A STUDY ON ANGUWAR RAMA GULLY EROSION SITE AND ENGINEERING CONTROL DESIGN

BY

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A STUDY REPORT SUBMITTED TO THE DEPARTMENT OF AGRICULTURAL ENGINEERING, IN PARTIAL FULFILMENT OF THE REQUIREMENTS FOR THE AWARD OF POST GRADUATE DIPLOMA CERTIFICATE IN AGRICUTURAL ENGINEERING (SOIL AND WATER OPTION) F.U.T. MINNA

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APPROVAL PAGE

This is to certify that this project is the original and approved work of Mr. Dunama Iliya Makama, PGD/AGRIC/98/99/58 and that it was prepared in accordance with the regulations governing the preparation and presentation of project in Federal University of Technology, Minna.

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DEDICATION

This work is dedicated to my beloved late father, Pa Iliya Makama, who during his life-time made all efforts to make me stand on my feet.

DECLARATION

I hereby declare that this research project was carried out by me under the effective and fair supervision of Engr. (Dr.) D. Adgizi of the Department of Agricultural Engineering, Federal University of Technology, Minna and that I have not copied some previous work carried out by some one else.

D. I. Makama
Name of Student

.....
Signature of Student

August 28th, 2000
Date

ACKNOWLEDGEMENT

Although so many turbulent experiences were paased through in the course of carrying out this study, with the guidance of the Almighty God, it was possible to overcome them.

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I also want to acknowledge the various contributions made by my Head of Department, Engr. (Dr.) M. G. Yisa, lecturers and the entire staff of the Department of Agricultural Engineering who inspired me to achieve success in this study.

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My sincere thanks too go to the following corporate organizations who provided materials and data for this research work and for the use of their library and laboratory facilities. These corporate organizations include National Water Research Institute, Kaduna; Food and Agricultural Organization (FAO), Abuja; United Nations Development Project (UNDP), Abuja; and the Zonal Engineering Mapping and Resource Services Limited, Kaduna.

I must not fail to appreciate the contributions made by the community of Zonkwa in Zangon Kataf Local Government Area for their cooperation and assistance in the course of carrying out site investigations.

My sincere appreciation likewise goes to my colleagues and friends, who have in various ways contributed to making this work a huge success. Dr. D.T. Gowon, Director SEFC Department; Engr. F. A. Omeh; Dr. E. Amba; Engr. F. O. Akintola and Engr. E. Ekanem all of the Department of Erosion, Flood and Coastal Zone Management, I thank you. To my friends, Arc. P. M. Bana, Mr. H. I. M. Kadam and Dr. P. Nyandaiti, you have always encouraged and supported me morally.

I must not forget my colleague, Mr. Adamu Dogara whose contribution deserves special mention for working tirelessly and round the clock typing my manuscripts.

Last but not the least, to my dear wife, Mrs. Margaret D. Makama, my beloved children and the entire members of my family for their understanding, love, patience and perseverance, without which it would have been impossible to accomplish this work.

ABSTRACT

The devastation of soil erosion is so great when allowed to continue unabated to gully erosion. The control therefore becomes expensive, time consuming and cumbersome. The communities so affected at that stage may not have the capacity to bear the cost of control.

The topic of the study, which is "A Study on Anguwar Rama Gully Erosion Site and Engineering Control Designs" was chosen for a number of reasons. Major among the reasons included the alarming rate of gully erosion in the area resulting into loss of lives and properties worth millions of naira. A school and a clinic in the area and also the road linking Zonkwa with Kachia towns are under threat. This study was therefore carried out so that engineering solutions could be proffered that could be used to solve the problem, and also to present the report as a thesis for the award of a Post Graduate Diploma certificate.

During the course of the investigation, several methods were used to obtain all the information on the nature, magnitude and the progression of the erosion in the study area. Reconnaissance visits were made to the site the gully erosion, measurements of dimensions of the gully were taken, size the area affected by the gully were determined, and members of the communities were interviewed on the history of the problem. Literature on gully and its control measures as well as climatological data (vegetation, temperature, rainfall, relative humidity, radiation, etc) of the study were also collected from relevant sources and analysed.

The result of the research indicated that Zangon Kataf L.G.A. lies within the area prone to severe flood and gully erosion in Kaduna State. Interviews with members of the community revealed that development of the gully dates back to about 3 decades. The average dimensions of the gully in the area 3.5 meters deep, 7.0 meters wide and about 500 meters long. This gully covers an area of about 100 hectares. The data collected were used in determining the most appropriate engineering designs for the control of the gully.

Based on the information and data obtained from the study, a number of recommendations were made to control the further development of the gully. These include improvement of the drainage channel; stream bank stabilisation with gabion walls; reduction of gully bed slope using drop structure; grassing of the surrounding gully banks and improvement of gully bed; and imbibing the culture of constant maintenance of the erosion control structures. Institutional measures were also recommended to discourage practices that are not environmentally friendly.

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CHAPTER ONE

INTRODUCTION

1.0 BACKGROUND OF THE STUDY

The nature of our watershed, influenced by the climatic and human factors have greatly induced environment hazards accompanied by some devastating consequences on our habitat.

Lives and properties worth hundreds of million of naira are annually lost through such hazards not only in Nigeria but the world over. This has in the recent times witnesses quite a number of such disasters in many forms and in various geographical locations of this country.

These losses are usually accompanied by devastating effects on the political well being and socio-economic lives of the people. According to 1998 World bank annual report (pg 26), Nigeria environmental losses when evaluated, could amount to about $1.2billion U.S. dollars annually, such annual losses if otherwise harnessed into development projects would have otherwise transferred the lives of the citizenry for betterment. To mention but few of such losses through disaster are:

i) The devastating effects of gullies on our productive lands. About 2000 very active gully sites have been identified throughout, the width and breath of this country. Eight hundred of whose length range from 300m-2000, 50m wide and 10m-50m deep. (National draft Policy on Soil erosion And Flood Control, by SEFC & Cz Mgt Dept;

ii) Erosion sites mostly found around Abia, Anambra, Ebonyi, Enugu, Delta and Akwa Ibom states are

also severe that thousand of hectares of land have been rendered un-cultivable while so many communities have been abandoned for new settlements.

iii) Communication has been cut-off between neighbouring communities due to deep gullies Roads are not motorable. Particularly in the Eastern states like Akwa Ibom, Bayelsa, Imo, Enugu, Anambra, Abia, Cross Rivers states.

iv) Coastal and marine erosion in Akwa Ibom, Bayelsa, Ogun,Ondo, Delta, Cross River and Lagos States.

v) Sand dunes across the dry arid and semi regions of Sokoto, Borno, Kano, Katsina, Jigawa, Yobe States which have rendered vast agricultural land un-productive. This has also contributed to the effects of desert encroachment. Frequent cases of flood nation wide prominent among which are:-

a) Ogunpa flood of 1982 and 1984 in Ibadan, Oyo State, where hundreds of lives and properties worth thousands of naira were destroyed;

b) Port Hacourt city flood of 1984 caused by 4 hours torrential rainfall in which thousand of people were rendered homeless and properties worth million of naira destroyed;

c) Sokoto flood in 1987 which resulted in loss of produce worth 41 million naira and 85,000 hectare of farmland destroyed;

d) The Maiduguri in Borno state flood disaster in which 13 lives were lost and 68 farm families rendered homeless;

e) Borno flood disaster with 200 lives lost;

f) Duguri in Bauchi flood disaster in which

about 3,500 hectares of farmland and crops worth about 30million were destroyed;

g) Anguwan Rogo flood in Jos in 1992 in which lives and properties worth millions of naira were destroyed;

h) Ilorin flood disaster of 1998 where, lives and properties worth millions of naira were lost.

1.1. FACTORS RESPONSIBLE FOR THE ENVIRONMENTAL DEGRADATION

These environmental hazards, which could be in form of flood, soil erosion, drought and desertification resulting in land degradation occurs at an increasingly alarming rates particularly when aided by human activities. These activities include reckless management of the environment such as bush burning, deforestation, agricultural activities, civil construction works blockage, poor water management, urbanisation, increased population pressure and other associated activities. Another important factor in land degradation is the fragile nature of our soils coupled with the climatic characteristics of our geographic disposition of the country, which is located within the tropics, latitude 2 and 14 to the North and longitudes 14 to the East. The tropics is known for its heavy, torrential rainfall that usually result in surface run-off. The effect of kinetic energy aided by watershed with step slope result into water erosion that could develop gully erosion, thus causing environmental degradation, and sometimes culminate into disasters.

It is estimated that 10% of Nigeria's land-mass is under severe erosion (National policy on soil Erosion and Flood Control, Drought and Desertification Mitigation by the Federal Ministry of Water Resources 1999 ▒ page 2)

AGRO-ECOLOGICAL ZONES AND THEIR RAINFALL DELINEATION

Table 1

ZONE	WET SEASON(S) AREA (%)	RAINFALL (mm p.a.)	KIND	LENGTH (days)	MEAN MONTHLY TEMPERATURE(S) MAX.	NORMAL	MINIMUM
Ultra Humid	2 Extended	2000+ 300-360			32 23	38.25	
Very Humid	14 250-300	1200-2000	Bimodal		33	28.24	21
Humid	21	1100-1400	Bimodal	200-250	37	30.26	18
Sub Humid	26	1000-1300	Minimodal	150-200	37	30.23	14
Plateau	2	1400-2000	Minimodal	200	31	24.20	14
Mountain	4	1400-2000	Bimodal	200-300	36	29.14	5
Dry sub-humid	27	600 - 1000	Minimodal	90 - 150	39	31.21	12
Semi-arid	4	400-600	Minimodal	90	40	32.33	13

The above is a broad classification of the various ecological and land resources zones and their climatic charateristics.

1.3 RESPONSES BY VARIOUS STAKE HOLDER

The effect of such visual distinction to the environment, has sparked off some reactions from various land stakeholders both Government and non-governmental Organisation (NGOs) due to the increasing occurrences of such disaster various at levels of government. ie Federal, state and local governments) as well as NGOs have responded positively to such disaster on environment , some of which are short term in nature while others are long term, These responses had been in form of:-

1. Emergency Relief Programme, where disaster victims are supplied relief materials to alleviate their

immediate suffering, such materials could be inform of food, clothing, shelter, medicare etc.

2. Evacuation victims of disasters from the sites in order to forestall further loss of lives and properties. Examples of such most recent disaster are those of Mozambique in Southern Africa in March 2000,Bangladesh flood disaster in India in 1999, etc.
3. Re-location of affected victims to safe areas like that of Loko village in Adamawa State in 1987
4. Public enlightenment Programmes that could educate members of the public on the dangers of environmental mismanagement
5. Execution of projects that are problem amelioration in nature in order to avert disasters. It's however, sad to note that despite such responses by various stakeholders little success has been achieved to justify the huge sum of money invested on disaster reduction programmes.

The approaches to disaster amelioration have often been haphazard. Funding had always been in piecemeal or even suffered total abandonment by successive administrations in the country. This approach has only resulted therefore in further compoundment of the problems they were initially meant to solve.

In the case of soil erosion control, the soils loss can easily assume an alarming dimension in a very short time. if left to continue, can result into some serious social and economic disaster particularly when it reaches the gully stage. Quite often when erosion is at sheet stage it doesn't draw the attention of even the enlightened land stake users until enormous damages and degradation has occurred, where as a lot could have been saved in terms of the amount of soil loss

CHAPTER TWO

LITERATURE REVIEW

2.0 DEFINITION OF EROSION

Erosion is the detachment, transportation and deposition of soil particles down slope by the action of water and wind. This is accelerated by human activities such as agriculture, construction, deforestation and bush burning.

In the past the problem of soil erosion was peculiar to some areas located in Nigeria's geographic or ecological zones. Today, the problem has assumed the entire ecological zones of the country. Two major processes by which erosion starts are through physical and chemical processes. These processes are aided by the combined activities of several factors such as wind, water, cold, heat, gases, gravity and plants life. This process by which weathering initiates erosion of rocks is by causing alteration in the surface layer known as geological erosion while, the removal of individual soil particles, the loss of organic matter (O.M) and plant material is known as soil erosion. Plants nutrient may be attached to the particles or removed in a soluble form by water. This reduces the productivity of the soil resulting in reduced yields of crops while the causing sedimentation along streams thus causing pollution and reduction in capacity of water reservoirs. In humid regions water is the first agent causing erosion while wind is the most important factor in arid regions.

2.1 SOIL EROSION BY WATER

Factors that influence by water include:-

i. Rainfall duration;
ii. rainfall distribution;
iii. Rainfall intensity;
iv. Size and shape of raindrops;
v. Topography;

vi. Geology and surface cultural of the water shed area;
vii. Moisture level of the soil before rainfall;
viii. Physical and chemical properties of the soil;
ix. Vegetation cover;
x. degree of land scope and length of slope

2.2 FORCES INVOLVED IN SOIL EROSION ARE: -

i. Attacking forces that remove and transport the soil particles;
ii. Resisting forces that retard erosion (resistance of soil to dispersion, movement and vegetation).

2.3 RAIN DROP EROSION

The impact of raindrop directly on the soil particles causes soil splash. The impact is so tremendous that it could raise the splash as high as 60cm laterally on a level surface. The intensity by which rain drops could be as fast as 13.4 meters per second.

The estimated soils splash into the air by such torrential rainfall could be as much as 245kg of soil hectare. the direction and distance of soil splash is determined by slope, wind, surface condition and impediments along the slope, as discussed earlier, under Forces Involved in Erosion

The impact of raindrop on bare soil not only cause splash but also decrease in soil aggregation and hence, deterioration of soil structure. The effects of all these is that infiltration of rain water into the soil erosion is reduced and therefore, there is excess surface run-off water on the soil.

It is at that stage that sheet erosion starts and develops from sheet to rill and gully erosions. An early move to tackle the problem at sheet or rill erosion would have saved a lot in terms of money, time and energy. Soil

erosion control would require haulistic approach, efficient and on a sustainable manner through an effective water-shade management principle. In this research work, the focus is on when erosion is at the disaster amelioration stage, which is the gully stage. This is the stage to which the attention of most land users are drawn to the effects of erosion because of its negative economic effects.

