DESIGN AND CONSTRUCTION OF A SURFACE IRRIGATION MODEL FOR GUZAN IRRIGATION PROJECT IN EDATI LOCAL GOVERNMENT, NIGER STATE, NIGERIA.

By

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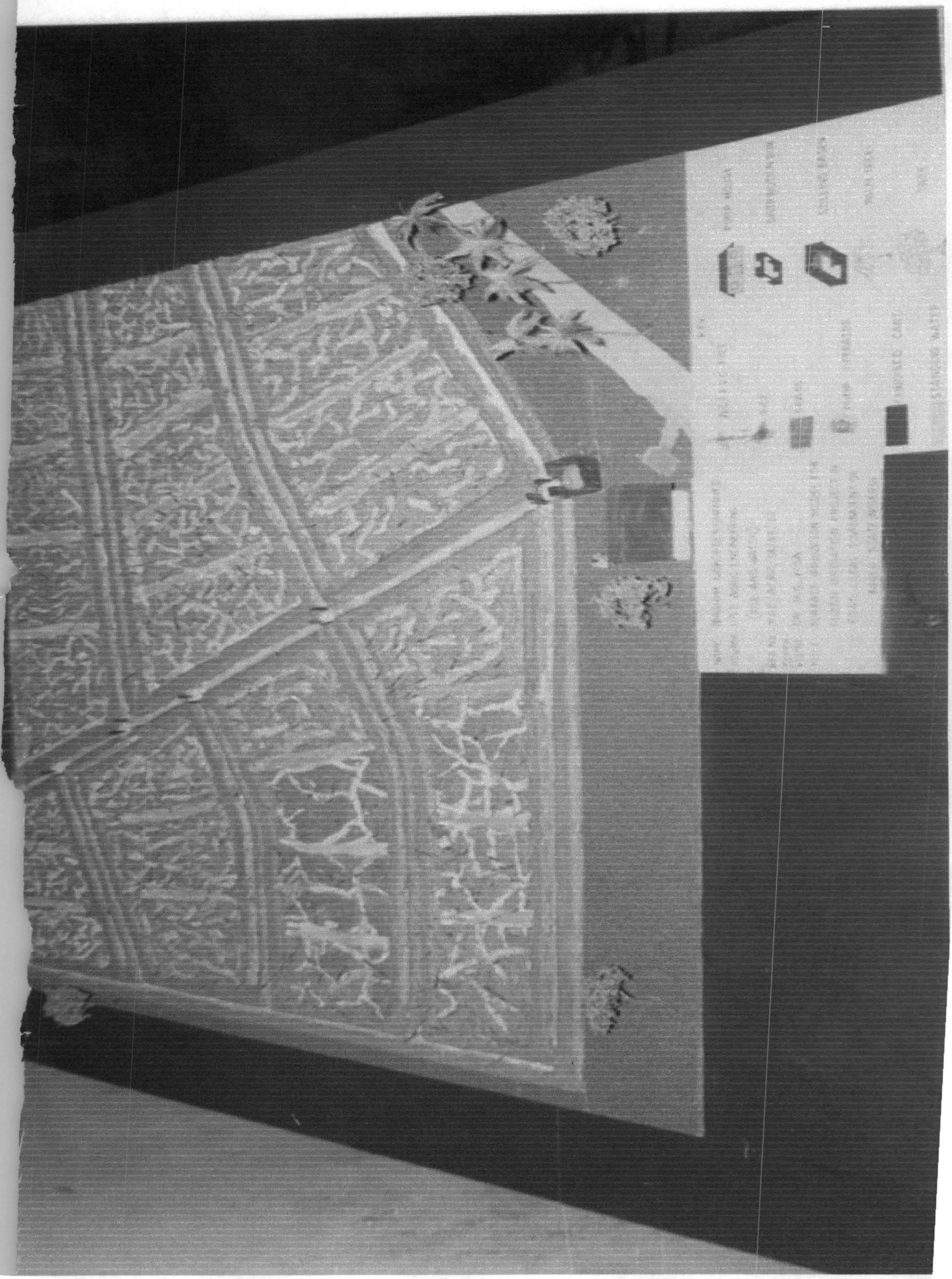

CERTIFICATION

The dissertation entittled "Design and Construction of a surface Irrigation Model for Guzan Irrigation Project in Edati Local Government, Niger State" by Ibrahim N. Mohammed meet the regulation governing the award of Post Graduate Diploma (PGD) of the Federal University of Technology, Minna and is approved for its contribution to knowledge and literary presentation.

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DEDICATION

THIS RESEARCH PROJECT IS DEDICATED TO MY PARENTS, LATE ALHAJI MOHAMMED NAKORDI, MALLAMA ZAINAB M.. NAKORDI, FATIMA .M. NAKORDI AND SARATU .M NAKORDI, FOR THEIR SUPPORT RIGHT FROM MY CHILDHOOD TO DATE.

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God bless you all. (Amen)

ABSTARCT

The Irrigation method chosen is the Check Basin System which is being practiced at the Scheme. The design is based on the existing Meteorological data, Topographic Map prepared by the Ministry of Agriculture, Irrigation Division and data collected from field experiment. From the analysis of the data obtained the textural class of the soil was found to be sandy loam, Bulk Density (BD) = 1.58gm/Cm^3 , Infiltration rate (I) =6.64 Cm/hr, Permanent Wilting Point (PWP) = 1.94%, Field Capacity (FC) = 10.21% and the discharge through the main canal = 0.263m^3/sec. Also, the Meteorological data obtained was used to determined the crop water requirement to be 360000m^3 and comsuptive use of rice to be 300mm/day. These values obtained are quite reliable as compared with the standard values since they fall within the range. This signifies the accuracy of the designed work.

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CHAPTER ONE

1.0 INTRODUCTION

The feasibility study of Guzan Irrigation Scheme (Project) has revealed that the area is suitable for large scale rice production. The scheme is on River Yiko which is a small perenial river draining water from the Kutigi area of Lavun Local Government, southwards into the Niger river.

A concrete dam about 20m long and about 6m high has been constructed on the river Yiko about a Kilometer away from the village. But the embankments are not completed so that the river flows unobstructed along its directed course. Canal intake structure and by-pass for excess water from the canal into the river have also been constructed. From here about 2,675m long canal (Main) has been constructed (Lined) and it ends abruptly when it approaches the area to be irrigated. This is an ambitious scheme designed for 1,600ha but it is presently lying idle due to incomplete dam and canal.

As an alternative, a lift irrigation scheme was commenced near the command area with two 150mm delivery pumps driven by 15HP Lister diesel engines. The intake for the pumps was from a pump fed by two diversion channels from the Yiko river. In this area the Yiko river is near its confluence with the River Niger and there is only a small level difference between the river bed and the rice fields from the bank.

1.1 GENERAL DFISCRIPTION OF THE PROJECT SITE

The project is Guzan Irrigation Scheme, located between latitude 9^0 5' N and longitude 5^0 4'E and about 18Km South-east of Enagi and is approached by taking the Bida - Kutigi - Mokwa highway up to Enagi and then taking laterite road from Enagi. The pilot scheme covers a total of 120ha of rice cultivation.

1.2 CLIMATIC CONDITION

The climate of the project area is essentially the same as typical of the middle belt of Nigeria with high temperature and excessive humidity during the most part of the year.

There are no meteorological stations in the vicinity of the project and the nearest stations which has records for a considerable period is Bida meteorological station and National Cereals Research Institute (NCIR) Badeggi.

1.2.1 RAINFALL

The project area lies inthe portion of the state where the normal annual rainfall ranges between 1100mm and 1200mm. Rainfal normally occurs between the month of April or May to October. The peak rainfall is recorded during the month of August.

1.2.2 TEMPERATURE

The temperature data have also been collected from the meterological stations in Bida and

NCRI. It is assumed that there would not be much difference in the temperatures of the project area as compared to those of Bida and NCRI. From the table it would appear that the hottest period is the month of March and April.Monthly temperature records show no wide variation, an ideal condition for crop production.

1.2.3 WIND SPEED

Wind speed is an important factor which need to be considered in the design of surface method of irrigation, as it affects the rate of evaporation from the soil and also rate of transpiration from the plant (Micheal 1985)

1.2.4 SUN SHINE

The sun shine record of the area was collected from Bida Meterological Stations.

1.2.5 RELATIVE HUMIDITY

Relative humidity records have also been abtained from NCRI and it is assumed that this fugures would not be very far from those of the project area. The figure shows that the humidity is generally high throughout the year and varies from a minimum of 51% to maximum of 87%.

1.3 SOURCE OF WATER

Source of water for the project is river Yiko which is a small perenial river draining water fron the Kutigi area of Lavun Local Government, southwards into the Niger river. The water is obtained by pumping into the canal which transport this water to the fields.

1.4 CROP GROWN

Specifically, rice is cultivated in large quantity in the project area. Rice (Oryza - sativa) has fibrous root system that usually does not penetrate deep in the soil. The full grown rice plant ranges in hieght from 0.6 to 1.5m. The shoot consists of main stem and several tillers (branches) that have developed from the lower nodes of the main system.

For flooded rice, planting is done in nurseries in May or June. The seeds are broadcast close together in moist, but unflooded soil. The seed germinates in 4-5 days, and by 7-8 weeks, they are ready for transplanting which is commonly done in July or August.

The spacing on the field at transplanting is 23cm x 23cm with 2-3 plants per stand. Indigenous rice matures in 4-5 months after planting. Harvesting is done by cutting the rice by the stem, tying them in bundles and allowing them to dry in the sun for some days before threshing.

1.5 TOPOGRAPHY

The topography of the project area makes it possible for the practice of surface irrigation. The topography of the area is relatively flat, that can be seen from the contour map.

1.6 SOCIO-ECONOMIC STUDIES

Reference is made to only five (5) villages sorrounding the project area. These are Enagi (south eastern part), Gbodoti (western part), Issa-Saba (eatern part), Wuchi (western part) and Sanmanagi (northern part).

1.6.1 POPULATION

The villages are small except Enagi which is the largest and at the same time the headquareters of Edati Local Government. The houses are built close to one another with a common wall dividing them into family units.

The total population of these vilages is about 15,000. There is a District Head stationed at Enagi who controls all these villages.

1.6.2 OCCUPATION

The occupation of the inhabitants is mainly farming. In the dry season when most farmers are idle, they take up fishing which is their popular hobby. However, agriculture is the main occupation of the people who are generally Nupes.

1.6.3 SOCIAL AMENITIES

Social amenities are not at immediate reach of the inhabitants of the area. In terms of educational facilities, there is only one primary school at the project area. There is a primary school and a secondary school at Enagi, the head quarters of Edati Local Government and also two (2) secondary schools and primary schools at Kutigi, the head quarters of Lavun Local Government which is close to the project area.

The recreation facilities such as hotels are substandard and are located at Kutigi.The market in Enagi is the center of trading activities especially on market days which is normally every Thursday. There is one (1) rural health center/hospital in Kutigi which caters for thehealth problems of the people and refer serious cases to Mokwa General Hospital or Federal Medical Centre, Bida.

CHAPTER TWO

.0 LITERATURE REVIEW

The practice of irrigation is as old as man. Many published work exist on the subject a few of vhich is here by reviewed.

.1 DEFINITION OF IRRIGATION

Irrigation, as defined by Isrealsen and Hansen (1982) is the applicationof water to the soil for he purpose of supplying the moisture essential for the development and growth of plants. Also rrigation, as described by Hans Ruthenberg (1980) is the practice that is adopted to supply water to n area where crops are grown, so as to reduce the length and the frequency of the periods in which lack of soil moisture is the limiting factor to plant growth. Irrigation Engineering is an applied ubject dealing with the investigation, planning, execution, control and servicing of irrigation and llied works. It is an inter-disciplinary area in which irrigation Engineers have to interact with agricul-ural and soil scientists, hydrologists and meteorologists, administrators and planners, and above all, he farmers for whose well being the various projects are formulated. Mazunder (1983).

Some of the objectives of irrigation are as follows:-

i. To ensure enough moisture essential for plant life.
ii. To provide crop insurance against short duration draught.
iii. To cool the soil and atmosphere to provide more favourable environment for plants growth.
iv. To leach the excess salts or dilute harmful salts in the soil.
v. To soften the tillage pans.

Irrigation is normally required under the following situations:-

a. When the total amount of rainfall is less than the amount reqiured by plants.
b. When the amount of rainfall is sufficient but the distribution does not coincides with the schedule of supply required by the plant. Mazunder (1983).

? HISTORICAL BACKGROUND

Man's dependence upon irrigation can be traced to earliest Biblical references. An ancient :en, supposed to have lived before 200BC directed her government to divert the water of Nile to gate the desert lands of Egypt. Isrealsen and Hansen (1982).

Irrigation in very early times was practiced by the Egyptians, the Asians and the Indians of : North America. For the most part, water supplies were available to those people only during riods of heavy rainfall. Schwab etal (1981). In Nigeria, espacially, Northern part of the country, igation was introduced since 1959 at Yau along the Yobe river.

2.3 EXTENT OF IRRIGATION

Irrigation is one means of improving the total volume of reliability of agricultural production by managing water for crops. It is estimated that about 13% of the world's arable lands are irrigated, and that they use about 1,400 billion cubic meter (m^3) of water per annum. The irrigated area in developing countries is estimated to increase at about 2.9% per annum.

Report presented at the 1974 world food conference suggested a desirable target up to 1985 to be the improvement of some 50 million hectares of existing irrigation. Also projections at the 1974 world food conference call for the need to establish by 1985 another 25 million hectares of irrigated land. Washinton (1970).

According to FAO's indicating world plan, 60% of the crops of middle east region are produced on irrigated land which comprised only 36% of the total cultivated land.

In Nigeria also, the River Basin Development Projects, some agricultural corporations and the Rural Development Programmes are embarking on large irrigation schème as well. This indicates that the area of land under irrigation in the country is continually increasing for the past few years.

