HYDROLOGICAL ANALYSIS FOR A MULTI-PURPOSE WATER RESOURCES PROJECT - A CASE STUDY

A DISSERTATION

Submitted in partial fulfillment of the requirements for the award of the degree
of
MASTER OF TECHNOLOGY
in
WATER RESOURCES DEVELOPMENT

By

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CANDIDATE'S DECLARATION

I hereby declare that the dissertation titled **"HYDROLOGICAL ANALYSIS FOR A MULTI-PURPOSE WATER RESOURCES PROJECT – A CASE STUDY"**, which is being submitted in partial fulfillment of the requirement of the award of the Degree of Master of Technology in Water Resources Development (Civil) at Department of Water Resources Development and Management (WRD&M), Indian Institute of Technology Roorkee (IIT Roorkee), is an authentic record of my own work carried out during 2006 - 2007 under the supervision and guidance of **Dr. M.L. Kansal**, Associate Professor, WRD&M Dept., IIT Roorkee – India.

I have not submitted the matter embodied in this dissertation for the award of any other degree.

Place: IIT Roorkee,

Dated: June 13, 2007

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CERTIFICATE

This is to certify that the above statement made by the candidate is correct to the best of my knowledge.

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SYNOPSIS

Many important water resources projects in the past have failed due to improper assessment of the hydrological conditions. Therefore, the hydrological analysis for a water resources project should of necessity precede structural and other detailed design studies. It involves the collection of relevant data and analysis of the data by applying the principles and theories of hydrology to seek solutions to practical problems. The probabilistic analysis of hydrology data is an important component of present day hydrological studies and enables the engineer to take suitable design decision consistent with economic and other criteria to be taken in a given project.

In many hydrological studies, the average rainfall over a specified area due to a storm, or due to number of storms, is required. For determination of the average precipitation over an area, a large number of raingauges are installed. The rainfall data of various raingauges is used to estimate the Mean Areal Precipitation over a catchment area.

It is well-known that streamflow varies over a water year. One of the popular methods of studying this streamflow variability is through flow duration curve. Flow Duration Curves find considerable use in water resources planning and development activities. One of the important uses is evaluating various dependable flows in the planning of water resources engineering projects.

In planning water resources projects, the peak magnitude of the flood have to be adopted properly. If the selected design flood is too high, it results in a unnecessary costly structure while adoption of a low design flood can results in the loss of the structure itself causing thereby a disaster to the people residing downstream, besides damaging valuable immovable properties.

Sedimentation of reservoir is a natural process, since large part of the silt eroded from the catchment and transported by the river, gets deposited on the bed of the reservoir. The deposition of the sediment will automatically reduce the water storing capacity of the reservoir, and if this process of deposition continues longer, a stage is likely to reach when the whole reservoir may get silted up and become useless. Therefore, it becomes necessary to estimate the sedimentation rates in planning and executing suitable measures for controlling sedimentation in order to prolong the life of the reservoir and its benefits.

This dissertation deals with a hydrological analysis approaches for the case study in planning a Multi-purpose Water Resources Project on Gola river near Kathgodam in district Nainital at Jamrani in the state of Uttarakhand, India. The study has been carried out to estimate Mean Areal Precipitation (MAP) over the given catchment , derive discharge data for Dam site, determine 75 % dependable annual water availability at Dam site by Flow Duration Curve, estimate Design Flood at Dam site and to estimate sedimentation flow rate at the Dam site.

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CHAPTER 1

INTRODUCTION

1.1. GENERAL

All life on earth is dependent, one way or another, on water. The study of the science of water is, therefore, important. Water occurs on the earth in all its three states, viz. liquid, solid and gaseous, and in various degrees of motion. Evaporation of water from water bodies such as oceans and lakes, formation and movement of clouds, rain and snowfall, streamflow and groundwater movement are some examples of the dynamic aspects of water. The various aspects of water related to the earth can be explained in terms of a cycle known as the hydrologic cycle.

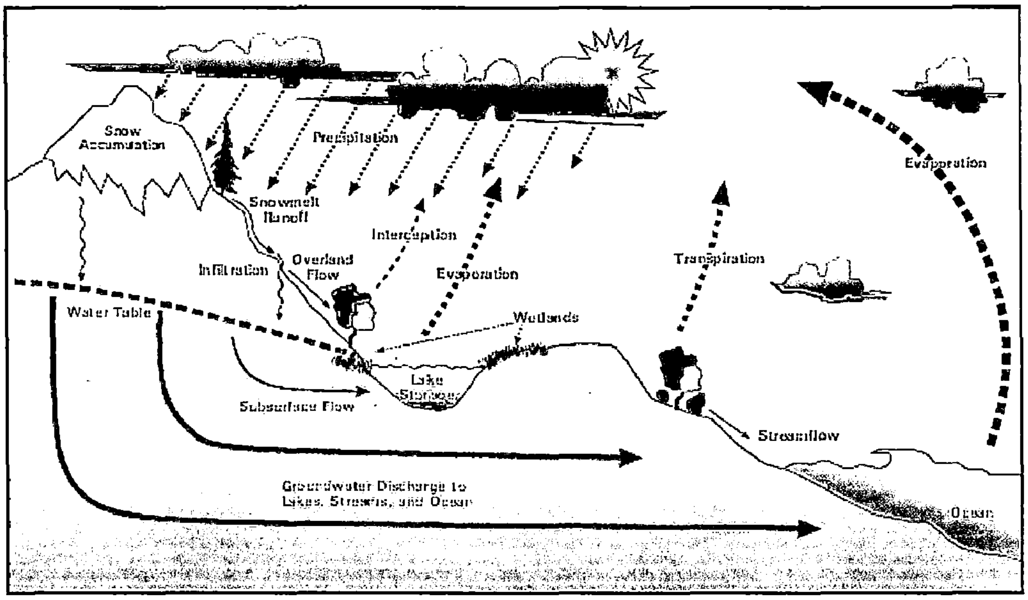


Fig. 1.1 Model of a Hydrologic Cycle

A convenient starting point to describe the cycle is in the oceans. Water in the oceans evaporates due to the heat energy provided by solar radiation. The water vapour moves upward and form clouds. While much of the clouds condense and fall back to the oceans as rain, a part of the clouds is driven to the land areas by winds.

There, they condense and precipitate onto the landmass as rain, snow, hail, sleet, etc. A part of the precipitation may evaporate back to the atmosphere even while falling. Another part may be intercepted by vegetation, structures and other such surface modifications from which it may be either evaporated back to atmosphere or move down to the ground surface.

A portion of the water that reaches the ground enters the earth's surface through infiltration, enhance the moisture content of the soil and reach the groundwater body. Vegetation sends a portion of the water from under the ground surface back to the atmosphere through the process of transpiration. The precipitation reaching the ground surface after meeting the needs of infiltration and evaporation moves down the natural slope over the surface and through a network of gullies, streams and rivers to reach the ocean. The groundwater may come to the surface through springs and other outlets after spending a considerably longer time than the surface flow. The portion of the precipitation which by a variety of paths above and below the surface of the earth reaches the stream channel is called runoff. Once it enters a stream channel, runoff becomes stream flow.

The variation of streamflow in space and time plays an important role in the design and operation of water-resources engineering projects, such as those for irrigation, water supply, flood control, water power and navigation. In all these projects hydrological investigations for the proper assessment of the streamflow is necessary. The hydrological study of a project should of necessity precede structural and other detailed design studies. It involves the collection of relevant data and analysis of the data by applying the principles and theories of hydrology to seek solutions to practical problems.

Many important projects in the past have failed due to improper assessment of the hydrological factors. Some typical failures of hydraulic structures are:

- Overtopping and consequent failure of an earthen dam due to an inadequate spillway capacity,

- Inability of a large reservoir to fill up with water due to overestimation of the stream flow. Such failure, often-called hydrologic failure underscore the uncertainty aspect inherent in hydrological studies, and
- Failure of bridges and culverts due to excess flood flow.

Various phases of the hydrological cycle, such as rainfall, runoff, evaporation and transpiration are all non-uniformly distributed both in time and space. Further, practically all hydrologic phenomena are complex and at the present level of knowledge, they can at best be interpreted with the aid of probability concepts. Hydrological events are treated as random processes and the historical data relating to the event are analysed by statistical methods to obtain information on probabilities of occurrence of various events. The probabilistic analysis of hydrologic data is an important component of present-day hydrological studies and enables the engineer to take suitable design decisions consistent with economic and other criteria to be taken in a given project.

1.2. OBJECTIVE AND SCOPE OF STUDY

The main objective of this study is to collect and carry out the hydrological analaysis for planning a proposed Multipurpose Water Resources Project on Gola River near Kathgodam in district Nainital near Jamrani village in the state of Uttarakhand, India.

The study has been carried out with following scope :

- to estimate Mean Areal Precipitation (MAP) over the Gola river catchment based on rainfall data recorded at a number of raingauges installed in the area.

- to derive relationship between the discharge at Jamrani Dam site and the discharge at Gola Barrage by regression analysis.

- to determine 75% dependable annual water availability at Jamrani Dam site and to draw a Flow Duration Curve at Jamrani Dam site.

- to estimate flood at Jamrani Dam Site based on annual peak flow from the derived data at Jamrani Dam site.

- to estimate sedimentation flow rate at Jamrani Dam site based on the observed sediment data and the derived discharge at Jamrani Dam site.

1.3. SOURCES OF DATA

The main components of the hydrological cycle are rainfall (precipitation), evaporation, transpiration, infiltration, runoff and ground water. Depending upon the problems at hand, a hydrologist would require data relating to the various relevant phases.

The hydro-meteorological data normally required are :

1. Weather records : temperature, humidity and wind velocity,
2. Precipitation data,
3. Stream-flow records,
4. Evaporation and transpiration data,
5. Infiltration characteristics of the area,
6. Groundwater characteristics, and
7. Physical and geological characteristics of the area under consideration.

In India, meteorological data, including weather and rainfall data, are collected by the India Meteorological Department (IMD) and by some state government agencies. Stream flow data of various rivers and streams are usually available with the state irrigation department. Flow in major rivers are monitored by Central government agencies such as the Central Water Commission (CWC). Groundwater data is normally available with the Central Groundwater Board and State Government groundwater development organisations. Data on evaporation, transpiration and infiltration is available with State Government organisations, such as the Irrigation Department and Department of Agriculture. The physical data of the basin can be obtained from the study of topographical maps available with the Survey of India. The geological characteristics of the basin can be obtained from Geological Survey of India and the State Geology Directorate.

1.4. ORGANISATION OF DISSERTATION REPORT

The study is presented in seven chapters. The contents of these chapters are briefly outlined below.

CHAPTER 1 : It deals with the general introduction of the subject and highlights the objective of the study.

CHAPTER 2 : It presents theories which are adopted in a hydrological analysis for water resources planning.

CHAPTER 3 : It describes details of the study area on Gola River near Kathgodam in district Nainital, Uttarakhand, India and the data availability of its hydro meteorological data.

CHAPTER 4 : It deals with estimation for Mean Areal Precipitation, water availability and the correlation between Jamrani Dam and Gola Weir. It further determines dependable annual flow at the dam site.

CHAPTER 5 : It deals with the estimation of the Design Flood which can be used in the water resources project planning.

CHAPTER 6 : It discusses a process of the deposition of sediment in the reservoir is known as Reservoir Sedimentation, and to estimate annual sedimentation rate of the proposed reservoir at the dam site.

CHAPTER 7 : It gives the summary and the conclusion of the study.

CHAPTER 2

HYDROLOGICAL ANALYSIS IN WATER RESOURCES PLANNING

2.1. INTRODUCTION

The water resources structures that we normally come across in practice are storage structures like dams, barrages, regulators, irrigation conveyance channels, bridges, etc. To plan these structures we need one or more of the following informations :

(i) Rainfall data of the catchment,

(ii) Catchment characteristics and the land use pattern,

(iii) Daily stream flows for determining the storage capacity of a reservoir,

(iv) Flood of certain frequency,

(v) Intake rate of sedimentation to estimate useful life of the reservoir.

As rainfall and general climatic condition affects our daily lives more directly than does streamflow, the other data in the form of records of rainfall, temperature, humidity, and pressure etc. are initiated long before stramflow records are obtained. Furthermore rainfall and general climatic records require little skill and training on the part of the observer, whereas reliable streamflow records demand the services of an engineer or at least of a skilled technician. Consequently, long-term data is available in respect of rainfall and climatic records for most of the drainage basins in India, whereas streamflow records are comparatively few and far between. Sometimes, good records are available on the main stream, whereas the problem at hand calls for a knowledge of the water availability of a tributary from the site of the available records or vice versa.

In planning water resources projects, the peak magnitude of the flood that have to be adopted in the design of irrigation, hydro-power and flood-control projects are of great importance to an engineer. If the selected design flood is too high, it results in a conservative and costly structure while adoption of a low design flood will cause damage. It will result in the loss of the structure itself causing thereby untold misery to the people residing downstream, besides damaging valuable immovable properties. The catchment characteristics helps in knowing the sediment rate and hence the useful life of the reservoir.

2.2. MEAN AREAL PRECIPITATION (MAP) ESTIMATION

The Rainfall recorded by a raingauge represents only the rainfall at that station. It is also called the *Point Rainfall.* In many hydrological studies, the average of rainfall over a specified area due to a storm, or due to a number of storms, is required. For determination of the average precipitation over an area, a large number of raingauge are installed. To convert the point rainfall values at various stations into an average value over a catchment the following three methods are in use :

1. Arithmetic Mean Method
2. Thiessen Polygon Method
3. Isohyetal Map Method

1. Arithmetic Mean Method

This method is suitably applied for a basin where the gauges are uniformly distributed and the individual gauge catches do not vary much from the mean. The basin should be a reasonably flat area. The assumption made is that all gauges weight equally. This method gives fairly good results if the topographic influences on precipitation and aerial representativeness are considered while selecting the gauge site. It is the simplest form in which the average of precipitation over the basin is obtained by taking simple arithmetic mean of all the gauged amounts within the basin : $P_{av} = \frac{P1 + P2 + ... + Pn}{n} = \frac{1}{n}\sum_{i=1}^{n} Pi$ (2.1) where *P1, P2, ……, Pn* are the precipitation recorded by *n* number of gauges located within the basin. This method gives a rough estimate of the average precipitation. It does not account for the topographic and other influences. For use of this method, no gauge station located outside the boundary of the watershed should be considered. This methods does not give accurate results and hence is rarely used in practice.

2. Thiessen Polygon Method

In the Thiessen Polygon Method, the rainfall recorded at each rain gauge stations is given a weightage on the basis of the area which it represents. This method is better than the Arithmetic Mean Method which gives equal weightage to all the stations. The following procedure is used.

Procedure :

(i) The positions of the rain gauge stations are marked on the plan of the catchment area over which the average rainfall depth is required.

(ii) The adjacent rain gauge stations are joined by straight lines; thus the entire area is divided into a series of triangles (see Fig. 2.1). The rain gauge stations which are outside the catchment area but are in its neighbourhood should also be considered.

(iii) Perpendicular bisectors are then drawn on the connecting lines to form polygons around stations. Each polygon contains only one rain gauge stations. The entire area of a particular polygon is nearer to the rain gauge stations contained therein than to any other rain gauge stations. Thus, each polygon represents the area of the influence of that rain gauge station.

(iv) For determination of the average of rainfall, the boundary of the catchment is taken as the outer limit of the Thiessen polygons. The areas of the polygons are determined either with a planimeter or with an overlay grid.

(v) The average precipitation of the area is given by

$$P_{av} = \frac{P_1 A_1 + P_2 A_2 + \ldots\ldots + P_n A_n}{A_1 + A_2 + \ldots\ldots + A_n} \quad (2.2)$$

or

$$P_{av} = \frac{\Sigma P_i A_i}{\Sigma A_i} = \frac{\Sigma P_i A_i}{A} \quad (2.2a)$$

where $A_1, A_2, \ldots A_n$ are the areas of the Thiessen polygons representing the stations 1, 2, ...n and $P_1, P_2, \ldots P_n$ are the corresponding precipitations, and A is the total area.

Sometimes above equations are written as $P_{av} = \Sigma P_i \left(\frac{A_i}{A}\right)$. (2.2*b*)

The ratio (A_i / A) is called the *weightage factor* for the stations.

Thus, weightage is given to various stations according to the influence areas. In this method, the stations situated outside the catchment area are also effectively used. Once the weightage factors have been determined, the computation of the average precipitation for different storms becomes easy. However, the method has one drawback that it is inflexible. A new Thiessen polygon network is required when there is a change in the location of the raingauges or when new rain gauge stations are set up. Moreover, no adjustment can be made for variations due to altitudes and other factors. However the advantage of this method is that, it is much more accurate than the previous methods and the procedure of computation becomes simple, once the areas of the polygons are measured. This method is popularly applied to most of the field problems.

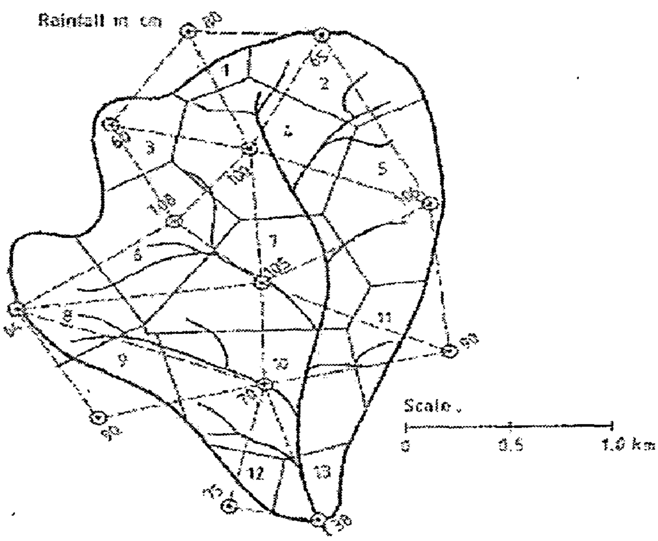


Fig.2.1 Typical Thiessen Polygon map

3. Isohyetal Map Method

Isohyets are the contours of equal rainfall depth. For plotting of an isohyetal map, rain gauge stations are marked on the plan of the catchment. The rainfall recorded at these stations is also marked on the plan. The rain gauge stations located outside the catchment but in its neighbourhood are also marked. The isohyets of various rainfall depths are then drawn by interpolating the values of the rainfall. Generally, a linear variation of rainfall depth is assumed between the two rain gauge stations. The procedure is similar to one used for drawing of the elevation contours from the spot levels in surveying. Fig. 2.2 shows a typical isohyetal map. For determination of the average rainfall depth, the catchment area between adjacent isohyets are measured. The catchment boundary is taken as the extreme limit of the areas. The average depth of the rainfall of an area between two adjacent isohyets is usually taken equal to the mean of the two isohyets values.

For the area between the last isohyet and the boundary of the catchment, a suitable value of the average depth should be taken, depending upon the distance of the outside isohyet and the actual boundary. The average of the rainfall of the entire catchment is given by

$$P_{av} = \frac{P_{12}.A_{12} + P_{23}.A_{23} + \ldots\ldots + P_{(n-1),n}.A_{(n-1),n}}{A_{12} + A_{23} + \ldots\ldots + A_{(n-1),n}} \tag{2.3}$$

or

$$P_{av} = \frac{\Sigma\, P_{ij}\, A_{ij}}{\Sigma\, A_{ij}} \tag{2.3a}$$

where P_{12} is the average precipitation over the area A_{12} between two adjacent isohyets marked 1 and 2 and so on.

The isohyetal map method is the most accurate method. In this method, all the relevant data is fully utilised and properly interpreted. Moreover, the method can be used to make adjustments for variations in altitudes of the stations due to ortographic influences.

Hence while constructing the isohyetal map for a hilly region, the interpolation between gauge stations can be done according to the difference in elevations of two stations, and not according to the distance between them. This is more logical because the precipitation generally depends upon the altitude. However, the method has disadvantage that it is laborious and not easily adaptable to a computer.

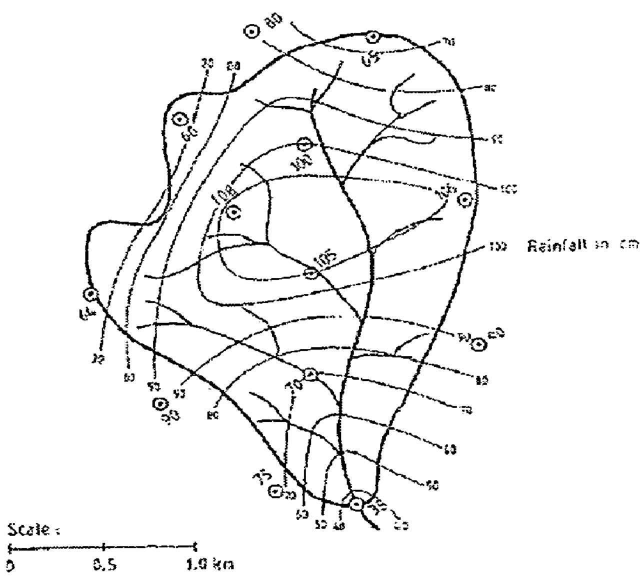


Fig. 2.2. Typical Isohyetal Map

2.3. REGRESSION ANALYSIS

The technique of regression analysis is a procedure for fitting an equation to a set of data. This techniques are used to identify the mathematical dependence between the observed values of physically related variables and thus can account for the additional information contained in the correlated sequences of events. However, the correlation between the desired statistical parameter as the dependent variable should be attempted only with the other physically and climatically related variable of the basin or region as independent variables. The procedure is certainly better than using relatively short historical sequences in hydrologic analyses.

Regression analysis determines the relationships between a *dependent* variable and an *independent* variable. The general regression formula between the independent variable x, and the dependent variable y, is given as

$$y = b_0 + b_1x + b_2x^2 + \ldots\ldots\ldots\ldots\ldots + b_nx^n + \varepsilon \qquad (2.4)$$

The constraints b_0, b_1, ..., b_n are unknown parameters to be determined from available data. The random error ε has zero mean and a constant standard deviation. The simplest form of the regression model assumes that the dependent variable varies linearly with the independent variable, that is,

$$y^* = a + bx \qquad (2.5)$$

The constant a and b are determined using **the least-square criterion**, which minimizes the sum of the square of the differences between observed and estimated values. Given the i-th raw data point (y_i, x_i), i = 1,2, ...,n, the sum of the squares of the deviations between observed and estimated value is defined as

$$S = \sum_{i=1}^{n} (y_i - a - bx_i)^2 \qquad (2.6)$$

The values of a and b are determined by solving the following necessary conditions for the minimization of S :

$$\frac{\partial S}{\partial a} = -2\sum_{i=1}^{n} (y_i - a - bx_i) = 0 \qquad (2.7)$$

$$\frac{\partial S}{\partial b} = -2\sum_{i=1}^{n} (y_i - a - bx_i)x_i = 0 \qquad (2.8)$$

After some algebraic manipulations, we obtain the following solution :

$$b = \frac{\sum_{i=1}^{n} y_i x_i - n\overline{yx}}{\sum_{i=1}^{n} x_i^2 - n\overline{x}^2} \tag{2.9}$$

$$a = \overline{y} - b\overline{x} \tag{2.10}$$

where

$$\text{x} = \frac{\sum_{i=1}^{n} x_i}{n}, \overline{y} = \frac{\sum_{i=1}^{n} y_i}{n} \tag{2.11}$$

The equations show that we need to compute b first, from which a can be computed. The estimates of a and b are valid for any probability distribution of y_i. However, if y_i is normally distributed with a constant standard deviation, a confidence interval can be established on the mean value of the estimator at $x = x^0$ (i.e., $y^0 = a + bx^0$) as

$$(a + bx^0) \pm t_{\frac{0}{2}, n-2} \sqrt{\frac{\sum_{i=1}^{n} (yi - y_i^*)^2}{n-2}} \sqrt{\frac{1}{n} + \frac{(x^0 - \overline{x})^2}{\sum_{i=1}^{n} x_i^2 - n\overline{x}^2}} \tag{2.12}$$

For future (predicted) values of the dependent variable, y, we are interested in determining its **prediction interval** (rather than the confidence interval on its mean value). As would be expected, the prediction interval of a future value is wider than the confidence interval on the mean value. Indeed, the formula for the prediction interval is the same as that of the confidence interval except that the term $\frac{1}{n}$ under the second square root is replaced with $\frac{(n+1)}{n}$.

We can test how well the linear estimator $y^* = a + bx$ fits the raw data by computing the ***correlation coefficient***, ***r***, using the formula

$$r = \frac{\sum_{i=1}^{n} y_i x_i - n\overline{yx}}{\sqrt{(\sum_{i=1}^{n} x_i^2 - n\overline{x}^2)(\sum_{i=1}^{n} y_i^2 - n\overline{y}^2)}} \tag{2.13}$$

where $-1 \leq r \leq 1$.

If r = ± 1, then a perfect linear fit exist between x and y. In general, the closer the value of $|r|$ to 1, the better the linear fit. If $r = 0$, then y and x may or not be independent, in the sense that two dependent variables may yield $r = 0$.

2.4. RAINFALL RUNOFF MODELLING

Rainfall is the source of water for runoff generation in the channel. During occurrence of rainfall, a part of it is intercepted by the vegetations, buildings and several objects lying over the ground surface, which does not reach the land surface. Few portion of rainfall also infiltrates into the soil, and lastly the rest amount of rainfall makes some depth of water over the ground surface, which tends to move from one place to another under effect of land gradient is called overland flow, which ultimately meets to the streams, channels etc. is known as runoff. Thus, runoff may be defined as that portion of rainfall which flows through the rivers, streams, nala etc.

Runoff Computation.

The commonly used methods to compute runoff rate are :

1. Rational Method,
2. SCS-Curve Number Method,
3. Hydrograph Method.

1. Rational Method

It is a common method for computing the peak runoff rate from small catchments. The peak runoff refers to the discharge rate used for design of hydraulic structures, that must carry the runoff. Rational method involves following formula for computing the peak runoff :

$$Q_p = \frac{C.I.A}{360} \qquad (2.14)$$

where, Q_p = peak runoff (m^3/s)

C = runoff coefficient

I = rainfall intensity (mm/hr)

A = area of catchment (ha).

2. SCS Curve Number Method

This method also known as *hydrologic soil cover complex number method*, was developed by Ogrosky and Mockus (1957) for determining peak rate of runoff from small catchments. A runoff *curve number* (CN) is developed through field studies by measuring runoff from different soils at various locations. The antecedent moisture condition and the physical characteristics of the watershed are correlated to give hydrologic soil groups. Soil of any catchments can be classified into the following four hydrologic soil groups.

Group A : It is characterized by low runoff generating potential. This group of soils are mainly constituted by sands or gravel particles. These soils involve high infiltration rate.

Group B : Soils of this group have moderate infiltration rate, even if they are thoroughly wetted. Soils are composed of moderately fine to moderately coarse particles.

Group C : This group of soil contains low infiltration rate. The soil may be composed of a thin hard layer which impedes the downward movement of water. Soils are generally constituted with moderately fine to fine particles.

Group D : This group of soils are characterized by high runoff potential due to very low infiltration rate. Clay soil is the example of this group.

Antecedent Moisture Content (AMC) is wetness status of the catchment. There are following three levels of AMC.

AMC-I : It refers to the lowest runoff generating potential of the catchment because of dryness of the soil.

AMC-II : Average moisture status regarding runoff generating potential.

AMC-III : It refers highest runoff generating potential of the catchment, because of saturation of soil from antecident rains.

In India, most of rain gauges are non-recording type. Rainfall data obtained from such non-recording gauges have been used to establish rainfall runoff relationships. The following relation is normally used for small catchments:

$$\frac{\text{Actual retention of rainfall}}{\text{Potential max. retention}} = \frac{\text{Direct runoff}}{\text{Rainfall} - \text{Initial abstraction}}$$

or
$$\frac{P - I_a - Q_d}{S} = \frac{Q_d}{P - I_a}$$

or
$$Q_d = \frac{(P - I_a)^2}{(P - I_a + S)} = \frac{(P - 0.2S)^2}{(P + 0.8S)} \qquad (2.15)$$

where : Q_d is the runoff depth (cm) over the catchment,

P is the mean rainfall (cm) over the catchment,

S is the potential maximum retention (cm),

I_a is the initial losses consisting of interception, depression storage and infiltration.

For black soil, I_a is taken as 0.1 S for AMC-II and III type, I_a is taken as 0.3 S for AMC-I type. For all other types, I_a is 0.2 S. In general the value of I_a is taken as 0.2 S. For all soil regions of India, except black soil region of AMC-II and III, Q_d is calculated as

$$Q_d = \frac{(P - 0.3S)^2}{(P + 0.7S)} \qquad (2.16a)$$

For black soil of AMC-II and III

$$Q_d = \frac{(P - 0.1S)^2}{(P + 0.9S)} \qquad (2.16b)$$

Now, S (cm) is related to curve number (CN) as follows :

$$CN = \frac{2540}{25.4 + S} \qquad (2.17)$$

The peak discharge in m^3/s can be calculated from the following relation

$$Q_p(\text{m}^3/\text{s}) = \frac{0.0208 \times A \times Q_d}{t_p} \qquad (2.18)$$

where for small catchments, time to peak t_p in h is obtained as

$$t_p = 0.6t_c + t_c^{1/2} \qquad (2.19)$$

where A is the catchment area (Ha), Qd is the depth of runoff (cm) is obtained from equation (2.15) or (2.16) depending on the type of soil and Q_p is the peak discharge (m^3/s).

3. Hydrograph Method

Hydrograph is the graphical presentation of instantaneous runoff rate against time. It is used for computing the runoff from the catchment. The unit hydrograph is mainly used for the purpose. The hydrograph will described in detail in sub-Chapter 2.6.2.

2.5. FLOW DURATION CURVE

A Flow Duration Curve can be drawn if a continuous record of daily flow (or average weekly or average monthly flow) is available for a long period. The flow duration curve represents the data in a condensed form and is extremely useful for the estimation of the available power.

The flow duration curves drawn from the record of the daily flow will be somewhat different from that obtained from the record of the average weekly flow or average monthly flow. It is observed that the shape of the curve depends upon the variability of the flow data. Because the variation of the daily flow is larger than that of the weekly flow, the flow duration curve computed from the average daily flow will show greater variability than the one from the average weekly flow. Likewise, the flow duration curve computed from the average weekly flow would show greater variability than that from the average monthly flow.

The flow duration curve drawn from the mean weekly flow rates will be more approximately than that drawn from the mean daily flow, because there is considerably variation in the flow which is not indicated in the mean weekly flow rates. Likewise, the error involved in the use of mean monthly flow rates is more than that in the use of mean weekly flow rates. The error in the use of the monthly flow rates may vary from 5 to 15 percent, depending upon the characteristics of the stream and the extent of utilisation of flow. However, the difference between the daily flow-duration curve and the monthly flow-duration curve will be negligible for a stream with a constrant steady discharge. On the other hand, the difference would be quite large for very flashy streams.

Procedure for drawing flow-duration curve

A Flow duration curve is a plot between the discharge as ordinate and the percentage of time that discharge is equalled or exceeded as abscissa (see Fig. 2.3). Before drawing the flow-duration curve, the stream flow data are collected, as explained earlier. Let us assume that the average daily flow data are available for one year (365 days) for which the flow-duration curve is to be drawn. The following procedure is used for plotting the flow-duration curve from the daily flow.

1. From the available record, the mean daily flow rates differing by a convenient magnitude. These flow rates are entered in column (1) of Table, in the order of descending magnitude.
2. The number of days a particular discharge has equalled or exceeded out of 365 days is entered in column(2) of the table. Of course, the lowest discharge would be equalled or exceeded all the 365 days.
3. The percentage of time a particular discharge is equalled or exceeded is computed from the relation.

$$P = \left(\frac{m}{n} \right) \text{ x } 100 \qquad (2.20)$$

   Where n is the total number of events, m is the number of times a particular event (in this case, discharge) has equalled or exceeded. The value of m is obtained from column (2) of the table. The values of p are entered in column (3).
4. A plot is then made between the discharge Q as ordinate and the percentage of time p as abscissa (Fig. 2.3). The lowest discharge would of course be exceeded 100% of time.

   Similar curves can be prepared using the mean weekly, mean monthly or mean annual flow rates. This method of computation is known as the Total Period Method.

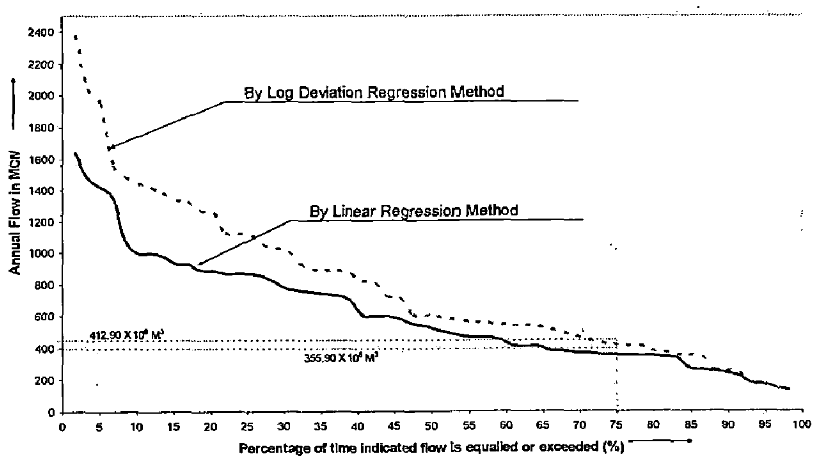


Fig. 2.3. Typical Flow Duration Curve

2.6. FLOOD ESTIMATION

A Flood is an unusually high stage in a river, normally the level at which the river overflows its bank and inundates the adjoining area. The damages caused by floods in terms of loss of life, property and economic loss due to disruption of economic activity are all too well-known. Crores of rupees are spent every year in flood control and flood forecasting. The hydrograph of extreme floods and stages corresponding to flood peaks provide valuable data for purposes of hydrologic design. Further, of the various characteristics of the flood hydrograph, probably the most important and widely used parameter is **the flood peak**. At a given location in a stream, flood peaks vary from year to year and their magnitude constitutes a hydrologic series which enable one to assign a frequency to a given flood peak value. In the design of practically all hydraulic structures the peak flow that can be expected with an assigned frequency (say 1 in 100 years) is of primary importance to adequately proportion the structure to accommodate its effect. The design of bridges, culvert waterways and spillways for dams and estimation of scour at a hydraulic structure are some examples wherein flood peak values are required.

To estimate the magnitude of a flood peak the following alternative methods are available :

1. Empirical Method,
2. Unit Hydrograph Technique,
3. Flood Frequency Analysis.

The use of a particular method depends upon

(i) the desired objective,

(ii) the available data,

(iii)the importance of the project.

1. Empirical Method

The empirical method used for the estimation of the flood peak are essentially regional formulae based on statistical correlation of the observed peak and important catchment properties. To simplify the form of the equation, only a few of the many parameters affecting the flood peak are used. For example, almost all formulae use the catchment area as a parameter affecting the flood peak and most of them neglect the flood frequency as a parameter. In view of these, the empirical formula are applicable only in the region from which they were developed and when applied to other areas they can at best give approximate values.

Flood-Peak-Area Relationships

By far the simplest of the empirical relationships are those which relate the flood peak to the drainage area. The maximum flood discharge Qp from a catchment area A is given by these formulaes as

$$Qp = f(A) \quad (2.21)$$

While there are a vast number of formulae of this kind proposed for various parts of the world, only a few popular formulae used in various parts of India are given below,

- Dickens Formula (1865)

$$Qp = C_D.\ A^{3/4} \quad (2.22)$$

Where Qp = maximum flood discharge (m^3/s)
A = catchment area (km^2)
C_D = Dickens constant with value between 6 to 30

The following are some guidelines in selecting the value of C_D :

	Value of C_D
North-Indian plains	6
North-Indian hilly regions	11 – 14
Central India	14 – 28
Coastal Andhra and Orissa	22 - 28

For actual use the local experience will be of aid in the proper selection of C_D.

Dickens formula is used in the central and northern parts of the country.

- Ryves Formula (1884)

$$Qp = C_R.\ A^{2/3} \quad (2.23)$$

Where Qp = maximum flood discharge (m^3/s)
A = catchment area (km^2)
and C_R = Ryves coefficient

This formula originally developed for the Tamil Nadu region, is in use in Tamil Nadu and parts of Karnataka and Andhra Pradesh. The values of C_R recommended by Ryves for use are :

C_R = 6.8 for areas within 80 km from the east coast
= 8.5 for areas which are 80 – 160 km from the east coast
= 10.2 for limited areas near hills

However, various major reservoir projects built in Tamil Nadu since 1950 have adopted considerably much higher values of C_R than the above.

- Inglis Formula (1930)

This formula is based on flood data of catchment in Western Ghats in Maharastra.

The flood peak Qp in m^3/s is expressed as

$$Qp = \frac{124\,A}{\sqrt{(A + 10.4)}} \quad (2.24)$$

where A is the catchment area in km^2.

Above equation with small modification is the constant in the numerator (124) is in use Maharasthra for designs in small catchments.

- Other Formulae

There are many such empirical formulae developed in various parts of the world.

There are some empirical formulae which relate the peak discharge to the basin area and also include the flood frequency. Fuller's formula (1914) derived for catchments in USA is a typical one of this kind and is given by

$$Q_{TP} = C_f \, A^{0.8}(1 + 0.8\log T) \quad (2.25)$$

where Q_{TP} = maximum 24-h flood with a frequency of T years in m^3/s,
A = catchment area in km^2,
C_f = a constant with values between 0.18 to 1.88.

2. Unit Hydrograph Technique (UH),

An Unit Hydrograph is the hydrograph of direct runoff resulting from unit depth of 1 cm of rainfall excess generated uniformly over the basin for a specified duration (D-hours). The term unit depth of rainfall excess means excess rainfall over and above all losses in the basin under consideration. The duration is the period of rainfall excess which is assumed to be uniformly distributed over the basin area. The specified duration is important as the shape and the peak of unit hydrograph of a basin depends on it. Thus for period of 3-h rainfall excess over the basin, the unit hydrograph is named as 3-h unit hydrograph. Sketch of an UH is shown in Figure 2.4. A watershed can have as many unit-hydrographs depending on the number of corresponding periods of rainfall excess. An unit hydrographs of 2, 6 or 12 h indicates that it is the duration of rainfall excess giving rise to the unit hydrograph. It never means the duration of the occurrence of unit hydrograph.

The concept of unit hydrograph was originally put forth by Sherman in 1932. The present definition is more refined and an universally accepted one based on the following principles and assumtions.

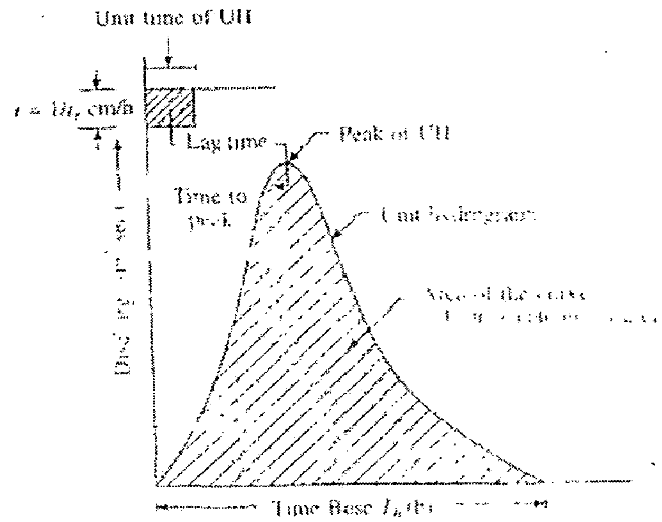


Fig. 2.4. Sketch of an Unit Hydrograph

Assumptions and Conditions in Unit Hydrograph

1. *The principle of time invariance* applies to the unit hydrograph, which means that a given rainfall excess will produce the same direct runoff hydrograph whatever may be the season of the year.
2. *The principle of linearity* is that when a D-hour rainfall excess of 1 cm depth over the basin produces a direct runoff hydrograph of 1 cm, then x cm depth of rainfall excess of the same duration (D-hour) over the same basin will produce a runoff of x cm depth. Conversely, the ordinates of the direct runoff hydrograph of D-hour duration may be brought to unit

hydrograph of D-hour by dividing the ordinates of DRH by (x/1). Similarly, if x_1 cm of rainfall excess produces y_1 cm of runoff and x_2 cm produces y_2 cm, then $(x_1 + x_2)$ cm of rainfall excess will produce $(y_1 + y_2)$ cm of DRH.

3. A storm of duration of rainfall excess t_r hours will always produce a surface runoff hydrograph of base T_b-hours regardless the intensity of rainfall in the period t_r. Time base T_b of runoff is sum of t_c and t_r where t_c is the time of concentration of the watershed upto the desired outlet.
4. An unit hydrograph is a lumped response of the catchment at the basin outlet.
5. The area of DRH due to unit hydrograph is the area of the basin multiplied by 1 cm.
6. When the duration of rainfall excess is D-h, the excess rainfall intensity is 1/D-cm/h. This is because the total rainfall producing a UH is 1 cm. For 1 h duration of rainfall excess, the intensity of rainfall excess is 1 cm/h.
7. Since the consideration for UH is the rainfall excess, the antecedent or subsequent storm conditions have no action to present derivation of UH.

Limitations of Unit Hydrograph

1. The maximum catchment limitation for derivation or application of unit hydrograph theory is upto 5000 km^2. For catchment exceeding this area, the basic assumption of uniform rainfall distribution over the basin due to the storm may be violated. However, the limitation on size of catchment area should also take into account the orographic features of the basin.
2. The application of UH is not suitable for very long basins.
3. The lower limit on the size of a basin to which the UH concept apply should preferably be more than 2 km^2.
4. When a large portion of basin is covered with snow, the UH principle should not be applied.
5. The duration of rainfall excess should preferably be 1/3 to 1/5 of basin lag.

6. UH should not be derived from a catchment where large storage exists.
7. If there is high variation in the rainfall intensity over the basin then for such storms UH should not be derived.

Fluctuations of intensities of rainfall in D-hour is taken care of by the catchment characteristics producing runoff. Total affect of variation of intensity on unit hydrograph is usually neglected. However it is not possible to quantify this limitation of variation in UH.

Uses of Unit Hydrograph

The important purposes for which a unit hydrograph can be used are :

1. *Computation of flood hydrograph for design of structure :* When the Probable Maximum Precipitation (PMP) or the Standard Project Storm (SPS) for a basin is known, the UH is convoluted over the excess rainfall of the histogram blocks of PMP or SPS to obtain the design flood at the project site.
2. *Extension of the flow records at a site :* The method is more or less the same as (1). All storm precipitation depths, i.e. rainfall excess for the entire period under consideration are multiplied successively by UH ordinates and added up to compute the runoff volumes. The work is enormous and cannot be handled manually. Use of a digital computing machine is necessary to calculate the runoff values for each storm.
3. *Flood forecasting models :* Unit Hydrograph developed for a basin are stored in a computer. Knowing the excess rainfall depths from telemeter gauges, flood can be forecasted for the basin by convoluting the UH over the excess storm rainfall and carrying out the channel routing if necessary.
4. *Comparing the catchment characteristics :* Two unit hydrographs of the same unit durations derived from two adjoining basins can be used to compare the hydro-meteorological cxharacteristics of the basins.

3. Flood Frequency Analysis

Flood frequency analysis considers the annual peak flows at a site for all the years. The method of analysis and predicting flood from the data runoff peaks is called flood frequency analysis. It gives only the magnitude of flood peak of desired recurrence interval or return period, but doesn't provide information about the complete hydrograph or the flood volume. Predication of flood peaks from the flood data of recorded maximum series are reliable when is carried out for return periods of less than the data length. However, when data is to be extrapolated, for example when flood peaks of 1000 or 10000 years are required to be predicted from an annual maximum services of say 30-40 years, then the prediction should be carried out with caution as the sample data may not be true representative of the population. There may be long term trend or a cycle associated with the system. For such predictions, confidence bends or limits are to be estimated at 95% or other acceptable percentages, depending on the precision requirement.

Frequency analysis for some important theoretical distributions are given below.

Gumbel's Distribution Method

This extreme value distribution was introduced by Gumbel (1941) and is commonly known as Gumbel's distribution. Gumbel probability distribution is widely used for extreme value analysis of hydrologic and meteorological data like floods, maximum rainfalls, maximum wind speed and other events. Gumbel defined a flood as the largest of the 365 daily flows and the annual series of flood flows constitute a series of largest values of flows. According to his theory of extreme events, the probability of occurrence of an event equal to or larger than a value x_0 is

$$P\,(X \geq x0) = 1 - e^{-e^{-y}} \qquad (2.26)$$

In which y is a dimensionless variable given by

$$y = \alpha\,(x - a)$$

$$a = \bar{x} - 0.45005\ \sigma_x$$

$$\alpha = 1.2825 / \sigma_x$$

Thus

$$y = \frac{1.2825(x-\bar{x})}{\sigma x} + 0.577 \qquad (2.27)$$

where $\bar{x}$ = mean and σ_x = standard deviation of the variate X. In practice it is the value of X for a given P that is required and as such Eq. (2.26) is transposed as

$$y_p = -\ln[-\ln(1-P)] \qquad (2.28)$$

Noting that the return period $T = 1/P$ and designating y_T = the value of y, commonly called the reduced variate, for given T

$$y_T = -[\ln.\ln(T/(T-1))] \qquad (2.29)$$

$$y_T = -[0.834 + 2.303 \log\log(T/(T-1))] \qquad (2.29a)$$

Now rearranging Eq. (2.27), the value of the variate X with a return period T is

$$x_T = \bar{x} + K\,\sigma x \qquad (2.30)$$

where

$$K = \frac{(yT - 0.577)}{1.2825} \qquad (2.31)$$

Further, Eqs. (2.30) and (2.31) constitute the basic Gumbel's equations and are applicable to an infinite sample size (i.e. $N \to \infty$).

Since practical annual data series of extreme events such as floods, maximum rainfall depths, etc, all have finite lengths of record, Eq.(2.31) is modified to account for finite N as given below for practical use.

Gumbel's equations for practical use.

Equation (2.30) giving the value of the variate X with a recurrence interval T is used as

$$x_T = \bar{x} + K\,\sigma_{n-1} \qquad (2.32)$$

where σ_{n-1} = standard deviation of the sample size of size N

$$= \sqrt{\frac{\sum(x-\bar{x})^2}{N-1}}$$

K = frequency factor expressed as $= \dfrac{yT - \bar{y}n}{Sn}$ (2.33)

in which y_T = reduced variate, a function of T and is given by

$$y_T = -\left[\ln.\ln\frac{T}{T-1}\right] \qquad (2.34)$$

or

$$y_T = -\left[0.834 + 2.303 \log\log\frac{T}{T-1}\right]$$

$\bar{y}n$ = reduced mean, a function of sample size N and is given in Table 2.1 ; for $N \to \infty$, $\bar{y}n \to 0.577$

S_n = reduced standard deviation, a function of sample size N and is given in Table 2.2 ; for $N \to \infty$, $Sn \to 1.2825$

These equations are used under the following procedure to estimate the flood magnitude corresponding to a given return based on an annual flood series.

1. Assemble the discharge data and note the sample size N. Here the annual flood value is the variate X. Find $\bar{x}$ and σ_{n-1} for the given data.
2. Using Tables 1C and 2C of Appendix-C to determine $\bar{y}n$ and Sn approriate to given N.
3. Find y_T for a given T by Eq. (2.34).
4. Find K by Eq. (2.33).
5. Determine the required x_T by Eq. (2.32).

Gumbel Probability Paper

The Gumbel probability paper is an aid for convenient graphical representation of Gumble's distribution. It consists of an abscissa specially marked for various convenient values of the return period T. To construct the T scale on the abscissa, first construct an arithmetic scale of y_T values, say from -2 to +7. For selected values of T, say 2, 10, 50, 100, 500 and 1000, find the values of y_T by Eq.(2.34) and mark off those positions on the abscissa. The T-scale is now ready for use.

The ordinate of a Gumbel paper on which the value of the variate, x_T (flood discharge, maximum rainfall depth, etc.) are plotted may have either an arithmetic scale or logarithmic scale. Since by Eqs (2.29) and (2.30) x_T varies linearly with y_T, a Gumbel distribution will plot as a straight line on a Gumbel probability paper. This property can be used advantageously for graphical extrapolation, whereever necessary.

To verify whether the given data follow the assumed Gumbel's distribution, the following procedure may be adopted. The value of x_T for some return periods $T < N$ are calculated by using Gumbel's formula and plotted as x_T vs T on a convenient paper such as a semi-log, log-log or Gumbel probability paper. The use of Gumbel probability paper results in a straight line for x_T vs T plot. Gumbel's distribution has the property which gives T = 2.33 years for the average of the annual series when N is very large. Thus the value of a flood with T = 2.33 years is called the *mean annual flood.* In graphical plots this gives a mandatory point through which the line showing variation of x_T with T must pass. For the given data, values of return periods (plotting positions) for various recorded values, x of the variate are obtained by the relation $T_p = (N + 1)/m$ and plotted on the graph described above.

A good fit of observed data with the theoretical variation line indicates the applicability of Gumbel's distribution to the given data series. By extrapolation of the straight line x_T vs T, values of x_T for $T > N$ can be determined easily.

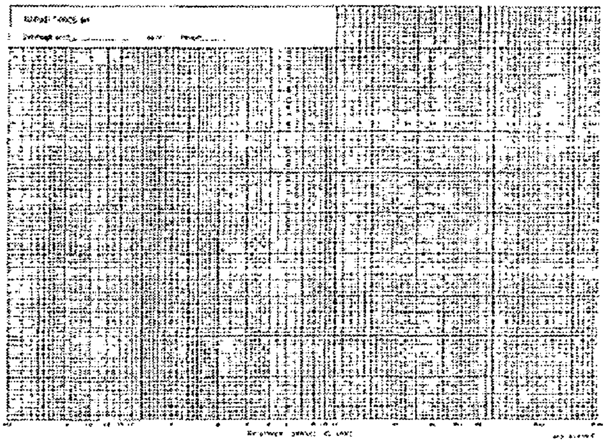


Fig. 2.5. Gumble's Probability Paper

Log-Pearson Type III Distribution

This distribution is extensively used in USA for projects sponsored by the US Government. In this the variate is first transformed into logarithmic form (base 10) and the transformed data is then analysed. If X is the variate of random hydrologic series, then the series of Z variates where

$$z = \log x \quad (2.35)$$

are first obtained. For this z series, for any recurrence interval T, gives

$$z_T = \bar{z} + K_z \, \sigma_z \quad (2.36)$$

where Kz = a frequency factor which is a function of recurrence interval T and the coefficient of skew Cs,

σ_z = standard deviation of the Z variate sample

$$= \sqrt{\frac{\sum (z - \bar{z})^2}{(N-1)}} \quad (2.36\ a)$$

and

Cs = coefficient of skew of variate Z

$$= \frac{N\sum(z-\bar{z})^3}{(N-1)(N-2)(\sigma z)^3} \quad (2.36\text{ b})$$

$\bar{z}$ = mean of the z values

N = sample size = number of years of record

The variations of $K_z = f(Cs, T)$ is given in Table 3C of Appendix-C.

After finding z_T by Eq. (2.36), the corresponding value of xT is obtained by Eq. (2.35) as

$$x_T = \text{antilog}\,(z_T) \quad (2.37)$$

Sometimes, the coefficient of skew C_s, is adjusted to account for the size of the sample by using the following relation proposed by Hazen (1930)

$$\hat{C}_s = C_s\left(\frac{1+8.5}{N}\right) \quad (2.38)$$

where $\hat{C}_s$ = adjusted coefficient of skew. However the standard procedure for use of log-Pearson Type III distribution adopted by US Water Resources Council does not include this adjustment for skew.

When the skew is zero, i.e. $C_s = 0$, the log-Pearson Type III distribution reduces to *log normal distribution.* The log-normal distribution plots as a straight line on logarithmic probability paper.

2.7. SEDIMENT SAMPLING & ANALYSIS

2.7.1. Sediment Sampling

Sediment is fragmented material that originates from chemical or physical disintegration of rocks. Sediment sampling involves collection of known volume of water-sediment mixture from the stream which is further analysed to determine the quantity of sediment yield. In case bed load is not measured, 2.5 to 15 % of the suspended load is generally added depending upon bed material to arrive at the total sediment yield. Sediment sampling can be taken through :

(a) depth integration sediment sampling method

(b) point integration sediment sampling method.

a. Depth Integration Sediment Sampling

Depth integrated samples are taken with a sampler that has an intake which points directly into the current. The sample is collected as it traverse the depth of the stream at a uniform speed. For stream less than 5 metre deep, the sampler is lowered to the bottom of the stream at a uniform rate and raised back to the surface at a uniform rate, but not necessarily the same rate. Streams from 5 to 10 metre deep are usually integrated in one direction only. Deeper streams are integrated in more than one sampling trip.

This method is advantageous to the fact that a single sample provides a discharge weighted concentration or a complete sampling vertical or for major fraction of a sampling vertical in very deep streams. However, it leaves an unsampled zone at the bottom which may required separate computation of unmeasured suspended sediment.

b. Point Integration Sediment Sampling

This method involves lowering the sampler to the sampling point, opening the valve for the desired sampling time, then closing the valve at the end of sampling period. It is useful to determine sediment distribution.

