

THE UNIVERSITY OF ZAMBIA
DEPARTMENT OF GEOGRAPHY
G421 PROJECT

THE MORPHOLOGY OF THE KAKUMBI

CONCAVE BANK BENCH ON

LUANGWA RIVER

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This Research Project was submitted on 17/06/88 as part of the Physical Geography single subject Major Programme for the award of a Bachelor of Arts with Education degree at the University of Zambia, Lusaka Campus

DEDICATION

I dedicate this project to my family

DECLARATION

I, EDITH NGOSA KARABASSIS, declare that this project has been composed by me and that the work recorded is my own. All maps and diagrams were drawn by me and all quotations have been distinguished by quotation marks. The sources of all materials used have been specifically acknowledged and the project has not been previously submitted for an academic award.

Karabassis

ACKNOWLEDGEMENTS

I wish to thank Mr H M Sichingabula the project Supervisor, whose suggestions and critical comments throughout the research period were highly commendable. Apart from providing suggestions and constructive comments, he also provided some references and aerial photographs and Maps that were useful throughout the project.

My acknowledgements also go to Mr G R Mulomba, Page and David who gave assistance during the collection of data in the field. Thanks also to Noel Luzongo who helped with transport.

Furthermore, I am greatly indebted to my parents for the financial contribution towards the production of this report.

Finally special thanks to Mrs C Mulomba who typed this research project.

A B S T R A C T

The study investigates the formation and development of concave bank benches on the Luangwa River in Eastern Zambia. The Kakumbi concave bank bench is studied in greater detail than the other two benches because of its accessibility and some of its interesting characteristics.

The morphology and internal characteristics of the Kakumbi bench are studied from detailed field observations and from small format photographs showing its internal structure. Its development is mapped and traced from topographical maps and time sequential aerial photographs between 1956 and 1982. The physical character of the bench is also determined from the analysis of particle sizes of sediment samples collected in the field.

The results of the analysis show that the bench consists of very fine sand which were deposited in a low flow environment with stream velocity less than 0.3m/s. This observation is consistent with the squamish and Barwon benches in Canada and Australia.

The study concludes that the development of a flow separation zone on the concave bank of the Kakumbi meander has resulted in the accumulation of sediments during bankful discharge and the subsequent development of the bench. This has provided the mechanism for reversing the process of channel migration.

TABLE OF CONTENTS

	<u>PAGE</u>
Dedication	i
Declaration	ii
Acknowledgements	iii
Abstract	iv

CHAPTER ONE: INTRODUCTION AND LITERATURE REVIEW

1.1	Introduction	1
1.2	Rationale	1
1.3	Aims	3
1.4	Scope of Study	3
1.5	Theoretical Back-ground	4

CHAPTER TWO: DESCRIPTION OF STUDY AREA

2.01	Introduction	9
2.02	Study Reach	9
2.03	Climate	12
2.04	Geology	12
2.05	Topography	13
2.06	Soils	13
2.07	Vegetation	14
2.08	Hydrology	15
2.09	Land-use	15

CHAPTER THREE: METHODOLOGY

3.1	Introduction	17
3.2	Documentary Sources	17
3.3	Use of Aerial Photographs	17
3.4	Use of Topographical Maps	18
3.5	Field Investigation	18

CHAPTER FOUR: DATA ANALYSIS AND PRESENTATION OF RESULTS

4.1	Introduction	21
4.2	Determination of Channel curvature Index	21
4.3	Assessment of Channel changes in the Kakumbi Concave bank bench	23
4.4	Characteristics of the bench	25
4.5	River discharge	26
4.6	Sediment Analysis	26
4.7	Sedimentary Facies of the Kakumbi Bend	31

CHAPTER FIVE: DISCUSSION AND INTERPRETARION OF RESULTS

	<u>Page</u>	
5.1	Introduction	37
5.2	Curvature Index and Concave bank bench formation	37
5.3	Development of the Kakumbi concave bank bench	43
5.4	Morphology and Internal Characteristics of the Kakumbi Concave bank bench	43
5.5	Sediment characteristics and Internal structure of the Bench	46
5.6	Concave bank and Recent Bench Sediment Characteristics	47
5.7	Summary	50

CHAPTER SIX: CONCLUSION

51

BIBLIOGRAPHY.....

53

FIGURES

PAGE

Figure 1.1	Location of Study Reach on the Luangwa river	2
Figure 1.2	Model of changing flow structure in a developing channel bend	6
Figure 2.1	Location of the studied Bends	10
Figure 2.2	Location of study Area	11
Figure 3	Location of Transects and sampling sites on the Bench	19
Figure 4.1	Definition of Channel Geometry Parameters	22
Figure 4.2	Annual Hydrograph of Luangwa River at Kakumbi in 1980/81 water year	27
Figure 4.3	Cummulative Grain-Size distribution of surface Sediments on the concave bank bench	29
Figure 4.4	Cummulative distribution of sediments in the vertical of the CONCAVE BANK and Recent concave bank bench	30
Figure 4.5	Sedimentray facies profile of the old Kakumbi Bench deposits	33
Figure 4.6	Sedimentary facies profile of the former concave bank	34
Figure 5.1	Location and planform of the Kakumbi Concave bank bench	40
Figure 5.2	Changes in the bench and channel Geometry	42
Figure 5.3	Planform changes in the Kakumbi Concave bank bench	44
Figure 5.4	Sketch of the morphology of the Kakumbi Concave bank bench	48

TABLES

	<u>PAGE</u>
Table 1	Curvature Index Ratios for the studied meander bends on the Luangwa River between 1956-1982 24
Table 2	Dimensional characteristics of the Kakumbi Bench 45
Table 3	Grain Size composition of sediments on the surface of the Kakumbi Bench 45
Table 4	Grain Size Composition of sediments on the Concave bank bench and former Concave bank 45

PLATES

Plate	1a.b.c	Sedimentary facies of the old Kakumbi Bench deposits 35
Plate	2a	Sedimentary facies of the Recent Kakumbi Bench deposits 36
Plate	2b	The Morphology of the Kakumbi Concave bank bench 36

CHAPTER ONE

INTRODUCTION AND LITERATURE REVIEW

1.2 INTRODUCTION

This study investigates the character and formation of concave bank benches and especially the Kakumbi concave bank bench on the Luangwa River in Eastern Zambia (Figure 1.1).

The term concave bank bench was first introduced by Woodyer (1975) to identify fine grained fluvial material deposited at the concave bank of a tightly curved bend on the Barwon River in New South Wales, Australia. In this study the terms concave bank bench and bank bench are used interchangeably.

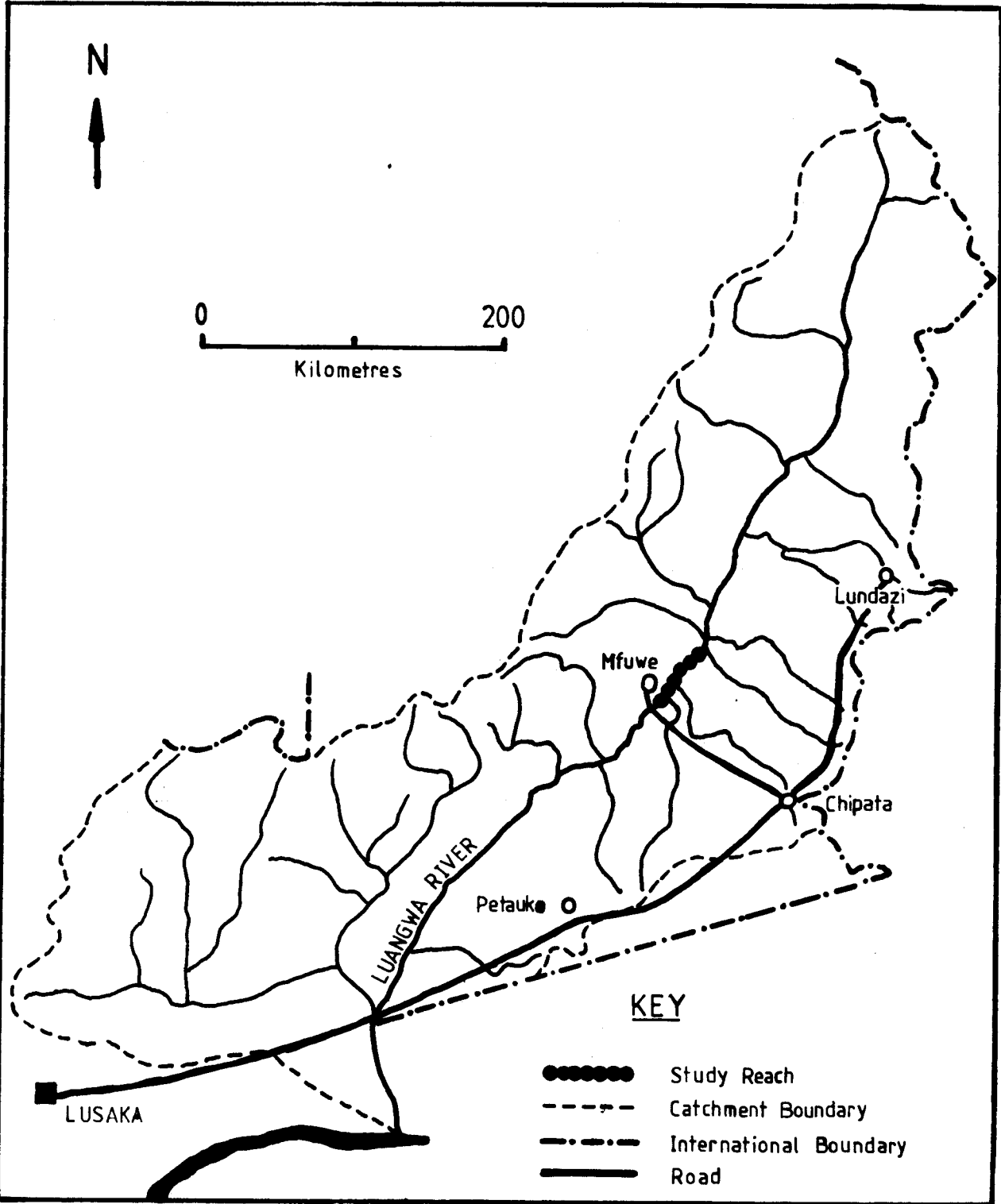
Concave bank benches are rare geomorphic features which have been identified on very few rivers. As a result very little is known about their formation and characteristics. The purpose of the present study is to investigate the character and origin of the three concave bank benches which have been identified on the Luangwa River. However, it was not possible to study all the benches in detail due to inaccessibility of the other two benches consequently this report describes in detail the morphological and internal characteristics of the Kakumbi concave bank bench.