Most land users including governments, non-governmental organisations (NGOs) as well as individuals would want to make attempts to control erosion at the gully stage. It is however, unfortunate that no even governments have enough resources to adequately tackle erosion problem when it is at gully stage because of the cost involved.

There have been attempts however by various levels of governments, non-governmental organisations (NGOs) and individuals to control gully erosion, some of which as far as racking havoc on community settlements.

Despite various efforts put in by those concerned, not much success has been achieved in the disaster amelioration attempts. The prospect of sustainability has always been a mirage. The interplay of effects of raindrop and the characteristics nature of the soil itself contributes a lot in soil erosion and it is expressed in formula known as universal loss Equation. This formula is used in predicting the quantity of soil that is lost through erosion annually.
Formula for universal soil equation is expressed as:

$$\mathbf{A = R \times K \times LS \times P \times C}$$

Where:

A = the soil loss, kg/m2s
R = Rainfall erosivity factor
K = The soil erodibility factor
S = The slope length factor

C = Cropping management factor
P = The factor of erosion control practice

2.4 USLE AND ITS APPLICATION

The primary objective of the soil loss prediction equation is to provide some specific and realistic guide to the conservation practices most suited for the farm filed, ie where crop cultivation is being practised. The USLE was developed as a method to predict average annual soil loss from sheet and rill erosion

Using the available parameters, cropping and management alternatives can be determined to reduce the estimated soil loss to suggested tolerance values for the soil types in line with principle developed by a renowned world scientists, Smith and Wischmeier (1957/67). The USLE may be used to:

i. As mentioned earlier, predict average annual soil loss in a field sloped with specific land use conditions;
ii. Guide the selection of the cropping management system;
iii. Predict the change in soil loss would result from a change in cropping or conservation practices on a specific fields;
iv. Estimated soil lose from land use areas other than agricultural;
v. Determined how conservation practices could be applied or altered to allow for more intensive cultivation, and
vi. Provide soil loss estimates for conservation to use for determining conservation needs.

Sheet Erosion:- Is the uniform removal of soil in thin layers from sloping land resulting from overland flow. the

overland flow eventually result into rill erosion.

Rill Erosion:- Is the removal of soil by water from small but well defined channels when there is a concentration of overland flow. Rills are small enough and could be removed by tillage operation.

In the event that the rill continues to developed unchecked it later advances to a gully stage. Thus the situation becomes easily noticeable and now draws attention the land user. This is the stage at which most land users respond through various amelioration programmes to salvage what remain of the land when the situation has already deteriorated sometimes beyond retention. At the stage gully, the control now becomes more cumbersome, very expensive, time consuming and above can cause hazards to lives and properties. In order to salvage what remains of the land, engineers, agronomist, geologist soil scientist, both skilled and unskilled personnel would be involved in carrying out control measures.

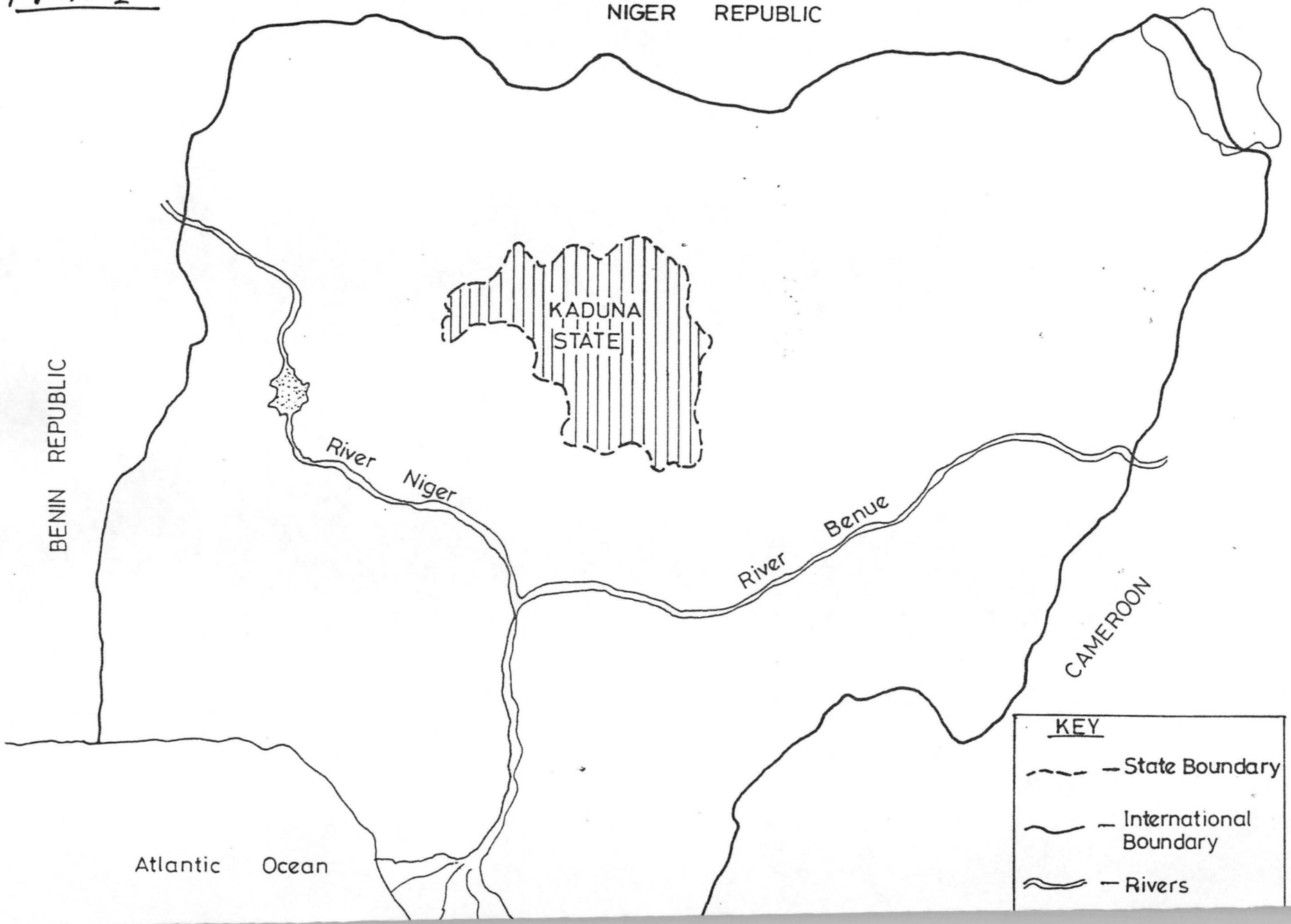
This is the stage where this research work focuses attention on. Quite often, the planners and the executors of such projects apply unhaulistic approach in trying to control erosion, but consequently, result into failures even when a lot of time and resources have been wasted on such projects.

2.5 CHOICE OF THE RESEARCH WORK

The choice of the topic for the research work was borne out of the desire and interest in carrying out an independent and in-depth study of a proposed pilot project at Zoknwa in Zangon Kataf LGA. It is also to recommend conservation measures and to carry out designs of engineering and agronomic practices that could help in the control of Anguwar Rama Ward in Zonkwa town in Zonkwa District of Zangon Kataf LGA. A lot of study work has already been carried out by some individuals and

MAP OF NIGERIA SHOWING LOCATION OF KADUNA STATE

FIG. 1



consultant who were commissioned by my former Ministry, Federal Ministry of Water Resources, in some areas around Zangon Kataf LGA. For example, the study carried out by a consultancy farm, Midlands consultancy service based at Kaduna on the proposed Kamanton-Ashafa Road Project in Ikulu District, the Sangon Erosion site in zonkwa District in the same LGA by the same firm. The Unguwan Wakili-Roligo Road Erosion site, all in the same LGA in 1993/4. Other studies that were also carried out around that area of Zangon Kataf gully Erosion studies by Niger Techno LTD in 1995/96.

A lot of data, in fact which were used in this research work were adopted since there was limited time to have made some investigation to verify some of the data presented by them in their investigation, and analysis, recommendations and design, carried out for the purpose of this project.

2.6 OBJECTIVES OF THE STUDY

The study has the following objectives:

i. To carry out a study on Anguwan Rama Gully Erosion site, which poses threat to houses and public buildings in the community with a view to recommend effective measures for its control;
ii. In recommending measures in the control of the gully erosion, to use an integrated engineering approach which is a strategy in the effective control of gully erosion;
iii. Examine the institutional framework currently in place with a view to recommend the review of such policies mainly focusing on community based participation that would ensure effective management of the water-shade system around the Zonkwa community area;
iv. To recommend a maintenance culture as an effective strategy in ensuring maximum use of the engineering control structure on sustainable

basis.

2.7 LOCATION OF THE AREA

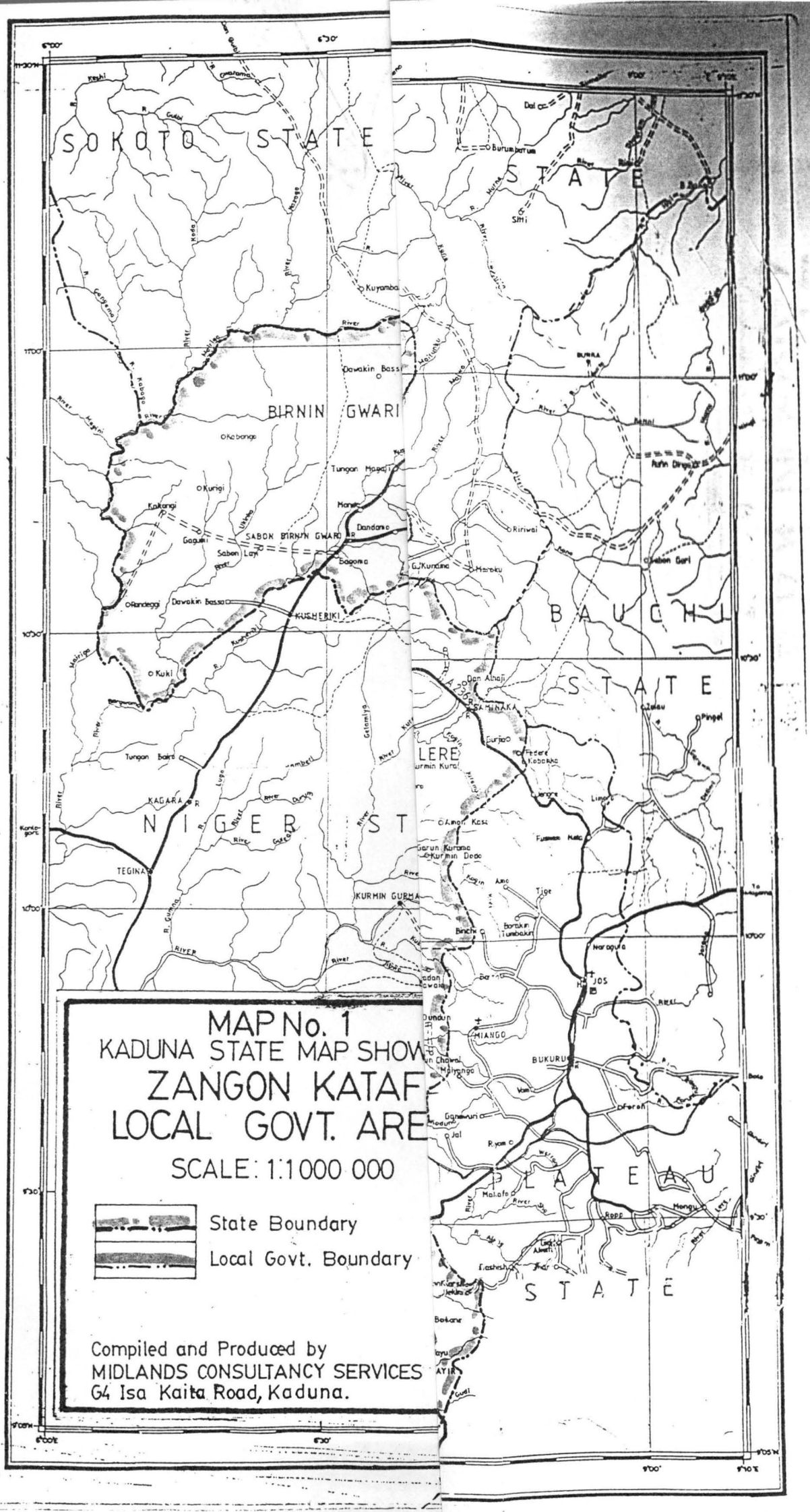
Zonkwa town erosion site is located on the south-eastern part of Zangon Kataf local Government Area of Kaduna state. It lies between latitudes 8 05 and 8 30'east and latitudes 9 30 and 10 15 North (Map of Zangon Kataf Local Government Area in Kaduna State).

The place occupies an area of about 3,640km, which represents about 7.5% of the entire landmass of Kaduna state.

2.8 PHYSICAL FEATURES

Zangon Kataf falls within Kaduna high plains of Hausa land. the area lies at a general height of between m and 900m above sea level. The land is generally undulating and dissected by rivers and streams, the geology of the area is basically those of igneous and metamorphic rocks. The basement complex rock formations constitute the oldest geological formation in Nigeria. These rocks have undergone varying degrees of alternations as a result of the effect of climatology changes resulting into weakening of the rock, thus making it easier for erosion to take place. The LGA forms a broad watershed, which is well drained by the dense network of rivers and streams. Two rivers are considered most prominent in the area. These are river Kaduna and Gurara (MapI). The Kaduna River system drains northwards. Notable amongst tributaries are the Kaduna Mariri and Bakin Kogi rivers.

The southern and eastern parts of Zangon Kataf LGA are drained by tributaries namely Kachia and Kogun Rivers. The LGA constitutes a large water catchment area and therefore, most of the rivers and streams at their youthful and active stages. Most of them are incised valleys with step slope which subject the area to severe erosion of all kinds. Some of the rivers however flow over relatively level land and are forced to slow down the rate


SOKOTO STATE
BIRNIN GWARI
SABON BIRNIN GWARI
KUSHERIKI
KAGARA
NIGER
TEGINA
KURMIN GURMA
BAUCHI
STATE
LERE
JOS
MIANGO
BUKURU
PLATEAU
STATE
MAP No. 1
KADUNA STATE MAP SHOW
ZANGON KATAF
LOCAL GOVT. ARE
SCALE: 1:1000 000
State Boundary
Local Govt. Boundary
Compiled and Produced by
MIDLANDS CONSULTANCY SERVICES
64 Isa Kaita Road, Kaduna.

of flow thereby developing into wide flood plains that form rich and fertile agricultural wetlands (fadama) such areas are generally prone to flooding during rainy season. See map No. 5.

