QUANTIFICATION AND USE OF CATCHMENT AREA WATER FOR IRRIGATION

PRESENTED BY

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(SOIL AND WATER OPTION)

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CERTIFICATION

This is to certify that this thesis has been read and approved as meeting the requirement, of the department of Agricultural Engineering, school of Engineering and Engineering technology Federal University of Technology Minna Niger State for the award of post graduate Diploma in soil and water conservation engineering.

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DEDICATION

This research work is sincerely dedicated to my Lord Jesus Christ for his mercy, loving kindness and protection granted me throughout the period of this programme; my beloved wife Mrs. Hope Rabi Momoh my son Sir Victor Enejo Momoh my family and friend for their patience and courage during the period.

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ABSTRACT

This work present the Quantification and use of catchment area water for irrigation. It aimed at trapping area catchment water for irrigation purpose where a dam or other means of water supply such as rivers, streams, or highly expensive schemes are in accessible. The size of the catchment area is 50 x 10m = $500m^2$. The surface area of the roof is $795m^2$. Border strip system is adopted and designed for the irrigation system. A rainfall intensity of 0.39m /hr was obtained from the rainfall observed at FUT Minna. The water required for irrigation is calculated to be $59.06m^3$/hr. The number of rainfall event is calculated to be 118 times. Since it is possible to have about 118 times in Minna, then it is possible to compound enough water to irrigate about $500m^2$ area. The design is to irrigate 1 ha/day for 8 working hours per day and having an irrigation interval of 7 days per each plot.

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CHAPTER ONE.

1.0 INTRODUCTION

Quantification and use of catchment area water for irrigation has attracted considerable attention in recent years in work covering a wide range of techniques from the collections of rain water from catchment area, roofs to the retention of surface and sub-surface flow in rivers. The main interest of these study is methods of collecting and conserving rain water as at early a stage as possible in the hydrological cycle to ensure the best use of rain fall, before it has run away into rivers and ground water, or has disappeared as evaporation. Additional benefits from such measures of water control will often include a reduction in both soil erosion and in the damage caused by flooding. The aim of water harvesting could hold out the greatest immediate hope for thousands of scattered, small communities that cannot be served by more centralized water supply scheme in the foreseeable future. In this study therefore, rainwater harvesting or collection is defined as the gathering and storage of water running off surface on which rain has directly fallen and not harvesting or collection of valley floodwater or stream flow.

This study would describe in mainly technical terms the different methods of collecting rainwater for irrigation, domestic, livestock and crop production purposes.

1.1 DESCRIPTION OF PROJECT AREA

The location of the project area is school of engineering and engineering technology FUT Minna. The area used is from the Julius Berger drainage line to Department of Agricultural Engineering offices covering a total of 50 by 100 meter as the catchment area. Detail is as contained in the area map. Fig 1.1

1.2 RAINFALL

Apart from the few cases when rain start in March/April, mostly the rain season start in may, when the expected amount of the precipitation is between 110mm and 190mm for the month Kowal (1970). The amount is adequate to permit storage, cultivation and to secure seed germination. According to the rainfall records from the water board Minna, Niger state office, for the past ten years (1992-2002) which have shown that the total average annual rainfall is 975mm, precipitation increases in amount and frequency during the month of June resulting gradula recharge of the soil profile which is competed by the middle of August, Kowal (1968). It has been remarked by Kowal (1968, 1971) that during this period which marks the beginning of the growing season, the capacity of the soil to absorb and retain moderate rainfall is good, hence little or no rainfall occurs at the end of September or early October. Thus the length of storage and growing season is approximately six months with highest intensity of rainfall in July and August and part of September.

1:1:1 CLIMATE

Data on rainfall, temperature and humidity, wind velocity etc are required in calculating the net water requirement of the inhabitant, livestock, animal to benefit from the rain harvester.

1.2.2 Mean Daily Temperature

Because of the tropical nature of the study area the mean daily temperature is 30^0C and ranges between 25^0 C to 35^0 C for most of the year, but it ranges between 22^0C of 30^0C during the month of December to middle of February .

1:2:3: Mean Annual Rainfall.

The annual rainfall normally starts in April and ends around early November. Therefore the mean annual rainfall varies between 180 days to 230 days of effective rainfall within an estimated annual rainfall ranging from 1200mm-1600mm from north to south. The rains are heavier during the month of June to September each years.

1:2:4 Relative Humidity

There is a considerable decrease in vapour pressure in Niger State during the dry season (harmatan period) giving a marked drop in humidity. The lowest mean relative humidity is 34% for the month of January and the highest 82% is recorded during the peak of the rainy season in the month of June- September. The relative humidity ranges between 72% - 86% mabogunje (1971)

1.4: Aim and Objective

Aim

The aim of this project is to quantify and trap available area catchment water, during wet periods, and utilize it for irrigation during dry spells.

Objective

The specific objectives are:-

i. To quantify the available water that can be generated in the catehment area.

ii. To design a surface, irrigation system (border) that will utilize their supply.

iii. To recommend the desirability and use of the work.

1.4 Statement of Problem and Justification

Nigeria receives abundant rainfall during the rainy season which prevails over the country from may to October. This rainfall contributes to stream flow which are highly concentrated during the period.

The lack of rain in the dry season, from November to early April prohibits raising additional crops during the period. Lack of reservoirs for storing the rain, and low flows of the stream prohibits irrigation, although the soils and climate are suitable for year-round growth of crops, and sustainable portable water supply throughout the period.

There is a growing national awareness for increasing and improving food production, human, animal and livestock water need to keep pace with population expansion and to maintain a better position in the world market.

Consequently, the demand of water harvesting for the purpose of storage for consumption and related uses will continue to increase.

The target users of this project are the small community or rural dwellers in Nigeria. They also constitute the bulk of the farming activities in Nigeria. Because of the relatively low income from their farming activities, they are unable to afford the huge financial cost of large mechanized water system, clean water for domestic and personal hygiene can improve. There may be new possibilities with regard to cooking, home maintenance might be better, and garden vegetables might be watered. All these benefit could be valued either as home production or, in the case of the vegetables, as market production and a benefit/cost ratio for the improved water supply could then be calculated.

More simply, we may look back at the different circumstances in which rain water harvesting is commonly applied and if asked: what is the significance of the techniques for people's livelihoods in relieving either time constraints or resource constraints.

1.5 Scope of the Project

This project present a brief summary to types and method for quantification and use of catchment area water for irrigation: Emphasis is on catchment area rainwater collection. The research presented are regarded as preliminary project design only. More data are needed from the evaluation of the study as input for final design and practical construction and utilization of catchment water collection for rural dwellers water supply scheme and irrigation purposes. The Blanney – Criddle method has been used in determining the water requirement for human, animal and livestock consumption inspite of its limitation in accuracy. The climatic records available at present are adequate for this method only. However the size, scope and target users of this system will likely not require a more sophisticated design requirement. On designing and constructing schemes which are socially, technically, economically and environmentally appropriate for use in different patterns of livelihood and organization. The study aims to present the subject from these various perspectives in order to emphasize the importance of such interdependent dimensions of rural development.

It is also desirable to plan well construct a reservoir for the collection of catchment area water for rural dweller as a source of water supply for irrigation and domestic uses especially scattered small communities where there is no access to boreholes or centralized water scheme.

It is my hope that at least the quantification and use of catchment area water will support the poor in their struggle to have access to water supply for irrigation and domestic uses.

CHAPTER TWO

2.0. LITERATURE REVIEW

Modern water supply without pumps or pipe is possible when Domestic water is situated next to your house. It may seem a little contradictory to, that water can be available at your house without some kind of pumping but if you have seen the rain on your roof and in your compound, you will have seen the great source from which all water originates ie the rain. Naturally, many people will claim that it rains so little in their area that no catchment system will ever be able to accumulate enough water for a whole years consumption.

Nevertheless, provided it rains once or twice a year, it is possible to establish a reliable water supply system based on the catchment of this rain (Nissen-petersen, 1980)

2.1 Precipitation

The term precipitation is used to encompass phenomena such as rainfall, hail and snow where water is one form or another falls, to the ground some of the precipitation evaporates partially or completely before reaching the ground. Precipitation reaching the earth surface may be intercepted by vegetation, It may infiltrate the surface of the ground, it may evaporate or it may run-off the surface.

Precipitation may occur in any of the forms and may change from one form to another during its descent. Forms of precipitation may be classified as drizzle or rain. Rain consist of generally larger particles, since most estimates of runoff rates are based on precipitation data, information regarding the amount and intensity of precipitation is of great importance.

For the purpose of this project instead of using rain gauge which is to measure the depth and intensity of rain falling on flat surface a rain water harvester is used.

2.2 Rainfall patterns in Nigeria

Nigeria has a tropical climate which is not wet throughout the year in the south-east, but has a marked dry season in the west and north, which increases inland from the coast. Two air masses the equatorial maritime air mass bringing rain and the tropical continental air mass bringing hot, dry winds from the Sahara to the north, dominate the weather system. Thus, the length of the rainy season decreases from nine months in the south (March-November) to only four and a half months in the north (May – September), and the harmatta, a dry, dusty wind from the Sahara, lows for three months in the north but for only a couple of weeks in the coastal belt. Fig2 (a) (b) and (c) show the se air masses and the resulting annual rainfall pattern and monthly fluctuations in three regions of Nigeria (Erik Nissen- Petersen. 1980)

2.3 Definition of Water – Harvesting

Water Harvesting can be defined as the process of collecting and storing natural precipitation from prepared catchments (roof tops, depressions and runoff) for use.

It consists basically of two components; the collection of water from or within the catchment, and its storage for future use. 'Water harvesting' is of relatively recent origin, it is currently practiced in different forms in the semi-aid regions of Australia, the United State, Middle East, the India sub continent and some parts of East African (Kerr, 1989).

2.4 Methods of Water – Harvesting

Water – Harvesting encompasses method to (a) Induce (b) collect (c) store runoff from various sources and for various purposes. The method applied depends strongly on local conditions and include such widely differing practices as farming terraced wadi beds (Evenari et al, 1971), growing trees on micro-catchment (Nat AC a Sc, 1974), catching runoff from sheet metal catchment (chiuretta and Bec 1975; Mikelson, 1975), storing runoff behind a dam (Bowler and Turner, 1977, Myhrman et al, 1978).

In spite of their differences, these methods have three common characteristics: They are applied in arid and semi arid regions where runoff has an intermittent character surface runoff occurs as a discrete event and subsurface water may flow part of the year and stop during the dry period because of the ephemerality of flow, storage is an integral part of water harvesting (Myers, 1975). They depend upon local water such as surface runoff, creek flow, spring and soaks (Burdass, 1975). They therefore do not include storing water river water in large reservoirs or the mining of ground water.