1.2 RATIONALE

Concave bank benches, because of their rare occurrence their formation and morphology are not well understood; But as more information is gained about their physical characteristics, the environment under which they form and their internal structure through individual studies, our knowledge will be enhanced and the geomorphic significance of these features will be

Fig. 1-1

LOCATION OF STUDY REACH ON THE LUANGWA RIVER



realised. It is hoped that the knowledge to be gained from this study will add to the little available knowledge on concave bank benches in fluvial geomorphology.

1.3 AIMS

The main objectives of this study are:-

1. To determine the factors that influence concave bank bench formation on the Luangwa River.
2. To Map and describe the morphology of the Kakumbi concave bank bench.
3. To trace the development of the Kakumbi concave bank bench.
4. To investigate the internal characteristics of the bench.

1.4 SCOPE OF STUDY

The scope of the study is limited to the mapping and description of the morphological and internal structure of the bench from which formative processes are deduced.

The identified characteristics of the Kakumbi concave bank bench are compared to those of the benches reported elsewhere.

Conclusions of the study are drawn from the analysis of the morphological, sedimentological and locational data of the Kakumbi Concave bank bench.

1.5 THEORETICAL BACK-GROUND

Literature on Concave bank benches is limited mainly because of the rarity of this unique geomorphic feature. Concave bank benches derive their name from their location against the concave bank (Cut bank) of a meander bend. The benches occur upstream of the bend axis (Page and Nanson 1982) and closely resemble in planform the concave or eddy accretions observed by Carey (1969) on abrupt angle bends of the lower Mississippi River. Woodyer (1975) first introduced the term concave bank bench to identify fine grained fluvial deposits found at the concave bank of the tightly curved bends of the Barwon River in New South Wales, Australia.

Carey had identified an essential feature similar to concave bank benches which formed on abrupt bends of about 90° on the Mississippi River where the flow impinges on an erosion resistant bank. Upstream of this impingement a large and powerful eddy forms at the concave bank and induces reverse flow. At the convex bank rapid erosion upstream results in the movement of the entire bend configuration downstream along the resultant valley wall. The vacated area at the upstream margin of the concave bank then fills by eddy accretion. Carey noted that these sediments tend to have a higher silt-clay content than any other alluvial deposit except bank swamp clays.

In contrast to the Mississippi River, concave bank bench development on the Barwon River is restricted to very tightly curved bends and is not associated with rapid channel migration (Woodyer

1975). The flow expansion which favours the development of reverse flows also provides the space for concave bank development is thought to occur only where cut-off or ancient channel influence present channel morphology.

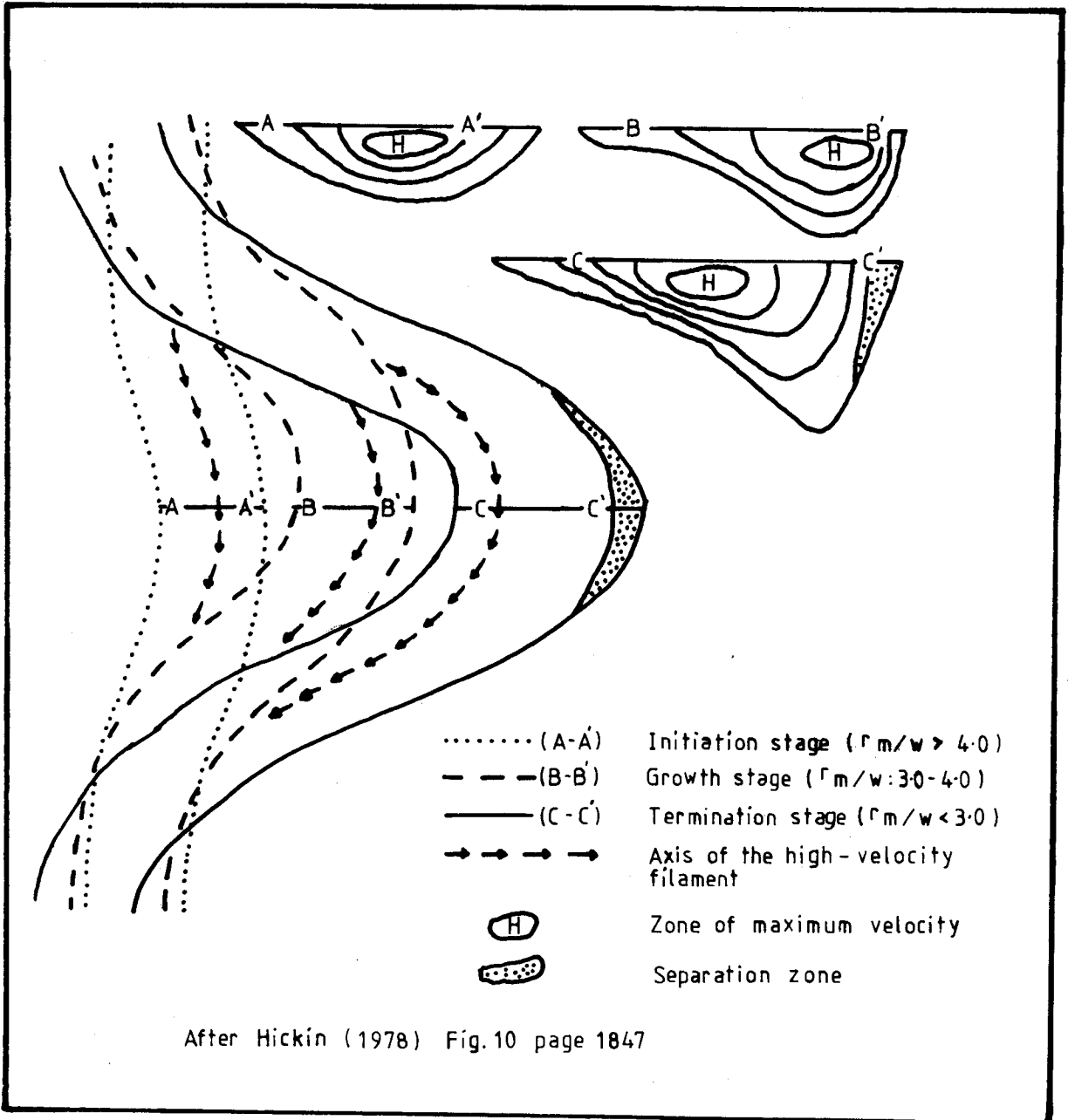
Concave bank benches have also been identified on the Squamish River in British Columbia, Canada where Hickin (1979) relates the formation of a flow separation envelope and subsequent concave bench to a model of discontinuous bend evolution developed for the Beatton River (Hickin and Nanson 1975; Hickin 1977).

In this Model (Figure 1.2) bends become progressively more curved as radius of curvature to width ratio declines below 4.0 at the bend axis, more inertia force is applied at the concave bank. Rapid erosion at the concave bank widens the channel at the bend axis and an associated separation zone develops. As r_m/W declines to values less than 3.0 the maximum velocity filament shifts from the concave to the Convex bank, providing a reverse process where the river starts to deposit on the concave separation zone and erode the convex bank. This provides a hydraulic explanation of arrested channel migration which is an alternative to Bagnold (1960) separation theory. The deposition of suspended sediments in the relatively quiet waters of the separation envelope eventually develops and forms a concave bank bench.

Concave bank bench formation provide supporting geomorphic evidence of proposed mechanism of channel lateral migration control.

Fig. 1.2

MODEL OF CHANGING FLOW STRUCTURE IN A
DEVELOPING CHANNEL BEND



After Hickin (1978) Fig.10 page 1847

The texture of the material in the concave bank bench on the Squamish River consist sediments which are very much finer and better sorted than overlying sand forming the point bar. Similar observations were made of the texture of the sediments on the concave bank benches of the Barwon river in New South Wales, Australia.

Concave bank benches have also been identified and described on the Murrumbidge River near Wagga Wagga, New South Wales, Australia by Page (1981). The concave bank benches on the Murrumbidge River are generally found on tightly curving bends with radius of curcuture to mean channel width ratios of less than 2.3 although Page also observed that not all such tightly curving bends contain a concave bank bench.

Unlike the Squamish and Barwon bench development, concave bank benches on the Murrumbidgee River initially develop as longitudinally shaped sand bar located close to the concave bank in the wide channel immediately upstream of the bend axis and is formed of bedload deposited before complete bench formation. The bar is formed by strong secondary current moving the bed from the main channel towards the concave bank. The formature processes give the benches on the Murrumbidge River the characteristic morphologies, consisting of a high point located near the main channel and a surface which slopes gently from this point towards the well defined secondary channel at the base of the original concave bank. By failing to migrate completely to the concave bank a secondary channel results between the bank and the bar at low flow.

It is quite apparent from the above discussion that different explanations of concave bank bench formation are possible. There is no single explanation which is sufficient to explain concave bench formation. The present study describes the unique characteristics of the Kakumbi concave bank bench on the Luangwa River and compares these features to other benches that have been studied.

