DAM PERFORMANCE AND SAFETY EVALUATION

A CASE STUDY OF LOWER USUMA DAM, USHAFA, BWARI L.G.A, ABUJA-FCT

BY

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PGD/Agric Eng./2003/183

A PROJECT REPORT SUBMITTED TO POSTGRADUATE SCHOOL IN PARTIAL FULFILLMENT OF THE REQUIREMENT FOR THE AWARD OF POST GRADUATE DIPLOMA IN AGRIC ENGINEERING (SOIL AND WATER OPTION).

DEPARTMENT OF AGRICULTURAL ENGINEERING, SCHOOL OF ENGINEERING AND ENGINEERING TECHNOLOGY.

FEDERAL UNIVERSITY OF TECHNOLOGY, MINNA, NIGER STATE.

P.M.B 65, MINNA

NIGERIA.

MARCH 2005.

CERTIFICATION

This is to certify that this project titled **Dam Performance and Safety Evaluation** was carried out by Daniel Adikwu, Reg. no. PGD/Agric Eng/ 2003/183 under the supervision of Engr. (Dr.) N.A. Egharevba and submitted to the Agricultural Engineering Department, Federal University of Technology, Minna, in partial fulfillment of the requirement for the award of post Graduate Diploma in Soil and Water Engineering .

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DEDICATION

This project work is dedicated to almighty God for his guidance all through and also to my beloved parents Mr. and Mrs. John Akor Adikwu for their support and encouragement.

FIG. 1: EXISTING LOWER USUMA WATER SYSTEM

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ACKNOWLEDGEMENTS

My special appreciation goes to the following personalities who had contributed immensely to the successful completion of this research.

First, I want to thank the head of department Agric Engineering, Engr. (Dr.) Adgidzi Donald and the programme coordinator, Dr. (Mrs.) Z. Osunde. I am deeply indebted to my project supervisor, Engr. (Dr.) N.A. Egahrevba who guided me all through and spent his ample time to read though the manuscripts, the entire staff of Agric engineering department and my fellow course mates who had rendered help in various dimensions.

I am grateful to the following individuals and organizations for permission to reproduce diagrams and copy right materials.

Engr. J. B. Anto, Operations Manager FCT-Water Board, Mr. Agbontaen O.S. and Mr. O.F. Benson, of Dam safety and instrumentation unit of Lower Usuma Dam, Abuja. Water and Dam Services Company, Abuja. Lower Usuma Dam, Ushafa, FCT and National Population Commission, Abuja.

Finally, I want to thank my brothers and sisters who have been of great assistance at all levels in this research. These acknowledgements will not be complete without appreciating someone special and dare to me. Gina, I thank you for your continuous understanding during the course of this work.

ABSTRACT

Rapid depletion of the raw water at the Usuma Dam Reservoir has become worrisome. Each year the draw down in the reservoir is lower than the previous years. There are fears that the Dam may not be able to cope in the next few years. The present performance of the dam is therefore evaluated in terms of the water level in the dam, rainfall records from the dam catchments and the population and water demand of FCT to determine the problem of acute water shortage. Also the safety of the dam is evaluated in terms of seepage, dam settlement, groundwater levels in the embankment and siltation. From the results of the parameters evaluated as shown in Tables 2, 3 and 10, it was discovered that the acute shortage of water in the dam was due to increase in population and water demand in FCT as well as insufficient rainfall at the dam catchments. The dam was found to be safe against seepage and ground water rise after careful analysis of the dam safety parameters as presented in Tables 4 and 11. These results follow the trend established by the dam safety team after long period of monitoring. From Tables 5 and 6, it was discovered that the dam was still undergoing settlement, but after a period of time as shown in Tables 7, 8 and 9, it was found that the dam had settled since the variations in the levels had become so minute compared to the change in levels observed during the earlier stage of settlement as presented in Tables 5 and 6 respectively.

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1.0 INTRODUCTION

1.1 General Overview

The importance of water in all aspects of human activities is well known. One basic condition for human, animal and plant survival is the availability of water. In any nation or country, water is a very important element for social stability and economic development. Civilization depends largely on its availability.

Water resources are not evenly distributed, so that is why in some areas there may be excess water, in other areas there may be a shortage. On the other hand, the amount of water available in any state, area or basin is invariable, while water demands increase continually.

Water demands for drinking purposes grow in parallel with population growth, while modern standards of living require increased amounts of water for domestic use such as gardening.

Water we have maintained is vital to the sustenance of life in the form of human existence animals and plants alike. It is gratifying to note that the Government of the day appreciates the particular need of both urban and rural people for portable water.

1.2 Population Growth and Water Demand in F.C.T

In the Federal Capital Territory (FCT) where the Water Board is ensuring qualitative water supply, is experiencing the highest influx of citizens from other part of the Federation apart from the designed administrative and residential area of the FCT, other satellite communities and slumps have sprang up in the adjoining hinterland.

the back (upstream) of a storage dam forms an artificial lake, called a reservoir. Release of water from the reservoir can be controlled through systems of pipes or gates called "outlet works".

Dams may be classified into a number of different categories, depending upon the purpose of classification. For the purpose of this report, it is convenient to consider three broad classifications according to: use (storage dams, diversion dams and detention dam), material comprising the structure (Earth dam, rock fill dam and concrete dam), and structural stability (gravity dam, arch dam and buttress dam). Dam can also be classified as large, medium and small.

The International Commission on Large Dams (ICOLD) defined large dams as all dams with heights of 15 meters or more measured from the lowest potion of the general foundations area to the crest.

The National Sub Committee on Dams and Nigeria Committee on Large Dams (NSCD/NICOLD) defined medium Dams as all dams with heights between 8 and 10 metres measured from the lowest portion of the general foundation area to the crest. They also defined small dams as all dams not more than 8 metres in height measured from the lowest portion of the general foundation area to the crest and impounding not more than 5 million cubic metres of water.

1.5 Existing Water Schemes in FCT

For the present water supply to the Federal Capital Territory, there are such dams as Lower Usuma, Jabi and Gwagwalada Weir. The Gwagwalada project provides water for Gwagwalada area village while the Jabi dam the oldest source of water to the Territory is not presently utilize. The Jabi reservoir has been subjected to substantial sedimentation from road works and building construction within its catchments. Most of the electro/mechanical installations at the treatment plant have broken down and the plant cannot be restored to functional operation. The Lower Usuma Dam is now clearly the dominant source of water to the FCT.

1.6 Objectives and Scope of the Study

The Lower Usuma Dam was designed in the early 1980's such that at full realization it would meet the water requirements of the FCT to the year 2000. Present population and water demand of the Territory is already higher than the predicted level. This project will therefore:

(a) Evaluate the present performance of the Dam to find out the actual cause(s) of the acute shortage of water in the dam

(b) Assess the present safety of the dam.

(c) Make recommendations to ensure that the dam is safe and supply adequate water to meet the yearnings of FCT dwellers presently and in the years ahead.

1.7 Project Location

The Lower Usuma Dam is located at Ushafa Village in Bwari Local Government of the FCT. It is situated at the elevation of 534 metres above mean sea level with an approximate latitude of 9°12'N and longitude 7°25' E.

1.8 Background of Lower Usuma Dam

The construction of Lower Usuma Dam started in early 1980's and was completed in the year 1984 by a French construction giant, Spie Batignolles Nig. Ltd. It commences full operation in 1987. The main purpose of the dam is for water supply to F.C.T. The dam comprises an earth fill dam with maximum Live Storage of about $8.8 \times 10^7 m^3$. Two treatment plants treat the raw water from the dam and the treated water is conveyed through a 1500mm diameter potable water transmission main to various locations within the FCT. Fig.1 shows the existing Lower Usuma Water System.

As stated earlier, the dam comprises of two earth fill structures:

i. The main dam across the Usuma river valley near the confluent of the two tributaries.

ii. The saddles dam to the north and downwards the line of the main dam.

The per capita consumption from the initial design stood at 320litres per person per day.

Key data on lower Usuma dam are listed on table 1.0. And fig 2.0 shows the Usuma Dam (main) typical cross-section with detail dimension.

Table 1: **Key Data on Lower Usuma Dam**

Dam crest elevation	579 Masl
Stream bed elevation	533 Masl
Maximum height of main dam	46m
Maximum height of saddle dam	18m
Full supply level	574 Masl
Maximum water level	576 Masl
Maximum Water level for raw water intake	568.5m
Storage capacity	100 Mm^3
Liver storage	88Mm^3
Freeboard	5.0m
Total crest length	1,320m
Crest width	10m
Upstream slope	1:3 and 1:3.25
Down stream slope	1:2 and 1:2.50
Earthwork volume	5Mm^3
Reservoir surface area	8.0km^2
Catchments area	200.00km^2
Spillway type	Open channel, 375m^3/s normal capacity (500m^3/s maximum capacity)

Source: Lower Usuma Dam Instrumentation Unit

Available statistics show that prior to 1999 the predicted rate of population growth of 2.5 percent annually was being overshot, and this amounted to a lot of pressure on Water Supply in the territory. The population of the territory that was estimated at 2.11 million in 1998 is expected to increase to over 5.93 million in the year 2033 while the present water demand of 211,400 cubic meters per day will increase to 1,074,627m^3/day in the years 2033.

The population and water demand of FCT from 1988 – 2033 is shown in Table 10

1.3 FCT Master Plan

The master plan for water supply envisaged the ultimate population of the city of Abuja to peaks at 3 million. The plan envisaged to be composed of light industry and services.

The master plan for water supply took advantage of the terrain by utilizing the water of the River Usuma in the northeast corner of the territory as a raw water source.

1.4 General Definition of Dam

Dam is a hydraulic structure that blocks the flow of a river, stream, or other waterway. Some dams divert the flow of river water into a pipeline, canal, or channel. Others raise the level of inland waterways to make them navigable by ships and barges. Many dams harness the energy of falling water to general electric power. Dams also hold water for drinking and crop irrigation, and provide flood control.