2.4 IRRIGATION DEVELOPMENT IN NIGERIA

The importance of irrigation development for food production is no longer an issue in Nigeria. The issue is how to sustain irrigated agriculture for the permanent benefit of the Nigerian population.

In the historical and current development of irrigation in Nigeria, it is noted that the setting upof the River Basin Development Authorities between 1973 and 1976 was a milestone in the development of irrigation in Nigeria.

It has been proposed to put about 2 milliom hectares of land under irrigation between 1980 - 1985 and beyond. To this end, substantial capital has already been invested in developing irrigation facilities.

The first irrigation division in Nigeria was established in 1949 in the ministry of agriculture of the Northern region. The activities of this division was confined to small scale irrigation schemes. FAO (1965).

The FAO report (1965), commissioned by the Federal Government which deals with perspective for agricultural development in Nigera up to 1980 can be considered the watershed in water resources and irrigation development in the country. This report recommended a more active involvement of the Federal Government in plant water resources and irrigation development for the country. The 1975 - 1980 plan period has brought a coherent irrigation development plan to Nigeria. The Federal Ministry of Water Resources which is responsible for irrigation development in the country was established during this period. International Commission on Irrigation and Drainage (ICID)

2.5 RIVER BASIN DEVELOPMENT AUTHORITY (RBDA) IN NIGERIA.

The continued existence of River Basin Development Authorities was reconfirmed by Decree No. 87 of 28 september, 1979. The River Basin Development Authorities in Nigeria are:-

i. The Anambra - Imo River Basin Develoment Authority.
ii. The Benin - Owena River Basin Develoment Authority.
iii. The Hadeja - Jamaare River Basin Develoment Authority.
iv. Lower Benue River Basin Develoment Authority.
v. The Niger River Basin Develoment Authority.
vi. Ogun - Osun River Basin Develoment Authority.
vii. Sokoto - Rima River Basin Develoment Authority.
viii. The Upper Benue River Basin Develoment Authority.
ix. The Cross River Basin Develoment Authority.
x. The Niger Delta River Basin Develoment Authority.
xi. The Chad Basin Development Authority.

The setting up of the R.B.D.A was certainly a milestone in the water resources and irrigation development in Nigeria.

2.6 CURRENT IRRIGATION PROJECTS IN NIGERIA

Current information on proposed projects was not available but, a survey based on questionaires administered to the states by the International Commission on Irrigation and Drainage (I.C.I.D.) shows that 11 of 19 state of the Federation were actually irrigating about 8,132ha by the end of 1980. This figure does not include areas being irrigated by Shadoof, Pump-line and other small systems.

In a survey of six northern states of Benue, Kaduna, Kano, Kwara, Niger and Sokoto. Ehaber (1979) found that a total for the six states of 5,540ha was irrigated by Shadoof, 2,370ha by small pumps and 8,150ha by other means such as buckets, calabashes and blocking of streams.

2.7 A COMPARISON WITH UPLAND FARMING

Irrigation farming has distinct advantages conpared with upland farming. However, irrigation avoids the stress to plant growth that is connected with very high temperatures in the soil surface. At the same time, the condition of agricultural production are improved, particularly water supply is ample, regular and reliable.

1. Irrigation farming compared with upland farming under similar conditions produces higher gross return per hactare.
   a. Higher yield per hectare of a particular crop may be achieved.
   b. Several harvests a year may be produced
2. Irrigation farming allows permanent land use, privided that salt damage can be avoided. The control of water reduces erosion.
3. Yield flunctuations from year to year are reduced with effective water management. With reliable water supplies, production is independent on the weather.
4. Irrigation farming leads to a more continous production process. The changes of a regular houseold supply of food and cash income improves.

2.8 IRRIGATION METHODS

The aim of irrigation project is to balance crop water requirements during the growth period when natural rainfall is insufficient. Generally, the growth period in tropical countries extends all round the year thereby needing perenial water where irrigationis most needed.

Irrigation water may be applied to crops by flooding it on the field surface (surface irrigation), by applying it beneath the soil surface (sub surface), by spraying it under pressure (sprinkler) or by applying it in drops (drip irrigation).

The water supply, the type of soil, topography of the land and the crop to be irrigated determine the correct method of irrigation to be used. Whatever the method of irrigation, it is necessary to design the system for most efficient use of water by the crop.

2.8.1 SURFACE IRRIGATION METHODS

In surface irrigation methods, water is applied directly to the soil surface from a channel located at the upper reach of the field. Water may be distributed to the crops in border strips, check basins or furrows.

Two general requirements of prime importance to obtain high efficiency in surface methods of irrigation are properly constructed water distribution systems to provide adequate control of water to the fields and proper land preparation to permit uniform distribution of water over the field.

2.8.2 BORDER IRRIGATION

This method of irrigation consist, of dividing the field into series of small plots by low flat dikes or ridges called borders. These are constructed in the direction of the greatest slope. The stream of water enters into the upper end of each plot and moves down the slope in a thin sheet and wets the area bounded by the dikes in a time depending on the type of soil, slope of the land, and size of the plot.

Where soil, water and topographic condition favours, the border method is the most efficient of any irrigation method. The main obstacle to more intensive use of the border method of irrigation is the steep or the rolling nature of irrigated lands. The slope should not be greater than 0.62m per 30m and cross slopes within the borders must be eliminated by grading or levelling. This is done to prevent water to collect along the low side of the boder against the ridges and not properly moistening the high side of the border.

2.8.3 FURROW IRRIGATION

This is used in the irrigation of row crops with the help of small channels or furrows to convey the water over the soil surface in small individual parallel streams. Water moves laterally and vertically downward to moisten the plant root zone. It is usually associated with the use of tractor and comparatively large, well levelled field, as for instance, fields for cotton growing. Ruthenberg (1980).

2.8.4 CHECK BASIN IRRIGATION

The field to be irrigated by the check basin method is divided into level rectangula areas bounded by dikes or ridges. water is turned in at one or more points until the desired gross volume has been applied to the area. The flow rate must be large enough to cover the entire basin in approximately 60 - 75% of the time required for the soil to absorb the desired amount of water. Water is ponded until infiltrated.

2.9 OBJECTIVE OF THE PROJECT.

The objective of this project is to design an effective surface irrigation method for large scale rice production.

2.9.1 JUSTIFICATION OF THE PROJECT

The focus of this project is to design an effective surface irrigation method that can be applicable both now and in the future. Surface irrigation method was selected because it is highly economical, feasible, generally easy and cheap to install where conditions are favourable.

CHAPTER THREE

3.0 METHODS AND MATERIALS

Laboratory analysis and determination of infiltration rate of the soil were done using the following materials:- Metal Core Samplers, Wooden hammer, Knife, Polythene bags, Double ring Infiltrometer, Measuring tape and Bucket.

3.1 SOIL SAMPLING

In order to reduce error to the bearest minimum, sampling was done in three (3) different points in the project field. A total of six (6) samples at depths of 15cm and 30cm were taken.

Soils collected at the various points and depths were put in plastic bags, well labelled to indicate depth and point of sampling.

3.2 LABORATORY EXPERIMENTS

3.2.1 SOIL MECHANICAL ANALYSIS (SOIL TEXTURE)

This was determined using Bouyoucos Hydrometer method of (1951). To this end, 50gm of airdry soil was weighed into a beaker and 50ml of Calgon (Sodium Hexametaphosphate) was added, stirred and left overnight. The solution was stirred for 10 - 15min and then tranfered to a 1000ml glass cylinder. Distilled water was added to the 1000ml mark. The cylinder was inverted to mix the solution with the added water using hand to close the mouth of the cylinder. The hydrometer was inserted in the cylinder and made up until it was suspended.

The temperature T_1 and hydrometer reading H_1 were taken after 40sec. The hydrometer was allowed to remain in suspension for three (3) hours after which its reading T_2 and H_2 were taken by the use of a thermometer.

3.2.2 BULK DENSITY DETERMINATION

This was determined by the undisturbed core method as described by Vomocil (1954). In this method, the six (6) soil samples obtained from the field after weighing were tranfered to a oven at 105^0C and left there for 24hrs. They were weighed again to determine their oven-dry weight. Bulk density is the oven-dry mass divided by the field volume of the sample.

3.2.3 INFILTRATION RATE DETERMINATION

This was determined by a double ring infiltrometer using the Richard (1952) method. Double ring infiltrometer with the following dimensions was used for the experiment:- Diameter of the inner ring and outer ring is 35cm and 45cm, the height of each of them is 45cm.

The inner cylinder was first driven vertically downwards into the soil to a depth of 15cm by the use of a wooden hammer and then the outer cylinder to the same depth. Enough water to fill each ring to a datum point was added and the water level measured at intervals, as the water infiltrates into the soil. The water level dropped and the time of measurement was recorded.

3.2.4 FIELD CAPACITY DETERMINATION

Laboratory method was employed. water was added to the six (6) samples collected from the field until saturation. The samples were allowed to drain freely and left for forty eight (48) hours after which they were transfered to oven at 105°C for twenty four (24) hours. The difference between the moisture content at saturation after 48hrs and the oven-dry weight is the field capacity.

3.2.5 PERMANENT WILTING POINT DETERMINATION

This was determined by the modified laboratory method of Briggs and Schantz (1912). The six (6) samples collected from the field were placed in containers which is open at the bottom. Water was added until saturation and free drainage was allowed to take place. Maize seed were selected and two (2) seeds were planted on each sample and regularly watered until germination was attained in five (5) days. The surface was sealed with candle wax to prevent evaporation. The plant was left to wilt. The plants became permanently wilted at exactly seventeen (17) days. The soil moisture content was determined to be the permanent wilting percentage.

3.3 MODELLING MATERIALS

Modelling was done using the following materials:- Plywood, Strawboard, Sand, Topbond glue, Poster colour, Grass, Rubber trees and palm tress, Evostik, Emboised card, Knife, Painting brush, Rubber tube and Colour pencils.

3.4 TOPOGRAPHIC MAP

Use was made of the Topographic map prepared by the Ministry of Agric and Natural Resources, Irrigation Division for the design work. The only work done on the map was changing the surveyed values from imperial to metric and then re-tracing it.

3.5 CLIMATOLOGICAL DATA

Climatological data were obtained from NCRI Badeggi and Bida Meteorologocal Station, for the determination of crop water requirement.

CHAPTER FOUR

4.0 DESIGN CONSIDERATION

4.1 SURFACE IRRIGATION DESIGN VARIABLES

i. **Depth of water to be applied:-**

The most important design variable is the depth of water to be applied at each irriga tion. This is generally given as an average depth for each field even though the soil water reservoir may not have been uniformly depleted through out the field, and the water will not be distributed uniformly over the soil as a result of the irrigation. Most surface irrigation systems in arid and semi-arid areas are designed to raise the soil water content of the root zone of its field capacity even though water may be wasted. This is done in order to utilize water supplies when available, and to reduce the total number of irrigations and hence also to reduce labour. Jensen, M.E. (1983).

ii. **Hydraulic variables:-**

Surface irrigation design is a problem in unsteady, non-uniform flow. The main design variables include the field slope and roughness, both of which may vary within a field. Another consideration is the erosiveness of the soil, which will limit maximum inflow rates to a field. Jensen, M.E. (1983).

iii. **Topography of the field:-**

The topography of a field limits the type of system which can be used. Those which have rolling terrain, irregular shapes and shallow soils may be impracticable to irrigate with surface systems. If surface systems are used, they will usually be of the non sophisticated types with relatively low efficiency and non-uniform water distribution when measured on a field basis. On the other hand, flat terrain, fields of regular shapes and deep soils may be adaptable to a wide range of systems, all of which have the potential for high efficiency and uniform water distribution.

Thus, a site under consideration for surface irrigation must be mapped to show field boundaries, land elevations and soil depths and textures. Such information will give land slopes and field shapes directly. It will also assist in determining how much water to apply. Jensen, M.E. (1983).

iv. **Infiltration:-**

The infiltration characteristics of the soil at each irrigation is a primary input variable. It varies with time and space. It is not at all unusual to have 10-fold variations in infiltration rates throughout a field. Such variations can make the design of an efficient irrigation system extremely difficult, if not impossible. Jensen, M.E. (1983).

4.2 CHECK BASIN DESIGN CONSIDERATION

Efficient irrigation by the check basin method depends on the knowledge of the hydraulics of flow in the basin.

The hydraulics of flow in check basin may be considered to comprise of:-

i. Initial spreading of the entrance stream to cover the full width of the basin and simul taneous advance of the irrigation stream.

ii. Advance of the water front after the initial spreading.

iii. Rise of water level after the advancing stream reaches the down stream end and

iv. Subsidence of water after the irrigation stream is stopped.

If the check basin irrigation system is properly designed, it is possible to apply the right amount of water nearly uniformly throughout the basin. The problem of efficient irrigation by check basin consists essentially of having the right size of basin to suit the available stream size for a particular set of soil and crop conditions. Micheal, A.M. (1978).

Other variables to be designed for in check basin method include:-

i. Opportunity time (T_n) required for intake of the selected net application depth.

ii. Basin length (L).

iii. Inflow time required (T_a).

iv. Maximum depth of flow, (d). Jensen, M.E. (1983).

4.3 ASSUMPTIONS/LIMITATIONS

For the design, the following assumptions are made:-

i. Good quality and sufficient quantity of water for the project.

ii. Irrigation efficiency = 65%.

iii. Roughness Coefficient (n) for earth excavated canals straight and well maintained = 0.023.

iv. Canal bed slope (S) = 0.001.

v. Side slope = 1.5:1 for shallow channels using sandy loam material.