The location and environmental setting of the study area are described in the next chapter.

2.1 INTRODUCTION

This chapter describes the physical setting of the study area. The study focuses on the Luangwa River, the third largest river in Zambia that rises in the North Eastern of Zambia near the border with Malawi and flows West in a rather direct course paralleling the trend of the valley. In the meandering reach, the river is characterised by the occurrence of cut-off meanders, oxbow-lakes, lagoons as well as a wide alluvial flood plain.

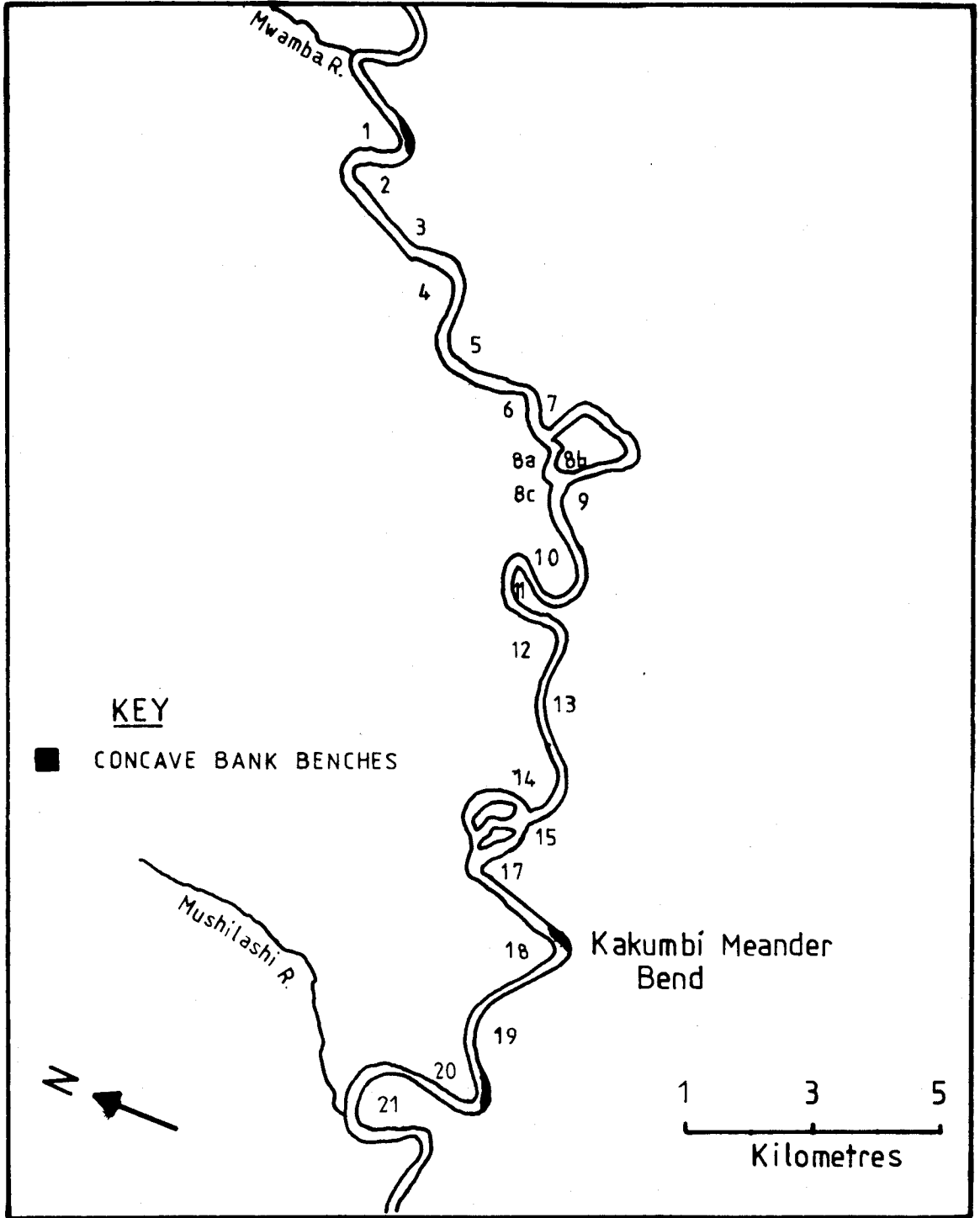
This study investigates channel changes at two geomorphic scales. The smaller scale covers a study reach of about 15 KM in length. In this reach meander parameters of width and radius of curvature were measured. At the larger scale at the bend level, detailed mapping of channel displacement and analysis of sedimentary structures of the concave bank bench are carried out for the Kakumbi Meander bend.

2.2 STUDY REACH

The study reach extends from Mwamba tributary in the North to Mushilashi tributary in the South (figure 2.1). It extends over a distance of approximately 15 KM. The precise location of the study reach on the Luangwa river is shown on the location Map of study reach in Figure 1.1. The study reach is sinuous with a relatively flat slope. The river is joined by several tributaries within the reach, which contribute to the total sediment load transported by the river.

