

Chapter 15 Preliminary Design

15.1 River Widening

River Widening is intended to flow down 1,800 m³/s flood discharge with full at the Back Road Bridge point in the middle section

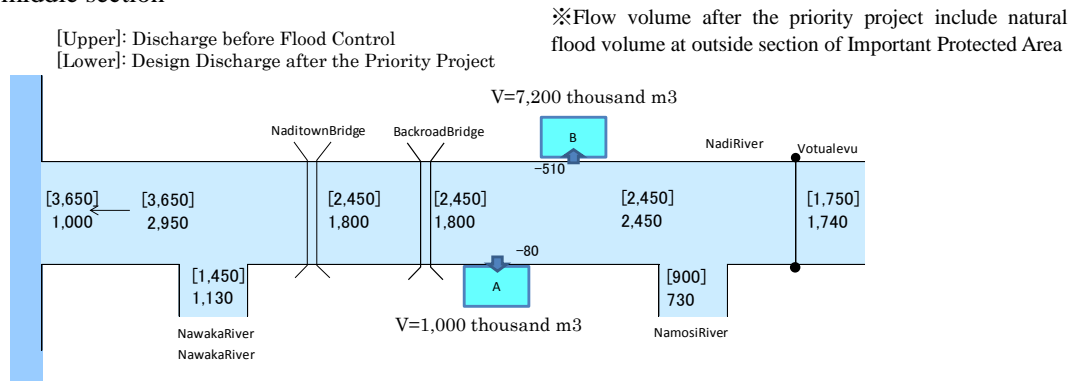


Figure 15-1 Designed Discharge Distribution in the Priority Project

15.1.1 Applicable design standards

Fiji does not have its own technical standards and guidelines for flood control and river facilities. Therefore, *Structural Ordinance for River Facilities* (July 20, 1976), and *Revised Edition, Ministry of Construction, Technical Criteria for River Works, Editorial Supervisor* by River Bureau, Ministry of Construction, is used as references in designing the river facilities.

15.1.2 Plan and Area

(1) Planned Area

River widening is conducted from 5.75k, near Narewa village, to 24.0k, near Votuarevu village.

This area is selected through flood analysis in order to prevent inundation of the Important Protected Area. Only river widening is conducted for the section between 5.75k to 8.0k, and the earth dike is not included in order to mitigate negative impact of the dike of main stream on other areas, including tributaries. The whole plan of the river widening is as described in Figure 15-3.

(2) Plan

Alignment of river widening is set considering the current alignment of the river channel and flood flow. The width of river widening is set, basically, the same as that of from center line between right bank side and left bank side from the point of view for fairness.

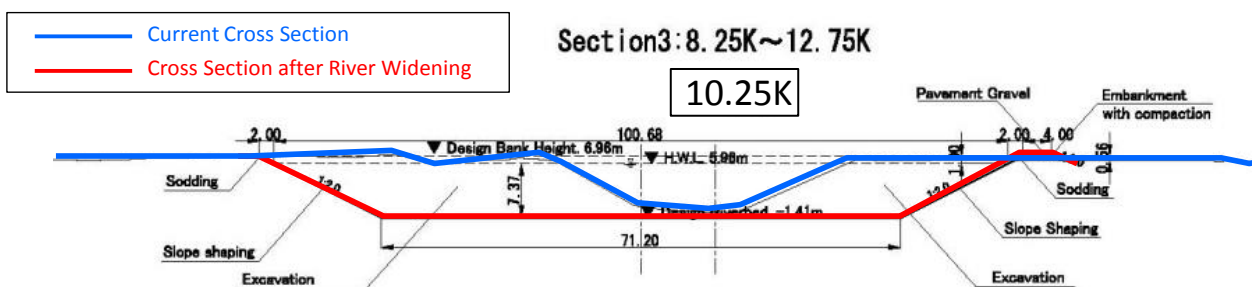


Figure 15-2 Basic Concept of River Widening

Based on the above explanation, the plan of river widening is shown in from Figure 15-3 to Figure 15.6.

15.1.3 Longitudinal Plan

Longitudinal Plan is as shown in Figure 15-7.

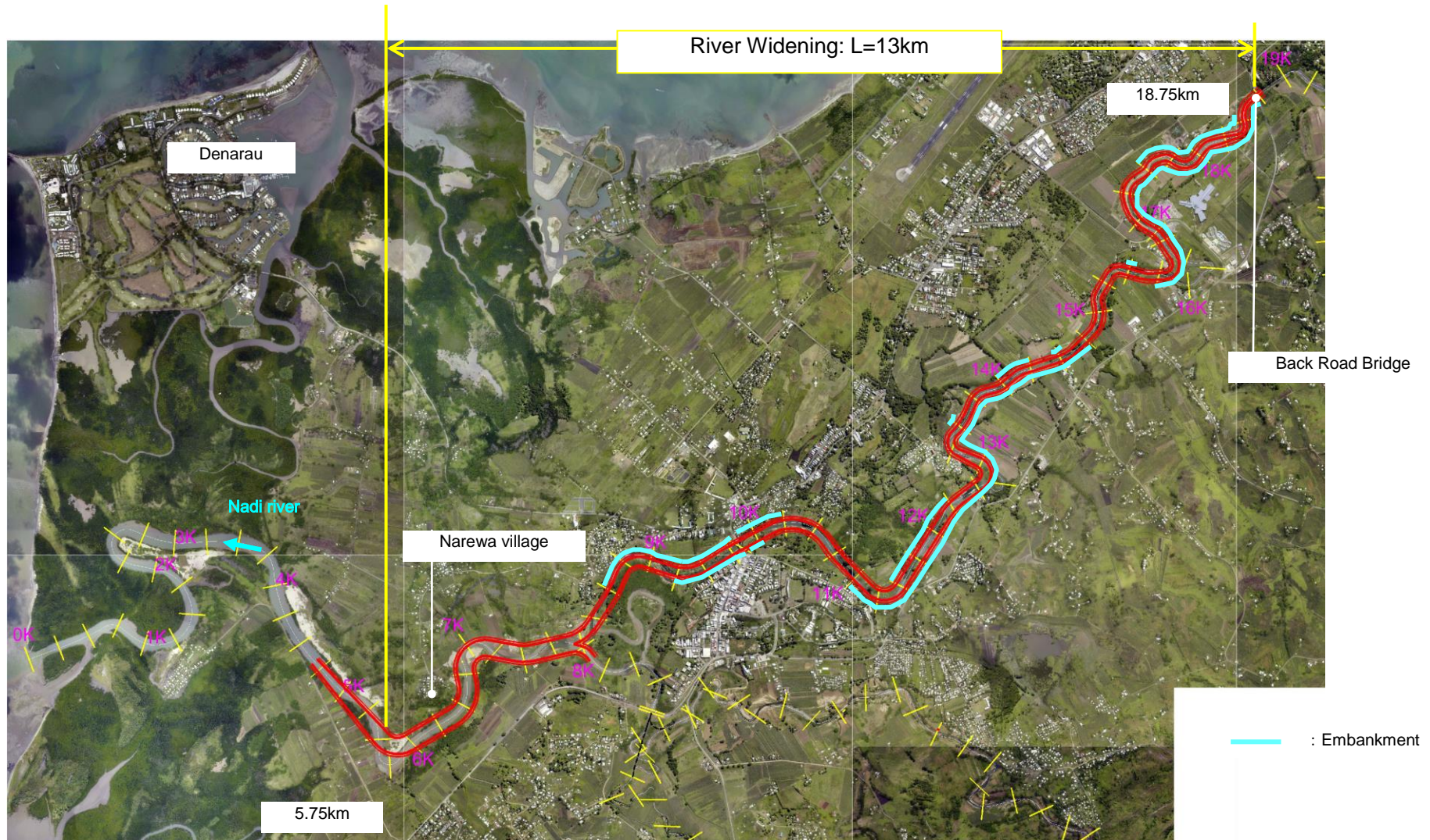


Figure 15-3 Whole Plan of River Widening

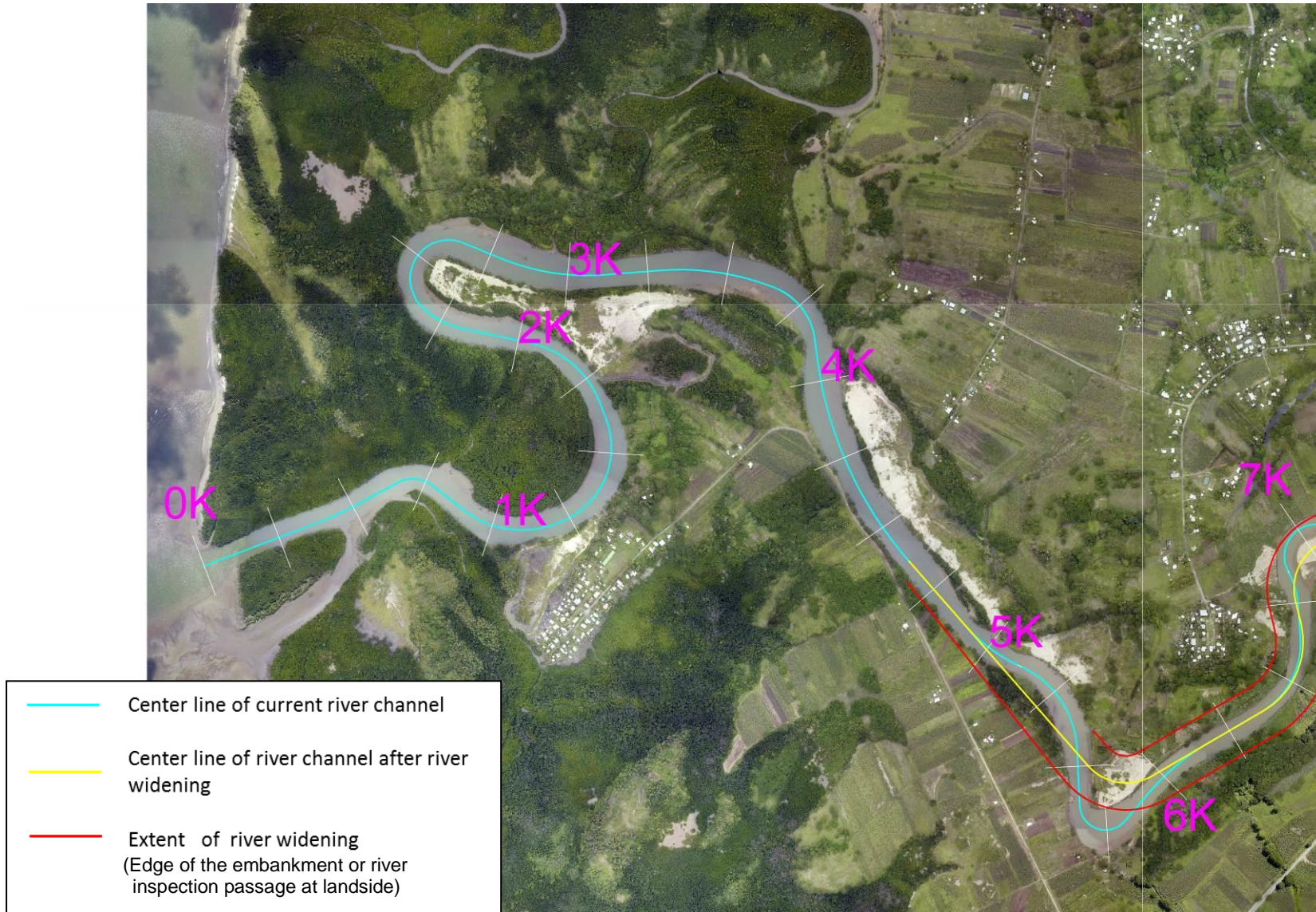


Figure 15-4 Plan of River Widening (1)

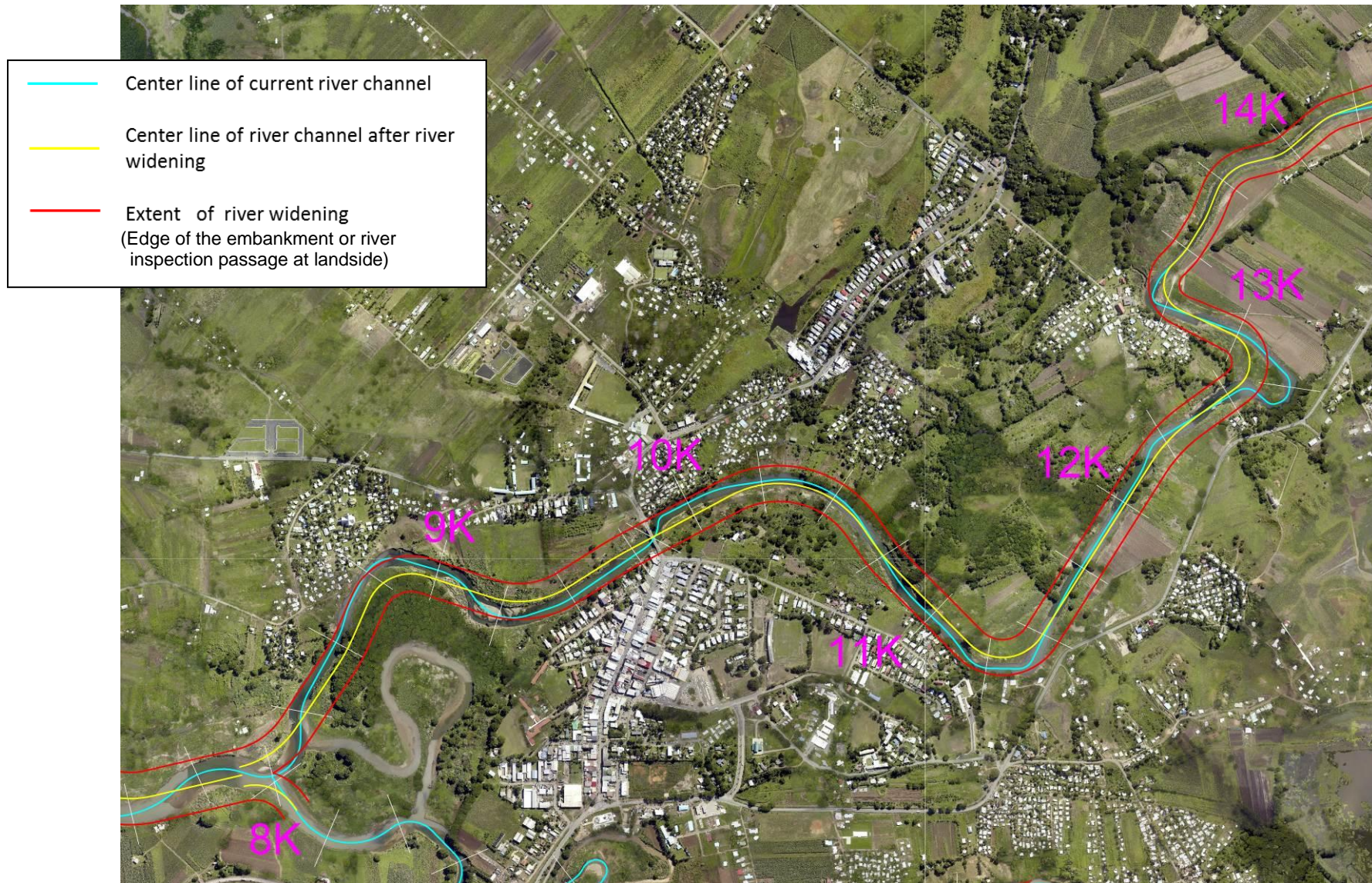


Figure 15-5 Plan of River Widening (2)

