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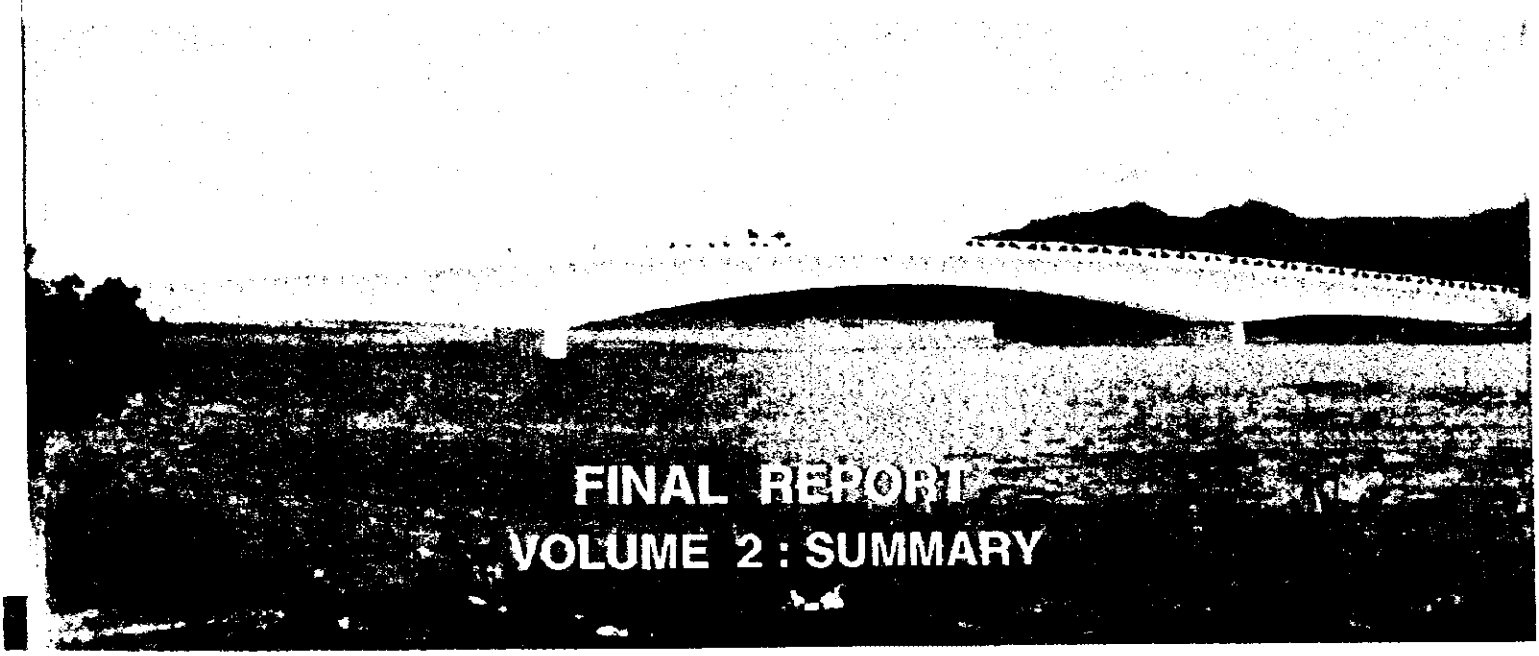
No. 2

MINISTRY OF WORKS AND SUPPLIES
THE REPUBLIC OF MALAWI

THE FEASIBILITY STUDY ON THE RECONSTRUCTION OF MANGOCHI ROAD BRIDGE IN THE REPUBLIC OF MALAWI



FINAL REPORT
VOLUME 2 : SUMMARY

AUGUST 1998

JAPAN INTERNATIONAL COOPERATION AGENCY

NIPPON KOEI CO., LTD.
CHODAI CO., LTD.

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NOTE

Following exchange rates are applied in this report
End of March, 1998

US$1.00 = Yen128.7
US$1.00 = MK 25.0

PREFACE

In response to a request from the Government of the Republic of Malawi, the Government of Japan decided to conduct a Feasibility Study on the Reconstruction of Mangochi Road Bridge and entrusted the study to the Japan International Cooperation Agency (JICA).

JICA sent a study team to Malawi in 1998, headed by Mr. Kazumasa TADA, Nippon Koei Co., Ltd., and composed of the members of Nippon Koei Co., Ltd. and Chodai Co., Ltd. The study team was sent twice between February and July 1998.

The team held discussions with the officials concerned of the Government of Malawi , and conducted field surveys in the study area. After the team returned to Japan, further studies were made and the present report was prepared.

I hope that this report will contribute to the promotion of the project and to the enhancement of friendly relations between our two countries.

I wish to express my sincere appreciation to the officials concerned of the Government of the Republic of Malawi for their close cooperation extended to the team.

August, 1998

Kimio Fujita
President
Japan International Cooperation Agency

August, 1998

Mr. Kimio Fujita
President
Japan International Cooperation Agency
Tokyo, Japan

Letter of Transmittal

We are pleased to submit to you the final report on the Feasibility Study on the Reconstruction of Mangochi Road Bridge in the Republic of Malawi.

This study was conducted by Nippon Koei Co,. Ltd & Chodai Co,. Ltd, under a contract with JICA, during the period from February 4, 1998 to August 17, 1998. In this study, we examined the feasibility and rationale of the project with due consideration to the present situation of Malawi.

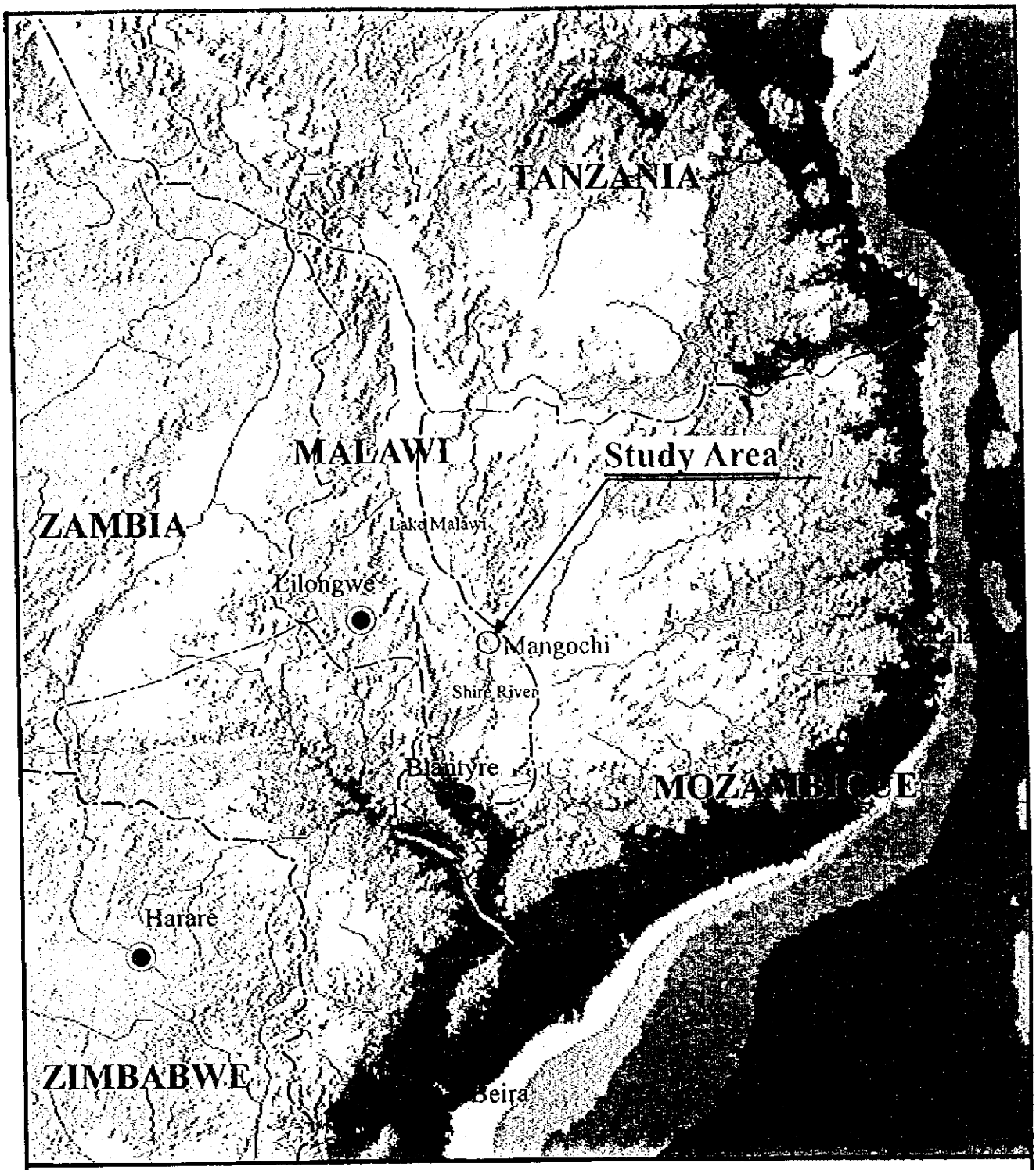
We wish to take this opportunity to express our sincere gratitude to the officials concerned of JICA, the Ministry of Foreign Affairs, the Ministry of Construction, and the Honshu-Shikoku Bridge Authority. We also would like to express our gratitude to the officials concerned of the Ministry of Works and Supplies in the Republic of Malawi for their cooperation and assistance throughout our field survey.

