# COMPUTATIONAL ANALYSIS AND FORECAST OF WATER LEVEL

A CASE STUDY OF HYDRONIGER PROJECT

KADUNA

by

**Olusegun-Owolabi Bosede Christiana**
**PGD/MCS/214/96**
**Department of Maths/Computer Science**
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**March, 1998.**

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OLUSEGUN-OWOLABI BOSEDE CHRISTIANA
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**A project submitted to the department of Maths/Computer Science, School of Science and Science Education. Federal University of Technology, Minna in partial fulfilment of the requirement for degree of Post graduate Diploma in Computer Science.**

**Department of Maths/Computer Science**

**Federal University of Technology, Minna.**

**March 1998.**

# CERTIFICATION

This is to certify that this project work is an original work undertaken by Olusegun-Owolabi Bosede Christiana PGD/MCS/214/96 and has been prepared in accordance with the regulation governing the preparation and presentation of project at the Federal University of Technology Minna.

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Dr. Reju S.A.
Project Supervisor

Date

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Dr. Adeboye K. R.
Head of Department

Date

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External Examiner

Date

## DEDICATION

This project work is dedicated to the memory of my late son **"Emmanuel 'Gbenga 'Damilare"** who slept in the Lord on 17th April 1996. Although you left me so young amidst confusive and unbelievable situation, your memory will forever remain fresh in the family. We love you so much but the Lord loves you better. "Rest in Peace until rapture."

## ACKNOWLEDGEMENTS

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Finally she humbly acknowledges the abundant mercies and love of God for her. With God's blessings and support at her climax trial period of life, the life lifter has made this work come to successful completion. To God be the glory.

# ABSTRACT

The fluctuation of the level of waters in the main water bodies calls for the attention of any government and organisations responsible for water usage in all areas of life. This fluctuation when reaching the extreme can be so disastrous to human life, plant and animal life, and can also affect most of our industries and productions.

The HYDRO-NIGER PROJECT was established to focus in this directions of water level monitoring and thereby make a forecast on any looming danger of high flood resulting from very high water level in main stream of Niger or less water due to the drop in the water level in the river which may not be sufficient for agricultural production or power generation.

This project therefore develops a program for the analysis of water level information collected on rivers consisting of three phases namely: the input phase, computational phase, and the output phase.

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# CHAPTER ONE

## 1.0 INTRODUCTION TO HYDROLOGICAL PROCESSES

## 1.1 INTRODUCTION

The level to which water surface rises in either a stream, river, reservoir or any water body changes from time to time. This fluctuation is as a result of the changes that occur in the hydrological and meteorological processes which are mainly precipitation, evapotranspiration, temperature, humidity, wind movement pattern, overland water flow (runoff) and subsurface/underground water flow.

The hydrological processes are greatly influenced by the meteorological processes. A change in the temperature and wind movement in an area is reflected in the rainfall pattern and evapotranspiration process in the area.

The hydrological processes form the phases in the hydrological cycle. The water vapour from the water surfaces is carried into the atmosphere to form precipitation which later comes back to the earth as rainfall, dew or ice. Part of it gets collected on leaves, houses, ground depressions; another part infiltrates into the ground to form the soil water and yet another runs over the land into rivers which is reflected in the increase of the river stage or level to which the water rises in the river.

The variable in these processes is measurable with certain instruments. The measurements made therefrom are regarded as data on such variables which are subject to processing and analysis so that they can be used in water resources development and proper management.

Such is the case with the HYDRONIGER PROJECT established in 1984 in relation with the government of Niger Republic to monitor water level fluctuation at some established points on River Niger. The selected points (stations) are equipped with a kind of automatic instruments that, after the collection of data (measurement of rainfall and water levels) transmits towards the TIROS-NOAA satellite which store the messages and further transmits the data to International Forecasting Centre at Niamey and other National receiving stations through already programmed computer system. The use of such processed information is directed to the management of abounding project on the Niger river mainly agricultural production and power generation which are grossly affected by the reduction of water in the river channel.

This project is therefore directed towards the analysis of data collected at the station on the river.

## 1.2 DEFINITION - HYDROLOGY

The word hydrology is derived from the Greek word hydor meaning water and logos, meaning sciences, and that is in short science of water. Hydrology is the study of water in all its phases with its hydraulics, physics and chemistry, meteorology, geology and biology. In this sense hydrology is concerned with all water on the earth. Their occurrence, distribution and circulation through the unending hydrologic cycle (of precipitation, consequent runoff, stream flow, infiltration and groundwater, eventual evaporation and reprecipitation), their physical and chemical properties with their effect on the environment and on life of all forms.

The branches of hydrology include meteorology which is the science of the atmosphere, hydrometeorology the study of the atmospheric water and hydrography study of surface waters.

In customary usage, hydrology has come to mean studies of precipitation and runoff, that is, it has been linked with problems associated with design and management of water resources projects such as water supply, flood control, irrigation, power generation, navigation, erosion control and pollution reduction.

### 1.2.1 Water levels

Stage, or water level is the elevation of the water surface of a stream, lake or other water body relative to a datum.

Water levels of rivers lakes and reservoirs are used directly in forecasting flows, in delineation of flood hazard areas, and in the design of structures in, or near, water bodies. Records of water level are obtained by systematic observations on a manual gauge, or from a water level recorder

### 1.2.2 Hydrological cycle

The hydrological cycle is defined by different paths through which the water in nature circulates. In principle, the paths penetrate three parts of the earth system: atmosphere, hydrosphere and lithosphere. The atmosphere is the gaseous envelope above the hydrosphere, the hydrosphere is the bodies of water that cover the surface of the earth, and the lithosphere comprises the unconsolidated strata and the solid rock below the hydrosphere.

The hydrologic cycle has no beginning or end, with the water evaporated from the oceans and the land becoming part of the atmosphere.

Water is lost to the atmosphere as vapour from the earth, the evaporated moisture is lifted and carried in the atmosphere until it finally precipitates to the earth on land or in the oceans in form of rain snow, hail, dew, sleet or frost (see figure 1.1.1).

Where the earth surface is covered by the vegetation, the falling precipitation is retained by the vegetation and so-called interception. Water that falls on the earth surface either directly or being released from the interception, infiltrates into the ground. Infiltration - movement of water into the soil in which case the vertical movement of water through the soil profile is called percolation.

The subsurface runoff of water which infiltrates the soil surface and moved laterally through the upper soil horizons toward the streams is called Subsurface flow or Interflow
(throughflow).

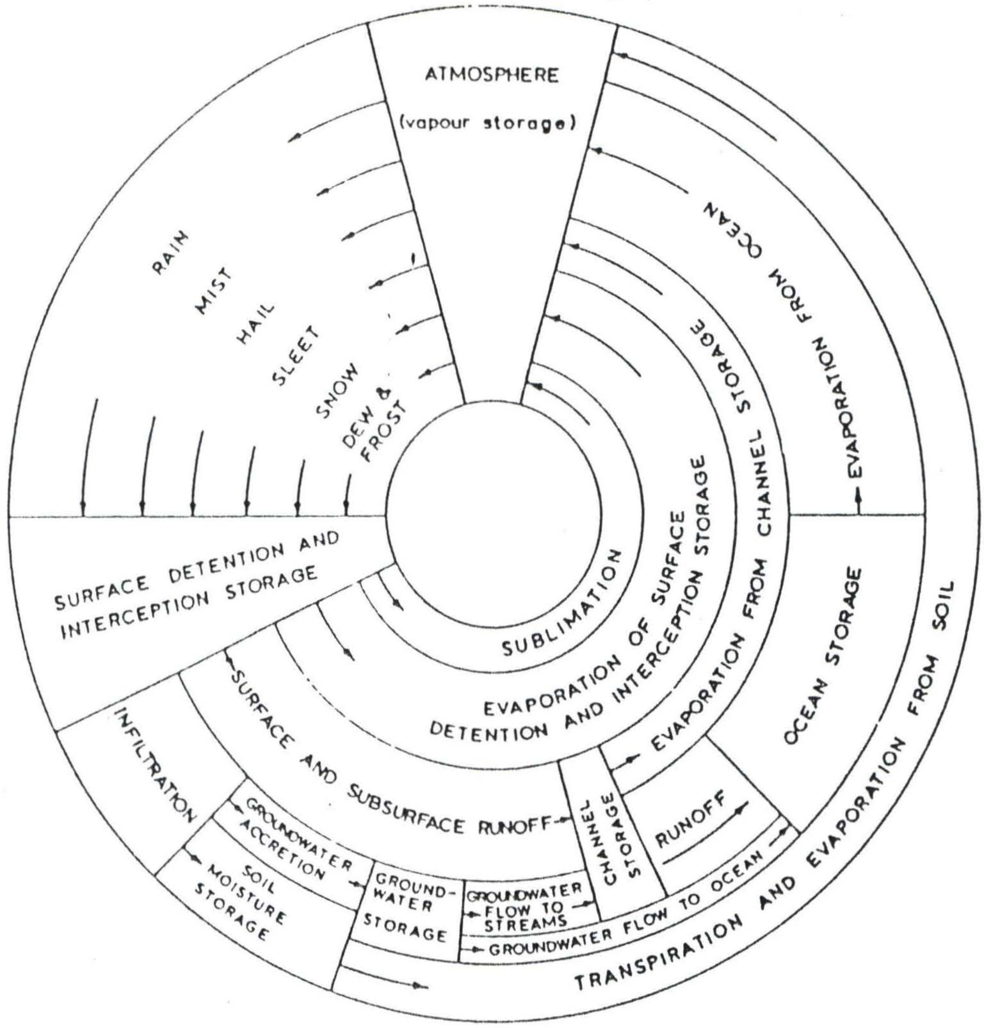



Fig. 1.1.1. The hydrological cycle as presented by Horton (1931)

The groundwater runoff or groundwater flow is that part of the runoff which infiltrated into the soil, percolated through the soil horizons and recharged the groundwater storage through which it has been discharged into the streams. The groundwater flow after reaching the streams and being joined by the subsurface runoff is called the baseflow or base runoff. That part of the precipitation which has not infiltrated into the soil and forms the surface runoff is called effective or net rainfall or rainfall excess (see figure 1.1.2).

## 1.3. HYDROLOGICAL PROCESSES

### 1.3.1 Precipitation

Precipitation is one of the main features of the hydrological cycles. It is a product of condensation of water vapour in the atmosphere delivered to the earth in a liquid or solid form.

The amount of precipitation depends on the availability of moisture in the atmosphere. The amount of precipitation can be defined as an accumulated total volumes for any selected period.

**Formation of Precipitation**

Four conditions are necessary for the production of precipitation.

(i) A mechanism to produce cooling of the air to or near saturation

(ii) A mechanism to produce growth of cloud droplets

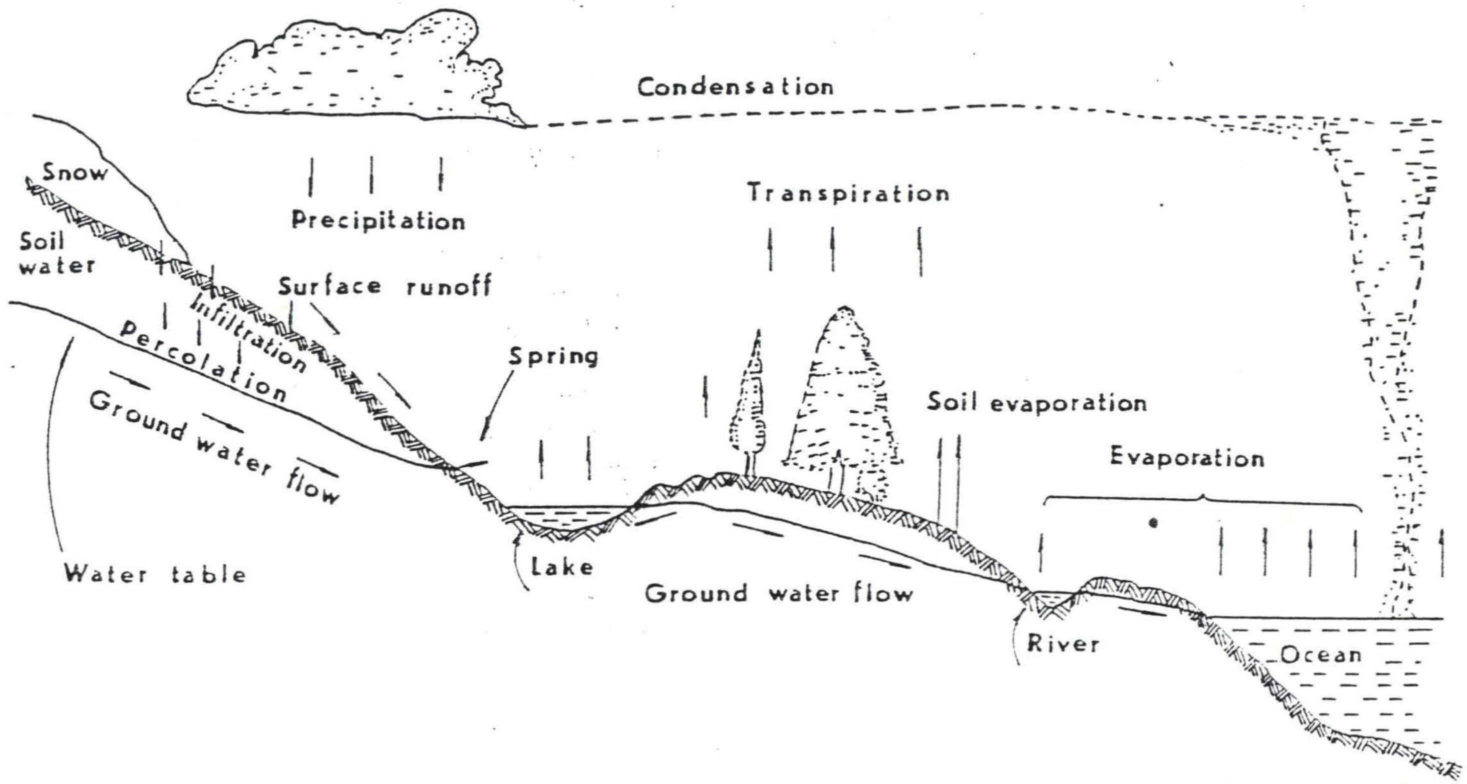



*Fig. 11.2 Main features of the hydrological cycle*

(iii) A mechanism to produce condensation

(iv) A mechanism to produce accumulation of sufficient intensity to account for the observed rate of rainfall.

The water vapour arising from the earth's surface is condensed on solid matter particles called freezing nuclei to form clouds in the atmosphere after it has been cooled by the lifting of the water vapour carrying air to the higher and cooler altitude. This is achieved by convective systems resulting from unequal radiative heating or cooling of the surface of the earth and atmosphere. It may also be accomplished by convergence caused by orographic barriers in the direction of air movement. The freezing nuclei are small particles of various substances usually ranging in size from about 0.1 to 10 micrometers in diameter. They nucleate the liquid phase and initiate the growth of ice crystals. As more water vapour diffuses to the nucleated water droplets or ice crystals, they grow rapidly to as much as 440 micrometer in diameter. The size and the corresponding weight that cannot be retained in the atmosphere except it falls back to the earth in any of its forms (rain, snow, hail, drizzle, glace or sleet).

**Measurement of Precipitation**

All forms of precipitation are measured on the basis of the vertical depth of water that would accumulate on a level surface if the precipitation remained where it fell. Therefore, different instruments and techniques have been developed for the collection of information on precipitation.

The commonest fundamental instrument of measurement is the precipitation gauges and technology has advanced to the use of radar for precipitation measurement.

### (a) Precipitation Gauges

Any gauge is an open receptacle with vertical sides fitted with a knife-edge rim (collector) on the top. A funnel is provided below the collector to direct the catch into the cylindrical measuring tube in the receptacle. This type is the simple form of the gauges known as the standard precipitation gauge (figure 1.3.1).