4.4 DESIGN EQUATIONS

$$Q = A.V \quad \text{.......... Equ. (i)}$$

Where:- Q = Discharge in m^3/sec.
A = Cross sectional area in m^2.
V = Velocity of flow in m/sec.

$$A = d(b + Zd) \quad \text{Equ. (ii)}$$

Where:- A = Cross sectional area of flow in m^2
b = Bottom width of the channel in m
d = Flow depth in m
Z = Side slope

$$P = b + 2d\sqrt{Z^2 + 1} \quad \text{Equ. (iii)}$$

Where:- P = Wetted perimeter in m
b, d, Z, as defined above.

$$R = \frac{A}{P} \quad \text{Equ. (iv)}$$

Where:- R = Hydraulic radius in m
A and P as defined above.

$$V = 1/n\ R^{2/3} S^{1/2} \quad \text{Equ. (v)}$$

Where:- V = Velocity of flow in m/s
n = The mannings roughness coefficient
R = Hydraulic radius
S = The canal bed slope.

$$CQt = ad \quad \text{Equ. (vi)}$$

Where:- C = Coefficient of flow
Q = Size of stream in m^3/sec
t = Irrigation application time in sec.
a = Area in m
d = The gross application depth in m.

$$Q = 0.0028CIA \quad \text{Equ. (vii)}$$

Where:- Q = Runoff discharge in m^3/sec
C = Runoff coefficient
I = Rainfall intensity in mm/hr
A = Catchment area in ha

$$T_c = 0.0078L^{0.77}S^{-0.385} \quad \text{Equ. (viii)}$$

Where:- T_c = Time of concentration in min
L = Maximum length of flow in m
S = Water shade gradient in m/m or the difference in elevation between the outlet and the most remote point divided by the length.

$$F = aT^b + c \quad \text{......................................} \quad \text{Equ. (ix)}$$

Where:- F = Cummulative intake (infiltration) in cm
T = Time water is in contact with the soil in min.
a, b and c = constants unique to each intake family which are normally given in table.

$$T_n = \left[(F_n - c)/a\right]^{1/b} \quad \text{......................................} \quad \text{Equ. (x)}$$

Where:- T_n = Opportunity time required for intake of the selected net application depth in min.
F_n = The desired net application depth in m.

$$L = \frac{6 \times 10^4 Q_u T_t}{\frac{aT_t^b}{1+b} + 7.0 + 1798n^{3/8}Q_u^{9/16}T_t^{3/16}} \quad \text{..........} \quad \text{Equ. (xi)}$$

Where:- L = Basin length m
Q_u = Unit inflow rate m^3/sec.
T_t = Required advance time for the desired efficiency in min.
n = Mannings Coefficient.

$$T_a = \frac{F_n L}{600\, Q_u E} \quad \text{......................................} \quad \text{Equ. (xii)}$$

Where:- T_a = The inflow time for the unit flow rate in min.
F_n = Net application depth mm
L = Basin length in m
E = Efficiency in %

$$d = 2250n^{3/8}Q_u^{9/16}T_a^{3/16} \quad \text{......................................} \quad \text{Equ. (xiii)}$$

Where:- d = The inflow depth at the inlet end of the basin strip in min.
n, Q_u, T_a = As defined above.

4.4.1 FORMULAE USED IN THE COMPUTATION OF PARAMETERS

A. Determination of soil texture

i. Percentage sand:-

$$= 100 - [H_1 + 0.36]T_1 - 20^oC] - 2.0]2$$

ii. Percentage clay:-

$$= H_2 + 0.36\,[T_2 - 20^oC] - 2.0]2$$

iii. Percentage silt:-

$$= 100 - [\text{Percentage sand} + \text{Clay}]$$

Where:- H_1 and H_2 are first and second hydrometer readings at 40secs and 3hrs respec tively.
T_1 and T_2 are first and second temperature readings at 40secs and 3hrs respec tively.

Soil textural traingle (U.S.D.A.) was used to know the soil textural class.

B. Formular for the analysis of gravimetric data of the samples.

i. $$F.C.P = \frac{W.F.C - O.D.W \times 100}{O.D.W} \quad (\%)$$

Where:- F.C.P. = Field Capacity Percentage
W.F.C. = Weight at field capacity (fresh weight) gm.
O.D.W. = Oven-dry weight gm

C. $$B.D. = \frac{O.D.W.}{V}$$

Where:- B.D. = Bulk density gm/cm^3
V = Volume of core cylinder cm^3

D. $$P.W.P. = \frac{W.P.P.W - O.D.W.}{O.D.W.} \times 100\%$$

Where:- P.W.P = Permanent wilting point
W.P.P.W = Weight at permanent wilting point (fresh) gm

E. $$A.W. = D_{rz} (F.C. - P.W.P.) / 100cm$$

Where:- A.W. = Available water
D_{rz} = Depth of the root zone cm

F. N.W.A. = A.W. x M.D.

Where:- N.W.A. = Net water application
M.D. = Moisture depletion usually taken as 50%. Larry (1988).

G. $$G.A. = \frac{N.W.A.}{E_i}$$

Where:- G.A. = Gross application cm
E.I = Irrigation efficiency

H. $I.A.T. = \frac{G.A}{I}$

Where:- I.A.T. = Irrigation application time (hr)
I = Infiltration rate

I. $V = \pi r^2 h$

Where:- V = Volume of core cylinder
r = Radius of circular base cm
h = Height of cylinder cm

J. $I.F = \frac{N.W.A.}{E.T_o}$

Where:- I.F = Iriigation frequency (days)
$E.T_o$ = Consumptive use mm/day

K. $E.t_p = r_f(0.45\ T + 8)\ (520 - R^{1.31})/100$

Where:- $E.t_p$ = Potential evapotranspiration (mm/day)
r_f = Ratio of maximum possible radiation to the annual maximum.
T = Temperature ^0C
R = Relative humidity (%)

TABLE 1 MONTHLY RAINFALL (mm) FOR 1990 - 1999

YEAR	JAN	FEB	MARCH	APRIL	MAY	JUNE	JULY	AUGUST	SEPT.	OCT.	NOV.	DEC.	TOTAL
1990	0.0	4.3	0.0	81.8	287.3	117.9	266.0	180.0	160.0	110.1	2.7	0.0	1210.7
1991	0.0	0.5	68.3	50.8	205.9	331.5	237.0	244.7	149.6	75.7	0.0	0.0	1364
1992	0.0	0.0	0.0	141.7	136.6	133.9	128.6	148.4	216.0	31.5	0.0	0.0	936.7
1993	0.0	0.0	61.6	8.9	154.7	241.8	206.8	308.4	240.4	152.8	0.0	0.0	1375.4
1994	0.0	0.0	0.0	38.9	171.9	151.4	75.8	425.7	194.0	102.1	0.0	0.0	1159.8
1995	0.0	0.0	22.9	43.8	92.3	128.7	236.7	307.5	152.2	105.6	12.3	0.0	1102
1996	0.0	18.9	0.0	12.6	199.9	190.7	201.8	326.1	170.5	41.3	0.0	0.0	1161.8
1997	0.0	0.0	64.9	53.9	129.3	279.2	219.0	227.2	147.5	135.4	7.2	0.0	1263.6
1998	0.0	0.0	0.0	67.1	213.2	75.5	239.7	145.5	153.7	103.0	0.0	0.0	997.7
1999	0.0	2.8	0.8	112.1	135.4	196.8	264.1	194.5	153.7	98.0	0.0	0.0	1158.2
Average	0.0	2.65	21.85	61.16	172.65	184.7	207.55	250.86	173.76	95.55	2.22	0.0	

Source:- NCRI

TABLE 2 MONTHLY MAXIMUM TEMPERATURE ^{0}C FOR 1990 - 1999

YEAR	JAN	FEB	MARCH	APRIL	MAY	JUNE	JULY	AUGUST	SEPT.	OCT.	NOV.	DEC.
1990	35	36	39	36	33	33	30	31	31	33	35	35
1991	35	37	37	35	32	32	30	30	32	32	35	33
1992	34	37	38	35	34	32	32	30	31	33	34	35
1993	34	37	37	38	37	32	31	31	32	33	35	35
1994	34	37	40	37	34	32	32	31	31	33	34	34
1995	34	36	39	38	35	33	32	31	32	33	35	35
1996	35	37	38	39	34	32	31	30	31	33	35	36
1997	36	37	38	36	34	32	32	32	32	33	36	35
1998	35	39	40	39	34	33	32	30	31	33	36	35
1999	35	37	38	37	34	32	31	30	31	33	35	35
Average	34.7	37	38.4	37	34.1	32.3	31.3	30.6	31.4	32.9	35	34.8

Source:- NCRI

TABLE 3 **MONTHLY MNIMUM TEMPERATURE °C FOR 1990 - 1999.**

YEAR	JAN	FEB	MARCH	APRIL	MAY	JUNE	JULY	AUGUST	SEPT.	OCT.	NOV.	DEC.
1990	19	18	19	24	23	22	23	23	23	23	21	20
1991	17	22	22	24	23	23	22	23	19	20	18	14
1992	13	14	21	23	22	23	21	21	21	21	18	13
1993	14	17	21	24	23	22	22	22	22	23	22	18
1994	18	18	24	24	24	23	23	23	23	23	19	15
1995	15	17	24	26	24	24	23	23	23	23	19	17
1996	15	21	24	25	23	22	23	22	21	21	16	16
1997	22	20	23	24	23	22	23	23	23	23	21	17
1998	17	21	23	27	25	24	24	24	23	24	20	17
1999	17	20	25	25	24	23	23	23	23	23	21	16
Average	16.7	18.8	22.6	24.7	23.4	22.8	22.7	22.7	22.1	22.4	19.5	16.3

Source:- NCRI

TABLE 4 **MONTHLY WINDRUN (Km) FOR 1990 - 1999.**

YEAR	JAN	FEB	MARCH	APRIL	MAY	JUNE	JULY	AUGUST	SEPT.	OCT.	NOV.	DEC.	TOTAL
1990	9.57	32.93	50.34	94.86	41.54	31.25	13.42	16.68	27.47	16.24	6.60	16.06	356.96
1991	10.50	37.86	43.74	64.64	47.58	26.29	15.07	20.39	19.41	11.54	1.50	5.23	303.75
1992	31.12	38.38	60.76	63.80	52.18	25.76	18.35	14.90	18.77	8.23	10.51	5.14	347.9
1993	26.27	42.58	75.29	141.89	131.12	88.51	75.61	73.26	80.86	60.75	36.08	38.24	870.48
1994	48.87	57.76	98.94	137.18	105.73	98.81	83.23	84.66	90.80	68.50	37.21	48.01	957.7
1995	41.99	62.51	89.36	115.86	98.57	107.27	85.26	77.72	81.01	65.84	47.29	38.03	910.7
1996	39.16	77.17	82.22	142.92	109.43	85.89	75.33	70.89	69.62	50.02	24.85	13.70	841.2
1997	22.70	48.61	72.89	102.08	83.22	80.49	84.61	74.91	88.11	72.85	41.11	38.43	810.51
1998	46.73	69.30	85.29	125.21	88.43	76.72	74.97	71.95	69.43	67.72	35.98	31.56	843.3
1999	42.22	53.19	96.82	119.21	112.91	92.38	92.39	84.33	87.74	68.02	35.76	39.88	832.5
Average	31.9	52.03	75.57	110.8	87.12	71.34	61.8	58.98	62.82	48.97	27.69	27.43	

Source:- NCRI

TABLE 5 MONTHLY SUNSHINE HOURS FOR 1990 - 1999.

YEAR	JAN	FEB	MARCH	APRIL	MAY	JUNE	JULY	AUGUST	SEPT.	OCT.	NOV.	DEC.	MEAN
1990	5.2	6.4	6.7	7.4	7.3	6.0	4.4	5.7	5.2	7.5	6.1	7.6	6.29
1991	5.0	6.0	7.1	7.6	7.5	6.2	4.5	6.2	5.4	7.8	6.5	7.9	6.48
1992	5.1	6.7	3.2	6.3	7.0	5.1	4.1	5.3	4.7	8.2	7.8	8.1	5.97
1993	5.7	7.9	7.2	8.1	7.6	6.0	4.8	5.5	7.1	6.9	6.3	7.1	6.68
1994	5.4	7.6	7.3	6.8	7.5	6.1	4.5	5.1	6.7	7.7	6.4	7.6	6.56
1995	5.0	7.0	7.2	7.1	7.4	6.2	4.7	3.7	5.4	7.2	8.6	8.2	6.48
1996	5.3	7.5	7.0	6.9	7.2	6.1	4.5	4.1	5.9	7.5	8.1	7.9	6.50
1997	5.8	8.1	7.5	7.3	7.7	6.7	4.6	4.8	5.8	6.3	9.5	7.2	6.72
1998	6.1	7.3	7.2	7.1	7.6	5.8	4.5	4.7	5.6	7.4	8.8	7.7	6.65
1999	7.8	8.1	8.7	7.7	7.1	5.3	4.7	4.9	5.5	7.8	8.6	7.5	6.98
Monthly mean	5.64	7.26	6.92	7.23	7.39	5.88	4.53	5.0	5.73	7.43	7.67	7.68	

Source:- Bida Meteorological Station

TABLE 6 MONTHLY PERCENTAGE RELATIVE HUMIDITY FOR 1990 - 1999.

YEAR	JAN	FEB	MARCH	APRIL	MAY	JUNE	JULY	AUGUST	SEPT.	OCT.	NOV.	DEC.
1990	72	52	47	72	82	86	89	87	87	86	86	81
1991	41	72	72	81	85	88	91	92	88	88	81	66
1992	65	53	66	82	84	86	88	87	87	82	62	63
1993	51	52	62	67	75	85	87	87	87	83	80	67
1994	66	46	66	69	80	84	84	85	85	81	69	53
1995	50	40	69	69	75	81	84	89	85	81	67	69
1996	67	65	65	65	78	83	86	88	87	77	65	68
1997	57	30	54	70	77	82	84	82	83	82	72	57
1998	52	43	33	68	82	82	85	84	85	82	74	59
1999	54	57	68	70	79	85	87	86	86	85	72	63
Average	57.5	51	60.2	71.3	79.7	84.2	87	87	86	82.7	72.8	64.6

Source:- NCRI

TABLE 7 MONTHLY RADIATION (mm) FOR 1990 - 1999.

