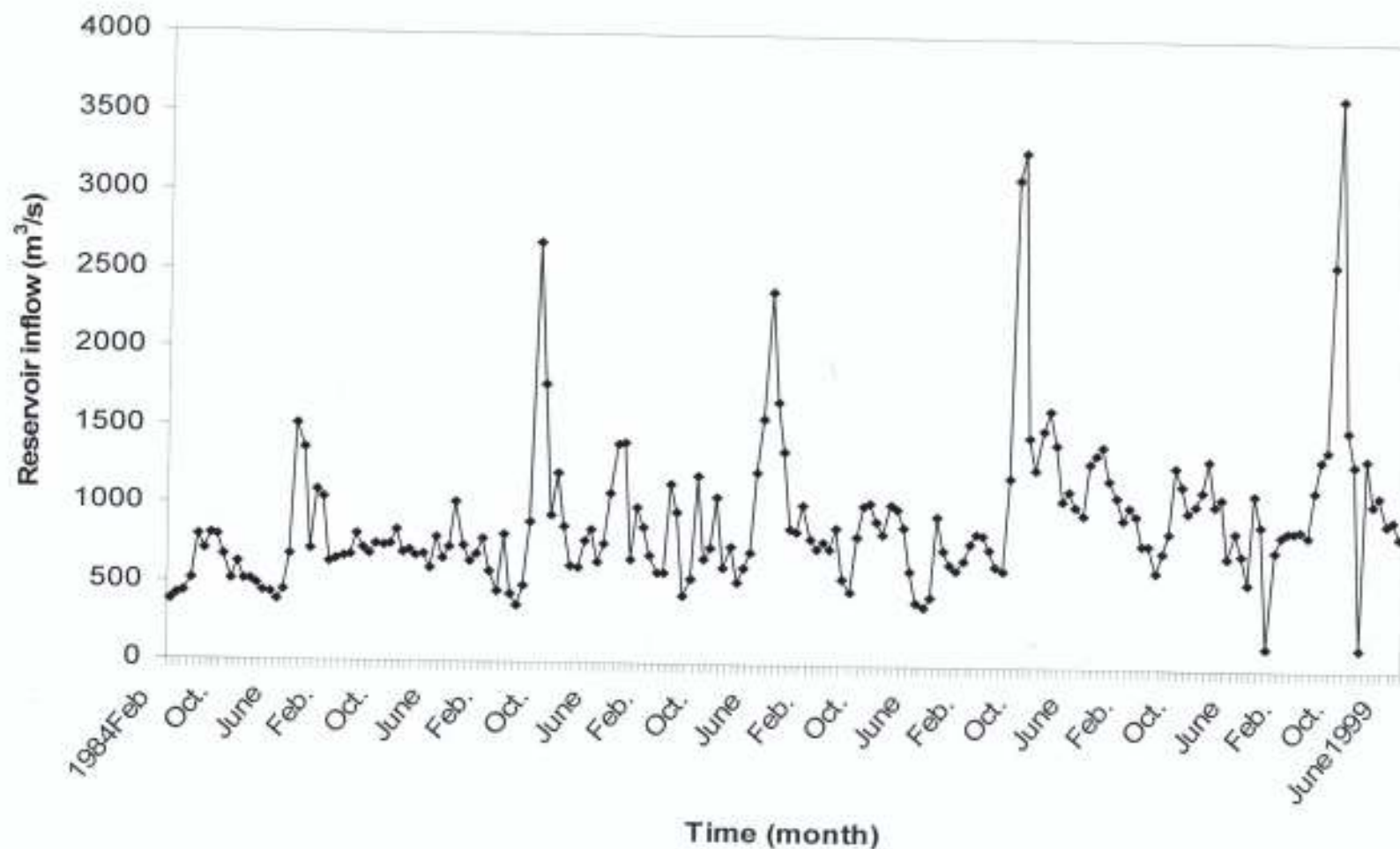


Figure 4.28: Annual and partial duration series for runoff (discharge) events at Jebba

CHAPTER FIVE

CONCLUSIONS AND RECOMMENDATIONS

5.1 Conclusions

Various plotting positions and probability distributions have been fitted to the available discharge records of River Niger. None of the methods used is generally ideal for the entire stretch of Rivers Niger and Kaduna. This may be due to variable drainage and weather condition, and uncontrolled release of water from the dams. This confirm Benjamin et.al's statement that because of the dam upstream, the stream flow will not be homogenous.

All the models have been examined evaluated by two statistical methods, viz coefficient of correlation and determination. Gumbel distribution is preferred to the among the 3 models for peak average reservoir inflow and peak discharge at River Kaduna at Wuya. Log Normal is suitable for peak discharge (runoff) of river Niger at Lokoja and peak discharge at Baro.

Flood is a natural phenomenon, that occur from time to time and may not be preventable but the frequency of flooding along Lower Niger Basin is due to erratic release of water from Shiroro, Kainji and Jebba dams which flow down to Lokoja. This is more pronounced since 1983 when Jebba dam was constructed and reduced flood cycle from 10 years to annual or bi-annual flooding. This study will serve as a guide to government and the operators of the dams for reducing or preventing loss of life and properties along flood plains or giving adequate warning on the occurrence of flood.

5.2 Recommendations

Since flood frequency occurrence within the lower river basin is mainly "man-induced", the rate could be reduced by control release of water from the reservoir and also with adequate information to the down stream users, improper operation of the dams have led to occurrence of extreme water levels in the river channel, therefore flood forecast should be adequate and precise. Therefore, the following recommendation are advanced based on observation from this study:

- ♣ A body should be set up to synchronize the release of water from the three Hydropower stations.
- ♣ The recent award of dredging of River Niger to Baro is a bold and wise decision of Federal Government, but it would be better if the job allow the flood water to be stored in the river channel.
- ♣ Proper land use and watershed management is also very important in flood control and may result in substantial change in run-off conditions and time of accumulation; careful selection of cultivation method in agricultural areas can reduce run-off volume.
- ♣ Lastly, non-structural method of flood control and proper flood plain mapping should be carried out along Lower Niger flood plain. Permanent structures like sugar factory should not be allowed to be established very close or at river “bottom land” but the land can only be used for grazing and other short duration crops. Preventive measure (flood plains development and regulations) involves the reduction of flood water by altering the human activities rather than physical forces of flooding (Smith et al 1999).

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APPENDIX 1

PEAK TURBINE RELEASE AT JEBBA (1984 2001) (m3/s)

LOG - GUMBEL

MONTH	YEAR	DISCHARGE (m3/s)	X=Log(Ro)	Rank (m)	Tr= N+1/m	P=1/Tr	yT=-ln[-ln(1-P)]	Qp=Qav+SD*(0.78yT-0.45)	Qp
AUG	1984	869.0	2.9390	18	1.06	0.95	-1.08	2.96	914.01
SEPT	1985	1502.0	3.1767	7	2.71	0.37	0.76	3.08	1211.82
JAN	1986	1025.0	3.0107	16	1.19	0.84	-0.61	3.08	1211.82
SEPT	1987	919.0	2.9633	17	1.12	0.89	-0.81	2.99	990.38
OCT	1988	1816.0	3.2596	4	4.75	0.21	1.44	3.25	1768.13
OCT	1989	1466.0	3.1661	8	2.38	0.42	0.60	3.15	1418.93
SEPT	1990	1163.0	3.0856	13	1.46	0.69	-0.14	3.07	1167.68
AUG	1991	2332.0	3.3677	2	9.50	0.11	2.20	3.33	2150.46
JAN	1992	1072.0	3.0302	14	1.36	0.74	-0.29	3.06	1123.74
MAR	1993	1058.0	3.0245	15	1.27	0.79	-0.44	3.03	1079.29
OCT	1994	3267.0	3.5141	1	19.00	0.05	2.92	3.41	2596.25
FEB	1995	1643.0	3.2156	5	3.80	0.26	1.19	3.22	1651.67
OCT	1996	1181.0	3.0722	12	1.58	0.63	0.00	3.08	1212.29
FEB	1997	1229.0	3.0896	11	1.73	0.58	0.15	3.10	1258.60
SEPT	1998	1451.0	3.1617	9	2.11	0.47	0.44	3.13	1390.59
OCT	1999	1856.0	3.2686	3	6.33	0.16	1.75	3.28	1919.50
JAN	2000	1575.0	3.1973	6	3.17	0.32	0.97	3.19	1560.75
JAN	2001	1436.0	3.1572	10	1.90	0.53	0.29	3.12	1307.64

AVERAGE 3.15
 STD. DEVIATION 0.16
 SKEW 0.85
 COR COEF(r) 0.9710

PEAK TURBINE RELEASE AT JEBBA (1984-2001)

