PUBLIC WORKS DEPARTMENT
MINISTRY OF INFRASTRUCTURE AND PUBLIC UTILITIES
REPUBLIC OF VANUATU

DATA COLLECTION SURVEY
FOR
RECONSTRUCTION OF TEOUMA BRIDGE
ON EFATE RING ROAD

SURVEY REPORT

JANUARY 2017

JAPAN INTERNATIONAL COOPERATION AGENCY

CTI ENGINEERING INTERNATIONAL CO., LTD.

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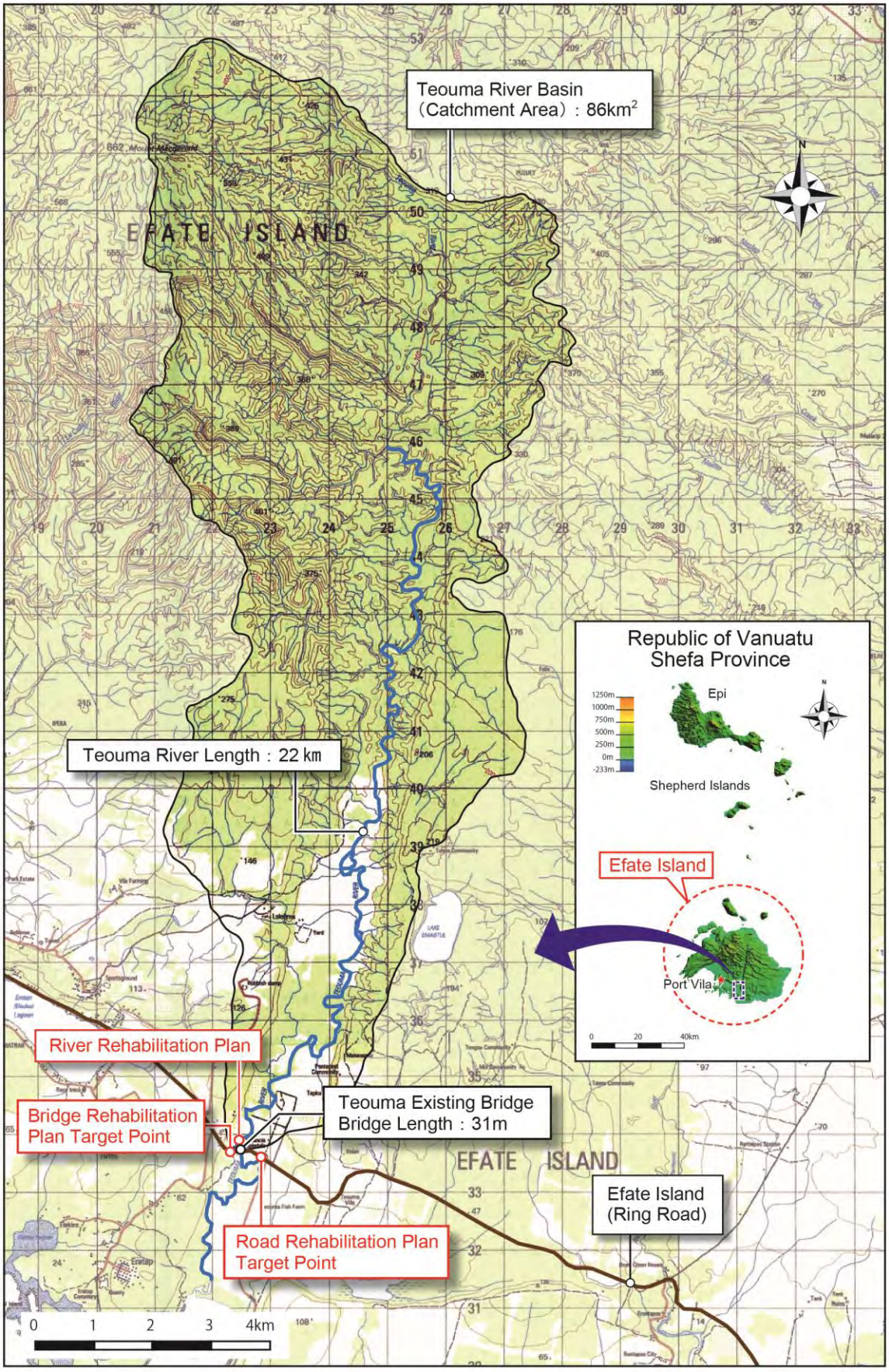
CR(3)
17-002

Exchange Rate

September 2015
1VT=0.9728 Japanese Yen
1US$=104.985 Vanuatu Vatu
1US$=102.129 Japanese Yen



Location Map

Photo

Teouma Bridge

Urgently Rehabilitated Approach Road

River Condition (Upstream of Teouma Bridge)

River Condition (Downstream of Teouma Bridge)

Right Approach Road at Teouma Bridge

Left Approach Road at Teouma Bridge
(Bridge Rehabilitation Area)

Photo

Slope Protection Site (Upstream, Right Side)

Slope Protection Site (Downstream, Left Side)

Slope Protection Site (Downstream, Right Side)

River Widening Site (Upstream, Left Side)

Road Improvement Site

Present Road Condition Improved in "the Project For Rehabilitation of Bridges on the Ring Road in Efate Island"

Photo

Private Land next to Top of River Bank (Upstream, Right Side)

Sedimentation inside of Curve (Upstream, Left Side)

Farming Field (Upstream, Left Side, River Widening Target Area)

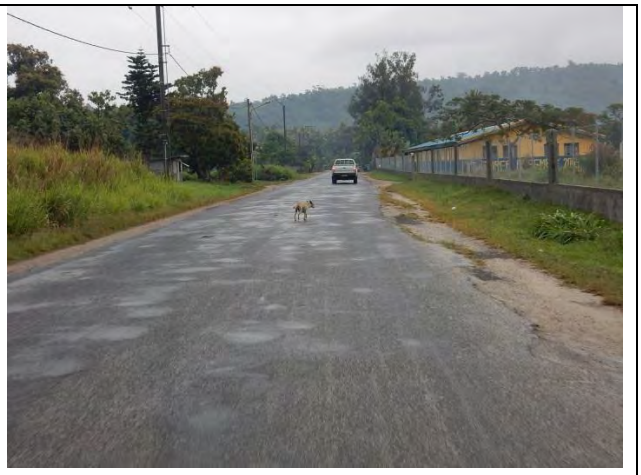
Farming Field (View from Diversion Point toward Road Improvement area, Upstream, Left Side)

Vegetation along River (Upstream, Left Side at around St. 4900, under Cutting)

People Washing Cloths in Teouma River

Photo

Rentapau Bridge



Ring Road Condition

(South of Efate Island, around Mele)

Ring Road Condition

(North of Efate Island, around Port Havannah)

Klems Hill Slope Failure Area

Sedimentation and Trees Blocking Cross Section Area in River (Creek Ai Culvert)

Aging Bridge (Lamin Bridge)

Photo

Conventional Salinity Concentration Test (Upstream, Teouma Bridge)

Conventional Salinity Concentration Test (River Mouth of Teouma River)

Field Investigation with PWD, DOL and DEPC

Stakeholder Meeting for Explanation of Draft Final Report

Field Investigation at Downstream Area of Teouma Bridge

Explanation of Draft Final Report to Director of PWD

Summary

1. Introduction

1.1 Background

Teouma Bridge constructed under “the project for rehabilitation of bridges on the ring road in the Efate Island in the Republic of Vanuatu” (completed in 2005) closed to vehicle traffic for six days due to the damages on Teouma Bridge caused by Cyclone Pam of the Category 5 in March, 2015. At present, the traffic has been secured by urgent repair works by the Government of Vanuatu. However for further rehabilitation, Vanuatu government faces the difficulty in securing human and financial resources for covering all rehabilitation works of the damages caused by Cyclone Pam.

Teouma Bridge, as mentioned above, has been constructed with the grant aid from Japan in 2005 and planned and designed under the limitation of time and budget as a quick restoration project. Such insufficient safety against floods then faced Cyclone Pam. Cyclone Pam brought the heaviest downpour, and caused big flood of the Teouma river basin as well as Efate Island. The river course changed intensively as progress of meandering resulting in widening the river course compared to it at the time of bridge construction. As a result, floodwater directly hit the abutment on the right bank and scoured the bottom of the abutment. And now, the bridge is under a very fragile condition to the heavy rain and can be easily damaged in the cyclone season every year even though the urgent rehabilitation measures have been done. In addition, It has been revealed that the approach road of the bridge have a high possibility of scouring of the embankment to block the traffic due to forming the bottleneck along the Teouma River and necessity of the study on the river improvement and the extension of the bridge. Considering the frequent geomorphologic changes of the river course, further detailed river morphologic classification and hydro-hydraulic analysis are required for the rehabilitation of the bridge and the river improvement. Therefore, in this time, the data collection survey to study and determine the direction of the bridge reconstruction and river improvement in coordination with the Government of Vanuatu will be conducted.

1.2 Objectives

The project conducts river geomorphologic classification by stereoscope device based on the satellite images and prepares river chronological change and micro-topography classification map for the Teouma River around Teouma Bridge in Efate Island in Vanuatu. The safety degree, potential risk and its possible measures shall be examined. In addition, the estimate of probable flood discharge and hydro-hydraulic analysis to grasp the flood phenomenon shall also be conducted. Based on these studies and analysis, river, bridge and road improvement plan shall be studied. Furthermore, necessity and direction of future’s cooperation shall also be studied in corporation with the Government of Vanuatu.

2. Socio-Economic and Natural Conditions

2.1 Socio-Economic Conditions

The population in Shefa Province, where the project is located, is at 78,723 in 2009, covers 33.6% of the total population of 234,023 and has the largest population among 6 provinces. Population density of 52 people/km2 and population growth rate of 3.7% is also the highest among those.

Since 2003, the real GDPs show the positive growth in every year except for 2015, when the Cyclone Pam attacked Vanuatu, and are approximately 2% in last 5 years. Major trading goods and those major trading partner countries are as follows; however exports are much larger than imports.

- Export Goods: Copra, wood, cava, beef, cocoa
- Export Partners: Thailand, Japan, Malaysia
- Import Goods: General machinery, transportation equipment, food, daily necessities
- Import Partners: China, Japan, Singapore

Regarding tourism, the number of the international tourists since 2010 is almost flat. The expense of about 300 million USD, however, is about equivalent to the imports in Vanuatu so that the tourism industry is the mainstay of the Vanuatu economy.

2.2 Natural Conditions

(1) Topography and Geology

Efate Island has a formation of raised limestone terraces and tuff rock. The Teouma River has 86 km2 of catchment area (at Teouma Bridge) and it is the largest catchment in Vanuatu. The river has its source in McDonald Mountain with the top elevation of 662 m, and flows down meandering in the rift valley whose width is approximately 1.5 km, sandwiched by limestone terraces.

(2) Climate

Vanuatu luxuriates in a tropical maritime climate with characteristic uniform temperature, high humidity and large amount of rainfall. Winds are generally moderate (9.3 km/hr to 18.5 km/hr) except during a tropical storm. The climate of Vanuatu can be defined by two main seasons, which is the cold (dry) season from May to October and the hot (wet/cyclone) season for other months. Generally, it is hottest in February and coolest in August. Average annual temperature in Port Vila is at about 25°C, hottest in February at about 27°C and coolest in August at about 23°C. Annual rainfall is around 2,100 mm.

(3) Earthquake

Vanuatu is located on Pacific Plate and raised by Indo-Australian Plate. This is the reason why there are so many earthquakes in Vanuatu. The middle size or larger earthquake hit 20 times up to 140 times every year.

(4) Damages Caused by Cyclone Pam

Cyclone Pam, classified as “Category 5”, hit Vanuatu in March, 2015. Affected population was at 166,600 and the number of fatalities was 11. Approximate number of damaged houses reached up to 15,000 and nearly 75,000 people were evacuated. Especially, the infrastructure such as roads, bridges, houses, water supply system and sewage system caught damages. Large flows and debris in it caused

damage to piers of the bridges, abutments, protection works for abutments, approach roads, causeway and culverts. Pavement of the roads was damaged partially.

3. Transport Sector

MIPU (Ministry of Infrastructure and Public Utilities) is in charge of this survey and PWD (Public Works Department) in MIPU is in charge of the implementation of the Project. Regarding improvement progress of road network in Efate Island, gravel pavement stretch is 117.6 km long and seal pavement stretch is 55.1 km long within total national road length of 192.7 km.

The approximate amount of the annual budget for whole PWD is generally set at 500 million Vatu. 60% of its budget is allotted to road and vehicle repairs and maintenance in Shefa Province, for instance. The budget item, “Road Repairs and Maintenance” is for relatively small maintenance of roads. The cost for the large scaled rehabilitations such as the one for the damage caused by a Cyclone cannot be covered by this budget and should be funded by foreign aid.

4. River Morphology

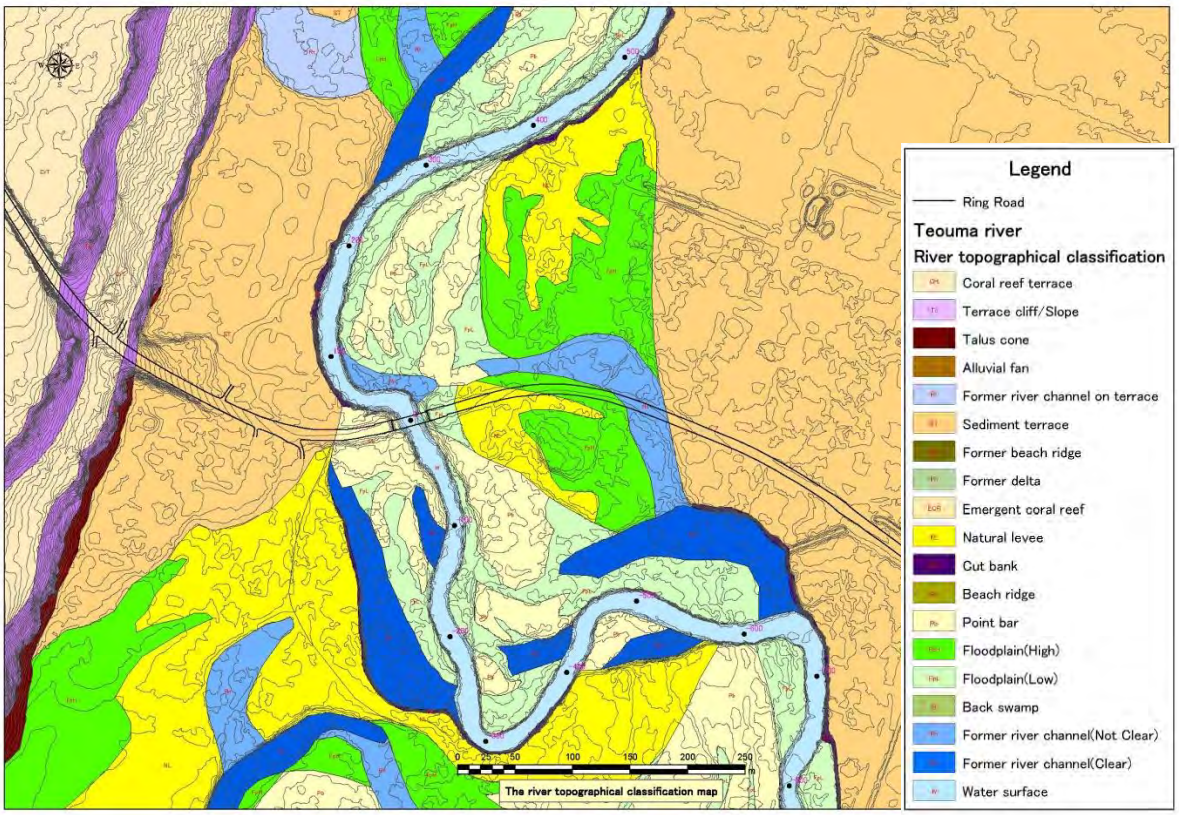
4.2 River Chronological Changes

The Teouma river course frequently meandered or oscillated laterally with Teouma Bridge as a fixed point because of the robust artificial structure whenever large-scale floods occurred. The following are the particular changes of the river course.

- The Teouma River flows down meandering inside a rift valley of about 1.5 km in width. A raised coral reef with an elevation of 40 to 100 m forms both sides of the valley. Averaged slope of the valley is about 0.333% in the upper part from a little downstream of the ring road, while it is about 0.125% in the lower part. Hence, the ring road is located close to the geographic transition point of the valley due to differences of formative factors such as fluvial or marine factor.
- Due to the above topography, no significant meandering but only lateral oscillation could be found in the upper part.
- Meanwhile, river meandering has occurred significantly in the evolution process of the river from beginning of channel meandering, to progress of meandering, to forming cut-off channel, and finally to resuming of meandering again.

4.2 River Geomorphologic Analysis

The formed microtopographies were identified through interpretation of the stereo-type satellite imagery taken in August 2015, and they were confirmed through field survey. The following figure shows geomorphologic classification along the Teouma River.



River Geomorphologic Classification Map around Teouma Bridge

Major topographic features around the bridge are summarized below.

- The sediment terrace extends over the rift valley, and the river developed the fluvial microtopographies through fluvial process of erosion, sediment transport, and sediment deposition. The river course changes converge within these areas from the macroscopic views. The sediment terrace, however, consists of erodible soils of sand and clay so that river meandering is progressing through erosion of the terrace along the concave bank immediately upstream of the bridge and 700 m to 900 m downstream of the bridge.
- Some former channels can be clearly identified downstream of the approach road at 50 m of west from the bridge. This fact means that the river flowed down along the more western side in the past. If there is no ring road and the bridge constructed, the river course easily could connect to the former river course.
- The former river channel, though it is unclear, is identified at eastern side of the bridge. This implies that river channel shifting could develop extending towards east and south directions over 90° angles.

4.3 Disaster Risks from River Course Chronological Changes and Geomorphology

The disaster risks related to geomorphologic features are enumerated below.

- Segment of the highest risk might be progressive meandering along the right bank immediately upstream of the bridge. The meandering has progressed in parallel with scouring of the sediment

terrace and forming cut bank by floodwater. Along the right bank, bank protection works shall be necessary to curb the scouring.

- Although some of the former river channels are unclear upstream of the bridge, there might be a possibility that river channel shifting could develop extending towards east and south directions over 90° angles. In order to control this kind of river course shifting, the above-mentioned bank protection, expansion of bridge to improve its artificial constriction of the river course and channel dredging to carry floodwater smoothly shall be necessary.
- Furthermore, the floodwater flowed down over the natural levee and higher floodplain of the left bank in the large-scale flood time such as Cyclone Pam or more intensive one. In order to cope with such large-scale floods, flood-proofing measures shall be necessary to protect the ring road and ensure the transport capacity.

5. Hydraulic and Hydrologic Analysis

5.1 Rainfall Analysis

Rainfall observation stations in Efate Island with long time records are Port Vila and Bauerfield (Air Port), and Bauerfield is selected as the representative station to compute the design probable rainfall through a comparative study. Probable rainfall data are computed using 30 years' observed record of daily rainfall. These are 261.9 mm in 5-year recurrence, 338.3 mm in 10-year recurrence, 423.4 mm in 20-year recurrence, 553.0 mm in 50-year recurrence and 666.4 mm in 100-year recurrence.

5.2 Flood Runoff Analysis

Using the abovementioned probable rainfall and employing SCS (Soil Conservation Service, US) unit hydrograph method, flood hydrograph is computed. These are 120 m3/s in 5-year recurrence, 250 m3/s in 10-year recurrence, 420 m3/s in 20-year recurrence, 720 m3/s in 50-year recurrence and 1,020 m3/s in 100-year recurrence.

5.3 Design Flood Discharge

Safety level shall be set at 100-year recurrence as ADB proposed. Furthermore, design flow capacity for the bridge structure shall be planned at 50-year flood level following the design standard in Japan. Matching this design direction, the design flow capacity of Teouma Bridge could be set at 720 m3/s and the design floodwater depth along the flood-proofing road shall be set at 1.1 m in depth. This situation could result in attaining 100-year safety level.

5.4 Hydraulic and Hydrologic Designing

The following hydraulic and hydrologic designing is made for river improvement works around Teouma Bridge and flood-proofing road.

(1) River Improvement Works

- Channel excavation for smoothing with earth slope of 1:3 along the left bank,
- Bank protection works with slope of 1:1 along the right bank, and

- Design channel dimension: bottom width of 40 m, water depth of 5.5 m, flow area of 280 m2, free board of 1 m and channel top width of 66 m.

(2) Flood-proofing Road

- Maximum overflow depth of 1.09 m, flow area of 168 m2 and average overflow velocity of 1.49 m/s.

6. Teouma Bridge Restoration Plan

6.1 Basic Component

Teouma Bridge restoration plan consists of three components as follows. River and bridge improvements shall be set at flood scale of 50-year recurrence, and flood-proofing road shall be cope with overbanking floodwater in 100-year recurrence. As a result, these structural components could attain 100-yaer safety around Teouma Bridge as a whole.

- River improvement with bank protection
- Bridge improvement with bridge extension
- Road improvement with flood-proofing road

6.2 River Improvement

Basic designing concept is described in 5.4, and river stretch to be improved is 300 m in the upper part of the bridge and 100 m in the lower part. The following three types of the slope protection works are proposed.

- Multi-Staged Steel Bar Gabion Slope Protection
- Steel Sheet Pile and Concrete Slope Protection
- Cobble Stone Masonry Slope Protection

6.3 Bridge Improvement

Through soundness inspection of the existing Teouma Bridge, it is clarified that the bridge structures can continuously utilized for the restoration plan as well. For bridge extension, the following four types are proposed.

- 30 m extension with steel sheet pile and steel bar gabion protection
- 30 m extension with steel bar gabion protection
- 35 m extension with steel sheet pile and steel bar gabion protection
- 35 m extension with steel bar gabion protection

6.4 Flood-proofing Road Improvement

Road stretch of 217 m long shall be improved against overbanking floodwater so that the following two types of improvements are proposed.

- Concrete type
- Stone masonry type

7. Approximate Project Cost and Implementation Schedule

7.1 Estimation of Approximate Project Cost

Basic information/data for the calculation of the approximate construction costs are collected and analyzed. These are major construction materials and goods, major equipment, procurement method of major temporary equipment and utilization of local consultants and contractors, present status of tax exemption for the projects and land acquisition situation including temporary works. Based on the survey results, two different approximate project costs which are A) using local hard limestone aggregates, B) using imported basalt aggregates for concrete and C) using imported basalt aggregates and rubble stones should be prepared and proposed. In the case of A), the estimated cost ranges from 1,480 to 1,730 million JPY, and as to B), it ranges 1,566 to 1,861 million JPY. Meanwhile, in the case of C), it ranges from 1,680 to 1,950 million JPY. According to interview of PWD counterparts, their first priority was given to the structure type of river improvement with sheet pile and concrete slope protection, bridge improvement with sheet pile and steel bar gabion protection, and flood-proofing road improvement with concrete type. The project cost of the selected structure component ranges 1,730 to 1,950 million JPY.

7.2 Implementation Schedule

If this project is implemented with the grant aid from Japan, this project will take long which needs 34 months from the signing of the Exchange of Note until the completion of the project.

8. Environmental and Social Consideration

In the course of the first survey in Vanuatu, natural and social environment, and legal system and related organizations for environmental and social consideration were surveyed. Furthermore, although scoping for the project site was made through field survey and literature research, any specific matters on natural and social environment and large-scale impact parameters could not be found. The encountered issue is land acquisition of areas along the river and ring road for rehabilitation and improvement works including temporary works of the detour bridge. No involuntary resettlement is anticipated. As described above, it can be a key for success projects to solicit consent from owners and leaseholders of lands concerned and facilitate the conveyance.

9. Need, Direction and Adequacy of Cooperation

Need, direction and adequacy of the project could be summarized below.

(1) ADB's Comprehensive Project

The "Cyclone Pam Road Reconstruction Project" funded by ADB and Global Environment Facility (GEF) comprehend this project. Since the reconstruction project covers this project of Teouma Bridge, the both projects shall move forward in step; therefore, the need of this project would be extremely high. As for ADB project, the feasibility study was completed in October 2016, and the construction will be commenced in June 2017. Finally the construction will be completed in June 2018.

(2) Effects to Real GDP

Although the real GDP has been continuously at approximately 2% since 2003, it became -0.8% in 2015 due to Cyclone Pam. The ring road also becomes access roads to tourist spots and they contribute to earn the foreign currency revenue. The reconstruction of Teouma Bridge, resulting in the flood safety improvement on the ring road will bring not only the local economic growth but also the national economic growth expressed some indexes such as the real GDP.

(3) Life of Residents

In Efate Island, the ring road is only one outer loop road and undertakes a big role to support local people for land transportation and their livelihood. Although the cause of disease and death used to be inaccessibility to such facilities, the ring road improved the accessibility dramatically.

10. Recommendations for the Preparatory Survey

10.1 Tasks of Vanuatu Side

In order to start the preparatory survey for reconstruction of Teouma Bridge on the Efate ring road, the Government of Vanuatu should submit the request letter for grant aid and assure the willingness of acceptance of land owners to sell the land for the project. Being triggered by the meeting to announce the project to local residents which will be held by the study team during the second survey in Vanuatu, PWD is expected to assure that the land acquisition is feasible.

10.2 Recommendations for Preparatory Survey

Since this survey aims at collection and compilation of the data related to reconstruction of Teouma Bridge, the basic design in the preparatory survey will be required after this survey. At that time, topographic survey and geological survey for river, bridge and road, and material survey for bridge and road, and EIA and Economic evaluation shall be conducted.

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Abbreviation

ADB	Asian Development Bank
ARF	Area Reduction Factor
ASPBAE	Asia South Pacific Bureau for Adult Education
BBB	Build Back Better
CAP	Environmental Protection and Conservation Act
CBD	Convention on Biological Diversity
CIF	Cost, Insurance and Freight
CPRRP	Cyclone Pam Road Reconstruction Project
CRP	Comprehensive Reform Program
DBST	Double Bituminous Surface Treatment
DEPC	Department of Environmental Protection and Conservation
DGMWR	Department of Geology, Mines and Water
DOF	Department of Forests
DOL	Department of Lands
DSPPAC	Department of Strategic Policy, Planning and Aid Coordination
DTM	Digital Terrain Model
EIA	Environmental Impact Assessment
EMMP	Environmental Monitoring and Management Programme
EMP	Environmental Management Program
EPA	Environmental Planning and Assessment Division
EPCA	Environmental Protection and Conservation Act
ESIA	Environmental and Social Impact Assessment
FAO	Food and Agriculture Organization of the United Nations
FOB	Free On Board
GDP	Gross Domestic Product
GHG	Greenhouse Gas
IEE	Initial Environmental Examination
IFC	International Finance Corporation
IMF	International Monetary Fund
JICA	Japan International Cooperation Agency
JPY	Japanese Yen
MALFFB	Ministry of Agriculture, Livestock, Forestry, Fisheries and Biosecurity
MCA	Millennium Challenge Account Project
MCC	Millennium Challenge Corporation
MDG	Millennium Development Goals
MFEM	Ministry of Finance and Economic Management
MIA	Ministry of Internal Affairs

MIPU	Ministry of Infrastructure and Public Utilities
MOL	Ministry of Lands and Natural Resources
NDMO	National Disaster Management Office
NGO	Non-Governmental Organization
OP	Operational Policy
PAA	Priorities and Action Agenda
PEA	Preliminary Environmental Assessment
PMO	Prime Minister's Office
PNG	Papua New Guinea
PPU	Physical Planning Unit
PRIF	Pacific Region Infrastructure Facility
PWD	Public Works Department
RAP	Resettlement Action Plan
ROW	Right of Way
SCS	Soil Conservation Service
TOR	Terms of Reference
USD	U.S. Dollar
VAT	Value-Added Tax
VEPAC	Vanuatu Education Policy Advocacy Coalition
VFD	Vanuatu Fisheries Department
VISIP	Vanuatu Infrastructure Strategic Investment Plan
VMGD	Vanuatu Meteorology and Geo-Hazards Department
VT	Vatu
WB	World Bank
WHO	World Health Organization
WPRO	Western Pacific Region
WPZ	Water Protection Zone

Chapter 1 Introduction

1.1 Background

Teouma Bridge constructed under "The project for rehabilitation of bridges on the ring road in the Efate Island in the Republic of Vanuatu" (completed in 2005) closed to vehicle traffic for six days due to the damages on Teouma Bridge caused by Cyclone Pam of the Category 5 in March, 2015. At present, the traffic has been secured by an emergency measure by the Government of Vanuatu. However for further rehabilitation, Vanuatu government faces the difficulty in securing human and financial resources for covering all rehabilitation works of the damages caused by Cyclone Pam.

Teouma Bridge, as mentioned above, has been constructed with the grant aid from Japan in 2005 and planned and designed with the following backgrounds.

- Essential restoration from the condition of emergent restored Teouma Bridge should be completed quickly.
- Quick restoration was taken on top priority so that the project was designed avoiding the land acquisition along the river and the road.
- As a result, the principal design condition is that the elevation of the surface of the pavement on the bridge could not be higher than the one of the approach road and should have been as low as it could be.

In such a manner, Teouma Bridge was restored with the limitation of the time and insufficient safety for flood, then faced Cyclone Pam. Cyclone Pam brought the heaviest downpour, and caused big flood of the Teouma River basin as well as Efate Island. The river course changed intensively as progress of channel meandering resulting in widening the river course compared to it at the time of bridge construction. As a result, river water directly hit the abutment on the right bank and scoured the bottom of the abutment. And now, the bridge is under a very fragile condition to the heavy rain and can be easily damaged in the cyclone season every year even though the urgent rehabilitation measures have been done. In addition, It has been revealed that the approach road of the bridge have a high possibility of scouring of the embankment to block the traffic due to forming the bottleneck along Teouma River and necessity of the study on the river improvement and the extension of the bridge. Considering the frequent morphological changes of the river course, further detailed river morphological classification and hydro-hydraulic analysis are required for the rehabilitation of the bridge and the river improvement. Therefore, in this time, the data collection survey to study and determine the direction of the bridge reconstruction and river improvement in coordination with the Government of Vanuatu will be conducted.

1.2 Objective

This project conducts river morphological classification by stereoscope device based on the satellite images and prepares river chronological change and micro-topography classification map for Teouma River around Teouma Bridge in Efate Island in Vanuatu. The safety degree, potential risk and its possible measures shall be examined. In addition, the estimate of probable flood discharge and hydro-hydraulic analysis to grasp the

flood phenomenon shall also be conducted. Based on these studies and analysis, river, bridge and road improvement plan shall be studied. Furthermore, necessity and direction of future's cooperation shall also be studied in corporation with the Government of Vanuatu.

1.3 Scope

The scope of the Study includes:

1) Review of Existing Data and Reports
2) Preparation of Inception Report
3) Explanation and Discussion of Inception Report
4) River Morphological Classification
5) Hydro-Hydraulic Analysis
6) Bridge Soundness Inspection
7) Study on River Improvement Plan
8) Study on Bridge Improvement Plan
9) Study on Road Improvement Plan
10) Data Collection on Procurement
11) Data Collection and Analysis on Environmental and Social Considerations
12) Study on overall Teouma Bridge Restoration Basic Plan
13) Study on the Direction of Japan's Cooperation Schemes
14) Preparation of Summary Report on Results of 1st Survey in Vanuatu
15) Preparation of Draft Data Collection Survey Report
16) Presentation and Discussion of Draft Data Collection Survey Report
17) Preparation of Final Report

1.4 Study Implementation Schedule

The Study will be undertaken from July 2016 to January 2017.

1.5 Study Organization

The study team members are listed below.

Kanehiro MORISHITA	Team Leader / River Planning (1) / Restoration Plan
Satoshi TAKATA	Deputy Team Leader / River Planning(2) / River Improvement Plan
Lamsal KHADANANDA	Hydro-Hydraulic Analysis
Minoru MIURA	Road and Bridge Improvement Plan
Yoshihisa NODA	Procurement Plan / Approximate Project Cost
Takayuki HATANO	Environmental and Social Considerations

Chapter 2 National Development Plan

2.1 National Development Plan

As a long-term comprehensive framework for the welfare improvement and in order to achieve the Comprehensive Reform Program (CRP), Priorities and Action Agenda (PAA) formulated in 2003 was revised in June 2006 with the target year from 2006 to 2015 saying the national vision as "An Educated, Healthy and Wealthy Vanuatu ".

Reflecting environmental vulnerability due to climate change, increase of young generation and unemployment, minimum progress on gender equality, PAA is again revised in February 2013 and the national vision is also changed to “a Just Educated, Healthy and Wealthy Vanuatu.”

The 2006 PAA explains the progress on PAA as:

- Extreme well economic growth in recent years brings significant increases in real per capita incomes.
- Tourism and construction have driven this growth but it has been concentrated in a few urban centers of the country.
- The share of agriculture, fishing and forestry in national income has declined reflecting the low growth in this sector and the much faster growth in urban centered tourism and construction.
- Vanuatu is achieving the progress in reducing poverty and in improving maternal mortality and is ‘on track’ for reducing child mortality, combating HIV/AIDS and other diseases. However, Vanuatu is ‘off track’ in promoting gender equality and in ensuring environmental sustainability.
- Much legislation was passed to put structural reforms into effect for MDG. However, there has often been a lack of capacity to implement many of these reforms.
- Reforming the aviation and telecommunication sectors was successful and tourism has grown largely because of it. Despite these successes, the necessary infrastructure is not yet in place to reduce costs of bringing goods to domestic markets and for export markets.

The PAA identifies seven Strategic Priorities to achieve the national Vision. The Strategic Priorities are:

- Private Sector Development and Employment Creation
- Macroeconomic Stability and Equitable Growth
- Good Governance and Public Sector Reform
- Primary sector development, environment, climate change, and disaster risk management
- Provision of Better Health Services, especially in rural areas
- Education and human resource development
- Economic Infrastructure and Support Services

Presently, new national strategic development plan (2016 to 2030) is under the work of compiling.

2.2 Road Sector Development in Priorities and Action Agenda

PAA proposes “Properly rehabilitate and maintain the road network”, “Improve road administration by amending the road and land transport” and “Review the Infrastructure Master Plan, priorities projects and only construct new roads when economic benefits have been demonstrated” as the strategies in Land Transport Section.

Chapter 3 Socio-Economic and Natural Condition at Project Area

3.1 Socio Economic Condition

3.1.1 Population

(1) Population in Urban Area and Rural Area

Table 3.1-1 shows the urban and rural population in Vanuatu in 2009.

The ratio in urban population is at 24.4% and the one in rural area is at 75.6%. Population growth rate in the urban area is at 3.5% and it is higher than the one in rural area, which is 1.9%.

Table 3.1-1 Population in Urban Area and Rural Area in 2009

Item	Population	Population Density (people/km^2)	Population Growth Rate (%)
Vanuatu	234,023	19	2.3
Urban Area	57,195	—	3.5
Rural Area	176,828	—	1.9

Source: "2009 National Population and Housing Census (Analytical Report Volume 2)", Vanuatu National Statistics Office

(2) Population by Province

Population in 6 provinces is shown in Table 3.1-2. Project area is located in Efate Island in Shefa Province. The population in Shefa Province is at 78,723 in 2009, covers 33.6% of the total population and has the largest population among 6 provinces. Population density of 52 people/km^2 and population growth rate of 3.7% are also the highest among those.

Total population of Shefa Province which has Port Vila as the capital and Sanma Province which has the second largest city, Luganville in Vanuatu is at 124,578 in 2009 and it becomes 53.2% of the total population in Vanuatu. This implies the tendency of concentration of population in urban area.

Table 3.1-2 Population by Province in 2009

Province	Population	Population Density (people/km^2)	Population Growth Rate (%)
Vanuatu	234,023	19	2.3
Torba	9,359	11	1.9
Sanma	45,855	11	2.4
Penama	30,819	26	1.5
Malampa	36,727	13	1.2
Shefa	78,723	52	3.7
Tafea	32,540	20	1.1

Source: "2009 National Population and Housing Census (Analytical Report Volume 2)", Vanuatu National Statistics Office

(3) Population and Household by Area Council in Efate Island

Population and the number of households in 11 Area Council in Efate Island in 2009 is shown in Table 3.1-3.

Efate Island has 68,458 populations in 2009. It accounts for 29.3% of the total population of Vanuatu and 87.0% of the one of Shefa Province.

The population in Port Vila, which is the exclusive developed city, is at 44,039 in 2009 with high concentration up to 64.3% of total population in Efate Island. It also has 13,809 households, which is at 65.9% of total number of households in Efate Island and these explain the extreme urbanization.

Table 3.1-3 Population and Household in Efate Island in 2009

Area Council	Population	Households	Population Distribution (%)	Household Distribution (%)
Efate Island with Surrounding Islands	68,458	13,809	100.0	100.0
Efate Island	65,790	13,247	96.1	95.9
Port Vila	44,039	9,097	64.3	65.9
Erakor	5,602	1,057	8.2	7.6
Eratap	4,466	855	6.5	6.2
Eton	1,616	347	2.4	2.5
Malarua	1,325	289	1.9	2.1
North Efate	2,762	477	4.0	3.4
Mele	3,594	675	5.3	4.9
Pango	2,386	450	3.5	3.3
Surrounding Islands	2,668	562	3.9	4.1
Ifira	811	147	1.2	1.1
Nguna	1,255	300	1.8	2.2
Emau	602	115	0.9	0.8

Source: “2009 National Population and Housing Census (Analytical Report Volume 2)”, Vanuatu National Statistics Office

(4) Distribution of Resident along Road in Efate Island

Distribution of residents along road in Efate Island in 2009 is shown in Figure 3－1.

24,419 people and 4,712 households in 10 Area Councils excluding Port Vila from totaling 11 Area Council, which is 35.7% of total population (68,458) and 34.1% of total households (13,809) in Efate Island and surrounding islands mostly exists along the ring roads or those feeder roads.

Efate Island has a ring road and its feeder roads. Most of the residents lives along those and utilize the roads for the land transportation. Especially, the roads are essential for transporting agricultural crops, animal products and marine products from rural areas to urban areas and commodities from urban areas to rural areas. In addition, the roads are utilized for accessing to the markets, schools, hospitals and public transportations. The ring road also has a function as an access road to several resort areas along it and a lot of tourists use it. Hence, the ring road contributes to the tourism in terms of acquisition of foreign currencies.

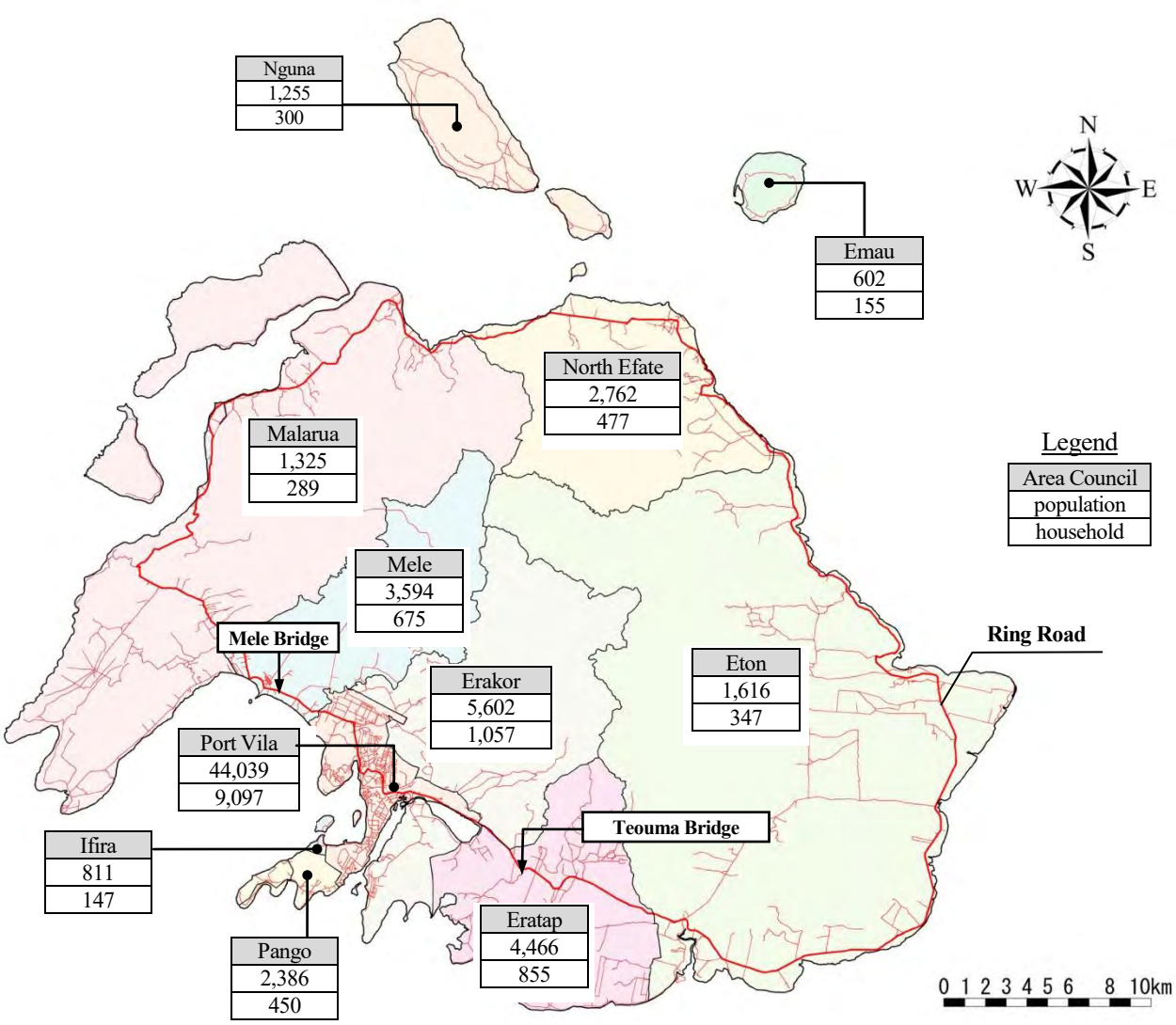


Figure 3－1　Distribution of Population and Household along Road in Efate Island in 2009

3.1.2　Economic Indicator

(1)　Consumer Price Index

Consumer Price indexes in Vanuatu from 2006 to 2016 were shown in Table 3.1-4 with the ones in Port Vila and Luganville. All indexes show the similar price escalation tendencies.

Table 3.1-4　Consumer Price Index from (2006 to 2016)

(year 2000 = 100)

	2006	2007	2008	2009	2010	2011	2012	2013	2014	2015	2016
Average in Vanuatu	116.3	120.8	126.7	132.1	135.4	137.0	138.8	140.8	142.0	145.5	145.9
Port Vila	116.1	120.6	126.1	131.5	135.1	136.7	138.6	140.6	141.7	145.9	146.0
Luganville	117.1	122.4	129.4	134.7	136.7	138.2	139.9	142.1	143.2	143.3	145.4

Source: Vanuatu National Statistics Office

(2) Real GDP

Real GDPs from 2001 to 2015 are shown in Table 3.1-5. Since 2003, the real GDPs show the positive growth in every year and are approximately 2% in last 5 years.

Table 3.1-5 Real GDP from 2001 to 2015

Year	2001	2002	2003	2004	2005	2006	2007	2008
GDP (100 million VT)	414	392	409	426	448	486	511	544
Growth Rate	-	-5.20%	+4.29%	+3.99%	+5.31%	+8.46%	+5.17%	+6.45%
Year	2009	2010	2011	2012	2013	2014	2015	-
GDP (100 million VT)	562	571	578	589	600	614	609	-
Growth Rate	+3.31%	+1.63%	+1.22%	+1.76%	+1.97%	+2.33%	-0.80%	-

Source: IMF

3.1.3 Import and Export

Imports and exports in Vanuatu are shown in Table 3.1-6. Exports are much larger than imports.

Table 3.1-6 Imports and Exports in Vanuatu

(Unit: million VT)

Year	1985	1995	2005	2010	2012	2013	2014	2015
Imports	70	95	149	285	296	313	313	367
Exports	31	28	38	49	55	39	63	39
Gap of Above	-39	-67	-111	-237	-241	-275	-250	-328

Imports in CIF, Exports in FOB, Source: Statistical Yearbook 2016 edition, Fifty-ninth issue, United Nations

According to the website of Ministry of Foreign Affairs in Japan, major trading goods and those major trading partner countries are as follows.

- Export Goods: Copra, wood, Kava, beef, cocoa
- Export Partner Countries: Thailand, Japan, Malaysia
- Import Goods: General Machinery, Transportation Equipment, Food, Daily Necessities
- Import Partner Countries: China, Japan, Singapore

3.1.4 Tourism

Number of international tourists coming to Vanuatu and their expense in Vanuatu are shown in Table 3.1-7. Although the number of the international tourists since 2010 is almost flat, the expense is about equivalent to the imports in Vanuatu.

Table 3.1-7 International Tourists Coming to Vanuatu and Tourist Expense

(Unit: thousand people, million VT)

Year	1995	2005	2010	2012	2013	2014
Tourist	44	62	97	108	110	109
Tourist Expense	-	104	242	268	314	284

Source: Statistical Yearbook 2016 edition, Fifty-ninth issue, United Nations

3.1.5 Poverty

Vanuatu Hardship and Poverty Report, compiled in 2013 with the assistance of United Nations Development Programme describe the poverty conditions in Vanuatu, Port Vila and Luganville with several indexes such as "Food Poverty", "Basic Needs Poverty and Vulnerability to Poverty" and "Poverty Gap Index and Squared Poverty Gap Index".

(1) Food Poverty

Food Poverty in Vanuatu in 2010 is about a half of the one in 2006 and it shows some improvement. This is due to the strong economic growth and increase of household produced food from 2006 to 2010. However, the food poverty in Luganville is oppositely increased.

Table 3.1-8 Food Poverty

(Unit: %)

	Household		Population	
	2006	2010	2006	2010
Average in Vanuatu	6.0	2.7	7.4	3.2
Port Vila	4.7	2.2	5.4	2.8
Luganville	2.2	6.0	2.2	8.2
Rural Area	5.1	2.0	6.6	2.6

Source: Vanuatu Hardship and Poverty Report, 2013

(2) Basic Needs Poverty and Vulnerability to Poverty

Basic Needs Poverty in Vanuatu shows the similar amount in 2006 and 2010. In Port Vila, improvement of approximately 2% can be observed. Contrarily, the one in Luganville is climbing up as Food Poverty.

Table 3.1-9 Basic Needs Poverty

(Unit: %)

	Household		Population	
	2006	2010	2006	2010
Average in Vanuatu	10.3	10.7	13.0	12.7
Port Vila	16.3	14.7	20.1	18.4
Luganville	10.4	19.4	12.2	23.6
Rural Area	9.0	8.5	11.5	10.0

Source: Vanuatu Hardship and Poverty Report, 2013

The proportions of the population very vulnerable to becoming poor, which can be defined with per capita expenditure that is 10% or less above the basic needs poverty line are nearly same in 2006 and 2010, from 3.0% to 3.4%, respectively. There were small increases in Port Vila and rural areas, but a nearly threefold increase in Luganville (6.9% in 2010).

(3) Poverty Gap Index and Squared Poverty Gap Index

Poverty Gap Index describes the depth of poverty and Squared Poverty Gap Index does the severity of poverty. Although Poverty Gap Index in Vanuatu was 5.6% in 2006, it becomes less and only 2.9% in 2010. In Port Vila, similar symptom can be seen. However, in Luganville, Poverty Gap Index rose from

2.9% to 6.4% in the previously referred years.

Squared Poverty Gap Index also shown similar tendency with Poverty Gap Index. Although those becomes small in Vanuatu and Port Vila, relatively sever poverty can be seen in Luganville.

Table 3.1-10 Poverty Gap Index and Squared Poverty Gap Index

(Unit: %)

	Poverty Gap Index		Squared Poverty Gap Index	
	2006	2010	2006	2010
Average in Vanuatu	5.6	2.9	3.0	1.0
Port Vila	10.4	5.4	5.1	2.0
Luganville	2.9	6.4	1.2	2.6
Rural Area	3.8	2.3	2.0	0.8

Source: Vanuatu Hardship and Poverty Report, 2013

3.1.6 New and Annual Registered Vehicle

Table 3.1-11 shows the annual number of newly registered private vehicle from 1996 to 2014 in Port Vila and Luganville. The annual numbers surged from 2004 to 2007 and are almost flat with a little more than 1,000since then.

Table 3.1-11 New and Annual Registered Vehicle

(Unit: nos)

Year	Motorcars	Pick-Ups	Trucks	Bus	Motor-Cycle	Total
1996	169	143	29	48	46	435
1997	137	175	50	42	21	425
1998	242	187	60	77	22	588
1999	195	132	34	49	22	432
2000	164	150	50	99	18	481
2001	162	128	37	39	19	385
2002	152	115	17	31	21	336
2003	131	146	27	40	16	360
2004	175	158	19	25	21	398
2005	233	192	53	100	37	615
2006	243	262	72	85	104	766
2007	340	332	152	138	46	1,008
2008	485	465	169	202	88	1,409
2009	391	385	105	151	86	1,118
2010	380	360	98	209	110	1,157
2011	426	355	68	229	94	1,172
2012	353	329	41	226	77	1,026
2013	350	461	60	243	117	1,231
2014	598	207	44	198	94	1,141

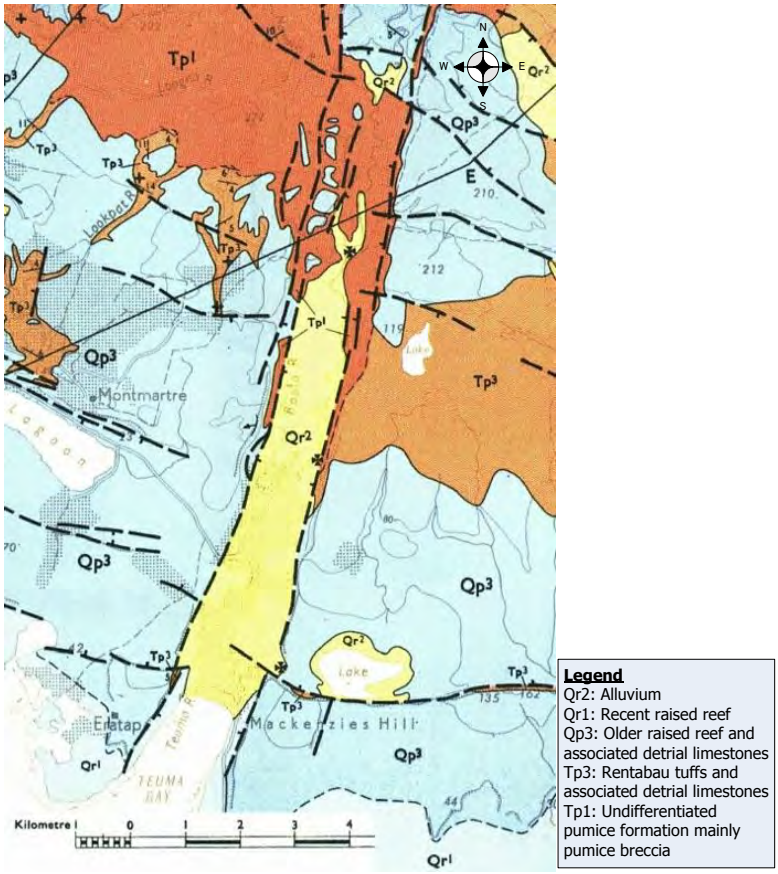
Note; These numbers only show the registered vehicles in Port Vila and Luganville.
Source: Statistical Pocketbook, 2002, 2007, 2011, 2014, Vanuatu National Statistics Office

3.2 Natural Condition

3.2.1 Geography and Geology

Efate Island has a formation of raised limestone terraces and tuff rock. Teouma River has 86 km^2 of catchment area (at Teouma Bridge) and it is the largest catchment area in Vanuatu. The size of the area is

between those of Shakujii River and Kanda River, which is categorized in “medium and small size rivers” in Japan. Teouma River has its source in McDonald Mountain with the top elevation of 662 m, and goes serpentinely in the graben whose width is approximately 1.5 km, sandwiched by limestone terraces as shown in Figure 3－2.



Source: Geology of Efaté and offshore islands, Sheet No. 9, New Hebrides Geological Survey

Figure 3－2　Geological Map around Teouma Bridge

3.2.2 Climate

Vanuatu luxuriates in a tropical maritime climate with characteristic uniform temperature, high humidity and large amount of rainfall. Winds are generally moderate (9.3 km/hr to 18.5 km/hr) except during a tropical storm.

According to Vanuatu Meteorology and Geo-Hazards Department (VMGD) in Ministry of Climate Change Adaptation (MCCA), the climate of Vanuatu can be defined by two main seasons, which is the cold (dry) season from May to October and the hot (wet/cyclone) season for other months. Generally, it is hottest in February and coolest in August. Average annual temperature in Port Vila is at about 25°C, hottest in February at about 27°C and coolest in August at about 23°C.

Rainfall in Vanuatu is highly affected by the geography of the land. The predominant southeast wind-flow is often saturated with moisture and contributes to a highly variable rainfall pattern. Especially it rains hard during La Niña years. Rainfall is particularly high on the southeast of the islands, which is the direction of winds coming, and low on the northwest of the island, which is the direction of winds going. Rainfall on

Efate Island shows this particular pattern. On the windward side, annual rainfall is measured from 2,400 mm to 3,000 mm and is almost half that amount on the leeward side. Generally, rainfall becomes highest from January to March. Flood occurs frequently during the cyclone and La Niña season at the lowland area close to rivers. High rainfall during La Nana sometimes damages crops severely.

Vanuatu is the country on the frequent path of the cyclone which is defined as the storm with the minimum wind speed of 63.0 km/hr (or 34 knots). Two or three cyclones pass Vanuatu every year.

Drought is related to El Niño Southern Oscillation (ENSO) and happens often in rain-shadow areas. Generally, the rainfall in the year of El Niño with negative Southern Oscillation Index (SOI) is less than half of the average annual rainfall. Lately, drought has been observed in 1982/83, 1994/95, and 1997/98. The severest one was in 1993.

Major monthly climate indexes in Port Vila is shown in Table 3.2-1. In the Table, comparing the condition of construction and the rainfall, the wet season is defined starting from December and ending April.

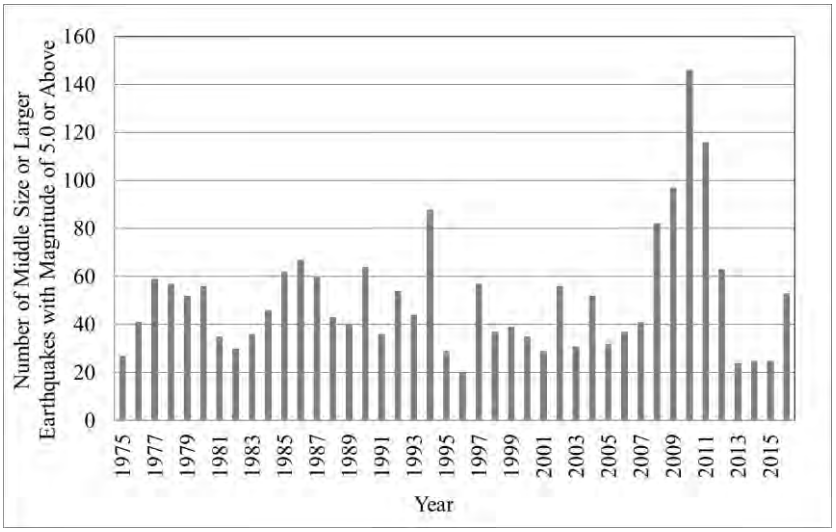
Table 3.2-1 Monthly Climate Indexes in Port Vila

Month	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec
Season	Wet				Dry							Wet
Rainfall (mm)	270	293	323	215	168	161	92	86	90	104	135	191
Min Temperature (℃)	22	22	22	22	20	19	18	17	18	18	20	21
Max Temperature (℃)	31	31	30	29	28	27	26	26	27	28	30	30
Sunshine Hour (hr)	198	172	176	173	169	139	159	180	182	208	200	196
Relative Humidity (%)	84	84	87	87	85	86	85	81	82	82	83	82

Source: Vanuatu Meteorological Services website (www.meteo.gov.vu)

3.2.3 Earthquake

Vanuatu is located on Pacific Plate and raised by Indo-Australian Plate. This is the reason why there are so many earthquakes in Vanuatu. Figure 3－3 shows the number of middle size or larger earthquakes with the magnitude of 5.0 or above, hit Vanuatu since 1975 to September 2016. This figure shows that the middle size or larger earthquake hit 20 times up to 140 times every year. Hence, the preparatory survey expected after this survey should take the seismic design into account.



Data Source: United States Geological Survey

Figure 3－3 Number of Middle Size or Larger Earthquakes with Magnitude of 5.0 or Above around Vanuatu

3.2.4 Damage Caused by Cyclone Pam

Cyclone Pam, classified as “Category 5”, hit Vanuatu in March, 2015. The estimated wind speed and estimated top speed are at 250 km/hr (69 m/s) and at 320 km/hr (89 m/s), respectively. Affected population was at 166,600 and the number of fatalities was 11. Approximate number of damaged houses reached up to 15,000 and nearly 75,000 people were evacuated. Post-Disaster Needs Assessment compiled by EU, UN and more right after the disaster estimated the total economic damage and loss at 48.6 billion VT. It consists of total damage at 29.3 billion VT typified by the damage in housing sector and total economic loss at 19.3 billion VT in agriculture and tourism sector and so on.

Especially, the infrastructure such as roads, bridges, houses, water supply system and sewage system caught damages. Large flows and debris in it caused damage to piers of the bridges, abutments, protection works for abutments, approach roads, causeway and culverts. Pavement of the roads was damaged partially. The damages in the provinces are summarized in Table 3.2-2.

In Efate Island, Cyclone Pam inflicted enormous damage on the ring road. Especially, at Teouma Bridge, the approach road at the right bank was washed away, right abutment and revetment in the upstream and downstream side of the bridge were scoured and approach road at the left bank was submerged. Those damages prevented the traffic for 6 days. The other damages on the structures along the ring road in Efate Island are shown in Table 3.2-3.

Source: JICA Survey Team

Photo 3－1　　Urgently Rehabilitated Teouma Bridge (Upstream View)

Table 3.2-2　　Damage Caused by Cyclone Pam in Province

Province	Damage
Torba	・Not under the path of Cyclone Pam ・Flooding and inundation ・Damages on culverts, roads and airports ・Damage and economic loss is estimated at 10.3billion VT (21% of total)
Sanma	・Not under the path of Cyclone Pam ・Flooding and inundation ・Damages on culverts, roads and airports
Penama	・Under the path of Cyclone Pam ・Disconnection of all traffic ・Disturbance on access to local market, hospital facility and educational facility. ・Damage and economic loss is estimated at 3.0 billion VT (6% of total)
Malampa	・Under the path of Cyclone Pam ・Disconnection of all traffic ・Disturbance on access to local market, hospital facility and educational facility. ・Damage and economic loss is estimated at 2.9 billion VT (6% of total)
Shefa	・Under the path of Cyclone Pam ・Disconnection of all traffic ・Disturbance on access to local market in Port Vila ・Disturbance on access to local hospital facility and local educational facility. ・Damage and economic loss is estimated at 31.9 billion VT (66% of total)
Tafea	・Under the path of Cyclone Pam ・Disconnection of all traffic ・Disturbance on access to local market, hospital facility and educational

Source：　Impact Assessment Report on Efate and Epi Island Transport Infrastructure, ADB
Post-Disaster Needs Assessment, EU, UN, SPC and WB

Table 3.2-3 Conditions of Damages and Proposed Method of Reconstruction

ID	Location	Structure	Damage Condition
BR02	Mele Bridge	Steel Girder, Concrete Slab	Extensive scouring. Eastern approach was washed out and western approach slab was undermined. Both abutments' scour protections failed. Guard fence failed.
BR08	Teouma Bridge	Pony Truss Bridge	Approach washed out on western end and river bank scour.
CT01	Creek Ai Culvert	Pipe Culvert	Western approach was washed out and 50% of the waterway is blocked. Eastern wingwall is cracked and scoured.
CT02	Havannah Culver	Pipe Culvert	Debris blocking the pipe and scour at downstream due to improper road drainage outlet, Damaged guardrails.
BC01	Marona Bridge and Culvert	RC Bridge, Pipe Culvert	Section of the approach washed out and 5 no of bridge curb damaged. Silt built-up inside the pipes.
CT04	Malatia Culvert	Pipe Culvert	Scouring adjacent to the road at north western corner, due to wave action, minor damage to wingwall. Pipes, embankment fill and/or gabions are subsiding, leading to a settlement of the road surface.
CT05	Sara Culvert	Pipe Culvert	Debris blocking waterway. Scour at upstream approach. Wingwall and curb damaged at downstream. Scour around pipe encased concrete. Damaged surfacing.
CT06	Epau Culvert	Pipe Culvert	Gravel built up blocking approximately 30-40% of the waterway in the upstream and gravel deposit in the downstream. Flood gauge dislodged.
CT07	Neslep Culvert	Pipe Culvert	All pipes were found to be substantially blocked. Large scour area on the southern approach.
CT08	La Cressonniere	Pipe Culvert	Debris blocking 50% of the cells and minor scour around downstream. Vegetation overgrowth and nutrient load leading to algae growth.
CT09	Eton Beach Culvert	Box Culvert	Failed guard railing and failed gabion protection on downstream. Damage was mainly due to storm surge.
CT10	Eton Dry Creek Culvert	Box Culvert	Failed guard railing, scoured around gabion protection on downstream and damaged sealed surface. Damage was mainly due to storm surge.
GT01 GT02	Klems Hill land slide and road side drain	Scouring by Surface water	Slope failure occurred above and below the road. The drainage system is partially blocked, exacerbating the effects of the TC Pam rain event.
RD01	Takara Storm Surge Repair	Asphalt Paved Road	Erosion and scouring damage incurred by the pavement with some sections of sealing lost.

Source: Inception Report, Cyclone Pam Road Reconstruction Project (ADB) and Impact Assessment Report on Efate and Epi Island Transport Infrastructure, (ADB)

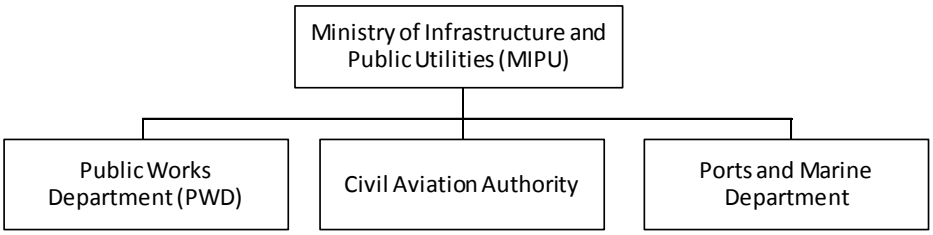
Chapter 4 Transport Sector Overview

4.1 Organization

Ministry of Infrastructure and Public Utilities (MIPU) is in charge of this survey and Public Works Department (PWD) in MIPU is in charge of the implementation of the Project.

4.1.1 Organization Chart (MIPU)

Figure 4－1 shows the organization chart of MIPU. MIPU is responsible for the public infrastructure of the government and strategically decide the direction of the three departments shown in Figure 4－1.



