

The Independent State of Papua New Guinea

**BASIC DESIGN STUDY REPORT  
ON  
THE PROJECT FOR THE URGENT REHABILITATION  
OF  
MARKHAM BRIDGE  
IN  
THE INDEPENDENT STATE OF PAPUA NEW GUINEA**

March 2007

JAPAN INTERNATIONAL COOPERATION AGENCY

CHODAI CO.LTD.

GM
JR
07-049

## **PREFACE**

In response to a request from the Government of the Independent State of Papua New Guinea, the Government of Japan decided to conduct a basic design study on the Project for the Urgent Rehabilitation of Markham Bridge and entrusted the study to the Japan International Cooperation Agency (JICA)

JICA sent to Papua New Guinea a study team from July 29 to August 27, 2006, and conducted a field study at study area. After the team returned to Japan, further studies were made. Then, a mission was sent to Papua New Guinea in order to discuss a draft basic design, and as this result, the present report was finalized.

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 Independent State of Papua New Guinea for their close cooperation extended to the teams.

March, 2007

Masafumi Kuroki

Vice-President

Japan International Cooperation Agency

March, 2007

## **Letter of Transmittal**

We are pleased to submit to you the basic design study report on the Project for the Urgent Rehabilitation of Markham Bridge in the Independent State of Papua New Guinea.

This study was conducted by Chodai Co., Ltd. under a contract to JICA, during the period from July 2006 to March 2007. In conducting the study, we have examined the feasibility and rationale of the project with due consideration to the present situation of Papua New Guinea and formulated the most appropriate basic design for the project under Japan's Grant Aid scheme.

Finally, we hope that this report will contribute to further promotion of the project.

Very truly yours,

Masahiko Mori  
Project Manager,  
Basic design study team on  
the Project for the Urgent Rehabilitation of  
Markham Bridge  
in the Independent State of Papua New Guinea  
Chodai Co., Ltd.

## ***SUMMARY***

## Summary

### 1. Overview of the Country

Covering the eastern half of the New Guinea Island, the Independent State of Papua New Guinea (hereafter referred to as “Papua New Guinea”), of which land area is 463,000 km<sup>2</sup>, is located at latitude 0 – 14 south and longitude 141 – 160 east and belongs to subtropical climate. The country’s population, 5.5million as of 2003 statistics, is growing yearly. The economy grew for the first time after three years of negative growth up to 2003 (GNI US\$2,739 million, per capita GNI US\$500), with the GNI becoming US\$3,873 million and per capita GNI, US\$660, in 2005. Since then, the country’s economy has been showing steady growth with brisk export of mining products, stable exchange rates, fall in inflation, and increase in foreign currency reserves.

### 2. Background and Outline of the Project

The total lengths of the national roads of Papua New Guinea is 7,598km, of which 2,647km is paved, and 4,952 unpaved. These roads have not yet formed a network to link major areas of the country, but are only forming networks inside 8 roughly divided areas. Because of this situation, Papua New Guinea government has a future plan of constructing major arterial road linking the capital city of Port Moresby and Lae via Wau road where Markham bridge is located.

In 2006, the transportation sector of Papua New Guinea published National Transport Development Plan (2006-2010) which is the revision of National Transport Development Plan (2001-2010). In this revised plan, an improvement plan for the three areas of land transportation, sea transportation, and air transportation is stated. However, the development plan did not well proceed because of the budget shortfall for 5 years during 2001-2005. To make full use of limited financial resources, the budget is to be preferentially allocated to maintenance and repair of existing infrastructure for the 5 years from now on.

Passage on the Markham bridge was temporarily closed for cars because its piers became subsided and the service road was partially broken by the flood on March 2004. In order to quickly restore this bridge, Papua New Guinea government constructed 4 temporary piers and a temporary bridge for the broken part of the service road as an emergency step in August 2004. However, having concluded that the risk stayed at the same level as that of immediately after the flood, in May 2004, the government requested to the Japanese government grant aid for restoration of the Markham bridge in order to secure stable lives of residents in the vicinity of Wau road. The preliminary study team sent from July to August 2005 reported no urgent need for reconstruction of the Markham bridge, however, found urgent need for repairing its piers, railing, and guardrail.

### 3. Outline of the Basic Design Study Result and the Project

In response to the request of the Papua New Guinea government, the Japanese government decided on conducting a basic design study, and sent a basic design study team to the site from July to August 2006. Then, based on the analysis of the field study the results made after returning, the team developed an outline of basic design. JICA sent the Draft Report Explanation team to explain the outline of basic design, which had discussion with the Papua New Guinea government on contents of the basic design.

From the field study, it was found that AusAID had repaired revetment work of the Lae side, conducted earthwork of the service road, and removed the temporary bridge. This has eliminated the need for removing the temporary bridge, which was one of the requests agreed upon in the preliminary study. However, it was also found that, regarding the revetment work and the service road which had been provided only repairs as an emergency measure, a part of the revetment bricks had already fallen out. Thus, it was determined that the revetment work and the service road required permanent repair. Although at the time of the preliminary study the number of requested piers had been three on the Lae side, four temporary piers were installed by the repair conducted by the Papua New Guinea government in August 2006. Since these piers were considered to have been damaged by the flood, the number of the target piers was increased to four. In addition, the abutment on the Lae side moved backward when earth bank of the backside of the abutment outflow. If left as it is, it would widen gap between the expansion joints set in between the abutment and the superstructure girder, which would cause traffic disturbance, and may damage the bridge itself by the impact of car passing. Therefore, moving back the abutment to the original position and reinforcing it to prevent from moving was included in this project.

Item	Content	Note
1) Lae side revetment work	Construct new steel sheet pile foundation (73.2m) Connect blocks	
2) Repair of abutment on Lae side	Install concrete footing and steel pipe pile for abutment	
3) Reconstruction of 4 piers on the Lae side	Remove the existing piers and construct a new piers	
4) Super structure	Repaint steel girder and repair a part of railing and guardrail, repaint all of railing and guardrail	Bridge length 560m
5) Approach road on the Lae side	Total road length 50m (pavement, slope protection, drain work)	

#### 4. Project Work Period and Cost Estimation

The project period is expected to be 4 months for design stage and 13.5 months for construction stage. Approximate cost for executing the project is estimated to be ¥614 million (¥612 million borne by Japan, ¥2 million by Papua New Guinea).

#### 5. Appropriateness of the Project

The beneficiaries of this project are the regions along the Wau road in Morobe Province, of which estimated population is about 200,000 (as of 2005), which is about 3.6% of the total population of Papua New Guinea (5.5 million).

Expected effect of implementation of this project is discussed as follows.

##### Direct Effect

- Repairing and altering temporary piers to permanent ones will improve pile bearing capacity, which will improve stability against settlement of piers.
- Paving the service road on the Lae side will remove the necessity for vehicles to slow down at the end of bridge, which will improve traveling performance, leading to reduction of traveling time.
- Replace a part of hand rail will improve pedestrian safety.

##### Indirect Effect

- The only life line becoming unaffected by weather will enhance reliability of the bridge, which will contribute to stabilizing transportation of daily commodities, improving access to medical and educational facilities, activating local industries such as agriculture and forestry and mining, and overall regional development.
- Building scour resistant structure by providing foundation to the revetment work will reduce risk of outflow of soil by flood in the future, which will bring about lifestyle stability to residents living in the vicinity.

