Flood Frequency Analysis of River Niger, Shintaku Gauging Station, Kogi State, Nigeria

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Abstract.- The study outlines a frequency distribution study on the highest annual flood statistics in Niger River located at Shintaku hydrologic Station for a period of 58 years. In order to determine optimal model for highest annual flood analysis generalised extreme value, Log normal, Gumbel maximum, Generalised Pareto and Log Pearson III, were tested. Based on error produced by criteria of goodness of Fit tests, the optimal model was determined. Results obtained indicated that Log Pearson type III was best to model maximum flood magnitude of Niger River at Shintaku station. The flood frequency curve was therefore derived using Log Pearson type III frequency distribution. Flood frequency curve showed that return periods of 50 and 100 years with the probabilities of 2% and 1% respectively, yielded discharges of 15300m³/s and 15600m³/s respectively. These results were strongly influenced by their topographical, geographical and climatic factors. The findings of this work will be useful for design engineers in deciding the dimension of hydraulic structures such as spillway, dams, canals, bridges and levees among others. Future studies are required to include flood forecasting in the development of inundation maps for Niger River.

Keywords—Return period, Frequency Distribution, Flood, Niger River, Flood Modelling

1 INTRODUCTION

A flood is an overflow of water on normally dry ground. Flood is very often caused by overflow of river, collapse of dam, snowmelt, heavy rainfall, tsunamis, storm surge, or coastal flooding. Flooding is a very frequent environmental hazard and it occurs at varying magnitudes. Flood is a common occurrence in most terrestrial portions of the globe, causing huge annual losses in terms of damage and disruption to economic livelihoods, businesses, infrastructure, services and public health (Ikuhuria, et al., 2012). Over the past 100 years, records of natural disasters show that floods and wind storms have been by far the most common causes of natural disaster worldwide (Few et al., 2004). Although flood hazards are natural phenomena, but anthropogenic activities are responsible for the damages and losses from floods. Human interventions in the natural processes such as increase in settlement areas, population growth and economic assets over low lying plains prone to flooding leading to alterations in the natural drainage and river basin patterns, deforestation and climate change, are the major drivers of flood incidents (European Commission, 2007; Balabanova and Vassilev, 2010; Kwak and Kondoh, 2008).

Bassa is a Local Government Area in the eastern part of Kogi State in north central Nigeria. According to Ikuhuria et al. (2012), the area is in the flood plain with incessant flood. The flood which ravaged the country in 2012 no doubt was perhaps the worst; with about 3000 families affected in Bassa; the Lokoja-Abuja highway was washed away. The total number of displaced persons who were housed in 87 camps across the state was 623,690 during the period; thousands of people lost their lives and properties worth billions of naira were destroyed (NIHSA, 2013). The 2012 flood disasters in Nigeria are significant because such heavy flooding have never occurred in the past forty years (Ikuhuria, et al., 2012).

According to Ojigi, et al. (2013), the devastation by these floods include huge destruction to the rural and urban infrastructures such as farmlands/crops, roads, buildings, drainages, bridges, powerlines, etc and socio-economic lives of the areas in most parts of the central states of Nigeria and other adjoining states along the rivers Niger and Benue. To manage flood risks successfully, knowledge is needed of both magnitude of any given flood and an estimate its likelihood of occurrence. Tao et al. (2002) noted that adequate knowledge of extreme flood of high return periods is required in the design and construction of certain projects such as dams and urban drainage systems, the management of water resources and prevention of flood damage. Flood frequency analysis is one of the methods used to estimates of the magnitude of the flood of a certain return period.

Manadhar (2010) reported that water resources engineer use flood frequency analysis for detailed assessment of flood events in the design of hydrological projects as it is essential to interpret past record of flood events in order to evaluate future possibilities of such occurrence. Analyses of flood frequency are also used to make forecasts of floods along the river. The technique involves the use historical annual peak flow data to compute statistical information such as mean values, standard deviation, skewness and reocurrence intervals. These statistical data are then used to construct frequency distributions, which are graphs and tables that tell the likelihood of various discharges as a function of recurrence interval or exceedance probability.

Many different statistical distributions are available and are often applied for flood frequency analysis. For many of them, there is no underlying justification for their use other than their flexibility in mimicking the shape of an observed statistical distribution (Wilson, 2011). However, a frequency distribution should not be selected simply because it provides the best fit to the data, but also the number of parameters of a distribution and knowledge about the properties of the catchment should be considered. Wang (1996) applied extreme value type I, II,
and III distributions with parameters estimated by the probability weighted moments to estimate floods of large return period from the lower bound censored samples. Ding et al. (1989) applied the weighted probability moments (WPM) for estimating parameters of the Pearson type III distribution. They showed that the WPM estimators were almost unbiased and the performed was better than that by the conventional moment method.