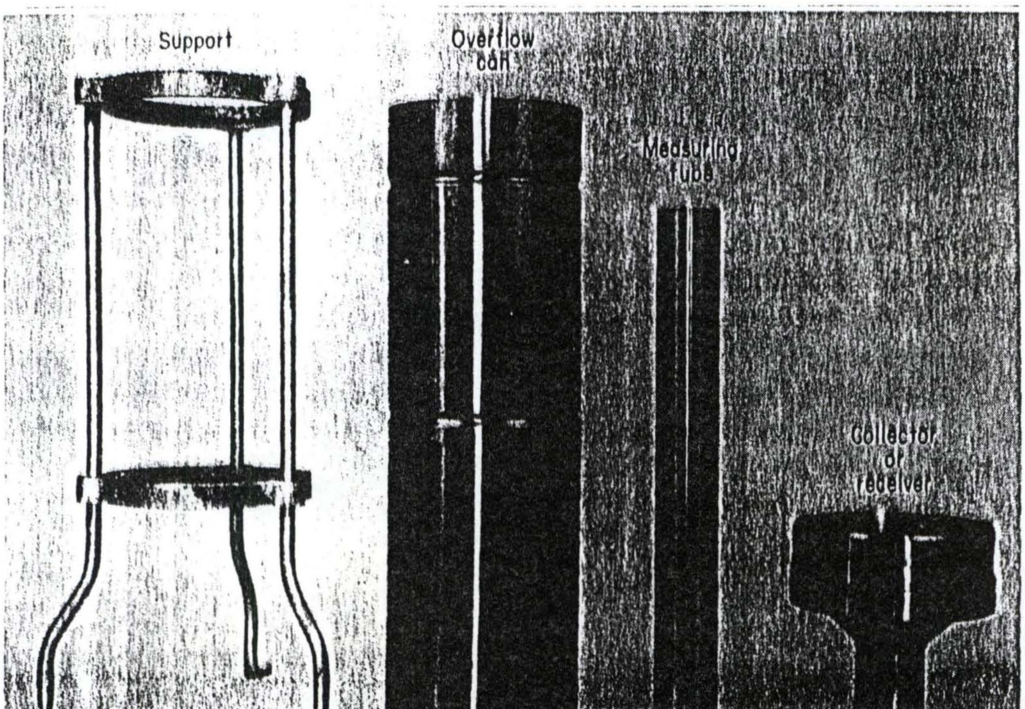



Fig 1-3-1 Standard 8-in precipitation gage. *(U.S. National Weather Service.)*

The other fundamental type is the recording gauges. The main difference here is the recording mechanism fitted into the simple gauge to automatically produce a record on precipitation. The three types of these gauges in common use are the tipping-bucket gauge, the weighing gauge and the float gauge.

In the tipping-bucket gauge the water caught in the collector is funneled into a two - compartment bucket 0.1mm or some other designed quantity of rain will fill one compartment and overbalance the bucket so that it tips, emptying into a reservoir and moving the second compartment into place beneath the funnel.

The weighing-type gauges weigh's the rain which falls into a bucket set on the platform of a spring or level balance. The increasing weight of the bucket and its contents is recorded or a chart.

**(b) Radar Measurement**

Radar is a high frequency radio device. The radar based on the principle of echo sounding transmits a pulse of electromagnetic energy focussed into a narrow beam of invisible energy in a direction determined by a movable antenna. The radiated wave which travels at the speed of light, is partially reflected by cloud or precipitation particles and returns as an echo to the radar, where it is received by the same antenna. The return signal is amplified and presented on a cathode ray tube (plan-position-indicator). The more intense the precipitation, the greater the reflectivity on the indicator and its range and bearings are automatically determined

### 1.3.2 <u>Runoff</u>

Runoff constitutes a part of the precipitation which goes into the stream channels. This thus causes the flow in a stream to be above a particular point or level. The mechanisms follow that when the rate at which rain falls (intensity)exceeds the rate of which water can enter into the soil (infiltrate), runoff will be generated by the excess water over the land surface. The excess water thereby flows over the land into the nearest stream channel.

Total runoff thus, comprises three main parts in view of the ways of travel: Overland flow, subsurface flow, and groundwater flow.

The overland flow is the water which travels over the land surface to a channel which when it occurs in sufficient quantity may result to flood peaks. But, the formation of surface runoff depends largely on the characteristics of the soil on which the rain falls. Surface flow over a permeable soil can occur only when the rainfall intensity exceeds the local infiltration capacity in many small and moderate storms, surface runoff may occur only form impermeable and saturated areas.

The subsurface flow is as the result of the part of the precipitation that infiltrated the soil surface and move laterally through the upper soil layer until it enters a stream channel. This depends on the physical characteristics of the soil. A very thus soil covers over a rock or hard pan favours substantial amounts of subsurface flow, but a uniformly permeable soil allows downward movement of water into the groundwater.

The portion that through percolation, enters into the groundwater may eventually flow into the streams as groundwater flow (also known as baseflow). Runoff, when measured as streamflow or discharge at a selected point on a stream may be presented in a graphical form of the discharge plotted against time known as hydrograph (figure 1.3.2).

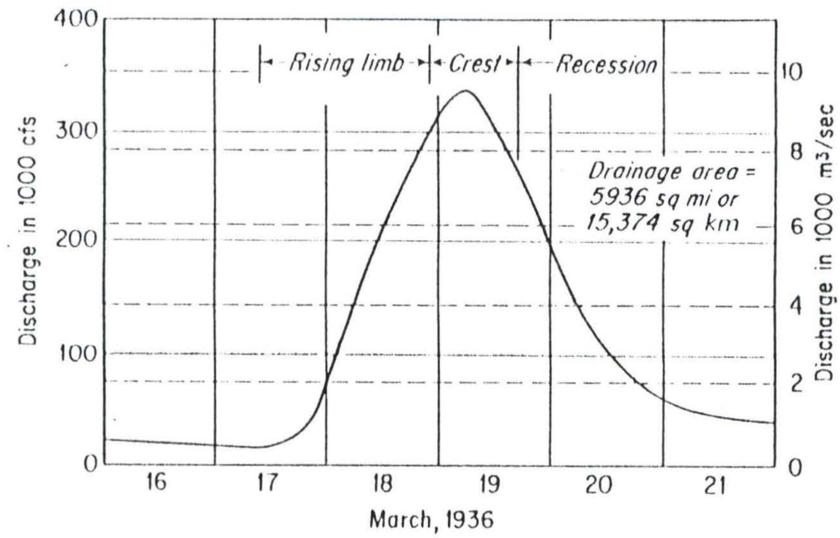



Fig 1-3-2 A typical hydrograph (Potomac River at Shepherdstown, W.Va.).

### 1.3.3 Infiltration

Infiltration is the entrance of water into the soil through the surface. The precipitation which does not evaporate will become runoff or infiltrates into the soil.

The initial part of precipitation is usually used up to fill up the basin recharge involved in interception by vegetation and local depressions. When the basin recharge is met, infiltration continues as long as there is supply of water at the soil surface by precipitation. Low rate of infiltration causes loss by runoff and high rate results in a loss by quick under - drainage below the soil. Infiltration has great values in the sense that it reduces floods and soil erosion furnishes stream flow in periods of dry weather, provides water for plants needs, and it recharges the groundwater reservoir. The maximum rate at which the water can enter the soil under a given condition is known as the infiltration capacity. This, when plotted against time results in a curve of infiltration capacity.

In the course of the described processes due to the atmospheric conditions and physiology of the plants, an important part of the precipitation is lost through evaporation, transpiration and evapotranspiration.

### 1.3.4 Evaporation

Evaporation is one of the major ways through which water get lost from the main water bodies. It is also an important element to be considered in water resources planning and Management.

Evaporation is well defined as the process by which water is changed from the liquid state into the gaseous state through the transfer of heat energy. Under natural condition, this process occurs either on a free water surface or on the soil surface.

The molecules of water are bounded together by a strong force of attractions. This force is not easily broken so as to set the molecules free from each other except by the increase in the heat content of the water body. This force is represented by the product of the masses of the two molecules of water divided by the square of the distance between them.

$$F = \frac{(m_1 \ x \ m_2)}{d^2} \quad \text{................ 1.3.1}$$

The main source of heat energy is the sun. When the sun rays strikes the water surface, a reaction produces heat energy which raises the temperature of the water body, thus, increases the kinetic energy of the molecules. Some of the molecules found their ways to the surface of the water where they would be loosely held to the main water body. As the temperature increases, they are free and escape into the atmosphere thereby giving room for other molecules to the surface. As the process continues, water thereby gets lost into the atmosphere in the form of vapour.

The U.S. class A Pan is an instrument for the direct measurement of the evaporation from free water surface. Other instruments include the use of atmometer and empirical formulae by which evaporation can be estimated.

### 1.3.5 Transpiration

Transpiration is another way through which water is lost to the atmosphere. The water vapour transpired by the plants is the by product of their food manufacturing process. The plants absorb water from the soil via the hairs of the roots. The required mineral salts in dilute solution are also absorbed carried by the water through the roots and stems to the leaves where the plant food is produced. The food, in water, is also distributed through the plants for cell growth and tissue building. The water is later emitted by the plant as vapour in the process of transpiration.

It is not possible to measure transpiration loss from an appreciable area under natural conditions and hence determinations are restricted to studies of small sample under laboratory condition. Such measurement is carried out with a phytometer.

### 1.3.6 Evapotranspiration

Evapotranspiration (ET) is a combined process of evaporation from water and land surfaces and transpiration from plants. These two processes are inseparable in cropped or vegetated field, so, it is considered to be the total water loss from a water shed.

Direct measurement of evaporation is not possible. Evapotranspiration can be estimated by means of soil evaporimeters and lysimeters, water or heat budget method, turbulent diffusion method, and various empirical formulae based on meteorological observational data.

## 1.4 BASIC DATA REQUIREMENT

Water is known to be an essential commodity for all plant and animal life. As time and development increases, the need for water for various uses increases in agriculture, industries, power generation, and navigation. These needs vary from time to time at different rates. So, to meet these needs, some parameters relating to the source of water need to be measured at the key points on the source of water especially in each major river channel. The main parameters needed to be measured includes rainfall and the streamflow to generate the data required for the analysis to determine the availability of water at the different times of the year for these needs.

Likewise in the design of hydraulic structures in water resources requires that the basic data needed should be readily available for long period of time in readily useable forms. Being in readily useable form means that the acquired data should have been processed from its crude form and published on a routine basis. Thus, for computational analysis of water level in streams, lakes, and reservoirs, there is the need for the long-term data collection for various purposes.

## 1.5 STREAM FLOW

Streamflow is caused by the runoff from precipitation and, on a natural developed river system, the fluctuation in water level (stage) and flow (discharge) results from variations in duration, frequency, intensity and areal cover of precipitation and in the catchment characteristics which control the rate and amount of runoff.

Over any given region the quantity of water flowing in streams can vary widely in both time and space, and the total quantity involved is essential of man's activities. Records of streamflows are required for the design of river structures such as bridges, dams and flood banks and for the operation of flood warning systems; records of low flows are needed for the evaluation of drought conditions and records of longer term mean flows are necessary for the design of power production and water resources systems.

Continuous and accurate information on steamflow is obtained satisfactorily from a network of river gauging stations.

A gauging station is a site on a river which has been selected, equipped and operated to provide the basic data from which systematic records of water level and discharge may be derived. It consists of a natural or artificial river cross-section where a continuous record of stage can be obtained and where a relation between stage and discharge can be determined.

### 1.5.2. Water level measurement

The stage of a stream is the elevation of its water surface with respect to an established datum plane. Since streamflow serves as the dependent variable, and it is difficult to make a direct, continuous measurement of it, the measurement of stage therefore becomes the most important of all measurements made in the course of flow measurement because it is the base to which all other measurements are related so, the river stage thus is the primary field data collected at most streamflow stations.

Fundamental techniques of water level determination include the use of some devices at a selected location on the stream. These devices come in two general form: direct (manual) and indirect (automatic) reading of water levels.

The direct determination involves the use of such instrument as a graduated staff gauge by an observer who takes the reading at pre-determined time interval and this is limited to the day time except for a critical study that may involve night measurement. The staff gauge is dipped into the water at the station and the water level is read from it.

The automatic gauges are installed on the streams at the gauging stations and thereby senses the changes in the water level. Such changes are transferred to the recording system of the gauge which continuously records the information both day and night and at all times.

### 1.5.1 Collection of Streamflow and Water level data

The collection, processing and storage of readily accessible, reliable, observational data on the elements of the hydrological cycle are essential in order to obtain a long-term picture of events. This provides satisfactory solutions to many water resources problems. Typical examples of data handled in this way are rainfall, evaporation, river stage and discharge, and groundwater levels such data have many applications for drought and flood investigations and for the design of reservoirs and flood-protection schemes. Some of the data may come from observing stations established only to serve a special purpose (for example hydroniger project) while other data may come from stations in networks set up to meet the needs of day-to-day hydrological forecasting and water management.

In developing countries a large volume of information is available in human memory and investigators usually rely on these informations for initial assessment of water level of a streamflow. The information may lack good accuracy but they serve as a starting point.

The flow of water in the streams highly depends on the level of water in them. For this, there is a relation between the water level and the water flow in streams. This relation is used to determine the flow when sufficient measurement of stage has been made. Therefore, we will focus our attention on stage measurement.

But, technology has developed to the stage that the stations are automated and the data are encoded and transmitted to receiving stations where they are decoded, processed and stored. However when designing a system for automatic transmission of measured data, the components to develop are:

(a) Measuring and encoding equipment.

(b) The transmission link

(c) Receiving, decoding and analysing.

The type of transmission link used is determined by the frequency band requirements and by the economics. Possible choices for transmission link include: commercial telephone and telegraph line, direct radio links, and satellite links.

Data transmission from satellites can take place in two ways: transmission of data as observed by sensors in the satellite or by relaying data observed at remote ground stations to central receiving locations.

# CHAPTER TWO

## 2.0 HYDROLOGICAL DATA CASE STUDY

### 2.1 HYDRO-NIGER PROJECT

Hydro-Niger project is a World Meteorological Organisation-United Nations Development Project (WMO-UNDP) assisted project for basin of River Niger in the Western part of Africa. The Project was initiated in the late 70's and became operational with a well developed forecasting system on flood in the Basin in August 1984.

Hydroniger is under the management of NBA (Niger Basin Authority) with World Meteorological Organisation as the technical executing agency. The project incorporated a satellite transmission system of data collection (fig. 2.1.1) ensuring a regional hydrological monitoring.

The main purpose of this project is to measure the stage (water level) of the River Niger and its main tributaries at some selected points in the Niger Basin in West African sub-region and keep for continuous forecasting purposes. Cumulative rainfall is also measured. This will allow for optimization of hydropower stations output vis-a-vis thermal power stations.

Also information obtained could be used in navigation, floods control, irrigation project, it will allow for knowledge in the availability of water for various purposes in the basin.

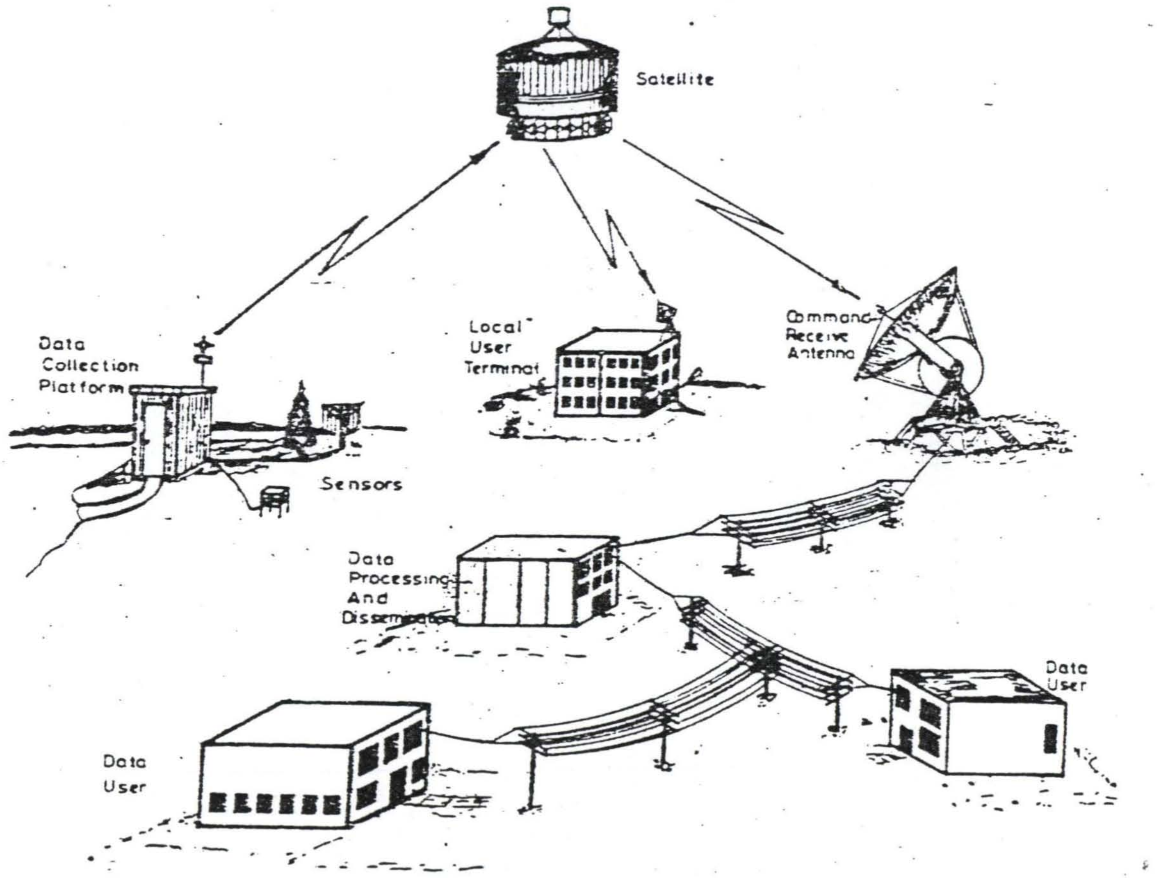



Fig. 2.1.1. Transmission and receiving system - statellite

The project promotes an integrated development policy of the water in the basin through:

(i) collection of regular and reliable hydrological data

(ii) control of water resources projects and hydraulic structure on the river system.

