SAFETY OPERATIONS AND MAINTENANCE OF DAMS

(CASE STUDY OF OYAN DAM)

BY

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PGD/AGRIC. ENGINEERING/ 2001/2002/172

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CERTIFICATION

THIS IS TO CERTIFY THAT THE PROJECT

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POST GRADUATE DIPLOMA (PGD) IS AN ORIGINAL WORK

CARRIED OUT BY

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DEDICATION

Glory be to Almighty Allah, the Lord of the worlds. This project is dedicated to Almighty God, the Beneficent, The Merciful. From Him we derives profound success and infinite guidance.

Also, to my family: Mrs. Hamdalat Lawal, Master AbdulGhaneyy Lawal and Miss Balqees Lawal.

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The completion of this project could not have been satisfactory without divine guidance and unfailing support from Almighty Allah. Also, I thank God for His protection over me, our lecturers and my colleagues throughout our course of study.

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May Almighty Allah reward each and everyone abundantly, Ameen.

CHAPTER 1

INTRODUCTION

1.1 THE DAM-KEYSTONE OF WATER DEVELOPMENT

A dam is an hydraulic structure placed across a river or stream for water storage to provide a supply of water. Also, it is a viable entity. A dam designed and constructed by a responsible agency is the single most important structure built to control and release water in a well-conceived and executed plan. It may serve to store and release water for multiple purposes such as flood control, power production, municipal and industrial uses, irrigation, fish and wildlife conservation, recreation and other beneficial uses, components of a dam for achieving its function is an assemblage of ancillary features: spillway, outlet works, power plant, gates, valves, trash racks, cranes an other intricate electrical, mechanical and structural facilities.

In its prime function of water storage, a dam must be operated in concert with a n overall project objectives for the release of water on a controlled basis to meet down stream needs and other project commitments. Orderly operating procedures and proper maintenance of a dam and its appurtenant works are vital to the continued success of the project development.

To ensure the integrity of a dam, the monitoring and inspection of it and its auxiliary facilities on a regular basis is vital. If a dam is an earth embankment, for example, we must periodically examine it for cracks, slides, sloughs, subsidence, seepage, boggy areas, and any outward appearing deterioration of up stream and down stream slope protection. We must similarly examine the general appearance of concrete structures at an earth dam. When the reservoir is low, we must direct our attention to the possible development of sink and seepage holes or any unusual beaching condition in exposed portions of the abetments and the reservoir floor.

Spillway tunnels and stilling basins of spillways and outlet works and the channels down stream from these basins must be periodically examined for erosion, under cutting, or general deteriorating. At least frequent intervals, the basins and channels must be either unwatered or examined under water by specially trained divers.

As a viable entity, an earth dam must be examined for its structural behaviour during contraction as well as during operation of the reservoir. Such structural behaviour data obtained at an earth dam may include: in place strength; pore-water pressure; horizontal and vertical interval movement and foundation settlement surface movement; both horizontal and vertically; and drainage or seepage through the embarkment, foundation, or abetments.

Similarly, at concrete dams we must obtain structural behaviour data, as well as uplift pressures. We must obtain structural behaviour movement of concrete dams from data obtained from reference point established in major apartment facilities such as spillway and outlet work structures. Additionally, at testing and reanalysis of stresses to determine whether there is now less than the desired margin of safety caused by material deterioration or other factors.

1.2 SAFETY OPERATIONS AND MAINTENANCE OF DAM

Instrumentation is a general term which refers to a means by which structural behaviour data are collected at dams and reservoirs. It include monitoring dam performance during construction and the useful life of a structure and in application of safety standards. Instrumentation provides a history of past performance for comparison with current and future measurements and with similar structures elsewhere and also enable research as to validity of design assumptions and thereby facilitate improvement in those assumption. Finally, rational decision on remedial actions are taken

1.3 MAINTENANCE OF DAMS

The following are detected through instrumentations:-

a. Movement of water through and around a dam
b. Temperature within the dam and in the reservoir at different depths
c. Movement of the dam as water surface elevation change and materials dry and cool
d. Water pressure in the dam, foundation and abutments.
e. Strain in the dam and foundation materials
f. Events serious enough to trigger alarm systems to warm of changing structural integrity
g. Water quality of reservoir waters and elsewhere to facilitate identifying sources of water or whether seepage water is dissolving solids in embankment materials

EMBANKMENT DAM INSTRUMENTATION AND REQUIRED MAINTENANCE

i. The maintenance of the standpipe type consists of minimizing plugging, keeping the cover intact and in place, checking the condition of the marking respective locations and identifying each gage in a series.

ii. The maintenance of the twin-tube type involves keeping the gage free-moving, taking care to avoid break or disconnecting fragile tubes, servicing broken dials and cleaning the glass or replace it

CONCRETE DAMS INSTRUMENTATION AND REQUIRED MAINTENANCE

Maintenance involves periodic cleaning of drains and uplift pressure devices. Deformation equipment most be serviced frequently to avoid corrosion. The power sources, usually batteries, should be check for satisfactory voltage levels, and the electrical contact on the gages and readout box must be clean and lubricated.

THE ANALYSIS AND FEEDBACK

Maximum effectiveness of instrumentation programs can be realized when the dam operator knows the purpose of the equipment, what variables are been measured, and readings are abnormal when compared to previous ones. The operator should be empowered to take a decisive and corrective measures during the process of the analyzing the product of instrumentation

OBJECTIVES

In this project an attempt is made to assess and evaluate the safety operations and maintenance of dams generally with a particular case study of oyan dam. The basic concept of dam instrumentation was high-lightened for dam construction.

JUSTIFICATION

Water is a commodity of nature which today is stored for various reasons including hydropower generation, municipal water supply, industry and irrigation fields. The growth of population on our planet and boosting of economic life has necessitated dam construction. Because of the risk factor associated with dam construction and their operation activities, I hereby express reasonable measures to be taken in the following chapters to achieve maximum and remarkable result in dam construction.

CHAPTER 2

LITERATURE REVIEWS

1 DAM DESIGN

A dam structure is constructed on a river or stream to allow for off-season storage of vital water supplies for irrigation, fish farming, domestic water, ground water re-charge, flood protection and conservation storage.

The actual storage capacity of such a reservoir must be greater than the net demand over a season, for irrigation requirement, evaporation losses, seepage and the dead storage. Embankment dams have advantages over equivalent concrete structures and are appropriate for farm or rural situations. When built on suitable sites and correctly designed and constructed using good earthwork materials, dams can be safe. Design and safety procedures require more technical expertise and an experienced civil engineer must be consulted. Earth dams normally require minimal maintenance and are better able to withstand foundation and abutment movements. Additional advantage can be gained by constructing the embankment from materials excavate from the reservoir area this provides a small increase in storage capacity and reduced cost. An earth dam is unique to an individual site, even though special emphasis are given to local conditions, certain guideline and generalities can be applied to all dams.

Such guidelines allow for safe and economic construction of embankments, but it must be emphasized that although most of the procedures are simple and more of a matter of common sense than advanced engineering knowledge, if the safety of any design or construction element is in question, a competent civil engineer must be consulted. A failed dam is not only a matter of a lost structure, but can result in the loss of life and in considerable expense for those downstream, therefore, all procedures in selecting, designing and building dams must be followed to the highest possible standards.

In all dam construction, safety must be given priority. The following guidelines are useful:

i) Unless experienced and qualified civil engineer is involved, it is advisable to restrict the construction of earth dams to heights of less than 8.0m from stream bed to finish crest level.

ii) Dams on catchment areas greater than 25km2 may require the advice of a hydrologist and a hydraulic structural engineer to assist in the design of spillway and other outlets and for estimation of free board

iii) Spillways must be wide enough and should at least be 15m wide and 1.5m deep for catchment exceeding 5km2.

iv) A dam that involved out of the ordinary topography, hydrology or soils should only be designed and constructed under the supervisor of a qualified engineer

A Dam which is not more than 8m high and impounding not more than 5 million cubic meters (mcm) is considered Small dam.

Large dam is defined as:

i) All dams above 15m in height measured from the lowest portion of the general foundation to the crest

ii) Dams between 10m and 15m in height provided they complied with at least on of the following conditions:

a. The capacity of the reservoir formed by the dam to be not less than 100, 100m3

b. The length of the crest of the dam to be not less than 500m

2. PROJECT PLANNING (WATER RESOURCE DEVELOPMENT)

2.1 General

A water resource development may be small or large, simple or complex serving one purpose or several, but it must provide the facilities to accomplish the optimum development of related physical resources. The investigations and studies made for these dams must be considered in relation to the function they perform in accomplishing the purpose of t
objectives, purposes and scope determine what must be investigated with respect to dams.

In several cases, the project will be of a dual or multi-purpose type. Hence, the investigations may include a large number of matters. Some or all of which will influence the selection of a dam site, the size of the dam, and the purpose it serves. The entire project must be investigated as a unit before the design requirements for a single future, such as a dam, can be firmly established. Each project purposes and ach increment of its size or scope must justify inclusion which is usually related to the benefits it produce the need it serves or the investment it can repay with or without interest. Feasibility studies of dams and reservoirs should always consider possible objections from a public health and nuisance stand point, and a proper effort should be made to mitigate the damages involved. Impounded fresh water held at a constant level makes and ideal breeding place for mosquitoes, thereby creating a nuisance and the possibility of transmitting malaria and encephalitis.

Many reservoirs will be in regions affected by drought and subject to flash floods. Under these climatic conditions, floodwater erosion of the watershed and stream banks will fill the streams with sediments to be caught in the reservoirs. The accumulation of the sediment may soon reduce the usefulness of reservoirs and ultimately completely eliminate its capacity. Loss of capacity and other damages due to situation of reservoirs an changes of the regimen of silt-laden streams as a result of reservoir operation should be considered for all proposed projects.

Examples of the purpose for building a dam include the following:

- Irrigation
- Domestic or municipal
- Industrial use
- Livestock
- Power development
- Flood control
- Wild life
- Water storage for stream flow regulation

3. SITE SELECTION

3.1 Desk Studies

The selection of a suitable site involves the use of aerial photographs and large scale maps. In Nigeria aerial photographs of scale 1:25,000 are normally obtained from the Federal Survey Department in Lagos and are expensive to reproduce, therefore one is constrained to use large scale contoured maps of 1:50,000 with contour intervals of 50ft (15m). This pre-site visit desk study is essential as it identifies promising sites and catchment sizes, as well as accessibility to the nearest power source, roads, bridges and buildings and can cause costly field investigation work.

Identifying suitable sites depends on the following geographical points:

- Where one or more streams or tributaries meet the main river course may offer good water storage.
- Where the site is close to where the water is required is a desirable site;
- Where narrow channel sections exist with wider basin area immediately upstream would result in short embankment and large storage,
- Where rock outcrops are found either in the river bed or on the valley sites present safe spillway locations especially on large catchments.
- Where sudden changes in stream gradient may point to good storage potential.

- The extent of the reservoir upstream of the dam can be assessed by following the contour whose have been selected as a suitable site. Figs. 1, 2 and 3 are examples of catchment and cross-section profiles of selected dam sites.

3.2 Filed Studies

Having located a few potential sites during the desk-study, a field visit of the area is organized to allow the most suitable site to be selected. Each potential sit is visited and any other that becomes apparent at the time of visit or can be sited by discussing with the local people with the local people. A rough reconnaissance of every site within the involved area, with checks on spillways, borrow areas and foundation conditions, will allow the merits and demerits of each site to be assessed. The most favourable site can be determined and preliminary surveys carried out.

3.3 Preliminary Surveys

Economic and design implications of each site can be determined from a brief preliminary survey using leveling instruments to take a line of spots heights across he profile and up the valley to provide indications of stream bed gradient. The bed gradient is necessary to estimate the fetch of the dam. For each site, the survey must be sufficiently detailed to enable comparative estimates to be made for various dam heights. The most economic height is calculated on the basis of the cost per unit volume of water stored. Comparison of the various alternative sites can now be possible.

3.4 Catchment Yield

The catchment run-off can be estimated using the formula Q = CIA

Where C = is a coefficient of the catchment
I = is the rainfall intensity in mm
A = is the area of the catchment in m2

The catchment yield is based on the run-off from a catchment and is an important factor is assessing the feasibility of a dam and determining the required height of the embankment.

The run-off estimation of a catchment requires expertise and is a whole subject of flood studies that requires a hydrologist input.

For us it will suffice as a guide to use 10% of the mean annual rainfall of the catchment area. The mean annual run-off of the catchment is assessed and represented by R in mm the catchment

embankment. The catchment yield in an average year is therefore given by:

$$Y = \frac{R}{1000} \times A \text{ in m3}$$

3.5 Storage Capacity

The storage capacity can be estimated using a formula $Q = \frac{LTD}{6}$ refer to Small Earth Dams and Weirs by Tim Stephens

Where Q is the capacity in M3

L is the length of the dam at full supply level in m (FSL)

T is the fetch or throw back in m (straight line)

D is the maximum depth in m, at SFL

This formula for capacity estimation must be revised by a more detailed survey when the site has been approved for construction.

3.6 Preliminary Volume of Earthworks

A preliminary survey stage one could estimate the volume of earthworks for each dam location by using the formula (refers to ?? Small Earth Dams and Weirs by Tim Stephens).

$$V = 0.216\ HL\ (2c + HS)$$

Where V is volume embankment in m3

H is the height to the crest in m

L is the crest length of the dam

C is the crest width in M

S is the combined slope value

0.216 is an empherically developed adjustment factor.

3.7 Catchment Size and Spillway Dimensions

It is important to estimate the catchment size using a large-scale topographic map, 1:50,000 contoured map of Nigeria has proud to be very useful. The calculation of catchment yield and peak flood depend on the catchment size. Hydrological data, rainfall and run-off, topographical factors and the shape of the catchment have direct influence. A typical catchment estimation is shown in Fig. 1. The flood

Generally, for dams impounding considerable storage, the inflow design flood is the maximum probable flood (MPF) which is defined as the largest flood that can reasonably be expected to occur on a given stream at a selected point. The determination of the maximum probable flood is based on a study of storm potential, run-off potential and run-off distribution as related to the physical characteristics of the watershed. The Rational Method Formula, Q = CIA which is familiar to engineers is deceptive in that a proper evaluation of the coefficient C and rainfall intensity I, requires a detailed hydrologic is needed for proper estimation of the maximum probable flood (MFP). Where the designer cannot sue a hydrologist or detailed hydrological information is not available, the Rational Method based on catchment area and an assumed uniform rainfall intensity and runoff becomes a useful tool for estimation of peak floods on small catchment.

The Rational Method is most appropriate for small catchments and requires the engineer to know the catchment area and the maximum daily rainfall.

Tim Stephens in his book on Small Earth Dams and Weirs gives a procedure to follow in calculating the maximum probable flood using the Rational Method.

We will therefore assume that data and charts are not available and estimate an approximate peak flood using the highest daily rainfall for the catchment assuming that the ground is saturated and that 100% run-off will occur.

A very approximate peak flood can therefore be calculated. Once the maximum probable flood has been estimated, the spillway length can be calculated using the formula.

$$Q = CLH^{3/2}$$

Where C is a coefficient of the spillway structure
L is the length of the spillway
H is the depth of water above the spillway crest

Coefficient C varies from 1.7 for grassed spillways to 2.2 for concrete ogee crested spillways. Therefore, the length of the spillway to accommodate the design flood is calculated.

4. DETAILED DESIGN EARTH DAMS

After the preliminary investigations have been made and a suitable site selected, a more detailed survey of the valley and reservoir area is carried out to allow for accurate estimates of quantities and provide the necessary data for design work.

4.1 Contour Survey

A detailed survey of the selected dam axis and the reservoir area is carried out either by gird, cross sections or spots height picking up all outstanding features. Modern survey methods allow the use of Total Station instrument. A contour map is drawn up normally at 0.5m intervals and on scale of 1.5000 or 1.2000 if the are is not too large. From this survey an estimation of the surface area of the reservoir can be assess for varying dam heights and a depth-city curve can be drawn up to provide a quick method of choosing the optimum full supply level (See Fig.4). it also provided details for the location of the embankment, spillway and outlet works.

where is Fig 2, Fig 3

4.2 Foundation Investigations and Construction Materials Search

4.2.1 *Foundation*

The current approach is to first carry out geophysical investigation using acceptable geophysical method such as VES (i.e. Vertical Electrical Soundings) or seismic method if available. It is normal to carry out these test along at least three lines, one on the dam axis and two others upstream and downstream of the chosen axis. A three-dimensional picture of the underlying strata emerges. This is now followed by a geotechnical investigation involving methods that offer an opportunity of sampling and testing the foundation without excessive without disturbance.

Test pit, trenches, large diameter auger borings which permit visual examination of the foundation are good methods of determining the character of the overburden. The recommended boring methods for exploring the foundation are rotary drilling, the drive sampling (Standard Penetration Tests), in-situ densities can be determined for cut samples from SPT test and natural moisture contents are also obtained for samples above water table.

Borings in rock require the use of rotary drill and diamond bits to obtain cores. Values of permeability of rock strata and soil overburden can be determined by water tests in boreholes. For instance in fractures zones, the use of packer test will allow the measurement of water intake at pressures comparable to the anticipated loading of the foundation. Normally these borings should aim at reaching depths at least equal to the height of the dam. At locations of appurtenant structures, such as spillways and outlets, the

4.2.2 Embankment Materials

Investigation of embankment materials ranges from cursory inspection during the reconnaissance stage to extensive studies of all possible sources of materials prior to undertaking the final design. The reconnaissance inspection should note the locations of available borrow areas with respect to the dam site, the character of the materials in each area and the probable quantity of each. In addition, to the engineering properties of the soils, many other factors should be considered including proximity, accessibility, natural moisture content, and workability of the material: cost of rights-of-way, stripping thickness of deposits, destruction of scenic features and adverse topography.

All potential borrow areas within the vicinity of the dam site should be investigated before more distant sources are considered.

Trial pits or boreholes should be dug at approximately 100m centres on a rough grid system. Plotting of profiles will indicate whether additional holes are needed to define the horizons encountered. Soil classification should be verified by labouratory testing on representative samples of the various materials encountered. An example of exploration for embankment materials for a dam is shown in fig 5.

4.2.3. <u>Rip-Rap</u>

The purpose of rip-rap is to preserve the shape of a surface or slope of underlying structure by preventing erosion due to wave action. Search for suitable sources of rip-rap is conducted the same way as in the search for earth embankment materials. Existing quarries, out crops and other promising areas should be investigated. The primary criteria for rip-rap are quality and size of the rock fragments. It is important to revaluate the ability of the rock to resist wave action, wetting and drying and other disintegrating forces.

5. DESIGN PRINCIPLES

The basic Principle of Design is to produce a satisfactory, functional structure at minimum cost. Consideration must be given to maintenance requirements so that economic initial cost of construction will not result in excessive maintenance cost.

For minimum cost, the dam must be designed for maximum utilization of the most economical materials available, including materials which must be excavated for the foundation and for appurtenant structures.

An earth fill dam must be safe and stable during all phases of construction and operation of the reservoir. To accomplish this, the following criteria must be met:

i) The embankment must be safe against overtopping during sufficient spillway and outlet works capacity.

ii) The slopes of the embankment must be stable during construction and under all conditions of reservoir

iii) The embankment must be designed so as not to impose excessive stress upon the foundation

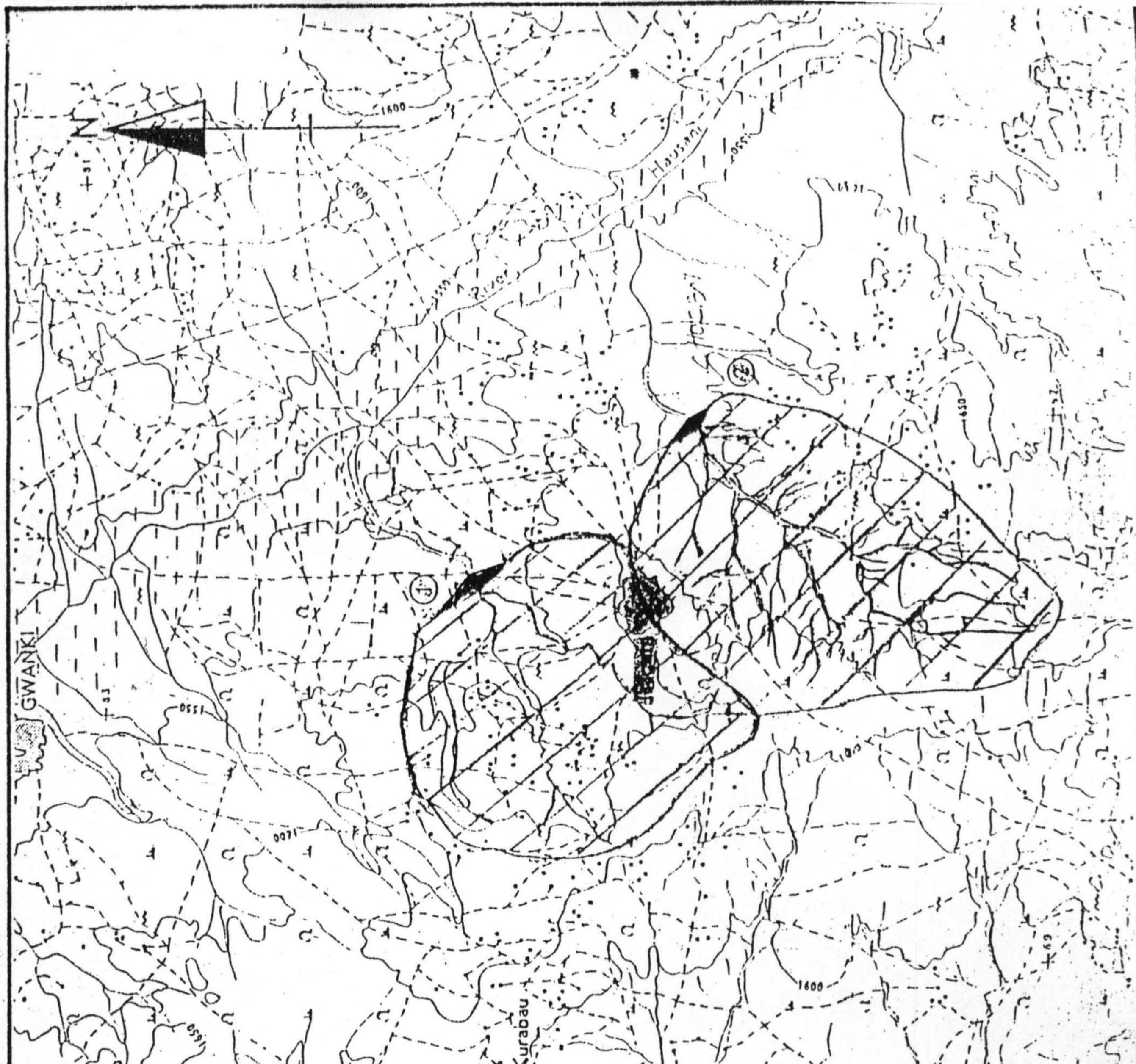
iv) Seepage flow through the embankment, foundation, and abutments must be controlled so that no internal erosion takes place. The amount of water lost through seepage must be controlled so that it does not interfere with planned project functions.

v) The embankment must be safe against overtopping by wave action (wave heights and run-up).

vi) The up streams slope must be protected against erosion by wave action and the crest and downstream slope must be protected against erosion due to wind and rain.

vii) If the dam is located in a region subjected to earthquakes, the design must be such that the most severe earthquake which can be reasonably anticipated will not impair its function.