2.7.2. Analysis of Sediment Sample

The sediment samples collected from a stream/river are analysed by two methods namely : (a) Gravimetric method and ; (b) Hydrometric method. Hydrometric method needs trained staff and is mostly adopted where laboratory has been set up and equipped for analysis.

Based on soil particle size the following standards are adopted for classifying coarse, medium and fine sediment particles :

i) Coarse sediment ----- Particles above 0.2 mm in diameter.

ii) Medium sediment ----- Particles between 0.075 to 0.20 mm.

iii) Fine sediment ----- Particles below 0.075 mm.

In addition, there are various kinds of salts dissolved in water along with organic matters. In case of low sediment concentration, the estimation of suspended sediment, particularly the fine sediment is difficult by hidrometric method and may give inaccurate results, the while same can be estimated easily by adopting gravimetric method of sediment analysis.

2.8. CONCLUSION

In Water Resources Structures Projects Planning, we need the following information :

(i) Rainfall data of the catchment,
(ii) Catchment characteristics and the land use pattern,
(iii) Daily stream flows for determining the storage capacity of a reservoir,
(iv) Flood of certain frequency,
(vi) Intake rate of sedimentation to estimate useful life of the reservoir.

For determination of the average precipitation over an area, a large number of rain gauges are installed, and to convert the point rainfall values at various stations into an average value over a catchment (Mean Areal Precipitation), the following three methods can be used :

(i) Arithmetic Mean Method
(ii) Thiessen Polygon Method
(iii) Isohyetal Map Method

Thiessen Polygon Method is the most popular applied to most of the field problems.

Regression Analysis technique is a procedure for fitting an equation to a set of data. This techniques are used to identify the mathematical dependence between the observed values of physically related variables and thus can account for the additional information contained in the correlated sequences of events. This procedure is certainly better than using relatively short historical sequences in hydrological analyses.

Computation of accurate runoff rate or volume due to any storm from the catchment is a difficult task, because it depends on several factors related to the catchment and atmosphere, prediction of whom is not easy. However, the commonly used methods are given below :

(i) Rational Method

(ii) SCS – Curve Number Method

(iii) Hydrograph Method

A Flow Duration Curve can be drawn if a continuous record of daily flow (or average weekly or average monthly flow) is available for a long period. The flow duration curve represents the data in a condensed form and is extremely useful for the estimation of the available power.

The Design Flood is considered as inflow at the upstream of the structure which the structure should pass safely. To estimate the magnitude of a flood peak, the following alternative methods are :

(i) Empirical Method

(ii) Unit Hydrograph Technique

(iii) Flood Frequency Analysis

Sediment sampling can be taken through :

(a) depth integration sediment sampling method

(b) point integration sediment sampling method.

The sediment samples collected from a stream/river are analysed by two methods namely :

(a) Gravimetric method and ;

(b) Hydrometric method.

CHAPTER 3

STUDY AREA AND DATA AVAILABILITY

3.1. BACKGROUND

Jamrani Dam Project is a Multi-purpose Water Resources Project to be executed in Kumaon region in the state of Uttarakhand, India (Fig. 3.1). Jamrani Dam Project consists of a diversion system (Gola Barrage) in its first phase on Gola River at Kathgodam in district Nainital, Utrarakhand and 130.6 metres high Roller Compacted Concrete Dam in second phase across river Gola about 10 kilometres upstream from Kathgodam near Jamrani village. It was sanctioned by Central Water Commission (C.W.C), Government of India in 1975. The first phase of the project was completed in 1982 and side by side investigations were continued for the main dam (the second phase).

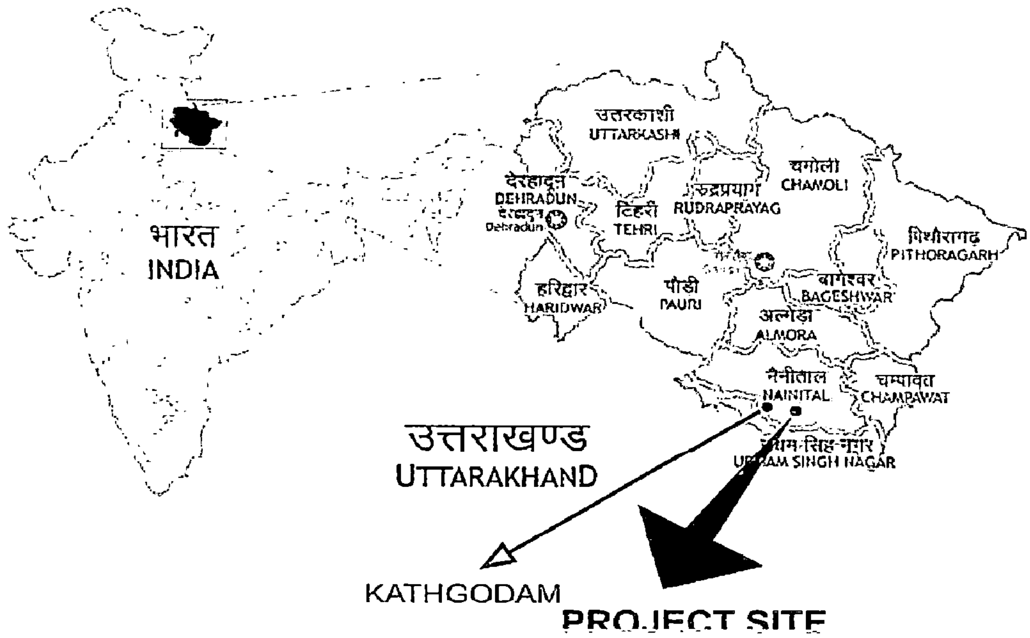


Fig. 3.1 Index Map of Proposed Jamrani Dam Site.

Gola river originates and flows through south eastern Kumaon Himalaya in the State of Uttarakhand. It is fed largely by the runoff during monsoon season, when its discharge is high but progressively gets reduced in winter and summer season.

Haldwani town is the gateway of Kumaon hills and a number of industrial units like sugar, cotton, soya oil, yarn, dairy, paper, electric goods and watches have been established around the town and other commercial units are proposed to be set up soon.

The growth and improvement has lead to an acute water shortage in the area of Tarai and Bhaber. Tarai and Bhaber areas mainly constitute of fertile agricultural land for which there is an acute shortage of water. At present there is no dependable source of water to meet the drinking water of the Haldwani town and nearby villages and as well as the need of irrigation water for agriculture. Though number of tubewells have been constructed and are in construction to meet this requirement but due to huge extraction of water, the water table has gone down considerably. Most of the surface water sources are either dried up or the discharge of them has been reduced which has affected the assured supply of water. On the other hand, a large quantity of water flows away during Monsoon period in Gola river.

3.2. THE PROJECT

Jamrani project consist of constructing a 130.6 metres high roller compacted concrete dam on river Gola near Jamrani village, about 10 kilometres upstream of Kathgodam in district Nainital, Uttarakhand. The latitude and longitude of the dam site are $29^{0}16'15''$ N and $79^{0}37'$ E respectively.

This dam will creates a storage reservoir of 208.6 MCM capacity, out of this 144.3 MCM as live storage and 64.3 MCM as the dead storage. Water for irrigation is proposed to be released through an outlet provided in the body of the dam. The water stored in the reservoir is to be utilised in the lean period for irrigation. This is to be picked up at Gola Barrage, already completed against this project as phase one, and diverted to two main feeders from left and right banks of the barrage. This project also provides for constructing of about 36 kms of feeder channels to augment the supplies in the existing channels of Tarai and Bhabar area, which are mostly completed except two feeders.

Salient Features of the Project :

1.	Type of Dam	Roller compacted concrete gravity dam
2.	Height above river bed	130.6 metres
3.	Top level	765.6 metres
4.	Type of spillway	Ogee type
5.	Waterway	4 bays of 13.25 metre each
6.	Width of piers	3.75 metres
7.	Crest level	749.00 metres
8.	Gates	Radial of size 13.25 x 13.5 metres
9.	Catchment area at dam site	450 km^2
10.	Catchment area at Gola Barrage site	600 km^2
11.	Normal rainfall in the catchment	1540 mm
12.	Reservoir capacity at Full Reservoir Level (762.0 M)	208.6 MCM
13.	Reservoir capacity at dead reservoir Level (716.63 M)	64.3 MCM
14.	Total live storage	144.3 MCM
15.	Water spread at full reservoir level	450 Hectares
16.	River bed slope	14 m/km
17.	River bed level at Dam site	635.00 metres
18.	Maximum tail water level	643.00 metres
19.	Gola Barrage (completed 1982)	
	a) Length	81.00 metres
	b) Crest level of water way	506.50 metres
	c) Crest level of sluice bay	506.50 metres
	d) D/S floor level	502.00 metres
	e) Design discharge	3250 cumecs
	f) Pond level	510.75 metres

(*source : 1989 - Report on Hydrology*)

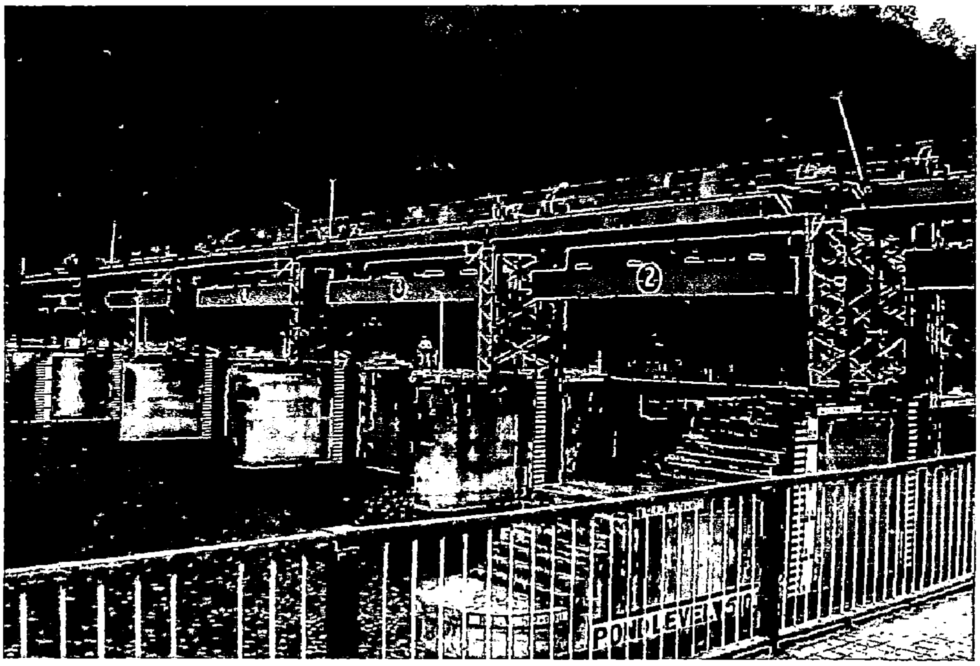


Fig. 3.2 Upstream view of Gola Barrage at Kathgodam

3.3. ADVANTAGES OF THE PROJECT

This project will help in providing an additional irrigation of 12993 Hect. in Uttarakhand and 47607 Hect. in Uttar Pradesh and the irrigation potential will increase from 52.4% to 92.7%. Construction of this Dam will help in solving the main problem of drinking water in Haldwani and Bhaber area, also ground water table in the Bhaber area will increase considerably causing the increase in continuous discharge of tubewell.

At present the flood of Gola river erodes the valuable agricultural land, damages other valuable property including human life. Construction of Dam will check the erosion, damages of property and meandering of river. Thus by constructing Dam the losses in crores will be saved. Construction of Dam will help in providing the facilities to rowing, yatching, boating and will develop the area for tourism, which also help in providing employment to local persons and will ultimately be helpful in changing the living standard and style of the peoples. The proposed generation of 30 MW electricity is being taken as indirect profit as electricity generation though will depend solely on the availability of water in the reservoir.

After the construction of the Dam, this entire area will have sufficient water for irrigation, drinking purpose. Thus the construction of Dam is the only solution to fulfill the developing needs of people and area.

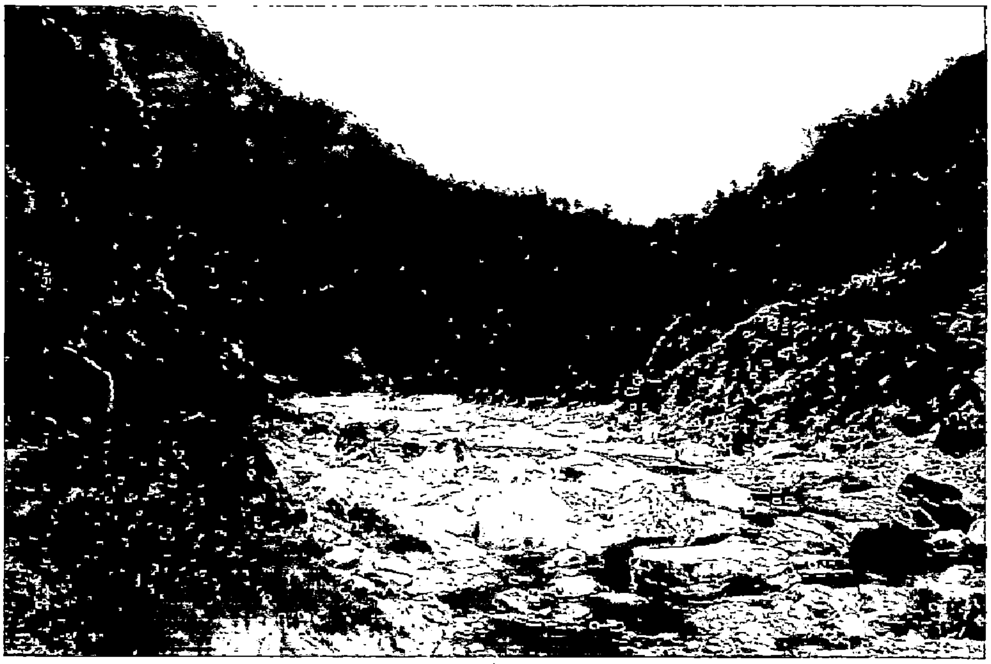


Fig. 3.3 Site for the proposed Jamrani Dam, located 10 km upstream of Gola Barrage

3.4. CLIMATE

The region has a dry season from October till May and a wet season from June to September when approximately 90% of the average rainfall of 1542 mm is received. May and June have very high temperatures (average maximum temperature between 35^0 to 40^0C and average minimum temperature varying between 16^0 to 25^0 C), whereas December and January are cooler months average maximum temperature between 17^0 to 24^0C and average minimum temperature varying between 5^0 to 10^0 C). The relative humidity at Pantnagar varies from 75 to 80 in July to September, whereas it is lowest (40 to 50) in April. At Dam site, it varies between 62 to 66 in July to September and 32 to 40 in March. The maximum wind velocity at dam site is observed as 80 km/hr in April and 15 km/hour in January (1989 report). The pan evaporation at Pantnagar (from data of 2002-2006) is minimum in December-January (1 to 2 mm/day) and maximum in April-May (8-9 mm/day). Due to development activities around Nainital and the adjoining areas, there is an overall ecological change and, the area is now considered to be good and prosperous from all angles.

3.5. HYDROLOGICAL AND METEOROLOGICAL DATA

3.5.1. Catchment Area

The catchment area at the proposed Jamrani dam site is 450 km^2, drained by the Gola River and its tributary called Kalsa river. The catchment area is hilly and valley is narrow with sides having steep slopes. A number of nalas drain off the basin into the river. The hills are bare with cultivation on the terraces here and there. There are no storage tanks or lakes in the catchment. The shape of the catchment is somewhat 'D' shaped. The compactness factor of the catchment (perimeter of catchment/circumference of a circle having area equal to catchment) is 1.27. The form factor of the catchment (average width of the catchment/axial length of the catchment) is 1.3. The catchment area plan is shown in Fig.3.4.

River Gola faces problems of flash flood during rainy season. The river flowing through mountaineous terrain, descends into plains at Kathgodam. Extensive flood plain deposits comprising of sand and boulders are present downstream of Kathgodam. Gola river originates and flows through southeastern Kamaun Himalaya in district Nainital. It is not a snowfed river. The river is fed largely by the runoff during monsoon season when its discharge is high but progressively gets reduced in the dry season. The flow is not sufficient to meet even the existing demand of drinking water. The river bed slope varies from 14 m/km at the dam site to 23 m/km in the upper reaches and that of its tributary Kalsa from 13 m/km to 23 m/km. The longitudinal section of river Gola is shown in Fig 3.5.

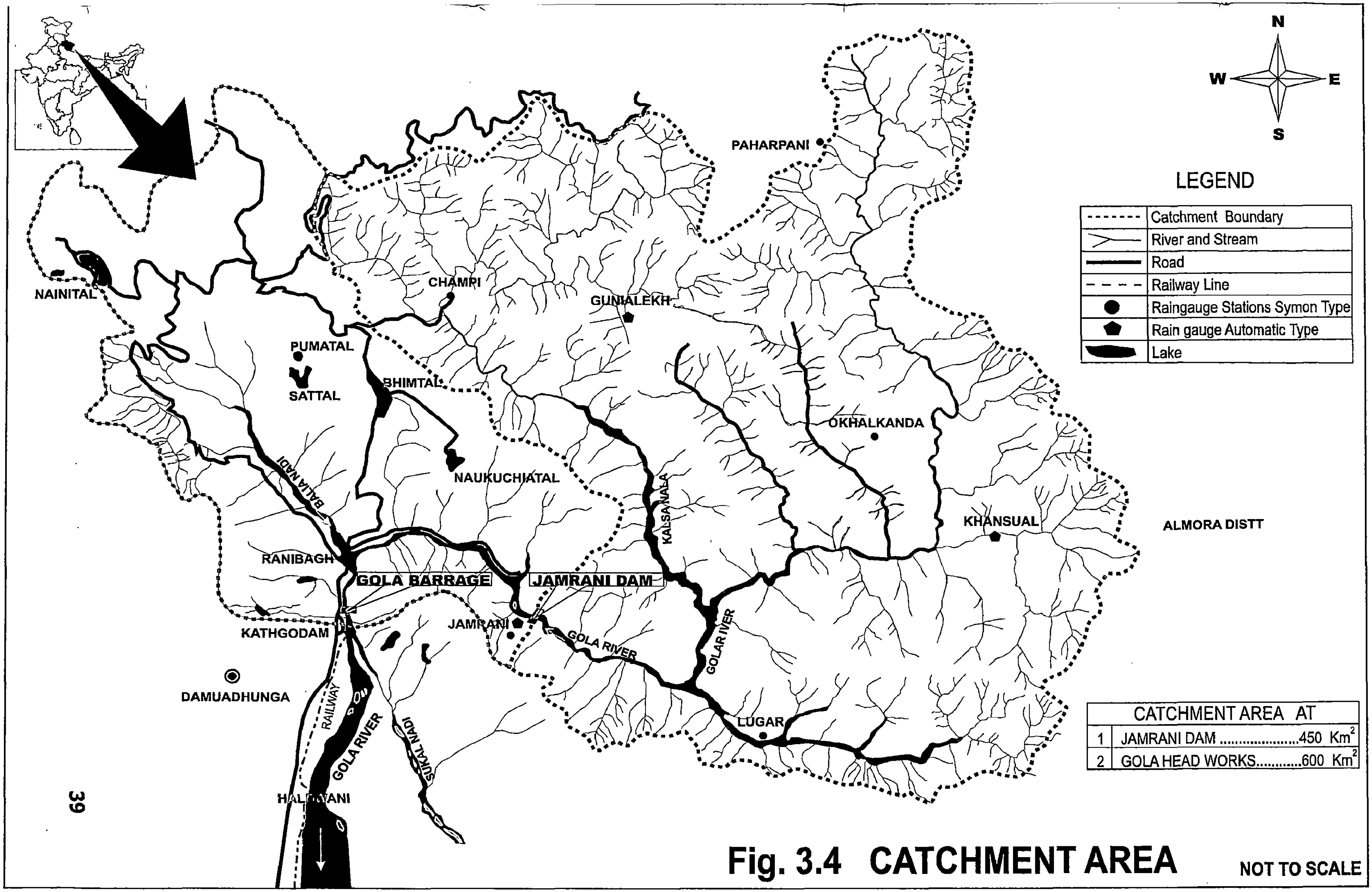


Fig. 3.4 CATCHMENT AREA

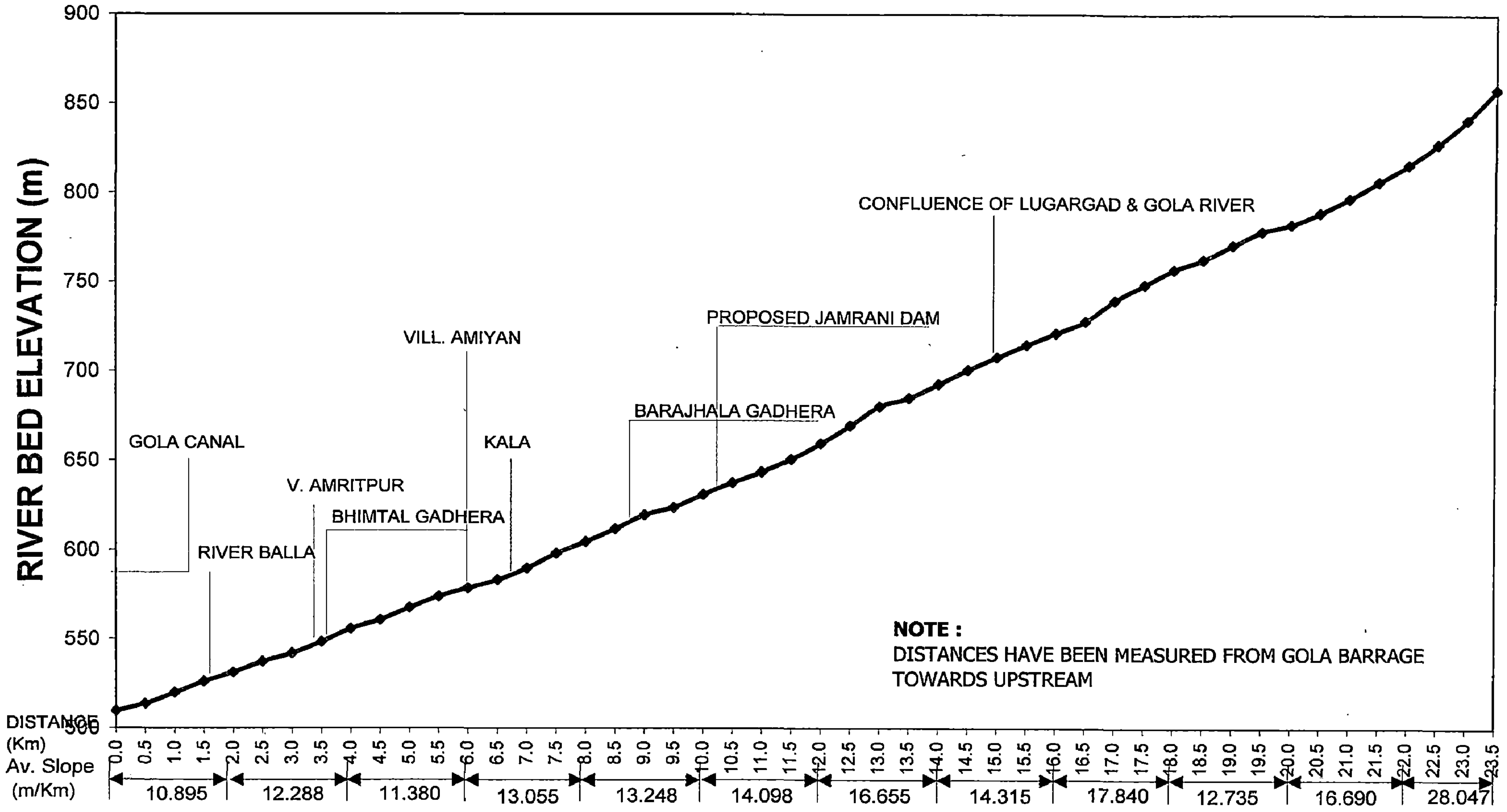


Fig-3.5 L - SECTION OF GOLA RIVER 0.00 to 23.5 Km

3.5.2. Precipitation data

In the year 1979 some Symon type rain gauges were installed in catchment area at Jamrani Dam site, Lugar, Okhalkanda, Paharpani and Champi. In the year 1984, three self recording rain gauges or pluviograph stations were established at dam site, Gunialekh and Khansu. However, the simultaneous short interval rainfall data for the flood events is only available at dam site. Some (4 years) of all ten-daily observed rainfall data (27 years) within catchment are given in Table-1.A, Table-2.A, Table-3.A & Table-4.A of Appendix-A.

3.5.3. Stream flow data at Dam site

Automatic river gauge recorder was established at dam site in 1984. It has been reported that the Gauge and discharge measurements were taken three to four times during the day and average discharge measurement were recorded as the daily discharge till 1993. The discharge site washed away during flood in 1993. After 1993, the discharge at dam site is measured in a very crude way by float method. During the visit to the dam site, it was informed that the discharge is taken by throwing a wooden piece in the river an at a fix section and then by measuring the time of reaching the same at some downstream section (about 100 m downstream). Further, the time of travel is related to average velocity and by multiplying with the average cross-sectional area, the discharge is measured. This discharge is further converted to 10-daily discharge data and is provided as the stream flow data at Dam site. Ten daily discharges observed at dam site since March 1977 till June 2006 are tabulated in Table-5A of Appendix-A.

3.5.4. Stream flow data at Gola weir

Long term gauge data of river Gola are available only at Gola Weir (now barrage) where it is being observed at 8 A.M. daily since 1948 till date. For the computation of discharge at Gola weir, the existing weir has been considered as broad crested weir with a vertical fall of about 2.5 to 3 m downstream. The observed 10 daily discharges since July 1948 till June 2006 are tabulated in Table-6.A of Appendix-A.

3.5.5. Temperature, humidity, wind velocity and Pan Evaporation data

Since temperature affects evaporation and snowmelt, it is needed in many water resources study. It is a measure of the ability of the atmosphere and water to receive and transfer heat. Temperature varies primarily with the magnitude of solar radiation and follows diurnal and seasonal cycles. Relative Humidity is the ratio (in %) of mixing ratio to the saturation mixing ratio has a significant influence on evapotranspiration. Relative Humidity does not vary drastically over a short time. Wind velocity is inputs in calculation of evapotranspiration, controlled by local pressure anomalies which in turn is influenced by the temperature and local topographic features. Evaporation is an important component of the hydrologic cycle. Pan evaporation provides an estimate of open water evaporation.

The apparatus of pan evaporation was fixed in 1975 at dam site and observations recorded are shown in Table-7.A of Appendix-A.

The data of maximum and minimum temperature, humidity and wind velocity is being observed since 1981 are also available.

CHAPTER 4

MEAN AREAL PRECIPITATION AND ANNUAL FLOW ESTIMATION FOR JAMRANI PROJECT

4.1. MEAN AREAL PRECIPITATION ESTIMATION

In this study, the Thiessen Polygon Method is adopted to estimate Mean Areal Precipitation (MAP) over a catchent area for Jamrani Dam site. In the Thiessen Polygon Method, the rainfall recorded at each rain gauge stations is given a weightage on the basis of the area which it represents. This method is better than the Arithmetic Mean Method which gives equal weightage to all the stations. This method is popularly applied to most of the field problems.

In the catchment area, since year 1979 some Symon type rain gauges were installed at Jamrani Dam site, Lugar, Okhalkanda, Paharpani and Champi. After that, in the year 1987, three self recording rain gauges or pluviograph stations were established at Jamrani Dam site and two other locations viz. at Gunialekh and Khansu. According to above information on Catchment Area of 450 Km^2 for Jamrani Dam site there were five rain gauge station since year 1979 until year 1987, and there are seven rain gauge stations since year 1987 till date.

The following is procedure for delineating area for each station in the catcment area based on seven rain gauge stations basis.

(a). All the gauges in and around the catchment area are accurately marked on a map drawn to scale.

(b). Consecutive stations are joined by dotted straight lines, forming triangles.

(c). Perpendicular bisectors are drawn to these dotted lines such that the bisectors form a polygon around each station.

(d). Each station on the map is thus enclosed by a polygon. A polygon represents an area for which the station rainfall is the representative.

(e). Area of each polygon is measured by a planimeter. Sum of the areas of all the polygons must be equal to total area of the catchment area. Areas of each stations are indicated on Fig. 4.1.

(f). Thiessen weights are computed by dividing the area of each polygon by the total area of the basin. Thus, sum of Thiessen weights for all stations should be equal to unity. If there are seven stations in and around the catchment area then seven thiessen polygons are drawn. Sum all the seven thiessen weights must be equal to unity.

(g). The average precipitation is computed from the relation

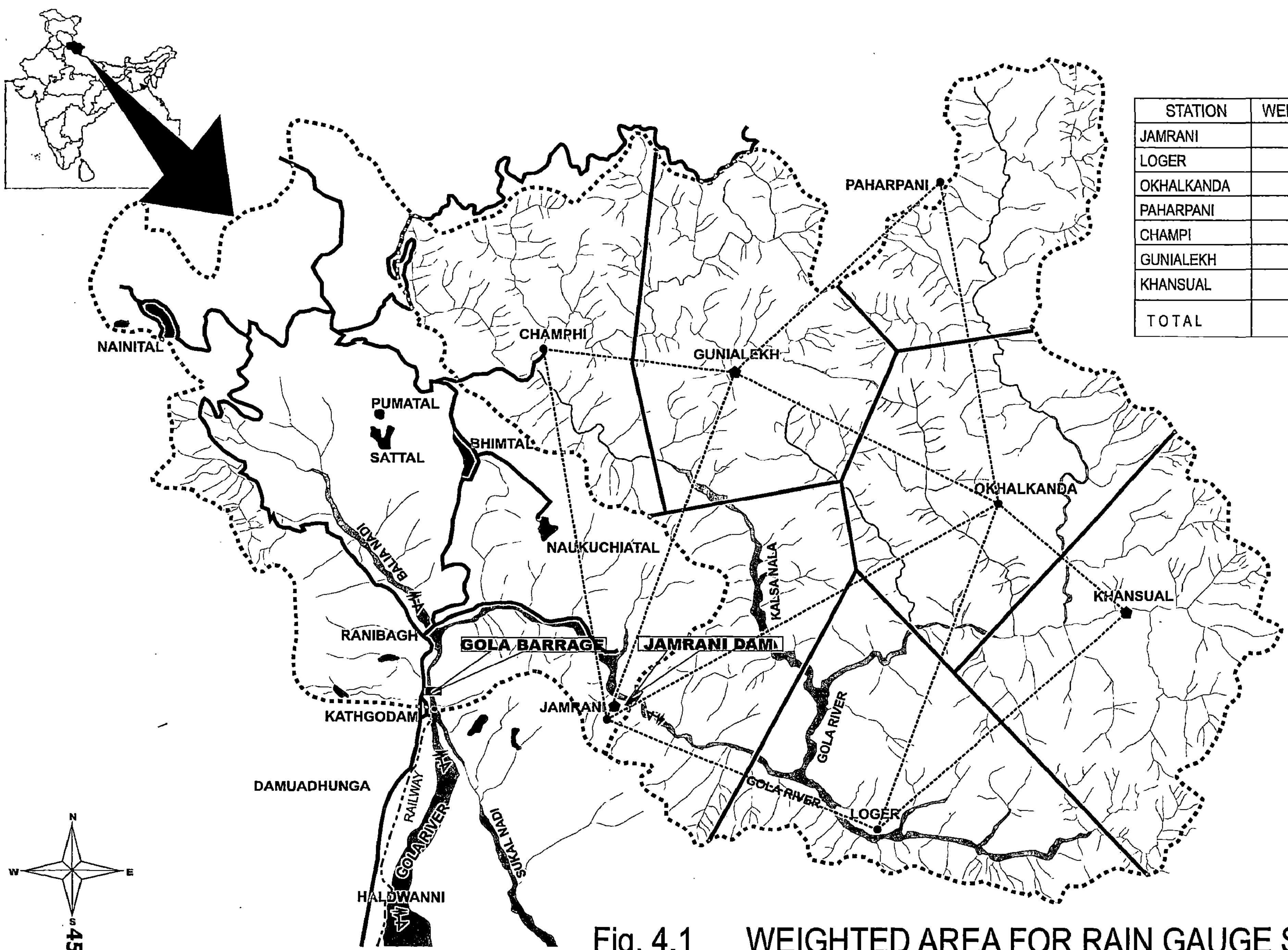
$$P_{av} = \frac{A_1P_1 + A_2P_2 + A_3P_3 + \dots\dots\dots + A_nP_n}{A_1 + A_2 + A_3 + \dots\dots\dots\dots + A_n}$$

or $$P_{av} = P_1W_1 + P_2W_2 + P_3W_3 + \dots\dots\dots\dots + P_nW_n$$

in which $P_1, P_2, \dots\dots\dots, P_n$ represents precipitation at stations 1, 2, 3, ..., n, and $A_1, A_2, \dots\dots\dots, A_n$, represents the area of polygons representing the corresponding stations, A is the total area of basin which is the sum of all the polygons and $W_1, W_2, \dots\dots\dots, W_n$ are Thiessen weights computed as $W_1 = A_1 / A, W_2 = A_2 / A, \dots\dots\dots, W_n = A_n / A$ such that $W_1 + W_2 + \dots\dots + W_n = 1.00$.

These calculations are indicated in examples on Table-1A, 2A, 3A & 4A of Appendix-A.

(h). Mean Annual Precipitation for each year from 1979-1980 to 2005-2006 are tabulated in Table-4.1 and Fig. 4.2, is found the average Precipitation P_{av} = 1541.83 mm and Standard Deviation S_n =334.36.



STATION	WEIGHTED AREA
JAMRANI	47.00 KM^2
LOGER	73.50 KM^2
OKHALKANDA	77.00 KM^2
PAHARPANI	49.50 KM^2
CHAMPI	60.00 KM^2
GUNIALEKH	69.00 KM^2
KHANSUAL	74.00 KM^2
TOTAL	450.00 KM^2

Fig. 4.1 WEIGHTED AREA FOR RAIN GAUGE STATIONS

Table-4.1

Catchment Annual Rainfall in (mm)

No.	Year (July to June)	Weighted Annual Rainfall (mm)
1	1979 - 80	1166.60
2	1980 - 81	1759.90
3	1981 - 82	1204.15
4	1982 - 83	1422.96
5	1983 - 84	1558.99
6	1984 - 85	1024.55
7	1985 - 86	1920.20
8	1986 - 87	1283.48
9	1987 - 88	1149.21
10	1988 - 89	1458.02
11	1989 - 90	1461.26
12	1990 - 91	1912.27
13	1991 - 92	1170.72
14	1992 - 93	1553.29
15	1993 - 94	2191.90
16	1994 - 95	1292.60
17	1995 - 96	1955.32
18	1996 - 97	1597.21
19	1997 - 98	1768.68
20	1998 - 99	2078.55
21	1999 - 2000	2071.17
22	2000 - 01	1828.01
23	2001 - 02	1039.78
24	2002 - 03	1471.67
25	2003 - 04	1527.25
26	2004 - 05	1389.92
27	2005 - 06	1371.65

$\overline{P}$ = **1,541.83** mm

Sn = **334.36**

see Table-1.A - 4.A for some example from detail calculations

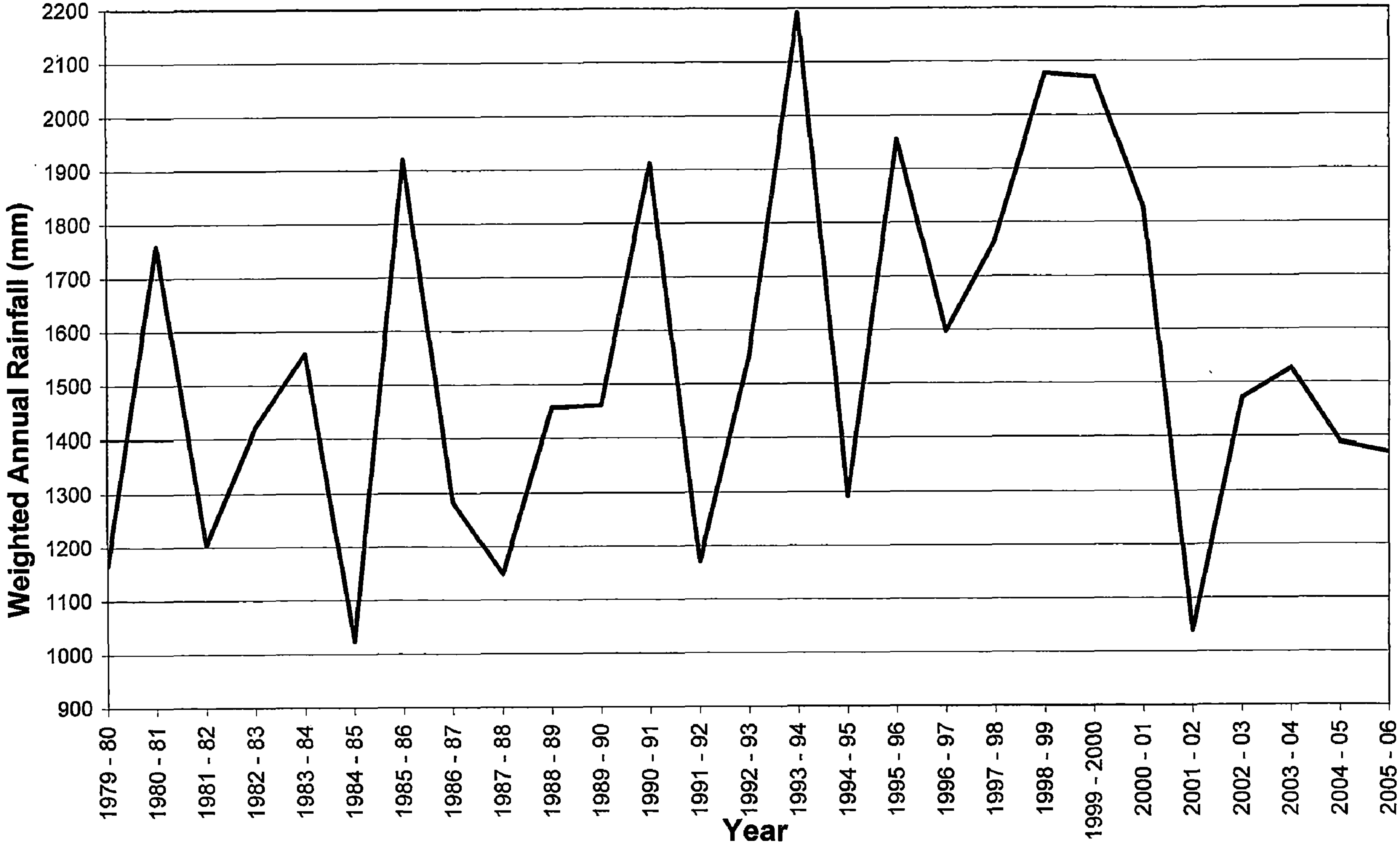


Fig. 4.2 CATCHMENT ANNUAL RAINFALL FOR JAMRANI DAM SITE

4.2. TEN-DAILY DISCHARGE CORRELATIONS

The 10-daily discharge observed at Gola Barrage during 58 years (1948 – 2006), whereas 10-daily discharge observed at Jamrani Dam site only 29 years (1977 – 2006). The aim of the sudy is to derive 10-daily discharge at Jamrani Dam site during 1948 until 2006 based on 10-daily discharge observed at Gola Barrage. The technique of Regression Analysis is adopted to derive that data by both Direct Linear Regression method and Log Deviation Regression Method.

The 10-daily discharge observed at both Gola Barrage and Jamrani Dam site are plotted for 36 separated periods namely for each ten-daily in a year. The water year has been considered to commence from 1st July every year to 30th June of the next year.

To develope correlation for the above 36 periods in a year, two approaches were basically used, viz :

(i) Direct linear regression

(ii) Log deviation method

The data for the period 1977 to 2006 are used in the analysis. For direct linear regression ten daily discharge (Q_J) at Jamrani are plotted against corresponding ten daily observed discharge (Q_G) at Gola weir for the different periods as examples shown in Fig. 1B of Appendix-B. Similarly for log deviation method, logaritmic deviations Q_{JD} and Q_{GD} about its mean of 10 daily observed discharges at the two sites are plotted as shown in Fig. 2B of Appendix-B. These figures show that the scatter in case of logaritmic deviations relation is larger than linear relation. The results of the correlation and correlation coefficient using the two approaches (Direct Linear Regression and Log Deviation Regression) are for illustration purpose, one set of computation are shown in Table-1B and 2B of Appendix-B and tabulated in Table-4.2.

The correlations used are :

Q_J = $a\,Q_G + b$ (Direct linear regression) 4.1

Q_{JD} = $a\,Q_{GD} + b$ (Log deviation regression) 4.2

where

Q_J is ten daily discharge in cumecs day at Jamrani Dam.

Q_G is ten daily discharge in cumecs day at Gola weir.

Q_{JD} is logarithmic deviation of ten daily discharge about its mean at Jamrani Dam.

Q_{GD} is logarithmic deviation of ten daily discharge about its mean at Gola weir.

a and b are the coefficients.

r is the coefficient of correlation.

It can be seen from the table-4.2 that relation derived using the first approach is better because the coefficient of correlation in each period are mostly higher than that of log deviation. It can also be seen that a physically meaningful relation in respect of river reach losses are obtained only using direct linear regression.

The relations obtained as above are used to derive the ten daily yield series at Jamrani Dam site from observed long term ten daily discharge at Gola weir from 1948 to 1976. From 1977 onwards observed flows at Jamrani site are included in the annual yield series. Table-4.3 and Table-4.4 show the up-to-date 10 daily, monthly and annual yield series at Jamrani Dam site using Linear and Log deviation correlation respectively.

4.3. DEPENDABLE FLOWS

Dependable flows have been estimated on annual basis by drawing flow duration curve. To draw this curve the annual yield series is arranged in descending order and ranking is done by assigning the first rank to the highest value and last rank to the lowest value. The probability of exceedance of a particular value is obtained by dividing its rank by (N + 1), where "N" is the total number of values. The use of (N + 1), ensures that the low flow can be lower than the lowest observed flow and the probability of exceeedance of lowest flow in series is 100%. Table-4.5 and Table-4.6 show the annual yield series in descending order together with rank, derived by linear and log deviation methods respectively. A flow duration curve is shown in Fig. 4.3. The 75% dependable annual flow is estimated as 355.9 MCM and 412.9 MCM by linear and log deviation method respectively.

TABLE-4.2

RESULTS OF REGRESSION ANALYSIS FOR TEN-DAILY OBSERVED DISCHARGE OF GOLA RIVER AT JAMRANI DAM AND GOLA WEIR

Type of Regression		JULY						AUGUST					
		1		2		3		1		2		3	
		Original Data	After removing outliers	Original Data	After removing outliers	Original Data	After removing outliers	Original Data	After removing outliers	Original Data	After removing outliers	Original Data	After removing outliers
Linear Regression	a	-57.04	6.95	66.68	-24.04	121.80	-54.19	441.69	-59.61	11.09	-135.26	107.74	-137.61
	b	0.92	0.53	0.80	0.73	0.79	0.80	0.03	0.82	0.85	0.85	0.77	0.97
	r	**0.88**	**0.97**	**0.55**	**0.95**	**0.69**	**0.98**	**0.07**	**0.93**	**0.94**	**0.94**	**0.69**	**0.98**
Log Deviation Regression	a	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
	b	0.82	0.90	0.81	1.29	0.76	1.08	0.50	1.07	0.76	1.28	1.05	1.20
	r	**0.80**	**0.97**	**0.55**	**0.93**	**0.64**	**0.94**	**0.50**	**0.83**	**0.59**	**0.92**	**0.70**	**0.93**

Type of Regression		SEPTEMBER						OCTOBER					
		1		2		3		1		2		3	
		Original Data	After removing outliers	Original Data	After removing outliers	Original Data	After removing outliers	Original Data	After removing outliers	Original Data	After removing outliers	Original Data	After removing outliers
Linear Regression	a	54.49	18.81	175.09	17.42	217.60	-6.81	105.40	-0.94	-4.01	-56.33	-0.59	-10.53
	b	0.92	0.69	0.64	0.67	0.64	0.74	0.59	0.65	1.02	0.99	0.95	0.82
	r	**0.74**	**0.98**	**0.88**	**1.00**	**0.73**	**0.99**	**0.41**	**0.95**	**0.99**	**1.00**	**0.91**	**0.98**
Log Deviation Regression	a	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
	b	1.10	0.98	0.93	1.07	0.82	1.04	0.89	0.99	1.03	1.01	1.09	1.02
	r	**0.72**	**0.95**	**0.69**	**0.94**	**0.59**	**0.96**	**0.50**	**0.92**	**0.84**	**0.93**	**0.85**	**0.94**

Type of Regression		NOVEMBER						DECEMBER					
		1		2		3		1		2		3	
		Original Data	After removing outliers	Original Data	After removing outliers	Original Data	After removing outliers	Original Data	After removing outliers	Original Data	After removing outliers	Original Data	After removing outliers
Linear Regression	a	-22.39	-22.66	-19.17	-0.95	-15.14	-2.28	-8.66	0.33	-23.82	2.59	-2.21	3.37
	b	1.02	1.01	1.01	0.71	0.90	0.65	0.82	0.63	1.09	0.56	0.74	0.61
	r	**0.92**	**0.95**	**0.90**	**0.90**	**0.78**	**0.87**	**0.78**	**0.80**	**0.85**	**0.87**	**0.53**	**0.81**
Log Deviation Regression	a	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
	b	1.18	1.21	1.09	0.89	0.97	0.95	0.82	0.93	1.01	0.85	0.85	0.87
	r	**0.90**	**0.93**	**0.87**	**0.86**	**0.75**	**0.83**	**0.65**	**0.76**	**0.77**	**0.83**	**0.57**	**0.78**

Type of Regression		JANUARY						FEBRUARY					
		1		2		3		1		2		3	
		Original Data	After removing outliers	Original Data	After removing outliers	Original Data	After removing outliers	Original Data	After removing outliers	Original Data	After removing outliers	Original Data	After removing outliers
Linear Regression	a	8.17	0.98	8.67	0.27	10.64	-5.83	18.97	1.66	-5.14	6.50	-26.18	-5.20
	b	0.52	0.66	0.49	0.68	0.48	0.80	0.26	0.62	0.88	0.48	1.43	0.81
	r	**0.46**	**0.90**	**0.46**	**0.77**	**0.46**	**0.89**	**0.32**	**0.88**	**0.53**	**0.92**	**0.84**	**0.96**
Log Deviation Regression	a	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
	b	0.61	0.96	0.57	0.89	0.60	0.97	0.47	0.82	0.88	0.82	1.06	1.12
	r	**0.44**	**0.86**	**0.44**	**0.75**	**0.44**	**0.83**	**0.40**	**0.82**	**0.73**	**0.86**	**0.77**	**0.93**

Type of Regression		MARCH						APRIL					
		1		2		3		1		2		3	
		Original Data	After removing outliers	Original Data	After removing outliers	Original Data	After removing outliers	Original Data	After removing outliers	Original Data	After removing outliers	Original Data	After removing outliers
Linear Regression	a	-9.97	-12.57	-6.29	-4.44	6.08	2.82	22.83	3.14	17.02	4.99	3.81	4.66
	b	0.95	0.95	0.84	0.83	0.50	0.59	-0.03	0.62	0.12	0.52	0.53	0.48
	r	**0.79**	**0.99**	**0.80**	**0.93**	**0.65**	**0.85**	**-0.16**	**0.87**	**0.13**	**0.77**	**0.55**	**0.68**
Log Deviation Regression	a	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
	b	0.87	1.14	0.94	1.06	0.55	0.80	-0.04	0.82	0.14	0.68	0.62	0.73
	r	**0.70**	**0.92**	**0.71**	**0.92**	**0.55**	**0.81**	**-0.06**	**0.86**	**0.12**	**0.73**	**0.51**	**0.67**

Type of Regression		MAY						JUNE					
		1		2		3		1		2		3	
		Original Data	After removing outliers	Original Data	After removing outliers	Original Data	After removing outliers	Original Data	After removing outliers	Original Data	After removing outliers	Original Data	After removing outliers
Linear Regression	a	15.03	0.84	6.27	2.33	14.44	0.63	-70.57	13.22	-106.36	4.28	87.76	-7.17
	b	0.21	0.63	0.40	0.58	0.17	0.61	2.15	0.18	2.79	0.54	0.24	0.78
	r	**0.17**	**0.86**	**0.70**	**0.90**	**0.32**	**0.90**	**0.83**	**0.69**	**0.82**	**0.78**	**0.24**	**0.91**
Log Deviation Regression	a	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
	b	0.21	0.77	0.56	0.85	0.27	0.77	0.79	0.48	1.04	0.89	0.64	0.93
	r	**0.17**	**0.84**	**0.65**	**0.88**	**0.31**	**0.86**	**0.65**	**0.72**	**0.72**	**0.80**	**0.60**	**0.85**

Table-4.3

Derived 10 - Daily Discharge of Gola River at Jamrani Dam Site by using Linear Regression Method

(cumec day)

YEAR	10-DAY	JUL	AUG	SEP	OCT	NOV	DEC	JAN	FEB	MAR	APR	MAY	JUN	TOTAL
1948-1949	1	113.64	354.74	927.47	239.04	138.54	82.92	42.82	263.11	62.90	31.04	37.95	64.32	2,358.49
	2	154.01	1,251.26	563.40	459.26	124.65	61.56	38.01	34.29	33.16	36.45	43.22	29.23	2,828.50
	3	176.93	5,151.02	414.18	198.90	97.11	49.55	38.17	40.24	31.26	23.67	66.69	52.34	6,340.05
TOTAL		**444.58**	**6,757.02**	**1,905.05**	**897.20**	**360.29**	**194.03**	**119.00**	**337.65**	**127.31**	**91.16**	**147.86**	**145.89**	**11,527.04**
1949-1950	1	177.50	1,130.13	934.85	559.23	103.09	56.34	46.52	53.49	38.45	33.95	25.85	22.38	3,181.79
	2	941.17	1,990.00	920.92	254.73	87.52	47.28	43.11	46.72	37.06	27.14	34.40	596.39	5,026.43
	3	1,290.93	2,749.98	1,755.35	217.35	68.25	54.67	51.93	32.79	382.07	24.00	51.26	767.06	7,445.64
TOTAL		**2,409.60**	**5,870.11**	**3,611.12**	**1,031.31**	**258.85**	**158.29**	**141.56**	**133.00**	**457.58**	**85.10**	**111.52**	**1,385.83**	**15,653.86**
1950-1951	1	938.48	2,842.12	1,142.41	276.74	130.86	79.58	54.31	55.91	34.67	34.20	45.57	26.05	5,660.91
	2	1,396.10	3,334.70	1,184.69	166.52	97.39	64.41	55.08	39.04	35.57	29.59	52.33	25.77	6,481.18
	3	2,596.13	2,711.18	962.44	139.53	76.37	65.77	53.21	26.71	38.57	24.77	25.64	95.40	6,815.74
TOTAL		**4,930.71**	**8,888.00**	**3,289.54**	**582.79**	**304.62**	**209.77**	**162.60**	**121.67**	**108.81**	**88.56**	**123.54**	**147.23**	**18,957.83**
1951-1952	1	42.51	480.77	47.24	189.25	90.16	57.79	54.04	37.87	59.50	40.65	41.98	26.05	1,167.81
	2	317.31	96.79	47.44	129.20	66.64	51.65	53.58	38.13	55.74	36.45	42.76	74.21	1,009.88
	3	433.01	4,725.39	25.01	119.44	60.51	55.77	59.05	46.80	49.49	32.64	45.28	733.28	6,385.68
TOTAL		**792.83**	**5,302.95**	**119.68**	**437.89**	**217.31**	**165.20**	**166.68**	**122.80**	**164.73**	**109.74**	**130.02**	**833.55**	**8,563.37**
1952-1953	1	92.60	1,744.39	1,006.68	102.09	90.36	33.66	28.50	26.46	22.06	22.48	23.33	19.32	3,211.93
	2	881.53	2,248.99	1,148.25	85.44	74.74	30.09	49.23	25.65	25.19	20.38	28.08	123.73	4,741.29
	3	435.49	2,447.73	206.31	106.65	51.22	31.43	45.77	18.29	24.83	18.68	29.24	1,113.61	4,529.24
TOTAL		**1,409.61**	**6,441.11**	**2,361.24**	**294.17**	**216.31**	**95.17**	**123.50**	**70.40**	**72.08**	**61.54**	**80.65**	**1,256.66**	**12,482.46**
1953-1954	1	238.83	460.76	1,148.62	125.62	85.92	43.04	115.03	67.88	70.66	43.25	28.18	18.04	2,445.82
	2	2,473.66	218.68	395.03	117.32	72.11	36.41	41.41	55.60	56.98	29.48	31.04	62.98	3,590.70
	3	2,336.85	844.42	266.69	110.34	56.35	39.97	50.57	48.75	53.74	24.92	34.55	144.85	4,011.99
TOTAL		**5,049.33**	**1,523.86**	**1,810.34**	**353.27**	**214.38**	**119.43**	**207.01**	**172.23**	**181.37**	**97.65**	**93.77**	**225.87**	**10,048.51**
1954-1955	1	56.98	945.96	496.70	1,538.26	237.62	83.24	61.37	39.29	51.35	22.98	22.83	21.88	3,578.46
	2	416.30	1,224.06	450.71	742.20	138.99	68.22	61.74	41.92	47.52	21.89	25.12	29.44	3,268.12
	3	1,342.61	1,346.59	371.40	286.15	97.43	69.62	92.57	37.65	36.27	20.26	38.94	194.77	3,934.25
TOTAL		**1,815.89**	**3,516.60**	**1,318.82**	**2,566.61**	**474.04**	**221.08**	**215.68**	**118.87**	**135.14**	**65.13**	**86.89**	**246.09**	**10,780.84**
1955-1956	1	627.85	1,034.11	628.36	2,490.77	398.31	133.07	81.43	51.01	47.67	40.40	24.72	405.57	5,963.26
	2	628.80	1,489.86	435.03	2,336.40	194.30	108.09	68.07	39.09	55.24	34.21	46.76	696.13	6,131.98
	3	675.81	853.25	625.67	618.82	143.26	102.92	71.13	40.97	45.54	25.44	504.86	639.76	4,347.42
TOTAL		**1,932.45**	**3,377.21**	**1,689.06**	**5,445.99**	**735.87**	**344.09**	**220.63**	**131.07**	**148.44**	**100.06**	**576.33**	**1,741.46**	**16,442.65**
1956-1957	1	1,862.75	771.38	807.41	714.52	512.04	106.74	76.29	49.09	44.66	36.31	22.95	20.92	5,025.05
	2	592.74	651.16	501.76	1,789.92	205.94	70.24	86.22	33.48	45.69	60.16	27.85	26.80	4,091.96
	3	709.97	-	385.61	648.59	130.84	73.83	82.57	26.47	12.44	26.74	31.13	32.06	2,160.24
TOTAL		**3,165.45**	**1,422.54**	**1,694.79**	**3,153.02**	**848.82**	**250.80**	**245.08**	**109.04**	**102.79**	**123.21**	**81.93**	**79.79**	**11,277.25**
1957-1958	1	82.00	404.84	344.63	136.60	170.56	58.04	58.33	48.47	43.40	19.32	32.15	21.90	1,420.23
	2	270.08	117.87	1,170.22	135.83	78.36	80.71	49.57	39.48	37.72	17.78	72.74	26.42	2,096.78
	3	952.77	331.19	184.04	101.24	64.80	70.71	63.45	36.35	33.21	15.17	35.52	24.03	1,912.48
TOTAL		**1,304.85**	**853.90**	**1,698.89**	**373.67**	**313.71**	**209.46**	**171.35**	**124.30**	**114.33**	**52.28**	**140.42**	**72.35**	**5,429.49**