Operation and maintenance of the bridge and the service road to be improved by this project are carried out based on Road Asset Management System (RAMS) and Bridge Management System (BMS), which are the systems of the Department of Works (hereafter referred to as “DOW”) that are in charge of the bridge. Although Morobe Province branch office is in charge of operation and maintenance of the Markham bridge, 5 skilled engineers are allocated and working under a very capable director. Therefore there should be no problem regarding manpower and competency. The annual maintenance and operation cost for the Markham bridge is 0.02% of the annual budget of the road maintenance and operation budget for 2007 of DOW, which is bearable amount for DOW.

As discussed above, by implementing permanent repair to the existing Markham bridge, its surrounding region will be connected to the province capital of Lae without being affected by weather, which would stabilize lifeline and provide constant access to medical and educational facilities, which would contribute to improvement in standard of living of the residents living in the vicinity of the project. In addition, Wau road becoming constantly available for traffic will improve reliability in cargo shipment, by which revitalization of local economy can be expected. In addition, improvement of the bridge of this project links to the “The Project for Reconstruction of Umi Bridge on the Highlands Highway” ,” The Project for reconstruction of Leron Bridge and Bitija Bridge on the Highlands Highway” and “The project for rehabilitation of bridges on the Highlands Highway” , and is in line with the basic policy of the Japanese government.

Considering the above factors, this project is expected to bring about substantial benefit to the development of its surrounding regions and contribute to improvement in standard of living of the local residents, which leads to reduction of poverty. Therefore, this project is considered to be appropriate for Japanese grant aid.

In order to effectively implement this project, the following should be taken into consideration.

- Security

Domestic security of Papua New Guinea is very poor. Therefore, stationing of police on the project site must be ensured by cooperation of the Papua New Guinea government.

- Local consent for cooperation and organizing committee of concerned parties

From the experience in “The project for rehabilitation of bridges on the Highlands Highway” , it has decided and noted as conditions in the minutes of the meeting with the Papua New Guinea government officials during the field survey for the basic design that a written consent for cooperation is obtained from the residents living in the vicinity of the project site and a committee of concerned parties (DOW, provincial government, police, and residents living in the vicinity of the project site) is organized. Implementation of these conditions must be ensured.



The Project for the Urgent Rehabilitation of Markham Bridge  
in the Independent State of Papua New Guinea

**Contents**

Preface

Letter of Transmittal

Summary

Contents

Location Map / Perspective

List of Figures & Tables

Abbreviations

**Chapter 1 Background of the Project**

..... 1-1

**Chapter 2 Contents of the Project**

2-1	Basic Concept of the Project .....	2-1
2-1-1	Objective and Environment of the Project.....	2-1
2-1-2	Outline of the Project.....	2-1
2-2	Basic Design of the Project .....	2-2
2-2-1	Design Policy .....	2-2
2-2-2	Basic Plan.....	2-6
2-2-3	Basic Design Drawings .....	2-10
2-2-4	Implementation Plan and Procurement of Resources .....	2-12
2-2-4-1	Implementation Policy .....	2-12
2-2-4-2	Implementation Conditions .....	2-12
2-2-4-3	Scope of Works .....	2-14
2-2-4-4	Construction Supervision .....	2-14
2-2-4-5	Quality Control Plan .....	2-15
2-2-4-6	Procurement Plan .....	2-15
2-2-4-7	Implementation Schedule .....	2-16
2-3	Obligations of the Recipient Country .....	2-18
2-3-1	Common Items of Japan's Grant Aid Scheme .....	2-18
2-3-2	Special Items of the Project .....	2-18
2-4	Project Management and Maintenance Plan .....	2-18
2-5	Project Cost Estimation .....	2-19
2-5-1	Initial Cost Estimation.....	2-19
2-5-2	Operation and Maintenance Cost Estimation.....	2-19
2-6	Other Relevant Issues .....	2-20

**Chapter 3 Project Evaluation and Recommendations**

3-1	Project Effect .....	3-1
3-2	Recommendations .....	3-2

[Appendices]

1. Member List of the Study Team
2. Study Schedule
3. List of Parties Concerned in the Recipient Country
4. Minutes of Discussions
5. Results of Traffic Volume Count
6. Results of Geological Investigation
7. Results of Hydrological Study



Project Location Map





**Perspective View of Markham Bridge**

## List of Tables & Figures

Table 2-1 High Water Level (HWL) .....	2-6
Table 2-2 Strength of Materials .....	2-7
Table 2-3 Scope of Works undertaken by the Japanese Government and PNG .....	2-14
Table 2-4 Quality Control Plan .....	2-15
Table 2-5 Source of the Major Construction Materials .....	2-16
Table 2-6 Project Implementation Schedule .....	2-17
Table 2-7 Maintenance Works for the Facilities.....	2-18
Table 2-8 Project Cost to be borne by Japan's Grant Aid.....	2-19
Table 2-9 Project Cost to be borne by Government of PNG .....	2-19
Table 2-10 Provisional Costs for the Maintenance Work to be borne by the Government of PNG ..	2-20
Table 3-1 Project Effect.....	3-1
Figure 1-1 The monthly precipitation data for the last decade from the observatory	
In the Nazab airport .....	1-2
Figure 2-1 General View of Abutment 1 .....	2-8
Figure 2-2 General View of Piers .....	2-8
Figure 2-3 Profile of the Bank Protection Steel Sheet Pile Foundation .....	2-9
Figure 2-4 Plan for the Pavement and Drainage Gutter .....	2-9
Figure 2-5 General Project Plan of Bridge.....	2-11
Figure 2-6 Changing River Flow from April to July.....	2-13
Figure 2-7 Temporary Staging.....	2-13
Figure 2-8 Profile of the Construction of Abutment .....	2-14

## **Abbreviations**

AusAID: Australian Agency for International Development

BMS: Bridge Management System

DBST: Double Bituminous Surface Treatment

DNPM: Department of National Planning and Monitoring

DOW: Department of Works

EL: Elevation

GDP: Gross Domestic Product

GNI: Gross National Income

HWL: High Water Level

JICA: Japan International Cooperation Agency

ODA: Official Development Assistance

RAMS: Road Asset Management System

## *CHAPTER 1*

### *Background of the Project*

## **Chapter 1 Background of the Project**

In the present situation, the only Wau road connects Lae city, which is the capital of Morobe Province, with the region as a significant road for about two hundred thousands people who live along the road. Likewise, the road is used for the transportation of the local products such as coffee, timber and gold. In case of the blockade of the Wau road, the tract will be isolated. It means that not only a supply of commodities will be stopped but also the any facilities such as school and hospital cannot be utilized. Hence, it is said that the blockade will cause serious economic damage to those who live in the region.

Due to the serious flood in March in 2004, the Markham Bridge could not be crossed for a while because of the serious settlement of the Pier 3 and the washout of a part of the access road. Therefore, in terms of securing a stable life for the residents, the Government of PNG judged that it was dangerous for the bridge to leave in such condition and requested to the Japanese government for renewal of the Markham Bridge on the road which connect Lae and the region in May in 2004. Similarly, as a way of urgent retrieval of the Markham Bridge, four temporary piers for the bridge and a temporary bridge at the place where the access road had collapsed were constructed by themselves in August in 2004. According to the request, Japan International Cooperation Agency organized and dispatched a basic design study team to PNG from July until August in 2005. As a result of the study, restoring the piers, guardrails and hand rails was concluded to be necessary and urgent although the request for renewing the bridge was not approved.