Fig. 2.1

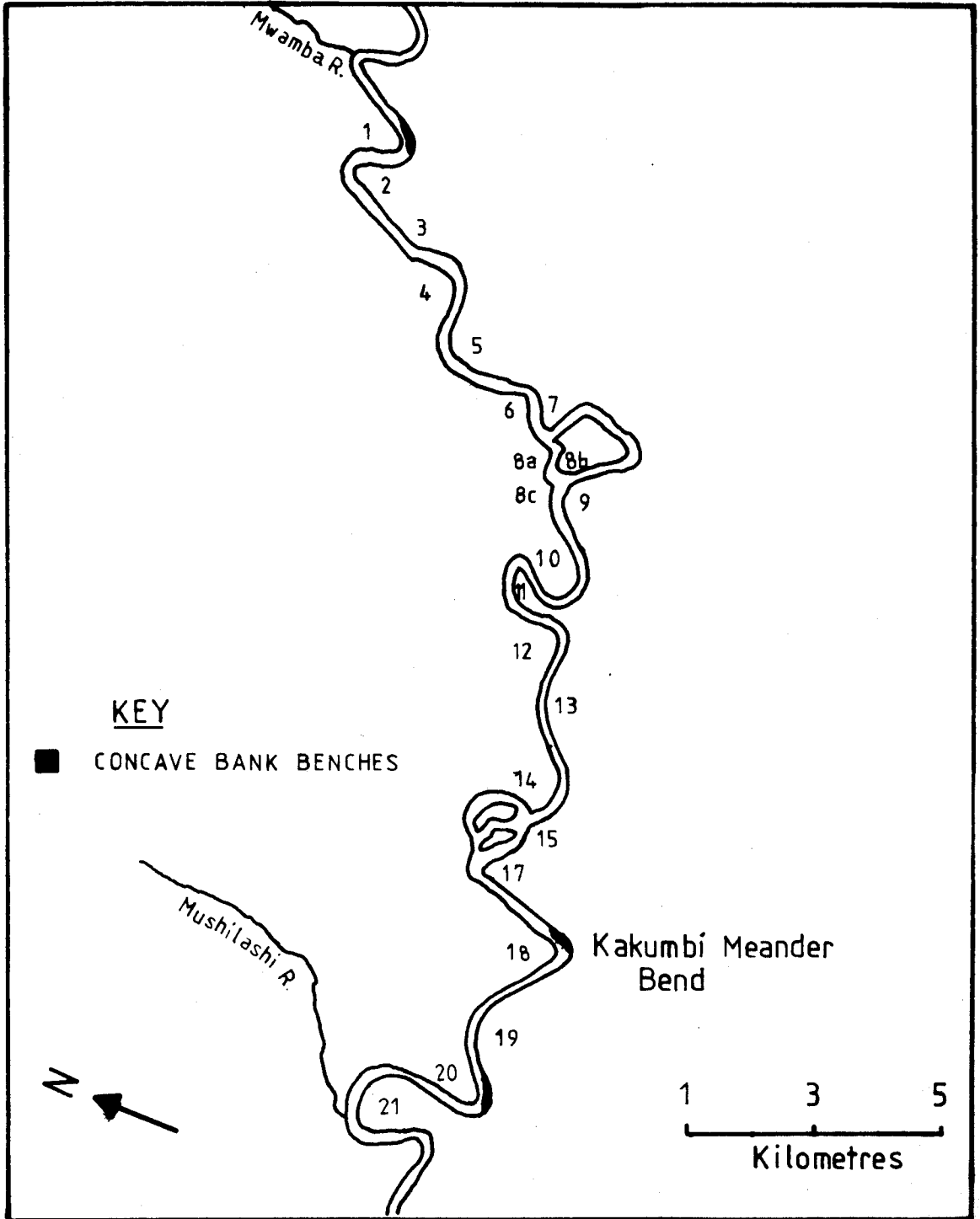
LOCATION OF THE STUDIED BENDS



The numbers stand for studied bends also presented on Table. 1

Fig. 2.1

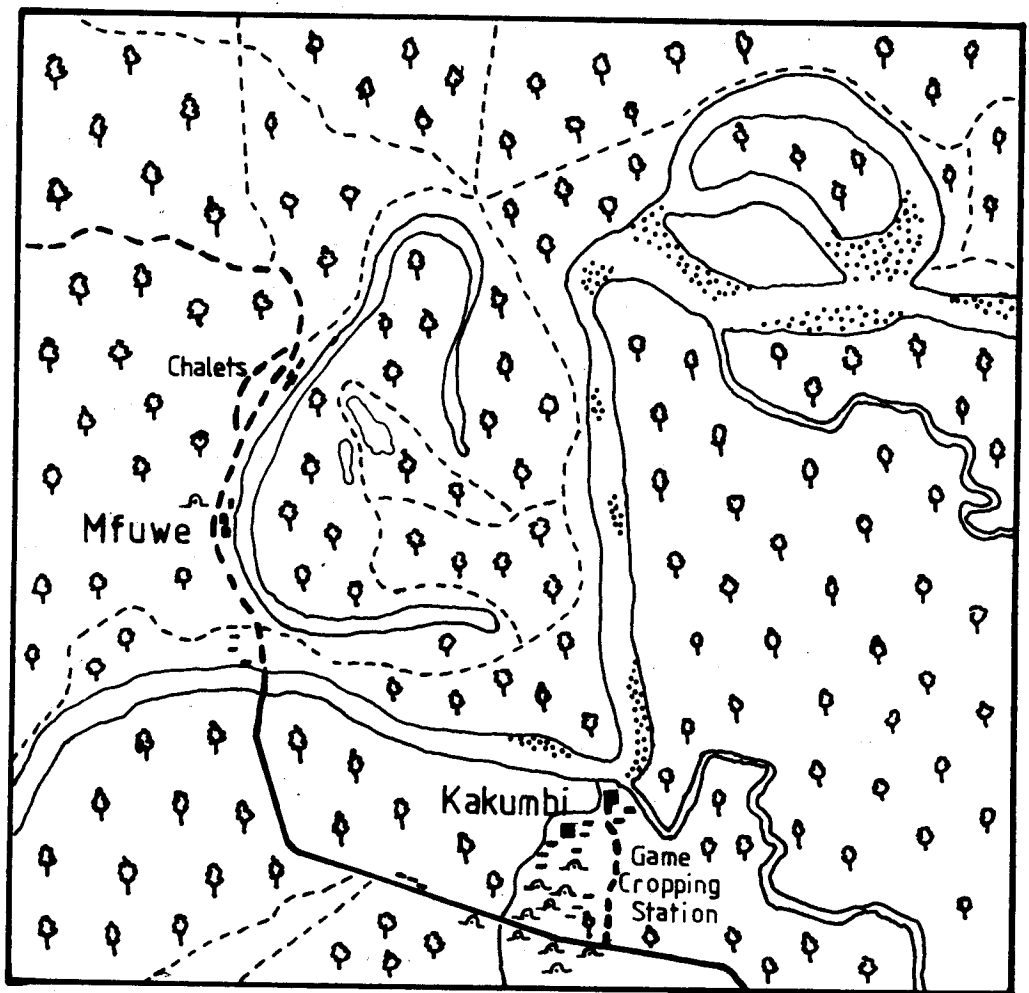
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


Fig. 2.2

LOCATION OF STUDY AREA



KEY

0 1 2
km

-  Permanent buildings
-  Hut, Village
-  Tarraced road
-  Motorable Tracks
-  Other Tracks
-  Sand or Mud
-  Woodland

The Kakumbi concave bank bench is located about 3.5 KM East of Mfuwe (Figure 2.2). The precise location of the study area is between 31°46'E and 31°49'E and between 13°03'S and 13°06'S. The actual bench is located on the eastern bank of the Luangwa River against the concave bank on the Kakumbi meander bend.

2.3 CLIMATE

The climate of the Luangwa valley like all other places in Zambia has three seasons; The dry cold season runs from May to August, followed by a hot dry season from September to October. The rainy season begins in November going up to April. The valley receives relatively low rainfall possibly due to a combination of the rain shadow and subsidence of local air.

2.4 GEOLOGY

The Luangwa valley in general is floored by the Karoo sediments that were deposited during the upper carboniferous to Mid Jurassic period. The Karoo sediments were deposited at two separate time periods. the lower Karoo deposition commenced with a basal conglomerate followed by coal measures, which are in turn overlain by the Madumabisa Mudstone formation. The Madumabisa Mudstone is overlain by the escarpment grit which marks the beginning of the upper Karoo sedimentation characterised by fluvial tile sediments. (Utting 1973 in Zambia Geographical Association 1973). In some areas the Karoo sediments have been intruded by dolerite/gabbro dykes of Mid durastic age associated with faulting of the Luangwa valley.

2.5 TOPOGRAPHY

Giardino (1973) in Zambia Geographical association) delimited the Luangwa Valley into a number of land systems of which the Alluvial Belt is the most significant to this study. It is characterised by a variably, nearly flat Landscape of recent alluvium displaying features such as oxbow lakes, Levees, point bar deposits, flood channels and a back plain which varies in width from 2-3 KM along major rivers.

Giardino delineated three different areas of alluviation.

- a) Active sedimentation characterised by an unvegetated surface easily discernable on aerial photographs.
- b) Recent area of sedimentation marked by grassland and occasional occurrence of trees.
- c) Old sedimentation area characterised by oxbow lakes and a denser vegetation cover with numerous trees.

The Kakumbi concave bench is an active sedimentation area clearly discernable on aerial photographs.

2.6 SOILS

The soils of the Luangwa Valley can be divided into two broad soil types. These are the Lower valley and the escarpment soils (Trapnell 1953 in Zambia Geographical Association) Alluvial Soils lie in a belt along the Luangwa and the main tributaries. The sandy nature of the soils indicate that they were derived from grits and sandstones which form the majority of the Karoo sediments.

Field observations made during this study show that the transport load of the Luangwa river is essentially sand silt. For there was no evidence of gravel of any significant amount. The Kakumbi concave bank bench is predominantly composed of very fine sand and is a typical example of alluvial soils found along the Luangwa and its tributaries.

2.7 VEGETATION

The Meander belt contains characteristic vegetation communities on each of its components:- levees, point bar deposits, flood channels, oxbow and back Swamps.

Evergreen trees are characteristic of recent levees while woodland savanna occur on the oldest levees and ridges of the point bar deposits. The seasonally water logged backswamps are dominated by grassland. The meanderbelt is completely inundated at times of high flood probably every four to five years.

The major factor influencing vegetation are the frequency and degree of flooding and the texture of the soil.

The Kakumbi concave bank bench comprises fine alluvial very well drained sands. It is generally a bare surface without any vegetation except for some grasses found downstream on the silt soils. Vegetation is not only important in regulating stream flow but also in stabilising the river banks against erosion.

2.8 HYDROLOGY

Data on the hydrological characteristics of the Luangwa river at Kakumbi gauging station is not up to date and is rather scanty. Velocity data was never collected until 1978 after the construction of Mfuwe Bridge. This is because there were no facilities to enable the regular collection of velocity records. Even after the construction of Mfuwe Bridge, the collection of data has not been made consistently such that available data can not be used for analytical purposes. The only station that has data that goes as far back as 1935 is Luangwa Bridge but it is too far away from the study area.

The annual regime at Luangwa Bridge shows a typical curve for rivers in Zambia. It shows a sharp rise in flow from December to the Maximum in February/march. Hereafter, discharge falls with a normal recession curve. By the end of the rains around April, the levels have fallen considerable and the flow thereafter is that due to interflow or from ground water which maintains the flow until the next rains.

2.9 LAND-USE

The Luangwa valley in general is sparsely populated and most of the people are engaged in some form of subsistence farming; but the area is heavily populated with game animals.

The Kakumbi settlement area is sandwiched between Lupande and Matizye tributaries that drain in the Luangwa river at Kakumbi meander bend, (see figure 2.2) on an elevated surface. The settlement was

strategically located on the interfluvium to avoid the devastating effects of flood incidences.

The landuse type that was important in the area at one time is game cropping. In 1966 the National Parks and Wildlife had established a game cropping station at Kakumbi. Their main objectives were to keep a check on the Hippo population as well as to study Hippo behaviour particularly the reproduction cycle. In order to protect the station from the rapidly migrating river bank, the river bank was stabilised in 1966.

Steel cables were aligned along the river bank between Lupande river and down stream joining the Luangwa river at Kakumbi bend. The steel cables were overlain with concrete and then trees were planted to give the river bank natural stability.

The game cropping station was later in the 1970's moved from Kakumbi to Nyamaluma where it is currently located.

The next chapter describes the types of data that were collected as well as the methods of collection.

3.1 INTRODUCTION

This chapter describes the various sources of data that was utilised for the study as well as the methods of data collection employed. The two main sources of data ^{were} documentary sources and field observations. These are briefly discussed below.

3.2 DOCUMENTARY SOURCES

A great deal of the information used for the study was obtained from the following sources; The university of Zambia Library and other literature sources provided the theoretical background to the study; Discharge data of the Luangwa river at Kakumbi was obtained from the Water Affairs department; Information on landuse of the area was obtained through personal interviews with relevant officials.

Most important of all were the aerial photographs and topographic Maps obtained from Survey Department.

3.3 USE OF AERIAL PHOTOGRAPHS

A set of sequential aerial photographs covering the study reach were obtained for the years; 1956; 1967; 1973 and 1982.

The criteria for selecting these years had more to do with the years when the study reach was covered than anything else.

The photographs were used to measure and calculate the ratio of the radius of bend curvature to channel width (r_m/W) for all the meander bends within the study reach. This was repeated for all the four time periods. The determination and significance of

curvature index is discussed in detail in the next chapter.

Aerial photographs were also used to monitor the development and changes in the Kakumbi concave bank bench.

3.4 USE OF TOPOGRAPHICAL MAPS

1:50 000 Topographical Maps (1231 D4; 1331 B2; 1331 B1) covering the study reach were used to identify the meander bends that were considered in calculating meander parameters.

Topographical Maps were also used for scaling and as base for maps compiled from aerial photographs before superimposing them. Other information obtained from the Maps include; topography and location of study area.