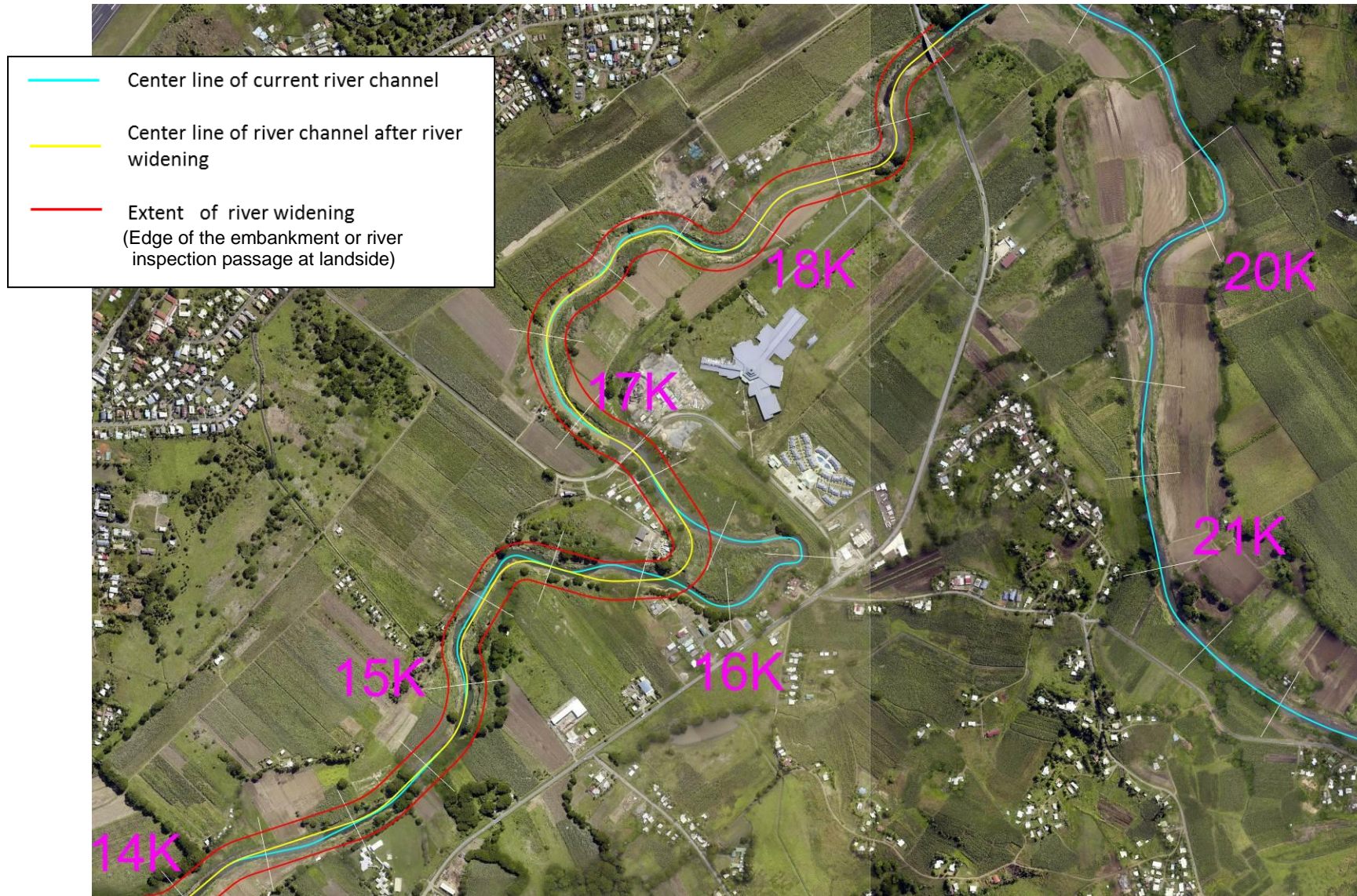


Figure 15-6 Plan of River Widening (3)

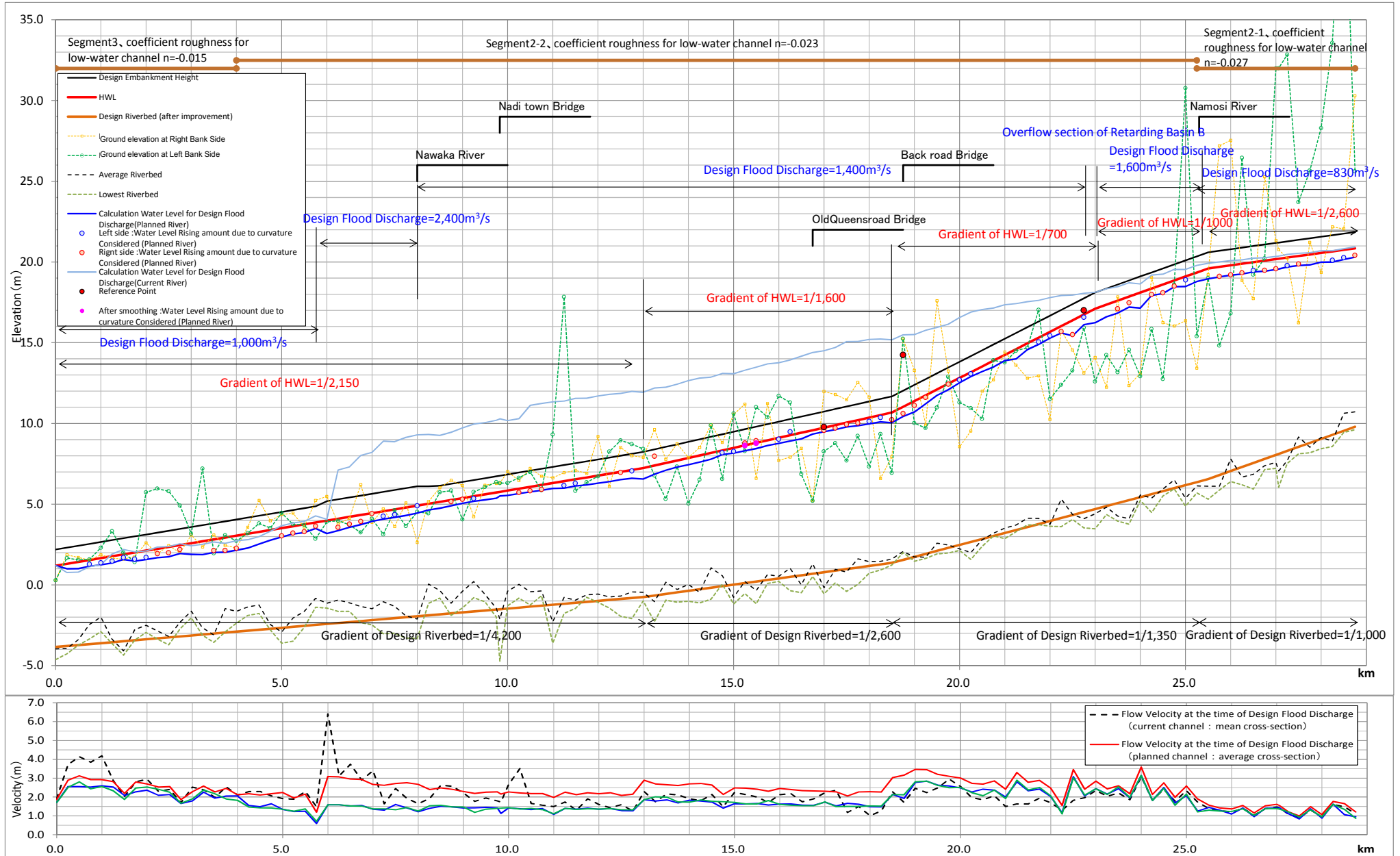


Figure 15-7 Designed Longitudinal Plan

15.1.4 Cross-Sectional Plan

(1) Slope Gradient

Although, in principle, the slope gradient of embankment is set loosely at 1:3 of either river side or land side slope based on River Embankment Design Criteria in Japan, 2007, River Improvement and Management Division, Water and Disaster Management Bureau, Ministry of Land, Infrastructure, Transport and Tourism, the slope gradient of either river side or land side of Nadi River is set as 1:2 for the following reasons: 1) Risk of dike breach due to riverbank erosion is low because cross-sectional shape of Nadi River after improvement is almost engraved to existing ground, 2) Height of embankment is from 0.5m to 3m if embankment is necessary and stability for structural and permeability is considered to be secured, and 3) The present situation of the bank is considered to be stable with almost 1:2 slope gradient through field investigation.

In addition, this project will hardly cause land side because low land area besides embankment will be filled with soil as mentioned later in "Backfilling at Hinterland".

Typical Cross Section of the river is as described in Figure 15-8.

On the other hand, slope gradient for other structures are set as below. Since the details of the structure of each shape are described later, only the outline is provided here for reference.

(2) Bank Width of the crown of embankment

The embankment width is decided in accordance with "Cabinet Order Concerning Structural Standards for River Management Facilities, Chapter III ,Article 21" based on flow rate as described in Table 15-1. As a result, the bank width of the crown is set as 4.0m

Table 15-1 Bank Width

Design Discharge (m ³ /s)	Bank Width (m)
Less than 500	3
More than 500, Less than 2000	4
More than 2000, Less than 5000	5
More than 5000, Less than 10000	6
More than 10000	7

Source: Cabinet Order Concerning Structural Standards for River Management Facilities, etc. Chapter III Article 21

(3) Inspection passage

In accordance with "Cabinet Order Concerning Structural Standards for River Management Facilities, Chapter III Article 27", the embankment is provided with an inspection passage. Inspection passage width is set as 3.0m

Typical Cross Section

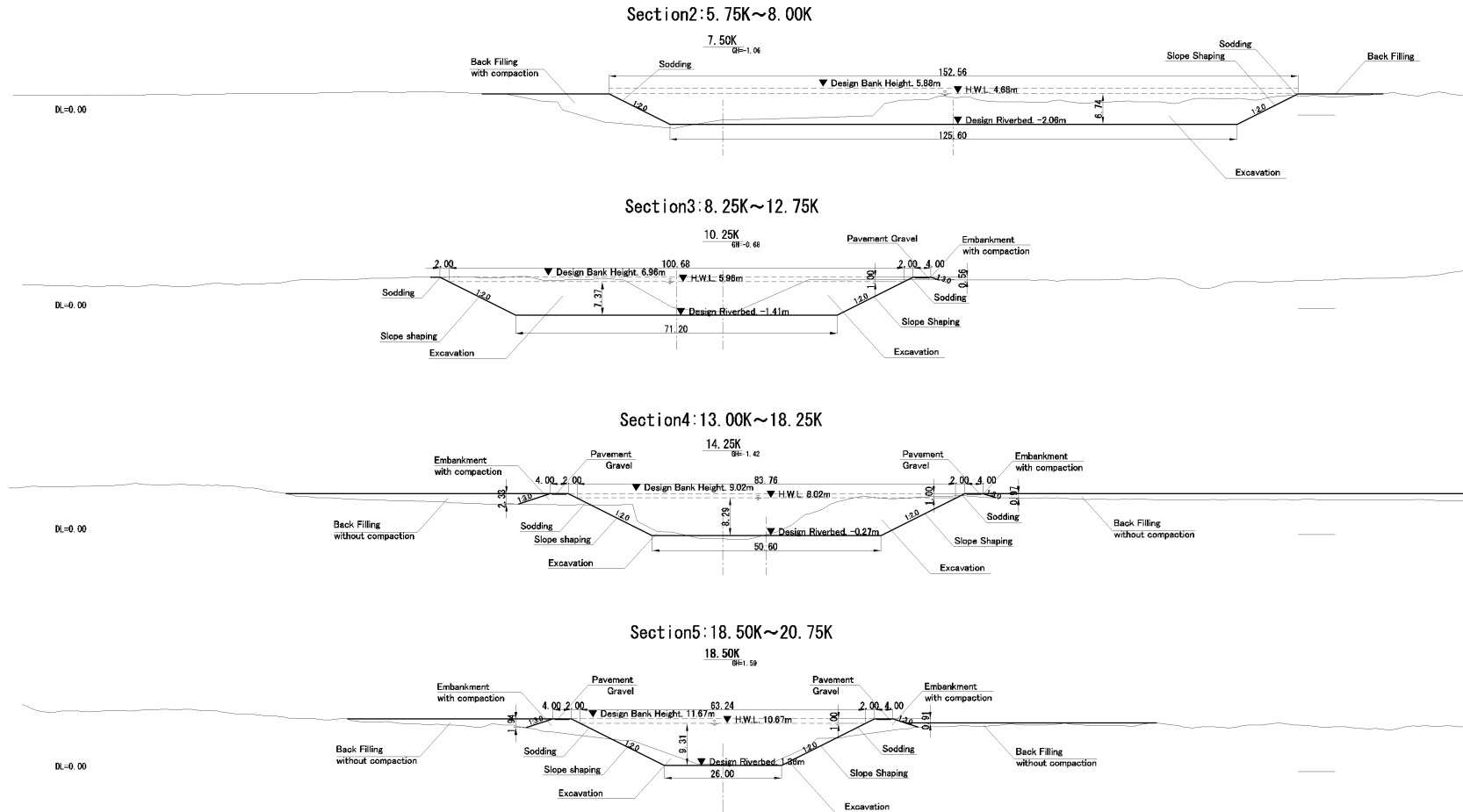


Figure 15-8 Typical Cross Section (Nadi River)

15.2 Retarding Basin A, B

Retarding Basin A and B can temporarily store, respectively, 80 m³/s and 510 m³/s of flood discharge volume 2,450 m³/s before flood control, and flow 1,800 m³/s at Back Road Bridge with full in order to prevent inundation in Important Protected Area in Nadi River Basin.