### **(1) River Condition**

The periphery of the Markham Bridge is situated near the seacoast and has high humidity and constant rain all year around. In the study period, the monthly precipitation data for the last decade could be obtained from the meteorological observatory in the Nadzab airport located at the suburbs of Lae and in Markham river basin and is shown in Figure 1-1. The high water levels during and after the construction period were calculated by using the data below and conducting hydrological and hydraulic analysis. According to Figure 1-1, the high rainfalls from January to March, in July, and in August can be pointed out as a significant tendency. Since the precipitation in flooding is important for analyzing the high water levels, the data of the maximum rainfall per a day was adopted for the design calculation.



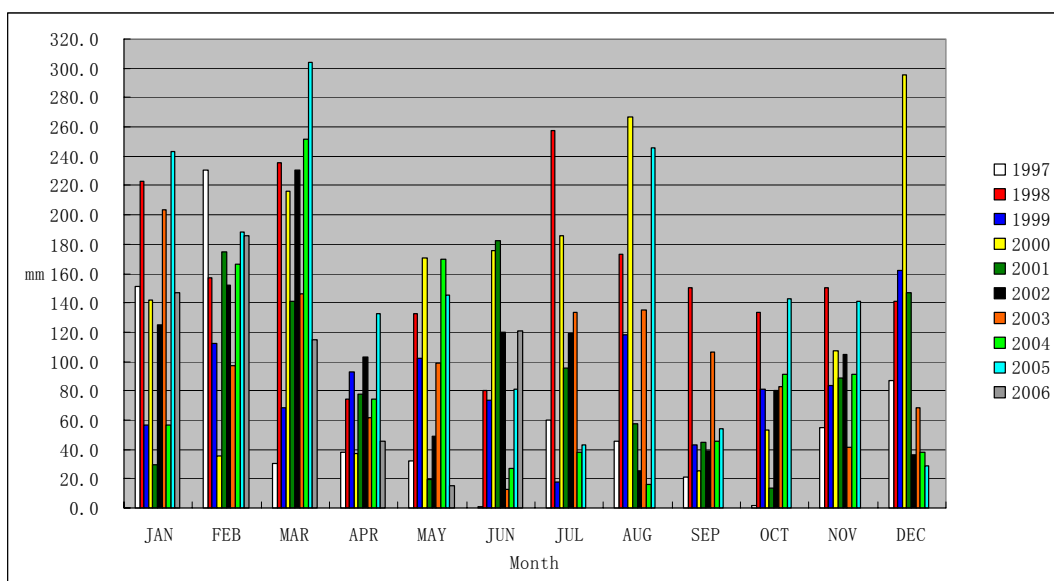


Figure 1-1 The monthly precipitation data  
for the last decade from the observatory in the Nadzab airport

## (2) Environmental and Social Considerations

Restoring and Rehabilitating works on roads and bridges are not mentioned in the latest environmental license system of Papua New Guinea although a new project on the national roads is classified as Level 2 which needs to acquire the approval of the environmental management plan for the project. Therefore, this rehabilitation project on Markham Bridge is categorized into Level 1 which does not need to obtain the approval. Likewise, as the result of the preliminary study, this project is specified as Category C of JICA Guidelines for Environmental and social Considerations. The Category C means that the project gives little deleterious effect to the region and the residents.

## *CHAPTER 2*

### *Contents of the Project*

## **Chapter 2 Contents of the Project**

### **2-1 Basic Concept of the Project**

#### **2-1-1 Objective and Environment of the Project**

Markham Bridge is located on the Wau road which connects the major towns in Milne Bay Province such as Bulolo, Wau and Lae, the second most populated town in Papua New Guinea (Hereinafter refer to as PNG). Over 200,000 local people who live in the area depend on the road for transport to Lae. The road is used for the transportation of local products from the area such as coffee, timber and gold.

The existing Markham Bridge has a one lane roadway and the bridge has enough capacity for the existing low level of traffic. However, the Government of PNG has a plan to construct a trunk road connecting the capital of the country, Port Moresby, and Lae through the Wau road and this road will become one of the most important roads for the country. The living standards of the local people and industrial activities will be improved by the completion of the road because the existing one lane roadway on the bridge will not accommodate the increased future traffic volume.

The existing Markham Bridge shall be maintained to keep a sufficient level of functionality as a lifeline for the local people until the completion of the new trunk road.

#### **2-1-2 Outline of the Project**

Markham Bridge is the longest bridge in PNG. The bridge was constructed 30 years ago and there have been no maintenance activities on the bridge since it was constructed. The existing bridge was damaged on the approach road on the Lae side and the abutment and the piers were damaged by the flood in March 2004. The Government of PNG carried out running repairs to the damaged areas, however the foundation of pier No.3 subsided due to scouring by flood water and the foundation is likely to subside again in future floods.

Although the superstructure of the bridge is in good condition, there is rust on the structure because the bridge was not properly maintained. Some parts of the safety facilities including the handrails and guardrails are damaged and need repair and repainting.

The approach road on the Lae side was washed away by the flood in March 2004 and the traffic on the bridge was maintained by a temporary bridge which was constructed in August 2004. Strengthening of piers No1 to No. 4 were carried out in August 2004 to avoid the failure of the bridge. Running repairs for the approach road and the bank protection were carried out by Aus AID in June 2006 and the temporary bridge was removed. These repair and strengthening works were carried out as an emergency measure to maintain the traffic flow but more substantial measures are needed.

The objectives of the project are to maintain the essential functions of the existing bridge for several decades by the repair or strengthening of the abutment and piers of the bridge and the approach road and carrying out bank protection works.

## **2-2 Basic Design of the Project**

### **2-2-1 Design Policy**

#### **(1) Basic Policy for the Structures**

The original request from the government of PNG for the Project was to reconstruct the Markham Bridge, however through meetings with the preliminary survey team from Japan and the Government of PNG, it was agreed to repair the existing bridge. The contents of the request from the Government of PNG, modified by the survey results by the preliminary survey team and agreed by the both party are as follows:

1. Construction of bank protection on the Lae side.
2. Repair of the three piers on the Lae side.
3. Repair of the handrails and guard rails.
4. Removal of the temporary bridge
5. Repair of the access road.

The demarcation of the scope of work between AusAID and Japan for the project shall be reexamined since AusAID planned to construct the bank protection near the bridge.

A detailed site survey, based on the preliminary survey, was carried out during this basic design study and the plan and implementation schedule for the relevant projects for AusAID and other International agencies was confirmed. This project will be

carried out based on the basic policies for the Project which were agreed by the Japanese team and the Government of PNG.

#### 1) Repair of the Bank Protection on the Lae side

The bank protection on the Lae side was repaired by AusAID in June 2006, however the concrete blocks forming the bank protection are sitting on the sand bed of the river and some of the blocks were already starting to collapse when the basic study team investigated the site. It is necessary to construct a foundation for the bank protection and the concrete blocks shall be connected to each other to avoid the collapse of the bank protection.

#### 2) Repair of the Abutment and Pier on the Lae side

Settlement of pier P3 occurred during the flood of March 2004, and the settlement of the pier would extend to the directly damage the superstructure. The piers from P1 to P4 are of the same construction and the settlement of pier P3 would influence the other piers. To strengthen these piers, temporary piers were constructed in August 2004, however the temporary piers did not directly support the superstructure. Piers P1 to P4 shall be reconstructed because there is a possibility that the existing piers will start to lean and subside again.

The abutment on the Lae side is leaning backwards and the foundation is not in a stable condition. The enlarged gap between the abutment and the girder of the bridge will cause some disruption to traffic driving over the expansion joint. Therefore, the body of the abutment will be put back to its original position and the foundation will be strengthened to avoid future movement.

#### 3) Repair of the Superstructure

There has been no maintenance work on the steel girder over the past 30 years and rusting will reduce the durability of the superstructure if maintenance work is not carried out. The steel girder shall be repainted to increase the durability of the steel girders. The parts of the handrail and guardrail that are damaged or missing shall be repaired and repainting shall be carried out to increase the durability of these structures.