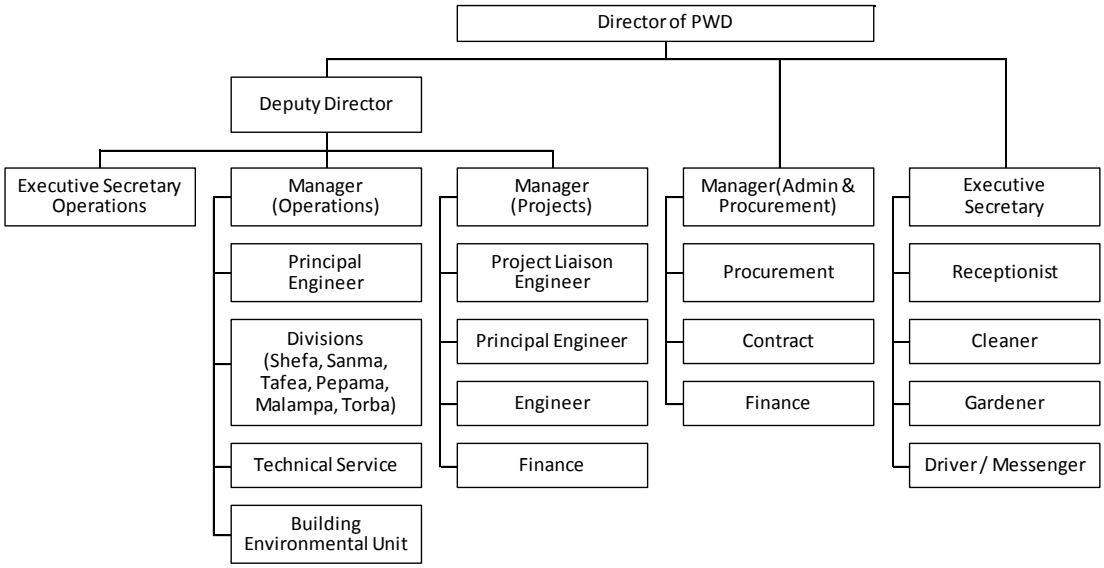
Source: PWD

Figure 4－1 Organization Chart of MIPU

MIPU also manages some public organizations such as Air Vanuatu, Airport Vanuatu, Telecom Vanuatu and Vanuatu Post.

4.1.2 Organization Chart (PWD)

Figure 4－2 shows the organization chart of Public Works Department (PWD). PWD consists of head office and totaling 6 division offices in Shefa, Sanma, Malampa, Tafea, Penama and Torba Provinces. The operation and maintenance of the ring road in Efate Island is handled by Shefa Office.



Source: PWD

Figure 4－2 Organization Chart of PWD

4.2 Road Sector

4.2.1 Strategy in Road Sector

The Government of Vanuatu considers that the road improvement will eliminate economic and social bottlenecks. Concretely, the Government of Vanuatu proposes the following three strategies in PAA.

- Properly rehabilitate and maintain the road network.
- Improve road administration by amending the road and land transport.
- Review the Infrastructure Master Plan, priorities projects and only construct new roads when economic benefits have been demonstrated.

Although the MIPU Corporate Plan 2011-2013 included sealing of 420km and construction of 303km of new roads. MIPU Corporate Plan 2014-2016 omitted these targets. This implies that MIPU selected a focus area on rehabilitation and maintenance of existing roads.

4.2.2 Road Inventory and Pavement

Road inventory is shown in Table 4.2-1 and the pavement conditions are shown in Table 4.2-2. 88% of roads in Vanuatu are a national road and 77% of the all roads are paved. However, asphalt road only account for only 4% of all roads.

Table 4.2-1 Road Inventory in Vanuatu

(Unit: km)

Province	Island	National	Provincial Road	Municipal Road	Total
Total in Vanuatu		1766.6	255.7	2.7	2024.9
Shefa	Efate	192.7	13.0	0.0	205.7
	Nguna	11.0	0.0	0.0	11.0
	Pele	3.0	0.0	0.0	3.0
	Emao	5.0	0.0	0.0	5.0
	Emae	10.0	0.0	0.0	10.0
	Tongoariki	5.5	0.0	0.0	5.5
	Tongoa	37.8	2.0	0.0	39.8
	Epi	59.0	7.0	0.0	66.0
	Sub Total	324.0	22.0	0.0	346.0
Sanma		486.2	129.8	2.7	618.7
Malampa		347.1	46.0	0.0	393.1
Tafea		205.5	6.8	0.0	212.3
Penama		361.8	51.1	0.0	412.8
Torba		42.0	0.0	0.0	42.0

Source: PWD

Table 4.2-2 Pavement Condition in Vanuatu

(Unit: km)

Province	Island	Earth	Gravel	Seal	Total
Total in Vanuatu		400.2	1303.4	72.9	1,776.5
Shefa	Efate	0.0	137.6	55.1	192.7
	Nguna	11.0	0.0	0.0	11.0
	Pele	3.0	0.0	0.0	3.0
	Emao	5.0	0.0	0.0	5.0
	Emae	10.0	0.0	0.0	10.0
	Tongoariki	5.5	0.0	0.0	5.5
	Tongoa	37.8	0.0	0.0	37.8
	Epi	0.0	59.0	0.0	59.0
	Sub Total	72.3	196.6	55.1	324.0
Sanma		6.0	462.3	17.8	486.1
Malampa		119.8	227.3	0.0	347.1
Tafea		30.0	185.5	0.0	215.5
Penama		172.1	189.7	0.0	361.8
Torba		0.0	42.0	0.0	42.0

Source: PWD

In Millennium Challenge Account Project (MCA) funded by the United States, 93km out of totaling 130km of the ring road in Efate Island were paved. This improvement added further weight to the ring road as a principal road. Vanuatu Infrastructure Strategic Investment Plan 2015-2024 (VISIP 2015) also describes the importance of improvement of feeder roads on the ring road to utilize the ring road more actively.

4.2.3 Budget in Road Sector

The summary of budgets for PWD in the last two years are shown in Table 4.2-3. The approximate amount of the annual budget for whole PWD is generally set at 500 million VT and it is divided by the main and 6 division offices. Although items in the budget are defined as shown in Table 4.2-3, the ones in the expense are segmentalized and the budget can be spent flexibly without the border of the items.

The budget item, “Road Repairs and Maintenance” is for relatively small maintenance of roads. The cost for the large scaled rehabilitations such as the one for the damage caused by a Cyclone cannot be covered by this budget and should be funded by foreign aid.

Table 4.2-3 Budget for PWD

(Unit: 1,000 VT)

Office	Item	2014	2015
Shefa Division	Subsistence Allowance	0	3,240
	Outsourcing Contracts	0	16,602
	Vehicle Fuel	0	2,900
	Transport – Freight	0	665
	Equipment Hire	0	24,002
	Road Material	0	11,154
	Road Repairs and Maintenance	105,195	36,650
	Vehicle Repairs and Maintenance	5,599	15,393
	Value Added Tax	0	187
	Overhead Expenses	72,989	108,054
Subtotal at Shefa Division		183,783	218,847
Head Office	(all the above)	100,962	15,535
Sanma Division	(all the above)	118,979	88,702
Malampa Division	(all the above)	46,932	55,188
Tafea Division	(all the above)	40,740	40,740
Penama Division	(all the above)	50,489	64,306
Torba Division	(all the above)	29,682	11,682
Total of Divisions		571,567	495,000

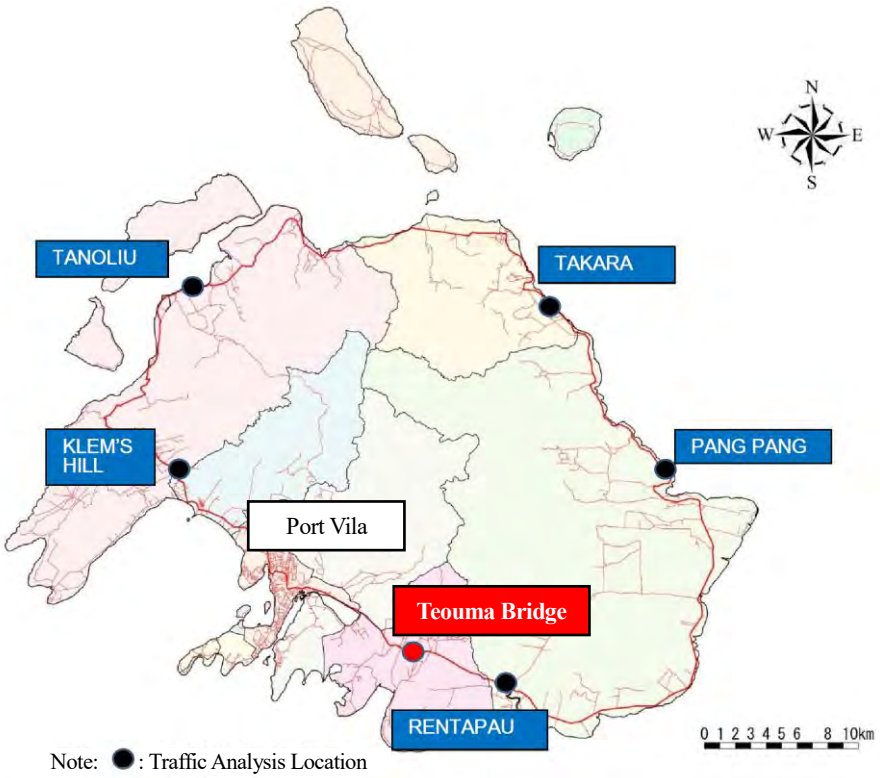
Source: PWD

4.2.4 Location of City, Town and Bridge with Traffic

Locations of cities including Port Vila, towns and Teouma Bridge are shown in Figure 4－3. PWD has conducted the traffic analysis for 4 times between 2008 and 2011, then once in 2016. The points of the traffic analysis are shown in the Figure 4－3 and Figure 4－4 and those results are shown in Table 4.2-4 and Table 4.2-5, respectively.

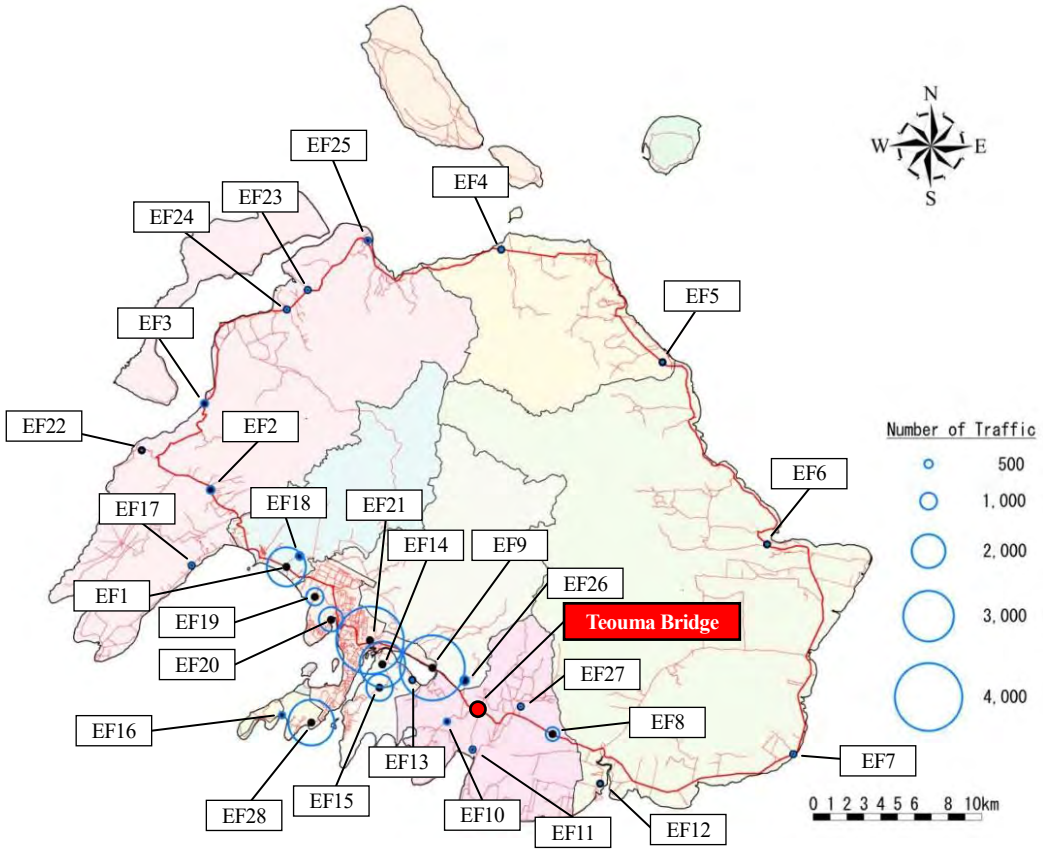
Traffic analysis was also performed in the Basic Design of the Project for Rehabilitation of Bridges on the Ring Road, 2003. The results in 2003 showed that the daily traffic at Teouma Bridge was 817 nos/day and at Rentapau Bridge was 273 nos/day. On the other hand, traffic analysis in 2016 surveyed by PWD did not include the survey at Teouma Bridge and shows that the traffic at adjacent point to Rentapau Bridge was 819 nos/day. Referring to the ratio of the traffic at Teouma Bridge to the one at Rentapau Bridge in 2003 analysis, which is 2.99 (817 / 273 = 2.99), the traffic at Teouma Bridge in 2016 can be estimated at 2,449 nos/day (819 x 2.99 = 2,449) and it shows the recent surge of traffic at Teouma Bridge.

In addition, it was also confirmed in the above mentioned basic design in 2003 that the traffic was rapidly increasing due to the residential and agricultural land development within commutation area of Port Vila near the improved ring road by the Project for Improvement of the Ring Road, 2001 introduced in Clause 4.4.1(1).



Source: JICA Survey Team (Locations for Traffic Analysis from 2008 to 2011 shown in Table 4.2-4)

Figure 4－3　Traffic Analysis Location (2008 to 2011)



Source: JICA Survey Team (Locations for Traffic Analysis in 2016 shown in Table 4－5)

Figure 4－4　Traffic Analysis Location (2016)

Table 4.2-4 Traffic Analysis Result (2008 to 2011)

(Unit: Nos)

When	Klems Hill	Tanoliu	Takara	Pangpang	Rentapau
August, 2008	518 (3,628)	135 (946)	66 (460)	55 (385)	86 (600)
September, 2010	556 (3,891)	321 (2,244)	236 (1,649)	160 (1,122)	345 (2,412)
December, 2010	558 (3,905)	409 (2,864)	200 (1,401)	171 (1,198)	368 (2,573)
February, 2011	527 (3,688)	263 (1,843)	143 (1,004)	129 (906)	283 (1,979)

Note: Upper: average daily traffic, Lower: weekly traffic
Source: PWD

Table 4.2-5 Traffic Analysis Result (2016)

(Unit: Nos/day)

ID	Motor Cycle and Quad Bike	Car, Sedan, Station Wagon	Small commercial (pick-ups, minibuses)	Medium commercial (6 tires, incl. 25 seater bus)	Truck (Single Unit)	Semi - Trailer	Total
EF1 (ring road)	80	426	1,503	309	0	0	2,318
EF2 (ring road)	10	70	325	60	2	0	467
EF3 (ring road)	6	50	302	81	0	0	439
EF4 (ring road)	8	37	110	17	0	0	172
EF5 (ring road)	17	15	70	8	0	0	110
EF6 (ring road)	5	14	99	10	2	0	130
EF7 (ring road)	3	48	152	8	4	0	215
EF8 (ring road)	6	44	735	28	6	0	819
EF9 (ring road)	39	304	3,101	341	53	0	3,838
EF10	4	19	317	23	14	0	377
EF11	3	35	207	23	1	2	271
EF12	3	15	83	0	0	0	101
EF13	0	19	120	1	0	0	140
EF14	41	176	2,302	183	0	0	2,702
EF15	32	89	1,368	59	21	0	1,569
EF16	6	57	231	45	0	0	339
EF17	9	9	206	17	1	1	243
EF18	5	24	353	36	4	0	422
EF19	26	65	927	17	0	0	1,035
EF20	56	300	941	147	0	0	1,444
EF21	316	775	2,239	674	0	0	4,004
EF22	1	7	34	6	0	0	48
EF23 (ring road)	1	21	200	2	0	0	224
EF24 (ring road)	1	24	192	4	0	0	221
EF25 (ring road)	34	64	159	60	0	0	317
EF26	2	15	411	88	0	1	517
EF27	0	2	197	5	2	0	206
EF28	201	1,460	974	70	10	0	2,715

Note: Largest traffic number is shown if the survey point is at intersection.
Source: PWD

4.3 Other Sector

4.3.1 Aviation Sector

Vanuatu has twenty nine airports including three international airports. VISIP 2015 mentions that the airports will be rationalized after the completion of the improvement of roads and inter-island shipping facilities.

PAA proposes the strategy in the aviation sector as follows.

- Ensure adequate maintenance and upgrading of existing domestic airports and airstrips.

4.3.2 Shipping Sector

Vanuatu having a lot of islands depends on water transport. However, insufficient maintenance of the port facilities prevents from effective economic activities on water transport. Especially, such propensity can be seen in remote outer islands where the poverty level is relatively high and populations are dispersed. In order to increase the capacity of inter-islands shipping and building the strategic subsidized shipping routes,

"Interisland Shipping Support Project" is carried by New Zealand and Asia Development Bank (ADB) presently.

The principal all-weather wharves where large cruise ship can lie are in Port Vila and Luganville and the number of the arrival of the cruise ship is surging. In 2012, more than 100 cruise ships were in Port Vila and more than 200 in Vanuatu. However, Vanuatu waters are not well charted and some charts date back to the 19th century. Navigating facilities are also lacking and those factors preventing from the further development.

PAA proposes the strategy in the shipping sector as follows.

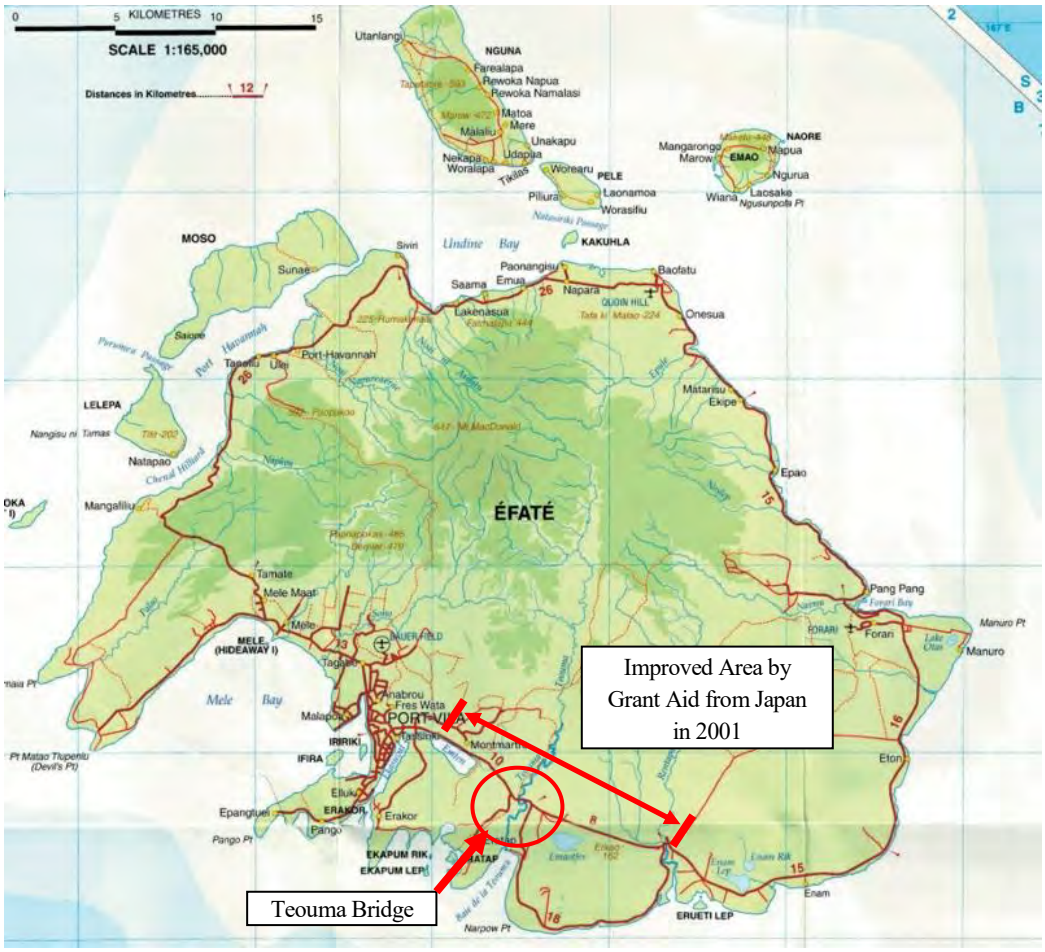
- Maintain and upgrade existing marine infrastructure including storage facilities.

4.4 Road and Bridge Project by Foreign Aid

4.4.1 Grant Aid from Japan

(1) Project for Improvement of the Ring Road (2001)

As shown in Figure 4－5, the outer ring road was constructed in Efate Island and it plays an important role on traffics for Port Vila and other villages. This road mostly used to be unpaved, damaged and weathered especially washed by the high tide along the sea shores. In order to improve this situation, the Government of Vanuatu requested a grant aid from Japan and the improvement of the road with its length of 14.2 km, east side of Port Vila, has been completed in 2001.



Source: JICA Survey Team

Figure 4－5　Improved Area by Grant Aid from Japan in 2001 and Teouma Bridge

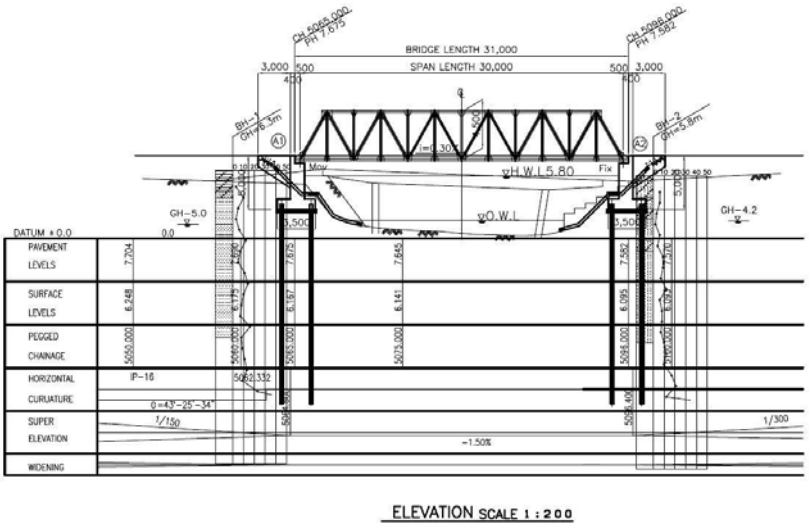
(2) Project for Rehabilitation of Bridges on the Ring Road (2005)

After the improvement of the ring road, in January 2002, a large earthquake with the magnitude of 7.2, its epicenter at 21 km in depth and at 50km away in west of Vanuatu hit Vanuatu. It caused some cracks and slope failure on the road which closed the traffic on the ring road. Teouma Bridge and Rentapau Bridge, which are out of the target of the above mentioned grant aid project in 2001, were also damaged by the earthquake. Those damages were so serious and could not be repaired by the urgent temporary methods that the radical improvement with replacement of the bridges was required. The replacement has been also performed with the grant aid from Japan in 2005.

The length of Teouma Bridge was changed from the original length, 25.34 m to 30.00 m in one span. The concepts of the new bridge are as follows.

- The span of the bridge is set at 30.0m referring to the river width.
- The elevation of the road on the bridge is set as low as it can be considering the negative effect of uplifting the bridge such as enlarging the inundation areas. (despite of the interview result of existing maximum past flood at 6.8 m)

- Considering the above mentioned concept, the elevation of the bottom of the girder is set at 6.8 m, design high water level at 5.8 m with the freeboard at 1.0 m (discharge with water level at 5.8 m is equivalent to the 10-year flood and the one in 6.8 m is to 20-year flood.)
- The elevation of the surface was elevated at 1.5 m, from 6.1 m (original road elevation) to 7.6 m (at the top of the road on the bridge girder) as referred in Figure 4－6.



Source: Basic Design of the Project for Rehabilitation of Bridges on the Ring Road, 2003

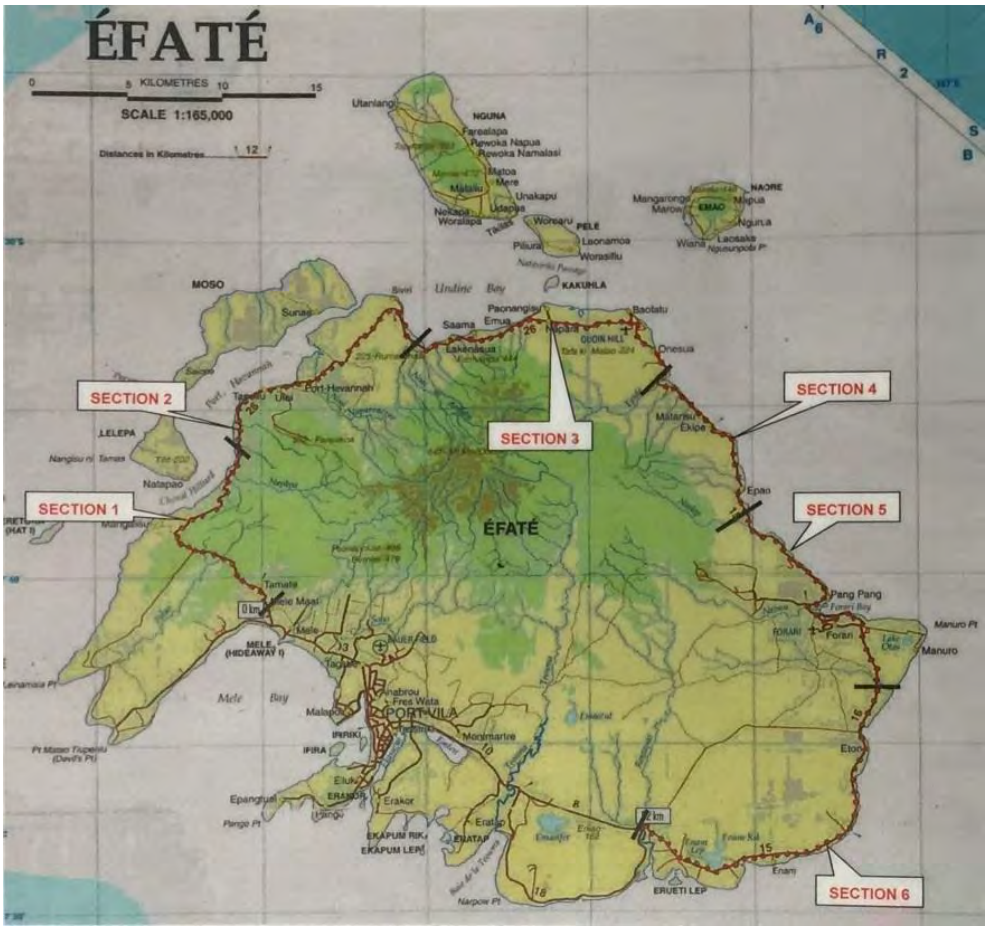
Figure 4－6　Side View of Teouma Bridge

4.4.2　Other Foreign Aid

(1)　Rehabilitation Project by Millennium Challenge Corporation

With the fund of Millennium Challenge Account (MCA) in the United States, Millennium Challenge Corporation (MCC) commenced rehabilitation of the ring road in Efate Island in March, 2006. This project aims to help facilitate poverty reduction through economic growth and the total project cost is at 65.69 million USD.

Especially, in Efate Island, the project aims at improvement of accessibility to major streets, wharves and an airport and finally at economic growth and facilitate investment in the agriculture and tourism sectors. Target area in the project is as shown in Figure 4－7 with improvement at 93km long and the project has been completed in August, 2011.



Source: As-Constructed Records: Modification of Final Design Report, MCA VA02: Efate Ring Road

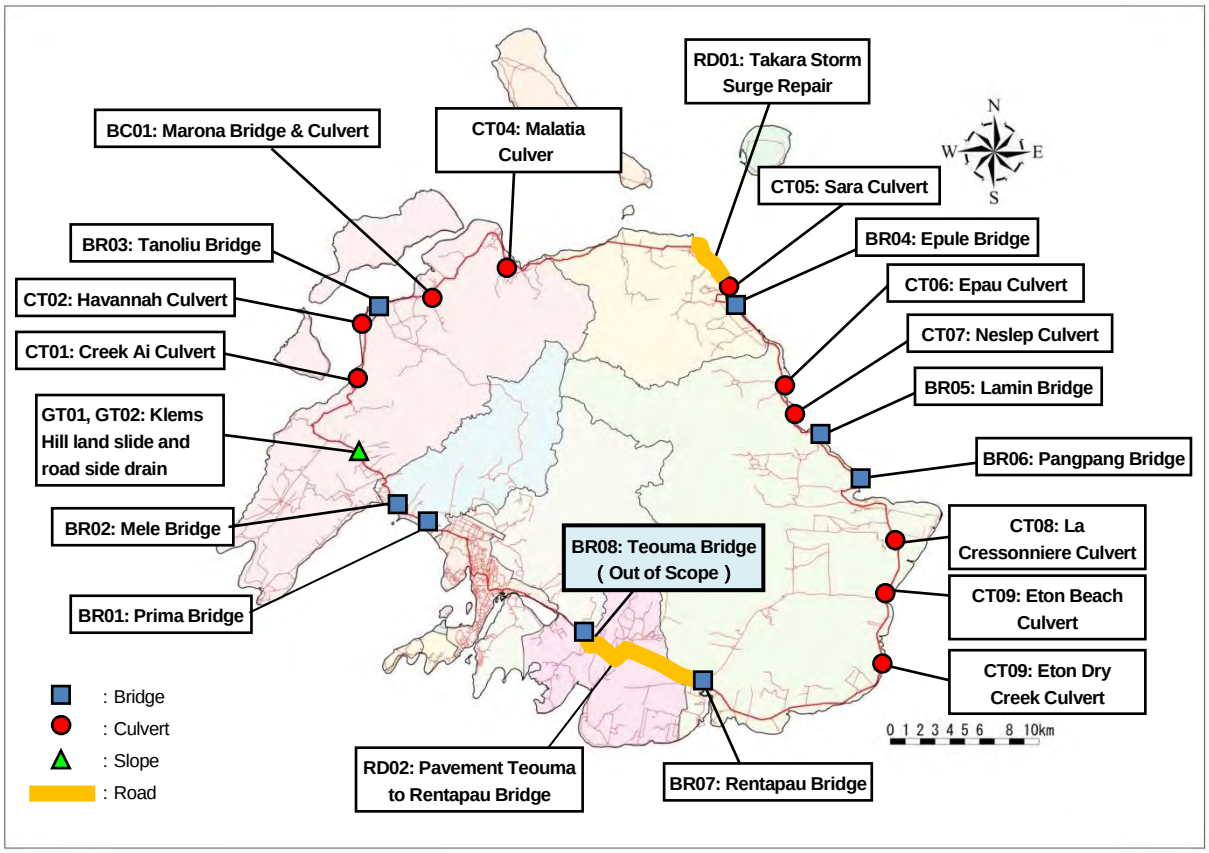
Figure 4－7　Target Area in MCC Project

(2) Reconstruction Project by ADB

While the survey team was in Vanuatu, the inception report for "Cyclone Pam Road Reconstruction Project (CPRRP)" was submitted to PWD by ADB and approved. The purpose of the project is to reconstruct the ring road in Efate Island and rehabilitate the socio-economic activities at the surrounding area up to the level before the damage caused by Cyclone Pam. The target structure for the reconstruction is twenty damaged roads and bridges (reconstruction of Teouma Bridge is out of scope.) The Project cost is estimated at 15.19 million USD and the schedule of the project is as follows.

- March, 2017: Completion of the feasibility study
- June, 2017: Completion of the detailed design
- July, 2017: Commencement of the construction
- June, 2018: Completion of the construction and the Project

Location of the target structures is shown in Figure 4－8 and conditions of damages and proposed methods of reconstruction are shown in Table 4.4-1. The methods of reconstructions in Table 4.4-1 are categorized into A, B and C, with small scale to big scale, respectively.



Source: JICA Survey Team

Figure 4－8　Location of Target Structure

Table 4.4-1 Conditions of Damages and Proposed Method of Reconstruction

ID	Location	Structure	Damage Condition	Reconstruction Method (Summary of OptionA to C)
BR01	Prima Bridge	Bailey Bridge	No notable Cyclone Pam damage. Upstream handrail missing. Guardrail inadequate.	Reconstruction of Revetment and Railing
BR02	Mele Bridge	Steel Girder, Concrete Slab	Extensive scouring. Eastern approach was washed out and western approach slab was undermined. Both abutments' scour protections failed. Guard fence failed.	Reconstruction of Revetment, Addition of Culvert, Reconstruction of Bridge
BR03	Tanoliu Bridge	Steel Girder, Wooden Slab	No notable Cyclone Pam damage. Bridge girders badly corroded. Guardrail length and alignment substandard.	Supporting Work, Reconstruction of Bridge
BR04	Epule Bridge	Bailey Bridge	No notable Cyclone Pam damage.	Supporting Work, Reconstruction of Bridge
BR05	Lamin Bridge	Steel Girder, Wooden Slab	No notable Cyclone Pam damage. Significant corrosion to the girders and damage to the decking.	Supporting Work, Reconstruction of Bridge
BR06	Pangpang Bridge	RC Girder, Concrete Slab	No notable Cyclone Pam damage.	Minor Repair
BR07	Rentapau Bridge	Pony Truss Bridge	No notable Cyclone Pam damage. Scouring on eastern abutment. Sediment deposits on the Ring Road surface.	Minor Repair
BR08	Teouma Bridge	Pony Truss Bridge	Approach washed out on western end and river bank scour.	(Out of Scope)
CT01	Creek Ai Culvert	Pipe Culvert	Western approach was washed out and 50% of the waterway is blocked. Eastern wingwall is cracked and scoured.	Supporting Work, Demolition and Larger Construction
CT02	Havannah Culver	Pipe Culvert	Debris blocking the pipe and scour at downstream due to improper road drainage outlet, Damaged guardrails.	Supporting Work, Demolition and Larger Construction
BC01	Marona Bridge and Culvert	RC Bridge, Pipe Culvert	Section of the approach washed out and 5 no of bridge curb damaged. Silt built-up inside the pipes.	Supporting Work, Demolition and Larger Construction
CT04	Malatia Culvert	Pipe Culvert	Scouring adjacent to the road at north western corner, due to wave action, minor damage to wingwall. Pipes, embankment fill and/or gabions are subsiding, leading to a settlement of the road surface.	Supporting Work, Demolition and Larger Construction
CT05	Sara Culvert	Pipe Culvert	Debris blocking waterway. Scour at upstream approach. Wingwall and curb damaged at downstream. Scour around pipe encased concrete. Damaged surfacing.	Supporting Work, Demolition and Larger Construction
CT06	Epau Culvert	Pipe Culvert	Gravel built up blocking approximately 30-40% of the waterway in the upstream and gravel deposit in the downstream. Flood gauge dislodged.	Supporting Work, Demolition and Larger Construction
CT07	Neslep Culvert	Pipe Culvert	All pipes were found to be substantially blocked. Large scour area on the southern approach.	Supporting Work, Demolition and Larger Construction
CT08	La Cressonniere	Pipe Culvert	Debris blocking 50% of the cells and minor scour around downstream. Vegetation overgrowth and nutrient load leading to algae growth.	Supporting Work, Demolition and Larger Construction
CT09	Eton Beach Culvert	Box Culvert	Failed guard railing and failed gabion protection on downstream. Damage was mainly due to storm surge.	Supporting Work, Addition of Culvert
CT10	Eton Dry Creek Culvert	Box Culvert	Failed guard railing, scoured around gabion protection on downstream and damaged sealed surface. Damage was mainly due to storm surge.	Replacement of Railing, Excavation, Supporting Work on Road Edge and Culvert, Protection of Pavement
GT01 GT02	Klems Hill land slide and road side drain	Scouring by Surface water	Slope failure occurred above and below the road. The drainage system is partially blocked, exacerbating the effects of the TC Pam rain event.	Drainage Improvement, Slope Cut, Anchoring
RD01	Takara Storm Surge Repair	Asphalt Paved Road	Erosion and scouring damage incurred by the pavement with some sections of sealing lost.	Patching (Small Scale to Large Scale)
RD02	Pavement Works -Teouma to Rentapau	Asphalt Paved Road	Surface damage.	Patching (Small Scale to Large Scale)

Source: Inception Report, Cyclone Pam Road Reconstruction Project

Chapter 5 River Morphological Survey

5.1 Necessity and Outline of River Morphological Survey

Teouma River is the largest river basin with a drainage area of 86 km^2 at Teouma Bridge in the Efate Island, which flows down meandering inside a rift valley of about 1.5 km in width. A raised coral reef forms both sides of the valley. According to comparison of changes in river courses of Teouma for 60 years using satellite imagery and aerial photos, vegetation covered along the river courses of about 20 m width as a natural river before Cyclone Pam attacked in 2015. During Cyclone Pam, the river course was widened twice through intensive riverbank erosion. Although Teouma Bridge with a 30 m-span had not any trouble structure for the passage of floodwater before Cyclone Pam, it becomes an artificial constriction due to the river widening. Thus some adequate countermeasures shall be necessary to allow passage of any floodwater smoothly.

Teouma River has changed its river courses frequently not only at Cyclone Pam but also at any past large-scale floods through interpretation with the past satellite imagery provided by Google. These river course changes occurred in a meso-topographic scale compared to small-scale manmade structures such as bridges and local flood control measures, so that underlying risks accompanying with the river morphological changes shall be predicted beforehand and appropriate countermeasures shall be incorporated among the project components. In due consideration mentioned above, the river morphological survey can clarify the following phenomena and facts.

- The chronological changes of the Teouma River course and their causal factors shall be clarified through interpretation of satellite imagery and aerial photos.
- Micro-topography along the river shall be interpreted using stereo-type satellite imagery in order to clarify long-term river morphological changes and flooding characteristics considering micro-topographic elements and their configuration, such as old river courses, back swamp, natural levee, etc.

In this study, the river geomorphological map was prepared through interpretation of stereo-type satellite imagery taken after the Cyclone Pam disaster, and chronological changes of river course was also prepared through overlaying the aerial photos and the satellite imagery taken since 1955. Based on these results, suitability of bridge location and appropriateness of countermeasures against floods shall be validated.

The survey was made by a sub-contract basis and subcontractor visited the site of Teouma River in August 2016 to confirm the interpreted results.

5.2 Materials for Geomorphological Survey

5.2.1 Satellite Imagery in Archives

As tabulated in Table 5.2-1, the chronological change map of river courses was prepared through overlaying the aerial photos and the satellite imagery taken since 1955 after various adjustments.

5.2.2 Stereo-type Satellite Imagery in Archives

In order to interpret geomorphologic components with satellite imagery using a stereo-scope, stereo-type satellite imagery taken on August 23, 2015 after the Cyclone Pam disaster, was purchased from the Archives. It is showed in Table 5.2-1 as well.

Table 5.2-1 Aerial Photos Procured by Ministry of Land and Satellite Imagery from Purchased Archives

Time when Imagery/ Photos were taken	Picture Source	Remarks
1955	Aero-Photo	From Ministry of Land
1972	Aero-Photo	From Ministry of Land
1986	Aero-Photo	From Ministry of Land
1991	Aero-Photo	From Ministry of Land
November 2002	Satellite Imagery in Archives	Quick Bird: 60 cm Resolution
June 2009	Satellite Imagery in Archives	Quick Bird: 60 cm Resolution
August 2013	Satellite Imagery in Archives	World View-2: 50 cm Resolution
August 2015	Stereo-type Satellite Imagery in Archives	World View-2: 50 cm Resolution

Source: JICA Survey Team

5.3 Chronological Changes of River Course

5.3.1 Periodical Changes

The river course changes with floods as a major causal factor between each aerial photos or satellite imagery shots are summarized below. Historical rainfall amount mentioned below is referred to Port Vila station.

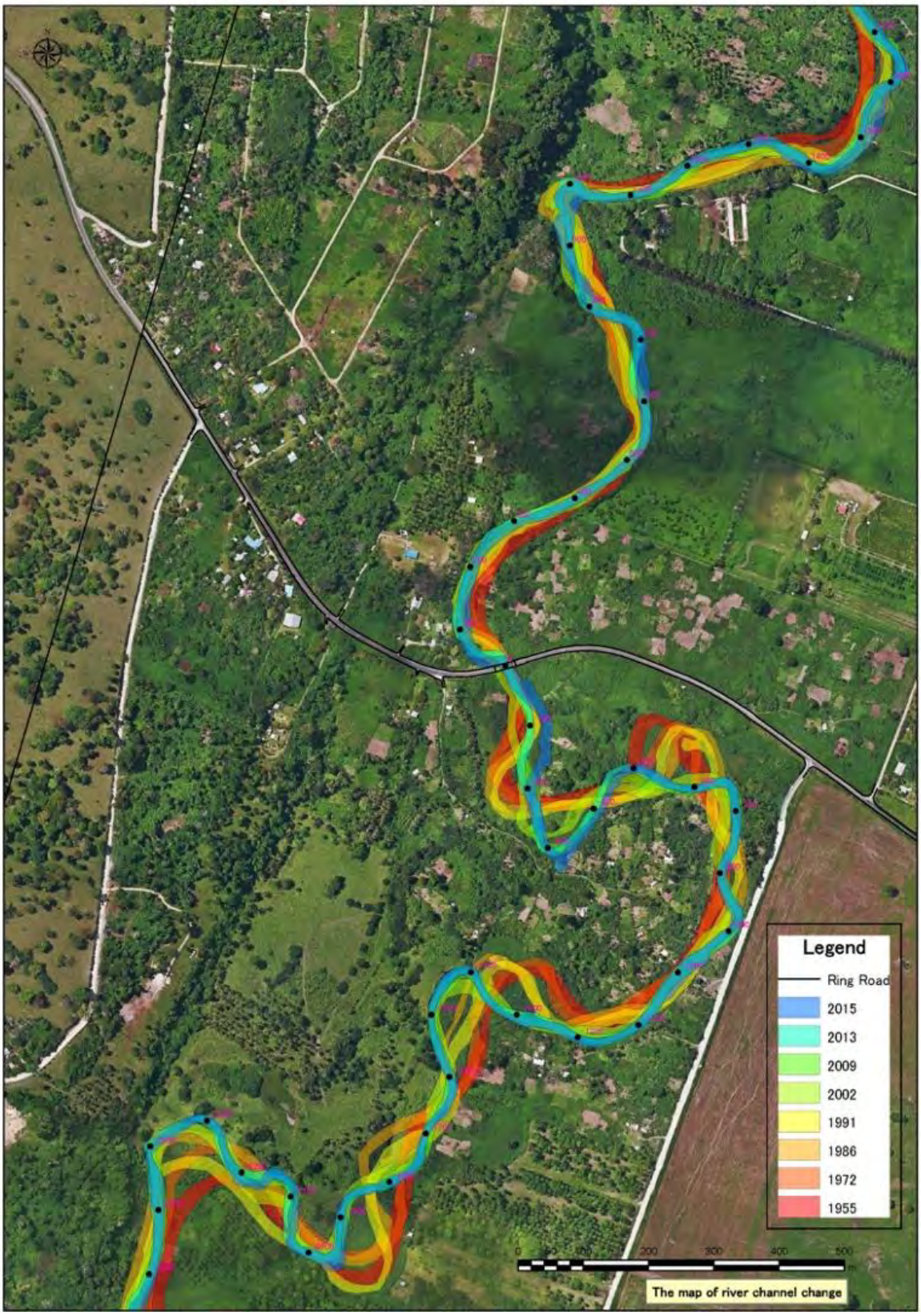
- From 1955 to 1972: for 17 years, river meandering progressed around 500 m downstream of Teouma Bridge. During this period, downpour of around 300 mm/day occurred twice in December 1959 and December 1971.
- From 1972 to 1986: for 14 years, lateral oscillation of the river course progressed towards right bank adjacent upstream of the bridge and river meandering and lateral oscillation progressed as well downstream of the bridge. During this period, long lasting downpour of around 407 mm/5days occurred in April 1985.
- From 1986 to 1991: for 5 years, only small lateral oscillation of river course occurred since significant downpour did not occur in this period.
- From 1991 to 2002: for 11 years, river meandering progressed downstream of the bridge. Three cutoff channels formed, of which they are two cutoff channels within 400 m downstream of the bridge and one at 500 m downstream of the bridge. Former meandering channels remain as an oxbow lake or an old river channel. During this period, downpours of 319 mm/day in May 1993 and 377 mm/day in January 1999 occurred.
- From 2002 to 2009: for 7 years, lateral oscillation of river course and meandering progressed upstream and downstream of the bridge. During this period, medium-scale downpours occurred four times: 369 mm/2days in May 2002, 231 mm/day in February 2004, 265 mm/2days in June 2006, 215 mm/day in April 2007.

- From 2009 to 2013: for 4 years, small lateral oscillation of the river course occurred since downpour of 266 mm/day only occurred in May 2010.
- From 2013 to 2015: lateral oscillation of the river course occurred upstream and downstream of the bridge since intensive downpour of 477 mm/2days occurred in March 2015, accompanying Cyclone Pam.

5.3.2 Chronological Changes of Teouma River Course

Chronological changes of the Teouma River course are depicted in Figure 5－1. The river course frequently meandered or oscillated laterally with Teouma Bridge as a fixed point because of the robust artificial structure whenever large-scale floods occurred. The following are the particular changes of the river course.

- Teouma River flows down meandering inside a rift valley of about 1.5 km in width. A raised coral reef forms both sides of the valley. Averaged slope of the valley is about 0.333% in the upper part from a little downstream of the ring road, while it is about 0.125% in the lower part. Hence, the ring road is located close to the geographic transition point of the valley.
- Due to the above topography, no significant meandering but only lateral oscillation could be found in the upper part.
- Meanwhile, river meandering has occurred significantly in the evolution process of the river from beginning of channel meandering, to progress of meandering, to forming cutoff channel, and finally to resuming of meandering again.



Source: JICA Survey Team

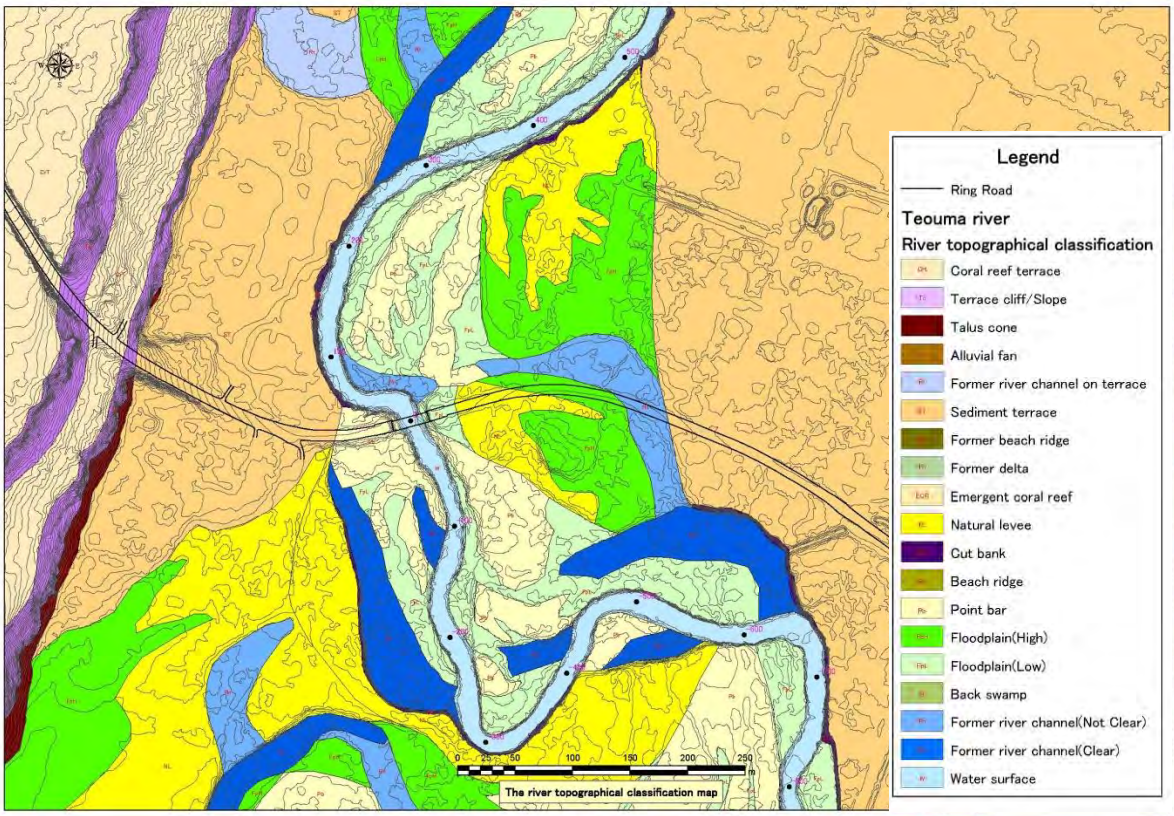
Figure 5－1　Chronological Changes of Teouma River Course from 1955 to 2015

5.4 River Geomorphologic Analysis

5.4.1 Preparation of River Geomorphologic Map

A lower part with the width ranging from 300 m to 500 m exists along the river course inside the valley. In this part, various alluvial microtopographies were formed and developed. These are natural levee, cut bank, higher floodplain, point bar, lower floodplain, backswamp and former river channel, enumerating from the higher elevation.

The formed microtopographies were identified through interpretation of the stereo-type satellite imagery taken in August 2015 as tabulated in Table 5.2-1 and they were confirmed through field survey. Figure 5－2 shows geomorphologic classification along Teouma River.



Source: JICA Survey Team

Figure 5－2 River Geomorphologic Classification Map around Teouma Bridge

5.4.2 Topographic Features around Teouma Bridge

As Figure 5－2 presents, several former river channels can be identified around the bridge. Furthermore, recent trace of meandering is incorporated into the former river channels. Major topographic features around the bridge are summarized below.

- The sediment terrace extends over the rift valley, and the river developed the fluvial microtopographies through fluvial process of erosion, sediment transport, and sediment deposition. The river course changes converge within these areas from the macroscopic views. The sediment terrace, however, consists of erodible soils of sand and clay so that river meandering is progressing through erosion of the terrace along the concave bank immediately upstream of the bridge and 700 m

to 900 m downstream of the bridge.

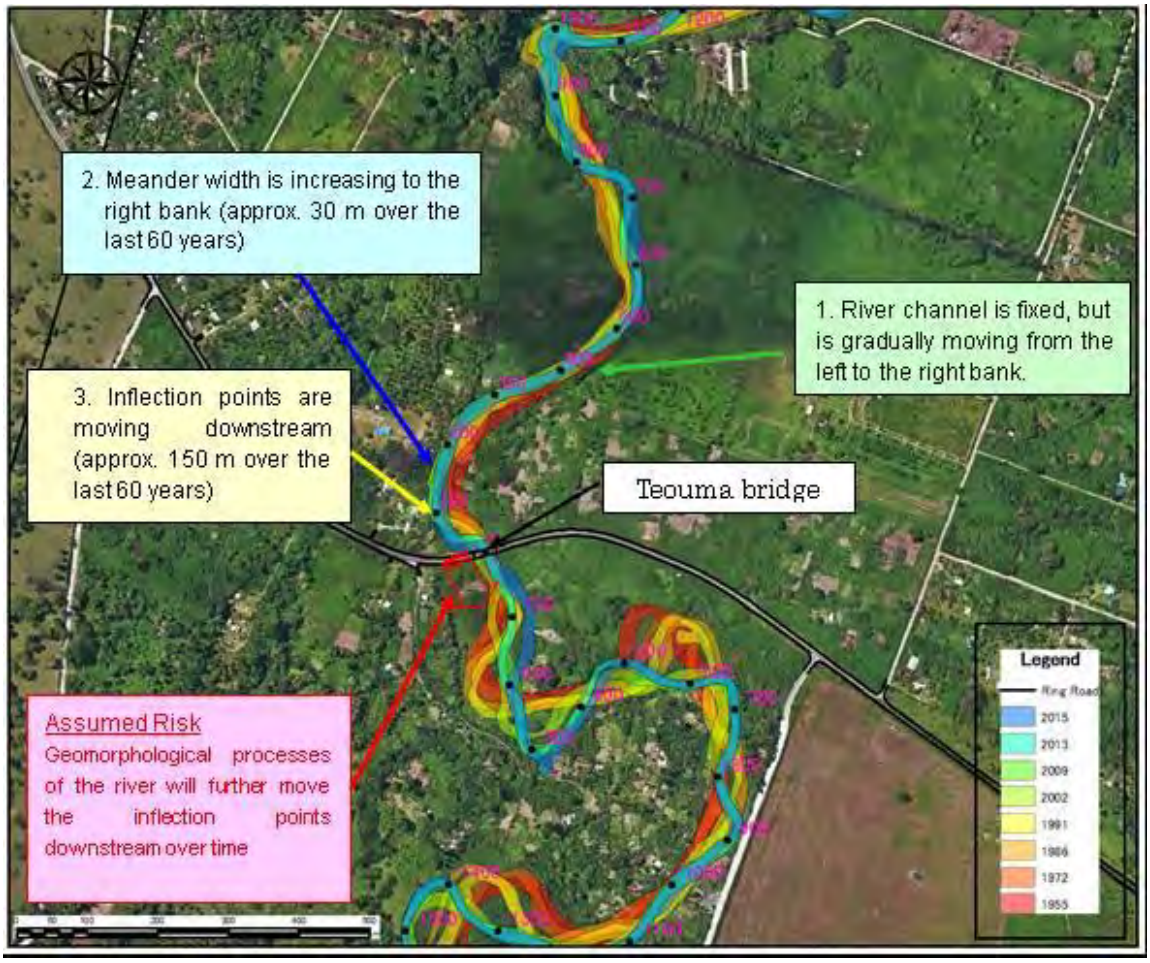
- Some former channels can be clearly identified downstream of the approach road at 50 m of west from the bridge. This fact means that the river flowed down along the more western side in the past. If there is no ring road and the bridge constructed, the river course easily could connect to the former river course.
- The former river channel, though it is unclear, is identified at eastern side of the bridge. This implies that river channel shifting could develop extending towards east and south directions over 90° angles.

As mentioned above, the river geomorphologic analysis is an approach which future possibility on river course changes and flooding situations could be predicted with from the historical fluvial process in the past. Combining chronological changes of river course, risks originated from fluvial process of Teouma River and their countermeasures are deliberated in the following section.

5.5 Risks on River/Flood Disaster and their Countermeasures around Teouma Bridge

5.5.1 Disaster Risks on River Course Change

Emerging disaster risks on river course change are progress of bank erosion along the concave bank and moving-down of inflection point of the immediately upstream bend of the bridge. During Cyclone Pam, earth abutment of the bridge along the right bank was washed away due to the above reason. Figure 5－3 presented these risks.



Source: JICA Survey Team

Figure 5－3　Disaster Risks on River Course Change

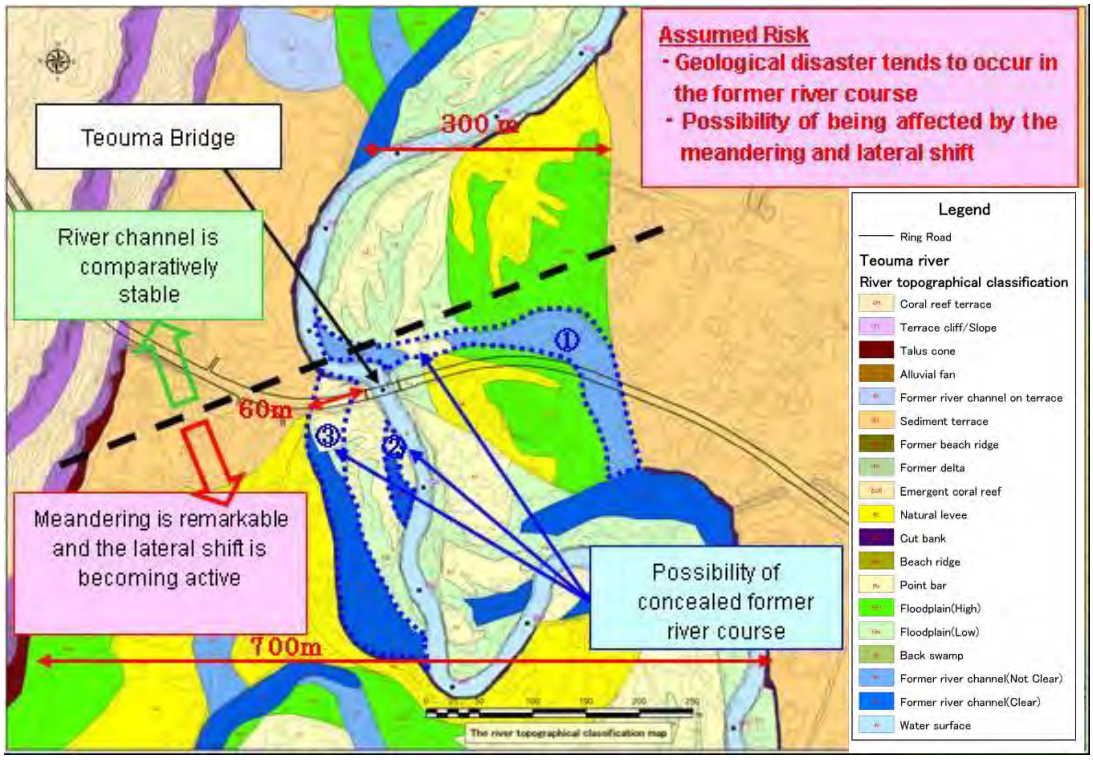
Against these fluvial processes, river improvement works combining bank protection and channel dredging to carry floodwater smoothly and expansion of bridge towards the right bank to improve its artificial constriction of the river course could be proposed as the necessary countermeasures.

5.5.2　Disaster Risks on River Geomorphology

Figure 5－4 summarizes classified river geomorphology and its relevant disaster risks. The disaster risks related to geomorphologic features are enumerated below.

- Segment of the highest risk might be progressive meandering along the right bank immediately upstream of the bridge. The meandering has progressed in parallel with scouring of the sediment terrace and forming cut bank by floodwater. Along the right bank, bank protection works shall be necessary to curb the scouring.
- Although some of the former river channels are unclear upstream of the bridge, there might be a possibility that river channel shifting could develop extending towards east and south directions over 90° angles. In order to control this kind of river course shifting, the above-mentioned bank protection, expansion of bridge to improve its artificial constriction of the river course and channel dredging to carry floodwater smoothly shall be necessary.

・ Furthermore, the floodwater flowed down over the natural levee and higher floodplain of the left bank in the large-scale flood time such as Cyclone Pam or more intensive one. In order to cope with such large-scale floods, flood-proofing measures shall be necessary to protect the ring road and ensure the transport capacity.



Source: JICA Survey Team

Figure 5－4　Disaster Risks on River Geomorphology

Chapter 6 Hydraulic and Hydrologic Analysis

6.1 Rainfall Analysis

6.1.1 Target Rainfall Station

After coming back to Japan, the survey team obtained the following reports regarding the historical rainfall records before 2000. As a result, the following two stations' daily rainfall series were collected.

- 'Cyclone Dani Rehabilitation Project, Rainfall Analysis, January 2000'
- Port Vila Commencement of Observation: 1948 Observation Period: 68 years
  (Data Missing: six years, Consecutive Period: 33 years)
- Bauerfield Commencement of Observation: 1986 Observation Period: 30 years

6.1.2 Filling of Missing Data

For the long time series of the daily rainfall observed at Bauerfield, the most critical part during Cyclone Pam was missing, only observed three days' rainfall due to difficulty to monitor meteorological parameters under such heavy storm. Meanwhile, Port Vila station fortunately observed rainfall during Cyclone Pam as tabulated in Table 6.1-1. Daily rainfall at Bauerfield during Cyclone Pam could be estimated using the data observed at Port Vila, in accordance with a ratio of daily rainfall in 4 days. The allotment ratios are 0.814 (514 mm) on 13th, 0.185 (117 mm) on 14th, 0.001 (1 mm) on 15th, March 2015, respectively.

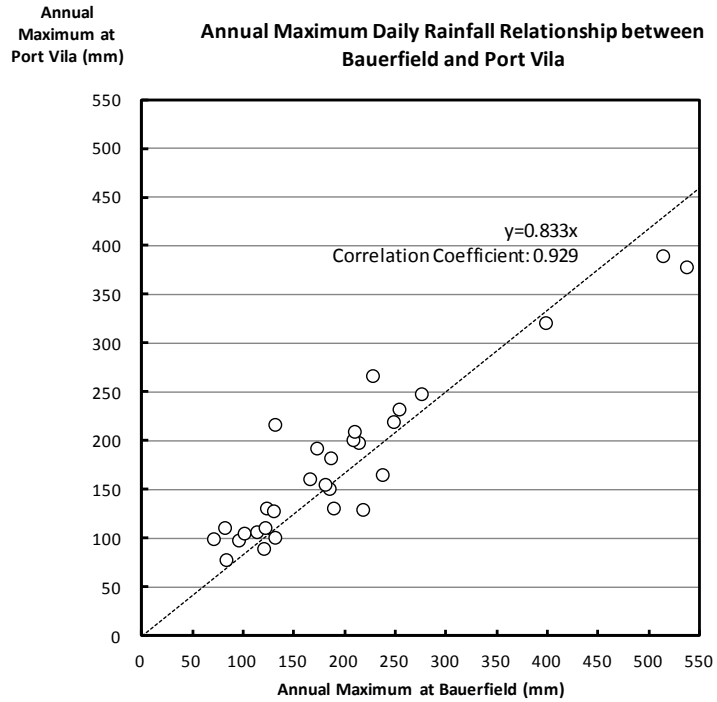
Table 6.1-1 Daily Rainfall Observed during Cyclone Pam

Date in March, 2015	Bauerfield	Port Vila
13	48mm	388.5mm
14	-	88.1mm
15	-	0.4mm
16	584mm	0.0mm
Total	632mm	477.0mm

Source: VMGD

6.1.3 Comparison between Bauerfield and Port Vila

Correlation between Bauerfield and Port Vila for the data period of 1986 to 2015 is depicted Figure 6－1. Both annual maximum daily rainfall data show the high correlation coefficient. Rainfall at Bauerfield is always 1.2 times bigger than the one at Port Vila.



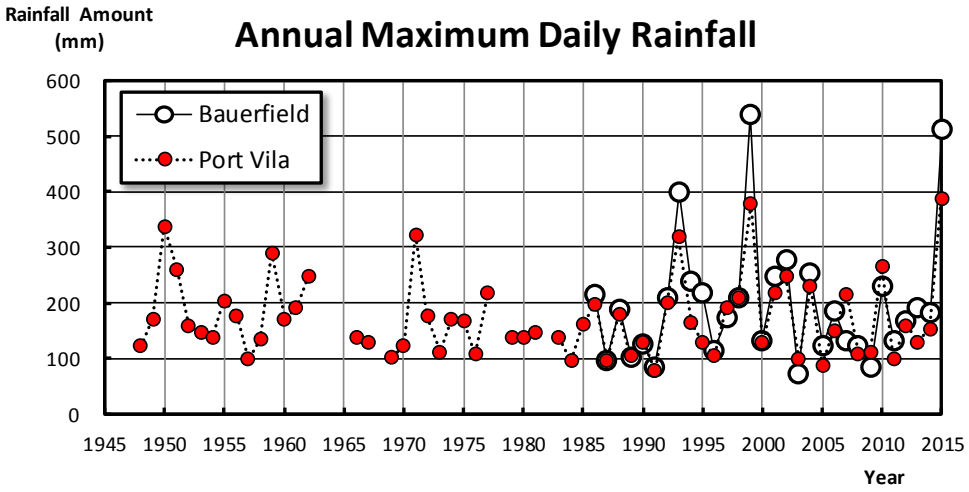
Source: JICA Survey Team

Figure 6－1　Relationship between Bauerfield and Port Vila Stations in Annual Maximum Daily Rainfall

6.1.4　Computation of Probable Daily Rainfall

Collected data are tabulated in Table 6.1-2, and data series of annual maximum daily rainfall at both stations are presented in Figure 6－2. As depicted in the figure, there are missing data period of 6 years at Port Vila so that the following two ways could be taken to compute the probable rainfall.