GUMBEL Distribution

MONTH	YEAR	DISCHARGE (m ³ /s)	Rank (m)	$T_r = N+1/m$	$P=1/T_r$	$y_T = -\ln[-\ln(1-P)]$	$Q_p = Q_{av} + SD * (0.78y_T - 0.45)$
AUG	1984	869.0	18	1.06	0.95	-1.08	743.77
SEPT	1985	1502.0	7	2.71	0.37	0.78	1231.68
JAN	1986	1025.0	16	1.19	0.84	-0.61	1231.68
SEPT	1987	919.0	17	1.12	0.89	-0.81	865.04
OCT	1988	1818.0	4	4.75	0.21	1.44	1883.30
OCT	1989	1466.0	8	2.38	0.42	0.60	1504.63
SEPT	1990	1163.0	13	1.46	0.68	-0.14	1167.48
AUG	1991	2332.0	2	9.50	0.11	2.20	2223.92
JAN	1992	1072.0	14	1.36	0.74	-0.29	1101.14
MAR	1993	1058.0	15	1.27	0.79	-0.44	1031.31
OCT	1994	3267.0	1	19.00	0.05	2.92	2549.82
FEB	1995	1643.0	5	3.80	0.26	1.19	1767.60
OCT	1996	1181.0	12	1.58	0.63	0.00	1232.34
FEB	1997	1229.0	11	1.73	0.58	0.15	1297.20
SEPT	1998	1451.0	9	2.11	0.47	0.44	1432.00
OCT	1999	1856.0	3	6.33	0.16	1.76	2027.36
JAN	2000	1575.0	6	3.17	0.32	0.97	1669.44
JAN	2001	1436.0	10	1.90	0.53	0.29	1363.33
AVERAGE		1492.33					
STD. DEVIA		579.23					
SKEW		1.87					
COR COEF		0.9424					

Source: Jebba Hydro-power Station

PEAK TURBINE RELEASE AT JE98A (1984-2001) (m³/s)

LOG-PEARSON DISTRIBUTION

MONTH	YEAR	DISCHARGE (m ³ /s)	X=Log(Q)	Rank (m)	Tr = N+1/m	P=1/Tr	K	LogQb=Xav+3D _x *K	Qp
AUG	1984	880.0	3.9390	18	1.06	0.93	-1.43	2.94	872.08
SEPT	1985	1833.0	3.1797	7	2.71	0.37	0.34	3.20	1575.22
JAN	1986	1025.0	3.0107	16	1.19	0.84	-1.03	3.00	1008.02
SEPT	1987	919.0	3.9333	17	1.12	0.89	-0.97	3.01	1016.62
OCT	1988	1818.0	3.2583	4	4.75	0.21	0.23	3.26	1828.53
OCT	1989	1498.0	3.1851	8	2.38	0.42	0.16	3.17	1481.19
SEPT	1990	1100.0	3.0438	13	1.45	0.69	-0.73	3.04	1105.36
AUG	1991	2330.0	3.3677	2	9.50	0.11	1.30	3.34	2179.71
JAN	1992	1072.0	3.0302	14	1.56	0.74	-0.79	3.04	1036.90
MAR	1993	1000.0	3.0045	15	1.27	0.79	-0.79	3.10	1233.34
OCT	1994	5067.0	3.5141	1	19.00	0.05	1.59	3.42	2639.36
FEB	1995	1643.0	3.2159	5	3.80	0.26	0.61	3.04	1735.93
OCT	1996	1181.0	3.0722	12	1.58	0.63	-0.47	3.08	1202.64
FEB	1997	1229.0	3.0926	11	1.73	0.58	-0.34	3.10	1200.11
SEPT	1998	1451.0	3.1617	9	2.11	0.47	-0.04	3.14	1391.76
OCT	1999	1896.0	3.2838	3	6.33	0.16	1.12	3.31	2047.10
JAN	2000	1579.0	3.1973	6	3.17	0.32	0.52	3.22	1677.56
JAN	2001	1436.0	3.1572	10	1.90	0.53	-0.22	3.14	1435.10
AVERAGE			3.15						
STD. DEVIATION			0.16						
SKEW			0.65						
COR COEF(r)			0.9598						

PEAK DISCHARGE AT WUYA (m³/S)

GUMBEL DISTRIBUTION

MONTH	YEAR	DISCHARGE (m ³ /s)	Rank (m)	Tr= N+1/m	P=1/Tr	y _T =-ln[-ln(1-P)]	Q _p =Q _{av} +SD*(0.78y _T -0.45)
SEPT	1970	3706.0	6	3.17	0.32	0.97	3628.99
SEPT	1971	1875.0	13	1.46	0.68	-0.14	1973.53
SEPT	1972	1359.0	16	1.19	0.84	-0.61	1271.97
JUL	1973	289.0	18	1.06	0.95	-1.08	576.14
SEPT	1974	3639.0	7	2.71	0.37	0.78	3343.82
OCT	1975	1512.0	15	1.27	0.79	-0.44	1524.43
SEPT	1976	4595.0	4	4.75	0.21	1.44	4334.30
SEPT	1977	7853.0	1	19.00	0.05	2.92	6532.47
SEPT	1978	6187.0	2	9.50	0.11	2.20	5457.66
SEPT	1979	3724.0	5	3.80	0.26	1.19	3952.72
SEPT	1980	2411.0	10	1.90	0.53	0.29	2619.45
SEPT	1981	1534.0	14	1.36	0.74	-0.29	1754.73
SEPT	1982	1311.0	17	1.12	0.89	-0.81	976.08
SEPT	1983	2701.0	9	2.11	0.47	0.44	2845.93
SEPT	1984	2869.0	8	2.38	0.42	0.60	3085.44
SEPT	1985	2316.0	11	1.73	0.58	0.15	2401.35
SEPT	1986	4966.0	3	6.33	0.16	1.76	4809.40
SEPT	1987	1961.0	12	1.58	0.63	0.00	2187.45
AVERAGE		3044.89					
STD. DEVIA		1910.30					
SKEW		1.07					
COR COEF		0.9880					

PEAK DISCHARGE AT WUJA (m³/S)

LOG - PEARSON DISTRIBUTION

MONTH	YEAR	DISCHARGE (m ³ /s)	X*Log(Qp)	Rank (m)	Tp= N+1/m	P=1/Tp	K	LogQp=X*Log+SD*Z	Qp
SEPT	1970	3706.0	3.8909	6	3.03	0.33	0.33	3.50	3193.79
SEPT	1971	1875.0	3.2730	13	1.33	0.72	-0.93	3.12	1774.27
SEPT	1972	1359.0	3.1011	16	1.13	0.89	-1.21	3.00	1111.65
JUL	1973	269.0	2.4609	18	1.00	1.00	1.45	3.86	7116.23
SEPT	1974	3429.0	3.5610	7	2.67	0.39	0.22	3.49	3114.55
OCT	1975	1510.0	3.1786	15	1.20	0.83	-1.14	3.02	1049.19
SEPT	1976	4525.0	3.6823	4	4.50	0.22	0.70	3.82	4183.91
SEPT	1977	7053.0	3.9010	1	16.00	0.03	1.21	3.78	6054.62
SEPT	1978	6167.0	3.7315	2	8.00	0.11	1.09	3.73	5407.35
SEPT	1979	3716.0	3.5710	3	3.60	0.28	0.51	3.55	3037.15
SEPT	1980	2411.0	3.3322	10	1.63	0.59	-0.37	3.27	1893.27
SEPT	1981	1534.0	3.1658	14	1.29	0.76	-1.00	3.07	1154.92
SEPT	1982	1311.0	3.1178	17	1.05	0.94	-2.14	2.60	409.36
SEPT	1983	2701.0	3.4316	9	2.00	0.50	1.24	3.76	6229.37
SEPT	1984	2909.0	3.4577	8	2.25	0.44	0.00	3.38	2490.60
SEPT	1985	2316.0	3.3547	11	1.54	0.61	-0.51	3.22	1676.77
SEPT	1986	4966.0	3.6960	3	6.00	0.17	0.82	3.80	4578.72
SEPT	1987	1961.0	3.2825	12	1.41	0.67	-0.68	3.17	1473.93

AVERAGE	3.39
STD. DEVIATION	0.33
SKEW	-1.16
COR COEF(r)	0.6049

PEAK DISCHARGE AT WUYA (m³/S)

LOG-GUMBEL DISTRIBUTION

MONTH	YEAR	DISCHARGE (m ³ /s)	X=Log(Qo)	Rank (m)	Tr= N+1/m	P=1/Tr	yT=-ln[-ln(1-P)]	Qp=Qav+SD*(0.78yT-0.45)	Qp
SEPT	1970	3706.0	3.5689	6	3.17	0.32	0.97	3.49	3087.99
SEPT	1971	1875.0	3.2730	13	2.38	0.42	0.61	3.40	2503.31
SEPT	1972	1359.0	3.1332	16	1.94	0.52	0.32	3.33	2114.25
JUL	1973	289.0	2.4609	18	1.72	0.58	0.14	3.28	1903.36
SEPT	1974	3639.0	3.5610	7	4.43	0.23	1.36	3.59	3886.75
OCT	1975	1512.0	3.1796	15	2.07	0.48	0.41	3.35	2232.40
SEPT	1976	4595.0	3.6623	4	7.75	0.13	1.98	3.75	5571.52
SEPT	1977	7853.0	3.8950	1	31.00	0.03	3.42	4.11	12905.13
SEPT	1978	6187.0	3.7915	2	15.50	0.06	2.71	3.93	8524.91
SEPT	1979	3724.0	3.5710	5	8.20	0.16	1.74	3.68	4838.55
SEPT	1980	2411.0	3.3822	10	3.10	0.32	0.94	3.48	3041.55
SEPT	1981	1534.0	3.1858	14	2.21	0.45	0.51	3.37	2361.33
SEPT	1982	1311.0	3.1178	17	1.82	0.55	0.23	3.30	2005.07
SEPT	1983	2701.0	3.4315	9	3.44	0.29	1.07	3.52	3276.11
SEPT	1984	2869.0	3.4577	8	3.88	0.26	1.21	3.55	3552.79
SEPT	1985	2316.0	3.3647	11	2.82	0.35	0.82	3.45	2838.96
SEPT	1986	4966.0	3.6960	3	10.33	0.10	2.28	3.82	6659.79
SEPT	1987	1961.0	3.2925	12	2.58	0.39	0.71	3.43	2661.25