YEAR	10-DAY	JUL	AUG	SEP	OCT	NOV	DEC	JAN	FEB	MAR	APR	MAY	JUN	TOTAL
1958-1959	1	726.58	287.17	413.01	689.75	230.15	90.11	61.24	47.54	62.61	36.12	27.55	22.62	2,694.43
	2	779.47	103.34	338.28	371.25	158.30	60.49	54.67	48.45	45.28	28.91	32.32	35.06	2,055.82
	3	1,328.05	990.50	824.58	295.58	115.44	81.27	71.37	49.23	37.93	26.21	39.49	48.13	3,907.77
TOTAL		**2,834.11**	**1,381.00**	**1,575.87**	**1,356.58**	**503.88**	**231.87**	**187.28**	**145.22**	**145.81**	**91.25**	**99.36**	**105.81**	**8,658.02**
1959-1960	1	361.57	785.65	319.10	324.71	222.47	81.10	51.73	45.93	41.07	36.62	26.80	21.23	2,317.97
	2	250.37	717.21	495.87	317.20	157.95	57.08	52.36	38.23	42.79	30.57	30.52	27.72	2,217.84
	3	732.69	586.98	448.51	244.41	104.26	60.53	62.09	31.09	38.22	26.55	31.56	33.00	2,399.87
TOTAL		**1,344.63**	**2,089.83**	**1,263.48**	**886.32**	**484.67**	**198.70**	**166.18**	**115.24**	**122.08**	**93.74**	**88.87**	**81.95**	**6,935.69**
1960-1961	1	103.09	688.80	1,051.26	623.45	178.23	41.78	92.79	75.38	49.51	31.16	24.28	27.49	2,987.23
	2	795.75	612.91	807.55	433.03	117.62	49.13	65.48	61.60	54.49	24.65	32.37	115.20	3,169.78
	3	375.17	976.73	449.03	268.19	93.21	50.16	64.09	59.52	41.58	21.80	38.57	194.54	2,632.57
TOTAL		**1,274.01**	**2,278.44**	**2,307.84**	**1,324.67**	**389.06**	**141.07**	**222.36**	**196.50**	**145.58**	**77.61**	**95.22**	**337.23**	**8,789.58**
1961-1962	1	517.13	1,080.19	452.75	152.66	232.06	77.63	67.44	79.10	235.17	42.14	29.51	23.08	2,988.85
	2	755.75	1,508.64	298.62	531.33	130.05	86.09	64.87	52.96	61.21	33.49	29.42	120.38	3,672.80
	3	708.13	1,420.31	222.74	283.69	100.29	90.72	175.05	80.42	49.02	28.66	36.68	193.29	3,388.99
TOTAL		**1,981.00**	**4,009.14**	**974.11**	**967.68**	**462.40**	**254.44**	**307.36**	**212.48**	**345.40**	**104.28**	**95.60**	**336.75**	**10,050.64**
1962-1963	1	68.96	228.95	218.57	225.26	127.83	68.69	52.46	45.62	49.61	42.88	38.89	25.69	1,193.40
	2	115.76	543.89	175.41	218.20	99.09	58.31	53.92	38.90	58.56	35.36	41.36	48.67	1,487.42
	3	570.21	493.47	2,105.00	151.83	73.51	58.27	62.09	35.30	48.01	29.67	36.25	50.39	3,714.01
TOTAL		**754.93**	**1,266.31**	**2,498.97**	**595.29**	**300.43**	**185.27**	**168.47**	**119.82**	**156.18**	**107.91**	**116.51**	**124.76**	**6,394.83**
1963-1964	1	153.55	331.94	857.16	233.91	171.06	84.88	62.56	59.63	64.84	35.13	36.31	24.43	2,115.39
	2	253.51	493.32	837.70	234.43	114.85	78.97	62.69	23.40	56.81	29.43	38.17	40.41	2,263.69
	3	346.05	2,602.45	427.35	209.07	95.35	67.48	70.81	56.76	37.45	29.04	48.82	95.17	4,085.80
TOTAL		**753.10**	**3,427.70**	**2,122.21**	**677.40**	**381.26**	**231.33**	**196.06**	**139.79**	**159.10**	**93.61**	**123.30**	**160.01**	**8,464.88**
1964-1965	1	406.68	886.59	985.02	403.95	140.96	68.50	52.46	42.64	46.60	51.69	25.91	22.58	3,133.57
	2	800.50	517.63	665.58	198.60	96.75	64.30	65.21	44.32	42.37	36.19	32.61	29.88	2,593.92
	3	1,681.97	766.92	1,117.32	167.33	77.35	54.92	89.85	49.88	51.08	29.19	37.90	36.35	4,160.05
TOTAL		**2,889.14**	**2,171.13**	**2,767.92**	**769.87**	**315.05**	**187.71**	**207.52**	**136.85**	**140.05**	**117.06**	**96.42**	**88.81**	**9,887.54**
1965-1966	1	100.71	562.52	401.07	101.63	78.04	43.55	34.31	27.58	27.20	25.83	19.87	21.18	1,443.48
	2	204.96	131.05	237.92	72.87	54.57	37.59	34.68	28.48	27.68	22.15	22.80	28.53	903.27
	3	175.49	1,058.30	149.48	91.89	44.52	38.57	34.01	18.45	26.66	18.87	31.98	211.07	1,899.29
TOTAL		**481.16**	**1,751.87**	**788.47**	**266.38**	**177.13**	**119.71**	**103.00**	**74.51**	**81.54**	**66.85**	**74.65**	**260.78**	**4,246.04**
1966-1967	1	97.00	783.76	246.37	100.33	84.81	45.00	44.34	37.06	34.86	41.52	34.73	24.60	1,574.38
	2	84.07	340.32	213.13	73.06	65.51	36.97	42.16	30.88	38.64	35.83	35.85	36.52	1,032.94
	3	591.89	288.51	128.61	90.08	49.14	48.08	45.93	27.85	58.10	33.99	40.34	49.61	1,452.14
TOTAL		**772.96**	**1,412.59**	**588.11**	**263.48**	**199.45**	**130.05**	**132.43**	**95.79**	**131.60**	**111.33**	**110.93**	**110.73**	**4,059.45**
1967-1968	1	269.67	629.44	700.74	183.73	121.27	63.02	54.44	58.39	63.19	37.43	29.63	25.71	2,236.64
	2	639.75	607.22	626.38	152.07	77.29	52.09	52.09	45.52	46.94	29.17	33.65	132.58	2,494.75
	3	588.85	2,055.17	334.92	157.00	65.00	60.53	72.01	68.43	44.71	27.99	40.59	674.24	4,189.42
TOTAL		**1,498.27**	**3,291.82**	**1,662.04**	**492.79**	**263.55**	**175.64**	**178.54**	**172.34**	**154.83**	**94.58**	**103.87**	**832.53**	**8,920.81**
1968-1969	1	230.66	199.35	192.55	161.76	87.74	51.61	46.78	36.44	36.71	29.18	29.69	21.16	1,123.63
	2	276.72	632.21	203.61	82.37	69.41	45.82	52.36	33.91	30.84	26.83	44.32	26.15	1,524.54
	3	255.09	560.01	261.51	72.95	56.16	55.65	50.65	29.95	29.67	23.14	42.35	37.29	1,474.42
TOTAL		**762.47**	**1,391.57**	**657.68**	**317.07**	**213.30**	**153.08**	**149.79**	**100.30**	**97.21**	**79.15**	**116.37**	**84.60**	**4,122.59**

YEAR	10-DAY	JUL	AUG	SEP	OCT	NOV	DEC	JAN	FEB	MAR	APR	MAY	JUN	TOTAL
1969-1970	1	45.00	637.80	540.11	319.25	129.04	63.65	48.57	41.84	29.92	23.60	19.93	46.39	1,945.09
	2	560.47	277.25	475.97	212.55	84.18	53.16	74.53	34.63	26.35	21.01	21.93	233.40	2,075.42
	3	459.17	801.45	1,597.81	194.88	70.00	58.70	63.93	30.03	26.48	18.72	31.31	737.96	4,090.44
TOTAL		**1,064.65**	**1,716.49**	**2,613.88**	**726.68**	**283.22**	**175.50**	**187.02**	**106.50**	**82.75**	**63.33**	**73.18**	**1,017.76**	**8,110.96**
1970-1971	1	291.45	323.99	376.71	130.43	81.88	43.74	25.20	23.55	32.54	18.76	16.21	45.98	1,410.43
	2	107.14	638.50	258.42	83.26	65.86	35.24	23.93	20.80	22.20	17.63	56.85	312.30	1,642.13
	3	297.17	397.54	191.73	83.03	43.48	32.83	28.01	14.97	22.23	15.46	93.11	146.18	1,365.74
TOTAL		**695.77**	**1,360.02**	**826.86**	**296.72**	**191.22**	**111.81**	**77.15**	**59.32**	**76.97**	**51.85**	**166.17**	**504.45**	**4,418.30**
1971-1972	1	522.22	277.00	714.40	98.32	103.09	50.86	32.40	33.78	26.91	19.26	14.83	18.55	1,911.59
	2	204.01	388.00	334.53	85.24	60.32	46.05	32.23	29.11	24.11	17.89	21.18	20.05	1,262.72
	3	203.25	226.14	141.49	100.25	58.63	42.90	64.25	16.43	21.82	16.18	17.77	27.07	936.17
TOTAL		**929.48**	**891.14**	**1,190.42**	**283.81**	**222.04**	**139.80**	**128.88**	**79.31**	**72.84**	**53.33**	**53.78**	**65.67**	**4,110.47**
1972-1973	1	149.36	146.78	228.43	127.50	88.75	46.19	32.99	24.35	21.38	20.38	18.61	21.19	925.91
	2	310.30	234.49	787.05	123.75	66.22	37.76	32.77	24.07	33.33	19.86	20.31	81.23	1,771.13
	3	206.21	147.86	186.48	173.81	42.64	35.33	42.41	14.64	24.00	18.00	29.36	241.81	1,162.55
TOTAL		**665.87**	**529.14**	**1,201.96**	**425.06**	**197.60**	**119.29**	**108.17**	**63.06**	**78.71**	**58.24**	**68.28**	**344.23**	**3,859.60**
1973-1974	1	103.41	378.27	207.11	188.28	139.35	59.61	43.48	31.73	19.15	22.61	17.35	19.25	1,229.59
	2	116.27	158.33	272.15	152.36	86.45	50.64	32.50	31.32	21.46	20.17	18.34	36.03	996.02
	3	174.61	163.09	180.11	154.37	66.04	52.96	36.33	20.07	23.77	17.81	19.24	20.99	929.39
TOTAL		**394.29**	**699.69**	**659.38**	**495.01**	**291.83**	**163.21**	**112.32**	**83.12**	**64.37**	**60.59**	**54.92**	**76.27**	**3,155.00**
1974-1975	1	43.68	238.13	162.33	60.81	36.93	29.18	46.72	46.73	37.29	23.10	16.09	19.77	760.77
	2	32.83	112.18	134.13	29.80	36.68	30.76	37.81	42.84	33.99	19.97	17.35	31.55	559.87
	3	389.33	118.08	85.39	54.58	29.51	38.45	65.37	41.05	29.25	17.91	20.88	339.70	1,229.49
TOTAL		**465.84**	**468.39**	**381.86**	**145.19**	**103.12**	**98.39**	**149.89**	**130.62**	**100.53**	**60.98**	**54.32**	**391.02**	**2,550.13**
1975-1976	1	329.08	683.15	874.07	188.21	107.43	51.99	41.24	33.09	37.58	24.78	24.40	21.18	2,416.19
	2	374.83	232.28	591.54	177.31	81.77	49.18	39.57	39.76	30.25	26.26	34.93	45.43	1,723.12
	3	244.53	277.45	305.77	156.09	60.84	48.75	41.77	41.62	26.01	20.60	25.58	34.33	1,283.33
TOTAL		**948.45**	**1,192.88**	**1,771.37**	**521.61**	**250.03**	**149.93**	**122.58**	**114.48**	**93.84**	**71.63**	**84.91**	**100.93**	**5,422.64**
1976-1977	1	44.53	323.08	223.05	132.18	76.02	47.71	32.66	31.73	31.86	22.88	23.67	23.68	1,013.05
	2	151.74	1,093.25	217.75	88.21	64.51	40.95	29.17	27.48	25.09	22.67	36.39	31.68	1,828.89
	3	292.21	388.32	178.86	94.59	49.20	48.39	31.13	20.48	24.70	22.42	34.51	92.15	1,276.96
TOTAL		**488.48**	**1,804.65**	**619.66**	**314.98**	**189.73**	**137.04**	**92.96**	**79.68**	**81.65**	**67.97**	**94.57**	**147.51**	**4,118.89**
1977-1978	1	75.20	184.62	206.93	128.05	85.72	63.10	44.68	38.51	57.92	27.50	16.43	14.34	943.00
	2	156.83	812.10	351.99	95.67	74.24	44.44	44.36	53.58	83.33	28.64	16.48	16.87	1,778.53
	3	463.58	218.68	176.20	99.54	61.05	53.74	45.83	28.78	54.47	24.53	19.35	99.42	1,345.17
TOTAL		**695.61**	**1,215.40**	**735.12**	**323.26**	**221.01**	**161.28**	**134.87**	**120.87**	**195.72**	**80.67**	**52.26**	**130.63**	**4,066.70**
1978-1979	1	450.00	926.66	988.82	170.77	80.02	61.43	42.83	48.89	61.82	34.78	21.80	18.85	2,906.67
	2	553.00	339.00	345.50	116.69	70.22	54.02	43.77	51.47	47.74	30.09	37.77	31.68	1,720.95
	3	209.00	357.00	230.00	102.23	65.67	49.21	55.76	53.64	45.22	27.33	32.53	96.00	1,323.59
TOTAL		**1,212.00**	**1,622.66**	**1,564.32**	**389.69**	**215.91**	**164.66**	**142.36**	**154.00**	**154.78**	**92.20**	**92.10**	**146.53**	**5,951.21**
1979-1980	1	82.77	126.82	138.84	83.22	43.37	27.37	28.01	27.84	32.57	20.76	18.04	19.39	649.00
	2	251.35	607.07	117.35	55.43	39.25	25.06	24.43	23.78	26.85	20.07	16.58	30.85	1,238.07
	3	396.05	370.06	97.64	54.12	33.44	28.26	26.04	19.81	21.75	19.86	15.58	38.93	1,121.54
TOTAL		**730.17**	**1,103.95**	**353.83**	**192.77**	**116.06**	**80.69**	**78.48**	**71.43**	**81.17**	**60.69**	**50.20**	**89.17**	**3,008.61**

YEAR	10-DAY	JUL	AUG	SEP	OCT	NOV	DEC	JAN	FEB	MAR	APR	MAY	JUN	TOTAL
1980-1981	1	134.07	501.54	517.36	215.47	65.56	35.38	30.64	34.57	25.98	22.14	18.64	17.05	1,618.40
	2	272.24	324.88	433.43	155.91	44.89	33.17	27.80	28.91	23.00	22.12	22.99	16.10	1,405.44
	3	504.37	178.07	393.12	115.62	36.99	35.05	68.51	21.26	25.34	21.06	19.56	281.62	1,700.57
TOTAL		**910.68**	**1,004.49**	**1,343.91**	**487.00**	**147.44**	**103.60**	**126.95**	**84.74**	**74.32**	**65.32**	**61.19**	**314.77**	**4,724.41**
1981-1982	1	192.02	472.00	184.36	77.00	40.00	46.00	36.30	40.00	54.00	34.50	40.00	45.23	1,261.41
	2	916.45	231.00	152.56	70.00	43.00	31.00	33.99	36.00	42.00	34.50	46.00	60.00	1,696.50
	3	816.57	198.00	51.56	78.00	50.00	35.50	39.86	24.00	45.50	32.00	35.70	46.00	1,452.69
TOTAL		**1,925.04**	**901.00**	**388.48**	**225.00**	**133.00**	**112.50**	**110.15**	**100.00**	**141.50**	**101.00**	**121.70**	**151.23**	**4,410.60**
1982-1983	1	77.11	291.28	1,027.02	442.66	50.98	33.42	32.78	25.31	33.44	18.78	31.47	21.96	2,086.21
	2	56.46	276.82	802.37	249.02	44.19	30.64	27.88	28.01	20.66	43.80	35.19	22.14	1,637.18
	3	370.04	1,559.09	838.82	68.87	37.21	35.62	33.59	20.92	22.78	44.93	51.49	130.86	3,214.22
TOTAL		**503.61**	**2,127.19**	**2,668.21**	**760.55**	**132.38**	**99.68**	**94.25**	**74.24**	**76.88**	**107.51**	**118.15**	**174.96**	**6,937.61**
1983-1984	1	144.08	242.00	298.11	354.76	68.91	57.30	55.09	67.57	13.15	13.36	13.15	29.16	1,356.64
	2	50.29	76.84	308.10	188.56	64.20	57.21	55.09	75.06	13.36	13.17	14.78	35.98	952.64
	3	655.74	121.90	1,819.88	139.16	60.21	57.24	62.05	88.30	14.75	13.14	19.67	368.71	3,420.75
TOTAL		**850.11**	**440.74**	**2,426.09**	**682.48**	**193.32**	**171.75**	**172.23**	**230.93**	**41.26**	**39.67**	**47.60**	**433.85**	**5,730.03**
1984-1985	1	523.76	1,190.47	1,062.50	685.33	38.41	23.62	23.52	16.97	14.82	11.16	12.53	9.52	3,612.61
	2	348.56	1,063.62	1,024.98	158.67	29.84	22.46	20.22	16.33	13.21	10.52	12.43	14.65	2,735.49
	3	1,352.27	1,395.48	960.99	54.77	27.24	22.91	19.12	12.43	12.82	9.91	12.41	31.07	3,911.42
TOTAL		**2,224.59**	**3,649.57**	**3,048.47**	**898.77**	**95.49**	**68.99**	**62.86**	**45.73**	**40.85**	**31.59**	**37.37**	**55.24**	**10,259.52**
1985-1986	1	70.50	608.68	547.22	437.62	183.32	78.74	57.37	34.20	37.54	24.69	20.87	22.46	2,123.21
	2	224.96	436.09	635.57	3,219.80	108.84	62.62	47.72	67.88	31.92	23.19	21.01	34.81	4,914.41
	3	922.98	880.49	382.59	404.23	84.53	71.79	44.41	34.47	31.55	22.18	28.13	92.59	2,999.94
TOTAL		**1,218.44**	**1,925.26**	**1,565.38**	**4,061.65**	**376.69**	**213.15**	**149.50**	**136.55**	**101.01**	**70.06**	**70.01**	**149.86**	**10,037.56**
1986-1987	1	656.89	970.98	414.94	458.14	187.52	91.79	88.78	57.18	29.18	18.95	46.26	80.79	3,101.40
	2	1,182.79	599.01	1,121.72	324.48	144.37	185.25	82.77	63.99	23.86	17.14	25.68	20.25	3,791.31
	3	1,253.21	896.32	605.43	228.94	102.52	151.94	76.76	39.85	22.98	15.74	18.35	17.92	3,429.96
TOTAL		**3,092.89**	**2,466.31**	**2,142.09**	**1,011.56**	**434.41**	**428.98**	**248.31**	**161.02**	**76.02**	**51.83**	**90.29**	**118.96**	**10,322.67**
1987-1988	1	139.82	127.00	353.50	34.03	39.30	29.49	26.54	21.04	20.98	19.91	55.66	15.48	882.75
	2	536.10	394.00	163.50	66.81	36.80	28.56	25.51	20.45	67.12	19.07	15.34	15.39	1,388.65
	3	292.50	957.00	170.00	70.32	32.38	27.38	27.02	17.83	24.99	19.25	16.54	36.66	1,691.87
TOTAL		**968.42**	**1,478.00**	**687.00**	**171.16**	**108.48**	**85.43**	**79.07**	**59.32**	**113.09**	**58.23**	**87.54**	**67.53**	**3,963.27**
1988-1989	1	188.54	340.50	139.42	130.78	43.22	32.75	51.12	26.65	20.41	18.22	14.82	15.66	1,022.09
	2	163.50	224.00	128.39	72.37	38.22	29.36	44.18	23.92	21.94	17.05	13.48	25.56	801.97
	3	321.00	171.00	192.81	59.95	42.03	33.10	33.11	18.20	20.38	15.82	15.35	52.16	974.91
TOTAL		**673.04**	**735.50**	**460.62**	**263.10**	**123.47**	**95.21**	**128.41**	**68.77**	**62.73**	**51.09**	**43.65**	**93.38**	**2,798.97**
1989-1990	1	40.13	445.00	763.00	178.30	49.37	36.79	27.14	22.89	185.34	35.79	20.21	21.10	1,825.06
	2	24.83	322.80	404.00	99.19	44.77	32.07	26.28	64.86	45.27	26.75	23.22	18.60	1,132.64
	3	591.00	563.00	286.00	75.61	43.75	32.19	26.82	61.88	43.11	20.82	26.84	30.36	1,801.38
TOTAL		**655.96**	**1,330.80**	**1,453.00**	**353.10**	**137.89**	**101.05**	**80.24**	**149.63**	**273.72**	**83.36**	**70.27**	**70.06**	**4,759.08**
1990-1991	1	2,208.61	1,417.00	802.00	225.00	62.35	36.16	57.25	21.36	36.11	18.31	15.38	19.02	4,918.55
	2	575.00	435.00	857.00	146.63	51.65	30.09	31.94	24.44	28.46	19.73	13.81	30.38	2,244.13
	3	404.00	1,160.00	363.00	89.42	45.41	75.12	27.98	23.87	24.28	16.73	24.96	22.89	2,277.66
TOTAL		**3,187.61**	**3,012.00**	**2,022.00**	**461.05**	**159.41**	**141.37**	**117.17**	**69.67**	**88.85**	**54.77**	**54.15**	**72.29**	**9,440.34**

YEAR	10-DAY	JUL	AUG	SEP	OCT	NOV	DEC	JAN	FEB	MAR	APR	MAY	JUN	TOTAL
1991-1992	1	22.92	144.62	120.78	68.58	29.03	27.75	28.18	34.74	20.07	15.76	13.18	19.41	545.02
	2	26.13	124.18	97.94	47.66	37.93	24.07	27.86	31.46	18.32	14.91	12.37	22.41	485.24
	3	53.33	182.16	96.63	41.28	29.26	39.36	30.19	20.41	19.19	13.73	14.13	69.35	609.02
TOTAL		**102.38**	**450.96**	**315.35**	**157.52**	**96.22**	**91.18**	**86.23**	**86.61**	**57.58**	**44.40**	**39.68**	**111.17**	**1,639.28**
1992-1993	1	27.49	239.90	47.84	16.44	37.51	17.68	20.81	18.40	18.40	22.74	14.67	12.63	494.51
	2	40.34	85.89	67.10	47.09	32.39	25.37	20.46	18.62	18.73	17.99	16.24	13.25	403.47
	3	265.94	107.96	25.46	54.02	31.82	25.97	20.85	15.50	40.83	15.88	14.94	16.05	635.22
TOTAL		**333.77**	**433.75**	**140.40**	**117.55**	**101.72**	**69.02**	**62.12**	**52.52**	**77.96**	**56.61**	**45.85**	**41.93**	**1,533.20**
1993-1994	1	32.61	280.23	1,588.86	46.46	63.01	35.29	28.76	20.27	24.92	19.02	14.96	14.67	2,169.06
	2	94.24	194.89	3,108.50	59.43	47.59	32.67	34.72	29.24	22.48	16.72	18.28	13.77	3,672.53
	3	407.97	127.83	320.10	84.70	37.61	33.70	32.71	25.83	22.74	15.59	16.44	26.35	1,151.57
TOTAL		**534.82**	**602.95**	**5,017.46**	**190.59**	**148.21**	**101.66**	**96.19**	**75.34**	**70.14**	**51.33**	**49.68**	**54.79**	**6,993.16**
1994-1995	1	36.35	213.76	91.46	72.47	38.35	26.37	27.91	25.99	24.98	21.14	18.50	13.61	610.89
	2	67.00	333.25	78.02	59.33	33.62	24.80	31.53	24.95	25.03	20.65	16.82	12.14	727.14
	3	94.00	193.29	59.84	47.81	29.18	26.70	27.71	21.57	24.05	19.40	16.88	63.14	623.57
TOTAL		**197.35**	**740.30**	**229.32**	**179.61**	**101.15**	**77.87**	**87.15**	**72.51**	**74.06**	**61.19**	**52.20**	**88.89**	**1,961.60**
1995-1996	1	53.69	60.31	1,961.25	107.97	39.78	30.48	23.83	23.80	26.64	19.99	13.74	18.49	2,379.97
	2	120.51	464.97	321.62	70.76	33.69	28.11	28.51	26.74	22.11	16.10	14.02	40.80	1,187.94
	3	62.07	139.81	155.39	68.13	31.59	28.69	27.62	27.85	24.39	14.39	13.76	140.08	733.77
TOTAL		**236.27**	**665.09**	**2,438.26**	**246.86**	**105.06**	**87.28**	**79.96**	**78.39**	**73.14**	**50.48**	**41.52**	**199.37**	**4,301.68**
1996-1997	1	121.32	138.83	520.97	75.80	42.23	34.91	27.82	25.26	20.90	29.07	20.38	15.58	1,073.07
	2	185.66	243.63	261.96	61.89	42.91	31.29	26.45	22.54	21.52	20.04	17.07	18.07	953.03
	3	124.16	376.57	133.54	60.05	37.82	31.86	29.94	16.77	21.44	18.62	16.57	34.60	901.94
TOTAL		**431.14**	**759.03**	**916.47**	**197.74**	**122.96**	**98.06**	**84.21**	**64.57**	**63.86**	**67.73**	**54.02**	**68.25**	**2,928.04**
1997-1998	1	46.29	209.20	76.60	69.00	51.31	52.08	43.75	31.00	33.23	36.62	41.94	17.85	708.87
	2	81.20	138.10	75.80	63.00	48.34	61.55	41.45	30.00	33.54	34.48	28.88	46.00	682.34
	3	79.10	82.50	71.00	67.90	42.93	45.52	36.86	24.47	35.30	29.98	22.40	102.50	640.46
TOTAL		**206.59**	**429.80**	**223.40**	**199.90**	**142.58**	**159.15**	**122.06**	**85.47**	**102.07**	**101.08**	**93.22**	**166.35**	**2,031.67**
1998-1999	1	1,206.85	774.29	482.86	309.71	366.39	96.49	51.85	44.30	40.46	21.45	12.43	17.08	3,424.18
	2	531.02	1,751.14	379.47	854.94	200.17	63.99	49.86	36.40	41.23	15.79	14.37	91.37	4,029.72
	3	773.48	1,668.05	645.82	577.83	103.38	57.55	57.74	31.49	36.81	14.37	12.89	116.77	4,096.19
TOTAL		**2,511.35**	**4,193.48**	**1,508.16**	**1,742.48**	**669.95**	**218.03**	**159.45**	**112.19**	**118.50**	**51.60**	**39.68**	**225.22**	**11,550.09**
1999-2000	1	468.07	845.16	472.79	346.81	110.44	36.09	26.02	34.32	19.07	14.80	17.13	1,436.36	3,827.06
	2	459.17	498.85	818.88	254.75	75.23	36.07	22.18	27.71	17.43	15.62	14.50	946.23	3,186.62
	3	864.68	444.66	552.23	207.27	41.35	32.78	21.50	20.52	17.63	15.68	17.31	1,451.84	3,687.45
TOTAL		**1,791.92**	**1,788.67**	**1,843.90**	**808.83**	**227.02**	**104.94**	**69.70**	**82.55**	**54.13**	**46.10**	**48.94**	**3,834.43**	**10,701.13**
2000-2001	1	976.41	1,001.12	2,711.28	646.92	123.24	32.59	24.71	17.92	16.16	14.19	12.21	28.03	5,604.78
	2	1,839.71	2,839.24	1,083.72	207.78	59.25	29.07	21.41	18.22	15.09	14.45	14.25	19.89	6,162.08
	3	1,563.94	2,312.50	751.29	212.44	39.99	26.09	21.54	14.40	15.54	13.88	14.88	412.60	5,399.09
TOTAL		**4,380.06**	**6,152.86**	**4,546.29**	**1,067.14**	**222.48**	**87.75**	**67.66**	**50.54**	**46.79**	**42.52**	**41.34**	**460.52**	**17,165.95**
2001-2002	1	524.60	622.50	263.58	153.04	50.42	22.76	18.47	19.23	56.86	18.39	18.88	20.92	1,789.65
	2	535.68	690.67	201.40	34.74	32.27	21.23	18.16	68.54	19.45	16.93	16.31	23.68	1,679.06
	3	749.21	429.60	327.97	68.37	25.61	21.67	20.95	16.72	20.60	19.85	17.45	24.67	1,742.67
TOTAL		**1,809.49**	**1,742.77**	**792.95**	**256.15**	**108.30**	**65.66**	**57.58**	**104.49**	**96.91**	**55.17**	**52.64**	**69.27**	**5,211.38**

YEAR	10-DAY	JUL	AUG	SEP	OCT	NOV	DEC	JAN	FEB	MAR	APR	MAY	JUN	TOTAL
2002-2003	1	257.84	157.33	1,115.17	283.52	53.17	26.42	23.63	28.63	232.25	18.31	14.70	13.51	2,224.48
	2	174.58	515.04	830.52	257.45	42.06	24.85	21.52	418.79	49.38	16.68	13.56	13.61	2,378.04
	3	170.36	376.91	342.22	351.66	33.17	23.66	23.50	212.92	26.46	15.35	14.05	16.48	1,606.74
TOTAL		**602.78**	**1,049.28**	**2,287.91**	**892.63**	**128.40**	**74.93**	**68.65**	**660.34**	**308.09**	**50.34**	**42.31**	**43.60**	**6,209.26**
2003-2004	1	21.33	279.45	246.44	330.37	155.08	44.56	22.95	24.42	18.24	15.64	16.04	24.94	1,199.46
	2	1,148.40	869.70	417.04	229.81	159.59	34.19	21.62	21.87	17.54	14.59	13.04	28.43	2,975.82
	3	236.94	749.92	1,074.73	182.76	151.80	29.52	23.70	17.87	17.99	17.31	19.15	20.11	2,541.80
TOTAL		**1,406.67**	**1,899.07**	**1,738.21**	**742.94**	**466.47**	**108.27**	**68.27**	**64.16**	**53.77**	**47.54**	**48.23**	**73.48**	**6,717.08**
2004-2005	1	169.25	193.58	255.37	206.91	64.97	30.32	19.19	30.84	19.23	15.15	13.29	13.93	1,032.03
	2	223.37	266.69	202.62	283.04	49.81	25.72	23.66	34.70	17.23	13.76	12.63	12.08	1,165.31
	3	177.06	2,192.08	481.59	205.84	40.39	23.39	34.75	18.12	17.10	13.42	13.86	43.76	3,261.36
TOTAL		**569.68**	**2,652.35**	**939.58**	**695.79**	**155.17**	**79.43**	**77.60**	**83.66**	**53.56**	**42.33**	**39.78**	**69.77**	**5,458.70**
2005-2006	1	134.18	64.92	90.00	276.05	81.56	40.58	20.90	19.12	18.10	16.83	13.77	20.34	796.35
	2	222.56	126.60	289.78	159.47	77.24	32.48	22.60	18.89	20.32	15.91	19.76	14.58	1,020.19
	3	116.64	129.52	2,401.21	114.95	65.65	24.96	23.41	14.12	20.40	14.51	17.20	19.90	2,962.47
TOTAL		**473.38**	**321.04**	**2,780.99**	**550.47**	**224.45**	**98.02**	**66.91**	**52.13**	**58.82**	**47.25**	**50.73**	**54.82**	**4,779.01**

Table-4.4

Derived 10 - Daily Discharge of Gola River at Jamrani Dam Site by using Log Deviation Regression Method

(cumec day)

YEAR	10-DAY	JUL	AUG	SEP	OCT	NOV	DEC	JAN	FEB	MAR	APR	MAY	JUN	TOTAL
1948-1949	1	181.17	540.67	1,290.56	365.51	193.36	121.92	60.86	345.79	88.69	36.90	45.35	136.27	3,407.07
	2	314.63	2,087.94	871.94	526.01	157.44	89.51	49.40	47.48	48.02	41.14	59.93	41.12	4,334.54
	3	312.01	6,542.64	591.66	260.51	145.26	65.86	53.35	62.72	38.56	28.91	83.39	70.96	8,255.82
TOTAL		**807.81**	**9,171.25**	**2,754.16**	**1,152.02**	**496.05**	**277.29**	**163.61**	**455.99**	**175.27**	**106.95**	**188.67**	**248.35**	**15,997.42**
1949-1950	1	289.62	1,552.46	1,301.05	853.18	150.89	82.68	66.24	68.55	59.96	40.75	30.57	24.43	4,520.39
	2	1,705.64	3,200.38	1,442.90	317.34	110.89	67.83	56.07	72.07	53.00	28.97	47.01	975.89	8,077.98
	3	1,815.91	3,572.28	2,476.55	283.46	103.08	73.17	70.03	43.52	514.24	29.42	63.91	923.12	9,968.69
TOTAL		**3,811.17**	**8,325.13**	**5,220.50**	**1,453.98**	**364.86**	**223.67**	**192.34**	**184.14**	**627.20**	**99.14**	**141.48**	**1,923.44**	**22,567.06**
1950-1951	1	1,581.84	3,786.41	1,595.83	422.93	184.16	116.99	77.57	71.75	55.52	41.08	54.67	34.22	8,022.98
	2	2,509.57	5,225.34	1,864.15	227.35	123.27	93.84	71.73	58.31	51.09	32.16	73.27	35.42	10,365.51
	3	3,577.93	3,524.28	1,362.19	186.66	114.95	89.00	71.59	36.55	48.48	30.59	31.57	122.30	9,196.08
TOTAL		**7,669.34**	**12,536.03**	**4,822.18**	**836.94**	**422.38**	**299.84**	**220.89**	**166.61**	**155.09**	**103.83**	**159.51**	**191.94**	**27,584.57**
1951-1952	1	60.39	705.13	40.38	289.67	135.40	84.82	77.18	47.89	84.70	49.61	50.28	34.22	1,659.67
	2	603.20	349.44	47.94	189.27	84.73	74.46	69.78	56.67	76.85	41.14	59.25	115.26	1,767.98
	3	657.72	6,016.08	44.72	161.67	91.77	74.73	78.67	59.61	63.28	42.56	56.36	882.85	8,230.03
TOTAL		**1,321.31**	**7,070.65**	**133.03**	**640.62**	**311.90**	**234.01**	**225.63**	**164.18**	**224.83**	**133.31**	**165.89**	**1,032.33**	**11,657.68**
1952-1953	1	145.44	2,354.00	1,403.07	156.92	135.64	49.20	40.03	32.80	40.70	25.58	27.49	16.27	4,427.13
	2	1,600.25	3,590.40	1,805.95	144.63	94.87	41.74	64.08	34.31	37.84	20.13	37.74	196.87	7,668.80
	3	661.07	3,198.36	299.52	145.76	78.19	40.02	62.57	26.88	29.84	21.32	36.11	1,336.32	5,935.94
TOTAL		**2,406.75**	**9,142.76**	**3,508.53**	**447.31**	**308.70**	**130.95**	**166.68**	**93.99**	**108.38**	**67.03**	**101.34**	**1,549.46**	**18,031.88**
1953-1954	1	393.75	679.02	1,604.65	192.75	130.32	63.05	165.89	87.58	97.81	53.05	33.42	12.86	3,514.16
	2	4,413.74	532.99	603.05	177.15	91.58	51.34	53.85	87.98	78.44	32.03	42.08	96.74	6,260.96
	3	3,227.90	1,214.88	384.38	150.35	85.69	52.20	68.39	61.85	69.04	30.81	42.81	181.26	5,569.55
TOTAL		**8,035.39**	**2,426.89**	**2,592.09**	**520.26**	**307.59**	**166.59**	**288.12**	**237.40**	**245.29**	**115.89**	**118.31**	**290.86**	**15,344.67**
1954-1955	1	84.96	1,312.14	678.75	2,344.32	312.06	122.39	87.84	49.77	75.13	26.24	26.87	23.09	5,143.56
	2	778.13	2,046.98	691.97	814.67	175.42	99.62	80.46	63.47	66.36	22.10	33.41	41.47	4,914.04
	3	1,885.68	1,836.12	531.54	369.04	145.73	94.48	119.31	49.10	45.36	23.73	48.36	240.78	5,389.22
TOTAL		**2,748.77**	**5,195.24**	**1,902.26**	**3,528.02**	**633.21**	**316.49**	**287.61**	**162.35**	**186.84**	**72.07**	**108.63**	**305.34**	**15,446.82**
1955-1956	1	1,054.35	1,427.17	865.73	3,795.07	504.57	195.95	117.02	65.27	70.79	49.28	29.18	1,046.26	9,220.65
	2	1,153.65	2,447.23	666.93	2,441.07	244.75	160.14	88.73	58.39	76.21	38.22	65.11	1,140.27	8,580.70
	3	985.50	1,225.80	888.89	782.85	212.71	141.98	93.31	52.92	57.92	31.61	636.48	771.34	5,881.31
TOTAL		**3,193.50**	**5,100.20**	**2,421.55**	**7,018.99**	**962.03**	**498.08**	**299.07**	**176.58**	**204.93**	**119.11**	**730.78**	**2,957.87**	**23,682.66**
1956-1957	1	3,151.35	1,084.34	1,120.04	1,089.69	640.82	157.08	109.54	62.73	67.26	43.87	27.03	20.54	7,574.28
	2	1,089.92	1,184.26	773.50	1,883.55	259.35	102.68	112.50	48.33	64.02	72.15	37.40	37.11	5,664.77
	3	1,031.62	154.08	551.51	819.88	194.56	100.49	107.19	36.27	13.04	33.58	38.50	46.78	3,127.48
TOTAL		**5,272.89**	**2,422.67**	**2,445.06**	**3,793.12**	**1,094.72**	**360.24**	**329.22**	**147.33**	**144.32**	**149.60**	**102.93**	**104.44**	**16,366.53**
1957-1958	1	127.44	606.05	462.76	209.48	231.72	85.19	83.42	61.91	65.78	21.40	38.27	23.14	2,016.55
	2	519.74	381.18	1,841.04	196.04	99.41	118.58	64.53	59.08	53.85	16.73	103.19	36.49	3,489.86
	3	1,359.40	579.96	268.22	139.03	98.04	96.05	84.00	47.62	41.20	15.99	44.04	37.20	2,810.74
TOTAL		**2,006.58**	**1,567.19**	**2,572.01**	**544.55**	**429.17**	**299.81**	**231.95**	**168.61**	**160.83**	**54.12**	**185.50**	**96.83**	**8,317.14**

YEAR	10-DAY	JUL	AUG	SEP	OCT	NOV	DEC	JAN	FEB	MAR	APR	MAY	JUN	TOTAL
1958-1959	1	1,222.02	452.50	559.87	1,051.97	303.11	132.53	87.65	60.68	88.35	43.62	32.65	25.06	4,060.01
	2	1,419.90	359.30	512.42	436.22	199.63	87.89	71.20	75.16	63.49	31.28	43.95	50.73	3,351.17
	3	1,866.02	1,395.60	1,168.44	380.77	172.05	111.10	93.61	62.40	47.60	32.78	49.05	65.94	5,445.35
TOTAL		**4,507.95**	**2,207.40**	**2,240.74**	**1,868.96**	**674.78**	**331.51**	**252.45**	**198.25**	**199.44**	**107.68**	**125.64**	**141.72**	**12,856.52**
1959-1960	1	602.19	1,102.96	426.50	495.99	293.91	119.23	73.82	58.55	63.04	44.28	31.72	21.36	3,333.55
	2	484.91	1,283.71	764.09	381.07	199.18	82.71	68.17	56.85	60.31	33.46	41.31	38.63	3,494.40
	3	1,062.29	896.40	639.91	317.12	155.71	81.52	82.35	41.57	48.00	33.29	39.04	47.90	3,445.09
TOTAL		**2,149.39**	**3,283.07**	**1,830.50**	**1,194.18**	**648.80**	**283.45**	**224.35**	**156.97**	**171.36**	**111.02**	**112.07**	**107.88**	**10,273.03**
1960-1961	1	163.26	976.59	1,466.37	950.99	240.91	61.19	133.54	97.50	72.96	37.06	28.64	38.06	4,267.09
	2	1,448.67	1,126.66	1,261.85	499.24	148.63	70.64	85.35	98.73	75.26	25.70	44.03	182.81	5,067.56
	3	579.64	1,378.56	640.64	346.70	139.56	66.73	84.78	74.21	52.56	26.06	47.89	240.50	3,677.82
TOTAL		**2,191.57**	**3,481.81**	**3,368.87**	**1,796.94**	**529.10**	**198.56**	**303.67**	**270.44**	**200.78**	**88.83**	**120.57**	**461.37**	**13,012.48**
1961-1962	1	866.34	1,487.30	616.32	233.94	305.40	114.11	96.67	102.42	291.16	51.58	35.04	26.30	4,226.58
	2	1,377.98	2,475.52	449.08	599.54	164.21	126.74	84.55	83.25	83.85	37.26	39.70	191.35	5,713.01
	3	1,029.13	1,927.32	322.61	365.98	149.91	124.58	219.32	98.21	62.64	36.50	45.51	239.01	4,620.71
TOTAL		**3,273.45**	**5,890.14**	**1,388.01**	**1,199.45**	**619.52**	**365.43**	**400.54**	**283.87**	**437.64**	**125.34**	**120.24**	**456.66**	**14,560.30**
1962-1963	1	105.30	376.53	283.71	344.52	180.53	100.91	74.88	58.14	73.07	52.56	46.51	33.26	1,729.93
	2	247.04	1,022.72	252.31	280.07	125.40	84.58	70.22	58.05	80.45	39.71	57.21	73.16	2,390.91
	3	842.94	780.72	2,967.95	201.96	110.77	78.30	82.35	46.41	61.28	38.03	44.97	68.63	5,324.32
TOTAL		**1,195.28**	**2,179.97**	**3,503.97**	**826.55**	**416.70**	**263.78**	**227.45**	**162.60**	**214.81**	**130.31**	**148.68**	**175.06**	**9,445.15**
1963-1964	1	248.94	510.93	1,190.70	357.69	232.32	124.81	89.57	76.67	90.97	42.31	43.35	29.90	3,038.16
	2	490.46	946.56	1,310.00	296.64	145.16	115.94	81.70	30.27	78.23	31.96	52.53	59.54	3,638.99
	3	540.32	3,389.76	610.17	273.16	142.69	91.44	92.93	71.05	46.96	37.08	60.83	122.02	5,478.40
TOTAL		**1,279.72**	**4,847.25**	**3,110.87**	**927.48**	**520.17**	**332.18**	**264.20**	**177.99**	**216.16**	**111.36**	**156.71**	**211.46**	**12,155.55**
1964-1965	1	678.78	1,234.67	1,372.29	616.67	196.26	100.63	74.88	54.20	69.54	64.21	30.65	24.96	4,517.74
	2	1,457.06	983.17	1,035.12	260.08	122.46	93.67	85.00	67.77	59.78	40.80	44.37	42.19	4,291.45
	3	2,343.82	1,119.00	1,579.86	221.24	116.38	73.52	116.01	63.15	65.44	37.30	47.05	51.89	5,834.65
TOTAL		**4,479.65**	**3,336.84**	**3,987.28**	**1,097.98**	**435.10**	**267.81**	**275.89**	**185.12**	**194.76**	**142.31**	**122.06**	**119.04**	**14,643.84**
1965-1966	1	159.21	811.81	542.92	156.22	120.88	63.80	48.48	34.28	46.74	30.01	23.25	21.22	2,058.82
	2	404.67	401.02	352.14	131.81	69.60	53.13	45.03	39.39	41.02	22.44	30.01	39.96	1,630.21
	3	310.07	1,479.48	219.65	127.40	68.40	50.20	48.31	27.06	32.32	21.61	39.58	260.21	2,684.28
TOTAL		**873.95**	**2,692.31**	**1,114.71**	**415.43**	**258.88**	**167.12**	**141.82**	**100.73**	**120.08**	**74.06**	**92.84**	**321.39**	**6,373.31**
1966-1967	1	152.91	1,100.50	323.20	154.24	128.99	65.94	63.07	46.82	55.75	50.76	41.43	30.34	2,213.93
	2	191.05	716.16	312.55	132.01	83.30	52.19	54.82	43.69	55.01	40.32	49.13	53.13	1,783.37
	3	872.21	527.16	190.32	125.15	75.15	63.77	62.76	37.85	74.96	44.60	50.13	67.70	2,191.76
TOTAL		**1,216.17**	**2,343.82**	**826.07**	**411.40**	**287.44**	**181.90**	**180.66**	**128.36**	**185.72**	**135.69**	**140.68**	**151.17**	**6,189.07**
1967-1968	1	446.13	899.12	968.53	281.26	172.67	92.54	77.76	75.03	89.03	45.35	35.19	33.31	3,215.92
	2	1,173.00	1,118.08	972.52	212.61	98.08	75.14	67.82	69.92	65.61	31.62	45.90	211.46	4,141.76
	3	868.10	2,712.72	480.27	208.39	98.33	81.52	94.38	84.44	56.80	35.48	50.44	812.45	5,583.31
TOTAL		**2,487.23**	**4,729.92**	**2,421.33**	**702.25**	**369.07**	**249.19**	**239.96**	**229.39**	**211.45**	**112.44**	**131.52**	**1,057.22**	**12,940.99**
1968-1969	1	379.89	337.91	246.76	247.80	132.50	75.70	66.62	46.00	57.91	34.44	35.27	21.17	1,681.97
	2	531.48	1,155.71	297.35	141.50	88.20	65.62	68.17	49.11	45.05	28.56	61.54	36.05	2,568.34
	3	417.53	863.04	377.10	103.84	85.41	74.56	68.48	40.27	36.40	28.11	52.67	53.01	2,200.41
TOTAL		**1,328.90**	**2,356.66**	**921.22**	**493.13**	**306.10**	**215.88**	**203.28**	**135.38**	**139.36**	**91.11**	**149.47**	**110.22**	**6,450.71**

YEAR	10-DAY	JUL	AUG	SEP	OCT	NOV	DEC	JAN	FEB	MAR	APR	MAY	JUN	TOTAL
1969-1970	1	64.62	910.04	740.39	487.67	181.98	93.47	69.22	53.14	49.93	27.06	23.33	88.46	2,789.31
	2	1,032.90	621.18	732.31	274.32	106.71	76.76	97.19	50.40	39.33	20.94	28.73	377.63	3,458.39
	3	693.04	1,161.72	2,255.14	255.51	105.64	78.91	84.58	40.36	32.08	21.39	38.73	888.43	5,655.53
TOTAL		**1,790.56**	**2,692.94**	**3,727.83**	**1,017.50**	**394.34**	**249.13**	**250.99**	**143.89**	**121.34**	**69.39**	**90.79**	**1,354.52**	**11,903.22**
1970-1971	1	483.12	500.55	508.33	200.08	125.48	64.08	35.23	28.95	53.01	20.66	18.79	87.36	2,125.63
	2	231.81	1,165.18	384.88	142.41	83.75	49.56	30.97	25.63	34.03	16.52	79.90	507.66	2,752.30
	3	474.34	662.04	279.03	116.38	66.88	42.02	41.03	23.06	26.32	16.43	116.73	182.84	2,047.10
TOTAL		**1,189.27**	**2,327.77**	**1,172.24**	**458.87**	**276.11**	**155.65**	**107.24**	**77.64**	**113.36**	**53.61**	**215.42**	**777.85**	**6,925.02**
1971-1972	1	874.98	439.24	987.94	151.17	150.89	74.59	45.70	42.48	46.40	21.32	17.09	14.21	2,865.99
	2	403.00	787.97	506.43	144.43	76.81	65.96	41.83	40.51	36.46	16.86	27.63	25.99	2,173.87
	3	347.54	450.00	208.42	137.80	89.02	56.38	84.97	24.74	25.76	17.52	21.64	40.83	1,504.61
TOTAL		**1,625.52**	**1,677.20**	**1,702.79**	**433.41**	**316.71**	**196.92**	**172.50**	**107.72**	**108.62**	**55.70**	**66.36**	**81.02**	**6,544.47**
1972-1973	1	241.83	269.32	297.72	195.62	133.71	67.70	46.56	30.01	39.90	22.80	21.71	21.26	1,388.15
	2	590.82	556.80	1,229.11	183.72	84.19	53.38	42.54	31.48	48.23	19.45	26.35	126.83	2,992.89
	3	351.54	353.16	271.65	229.30	65.65	45.59	58.49	22.69	28.72	20.29	36.27	296.86	1,780.20
TOTAL		**1,184.19**	**1,179.28**	**1,798.48**	**608.64**	**283.54**	**166.67**	**147.59**	**84.18**	**116.85**	**62.54**	**84.33**	**444.95**	**6,161.24**
1973-1974	1	163.80	571.38	267.44	288.19	194.33	87.51	61.82	39.77	37.28	25.75	20.17	16.08	1,773.52
	2	247.94	442.11	406.81	212.91	109.56	72.93	42.19	44.46	33.07	19.86	23.46	52.33	1,707.63
	3	308.88	372.00	262.70	205.12	99.85	70.73	51.12	28.92	28.40	20.00	23.49	33.57	1,504.78
TOTAL		**720.62**	**1,385.49**	**936.96**	**706.22**	**403.73**	**231.17**	**155.13**	**113.16**	**98.75**	**65.61**	**67.12**	**101.99**	**4,985.94**
1974-1975	1	62.37	388.52	203.84	94.05	71.63	42.59	66.53	59.61	58.60	26.40	18.63	17.47	1,110.25
	2	100.49	372.61	186.39	87.87	47.17	42.76	49.13	65.10	49.08	19.58	22.02	44.95	1,087.14
	3	598.75	316.32	129.58	80.99	46.46	50.03	86.33	53.01	35.84	20.15	25.56	413.57	1,856.59
TOTAL		**761.61**	**1,077.45**	**519.82**	**262.91**	**165.26**	**135.37**	**201.99**	**177.73**	**143.51**	**66.14**	**66.21**	**475.99**	**4,053.98**
1975-1976	1	547.02	969.21	1,214.71	288.09	156.09	76.26	58.56	41.57	58.94	28.62	28.80	21.22	3,489.08
	2	704.86	553.47	916.88	238.36	103.69	70.72	51.44	59.60	44.31	27.81	47.77	67.82	2,886.72
	3	403.27	513.48	439.30	207.26	92.25	64.73	57.72	53.66	31.44	24.24	31.49	49.48	1,968.31
TOTAL		**1,655.15**	**2,036.16**	**2,570.89**	**733.71**	**352.02**	**211.71**	**167.72**	**154.83**	**134.69**	**80.67**	**108.06**	**138.51**	**8,344.11**
1976-1977	1	63.81	499.37	290.08	202.75	118.46	69.94	46.08	39.77	31.86	22.88	23.67	23.68	1,432.35
	2	310.63	1,849.98	319.93	147.46	82.06	58.23	37.83	37.58	25.09	22.67	36.39	31.68	2,959.53
	3	467.64	650.64	260.94	130.76	75.24	64.21	44.81	29.39	24.70	22.42	34.51	92.15	1,897.41
TOTAL		**842.08**	**2,999.99**	**870.95**	**480.98**	**275.76**	**192.37**	**128.72**	**106.74**	**81.65**	**67.97**	**94.57**	**147.51**	**6,289.28**
1977-1978	1	75.20	184.62	206.93	128.05	85.72	63.10	44.68	38.51	57.92	27.50	16.43	14.34	943.00
	2	156.83	812.10	351.99	95.67	74.24	44.44	44.36	53.58	83.33	28.64	16.48	16.87	1,778.53
	3	463.58	218.68	176.20	99.54	61.05	53.74	45.83	28.78	54.47	24.53	19.35	99.42	1,345.17
TOTAL		**695.61**	**1,215.40**	**735.12**	**323.26**	**221.01**	**161.28**	**134.87**	**120.87**	**195.72**	**80.67**	**52.26**	**130.63**	**4,066.70**
1978-1979	1	450.00	926.66	988.82	170.77	80.02	61.43	42.83	48.89	61.82	34.78	21.80	18.85	2,906.67
	2	553.00	339.00	345.50	116.69	70.22	54.02	43.77	51.47	47.74	30.09	37.77	31.68	1,720.95
	3	209.00	357.00	230.00	102.23	65.67	49.21	55.76	53.64	45.22	27.33	32.53	96.00	1,323.59
TOTAL		**1,212.00**	**1,622.66**	**1,564.32**	**389.69**	**215.91**	**164.66**	**142.36**	**154.00**	**154.78**	**92.20**	**92.10**	**146.53**	**5,951.21**
1979-1980	1	82.77	126.82	138.84	83.22	43.37	27.37	28.01	27.84	32.57	20.76	18.04	19.39	649.00
	2	251.35	607.07	117.35	55.43	39.25	25.06	24.43	23.78	26.85	20.07	16.58	30.85	1,238.07
	3	396.05	370.06	97.64	54.12	33.44	28.26	26.04	19.81	21.75	19.86	15.58	38.93	1,121.54
TOTAL		**730.17**	**1,103.95**	**353.83**	**192.77**	**116.06**	**80.69**	**78.48**	**71.43**	**81.17**	**60.69**	**50.20**	**89.17**	**3,008.61**