Although these basins are filled with flood water when large-scale flood (with more than 1/10 design return period) occurs, water is drained to the river after flooding, and basins return to normal condition, which is suitable for cultivation. In addition, the river dike (surrounding dike of retarding basins) is constructed together with the retarding basins to reduce inundation damage by small-scale flood.

15.2.1 Retarding Basin A

(1) Layout and Facilities Design

The profile of retarding Basin A is as shown in Table 15-2, and its layout is as shown in Figure 15-9.

Table 15-2 Specifications for Retarding Basin A of the Priority Project

Retarding Basin A	
Location	Leftbank Side: 18.75 k ~ 21.0k
Flood Control Discharge (1000m ³)	996
Peak Cut Discharge (m ³ /s)	80
Peak water level in the basin by calculation (EL.m)	14.50
Length and Location of Overflow Dike	60m
	20.455 ~ 20.5k
Elevation of the top of Overflow Dike (EL.m)	13.53
	(20.5k HWL)
Peak water level at overflow dike by calculation (EL.m)	14.51
Overflow Depth (m)	0.98
Design Elevation of Height of Embankment surrounding the basin (EL.m)	14.53
	(20.5k Design Embankment Height)
Specifications of discharge.	B1.5×H1.5×1Gate
	Elevation of the bottom of drainage waterway EL. 9.59 m
	Outflow Rate Q=10.9m ³ /s
	Drainage Time t=17.0 hrs

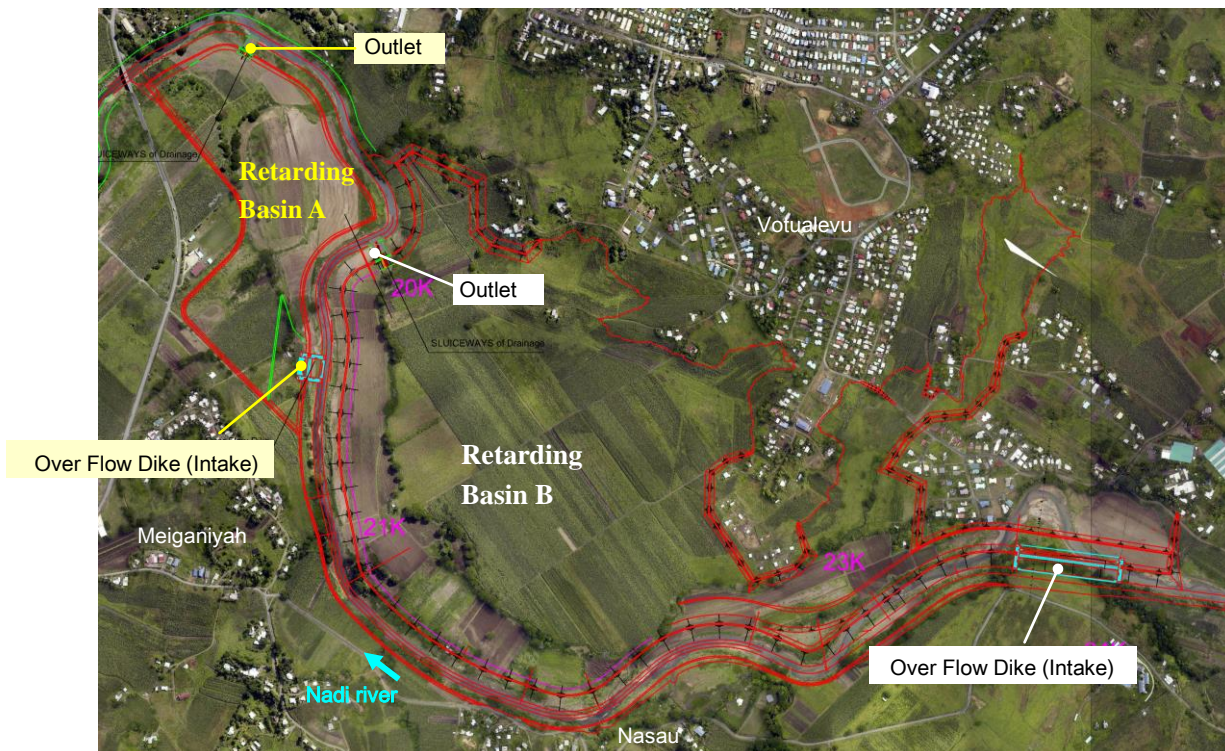


Figure 15-9 Layout of Retarding Basin A

(2) Cross-Sectional Plan

Crown width of embankment is set as 4.0m. Either river or land side of slope gradient is set as 1:3.

Typical Cross Section of Retarding Basin

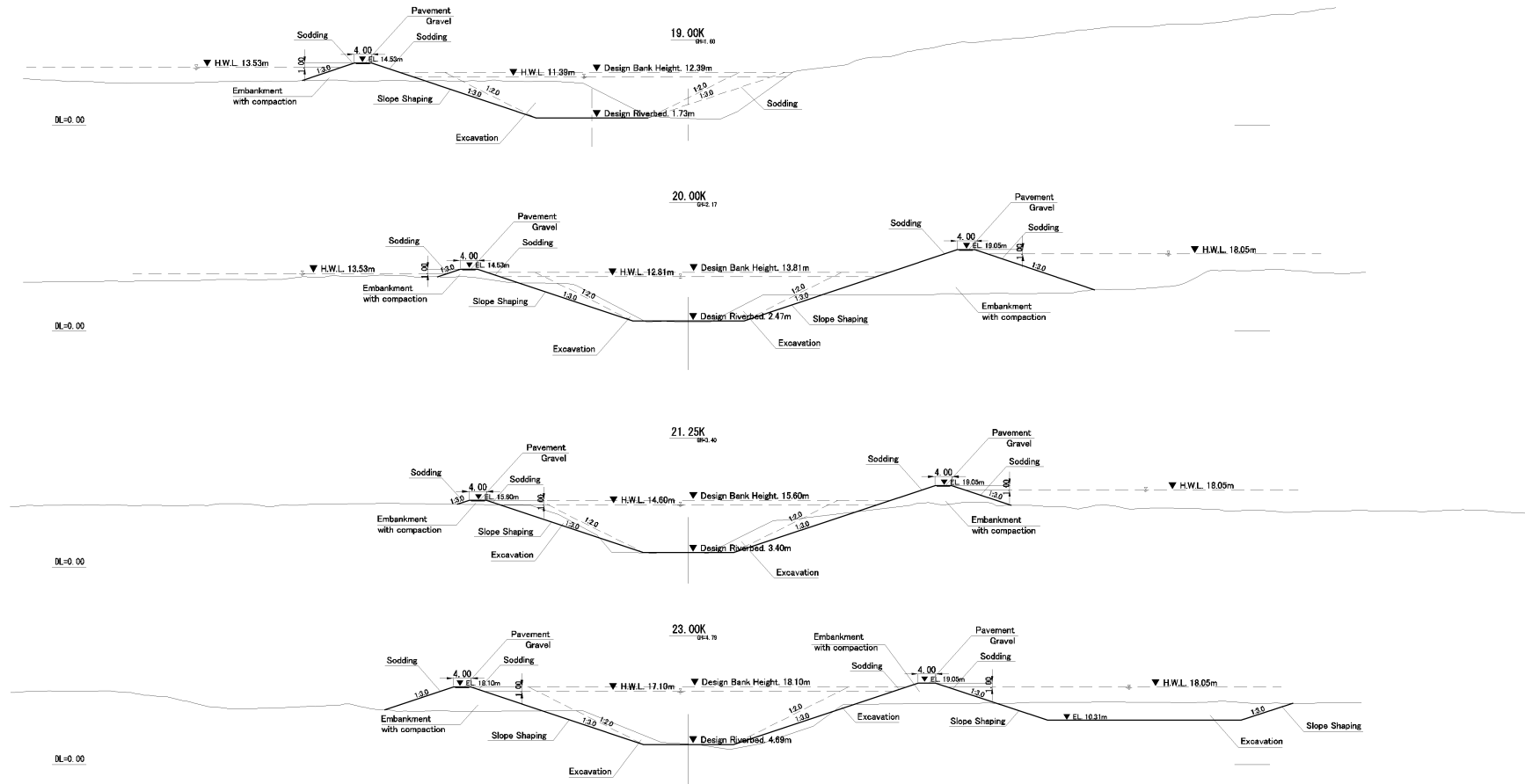


Figure 15-10 Typical Cross Section (Retarding Basin A, B)

(3) Overflow Dike

The specifications of overflow dike are set in order to secure peak cut discharge. A Typical Cross Section of overflow dike is shown in Figure 15-11.

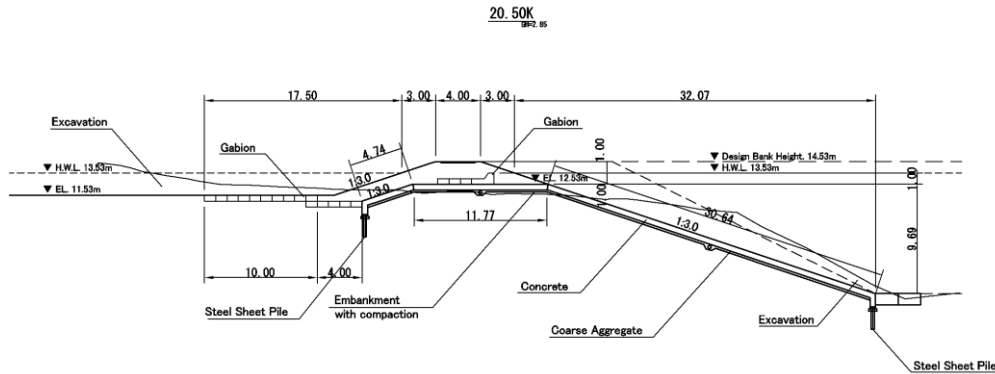


Figure 15-11 Typical Cross Section of Overflow Dike

15.2.2 Retarding Basin B

(1) Layout and Facilities Design

The profile of retarding Basin B is as shown in Table 15-3, and its layout is as shown in Figure 15-12.