Finally we hope this report will contribute to the realization of the project.

Very truly yours.

多田一正

Kazumasa TADA
Team Leader
The Feasibility Study on
the Reconstruction of the Mangochi Road Bridge
Nippon Koei Co,. Ltd.
Chodai Co,. Ltd.



The Feasibility Study on The Reconstruciton of Mangochi Road Bridge in The Republic of Malawi	Location Map

Project Summary Table	
Objectives of the Project	Since export and imports of Malawi has depended upon external port due to the land locked country, the Government of Malawi is putting a high priority to rehabilitation of roads to these external ports. Existing Mangochi Bridge is located in national road 3 leading to Nacala port in Mozambique. Among corridors leading to external ports, this Nacala corridor is the shortest one. Now that inner war within Mozambique has setteled down, importance of Nacala corridor has strongly been recongnized.As detailed design of adjoining road to Mangochi Bridge was completed with Kuwait fund, this road is to implement in very near future. On the other hand, Mangochi Bridge has only one lane, then traffic capacity of this bridge will not meet future traffic demands togather with insuficiency of traffic bearing capacity. Consequently, This bridge is required to be rehabilitated.
Methodology of the Study	Following methodology was incorporated into the process of the Study. * Investigation of Natural Condition *Assessment of Exising Bridge *OD Survey and Traffic Count *Initial Environmental Evaluation *Study of Design Criteria and Traffic Load * Formulation of Socio-economic Frame Work * Traffic Demand Forecast * Selection of Bridge Plan * Environmental Impact Assessment * Design Works and Construction Plan * Cost Estimate * Implementation Plan * Economic Evaluation
Contents of Project	Location: Mangochi City Project Cost: 14,668,959US$ Construction Cost: 9,308,839US$ Navigational Clearance: Vertical Clearance 4.4 m (from high water level) Horizontal Clearance (25.0 m) Project Length: 545m(Bridge Length and Approach Road) Total Bridge Length: 220m(60m-100m-60m) Bridge Type: Cast in Situ Prestressed Concrete Box Girder Two Lane Bridge With: 10.50m
Evaluation of the Project	The EIRR of the Project is 7.0 %
Conclusions and Recommendations	The new Mangochi Bridge is technically and economically feasible under proper finance and accordingly recommends that it be immediately implemented.

Synopsis

Malawi imports and exports have depended upon a northern transportation corridor via the port of Dar es Salaam in Tanzania and a southern corridor via the port of Durban in South Africa. This is because transportation from the port of Nacala has severely deteriorated due to the political turmoil and subsequent civil war in Mozambique.

The Government of Malawi however has put a high priority on the Nacala corridor since the recent cessation of the civil war in Mozambique. Also the existing Mangochi Bridge over the Shire River as a bridge component of the Nacala corridor is deteriorating as it has been nearly 30 years since the existing bridge was constructed.

For the Nacala corridor in Mozambique, the Government of Japan is implementing the rehabilitation of three bridges with a grant aid and the World Bank has a plan of urgent road rehabilitation. Within the section of this corridor in Malawi, the feasibility study and detailed design between the Mangochi Bridge and the border of Mozambique has been completed by the Kuwait Fund except for the bridge itself.

With this background the rehabilitation of the Mangochi Bridge is expected to establish an efficient international transportation link along the Nacala corridor and consequently, the Government of Malawi has requested the assistance of the Government of Japan to carry out a feasibility study for the reconstruction of the Mangochi Bridge.

Since Malawi's economy is heavily dependent on foreign trade, the availability of dependable external transport links at a reasonable cost is crucial. The international routes are by road or rail from Blantyre through Mozambique to the port of Nacala, by road and/or rail to the ports of Beira and Durban, and by rail, lake, and/or road to the port of Dar-es-Salaam.

Prior to the disruption of international traffic through Mozambique due to that country's civil war, the Nacala and Beira ports handled over 90% of Malawi's international traffic.

Presently the total number of motor vehicles crossing the Mangochi Bridge is 398 per day, (not including motorcycles.)

And it was determined that the traffic on the Mangochi Bridge has been consistently increasing at an overall traffic growth rate of 11.0% per annum from 1989 to 1998.

Traffic assignment results are shown bellow:

Traffic Assignment Results for the Mangochi Bridge, Vehicles per Day

Description	Without New Bridge				With New Bridge			
	2002	2005	2012	2022	2002	2005	2012	2022
Normal & Develop. Traffic	765	931	1,485	2,500	799	972	1,556	2,888
Induced Traffic	0	0	0	0	46	54	90	172
Total Traffic	765	931	1,485	2,500	845	1,026	1,646	3,060

Note: Diverted traffic due to a shift in routes (not modes) is included in normal and development traffic.

Source: JICA Study Team.

Outline of the design of study is as follows.

Proposed Bridge Route

The optimum bridge route was selected based on the evaluation of economic, engineering and environmental aspects and the route, which follows the same alignment on national highway M3 and is almost parallel and located 30 m downstream of the existing bridge is recommended as the best alternative route.

Project facility

(1) Bridge

Location	:	30 m downstream of the existing bridge
Bridge width	:	Total width 9.7m
Carriageway	:	7.3m
Sidewalk	:	1.3m
Bridge length	:	220m
Span arrangement	:	Main span 100m Side span 60 m
Bridge Type	:	Three span continuous prestressed concrete box girder
Foundation type	:	Open caisson for pier and cast in situ pile for abutment

(2) Approach Road

Road width	:	10.5 m
Carriageway	:	7.3 m
Side walk	:	1.6m
Shoulder	:	1.5m
Total Length	:	325 m (Mangochi side 125 m, Ntagaluka side 200 m)
Pavement	:	DBST for carriageway

The EIA for this Project conform to Malawian, World Bank and JICA methodologies and standards. The Project was assessed against a standard checklist of possible environmental effects with both the construction and operational stages being assessed.

Three ministries have the responsibility for environmental protection in Malawi. The ministries mainly involved with this Project are the Ministry of Works and Supplies (MOWS), Ministry of Water Development (MOWD) and the Ministry of Research and Environmental Affairs (MOREA). MOREA is a statutory authority for all EIA studies.

The Project site is located in the middle of the Upper Shire River that connects Lakes Malawi and Malombe. This river is a migratory path for chambo fish and an important place for local chambo fisheries. Around the Project site, there is a large embankment on the east bank that provides a bottle-necked shape to the river. Due to this topographic feature, the effect of the scouring around the existing bridge piers is significant. There are historical monuments (Queen Victoria clock tower and a gun from HMS Guendolin) on the west bank while a police check point exists on the east bank.

Based on the knowledge of the local environment surrounding the study area, the initial environmental evaluation (IEE) was carried out, being mainly concerned with the environmental impacts on the water resources, erosion and/or sedimentation, fishery, historical monuments, and the resettlement issues. Throughout this IEE, Route A was selected as the preferred option, and a full EIA was undertaken for this option.

The quality testing of the Shire River water was conducted in order to obtain the baseline data for the Project. The water quality testing was carried out with respect to 12 parameters such as pH, conductivity, dissolved oxygen, biological oxygen demand etc. From the testing, it was found that the present water quality of the Shire River is relatively clean, and impacts caused by any accidents such as oil spillage would be significant and cause severe damage to the local environment.

A Socio-cultural opinion survey was carried out at Mangochi Township (150 interviewees),

and opinions and comments about the relationship between the new bridge construction Project and the surrounding local environment were collected. From this survey, it was found that people show great concern about the bridge Project and recognize the importance that the new bridge will provide, safer, easier and faster transport for the local community. These benefits will be increased considerably once the rehabilitation of the entire Nacala corridor between Mangochi and Chiponde is finished. Deforestation is the biggest environmental concern for the local residents with fish conservation also important. Most of interviewees considered that the new bridge Project would not have a strong influence on the surrounding environment. Relocation of historical monuments caused by the new bridge Project was agreed to by most of interviewees. However, special care must be taken concerning the relocation of the historical monuments located at the bridge site as well as considering other major issues such as water resources conservation.

The EIA for the Mangochi Bridge reconstruction Project has demonstrated several negative impacts as well as major positive ones. Any predicted negative impacts are of minor significance and can be further reduced or avoided by the recommended mitigation measures. No more environmental studies are required.

Cost estimation was carried out under the following assumptions:

Cost estimation was made at price levels as at the end of March 1998.

The foreign currency exchange rate was assumed to be; US$1.0=Yen 128.70

Malawi Kwach=Yen5.27

Materials and equipment, which cannot be procured in Malawi, are basically imported from South Africa and Japan.

The total Project cost is estimated at US $ 14,668,959 (US $ 9,604,681 for the foreign portion and US $ 5,064,278 for the local portion) and is summarized bellow.