They are relatively small – scale operations in terms of catchment area, volume storage, and capital investment. This characteristics is a logical consequence of the other two characteristics.

A distinction is made between runoff collection and water harvesting. While water harvesting involves the inducement, and collection of storage of runoff water from the catchment area by either compacting the soil, construction of concrete or Block reservoir, or treating it with chemicals in order to obtain more runoff water to store and use in command area (Frasier and myers, 1983). In runoff collection, management practices may deliberately try to maximize in situ infiltration and storage. Both practices consist basically of the land that sheds water (catchment) and its storage within the command area for future use (laryea, 1992).

2.4.1 Runoff Inducement

The success or failure of rainwater harvesting depends to a great extent on the quantity of water that can be harvested from an area under given climatic conditions. The threshold retention of a catchment is the quantity of precipitation required to initiate runoff (Frik et al; 1979).

Sometimes natural surface that can yield a good water harvest are available e.g sandstone rock slope (Chiarella and Beck, 1975), slickrock hillsides (Frasier, 1975; MC. Bride and Shiflet, 1975), or granite outcrops. (Brdass, 1975).

Different methods of reducing surface storage and lowering infiltration capacity (which are the main parameters determining threshold retention and runoff efficiency) can be classified as (i) vegetation management (ii) surface treatment and (iii) use of chemicals (Boers and Ben-Asher, 192).

2:4:2 Runoff Collection

In rainwater harvesting many methods of collecting surface runoff have been developed (Nat. Acadi-Sci, 1974). For the purpose of this review these methods are discussed under.

Micro-catchment water Harvesting (MCWH)

Runoff Farming Water harvesting (RFWH).

Water harvesting by wax treated soil surface.

Micro-Catchment water Harvesting (MCWH)

Micro-Catchment water Harvesting is method of collecting surface runoff from a contributing Area (CA) over a flow distance of less than 100m storing it for consumptive use in the root zone of an adjacent infiltration Basin (IB) (Boers and Ben. Asher 1982) The contributing Area (CA) and the infiltration Basin are the two basic element of a micro-catchment (MC) In the IB. There may be a single tree (Evenari et al 1971) bush or a row crop (Gardner, 1975).

The aim of MCWH is to store sufficient runoff water in the root zone below the basin during the rainy season to cover the water requirement of the crop or tree during growing season (Boers, Zondervan and Ben-Asher, 1986) This water harvesting method has been tested in a number of countries since 1963 (National Academy of sciences. 1974).

2.4.3 **Types of MCWH**

Boers and Ben- Asher (1982) classified these into contour catchment water harvesting Desert strip farming, contour Bench Farming, and Runoff Based pitcher farming However Nissen – Peterson, (1980) classifies catchments areas with hard surfaces such as metal roofs and rocks.

Half Runoff – In areas with semi-hard surfaces e.g. roads. Compounds around a house and rocky slopes.

Quarter Runoff-Collected from areas with loose soil surfaces such as field and valleys. The primary interest of this research is harvesting rainwater from existing ground surface for human and domestic uses.

Therefore emphasis will be made on this method of MCWH.

To calculate the volume of rainwater available from ground surface catchment, the length of the area along the direction of flow is multiplied by the width perpendicular to flow direction to obtain the area of catchment. The depth of rainfall as obtained from a meteorological station is multiplied by the calculated area to obtain the total volume of rainfall that can be collected neglecting minor losses due to splash, evaporation etc (NISSEN-Petersen, 1980)

2.3.4 Runoff Farming Water Harvesting (RFWH)

Boers and Ben-Asher, (1982) define (FRWH) as a method of collecting surface runoff from a catchment Area (CA) using channel, dams, or diversion system and storing it in a surface Reservoir (SR) or in the root-zone of a farmed area (FA) for directed consumptive use. The water collected from the (CA) and stored in the SR is primary sources for consumption domestic uses and crop production (Boers and Ben – Asher, 1982). More water from the Catchment Area can be stored in an SR in the soil profile, so SR enables users to maintain a better water distribution in space and time. One of the major design problem is to determine the relative sizes if CA and SR is the investment for construction of SR and the system to distribute the water from the SR to the end users. Furthermore, in runoff farming, the problem is that few rainfall data are available for flood prediction and often there are no runoff data at all cooley et al, 1975). If the (FA) is too small compared with the size of the flood; water will be lost deep percolation conversely, if FA is too large compared with the size of the flood, crops may suffer lack of soil water.

Water Harvesting by Wax-Treated soil Surfaces .

A relatively new water-harvesting treatment is the application of paraffin wax to soil to create a water repellant catachment surface the first two tools such were installed at the Granite Reef test site in 1972 by applying ground paraffin wax (0.7 kg/mm^2 average rate) top smoothed, rain compacted soils. Solar energy melted the wax in the soil. The cacthment are still optional after 7 years of natural weathering. Average runoff efficiency (yearly) runoff/yearly rainfall) for the two catchments averaged 87% for the 7 years. Year 7 averages 85% i.e only 2% less than the 7-year average. Also, the 7 year average runoff efficiency of the two catchment was only 10% less than that of a plastic membrane, but was more than four times greater that of a simple, cleared and smoothed soil surface and nearly six times greater than of a small untreated, natural desert watershed. Both laboratory and filed test indicated that the wax treatment is most successful on sandy soils containing less than 20-25% clay plus fine silt (Fink, Frasier and Cooley, 1980) Furthermore, the quality of the collected water was excellent (1) refined paraffin wax added no questionable organize compounds to the runoff water; (2) salt content of the runoff water was less than 50ppm (3) sediment content in the runoff to water was low because the wax helped to stabilized the soil (Fink, et al 1980).

2.4.5 Storage of Runoff

Most areas with low rainfall suffer from lack of portable water for consumption animal, livestock and domestic uses. Often life-saving reservoir at the most critical stage could substantially improve their life.

Generally, storage of rainwater in the soil profile is cheaper and more efficient than storage of runoff in excavated tanks However, the major limitation of storage in the soil profile is its limited capacity.

In most of the rain fed areas, rainwater conservation measures cannot conserve all the rainwater and a certain amount of runoff is bound to occur. This runoff can be collected and stored in tanks for life – saving (verma and samra, 1990),

Use of water harvesting tanks in rainfed areas has come into practice only recently and not much literature is available on the design of tanks, hence a suitable technology is not available to end users (Verma and Sarma, 1990).

2.4.6 **Types of Storage.**

Farm-ponds – can be of regular or irregular shape excavated into the soil to about 3m dept. The width varies from 105 to 50m. The irregular shape mainly provide water for the livestock of nomadic Cattle rearers. The secondary purpose to provide supplementary water for irrigation especially at critical growth periods in the dry season.

While maximum storage capacity can be expected for circular ponds, water harvesting can be easier for square or rectangular pond (Radder, et al, 1995).

Bentonite, clays, bitumen, soil and cement mixtures, stones or bricks in cement mortar, asphalt compounds polyethene/rubber sheets are recommended as construction materials for coarse textured soils: and the addition of antieraporants (oil emulsions, plants residues gum mixtures, fatty alcohol etc) is also suggested (Radder, Belganni, itnal, 1995.)

2.4.1 Surface and subsurface reservoir

While the former is of similar characters with ponds the latter uses the principles of MCWH techniques (already discussed) which direct water from a catchment through a slope ponded in a basin where it is needed. The water infiltrates the soil and remains in the subsoil for use of farm crops.

2.4.8 Design of storage tank.

A proper design of storage reservoir for a Catchment area rainfall harvesting involves: hydrological analysis including probability of occurrence of runoff, hydranlic design to determine physical size of the tank considering seepage and evaporation losses.

Policies for utilizing the stored water in terms of (i) timing (ii) quantity (iii) selection of irrigation system economic viability of the scheme. The design of water harvesting tanks and supplemental irrigation system is highly location- specific and, thus, making it very difficult to develop a general model which can be used for all areas (Verma and Sarma, 1990)

2.5 Feasibility of Water Harvesting and Economics.

Feasibility of water harvesting depends on the availability of runoff, the cost of installation of the water harvesting system land management , cost associated with crops produced or the output to the end users from an economic point of view, these catchment system need no fuel, no spare parts and very little skill. They save money as well as conserve foreign exchange. The systems do not permit the breeding or spreading of those diseases which are often found in common water holes and other water-sources used in rural areas. Furthermore, these low-cost systems, when used appropriately, promote rural employment skill and self-reliance (Nissen – Petersen, 1980)

CHAPTER THREE

MATERIALS AND METHODS

3.0 MATERAILS

The materials used in this project are grouped under catchment area, climatic Data, water requirement and irrigation system.

3.1 Catchment Area.

The catchment area used is an excavated land area of 10 m by 50m which serves as the reservoir for the irrigation system. It is located directly at the back of Agricultural Engineering office block about 130m from the FUT drainage. The surface area of the roof used for harvesting the rain water is 795m^2.

3.2 Climatic Data.

A 10 – year rainfall records were obtained from department of meteorological services federal ministry of Aviation Minna Airport from the year 1992 – 2002. as given in table 3.1 to 3.4

3.2.1 Monthly Annual Rainfall

The annual rainfall normally starts in April and ends around early November. Therefore the mean annual rainfall varies between 180 days to 230 days of effective rainfall within an estimated annual rainfall from 1000mm to 1500mm from North to South. The rains are heavier during the month of June – September each year. (Table 3.1)

3.2.2 **Mean Daily Temperature**

In FUT Minna Niger State, the air temperature usually drops during the harmattan period of November to March, temperatures are high with low relative humidity until it reaches a peak in March just before the rain starts. The mean daily temperature in Niger State for the period of 1992 – 2002 are 34^0 and 30^0C in the dry and wet seasons respectively. (Table 3.2)

3.23. **Sunshine**

Sunshine solar radiation in FUT Minna Niger State is Virtually bisected by the line for the 2400 sunshine hours annually. The monthly pattern of variation is however the mere critical issue. During the dry season months (November – May) the monthly variation is the amount of sunshine follows the general trend of an increase from under 230 hrs in the South of Minna to over 265 hours in the month. (Table 3.3)

3.2.3 **Relative Humidity**

There is a considerate decrease in vapour pressure in Minna Niger State during the dry season (Hammattan period/giving a marked drop in humidity. (Table 3.4)

TABLE 3.1 TOTAL MONTHLY RAINFALL (mm) (1993 – 2002) FOR MINNA

YEARS	JAN	FEB	MARCH	APRIL	MAY	JUNE	JULY	AUG.	SEPT.	OCT.	NOV	DEC
1993	0.00	0.00	0.00	0.00	174.40	170.50	189.70	271.10	178.30	63.30	xxx	0.00
1994	0.00	0.00	7.30	72.50	114.40	239.00	142.50	367.20	261.30	208.10	0.00	0.00
1995	0.00	0.00	0.00	100.50	123.20	144.50	153.70	409.00	189.10	135.70	236.00	0.00
1996	0.00	0.00	0.00	48.60	164.70	225.00	259.70	257.00	191.10	127.90	0.00	0.00
1997	0.00	0.00	3.60	92.20	238.40	233.00	172.40	192.90	273.30	115.00	6.10	0.00
1998	0.00	0.00	TR	35.70	121.20	221.00	155.50	243.00	261.90	212.60	0.00	0.00
1999	0.00	7.90	0.00	3.60	102.80	164.20	243.90	254.70	237.10	212.20	0.00	0.00
2000	0.00	0.00	0.00	93.90	135.90	161.00	208.80	308.50	303.00	153.40	0.00	0.00
2001	0.00	0.00	0.00	98.80	139.00	331.70	244.60	230.20	298.80	25.70	0.00	0.00
2002	0.00	0.00	0.00	626.4	42.60	201.00	143.00	226.50	260.60	180.30	0.25	0.00
TOTAL	0.00	7.90	10.9	626.4	1356.1	2090.9	1913.8	2760.1	2154.8	1434.2	236.25	0.00
MEAN	0.00	0.79	1.1	62.64	135.66	209.1	191.2	276	215.5	143.42	23.63	0.00

Source: Dept of Meteorological Services, Fed. Min. of Aviation, Minna, Airport, Niger State.