An earth fill dam designed to meet the above criteria will prove permanently safe provided proper construction method and control are achieved.

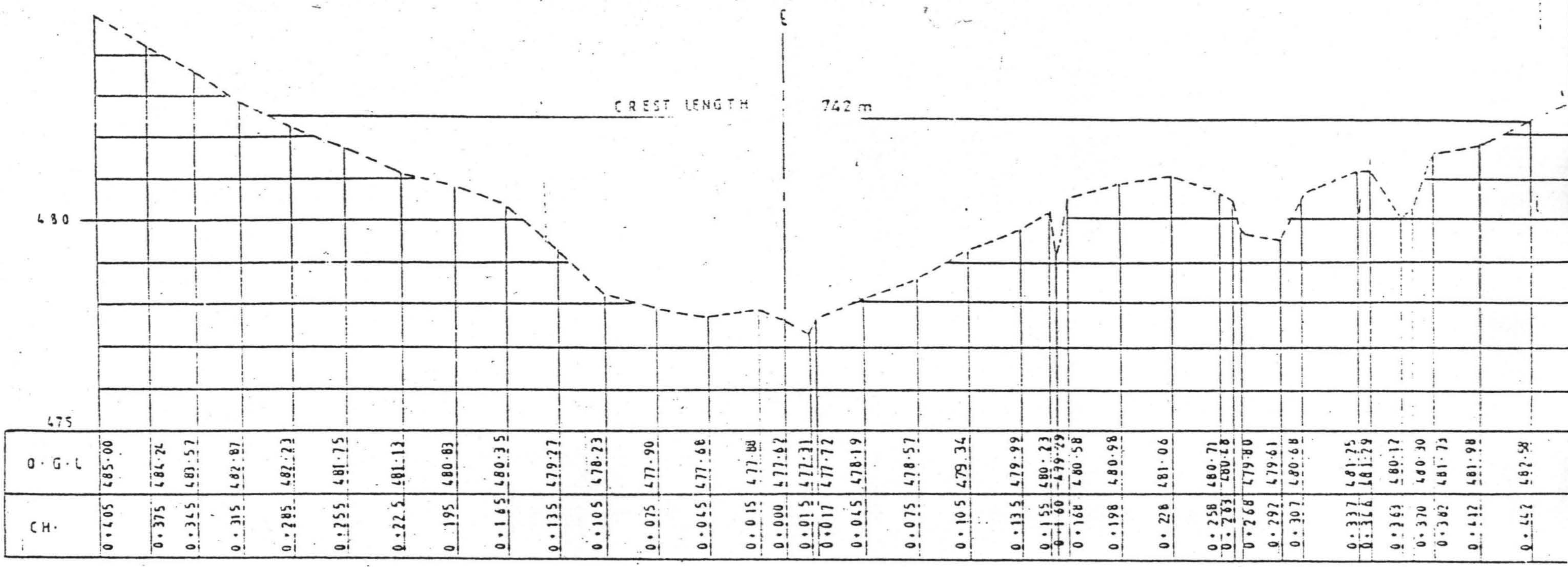


TSAGEM ALTERNATIVE DAM SITES
CATCHMENT AREAS

FIG 1

17

SCALE 1:50,000

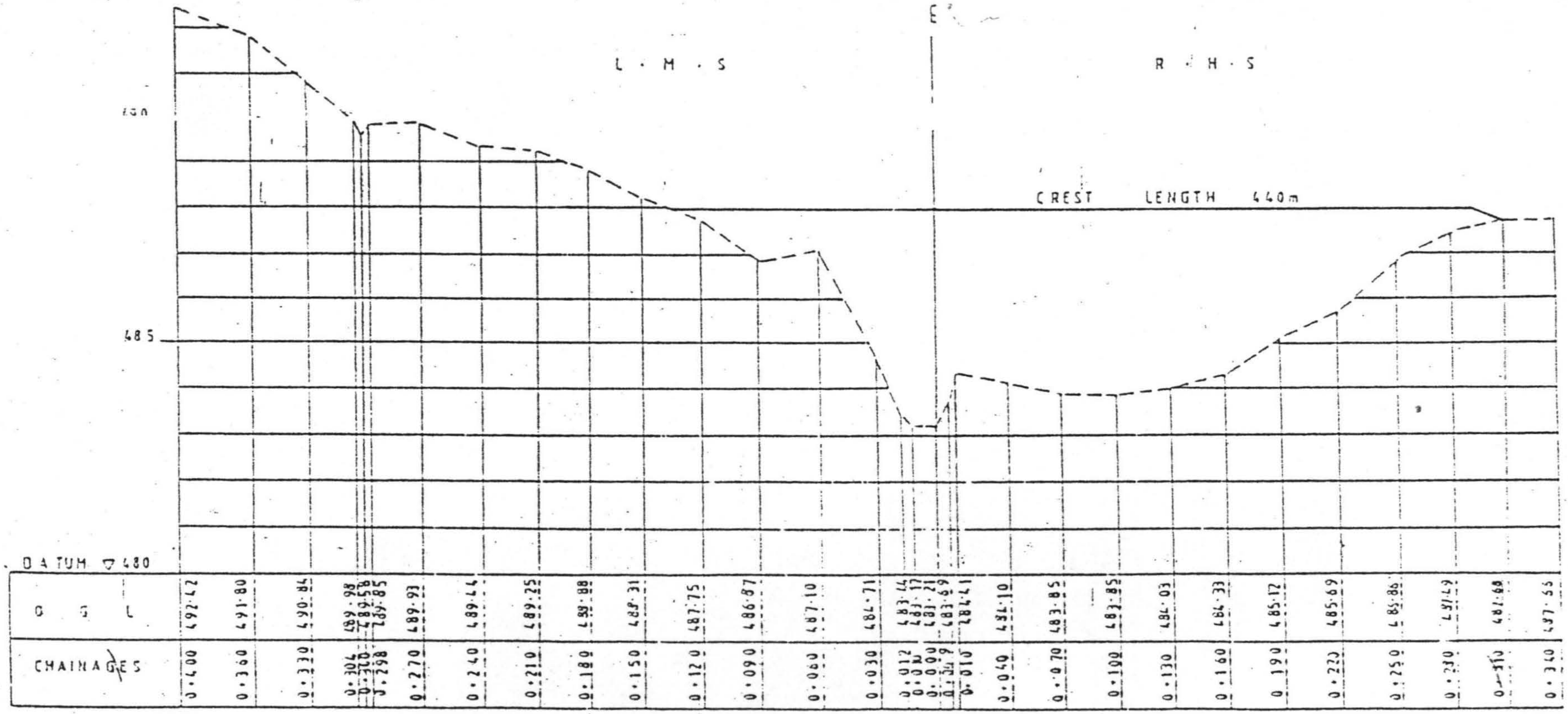


Tsagem (Alternative 1)

Scale Hor. 1 : 3,000
Vert. 1 : 150

FIG. 2

THE CROSS-SECTION PROFILE

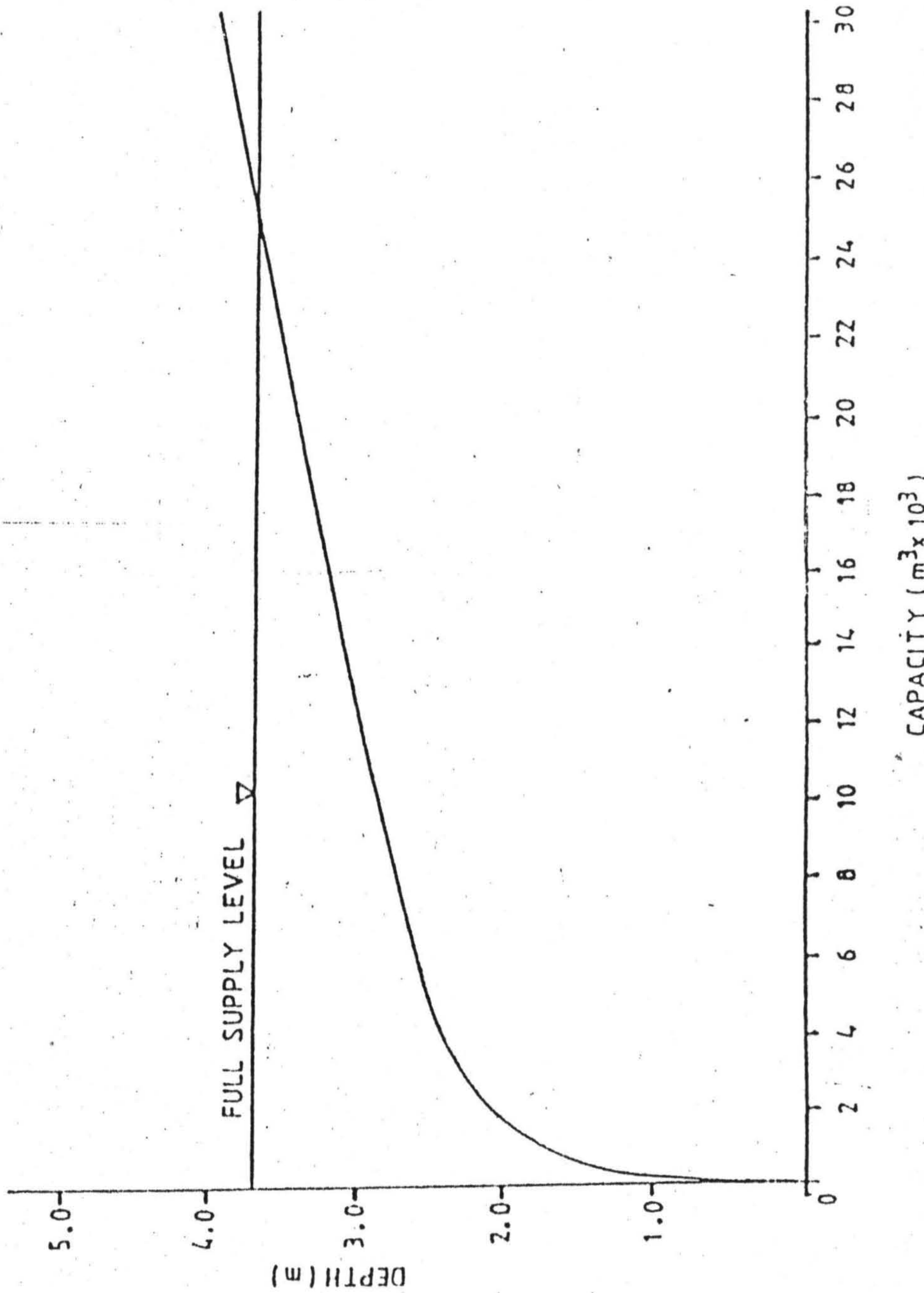


Tsagem (Alternative II) FIG 3

Scale Hor. 1 : 3,000
Vert 1 : 150

THE CROSS-SECTION PROFILE

FIGURE 4 TYPICAL DEPTH CAPACITY CURVE



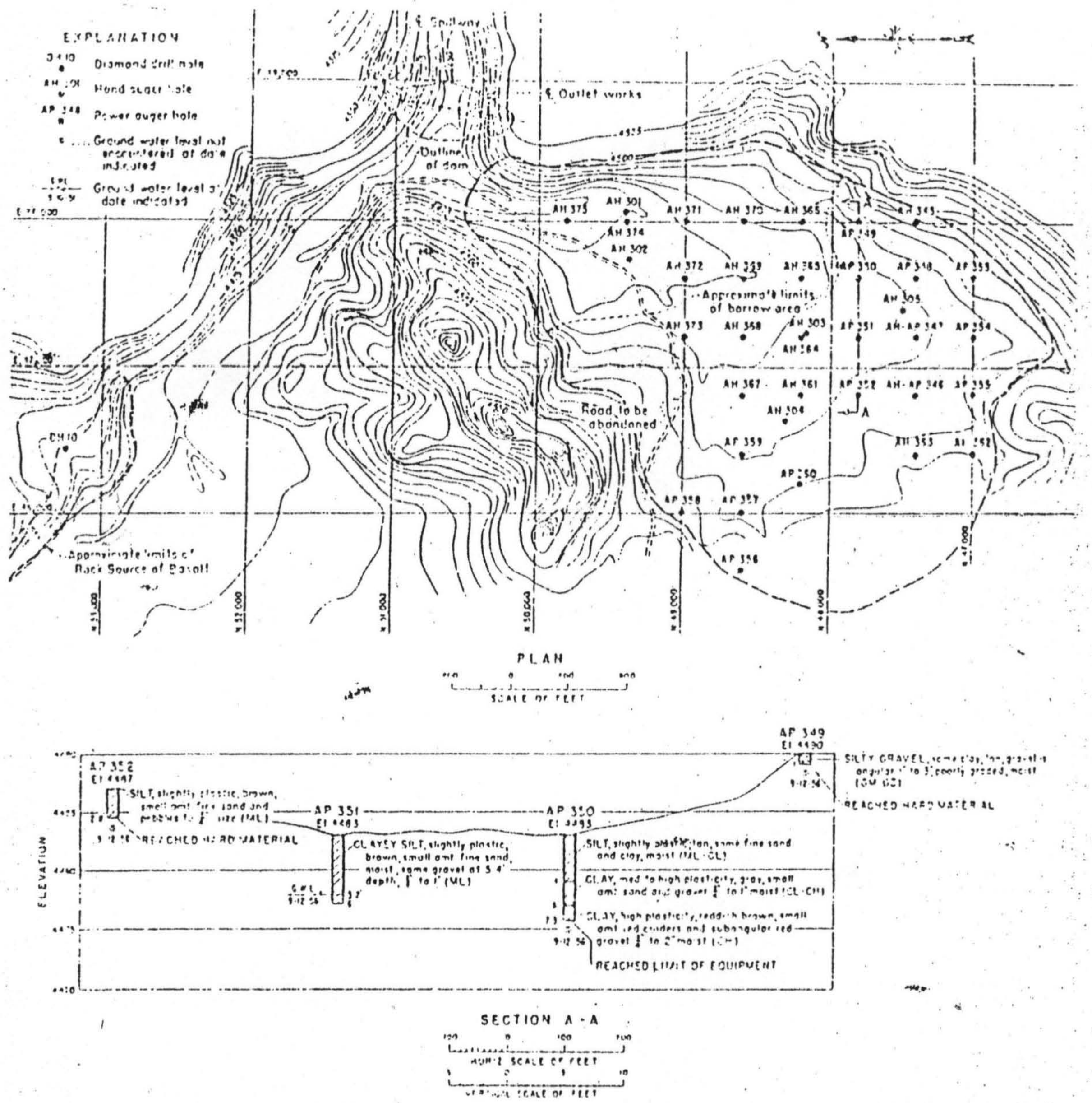


FIG. 5 Exploration for embankment materials—borrow area location map and typical cross section.

DAM SAFETY OPERATIONS

ISSUE ON DAM SAFETY

Water for producing food on irrigated land, water for human consumption and industrial use water for producing electrical energy, and protection from flood water is vital in today's world. Efficient water resources management requires dams which create storage capacity for the regulation of discharge adjusted to demand and for the retention of floods, and which produce head for diversion by gravity flow and/or for power production.

The number, heights and lengths of dams built to date been increasing steadily as have the technical problems. Problems have been compounded because it is increasingly necessary to locate dams at less Favourable sites .

A dam failure results in a catastrophe often with considerable loss of life or property. Even if only the availability of the reservoir or the reliability of its operation is impaired, vital economic interests will be affected, or environmental damage may incurred. All failures, therefore, have caused dam owners and engineers to give to great deal of care and attention to dam safety and to make safety a predominant factor among other considerations regarding dam engineering and operations.

The safety of a dam manifest itself in the dam free of any conditions or developments that could lead to its deterioration or destruction. The margin which separates the actual conditions of a dam, or the conditions it is designed for, from those leading to its damage or destruction is measure of its safety. Therefore, a dam had to be supplied with appropriate reserve, taking into account all reasonable imaginable scenarios of normal utilization and exceptional hazard which it may have to withstand during its life.

In dealing with safety problems during design, construction, operation, maintenance, and surveillance of dams, it is essential to carefully register, process, and study all available information incidents of unacceptable performance of damage, impairment of serviceability, or outright failure. The detail analysis and the step to be adopted regarding dam safety are itemized in the dam instrumentation Literature review and grouped in the appendix A and B attached with the project

DAM MAINTENANCE

The durability and guarantee of proper operation of structures requires a minimum of maintenance. Generally, dams react to the force exerted in them such as thrust of water, temperature variations, temperature, first and aggressive water etc.

Basically, dams age over time. The owner must set up or have set up a maintenance manual defining the nature of the work required and frequencies.

Those actions will concern the following fields:-

(a) Maintenance of access to the various parts of the dam:
(b) Removal of shrub growth from dam faces, channels, drain outlet and along 20-meter band downstream from the fill dam
(c) Maintenance and inspection of the spillway (repair of masonry joints, removal of trees or branches, materials from landslides or rockslides, etc)
(d) Maintenance and inspection of proper functioning of monitoring systems (drains, piezometers, pendulum, etc)
(e) Maintenance and test on the operation of flood discharge and bottom outlet structures.

In any works to modify these structure are envisaged, they must be given prior technical study, which in turn must be submitted to inspection department (e.g heightening the dam)

The measurement should be analyzed immediately, using graphs that help visualize changes. Technical department or the consulting Engineer can define upper and lower boundaries on the range of normal behaviour. It is essential that this raw information be analyzed rapidly.

Any abnormal or doubtful measurement should be checked and taken again before being validated. These inspection sheets should be filled by the owner or operator in a special place and be both clear and keep, as part of the dams history.
The detail maintenance steps to be taken in different sections, types and structures in dams project are grouped as follows:

CHAPTER THREE

MATERIALS AND METHODS

This project work involves visual survey and instrumentation application. The survey work involves questionnaires administered to the offices involved with operation and maintenance of the Oyan dam, communities and visual inspections.

3.1 **QUESTIONNAIRES ADMINISTRATION:** A questionnaires was developed to acquire first hand information about the Oyan dam and to compute the proposal to be adopted in carrying out the comprehensive monitoring, maintenance and inspection of the dam. Furthermore, the objectives of the questionnaires administration are as follows:

i. To ascertain the exact location of the dam
ii. To ascertain the safety of the dam
iii. Report on identification defects such as deterioration on embankment, excessive seepage between and under the embankment, structural distress and structural element, and conditions of geological environments.
iv. To compile status report on the dam highlighting the present integrity vis-à-vis design guidelines and operational procedures and
v. To recommend corrective measures

In summary many officers, professionals (such as engineers, geologists, hydrologists and local people were involved and their response are remarkable. The format for the questionnaires is attached in the appendix A.

3.2 VISUAL INSPECTION

VISUAL INSPECTION:-

Is a qualitative method, but crucial as its embraces the greatest number of parameters.

The points that required special surveillance are as follows:-

(a) The state of the faces, cracks, traces of calcite for a concrete dam, collapse or swelling for an earth dam, inflows of water,

(b) The state of drainage channel to determine debris,

(c) The state of the ground downstream from the dam or spring,

(d) The state of spillways to check materials obstructing the chute,

(e) The behaviour of reservoir banks, mostly after emptying of the reservoir.

This has further broken into the following aspects for proper assessment.

3.3 DAM INSTRUMENTATION

The overall purpose of dam instrumentation is to monitor behaviour of dam during dam construction, reservoir filling and post impoundment. Its also used to develop correctives and maintenance programmes for dam. The following instrumentation devices were noticed, the information collates as a data are analyzed to test the operation and maintenance policies of the Oyan dam. The status of instrumentation facilities are in table 2 also, their performance is attached as a instrumentation plottings see figures1 –8

3.3.1. Hydaulic Piezometers:-

Oyan dam was equipped with standpipe piezometers installed in two arrears, upon appraisal of the records of internal water level taken, there is energy indication of absences of internal erosion, boiling or any form of internal deformation.

3.3.2. **Internal pressure /uplift**

The dam considered composite (concrete & earthfil) is equipped with devices to measure the internal water pressure and to dissipate this pressure when it does occur to prevent uplift and resultant overturning of the concrete section.

3.3.3. **Emergency Preparedness**

The dam is equipped with manually or electrically operated alarm system and redial gates for flood water releases.

3.3.4. **Law Water Releases**

A Combination of butterfly and howel bunger values facilities are in place for downstream release particularly dry season.

3.3.5. **The Power Station**

The power station houses 3 hydro-turnine generators of 3MW each.

3.4. **FIELD REPORTS**

To appraise the conditions of the various section of the dam under the project, I sent the format of the questionnaire to the team of professionals like engineers, Geologists, Hydrologists and to proceed for reconnaissance tours to the various sections of the Oyan dam. Visual inspection were carried out on the dam and its facilities, and relevant records such as drawings (Figures 1 and 2) construction data, instrumentation records (Figures 1 to 8) maintenance records (were reviews (Where available) for the dam. Also the local communities were asked questions basically on the performances of the dam relating to the various sections of the areas. Like upstream, downstream, reservoir areas. Furthermore, questions were asked about any natural occurrences like earthquake, flooding, etc. the table below shows the people concerns.

Table 2

Professionally	Dam Body/no	Reservoir Area /N0	Downstream & Upstream /No	Outlet Works/No	Spillway Structure
Engineers	2	2	2	3	2
Hydrologists	3	3	3	3	3
Hydrologists	2	2	2	1	1
Villages	10	5	20	5	5

CHAPTER FOUR

RESULTS AND DISCUSSIONS

4.1 Background Information

4.1.1 OYAN DAM

The Oyan River Sam is one of the few multi-purpose dams for the development of the Ogun River Basin. The dam located on the Oyan River, a tributary of the Ogun River, some 20 kilometres North-West of Abeokuta. From this point, the catchments area is 9,000sq km, occupying parts of Oyo and Ogun States. The average annual flow through the dam reservoir is about 1,770 million cubic metres (mcm). It is owned by the Federal Government of Nigeria through the Ogun-Oshun River Basin Development Authority.

The dam has a gross storage capacity of 270 million cubic metres (MCM) covering an area of 40sq km at an elevation of 63 metres. With this reservoir capacity, it was planned to supply 525 AND 175 MILLION LITRES PER DAY (MID) for Municipal and Industrial (M&I) requirements of Lagos and Abeokuta, respectively. It will also allow for the irrigation of 12,500 hectares of land in the Lower Ogun Project which is currently under construction, and the generation of 9.0 Megawatts (M.W.) of electricity through three (3 No) Hydro turbines.