- After removing six years of data missing, data series for 62 years as regarded as consecutive time series will be analyzed.
- Data series for 33 years after 1983 as regarded as complete consecutive time series will be analyzed.



Source: JICA Survey Team

Figure 6－2　Annual Maximum Daily Rainfall Series at Bauerfield and Port Vila

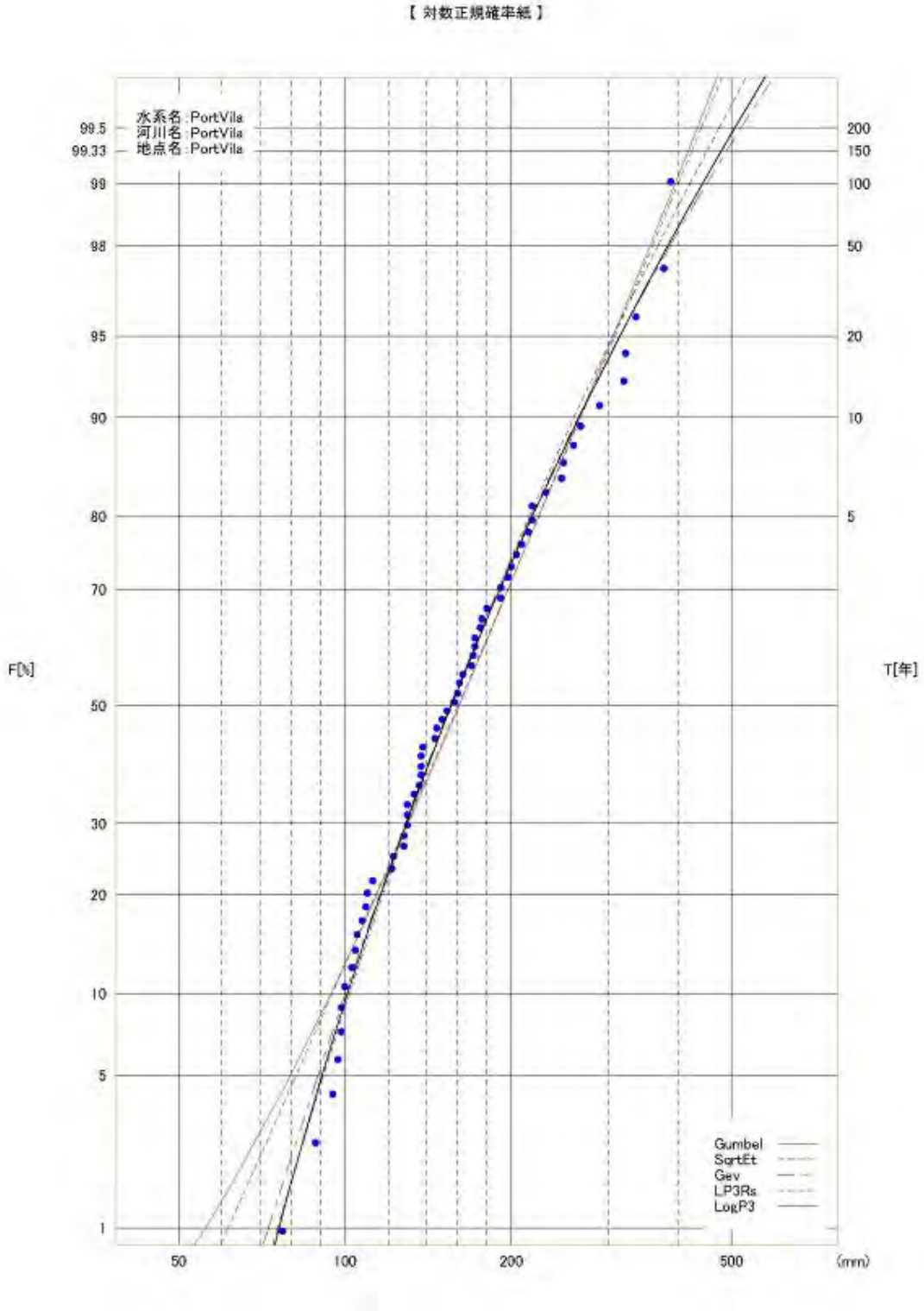
Table 6.1-2 Annual Maximum Daily Rainfall Series at Bauerfield and Port Vila

(Unit: mm)

Year	Port Vila	Year	Port Vila	Bauerfield
1948	121.7	1986	197.3	214.8
1949	171.7	1987	97.3	96.1
1950	337.1	1988	180.6	187.8
1951	259.1	1989	104.2	102.6
1952	158.0	1990	129.5	124.8
1953	146.1	1991	77.0	84.9
1954	137.1	1992	199.5	210.2
1955	204.2	1993	319.2	399.0
1956	176.5	1994	163.5	239.0
1957	98.6	1995	128.0	219.1
1958	133.4	1996	105.1	114.9
1959	289.6	1997	191.4	174.3
1960	170.9	1998	208.7	210.5
1961	191.3	1999	377.4	538.8
1962	246.6	2000	127.5	130.5
1963	NA	2001	217.9	248.8
1964	NA	2002	247.6	276.3
1965	NA	2003	98.6	71.2
1966	138.7	2004	230.8	254.4
1967	129.5	2005	88.4	121.8
1968	NA	2006	150.0	185.9
1969	102.9	2007	214.9	132.3
1970	121.9	2008	109.0	122.9
1971	322.3	2009	110.0	83.4
1972	175.5	2010	266.0	229.4
1973	111.9	2011	100.0	132.1
1974	171.7	2012	160.0	167.1
1975	168.7	2013	129.1	190.1
1976	107.6	2014	153.3	181.1
1977	218.5	2015	388.5	514.4
1978	NA			
1979	136.8			
1980	136.4			
1981	145.5			
1982	NA			
1983	136.9			
1984	95.0			
1985	161.1			

Source: VMGD

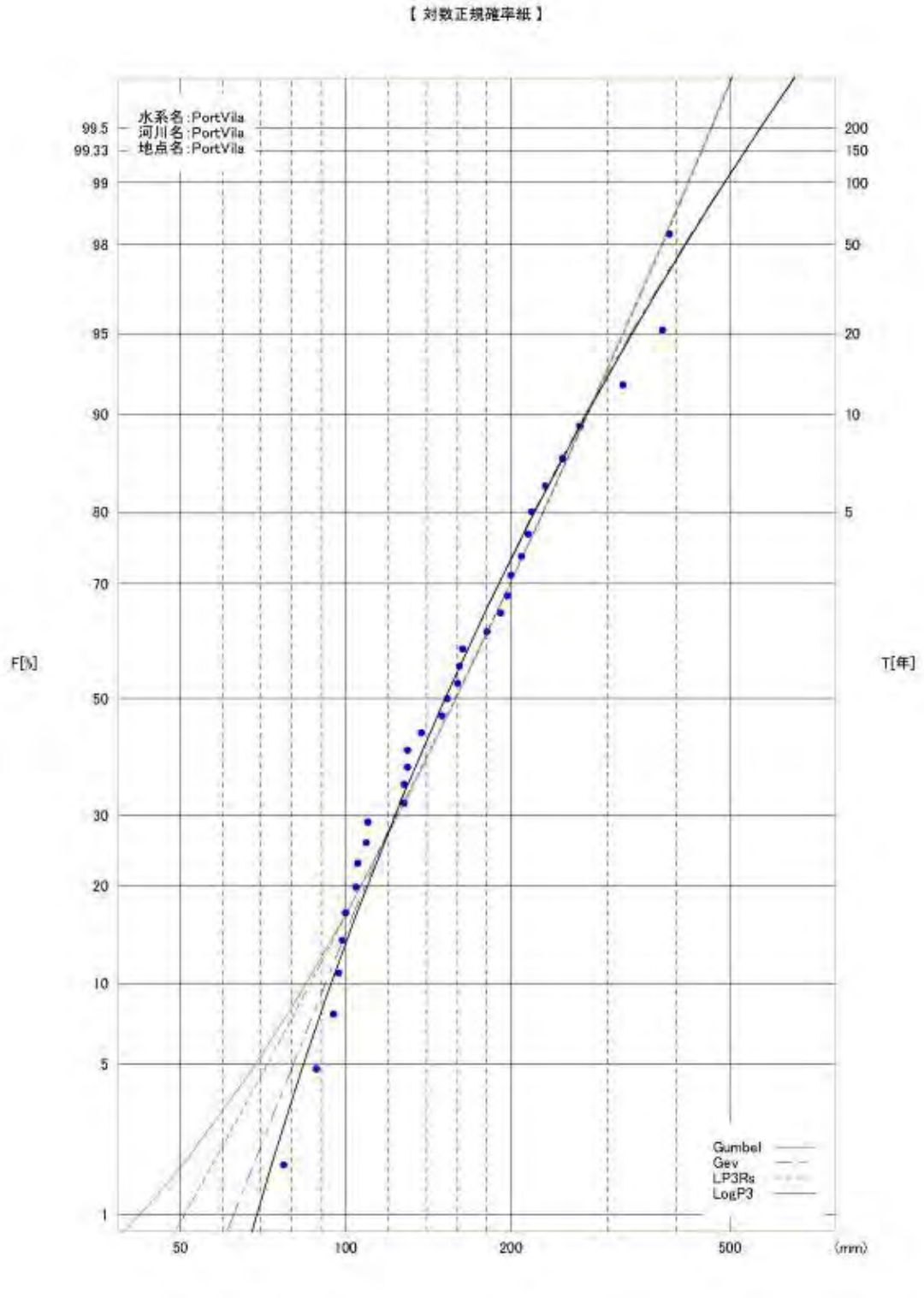
The probable rainfall is computed through comparison among various probable distribution curves and the annual maximum daily rainfall observed at Bauerfield and Port Vila. Among the curves, Log-Peason Type 3 distribution shows the best fit to the historical data as presented in Figure 6－3、Figure 6－4 and Figure 6－5 . Table 6.1-3 presents probable rainfall amounts at both stations.



Source: JICA Survey Team

Figure 6－3　Probability Distribution Curves to Fit Observed Data at Port Vila

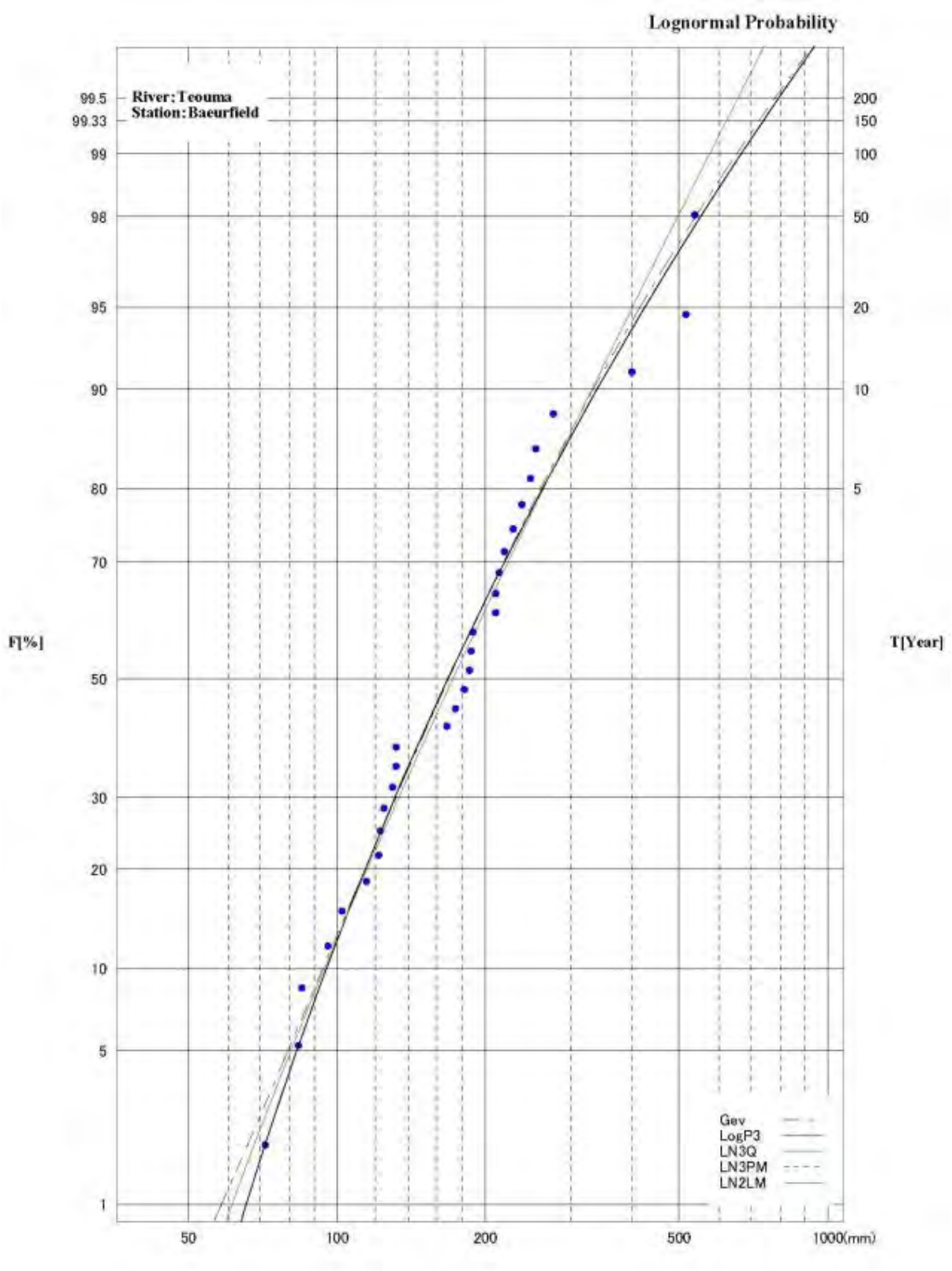
(Data for 62 years)



Source: JICA Survey Team

Figure 6－4　Probability Distribution Curves to Fit Observed Data at Port Vila

(Data for 33 years)



Source: JICA Survey Team

Figure 6－5　Probability Distribution Curves to Fit Observed Data at Bauerfield

Table 6.1-3 Probable Daily Rainfall Computed and Comparison of Former Study Result in 2003

(Unit: mm)

Recurrence Period (Year)	2	5	10	20	50	100
Bauerfield: Data for 30 Years	167.9	261.9	338.3	423.4	553.0	666.4
Port Vila : Data for 62 Years	155.3	217.6	264.5	313.7	384.4	443.1
Port Vila : Data for 33 Years	151.3	220.3	273.9	331.6	416.4	488.5
Basic Design in 2003	149.0	202.0	240.0	288.0	360.0	408.0

Note: Probable rainfall in basic design for Teouma Bridge in 2003 is derived from the probable rainfall intensity curve in Port Vila which was prepared in 2000 after Cyclone Dani. In the basic design report, however, there is no description on amounts of probable rainfall used for design discharge computation.

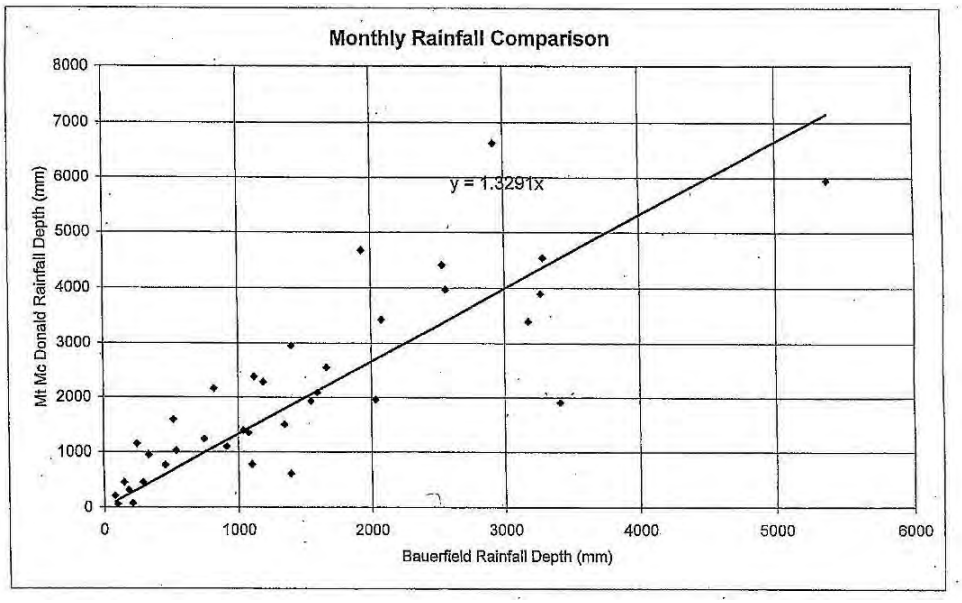
Source: JICA Survey Team

6.1.5 Selection of Representative Rainfall Station

As presented in Table 6.1-3, probable rainfall at Bauerfield is bigger than the one at Port Vila. This fact shows correlation result as shown in Figure 6－1. Furthermore, Figure 6－6 depicts relationship of monthly rainfall between Mt. McDonald and Bauerfield presented in the Cyclone Deni Report, 2000. Although the details of the data origin and source are not clear, occurrence of bigger rainfall than the one at Bauerfield can be easily imagined in the headwater of Teouma River.

In due consideration of the above, rainfall at Bauerfield might be most likely to represent the rainfall situation in the Teouma basin. Thus in this study Bauerfield station was selected as the representative station.

In comparison of observed rainfall during Cyclone Pam of 514 mm at Bauerfield and 388 mm at Port Vila to probable rainfall as presented in Table 6.1-3, the rainfall probability could be estimated as about 50-year recurrence.



Source: JICA Survey Team

Figure 6－6 Comparison of Monthly Rainfall between Bauerfield Station and Mt McDonald Station

6.2 Rainfall-Runoff Analysis

6.2.1 Area Reduction Factor (ARF)

The area reduction factor (ARF) is considered to use point rainfall to the extensive catchment. The ARF should be used with the United States Soil Conservation Services (SCS) Unit Hydrograph method if it is applied to catchment larger than 10 km^2 for the rainfall-runoff analysis. The ARF based on catchment area and time of concentration of flood established by Auckland Regional Council and published on Technical Publication No. 108, April 1999 are used for reference, and the values of ARF are presented in Table 6.2-1. Due to having the catchment area 86 km^2 and time of concentration of flow about 5.6 hours, the area reduction factor of 0.85 is considered for the catchment to estimate the basin rainfall.

Table 6.2-1 Area Reduction Factor (ARF)

Catchment Area (km^2)	Time of Concentration of Flow (hour)						
	0.5	1	2	3	6	12	24
< 10	1.00	1.00	1.00	1.00	1.00	1.00	1.00
20	0.90	0.91	0.93	0.94	0.95	0.96	0.97
50	0.72	0.75	0.82	0.86	0.92	0.94	0.96
100	0.71	0.74	0.79	0.83	0.86	0.89	0.90
200	0.70	0.72	0.75	0.79	0.82	0.85	0.86
500	0.68	0.70	0.72	0.74	0.76	0.79	0.81

Source: Guidelines for stormwater runoff modeling in the Auckland Region, Auckland Regional Council, Technical Publication No. 108, April 1999, page 5.

6.2.2 SCS Unit Hydrograph

The catchment hydrograph was developed by SCS Unit Hydrograph method. The ordinate of the unit hydrograph is expressed as the ratio of discharge to peak discharge (q/qp) and abscissa in the ratio of a time to the time to peak (t/tp). This method computes the runoff from the catchment being based on retention capacity of soil (S), which is predicted by the wetness and physical features of the catchment. To estimate retention capacity (S) of the catchment, a suitable curve number (CN) for the catchment was decided based on the land cover type, hydrological conditions and soil groups. The curve number (CN) of 36 was considered for the catchment due to having soil of group A and land cover type woods with fair hydrological conditions in the catchment. As a result, catchment's soils have low runoff and high infiltration rates due to having porous volcanic soils with coral rocks mostly covered by unburned woods with grazing. The definition of different hydrologic soil group is given in Table 6.2-2 and curve numbers proposed for different type of woods cover is presented in Table 6.2-3. Further, average soil moisture condition or antecedent moisture content (AMC) level II was used to estimate the runoff depth from the catchment.

Table 6.2-2 Hydrologic Soil Groups Defined by SCS

Hydrologic Soil Group	Definition
A	Soils have low runoff potential and high infiltration rate, they consist chiefly sand or gravel particles.
B	Soils have moderate infiltration rate, they consist chiefly moderately fine to moderately coarse textured soils.
C	Soils have low infiltration rate, they consist chiefly soils with moderately fine to fine texture.
D	Soils have high runoff potential and very low infiltration rate, they consist chiefly clay soils.

Source: Urban hydrology for small watersheds, United States Department of Agriculture, Natural Resources Conservation Services, Conservation Engineering Division, Technical Release 55, June 1986, Appendix A.

Table 6.2-3 Proposed Curve Numbers (CN) by SCS

Cover Type	Hydrologic Condition	Curve Numbers for Hydrologic Soil Groups			
		A	B	C	D
Woods	Poor	45	66	77	83
	Fair	36	60	73	79
	Good	30	55	70	77

Poor: Forest litter, small tree, and brush are destroyed by heavy grazing or regular burning
Fair: Woods are grazed but not burned and some forest litter covers the soil
Good: Woods are protected from grazing and litter and brush adequately cover the soil
Source: Urban hydrology for small watersheds, United States Department of Agriculture, Natural Resources Conservation Services, Conservation Engineering Division, Technical Release 55, June 1986, page 2-7.

Considering the above mentioned physical and hydrological conditions in the catchment the runoff depth was estimated for a given basin rainfall amount. The relation for runoff depth (Q) estimation is as presented as follows.

$$Q = \frac{(P - I_a)^2}{(P - I_a) + S)}$$

Where,

Q = Runoff depth (mm)
P = Rainfall (mm)
S = Potential maximum retention (mm)
I_a = Initial abstraction (mm)

For estimating the time of concentration of flow (Tc) in the catchment, the travel time of the flow from a catchment boundary to an inlet of the river channel (T1) at the upstream and travel time from the inlet to an outlet of the river channel (T2) were considered. The travel time T1 was considered as 30 minutes and the travel time T2 was estimated by the given relation.

$$T_2 = 0.14 * C * L^{0.66} \left(\frac{CN}{200 - CN} \right)^{-0.55} G^{-0.3}$$

$$T_c = T_1 + T_2$$

Where,

L = River channel length (km)

C = Channelization factor for runoff velocity (0.77)

G = Gradient (slope) of river channel

T_1 = Travel time from catchment boundary to inlet of river channel (hour)

T_2 = Travel time from inlet to outlet of river channel (hour)

T_c = Time of concentration of flow (hour)

The slope of the river channel (G) was calculated from the elevation difference between the inlet (360 m) and the outlet (7 m) of the river and the length of the river (17 km).

The time to the peak (tp) in the unit hydrograph is estimated by the given relation.

$$t_p = 0.67 T_c$$

The amount of peak flow from the catchment is estimated as follows.

$$q_p = 0.208 \left(\frac{A.Q}{t_p} \right)$$

Where,

A = Area of catchment (km^2)

Q = Runoff depth (mm)

t_p = Time to peak (hour)

q_p = Peak discharge (m^3/s)

For the estimated peak discharge (qp) and the time to the peak (tp), the unit hydrograph (UHG) can be developed from the synthetic dimensionless hydrograph provided by the SCS. Using the synthetic dimensionless hydrograph provided by the SCS, the catchment's hydrographs of 2, 5, 10, 20, 50 and 100 years recurrence periods were developed with input of probable basin rainfalls of the periods.

6.2.3 Muskingum Routing

After developing the catchment's hydrograph of different recurrence periods by SCS Unit Hydrograph method, the Muskingum routing was applied to estimate probable discharge at the location of Teouma Bridge for various recurrence periods. The Muskingum routing module of MIKE 11 one dimensional river flow simulation model was used for the flow routing. The relation used for flow routing is as follows.

$$Q_{i+1}^{j+1} = C_1 Q_i^{j+1} + C_2 Q_i^j + C_3 Q_{j+1}^i + C_4$$

Where,

i = Considered grid point

j = Time level

C = Constants

Q = Discharge at the grid point

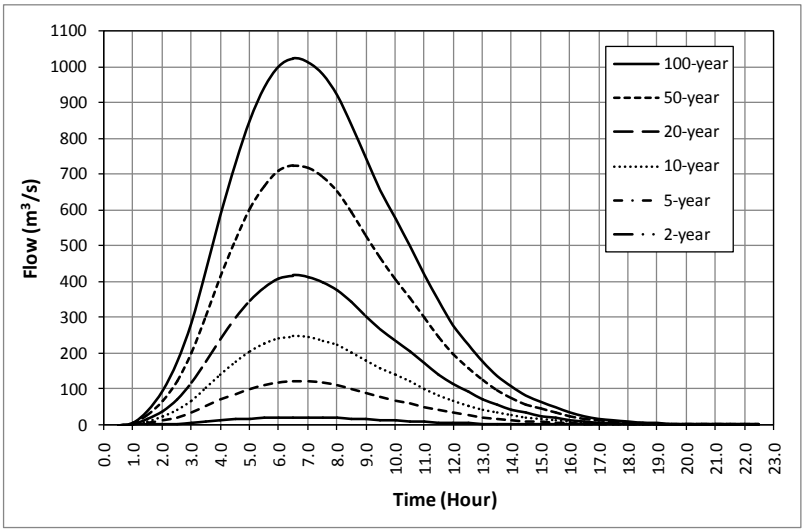
6.2.4 Probable Flood Hydrograph

The probable hydrographs at Teouma Bridge were developed by performing Muskingum Routing of the flows estimated by SCS Unit Hydrograph method. The probable flows estimated at Teouma Bridge after Muskingum routing are presented in Table 6.2-4 and Figure 6－7.

Table 6.2-4 Probable Point Rainfall and Flows at Teouma Bridge after Muskingum Routing

Recurrence Period (Year)	Probable Daily Rainfall (mm)	Probable Flood Peak (m^3/s)	Runoff Ratio
2	167.9	20	0.044
5	261.9	120	0.165
10	338.3	250	0.258
20	423.4	420	0.350
50	553.0	720	0.464
100	666.4	1020	0.544

Source: JICA Survey Team



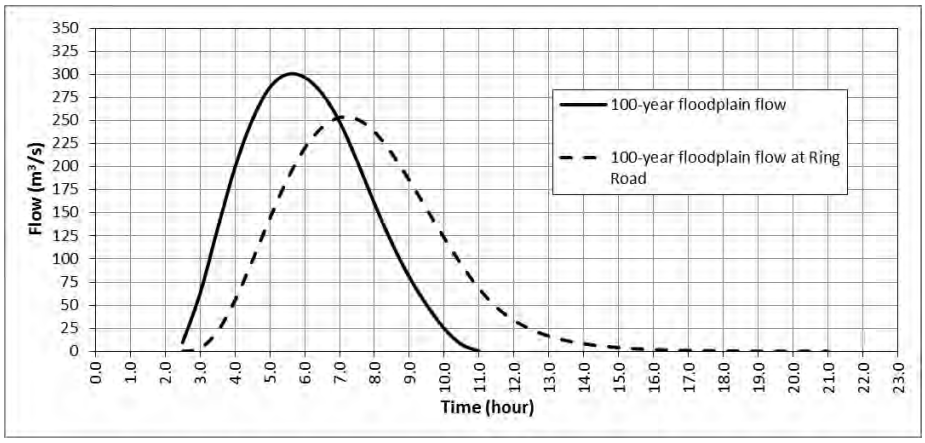
Source: JICA Survey Team

Figure 6－7 Probable Flood Hydrograph at Teouma Bridge

6.2.5 Floodplain Hydrograph

The amount of overbanking flow of 100-year flow from river channel into the left bank of Teouma River at upstream of the ring road was estimated by using the MIKE 11 flood simulation model. The overbanking

flood on the floodplain was routed using Muskingum routing. The amount of 100-year floodplain flow estimated, and the amount of floodplain flow estimated at the location of ring road after Muskingum routing are presented in Figure 6－8.

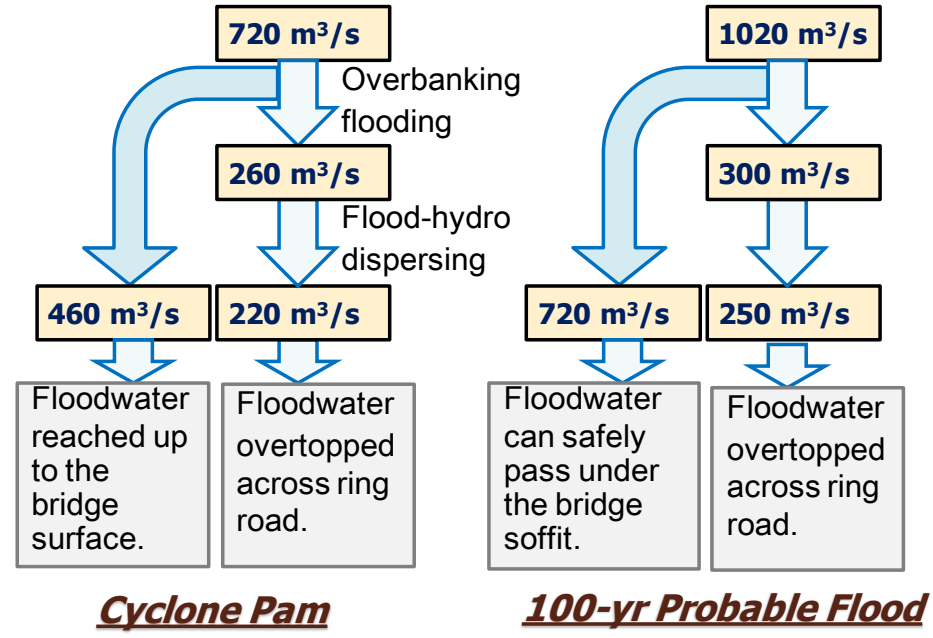


Source: JICA Survey Team

Figure 6－8　Probable 100-year Floodplain Hydrograph

6.2.6　Summary of Rainfall-Runoff Analysis

Daily rainfall observed at Bauerfield during Cyclone Pam is 514 mm, and it is almost equivalent to probable rainfall in 50-year recurrence. Flood situation during Cyclone Pam, assuming similar to the 50-year flood, as well as 100-year flood is illustrated in Figure 6－9.



Source: JICA Survey Team

Figure 6－9　Flood Situations under Cyclone Pam and 100-year Storm

Based on Figure 6－9, flood situations are summarized as follows.

- It is reported by the residents that floodwater passed the bridge surface or a little above. Flood flow of 460 m^3/s could pass through computation based on this situation. On the other hand, flooding water of

220 m^3/s flowed down over the ring road with about 1 m depth. It also coincides with the residents' report.

- Safety level shall be set at 100-year recurrence as ADB proposed. Furthermore, design flow capacity for the bridge structure shall be planned at 50-year flood level following the design standard in Japan. Matching this design direction, the design flow capacity of Teouma Bridge could be set at 720 m^3/s and the design floodwater depth along the flood-proofing road shall be set at 1.1 m in depth. This situation could result in attaining 100-year safety level.

6.3 Hydrological Designing

6.3.1 Unsteady Flow Analysis for River Improvement

River flow simulation was performed with unsteady flow considering 50-year flood. MIKE11 is a fully dynamic and one-dimensional modelling tool for the detailed analysis, design, management and operation of both simple and complex river and channel systems. The Hydrodynamic (HD) module is the nucleus of the MIKE11 modelling system and forms the basis for other modules. One-dimensional river flows and water levels were generated using fully dynamic flow routing procedure.

(1) Downstream Boundary Condition

Downstream boundary condition in the model was set at the river mouth. The average of the maximum sea water levels of Port Vila was set as downstream boundary condition in the model. The average maximum sea water level at Port Vila is 1.50 m.

(2) River Cross-Sections Data

River cross-sections data extracted from 1.0 m grid digital terrain model (DTM) were used. Although in the river stretch between KM4.6 and KM4.9 the proposed dimensions of river channel for river improvement were used for river cross sections.

(3) Manning's Roughness Coefficient

The Manning's roughness coefficient of 0.025 was applied for river flow simulation.

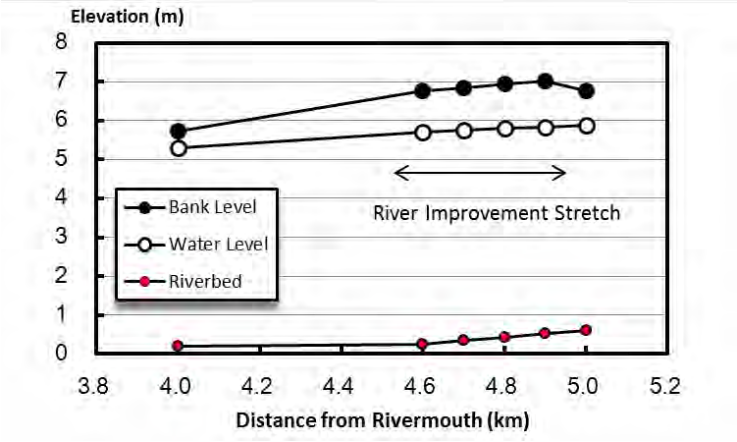
The simulated water levels profile with 50-year flood in Teouma River after improvement of river section between KM4.6 and KM4.9 are presented in Table 6.3-1 and Figure 6－10. The simulation result shows that the maximum water level in Teouma River reaches up to 5.7 m at KM4.6 river section upstream of the ring road during 50-year flood with the proposed river channel dimensions for river improvement.

Table 6.3-1 Maximum Water Level with 50-year Flood

River Section	Maximum Water Level (m)

KM5.0	5.877
KM4.9	5.839
KM4.8	5.792
KM4.7	5.746
KM4.6	5.700
KM4.0	5.312

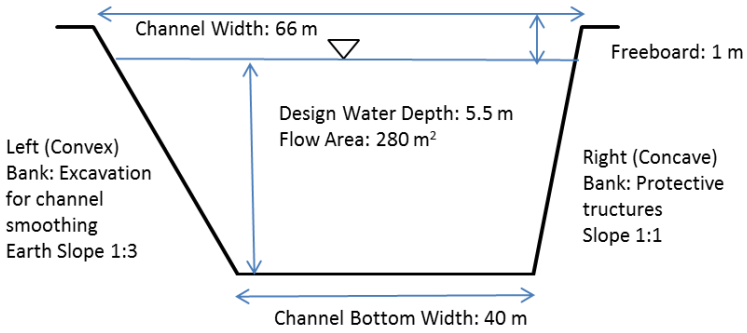
Source: JICA Survey Team



Source: JICA Survey Team

Figure 6－10 Maximum Water Level Profile with 50-year Flood

Based on the hydraulic computation, the proposed cross-section as shown in Figure 6－11 is proposed along the bend around Teouma Bridge.



Source: JICA Survey Team

Figure 6－11 Typical Design Cross-section along the Bend around Teouma Bridge

6.3.2 Hydraulic Calculation for Flood-proofing Road

As described in 6.2.5, some part of the large-scale flood hydrograph will overtop the river bank and will flow across the floodplain towards the ring road. It may occur in the flood events larger than 50-year recurrence period. The design safety level is at 100-year recurrence to protect Teouma Bridge against the flood by entire protection system including river, bridge and road improvement.

To compute the overflow discharge along the road, the following broad-crested weir equation is adopted.

$Q = CBH^{1.5}$

Where,

C = Coefficient of overflow (C = 1.560 as a general constant)

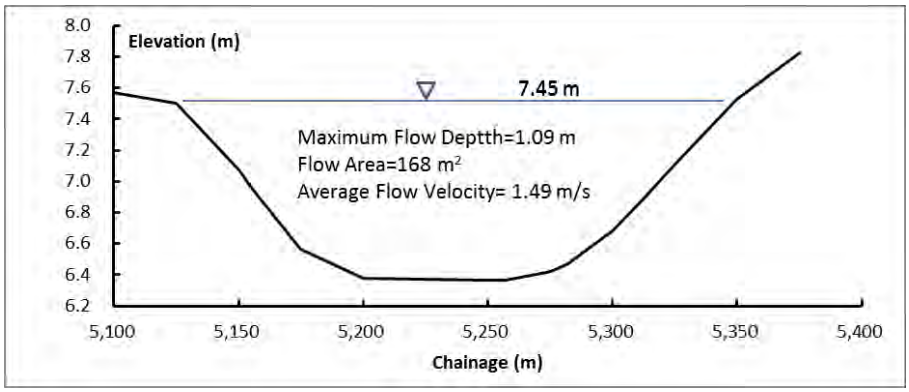
B = Weir length (m)

H = Overflow depth (m)

Q = Discharge (m^3/s)

As illustrated in Figure 6－8, the overtopping peak discharge across the ring road could be estimated at 250 m^3/s during 100-year flood. Referring to the longitudinal profile of upstream side of the ring road, overtopping flow discharge is computed as presented in Figure 6－12.

Design high water level is 7.45 m and its maximum flow depth is 1.09 m, stretching approximate 225 m in length on the ring road.



Source: JICA Survey Team

Figure 6－12 Typical Design of Flood-proofing Road in 100-Year Flood

Chapter 7 Damage Situation Survey on Teouma Bridge

The damage situation in Vanuatu and especially on the ring road in Efate Island caused by Cyclone Pam hit in March 2015 was explained in Clause 3.2.4. This chapter explains the damage situation and emergency measure on Teouma Bridge as the target structure in the project. The basic soundness inspection result is also shown in this chapter in order to confirm the damage on the Teouma Bridge.

7.1 Damage Situation and Emergency Measure

Damage situation on Teouma Bridge and the road in the left side of the bridge and emergency measure taken by PWD is explained as follows and shown in Photo 7－1.

(1) Damage Situation

- Backfill of the right abutment and the approach road was eroded at about 10m in width.
- The foundation soil material of the right abutment was washed away resulting in exposing foundation piles.
- Railing on the approach road in the right upstream side of Teouma Bridge was washed away.
- Water pipe and a pipe for electricity cable attached on the bridge were broken and disconnected.
- Cylinder gabions for the right abutment were washed away and the riverbed is scoured.
- Cylinder gabions for the left abutment were washed away and the riverbed is scoured.
- The upper bridge structure seemed to suffer any damage (with visual observation.)
- Flooding water overtopped the topographically concaved portion of the ring road at valley floor at about 160 m away from the left end of the bridge. The pavement and subgrade seemed to suffer any damage.

(2) Emergency Measure

- Eroded portion of the backfill of the right abutment and the approach road was filled with soil. The approach road was coated with spread seal pavement and opened to traffic.
- Big rock masonry was applied for the slope protection of the approach road in the right upstream side of Teouma Bridge.
- The water pipe and cables are temporarily restored.
- Urgently, the diversion waterway with about 10 m in width was excavated toward Teouma Bridge at right angle.

Erosion of backfill of the right abutment and approach road and slope protection with big rock masonry

Backfill and spread seal pavement at approach road

Foundation of right abutment and cylinder gabions were washed away.

Erosion of river slope on right upstream side of the bridge and washed away railing

Foundation of left abutment and cylinder gabions were washed away.

Excavation of diversion waterway

Source: JICA Survey Team

Photo 7－1　Damage Situation and Emergency Measure of Teouma Bridge

7.2　Soundness Inspection of Teouma Bridge

Although Cyclone Pam damaged the backfill and the foundation of the abutment, the upper bridge structure seemed to be in good condition. For proposing the bridge improvement, the soundness inspection on Teouma Bridge was performed and detailed damage situation on the upper bridge structure was

investigated (refer to Attachment 3)

The summary of the inspection result is shown in Table 7.2-1. According to the result, it is confirmed that the bridge is in excellent condition. Hence, the reuse of the bridge structure should be taken into account for the selection criteria for the bridge improvement.

Table 7.2-1 Teouma Bridge Soundness Inspection Result

Object		Result	Evaluation
Bridge			Very Good
	Superstructure	Dirt retention caused by the surge of flooding water could be confirmed but there is no damage observed.	Very Good
	Concrete Slab	Concrete surface could not be observed since it was covered bituminous pavement. However, no damage was seen from the side view.	Very Good
	Abutment	No crack	Very Good
	Hinged Bearing	No damage	Very Good
	Expansion Joint	No damage	Very Good
Ancillary Facility			Good
	Curb	Small damages such as a crack could be seen at the position of drainage pipes and at the left downstream side of Teouma River. The one in the left downstream side may be caused by the crash of a vehicle. Generally, in good condition.	Good
	Railing	The damages in the left downstream side of Teouma Bridge were observed and may be caused by the crash of a vehicle. Generally, in good condition.	Good
	Drainage Pipe	The damages at the middle of Teouma Bridge were observed and may be caused by the surge of flooding water. Generally, in good condition.	Good
	Abutment Protection	Some tubular gabions have been washed away.	Damaged
	Riverbed	Some part of riverbed was scoured and some tubular gabions are pendent.	Scoured
	Approach Road	Approach road in the right bank side was washed away and emergently reconstructed by the local government. Huge rock seems to be working for slope stability.	Damaged
Concrete Strength		Concrete strength at selected 6 points was investigated with Schmidt Hammer. All points showed more than 300kg/m^2 and it explained that the concrete is in good condition.	Very Good
Displacement of Abutment		No displacement	Very Good
Total Evaluation			Very Good

Source: JICA Survey Team

Chapter 8 Teouma Bridge Restoration Plan

8.1 Three Component of Reconstruction of Teouma Bridge

Teouma Bridge restoration plan consists of three components as follows.

- River improvement with bank protection
- Bridge improvement with bridge extension
- Road improvement with flood-proofing road

Following clauses explain more about the plan.

8.2 River Improvement Plan and Structure Type of Bank Protection

Basic concept of the river improvement plan is as follows.

- Based on the result of the hydraulic computation, the cross section of the river and its structure adequate for the 50-year flood are proposed.

Following clause explains the basic scheme and the structural features.

8.2.1 Basic Scheme for River Improvement

Basic scheme for river improvement is as follows.

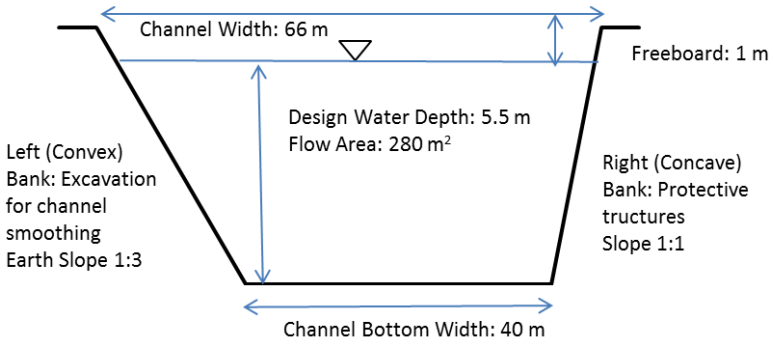
- River improvement consists of three portions which are “Riverbank and Riverbed Excavation”, “River Widening” and “Slope Protection”.
- River channel alignment is adjusted to stabilize the flow and the river itself based on the original river alignment and the concept of the bridge improvement.
- Slope protection is designed with the consideration of the effect of water level surge and acceleration of flow at the bend.
- The proposed structure is designed to withstand earthquakes in Vanuatu.

Regarding the study and the design, the following manuals and guidelines were referred.

- Manual for Government Ordinance for Structural Standard for River Administration Facilities, Japan
- Guideline of River Planning, Japan
- Basic Policy for Disaster Rehabilitation to Maintain Beauty of Mountains and Rivers, Japan
- Design and Construction Standard of Steel Bar Gabion Revetment, Japan
- Standard of Multi-Staged Steel Bar Gabion Revetment, Japan.

(1) Typical Cross Section

The cross section for 50-year flood discharge (720 m^3/s) introduced in Chapter 6 is shown in Figure 8.1.



Source: JICA Survey Team

Figure 8－1 Typical Cross Section for River Improvement

In addition, the effect of the water level surge and acceleration of the flow at the bend is considered.

(2) Target Area of River Improvement

The purpose of the river improvement is to ensure the safe flow with the design discharge at Teouma Bridge and the target area of river improvement should be ideally minimized in the upstream and downstream area. The end of the area in the upstream side is set at the diversion point of the flow, which goes in the direction to the flood–proofing road (St. 4950 in the right bank and St. 4990 in the left bank). Downstream end is set at 100m downstream side of Teouma Bridge (St. 4550).

(3) Improvement of River Alignment

Considering the land use, the river is widened to the left side of the river in the upstream area and to the right side in the downstream area.

(4) Target Location of Slope Protection

Considering the elevation at the target area mentioned in the Clause (2), the slope protection is proposed at the right side in the upstream area and at the both side in the downstream area.

(5) Seismic Condition

In ”Basic Design of the Project for Rehabilitation of Bridges on the Ring Road , 2003”, Teouma Bridge was designed with the seismic force. The structure in this project should also bear the seismic force and the wooden pile is provided for the slope stability under the seismic condition.

(6) Water Amenity

It is confirmed that residents living in the vicinity of Teouma River utilize the river for laundry, swimming, fishing, shipping (such as vegetables), and dish washing at home. Considering these situations, the proper care of water amenity should be taken for the slope protection design.

8.2.2 Selection Criteria for River Improvement Plan and Structure Type

Three types of the slope protection works are proposed considering the above mentioned design velocity,

design manuals and guidelines, and construction conditions.

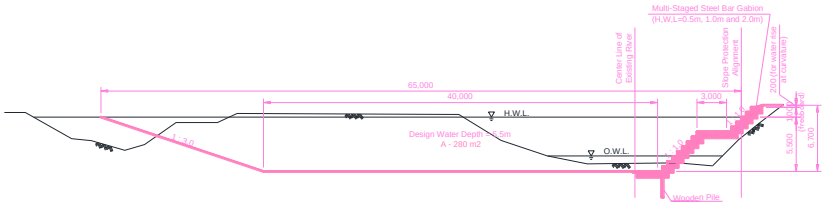
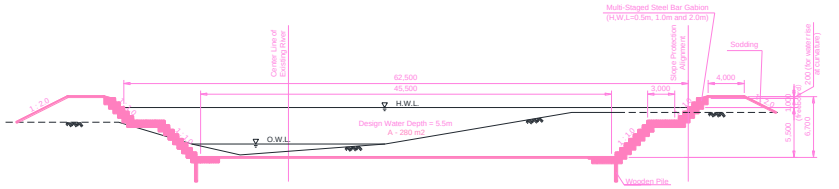
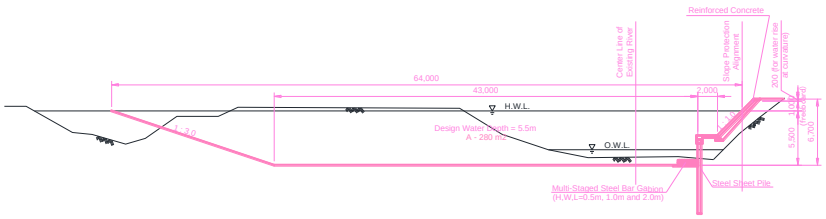
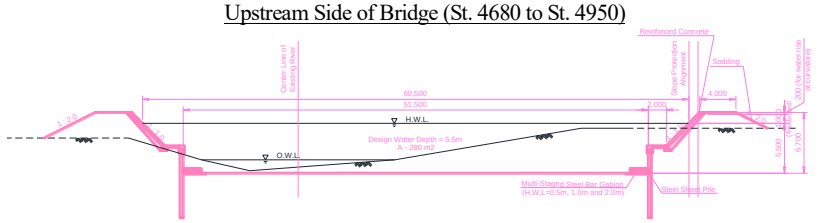
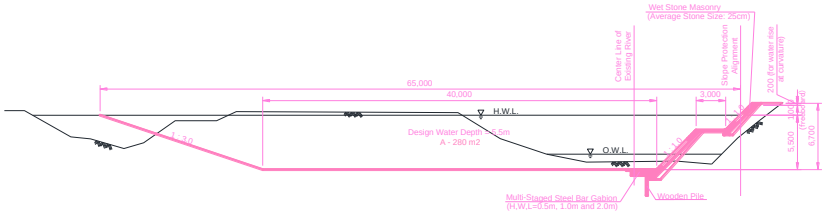
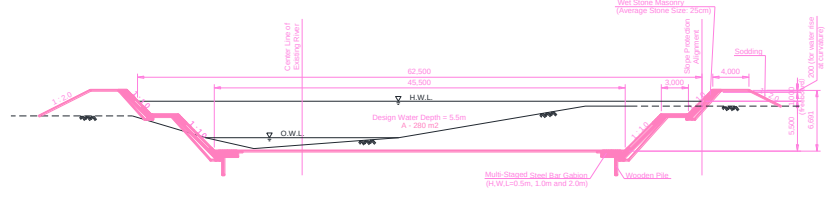
- Multi-Staged Steel Bar Gabion Slope Protection
- Steel Sheet Pile and Concrete Slope Protection
- Wet Stone Masonry Slope Protection

All types have the earth cut slope without protection in the upstream side of the bridge and in the inner side of the curvature of the river.

The protection of the bottom of the slope protection can be done with either foot protection in front of the base concrete or deepening the elevation of the bottom of the slope protection. In this selection criteria proposal, the foot protection with its top level at the design river bottom is proposed. This is the result of consideration to the size of the river (not big), existing maximum scouring depth (approximately at 30cm), the height of the slope (at 6.7m), the fact that scouring in front of the slope will affect negatively to the slope stability. For the steel sheet pile and concrete slope protection, there is no structure to be protected such as base concrete and steel bar gabion. However, the foot protection is provided in order to maintain the elevation of the river bottom in front of the steel sheet pile and passive pressure produced by the river bottom.

For proposing river improvement, the selection criteria for river improvement plan and structure type is shown in Table 8.2-1. Draft structure design is also shown in the Attachment-4.

Table 8.2-1 Selection Criteria for River Improvement Plan and Structure Type

Type	Conceptual Drawing
Type 1: Steel Bar Gabion Upstream Side of Bridge: ・ Slope protection with steel bar gabion at right bank ・ River widening to the left Downstream Side of Bridge: ・ Slope protection with steel bar gabion at both banks ・ River widening to the right Both: ・ Foot protection with steel bar gabion ・ Wooden pile for slope stability	 Upstream Side of Bridge (St. 4680 to St. 4950)  Downstream Side of Bridge (St. 4550 to St. 4680)
Advantage ・ Permanent Structure ・ Lots of voids, good for habitation of flora and fauna ・ Simple construction steps Disadvantage ・ Steel bar gabion needs to be imported, expensive	
Type 2: Steel Sheet Pile and Concrete Upstream Side of Bridge: ・ Slope protection with steel sheet pile and concrete at right bank ・ River widening to the left Downstream Side of Bridge: ・ Slope protection with steel sheet pile and concrete at both banks ・ River widening to the right Both: ・ Scouring measure with steel bar gabion	 Upstream Side of Bridge (St. 4680 to St. 4950)  Downstream Side of Bridge (St. 4550 to St. 4680)
Advantage ・ no coffering Disadvantage ・ Steel sheet pile needs to be imported, expensive ・ Not good for habitation of flora and fauna	
Type 3: Concrete Stone Masonry Upstream Side of Bridge: ・ Slope protection with cobble stone masonry at right bank ・ River widening to the left Downstream Side of Bridge: ・ Slope protection with cobble stone masonry at both banks ・ River widening to the right Both: ・ Foot protection with steel bar gabion ・ Wooden pile for slope stability	 Upstream Side of Bridge (St. 4680 to St. 4950)  Downstream Side of Bridge (St. 4550 to St. 4680)
Advantage ・ Mostly procurable in Vanuatu Disadvantage ・ Require high quality control of construction and stones ・ Not good for habitation of flora and fauna	

Note: These cross sections are shown facing downstream side.
Source: JICA Survey Team

8.3 Bridge Improvement Plan and Structure Type of Bridge Extension

Basic concept of the bridge improvement plan is as follows.

- Based on the result of the hydraulic computation, the cross section of the river and the bridge structure adequate for the 50-year flood are proposed.

Following clause explains the basic scheme and the structural features.

8.3.1 Basic Scheme for Bridge Improvement

Basic scheme for bridge improvement is as follows.

- Bridge improvement consists of five portions which are “Reuse and Repair of the Existing Bridge”, ”Demolition of Abutment in the Right Bank with Construction of New Pier”, ”Construction of New Abutment in the Right Bank”, “New Bridge Construction at Extended Area” and “Slope Protection”.
- Bridge is extended to the right considering the existing river alignment.
- The abutment in the right bank is demolished and the pier is constructed there.
- Referring to the “Basic Design of the Project for Rehabilitation of Bridges on the Ring Road, 2003”, the proposing structure can bear the seismic force.

Regarding the study and the design, the following manuals and guidelines were referred.

- Manual for Government Ordinance for Structural Standard for River Administration Facilities, Japan
- Specifications for Highway Bridges and Its Exposition, Japan
- Design and Construction Standard of Steel Bar Gabion Revetment, Japan
- Standard of Multi-Staged Steel Bar Gabion Revetment, Japan.

(1) Abutment in Right Bank

In order to minimize the land acquisition, the abutment in the right bank is demolished and new pier is constructed there.

(2) Extended Structure

In order to adjust the alignment of the bridge and the elevation of the girder, extended bridge structure is the warren type pony truss steel structural members same as the existing bridge. Since the extension spans of 30m and 35m do not affect the elevation of the bridge, the bridges with the span of 30m and 35m are proposed. The freeboard for them is set at 1.0m

(3) Abutment Protection

Two kinds of protections which are with Multi-Staged Steel Bar Gabion and with the combination of Steel Sheet Pile and Multi-Staged Steel Bar Gabion are proposed.

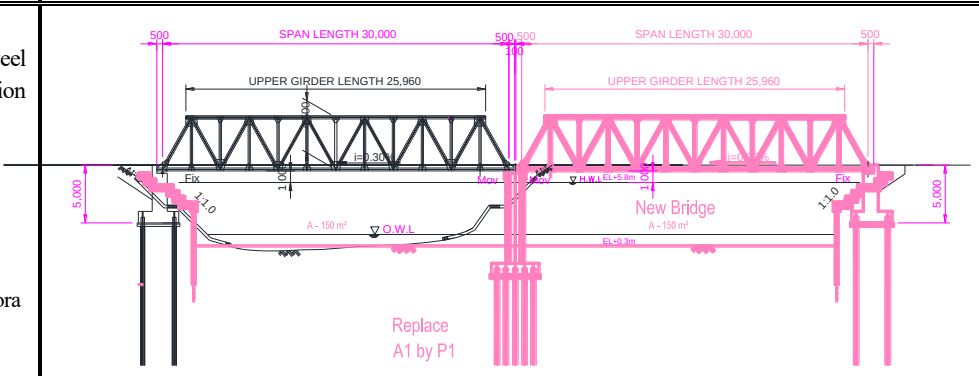
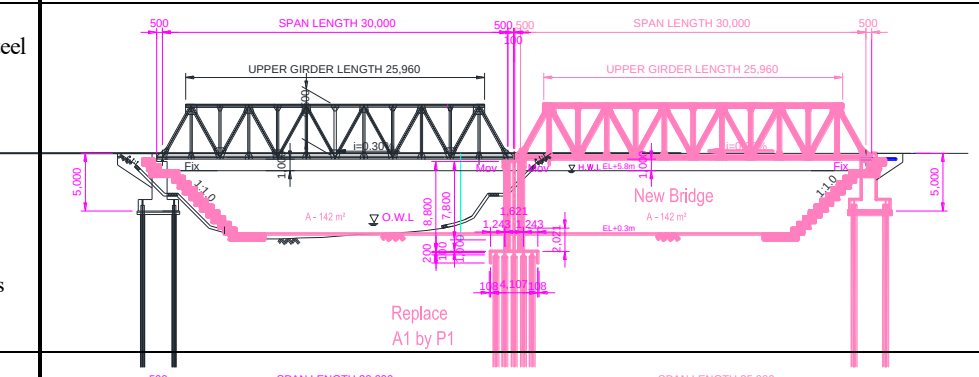
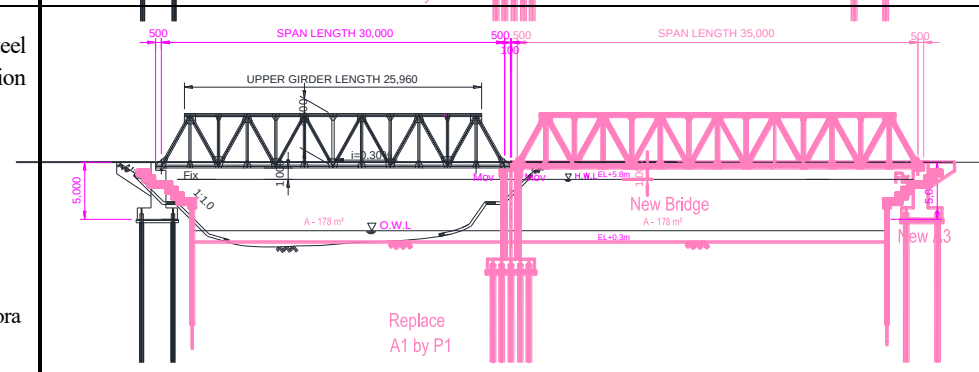
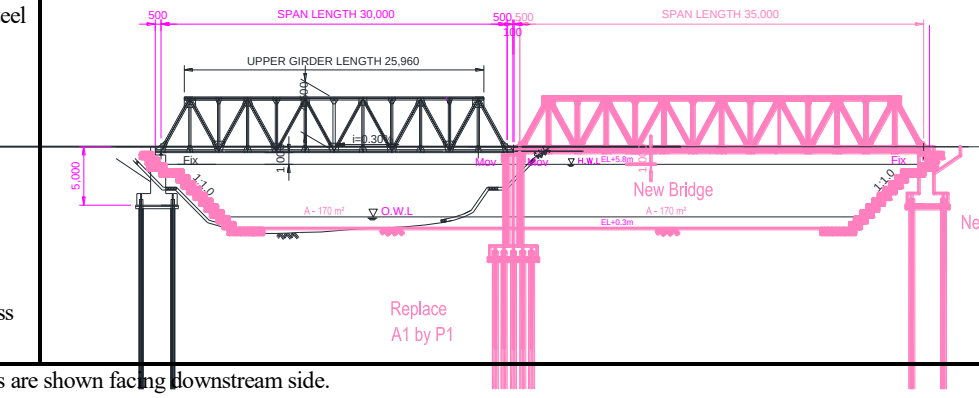
(4) Seismic Condition

In ”Basic Design of the Project for Rehabilitation of Bridges on the Ring Road , 2003”, Teouma Bridge was designed with the seismic force. The bridge structure in this project should also bear the seismic force.

8.3.2 Selection Criteria for Bridge Improvement Plan and Structure Type

For proposing bridge improvement, the selection criteria for bridge improvement plan and structure type is shown in Table 8.3-1. Draft structure design is also shown in the Attachment-4.

Table 8.3-1 Selection Criteria for Bridge Improvement Plan and Structure Type

Type	Conceptual Drawing
Type 1: 30m Extension, Steel Sheet Pile and Steel Bar Gabion Protection Advantage ・ Less land acquisition ・ Tolerant of scouring Disadvantage ・ Relatively expensive ・ Not good for habitation of flora and fauna	
Type 2: 30m Extension, Steel Bar Gabion Protection Advantage ・ Less land acquisition ・ Economical coffering ・ Lots of voids, good for habitation of flora and fauna Disadvantage ・ Less additional room of cross section	
Type 3: 35m Extension, Steel Sheet Pile and Steel Bar Gabion Protection Advantage ・ Larger cross section ・ Larger land acquisition ・ Tolerant of scouring Disadvantage ・ Relatively expensive ・ Not good for habitation of flora and fauna	
Type 4: 35m Extension, Steel Bar Gabion Protection Advantage ・ Larger cross section ・ Larger land acquisition ・ Tolerant of scouring ・ Economical coffering ・ Lots of voids, good for habitation of flora and fauna Disadvantage ・ Cross section in type 4 is less than the one in type 3.	

Note: These cross sections are shown facing downstream side.
Source: JICA Survey Team

8.4 Road Improvement Plan and Structure Type of Flood-Proofing Road

Basic concept of the road improvement plan is as follows.

・ Based on the result of the hydraulic computation, the cross section and the structure of the

flood-proofing road adequate for 100-year flood at the ring road are proposed.

Following clause explains the basic scheme and the structural features.

8.4.1 Basic Scheme for Road Improvement

Basic scheme for road improvement is as follows.

- Road improvement consists of two portions which are "Demolition of Existing Road and Construction of Flood-Proofing Road" and "Construction of Apron and Floor Protection".
- The elevation of the top of the flood-proofing road is same as the one of the existing road.

Regarding the study and the design, sections for groundsill and overtopping weir in Technical Standards for River and Sabo Works for Design, Japan were referred.

(1) Target Area for Road Improvement

Overtopping area at the ring road with the 100-year flood (Ch. 5345 to Ch. 5128) is to be flood-proofing road.

(2) Structure Combination for Flood-Proofing Road

Two types of the flood-proofing road are proposed as shown in Table 8.4-1

Table 8.4-1 Structure Combination of Flood-Proofing Road

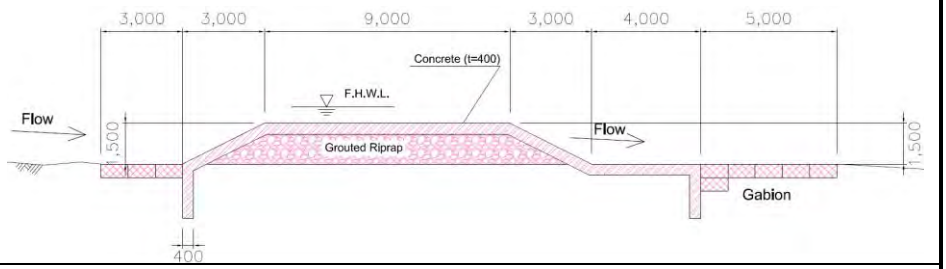
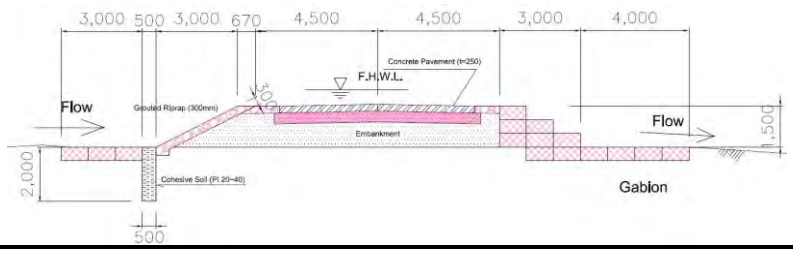
Parts	Type 1: Concrete	Type 2: Stone Masonry
Main Body	Concrete	Stone Masonry
Impermeable Wall	Concrete	Impermeable Clay
Subgrade	Grouted Riprap Subgrade	Earth Subgrade
Pavement	Concrete	Concrete
Apron	Concrete	Gabion
Floor Protection	Gabion	Gabion

Source: JICA Survey Team

8.4.2 Selection Criteria for Road Improvement Plan and Structure Type

For proposing road improvement, the selection criteria for road improvement plan and structure type is shown in Table 8.4-2. Draft structure design is also shown in the Attachment-4.