TABLE 3.2 TOTAL MONTHLY TEMPERATURE (^0C) 1993-2002) FOR MINNA

YEARS	JAN	FEB	MARCH	APRIL	MAY	JUNE	JULY	AUG.	SEPT.	OCT.	NOV	DEC
1993	26.65	27.60	30.40	31.50	29.40	26.85	25.70	25.55	25.50	27.25	xxxx	27.65
1994	27.25	29.90	32.20	30.50	28.45	26.85	26.05	25.25	25.80	26.20	26.70	26.45
1995	26.75	29.40	31.95	31.30	28.40	27.10	26.10	25.40	26.10	26.95	27.15	26.75
1996	27.75	30.25	31.60	31.30	28.05	26.00	25.25	24.70	25.45	25.95	26.25	26.70
1997	28.20	28.35	30.85	29.80	27.50	26.60	25.85	26.30	26.20	26.85	27.20	26.90
1998	27.35	31.15	32.25	32.35	28.95	27.10	26.10	25.35	25.95	26.95	27.80	27.65
1999	28.05	29.90	32.05	31.65	28.95	27.05	25.70	25.35	25.70	26.95	27.65	27.25
2000	28.70	28.60	31.70	31.75	30.50	26.25	25.60	25.20	25.95	26.95	27.10	26.65
2001	27.65	29.95	31.55	30.35	28.95	26.40	25.55	25.00	25.20	27.05	26.55	27.50
2002	26.80	29.62	32.24	30.85	30.30	27.00	26.23	25.85	25.85	26.55	27.35	27.20
TOTAL	275.15	294.72	316.79	311.35	289.45	26.7	258.13	253.95	257.7	267.65	243.75	270.7
MEAN	27.52	29.47	31.68	31.14	29	26.7	25.81	25.40	25.77	26.77	24.38	27.1

Source: Dept of Meteorological Services, Fed. Min. of Aviation, Minna, Airport, Niger State.

MONTHLY RECORD OF SUNSHINE DURATION (HRS) IN MINNA FROM 1993 – 2002

YEARS	JAN	FEB	MARCH	APRIL	MAY	JUNE	JULY	AUG.	SEPT.	OCT.	NOV	DEC
1993	3.7	4.5	4.5	3.6	6.6	5.3	5.5	5.6	5.7	4.7	7.0	7.8
1994	10.6	10.6	10.5	9.2	7.4	3.4	2.2	9.9	8.7	10.3	3.4	5.3
1995	8.5	5.1	3.4	6.7	6.5	6.0	7.4	6.9	6.9	8.2	7.6	6.7
1996	5.3	5.0	1.5	5.3	7.0	3.7	7.2	7.4	2.0	5.1	6.1	5.9
1997	7.7	9.9	10.2	9.8	10.3	8.8	9.4	6.0	7.6	6.4	9.7	9.0
1998	8.1	1.7	8.6	7.0	2.0	8.0	5.0	8.5	6.7	4.2	6.7	4.9
1999	5.1	2.5	7.5	5.8	4.5	1.3	7.8	4.9	4.0	4.2	7.6	0.9
2000	7.8	1.3	4.5	2.4	8.8	7.5	9.0	4.0	3.8	3.9	4.1	3.5
2001	7.5	5.6	6.5	6.8	7.4	8.0	4.2	4.5	7.4	4.3	3.0	1.8
2002	1.3	2.0	5.1	6.9	4.5	2.3	2.5	2.0	7.4	1.2	3.5	6.4
TOTAL	65.6	48.2	62.3	63.5	65	53.7	60.2	59.7	59.6	52.5	58.7	52.2
MEAN	6.6	4.8	6.2	6.4	6.5	5.4	6.02	6	6	5.3	5.9	5.22

Table 3. .3 Source: Dept of Meteorological Services, Fed. Min. of Aviation, Minna, Airport, Niger State.

TABLE 3.4 MONTHLY RELATIVE HUMIDITY (%) (1991 – 2001) FOR MINNA

YEARS	JAN	FEB	MARCH	APRIL	MAY	JUNE	JULY	AUG.	SEPT.	OCT.	NOV	DEC
1991	27.00	51.00	49.00	69.00	81.00	95.00	88.00	90.00	81.00	77.00	46.00	34.00
1992	28.00	25.00	55.00	68.00	76.00	82.00	97.00	88.00	83.00	77.00	49.00	38.00
1993	33.00	40.00	53.00	63.00	72.00	80.00	86.00	86.00	81.00	71.00	xx	44.00
1994	40.00	25.00	55.00	63.00	74.00	80.00	64.00	87.00	85.00	76.00	45.00	30.00
1995	34.00	27.00	48.00	62.00	72.00	77.00	81.00	86.00	80.00	73.00	39.00	34.00
1996	33.00	42.00	57.00	63.00	73.00	81.00	87.00	85.00	84.00	74.00	32.00	31.00
1997	31.00	18.00	46.00	64.00	70.00	82.00	85.00	85.00	82.00	78.00	45.00	28.00
1998	32.00	32.00	25.00	61.00	76.00	80.00	86.00	87.00	83.00	77.00	47.00	36.00
1999	31.00	36.00	58.00	57.00	70.00	78.00	84.00	81.00	82.00	79.00	50.00	33.00
2000	40.00	25.00	34.00	63.00	69.00	-	85.00	87.00	84.00	74.00	45.00	33.00
2001	31.00	30.00	44.90	57.00	61.00	70.00	76.00	79.00	73.00	52.00	43.70	35.60
TOTAL	359.70	351.12	524.92	689.7	794.20	805.20	929.00	949.30	897.60	803.00	442.20	376.20
MEAN	32.7.00	31.92	47.72	62.70	72.20	73.20	86.30	85.50	81.60	73.00	40.20	34.20

Source: Dept of Meteorological Services, Fed. Min. of Aviation, Minna, Airport, Niger State.

The lowest mean relative humidity is 18 % in the month of February and the highest of 95% in the month of June. The relative humidity is the range of 82-96% (mabogunje, 1971)

3.3 Observation of Rainfall

The rainfall which serves as a volume of water in the harvesting catchment area is observed three times as shown in Table 4.1 The total amount of rainfall taken three times are 75cm, 70cm and 80cm.

Total rainfall amount = 225cm

The mean Rainfall amount harvested $= \frac{225}{3} = 75cm$

The mean total rainfall collected from the Dept of meteorological services, Fed. Min of Aviation, Minna, Airport, Niger State is 104.6mm.

For successful irrigation design it is essential to know how much water would be applied to crops and how frequently, specifically the crop water requirements are to be made at the period of peak moisture demand. In planning on irrigation system for an area, data on irrigation water requirement and intervals are sometimes already available for local field experiments.

In such cases, planning becomes largely an engineering problem. For this project, the use of blaney-morin – Nigeria (BMN) Evapotranspiration model is considered to estimate the irrigation water requirement of the crop. Irrigation is generally defined as the application of water to the soil to supply moisture essential for the plant growth and thereby eliminate the moisture limitation to the crop production.

The practice includes the development of water sources the method of application and the efficient water management.

Evapotranspiration, ET, is often predicted on the basis of climatological data. The magnitude and variation of evapotranspiration to one or more climatic factors (temperature day length, humidity, wind, sunshine, radiation and rainfall. In estimating the irrigation water requirement of maize crop in Minna-Nigeria.

There is substantiated evidence, however that temperature-based ET models though simple are not sufficiently in areas where the temperature is relatively constant while other meteorological factors that also promote evaporation vary (Michael 1978, Hashemi and Habibian, 1979) Duru and Yusuf (1980) have shown this to be true under Nigeria conditions. But the need to be able to compute ET rapidly and accurately remains undisputed.

In Nigeria and perhaps in other developing countries, there is the added need to compute ET from those meteorological parameters which requires a minimum of the commonly available parameters over a more complex and sophisticated model with comparable accuracy of prediction. A modified form of the Blaney-morin ET model is proposed here as satisfying these requirements.

To supply water to field capacity level, it is important to know the water requirement of the crops and how much water can be retained in the soil such knowledge will provide a safeguard against the risk of either over-irrigation or under irrigation, both of which have negative effects on both soils and crops.

Various attempts have been made especially in the U.S.A. to estimate crop water requirement of all the relationship available the one based on penman's equation (Penman 1948) seems closer to reality and has a more universal application until Blaney-Morin-Nigeria (BMN) ET model was established under the conditions of Nigeria.

3.4 Blaney-Morin-Nigeria (BMN)ET MODEL

This method was developed in Nigeria by Duru (1984) and is an extension of the Blaney – Morin Evapotranspiration equation Duru (1984) gave a generalized form of the Blaney-Morin-Nigeria equation as:

$$ETC = \frac{Kc\ Pt\ (H-R^{n})}{100} \text{ – Equation 4.1}$$

Where

ETC = Crop Evapotranspiration (inches per period)

Kc = Crop coefficient

P = Ratio of maximum sunshine hours for period of interest to the annual maximum

T = Air temperature

R = Relative Humidity (%)

H and N = Constant

Duru then evaluated H and N under Nigeria condition after replacing the sunshine term P, with the radiation term of which he suggested as better radiation of seasonal weather changes than sunshine, the result is the Blaney-Morin-Nigeria model which has the form of

$$ETP = \frac{rf\ (0.45\ t + 8)\ (520 - R^{1..3.1})}{100} \text{ – Eqt 3.2}$$

Where:

Etp = Potential Evaportanspiration mm/day

Rf – radiation ratio, that is ratio of maximum

Possible radiation for a given month to maximum possible radiation for the year.