YEAR	JAN	FEB	MARCH	APRIL	MAY	JUNE	JULY	AUGUST	SEPT.	OCT.	NOV.	DEC.
1990	427.1	468.0	583.5	511.1	489.6	449.6	359.4	397.7	453.3	489.1	511.4	467.1
	13.8	16.1	18.8	17.0	15.8	15.0	11.6	12.2	15.1	15.8	17.0	15.1
1991	450.5	471.7	494.3	491.4	437.9	444.6	379.7	354.1	423.0	452.6	509.9	451.9
	14.5	16.8	15.9	16.4	14.1	14.8	12.2	11.4	14.1	14.6	17.0	14.6
1992	463.0	517.7	484.0	488.7	496.7	390.9	381.2	766.9	395.5	512.9	491.6	475.1
	14.9	17.9	15.6	16.3	16.0	13.0	12.3	24.7	13.2	16.5	16.4	15.3
1993	455.1	489.1	525.2	529.9	479.3	379.0	380.1	385.1	421.2	816.1	393.5	450.5
	14.7	17.5	16.9	17.7	15.5	12.6	12.3	12.4	14.04	23.6	13.1	14.5
1994	400.4	434.7	570.8	478.3	471.3	420.4	379.5	338.4	347.9	447.7	536.5	478.1
	12.9	15.5	18.4	15.9	15.2	14.0	12.2	10.9	11.6	14.4	17.9	15.4
1995	434.0	498.3	509.4	496.0	476.8	414.3	366.2	352.4	410.8	493.3	523.1	476.4
	14.0	17.8	16.4	16.5	15.4	13.8	11.8	11.4	13.7	15.9	17.4	15.4
1996	486.1	504.2	559.8	519.4	482.2	399.3	364.5	500.2	385.6	441.6	530.5	496.9
	15.7	17.4	18.1	17.3	15.6	13.3	11.8	16.1	12.9	14.2	17.7	16.0
1997	458.3	474.7	509.2	507.7	457.3	403.5	407.5	373.8	436.7	453.8	543.9	492.1
	14.8	16.95	16.4	16.9	14.8	13.5	13.1	12.1	14.6	14.6	18.1	15.9
1998	456.8	488.3	535.3	516.1	479.0	432.8	365.7	348.1	383.2	483.0	564.9	461.3
	14.7	17.4	173	17.7	15.5	14.4	11.8	11.2	12.8	15.6	18.8	14.9
1999	459.0	478.4	578.0	512.7	489.5	414.8	383.9	347.3	374.9	476.4	544.6	510.3
	14.8	17.1	18.6	17.1	15.8	13.8	12.4	11.2	12.5	15.4	18.2	16.5
Average	449.03	482.5	534.95	505.13	475.93	414.92	376.77	414.6	403.21	506.7	514.99	475.97
	14.48	17.05	17.26	16.84	15.35	13.8	12.15	13.40	13.44	16.35	17.16	15.35

Source:- Bida Meteorological Station.s

CHAPTER FIVE

5.0 RESULTS AND DISCUSSION

5.1 RESULTS OF LABORATORY EXPERIMENTS

The laboratory experiments carried out gave the following results:-

5.1.1 SOIL TEXTURE

Soil samples used for this experiment weretaken in such a way as to represent the entire field. U.S.D.A. method of soil classification was used to determine the soil class.

From the experiment discribed in section 3.2.1, the following results were obtained:-

TABLE 8

Sample Point/Depth	H_1	H_2	T_1 °C	T_2 °C
P_1 (0 - 15cm)	14.5	0.5	27	27
P_1 (15 - 30cm)	15.0	3	27	27
P_2 (0 - 15cm)	4.5	0.0	26	27
P_2 (15 - 30cm)	12.5	1.5	27	27
P_3 (0 - 15cm)	10.5	1	27	27
P_3 (15 - 30cm)	12.0	1.5	27	27

Where H_1 and H_2 are the first and second hydrometer readings and T_1 and T_2 are the first and second temperature readings in °C.

Using the above result, we have:-

TABLE 9

Laboratory Registration	Sample Point/Depth	% Sand	%Silt	% Clay
1	P_1 (0 - 15cm)	69.96	28.0	2.04
2	P_1 (15 - 30cm)	68.96	24.0	7.04
3	P_2 (0 - 15cm)	90.68	8.28	1.04
4	P_2 (15 - 30cm)	73.96	22.0	4.04
5	P_3 (0 - 15cm)	77.96	19.0	3.04
6	P_3 (15 - 30cm)	74.96	21.0	4.04

From the U.S.D.A. Textural triangle, the textural class of the soil is sandy loam. See Appendix A for the calculations.

5.1.2 BULK DENSITY (B.D)

The soil samples obtained for this experiment were also taken to represent the entire field.

From the experiment described in section 3.2.2, the results obtained were:-

TABLE 10

Sample Point/Depth	Fresh Weight	Dry Weight	Volume of Sample	Bulk Density (gm/cm^3)
P_1 (0 - 15cm)	477.75	436.59	288.67	1.51
P_1 (15 - 30cm)	448.44	425.82	288.67	1.48
P_2 (0 - 15cm)	482.41	412.92	288.67	1.43
P_2 (15 - 30cm)	556.96	507.88	288.67	1.76
P_3 (0 - 15cm)	522.70	497.46	288.67	1.72
P_3 (15- 30cm)	485.7	450.78	288.67	1.56

Bulk Density (B.D) = 1.58gm/cm³ (Average value). See Appendix A.

5.1.3 INFILTRATION RATE (I)

The result of the infiltration rate experiment described in section 3.2.3 is as follows:-

TABLE 11

Time (mins)	Infiltration (cm)	Cummulative Infiltration	Infiltration Rate(cm/hr)
0	0.0	-	-
10	2.0	2.0	12
20	1.25	3.25	7.5
30	1.0	4.25	6
40	0.75	5.0	4.5
50	1.0	6.0	6
60	1.0	7.0	6
70	0.75	7.75	4.5

Infiltration Rate (I) = 6.64cm/hr (Average value). See Appendix A for calculations

5.1.4 FIELD CAPACITY (F.C)

Below is the result of field capacity as determined in the laboratory.

TABLE 12

Laboratory Registration	sample point/ Depth (cm)	Field Capacity (%)
1	P_1 (0 - 15cm)	13.79
2	P_1 (15 - 30cm)	9.84
3	P_2 (0 - 15cm)	11.93
4	P_2 (15 - 30cm)	8.32
5	P_3 (0 - 15cm)	11.90
6	P_3 (15 - 30cm)	5.45

Field capacity (F.C) = 10.21% (Average value).

5.1.5 PERMANENT WILTING POINT (P.W.P)

The result of permanent wilting point experiment as described in section 3.2.4 is as follows:-

TABLE 13

Sample Point/Depth	Fresh Weight	Dry Weight	P.W.P (%)
P_1 (0 - 15cm)	133.33	132.46	0.6568
P_1 (15 - 30cm)	163.50	156.57	4.4261
P_2 (0 - 15cm)	129.58	125.67	3.1113
P_2 (15 - 30cm)	170.11	165.78	2.6118
P_3 (0 - 15cm)	153.98	153.58	0.2605
P_3 (15 - 30cm)	124.00	123.83	0.1373

Permanent wilting point (P.W.P) % = 1.94%.

5.2 OTHER PARAMETERS OBTAINED

The results obtained from sections 5.1.3 to 5.1.5 were used to determine the following parameters:-

i. Available water (A.W) = 4.96cm
ii. Net water application (N.W.A) = 2.48cm
iii. Gross application (G.A.) = 3.82cm
iv. Irrigation application time (I..A.T) = 0.58hrs

5.3 DISCUSSION OF RESULTS

In discussing the above results, the following limitations were considered:-

i. While bagging and transporting the soil samples from the site to the laboratory, the soil structures were disturbed.
ii. The metal core sampler used for sampling was locally constructed.

iii. The ring infiltrometers used for the infiltration rate experiment was also locally con structed.

iv. In wetting the soil for the permanent wilting and field capacity experiments, ideal conditions were assumed.

The limitations will definately have some effects on the results of the experiments conducted. However, values obtained for the infiltration rate, field capacity and permanent wilting point are 6.64cm/hr, 10.21% and 1.94% respectively.

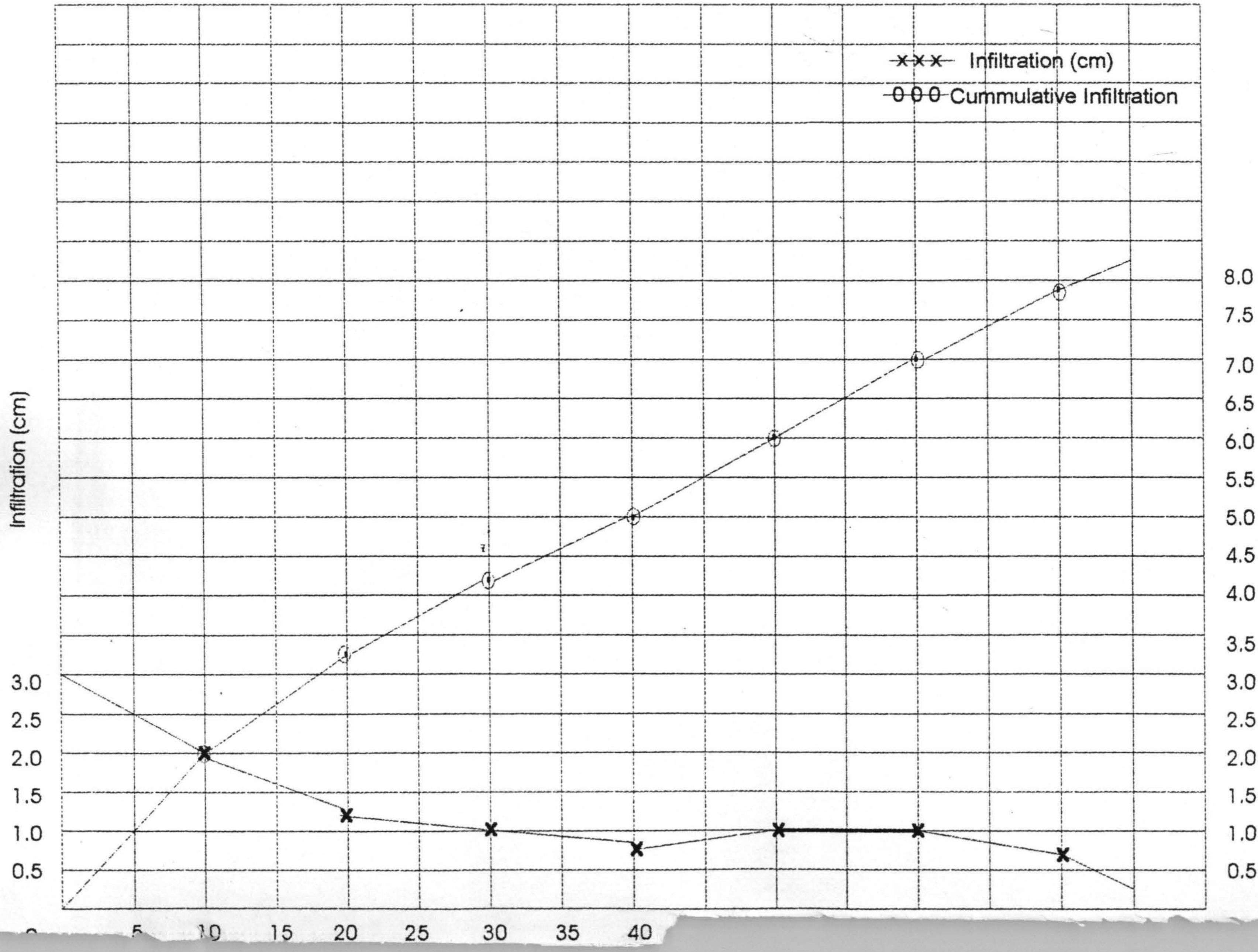
The values of infiltration rate of 6.64cm/hr and field capacity of 10.21% fall within the standard range of between 1.3 - 7.6cm/hr according to Israelsen Hensen (1979) and (5 - 15)% according to A.M. Micheal (1978).

Though the permanent wilting point of 1.94% obtained from the experiment did not fall within the ranges given by Israelsen Hansen (1979) and A.M. Micheal (1978) 4 - 8%, 3 - 8% and 15 - 27%, permanent wilting is not a soil constant or a unique soil property. There is no single soil water content at which plant cease to withdraw water even though wilted, plant will absorb water, but not at rates sufficient to regain tugor. Hansen (1983).

The soil Bulk density (B.D) is influenced by the structure, texture and degree of compaction of the soil. However, Bulk density is the ratio of the dried weight of soil, to an equal volume and since care was taken to ensure that there was no particle loss during the experiment, the value of 1.58gm/cm^3 obtained can also be said to be authentic.

The values obtained for available water, net water application, gross application and irrigation application time are strictly based on the experimental values obtained from other parameters mentioned above.

Fig 1 Infiltration against time and Cummulative Infiltration against time



CHAPTER SIX

6.0 ECONOMIC ANALYSIS

6.1 CONSTRUCTION COST

Though the contour map prepared by the Ministry was adopted for use in this design work, the production of this map involves:-

-	Two (2) surveyors for N500.00 per day x 5 days	=	N5,000.00
-	Four (4) chain men for N250.00 per day x 5 days	=	N2,500.00
-	One (1) draught man for N500.00 for plotting		
-	One (1) draught man for N200.00 for tracing		
	TOTAL COST	=	N8,200.00

6.1.1 COST OF CANAL EXCAVATION BY VOLUME AND EMBANKMENT COMPACTION

a. **Main canal:-**

Area = $0.191m^2$ (See Appendix B_1)

-	Excavation per meter lenght will give a volume of $0.191m^3$.				
-	Total lenght of canal	=	1000m		
-	Total volume to be excavated	=	1000 x 0.191	=	$191m^3$.
-	Cost of excavation per meter lenght			=	N100.00
-	Total cost of excavation	=	N100 x 191	=	N1,910.00

b. **Field channel 1:-**

Area = $0.0308m^2$.