4.1.2 THE DAM

The dam comprises mainly the following:

- The embankment with a central gated concrete spillway.
- Auxiliary Spillway.
- Power Station
- Access Road of about 5km length

4.1.3. DAM EMBANKMENT

The earth fill of the embankment consists of a central impervious core of clay lateritic material surrounded by a shell of compacted granular. The downstream side of the core is separated from the shell by the chimney drain. A cut-off trench extending rock is provided over the entire length of the embankment. A grout curtain is provided at the bottom of the cut off trench. The upstream face of the embankment up to the crest is protected with dumped riprap. The downstream.

face is grassed except the toe up to 75cm above maximum tail water level which is protected with dumped riprap. Suitable provisions of carpet rain of sand and toe drain consisting of rock-fill core embedded in gravel and sand have also been provided. A 90cm high wave wall is provided along the upstream edge of the embankment. The total length of earth embankment is 1.002 metres and maximum height is 30 metres.

The gated concrete Spillway consists of a central portion with 4 radial Spillway gates of 15m x 7m and downstream Stilling Basin 70 metres long with retaining walls of reinforced concrete to support the earth embankment. In each of the three Spillway piers, an outlet of 1.8 metre-diameter steel pipe is provided to regulate M & I releases. The spillway is provided with an operating bridge and an 8m wide road bridge. It is connected to the main river by means of the approach and discharge channels.

An Auxiliary Spillway of some 400 metres length is provided about one kilometer to the West of the Dam. The dam is equipped with Stand Piezometers and pressure cells.

A floating boom is provided as the primary trash rack for protection of the intake area particularly that of the penstock.

Geological formation of the dam area shows a granite gneiss rock intruded by pegmatite. It was reported that Rock blasting for quarry at a location some 1.8km from the dam had been stopped. It was however monitored and controlled with the aid of a seismograph when it lasted.

The dam is equipped with an alarm system and radial gates for flood water releases as a measure of emergency preparedness. The gates can be operated manually or electrically. In addition to the gates, there is also an ungated auxiliary spillway.

THE POWER STATION

The power station houses 3 turbine generators of 3 Mega Watts each. The super structure consists of a machine hall to house the electrical and control room. The intake of the penstock is located on the upstream right hand side. The three inlet openings are each fitted with a trash rack fixed to the structure. The penstock of 3.8m diameter is trifurcated into 2.5m diameter sections, feeding the three turbines. The dam was commissioned in 1983 with the following Principal data.

PRINCIPAL DATA

Areas

Catchment	9,000sq. km,
Reservoir	40 sq. km

Hydrology

Average Annual Rainfall	1,170 mm
Mean Annual Runoff	1,770 mcm

Reservoir

Normal Water Level	EL 63.00m
Maximum Water Level	EL 65.50m
Minimum Water Level	El 47.50m
Gross Storage	270mcm
Dead Storage	16 mcm

Embankment

Crest Length	1,044m
Maximum Height	30.44m
Top of Embankment	EL 67.70m

Service Spillway

Length	75m
No. of Gates and Size	4 x 15 x 7m
Crest of Spillway	EL 56.00m
Pier Width	3m
Capacity	3,440 Cumecs

Auxiliary Spillway

Length	400m
Crest of Spillway	EL 63.25m
Capacity	1,990 Cumecs
Total Spillway Capacity	5,430 cumecs (having a return period of 1:10,000 years)

Outlets

No.	3
Diameter	1.8m
Centre Line	EL 43.3m
Capacity (at L.W.L. of 47.5m)	15.0 cumecs each

Penstock

Centre Line	EL 41.05m
Diameter	3.8m
Installed Capacity	3 x 3 M. W.

8.4.3 OBSERVATIONS/FINDINGS

~~The team of experts At~~ the site-~~visits~~ I inspected thoroughly all the facilities at the dam particularly those facilities that are pertinent to the safety of the structure. It also gained insight into the background of the dam by references to the design reports/drawings where available. In particular the investigators called for the reports on the ground vibration monitoring at Oyan Dam site while the blasting operations lasted. The findings and recommendations are as follows:

4.3.1 Upstream Slope

The upstream slope is protected by ripraps as earlier reported. The team found the slope in a highly commendable state. There was evidence of constant maintenance as reflected in the absence of vegetable growths on the slopes. The few that could not be completely uprooted were treated with herbicides.

There were clear marks of previous reservoir levels on the upstream ripraps showing that the maintenance activities on the slope has been a regular feature on the programme of the owners of the dam. Please see plates 7, 8.

installation of the wave boards largely unnecessary.

The slope was further inspected for any evidence of Wave action or Surface erosion as might be observed in any form of material transport. The entire slope was found to be trouble free.

4.3.2 Downstream Slope

The downstream slope of the dam is of generally 1:2.5 grade. It is grassed as earlier reported. The grass was being moved at the time of visit and it enabled through inspection of the integrity of the slopes.

The slope was found to be free of any form of growths, such as trees, that could enfeeble the integrity of the dam. It was also found to be free of animal burrows or such debilitating activities.

The slope was further combed for slides, cracks or breakages or any signs of fore-seeable emergency of any kind of deformations. The slope was found to be free of faults.

The lower half of the slope was inspected particularly for Wetness or springs in order to assess the effectiveness or otherwise of the installed internal filter of the dam. The slope was found free of any form of Wetness or springs.

4.3.3 **Movements:**

Records of Triangulation carried out over the years were inspected. The survey team of the Clients and my self ~~with those of the~~ [redacted] carried out triangulation procedure of the Monuments to confirm the status of the entire dam structure with respect to general movements on the dam structures.

It probed the concrete spillway structure particularly for settlement, sliding or overturning. It was found to be absolutely in equilibrium.

The tests also probed the embankment for Settlement, Heaving or Slides either rotational or translational. Both the upstream and downstream slopes were also found to be in equilibrium.

4.3.4 **Instrumentations**

a. Hydraulic Piezometers

in pervious sands and gravels, pore water pressures at any point can be

vation

and measuring the height to which the water rises in it. For fine-grained soils as are used in most embankment dams, other types of piezometers have been designed, because the water takes too much time to seep from impervious soils into open pipes and to reach equilibrium.

Hydraulic piezometers in earth usually consist of a porous stone tip with a pipe or tube leading to a point on the surface of the embankment where the pressure can be measured. Experience has demonstrated that small diameter plastic rubes are most satisfactory for the purpose, and now these are used generally. Where the piezometer is embedded in the impervious section of the dam, the porous tip is often, but not always, surrounded by a small pocket of sand which acts as a collection reservoir for the pore water and increases the effective area of the porous tip.

The success of the piezometers depends on how carefully they are installed.

Oyan River Dam was equipped with Stand pipe piezometers installed in two arrays. The array along the crest were embedded in the impervious section of the dam while the array on the downstream slope were embedded in the pervious section of the dam.

We found that one of the piezometers have collapsed and it is no longer functioning.

We called for the records of Internal water levels taken over the years with the piezometers. Upon appraisals we found that the record shows consistency in levels thus indicating absence of internal erosion, boiling or any form of internal deformations.

4.3.5 Internal Pressure/Uplift

The Oyan dam could infact be considered as two types of dams constructed together.

- The concrete dam section comprising the spillway monolith
- The earth fill dam consisting of central impervious core lateritic materials with surrounding comp[acted granular fill.

The concrete section, which incidentally is located at the central portion of the dam, it subjected to excessive internal water pressure, will result in uplift of these concrete section and may end up disastrously in overturning.

To prevent this senario, the dam is equipped with devices to measure the internal water pressure and to dissipate this pressure when it does occur.

We found that the pressure read-out devices installed in the gallery of the dam are largely in need of maintenance as some of the tubes have collapsed while some others have been blocked up by granular materials. There are recommended for urgent action as the monitoring of pressure around the concrete section of the dam would be ineffective without these devices.

4.3.6 Emergency Preparedness

As reported earlier, the dam is equipped with an alarm system and radial gates for flood water releases as a measure of emergency preparedness. The gates can be operated manually or electrically. In addition to the gates, there is also an ungated auxiliary spillway.

Please note the level of the mark of water at reservoir full with the level of the top of the radial gates, plates 7, 8 and 14 refer. These levels are about the same. It paints a situation that might allow the water to spill over the barrage (cascade) resulting in cavitations around the barrage. This situation of course will be followed by violent agitation of the concrete section and with the eventual segregation on the part of the neighbour soil mass. The next logical effect is the collapse of the dam. At this scenario is initiated at the point that water spills over the radial gates, this initial point must never be allowed to set in. in order to prevent this happening, an alarm triggers on when flood water is about a foot to the top of the barrage. The alarm sounds both at the dam site and the Project

discharge of flood water from the bottom of the gate which in fact is the crest level on the ogee spillway.

Generally, reservoir water level are observed and recorded from the level gauges, which have readouts both on the top of the dam and the control room at the observatory. However, the electrical alarm facility of the dam has served as a reliable flood warning system for the dam.

4.3.7 **Low Water Releases**

It was observed that there are facilities for down-stream releases particularly during the dry season. These facilities consisted of a combination of butterfly valve s and howel bunger valves. The Howel bunger valve is essentially an energy dissipator and could easily be destroyed by improper operation. Two (2 No) out of the installed 3 No were functional at the time of inspections. It was reported that one of the functioning valves had just been repaired. It is needful to repair the third set and the three fully functional.

4.3.8 **The Power Station**

The Power Station houses 3 hydro-turbine generators of 3 Mega Watts each. They are yet to be fully fitted and tested. The intake of the penstock is located on the upstream right hand side of the concrete section of the dam. It consists of the gates and trash racks and are operated by mobile cranes.

It was observed that even though this system is not in operation, one of the lifting cables has been seriously injured and it is at a snapping point.

It was also observed that there is serious concrete degradation on the walls of the base floor of the powerhouse adjoining the penstock. There is therefore the urgent need for grouting works to restore the integrity of the concrete wall.

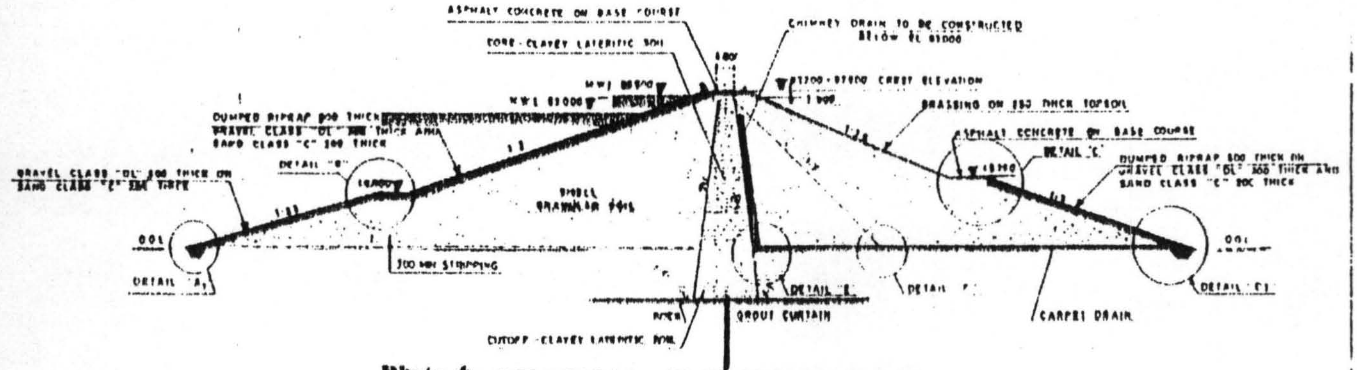


Plate 1 SECTION THROUGH DAM

Figure 1

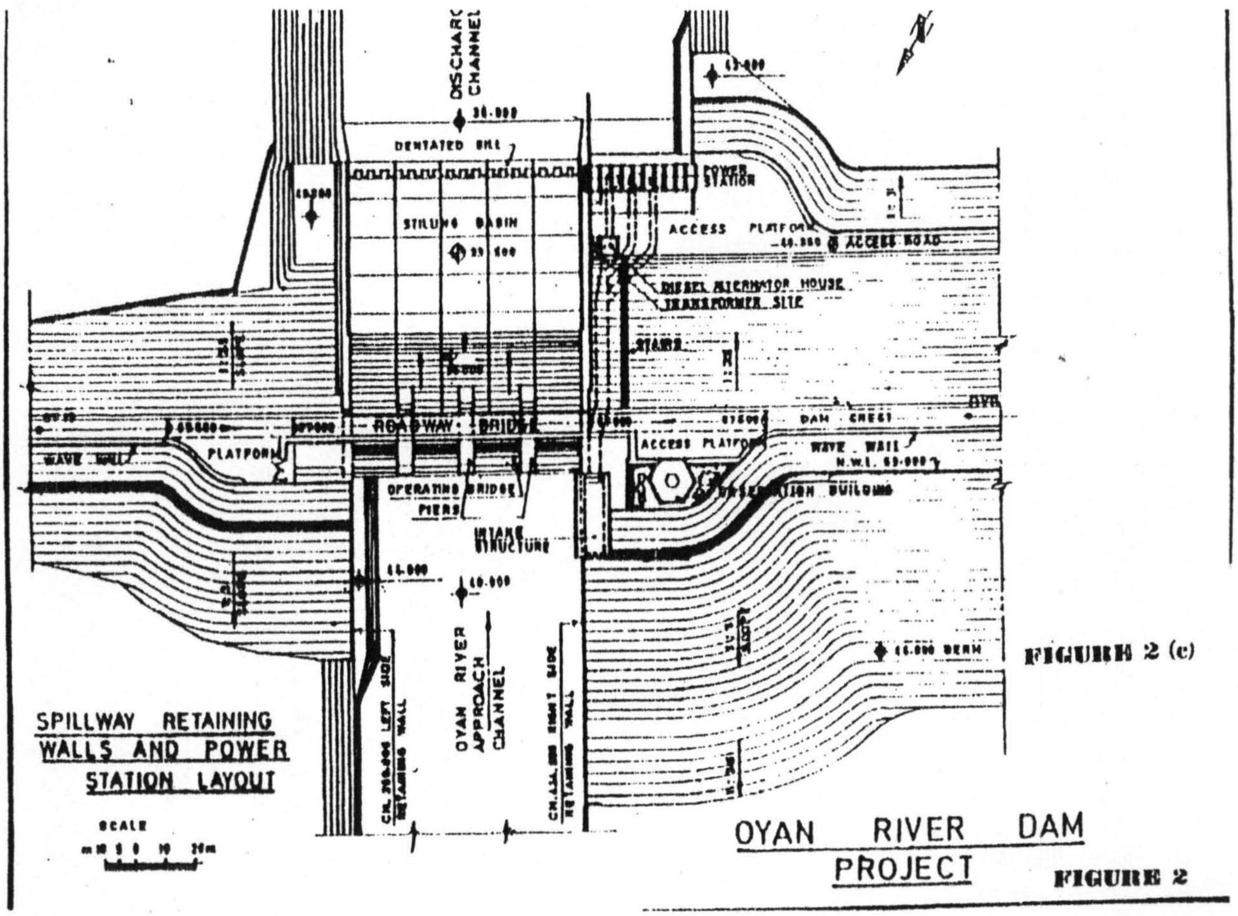


Plate 2 DAM PROFILE

4.4 ANALYSIS OF TABLES AND FIGURES

The tables and figures attached are collated as data and analyzed as thus:

Table 1 Shows the result of the elected piezometer reading and this indicates that contact release of water from dam reservoir areas as the days increases the corresponding reservoir water level decrease to ensure better stability of the dam. The highest was 285.12 masl (07/09/2004) and the lowest was 284. 48 masl (27/09/2004).

B. The programme of work and progress of work of Oyan dam is presented in tabular form in figure 1 to show the arrangement of activities at the dam site with corresponding grading to express even attention from the operator of the dam.

C. Figure 2 represents the maximum and minimum monthly reservoir level from May to October 2004. the maximum reservoir level is observed around June. Also this show that its rains more in the month of August than the other months to increase the reservoir level.

D. The functioning of the new relief wells constructed in relationship to the monthly average discharge is represented in figure 3. The month of September discharge more heater than months because of the previous maximum reservoir level that occurred in the month of August.

E. The fluctuation of reservoir water level during the rainy season is shows in figure 4. The first week of the month of August, third, to forth week of the month September and the month of October signify irregular reservoir water level but month August, September have relating constant.

F. Figure 5. Shows the depth of rainfall in mm.in the month of September and its heaviest on 1st and 19^{th} of the month respectively to increase the reservoir level capacity.

G. The new relief walls percentage flowing dripping and not flowing in expressed in figure 6. the months Jun indicate no flowing because of lack of adequate rainfall in that period as month July – September shows more flowing more rainfall indicate.

H. The capacity of the reservoir of the month of September is shown in figure 7 of to express the volume of heater and its volume of maximum ($300x10^6m^3$) in the mid month because of more rainfall.

I. The daily reservoir inflows of outflow capacity during September in represented by figure 8 to test the safety operation of the dam. The inflow is not regular because of weather and the out flow is averagely constant.

BEHAVIOUR OF SOME RANDOMLY SELECTED STANDPIPE PIEZOMETERS AND RELIEF WELL DISCHARGES WITH FLUCTUATION OF RESERVOIR WATER LEVEL.

NOTE: THE RESERVOIR WATER LEVELS ARE IN DESCENDING ORDER WHILE THE CORRESPONDING DATES DURING WHICH THE READING WERE TAKEN ARE NOT SEQUENTIAL.

Date	Rerservoir Water Level (Masl)	Seclected Piezometric Readings (Masl)					Selected Relief Well Discharges (L/Min)							
		Ref. No FA_1	Ref.No. FA_2	Ref.No FC_1	Ref.No FC_2	Ref.No FD_1	No.3	No.11	No.43	No.53	No.72	No.84	No.130	No.134
07/09/0[illegible]	285.12	280.69	277.38	277.75	277.40	276.86	46.04	26.55	10.44	18.00	21.63	19.98	34.20	49.80
18/08/0[illegible]	284.75	280.61	277.28	277.59	277.40	276.82	29.22	17.22	6.65	12.87	15.65	23.60	23.60	40.68
16/10/0[illegible]	284.55	280.67	277.41	277.62	277.41	276.99	11.67	12.35	5.98	10.01	16.44	22.68	22.68	40.68
27/09/0[illegible]	284.48	280.71	277.43	277.65	277.40	276.88	27.36	18.87	7.00	10.41	14.79	26.16	26.16	44.64

AN DAM RESULTS - PROGRAMME OF WORK AND PROGRESS OF WORK

11/12/04

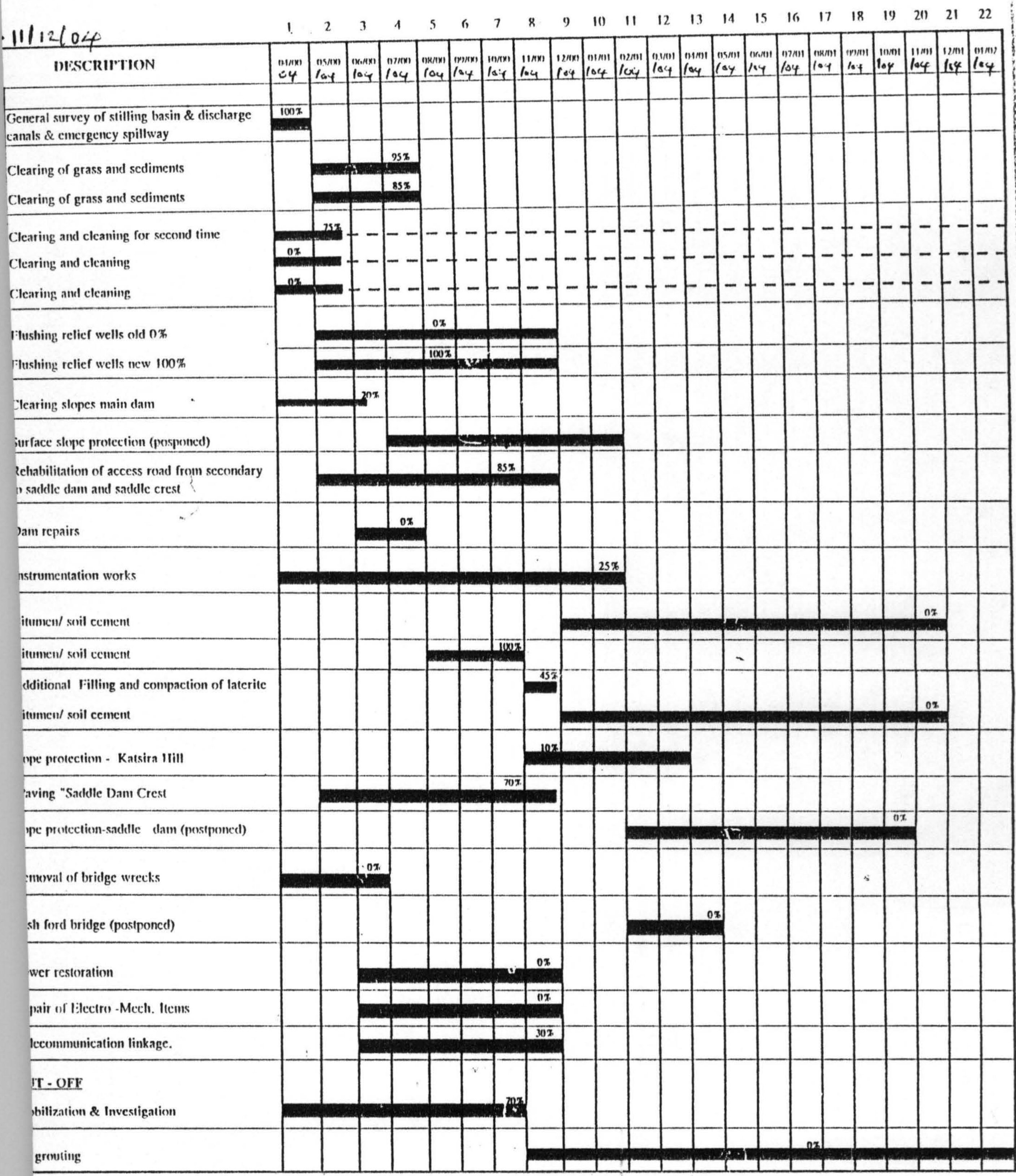
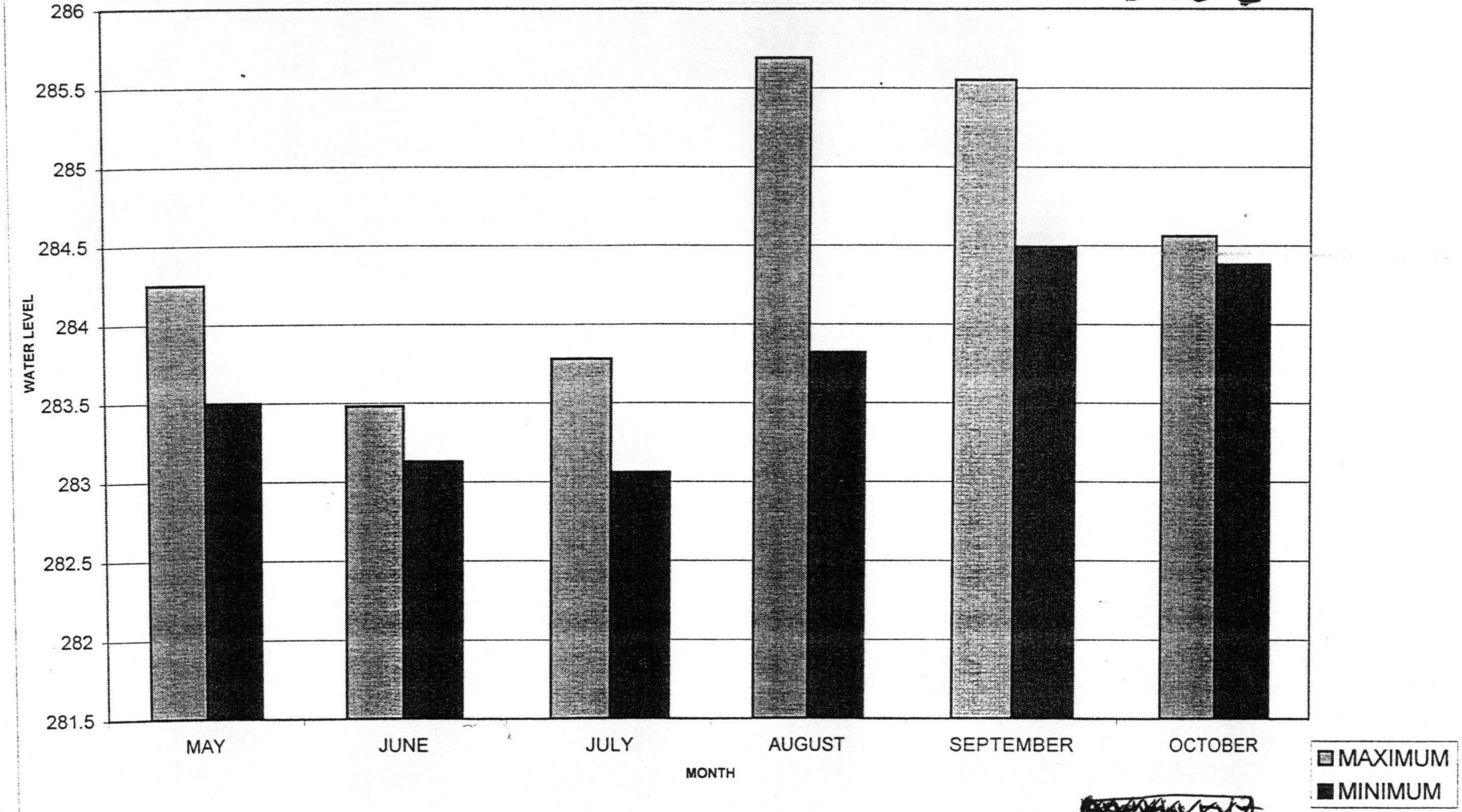