## 2.1.1 <u>Niger River basin</u>

As River Nile is to the eastern bloc of Africa, Niger is the major river in the western part of the continent. It is about 4,200 km long and has its source from highland of Guinea Republic in the Fonta Djalon mountains of wet tropical climate (Fig. 2.1.2). It flows moving up North describing an arc in the semi-arid zone of Mali and Niger Republic and the moves South into Nigeria before discharging into Atlantic Ocean. Some major tributaries of river Niger are Sakarani, Bani, Sokoto, Kaduna and Benue rivers.

The entire river basin of River Niger, which is about two million square kilometres (2m $km^2$) therefore extends over several West African countries. The countries are grouped together to form Niger Basin Authority.

The member states are Guinea, Mali, Niger, Benin, Nigeria, Cote d'Ivorve, Cameroon and Burkina Fasso. A total number of sixty-seven (67) hydrological stations using Data Collection Platforms (DCP) are established at the selected locations in the basin. Data being collected are the:

(i) Water level - using air bubble pressure method, and

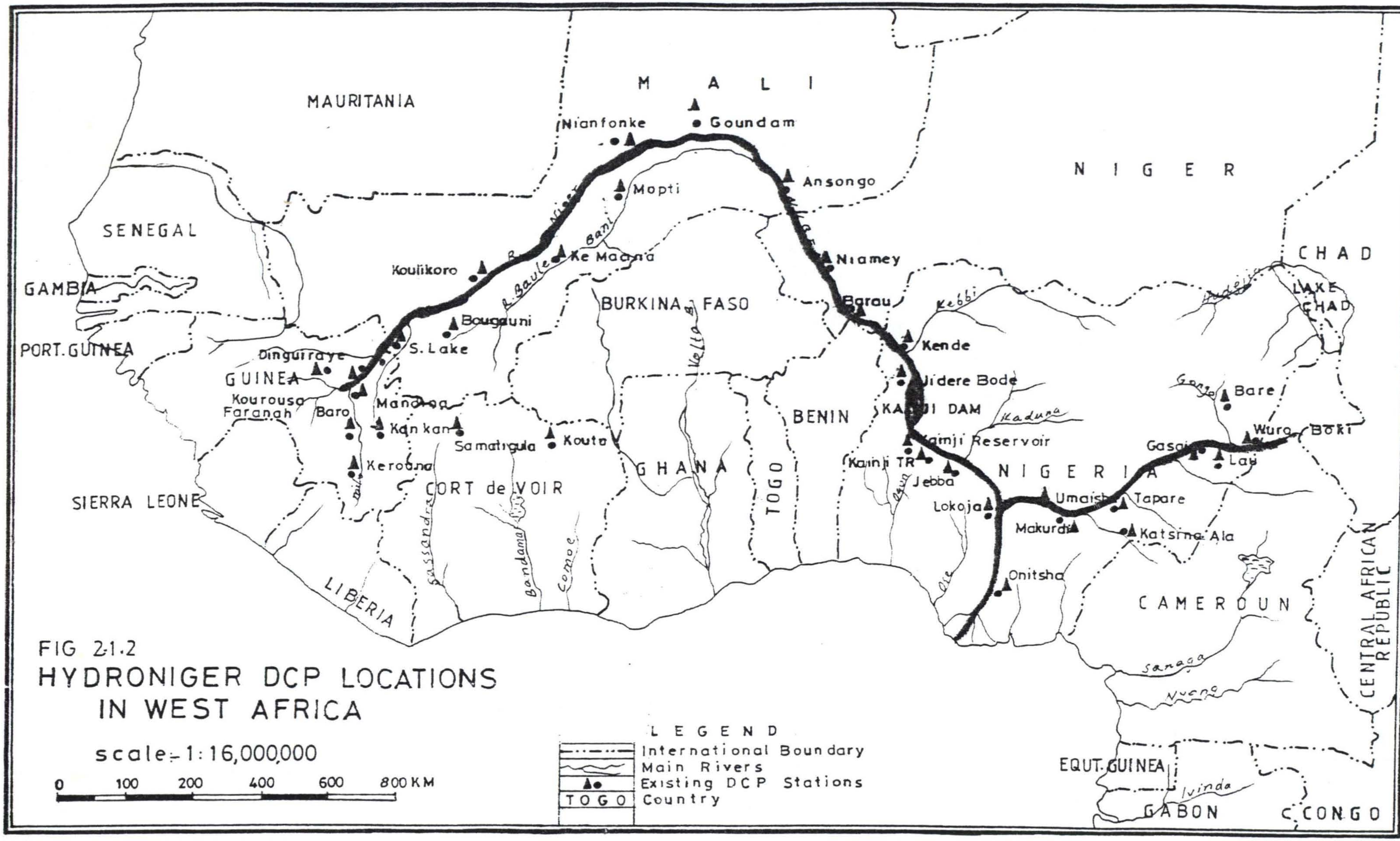



FIG 2.1.2
HYDRONIGER DCP LOCATIONS IN WEST AFRICA

(ii) Rainfall - using tipping bucket raingauge which is installed as an accessory to the platform (Figure 2.1.3).

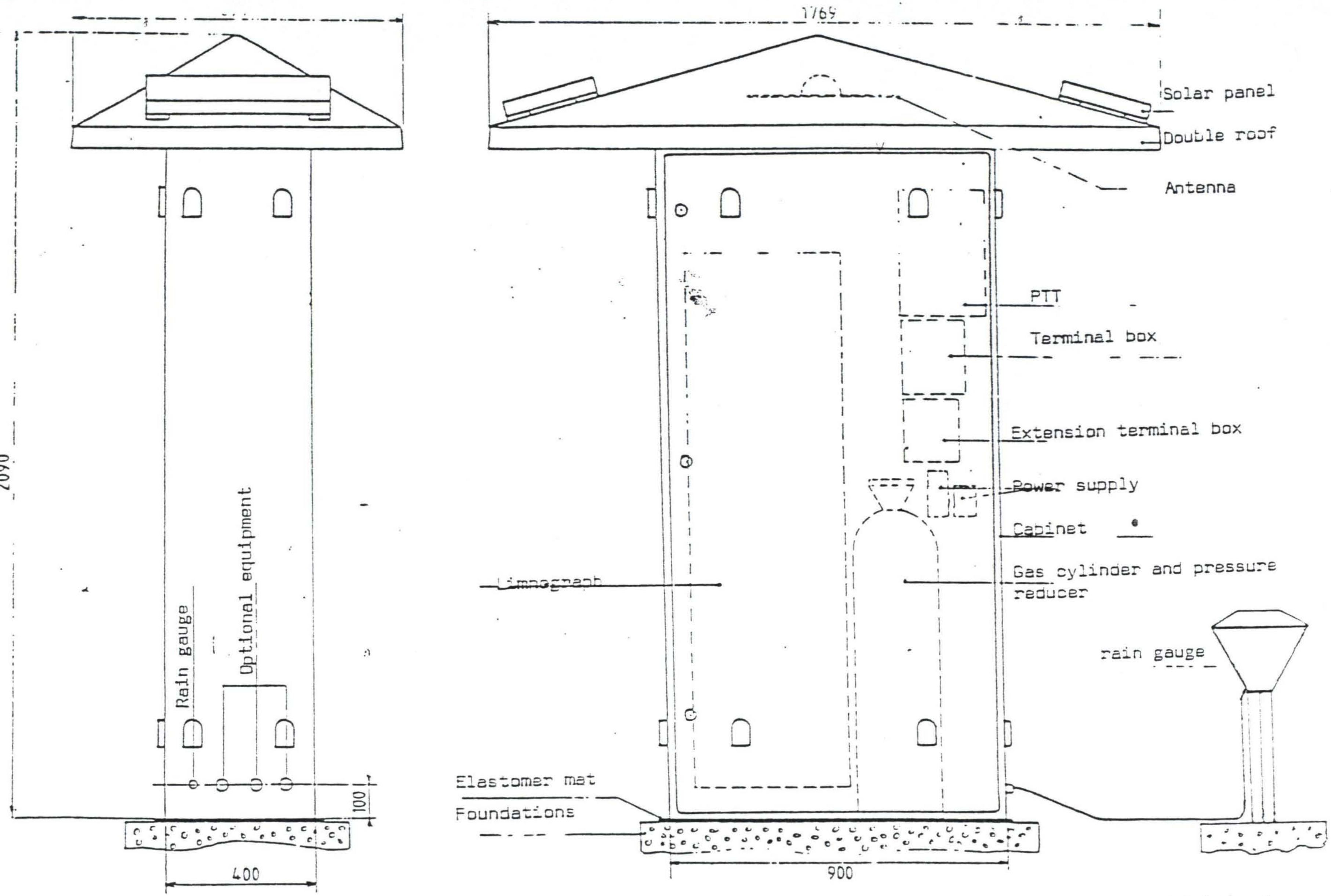
The platform is equipped with a timer, tele-transmitter transmitting messages at every 125 seconds (2 mins. 5 secs), a battery operated coder, the ARGOS beacons, pneumatic limnographs fed by 20 litres compressed-air bottles under pressure of 200 bars.

The system of the platform, with associated transmission ARGOS beacons and TIROS-NOAA satellites, communicates with an International Prediction Centre (IPC) at Niamey in Niger Republic. Other National Prediction Centres (NPC) receive their data from the IPC for onward transmission to local interested stations.

The recorded water levels are transmitted simultaneously in coded messages by the ARGOS beacons at 100 seconds interval using the TIROS-NOAA satellite, which passes over each platform from six to eight times each day.

The satellite stores the data and transmits them to the International Prediction Centre at Niamey as well as to the individual National Prediction Centre.

Under this regional hydrological network development programme a National Prediction Centre (NPC) is locted in each of the member state led Niamey, Niger Republic as the headquarters other member of states has the following number of Data Collection Platform Stations.




All dimensions given in mn unless otherwise stated.

Fig 2.1.3. Cross-Sectional View of Data Collection Platform

**Table 2.1 Niger River Basin Member states**

| S/No | Country | No of DCP | NFC Location |
|---|---|---|---|
| 1. | Guinea | 7 | Conakry |
| 2. | Mali | 22 | Bamako |
| 3. | Niger | 9 | Niamey |
| 4. | Nigeria | 18 | Kaduna |
| 5. | Cote d'Ivoire | 2 | Abidjan |
| 6. | Cameroon | 5 | Younde |
| 7. | Burkina Fasso | 1 | Onaga |
| 8 | Benin Republic | 3 | Cotonou |

**Table 2.2 Data Collection Platforms in Nigeria.**

| S/NO. | STATIONS | RIVER |
|---|---|---|
| 1. | Kende | Sokoto |
| 2. | Jidere Bode | Niger |
| 3. | Kainji Reservoir | Niger |
| 4. | Kainji T/R | Niger |
| 5. | Jebba | Niger |
| 6. | Wuya | Kaduna |
| 7. | Baro | Niger |
| 8. | Lokoja | Niger |
| 9. | Onitsha | Niger |
| 10. | Umaisha | Benue |
| 11. | Makurdi | Benue |
| 12. | Katina-Ala | Kastina-Ala |
| 13. | Ibi | Benue |
| 14. | Tapare | Donga |
| 15. | Gassol | Taraba |
| 16. | Lau | Benue |
| 17. | Bare | Gongola |
| 18. | Wurobokki | Benue |

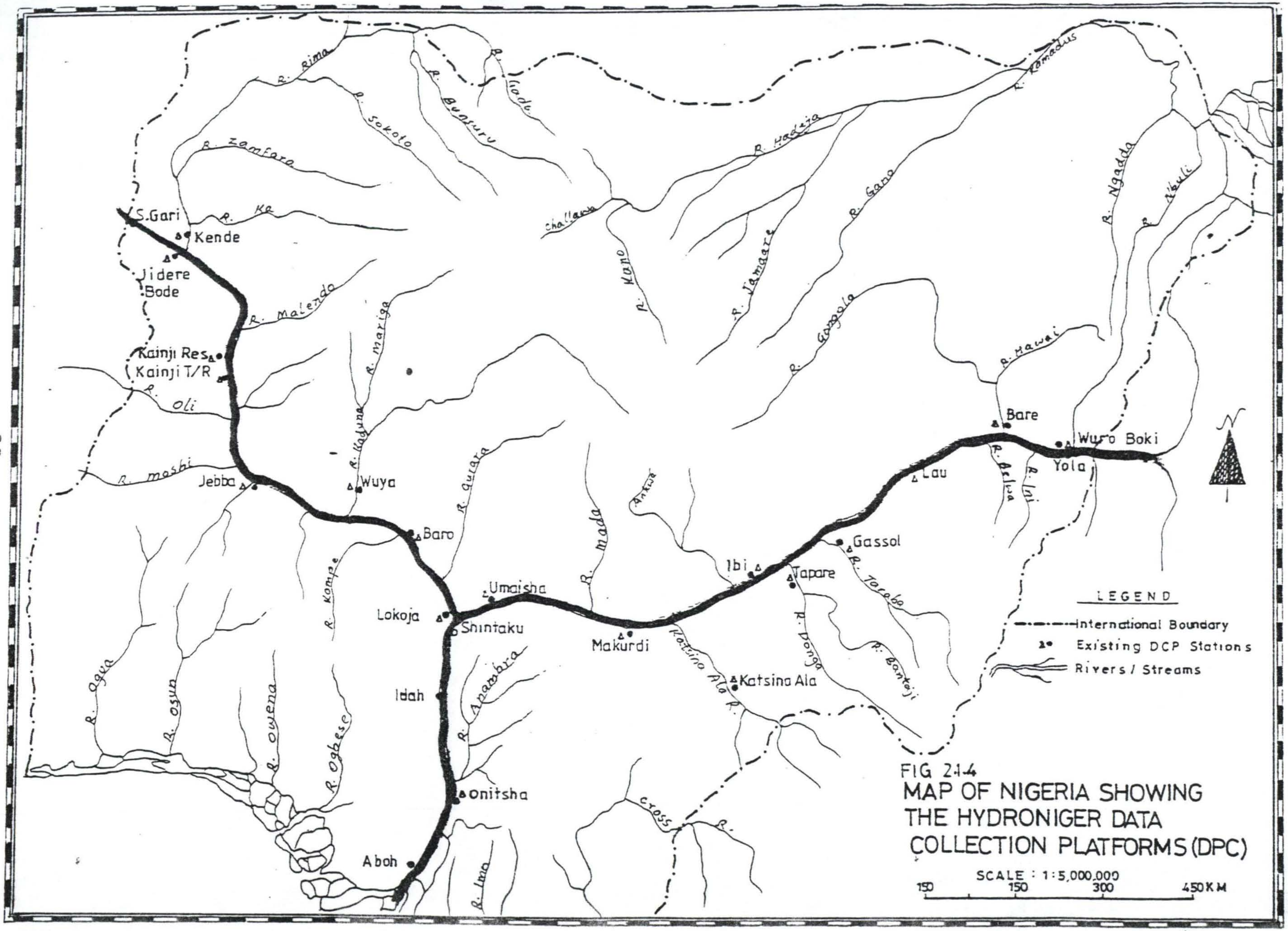



FIG 2.1.4
MAP OF NIGERIA SHOWING THE HYDRONIGER DATA COLLECTION PLATFORMS (DPC)

The eighteen Data Collection Platform Stations in NIgeria are spread as shown in figure 2.1.4.