Table 15-3 Specifications for Retarding Basin B at the Priority Project

Retarding Basin B	
Location	Rightbank Side: 19.75k~24.10k
Flood Control Discharge (1000m ³)	7,157
Peak Cut Discharge (m ³ /s)	510
Peak water level in the basin by calculation (EL.m)	18.50
Length and Location of Overflow Dike	300m
	23.65k~23.95k
Elevation of the top of Overflow Dike (EL.m)	17.25
	(23.75k HWL-0.4m)
Peak water level at overflow dike by calculation (EL.m)	18.89
Overflow Depth (m)	1.64
Design Elevation of Height of Embankment surrounding the basin (EL.m)	19.05
	(23.95k Design Embankment Height)
Specifications of discharge.	B2.5×H2.5×2Gates
	Elevation of the bottom of drainage waterway EL. 8.20 m
	Outflow Rate Q=93.1m ³ /s
	Drainage Time t=16.4 hrs

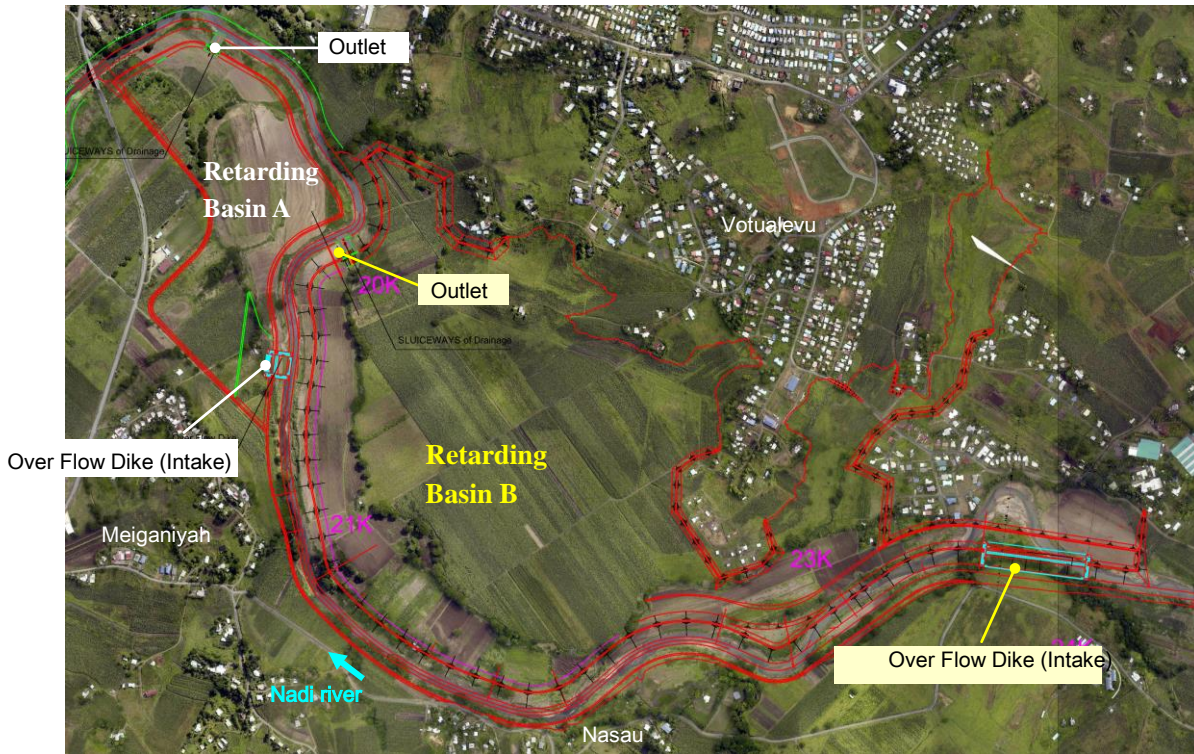


Figure 15-12 Layout of Retarding Basin B

(2) Cross-Sectional Plan

A Typical Cross Section of the retarding basin is as shown in Figure 15-10 earlier.

(3) Overflow Dike

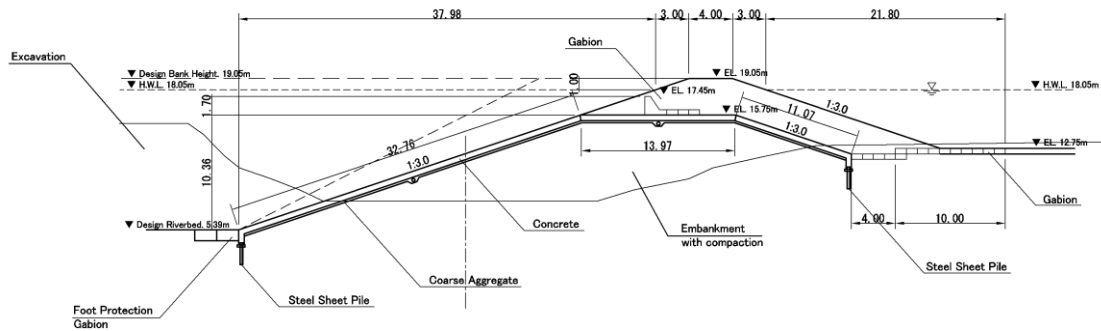


Figure 15-13 Typical Cross Section of Overflow Dike

15.3 Surrounding Dike of Nadi Town

The Surrounding Dike of Nadi Town is built mainly to prevent Nawaka River from flooding the Important Protected Area where Nadi Town center is located. Construction range and height of surrounding dike is determined through hydrological analysis.

(1) Plan

Plan of Surrounding Dike is as described in Figure 15-14.

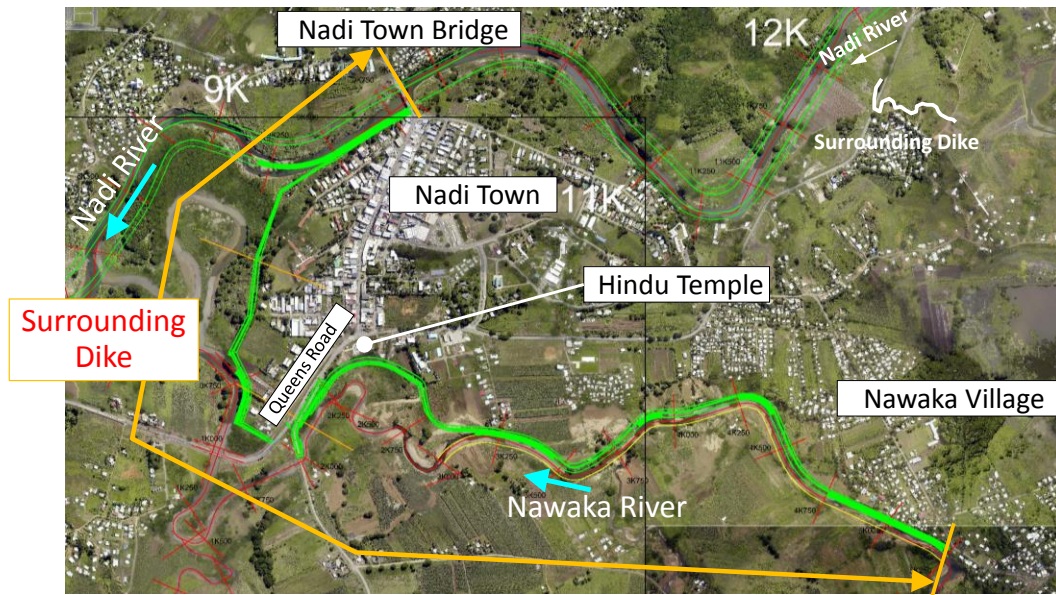


Figure 15-14 Plan of Surrounding Dike

(2) Longitudinal Plan

The height of surrounding dike of Nadi Town is, basically, set the same as that of the Master Plan.

The longitudinal plan of surrounding dike is as shown in Table 15-4.

Table 15-4 Longitudinal Plan of Surrounding Dike of Nadi Town

No.	Cross Section	Existing Ground Level	HWL	Inundation Depth by calculation when 1/50 flood occurs		Proposed height of Surrounding Dike	Setting Basis
				River	Landside		
1	Cross 1	6.36	5.76	—	—	6.76	Following the elevation of the crest of embankment of the Nadi River
2	Nadi 9.75K	6.36	5.72	6.28	—	6.72	
3	Nadi 9.50K	5.96	5.61	6.16	—	6.61	
4	Cross 2	5.43	—	—	5.73	6.67	
5	Cross 3	3.31	—	—	5.73	6.70	
6	Cross 4	5.19	—	—	5.73	6.74	
7	Cross 5	5.28	—	—	6.68	8.00	
8	Nawaka 0.75K	5.44	5.79	6.72	6.68	8.00	Following the inundation depth of landside when 1/50 flood occurs ← Location of Queens Road
9	Cross 6	6.14	—	—	7.79	8.00	
10	Nawaka 2.00K	6.20	7.26	—	8.68	9.00	
11	Cross 7	6.24	—	—	8.58	9.00	
12	Nawaka 2.50K	6.50	—	8.78	8.67	9.00	
13	Nawaka 2.25K	6.50	7.56	8.73	8.67	9.00	
14	Cross 8	6.56	—	—	8.76	9.00	
15	Cross 9	6.62	—	—	8.76	9.00	
16	Nawaka 2.75K	6.80	8.15	8.79	8.77	9.15	Following the elevation of the crest of embankment of the Nawaka River
17	Nawaka 3.25K	7.04	8.73	8.95	8.91	9.73	
18	Nawaka 3.50K	6.23	9.03	9.09	9.02	10.03	
19	Nawaka 3.75K	7.26	9.32	9.24	9.03	10.32	
20	Nawaka 4.00K	6.93	9.62	9.84	9.40	10.62	
21	Nawaka 4.25K	10.07	9.91	10.05	9.29	10.91	
22	Nawaka 4.50K	8.25	10.20	10.85	9.73	11.20	
23	Nawaka 4.75K	9.58	10.50	11.21	11.21	11.50	
24	Nawaka 5.00K	10.94	10.79	11.60	11.23	11.79	
25	Nawaka 5.25K	11.00	11.09	12.11	—	12.09	

(3) Cross-Sectional Plan

Crown width of embankment is set as 4.0m. Either river or land side of slope gradient is set as 1:3.

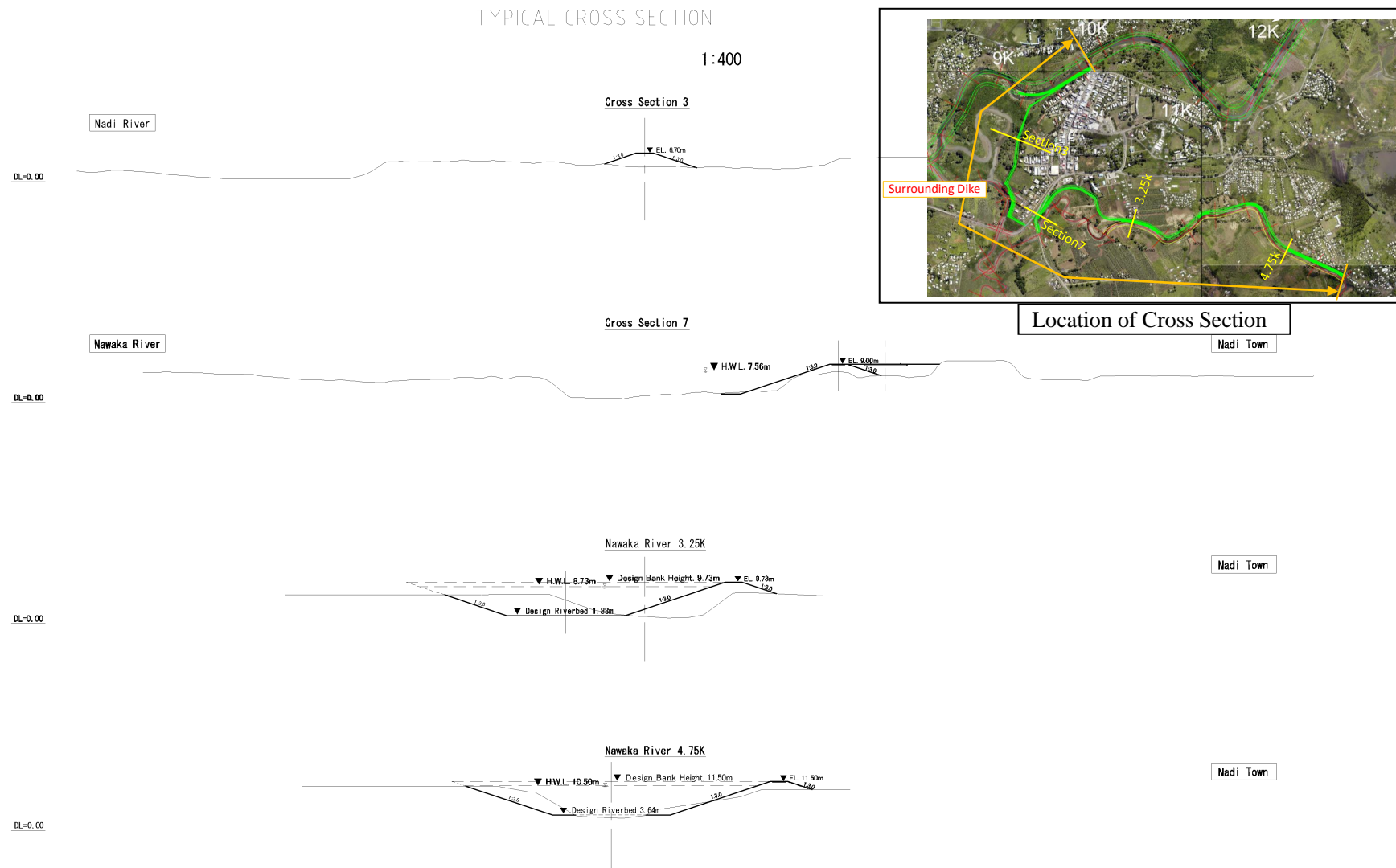


Figure 15-15 Typical Cross Section (Surrounding Dike of Nadi Town)

15.4 Ring Dike

Ring Dike is built in order to protect the community, which is located in downstream natural inundation area, from flooding.

(1) Plan

Ring Dike is built around the outer edge of the community to be protected. Access slope road from outer side of ring dike to inner side, drainage system and outlet are also built.

Plan of Ring Dike is as shown in Figure 15-16.