T = Air Temperature (^0C)

R = Relative Humidity (%).

3.5 Reference Crop Evapotranspiration

Collected and evaluated climatic and crop data based on meteorological data available are computed, select production method to calculate ETO.

The meteorological data was collected from the Dept. of meteorological service, Fed. Min. of Aviation Minna. The data collected covered the years 1992 – 2002.

3.6 Crop.

Maize is conventionally sown at Minna in early June and Matures after 120 days. The length of normal growing season or period is 3 months.

3.6.1 Crop Coefficient Factor (KC)

Select cropping pattern and determine time of planting or sowing, rate of crop development, length of crop development stages and growing period.

Select Kc for maize crop and stage of crop development. In Minna, dry season maize crops are grown in Oct/November to March/April and during these months, rainfall is generally less than 20mm/month. For all latitudes therefore rainfall is assumed to be zero for ease of budgeting.

3.6.2 Crops for Different Stages of Crop growth and prevailing climatic conditions. As contained in table 3.5

Table 3.5

Crop Coefficient (Kc) for Field And Vegetable

Crop Humidity	Rhamin	>70%	Rhmin		<200%
Wind m.sec	0-5	5-3	0-5		5-8
Crop stage					
Initial	1				
Crop dev.	2				
Mid – Season	3				
Of harvest or					
Maturity	4				
Castor beans	3	1.05	1.1	1.15	12
Celery	4	.5	.5	.5	.5
Corn (sweet)	3	1.05	1.1	1.15	1.2
(maize)	4	.95	1.0	.05	1.1
Corn (grain)	3	1.05	1.1	1.15	1.2
(maize)	4	.55	.55	.6	.6
Cotton	3	1.05	.115	1.2	1.25
Flax	3	1.0	1.05	1.1	1.15

Source: (FAO, 1983).

The Evapotranspiration factor which is the Kc is multiplied by the reference Evaportrasnpiration to be calculated from the climatic data collected to determine the crop water requirement ETC.

3.7 Irrigation Design

Irrigation is generally defined as the application of water to soil for the purpose of supplying the moisture essential for plant growth.

However, a broader and more inclusive definition is that irrigation is the application of water to the soil for the following.

(1) To add water to soil to supply the moisture essential for plant growth.

(2) To provide crop insurance against short duration droughts.

(3) To wash out or dilute salts in the soil.

(4) To reduce the hazard of soil piping

(5) To soften tillage pans.

3.8 Scope of Irrigation.

Irrigation is not restricted to application of water to soil it extends from the water shed to the farm and on to the channel observing one portion of our irrigation system without considering its other components will lead to faulty design and in adequate preparation the layout of irrigation system on the farm method of control and disposition to excess and waste water also have vital significances.

3.7.2 Methods of Irrigation

The operator must have a complete control at all times of water as it flows from the canals to the fields. This will ensure economic and efficient distribution of irrigation water of whatever methods of irrigation used.

The basic ones used are

(1) Surface method

(2) Sub-Surface method

(3) Sprinkler method

The method used for this project is the surface method.

3.7.3 **Surfaces Method.**

This is divided into three parts

Boarder Irrigation

Furrow and corrugation Irrigation

Basin Irrigation

3.8 Border Irrigation

Border – Strip type of irrigation system is where by the entire field is divided into a number of strips preferably not over 9-18m wide and 100-400m long, separated by low levees.

Water is turned from the supply ditch into these strips which flows slowly towards the lower end wetting the soil as it advances.

It is best to make the border slope from 0.6 to 1.2m per 300m.

Border method is suitable to soils of wide variation.

ii **Furrow**

This method of Irrigation is essential where the topography of the land is sloping. The Furrow are constructed down the slope with the necessary adjustment to check the velocity and subsequently to check the velocity and subsequent erosion.

Most crops such as potatoes, Corn, fruit and vegetable are irrigated by this method. The size of furrow is governed by the spacing of the crop rows, size, and nature of corps and the condition of the land to be irrigated.

iii **Basin**

This method is used on a flat topography and on heavy soils that require longer time to lake in water. The basin method is sometimes used in leaching salts by deep percolation from a salty area. The size of basin can be rectangular, square or even irregular in shape

3.9 **Surface Irrigation System**

Border strip Irrigation System is considered after collecting rain water in the reservoir the water is used for agricultural purpose for maize

Determination of crop water requirement (Et Crop) using Blanney – Morin – Nigeria method.

3.9.1 Irrigation Efficiency

$$Ea = \frac{(PSa)\ D\ days}{Et\ crop}$$

Ea = Application efficiency losses

Ps = Factor

D = Roofing depth

Et = Evapotranspiration of Crop.

Application or Discharge Rate per unit area.

$$QA = \frac{1.1574 \times Et\ crop}{Fwu} \quad \text{(walker 1980)}$$

Where

QA = System discharge per unit area

Et crop = Crop Evaportanspiration mm/day

Ea = System application Efficiency

U = Use factor which is numbers of hours operated per day as a fraction of 24.

3.9.2 Surface Irrigation

Surface Irrigation uses open channel flow to spread water over a field. The driving force in such system is gravity and hence the alternate term, gravity flooding. Once distributed over, tends to be smaller and more densely distributed.

This can result in anchorage and aeration problems for some crops. The solid set structure of trickle, Irrigation system along with filtration requirements makes this a high cost agricultural technology (walker, W.R., 1980). However, as will be shown other types of trickle system have been developed and significantly cheap to install.

3.9.3 Soil

In an outline of Northern Nigeria Soils (1970) classified Minna soil in two groups thus.

3.9.4 Lithosol

Very weak differentiation of genetic horizons containing, course element. The profile description.

0- 23cm	Predominantly Sandy Loam
23 – 51 cm	peddish vesicular Iron stone fine sub-rounded quartz, Strongly cemented.

Patricle Size Distribution (PSD)

9 – 23cm depth

20 – 0.2mm diameter 47%

0.02mm – 0.02mm dia 31%

0.02 – 0.002mm dia 2%

0.002mm dia 20%

PH 5.6

Na 0.06

K 0.07

Ca 4.72

CFc 3.2 meg/100g soil.

Undifferentiated ferrisols profile.

0 - 8cm dept loan sand

8- 61cm depth Sandy clay 10 am

Table 3.6

PSD

Depth cm	Size da (mm)	Percentage (5%)
0	2 – 0.2	34 sand
0.2	0.02	52
0.02	0.002	8 Silt
0.002	0.2	6 Clay
8-612		30 sand
0.2	0.02	36
0.02	0.002	8 silt
0.002		26 clay

CHAPTER FOUR

4.0 RESULTS AND DISCUSSION.

In this project an attempt is made to described rainwater collection techniques using catchment area as a source of water for irrigation. A surface irrigation system is considered.

Design consideration of the catehment water areas, the observed rainfall, the annual rainfall data, irrigation system and the size of the pump used;

4.1 Rain Catchment Areas

The sketch of the rain water catchment areas for the project is shown below in fig 4.1. The catchments area is 50m x 10m = 500m^2.

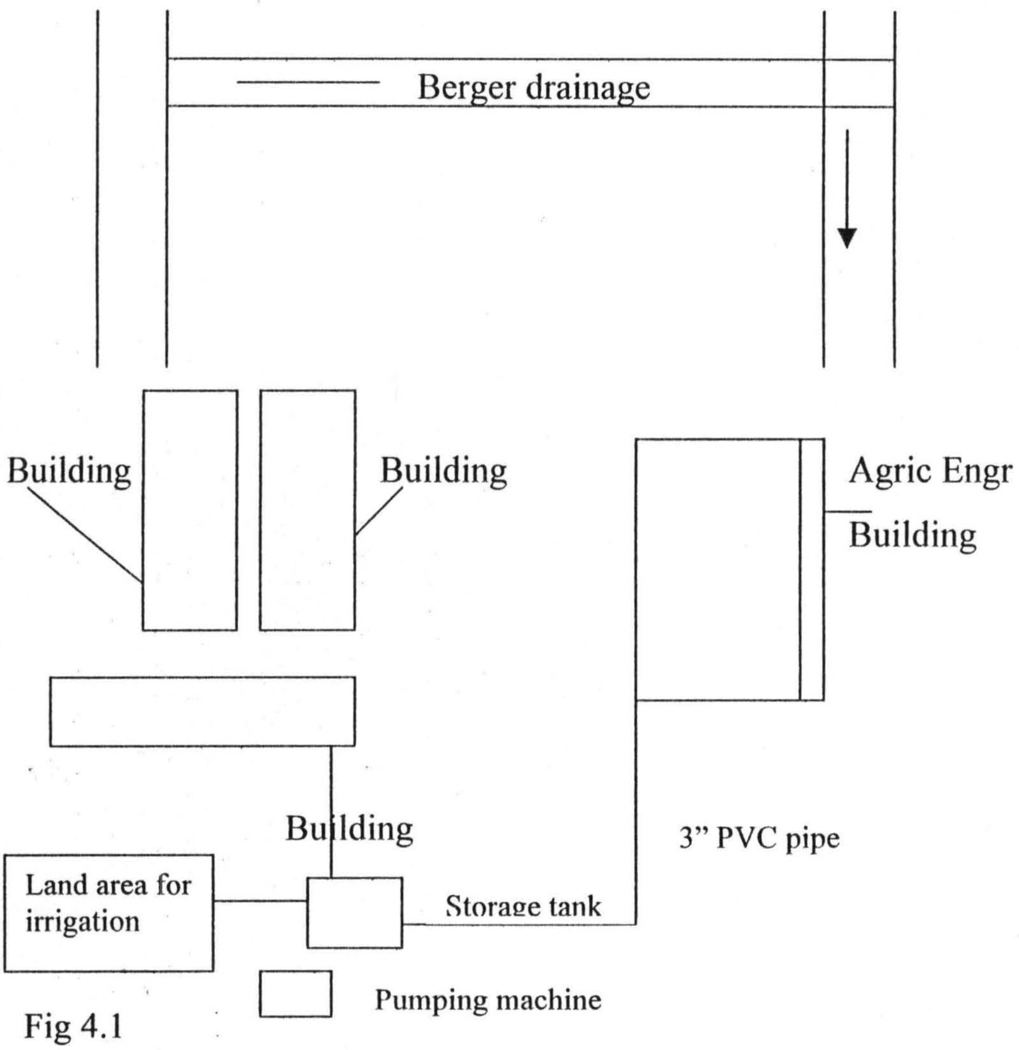


Fig 4.1

4.2 The observed Rainfall at FUT

Table 4.1

Reading	Rainfall (m) amount	Time
1st Reading	0 .75	3.30pm – 5pm ($1^1/_2$ hrs)
2nd Reading	0.70	9pm – 10^{15} pm ($1^1/_4$ hrs)
3rd Reading	0.80	7 pm – 10 pm. (3hrs)

The mean Rainfall amount = 0.75 + 0.70 + 0.80 = 2.25m

The time = $1\,^1/_2 + 1^1/_4 + 3 = 5\,^3/_4$ hrs

The Rainfall intensity $= \frac{\text{Rainfall amount}}{\text{Total time}} = \frac{2.25}{5\,^3/_4} = \frac{2.25}{23} = 0.39$ The

Rainfall Intensity = 0.39 m /hr

The Reservoir tank size = 1.2 x 1.2 x 1.2 = 1.728 = 1.73 m^3

The amount of rainfall harvested for the three readings are

1st reading Vol. $= \frac{1.73}{1.2} \times 0.75 = 1.08125 = 1.08m^3$

2nd reading Vol. $= \frac{1.73}{1.2} \times 0.70 = 1.0092 = 1.01m^3$

3rd reading Vol. $= \frac{1.73}{1.2} \times 0.80 = 1.153 = 1.15m^3$

Mean Volume $= \frac{1.08 + 1.01 + 1.15}{3} = 3.24 = 1.08m^3$

Table 4.2 The storm amount and volume.