Apart from the mountain plains and river network that characterise the area, there is also a hill that disrupts the general outlook of the landscape. These include the wadon, zonkwa. Kamuru Kaje, Dutsen Bako Gidan Kajere,hills (map II). Some of these hills are as high as 1000, above the sea level

2.9.0 SOIL

Soils around Zonkwa Area could generally be classified within the ferriginious type, this is because, the soils within this area developed over the pre-cambian basement complex rock formation. Inspite of this however, the soils are generally shallow to moderately deep ranging from 15-20cm deep [map 3]. The shallow nature of the soil could partly be attributed to the effect of the relatively high rainfall in the area that gives rise to severe rate of sheet erosion. This transports some enormous quantities of top soil down streams. The soils are generally rich in organic matter and because of the organic matter content, which is high in fertility, the vegetation cover is dense

2.10 CLIMATE

The entire Kaduna state lies within the tropical continental air mass that is the harmattan from the North East, commonly referred to as the North East trade winds and the tropical maritime air mass from the south west, often described as the South westerlies. The North east trade winds begins in the month of November and last up to early March. During this period precipitation is almost will and therefore, humidity is as low as between 20-30%

2.11 TEMPERATURE

Temperature in Kaduna State is generally high. This is

influenced by changes in season and altitude. The mean annual temperature around the area ranges between 22 ▒80 C to 26.7 C. Mean annual maximum temperature is about 27.8 C while the minimum ranges between 16.7 C to 18.9 C [see table 1].

2.12 VEGETATION

Zonkwa LGA falls within the guinea Savannah. There are also patches of some low land forest otherwise, known as Gallery forest" which characterised the river valleys. The grasses are generally tall (2m-3m) with close standing, deep rooted fire resistant deciduous plants, commonest among which are Azelia, Africa, Khaya snegalatants, Aisobalina Aidoko, Pakia clapatoniana etc. These trees exceed 30m in height.

2.13 FACTORS OF FLOOD AND EROSION IN ZANGON KATAF LGA

It is estimated that 20% of the landmass of Kaduna State is prone to severe erosion while 15.5% is prone to flood (feasibility study report by Midland Consultancy Service 1993). Most of these are found in the southern part of the state where Zangon Kataf LGA is located (map 5). The entire ZKLGA is known to be moderately to highly prone to erosion (map3). This situation could be attributed to a combination of factors of climatology and geomorphology.

2.14 CLIMATOLIGICAL FACTORS

The most important climatogical factors responsible for erosion in ZKLGA is rainfall. This is because of its disposition (longitude and latitude) on the map. The annual average rainfall exceeds 1500mm. It sometimes goes as high as 200mm. See Agro-Ecological table 1.

The rainfall is also torrential in nature resulting in large volumes of surface and subsurface runoff causing sheet erosion. In these process, enormous quantities of top soil is moved downstream sometimes resulting to gully erosion. See erosivity and erodibility factors index for

the area.

2.15 GEOMOPHOLIGICAL FACTORS

There are three major geomorphological factors that contribute to the problem of erosion in Zangon Kataf LGA. These are:

1. Topography - They Land lies generally at a height of about 800m above see level, The entire area constitute an extensive water shed from where both the Kaduna and the Gurara river systems takes their source of water. These watersheds have steep slopes that make the area prone to erosion;
2. Drainage system - The area is drained by a dense network of river streams, most of which are at their youth stages and therefore very active, particularly at the head of the streams:
3. Soils - Most soils in this area range from shallow to moderately shallow and are therefore, prone to water erosion.

In this project work therefore, a conscious effort has been made to apply an integrated engineering and agronomic approach in solving at the project site, Zonkwa gully Erosion control project.

2.16 MAGNITUDE OF THE PROBLEM AT PROJECT SITE

Zonkwa town is located on a watershed of Zongon Kataf LGA. By its location, it is expected that numerous streams traverse the area. It is however, unfortunate modern development has tempered with equosystem particularly with the farming activities taking place un abated, increase in the generation of domestic waste in this town and the lack proper method of collection, transportation and disposal. In most cases the natural drains become dumping sites and rendered ineffective. Further to this, there is lack of properly developed drainage system in Zonkwa town. A lot of storm and domestic waste-water are poorly disposed of in many parts of the town (see map No. 2).

MAP No. 3

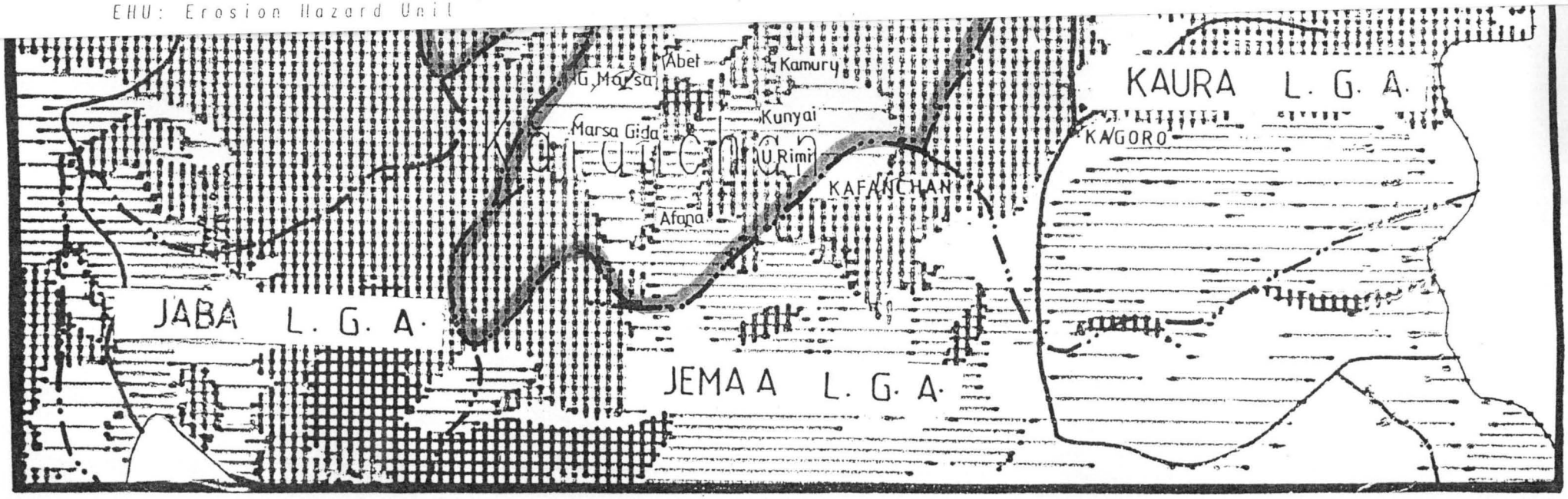
EROSION PRONE AREAS WITHIN ZANGON KATAF LOCAL GOVT. AREA

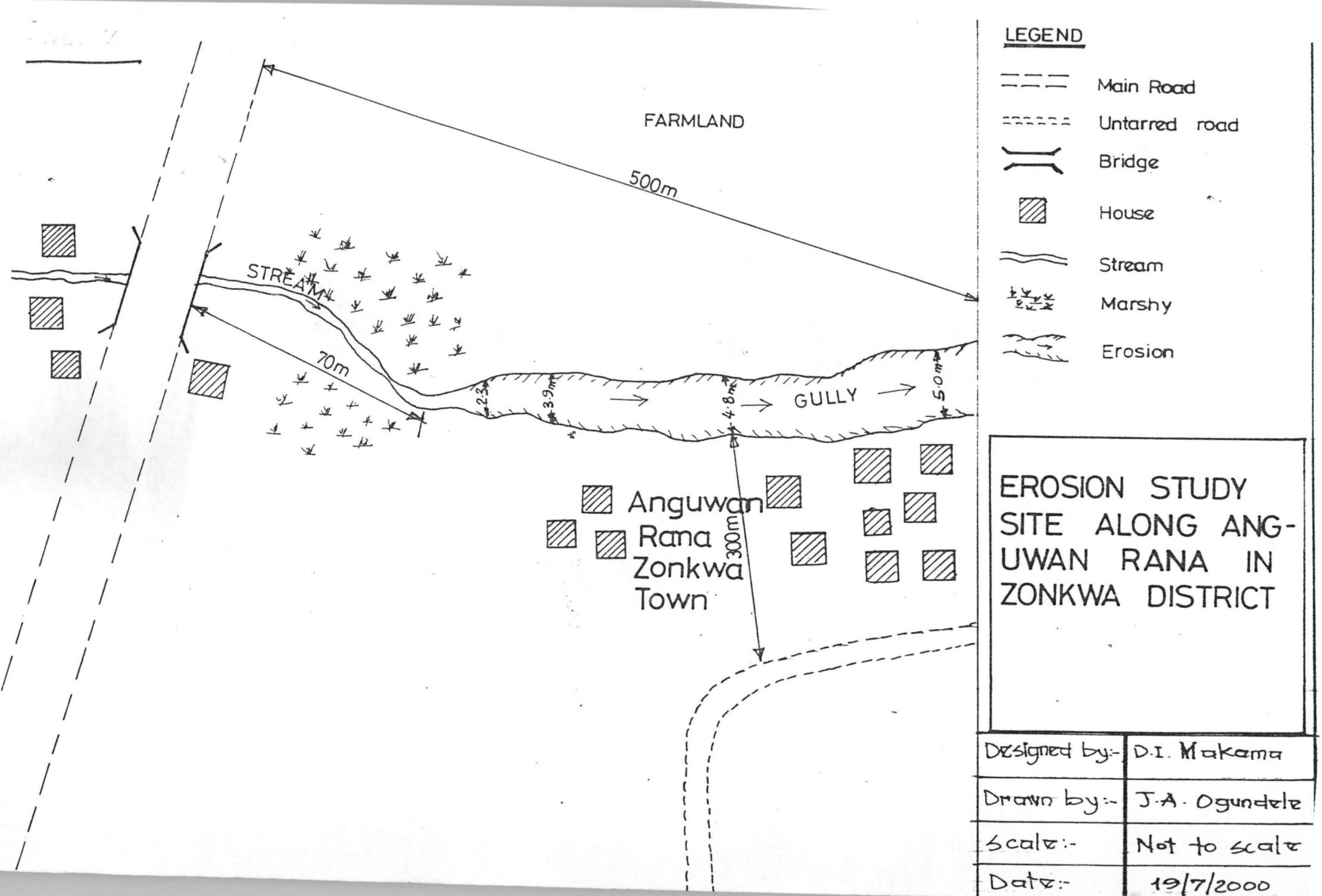
Kilometres 7 3·5 0 7 14 21 28 35 42 Kilometres

SCALE: 1:350 000

	EHU
Low	0 - 5
Low to medium	5 - 10
Medium	10 - 25
Medium to moderate	25 - 50
Moderate	50 - 100
Moderate to high	100 - 250
High	> 250

EHU: Erosion Hazard Unit




FARMLAND
500m
STREAM
70m
2.3m
3.9m
4.8m
GULLY
5.0m
300m
Anguwan
Rana
Zonkwa
Town
LEGEND
Main Road
Untarred road
Bridge
House
Stream
Marshy
Erosion
EROSION STUDY SITE ALONG ANG-UWAN RANA IN ZONKWA DISTRICT
Designed by:- D.I. Makama
Drawn by:- J.A. Ogundele
Scale:- Not to scale
Date:- 19/7/2000

CHAPTER THREE

3.0 METHODOLGY

In carrying out this research work the following steps were used in the attainment of a successful research investigation and analysis of data, recommendation on ways to tackle the erosion problems and consequently leading to the engineering designs of structures:

i. Identifying of the source of problem at the site, its nature and magnitude;
ii. Carry out site investigation;
iii. Collection of design data and analysis;
iv. Design and conservation structures with specifications;
v. Review of approved plan leading to the final design for implementation.

3.1 INVESTIGATION CARRIED OUT AT THE SITE

As earlier mentioned, most data obtained from investigations which should have been carried out were adopted from studies carried out by some consulting firms or National Institute for Water Resources Kaduna who had done some substantial studies in and within the Anguwar Rama Project Research site, Zonkwa in Zangon Kataf LGA. Since, the information and data so obtained are likely not going to be much different from those that could have been obtained if investigations of the project site were carried out. The reason, for doing so, is not far fetched in view of the economic difficulties encountered in the course of this research work as the study is capital intensive, coupled with time constraints. It was possible however, to carry out the following investigation:

i. Reconnaissance survey of the site (Watershed

area);

ii. Identifying the problems existing on the site;

iii. Take measurement of the size of the gully erosion;

iv. Survey the land use of the area where the project is located;

v. Interview the inhabitant of the area and the economic importance of the project site. hence the need to embark on the control measures in order to minimise the effect and the development of the gully.

3.2 TOPOGRAPHIC MAP OF THE PROJECT STUDY SITE

The topographic survey of the area could not be carried out in view of the time constraints and funds that could have made it possible to conduct the survey However, the watershed map of Zangon Kataf LGA was adopted in this research Midland consultancy services Kaduna (October.5th 1993) to give us an idea of the nature of the water shed of the study site, Anguwan Rama, Gully erosion site in Zonkwa District of Zangon Kataf LGA (map I).

3.3 SOIL INVESTIGATION

Soils test and investigation carried out by the National Institute of Water Resources on a similar project around Sanzom in Zangon Kataf District of Zangon Kataf LGA was made use of, to also apply to Anguwan Rama which is less than 3kms distance between the two towns the following soil investigation were carried out:-

i. The geo-morphological characteristics of the soils;

ii. Laboratory test which included:-
-National moisture content (NMC)
-B.S compaction test
-Particle size distinction
(summary out the result are provided in Fig. 3);

iii. Infiltration and permeability;
iv. Top soil depth;
v. Water holding capacity;
vi. Aggregation and surface sealing.