Table 8.4-2 Selection Criteria for Road Improvement Plan and Structure Type

Type	Conceptual Drawing
Type 1: Concrete Advantage ・ Durable Disadvantage ・ Larger land acquisition	
Type 2: Stone Masonry Advantage ・ Environmentally Friendly ・ Less land acquisition ・ Economical Disadvantage ・ May require maintenance	

Source: JICA Survey Team

Chapter 9 Approximate Project Cost and Implementation Schedule

Approximate project costs and an implementation schedule are very important issues for the preparation of the basic concept of Teouma Bridge restoration plan and the study on the necessity and the direction of cooperation.

Basic information for the calculation of the approximate construction costs and the study on the implementation schedule is 1) major construction materials and goods, 2) major equipment, 3) procurement method of major temporary equipment and 4) utilization of Local consultants and contractors. In addition, 5) present status of tax exemption for the projects and 6) collection of basic information for land acquisition which are related to the initial conditions for the grant aid from Japan will be mentioned in the following clauses.

Further, regarding the aforementioned basic concepts and structure types for river, bridge and road improvement plans based on the above mentioned basic information and the framework of the grant aid from Japan, the results of the calculation of the approximate projects costs and the study on the implementation schedule are proposed as well.

9.1 Procurement Plan for Major Construction Materials and Goods

The procurement plan for the major construction materials and goods on the construction stage for the structure designs for river, bridge and road improvement plans prepared based on the hydrological analysis is shown in Table 9.1-1.

The procurement plan for construction materials and goods is prepared based on the following policies and quality assurance on the construction stage.

- Procurement plan should be consistent with the “Utilization of the materials originating from corals for the infrastructure project in in Oceanian countries”
- Selection criteria and notes on quality, supply capacity, delivery period for the quality assurance on the construction sage are shown in Table 9.1-1. However, the most appropriate procurement plan shall be prepared based on this procurement plan in the preparatory survey stage.
- The locally available aggregate material for the concrete structure, spread seal pavement and cement concrete pavement has been produced with a crushed lime stone. This local crushed lime stone may not be complied with the specifications for the aggregate materials. On the other hand, the aggregate materials for the infrastructure projects in Oceanian counties are generally produced from basalt according to the records of previous projects. Although the basalt can be found in the north part of Efate Island, the basalt aggregate materials are not available because the quarry has been closed at this moment. The basalt aggregate materials can be procured from the third countries such as Fiji, etc. Based on these circumstances, two procurement plans for aggregate materials are prepared.
- During preparatory survey, material test for aggregates such as dry density, absorption rate, loss ratio of stability test, abrasion test, etc. should be conducted. It is also necessary to determine the application range of the aggregate materials based on the trial mix.

- Since there is a big gap in the cost between two plans which are local procurement and third country for aggregate procurement, two approximate project costs shall be calculated respectively (refer to plan A and plan B in Clause 9.7)
- The imported quality cement and cutback asphalt materials can be procured locally even though the supply capacity may not be sufficient.
- The procurement of a steel bar gabion, a steel sheet pile for revetment, a H-shaped steel pile and a panel type gabion are impossible based on the local market survey.
- Based on the study on the quality assurance of the structure and raw materials, it is considered that the procurement from Japan is most appropriated.
- The locally available crushed lime stone is qualified for the filling materials for gabion (hard stone), grouted riprap structure and base course materials (graded and crushed material) based on the study. During the preparatory survey, it is necessary that the material test on apparent specific gravity, absorption rate, compressive strength, etc. should be conducted to classify the rock hardness which is categorized as hard, semi hard and soft in order to determine the application range of the crushed lime stone.
- Regarding the procurement of steel pony truss girders, according to the record of the grant aid projects that include the implementation of a steel girder in Oceanian countries, Japanese steel bridge fabricators generally joined the project as sub-contractors to secure the quality of the projects. In those projects, the steel materials for girders were procured from Japanese manufacturers and the fabrication of the girder was done with two different methods. One is by the local subsidiary of the Japanese bridge fabricator in third countries such as Vietnam, Myanmar and Philippines etc. The other is by the local fabricators affiliated with Japanese bridge fabricators in third countries.

Table 9.1-1 Procurement Plan for Major Construction Materials and Goods

Item	Procured from			Remark (Quality, Capacity, Delivery Period, Cost, etc.)
	Vanuatu	Japan	Third Country	
Cement	○ Imported			・Conformity with specifications, checked by mill test certificate
Concrete aggregate (coarse, fine)	○ Limestone		○ Basalt	・Conformity with specifications of local materials, checked by material test ・Conformity with specifications of materials from third county, checked by test certificate ・Quarantine inspection certificate, check for Custom Clearance for imported material
Reinforcement bar			○	・Conformity with specifications of materials from third county, checked by test certificate
Wooden pile for slope protection	○			・Local coconut-tree
Multi–staged steel bar gabion		○		・Conformity with specifications, checked with "Standard of Multi-Staged Steel Bar Gabion Revetment, Japan"
Rubble stone for multi –staged steel bar gabion	○ Limestone			・Conformity with specifications, checked by material test (hard, semi-hard, soft stone)
Steel sheet pile for revetment		○		・Conformity with specifications, checked by mill test certificate
Rubble stone for Grouted Riprap	○ Limestone			・Conformity with specifications, checked by material test (hard, semi-hard, soft stone)
Steel warren type pony truss girder		○ Steel Materials	○ Fabricatio n	・Conformity with specifications of steel materials, checked by mill test certificate ・Conformity with specifications of fabrication, checked by manufacturer inspection, inspection records, etc.
H-shaped steel pile for foundation		○		・Conformity with specifications of Steel materials, checked by mill test certificate
Aggregate for spread seal pavement (surface/binder: crushed stone/sand)	○ Limestone		○ Basalt	・Conformity with specifications of local materials, checked by material test ・Conformity with specifications of imported materials, checked by material test certificate ・Quarantine inspection certificate, check for Custom Clearance for imported material
Cutback asphalt	○ Imported			・Conformity with specifications of imported materials, checked by material test certificate by manufacturers
Aggregate for pavement	○ Limestone			・Conformity with specifications of local materials, checked by material test
Panel type gabion		○		・Conformity with specifications, checked by material test certificate issued by manufacturers
Rubble stone for panel type gabion	○ Limestone			・Conformity with specifications, checked by material test (hard, semi-hard, soft stone)
Rubble stone for wet stone masonry	○ Limestone			・Conformity with specifications, checked by material test (hard, semi-hard, soft stone)
Aggregate material for cement concrete pavement	○ Limestone		○ Basalt	・Conformity with specifications of local materials, checked by material test ・Conformity with specifications of imported materials, checked by material test certificate ・Quarantine inspection certificate, check for Custom Clearance for imported material

Source: JICA Survey Team

9.2 Procurement Plan for Major Construction Equipment

The procurement plan for the local construction equipment based on the results of the market research is shown in Table 9.2-1. The procurement plan for the major construction equipment has been prepared based on the following policies, efficient construction schedule and safety management.

- There is no registered lease company for construction equipment in local market.
- Some of the local contractors can lease some of the construction equipment. However, the construction equipment is limited to the small construction works and the local contractors have not had the big scale and complicated projects. Further, the supply capacity is also limited because the number of the owned equipment is limited.
- The intensive maintenance and check-out works are required for the locally procured equipment for quality control and safe management.
- The locally unavailable equipment shall be procured from Japan or the third counties. The procurement plan shall be finalized considering the transportation costs, delivery period, etc. during the preparatory survey.

Table 9.2-1 Procurement Plan for Major Construction Equipment

Type of Equipment	Procured from			Remarks
	Vanuatu	Japan	Third Country	
Bulldozer	○	○	○	Equipment from Vanuatu is from local contractors
Tractor Shovel		○	○	
Backhoe	○	○	○	Equipment from Vanuatu is from local contractors
Wheel Loader	○	○	○	Equipment from Vanuatu is from local contractors
Giant Breaker		○	○	
Breaker		○	○	
Engine Compressor	○	○	○	Equipment from Vanuatu is from local contractors
Dump Truck	○			From local contractors
Truck With Crane		○	○	
Trailer, Truck	○			From local transport company
Cargo Truck	○			From local transport company
Small Truck (Pick Up)	○			From local leasing company
Crawler Crane		○	○	
Rough Terrain Crane		○	○	
Truck Crane	○	○	○	Equipment from Vanuatu is from local contractors
Vibratory Hammer		○		
Generator	○	○	○	Equipment from Vanuatu is from local contractors
Concrete Mixer	○			For concrete mixing, from local contractors
Concrete Pumping Car		○	○	
Motor Grader	○	○	○	Equipment from Vanuatu is from local contractors
Tire Roller		○	○	
Vibratory Roller	○	○	○	Equipment from Vanuatu is from local contractors
Macadam Roller		○	○	
Rammer / Tamper	○			From local contractors
Asphalt Kettle	○			From local contractors
Asphalt Distributer	○			From local contractors
Chip Spreader	○			From local contractors
Sprinkler Truck	○			From local contractors
Submergible Pump	○	○	○	Local equipment is from local contractors
Fuel, Oil	○			Local purchase

Source: JICA Survey Team

9.3 Procurement Plan for Major Temporally Material and Equipment

The procurement plan for the major temporary materials and equipment on the construction stage for river, bridge and road improvement plans was proposed in Table 9.3-1 Procurement Plan for Major Temporary Materials and Equipment

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This procurement plan has been prepared based on the following policies, efficient construction schedule and safety management such as road construction work and riverside land work.

- The main structure works in the river during rainy season which is from December to April is basically suspended.
- The standard and specifications for temporary facilities shall comfort to the standard, guideline and other requirements stipulated in each construction method.
- The registered lease company for the temporary construction material and equipment has not been seen in the local market.
- The steel truss temporary bridge for the detour is procured from third countries because it is not available in Vanuatu.
- The concrete batching plant is procured from Japan to address the issue on the mix proportion with the aggregate originated from coral materials.
- There are several crushing plants with crushing sedimentary limestones so called Coronous in Efate Island. However, the characteristics of the Coronous might not conform to the requirements as stipulated in Clause 9.1. Hence, it is assumed the Coronous is utilized for base course material for road improvement and detour works. It is considered that the aggregate for the concrete structure should be produced by the crushing plant procured from Japan or the third countries.
- The quality wooden materials and plywood for form works and safety goods and facilities can be procured from Vanuatu although the supply capacity might not be enough. The sand bags can be locally procured.
- The temporary gantry, scaffolding, soil cofferdam, steel for shoring, steel sheet pile, equipment for girder erection and material test instruments should be procured from Japan or the third countries based on the results of the market research. However, the final procurement plan should be prepared during the preparatory survey considering the cost including transportation and delivery period.

Table 9.3-1 Procurement Plan for Major Temporary Materials and Equipment

Type of Equipment	Procured from			Remarks
	Vanuatu	Japan	Third Country	
Steel truss temporary bridge(detour bridge)			○	・Conformity with specifications, checked by a catalogue, test certificate, etc.
Weighing scale for concrete batching		○		・Concrete mixing is done by Transit mixer ・Conformity with specifications of instruments, checked by broacher.
Crushing Plant	○	○	○	・From local contractors
Wooden materials for formworks	○ Imported			・Conformity with specifications, checked by broacher or test certificate
Plywood for formworks	○ Imported			・Conformity with specifications, checked by broacher or test certificate
Steel materials for temporary gantry		○	○	・Conformity with specifications, checked by broacher or test certificate
Steel materials for scaffolding		○	○	・Conformity with specifications, checked by broacher or test certificate
Steel sheet pile for cofferdam		○	○	・Conformity with specifications, checked by broacher or mill test certificate
Steel materials for soil cofferdam		○	○	・Conformity with specifications, checked by broacher or mill test certificate
Sand bags for cofferdam	○			
Steel materials for girder erection		○		・Conformity with specifications, checked by broacher or mill test certificate
Steel materials for shoring		○	○	・Conformity with specifications, checked by broacher or mill test certificate
Instruments for material test		○ JIS		・Conformity with specifications, checked by broacher or test certificate
Safety facilities and equipment	○ Imported			

Source: JICA Survey Team

9.4 Local Consultants and Contractors

Capacity and status of the consultants and contractors working in Vanuatu are studied and compiled for the calculation of the approximate project cost for river, bridge and road improvement works.

The results of data collection on the profile, work records and capacity of the consultants and contractors related to the foreign assisted projects are shown in the following.

(1) Present Status and Structure of Consultants in Vanuatu

The results of survey on present status and structure of the consultants in Vanuatu are shown in Table 9.4-1. The reliable consultants for the topographic survey, the geotechnical survey, the material test and the construction supervision during the preparatory survey and the implementation stage under the framework of the grant aid from are very few and such works are generally performed by the

consultants from the third countries. These issues should be taken into account for preparation of the approximate project costs and the implementation schedule.

Table 9.4-1 Local Consultant Profile

Company Name	Outline	Work Records and Capacity
Qualao Consulting	Local general consultant	・Providing supervision works for the Japan's loan project, "The Port Vila Lapetasi International Multi-Purpose Wharf Development Project"
Geomap	Local consultant. Allied with Fletcher Construction Group (Contractors in New Zealand)	・Mainly conducting topographical survey with support of Fletcher
Kramer Ausenco	Construction consultant. A head office is in Papua New Guinea and branch offices are in Vanuatu, Australia and Fiji.	・Mainly conducting topographical survey, environmental assessment and dispatch of civil engineers in Vanuatu
Tonkin/ Taylor International	General construction consultants. A head office is in New Zealand and in charge of the entire area of Oceanian counties. Major work items are topographic survey, geographical survey, environmental assessment and supervision work	・Conducting many consulting works in Oceanian countries ・Participating in the many survey works of the Japan's grant aid projects

Source: JICA Survey Team

(2) Present Status and Structure of Contractors in Vanuatu

The results of survey on present status and structure of the contractors in Vanuatu are shown in Table 9.4-2.

The big projects requiring high technologies have been undertaken by the major potent Japanese or the third country's contractors in Oceanian countries according to the local contractors. On the other hand, the local contractors have undertaken only small projects or the work not requiring high technologies.

Hence, it is considered that the local contractors can supply labors only during the implementation of the project.

The preparation of the approximate project costs and implementation schedule should consider such circumstances.

Table 9.4-2 Local Contractor Profile

Company Name	Outline	Work Records and Capacity
Geomap	Contactor allied with Fletcher Construction Group (also offering consultant services)	・Participated in "the Project for Improvement of the Ring Road In Efate Island In the Republic Of Vanuatu" as mainly labor dispatcher
Lonbu	Local Contractor	・Participated in "the Project for the Redevelopment of Vila Central Hospital in the Republic of Vanuatu" funded by Japan's grant aid as labor dispatcher ・Has no construction equipment
Enterprise Dinh Van Tu	Local Contractor	・Mainly supply concrete aggregates, ready-mixed concrete and lease equipment ・Conducted the urgent construction for damages caused by Cyclone Pam. ・Has no experience of a big project
Pierre-Henri Brunet	Local Contractor	・Supply the ready mixed concrete to the major projects in Vanuatu ・Has no experience of a big civil project ・Has experience of big building project.
Downer EDI Works Ltd.	Established by Downer (New Zealand Contractor) as a local subsidiary in 2009 in Vanuatu	・Paved 93 km of the ring road in Efate Island in MCA funded project ・Implementing "Port Vila Urban Development Project" funded by ADB and Australian Government ・Constructing port facility such as a new jetty for large cruise ships
Fletcher	A member of Fletcher Construction Group (New Zealand Contractor) under South Pacific Division of Fletcher Construction	・Has many big scale civil projects implemented by international aid organization ・Has many big scale building projects
Hawkins	One of the Big New Zealand contractors	・Implementing domestic wharfs in Interisland Shipping Support Project funded by ADB and New Zealand ・Upgrading the Main Fatumaru Bay Park in "Vanuatu Tourism Infrastructure Project" funded by New Zealand
CCECC (South Pacific) Ltd.	Chinese contractor operating in the southern pacific area since 2013.	・Implementing big scale road and building projects (with unknown fund source)

Source: JICA Survey Team

9.5 Tax Exemption for Procured Materials, Equipment and Goods

The status of the implementation of tax exemption for the custom import duty, import duty and value-added tax of the procured materials, equipment and goods under the framework of the grant aid project is very major information for the calculation of the approximate project cost and the preparation of the implementation schedule for the river, bridge and road improvement plan.

The results of the interview on the status of the application procedure, process, approval system for the tax exemption from the implementation organization (PWD) and a Japanese contractor in Vanuatu are explained in this chapter.

In fact, the approval and implementation of the tax exemption are smoothly and certainly being executed according to the Japanese contractor.

- Implementing organization (PWD) applies for tax exemption of custom import duty, import duty and value added tax to Department of Strategic Policy Planning & Aid Coordination (DSPPAC) and Prime Minister's Office (PMO) based on the exchange note and contract documents.
- DSPPAC submits the application for duty exemption for the importation materials to Customs and Inland Revenue (CIR) under Department of Customs and Vat office under CIR.
- CIR issues "the Request for Duty and VAT exemption with Approval Reference X No." to PWD and DSPPAC. At the same time, "VAT Zero- rating Approval Certificates for Approved Aid Project" is also issued.
- The contractor applies the tax exemption for custom import duty, import duty and VAT based on the certificate, and the tax exemption is implemented.

9.6 Land Acquisition

The approval of the environment concerns for land acquisition which is obligation of PWD is bound issue for the study on needs and direction of cooperation. The results of the study on the approximate area of the land acquisition were tabulated as follows. This aims to assist PWD to clarify what should be done and be confirmed.

(1) Computation of the Land Area to be Acquired

Computation criteria for land acquisition based on the drawings for river, bridge and road improvement plan are shown in Table 9.6-1 and Figure 9－1. The study on the computation of the land area to be acquired is done based on the following policies.

- The confirmation of land owner including ROW is requested to PWD at some areas. After the clarifications are done, the re-computation of the land area to be acquired is required.
- Topographic survey which is necessary for the computation of the land area to be acquired was not in TOR of the consulting service in this survey and not conducted. Hence, the computation for the land area to be acquired has been done based on the topographic model of DTM (digital terrain model) and a simple cross section survey instead of the topographic survey
- The topographic survey should be conducted during the preparatory survey so that the land area to be acquired for the river, bridge and road improvement plan is more accurately computed.

Table 9.6-1 Computation Criteria for Land Acquisition

(Unit: m^2)

Components		Land Acquisition Area				Total
Large Classification	Middle Classification	Left Upstream (Private)	Right Upstream (Private)	Left Downstream (Customary Land)	Right Downstream (Customary Land)	
River Improvement	Multi-Staged Steel Bar Gabion Slope Protection	2,052	1,281	1,430	4,663	9,426
	Steel Sheet Pile + Reinforced Concrete Slope Protection	1,970	1,281	1,243	4,465	8,959
	Grouted Riprap Slope Protection	2,052	1,281	1,430	4,663	9,426
Bridge Improvement	Span Length 30.0m+30.0m Multi-Staged Steel Bar Gabion Slope Protection	0	0	0	292	292
	Span Length 30.0m+30.0m Steel Sheet Pile + Multi-Staged Steel Bar Gabion Slope Protection	0	0	0	292	292
	Span Length 30.0m+35.0m Multi-Staged Steel Bar Gabion Slope Protection	0	0	0	362	362
	Span Length 30.0m+35.0m Steel Sheet Pile + Multi-Staged Steel Bar Gabion Slope Protection	0	0	0	362	362
Road Improvement	Concrete	0	0	1,030	0	1,030
	Grouted Riprap	0	0	317	0	317

Source: JICA Survey Team

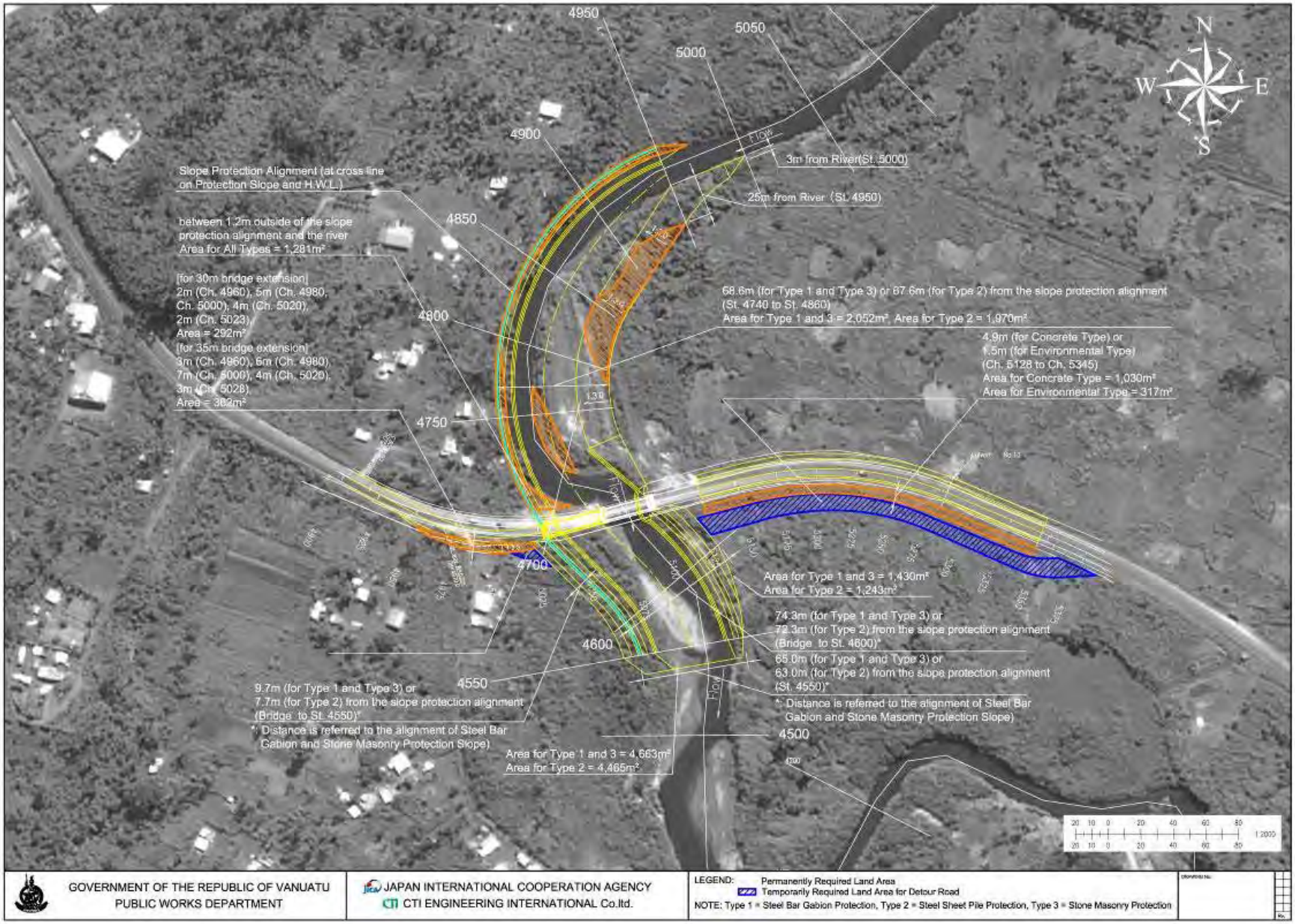


Figure 9－1　Plan for Land Acquisition and Land Lease (Draft)

(2) Computation of Land Lease Area

The detour road is indispensable because the entire width of the target section on the ring road for this project (river, bridge and road improvement plan) will be occupied and closed by the contractor during construction.

Computation criteria for the land lease for detour road is shown in Figure 9－1 and Table 9.6-2.

The study on the computation of the land lease is done based on the following policies.

- Traffic control on the detour road during construction should be done by PWD. PWD should also lease the land for the detour road.
- The land area for the detour road should be reviewed during the preparatory survey based on the topographic survey to be conducted and the detour road plan to be prepared.

Table 9.6-2 Computation Criteria for Land Lease for Detour Road

(Unit: m^2)

Item	Land Lease Area				Total
	Left Upstream (Private)	Right Upstream (Private)	Left Downstream (Customary Land)	Right Downstream (Customary Land)	
Detour Road	0	0	2,342	99	2,441

Source: JICA Survey Team

(3) Land for Temporary Facilities

The land for temporary facilities such as material and equipment stock yard, plants, access road shall be finalized by a method statement to be prepared by contractors and shall be leased by contractors. Therefore, the land for temporary facilities shall be out of the computation of the target area for land lease.

9.7 Calculation of Approximate Project Cost

The approximate project cost is calculated based on the following policies.

- The study on the source of material (local or foreign) for aggregates for concrete structure, spread seal pavement and cement concrete pavement is required considering the quality assurance.
- The project costs based on imported aggregates and the one on the local aggregates have big gap. Therefore, two different types of the project costs using imported and local aggregates are necessary.
- The two different approximate project costs which are A) using local hard limestone aggregates and B) using imported basalt aggregates should be prepared and proposed. The procurement plan for A) and B) are shown in Table 9.7-1 Procurement Schedule for Aggregates (Plan A and B)
- The approximate project costs in three cases, with 1) the highest cost, 2) the lowest cost and 3) the smallest ROW for plan A and plan B are proposed as follows. The outline and specifications of each

case and plan are also shown as follows.

Table 9.7-1 Procurement Schedule for Aggregates (Plan A and B)

Work Items	Plan A		Plan B	
	Hard Limestone (Local)	Basalt (Imported)	Hard Limestone (Local)	Basalt (Imported)
Aggregate for Concrete Structure	○	—	—	○
Aggregate for Spread Seal Pavement	○	—	—	○
Aggregate for Cement Concrete Pavement	○	—	—	○
Rubble Stone for Multi-Staged Steel Bar Gabion	○	—	○	—
Rubble Stone for Panel Type Gabion	○	—	○	—
Rubble Stone for Wet Stone Masonry (River Improvement)	○	—	○	—
Rubble Stone for Grouted Riprap (Road Improvement)	○	—	○	—

Source: JICA Survey Team

(1) Approximate Project Cost for Plan A (Local Aggregate)

1) The Highest Cost Case in Plan A

Total Approximate Project Cost : 1.73 billion yen

1. Approximate Project Cost: 1.648 billion yen

Item		Cost (million yen)	Specifications
Project Cost		1,647.7	I + II
I	Construction Cost	1,384.5	・Riverbank and Riverbed Excavation, River Widening, Earth Cut Slope, Steel Sheet Pile + Concrete Slope Protection ・Reuse and Repair of Existing Bridge (30 m), Extension with New Bridge (35 m), Demolition of Right Abutment, New Pier, New Right Abutment, Steel Sheet Pile + Multi-Staged Steel Bar Gabion Protection ・Demolition of Existing Road, New Flood-Proofing Road with Apron and Floor Protection (Concrete Road, Panel Type Gabion Protection and Grouted Riprap for Subgrade) ・Land Acquisition: 10,351 m^2 (River Improvement: 8,959 m^2, Bridge Improvement: 362 m^2, Road Improvement: 1,030 m^2)
	Direct Cost	1,006.5	
	・River Imp.	547.7	
	・Bridge Imp.	200.6	
	・Road Imp.	130.8	
	・Detour	127.4	
	Temporary Works	44.0	
	Site Expense	229.4	
	Overhead	104.6	
II	Consulting Service	263.2	・DD: 4.5Month (including 1.0 at site and 0.5 month for tender document approval) ・Tender Assistance: 4.0Month (including Pre-Qualification: 0.5 month, Approval of Contract: 0.5) SV: 25.0 Month, Resident Engineer (for River Improvement: 1 person, Road and Bridge Improvement: 1 person)
	Detailed Design	34.3	
	Tender Assistance	4.8	
	Supervision	224.1	

Note: Exchange rate: USD 1.00 = JPY102.129 VT 1.00＝JPY 0.9728

Source: JICA Survey Team

2. Contingency: 0.082 billion yen

・Contingency is set at 5% of the project cost: 82.4 (million yen)

2) The Lowest Cost Case in Plan A

Total Approximate Project Cost : 1.47 billion yen

1. Approximate Project Cost: 1.397 billion yen

Item		Cost (million yen)	Specifications
Project Cost		1,397.4	I + II
I	Construction Cost	1,134.2	・Riverbank and Riverbed Excavation, River Widening, Earth Cut Slope, Wet Stone Masonry Slope Protection ・Reuse and Repair of Existing Bridge (30m), Extension with New Bridge (30m), Demolition of Right Abutment, New Pier, New Right Abutment, Multi-Staged Steel Bar Gabion Protection ・Demolition of Existing Road, New Flood-Proofing Road with Apron and Floor Protection (Concrete Road, Grouted Riprap Protection and Panel Type Gabion Protection) ・Land Acquisition: 10,035 m^2 (River Improvement: 9,426 m^2, Bridge Improvement: 292 m^2, Road Improvement: 317m^2)
	Direct Cost	822.8	
	・River Imp.	397.2	
	・Bridge Imp.	207.0	
	・Road Imp.	72.3	
	・Detour	146.3	
	Temporary Works	36.0	
	Site Expense	187.5	
	Overhead	87.9	
II	Consulting Service	263.2	・DD: 4.5Month (including 1.0 at site and 0.5 month for tender document approval) ・Tender Assistance: 4.0Month (including Pre-Qualification: 0.5 month, Approval of Contract: 0.5) SV: 25.0 Month, Resident Engineer (for River Improvement: 1 person, Road and Bridge Improvement: 1 person)
	Detailed Design	34.3	
	Tender Assistance	4.8	
	Supervision	224.1	

Note: Exchange rate: USD 1.00 = JPY102.129 VT 1.00＝JPY 0.9728

Source: JICA Survey Team

2. Contingency: 0.070 billion yen

・Contingency is set at 5% of the project cost: 69.9 (million yen)

3) Smallest Land Acquisition in Plan A

Total Approximate Project Cost : 1.66 billion yen

1. Approximate Project Cost: 1.579 billion yen

Item		Cost (million yen)	Specifications
Project Cost		1,578.7	I + II
I	Construction Cost	1,315.5	・Riverbank and Riverbed Excavation, River Widening, Earth Cut Slope, Steel Sheet Pile + Concrete Slope Protection ・Reuse and Repair of Existing Bridge (30m), Extension with New Bridge (30m), Demolition of Right Abutment, New Pier, New Right Abutment, Multi-Staged Steel Bar Gabion Protection ・Demolition of Existing Road, New Flood-Proofing Road with Apron and Floor Protection (Concrete Road, Grouted Riprap Protection and Panel Type Gabion Protection) ・Land Acquisition: 9,568 m^2 (River Improvement: 8,959 m^2, Bridge Improvement: 292 m^2, Road Improvement: 317m^2)
	Direct Cost	955.9	
	・River Imp.	570.1	
	・Bridge Imp.	187.6	
	・Road Imp.	65.5	
	・Detour	132.7	
	Temporary Works	41.8	
	Site Expense	217.8	
	Overhead	100.0	
II	Consulting Service	263.2	・DD: 4.5Month (including 1.0 at site and 0.5 month for tender document approval) ・Tender Assistance: 4.0Month (including Pre-Qualification: 0.5 month, Approval of Contract: 0.5) SV: 25.0 Month, Resident Engineer (for River Improvement: 1 person, Road and Bridge Improvement: 1 person)
	Detailed Design	34.3	
	Tender Assistance	4.8	
	Supervision	224.1	

Note: Exchange rate: USD 1.00 = JPY102.129 VT 1.00＝JPY 0.9728

Source: JICA Survey Team

2. Contingency: 0.079 billion yen

・Contingency is set at 5% of the project cost: 78.9 (million yen)

(2) Approximate Project Cost for Plan B (Imported Aggregate)

1) The Highest Cost Case in Plan B

Total Approximate Project Cost : 1.86 billion yen

1. Approximate Project Cost: 1.772 billion yen

Item		Cost (million yen)	Specifications
Project Cost		1,772.1	I + II
I	Construction Cost	1,508.9	・Riverbank and Riverbed Excavation, River Widening, Earth Cut Slope, Steel Sheet Pile + Concrete Slope Protection ・Reuse and Repair of Existing Bridge (30 m), Extension with New Bridge (35 m), Demolition of Right Abutment, New Pier, New Right Abutment, Steel Sheet Pile + Multi-Staged Steel Bar Gabion Protection ・Demolition of Existing Road, New Flood-Proofing Road with Apron and Floor Protection (Concrete Road, Panel Type Gabion Protection and Grouted Riprap for Subgrade) ・Land Acquisition: 10,351 m^2 (River Improvement: 8,959 m^2, Bridge Improvement: 362 m^2, Road Improvement: 1,030 m^2)
	Direct Cost	1,097.9	
	・River Imp.	515.8	
	・Bridge Imp.	210.7	
	・Road Imp.	251.4	
	・Detour	120.0	
	Temporary Works	48.0	
	Site Expense	250.3	
	Overhead	112.7	
II	Consulting Service	263.2	・DD: 4.5Month (including 1.0 at site and 0.5 month for tender document approval) ・Tender Assistance: 4.0Month (including Pre-Qualification: 0.5 month, Approval of Contract: 0.5) SV: 25.0 Month, Resident Engineer (for River Improvement: 1 person, Road and Bridge Improvement: 1 person)
	Detailed Design	34.3	
	Tender Assistance	4.8	
	Supervision	224.1	

Note: Exchange rate: USD 1.00 = JPY102.129 VT 1.00＝JPY 0.9728

Source: JICA Survey Team

2. Contingency: 0.089 billion yen

・Contingency is set at 5% of the project cost: 88.6 (million yen)

2) The Lowest Cost Case in Plan B

Total Approximate Project Cost : 1.53 billion yen

1. Approximate Project Cost: 1.479 billion yen

Item		Cost (million yen)	Specifications
Project Cost		1,479.0	I + II
I	Construction Cost	1,215.8	・Riverbank and Riverbed Excavation, River Widening, Earth Cut Slope, Wet Stone Masonry Slope Protection ・Reuse and Repair of Existing Bridge (30m), Extension with New Bridge (30m), Demolition of Right Abutment, New Pier, New Right Abutment, Multi-Staged Steel Bar Gabion Protection ・Demolition of Existing Road, New Flood-Proofing Road with Apron and Floor Protection (Concrete Road, Grouted Riprap Protection and Panel Type Gabion Protection) ・Land Acquisition: 10,035 m^2 (River Improvement: 9,426 m^2, Bridge Improvement: 292 m^2, Road Improvement: 317m^2)
	Direct Cost	882.7	
	・River Imp.	425.3	
	・Bridge Imp.	218.8	
	・Road Imp.	101.5	
	・Detour	137.1	
	Temporary Works	38.6	
	Site Expense	201.2	
	Overhead	93.3	
II	Consulting Service	263.2	・DD: 4.5Month (including 1.0 at site and 0.5 month for tender document approval) ・Tender Assistance: 4.0Month (including Pre-Qualification: 0.5 month, Approval of Contract: 0.5) SV: 25.0 Month, Resident Engineer (for River Improvement: 1 person, Road and Bridge Improvement: 1 person)
	Detailed Design	34.3	
	Tender Assistance	4.8	
	Supervision	224.1	

Note: Exchange rate: USD 1.00 = JPY102.129 VT 1.00＝JPY 0.9728

Source: JICA Survey Team

2. Contingency: 0.074 billion yen

・Contingency is set at 5% of the project cost: 74.0 (million yen)

3) The Smallest Land Acquisition in Plan B

Total Approximate Project Cost : 1.71 billion yen

1. Approximate Project Cost: 1.621 billion yen

Item		Cost (million yen)	Specifications
Project Cost		1,621.4	I + II
I	Construction Cost	1,358.2	・Riverbank and Riverbed Excavation, River Widening, Earth Cut Slope, Steel Sheet Pile + Concrete Slope Protection ・Reuse and Repair of Existing Bridge (30m), Extension with New Bridge (30m), Demolition of Right Abutment, New Pier, New Right Abutment, Multi-Staged Steel Bar Gabion Protection ・Demolition of Existing Road, New Flood-Proofing Road with Apron and Floor Protection (Concrete Road, Grouted Riprap Protection and Panel Type Gabion Protection) ・Land Acquisition: 9,568 m^2 (River Improvement: 8,959 m^2, Bridge Improvement: 292 m^2, Road Improvement: 317m^2)
	Direct Cost	987.3	
	・River Imp.	555.8	
	・Bridge Imp.	206.3	
	・Road Imp.	95.9	
	・Detour	129.3	
	Temporary Works	43.1	
	Site Expense	225.0	
	Overhead	102.8	
II	Consulting Service	263.2	・DD: 4.5Month (including 1.0 at site and 0.5 month for tender document approval) ・Tender Assistance: 4.0Month (including Pre-Qualification: 0.5 month, Approval of Contract: 0.5) SV: 25.0 Month, Resident Engineer (for River Improvement: 1 person, Road and Bridge Improvement: 1 person)
	Detailed Design	34.3	
	Tender Assistance	4.8	
	Supervision	224.1	

Note: Exchange rate: USD 1.00 = JPY102.129 VT 1.00＝JPY 0.9728

Source: JICA Survey Team

2. Contingency: 0.081 billion yen

・Contingency is set at 5% of the project cost: 81.1 (million yen)

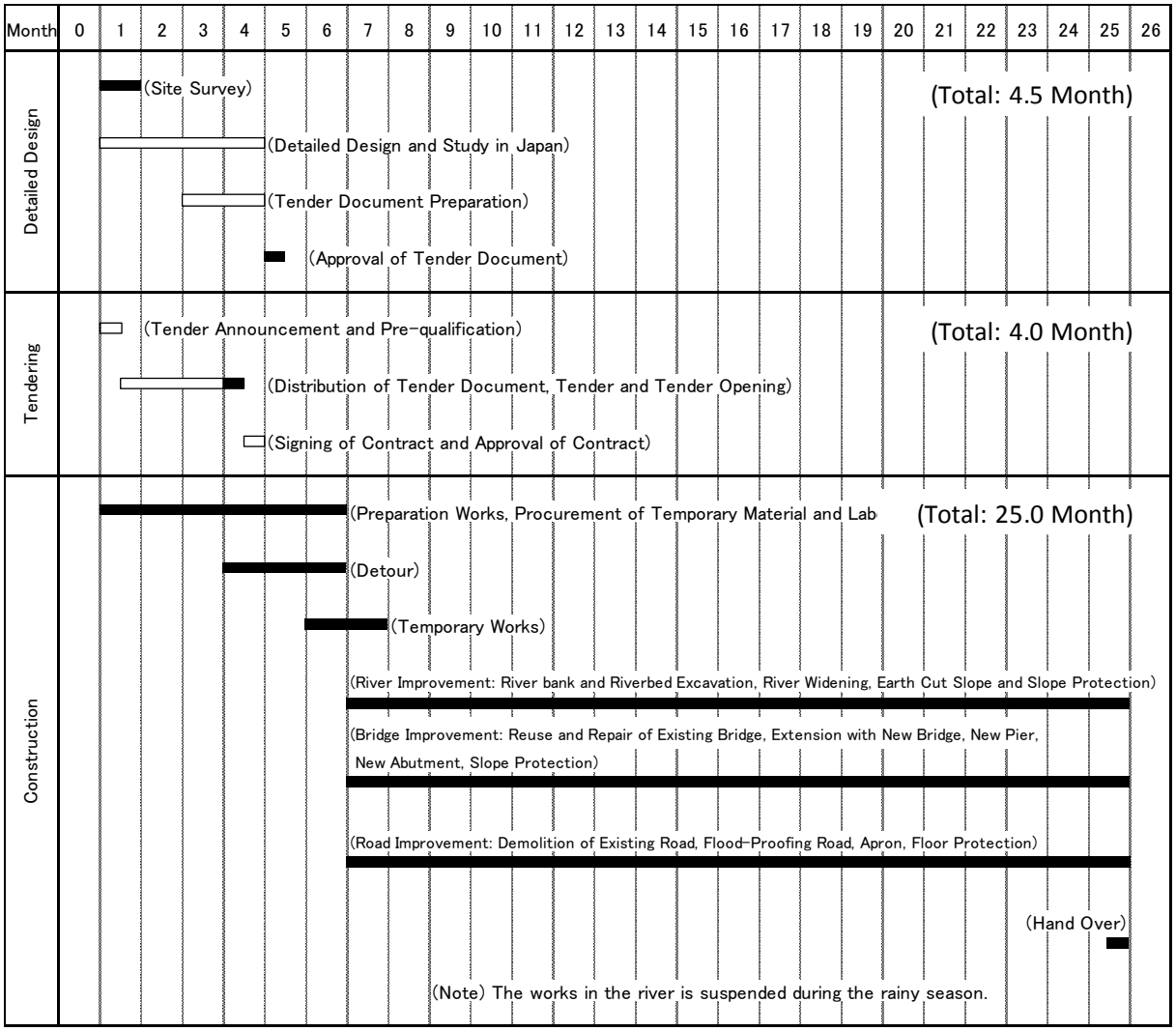
9.8 Study on Implementation Schedule

The implementation schedule for the detailed design, tendering and implementation of the project expected after this survey is shown in Table 9.8-1.

If this project is implemented with the grant aid from Japan, the grant type B is recommended. This is because,

1) This project will take long which needs 34 months from the signing of the Exchange of Note until the completion of the project.
2) Single Exchange of Note for both the detailed design and construction will accelerate the progress of the project.

Table 9.8-1 Implementation Schedule (Draft)



Source : JICA Survey Team

Chapter 10 Environmental and Social Consideration

10.1 Baseline Information on Environmental and Social Conditions in Vanuatu

10.1.1 Natural Environment

(1) Land Use

Vanuatu is a Y-shaped archipelago with about 82 relatively small, geologically newer islands of volcanic origin ranging about 1,300 km between the most northern and southern islands. In 65 out of 82 islands, people inhabit. The total area of the country is about 12,300 km^2. Major indicators in Vanuatu's land use are shown in Table 10.1-1.

Table 10.1-1 Major Indicators in Vanuatu's Land Use

Vegetation Type	Area (km^2)	% of Land Area
Thickets (3-8 m)	4,339	35.4
Bare ground or agricultural and inhabited land	2,523	20.6
Low forest (10-20 m)	2,341	19.1
Mid-height forest (20-30 m)	2,053	16.7
Grassland	511	4.2
Scrub (<3 m)	450	3.7
Mangroves	25	0.2
Swamp Communities	23	0.2
Woodland (<10m)	4	0.03
Land area	12,269	100

Source: JICA Survey Team, based on Initial Environmental Examination (IEE) of Port Vila Urban Development Project (ADB/ Australian Government)

(2) Hydrology

1) Surface Water

The distribution of water in the country varies with the topography of the island. The highly-raised volcanic islands have rivers and streams and groundwater while the low-lying coral islands rely on groundwater or water obtained from rainwater tanks or from a lens of fresh groundwater floating on the underlying salt water. Some smaller islands such Mataso and Buninga in the Shepherd islands in Shefa province, all of Torres islands, and small islands off Malekula and Santo have neither surface water nor groundwater.

The primary permanent surface water features within or adjacent to the urban area of Port Vila comprise several rivers. These are as follows.

- Central: Tagabe River
- Northwest: La Colle River, Teunono River, Tepwukoa River, Teae River

・ South: Teouma River, Rentapau River

Teouma River, the largest river in Efate Island, is 28 km long with 91 km^2 of catchment area.

2) Groundwater

Rainfall in Port Vila area amounts to approximately 2,000 mm per year and 20% of becomes groundwater. In many parts of Vanuatu, there are substantial amounts of groundwater which can provide large amounts of water even during severe drought. Groundwater sources can also be accessed to either through dug-wells or boreholes.

A rough estimate for renewable surface water resources by Food and Agriculture Organization of the United Nations (FAO) could be 10 billion m^3 per year. Renewable groundwater resources have been estimated at 4.4 billion m^3/year, which are considered to be drained entirely by the surface water network (overlap).

Table 10.1-2 Annual Renewable Freshwater Resources in Vanuatu

Item	Year	Value	
Precipitation (long-term average)	-	2,000	mm/year
	-	24.4	billion m^3/year
Internal renewable water resources (long-term average)	-	10.0	billion m^3/year
Total renewable water resources	-	4.0	billion m^3/year
Dependency ratio	-	0.0	%
Total renewable water resources per inhabitant	2015	37,793	m^3/year

Source: JICA Survey Team, based on FAO Aquastat HP (www.fao.org/nr/water/aquastat)

Most of the formal water supply of the Port Vila area is derived from groundwater wells located at Tagabe within a designated Water Protection Zone. One spring source and four wells north of the town and close to the Tagabe River all are used to meet the water requirements for the urban population. Three of the wells are drilled into limestone formations, and the other into alluvial sediments overlying limestone. Additionally, beyond the current reach of the urban piped supply system, a large number of people living in the areas surrounding Port Vila rely on groundwater abstracted from private wells and boreholes for domestic, agricultural and light industrial use. In some areas, where piped water is not provided, private wells, boreholes and rivers are the only source of water.

Port Vila's water supply is owned by the State but is managed, maintained, improved and operated by a private company, UNELCO. In Port Vila, UNELCO provides 9,200 m^3 of water per day from boreholes. The ultimate capacity of the water resource is 60,000 m^3 per day. The rate for unaccounted water in 2000 is at 21%.

Because of the prevalent limestone formations, many areas have fairly high carbonate content. In other areas, such as the Pango peninsula, groundwater is fairly saline, due to saltwater intrusion. Groundwater in Teouma Valley is also saline, but in this case salinity is ascribed to residual sea water trapped within the valley sediments and subsequently modified by reaction with silicate minerals. Some of the groundwater from Teouma Valley originates from thermal springs with

temperatures above ambient levels.

(3) Flora and Fauna

Vanuatu is located at the eastern limit of distribution of Indo-Malaysian species and at the western limit of many Pacific species. However, compared to other neighboring biogeographic regions such as Papua New Guinea (PNG), New Caledonia or the Solomon Islands, Vanuatu does not present high levels of diversity or endemicity of terrestrial species. Overall richness and endemism in Vanuatu range from low to moderate in comparison with those of other eco-regions. This seemingly impoverished state results from the islands' size, geological youth and their relative isolation from large expanses of land. Frequent damages inflicted by cyclonic, seismic and volcanic activity have further impacted on the development of a rich biodiversity.

The forests of Vanuatu are not as tall are those of PNG and Solomon Islands, rarely exceeding 30 m in height. Scrub, grassland and freshwater/marine ecosystems make up most of the remainder.

The number of species of flora and fauna in Vanuatu are summarized as below

1) Flora

There around 1,000 vascular plants of which 150 are endemic and, 700 species of bryophytes. The representatives are:

- ✓ 158 species of orchids, including 7 endemics;
- ✓ 21 species of palm trees, including one endemic monospecific genus (Carpoxylon macrospermum a palm tree and 14 endemic species, 11 of which are rare or vulnerable;
- ✓ 12 species of araceae, including 8 endemics; and
- ✓ Around 250 species of pterophytes.

2) Fauna

1. Invertebrates

- ✓ 80 species of butterfly, including 5 endemics;
- ✓ 12 species of bees including 7 endemics;
- ✓ 12 species of ants and termites;
- ✓ Over 200 species of flies;
- ✓ 73 species of land snails; and
- ✓ 22 species of earthworms.

2. Birds

There is a repertoire of 121 species, some of which are rare or vulnerable, including:

- ✓ 74 species of land and freshwater birds;

- ✓ 32 species of sea-birds of which few are resident;
- ✓ 15 species of shore-birds, including 7 endemic; and
- ✓ Green Palm Lorikeet (Charmosyna palmarum), Vanuatu Mountain Pigeon (Ducula bakeri), Pacific Imperial Pigeon (Ducula pacifica), Royal Parrotfinch (Erythrura cyaneovirens), Peregrine Falcon (Falco peregrinus), Santa Cruz Ground Dove (Gallicolumba sanctaecrucis) and the Incubator Bird (Megapodius freycinet).

3. Reptiles and Amphibians

A repertoire of around 30 species, including:

- ✓ 19 species of lizards, 4 are endemic and one species near extinction was introduced from Fiji (Green Banded Iguana or Brachylophus fasciatus);
- ✓ 2 species of snake (Pacific Boa or Candoia bibroni);
- ✓ 4 species of sea turtles all endangered worldwide (Green turtle or Chelonia mydas, Hawksbill Turtle or Eretmochelys imbricata, Loggerhead Turtle or Caretta caretta, and Leatherback Turtle or Dermochelys coriacea;
- ✓ 1 species of saltwater crocodile (Crocodylis porosus);
- ✓ 2 species of sea snake such as Yellow-bellied Sea Snake (Pelamis platurus) and Laticauda sp.; and
- ✓ 2 introduced species of frog.

4. Mammals

There are 12 species of chiropterae (Flying Foxes and Bats) which represent the only native mammals with one endemic species and, a range of introduced mammals that include:

- ✓ 4 species of flying foxes (Pteropus sp.), all endemic;
- ✓ 8 other bats species (microchiroptera), 2 endemic of which the Nendo tube-nosed bat (Nyctimene santacrucis) is presumed to be extinct; and
- ✓ All other mammal species have been introduced being rats (Rattus exulans, Rattus norvegicus, and Rattus vattus), mice (Mus musculus), feral cattle (Bos Taurus), feral goat (Capra hircus), feral pig (Sus scrofa), feral cats and dogs.

5. Fish

The fish observed in the Teouma River are as below. Any rare or endangered species are not reported.

Scientific Name	Common Name	IUCN Class	Life Cycle
Fish			
Anguilla marmorata	Giant Mottled-eel	LC	Eel fishes go to deep ocean to spawn. Glass eels arrive in estuaries between October and April every year with a peak season in January to February.
Anguilla megastoma	Polynesian long-finned eel	DD	
Microphis brachyurus	Short-tailed pipefish	-	Reproduction in freshwater
Microphis manadensis	Menado Pipe Fish	LC	
Microphis retzii	Ragged-tail pipefish	LC	
Mircophis spinachioides	Spinach Pipe Fish	DD	
Crenimugil crenilabis	Fringelip mullet	LC	Egg laying at sea
Mugil cephalus	Flat-headed mullet	LC	Reproduction takes place at sea.
Ambassis interrupta	Long-spined glass perchlet	LC	Mangroves and brackish water species
Kuhlia marginata	Dark-margined flagtail	LC	Lives in lower parts of river including the brackish waters.
Kuhlia munda	Silver flagtail	DD	Reproduction takes place at sea in coastal zones.
Kuhlia mugil	Barred flagtail	LC	Egg laying at coastal zones. Estuaries used as nurseries.
Kuhlia rupestris	Rock flagtail	LC	Egg laying is at estuaries or at sea. Salinity greater than 25% is needed for reproduction to succeed. This species need freshwater to complete its life cycle.
Butis amboinensis	Olive flathead-gudgeon	LC	Inhabits mangroves, estuaries and lower course of the rivers.
Eleotris melanosoma	Broadhead sleeper	LC	Hatching in river, larvae go to the sea for 4 months. Juveniles return to estuaries.
Eleotris fusca	Broadhead sleeper	LC	Hatching in the river, larvae go to the sea for no longer than 6 months. After marine phase, juveniles recruit in estuaries and migrate upstream.
Hypseleotris cyprinoides	Tropical carp gedgeon	DD	Part life cycle in freshwater and part in marine.
Ophiocara porocephala	Northern mud gudgeon	LC	Inhabits the mangrove and estuaries.
Glossogobius celebius	Celebes Goby	DD	Part life cycle in freshwater and part in marine.
Redigobius bikolanus	Speckled Goby	LC	
Schismatogobius vanuatuensis		DD	
Sicyopterus lagocephalus	Red-tailed Goby	LC	Reproduction and embryonic development takes place in freshwater. Larvae are carried out to the sea. Spent 130 to 240 days in sea, before moving back to river where it completes its life cycle.
Stenogobius yateiensis	Yate's Goby	LC	Reproduction in freshwater. Larvae go to the sea where they undergo planktonic life for several months. Return to freshwater to complete life cycle.
Stiphodon atratus	Black stiphodon	LC	
Stiphodon rutilaureus	Golden-red stiphodon	LC	
Stiphodon sapphirinus	Sapphire stiphodon	LC	
Crustacean			
Atyoida pilipes	Green Lace Shrimp	LC	Larval stage in saltwater condition
Atyopsis spinipes	Bamboo Shrimp	LC	Planktonic stage in saltwater condition
Caridina brevicarpalis	Short Carpus Shrimp	LC	Larval carried to estuaries, juvenile at sea and migrate back to freshwater.
Caridina typus	Type Shrimp	LC	
Caridina weberi	Weber's Shrimp	LC	Larval stage at sea.

Scientific Name	Common Name	IUCN Class	Life Cycle
Palaemon concinnus	Mangrove Prawn	-	Lives in estuarine brackish waters or in still waters as well as in the lower part of the river's lower course.
Macrobrachium australe	Koua River Prawn	LC	Reproduction takes place in fresh or brackish waters. Juveniles then migrate inland.
Macrobrachium bariense	Berit River Prawn	LC	Reproduction takes place is freshwater.
Macrobrachium lar	Giant Jungle Prawn	LC	Reproduction takes place in fresh or brackish.
Varuna litterata	Varuna Crab	-	Larvae are carried to sea after hatching and juveniles then migrate to freshwater.
Gastropod			
Neritid sp	Nerite snail	LC	
Tarabia granifera	Quilted Melania	LC	

Note: LC (Least Concerned), DD (Data Deficient)

Source: DEPC

10.1.2 Social Environment

(1) Population

Vanuatu has 234,023 people (2009 census) including 78,723 in Shefa province and 44,039 in Port Vila. Average annual population growth of Vanuatu is 2.3% while 3.7% in Shefa. Supposed to employ these population growths, expected population in 2016 would be about 274,402 in Vanuatu and 101,520 in Shefa.

(2) Economy

The real GDP in 2014 was reported at 61.4 billion Vatu (equivalent to 0.57 billion USD) as shown in Table 3.1-5. The sector contributing to generating nation's wealth is services, followed by agriculture and industry. Annual growth rate of GDP (2013-2014) was 2.3% and is expected to increase gradually year by year. Outlines by sector are presented as follows.

1) Agriculture

Major agro-products are beef, copra, coconut oil, cocoa and cassava. These products are exported worldwide. About 80% of rural population engages in subsistence farming. The exported are vanilla, spice and sandalwood oil product.

2) Industry

The scale of industry sector is small and most products are for domestic use. The products include processed foods (bread, ice cream, cheese and beverage), plastic commodity, boats, timber, furniture, small-scale circuit and garments.

3) Services

The sector consists of retail wholesale, tourism-related business (travel agency, taxi/car rental, tourist information, restaurant etc.), financing service (accounting, bank). Port Vila plays the center of the sector.

(3) Education

Most recently the Education Experience Survey and Literacy Assessment in Shefa Province highlighted education as a key socio-economic concern. A high percentage of population in Shefa has completed primary education (70.7%) as shown in Table 10.1-3. Significantly less attended secondary education (Secondary to Year 10: 16.75%; Secondary to Year 12/13: 2.85%). Tertiary educational attainment in Shefa is the lowest at only 0.45%.

Table 10.1-3 Highest Level of Education Attended for Adults

Declared Level of Schooling	Percentage Adults Attended (%)
Never Attended	9.25
Primary	70.70
Secondary to Year 10	16.75
Secondary to Year 12/13	2.85
University	0.45
Total	100.00

Source: Education Experience Survey and Literacy Assessment, Shefa Province, Vanuatu, ASPBAE and VEPAC, April 2011

Besides formal education, community and technical education are also accessible in Shefa. Thirty percent of the population had participated in community education/training program for 2008-2011. The focus of these training programs was: religious instruction, literacy improvement, cash income skills, community development and health. Technical/vocational education, on the other hand, was attended by only 10 percent of both females and males.

(4) Health Care

Disease patterns in Vanuatu are changing. In the past the main causes of illness and death were preventable or treatable conditions resulting from poor access to health services. This included problems such as: acute respiratory infection, pneumonia, gastrointestinal diseases, skin infections, parasitic infestation, and complications associated with pregnancy and birth. In these days, on the other hand, lifecycle-related diseases such as heart ailment and diabetes have become the major diseases.

Each province has a provincial administration including a rural health office that is responsible for the administration of health facilities in the province right down to dispensaries. The government is in the process of better defining the functions for each level of health facility and better corresponding resource packages to support the revitalization of primary health care. The type and number of government-funded facilities in each province is shown in Table 10.1-4.

Table 10.1-4 Health Facilities by Province in Vanuatu, 2009

Province / Indicator	Shefa	Malampa	Penama	Sanma	Tafea	Torba	Total
Hospital	1	1	1	1	1	1	6
Health Center	3	8	6	11	6	3	37

Indicator \ Province	Shefa	Malampa	Penama	Sanma	Tafea	Torba	Total
Dispensary	23	19	20	12	10	5	89
Aid Post	42	44	36	56	33	20	231
Total	69	72	63	80	50	29	363
Facilities per 1,000 population	0.88	1.96	2.04	1.74	1.54	3.10	1.55

Source: WHO-WPRO and Min. of Health (2012): Vanuatu Health Service Delivery Profile

(5) Culture & Custom

Vanuatu has a rich cultural history, and the Ni-Vanuatu people adhere closely to many ancient traditional practices, even up to the present day. The concept of so-called “kastom” relates to cultural, historical and religious traditions. It is most intimately tied to the land, natural resources, and reverence for the spiritual forces of nature. While there are many sites that are preserved by their custom-owners, sites that are officially designated as having cultural or historical significance are limited in number.

In accordance with some estimates, the population of Vanuatu in ancient times was much higher than today, probably with as many as 2.5 million inhabitants. Vanuatu is rich in settlement sites from these ancient times, but many of the sites have disappeared and have not been relocated. One of the most significant archaeological discoveries in the South Pacific took place in 2004, when extensive remains of a site from the ancient Lapita culture (approx. 3,200 years B.P.) were unearthed in Teouma, in Port Vila’s peri-urban area. This site contained human remains and extensive deposits of ancient pottery, and is believed to be the largest known Lapita site in the Pacific.

An informal system of "town chiefs" supplements the state police force and judiciary. Leading elders in the towns meet to resolve disputes and punish offenders. Punishment sometimes involves the informal banishment of an accused person back to his or her home island. Unofficial settlement procedures frequently are used to handle disputes in rural areas.

(6) Ethnicity

According to the statistics[6], ethnicity in Vanuatu is summarized as below:

- Ethnic groups: Ni-Vanuatu 97.6%, part Ni-Vanuatu 1.1%, other 1.3% (in 2009)
- Languages: local languages (more than 100) 63.2%, Bislama (official; creole) 33.7%, English (official) 2%, French (official) 0.6%, other 0.5% (in 2009)
- Religions: Protestant 70% (includes Presbyterian 28%, Anglican 15%, Seventh Day Adventist 13%, others 14%), Roman Catholic 12.4%, customary beliefs 3.7% (including John Frum cargo cult), other 12.6%, none 1.1%, unspecified 0.2% (in 2009)

[6] 2016 CIA World Factbook and Other Sources (www.cia.gov/library/publications/the-world-factbook/geos/nh.html)

(7) Land Ownership

1) Custom Tenure

At Independence from the Anglo-French Condominium Government in 1980, the land in Vanuatu was formally restored to the customary landholders. The new Constitution proclaimed: *All land in the Republic of Vanuatu belongs to the indigenous custom owners and their descendants*. It further proclaimed that the rules of "kastom" form the basis of land ownership and use in Vanuatu[7]. Under kastom, individual, family and clan identity is intrinsically linked to the land. As such, land is regarded not just as a physical entity, but is culturally linked with heritage, power, spirituality, and custodianship. Hence the exchange of rights to land is central to kastom, ensuring that harmony, authority, relationship networks and social responsibility are maintained and mediated both within and between clans.

Vanuatu has a variety of ethnicity (over 115 cultures and 106 languages), and hence there is no single, universally acceptable form of customary practice. In addition, kastom practices are dynamic, evolving over time. As a result there are a variety of customary systems of land use and ownership, very few of which have been documented, and only rare cases are legally codified. Hence, despite the legal fact that all land in Vanuatu belongs to the indigenous custom owners and their descendants, the rights to any particular piece of land are often not easily identifiable, but rather are contingent upon oral histories, 'memory culture', complex local categories, and varying inheritance practices (which in some cases can disadvantage women. Rights have also been further blurred by ongoing development. Clustering of the population into villages, plantation communities and towns has been as common in Vanuatu as elsewhere, and in consequence many customary landholders no longer live within their traditional boundaries or even with their community. Because of this, boundaries and rights have inevitably become less certain over time.

2) Leasehold System

At Independence, a leasehold system was introduced to allow existing private users (mainly colonial plantation owners) to maintain access to the lands they had developed. In addition, existing public and freehold titles within Port Vila and Luganville were also protected by the establishment of a relatively secure urban leasehold system.

Under the current law, Government or private investors can negotiate long‐term leases with customary owners (e.g. 75-year renewable lease). Furthermore, while all land is deemed customary, any leases entered into are also deemed by law to be incontestable; hence once a lease has gone through the formal registration process, there is no legal recourse for a customary owner to rescind the deal, no matter what the circumstances. The incontestable status of such leasing arrangements is meant to provide protection for the public or private sector to develop land without fear of undue repercussions, yet these arrangements are often 'private' dealings that overlay significant customary disputes. In such circumstances, the only option for a disenfranchised customary land owner or user is to enter into a dispute with the person who signed the lease on his or her behalf, in order to gain a

[7] Refer to Article 73 and 74 of the Constitution.

share of whatever proceeds that person has procured. However, there is no way for the disenfranchised to regain any right to the land itself.

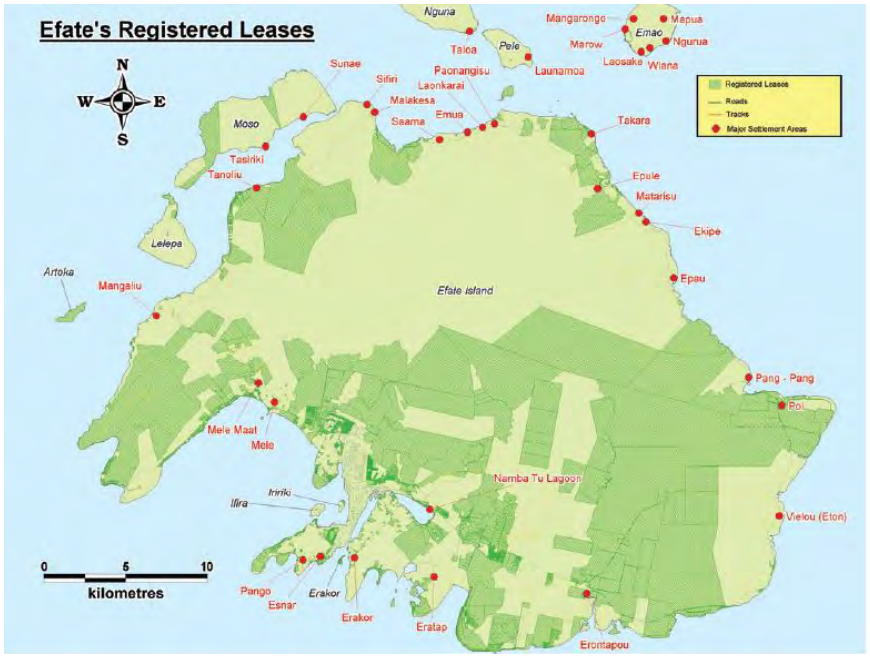
According to the data shown in Table 10.1-5, there were approximately 13,815 registered leases in Vanuatu, covering 1,141.6 km^2 of the land, representing 9.3 percent of the total area of Vanuatu. This includes 5,420 subdivisions, but excludes 989 leases that have been cancelled by the Department of Lands. However, these figures are indicative only and need to be treated with caution, as the quality of the data is questionable. For example, area data were missing for 8 percent of the records, and the approximate backlog of unregistered documents is estimated to be 4,000 leases as of October 2011, suggesting that the area under lease may actually be much higher.