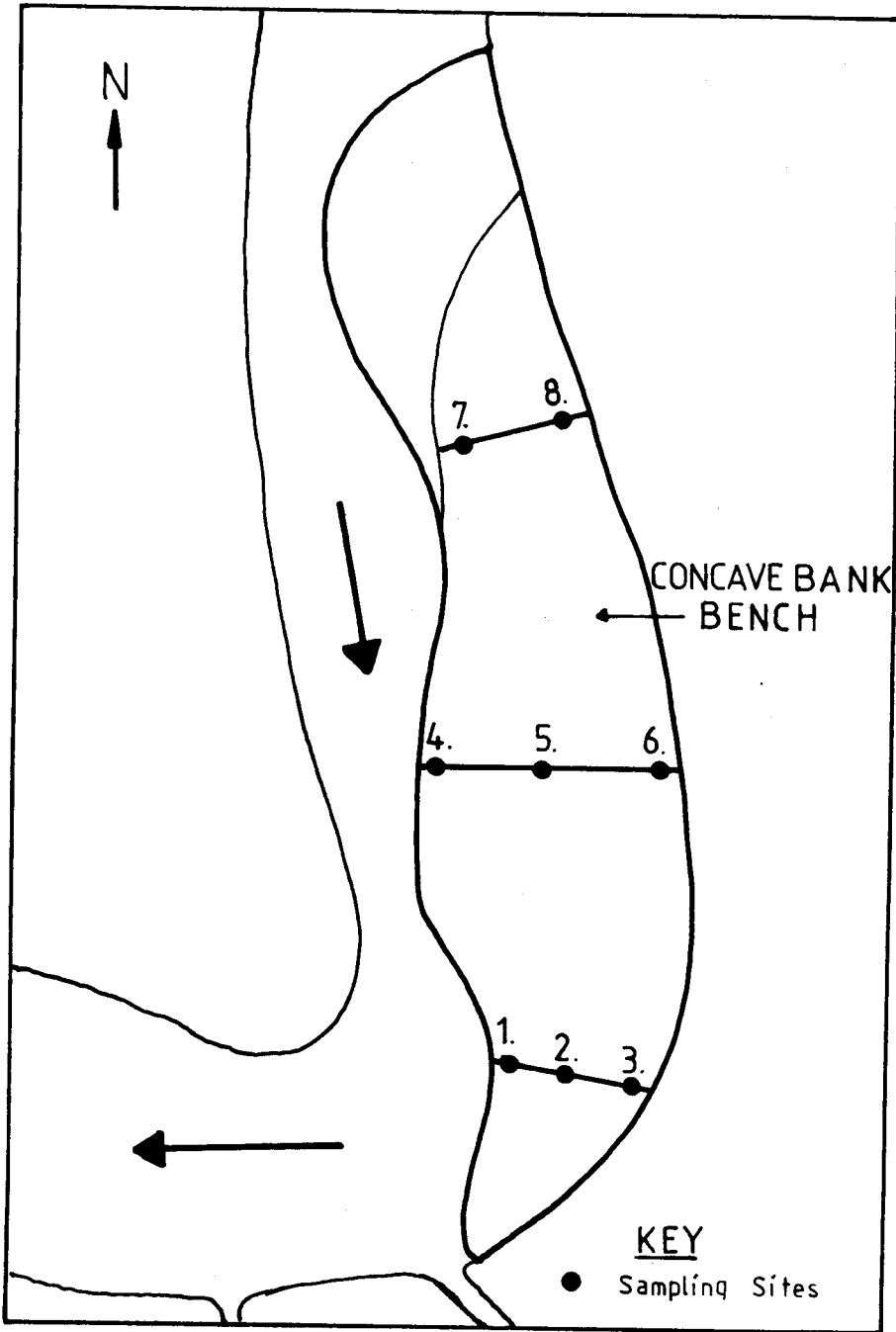
3.5 FIELD INVESTIGATION

Data collected from the field include; profile descriptions of the facies on both the concave bank bench and the former concave bank of the river and soil samples for Laboratory analysis in the Geography physical laboratory at the university of Zambia.

During field data collection three transect lines were selected across the concave bench, from the near edge of the river to the former concave bank (Figure 3.1). Three soil samples were collected from three different sites along the first transect line downstream of the bench. Another Three samples were obtained along the second transect (Middle Section). Finally two samples were

Fig. 3

LOCATION OF TRANSECTS AND SAMPLING SITES ON THE BENCH



collected along the third transect upstream of the bench. Each of the soil samples were collected from an average depth of 30cm below the surface.

Three other soil samples were collected from the former concave bank in the vertical and one more on the bench in the vertical.

The analysis of sediment samples and the grain size particle distribution is presented in the chapters that follow.

Profile descriptions were carried out right there in the field using the Munsell Colour Chart. The information obtained include: Soil Colour, Soil Texture and Concretions or Mottles.

Three profiles were investigated at three different sites. Two sites were selected one on the downstream, the other one was located mid way through the concave bank bench. The third site was located on the former concave bank of the river.

To accompany the profile descriptions small format photographs were taken to illustrate the stratification of the sedimentary sequences on the concave bank bench.

The next chapter describes the various methods of data analysis and gives a brief discussion of some of the results.

CHAPTER FOUR

DATA ANALYSIS

AND

PRESENTATION OF RESULTS

4.1 INTRODUCTION

This chapter describes the various methods employed in the analysis of data collected in the field. It also gives the justifications of the methods used and their shortfalls.

4.2 DETERMINATION OF CHANNEL CURVATURE INDEX

Channel curvature Index refers to the ratio of the radius of channel curvature (r_m) to channel width (W) as defined in Figure 4.1. Channel curvature index is a ratio used to describe the planform geometry of channel meander bends. Small channel curvature index represent very tightly curved meander bends (ie < 3.0) while large ratios (> 0.9) represent open meander bends, The importance of this ratio is that it is related to channel migration rate at the axis of a channel bend. The pattern of secondary flow accords with the general model of spiral flow in meanders. Divergence from this ideal pattern is explained by bend-flow interaction induced by the variable planform geometry of the channel.

The channel curvature index was determined as follows:-

A series of aerial photographs were joined together into a mosaic. The outline of the river was inscribed onto a tracing paper, and channel curvature and channel width were measured. Channel width was defined as bankful width measured at the inflection point of the river, because width measurement is not complicated by the presence of separated flow which

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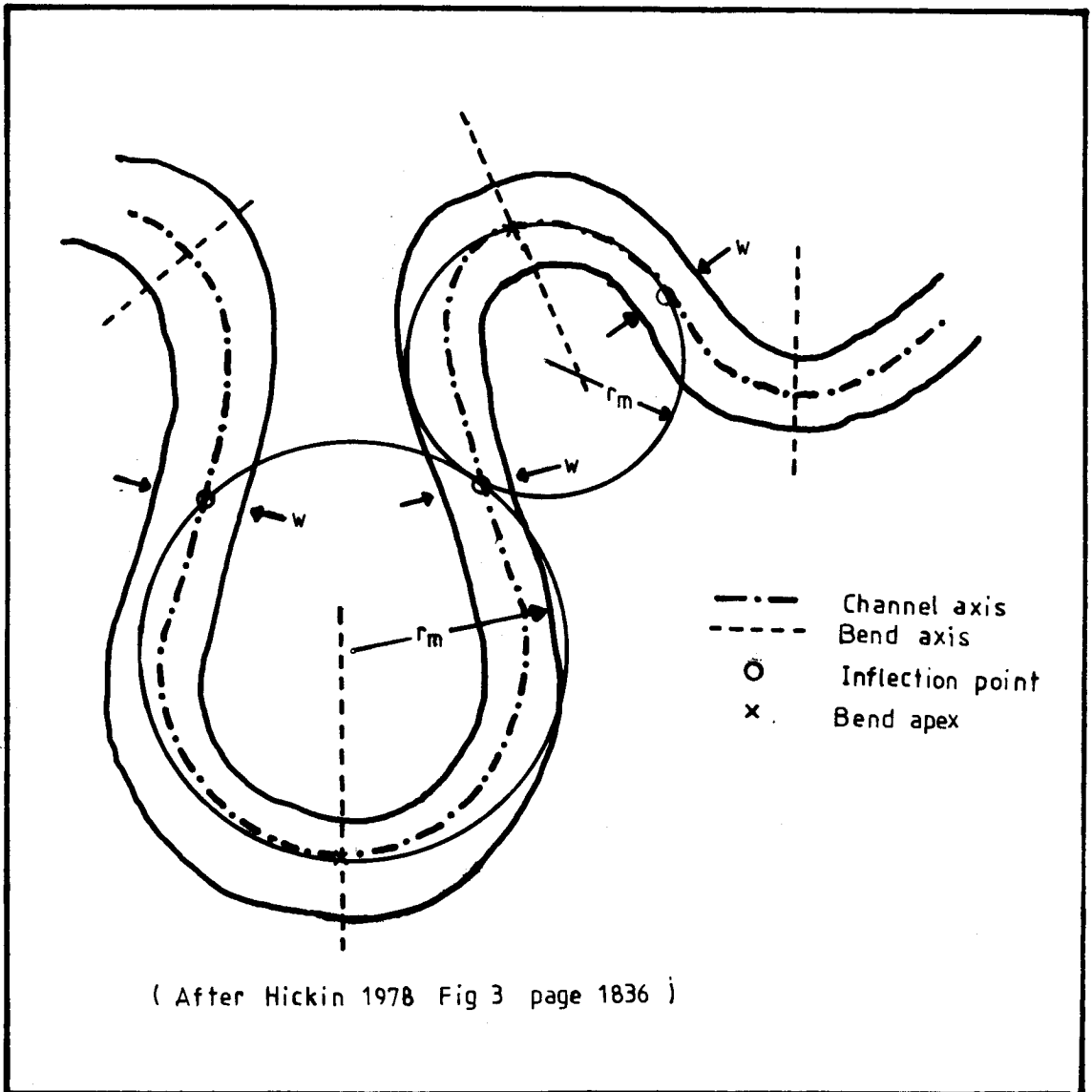
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Fig. 4.1

DEFINITION OF CHANNEL GEOMETRY PARAMETERS



often occurs elsewhere in the channel bend (Hickin 1978). The banks of the river were taken to coincide with the channel - ward limit of the perennial trees which are easily identifiable from photographs, (Nunnally 1967). This procedure was repeated for the four measurement intervals. The results are presented on table 1.