Storm Date	Storm Amount(m)	Storm Duration(hr	Volume (m^3) collected
29/05/2003	0.75	$1^1/_2$	$1.08m^3$
5/09/2003	0.70	$1^1/_4$	$1.01m^3$
12/09/2003	0.80	3	$1.15m^3$

From above for every one hour rainfall about $0.4m^3$ expected.

The relationship between the rainfall intensity at FUT Minna and the annual rainfall collected from Minna meteorological station could be said to be related.

$R \; \alpha \; Q^c$ Where

R = Rainfall intensity calculated = 0.39m/hrs.

q = Discharge m^3/hr.

C = Constant

$R = K\,q^c$

$\Rightarrow \text{Log } R = \text{Log } K + C \log q$

$\Rightarrow y = Mx + c$

$y = \log R$

M = c

$X = \log q$

From the observed rainfall collected at Agric Engr Building

R^1 = 0.75m/hr

R^2 = 0.70m/hr

R^3 = 0.80m/hr

$$\text{The rainfall intensity } q = \frac{\text{Rainfall amount}}{\text{Time}}$$

The take taken

Form R1 = 0.75 m

Time = $1\frac{1}{2}$ hrs

For R2 = 0.70m

Time = $1\frac{1}{4}$ hrs

For R3 = 0. 8m

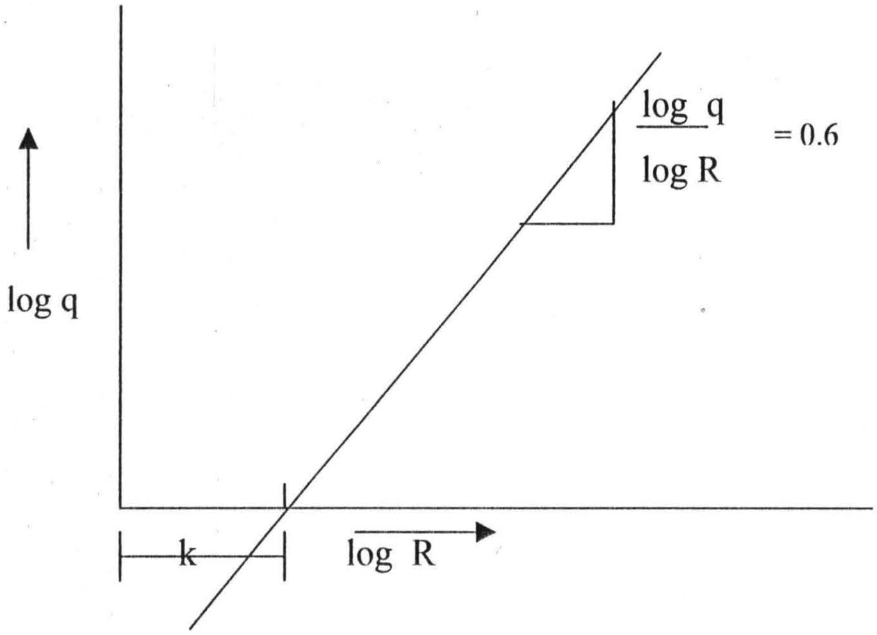
For R3 = 0. 8m

Time = 3 hrs

$\therefore$ q1 $= \frac{0.75}{1^1/_2} = 0.75 \times \frac{2}{3} =$ 0.50m/hr

q2 $\frac{0.70}{1^1/_4} = 0.70 \times \frac{4}{5} =$ 0.56m/hr

q3 $\frac{0.80}{3} =$ 0. 26.7 m/hr.



Not to scale

Log q^1 = Log 0.50 = 0.30

Log q^2 = Log 0.56 = 0.25

Log q^3 = Log 0.267 = 0.57

The mean rain intensity = 1.327m /hr.

C = slope

K = Intercept

From graph

C = 0.6

K = 1.4

FIG 4.2 THE RELATIONSHIP OF OBSERVED RAINFALL AND THE RAIN INTENSITY MEASURED IN FUT MINNA

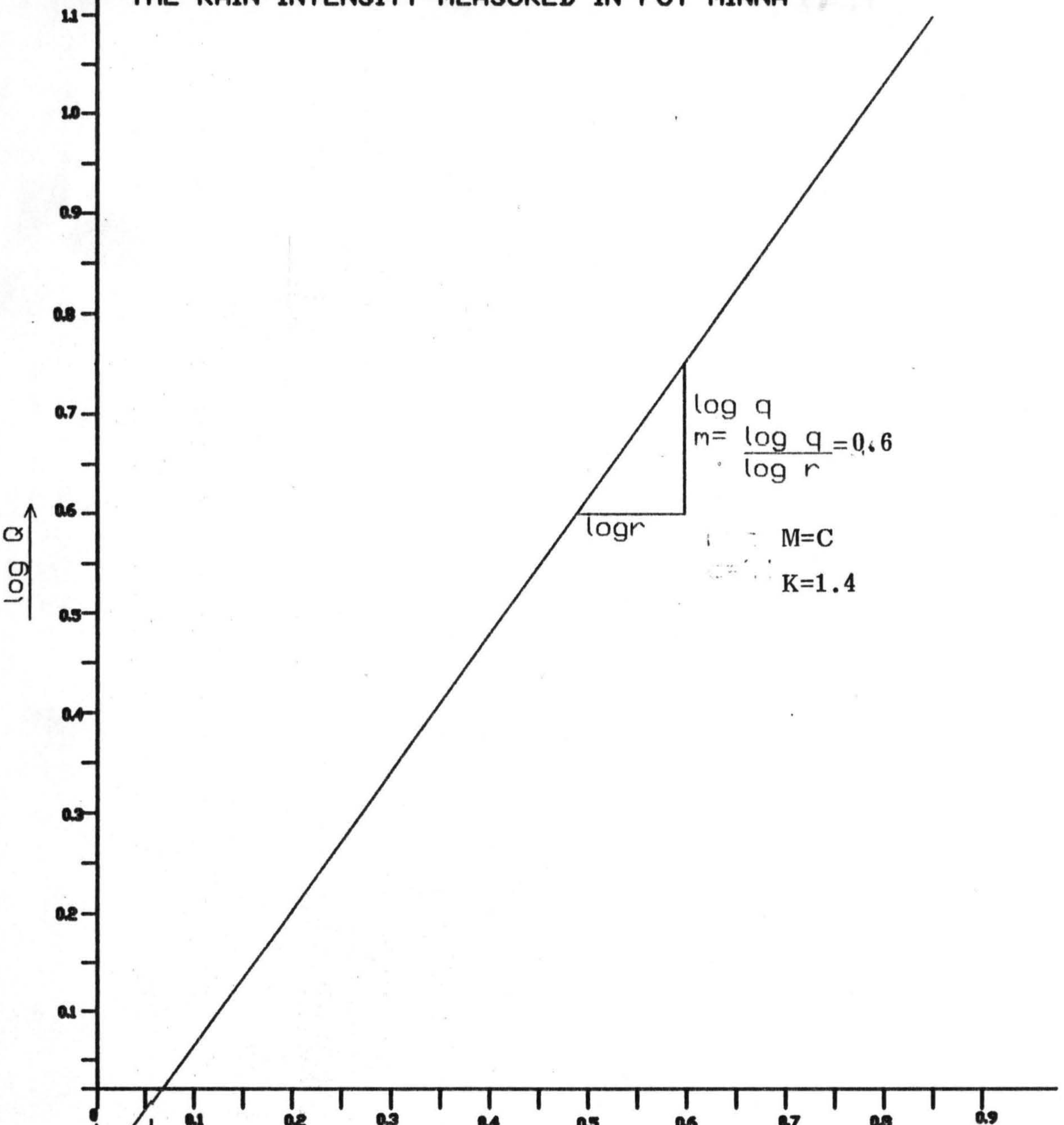
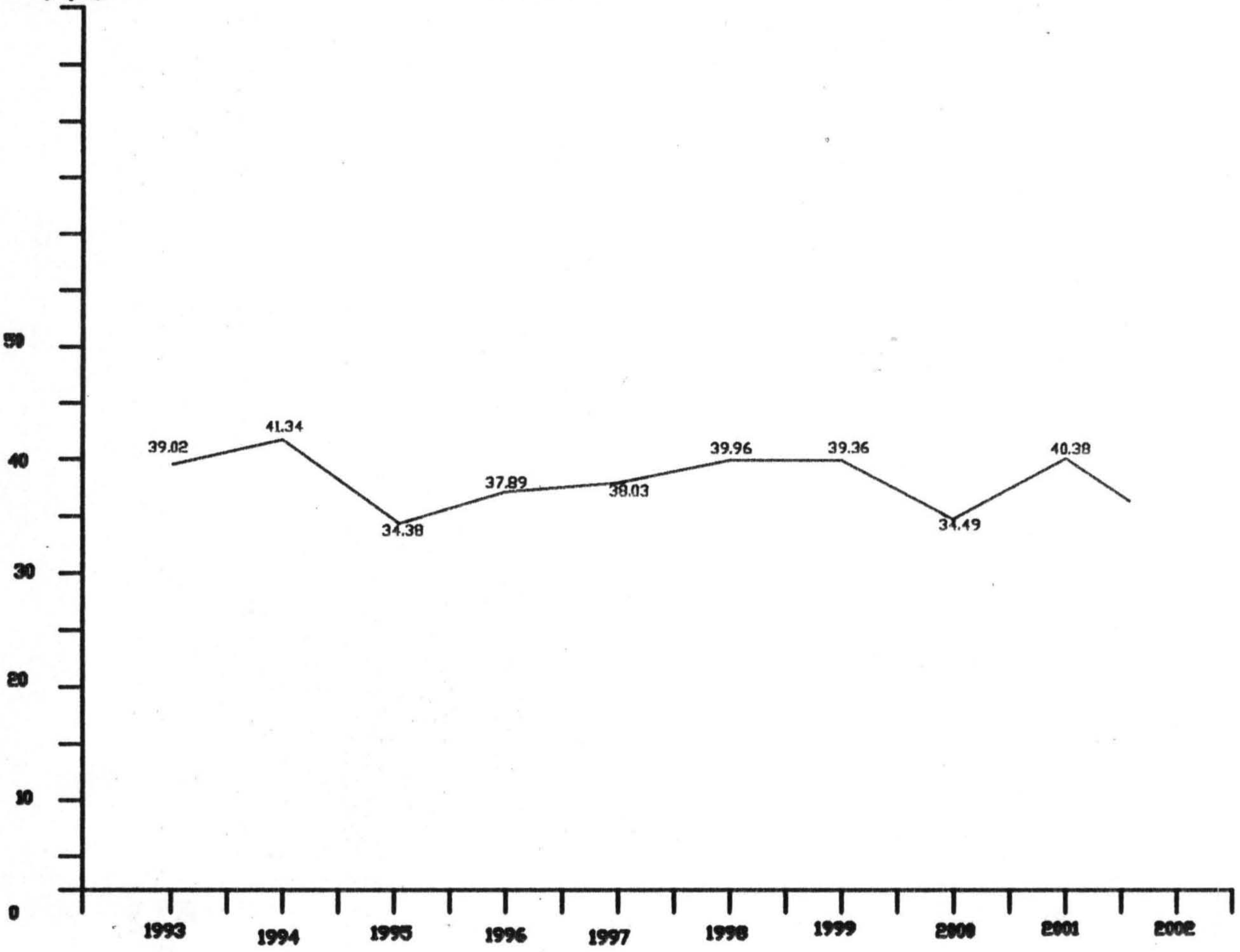