Table 10.1-5 Number of Leases and Leased Area by Province/Island, December 2010

Item / Province/Island	No. of Leases	Area Leased (km^2)	Area of Province/ Island (km^2)	% under Lease
Shefa	9,858	490.9	1,500.6	32.7
Efate/Outer islands	9.821	426.4	970.4	44.0
(Efate-rural)	(5,399)	(418.0)	(958.6)	(43.6)
(Efate-urban)	(4,422)	(8.2)	(11.8)	(69.5)
Malampa	121	114.2	2,760.6	4.1
Penama	32	2.8	1,193.4	0.2
Sanma	3,706	452.3	4,200.0	10.8
Tafea	83	80.3	1,613.3	5.0
Torba	15	1.2	726.3	0.2
Total	13,815	1,141.6	11,994	9.5

Source: World Bank - Justice for the Poor Briefing Notes, Vol. 7 Issue 1, May 2012

The area leased is highest in the provinces of Shefa (490.9 km^2) and Sanma (452.3 km^2). Within these provinces, leasing on Efate and the outer islands (44%) and Santo (10%) accounts for the majority of the leased land. On Efate (Port Vila), 69.5% of urban land is under lease. The distribution of areas leased which are registered on Efate Island is depicted in Figure 10－1.



Source: World Bank - Justice for the Poor Briefing Notes, Vol. 7 Issue 1, May 2012

Figure 10－1　　Map of Land Leases on Efate Island

(8) Community Leadership

There were and are many different forms of indigenous community leadership in Vanuatu. Historically, missionaries and officials of the Anglo‐French Condominium Government introduced into this diversity the concept 'Chief,' a title used to designate the men who represented their communities in the non-traditional contexts of church and state. During the period in which Vanuatu sought and achieved Independence, this role for chiefs altered. They became not so much those who engaged with the new, as those who represented the old. The foundation of the National Council of Chiefs defined chiefs as authoritative representatives of indigenous knowledge and practice, and constituted them as advisers to the Parliament, giving traditionalist Vanuatu people a stake in the creation of the new nation.

Every village has a chief, a respected person elected by the villagers whose role is to manage the issues concerning the village. Sometimes they are generations of the same family, but if the chief is not doing the job right, they can very well change to find a better one. It is a tradition to go and meet the chief when coming into a village.

10.2 System and Organization on Environmental and Social Considerations in Vanuatu

10.2.1 Laws & Standards Concerned

(1) Natural Environment

1) The Constitution 1980

Vanuatu's Constitution holds that it is a fundamental duty of all "to protect the Republic of Vanuatu and to safeguard the national wealth, resources and environment in the interests of the present generation and of future generations." To implement this constitutional provision, the Government is empowered to enact specific laws and create institutions to protect and manage the environment.

2) Environmental Protection and Conservation Act (EPCA) 2010

The main parts of the EPCA deal with 1) administration; 2) Environmental Impact Assessment (EIA); 3) biodiversity and protected areas; and 4) offenses under the Act. The Act provides for a department to develop, implement, and coordinate the Government's environmental policies and programs. The Act makes it mandatory to 1) prepare and publish a national state of environment report at least once every ten years and 2) maintain a publicly accessible environmental registry. The Act provides for establishment of Biodiversity Advisory Council, and specifically covers the issues of bio-prospecting and community conservation areas. The process and procedures for an Environmental and Social Impact Assessment (ESIA) are outlined in the subsequent EIA Regulations (2011).

3) National Parks Act 1993

The Act provides for the establishment of the National Parks Board under Section 3 and the ability of this board to declare national parks for the protection of all ecological functions therein. The Efate Land Management Area (National Park) has been established in the center of the island to protect the islands natural, cultural and historical resources.

4) Water Resources Management Act 2002

This Act applies to all water in Vanuatu, including surface water, groundwater; and any estuarine or coastal sea water. Part 2 of the Act relates to the use of water and associated works, and outlines the process for applications to use water resources. The Director for Water Resources regulates and controls the taking or use of any water, the construction or operation of any bore or works, and the doing of any act which may detrimentally affect a water resource. Information on water usage during a construction work is stipulated in Chapter 4. Under Part 2, Sections 6 and 7 of the Act, a person must apply to the Director for the right to use water, or to construct, operate or maintain works, for any purpose that is not a customary or an existing use of water. In accordance with Section 10 of the Act, the application will be consistent with any National Water Resource Management Policy or Plan currently in force, and will outline how the project will not create a water shortage or a health nuisance; not adversely affect other lawful users of the water resource; not damage the water resource or its environment; be compatible with other uses and works in the immediate area; and be consistent with any relevant regulations.

5) Public Health Act 1994

The Act provides the basic requirements for sanitary systems for all dwellings in rural and urban areas and the prevention of the contamination of water sources.

6) Health and Safety at Work Act 1986

The Act provides for the health, safety and welfare of persons at work in Vanuatu. Section 2 of this Act outlines the duties of employers to their employees. This includes the provision and maintenance of safe plan and systems of work; ensuring safety in relation to the use, handling, storage and transport of substances; the provision of training and supervision; the provision of safe means of access to and egress from the workplace, and the provision of adequate facilities for employee welfare.

7) Fisheries Act 2014

The Act provides the management, development and regulation of fisheries within Vanuatu waters, and for the control of fishing vessels entitled to fly the flag of Vanuatu outside of Vanuatu waters in a manner consistent with Vanuatu's international obligations, and for related matters.

8) Fisheries Regulations Order 2009

The Regulations Order outlines regulations for the implantation of most aspects of the Fisheries Act.

9) Foreshore Development Act 1975

The Act is administered by the Ministry of Internal Affairs. Under this Act it is a requirement for any foreshore development to firstly obtain permission for such development from the Minister responsible for town and country planning. Foreshore development is defined as building, engineering, or other operations on land below the mean high water mark and the bed of the sea within the territorial waters of Vanuatu (including the ports and harbors thereof).

(2) Social Environment

1) The Constitution 1980

The Constitution, as "the supreme Law of Vanuatu", contains two relevant sections which have relation to land acquisition and resettlement. Chapter 5, Articles 29 to 32, of the Constitution refers to the "National Council of Chiefs". Of relevance is the Article 30 which recognizes the National Council of Chiefs membership having the competence to discuss, and may be consulted on, any issue related to customs, culture and its preservation in any matter, as required by the National Government.

Another chapter, considering the traditional ties between Vanuatu nationals and the land, Chapter 12 of the Constitution is devoted to land. The majority of discussions related to land have centered on Articles 30 (in Chapter 5) and Articles 73, 74, 75 and 76 of Chapter 12. However, of relevance to Land Acquisition and Resettlement are all nine articles (Article 73 to 81), but dependent upon the situation. This includes that all land is owned by its traditional, customary owners; parliament prescribes the criteria for compensation payment for land; the Government may own and acquire land for State interest and may redistribute land away from traditional owners, in such cases as informal settlements and relocating of residents from other islands; and disputes in land ownership.

2) Land Reform Act 1980, last amended in 2014

This Act specifies that all land titles will be customary or transferred to the traditional owners, whose lineage can be traced back locally to 200 years. It specifically outlines indigenous owners and the non-indigenous land users.

3) Land Leases Act 1988, last amended in 2013

The Act has 23 sections that discuss the Land Records Office and laws regarding leases including its definition, terms, types, registration and obligations of lessors and lessees. Of relevance to a project are the discussions on requirement to provide rights of way, rights of water and rights to sites for government infrastructure.

The Act also discusses variation of agreements and condition of lease by the Ministry of Lands and

Natural Resources (MOL). This is where a change of lease agreement using a prescribed form under this Act may be executed by both lessor and lessee prior to the expiration of the lease. A lessor also may sublease the land for the remaining life of the lease. The Act also includes the registration of caution or restrictions, including its definition such as mortgage or claims arising from bankruptcy, its placement and removal on a leased property. The leaseholder may also grant easement over his land. Fees imposed on subleasing of leaseholds are also provided in the Act.

4) Land Acquisition Act 1992, last amended in 2000

The Act is the key law directly related to Land Acquisition and Resettlement. This Act, gives the MOL, full discretionary powers to acquire land on behalf of the Government. It covers to an extent, that which will be compensated under the Act; compensation for damages made during the process of land valuation; compensation entitlements for land and for rents and business losses; basic rights for grievance and appeals; and notice periods. This Act does recognize market value compensation for land but is very vague in compensation entitlements for rents and businesses.

5) Custom Land Management Act 2013, last amended in 2014

This Act strengthens the legal framework concerning title to custom land and concerns management of custom land by customary institutions. It formalizes the recognition of customary institutions termed 'nakamals', which means the meeting at the traditional meeting place, and 'custom area land tribunals' to determine the rules of custom which form the basis of ownership and use of land in Vanuatu. In general the Act aims at holding of custom land by owners as a group. Custom land means land owned or occupied, or land in which an interest is held, by one or more persons in accordance with the rules of custom. For the purposes of this Act, each island is divided into custom areas. Larger islands are divided into many custom areas. The Act also provides for appointment of a National Coordinator of Land Dispute Management and provides with respect to the process of determination of custom owners and determination of land disputes by nakamals or custom area land tribunals and review of such determinations by court. A custom land must not be registered under the Land Leases Act unless the National Coordinator confirms by certification of the custom owners list, the names of the custom owners and the representatives of the custom owners, who may sign on behalf of the custom owners.

6) Customary Land Tribunal Act 2001, last amended in 2014

As per the title, this Act details the set-up of the Customary Land Tribunal at village, island etc. level, its basic terms of reference (TOR), especially for dispute resolution and process for affected person to appeal the tribunal decision.

7) Valuation of Land Act 2002

This Act stipulates relates to the organization of the "Valuer General" Office and their role. The Act does not stipulate minimum approach to valuation of the land, which is more directly specified in the "Land Acquisition Act". Furthermore, this Act is unclear about the role of the Valuer General office in terms of relocation/involuntary displacement of households as well as valuation of structures, incomes and businesses.

8) Land Surveyors Act 1984

This is basically a code of conduct, or a terms of reference for registered land surveyors, whom must be registered through the Land Surveyors Board.

10.2.2 EIA System in Vanuatu

The Environmental Planning and Assessment Division (EPA), under the Department of Environmental Protection and Conservation (DEPC) of the MCCA, is responsible to administer effectively the implementation of the EIA provisions mandated under Environmental Protection and Conservation Act (CAP 283) and the EIA Regulation. The EIA system is outlined as follow.

(1) Requirements by the EIA laws of Vanuatu

The EIA laws require a 'Preliminary Environment Assessment (PEA)' Application be made to the DEPC for any project, proposal or development activity that:

- is likely to impact on the environment of Vanuatu; and
- requires any license, permit or approval under any other law of Vanuatu.

The DEPC will then carry out a PEA on that particular project, proposal or development activity. The EIA regulations contain a list of activities that must undergo a PEA. The purpose of the list is to provide investors, developers and the general public with guidance as to the types of activities that require a PEA. The activities include:

- Retail and wholesale developments;
- Commercial farming;
- Sub-division developments;
- Foreshore developments, e.g. the construction or alteration of a marina, jetty, swimming pool, artificial island, sea wall, reclamation, dredging , the clearance of mangroves or the disturbance of any other coastal/estuarine ecosystem such as coral or sand;
- Any development impacting a water source (river, stream, lake, estuary, underground aquifer etc.);
- Tourism-related developments, e.g. hotel, restaurant or golf course;
- Mining, quarrying and logging;
- Clearing of tress, bushes and natural vegetation over areas of more than 10 ha;
- Industrial development, e.g. the construction or alteration of a fish processing plant, abattoir, cannery, oil mill, brewery, garage, service station, manufacture of cement, lime or plaster, structural or fabricated metal products, soap, chemicals, paper, bottles and plastics;
- Transportation and telecommunication facilities, e.g. the construction or alteration of a road, bridge, airport or telecommunications tower;
- Energy generation facilities and other infrastructure services, such as the construction or alteration of power stations, geothermal activities and pipelines;

- Waste disposal facilities, such as incinerators, rubbish tips or landfill; and
- Recreational facilities, such as the construction or alteration of a stadium or playground.

No such activities may commence until approval is given by the DEPC, despite any other approval, permit or consent given by any other government body. Activities that commence without approval under the EIA provisions can result in significant penalties and/or criminal prosecution, stop notices and restoration notices.

(2) EIA Process

When the DEPC receives a valid PEA application, the DEPC will:

1. Conduct a site inspection;
2. Prepare a PEA report based on application, the site inspection and consultation with relevant persons or government bodies; and
3. Make one of the following determinations:
   a. The project can be 'approved' with or without terms and conditions of approval;
   b. The project requires an EIA; or
   c. An EIA is not appropriate in the circumstances and an alternate agreed process must be followed.

If the DEPC determines that an EIA is required, there are a number of requirements that must be fulfilled before a final determination to approve or reject an application, such as:

1. An independent consultant be appointed to prepare an EIA report (which is a comprehensive study of the potential environmental or resource management and social-cultural impacts of the project);
2. Terms of Reference for an EIA report be negotiated between the DEPC and the project proponent;
3. The DEPC may determine that public consultation is necessary; and
4. An EIA review committee must convene to review the EIA material and to provide a recommendation to the Director of the DEPC.

(3) Compliance Monitoring

As a part of the ongoing compliance monitoring activities of DEPC through the EPA Division, the Division will increase its compliance monitoring work on development projects within Port Vila and Luganville, and on development projects that had obtained environmental approvals to verify that environmental approval conditions are being followed.

(4) Environmental Audit Assessments

It is also a requirement under the EIA laws to carry Environmental Audits. It is the Divisional plan to do Environmental audit assessments on subdivision projects in the peri-urban areas of Port Vila and around Efate for a start to ensure all subdivision necessities are in place. The DEPC wishes to appeal to all investors and project proponents to observe and comply with the provisions of the EIA laws as it is essential to the management and protection of the national environment.

(5) Terms of Reference (TOR)

Upon receiving information that a project needs full EIA report, the Director then develops a Terms of Reference (TOR) that will direct the EIA study. The Director will make sure that the TOR covers all parts concerned.

Upon the finalization of an EIA report, if the study does not address an important subject, the Director may in writing notify the developer and request for full coverage of the study. If the report covers all important issues the Director may in writing issue to agree to the project.

In case the EIA report shows major damages to the environment, the Director of environment may decline the project in writing to notify the developer with clear details stating reasons for declining. When the Director agrees to the report, he/she may in writing inform the Minister to sign for the development to proceed.

10.2.3 Practices in Resettlement and Land Acquisition

(1) Identification of Areas for Acquisition

A majority of Government land acquisition in Vanuatu has been for smaller social services projects such as for village health facilities and educational institutions. The land acquisition legislation and process have not been utilized for urban development infrastructure projects. In the year prior to an infrastructure development project, each Ministry and other Government agencies will develop their work plans for the following fiscal year. This is inclusive of the other feasibility study requirements such as budgeting, environmental, engineering etc. At this time proposals for projects where land acquisition is involved should be submitted. This is subject to the approval of the Council of Ministers. There is no minimum standard that requires the projects to minimize land acquisition and impact on the community.

(2) Process for Relocation or Land Acquisition

On an annual basis, the Government allocates in its National budget 200 million VT for Government Land Acquisition projects. According to MOL, if the budget is not spent the remaining amount accrues on top of the normal, annual 200 million VT budget. In the event that the budget is used up, with finances still required, the Government and Ministry executing a project, is responsible to find further finances to cover the necessary Land Acquisition budget requirement.

Once a plot of land is selected for a government project, a notice signed by the Minister of MOL is provided to the customary owners/title holders and a public notice is erected in full public view. The

notice is made for a minimum of 30 days.

After this period, the land is assessed and valued. The land valuation is stipulated by law, but generally involves valuing of the following:

1. Lease type – residential/agricultural/commercial/special industrial;
2. Location of property from CBD, aesthetic view, amenities, waterfront, type of neighborhood;
3. Marketability – number of properties marketed nearby in recent times and price range of those transactions;
4. Physical characteristics – terrain, vegetation, soil type, improvements made and size; and
5. Intangibles – interest, customary and other resource rights attached.

Valuations include both land and structures affected and may include value of income produced from land. However, this does not include "non-land producing" incomes such as income from shop business etc. Any damage to the land, caused by valuation investigations, is by law, liable for compensation to the existing owners. Once the valuation has been made and signed by the Minister, the owners have 30 days to file objections, at the same time, the MOL must disclose information on the valuation and proposed land acquisition over a 30-day period by radio at least 3 times on separate occasions, in one national newspaper each week, on the main notice boards and on the land itself. Objections must be lodged within this 30 days period, and on decision by the Minister, the objector, if dissatisfied, may appeal the Minister's decision through the Supreme Court of Vanuatu. However, if the issues are related to tradition and custom, then the National Council of Chiefs may be consulted, if necessary, although not compulsory.

(3) Carrying out the Acquisition of Land/Structures

After a 30-day notice period, and as long as all conflict claims and complaints are resolved, the physical compensation processes can then commence. The MOL is responsible for this process, monitored by the Ministry of Finance and Economic Management (MFEM). However, problems in moving through this stage may include complaints about the process of valuation to compensation itself; and process of the assessment of disputes. This is generally supposed to be settled through the Customary Lands Tribunal, or if unresolved, through the Supreme Court.

The land acquisition usually needs a period of 6 to 8 months from the application to completion. The period, however, can be shortened with the degree of project importance or interest by the GoV.

10.2.4 Policy Difference and Solution

Comparisons between the JICA Guidelines for Environmental and Social Considerations 2010 (hereinafter referred to as "JICA Guidelines") and the related laws and regulations in Vanuatu are drafted by the study team as shown in Table 10.2-1 (environmental aspect) and Table 10.2-2 (social aspect), respectively. Any differences between the laws and practices of Vanuatu and JICA Guidelines will be basically resolved in favor of the JICA Guidelines, as long as not violating laws in Vanuatu.

Note the proposed comparisons will be updated in harmony with the departments concerned of Vanuatu since they are still on a draft basis.

Table 10.2-1 Comparison between JICA Guidelines and Related Laws/Regulations in Vanuatu (draft) – Environmental Aspect (1/2)

No.	JICA Guidelines	Related Laws/ Regulations in Vanuatu	Different Point	Policy to Bridge the Gap
1.	[complying with laws] The Project must comply with laws, regulations and standards concerning environmental and social considerations established by the governments (central and local governments) where the Project is implemented. Furthermore, the Project must satisfy policies and plans concerning environmental and social considerations established by the governments where the Project is implemented.	[Implementation of PEA and EIA] - Under the Environmental Protection and Conservation Act (EPCA) (2010), all activities or proposed projects that impact or are likely to impact the environment must make an application for approval to the Department of Environmental Protection and Conservation (DEPC). - Once an application is lodged and fee paid, the DEPC EIA Unit officers carry out a preliminary environmental assessment (PEA) and determine whether an EIA is required or not. - An EIA is required for those activities/ projects that cause or are likely to cause significant impacts on "environment, social and/or custom".	No difference	
2.	[Examination of Avoidance and Mitigation Measures] During the implementation of the Project, from its planning stage, the impact on the natural and social environment of the Project must be studied and examined in the as early stage as possible. Alternative and mitigation measures to avoid and minimize the impact must be studied and the result must be reflected in the Project plan.	[Examination of avoidance and mitigation measures] The proponent is required to first submit an application containing a description of the proposed activity/ project and identification of likely environmental impacts and required measures to avoid or mitigate the impacts (EIA regulations (2011).	It is not clear whether the result of identification of measures to avoid or mitigate the impacts is reflected in the Project.	It is necessary to ensure that the identified required measures to avoid or mitigate the impacts are reflected in the Project plan.
3.	[Examination of alternatives] In order to avoid and minimize the negative impact of the Project and to select the best option from the aspect of environmental and social consideration, several alternatives must be examined.	[Notification of alternatives and mitigation measures] - An EIA report must include a statement of the various alternatives that have been considered for the project, proposal or development activity, including the option of taking no action, and an outline of the reasons for choosing the proposed action. - An EIA report must include a statement of the mitigation action proposed in respect of any adverse impacts identified in the report (EIA regulations (2011).	No difference	
4.	[Scope of study and examination] Regarding environmental and social considerations, the impact to be examined includes the impact on human health and security and that on the natural environment (including cross-border and global impact) through air, water, soil, waste, accidents, water use, climate change, ecosystem and fauna and flora. It also includes the impact with respect to social considerations.	[EIA-covered project] - All projects, proposals or development activities that will do or are likely to do all or any of the following are subject to the EIA provisions: a) affect coastal dynamics or result in coastal erosion; b) result in the pollution of water resources; c) affect any protected, rate, threatened or endangered species, its habitat or nesting grounds; d) result in the contamination of land; e) endanger public health; f) affect important custom resources; g) affect protected or proposed protected areas; h) affect air quality; i) result in the unsustainable use of renewable resources; and j) result in the introduction of foreign organisms and species. (Environmental Protection and Conservation Act)	The environmental standards are not mentioned in EPCA and EIA regulations.	Referring to internationally acknowledged guidelines (WHO, IFC, etc.) or standards of advanced countries. The expected impact shall be compared and examined.

Source: JICA Survey Team

Table 10-6 Comparison between JICA Guidelines and Related Laws/Regulations in Vanuatu (draft) – Environmental Aspect (2/2)

No.	JICA Guidelines	Related Laws/ Regulations in Vanuatu	Different Point	Policy to Bridge the Gap
5.	[Information disclosure and public involvement] As for the Project which is expected to put relatively big impact on the environment, from the early stage when alternatives of the Project are examined, the information should be disclosed. And then, it is necessary that the stakeholders such as local residents are fully consulted and that the result is reflected in the Project.	[Decision-making] - The project proponent must conduct public consultations on the project, proposal or development activity at times and places as determined by the Director and convenient for those likely to with to take part. - At least one of the public consultation meetings must be held in the close vicinity of the area of the proposed development. - Notices of public consultation meetings must be given by the project proponent in the manner directed by the Director and such notices must inform the public of: a) the locality and the nature of the project, proposal or development activity b) the location and the time of the public consultation meeting - The cost of convening public consultation meetings is to be met by the project proponent (EIA regulations (2011). [Decision-making on EIA] - The project proponent must conduct public consultations on the project, proposal or development activity at times and places as determined by the Director and convenient for those likely to with to take part. - At least one of the public consultation meetings must be held in the close vicinity of the area of the proposed development. - If a public consultation meeting is held, notice of it must be given by the project proponent in the manner directed by the Director and must inform the public of: a) the locality and the nature of the project, proposal or development activity; b) where copies of the EIA report can be obtained; c) the location and the time of the meeting; and d) time limit as determined by the Director for the submission of comments in writing. - The cost of convening public consultation meetings is to be met by the project proponent (EIA regulations (2011).	It is not clear from which stage of the project public consultations take place. It is not clear whether the result of public consultations is reflected in the project.	Public consultations shall take place from as early stage of the project as possible. The result of the consultations shall be recorded and reflected in the project.
6.	[Monitoring] The donor country shall check the monitoring results which are deemed important for a certain period in order to verify whether the host country considers the environmental and social impact. Information necessary for verifying the monitoring results shall be reported by the host country via a proper manner such as documentation etc.	[Monitoring System] - An environmental management and monitoring plan (EMMP) for a project, proposal or development activity must be submitted with the EIA report. - An EMMP must: a) describe the environmental protection measures that will be put in place by the proponent; b) include and environmental monitoring and surveillance program of action; and c) provide for an environmental monitoring manager to be appointed by the project proponent to verify that the EMMP and protection measures are being fulfilled and adverse impacts are documented. (EIA regulations (2011))	It is not clear whether the result of monitoring is documented in a proper manner.	The result of monitoring shall be documented and submitted to relevant agencies.

Source: JICA Survey Team

Table 10.2-2 Comparison between JICA Guidelines and Related Laws/Regulations in Vanuatu (draft) – Social Aspect (1/3)

No.	JICA Guidelines	Related Laws/ Regulations in Vanuatu	Different Point	Policy to Bridge the Gap
1	[Avoidance of involuntary resettlement] Involuntary resettlement and loss of means of livelihood are to be avoided when feasible by exploring all viable alternatives.	No provision.	There is no minimum standard that requires the projects to minimize land acquisition and impact on the community.	The project shall adopt the objective of minimizing involuntary land acquisition and resettlement impacts on community and business/ productive interests are avoided through careful technical design.
2	[Mitigation measures for displacement] When population displacement is unavoidable, effective measures to minimize impact and to compensate for losses should be taken.	No provision.	There is no minimum standard that requires the projects to minimize land acquisition and impacts on the community.	The project will ensure that all resettlement and land acquisition and impacts on community and business/ productive interests are minimized wherever possible.
3	[Securing livelihood and assistance] People who must be resettled involuntarily and people whose means of livelihood will be hindered or lost must be sufficiently compensated and supported, so that they can improve or at least restore their standard of living, income opportunities and production levels to pre-project levels.	- Compensation is determined based on issues including land type, crops etc. (Land Acquisition Act) - Land is valued by Valuer- General in the MLNR.	Compensation does not include “non-land producing” incomes such as income from shop business etc. Laws and practices in Vanuatu do not recognize the standards of living of the poor and vulnerable, in determining compensation for land acquisition and resettlement. There are no provision to improve or at least restore the livelihood of all DPs.	The project will ensure all resettlement and land acquisition and impacts on community and business/ productive interests are minimized whenever possible.
4	[Valuation based on replacement cost] Compensation must be based on the full replacement cost as much as possible.	- In Vanuatu valuation of land is stipulated by Law, and is conducted based on several factors regarding that specific plot of affected land such as lease and ownership type; location of property; amenities; market price of nearby properties; physical land characteristics; and intangibles. (Land Acquisition Act) - The law specifically points out times for disclosure prior to valuation, time for objection to valuation and acquisition of lands and assets. (Land Acquisition Act) - Land is valued by Valuer General in MLNR. The VG will determine compensation requirements relating to land, land-based income losses. All other compensations (monetary and non-monetary) will be based on replacement at the existing market rates.	The law does not provide any clauses for prompt compensation, income restoration and entitlements.	The RAP includes a provision for restoration for APs under the project.

Source: JICA Survey Team

Table 10-7 Comparison between JICA Guidelines and Related Laws/Regulations in Vanuatu (draft) – Social Aspect (2/3)

No.	JICA Guidelines	Related Laws/ Regulations in Vanuatu	Different Point	Policy to Bridge the Gap
5	[Compensation prior to displacement] Compensation and other kinds of assistance must be provided prior to displacement.	- Compensation is to be provided after a period of disclosure and a period for objection has finished.	Legislation does not clearly state that compensation will be provided prior to commencement of construction, which force physical/ economic displacement impacts to occur.	The project will ensure that land acquisition, resettlement and/ or compensation measures are completed prior to commencing of construction.
6	[Development and disclosure of RAP] For projects that entail large-scale involuntary resettlement, resettlement action plans must be prepared and made available to the public.	- Under Vanuatu Law, land acquisition and resettlement and compensation are carried out focusing on households affected and the values of the land and structures affected. (Land Acquisition Act)	An RAP per se is not necessarily required.	The project will ensure that a RAP is prepared and is updated at the time of detailed design.
7	[Holding public consultation meetings] In preparing a resettlement action plan, consultations must be held with the affected people and their communities based on sufficient information made available to them in advance.	- The law, and current practices, does require the land acquisition and relocation orders to be disclosed several times over radio and in the printed media over a 1-month period, as well as display on-site. (ADB reports)	There is no recognition of vulnerable groups nor the consultation with, or participation of APs/ DPs at any part of the process, except in the case of people given opportunity to make objections.	JICA GL will be enforced in that prepared RP and its implementation will require a level of participation and consultation.
8	[Use of local language] When consultations are held, explanations must be given in a form, manner, and language that are understandable to the affected people.	- A notice for land acquisition is in writing and in Bislama, English and French languages. (Land Acquisition Act)	Only the radio would be useful for the illiterate to become informed of any pending land acquisition and resettlement activity on a specific site.	The project will require public hearings/ meetings to be held.
9	[Promoting public involvement] Appropriate participation of affected people must be promoted in planning, implementation, and monitoring of resettlement action plans.	- The law and current practices require that land acquisition and relocation orders for a specific site be disclosed several times over radio and in the printed media over a 1-month period, as well as display on-site. (ADB reports)	Only the radio would be useful for the illiterate to become informed of any pending land acquisition and resettlement activity on a specific site.	The project will require public hearings/ meetings to be held.
10	[Establishing grievance redness mechanism] Appropriate and accessible grievance mechanisms must be established for the affected people and their communities.	- Vanuatu already has a Grievance redress system for general village matters, followed by the chief. MLNR has also recently been set up at Provincial level, through the Customary Land Tribunal. (Land Acquisition Act, Customary Land Tribunal Act)	No difference.	The project ensure an appropriate multiple level grievance redress system, which allows AP/DP participation, relatively rapid action and results, as well as encompassing existing grievance procedures.

Source: JICA Survey Team

Table 10-7 Comparison between JICA Guidelines and Related Laws/Regulations in Vanuatu (draft) – Social Aspect (3/3)

No.	JICA Guidelines	Related Laws/ Regulations in Vanuatu	Different Point	Policy to Bridge the Gap
11	[Identifying eligibility] Affected people are to be identified and recorded as early as possible in order to establish their eligibility through an initial baseline survey (including population census that serves as an eligibility cut-off date, asset inventory, and socioeconomic survey), preferably at the project identification stage, to prevent a subsequent influx of encroachers of others who wish to take advantage of such benefits. (WB OP 4.12 Para. 6)	- The law and current practice does specify census requirements and protocols for managing inflow of ineligible people. (Land Acquisition Act)	No difference.	For this project, a census of APs including inventory of losses and basic socio- economic information at household level will be undertaken. The inventory o flosses will cover the value of impacted land, structures, business/ livelihoods and assets. The 'cut-off" date for the RAP will be the date when the inventory of affected people is completed and set out in the RAP.
12	[Eligibility requirements] Eligibility of benefits includes, the PAPs who have formal legal rights to land (including customary and traditional land rights recognized under law), the PAPs who don't have formal legal rights to land at the time of census but have a claim to such land or assets and the PAPs who have no recognizable legal right to the land they are occupying. (WB OP 4.12 Para. 15)	No provision	Laws have no clauses that recognize encroachers in any way to be entitled or NOT entitled to compensation or rehabilitation.	The project will recognize encroachers, who are legitimately affected at the time of the census/ detailed measurement survey conducted.
13	[Land-to-land Compensation] Preference should be given to land-based resettlement strategies for displaced persons whose livelihoods are land-based. (WB OP 4.12 Para. 11)	- In Vanuatu, land acquisition, resettlement and compensation for land-based losses are included under the law. (Land Acquisition Act)	No difference	WB OP 4. 12 will be enforced to ensure that preference is given to land- based resettlement strategies for DPs whose livelihoods are land-based.
14	[Assistance during transition] Provide support for the transition period (between displacement and livelihood restoration). (WB OP 4. 12, para.6)	- In Vanuatu, land acquisition, resettlement and compensation for land-based losses are included under the law. (Land Acquisition Act)	Impacts on business and their employees are less clear and there is no recognizable transitional support mechanism under the law.	WB OP 4. 12 will be enforced in supplementing the Law of Vanuatu, in order to cover transition assistance requirements, business and employees impacted, as required.
15	[Consideration to vulnerable group] Particular attention must be paid to the needs of the vulnerable groups among those displaced, especially those below the poverty line, landless, elderly, women and children, ethnic minorities etc. (WB OP 4.12 Para. 8)	No provision.	There is no recognition of vulnerable groups nor the consultation with or participation by APs at any part of the process, except in the case of people given the opportunity to make objections.	WB OP4.12 will be enforced in that the prepared RAP and its implementation will require participation and consultation of vulnerable groups.

Source: JICA Survey Team

10.2.5 Role of Related Organizations

The organizations and its roles on environmental and social considerations in Vanuatu are summarized in Table 10.2-3.

Table 10.2-3 Organizations and its Roles on Environmental and Social Considerations in Vanuatu

Ministry	Department/Unit	Description
Ministry of Lands and Natural Resources (MOL)	Department of Geology, Mines and Water Resources (DGMWR)	The DGMWR is responsible for the protection, management and use of water resources in Vanuatu. This includes surface water, groundwater, and coastal waters. The DGMWR, through the Minister responsible for Water Resources, has the power to declare any area to be a Water Protection Zone (WPZ) to (i) conserve or protect any significant water resource; (ii) conserve or protect any water resource used or intended for water supply; (iii) promote the protection, management or use of water in rural and urban areas; or (iv) deal with any emergency which may affect the water supply. The DGMWR also operates an analytical laboratory that has the capability to conduct water quality analysis. The department also has other mandates relating to mines and mineral resources.
	Department of Lands (DOL)	The Department is comprised of five sections such as 1) Land Survey, 2) Land Management, 3) Land Registry, 4) Customary Lands Tribunal and 5) Valuer General's Office.
Ministry of Infrastructure and Public Utilities (MIPU)	Public Works Department (PWD)	The PWD has the overall responsibility for maintenance of drainage systems and roads in Vanuatu. The department liaises very closely with the DEPC for new projects, to ensure that they comply with the provisions of the Environmental Protection and Conservation Act (EPCA).
Ministry of Climate Change Adaptation (MCCA)	Department of Environmental Protection and Conservation (DEPC)	The DEPC (established in 1986 and upgraded to have departmental status in 2010) is responsible for the formulation and implementation of environmental policies with the aim of ensuring ecologically sustainable development in Vanuatu. The DEPC is the national focal point for the United Nations Convention on Biological Diversity (CBD) and amongst the Department's responsibilities is to ensure that development and activities in the country are in line with Vanuatu's commitments under various international and regional environmental treaties and agreements. The Department has three main divisions such as 1) Environment Management and Conservation, 2) Extension Services, and 3) Research and Monitoring. The DEPC is currently housed in the MOL although has been regularly relocated within Vanuatu's various ministries, including the Ministry of Internal Affairs and the Ministry of Health and Environment, with successive changes in government.
	Vanuatu Meteorology and Geo-Hazards Department (VMGD)	The VMGD, which was reformed from the VMS in 2010 is responsible for providing meteorological and geohazards' information to the public, including reports on cyclones, tsunamis, and seismology. The department is also the secretariat of the National Advisory Committee on Climate Change which advises on climate issues. The roles of VMGD include: 1) weather forecast, 2) climate change/planning, 3) geo-hazards, 4) observation and 5) ICT.
Ministry of Agriculture, Livestock, Forestry, Fisheries and Biosecurity (MALFFB)	Department of Fisheries Vanuatu Fisheries Department (VFD)	The VFD is mandated to provide for the control and development of the fisheries resources of Vanuatu. This is achieved through licensing, protection of target species, prohibitions on specified fishing methods or gear, and designation and management of protected areas.
	Department of Forests (DOF)	The DOF is responsible for the protection, development and sustainable management of forests, and regulation of the forest industry.
Ministry of Internal Affairs	Physical Planning Unit (PPU)	The PPU has overall responsibility for exercising planning controls for Vanuatu. Its mandated functions include urban development planning and foreshore development planning.
Other	Vanuatu Cultural Council	The Council is a quasi-governmental entity that serves as the administrative and regulatory arm of the Vanuatu Cultural Centre, and that has authority for making decisions on the protection of sites and properties of cultural, traditional and aesthetic significance.

Source: JICA Survey Team

10.3 Result of Field Survey and Scoping

Summary of observations from a brief field survey during the 1st site study in August 2016 by the study team is as follows.

10.3.1 Natural Environment

(1) Pollution

- The main pollution source is the passing cars which generate exhausted gas and noise.
- There seems no water pollution source upstream Teouma River since the water quality is good with high transparency (estimated 0.8m or more). The salinity level of Teouma River was not detected at points of up- and down-stream of Teouma Bridge at full tide[8].

(2) Flora & Fauna

- No areas to be conserved or protected as an ecological sanctuary are observed.
- The vegetation consists of weeds, shrubs and low/medium-tall trees. Most of them seem secondary species, not for protection.

  Fruit trees such as banana, coconut and papaya are planted sparsely. The fruits are for private use and products in local markets.
- Small fish (around 5cm-long) swim in Teouma River around Teouma Bridge. Neither amphibians nor other aquatic organisms are found during the survey.
- Terrestrial animals observed are only dogs and small birds (name unknown). They are estimated least concerned species.

(3) Topography and Geology

- Teouma River flows in a narrow lowland between plateaus. The slope of the narrow area is gentle and the water flow speed is not fast. Since the area is located in a lower part, the area would be easily inundated when a storm comes.
- The geology of the study area consists of recent riverine alluvial sands, dominantly from volcanic tuffs which contain recent fault plains.
- The right bank of upstream Teouma Bridge is sharper and narrower than the left bank.

10.3.2 Social Environment

(1) Use of Resources

- Teouma River is reported to be used for laundry, swimming, fishing, commodity conveyance (e.g. crops) etc. The survey team found a family who filled plastic tanks with the river water for a housework purpose (for washing dishes, not for drinking) upstream along the left bank.

[8] The measurement was done at 2 pm on 10 December 2016. The digital salinometer used was YK-31SA.

- The northeast part of Teouma Bridge is for cultivation such as banana, maize, mango etc.
- The nearest street stall from the target site sells products including: banana, bell pepper, cabbage, Chinese cabbage, carrot, green papaya, maize and potato, which are produced in the area.

(2) Land Tenure

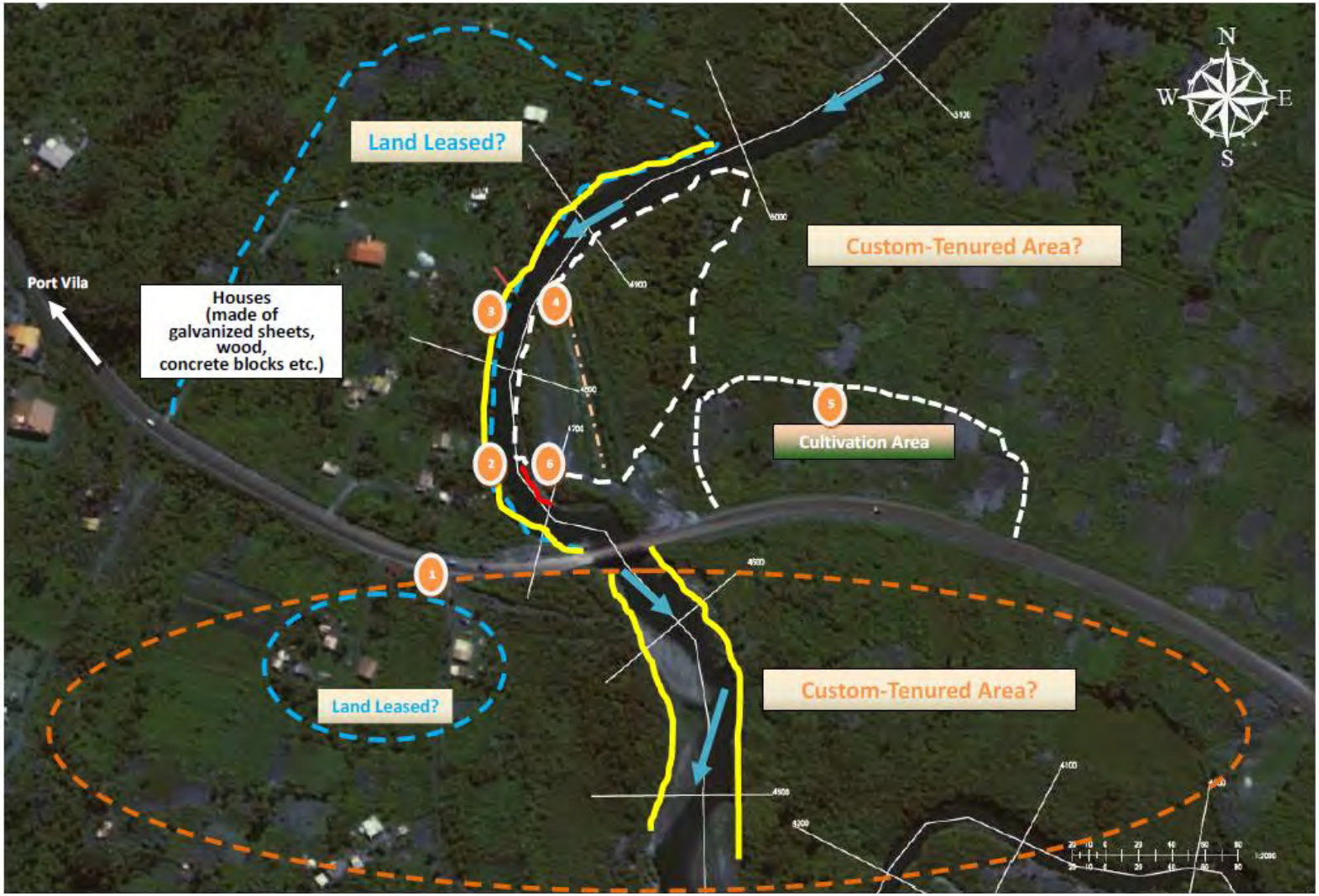
- According to the Department of Lands, there are land lessees upstream Teouma River, while being mostly customary lands downstream. However, the ownership of individual land (government, private, customary etc.) is partially unsure and to be clarified.
- The chief of the area (Teouma Bridge of Eratap) has powers to manage the land in which he is in charge of. The survey team got permission from the chief to cut grasses for a better observation of the ground condition.

(3) Land Acquisition/Resettlement

- For the re-construction and improvement works, some lands along the river and road will be needed.
- During Teouma Bridge re-construction, the area in the south part of the bridge will be acquired for a temporary road and bridge.
- No disputes have been reported in customary lands of the project area, according to the DOL.
- No involuntary resettlement is anticipated.

The results of the brief field survey as mapping and descriptions with phots are presented in Figure 10－2 and Figure 10－3, respectively.

Map of the Study Area (Teouma Bridge & River)



Source: JICA Survey Team, Based on PWD data

Figure 10－2　Map of the Study Area with Results of Brief Field Survey

Snapshots around Teouma Bridge & River

①
Street Stall (main)
Products Sold (bottom right)
- 100 vt for a bunch of bananas
- Visitors by cars frequently drop by for buying.

②
Coconut Trees in a House Garden (main)
Low/middle-tall Secondary Trees (bottom right)
- Branches and leaves of the big tree touch on the river surface.

③
Path from the Riverside to Inland
- Grasses cover on the river edge.
- Tree branches are toward the river.

④
Bushes along the Left Bank (main)
Wild Banana Trees (bottom right)
- Riverside width is 1.5-2m
- Bananas are freely picked to eat/sell etc.

⑤
Cultivation Area (main)
Papaya Trees (bottom right)
- maize, taro, sweet potato etc.

⑥
Laundry in the River (main)
Water Tanks for Home Use (upper left)
- >80cm of water transparency, small fish are seen

To the Upstream
(from Teouma Bridge)

To the Downstream
(from Teouma Bridge)

Source: JICA Survey Team

Figure 10－3　Descriptions of Impressive Sites in the Study Area

10.3.3 Cadastral Condition in the Project Area

Figure 10－4 illustrates the current cadastral condition (land boundary (black lines) and owner classifications (numbers in square)) overlapping the area to be needed for the reconstruction works.

During the 2nd field study on 13 December 2016, the study team held a group meeting with major stakeholders on land issue in order to make sure the land ownership of the affected area (e.g. owned by the government, customary, private etc.) and preference for the project implementation. The motivation derives from that the issue could be one of big bottlenecks to go forward the project. The contents confirmed during the meeting were as follows:

- There are currently three customary landowners in the area, and who would be willing to work with the project. There has been a recent declaration made by the Supreme Court, and they have the required "green certificate" certifying them as customary landowners of the area.
- No disputes have been reported in customary lands of the project area, according to the DOL.
- The first step to acquire part of customary lands is to consult the area chief, because the chief is the manager of such lands. For the acquisition of lands such as the leased and customary, DOL will help to find a land owner to negotiate.
- It was confirmed that all the participants in the meeting expressed positive to implement the proposed project, and the related residents agreed to offer necessary lands.

10.3.4 Scoping

Based on the results during the 1st field study in August 2016 and the 2nd field study in December 2016, a draft scoping on the environmental and social impacts is shown in Table 10.3-1. The scoping will be revised and become basal information to develop the TOR for the baseline survey in the preparatory study stage.

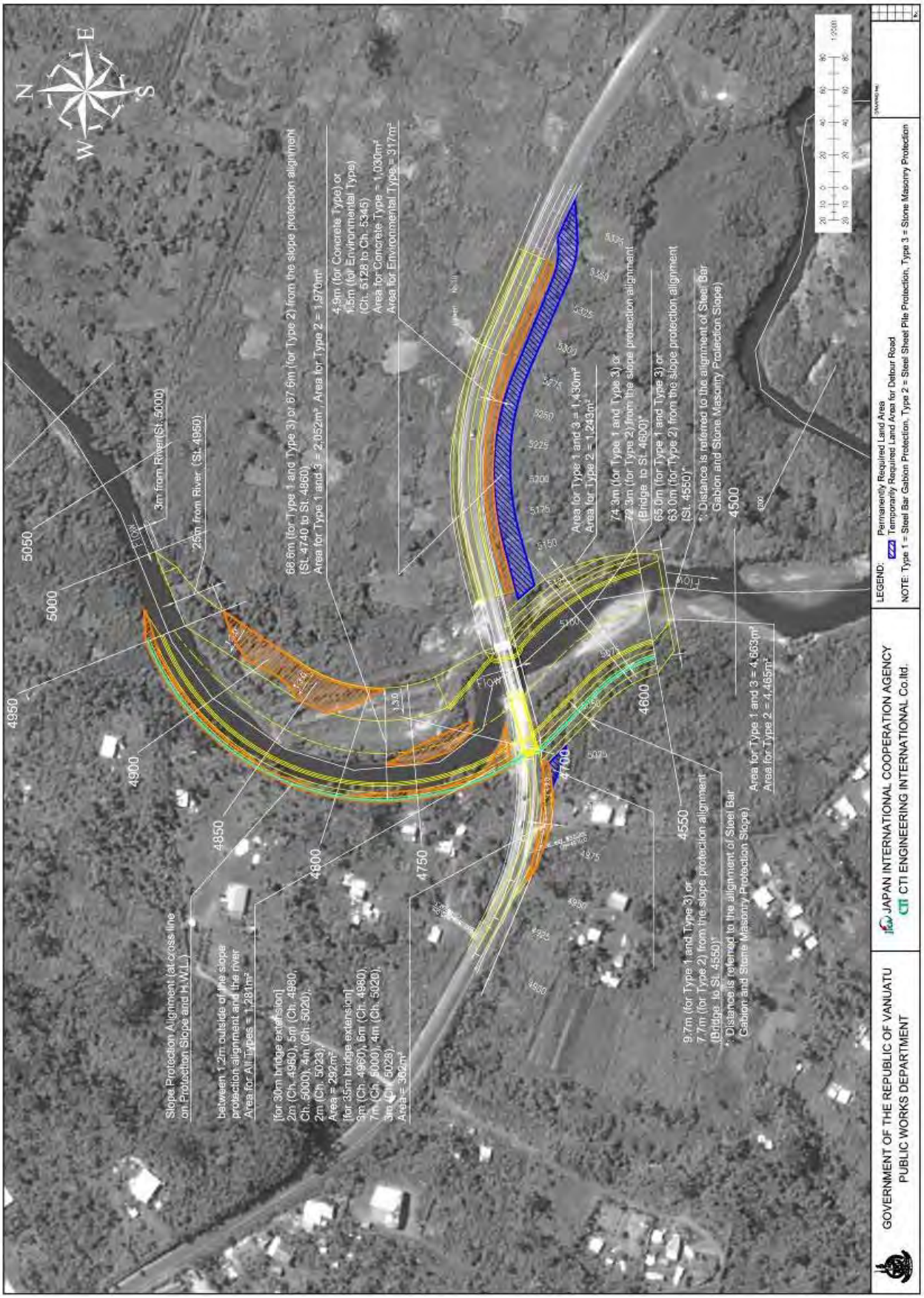


Figure 10－4　Land Area Required for the Project and Current Cadastral Condition[9]

[9] Numbers in blue: leased lands which lessees are identified. In green: customary lands. In orange: public domains for river and road.

Table 10.3-1 Draft Scoping for Environmental and Social Impacts (1/4)

	No.	Impact Item	Rating		Description of Impacts
			Pre/ Const.	Opera-tion	
Pollution	1	Air Pollution	B-	B-	[Construction Phase] During the construction works, exhaust gas and dust caused by construction vehicles and equipment can temporally deteriorate air quality around the construction sites.
					[Operation Phase] Negative impacts on air quality are expected due to increase of traffic on the reconstructed road and bridge, but the extent may be limited.
	2	Water Pollution	B-	D	[Construction Phase] Soil runoff from cut and fill for embankment work, debris of the old bridge and wastes by new bridge construction may give negative impact on water quality in Teouma River. Organic polluted water such as night soil from a base camp may give affection on the water quality..
					[Operation Phase] No adverse impacts are expected since no facilities to generate soil runoff or sewer water are operated.
	3	Noise and Vibration	B-	B-	[Construction Phase] The operation of construction vehicles and equipment can temporally increase levels of noise and vibration nearby the construction sites.
					[Operation Phase] Increase of traffic volume may generate a bit more noise and vibration on the re-constructed road than before, but the level is expected limited.
	4	Soil Contamination	B-	D	[Construction Phase]If unintentional considerable spilled fuel and oil from construction vehicles or equipment occur, it may contaminate soil in the construction sites.
					[Operation Phase] No adverse impacts are expected since no facilities to discharge chemical substance are operated.
	5	Waste	B-	D	[Construction Phase]Wastes can be temporally generated with construction waste, dredged soil and grass/trees cut from the construction sites, and domestic wastes and night soil from a construction site office and base camp.
					[Operation Phase] No adverse impacts are expected since no facilities to generate waste are operated.
	6	Ground Subsidence	D	D	[Construction Phase] [Operation Phase] No serious adverse impacts are expected on the ground subsidence since the project does not require use of large scale groundwater,
	7	Offensive Odor	B-	D	[Construction Phase]Operation of construction vehicles, equipment and site office/base camp can temporally generate offensive odor from exhaust gas, discharging water, domestic waste or dredged soil.
					[Operation Phase] No adverse impacts are expected since no facilities to generate offensive odor are operated.
	8	Bottom Sediment	B-	D	[Construction Phase]If the work for riverbank improvement is done without protection of cut and fill, it may temporally generate soil runoff, and affect the bottom sediment in Teouma River. Demolition and re-construction of bridge may cause water pollution of Teouma River, but the extent of impact on the bottom sediment is expected minor.
					[Operation Phase] No adverse impacts are expected since no facilities to generate soil runoff to worsen bottom sediment are operated.

Rating:
A+/-: Significant positive/negative impact is expected.
B+/-: Positive/negative impact is expected to some extent.
C: Extent of positive/negative impact is unknown (Examination is needed. Impacts may become clear as study progresses.)
D: No impact is expected
Source: JICA Survey Team

Table 10-9 Draft Scoping for Environmental and Social Impacts (2/4)

	No.	Impact Item	Rating		Description of Impacts
			Pre/ Const.	Opera-tion	
Natural Environment	9	Protected Areas	D	D	[Construction Phase] [Operation Phase] No impacts are expected since the project sites are not located in the protected areas.
	10	Flora, Fauna and Biodiversity	B-	B+	[Construction Phase] As the plants and trees in the project site are consisted of secondary vegetation, the project may not give serious adverse impacts on the flora system. Considering the status of flora system, there seems no or few animals to be protected there. However, the construction works may give some adverse impact on fish and their habitats in Teouma River.
					[Operation Phase] As no facilities to worsen ecosystem are operated, no adverse impacts are expected. Furthermore, the riverine environment will be properly preserved since the installed embankment will be designed eco-friendly.
	11	Hydrological Situation	B-	B+	[Construction Phase]If the construction works are done without sufficient protection for cut and fill, it may temporally generate soil runoff and may affect the flow of Teouma River. Also, the river flow may be changed since demolition and re-construction of bridge will need the work in the river. However, the degree of impact is uncertain at present.
					[Operation Phase] The structures to be constructed will contribute to protecting the flood prone area and controlling the flow of Teouma River.
	12	Topography and Geographical Features	B-	B+/-	[Construction Phase] The bank protection work may temporary disturb the topography along the river but the extent be limited because the work area is not wide.
					[Operation Phase] The embankment will change the original topographic feature along Teouma River. However, the project can enforce the bank and protect the area from cyclone attacks.
	13	Soil Erosion	B-	D	[Construction Phase] If the construction works are done without protection for cut and fill, it may temporally generate soil erosion.
					[Operation Phase] No negative impacts are expected since the new embankment will work not to generate soil erosion,
	14	Groundwater	C	D	[Construction Phase] Since the project does not plan deep excavation and dredging, impact on the groundwater is not anticipated. However, the status of water veins and use of groundwater are unsure at present.
					[Operation Phase] No adverse impact on groundwater quality is anticipated since the constructed structures do not touch water veins of groundwater
Social Environment:	15	Involuntary Resettlement and Land Acquisition	B-	C	[Pre-/during construction Phase] Although there will be no involuntary resettlement by the project, some private or customary lands will be acquired for the embankment and road construction.
					[Operation Phase] Land issues in operation phase may be anticipated but the extent is unsure.
	16	Local Economy such as Employment and Livelihood, etc.	B+	B+	[Pre-/during construction Phase] Since the land to be acquired is covered with weeds and not for cultivation or business use, there seems no impact on local economy by the land acquisition. Meanwhile, the construction activities will demand for workers (especially unskilled), and it can provide a temporary boost for local employment. Besides, the local service sector can provide the construction workers accommodation, foods and beverages, and it can facilitate business opportunities for the local service sector.
					[Operation Phase]As the structures of river flood mitigation by storm rainfall will reduce the flooding and inundation damages, the local economic activities will be sustained and developed.

Rating:
A+/-: Significant positive/negative impact is expected.
B+/-: Positive/negative impact is expected to some extent.
C: Extent of positive/negative impact is unknown (Examination is needed. Impacts may become clear as study progresses.)
D: No impact is expected
Source: JICA Survey Team

Table 10-9 Draft Scoping for Environmental and Social Impacts (3/4)

	No.	Impact Item	Rating		Description of Impacts
			Pre/ Const.	Opera-tion	
Social Environment:	17	Land Use and Utilization of Local Resources	B-	B+	[Construction Phase] The construction works require land acquisition and it may change the existing land use. But the extent is quite limited.
					[Operation Phase]As the structures of river flood mitigation by storm rainfall will reduce the flooding and inundation damages, more productive land use and utilization of local resources will be expected.
	18	Social Institutions such as Social Infrastructure and Local Decision-making Institutions	C	D	[Construction Phase] Since land issues will arise, decision-making at local level may affect the direction of the project but the extent is uncertain.
					[Operation Phase]No adverse impact on social institutions is anticipated since the project will contribute to securing existing local assets.
	19	Existing Social Infrastructures and Services	B-	B+	[Construction Phase]The construction work will disturb using the river by local people such as laundry, fishing etc. as well as vehicle transportation. In addition, vehicles for construction works will give impact on the road traffic nearby.
					[Operation Phase]As the structures of river flood mitigation by storm rainfall will reduce the flooding and inundation damages, the existing social infrastructures and services will be sustained and developed.
	20	Misdistribution of Benefit and Damage	D	D	[Construction Phase] [Operation Phase]As the project aims at protection of flood/ inundation and smooth traffic and contribution for disaster prevention in the region, no adverse impacts are expected on misdistribution of benefit and damage.
	21	Local Conflict of Interests	B-	D	[Construction Phase] Local people can contest for seeking job opportunities as the construction workers.
					[Operation Phase] As the project aims at protection of flood/ inundation and smooth traffic and contribution for disaster prevention in the region, no adverse impacts are expected on local conflict of interests.
	22	Water Usage or Water Rights and Rights of Common	B-	D	[Construction Phase] Works for river improvement and bridge re-construction may disturb river water use for local people. Since the water rights of the target river may exist, further investigation is required.
					[Operation Phase] The structures installed will give no impact on water usage or rights. People will be able to use the river water at the same level as before.
	23	Hazards (Risk), Infectious Diseases such as HIV/AIDS	C	D	[Construction Phase]As the local employment may be promoted for the projects, considerable influx of workers is unexpected. However, a risk of infectious diseases due to the inflow of laborers from other areas is unclear.
					[Operation Phase] No outbreak of such diseases is anticipated since new mass entry of people is not expected.
	24	Cultural Heritage	C	B+	[Construction Phase] No specific cultural heritage is reported in the project sites. However, further survey is needed to identify locally admired heritage.
					[Operation Phase] The cultural heritage will be protected by the project if there exists.
	25	Landscape	B-	C	[Construction Phase] Construction machines and vehicles will disturb the landscape mainly along the target river. However, the extent is expected minor since there are no picturesque places to be preserved.
					[Operation Phase] The newly built structures of river revetment may change the existing landscape. However, as the proposed structure will be designed based on an eco-friendly concept, it will not seriously change or detract surrounding landscape.

Rating:
A+/-: Significant positive/negative impact is expected.
B+/-: Positive/negative impact is expected to some extent.
C: Extent of positive/negative impact is unknown (Examination is needed. Impacts may become clear as study progresses.)
D: No impact is expected
Source: JICA Survey Team

Table 10-9 Draft Scoping for Environmental and Social Impacts (4/4)

	No.	Impact Item	Rating		Description of Impacts
			Pre/ Const.	Opera-tion	
Social Environment:	26	The Poor, Indigenous and Ethnic People	C	D	[Pre-/during Construction Phase] Further study will be needed before construction whether indigenous and ethnic people would reside in. In case there is, such people shall be treated in accordance with domestic and international rules.
					[Operation Phase] Since considerations shall be done before and during construction, no negative impacts are expected.
	27	Working Conditions	B-	D	[Construction Phase] There is a possibility of accidents involving workers and the local people in/nearby the construction sites. Operation of construction vehicles and equipment can temporally disturb their health and security.
					[Operation Phase] No negative impact on working conditions is anticipated since there will be no hazardous activities.
	28	Gender/ Children's Rights	C	D	[Construction Phase] Unfair employment to women for the construction work may happen but the extent is unclear.
					[Operation Phase] There will be no impact on gender/children's rights since the new structures are for flood mitigation in the area.
Others	29	Accidents	B-	B+	[Construction Phase] Traffic accident caused by construction vehicles is anticipated.
					[Operation Phase] The installed embankment, road and bridge will help to decrease damages by flooding. Furthermore, these structures will be designed better for pedestrians along the road and users of the facilities.
	30	Transboundary Impacts and Climate Change	D	C	[Construction Phase] The construction work generates some GHG, but adverse impact is not anticipated because the scale is small.
					[Operation Phase] No impact on transboundary issue is anticipated since the project is done in the quite limited area and contributes to mitigating natural disasters. Since an increase in traffic volume is expected in operation phase, emission of GHGs such as CO, CO_2 will increase. However, the extent of emission may not be large then the impact on climate change is expected minor.

Rating:
A+/-: Significant positive/negative impact is expected.
B+/-: Positive/negative impact is expected to some extent.
C: Extent of positive/negative impact is unknown (Examination is needed. Impacts may become clear as study progresses.)
D: No impact is expected
Source: JICA Survey Team

10.4 Considerations toward Preparatory Study

10.4.1 Acquisition and Compensation for the Project Area

One of factors which often hamper the progress of an infrastructure project is deemed land acquisition in countries including Vanuatu. As described above, it can be a key for success projects to solicit consent from owners and leaseholders of lands concerned and facilitate the conveyance. In compensation, eligible persons and compensation covered will be identified (developing an entitlement matrix) in accordance with the stipulations of JICA Guidelines and World Bank's Safeguard Operation Policy 4.12 (WB OP 4.12[10]) without deviating related laws and regulations in Vanuatu.

The comparative analysis between JICA Guidelines and related laws/regulations in Vanuatu was drafted in Table 10.2-2. In the future preparatory study stage, improving the draft with stakeholders' opinions becomes important as well as developing an entitlement matrix. The JICA Guidelines stipulates the basic policy on land acquisition, compensation and livelihood assistance as below[11]:

[10] Operation Policy for involuntary relocation
[11] Although the JICA Guidelines mentions "involuntary resettlement", it cannot be a problem to switch to land acquisition.

People who must be resettled involuntarily and people whose means of livelihood will be hindered or lost must be sufficiently compensated and supported by project proponents etc. in a timely manner. Prior compensation, at full replacement cost, must be provided as much as possible.

Host countries must make efforts to enable people affected by projects and to improve their standard of living, income opportunities, and production levels, or at least to restore these to pre-project levels. Measures to achieve this may include: providing land and monetary compensation for losses (to cover land and property losses), supporting means for an alternative sustainable livelihood, and providing the expenses necessary for the relocation and re-establishment of communities at resettlement sites.

For private properties, valuation and compensation for lands will be conducted in line with the policy of JICA Guidelines within related laws such as the constitution and Land Acquisition Act. Meanwhile, the new Custom Land Management Act will be employed for the land which is managed by local custom in the downstream Teouma Bridge, and it is essential to tackle with the issue cautiously and friendly since negative feelings by the landowners or local people could give an adverse impact on the project implementation.

10.4.2 JICA's Environmental Category and Local Subcontracting (EIA and RAP)

JICA categorizes a project in accordance with the impact level on environmental and social aspects taking into account the content, scale, location etc. The Category-A project corresponds to a project which may give a critical or undesirable impact on the environmental and social aspects. On necessary projects among Category-A and Category-B (projects which their potential impacts on the environment and society are considered less adverse than those of Category-A projects), JICA establishes an Advisory Committee to make advice on environmental and social considerations in preparatory surveys. JICA reports to the Committee, and the Committee makes advice as needed at the environmental review and monitoring stages.

In the EIA regulation in Vanuatu, DEPC conducts a "Preliminary Environmental Assessment (PEA)" and determines whether the project concerned would be required to implement an EIA or not, based on the results of the PEA. If implementing an EIA is mandatory, DEPC will develop the TOR for surveying with the project entities, nominate an independent consultant and create an EIA report. Table 10.4-1 shows items and outlines of the EIA in Category-A projects under the JICA GL. The actual EIA report, however, is ideal to fulfill the items and requirements in Table 10.4-1, while conforming to the Vanuatu's EIA regulation.

Table 10.4-1 Items and Outlines of the EIA in Category-A Projects under the JICA GL

No.	Item	Outline
1	Executive summary	To discuss significant findings and recommended actions.
2	Policy, legal & admin. framework:	To describe the framework within which the EIA report is to be carried out.
3	Project description	To describe the proposed project and its geographic, ecological, social and temporal context, including any off-site investments that may be required (e.g. dedicated pipelines, access roads, power plants, water supply, housing, or raw material and product storage facilities). It also indicates the need for any resettlement or social development plan. It normally includes a map showing the project site and the area affected by the project.
4	Analysis of alternatives	To compare systematically feasible alternatives to the proposed project site, technology, design, and operation including the "without project" situation in terms of the following: the potential environmental impacts; the feasibility of mitigating these impacts; their capital and recurrent costs; their suitability under local conditions; and their institutional, training, and monitoring requirements. For each of the alternatives, it quantifies the environmental impacts to the extent possible, and attaches economic values where feasible. It also states the basis for selecting the particular proposed project design, and offers justification for recommended emission levels and approaches to pollution prevention and abatement.
5	Baseline data	To assess the dimensions of the study area and describes relevant physical, biological, and socio-economic conditions, including all changes anticipated to occur before the project commences. Additionally, it takes into account current and proposed development activities within the project area but not directly connected to the project. Data should be relevant to decisions about project site, design, operation, or mitigation measures, and it is necessary to indicate the accuracy, reliability, and sources of the data.
6	Environmental impacts	To predict and assess the project's likely positive and negative impacts in quantitative terms, to the extent possible. It identifies mitigation measures and any negative environmental impacts that cannot be mitigated, and explores opportunities for environmental enhancement. It identifies and estimates the extent and quality of available data, essential data gaps and uncertainties associated with predictions, and it specifies topics that do not require further attention.
7	Environmental Management Plan (EMP)	To describe mitigation, monitoring, and institutional measures to be taken during construction and operation in order to eliminate adverse impacts, offset them, or reduce them to acceptable levels.
8	Consultation	To make a record of consultation meetings (date, venue, participants, procedures, opinions of major local stakeholders and responses to them, and other items), including consultations for obtaining the informed views of the affected people, local NGOs, and regulatory agencies.