-	Total lenght	=	400m		
-	Total volume to be excavated	=	400 x 0.0308	=	$12.32m^3$.
-	Cost of excavation	=	N100 x 12.32	=	N1,232.00

c. **Field channel 2:-**

Area = $0.0250m^2$.

-	Total lenght	=	700m		
-	Total volume to be excavated	=	700 x 0.0250	=	$17.50m^3$.
-	Total cost of excavation	=	N100 x 17.50	=	N1,750.00

d **Field channel 3:-**

Area = $0.0202m^2$.

-	Total lenght	=	450m		
-	Total volume to be excavated	=	450 x0.0202	=	$9.09m^3$.
-	Total cost of excavation	=	N100 x 9.09	=	N909.00

e. **Field channel 4:-**
Area = 0.0298m².

-	Total lenght	=	700m	
-	Total volume to be excavated	=	700 x 0.0298 =	20.86m³.
-	Total cost of excavation	=	N100 x 20.86 =	N2,086.00

f. **Field channel 5:-**
Area = 0.0319m².

-	Total lenght	=	518m	
-	Total volume to be excavated	=	518 x 0.0319 =	16.52m³.
-	Total cost of excavation	=	N100 x 16.52 =	N1,652.00

g. **Field channel 6:-**
Area = 0.0274m².

-	Total lenght	=	621m	
-	Total volume to be excavated	=	621 x 0.0274 =	17.02m³.
-	Total cost of excavation	=	N100 x 17.02 =	N1,702.00

h. **Field channel 7:-**
Area = 0.0274m².

-	Total lenght	=	621m	
-	Total volume to be excavated	=	621 x 0.0274 =	17.02m³.
-	Total cost of excavation	=	N100 x 17.02 =	N1,702.00

i. **Drainage Construction:-**
Area = 0.0031m².

-	Total lenght	=	3946.32m	
-	Total volume to be excavated	=	3946.32 x 0.0031=	12.23m³.
-	Total cost of excavation	=	N100 x 12.23 =	N1,223.00
	Total cost of channel and drainage construction		=	**N14,166.00**

6.1.2 COST OF IRRGATION STRUCTURES AND EQUIPMENT

a.
- 2 A.C pipe of 5cm diameter for the drains
- Each cost N2,000.00
- Total cost for the 2 = N4,000.00

b.
- 10 plastic pipes (13.2mm) diameter for the field channels
- Each cost N500.00
- Total cost for the 10 = N5,000.00

c.
- Cost of constructing 1 distribution box, labour and materials inclusive = N1,000.00
- Total cost for the 5 = N 5,000.00

d. - Cost of constructing the stilling basin is estimated to be N2,000.00

TOTAL COST = N16,000.00

6.2 COST OF IRRIGATION PUMP

a. - 2 H-R3 pumps to be purchased at the rate of N250,000.00 each.
- Total cost for the 2 pumps = N500,000.00

b. - Cost of fuel (diesel)
- Tank capacity is 32litres which will cost N22 x 32 = N704.00 to be able to work for a day.

6.3 COST OF WATER SUPPLY

- 2 irrigators are required per day for N250.00 each.
- Total cost = N250.00 x 2 = N500.00 per day
- One pump operator for N350.00 per day

Total cost of water supply per day = N850.00

6.4 COST OF MAINTENANCE

a. - Seasonal maintenance of the main canal, field channels and all the irrigation structures:-
  - 10 labourers are required for N250.00 per day for 4 weeks
    = N250.00 x 10 x 30 = N75,000.00.

b. - Pump maintenance:-
These include cost of servicing and labour cost per season which is estimated to be N20,000.00.

Therefore, total cost of maintenance = labour + pump mantenance cost = N95,000.00.

Item 6.1 to 6.4 constitute irrigation cost. Total cost of irrigation for the project
= N634,920.00.

6.5 CROP PRODUCTION COST

- Cultivation per hectare (land preparation) will cost N1,200.00
- Cost of seed for planting per hectare = N120.00
- Cost of planting per hectare = N500.00
- Cost of weeding per hectare = N800.00
- 4 bags of fertilizer (N.P.K) is required per hectare, each cost N1,000.00 including cost of transportation and handling charges.
- Cost of harvesting per hectare = N1,000.00
- Cost of threshing and bagging per hectare = N1,500.00

Total cost of production per hectare = N6,120.00

For the total land area of 120ha, the crop production cost will be

= N6,120.00 x 120 = N734,400.00

6.6 OUT PUT:-

Yield of rice in tones per hectare under normal circumstances is estimated to be 2 tones (40 bags)

- Total yield expected for the whole area = 40 x 120 = 4,800 bags
- Cost of rice per bag = N1,000.00
- Total cost of rice per hectare = N1,000 x 40 = N40,000.00
- Total cost for the total land area of 120ha = N40,000.00 x 120 = N4,800,000.00.

6.7 COST BENEFIT RATIO

Cost benefit ratio also known as expenditure - income ratio is the ratio of total investment per year or production season to the total benefit anticipated from the project for the same period.

A project is said to viable when the benefit (income) is greater than the cost (expenditure). From the calculations above, the total cost (expenditure) is N1,369,320.00 while the benefit is N4,800,000.00.

Therefore, the cost benefit ratio = $\frac{N1,369,320.00}{N4,800,000.00.} = \frac{1}{3} = 1:3$

The cost benefit ratio arrived at indicate the viability of the project for the cropping season under consideration. Since most of the items that constitute the irrigation cost are permanent items, this will definately reduce the irrigation cost in the subsequent years, thus, leading to a continually increased benefit over cost.

The viability of this project work will be even be more than the initial cropping season.

CHAPTER SEVEN

CONCLUSION AND RECOMMENDATIONS

CONCLUSION

The field capacity (FC), Permanent wilting point (P.W.P), Bulk density (B.D) and Infiltration rate (I) of the soil sample were found to be 10.21%, 1.94%, 1.58gm/cm^3 and 6.64cm/hr respectively.

The average monthly irrigation frequency obtained was 7 days. However, the monthly irriga tion frequencies obtained should serve as a giude to the irrigator and should use his discretion where conditions do not permit strict adherence to the calculated values.

. The irrigation application time was calculated to be equal to 0.58hrs. To achieve the design irrigation efficiency, therefore, the irrigator must not deviate from the said time by more than 20min.

4. The design values obtained for the canals, field drainds and those for the basins are given in appendix B_1 and B_2.

5. An economic analysis of the project shows that the project will cost N1,369,320.00 while the benefit will be N4,800,000.00. This gave a cost benefit ratio of 1:3 indicating the viability of the project.

2 RECOMMENDATIONS

Finally, it is recommended that any one who wishes to adopt this design work should adjust the alues obtained to suit local conditions of soil, weather and economy.

The use of two (2) H-R3 pump (Lister engine) which 21HP and has a discharge of 2.7 cusecs 0.0765m^3/sec) is hereby recommended for the design work.

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APPENDIX A SIMPLE CALCULATION OF PARAMETERS

A. DETERMINATION OF SOIL TEXTURE

i. Point One $(P_1(0 - 15cm))$

Percentage sand:-

100 - [14.5 + 0.36] 27 - 20] - 2.0]2 = 69.96%

Percentage clay:-

0.5 + 0.36 [27 - 20] - 2.0]2 = 2.04%

Percentage silt:-

100 - [69.96 + 2.04] = 28%

Point One $(P_1(15 - 30cm))$

Percentage sand:-

100 - [15.0 + 0.36] 27 - 20] - 2.0] 2 = 68.96%

Percentage clay:-

3 + 0.36 [27 - 20] -2.0]2 = 7.04%

Percentage silt:-

100 - [68.96 + 7.04] = 24%

ii. Point Two $(P_2(0 - 15cm))$

Percentage sand:-

100 - [4.5 +0.36] 26 - 20] -2.0]2 = 90.68%

Percentage clay:-

0.0 + 0.36[27 - 20] -2.0]2 = 1.04%

Percentage silt:-

100 - [90.68 + 1.04] = 8.28%

Point Two $(P_2(15 - 30cm))$

Percentage sand:-

100 - [12.5 + 0.36] 27 - 20]-2.0]2 = 73.96%

Percentage clay:-

1.5 + 0.36 [27 - 20] -2.0]2 = 4.04%

Percentage silt:-

100 - [73.96 + 4.04] = 22%

iii. **Point Three $(P_3(0 - 15cm))$**

Percentage sand:-

100 - [10.5 + 0.36] 27 - 20] -2.0]2 = 77.96%

Percentage clay:-

1 + 0.36[27 -20]-2.0]2 = 3.04%

Percentage silt:-

100 - [77.96 + 3.04] = 19.0%

Point Three $(P_3(15 - 30cm))$

Percentage sand:-

100 - [12.0 + 0.36] 27 - 20] -2.0]2 = 74.96%

Percentage clay:-

1.5 +0.36 [27 - 20] -2.0]2 = 4.04%

Percentage silt:-

100 - [74.96 + 4.04] = 21%

From the U.S.D.A Textural triangle, the soil class is sandy loam.

B. **BULK DENSITY (B.D)**

$$\frac{455.24}{288.67} = 1.58gm/cm^3.$$

C. **PERMANENT WILTING POINT (P.W.P.)**

$$\frac{145.75 - 142.98}{142.98} \times 100 = 1.94\%$$

D. **AVAILABLE WATER (A.W.)**

$$\frac{60\ (10.21 - 1.94)}{100} = 4.96cm$$

E. **NET WATER APPLICATION (N.W.A.)**

Moisture deficit (M.D) is taken as 50%. Larry (1988).

4.96 x 0.5 = 2.48cm

F. **GROSS APPLICATION (G.A.)**

$$\frac{2.48}{0.65} = 3.82cm$$

G. INFILTRATION RATE (I)

$$\frac{7.75}{10/60} = 6.64\text{cm/hr}$$

H. IRRIGATION APPLICATION TIME (I.A.T.)

$$\frac{3.82}{6.64} = 0.58\text{hrs}$$

I. VOLUME OF CORE SAMPLER

$$3.142\,(3.5)^2\,(7.5) = 288.67\text{m}^3$$

APPENDIX B_1 **DESIGN CALCULATIONS**

MAIN CANAL DESIGN:-

Data:- a = 120ha C = 100 d = 0.0382m t = 0.58hrs

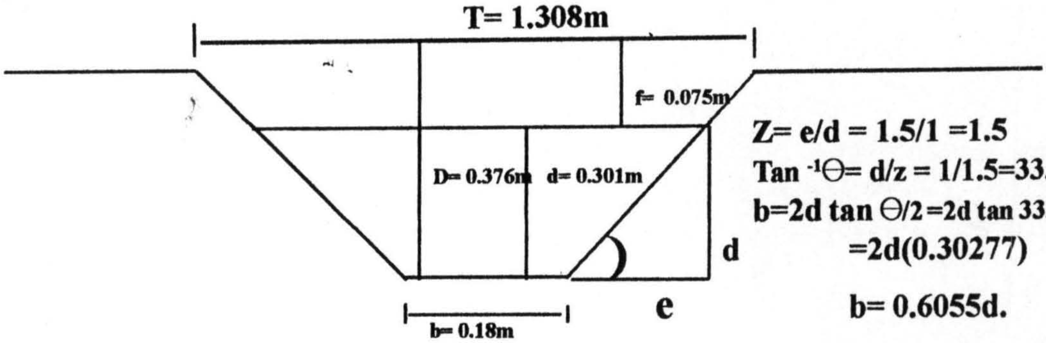
From CQt = a.d $\longrightarrow Q = \frac{a.d}{Ct} = \frac{120 \times 10{,}000 \times 0.0382}{100 \times 0.58 \times 3{,}600} = 0.2195m^3/sec.$

Adding 20% to cover losses, we have:

$0.2195 + 0.2195 \times 0.2 =$ $0.2634m^3/sec$

Q(Main canal) = $0.2634m^3/sec$. Discharge to be pumped into the main canal.

Figure 2:



Z= e/d = 1.5/1 =1.5
$Tan^{-1}\Theta$= d/z = 1/1.5=33.69^0
b=2d tan Θ/2 =2d tan 33.69/2
=2d(0.30277)

b= 0.6055d.

Data: Q = $0.263m^3/sec$, n = 0.023, S =0.001, Side slope = 1.5: 1

Q = A V, A = d(b + z d), $P = b + 2d\sqrt{Z^2 + 1}$, R = A/P = d/2 for optimal or best hydraulic section.

$V = 1/nR^{2/3}S^{1/2}$, T = b + 2DZ

Using trial and error method:-

When d = 0.304m

b = 0.6055 x 0.304 = 0.1841m

A = 0.304(0.2422 + 1.5 x 0.304) = $0.195m^2$.

$P = 0.2422 + 2 \times 0.304\sqrt{1.5^2 + 1}$ = 1.280m.

$R = \frac{0.337}{2.842} = \frac{0.304}{2} = 1.002m$

$V = \frac{1}{0.023}(1.002)^{2/3}(0.001)^{1/2}. = 1.377m/sec$

Q = 0.195 x 1.377 = $0.269m^3/sec$

When d = 0.301m

A = $0.191m^2$.