No	Work Item	Foreign (US$)	Local (US$)	Total (US$)
1)	Construction Cost			
A)	Preparation Works	43,966	698,160	742,126
B)	Temporary Works	349,425	94,220	443,645
C)	Bridge	5,072,424	2,446,138	7,518,562
D)	Approach Road	106,936	497,570	604,506
	Total(1)	5,572,751	3,736,088	9,308,839
2)	Engineering Fee	1,312,209	68,243	1,380,452
3)	Non-Eligible Cost			
3.1	Demolition of the Existing Bridge		28,000	28,000
3.2	Relocation of Power Line		6,000	6,000
3.3	Taxes and Duties	1,807,199	736,712	2,543,911
3.4	MOWS's Administration Cost	39,366	2,047	41,413
3.5	Environmental Program	0	26,800	26,800
	Total 3)	1,846,565	799,599	2,646,125
4)	Contingencies	873,153	460,389	1,333,542
5)	Project Cost (1+2+3+4)	9,604,681	5,064,278	14,668,959

The direct economic benefits of the Project (i.e., savings in vehicle operating costs calculated in section 3) vary by year, increasing from an initial US$135,385 in 2002 to US$174,231 in 2005 and US$1,450,375 in 2022. The total economic Project cost was determined to be US$11,153,199. The resultant EIRR of the project is 7.0%.

The indirect benefits of the Project are substantial, and it is the consultant's opinion that these factors remove any doubt concerning the economic viability of the Project. The recommendation of the study is that the Project should be implemented immediately. The new Mangochi Bridge will be an important asset to the Malawian economy which will safeguard the confidence and security needed to continue the current strong regional and national economic growth.

Conclusions of the Study are summarized bellow:

The total quantity of commodities to and from Malawi dealt with at Nacala port in Mozambique has dominated recently other external ports due to the settlement of Mozambique's civil war, the Nacala corridor has a significant road network in Malawi fulfilling an important international transport route as well as railway between Nacala and Blantyre. While the current daily traffic volume counts 398 vehicles in terms of motorized vehicles, 931 and 1,026 vehicles are estimated respectively in the years 2005 and 2022 in the case of "without new bridge"scenario and 2,500 and 3,060 vehicles has been assessed in case of "with new bridge" scenario on the assumption that the adjacent road rehabilitation Project is carried out. In consideration of the future increasing traffic volume and the increase in the weight of vehicles, the existing Mangochi Bridge on the Nacala corridor will not stand the future traffic conditions due to insufficient load carrying and one lane capacities.

On the other hand, road rehabilitation works at both sides of the Mangochi Bridge are scheduled to be implemented. In this regard, the necessity of the rehabilitation of the Mangochi Bridge is required in conjunction with the rehabilitation scheme of the road network.

The direct economic benefit of the Project is composed of savings in distance and time-related vehicle operating costs. These economic benefits vary annually, increasing from an initial US $ 135,385 in 2002 to US $ 174,231 in 2005 and US $ 1,450,375 in 2022.

Indirect benefits can be identified in two categories: transportation effects and regional development effects.

(1) Transportation Effects can be summarized as follows:

- Improvement of traffic safety and reduction of risk and uncertainty
- Strengthening of Malawi's international road network
- Strengthening of Mozambique's international and domestic traffic through Malawi
- Improvement of accessibility to remote area

- Reduced transport tariffs and increased tax revenue

(2) Regional Development Effects

- Promotion of a market-oriented economy
- Upgrading of living standards in rural area
- Modernization of agriculture
- Promotion of agro-industries and fish-processing industries
- Promotion of resource development
- Tourism development
- Balanced development in the region
- Technology transfer

Based on results of the bridge design study, a pre-stressed concrete bridge, 220m in length has been adopted for the new Mangochi Bridge and has been located just downstream of the existing bridge.

The total Project cost is estimated to be US$14,688,959 in which the foreign currency and local currency are US $ 9,604,681 and US $ 5,064,278 respectively. The total construction period is estimated at 26 months.

The surroundings near the Project site in the Shire River are regarded as the migratory path of the chambo fish and also a historical monument of Queen Victoria clock tower exists. Any predicated negative impacts are of minor significance with the construction of a new bridge and can be reduced or avoided by utilization of the recommended mitigation measures.

EIRR is estimated to be 7.0%. As the indirect benefits of the Project are substantial, the Study Team regards that these indirect factors remove any doubt concerning the economic viability of the Project.

The following works are expected to be undertaken by the Government of Malawi when the Project is implemented:

1) Adjustment of plans between this Project and the adjoining road Project
2) Relocation of power lines and other necessary facilities such as water intakes etc.
3) Demolition of the existing bridge
4) Land acquisition and compensation
5) Environmental Impact Assessment and monitoring

In conclusion the Study Team considers that construction of the new Mangochi Bridge is

technically and economically feasible under proper financing and accordingly recommends that it be immediately implemented.

CONTENTS

CHAPTER 1 INTRODUCTION

1.1 Background

The Export and Import of Malawi have previously depended upon the northern corridor via the port of Dar es Salaam in Tanzania and a southern corridor via the port of Durban in South Africa as transportation from the port of Nacala deteriorated severely due to the political turmoil and the following civil war in Mozambique.

However, the Government of Malawi is putting a high priority on the Nacala corridor as a result of the recent termination of the civil war in Mozambique. The existing Mangochi Bridge over the Shire River as a bridge component of the Nacala is deteriorating, as it has been 30years since the existing bridge was constructed.

For the Nacala corridor in Mozambique, the Government of Japan is implementing the rehabilitation of three bridges with grant aid and the World Bank has a plan of urgent road rehabilitation. Within the section of this corridor in Malawi, the feasibility study and detailed design between the Mangochi Bridge and the border of Mozambique has been completed by the Kuwait Fund except this bridge itself.

With this background the rehabilitation of the Mangochi Bridge is expected to establish an efficient international transportation infrastructure through the Nacala corridor. Consequently, the Government of Malawi has requested the assistance of the Government of Japan to carry out a feasibility study of the reconstruction of the Mangochi Bridge.

In response to this request, the Government of Japan decided to carry out the study and entrusted its execution to the Japan International Cooperation Agency (hereinafter referred to as "JICA"); the official agency responsible for the implementation of technical cooperation programs by the Government of Japan.

JICA dispatched a preparatory study team to formulate an approach on technical cooperation. Based on the agreed approach, JICA arranged an advisory committee (hereinafter referred to as "the Advisory Committee") and

recruited a Study Team (hereinafter referred to as "the Study Team").

1.2 Objectives of the Study

The major objectives of the Study were:

1) To execute the feasibility study on the reconstruction of the Mangochi road bridge targeting 2005.

2) To promote technical transfer of knowledge and technology through the execution of this feasibility study.

1.3 Scope of the Study

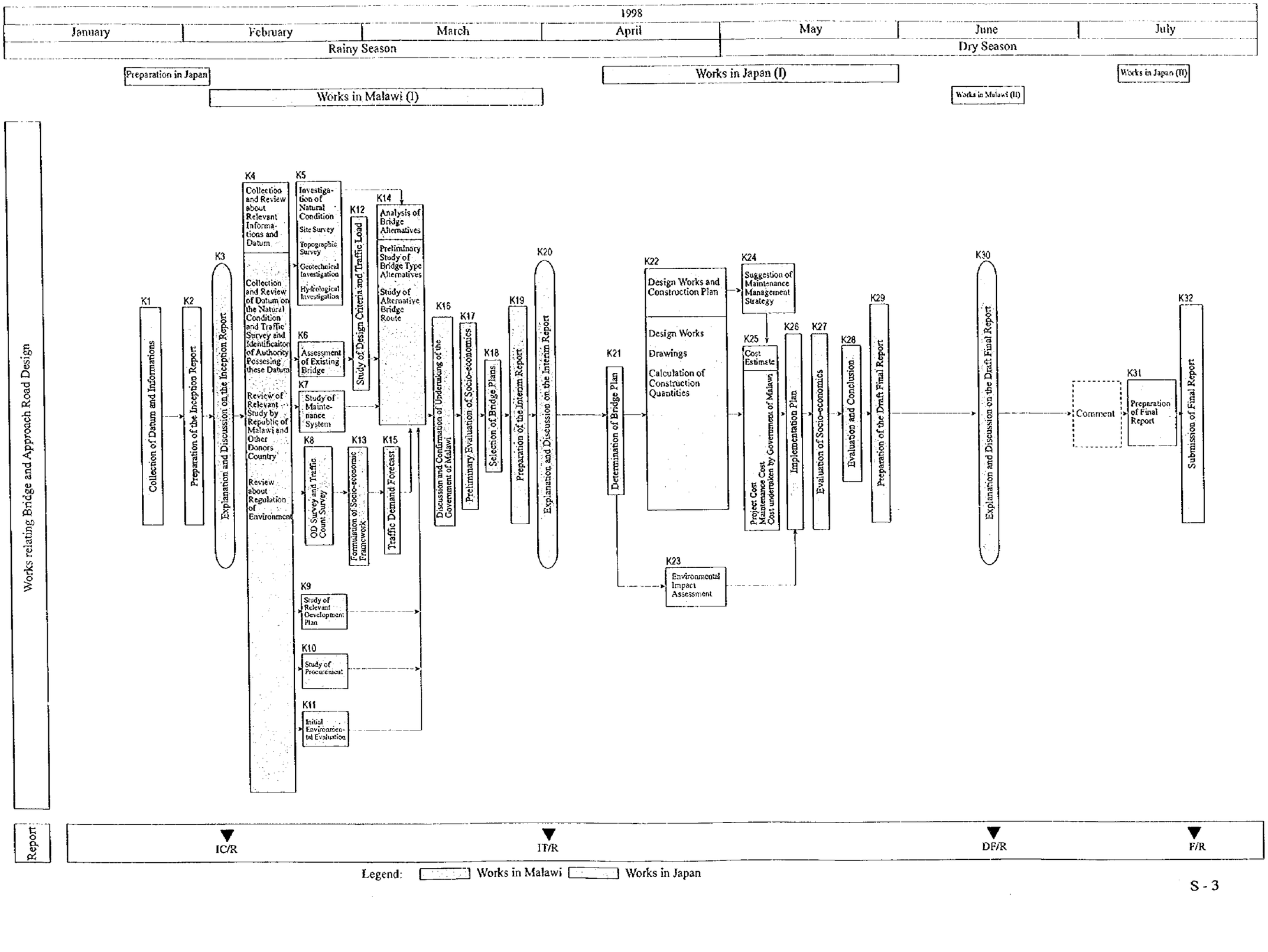
The Study started from the beginning of February 1998 and will come to an end in July 1998. An overall work flow illustrating the inter-relationship of each activities in the Study is presented in Figure 1.1.