Source: JICA GL (English version)

Land acquisition, compensation and livelihood assistance are usually surveyed and reported in the form of a Resettlement Action Plan (RAP). Although the data collection survey reveals that the project will not anticipate involuntary resettlement of people, required items such as valuating land acquired, identifying the eligibility, establishing the grievance redness system etc. are to be surveyed in the preparatory study by developing a RAP. The contents of RAP are created in accordance with the items stipulated in JICA GL and World Bank Safeguard Policy OP 4.12, Annex A[12].

10.4.3 Approval and License on Environmental and Social Issues

The proposed project needs an approval of EIA from MOL during the preparatory study stage to implement.

[12] https://policies.worldbank.org/sites/ppf3/PPFDocuments/Forms/DispPage.aspx?docid=1573&ver=current

In accordance with the result from an interview with the official responsible for EIA in DEPC, the project has a high possibility for EIA implementation. As mentioned above, however, a decision is made whether the EIA would be needed or not, based on the result from the PEA. The approval and license which is required before the construction may include permissions for tree felling, river use etc. Through the field survey that the study team conducted, both rare species and protected sites have not been reported and confirmed in the project area. Existence of such permissions and rare species will be re-confirmed through the environmental and social survey during the preparatory study stage.

10.4.4 Burden by Vanuatu Side

JICA GL requests the following items on environmental and social aspects to project proponents.

- Project proponents etc. are required to incorporate the output of environmental and social considerations of projects.
- When JICA provides support for and examinations of environmental and social considerations, JICA examines the requirements that must be met, as mentioned in JICA GL. In addition, JICA examines the items shown in JICA GL in order to satisfy "the environmental impact assessment reports" required for Category-A projects.

As mentioned above, the Japanese side will conduct support Vanuatu to secure proper environmental and social considerations by Vanuatu and to confirm the performance, in order to avoid or minimize impacts on the environment and local society by the proposed project and to prevent an impact which is not able to accept, on the assumption that Vanuatu would bear the responsibility regarding the environmental and social considerations derived from the project.

Burdens on the environmental and social aspects by Vanuatu may include such as:

Coordination

- Arrangement among authorities concerned
- Acquisition of necessary permission & license
- Others

Financial

- All costs regarding RAP activity like land acquisition, compensation, livelihood assistance etc.
- Costs for O&M and monitoring in operation phase
- Others

An earlier preparation is important to secure the required budget, based on the results obtained through the preparatory study stage.

Chapter 11 Need, Direction and Adequacy of Cooperation

11.1 Need and Direction of Project

11.1.1 Comprehensive Project by ADB

CPRRP funded by ADB and Global Environment Facility (GEF) comprehend this project and it is presently in the feasibility study stage. The summary of the project is shown in Table 11.1-1.

CPRRP aims to reconstruct the damaged ring road in Efate Island caused by Cyclone Pam excluding Teouma Bridge, which is considered in the project to be reconstructed by JICA assistance. So to speak, CPRRP comprehends this project. Hence, reconstruction of Teouma Bridge by JICA is required in order to maintain and improve the function of the ring road with CPRRP and the ring road increase its create the resilient ring road to for synergy effect.

Table 11.1-1 Summary of Cyclone Pam Road Reconstruction Project

Item	Description
Project Name	Cyclone Pam Road Reconstruction Project
Funder	ADB, GEF
Fund Amount	USD 16,290,000
Implementation Organization	PWD, MIPU
Purpose	The CPRRP aims to accelerate economic and social recovery in Vanuatu's TC Pam-affected areas and contribute to Ni-Vanuatu resilience. The development objective is to restore socioeconomic activities of people around the Efate ring road to pre-cyclone levels. This will be achieved by providing disaster resilient road and bridge infrastructure by reconstructing priority assets i.e. "building back better" (BBB).
Schedule	March, 2017: Completion of the feasibility study June, 2017: Completion of the detailed design July, 2017: Commencement of the construction June, 2018: Completion of the construction and the Project

Source: Inception Report, Cyclone Pam Road Reconstruction Project

11.1.2 Effect to Real GDP

Although the real GDP has been continuously at approximately 2% since 2003, it became -0.8% in 2015 due to Cyclone Pam (refer to Table 3.1-5).

On the other hand, as mentioned in Clause 3.1.1, most of the people live along the ring road or its feeder roads and they utilize the roads for land transportation and their daily life. Those roads also become access roads to tourist spots and they contribute to earn the foreign currency revenue. Considering the fact that approximately 30% of the population in Vanuatu lives in Efate Island where Port Vila or the capital is and outer islands, the reconstruction of Teouma Bridge, resulting in the flood safety improvement on the ring road will bring not only the local economic growth but also the national economic growth expressed some indexes such as the real GDP.

11.2 Adequacy of Project

The expected project effects are explained in the following clauses.

11.2.1 Traffic

The daily traffic amount at Teouma Bridge can be estimated between approximately 800 nos/day (traffic amount between Teouma Bridge and Rentapau) and 3,800 nos/day (between the center of Port Vila and Teouma Bridge) as expected from Table 4.2-5. As an index to be referred, the amount of the traffic at Rentapau has a tendency to increase (refer to Table 4.2-4 and Table 4.2-5) so that Teouma Bridge plays an even greater role in supporting the traffic in Efate Island hereafter. Hence, reconstruction of Teouma Bridge is necessary and adequate for adapting the ring road to increasing traffic.

11.2.2 Life of Resident

In Efate Island, the ring road is only one outer loop road and undertakes a big role to support local people for land transportation and their livelihood. For Example, Efate Island has limited hospital facility with one hospital and some health centers only along the ring road. Although the cause of disease and death used to be inaccessibility to such facilities, the ring road improved the accessibility dramatically. In such a way, reconstruction of Teouma Bridge maintains and improves the level of livelihood in Efate Island.

11.2.3 Tourism

The locations of famous tourist spots are shown in Figure 11－1. The spreading tourist spots are mostly along the ring road and the foreign tourists visit there from Bauerfield Airport or the wharves through the ring road. Teouma Bridge is one of the structures to support such transportation and contributes to obtain foreign currency revenue through tourism. Hence, reconstruction of it has important implications for the tourism in Vanuatu.

Source: Destination Vanuatu (http://www.vanuatuparadise.com)

Figure 11－1　　Tourist Spot along Ring Road

11.3 Discussion and Confirmation on the Approximate Project Cost and Implementation Schedule of River, Bridge and Road Improvement

The basic schemes and selection criteria on the three components (the river, the bridge and the road) in the Teouma Bridge Restoration Plan explained in the Chapter 8 and the approximate project cost and the implementation schedule discussed in the Chapter 9 were proposed to During the proposal, 1) security of independence on Teouma Bridge Restoration Plan by PWD, 2) needs, a direction and adequacies of the project and 3) precocious expression of the effect of the project and its maintenance were considered.

The summary of the results of the discussion were as follows.

- Restoration of Teouma Bridge is necessary and adequate corroborated with Cyclone Pam Road Reconstruction Project (CPRRP) performed by ADB in order to improve and maintain the function of the ring road in Efate Island. Those projects increase the reliability of the ring road in a synergistic manner.
- Level of the lives of surrounding societies will be recovered up to the one before the damages caused by Cyclone Pam with resilient Teouma Bridge to the floods with the concept of "Building Back Better (BBB)."
- There is no more alternatives than the ones proposed by JICA Survey Team on the basic schemes and

selection criteria. It was also confirmed that the proposed ones meet the technical needs and adequacies required.

- PWD proposed the priorities of the selection criteria based on the discussion about the durability of the structures, implementation and material qualities with BBB concept.

11.3.1 Priority of Selection Criteria

The priorities proposed by PWD are shown in the Table 11.3-1 to Table 11.3-3.

These priorities were made with the condition that the extension length of the bridge (30m or 35m) and the countries of origin of the aggregates and gravels (local or the third countries) would be proposed based on the geological and geographical survey performed during the preparatory survey followed by this survey.

Table 11.3-1 Selection Criteria Firstly Prioritized by PWD

Component	Basic Scheme	Selection Criteria
River Improvement	Riverbank and Riverbed Excavation, River Widening、Earth Cut Slope (Upstream, Left) and Slope Protection (Upstream Right, Downstream Both) (refer to Attachment4, Attachment-F 4-1)	・Slope Protection: Steel Sheet Pile + Reinforced Concrete (refer to Attachment4, Attachment-F 4-4, 4-5)
Bridge Improvement	Reuse and Repair of the Existing Bridge (30m), New Bridge Construction at Extended Area (35m), Demolition of Abutment in the Right Bank with Construction of New Pier, Construction of New Abutment in the Right Bank and Slope Protection (refer to Attachment4, Attachment-F 4-1)	・Existing Structural Member: Warren Type Pony Truss Steel ・New Structural Member: Warren Type Pony Truss Steel ・Slope Protection: Steel Sheet Pile + Multi-Staged Steel Bar Gabion (refer to Attachment4, Attachment-F 4-11, 4-9)
Road Improvement	Demolition of Existing Road and Construction of Flood-Proofing Road with Construction of Apron and Floor Protection (refer to Attachment4, Attachment-F 4-1, F 4—12)	・Flood-Proofing Road: Concrete + Grouted Riprap ・Apron: Concrete ・Floor Protection: Panel Type Gabion (refer to Attachment4, Attachment-F 4-13)

Source: JICA Survey Team

Table 11.3-2 Selection Criteria Secondary Prioritized by PWD

Component	Basic Scheme	Selection Criteria
River Improvement	Riverbank and Riverbed Excavation, River Widening、Earth Cut Slope (Upstream, Left) and Slope Protection (Upstream Right, Downstream Both) (refer to Attachment4, Attachment-F 4-1)	・Slope Protection: Multi-Staged Steel Bar Gabion (refer to Attachment4, Attachment-F 4-2, 4-3)
Bridge Improvement	Reuse and Repair of the Existing Bridge (30m), New Bridge Construction at Extended Area (35m), Demolition of Abutment in the Right Bank with Construction of New Pier, Construction of New Abutment in the Right Bank and Slope Protection (refer to Attachment4, Attachment-F 4-1)	・Existing Structural Member: Warren Type Pony Truss Steel ・New Structural Member: Warren Type Pony Truss Steel ・Slope Protection: Multi-Staged Steel Bar Gabion (refer to Attachment4, Attachment-F 4-10, 4-8)
Road Improvement	Demolition of Existing Road and Construction of Flood-Proofing Road with Construction of Apron and Floor Protection (refer to Attachment4, Attachment-F 4-1, F 4—12)	・Flood-Proofing Road: Cement Concrete Pavement + Stone Masonry ・Apron: Panel Type Gabion ・Floor Protection: Panel Type Gabion (refer to Attachment4, Attachment-F 4-14)

Source: JICA Survey Team

Table 11.3-3 Selection Criteria Thirdly Prioritized by PWD

Component	Basic Scheme	Selection Criteria
River Improvement	Riverbank and Riverbed Excavation, River Widening、Earth Cut Slope (Upstream, Left) and Slope Protection (Upstream Right, Downstream Both) (refer to Attachment4, Attachment-F 4-1)	・Slope Protection: Wet Stone Masonry (refer to Attachment4, Attachment-F 4-6, 4-7)
Bridge Improvement	Reuse and Repair of the Existing Bridge (30m), New Bridge Construction at Extended Area (35m), Demolition of Abutment in the Right Bank with Construction of New Pier, Construction of New Abutment in the Right Bank and Slope Protection (refer to Attachment4, Attachment-F 4-1)	・Existing Structural Member: Warren Type Pony Truss Steel ・New Structural Member: Warren Type Pony Truss Steel ・Slope Protection: Multi-Staged Steel Bar Gabion (refer to Attachment4, Attachment-F 4-10, 4-8)
Road Improvement	Demolition of Existing Road and Construction of Flood-Proofing Road with Construction of Apron and Floor Protection (refer to Attachment4, Attachment-F 4-1, F 4—12)	・Flood-Proofing Road: Cement Concrete Pavement + Stone Masonry ・Apron: Panel Type Gabion ・Floor Protection: Panel Type Gabion (refer to Attachment4, Attachment-F 4-14)

Source: JICA Survey Team

11.3.2 Calculation of Approximate Project Cost with PWD Priority

The following concepts and notes were considered for the calculation of the approximate project costs with the PWD priorities.

- The calculation should be done following the concept and notes for the calculation described in the Clause 9.7
- In the CPRRP performed by ADB, it is described that the apparent specific gravity of the lime stones for gabions fell below the standard or reference value so that the lime stones were not applicable. Hence, the approximate project costs with the rock material from the third countries for gabions were

calculated as C) in addition to A) and B) described in the Clause 9.7.

- Further study with geological tests such as an apparent specific gravity test, a water absorption test and a compression test will be required in the following preparatory survey in order to clarify the applicability of the lime stone for gabions, which defines the class of hardness of the rock (hard rock, semi-hard rock and soft rock).

Table 11.3-4 shows the procurement schedules with A) using local hard limestone aggregates, B) using imported basalt aggregates and C) using imported basalt aggregates and imported basalt rubble stones for gabions.

Table 11.3-4 Procurement Schedule for Aggregates (Plan A, B and C)

Work Items	Plan A		Plan B		Plan C	
	Hard Limestone (Local)	Basalt (Imported)	Hard Limestone (Local)	Basalt (Imported)	Hard Limestone (Local)	Basalt (Imported)
Aggregate for Concrete Structure	○	—	—	○	—	○
Aggregate for Spread Seal Pavement	○	—	—	○	—	○
Aggregate for Cement Concrete Pavement	○	—	—	○	—	○
Rubble Stone for Multi-Staged Steel Bar Gabion	○	—	○	—	—	○
Rubble Stone for Panel Type Gabion	○	—	○	—	—	○
Rubble Stone for Wet Stone Masonry (River Improvement)	○	—	○	—	○	—
Rubble Stone for Grouted Riprap (Road Improvement)	○	—	○	—	○	—

Source: JICA Survey Team

Regarding the PWD priorities, the approximate project costs with 1) the first prioritized case, 2) the second prioritized case and 3) the third prioritized case were proposed.

Table 11.3-5 shows the summary of the approximate project costs with PWD Priorities. Details were shown in the following pages.

Table 11.3-5 Summary of Approximate Project Cost with PWD Priority (Plan A, B and C)

(Unit: Billion JPY)

PWD Priority	Plan A	Plan B	Plan C
1st Prioritized Case	1.730	1.861	1.950
2nd Prioritized Case	1.579	1.623	2.030
3rd Prioritized Case	1.480	1.566	1.680

Source: JICA Survey Team

(1) Approximate Project Cost for Plan A (Local Aggregate, 35.0m Extension of Bridge)

1) The First Prioritized Cost Case in Plan A

Total Approximate Project Cost : 1.730 billion yen

1. Approximate Project Cost: 1.648 billion yen

Item		Cost (million yen)	Specifications
Project Cost		1,647.7	I + II
I	Construction Cost	1,384.5	・Riverbank and Riverbed Excavation, River Widening, Earth Cut Slope, Steel Sheet Pile + Reinforced Concrete Slope Protection ・Reuse and Repair of Existing Bridge (30 m), Extension with New Bridge (35 m), Demolition of Right Abutment, New Pier, New Right Abutment, Steel Sheet Pile + Multi-Staged Steel Bar Protection ・Demolition of Existing Road, New Flood-Proofing Road with Apron and Floor Protection (Concrete Road, Panel Type Gabion Protection and Grouted Riprap for Subgrade)
	Direct Cost	1,006.5	
	・River Imp.	547.7	
	・Bridge Imp.	200.6	
	・Road Imp.	130.8	
	・Detour	127.4	
	Temporary Works	44.0	
	Site Expense	229.4	
	Overhead	104.6	
II	Consulting Service	263.2	・DD: 4.5Month (including 1.0 at site and 0.5 month for tender document approval) ・Tender Assistance: 4.0Month (including Pre-Qualification: 0.5 month, Approval of Contract: 0.5) SV: 25.0 Month, Resident Engineer (for River Improvement: 1 person, Road and Bridge Improvement: 1 person)
	Detailed Design	34.3	
	Tender Assistance	4.8	
	Supervision	224.1	

Note: Exchange rate: USD 1.00 = JPY102.129 VT 1.00＝JPY 0.9728

Source: JICA Survey Team

2. Contingency: 0.082 billion yen

・Contingency is set at 5% of the project cost: 82.4 (million yen)

(1) Approximate Project Cost for Plan A (Local Aggregate, 35.0m Extension of Bridge)

2) The Second Prioritized Cost Case in Plan A

Total Approximate Project Cost : 1.579 billion yen

1. Approximate Project Cost: 1.504 billion yen

Item		Cost (million yen)	Specifications
Project Cost		1,503.8	I + II
I	Construction Cost	1,240.6	・Riverbank and Riverbed Excavation, River Widening, Earth Cut Slope, Multi-Staged Steel Bar Gabion Slope Protection ・Reuse and Repair of Existing Bridge (30m), Extension with New Bridge (35m), Demolition of Right Abutment, New Pier, New Right Abutment, Multi-Staged Steel Bar Gabion Protection ・Demolition of Existing Road, New Flood-Proofing Road with Apron and Floor Protection (Concrete Road, Grouted Riprap Protection and Panel Type Gabion Protection)
	Direct Cost	900.8	
	・River Imp.	478.6	
	・Bridge Imp.	213.7	
	・Road Imp.	68.9	
	・Detour	139.6	
	Temporary Works	39.4	
	Site Expense	205.3	
	Overhead	95.1	
II	Consulting Service	263.2	・DD: 4.5Month (including 1.0 at site and 0.5 month for tender document approval) ・Tender Assistance: 4.0Month (including Pre-Qualification: 0.5 month, Approval of Contract: 0.5) SV: 25.0 Month, Resident Engineer (for River Improvement: 1 person, Road and Bridge Improvement: 1 person)
	Detailed Design	34.3	
	Tender Assistance	4.8	
	Supervision	224.1	

Note: Exchange rate: USD 1.00 = JPY102.129 VT 1.00＝JPY 0.9728

Source: JICA Survey Team

2. Contingency: 0.075 billion yen

・Contingency is set at 5% of the project cost: 75.2 (million yen)

(1) Approximate Project Cost for Plan A (Local Aggregate, 35.0m Extension of Bridge)

3) The Third Prioritized Cost Case in Plan A

Total Approximate Project Cost : 1.480 billion yen

1. Approximate Project Cost: 1.409 billion yen

Item		Cost (million yen)	Specifications
Project Cost		1,409.1	I + II
I	Construction Cost	1,145.9	・Riverbank and Riverbed Excavation, River Widening, Earth Cut Slope, Wet Stone Masonry Slope Protection ・Reuse and Repair of Existing Bridge (30m), Extension with New Bridge (35m), Demolition of Right Abutment, New Pier, New Right Abutment, Multi-Staged Steel Bar Gabion Protection ・Demolition of Existing Road, New Flood-Proofing Road with Apron and Floor Protection (Concrete Road, Grouted Riprap Protection and Panel Type Gabion Protection)
	Direct Cost	831.4	
	・River Imp.	393.1	
	・Bridge Imp.	221.8	
	・Road Imp.	71.6	
	・Detour	144.9	
	Temporary Works	36.3	
	Site Expense	189.5	
	Overhead	88.7	
II	Consulting Service	263.2	・DD: 4.5Month (including 1.0 at site and 0.5 month for tender document approval) ・Tender Assistance: 4.0Month (including Pre-Qualification: 0.5 month, Approval of Contract: 0.5) SV: 25.0 Month, Resident Engineer (for River Improvement: 1 person, Road and Bridge Improvement: 1 person)
	Detailed Design	34.3	
	Tender Assistance	4.8	
	Supervision	224.1	

Note: Exchange rate: USD 1.00 = JPY102.129 VT 1.00＝JPY 0.9728

Source: JICA Survey Team

2. Contingency: 0.071 billion yen

・Contingency is set at 5% of the project cost: 70.5 (million yen)

(2) Approximate Project Cost for Plan B (Imported Aggregate, 35.0m Extension of Bridge)

1) The First Prioritized Cost Case in Plan B

Total Approximate Project Cost : 1.861 billion yen

1. Approximate Project Cost: 1.772 billion yen

Item		Cost (million yen)	Specifications
Project Cost		1,772.1	I + II
I	Construction Cost	1,508.9	・Riverbank and Riverbed Excavation, River Widening, Earth Cut Slope, Steel Sheet Pile + Reinforced Concrete Slope Protection ・Reuse and Repair of Existing Bridge (30 m), Extension with New Bridge (35 m), Demolition of Right Abutment, New Pier, New Right Abutment, Steel Sheet Pile + Multi-Staged Steel Bar Protection ・Demolition of Existing Road, New Flood-Proofing Road with Apron and Floor Protection (Concrete Road, Panel Type Gabion Protection and Grouted Riprap for Subgrade)
	Direct Cost	1,097.9	
	・River Imp.	515.8	
	・Bridge Imp.	210.7	
	・Road Imp.	251.4	
	・Detour	120.0	
	Temporary Works	48.0	
	Site Expense	250.3	
	Overhead	112.7	
II	Consulting Service	263.2	・DD: 4.5Month (including 1.0 at site and 0.5 month for tender document approval) ・Tender Assistance: 4.0Month (including Pre-Qualification: 0.5 month, Approval of Contract: 0.5) SV: 25.0 Month, Resident Engineer (for River Improvement: 1 person, Road and Bridge Improvement: 1 person)
	Detailed Design	34.3	
	Tender Assistance	4.8	
	Supervision	224.1	

Note: Exchange rate: USD 1.00 = JPY102.129 VT 1.00＝JPY 0.9728

Source: JICA Survey Team

2. Contingency: 0.089 billion yen

・Contingency is set at 5% of the project cost: 88.6 (million yen)

(2) Approximate Project Cost for Plan B (Imported Aggregate, 35.0m Extension of Bridge)

2) The Second Prioritized Cost Case in Plan B

Total Approximate Project Cost : 1.623 billion yen

1. Approximate Project Cost: 1.546 billion yen

Item		Cost (million yen)	Specifications
Project Cost		1,546.4	I + II
I	Construction Cost	1,283.2	・Riverbank and Riverbed Excavation, River Widening, Earth Cut Slope, Multi-Staged Steel Bar Gabion Slope Protection ・Reuse and Repair of Existing Bridge (30m), Extension with New Bridge (35m), Demolition of Right Abutment, New Pier, New Right Abutment, Multi-Staged Steel Bar Gabion Protection ・Demolition of Existing Road, New Flood-Proofing Road with Apron and Floor Protection (Concrete Road, Grouted Riprap Protection and Panel Type Gabion Protection)
	Direct Cost	932.2	
	・River Imp.	464.5	
	・Bridge Imp.	231.9	
	・Road Imp.	100.3	
	・Detour	135.5	
	Temporary Works	40.7	
	Site Expense	212.5	
	Overhead	97.9	
II	Consulting Service	263.2	・DD: 4.5Month (including 1.0 at site and 0.5 month for tender document approval) ・Tender Assistance: 4.0Month (including Pre-Qualification: 0.5 month, Approval of Contract: 0.5) SV: 25.0 Month, Resident Engineer (for River Improvement: 1 person, Road and Bridge Improvement: 1 person)
	Detailed Design	34.3	
	Tender Assistance	4.8	
	Supervision	224.1	

Note: Exchange rate: USD 1.00 = JPY102.129 VT 1.00＝JPY 0.9728

Source: JICA Survey Team

2. Contingency: 0.077 billion yen

・Contingency is set at 5% of the project cost: 77.3 (million yen)

(2) Approximate Project Cost for Plan B (Imported Aggregate, 35.0m Extension of Bridge)

3) The Third Prioritized Cost Case in Plan B

Total Approximate Project Cost : 1.566 billion yen

1. Approximate Project Cost: 1.491 billion yen

Item		Cost (million yen)	Specifications
Project Cost		1,490.6	I + II
I	Construction Cost	1,227.4	・Riverbank and Riverbed Excavation, River Widening, Earth Cut Slope, Wet Stone Masonry Slope Protection ・Reuse and Repair of Existing Bridge (30m), Extension with New Bridge (35m), Demolition of Right Abutment, New Pier, New Right Abutment, Multi-Staged Steel Bar Gabion Protection ・Demolition of Existing Road, New Flood-Proofing Road with Apron and Floor Protection (Concrete Road, Grouted Riprap Protection and Panel Type Gabion Protection)
	Direct Cost	891.2	
	・River Imp.	421.8	
	・Bridge Imp.	232.8	
	・Road Imp.	100.7	
	・Detour	135.9	
	Temporary Works	38.9	
	Site Expense	203.1	
	Overhead	94.2	
II	Consulting Service	263.2	・DD: 4.5Month (including 1.0 at site and 0.5 month for tender document approval) ・Tender Assistance: 4.0Month (including Pre-Qualification: 0.5 month, Approval of Contract: 0.5) SV: 25.0 Month, Resident Engineer (for River Improvement: 1 person, Road and Bridge Improvement: 1 person)
	Detailed Design	34.3	
	Tender Assistance	4.8	
	Supervision	224.1	

Note: Exchange rate: USD 1.00 = JPY102.129 VT 1.00＝JPY 0.9728

Source: JICA Survey Team

2. Contingency: 0.075 billion yen

・Contingency is set at 5% of the project cost: 74.5 (million yen)

(3) Approximate Project Cost for Plan C (Imported Aggregate and Rubble Stone, 35.0m Extension of Bridge)

1) The Third Prioritized Cost Case in Plan C

Total Approximate Project Cost : 1.950 billion yen

1. Approximate Project Cost: 1.857 billion yen

Item		Cost (million yen)	Specifications
Project Cost		1,856.7	I + II
I	Construction Cost	1,593.5	・Riverbank and Riverbed Excavation, River Widening, Earth Cut Slope, Steel Sheet Pile + Reinforced Concrete Slope Protection ・Reuse and Repair of Existing Bridge (30 m), Extension with New Bridge (35 m), Demolition of Right Abutment, New Pier, New Right Abutment, Steel Sheet Pile + Multi-Staged Steel Bar Protection ・Demolition of Existing Road, New Flood-Proofing Road with Apron and Floor Protection (Concrete Road, Panel Type Gabion Protection and Grouted Riprap for Subgrade)
	Direct Cost	1,160.2	
	・River Imp.	533.9	
	・Bridge Imp.	208.4	
	・Road Imp.	301.9	
	・Detour	116.0	
	Temporary Works	50.7	
	Site Expense	264.5	
	Overhead	118.1	
II	Consulting Service	263.2	・DD: 4.5Month (including 1.0 at site and 0.5 month for tender document approval) ・Tender Assistance: 4.0Month (including Pre-Qualification: 0.5 month, Approval of Contract: 0.5) SV: 25.0 Month, Resident Engineer (for River Improvement: 1 person, Road and Bridge Improvement: 1 person)
	Detailed Design	34.3	
	Tender Assistance	4.8	
	Supervision	224.1	

Note: Exchange rate: USD 1.00 = JPY102.129 VT 1.00＝JPY 0.9728

Source: JICA Survey Team

2. Contingency: 0.093 billion yen

・Contingency is set at 5% of the project cost: 92.8 (million yen)

(3) Approximate Project Cost for Plan C (Imported Aggregate and Rubble Stone, 35.0m Extension of Bridge)

2) The Third Prioritized Cost Case in Plan C

Total Approximate Project Cost : 2.030 billion yen

1. Approximate Project Cost: 1.933 billion yen

Item		Cost (million yen)	Specifications
Project Cost		1,932.5	I + II
I	Construction Cost	1,669.3	・Riverbank and Riverbed Excavation, River Widening, Earth Cut Slope, Multi-Staged Steel Bar Gabion Slope Protection ・Reuse and Repair of Existing Bridge (30m), Extension with New Bridge (35m), Demolition of Right Abutment, New Pier, New Right Abutment, Multi-Staged Steel Bar Gabion Protection ・Demolition of Existing Road, New Flood-Proofing Road with Apron and Floor Protection (Concrete Road, Grouted Riprap Protection and Panel Type Gabion Protection)
	Direct Cost	1,216.0	
	・River Imp.	730.8	
	・Bridge Imp.	214.1	
	・Road Imp.	158.1	
	・Detour	113.0	
	Temporary Works	53.1	
	Site Expense	277.2	
	Overhead	123.0	
II	Consulting Service	263.2	・DD: 4.5Month (including 1.0 at site and 0.5 month for tender document approval) ・Tender Assistance: 4.0Month (including Pre-Qualification: 0.5 month, Approval of Contract: 0.5) SV: 25.0 Month, Resident Engineer (for River Improvement: 1 person, Road and Bridge Improvement: 1 person)
	Detailed Design	34.3	
	Tender Assistance	4.8	
	Supervision	224.1	

Note: Exchange rate: USD 1.00 = JPY102.129 VT 1.00＝JPY 0.9728

Source: JICA Survey Team

2. Contingency: 0.097 billion yen

・Contingency is set at 5% of the project cost: 96.6 (million yen)

(3) Approximate Project Cost for Plan C (Imported Aggregate and Rubble Stone, 35.0m Extension of Bridge)

3) The Third Prioritized Cost Case in Plan C

Total Approximate Project Cost : 1.680 billion yen

1. Approximate Project Cost: 1.600 billion yen

Item		Cost (million yen)	Specifications
Project Cost		1,599.7	I + II
I	Construction Cost	1,336.5	・Riverbank and Riverbed Excavation, River Widening, Earth Cut Slope, Wet Stone Masonry Slope Protection ・Reuse and Repair of Existing Bridge (30m), Extension with New Bridge (35m), Demolition of Right Abutment, New Pier, New Right Abutment, Multi-Staged Steel Bar Gabion Protection ・Demolition of Existing Road, New Flood-Proofing Road with Apron and Floor Protection (Concrete Road, Grouted Riprap Protection and Panel Type Gabion Protection)
	Direct Cost	971.2	
	・River Imp.	426.1	
	・Bridge Imp.	240.5	
	・Road Imp.	177.6	
	・Detour	127.0	
	Temporary Works	42.4	
	Site Expense	221.4	
	Overhead	101.5	
II	Consulting Service	263.2	・DD: 4.5Month (including 1.0 at site and 0.5 month for tender document approval) ・Tender Assistance: 4.0Month (including Pre-Qualification: 0.5 month, Approval of Contract: 0.5) SV: 25.0 Month, Resident Engineer (for River Improvement: 1 person, Road and Bridge Improvement: 1 person)
	Detailed Design	34.3	
	Tender Assistance	4.8	
	Supervision	224.1	

Note: Exchange rate: USD 1.00 = JPY102.129 VT 1.00＝JPY 0.9728

Source: JICA Survey Team

2. Contingency: 0.080 billion yen

・Contingency is set at 5% of the project cost: 80.0 (million yen)

Attachment

Attachment 1: Minutes of the Meeting on the Inception Report

Attachment 2: Minutes of the Meeting on the Progress Report and Handout

Attachment 3: Soundness Inspection Result on Teouma Bridge

Attachment 4: Draft Structure Design

Attachment 5: Minutes of the Meeting on the Draft Final Report

Attachment 1: Minutes of Meeting on the Inception Report

MINUTES OF THE MEETING
ON
THE INCEPTION REPORT
FOR
DATA COLLECTION SURVEY
FOR
RECONSTRUCTION OF TEOUMA BRIDGE
ON EFATE RING ROAD
IN THE REPUBLIC OF VANUATU

CONFERENCE ROOM, PUBLIC WORKS DEPARTMENT
PMB 044, PORT VILA
August 2, 2016

KANEHIRO MORISHITA
Leader of JICA Study Team

SAMUEL NAMURI
Director
Public Works Department

As the commencement of the Data Collection Survey for Reconstruction of Teouma Bridge on Efate Ring Road in the Republic of Vanuatu, Japan International Cooperation Agency (hereinafter referred to as "JICA") Study Team and Public Works Department (hereinafter referred to as "PWD") held a meeting to confirm the concept of the reconstruction of Teouma Bridge with the Inception Report ("IC/R") on August 2, 2016. The Meeting was chaired by Mr. Samuel Namuri, Director of PWD, and the attendees are as listed in the Annex.

1. Concept of Reconstruction of Teouma Bridge and It's Survey

The concept of the reconstruction of Teouma Bridge was explained by Mr. Kanehiro Morishita, the Leader of the JICA Study Team, and discussions were made. The principal items discussed and agreed in the Meeting are as summarized below:

(1) Reconstruction consists of three components, 1) bridge rehabilitation, 2) bank protection with river excavation and 3) road rehabilitation as a flood-proofing.

(2) The study of the reconstruction aims at a target year of 100 years with three components mentioned in clause (1) (50 years with Teouma Bridge only).

(3) Confirmation of land ownership is an important issue.

(4) Flood-proofing road without culverts is recommended since culverts are easily clogged.

(5) River excavation is useful to lower the flood level.

(6) Present concept of not changing the height of the bridge is preferable since elevation of the bridge would lead the elevation of the approach roads, which requires the additional land acquisition.

(7) Considering the size of the land acquisition, additional land acquisition required from the gap of alignments of new bridge and the existing road would be acceptable.

(8) PWD will distribute the road manual to JICA Study Team and it will be considered as a reference for the data collection survey.

2. Comment on IC/R and Answer to Questionnaire

(1) Mr. Morishita submitted the IC/R and questionnaire to be reviewed.

3. Future Communication

(1) Mr. Jason Andrews is the contact person Mr. James Hakwa is the one to discuss the technical issues.

The Meeting was adjourned at 10:50 am.

ANNEX ATTENDANCE SHEET

Name	Position / Company	E-mail Address	Contact No/s
1. Jason Andrews	Environmental and Social Officer/PWD		
2. Ambatha Paraliu	Manager (Operations) /PWD		
3. Samuel. Namuri	Director/PWD		
4. James Hakwa	Principle Engineer/PWD		
5. Yoko Asano	Project Formulation Advisor /JICA		
6. Kanchiro Morishita	Team Leader/ River Planning①/ Restoration Concept Plan		
7. Satoshi Takata	Deputy Team Leader/ River Planning②/ River Improvement Plan		
8. Khadanada Lamsal	Hydro-Hydraulic Analysis		
9. Minoru Miura	Road Bridge Improvement Plan		
10. Yoshihisa Noda	Procurement Plan/ Approximate Project Cost		

Attachment 2: Minutes of Meeting on the Progress Report and Handout

MINUTES OF THE MEETING
ON
THE PROGRESS REPORT
SURVERY RESULTS AND TECHNICAL DESIGN NOTE
FOR
DATA COLLECTION SURVEY
FOR
RECONSTRUCTION OF TEOUMA BRIDGE
ON EFATE RING ROAD
IN THE REPUBLIC OF VANUATU

CONFERENCE ROOM, PUBLIC WORKS DEPARTMENT
PMB 9044, PORT VILA
August 23, 2016

KANEHIRO MORISHITA
Leader of JICA Study Team

JONE ROQARA
Deputy Director
Public Works Department

At the end of the first site survey of the Data Collection Survey for Reconstruction of Teouma Bridge on Efate Ring Road in the Republic of Vanuatu, Japan International Cooperation Agency (hereinafter referred to as "JICA") Study Team and Public Works Department (hereinafter referred to as "PWD") held a meeting to confirm the survey results and to discuss the technical design note of the reconstruction of Teouma Bridge with the Progress Report ("PR/R") on August 23, 2016. The Meeting was chaired by Mr. Jone Roqara, Deputy Director of PWD, and the attendees are as listed in the Annex.

1. Survey Result and Technical Design Note

The survey results were explained by Mr. Kanehiro Morishita, the Leader of the JICA Study Team, and supplementary explanation was added by Mr. Satoshi Takata, Mr. Yoshihisa Noda and Mr. Takayuki Hatano.

The principal items discussed and agreed in the Meeting are as summarized below:

(1) Deputy Director, Mr. Roqara and Mr. Baleilevuka asked about the river condition at the lower stream of the Teouma Bridge after the proposed improvement. JICA Study Team will reconsider the alignment of the structure.

(2) Mr. Roqara asked the question if the road will be submerged during the flood. JICA study team confirmed that the flood-proofing road will be submerged with the flood over 50-year return period.

(3) Mr. Roqara requested more information about Kago-Mat since the big debris and trees are washed out from the upstream of the Teouma Bridge and may cause the damage on the river protection. JICA Study Team will provide the data later.

(4) JICA Study Team confirmed that the elevation of the bridge and road will be the same after the improvement.

(5) Ms. Asano emphasized the importance of the land acquisition and the responsibility of the government on the land acquisition. Mr. Roqara agreed with the idea.

(6) Mr. Hakwa requested to compile the advantage and the disadvantage on each option. JICA Study Team will prepare them later.

(7) Mr. Baleilevuka requested the JICA Study Team to keep the one span option open and reconsider it.

(8) Mr. Roqara asked about the possibility of the application of the concrete surface protection at the bridge abutment and requested the consideration on the maintenance situation in Vanuatu. JICA Study Team explained that the design of abutment protection is consistent with the design of the protection of the river bank.

(9) Mr. Roqara requested the list of the references such as design standards in the draft final report.

(10) JICA Study Team requested the PWD restoration plan of Teouma Bridge including the budget information. Mr. Roqara will send them to Mr. Morishita by email.

The Meeting was adjourned at 16:00 pm.

ANNEX ATTENDANCE SHEET

Name	Position / Company	E-mail Address	Contact No/s
1. Jone Roqara	Deputy Director/PWD		
2. Harold Allanson	Project Engineer/PWD		
3. James Hakwa	Principle Engineer/PWD		
4. Paula Baleilevuka	Engineer/PWD		
5. Yoko Asano	Project Formulation Advisor /JICA		
6. Kanehiro Morishita	Team Leader/ River Planning①/ Restoration Concept Plan		
7. Satoshi Takata	Deputy Team Leader/ River Planning②/ River Improvement Plan		
8. Khadanada Lamsal	Hydro-Hydraulic Analysis		
9. Minoru Miura	Road Bridge Improvement Plan		
10. Yoshihisa Noda	Procurement Plan/ Approximate Project Cost		
11. Takayuki Hatano	Environmental and Social Consideration		

Japan International Cooperation Agency (JICA)
The Republic of Vanuatu, Ministry of Infrastructure and Public Utilities, Public Works Department

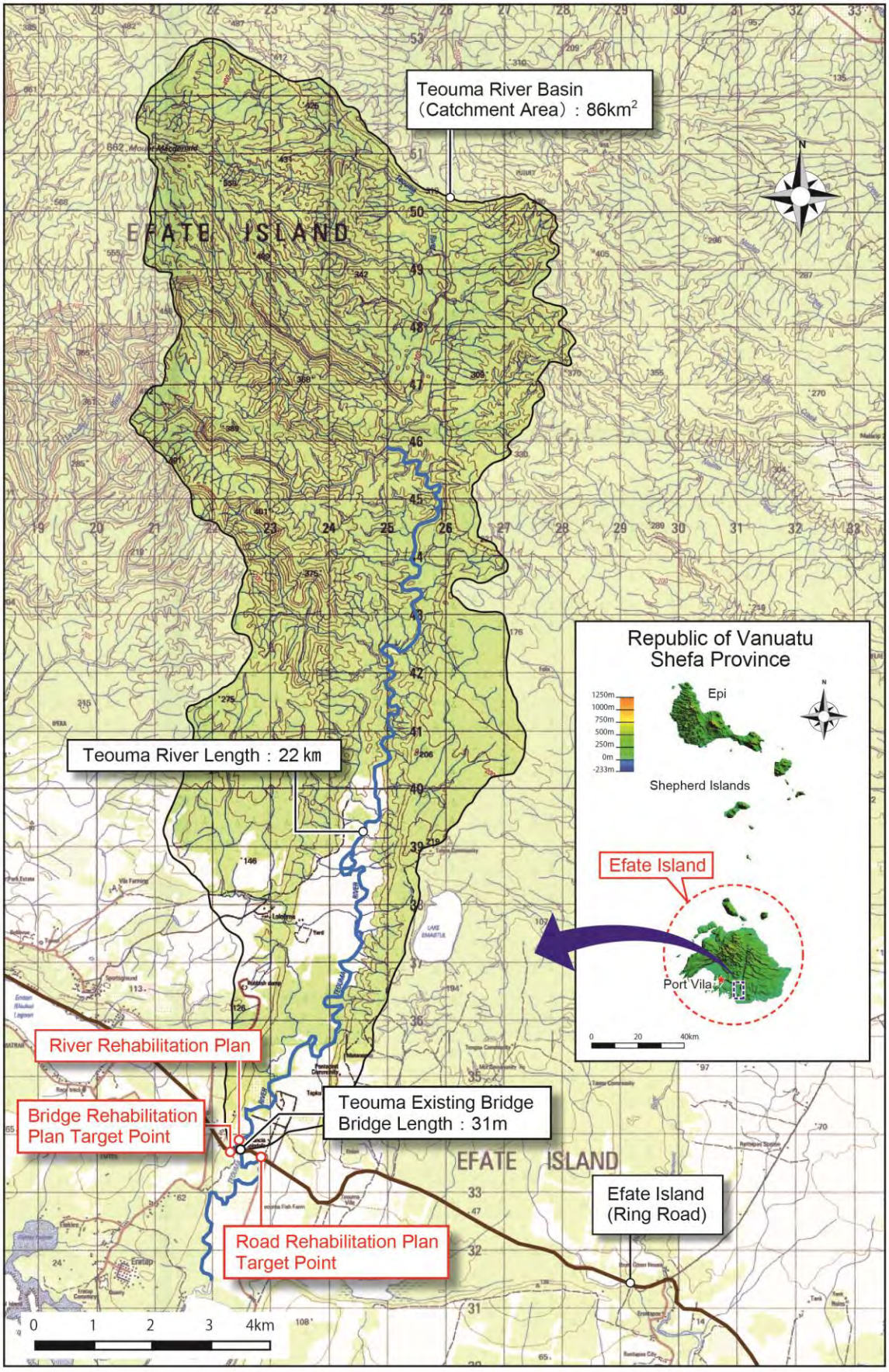
Data Collection Survey for Reconstruction of Teouma Bridge on Efate Ring Road in the Republic of Vanuatu

PROGRESS REPORT

Survey Results and Technical Design Note

August 2016

CTI Engineering International Co., Ltd.



Location Map

Table of Contents

Chapter 1 Introduction

1.1 Background

Existing Teouma Bridge constructed under "The project for rehabilitation of bridges on the ring road in the Efate Island in the Republic of Vanuatu" (completed in 2005) closed to vehicle traffic for six days due to the damages on Teouma Bridge caused by Cyclone Pam of the Category 5 in March, 2015. At present, the traffic has been secured by an emergency measure by the Government of Vanuatu; however for further rehabilitation, Vanuatu Government faces the difficulties in securing human and financial resources for covering all rehabilitation works of the relevant infrastructures damaged by Cyclone Pam.

In 2005, Cyclone Pam brought the heaviest downpour, and caused big flood of the Teouma River basin as well as the Efate Island. The river course changed intensively as progress of channel meandering resulting in widening the river course compared to it at the time of bridge construction. As a result, river water directly hit the abutment on the right bank and scoured the bottom of the abutment. And now, the bridge is under a very fragile condition to the heavy rain and can be easily damaged in the cyclone season every year even though the urgent rehabilitation measures have been done. In addition, It has been revealed that the approach road of the bridge have a high possibility of scouring of the embankment to block the traffic due to forming the bottleneck along the Teouma River and necessity of the study on the river improvement and the replacement of the bridge. Considering the frequent morphological changes of the river course, further detailed river morphological study and hydro-hydraulic analysis are required for the rehabilitation of the bridge and the river improvement. Therefore, the data collection survey is commenced to study and determine the direction of the bridge reconstruction and river improvement in coordination with the Government of Vanuatu.

1.2 Objective

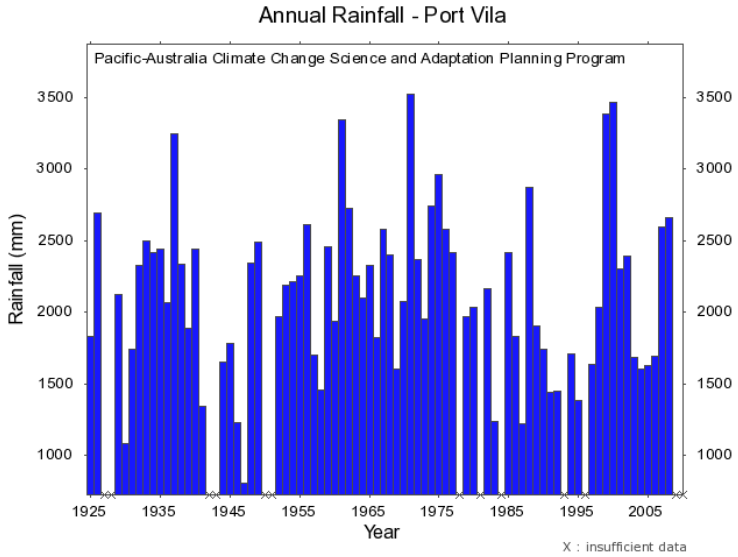
This project conducts river morphological classification by stereoscope device based on the satellite imageries and prepares river chronological change and micro-topography classification map for the Teouma River around the Teouma Bridge in the Efate Island in Vanuatu. The safety degree, potential risk and its possible measures shall be examined. In addition, the estimate of probable flood discharge and hydro-hydraulic analysis to grasp the flood phenomenon shall also be conducted. Based on these studies and analysis, river, bridge and road improvement plan shall be studied. Furthermore, necessity and direction of future cooperation shall also be studied in corporation with the Government of Vanuatu.

Chapter 2 Hydrological and Hydraulic Survey

2.1 Data Collection and Analysis on Rainfall

2.1.1 Selection of Representative Station for Statistic Analysis

In the Efate Island, where the Teouma River basin is located, there are two meteorological observatories; namely Nambatu (Port Vila) and Bauerfield (Airport). Although the longest monitored station is Nambatu, the data contain frequent insufficient data as illustrated below. Even though the observed period of 30 years at Bauerfield is shorter than the one at Nambatu, the rainfall data monitored at Bauerfield would be better to utilize for statistical analysis.



Source: Pacific Climate Change Data Portal, Bureau of Meteorology, Auatralia

Figure 2.1.1 Annual Rainfall Series at Port Vila Station

2.1.2 Filling of Missing Data

For the long time series of the daily rainfall observed at Bauerfield, the most critical part during Cyclone Pam was missing: only observed three days' rainfall due to difficulty to monitor meteorological parameters under heavy storm. Meanwhile, Nambatu (Port Vila) station fortunately observed rainfall during Cyclone Pam as tabulated below.

Table 2.1.1 Daily Rainfall Observed at Bauerfield and Nambatu

Date in March, 2015	Bauerfield	Nambatu
13	48mm	388.5mm
14	-	88.1mm
15	-	0.4mm
16	584mm	0mm
Total	632mm	477.0mm

Daily rainfall at bauerfield during Cyclone Pam could be estimated using the data observed at Nambatu, in accordance with a ratio of daily rainfall in 4 days. The allotment ratios are 0.814 on 13th,

0.185 on 14th, 0.001 on 15th, March 2015, respectively. As a reference, correlation between Bauerfield and Nambatu for the data period of 2000 to 2015 is depicted below. Both annual maximum daily rainfall data show the high correlation coefficient.

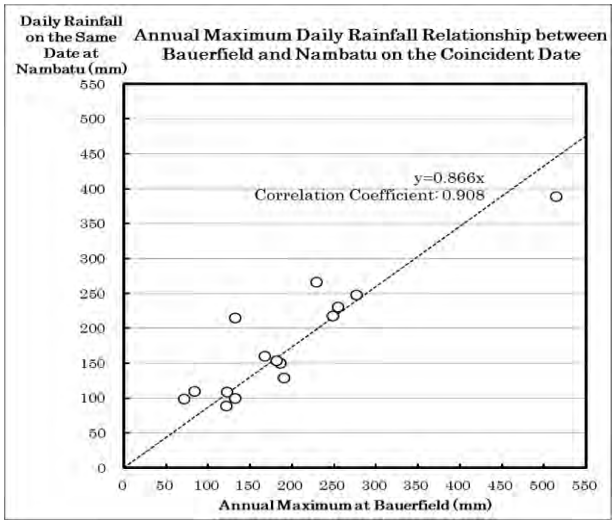


Figure 2.1.2 Relationship between Bauerfield and Nambatu Stations in Annual Maximum Daily Rainfall

Historical rainfall data at Bauerfield were collected from the VMGD in order to compute the probable rainfall for hydrological designing, such as bridge and bank protection works, and flood-proofing road. Those collected data are tabulated below. Data series of annual rainfall and annual maximum daily rainfall are presented in **Figures 2.1.3**.

Table 2.1.2 Rainfall Data Recorded at Bauerfield

Year	Annual Rainfall (mm)	Daily Maximum Rainfall (mm)	Year	Annual Rainfall (mm)	Daily Maximum Rainfall (mm)
1986	1,888	214.8	2001	2,647	248.8
1987	1,295	96.1	2002	3,022	276.3
1988	3,158	187.8	2003	1,446	71.2
1989	2,301	102.6	2004	2,020	254.4
1990	2,192	124.8	2005	1,843	121.8
1991	1,636	84.9	2006	1,824	185.9
1992	1,798	210.2	2007	2,590	132.3
1993	1,774	399.0	2008	3,054	122.9
1994	2,209	239.0	2009	1,838	83.4
1995	1,648	219.1	2010	2,520	229.4
1996	2,095	114.9	2011	2,740	132.1
1997	1,838	174.3	2012	2,435	167.1
1998	2,231	210.5	2013	2,394	190.1
1999	4,104	538.8	2014	2,641	181.1
2000	3,229	130.5	2015	2,464	577.0

Data Source: VMGD

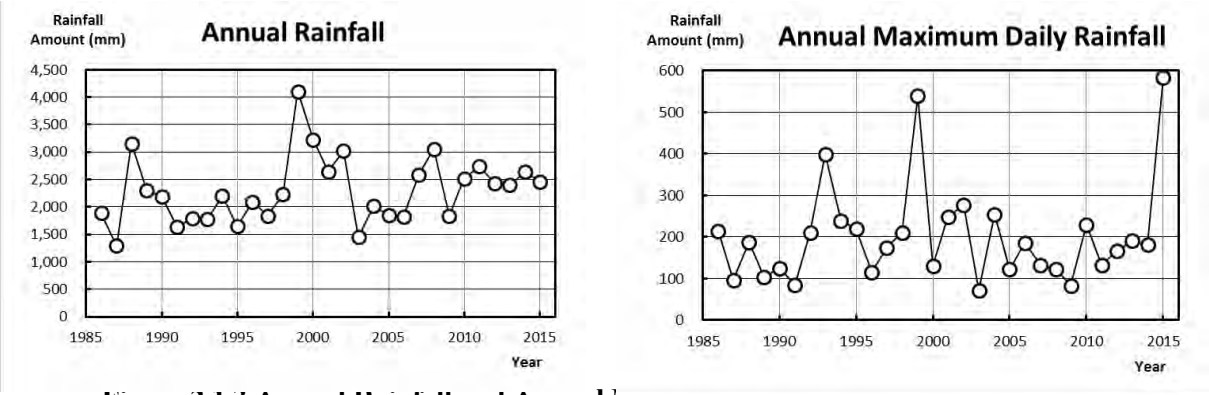


Figure 2.1.3 Annual Rainfall and Annual Maximum Daily Rainfall at Bauerfield

2.1.3 Estimation of Probable Rainfall

The probable rainfall was computed through comparison among various probable distribution curves and the annual maximum daily rainfall observed at Bauerfield. Among the curves, Log-Peason Type 3 distribution shows the best fit to the historical data as presented in **Figure 2.1.4**.

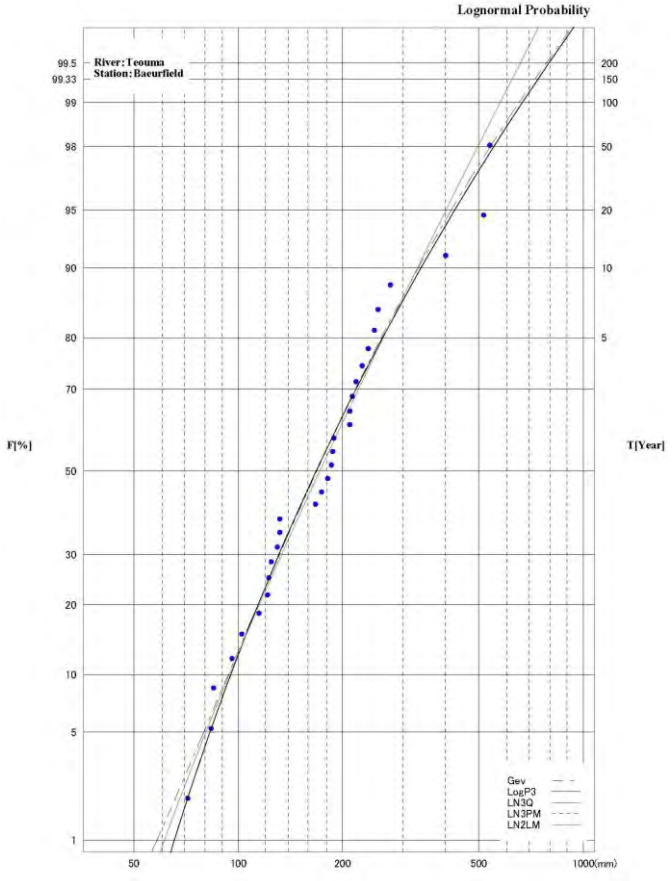


Figure 2.1.4 Probability Distribution Curves to Fit the Observed Data

The computed probable daily rainfall is tabulated below.

Table 2.1.3 Probable Daily Rainfall at Bauerfiled

Recurrence Period (Year)	2	5	10	20	50	100
Probable Rainfall (mm)	167.9	261.9	338.3	423.4	553.0	666.4

As presented in the above table, the observed daily rainfall of 577 mm during Cyclone Pam could be evaluated at a 50-year storm approximately.

2.2 Rainfall-Runoff Analysis

2.2.1 Area Reduction Factor (ARF)

The area reduction factor (ARF) is considered to use point rainfall to the extensive catchment. The ARF should be used with the United States Soil Conservation Services (SCS) Unit Hydrograph method if it is applied to catchment larger than 10 km^2 for rainfall-runoff analysis. The ARF established based on catchment area and time of concentration of flood by Auckland Regional Council and published on Technical Publication No. 108, April 1999 are used for reference, and the values of ARF are presented in **Table 2.2.1**. Due to having the catchment area 86 km^2 and time of concentration of flow about 5.6 hours, the area reduction factor 0.85 is considered for the catchment to estimate the basin rainfall.

Table 2.2.1 Area Reduction Factor (ARF)

Catchment Area (km^2)	Time of Concentration of Flow (hour)						
	0.5	1	2	3	6	12	24
< 10	1.00	1.00	1.00	1.00	1.00	1.00	1.00
20	0.90	0.91	0.93	0.94	0.95	0.96	0.97
50	0.72	0.75	0.82	0.86	0.92	0.94	0.96
100	0.71	0.74	0.79	0.83	0.86	0.89	0.90
200	0.70	0.72	0.75	0.79	0.82	0.85	0.86
500	0.68	0.70	0.72	0.74	0.76	0.79	0.81

Source: Guidelines for stormwater runoff modeling in the Auckland Region, Auckland Regional Council, Technical Publication No. 108, April 1999, page 5.

2.2.2 SCS Unit Hydrograph

The catchment hydrograph was developed by SCS Unit Hydrograph method. The ordinate of the unit hydrograph is expressed as the ratio of discharge to peak discharge (q/q_p) and abscissa in the ratio of time to the time to peak (t/t_p). This method computes the runoff from the catchment being based on retention capacity of soil (S), which is predicted by the wetness and physical features of the catchment. To estimate retention capacity (S) of the catchment, a suitable curve number (CN) for the catchment was decided based on the land cover type, hydrological conditions and soil groups. The curve number (CN) of 36 was considered for the catchment due to having soil of group A and land cover type woods with fair hydrological conditions in the catchment. Because catchment's soils have low runoff and

high infiltration rates due to having porous volcanic soils with coral rocks mostly covered by unburned woods with grazing. The definition of different hydrologic soil group is given in **Table 2.2.2** and curve numbers proposed for different type of woods cover is presented in **Table 2.2.3**. Further, average soil moisture condition or antecedent moisture content (AMC) level II was used to estimate the runoff depth from the catchment.

Table 2.2.2 Hydrologic Soil Groups Defined by SCS

Hydrologic soil group	Definition
A	Soils have low runoff potential and high infiltration rate, they consist chiefly sand or gravel particles
B	Soils have moderate infiltration rate, they consist chiefly moderately fine to moderately coarse textured soils.
C	Soils have low infiltration rate, they consist chiefly soils with moderately fine to fine texture.
D	Soils have high runoff potential and very low infiltration rate, they consist chiefly clay soils.

Source: Urban hydrology for small watersheds, United States Department of Agriculture, Natural Resources Conservation Services, Conservation Engineering Division, Technical Release 55, June 1986, Appendix A.

Table 2.2.3 Proposed Curve Numbers (CN) by SCS

Cover type	Hydrologic condition	Curve numbers for hydrologic soil groups			
		A	B	C	D
Woods	Poor	45	66	77	83
	Fair	36	60	73	79
	Good	30	55	70	77

Poor: Forest litter, small tree, and brush are destroyed by heavy grazing or regular burning

Fair: Woods are grazed but not burned and some forest litter covers the soil

Good: Woods are protected from grazing and litter and brush adequately cover the soil

Source: Urban hydrology for small watersheds, United States Department of Agriculture, Natural Resources Conservation Services, Conservation Engineering Division, Technical Release 55, June 1986, page 2-7.

Considering the above mentioned physical and hydrological conditions in the catchment the runoff depth was estimate for a given basin rainfall amount. The relation for runoff depth (Q) estimation is as presented below.

$$Q = \frac{(P - I_a)^2}{(P - I_a) + S)}$$

where,

Q Runoff depth (mm)

P Rainfall (mm)

S Potential maximum retention (mm)

I_a Initial abstraction (mm)

For estimating the time of concentration of flow (T_c) in the catchment, the travel time of flow from catchment boundary to inlet of river channel (T_1) at the upstream and travel time from inlet to outlet of river channel (T_2) were considered. The travel time T_1 was considered as 30 minutes and the travel time T_2 was estimated by the given relation,

$$T_2 = 0.14 * C * L^{0.66} \left(\frac{CN}{200 - CN} \right)^{-0.55} G^{-0.3}$$

$$T_c = T_1 + T_2$$

where,

L	River channel length (km)
C	Channelization factor for runoff velocity (0.77)
G	Gradient (slope) of river channel
T_1	Travel time from catchment boundary to inlet of river channel (hour)
T_2	Travel time from inlet to outlet of river channel (hour)
T_c	Time of concentration of flow (hour)

The slope of river channel (G) was calculated from the elevation difference between inlet (360 m) and outlet (7 m) of the river and length of river (17 km).

The time to peak (t_p) in unit hydrograph is estimated by given relation,

$$t_p = 0.67 T_c$$

The amount of peak flow from the catchment is estimated as follows,

$$q_p = 0.208 \left(\frac{AQ}{t_p} \right)$$

where,

A	Area of catchment (km^2)
Q	Runoff depth (mm)
t_p	Time to peak (hour)
q_p	Peak discharge (m^3/s)

For estimated peak discharge (q_p) and time to peak (t_p), the unit hydrograph (UHG) can be developed from the synthetic dimensionless hydrograph provided by the SCS. Using the synthetic dimensionless hydrograph provided by the SCS, the catchment's hydrographs of 2, 5, 10, 20, 50 and 100 years recurrence periods were developed with input of probable basin rainfalls of the periods.

2.2.3 Muskingum Routing

After developing the catchment's hydrograph of different recurrence periods by SCS Unit Hydrograph method, the Muskingum routing was applied to estimate probable discharge at the location of Teouma Bridge for various recurrence periods. The Muskingum routing module of MIKE 11 one dimensional

river flow simulation model was used for the flow routing. The relation used for flow routing is as presented below,

$$Q_{i+1}^{j+1} = C_1 Q_i^{j+1} + C_2 Q_i^j + C_3 Q_{j+1}^i + C_4$$

where,

i	Considered grid point
j	Time level
C	Constants
Q	Discharge at the grid point

2.2.4 Probable Flood Hydrograph

The probable hydrographs at Teouma Bridge were developed by performing Muskingum Routing of the flows estimated by SCS Unit Hydrograph method. The probable flows estimated at Teouma Bridge after Muskingum routing are presented in **Table 2.2.4** and **Figure 2.2.1**.