YEAR	10-DAY	JUL	AUG	SEP	OCT	NOV	DEC	JAN	FEB	MAR	APR	MAY	JUN	TOTAL
1980-1981	1	134.07	501.54	517.36	215.47	65.56	35.38	30.64	34.57	25.98	22.14	18.64	17.05	1,618.40
	2	272.24	324.88	433.43	155.91	44.89	33.17	27.80	28.91	23.00	22.12	22.99	16.10	1,405.44
	3	504.37	178.07	393.12	115.62	36.99	35.05	68.51	21.26	25.34	21.06	19.56	281.62	1,700.57
TOTAL		**910.68**	**1,004.49**	**1,343.91**	**487.00**	**147.44**	**103.60**	**126.95**	**84.74**	**74.32**	**65.32**	**61.19**	**314.77**	**4,724.41**
1981-1982	1	192.02	472.00	184.36	77.00	40.00	46.00	36.30	40.00	54.00	34.50	40.00	45.23	1,261.41
	2	916.45	231.00	152.56	70.00	43.00	31.00	33.99	36.00	42.00	34.50	46.00	60.00	1,696.50
	3	816.57	198.00	51.56	78.00	50.00	35.50	39.86	24.00	45.50	32.00	35.70	46.00	1,452.69
TOTAL		**1,925.04**	**901.00**	**388.48**	**225.00**	**133.00**	**112.50**	**110.15**	**100.00**	**141.50**	**101.00**	**121.70**	**151.23**	**4,410.60**
1982-1983	1	77.11	291.28	1,027.02	442.66	50.98	33.42	32.78	25.31	33.44	18.78	31.47	21.96	2,086.21
	2	56.46	276.82	802.37	249.02	44.19	30.64	27.88	28.01	20.66	43.80	35.19	22.14	1,637.18
	3	370.04	1,559.09	838.82	68.87	37.21	35.62	33.59	20.92	22.78	44.93	51.49	130.86	3,214.22
TOTAL		**503.61**	**2,127.19**	**2,668.21**	**760.55**	**132.38**	**99.68**	**94.25**	**74.24**	**76.88**	**107.51**	**118.15**	**174.96**	**6,937.61**
1983-1984	1	144.08	242.00	298.11	354.76	68.91	57.30	55.09	67.57	13.15	13.36	13.15	29.16	1,356.64
	2	50.29	76.84	308.10	188.56	64.20	57.21	55.09	75.06	13.36	13.17	14.78	35.98	952.64
	3	655.74	121.90	1,819.88	139.16	60.21	57.24	62.05	88.30	14.75	13.14	19.67	368.71	3,420.75
TOTAL		**850.11**	**440.74**	**2,426.09**	**682.48**	**193.32**	**171.75**	**172.23**	**230.93**	**41.26**	**39.67**	**47.60**	**433.85**	**5,730.03**
1984-1985	1	523.76	1,190.47	1,062.50	685.33	38.41	23.62	23.52	16.97	14.82	11.16	12.53	9.52	3,612.61
	2	348.56	1,063.62	1,024.98	158.67	29.84	22.46	20.22	16.33	13.21	10.52	12.43	14.65	2,735.49
	3	1,352.27	1,395.48	960.99	54.77	27.24	22.91	19.12	12.43	12.82	9.91	12.41	31.07	3,911.42
TOTAL		**2,224.59**	**3,649.57**	**3,048.47**	**898.77**	**95.49**	**68.99**	**62.86**	**45.73**	**40.85**	**31.59**	**37.37**	**55.24**	**10,259.52**
1985-1986	1	70.50	608.68	547.22	437.62	183.32	78.74	57.37	34.20	37.54	24.69	20.87	22.46	2,123.21
	2	224.96	436.09	635.57	3,219.80	108.84	62.62	47.72	67.88	31.92	23.19	21.01	34.81	4,914.41
	3	922.98	880.49	382.59	404.23	84.53	71.79	44.41	34.47	31.55	22.18	28.13	92.59	2,999.94
TOTAL		**1,218.44**	**1,925.26**	**1,565.38**	**4,061.65**	**376.69**	**213.15**	**149.50**	**136.55**	**101.01**	**70.06**	**70.01**	**149.86**	**10,037.56**
1986-1987	1	656.89	970.98	414.94	458.14	187.52	91.79	88.78	57.18	29.18	18.95	46.26	80.79	3,101.40
	2	1,182.79	599.01	1,121.72	324.48	144.37	185.25	82.77	63.99	23.86	17.14	25.68	20.25	3,791.31
	3	1,253.21	896.32	605.43	228.94	102.52	151.94	76.76	39.85	22.98	15.74	18.35	17.92	3,429.96
TOTAL		**3,092.89**	**2,466.31**	**2,142.09**	**1,011.56**	**434.41**	**428.98**	**248.31**	**161.02**	**76.02**	**51.83**	**90.29**	**118.96**	**10,322.67**
1987-1988	1	139.82	127.00	353.50	34.03	39.30	29.49	26.54	21.04	20.98	19.91	55.66	15.48	882.75
	2	536.10	394.00	163.50	66.81	36.80	28.56	25.51	20.45	67.12	19.07	15.34	15.39	1,388.65
	3	292.50	957.00	170.00	70.32	32.38	27.38	27.02	17.83	24.99	19.25	16.54	36.66	1,691.87
TOTAL		**968.42**	**1,478.00**	**687.00**	**171.16**	**108.48**	**85.43**	**79.07**	**59.32**	**113.09**	**58.23**	**87.54**	**67.53**	**3,963.27**
1988-1989	1	188.54	340.50	139.42	130.78	43.22	32.75	51.12	26.65	20.41	18.22	14.82	15.66	1,022.09
	2	163.50	224.00	128.39	72.37	38.22	29.36	44.18	23.92	21.94	17.05	13.48	25.56	801.97
	3	321.00	171.00	192.81	59.95	42.03	33.10	33.11	18.20	20.38	15.82	15.35	52.16	974.91
TOTAL		**673.04**	**735.50**	**460.62**	**263.10**	**123.47**	**95.21**	**128.41**	**68.77**	**62.73**	**51.09**	**43.65**	**93.38**	**2,798.97**
1989-1990	1	40.13	445.00	763.00	178.30	49.37	36.79	27.14	22.89	185.34	35.79	20.21	21.10	1,825.06
	2	24.83	322.80	404.00	99.19	44.77	32.07	26.28	64.86	45.27	26.75	23.22	18.60	1,132.64
	3	591.00	563.00	286.00	75.61	43.75	32.19	26.82	61.88	43.11	20.82	26.84	30.36	1,801.38
TOTAL		**655.96**	**1,330.80**	**1,453.00**	**353.10**	**137.89**	**101.05**	**80.24**	**149.63**	**273.72**	**83.36**	**70.27**	**70.06**	**4,759.08**
1990-1991	1	2,208.61	1,417.00	802.00	225.00	62.35	36.16	57.25	21.36	36.11	18.31	15.38	19.02	4,918.55
	2	575.00	435.00	857.00	146.63	51.65	30.09	31.94	24.44	28.46	19.73	13.81	30.38	2,244.13
	3	404.00	1,160.00	363.00	89.42	45.41	75.12	27.98	23.87	24.28	16.73	24.96	22.89	2,277.66
TOTAL		**3,187.61**	**3,012.00**	**2,022.00**	**461.05**	**159.41**	**141.37**	**117.17**	**69.67**	**88.85**	**54.77**	**54.15**	**72.29**	**9,440.34**

YEAR	10-DAY	JUL	AUG	SEP	OCT	NOV	DEC	JAN	FEB	MAR	APR	MAY	JUN	TOTAL
1991-1992	1	22.92	144.62	120.78	68.58	29.03	27.75	28.18	34.74	20.07	15.76	13.18	19.41	545.02
	2	26.13	124.18	97.94	47.66	37.93	24.07	27.86	31.46	18.32	14.91	12.37	22.41	485.24
	3	53.33	182.16	96.63	41.28	29.26	39.36	30.19	20.41	19.19	13.73	-14.13	69.35	609.02
TOTAL		**102.38**	**450.96**	**315.35**	**157.52**	**96.22**	**91.18**	**86.23**	**86.61**	**57.58**	**44.40**	**39.68**	**111.17**	**1,639.28**
1992-1993	1	27.49	239.90	47.84	16.44	37.51	17.68	20.81	18.40	18.40	22.74	14.67	12.63	494.51
	2	40.34	85.89	67.10	47.09	32.39	25.37	20.46	18.62	18.73	17.99	16.24	13.25	403.47
	3	265.94	107.96	25.46	54.02	31.82	25.97	20.85	15.50	40.83	15.88	14.94	16.05	635.22
TOTAL		**333.77**	**433.75**	**140.40**	**117.55**	**101.72**	**69.02**	**62.12**	**52.52**	**77.96**	**56.61**	**45.85**	**41.93**	**1,533.20**
1993-1994	1	32.61	280.23	1,588.86	46.46	63.01	35.29	28.76	20.27	24.92	19.02	14.96	14.67	2,169.06
	2	94.24	194.89	3,108.50	59.43	47.59	32.67	34.72	29.24	22.48	16.72	18.28	13.77	3,672.53
	3	407.97	127.83	320.10	84.70	37.61	33.70	32.71	25.83	22.74	15.59	16.44	26.35	1,151.57
TOTAL		**534.82**	**602.95**	**5,017.46**	**190.59**	**148.21**	**101.66**	**96.19**	**75.34**	**70.14**	**51.33**	**49.68**	**54.79**	**6,993.16**
1994-1995	1	36.35	213.76	91.46	72.47	38.35	26.37	27.91	25.99	24.98	21.14	18.50	13.61	610.89
	2	67.00	333.25	78.02	59.33	33.62	24.80	31.53	24.95	25.03	20.65	16.82	12.14	727.14
	3	94.00	193.29	59.84	47.81	29.18	26.70	27.71	21.57	24.05	19.40	16.88	63.14	623.57
TOTAL		**197.35**	**740.30**	**229.32**	**179.61**	**101.15**	**77.87**	**87.15**	**72.51**	**74.06**	**61.19**	**52.20**	**88.89**	**1,961.60**
1995-1996	1	53.69	60.31	1,961.25	107.97	39.78	30.48	23.83	23.80	26.64	19.99	13.74	18.49	2,379.97
	2	120.51	464.97	321.62	70.76	33.69	28.11	28.51	26.74	22.11	16.10	14.02	40.80	1,187.94
	3	62.07	139.81	155.39	68.13	31.59	28.69	27.62	27.85	24.39	14.39	13.76	140.08	733.77
TOTAL		**236.27**	**665.09**	**2,438.26**	**246.86**	**105.06**	**87.28**	**79.96**	**78.39**	**73.14**	**50.48**	**41.52**	**199.37**	**4,301.68**
1996-1997	1	121.32	138.83	520.97	75.80	42.23	34.91	27.82	25.26	20.90	29.07	20.38	15.58	1,073.07
	2	185.66	243.63	261.96	61.89	42.91	31.29	26.45	22.54	21.52	20.04	17.07	18.07	953.03
	3	124.16	376.57	133.54	60.05	37.82	31.86	29.94	16.77	21.44	18.62	16.57	34.60	901.94
TOTAL		**431.14**	**759.03**	**916.47**	**197.74**	**122.96**	**98.06**	**84.21**	**64.57**	**63.86**	**67.73**	**54.02**	**68.25**	**2,928.04**
1997-1998	1	46.29	209.20	76.60	69.00	51.31	52.08	43.75	31.00	33.23	36.62	41.94	17.85	708.87
	2	81.20	138.10	75.80	63.00	48.34	61.55	41.45	30.00	33.54	34.48	28.88	46.00	682.34
	3	79.10	82.50	71.00	67.90	42.93	45.52	36.86	24.47	35.30	29.98	22.40	102.50	640.46
TOTAL		**206.59**	**429.80**	**223.40**	**199.90**	**142.58**	**159.15**	**122.06**	**85.47**	**102.07**	**101.08**	**93.22**	**166.35**	**2,031.67**
1998-1999	1	2,037.57	1,088.14	659.09	473.15	466.33	141.96	74.00	56.40	62.32	24.21	14.16	10.30	5,107.63
	2	980.85	2,840.69	578.21	929.67	252.11	93.19	64.90	51.08	58.32	14.12	17.64	143.53	6,024.32
	3	1,117.36	2,233.81	917.21	731.86	154.43	77.27	77.08	50.62	46.09	14.76	15.48	147.78	5,583.74
TOTAL		**4,135.78**	**6,162.64**	**2,154.50**	**2,134.69**	**872.88**	**312.42**	**215.97**	**158.10**	**166.73**	**53.10**	**47.27**	**301.60**	**16,715.69**
1999-2000	1	468.07	845.16	472.79	346.81	110.44	36.09	26.02	34.32	19.07	14.80	17.13	1,436.36	3,827.06
	2	459.17	498.85	818.88	254.75	75.23	36.07	22.18	27.71	17.43	15.62	14.50	946.23	3,186.62
	3	864.68	444.66	552.23	207.27	41.35	32.78	21.50	20.52	17.63	15.68	17.31	1,451.84	3,687.45
TOTAL		**1,791.92**	**1,788.67**	**1,843.90**	**808.83**	**227.02**	**104.94**	**69.70**	**82.55**	**54.13**	**46.10**	**48.94**	**3,834.43**	**10,701.13**
2000-2001	1	976.41	1,001.12	2,711.28	646.92	123.24	32.59	24.71	17.92	16.16	14.19	12.21	28.03	5,604.78
	2	1,839.71	2,839.24	1,083.72	207.78	59.25	29.07	21.41	18.22	15.09	14.45	14.25	19.89	6,162.08
	3	1,563.94	2,312.50	751.29	212.44	39.99	26.09	21.54	14.40	15.54	13.88	14.88	412.60	5,399.09
TOTAL		**4,380.06**	**6,152.86**	**4,546.29**	**1,067.14**	**222.48**	**87.75**	**67.66**	**50.54**	**46.79**	**42.52**	**41.34**	**460.52**	**17,165.95**
2001-2002	1	524.60	622.50	263.58	153.04	50.42	22.76	18.47	19.23	56.86	18.39	18.88	20.92	1,789.65
	2	535.68	690.67	201.40	34.74	32.27	21.23	18.16	68.54	19.45	16.93	16.31	23.68	1,679.06
	3	749.21	429.60	327.97	68.37	25.61	21.67	20.95	16.72	20.60	19.85	17.45	24.67	1,742.67
TOTAL		**1,809.49**	**1,742.77**	**792.95**	**256.15**	**108.30**	**65.66**	**57.58**	**104.49**	**96.91**	**55.17**	**52.64**	**69.27**	**5,211.38**

YEAR	10-DAY	JUL	AUG	SEP	OCT	NOV	DEC	JAN	FEB	MAR	APR	MAY	JUN	TOTAL
2002-2003	1	257.84	157.33	1,115.17	283.52	53.17	26.42	23.63	28.63	232.25	18.31	14.70	13.51	2,224.48
	2	174.58	515.04	830.52	257.45	42.06	24.85	21.52	418.79	49.38	16.68	13.56	13.61	2,378.04
	3	170.36	376.91	342.22	351.66	33.17	23.66	23.50	212.92	26.46	15.35	14.05	16.48	1,606.74
TOTAL		**602.78**	**1,049.28**	**2,287.91**	**892.63**	**128.40**	**74.93**	**68.65**	**660.34**	**308.09**	**50.34**	**42.31**	**43.60**	**6,209.26**
2003-2004	1	21.33	279.45	246.44	330.37	155.08	44.56	22.95	24.42	18.24	15.64	16.04	24.94	1,199.46
	2	1,148.40	869.70	417.04	229.81	159.59	34.19	21.62	21.87	17.54	14.59	13.04	28.43	2,975.82
	3	236.94	749.92	1,074.73	182.76	151.80	29.52	23.70	17.87	17.99	17.31	19.15	20.11	2,541.80
TOTAL		**1,406.67**	**1,899.07**	**1,738.21**	**742.94**	**466.47**	**108.27**	**68.27**	**64.16**	**53.77**	**47.54**	**48.23**	**73.48**	**6,717.08**
2004-2005	1	169.25	193.58	255.37	206.91	64.97	30.32	19.19	30.84	19.23	15.15	13.29	13.93	1,032.03
	2	223.37	266.69	202.62	283.04	49.81	25.72	23.66	34.70	17.23	13.76	12.63	12.08	1,165.31
	3	177.06	2,192.08	481.59	205.84	40.39	23.39	34.75	18.12	17.10	13.42	13.86	43.76	3,261.36
TOTAL		**569.68**	**2,652.35**	**939.58**	**695.79**	**155.17**	**79.43**	**77.60**	**83.66**	**53.56**	**42.33**	**39.78**	**69.77**	**5,458.70**
2005-2006	1	134.18	64.92	90.00	276.05	81.56	40.58	20.90	19.12	18.10	16.83	13.77	20.34	796.35
	2	222.56	126.60	289.78	159.47	77.24	32.48	22.60	18.89	20.32	15.91	19.76	14.58	1,020.19
	3	116.64	129.52	2,401.21	114.95	65.65	24.96	23.41	14.12	20.40	14.51	17.20	19.90	2,962.47
TOTAL		**473.38**	**321.04**	**2,780.99**	**550.47**	**224.45**	**98.02**	**66.91**	**52.13**	**58.82**	**47.25**	**50.73**	**54.82**	**4,779.01**

Table-4.5

ANNUAL SERIES ARRANGED IN DESCENDING ORDER
(By Linear Regression Method)

Year	Rank	Percentage of Time (%)	Annual flow in cumecs day	Annual flow in million cubic metre (MCM)
1	2	3	4	5
1950 - 51	1	2	18,957.83	1,638.0
2000 - 01	2	3	17,165.95	1,483.1
1955 - 56	3	5	16,442.65	1,420.6
1949 - 50	4	7	15,653.86	1,352.5
1952 - 53	5	8	12,482.46	1,078.5
1998 - 99	6	10	11,550.09	997.9
1948 - 49	7	12	11,527.04	995.9
1956 - 57	8	14	11,277.25	974.4
1954 - 55	9	15	10,780.84	931.5
1999 - 2000	10	17	10,701.13	924.6
1986 - 87	11	19	10,322.67	891.9
1984 - 85	12	20	10,259.52	886.4
1961 - 62	13	22	10,050.64	868.4
1953 - 54	14	24	10,048.51	868.2
1985 - 86	15	25	10,037.56	867.2
1964 - 65	16	27	9,887.54	854.3
1990 - 91	17	29	9,440.34	815.6
1967 - 68	18	31	8,920.81	770.8
1960 - 61	19	32	8,789.58	759.4
1958 - 59	20	34	8,658.02	748.1
1951 - 52	21	36	8,563.37	739.9
1963 - 64	22	37	8,464.88	731.4
1969 - 70	23	39	8,110.96	700.8
1993 - 94	24	41	6,993.16	604.2
1982 - 83	25	42	6,937.61	599.4
1959 - 60	26	44	6,935.69	599.2
2003 - 04	27	46	6,717.08	580.4
1962 - 63	28	47	6,394.83	552.5
2002 - 03	29	49	6,209.26	536.5
1978 - 79	30	51	5,951.21	514.2
1983 - 84	31	53	5,730.03	495.1
2004 - 05	32	54	5,458.70	471.6
1957 - 58	33	56	5,429.49	469.1
1975 - 76	34	58	5,422.64	468.5
2001 - 02	35	59	5,211.38	450.3
2005 - 06	36	61	4,779.01	412.9
1989 - 90	37	63	4,759.08	411.2
1980 - 81	38	64	4,724.41	408.2
1970 - 71	39	66	4,418.30	381.7
1981 - 82	40	68	4,410.60	381.1
1995 - 96	41	69	4,301.68	371.7
1965 - 66	42	71	4,246.04	366.9

Year	Rank	Percentage of Time (%)	Annual flow in cumecs day	Annual flow in million cubic metre (MCM)
1	2	3	4	5
1968 - 69	43	73	4,122.59	356.2
1976 - 77	44	**75**	4,118.89	**355.9**
1971 - 72	45	76	4,110.47	355.1
1977 - 78	46	78	4,066.70	351.4
1966 - 67	47	80	4,059.45	350.7
1987 - 88	48	81	3,963.27	342.4
1972 - 73	49	83	3,859.60	333.5
1973 - 74	50	85	3,155.00	272.6
1979 - 80	51	86	3,008.61	259.9
1996 - 97	52	88	2,928.04	253.0
1988 - 89	53	90	2,798.97	241.8
1974 - 75	54	92	2,550.13	220.3
1997 - 98	55	93	2,031.67	175.5
1994 - 95	56	95	1,961.60	169.5
1991 - 92	57	97	1,639.28	141.6
1992 - 93	58	98	1,533.20	132.5

NOTE :

1. 75% dependable water availability year 1976 - 1977
2. The 75% dependable annual flow = 355.90 MCM
3. Irrigation year has been assumed to commence from 1st July every year to 30th June of next year.

Table-4.6

ANNUAL SERIES ARRANGED IN DESCENDING ORDER
(By Log Deviation Regression Method)

Year	Rank	Percentage of Time (%)	Annual flow in cumecs day	Annual flow in million cubic metre (MCM)
1	2	3	4	5
1950 - 51	1	2	27,589.32	2,383.7
1955 - 56	2	3	23,690.76	2,046.9
1949 - 50	3	5	22,572.60	1,950.3
1952 - 53	4	7	18,035.77	1,558.3
2000 - 01	5	8	17,165.95	1,483.1
1998 - 99	6	10	16,715.69	1,444.2
1956 - 57	7	12	16,371.70	1,414.5
1948 - 49	8	14	15,997.42	1,382.2
1954 - 55	9	15	15,453.90	1,335.2
1953 - 54	10	17	15,353.22	1,326.5
1964 - 65	11	19	14,653.59	1,266.1
1961 - 62	12	20	14,576.49	1,259.4
1960 - 61	13	22	13,023.05	1,125.2
1967 - 68	14	24	12,954.99	1,119.3
1958 - 59	15	25	12,865.78	1,111.6
1963 - 64	16	27	12,168.65	1,051.4
1969 - 70	17	29	11,909.12	1,028.9
1951 - 52	18	31	11,667.22	1,008.0
1999 - 2000	19	32	10,701.13	924.6
1986 - 87	20	34	10,322.67	891.9
1959 - 60	21	36	10,278.88	888.1
1984 - 85	22	37	10,259.52	886.4
1985 - 86	23	39	10,037.56	867.2
1962 - 63	24	41	9,451.93	816.6
1990 - 91	25	42	9,440.34	815.6
1975 - 76	26	44	8,352.30	721.6
1957 - 58	27	46	8,324.12	719.2
1993 - 94	28	47	6,993.16	604.2
1982 - 83	29	49	6,937.61	599.4
1970 - 71	30	51	6,928.54	598.6
2003 - 04	31	53	6,717.08	580.4
1971 - 72	32	54	6,547.64	565.7
1968 - 69	33	56	6,456.66	557.9
1965 - 66	34	58	6,377.01	551.0
1976 - 77	35	59	6,293.54	543.8
2002 - 03	36	61	6,209.26	536.5
1966 - 67	37	63	6,194.77	535.2
1972 - 73	38	64	6,164.41	532.6
1978 - 79	39	66	5,951.21	514.2
1983 - 84	40	68	5,730.03	495.1
2004 - 05	41	69	5,458.70	471.6
2001 - 02	42	71	5,211.38	450.3

Year	Rank	Percentage of Time (%)	Annual flow in cumecs day	Annual flow in million cubic metre (MCM)
1	2	3	4	5
1973 - 74	43	73	4,989.78	431.1
2005 - 06	44	**75**	4,779.01	**412.9**
1989 - 90	45	76	4,759.08	411.2
1980 - 81	46	78	4,724.41	408.2
1981 - 82	47	80	4,410.60	381.1
1995 - 96	48	81	4,301.68	371.7
1977 - 78	49	83	4,066.70	351.4
1974 - 75	50	85	4,061.78	350.9
1987 - 88	51	86	3,963.27	342.4
1979 - 80	52	88	3,008.61	259.9
1996 - 97	53	90	2,928.04	253.0
1988 - 89	54	92	2,798.97	241.8
1997 - 98	55	93	2,031.67	175.5
1994 - 95	56	95	1,961.60	169.5
1991 - 92	57	97	1,639.28	141.6
1992 - 93	58	98	1,533.20	132.5

NOTE :

1. 75% dependable water availability year 2005 - 2006
2. The 75% dependable annual flow = 412.90 MCM
3. Irrigation year has been assumed to commence from 1st July every year to 30th June of next year.

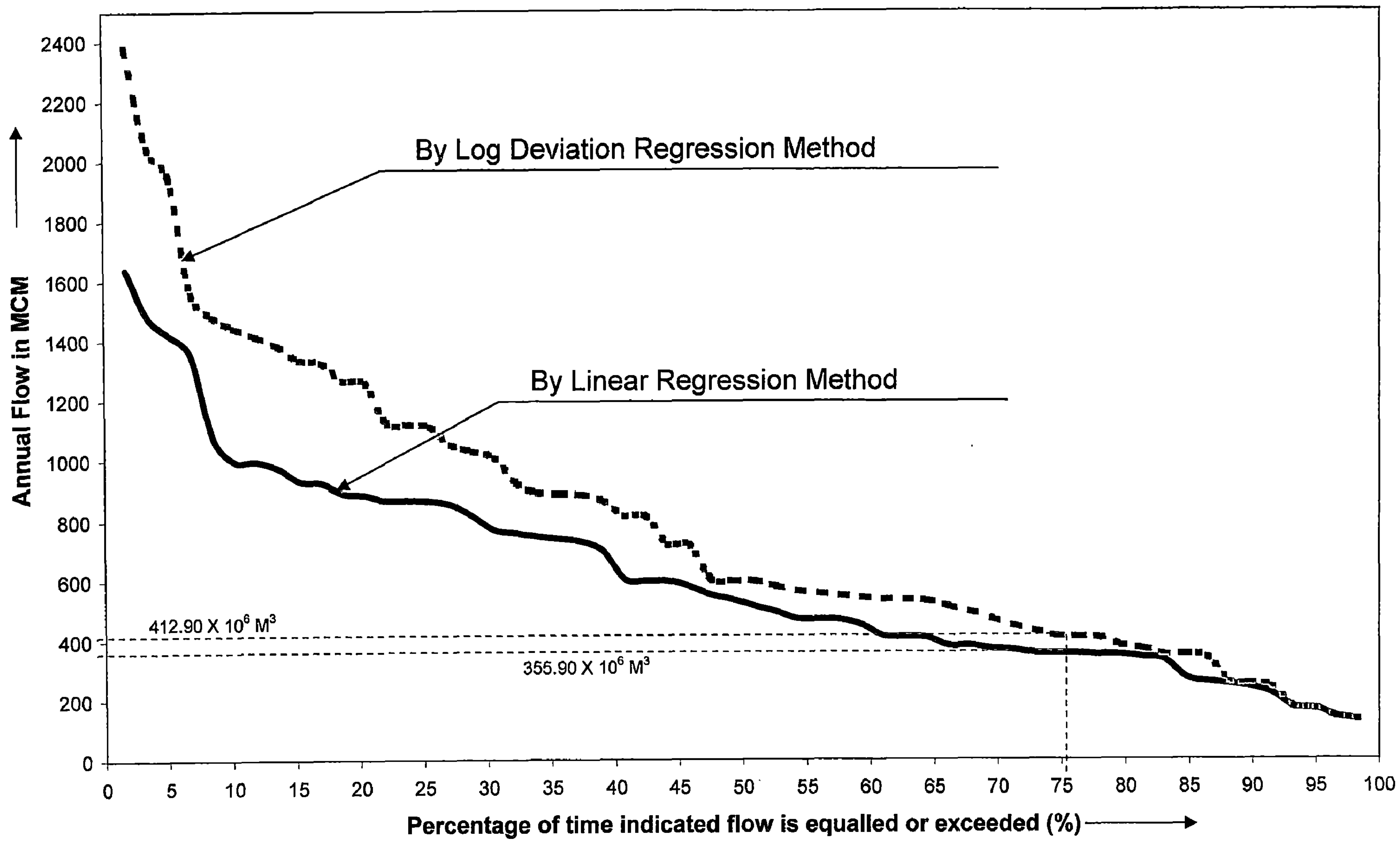


Fig. 4.3 FLOW DURATION CURVE AT JAMRANI DAM SITE

CHAPTER 5

DESIGN FLOOD ESTIMATION

5.1. DESIGN FLOOD

A Flood is an unusual high stage of a river that overflows the natural or man made banks spreading water to its flood plains that are thickly populated due to the obvious advantage of water supply and irrigation. It is possible to predict and contain a flood to reasonable extent with the forecasting models and technologies. The first information required to predict a flood at a particular place and time is the measurement of all the floods for maintaining a good record. Analysis of flood records gives an in-depth knowledge based on which flood prediction and protection measures can be carried out. However, for urban areas where catchments sizes are small, flood prediction may be carried out on empirical relations.

The Design Flood is a flood used for the design of a structure on considerations of its safety, economy, life expectancy and probable damage considerations.

The Design Flood is considered as inflow at the upstream of the structure which the structure should pass safely. The problem of computation of design flood for a sructure is carried out under the following methods :

(1) For ungauged catchment
   - (a) Rational approach
   - (b) Empirical equations
   - (c) Envelope curves

(2) For gauged catchment
   - (a) Flood Frequency analysis
   - (b) Unit Hydrograph approach

Catchment Area for Jamrani Dam site is gauged catchment, so that methods that used to estimate Flood Design are Flood Frequency Analysis and Unit Hydrograph approach.

5.2. FLOOD FREQUENCY ANALYSIS

Flood Frequency Analysis considers the annual peak flows at a site for all the years. The method of analysis and predicting flood from the data of runoff peaks is called flood frequency analysis. It gives only the magnitude of flood peak of desired recurrence interval or return period, but doesn't provide information about the complete hydrograph or the flood volume.

In this study, methods of flood frequently analysis are used are :

1. Gumbel's extreme-value distribution,
2. Log-Pearson Type III distribution.

5.2.1. Gumbel's Method

Gumbel defined a flood as the largest of the 365 daily or 10-daily flows and the annual series of flood flows. Flows used are derived discharge data by using direct linear regression in Table-4.3. Following steps are used for estimating the flood illustrated in Table-5.1 and 5.1*a*.

a). Maximum flood of every years in size N years are arranged in descending order, from the largest flood to the lowest flood.
Here the annual flood value is the variate X.

b). Then find mean $\bar{x}$ and standard deviation σ_{n-1} for the given data.

c). Using Table-1.C and 2.C of Appendix C to determine $\bar{y}_n$ and S_n appropriate to given N years.
For N = 58 years → $\bar{y}_n = 0.5515$ and $S_n = 1.1721$

d). See Table-5.1a to find y_T appropriate to a given T by equation

$$y_T = -\left[0.834 + 2.303 \log\log\frac{T}{T-1}\right].$$

e). Find K appropriate to a given y_T by equation

$$K = \frac{y_T - \bar{y}_n}{S_n}$$

f). Last, determine the value of the variate x with a return period T by

$$x_T = \bar{x} + K\sigma_{n-1}$$

TABLE-5.1

GUMBEL'S METHOD CALCULATION OF DERIVED DISCHARGE OF GOLA RIVER AT JAMRANI DAM SITE

(DERIVED DISCHARGE DATA BY LINEAR REGRESSION)

Year	Max. flood (m^3/s)	Order number m	Tp = (N+1)/m (years)
1948 - 49	5151.02	1	59.00
1951 - 52	4725.39	2	29.50
1950 - 51	3334.70	3	19.67
1985 - 86	3219.80	4	14.75
1993 - 94	3108.50	5	11.80
2000 - 01	2839.24	6	9.83
1949 - 50	2749.98	7	8.43
1963 - 64	2602.45	8	7.38
1955 - 56	2490.77	9	6.56
1953 - 54	2473.66	10	5.90
1952 - 53	2447.73	11	5.36
2005 - 06	2401.21	12	4.92
1990 - 91	2208.61	13	4.54
2004 - 05	2192.08	14	4.21
1962 - 63	2105.00	15	3.93
1967 - 68	2055.17	16	3.69
1995 - 96	1961.25	17	3.47
1956 - 57	1862.75	18	3.28
1983 - 84	1819.88	19	3.11
1998 - 99	1751.14	20	2.95
1964 - 65	1681.97	21	2.81
1969 - 70	1597.81	22	2.68
1982 - 83	1559.09	23	2.57
1954 - 55	1538.26	24	2.46
1961 - 62	1508.64	25	2.36
1999 - 2000	1451.84	26	2.27
1984 - 85	1395.48	27	2.19
1958 - 59	1328.05	28	2.11
1986 - 87	1253.21	29	2.03
1957 - 58	1170.22	30	1.97
2003 - 04	1148.40	31	1.90
2002 - 03	1115.17	32	1.84
1976 - 77	1093.25	33	1.79
1965 - 66	1058.30	34	1.74
1960 - 61	1051.26	35	1.69
1978 - 79	988.82	36	1.64
1987 - 88	957.00	37	1.59
1981 - 82	916.45	38	1.55
1975 - 76	874.07	39	1.51
1977 - 78	812.10	40	1.48
1972 - 73	787.05	41	1.44
1959 - 60	785.65	42	1.40
1966 - 67	783.76	43	1.37
1989 - 90	763.00	44	1.34
2001 - 02	749.21	45	1.31
1971 - 72	714.40	46	1.28
1970 - 71	638.50	47	1.26
1968 - 69	632.21	48	1.23

Year	Max. flood (m^3/s)	Order number m	Tp = (N+1)/m (years)
1979 - 80	607.07	49	1.20
1996 - 97	520.97	50	1.18
1980 - 81	517.36	51	1.16
1974 - 75	389.33	52	1.13
1973 - 74	378.27	53	1.11
1988 - 89	340.50	54	1.09
1994 - 95	333.25	55	1.07
1992 - 93	265.94	56	1.05
1997 - 98	209.20	57	1.04
1991 - 92	182.16	58	1.02

N = **58**

$\overline{x}$ = **1510** m^3/s

σ_{n-1} = **1055.2** m^3/s

$\overline{Y_n}$ = 0.5515

$\overline{S_n}$ = 1.1721

TABLE-5.1a

Results of Computation at Jamrani Dam Site by Gumbel's Method

T	Y_T	K	X_T
2.33			**1510 m^3/s**
5	1.49994	0.81	**2364 m^3/s**
10	2.25037	1.45	**3040 m^3/s**
20	2.97020	2.06	**3688 m^3/s**
50	3.90194	2.86	**4527 m^3/s**
100	4.60015	3.45	**5155 m^3/s**
150	5.00729	3.80	**5522 m^3/s**
200	5.29581	4.05	**5781 m^3/s**
500	6.21361	4.83	**6608 m^3/s**
1000	6.90726	5.42	**7232 m^3/s**

Note :

$T_{2.33}$ = The Property of Gumbel's distribution for the average of the annual series

5.2.2. Graphical Method using Gumbel Probability Paper

The Gumbel probability paper is an aid for convenient graphical representation of Gumbel's distribution. Purpose of this method is to check the calculations of Gumbel's Method by a graphical means.

For such plottings, the recurrence interval is taken on abscissa and the event magnitudes as ordinate. The ordinate of Gumbel paper on which the value, x_T (flood discharge, maximum rainfall depth, etc) are plotted may have either an arithmetic scale or logarithmic scale whereas recurrence interval T years on arithmetic scale. Gumbel distribution will plot as a straight line on a Gumbel probability paper. This property can be used advantageously for graphical extrapolation, wherever necessary.

The following procedure may be adopted for graphical method using Gumbel probabilty paper.

a). The value of x_T for some return periods $T < N = 58$ are calculated by using Gumbel's formula and plotted as x_T vs T on Gumbel probability paper. In this case, T = 5, 10, 20, and 50 years are appropriate for in which x_T= 2364, 3040, 3688, 4527 cumecs respectively. These values are plotted on Gumbel's probability paper.

b). Gumbel's distribution has the property which satisfied T = 2.33 years for the x_T is the average of the annual series when N is very large. With this rule, for T = 2.33 years, $x_T = \bar{x}$ = 1510 cumecs. Thus, the value of a flood with T = 2.33 years is called the *mean annual flood*. In graphical plots this gives a mandatory point through which the line showing variation of x_T with T must pass.

c). The use of Gumbel probability paper results in a straight line for x_T vs T plot. By extrapolation of the straight line x_T vs T, values of x_T for $T > N$ can be determined easily. In this study, values of x_T for $T > N = 58$ years are T = 100, 150, 200, 500, and 1000 years. The corresponding value of x_T are 5250, 5600, 5900, 6800 and 7500 cumecs respectively. Graphically, the results are shown in Fig.-5.1.

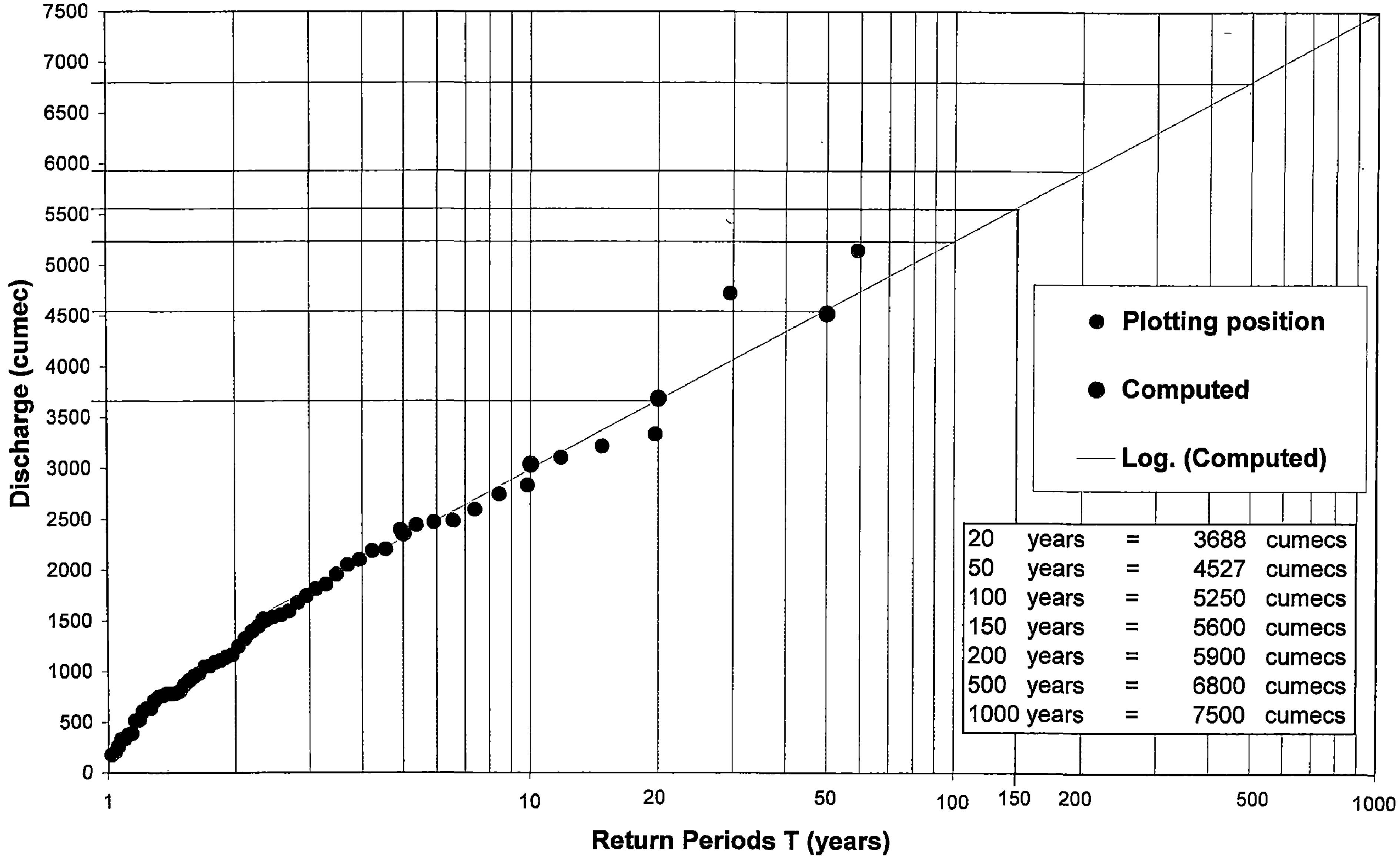


Fig. 5.1 GUMBEL GRAPHICAL METHOD FOR JAMRANI DAM

5.2.3. Log Pearson Type III Distribution

This distribution is widely used in United States, India and other countries as the standard distribution for flood frequency analysis of annual maximum floods. Stepwise procedure to fit Log-Pearson type III distribution to the observed series are outlined below.

a). Transfer the observed data series to the logarithmic values. Generate x_i series as $z_i = \log_{10} x_i$ and the transferred data is then analysed.

b). Find number of years of record (*N*), mean of the *z* values ($\bar{z}$), standard deviation (σ_z) and coefficient of skewness (C_s) for the log transferred series.

$$\sigma_z = \sqrt{\sum (z-\bar{z})^2/(N-1)} \quad \text{and} \quad C_s = \frac{N\sum (z-\bar{z})^3}{(N-1)(N-2)(\sigma_z)^3}$$

c). To compute flood of required return period *T*, find frequency factor K_z from Table 3C of Appendix C corresponding to the skewness coefficient of the log transferred series.

d). After get this K_z, find $z_T = \bar{z} + K_z\sigma_z$, for any recurrence interval *T*.

e). By taking antilog of z_T, find x_T which is desired value of the event for the return period *T*. For more clear explanation of calculation, please refer to Table-5.2 and 5.2*a*.

TABLE-5.2

LOG PEARSON TYPE III DISTRIBUTION'S METHOD CALCULATION OF DERIVED DISCHARGE OF GOLA RIVER AT JAMRANI DAM SITE

(DERIVED DISCHARGE DATA BY LINEAR REGRESSION)

Year	Max. flood (cumecs) x	z = log x	$(z - \bar{z})$	$(z - \bar{z})^2$	$(z - \bar{z})^3$
1948 - 49	5151.02	3.7119	0.6416	0.4117	0.2642
1949 - 50	2749.98	3.4393	0.3691	0.1362	0.0503
1950 - 51	3334.70	3.5231	0.4528	0.2050	0.0928
1951 - 52	4725.39	3.6744	0.6042	0.3650	0.2206
1952 - 53	2447.73	3.3888	0.3185	0.1015	0.0323
1953 - 54	2473.66	3.3933	0.3231	0.1044	0.0337
1954 - 55	1538.26	3.1870	0.1168	0.0136	0.0016
1955 - 56	2490.77	3.3963	0.3261	0.1063	0.0347
1956 - 57	1862.75	3.2702	0.1999	0.0400	0.0080
1957 - 58	1170.22	3.0683	-0.0020	0.0000	0.0000
1958 - 59	1328.05	3.1232	0.0530	0.0028	0.0001
1959 - 60	785.65	2.8952	-0.1750	0.0306	-0.0054
1960 - 61	1051.26	3.0217	-0.0485	0.0024	-0.0001
1961 - 62	1508.64	3.1786	0.1083	0.0117	0.0013
1962 - 63	2105.00	3.3233	0.2530	0.0640	0.0162
1963 - 64	2602.45	3.4154	0.3451	0.1191	0.0411
1964 - 65	1681.97	3.2258	0.1556	0.0242	0.0038
1965 - 66	1058.30	3.0246	-0.0456	0.0021	-0.0001
1966 - 67	783.76	2.8942	-0.1761	0.0310	-0.0055
1967 - 68	2055.17	3.3128	0.2426	0.0589	0.0143
1968 - 69	632.21	2.8009	-0.2694	0.0726	-0.0196
1969 - 70	1597.81	3.2035	0.1333	0.0178	0.0024
1970 - 71	638.50	2.8052	-0.2651	0.0703	-0.0186
1971 - 72	714.40	2.8539	-0.2163	0.0468	-0.0101
1972 - 73	787.05	2.8960	-0.1742	0.0304	-0.0053
1973 - 74	378.27	2.5778	-0.4924	0.2425	-0.1194
1974 - 75	389.33	2.5903	-0.4799	0.2303	-0.1105
1975 - 76	874.07	2.9415	-0.1287	0.0166	-0.0021
1976 - 77	1093.25	3.0387	-0.0315	0.0010	0.0000
1977 - 78	812.10	2.9096	-0.1606	0.0258	-0.0041
1978 - 79	988.82	2.9951	-0.0751	0.0056	-0.0004
1979 - 80	607.07	2.7832	-0.2870	0.0824	-0.0236
1980 - 81	517.36	2.7138	-0.3565	0.1271	-0.0453
1981 - 82	916.45	2.9621	-0.1081	0.0117	-0.0013
1982 - 83	1559.09	3.1929	0.1226	0.0150	0.0018
1983 - 84	1819.88	3.2600	0.1898	0.0360	0.0068
1984 - 85	1395.48	3.1447	0.0745	0.0055	0.0004
1985 - 86	3219.80	3.5078	0.4376	0.1915	0.0838
1986 - 87	1253.21	3.0980	0.0278	0.0008	0.0000
1987 - 88	957.00	2.9809	-0.0893	0.0080	-0.0007
1988 - 89	340.50	2.5321	-0.5381	0.2896	-0.1558
1989 - 90	763.00	2.8825	-0.1877	0.0352	-0.0066
1990 - 91	2208.61	3.3441	0.2739	0.0750	0.0205
1991 - 92	182.16	2.2605	-0.8098	0.6558	-0.5310
1992 - 93	265.94	2.4248	-0.6455	0.4166	-0.2689
1993 - 94	3108.50	3.4926	0.4223	0.1783	0.0753
1994 - 95	333.25	2.5228	-0.5475	0.2997	-0.1641

Year	Max. flood (cumecs) x	z = log x	(z - $\bar{z}$)	(z - $\bar{z}$)^2	(z - $\bar{z}$)^3
1995 - 96	**1961.25**	3.2925	0.2223	0.0494	0.0110
1996 - 97	**520.97**	2.7168	-0.3534	0.1249	-0.0442
1997 - 98	**209.20**	2.3206	-0.7497	0.5620	-0.4214
1998 - 99	**1751.14**	3.2433	0.1731	0.0300	0.0052
1999 - 2000	**1451.84**	3.1619	0.0917	0.0084	0.0008
2000 - 01	**2839.24**	3.4532	0.3830	0.1467	0.0562
2001 - 02	**749.21**	2.8746	-0.1956	0.0383	-0.0075
2002 - 03	**1115.17**	3.0473	-0.0229	0.0005	0.0000
2003 - 04	**1148.40**	3.0601	-0.0102	0.0001	0.0000
2004 - 05	**2192.08**	3.3409	0.2706	0.0732	0.0198
2005 - 06	**2401.21**	3.3804	0.3102	0.0962	0.0298
TOTAL		**178.0746**		**6.1482**	**-0.8430**

N = **58**

$\bar{Z}$ = **3.0703**

σ_Z = **0.3284**

Cs = **-0.432**

Return Period (T)	Cs -0.4	Cs -0.432	Cs -0.5
10	1.231	**1.226**	1.216
20	**1.382**	**1.373**	**1.356**
50	1.834	**1.816**	1.777
100	2.029	**2.005**	1.955
150	**2.115**	**2.088**	**2.0315**
200	2.201	**2.171**	2.108
500	**2.328**	**2.292**	**2.218**
1000	2.540	**2.495**	2.400

[shaded] = *these values are from interpolated*

TABLE-5.2a

Results of Computation at Jamrani Dam Site by Log Pearson type-III Distribution

Return Period T *(years)*	Kz *from table Cs = -0.432*	$K_z . \sigma_z$	Z_T $= \bar{Z} + K_z . \sigma_Z$	x_T = antilog Z_T *(cumecs)*
20	1.373	0.4511	3.5213	**3322**
50	1.816	0.5963	3.6665	**4640**
100	2.005	0.6585	3.7288	**5355**
150	2.088	0.6857	3.7560	**5701**
200	2.171	0.7130	3.7832	**6070**
500	2.292	0.7528	3.8231	**6654**
1000	2.495	0.8193	3.8896	**7755**

5.3. Unit Hydrograph Principle

In the early years, the design flood were calculated by well known empirical formulae viz : Dickens, Ryves, Inglis and Ali Nawaz Jung etc. In these formulae, flood discharge is related to catchment area only and all other factors are included in a constant which is to be decided by the designer from his experience. Even intensity of the storm rainfall which is a prime factor responsible for the flood and which varies substantially from place to place is not indicated in the above formulae. The need to evolve a method on estimation of design flood peak of desired frequency knowing the physical characteristics of the catchments and design rainfall has been recognised and a committee of engineers under the Chairmanship of Dr. A.N. Khosla have recommended Systematic and sustained collection of hydro-meteorological data of selected catchments in different climatic zones of India for evolution of a rational approach for determination of flood discharges. The committee felt that design discharge should be maximum flood on record for a period not less than 50 years. Where adequate records are available extending over a period of not less than 50 years, the design flood should be 50 year flood determined from probability curve on the basis of recorded floods during the period. In case where the requisite data, as above are not available, the design flood should be decided based on the ground and meteorological characteristics obtained on the basis of design storm. In this study, a method has been based on unit hydrograph principle to derive the design flood.

The various steps necessary to estimate the design flood / design flood hydrograph are as under :

1). Preparation of catchment area plan of the catchment in question.
2). Determination of physiographic parameters viz; the cathment area (A), the length of the longest stream (L) and equivalent stream slope (S), see Fig. 1C of Appendix-C.
3). Determination of 2-hr synthetic unit hydrograph parameters (for the specified unit duration) i.e. the unit peak discharge (q_p), the peak discharge (Q_p), the basin lag (t_p), the period of U.H. (Tm), widths of the U.H. at 50% and 75% of Qp (W_{50} and W_{75}), widths of the rising limb of

U.H. at 50% and 75% of Qp (W_{R50} and W_{R75}) and time base of U.H. (T_B), see Fig. 2C of Appendix-C.

4). Preparation of a synthetic unit hydrograph.

5). Estimation of design storm duration (T_D).

6). Estimation of point rainfall and areal rainfall for design storm duration (T_D).