FIG 4.3 MEAN ETO BY BMN MODEL FOR 10 YEARS PERIOD(1993-2002)



The relationship of the rain intensity q to the total area of the cachment area.

Catchment. area = 50 x 10 = 500m^2

To determine the total discharge of water in the catchment area for irrigation purpose.

$\therefore$ Q = AR^c

A = 500m^2

R = 1.327

C = 0.6

Q = 500 x 1.327$^{0.6}$

= 500 x 1.25265 = 59.06

Q = 59.06m^3 /hr

Form the observed rainfall intensity 0.39m/hr

FUT Minna considering the area of the rain water catchment a discharge of 59.06m$^{\cdot 3}$ /hr of water is compounded.

It could as well be deduced that in any part of Minna Niger State knowing the rainfall intensity you can also determine the discharge of water in any given surface area of a reservoir.

If the discharge (Q)of water 59.06m^3 /hr is calculated and the water requirement of the crop is determined then the design for the irrigation. system for maize to be grown can be determined to avoid not enough water for the irrigation operations.

The mean rainfall amount = 0.75 + 0.70 + 0.80 = 2.25m

The time = 1.5 + 1.5 + 1.25 + 3 = 5.75 hrs.

The mean time = $\frac{5.75}{3}$ = 1.92 hrs.

The mean volume = $1.08m^3$

The required amount of water needed for the area $500m^3$)

$= Q = AR^c$

Where =

$A = 500m^2$

$R = 1.327$

$C = 0.6$

$Q = 500 \times 1.327^{0.6}$

$= 59.06\ m^3/hr$

The average = $\frac{1.08}{1.92}$ = 0.506

If the required water needed for irrigation is calculated to be $59.06m^3/hr$. To know whether it is possible to obtain the water, we need to know the number of rainfalls required to fall to make the amount of water.

The number of rainfall event needed to meet up the required water for irrigating $500m^2$ area

$= \frac{59.06}{0.506} = \frac{59.06}{50.6}$ = 118 rainfalls

Since it is possible to have about 118 rainfalls in Minna then it is possible to compound enough water to irrigate about $500m^2$ area.

4.3 Surface Irrigation

Surface channel uses open channel flow to spread water over a field. The driving force in such system is gravity and hence the alternate term, gravity flooding. Once distributed over, tends to be smaller and more densely distributed.

The catchment area water in this topic serves as a source of water for irrigation.

4.4 Water Application

Irrigation may be applied to crops by flooding it on the field surface, by applying it beneath the soil surface, by applying it under or by applying it in drips.

The common methods of irrigation are:-

(i) Surface which include Border, basin or furrow methods

(ii) Sub-Surface

(iii) Sprinkler Rotating head or perforated pipe

(iv) Drip.

The water supply, the types of soil, the topography of the land and the crop to be irrigated determine the method of irrigation to be used. Whatever the method of irrigation it is necessary to design the system for the most efficient use of water by the plant. For this project border strip shall be used. Border strips are of land with down ward slope but level as possible that are separated by parallel border as levees.

At the upper end water is applied by means of divertion boxes installed in the bank of an irrigation ditches or by large siphon tubes.

To encourage a proper spread the border strip should be leveled for the first 10m or so with a uniform downward slope there after. A level cross section will facilitate an even rate of advance precise land leveling is essential for the success of the method. At the lower end a drainage ditch is constructed to collect run-off . Both close growing crops (alfalfa, pastures and row crops can be irrigated by the border strip methods.

Discharges required to irrigated border strips can be large sometimes reaching 300m3/hr poor design can result in very large losses of water to deep percolation and or run-off because of the large discharge involved.

4.5 Determination of Evapotranspiration (ETO)

Using the Climatic factor o determine evapotranspiration of the crop (Eto) The Blaney – Morin – Nigeria model is used. The BMN model formula was developed in 1998 and the data given in tables 3.1-3.4 were used in the determination of crop potential Evaporanspiration (ETO)

Sample 4.1

Calculation

$$Eto = \frac{rf\,(0.46\,T + 8)\,(520 - R^{1.31})}{100}$$

Eto = Potential evapotranspiration mm/day

rf = radiation ratio, that is ratio of maximum possible radiation for a given month to maximum possible radiation for the year.

T = Temperature (0C)

R = Relative humidity (%)

$$Eto > \frac{(0.46 \times 28.5 + 8)\ 520 - 27)^{1.31}.}{100}$$

rf Add will the radiations for 1991 – 2002

3.7 + 4.5 + 4.5 + 3.6 + 6.6 + 5.3 + 5.5 + 5.6 + 5.7 + 4.7 + 7.0 + 7.8 = 64.5

$$rf - \frac{3.7}{64.5} = 0.06$$

$$Eto = 0.06\ (04.45 \times 28.5) + 8\ \frac{(520 - 27^{1.31}.)\ 75.00}{100}$$

$$\frac{8.76\ 95 \times 445}{100} = 39.02 mm/day.$$

the calculation is done for the 10 years and plotted.

See fig 4.1.

4.6 Design of the Irrigation System

The major aspect to be taken to consideration are:

(a) Water sources

(b) Quality and quantity

Quality ⇒the chemical content is considered salts⇒ salinity and burn which will kill the crops and injuries to consumer. Presnece of suspended solids.

Quality

- Determination of the types of soil and the infiltration rates of the soil. Carry out the soil survey upto depth 1.2mm

- To know whether the soil is homogenous or heterogenous.
- Also determine the water holding capacity (WHC)

c. Consider also the erodibility of the soil of the soil. In erodible soil, the velocity is lowered

d. Topography – General slope and direction of flow should be determine, to help to know the degree of slope.

4.6.1 BORDER STRIP

A 2 hectare farm is to be irrigated by 1 ha daily in on 8 hours working day. The consumptive use of the crop is 20mm/day and its effective root zone depth is 97cm the soil has a FC and WP of 20% and 5% respectively by dry weight and a specific gravity of 1.6. from measurement it was found that water application efficiency is 50% and the conveyance efficiency is 50 and the conveyance efficiency from the release gate to the farm is 60%. If the MAD is limited to 60% and the crop takes 91 days to matured compute the required discharge in L/sec at the farm turnout.

ii. The gross volume of water m2/season to be diverted from the release gate for growing the crops.

4.6.2 Information

- To design border system
- To irrigate 1 hr daily in 8 hrs
- Total area 21a

B. Soil Parameter (Evaluated)

i. Field capacity Fc = 20%

ii Wilting point Wp = 5%

iii Specific gravity = 1.6

iv F =- 70 + 0.652 + 20

To pography to be leveled to 0.45% slope

Field length	=	100m
Field width	=	500m
Growth period	=	91 days
MAD	=	60%

Efficiency

Ea = 50%

Ec = 60%

Fa = [Fc – wp] Bd. RED. MAD = MM

= (0.2 – 0.05) 1.6 X 970 X 0.6

= 139.7mm = 140m

Irrigation frequency $\frac{c\ Fn}{Cu} = \frac{140mm}{20mm/s}$ = 7 days

Gross depth of water $Fg = \frac{Fu}{Ea}$

$= \frac{140}{0.5}$ =280mm

Ea (Ta-Tl)

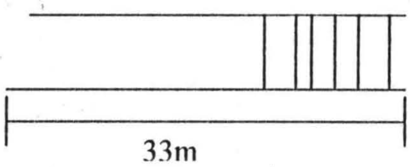
∴ of = 100 (140 x 10-3 = $0.00334 m^3/sec$

50 x 2.29 x 366 = 3.34L/sec

Discharge required per strip

= 3.34 x 33

110 L/sec



Assume a strip of 5.5m width

No of strips/set = 33/5.5 = 6.5 strips set

Discharge strip qs = 3.3.4x5.5

= 18.4L/sec.

Discharge required at release gate

$$Qr = \frac{qt}{Ec} = \frac{110 \text{ i/sec}}{0.6}$$

= 183 i/sec

Plot 1	Plot 2	Plot 3	Plot 4	Plot 5

NOTE discharge through a siphon = cq √2 gh

Taking 1 plot

Introduction attached is the specification of border design for the project. There is a problem of high discharge from the release gate of 183L/sec. This would call for a large channel to be constructed. If the working hr and days/work could be increased the discharge would then be much less.

However the design has been based on the requirement of 1 ha daily over an 8 hr working day this has been designed to Irrigate 1 ha in 7 hrs given 1 hr extra for break and shifts.

The internal between irrigation is 7 days per each plot.

4.8 **Crop**

Maize

Variety – T Sr white (tropical Zone streak resistant.

Open pollinated and certificated seed planting date – June

Germination – 4 days

2 weeks after planting – fertilizer application (Split)

6weeks after planting – formation of leaf flag

6weeks after planting – Teaseling fand cobins

10 weeks after planting - maturing

12 weeks after planting – grown colouration on cob

Total of 125 days from planting to harvesting.