Lu & Stedinger (1992) developed simple formula for the sampling variance of quartile estimators for the generalized extreme value (GEV) distribution when weighted probability moments (WPM) or L-moments are used for estimating all three parameters or just two parameters. It was found that the sampling variance of three-parameter 100-year flood estimators could be reduced by a factor of 2-3 if the GEV shape parameter was given and for distributions with realistic shape parameters, the two-parameter 100-year flood estimator with a fixed regional shape parameter generally gave a smaller MSE than did a three-parameter estimator even if the shape parameter was misrepresented. Rao & Hamed (2000) discussed probability distributions which are commonly applied in flood frequency analysis with different parameter estimation methods.

Bacchi et al. (1994) studied a bivariate exponential distribution by using the Gumbel distribution as an approximation to the probability distribution of extreme rainfall. Correia (1987) deduced the joint distribution of flood peak and duration by using the partial duration series method (PDS). Practical application has shown that 3-parameter distributions are very sensitive to outlier events (Cunnane, 1989). The higher the number of parameters, the more flexible the distribution, but also the more easily the distribution can follow particular peculiarities of the data set. With 2-parameter distributions, estimates of the tail quartiles can be severely biased if the shape of the tail of the true frequency distribution is not well represented by the fitted distribution (Izinyon & Ajumuka, 2013). The use of a distribution with more parameters, when these can be accurately estimated, yields less biased estimates of quartiles in the tails of the distribution. This study is to determine which frequency distribution model that adequately fits the statistical characteristics of observed hydrological data for the prediction of the flood of the Niger River in Shintaku area of Kogi State, Nigeria.

1.1 Study Area

Shintaku gauging station at River Niger was established in the 1957, it lies in the north central of Nigeria (latitude 070 10’and longitude 060 45’). The station is located at the left side bank of the River Niger with drainage area of 1,099,750km² (Izinyon & Ajumuka, 2013). The Figure 1 shows the map of River Niger at Shintaku. The region's climate is tropical, generally hot throughout the year with two distinct season; the wet season is between April and September of every year, and the dry season is between October and March of the following year. Annual rainfall ranges from 1016mm to 1524mm (NIHSA, 2013). The vegetation of the state consists of mixed leguminous (guinea) woodland to forest savannah.

![Fig. 1: River Niger at Shintaku Guaging Station](image)

2 Methodology

The hydrological data for the Shintaku station of the River Niger for 58 years (1957-2014) was collected and tested for randomness, stationarity, consistency and homogeneity. Using the MS Excel software, the following tests were carried out for the hydrological data: turning point test for trend and randomness, Mann Kendall’s test for stationarity, Man-Whitney tests for homogeneity and stationarity (Fill & Stedinger, 1995). According to Tao et al. (2000), the Mann-Kendall test statistic, S, is calculated using the formula in (1).

\[ S = \sum_{j=2}^{n-1} \sum_{k=1}^{j} \text{sgn}(x_j - x_k) \]  

Where \( x_j \) and \( x_k \) are the annual values in years \( j \) and \( k \), respectively, and

\[ \text{sgn}(x_j - x_k) = \begin{cases} 
1 & \text{if } x_j - x_k > 0 \\
0 & \text{if } x_j - x_k = 0 \\
-1 & \text{if } x_j - x_k < 0 
\end{cases} \]  

When \( S \) has a high positive value, it is an indication of an increasing trend, while a decreasing trend is indicated by a very low negative value. To statistically quantify the significance of the trend, Rao (2000) suggested that the associated probability of \( S \) need to be calculated for a given sample size, \( n \). The variance of \( S \) is computed as

\[ \text{VAR}(S) = \frac{1}{18} [n(n - 1)(2n + 5) - \sum_{p=1}^{q} t_p (t_p - 1)(2t_p + 5)] \]  

Here \( q \) is the number of tied groups and \( t_p \) is the number of data values in the \( p^{th} \) group. The values of \( S \) and \( \text{VAR}(S) \) are used to compute the test statistic \( Z \) as follows

\[ z = \begin{cases} 
\frac{S - 1}{\sqrt{\text{VAR}(S)}} & \text{if } S > 0 \\
0 & \text{if } S = 0 \\
\frac{S + 1}{\sqrt{\text{VAR}(S)}} & \text{if } S < 0 
\end{cases} \]  