#### 4) Repair of the Approach Road

There is no pavement on the approach road in the area that was repaired by AusAID. There is no slope protection against erosion by water flow from the road and there are many ruts and potholes on the road. The bridge structure has been damaged by the impact of road traffic on the ruts and potholes. Therefore, the construction works will include the road pavement in the area behind the abutment, slope protection and drainage for the water from the road.

## **(2) Basic Policy for the Natural Environment**

### **1) Hydraulic Analysis**

A 1: 100,000 map and a 1:250,000 map for the Markham River basin were used for the calculation of the catchments area of the river basin. The precipitation data for the last ten years was obtained from the records of the Nadzab Airport near the bridge site. The discharge of the river at the bridge location for each return period was analyzed using the PNG Flood Estimation Manual.

### **2) Seismic Analysis**

The seismic coefficient used for the study of the earthquake resistance of the structure was calculated based on the “Earthquake Engineering for Bridges in Papua New Guinea 1985 Revision”

## **(3) Basic Policy for the Social Environment**

### **1) Land Ownership**

This project involves repair work to the existing bridge and so there is no need to procure new land, however it is necessary to use some land on a temporary basis for the construction yard. The land area on the Lae side which was reclaimed by AusAID as a result of the bank protection works may be suitable for the construction yard.

### **2) Security Issues**

It is essential that the Markham Bridge site is guarded against violent crime and vandalism. Police shall be permanently stationed in the construction yard to prevent theft of construction equipment and for the safety of the workers.

## **(4) Design Standards**

The main objective of the project is to repair the existing bridge. The existing steel girder will be reused and so the design standard for the superstructure does not influence the repair work. However, the four existing piers will be completely replaced and so the current design standards shall be applied to the design of new piers. We could not find any significant difference between the standards of Japan, the PNG and Australia. We will use the Japanese standard, with reference to the PNG and the Australian standards, for the design of the substructures.

## **(5) Environment for the Project**

### **1) Procurement of Construction Materials and Equipment**

The majority of the materials and equipment necessary for the bridge repair work are available in PNG. Wherever possible, they will be procured in the Lae city area and will only be procured from Port Moresby, Japan or other third country when the resources are not available near Lae city.

### **2) Labor Force**

The organization including engineers and labor will be planned taken into consideration the labor law, calendar, basis of the payment for labor and the environment for construction in PNG.

### **3) Local Contractor**

There is a concrete plant and an iron works factory in the Lae area. Engineers with a satisfactory technical level are employed by these companies and the products from the companies are acceptable for the project. The materials for the project will be procured from these companies.

## **(6) Basic Policy for the Maintenance and the Operation of the Bridge**

The transportation sector of the Government of PNG has formulated “National Transport Development Plan (2001-2010)”. A review of the plan was carried out in 2006 and the Government gave priority to the maintenance and repair of the existing infrastructure rather than the construction of new infrastructure for the effective use of the limited budget.

Maintenance technology including the repair and repainting of steel structures, repair methods for substructures, bank protection and maintenance of the approach road will be transferred through the Project.

## **(7) Policy of Grade Setting for the Bridge Repair**

The existing structure will be utilized as much as possible for the bridge repair. Steel piles will be used as a part of the foundation of new piers and it may be possible to recycle the steel piles that are to be used for the temporary support piers for use in the permanent foundation of the new piers. The foundation of the abutment is an integral type and it may be possible to recycle the main body of the abutment. The abutment pile foundation will be strengthened because the bearing capacity of the pile foundation against the horizontal force is not sufficient. Four piles will be added to the foundation.

### **2-2-2 Basic Plan**

#### **1) Hydraulic Condition**

The high water level for each return period at the bridge location is shown in Table 2-1.

Table 2-1 High Water Level (HWL)

Item	Discharge (m <sup>3</sup> )	High Water Level (m)	Description
Dry Season	-	9.50	Hearing on site survey
Two year return period	1,957	10.67	Same as existing flood trace on the pier
Five year return period	2,540	10.99	High water level for the construction at the flood season
Ten year return period	2,916	11.18	
Hundred year return period	3,798	11.58	HWL for design
Height of river bed	-	7.47	Height of river bed between P12 and P13

#### **2) Design Assumptions**

##### **1. Horizontal seismic coefficient**

The seismic coefficients are calculated based on the “Earthquake Engineering for bridges in Papua New Guinea 1985 Revision”



The seismic coefficients are calculated by the following formula

$$V = C \times I \times M \times W_t$$

Where:

- V: Magnitude of the earthquake
- C: Coefficient determined by the ground condition and area
- I: Coefficient by the importance
- M: Material Coefficient
- W<sub>t</sub>: Weight from superstructure

The seismic coefficient for designing the abutment is 0.32 and the seismic coefficients for the pier are 0.25 for the longitudinal direction and 0.32 for the lateral direction respectively.

## 2. Design Live Load

A-live loading determined from the Japanese Standard of Road Bridge is adopted for the design.

## 3. Material Strength

The strength of materials which will be used for the project are shown in Table 2-2

Table 2-2 Strength of Materials

Type	Strength
Concrete	Design strength for substructure 24N/mm <sup>2</sup>
Reinforcement bar	SD295 and SD345 (ultimate strength) 295,440N/mm <sup>2</sup>
Steel Plate	SM490Y: over 16mm less 40mm (ultimate strength) 355N/mm <sup>2</sup>
Steel pipe pile	SKK490(ultimate strength)315N/mm <sup>2</sup>

## 3) Plan for Bridge Repair

### 1. Abutment (A1) on the Lae side

Four steel piles and a concrete slab at the basement are added for the abutment repair work. The approach slab is constructed using pre cast concrete to minimize the delay to traffic.

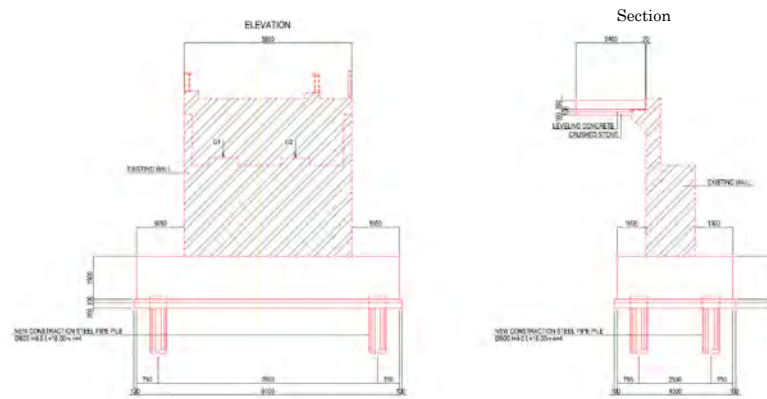


Figure 2-1 General View of Abutment 1

## 2. Piers P1 to P4

The pier pile caps are to be constructed 2.0m under the existing river bed. The 600mm diameter steel piles in the temporary support piers are to be recycled as a part of the permanent foundation for the new piers. The pier column is a wall type, the same as the existing piers.