Dam can be built to divert water out of rivers for use in other locations to capture water and store it for later use. The volume of water flowing in any given river varies seasonally. In rainy season, rivers typically swell with water from rain storms and mountain snowmelt. In dry season, many rivers reduced in levels. Storage dams impound seasonal flood water so it can be

The intake structure is located near the deepest portion of the reservoir. The dam and reservoir area are devoid of human settlements except for the Camp used by the contractors during construction located downstream adjacent the treatment plant. Management of the upstream watershed and reservoir area appears quite good with the soil essentially undisturbed and the area characterized by good vegetation cover most of the year, hence the excellent quality of water from the reservoir is achieved.

The reservoir water is quite clean with little turbidity even during the rainy season. It is either that the sediments reaching the reservoir have settled and/or that the sediment production is minimal.

1.8.1 *Lower Usuma Water Treatment Plant*

Two water treatment plants are located downstream of the Lower Usuma Dam. Each plant is currently operating at a rate of 5,000 m^3/hr, a level which is in excess of the plant design capacity of 4860 m^3/hr.

Raw water from the reservoir to the treatment plants and clean water from the plants to the service areas is by gravity. Pumping to the plants, however, would be required when reservoir level drops to elevation 570masl due to overdraft or draught. A set of three pumps, two duty and one standby is provided for this task.

1.8.2 **Water Conveyance System**

Transmission mains of diameter 1500mm conveys treated water by gravity from the treatment plants to the various locations of the FCT. Downstream of the treatment plants, the 1500mm diameter mains splits into two delivery lines; one a 1500mm diameter steel line to the city of FCT and the other a 1000mm diameter fibre glass line leading to Kubwa a satellite town of the FCT, the Abuja International Airport and via a steel line, to Gwagwalada.

Reticulation comprises an extensive system of pipelines of various sizes and several storage and regulation reservoirs.

The Lower Usuma Dam was built on the River Usuma to provide raw water to the first two phases of the treatment plant. It has a reservoir capacity of 100 million cubic meters storage and the first and second treatment plants. Each has a capacity of 120 million litres per day with a total capacity of 240 million litres per day. A trunk line 40 kilometers long and diameter 1.5 meter transport the water from the treatment plant to storage tanks 3 and 4 located in Maitama and Asokoro respectively. Each of the storage tanks has a capacity of 24 million litres. The storage tanks has satellite tanks, which feed the districts, which are at high elevation, Maitama in the case of tank 3 and Asokoro in the case of tank 4.

A trunk line with a 1 meter diameter has been extended from the Usuma Dam Water works to a storage tank in Kubwa with a capacity of 10 million litres. The line has further been extended to the airport and to Gwagwalada town.

1.8.3 Safety and Instrumentation in Lower Usuma Dam

The dam is built principally for water supply to the FCT. It is an earth dam highly instrumented for daily monitoring of its integrity and care against failures, because dam failure is of grave consequences to life and ecology. The instrumentation of lower usuma dam consists of the following; pore pressure cells, piezometers, inclino- Tassometers and surface deflection benchmarks.

Daily monitoring of the dam through adequate instrumentation and follow up action on the data collected help to preserve the integrity and the life of the dam and failures can thus be guided against or minimized.

CHAPTER TWO

2.0 LITERATURE REVIEW

2.1 General Overview

Dams rank among the oldest types of human-made structures. The earliest known dams were relatively small and built to provide water for irrigation in Mesopotamia, one of the first centres of urban civilization. Ruminants of ancient dams persist today as ruins or parts of modern dams. Ruins of the Jawa Dam, believed to have been constructed around 3000BC, still stand in Jordan. The Ma'rib Dam, located in what is now Yeme, has been rebuilt several times since it was first constructed more than 2,700 years ago. (Microsoft Encarta; 2002.)

The engineers of ancient Rome were masters of collecting and distributing water. Beginning around the 1st century AD, they constructed a system of large Dams to impound river water in regions surrounding the Mediterranean sea. The Romans' largest reservoir, the lake of Homes, was created in AD 284 in what is now Sepia. A dam impounded approximately 90 million cubic meters (117 million cubic yards) of water.

Significant portraits of the Roman – Built Cornalvo and Proserpine dams in Spain remain in service after more than 1,700 years. The Romans often used buttresses to support dam walls. Historical data indicates that the Romans also understood the principle of arch dams and built one at Dara, on the present-day border between Turkey and Syria. However, no trace of the arched portion of the dams remains.

Dam construction waned in western Europe after the fall of the Roman empire. In the 14th century the I1 – Khanid dynasty of the Mongol empire built several major dams in present-day Iran. Their Kurit Dam, a Masonry arch structures 58m high stood as the tallest dam in the world until the late 19^{th} century.

In the late 19^{th} century, dam engineers resurrected the use of concrete which had not been used in dam construction since ancient Roman times. Among the first of the modern concrete dams are Boyd's corner Dam, built to provide water to residents of New York City in 1872, and the San Mateo Dam near San Francisco, California, completed in 1890. (Encarta; 2002)

2.1.1 *Dams of the 20^{th} Century*

During the 20^{th} century dam engineers expanded upon the mathematical formulas and structural designs pioneered in the 19^{th} Century. Twentieth – century designs incorporated sophisticated mathematics and materials science, giving rise to higher and stronger dams than ever before. These engineering marvels captured the attention of the general public, who regarded them as major symbols of civil achievement. Dams tamed raging rivers. In so doing they eliminated floods, provided people with water and electricity, and caused arid deserts to yield thriving agricultural crops.

Irrigation projects of this nature were being undertaken around the world. For example, the original Aswan Dam, completed in 1902, was built to control annual flooding of the Nile River in Egypt and to increase irrigation in the Nile River delta.

Hydroelectric power also gained importance during the early years of the 20^{th} century. When the Keokuk Dam, on the Mississippi River at Keokuk, Iowa, began operation in 1913, it was the largest hydroelectric dam in the world by 1920. By 1920 hydroelectric power plants accounted for 40 percent of the electric power produced in the united states.

During the great depression of the 1930s, dam construction attracted significant attention because it provided a highly visible means of putting people to work. Dams also symbolized progress and success in the face of economic adversity. Hoover Dam was constructed between 1931 and 1936, during the height of the great depression. The huge project provided with a sense of national pride and put thousands of people to work during this difficult time.

In the later 20th century large dams continued to have as a source of pride throughout the world. This is perhaps best exemplified by the efforts of the people's republic of china to build the three Gorges Dam across the Yangtze River. More than 200m high and 1.6km long, the dam will create a reservoir 630km long for irrigation of the Yangtze valley when it is completed in 2009. The dam's hydroelectric power plant is expected to generate more than 18,000 megawatts of electricity, which will be distributed to users throughout China. (Encarta, 1993).

2.2 Water Supply

According to the World Health Organization (WHO), 80% of all sickness in the world can be attributed to inadequate water and sanitation. It is for that reason that the United Nations proclaimed the period 1981 – 1990 to be the international drinking water and sanitation decade.

The particular goal of the decade (ratified at the UN conference of mar del Plata, 1977) was to provide all the world's population with adequate access of safe water and hygienic latrines by 1990. (M.A. Hassan, 2000).

Currently, there are more than 4000 million people in the developing countries, about 75% of whom live in rural areas. While 75% of the Urban population have reasonably safe water, less than 30% of those in rural areas have water. The remaining still rely on traditional, and generally inadequate or unsafer, water source (Eijekemp, 1985).

In the past, water supply systems in developing countries like Nigeria, have been Constructed using the same technologies as more industrialized countries. The emphasis has, therefore, traditionally been on high capital, centralized pumping system with elaborate distribution networks. In addition to high construction costs, these system required operation and maintenance expenses that were often not within the paying capacity of the villages concerned.

In many cases, therefore the central government that had installed the systems was also faced with the maintenance costs, and scarcity of funds led to a multitude of poorly maintained, and often in operative, water supply systems.

The cost of providing traditional water supply systems to the people that do have access to clean water would be staggering, running into billions of Naira. Therefore, and certainly under the influence of the world wide economic recession, various countries and donor agencies (like the UNCEF) have shifted emphasis, away from the traditional capital intensive projects to low-cost, locally maintainable and sustainable systems. (M.A. Hassan; 2000).

2.2.1 Water in the Dry Season

Between the months of April and October, there is always abundant water every where, so much as to cause natural disaster as flood destroy homes, farmlands and so many other things that water would have helped to conserve. This plentiful water is sustained within the period of the rainy season. That is the reason why rivers overflow their banks, seas and oceans break through the coastal regions. That season too could pose a danger to dams.

As the rainy season gradually reduces in intensity around November, a period of water search sets in. in some areas, the period between November and March poses a great deal of difficulty, in getting water. Wells dry up, even rivers could dry up completely. The only steady water during the period is pipe borne.

This method is made possible through the building of Dams and Water Treatment Plants. The treatment plants not only supply steady water but also chemically treated water that is steady, sufficient in quantity and pure in quality.

The energy put in to achieve the goal of supplying enough water is enormous and requires expertise. Consumers must therefore cultivate the habit of water conservation. (Abuja Water News Vol. 1 No. 4 October – December 1995).

2.3 Dam Failures and Incidents in Nigeria

Historically, most reported dam incidents and failures in Nigeria and elsewhere have been on earthfill and rockfill dams.

There are over 200 dams in Nigeria, which are used mainly for water supply, irrigation, hydropower generation, and sometime flood control, which are either completed, or under-construction. About 80% of these dams are earth fill dams, which is the most common. Some of the largest dams are Kainji, Lower Usuma, Jebba, Bakalori, Tiga, Shiroro. A high proportion of these dams are located upstream of major towns with large population and considerable commercial and industrial activities.

Therefore, the uncontrolled release of the stored water in the reservoir, which results when the embankment is downstream breached, can inflict catastrophic damage on lives and properties.