1.4 Major Meetings Held

During the study period, the following meetings were held in Malawi and the minutes of each meeting is attached in Appendix 1.2.

Meeting	Data	Main Subjects
First Steering Committee	February 10, 1998	Inception Report
Second Steering Committee	April 2, 1998	Interim Report
Third Steering Committee	July 1, 1998	Draft Final Report

Figure 1.1 Work Flow Diagram



CHAPTER 2 SITE SURVEY AND INVESTIGATION

2.1 Topographic Surveys

The Topographic Survey for the Project was conducted to obtain the basic data and information for the design of new bridge. The Survey was carried out in the vicinity of the existing Mangochi Bridge.

The work comprised of the following:

(1) Center line Survey

A center line survey was conducted along three proposed alignments crossing the Shire River such as Route-A (adjacent to the existing bridge), Route-B (250m upstream of the existing bridge) and Route-C (250m downstream of the existing bridge).

(2) Cross section survey

A cross section survey was conducted on each of the three proposed center lines with the width of the survey area being 25m on each side of the road center line.

(3) Cross section of the Shire River

The cross section of the river survey were carried out at designated proposed alignment areas of the river

The elevation of the existing bridge structure was measured during the field in survey.

The Topographic survey maps and DXF files were produced based on the results of this work.

2.2 Geotechnical Investigation

This survey was done to obtain the basic data for the preliminary design. The subsurface exploration including drilling, sampling and laboratory testing were conducted at the alternative proposed Route A. For the other two alternative routes (Route B and C) the boring data was collected from MOWS.

The proposed site was dominated by quaternary alluvial deposits, which were mainly composed of dense to very dense medium sandy clay. The North-East bank was marshy whereas the South-West bank has a gentle sloping beach which attracts frequent visits by people. Within the confines of the bridge there were no traces of any cohesive soils or underlying rock.

Soil Investigation at the Bridge Site

The field work including boring, sampling and standard penetration tests were carried out at Rout A. The work was conducted near the abutment and pier of the proposed bridges.

Laboratory tests were also carried out.

2.3 Hydrological Investigation

The hydrological Investigation was to collect and study the hydrological conditions of Lake Malawi and the Shire River. The hydrological data and information was used for the bridge design.

The water level of Lake Malawi and the Shire River depends on the operation of the Liwonde barrage since 1965. The barrage has regulated the flow of the Shire River for 23 years. Therefore, the water level of Lake Malawi has been maintained at about 476 m in the wet season with the highest lake level recorded at 477.23 m in 1979. The high water level of Liwonde barrage is measured at 475.74 m.

The observation record of the Shire River at Mangochi indicate that the highest water level was at 476.74m in 1980 and the peak flood discharge was 1,050m3/sec . The river gradient at Mangochi is 1/33,000.

The result of the river bed investigation by the study team seems to indicate that there is no scouring damage around the existing bridge. Scour protections are provided at the existing piers.

Topographic Survey in this study indicates that the river bed elevation at the existing bridge is from 2 to 4 meters lower than at 200m up and downstream from the existing bridge. This indicates that the river bed degradation occurred around the existing bridge due to the blockage of the river by the embankment

at the Ntagaluka side and the existing piers.

The mean flow velocity of the river current at the existing bridge is approximately 0.2m/sec. The maximum flow velocity at mid-span of the existing bridge pier is about 0.6m/sec. The water depth was measured between 6 to 10 meters.

From the result of the investigation, the recommended hydrological data for the bridge design are therefore shown in Table 2.1.

Table 2.1 Recommended Hydrological Data for Bridge Design

Items	Unit	
High Water Level	m	476.8
Peak Flood Discharge	m3/sec	1,100
River Gradient		1/33,000

CHAPTER 3 SOCIOECONOMIC AND TRAFFIC STUDIES

3.1 The Study Area

Since Malawi's economy is heavily dependent on foreign trade, the availability of dependable external transport links at reasonable cost is crucial. The international routes are by road and/or rail from Blantyre through Mozambique to the port of Nacala, by road and/or rail to the ports of Beira and Durban, and by rail, lake, and/or road to the port of Dar es Salaam.

Prior to the disruption of international traffic through Mozambique due to that country's civil war, the Nacala and Beira ports handled over 90% of Malawi's international traffic.

The World Bank's population estimate for Malawi is 10.14 million people in 1996, Between 1964, when Malawi gained independence, and 1994 the population increased from 4 million to 10 million, an average annual growth rate of 3.1%.

The Malawian economy is agriculture-based. Agriculture usually accounts for more than one-third of GDP and over 90% of export earnings. The country's staple crop is maize, although tobacco is by far Malawi's largest export, followed by tea and sugar.

Mangochi District has an area of 6,272 sq. km covering about 5.3% of the country's total area. The arable land in Mangochi District is used for growing a wide variety of crops. Mangochi also serves as one of Malawi's tourism centers.

3.2 Implication of Future Development

There are two ongoing road projects that are of substantial significance to the proposed bridge project: (i) the Liwonde-Naminga-Nsanama-Chiponde-Mangochi Road and (ii) the Rehabilitation of Route 8 from Nampula to Mandimba, Mozambique. Both projects will result in significant improvement of the road between the Mangochi Bridge and Nampula, Mozambique.

3.3 Traffic Surveys and Future Traffic Demand

A total of seven traffic survey sites were chosen, all located in south-central Malawi.

The majority of traffic crossing the Mangochi Bridge consists of pedestrians (4,362 per day) and bicycles (2,154 per day) with traffic shares of 63% and 31% respectively. Their high volumes demonstrate the importance of this bridge for local residents in carrying out daily activities. The total number of motor vehicles crossing the Mangochi Bridge was 398 per day, not including motorcycles.

Based on historical traffic count data adjusted to account for seasonal variation, it was determined that traffic on the Mangochi Bridge has been consistently increasing at an overall traffic growth of 11.0% per year from 1989 to 1998.

The assignment results are summarized in Table 3.1. The forecast traffic volume in the without new bridge case is estimated to reach 2,000 vehicle per day by year 2017, after which substantial delays would be incurred in the without new bridge case. At a level of 2,500 vehicles per day (reached in 2021), any additional traffic would divert to another route. This assumption was validated by traffic simulation runs.

Table 3.1 Traffic Assignment Results for the Mangochi Bridge, Vehicles per Day

Description	Without New Bridge				With New Bridge			
	2002	2005	2012	2022	2002	2005	2012	2022
Normal & Develop. Traffic	765	931	1,485	2,500	799	972	1,556	2,888
Induced Traffic	0	0	0	0	46	54	90	172
Total Traffic	765	931	1,485	2,500	845	1,026	1,646	3,060

Note: Diverted traffic due to a shift in routes (not modes) is included in normal and development traffic.

Source: JICA Study Team.

CHAPTER 4 BRIDGE AND APPROACH ROAD DESIGN

4.1 General

The optimum route for the Project is the alternative route A and the selected bridge type is a three span continuous prestressed concrete box girder bridge. The bridge length is 220 m.

4.2 Superstructure

(1) Span Arrangement

The span arrangement considering the structural balance for a three span bridge was arrange for two side spans of 60 m and a center span of 100m.

(2) Super structure

The center span and part of the end spans will be constructed by balancing cantilever erection method. The center span will be connected by the center cable at the final stage of the construction to form the continuous girder. The cross section of girder is a single box type with cantilever slab decks for a total bridge width is 9.7 m. The prestressing steel materials used in the design are as follows:

Multi-strand 12T12.7	:	For longitudinal prestressing
Single-strand 1T22	:	For lateral prestressing
PC bar Φ26	:	For vertical prestressing

4.3 Substructure

(1) Pier

The loads from the superstructure caused by dry shrinkage, creep and seismic force are distributed equally between both piers through elastic rubber bearings. The pier shaft also was checked against the working force of unbalanced moment which was anticipated to occur during the cantilever erection works of the superstructure.