Table 2.2.4 Probable Point Rainfall and Flows at Teouma Bridge after Muskingum Routing

Recurrence Period (Year)	Probable Daily Rainfall (mm)	Probable Flood Peak (m^3/s)	Runoff Ratio
2	167.9	20	0.044
5	261.9	120	0.165
10	338.3	250	0.258
20	423.4	420	0.350
50	553.0	720	0.464
100	666.4	1020	0.544

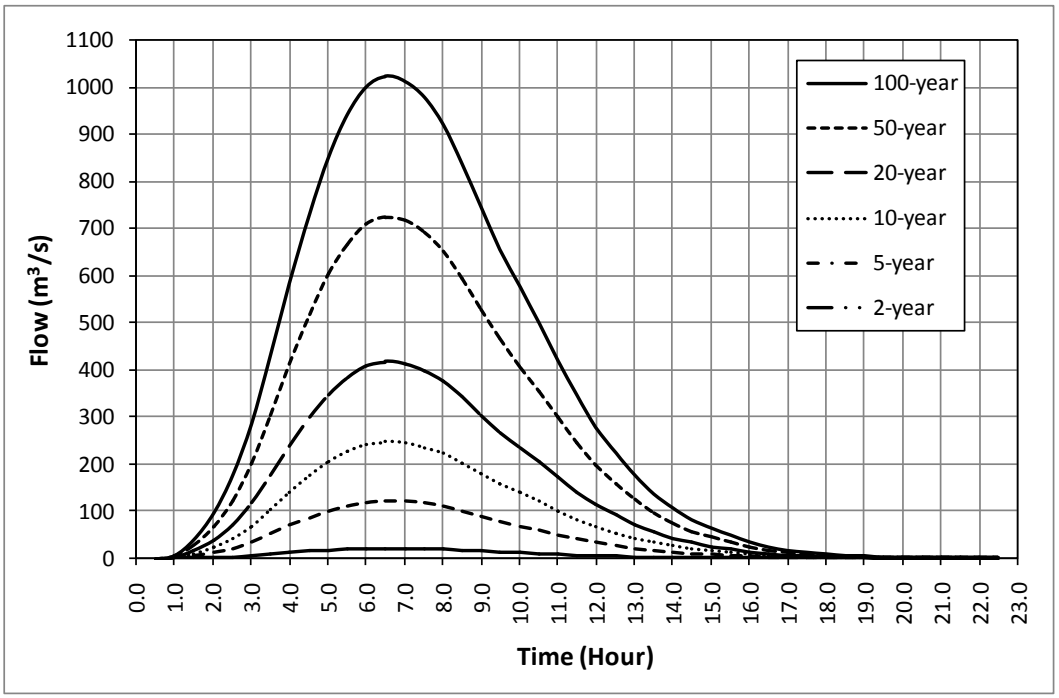


Figure 2.2.1 Probable Flood Hydrograph at Teouma Bridge

2.2.5 Floodplain Hydrograph

The amount of overbanking flow of 100-year flow from river channel into the left bank of the Teouma River at upstream of the ring road was estimated by using the MIKE 11 flood simulation model. The overbanking flood on the floodplain was routed using Muskingum routing. The amount of 100-year floodplain flow estimated, and the amount of floodplain flow estimated at the location of ring road after Muskingum routing are presented in **Figure 2.2.2.**

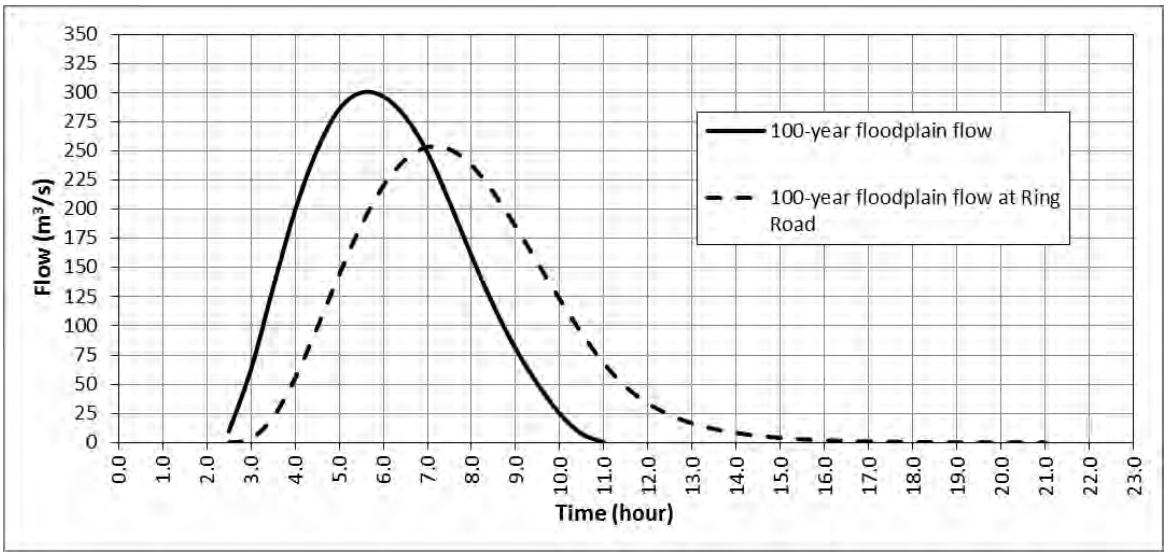


Figure 2.2.2 Probable 100-year Floodplain Hydrograph

2.3 Hydrological Designing

2.3.1 Unsteady Flow Analysis for River Improvement

River flow simulation was performed with unsteady flow considering 50-year flood. The MIKE11 is a fully dynamic, one-dimensional modelling tool for the detailed analysis, design, management and operation of both simple and complex river and channel systems. The Hydrodynamic (HD) module is the nucleus of the MIKE11 modelling system and forms the basis for other modules. One-dimensional river flows and water levels were generated using fully dynamic flow routing procedure. The conservation of mass is expressed as:

$$\frac{\partial A}{\partial t} + \frac{\partial Q}{\partial x} = q$$

The momemtum equation is:

$$\frac{\partial Q}{\partial t} + \frac{\partial (Q^2 / A)}{\partial x} + gA(\frac{\partial h}{dx} + S_f) = 0$$

where,

A	Cross-section area of flow (m^2)
h	Water surface elevation (m)
g	Acceleration due to gravity (m/s^2)
q	Lateral inflow ($m^3/s/m$)
t	Time elapsed (s)
x	Longitudinal distance (m)
S_f	Friction slope
Q	Discharge (m^3/s)

(1) Upstream Boundary Condition

Upstream boundary condition in the model was set at KM5.1 of the Teouma River. The 50-year flood hydrograph was input as upper boundary condition in the model.

(2) Downstream Boundary Condition

Downstream boundary condition in the model was set at river mouth. The average of maximum sea water levels of Port Vila was set as downstream boundary condition in the model. The average maximum sea water level at Port Vila is 1.50 m.

(3) River Cross-Sections Data

River cross-sections data extracted from 1.0 m grid digital terrain model (DTM) were used. But in the river stretch between KM4.6 and KM4.9 the proposed dimensions of river channel for river improvement were used for river cross sections.

(4) Manning's Roughness Coefficient

The Manning's roughness coefficient of 0.025 was applied for river flow simulation.

(5) Simulation Results

The simulated water levels profile with 50-year flood in Teouma River after improvement of river section between KM4.6 and KM4.9 are presented in **Table 2.3.1** and **Figure 2.3.1**. The simulation result shows the maximum water level in Teouma river reaches up to 5.7 m at KM4.6 river section at upstream of ring road during 50-year flood with proposed river channel dimensions for river improvement.

Table 2.3.1 Maximum Water Level with 50-year Flood

River Section	Maximum Water Level (m)
KM5.0	5.877
KM4.9	5.839
KM4.8	5.792
KM4.7	5.746
KM4.6	5.700
KM4.0	5.312

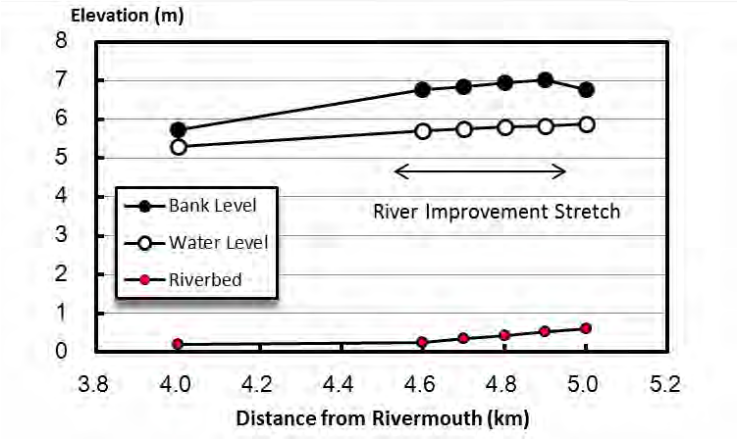


Figure 2.3.1 Maximum Water Level Profile with 50-year Flood

(6) Proposed Typical Cross-section

Based on the hydraulic computation, the proposed cross-section as shown in **Figure 2.3.2** is proposed along the bend around the Teouma Bridge.

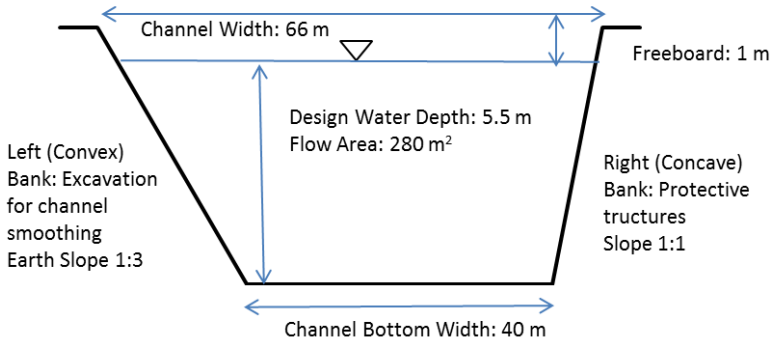


Figure 2.3.2 Typical Design Cross-section along the Bend around Teouma Bridge

2.3.2 Hydraulic Calculation for Flood-proofing Road

As described in 2.2.5, some part of the large-scale flood hydrograph will overtop the river bank and will flow across the floodplain towards the ring road. It may occur in the flood events larger than 50-year recurrence period. The design safety level is 100-year recurrence to protect the Teouma Bridge against the flood by entire protection system including river, bridge and road improvement.

To compute the overflow discharge along the road, the following broad-crested weir equation is adopted.

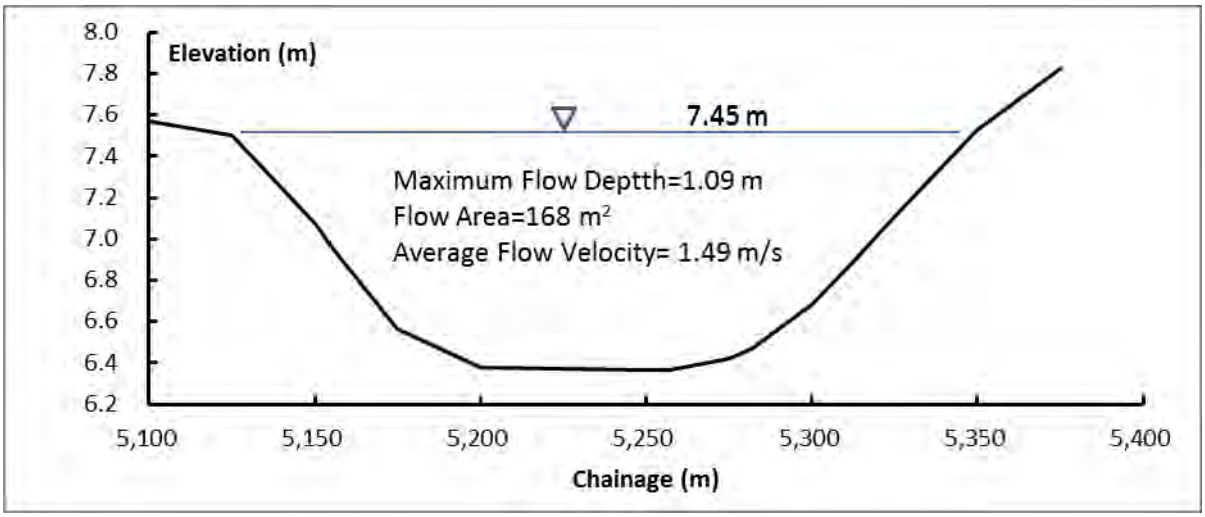
$Q = CBH^{1.5}$

where,

C	Coefficient of overflow (C = 1.560 as a general constant)
B	Weir length (m)
H	Overflow depth (m)
Q	Discharge (m^3/s)

As illustrated in Figure 2.2.2, overtopping peak discharge across the ring road could be estimated at 250 m^3/s during 100-year flood. Referring to the longitudinal profile of upstream side of the ring road, overtopping flow discharge is computed as presented in **Figure 2.3.3**.

Design high water level is 7.45 m and its maximum flow depth is 1.09 m, extending approximate 225 m in length.



Chapter 3 Environmental and Social Considerations

3.1 Observations from Field Survey

Summary of observations from a brief field survey by the Study Team is as follow:

(1) Pollution

- The main pollution source is the passing cars which generate exhausted gas and noise.
- There seems no water pollution source upstream Teouma River since the water quality is good with high transparency (estimated 0.8m or more).

(2) Flora & Fauna

- No areas to be conserved or protected as an ecological sanctuary are observed.
- The vegetation consists of weeds, shrubs and low/medium-tall trees. Most of them seem secondary species, not for protection.
- Fruit trees such as banana, coconut and papaya are planted sparsely. The fruits are for private use and products in local markets.
- Small fish (around 5cm-long) swim in Teouma River around Teouma Bridge. Neither amphibians nor other aquatic organisms are found during the survey.
- Terrestrial animals observed are only dogs and small birds (name unknown). They are estimated least concerned species.

(3) Topography and Geology

- Teouma River flows in a valley plain between raised coral terraces. The slope of the plain is gentle and the water flow velocity is not fast. Since the area is located in a lower part, the area would be easily inundated when a storm comes.
- The geology of the study area consists of recent riverine alluvial sands, dominantly from volcanic tuffs which contain recent failure plains.
- The right bank of immediately upstream of Teouma Bridge is a cliff form due to a bending concave bank.

(4) Use of Resources

- Teouma River is reported to be used for laundry, swimming, fishing, commodity conveyance (e.g. crops) etc. The team found a family who filled plastic tanks with the river water for a housework purpose (for washing dishes, not for drinking) at the upper left bank.
- Local people do fishing in Teouma River for self-consumption and commercial purposes. For self-consumption and small amount of selling, no license is required. Big amount sellers shall get a license from the Vanuatu Fisheries Department (VFD), under the Ministry of Agriculture, Livestock, Forestry, Fisheries, and Biosecurity (MALFFB).
- The Department of Natural Water Resources under the Ministry of Lands and Natural Resources (MOL) is responsible for river water management.
- The northeast part of Teouma Bridge is for cultivation such as banana, maize, mango etc.
- The nearest street stall from the project site sells products including: banana, bell pepper, cabbage, Chinese cabbage, carrot, green papaya, maize and potato, which are produced in the area.

⑸ Land Tenure

- According to the Land Department, there are land lessees upstream Teouma River, while being customary lands downstream. However, the ownership of individual land (government, private, customary etc.) is unsure and to be clarified.
- The chief of the area (Teouma Bridge of Eratap village) has powers to manage the land in which he is in charge of. The study team got permission to cut grasses for a better observation.

⑹ Land Acquisition/Resettlement

- For the construction and improvement works, some lands along the river and road will be needed.
- During the Teouma Bridge reconstruction, the area in the south part of the bridge will be acquired for a detour road and bridge.
- No involuntary resettlement is anticipated.

⑺ NGO Activity in Vanuatu

According to hearings from a few organizations, there is no report about disturbance or pressures to internationally-donated projects by NGOs. On the other hand, the ownership often becomes an issue, even in the sea and river. This conflict can be a bottleneck of project implementation. See the attached observation map and pictures of the study area for further understanding.

3.2 Conclusion and Way Forward

Although the natural environment is not special in the study area, further studies like Initial Environmental Examination (IEE) or Environmental Impact Assessment (EIA) in case are needed. Besides the natural environment, a more careful investigation on social aspects is necessary. The main challenge includes to 1) identify land ownership of affected land, 2) develop an entitlement matrix, 3) involve stakeholders, 4) perform land acquisition and livelihood assistance (if necessary), and 5) follow up the process (e.g. grievance redress, monitoring etc.).

3.3 Request to Vanuatu Side

Provision of the following data/information which the Study Team has requested PWD:

⑴ Natural Environment

- Land use map (incl. fauna & flora distribution map)
- Natural sanctuary (location map)
- Cultural heritage (ditto)
- National parts (ditto)
- Other protected areas (ditto)

⑵ Social Environment

- General land ownership system
- Cadastral information of the target area (map, register of title deeds)

3.4 List of Persons Concerned on Environmental and Social Considerations

The persons introduced by PWD are listed in the table below.

	Name	Organization	Title	Contact
1	Jason Raubani, Mr.	Min. Lands and Natural Resources (MOL)	Director of Environment	
2	Donna Kalfatak, Ms.		Officer on biodiversity	
3	Reedly Tari, Mr.		Officer in charge of EIA	
4	Iain Haggerty, Mr.		EIA technical advisor	
5	Jean Marc Pierre, Mr.		Director of Land	
6	Paul Gambetta, Mr.		Director of Lands survey	
7	Simil Johnson, Mr.		Director of dept. statistics	
8	Erie Sami, Mr.		Officer in charge of water management	
9	Uravo Nafuki, Ms.	Public Works Department (PWD)	Senior Env/Social Officer (north)	
10	Jason Andrews, Mr.		Senior Env/Social Officer (south)	

Map of the Study Area (Teouma Bridge & River)

Snapshots around Teouma Bridge & River

①
Street Stall (main)
Products Sold (bottom right)
- 100 vt for a bunch of bananas
- Visitors by cars frequently drop by for buying.

②
Coconut Trees in a House Garden (main)
Low/middle-tall Secondary Trees (bottom right)
- Branches and leaves of the big tree touch on the river surface.

③
Path from the Riverside to Inland
- Grasses cover on the river edge.
- Tree branches are toward the river.

④
Bushes along the Left Bank (main)
Wild Banana Trees (bottom right)
- Riverside width is 1.5-2m
- Bananas are freely picked to eat/sell etc.

⑤
Cultivation Area (main)
Papaya Trees (bottom right)
- maize, taro, sweet potato etc.

⑥
Laundry in the River (main)
Water Tanks for Home Use (upper left)
- >80cm of water transparency, small fish are seen

To the Upstream
(from Teouma Bridge)

To the Downstream
(from Teouma Bridge)

Chapter 4 Design Technical Note

4.1 Teouma Bridge Restoration Plan

Teouma Bridge restoration plan consists of three components. The first one is river improvement with bank protection. The second is bridge improvement with bridge extension and the final one is road improvement with a flood-proofing road. Following clauses explain the selection criteria and describe the features of these structures.

4.2 Selection of Criteria for River Improvement Plan / Structure Type of Bank Protection at Bend

4.2.1 Design Standard

There is no design standard in PWD for river structures such as an embankment, a revetment, and a retaining wall. In the previous donor agency projects, Australian design standard was sometimes applied. As the design standards for the river improvement plan, the followings are applicable.

- Vanuatu Resilient Roads Manual (A Design Guide for Low Volume Rural Roads in Vanuatu, Based on Accessibility, Security and Sustainability), June 2014
- Design and Construction Standard of Kago-Mat Revetment, Ministry of Land, Infrastructure and Transport, Japan, April 2009
- Standard of Multi-Layered Kago-Mat Revetment, Ministry of Land, Infrastructure and Transport, Japan, May 1998
- General Specification of Civil Works, Ministry of Land, Infrastructure and Transport, Japan, March 2015
- Construction Material Specification, Bureau of Construction, Tokyo Metropolitan Government, Japan, 2015
- Manual for Government Ordinance for Structural Standard for River Administration Facilities, Japan River Association, November 1999
- Japanese Industrial Standards (JIS A 5003, A 5006 and JIS A 5513)

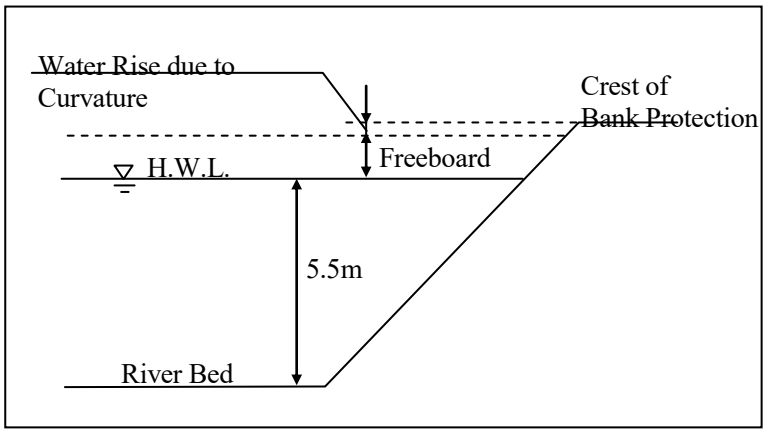
The term Kago-Mat here is a box made with an iron bar whose diameter is at 6mm at the frame and 5mm at the top, the side and the bottom. It is filled with cobble hard stones and/or crashed hard rock whose diameter is between 15cm to 20cm. The design lifetime of Kago-Mat is 30 years. Details of the specification are described in the attached drawing.

4.2.2 Design Concept

The river improvement is proposed to protect the right river bank and keep the smooth river flow even under Teouma Bridge. In order to achieve the purpose, following issues are studied and proposed.

(1) Revetment Height

The bank protection height is considered to be at the design flood level heightened with a freeboard and water rise due to the curvature of the river. The relevant water levels and bank protection height are shown in **Figure 4.2.1**.



Source: JICA Study Team

Figure 4.2.1 Water Level and Bank Protection Height Relation for River Improvement

The relation among the water rise due to the curvature, an average velocity and a radius of the curvature is shown in the following equation.

$$\Delta h = \frac{1}{2} \times \frac{Bv^2}{gr_c}$$

where: Δh: water rise due to the curvature
B: river width at the surface (= 66 – 3 – 1 = 62m)
v: average velocity (2.61m/s)
g: gravity acceleration (9.81 m/s^2)
rc: radius of curvature at the center of the river (150 – 1 – 31 = 118m)

Solving this equation, the water rise due to the curvature is obtained as 0.20m.

(2) Freeboard

Taking the deign flood discharge of 720 m^3/s into account and referring to the Manual for Government Ordinance for Structural Standard for River Administration Facilities in Japan, the freeboard is set at 1.0 m. The relation between the design flood discharge and the freeboard in the manual is shown in **Table 4.2.1**.

Table 4.2.1 Design Flood Discharge and Freeboard

Design Flood Discharge (m^3/s)	Freeboard (m)
Less than 200	0.6
200 - 500	0.8
500 - 2 ,000	1.0
2,000 - 5,000	1.2

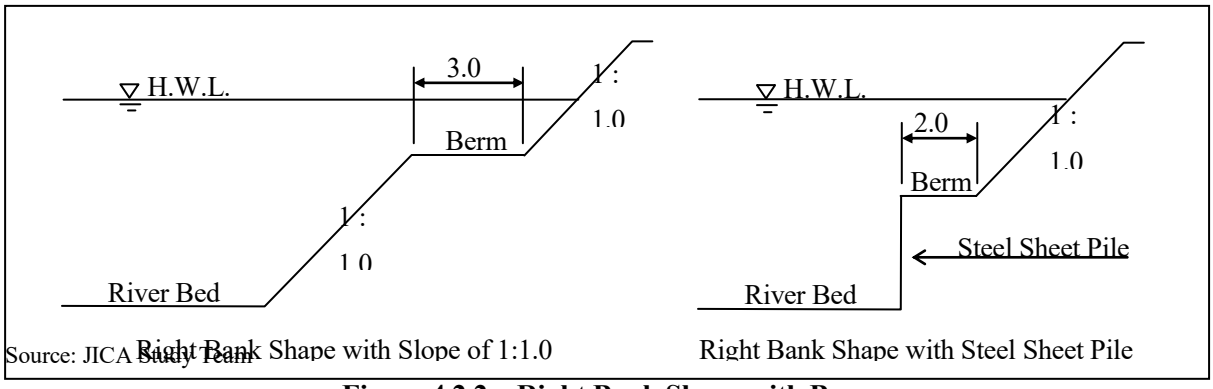
(3) Slope

The slope of the bank protection is proposed at 1:1.0 (vertical to horizontal). The cut slope in the left bank at the upstream side of the bridge is proposed at 1:3.0.

(4) Berm

According to the said ordinance in Japan, the berm is recommended if the height of the slope is over 5.0 m or 6.0 m with the slope of 1:2.0 or steeper. The height of the slope in the typical cross-section in the study is 6.6 m; hence the berm with 3m width for the slope protection of 1:1.0 is proposed.

Slope protection with a steel sheet pile generally requires the berm at the top of the coping concrete for the maintenance purpose and the slope stability requirement. Hence, the berm with 2.0 m width is proposed at the coping concrete. The height and the length of the steel pile will be re-evaluated in the future project.



Source: JICA Study Team

Figure 4.2.2 Right Bank Shape with Berm

4.3 Selection Criteria for Bridge Improvement Plan / Structure Type of Bridge Extension

4.3.1 Design Standard

Reference is made to the following manuals and standard specifications for outline design requirement of rural roads. Manuals and standard specifications for outline design requirement of urban roads is neither used nor found in PWD.

- Vanuatu Resilient Roads Manual (A Design Guide for Low Volume Rural Roads in Vanuatu, Based on Accessibility, Security and Sustainability), June 2014

In addition, the manual of government ordinance mentioned in the clause of design standard for river improvement is also referred.

4.3.2 Direction and Length of Bridge Extension

Teouma Bridge shall be extended to the right bank side of the river. The extended length will not be less than 30 m based on the results of the hydro-hydraulic analysis.

4.3.3 Bridge Type

Culvert structure cannot be adopted because the span length of the culvert cannot exceed the required span length as a bridge based on the design planned water volume. A warren type pony truss structure same as the existing bridge type shall be proposed for the extension of the bridge because the height of the pavement and the cross beams of the new bridge should be same as the existing bridge and the erection of this type of bridge doesn't require big equipment. The proposed drawings are attached hereto.

4.3.4 Exiting bridge

The existing bridge structure such as the warren type pony truss steel structural members and the abutment in the left bank will be utilized as much as possible.

4.3.5 Riverbank Protection Type at Bridge Abutment

Considering the continuity of the bank protection, the bank protection mentioned in the previous clause is also applied at river side of the bridge abutment.

4.4 Selection Criteria for Road Improvement Plan / Structure Type of Flood-Proofing Road

4.4.1 Design Standard

Reference is made to the Australian standards for outline design requirement of bridges.

4.4.2 Reinforced type of Structure

The section of the road where the flood water overflows is the target to be reinforced. The structure with pipe culverts should not be adopted because the frequency of the flood is low and the maintenance works are required. Concrete type and environmental type are proposed as attached drawings.

4.4.3 Target Section

The target section is the road area inundated by the larger than 50-year flood.

Teouma Bridge Restoration Plan

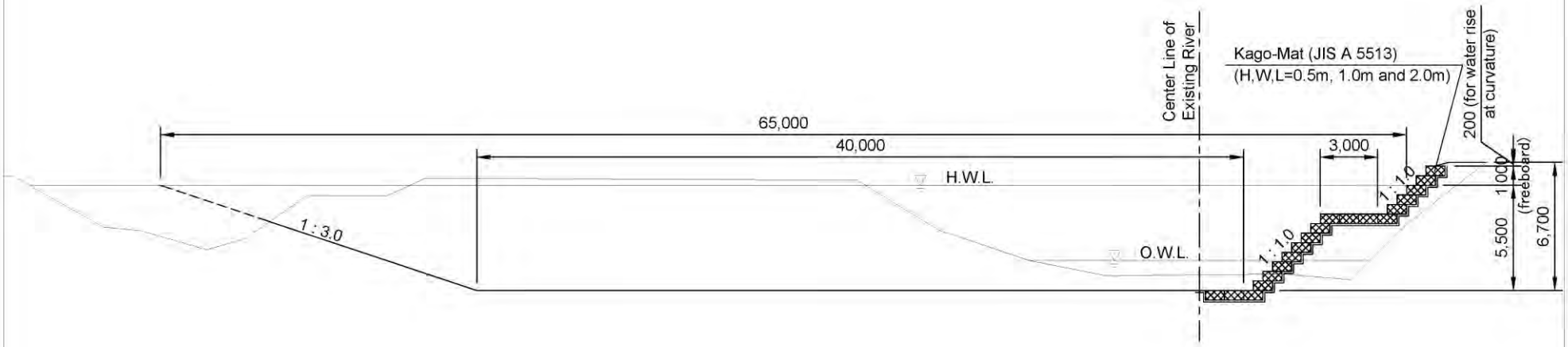
Plan Map
(Layout of Components)

GOVERNMENT OF THE REPUBLIC OF VANUATU PUBLIC WORKS DEPARTMENT	JAPAN INTERNATIONAL COOPERATION AGENCY CTI ENGINEERING INTERNATIONAL Co.ltd.	PROJECT	TITLE	DRAWING No.

Selection Criteria for River Improvement Plan and Structure Type

No.1: KAGO-MAT SLOPE PROTECTION TYPE

1. West side slope is protected with Kago-Mat.
2. East side bank is excavated and the river is widen.
3. Foot protection with Gabion on the west side slope is provided.



TYPICAL CROSS SECTION

SCALE 1:200

Specification of Kago-Mat for Permanent Structure
(H, W, L = 0.5m, 1.0m and diaphragm in every 2.0m) [1 and (2

Item	Position	Japan	As reference: Gabion in Vanuatu [3
Diameter of Wire	Mesh	Ø5.0mm [1	Ø2.7mm
	Frame	Ø6.0mm [1	
Mesh Aperture	Bottom	10.0cm in square [1	60mm to 100m in hexagon
	Other	6.5cm in square [1	
Wire Tensile Strength		290 MPA or above [2 (AS2423)	350 MPA or above
Coating	Galvanized (Zn 90%+ Al10%), 300g/m² [2, (5		Galvanized and PVC coated (AS/NZS 4534)

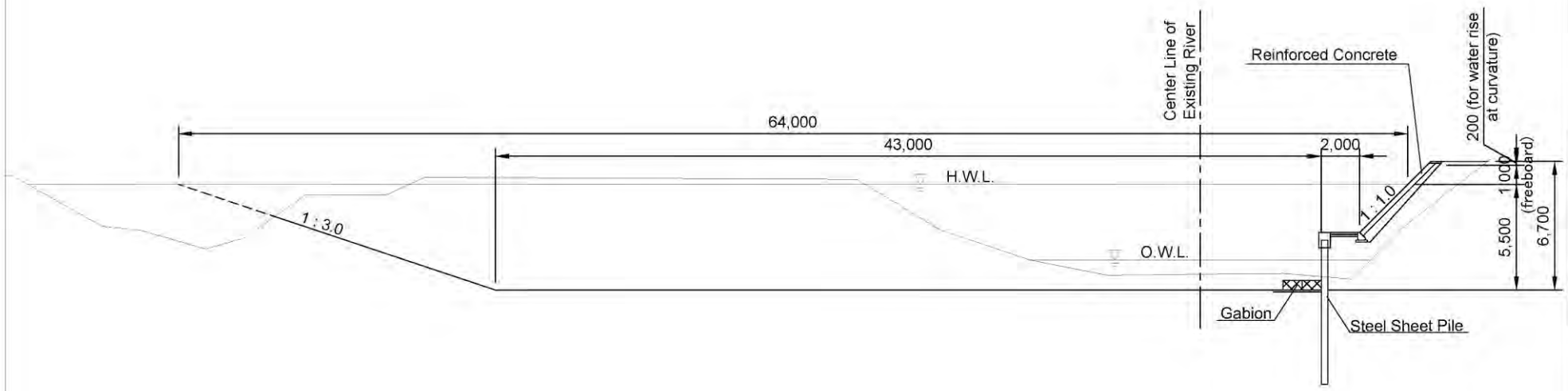
Specification of Inner Rock Material for Kago-Mat

Item	Japan	As reference: Gabion in Vanuatu [3
Diameter	15cm to 20 cm [2 (17.5cm in average)	10 cm to 25cm, top layer: 10cm to 15cm
Quality	hard, durable, no crack, no local friability, uniform color [4, (5	hard and durable
Type of Rock	Andesite, Basalt, Granite, Hard Sandstone or Similar Hard Rock [4, (5	Coronous and Basalt Cobble

Reference:
1) JIS A 5513
2) Design and Construction Standard of Kago-Mat Revetment (Ministry of Land, Infrastructure and Transport)
3) Vanuatu Resilient Roads Manual, Standard Technical Specification for Road and Bridge Works, Group 20, "20.1 Gabions and Reno Mattress"
4) JIS A 5003, A 5006, (1520, T-2, specific gravity: 2.45 or above)
5) Construction Material Specification, Bureau of Construction, Tokyo Metropolitan Government

No.2: STEEL SHEET PILE AND CONCRETE SLOPE PROTECTION

1. West side slope is protected with SSP and Reinforced Concrete.
2. East side bank is excavated and the river is widen.
3. Foot protection with Gabion on the west side slope is provided.

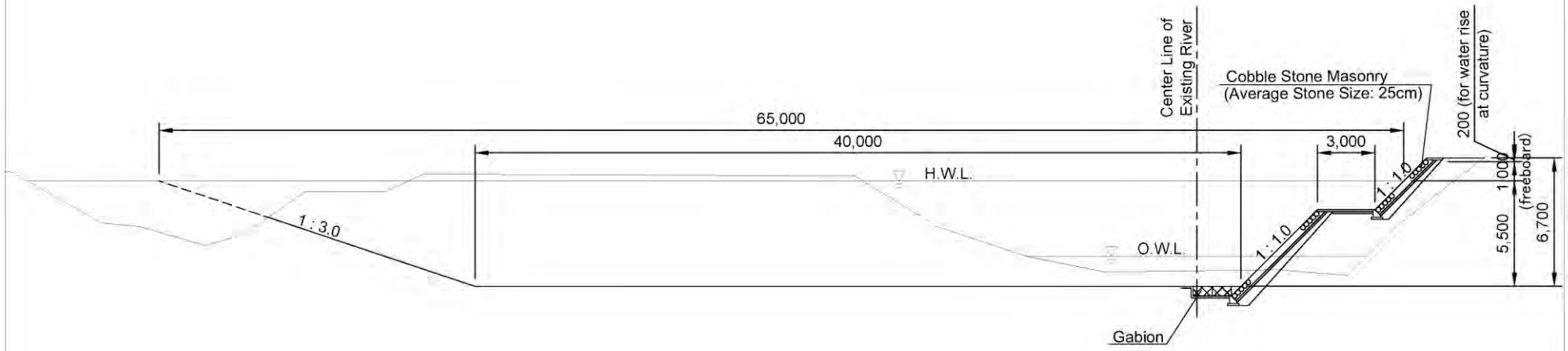


TYPICAL CROSS SECTION

SCALE 1:200

No.3: COBBLE STONE MASONRY PROTECTION

1. West side slope is protected with Cobble Stone Masonry.
2. East side bank is excavated and the river is widen.
3. Berm is provided for stability of slope and used for maintenance of the slope (if the height of the slope is larger than 6m).
4. Foot protection with Gabion on the west side slope is provided.



TYPICAL CROSS SECTION

SCALE 1:200

Selection Criteria for Bridge Improvement Plan and Structure Type

No. 2 Plan(30m) / New Pier Plan with Kago-Mat Riverbank Protection

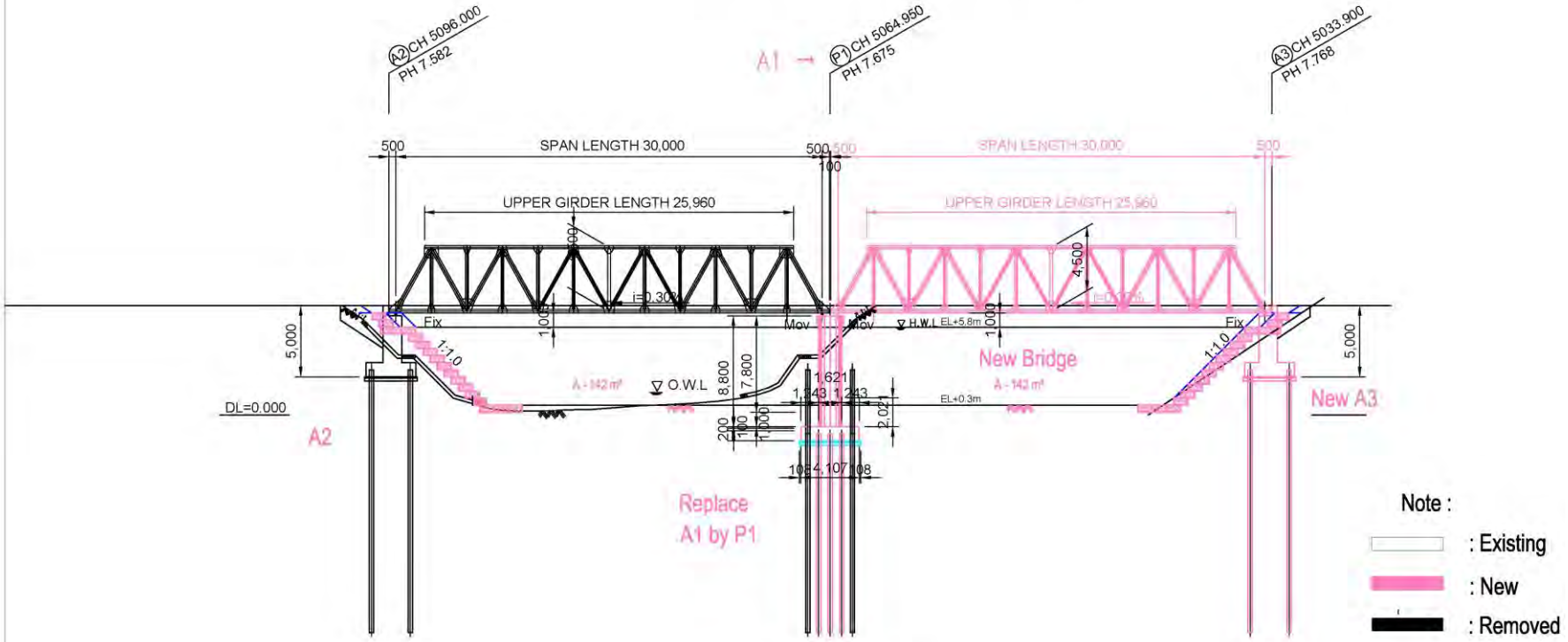
1. Existing Abutment (A1) is demolished except Piles
2. New Pier (P1) is constructed with additional Piles
3. New Abutment (A3) is constructed on the right bank
4. New Bridge is elected on the right bank
5. New Riverbank Protections(Kago-Mat Type) are constructed for both Abutments

Specification of Kago-Mat for Permanent Structure
(H, W, L = 0.5m, 1.0m and diaphragm in every 2.0m)

Item	Position	Japan	As reference: Vanuatu
Diameter of Wire	Mesh	Ø5.0mm	Ø2.7mm
	Frame	Ø6.0mm	
Mesh Aperture	Bottom	10.0cm in square	60mm to 100m in hexagon
	Other	8.5cm in square	
Wire Tensile Strength		290 MPA or above	350 MPA or above (AS2423)
Coating	Galvanized (Zn 90%+ Al10%) 300g/m²		Galvanized and PVC coated (AS/NZS 4534)

Specification of Inner Rock Material for Kago-Mat

Item	Japan	As reference: Vanuatu
Diameter	15cm to 20 cm (17.5cm in average)	10 cm to 25cm, top layer: 10cm to 15cm
Quality	hard, durable, no crack, no local friability, uniform color	hard and durable
Type of Rock	Andesite, Basalt, Granite, Hard Sandstone or Similar Hard Rock	Coronous and Basalt Cobble



ELEVATION

SCALE 1 : 300

No. 2 Plan(30m) / New Pier Plan with SSP Riverbank Protection

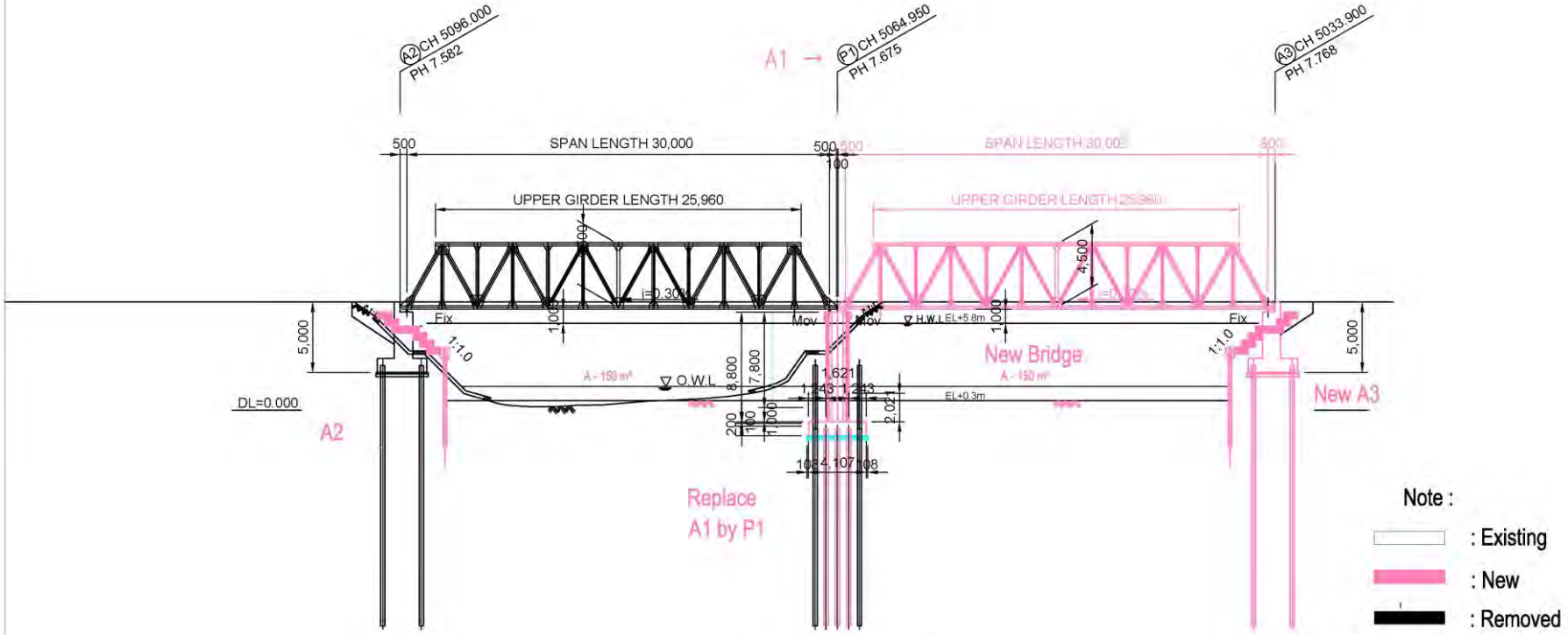
1. Existing Abutment (A1) is demolished except Piles
2. New Pier (P1) is constructed with additional Piles
3. New Abutment (A3) is constructed on the right bank
4. New Bridge is elected on the right bank
5. New Riverbank Protections (Steel Sheet Pile type) are constructed for both Abutments

Specification of Kago-Mat for Permanent Structure
(H, W, L = 0.5m, 1.0m and diaphragm in every 2.0m)

Item	Position	Japan	As reference: Vanuatu
Diameter of Wire	Mesh	Ø5.0mm	Ø2.7mm
	Frame	Ø6.0mm	
Mesh Aperture	Bottom	10.0cm in square	80mm to 100m in hexagon
	Other	6.5cm in square	
Wire Tensile Strength		290 MPA or above	350 MPA or above (A3243)
Coating		Galvanized (Zn 90%+ Al10%), 300g/m²	Galvanized and PVC coated (AS/NZS 4534)

Specification of Inner Rock Material for Kago-Mat

Item	Japan	As reference: Vanuatu
Diameter	15cm to 20 cm (17.5cm in average)	10 cm to 25cm, top layer: 10cm to 15cm
Quality	hard, durable, no crack, no local friability, uniform color	hard and durable
Type of Rock	Andesite, Basalt, Granite, Hard Sandstone or Similar Hard Rock	Coronous and Basalt Cobble



ELEVATION

SCALE 1 : 300

No. 2 Plan(35m) / New Pier Plan with Kago-Mat Riverbank Protection

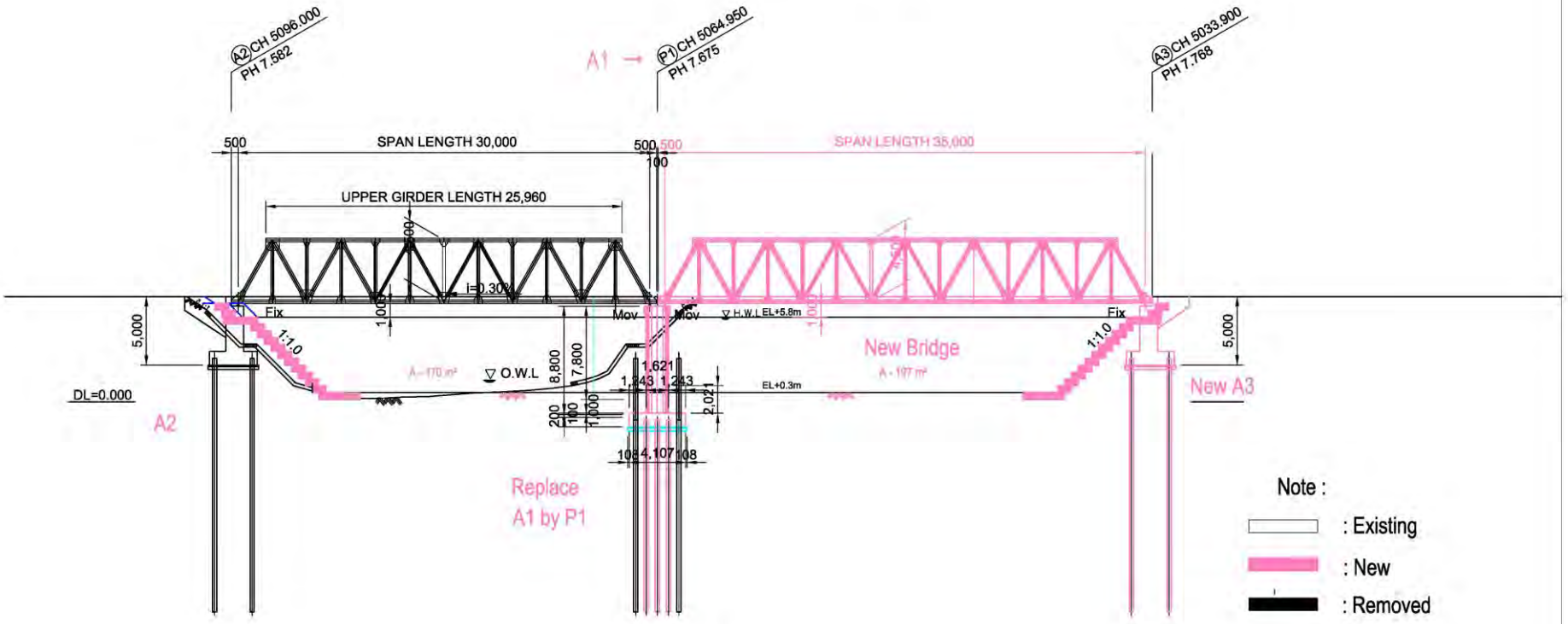
1. Existing Abutment (A1) is demolished except Piles
2. New Pier (P1) is constructed with additional Piles
3. New Abutment (A3) is constructed on the right bank
4. New Bridge is elected on the right bank
5. New Riverbank Protections(Kago-Mat Type)
   are constructed for both Abutments

Specification of Kago-Mat for Permanent Structure
(H, W, L = 0.5m, 1.0m and diaphragm in every 2.0m)

Item	Position	Japan	As reference: Vanuatu
Diameter of Wire	Mesh	Ø5.0mm	Ø2.7mm
	Frame	Ø6.0mm	
Mesh Aperture	Bottom	10.0cm in square	60mm to 100m in hexagon
	Other	6.5cm in square	
Wire Tensile Strength		290 MPA or above	350 MPA or above (AS2423)
Coating	Galvanized (Zn 90%+ Al10%), 300g/m²		Galvanized and PVC coated (AS/NZS 4534)

Specification of Inner Rock Material for Kago-Mat

Item	Japan	As reference: Vanuatu
Diameter	15cm to 20 cm (17.5cm in average)	10 cm to 25cm, top layer: 10cm to 15cm
Quality	hard, durable, no crack, no local friability, uniform color	hard and durable
Type of Rock	Andesite, Basalt, Granite, Hard Sandstone or Similar Hard Rock	Coronous and Basalt Cobble



ELEVATION

SCALE 1 : 300

No. 2 Plan(35m) / New Pier Plan with SSP Riverbank Protection

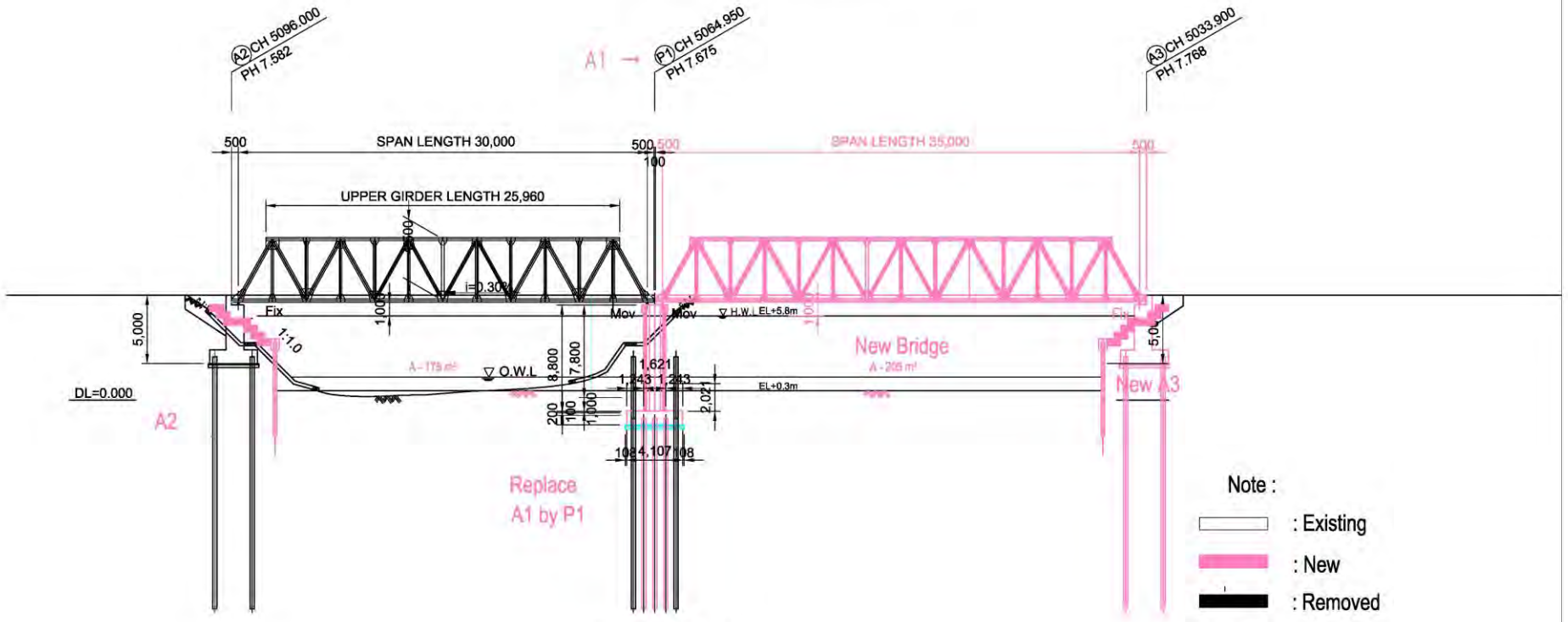
1. Existing Abutment (A1) is demolished except Piles
2. New Pier (P1) is constructed with additional Piles
3. New Abutment (A3) is constructed on the right bank
4. New Bridge is elected on the right bank
5. New Riverbank Protections (Steel Sheet Pile type) are constructed for both Abutments

Specification of Kago-Mat for Permanent Structure
(H, W, L = 0.5m, 1.0m and diaphragm in every 2.0m)

Item	Position	Japan	As reference: Vanuatu
Diameter of Wire	Mesh	Ø5.0mm	Ø2.7mm
	Frame	Ø6.0mm	
Mesh Aperture	Bottom	10.0cm in square	60mm to 100m in hexagon
	Other	6.5cm in square	
Wire Tensile Strength		290 MPA or above	350 MPA or above (AS2423)
Coating	Galvanized (Zn 90%+ Al10%), 300g/m²		Galvanized and PVC coated (AS/NZS 4534)

Specification of Inner Rock Material for Kago-Mat

Item	Japan	As reference: Vanuatu
Diameter	15cm to 20 cm (17.5cm in average)	10 cm to 25cm, top layer: 10cm to 15cm
Quality	hard, durable, no crack, no local friability, uniform color	hard and durable
Type of Rock	Andesite, Basalt, Granite, Hard Sandstone or Similar Hard Rock	Coronous and Basalt Cobble

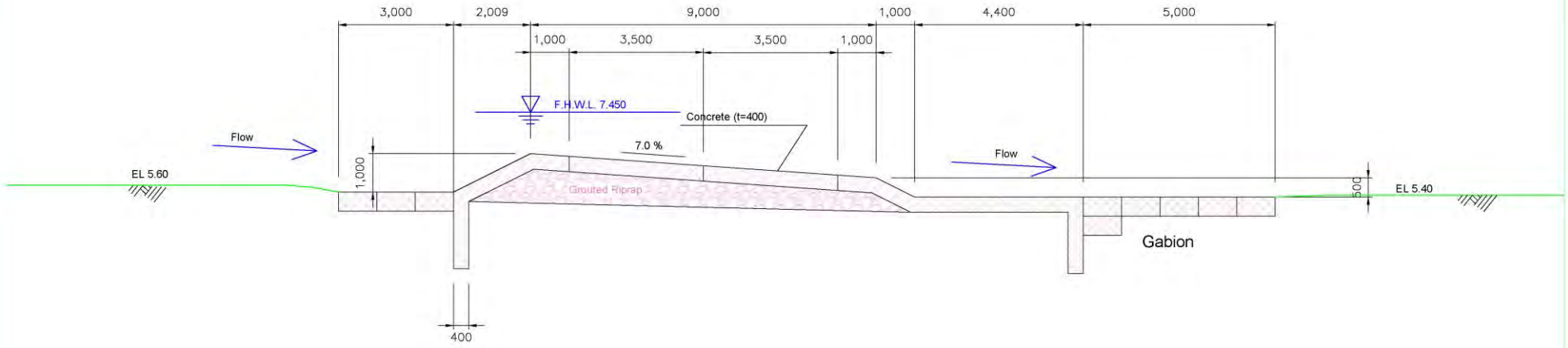


ELEVATION

SCALE 1 : 300

Selection Criteria for Road Improvement Plan and Structure Type

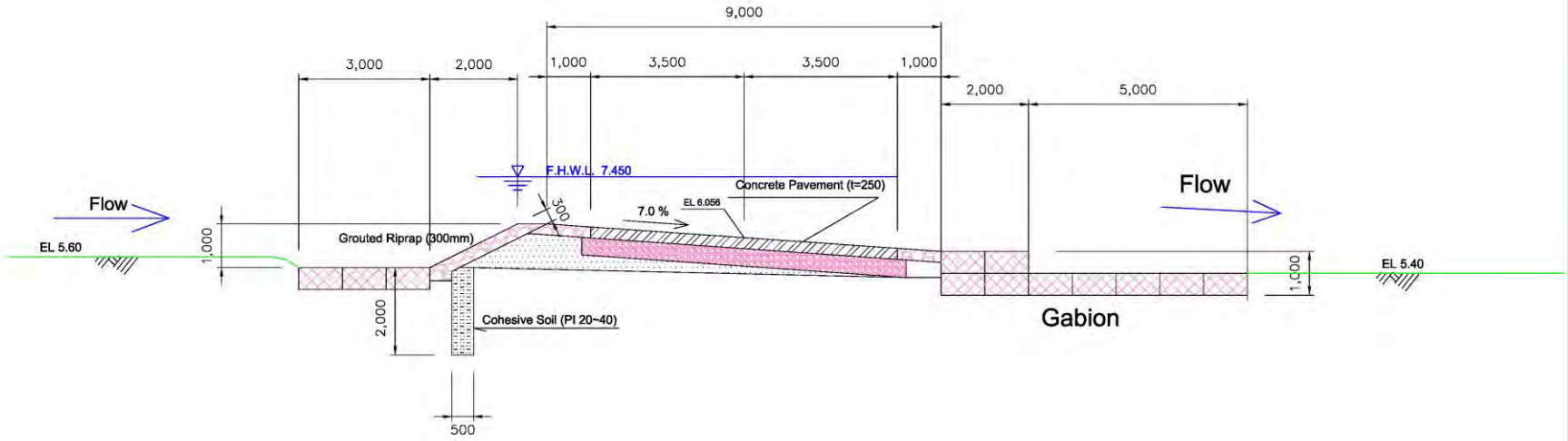
No.1 CONCRETE TYPE



CROSS SECTION at STA. 5225

SCALE 1 : 100

No.2 ENVIRONMENTAL TYPE



CROSS SECTION STA.5225

SCALE 1 : 100

Attachment 3: Soundness Inspection Result of Teouma Bridge

Soundness Inspection Result of Teouma Bridge

1. Primary Member

	Bridge Member			Check Point		Damage				Remarks
	Member	Material				Good	Fair	Poor	Bad	
Visual Inspection	(1) Superstructure			1	Missing	○				
				2	Deformation	○				
				3	Crack	○				
				4	Aging, Rust, Corrosion	○				
				5	Loose Bolt, Missing Bolt	○				
				6	Abnormal Vibration	○				
				7	Peeling of Paint	○				
	(2) Concrete Deck Slab			1	Bubble, Honeycomb	○				Maximum crack width:
				2	Cold Joint	○				(No Crack) mm
				3	Sand Streaking, Surface Bubble	○				
				4	Crack	○				
				5	Flaking, Scaling	○				
				6	Free Lime	○				
				7	Rebar Corrosion Stain, Water Leak	○				
				8	Rebar Exposure, Rust on Reber	○				
	(3) Abutment			1	Bubble, Honeycomb	○				Maximum crack width:
				2	Cold Joint	○				at Side Wall 3.0 mm
				3	Sand Streaking, Surface Bubble	○				
				4	Crack	○				
				5	Flaking, Scaling	○				
				6	Free Lime	○				
				7	Rebar Corrosion Stain, Water Leak	○				
				8	Rebar Exposure, Rust on Reber	○				
				9	Settlement, Displacement	○				
	(4) Hinged Bearing	Metal	○	1	Corrosion (for Metal)	○				
		Rubber		2	Loose Bolt	○				
				3	Inexpected Displacement	○				
				4	Bulging, Rupture	○				
				5	Crack on Bearing Supporting Concrete	○				
	(5) Expansion Joint	Metal	○	1	Water Leak	○				
		Rubber		2	Abnormal Spave, noise	○				
				3	Elevation Difference	○				
				4	Displacement	○				
				5	Crack	○				

2. Secondary Member

	Bridge Member			Check Point		Damage				Remarks
	Member	Material				Good	Fair	Poor	Bad	
Visual Inspection	(1) Curb	Metal		1	Crack, Flaking	○				Crack around drainage pipe
		Concrete	○	2	Loose Bolt, Missing Bolt	-	-	-	-	
				3	Damage caused by Impact		○			Partially broken
	(2) Railing	Metal	○	1	Crack, Flaking	-	-	-	-	
		Concrete		2	Loose Bolt, Missing Bolt	○				
				3	Damage caused by Impact		○			Partially broken
	(3) Drainage Pipe	PVC	○	1	Clogging	○				PVC : polyvinyl chloride
		Metal		2	Crack			○		Broken and washed away partially
	(4) Slope Protection	Gabion	○	1	Settlement			○		Settlement with scouring
		Others		2	Scouring			○		Partially washed away
				3	Crack	-	-	-	-	
	(5) Riverbed			1	Scouring			○		Lower parts of gabions were exposed.
				2	Sedimentation	-	-	-	-	
	(6) Approach Road	Concrete		1	Crack	○				
		Spread Seal	○	2	Pot-hole	○				Erroded at the right bank
				3	Settlement			○		(rehabilitated)

3. Concrerte Strength Test with Schmidt Hammer

Concrete Deck Slab

Location-1:	38.0	KN/m^2
Location-2:	31.7	KN/m^2
Location-3:	40.1	KN/m^2

Abutment-1

Location-1:	40.1	KN/m^2
Location-2:	31.0	KN/m^2
Location-3:	40.1	KN/m^2

Abutment-2

Location-1:	32.3	KN/m^2
Location-2:	36.2	KN/m^2
Location-3:	31.0	KN/m^2

4. Displacement on Bridge Axial Direction

Abutment-1

Right Side;	0	mm
Left Side;	0	mm

Abutment-2

Right Side;	0	mm
Left Side;	0	mm

Photo for Soundness Inspection of Teouma Bridge

Superstructure (good condition)

Superstructure (good condition)

Side Wall on Right Abutment (Cracks)

Hinged Bearing (good condition)

Damage on Railing and Curb

Damage on Drainage Pipe

Photo for Soundness Inspection of Teouma Bridge

Damage on Gabion Protection (Left Bank)

Damage on Gabion Protection (Right Bank)

Damaged Railing

Measurement for Rebound Number on Right Abutment

Measurement for Rebound Number on Left Abutment

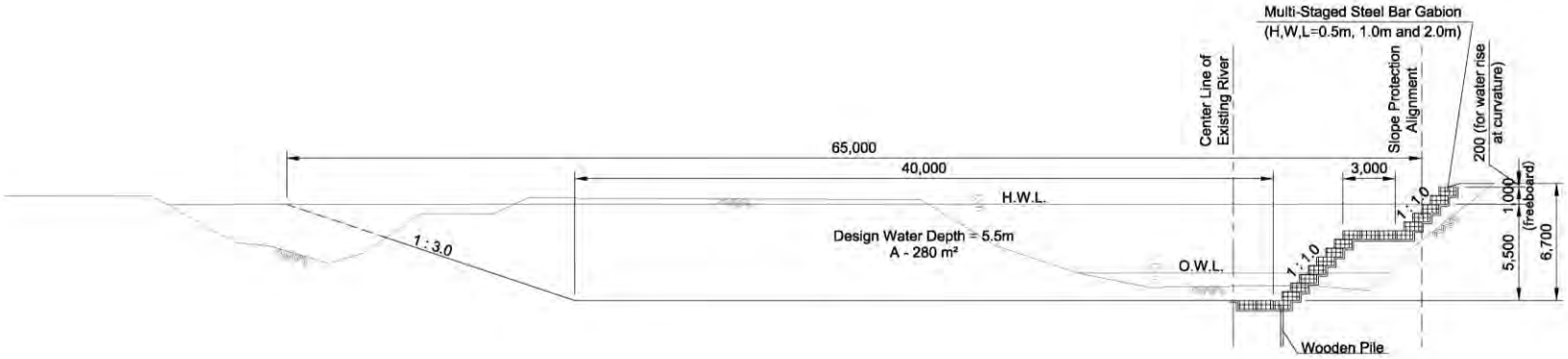
Measurement for Rebound Number on Concrete Deck Slab

Attachment 4: Draft Structure Design

Attachment-F 4-1 River・Bridge・Road Improvement Layout

TYPE 1 : SLOPE PROTECTION (MULTI-STAGED STEEL BAR GABION, UPSTREAM)

1. Right side slope is protected with Multi-Staged Steel Bar Gabion.
2. Left side bank is excavated and the river is widen.
3. Berm is provided for stability of the slope and used for maintenance of the slope.
4. Foot protection for the right side slope is provided.



TYPICAL CROSS SECTION (St. 4680 to St. 4950)

SCALE 1:250

Note: The corss secction is shown facing downstream side.