AVERAGE	3.39
STD. DEVIATION	0.33
SKEW	-1.16
COR COEF(r)	0.9499

PEAK DISCHARGE AT WUYA (m³/s)

LOG-NORMAL DISTRIBUTION

MONTH	YEAR	DISCHARGE (m ³ /s)	X=Log(Qo)	Rank (m)	Tr= N+1/m	P=1/Tr	K	LogQp=Xav+SD.*K	Qp
SEPT	1970	3708.0	3.5669	8	3.00	0.33	0.44	3.53	3111.94
SEPT	1971	1875.0	3.2730	13	1.38	0.72	-0.56	3.20	1590.91
SEPT	1972	1359.0	3.1332	16	1.13	0.89	-1.23	2.90	976.40
JUL	1973	289.0	2.4609	18	1.00	1.00	2.33	4.15	14057.52
SEPT	1974	3639.0	3.5610	7	2.57	0.39	0.25	3.48	3022.20
OCT	1975	1512.0	3.1769	15	1.20	0.83	-0.92	3.09	1293.35
SEPT	1976	4595.0	3.6623	4	4.50	0.22	0.77	3.64	4378.10
SEPT	1977	7053.0	3.8450	1	18.00	0.06	1.57	3.60	7809.45
SEPT	1978	8187.0	3.7915	2	9.00	0.11	0.98	3.71	5100.00
SEPT	1979	3724.0	3.5710	5	3.60	0.28	0.55	3.55	3791.55
SEPT	1980	2411.0	3.3822	10	1.50	0.68	-0.15	3.54	2189.92
SEPT	1981	1534.0	3.1853	14	1.29	0.78	-0.77	3.14	1377.68
SEPT	1982	1311.0	3.1178	17	1.03	0.94	-1.57	2.88	759.05
SEPT	1983	2751.0	3.4315	9	2.00	0.50	0.00	3.39	2456.11
SEPT	1984	2749.0	3.4377	8	2.25	0.44	0.15	3.44	2756.30
SEPT	1985	2316.0	3.3647	11	1.00	0.91	-0.28	3.30	1995.08
SEPT	1986	4989.0	3.6960	3	6.00	0.17	0.06	3.73	6036.95
SEPT	1987	1931.0	3.2920	12	1.50	0.67	-0.44	3.25	1798.05
AVERAGE			3.38						
STD. DEVIATION			0.33						
SKEW			-1.15						
COR. COEF(r)			0.2209						

PEAK DISCHARGE AT BARO (m³/S)

GUMBEL DISTRIBUTION

MONTH	YEAR	DISCHARGE (m ³ /s)	Rank (m)	Tr= N+1/m	P=1/Tr	y _r =-ln[-ln(1-P)]	Q _p =Q _{av} +SD*(0.78y _r -0.45)
OCT	1961	4746.0	15	1.93	0.52	0.32	4565.70
OCT	1962	7548.0	1	29.00	0.03	3.35	7731.36
OCT	1963	5996.0	6	4.83	0.21	1.46	5760.65
SEPT	1964	6809.0	2	14.50	0.07	2.64	6989.00
SEPT	1965	5508.0	9	3.22	0.31	0.99	5268.12
SEPT	1966	6173.0	4	7.25	0.14	1.91	6226.03
OCT	1967	6601.0	3	9.67	0.10	2.21	6546.36
AUG	1968	5766.0	8	3.63	0.28	1.13	5415.06
SEPT	1969	5999.0	5	5.80	0.17	1.66	5972.40
SEPT	1970	5235.0	13	2.23	0.45	0.52	4777.15
SEPT	1971	5357.0	11	2.64	0.38	0.74	5007.54
SEPT	1972	3564.0	23	1.26	0.79	-0.45	3760.14
SEPT	1973	3414.0	25	1.16	0.86	-0.68	3521.10
SEPT	1974	5377.0	10	2.90	0.34	0.86	5133.14
SEPT	1975	4451.0	19	1.53	0.66	-0.06	4169.22
OCT	1976	3739.0	22	1.32	0.76	-0.35	4234.67
SEPT	1977	3540.0	24	1.21	0.83	-0.56	4234.67
SEPT	1978	4576.0	17	1.71	0.59	0.13	4365.28
SEPT	1979	5855.0	7	4.14	0.24	1.29	5577.52
SEPT	1980	4698.0	16	1.81	0.55	0.22	4464.54
SEPT	1981	2529.0	27	1.07	0.93	-0.98	3207.91
SEPT	1982	1770.0	28	1.04	0.97	-1.21	2967.33
SEPT	1983	4247.0	21	1.38	0.72	-0.25	3970.60
OCT	1984	5327.0	12	2.42	0.41	0.63	4889.38
SEPT	1985	2842.0	26	1.12	0.90	-0.82	3379.55
SEPT	1986	4470.0	18	1.61	0.62	0.03	4267.11
OCT	1987	4355.0	20	1.45	0.69	-0.16	4070.72
SEPT	1988	4941.0	14	2.07	0.48	0.42	4669.60

AVERAGE	4836.89
STD. DEVIA	1338.27
SKEW	-0.28
COR COEF	0.9585

PEAK DISCHARGE AT BARO (m³/s)

LOG - PEARSON DISTRIBUTION

MONTH	YEAR	DISCHARGE (m ³ /s)	X=Log(Qp)	Rank (m)	T=N+1/m	P=1/T	K'	LogQp=Xav+SD _x *K'	Qp
OCT	1961	4748.0	3.6763	15	1.03	0.92	0.13	3.69	4820.70
OCT	1962	7548.0	3.8776	1	29.00	0.03	1.23	3.85	7087.58
OCT	1963	5890.0	3.7779	6	4.83	0.21	0.82	3.75	6225.37
SEPT	1964	8808.0	3.8331	2	14.80	0.07	1.18	3.83	8761.69
SEPT	1965	5505.0	3.7410	9	3.22	0.31	0.61	3.75	5819.18
SEPT	1966	6173.0	3.7905	4	7.05	0.14	1.04	3.81	6452.64
OCT	1967	6501.0	3.8159	3	9.67	0.10	1.08	3.82	6852.72
AUG	1968	5795.0	3.7609	8	3.53	0.28	0.67	3.76	5737.80
SEPT	1969	5999.0	3.7781	5	5.80	0.17	0.90	3.76	6207.56
SEPT	1970	6235.0	3.7182	13	2.23	0.45	0.30	3.71	5095.88
SEPT	1971	5357.0	3.7283	11	2.84	0.35	0.46	3.73	5353.94
SEPT	1972	3504.0	3.5519	23	1.28	0.78	-1.41	3.47	2947.46
SEPT	1973	3414.0	3.5333	25	1.16	0.86	-0.03	3.65	4551.86
SEPT	1974	8377.0	3.7305	10	2.80	0.34	0.54	3.74	8503.60
SEPT	1975	4451.0	3.6485	19	1.53	0.66	-0.30	3.62	4204.93
OCT	1976	3739.0	3.5728	22	1.30	0.76	-0.61	3.56	3809.15
SEPT	1977	3540.0	3.5490	24	1.21	0.83	0.35	3.71	5177.58
SEPT	1978	4576.0	3.6605	17	1.71	0.59	0.01	3.67	4637.57
SEPT	1979	5655.0	3.7675	7	4	0.24	0.76	3.77	5898.50
SEPT	1980	4698.0	3.6719	16	1.81	0.55	0.04	3.77	5898.50
SEPT	1981	2529.0	3.4029	27	1.07	0.93	-2.39	3.33	2193.64
SEPT	1982	1770.0	3.2480	28	1.04	0.97	-2.80	3.26	1631.43
SEPT	1983	4247.0	3.6281	21	1.50	0.67	-0.46	3.60	3932.53
OCT	1984	5327.0	3.7285	12	2.42	0.41	0.39	3.72	5243.16
SEPT	1985	2642.0	3.4508	26	1.12	0.90	-2.00	3.39	2436.13
SEPT	1986	4470.0	3.6503	18	1.61	0.62	-0.16	3.64	4374.84
OCT	1987	4355.0	3.6390	20	1.45	0.69	-0.39	3.61	4091.93
SEPT	1988	4941.0	3.6938	14	2.07	0.48	0.24	3.70	4934.69

AVERAGE 1 3.67
 STD. DEVIATION 0.14
 SKEW -1.19
 COR COEF(r) 0.9407

PEAK DISCHARGE AT BARO (m³/s)