7). Distribution of areal rainfall during design storm duration (T_D) to obtain rainfall increments for unit duration intervals.

8). Estimation of rainfall excess units after subtraction of design loss rate from rainfall increments.

9). Estimation of base flow.

10). Computation of design flood peak.

11). Computation of design flood hydrograph.

The details of the calculation are as follows :

FLOOD ESTIMATION BY USING UNIT HYDROGRAPH METHOD FOR 50-YEARS RETURN PERIOD

Step 1 **Preparation of Cathment Area Plan**

A Cathment Area Plan (Fig. 3.4) showing main rivers was prepared.

Step 2 **Determination of Physiographic Parameters**

The following physiographic parameters were determined from the catchment area plan & long-section of Gola river (Fig. 3.5).

1. **A** = 450 Km^2 (known)
2. **L** = 23.5 Kms (known)
3. **S** = 13.16 m/Km (get from the below computation)
4. **$L/\sqrt{S}$** = 6.48

TABLE-5.3 CALCULATION OF EQUIVALENT STREAM SLOPE (S)

Segment No.	Distance from gauging site (Kms)	Bed Level of River (m)	Length of each segment L_i (Km)	Height above datum D_i (m)	$(D_{i-1} + D_i)$ (m)	$L_i . (D_{i-1} + D_i)$
1	0.0	509.605 (Datum)	0.00	0.00	0.00	0.00
2	0.5	513.735	0.50	4.13	4.13	2.07
3	1.0	519.915	0.50	10.31	14.44	7.22
4	1.5	526.215	0.50	16.61	26.92	13.46
5	2.0	531.395	0.50	21.79	38.40	19.20
6	2.5	537.475	0.50	27.87	49.66	24.83
7	3.0	542.110	0.50	32.51	60.38	30.19
8	3.5	548.460	0.50	38.86	71.36	35.68
9	4.0	555.970	0.50	46.37	85.22	42.61
10	4.5	560.975	0.50	51.37	97.74	48.87
11	5.0	567.675	0.50	58.07	109.44	54.72
12	5.5	574.035	0.50	64.43	122.50	61.25
13	6.0	578.730	0.50	69.13	133.56	66.78
14	6.5	583.320	0.50	73.72	142.84	71.42
15	7.0	589.885	0.50	80.28	154.00	77.00
16	7.5	598.145	0.50	88.54	168.82	84.41
17	8.0	604.840	0.50	95.24	183.78	91.89
18	8.5	611.965	0.50	102.36	197.60	98.80
19	9.0	619.875	0.50	110.27	212.63	106.32
20	9.5	624.135	0.50	114.53	224.80	112.40
21	10.0	631.335	0.50	121.73	236.26	118.13
22	10.5	637.955	0.50	128.35	250.08	125.04
23	11.0	643.830	0.50	134.23	262.58	131.29
24	11.5	650.820	0.50	141.22	275.44	137.72
25	12.0	659.530	0.50	149.93	291.14	145.57
26	12.5	669.660	0.50	160.06	309.98	154.99
27	13.0	680.400	0.50	170.80	330.85	165.43
28	13.5	685.030	0.50	175.43	346.22	173.11
29	14.0	692.840	0.50	183.24	358.66	179.33
30	14.5	700.800	0.50	191.20	374.43	187.22
31	15.0	707.905	0.50	198.30	389.50	194.75
32	15.5	714.855	0.50	205.25	403.55	201.78
33	16.0	721.470	0.50	211.87	417.12	208.56
34	16.5	728.110	0.50	218.51	430.37	215.19
35	17.0	740.030	0.50	230.43	448.93	224.47
36	17.5	748.815	0.50	239.21	469.64	234.82
37	18.0	757.150	0.50	247.55	486.76	243.38
38	18.5	762.995	0.50	253.39	500.94	250.47
39	19.0	770.935	0.50	261.33	514.72	257.36

Segment No.	Distance from gauging site (Kms)	Bed Level of River (m)	Length of each segment L_i (Km)	Height above datum D_i (m)	$(D_{i-1} + D_i)$ (m)	$L_i \cdot (D_{i-1} + D_i)$
40	19.5	778.680	0.50	269.08	530.41	265.20
41	20.0	782.620	0.50	273.02	542.09	271.05
42	20.5	789.160	0.50	279.56	552.57	276.29
43	21.0	797.270	0.50	287.67	567.22	283.61
44	21.5	806.520	0.50	296.92	584.58	292.29
45	22.0	816.000	0.50	306.40	603.31	301.66
46	22.5	827.710	0.50	318.11	624.50	312.25
47	23.0	841.330	0.50	331.73	649.83	324.92
48	23.5	858.070	0.50	348.47	680.19	340.10
		total	**23.50**			**7265.01**

$$S = \frac{\Sigma L_i (D_{i-1} + D_i)}{L^2} = \frac{7265.01}{552.25} = \mathbf{13.16\ m/Km}$$

Step 3 Determination of Synthetic Unit Hydrograph (SUH) parameters

2-hr UH is UH produced 1 cm RE in 2 hour duration

2-hr UH parameters may be found out by using one of the following approaches :

i. by using the synthetic relations

ii. by using coaxial diagram

i. By using the synthetic relations

q_p	$= 2.03 / (L/\sqrt{S})^{0.64\text{ξ}}$	=	0.604	≈	**0.60**	cumec/Km²
Qp	$= q_p \times CA$	=	270.00	≈	**270.00**	cumecs
t_p	$= 1.858 / (q_p)^{1.038}$	=	3.16	≈	**3.00**	hours
T_m	$= tp + (tr/2)$	=	4	≈	**4.00**	hours
W_{50}	$= 2.217 / (q_p)^{0.99}$	=	3.68	≈	**3.70**	hours
W_{75}	$= 1.477 / (q_p)^{0.876}$	=	2.31	≈	**2.30**	hours
WR_{50}	$= 0.812 / (q_p)^{0.907}$	=	1.29	≈	**1.30**	hours
WR_{75}	$= 0.606 / (q_p)^{0.791}$	=	0.91	≈	**0.90**	hours
T_B	$= 7.744 \times (t_p)^{0.779}$	=	18.22	≈	**18.00**	hours

tr (unit duration   2 hours

ii. By using coaxial diagram

The synthetic relations have been transferred on one graph sheet in Fig.-3C of Appendix C in such a way that with the known values of L, S, L / √ S, the values of q_p can be found out.

Similarly with the known value of q_p, the other parameters like t_p, W_{50}, W_{75}, W_{R50}, W_{R75} can be directly read from the respective relation (curves).

Again with the known value of tp, the value T_B is read from the respective relation.

The values so obtained are similar to the calculated are as shown above.

Step 4 Preparation of 2-hr Synthetic Unit Hydrograph

The parameters got in Step-3 were plotted to scale on a graph paper as shown in Fig.-5.2.

The points were joined to fit a trial synthetic Unit Hydrograph.

By definition, the volume of the unit hydrograph must be equivalent to 1.0 cm depth of direct runoff over the entire catchment (A) in Km².

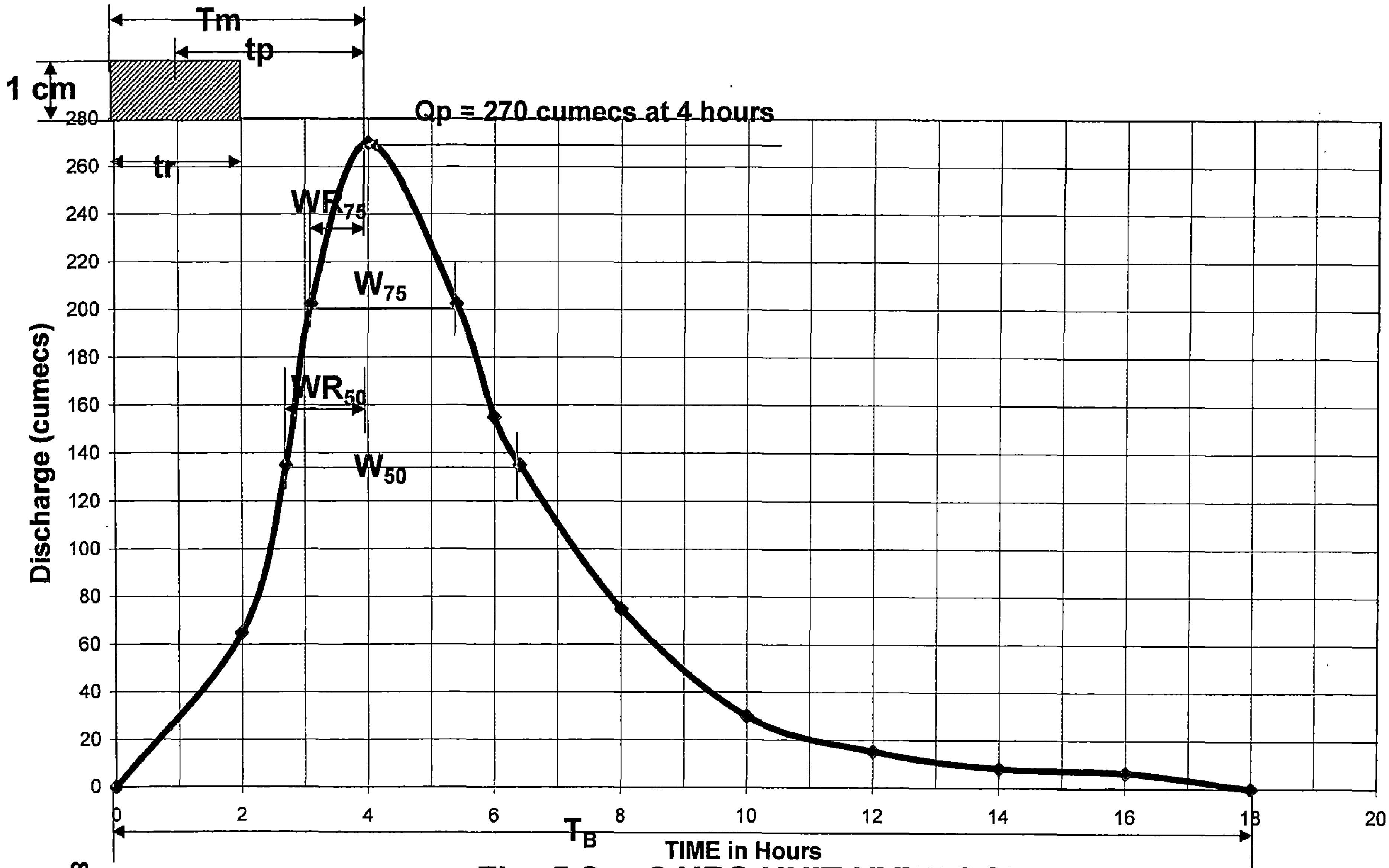


Fig.-5.2 2 HRS UNIT HYDROGRAPH

Step 5 Estimation of Design Storm duration

The design storm duration is

T_D = 1.1 x tp = 1.1 x 3 = 3.30 hrs ≈ **4.00** hours

Adjusting the design storm duration to nearest even hour, adopted design storm duration is 4 hrs

Step 6 Estimation of Point Rainfall and Areal Rainfall

Point rainfall estimated for 50-year return period for duration of 24-hr = 44 cm from isopluvial map reading in Fig.-4C of Appendix C

Design storm duration (T_D) for the catchment = 4 hrs. get value of ratio = 0.607 from Fig-6C of Appendix C

50-yr, 4-hr point rainfall = 44 x 0.607 = **26.708** cm

Area = 450 Km^2 and 4-hr point rainfall, we get areal reduction factor = 0.76 from Table-4C of Appendix C

So, above point rainfall = 0.76 x 26.708 = **20.30** cm

Step 7 Time distribution of Areal Rainfall

Areal rainfall estimated for 50-yr Return Period for a Design storm duration of 4-hrs got in Step 6 above was distributed to give 2-hrs gross rainfall units as shown in the following table by using Fig. 7C of Appendix C.

TABLE-5.4

Hr	%age of storm duration	cumulative % of total rainfall	cumulative rainfall	2-hr gross rainfall increments
1	2	3	4	5
0	0.00	0	0.00	0.00
2	50.00	82	16.64	16.64
4	100.00	100	20.30	3.65
			total	**20.30**

Step 8 Estimation of Rainfall Excess Units

Col.5 of the Table-5.4 in Step-7 gives the 2 hourly gross rainfall units.
Design value of loss rate of 0.3 cm/hr is subtracted from each of the units to give the rainfall excess units.
For 2-hrs, the loss rate is to be subtracted = 2 x 0.3 = 0.6 cm
The table below illustrates the procedure for calculation of rainfall excess units :

TABLE-5.5

Hr	Gross rainfall (col.5) of Step 7	Loss / 2-hrs cm	2-hr Rainfall excess (cm)
0	-	-	-
2	16.64	0.60	16.04
4	3.65	0.60	3.05

Step 9 Estimation of Base Flow

Model value of base flow for this subzone = 0.05 cumecs/Km^2

So, total base flow for the catchment of 450 Km^2 = 0.05 x 450 = 22.5 cumecs

However, from flood of 1986, the base flow is 35.48 cumec, hence the adopted base flow is **35.48** cumec.

Step 10 Estimation of Design Flood (peak only)

For estimation of the peak discharge, the rainfall excess units have to be re-arranged against the unit hydrograph ordinates such that maximum rainfall excess is placed against the maximum unit hydrograph ordinate the next lower value of rainfall excess comes against the next lower value of unit hydrograph ordinate and so on.

In this case, the maximum peak discharge ordinate of UH was occuring at 4 th hour.
The UH ordinates at 2-hr interval from the peak hour of 4 th were read from Fig.5.2 of 2-hr UH near the neighbourhood of the peak and tabulated as under. The maximum 2-hourly rainfall excess unit was placed against the peak discharge of UH. Likewise, the next lower rainfall excess unit was placed against the next lower UH ordinate in the following table and so on.
Summation of the products of cols (2) and (3) gives the total direct runoff to which base flow is added to get the total peak discharge.

TABLE-5.6

Time Hr	**SUH ordinates (cumecs)**	**2-hr Rainfall excess (cm)** *(after rearranged)*	**Direct Runoff (cumecs)**
1	2	3	4 = (2) x (3)
2	65.0	3.05	198.49
4	270.0 ← max →	16.04	4331.99
		Total	**4530.48**
	Add Base Flow from Step-9		35.48
	Total Peak Discharge		**4565.96**

Step 11 2-hr Rainfall Excess sequence

The 2-hour rainfall excess sequence shown in col.3 of Table-5.6 in Step 10 was reversed to obtain critical sequence as shown below :

TABLE-5.7

Time Hr	**Critical 2-hr rainfall excess sequence**
2	16.04
4	3.05

Table-5.8 COMPUTATION OF DESIGN FLOOD HYDROGRAPH FOR 50 YEARS RETURN PERIOD

Time (hours)	SUH ordinates (cumecs)	2-hourly rainfall excess (cm)		Total (cumecs)	Base Flow (cumecs)	Flood Hydrograph (cumecs)	Remark
		16.04	**3.05**				
0	0.00	0.00		0.00	35.48	35.48	
2	65.00	1042.89	0.00	1042.89	35.48	1078.37	
4	270.00	4331.99	198.49	4530.48	35.48	**4565.96**	**Peak Flood**
6	155.00	2486.89	824.49	3311.37	35.48	3346.85	
8	75.00	1203.33	473.32	1676.65	35.48	1712.13	
10	30.00	481.33	229.02	710.36	35.48	745.84	
12	15.25	244.68	91.61	336.29	35.48	371.77	
14	8.25	132.37	46.57	178.93	35.48	214.41	
16	6.50	104.29	25.19	129.48	35.48	164.96	
18	0.00	0.00	19.85	19.85	35.48	55.33	
20			0.00	0.00	35.48	35.48	

Result : Design Flood for 50 Years is 4566 cumecs

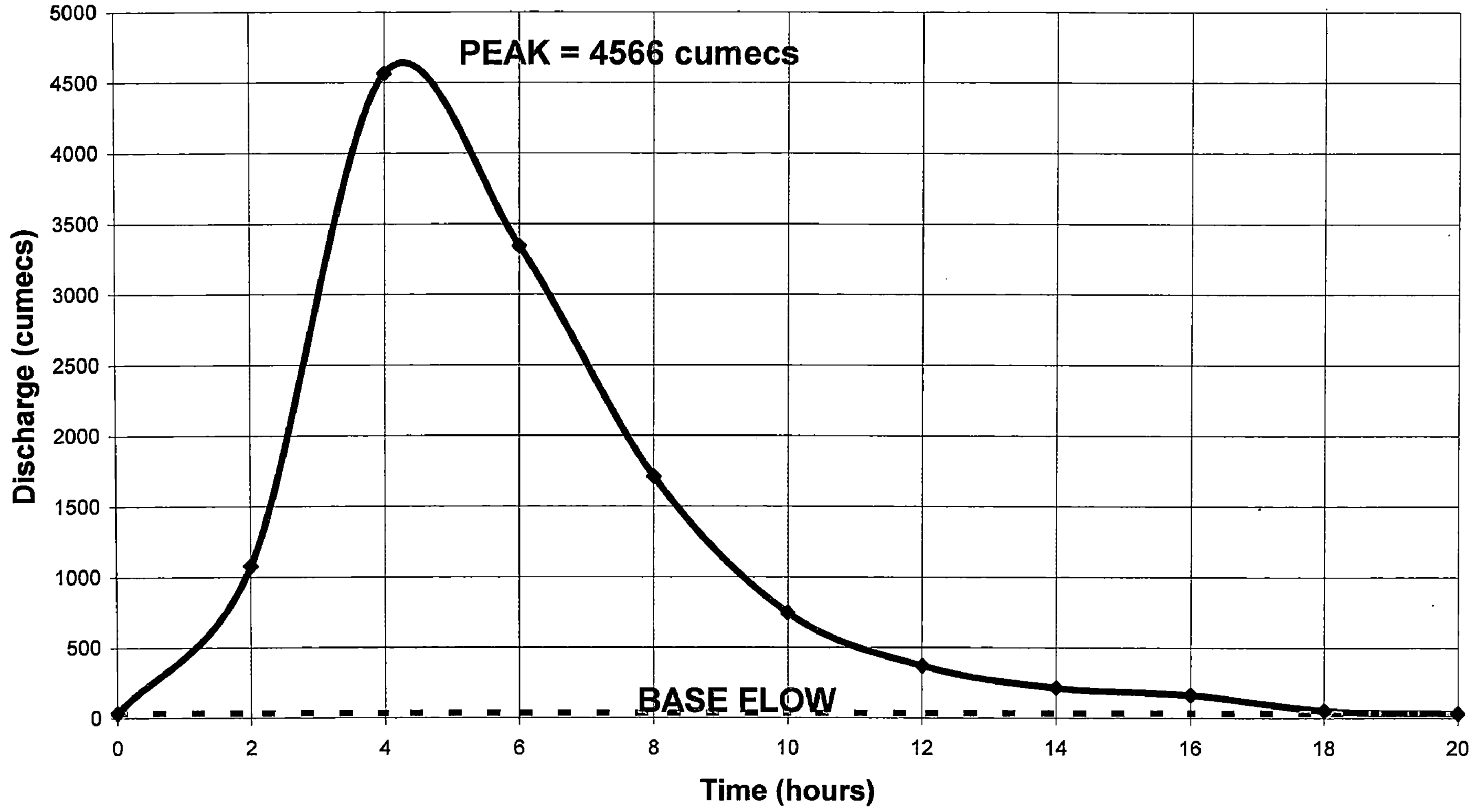


Fig.-5.3 DESIGN FLOOD HYDROGRAPH - 50 years

FLOOD ESTIMATION BY USING UNIT HYDROGRAPH METHOD FOR 100-YEARS RETURN PERIOD

Step 1 to Step 5 are same with Flood Estimation for 50 Years Return Period.

Step 6 Estimation of Point Rainfall and Areal Rainfall

Point rainfall estimated for 100-year return period for duration of 24-hr = 48 cm from isopluvial map reading in Fig.-5C of Appendix C

Design storm duration (T_D) for the catchment = 4 hrs. get value of ratio = 0.607
from Conversion ratio = (100-yr 4-hr rainfall / 100-yr 24-hr rainfall) in section 4.2 page 61 of Flood Estimation Report for Upper Indo-Ganga Plains (sub zone-1e).

100-yr, 4-hr point rainfall = 48 x 0.607 = **29.136** cm

Area = 450 Km^2 and 4-hr point rainfall, we get areal reduction factor = 0.76 from Table-4C of Appendix C

So, above point rainfall = 0.76 x 29.136 = **22.14** cm

Step 7 Time distribution of Areal Rainfall

Areal rainfall estimated for 100-yr Return Period for a Design storm duration of 4-hrs got in Step 6 above was distributed to give 2-hrs gross rainfall units as shown in the following table by using Fig. 7C of Appendix C.

TABLE-5.9

Hr	%age of storm duration	cumulative % of total rainfall	cumulative rainfall	2-hr gross rainfall increments
1	2	3	4	5
0	0.00	0	0.00	0.00
2	50.00	82	18.16	18.16
4	100.00	100	22.14	3.99
			total	**22.14**

Step 8 Estimation of Rainfall Excess Units

Col.5 of the Table-5.4 in Step-7 gives the 2 hourly gross rainfall units.
Design value of loss rate of 0.3 cm/hr is subtracted from each of the units to give the rainfall excess units.
For 2-hrs, the loss rate is to be subtracted = 2 x 0.3 = 0.6 cm
The table below illustrates the procedure for calculation of rainfall excess units :

TABLE-5.10

Hr	Gross rainfall (col.5) of Step 7	Loss / 2-hrs cm	2-hr Rainfall excess (cm)
0	-	-	-
2	18.16	0.60	17.56
4	3.99	0.60	3.39

Step 9 Estimation of Base Flow

Model value of base flow for this subzone = 0.05 cumecs/Km^2

So, total base flow for the catchment of 450 Km^2 = 0.05 x 450 = 22.5 cumecs

However, from flood of 1986, the base flow is 35.48 cumec, hence the adopted base flow is **35.48** cumec.

Step 10 Estimation of Design Flood (peak only)

For estimation of the peak discharge, the rainfall excess units have to be re-arranged against the unit hydrograph ordinates such that maximum rainfall excess is placed against the maximum unit hydrograph ordinate the next lower value of rainfall excess comes against the next lower value of unit hydrograph ordinate and so on.

In this case, the maximum peak discharge ordinate of UH was occuring at 4 th hour.

The UH ordinates at 2-hr interval from the peak hour of 4 th were read from Fig.5.2 of 2-hr UH near the neighbourhood of the peak and tabulated as under. The maximum 2-hourly rainfall excess unit was placed against the peak discharge of UH. Likewise, the next lower rainfall excess unit was placed against the next lower UH ordinate in the following table and so on.

Summation of the products of cols (2) and (3) gives the total direct runoff to which base flow is added to get the total peak discharge.

TABLE-5.11

Time Hr	**SUH ordinates (cumecs)**	**2-hr Rainfall excess (cm)** *(after rearranged)*	**Direct Runoff (cumecs)**
1	2	3	4 = (2) x (3)
2	65.0	3.39	220.08
4	270.0 ← max →	17.56	4740.54
		Total	**4960.62**
	Add Base Flow from Step-9		35.48
	Total Peak Discharge		**4996.10**

Step 11 2-hr Rainfall Excess sequence

The 2-hour rainfall excess sequence shown in col.3 of Table-5.6 in Step 10 was reversed to obtain critical sequence as shown below :

TABLE-5.12

Time Hr	**Critical 2-hr rainfall excess sequence**
2	17.56
4	3.39

Table-5.13 COMPUTATION OF DESIGN FLOOD HYDROGRAPH FOR 100 YEARS RETURN PERIOD

Time (hours)	SUH ordinates (cumecs)	2-hourly rainfall excess (cm)		Total (cumecs)	Base Flow (cumecs)	Flood Hydrograph (cumecs)	Remark
		17.56	3.39				
0	0.00	0.00		0.00	35.48	35.48	
2	65.00	1141.24	0.00	1141.24	35.48	1176.72	
4	270.00	4740.54	220.08	4960.62	35.48	**4996.10**	**Peak Flood**
6	155.00	2721.42	914.17	3635.59	35.48	3671.07	
8	75.00	1316.82	524.80	1841.62	35.48	1877.10	
10	30.00	526.73	253.94	780.66	35.48	816.14	
12	15.25	267.75	101.57	369.33	35.48	404.81	
14	8.25	144.85	51.63	196.48	35.48	231.96	
16	6.50	114.12	27.93	142.06	35.48	177.54	
18	0.00	0.00	22.01	22.01	35.48	57.49	
20			0.00	0.00	35.48	35.48	

Result : Design Flood for 100 Years is 4996 cumecs

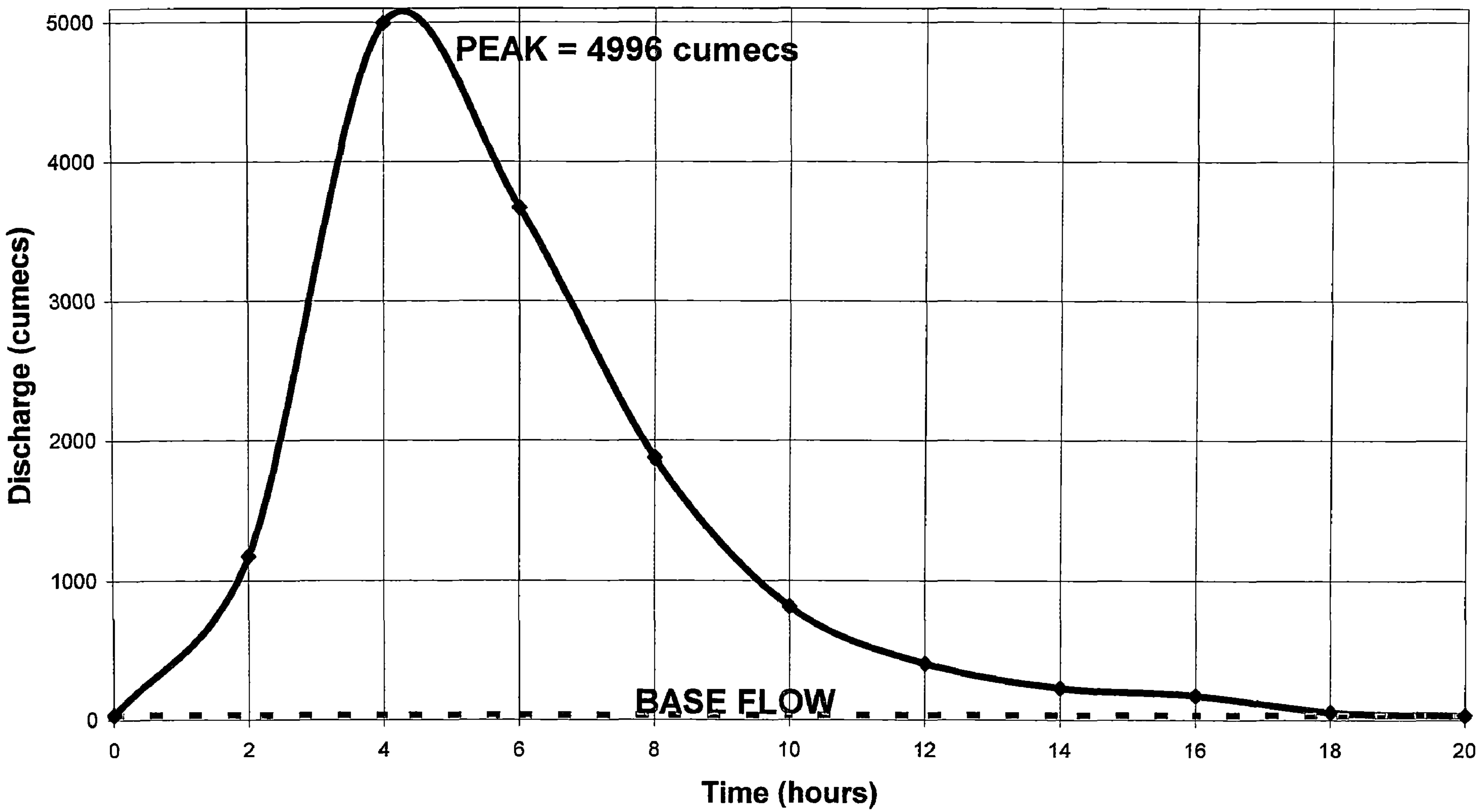


Fig.-5.4 DESIGN FLOOD HYDROGRAPH - 100 Years

CHAPTER 6

SEDIMENTATION OF RESERVOIR

6.1. INTRODUCTION

The development of water resources involves the construction of storage reservoir for storing water during the floods so that it may be used during periods of low supply for various purposes such as power generation, irrigation, domestic supply etc. The ultimate destiny of all reservoirs is to get filled with sediment. If the sediment inflow is large in comparison to the reservoir capacity, the useful life of the reservoir may be very short.

Sediments are the fragmented materials, originated either due to chemical or physical disintegration of rocks. Sediments are transported by the water and air. The size of sediment may vary from big boulders to colliodal. Amongts various agents causing transportation of sediments, the flowing water is one of the main. Therefore, sediment transported by water is generally considered in general view.

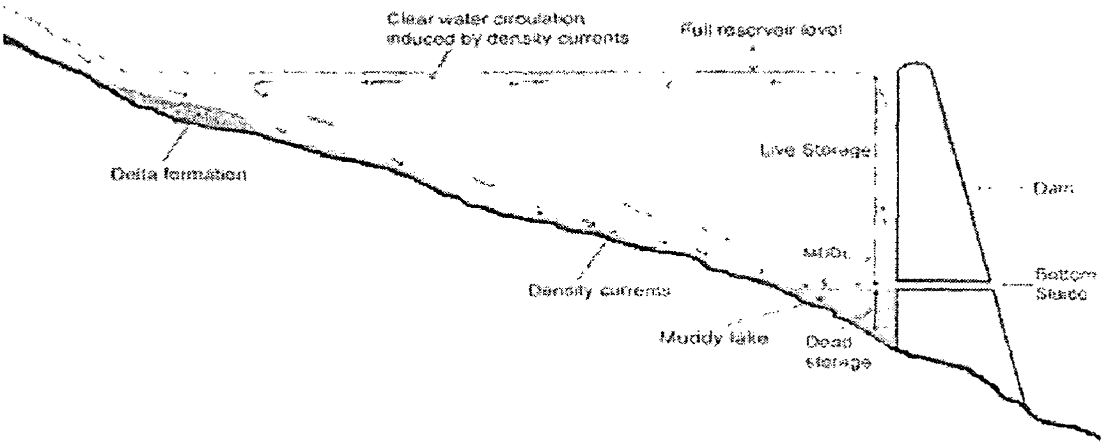


Fig. 6.1 Sediment deposit in a typical section of reservoir

Every river carries certain amount of sediment load. The sediment particles try to settle down to the river bottom due to the gravitational force, but may be kept in suspension due to the upward currents in the turbulent flow which may overcome the gravity force. Due to these reasons, the river carries fine sediment in suspension as suspended load, and larger solids along the river bed as bed load. When the silt laiden water reaches a reservoir in the vicinity of a dam, the velocity and the turbulence are considerably reduced. The bigger suspended particles and most of the bed load, therefore, gets deposited in the head reaches of the reservoir. Fine particles may travel some more distance and may finally deposit farther down in the reservoir, as shown in Fig. 6.1. Some very fine particles may remain in suspension for much longer period, and may finally escape from the dam along with the water discharged through the sluiceways, turbines, spillway, etc.

The deposition of sediment in the reservoir is known as Reservoir Sedimentation. The deposition of the sediment will automatically reduce the water storing capacity of the reservoir, and if this process of deposition continues longer, a stage is likely to reach when the whole reservoir may get silted up and become useless.

6.2. RESERVOIR AND CATCHMENT CHARACTERISTICS

The reservoir of the Jamrani dam will spread between elevation 635 and 761.3 m for a distance of 9 km along Gola river and for approximately 4.5 km in the Lugar-gad. In the reservoir area, there are only three slides. These occur on the left bank of Gola river varying in width from 120 m to 168 m at the river level and in a height from 50 to 61 m. Two of these are in rock slides while the third is the debris slide. All the three slides are in granite prophyey. Since these slides are of small dimension and do not appear to be deep there would be no stability problem. The lithology of the entire catchment area has been compiled from the geological maps. The catchment is well dissected by numerous streams and the main drainages are Kalsa river, Gola river and Lugargad. The relief varies between elevation 635 and 2296 m.

6.3. SEDIMENTATION DATA

Available Sediment data observed at a proposed Jamrani Dam site from 1985 to 2006, observed from 15 June until 15 October during Monsoon season. Those sediment data observed as shown in Table-6.1.

Average sediment at Jamrani Dam site is shown in Fig.6.2.

In estimating sediment rate occurred at Jamrani Dam site, relationships were made between 10-daily observed discharge at Dam site and 10-daily observed sediment at Dam site as shown in Table-6.2 and its calculation of Sediment Rate is indicated in Table-6.3

Then, also calculation of sediment rate is divided in 5 years basis are :

- Sed. Rate during 1985 to 1990 : 49.64 Hect.m/100 Km^2/year (Table-6-4*a*).
- Sed. Rate during 1991 to 1995 : 31.89 Hect.m/100 Km^2/year (Table-6-4*b*).
- Sed. Rate during 1996 to 2000 : 226.02 Hect.m/100 Km^2/year (Table-6-4*c*).
- Sed. Rate during 2001 to 2006 : 100.19 Hect.m/100 Km^2/year (Table-6-4*d*).

Average Sediment at Jamrani Dam site for different years are shown in Fig. 6.3.

From above results of calculation, annual sediment rate at Jamrani Dam site is more high than average of some reservoirs in India because of several factors namely a landslide ever taken place in 1993 and mining practices at that site.

TABLE-6.1

DAILY AND TEN-DAILY SEDIMENT DATA OBSERVED AT JAMRANI DAM SITE, 1985 - 2006 (ppm)

Month	Date	1985 by volume	1985 10-daily	1986 by volume	1986 10-daily	1987 by volume	1987 10-daily	1988 by volume	1988 10-daily	1989 by volume	1989 10-daily	1990 by volume	1990 10-daily	1991 by volume	1991 10-daily	1994 by volume	1994 10-daily	1995 by volume	1995 10-daily	1996 by volume	1996 10-daily	1997 by volume	1997 10-daily
JUNE	15			22.3						11.3725				37.575						3205.6			
	16			16.39167		0		0		18.09125				11.4375						4230.92		0	
	17			19.69167	120.84	0	0.00	0	0.00	1.63375	11.67			56.45	25.39					766.433	3734.20	0	0.00
	18			16.3525		0		0		1.307				21.475						664.817		0	
	19			342.93		0		0		9.82375				0						8737.47		0	
	20			307.35		0		0		27.77625										4599.97		0	
	21			218.8167		0		0		21.315		3.2375						5384.12		6986.65		87.9167	
	22			152.0617		0		0		142.7463		39.2375						535.55		3592.55		11.0333	
	23			146.45		0		8.2875		44.24375		0						418.133		4740.23		70.7	
	24			411.0167		0		0		506.665		0						432.9		1050.23		15.4833	
	25			825.8508	329.61	0	0.49	0	55.83	468.8913	498.37	0	18.64					370.833	1651.38	957.917	3434.17	13.1667	699.22
	26			556.8583		0		0		1765.578		0						1916.88		1056.98		10.8833	
	27			447.7417		4.9		1.625		257.045		69.96875						889.467		960.3		8.78333	
	28			186.9083		0		361.775		685.11		53.96875						1131.9		2167.4		4888.28	
	29			254.0583		0		150.175		865.665		0						3168.55		9052.32		1830.77	
	30			96.29167		0		36.4375		226.4338		0						1265.42		3777.1		55.2333	
JULY	1			129.3725		0		96.8		9.825		124.9875						565.283		1420.37		332.95	
	2			49.23375		0		119.4		32.67875		0						477.283		997.85		55.4667	
	3			59.22		85.525		407.8125		40.99625		0						438.767		1208.15		13.1667	
	4			45.95125		0		426.2188		59.04625		96.025						769.383		1022.2		0	
	5			90.3975	252.41	486.175	212.88	2221.963	1371.34	19.7025	69.26	241.75	832.67					523.167	1521.63	1359.98	1626.65	70.3	199.19
	6			176.2775		41.075		5252.338		1.63375		341.1375						1611.05		975.367		11.125	
	7			302.7575		753.15		3303.188		1.63375		21.6375						3729.25		1175.32		24.2333	
	8			105.785		739.9625		1422.3		251.1075		14.875						1827.98		918.883		833.233	
	9			441.485		16.3125		334.2875		264.5813		993.15						4232.23		4045.05		355.15	
	10			1123.663		6.5875		129.1375		11.4025		6492.163						1041.93		3142.28		296.25	
	11			1078.825		13.0625		329.6938		1.66625		968.525						2171.17		2626.15		111.8	
	12			1236.813		121.7		2825.425		94.935		1078.663		44.65				3639.97		3588		671.433	
	13			1391.338		3.325		3142.425		27.595		144.1125		26.6				1253.95		2570.15		448.833	
	14			2070.7		505.95		1204.056		206.53		665.075		0				337.5		4273.12		1863.63	
	15			1891.738	1800.52	1663.838	300.97	223.2188	830.72	1326.143	373.87	341.5125	341.93	151.4	60.95			402.517	2650.17	7017.93	4152.89	6208.9	1048.39
	16			1892.588		701.8375		241.15		1898.72		114.225		158.313				5738.27		6368.28		315.933	
	17			2388.863		0		31.925		169.9563		73.1375		116.65				2786.82		7945.78		184.433	
	18			1388.363		0		52.53125		6.555		6.6		47.625				4791.87		5891.35		68.7833	
	19			2623.863		0		114.4813		0		6.575		0				4217.73		886.967		204.433	
	20			2042.138		0		142.2688		6.575		22.8625		3.325				1163.95		361.183		405.75	
	21			2279.575		4.9125		718.4188		2858.106		62.2125		3.2625				2704.58		244.433		228.383	
	22			1513.05		3.2625		205.3313		776.0363		291.125		4.8875				9793.32		92.0833		160.65	
	23			2487.488		80.55		160.5625		396.4413		166.8125		0				6115.53		3549.92		66.1117	
	24			1613.463		6.5625		24.7875		2849.843		57.5875		0				3377.77		185.417		3767.55	
	25			418.975	1919.17	340.0625	172.13	17.25	341.00	19.725	696.34	49.325	233.52	9.95	2.54			1658.45	2705.40	142.133	552.09	81.1667	409.98
	26			969.0625		796.0875		774.8188		0		772.8625		0				907.05		13.2167		52.6167	
	27			1582.113		235.3625		691.3625		105.25		245		0				1301.8		24.2667		4.38333	
	28			1283.513		292.6875		337.5625		4.90125		305.7125		0				746.483		15.2667		126.65	
	29			3186.363		130.7125		311.1313		104.7763		256.65		0				1350.85		10.9167		0	
	30			3521.588		3.275		241.3		405.3463		361.425		6.55				993.55		19.9		22.2167	
	31			2255.7		0		268.4688		139.3175		0		3.2625				809.967		15.4333		0	
AUGUST	1			2227.1		0		605.6813		109.5875		26.275		0				854.183		1147.8		629	
	2			3166.25		4.9		682.125		72.125		8.2125		0				836.3		1318.92		10114.1	
	3			3314.125		9.8		505.5438		0		319.025		4.925				801.917		1115.28		8709.9	
	4			7218.8		6.525		419.9688		6.525		71.05		16.6				627.8		1249.07		6238.9	
	5			4770.85	3648.00	0	5.08	255.8813	404.87	4.8625	40.19	380.475	144.19	0	12.07			822.683	816.55	980.15	1954.45	1951.72	4781.59
	6			2910.025		3.325		164.9938		54.275		153.95		87.7375				1117.65		1132.98		5856.22	
	7			4391.213		6.5625		148.8313		148.0625		81.6625		4.9125				774.083		1330.35		4234.25	
	8			3155.2		8.25		261.3938		0		78.875		6.5625				633.617		1419.15		2764.82	
	9			3701.575		6.5375		296.025		6.475		172.975		0				446.833		5808.3		3621.3	
	10			1604.875		4.925		508.0063		0		149.375		0				1140.4		4042.52		3695.55	
	11			1613.463		0		447.6063		1.6375		478.1		0				1756.85		3102.07		3098.15	
	12			713.4		159.5375		329.0188		0		873.9875		0				2926.65		2100.08		3033.82	
	13			1173.188		347.35		273.5188		0		767.65		0				6081.1		4426.03		2346.7	
	14			592.15		41.075		150.8063		0		1035.6		0				6607.03		4611.1		2335.52	
	15			898.0125	1330.61	9.9	57.91	176.225	403.50	4.89	3.77	762.3625	997.46	3.2875	170.43			2777.77	3080.16	2620.9	2368.97	1616.33	1372.12
	16			841.6625		8.1625		24.61875		4.8875		326.8625		1102.9				3141.8		1650		379.983	
	17			1723.713		4.8875		187.0375		26.3		1386.263		365.788				2028.87		1119.03		291.183	
	18			1806.838		3.2625		324.3125		0		2311.85		68.175				2750.88		1307.57		196.183	
	19			2071.163		3.275		617.1625		0		1589.638		129.738				1267.03		1534.02		219.75	
	20			1872.463		1.6625		1504.738		0		442.2625		34.3875				1463.63		1218.9		203.55	
	21			1040		3.2625		346.5875		0		95.6625		3.2875				805.25		2804.33		161.267	
	22					8.15		686.5571		465.675		556.3875		11.625				723.1		2329.53		636.167	
	23					6.575		473.2429		29.2625		103.6875		0				1107.13		2907.43		198.667	
	24					1.6375		441.2563		6.5875		34.8		0				1073.5		388.167		325.1	
	25				920.85	1.625	75.53	385.3875	305.48	1.625	916.39	206.1875	230.45	371.35	252.10			885.283	1707.92	745.583	1419.50	266.017	280.61
	26					1.625		192.775		0		424.9		905.025				1222.93		893.817		305.3	
	27					11.4125		50.325		0		98.0625		773.1				3391.1		1069.62		261.05	
	28			2215.55		26.2625		60.31875		8449.488		626.2125		398.888				2666.67		1142.98		282.883	
	29			675.9		65.9		166.4938		1015.838		150.5625		190.813				2669.8		1205.18		310.067	
	30			210.5		696.175		95.8625		17.975		70.2875		48.4625				2794.2		1064		206.65	
	31			462.3125		8.175		461.4357		82.7875		168.15		72.4625				1448.17		1083.9		133.583	

Month	Date	1998 by volume	1998 10-daily	1999 by volume	1999 10-daily	2000 by volume	2000 10-daily	2001 by volume	2001 10-daily	2002 by volume	2002 10-daily	2003 by volume	2003 10-daily	2004 by volume	2004 10-daily	2005 by volume	2005 10-daily	2006 by volume	2006 10-daily
JUNE	15					2239						0							
	16	100.95		453.273		3422.18		4375.17		576.163		0							
	17	2308.4	703.96	1377.54	641.43	1284.1	2878.63	1993.43	2600.33	311.842	327.22	0	299.86		458.79				
	18	844.15		266.298		3010.65		1419.75		277.465		255.555							
	19	144.067		293.317		3162.27		2838.27		228.685		988.027							
	20	122.217		316.735		4153.55		2375.03		241.925		555.555		458.79					
	21	77.1833		204.433		2729.12		3937.88		413.748		0		686.977					
	22	0		652.567		2548.72		1920.87		353.802		417.472							
	23	98.6667		799.967		1106.27		1387.98		1696.95		585.707							
	24	44		1012.83		1063.55		1209.2		1689.03		355.555							
	25	0	853.78	1175.87	688.62	928.867	2167.72	768.75	2333.97	1627.38	1055.77	953.947	370.69		686.98		1841.38		
	26	0		275.733		431.117		1210.35		947.42		1114.38				3125.53			
	27	406.867		709.797		1149.37		5979.93		1559.65		152.215				438.15			
	28	1285.62		500.083		3028.3		3429.38		1123.68		126.667				1217.08			
	29	3654.37		165.055		5370.25		2092.82		684.092		0				2519.27			
	30	2971.05		186.868		3321.6		1422.57		461.967		0				1908.87			
JULY	1	2017.9		120.907		962.1		1323.85		1730.46		4.44333				364.433			
	2	4977.47		153.51		1031.1		1364.43		1927.47		0				460			
	3	7249.25		90.9083		539.217		1211.4		3942.63		0				177.75			
	4	1733.35		136.647		454.95		1383.02		4237.77		0				2626.92			
	5	1387.07	3023.20	241.228	765.24	748.833	1066.98	3273.32	1824.76	4175.27	2564.16	0	883.10		2862.23	181.733	499.23		0.00
	6	1982.57		2617.22		685.783		2748		3677.77		0		2727.78		245.433			
	7	3371.42		1871.37		1569.47		3406.65		2899.98		1444.15		2234		302.867			
	8	1860.67		1263.6		2384.43		1304.82		1035.55		1359.42		1014.39		239			
	9	1870		711.112		1287.27		1115.53		866.433		2797.78		7971.19		206.183			
	10	3782.27		345.925		1028.65		1116.5		1148.22		3225.18		363.783		188.017		0	
	11	2475.72		488.888		753.317		758.8		997.995		812.955		388.89		254.067		0	
	12	3480.15		351.463		1222.95		3439.6		938.353		640.06		955.557		260.783		0	
	13	1604.75		641.667		1147.93		2705.85		452.457		383.713		1435.38		312.467			
	14	1846.2		879.737		1291.38		7371.53		922.427		743.568		259.993		471.383			
	15	809.85	1755.32	823.595	663.85	873.95	1121.14	6775.53	3764.47	856.843	2119.86	621.198	417.91	60	328.84	225.867	248.48		0.00
	16	1169.07		926.608		368.017		4725.87		623.947		384.242		33.3333		190.767			
	17	4560.27		258.308		1592.82		2817.77		3778.61		382.218		121.93		230.25			
	18	1512.58		248.45		1118.42		2224.18		5557.6		211.112		33.325		174.183			
	19	78.3833		443.855		1658		2065.77		4064.21		0		0		177.767			
	20	16.1833		575.878		1184.62		4759.99		3006.14		0		0		187.267			
	21	30.9167		919.15		1442.22		2283.8		2953.36		142.543		0		165.917			
	22	24.1833		629.24		1275.53		2074.83		2754.01		114.347		654.01		144.417			
	23	19.8833		1750.15		383.733		2710.22		2081.76		0		0		165.183			
	24	39.4		334.05		603.35		6702.97		1938.19		0		0		177.767			
	25	33.2	343.77	3129.61	1564.04	348.1	1062.53	2722.92	2924.28	1886.89	1526.27	0	273.17	0	269.39	682.2	307.09		
	26	3453.63		439.622		516.967		2084.9		1567.89		48.245		0		862.85			
	27	24.2167		226.667		76.3667		3727.1		1294.01		54.825		0		659.917			
	28	28.75		414.533		1276.77		2130.82		587.71		0		0		54.9467			
	29	24.1833		2615.97		1503.4		2742.38		646.123		0		1426.67		154.517			
	30	4.35		2785.51		2515.1		3431.6		512.722		1429.68		531.287		165.833			
	31	98.8		3959.94		1746.25		1555.52		564.36		1215.23		351.315		144.417			
AUGUST	1	255.6		1207.02		8723.78		573.517		1568.93		361.198		593.888		290.583			
	2	254.85		1881.75		1630.24		797.4		1513.52		225.498		1003.96		626.833			
	3	1127		1552.52		5454.87		878.35		3383.6		510.985		1225.35		106.133			
	4	697.167		949.333		4871.1		1041.92		3442.59		348.638		862.427		956.69			
	5	368.417	1166.36	2439.22	6214.84	3522.05	3711.79	1316.65	761.99	2748.21	2369.87	258.48	368.91	747.952	1577.27	641.067	482.32		
	6	527.183		15488		2076.65		883.3		2262.22		252.79		1652.54		1398.58			
	7	2664.38		16107.2		313.717		708.15		2104.12		566.667		1760		441.417			
	8	1066.03		6409.23		758.617		608.9		1393.34		547.197		2283.66		361.817			
	9	2019.63		12071.8		2311.1		514.4		1263.63		295.672		1695.55		0			
	10	2683.33		4042.38		7455.75		297.35		4018.52		323.968		3942.35		0			
	11	2179.83		2636.63		9994.73		361.817		4617.77		368.947		1905.45		0			
	12	844.483		1737.93		4071.08		800.917		4346.05		439.333		2468.51		197.483			
	13	1187.62		603.9		5737.62		1495.65		4064.68		204.825		2924.03		1082.13			
	14	2100.63		54.95		7577.3		1287.25		3242.28		33.3333		1897.02		1139.95			
	15	2751.03	5651.00	143.983	601.03	1459.97	3733.79	1755.82	1539.71	2230.67	2837.27	4.38333	1190.33	2062.13	1616.12	912.25	497.79		102.28
	16	4424		122.222		3140.05		2102.73		2179.53		872.482		2646.58		614.883			
	17	4349.93		65.6167		2264.43		2757.58		2053.04		1044.44		488.682		304.433			
	18	13342.5		297.617		1170.45		2004.43		1997.56		1069.27		1020.99		55.1667			
	19	14700.5		77.0283		991.15		1608.37		1938.96		548.305		316.813		66.65		56.4675	
	20	10629.4		270.367		931.1		1222.48		1702.15		7317.98		423.01		604.983		148.093	
	21	11472.1		379.667		871.1		611.8		1631.14		5125.83		2315.26		537.75		15.555	
	22	4912.88		199.683		798.233		2059.83		1515.26		14130.6		1307.11		519.488		19.785	
	23	2420.02		929.95		759.367		1804.9		1459.02		2399.56		744.065		132.733		13.335	
	24	3040.22		1599.53		861.333		893.317		1222.71		1504.44		1609.36		21.9		24.1217	
	25	1780.67	2485.46	1606.4	866.33	865.2	883.79	757.767	1005.89	1112.28	1144.61	2428.7	3303.55	1165.23	3070.40	126.267	148.05	61.4617	1815.97
	26	2119.62		1792.08		955.8		718.133		1117.05		4933.25		8911.61		38.4833		668.712	
	27	577.783		1303.63		951.1		553.35		1146.64		2400		9544.45		22.0667		1079.58	
	28	286.683		903.167		891.083		599.683		1004.31		708.467		4386.67		55.4667		1436.73	
	29	314.917		660.567		872.333		1053.32		797.857		832.228		1748.33		104.017		226.973	
	30	135.067		55.2433		889.5		1092.08		768.088		949.313		1257.06		54.9333		9926.43	
	31	280.117		99.6833		1006.87		922.633		816.347		926.665		785.298		15.4667		6502.95	

Month	Date	1985 by volume	1985 10-daily	1986 by volume	1986 10-daily	1987 by volume	1987 10-daily	1988 by volume	1988 10-daily
SEPTEMBER	1			528.5		323.3625		260.3667	
	2			336.65		14.7375		381.3625	
	3			167.7375		8.175		145.1188	
	4			25		14.925		429.87	
	5			10	132.27	11.4625	39.06	111.18	184.76
	6			164.4625		1.6375		58.2875	
	7			14.925		0		66.75625	
	8			42.75		4.8875		57.65	
	9			26.1375		1.6375		57.43125	
	10			8.525		9.7875		279.5563	
	11			29.8		6.5625		70.70625	
	12			236.275		3.25		35.525	
	13			666.5875		1.6375		36.88125	
	14			120.9		0		25.425	
	15			289.225	253.77	1.6625	1.80	27.09375	119.00
	16			424.525		0		24.725	
	17			384.9875		0		25.48125	
	18			143.075		3.2875		374.4125	
	19			60		1.625		456.1688	
	20			182.5375		0		113.6	
	21			856.8875		1.6375		433.15	
	22			352.8125		1.6375		987.0688	
	23			180.175		4.925		1880.25	
	24			82.4875		3.2625		640.9188	
	25			110.6375	499.96	3.275	2.78	420.6688	481.87
	26			238.4625		3.25		50.775	
	27			671.4125		3.2625		104.7063	
	28			458.8625		4.9		169.8125	
	29			1213.725		0		45.28125	
	30			834.0625		1.625		86.03125	
OCTOBER	1	14.21167		229.275		3.3		97.525	
	2	15.32333		756.325		3.3		58.2375	
	3	9.825		167.3		1.6625		84.275	
	4	6.565		169.3875		0		33.83125	
	5	122.785	188.84	148.3125	241.85	0	0.83	16.4625	41.40
	6	10.93667		138.7		0		28.81875	
	7	6.58		126.1625		0		18.1625	
	8	77.80625		226.6375		0		42.8125	
	9	264.3025		319.0625		0		7.86875	
	10	1360.109		137.3		0		28.04375	
	11	683.0842		32.7		0		38.225	
	12	396.6558		31.2625		0		17.23125	
	13	3190.809	2160.53	3.2875	20.71	0	0.00	17.25	19.30
	14	4283.982		18.0875		0		10.69375	
	15	2238.142		18.2125		0		13.1	