The earliest dams in the country were completed after 1935. Although dam construction is a recent phenomenon in Nigeria, there have been many dam incidents in the country, which are due to many factors including:

1. Lack of maintenance
2. Ageing
3. Inadequate design and construction supervision.
4. Non-adherence to operating specifications
5. Overtopping or lack of inadequate spillway
6. Internal erosion of fine grained soil from the embankment itself, its foundation or the abutments resulting in piping.
7. Stability problems resulting from too high pore pressure and hydraulic gradients.
8. Lack of government attention to the safety aspects of dams.
9. Non engagement of competent specialists for investigations, design, construction supervision and safety evaluation among others.

In a developing country like Nigeria, these factors are clearly manifested on many dam projects thereby creating serious concern to engineers.

The great number of incidents in Nigeria occurred in 1988, one of the wettest years on record, while the most dramatic incident was the collapse on 16th of August 1988 of the Bagauda dam in Kano State. Other which collapsed in 1988 were Magada and Kulde dams also in Kano State, Alau dam in Borno State, Ojerimin dam in the defunct Bendel State, Erinie river dam in Oyo State, Lugu dam in Sokoto State. Numerous other dams incidents including partial failures, onshore seepage were recorded throughout the country in 1988.

Dam failures have occurred in other parts of the world as well and there are indications that many dams around the world are not safe. In the United State, for example about 30% of the 70,000 known dams are regarded as unsafe (O.S. Agbontaen, 1997).

2.4 Ecological and Environmental Considerations

The rapid increase in the world's population and the increasing demands this population has made on the Planet's material resources have called into question the long-term effect of man upon his environment. The realization that man is an integral part of nature and that his interaction with the fragile ecological systems, which surround him, is of paramount importance to his continued survival, is prompting a reevaluation of the functional relationships that exist between the environment, its ecology, and man.

Increasingly of concern is the effect, which man's structures have, upon the ecosystems in which they are placed and especially on the fish, wildlife, and human inhabitants adjacent these structures. The need to store water for use through periods of drought, to supply industry and agriculture with water for material goods and foodstuffs, to provide recreational water in ever-increasing amounts, and the high rate of electric power demand has required the use of dams and canals. These structures help man and yet at the same time cause problems in the environment and in the ecosystem into which they are placed. Many of these problems are exceedingly complex and few answers, which encompass the total effect of a structure on its environment, are readily available.

Some of the answers to these problems must be the development and protection of a quality environment, which serves both the demands of nature for ecological balance and the demands of man for social and psychological balance.

The present challenge is to develop and implement new methods of design and construction, which minimize environmental disturbances while also creating esthetic and culturally pleasing conditions under which man can develop his most desirable potentialities. (E. A. Seaman and L. W. Davidson, 1977).

CHAPTER THREE

3.0 METHODOLOGY

3.1 General Overview

In a bid to evaluate the safety and present performance of Lower Usuma Dam, it is imperative to have a sound knowledge of the past records of the dam as well as the present records so that proper evaluation can be made.

The present record can be obtained through measurements and data collections of some of the key parameters of the dam.

Some key parameters of the dam to be assessed in the cause of this research will include safety parameters to evaluate the present dam safety status, as well as the parameters that will aid the determination of water shortage in the Dam. Therefore, the following parameters will be evaluated:

i. Settlement of the dam embankment
ii. Water level in embankment
iii. Seepage through the dam embankment
iv. Piezometric reading of the dam embankment
v. Rainfall records of the catchments
vi. Desiltation of the dam reservoir

Emphasis will be laid only on the main dam in the course of this research.

To assess the safety of the dam, analysis will be base solely on the settlement of the dam embankment, seepage through the embankment, piezometric measurements to determine the groundwater level in the embankment and finally, desiltation of the dam reservoir.

In finding the cause(s) of the acute water shortage in the dam, the following parameters will be critically analyzed;

- Rainfall records in the dam catchments.

- Water level in the embankment.
- Population growth and water demand in FCT.

3.2 Method of Data Collection

3.2.1 Personal Contact

This is the method were I have to be present personally at the Lower Usuma Dam with the concerned technical staff of the dam to carry out physical measurements of some of the parameters on weekly and monthly basis as the case may be.

In other to collect data on the past records of the various parameters analyzed, I personally visited the units/department concerned such as the dam safety and instrumentation unit, meteorological unit, and the laboratory unit.

3.3 Methods of Data Analysis

3.3.1 Tabular Presentation Method

In the tabular method of data analysis, the monthly readings from January to December are summed up and an average is computed by dividing the total summation by the total number of months i.e. twelve. In this case, an average monthly result is achieved. This result is then presented in a table format.

3.3.2 Charts/Graphical Method

Data collected are recorded in tabular form which is later processed using computer software (excel). Some of the parameters are presented in charts so as to illustrate strongly the relationship and behavioral pattern of these parameters. Basically, these charts/graphs are in a form of bar charts pie charts and line graphs.

3.4 Procedures in Parameters Determination

3.4.1 Surface Deflection Benchmarks

These essentially are survey benchmark which gives an indication of the localized settlement of the dam.

An iron rod of length 1.5 metres is driven into the soil with 0.3 metres being exposed. A concrete prism is then cast around the rod. The tip of the rod is sharpened and covered with a cap. When survey readings are to be taken, the cap is removed and the measuring staff placed on the tip.

On the main dam, these benchmarks are twelve in number, installed at 100 metres intervals each at three stages. These are, the dam crest down stream side, on the berm, the toe and or the ground level on both the downstream face and the upstream cofferdam and midway of the upstream face.

On the saddle dam, the benchmarks are similarly placed at the toe at 50 metres each at three stages at the downstream face. On the upstream face the settlement points are placed on the upstream blanket and at an intermediate level.

Measurements of the levels are taken with reference to the level given as the permanent reference level located at one of the abutment side of the dam. A survey staff and spirit level are the instruments usually used for this exercise.

When the spirit level is mounted on the tripod stand, the staff is placed on the tip of the various rods already established on ground and readings are taken from the instrument. Results obtained are tabulated as shown in chapter 4 of this report.

3.4.2 Water Level Measurement

Water level at the reservoir of Lower Usuma Dam can be determine in two ways.

(a) It can be read directly from the calibrated steel rule installed on the intake tower.

(b) Alternatively and preferably, the water level can be measured using the surveyor's Instruments (Spirit Level and Staff).

On the upstream embankment of the dam are pillars constructed at different levels. At the abutment side of the dam is a pillar with a known level, which serves as a reference level to which other level at the dam is referenced.

The level is usually taken either twice or once in a week as the case may be. The survey department carries this out. The present water level at the embankment is determine by positioning the surveyor's level instrument firmly, and then place the calibrated staff on the pillar where the current water level falls within. The reading on the staff is recorded and later added or subtracted from the reference level at the abutment; the final result shows the current water level at the embankment. Results of average monthly water level of Lower Usuma Dam are shown on chapter four. The minimum and maximum water level for each was taken while the mean water level was determined by finding the average water level from January to December. The minimum mean and maximum mean were calculated by taken the average of the minimum values and maximum values respectively. From the Table of water level, minimum and maximum water levels were plotted in charts.

3.4.3 Chambers Flow Measurement

The seepage chamber measures the seepage through the dam. It consists of two PVC pipes of 100mm diameter laid parallel and directly from the toe of the dam and takes water from the dam and discharges it into an enclosed rectangular concrete manhole of varying heights and cross-sectional area. These chambers are four in number situated at intermediate locations in series.

Seepage through the dam is measured in the chamber by collecting a know volume of water using a graduated cylinder at a specified time. The quantity of flow collected in a graduated cylinder is recorded against the time taken for the flow using the stopwatch. Results are tabulated and presented in chapter four. From the monthly seepage data, the minimum, maximum, total and mean seepage were computed. The minimum and maximum seepage for each year were determined by taken the minimum and maximum seepage for each year respectively. Total seepage for each year was determined by summing the seepage from January to December. Summing the seepage from January to December and dividing by the total number of months, i.e. twelve (12) compute mean seepage. The results are presented in a Table as shown in chapter four.

3.4.4 Piezometric Measurement

The piezometers are all located on the downstream toe of the main dam, saddle dam and on the downstream berm i.e. level 565 meters. It measures the ground water level at the embankment.

The piezometers are open 50mm diameter PVC stand pipe perforated at the base and surround by calibrated sand for a height of 3 meters when installed in fill and overburden and 6 meters when installed on the rock. There are installed at 100 meters interval from station 200 meters to 1,100 meters in the main dam and at 50 meters interval from station 50 meters to 300 meters and also 340 meters in the saddle dam.

The water level in the piezometers is measured by the use of a probe lowered into the pipe. When the tip of the probe touches the water surface, an audible sound is emitted. The measuring tape, which is attached to one end of the probe, is read and the water level at the embankment was obtained. The results are presented in a tabular form and thereafter, the total, minimum, maximum and mean readings for each year were computed. The total reading for each year was determined by summing all the readings for the year. The minimum and maximum values were read directly from the table by careful observations of the data. The mean value is total value divided by twelve months. Charts were plotted to show the relationships in the minimum, maximum, total and mean piezometric readings as shown in chapter four.

3.4.5 Rainfall Records

The meteorological unit of the Lower Usuma Dam determines rainfall records. In the meteorological station, the daily rainfalls are recorded using the rain gauge, and at the end of each month, the average rainfall was determined by dividing the total rainfall by the number of days within the month. Thereafter, the total, minimum, maximum and mean rainfall for each was computed using the same procedure adopted in the piezometric readings. Charts of various forms were later plotted to illustrate these parameters as presented in chapter four.

3.4.6 **Desiltation**

Desiltation is the process of removing silt from the dam reservoir. At Lower Usuma Dam, three (3) gate valves are situated at the intake tower of the dam. Two of the gate valves are installed at the bottom of the intake tower and are hydraulically controlled. The third valve is installed at the side of the intake tower outside and is permanently left open.