### 2.1.2 HYDRO-NIGER System

The hydro-niger system components consist of water two level sensor (Bubble Gauge) rain gauge, water level encoder, mercury manometer system, platform transmission antennae, platform solar power/battery.

Data Collection Platform senses water level which is encoded into binary digits by encoder. Values passed to platform transmission unit for transmission to satellite. Data are relayed by satellite to ground receiving station equipped with antennae and pre-amplification unit. Receiver passes information to computer and is decoded into decimal and hexadecimal units. Data is stored and printed automatically. Visual Display Unit (VDU) displays data on request. The time between sensing and printing is 10 - 20 minutes, depending on size of acquired data during satellite pass.

The purpose of data collection is for flood warning and water resources assessment.

## 2.2 DATA ANALYSIS

Data from the field observation stations are collected through automatic transmitting systems. These data consist of gauging station records conducted systematically, various types of special records such as, Battery voltage, Solar panel capacity, temperature is also accompanied by special reports on the conditions of the observing post requesting for maintenance, repairs etc.

All types of data may contain various types of errors that may be random or systematic and therefore all incoming data must be promptly checked. Whenever possible, periods of missing gauge readings are, estimated on the basis of records from nearby stations.

The various simple form of analysis includes: -

(i) Calculation of daily monthly and annual mean.

(ii) The calculation of cumulative runoff

(iii) The use of a flow-mass-curve which is a graph of the cumulative values of the daily or monthly discharge (as ordinate) plotted against time (as abscissa). The flow mass curve method is also known as ripple method and has many useful applications in the design of storage reservoirs. The difference between the ordinate of any two points on the mass-curve is the summation of the flows during the intervening period of time.

(iv) The use of the duration curve. This curve shows the percentage of time that the flow exceeds a given value. The curve commonly used in computing hydroelectrical power potential.

A graph showing stage and discharge with respect to time is known as a hydrograph. When the stage is plotted against time, the graph is usually called a stage hydrograph which is usually shown on the record chart of a recording gauge station.

From the hydrograph analysis. The mean daily discharge can be calculated from the hourly discharge by using the equation of the form:

$$\overline{Q_d} = \sum_{1}^{24} \frac{Q_h}{24} \quad .......... \quad 2.2.1$$

where $Q_d$ is the mean daily discharge, and $Q_h$ is the hourly discharge.

Similarly mean monthly discharge is calculated from mean daily discharge as:

$$Q_m = \sum_{1}^{n} \frac{Q_d}{n} \quad ........... \quad 2.2.2$$

where $Q_m$is the mean monthly discharge, $Q_d$ is the mean daily discharge, and n, the number of day the month.

Mean annual discharge can be determined by:

$$Q_a = \sum_{1}^{m} \frac{Q_d}{m} \quad .......... \quad 2.2.3$$

where m = 365 or 366 depending the mean is calculated for a normal or leap year.

Less accurate mean annual discharge can be calculated as:

$$Q_a = \sum_{1}^{12} \frac{Q_m}{12} \quad ......... \quad 2.2.4$$

### 2.2.1 Missing Data

Gaps are often found in the gauge height records or discharge records which may results from the absence of the observer or as a result of fault in the instrument. In some cases the data can be completed by simple means, in others, more advanced statistical methods have to be applied.

When one gauge height daily reading is missing during a period of stable or slightly fluctuating records, it can be filled by simple interpolation between the values of a previous and the following day. This can be calculated by using the equation;

$$Y = \frac{(x_2 - x)y_1 + (x - x_1)y_2}{x_2 - x_1} \qquad \text{..................} \quad 2.2.1.1$$

where Y = missing record corresponding to the record x in the complete observation, $y_1$, $y_2$ = values in the incomplete record which are known and the corresponding with $x_1$, and $x_2$ records in the complete record.

But when a longer period of records is missing, the statistical method of linear regression can be used:

$$Q_1 = a_1 . Q_2 + a_2$$

where $Q_1$, and $a_2$ are discharge record upstream and downstream.

$a_1$, and $a_2$ are constants.

### 2.2.2 Data storage

With an increasing amount of data collection and computerization of the hydrological working methods, attempts are now made to store the data in a form immediately ready for computer processing. Data for such purpose are stored on punched tapes, punched cards, magnetic tapes or discs. Such a type of data storage provides the possibility of using basic data repeatedly for basic analysis, for advanced analysis as well as special studies.

## 2.3. IMPORTANCE OF HYDRO-NIGER TO BENEFITING COUNTRIES

1. It promotes unity. The waters of the Niger river are of vital importance to at least eight (8) countries of West Africa, and an early warning flood prediction system is a crucial factor in distribution and multiple use. The HYDRONIGER Project is part of an overall strategy for the river basin orchestrated by the Niger River Basin Authority whose function is to promote an integrated water development policy for the nine member states.
2. It is evident that the capacity to predict flow rates in specific reaches of the river or the surrounding basin provides an important tool for a variety of uses.
3. Variation of flows has always made traditional flood-recession cultivation a hazardous business. On numerous occasions newly planted seed has been washed out by subsequent rise in the waters or dramatic diminuition of

flows has seen crops wither for want of water. Hence if flood prediction in the lengthy and often leisurely Niger is largely designed to expand water-use possibilities, it is about saving life and protecting property.

4. Reliable information on the river's flow fluctuations will be of enormous benefit in the planning of future structures and enhance the security of sites while structures are under construction.

5. With the operation of major dams along the river such as Kainji, Selique, Markala, Lagdo, Jebba etc. These structures improve flows control and importantly for the riparian states, enhance the navigability of the river.

# CHAPTER THREE

## 3.0 HYDROLOGICAL ANALYSIS ALGORITHM

### 3.1 ALGORITHM

An algorithm is the sequence of logical steps required to perform a specific task such as solving a problem. Algorithm design is the preliminary planning aspect of programming that lead to a more coherent and efficient product.

A good algorithm must have a number of specific properties such as:

1. Each step must be deterministic; that is, nothing can be left to chance.
2. The process must always end after a finite number of steps. An algorithm cannot be open-ended.
3. The algorithm must be expressed both by step-by-step English description and by visual or graphical representation (flowchart).

#### 3.1.1 Flowcharting

A Flowchart is a visual or graphical representation of an algorithm. The flowchart employs a series of blocks and arrows, each of which represents a particular operation or step in the algorithm. The arrows represent the sequence in which the operations are implemented.

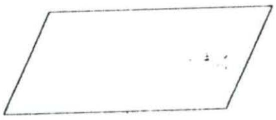
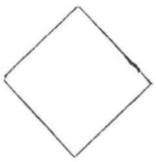
Flowchart are used for expressing and communicating algorithms. They proved useful in planning, unraveling, or communicating the logic of program. They are excellent pedagogical tools. They are ideal vehicles for visualizing some of the fundamental logical structures employed in computer programming.

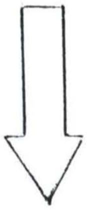
### 3.1.2 Pseudocode

Pseudocode is an alternative way to express an algorithm that bridges the gap between flowcharts and computer code. This technique uses English like statements in place of the graphical symbols of the flowchart. It is a way of organizing thoughts. It provides for framework for communicating with other programers. It is easier to develop a program with it than with a flowchart. The peudocode is also easier to modify.

### 3.1.3 Flowchart symbols

Some of the symbols used in flowchart for this project include:-

| SYMBOL | NAME | FUNCTION |
|---|---|---|
|  | **Terminal** | It represent the beginning or end of a program. |
| | **Flowlines** | It represent the flow of logic. A flowchart is read by beginning at the start terminal and following the flowline to trace the algorithm's logic. |
|  | **Process** | It represent calculations or data manipulations. This symbols can also be used to represents major program segments or modules. |
|  | **Input/Output** | It represents inputs or outputs of data and information. Thus at one key point they might be used to designate the input of information from a keyboard, whereas at other point they might represent the output of data to a printer or monitor. |
|  | **Decision** | It represent a comparison, question, or decision that determines alternative path to be followed. This is the only symbol that has more than one exit flowline. The proper exit path is determined by the correct answer to a question or conditional statement contained in the block. |

| | | |
|---|---|---|
|  | **On page Connector** | It represent a break in the path of a flowchart that is used to continue flow from on point on a page to another. Circular connectors allow the flow to be discontinued at one section of a flowchart and start again at another location. |
|  | **Off page Connector** | It represents a break in the path of a flowchart that is used when it is too large to fit on a single page. The connector symbols marks where the algorithm ends on the first page and where it continues on the second. |

## 3.2 STEPS

The steps involved to produce and maintain the computer program for this work are:

**Step 1**

Developing the underlying logic of the program.

↓

**Step 2**

Writing the program in computer language.

↓

**Step 3**

Debugging and Testing ensuring that the program is error-free and reliable.

↓

**Step 4**

Documentation
Making the program easy to use and understand

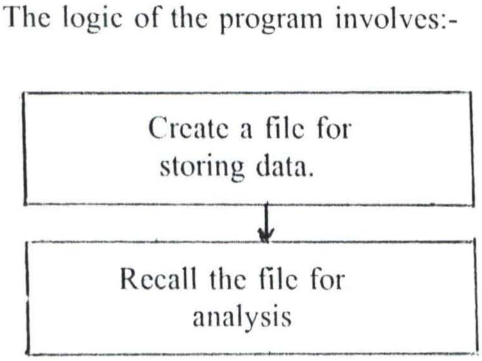
↓

**Step 5**

Storage and maintenance
Saving the program and improving it in the light of experience.

### 3.2.1 Logic of the program

The logic of the program involves:-




#### 3.2.1.1 File

A file can be defined as a section of external storage that has a name. Each individual piece of information on a file is called an item. A group of item that relate to the same object is called a record.

Sequential and direct access files made up the two types of files used on personal computer. Sequential files are those in which items are entered and accessed in sequence. They are very much like read/data statement. Direct access files are those in which record can be accessed directly without having to make way through all previous record. They are similar to Arrays.

Statements that are common with sequential file systems are:-

a. Opening a file:- That is establishing a communication between a program and a file.

b. Transferring data to a file from a program.

c. Transferring data from a file to a program.

d. Closing a file:- That is terminating communication between a program and a file. This will prevent the computer from writing other information onto the files and possibly destroying valuable data.

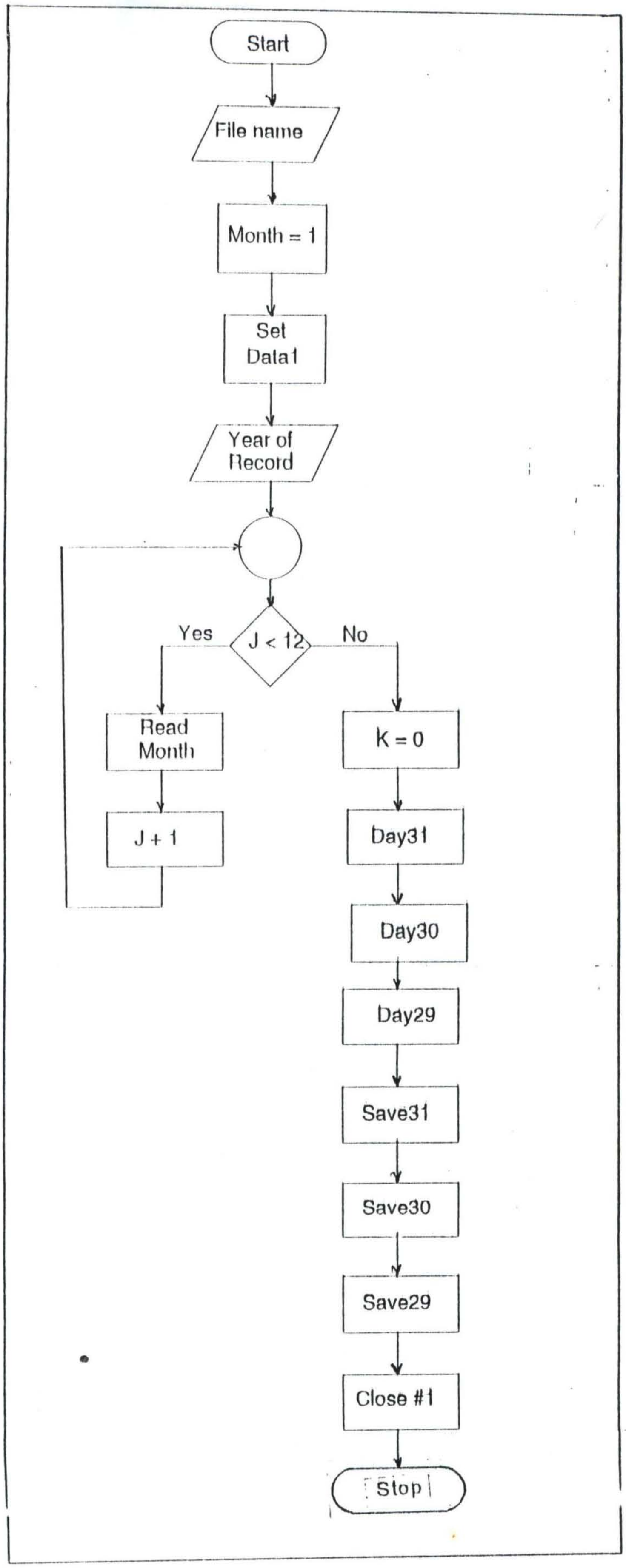



Figure 3.1 Flowchart to create a file for Data storage.

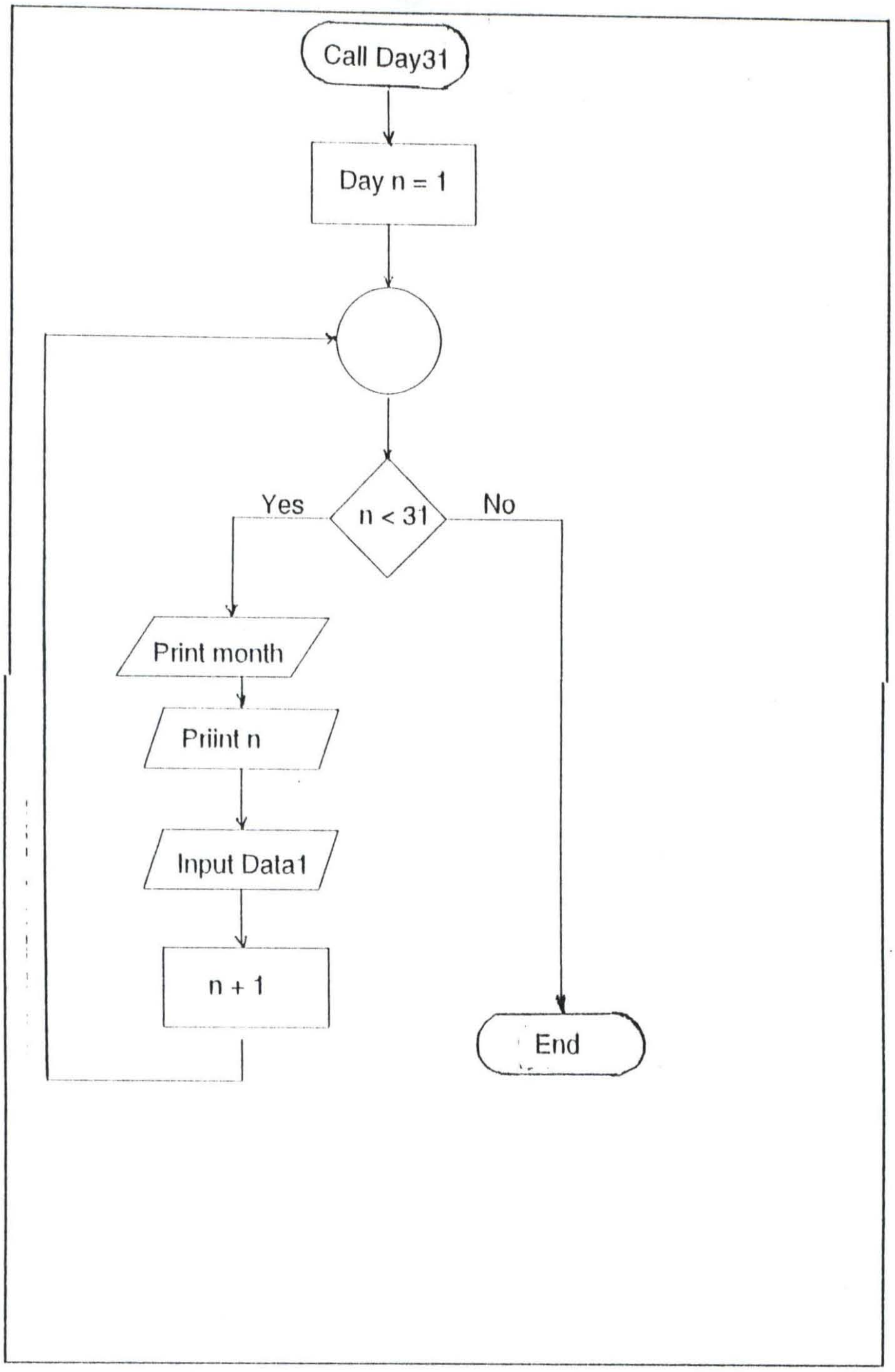



**Figure 3.2 Flowchart for Day31.**

**Procedure Day31**
Set Day(n) to 1
Do while n <= 31
Print month, Day(n)
Input Data1 (k,n)
Add 1 to day(n)
End Procedure.