figure 1

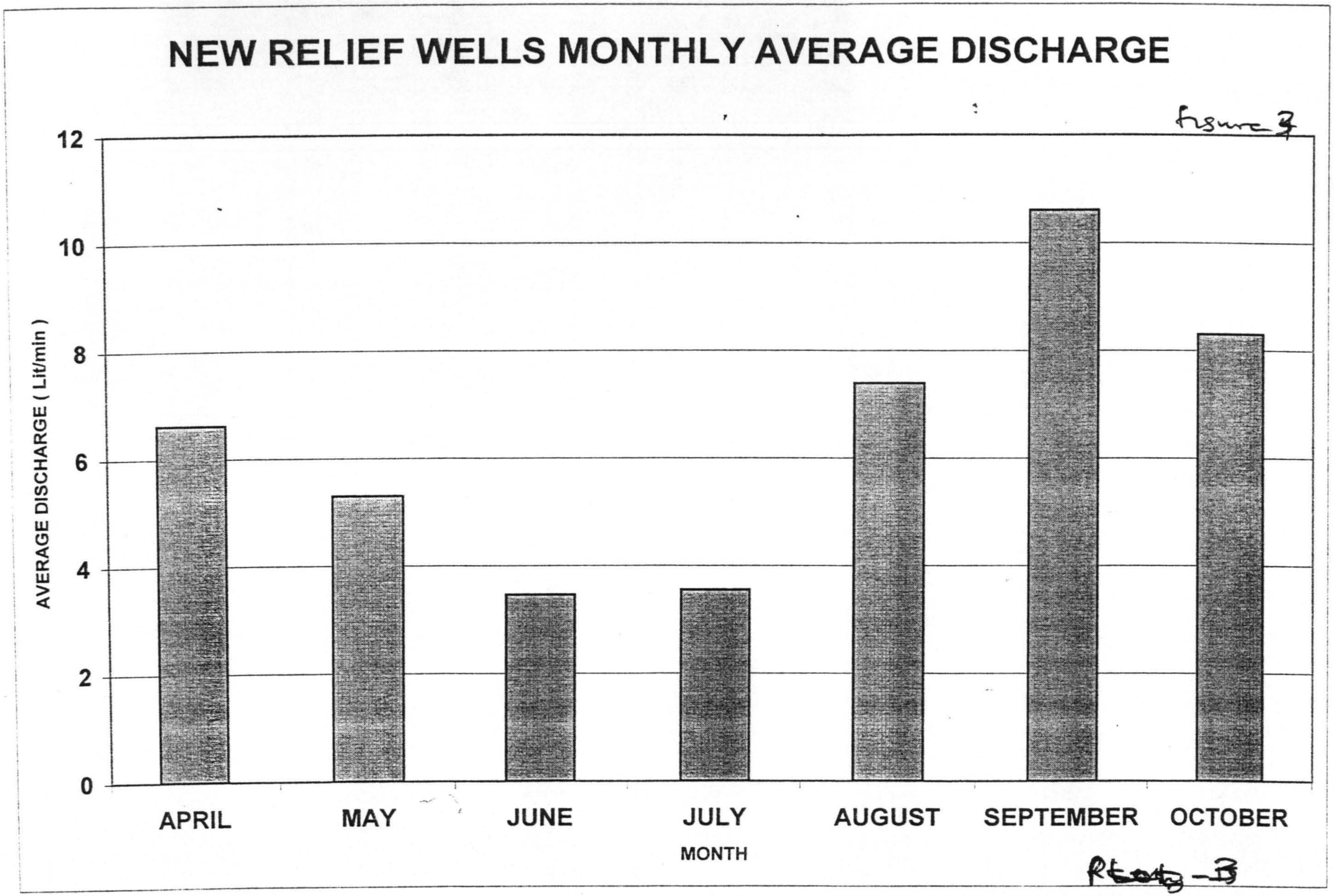
MAXIMUM AND MINIMUM MONTHLY RESERVOIR LEVEL,
MAY — OCTOBER 2000

Figure-2



Plotting-2

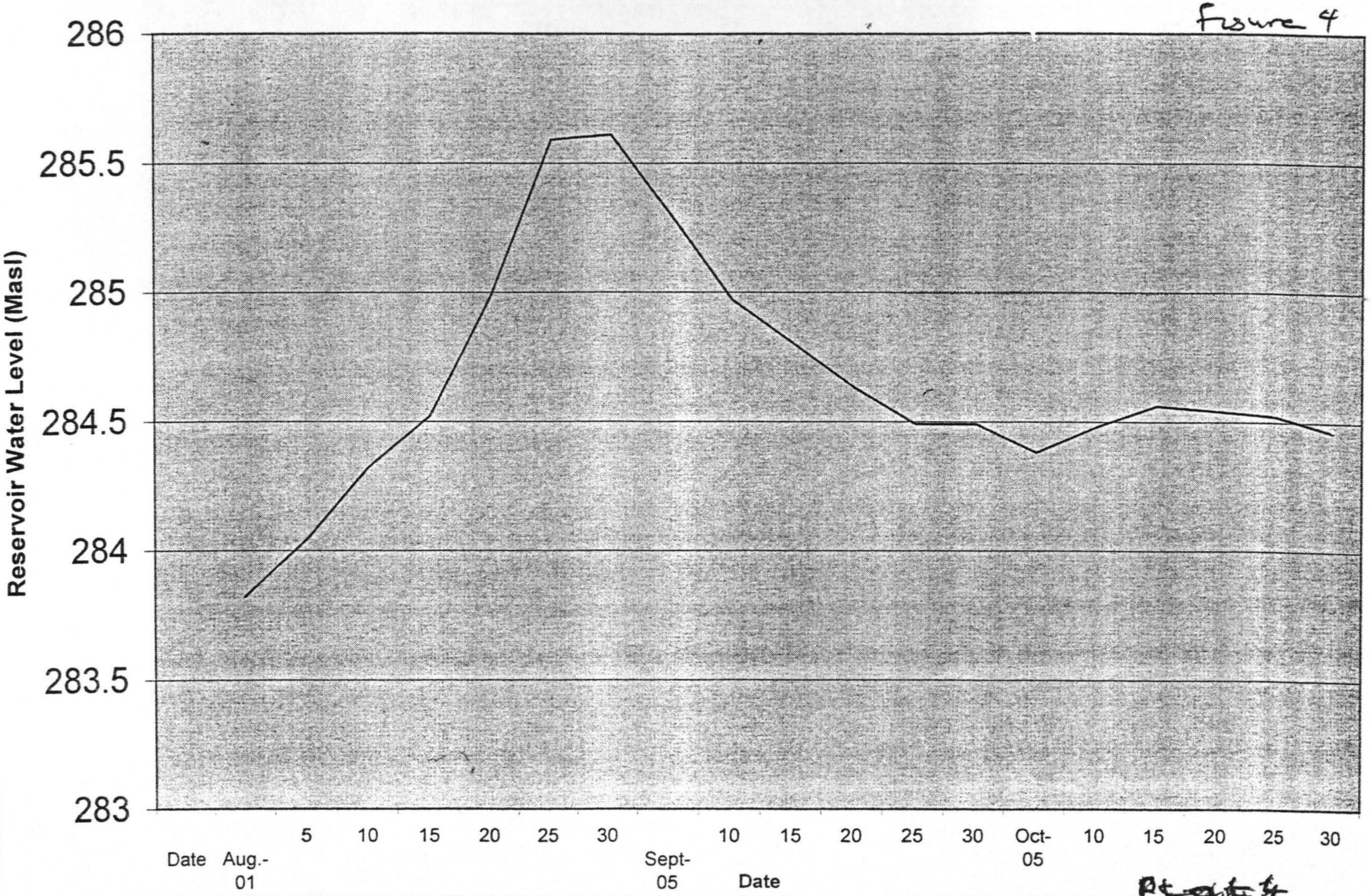
40

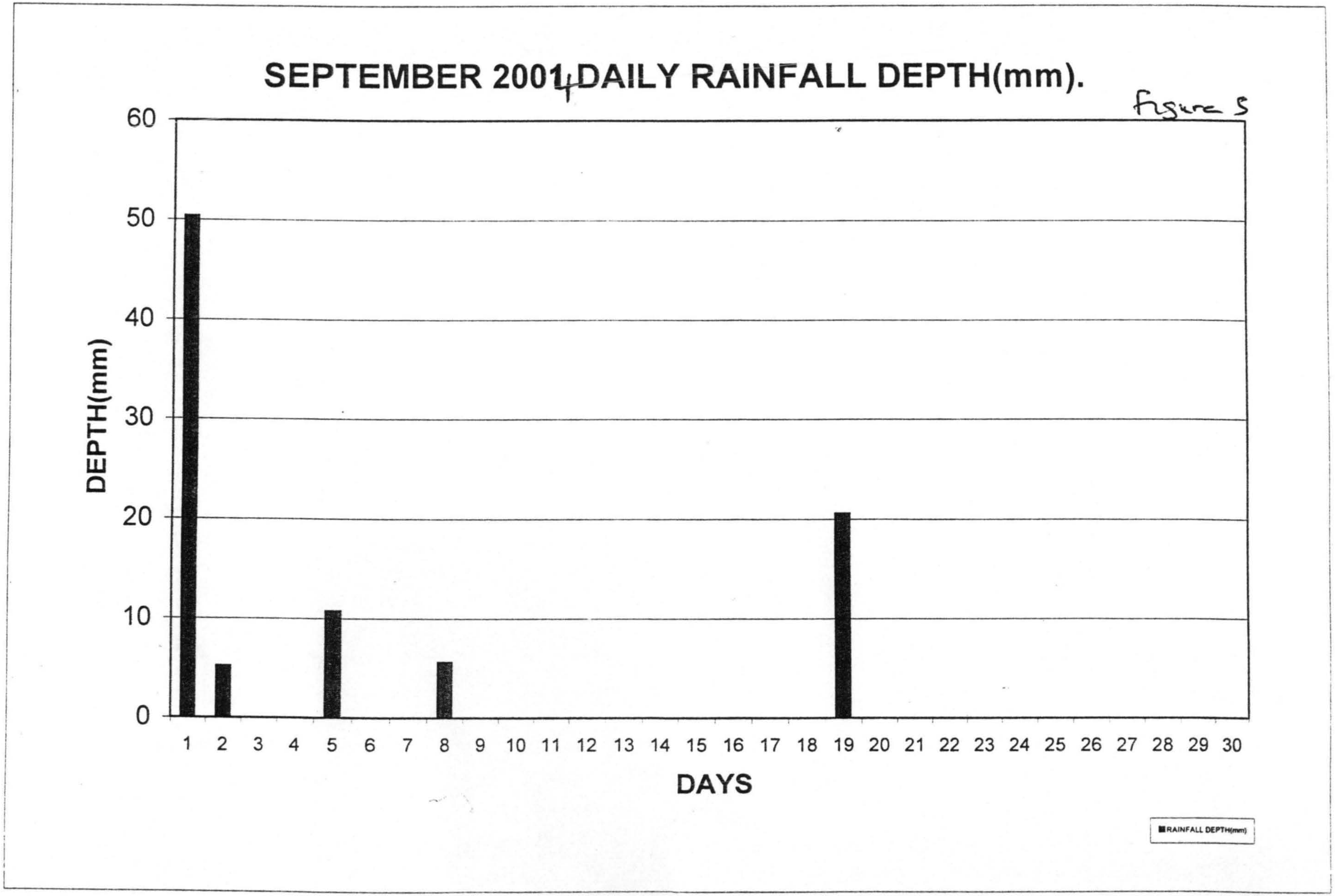

NEW RELIEF WELLS MONTHLY AVERAGE DISCHARGE
figure 3
AVERAGE DISCHARGE (Lit/min)
12
10
8
6
4
2
0
APRIL
MAY
JUNE
JULY
AUGUST
SEPTEMBER
OCTOBER
MONTH

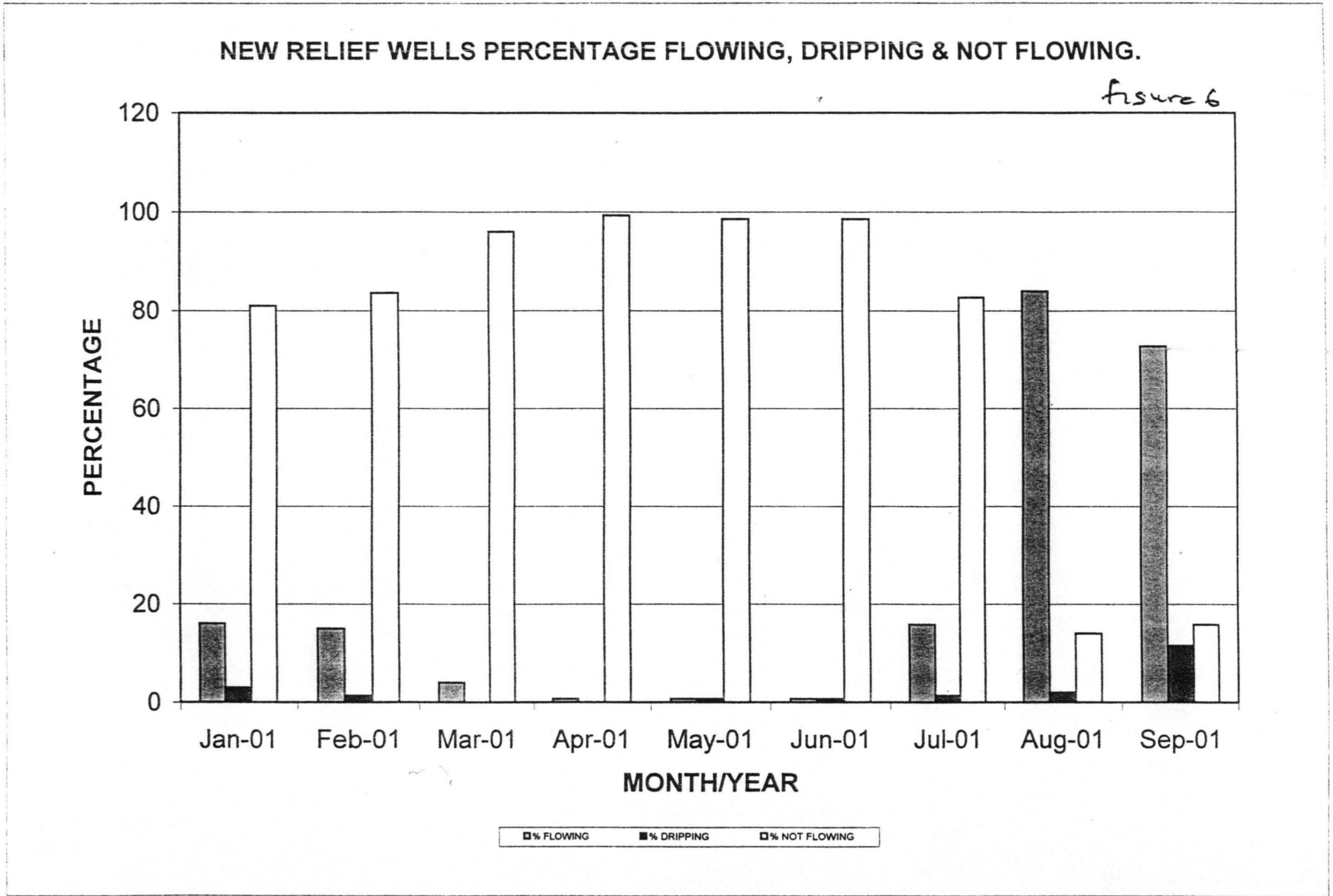
41

Fig. 2 Fluctuation of reservoir Water Level During the Rainy Season

Figure 4




SEPTEMBER 2001 DAILY RAINFALL DEPTH(mm).
DEPTH(mm)
0
10
20
30
40
50
60
1 2 3 4 5 6 7 8 9 10 11 12 13 14 15 16 17 18 19 20 21 22 23 24 25 26 27 28 29 30
DAYS
RAINFALL DEPTH(mm)

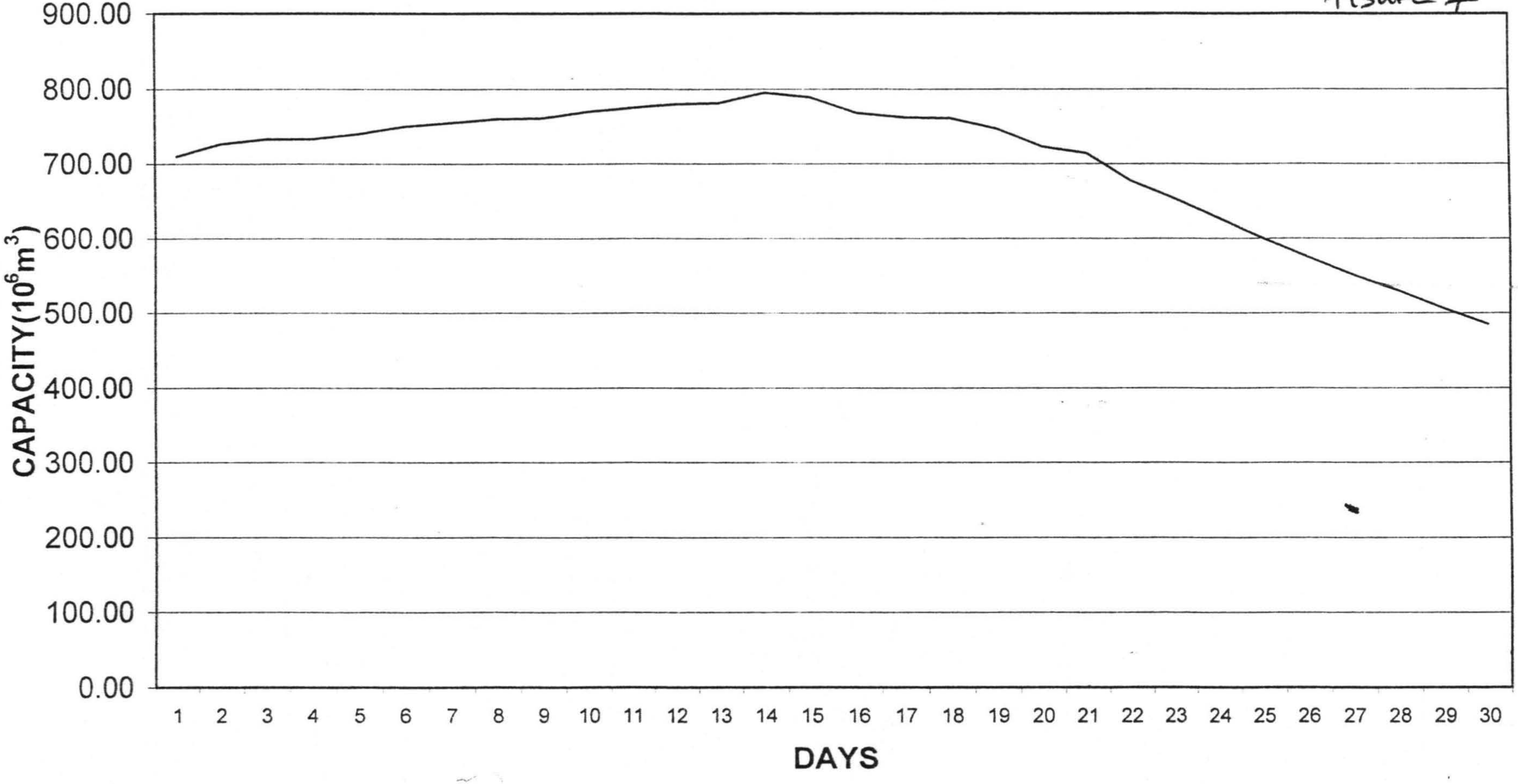


NEW RELIEF WELLS PERCENTAGE FLOWING, DRIPPING & NOT FLOWING.
figure 6
120
100
80
60
40
20
0
PERCENTAGE
Jan-01
Feb-01
Mar-01
Apr-01
May-01
Jun-01
Jul-01
Aug-01
Sep-01
MONTH/YEAR
% FLOWING
% DRIPPING
% NOT FLOWING