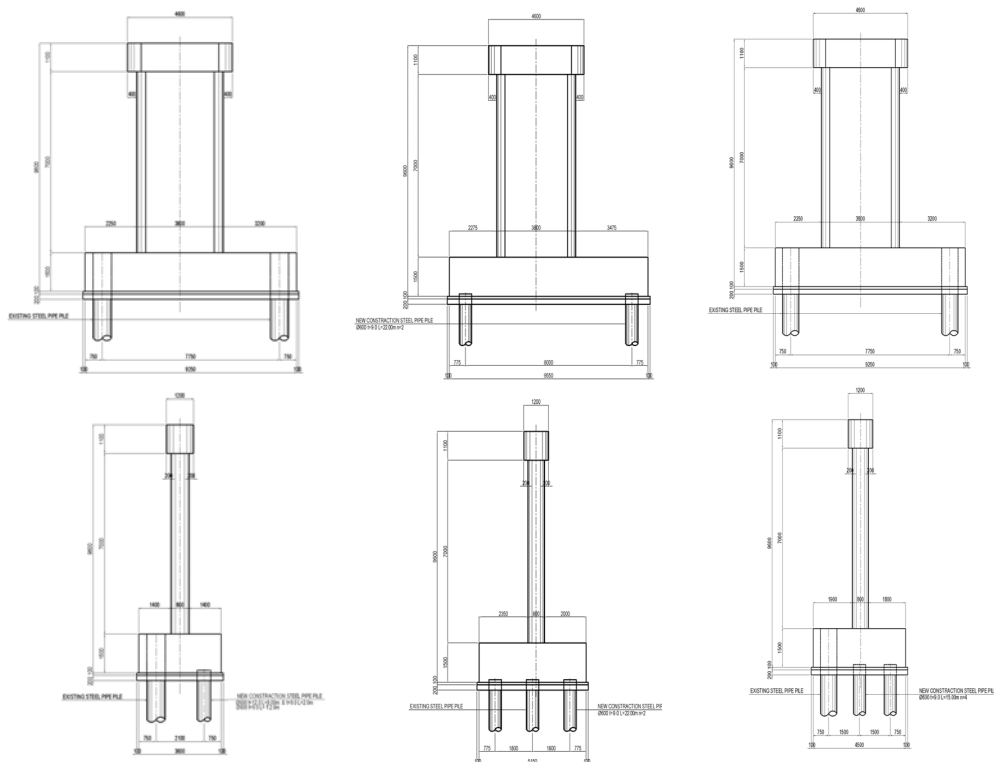


Figure 2-2 General View of Piers

## 3. Superstructure

The steel girder, handrails and guardrails will be repainted and some parts of bridge will be repaired to extend the life of the steel structure. The bearings on abutment A1 and from piers P1 to P4, are very deformed and they will be replaced with new

bearings. The steel structure will be painted with long life epoxy paint.

#### 4. Bank Protection

The concrete blocks, which AusAID used for the urgent repairs, will be used for the repair of bank protection. A steel sheet pile foundation will be constructed for the bank protection to avoid scouring of the foundation by the river flow.

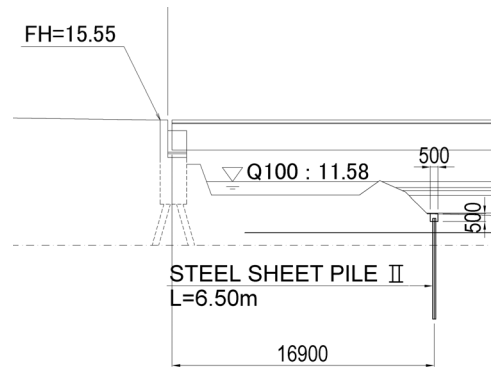


Figure 2-3 Profile of the Bank Protection Steel Sheet Pile Foundation

#### 5. Approach Road

The pavement and slope protection works will be constructed on the approach road on the Lae side. The approach road will be paved with a double bituminous surface treatment (DBST), the same as the pavement of the connection road to the bridge. The pavement will be extended by 50m and a drainage gutter will be installed. The plan for the pavement and drainage gutter is shown in Figure 2-4.

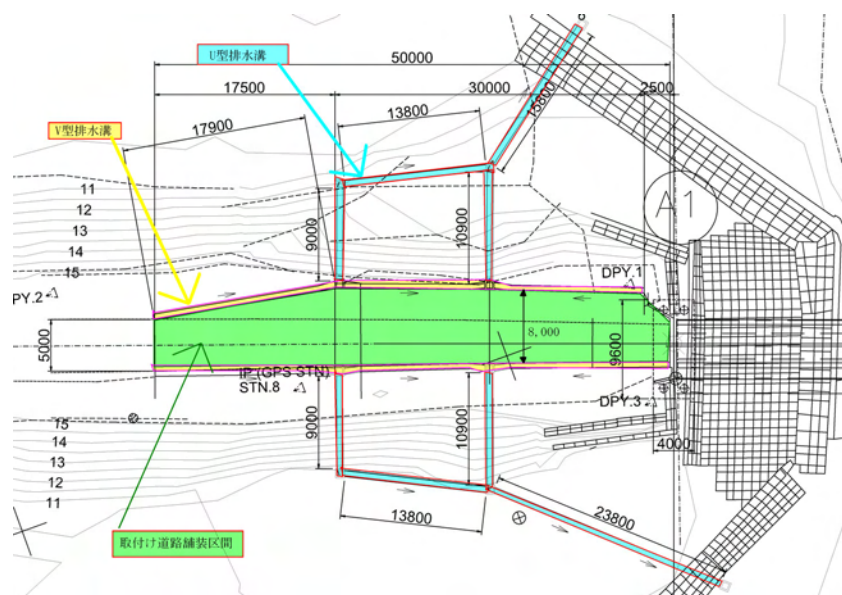


Figure 2-4 Plan for the Pavement and Drainage Gutter

### **2-2-3 Basic Design Drawings**

Figure 2-5 shows the general project plan of bridge.



## **2-2-4 Implementation Plan and Procurement of Resources**

### **2-2-4-1 Implementation Policy**

The following items shall be taken into consideration when implementing the project using grant aid.

1. Establish a tight liaison between the Government of PNG, the consultants and the contractors for the smooth implementation of the project.
2. Establish a stakeholder committee with the cooperation of the Department of Works (DOW), the provincial government and the police to get understanding by the local people and promote communication with local people and societies.
3. Make the most of the local labor and materials to activate the local economy, to promote technical transfer and to increase the opportunity for employment.
4. Establish a construction schedule taking into consideration the precipitation.
5. Safety measures shall be established corresponding to the security condition of PNG.

### **2-2-4-2 Implementation Conditions**

#### **1) Safety Measures**

With the poor security situation at the construction site, police shall be permanently stationed at the site throughout the construction term. A 24-hour security system shall be established to prevent the theft of construction materials and equipment. A communication system shall be established, with mobile phones and radios, to maintain communications between the workers on the site and engineers all the times.

Construction supervision shall be carried out by two engineers from the contractor and the consultant. Counterpart engineers from the government of PNG shall be assigned to the construction site for the technical transfer through activities for the local people or stakeholders of the project.

#### **2) Construction Yard**

The area beside the approach road on the Lae side is suitable for the project construction yard. It is necessary to increase the height of the land to keep the construction yard above the high water level in the flood season.

#### **3) High Water Level during the Construction Term**

There are heavy rains throughout the year in the area near Markham Bridge and it is necessary to be prepared for a rapid increase in water levels due to heavy rainfall throughout the construction period. High water levels at the construction site are expected from January to March. However, there are some heavy rains throughout the year and it is not easy to clearly distinguish the dry and rainy seasons in the area.