The two valves at the bottom of the intake tower are located at upstream and downstream each. The openings of these valves are controlled hydraulically, and two modes of forces are applied during opening. These are single stroke and double stroke forces.

The single stroke force is used when there is less resisting force on the gate valve. Invariably, if there is any unforeseen force acting on the gate, the double stroke is used as the last option.
These gate valves are installed at the bed of the river damed, and this is to ease the substantial amount of silt removal.

Also "bed sounding" is usually carried out on the reservoir using a motorized Canoe. The essence of the bed sounding is to be able to measure or determine the depth at different locations, the level of silt accumulation and possible dredging.

The silt removal exercise at Lower Usuma Dam is carried out once in every four (4) years. This is in view of the hilly nature of the dam catchments area, which drastically reduces the production of silt, compared to unhilly catchments areas where production of silt is at a higher rate.

I understood in one of my visit to the site that a construction giant, Julius Berger Nigeria Limited had just been called upon to carry out the Bed sounding of the reservoir. The FCT-Water Board is arranging for the take off of this exercise, and hopefully, it shall kick-off before ending of March, 2005.

CHAPTER FOUR

4.0 RESULTS AND DISCUSSION

4.1 General Overview

As discussed in chapter three, analysis are based on readings and measurement of some key parameters of the dam which includes:

i. The settlement of dam embankment

ii. Water level in the dam

iii. Chamber flow (Seepage)

iv. Piezometric reading of dam embankment

v. Rainfall records of the catchments

Results on these parameters are presented in tabular forms. From the months of January to December of each year, the monthly average results are recorded. Charts in the form of bar, pie and line charts were plotted to demonstrate the relationships and behaviors of each of the parameters evaluated.

4.2 Presentation of Results and Discussion

Discussions on each of the parameters listed in item 4.1 with their results are presented below.

4.2.1 *Water Level in Lower Usuma Dam*

From Table 2, it was discovered that the maximum water level in the dam in the years under review is 574. 63M and that was in September 1990. Also, the minimum water level of 569.65M occurred in June 2001. Fig. 3 is a line chart showing the maximum water level from 1987 – 2004.

The water level in the dam is a function of the rate of withdrawal of water from the dam and recharge from the catchments. The Lower Usuma Dam relies solely on rainfall from the catchments as means of recharge. The

TABLE 2

MONTHLY AVERAGE WATER LEVEL(METERS) IN LOWER USUMA DAM FROM 1987-2004

YEAR	JAN	FEB	MAR	APR	MAY	JUN	JUL	AUG	SEP	OCT	NOV	DEC	MEAN	Min level	Max level
1987	573.83	573.69	573.69	573.47	573.30	573.36	573.69	574.23	574.17	574.23	573.92	573.66	573.77	573.30	574.23
1988	573.63	573.33	573.32	573.05	573.27	573.52	573.50	573.92	573.89	573.95	573.86	573.52	573.56	573.05	573.95
1989	573.35	572.85	573.01	572.72	572.72	573.44	574.00	574.00	573.95	574.00	573.92	573.72	573.47	572.72	574
1990	573.18	572.96	573.86	573.12	573.09	573.58	574.59	574.63	574.63	573.92	573.82	573.50	573.74	572.86	574.63
1991	573.92	573.09	573.12	573.12	573.16	573.74	574.19	574.28	574.05	574.04	573.92	573.66	573.69	573.09	574.28
1992	573.70	573.42	573.17	573.04	573.43	573.51	573.94	574.17	574.19	574.17	573.92	573.78	573.70	573.04	574.17
1993	573.50	573.27	573.08	572.78	572.50	572.90	573.45	574.11	574.14	574.63	573.91	573.69	573.50	572.50	574.63
1994	573.29	572.81	573.40	571.90	572.87	573.37	573.95	574.16	574.22	574.16	574.01	573.66	573.48	571.90	574.22
1995	573.25	572.79	573.32	571.58	571.24	571.86	572.33	573.63	574.20	574.10	573.89	573.56	572.98	571.24	574.2
1996	573.12	572.63	572.14	571.58	571.02	571.52	572.00	572.94	574.21	573.99	573.68	573.21	572.67	571.02	574.21
1997	573.75	572.30	571.69	571.41	571.74	572.10	572.77	573.43	574.02	574.11	573.88	573.58	572.90	571.41	574.11
1998	573.07	572.49	571.92	571.48	571.58	571.31	572.82	574.13	574.20	574.06	573.84	573.49	572.87	571.31	574.2
1999	573.04	572.33	571.99	571.61	571.34	571.28	572.20	573.78	574.05	574.02	573.80	573.18	572.72	571.28	574.05
2000	572.74	572.18	571.61	571.19	570.82	571.33	571.87	573.63	574.31	573.93	573.46	572.86	572.49	570.82	574.31
2001	572.19	571.56	570.91	570.28	569.78	569.65	571.55	573.46	574.06	573.92	573.32	572.71	571.95	569.65	574.06
2002	572.02	571.39	570.81	571.23	570.54	569.54	571.12	570.24	571.24	570.54	573.04	572.14	571.15	570.24	574.04
2003	572.65	571.94	571.17	570.57	570.13	570.34	570.79	571.80	573.12	573.72	573.50	572.83	571.88	570.13	573.72
2004	571.95	571.37	570.58	569.87	569.40	569.44	570.47	570.38	571.01	571.10	570.65	570.14	570.53	570.58	571.95
													MEAN	**9,751.26**	**9792.785**

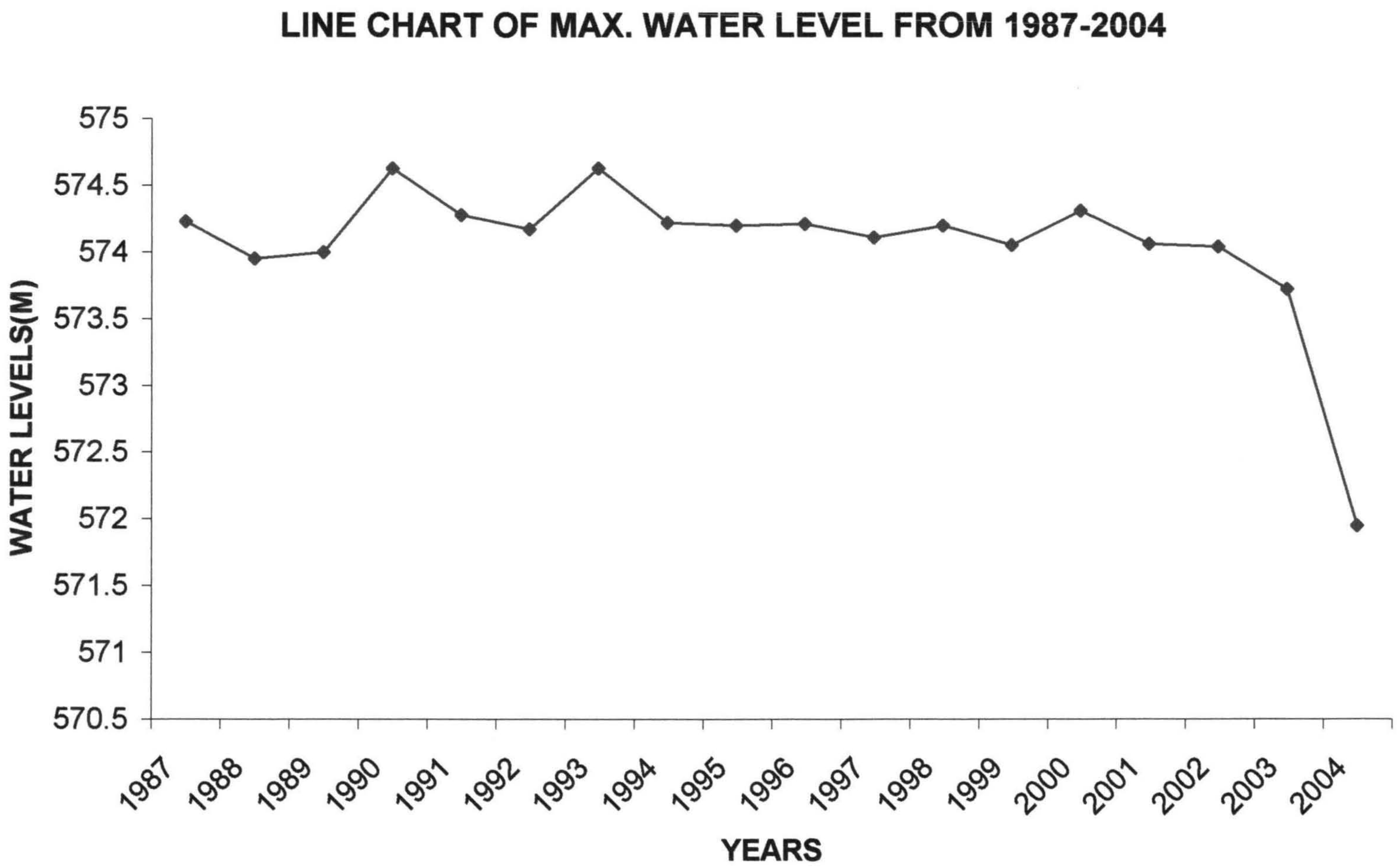
LINE CHART OF MAX. WATER LEVEL FROM 1987-2004
575
574.5
574
573.5
573
572.5
572
571.5
571
570.5
WATER LEVELS(M)
1987
1988
1989
1990
1991
1992
1993
1994
1995
1996
1997
1998
1999
2000
2001
2002
2003
2004
YEARS

FIG. 3

maximum level of water in the dam for 2004 is 571.95m and this indicate a drastic fall in water level attributed to the corresponding drop in rainfall as shown in Table 3. In addition, the increase in water demand resulted to considerable withdrawal of water from the dam to meet this demand.