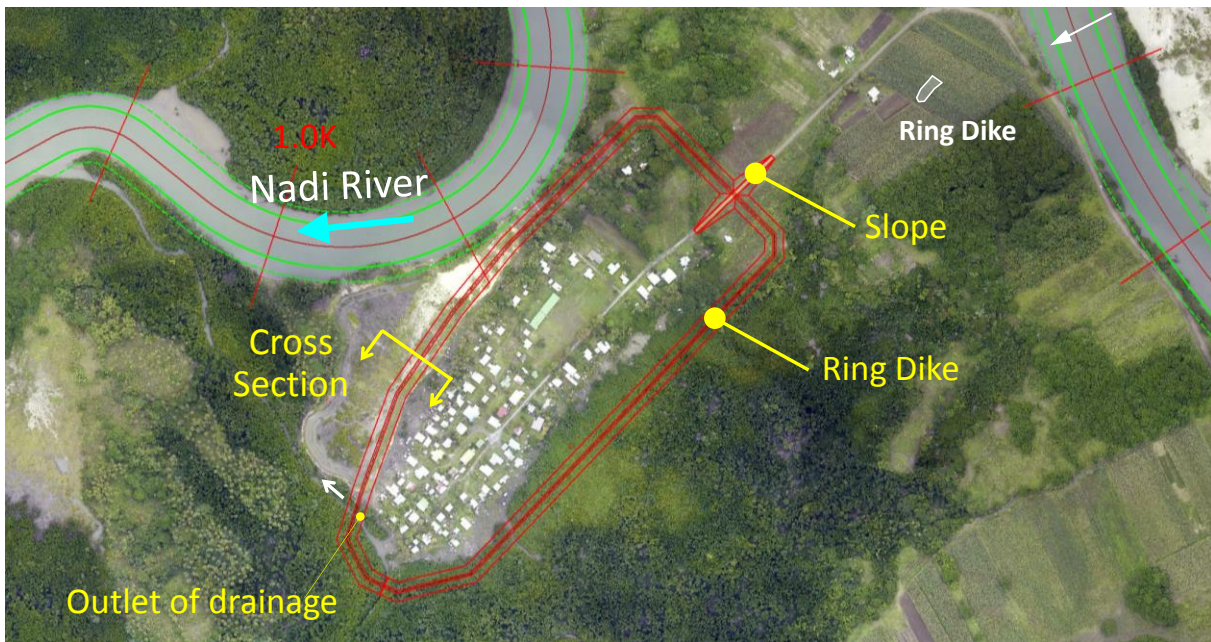


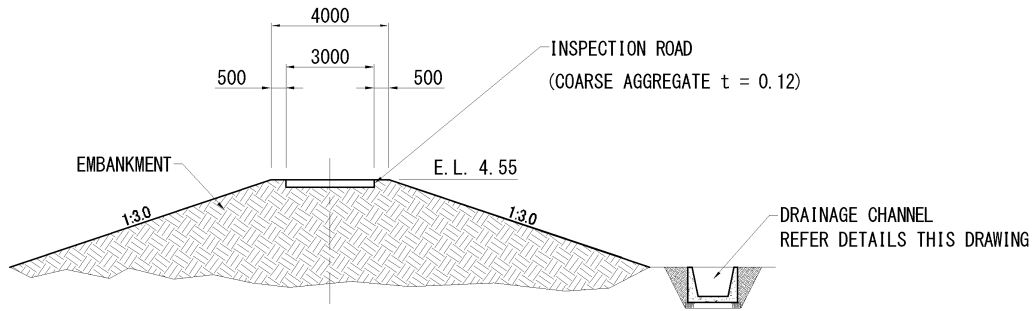
Figure 15-16 Plan of Ring Dike

(2) Longitudinal Plan

The elevation of inundation in downstream retarding basin is higher than water level in the Nadi River. Therefore, the elevation of the crest of Ring Dike is set considering the elevation of inundation. The elevation of the crest of Ring Dike is set at E.L. 4.55m for the entire section.

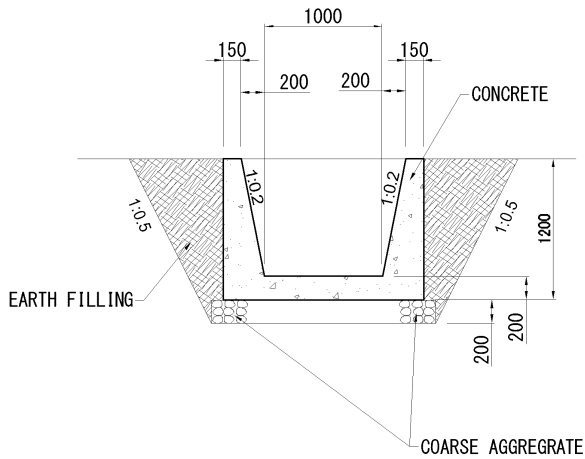
(3) Cross-Sectional Plan

Crown width of embankment is set as 4.0m. Either river or land side of slope gradient is set as 1:3.



EMBANKMENT ARRANGEMENT DETAILS

1 : 500



DRAINAGE CHANNEL DETAILS

1 : 50

Figure 15-17 Typical Cross Section (Ring Dike)

15.5 Shortcuts of tributaries

Surrounding Dike of Nadi Town mentioned before in Chapter 15.3 causes negative impact (Increasing of Inundation Depth) around the confluence points of Nawaka River and the Malakua River. Building shortcuts of tributaries, which can drain the flood flow smoothly to downstream, are planned in order to mitigate the negative impact.

The specifications (length, width) of shortcuts are set through hydrological analysis. Details of selection of counter measures and flood analysis result are mentioned in “Final Report: Volume II, Main Report, Part I :Master Plan Sturdy, 7.7.3(3) Counter Measures for Negative Impact caused by the Priority Project”.

The plan and typical cross sections of the shortcuts are described in Figure 15-18 and Figure 15-19, respectively.

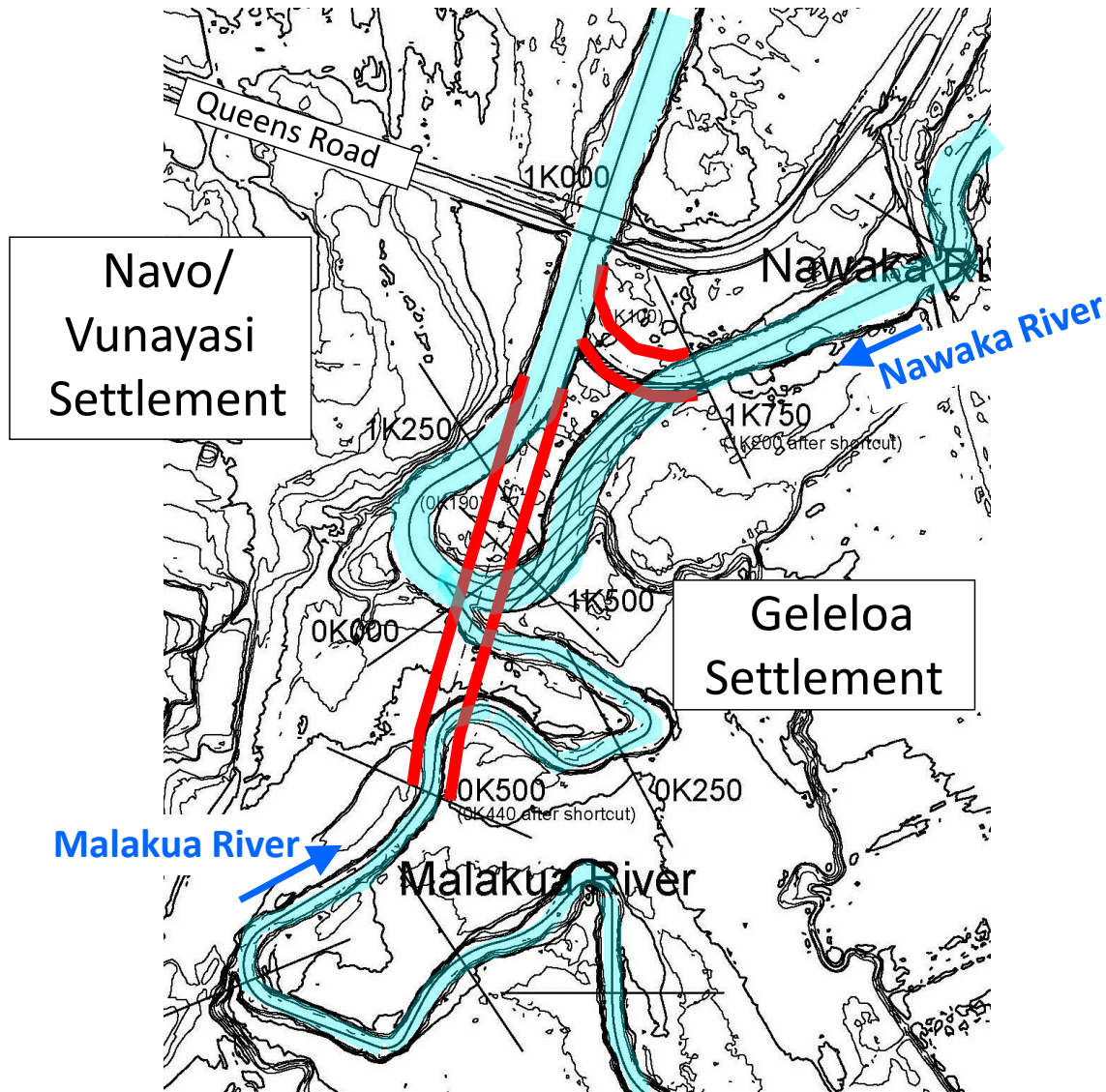
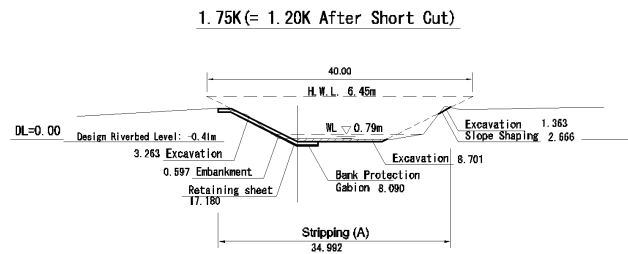
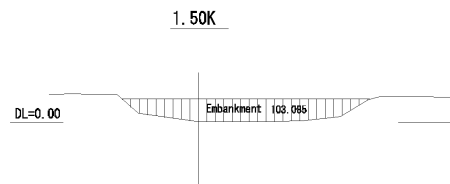
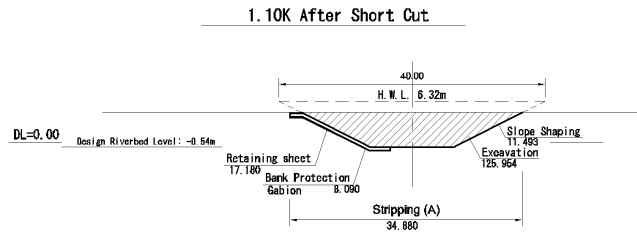


Figure 15-18 Plan of Shortcuts of Tributaries

Nawaka River Short Cut Section



Malakua River Short Cut Section

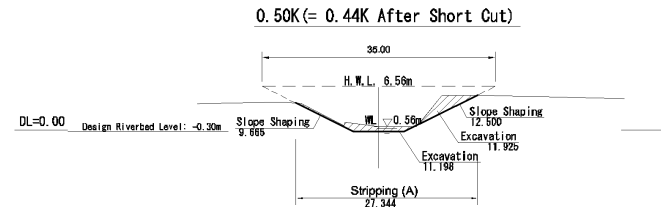
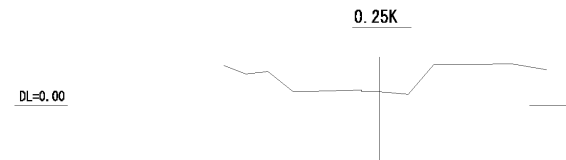
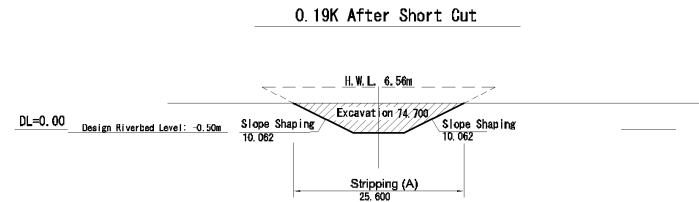


Figure 15-19 Typical Cross Section (Shortcuts of Tributaries)

15.6 Rebuilding of Bridges

15.6.1 Design Standards

The major technical standards shown in the Table 15-5 will be applied in the preliminary design of bridges in this project. There are some bridge design standards based on the standards of New Zealand and Australia in Fiji. These standards specify the basic regulations such as live loads but details are not provided. Therefore, the standards of Fiji, New Zealand, Australia and Japan is referred to the preliminary design in this project. Furthermore, the details should be decided through discussion with MOT when the detailed design is implemented.

Table 15-5 Major Technical Standards and Reference Documents

No.	Name	Editor / Publishing Office	Date of publication	Remarks
1	Cabinet Order Concerning Structural Standards for River Management Facilities, etc.	Japan River Association	January 2000	
2	Specifications for highway bridges	Japan Road Association	March 2012	
3	Government Order on Road Design Standards	Japan Road Association	February 2004	
4	Design Guide – Bridge wharf, jetty, culvert and crossing structures - Revision: Version A	Fiji Road Authority	June 2015	Bridge Design Standards
5	Guide to road design	Austroroad	August 2010	Road Design Standards
6	Bridge manual (SP/M/022) Third Edition	New Zealand Transport Agency	September 2014	Bridge Design Standards
7	AS/NZS 1170.0:2002	Australian/New Zealand Standard	June 2002	General requirements are shown in structural design
8	NZS 1170.5: 2004	New Zealand Standard	December 2004	Seismic Design Standards
9	NZS 3101:2006	New Zealand Standard	March 2006	Design Standards for Concrete Structures

Source: JICA Study Team

15.6.2 Preliminary Design of Nadi Town Bridge

(1) Summary

The bridge concerned is located at point where Queens Road, a primary arterial road, crosses the Nadi River (see Figure 15-20). The bridge consists of a 3-span steel cantilever girder bridge and a simple span steel girder bridge, with total length of 72.0m, and it was constructed in 1965 (see Photo15-1, Figure 15-21). This bridge was planned to be rebuilt since freeboard (clearance below the girder) could not be maintained and length of bridge is not enough after widening. The plan was to build the new bridge, which is 108 m long, at the same location due to the limitation of land (see Figure 15-22).