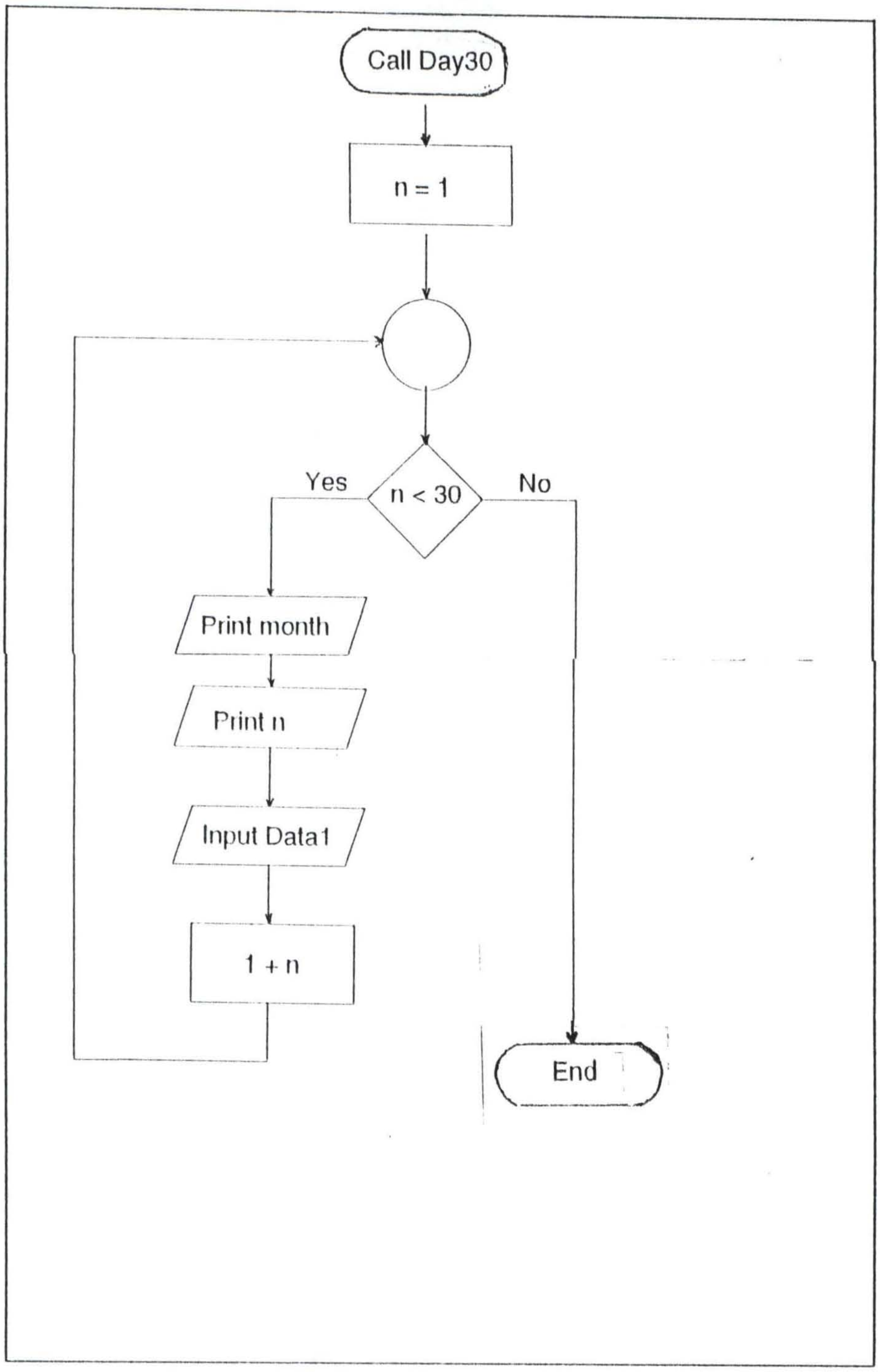



**Figure 3.3 Flowchart for Day30.**

**Procedure Day30**
Set Day(n) to 1
  Do while n <= 30
    Print month, Day(n)
    Input Data1 (k,n)
    Add 1 to day(n)
End Procedure.

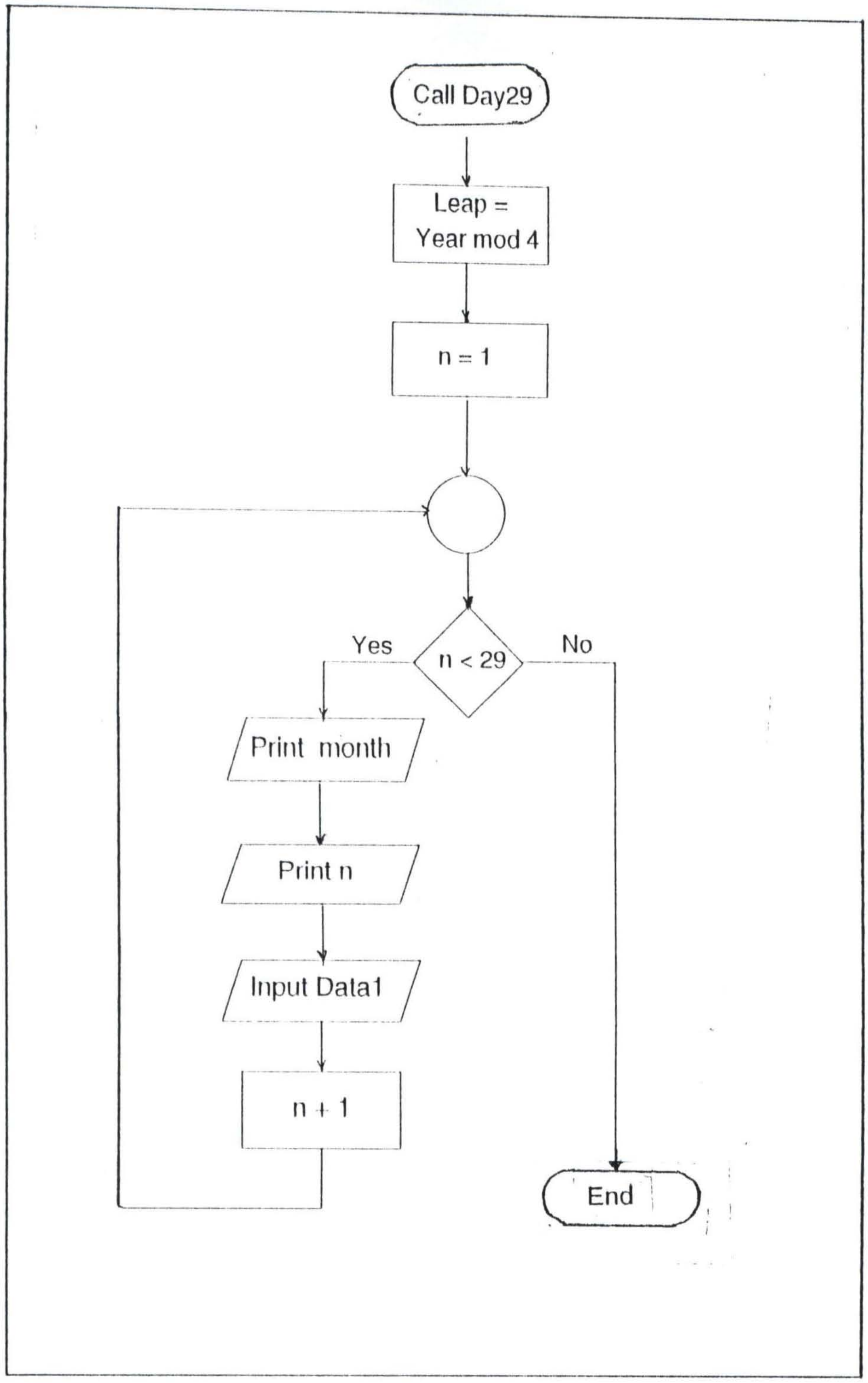



**Figure 3.4 Flowchart for Day29.**

```
Procedure Day29
Set leap = year mod 4
   Do while n <= 29
         If n = 29 and leap <> 0
   Exit Do
         End if
           Print month
           Print day(n)
          Input Data1(k,n)
         Add 1 to n
End procedure.
```

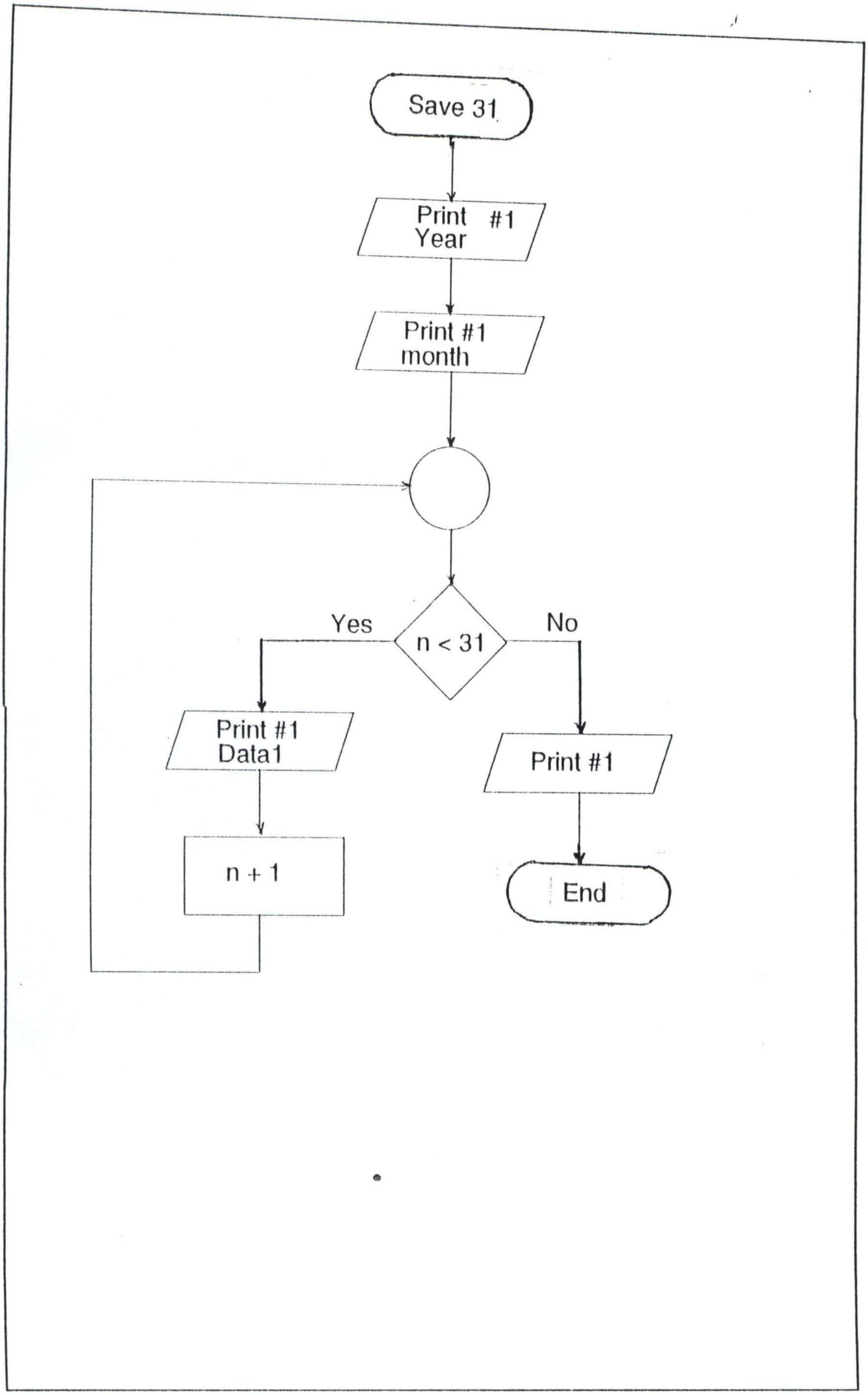



**Figure 3.5 Flowchart for Save31.**

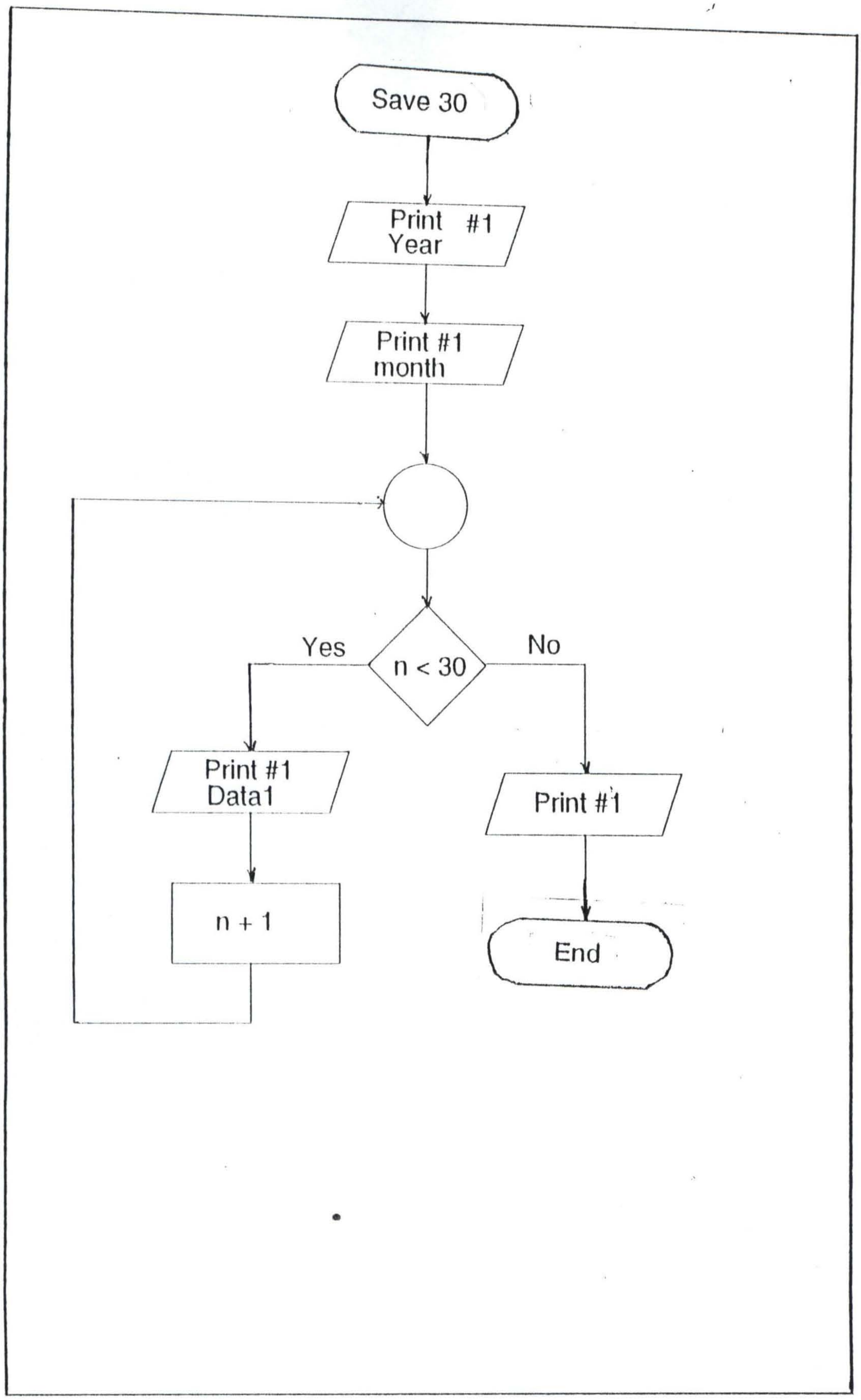



Figure 3.6 Flowchart for Save30.