Summary for maize.

The KC of maize = 0.48

June – planting sub-humid Nigeria and early October harvesting

Panting data – June

Initial stage – 20 days

Crop development - 30 days

Mid – season – 40 days

Late Season - 30 days

120 days

Crop coefficient factor (Kc) for maize, the different s stages of croup grower and prevailing climatic conditions were obtained

Kc for maize = 0.48

Kc for development stage = 1.05

Kc. For maturing stage = 0.55

4.8.1 **Determination of Crop Evapotranspiration (Etc)**

Assuming 1 ha of land

A = 100 x 100m2

= 1000 m2

The irrigation water requirement e.g June

= Etc = Etp x Kc

= 39.02 x 0.48

= 18.7296mm/day

The water required for the maize

For the month of June

= No. of days in June 30 days

= 30 x 18.7296

= 561.888×10^{-3}

Water required for maize for the monta =

Volue = Ax d

= $10000 \times 561.888 \times 10^{-3}$

= 56110 m3

Take efficiency of 60%

Volume = 5610 x 0.6

= $337m^3$

4.9 **Pump**

In choosing pump size for the irrigation of the garden, discharge expected per day should first be determined. In order to find this, knowing the discharge in the main distributory canal to be 0.52m3/hr

$\therefore$ Discharge per day = 0.52 x 3600

= 1872m^3/hr

The depth to which the water to be pumped in order to calculate the water horse power (WHP) for he pump.

Where

WHp = water horse power

Q = Discharge per hr m^3/hr

H = total dynamic head.

Conveyance Efficiency

3" PVC pipes are used as conveyance material from the pump.

A 3" suction hose takes water from the source of water and a 3" delivery hose is attached to the PVC pipe because of the distance from the source to the field.

DESIGN CALCULATION

Structural Design for Reservoir of size 6m x 3m x 2m

Assumed thickness to be 300mm for both wall and base

Plan

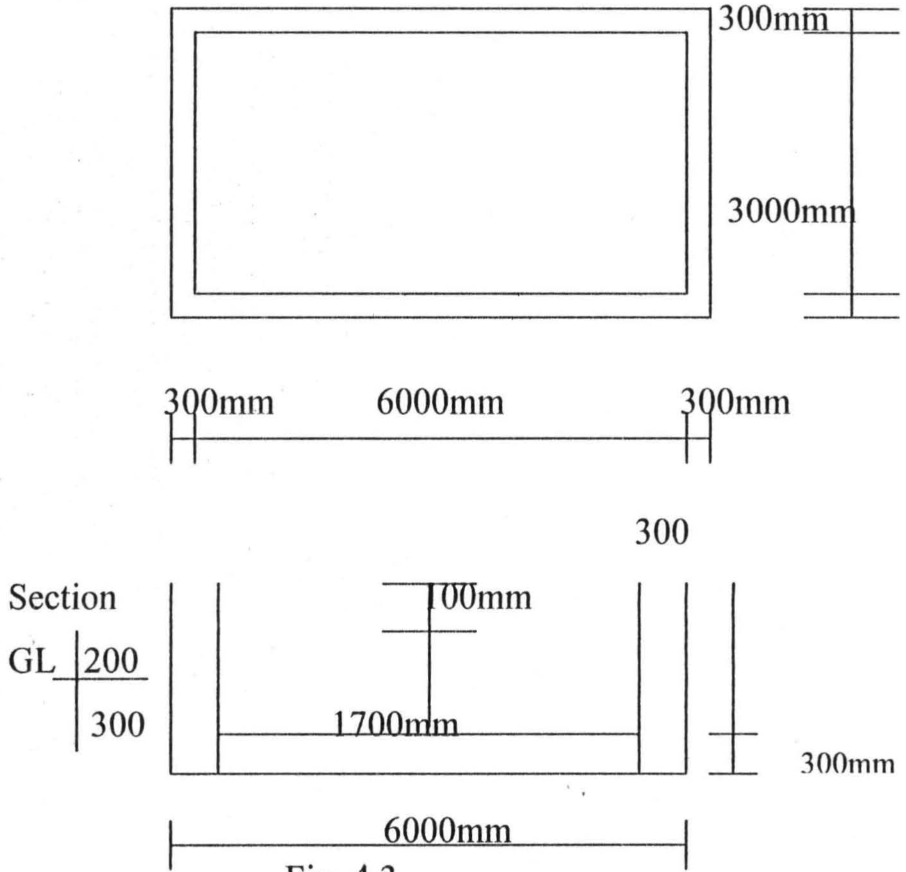


Fig. 4.3

Wall height is 2m which is treated as cantilever wall, the spanning is assumed to be Ly/Lx = 6 /3 = 2 the slab is treated as two – way spanning slab

height of pore water = 2-0.1+03 = 1.6m pressure.

height of active earth

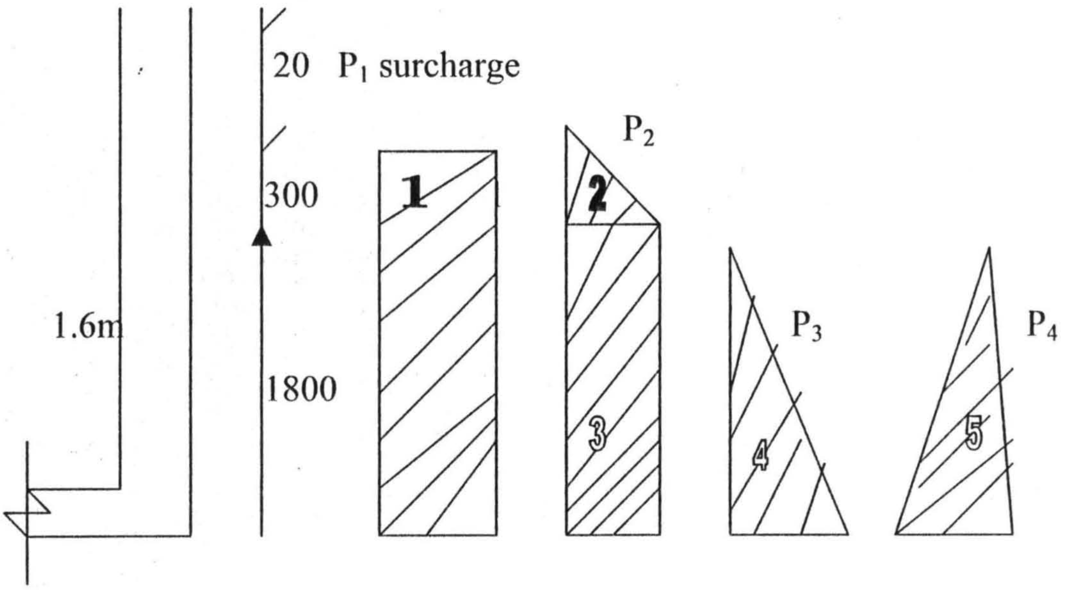
Pressure = 2- 02 = 1.8m

height of retaining

wall = 2 – 0.2 = 1.8

Assumed a surcharge load of 5.0 KN/M 2 and angle of internal friction as 30 degree

Active pressure Diagram



P^1 = Surcharge

P^2 = active earth pressure - bulk soil

P^3 = active earth pressure - submerged

P^4 = active water pressure

Active pressure = Pa = Ka χ H

Ka = Co-efficient of active pressure is

Calculated from ka = tan 2 (45 – 0/2)

ϕ = Angle of Internal resistance of the soil

χ = bulk density of the soil

H = wall height

$\Rightarrow$ $\theta = 30^0$, χ = 18kw/m^2

$\theta^1 = 300$ $\chi^1 = 9.81$ kn/m^2 (water density)

$\Rightarrow$ $K_a = \tan 2\ (45 - 30/2) = 0.\ 33$

$P_a = 0.33 \times 18 \times 1.8 = 10.69$kn/m^2

P_1 = Surcharge

$= 0.33 \times 5 \times 1.8 = 2.97$ kn.m^2

P_2= (2) $10.\ 69 \times 0.3\ \frac{1}{2} = 1.60$ kn/m

(3) $10.69 \times 1.5 = 16.04$kn/m^2

$P_2 = 17.64$kn/m^2

P_3 = Submerged (4)

$\Rightarrow$ $18 - 9.81 = 8.19$ kn/m^2

$\therefore$ $Pa = 0.33 \times 8.19 \times 1.8 = 4.86$kn/m^2

$\therefore$ $P_3 = 4.86 \times 1.5 \times \frac{1}{2} = 3.65$kn/m^2

P_4 = water pressure (5)

θ for water 0

$\therefore$ k_a 1.0 $p_a = k_a\ \chi\ W_h$

$\Rightarrow$ $1.0 \times 9.81 \times 1.6 = 15.\ 70$ KN/m2

$\Rightarrow$<u>15.70KN/M^2</u>

$\therefore$ $p_4 = (5) = 15.\ 70 \times 1.6/2 = 12.56$ kn/m^2

total horizontal forces

$P_1 + P_2 + P_3 + P_4$

$2.97 + 17.64 + 3.\ 65 + 12.56$

$=$ 36.82 KN/m^2

total forces = 36.82KN/m^2

Moment due to load about wall center

$\Rightarrow (P_1 \pi x x - C)$

$\overline{X}$ = Centre P = forces, center line = 0.15

$2.9 x (\frac{1.8}{2} - 1.5) + 1.60 (\frac{0.3}{3} + 1.5 - 0.15) + 160.04 (\frac{1.5}{2}$

$- 0.15) + 3.65 (1.5/3 - 0.15) + 12.56 (1.6/3 - 0.15)$

$\Rightarrow 2.23 + 2.32 + 9.624 + 1.28 + 4.81 = 20.26$

Moment = 20.26KNM

Designed Assumption

Feu = 30 N/mm^2

Fy = 410 N/mm^2

h = 300mm

c = 25mm

θ of bar = y16

D = h – C- $^C/2$ = 300 – 25 – 16/2 = 267mm

$K = \frac{m}{bd^2 fcu}$ & 0.156 $\frac{20.26 \times 106}{1000 \times 267^2 \times 30}$

$\Rightarrow 0.009 < 0.156$

$Z = d (0.5 + \sqrt{0.25 - \frac{k}{0.9}} \leq 0.95d$

$\Rightarrow 267 (0.5 + \sqrt{0.25 - \frac{0.009}{0.9}}$

$\Rightarrow 264 \leq 254$ used Z = 254

$$As = \frac{M}{0.87 f_y Z} = \frac{20.26 \times 10^6}{0.87 \times 410 \times 254}$$