3.4 SOIL INVESTIGATION RESULTS

1) Geomorphological characteristics of the soil:-
The main rock types of the unit are granite, gnesium, magmatite and sandstone. These are among the oldest members of the pre-cambrian rocks of north central Nigeria.There is a great fluctuation in the bedrock level, which makes it difficult to predict the exact depth of rocks below the surface.

II) For the Laboratory test of the soil at the Sanzom Erosion site, three soil samples at difficult locations were taken for analysis at chainages 1+00, 2+10 and 3+50m respectively in accordance with the civil engineering practice CP 2001. Site investigation. The summary of the result is as contained in table 2. The result of the shear box. B.S compaction test, and practice size distribution result are presented in a graphic format contained in Figures 2 and 3 respectively.

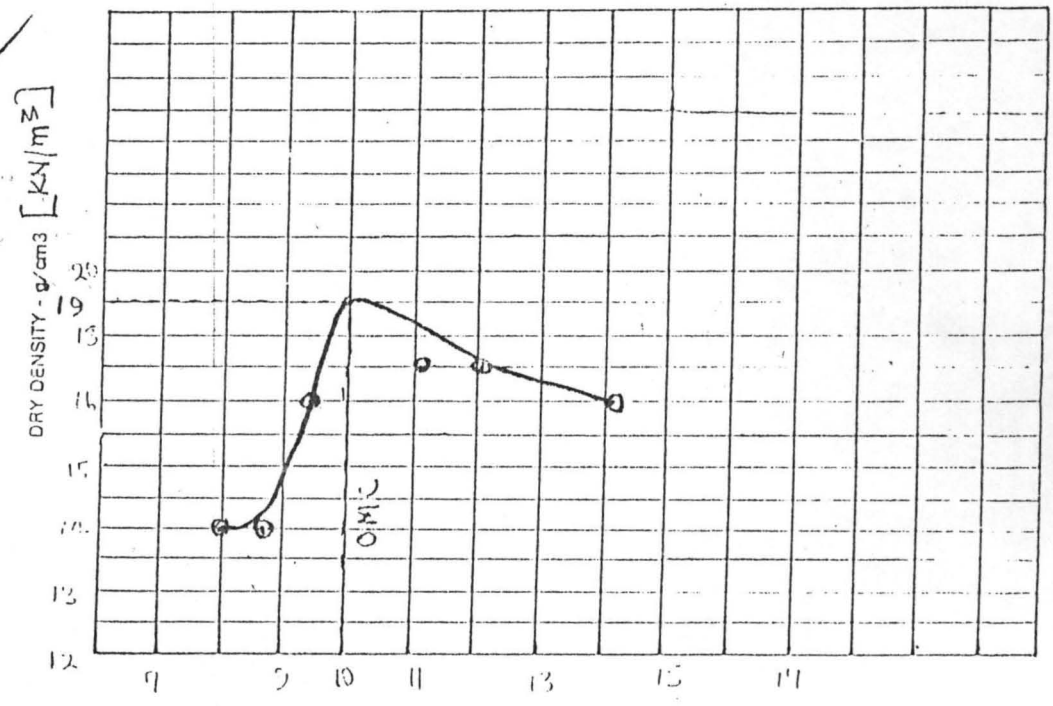
3.5 CONSTRUCTION MATERIAL

It became obvious that additional soil materials would be required from location either than that which could be obtained from the erosion site for stabilisation works. Hence, it is necessary to look for a suitable location where such fill material could be obtained. There is also the need to carry out a thorough investigation to ascertain the suitability of such material from a borrow pit, which has to be within the vicinity of the Anguwar Rama project site. This borrow pit invariance is to be the same pit which was used for the Sanzom Erosion site located some two kilometers away from Anguwan Rama, the proposed erosion site while conducting the sampling on naturally occurring materials on the proposed pit. Random digging was done at the borrow area, ranging from 0.00m

NATIONAL WATER RESOURCES INSTITUTE

SOIL MECHANICS LABORATORY	Fig. DETERMINATION OF COMPACTION	APPENDIX
		DATE:
PROJECT/LOCATION:		OPERATOR:
NO. OF SAMPLE: B	CLASSIFICATION OF SOIL	

Test No.		1	2	3	4	5	6
Weight of wet soil + mould (g)	W_2	3485	3470	3640	3986	3820	3785
W2 Weight of mould (g)	W_1	2005	2005	2065	2005	2005	2005
Weight of wet soil (g)	$W_2 - W_1$	1480	1465	1685	1781	1815	1780
Volume of mould (cm3)	V	948	948	948	948	948	948
Wet density of soil (g/cm3)	$\frac{W_2 - W_1}{V}$	1·56	1·54	1·78	2·01	1·92	1·88
Moisture content (%)	m	8·0	8·8	9·5	10·0	12·2	14·2
Dry density of soil (g/cm3)	$\frac{\text{wet dens}}{100 + m}$	0·014	0·014	0·016	0·019	0·017	0·016



NO. OF SAMPLE	M_N	MDD	OMC	LL	PI	IC
-	%	g/cm3	%	%	-	
2		19 KN/m3	10·0	21	13·51	7·5

see P.5

SOIL MECHANICS LABORATORY

NATIONAL WATER RESOURCES INSTITUTE

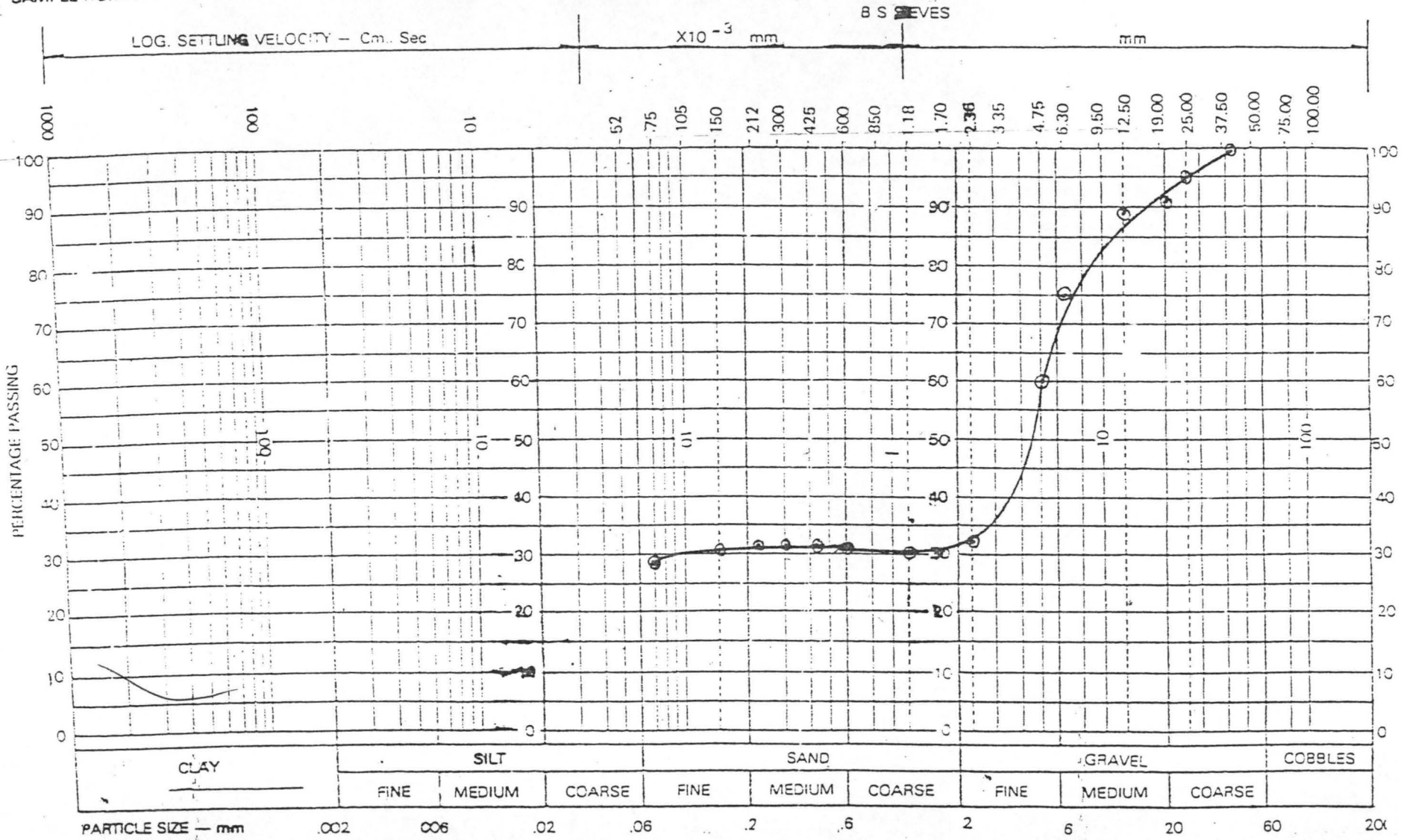
FIG. 2.5

TEST DATA

CHART FOR RECORDING PARTICLE SIZE DISTRIBUTION

SITE: BORROW AREA MATERIAL BOREHOLE NO: TP2 REMARKS: DATE:

SAMPLE NO: DEPTH: 0 – 1.0m OPERATOR: CE



6

18

ground level to a depth of 1 (one) meter, and the area covered by such material was determined to ensure sufficient fill material. The yield of the borrow pit was reduced by factor of 1.5. The samples were tested in the Lab for the following:-

i. Proctor compaction test;
ii. Sieve analysis;
iii. Natural moisture content;
iv. Dry density test;
v. Direct shear teat;
vi. Organic matter content

The result of these tests are as presented in table 2 below.

Table 2.

SAMPLE NUMBER	LL	PL	PL	PL	MDD(mg/m2	O.M.C. %	UNSOAKED	SOAKED	AASHTO	UNIFIED
SAMPLE 1	0.00-80CM	31.80	19.00	12.80	1.61	10.90	8.20	11.50	A-2-6	GP
SAMPLE2	0.00-100CM	40.00	25.90	14.10	1.62	8.50	10.50	14.40	A-2-6	GM
SAMPLE 3	0.00-100CM	36.00	13.40	22.60	1.56	9.00	8.80	8.90	A-2-6	GC

KEY
LL = liquid limit (%)
PL = plasticity
CBR=(%)=compressibility
AASHTO=
MDD Mineral Deposit depth
OMC=Organic matter content

3.6 SETTLEMENT PATTERN/ OCCUPATION

The project site area which is located in anguwan Rama in Zankwa town is mostly inhabited by Kataf tribe, and could be described as a fair densely populated settlement. As most rural settlement in the country, the area falls within what could be regarded as the low income area but are however, fairly enlightened, because of the early influence by the coming of the missionaries in the area, there is high level of influence of western education. The rough estimate of the population may be put at slightly higher than 10,000. Farming is the most important occupation in the area. Eighty (80%) of the people in that area are farmers. Twenty percent of the rest of the people are engaged in other business like, trading hunting, fishing, etc.

A very large proportion of the farmers in the town use land that falls within the watershed catchment area of the proposed project site, for farming. It is therefore, obvious that the activities of these farmers have greatly been responsible for environmental problems that have compounded at the proposed project site over the years. The farmers in the area practice mixed farming system. Crops as millet, groundnut, yams, cassava, rice, guinea corn are grown as annual food crops while, animals like goat, sheep, cattle are also reared in large numbers for sale and domestic consumption.

3.7 AVAILABILITY OF SOME BASIC UTILITIES.

Certain basic utilities are available for use in the area. These include schools, both primary and secondary, rural water scheme, rural electricity supply, good health clinic and tarred road which runs from Kaduna to Kagoro through Zonkwa.

3.8 ANALYSIS OF THE RESULT OF BORROW PIT TEST IN TABLE.

From result of test conducted of the burrow pit and the engineering use of the materials to be used for fills making use of Wagner (1957) developed chart. It shows between 30-

33% fine sand, 32% fine gravel and 35-40% coarse gravel. The result of the sieve test shows that the burrow pit contains material that is very good for fill. See table 3.

3.9 HYDRAULIC AND STRUCTURAL DESIGN CRITERIA

The drainage channel design criteria are generally established partly on the basis of sound scientific theory and analysis and also partly on bias of experience. The design of drainage channel and procedures for drainage design.

There exists two distinct natural drainage system in the project site. These are the minor erosion channels just advancing from rill into gullies empty their sub surface water flow into the main gully, which has been discharged from a culvert flow. These can be corrected by establishment of soil conservation mulching practice or through conservation cultivation practices across the slope by those farmers who cultivate their farms around the project site measuring almost 100ha in size. Since the area also boarders along the major road leading into Zonkwa town, the township administration of the local government should provide the township with adequate drainage system to facilitate for proper drainage of the excess run off water from the village itself.

The initial storm could be designed using an on return period of 5 years or 10 years depending on the adjacent land use. The major drainage channel however, is often designed for a discharge of 25 years return period, if the catchment area is above 500 hectares. For the purpose, therefore, this consideration is must applicable since the land area is above 500ha.

3.10 DESIGN STORM INTENSITY

Various methods are available for runoff calculations. The most commonly used for a small catchment area like this one, is the rational formula, which relates runoff to rainfall.