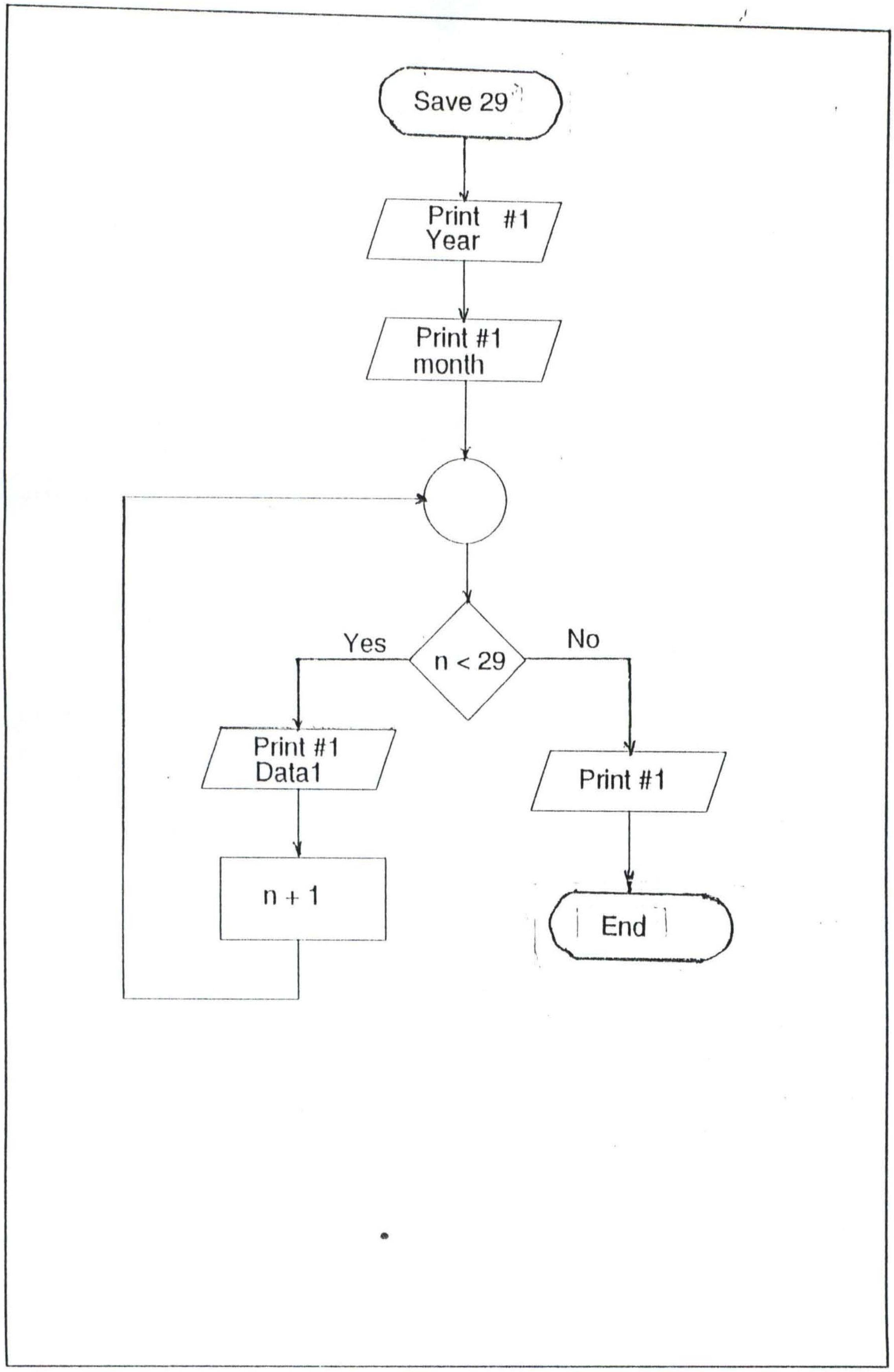



**Figure 3.7 Flowchart for Save29.**

### 3.2.2 Logic to recall created file for computation

The following are the steps to read back data from the created file, do necessary computation and output results:

**Pseudocode**

```
Open created file for input as #1
Input Year of record to be printed
Do while not EOF(1)
Line Input #1, Var1$
   Determine various months of the Year
     Select Case month
       Case of months with 31 days
       Case of months with 30 days
       Case of February
     End Select
  End do
  Close #1
  Determine the Min, Max, Average data for selected case month
  Output result on the screen
  Output result to printer
```

This can be represented in flowchart as thus:

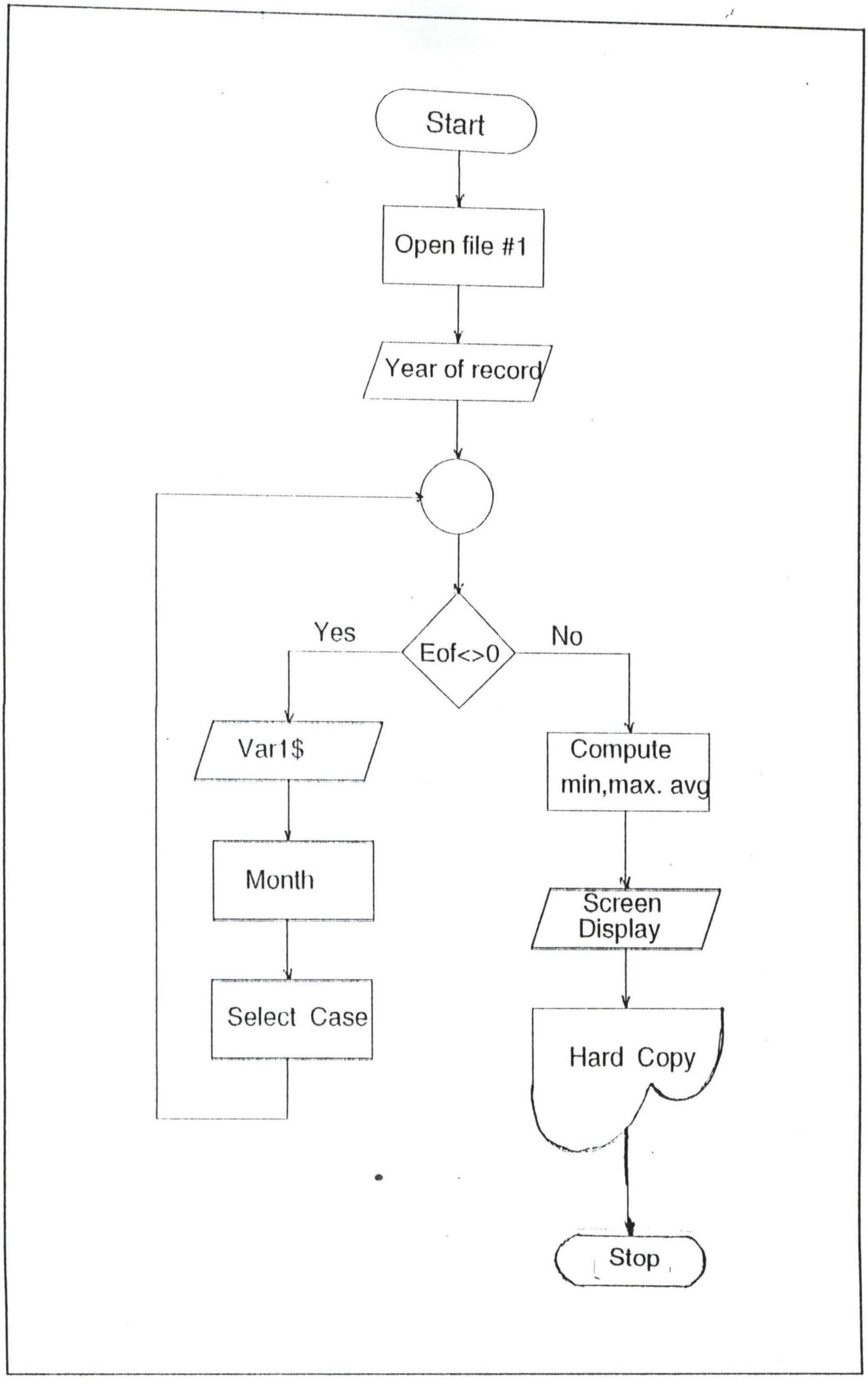



**Figure 3.8 Flowchart to recall a file for Computation.**

## CHAPTER FOUR

# COMPUTATIONAL EXPERIMENTATION

HYDROLOGICAL DATA

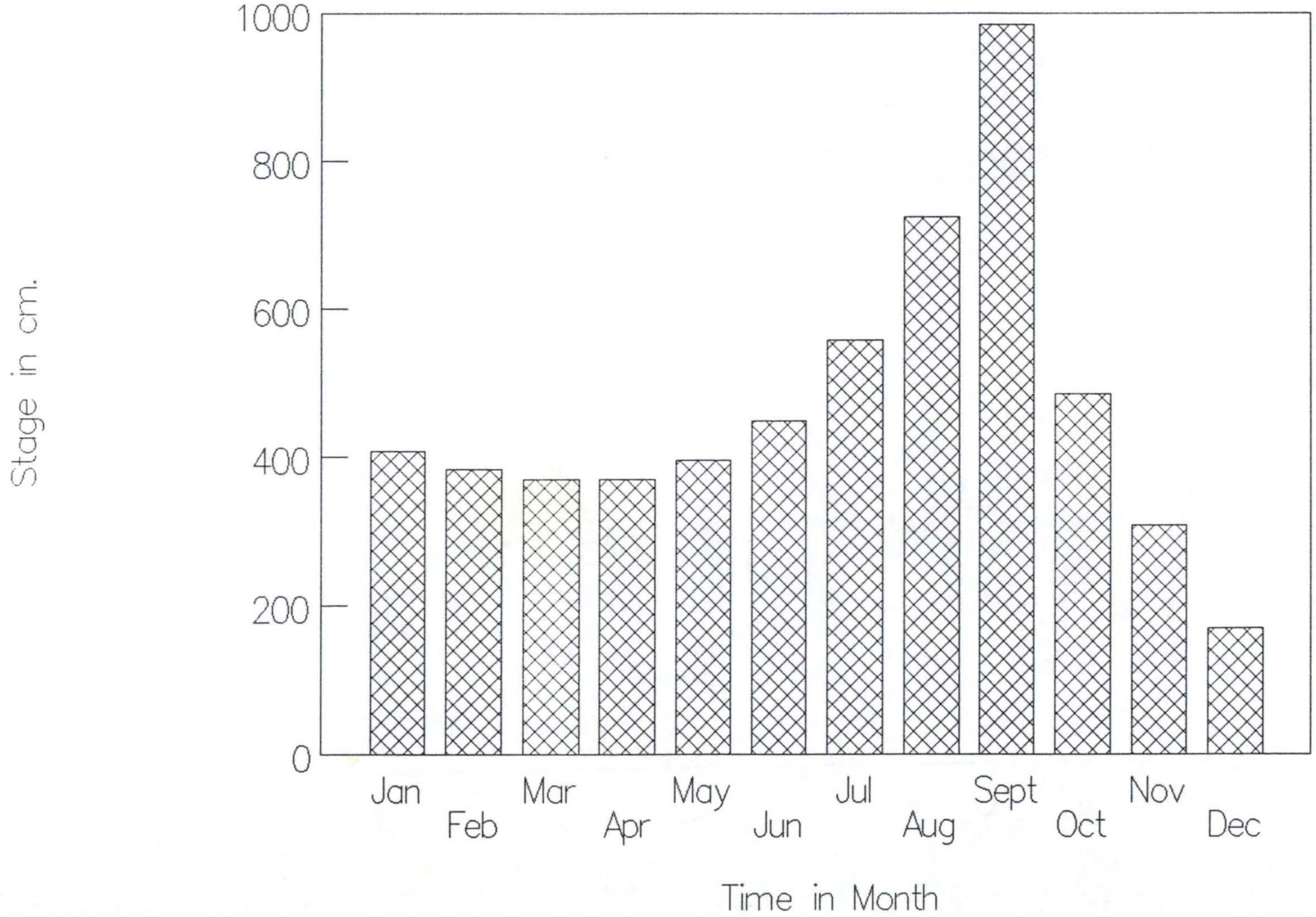
Water Level measurement in river ............

Station: ............ . Year: .......

| DAY | JAN | FEB | MAR | APR | MAY | JUN | JUL | AUG | SEP | OCT | NOV | DEC |
|---|---|---|---|---|---|---|---|---|---|---|---|---|
| 1 | 441.0 | 413.0 | 379.0 | 379.0 | 399.0 | 449.0 | 558.0 | 725.0 | 985.0 | 673.0 | 481.0 | 304.0 |
| 2 | 439.0 | 411.0 | 377.0 | 375.0 | 395.0 | 454.0 | 560.0 | 726.0 | 992.0 | 678.0 | 497.0 | 296.0 |
| 3 | 437.0 | 409.0 | 376.0 | 373.0 | 397.0 | 457.0 | 561.0 | 726.0 | 999.0 | 675.0 | 516.0 | 284.0 |
| 4 | 434.0 | 408.0 | 375.0 | 371.0 | 399.0 | 466.0 | 563.0 | 731.0 | 999.3 | 668.0 | 533.0 | 276.0 |
| 5 | 432.0 | 407.0 | 374.0 | 370.0 | 399.0 | 473.0 | 565.0 | 735.0 | 999.0 | 659.0 | 539.0 | 269.0 |
| 6 | 431.0 | 407.0 | 374.0 | 369.0 | 399.0 | 480.0 | 567.0 | 747.0 | 995.0 | 633.0 | 538.0 | 261.0 |
| 7 | 429.0 | 406.0 | 374.0 | 369.0 | 398.0 | 478.0 | 569.0 | 761.0 | 992.0 | 623.0 | 536.0 | 255.0 |
| 8 | 429.0 | 406.0 | 374.0 | 371.0 | 398.0 | 474.0 | 571.0 | 780.0 | 992.0 | 619.0 | 535.0 | 253.0 |
| 9 | 429.0 | 405.0 | 373.0 | 373.0 | 398.0 | 485.0 | 572.0 | 790.0 | 992.0 | 630.0 | 532.0 | 249.0 |
| 10 | 428.0 | 403.0 | 373.0 | 375.0 | 402.0 | 499.0 | 575.0 | 796.0 | 994.0 | 644.0 | 527.0 | 243.0 |
| 11 | 426.0 | 401.0 | 372.0 | 378.0 | 405.0 | 511.0 | 578.0 | 803.0 | 991.0 | 648.0 | 522.0 | 239.0 |
| 12 | 424.0 | 400.0 | 371.0 | 377.0 | 407.0 | 524.0 | 578.0 | 824.0 | 989.0 | 634.0 | 515.0 | 232.0 |
| 13 | 423.0 | 399.0 | 370.0 | 374.0 | 409.0 | 523.0 | 580.0 | 836.0 | 988.0 | 653.0 | 510.0 | 218.0 |
| 14 | 421.0 | 398.0 | 370.0 | 371.0 | 412.0 | 522.0 | 587.0 | 856.0 | 993.0 | 678.0 | 497.0 | 217.0 |
| 15 | 419.0 | 397.0 | 371.0 | 370.0 | 422.0 | 525.0 | 587.0 | 878.0 | 999.2 | 681.0 | 483.0 | 218.0 |
| 16 | 418.0 | 396.0 | 370.0 | 370.0 | 434.0 | 528.0 | 589.0 | 894.0 | 999.7 | 664.0 | 478.0 | 217.0 |
| 17 | 417.0 | 394.0 | 373.0 | 370.0 | 442.0 | 534.0 | 595.0 | 906.0 | 999.1 | 646.0 | 464.0 | 215.0 |
| 18 | 415.0 | 393.0 | 374.0 | 370.0 | 444.0 | 548.0 | 598.0 | 914.0 | 999.2 | 634.0 | 447.0 | 212.0 |
| 19 | 416.0 | 392.0 | 373.0 | 373.0 | 452.0 | 555.0 | 609.0 | 918.0 | 999.2 | 636.0 | 425.0 | 206.0 |
| 20 | 414.0 | 391.0 | 373.0 | 376.0 | 459.0 | 556.0 | 621.0 | 927.0 | 999.2 | 632.0 | 406.0 | 197.0 |
| 21 | 413.0 | 390.0 | 376.0 | 377.0 | 464.0 | 557.0 | 633.0 | 934.0 | 999.3 | 624.0 | 388.0 | 191.0 |
| 22 | 411.0 | 388.0 | 379.0 | 377.0 | 494.0 | 559.0 | 645.0 | 940.0 | 999.4 | 622.0 | 374.0 | 192.0 |
| 23 | 411.0 | 387.0 | 388.0 | 378.0 | 516.0 | 561.0 | 656.0 | 951.0 | 999.5 | 614.0 | 360.0 | 190.0 |
| 24 | 413.0 | 396.0 | 394.0 | 380.0 | 517.0 | 560.0 | 661.0 | 961.0 | 999.6 | 606.0 | 342.0 | 188.0 |
| 25 | 410.0 | 386.0 | 393.0 | 387.0 | 515.0 | 562.0 | 659.0 | 962.0 | 999.5 | 592.0 | 330.0 | 186.0 |
| 26 | 409.0 | 384.0 | 391.0 | 394.0 | 514.0 | 564.0 | 662.0 | 967.0 | 999.4 | 561.0 | 326.0 | 176.0 |
| 27 | 408.0 | 384.0 | 391.0 | 401.0 | 514.0 | 564.0 | 681.0 | 969.0 | 999.9 | 640.0 | 322.0 | 174.0 |
| 28 | 409.0 | 383.0 | 391.0 | 410.0 | 509.0 | 569.0 | 692.0 | 970.0 | 999.9 | 521.0 | 316.0 | 173.0 |
| 29 | 409.0 | 0.0 | 388.0 | 416.0 | 504.0 | 574.0 | 662.0 | 975.0 | 999.9 | 501.0 | 310.0 | 172.0 |
| 30 | 409.0 | 0.0 | 386.0 | 416.0 | 515.0 | 574.0 | 692.0 | 972.0 | 999.9 | 491.0 | 307.0 | 171.0 |
| 31 | 0.0 | 0.0 | 384.0 | 0.0 | 509.0 | 0.0 | 695.0 | 969.0 | 0.0 | 484.0 | 0.0 | 170.0 |
| AVG | 407.2 | 397.6 | 378.3 | 379.7 | 446.5 | 522.8 | 610.4 | 865.9 | 996.4 | 621.4 | 445.2 | 220.8 |
| MIN | 408.0 | 383.0 | 370.0 | 369.0 | 395.0 | 449.0 | 558.0 | 725.0 | 985.0 | 484.0 | 307.0 | 170.0 |
| MAX | 441.0 | 413.0 | 394.0 | 416.0 | 517.0 | 574.0 | 695.0 | 975.0 | 999.9 | 681.0 | 539.0 | 304.0 |