P = 1.268m

R = 1.001m

V = 1.376m/sec

Q = $0.263m^3/sec$ (OK)

b = 0.6055 x 0.301 = 0.18m

d = 4/5D, D = 0.301/0.8 = 0.376m

f (D - d) = 0.376 - 0.301 = 0.075m

T = 0.18 + 2 x 0.376 x 1.5 = 1.308m

When d = 0.302m

A = $0.192m^2$

P = 1.272m

R = 0.1000m

V = 1.375m/sec

Q = $0.264m^3/sec$

Summary:-

Q = $0.265m^3/sec$

d = 0.36m

b = 0.218m

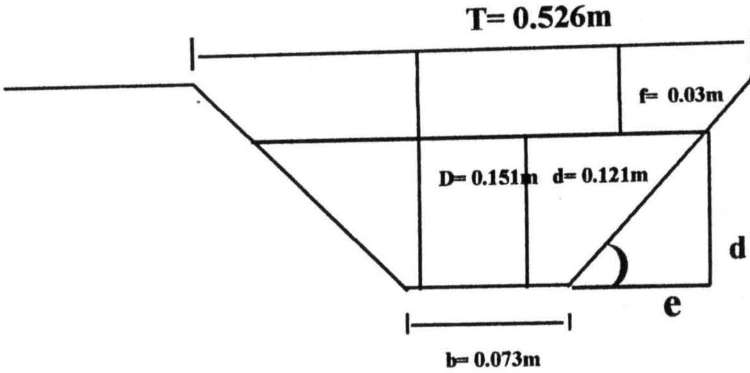
D =0.45m

f= 0.09m

T = 1.568m

FIELD CHANNEL 1

Figure 3:



Z= e/d = 1.5/1 =1.5
$Tan^{-1}\Theta$= d/z = 1/1.5=33.69⁰
b=2d tan Θ/2 =2d tan 33.69/2
=2d(0.30277)

b= 0.6055d.

Data:- a = 19.4ha, C =100, d = 0.0382m, t = 0.58hrs

From CQt = a d ⟶ Q = $\frac{a\,d}{C\,t} = \frac{19.4 \times 10{,}000 \times 0.0382}{100 \times 0.58 \times 3{,}600}$ = 0.035m³/sec

Adding 20% to cover losses, we have:-

0.035 + 0.035 x 0.2 = 0.042m³/sec Q(F.C 1) = 0.042m³/sec

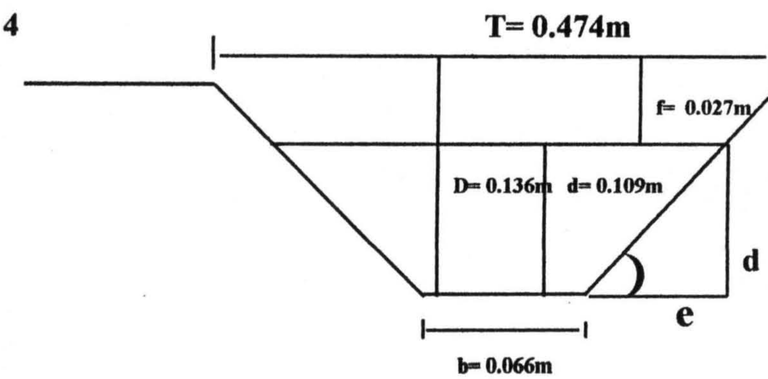
Using trial and error:-

When d = 0.126m	When d = 0.124m	When d = 0.122m	When d = 0.121m
A = 0.0334m².	A = 0.0324m²	A = 0.0313m²	A = 0.0308m²
P = 0.5306m	P = 0.5222m	P = 0.5138m	P = 0.5096m
R = 0.9992m	R = 1.0007m	R = 0.9987m	R = 0.9990m
V = 1.374m/sec	V = 1.376m/sec	V = 1.374m/sec	V = 1.374m/sec
Q = 0.0459m³/sec	Q = 0.045m³/sec	Q = 0.043m³/sec	Q = 0.042m³/sec

Summary:- Q = 0.042m³/sec, d = 0.121m, D = 0.151m, b = 0.073m, f = 0.03m, T = 0.526m

FIELD CHANNEL 2

Figure 4



Z= e/d = 1.5/1 =1.5
$Tan^{-1}\Theta$= d/z = 1/1.5=33.69⁰
b=2d tan Θ/2 =2d tan 33.69/2
=2d(0.30277)

b= 0.6055d.

Data:- a = 15.18ha, C = 100, d = 0.0382m, t = 0.58hrs

From CQt = a d ⟶ $Q = \frac{a\,d}{C\,t} = \frac{15.18 \times 10{,}000 \times 0.0382}{100 \times 0.58 \times 3{,}600} = 0.028 m^3/sec$

Adding 20% to cover losses, we have:-

$0.028 + 0.028 \times 0.2 = 0.034 m^3/sec$ Q (F.C 2) = $0.034 m^3/sec$

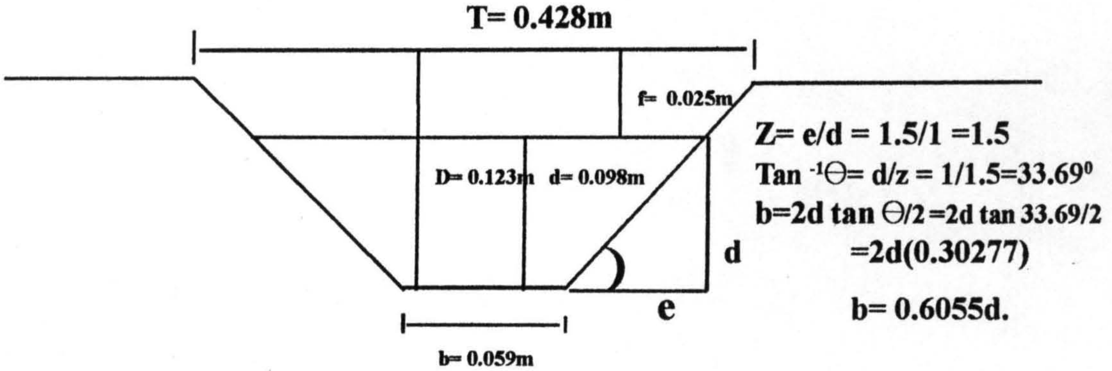
Using trial and error:-

When d = 0.11m	When d = 0.105m	When d = 0.108m	When d = 0.109m
A = $0.0255m^2$.	A = $0.0232m^2$	A = $0.0186m^2$	A = $0.0250m^2$
P = 0.4633m	P = 0.4422m	P = 0.4548m	P = 0.4591m
R = 1.0007m	R = 0.9993m	R = 0.7574m	R = 0.9992m
V = 1.3755m/sec	V = 1.3743m/sec	V = 1.1414m/sec	V = 1.3742m/sec
Q = $0.0351m^3/sec$	Q = $0.0319m^3/sec$	Q = $0.0212m^3/sec$	Q = $0.034m^3/sec$

Summary:- Q = $0.034m^3/sec$, d = 0.109m, D = 0.136m, b = 0.066m, f = 0.027m, T = 0.474m

FIELD CHANNEL 3

Figure 5:



Data:- a = 12.4ha, C = 100, d = 0.0382m, t = 0.58hrs

From CQt = a d ⟶ $Q = \frac{a\,d}{C\,t} = \frac{12.4 \times 10{,}000 \times 0.0382}{100 \times 0.58 \times 3{,}600} = 0.023 m^3/sec$

Adding 20% to cover losses, we have:-

$0.023 + 0.023 \times 0.2 = 0.028 m^3/sec$ Q(F.C 3) = $0.028 m^3/sec$

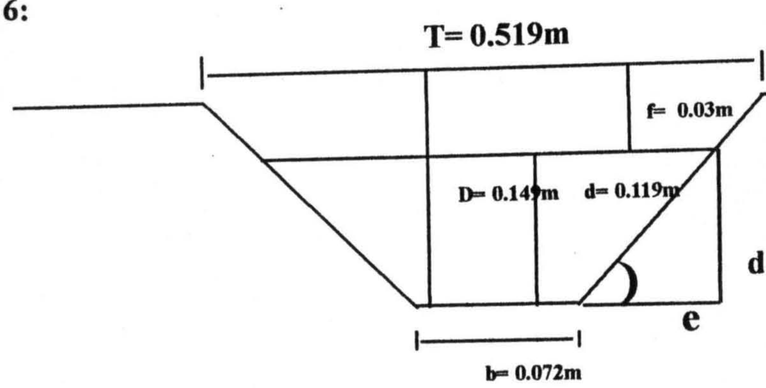
Using trial and error:-

When d = 0.101m	When d = 0.10m	When d = 0.095m	When d = 0.098m
A = $0.0215m^2$.	A = 0.0211m	A = $0.0190m^2$	A = $0.0202m^2$
P = 0.4254m	P = 0.4212m	P = 0.4001m	P = 0.4127m
R = 1.0008m	R = 1.0019m	R = 0.9998m	R = 0.9989m
V = 1.3756m/sec	V = 1.3767m/sec	V = 1.3747m/sec	V = 1.3739m/sec
Q = $0.0296m^3/sec$	Q = $0.0290m^3/sec$	Q = $0.0261m^3/sec$	Q = $0.0278m^3/sec$

Summary:- Q = $0.028m^3/sec$, d = 0.098m, D = 0.123m, b = 0.059m, f = 0.025m, T = 0.428m

FIELD CHANNEL 4

Figure 6:



Z= e/d = 1.5/1 =1.5
Tan $^{-1}\Theta$= d/z = 1/1.5=33.69^0
b=2d tan Θ/2 =2d tan 33.69/2
=2d(0.30277)
b= 0.6055d.

Data:- a = 18.32ha, C = 100, d = 0.0382m, t = 0.58hrs

From CQt = a d ⟶ $Q = \frac{a\,d}{C\,t} = \frac{18.32 \times 10{,}000 \times 0.0382}{100 \times 0.58 \times 3{,}600}$ = 0.034m³/sec

Adding 20% to cover losses, we have:-
0.034 + 0.034 x 0.2 = 0.041m³/sec. Q (F.C 4) = 0.041m³/sec

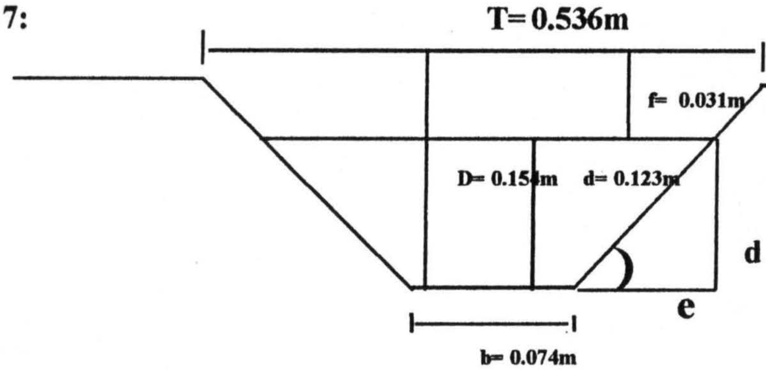
Using trial and error:-

When d = 0.121m	When d = 0.120m	When d = 0.115m	When d = 0.119m
A = 0.0308m²	A = 0.0303m²	A = 0.0278m²	A = 0.0298m²
P = 0.5096m	P = 0.5054m	P = 0.4843m	P = 0.5012m
R = 0.9990m	R = 0.9992m	R = 0.9977m	R = 0.9993m
V = 1.374m/sec	V = 1.3742m/sec	V = 1.3728m/sec	V = 1.3743m/sec
Q = 0.042m³/sec	Q = 0.0416m³/sec	Q = 0.0382m³/sec	Q = 0.041m³/sec

Summary:- Q = 0.041m³/sec, d = 0.1119m, D = 0.149m, b =0.072m, f = 0.03m, T = 0.519m

FIELD CHANNEL 5

Figure 7:



Z= e/d = 1.5/1 =1.5
Tan $^{-1}\Theta$= d/z = 1/1.5=33.69^0
b=2d tan Θ/2 =2d tan 33.69/2
=2d(0.30277)
b= 0.6055d.

Data: a = 20.0ha, C = 100, d = 0.0382m, t = 0.58hrs

From CQt = a d $\longrightarrow$ Q = $\frac{a\,d}{C\,t}$ = $\frac{20.0 \times 10{,}000 \times 0.0382}{100 \times 0.58 \times 3{,}600}$ = $0.037m^3/sec$

Adding 20% to cover losses, we have:-
$0.037 + 0.037 \times 0.2 = 0.044m^3/sec$ Q(F.C 5) = $0.044m^3/sec$

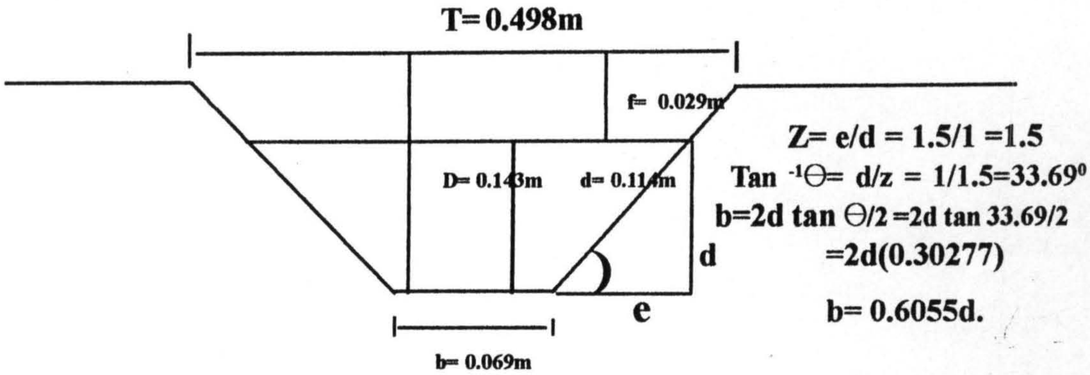
Using trial and error method:-

When d = 0.125m	When d = 0.124m	When d = 0.123m
$A = 0.0329m^2$	$A = 0.0324m^2$	$A = 0.0319m^2$
P = 0.5264m	P = 0.5222m	P = 0.5180m
R = 1.0000m	R = 1.0007m	R = 1.0031m
V = 1.375m/sec	V = 1.376m/sec	V = 1.376m/sec
$Q = 0.0452m^3/sec$	$Q = 0.045m^3/se$	$Q = 0.044m^3/sec$

Summary:- $Q = 0.044m^3/sec$, d = 0.123m, D = 0.154m, b = 0.074m, f = 0.031m, T = 0.536m

FIELD CHANNEL 6

Figure 8:



Data:- a = 17.42ha, C = 100, d = 0.0382m, t = 0.58hrs.