LOG - NORMAL DISTRIBUTION

MONTH	YEAR	DISCHARGE (m ³ /s)	X=Log(Qo)	Rank (m)	Tr= N+1/m	P=1/Tr	K	LogQp=Xav+SD _x *K	Qp
OCT	1961	4746.0	3.6763	15	1.93	0.52	-0.05	3.66	4551.61
OCT	1962	7548.0	3.8778	1	29.00	0.03	1.90	3.93	8495.94
OCT	1963	5996.0	3.7779	6	4.83	0.21	0.81	3.78	5990.83
SEPT	1964	6809.0	3.8331	2	14.50	0.07	1.50	3.87	7479.32
SEPT	1965	5508.0	3.7410	9	3.22	0.31	0.49	3.73	5419.46
SEPT	1966	6173.0	3.7905	4	7.25	0.14	1.09	3.82	6559.09
OCT	1967	6801.0	3.8196	3	9.67	0.10	1.28	3.84	6972.78
AUG	1968	5766.0	3.7609	8	3.63	0.28	0.56	3.74	5537.01
SEPT	1969	5999.0	3.7781	5	5.80	0.17	0.96	3.80	6293.66
SEPT	1970	5235.0	3.7189	13	2.23	0.45	0.13	3.68	4824.76
SEPT	1971	5357.0	3.7289	11	2.64	0.38	0.30	3.71	5101.22
SEPT	1972	3664.0	3.5519	23	1.26	0.79	-0.81	3.55	3575.25
SEPT	1973	3414.0	3.5333	25	1.16	0.86	-1.09	3.51	3266.55
SEPT	1974	5377.0	3.7305	10	2.90	0.34	0.41	3.72	5280.72
SEPT	1975	4451.0	3.6485	19	1.53	0.66	-0.41	3.61	4056.02
OCT	1976	3739.0	3.5728	22	1.32	0.76	-0.17	3.64	4382.83
SEPT	1977	3540.0	3.5490	24	1.21	0.83	-0.92	3.54	3447.09
SEPT	1978	4576.0	3.6605	17	1.71	0.59	-0.23	3.63	4304.94
SEPT	1979	5855.0	3.7675	7	4.14	0.24	0.70	3.76	5796.31
SEPT	1980	4896.0	3.6719	16	1.81	0.55	-0.13	3.65	4439.33
SEPT	1981	2529.0	3.4029	27	1.07	0.93	-1.50	3.46	2683.72
SEPT	1982	1770.0	3.2480	28	1.04	0.97	-1.90	3.40	2521.05
SEPT	1983	4247.0	3.6281	21	1.38	0.72	-0.58	3.58	3843.58
OCT	1984	5327.0	3.7265	12	2.42	0.41	0.23	3.70	4975.38
SEPT	1985	2842.0	3.4538	26	1.12	0.90	-1.28	3.49	3071.76
SEPT	1986	4470.0	3.6503	18	1.61	0.62	-0.30	3.62	4198.74
OCT	1987	4355.0	3.6390	20	1.45	0.69	-0.49	3.60	3952.17
SEPT	1988	4941.0	3.6938	14	2.07	0.48	0.05	3.67	4705.74

AVERAGE	3.67
STD. DEVIATION	0.14
SKEW	-1.19
COR COEF(r)	0.9625

PEAK DISCHARGE AT PARO (m³/s)

LOG-GUMBELL DISTRIBUTION

MONTH	YEAR	DISCHARGE (m³/s)	X=Log(Qo)	Rank (m)	T= N+1/m	P=1/T	yT=-ln[-ln(1-P)]	Qp=Qav+SD*(0.78yT-0.45)	Qp
SEPT	1961	4746.0	3.6763	15	1.93	0.52	0.72	3.64	4337.26
SEPT	1962	7548.0	3.8778	1	29.00	0.03	3.33	3.97	9250.87
OCT	1963	5996.0	3.7779	6	4.83	0.21	1.46	3.76	5772.66
SEPT	1964	6809.0	3.8331	2	14.50	0.07	2.64	3.89	7745.31
SEPT	1965	5539.0	3.7410	9	3.22	0.31	0.89	3.71	5131.09
SEPT	1966	6173.0	3.7905	4	7.25	0.14	1.91	3.81	6452.67
OCT	1967	6501.0	3.8196	3	9.67	0.10	2.21	3.84	6756.91
AUG	1968	5786.0	3.7639	8	3.63	0.28	1.13	3.73	5314.70
SEPT	1969	5999.0	3.7781	5	5.80	0.17	1.69	3.76	5072.69
SEPT	1970	6235.0	3.7183	13	2.23	0.45	0.82	3.66	4562.34
SEPT	1971	5357.0	3.7289	11	2.64	0.38	0.74	3.68	4620.91
SEPT	1972	3564.0	3.5519	23	1.26	0.79	-0.45	3.55	3576.87
SEPT	1973	3414.0	3.5333	25	1.16	0.86	-0.68	3.53	3378.02
SEPT	1974	5377.0	3.7305	10	2.90	0.34	0.88	3.70	4968.00
SEPT	1975	4451.0	3.6485	19	1.53	0.66	-0.06	3.60	3944.70
SEPT	1976	3739.0	3.5728	22	1.32	0.76	-0.35	3.60	4005.96
SEPT	1977	3540.0	3.5490	24	1.21	0.83	-0.58	3.60	4006.66
SEPT	1978	4576.0	3.6605	17	1.71	0.59	0.13	3.62	4171.10
SEPT	1979	5655.0	3.7575	7	4.14	0.24	1.29	3.74	5525.36
SEPT	1980	710.0	3.6719	16	1.81	0.55	0.22	3.63	4233.53
SEPT	1981	2621.0	3.4029	27	1.07	0.93	-0.98	3.50	3134.13
SEPT	1982	1770.0	3.2490	29	1.04	0.97	-1.21	3.47	2958.60
SEPT	1983	4247.0	3.6291	18	1.38	0.72	-0.25	3.59	3761.61
OCT	1984	6327.0	3.7915	12	2.42	0.41	0.63	3.67	4686.52
SEPT	1985	2642.0	3.4195	28	1.12	0.90	-0.82	3.51	3265.52
SEPT	1986	4470.0	3.6493	14	1.81	0.62	0.03	3.61	4038.19
OCT	1987	4351.0	3.6390	15	1.45	0.69	-0.16	3.59	3852.81
SEPT	1988	4911.0	3.6938	14	2.07	0.48	0.42	3.65	4448.44
MEAN			3.67						
STANDARD DEVIATION			0.14						
SKEW			0.15						
COR COEF(r)			0.10						

PEAK DISCHARGE AT BARO (m³/s)

LOG - PEARSON DISTRIBUTION

MONTH	YEAR	DISCHARGE (m³/s)	X=Log(Qo)	Rank (m)	T _r =N+1/m	P=1/T _r	K	LogQp=Xav+SD _x *K	Qp
OCT	1961	4748.0	3.6763	15	1.83	0.52			
OCT	1962	7348.0	3.8673	1	29.00	0.03	0.13	3.63	4833.70
OCT	1963	5996.0	3.7779	6	4.83	0.21	1.33	3.66	7067.58
SEPT	1964	6939.0	3.8331	2	14.50	0.07	0.62	3.78	6022.37
SEPT	1965	5508.0	3.7410	9	3.22	0.31	1.18	3.83	6791.69
SEPT	1966	6173.0	3.7905	4	7.25	0.14	0.91	3.75	5019.18
OCT	1967	6501.0	3.8135	3	9.67	0.10	1.04	3.81	6452.84
AUG	1968	5768.0	3.7609	8	3.63	0.28	1.03	3.82	6552.79
SEPT	1969	5399.0	3.7761	5	5.80	0.17	0.67	3.75	5737.30
SEPT	1970	5205.0	3.7199	13	3.23	0.46	0.92	3.79	6207.59
SEPT	1971	5357.0	3.7389	11	3.64	0.39	0.39	3.71	5099.56
SEPT	1972	3654.0	3.5619	23	1.26	0.79	0.46	3.73	5350.64
SEPT	1973	3414.0	3.5299	25	1.16	0.86	-1.41	3.47	2647.48
SEPT	1974	5377.0	3.7305	10	3.80	0.34	-0.03	3.68	4591.68
SEPT	1975	4451.0	3.6485	19	1.53	0.63	0.54	3.74	5503.60
OCT	1976	3739.0	3.5726	22	1.32	0.76	-0.30	3.62	4204.93
SEPT	1977	3540.0	3.5490	24	1.21	0.83	-0.61	3.58	3809.15
SEPT	1978	4076.0	3.6735	17	1.47	0.68	0.25	3.71	5177.58
SEPT	1979	5655.0	3.7575	7	4	0.24	0.01	3.57	4837.67
SEPT	1980	4898.0	3.6719	16	1.81	0.55	0.76	3.77	5698.50
SEPT	1981	2529.0	3.4029	27	1.07	0.93	0.04	3.57	4636.44
SEPT	1982	1770.0	3.2430	28	1.04	0.97	-2.39	3.33	1115.64
SEPT	1983	4247.0	3.6291	21	1.38	0.72	-2.60	3.29	1831.43
OCT	1984	5327.0	3.7263	12	2.42	0.41	-0.46	3.60	3982.50
SEPT	1985	2942.0	3.4596	26	1.12	0.90	0.29	3.72	5243.15
SEPT	1986	4470.0	3.6503	18	1.61	0.62	-2.00	3.39	2436.13
OCT	1987	4355.0	3.6390	20	1.45	0.69	-0.18	3.64	4374.81
SEPT	1988	4941.0	3.6938	14	2.07	0.48	-0.39	3.61	4081.95
							0.24	3.70	4934.69
AVERAGE			3.67						
STD. DEVIATION			0.14						
SKEW			-1.19						
COR COEF(r)			0.9457						

PEAK MONTHLY RUN-OFF OF RIVER NIGER AT LOKOJA (m³/S)