Five flood frequency distribution models: Generalised extreme value, Log normal, Gumbel maximum, Generalised Pareto and Log Pearson III, were considered. Probability distribution function (PDF) of Normal probability distribution is given by

\[ f(x) = \frac{1}{\sigma \sqrt{2\pi}} \exp\left( -\frac{(x-\mu)^2}{2\sigma^2} \right) \text{ for } -\infty < x < \infty, \text{ and } -\infty < \mu < \infty, \sigma > 0 \]  

This equation is defined by two parameters: the mean (\( \mu \)) and the standard deviation (\( \sigma \)). The lognormal distribution assumed that the logarithms of the discharge
are themselves normally distributed. The equation describing the normal distribution was used with the following substitutions.

\[ Y_i = \log X_i \]

(6)

The Probability distribution function for the Gumbel Extreme Value type I distribution is expressed as:

\[ f(x) = \left( \frac{1}{\alpha} \right) \exp \left[ - \left( \frac{x - \beta}{\alpha} \right) \right] - \exp \left( - \left( \frac{x - \beta}{\alpha} \right) \right) \]  

(7)

The Probability Distribution function of Log Pearson Type III distribution is given by:

\[ f(x) = \frac{1}{\sqrt{2\pi \sigma \zeta}} \exp \left[ - \frac{(\log x - \zeta)^2}{2\sigma^2} \right] \]  

(8)

The Log Pearson Type III distribution follows the expression:

\[ \log X = \log x + K \sigma_{\log x} \]  

(9)

But then Log X is the logarithm of the discharge of the desired quantile, Log x is the mean of the logarithm of the sample, \( \sigma_{\log x} \) is the standard deviation of the logarithm of the sample and K is the Pearson frequency factor. For the log Pearson type III distribution, the frequency factor K is a function of the specified probability and the skew of the logarithms of the sample.

The skew \( G \) was computed using the equation:

\[ G = \frac{\sqrt{n} \sum (\log x - \bar{\log} x)^2}{(n-1)(\sqrt{2\pi} \sigma_{\log x})} \]  

(10)

The Generalized Extreme Value distribution with continuous shape parameter (k), continuous scale parameter (\( \sigma \)), and continuous location parameter (\( \mu \)) has a PDF given by:

\[ f(x) = a^{-1} \exp \left[ (1-k)y - \exp(-y) \right] \]  

(11)

Where: \( y = -k^{-1} \log \left[ 1 - \frac{k(x-\mu)}{\sigma} \right], k \neq 0 \) and \( y = \frac{x-\mu}{\sigma}, k = 0 \)

The Generalized Pareto distribution with continuous shape parameter (k), continuous scale parameter (\( \sigma \)), and continuous location parameter (\( \mu \)) has a PDF given by:

\[ f(x) = a^{-1} \exp \left[ -(1-k)y \right] \]  

(12)

Where: \( y = -k^{-1} \log \left[ 1 - \frac{k(x-\mu)}{\sigma} \right], k \neq 0 \) and \( y = \frac{x-\mu}{\sigma}, k = 0 \)

Analysis of the flood frequency was relatively straightforward and involved fitting a theoretical statistical distribution to the observed flood data (Wilson, 2011). In this study, at-site flood frequency analysis method for the gauge station was adopted owing to the availability of about 58 years data to carry out the analysis. This study focused on at-site analysis, since the period of record was long and the annual maximum series (AMS) for characterizing the flood frequency events was applied (Raghunath, 2006).

The probability distribution of the observed data was compared with various theoretical probability distributions by correctly displaying the fitted Probability Density Function (PDF) on top of the histogram of the observed sample data. The five flood frequency distribution models were tested using the goodness of fit and the best fitting model was selected. This study used three goodness of fit tests: the Anderson-Darling (A-D) test, the Kolmogorov-Smirnov (K-S) and the Chi-squared (C-S) test to test the statistical hypothesis whether a particular distribution provides an adequate fit to the observed annual maximum flood series (AM) data and can be approved as the best fit distribution. Kolmogorov-Smirnov (KS) test was used to decide if a sample comes from a hypothesized continuous distribution. The Kolmogorov-Smirnov statistic (D) is based on the largest vertical difference between the theoretical and the empirical cumulative distribution function:

\[ D = \max \left( F(x_i) - \frac{i-\frac{1}{2}}{n}, \frac{i}{n} - F(x_i) \right) \]  