44

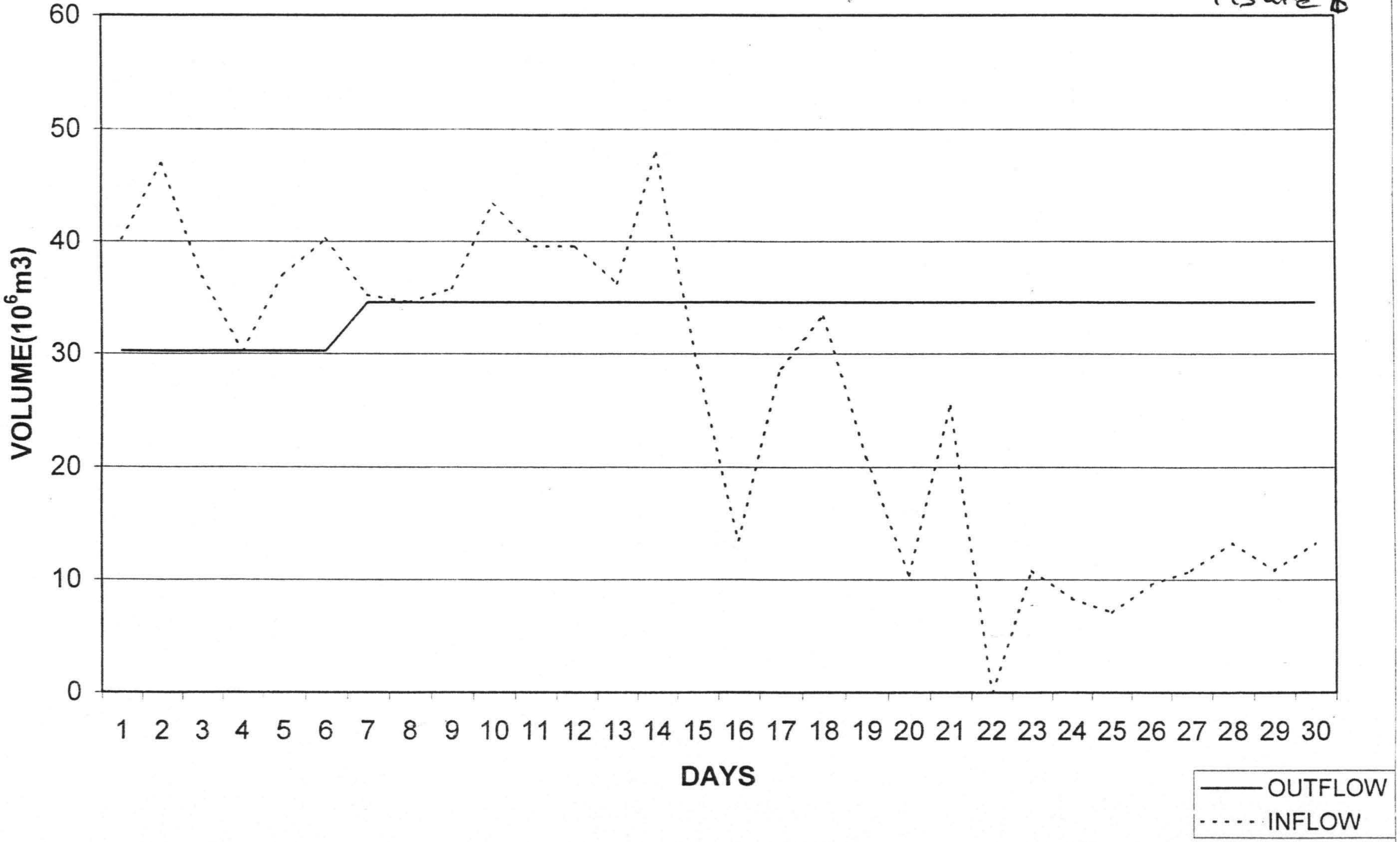
SEPTEMBER 2001 DAILY RESERVOIR CAPACITY

figure 7



SEPTEMBER 2001 DAILY RESERVOIR INFLOW & OUTFLOW CAPACITY

figure 8



CHAPTER 5

CONCLUSIONS

At the end of the field trip and site visit the following conclusion are made:

1. It was observed that the Department of Met services of the Federal Ministry of Aviation with their state of the art equipment has capability of provide or generate reliable metrological data.
2. Seepage was observed, play an important role in the performance and safety operations of dam structure
3. it was also observed that planning, investigation and design of dams is much disciplinary, crucial and professional.
4. Also noted was the useful life Instrumentation, monitoring an appropriate processing Instrumentation data in dams and their foundations.
5. Also observed was the need for instrumentation data in dams and their foundations.
6. The safety of the dam depends to a large extent on the proper understanding of the property of its foundation, the dam body and the reservoir.
7. The role of private sector in dam maintenance was emphasized, if engaged, this would play significant role in saving our dams from deterioration and also provide capacity building and gainful employment opportunities for our young Engineers.

RECOMMENDATIONS

1. It is accordingly recommended that the Federal Ministry of Aviation along with other relevant agencies be patronized not only for data acquisition but also for training purpose.
2. regarding seepage phenomena etc, continuous monitoring and control through regular collection, analysis and interpretation of data are inevitable.
3. Dam break simulation for major dams with high hazard potential should be carried out.
4. It is recommended that planning, investigation and design of dams should be handled by group of experienced and dedicated professionals.
5. On the sedimentation of dams, it is recommended that evaluation of factors affecting reservoir sediment deposition such as data collection and reservoir survey should be carried out regularly or forestall undue sedimentation in the reservoir and consequent reduction of reservoir of storage capacity.
6. On the issue of instrumentation, data collected should be checked and processed by trained staff.
7. It is recommended that comprehensive geological/hydrological, geotechnical Investigations be carried out before the design and construction of dams
8. One of the major lessons learnt is the need to Institutionalize dam safety inspection and maintenance by trained staff in each River Basin Development authority under the Inspection Division of the Department of dams and Reservoir Operations.
9. A reasonable amount of fund should be provided to carry out a comprehensive safety operations and maintenance of dam at regular interval to guarantee safety, stability and durability

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6. Robert B. Jansen, (1983) Dams and Public Safety, A Water Resources Technical Publication, Published by U.S. Department by the Interior (Bureau of Reclamation, USA 30 – 45.

Progress Photographs

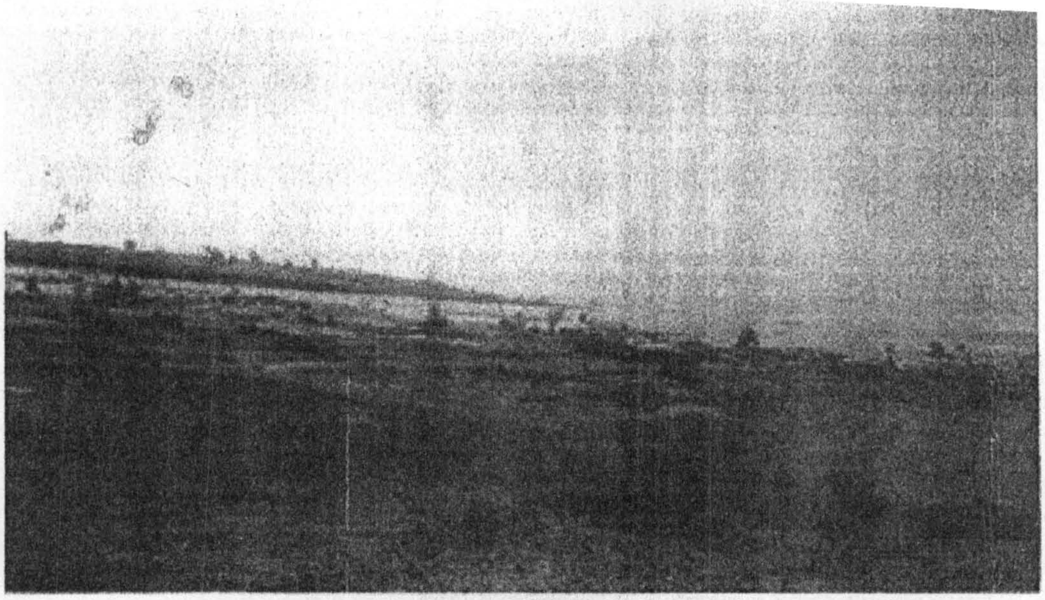
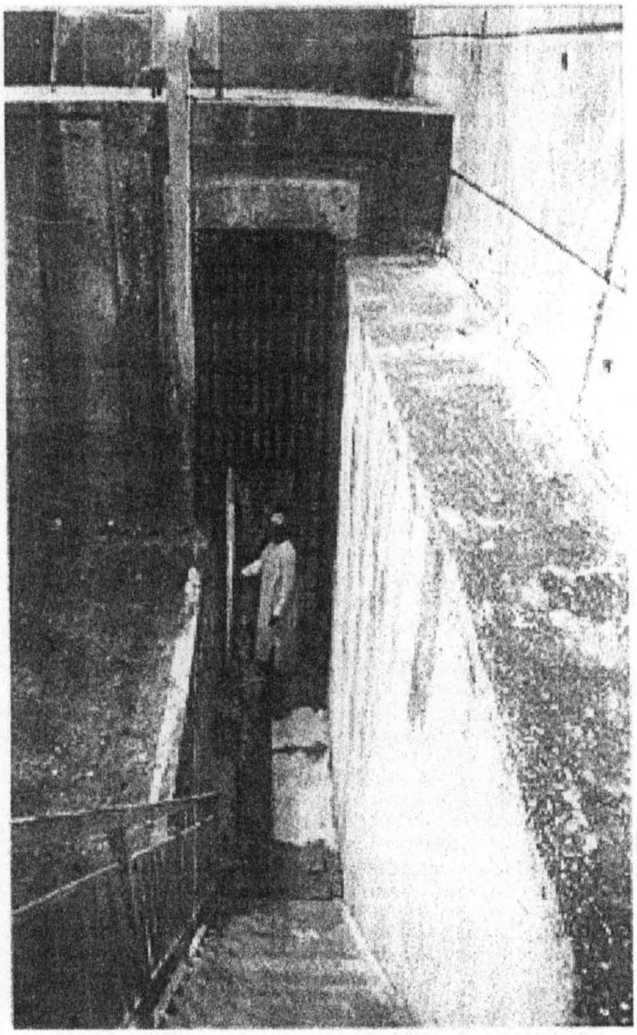


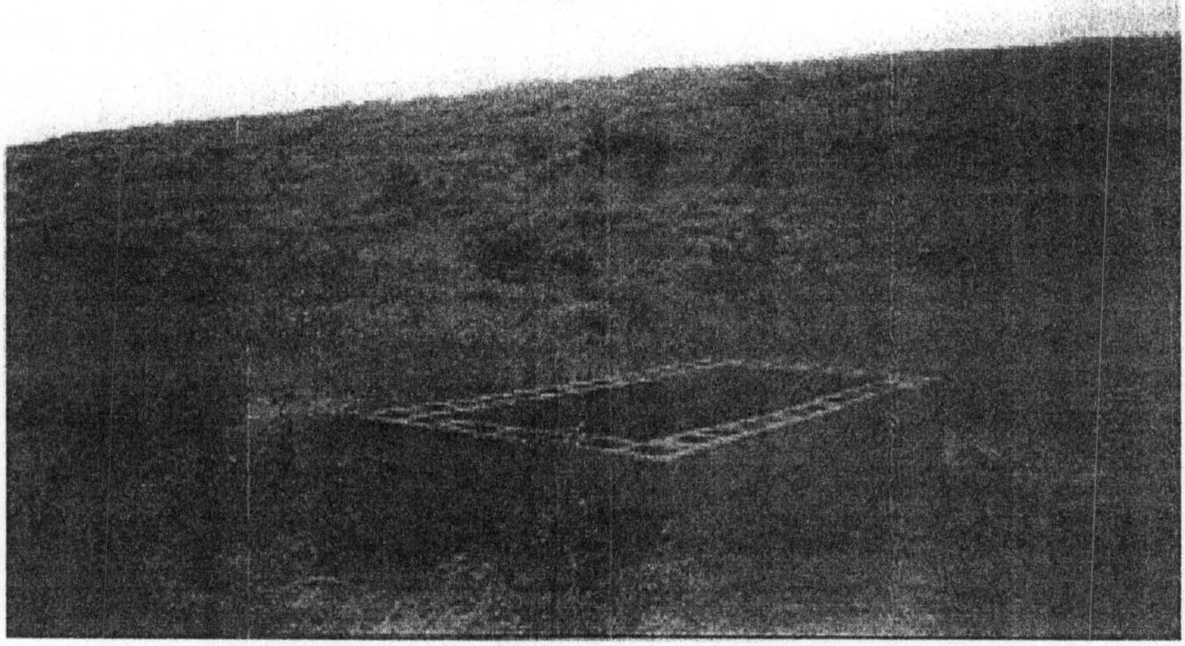
PLATE NO 1: EMERGENCY SPILLWAY OUTREACH.



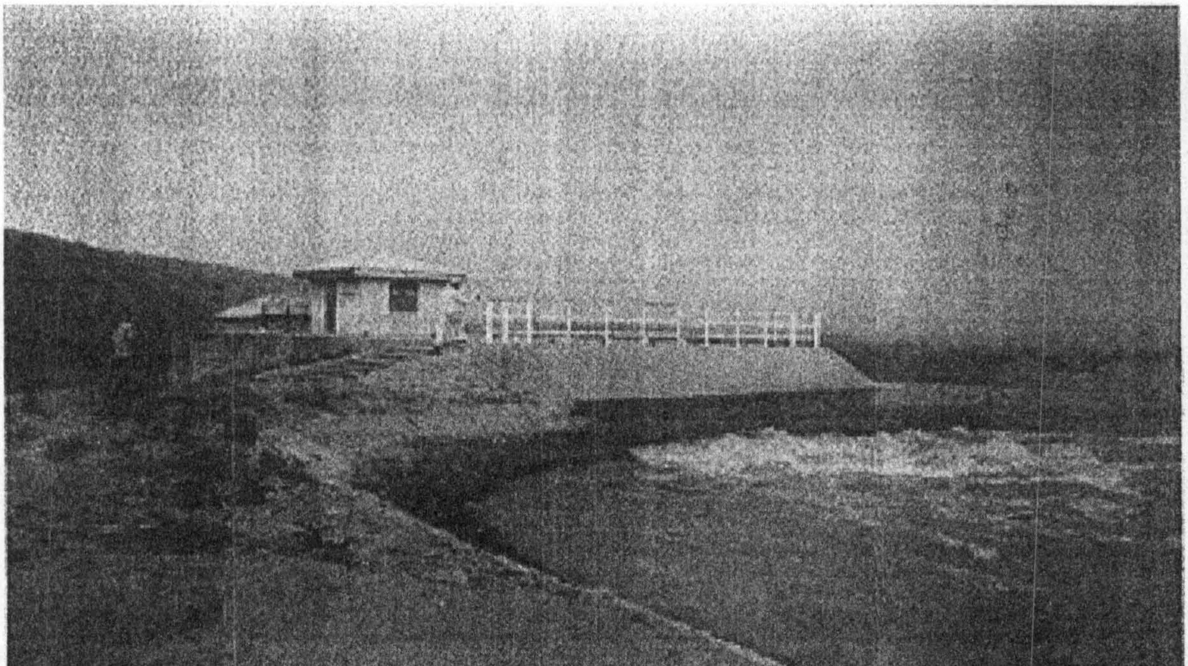
TE NO 2: PHOTOGRAPHS SHOWING THE PROJECT MANAGER AT THE ENTRANCE INTO THE GALLERY.

ATE NO 3: FAILURE OF RETAINING WALL AT DOWN STREAM APPROACH CHANNEL OF THE SPILLWAY.

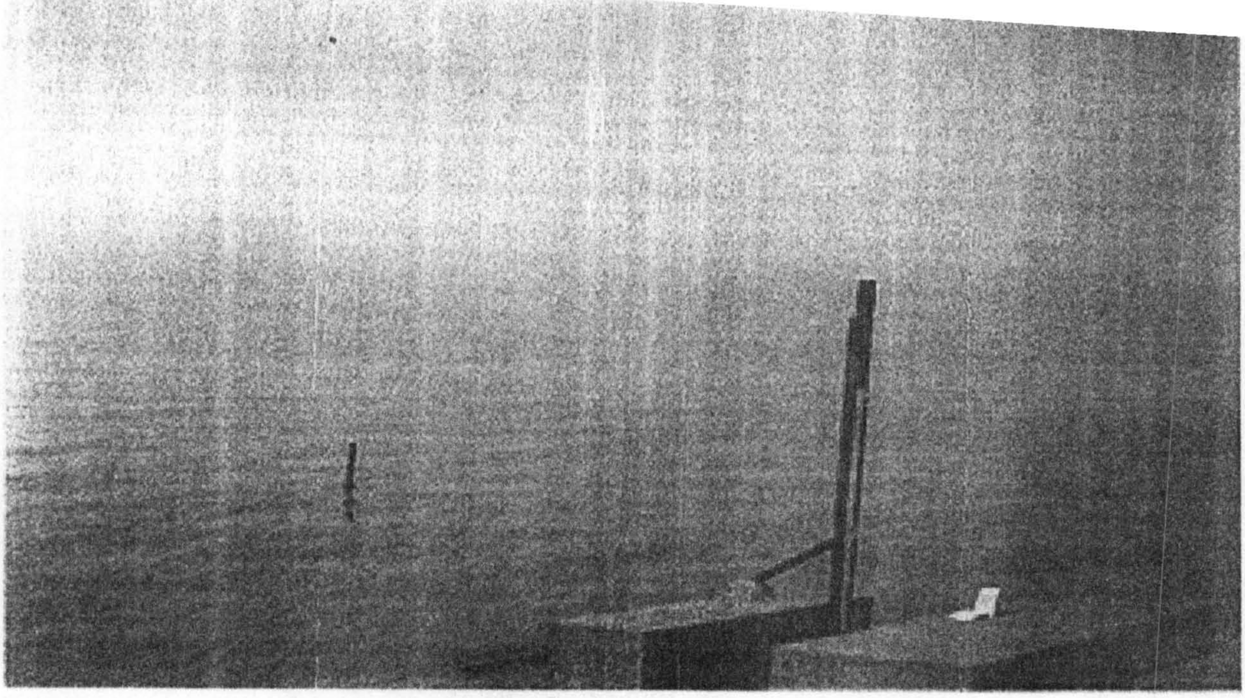
ATE NO 4: PICTURE SHOWING PROJECT OFFICERS OPENING THE ENTRANCE OF THE DAM.



.ATE NO 5: RECTANGULAR CONSTRUCTION THROUGH WHICH FLOWS FROM TOE DRAIN ARE MEASURED BY MEANS OF V-NOTCH WEIRS.

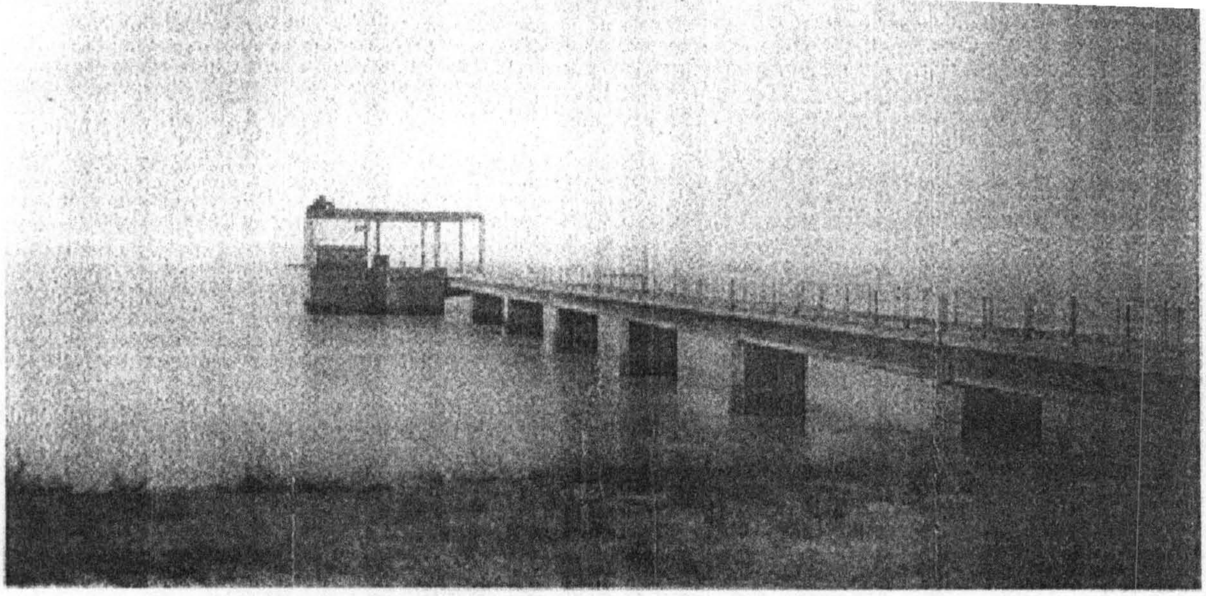


.ATE NO 6: CONVEYANCE SYSTEM FOR CONVEYING WATER FOR THE OGUN IRRIGATION PROJECT.

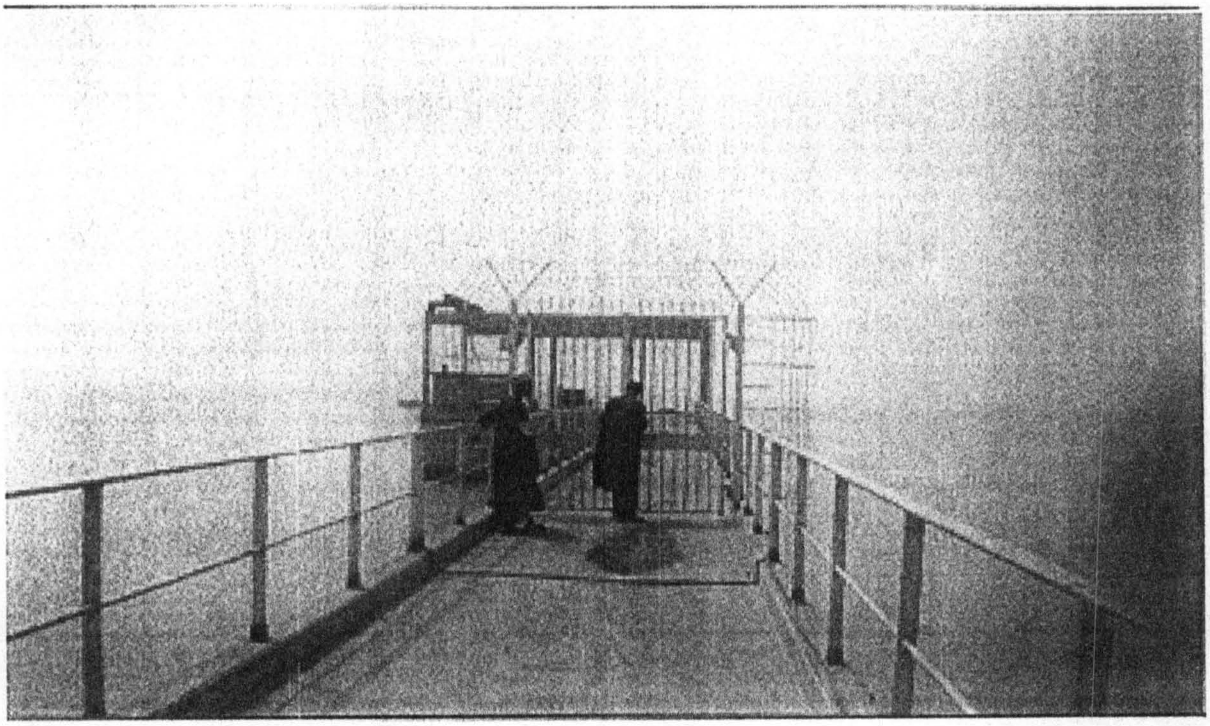


ATE NO 7: GAUGE INSTALLATION FOR READING STAGES AT OYAN

ATE NO 8: PROJECT OFFICE AT OYAN DAM SITE.