LOG-GUMBEL DISTRIBUTION

MONTH	YEAR	RUNOFF (m ³ /s)	X=Log(Qo)	Rank (m)	Tr= N+1/m	P=1/Tr	yT=-ln[-ln(1-P)]	Qp=Ray+SD*(0.78yT-0.45)	Qp
OCT	1960	22444.0	4.3511	4	7.75	0.13	1.98	4.34	21958.12
OCT	1961	15538.0	4.1914	21	1.48	0.68	-0.12	4.15	14098.22
OCT	1962	23312.0	4.3676	2	15.50	0.06	2.71	4.41	25599.87
SEPT	1963	19549.0	4.2911	10	3.10	0.32	0.94	4.25	17650.33
OCT	1964	20831.0	4.3187	5	6.20	0.16	1.74	4.32	20868.63
SEPT	1965	18614.0	4.2698	12	2.58	0.39	0.71	4.23	18819.82
OCT	1966	20085.0	4.3029	7	4.43	0.23	1.36	4.29	19282.94
OCT	1967	19732.0	4.2952	8	3.88	0.26	1.21	4.27	18667.85
SEPT	1968	18687.0	4.2762	11	2.82	0.35	0.82	4.24	17218.79
SEPT	1969	23537.0	4.3718	1	31.00	0.03	3.42	4.47	29730.69
SEPT	1970	20211.0	4.3056	6	5.17	0.19	1.54	4.30	20002.02
SEPT	1971	17623.0	4.2481	15	2.07	0.48	0.41	4.20	15786.70
SEPT	1972	13951.0	4.1446	23	1.35	0.74	-0.30	4.13	13573.51
SEPT	1973	12283.0	4.0893	24	1.29	0.77	-0.40	4.12	13307.26
OCT	1974	17164.0	4.2346	16	1.94	0.52	0.32	4.19	15480.01
OCT	1975	19681.0	4.2936	9	3.44	0.29	1.07	4.26	18129.80
OCT	1976	12100.0	4.0828	25	1.24	0.81	-0.50	4.12	13033.73
OCT	1977	15197.0	4.1818	22	1.41	0.71	-0.21	4.14	13836.19
SEPT	1978	17045.0	4.2316	17	1.82	0.55	0.23	4.18	15186.69
SEPT	1979	17870.0	4.2521	14	2.21	0.45	0.51	4.21	16109.75
OCT	1980	22808.0	4.3581	3	10.33	0.10	2.28	4.37	23418.08
SEPT	1981	17979.0	4.2548	13	2.38	0.42	0.61	4.22	16452.71
SEPT	1982	11538.0	4.0621	27	1.15	0.87	-0.72	4.09	12441.60
SEPT	1983	9130.0	3.9605	29	1.07	0.94	-1.01	4.07	11700.30
SEPT	1984	8536.0	3.9313	30	1.03	0.97	-1.23	4.05	11157.47
SEPT	1985	15913.0	4.2018	19	1.63	0.61	0.05	4.17	14630.00
SEPT	1986	11327.0	4.0541	28	1.11	0.90	-0.85	4.08	12101.71
SEPT	1987	11758.0	4.0703	26	1.19	0.84	-0.60	4.11	12747.78
OCT	1988	15657.0	4.1947	20	1.55	0.65	-0.04	4.16	14362.08
OCT	1989	16303.0	4.2123	18	1.72	0.58	0.14	4.17	14904.13

AVERAGE	4.21
STD. DEVIATION	0.12
SKEW	-0.81
COR COEF(r)	0.8485

PEAK MONTHLY RUN-OFF OF RIVER NIGER AT LOKOJA (m³/S)

LOG-NORMAL DISTRIBUTION

MONTH	YEAR	RUNOFF (m ³ /s)	X=Log(Qo)	Rank (m)	Tr= N+1/m	P+1.Tr	K	LogOp=Kln+SD _x *K	Qp
OCT	1960	22444.0	4.3511	4	7.75	0.13	1.17	4.35 22353.69	
OCT	1961	16538.0	4.1614	21	1.46	0.63	-0.47	4.16 14457.37	
OCT	1962	23312.0	4.3676	3	15.50	0.05	1.57	4.40 24385.05	
SEPT	1963	16546.0	4.2911	10	3.10	0.32	0.47	4.27 18532.16	
OCT	1964	20631.0	4.3157	5	6.20	0.16	1.00	4.33 21407.89	
SEPT	1965	16914.0	4.2088	12	2.58	0.39	0.23	4.26 17809.72	
OCT	1966	20395.0	4.3029	7	4.43	0.23	0.74	4.30 19045.11	
OCT	1967	19732.0	4.2882	8	3.85	0.38	0.54	4.29 18424.02	
SEPT	1968	18537.0	4.2762	11	2.82	0.35	0.39	4.28 18131.05	
SEPT	1969	23537.0	4.3713	1	31.00	0.03	1.80	4.44 27277.77	
SEPT	1970	20211.0	4.3066	6	5.17	0.19	0.89	4.32 20735.03	
SEPT	1971	17623.0	4.2461	15	2.07	0.48	0.05	4.22 16571.27	
SEPT	1972	12051.0	4.1446	23	1.35	0.74	-0.64	4.14 13745.64	
SEPT	1973	12263.0	4.0933	24	1.2	0.77	-0.63	4.12 13068.12	
OCT	1974	17164.0	4.2346	16	1.4	0.62	-0.09	4.21 18112.19	
OCT	1975	19861.0	4.2936	9	3.44	0.29	0.55	4.25 19577.77	
OCT	1976	12100.0	4.0829	25	1.24	0.81	-0.58	4.11 12382.93	
OCT	1977	15197.0	4.1818	22	1.41	0.71	-0.55	4.18 14064.13	
SEPT	1978	17048.0	4.2316	17	1.82	0.58	-0.13	4.20 16776.25	
SEPT	1979	17670.0	4.2521	14	2.21	0.45	0.13	4.23 18224.14	
OCT	1980	22908.0	4.3581	3	10.33	0.10	1.78	4.36 23039.90	
SEPT	1981	17879.0	4.2515	13	2.38	0.42	0.20	4.24 17250.54	
SEPT	1982	11536.0	4.0621	27	1.15	0.87	-1.14	4.06 12022.12	
SEPT	1983	9130.0	3.9505	29	1.07	0.94	-1.57	4.03 10686.57	
SEPT	1984	8036.0	3.9013	30	1.03	0.97	-1.90	3.99 9738.17	
SEPT	1985	12013.0	4.2018	19	1.83	0.61	-0.28	4.18 15162.05	
SEPT	1986	11027.0	4.0541	26	1.11	0.90	-1.28	4.09 11503.46	
SEPT	1987	11758.0	4.0709	26	1.15	0.94	-1.00	4.10 12472.01	
SEPT	1988	15657.0	4.1947	20	1.55	0.65	-0.39	4.17 14726.09	
SEPT	1989	16303.0	4.2123	18	1.72	0.63	-0.20	4.19 15172.37	

AVERAGE	4.21
STD. DEVIATION	0.32
SKEN	-0.31
COEFF OF (r)	0.9048

PEAK MONTHLY RUN-OFF OF RIVER NIGER AT LOKOJA (m³/s)

LOG - PEARSON DISTRIBUTION

MONTH	YEAR	RUNOFF (m ³ /s)	X=Log(Qo)	Rank (m)	Tr= N+1/m	P=1/Tr	K	LogQp=Xav+SD _x *K	Qo
OCT	1960	22444.0	4.3511	4	7.75	0.13	1.57	4.34	21634.25
OCT	1961	16529.0	4.1914	21	1.43	0.69	-0.42	4.18	14907.23
OCT	1962	23312.0	4.3679	2	15.50	0.06	1.35	4.37	23502.54
SEPT	1963	18549.0	4.2711	10	3.10	0.32	0.57	4.29	19039.89
OCT	1964	20831.0	4.3177	5	6.20	0.16	0.83	4.32	21006.33
SEPT	1965	18014.0	4.2538	12	2.83	0.35	0.40	4.25	18192.39
OCT	1966	20035.0	4.3029	7	4.43	0.23	0.71	4.31	20194.50
OCT	1967	19732.0	4.2952	8	3.89	0.26	0.71	4.30	19800.17
SEPT	1968	18667.0	4.2702	11	2.62	0.38	0.49	4.27	18372.85
SEPT	1969	23537.0	4.3718	1	31.00	0.03	1.53	4.33	21564.81
SEPT	1970	20211.0	4.3056	6	5.17	0.19	0.89	4.32	20764.26
SEPT	1971	17823.0	4.2491	15	1.77	0.48	0.18	4.23	17154.28
SEPT	1972	13951.0	4.1449	29	1.00	0.74	-0.63	4.14	13432.65
SEPT	1973	12283.0	4.0903	24	1.29	0.77	-0.69	4.13	12558.75
OCT	1974	17164.0	4.2349	16	1.94	0.52	0.07	4.22	16667.44
OCT	1975	19091.0	4.2838	9	3.44	0.29	0.64	4.28	19115.79
OCT	1976	12100.0	4.0828	25	1.24	0.61	-0.69	4.11	12344.58
OCT	1977	19197.0	4.1816	22	1.41	0.71	-0.51	4.15	14280.99
SEPT	1978	17045.0	4.2316	17	1.82	0.55	-0.02	4.21	16252.08
SEPT	1979	17870.0	4.2521	14	2.21	0.45	0.25	4.24	17495.62
OCT	1980	22639.0	4.3591	3	10.33	0.10	1.17	4.35	22399.73
SEPT	1981	17879.0	4.2548	13	2.30	0.42	0.33	4.25	17639.55
SEPT	1982	11538.0	4.0621	27	1.15	0.67	-1.59	4.03	10726.76
SEPT	1983	9130.0	3.9605	28	1.07	0.94	-2.14	3.96	8178.19
SEPT	1984	8536.0	3.9313	30	1.03	0.97	1.17	4.35	22332.73
SEPT	1985	15913.0	4.2016	19	1.85	0.61	-1.50	4.03	10720.88
SEPT	1986	11327.0	4.0541	26	1.11	0.60	-1.84	3.99	9504.05
SEPT	1987	11750.0	4.0703	26	1.19	0.74	-1.11	4.08	12097.05
SEPT	1988	10857.0	4.1647	20	1.05	0.65	-0.32	4.18	14870.79
SEPT	1989	18009.0	4.2123	18	1.72	0.58	-0.11	4.20	18099.59
AVERAGE			4.21						
STD. DEVIATION			0.12						
SKEW			-0.91						
COR COEF(r)			0.7019						