1) Superstructure

The HWL around the rebuilt bridge location is high; there is no alternative other than making the design vertical alignment higher than existing bridge in order to maintain the design freeboard below girder. Also, it was needed to employ a low height girder bridge because the elevation of road surface could not be raised due to the neighboring traffic junction and shopping street, and river block and cost issue considerations. Therefore, a 3-span PC continuous post-tension T-Girder Bridge was planned considering the past experiences of

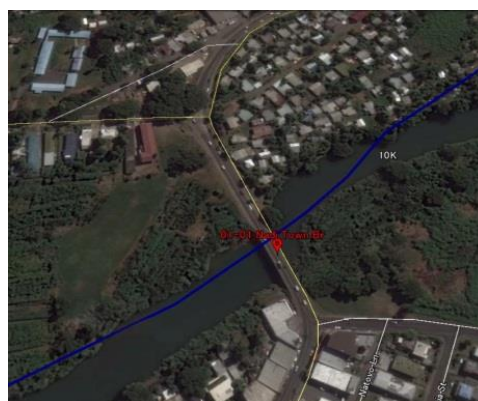


Figure 15-20 Bridge Location



**Photo 15-1 Current View
(from lower left bank)**

successful construction and cost performance.

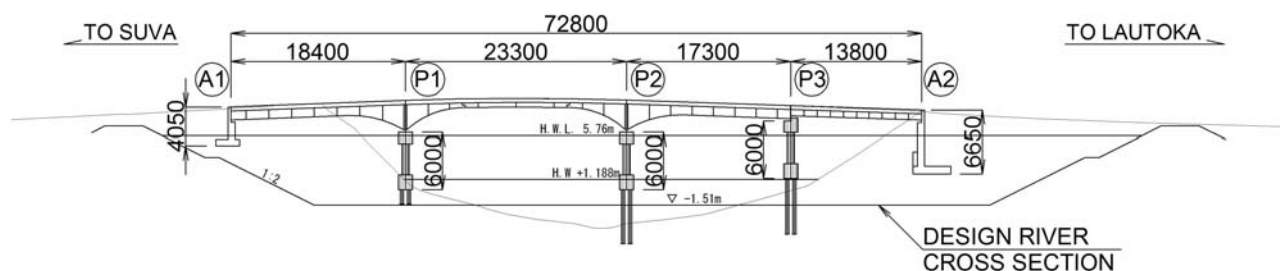


Figure 15-21 (1) Side View of Existing Bridge (Nadi Town Bridge) Source: JICA Study Team

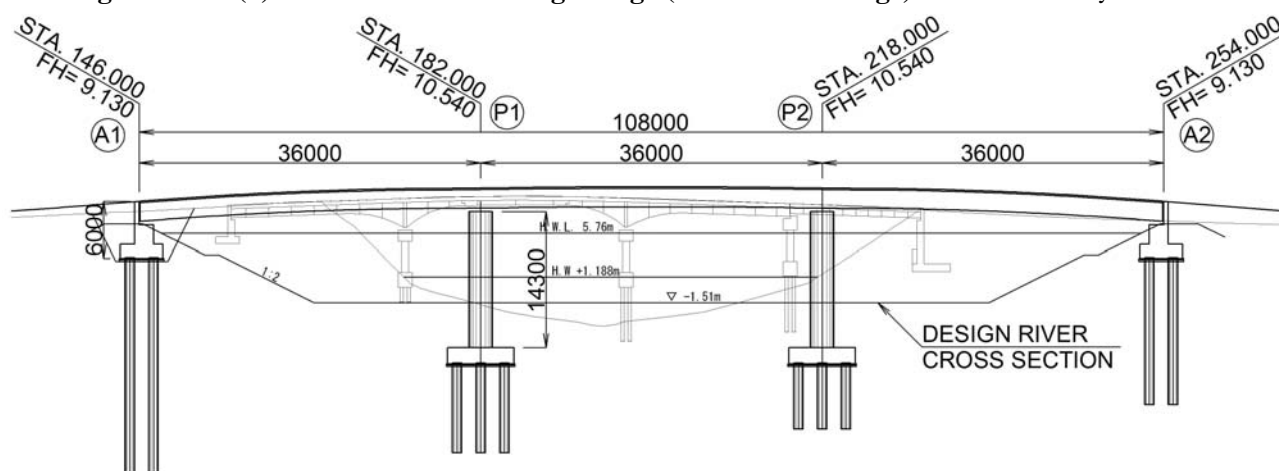


Figure 15-21 (2) Side view of new bridge (Nadi Town Bridge) Source: JICA Study Team

(2) Consideration of Road Alignments

1) Design Policy

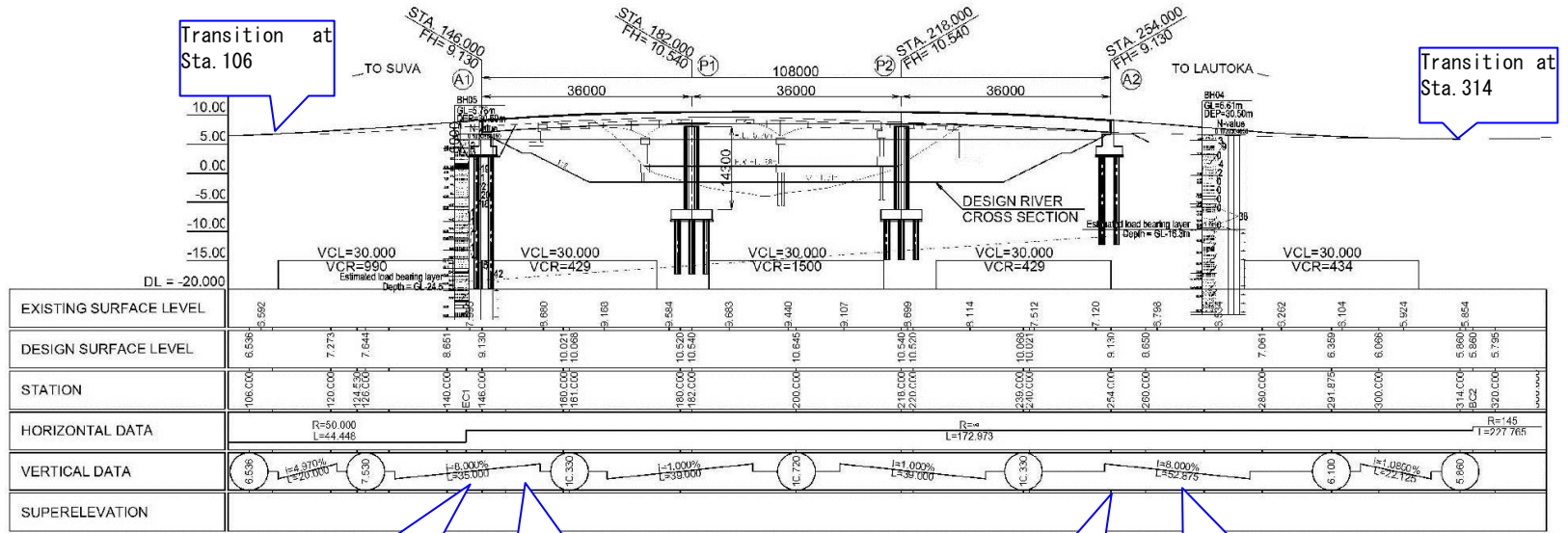
In this planning project, cross sectional plan, horizontal and vertical alignment are examined, and also the road alignment for bridge section and approach roads on both sides of the existing bridge are planned in order not to redo the detailed road & bridge design in the future.

The basic design principles in this planning are as follows:

- ✓ The number of carriageways should be the same as that of the existing bridge.
- ✓ The horizontal alignment should not be changed due to the limitation of land.
- ✓ The vertical alignment should be set up based on the girder height of the specified type of superstructure, and the clearance below girder. Also, the approach roads on both sides of the existing bridge should be connected to the present earth work section, but it is required not to raise elevation of road surface around the neighboring traffic junction as much as possible to keep the access to the neighboring shopping stores and residential houses. To realize this, transition toward the existing elevation is considered making the improvement area as short as possible under the applicable standards with consideration of mobility.

2) Consideration of Road Alignments

The plan and vertical section drawings, which are prepared according to the above-mentioned principles, are shown in Figure 15-22.



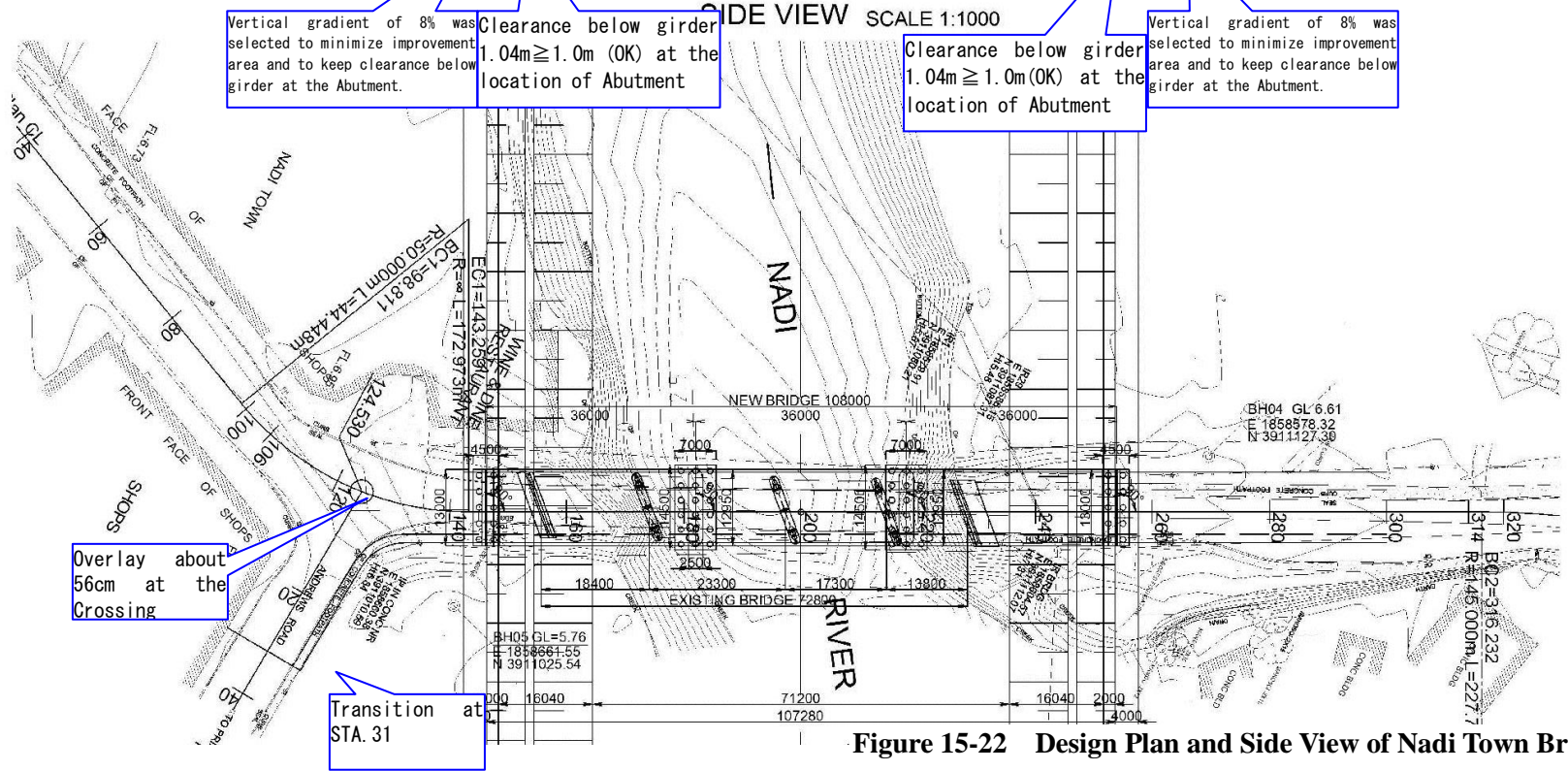
Transition at Sta. 106

Transition at Sta. 314

Vertical gradient of 8% was selected to minimize improvement area and to keep clearance below girder at the Abutment.

Clearance below girder 1.04m ≥ 1.0m (OK) at the location of Abutment

Vertical gradient of 8% was selected to minimize improvement area and to keep clearance below girder at the Abutment.



Overlay about 56cm at the Crossing

Transition at STA. 31

Figure 15-22 Design Plan and Side View of Nadi Town Bridge

Source: JICA Study Team

15.6.3 Preliminary Design of Old Queens Road Bridge

(1) Summary

The bridge concerned is located at the point where the primary rural road of Old Nadi Back Road crosses the Nadi River (see Figure 15-24), and it is a 9-span simple steel bridge, with a total length of 99.3m, constructed in 1936. The width is about 3m and its sidewalk was constructed on the overhanging beam additionally. Moreover, a tramline also passes on this bridge girder, which span is divided the same as that of the road bridge, and the substructure is combined (see Photo15-2, Figure 15-23). This bridge was decided to be reconstructed because of the following reasons:

- ✓ Span length is short (maximum span length is 12.3m, and the number of piers is 8, while, the *Cabinet Order concerning structural Standards for River Management Facilities*, etc. specifies standard span length as 20m, and limits maximum number of piers to 4), and there is inconsistency between the direction of normal river normal line and the direction of piers, which may lead to flow blockage after the improvement.
- ✓ Piers were located within the planned slope, and the stability of revetment body cannot be confirmed.
- ✓ The foundation was exposed due to the scouring of river bed, and structural stability may become a big issue.

The new bridge was planned as below considering the site conditions and planned cross section of the river (see Figure 15-24).

1) Road Bridge

Road width was planned as two-lane road, one lane for each direction like the approach roads, and the tramline was planned to move to the lower river side due to the land limitation.

The clearance below girder was secured by raising the vertical alignment higher than current elevation because of high HWL. Meanwhile, formation level of road surface could not be raised because of adjacent cement factory or many residential houses. In addition, river blockage and cost were to be considered. Considering these situation, it was required to employ low height girders. Hence, PC 3-span Continuous Post Tension I-Girder Bridge (bridge length of 96m) was planned considering the past successful construction experiences in Fiji and construction cost.