The removal of the existing piers and piling shall be carried out from April to July by changing the river flow. (Figure 2-6) Steel sheet piling and construction of the temporary staging are to be carried out in August. (Figure 2-7)

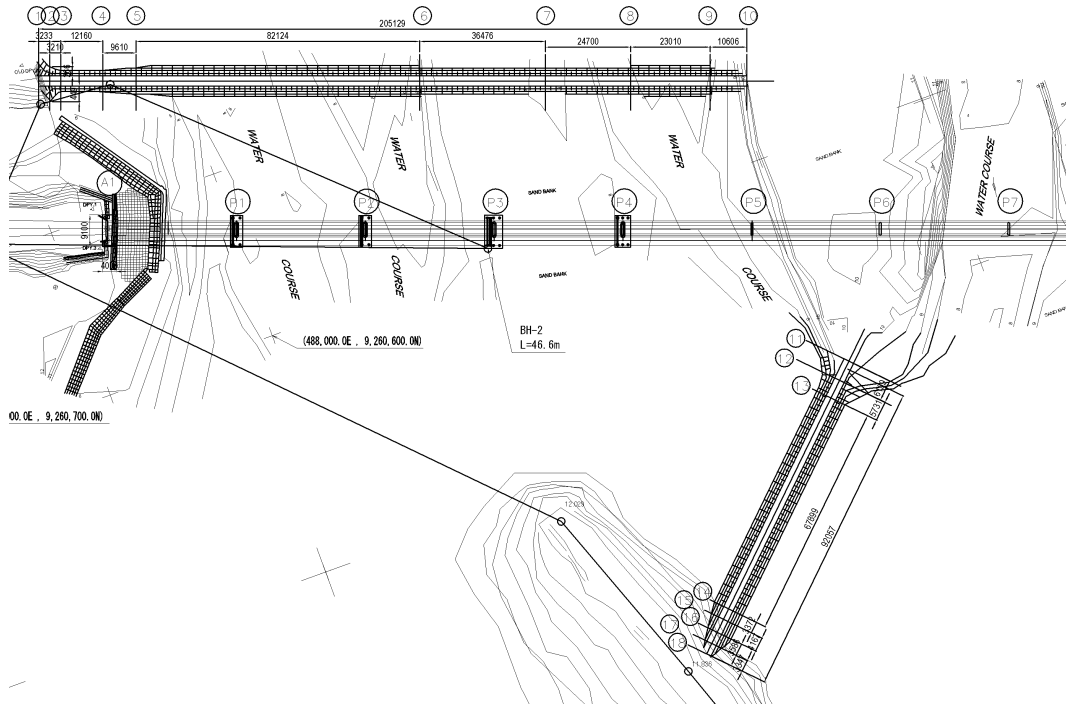


Figure 2-6 Changing River Flow from April to July

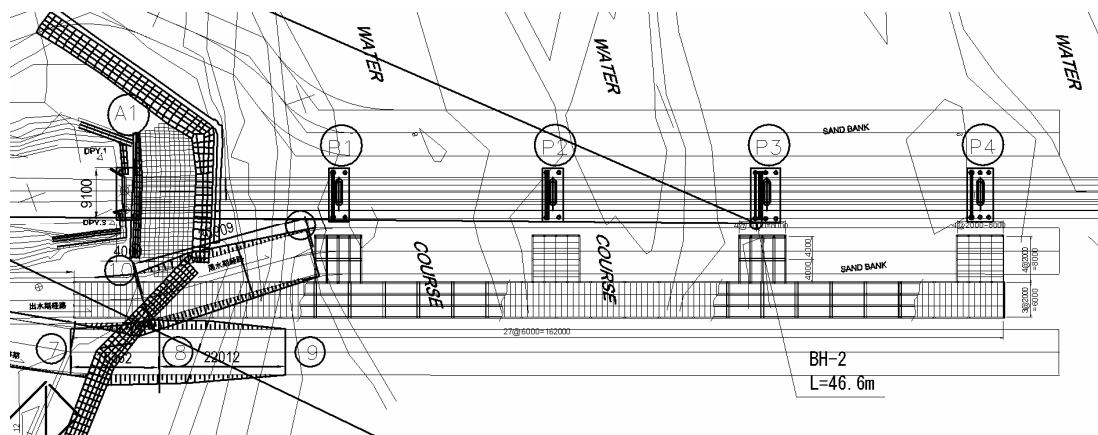


Figure 2-7 Temporary Staging

#### 4) Strengthening of Abutment

A temporary bridge will be installed behind the abutment during the construction and a combination of piles and sheet piles are used to support the embankment of the approach road. The profile of the construction of the abutment is shown in Figure 2-8

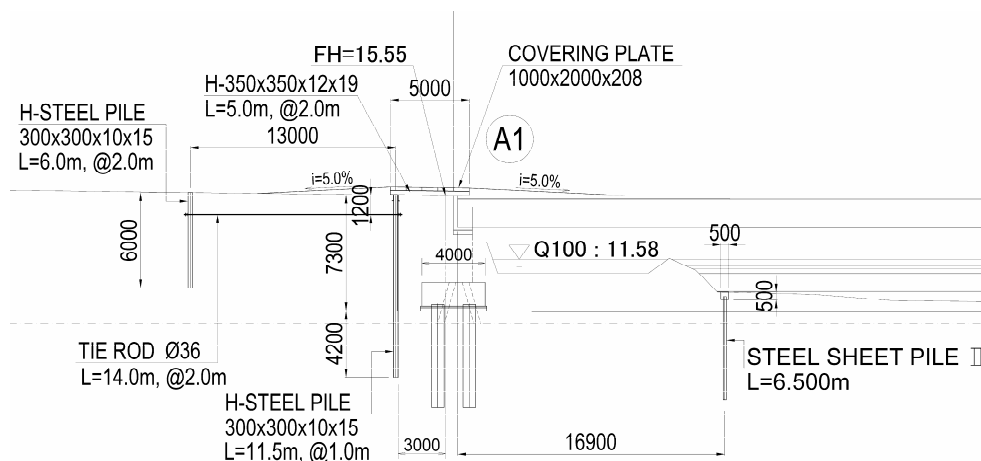


Figure 2-8 Profile of the Construction of Abutment

### 5) Construction Method for the Steel Sheet Pile

The steel sheet piles for the bank protection and temporary coffer dam for the pier foundation will be constructed using a silent pile driver, since the construction shall be carried out with a limitation of over head clearance under the bridge girder.

### 2-2-4-3 Scope of Works

The scope of works for each party is indicated in Table 2-3. Acquisition of the construction yard and maintenance of the bridge after the rehabilitation is the responsibility of the recipient country.

Table 2-3 Scope of Works undertaken by the Japanese Government and the PNG.

Item	Japanese Government	Government of PNG	Contents of works
Acquisition of Construction yard Construction of gate and fence Supply electricity, water and police station.		○	Rent the land upstream of the bridge on the Lae side including road connection to the approach road.
Rehabilitation of abutment A1, from piers P1 to P4.	○		Strengthening of the abutment and replacement and new construction of piers including temporary facilities.
Repair of superstructure	○		Repair parts of handrail, repainting of steel structure and replacement of bearings.
Strengthening of bank protection	○		Construction of foundation and connect blocks of bank protection
Rehabilitation of approach road	○		Pavement , drainage and slope protection
Maintenance of the approach road and the bridge		○	

### 2-2-4-4 Construction Supervision

Construction supervision includes management of quality, time schedules and safety at the construction site. Quality Management will include monitoring the quality of construction materials and maintaining the accuracy of the structures. Mill sheets from manufacturers, material tests at the construction site and piece work shall be monitored and examined throughout the supervision. Time schedule control will



include reviewing the progress of the works through weekly progress meeting and by identifying the critical path of the work items, which must be completed on the scheduled dates specified in the contract which accord to the grant aid system. If problems arise during the construction, the problem will be presented to the responsible parties and they will be required to take the necessary counter measures to solve the problems. Safety management will include monitoring to ensure that the contractor provides continuing safety education to the workers and the contractor performs routine inspection to verify safety on site.