Month	Date	1989 by volume	1989 10-daily	1990 by volume	1990 10-daily	1991 by volume	1991 10-daily	1994 by volume	1994 10-daily	1995 by volume	1995 10-daily	1996 by volume	1996 10-daily
SEPTEMBER	1	1.625		23.1625		0		15.155		869.333		934.25	
	2	1141.313		31.3125		0		11.1833		561.217		3109.15	
	3	830.6125		14.7625		0		22.2167		2409.97		6567.37	
	4	4.925		241.0625		10		13.1333		4127.33		2213.9	
	5	4.525	270.82	23.775	119.66	101.288	17.35	15.55	101.68	7912.38	2364.99	8313.9	6121.07
	6	3.2625		115.9		52.375		164.417		3859.42		6300.25	
	7	4.9125		154.5625		8.25		422.033		2411.53		5553.05	
	8	1.625		229.875		0		335.55		1339.97		6596.48	
	9	3.2375		347.65		0		8.76667		112.183		7405.13	
	10	712.1625		16.4625		1.625		8.83333		46.55		4217.17	
	11	1.6125		14.75		6.6125		8.8		30.9		3156.08	
	12	0		556.65		0		15.55		326.867		2955.2	
	13	0		399.3		13.1		24.1167		836.7		2352.45	
	14	1.6125		447.9625		14.825		19.9833		691.983		1132.45	
	15	0	0.65	447.9625	229.69	57.775	199.61	0	6.85	417.133	281.90	102.834	970.90
	16	0		70.7		1838.01		0		186.15		3.915	
	17	0		204.275		65.7875		0		81.1167		3.915	
	18	3.225		3.2875		0		0		111.1		2.18333	
	19	0		4.925		0		0		0		0	
	20	0		147.05		0		0		137.067		0	
	21	1.6125		194.075		0		0		91.0833		2.21667	
	22	0		227.125		0		0		55.55		0	
	23	0		17.9875		0		0		79.15		2.21667	
	24	0		236.8625		0		0		223.65		0	
	25	189.5375	19.44	13.125	84.20	0	0.82	0	0.00	1.71667	45.12	0	3.76
	26	0		13.175		0		0		0		0	
	27	0		62.1625		0		0		0		0	
	28	0		6.5375		4.925		0		0		0	
	29	3.25		26.3		1.6375		0		0		0	
	30	0		44.6125		1.6625		0		0		33.1167	
OCTOBER	1	0		6.625				0		0		10.2667	
	2	0		0				0		0		0	
	3	0		43.325				0		0		0	
	4	0		0				0		0		0	
	5	0	0.00	0	5.33			0	0.00	0	0.00	0	1.03
	6	0		0				0		0		0	
	7	0		1.6625				0		0		0	
	8	0		1.65				0		0		0	
	9	0		0				0		0		0	
	10	0		0				0		0		0	
	11	0		0				0		0		0	
	12	0		0				0		0		0	
	13	0	0.00	1201.575	241.63			0	0.00	0	0.00	0	0.00
	14	0		6.575				0		0		0	
	15	0		0				0		0			

Month	Date	1997 by volume	1997 10-daily	1998 by volume	1998 10-daily	1999 by volume	1999 10-daily	2000 by volume	2000 10-daily	2001 by volume	2001 10-daily
SEPTEMBER	1	516.617		133.35		703.383		1026.67		870	
	2	44.4333		116.817		1888.87		1068.12		893.717	
	3	15.35		95.1833		2233.8		958.75		1210.28	
	4	0		46.2		2009.55		814.417		1987.17	
	5	58.8333	310.82	89.6	80.26	3094.88	2380.93	382.117	927.53	1932.15	1308.40
	6	58.8333		104.433		3927.68		624.417		1332.3	
	7	288.367		83.7667		3632		577.05		1243.42	
	8	236.85		45.95		1258.68		2008.22		1221.65	
	9	1381.55		48.15		3962.7		1137.75		1271.1	
	10	509.317		61.1333		1097.76		677.767		1122.22	
	11	1244.95		103.633		9150.4		1420.1		1259.95	
	12	2516.65		90.8		14058.9		763.85		1105.93	
	13	693.6		121.2		4181.05		1244.33		1017.52	
	14	256.433		90.4033		143.563		1764.43		960.017	
	15	383.9	765.24	55.2667	75.41	268.422	3166.86	1270.31	1306.97	897.767	878.65
	16	218.8		70.2667		432.457		1128.21		852.487	
	17	1263.72		93.1667		1038.8		1300.85		770.867	
	18	292.15		64.2		696.783		1635.94		727.967	
	19	383		24.4667		1198.76		1837.78		645.683	
	20	419.217		40.6667		499.415		703.9		548.367	
	21	1111.9		71.8667		243.783		811.067		577.3	
	22	826.183		105.433		168.863		1276.6		475.85	
	23	100.637		97.15		3775.15		1144.72		474.917	
	24	267.517		2488.87		2173.87		1039.5		477.767	
	25	43.8833	284.22	1530.65	462.76	1220.23	828.67	922.25	655.45	418.083	384.18
	26	0		82.2167		120.688		893.95		414.433	
	27	65.4		103.717		252.777		459.9		323.65	
	28	0		11.0333		333.333		6.55		243.867	
	29	44.4333		81.8667		0		0		299.967	
	30	382.217		54.8		0		0		135.933	
OCTOBER	1	124.1		43.5667		0		0		668.317	
	2	432.633		21.7833		110.67		0		258.567	
	3	1258.27		0		88.3783		0		233.733	
	4	1242.48		66.6667		22.075		0		593.283	
	5	811.4	650.69	44.4333	17.65	0	68.05	0	0.00	548.883	394.49
	6	788.583		0		161.567		0		413.65	
	7	769.45		0		297.777		0		407.883	
	8	468.383		0		0		0		278.483	
	9	316.967		0		0		0		288.5	
	10	296.667		0		0		0		255.533	
	11	88.15		0		0		0		251.1	
	12	202.133		0		0		0		76.7167	
	13	315.55	174.04	4.38	0.88	0	0.00	0	0.00	44.1333	74.39
	14	179.183		0		0		0		0	
	15	85.1833		0		0		0		0	

Month	Date	2002 by volume	2002 10-daily	2003 by volume	2003 10-daily	2004 by volume	2004 10-daily	2005 by volume	2005 10-daily	2006 by volume	2006 10-daily
SEPTEMBER	1	3651.14		298.975		534.345		10.95		1517.61	
	2	3445.32		414.327		746.665		0		394.122	
	3	4191.08		153.51		405.488		0		356.228	
	4	5146.41		932.967		0		366.667		519.972	
	5	4574.04	3845.69	546.835	620.73	0	224.01	673.683	123.24	218.977	324.26
	6	3932.6		313.653		0		0		30.8317	
	7	4032.13		323.392		100.005		0		50.555	
	8	4301.72		624.267		122.22		99.7083		62.2217	
	9	3066.43		1409.27		226.665		11.1117		35.4533	
	10	2115.06		1190.15		104.693		70.32		56.6675	
	11	2802.3		811.55		0		0		100	
	12	3465.88		802.573		133.992		0		29.78	
	13	2871.11		1034.94		88.8883		0		25.2617	
	14	2284.21		1415.18		327.017		11.1117		183.342	
	15	2193.42	2527.50	1056.35	2308.82	169.212	340.74	179.97	350.46	528.888	145.87
	16	3724.87		633.383		778.508		1008.89		200	
	17	2801.26		845.087		965.352		1253.28			
	18	2115.29		7762.9		366.667				99.335	
	19	1426.67		7341.74		0				66.225	
	20	1590.01		1384.5		577.778				80	
	21	1333.58		1091.8		940.788				122	
	22	1248.2		1092.9		7217.4				6.62	
	23	613.012		3585.02		3026.67					
	24	603.165		3884.31		978.217					
	25	710.233	639.17	3206.14	2122.86	898.462	1674.53		0.00	20	49.64
	26	476.713		2324.09		898.773					
	27	407.457		2924.12		720					
	28	357.075		1994.87		804.823					
	29	363.658		702.777		622.368		0			
	30	280.603		422.57		637.778		0			
OCTOBER	1	121.638		226.667		0		0			
	2	44.445		424.097		0		0			
	3	121.343		506.978		222.222		0			
	4	32.8933		325.498		0		0			
	5	0	32.03	0	446.34	0	22.22	0	0.00		
	6	0		321.783		0		0			
	7	0		578.365		0		0			
	8	0		925.455		0		0			
	9	0		922.742		0		0			
	10	0		237.778		0		0			
	11	0		0		1893.89		0			
	12	0		0		175.555		0			
	13	0	0.00	0	0.00	0	413.89	0	0.00		
	14	0		0		0		0			
	15	0		0		0		0			

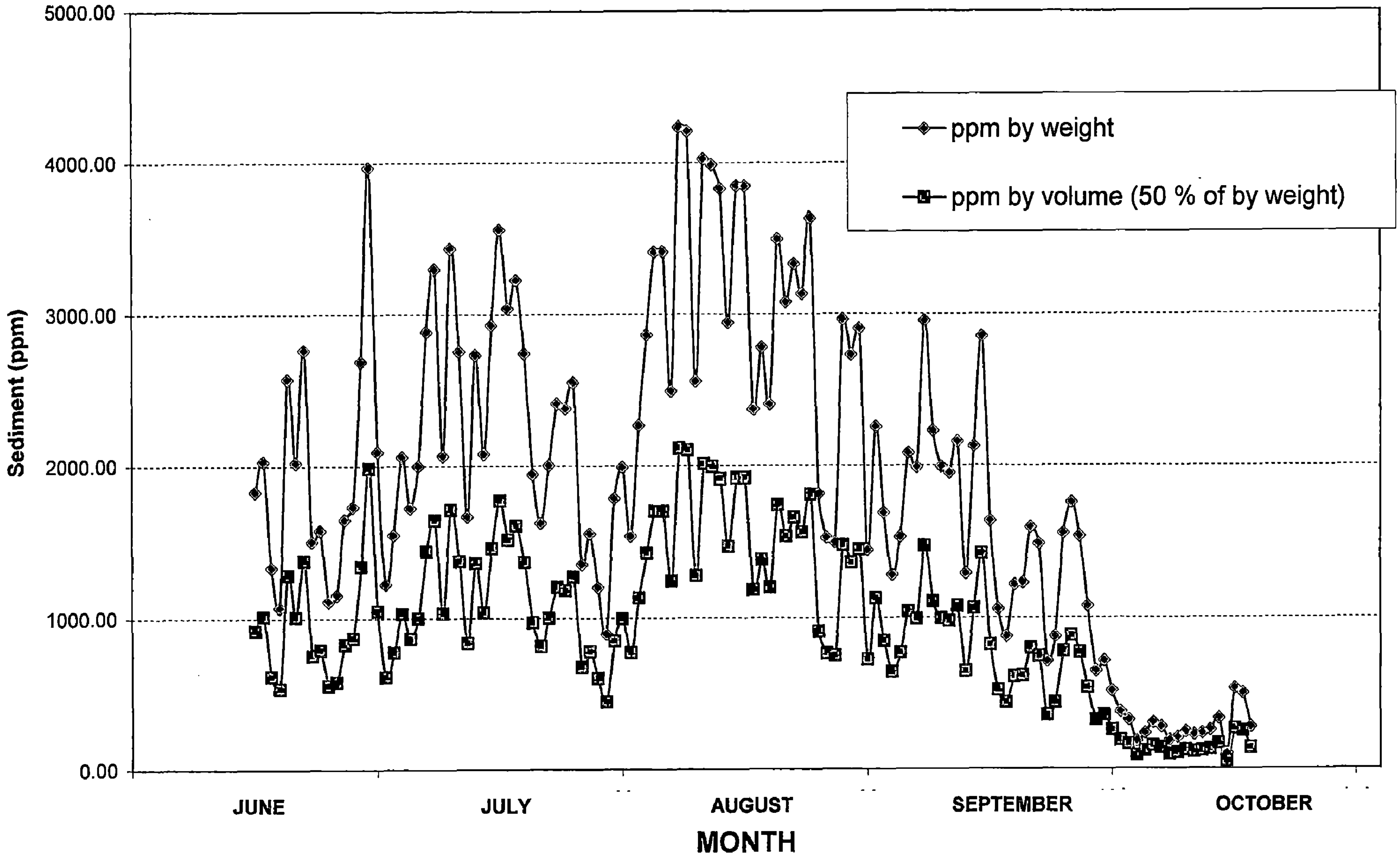


Fig. 6.2 AVERAGE SEDIMENT AT JAMRANI DAM SITE (1985-2006)

TABLE-6.2

10-DAILY OBSERVED DISCHARGE AND 10-DAILY OBSERVED SEDIMENT AT JAMRANI DAM SITE

10-DAILY OBSERVED DISCHARGE AT DAM SITE

MONTH	10-DAILY	1985	1986	1987	1988	1989	1990	1991	1994	1995	1996	1997	1998	1999	2000	2001	2002	2003	2004	2005	2006	Average
June	1	9.52	22.46	80.79	15.48	15.66	21.10	19.02	14.67	13.61	18.49	15.58	17.85	17.08	1,436.36	28.03	20.92	13.51	24.94	13.93	20.34	91.97
	2	14.65	34.81	20.25	15.39	25.56	18.60	30.38	13.77	12.14	40.80	18.07	46.00	91.37	946.23	19.89	23.68	13.61	28.43	12.08	14.58	72.01
	3	31.07	92.59	17.92	36.66	52.16	30.36	22.89	26.35	63.14	140.08	34.60	102.50	116.77	1,451.84	412.60	24.67	16.48	20.11	43.76	19.90	137.82
July	1	70.50	656.89	139.82	188.54	40.13	2,208.61	22.92	36.35	53.69	121.32	46.29	1,206.85	468.07	976.41	524.60	257.84	21.33	169.25	134.18		386.50
	2	224.96	1,182.79	536.10	163.50	24.83	575.00	26.13	67.00	120.51	185.66	81.20	531.02	459.17	1,839.71	535.68	174.58	1,148.40	223.37	222.56		438.01
	3	922.98	1,253.21	292.50	321.00	591.00	404.00	53.33	94.00	62.07	124.16	79.10	773.48	864.68	1,563.94	749.21	170.36	236.94	177.06	116.64		465.77
August	1	608.68	970.98	127.00	340.50	445.00	1,417.00	144.62	213.76	60.31	138.83	209.20	774.29	845.16	1,001.12	622.50	157.33	279.45	193.58	64.92		453.38
	2	436.09	599.01	394.00	224.00	322.80	435.00	124.18	333.25	464.97	243.63	138.10	1751.14	498.85	2,839.24	690.67	515.04	869.70	266.69	126.60		593.31
	3	880.49	896.32	957.00	171.00	563.00	1,160.00	182.16	193.29	139.81	376.57	82.50	1668.05	444.66	2,312.50	429.60	376.91	749.92	2,192.08	129.52		731.86
September	1	547.22	414.94	353.50	139.42	763.00	802.00	120.78	91.46	1,961.25	520.97	76.60	482.86	472.79	2,711.28	263.58	1,115.17	246.44	255.37	90.00		601.51
	2	635.57	1,121.72	163.50	128.39	404.00	857.00	97.94	78.02	321.62	261.96	75.80	379.47	818.88	1,083.72	201.40	830.52	417.04	202.62	289.78		440.47
	3	382.59	605.43	170.00	192.81	286.00	363.00	96.63	59.84	155.39	133.54	71.00	645.82	552.23	751.29	327.97	342.22	1,074.73	481.59	2,401.21		478.59
October	1	437.62	458.14	34.03	130.78	178.30	225.00	68.58	72.47	107.97	75.80	69.00	309.71	346.81	646.92	153.04	283.52	330.37	206.91	276.05		232.16
	2	3,219.80	324.48	66.81	72.37	99.19	146.63	47.66	59.33	70.76	61.89	63.00	854.94	254.75	207.78	34.74	257.45	229.81	283.04	159.47		342.84
	3	404.23	228.94	70.32	59.95	75.61	89.42	41.28	47.81	68.13	60.05	67.90	577.83	207.27	212.44	68.37	351.66	182.76	205.84	114.95		164.99

10-DAILY OBSERVED SEDIMENT AT DAM SITE

MONTH	10-DAILY	1985	1986	1987	1988	1989	1990	1991	1994	1995	1996	1997	1998	1999	2000	2001	2002	2003	2004	2005	2006	Average
June	1																					
	2		120.84	0.00	0.00	11.67		25.39			3,734.20	0.00	703.96	541.43	2,878.63	2,600.33	327.22	299.86	458.79			835.88
	3		329.61	0.49	55.83	498.37	18.64			1,551.38	3,434.17	699.22	853.78	588.52	2,167.72	2,333.97	1,055.77	370.59	686.98	1,841.38		1,030.40
July	1		252.41	212.88	1,371.34	69.26	832.57			1,521.63	1,626.55	199.19	3,023.20	755.24	1,066.98	1,824.75	2,564.15	883.10	2,862.23	499.23	0.00	1,150.87
	2		1,800.52	300.97	830.72	373.87	341.93	60.95		2,650.17	4,152.89	1,048.39	1,755.32	563.85	1,121.14	3,764.47	2,119.86	417.91	328.84	248.48	0.00	1,215.57
	3		1,919.17	172.13	341.00	696.34	233.52	2.54		2,705.40	392.09	409.98	343.77	1,564.04	1,062.53	2,924.28	1,526.27	273.17	269.39	307.09		890.75
August	1		3,648.00	5.08	404.87	40.19	144.19	12.07		815.55	1,954.45	4,781.58	1166.36	6,214.84	3,711.79	761.99	2,369.87	368.91	1,577.27	482.32		1,674.08
	2		1,330.61	57.91	403.50	3.77	997.46	170.43		3,080.16	2,368.97	1,372.12	5651.00	601.03	3,733.79	1,539.71	2,837.27	1,190.33	1,615.12	497.79	102.28	1,530.74
	3		920.85	75.53	305.48	915.39	230.45	252.10		1,707.92	1,419.50	280.61	2485.46	866.33	883.79	1,005.89	1,144.61	3,303.55	3,070.40	148.05	1815.97	1,157.33
September	1		132.27	39.06	184.76	270.82	119.86	17.35	101.68	2,364.99	5,121.07	310.82	80.26	2,380.93	927.53	1,308.40	3,845.59	620.73	224.01	123.24	324.26	973.56
	2		253.77	1.80	119.00	0.65	229.69	199.61	6.85	281.90	970.90	765.24	75.41	3,166.86	1,306.97	878.65	2,527.50	2,308.82	340.74	350.46	145.87	733.19
	3		499.96	2.78	481.87	19.44	84.20	0.82	0.00	45.12	3.76	284.22	462.76	828.87	655.45	384.18	639.17	2,122.86	1,674.53	0.00	49.54	433.66
October	1	188.84	241.85	0.83	41.40	0.00	5.33		0.00	0.00	1.03	650.89	17.65	68.05	0.00	394.49	32.03	446.94	22.22	0.00		117.31
	2	2,160.53	20.71	0.00	19.30	0.00	241.63		0.00	0.00	0.00	174.04	0.88	0.00	0.00	74.39	0.00	0.00	413.89	0.00		172.52
	3																					

TABLE-6.3
CALCULATION OF SEDIMENT RATE

MONTH	10-DAILY	Average Discharge (1985 - 2006) (cumec)	Average Sediment (1985 - 2006) (ppm)	Sediment load (m^3/day)	Sediment load m^3
June	2	72.01	836	5,201	26,004
	3	137.82	1,030	12,270	122,699
July	1	386.50	1,151	38,432	384,320
	2	438.01	1,216	46,002	460,020
	3	465.77	891	35,846	358,460
August	1	453.38	1,674	65,577	655,771
	2	593.31	1,531	78,469	784,690
	3	731.86	1,157	73,181	731,811
September	1	601.51	974	50,596	505,961
	2	440.47	733	27,903	279,030
	3	478.59	434	17,932	179,320
October	1	232.16	117	2,353	23,530
	2	342.84	173	5,110	25,551

Annual Sediment Load **4,537,167.82** m^3/year

Sediment Rate **100.83** Hect.m/100 Km^2/yı

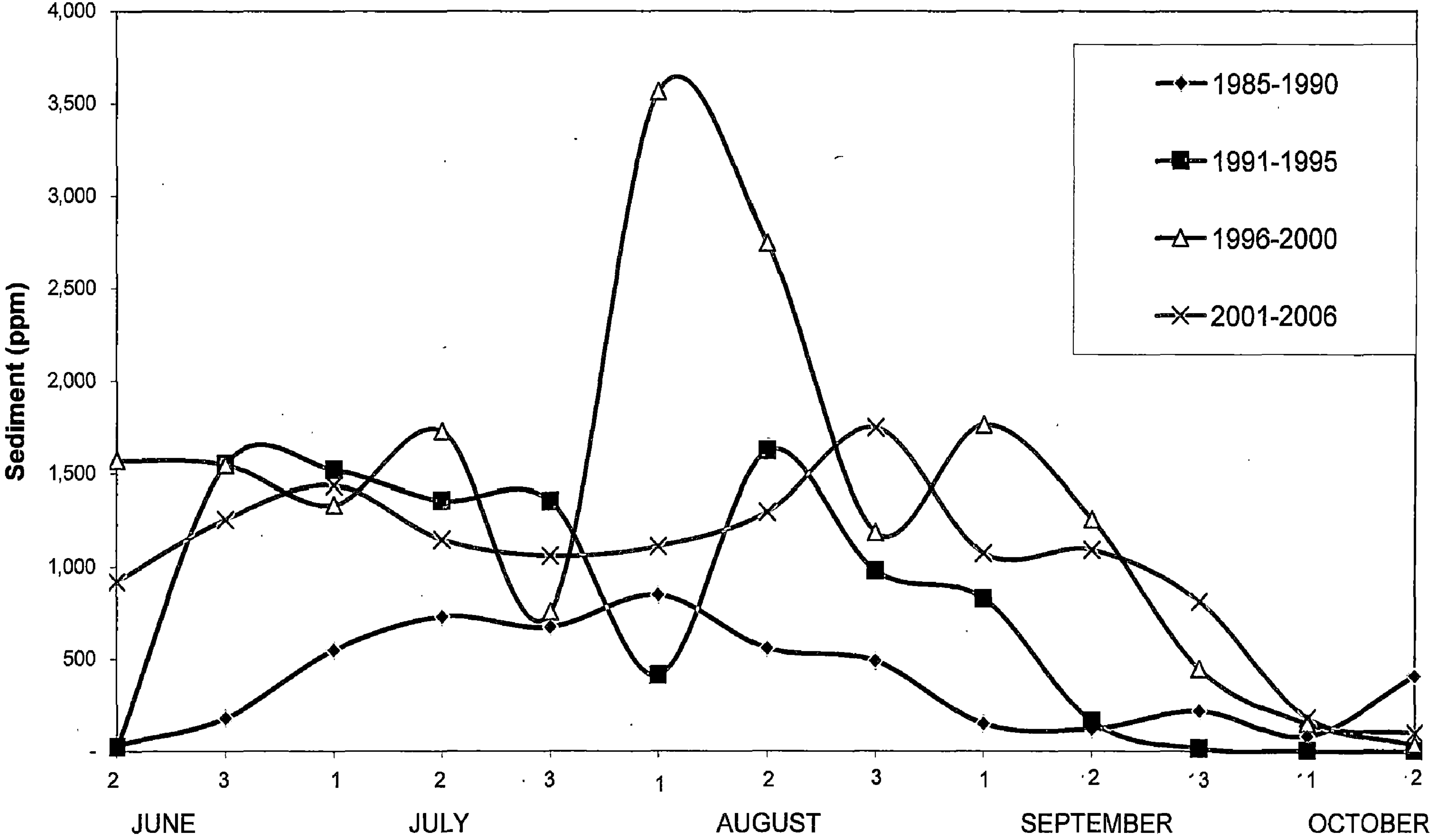


Fig. 6.3 AVERAGE SEDIMENT AT JAMRANI DAM SITE FOR DIFFERENT YEARS

<u>TABLE-6-4*a*</u>

CALCULATION OF SEDIMENT RATE AT JAMRANI DAM SITE (1985-1990)

MONTH	10-DAILY	Average Discharge (1985 - 1990) (cumec)	Average Sediment (1985 - 1990) (ppm)	Sediment load (m^3/day)	Sediment load m^3
June	2	21.54	33.13	62	308
	3	43.46	180.59	678	6,781
July	1	550.75	547.69	26,062	260,618
	2	451.20	729.60	28,442	284,423
	3	630.78	672.43	36,647	366,473
August	1	651.53	848.47	47,762	477,617
	2	401.82	558.65	19,395	193,946
	3	771.30	489.54	32,623	326,230
September	1	503.35	149.35	6,495	64,953
	2	551.70	120.98	5,767	57,668
	3	333.31	217.65	6,268	62,677
October	1	243.98	79.71	1,680	16,802
	2	654.88	407.03	23,030	115,152

Annual Sediment Load **2,233,649.50** m^3/year

Sediment Rate **49.64** Hect.m/100 Km^2/year

<u>TABLE-6-4*b*</u>

CALCULATION OF SEDIMENT RATE AT JAMRANI DAM SITE (1991-1995)

MONTH	10-DAILY	Average Discharge (1991 - 1995) (cumec)	Average Sediment (1991 - 1995) (ppm)	Sediment load (m^3/day)	Sediment load m^3
June	2	18.76	25.39	41	206
	3	37.46	1,551.38	5,021	50,211
July	1	37.65	1,521.63	4,950	49,503
	2	71.21	1,355.56	8,341	83,405
	3	69.80	1,353.97	8,165	81,654
August	1	139.56	413.81	4,990	49,898
	2	307.47	1,625.29	43,176	431,761
	3	171.75	980.01	14,543	145,429
September	1	724.50	828.01	51,830	518,305
	2	165.86	162.79	2,333	23,328
	3	103.95	15.31	138	1,375
October	1	83.01	-	-	-
	2	59.25	-	-	-

Annual Sediment Load **1,435,074.66** m^3/year

Sediment Rate **31.89** Hect.m/100 Km^2/year

TABLE-6-4c

CALCULATION OF SEDIMENT RATE AT JAMRANI DAM SITE (1996-2000)

MONTH	10-DAILY	Average Discharge (1996 - 2000) (cumec)	Average Sediment (1996 - 2000) (ppm)	Sediment load (m^3/day)	Sediment load m^3
June	2	228.49	1,572	31,027	155,135
	3	369.16	1,549	49,396	493,956
July	1	563.79	1,334	64,992	649,921
	2	619.35	1,728	92,486	924,856
	3	681.07	754	44,397	443,972
August	1	593.72	3,566	182,916	1,829,164
	2	1,094.19	2,745	259,543	2,595,430
	3	976.86	1,187	100,195	1,001,951
September	1	852.90	1,764	129,999	1,299,990
	2	523.97	1,257	56,909	569,088
	3	430.78	447	16,637	166,373
October	1	289.65	148	3,692	36,918
	2	288.47	35	872	4,360

Annual Sediment Load **10,171,113.41** m^3/year

Sediment Rate **226.02** Hect.m/100 Km^2/year

TABLE-6-4*d*

CALCULATION OF SEDIMENT RATE AT JAMRANI DAM SITE (2001-2006)

MONTH	10-DAILY	Average Discharge (2001 - 2006) (cumec)	Average Sediment (2001 - 2006) (ppm)	Sediment load (m^3/day)	Sediment load m^3
June	2	18.71	921.55	1,490	7,449
	3	89.59	1,257.74	9,735	97,353
July	1	221.44	1,438.91	27,530	275,298
	2	460.92	1,146.59	45,661	456,611
	3	290.04	1,060.04	26,564	265,642
August	1	263.56	1,112.07	25,323	253,233
	2	493.74	1,297.08	55,332	553,324
	3	775.61	1,748.08	117,143	1,171,428
September	1	394.11	1,074.37	36,584	365,838
	2	388.27	1,092.01	36,633	366,333
	3	925.54	811.71	64,910	649,102
October	1	249.98	179.14	3,869	38,690
	2	192.90	97.66	1,628	8,138

Annual Sediment Load **4,508,439.07** m^3/year

Sediment Rate **100.19** Hect.m/100 Km^2/year

CHAPTER 7

SUMMARY AND CONCLUSION

7.1. SUMMARY

1. The average precipitation for Jamrani Dam site based on rainfall data recorded from five and seven rain gauge stations since 1979-1980 to 2005-2006 is **1541.83 mm**.

2. 10-daily observed discharge data available at dam site only from 1977 to 2006 while at Gola Barrage has long term data 10-daily observed discharge since 1948 till to date. Based on above condition, derived 10-daily discharge data for dam site from 1948 to 1977 has been carried out by regression analysis either by direct linear regression method or log deviation regression method.

   Direct Linear Regression method is more appropriate than Log Deviation Regression method because the coefficient of correlation in each period of the first method are most higher than of the last method. Therefore, for dependable flow and design flood estimation, derived data by using Direct Linear Regression is adopted.

   Result of direct linear regression are tabulated as follows :

TABLE-7.1

RESULTS OF DIRECT LINEAR REGRESSION

FOR 10-DAILY DERIVED DISCHARGE AT JAMRANI DAM SITE

1st July			**2nd July**			**3rd July**		
a = 6.95	b = 0.53	r = **0.97**	a = -24.04	b = 0.73	r = **0.95**	a = -54.19	b = 0.80	r = **0.98**
correlation : $Q_J = 0.53\ Q_G + 6.95$			correlation : $Q_J = 0.73\ Q_G - 24.04$			correlation : $Q_J = 0.80\ Q_G - 54.19$		
1st August			**2nd August**			**3rd August**		
a = -59.61	b = 0.82	r = **0.93**	a = -135.26	b = 0.85	r = **0.94**	a = -137.61	b = 0.97	r = **0.98**
correlation : $Q_J = 0.82\ Q_G - 59.61$			correlation : $Q_J = 0.85\ Q_G - 135.26$			correlation : $Q_J = 0.97\ Q_G - 137.61$		
1st September			**2nd September**			**3rd September**		
a = 18.81	b = 0.69	r = **0.98**	a = 17.42	b = 0.67	r = **1.00**	a = -6.81	b = 0.74	r = **0.99**
correlation : $Q_J = 0.69\ Q_G + 18.81$			correlation : $Q_J = 0.67\ Q_G + 17.42$			correlation : $Q_J = 0.74\ Q_G - 6.81$		

1st October			2nd October			3rd October		
a = -0.94	b = 0.65	r = **0.95**	a = -56.33	b = 0.99	r = **1.00**	a = -10.53	b = 0.82	r = **0.98**
correlation : $Q_J = 0.65\ Q_G - 0.94$			correlation : $Q_J = 0.99\ Q_G - 56.33$			correlation : $Q_J = 0.82\ Q_G - 10.53$		
1st November			**2nd November**			**3rd November**		
a = -22.86	b = 1.01	r = **0.95**	a = -0.95	b = 0.71	r = **0.90**	a = -2.28	b = 0.65	r = **0.87**
correlation : $Q_J = 1.01\ Q_G - 22.86$			correlation : $Q_J = 0.71\ Q_G - 0.95$			correlation : $Q_J = 0.65\ Q_G - 2.28$		
1st December			**2nd December**			**3rd December**		
a = 0.33	b = 0.63	r = **0.80**	a = 2.59	b = 0.56	r = **0.87**	a = 3.37	b = 0.61	r = **0.81**
correlation : $Q_J = 0.63\ Q_G + 0.33$			correlation : $Q_J = 0.56\ Q_G + 2.59$			correlation : $Q_J = 0.61\ Q_G + 3.37$		
1st January			**2nd January**			**3rd January**		
a = 0.98	b = 0.66	r = **0.90**	a = 0.27	b = 0.68	r = **0.77**	a = -5.83	b = 0.80	r = **0.89**
correlation : $Q_J = 0.66\ Q_G + 0.98$			correlation : $Q_J = 0.68\ Q_G + 0.27$			correlation : $Q_J = 0.80\ Q_G - 5.83$		
1st February			**2nd February**			**3rd February**		
a = 1.66	b = 0.62	r = **0.88**	a = 6.50	b = 0.48	r = **0.92**	a = -5.20	b = 0.81	r = **0.96**
correlation : $Q_J = 0.62\ Q_G + 1.66$			correlation : $Q_J = 0.48\ Q_G + 6.50$			correlation : $Q_J = 0.81\ Q_G - 5.20$		
1st March			**2nd March**			**3rd March**		
a = -12.57	b = 0.95	r = **0.99**	a = -4.44	b = 0.83	r = **0.93**	a = 2.82	b = 0.59	r = **0.85**
correlation : $Q_J = 0.95\ Q_G - 12.57$			correlation : $Q_J = 0.83\ Q_G - 4.44$			correlation : $Q_J = 0.59\ Q_G + 2.82$		
1st April			**2nd April**			**3rd April**		
a = 3.14	b = 0.62	r = **0.87**	a = 4.99	b = 0.52	r = **0.77**	a = 4.66	b = 0.48	r = **0.68**
correlation : $Q_J = 0.62\ Q_G + 3.14$			correlation : $Q_J = 0.52\ Q_G + 4.99$			correlation : $Q_J = 0.48\ Q_G + 4.66$		
1st May			**2nd May**			**3rd May**		
a = 0.84	b = 0.63	r = **0.86**	a = 2.33	b = 0.58	r = **0.90**	a = 0.63	b = 0.61	r = **0.90**
correlation : $Q_J = 0.63\ Q_G + 0.84$			correlation : $Q_J = 0.58\ Q_G + 2.33$			correlation : $Q_J = 0.61\ Q_G + 0.63$		
1st June			**2nd June**			**3rd June**		
a = 13.22	b = 0.18	r = **0.69**	a = 4.28	b = 0.54	r = **0.78**	a = -7.17	b = 0.78	r = **0.91**
correlation : $Q_J = 0.18\ Q_G + 13.22$			correlation : $Q_J = 0.54\ Q_G + 4.28$			correlation : $Q_J = 0.78\ Q_G - 7.17$		

3. 75% dependable annual flow at Jamrani Dam site is estimated as **355.9 MCM**.

4. Design Flood Estimation is carried out by the following methods :
   - Gumbel's Method and then checked by Gumbel Probability paper
   - Log Pearson type III Distribution
   - Unit Hydrograph principle

Comparison of result obtained by four methods are tabulated in Table-7.2.

TABLE-7.2

CALCULATION RESULTS OF FLOOD ESTIMATION AT JAMRANI DAM SITE

(cumecs)

Return Period (T years)	METHODS			
	Gumbel's	Graphical by prob. paper	Log Pearson type III	Unit Hydrograph
20	3688	3688	3322	
50	4527	4527	**4640**	4566
100	5155	5250	**5355**	4996
150	5522	5600	5701	
200	5781	5900	6070	
500	6608	6800	6654	
1000	7232	7500	7755	

5. Sediment data at Jamrani Dam site is observed from 1985 to 2006, between 15 June and 15 October for each year.

Sediment Rate during 1985 to 2006 is 100.83 Hect.m/100 Km^2/year.

Then, also calculation of sediment rate is divided in 5 years basis are :

- Sed. Rate during 1985 to 1990 : 49.64 Hect.m/100 Km^2/year.
- Sed. Rate during 1991 to 1995 : 31.89 Hect.m/100 Km^2/year.
- Sed. Rate during 1996 to 2000 : 226.02 Hect.m/100 Km^2/year.
- Sed. Rate during 2001 to 2006 : 100.19 Hect.m/100 Km^2/year.

From above results of calculation, annual sediment rate at Jamrani Dam site is more high than average of some reservoirs in India because of several factors namely a landslide ever taken place in 1993 and mining practices at that site.

7.2. CONCLUSION

Hydrology finds its greatest application in the design and operation of water resources engineering projects. Many important projects in the past have failed due to improper assessment of the hydrological factor.

Therefore the Hydrological Analysis of a project should of necessity precede structural and other detailed design studies.

It involves the collection of relevant data and analysis of the data by applying the principles and the theories of hydrology to seek solutions to practical problems.

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APPENDIX – A

AVAILABLE DATA

Table-1.A

10 - Daily observed Rainfall data within the Catchment Area = 450 Km^2

The weight :				
	Jamrani (J)	=	39.00	Km2
	Lugar (L)	=	87.00	Km2
	Okhalkanda (O)	=	151.00	Km2
	Paharpani (P)	=	66.00	Km2
	Champi (C)	=	107.00	Km2
	Total	=	**450.00**	Km2

1979 - 80		RAINFALL					MAP
Month.	Ten-daily	J (mm)	L (mm)	O (mm)	P (mm)	C (mm)	(mm)
JUL	1	119.00	92.71	2.00	25.50	34.80	40.92
	2	230.57	257.81	182.90	101.60	137.20	178.72
	3	326.00	250.19	115.60	147.30	143.90	171.23
AUG	1	21.60	40.64	41.20	59.70	62.60	47.19
	2	725.60	69.80	159.00	128.30	139.00	181.60
	3	21.60	93.90	6.40	-	-	22.17
SEP	1	1.60	13.90	-	11.40	-	4.50
	2	31.20	42.40	27.70	16.50	18.00	26.90
	3	-	-	-	-	-	-
OCT	1	-	-	4.30	-	4.00	2.39
	2	8.00		1.50	-		1.20
	3	-	-	-	-	-	-
NOV	1	-	-	-	-	-	-
	2	-	-	-	-	-	-
	3	7.60	11.43	11.40	-	-	6.69
DEC	1	2.40	-	1.50	-	-	0.71
	2	-	-	-	-	-	-
	3	14.40	36.60	27.90	19.70	55.90	33.87
JAN	1	16.80	7.62	8.90	10.10	20.30	12.22
	2	-	-	-	-	-	-
	3	-	-	-	-	-	-
FEB	1	30.40	18.30	33.53	7.60	14.40	21.96
	2	12.80	18.80	19.00	5.55	6.30	13.43
	3	1.30	2.80	8.90	2.90	2.90	4.76
MAR	1	56.00	8.90	104.10	13.50	84.40	63.55
	2	-	-	10.30	1.30	4.30	4.67
	3	8.80	10.90	16.20	8.90	15.20	13.23
APR	1	7.20	8.26	7.40	-	12.70	7.72
	2	-	-	3.80	-	-	1.28
	3	-	-	-	-	-	-
MAY	1	0.40	15.72	6.80	-	-	5.36
	2	24.00	-	6.90	12.70	48.30	17.74
	3	-	16.80	5.80	41.90	-	11.34
JUN	1	184.80	124.70	55.60	44.50	91.19	86.99
	2	93.48	185.90	78.50	95.30	139.90	117.63
	3	74.56	65.90	76.70	73.70	45.70	66.62

TOTAL OF MAP = 1,166.60

SOURCE: FROM 1979-80 TO 1986-87 RECORDS OF EXISTING 5 RAIN GAUGE STATIONS INSTALLED IN THE CATCHMENT AREA

Table-2.A

10 - Daily observed Rainfall data within the Catchment Area = 450 Km^2

Jamrani (J)	=	39.00	Km2
Lugar (L)	=	87.00	Km2
Okhalkanda (O)	=	151.00	Km2
Paharpani (P)	=	66.00	Km2
Champi (C)	=	107.00	Km2
	Total =	**450.00**	Km2

1986 - 87		RAINFALL					MAP
Month.	Ten-daily	J (mm)	L (mm)	O (mm)	P (mm)	C (mm)	(mm)
JUL	1	405.00	27.50	278.75	193.50	236.50	218.57
	2	111.75	170.12	322.00	146.25	43.75	182.48
	3	173.68	175.12	160.00	93.50	118.50	144.49
AUG	1	160.96	44.00	37.50	31.75	29.75	46.77
	2	129.92	221.37	27.50	62.25	107.00	97.86
	3	89.96	117.75	11.25	46.75	31.50	48.68
SEP	1	-	7.50	-	1.00	-	1.60
	2	134.75	-	162.50	206.25	121.25	125.29
	3	49.75	90.50		62.50	65.75	46.61
OCT	1	10.35	-	-	15.50	17.50	7.33
	2	18.40	20.00	7.50	13.75	26.50	16.30
	3	11.20	-	-	-	-	0.97
NOV	1	-	-	-	-	-	-
	2	-	-	-	-	-	-
	3	11.20	10.12	11.20	11.20	10.25	10.77
DEC	1	-	-	-	-	-	-
	2	108.00	42.62	46.25	108.00	99.25	72.56
	3	3.20	-	-	3.20	-	0.75
JAN	1	-	-	-	-	-	-
	2	20.00	17.62		26.30	17.70	13.21
	3	-	-	-	-	-	-
FEB	1	40.00	-	-	3.25	-	3.94
	2	-	5.12	37.50	70.25	87.25	44.62
	3	-	-	-	-	0.50	0.12
MAR	1	15.00	-	8.75	7.00	-	5.26
	2	-	-	12.50	7.75	-	5.33
	3	12.00	-	3.75	13.75	13.00	7.41
APR	1	-	10.00	13.75	36.75	10.75	14.49
	2	19.20	-	-	-	-	1.66
	3	59.20	43.75	28.75	46.37	19.80	34.75
MAY	1	14.24	40.50	48.76	76.50	102.00	60.90
	2	-	2.87	31.25	15.25	11.75	16.07
	3	132.00	-	-	9.00	2.00	13.24
JUN	1	2.40	53.98	25.90	54.86	59.30	41.48
	2	-	-	-	-	-	-
	3	-	-	-	-	-	-

TOTAL OF MAP = 1,283.48

SOURCE: FROM 1979-80 TO 1986-87 RECORDS OF EXISTING 5 RAIN GAUGE STATIONS INSTALLED IN THE CATCHMENT AREA

Table-3.A

10 - Daily observed Rainfall data within the Catchment Area = 450 Km^2

Jamrani (J)	=	47.00	Km2
Lugar (L)	=	73.50	Km2
Okhalkanda (O)	=	77.00	Km2
Paharpani (P)	=	49.50	Km2
Champi (C)	=	60.00	Km2
Gunialekh (G)	=	69.00	Km2
Khansual (K)	=	74.00	Km2
Total	=	**450.00**	Km2

1987 - 88		**RAINFALL**							
Month.	Ten-daily	J (mm)	L (mm)	O (mm)	P (mm)	C (mm)	G (mm)	K (mm)	(MAP) (mm)
JUL	1	146.00	86.98	45.72	32.51	61.22	68.50	108.20	77.31
	2	277.20	214.76	144.78	111.25	96.01	184.75	265.43	185.82
	3	121.14	153.03	33.02	54.35	55.37	38.00	77.47	75.22
AUG	1	39.11	20.45	18.54	10.15	17.78	12.00	29.72	20.81
	2	171.70	168.12	213.36	89.92	143.51	77.72	143.51	146.44
	3	296.42	181.73	138.43	95.48	169.60	34.29	362.29	182.28
SEP	1	66.04	73.15	24.84	44.45	22.86	33.13	20.06	39.41
	2	12.44	-	-	10.92	2.54	12.70	1.27	5.00
	3	12.70	26.92	-	8.12	-	-	-	6.62
OCT	1	-	-	-	12.19	12.19	-	7.62	4.22
	2	12.70	50.16	-	28.45	11.43	-	6.35	15.22
	3	-	-	-	-	-	-	-	-
NOV	1	-	-	-	-	-	-	-	-
	2	-	-	-	-	15.24	-	-	2.03
	3	-	-	-	-	-	-	-	-
DEC	1	-	-	-	-	-	-	-	-
	2	-	15.24	17.70	22.60	-	-	20.32	11.35
	3	-		-	-	-	-	-	-
JAN	1	-	-	-	1.27	-	-	-	0.14
	2	2.54	-	8.89	20.07	1.52	-	8.64	5.62
	3	-	-	-	0.76	-	-	-	0.08
FEB	1	-	-	-	-	-	-	-	-
	2	8.13	-	6.35	13.21	7.37	1.26	10.67	6.32
	3	9.75	7.62	69.85	63.50	74.93	6.10	70.61	43.74
MAR	1	39.88	30.48	21.59	71.88	-	29.97	21.84	28.93
	2	45.47	35.56	69.85	56.39	-	5.08	83.06	43.15
	3	2.54	-	8.89	6.10	-	-	-	2.46
APR	1	-	-	-	-	-	-	-	-
	2	7.11	27.94	38.10	25.40	40.89	4.32	36.83	26.79
	3	2.03	6.98	-	15.74	13.72	2.79	11.94	7.30
MAY	1	12.23	8.89	64.77	60.96	-	6.35	35.56	27.34
	2	25.15	4.32	8.89	8.13	-	-	33.57	11.27
	3	11.18	13.20	-	10.67	-	3.05	29.97	9.89
JUN	1	11.43	40.51	36.58	38.86	40.64	17.78	29.67	31.37
	2	148.94	21.08	8.89	36.83	6.86	53.38	19.81	36.93
	3	221.12	101.09	-	73.91	95.76	148.59	78.23	96.15

TOTAL OF MAP = 1,149.21

SOURCE :

FROM 1987-88 TO 2005-06 RECORDS OF EXISTING 7 RAIN GAUGE STATIONS INSTALLED IN THE CATCHMENT AREA

Table-4.A

10 - Daily observed Rainfall data within the Catchment Area = 450 Km^2

Jamrani (J)	=	47.00	Km2
Lugar (L)	=	73.50	Km2
Okhalkanda (O)	=	77.00	Km2
Paharpani (P)	=	49.50	Km2
Champi (C)	=	60.00	Km2
Gunialekh (G)	=	69.00	Km2
Khansual (K)	=	74.00	Km2
Total	=	**450.00**	Km2

2005 - 06		RAINFALL							
Month.	Ten-daily	J (mm)	L (mm)	O (mm)	P (mm)	C (mm)	G (mm)	K (mm)	(MAP) (mm)
JUL	1	172.72	83.40	240.03	10.16	119.89	184.66	99.06	136.94
	2	100.86	116.33	154.94	107.19	71.88	138.94	76.21	114.74
	3	119.38	127.00	114.30	55.12	98.55	137.32	20.32	100.17
AUG	1	38.10	76.81	113.03	34.37	43.18	72.90	12.70	60.97
	2	218.44	218.68	88.90	88.90	39.70	85.09	-	108.41
	3	97.79	59.92	30.48	7.62	15.24	29.21	-	34.36
SEP	1	64.77	92.44	-	30.64	6.86	-	-	28.92
	2	123.17	166.11	204.47	41.87	179.83	309.88	10.41	157.77
	3	299.72	381.76	257.05	328.00	298.45	437.38	320.04	344.65
OCT	1	-	-	-	-	1.52	-	-	0.20
	2	-	-	13.97	-	3.81	-	-	2.90
	3	-	-	-	-	-	-	-	-
NOV	1	-	-	-	-	-	-	-	-
	2	-	-	-	-	-	-	-	-
	3	-	-	-	-	-	-	-	-
DEC	1	-	-	-	-	-	-	-	-
	2	-	-	-	-	-	-	-	-
	3	1.27	1.78	15.24	2.54	5.08	11.43	5.08	6.63
JAN	1	-	-	-	-	5.08	-	-	0.68
	2	-	-	-	-	-	-	-	-
	3	-	-	-	-	-	-	-	-
FEB	1	-	-	-	-	-	-	-	-
	2	-	-	-	-	-	-	-	-
	3	-	-	-	-	-	-	-	-
MAR	1	5.08	-	22.86		33.02	-	-	8.84
	2	29.72	41.65	77.47	38.10	52.07	130.05	39.37	61.96
	3	-	-	-	-	1.27	-	-	0.17
APR	1	-	-	-	2.29	-	-	-	0.25
	2	-	-	13.97	2.54	-	5.08	2.50	3.86
	3	-	6.60	-	-	-	3.81	3.81	2.49
MAY	1	33.02	-	-	22.86	3.81	-	6.35	7.52
	2	-	16.76	-	-	50.80	-	12.70	12.10
	3	38.10	47.61	-	12.70	27.94	-	-	18.30
JUN	1	88.90	54.35	100.33	11.43	72.39	90.17	-	61.69
	2	10.16	8.38	24.13	3.81	8.13	-	-	8.31
	3	42.16	138.17	123.19	76.20	81.28	87.63	24.13	88.81

TOTAL OF MAP = 1,371.65

SOURCE :

FROM 1987-88 TO 2005-06 RECORDS OF EXISTING 7 RAIN GAUGE STATIONS INSTALLED IN THE CATCHMENT AREA

Table-5.A

10 - Daily Discharge observed at Dam Site (Cumecs)

YEAR	10-DAY	JUL	AUG	SEP	OCT	NOV	DEC	JAN	FEB	MAR	APR	MAY	JUN	TOTAL
1976-1977	1									31.86	22.88	23.67	23.68	
	2									25.09	22.67	36.39	31.68	
	3									24.70	22.42	34.51	92.15	
TOTAL		-	-	-	-	-	-	-	-	**81.65**	**67.97**	**94.57**	**147.51**	-
1977-1978	1	75.20	184.62	206.93	128.05	85.72	63.10	44.68	38.51	57.92	27.50	16.43	14.34	943.000
	2	156.83	812.10	351.99	95.67	74.24	44.44	44.36	53.58	83.33	28.64	16.48	16.87	1,778.530
	3	463.58	218.68	176.20	99.54	61.05	53.74	45.83	28.78	54.47	24.53	19.35	99.42	1,345.170
TOTAL		**695.61**	**1,215.40**	**735.12**	**323.26**	**221.01**	**161.28**	**134.87**	**120.87**	**195.72**	**80.67**	**52.26**	**130.63**	**4,066.700**
1978-1979	1	450.00	926.66	988.82	170.77	80.02	61.43	42.83	48.89	61.82	34.78	21.80	18.85	2,906.670
	2	553.00	339.00	345.50	116.69	70.22	54.02	43.77	51.47	47.74	30.09	37.77	31.68	1,720.950
	3	209.00	357.00	230.00	102.23	65.67	49.21	55.76	53.64	45.22	27.33	32.53	96.00	1,323.590
TOTAL		**1,212.00**	**1,622.66**	**1,564.32**	**389.69**	**215.91**	**164.66**	**142.36**	**154.00**	**154.78**	**92.20**	**92.10**	**146.53**	**5,951.210**
1979-1980	1	82.77	126.82	138.84	83.22	43.37	27.37	28.01	27.84	32.57	20.76	18.04	19.39	649.000
	2	251.35	607.07	117.35	55.43	39.25	25.06	24.43	23.78	26.85	20.07	16.58	30.85	1,238.070
	3	396.05	370.06	97.64	54.12	33.44	28.26	26.04	19.81	21.75	19.86	15.58	38.93	1,121.540
TOTAL		**730.17**	**1,103.95**	**353.83**	**192.77**	**116.06**	**80.69**	**78.48**	**71.43**	**81.17**	**60.69**	**50.20**	**89.17**	**3,008.610**
1980-1981	1	134.07	501.54	517.36	215.47	65.56	35.38	30.64	34.57	25.98	22.14	18.64	17.05	1,618.400
	2	272.24	324.88	433.43	155.91	44.89	33.17	27.80	28.91	23.00	22.12	22.99	16.10	1,405.440
	3	504.37	178.07	393.12	115.62	36.99	35.05	68.51	21.26	25.34	21.06	19.56	281.62	1,700.570
TOTAL		**910.68**	**1,004.49**	**1,343.91**	**487.00**	**147.44**	**103.60**	**126.95**	**84.74**	**74.32**	**65.32**	**61.19**	**314.77**	**4,724.410**
1981-1982	1	192.02	472.00	184.36	77.00	40.00	46.00	36.30	40.00	54.00	34.50	40.00	45.23	1,261.410
	2	916.45	231.00	152.56	70.00	43.00	31.00	33.99	36.00	42.00	34.50	46.00	60.00	1,696.500
	3	816.57	198.00	51.56	78.00	50.00	35.50	39.86	24.00	45.50	32.00	35.70	46.00	1,452.690
TOTAL		**1,925.04**	**901.00**	**388.48**	**225.00**	**133.00**	**112.50**	**110.15**	**100.00**	**141.50**	**101.00**	**121.70**	**151.23**	**4,410.600**
1982-1983	1	77.11	291.28	1,027.02	442.66	50.98	33.42	32.78	25.31	33.44	18.78	31.47	21.96	2,086.210
	2	56.46	276.82	802.37	249.02	44.19	30.64	27.88	28.01	20.66	43.80	35.19	22.14	1,637.180
	3	370.04	1,559.09	838.82	68.87	37.21	35.62	33.59	20.92	22.78	44.93	51.49	130.86	3,214.220
TOTAL		**503.61**	**2,127.19**	**2,668.21**	**760.55**	**132.38**	**99.68**	**94.25**	**74.24**	**76.88**	**107.51**	**118.15**	**174.96**	**6,937.610**
1983-1984	1	144.08	242.00	298.11	354.76	68.91	57.30	55.09	67.57	13.15	13.36	13.15	29.16	1,356.640
	2	50.29	76.84	308.10	188.56	64.20	57.21	55.09	75.06	13.36	13.17	14.78	35.98	952.640
	3	655.74	121.90	1,819.88	139.16	60.21	57.24	62.05	88.30	14.75	13.14	19.67	368.71	3,420.750
TOTAL		**850.11**	**440.74**	**2,426.09**	**682.48**	**193.32**	**171.75**	**172.23**	**230.93**	**41.26**	**39.67**	**47.60**	**433.85**	**5,730.030**
1984-1985	1	523.76	1,190.47	1,062.50	685.33	38.41	23.62	23.52	16.97	14.82	11.16	12.53	9.52	3,612.610
	2	348.56	1,063.62	1,024.98	158.67	29.84	22.46	20.22	16.33	13.21	10.52	12.43	14.65	2,735.490
	3	1,352.27	1,395.48	960.99	54.77	27.24	22.91	19.12	12.43	12.82	9.91	12.41	31.07	3,911.420
TOTAL		**2,224.59**	**3,649.57**	**3,048.47**	**898.77**	**95.49**	**68.99**	**62.86**	**45.73**	**40.85**	**31.59**	**37.37**	**55.24**	**10,259.520**
1985-1986	1	70.50	608.68	547.22	437.62	183.32	78.74	57.37	34.20	37.54	24.69	20.87	22.46	2,123.210
	2	224.96	436.09	635.57	3,219.80	108.84	62.62	47.72	67.88	31.92	23.19	21.01	34.81	4,914.410
	3	922.98	880.49	382.59	404.23	84.53	71.79	44.41	34.47	31.55	22.18	28.13	92.59	2,999.940
TOTAL		**1,218.44**	**1,925.26**	**1,565.38**	**4,061.65**	**376.69**	**213.15**	**149.50**	**136.55**	**101.01**	**70.06**	**70.01**	**149.86**	**10,037.560**