2) Tramline Bridge

“Through bridge type” was selected to secure the clearance below girder because the vertical alignment could not be changed considering the climbing capacity and safe operation of trams.

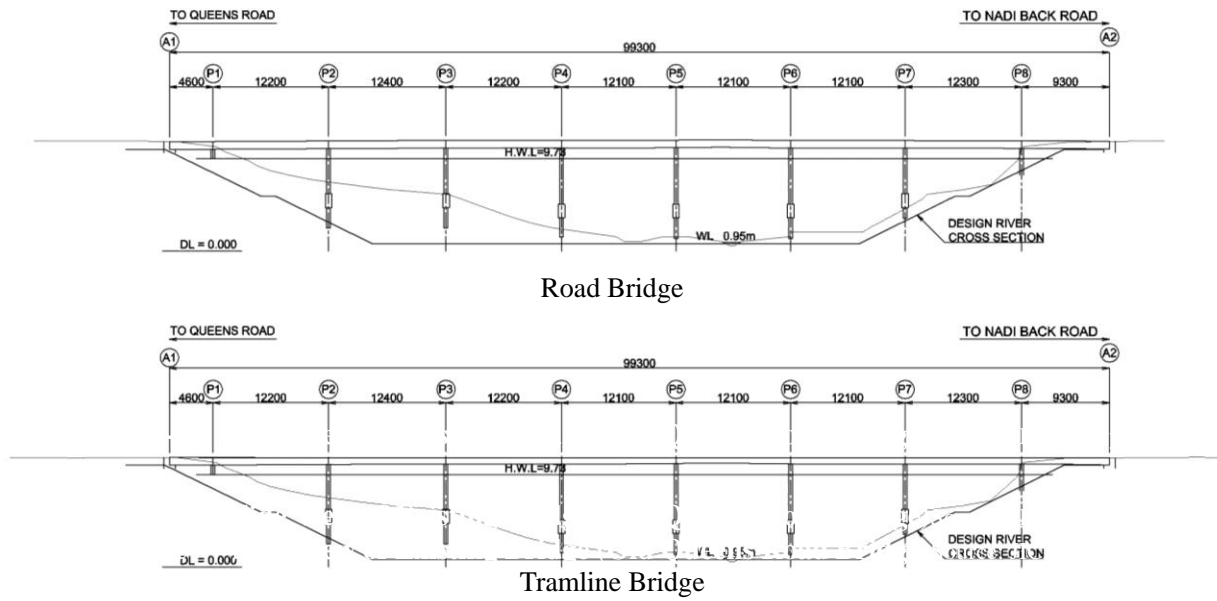
A Steel 3-span Continuous Through-Bridge with the same span division as that of the Road Bridge was selected considering the past successful construction experiences in Fiji and construction cost.



Figure 15-23 Bridge Location

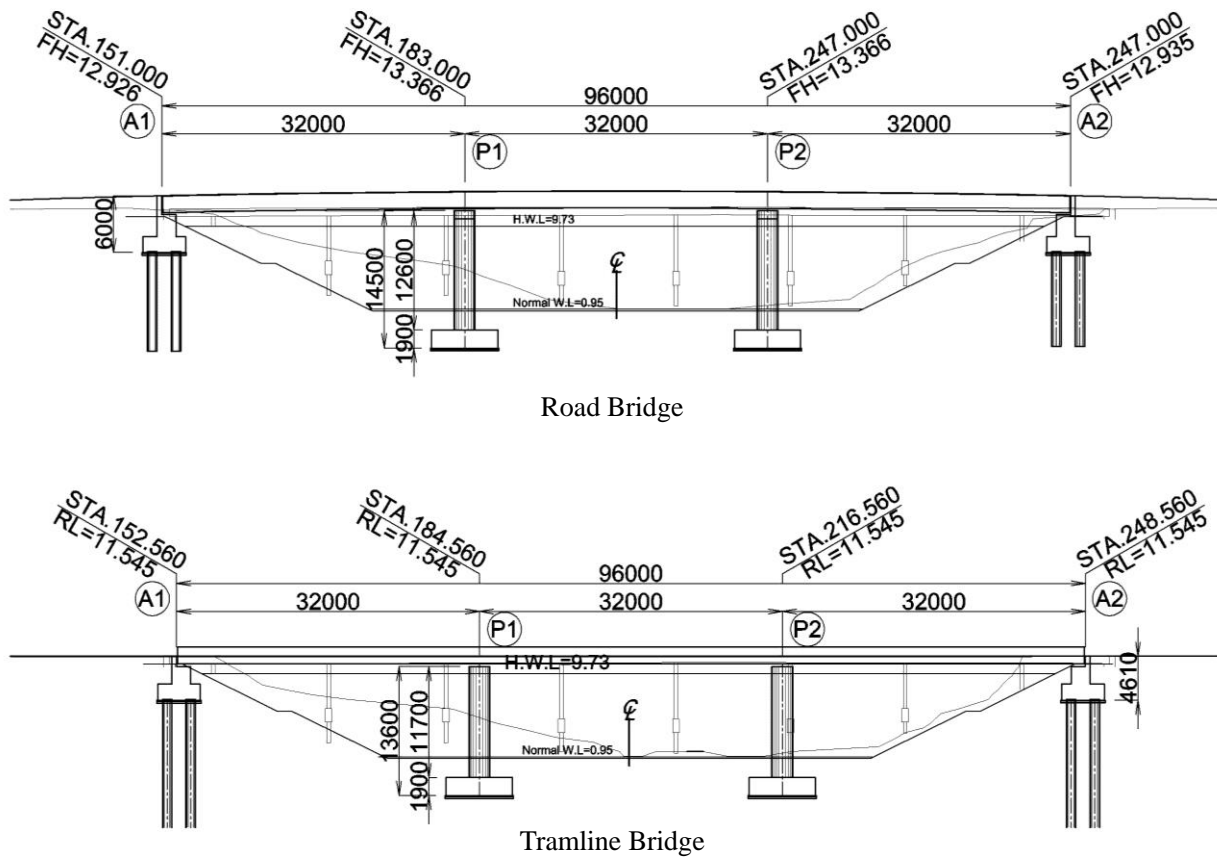


Photo 15-2 Site Photo



Source: JICA Study Team

Figure 15-24 Side view of existing bridge (Old Queens Road Bridge)



Source: JICA Study Team

Figure 15-25 Side view of new bridge (Old Queens Road Bridge)

(2) Consideration of Road Alignments

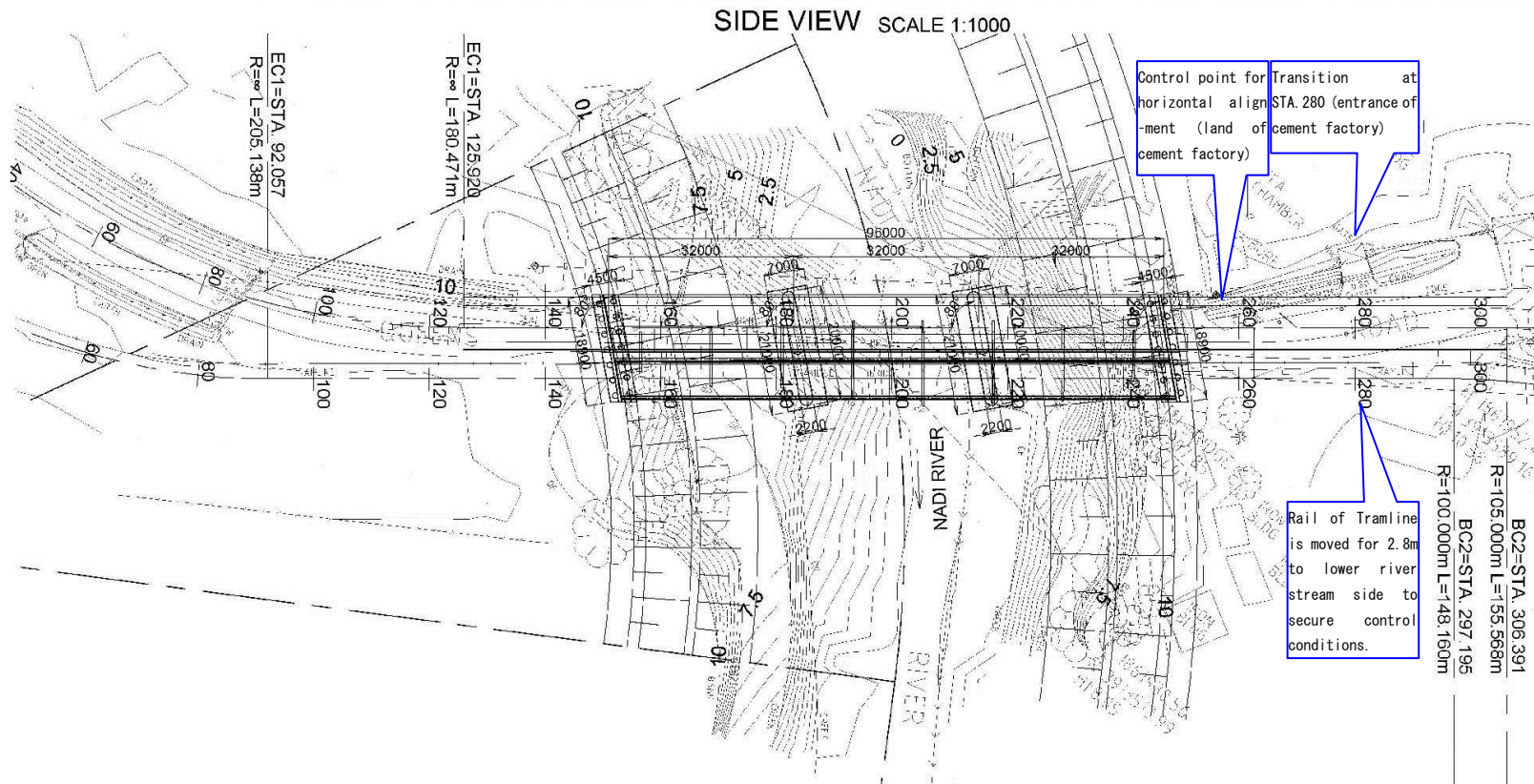
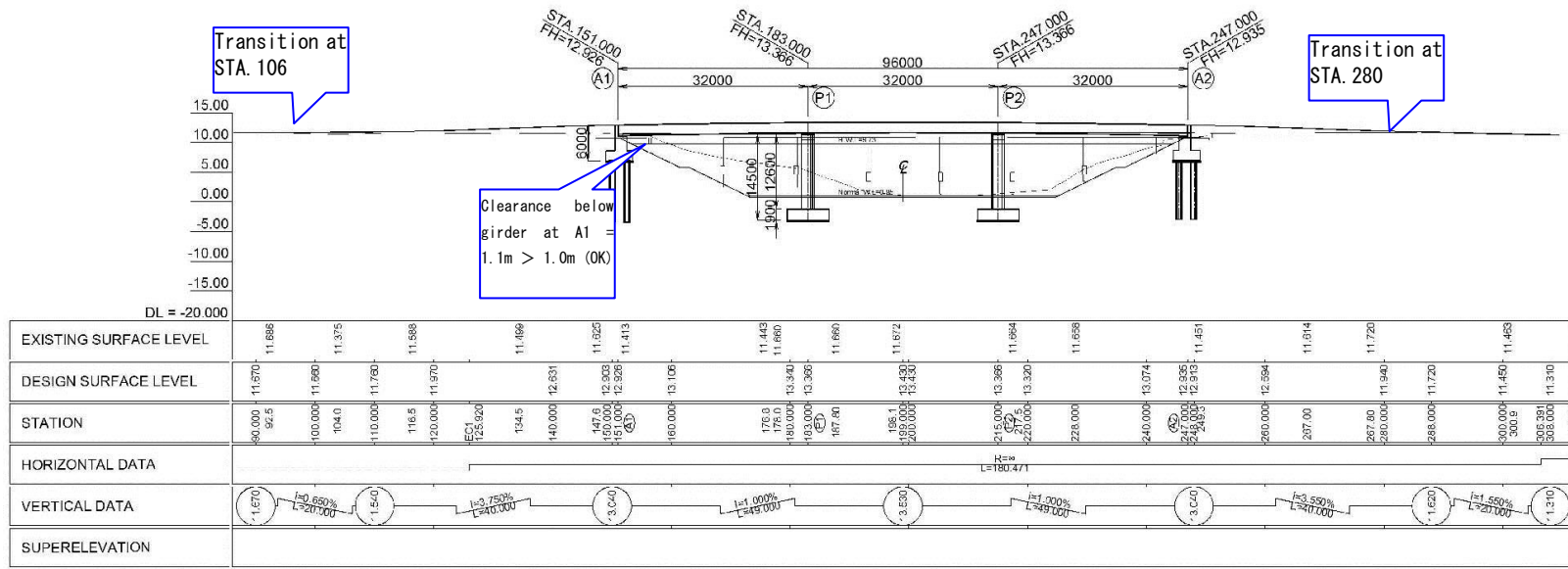
1) Design Policy

In this planning project, cross sectional plan, horizontal & vertical alignment are examined, and also the road & tramline alignments for bridge section and approach roads on both sides of the existing bridge are planned in order not to redo the detailed road & bridge design in the future. The basic principles of the design in this planning are as follows:

- ✓ Road width was planned as two-lane road, one lane for each direction, like the approach roads. Horizontal alignment should be controlled by the land of cement factory on the left bank side.
- ✓ Vertical alignment of road should be controlled by girder height of the superstructure type as mentioned below and the clearance under the girder. The transition section is set at front and behind the bridge. The access should be secured by limiting the raise of the road surface around the entrance of the cement factory.
- ✓ Horizontal alignment of tramline should be parallel to the road, and the transition section should be toward the existing road conditions. The vertical transition should be toward achieving the current level considering the climbing capacity and safe operation of trams.