The meander bends were classified into 3 groups:-

- 1) Open meander bends with $rm/W > 9$ (bends 13 and 19 in figure 2.1) open meanders are characterised by very large values of curvature index.
- 2) The majority of the bends fall within the intermediate range $3.0 < rm/W < 9.0$. It is not possible to categorise these bends within the three groups because curvature index is not stable but varies through time.
- 3) Finally very tight meander bends with $rm/W < 3.0$. These bends are characterised by very small values of channel curvature radius with relatively larger values of channel width.

Concave bank benches have been identified on bends 1, 18 and 20 and are all located on the eastern banks of very tightly curved meander bends. the location of the benches are indicated with a dark shading on figure 2.1.

4.3 ASSESSMENT OF CHANNEL CHANGES IN THE KAKUMBI CONCAVE BANK BENCH

Changes in the morphology of the meander bend and the bench at Kakumbi were determined from aerial photographs for the years 1956, 1967, 1973 and 1982.

TABLE 1

CURVATURE INDEX RATIOS FOR THE STUDIED MEANDER
LUANGWA RIVER BETWEEN 1956 - 1982

MEANDER NUMBER	1956 rw/W	1967 rm/W	1973 rm/W	1982 rm/W
1	2.8	2.6	2.5	1.8
2	3.4	3.0	3.1	2.6
3	2.5	5.3	6.6	4.3
4	4.0	5.0	5.2	2.9
5	7.8	7.0	-	5.3
6	4.6	2.6	4.2	3.7
7	1.7	1.0	1.5	3.0
8a	5.1	2.0	1.4	3.4
8b	2.4	1.9	1.0	-
8c	-	-	1.0	-
9	4.9	4.8	3.0	8.3
10	3.1	3.5	2.8	
11a	2.0	-	1.1	1.2
11b	2.7	-	1.8	1.6
12	6.4	4.0	3.7	3.3
13	9.4	12.5	8.4	10.4
14	3.9	3.0	3.5	3.5
15	5.9	4.8	7.8	6.6
16	4.9	4.0	2.6	3.8
17	2.0	1.0	1.3	1.0
18	1.3	1.5	1.3	1.6
19	11.5	12.3	9.5	12.1
20	-	2.8	1.8	1.8
21	7.0	4.6	5.8	4.3

The blank spaces on the table represent bends that were either not covered by aerial photographs or were not existant then but have just developed or have been abandoned as the river has taken different courses.

Outlines of the Kakumbi meander bend and the concave bank bench were traced from the aerial photographs for the four time periods on separate sheets of paper. Roads and permanent buildings were used as landmarks when superimposing outlines of maps compiled from photographs. The scale of the final super-imposed diagram was reduced by about 2.5 for easy measurement (1:8000).

4.4 CHARACTERISTICS OF THE BENCH

Quantitative measurements of mean width, length and surface area of the bench were made.

Mean Width measurement was obtained as the sum of width measurements made at several points divided by the total number of observations:-

$$W = \frac{W_1 + W_2 + W_n}{N}$$

Length of the bench was determined as the longitudinal distance between the upstream and downstream ends across the mid point of the bench.

Surface area of the bench was determined using the method of squares and converted to ground measurements according to the scale of the map.

This procedure was repeated for the years 1967, 1973 and 1982. The results of the analysis and assesment of the changes in the size of the bench are discussed in the next chapter.

4.5 RIVER DISCHARGE

Balek (1971 in Zambia Geographical Association) estimated that a flood of 2185 cumecs can be expected once every 2 years while one of 6011.7 cumecs is only expected every 1000 years. Hew also reports that the estimation of the once in 100 year flood for the Luangwa is very close to the experience of 1971. This flood incidence was supported by chief Mwanya, whose people have lived in the area for 100 years, who commented that nothing like these floods have happened during the past years.

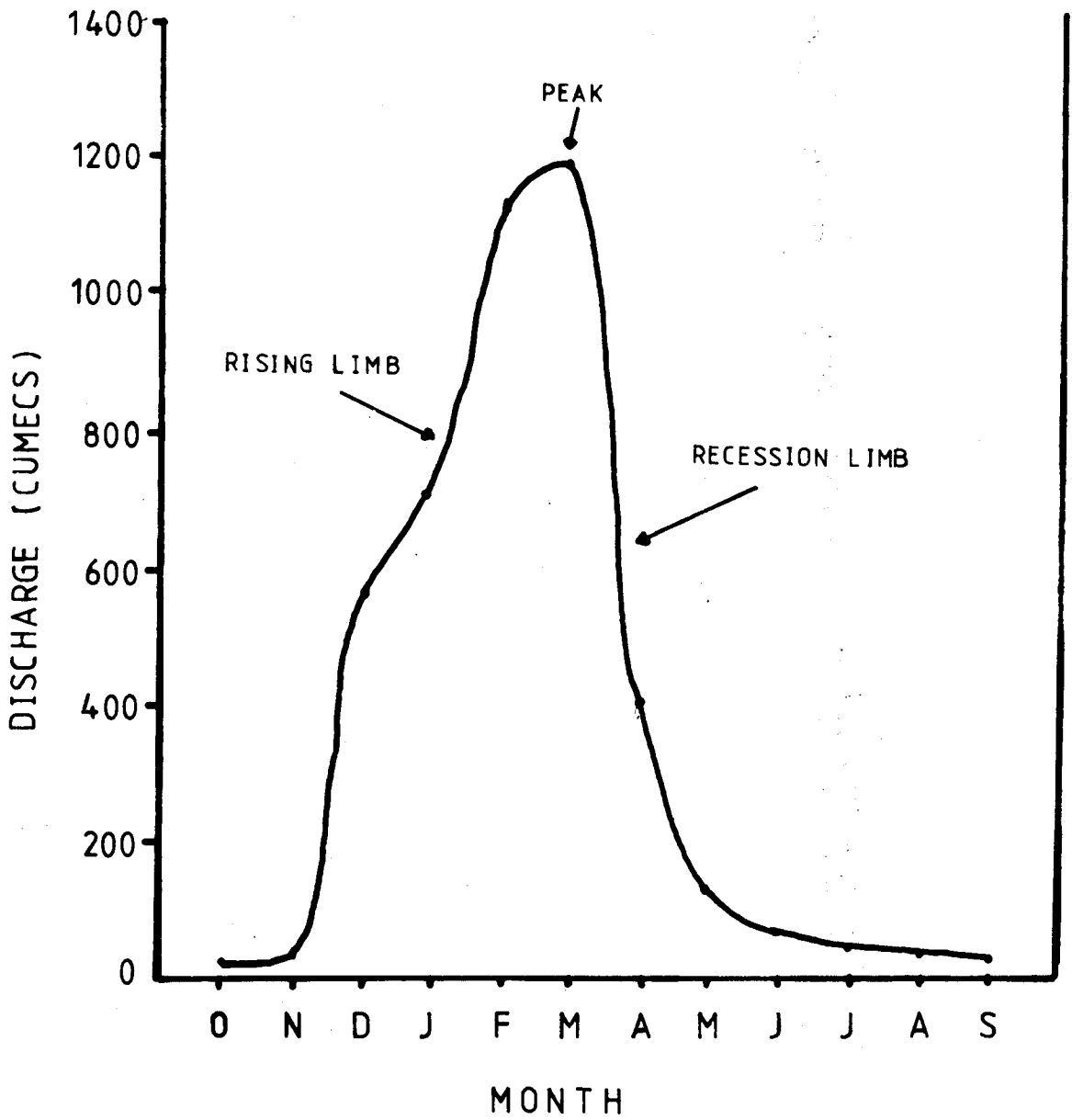
Figure 4.2 shows a typical annual Hydrograph for the Luangwa River at Kakumbi that you would expect every year. This Hydrograph is for the 1980/81 water year. The Luangwa River is flashy, characterised by a sharp rise in discharge with the onset of the rains from Decemberto a maximum in February/March. Thereafter discharge falls sharply from a Maximum discharge of about 1200 cumecs to a minimum flow of about 20 cumecs. The wet season rains have little effect on the flow until December, even though the rain season starts towards the end of October in the north, these early rains being utilised to "re-charge" the soil and for evapotranspiration. The peak flow at the beginning has a time lag of about a month which occurs after peak rainfall.

4.6 SEDIMENT ANALYSIS

The primary function of particle size analysis is to obtain quantitative data about the size and distribution of the particles in the sediments. Grain

Fig. 4.2

ANNUAL HYDROGRAPH OF LUANGWA RIVER AT
KAKUMBI IN 1980/81 WATER YEAR



size of sediments transported by a river is related to the flow power. Therefore particle size distribution will depict the depositional environment of the river at the time of deposition.

There are two main methods used in particle size analysis; Sieve analysis which covers a wide range of particle sizes, and sedimentation method often used for the analysis of very fine grains.

Sieve analysis method was used although sedimentation would have been more appropriate due to the non availability of the sedimentation apparatus.

Laboratory analysis of particle size distribution was conducted as follows:-

Ten sieve sizes ranging from 1mm to 0.045mm were arranged with the coarsest sieve at the top. A tight filling pan or receiver was placed below the bottom sieve to receive the final undersize. A lid was placed on top of the coarsest sieve to prevent escape of the samples.