ATE NO 9: ACCESS BRIDGE LEADING TO THE BULKHEAD GATE CONTROLLING CRANE AND METEOROLOGICAL EQUIPMENT.



TE NO 10: SECURITY MEN OPENING THE GATE LEADING TO TH CRANE

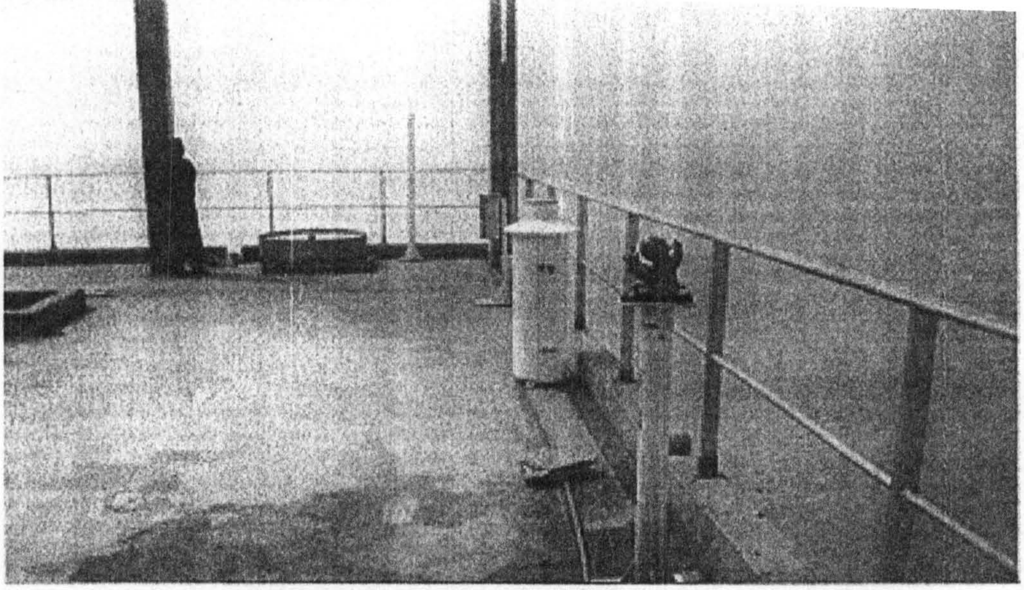
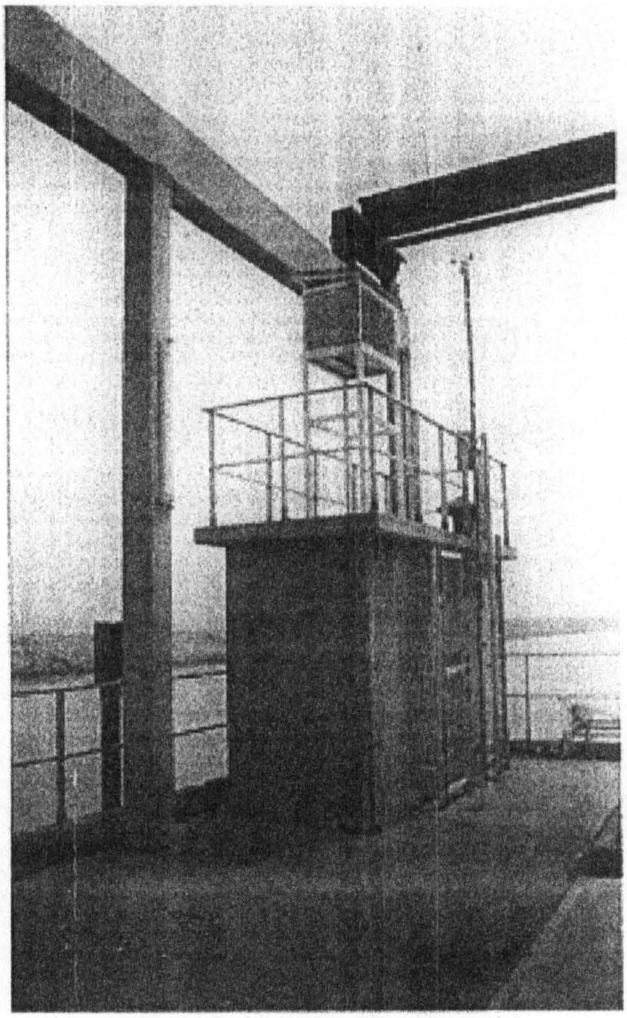
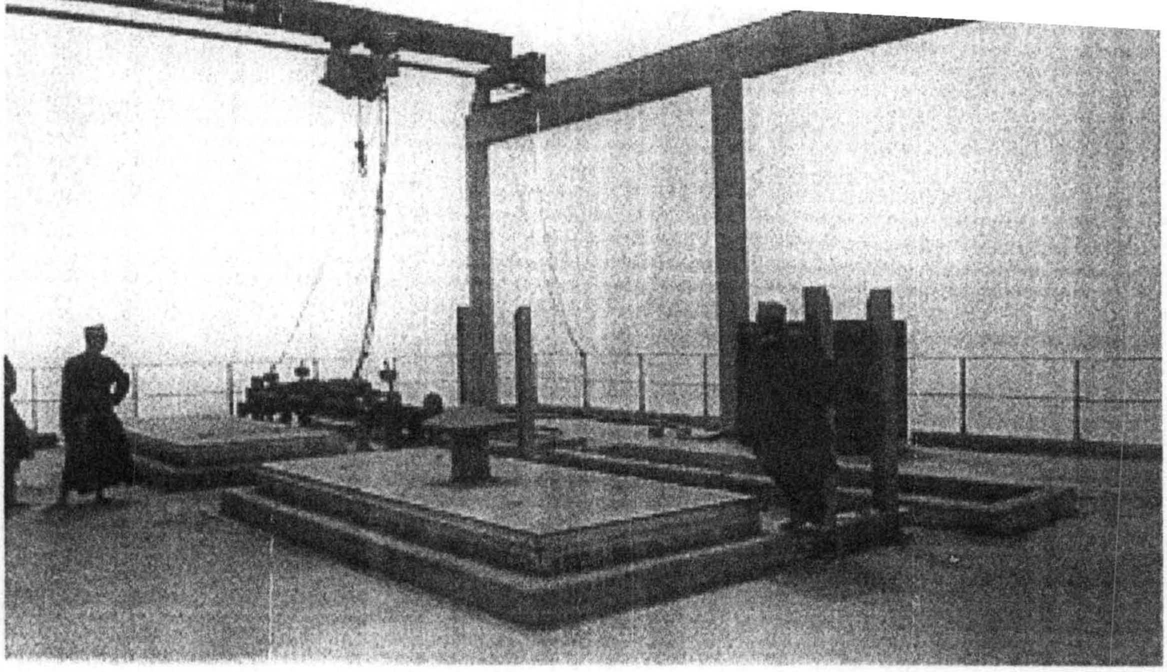


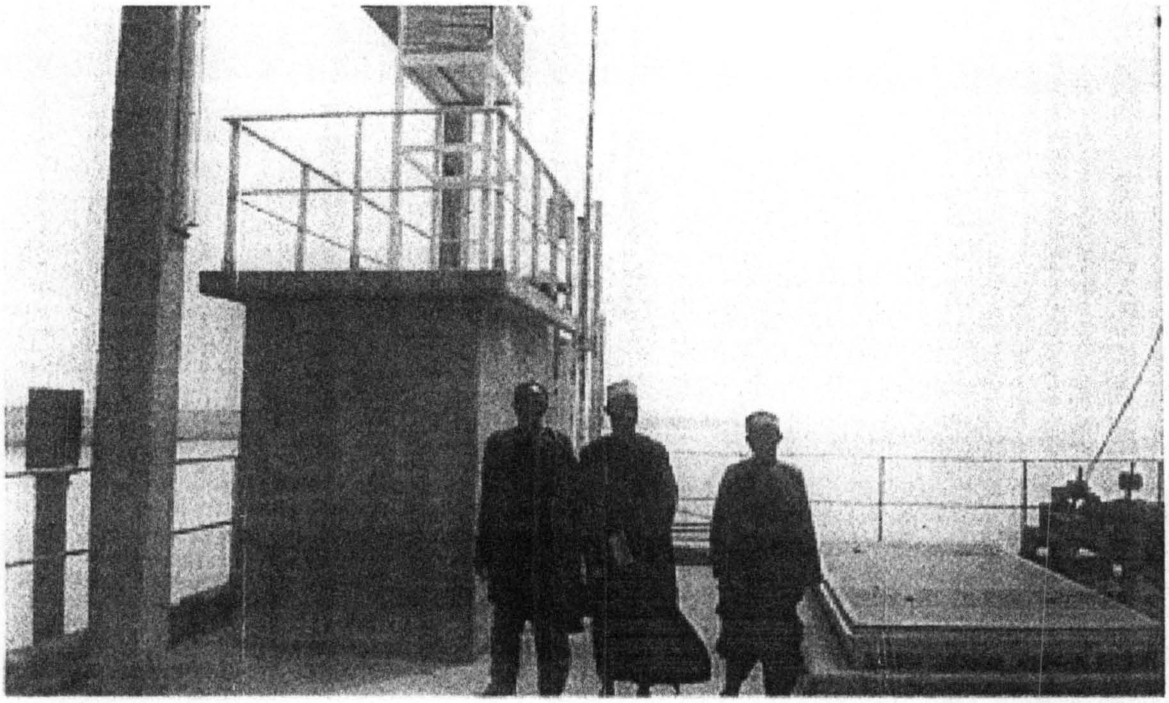
PLATE NO 11: PICTURE SHOWING THE CRANES AND THE METEOROLOGICAL EQUIPMENT.



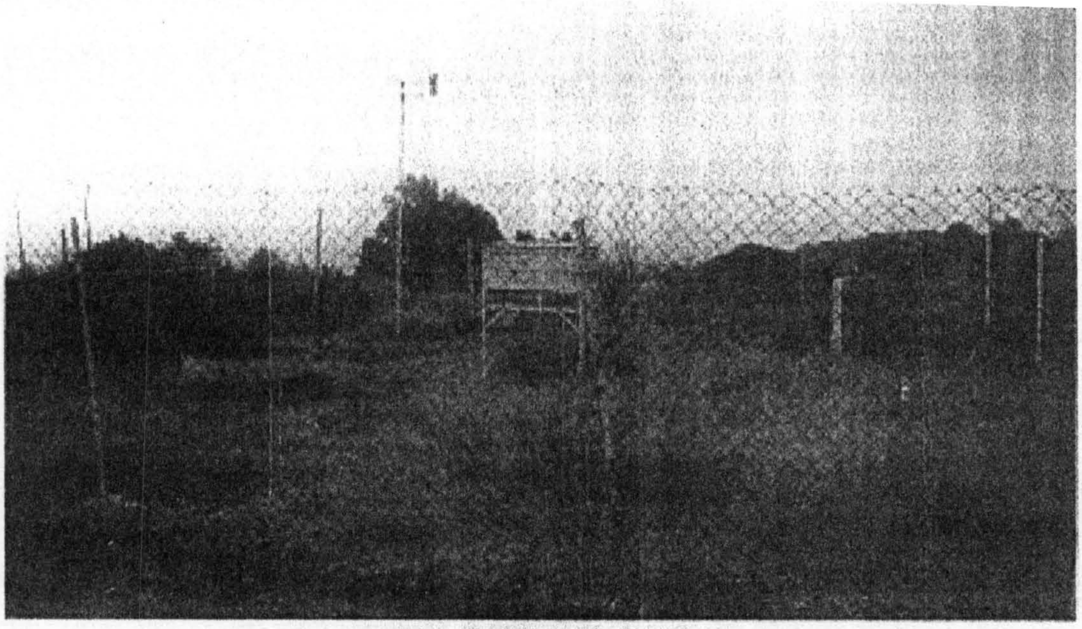
LATE NO 12: PICTURE SHOWING THE CRANES AND THE METEOROLOGICAL EQUIPMENT.



ATE NO 13: PICTURE SHOWING THE CRANES AND THE METEOROLOGICAL EQUIPMENT.



LATE NO 14: PICTURE SHOWING THE CRANES AND THE METEOROLOGICAL EQUIPMENT.

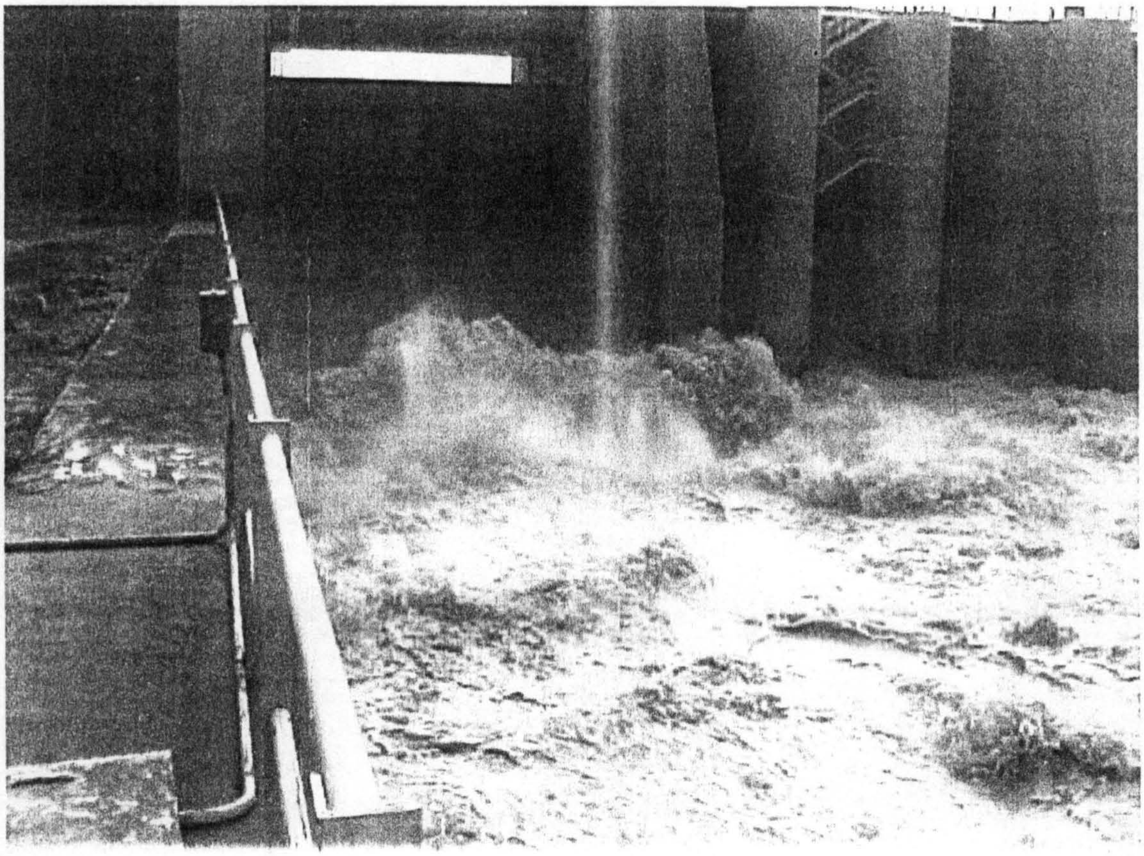


LATE NO 15 METEOROLOGICAL STATION FOR OYAN

LATE NO 16: THE ORIGINAL SPILLWAY BEFORE THE CONSTRUCTION OF THE NEW EMERGENCY SPILLWAY.

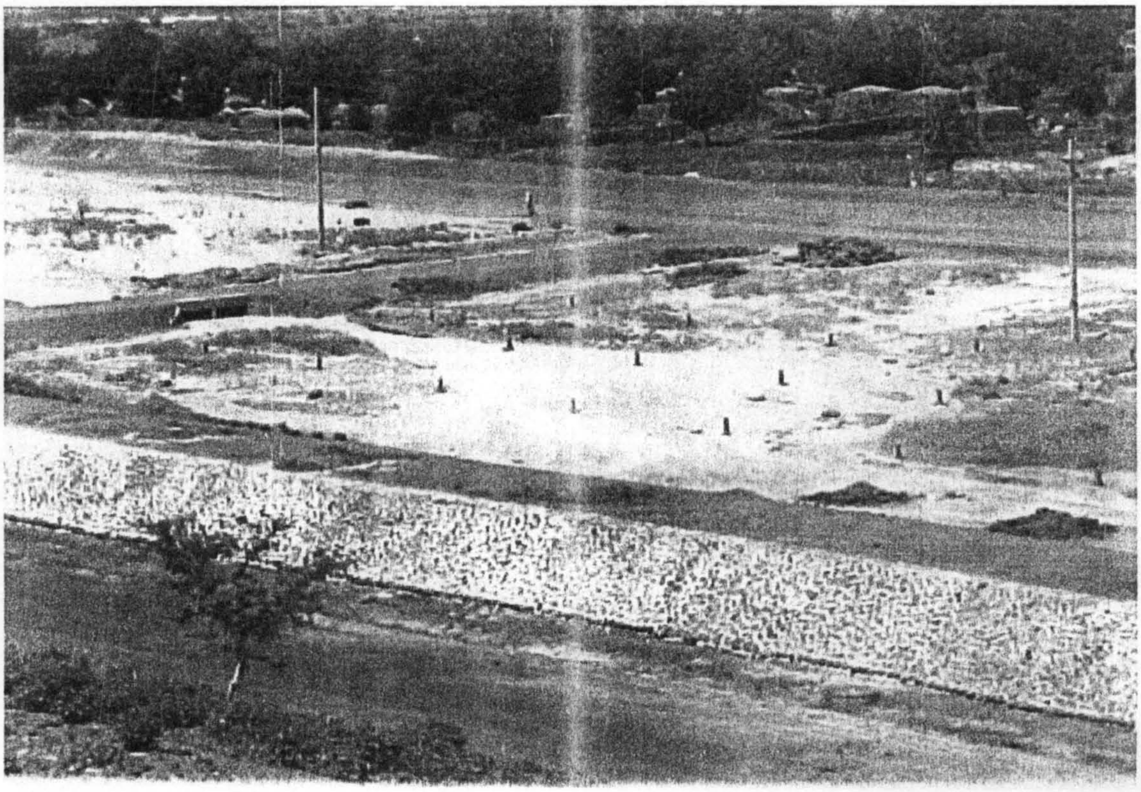
LATE NO|7: PART OF THE DOWNSTREAM EMBANKMENT.

LATE NO|8: PICTURE SHOWING SHRUBS ON THE UPSTREAM FACE OF THE EMBANKMENT.

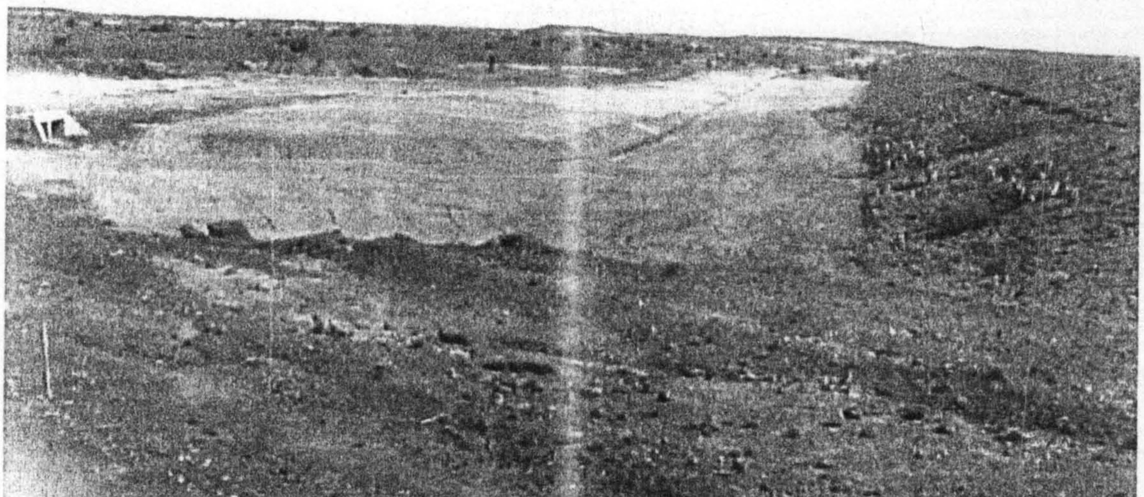


GROUP IIN:SPILLWAY GATES FLOOD DISCHARGE : MONTH OF SEPTEMBER WITNESSED A PEAK DISCHARGE RATE OF $400m^3/s$

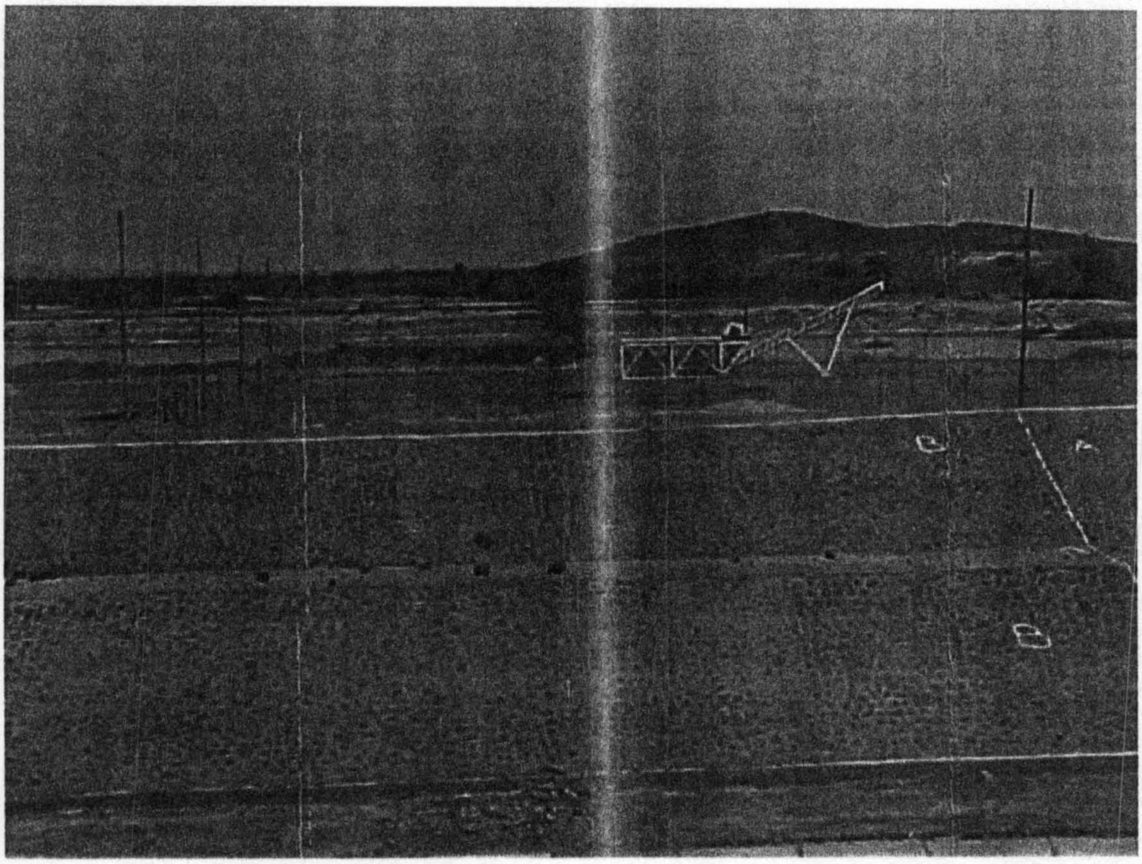
GROUP R :DRAINAGE CANAL AND STRUCTURES; INTERFACE POINT UNDERPASS CULVERT , JOINT SITE INSPECTION OF FLOODED CULVERT OUTLET DUE TO BACKFLOW DISCHARGE.