$= 233.62mm^2$

$$As\ min = \frac{0.25 \times 100 \times 300}{100} = 750mm^2$$

Provide Y16 @ 250mm o/c As $804mm^2$

Check for Flexure crack

Designed concrete strength = Fx/1.3

$\Rightarrow$ 30/1.3 = 23.08 N/mm^2

αc (modula ration) for Fcu c 3.0N/M3 = 26/CV/M2

$$\Rightarrow \alpha c \text{ For } \frac{2E}{Ec} = \frac{2 \times 200\,000}{26000}$$

$= 15.4$

$$\frac{\alpha_c\ As}{bd} = \frac{15.4 \times 804}{1000 \times 267} = 0.05$$

X = 0.2d = 53.4

$$Fs = \frac{20.26 \times 10\ 6}{1000 \times (267 - 53.4/3)} = 81.30N/mm2$$

130N.mm2

81.30N/mm2 less 130n/mm2 required

Check for thermal cracking

$$P = \frac{AS}{Bd} = \frac{804}{100 \times 267} = 0.003$$

S max (Maximum crack width)

$$\frac{FCt}{Fb} \times \frac{\phi}{2p} = 0.8 \times \frac{25}{2 \times 0.003} = 3333$$

Wmax (Permissible crack width)

$$Wmax\ (S\ max\ T\ \frac{\alpha c}{2} = 3333 \times \frac{30 \times 10 \times 10^{-6}}{2}$$

$$= 0.500mm$$

This is more than 0.2mm permissible hence increase reinforcement provide Y 16 @ 100m c/c As provide 2010mm^2

$$\therefore P = \frac{As}{bd} = \frac{2010}{1000 \times 267} = 0.008$$

$$S\ max = \frac{0.8 \times 25}{2 \times 0.008} = 1250$$

$$W\ max = \frac{1250 \times 30 \times 10 \times 10^{-6}}{2} = 0.188mm$$

Which is less than 0. 2mm

Critical ratio rcr $= \frac{Fcr}{Fy}$ $= 1.3N/mm^2$ 3 day

$\Rightarrow \quad \frac{1.30}{410} = 0.003$

P = 0.008 > 0.003 critical ratio OK

$\therefore$ Provide Y 16 @ 100mm c/c

Aspr. 2010mm2

$Asm = \frac{0.25 \times 300 \times 100}{100} = 750mm^2$

Dist bar provide Y16 @ 250mm c/c

As pro 804 mm^2.

Based Designed

Wt of water = Area of base x height water

x unit weight of water

$\Rightarrow \quad 3 \times 6 = 18m^2$ = Area of base

water height = 1.6m

unit wt = 9.81 Kn/m2

$n = 1.4gk + 1.6\,qk$

$n = 1.4\ (405.12) + 1.6\,(28.8)$

$= 613.25KN$

over the base assuming even distribution

$$Udl = \frac{613.25}{3.3 \times 6.3} = 29.50KN/m^2$$

taking a 1m strip within the 1.6m of water the critical value are walls

$\Rightarrow \quad 4(1.6 \times 0.3 \times 24 \times 1.4) = 64.51KN/m$

Base $= 3.3 \times 0.3 \times 24 \times 14 = 33.26$ KN/m

Base $= 6.3 \times 0.3 \times 24 \times 1.4 = 63.50$KN/m

Water $= 1.6 \times 3 \times 6 \times 9.81 \times 1.6 = 452.$

Total $=$ 613.31 KN/m

Load per metre runs

$$\Rightarrow \frac{613.31}{6.3} = 97.35\ KN/m^2$$

this is more critical $\therefore$ Use

94.35 KN/m^2 at ULS

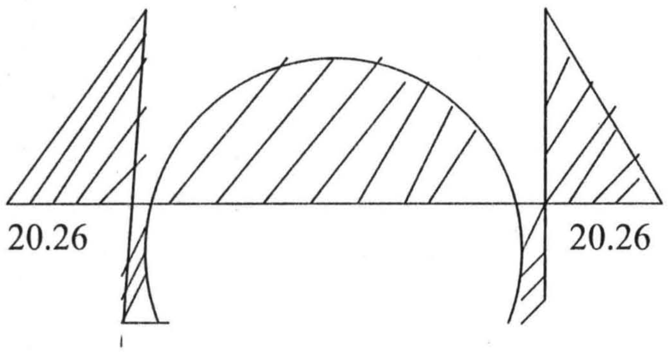
Max $= 0.125nlx2 = 0.125 \times 3.3^2 \times 97.35$

$= 132.52KNM$

Span moment $= 132.52 = 20.26$

$= 112.26$ KNM.

BMD



K = $\frac{11}{10(}$ 56

Z = 267 (0.5 +√ 0.25 – $\frac{0.05}{0.9}$

Z = 251.24 α 254

As = $\frac{112.26 \times 106}{0.87 \times 410 \times 251.24}$ = 1253mm^2

∴ Provide Y16 @ 100 c/o

As pro 21010mm^2

As in wall

∴ Used the same reinforcement as in wall.

CHAPTER FIVE

5.0 CONCLUSION AND RECOMMENDATION

5.1 CONCLUSION

Amongst various methods of Rain harvester a catchment area water harvester is considered of low capital intension compared to others.

The 'observed rainfall taking in FUT Minna where the rainfall intensity is obtained as the volume of water for Irrigation operations. The relationship of the observed rainfall taken compared to the annual Rainfall data collected from Minna metrological station shows that at any paint in Minna Niger State the rain intensity at a catchment area is the same throughout Minna Niger State. The Climatic factor used in calculating the evapotranspiration a BMN model is significant in predicting ET. The Blaney – Morin-model implies that, under Nigeria conditions, accurate prediction of Etp can be obtained from temperature, relative humidity and radiation.

The effect of wind can be ignored without much loss of accuracy with BMN MODEL. The results showed that BMN over predicts annual Etp values of 55.96 mm/day.

Compared FAO 1983 irrigation and drainage paper – 24 standard, the result were consistent of the BMN model.

Economic considerations however set a limit to acceptable over prediction thus the BMN predicts to lesser degree. Duru (1984) For agricultural operations, irrigation is the only source of water during the dry period.

The amount of water required for the Irrigation is $59.06m^3/hr$ for $500m^2$ the BMN model is the best model for the water management to avoid excess application of water to the maize crop which is detrimental to the plant growth. It is best to maximize the available irrigation water for optimum usage. If the amount of water required to irrigate is calculated to be 59.06 m^3/hr. We need to know the number of rainfalls required to fall to make the amount of water required for the irrigation.

The number of rainfall events needed to meet up the required water to cover $500m^2$ is 118. Since it is possible to have about 118 rainfalls in Minna then it is possible to compound 59.06 5/hr of water for Irrigation.

5.2 RECOMMENDATIONS

The use of Rainwater catchment area serves as hopes for thousand of scattered small community that do not have a river passing through their community and have no access to dams can make use of this method to bring food on their table.

The use of BMN evapotranspiration model to estimate the irrigation water requirement of crops is a challenge to our Agricultural Engineers in Nigeria to do more research work by using our climatic data in enhancing crop production in Nigeria.

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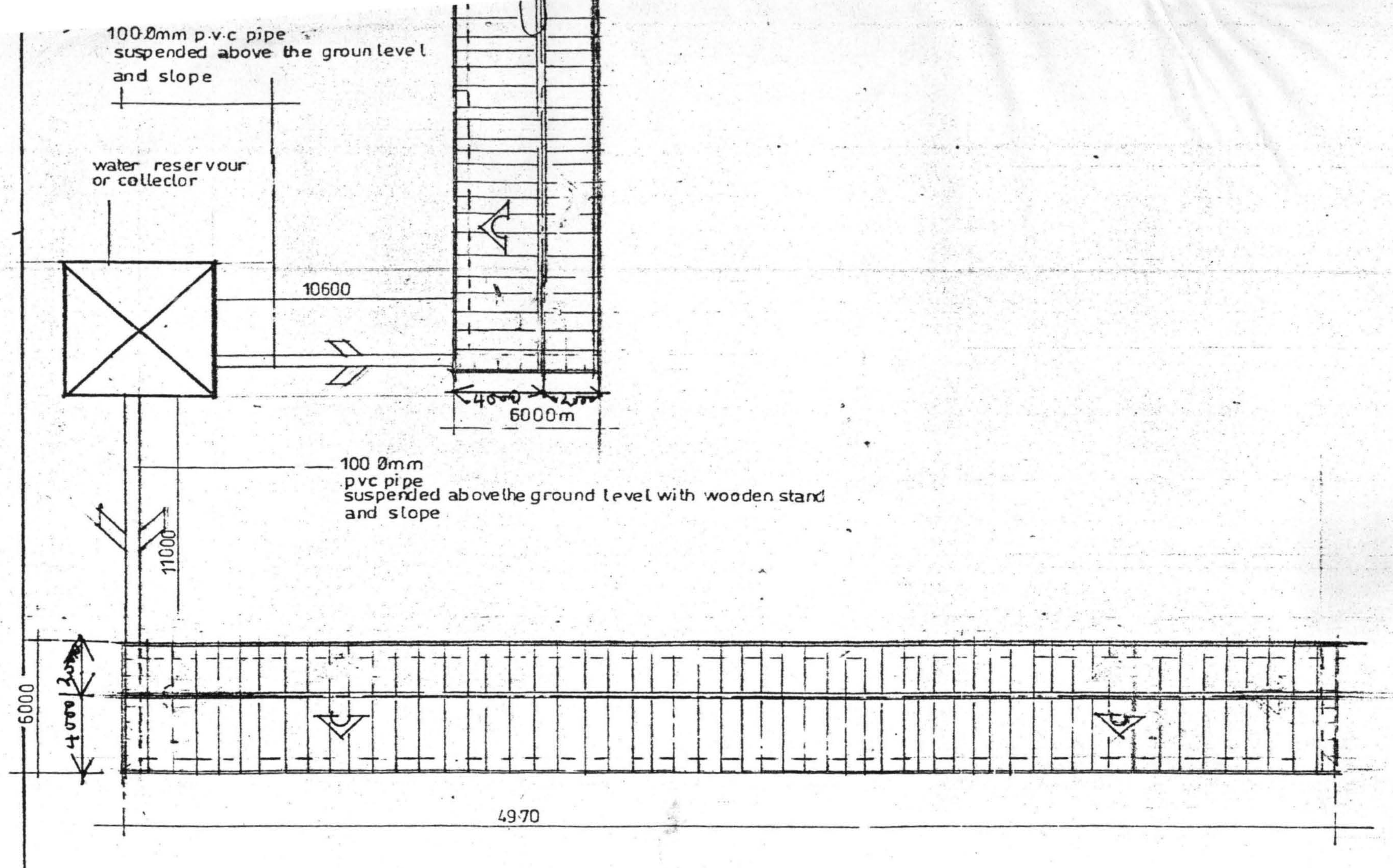

DRAWING SHOWING THE CATCHMENT AREA