From CQt = a d $\longrightarrow$ Q = $\frac{a\,d}{C\,t}$ = $\frac{17.42 \times 10{,}000 \times 0.0382}{100 \times 0.58 \times 3{,}600}$ = $0.032m^3/sec$

Adding 20% to cover losses, we have:-
$0.032 + 0.032 \times 0.2$ = $0.038m^3/sec$ Q(F.C. 6) = $0.038m^3/sec$

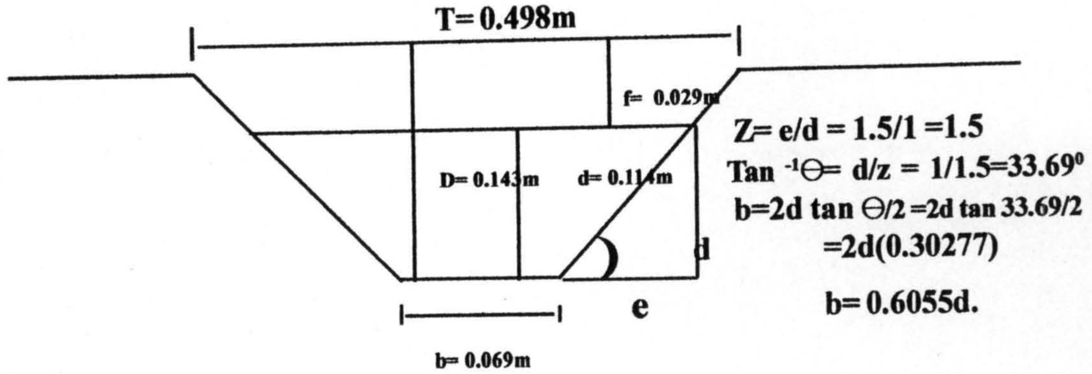
Using trial and error method:-

When d = 0.11m	When d = 0.112m	When d = 0.111m	When d = 0.114m
$A = 0.0255m^2$.	$A = 0.0264m^2$.	$A = 0.0259m^2$.	$A = 0.0274m^2$
P = 0.4633m	P = 0.4717m	P = 0.4675m	P = 0.4801m
R = 1.0007 m	R = 0.9994m	R = 0.9982m	R = 1.0013m
V = 1.3755m/sec	V = 1.3744m/sec	V = 1.3732m/sec	V = 1.3761m/sec
$Q = 0.035m^3/sec$	$Q = 0.036m^3/sec$	$Q = 0.0356m^3/sec$	$Q = 0.038m^3/sec$

Summary:- $Q = 0.038m^3/sec$, d = 0.114m, D = 0.143m, b = 0.069m, f = 0.029m, T = 0.498m

FIELD CHANNEL 7

Figure 9:



Data:- a = 17.42ha, C = 100, d = 0.0382m, t = 0.58hrs.

From CQt = a d ⟶ Q = $\frac{a\,d}{C\,t} = \frac{17.42 \times 10{,}000 \times 0.0382}{100 \times 0.58 \times 3{,}600} = 0.032\text{m}^3/\text{sec}$

Adding 20% to cover losses, we have:-
0.032 + 0.032 x 0.2 = 0.038m^3/sec Q(F.C. 6) = 0.038m^3/sec

Using trial and error method:-

When d = 0.11m	When d = 0.112m	When d = 0.111m	When d = 0.114m
A = 0.0255m^2.	A = 0.0264m^2.	A = 0.0259m^2.	A = 0.0274m^2
P = 0.4633m	P = 0.4717m	P = 0.4675m	P = 0.4801m
R = 1.0007 m	R = 0.9994m	R = 0.9982m	R = 1.0013m
V = 1.3755m/sec	V = 1.3744m/sec	V = 1.3732m/sec	V = 1.3761m/sec
Q = 0.035m^3/sec	Q = 0.036m^3/sec	Q = 0.0356m^3/sec	Q = 0.038m^3/sec

Summary:- Q = 0.038m^3/sec, d = 0.114m, D = 0.143m, b = 0.069m, f= 0.029m, T = 0.498m

FIELD DRAIN DESIGN USING F.C 7

First we have to determine Time of consentration (T_c)

$T_c = 0.0195L^{0.77}S^{-0.385}$ in min

L = 621m, S = 0.0046

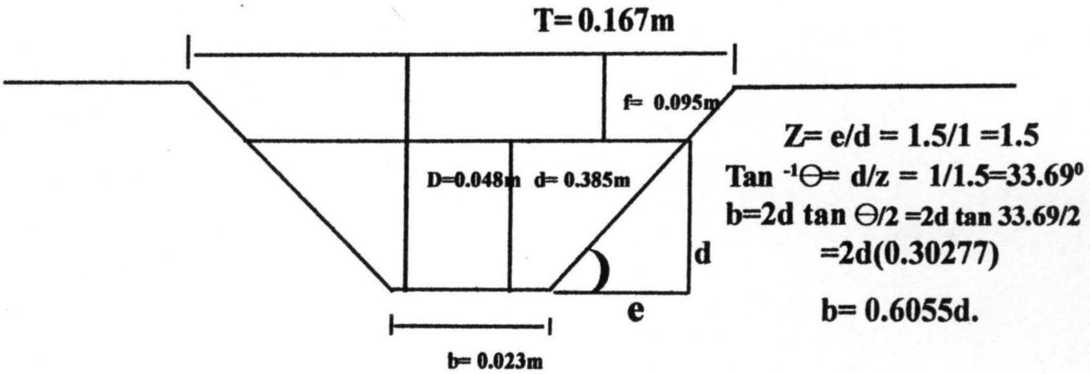
$T_c = 0.0195\,(621)^{0.77}(0.0046)^{-0.385}$ = 22min

Rainfall intensity from the graph of rainfall intensity versus Time = 125mm/hr from Fig 11 and Runoff coefficent. from table14 = 0.25 using 10years return period since I used 10years record.

Q = 0.0028CIA

= 0.0028 x 0.25 x 125/1000 x 3600 x 17.28 x 10,000= 0.042m^3/sec

Figure 10:



Using trial and error:-

When d = 0.038m	When d = 0.039m	When d = 0.0385m
A = 0.0030m².	A = 0.0032m²	A = 0.0031m²
P = 0.160m	P = 0.164m	P = 0.162m
R = 0.987m	R = 1.0000m	R = 0.994m
V = 1.363m/sec	V = 1.375m/sec	V = 1.369m/sec
Q = 0.0041m³/se	Q = 0.0044m³/sec	Q = 0.0042m³/sec

Summary:- Q = 0.0042m³/sec, D = 0.048m, d = 0.0385m, b = 0.023m, f = 0.0095m, T = 0.167m

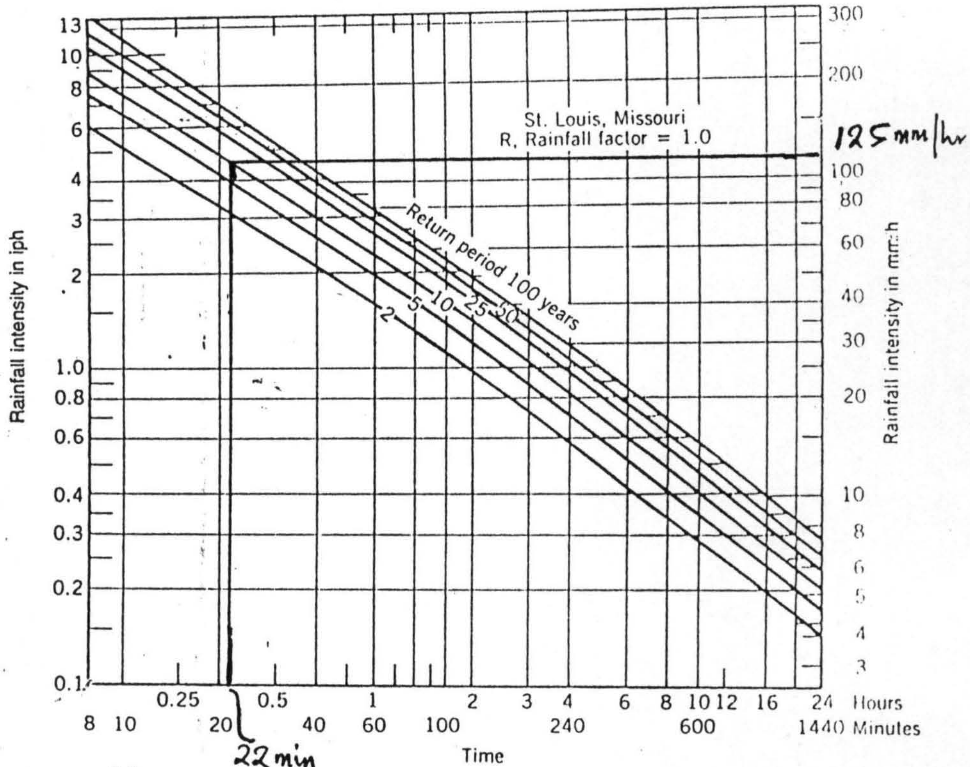


Figure 11 Rainfall intensity-duration-return period data for St. Louis, Missouri, with $R = 1.0$. *Source:* Hershfield (1961) and Weiss (1962).

Table 14 Runoff Coefficients in the Rational Equation for Moderate Slopes

	Runoff Coefficient, C			
	Hydrologic Soil Group[a]			
Land Use, Crop, Management	*A*	*B*	*C*	*D*
Cultivated, with crop rotation				
Row crop, pp[b]	0.55	0.65	0.70	0.75
Row crop, cp[b]	0.50	0.55	0.65	0.70
Small grain, pp	0.35	0.40	0.45	0.50
Small grain, cp	0.20	0.22	0.25	0.30
Meadow	0.30	0.35	0.40	0.45
Pasture, permanent, moderate grazing	0.10	0.20	0.25	0.30
Woods, permanent, mature, no grazing	0.06	0.13	0.16	0.20
Urban residential				
30 percent of area impervious	0.30	0.40	0.45	0.50
70 percent of area impervious	0.50	0.60	0.70	0.80

[a]Hydrologic Soil Groups
- A Well-drained sands and gravels with a high water transmission rate.
- B Moderately to well-drained, moderately fine to moderately coarse texture with a moderate transmission rate.
- C Poor to moderately well-drained, moderately fine to fine texture with a slow transmission rate.
- D Poorly drained, clay soils with a high swelling potential, permanent water table, claypan, or shallow soils over nearly impervious material with a very slow transmission rate.

[b]cp, with good conservation practices.
pp, with poor conservation practices.

APPENDIX B_2 CHECK BASIN DESIGN CALCULATIONS

The selection of an intake family is done by plotting the values of cummulative infiltration rate to time obtained from the infiltration rate experiment on table 11. The intake family is that of the curve closest to which the points fall. In this case, the points fall on the curve 1.5 from Fig. 12.

Therefore, the intake family = 1.5, values of constants a = 2.284, b = 0.799 and c = 70 (from table 15). Desired depth (Net) application (F_n) = 24.8mm - calculated.
Assumptions:-
Mannings coefficient (n) = 0.023
Efficiency (E) = 80%
Efficiency advance ratio from table = 0.58.

BASIN DESIGN FOR FIELD CHANNEL 1

Intake family	= 1.5
Values of	a = 2.284, b = 0.799, c = 7.0
Efficiency (E)	= 80%
Unit inflow rate (Q_u)	= 0.042/19.4ha = 0.0022m³/sec
Desired depth (Net) application (F_n)	= 24.8mm
Mannings coefficient (n)	= 0.023
Efficiency advance ratio	= 0.58.

Opportunity Time (T_n):-

$$= \left(\frac{24.8 - 7.0}{2.248}\right)^{1/0.799} = 13\text{min}$$

Advance Time (T_t):-

$$= (0.58)(13) = 8\text{min}$$

Basin Lenght (L):-

$$= \frac{(6 \times 10^4)(0.0022)(8)}{\frac{(2.284)(8)^{0.799}}{1 + 0.799} + 7.0 + 1798\,(0.023)^{3/8}(0.0022)^{9/16}(8)^{3/16}} = 31\text{m}$$

Inflow Time (T_a):-

$$= \frac{24.8 \times 31}{600 \times 0.0022 \times 80} = 7\text{min}$$

Minimum Depth of Flow (d):-

$$= 2250\,(0.023)^{3/8}(0.0022)^{9/16}(7)^{3/16} = 25\text{min}$$

BASIN DESIGN FOR FIELD CHANNEL 2

Area = 15.18ha
Q_u = 0.034/15.18ha = 0.0022m³/sec
Opportunity time (T_n) = 13min
Advance time (T_t) = 8min
Basin lenght (L) = 31m
Inflow time (T_a) = 7min
Maximum depth of flow (d) = 25min

The design is the same as for field channel 1.

BASIN DESIGN FOR FIELD CHANNEL 3

Area = 12.4ha
Q_u = 0.028/12.4ha = 0.0023m³/sec
Opportunity time (T_n) = 13min
Advance time (T_t) = 8min.
Basin length (L) = 32min
Inflow time (T_a) = 7min
Maximum depth of flow (d) = 26min

BASIN DESIGN FOR FIELD CHANNELS 4, 5, 6 AND 7.