4.2.2 *Rainfall at Lower Usuma Dam Catchment*

Considering Table 3, it was observed that the maximum rainfall in years under review is 528.30mm recorded in August 1995. While the minimum rainfall stood at 0.5mm recorded in February 1981 and January 1992 respectively. The total rainfall drop from 1,466.97 and 1,477.49 as recorded in 2002 and 2003 to 1,38570 in 2004. Due to this drop in total rainfall in 2004, there is a sharp corresponding drop in water level presently in the dam. This can therefore be seen as one of the major cause of the acute shortage of water currently experiencing in the dam since rainfall is the main source of recharge to the dam. The sharp drop in rainfall can be seen in a bar chart of maximum rainfall shown in fig. 4 in the appendix. Also in the appendix is a line chart of minimum, maximum, total and mean rainfall from 1981 – 2004.

4.3.3. *Seepage Through the Dam Embankment*

Results on seepage through the dam embankment are shown in Table 4. From the Table, it is observed that the seepage from the months of January to December 2003 and 2004 followed the trend or pattern established in the previous years i.e. 1989-1999 as shown in Table 4. After long period of monitoring, the dam safety team established these trends. All seepage values were less than $1m^3$/Sec except in 1995 in the months of August and September where seepage of 1.10 m^3/Sec and 1.22 m^3/s were recorded respectively. These slight differences invariably were as a result of high rainfall also recorded in August and September 1995 as shown in table 3. The maximum seepage recorded in the years 2002,2003 and 2004 are $0.6m^3/s$, $0.55m^3/s$ and $0.53m^3/s$ respectively. Since these results follows the normal trend as shown in Table 4, the dam will be considered safe against seepage.

TABLE 3

MONTHLY RAINFALL(mm) AT LOWER USUMA DAM CATCHMENT FROM 1981 TO 2004

YEAR	JAN	FEB	MAR	APR	MAY	JUN	JUL	AUG	SEP	OCT	NOV	DEC	MIN.	MAX.	TOTAL	MEAN
1981	-	0.50	22.50	107.00	98.00	152.00	295.00	336.00	355.10	287.00	-	-	0.50	355.10	1,653.10	137.76
1982	0.50	47.00	23.00	58.00	117.20	126.50	277.60	460.20	291.00	194.70	70.30	-	0.50	460.20	1,666.00	138.83
1983	-	-	-	17.00	126.10	144.40	212.80	352.00	191.30	55.60	29.20	-	17.00	352.00	1,128.40	94.03
1984	-	-	39.70	65.30	96.10	190.80	204.40	248.50	226.70	131.10	-	-	39.70	248.50	1,202.60	100.22
1985	-	-	122.40	43.00	119.70	252.80	238.40	183.20	428.40	35.70	-	-	35.70	428.40	1,423.60	118.63
1986	-	-	73.50	37.50	190.80	145.10	210.60	179.60	431.00	184.90	22.10	-	37.50	431.00	1,475.10	122.93
1987	-	1.40	13.10	45.50	78.70	89.20	80.10	278.00	281.10	112.65	-	-	1.40	281.10	979.75	81.65
1988	14.20	6.47	34.08	57.63	164.63	207.17	199.77	255.82	283.93	93.74	-	-	6.47	283.93	1,317.44	109.79
1989	-	-	63.96	74.59	86.21	105.07	103.00	308.40	170.54	175.32	-	-	63.96	308.40	1,087.09	90.59
1990	-	-	-	103.00	170.00	125.00	390.00	180.00	170.00	100.00	-	4.20	100.00	390.00	1,242.20	103.52
1991	-	12.67	60.82	13.82	49.20	308.30	120.70	352.50	159.50	269.70	-	-	12.67	352.50	1,347.21	112.27
1992	-	-	24.30	72.02	14.55	180.20	202.20	308.68	285.80	157.50	8.20	-	8.20	308.68	1,253.45	104.45
1993	-	35.40	42.50	6.80	93.70	236.90	139.70	260.90	314.30	107.30	29.90	-	6.80	314.30	1,267.40	105.62
1994	-	2.20	3.40	54.20	200.80	174.20	184.00	435.80	435.80	286.20	17.40	-	2.20	435.80	1,794.00	149.50
1995	-	-	21.60	25.70	163.80	159.20	287.80	528.30	327.00	190.85	13.90	-	13.90	528.30	1,718.15	143.18
1996	-	1.25	21.70	41.05	170.20	236.80	161.10	242.50	260.00	228.30	-	-	1.25	260.00	1,362.90	113.58
1997	8.20	-	88.25	131.90	235.50	222.10	305.95	178.75	311.50	236.80	12.00	-	8.20	311.50	1,730.95	144.25
1998	-	-	3.30	29.10	236.70	94.90	312.60	303.60	309.60	199.80	-	-	3.30	312.60	1,489.60	124.13
1999	-	0.60	12.20	73.45	164.60	134.20	435.50	287.80	180.20	171.10	1.00	-	0.60	435.50	1,460.65	121.72
2000	-	-	17.40	61.90	157.30	208.40	230.70	322.30	235.90	81.20	-	-	17.40	322.30	1,315.10	109.59
2001	-	-	20.30	31.20	157.40	209.55	560.50	294.40	248.60	129.65	-	-	20.30	560.50	1,651.60	137.63
2002	-	1.10	46.10	65.10	79.67	135.80	326.86	330.84	276.50	205.00	-	-	1.10	326.86	1,466.97	122.25
2003	-	38.40	7.44	25.41	76.56	235.36	176.58	375.00	210.48	288.41	43.85	-	7.44	375.00	1,477.49	123.12
2004	-	-	-	53.14	116.50	201.56	262.59	298.74	289.35	142.56	21.26	-	21.26	298.74	1,385.70	115.48

TABLE 4

MONTHLY AVERAGE SEEPAGE MEASUREMENT (M^3/S) IN LOWER USUMA DAM FROM 1989 - 2004

YEAR	JAN	FEB	MAR	APR	MAY	JUN	JULY	AUG	SEP	OCT	NOV	DEC	MIN	MAX	TOTAL	MEAN
1989	0.4772	0.3652	0.467	0.466	0.4823	0.4964	0.5036	0.6688	0.6935	0.7089	0.7089	0.5585	0.3652	0.7089	6.5963	0.5497
1990	0.537	0.4776	0.48	0.5242	0.518	0.5704	0.6176	0.6398	0.6618	0.6	0.6	0.61	0.4776	0.6618	6.8364	0.5697
1991	0.3824	0.4106	0.4526	0.4814	0.6032	0.6368	0.6838	0.7324	0.7506	0.7454	0.7454	0.625	0.3824	0.7506	7.2496	0.6041
1992	0.4622	0.4724	0.4936	0.5788	0.612	0.618	0.6246	0.7284	0.7734	0.7321	0.7321	0.623	0.4622	0.7734	7.4506	0.6209
1993																
1994	0.4321	0.4652	0.4852	0.5631	0.492	0.469	0.6314	0.7506	0.7469	0.7432	0.7408	0.6342	0.4321	0.7506	7.1537	0.5961
1995	0	0	0	0.5088	0.488	0.4636	0.5448	1.1004	1.2208	0.7426	0.7944	0.612	0.488	1.2208	6.4754	0.5396
1996	0.5362	0	0.498	0.48	0.4718	0.475	0.4758	0.5806	0.7465	0.7523	0.7523	0.6312	0.498	0.7523	6.3997	0.5333
1997	0.4714	0	0	0.3608	0.3919	0.5208	0.30375	0	0.8003	0.8306	0	0	0.3608	0.8306	3.67955	0.3066
1998	0	0	0.3986	0	0	0.398	0.4864	0.4682	0.681	0.5102	0.3952	0.3106	0.3106	0.681	3.6482	0.3040
1999	0.423	0.3836	0.3442	0.317	0.415	0.3094	0.5271	0.7448	0.5972	0.5632	0.5322	0.5014	0.317	0.7448	5.6581	0.4715
2000																
2001																
2002	0.4898	0.5684	0.3996	0.3613	0.3312	0.3476	0.3844	0.4724	0.5232	0.642	0.52	0.502	0.3312	0.642	5.5419	0.4618
2003	0.518	0.4756	0.3982	0.4256	0.5082	0.345	0.3166	0.4528	0.5514	0.5412	0.523	0.501	0.3166	0.5514	5.5566	0.4631
2004	0.438	0.5305	0.4602	0.4913	0.523	0.4258	0.4265	0.449	0.459	0.521	0.52	0.501	0.4258	0.5305	5.7453	0.4788

REMARKS:

A. O = NO SEEPAGE RECORD
B. NO SEEPAGE RECORD FOR 1993,2000 AND 2001

4.3.4 *Piezometric Readings.*

The piezometer readings give the groundwater level in the embankment. Generally, a level of between 5 to 6 meters forms the range in groundwater level of the dam for the years under review. The maximum groundwater level is 7.53m recorded in the month of August 1989, while the minimum groundwater level is 4.59m recorded in the month of September 1993. See fig. 4 for maximum and mean piezometer readings. This change in groundwater level is principally a function of rainfall. The results obtained for 2002, 2003, and 2004 also followed the trends for the previous years records established; therefore the dam is safe against the action of ground water.

4.3.5 *Settlement of Dam Embankment*

Considering table 5 and 6, it is observed that between 1984 – 1985, the dam embankment was really undergoing settling i.e. during the earlier stage of construction. A level of between 578.822 and 578.636 meters were often seen. This gives a difference in level of 0.186 meters indicating real settlement.

From years 2002 – 2004, the dam had settled finally. This can be seen in Tables 7, 8 and 9 in the appendix where the change in levels have become very insignificant. The levels had decreased from 578.822 as noticed during 1984 – 1985, to between 578.424 and 578,370 on average, and continues within these range of values.