(13)

Where:

\[ 1 \leq i \leq n \]

The Anderson-Darling procedure is a general test to compare the fit of an observed cumulative distribution function to an expected cumulative distribution function. This test gives true weight to the tails than the Kolmogorov–Smirnov test. The Anderson-Darling test statistic (A^2) is:

\[ A^2 = -n - \frac{1}{n} \sum_{i=1}^{n} (2i-1) \times [\ln F(x_i) - \ln(1 - X_n - i - 1)] \]  

(14)

Chi-square test was used to test the goodness of fit of the flood to the probability distribution (Salas et al., 1980). This was performed by plotting cumulative probability curves and applying classical statistical inferences to the data. According to Rao & Hamed (2000), for the boundaries (i.e. I), the theoretical frequency, \( n_i \) corresponding to the observed frequency, \( O_i \) of bin I of the histogram, the Chi-square statistic is obtained as:

\[ \chi^2 = \sum_{i=1}^{n} \frac{(O_i-n_i)^2}{n_i} \]  

(15)

The null hypothesis stating that the observed sample is drawn from the theoretical distribution is accepted if \( \chi^2 < \chi^2_{N-k-1,1-\alpha} \)

where, \( \chi^2_{N-k-1,1-\alpha} \) is the chi-square value for N-K-1 degree of freedom and \( \alpha \) significant level.

The following assumptions were used to validate flood analyses (Jha & Machiwal, 2012):

i. A long and high-quality observational record was available.

ii. There was no serial correlation between flood events.

iii. The physical system was stationary (i.e., not subject to changes) and, as a result, the observational record was a representative sample of all possible flood events.

iv. The frequency distributions built from the historical time series represented instantaneous probability distributions at any point in time.

# 3 Results and Discussions

## 3.1 Descriptive Statistics of Flood Data

The descriptive statistics for the annual maximum discharge of Shintaku gauging station of River Niger are presented in Table 1. The results of the descriptive statistics show that the sample mean was 12405 m³/s, the sample standard deviation was 1990.4, skewness was -0.37994, coefficient of variance was 0.16046 and standard error was 346.49. The maximum and minimum discharges were 15873 m³/s and 7730.6 m³/s respectively, with upper quartile of 13755 m³/s and lower quartile of 11116 m³/s. The Skewness of the data was negative, which is -0.37994. A chart showing the discharge of the historical data is given in Figure 2.
It can be seen that the year 1969 has the highest discharge of 15873 m³/s and the lowest discharge of 7730 m³/s was observed in the year 1984.

### Table 1. Descriptive Statistics of the Historical Data

| Statistic | Value  |
|-----------|--------|
| Sample Size | 33     |
| Range      | 8142.7 |
| Mean       | 12405.0|
| Variance   | 3.9618E+6|
| Std. Deviation | 1990.4 |
| Coef. of Variation | 0.16046 |
| Std. Error | 346.49 |
| Skewness   | -0.37994|
| Excess Kurtosis | -0.24434 |

![Fig. 2: The discharge of River Niger at Shintaku for 1957-1989](image)

### 3.2 Statistical Tests on Flood Data

Turning point test for trend and randomness revealed that the null hypothesis (H₀) of no dependence in the series was not rejected at 5% level of significance because -1.96 < z < 1.96 i.e. z = 0.565. A section of ten (10) years was taken from the data and analysed using the Kendall’s correlation test. The standard test statistic, z = 0.8052 means -1.965 ≤ z ≤ 1.96, since this is within the limits ± 1.96, the Ho (null hypothesis) of no trend in the series at the 5% level of significance using a two-tailed test was not rejected. For Man-Whitney Tests for homogeneity and stationarity, test statistic, z = -0.0242 which is -1.96 ≤ z ≤ 1.96. Therefore, the hypothesis H₀ was accepted that the variables are from the same data.

### 3.3 Probability Distribution of Flood Data

According to the result of the three tests of the goodness of fit, the distribution with the lowest statistic value is the best fitting model. The result of the three goodness of fit test is shown in Table 2. From Table 2, it was observed that Log-Pearson 3 (LP) distribution was ranked first by Kolmogorov-Smirnov (K-S), Anderson-Darling (AD) and ranked second by Chi-Square (C-S). Compared to the other distributions Log-Pearson 3 was the most fit distribution; this was followed by Log-Normal (LN) distribution which was ranked first in chi-square (C-S), second in Anderson Darling (AD) and third in Kolmogorov-Smirnov (K-S). The third distribution is the Gumbel max extreme value type I(GM) which was ranked third in both chi-square and Anderson Darling and fifth in Kolmogorov-Smirnov. It would be observed that the distributions Generalized Extreme value (GEV) and Generalized Pareto (GP) was not applicable for Chi-Square. Hence, the best fitting distribution for the historical data of Niger River at Shintaku gauging station is the Log-Pearson 3 distribution. The best fitting distribution can be shown using distribution graphs to access the suitability of each distribution on the observed data (Figure 3).