(2) Abutment

Reversed T type abutments were proposed as the most appropriate type of abutment based on engineering and economic considerations.

4.4 Foundation

(1) Open caisson

The open type caisson foundation was adopted to the foundation of piers based on the results of studies on construction cost, availability of material and construction site conditions. The open caissons will be erected on the temporary island at the location of the pier and the inside of the caisson will be excavated until the foundation reaches the bearing stratum. The pile cap and pier shaft will be constructed inside of cut-off wall.

(2) Cast in situ concrete pile foundation

Cast in situ concrete piles having 1.2 meter diameter will be used in the foundation of the abutments. The piles will be cast on the embankment which will be constructed on the river bank.

4.5 Approach Road

(1) Pavement Design

The pavement consists of Sub-grade, Subbase Course, Base Course and Surface Course. The subgrade is the upper layer of the natural soil which may be undisturbed local material or may be soil excavated from a borrow pit and placed as fill.

Subbase Course of 100 mm thickness will consist of unprocessed natural gravel, gravel-sand or gravel- sand -clay. Base Course of 150 mm thickness will consist of crushed stone or gravel stabilized either with cement, lime or bitumen. The Surface Course of 50 mm thickness is the uppermost layer of pavement and will consist of bituminous surface dressing, chip and spray treatment or a layer of premixed bituminous material.

(2) Miscellaneous Road Structures and Facilities

1) Guard Rail

Part of the embankment of the Approach Road will accommodate a guard rail for protection against traffic accident.

2) Centerline Mark

In order to ensure safe driving, a painted centerline on the road will be provided.

3) Slope Protection

Sodding or seeding will be employed for slope protection on the embankment.