YEAR	10-DAY	JUL	AUG	SEP	OCT	NOV	DEC	JAN	FEB	MAR	APR	MAY	JUN	TOTAL
1986-1987	1	656.89	970.98	414.94	458.14	187.52	91.79	88.78	57.18	29.18	18.95	46.26	80.79	3,101.400
	2	1,182.79	599.01	1,121.72	324.48	144.37	185.25	82.77	63.99	23.86	17.14	25.68	20.25	3,791.310
	3	1,253.21	896.32	605.43	228.94	102.52	151.94	76.76	39.85	22.98	15.74	18.35	17.92	3,429.960
TOTAL		**3,092.89**	**2,466.31**	**2,142.09**	**1,011.56**	**434.41**	**428.98**	**248.31**	**161.02**	**76.02**	**51.83**	**90.29**	**118.96**	**10,322.670**
1987-1988	1	139.82	127.00	353.50	34.03	39.30	29.49	26.54	21.04	20.98	19.91	55.66	15.48	882.750
	2	536.10	394.00	163.50	66.81	36.80	28.56	25.51	20.45	67.12	19.07	15.34	15.39	1,388.650
	3	292.50	957.00	170.00	70.32	32.38	27.38	27.02	17.83	24.99	19.25	16.54	36.66	1,691.870
TOTAL		**968.42**	**1,478.00**	**687.00**	**171.16**	**108.48**	**85.43**	**79.07**	**59.32**	**113.09**	**58.23**	**87.54**	**67.53**	**3,963.270**
1988-1989	1	188.54	340.50	139.42	130.78	43.22	32.75	51.12	26.65	20.41	18.22	14.82	15.66	1,022.090
	2	163.50	224.00	128.39	72.37	38.22	29.36	44.18	23.92	21.94	17.05	13.48	25.56	801.970
	3	321.00	171.00	192.81	59.95	42.03	33.10	33.11	18.20	20.38	15.82	15.35	52.16	974.910
TOTAL		**673.04**	**735.50**	**460.62**	**263.10**	**123.47**	**95.21**	**128.41**	**68.77**	**62.73**	**51.09**	**43.65**	**93.38**	**2,798.970**
1989-1990	1	40.13	445.00	763.00	178.30	49.37	36.79	27.14	22.89	185.34	35.79	20.21	21.10	1,825.060
	2	24.83	322.80	404.00	99.19	44.77	32.07	26.28	64.86	45.27	26.75	23.22	18.60	1,132.640
	3	591.00	563.00	286.00	75.61	43.75	32.19	26.82	61.88	43.11	20.82	26.84	30.36	1,801.380
TOTAL		**655.96**	**1,330.80**	**1,453.00**	**353.10**	**137.89**	**101.05**	**80.24**	**149.63**	**273.72**	**83.36**	**70.27**	**70.06**	**4,759.080**
1990-1991	1	2,208.61	1,417.00	802.00	225.00	62.35	36.16	57.25	21.36	36.11	18.31	15.38	19.02	4,918.550
	2	575.00	435.00	857.00	146.63	51.65	30.09	31.94	24.44	28.46	19.73	13.81	30.38	2,244.130
	3	404.00	1,160.00	363.00	89.42	45.41	75.12	27.98	23.87	24.28	16.73	24.96	22.89	2,277.660
TOTAL		**3,187.61**	**3,012.00**	**2,022.00**	**461.05**	**159.41**	**141.37**	**117.17**	**69.67**	**88.85**	**54.77**	**54.15**	**72.29**	**9,440.340**
1991-1992	1	22.92	144.62	120.78	68.58	29.03	27.75	28.18	34.74	20.07	15.76	13.18	19.41	545.020
	2	26.13	124.18	97.94	47.66	37.93	24.07	27.86	31.46	18.32	14.91	12.37	22.41	485.240
	3	53.33	182.16	96.63	41.28	29.26	39.36	30.19	20.41	19.19	13.73	14.13	69.35	609.020
TOTAL		**102.38**	**450.96**	**315.35**	**157.52**	**96.22**	**91.18**	**86.23**	**86.61**	**57.58**	**44.40**	**39.68**	**111.17**	**1,639.280**
1992-1993	1	27.49	239.90	47.84	16.44	37.51	17.68	20.81	18.40	18.40	22.74	14.67	12.63	494.510
	2	40.34	85.89	67.10	47.09	32.39	25.37	20.46	18.62	18.73	17.99	16.24	13.25	403.470
	3	265.94	107.96	25.46	54.02	31.82	25.97	20.85	15.50	40.83	15.88	14.94	16.05	635.220
TOTAL		**333.77**	**433.75**	**140.40**	**117.55**	**101.72**	**69.02**	**62.12**	**52.52**	**77.96**	**56.61**	**45.85**	**41.93**	**1,533.200**
1993-1994	1	32.61	280.23	1,588.86	46.46	63.01	35.29	28.76	20.27	24.92	19.02	14.96	14.67	2,169.060
	2	94.24	194.89	3,108.50	59.43	47.59	32.67	34.72	29.24	22.48	16.72	18.28	13.77	3,672.530
	3	407.97	127.83	320.10	84.70	37.61	33.70	32.71	25.83	22.74	15.59	16.44	26.35	1,151.570
TOTAL		**534.82**	**602.95**	**5,017.46**	**190.59**	**148.21**	**101.66**	**96.19**	**75.34**	**70.14**	**51.33**	**49.68**	**54.79**	**6,993.160**
1994-1995	1	36.35	213.76	91.46	72.47	38.35	26.37	27.91	25.99	24.98	21.14	18.50	13.61	610.890
	2	67.00	333.25	78.02	59.33	33.62	24.80	31.53	24.95	25.03	20.65	16.82	12.14	727.140
	3	94.00	193.29	59.84	47.81	29.18	26.70	27.71	21.57	24.05	19.40	16.88	63.14	623.570
TOTAL		**197.35**	**740.30**	**229.32**	**179.61**	**101.15**	**77.87**	**87.15**	**72.51**	**74.06**	**61.19**	**52.20**	**88.89**	**1,961.600**
1995-1996	1	53.69	60.31	1,961.25	107.97	39.78	30.48	23.83	23.80	26.64	19.99	13.74	18.49	2,379.970
	2	120.51	464.97	321.62	70.76	33.69	28.11	28.51	26.74	22.11	16.10	14.02	40.80	1,187.940
	3	62.07	139.81	155.39	68.13	31.59	28.69	27.62	27.85	24.39	14.39	13.76	140.08	733.770
TOTAL		**236.27**	**665.09**	**2,438.26**	**246.86**	**105.06**	**87.28**	**79.96**	**78.39**	**73.14**	**50.48**	**41.52**	**199.37**	**4,301.680**
1996-1997	1	121.32	138.83	520.97	75.80	42.23	34.91	27.82	25.26	20.90	29.07	20.38	15.58	1,073.070
	2	185.66	243.63	261.96	61.89	42.91	31.29	26.45	22.54	21.52	20.04	17.07	18.07	953.030
	3	124.16	376.57	133.54	60.05	37.82	31.86	29.94	16.77	21.44	18.62	16.57	34.60	901.940
TOTAL		**431.14**	**759.03**	**916.47**	**197.74**	**122.96**	**98.06**	**84.21**	**64.57**	**63.86**	**67.73**	**54.02**	**68.25**	**2,928.040**

YEAR	10-DAY	JUL	AUG	SEP	OCT	NOV	DEC	JAN	FEB	MAR	APR	MAY	JUN	TOTAL
1997-1998	1	46.29	209.20	76.60	69.00	51.31	52.08	43.75	31.00	33.23	36.62	41.94	17.85	708.870
	2	81.20	138.10	75.80	63.00	48.34	61.55	41.45	30.00	33.54	34.48	28.88	46.00	682.340
	3	79.10	82.50	71.00	67.90	42.93	45.52	36.86	24.47	35.30	29.98	22.40	102.50	640.460
TOTAL		**206.59**	**429.80**	**223.40**	**199.90**	**142.58**	**159.15**	**122.06**	**85.47**	**102.07**	**101.08**	**93.22**	**166.35**	**2,031.670**
1998-1999	1													
	2													
	3													
TOTAL														
1999-2000	1	468.07	845.16	472.79	346.81	110.44	36.09	26.02	34.32	19.07	14.80	17.13	1,436.36	3,827.060
	2	459.17	498.85	818.88	254.75	75.23	36.07	22.18	27.71	17.43	15.62	14.50	946.23	3,186.620
	3	864.68	444.66	552.23	207.27	41.35	32.78	21.50	20.52	17.63	15.68	17.31	1,451.84	3,687.450
TOTAL		**1,791.92**	**1,788.67**	**1,843.90**	**808.83**	**227.02**	**104.94**	**69.70**	**82.55**	**54.13**	**46.10**	**48.94**	**3,834.43**	**10,701.130**
2000-2001	1	976.41	1,001.12	2,711.28	646.92	123.24	32.59	24.71	17.92	16.16	14.19	12.21	28.03	5,604.780
	2	1,839.71	2,839.24	1,083.72	207.78	59.25	29.07	21.41	18.22	15.09	14.45	14.25	19.89	6,162.080
	3	1,563.94	2,312.50	751.29	212.44	39.99	26.09	21.54	14.40	15.54	13.88	14.88	412.60	5,399.090
TOTAL		**4,380.06**	**6,152.86**	**4,546.29**	**1,067.14**	**222.48**	**87.75**	**67.66**	**50.54**	**46.79**	**42.52**	**41.34**	**460.52**	**17,165.950**
2001-2002	1	524.60	622.50	263.58	153.04	50.42	22.76	18.47	19.23	56.86	18.39	18.88	20.92	1,789.650
	2	535.68	690.67	201.40	34.74	32.27	21.23	18.16	68.54	19.45	16.93	16.31	23.68	1,679.060
	3	749.21	429.60	327.97	68.37	25.61	21.67	20.95	16.72	20.60	19.85	17.45	24.67	1,742.670
TOTAL		**1,809.49**	**1,742.77**	**792.95**	**256.15**	**108.30**	**65.66**	**57.58**	**104.49**	**96.91**	**55.17**	**52.64**	**69.27**	**5,211.380**
2002-2003	1	257.84	157.33	1,115.17	283.52	53.17	26.42	23.63	28.63	232.25	18.31	14.70	13.51	2,224.480
	2	174.58	515.04	830.52	257.45	42.06	24.85	21.52	418.79	49.38	16.68	13.56	13.61	2,378.040
	3	170.36	376.91	342.22	351.66	33.17	23.66	23.50	212.92	26.46	15.35	14.05	16.48	1,606.740
TOTAL		**602.78**	**1,049.28**	**2,287.91**	**892.63**	**128.40**	**74.93**	**68.65**	**660.34**	**308.09**	**50.34**	**42.31**	**43.60**	**6,209.260**
2003-2004	1	21.33	279.45	246.44	330.37	155.08	44.56	22.95	24.42	18.24	15.64	16.04	24.94	1,199.460
	2	1,148.40	869.70	417.04	229.81	159.59	34.19	21.62	21.87	17.54	14.59	13.04	28.43	2,975.820
	3	236.94	749.92	1,074.73	182.76	151.80	29.52	23.70	17.87	17.99	17.31	19.15	20.11	2,541.800
TOTAL		**1,406.67**	**1,899.07**	**1,738.21**	**742.94**	**466.47**	**108.27**	**68.27**	**64.16**	**53.77**	**47.54**	**48.23**	**73.48**	**6,717.080**
2004-2005	1	169.25	193.58	255.37	206.91	64.97	30.32	19.19	30.84	19.23	15.15	13.29	13.93	1,032.030
	2	223.37	266.69	202.62	283.04	49.81	25.72	23.66	34.70	17.23	13.76	12.63	12.08	1,165.310
	3	177.06	2,192.08	481.59	205.84	40.39	23.39	34.75	18.12	17.10	13.42	13.86	43.76	3,261.360
TOTAL		**569.68**	**2,652.35**	**939.58**	**695.79**	**155.17**	**79.43**	**77.60**	**83.66**	**53.56**	**42.33**	**39.78**	**69.77**	**5,458.700**
2005-2006	1	134.18	64.92	90.00	276.05	81.56	40.58	20.90	19.12	18.10	16.83	13.77	20.34	796.350
	2	222.56	126.60	289.78	159.47	77.24	32.48	22.60	18.89	20.32	15.91	19.76	14.58	1,020.190
	3	116.64	129.52	2,401.21	114.95	65.65	24.96	23.41	14.12	20.40	14.51	17.20	19.90	2,962.470
TOTAL		**473.38**	**321.04**	**2,780.99**	**550.47**	**224.45**	**98.02**	**66.91**	**52.13**	**58.82**	**47.25**	**50.73**	**54.82**	**4,779.010**

Table-6.A

10 - Daily Discharge observed at Gola Barrage (Cumecs)

YEAR	10-DAY	JUL	AUG	SEP	OCT	NOV	DEC	JAN	FEB	MAR	APR	MAY	JUN	TOTAL
1948-1949	1	201.30	505.30	1,316.90	369.20	159.80	131.10	63.40	421.70	77.80	45.00	58.90	283.90	3,634.30
	2	243.90	1,631.20	814.90	520.80	176.90	105.30	55.50	57.90	45.30	60.50	70.50	46.20	3,828.90
	3	288.90	5,452.20	568.90	255.40	152.90	75.70	55.00	56.00	48.20	39.60	108.30	76.30	7,177.40
TOTAL		**734.10**	**7,588.70**	**2,700.70**	**1,145.40**	**489.60**	**312.10**	**173.90**	**535.60**	**171.30**	**145.10**	**237.70**	**406.40**	**14,640.60**
1949-1950	1	321.80	1,450.90	1,327.60	861.80	124.70	88.90	69.00	83.60	52.60	49.70	39.70	50.90	4,521.20
	2	1,322.20	2,500.30	1,348.50	314.20	124.60	79.80	63.00	83.80	50.00	42.60	55.30	1,096.50	7,080.80
	3	1,681.40	2,976.90	2,381.30	277.90	108.50	84.10	72.20	46.80	642.80	40.30	83.00	992.60	9,387.80
TOTAL		**3,325.40**	**6,928.10**	**5,057.40**	**1,453.90**	**357.80**	**252.80**	**204.20**	**214.20**	**745.40**	**132.60**	**178.00**	**2,140.00**	**20,989.80**
1950-1951	1	1,757.60	3,538.70	1,628.40	427.20	152.20	125.80	80.80	87.50	48.70	50.10	71.00	71.30	8,039.30
	2	1,945.40	4,082.30	1,742.20	225.10	138.50	110.40	80.60	67.80	48.20	47.30	86.20	39.80	8,613.80
	3	3,312.90	2,936.90	1,309.80	183.00	121.00	102.30	73.80	39.30	60.60	41.90	41.00	131.50	8,354.00
TOTAL		**7,015.90**	**10,557.90**	**4,680.40**	**835.30**	**411.70**	**338.50**	**235.20**	**194.60**	**157.50**	**139.30**	**198.20**	**242.60**	**25,007.10**
1951-1952	1	67.10	659.00	41.20	292.60	111.90	91.20	80.40	58.40	74.30	60.50	65.30	71.30	1,673.20
	2	467.60	273.00	44.80	187.40	95.20	87.60	78.40	65.90	72.50	60.50	69.70	129.50	1,632.10
	3	609.00	5,013.40	43.00	158.50	96.60	85.90	81.10	64.10	79.10	58.30	73.20	949.30	7,311.50
TOTAL		**1,143.70**	**5,945.40**	**129.00**	**638.50**	**303.70**	**264.70**	**239.90**	**188.40**	**225.90**	**179.30**	**208.20**	**1,150.10**	**10,616.80**
1952-1953	1	161.60	2,200.00	1,431.70	158.50	112.10	52.90	41.70	40.00	35.70	31.20	35.70	33.90	4,335.00
	2	1,240.50	2,805.00	1,687.80	143.20	106.60	49.10	72.00	39.90	35.70	29.60	44.40	221.20	6,475.00
	3	612.10	2,665.30	288.00	142.90	82.30	46.00	64.50	28.90	37.30	29.20	46.90	1,436.90	5,480.30
TOTAL		**2,014.20**	**7,670.30**	**3,407.50**	**444.60**	**301.00**	**148.00**	**178.20**	**108.80**	**108.70**	**90.00**	**127.00**	**1,692.00**	**16,290.30**
1953-1954	1	437.50	634.60	1,637.40	194.70	107.70	67.80	172.80	106.80	85.80	64.70	43.40	26.80	3,580.00
	2	3,421.50	416.40	563.60	175.40	102.90	60.40	60.50	102.30	74.00	47.10	49.50	108.70	5,182.30
	3	2,988.80	1,012.40	369.60	147.40	90.20	60.00	70.50	66.50	86.30	42.20	55.60	194.90	5,184.40
TOTAL		**6,847.80**	**2,063.40**	**2,570.60**	**517.50**	**300.80**	**188.20**	**303.80**	**275.60**	**246.10**	**154.00**	**148.50**	**330.40**	**13,946.70**
1954-1955	1	94.40	1,226.30	692.60	2,368.00	257.90	131.60	91.50	60.70	65.90	32.00	34.90	48.10	5,103.90
	2	603.20	1,599.20	646.70	806.60	197.10	117.20	90.40	73.80	62.60	32.50	39.30	46.60	4,315.20
	3	1,746.00	1,530.10	511.10	361.80	153.40	108.60	123.00	52.80	56.70	32.50	62.80	258.90	4,997.70
TOTAL		**2,443.60**	**4,355.60**	**1,850.40**	**3,536.40**	**608.40**	**357.40**	**304.90**	**187.30**	**185.20**	**97.00**	**137.00**	**353.60**	**14,416.80**
1955-1956	1	1,171.50	1,333.80	883.40	3,833.40	417.00	210.70	121.90	79.60	62.10	60.10	37.90	2,179.70	10,391.10
	2	894.30	1,911.90	623.30	2,416.90	275.00	188.40	99.70	67.90	71.90	56.20	76.60	1,281.20	7,963.30
	3	912.50	1,021.50	854.70	767.50	223.90	163.20	96.20	56.90	72.40	43.30	826.60	829.40	5,868.10
TOTAL		**2,978.30**	**4,267.20**	**2,361.40**	**7,017.80**	**915.90**	**562.30**	**317.80**	**204.40**	**206.40**	**159.60**	**941.10**	**4,290.30**	**24,222.50**
1956-1957	1	3,501.50	1,013.40	1,142.90	1,100.70	529.60	168.90	114.10	76.50	59.00	53.50	35.10	42.80	7,838.00
	2	844.90	925.20	722.90	1,864.90	291.40	120.80	126.40	56.20	60.40	106.10	44.00	41.70	5,204.90
	3	955.20	128.40	530.30	803.80	204.80	115.50	110.50	39.00	16.30	46.00	50.00	50.30	3,050.10
TOTAL		**5,301.60**	**2,067.00**	**2,396.10**	**3,769.40**	**1,025.80**	**405.20**	**351.00**	**171.70**	**135.70**	**205.60**	**129.10**	**134.80**	**16,093.00**
1957-1958	1	141.60	566.40	472.20	211.60	191.50	91.60	86.90	75.50	57.70	26.10	49.70	48.20	2,019.00
	2	402.90	297.80	1,720.60	194.10	111.70	139.50	72.50	68.70	50.80	24.60	121.40	41.00	3,245.60
	3	1,258.70	483.30	257.90	136.30	103.20	110.40	86.60	51.20	51.50	21.90	57.20	40.00	2,658.20
TOTAL		**1,803.20**	**1,347.50**	**2,450.70**	**542.00**	**406.40**	**341.50**	**246.00**	**195.40**	**160.00**	**72.60**	**228.30**	**129.20**	**7,922.80**

YEAR	10-DAY	JUL	AUG	SEP	OCT	NOV	DEC	JAN	FEB	MAR	APR	MAY	JUN	TOTAL
1958-1959	1	1,357.80	422.90	571.30	1,062.60	250.50	142.50	91.30	74.00	77.50	53.20	42.40	52.20	4,198.20
	2	1,100.70	280.70	478.90	431.90	224.30	103.40	80.00	87.40	59.90	46.00	51.70	57.00	3,001.90
	3	1,727.80	1,163.00	1,123.50	373.30	181.10	127.70	96.50	67.10	59.50	44.90	63.70	70.90	5,099.00
TOTAL		**4,186.30**	**1,866.60**	**2,173.70**	**1,867.80**	**655.90**	**373.60**	**267.80**	**228.50**	**196.90**	**144.10**	**157.80**	**180.10**	**12,299.10**
1959-1960	1	669.10	1,030.80	435.20	501.00	242.90	128.20	76.90	71.40	55.30	54.00	41.20	44.50	3,350.50
	2	375.90	1,002.90	714.10	377.30	223.80	97.30	76.60	66.10	56.90	49.20	48.60	43.40	3,132.10
	3	983.60	747.00	615.30	310.90	163.90	93.70	84.90	44.70	60.00	45.60	50.70	51.50	3,251.80
TOTAL		**2,028.60**	**2,780.70**	**1,764.60**	**1,189.20**	**630.60**	**319.20**	**238.40**	**182.20**	**172.20**	**148.80**	**140.50**	**139.40**	**9,734.40**
1960-1961	1	181.40	912.70	1,496.30	960.60	199.10	65.80	139.10	118.90	64.00	45.20	37.20	79.30	4,299.60
	2	1,123.00	880.20	1,179.30	494.30	167.00	83.10	95.90	114.80	71.00	37.80	51.80	205.40	4,503.60
	3	536.70	1,148.80	616.00	339.90	146.90	76.70	87.40	79.80	65.70	35.70	62.20	258.60	3,454.40
TOTAL		**1,841.10**	**2,941.70**	**3,291.60**	**1,794.80**	**513.00**	**225.60**	**322.40**	**313.50**	**200.70**	**118.70**	**151.20**	**543.30**	**12,257.60**
1961-1962	1	962.60	1,390.00	628.90	236.30	252.40	122.70	100.70	124.90	255.40	62.90	45.50	54.80	4,237.10
	2	1,068.20	1,934.00	419.70	593.60	184.50	149.10	95.00	96.80	79.10	54.80	46.70	215.00	4,936.50
	3	952.90	1,606.10	310.20	358.80	157.80	143.20	226.10	105.60	78.30	50.00	59.10	257.00	4,305.10
TOTAL		**2,983.70**	**4,930.10**	**1,358.80**	**1,188.70**	**594.70**	**415.00**	**421.80**	**327.30**	**412.80**	**167.70**	**151.30**	**526.80**	**13,478.70**
1962-1963	1	117.00	351.90	289.50	348.00	149.20	108.50	78.00	70.90	64.10	64.10	60.40	69.30	1,770.90
	2	191.50	799.00	235.80	277.30	140.90	99.50	78.90	67.50	75.90	58.40	67.30	82.20	2,174.20
	3	780.50	650.60	2,853.80	198.00	116.60	90.00	84.90	49.90	76.60	52.10	58.40	73.80	5,085.20
TOTAL		**1,089.00**	**1,801.50**	**3,379.10**	**823.30**	**406.70**	**298.00**	**241.80**	**188.30**	**216.60**	**174.60**	**186.10**	**225.30**	**9,030.30**
1963-1964	1	276.60	477.50	1,215.00	361.30	192.00	134.20	93.30	93.50	79.80	51.60	56.30	62.30	3,093.40
	2	380.20	739.50	1,224.30	293.70	163.10	136.40	91.80	35.20	73.80	47.00	61.80	66.90	3,313.70
	3	500.30	2,824.80	586.70	267.80	150.20	105.10	95.80	76.40	58.70	50.80	79.00	131.20	4,926.80
TOTAL		**1,157.10**	**4,041.80**	**3,026.00**	**922.80**	**505.30**	**375.70**	**280.90**	**205.10**	**212.30**	**149.40**	**197.10**	**260.40**	**11,333.90**
1964-1965	1	754.20	1,153.90	1,400.30	622.90	162.20	108.20	78.00	66.10	61.00	78.30	39.80	52.00	4,576.90
	2	1,129.50	768.10	967.40	257.50	137.60	110.20	95.50	78.80	56.40	60.00	52.20	47.40	3,760.60
	3	2,170.20	932.50	1,519.10	216.90	122.50	84.50	119.60	67.90	81.80	51.10	61.10	55.80	5,483.00
TOTAL		**4,053.90**	**2,854.50**	**3,886.80**	**1,097.30**	**422.30**	**302.90**	**293.10**	**212.80**	**199.20**	**189.40**	**153.10**	**155.20**	**13,820.50**
1965-1966	1	176.90	758.70	554.00	157.80	99.90	68.60	50.50	41.80	41.00	36.60	30.20	44.20	2,060.20
	2	313.70	313.30	329.10	130.50	78.20	62.50	50.60	45.80	38.70	33.00	35.30	44.90	1,475.60
	3	287.10	1,232.90	211.20	124.90	72.00	57.70	49.80	29.10	40.40	29.60	51.40	279.80	2,465.90
TOTAL		**777.70**	**2,304.90**	**1,094.30**	**413.20**	**250.10**	**188.80**	**150.90**	**116.70**	**120.10**	**99.20**	**116.90**	**368.90**	**6,001.70**
1966-1967	1	169.90	1,028.50	329.80	155.80	106.60	70.90	65.70	57.10	48.90	61.90	53.80	63.20	2,212.10
	2	148.10	559.50	292.10	130.70	93.60	61.40	61.60	50.80	51.90	59.30	57.80	59.70	1,626.50
	3	807.60	439.30	183.00	122.70	79.10	73.30	64.70	40.70	93.70	61.10	65.10	72.80	2,103.10
TOTAL		**1,125.60**	**2,027.30**	**804.90**	**409.20**	**279.30**	**205.60**	**192.00**	**148.60**	**194.50**	**182.30**	**176.70**	**195.70**	**5,941.70**
1967-1968	1	495.70	840.30	988.30	284.10	142.70	99.50	81.00	91.50	78.10	55.30	45.70	69.40	3,271.60
	2	909.30	873.50	908.90	210.50	110.20	88.40	76.20	81.30	61.90	46.50	54.00	237.60	3,658.30
	3	803.80	2,260.60	461.80	204.30	103.50	93.70	97.30	90.80	71.00	48.60	65.50	873.60	5,174.50
TOTAL		**2,208.80**	**3,974.40**	**2,359.00**	**698.90**	**356.40**	**281.60**	**254.50**	**263.60**	**211.00**	**150.40**	**165.20**	**1,180.60**	**12,104.40**
1968-1969	1	422.10	315.80	251.80	250.30	109.50	81.40	69.40	56.10	50.80	42.00	45.80	44.10	1,739.10
	2	412.00	902.90	277.90	140.10	99.10	77.20	76.60	57.10	42.50	42.00	72.40	40.50	2,240.30
	3	386.60	719.20	362.60	101.80	89.90	85.70	70.60	43.30	45.50	38.50	68.40	57.00	2,069.10
TOTAL		**1,220.70**	**1,937.90**	**892.30**	**492.20**	**298.50**	**244.30**	**216.60**	**156.50**	**138.80**	**122.50**	**186.60**	**141.60**	**6,048.50**

YEAR	10-DAY	JUL	AUG	SEP	OCT	NOV	DEC	JAN	FEB	MAR	APR	MAY	JUN	TOTAL
1969-1970	1	71.80	850.50	755.50	492.60	150.40	100.50	72.10	64.80	43.80	33.00	30.30	184.30	2,849.60
	2	800.70	485.30	684.40	271.60	119.90	90.30	109.20	58.60	37.10	30.80	33.80	424.30	3,146.00
	3	641.70	968.10	2,168.40	250.50	111.20	90.70	87.20	43.40	40.10	29.30	50.30	955.30	5,436.20
TOTAL		**1,514.20**	**2,303.90**	**3,608.30**	**1,014.70**	**381.50**	**281.50**	**268.50**	**166.80**	**121.00**	**93.10**	**114.40**	**1,563.90**	**11,431.80**
1970-1971	1	536.80	467.80	518.70	202.10	103.70	68.90	36.70	35.30	46.50	25.20	24.40	182.00	2,248.10
	2	179.70	910.30	359.70	141.00	94.10	58.30	34.80	29.80	32.10	24.30	94.00	570.40	2,528.50
	3	439.20	551.70	268.30	114.10	70.40	48.30	42.30	24.80	32.90	22.50	151.60	196.60	1,962.70
TOTAL		**1,155.70**	**1,929.80**	**1,146.70**	**457.20**	**268.20**	**175.50**	**113.80**	**89.90**	**111.50**	**72.00**	**270.00**	**949.00**	**6,739.30**
1971-1972	1	972.20	410.50	1,008.10	152.70	124.70	80.20	47.60	51.80	40.70	26.00	22.20	29.60	2,966.30
	2	312.40	615.60	473.30	143.00	86.30	77.60	47.00	47.10	34.40	24.80	32.50	29.20	1,923.20
	3	321.80	375.00	200.40	135.10	93.70	64.80	87.60	26.60	32.20	24.00	28.10	43.90	1,433.20
TOTAL		**1,606.40**	**1,401.10**	**1,681.80**	**430.80**	**304.70**	**222.60**	**182.20**	**125.50**	**107.30**	**74.80**	**82.80**	**102.70**	**6,322.70**
1972-1973	1	268.70	251.70	303.80	197.60	110.50	72.80	48.50	36.60	35.00	27.80	28.20	44.30	1,425.50
	2	458.00	435.00	1,148.70	181.90	94.60	62.80	47.80	36.60	45.50	28.60	31.00	142.50	2,713.00
	3	325.50	294.30	261.20	224.80	69.10	52.40	60.30	24.40	35.90	27.80	47.10	319.20	1,742.00
TOTAL		**1,052.20**	**981.00**	**1,713.70**	**604.30**	**274.20**	**188.00**	**156.60**	**97.60**	**116.40**	**84.20**	**106.30**	**506.00**	**5,880.50**
1973-1974	1	182.00	534.00	272.90	291.10	160.60	94.10	64.40	48.50	32.70	31.40	26.20	33.50	1,771.40
	2	192.20	345.40	380.20	210.80	123.10	85.80	47.40	51.70	31.20	29.20	27.60	58.80	1,583.40
	3	286.00	310.00	252.60	201.10	105.10	81.30	52.70	31.10	35.50	27.40	30.50	36.10	1,449.40
TOTAL		**660.20**	**1,189.40**	**905.70**	**703.00**	**388.80**	**261.20**	**164.50**	**131.30**	**99.40**	**88.00**	**84.30**	**128.40**	**4,804.20**
1974-1975	1	69.30	363.10	208.00	95.00	59.20	45.80	69.30	72.70	51.40	32.20	24.20	36.40	1,126.60
	2	77.90	291.10	174.20	87.00	53.00	50.30	55.20	75.70	46.30	28.80	25.90	50.50	1,015.90
	3	554.40	263.60	124.60	79.40	48.90	57.50	89.00	57.00	44.80	27.60	33.20	444.70	1,824.70
TOTAL		**701.60**	**917.80**	**506.80**	**261.40**	**161.10**	**153.60**	**213.50**	**205.40**	**142.50**	**88.60**	**83.30**	**531.60**	**3,967.20**
1975-1976	1	607.80	905.80	1,239.50	291.00	129.00	82.00	61.00	50.70	51.70	34.90	37.40	44.20	3,535.00
	2	546.40	432.40	856.90	236.00	116.50	83.20	57.80	69.30	41.80	40.90	56.20	76.20	2,613.60
	3	373.40	427.90	422.40	203.20	97.10	74.40	59.50	57.70	39.30	33.20	40.90	53.20	1,882.20
TOTAL		**1,527.60**	**1,766.10**	**2,518.80**	**730.20**	**342.60**	**239.60**	**178.30**	**177.70**	**132.80**	**109.00**	**134.50**	**173.60**	**8,030.80**
1976-1977	1	70.90	466.70	296.00	204.80	97.90	75.20	48.00	48.50	35.60	27.70	39.80	30.10	1,441.20
	2	240.80	1,445.30	299.00	146.00	92.20	68.50	42.50	43.70	30.30	28.90	47.20	32.10	2,516.50
	3	433.00	542.20	250.90	128.20	79.20	73.80	46.20	31.60	32.70	27.10	34.30	84.50	1,763.70
TOTAL		**744.70**	**2,454.20**	**845.90**	**479.00**	**269.30**	**217.50**	**136.70**	**123.80**	**98.60**	**83.70**	**121.30**	**146.70**	**5,721.40**
1977-1978	1	136.10	235.70	257.30	194.40	108.20	67.10	55.90	37.20	46.70	38.70	32.90	50.70	1,260.90
	2	241.50	1,146.70	407.20	166.00	96.90	57.00	91.30	68.10	87.90	37.00	29.90	71.80	2,501.30
	3	516.00	309.10	241.60	142.70	82.60	67.80	45.70	27.90	70.90	35.70	37.30	102.70	1,680.00
TOTAL		**893.60**	**1,691.50**	**906.10**	**503.10**	**287.70**	**191.90**	**192.90**	**133.20**	**205.50**	**111.40**	**100.10**	**225.20**	**5,442.20**
1978-1979	1	706.40	1,235.30	1,335.40	342.70	119.30	93.60	50.40	67.50	78.70	41.20	33.70	36.30	4,140.50
	2	388.20	545.50	454.70	325.90	109.60	79.60	56.50	70.30	63.80	37.30	69.70	90.30	2,291.40
	3	378.30	530.20	292.90	150.30	105.00	71.50	70.20	63.70	56.00	36.00	45.70	216.80	2,016.60
TOTAL		**1,472.90**	**2,311.00**	**2,083.00**	**818.90**	**333.90**	**244.70**	**177.10**	**201.50**	**198.50**	**114.50**	**149.10**	**343.40**	**8,448.50**
1979-1980	1	189.30	185.50	199.80	97.70	55.80	41.50	39.60	38.90	47.60	25.50	14.90	34.10	970.20
	2	396.80	765.50	151.20	85.00	40.60	39.30	38.80	31.50	33.20	21.40	14.40	55.10	1,672.80
	3	415.40	363.40	127.60	73.90	66.80	48.20	36.60	26.30	29.10	18.20	16.80	54.70	1,277.00
TOTAL		**1,001.50**	**1,314.40**	**478.60**	**256.60**	**163.20**	**129.00**	**115.00**	**96.70**	**109.90**	**65.10**	**46.10**	**143.90**	**3,920.00**

YEAR	10-DAY	JUL	AUG	SEP	OCT	NOV	DEC	JAN	FEB	MAR	APR	MAY	JUN	TOTAL
1980-1981	1	376.90	565.80	695.80	194.60	92.60	69.30	53.10	57.10	41.20	42.00	18.40	33.50	2,240.30
	2	400.90	421.50	333.40	134.50	80.90	53.60	52.50	49.30	36.60	36.90	26.50	35.20	1,661.80
	3	376.80	354.40	245.50	122.60	77.70	64.10	80.60	33.10	48.90	34.90	30.10	1,044.80	2,513.50
TOTAL		**1,154.60**	**1,341.70**	**1,274.70**	**451.70**	**251.20**	**187.00**	**186.20**	**139.50**	**126.70**	**113.80**	**75.00**	**1,113.50**	**6,415.60**
1981-1982	1	392.50	650.90	213.40	103.60	70.40	47.50	30.30	28.30	49.60	26.90	23.30	25.60	1,662.30
	2	1,143.60	350.80	184.80	68.80	60.20	43.20	25.70	22.00	48.00	23.50	64.90	28.70	2,064.20
	3	604.40	264.20	103.90	65.30	46.40	41.20	29.20	20.10	44.90	31.30	33.00	25.80	1,309.70
TOTAL		**2,140.50**	**1,265.90**	**502.10**	**237.70**	**177.00**	**131.90**	**85.20**	**70.40**	**142.50**	**81.70**	**121.20**	**80.10**	**5,036.20**
1982-1983	1	21.60	226.50	553.40	120.40	56.50	27.60	33.30	34.80	14.40	10.80	30.60	28.50	1,158.40
	2	33.90	208.90	347.30	96.30	47.40	29.50	28.90	30.00	19.30	18.80	43.60	28.10	932.00
	3	57.50	1,209.70	180.10	75.40	36.90	35.70	52.60	19.60	11.90	43.90	70.90	63.00	1,857.20
TOTAL		**113.00**	**1,645.10**	**1,080.80**	**292.10**	**140.80**	**92.80**	**114.80**	**84.40**	**45.60**	**73.50**	**145.10**	**119.60**	**3,947.60**
1983-1984	1	248.50	147.90	172.40	315.70	98.60	37.80	54.50	42.10	54.50	33.10	23.50	332.70	1,561.30
	2	183.80	186.40	181.80	141.40	81.50	53.50	57.10	215.20	41.10	30.90	31.90	84.80	1,289.40
	3	459.20	203.40	166.80	143.10	78.10	55.30	56.90	87.49	44.90	30.10	41.00	401.30	1,767.59
TOTAL		**891.50**	**537.70**	**521.00**	**600.20**	**258.20**	**146.60**	**168.50**	**344.79**	**140.50**	**94.10**	**96.40**	**818.80**	**4,618.29**
1984-1985	1	508.41	345.63	357.00	129.05	66.72	49.60	64.32	36.57	30.03	219.17	35.95	25.08	1,867.53
	2	164.00	188.71	229.33	93.45	57.63	46.71	46.76	34.99	26.98	24.97	24.23	75.33	1,013.09
	3	1,673.38	412.21	153.96	80.92	55.66	49.23	44.50	26.21	27.54	21.26	45.97	245.27	2,836.11
TOTAL		**2,345.79**	**946.55**	**740.29**	**303.42**	**180.01**	**145.54**	**155.58**	**97.77**	**84.55**	**265.40**	**106.15**	**345.68**	**5,716.73**
1985-1986	1	399.73	832.62	1,037.70	589.83	197.23	108.48	79.24	49.23	50.19	41.70	36.94	38.50	3,461.39
	2	514.70	792.54	768.19	3,159.02	129.74	99.34	65.45	135.15	45.55	39.20	69.55	139.31	5,957.74
	3	1,306.56	2,370.67	546.49	493.49	116.44	118.78	65.39	45.69	48.12	39.52	45.94	1,093.27	6,290.36
TOTAL		**2,220.99**	**3,995.83**	**2,352.38**	**4,242.34**	**443.41**	**326.60**	**210.08**	**230.07**	**143.86**	**120.42**	**152.43**	**1,271.08**	**15,709.49**
1986-1987	1	1,277.71	672.78	238.28	255.16	109.70	77.76	53.74	42.35	35.24	28.87	36.94	40.00	2,868.53
	2	1,139.22	341.73	758.42	193.24	98.91	150.35	56.29	56.91	32.15	27.76	33.22	32.27	2,920.47
	3	695.49	904.13	348.38	144.97	88.83	77.99	53.89	34.67	35.18	26.94	28.24	30.51	2,469.22
TOTAL		**3,112.42**	**1,918.64**	**1,345.08**	**593.37**	**297.44**	**306.10**	**163.92**	**133.93**	**102.57**	**83.57**	**98.40**	**102.78**	**8,258.22**
1987-1988	1	97.91	94.28	338.09	81.83	54.16	40.07	34.12	26.57	29.71	23.59	18.62	23.94	862.89
	2	351.33	271.36	208.91	70.29	45.64	37.75	29.37	27.28	58.57	22.41	18.76	23.66	1,165.33
	3	192.93	595.67	122.19	70.27	42.64	38.58	30.08	24.70	30.67	27.93	22.27	94.25	1,292.18
TOTAL		**642.17**	**961.31**	**669.19**	**222.39**	**142.44**	**116.40**	**93.57**	**78.55**	**118.95**	**73.93**	**59.65**	**141.85**	**3,320.40**
1988-1989	1	1,100.71	698.56	288.51	154.98	61.29	45.30	83.64	34.63	25.61	24.05	19.07	42.33	2,578.68
	2	222.27	719.38	217.46	101.84	54.16	42.05	51.89	32.00	29.09	22.58	19.98	60.78	1,573.48
	3	462.32	570.62	300.08	84.28	48.47	48.82	45.05	23.97	26.83	20.17	22.49	126.14	1,779.24
TOTAL		**1,785.30**	**1,988.56**	**806.05**	**341.10**	**163.92**	**136.17**	**180.58**	**90.60**	**81.53**	**66.80**	**61.54**	**229.25**	**5,931.40**
1989-1990	1	58.63	319.41	846.38	139.22	63.18	48.19	35.82	27.62	199.04	49.32	31.04	27.39	1,845.24
	2	92.73	157.04	354.78	102.63	55.63	43.21	33.76	57.41	59.19	36.42	46.86	37.66	1,077.32
	3	285.35	533.78	224.17	85.10	54.83	42.68	33.80	83.96	58.99	30.53	50.32	71.69	1,555.20
TOTAL		**436.71**	**1,010.23**	**1,425.33**	**326.95**	**173.64**	**134.08**	**103.38**	**168.99**	**317.22**	**116.27**	**128.22**	**136.74**	**4,477.76**
1990-1991	1	1,813.41	591.85	589.93	256.08	88.82	65.42	82.48	40.21	60.53	26.65	22.21	46.29	3,683.88
	2	1,030.16	1,542.78	722.66	167.71	76.57	60.69	52.72	40.43	39.67	27.31	22.07	59.37	3,842.14
	3	501.29	765.83	400.92	130.14	74.09	77.74	51.23	32.91	34.22	24.01	31.92	26.84	2,151.14
TOTAL		**3,344.86**	**2,900.46**	**1,713.51**	**553.93**	**239.48**	**203.85**	**186.43**	**113.55**	**134.42**	**77.97**	**76.20**	**132.50**	**9,677.16**

YEAR	10-DAY	JUL	AUG	SEP	OCT	NOV	DEC	JAN	FEB	MAR	APR	MAY	JUN	TOTAL
1991-1992	1	29.71	148.33	301.07	90.75	48.56	39.84	41.31	53.17	28.21	20.57	17.29	70.03	888.84
	2	462.34	288.57	235.71	70.26	50.79	35.37	37.12	37.97	24.22	19.13	17.97	27.56	1,307.01
	3	60.58	464.05	138.35	64.30	45.36	76.52	39.02	28.08	24.31	18.78	25.36	454.61	1,439.32
TOTAL		**552.63**	**900.95**	**675.13**	**225.31**	**144.71**	**151.73**	**117.45**	**119.22**	**76.74**	**58.48**	**60.62**	**552.20**	**3,635.17**
1992-1993	1	35.54	591.88	406.17	170.06	62.65	46.15	34.41	29.85	27.28	29.26	23.09	24.84	1,481.18
	2	325.97	365.02	437.80	110.89	55.04	42.39	35.82	28.55	26.40	25.41	19.49	22.98	1,495.76
	3	576.94	511.36	217.86	89.20	53.51	41.06	35.30	22.41	77.03	23.66	23.09	39.93	1,711.35
TOTAL		**938.45**	**1,468.26**	**1,061.83**	**370.15**	**171.20**	**129.60**	**105.53**	**80.81**	**130.71**	**78.33**	**65.67**	**87.75**	**4,688.29**
1993-1994	1	35.37	296.77	2,302.00	241.42	94.85	60.02	42.22	40.75	79.09	23.65	21.22	26.77	3,264.13
	2	289.22	278.72	4,632.70	159.99	74.90	53.25	49.38	58.99	25.18	23.26	28.64	29.43	5,703.66
	3	623.21	240.09	502.62	141.14	66.21	60.41	43.47	60.37	26.73	22.35	25.98	140.38	1,952.96
TOTAL		**947.80**	**815.58**	**7,437.32**	**542.55**	**235.96**	**173.68**	**135.07**	**160.11**	**131.00**	**69.26**	**75.84**	**196.58**	**10,920.75**
1994-1995	1	273.20	546.66	286.81	111.15	59.85	43.09	52.77	34.18	37.01	24.02	18.98	19.52	1,507.24
	2	223.97	591.17	223.06	89.70	45.81	37.35	55.12	39.67	33.76	21.59	18.68	23.71	1,403.59
	3	233.91	611.42	138.36	80.56	46.14	36.00	50.26	34.86	31.40	21.31	19.77	30.00	1,333.99
TOTAL		**731.08**	**1,749.25**	**648.23**	**281.41**	**151.80**	**116.44**	**158.15**	**108.71**	**102.17**	**66.92**	**57.43**	**73.23**	**4,244.82**
1995-1996	1	264.18	228.75	1,707.13	167.66	67.49	51.05	44.54	39.56	38.93	28.75	19.61	48.22	2,705.87
	2	448.47	1,105.35	450.45	115.48	61.46	55.23	51.58	42.08	36.78	26.59	21.84	65.99	2,481.30
	3	394.37	624.57	270.79	91.38	59.56	56.17	48.04	45.31	35.74	25.25	93.68	148.03	1,892.89
TOTAL		**1,107.02**	**1,958.67**	**2,428.37**	**374.52**	**188.51**	**162.45**	**144.16**	**126.95**	**111.45**	**80.59**	**135.13**	**262.24**	**7,080.06**
1996-1997	1	101.58	305.97	697.68	177.16	80.39	58.80	45.30	42.10	35.00	41.08	36.95	43.15	1,665.16
	2	228.92	471.25	358.49	131.86	61.46	53.39	42.19	38.34	33.16	39.67	34.97	56.42	1,550.12
	3	248.21	598.61	181.25	105.40	59.57	55.30	50.02	28.81	40.75	40.06	31.44	122.09	1,561.51
TOTAL		**578.709**	**1,375.83**	**1,237.42**	**414.42**	**201.42**	**167.49**	**137.51**	**109.25**	**108.91**	**120.81**	**103.36**	**221.66**	**4,776.79**
1997-1998	1	84.46	5,705.22	232.09	148.61	88.85	65.14	61.32	50.56	49.80	47.74	51.27	36.16	6,621.22
	2	408.01	410.86	231.69	119.66	76.26	60.69	64.18	44.08	57.92	49.04	48.39	49.69	1,620.47
	3	225.54	281.17	183.65	108.14	74.07	50.70	62.01	40.40	57.05	38.83	40.62	266.86	1,429.04
TOTAL		**718.01**	**6,397.25**	**647.43**	**376.41**	**239.18**	**176.53**	**187.51**	**135.04**	**164.77**	**135.61**	**140.28**	**352.71**	**9,670.73**
1998-1999	1	2,263.97	1,016.95	672.54	477.93	385.40	152.64	77.08	68.78	54.67	29.53	18.39	21.45	5,239.33
	2	760.35	2,219.29	540.38	920.47	283.27	109.64	72.92	62.29	55.02	20.77	20.75	161.27	5,226.42
	3	1,034.59	1,861.51	881.93	717.51	162.56	88.82	79.46	45.20	57.61	20.22	20.10	158.90	5,128.41
TOTAL		**4,058.91**	**5,097.75**	**2,094.85**	**2,115.91**	**831.23**	**351.10**	**229.46**	**176.27**	**167.30**	**70.52**	**59.24**	**341.62**	**15,594.16**
1999-2000	1	786.98	666.35	311.97	239.42	112.36	77.76	63.72	97.73	44.26	31.13	40.07	501.19	2,972.94
	2	325.83	433.45	623.94	186.56	96.97	76.20	59.48	71.53	37.92	29.68	32.62	258.99	2,233.17
	3	573.08	257.43	318.78	177.76	87.59	76.40	58.74	46.37	37.72	32.58	34.78	317.73	2,018.96
TOTAL		**1,685.89**	**1,357.23**	**1,254.69**	**603.74**	**296.92**	**230.36**	**181.94**	**215.63**	**119.90**	**93.39**	**107.47**	**1,077.91**	**7,225.07**
2000-2001	1	494.14	1,028.75	1,112.93	226.97	126.26	83.13	67.37	45.95	41.37	29.71	33.45	92.13	3,382.16
	2	456.04	1,150.90	473.34	198.33	104.87	74.05	64.63	45.30	37.32	45.50	41.96	49.91	2,742.15
	3	479.73	923.99	331.76	162.28	94.13	74.76	64.00	35.82	37.45	33.45	36.98	163.73	2,438.08
TOTAL		**1,429.91**	**3,103.64**	**1,918.03**	**587.58**	**325.26**	**231.94**	**196.00**	**127.07**	**116.14**	**108.66**	**112.39**	**305.77**	**8,562.39**
2001-2002	1	128.18	305.40	287.60	105.71	62.67	51.84	33.73	37.63	151.75	32.17	26.79	30.98	1,254.45
	2	593.72	324.36	179.06	90.01	56.85	44.93	36.70	133.36	47.17	26.14	25.98	27.31	1,585.59
	3	538.77	447.54	126.16	84.23	53.77	41.54	42.67	37.29	45.44	41.89	29.65	33.76	1,522.71
TOTAL		**1,260.67**	**1,077.30**	**592.82**	**279.95**	**173.29**	**138.31**	**113.10**	**208.28**	**244.36**	**100.20**	**82.42**	**92.05**	**4,362.75**

YEAR	10-DAY	JUL	AUG	SEP	OCT	NOV	DEC	JAN	FEB	MAR	APR	MAY	JUN	TOTAL
2002-2003	1	284.64	90.94	751.58	158.46	79.23	50.82	41.48	61.77	132.71	49.12	30.02	79.82	1,810.59
	2	69.75	297.06	460.84	122.98	64.32	44.57	38.43	145.56	78.07	37.63	30.02	34.72	1,423.95
	3	96.68	215.42	230.62	105.94	62.39	40.27	39.30	115.95	69.92	32.63	36.19	103.88	1,149.19
TOTAL		**451.07**	**603.42**	**1,443.04**	**387.38**	**205.94**	**135.66**	**119.21**	**323.28**	**280.70**	**119.38**	**96.23**	**218.42**	**4,383.73**
2003-2004	1	53.99	247.17	538.54	329.20	131.27	77.79	63.84	54.95	37.77	24.70	29.91	40.24	1,629.37
	2	331.35	1,176.45	489.81	216.13	110.64	73.06	54.16	47.57	34.82	20.71	31.66	52.57	2,638.93
	3	222.28	1,049.11	1,692.75	175.99	120.97	43.91	62.77	36.48	32.72	25.44	58.10	41.29	3,561.81
TOTAL		**607.62**	**2,472.73**	**2,721.10**	**721.32**	**362.88**	**194.76**	**180.77**	**139.00**	**105.31**	**70.85**	**119.67**	**134.10**	**7,830.11**
2004-2005	1	473.00	199.21	259.48	201.61	134.61	81.49	56.71	87.83	57.47	39.53	41.57	31.18	1,663.69
	2	136.61	255.15	212.79	223.29	105.26	70.34	60.67	95.81	47.62	33.08	38.23	31.35	1,310.20
	3	154.09	2,343.59	497.77	183.91	120.54	67.54	101.31	60.13	52.69	28.56	39.61	35.85	3,685.59
TOTAL		**763.70**	**2,797.95**	**970.04**	**608.81**	**360.41**	**219.37**	**218.69**	**243.77**	**157.78**	**101.17**	**119.41**	**98.38**	**6,659.48**
2005-2006	1	184.69	302.92	416.50	504.06	168.66	79.96	65.96	41.98	31.59	35.27	27.58	66.15	1,925.32
	2	281.76	461.78	1,048.47	102.02	139.30	79.16	54.51	38.38	54.43	32.53	46.07	41.99	2,380.40
	3	420.17	330.14	3,155.65	199.08	104.17	79.29	51.89	27.78	39.02	30.87	43.75	52.89	4,534.70
TOTAL		**886.62**	**1,094.84**	**4,620.62**	**805.16**	**412.13**	**238.41**	**172.36**	**108.14**	**125.04**	**98.67**	**117.40**	**161.03**	**8,840.42**
2006-2007	1	82.16	248.33											
	2	160.79	196.84											
	3	519.69	650.40											
TOTAL		**762.64**	**1,095.57**	-	-	-	-	-	-	-	-	-	-	

Table-7.A

PANEVAPORATION DATA AT JAMRANI DAM SITE (in cm.)