Specification of Steel Bar Gabion for Permanent Structure
(H, W, L = 0.5m, 1.0m and connected in every 2.0m)

Item	Position	Japan	As reference: Gabion in Vanuatu[3]
Diameter of Wire	Coiled Wire	Ø5.0mm[2]	Ø2.7mm
	Frame	Ø6.0mm[2]	
	Other	Ø6.0mm or thicker	
Mesh Aperture	All	10.0 cm x 15.0 cm or smaller in rectangular	60mm to 100m in hexagon
Wire Tensile Strength	Before Welding	540 MPA or above[4]	350 MPA or above (AS2423)
	After Welding	490 MPA or above[4]	
	Galvanized (Zn 90%+ Al10%), 300g/m²[2, (5		Galvanized and PVC coated (AS/NZS 4534)

Specification of Inner Rock Material for Steel Bar Gabion

Item	Japan	As reference: Gabion in Vanuatu[3]
Diameter	15cm to 20 cm[2] (17.5cm in average)	10 cm to 25cm, top layer: 10cm to 15cm
Quality	hard, durable, no crack, no local friability, uniform color[5, (6	hard and durable
Type of Rock	Andesite, Basalt, Granite, Hard Sandstone or Similar Hard Rock[5, (6	Coronous and Basalt Cobble

Reference:

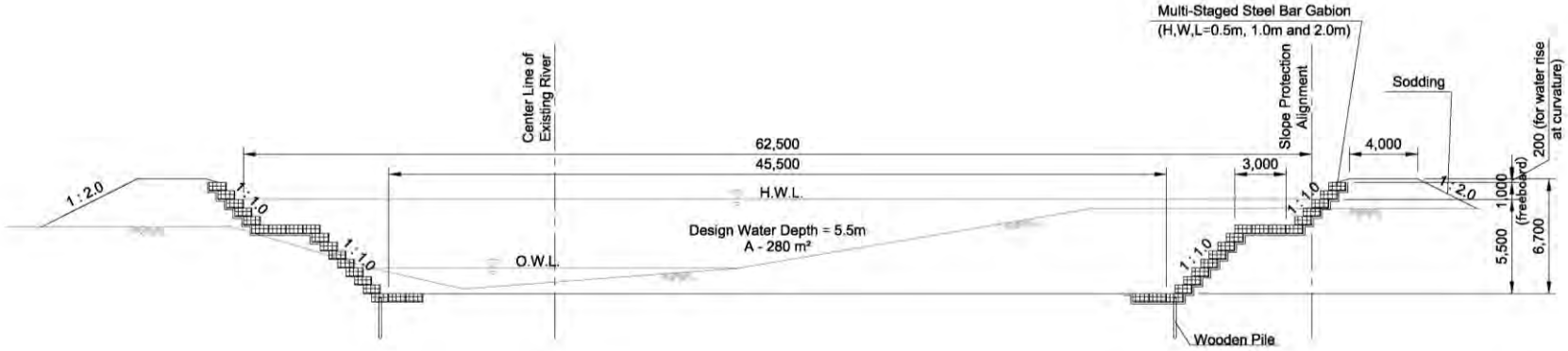
1) JIS A 5513
2) Design and Construction Standard of Multi-Staged Steel Wire Gabion Slope Protection, Trial Edition (Ministry of Construction)
3) Vanuatu Resilient Roads Manual, Standard Technical Specification for Road and Bridge Works, Group 20, "20.1 Gabions and Reno Mattress"
4) JIS G3532 (before welding), G3551 (after welding)
5) Construction Material Specification, Bureau of Construction, Tokyo Metropolitan Government
6) JIS A 5003, A 5006, (1520, T-2, specific gravity: 2.45 or above)

PWD Priority : The Second

Attachment-F 4-2 River Improvement: Typical Cross Section with Multi-Staged Steel Bar Gabion Slope Protection (Upstream)

TYPE 1 : SLOPE PROTECTION (MULTI-STAGED STEEL BAR GABION, DOWNSTREAM

1. Slope in the river side is protected with Multi-Staged Steel Bar Gabion and the one in the land side is protected with Sodding.
2. Right side bank is excavated and the river is widen.
3. Berm is provided for stability of the slopes and used for maintenance of the slopes.
4. Foot protection is provided.



TYPICAL CROSS SECTION (St. 4550 to St. 4680)

SCALE 1:250

Note: The corss secction is shown facing downstream side.

Specification of Steel Bar Gabion for Permanent Structure
(H, W, L = 0.5m, 1.0m and connected in every 2.0m)

Item	Position	Japan	As reference: Gabion in Vanuatu[3]
Diameter of Wire	Coiled Wire	Ø5.0mm[2]	Ø2.7mm
	Frame	Ø6.0mm[2]	
	Other	Ø6.0mm or thicker	
Mesh Aperture	All	10.0 cm x 15.0 cm or smaller in rectangular	60mm to 100m in hexagon
Wire Tensile Strength	Before Welding	540 MPA or above[4]	350 MPA or above (AS2423)
	After Welding	490 MPA or above[4]	
	Galvanized (Zn 90%+ Al10%), 300g/m²[2, (5		Galvanized and PVC coated (AS/NZS 4534)

Specification of Inner Rock Material for Steel Bar Gabion

Item	Japan	As reference: Gabion in Vanuatu[3]
Diameter	15cm to 20 cm[2] (17.5cm in average)	10 cm to 25cm, top layer: 10cm to 15cm
Quality	hard, durable, no crack, no local friability, uniform color[5, (6	hard and durable
Type of Rock	Andesite, Basalt, Granite, Hard Sandstone or Similar Hard Rock[5, (6	Coronous and Basalt Cobble

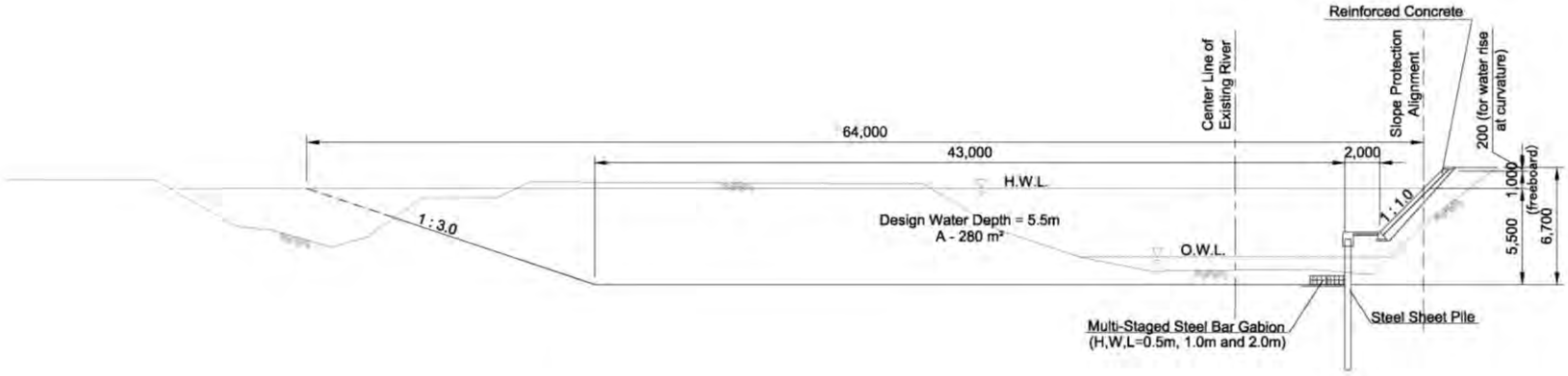
Reference:
1) JIS A 5513
2) Design and Construction Standard of Multi-Staged Steel Wire Gabion Slope Protection, Trial Edition (Ministry of Construction)
3) Vanuatu Resilient Roads Manual, Standard Technical Specification for Road and Bridge Works, Group 20, "20.1 Gabions and Reno Mattress"
4) JIS G3532 (before welding), G3551 (after welding)
5) Construction Material Specification, Bureau of Construction, Tokyo Metropolitan Government
6) JIS A 5003, A 5006, (1520, T-2, specific gravity: 2.45 or above)

PWD Priority : The Second

Attachment-F 4-3 River Improvement: Typical Cross Section with Multi-Staged Steel Bar Gabion Slope Protection (Downstream)

TYPE 2 : SLOPE PROTECTION (STEEL SHEET PILE AND CONCRETE, UPSTREAM)

1. Right side slope is protected with SSP and Reinforced Concrete.
2. Left side bank is excavated and the river is widen.
3. Berm is used for maintenance of the slope.
4. Foot protection for the right side slope is provided.



TYPICAL CROSS SECTION (St. 4680 to St. 4950)

SCALE 1:250

Note: The corss secction is shown facing downstream side.

Specification of Steel Bar Gabion for Permanent Structure
(H, W, L = 0.5m, 1.0m and connected in every 2.0m)

Item	Position	Japan	As reference: Gabion in Vanuatu[3]
Diameter of Wire	Coiled Wire	Ø5.0mm[2]	Ø2.7mm
	Frame	Ø6.0mm[2]	
	Other	Ø6.0mm or thicker	
Mesh Aperture	All	10.0 cm x 15.0 cm or smaller in rectangular	60mm to 100m in hexagon
Wire Tensile Strength	Before Welding	540 MPA or above[4]	350 MPA or above (AS2423)
	After Welding	490 MPA or above[4]	
Coating	Galvanized (Zn 90%+ Al10%), 300g/m²[2, (5		Galvanized and PVC coated (AS/NZS 4534)

Specification of Inner Rock Material for Steel Bar Gabion

Item	Japan	As reference: Gabion in Vanuatu[3]
Diameter	15cm to 20 cm[2] (17.5cm in average)	10 cm to 25cm, top layer: 10cm to 15cm
Quality	hard, durable, no crack, no local friability, uniform color[5, (6]	hard and durable
Type of Rock	Andesite, Basalt, Granite, Hard Sandstone or Similar Hard Rock[5, (6]	Coronous and Basalt Cobble

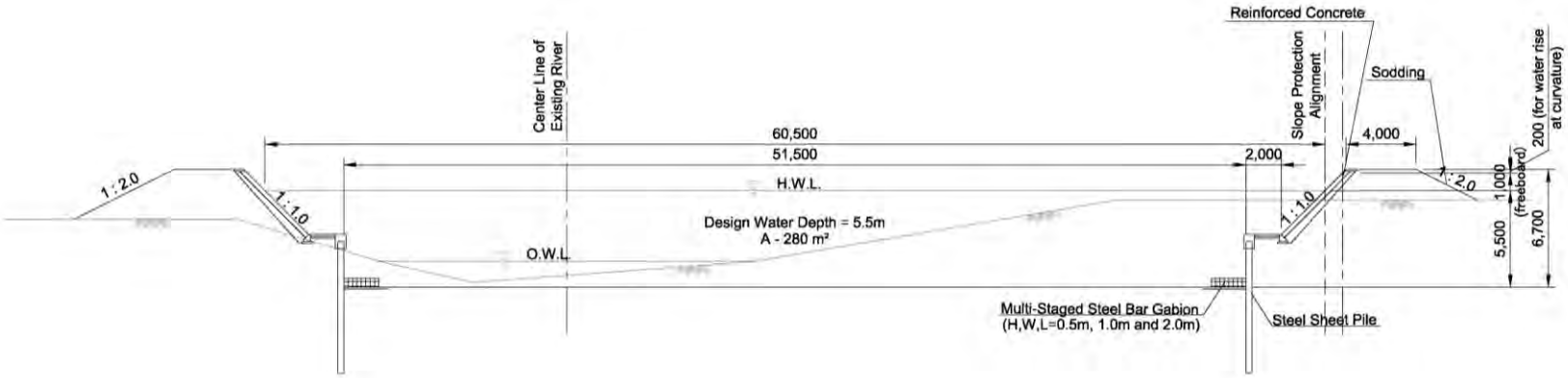
Reference:
1) JIS A 5513
2) Design and Construction Standard of Multi-Staged Steel Wire Gabion Slope Protection, Trial Edition (Ministry of Construction)
3) Vanuatu Resilient Roads Manual, Standard Technical Specification for Road and Bridge Works, Group 20, "20.1 Gabions and Reno Mattress"
4) JIS G3532 (before welding), G3551 (after welding)
5) Construction Material Specification, Bureau of Construction, Tokyo Metropolitan Government
6) JIS A 5003, A 5006, (1520, T-2, specific gravity: 2.45 or above)

PWD Priority : The First

Attachment-F 4-4 River Improvement: Typical Cross Section with Steel Sheet Pile and Reinforced Concrete Slope Protection (Upstream)

TYPE 2 : SLOPE PROTECTION (STEEL SHEET PILE AND CONCRETE, DOWNSTREAM

1. Slope in the river side is protected with SSP and Reinforced Concrete and the one in the land side is protected with Sodding.
2. Right side bank is excavated and the river is widen.
3. Berm is used for maintenance of the slopes.
4. Foot protection is provided.



TYPICAL CROSS SECTION (St. 4550 to St. 4680)

SCALE 1:250

Note: The corss secction is shown facing downstream side.

Specification of Steel Bar Gabion for Permanent Structure
(H, W, L = 0.5m, 1.0m and connected in every 2.0m)

Item	Position	Japan	As reference: Gabion in Vanuatu[3]
Diameter of Wire	Coiled Wire	Ø5.0mm[2]	Ø2.7mm
	Frame	Ø6.0mm[2]	
	Other	Ø6.0mm or thicker	
Mesh Aperture	All	10.0 cm x 15.0 cm or smaller in rectangular	80mm to 100m in hexagon
Wire Tensile Strength	Before Welding	540 MPA or above[4]	350 MPA or above (AS2423)
	After Welding	490 MPA or above[4]	
Coating	Galvanized (Zn 90%+ Al10%), 300g/m²[2, (5		Galvanized and PVC coated (AS/NZS 4534)

Specification of Inner Rock Material for Steel Bar Gabion

Item	Japan	As reference: Gabion in Vanuatu[3]
Diameter	15cm to 20 cm[2] (17.5cm in average)	10 cm to 25cm, top layer: 10cm to 15cm
Quality	hard, durable, no crack, no local friability, uniform color[5, (6	hard and durable
Type of Rock	Andesite, Basalt, Granite, Hard Sandstone or Similar Hard Rock[5, (6	Coronoua and Basalt Cobble

Reference:

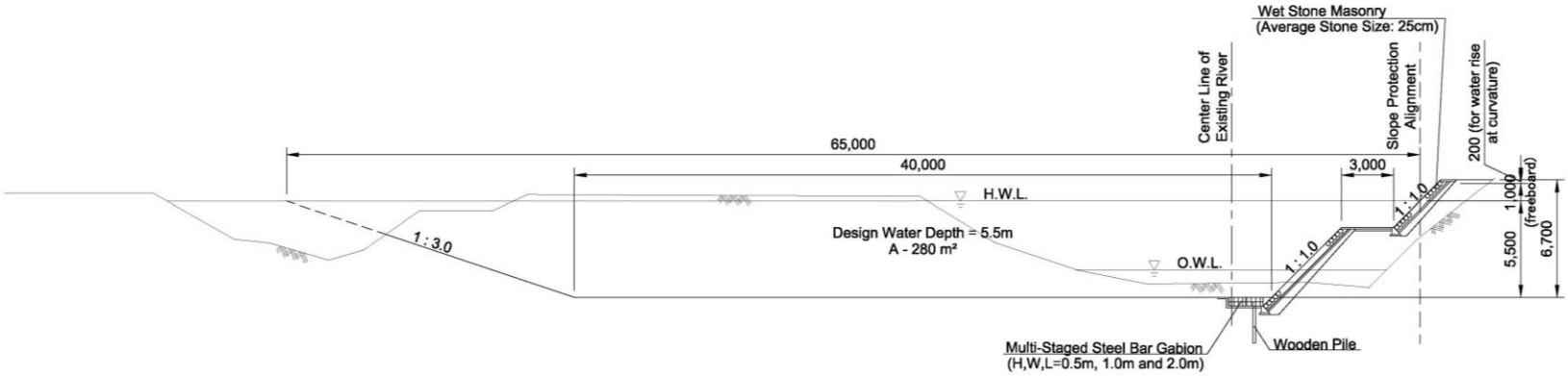
1) JIS A 5513
2) Design and Construction Standard of Multi-Staged Steel Wire Gabion Slope Protection, Trial Edition (Ministry of Construction)
3) Vanuatu Resilient Roads Manual, Standard Technical Specification for Road and Bridge Works, Group 20, "20.1 Gabions and Reno Mattress"
4) JIS G3532 (before welding), G3551 (after welding)
5) Construction Material Specification, Bureau of Construction, Tokyo Metropolitan Government
6) JIS A 5003, A 5006, (1520, T-2, specific gravity: 2.45 or above)

PWD Priority : The First

Attachment-F 4-5 River Improvement: Typical Cross Section with Steel Sheet Pile and Reinforced Concrete Slope Protection (Downstream)

TYPE 3 : SLOPE PROTECTION (WET STONE MASONRY, UPSTREAM)

1. Right side slope is protected with Wet Stone Masonry.
2. Left side bank is excavated and the river is widen.
3. Berm is provided for stability of the slope and used for maintenance of the slope.
4. Foot protection for the right side slope is provided.



TYPICAL CROSS SECTION (St. 4680 to St. 4950)

SCALE 1:250

Note: The corss secction is shown facing downstream side.

Specification of Steel Bar Gabion for Permanent Structure
(H, W, L = 0.5m, 1.0m and connected in every 2.0m)

Item	Position	Japan	As reference: Gabion in Vanuatu[3]
Diameter of Wire	Coiled Wire	Ø5.0mm[2]	Ø2.7mm
	Frame	Ø6.0mm[2]	
	Other	Ø6.0mm or thicker	
Mesh Aperture	All	10.0 cm x 15.0 cm or smaller in rectangular	60mm to 100m in hexagon
Wire Tensile Strength	Before Welding	540 MPA or above[4]	350 MPA or above (AS2423)
	After Welding	490 MPA or above[4]	
Coating	Galvanized (Zn 90%+ Al10%), 300g/m²[2, (5		Galvanized and PVC coated (AS/NZS 4534)

Specification of Inner Rock Material for Steel Bar Gabion

Item	Japan	As reference: Gabion in Vanuatu[3]
Diameter	15cm to 20 cm[2] (17.5cm in average)	10 cm to 25cm, top layer: 10cm to 15cm
Quality	hard, durable, no crack, no local friability, uniform color[5, (6	hard and durable
Type of Rock	Andesite, Basalt, Granite, Hard Sandstone or Similar Hard Rock[5, (6	Coronous and Basalt Cobble

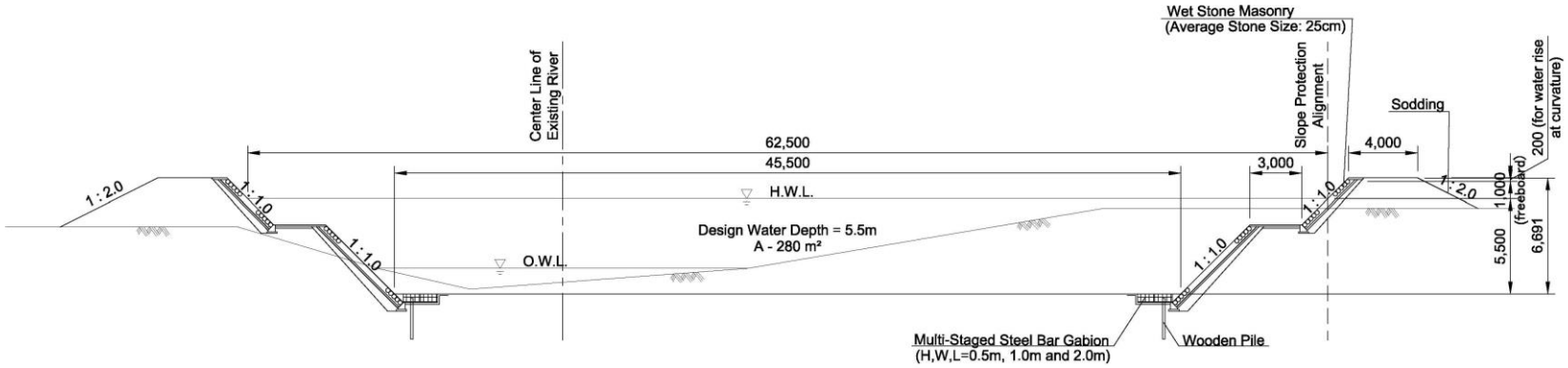
Reference:
1) JIS A 5513
2) Design and Construction Standard of Multi-Staged Steel Wire Gabion Slope Protection, Trial Edition (Ministry of Construction)
3) Vanuatu Resilient Roads Manual, Standard Technical Specification for Road and Bridge Works, Group 20, "20.1 Gabions and Reno Mattress"
4) JIS G3532 (before welding), G3551 (after welding)
5) Construction Material Specification, Bureau of Construction, Tokyo Metropolitan Government
6) JIS A 5003, A 5006, (1520, T-2, specific gravity: 2.45 or above)

PWD Priority : The Third

Attachment-F 4-6 River Improvement: Typical Cross Section with Wet Stone Masonry Slope Protection (Upstream)

TYPE 3 : SLOPE PROTECTION (WET STONE MASONRY, DOWNSTREAM)

1. Slope in the river side is protected with Wet Stone Masonry and the one in the land side is protected with Sodding.
2. Right side bank is excavated and the river is widen.
3. Berm is provided for stability of the slopes and used for maintenance of the slopes.
4. Foot protection is provided.



TYPICAL CROSS SECTION (St. 4550 to St. 4680)

SCALE 1:250

Note: The corss secction is shown facing downstream side.

Specification of Steel Bar Gabion for Permanent Structure
(H, W, L = 0.5m, 1.0m and connected in every 2.0m)

Item	Position	Japan	As reference: Gabion in Vanuatu[3]
Diameter of Wire	Coiled Wire	Ø5.0mm[2]	Ø2.7mm
	Frame	Ø6.0mm[2]	
	Other	Ø6.0mm or thicker	
Mesh Aperture	All	10.0 cm x 15.0 cm or smaller in rectangular	60mm to 100m in hexagon
Wire Tensile Strength	Before Welding	540 MPA or above[4]	350 MPA or above (AS2423)
	After Welding	490 MPA or above[4]	
Coating	Galvanized (Zn 90%+ Al10%), 300g/m²[2, (5		Galvanized and PVC coated (AS/NZS 4534)

Specification of Inner Rock Material for Steel Bar Gabion

Item	Japan	As reference: Gabion in Vanuatu[3]
Diameter	15cm to 20 cm[2] (17.5cm in average)	10 cm to 25cm, top layer: 10cm to 15cm
Quality	hard, durable, no crack, no local friability, uniform color[5, (6	hard and durable
Type of Rock	Andesite, Basalt, Granite, Hard Sandstone or Similar Hard Rock[5, (6	Coronous and Basalt Cobble

Reference:

1) JIS A 5513
2) Design and Construction Standard of Multi-Staged Steel Wire Gabion Slope Protection, Trial Edition (Ministry of Construction)
3) Vanuatu Resilient Roads Manual, Standard Technical Specification for Road and Bridge Works, Group 20, "20.1 Gabions and Reno Mattress"
4) JIS G3532 (before welding), G3551 (after welding)
5) Construction Material Specification, Bureau of Construction, Tokyo Metropolitan Government
6) JIS A 5003, A 5006, (1520, T-2, specific gravity: 2.45 or above)

PWD Priority : The Third

Attachment-F 4-7 River Improvement: Typical Cross Section with Wet Stone Masonry Slope Protection (Downstream)

TYPE 1 : PLAN (30m) / NEW PIER PLAN WITH ABUTMENT PROTECTION (MULTI-STAGED STEEL BAR GABION)

1. Existing Abutment (A1) is demolished except for Piles.
2. New Pier (P1) is constructed with additional Piles.
3. New Abutment (A3) is constructed on the right bank.
4. New Bridge is elected on the right bank.
5. New Abutment Protections with Multi-Staged Steel Bar Gabion are constructed for both Abutments.

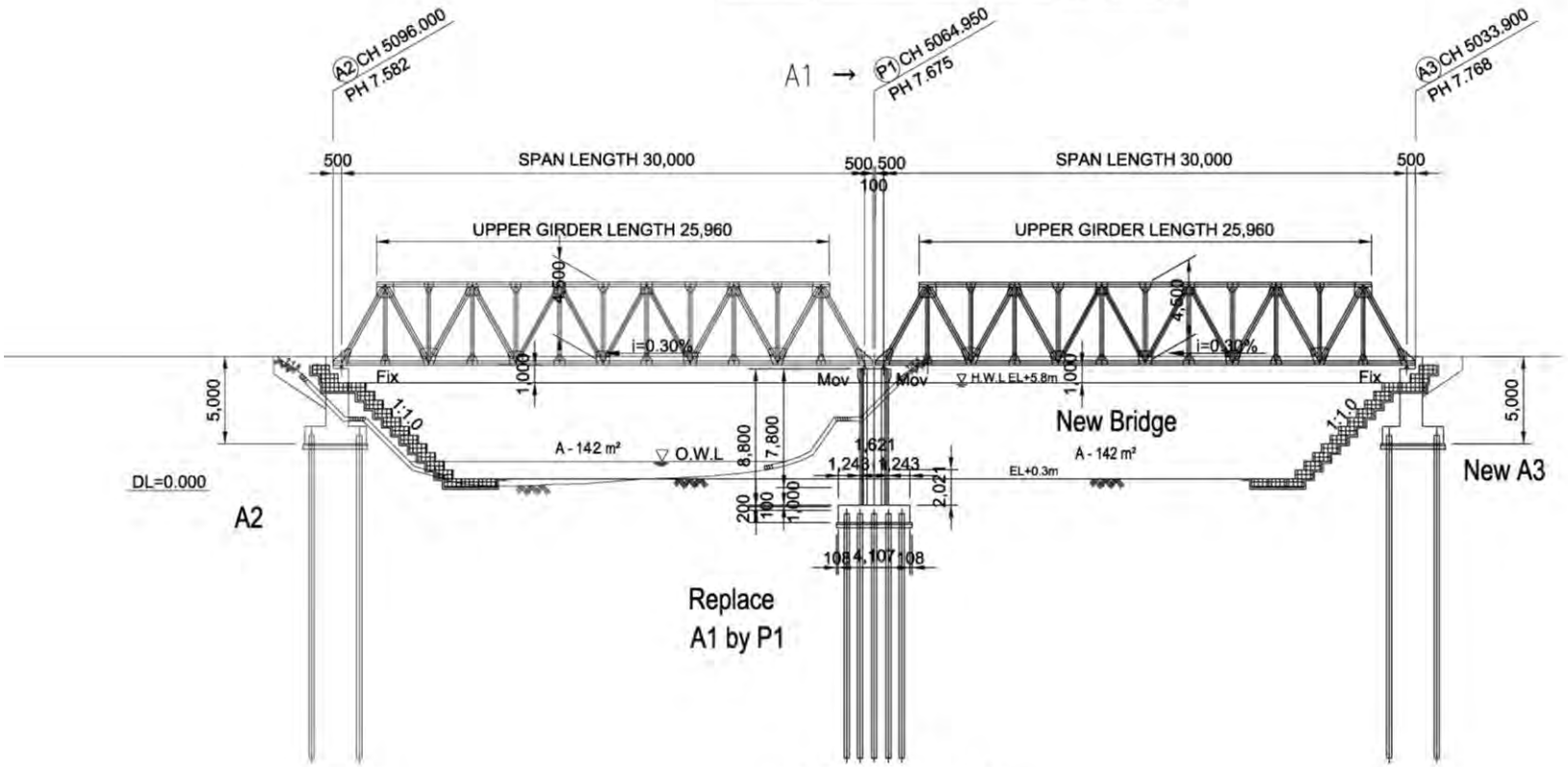
Note: The cross section is shown facing downstream side.

Specification of Steel Bar Gabion for Permanent Structure
(H, W, L = 0.5m, 1.0m and connected in every 2.0m)

Item	Position	Japan	As reference: Gabion in Vanuatu
Diameter of Wire	Coiled Wire	Ø5.0mm	Ø2.7mm
	Frame	Ø6.0mm	
	Other	Ø6.0mm or thicker	
Mesh Aperture	All	10.0 cm x 15.0 cm or smaller in rectangular	80mm to 100m in hexagon
Wire Tensile Strength	Before Welding	540 MPA or above	350 MPA or above (AS2423)
	After Welding	490 MPA or above	
Coating	Galvanized (Zn 90%+ Al10%), 300g/m²		Galvanized and PVC coated (AS/NZS 4534)

Specification of Inner Rock Material for Steel Bar Gabion

Item	Japan	As reference: Gabion in Vanuatu
Diameter	15cm to 20 cm (17.5cm in average)	10 cm to 25cm, top layer: 10cm to 15cm
Quality	hard, durable, no crack, no local friability, uniform color	hard and durable
Type of Rock	Andesite, Basalt, Granite, Hard Sandstone or Similar Hard Rock	Coronous and Basalt Cobble



ELEVATION
SCALE 1 : 250

PWD Priority : The Second・The Third

Attachment-F 4-8 Bridge Improvement: New Pier Plan with Abutment Protection (Multi-Staged Steel Bar Gabion) with 30m Extension

TYPE 2 : PLAN (30m) / NEW PIER PLAN WITH ABUTMENT PROTECTION (STEEL SHEET PILE)

1. Existing Abutment (A1) is demolished except for Piles.
2. New Pier (P1) is constructed with additional Piles.
3. New Abutment (A3) is constructed on the right bank.
4. New Bridge is elected on the right bank.
5. New Abutment Protections with Steel Sheet Pile are constructed for both Abutments.

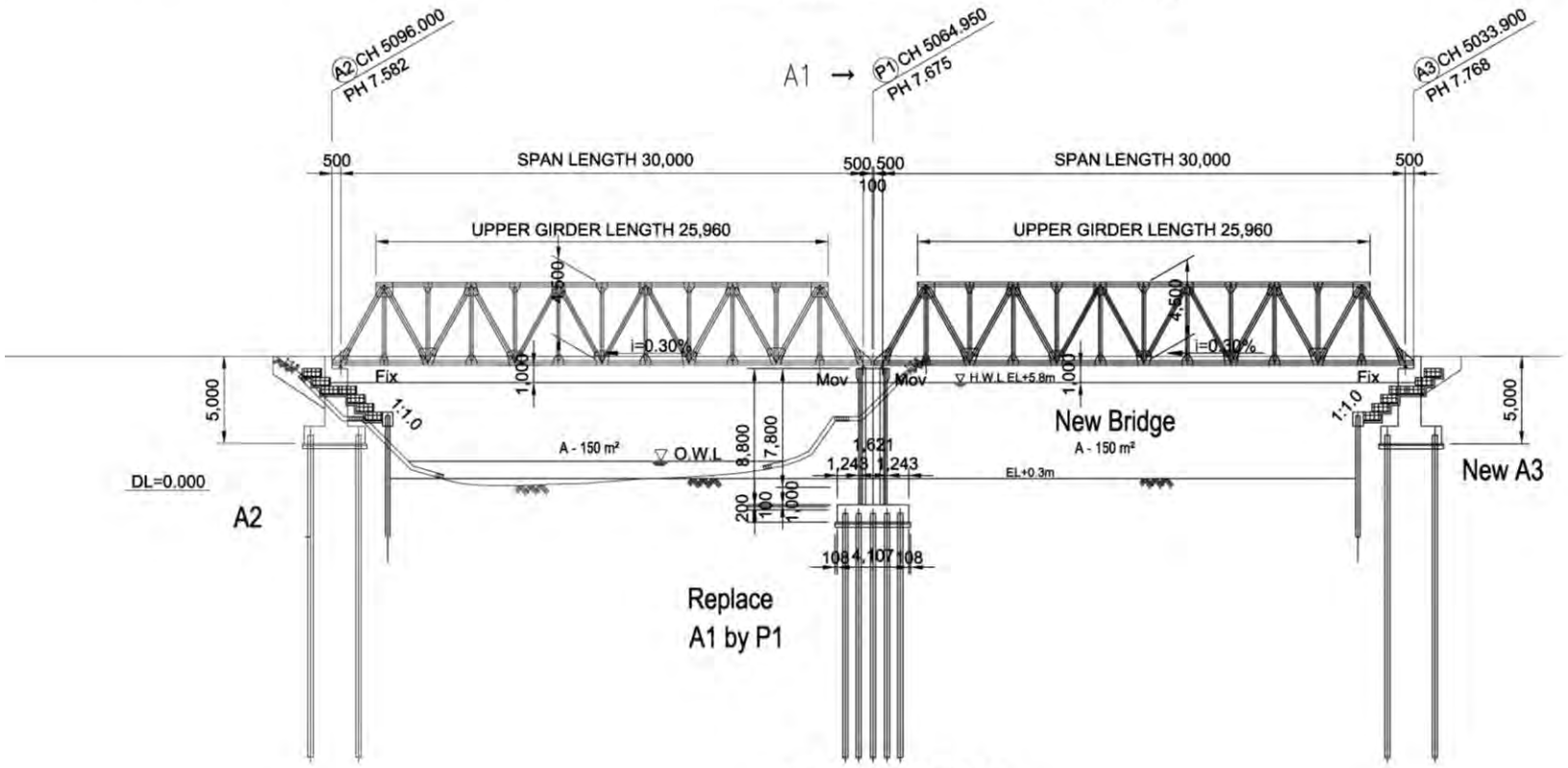
Note: The cross section is shown facing downstream side.

Specification of Steel Bar Gabion for Permanent Structure
(H, W, L = 0.5m, 1.0m and connected in every 2.0m)

Item	Position	Japan	As reference: Gabion in Vanuatu
Diameter of Wire	Coiled Wire	Ø5.0mm	Ø2.7mm
	Frame	Ø6.0mm	
	Other	Ø6.0mm or thicker	
Mesh Aperture	All	10.0 cm x 15.0 cm or smaller in rectangular	60mm to 100m in hexagon
Wire Tensile Strength	Before Welding	540 MPA or above	350 MPA or above (AS2423)
	After Welding	490 MPA or above	
Coating	Galvanized (Zn 90%+ Al10%), 300g/m²		Galvanized and PVC coated (AS/NZS 4534)

Specification of Inner Rock Material for Steel Bar Gabion

Item	Japan	As reference: Gabion in Vanuatu
Diameter	15cm to 20 cm (17.5cm in average)	10 cm to 25cm, top layer: 10cm to 15cm
Quality	hard, durable, no crack, no local friability, uniform color	hard and durable
Type of Rock	Andesite, Basalt, Granite, Hard Sandstone or Similar Hard Rock	Coronous and Basalt Cobble



ELEVATION
SCALE 1 : 250

PWD Priority : The First

Attachment-F 4-9 Bridge Improvement: New Pier Plan with Abutment Protection (Steel Sheet Pile + Multi-Staged Steel Bar Gabion) with 30m Extension

TYPE 3 : PLAN (35m) / NEW PIER PLAN WITH ABUTMENT PROTECTION (MULTI-STAGED STEEL BAR GABION)

1. Existing Abutment (A1) is demolished except for Piles.
2. New Pier (P1) is constructed with additional Piles.
3. New Abutment (A3) is constructed on the right bank.
4. New Bridge is elected on the right bank.
5. New Abutment Protections with Multi-Staged Steel Bar Gabion are constructed for both Abutments.

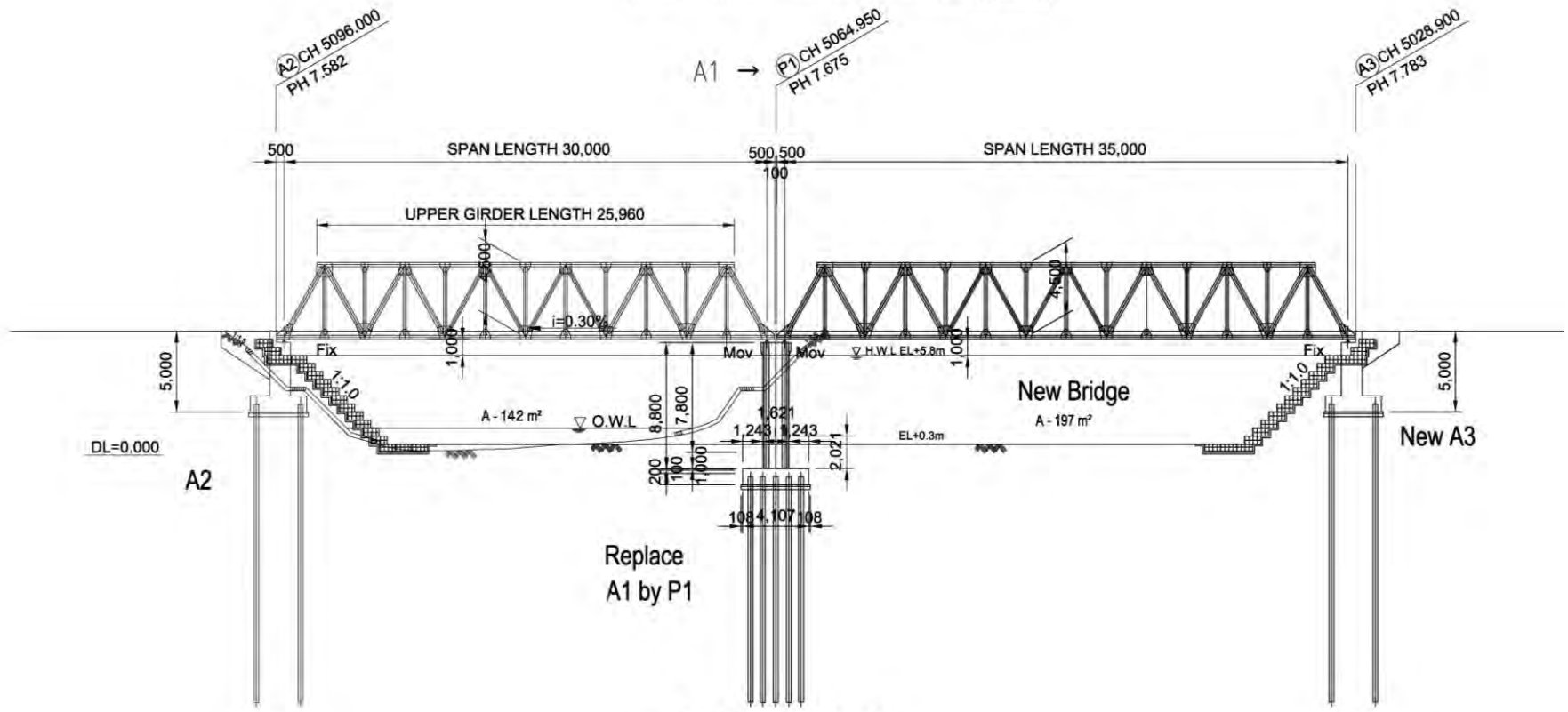
Note: The cross section is shown facing downstream side.

Specification of Steel Bar Gabion for Permanent Structure
(H, W, L = 0.5m, 1.0m and connected in every 2.0m)

Item	Position	Japan	As reference: Gabion in Vanuatu
Diameter of Wire	Coiled Wire	Ø5.0mm	Ø2.7mm
	Frame	Ø6.0mm	
	Other	Ø6.0mm or thicker	
Mesh Aperture	All	10.0 cm x 15.0 cm or smaller in rectangular	60mm to 100m in hexagon
Wire Tensile Strength	Before Welding	540 MPA or above	350 MPA or above (AS2423)
	After Welding	490 MPA or above	
Coating	Galvanized (Zn 90%+ Al10%), 300g/m²		Galvanized and PVC coated (AS/NZS 4534)

Specification of Inner Rock Material for Steel Bar Gabion

Item	Japan	As reference: Gabion in Vanuatu
Diameter	15cm to 20 cm (17.5cm in average)	10 cm to 25cm, top layer: 10cm to 15cm
Quality	hard, durable, no crack, no local friability, uniform color	hard and durable
Type of Rock	Andesite, Basalt, Granite, Hard Sandstone or Similar Hard Rock	Coronous and Basalt Cobble



ELEVATION
SCALE 1 : 250

PWD Priority : The Second・The Third

Attachment-F 4-10 Bridge Improvement: New Pier Plan with Abutment Protection (Multi-Staged Steel Bar Gabion) with 35m Extension

TYPE 4 : PLAN (35m) / NEW PIER PLAN WITH ABUTMENT PROTECTION (STEEL SHEET PILE)

1. Existing Abutment (A1) is demolished except for Piles.
2. New Pier (P1) is constructed with additional Piles.
3. New Abutment (A3) is constructed on the right bank.
4. New Bridge is elected on the right bank.
5. New Abutment Protections with Steel Sheet Pile are constructed for both Abutments.

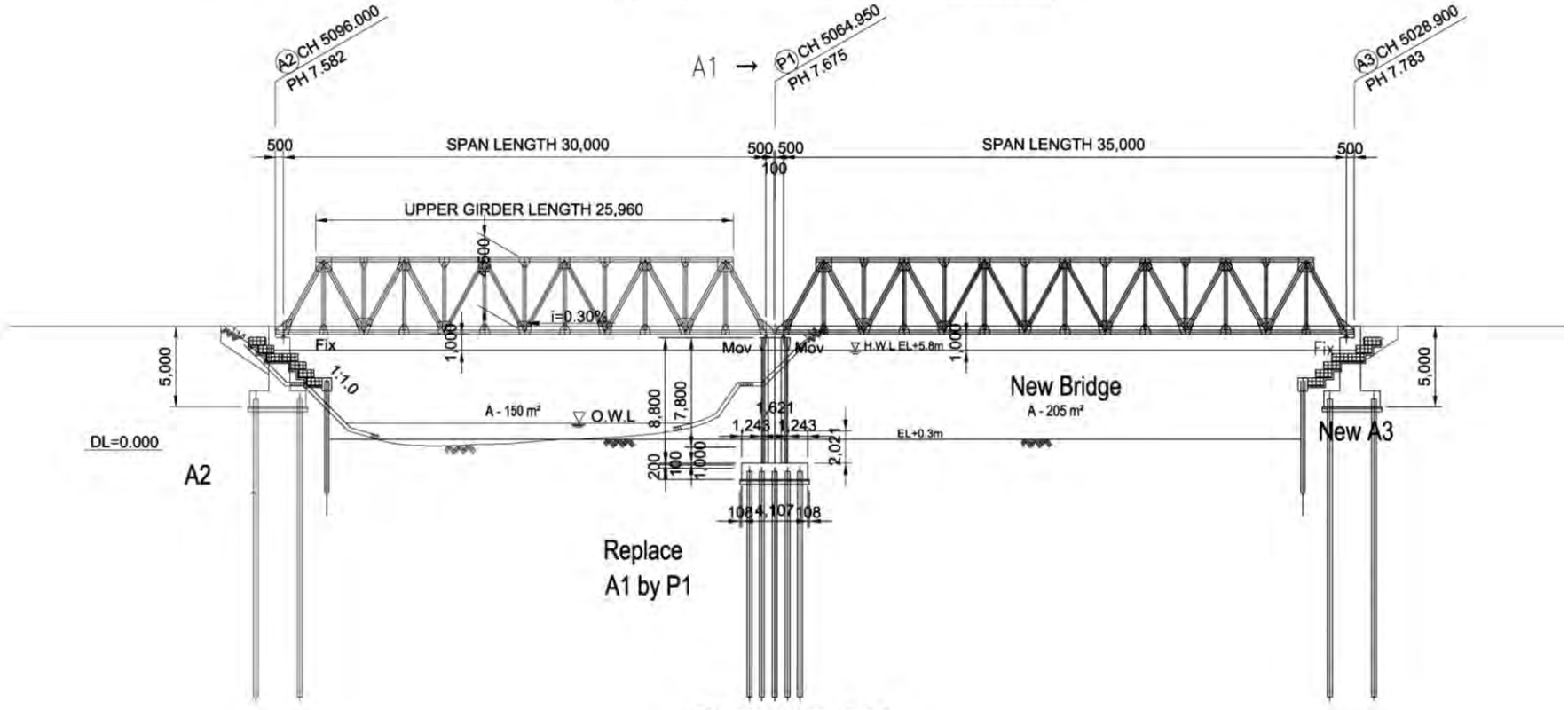
Note: The cross section is shown facing downstream side.

Specification of Steel Bar Gabion for Permanent Structure
(H, W, L = 0.5m, 1.0m and connected in every 2.0m)

Item	Position	Japan	As reference: Gabion in Vanuatu
Diameter of Wire	Coiled Wire	Ø5.0mm	Ø2.7mm
	Frame	Ø6.0mm	
	Other	Ø6.0mm or thicker	
Mesh Aperture	All	10.0 cm x 15.0 cm or smaller in rectangular	80mm to 100m in hexagon
Wire Tensile Strength	Before Welding	540 MPA or above	350 MPA or above (AS2423)
	After Welding	490 MPA or above	
Coating	Galvanized (Zn 90%+ Al10%), 300g/m²		Galvanized and PVC coated (AS/NZS 4534)

Specification of Inner Rock Material for Steel Bar Gabion

Item	Japan	As reference: Gabion in Vanuatu
Diameter	15cm to 20 cm (17.5cm in average)	10 cm to 25cm, top layer: 10cm to 15cm
Quality	hard, durable, no crack, no local friability, uniform color	hard and durable
Type of Rock	Andesite, Basalt, Granite, Hard Sandstone or Similar Hard Rock	Coronous and Basalt Cobble



ELEVATION

SCALE 1 : 250

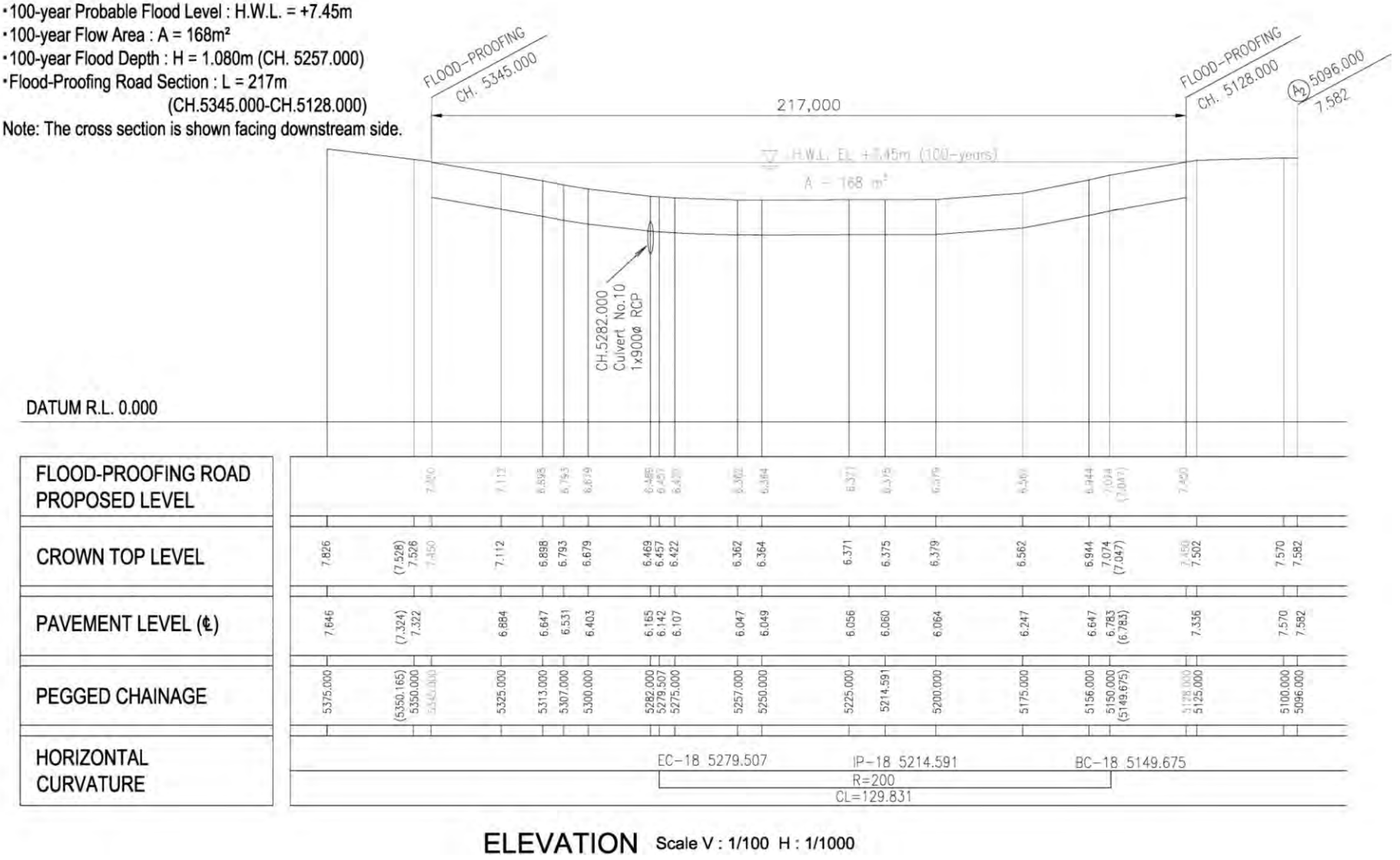
PWD Priority : The First

Attachment-F 4-11 Bridge Improvement: New Pier Plan with Abutment Protection (Steel Sheet Pile + Multi-Staged Steel Bar Gabion) with 35m Extension

STRUCTURE TYPE OF FLOOD-PROOFING ROAD

- 100-year Probable Flood Level : H.W.L. = +7.45m
- 100-year Flow Area : A = 168m²
- 100-year Flood Depth : H = 1.080m (CH. 5257.000)
- Flood-Proofing Road Section : L = 217m
  (CH.5345.000-CH.5128.000)

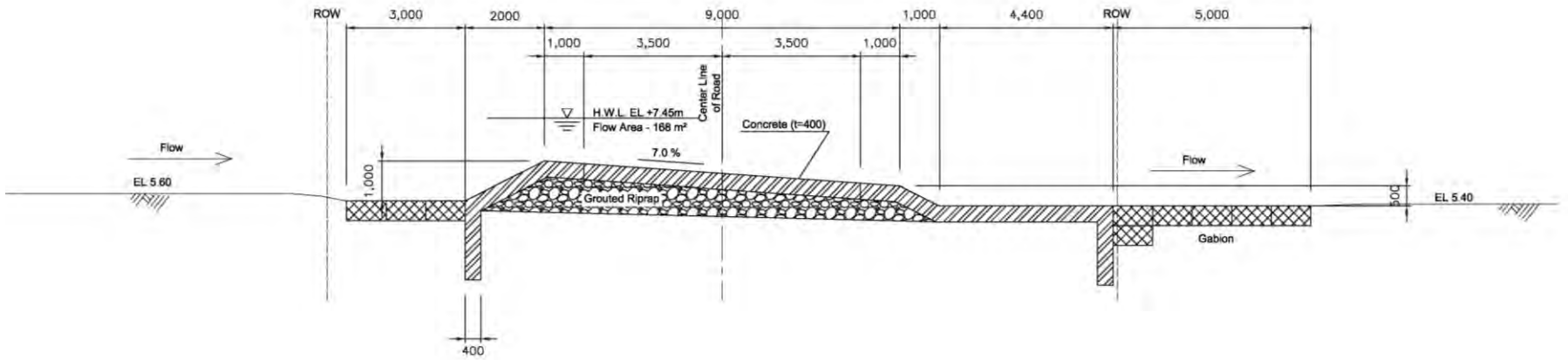
Note: The cross section is shown facing downstream side.



ELEVATION Scale V : 1/100 H : 1/1000

Attachment-F 4-12 Road Improvement: Flood-Proofing Road Longitudinal Section

TYPE 1: FLOOD-PROOFING ROAD (CONCRETE)



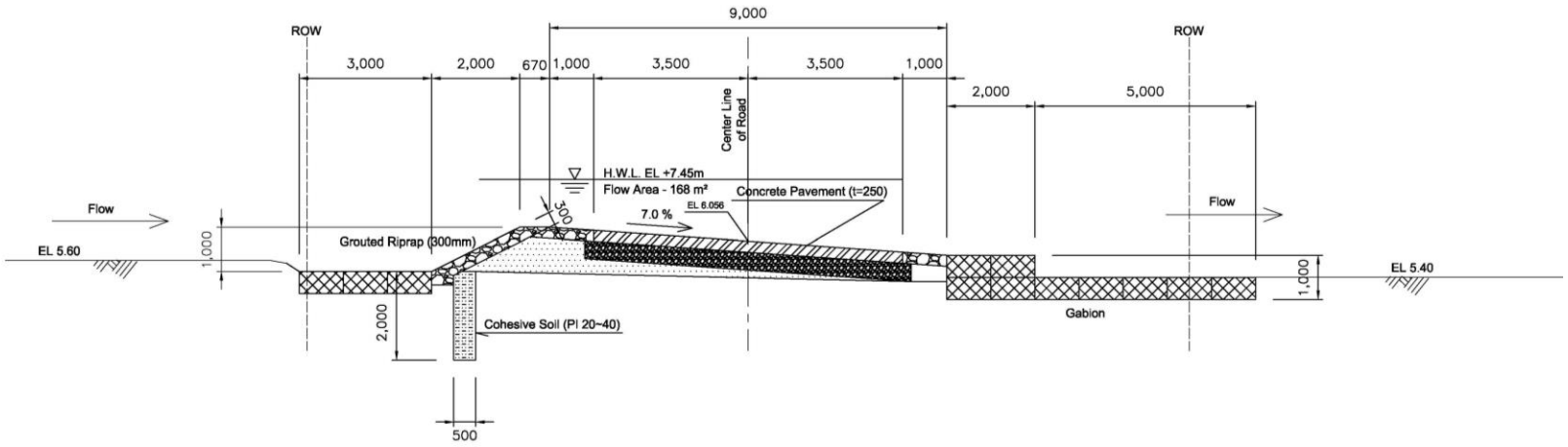
TYPICAL CROSS SECTION (CH 5225)

SCALE 1:100

PWD Priority : The First

Attachment-F 4-13 Road Improvement: Typical Cross Section of Flood-Proofing Road (Concrete + Grouted Riprap Subgrade)

TYPE 2 : FLOOD-PROOFING ROAD (GROUTED RIPRAP)



TYPICAL CROSS SECTION (CH 5225)

SCALE 1:100

PWD Priority : The Second・The Third

Attachment-F 4-14 Road Improvement: Typical Cross Section of Flood-Proofing Road (Stone Masonry + Cement Concrete Pavement)

Attachment 5: Minutes of Meeting on the Draft Final Report

MINUTES OF THE MEETING
ON
THE DRAFT SURVEY REPORT,
SURVEY RESULTS AND FUTURE REMARKS
FOR
DATA COLLECTION SURVEY
FOR
RECONSTRUCTION OF TEOUMA BRIDGE
ON EFATE RING ROAD
IN THE REPUBLIC OF VANUATU

CONFERENCE ROOM, PUBLIC WORKS DEPARTMENT
PMB 9044, PORT VILA
December 15, 2016

KANEHIRO MORISHITA
Leader of JICA Study Team

SAMUEL NAMURI
Director
Public Works Department

REPUBLIC OF VANUATU
PUBLIC WORKS HEAD OFFICE
DIRECTOR
Travaux Publics
GOVERNMENT
RÉPUBLIQUE DE VANUATU

Witness

TAKAHIRO YOKOTA
Deputy Director
Pacific and Southeast Asia Division 6
Southeast Asia Pacific Department
Japan International Cooperation Agency

At the end of the second site survey of the Data Collection Survey for Reconstruction of Teouma Bridge on Efate Ring Road in the Republic of Vanuatu, Japan International Cooperation Agency (hereinafter referred to as "JICA") Study Team (herein referred to as "JST") and Public Works Department (hereinafter referred to as "PWD") held a meeting to confirm the survey results regarding the engineering and environmental and social aspects with the Draft Survey Report (hereinafter referred to as "DS/R"), and future remarks at 10 am on December 15, 2016. The Meeting was chaired by Mr. Junior Shim George, Manager (Projects) of PWD, and the attendees are as listed in the Annex-1.

1. Review of Meetings Held

Mr. Kanehiro Morishita, the Leader of JST made a review of meetings held with PWD. The points were summarized as below and the attendees are as listed in the Annex-2.

(1) December 7, 2016: Discussion on the Draft Survey Report

- JST explained the summary of the DS/R and made discussions with PWD.
- The PWD asked JST about bridge span and implementation schedule. JST answered with additional explanations and PWD agreed with the contents.

(2) December 8, 2016: Discussion on Structural Design

- JST explained the structural designs for river improvement, bridge and flood-proofing road.
- After discussions regarding engineering and working/maintenance aspects, JST requested PWD to file their priority in structural designs to JST. PWD agreed with the request to announce their priority to JST by December 9, 2016.

(3) December 9, 2016: Discussion on the Structural Design Priority

- Mr. Junior Shim George, Manager (Projects) of PWD officially announced the priority for structural designs to JST as:
  - River protection: 1st-Sheet pile; 2nd-Multi-staged steel bar gabion (previously called as Kago Mat), and 3rd-Wet stone masonry;
  - Bridge: 1st-Sheet pile, and 2nd-Multi-staged steel bar gabion;
  - Road: 1st-Concrete, and 2nd-Grouted riprap.
- Mr. Junior Shim George added that PWD put the priority on "durability" of the structure first, followed by constructability and maintenance.
- PWD and JST agreed with the priority concept of design, and PWD agreed to submit an application form for grant aid based on the agreed draft.

(4) December 13, 2016: Stakeholder Meeting with Local Residents

- JST and PWD made a presentation of the survey especially focusing on land management to the possible stakeholders including local residents (leaseholders), government officials concerned.
- The chief representative stated that there are currently three customary landowners in this area, and who would be willing to work with the project. There has been a recent declaration made by the Supreme Court that the family Pakoa Kalpoilep is the customary landowners, as well as the other two families, and they have their required "green certificate" certifying them as customary landowners of the area. They are in the process of rectifying lease documents, to amend lessor as "Minister of Lands" to their names. (The project needs to get a copy of their green certificate and rectified leases).

T.Y

- The Department of Lands or DOL, the major organization to handle the lands, noted there are no disputes in the customary lands of the project area, and that the acquisition process would take approximately 6-8 months, and may be faster depending on the government of the day's priorities.
- The DOL also added that the first step to acquire part of customary lands is to consult the area chief, because the chief is the manager of such lands. For the acquisition of leased lands, DOL will help to find a land owner to negotiate.
- JST expressed that one of the project aims was to secure the flood carrying capacity of the bridge section, so that the flood magnitude and frequency of its occurrence would not change. Thus the community-based flood management is crucial to cope with the disastrous floods like Cyclone Pam.
- In response to the JST's explanation, Mr. Michel Kalworai, Secretary General of Shefa Provincial Government expressed the necessity of some measurements for disaster prevention such as establishing the River Management Committee and setting up the buffer zone along the river bank.
- In addition, JST planned to visit the site after the meeting.
- After discussions among the participants, JST agreed to consider the demands from the participants in the further process.
- All the local residents expressed "positive" to implement the proposed project, and PWD and JST confirmed.

2. Confirmation of Survey Results and Future Remarks

In accordance with the reviews, PWD and JST discussed the survey results with the DS/R in order to attain an agreement. The principal items discussed, agreed and remarked in the Meeting were as summarized below:

(1) Mr. Paula Baleilevuka of PWD requested to consider a single-span bridge design for Teouma Bridge. JST explained adequacy of additional span by utilizing the existing span, because the existing span has no defects so as to save the total costs. Furthermore, drift woods can pass through the 30 m span with freeboard of 1 m.

(2) PWD requested to change the direction of river cross-section drawings in accordance with the PWD's road criteria. JST responded to add the note of direction in the drawings of the DS/R and the both parties agreed.

(3) PWD asked JST to establish the maintenance plan. Mr. Miura of JST responded the plan would be developed after determining the structure design and the design team will assist the development.

(4) PWD agreed to identify the land area required for the project and file the information to the Minister of Lands through the Minister of MIPU to facilitate the land acquisition by the end of December 2016.

(5) JST found that there were small member of families living in the flood high-risk area through the site visit on December 13, 2016.

(6) JICA and JST requested PWD to facilitate the disaster prevention activities for the residents downstream of the Teouma Bridge in cooperation with NDMO and Shefa Provincial Government, although the scope of the project focuses on the structural measures including reconstruction of bridge, river bank and ring road.

T.Y

(7) JICA and JST requested PWD to provide necessary documents to confirm the government priority.

(8) JST requested PWD to submit review comments on the DS/R by January 6, 2017 to Mr. Morishita by email.

(9) JST stressed the importance of the land acquisition which could be the biggest bottleneck to implement the project, and the responsibility of the GoV. PWD agreed with the remark and promised to work for the matter.

The Meeting was adjourned at 12:50 pm.

T.T

Annex-1

Attendee List

Name	Position / Affiliation	E-mail Address	Phone (+678)
1. Harold Allanson, Mr.	Project Engineer/PWD		
2. Paula Baleilevuka, Mr.	Engineer/PWD		
3. Junior Shim George, Mr.	Project Manager/PWD		
4. Ambatha Paraliu, Mr.	Manager (Operations) /PWD		
5. Takahiro Yokota, Mr.	Deputy Director/JICA HQ		
6. Yoko Asano, Ms.	Project Formulation Advisor /JICA Vanuatu		
7. Judy Robert, Ms.	Program officer/JICA Vanuatu		
8. Kanehiro Morishita, Mr.	Team Leader/ River Planning 1/ Restoration Concept Plan/ JST		
9. Minoru Miura, Mr.	Road Bridge Improvement Plan/ JST		
10. Takayuki Hatano, Mr.	Env. and Social Consideration/ JST		

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Annex-2

Attendee Lists of Meetings Held

December 7, 2016, 09:00-11:30 am

Name	Position / Affiliation	E-mail Address	Mobile (+678)
1. Harold Allanson, Mr.	Project Engineer/PWD		
2. Paula Baleilevuka, Mr.	Engineer/PWD		
3. Junior Shim George, Mr.	Project Manager/PWD		
4. Chris Marlow, Mr.	Contract Admin. Manager/ PWD		
5. Uravo Nafuki, Ms.	Senior Env./Social Officer/ PWD		
6. Yoko Asano, Ms.	Project Formulation Advisor /JICA Vanuatu		
7. Kanehiro Morishita, Mr.	Team Leader/ River Planning 1/ Restoration Concept Plan/ JST		
8. Minoru Miura, Mr.	Road Bridge Improvement Plan/ JST		
9. Takayuki Hatano, Mr.	Env./Social Considerations/ JST		

December 8, 2016, 14:00-16:00 pm

Name	Position / Affiliation	E-mail Address	Phone (+678)
1. Harold Allanson, Mr.	Project Engineer/PWD		
2. Junior Shim George, Mr.	Project Manager/PWD		
3. Paula Baleilevuka, Mr.	Engineer/PWD		
4. Yoko Asano, Ms.	Project Formulation Advisor /JICA Vanuatu		
5. Judy Robert, Ms.	Program Officer/JICA Vanuatu		
6. Kanehiro Morishita, Mr.	Team Leader/ River Planning 1/ Restoration Concept Plan/ JST		
7. Minoru Miura, Mr.	Road and Bridge Improvement Plan/ JST		
8. Takayuki Hatano, Mr.	Env./Social Considerations/ JST		

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December 9, 2016, 15:45-16:15 pm

Name	Position / Affliation	E-mail Address	Phone (+678)
1. Ambatha Paraliu, Mr.	Manager (Operations) /PWD		
2. Harold Allanson, Mr.	Project Engineer/PWD		
3. Junior Shim George, Mr.	Project Manager/PWD		
4. Kanehiro Morishita, Mr.	Team Leader/ River Planning 1/ Restoration Concept Plan/ JST		
5. Minoru Miura, Mr.	Road Bridge Improvement Plan/ JST		
6. Takayuki Hatano, Mr.	Env./Social Considerations/ JST		

December 13, 2016, 09:00-11:00 am

Name	Position / Company	E-mail Address	Phone (+678)
1. Noel Takau, Mr.	Representative of the Area Chief		
2. Toka Kaibia, Mr.	Local resident/Teouma bridge		
3. Harold Rodin, Mr.	Local resident/Teouma bridge		
4. Timothy Noulawas, Mr.	Local resident/Teouma bridge		
5. Robinson Kalwasei, Mr.	Local resident/Teouma bridge		
6. Nalau Joel, Mr.	Local resident/Teouma bridge		
7. Malian Andrew, Mr.	Eratap Village Area Secretary		
8. Michel Kalworai, Mr.	Secretary General (SG) of SHEFA Provincial Government		
9. Noel Naki, Mr.	Land officer/DOL		
10. Jay Hinge, Ms.	Land officer/DOL		
11. Jimmy Pierre, Mr.	Land officer/DOL		
12. Kate McPherson, Ms.	EIA specialist/DEPC		
13. Norma Tor, Ms.	EIA officer/DEPC		
14. Uravo Nafuki, Ms.	Senior environmental specialist/PWD		
15. Takahiro Yokota, Mr.	Deputy Director/JICA HQ		
16. Yoko Asano, Ms.	Project Formulation Advisor /JICA Vanuatu		
17. Judy Robert, Ms.	Program officer/JICA Vanuatu		

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Name	Position / Company	E-mail Address	Phone (+678)
18. Kanehiro Morishita, Mr.	Team Leader/ River Planning 1/ Restoration Concept Plan/ JST		
19. Minoru Miura, Mr.	Road Bridge Improvement Plan/ JST		
20. Takayuki Hatano, Mr.	Env./Social Considerations/ JST		

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