The formula is:-

$$Qp = \frac{C.I.A}{360}$$

Where : Qp = peak discharge flow (M /sec)

I = Uniform intensity of design storm of a given concentration duration (mm/hr)

C = Discharge coefficient

A = Basin area (Ha)

N.B. The formula was originally developed to estimate peak discharge from small urban basins with, a large of impervious soils, not exceeding 50ha. Several formula have been developed relating Tc to basin characteristics. The most accepted however, is that which was developed by Kirpich 1940, for small catchment basin area less than 50ha

$$Tc = \frac{L\ 1.15}{3080H\ 0.38}$$

Where, Tc = time of concentration in hrs

L = Maximum basin travelling heights (M)

H = difference in elevation over above discharge (m)

3.11 DISCHARGE COEFFICIENT

Discharge co-efficient indicates the proportion of the design rainfall actually discharge rapidly from the basin and which contributes to the peak discharge. The value depends directly on the infiltration characteristics of the soils, retention characteristics of the basin and with the rainfall intensity plus, storm duration, all in trying to determine the discharge co-efficient (C). The U>S soil conservation service (1972) has developed a table for use in the determination of discharge coefficient in the rational formula

Table 3

INFILTRATION RATE OF THE SOIL			
ARABLE LAND	HIGH	MEDIUM	LOW
SLOPE <5% 5-10% 10-30%	C=0.30 0.40 0.50	C=0.50 0.60 0.70	C=0.60 0.70 0.80
PASTURE SLOPE<5% 5-10% 10-30%	C=0.10 0.15 0.20	C=0.30 0.35 0.40	C=0.40 0.55 0.60
FOREST SLOPE<5% 5-10% 10-30%	C=0.10 0.25 0.30	C=0.30 0.35 0.50	C=0.40 0.50 0.60

Since the average slope is 2% along the gully channel which is not up to 5% slope on the standard U.S chart the discharge co-efficient rate of 0.5% was used for design purpose of this project

3.12 TIME OF CONCENTRATION

This is the time it takes to flow from the most remote catchment area to a point being investigated. this is obtained, by dividing the travel distance (l0 by velocity of the flow (v) represented by formula.

$$\mathbf{Tc = L/V}$$

Where: **Tc** = Time of concentration of flow water,
L = Travel distance of flow water,
V = velocity of flow

The velocity of flow from the channel can be estimated by using chezy mannings formula expressed as:-

V = km R 2/3, S.1/2 Q=A/n R2/3 S1/2

Where: **V** = Flow velocity M/S
Q = discharge rate M3/sec
R = hydraulic radius (m)
S = Hyudraulic gradient
Km = manning coefficient of roughness (M 3/sec.)

Calculating time of concentration

To calculate the time of concentration (TC) first of all we must calculate the velocity of the flow;- The manning coefficient of 0.04 is here used for vegetative water way, slope 2%

$$Q = \frac{A}{NR2/3.S1/2}$$

$$V = \frac{100\ Ha}{(0.04)\ (3.50\ 2/3)\ (2\ 1/2)}$$

$$V = \frac{100}{(0.04)(3.5\quad)(2\quad)}$$

$$V = \frac{100}{(0.04)(2.31)(1.41)}$$

$$V = \frac{100}{0.130284}$$

$$= 7.68 M3/sec$$

To calculate time concentration therefore using formula

$$Tc = L/V$$

$$\text{Substituting} = \frac{\text{Travel distance}}{\text{Velocity}}$$

3.13 **RAINFALL INTENSITY**

This is a function of time of concentration (TC) which has earlier been taken as the time required for the maximum run off rate that occurs when the time of rainfall equals the time of concentration through formula.

$$I = \frac{A}{Tc + B}$$

Where A+B = are constants developed for particular area and return period.

It could not however, be applied for the purpose of this design as A&B are not available for this project area.

The alternatives formula has been used is that which relates to daily rainfall of 24hrs.

$$I = \frac{R.12}{12} \quad \frac{12}{Tc}$$

Where **I** = is the rainfall intensity in mm/hr

R = the daily rainfall in mm/day

Tc = the concentration time within the catchment in hrs

The analysis of the rainfall intensifies at various periods was however, analised on probability analysis of different return periods as below:-

Table 4

RETURN PERIOD YR	RAINFALL INTENSITY (MM/HR
2 5 10 25	112 152 74 208

N.B

In the case of this design, the rainfall intensity from a return period of 25 years was used ie 208 mm/hr. The catchment area of 100ha was used.

3.14 DESIGN DISCHARGE RATE

The compaction of the drainage basin was bases on formula

$$Q = \frac{0.6x208x100}{360} = 34.66m3/sec$$

DESIGN DATA

In carrying out the detailed design, it was necessary that certain design parameters are available and that such parameters required for the erosion control are:-

i. Topographic detailed
ii. Slope of channel bed

FIG. 17 KADUNA YEARLY RAINFALL DISTRIBUTION

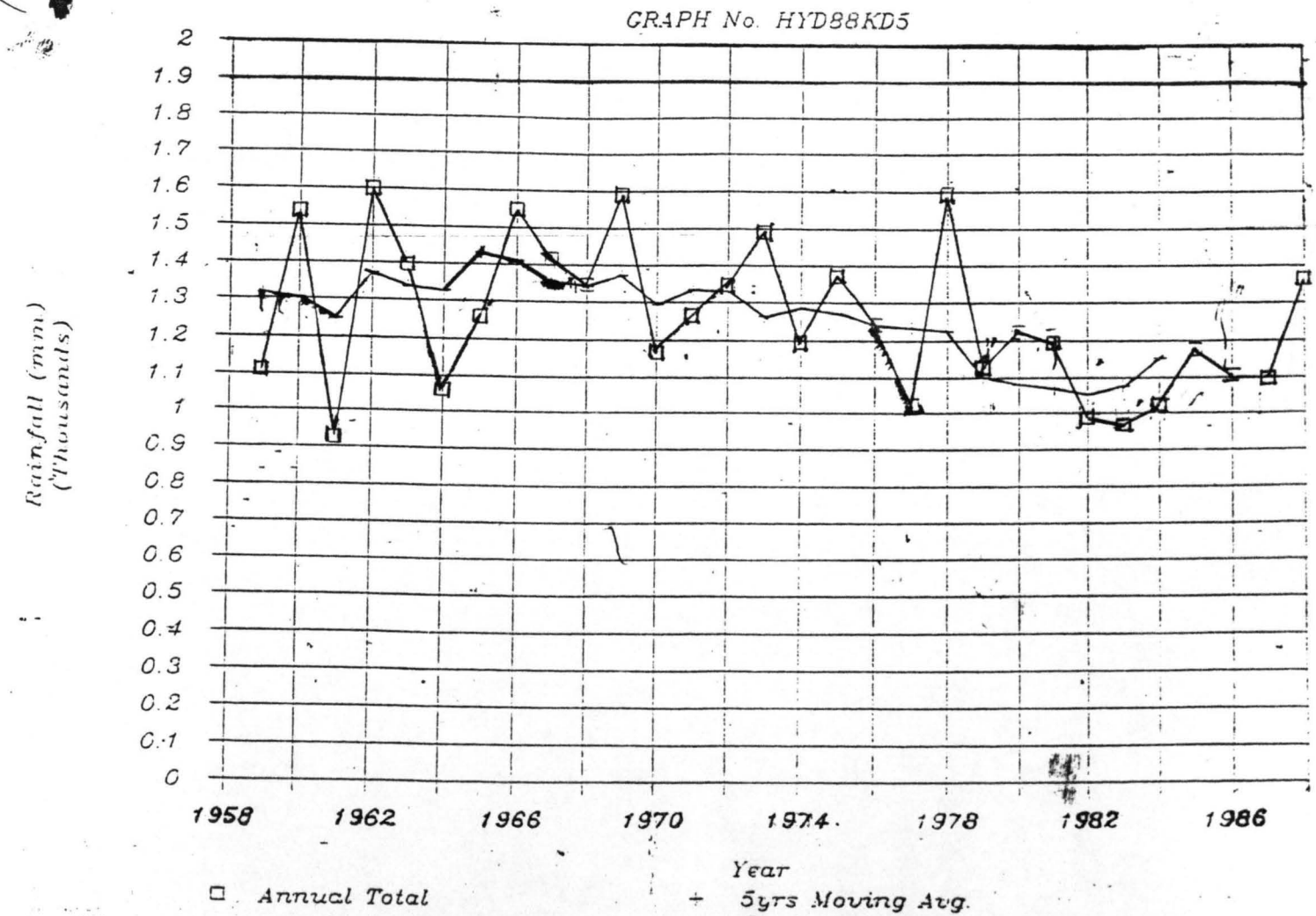
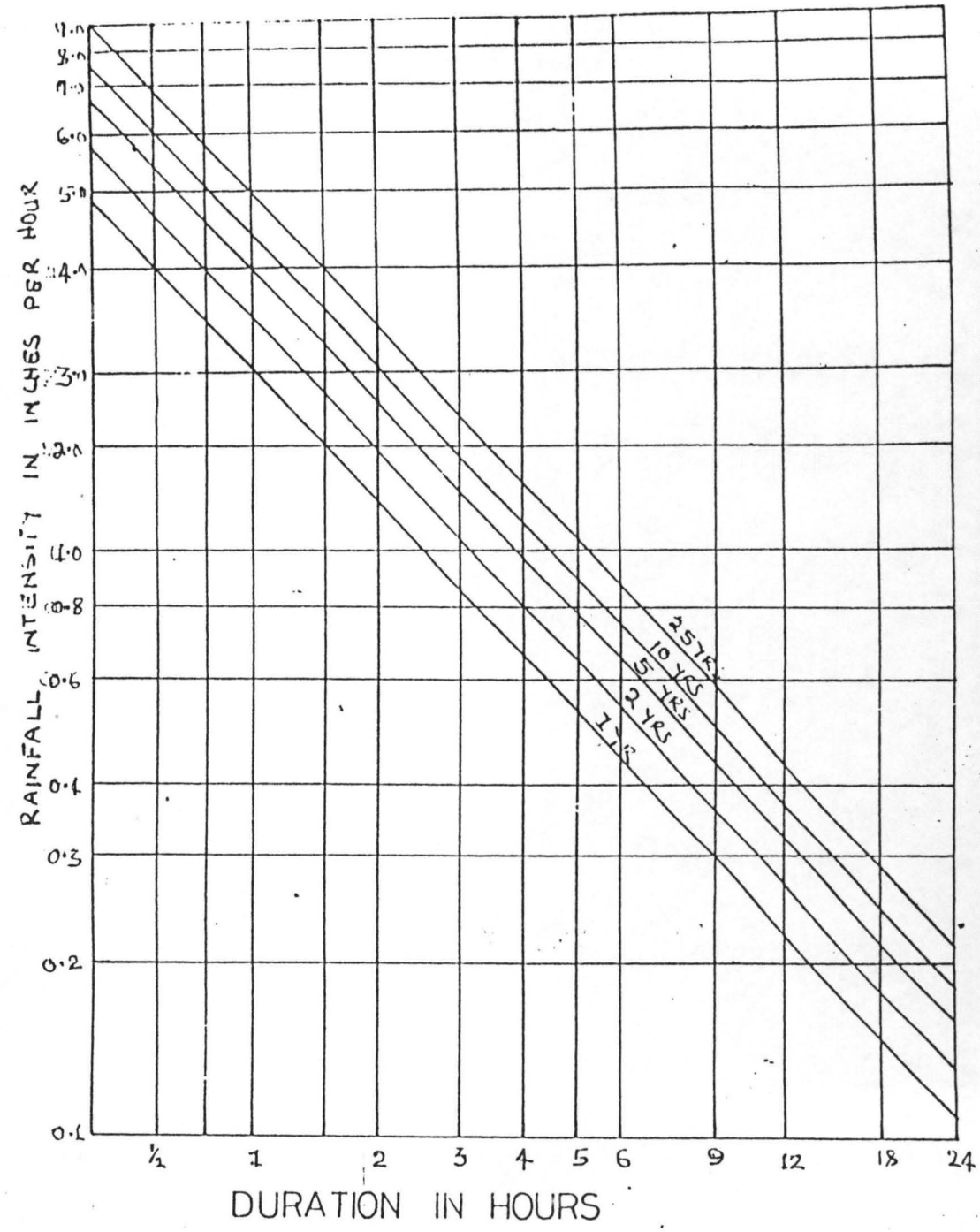


Fig 5 FIG 3.2 KADUNA INTENSITY DURATION CURVE



iii. Runoff discharge in the catchment area

iv. Soil parameter.

Already, parameter 1,II,III have been handled in the earlier sections of the report.

3.15 SOIL PARAMETER

The major soil parameter selected for the design is that of the mass density. The shear strength of the soil defined in terms of the internal friction and the cohesion of the soil are

The mass density of soil **0 = 19KN/m3**

Cohesion of soil **C = 21.5KN/M3**

Internal friction angle **0=29**

CHAPTER FOUR

4.0 RECOMMENDED SOIL EROSION CONTROL MEASURES FOR THE SITE FOR THE CONSERVATION STRUCTURES

Having inspected the site and carried out some investigations, the following erosion control measures are hereby recommended for the site:- these includes

i. Drainage channel improvement
ii. Bank stabilisation with gabion
iii. Reduction of gully bed slope, using drops structure
iv. Grassing of the surrounding gully bank as well as the improved gully bed.
v. Ensure constant maintenance culture of the erosion control structures.