4.3.6 *Population Growth and Water Demand in FCT*

Population growth and water demand of the FCT have been on the tremendous increase. This is due to the influx of citizens from other parts of the federation seeking for the so-called "national cake". The predicted population growth of 2.5 percent annually had been overshot, and this has resulted to high water demand in the Territory.

From table 10, the population of the territory, which was estimated at 2.11million in 1998, with water demand of 211,400m^3/s is expected to have grown by the year 2004 following the trend of growth seen in Table 10. This increase in population and water demand had led to the continuous withdrawal of water from the dam for treatment trying to meet up the demand. The rate of withdrawal of water from the dam is far higher than the rate of recharge through rainfall from the catchments especially in the year 2004 where the total rainfall at the catchments stood at 1,385.70mm. This decrease in total rainfall had led to this present problem of gross fall in water level in the dam. The per capita demand of 320 liters per day as designed have been over shot considering the pattern at which water demand increases in Table 5. This increase in population and per capita water consumption implies that the demand for water is high and not commensurable with the supply. The two treatment plants are expected to produce at a rate of 10,000m^3/hr during full production to be able to meet the 320 liters per capita demand as designed. currently, the plants are operating at 8,000m3/hr due to the fall in water level in the dam and at this rate of production, the quantity can not meet with the demand as designed not to talk of the present demand .

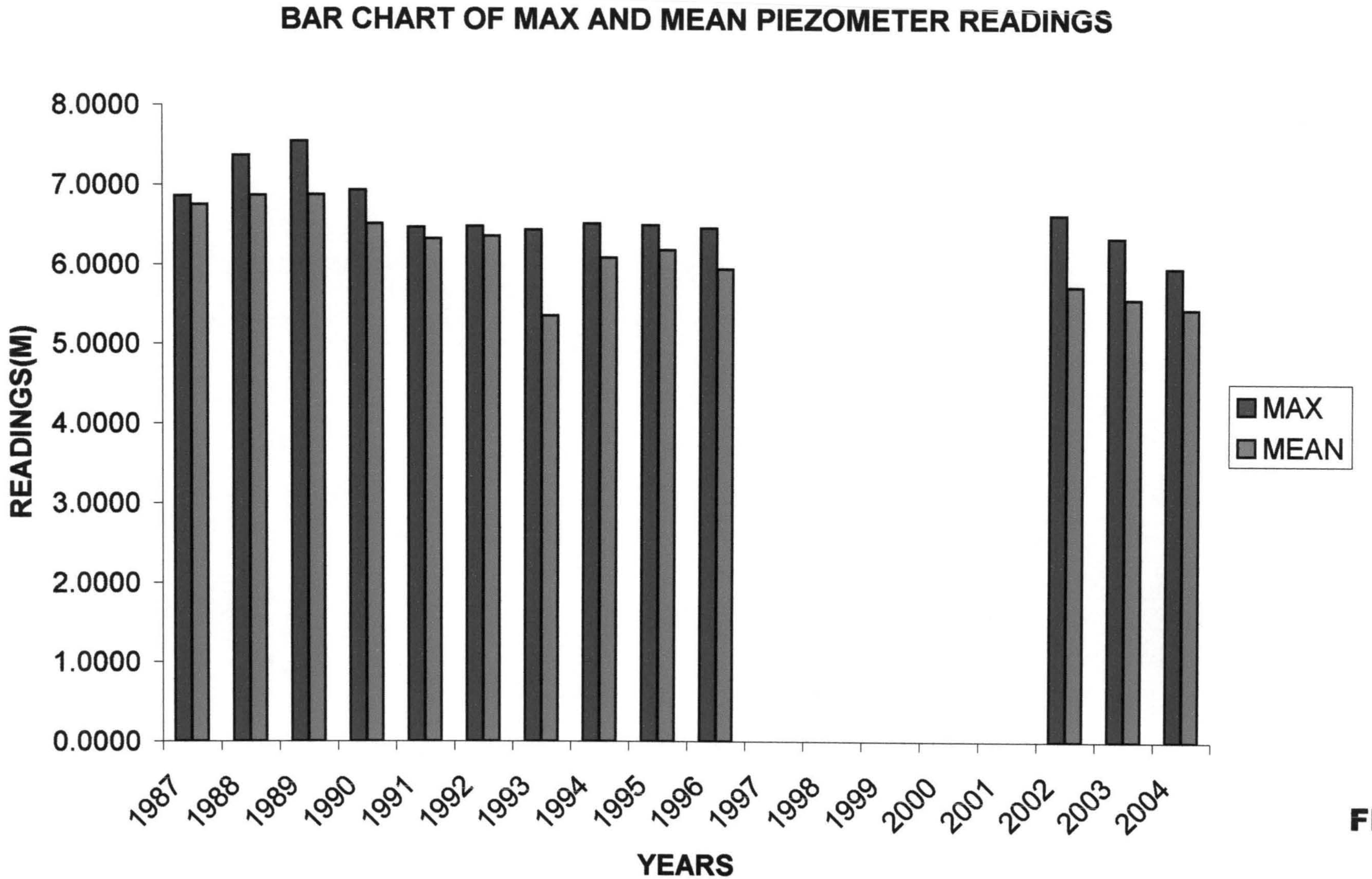
BAR CHART OF MAX AND MEAN PIEZOMETER READINGS
8.0000
7.0000
6.0000
5.0000
4.0000
3.0000
2.0000
1.0000
0.0000
READINGS(M)
1987
1988
1989
1990
1991
1992
1993
1994
1995
1996
1997
1998
1999
2000
2001
2002
2003
2004
YEARS
MAX
MEAN

FIG. 4

Table 5:

MAIN DAM

Bench Marks Levelling(1984-1985)

LINE ONE DOWNSTREAM

DATE	100	200	300	400	500	600	700	800	900	1000	1100	1200
30/10/84	578.678	578.757	578.679	578.743	578.66	578.691	578.645	578.82	578.486	578.704	578.62	578.655
8/11/1984	578.676	578.759	578.682	578.745	578.663	578.692	578.643	578.822	578.488	578.709	578.64	578.662
14/11/84	578.675	578.757	578.678	578.742	578.658	578.686	578.636	578.815	578.481	578.703	578.616	578.654
21/11/84	578.673	578.754	578.675	578.735	578.654	578.682	578.631	578.811	578.478	578.696	578.611	578.646
27/11/84	578.669	578.75	578.668	578.729	578.648	578.678	578.627	578.81	578.48	578.699	578.614	578.651
6/12/1984	578.666	578.75	578.667	578.728	578.647	578.677	578.622	578.807	578.477	578.698	578.614	578.653
14/12/84	578.666	578.747	578.663	578.725	578.645	578.673	578.618	578.806	578.474	578.694	578.61	578.646
20/12/84	578.665	578.748	578.663	578.724	578.646	578.675	578.621	578.809	578.48	578.702	578.615	578.655
3/11/1985	578.667	578.749	578.662	578.721	578.645	578.573	578.62	578.804	578.475	578.7	578.616	578.657
10/1/1985	578.672	578.753	578.666	578.725	578.649	578.675	578.619	578.808	578.48	578.703	578.616	578.656
17/1/85	578.675	578.755	578.666	578.724	578.648	578.677	578.62	578.809	578.482	578.703	578.617	578.658
23/1/85	578.668	578.748	578.659	578.72	578.646	578.676	578.617	578.807	578.476	578.698	578.613	578.655
29/1/85	578.657	578.737	578.649	578.708	578.636	578.665	578.61	578.799	578.474	578.696	578.608	578.652
7/2/1985	578.667	578.745	578.715	578.715	578.643	578.67	578.613	578.804	578.478	578.7	578.614	578.657

Table 6:

MAIN DAM

Bench Marks Levelling (1985)

LINE ONE DOWNSTREAM

DATE	100	200	300	400	500	600	700	800	900	1000	1100	1200
20/2/85	578.659	578.738	578.648	578.707	578.663	578.663	578.605	578.796	578.474	578.694	578.608	578.654
12/3/1985	578.663	578.741	578.651	578.712	578.64	578.669	578.609	578.8	578.477	578.698	578.609	578.653
26/6/85	578.639	578.709	578.671	578.689	578.609	578.633	578.576	578.772	578.457	578.676	578.596	578.646
12/7/1985	578.644	578.707	578.619	578.683	578.605	578.627	578.569	578.762	578.45	578.667	578.59	578.639
9/8/1985	578.636	578.701	578.612	578.681	578.6	578.623	578.566	578.758	578.444	578.662	578.587	578.627
12/9/1985	578.634	578.7	578.609	578.679	578.584	578.614	578.56	578.75	578.439	578.646	578.58	578.609
12/10/1985	578.633	578.689	578.599	578.674	578.574	578.597	578.549	578.549	578.636	578.636	578.556	578.598

TABLE 10

Population and Water Demand for FCT, 1998 - 2033

Community	1998			2008			2018			2028			2033 (Ultimate)		
	Population (x 1000)	P.c.d. L/day	Water Demand	Population (x 1000)	P.c.d. L/day	Water Demand	Population (x 1000)	P.c.d. L/day	Water Demand	Population (x 1000)	P.c.d. L/day	Water Demand	Population (x 1000)	P.c.d. L/day	Water Demand
Abuja Municipal	1,300	120	156,000	1,905	150	285,750	2,511	180	451,980	3,309	200	661,800	3,799	214	812,986
Area Council Headquarters	310	90	27,900	433	110	47,630	571	120	68,520	752	140	105,280	863	150	129,450
Satellite Towns	250	70	17,500	349	90	31,410	460	110	50,600	607	120	75,840	697	128	89,216
Other Villages	250	40	10,000	287	50	14,350	378	60	22,680	499	70	34,390	573	75	42,975
FCT Total	2110	-	211,400	2,974	-	379,140	3,919	-	593,780	5,167	-	874,850	874,850		1,074,627

P.c.d. = Per Capita Per day
L/day = Litres per day
m3/d = Cubic metres per day

CHAPTER FIVE

5.0 CONCLUSION AND RECOMMENDATIONS

5.1 Conclusion

Generally, it was not easy getting past records of some of the parameters analyzed. Data were missing in some of the years due to improper documentation and carelessness in handling on the aspect of some of the field staff responsible for the job.