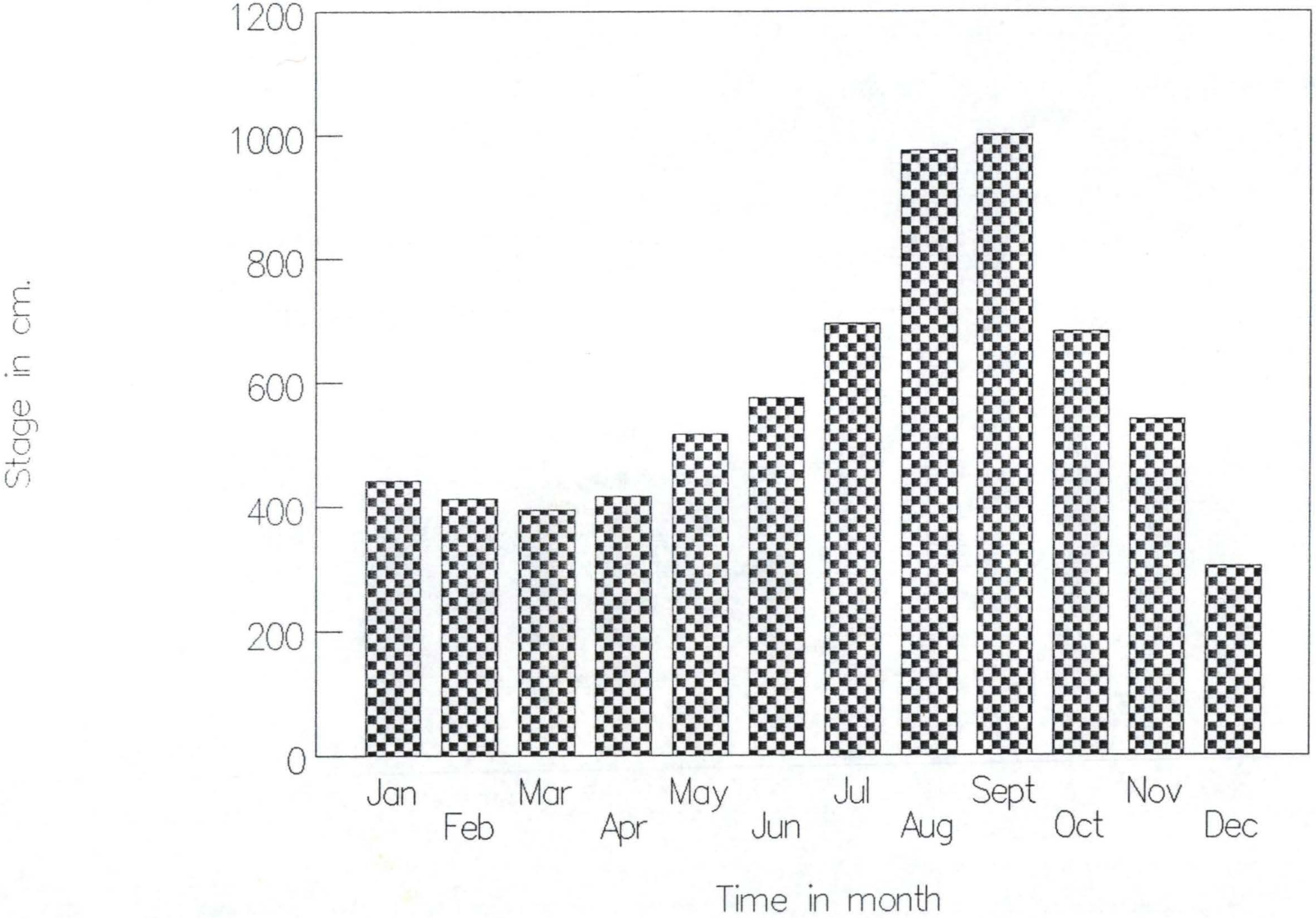
MINIMUM VALUES OF WATER LEVEL

Station: Makurdi; River: Benue; Year 95



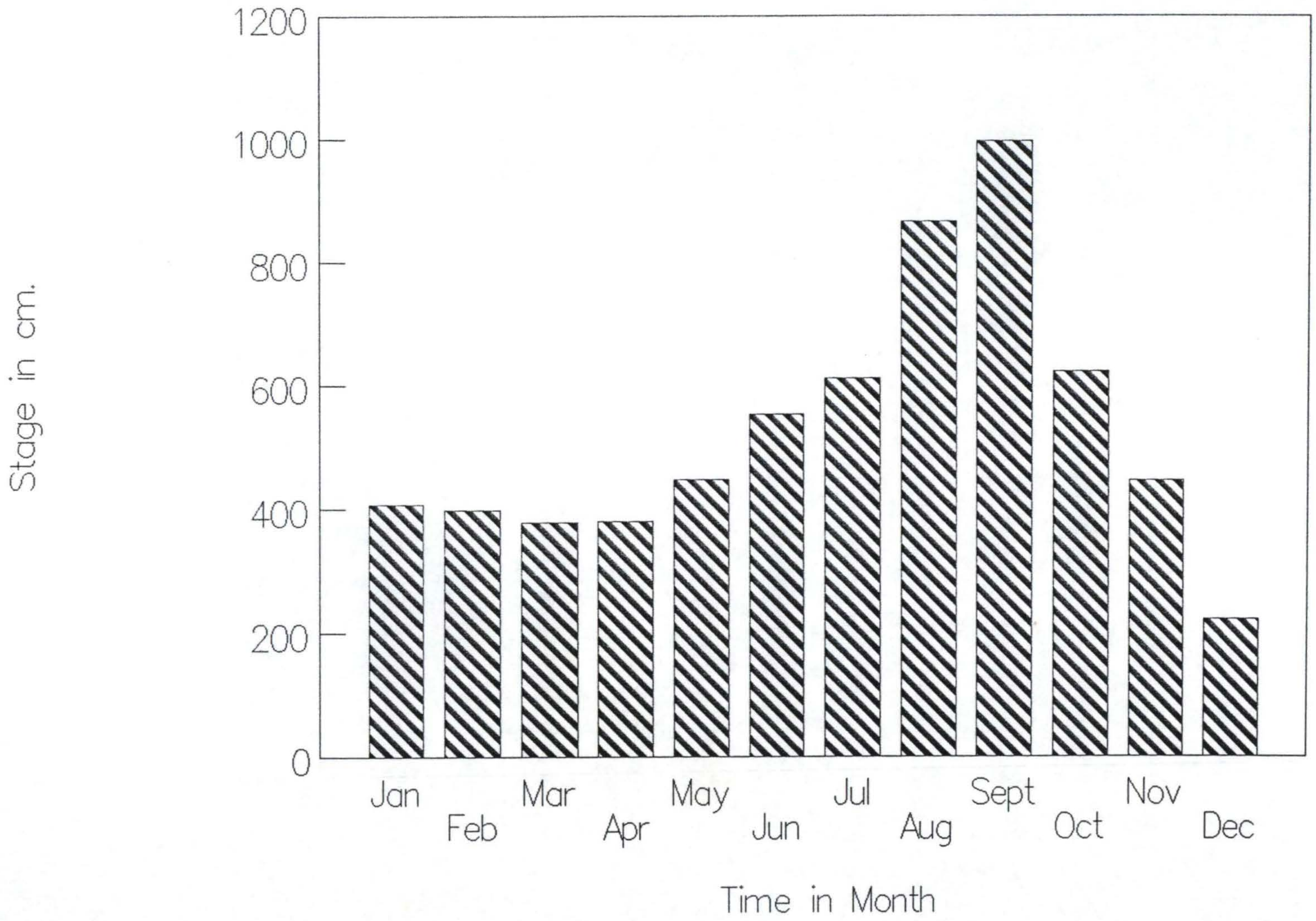
# MAXIMUM VALUES OF WATER LEVEL

## Station: Makurdi; River: Benue; Year 95



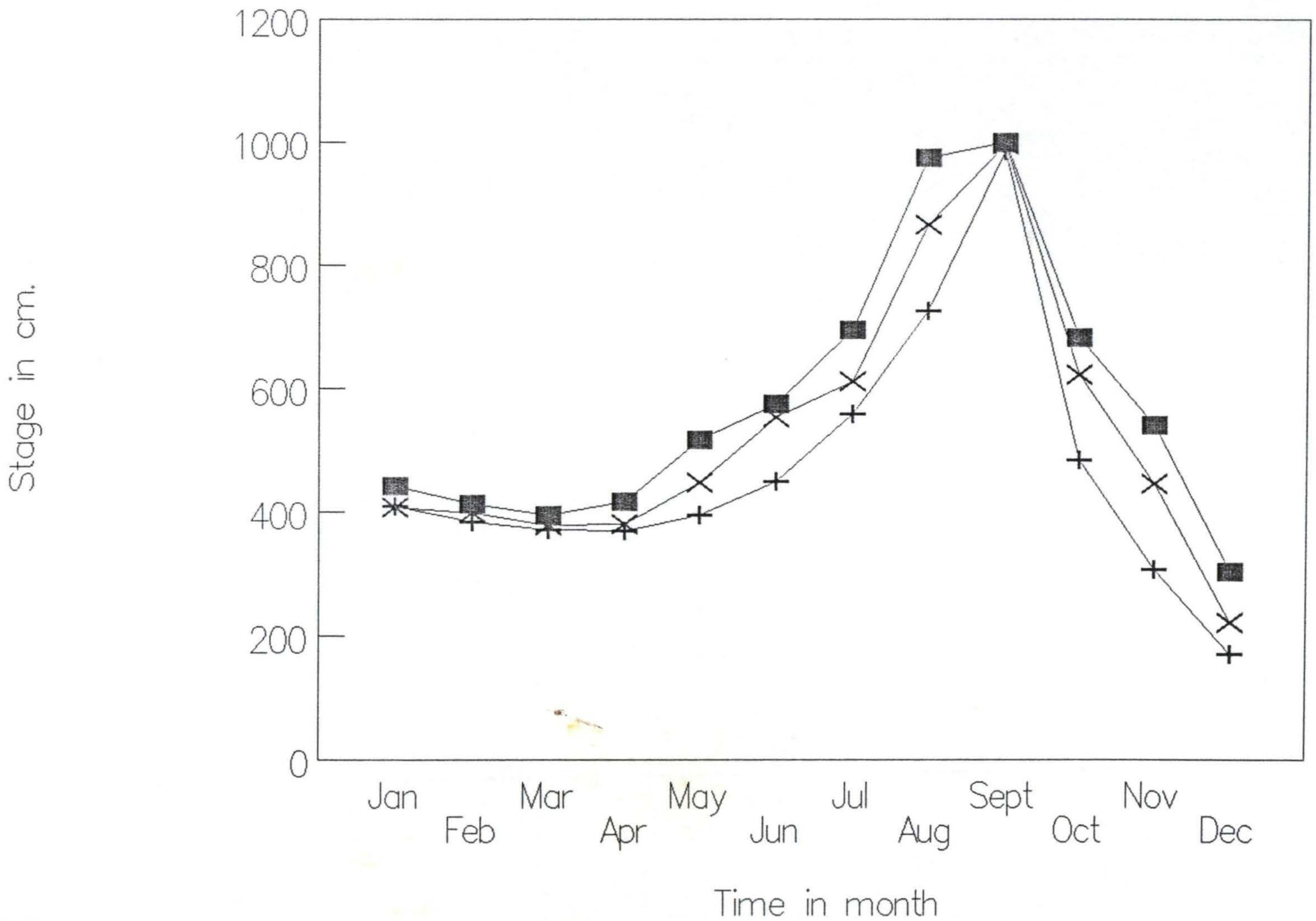
# AVERAGE VALUES OF WATER LEVEL

## Station: Makurdi; River: Benue; Year 95



# MAXIMUM, MINIMUM, AND AVERAGE VALUES

## Station: Makurdi; River: Benue; Year 95



# CHAPTER FIVE

## 5.0 CONCLUSION AND RECOMMENDATION

### 5.1 CONCLUSION

Water management planning is based on reliable information on river flow and groundwater reserves.

Reliable information on and forecasts of water flow are necessary for multipurpose reservoirs in flood zones.

This thesis would enable interested people to have an idea on constructing an algorithm and writing simple basic program to analyse water level. Results obtained from analysis must be accurate and error free as these data are essential for the prediction of the state of water flow in the river in the near future.

Accurate data from the analysis can be used to estimate the amount of water that would be available to a particular location and hence bring warning if it will pose danger on life and property.

### 5.2 RECOMMENDATIONS

Water is essential in all aspect of life, therefore more emphasis should be laid on unique method for writing program in Basic language, Fortran language, Pascal language and Database management language which will be made available to all and future hydrological forecasting centre in the country to analyse daily availabiliity of water level on the country major rivers.

More importance should be attached to this hydro-niger project by the government since it is both beneficial to present and future generation.

Since power supply system of the country is often interrupted, the National Forecasting Centre in Kaduna should be equipped with automatic generator to serve as on alternative source of power supply so as to avoid continuous loss of data transmission during the general power supply failure. Also parallel method of data collection system (that is collection of data on site by gauge reader and transmission of data by satellite to receiving station) should be continue.

Interested person could pick up from where it is stopped.

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4. **Starosolzky, O. et al:** Hydrological Forecasting, International Postgraduate Course on hydrological method for Developing Water Resources Management. Number 9, Third course. Research Institute for Water Resources Dev. Budapest, VIII. 1970.

5. **Steven C.C. & Raymond P.C:** Introduction to computing for Engineers. McGraw-Hill International Editions. Computer Science Series 1986.