4.1 MAIN CHANNEL DRAIN

Trapezoidal shape of drainage canal was chosen for the drain. An assumption of 80% of the total flow of 34.66M3/sec will be lined by the channel design.

$$Q = 80\% \ (34.66M3/sec) = 27.73M3/sec.$$

Using planning formula for trapezoidal shape

$$Q = 27.73M3/sec$$

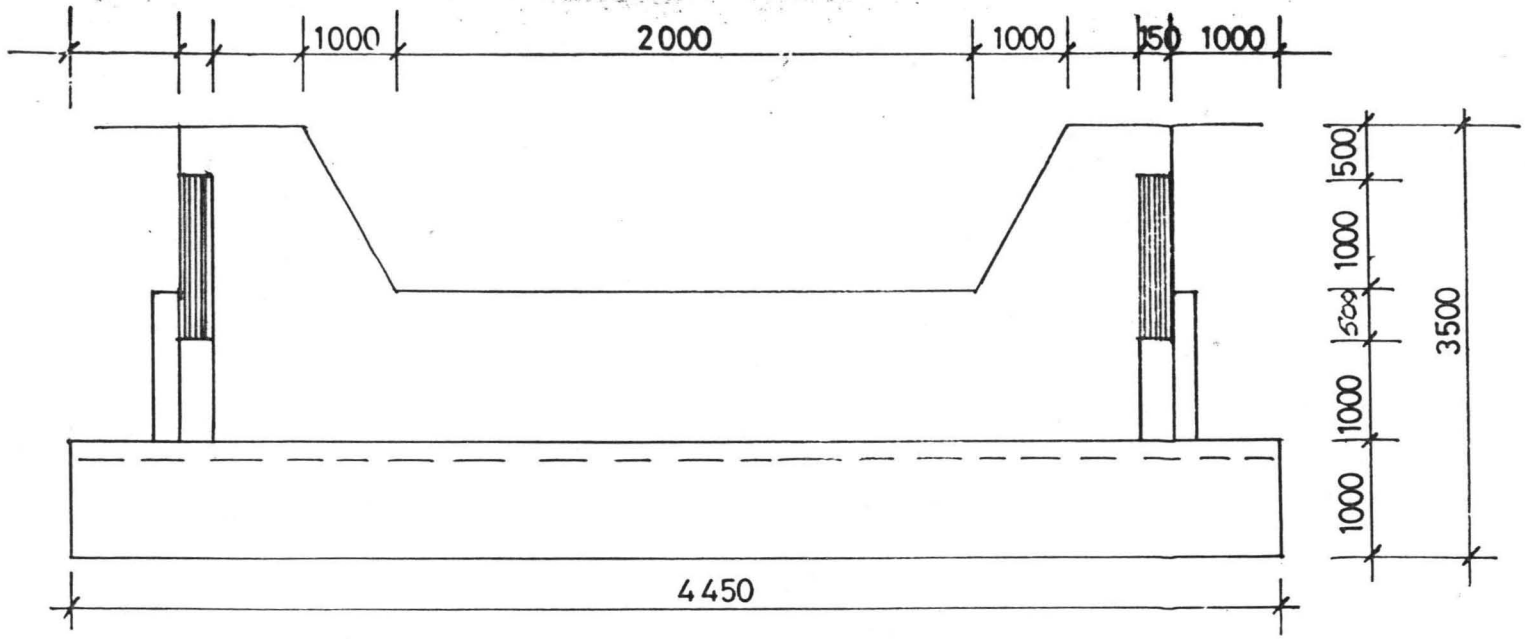
$$S = 1\%$$

$$Ks = 1.5 \text{ for roughness co-efficient}$$

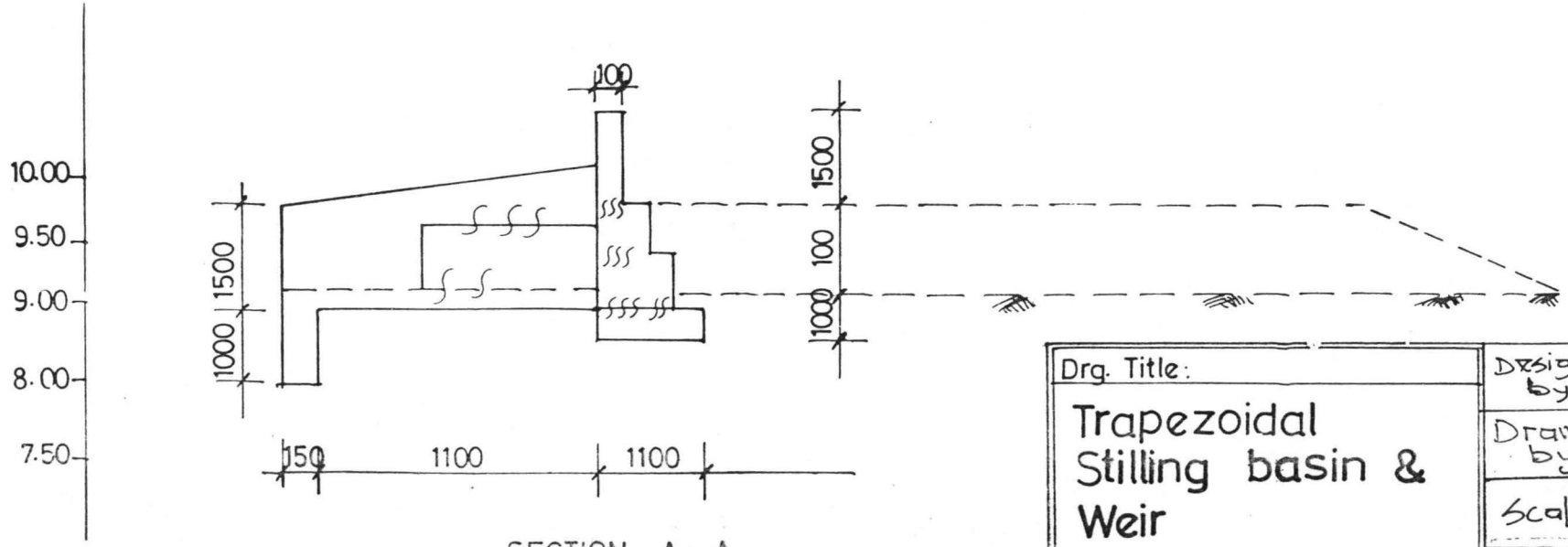
$$A = 1/2\ [b+1.2d]$$

$$B = [1.2d+1.55$$

$$= 2.355d$$



FRONT VIEW



SECTION A - A

Drg. Title: Trapezoidal Stilling basin & Weir	
Designed by:-	D. I. Makama
Drawn by:-	J. A. Ogundele
Scale:-	Not to Scale

$$A = 1/2\,[1.2+2.355]d$$
$$= 1.7777d$$

for wetted perimeter $P = 1.2d + 2.355d = 3.355d = 1.777d$

$$S = 1\%,\ R = A/P = \frac{1.777d}{3.55d} = 0.501$$

$$P = \frac{3.55d}{R\ 0.501} = 7.93$$

Using $Ks = 1.5mm$
with $R = 0.501.S = 100m$ in 10,000

$$Q = 27.73M3$$

$$V = 7.68M3/sec$$

4.1.2 Retaining Wall Adopted

The Retaining wall adopted in the design has a total height of 3.5m This is to confirm with the depth of the gully. The earth fill acting on the wall of the channel has a unit weight of 19KN/M3 with internal friction angle of 29o. The concrete material will be of 28 days strength with stress of 30N/mm3 and a steel strength of 410N/mm3 as specified in the drain. All specifications are in accordance with British code of practice, specified in Tech. Guide, B58110 of 1987.

4.1.3 Side Channel Capacity.

Except where, the gully erosion is so critical, stones are normally used for rip-raping, in order, to reduce cost of Gabion mattresses were used for a distance of about 50m while stones were used along a distance of 150m

4.2 RIPRAP MATERIAL SOURCING

Material required for embarkment and channel side slope stabilisation fill are those with relatively high density and heaviest blocks available. These are easily obtainable at Zongon Kataf and are generally characterised by the

ranges of igneous rocks, which are tough and durable. The combination of mechanical properties with block size is best in rocks of granite basalt and granite groups.

For embankment work, most rocks are however, generally acceptable for construction in dry season. The porosity of such rocks should be very low because of the ability to absorb water which may lead to eventual loss of strength and consequently to failure.

For the purpose of this construction work, the size of the rocks should be between 70mm-150mm for channel bed lining reno mattress and for gabin wall, 50% sizes be less than 110mm size

4.2.1 Slope stability Analysis Of Gabion Wall Bank

The commonest for investigating slope stability is the Swedish method of circular ship surface. A likely slip surface is drawn the soil mass is divided into slices. Actuating moments, which may cause the slip are computed the resisting moments after which a moment of safety is arrived at as:

FOS = Maximum resisting moment (actuating moment)
In general the factor safety is expressed as

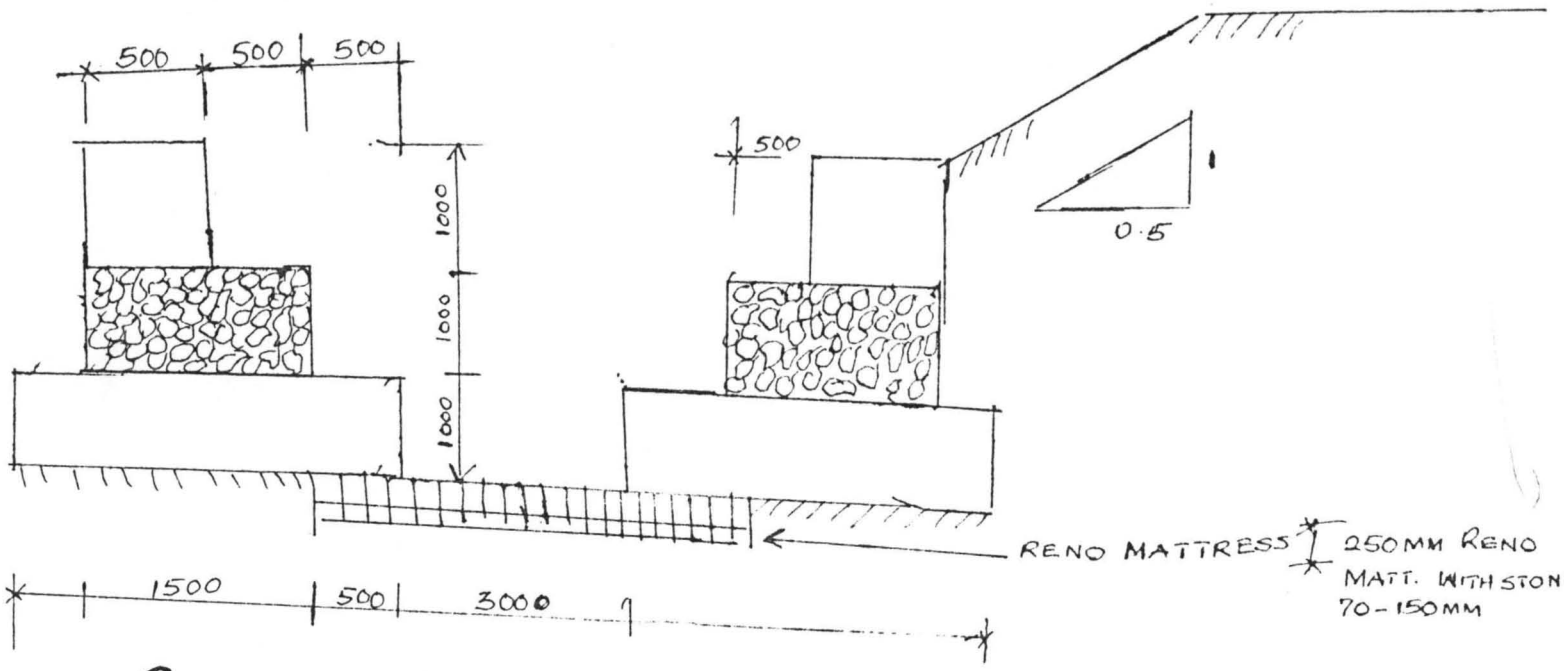
$$F = \frac{CL + \tan Q\{Wn}{\{W1}$$

Where L = total slip surface
Wn, W, = Normal and tangential weight of soil mass
C = soil cohesion

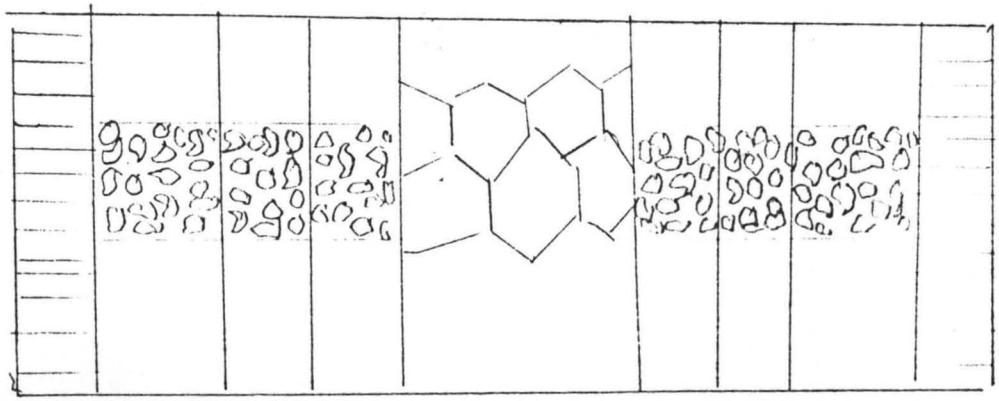
N.B This approach is considered most suitable for both C=O and C = q soils. In a situation where pore water is taken into consideration, the factor of safety is computed from formula.

$$F = \frac{CL + \tan Q \& \{Wn-UL)}{WI}$$

FIG. 7



CROSS SECTION AT CHANAGE 0+170-280



SECTION OF GABION WALL

Where: C and Q are effective values. To ensure stability analysis of the overall stability of the slope cullman procedure was adopted the formula used for the designing of stable channel is:

$$= \frac{\text{(VUL) 10/3 B3/4 N2}}{\text{Q3/4}}$$

Where ie =stable slope

Ul (M/s) =maximum permissible velocity depending on size of bed materials.

V = ratio b/w mean velocity of water and the corresponding velocity of river bed

=1.3-1.5

B(m) wetted perimeter equals to width of river

[m

4.3 GABION SECTION AND WALL DESIGN CALCULATIONS

From change 0+170+280

Established bed width for the full floor of Q =37.66M2/sec, S=1.100

Assume trapezoidal shape for the lining of walls Ks=60 equivalent of artificial natural channel design based on Colabrooks formula

$$\mathbf{A = 1/2\,[B+1.2d]}$$

$$\mathbf{B = [1.2d+1.55d] = 3.155d}$$

$$\mathbf{A = \frac{2.750}{7.68d} = 0.358d}$$

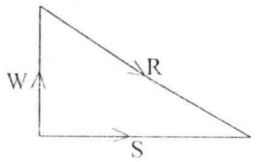
$$\mathbf{\frac{P}{R} = \frac{3.155d}{0.358d} = 8.813d}$$

WALL DESIGN

To design the wall of gabion, the bending Moment, shear stress and normal stress will be checked at every change in cross section wall and soild base (Wg + Wo).