Breakdown of facilities and insufficient funding from government to procure or repair these equipment had also made it difficult for the staff to fully monitor some of the safety measures put in place to guide against failures of the dam. Example of such equipment that are no longer functional at the dam includes: pore pressure cells and inclino-Tassometer. Results obtained from other safety parameters evaluated, followed the normal established trend by the dam safety monitoring unit, therefore, Lower Usuma Dam can generally be considered as been safe.

In the case of acute water shortage in the dam, it had been discovered from the evaluation made in some of the parameters that the major causes of the shortage are due to:

i. Insufficient rainfall at the dam catchments especially in the year 2004, resulting to the sharp drop in water level presently experiencing in the dam.

ii. The continuous rise in population and the corresponding increase in water demand in FCT had also contributed immensely to the sharp drop in water level at the dam since the rate of withdrawal of water to meet the yearnings of the citizens in FCT is far higher than the rate of recharge of the dam.

These are the two major courses of the acute water shortage in the dam as identified through analysis of data during this research.

5.2 Recommendations

In the course of this research, I encountered a lot of problems most especially in the areas of data collection.

Also, there is a great problem of water scarcity presently ongoing in the territory. In view of this, the FCT-water board had begun an awareness campaign on radio and television stations intimating the public of this scarcity and pleading for any abuse of water in the territory.

To avoid such difficulties in data collection, and to find a long lasting solution to this shortage in water supply, I hereby recommend strongly that:

1. Due to the sensitive nature of the FCT-Water Board (Lower Usuma Dam), the government should computerized the office so that all relevant documents can be stored in a data base and can be assessed at any given time for research purposes or other uses.
2. A comprehensive programme of monitoring the dam safety should be put in place by the government. Continuous funding of the agency so that the breakdown facilities and other exhausted materials can be repaired and replaced for proper monitoring can only carry this out.
3. The Gurara Water Transfer Project is a gigantic water project presently on going. This project when completed is to among others provide water to meet FCT demand for the next 50 years. The government had taken a right step in a right direction since the raw water transferred on completion of the project would feed the Lower Usuma Dam.

REFERENCES

1. Abuja Water News (A.W.N), 1995: "Water in the dry season", A report Published on the AWN, Vol. 4, October – December.

2. E. A. Seaman and L. W. Davidson: "Ecological and Environmental Considerations". A Water Resources Publication of the United States Department of the Interior, Bureau of Reclamation.

3. Eijekemp, 1985: Rural Water Supply. A Report Published In AWN, Vol. 3 No. 2.

4. Encarta, 1993: "Dams of the 20th Century". A Publication on Microsoft Encarta.

5. Encarta, 2002: A Publication on "Dams", Encarta Encyclopedia.

6. Mardel Plata, 1977: A Water Journal Publication of the UN Conference on "Water Supply".

7. M. A. Hassan, 2000: "Selecting the most Appropriate Water Source". A paper presentation on AWN of the FCT Water Board, Abuja.

8. O. S. Agbontaen, 1997: "Dam Failures and Incidents in Nigeria". A paper presentation in AWN, Vol. 2. No. 3.

APPENDIX 1

1. Bench Marks Leveling (m) 2002 – 2003.
2. Bench Marks Leveling (m) 2003
3. Bench Marks Leveling (m) 2004
4. Monthly average piezometer reading (m) 1987-2004

TABLE 7: Main Dam

Bench Mark Measurement (meters) 2002/2003

LINE: ONE

DATE	100	200	300	400	500	600	700	800	900	1000	1100	1200
30/1/02	578.424	578.447	578.367	578.456	578.32	578.271	578.271	578.343	578.113	578.38	578.292	578.525
26/2/02	578.424	578.46	578.383	578.475	578.345	578.317	578.32	578.372	578.151	578.4	578.298	578.53
28/2/02	578.425	578.457	578.371	578.46	578.34	578.316	578.321	578.37	578.121	578.389	578.297	578.527
24/4/02	578.433	578.449	578.371	578.456	578.328	578.287	578.289	578.344	578.118	578.377	578.301	578.508
30/5/02	578.43	578.452	578.372	578.457	578.335	578.31	578.311	578.345	578.124	578.379	578.302	578.512
25/6/02	578.42	578.449	578.372	578.459	578.33	578.295	578.297	578.351	578.128	578.384	578.309	578.519
26/7/02	578.422	578.451	578.373	578.456	578.332	578.296	578.298	578.351	578.122	578.384	578.306	578.52
29/8/02	578.417	578.44	578.37	578.453	578.325	578.282	578.297	578.349	578.122	578.382	578.307	578.521
30/9/02	578.419	578.445	578.372	578.452	578.321	578.283	578.297	578.351	578.126	578.373	578.308	578.522
31/10/02	578.42	578.443	578.381	578.467	578.329	578.305	578.299	578.348	578.12	578.387	578.318	578.533
28/11/02	578.42	578.448	578.382	578.456	578.33	578.301	578.297	578.345	578.116	578.378	578.314	578.524
16/12/02	578.418	578.45	578.381	578.461	578.333	578.297	578.296	578.343	578.109	578.362	578.286	578.521
29/1/03	578.415	578.447	578.383	578.462	578.33	578.298	578.295	578.342	578.107	576.372	578.317	578.518
26/2/03	578.413	578.487	578.372	578.441	578.34	578.297	578.292	578.342	578.105	578.361	578.282	578.516

TABLE 9: Main Dam

Bench Mark Measurement (meters) (2004)

LINE: ONE

DATE	100	200	300	400	500	600	700	800	900	1000	1100	1200
30/1/04	578.424	578.496	578.372	578.461	578.332	578.297	578.295	578.348	578.122	578.372	578.302	578.511
27/4/04	578.412	578.436	578.36	578.45	578.32	578.29	578.287	578.34	578.11	578.38	578.289	578.508
31/8/04	578.422	578.447	578.364	578.459	578.336	578.301	578.291	578.342	578.014	578.376	578.296	578.502
20/12/04	578.424	578.442	578.362	578.452	578.329	578.3	578.291	578.339	578.092	578.379	578.291	578.506

TABLE 11

MONTHLY AVERAGE PIEZOMETER READINGS(METERS) FROM 1987-2004

YEAR	JAN	FEB	MAR	APR	MAY	JUN	JUL	AUG	SEP	OCT	NOV	DEC	TOTAL	MIN	MAX	MEAN
1987	6.7542	6.7798	6.8525	6.8435	6.8284	6.8011	6.7579	6.8386	6.6128	6.5286	6.7129	6.6400	80.9503	6.5286	6.8525	6.7459
1988	6.7286	6.7071	6.8614	6.8586	6.8557	6.8443	6.6771	6.4600	7.1650	7.2767	7.3650	6.5371	82.3366	6.4600	7.3650	6.8614
1989	6.6929	7.1643	6.8543	6.8814	6.8729	6.8000	6.7371	7.5383	7.3050	7.3200	7.2600	5.0286	82.4548	5.0286	7.5383	6.8712
1990	6.3209	6.4236	6.4555	6.4091	6.9300	6.4718	6.4973	6.4818	6.8690	6.8280	5.5470	6.8110	78.0450	5.5470	6.9300	6.5038
1991	6.3691	6.3873	6.4400	6.4745	6.4609	6.0700	6.2691	5.9509	6.3900	6.3080	6.2700	6.4020	75.7918	5.9509	6.4609	6.3160
1992	6.3627	6.3655	6.4164	6.4718	6.4409	6.3382	6.2791	6.3140	6.2460	6.2100	6.3623	6.3520	76.1589	6.2100	6.4718	6.3466
1993	4.6022	5.5621	5.4010	5.4610	5.4967	5.3631	4.6230	4.5622	4.5960	6.1025	6.4262	5.9810	64.1770	4.5960	6.4262	5.3481
1994	5.4661	5.9711	5.9128	5.9578	6.5027	6.4934	6.4727	6.0491	5.9690	5.9950	6.4900	5.6100	72.8897	5.4661	6.5027	6.0741
1995	6.3300	6.3820	6.4245	6.4545	6.4655	6.4845	6.3445	5.4982	5.7336	5.8643	6.1772	5.8936	74.0524	5.4982	6.4845	6.1710
1996	6.3291	6.4073	6.4100	6.4473	5.4830	5.2560	5.8003	5.6493	5.6915	5.7779	5.9776	5.9356	71.1649	5.2560	6.4473	5.9304
1997																
1998																
1999																
2000																
2001																
2002	5.8511	5.3169	5.3733	5.4233	5.6578	5.7467	6.0800	4.8380	4.9978	6.1267	6.6144	6.5544	68.5804	4.8380	6.6144	5.7150
2003	5.1189	5.5022	5.4811	5.3622	5.4944	5.6361	5.7778	5.2767	5.0467	5.5867	6.1006	6.3275	66.7109	5.1189	6.3275	5.5592
2004	5.4384	5.4022	5.4350	5.5100	5.9189	5.3450	5.2825	5.1950	5.1175	5.0600	5.5803	5.9539	65.2387	5.0600	5.9539	5.4366

REMARKS:
NO RECORD OF PIEZOMETRIC READING FROM 1997-2001

APPENDIX II

1. Pie Chart showing percentage of total seepage (M^3/S)
2. Bar Chart of maximum rainfall from 1987 – 2004
3. Line Chart of minimum, maximum, total and mean rainfall from 1981 – 2004.