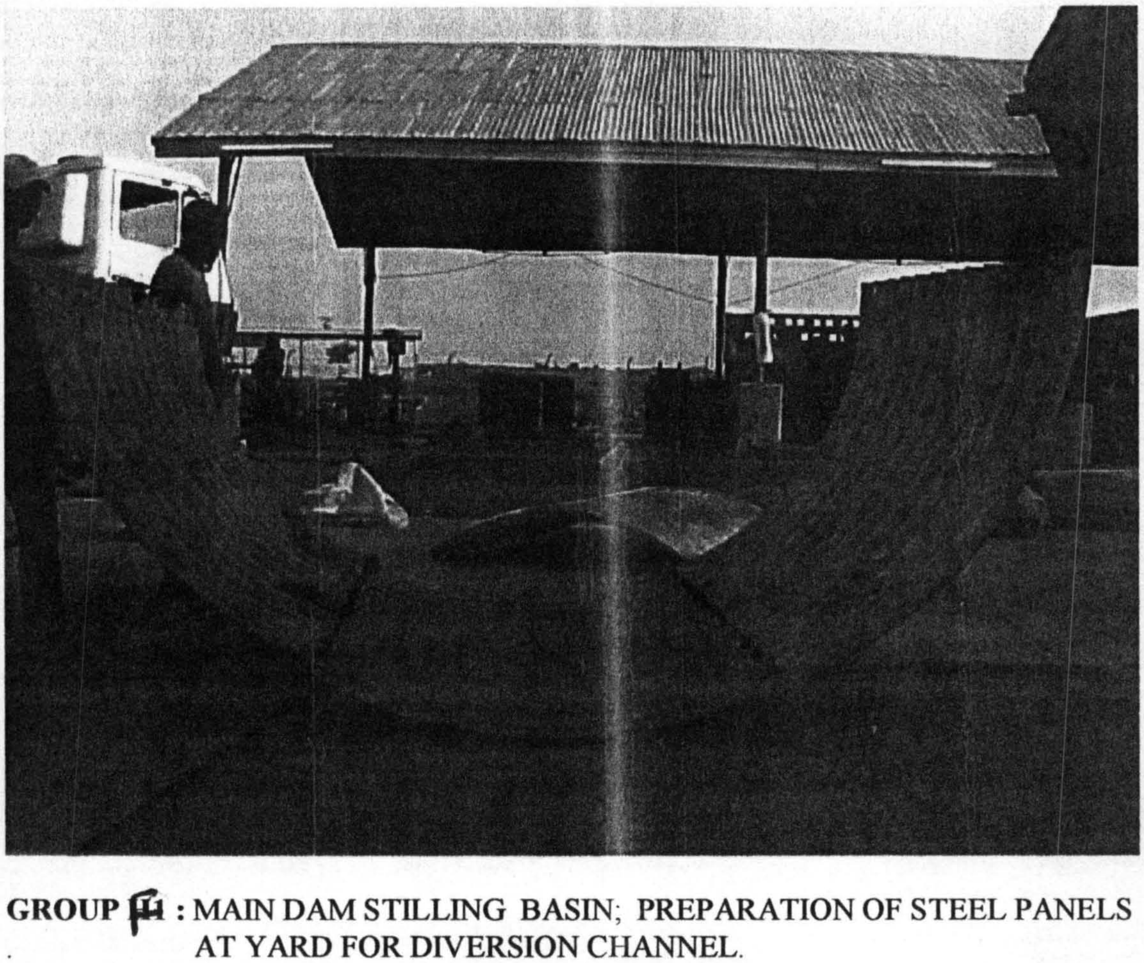
GROUP C: ROAD BESIDE OLD RELIEF WELLS. BEGINNING OF TREE PLANTING.



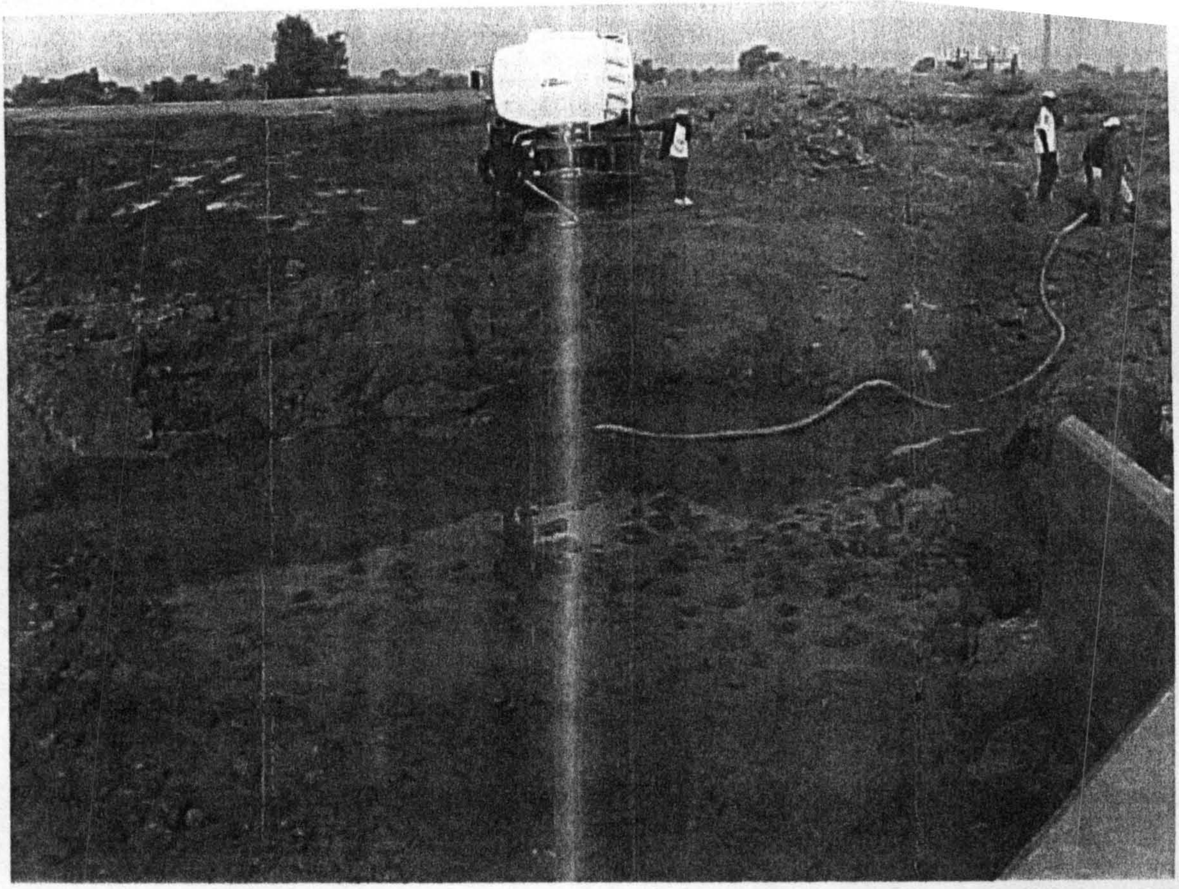
GROUP N: ROAD SECONDARY – SADDLE DAM. CHANNELISATION WORK, CULVERT CH.0 + 090 – 0 + 780.



GROUP G : MAIN DAM STILLING BASIN.; MOBILIZATION OF PLANT AND EQUIPMENT TO SITE.

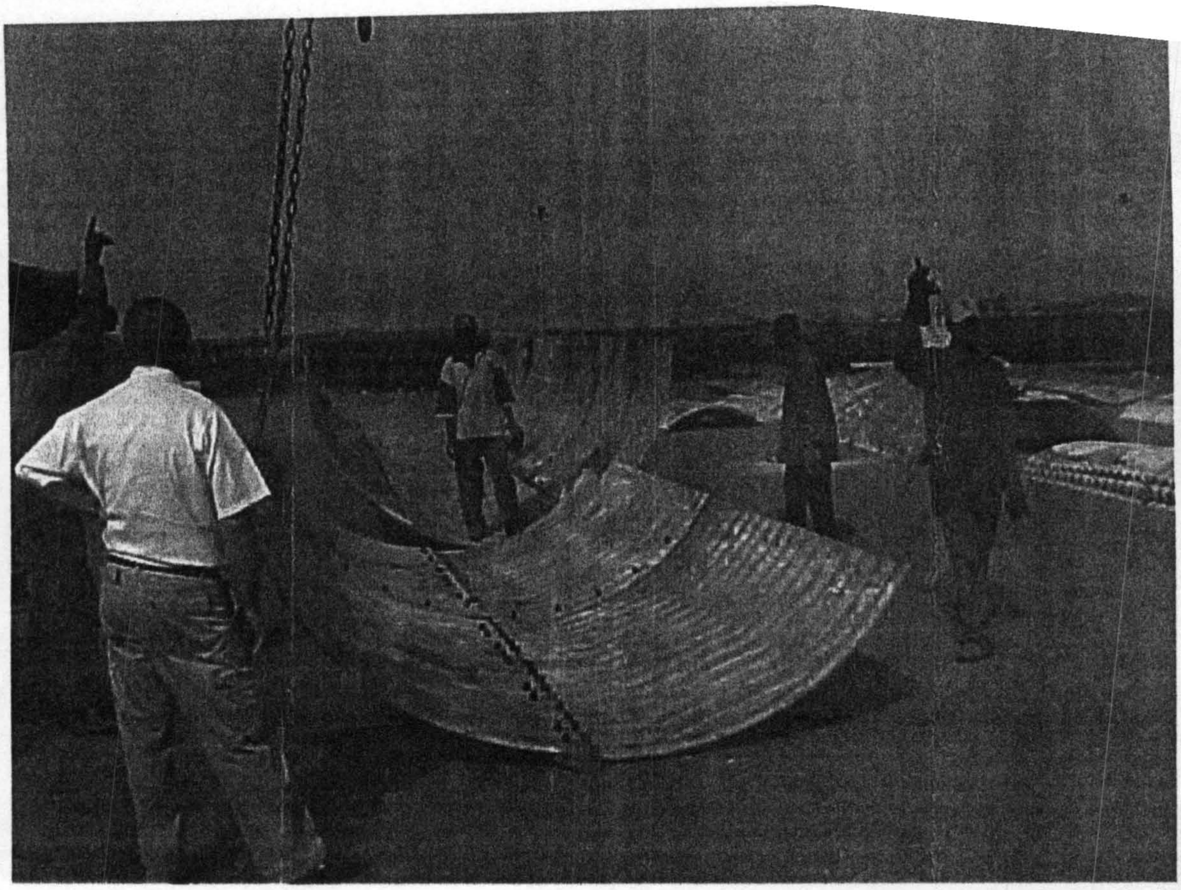


GROUP F : MAIN DAM STILLING BASIN; PREPARATION OF STEEL PANELS AT YARD FOR DIVERSION CHANNEL.

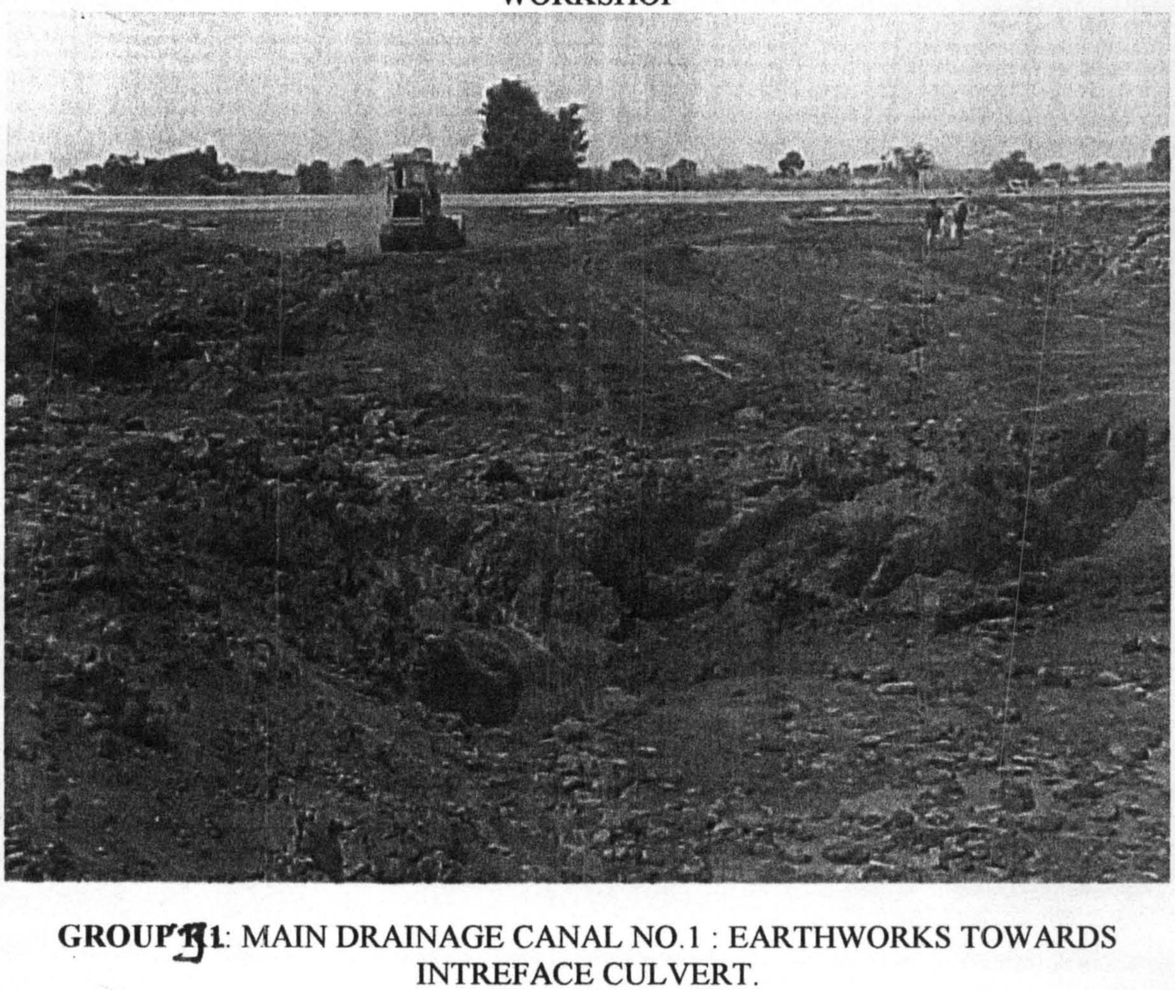


GROUP G: MAIN DRAINAGE CANAL NO.1, PLACEMENT OF FILTER BEDDING.

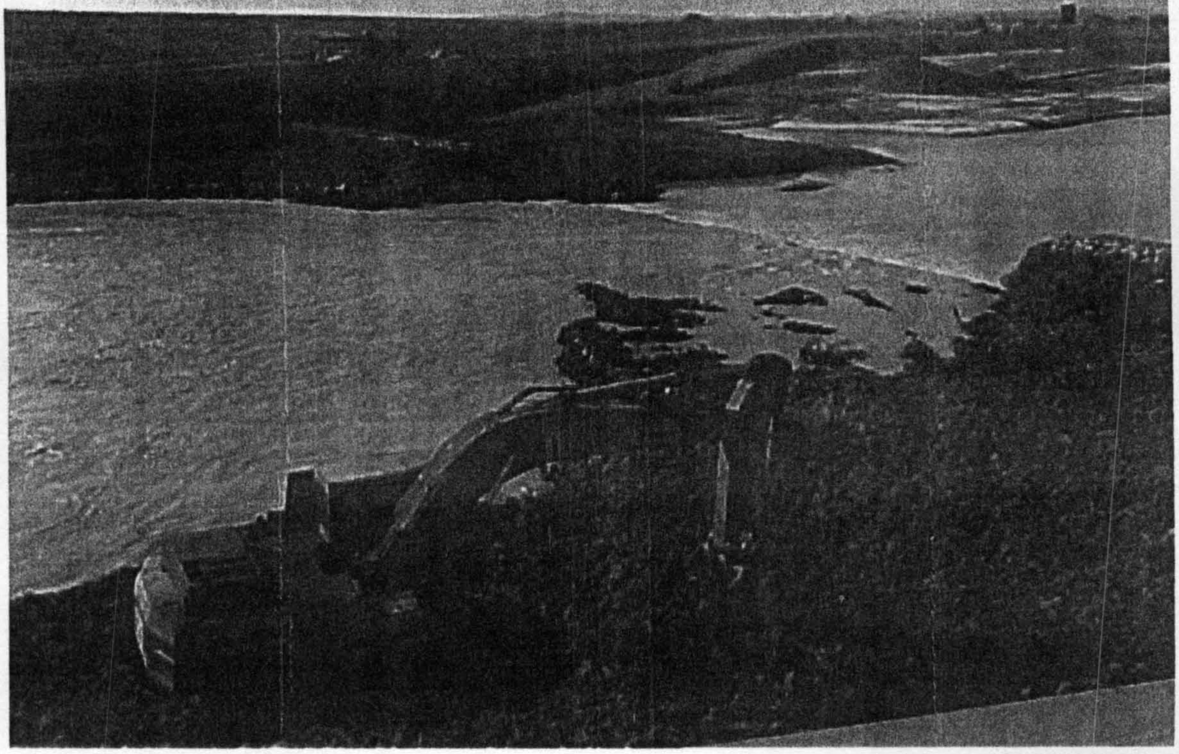
GROUP H: EMERGENCY SPILLWAY: PREPARATION OF RENO MATTRESSES.



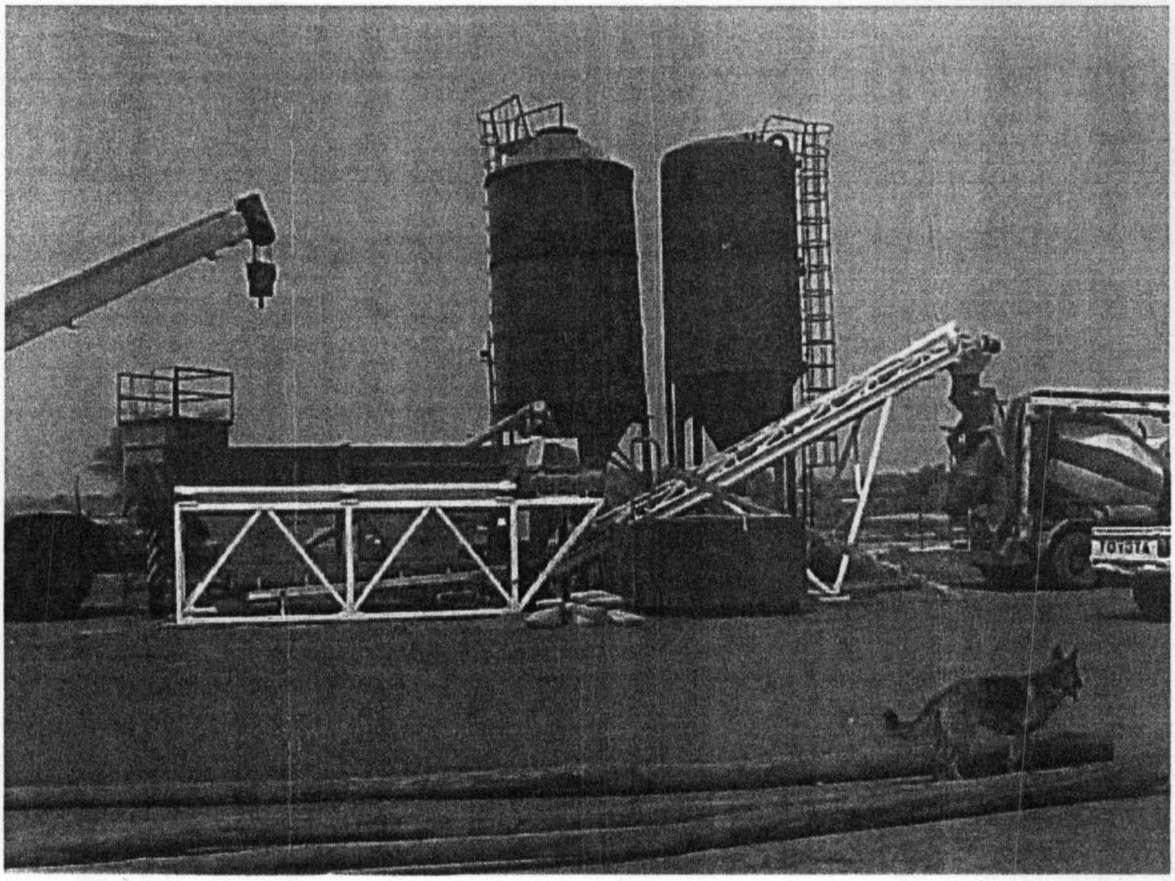
GROUP I1: STILLING BASIN, ASSEMBLY OF DIVERSION CANAL AT WORKSHOP



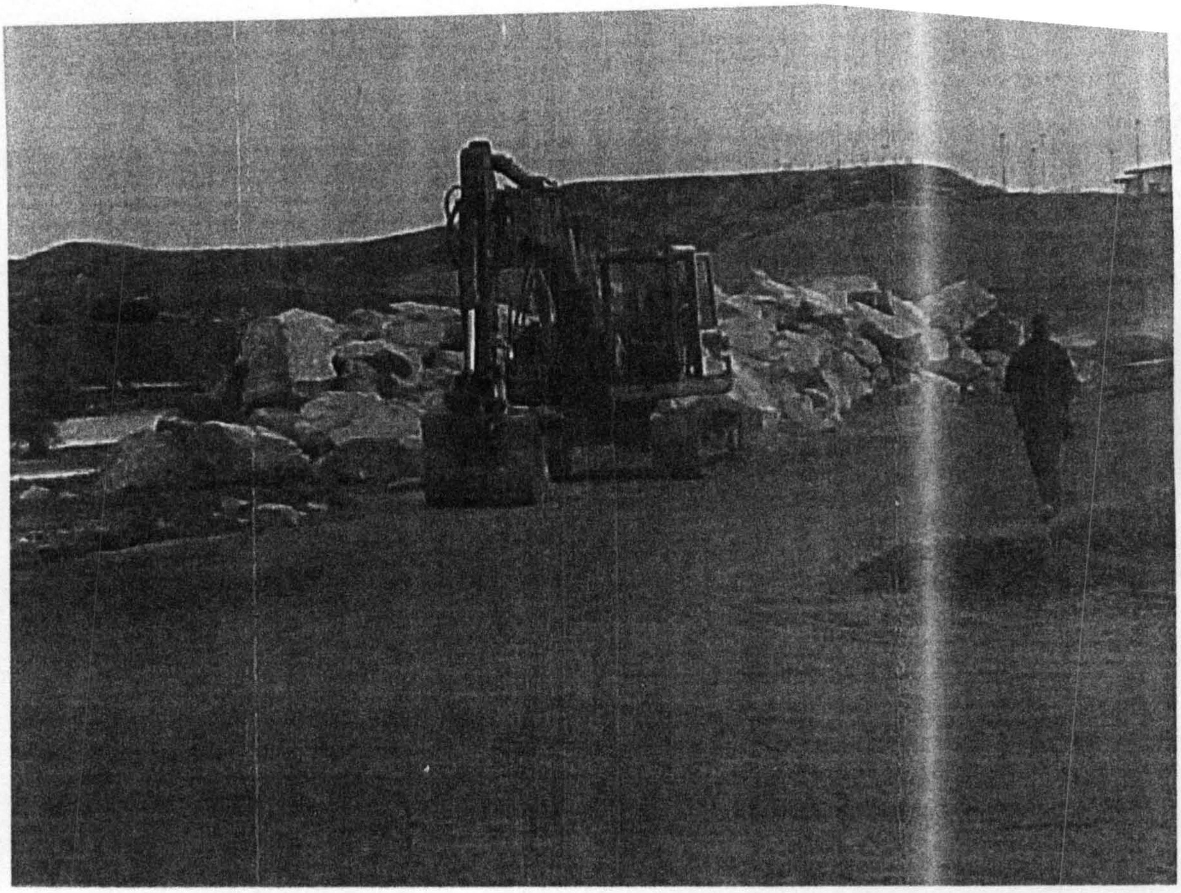
GROUP J1: MAIN DRAINAGE CANAL NO.1 : EARTHWORKS TOWARDS INTREFACE CULVERT.