W = Wg (gabion) + Wo (soil above base)

At any section let

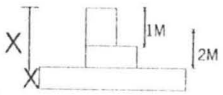


W = Bending moment

N = Vertical Load

Lecentually $e = \frac{M}{N}$

$\gamma \text{ Max} = \frac{N}{}$

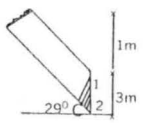


h – 20 h = height of wall above section

checking the wall at x –x

At x – x $ch = \frac{wh \sin (x - x^2)}{\cos (2\phi - x)}$

$Wh = 155 - (\frac{1}{2} \times 2 \times 16) = \frac{54.6 \times 3}{2} = 61.5 \text{ KN/M}$

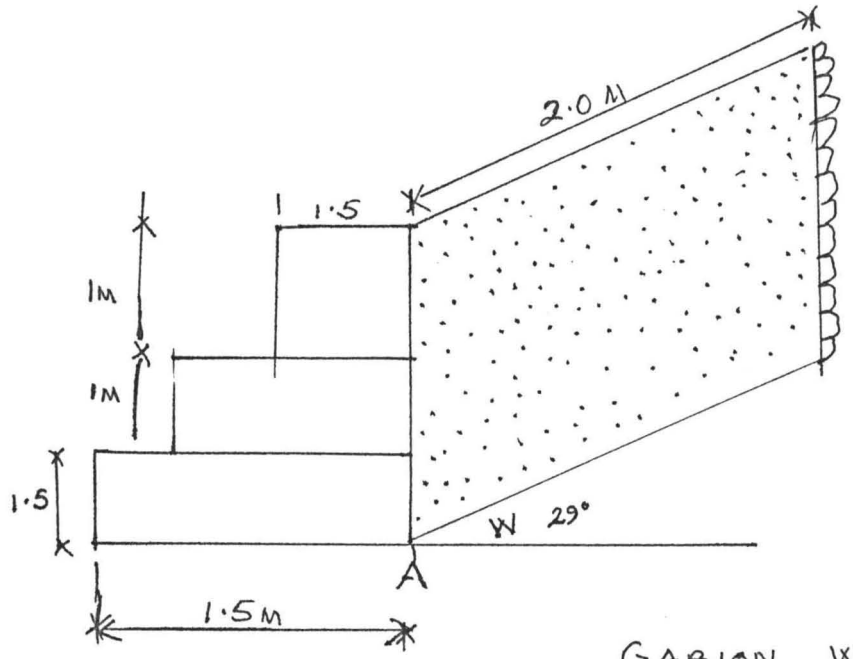


$sh. = \frac{61.5 \sin (45 - 29)}{\cos (2 \times 29^{\circ} - 45)} = \frac{16.95}{0.974} = 17.38 \text{ KN/M}^2$

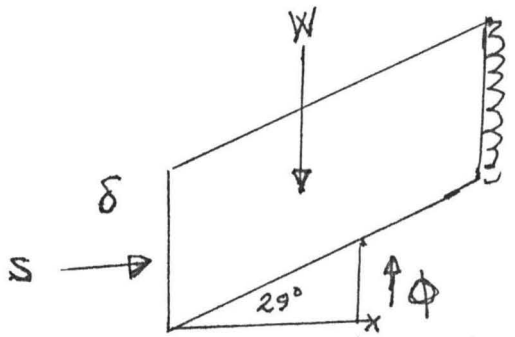
$Mx = 17.38 \cos 45 \times 2/3 = \cos 45.x\ 0.666 = 4.71 \text{ KN/M}^2$

$N = 2\ \gamma g = 2 \times 16.5 = 33$

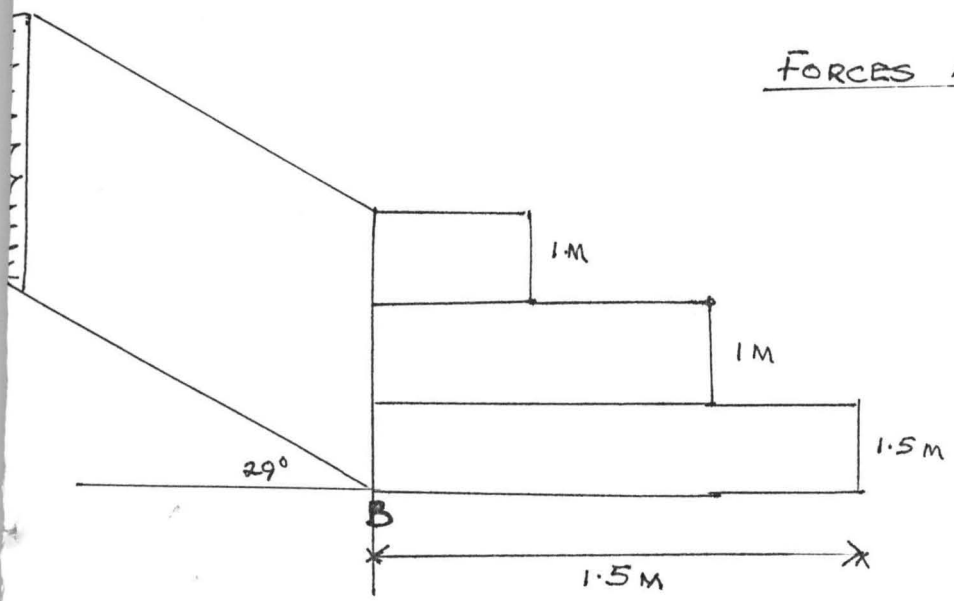
$e = M = \frac{4.71}{33} = \frac{0.142m}{}$



GABION WALL DESIGN (RIGHT SIDE)



FORCES ACTING ON GABION WALL



GABION WALL DESIGN (LEFT SI

4.5,1 Structural Consideration

The retaining wall is to be designed to withstand bending moments of the base. The determination of reinforce amount and quantities in based on the British code of practice BS 8110 of 1987

4.5.2 Elevation

The elevation difference chanage 0+00 and chanage is with an average depth of 3.2 m to 3.5 m high. In the design, an average gully depth of 3.5 m was made use of, to take care of differences in the right and left bank levels between chanage

4.5.3 Alignment

The horizontal alignment will as much as possible maintain the existing gully layout to avoid either excessive fill material or require excessive cut which are likely to increased construction cost. Minor cuts may required however at certain side walls to smother the bends on the side walls to enhance smooth flow of transition and efficient placing of gabion walls. Vertical alignment in terms of elevation will be laid to the slope as could be seen in drawing on Fig. 8. See calculation of the drop structure on page 2 .

4.5.4 Materials

Although, soil conservation engineers may be expected to select, determine quantities and sizes of material to be use for engineering construction, it could be best after the design to leave the work to a structural engineer and quantity surveyors, who are experts in the field to determine these aspects.

The determination of the reinforcement and estimation of the cost known as Bill of quantities was in the project work left out to be done by these calibre of consultants and are not included in this report.

4.5.5 **Check Residual Velocity at Underside of the Reno Lining**

Formula for Residual velocity:-

$$Vb = \frac{1/nf\,[dm]\ 2\ i1}{2.3.2}$$

Where :

i=slope

dm=0 of stone at least 50% are of the size

nf= rough wett

nf=0.0025,dm=25, dm=012 (120)

Vp=1/0.22f $\frac{(0.12}{2}$) 2/3 (1/200) 0.5 = 0.427M/s

allowance velocity for course and

=0.75m/s

Vb< μ

* There would be no need for filter under side of the renomattrasses

4.6. **DESIGN OF GABION WALLS**

Assuming the backfill material proportions angle of friction is 0=30-35

density=19kn/M3

The highest gabion wall is 4m.

Assume super imposed load of 10KN/M2 due to compaction of material

Where W=ruplire angle at the at the loading state.

Using variation of Callomb's method in cullman (PP58

The trust angle behind the wall is given as:-

$S=\frac{W \sin (W-0)}{\cos (+ W)}$ W-1ton of ABCD wedge soil

To increase the FOS, increase the base width to increase the overall width

. . $Zc = Z\ 2 - 2.2$

$= 2.12 - 2.2 = 0.08$m less than 0.5m

Therefore, provide 0.5m high gabion with 140mm concrete coping to localise the hydraulic jump formation.

4.7.1 **Checking for Sliding**

Weight of gabion Wg = 1b [3 x 1 + 0.5 x 2 + 1 x 05]

Resistance sliding = 148KM/m tan Ø

= 148 tan 29 = 82.04 KN/m

. . FOS against sliding = $\frac{82.04}{47.75}$ = 1.92 >1.5

It is therefore, O.K.

Overturning

Overturning Moment M = 5 cos Ø x H/3 = 37.59 x 3/3

= 37.59 KM/m

Restraining Moment M, = Wo [3 – 0.5] + Wg x

= x = 1.431 from 0

FOS against overturning = $\frac{M_1}{M}$ = $\frac{60\ [3 - 0.5] + 88 \times 1.4318}{55}$

= $\frac{276}{55}$ = 50 ≥ 1.5 O.K

Co-efficient of friction U = tan Ø = tan 29^0 = 0.554

Horizontal thrust (H) = S cos: Ø = 54.6 cos 29^0

$$= \underline{\underline{47.75\ KN/M^2}}$$

Resistance (V) = U Wg = 0.554 x 72
= 39.91 KN/M^2

FOS against sliding – $\frac{V}{H} = \frac{39.91}{47.75} = \underline{\underline{0.84}}$

The F O S therefore is not O.K as the value for $\dot{\alpha}$ = 30 is the Lowest one the table.

To increase the FOS therefore the width has to be increased to increase the overall soil weight by at list 0.5m to make up the bottom width to 3.5m.

Wt of gabion = 72 + (1 x 16) = 88KN/m^2

Wt of soil Wo on wall footing = 1.0 x 3 x 20 = 60 KN/m^2

Total (TL) KN/m2 88 + 60 = 148 KN/m^2

For Unit Wt. of Wall

W=[1.6 -1.5] & d [4/d an--1.5]Po

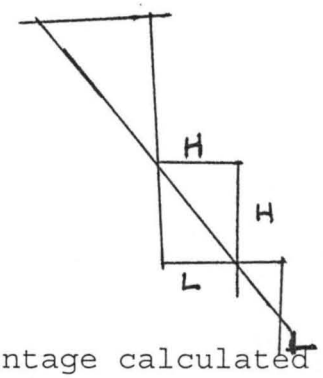
21 an

Take 0 -29o ignoring cohesion C.

<	sin ( ) cos 2 ( )	1 W tan	S (Kn/M3)
30	0.017 0.883	1.732	301.4
			5.80
35	0.10.5 0.921	1.428	240.6
			27.43
40	0.191 0.951	1.192	193.4
			38.84
45	0.075 0.974	1.000	1555
			54.6max
50	0.358 0.990	0837	122.8
			44.4
42.5	0.253 0.904	0.71	173.2
			41.86
47.5	0.317 0.983	0.196	138.25
			44.58

The wall and the forces acting on it can be expressed as follows:-

4.7 DESIGN OF DROP STRUCTURE



B =4d =4 x1.0 =4m

$i_q = \frac{(1.3.3.5)_{10/3}\ (4)\ 3/4\ \ (0.025)2}{(27.73)^{4/3}}$

$i_q = \frac{(156.010)\ (6.35)\ \ (6.25)^{-0.04}}{83.870}$

=0.619 =6% slope

Cross checking the allowable slope percentage calculated by standard values the slope is too excessive as it should not

be more than 0.5% as the velocity would be too much and can cause movement in the lining material of the drop.
A slope of 0.5% should then be used instead of the 0.6% therefore, lining ie to 0.5%
H=drop height = L (I-ie)
with L=40, H=40 (0.04-0.005)
= 1.4m

The drop structure in the gabion/reno lined section of the reach is similar a wear which has been filled by deposited material p to the level of the crest
Q = 27.73 M3/s, which of channel 3.3 = $\frac{27.73}{3.30}$

= 8.40M2/Sec

Drop (d) $q^0/gh2 = \frac{(8.4)2}{34.66\ (1.5)3}$ U = 2.5, $q = \frac{1}{L_0}$, H = 1.5

The stilling pool causing dissipation is then calculated from

$2v = Dv\ 122 \quad U = 0.51)^{0.27} \times 1.2$
$= 1.065m$

Basin length, $LB = L_1 + L_2$
$L_1 = 4.30 \quad 0.27 \times H = 4.3\ (0.58)^{0.27} \times 1.5 = 4.3(0.8636) \times 1.5$
$= 5.57$