YEAR	JAN	FEB	MAR	APR	MAY	JUN	JUL	AUG	SEP	OCT	NOV	DEC
1974						3.60	2.80	1.70	2.90	4.90	2.20	2.40
1975	7.07	8.70	8.50	24.70	28.10	9.30	1.60	0.90	0.90	23.44		
1976					21.70					15.35	4.25	5.10
1977	6.00	1.50	23.00	29.20	35.60	27.00	1.50	3.70	3.40	8.10	6.40	2.30
1978	3.00	5.15	10.90	29.50	68.80	38.20	3.70	2.70	4.30	16.09	10.10	6.10
1979	5.40	7.00	16.70	27.60	48.80	49.70	28.40	40.00	53.60	33.70	13.40	7.30
1980	6.40	16.60	14.40	39.40	59.20	27.30	7.80	11.30	18.10	24.00	14.10	1.70
1981	1.30	7.30	13.70	26.50	37.70	30.10	7.50	11.90	35.80	31.80	9.60	4.30
1982	2.70	3.80	10.60	22.10	30.20	32.10	28.50	7.40	9.90	7.70	3.80	1.80
1983	9.00	4.90	15.50	19.80	22.40	24.30	14.70	2.10	16.50	10.50	10.30	2.50
1984	4.20	26.10	8.30	15.10	20.70	8.20	7.34	8.10	9.45	10.10	4.56	1.04
TOTAL	**45.07**	**81.05**	**121.60**	**233.90**	**373.20**	**249.80**	**103.84**	**89.80**	**154.85**	**185.68**	**78.71**	**34.54**
Average Jamrani	5.01	9.01	13.51	25.99	37.32	24.98	10.38	8.98	15.49	16.88	7.87	3.45
Average Pantnagar	10.30	13.70	22.70	47.00	45.30	31.00	27.10	16.10	16.50	19.30	11.20	8.10

PANEVAPORATION DATA AT PANTNAGAR (in cm.)

YEAR	JAN	FEB	MAR	APR	MAY	JUN	JUL	AUG	SEP	OCT	NOV	DEC
2002	6.27	9.26	12.99	20.62	21.78	27.48	23.07	17.14	12.31	11.62	9.02	7.37
2003	3.49	7.17	10.90	20.15	26.22	20.10	16.03	11.31	8.95	9.50	6.52	4.47
2004	3.39	6.48	15.02	22.44	25.69	18.76	15.00	12.96	11.16	9.02	5.43	4.64
2005	4.55	6.57	11.98	23.12	22.66		16.48	14.97	12.86	9.02	7.09	5.94
2006	4.92	7.44	15.69	23.74	25.77	20.42	15.29	14.99	12.23	9.67	6.92	5.25
TOTAL	**22.62**	**36.92**	**66.58**	**110.07**	**122.12**	**86.76**	**85.87**	**71.37**	**57.51**	**48.83**	**34.98**	**27.67**
Average Pantnagar	**4.52**	**7.38**	**13.32**	**22.01**	**24.42**	**21.69**	**17.17**	**14.27**	**11.50**	**9.77**	**7.00**	**5.53**

APPENDIX – B

COMPUTATION SHEET

TABLE-1B

THE RELATIONSHIP BETWEEN JAMRANI DAM (QJ) TO GOLA BARRAGE (QG) DISCHARGE FOR THE PERIOD 1976 - 2006 WITH EACH 10-DAILY BY DIRECT LINEAR REGRESSION

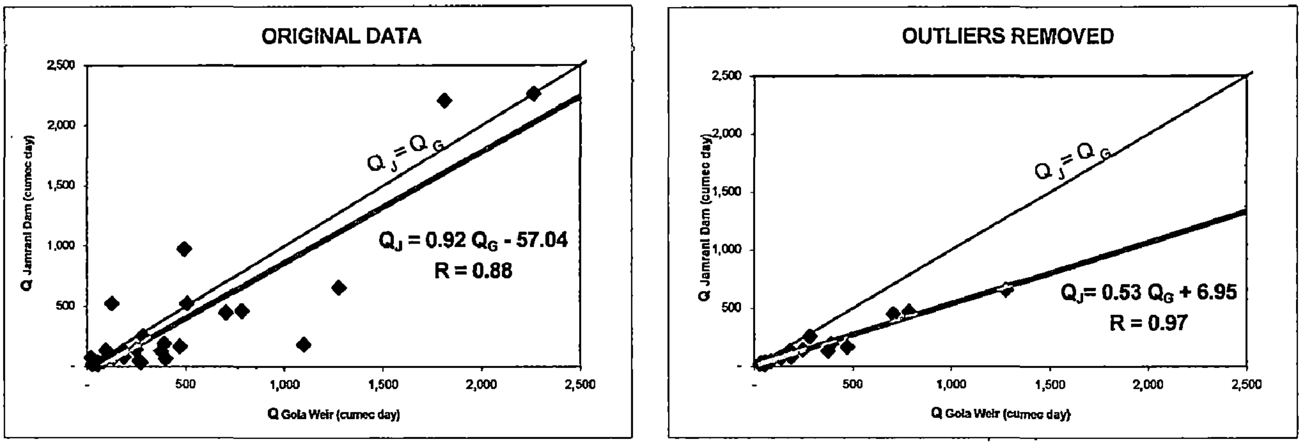
1st 10-DAILY IN MONTH OF JULY

MONTH	10 - DAILY	YEAR	X GOLA BARRAGE (QG)	Y JAMRANI DAM (QJ)	X^2	Y^2	X.Y
JULY	1	1976-77			0.00	0.00	0.00
		1977-78	136.10	75.20	18,523.21	5,655.04	10,234.72
		1978-79	706.40	450.00	499,000.96	202,500.00	317,880.00
		1979-80	189.30	82.77	35,834.49	6,850.87	15,668.36
		1980-81	376.90	134.07	142,053.61	17,974.76	50,530.98
		1981-82	392.50	192.02	154,056.25	36,871.68	75,367.85
		1982-83			0.00	0.00	0.00
		1983-84	248.50	144.08	61,752.25	20,759.05	35,803.88
		1984-85			0.00	0.00	0.00
		1985-86			0.00	0.00	0.00
		1986-87	1,277.71	656.89	1,632,542.84	431,504.47	839,314.92
		1987-88			0.00	0.00	0.00
		1988-89			0.00	0.00	0.00
		1989-90	58.63	40.13	3,437.48	1,610.42	2,352.82
		1990-91			0.00	0.00	0.00
		1991-92	29.71	22.92	882.68	525.33	680.95
		1992-93	35.54	27.49	1,263.09	755.70	976.99
		1993-94	35.37	32.61	1,251.04	1,063.41	1,153.42
		1994-95			0.00	0.00	0.00
		1995-96			0.00	0.00	0.00
		1996-97			0.00	0.00	0.00
		1997-98	84.46	46.29	7,133.49	2,142.76	3,909.65
		1998-99			0.00	0.00	0.00
		1999-2000	786.98	468.07	619,337.52	219,089.52	368,361.73
		2000-01			0.00	0.00	0.00
		2001-02			0.00	0.00	0.00
		2002-03	284.64	257.84	81,019.93	66,481.47	73,391.58
		2003-04	53.99	21.33	2,914.92	454.97	1,151.61
		2004-05	473.00	169.25	223,729.00	28,645.56	80,055.25
		2005-06	184.69	134.18	34,110.40	18,004.27	24,781.70
TOTAL			**5,354.42**	**2,955.14**	**3,518,843.16**	**1,060,889.29**	**1,901,616.42**
N			**17**	**17**			
MEAN			**314.97**	**173.83**			

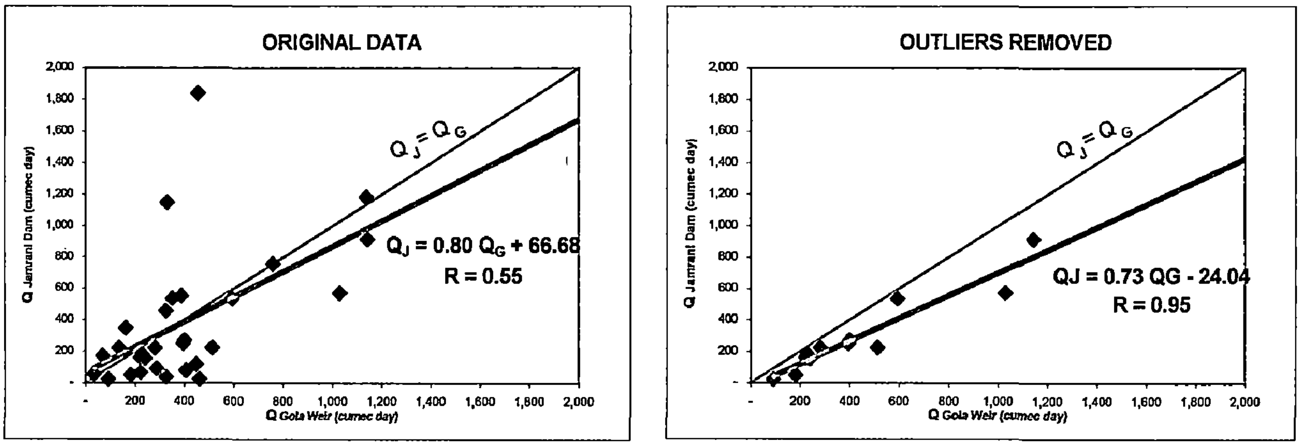
a = 6.95

b = 0.53

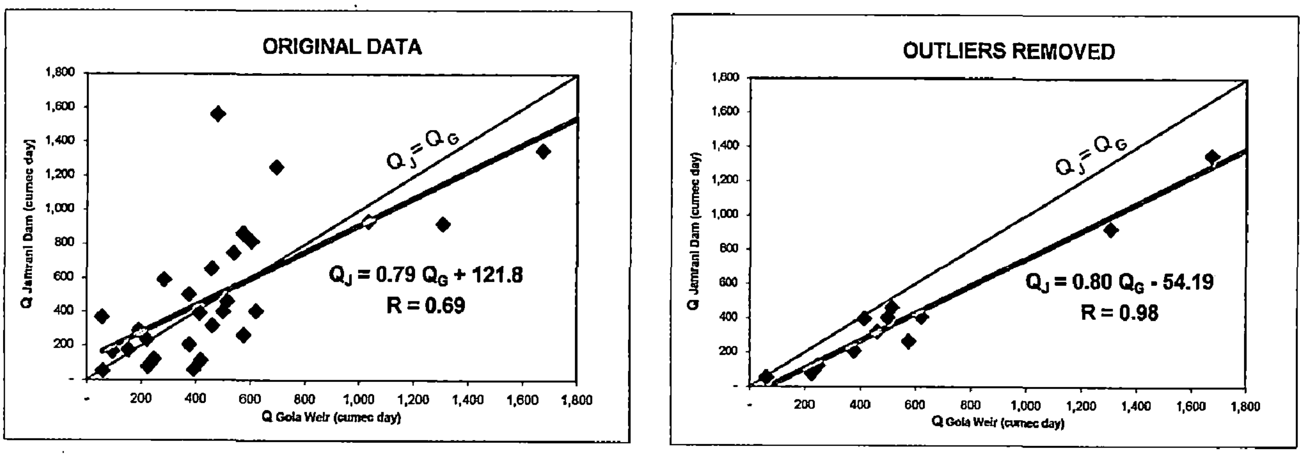
r = 0.97



1st TEN-DAILY DISCHARGE FOR JULY (1976 - 2006)



2nd TEN-DAILY DISCHARGE FOR JULY (1976 - 2006)



3rd TEN-DAILY DISCHARGE FOR JULY (1976 - 2006)

Fig. 1B **PLOT OF 10-DAILY OBSERVED DISCHARGE OF GOLA RIVER AT JAMRANI DAM & GOLA WEIR** (BY DIRECT LINEAR REGRESSION) **FOR MONTH OF JULY**

TABLE-2B

THE RELATIONSHIP BETWEEN JAMRANI DAM (QJ) TO GOLA BARRAGE (QG) DISCHARGE FOR THE PERIOD 1976 - 2006 WITH EACH 10-DAILY BY LOG DEVIATION REGRESSION

1st 10-DAILY IN MONTH OF JULY

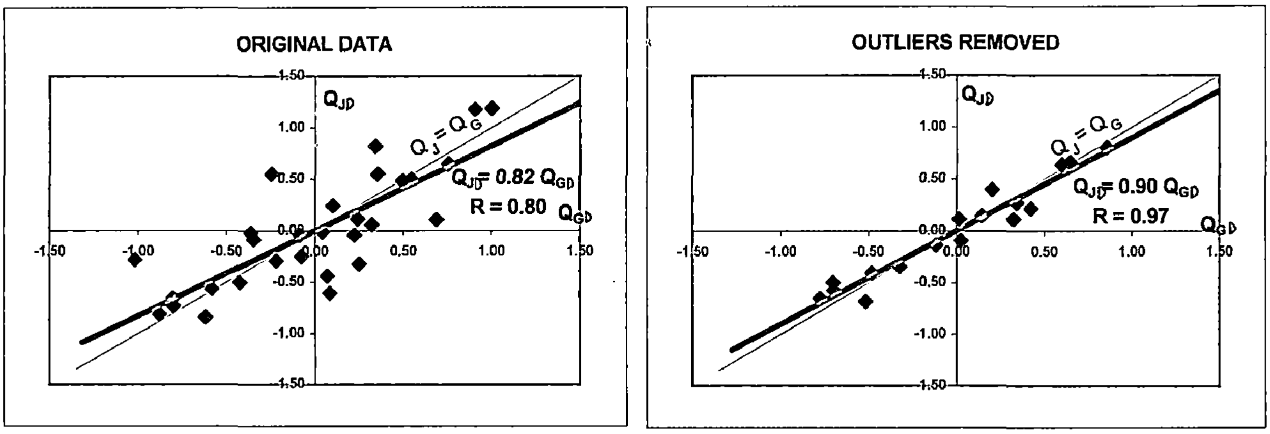
MONTH	10 - DAILY	YEAR	X GOLA BAR. (QG)	Log x	X (Log x - Log x̄)	Y JAMRANI DAM (QJ)	Log y	Y (Log y - Log ȳ)	X^2	Y^2	X.Y
JULY	1	1976-77							0.00	0.00	0.00
		1977-78	136.10	2.13	-0.11	75.20	1.88	-0.13	0.01	0.02	0.02
		1978-79	706.40	2.85	0.60	450.00	2.65	0.64	0.36	0.41	0.39
		1979-80	189.30	2.28	0.03	82.77	1.92	-0.09	0.00	0.01	0.00
		1980-81	376.90	2.58	0.33	134.07	2.13	0.12	0.11	0.01	0.04
		1981-82	392.50	2.59	0.35	192.02	2.28	0.27	0.12	0.07	0.09
		1982-83									
		1983-84	248.50	2.40	0.15	144.08	2.16	0.15	0.02	0.02	0.02
		1984-85									
		1985-86									
		1986-87	1,277.71	3.11	0.86	656.89	2.82	0.81	0.74	0.65	0.69
		1987-88									
		1988-89									
		1989-90	58.63	1.77	-0.48	40.13	1.60	-0.41	0.23	0.17	0.20
		1990-91									
		1991-92	29.71	1.47	-0.78	22.92	1.36	-0.65	0.60	0.42	0.50
		1992-93	35.54	1.55	-0.70	27.49	1.44	-0.57	0.49	0.33	0.40
		1993-94	35.37	1.55	-0.70	32.61	1.51	-0.50	0.49	0.25	0.35
		1994-95									
		1995-96									
		1996-97									
		1997-98	84.46	1.93	-0.32	46.29	1.67	-0.35	0.10	0.12	0.11
		1998-99									
		1999-2000	786.98	2.90	0.65	468.07	2.67	0.66	0.42	0.44	0.43
		2000-01									
		2001-02									
		2002-03	284.64	2.45	0.21	257.84	2.41	0.40	0.04	0.16	0.08
		2003-04	53.99	1.73	-0.52	21.33	1.33	-0.68	0.27	0.46	0.35
		2004-05	473.00	2.67	0.43	169.25	2.23	0.22	0.18	0.05	0.09
		2005-06	184.69	2.27	0.02	134.18	2.13	0.12	0.00	0.01	0.00
TOTAL			5,354.42	38.22	0.00	2,955.14	34.18	0.00	4.18	3.60	3.76
N			17								
MEAN			314.97	2.25	0.00	173.83	2.01	0.00			

a = 0.00

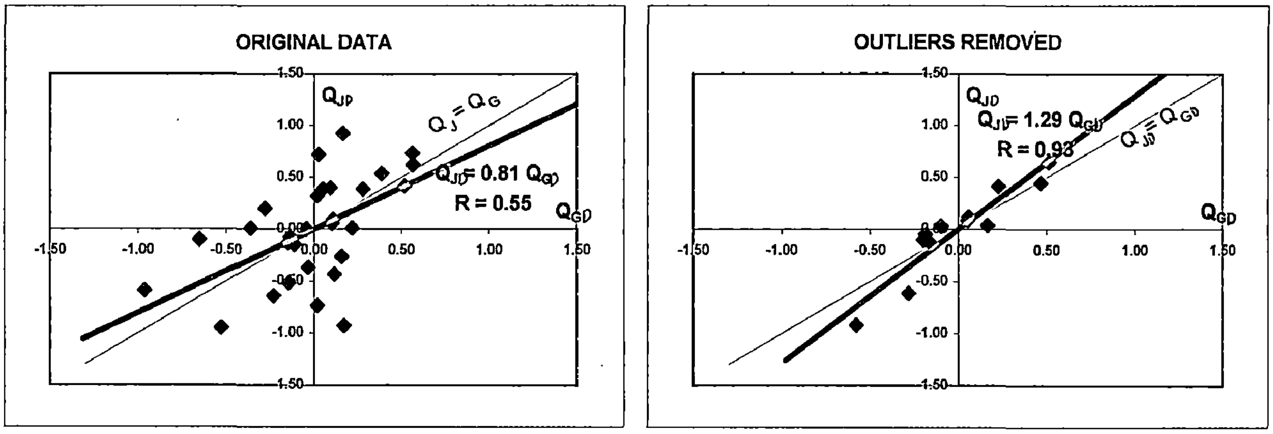
b = 0.90

r = 0.97

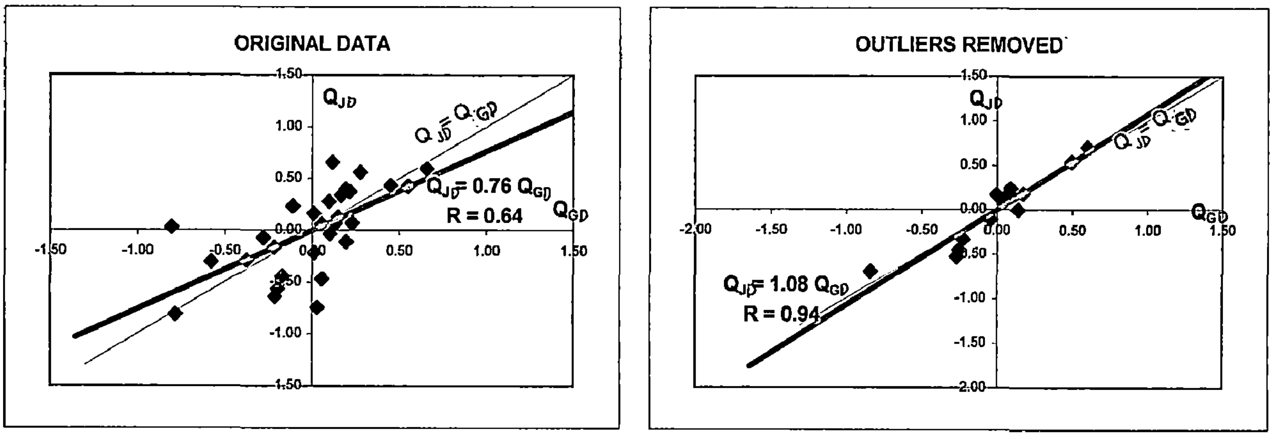
Y = 0.90 X



1st TEN-DAILY DISCHARGE FOR JULY (1976 - 2006)



2nd TEN-DAILY DISCHARGE FOR JULY (1976 - 2006)



3rd TEN-DAILY DISCHARGE FOR JULY (1976 - 2006)

Fig. 2B **PLOT OF 10-DAILY OBSERVED DISCHARGE OF GOLA RIVER AT JAMRANI DAM & GOLA WEIR** (BY LOG DEVIATION REGRESSION) **FOR MONTH OF JULY**

APPENDIX – C

SUPPORTING TABLES & GRAPHS

TABLE-1C REDUCED MEAN $\bar{y}_n$ IN GUMBEL'S EXTREME VALUE DISTRIBUTION

N = sample size

N	0	1	2	3	4	5	6	7	8	9
10	0.4952	0.4996	0.5035	0.5070	0.5100	0.5128	0.5157	0.5181	0.5202	0.5220
20	0.5236	0.5252	0.5268	0.5283	0.5296	0.5309	0.5320	0.5332	0.5343	0.5353
30	0.5362	0.5371	0.5380	0.5388	0.5396	0.5402	0.5410	0.5418	0.5424	0.5430
40	0.5436	0.5442	0.5448	0.5453	0.5458	0.5463	0.5468	0.5473	0.5477	0.5481
50	0.5485	0.5489	0.5493	0.5497	0.5501	0.5504	0.5508	0.5511	0.5515	0.5518
60	0.5521	0.5524	0.5527	0.5530	0.5533	0.5535	0.5538	0.5540	0.5543	0.5545
70	0.5548	0.5550	0.5552	0.5555	0.5557	0.5595	0.5561	0.5563	0.5565	0.5567
80	0.5569	0.5570	0.5572	0.5574	0.5576	0.5578	0.5580	0.5581	0.5583	0.5585
90	0.5586	0.5587	0.5589	0.5591	0.5592	0.5593	0.5595	0.5596	0.5598	0.5599
100	0.5600									

TABLE-2C REDUCED STANDARD DEVIATION S_n IN GUMBEL'S EXTREME VALUE DISTRIBUTION

N = sample size

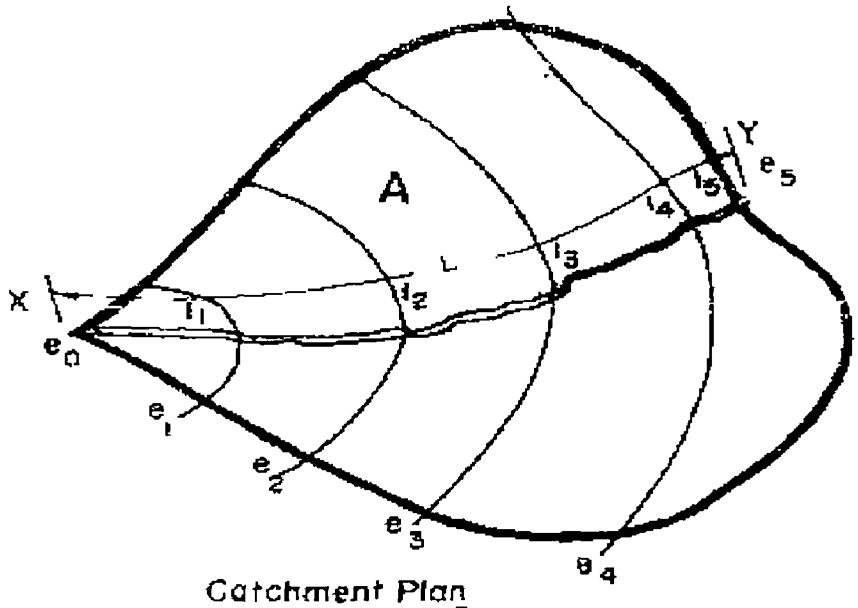
N	0	1	2	3	4	5	6	7	8	9
10	0.9496	0.9676	0.9833	0.9971	1.0095	1.0206	1.0316	1.0411	1.0493	1.0565
20	1.0628	1.0696	1.0754	1.0811	1.0864	1.0915	1.0961	1.1004	1.1047	1.1086
30	1.1124	1.1159	1.1193	1.1226	1.1255	1.1285	1.1313	1.1339	1.1363	1.1388
40	1.1413	1.1436	1.1458	1.1480	1.1499	1.1519	1.1538	1.1557	1.1574	1.1590
50	1.1607	1.1623	1.1638	1.1658	1.1667	1.1681	1.1696	1.1708	1.1721	1.1734
60	1.1747	1.1759	1.1770	1.1782	1.1793	1.1803	1.1814	1.1824	1.1834	1.1844
70	1.1854	1.1863	1.1873	1.1881	1.1890	1.1898	1.1906	1.1915	1.1923	1.1930
80	1.1938	1.1945	1.1953	1.1959	1.1967	1.1973	1.1980	1.1987	1.1994	1.2001
90	1.2007	1.2013	1.2020	1.2026	1.2032	1.2038	1.2044	1.2049	1.2055	1.2060
100	1.2065									

TABLE-3C $K_Z = F(C_s, T)$ FOR USE IN LOG-PEARSON TYPE III DISTRIBUTION

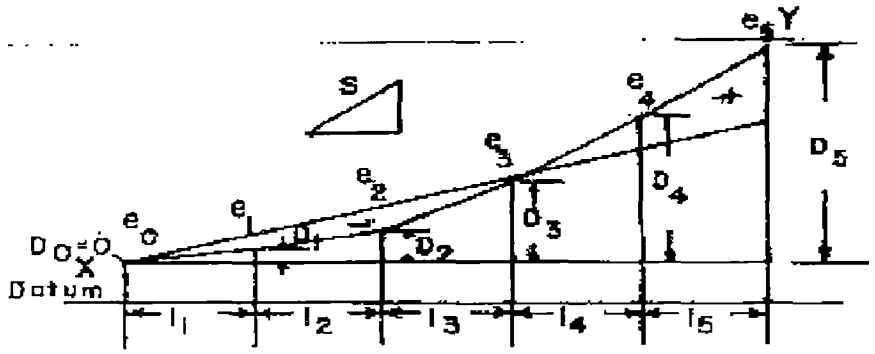
Coefficient of skew, C_s	Recurrence Interval T in years						
	2	**10**	**25**	**50**	**100**	**200**	**1000**
3.0	-0.396	1.180	2.278	3.152	4.051	4.970	7.250
2.5	-0.360	1.250	2.262	3.048	3.845	4.652	6.600
2.2	-0.330	1.284	2.240	2.970	3.705	4.444	6.200
2.0	-0.307	1.302	2.219	2.912	3.605	4.298	5.910
1.8	-0.282	1.318	2.193	2.848	3.499	4.147	5.660
1.6	-0.254	1.329	2.163	2.780	3.388	3.990	5.390
1.4	-0.225	1.337	2.128	2.706	3.271	3.828	5.110
1.2	-0.195	1.340	2.087	2.626	3.149	3.661	4.820
1.0	-0.164	1.340	2.043	2.542	3.022	3.489	4.540
0.9	-0.148	1.339	2.018	2.498	2.957	3.401	4.395
0.8	-0.132	1.336	1.998	2.453	2.891	3.312	4.250
0.7	-0.116	1.333	1.967	2.407	2.824	3.223	4.105
0.6	-0.099	1.328	1.939	2.359	2.755	3.132	3.960
0.5	-0.083	1.323	1.910	2.311	2.686	3.041	3.815
0.4	-0.066	1.317	1.880	2.261	2.615	2.949	3.670
0.3	-0.050	1.309	1.849	2.211	2.544	2.856	3.525
0.2	-0.033	1.301	1.818	2.159	2.472	2.763	3.380
0.1	-0.017	1.292	1.785	2.107	2.400	2.670	3.235
0.0	0.000	1.282	1.751	2.054	2.326	2.576	3.090
-0.1	0.017	1.270	1.716	2.000	2.252	2.482	2.950
-0.2	0.033	1.258	1.680	1.945	2.178	2.388	2.810
-0.3	0.050	1.245	1.643	1.890	2.104	2.294	2.675
-0.4	0.066	1.231	1.606	1.834	2.029	2.201	2.540
-0.5	0.083	1.216	1.567	1.777	1.955	2.108	2.400
-0.6	0.099	1.200	1.528	1.720	1.880	2.016	2.275
-0.7	0.116	1.183	1.488	1.663	1.806	1.926	2.150
-0.8	0.132	1.166	1.448	1.606	1.733	1.837	2.035
-0.9	0.148	1.147	1.407	1.549	1.660	1.749	1.910
-1.0	0.164	1.128	1.366	1.492	1.588	1.664	1.880
-1.4	0.225	1.041	1.198	1.270	1.318	1.351	1.465
-1.8	0.282	0.945	1.035	1.069	1.087	1.097	1.130
-2.2	0.330	0.844	0.888	0.900	0.905	0.907	0.910
-3.0	0.396	0.660	0.666	0.666	0.667	0.667	0.668

TABLE-4C AREAL TO POINT RAINFALL RATIOS (%)

Area (Km^2)	1 hr.	3 hr.	6 hr.	12 hr.	24 hr.
50	88	92	95	96	98
100	80	88	91	94	96
150	73	84	88	92	94
200	68	81	86	90	93
250	63	78	85	89	91
300	60	76	84	88	90
350	-	74	83	87	89
400	-	73	82	86	88
450	-	73 → (76)	81	85	87
500	-	72	80	84	86
600	-	-	-	82	85
700	-	-	-	80	83
800	-	-	-	79	82
900	-	-	-	78	81
1000	-	-	-	77	81
1200	-	-	-	76	80
1400	-	-	-	-	79
1600	-	-	-	-	78
1800	-	-	-	-	77
2000	-	-	-	-	77
2500	-	-	-	-	77



Catchment Plan



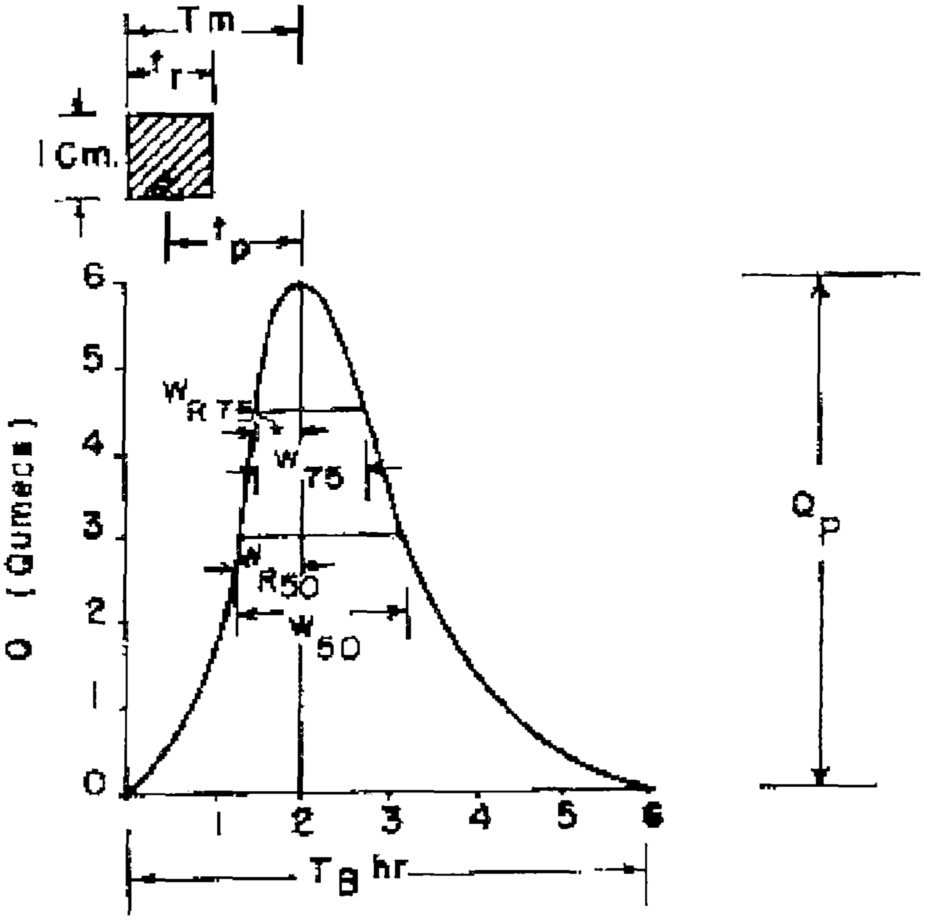
L– Section

$$S = \frac{\sum_{i=1}^{n} (D_i + D_{i-1})\, l_i}{L^2}$$

Where :

- S = Equivalent stream slope (m/km)
- L = Length of longest stream course (km)
- I_i = $I_1, I_2, I_3, \ldots\ldots\ldots\ldots I_n$ = Segment lengths (km)
- e_i = $e_1, e_2, e_3, \ldots\ldots\ldots\ldots e_n$ = Contour elevations (km)
- D_i = $D_0, D_1, D_2, \ldots\ldots\ldots D_n$
  = $(e_0 - e_0), (e_1 - e_0), (e_2 - e_0), \ldots\ldots\ldots\ldots (e_n - e_0)$ (m)
- A = Catchment Area (km^2).

Fig. 1C Physiographic Parameters



U.H.	=	Unit Hydrograph
t_r	=	Unit Rainfall Duration adopted in a specific study (hr)
T_m	=	Time from the start of rise to the peak of the U.H. (hr)
Q_p	=	Peak Discharge of Unit Hydrograph (cumecs)
T_p	=	Time from the centre of rainfall excess duration to the U.H. Peak (hr)
W_{50}	=	Width of the U.H. measured at 50% of peak discharge ordinate (hr)
W_{75}	=	Width of the U.H. measured at 75% of peak discharge Ordinate (hr)
W_{R50}	=	Width of the rising limb of U.H. measured at 50% of peak discharge ordinate (hr)
W_{R75}	=	Width of the rising limb of U.H. measured at 75% of peak discharge ordinate (hr)
T_B	=	Base width of Unit Hydrograph (hr)
A	=	Catchment Area (Km^2)
q_p	=	Q_p / A = cumec per Km^2

Fig. 2C Unit Hydrograph Parameters

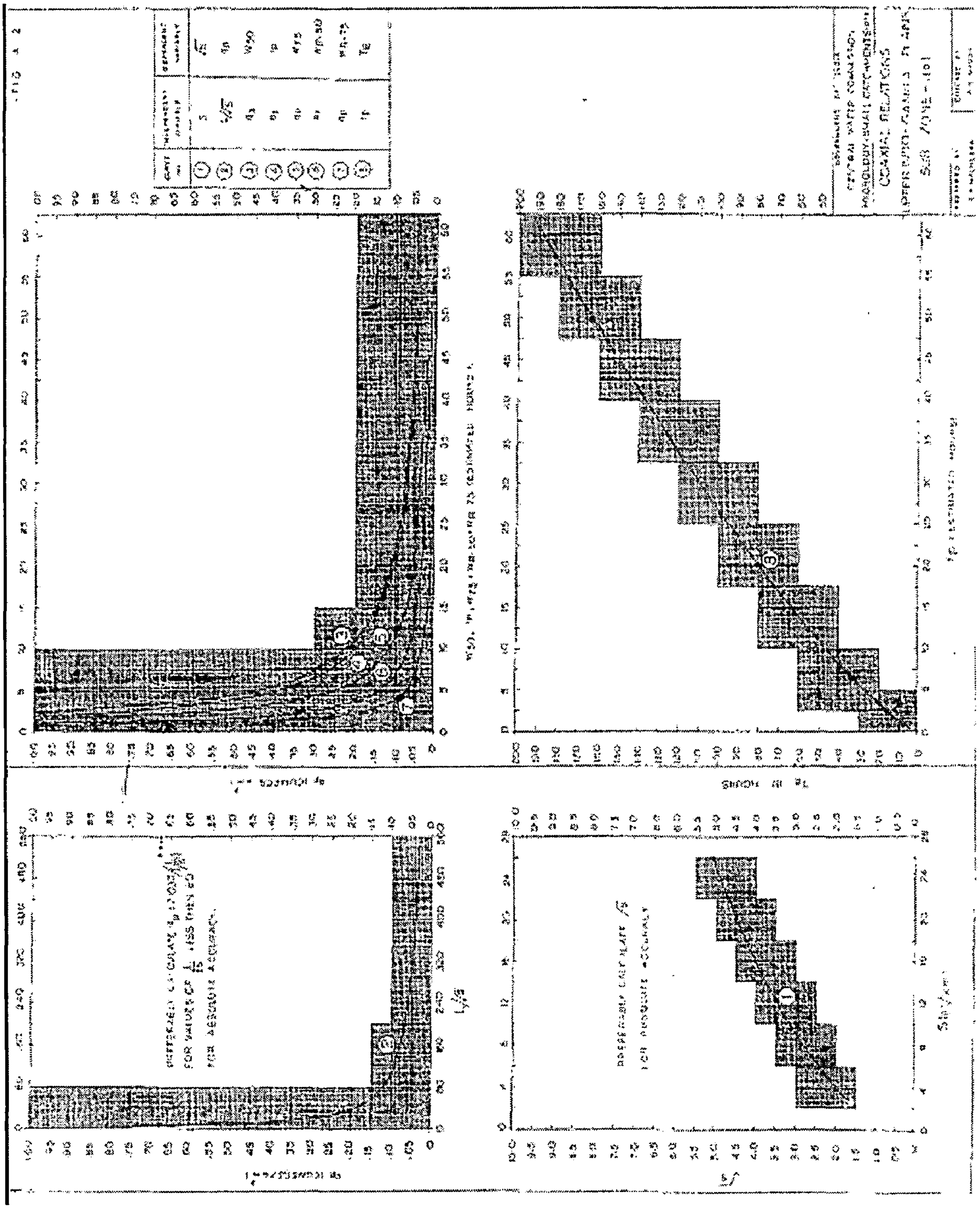


Fig. 3C Coaxial Relations Graph

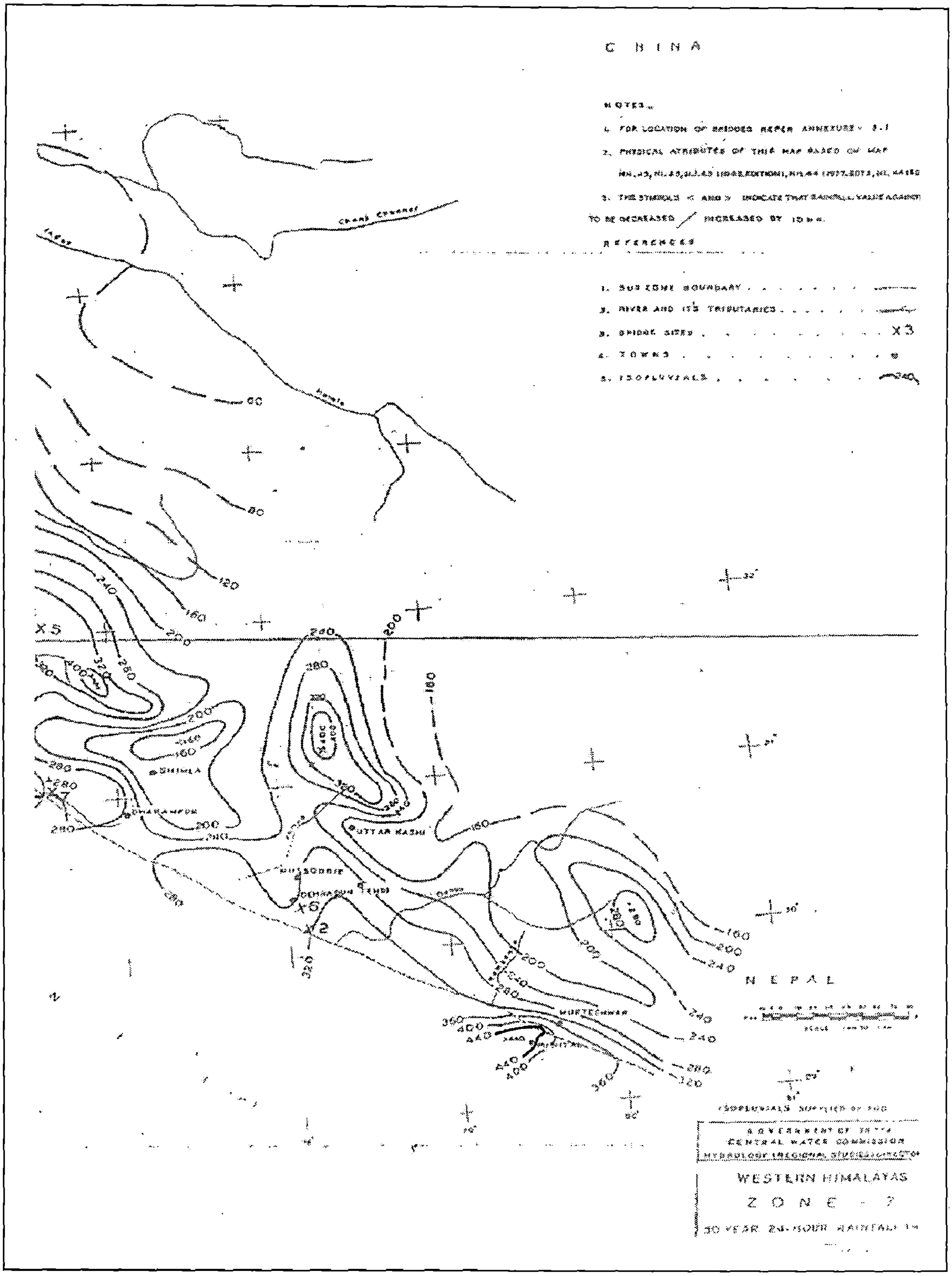


Fig. 4C Isopluvial Map for 50 Year – 24 Hour Point Rainfall (mm)

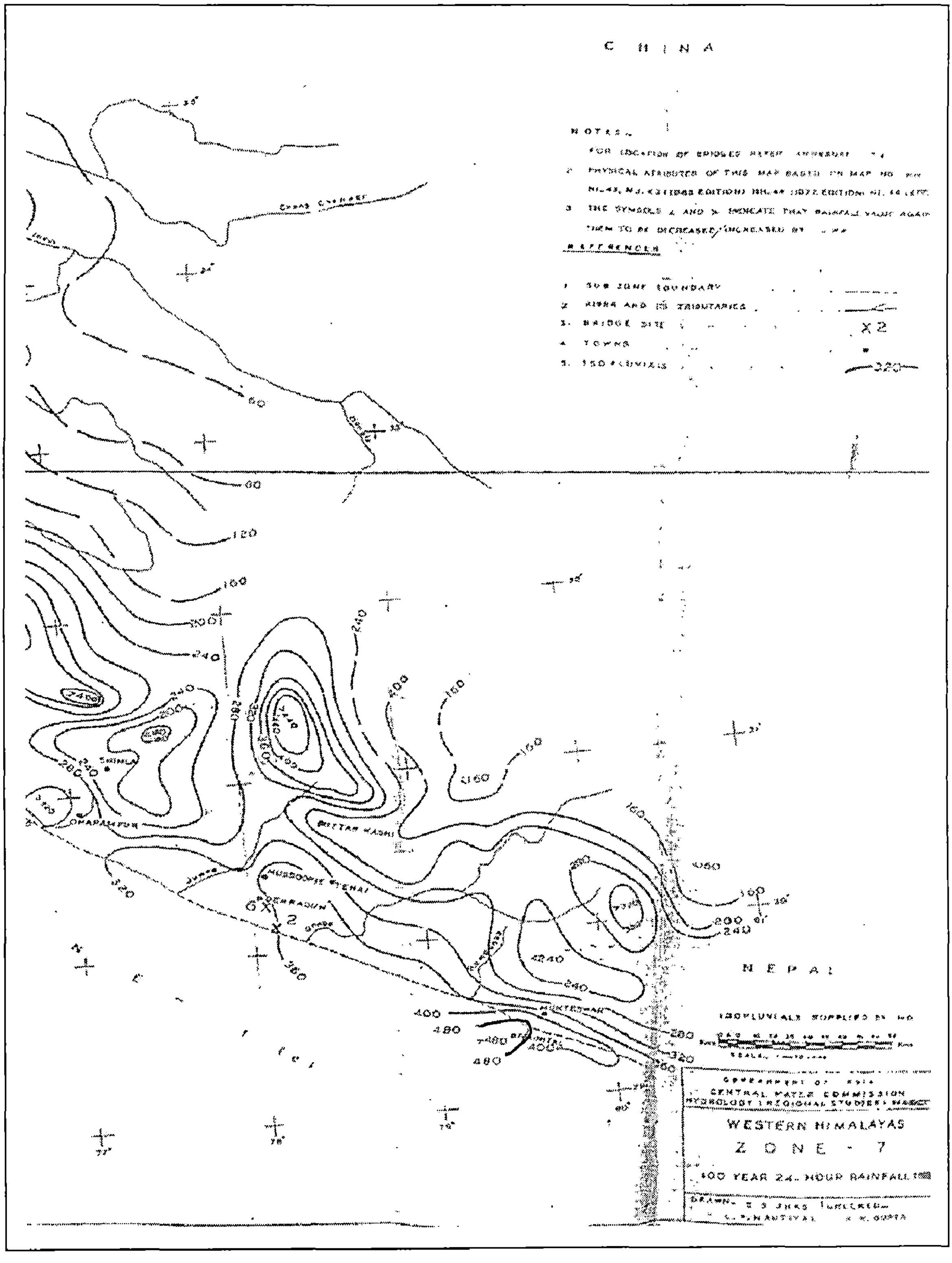
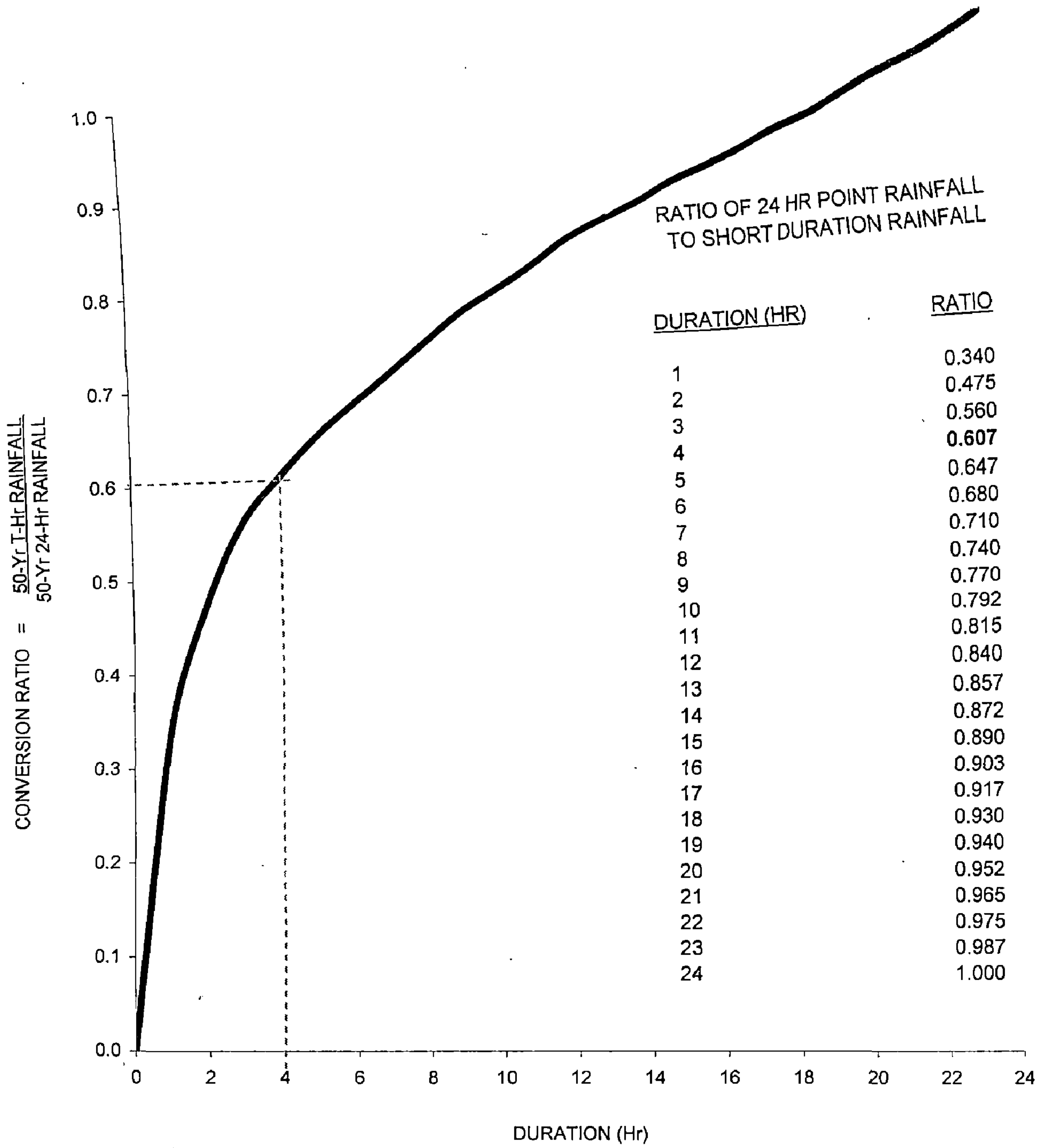


Fig. 5C Isopluvial Map for 100 Year – 24 Hour Point Rainfall (mm)



DURATION (HR)	RATIO
1	0.340
2	0.475
3	0.560
4	**0.607**
5	0.647
6	0.680
7	0.710
8	0.740
9	0.770
10	0.792
11	0.815
12	0.840
13	0.857
14	0.872
15	0.890
16	0.903
17	0.917
18	0.930
19	0.940
20	0.952
21	0.965
22	0.975
23	0.987
24	1.000

Fig. 6C Design Storm Duration (T_D) vs Ratio

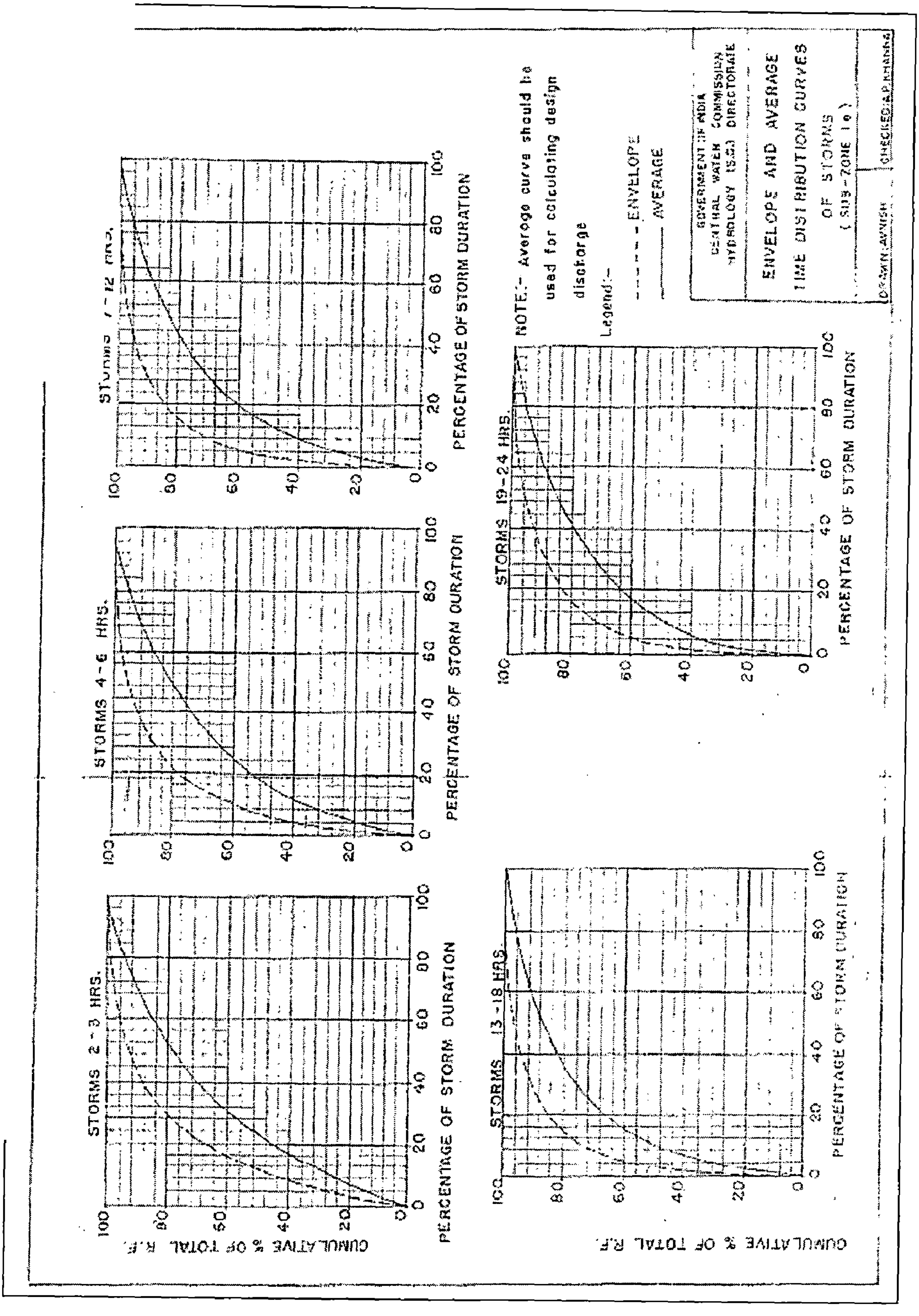


Fig. 7C Time Distribution Curves of Storms