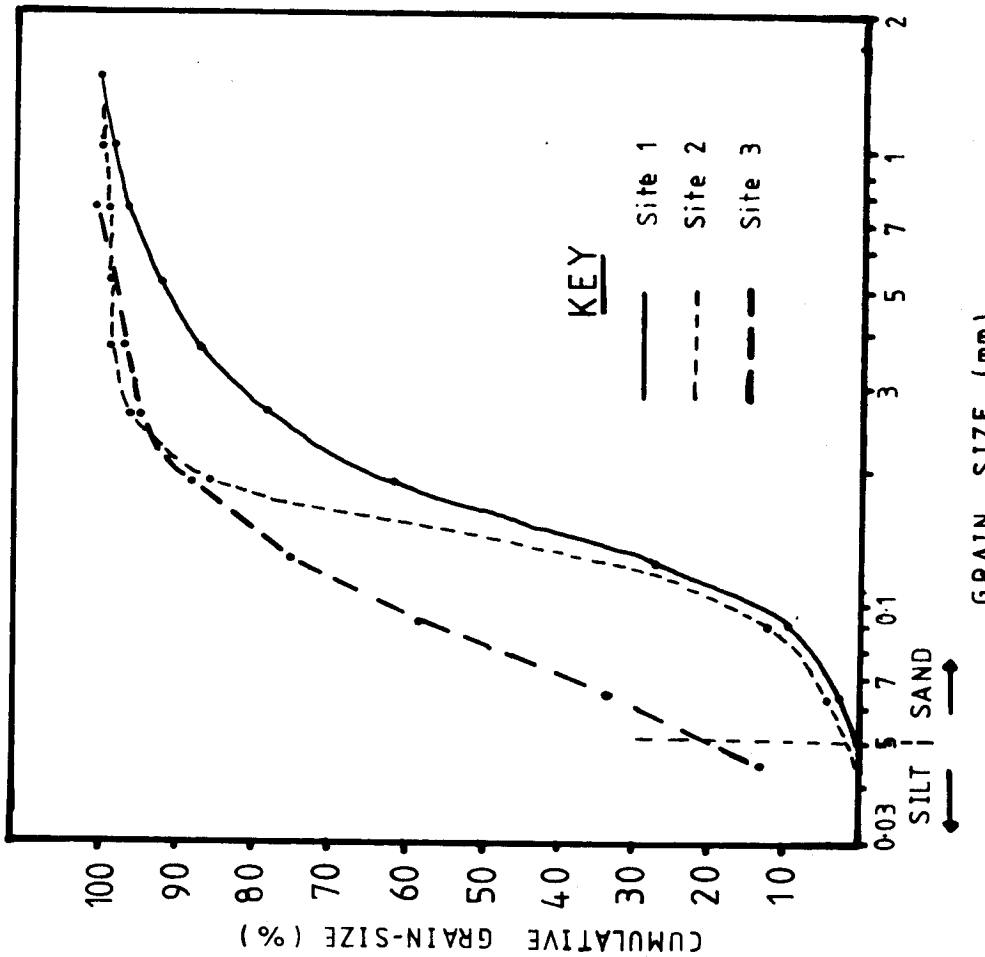
The sediments were automatically shaken for fifteen minutes. The amount of sediments collected on each successive sieve was weighed using an electronic balance (Mettler P125) to determine the weight of each category of sediments.

Fig. 4-3

CUMULATIVE GRAIN-SIZE DISTRIBUTION OF SURFACE SEDIMENTS

ON THE CONCAVE BANK BENCH

A. TRANSECT: 1



B. TRANSECTS: 2 AND 3

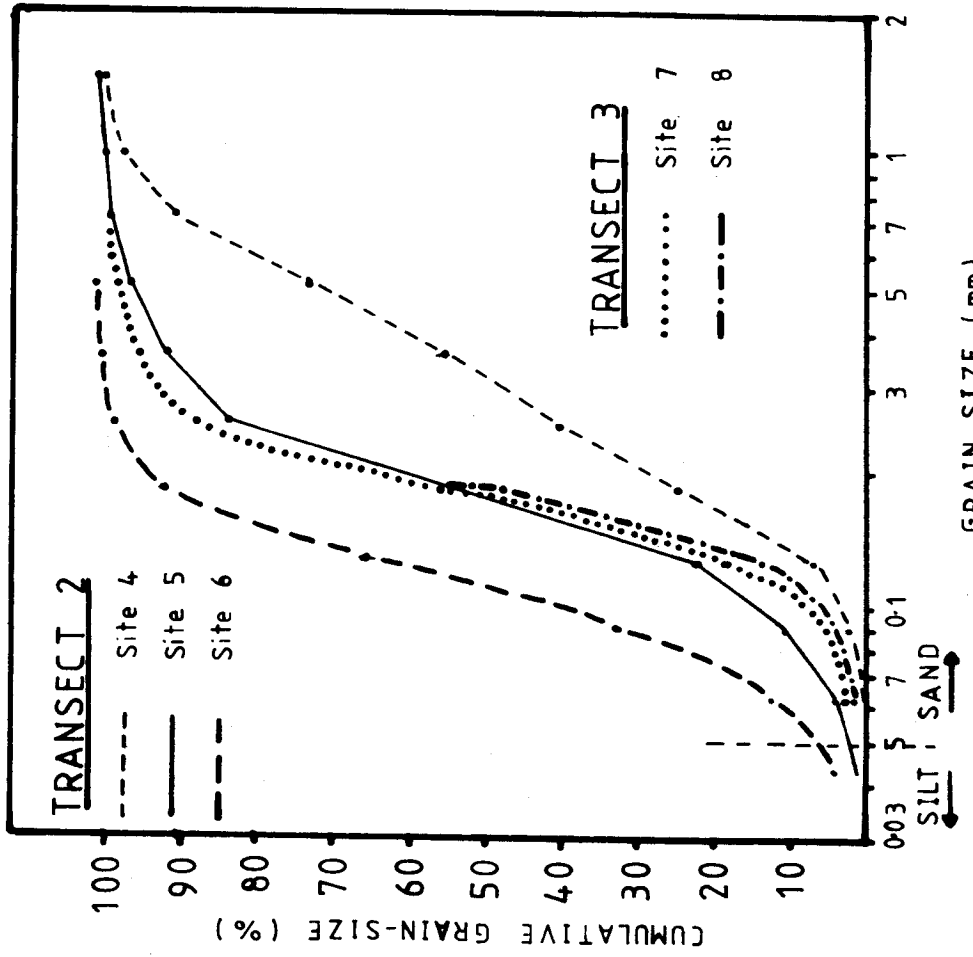
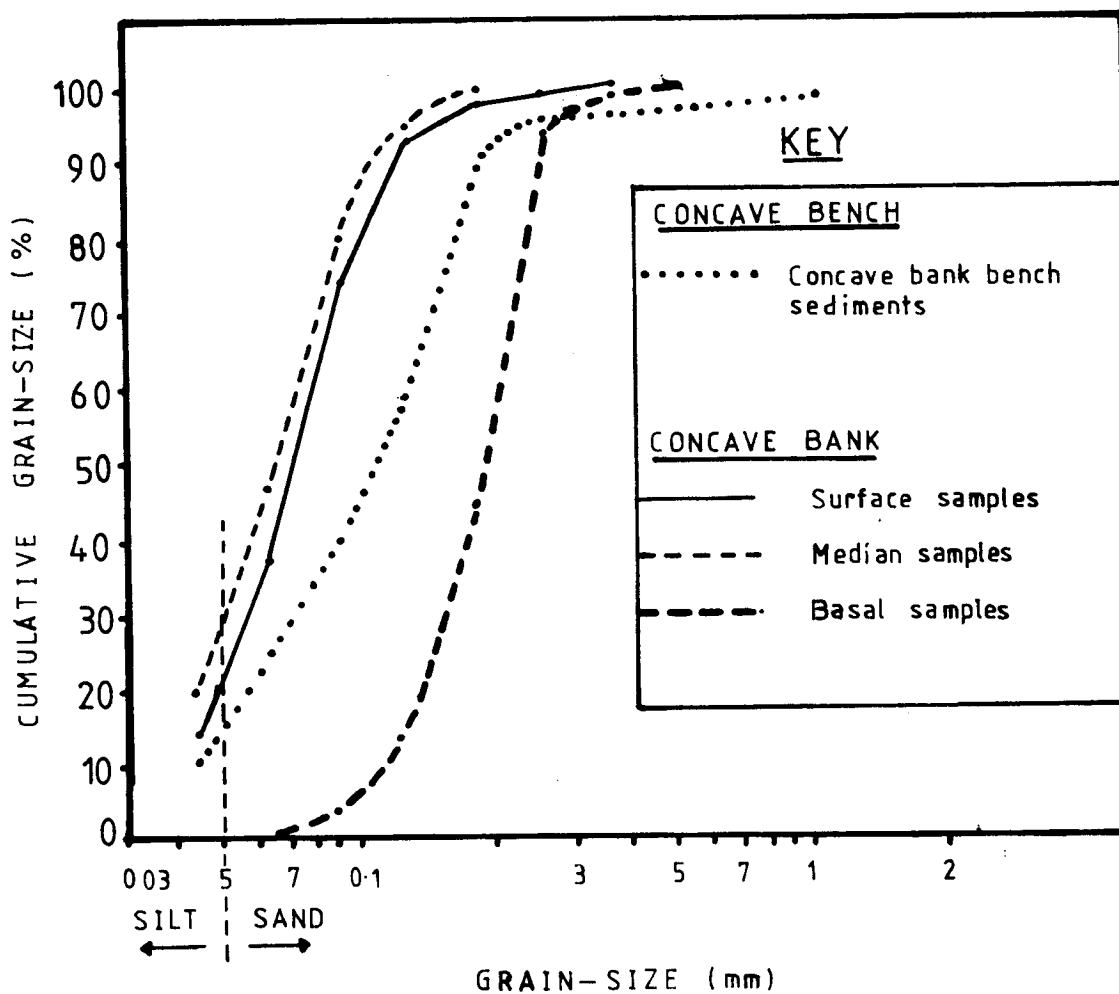


Fig. 4.4

CUMULATIVE GRAIN SIZE DISTRIBUTION OF SEDIMENTS IN
THE VERTICAL OF CONCAVE BANK AND THE RECENT
CONCAVE BANK BENCH



It must be mentioned that the sieve analysis method is complicated by the presence of near size particles which tend to stick in the sieve aperture and thereby reducing the effective area of the sieving medium. This problem becomes more serious with test sieves of very small aperture.