The all have the same unit inflow rate (Q_u) = 0.0022m³/sec
Opportunity time (T_n) = 13min
Advance time (T_t) = 8min.
Basin length (L) = 31min
Inflow time (T_a) = 7min
Maximum depth of flow (d) = 25min

TABLE 15. INTAKE FAMILY AND FURROW / Basin ADVANCE COEFFICIENTS

Intake family	a	b	c	f	g
0.05	0.5334	0.618	7.0	7.16	1.088×10^{-4}
0.10	0.6198	0.661	7.0	7.25	1.251×10^{-4}
0.15	0.7110	0.683	7.0	7.34	1.414×10^{-4}
0.20	0.7772	0.699	7.0	7.43	1.578×10^{-4}
0.25	0.8534	0.711	7.0	7.52	1.741×10^{-4}
0.30	0.9246	0.720	7.0	7.61	1.904×10^{-4}
0.35	0.9957	0.729	7.0	7.70	2.067×10^{-4}
0.40	1.064	0.736	7.0	7.79	2.230×10^{-4}
0.45	1.130	0.742	7.0	7.88	2.393×10^{-4}
0.50	1.196	0.748	7.0	7.97	2.556×10^{-4}
0.60	1.321	0.757	7.0	8.15	2.883×10^{-4}
0.70	1.443	0.766	7.0	8.33	3.209×10^{-4}
0.80	1.560	0.773	7.0	8.50	3.535×10^{-4}
0.90	1.674	0.779	7.0	8.68	3.862×10^{-4}
1.00	1.786	0.785	7.0	8.86	4.188×10^{-4}
1.50	2.284	0.799	7.0	9.76	5.819×10^{-4}
2.00	2.753	0.808	7.0	10.65	7.451×10^{-4}

Intake (see equations [13.1] and [13.40]) Advance (see equation [13.35])

$F = (aT^b + c)\, P/W$, mm

T = minutes

$\frac{P}{W} = \frac{\text{Wetted perimeter}}{\text{Furrow spacing}}$

$T_T = \frac{x}{f}\, e^{(gx/QS^{1/2})}$, min

Q = furrow inflow

S = furrow slope

x = distance

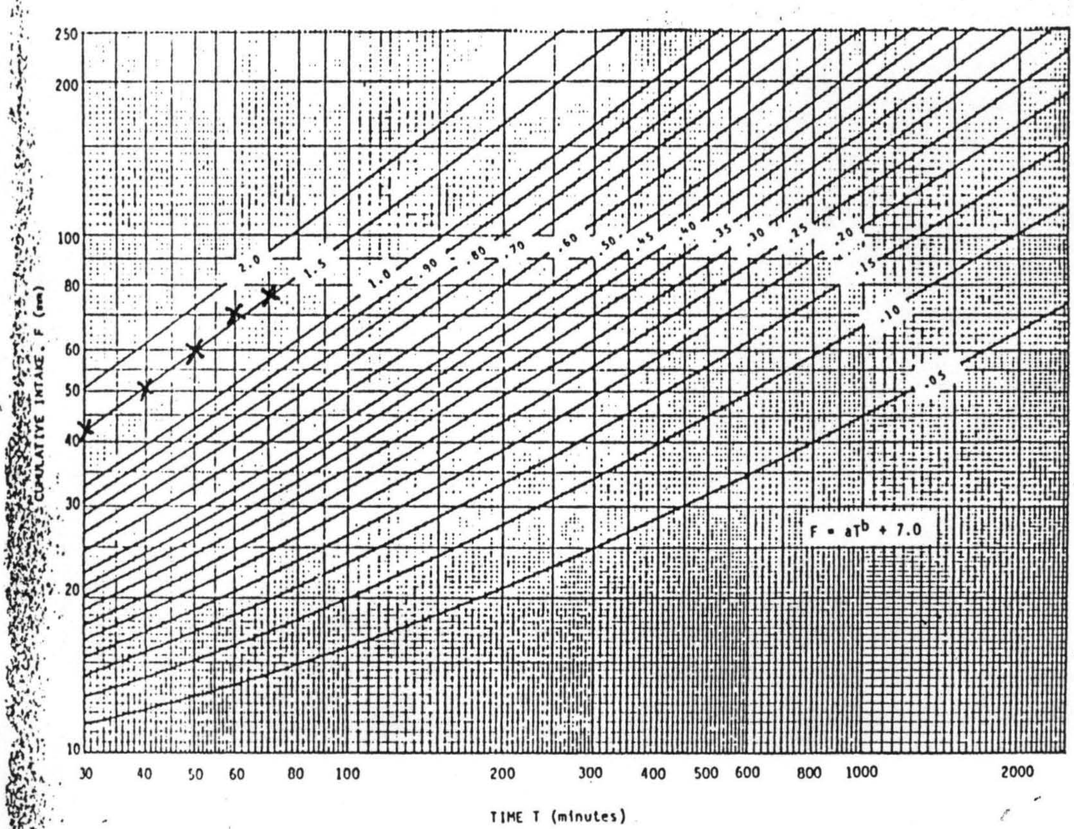


FIG. 12 Intake families (USDA, 1979).

TABLE 16 EFFICIENCY AS A FUNCTION OF THE EFFICIENCY ADVANCE RATIO $R(R = T_t/T_n)$

Efficiency, E	Efficiency advance ratio $R(R = T_t/T_n)$
Percent	—
95	0.16
90	0.28
85	0.40
80	0.58
75	0.80
70	1.08
65	1.45
60	1.90
55	2.45
50	3.20

EFFICIENCY (E) — EFFICIENCY ADVANCE RATIO

APPENDIX C

TABLE 17 **BLANEY MORIN NIGERIA EVAPOTRANSPIRATION MODEL AVERAGE VALUES OF 10 YEARS (1990 - 1999) WAS USED**

Year/Month 1990 - 1999	Mean Temp. ^0C	Relative Humidity %	Radiation	Rainfall	r_r	$r_r(0.45T + 8)$	$520\text{-}RH^{1.31}$	ET_o mm/day $\frac{r_r(0.45T+8)(520-RH^{1.31})}{100}$
January	25.7	57.5	12.98	0.0	0.081	1.585	318.09	5.042
February	27.9	51	17.12	0.095	0.087	1.788	347.45	6.212
March	30.5	60.2	17.24	0.705	0.096	2.086	305.58	6.374
April	30.8	71.3	16.88	2.039	0.091	1.989	252.36	5.019
May	28.8	79.7	15.36	5.569	0.086	1.803	210.32	3.792
June	27.6	84.2	13.8	6.157	0.075	1.532	187.22	2.868
July	27.0	87.0	10.84	6.695	0.068	1.3702	172.65	2.366
August	26.7	87.0	13.41	8.092	0.075	1.501	172.65	2.591
September	26.8	86.0	13.53	5.792	0.073	1.464	177.87	2.604
October	27.7	82.7	16.33	3.082	0.091	1.862	194.96	3.630
November	27.3	72.8	17.49	0.074	0.093	1.887	244.96	4.622
December	25.6	64.6	15.36	0.0	0.086	1.679	284.22	4.782
			$\sum 180.34$					$\sum ET_o = 49.902$ mm/day

$ET_o = 17{,}964.72$ mm/year

Irrigation period is from Novenber to March

$ET_C = ET_o \times K.C$

For November:-
$ET_c = 4.622 \times 1.15 = 5.315$

For December:-
$ET_c = 4.782 \times 1.15 = 5.499$

January:-
$ET_C = 5.042 \times 1.1 = 5.546$

Febrary:-
$ET_c = 6.212 \times 1.1 = 6.833$

March:-
$ET_c = 6.374 \times 1.0 = 6.374$

TOTAL = 29.567 Apprx. 30 x 10

Consumptive use of rice = 300mm

Water requirement for rice for the total area = $1/10^3 \times 300 \times 120 \times 10{,}000$

PPENDIX D MONTHLY IRRIGATION FREQUENCY (I.F) IN DAYS

January	=	24.8/5.042	=	5days
February	=	24.8/6.212	=	4days
March	=	24.8/6.374	=	4days
April	=	24.8/5.019	=	5days
May	=	24.8/3.792	=	7days
June	=	24.8/2.868	=	9days
July	=	24.8/2.366	=	10days
August	=	24.8/2.591	=	10days
September	=	24.8/2.604	=	10days
October	=	24.8/3.630	=	7days
November	=	24.8/4.622	=	5days
December	=	24.8/4.782	=	5days

The average irrigation frequency = 7days

'PENDIX E SUMMARY OF DESIGNED VALUES

Summary of the designed values for the irrigation canals, field drains and Basins as obtained from ; preceeding calculations are as follows:-

.BLE 18 Channel Design

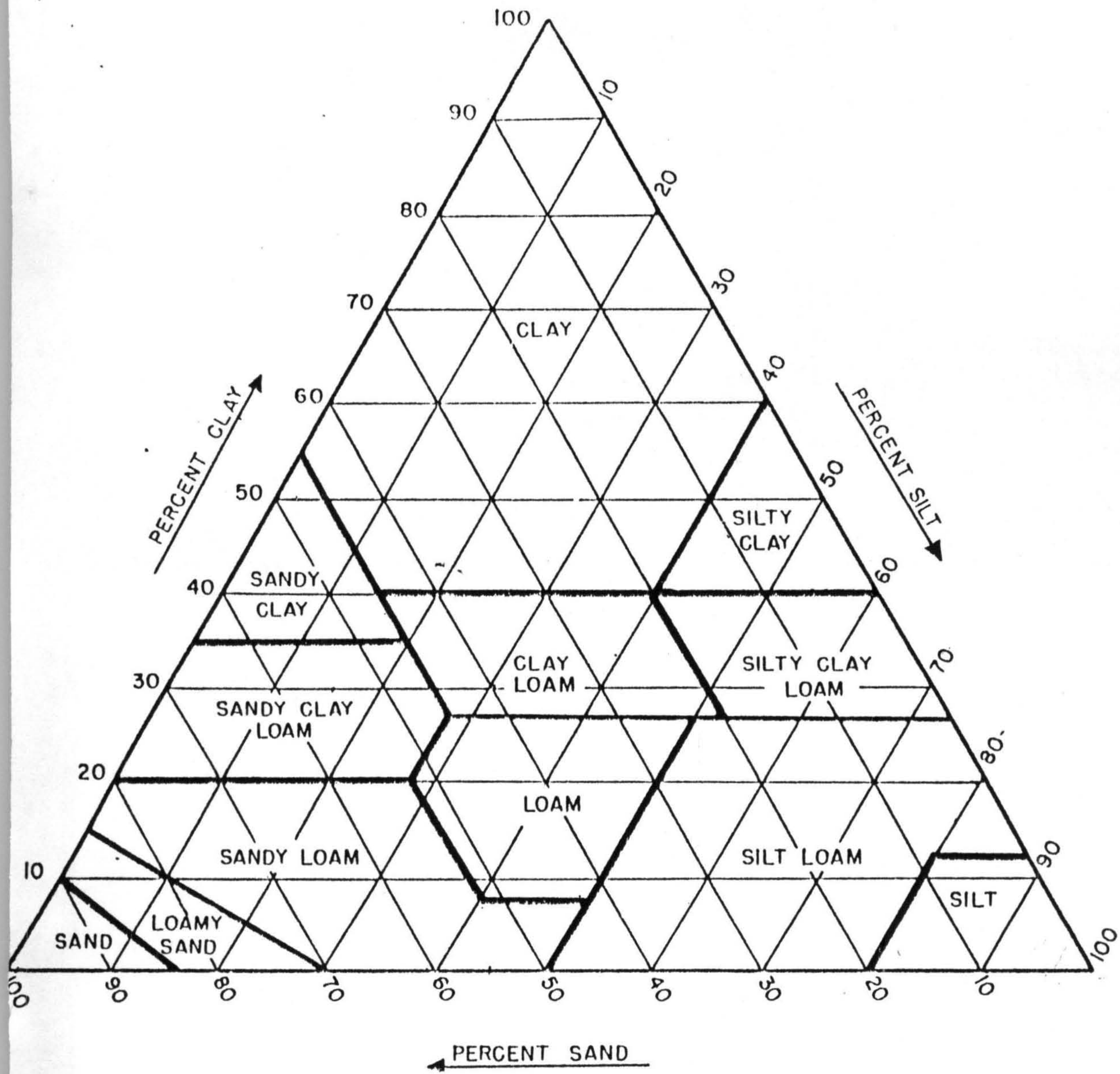
	$Q(m^3/sec)$	D(m)	d(m)	b(m)	f(m)	T(m)
			Parameters			
ain canal	0.263	0.376	0.301	0.18	0.075	1.308

	$Q(m^3/sec)$	D(m)	d(m)	b(m)	f(m)	T(m)
			Parameters			
eld channel 1	0.042	0.151	0.121	0.073	0.03	0.526
eld channel 2	0.034	0.136	0.109	0.066	0.027	0.474
eld channel 3	0.028	0.123	0.098	0.059	0.025	0.428
eld channel 4	0.041	0.149	0.119	0.072	0.03	0.519
eld channel 5	0.044	0.154	0.123	0.074	0.031	0.536
eld channel 6	0.038	0.143	0.114	0.069	0.029	0.498
eld channel 7	0.038	0.143	0.114	0.069	0.029	0.498

	$Q(m^3/sec)$	D(m)	d(m)	b(m)	f(m)	T(m)
			Parameters			
ield drain	0.0042	0.048	0.0385	0.023	0.0095	0.167

'ABLE 19 BASIN DESIGN

	$Q(m^3/sec)$	T_n(min)	T_t(min)	T_a(min)	L(m)	d(m)
			Parameters			
'ield channel 1(plot 1)	0.0022	13	8	7	31	25
'ield channel 2 (plot 2)	0.0022	13	8	7	31	25
'ield channel 3 (plot 3)	0.0023	13	8	7	32	26
'ield channel 4 (plot 4)	0.0022	13	8	7	31	25
'ield channel 5 (plot 5)	0.0022	13	8	7	31	25
'ield channel 6 (plot 6)	0.0022	13	8	7	31	25
'ield channel 7 (plot 7)	0.0022	13	8	7	31	25



·Proportions of sand, silt, and clay in the basic soil-textural classes. (From U.S. Dept. Agr. Handb. 18. Soil Survey Manual. 503 pp., illus. 1951.)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EDATI LOCAL GOVERNMENT OF
NIGER STATE, NIGERIA
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AC/PVC PIPE
RICE
GRASS
PUMP OPERATOR
EMBOSSED CARD
STANDING WATER
PUMP HOUSE
DISTRIBUTION BOX
STILLING BASIN
PALM TREE
TREE