With the poor security situation at the site, safety during the construction term is essential. It is necessary that construction supervision shall be carried out by two engineers to prevent serious crimes. The permanent supervisor from the consultant shall oversee the special construction works which differ from an ordinary bridge construction. Another permanent supervisor shall oversee the repair and painting works for the steel structure including the girder, handrails and guard rails, since the work shall be carried out all over the bridge. Reconstruction of the substructures and foundations shall be carried out at the same time and the construction will become intricate. Therefore, two permanent supervisors will be assigned from the consultant for the construction supervision.

#### 2-2-4-5 Quality Control Plan

The quality control plan for materials and testing frequency are shown in Table 2-4

Table 2-4 Quality Control Plan

	Item	Contents	Frequency
Material Inspection	Aggregates	Particles, specific gravity, hardness stability	One test report for every 250m <sup>3</sup> at each quarry site
	Cement	Particle, specific gravity, strength	One test report for every 30 tone for each supplier
	Reinforcement Bar	Strength, bending	One test report for every diameter from each lot
	Asphalt	Needle penetration, viscosity, softening	One test report from every lot
	Embankment soil	Particle, specific gravity, consolidation, moisture content, plastic/liquid limit, CBR	One test report for every 500m <sup>3</sup> from each pit
Product Inspection	Fresh concrete	Temperature, consistency	One test report for every 5 m <sup>3</sup> , at site
	Hardened concrete	Strength, unit weight	Two test reports for every 30m <sup>3</sup> , specimen tests at 7 & 28days
	Asphalt mix	Temperature, asphalt content	One test report for every 10 tones, at site
	Pavement base layer	Site density	One test for every 25m <sup>2</sup> , at site
	Bearing strata for pile	Location, bearing capacity	Confirmed by rebound test
	Pile	Dimension, straightness	Measurement recorded for all piles
	Foundation and substructure	Location, Dimension, elevation	
	Painting	Thickness, finish	One report for every 200~500m <sup>2</sup>
	Asphalt pavement	Thickness, flatness, elevation	Thickness recorded every 100m <sup>2</sup> , flatness & elevation recorded every 5m.

#### 2-2-4-6 Procurement Plan

Most of the construction materials for the bridge construction were imported from Australia, New Zealand and other countries in general but they are available from the market in PNG. Several items such as large size steel pipe piles, special shaped steel shall be procured from Japan or other third countries. Sources of the materials are

shown in Table 2-5

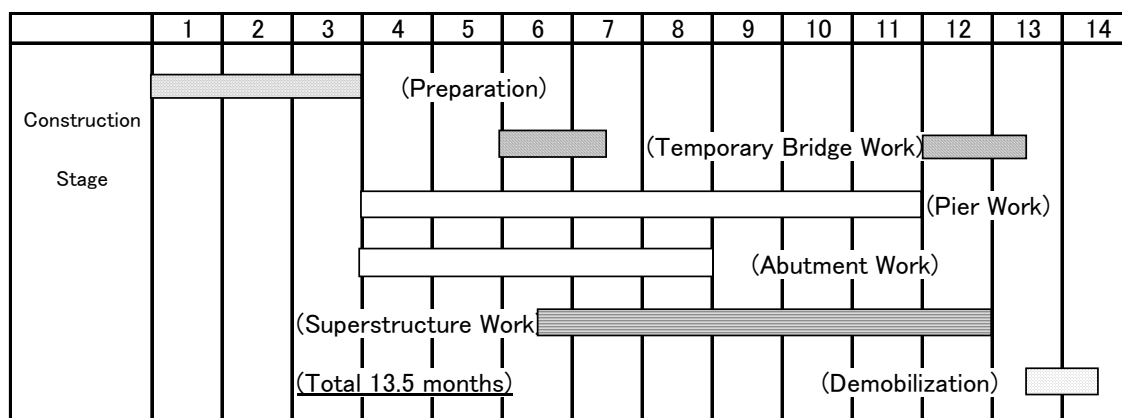
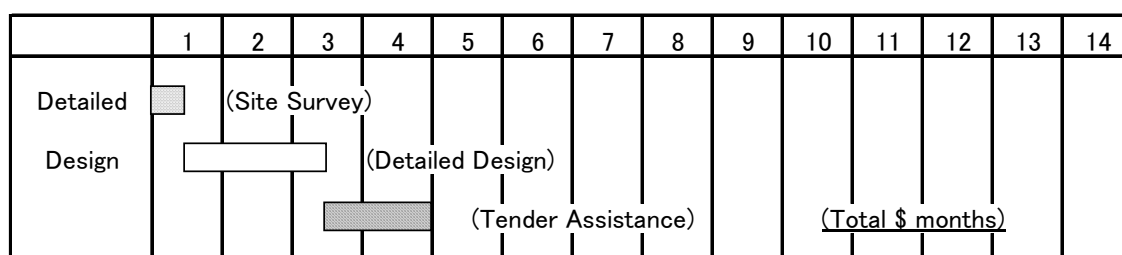
Table 2-5 Sources of the Major Construction Materials

	Item	Source	Remarks
Construction Material	Aggregates	PNG (Lae)	
	Cement	PNG (Lae)	
	Reinforced bar	PNG	
	Steel material	PNG (General Type) Japan, Third countries ( Special Type)	Singapore, Australia New Zealand.
	Plywood	PNG	
	Asphalt	PNG	No plant in Lae
	Paint	PNG	
	Fuel Oil	PNG	
	Bearings	Japan, Third countries	Singapore, Australia New Zealand
	Handrail Guard rail	PNG	
Construction Equipment	Road equipment	PNG	
	Excavation Equipment	PNG	
	Cranes	PNG	
	Pile drivers	Singapore	Diesel hammer Vibro hammer
	Silent pile driver	Japan or Third country	Singapore
	Concrete plant	PNG	
	Generators	PNG	
	Vehicles	PNG	
Employee	Foreman	Japan or Third country	Australia New Zealand
	Skilled labor	PNG、 third country	Australia
	Labor	PNG	
	Typist	PNG	
Furniture, office & test equipment	Office equipment	PNG	
	Telecommunication	PNG	
	Furniture	PNG	
	Container house	PNG	
	Test equipment	PNG、 third country	Australia

#### 2-2-4-7 Implementation Schedule

The project implementation schedule is shown in Table 2-6.

Table 2-6 Project Implementation Schedule



## 2-3 Obligations of the Recipient Country

Obligations of the recipient country for this project are indicated below:

### 2-3-1 Common Items of Japan's Grant Aid Scheme

- To secure land necessary for the site of the project (Borrow land upstream of the bridge on the Lae side).
- To open a bank account in the name of the Government of bank in Japan (B/A) and issue the authorization to pay (A/P)
- To ensure all the expenses and prompt execution for unloading, custom clearance.
- To exempt Japanese nationals from custom duties, internal taxes and other fiscal levies which will be imposed in the recipient country with respect to the supply of the goods and services under the project.
- To issue permissions and licenses necessary for the implementation the project
- To ensure proper maintenance, management and preservation of the facilities constructed by Japan's Grant Aid.