Figures 4.3 and 4.4 show the cumulative grain size distribution of surface sediments of the kakumbi concave bank bench and concave bank in the verticle. The results are discussed in detail in the next chapter.

4.7 SEDIMENTARY FACIES OF THE KAKUMBI BEND

Figure 4.5 and plate 1 a.b:c. show the sedimentary facies of the concave bank bench on the downstream. The internal structure of the profile consists horizontally interbedded alternating very fine sand and silt. The individual strata range from 10cm to 30cm in thickness which probably correspond with single flood events. From the bottom the sediments were laid down in succession in the following manner: fine sand, silt, very fine sand, silt, very fine sand, silt, very fine sand. The formative processes of the facies show a cyclic sequence. Each of these very fine sand/silt sequence may well represent separate sequences of facies formation. It shows an upward fining sequence for each flood event. Since grain size is a measure of flow power at the time of deposition, each of the distinct sequence were laid down in a decreasing flow environment. The whole profile is characterised by a series of fining upward sequence which may be thought to have been formed in a cyclic manner. There are also reddish brown mottles which may be due to presence of iron oxide.

Plate 2a shows the sedimentary facies on the mid point of the concave bank bench. The sedimentary sequence is homogeneous from the top to the bottom. It appears like it was deposited during a single recent flood event.

Figure 4.6 shows the profile of facies structure of the former concave bank. It shows distinct stratification of facies and displays a pattern as that observed on the concave bank bench (see figure 4.5). It consists predominantly very fine sand interbedded with thin layers of silt.

The sedimentary facies are discussed further in the next chapter.

Fig. 4.5 SEDIMENTARY FACIES PROFILE OF THE OLD KAKUMBI BENCH DEPOSITS

DEPTH (cm)

DESCRIPTION

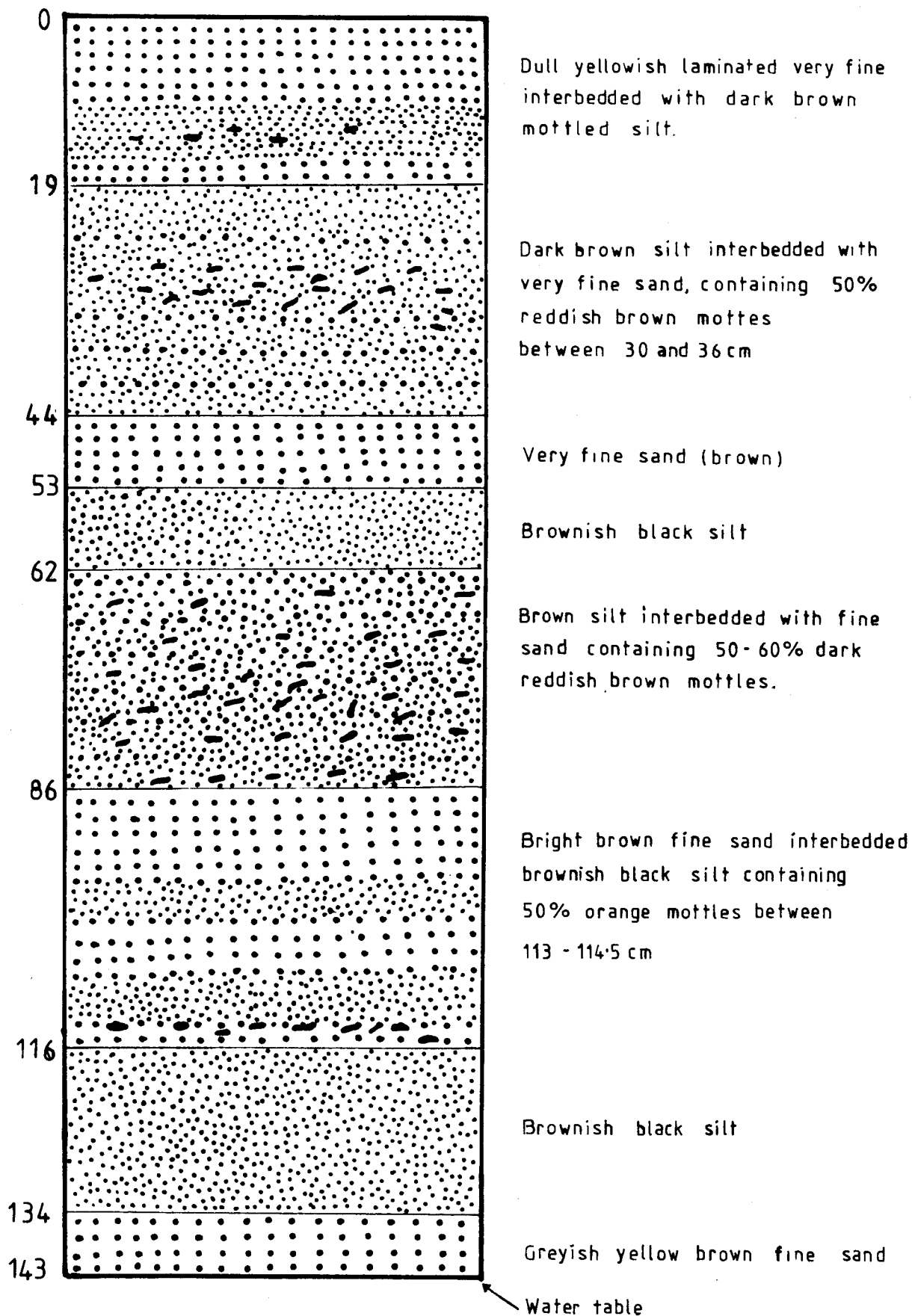


PLATE 1

PLATE 20

C.

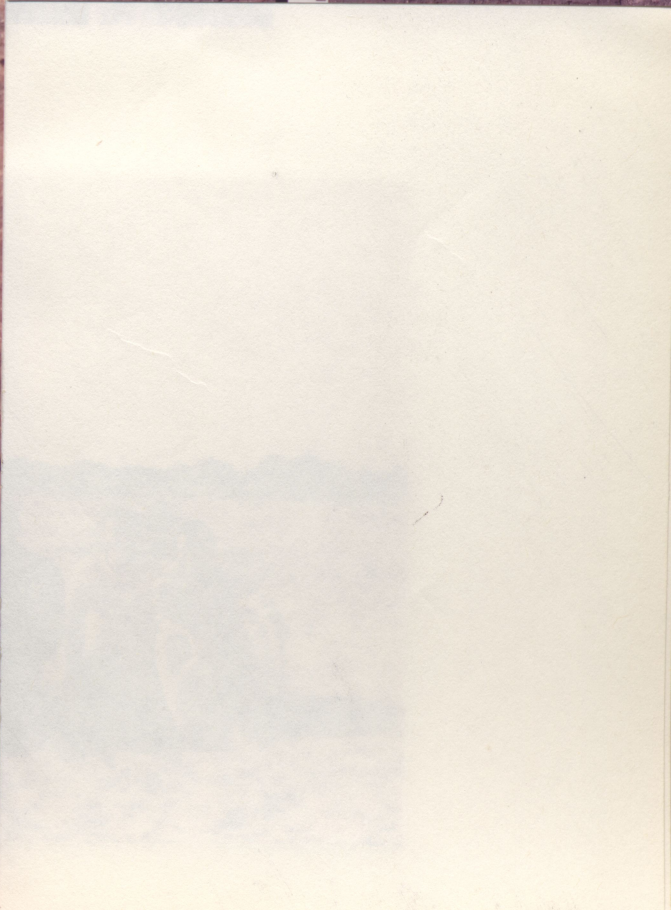


PLATE 2a

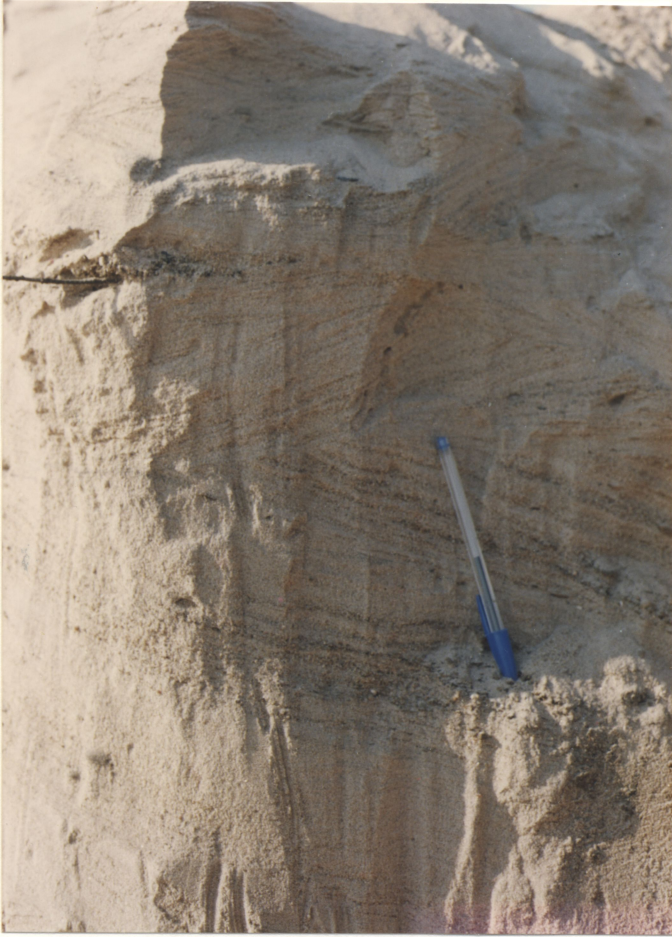


PLATE 2b