PEAK MONTHLY RUN-OFF OF RIVER NIGER AT LOKOJA (m³/s)

GUMBEL DISTRIBUTION

MONTH	YEAR	RUNOFF (m ³ /s)	Rank (m)	Tr= N+1/m	P=1/Tr	y _i =-ln[-ln(1-P)]	Qp=Qav+SD*(0.78y _i -0.45)
OCT	1960	22444.0	4	7.75	0.13	1.99	21414.28
OCT	1961	16538.0	21	1.48	0.63	-0.12	14624.80
OCT	1962	23312.0	2	15.50	0.06	2.71	23705.62
SEPT	1963	19549.0	10	3.10	0.32	0.94	18087.98
OCT	1964	20031.0	5	6.20	0.16	1.74	20634.49
SEPT	1965	19814.0	12	2.53	0.39	0.71	17329.56
OCT	1966	20055.0	7	4.43	0.23	1.36	19423.08
OCT	1967	19732.0	8	3.68	0.28	1.21	18925.90
SEPT	1968	19897.0	11	2.82	0.35	0.82	17688.91
SEPT	1969	23537.0	1	31.00	0.03	3.42	26057.84
SEPT	1970	20211.0	6	5.17	0.19	1.54	19284.53
SEPT	1971	17623.0	15	1.07	0.49	0.41	16352.13
SEPT	1972	13051.0	23	1.35	0.74	-0.30	14043.81
SEPT	1973	12283.0	24	1.29	0.77	-0.40	13740.00
OCT	1974	17164.0	16	1.24	0.52	0.32	16057.52
OCT	1975	19831.0	9	3.44	0.29	1.07	18478.88
OCT	1976	12100.0	25	1.24	0.81	-0.50	13421.81
OCT	1977	15197.0	22	1.41	0.71	-0.21	14337.32
SEPT	1978	17045.0	17	1.62	0.55	0.23	15764.39
SEPT	1979	17870.0	14	2.21	0.45	0.51	16066.53
OCT	1980	22808.0	3	10.33	0.10	2.29	22400.35
SEPT	1981	17979.0	13	2.38	0.42	0.61	16991.32
SEPT	1982	11538.0	27	1.15	0.87	-0.72	12709.37
SEPT	1983	9130.0	29	1.07	0.94	-1.01	11760.00
SEPT	1984	8538.0	30	1.03	0.97	-1.23	11040.12
SEPT	1985	16013.0	19	1.63	0.61	0.05	15102.14
SEPT	1986	11327.0	28	1.11	0.90	-0.85	12224.93
SEPT	1987	11758.0	26	1.19	0.84	-0.69	13001.80
OCT	1988	16057.0	20	1.15	0.65	-0.04	14908.93
OCT	1989	16303.0	18	1.12	0.58	0.14	15476.61
AVERAGE		16086.10					
STD. DEVIA		4139.32					
SKEW		-0.31					
CCR COEF		0.9543					

PEAK DISCHARGE AT BARO (m³/s)

LOG - NORMAL DISTRIBUTION

MONTH	YEAR	DISCHARGE (m ³ /s)	X=Log(Qo)	Rank (m)	Tr= N+1/m	P=1/Tr	K	LogQp=Xav+SD _x *K	Qp
OCT	1961	4748.0	3.6763	15	1.93	0.52	-0.05	3.66	4551.61
OCT	1962	7548.0	3.8778	1	29.00	0.03	1.90	3.93	8495.94
OCT	1963	5996.0	3.7779	6	4.83	0.21	0.81	3.78	5990.83
SEPT	1964	6809.0	3.8331	2	14.50	0.07	1.50	3.87	7479.32
SEPT	1965	5508.0	3.7410	9	3.22	0.31	0.49	3.73	5419.48
SEPT	1966	6173.0	3.7905	4	7.25	0.14	1.09	3.82	6558.09
OCT	1967	6801.0	3.8198	3	9.67	0.10	1.28	3.84	6972.78
AUG	1968	5766.0	3.7609	8	3.63	0.28	0.56	3.74	5537.01
SEPT	1969	5999.0	3.7781	5	5.80	0.17	0.96	3.80	6293.68
SEPT	1970	5235.0	3.7189	13	2.23	0.45	0.13	3.68	4824.76
SEPT	1971	5357.0	3.7289	11	2.64	0.38	0.30	3.71	5101.22
SEPT	1972	3564.0	3.5519	23	1.26	0.79	-0.81	3.55	3575.25
SEPT	1973	3414.0	3.5333	25	1.16	0.86	-1.09	3.51	3266.55
SEPT	1974	5377.0	3.7305	10	2.90	0.34	0.41	3.72	5280.72
SEPT	1975	4451.0	3.6485	19	1.53	0.66	-0.41	3.61	4056.02
OCT	1976	3739.0	3.5728	22	1.32	0.76	-0.17	3.64	4382.83
SEPT	1977	3540.0	3.5490	24	1.21	0.83	-0.92	3.54	3447.09
SEPT	1978	4576.0	3.6605	17	1.71	0.59	-0.23	3.63	4304.94
SEPT	1979	5855.0	3.7675	7	4.14	0.24	0.70	3.76	5798.31
SEPT	1980	4698.0	3.6719	16	1.81	0.55	-0.13	3.65	4439.33
SEPT	1981	2529.0	3.4029	27	1.07	0.93	-1.50	3.48	2863.72
SEPT	1982	1770.0	3.2480	28	1.04	0.97	-1.90	3.40	2521.05
SEPT	1983	4247.0	3.6281	21	1.38	0.72	-0.58	3.58	3843.58
OCT	1984	5327.0	3.7265	12	2.42	0.41	0.23	3.70	4975.38
SEPT	1985	2842.0	3.4536	26	1.12	0.90	-1.26	3.49	3071.76
SEPT	1986	4470.0	3.6503	18	1.61	0.62	-0.30	3.62	4198.74
OCT	1987	4355.0	3.6390	20	1.45	0.69	-0.49	3.60	3952.17
SEPT	1988	4941.0	3.6938	14	2.07	0.48	0.05	3.67	4705.74

AVERAGE	3.67
STD. DEVIATION	0.14
SKEW	-1.19
COR COEF(r)	0.9625

PEAK DISCHARGE AT BARO (m³/S)

LOG-GUMBEL DISTRIBUTION

MONTH	YEAR	DISCHARGE (m³/s)	X=Log(Qo)	Rank (m)	Tr= N+1/m	P=1/Tr	yT=-ln[-ln(1-P)]	Qp=Qav+SD*(0.78yT-0.45)	Qp
OCT	1961	4746.0	3.6763	15	1.93	0.52	0.32	3.64	4337.26
OCT	1962	7548.0	3.8776	1	29.00	0.03	3.35	3.97	9250.87
OCT	1963	5996.0	3.7779	6	4.83	0.21	1.46	3.76	5772.86
SEPT	1964	6809.0	3.8331	2	14.50	0.07	2.64	3.89	7745.31
SEPT	1965	5508.0	3.7410	9	3.22	0.31	0.99	3.71	5131.08
SEPT	1966	6173.0	3.7905	4	7.25	0.14	1.91	3.81	6452.87
OCT	1967	6601.0	3.8196	3	9.67	0.10	2.21	3.84	6986.91
AUG	1968	5766.0	3.7609	8	3.63	0.28	1.13	3.73	5314.70
SEPT	1969	5999.0	3.7781	5	5.80	0.17	1.66	3.78	6072.89
SEPT	1970	5235.0	3.7189	13	2.23	0.45	0.52	3.66	4562.34
SEPT	1971	5357.0	3.7289	11	2.64	0.38	0.74	3.68	4820.91
SEPT	1972	3564.0	3.5519	23	1.26	0.79	-0.45	3.55	3576.87
SEPT	1973	3414.0	3.5333	25	1.16	0.86	-0.68	3.53	3378.02
SEPT	1974	5377.0	3.7305	10	2.90	0.34	0.88	3.70	4968.00
SEPT	1975	4451.0	3.6485	19	1.53	0.66	-0.06	3.60	3944.70
OCT	1976	3739.0	3.5728	22	1.32	0.76	-0.35	3.60	4006.96
SEPT	1977	3540.0	3.5490	24	1.21	0.83	-0.56	3.60	4006.96
SEPT	1978	4576.0	3.6605	17	1.71	0.59	0.13	3.62	4134.16
SEPT	1979	5855.0	3.7675	7	4.14	0.24	1.29	3.74	5525.36
SEPT	1980	4698.0	3.6719	16	1.81	0.55	0.22	3.63	4233.53
SEPT	1981	2529.0	3.4029	27	1.07	0.93	-0.98	3.50	3134.13
SEPT	1982	1770.0	3.2480	28	1.04	0.97	-1.21	3.47	2958.80
SEPT	1983	4247.0	3.6281	21	1.38	0.72	-0.25	3.58	3761.61
OCT	1984	5327.0	3.7265	12	2.42	0.41	0.63	3.67	4686.52
SEPT	1985	2842.0	3.4536	26	1.12	0.90	-0.82	3.51	3265.52
SEPT	1986	4470.0	3.6503	18	1.61	0.62	0.03	3.61	4038.19
OCT	1987	4355.0	3.6390	20	1.45	0.69	-0.16	3.59	3852.81
SEPT	1988	4941.0	3.6938	14	2.07	0.48	0.42	3.65	4446.44