GROUP 4: STILLING BASIN, REMOVAL OF DEBRIS.



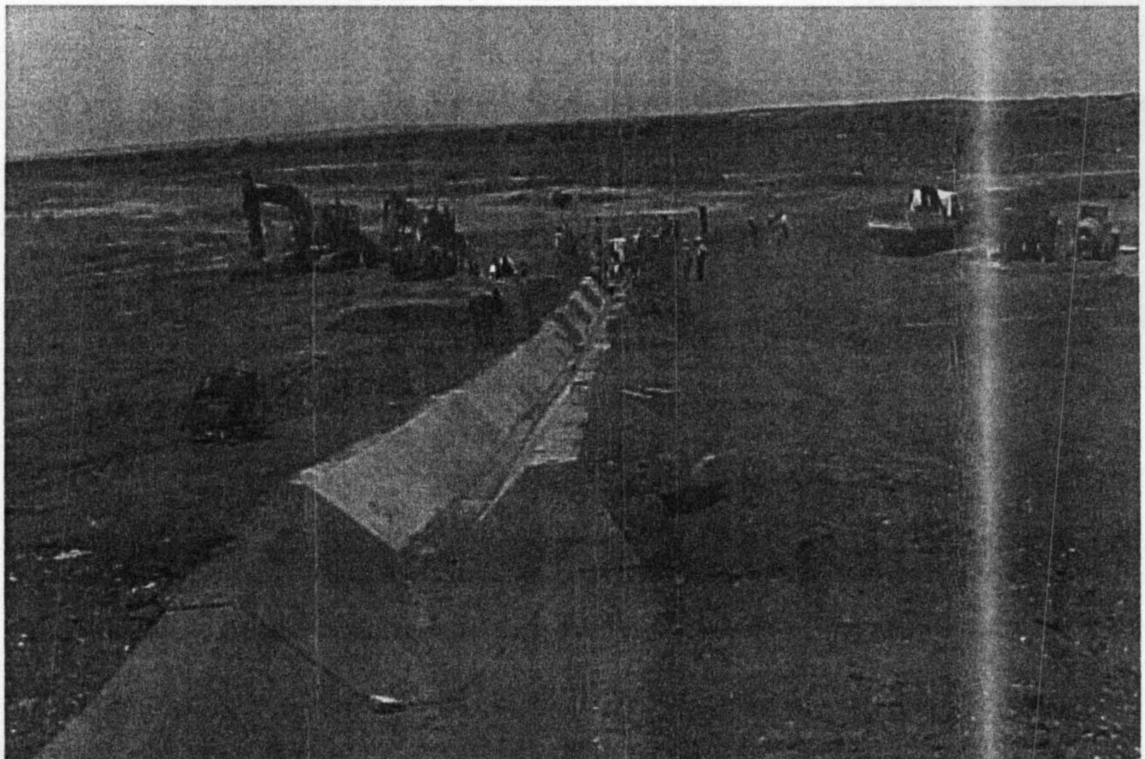
GROUP 4: STILLING BASIN, BATCHING PLANT INSTALLED.



GROUP M: STILLING BASIN, GATHERING BOULDERS.

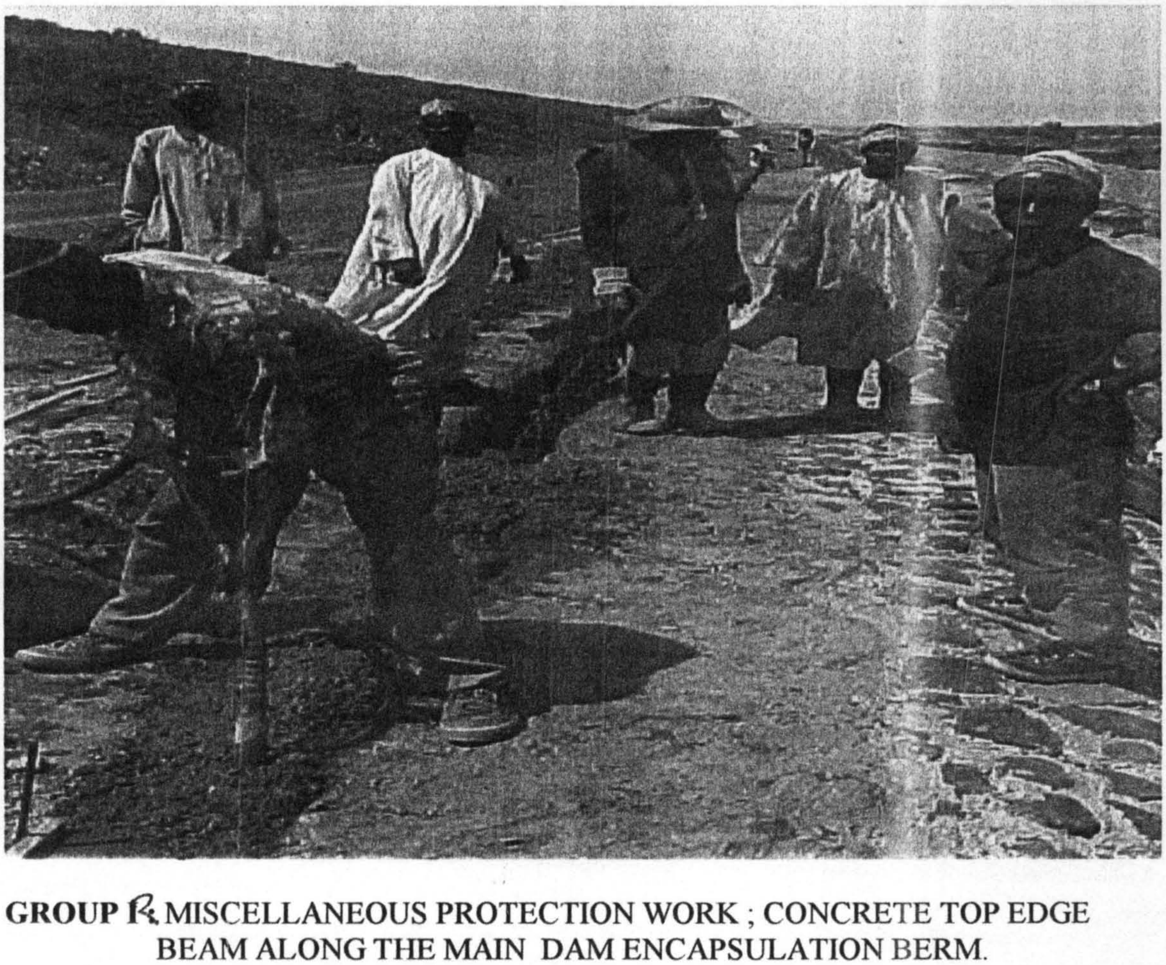
GROUP N: STILLING BASIN, CONSTRUCTION OF ACCESS ROAD.

GROUP O : MISCELLANEOUS PROTECTION WORK; FORMWORK AND REINFORCEMENT FOR STAIRCASES AT THE UPSTREAM SLOPE OF THE ACCESS ROAD BESIDE OLD RELIEF WELL AND MAIN DAM ENCAPSULATION BERM.

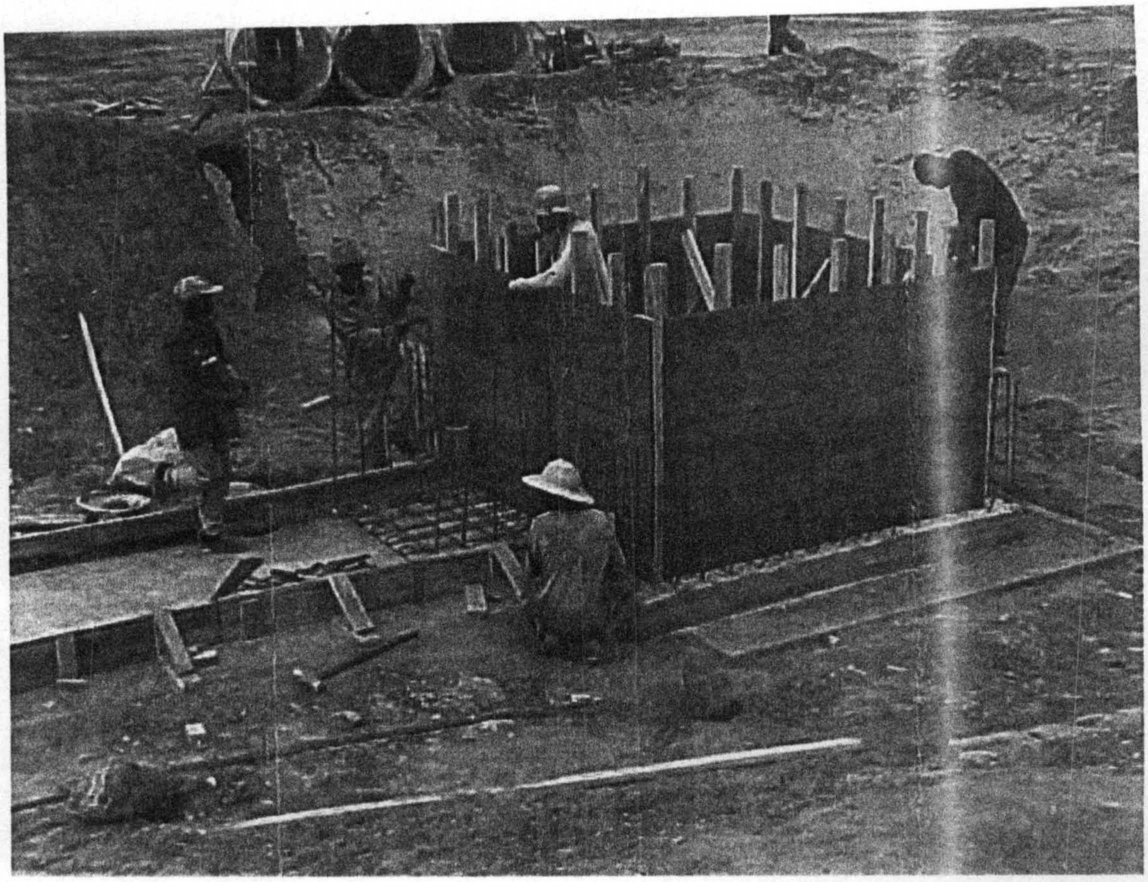


GROUP P: ROAD SECONDARY- SADDLE DAM ; CONCRETE LINED DRAINAGE CHANNEL TOWARDS INLET OF CULVERT AT CH 0+090.

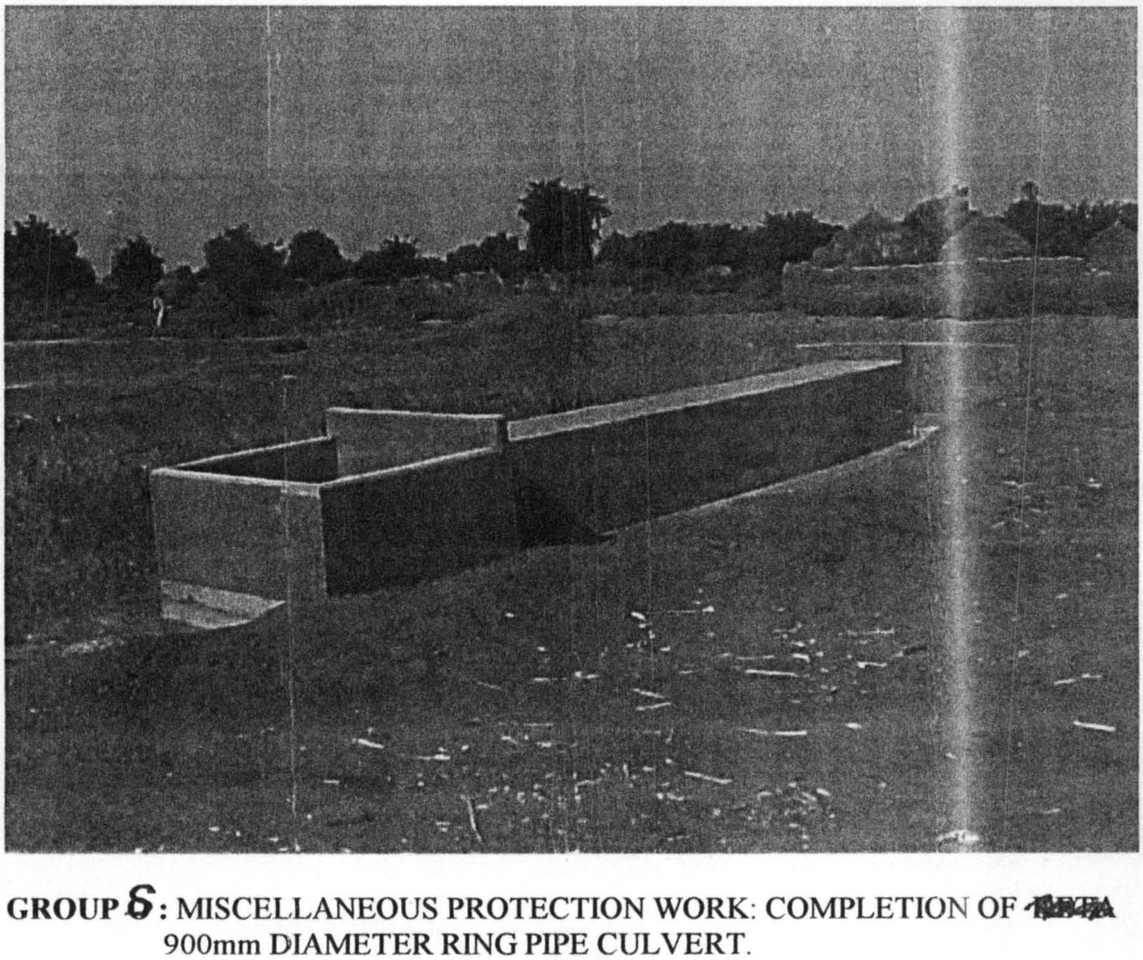
GROUP Q ROAD BESIDE OLD RELIEF WELLS ; UPSTREAM EMBANKMENT TOE BEAM.



GROUP R MISCELLANEOUS PROTECTION WORK ; CONCRETE TOP EDGE BEAM ALONG THE MAIN DAM ENCAPSULATION BERM.



GROUP Q : MISCELLANEOUS PROTECTION WORK: KETA 900mm DIAMETER RING PIPE CULVERT ; BLINDING, REINFORCEMENT AND FORMWORK FOR THE SUMP.



GROUP S : MISCELLANEOUS PROTECTION WORK: COMPLETION OF [redacted] 900mm DIAMETER RING PIPE CULVERT.

GROUP T2 : EMERGENCY SPILLWAY; PLACEMENT OF ANCHOR BEAM.

GROUP U1 : EMERGENCY SPILLWAY; BLINDING AND CASTING OF SLAB.

APPENDIX A

QUESTIONNAIRE FORMAT

The questionnaire format was developed to acquire first hand information about the Oyan Dam and to compute the proposal to be adopted in carrying out the comprehensive monitoring, maintenance and inspection of the dam. All information supplied in this questionnaire will be used specifically for research purposes only, and it will be treated with utmost confidence.

I therefore, seek your co-operation by answering these questions without any bias mind but as accurate as possible.

Section I

1. Dam:..
2. Project:...
3. Location:..
4. Name Of Officer [S]:..
5. Position/Office Held:..
6. Department/Unit:...

Section II: CONSTRUCTION/EQUIPMENT DATA

Please fill in the relevant information

A) Reservoir Drainage Area:..

Total Storage:..MCM

Total Run Off Per Year:.. m^3

Minimum Operation Level:..

Draw Down:...

Surface Area:.. km^2

Capacity - Gross:..MCM

Active:...MCM

Usage Storage:..MCM

) **Dam** Type:..

Structural Height:..m

Maximum Base Width:..m

Crest Width:...m

Crest Length:..m

Crest Elevation:...m

Total Fill:.. m^3

C) **Outlet Works** Capacity of Supply:...Cumecs

D) **Spill Way** Type:..

Crest Length:..m

Max. Discharge:...Cumecs

Crest Elevation:...M.a.s.l

Max. Head...m

E) **Gates** Type:..

Capacity:...

Condition:...

F)	**Turbines**	Type:..
		Quantity:..
		Hydraulic Head available:..m
		Gross Level:..m
		Operating Head:..m
		Effective or Net Head:..m
G)	**Generators**	Type:.. S/no:.....................................
		Voltage:.............................. Amps:.................... RPM:.................
		Capacity:.. Kw or KVA
		Condition :...(Working, Not Working)
		Serial Nos of Engine:................................ Make of Engine:................
		Model No.:..
		Others:..
		....
H)	**Pump**	Types:..
		Nos:..
		Capacity:...
		Specifications:..
		Others:..
		....
I)	**Communication Equipment.**	Type:..
		Quantity:...
		Model:..

Capacity:..

Others:...

....

J) **Remote Control Equipment.**

Type:...

Quantity:..

Capacity:..

Condition:...

Others:...

....

K) **Transformers**

Type:...

Model:...

Quantity:..

Others:...

....

Capacity:..

Specifications (please list):..

....

....

L) **Transmission Line and Distance Network**

1) Voltage:..

2) Conditions:..
....

3) Distance:..

4) Size of Conductors:...

M) **Access Road** Type:..

Width:..

Total Length:..

N) **Canals** Type(s):..

Length:..

Width:..

Others:..

....

O) **Crane and Handling Equipment** Type:..

Weights:................................ (Tons), Single or 3 phase:...................

Motor Capacity:..Kw

Others:..

....

P) **Facilities and Buildings** (I) **Structure Types:**..

Conditions:..

....

Defects (if any) - please list:..

....

....

(II) **Electrical Works**

Conditions:..

Damages (if any) - please list:..

....

76

Adequate or Inadequate:..

(III) **Plumbing Works:**

Conditions:..

Damages (if any) - please list:...

....

....

(IV) **Furnitures:**

Types:...

....

Conditions..

Damages (if any) please list:...

....

....

Q) **Control Panels** Types:...

Conditions:..

Specification:..

....

....

Problems (if any) please list:...

....

....

R) **Work shop** List Equipment in place:..

....

....

Conditions of the Equipment:...

....

....

Adequate or Inadequate:...

....

Problems (if any) please list:..

....

S) **Irrigation Area** Gross Irrigation Area:..ha

Total Length of Drains:...Km

Pumping Station Capacity:...m^3/hr

Section III: **<u>GENERAL</u>**

1. When were the Electrical and Mechanical Equipment Installed ?...

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2. What are the problems with these equipment ? (please list)

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3. In operating these equipment, what basic procedures do you adopt ?

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4. What are the safety measures adopted in operating these equipments ?

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5. What are the operational status of these equipment ?

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6. Are the necessary spare parts required to keep these equipments in operating condition available ?

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7. Are your staff given the required training to handle these Plants/Equipment ?

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8. How often are these equipment maintained ?

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9. What methods do you use in irrigating the crops and what are their efficiencies ?

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10. Do you have problems of siltation, if yes to what level ?

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11. Are there areas where there are cracks and leakages ? (please list)

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12. Is there provision for stand by Power ? If yes what is it status now ?

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13. Are there problems of faulting, Clay seams, sink holes, Depressions, if yes what areas ? (please list)

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14. Is there any case of movement, Land slides etc. ? If yes where?

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15. Are there problems of Seepages, and to what level ?

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16. How often do you clear the Vegetative growth on the upstream face of the Dam ?

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17 Do you have areas where the stone pitched face has collapsed ? (please list)

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....

18. What is the present condition of the Bridges in the Dam, are there particular problems with the Bridge structures ? (please list).

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19. What is the status of the Drainage Gallery ? (please list problems)

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....

20. Please list all the peculiar problems facing the full operation of the Dam and its facilities.

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21. What do you require to operate to full capacity ? (please list)

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....

22. Do you have cases of flood, and to what level ?

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23. How often do you release water for downstream uses during the dry season and to what capacity ? (please state).

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24. How is the condition of the Stilling Basin, are there cracks joints, etc ?

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25. Are the Emergency Control Facilities in place adequate ? If no, what other facilities do you require ?

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26. Is the security in the Dam adequate ?

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27. Are the Performance Instruments in place in the Dam adequate ?

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....

28. What are the main problems with the Supply Canals ?

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29. In your own opinion, what are the major problems affecting the full operation of the Dam and Facilities ?

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30. What suggestions do you have to contribute towards the total rehabilitation of the Dam ?

....

....

....

31. There are problems with the Buildings housing the facilities ? (Please list)

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32. Are there adequate furnitures in place and what other facilities do you need ?

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....

33. What additional Manpower do you need to improve the operations of the Dam ? (please list).

....

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Signature:______________________ Date:__________