### Table 2. Goodness of Fit Test

| Distribution | Statistic | Rank 1st | Rank 2nd | Rank 3rd | Rank 4th | Rank 5th |
|--------------|-----------|----------|----------|----------|----------|----------|
| Kolmogorov Smirnov | Log P | 63 | 93 | 66 | 12 | 2 |
| Anderson Darling | GEV | 1.029 | 1.602 | 4.424 | 5.038 | 20.47 |
| Chi-square | GM | 7.763 | 11.14 | 13.62 | N/A | N/A |

Note: GEV: Generalized Extreme Values, GP: Generalized Pareto, GM: Gumble Max (EVI), LP: Log Pearson 3, LN: log Normal and N/A Not applicable.

### Table 3. Result of Estimated Parameters for each Distribution

| Distribution | μ | σ | α | k | β | γ |
|--------------|---|---|---|---|---|---|
| Gumbel GM | 12239 | 1028.2 | 11.48 | 0.10475 | 0.03118 | 9.4544 |
| Log Pearson 3 | 11.48 | 2 | 0.10475 | 0.03118 | 9.4544 |

Where: μ = continuous location parameter, σ = continuous scale parameter, k = continuous shape parameter, α = first scale parameter, β = first shape parameter and γ = second scale parameter (Note that in Log Pearson 3: α = shape parameter, β = scale parameter and γ = location parameter).

### 3.4 Estimation of Distribution Population Parameters

The results of the estimated parameters of the five fitted distributions for Shintaku station of River Niger are shown in Table 3.
The flood frequency curve for the Shintaku station was presented in Figure 4. It can be seen that the recurrence interval of 100 years had a discharge of 15600 m³/s compared to 9304.42 m³/s obtained by Adebayo and Alatise (2007) for the same River Niger at Pategi using the same model (Log Pearson Type 3), and the recurrence interval of 10 years had a discharge of 14500 m³/s compared to 5455.35 m³/s obtained by Adebayo and Alatise (2007)) for River Niger at Pategi. Similarly, the recurrence interval of 50 years had a discharge of 15300 m³/s. This disparity maybe due to the different discharge values recorded at the two hydrologic stations of the River: Pategi and Shintaku respectively.

Since the return period is the inverse of the probability, the return periods were calculated using the Log Pearson Type III as shown in Table 7.

### Table 4. Computation of Flood Frequency Curve Values

| Pr (%) | k' | log x = log x₀ + k'σ₀ | X(m³/s) |
|--------|----|------------------------|--------|
| 99     | -2.755 | -0.12670 | 3.97927 | 9533.89 |
| 90     | -1.328 | -0.06110 | 4.04491 | 11089.50 |
| 50     | 0.099  | 0.00455 | 4.11055 | 12989.90 |
| 10     | 1.200  | 0.05520 | 4.16120 | 14494.40 |
| 5      | 1.458  | 0.06707 | 4.17307 | 14895.90 |
| 2      | 1.720  | 0.07912 | 4.18512 | 15315.10 |
| 1      | 1.880  | 0.08648 | 4.19248 | 15576.90 |

### Table 5. Upper Limits Values (95% of k')

| Pr (%) | k' | log x = log x₀ + k'σ₀ | X(m³/s) |
|--------|----|------------------------|--------|
| 99     | -2.755 | -0.120394 | 3.98561 | 9674.1 |
| 90     | -1.328 | -0.080304 | 4.04797 | 11167.9 |
| 50     | 0.099  | 0.004326 | 4.11033 | 12892.3 |
| 10     | 1.200  | 0.052440 | 4.15844 | 14402.6 |
| 1      | 1.880  | 0.082156 | 4.18816 | 15422.7 |

### Table 6. Lower Limits Values (5% of k')

| Pr (%) | k' | log x = log x₀ + k'σ₀ | X(m³/s) |
|--------|----|------------------------|--------|
| 99     | -3.115 | -0.1433 | 3.962710 | 9177.20 |
| 90     | -1.578 | -0.0726 | 4.033412 | 10799.71 |
| 50     | -0.071 | -0.0033 | 4.102734 | 12688.76 |
| 10     | 0.99  | 0.04554 | 4.151540 | 14173.56 |
| 1      | 1.59 | 0.07314 | 4.179140 | 15105.67 |