AVERAGE	3.67
STD. DEVIATION	0.14
SKEW	-1.19
COR COEF(r)	0.9168

PEAK MONTHLY RUN-OFF OF RIVER NIGER AT LOKOJA (m³/S)

LOG-GUMBEL DISTRIBUTION

MONTH	YEAR	RUNOFF (m ³ /s)	X=Log(Qo)	Rank (m)	Tr= N+1/m	P=1/Tr	yT=-ln[-ln(1-P)]	Qp=Rav+SD*(0.7ByT-0.45)	Qp
OCT	1960	22444.0	4.3511	4	7.75	0.13	1.98	4.34	21958.12
OCT	1961	15536.0	4.1914	21	1.48	0.68	-0.12	4.15	14098.22
OCT	1962	23312.0	4.3676	2	15.50	0.06	2.71	4.41	25599.87
SEPT	1963	19549.0	4.2911	10	3.10	0.32	0.94	4.25	17650.33
OCT	1964	20831.0	4.3187	5	6.20	0.16	1.74	4.32	20868.63
SEPT	1965	18614.0	4.2698	12	2.58	0.39	0.71	4.23	16819.92
OCT	1966	20095.0	4.3029	7	4.43	0.23	1.36	4.29	19282.94
OCT	1967	19732.0	4.2952	8	3.88	0.26	1.21	4.27	18867.95
SEPT	1968	18887.0	4.2762	11	2.82	0.35	0.82	4.24	17216.79
SEPT	1969	23537.0	4.3718	1	31.00	0.03	3.42	4.47	29730.69
SEPT	1970	20211.0	4.3056	6	5.17	0.19	1.54	4.30	20002.02
SEPT	1971	17623.0	4.2461	15	2.07	0.48	0.41	4.20	15786.70
SEPT	1972	13951.0	4.1446	23	1.35	0.74	-0.30	4.13	13573.51
SEPT	1973	12283.0	4.0893	24	1.29	0.77	-0.40	4.12	13307.26
OCT	1974	17164.0	4.2346	16	1.94	0.52	0.32	4.19	15480.01
OCT	1975	19661.0	4.2936	9	3.44	0.29	1.07	4.26	18129.80
OCT	1976	12100.0	4.0828	25	1.24	0.81	-0.50	4.12	13033.73
OCT	1977	15197.0	4.1818	22	1.41	0.71	-0.21	4.14	13836.19
SEPT	1978	17045.0	4.2316	17	1.82	0.55	0.23	4.18	15186.69
SEPT	1979	17870.0	4.2521	14	2.21	0.45	0.51	4.21	16109.75
OCT	1980	22806.0	4.3581	3	10.33	0.10	2.28	4.37	23418.08
SEPT	1981	17979.0	4.2548	13	2.38	0.42	0.61	4.22	16452.71
SEPT	1982	11538.0	4.0821	27	1.15	0.87	-0.72	4.09	12441.60
SEPT	1983	9130.0	3.9805	29	1.07	0.94	-1.01	4.07	11700.30
SEPT	1984	8536.0	3.9313	30	1.03	0.97	-1.23	4.05	11157.47
SEPT	1985	15913.0	4.2018	19	1.63	0.61	0.05	4.17	14630.00
SEPT	1986	11327.0	4.0541	28	1.11	0.90	-0.85	4.08	12101.71
SEPT	1987	11758.0	4.0703	26	1.19	0.84	-0.60	4.11	12747.78
OCT	1988	15657.0	4.1947	20	1.55	0.65	-0.04	4.16	14362.08
OCT	1989	16303.0	4.2123	18	1.72	0.58	0.14	4.17	14904.13

AVERAGE	4.21
STD. DEVIATION	0.12
SKEW	-0.81
COR COEF(r)	0.8485

PEAK MONTHLY RUN-OFF OF RIVER NIGER AT LOKOJA (m³/S)

LOG-NORMAL DISTRIBUTION

MONTH	YEAR	RUNOFF (m ³ /s)	X=Log(Qo)	Rank (m)	Ti= N+1/m	P=1/Ti	K	LogQp=Xav+SD _x *K	Qp
OCT	1960	22444.0	4.3511	4	7.75	0.13	1.17	4.35 22503.65	
OCT	1961	15533.0	4.1914	21	1.43	0.69	-0.47	4.16 14407.97	
OCT	1962	22310.0	4.3478	2	15.50	0.06	1.57	4.40 24935.03	
SEPT	1963	19549.0	4.2911	10	2.10	0.32	0.47	4.27 18832.16	
OCT	1964	20851.0	4.3157	8	6.20	0.16	1.00	4.33 21407.59	
SEPT	1965	19914.0	4.2963	12	2.58	0.39	0.26	4.28 17605.72	
OCT	1966	20065.0	4.3039	7	4.43	0.23	0.74	4.30 19945.11	
OCT	1967	19713.0	4.2952	6	3.68	0.26	0.54	4.30 19434.10	
SEPT	1968	18587.0	4.2702	11	2.82	0.35	0.39	4.26 16129.05	
SEPT	1969	23637.0	4.3710	1	31.00	0.03	1.90	4.44 27377.77	
SEPT	1970	20211.0	4.3058	6	7.75	0.13	0.89	4.32 20726.03	
SEPT	1971	17823.0	4.2461	15	2.67	0.49	0.05	4.24 17377.77	
SEPT	1972	13951.0	4.1445	22	1.35	0.74	-0.64	4.14 13745.64	
SEPT	1973	12235.0	4.0893	24	1.25	0.77	-0.83	4.12 13058.12	
OCT	1974	17184.0	4.2348	16	2.50	0.52	-0.05	4.21 16112.12	
OCT	1975	19061.0	4.2819	9	3.44	0.29	0.95	4.26 16957.48	
OCT	1976	12100.0	4.0836	25	1.24	0.81	-0.88	4.11 12682.90	
OCT	1977	15167.0	4.1810	22	1.41	0.71	-0.55	4.10 14034.10	
SEPT	1978	17045.0	4.2318	17	1.82	0.55	-0.13	4.20 15770.20	
SEPT	1979	17679.0	4.2521	14	2.21	0.45	0.13	4.23 16234.14	
OCT	1980	22808.0	4.3561	3	10.33	0.10	1.26	4.33 23089.08	
SEPT	1981	17679.0	4.2545	13	2.38	0.42	0.20	4.24 17266.54	
SEPT	1982	11533.0	4.0621	27	1.15	0.87	-1.14	4.08 12022.12	
SEPT	1983	9133.0	3.9605	29	1.07	0.94	-1.57	4.03 10600.07	
SEPT	1984	8508.0	3.9213	30	1.03	0.97	-1.60	3.99 8753.17	
SEPT	1985	15913.0	4.2018	19	1.63	0.61	-0.28	4.18 15162.03	
SEPT	1986	11327.0	4.0541	28	1.11	0.90	-1.28	4.05 11503.43	
SEPT	1987	11758.0	4.0703	28	1.16	0.86	-1.00	4.10 12472.01	
SEPT	1988	16857.0	4.1947	20	1.55	0.65	-0.39	4.17 14725.00	
SEPT	1989	16303.0	4.2123	18	1.72	0.58	-0.20	4.19 15472.57	

AVERAGE	4.21
STD. DEVIATION	0.12
SKEW	-0.61
COR. COEF(r)	0.943

PEAK MONTHLY RUN-OFF OF RIVER NIGER AT LOKOJA (m³/s)