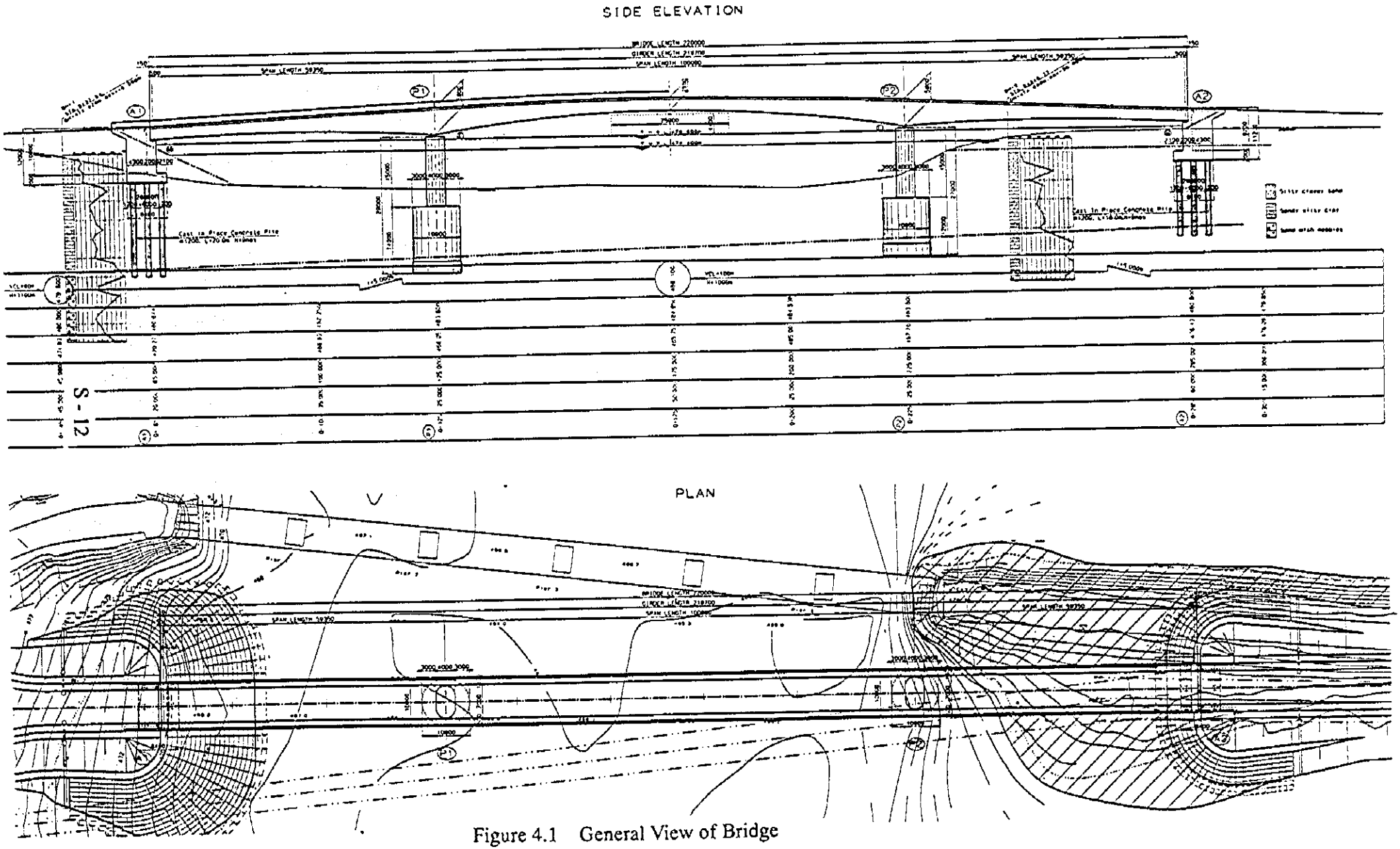


Figure 4.1 General View of Bridge

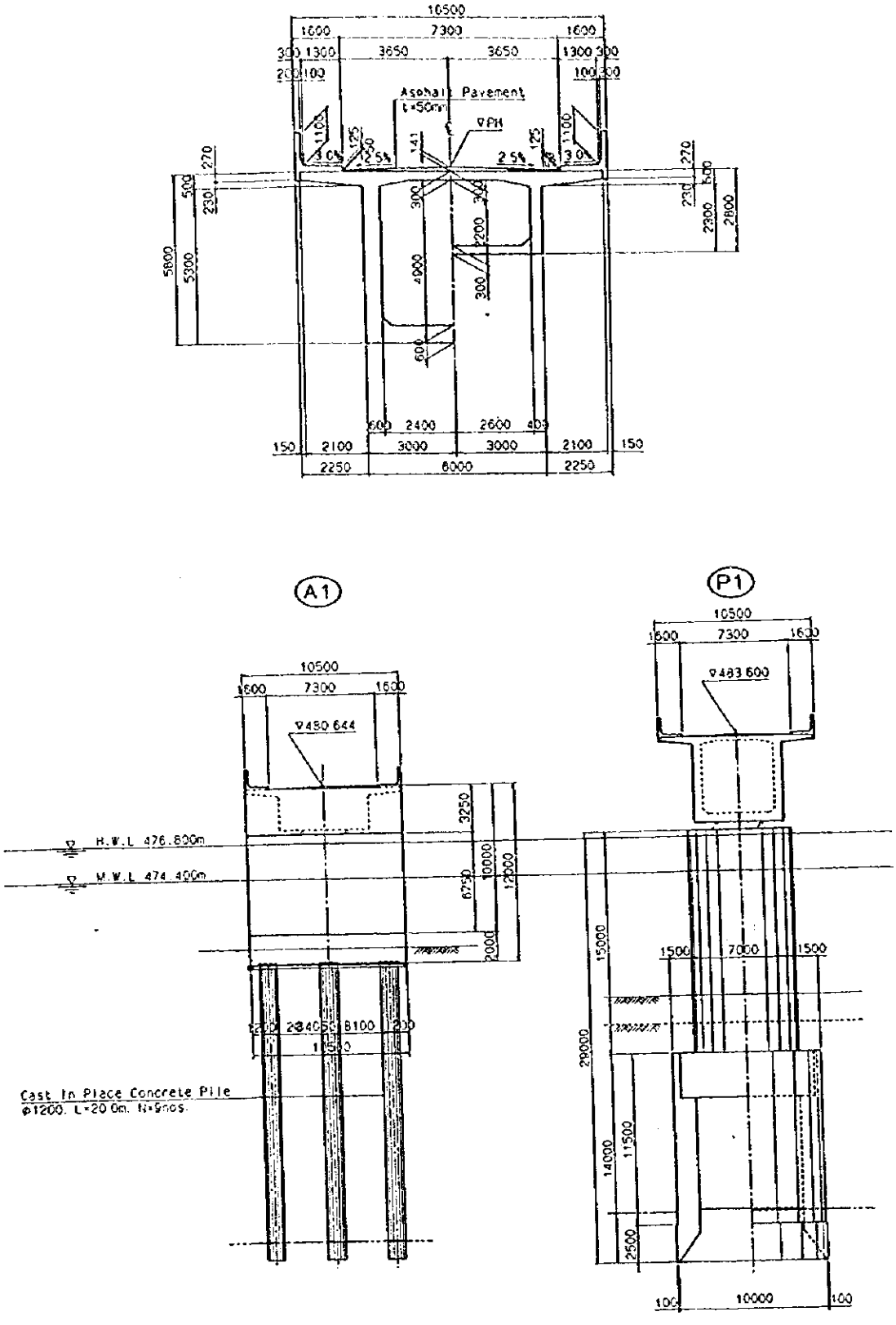


Figure 4.2 Cross Section of Structure

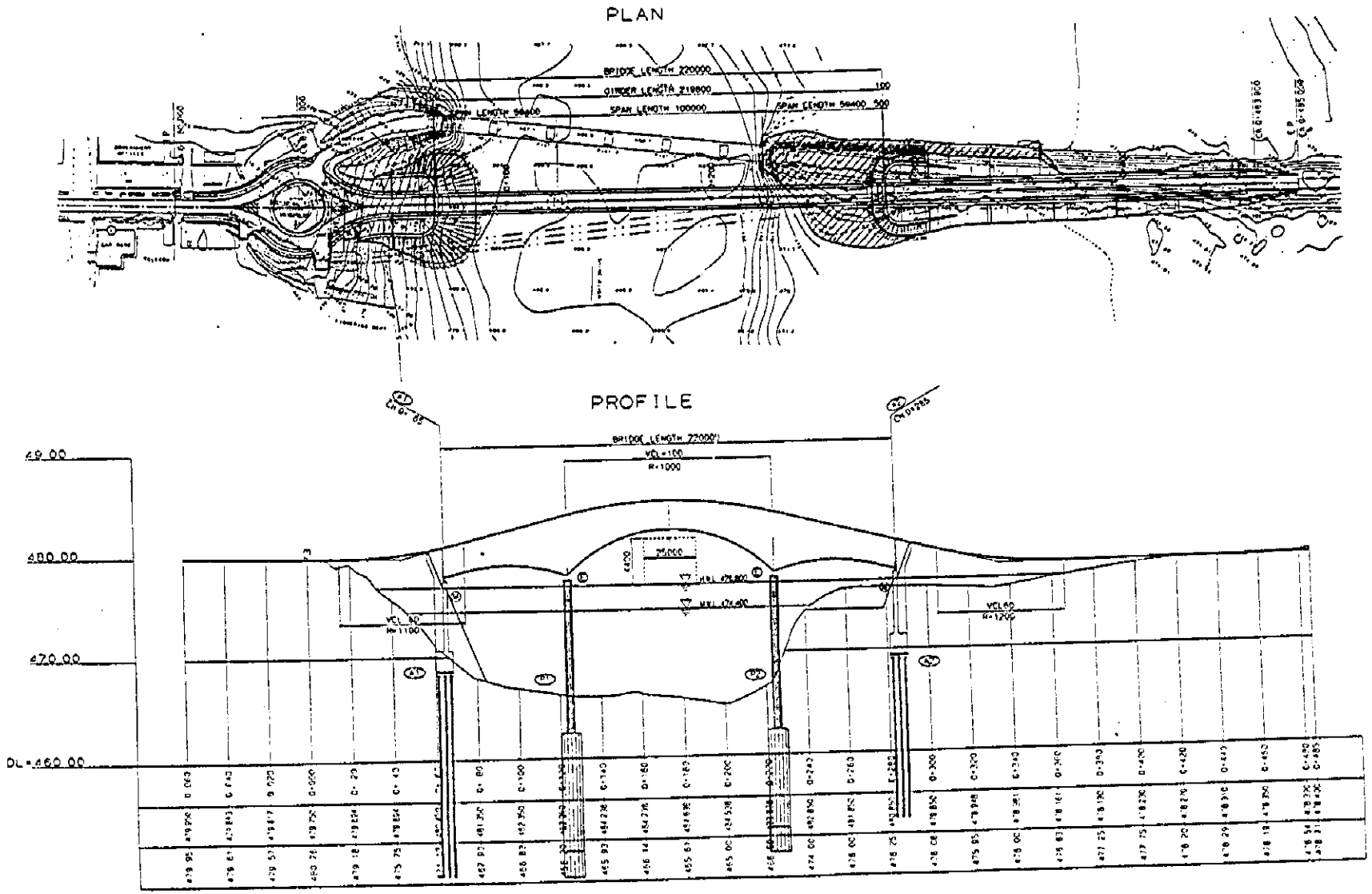


Figure 4.3 Plan and Profile

TYPICAL CROSS SECTIONS

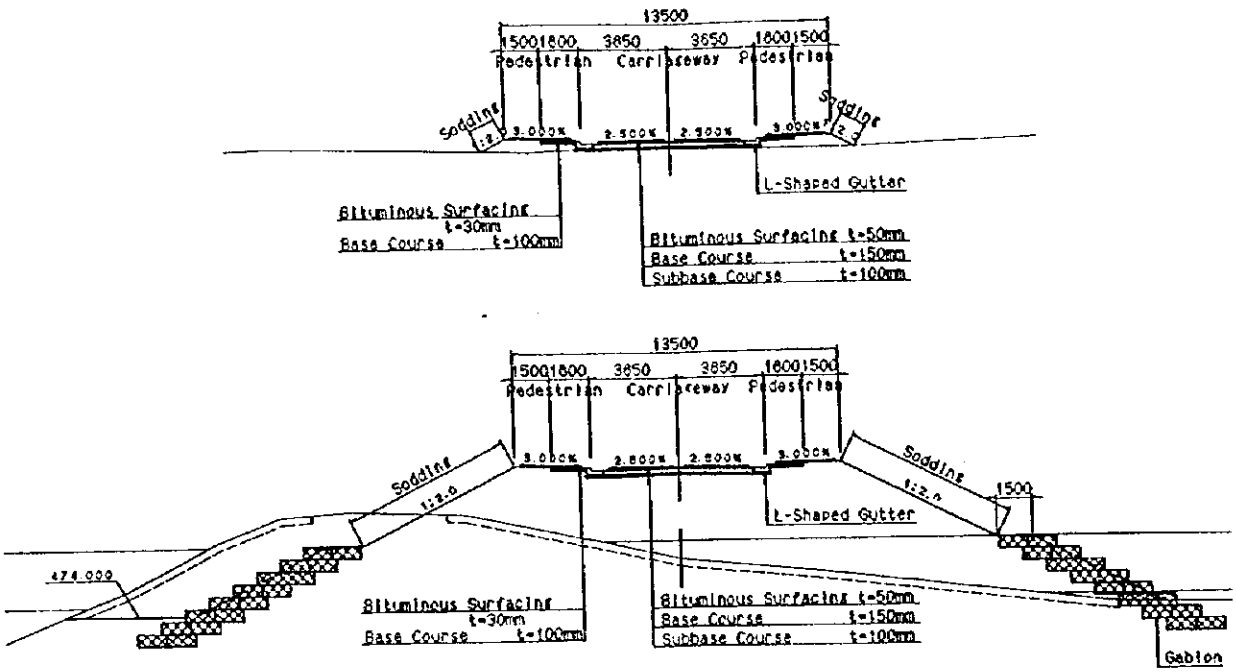


Figure 4.4 Cross Section of Road

CHAPTER 5 ENVIRONMENTAL IMPACT ASSESSMENT

This report contains the results of the Environmental Impact Assessment (EIA) undertaken for the reconstruction of Mangochi Road Bridge project. The EIAs for this project conform to Malawian, World Bank and JICA methodologies and standards. The Project was assessed against a standard checklist of possible environmental effects that could be positive or negative, permanent or temporary, localized or widespread, and of major, medium or low/ nil significance. Both the construction and operation stages were assessed.

Three ministries have the responsibility for the environmental protection in Malawi. The ministries mainly involved with this Project are the Ministry of Works and Supplies (MOWS), Ministry of Water Development (MOWD) and the Ministry of Research and Environmental Affairs (MOREA). MOREA is a statutory authority for all EIA studies.

The Project site is located in the middle of the Upper Shire River that connects Lakes Malawi and Malombe, a migratory path of chambo fish and an important place for local chambo fishery. Currently, an "active-gear "fishing is temporally banned for fish resource conservation November – March. Around the Project site, there is a large embankment on the east bank, and that provides a bottle-necked shape of the river. Due to this topographic feature, the effect of the scouring around the existing bridge piers is significant. There are historical monuments (Queen Victoria clock tower and a gun from HMS Guendolin) on the west bank while a police check point exists on the east bank.

Based on the knowledge of the local environment surrounding the study area, the initial environmental evaluation (IEE) was carried out, mainly concerned with environmental impacts on the water resources, erosion/or sedimentation, fishery, historical monuments, and the resettlement issues. Throughout this IEE, Route A (Total length of the proposed bridge span along this option is 220 m) with 3-span plan (2 piers, 60 m + 100 m + 60 m) was selected as the preferred option, and a full EIA was undertaken for this option.

The water quality test of the Shire River water was conducted in order to

obtain the baseline data for of this project. Six sampling points were chosen around the existing bridge site. The water quality test was carried out with respect to following 12 parameters such as pH, conductivity, TDS, dissolved oxygen, biological oxygen demand, chemical oxygen demand, phosphate, nitrate, turbidity, permanganate value, suspended solid, and E-Coli. From this test, it was found the current water quality of the Shire River is relatively clean and is in good condition, so impacts caused by the any accidents such as oil spillage would be significant and cause severe damage to the local environment.