### Table 7. Flood Frequency Curve Values

| Return period Tr (Year) | k' | log x = log x₀ + k'σ₀ | Q(m³/s) |
|------------------------|----|------------------------|--------|
| 2                     | 0.090  | 0.004140 | 4.110140 | 12886.65 |
| 5                     | 0.857  | 0.039422 | 4.145422 | 13977.26 |
| 10                    | 1.200  | 0.053200 | 4.161200 | 14494.39 |
| 25                    | 1.528  | 0.070288 | 4.176288 | 15006.80 |
| 50                    | 1.720  | 0.079120 | 4.185120 | 15315.11 |
| 100                   | 1.880  | 0.086480 | 4.192480 | 15576.86 |
| 200                   | 2.016  | 0.092736 | 4.198736 | 15802.87 |

3.5 **Estimation of Quartile for Shintaku Station**

From the parameters obtained in Table 3, quartile was estimated for the most suited flood frequency analysis distributions, which is the Log Pearson 3 flood frequency distribution. Using Mean, x₀ = 4.106, Standard deviation, σ₀ = 0.046, Skewness, Cₚ = -0.6, Log Pearson 3 flood frequency distribution was evaluated and presented in Tables 4, 5, 6 and 7. The value of the Skewness, Cs was used to obtain the value of k' from the Han (2011).

The hydrological data for the Shintaku station of the River Niger for 58 years (1957-2014) was collected and tested and found to be random, stationary, consistent and homogeneous. Five flood frequency distribution models (Generalised extreme value, Log normal, Gumbel maximum, Generalised Pareto and Log Pearson III) were considered and tested using the goodness of fit and the Log Pearson type III distribution was the model that best fit the data of the flood area. The flood frequency curve was drawn and the recurrent interval of 50 and 100 years produced discharges of 15300 m³/s and 15600 m³/s respectively. It was also observed that as the return period increases the discharge increases also. These results can vary between the flow gauge stations which are strongly influenced by their geographical, topographical and climatic factors.

The research study can be used by planning and designing engineers for deciding the dimension of hydraulic structures such as bridges, dams, canals, levees and spillways among others across the Shintaku area of River Niger. This study can be further extended into preparation of flood forecasting techniques and flood inundation maps for Niger River.
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APPENDIX

58-year Record of River Niger at Shintaku station, Kogi State

| Year | Discharge, Q (m/s) | Year | Discharge, Q (m/s) |
|------|-------------------|------|-------------------|
| 1957 | 14678             | 1986 | 10143.2           |
| 1958 | 11892.4           | 1987 | 9630.55           |
| 1959 | 13430.5           | 1988 | 12178.9           |
| 1960 | 1453.12           | 1989 | 11515.4           |
| 1961 | 12339.2           | 1990 | 12147             |
| 1962 | 15436             | 1991 | 12029             |
| 1963 | 13701.9           | 1992 | 12291             |
| 1964 | 14968.5           | 1993 | 12814             |
| 1965 | 14938.4           | 1994 | 12761             |
| 1966 | 13370.1           | 1995 | 13491             |
| 1967 | 13475.7           | 1996 | 13775             |
| 1968 | 13083.6           | 1997 | 14360             |
| 1969 | 15873.3           | 1998 | 14920             |
| 1970 | 14425.7           | 1999 | 15079             |
| 1971 | 12402.2           | 2000 | 15260             |
| 1972 | 10836.9           | 2001 | 15339             |
| 1973 | 10429.7           | 2002 | 16096             |
| 1974 | 13083.6           | 2003 | 16480             |
| 1975 | 13807.4           | 2004 | 16360             |
| 1976 | 10595.6           | 2005 | 15857             |
| 1977 | 11394.8           | 2006 | 15270             |
| 1978 | 12601.1           | 2007 | 15349             |
| 1979 | 12420.2           | 2008 | 15603             |
| 1980 | 11786.8           | 2009 | 15064             |
| 1981 | 12450.3           | 2010 | 14737             |
| 1982 | 9359.13           | 2011 | 14714             |
| 1983 | 8680.57           | 2012 | 14648             |
| 1984 | 7730.59           | 2013 | 14429             |
| 1985 | 12043.2           | 2014 | 14379             |

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