LOG-PEARSON DISTRIBUTION

MONTH	YEAR	RUNOFF (m ³ /s)	X=Log(Qp)	Rank (m)	Ti= N+1/m	P=1/Ti	K	LogOp=Xav+SD _x *K	Qp
OCT	1960	22444.0	4.3511	4	7.75	0.13	1.07	4.34	21034.25
OCT	1961	15538.0	4.1914	21	1.48	0.68	-0.42	4.16	14307.23
OCT	1962	23512.0	4.3739	2	15.50	0.06	1.36	4.37	23602.64
SEPT	1963	10548.0	4.2911	10	3.10	0.32	0.97	4.26	10729.60
OCT	1964	20851.0	4.3167	6	6.20	0.16	0.93	4.32	21000.58
SEPT	1965	18914.0	4.2808	12	2.58	0.39	0.40	4.26	18192.38
OCT	1966	20383.0	4.3029	7	4.43	0.23	0.76	4.31	20184.20
OCT	1967	18732.0	4.2852	8	3.68	0.26	0.71	4.30	19800.17
SEPT	1968	18897.0	4.2702	11	2.82	0.35	0.49	4.27	18572.65
SEPT	1969	23037.0	4.3718	1	31.00	0.03	1.03	4.33	21554.81
SEPT	1970	20211.0	4.3008	6	5.17	0.19	0.89	4.32	20704.26
SEPT	1971	17623.0	4.2481	15	1.77	0.48	0.18	4.23	17154.28
SEPT	1972	13051.0	4.1446	23	1.5	0.74	-0.60	4.14	13302.88
SEPT	1973	12283.0	4.0893	24	1.29	0.77	-0.69	4.13	13568.75
OCT	1974	17184.0	4.2346	16	1.94	0.62	0.07	4.22	16027.77
OCT	1975	19681.0	4.2926	9	3.44	0.29	0.84	4.29	19418.78
OCT	1976	12103.0	4.0828	25	1.24	0.81	-0.89	4.11	12044.36
OCT	1977	15197.0	4.1813	22	1.41	0.71	-0.51	4.15	14230.99
SEPT	1978	17043.0	4.2316	17	1.62	0.55	-0.02	4.21	16262.03
SEPT	1979	17670.0	4.2521	14	2.21	0.45	0.25	4.24	17495.92
OCT	1980	22608.0	4.3581	3	10.33	0.10	1.17	4.35	22338.73
SEPT	1981	17979.0	4.2548	13	2.36	0.42	0.33	4.25	17839.65
SEPT	1982	11630.0	4.0721	27	1.15	0.67	-1.56	4.03	10729.78
SEPT	1983	9130.0	3.9603	29	1.07	0.94	-2.14	3.98	8176.19
SEPT	1984	8536.0	3.9313	30	1.03	0.97	-1.17	4.35	22389.73
SEPT	1985	15913.0	4.2018	19	1.63	0.61	-1.56	4.03	10729.66
SEPT	1986	11327.0	4.0541	26	1.11	0.90	-1.89	3.99	9654.05
SEPT	1987	11709.0	4.0703	26	1.19	0.84	-1.11	4.09	12097.03
SEPT	1988	15667.0	4.1947	20	1.55	0.65	-0.32	4.16	14970.79
SEPT	1989	16503.0	4.2123	13	1.72	0.58	-0.11	4.20	15952.38
AVERAGE			4.21						
STD. DEVIATION			0.12						
SKEW			-0.91						
COR COEFF(r)			0.7619						

PEAK MONTHLY RUN-OFF OF RIVER NIGER AT LOKOJA (m³/s)

GUMBEL DISTRIBUTION

MONTH	YEAR	RUNOFF (m ³ /s)	Rank (m)	Tr= N+1/m	P=1/Tr	$y_T = -\ln[-\ln(1-P)]$	$Q_p = Q_{av} + SD \cdot (0.78y_T - 0.45)$
OCT	1960	22444.0	4	7.75	0.13	1.98	21414.28
OCT	1961	15538.0	21	1.48	0.68	-0.12	14624.80
OCT	1962	23312.0	2	15.50	0.06	2.71	23765.62
SEPT	1963	19549.0	10	3.10	0.32	0.94	18067.98
OCT	1964	20831.0	5	6.20	0.16	1.74	20634.49
SEPT	1965	18614.0	12	2.58	0.39	0.71	17329.56
OCT	1966	20085.0	7	4.43	0.23	1.36	19423.56
OCT	1967	19732.0	8	3.88	0.26	1.21	18926.90
SEPT	1968	18887.0	11	2.82	0.35	0.82	17686.91
SEPT	1969	23537.0	1	31.00	0.03	3.42	26057.84
SEPT	1970	20211.0	6	5.17	0.19	1.54	19984.58
SEPT	1971	17623.0	15	2.07	0.48	0.41	16358.13
SEPT	1972	13951.0	23	1.35	0.74	-0.30	14043.61
SEPT	1973	12283.0	24	1.29	0.77	-0.40	13740.06
OCT	1974	17164.0	16	1.94	0.52	0.32	16057.52
OCT	1975	19661.0	9	3.44	0.29	1.07	18478.68
OCT	1976	12100.0	25	1.24	0.81	-0.50	13421.81
OCT	1977	15197.0	22	1.41	0.71	-0.21	14337.32
SEPT	1978	17045.0	17	1.82	0.55	0.23	15764.39
SEPT	1979	17870.0	14	2.21	0.45	0.51	16668.53
OCT	1980	22808.0	3	10.33	0.10	2.28	22400.65
SEPT	1981	17979.0	13	2.38	0.42	0.61	16991.32
SEPT	1982	11538.0	27	1.15	0.87	-0.72	12709.37
SEPT	1983	9130.0	29	1.07	0.94	-1.01	11768.05
SEPT	1984	8536.0	30	1.03	0.97	-1.23	11040.12
SEPT	1985	15913.0	19	1.63	0.61	0.05	15192.14
SEPT	1986	11327.0	28	1.11	0.90	-0.85	12284.93
SEPT	1987	11758.0	26	1.19	0.84	-0.60	13081.90
OCT	1988	15657.0	20	1.55	0.65	-0.04	14908.93
OCT	1989	16303.0	18	1.72	0.58	0.14	15476.61
AVERAGE		16886.10					
STD. DEVIA		4139.32					
SKEW		-0.31					
COR COEF(		0.9548					

PEAK TURBINE RELEASE AT JESSA (1984-2001) (m3/s)

LOG-GUMBEL

YEAR	DISCHARGE (m3/s)	Rank	$T^* = (N+1)/n$	$b = 1/T^*$	$(T^* - 4)/(n(1.2))$	$Qp = Qm + 50 \times (1.75/T^* - 0.45)$	Qp
1984	1590	18	1.05	0.95	-1.03	7.08	394.01
1985	1500.0	7	0.71	0.37	0.75	5.08	121.62
1986	1025.0	16	1.15	0.84	-0.51	6.08	121.62
1987	819.0	17	1.12	0.88	-0.51	6.08	121.62
1988	1818.0	4	0.71	0.21	1.44	4.25	800.38
1989	1426.0	5	0.33	0.42	0.63	4.25	1788.13
1990	1133.0	15	1.45	0.05	-0.14	5.07	148.63
1991	1881	2	0.55	0.11	2.20	5.07	148.63
1992	1072.0	14	1.36	0.74	-0.28	5.07	148.63
1993	1058.0	15	1.47	0.79	-0.42	5.05	1123.14
1994	8267.0	1	18.00	0.05	2.62	3.03	1075.38
1995	1543.0	5	3.80	0.26	0.92	3.41	2888.25
1996	1181.0	12	1.53	0.53	0.00	5.22	1037.87
1997	1429.0	11	1.71	0.58	0.18	5.08	1212.49
1998	1451.0	9	2.11	0.47	0.44	5.19	1256.80
1999	1855.0	3	0.33	0.16	1.78	5.26	1351.59
2000	1575.0	8	3.17	0.32	1.07	5.18	1010.50
2001	1433.0	10	1.93	0.53	0.29	5.12	1007.64

AVERAGE
STD. DEVIATION
ERR. %
CONF. COEFF.

0.48
0.48
0.55
0.5710

PEAK TURBINE RELEASE AT JEBBA (1984-2001) (m³/s)

LOG-GUMBEL

MONTH	YEAR	DISCHARGE (m ³ /s)	X=Log(Ro)	Rank (m)	Tr=N+1,m ⁻¹ P=1.Tr	yT=-ln[-ln(1-P)]	Qp=Qav+5D*(0.76yT-0.45)	Qp	
AUG	1984	889.0	2.9390	18	1.06	0.95	-1.03	2.98	914.01
SEPT	1985	1502.0	3.1787	7	2.71	0.97	0.79	3.08	1211.52
JAN	1986	1025.0	3.0107	16	1.19	0.84	-0.81	3.08	1211.82
SEPT	1987	919.0	2.9633	17	1.12	0.89	-0.81	2.99	980.38
OCT	1988	1818.0	3.2596	4	4.75	0.21	1.44	3.25	1788.13
OCT	1989	1455.0	3.1661	8	2.38	0.42	0.63	3.15	1418.63
SEPT	1990	1193.0	3.0658	13	1.46	0.69	-0.14	3.07	1167.66
AUG	1991	2332.0	3.3677	2	9.50	0.11	2.20	3.33	2150.46
JAN	1992	1072.0	3.0902	14	1.38	0.74	-0.29	3.06	1123.74
MAR	1993	1058.0	3.0245	15	1.27	0.79	-0.44	3.03	1079.29
OCT	1994	3257.0	3.5141	1	19.00	0.05	2.92	3.41	2596.25
FEB	1995	1643.0	3.2158	5	3.80	0.26	1.19	3.22	1651.87
OCT	1996	1181.0	3.0722	12	1.58	0.63	0.00	3.08	1212.29
FEB	1997	1229.0	3.0896	11	1.73	0.58	0.15	3.10	1286.60
SEPT	1998	1451.0	3.1617	9	2.11	0.47	0.44	3.13	1360.59
OCT	1999	1855.0	3.2686	3	6.33	0.18	1.78	3.26	1919.50
JAN	2000	1570.0	3.1973	6	3.17	0.32	0.67	3.19	1580.76
JAN	2001	1435.0	3.1572	10	1.90	0.53	0.29	3.12	1307.64

AVERAGE	3.15
STD. DEVIATION	0.16
SKEW	0.55
COR COEF(r)	0.8710