$Z_1 = 0.540^{0.425} = H = (0.54)(0.58)^{0.425} \times 1.5$
$= 0.643m$

$Z_2 = (1.66)^{0.27}\ H = 1.66\ (U \quad 0.55)^{0.27} \times 1.5$
$= 2.12$

$L_2 = 5.57\ (2 - 2) = 5.57 \times 1.5 = 8.355m$
$2.12m$

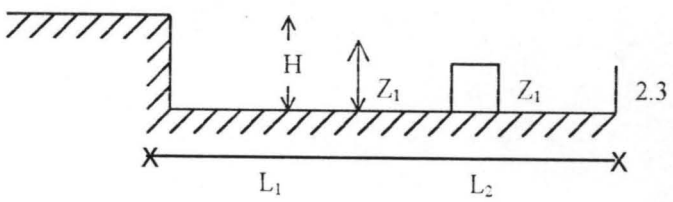
$LB = (z_2 + z_1) = 5.57 \times$

$LB = L_1 + L_2 = 5.57 + 8.355 = 13.925m$

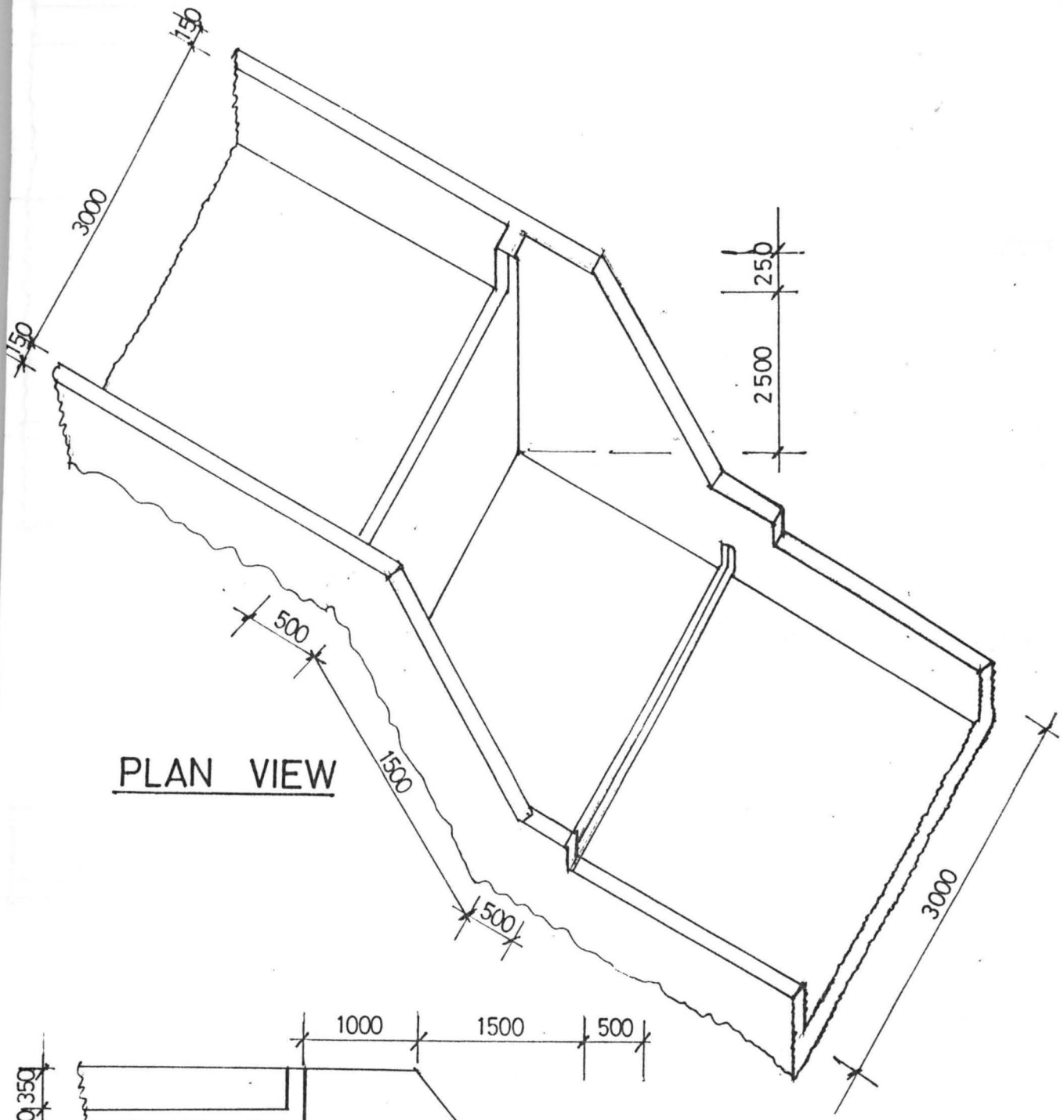
The weight Zc of the floor block is
$Q = (Z - 2c) \quad 2(Zz - 2c)$
$Z2 - 2c = 1/2mg\ (Q/10)\ \ 2]\ ½$
$= [\ \frac{1}{}$

$(2 \times 0.4 \times 98)\ \frac{27.84)2}{2.5}\ ½$
$\frac{(\ 1\ )}{(78.7)}\ (3.834)\ ½$

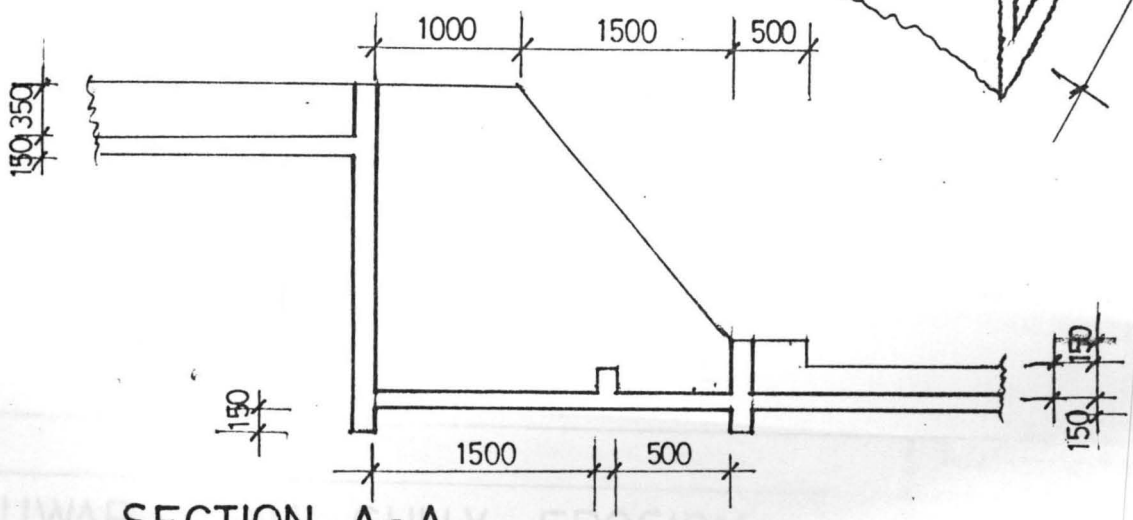
$= 0.0489)\ \ 0.5$



NGUWAR RANA GULLY EROSION CONTROL STRUCTURE
T ZONKWA, KADUNA STATE.



PLAN VIEW



SECTION A-A

Designed by:- D.I. Makama

be more than 0.5% as the velocity would be too much and can cause movement in the lining material of the drop.
A slope of 0.5% should then be used instead of the 0.6% therefore, lining ie to 0.5%
H =drop height =L [i-ie]
with L =40,H=40 [0.04-0.005]
= 1.4m
The drop structure in the gabion/reno lined section of the reach is similar a wear which has been filled by deposited material up to the level of the crest
Q =27.73 M3/s,width of channel 3.3 =27.73 / 3.30

= 8.40M2/sec

Drop (d) q²/gh2 =(8.4)2 / 34.66 (1.5)3

$\varphi = 2.5$, $q = \frac{\Phi}{L_D}$, $H = 1.5$

The stilling pool causing dissipation is then calculated from

2v =Dv 122 $U = (0.51)^{0.27} \times 1.2$

=1.065m

Basin length, LB $=L_1 + L_2$

L_1=4.30 0.27 x H=4.3 $(0.58)^{0.27}$)x 1.5 $= 4.3(0.8636) \times 1.5$

$= 5.57$

$Z_1 = 0.540^{0.425}$ $= H=(0.54)(0.58)^{0.425} \times 1.5$

0.643M

Z2 $=(1.66)^{0.27}$ H=1.66 (φ 0.55)$^{0.27}$ x1.5

2.12

L2 =5.57 (2- 2] =5.57 x1.5 =8.355m

2.12 M

LB $=(Z_2 + Z_1)$=5.57x

$L_B = L_1 + L_2 = 5.57 + 8.355 = 13.925\,M$

The weight Zc of the floor block is

Q = [Z -2c] 2 (Zz-2c)

Z2-2c =1/2mg (Q/10) 2] 1/2

=[1

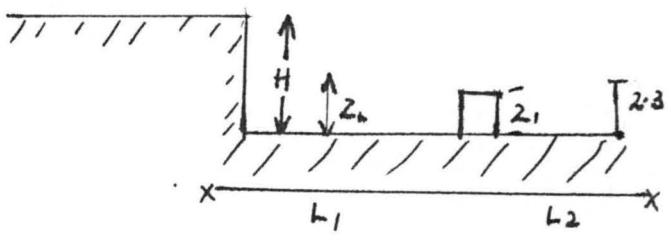
(2x0.4x98) 27.84)2 1/2

2.5

[1) (3.834) 1/2

(78.7)

=0.0489) 0.5



CHAPTER FIVE

CONCLUSION

The engineering solution to erosion control is by no means an easy task as could be observed considering all the steps an engineer has to go through in order to control erosion on a piece of land. The business of erosion control is not only very expensive, but takes soil conservation engineer painstaking processes to proffer solutions when is at gully stage.

It is important to note that gully erosion does not start in a day. Certain factors or conditions must have been responsible for starting an erosion. Such conditions much have persisted if left unchecked over a long period of time. If early attention were to have been given at sheet stage or even rill stage, a lot of cost savings would have been achieved and above all the natural endowment would have been conserved. The soil conservation engineer must never have an illusion that the business of soil erosion control could be achieved without the contribution of other professionals and stakeholders. Such professionals should include, agronomist, structural engineers, quantity surveyors, skilled and unskilled labourers, while stakeholders would include Government at various levels, NGOs, local, communities and individuals. All hands must be on deck to ensure a successful project implementation and its sustainability so as to achieve maximum benefits from it. (Engr. (Dr.) M.G. Yisa 1999)

An effective management is very essential in ensuring the success and sustainability of projects of this nature. One of the problems associated with implementation of such projects is the issue of maintenance, quite a number of successful project have in the past failed for lack implementation.

5.1 MAINTENANCE CHECKLIST

Central Measure	Problem to look for	Possible Remedies
Conveyance Structures Pipe drain, chuttes Concrete drains,	blocked inlet or outlet	Remove Sediment or debris Enlarge handwall
	Scour on drain floor, And cracks on walls	Refill with equivalent or Similar material
	Erosion at outlet	Enlarge riprap apron and use large stones or convey runnoff to more Suitable outlet.
Check dams	sediment accumulation	remove Sediment after each storm
	Flow exaping around	Build up ends of dan and provide
	Sides of check dam or Structure	low entral area for spillway
	Erosion of dam fill material	Rebuild with equivalent fill Material and compact
	Displacement of sand bags stones or straw bales	check drainage area and peak flows. Reinforce dam with larger Stones or divert portion of flow another outlet
Gabion/Renomattresses	Tilting of gabion	Reconstruct wall entirely, on a complete dislodge new base or foundation
	Lowering of wall height	Increase brackets to make up the required level
	And escape of trapped sediments	Stretch wire mesh over fabric to proper depth lack fill
Silt fences or wicker work fence	Undercutting of fence	Check fence rust, size and broadening depth, guage mesh and fabric strength

	Fence collapsing	Check drainage area and slope length, check gradient behind barrier, correct any standard condition.
Outlet protection	Dislogded stones	Replace with larger stones in or use caged stones in wire mesh.
	Erosion below outlet	Enlarge riprap apron or line receeding out below channel. Or convey runoff to a more suitable outlet. Make sure discharge outlet is on level or nearly level grade
	Outlet scocur	Install proper filter fabric or graded top soil areas below the outlet and grass
Inlet protection	flooding around or below	remove accumulated sediment or inlet
		Reconstruct to more suitable inlet Such as a basin

Find below a post construction maintenance check list which should be intensified for at least 2-5 years, following completion of a project to ensure stability of conservation structures and suitability of the erosion site

5.2 Stabilization of the conservation Structures

i. Structure like stream bank stabilisation materials should be checked against sipages to avoid structural sliding or shifting

ii. Check sills and weirs for any defect or damages

iii Avoid excessive use of machineries or implements across the main channel against damages

iv Farmers should not be allowed to cultivate too close to the gully in order not to cause damages to the structures

v. Gabion works and reno mattresses should be checked and damaged areas should be mended immediately

5.2 **COMMUNITY INVOLVEMENT**

The engineering control of gully erosion is by no means a cheap venture but on an expensive one. It is therefore, not likely that the control of gully of such magnitude can be afforded by any of our communities in this country.

This is why government at various levels, LGs, States and Federal has always considered it as one of its primary responsibility to any community befallen with such catastrophy.

There is the danger however, that when such projects are eventually designed and implemented by government alone, without communal involvement, the community so affected consequently shows nonchalance to such projects, which make collective responsibility lacking.

The community so affected, ie the Anguwar Rama of Zonkwa in Zangon Kataf should be involved right at the planning stage as has been done during a recognisance visit to the area.

The team had to pay a visit to the warded and his community who even vuluntered to assist in the investigations carried out at the project site.

If the government eventually decides to carry out the control of the gully site, the community must be informed well ahead of time and operation sort

Farmers must be well enlightened on the menace of erosion as those that should be avoided in order not encourage erosion.

5.3 NON GOVERNMENTAL AGENCY INVOLVEMENT

In view of its importance in the factors of production, land should not be allowed to degenerate to levels beyond reclamation. The different arms of government that are usually involved in its reclamation activities have always failed because of one reason or another. It is therefore recommended that all take-holders of the use of land co-operate in the implementation of amelioration projects. These stake-holders include the three tiers of government (Local Governments, States and Federal), NGOs, the private sector organisations and the communities where such projects are executed. The NGOs and the private sector organisations should be made to contribute certain percentage of their profits for the implementation of such projects as well as suggest solutions to the problems at stake.

APPENDIX TWO

ENGINEERING USE CHART FOR SOILS AND THEIR TEXTURE (FROM A. A. WAGNER, 1957)

TYPICAL NAME OF SOIL GROUP	GROUP SYMBOL	IMPORTANT PROPERTIES				RELATIVE DESIRABILITY FOR VARIOUS USES			
		Permeability when compacted	Shear Strength when Compacted and Saturated	Work ability as a construction Material	Compressibility when compacted and saturated	Homogenous Embankment	Core	Shell	Surfacing
Well graded gravels, gravelly sand mixtures, little of no fines	GM	Pervious	Excellent	Excellent	Negligible	-	-	1	3
Poorly graded gravels, gravelly sand mixtures little or no fines	GP	Very Pervious	Good	Good	Negligible	-	-	2	-
Silty gravels poorly graded gravel-sand - silt mixtures	GM	Semi pervious to Impervious	Good	Good	Negligible	2	4	-	3
Clayey gravels, poorly gravels-sand-clay mixitures	GC	Impervious	Excellent	Good	Very low	1	1	-	3
Well graded sands, gravelly sands, little or no fines	SW	Pervious	Excellent	Excellent	Negligible	-	-	if gravelly	4
Poorly graded sands, gravelly sands little or no fines	SP	Pervious	Good	Fair	very low	-	-	if gravelly	-
Silty sands poorly graded sand-silt mixture	SM	Semi pervious to impervious	Good	Fair	Low	4	5	-	6
Clayey sands, poorly graded sand Clay mixtures	SC	Impervious	Good to fair	Good	Low	3	2	-	2
In organic silts and very fine sands, rock flour, silty or clayey fine sands with slight plastiaty	ML	Semi pervious to impervious	Fair	Fair	Medium	6	6	-	-
In organic clay of low-medium plasticity, gravelly clay, lean clays	CL	Impervious	Fair	Good to fair	Medium	3	3	-	-
Organic silts and organic silt-clay of low plasticity.	OL	Semi-pervious to impervious	poor	Fair	Medium	8	8	-	-
In organic silts, micro gaseous and di-mcrogasseous fine sandy or silty soils plastic silts microgauss	MH	Semi pervious to impervious	fair to poor	Poor	High	9	9	-	-

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