Socio-cultural opinion survey was carried out at Mangochi Township (150 interviewees), and opinions and comments about the relationship between the new bridge construction project and its surrounding local environment with were collected. From this survey, it was found that people show great concern about this bridge project and recognize the importance of the new bridge that will provide a safer, easier and faster transport to the local community. Those benefits will be increased considerably once the rehabilitation of entire Nacala corridor between Mangochi and Chiponde is finished. Deforestation is the biggest environmental concern for local residents and the fish conservation is next. Most of interviewees see that this new bridge project will not have strong influence on the surrounding environment. Relocation of historical monuments caused by the new bridge project is agreeable for most of interviewees. However, a special care must be paid about the relocation of the historical monuments located at the bridge site as well as other major issues such as water resources conservation.

The EIA for the Mangochi Bridge reconstruction project have demonstrated several negative impacts as well as major positive ones. Any predicted negative impacts are of minor significance and can be reduced further or avoided by the recommended mitigation measures. No more environmental studies are required. Table 5.1 is a brief summary of the mitigation measures of the negative impacts identified and its related monitoring activities to be undertaken.

Table 5.1 Mitigation Measures and Its Monitoring Activities

Element	*Mitigation Measure*	Monitoring Method
Soils	Avoid the wet season for any significant earthwork. Bare slopes should be revegetated. Suitably graded to ensure that run-off speed can not cause erosion.	Make a daily inspection of earth works, and ensure that slopes are suitably graded. Once earthworks are complete, monitor restoration measures implemented by Contractor, such as revegetation or use of geotextiles.
Vegetation	Minimize the area to be cleared.	Ensure that excessive clearance of vegetation is avoided. The Contractor must seek approval of the engineer prior to clearance.
Animals and birds	The effect of construction is likely to be very minor, and birds and wildlife will relocate to area further away from working site.	Carry out regular inspections of animal intrusion evidence onto the site. If animal intrusion onto the site becomes a significant problem, consultation should be carried out with National Park and Wildlife Department.
Fish	Avoid any construction activities that would cause severe water quality degradation during the fish spawning period (November – March).	Monitor contractor's procedures for preventing polluted water from flowing into the Shire River. EM to take water samples from the Shire River.
River Morphology	Due to the partial cutting of the embankment on east bank, the effect of scouring will be lessened and the sedimentation will appear. Long-term, intensive riverbed monitoring will be necessary.	Monitor generation of lagoon or sand-bar, and measure riverbed elevation at up/down-streamside of new bridge route for safe bigger-sized ship transport.
Land Take	Approximately 6,550m^2 of land (no private land involved) will be used on both sides of land.	Ensure contractor gives advance warning of any land take or demolition. MOWS to arrange compensation for land loss where necessary.
Health	Basic health and safety education must be given. Anti-Malaria drug should be taken regularly.	Ensure that Contractor has liaised with relevant government bodies and that education and awareness campaigns are implemented.
Road Safety	Trucks should avoid driving through the residential area.	Monitor the condition of trucks arriving at the site and keep a record of night driving.
Fisheries	Avoid any construction activities that would cause severe water quality degradation during the fish spawning period (November – March).	Monitor the procedures of the contractor and ensure that pollution (sediment or chemicals) does not enter the Shire River. Environmental Monitor to take water samples.

Historical/ Cultural/ Archaeological	Relocate *Gun from HMS Guendlin* to a secure open space such as the place in the vicinity of Queen Victoria Monument. Accident reduction measures such as the design of roundabout must considered.	Inspect all excavations or earthworks around historical monuments, and where archaeological remains are found work must stop until engineer give the all clear to proceed. Contact with National Antiquities Department in the event of the relocation of *Gun from HMS Guendolin* or in the event of a significant archaeological find.
Quarry	Trucks used for the transportation should be routed. Borrow pits should be filled or graded.	Inspect borrow pits to ensure that they have been properly filled/graded/or restored after excavation.
Energy	Supply the construction workforce with an alternative source of energy.	Inspect the provisions made by Contractor to supply energy to the workforce, and ensure that fuelwood is not being collected.
Noise	Limit working hours to daytime hours.	Noise measurement should be carried out at the center and the boundary of the work site and at the nearest sensitive receiver.
Air Pollution	Use water sprays.	Observations should be made on the level of dust generated during construction activities. Damping down should be carried out if levels are unacceptable.
Water Resources	Take adequate step to prevent pollution, including the use of interceptors. Provide new water intake facility prior to work.	Inspect provisions made by Contractor to provide the construction workforce and local residents with drinking water during the construction period. The water intake works should be moved upstream from the proposed work.
Landscape	Contractor must agree the earthworking with engineer before commencing work.	Make visual inspection of earthworks to ensure that excessive excavation is not being carried out. Temporary screening may be appropriate in some cases.

CHAPTER 6 CONSTRUCTION PLAN AND COST ESTIMATES

6.1 Construction Method

The Mangochi Bridge will be a pre-stressed concrete bridge with a single box girder. The Structure is to be constructed in the following manners:

(1) Foundation and Substructure

Prior to construction of the substructure, a temporary landing stage composed of a combination of H type piles will be erected with a crawler crane in order to approach the pier position and to install a coffer dam using double H type sheets. Next, the working chamber of the open caisson will be set and the open caisson will be forced to sink gradually to the required depth using a pulling. After completion of the foundation, the pier body will be constructed.

(2) Superstructure

The superstructure is to be erected by the balanced cantilever erection method, in which travelling form work will be used in building each segment of the box girder. After construction of the cantilever superstructure will be extended from each pier, the key segment of the center portion will be subsequently cast in sites to rigidly connect both extended cantilevers.

6.2 Cost Estimates

Cost estimate was done under following assumptions:

(1) Cost estimate is calculated at the price level as of the end of March 1998.

(2) The foreign currency exchange rates are assumed to be ;

US$1.0=Yen 128.70

Malawi Kwach=Yen5.27

(3) Materials and equipment, which cannot be procured in Malawi, will be generally to be imported from South Africa and Japan.

(4) It is assumed that the project construction will be undertaken by an international contractor selected in a competitive tender under the supervision of an international consultant.

6.3 Total Project Cost

The total project cost is estimated at US $ 14,668,959 (US $ 9,604,681 for the foreign portion and US $ 5,064,278 for the local portion) and is summarized in Table 6.1.

Table 6.1 Summary of the Project Cost

No	Work Item	Foreign (US$)	Local (US$)	Total (US$)
1)	Construction Cost			
A)	Preparation Works	43,966	698,160	742,126
B)	Temporary Works	349,425	94,220	443,645
C)	Bridge	5,072,424	2,446,138	7,518,562
D)	Approach Road	106,936	497,570	604,506
	Total(1)	5,572,751	3,736,088	9,308,839
2)	Engineering Fee	1,312,209	68,243	1,380,452
3)	Non-Eligible Cost			
3.1	Demolition of the Existing Bridge	0	28,000	28,000
3.2	Relocation of the Power Line	0	6,000	6,000
3.3	Taxes and Duties	1,807,199	736,712	2,543,911
3.4	MOWS's Administration Cost	39,366	2,047	41,413
3.5	Environmental Program	0	26,800	26,800
	Total 3)	1,846,565	799,599	2,646,125
4)	Contingencies	873,153	460,389	1,333,542
5)	Project Cost (1+2+3+4)	9,604,681	5,064,278	14,668,959

6.4 Maintenance Cost

Although a continuous PC Box Girder Bridge is almost free of maintenance over the anticipated life of the structure, a minimum of maintenance is required. The maintenance items and interval of maintenance are adopted as shown in Table 6.2.

Table 6.2 Maintenance Costs

Item	Maintenance Interval	Maintenance Cost (US$)
1. Bridge, Approach road and bank protection	Annual	6140

CHAPTER 7 IMPLEMENTATION PROGRAM

Implementation Program is shown in Figure 7.1.

It is estimated that the total construction period, which comprises the mobilization works, construction of substructures, and superstructures, and related road, is twenty six(26) months.