### 2-3-2 Special Items for the Project

- Before the start of construction, acquire a letter of agreement from the residents near the construction site for the smooth implementation of the project.
- Before the start of construction, establish a committee consisting of stakeholders, including the DOW, the Provincial Government, the Police and local representatives.
- Acquire a letter of agreement that the Australia agrees that for this project, we can use the concrete blocks and modify the bank protections constructed by AusAID.
- To build a police station
- To permit the police officers to be provided with accommodation near the site

## 2-4 Project Management and Maintenance Plan

The maintenance works needed for the road and bridge after the completion of the project are shown in Table 2-7

Table 2-7 Maintenance Works for the Facilities

Work item	Frequency	Location	Content of work
Road and bridge maintenance	Continuous	Whole facility	Maintenance work based on the RAMS, BMS DOW system
Bridge maintenance	Twice per annum	Expansion joints	Cleaning of expansion joints, if damage is detected take photos and record the date
		Drainage	Cleaning drainage pipes, if damage is detected take photos and record the date
		Bearings	Cleaning the periphery of bearings. Confirm the movement and deterioration of elastomeric bearings.
		Handrails Guard rails	Confirm the degree of deterioration if damage is detected take photos and record the date
		Steel Girder	Confirm the paint condition and rust. If problems are detected , take photos and record the date
	After flooding	Abutment, Pier	Confirm local scour and subsidence of the structure.
Approach road	Twice per annum	Pavement	Repair potholes
		Shoulder	Weed and level shoulder
		Slope	Repair slope erosion
		Gutter	Removal of deposits
Bank protection	Twice per annum and after a flood	Concrete Block	Confirm movement due to erosion. Repair protection if problems are detected
Periodical bridge repair	Every 10 years	Steel member	Prepare budget and repaint

## 2-5 Project Cost Estimation

### 2-5-1 Initial Cost Estimation

The cost of the Project to be borne by Japan's Grant Aid is estimated at 612 million Japanese Yen as summarized in Table 2-8. The cost required for fulfilling the undertakings by the Government of PNG is estimated at 1.7 million Japanese Yen as shown in Table 2-9.

Table 2-8 Project Cost to be borne by Japan's Grant Aid

Items		Amount (Million Japanese Yen)
(1) Construction Cost	Substructure	254
	Superstructure	120
	Bank Protection	117
	Approach Road	50
(2) Detailed Design and Construction Supervision		71
<b>TOTAL</b>		<b>612</b>

Table 2-9 Project Cost to be borne by Government of PNG

Items	Amount (Kina)	Yen Equivalent (Million Yen)
(1) Acquisition of land for construction yard	36,250	1.5
(2) Construction of police station	5,000	0.2
<b>TOTAL</b>	<b>41,250</b>	<b>1.7</b>

#### Cost Estimate Assumptions

The project cost estimate is based on the following assumptions:

- Estimate Date : August 2006
- Exchange Rate : 1.0 US\$ = 116.77 Yen  
: 1.0 Kina = 38.49 Yen = 0.33US\$  
Average Rate for the 6 months to the end of July 2006
- Construction Period: 13.5 months

The Project is implemented under Japan's Grant Aid Scheme. The above project costs will be revised by the Japanese Government before the signing of the Exchange of Notes (E/N).

### 2-5-2 Maintenance Cost Estimation

Using the DOW maintenance system, the periodical maintenance is carried out twice per annum. However, it is necessary to prepare a budget for the maintenance work since there has not been any maintenance activity for Markham Bridge in the past. Provisional costs for the maintenance work to be borne by the government of PNG are shown in Table 2-10.

Table 2-10 Provisional Costs for the Maintenance Work to be borne by the Government of PNG

Work item	Frequency	Cost (Kina)
Inspection and maintenance of bridge	Twice per annum	5,000
Periodical repair of pavement	Every three years	50,000
Repaint of steel structure	Every ten years	560,000
Total per ten years		827,000
Average cost per annum		82,700

## 2-6 Other Relevant Issues

Following issues shall be taken into consideration during the implementation of the project;

- 1) To obtain the agreement with the neighboring residents in order to implement the project smoothly before start the project
- 2) To establish the committee which consists of those who are related to the project such as DOW's and provincial officer, policeman, and the neighboring residents before start the project
- 3) To obtain the written approval by AusAID for repairing the damaged parts of the bank protection and for using the concrete blocks which were used in the AusAID's project
- 4) To build the police station
- 5) To permit the police officers to utilize the existent accommodation near the site

## *CHAPTER 3*

### *Project Evaluation and Recommendations*

## Chapter 3 Project Evaluation and Recommendations

### 3-1 Project Effect

Project effect is summarized in Table 3-1.

Table 3-1 Project Effect

Current situation and problems	Countermeasures by the project	Direct effects and their level	Indirect effects and their level
The Markham Bridge could not be crossed for a while because of the serious settlement of the Pier 3 and the washout of a part of the access road due to the flood in March in 2004. There is great possibility for temporary piers which were constructed in August in 2004 to be damaged.	Existing four piers will be removed and reconstructed.	Improve of the bearing capacity and increase in the stability against settlement. (The safety factor will change from 2 to 3.)	Any public facilities such as school and hospital can be always utilized. Commodities can be always supplied. The life standard of the residents will improve. The regional industry such as agriculture, forestry, and mining will improve. The regional development will be encouraged.
Need to repair the abutment on the Lae side because of leaning backwards.	The body of the abutment will be put back to its original position and the foundation will be strengthened by additional footing and piles.	The gap between the abutment and the girder of the bridge will decrease. The discomfort in driving over the expansion joint will be relieved.	The durability of the cars passing over the bridge will improve
Vehicles need to pass the road slow due to the rutted road.	The access road will be paved.	Possible to shorten the time for passing the road.	The regional industry will improve.
Some parts of the bank protection on the Lae side which repaired by AusAID in June in 2006 start collapsing.	The steel sheet pile foundation for the bank protection will be constructed and the concrete blocks will be connected to each other.	The bank protection will strengthen.	The life of the residents can be stable because the possibility of damage by future flood can decrease.
The steel girder, handrail and guardrail have corroded.	The steel girder, handrail and guardrail will be re-painted.	The durability of the superstructure will improve. The traffic condition will improve and become stable.	The regional industry such as agriculture, forestry, and mining will improve. The regional development will be encouraged.
A part of handrail have been stolen.	The stolen part of handrail will be reconstructed.	The pedestrian safety will improve.	The life of the residents can be stable.



### **3-2 Recommendations**

The following issues shall be quantified in order to be certain of the effects of the projects:

#### **(1) Improvement and maintenance for road section, including the project bridge**

Where bridge improvement work is a limited point area project, without improvements to adjacent roads, no effective benefit is expected from the project. Since the Wau road from the Markham Bridge to Lae city particularly has many potholes, it is necessary to improve the road rapidly. Similarly, in order to maintain the Markham Bridge in good condition, regular inspection and proper maintenance will be necessary. Therefore, it is important that DOW will secure appropriate budget and a fair number of personnel.

#### **(2) Transference of rehabilitating and maintenance skills through the project**

The PNG's engineers can inherit some skills such as how to re-paint on steel girder and replace bridge bearing, which is related to bridge rehabilitation and maintenance, from the Japanese engineers through the project. Moreover, the inherited engineers need to inform the other engineers about the skills in order to manage the domestic bridges by themselves in the future.

#### **(3) Technical cooperation and coordination with the other donors**

Utilization of the steel-pipe piles of temporary piers and re-utilization of the concrete blocks which were used in the AusAID's project are planned in the project. Therefore, exchanging technical information about the above materials with the institutions and companies which were in charge of the previous projects is useful in order to implement the project smoothly.

Likewise, as regards restoring the pavement in the project, it is significant to liaise with other donors such as AusAID on the up-to-date information of the road.