PIE CHART SHOWING PERCENTAGE OF TOTAL SEEPAGE(M3/S)

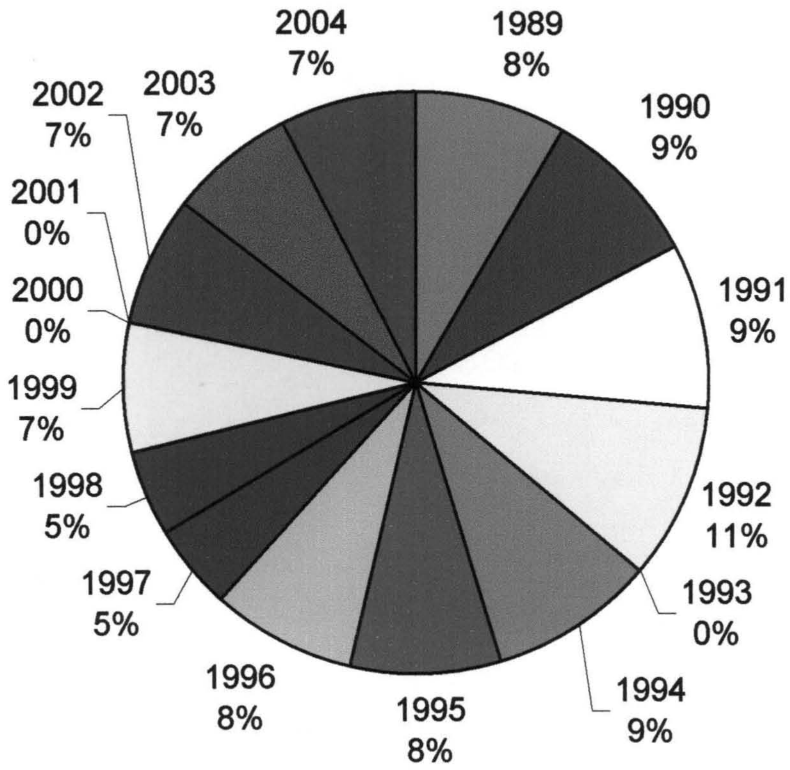

FIG. 5

BAR CHART OF MAX. RAINFALL FROM 1987-2004

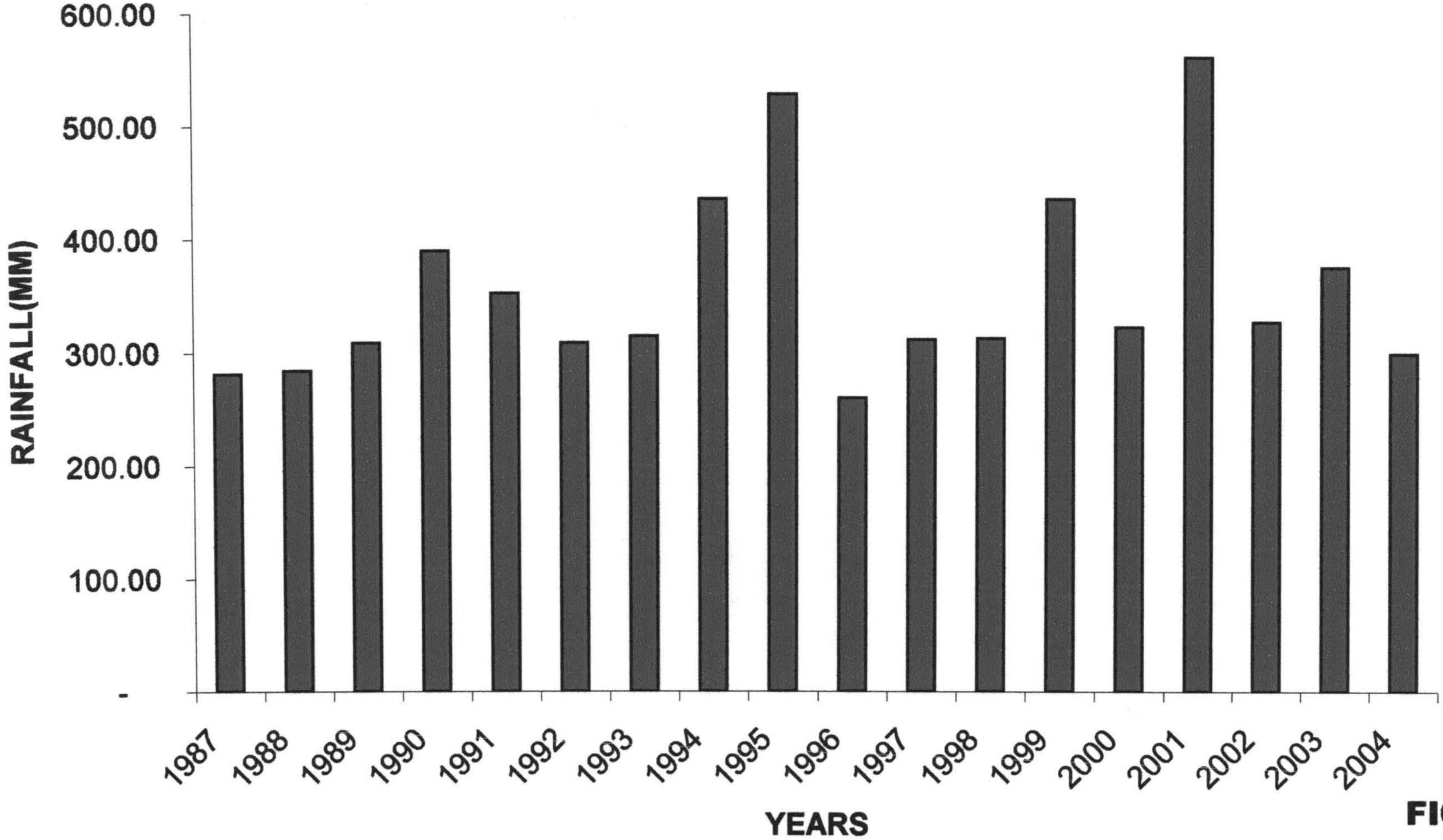

FIG. 6

A LINE CHART OF MIN, MAX,TOTAL AND MEAN RAINFALL FROM 1981-2004

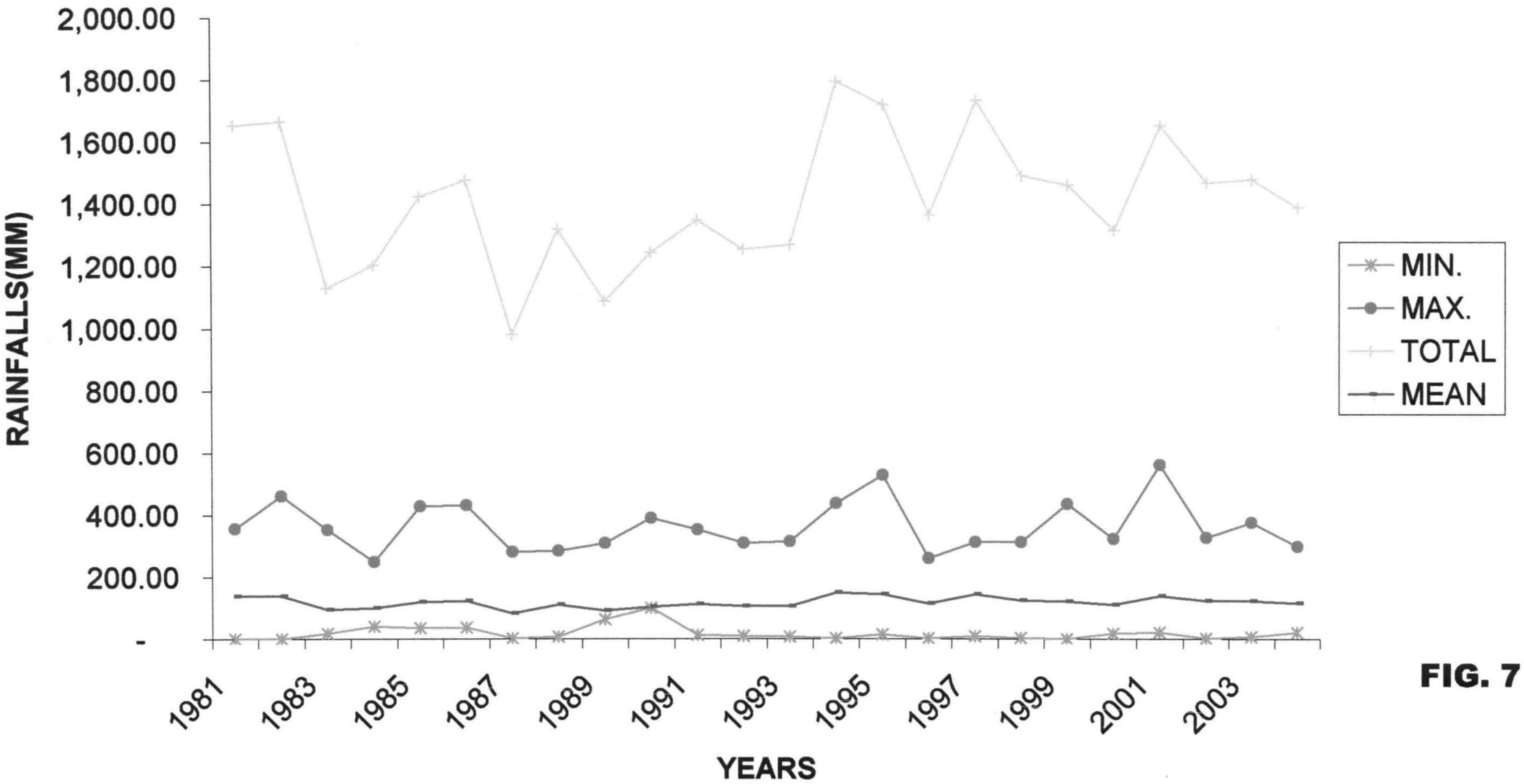

FIG. 7