Figure 7.1 Implementation Program

Implementation Schedule and Disbursement

Item \ Month	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19	20	21	22	23	24	25	26	27	28	29	30	31	32	33	34	FC	LC
Detailed Design																																				
Arrangement of adjoining Road Project																																				
Preparation of Tender																																				
Tender																																				
Contract																																				
Environmental Assessment																																				
Land Acquisition etc																																				
Construction Stage									1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19	20	21	22	23	24	25	26		
Mobilization/Preparation																																				
A1 Abutment																																				
P1 Pier																																				
P2 Pier																																				
A2 Abutment																																				
Tempory Piers																																				
Revetment (A1)																																				
Revetment (A2)																																				
Superstructure (P1)																																				
Superstructure(P2)																																				
Surface Work of the Bridge																																				
Approach Road																																				
Remaining Work																																				
Total Construction Period																																				

Fund Requirement

Unit: 1,000$

1) Construction Works	FC		1954.3	2879.3	739.1	5572.8	
	LC		1798.1	1390.0	547.9		3736.1
2) Engineering Cost	FC	206.1	448.4	415.4	242.3	1312.2	
inclusive of the detailed design work	LC	3.1	19.8	28.7	16.7		68.2
3) Non-Eligible Cost							
3.1) Demolition Cost of the Existing Brid	FC						
	LC		28.0				28.0
3.2) Relocation Cost of the Power Line	FC						
	LC		6.0				6.0
3.3) Tax and Duties	FC	54.1	630.7	864.8	257.6	1807.2	
	LC	0.6	352.0	274.7	109.3		736.7
3.4) MOWS's administration Cost	FC	6.2	13.5	12.5	7.3	39.4	
	LC	0.1	0.6	0.9	0.5		2.0
3.5) Environmental Program	FC						
	LC		8.9	8.9	9.0		26.8
Sub Total(Non-Eligible Cost)	FC	60.3	644.1	877.3	264.9	1846.6	
	LC	0.7	395.5	284.5	118.8		799.6
4) Contigency	FC	26.6	304.7	417.2	124.6	873.2	
	LC	0.4	221.3	170.3	68.3		460.4
Total Cost	FC	293.0	3351.6	4589.2	1370.9	9604.7	
	LC	4.1	2434.8	1873.5	751.8		5064.3
						14669.0	

CHAPTER 8 EVALUATION OF THE PROPOSED BRIDGE RECONSTRUCTION PROJECT

8.1 Indirect Benefits

Two main categories of indirect benefits were identified: transport effects and regional development effects. Transport effects include: (i) improvement of traffic safety; (ii) strengthening of Malawi's international road network; (iii) strengthening of Mozambique's international and domestic traffic through Malawi; (iv) improvement of accessibility to remote areas; and (v) reduced transport tariffs and increased tax revenue. Regional development effects include: (i) promotion of market-oriented economy; (ii) upgrading of living standards in rural areas; (iii) modernization of agriculture; (iv) promotion of agro-industries and fish-processing industries; (v) promotion of resource development; (vi) tourism development; (vii) balanced development of the region; and (viii) technology transfer.

8.2 Economic Evaluation

The basic conditions for the economic evaluation are the following: (1) base year of 2002, (2) evaluation period of 50 years, and (3) evaluation indicators consisting of economic internal rates of return (EIRRs), net present values (NPVs), and benefit-cost (B/C) ratios.

The direct economic benefits of the new bridge are calculated as savings in vehicle operating costs (VOCs) by a "with" and "without" project comparison scenario. For the estimated of time-related VOCs, passenger time costs, crew costs, and cargo time costs are used. Distance-related costs are composed of the vehicle, fuel, oil, tires, maintenance, and time-related costs. These economic benefits vary by year, increasing from an initial US$135,385 in 2002 to US$174,231 in 2005 and US$1,450,375 in 2022. With respect to the project cost (see section 6), the taxes and duties component of US$2,543,911 and its portion of contingencies (US$254,391) were subtracted from the total financial cost of US$14,669,700. The annual maintenance cost of US$6,140 was assumed to begin in the first year of operation. The Standard Conversion Factor of 0.92 determined earlier was applied to these costs. Based on this procedure, the total economic project cost was determined to be

US$10,921,686 in year 2002.

The resultant EIRR of the project is 7.0%, the same as was calculated in the preliminary evaluation.

The indirect benefits of the project outlined earlier are substantial, and it is the consultant's opinion that these factors remove any doubt concerning the economic viability of the project. The recommendation of the study is that the project should be implemented immediately. The new Mangochi Bridge will be an important asset to the Malawian economy which will safeguard the confidence and security needed to continue the current strong regional and national economic growth.

CHAPTER 9 CONCLUSIONS AND RECOMMENDATIONS

The Feasibility Study on the Construction of the Mangochi Bridge in the Republic of Malawi presents the results of many types of economic and engineering studies (e.g., traffic surveys, topographic surveys, geological surveys, river hydrological studies, environmental examination, bridge design plan studies, design calculations, and cost estimates) ,and the following conclusions and recommendations are made:

(1) Existing Mangochi Bridge

As far as the substructure of the existing bridge is concerned, no major signs of deterioration has been detected except for erosion of ground nearby the abutments. However some symptoms of deterioration were found at the end strut, pin joint, and timber deck in the superstructure. In consideration of the future increased traffic volume and the future heavy weight of vehicles the existing bridge is unlikely to remain structurally sound in the future due to (a) being a one lane bridges, (b) increased traffic demand and (c) insufficient load bearing capacity.

(2) Role of the existing Mangochi Bridge

For international trade, Malawi heavily depends on the external ports of Nacala, Beira, Durban and Dar-es-Salaam. Among these the Nacala port in Mozambique has a significance role in Malawi's international trade because this transportation route is the shortest. The total quantities of commodities to and from Malawi dealt with at Nacala port has dominated recently those of other ports as a result of the settlement of Mozambique's political situation. The Mangochi Bridge is located on national road No.3 connecting Nacala to Lilongwe or Blantyre fulfilling an important road transportation system as well as the railway system connecting Nacala and Blantyre.

(3) Road Rehabilitation Plan neighboring Mangochi Bridge

Road rehabilitation works at both sides of the Mangochi Bridge is scheduled to be implemented along Route No.3 within Malawi and furthermore along the extended net work in Mozambique (Route No.8)

where bridge rehabilitation works are in progress under Japanese Grant Aid. In this context the rehabilitation of the Mangochi Bridge is required as an integral part of the rehabilitation scheme of the road network.

(4) Result of Traffic Survey and Traffic Demand

The traffic survey conducted in March 1998 on the existing bridge observed a traffic count result as follows:

24-Hour Traffic Counts

Pedestrian	Bicycle	Motorcycle	Motorized vehicle
4,362	2,154	54	398

Future traffic demands are estimated as follows:

Traffic Assignment Results, Vehicles per Day

	Without New Bridge	With New Bridge
Total Traffic (2005 year)	931	1,026
Total Traffic (2022 year)	2,500	3,060

While current daily traffic volume counts 398 vehicles in terms of motorized vehicles, 931 and 1,026 vehicles are estimated respectively in the years 2005 and 2022 in the case of "without new bridge". On the other hand, 2,500 and 3,060 vehicles have been estimated to use the bridge in the case of "with new bridge" based on the assumption that the adjacent road rehabilitation Project is carried out.

(5) Expected Benefits to emerge from completion of new the Mangochi Bridge

a) Direct Benefits

The direct economic benefit of the Project is composed of savings in distance and time-related vehicle operating cost. These economic benefits vary year by year, increasing from an initial US $ 135,385 in 2002 to US $ 174,231 in 2005 and US $ 1,450,375 in 2022.

b) Indirect Benefits

Indirect benefits can be identified in two categories: transport effects and regional development effects.

i) Transportation Effects:

- Improvement of traffic safety and reduction of risk and uncertainty
- Strengthening of Malawi's international road network
- Strengthening of Mozambique's international and domestic traffic through Malawi
- Improvement of accessibility to remote area
- Reduced transport tariffs and increased tax revenue

ii) Regional Development Effects

- Promotion of a market-oriented economy
- Upgrading of living standards in the rural areas
- Modernization of agriculture
- Promotion of agro-industries and fish-processing industries
- Promotion of resource development
- Tourism development
- Balanced development of the region
- Technology transfer

(6) Basic Design of the Bridge

Based on the preparatory design of the bridge in which the selection of bridge type together with span arrangement and location of the bridge were studied, a pre-stressed concrete bridge 220m long was adopted for the new Mangochi Bridge and will be located 30m downstream of the existing bridge. The following are the main parameters of the new bridge.

Navigational Clearance	:	4.40m from high water level
Bridge Width	:	10.50m
Number of Lane	:	two lane (3.65mx2)

Side Walk	:	1.30m both side
Span Arrangement	:	60m-100m-60m
Bridge Type	:	Cast-in-situ Pre-stressed concrete single box girder

(7) Environmental Impact Assessment

Although the Shire River is regarded as the migratory path of chambo fish and the historical monument of Queen Victoria clock tower exists, any predicated negative impacts are of minor significance during the construction of the new bridge and can be reduced or avoided by the utilization of the recommended mitigation measures.

(8) Construction Plan

The total construction period is estimated to be 26 months. For the construction of the foundations of both piers, an open caisson is to be used utilizing the jack down method for sinking. The superstructure of pre-stressed concrete will be constructed by the balanced cantilever method.

(9) Total Project Cost

The total Project cost is estimated to be US$14,668,959 of which the foreign currency portion and local portion are US $ 9,604,681 and US $ 5,064,278 respectively.

(10) Economic Evaluation

EIRR is estimated to be 7.0%. As the indirect benefits of the Project outlined in (5) above are substantial, the Study Team considers that these indirect factors remove any doubt concerning the economic viability of the Project.

(11) Expected Works to be undertaken by the Government of Malawi

The following works are expected to be undertaken by the Government of Malawi:

- Adjustment of plans between this Project and the adjoining road project
- Relocation of the power line and other necessary facilities
- Demolition of the existing bridge
- Land acquisition and compensation
- Environmental Impact Assessment and monitoring

In conclusion the Study Team considers that the construction of the new Mangochi Bridge is technically and economically feasible under proper finance and accordingly recommends that it be immediately implemented.

report vol. 2 summary

JICA