## APPENDIX I

**Basic Program to create a File for storing Data**

```
1000 Rem Basic program to create a file
1010 Rem for storing Data
1020 Input "Create a file named"; filnam$
1030 Open filnam$ for Output as #1
1040 Input "Year of record"; Year
1050 Data Jan, Feb, Mar, Apr, May, Jun, Jul, Aug, Sep,
1060 Data Oct,Nov, Dec
1070 Dim Month$(12), Data(12,31)
1080 For J = 1 to 12
1090    Read Month$(J)
1100 Next J
1110 K = 0
1120 Gosub Day31
1130 Gosub Day29
1140 Gosub Day31
1150 Gosub Day30
1160 Gosub Day31
1170 Gosub Day30
1180 Gosub Day31
1190 Gosub Day31
1200 Gosub Day30
1210 Gosub Day31
1220 Gosub Day30
1230 Gosub Day31
1240 K = 0
1210 Gosub Save31
1220 Gosub save29
1230 Gosub save31
1240 Gosub save30
1250 Gosub save31
1260 Gosub save30
1270 Gosub save31
1280 Gosub save31
1290 Gosub save30
1300 Gosub save31
1310 Gosub save30
1320 Gosub save31
1340 Close#1
1350 End
```

**Day31**:

```
4000 Cls
4010 K = K + 1
4020 For N = 1 to 31
4030     Locate 5,5: Print month$(K)
4040     Locate 5,16: Print N
4050     Locate 5,20: Input Data1(K,N)
4060     Locate 5,5: Print Space$(40)
4070 Next N
4090 Return.
```

**Day30:**

```
5000 Cls
5010 K = K + 1
5020 For N = 1 to 30
5030     Locate 5,5: Print month$(K)
5040     Locate 5,16: Print N
5050     Locate 5,20: Input Data1(K,N)
5060     Locate 5,5: Print Space$(40)
5070 Next N
5080 Return.
```

**Day29:**

```
6000 Leap = Year mod 4
6010 cls
6020 K = K + 1
6030 For N = 1 to 29
6040     If N = 29 And Leap <> 0 Then
6050 Exit for
6060     End if
6070     Locate 5,5: Print month$(K)
6080     Locate 5,16: Print N
6090     Locate 5,20: Input Data1(K,N)
6100     Locate 5,5: Print Space$(40)
6120 Next N
6130 Return.
```

**Save30:**

```
2000 K = K + 1
2010 Print #1, Using "####"; Year;
2020 Print #1, Month$(K);
2030 For N = 1 to 30
2040     Print #1, Using "####.##"; Data1(K,N);
```

```
2050 Next N
2060 Print #1
2070 Return.
```

**Save31:**

```
2090 K = K + 1
2100 Print #1, Using "####"; Year;
2110 Print #1, Month$(K);
2120 For N = 1 to 31
2130     Print #1, Using "####.##"; Data1(K,N);
2140 Next N
2150 Print #1
2160 Return.
```

**Save29:**

```
2200 K = K + 1
2210 Print #1, Using "####"; Year;
2220 Print #1, Month$(K);
2230 For N = 1 to 29
2240    If leap <> 0 And N = 29 Then
2250    End if
2260    Print #1, Using "####.##"; Data1(K,N);
2270 Next N
2280 Print #1
2290 Return.
```

## APPENDIX II

```
1000 CLS
1010 REM BASIC PROGRAM TO READ BACK DATA FOR
1020 REM COMPUTATIONAL ANALYSIS
1030   TIMER ON
1040   CLS
1050   PRINT "Time:"; TIME$
1060   StartTime = TIMER
1070   WHILE TimePast <= .8
1080 LOCATE 5, 20: PRINT "COMPUTATIONAL ANALYSIS OF"
1090 LOCATE 5, 56: PRINT "HYDROLOGICAL DATA"
1100 LOCATE 6, 20: PRINT "A CASE STUDY OF HYDRO-NIGER
1120 LOCATE 6,49: PRINT "PROJECT,KADUNA"
1130 LOCATE 13, 40: PRINT "BY"
1140 LOCATE 22, 22: PRINT "MRS OLUSEGUN-OWOLABI BOSEDE" 1150
LOCATE 22, 51: PRINT CHRISTIANA"
1160 LOCATE 23, 35: PRINT "PGD/MCS/214/96"
1170      TimePast = TIMER - StartTime
1180   WEND
1190   TIMER OFF
1200 LOCATE 25, 45: PRINT "Press any key"
1210 CLS
1220 LOCATE 5, 20: PRINT "COMPUTATIONAL ANALYSIS OF"
1230 "HYDROLOGICAL DATA"
1240 OPEN "WATER.DAT" FOR INPUT AS #1
1250 DIM DATA1(12, 31), month$(12)
1260 LOCATE 10, 27: INPUT "YEAR OF RECORD TO BE PRINTED"; 1270
LOCATE 10,56: INPUT "YEAR
1280 RECN = 1: DAY = 0: month = 0
1290 DO WHILE NOT EOF(1)
1300 LINE INPUT #1, Var1$
1310 IF VAL(MID$(Var1$, 1, 4)) = YEAR THEN
1320   IF MID$(Var1$, 5, 3) = "JAN" THEN
1330     month = 1: month$(month) = MID$(Var1$, 5, 3)
1340   END IF
1350 IF MID$(Var1$, 5, 3) = "FEB" THEN
1360   month = 2: month$(month) = MID$(Var1$, 5, 3)
1370 END IF
1380 IF MID$(Var1$, 5, 3) = "MAR" THEN
1390   month = 3: month$(month) = MID$(Var1$, 5, 3)
1400 END IF
```

```
1410 IF MID$(Var1$, 5, 3) = "APR" THEN
1420   month = 4: month$(month) = MID$(Var1$, 5, 3)
1430 END IF
1440 IF MID$(Var1$, 5, 3) = "MAY" THEN
1450   month = 5: month$(month) = MID$(Var1$, 5, 3)
1460 END IF
1470 IF MID$(Var1$, 5, 3) = "JUN" THEN
1480   month = 6: month$(month) = MID$(Var1$, 5, 3)
1490 END IF
1500 IF MID$(Var1$, 5, 3) = "JUL" THEN
1510   month = 7: month$(month) = MID$(Var1$, 5, 3)
1520 END IF
1530 IF MID$(Var1$, 5, 3) = "AUG" THEN
1540   month = 8: month$(month) = MID$(Var1$, 5, 3)
1550 END IF
1560 IF MID$(Var1$, 5, 3) = "SEP" THEN
1570   month = 9: month$(month) = MID$(Var1$, 5, 3)
1580 END IF
1590 IF MID$(Var1$, 5, 3) = "OCT" THEN
1600   month = 10: month$(month) = MID$(Var1$, 5, 3)
1610 END IF
1620 IF MID$(Var1$, 5, 3) = "NOV" THEN
1630   month = 11: month$(month) = MID$(Var1$, 5, 3)
1640 END IF
1650 IF MID$(Var1$, 5, 3) = "DEC" THEN
1660   month = 12: month$(month) = MID$(Var1$, 5, 3)
1670 END IF


SELECT CASE month$(month)
CASE "JAN", "MAR", "MAY", "JUL", "AUG", "OCT", "DEC"
1680 K = 8
1690 FOR N = 1 TO 31
1700   DATA1(month, N) = VAL(MID$(Var1$, K, 7))
1710   K = K + 7
1720 NEXT N

CASE "APR", "JUN", "SEP", "NOV"
1730 K = 8
1740 FOR N = 1 TO 30
1750   DATA1(month, N) = VAL(MID$(Var1$, K, 7))
1760   K = K + 7
1770 NEXT N
```

```
CASE IS = "FEB"
1780 K = 8
1790 IF YEAR MOD 4 = 0 THEN
1800    R = 29
1810 ELSE
1820    R = 28
1830 END IF
1840 FOR N = 1 TO R
1850    DATA1(month, N) = VAL(MID$(Var1$, K, 7))
1860    K = K + 7
1870 NEXT N
END SELECT
1880 END IF
1890 LOOP
1900 CLOSE #1


1910 DIM MIN(12), MAX(12), AVG(12)
1920 REM DETERMINE MIN
1930 FOR j = 1 TO 12
1940 Sum = 0
SELECT CASE month$(j)
CASE "JAN", "MAR", "MAY", "JUL", "AUG", "OCT", "DEC"
1950 FOR N = 1 TO 31
1960    IF DATA1(j, N) <> 0 THEN
1970       MIN(j) = DATA1(j, N)
1980       MAX(j) = DATA1(j, N)
1990 EXIT FOR
2000 END IF
2010 NEXT N

2020 FOR N = 1 TO 31
2030   Sum = Sum + DATA1(j, N)
2040    IF DATA1(j, N) <> 0 AND DATA1(j, N) < MIN(j) THEN
2050      MIN(j) = DATA1(j, N)
2060    END IF
2070 IF DATA1(j, N) <> 0 AND DATA1(j, N) > MAX(j) THEN
2080    MAX(j) = DATA1(j, N)
2090 END IF
2100 NEXT N
2120 AVG(j) = Sum / 31
```

```
CASE "APR", "JUN", "SEP", "NOV"
2130 FOR N = 1 TO 30
2140   IF DATA1(j, N) <> 0 THEN
2150     MIN(j) = DATA1(j, N)
2160     MAX(j) = DATA1(j, N)
2170 EXIT FOR
2180   END IF
2190 NEXT N
2200 FOR N = 1 TO 30
2210   Sum = Sum + DATA1(j, N)
2220 IF DATA1(j, N) <> 0 AND DATA1(j, N) < MIN(j) THEN
2230     MIN(j) = DATA1(j, N)
2240 END IF
2250 IF DATA1(j, N) <> 0 AND DATA1(j, N) > MAX(j) THEN
2260     MAX(j) = DATA1(j, N)
2270 END IF
2280 NEXT N
2290 AVG(j) = Sum / 30


CASE "FEB"
2300 IF YEAR MOD 4 = 0 THEN
2310     R = 29
2320 ELSE
2330   R = 28
2340 END IF
2350 FOR N = 1 TO R
2360   IF DATA1(j, N) <> 0 THEN
2370     MIN(j) = DATA1(j, N)
2380     MAX(j) = DATA1(j, N)
2390 EXIT FOR
2400   END IF
2410 NEXT N
2420 FOR N = 1 TO R
2430     Sum = Sum + DATA1(j, N)
2440   IF DATA1(j, N) <> 0 AND DATA1(j, N) < MIN(j) THEN
2450     MIN(j) = DATA1(j, N)
2460   END IF
2470 IF DATA1(j, N) <> 0 AND DATA1(j, N) > MAX(j) THEN
2480     MAX(j) = DATA1(j, N)
2490 END IF
2500 NEXT N
2510 AVG(j) = Sum / R
```

```
END SELECT
2520 NEXT j


2530 REM TO DISPLAY RESULT ON SCREEN
2540 CLS
2550 DO
2550 LOCATE 23, 1: PRINT "PRESS ANY KEY": CLS
2570 LOOP UNTIL INKEY$ = ""
2580 X$ = "DAY  JAN   FEB   MAR   APR   MAY   JUN   JUL
2590 AUG   SEP   OCT   NOV   DEC"
2600 LOCATE 1, 1: PRINT X$;
2610 p = 2: m = 5
2620 FOR N = 1 TO 31
2630 FOR K = 1 TO 12
2640 LOCATE p, 1: PRINT N;
2650   IF K = 1 THEN
2660     LOCATE p, 5: PRINT USING "###.#"; DATA1(K, N);
2670   ELSE
2680     LOCATE p, 6 + (K - 1) * 6: PRINT USING "###.#"; DATA1(K, N);
2690   END IF
2700 NEXT K
2710 PRINT
2720 p = p + 1
2730 IF p = 21 THEN
2740 LOCATE 22, 10: PRINT "Press any key to continue..."
2750 DO
2780 LOOP UNTIL INKEY$ <> ""
2790 CLS : p = 2: m = 5
2800 LOCATE 1, 1: PRINT X$
2810 END IF
2820 NEXT N
2830 PRINT
2840 X$ ="------------------------------------"
2850 p = p + 1
2860 LOCATE p, 1: PRINT "AVG"
2870 FOR K = 1 TO 12
2880 IF K = 1 THEN
2890    LOCATE p, 5: PRINT USING "###.#"; AVG(K);
2900 ELSE
2910    LOCATE p, 6 + (K - 1) * 6: PRINT USING "###.#"; AVG(K);
2920 END IF
2930 NEXT K
```

```
2940 PRINT
2950 p = p + 1
2960 LOCATE p, 1: PRINT "MIN"
2970 FOR K = 1 TO 12
2980 IF K = 1 THEN
2990    LOCATE p, 5: PRINT USING "###.#"; MIN(K);
3000 ELSE
3010    LOCATE p, 6 + (K - 1) * 6: PRINT USING "###.#"; MIN(K);
3020 END IF
3030 NEXT K
3040 PRINT
3050 p = p + 1
3060 LOCATE p, 1: PRINT "MAX"
3070 FOR K = 1 TO 12
3080 IF K = 1 THEN
3090   LOCATE p, 5: PRINT USING "###.#"; MAX(K);
3100 ELSE
3120   LOCATE p, 6 + (K - 1) * 6: PRINT USING "###.#"; MAX(K);
3130 END IF
3140 NEXT K
3150 PRINT
3160 PRINT "----------------------------------------------"
3170 DO
3180 LOCATE 22, 1: PRINT " press any key"
3190 LOOP UNTIL INKEY$ <> ""
3200 LOCATE 23, 20: PRINT "please ensure that the printer is ON and ONLINE"
3210 DO
3220 LOOP UNTIL INKEY$ <> ""
3230 REM TO PRINT RESULT ON PAPER
3240 CLS
3250 LPRINT TAB(28); "HYDROLOGICAL DATA"
3260 LPRINT
3270 LPRINT "Water Level measurement in river........"
3280 LPRINT
3290 LPRINT "Station: ............ .  Year: ......."
3300 LPRINT
3310 DO
3320 LOCATE 24, 1: PRINT "PRESS ANY KEY"
3330 LOOP UNTIL INKEY$ = ""
3340 X$ = "DAY  JAN   FEB   MAR   APR   MAY   JUN   JUL
                AUG  SEP   OCT   NOV   DEC  "
3350 LOCATE 1, 1: LPRINT X$
3360 p = 2: m = 5
```

```
3370 FOR N = 1 TO 31
3380 LPRINT TAB(1); N;
3390 FOR K = 1 TO 12
3400 IF K = 1 THEN
3410   LPRINT TAB(5); USING "###.#"; DATA1(K, N);
3420 ELSE
3430   LPRINT TAB(6 + (K - 1) * 6); USING "###.#";  DATA1(K, N);
3440 END IF
3450 NEXT K
3460 LPRINT
3470 p = p + 1
3480 IF p = 21 THEN
'3490    LOCATE 22, 10: PRINT "Press any key to  continue..."
3500    DO
3510    LOOP UNTIL INKEY$ <> ""
3520    CLS : p = 2: m = 5
'3530 LOCATE 1,1: LPRINT X$
3540 END IF
3550 NEXT N
3560 LPRINT
3570 LPRINT "--------------------------------------" 3580 p = p + 1
3590 LPRINT TAB(1); "AVG";
3600 FOR K = 1 TO 12
3610 IF K = 1 THEN
3620   LPRINT TAB(5); USING "###.#"; AVG(K);
3630 ELSE
3640   LPRINT TAB(6 + (K - 1) * 6); USING "###.#";  AVG(K);
3650 END IF
3660 NEXT K
3670 LPRINT
3680 p = p + 1
3690 LPRINT TAB(1); "MIN";
3700 FOR K = 1 TO 12
3710 IF K = 1 THEN
3720    LPRINT TAB(5); USING "###.#"; MIN(K);
3730 ELSE
3740    LPRINT TAB(6 + (K - 1) * 6); USING "###.#";  MIN(K);
3750 END IF
3760 NEXT K
3780 LPRINT
3790 p = p + 1
3800 LPRINT TAB(1); "MAX";
3810 FOR K = 1 TO 12
```

```
3820  IF K = 1 THEN
3830    LPRINT TAB(5); USING "###.#"; MAX(K);
3840  ELSE
3850    LPRINT TAB(6 + (K - 1) * 6); USING "###.#";  MAX(K);
3860  END IF
3870 NEXT K
3880 LPRINT
3890 LPRINT "----------------------------------------"
```