2) Consideration of Alignments

Plan and side view drawings of the road design prepared based on the above-mentioned principle are shown in the next page.



PLAN VIEW SCALE Figure 15-26 Plan and Side View of Old Queens Road Bridge

Source: JICA Study Team

15.7 Approximate Construction Quantity

Approximate Construction Quantity is as described in Table 15-6 and Table 15-7.

Table 15-6 Approximate Construction Quantity (River Works)

This document is a preceding summary for the Public Consultation. Therefore, it does not contain the information that can be inferred a project cost.

Table 15-7 Approximate Construction Quantity (Bridge Works)

This document is a preceding summary for the Public Consultation. Therefore, it does not contain the information that can be inferred a project cost.

15.8 Construction Planning

15.8.1 River Works

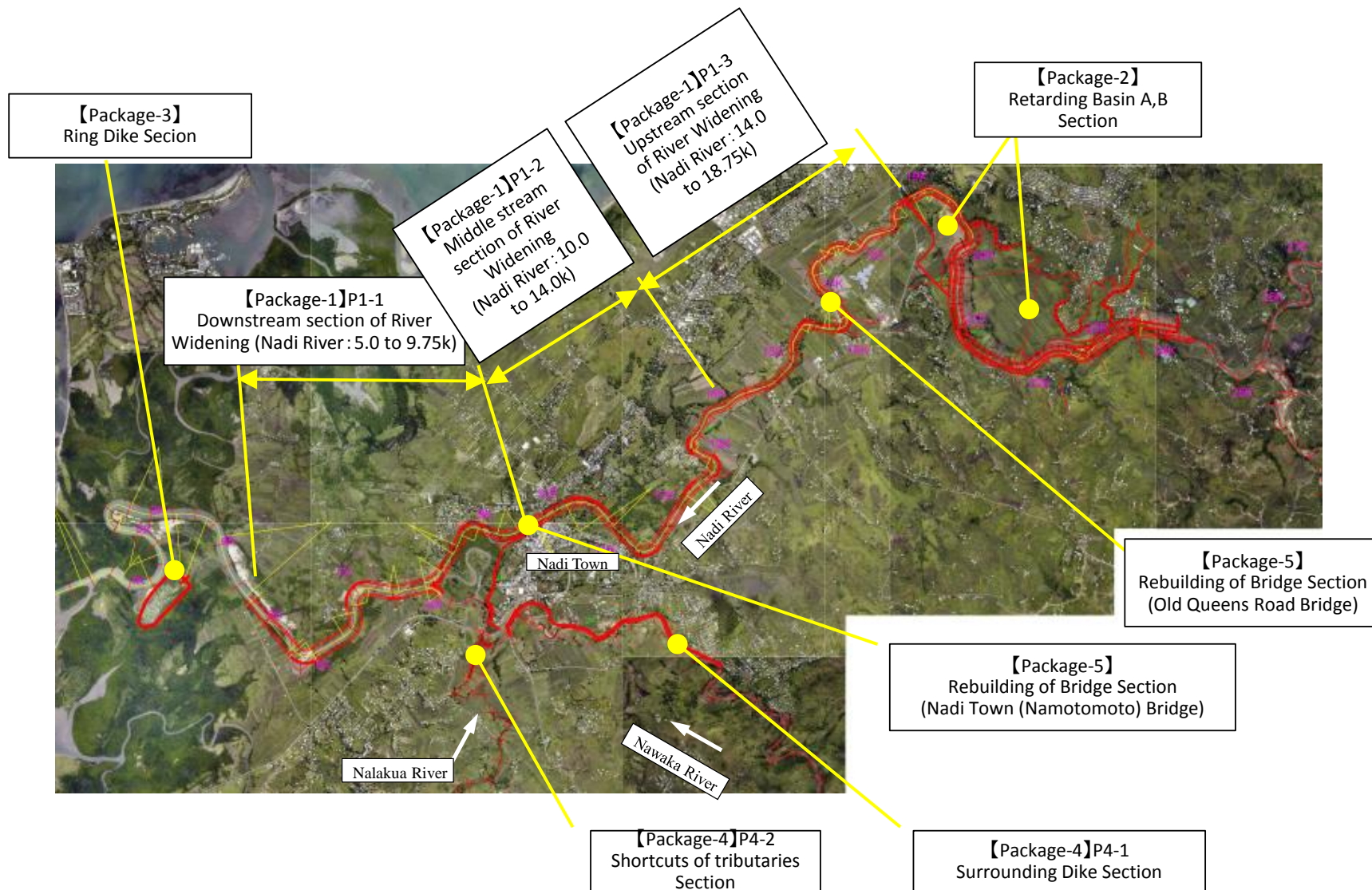
(1) Construction Section

Construction work under this Project has been divided into four (4) major construction sections, some of which are subdivided into smaller construction sections. Construction sections are as shown in Table 15-8 and Figure 15-27.

Table 15-8 Division of Construction Sections

Construction Sections		Contents of Works
Major Section	Break Down	
Package-1: River Widening	P1-1: Downstream section of River Widening (Nadi River : 5.0–9.75k)	• River Widening (Excavation and Embankment)
	P1-2: Middle stream section of River Widening (Nadi River : 10.0–14.0k)	• River Widening (Excavation and Embankment)
	P1-3: Upstream section of River Widening (Nadi River : 14.0–18.75k)	• River Widening (Excavation and Embankment)
Package-2: Retarding Basin A, B Section		• Construction of Retarding Basin A, B
Package-3: Ring Dike Section		• Construction of Ring Dike
Package-4: Surrounding Dike and shortcuts of tributaries Section	P4-1 Surrounding Dike Section	• Construction of Embankment on left bank side of Nadi River • Construction of Embankment on right bank side of Nawaka River
	P4-2 Shortcuts of tributaries Section	• Shortcuts of tributaries
Package-5: Rebuilding of Bridge Section		• Rebuilding of Nadi Town Bridge (Namotomoto Bridge) • Rebuilding of Old Queens Road Bridge

Source: JICA Study Team



Source: JICA Study Team

Figure 15-27 Division of Construction Sections

(2) Work Schedule

The calculation result of construction period is as shown in Table 15-9. The work schedule is as described in Table 15-10.

Table 15-9 Construction Period (River Work)

Package	Section	Main Earth Works	Construction Execution Volume (m ³ /日)	Construction Volume (m ³)	Number of Equipments (Nos)	Work Day (days)	Ratio	Construction Period	
								Day (days)	Month (month)
P1 River Widening	P1-1 River Widening in downstream section	Installation of Cofferdam	600	143,693	3	80	1.7	136.0	4.5
		Removal of Cofferdam	600	143,693	3	80	1.7	136.0	4.5
		Excavation	710	1,781,637	12	210	1.7	357.0	11.9
		Embankment and Backfilling	320	424,593	6	222	1.7	378.0	12.6
	P1-2 River Widening in middle stream section	Installation of Cofferdam	600	76,500	3	43	1.7	74.0	2.5
		Removal of Cofferdam	600	76,500	3	43	1.7	74.0	2.5
		Excavation	710	1,218,717	12	144	1.7	245.0	8.2
		Embankment and Backfilling	320	276,153	6	144	1.7	245.0	8.2
	P1-3 River Widening in upstream section	Installation of Cofferdam	600	39,558	6	11	1.7	19.0	0.6
		Removal of Cofferdam	600	39,558	6	11	1.7	19.0	0.6
		Excavation	710	927,827	12	109	1.7	186.0	6.2
		Embankment and Backfilling	320	496,517	6	259	1.7	441.0	14.7
P2 Retarding Basin	P2 Retarding Basin A,B	Installation of Cofferdam	600	41,605	6	12	1.7	21.0	0.7
		Removal of Cofferdam	600	41,605	6	12	1.7	21.0	0.7
		Excavation	710	1,257,035	5	34	1.7	58.0	1.9
		Embankment and Backfilling	320	1,159,681	4	87	1.7	148.0	4.9
P3 Ring Dike	P3 Ring Dike	Excavation	320	6,446	2	3	1.7	6.0	0.2
		Embankment and Backfilling	300	78,970	2	37	1.7	63.0	2.1
		—	—	—	—	—	—	—	—
P4 Surrounding Dike & Shortcut	P4-1 Surrounding Dike of Nadi Town	Excavation	320	290,737	2	51	1.7	87.0	2.9
		Embankment and Backfilling	300	285,614	2	53	1.7	91.0	3.0
		—	—	—	—	—	—	—	—
	P4-2 Shortcuts of tributaries	Excavation	320	23,431	2	37	1.7	63.0	2.1
		Embankment and Backfilling	300	27,725	2	47	1.7	80.0	2.7
—	—	—	—	—	—	—	—		

Source: JICA Study Team

15.8.2 Bridge Works

(1) Nadi Town Bridge

A1 Abutment of Nadi Town Bridge is located adjacent to the urban area and A2 Abutment is adjacent to the residential houses and a primary school. The traffic volume of Queens Road, which the bridge is located, is quite heavy because it is a primary road in the region. The bridge is located in a tidal river section area.

The flow of bridge rebuilding, principle of construction at each step, and typical construction period are explained hereunder, considering the above-mentioned site conditions.

1) Construction Process

The construction process flow of this bridge is shown in Figure 15-28. The planning of river improvement work planning at the bridge rebuilding location is underway, but it will be implemented separately from this bridge because of its excessive length.

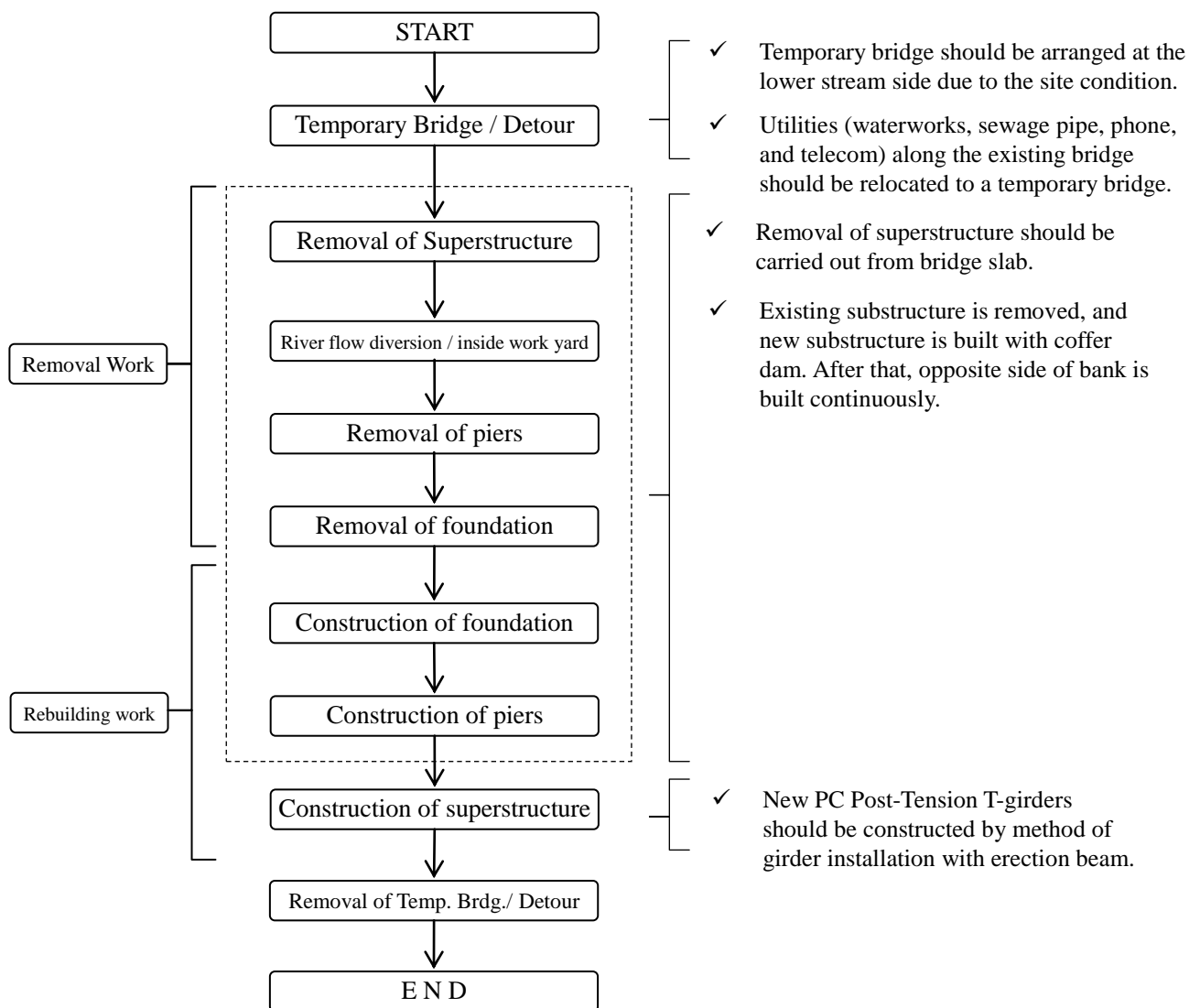


Figure 15-28 Construction Flow (Nadi Town Bridge)

2) Work Schedule

The outline of construction schedule is as shown in Table 15-11. The substructure in the present river channel is to be constructed in a dry season. The superstructure is to be constructed by the erection girder method over the water surface and behind of abutment so that the construction can be done through the year.

Table 15-11 Process Scheduling (Nadi Town Bridge)

Item	M	1st Year												2nd Year												3rd Year											
		1	2	3	4	5	6	7	8	9	10	11	12	1	2	3	4	5	6	7	8	9	10	11	12	1	2	3	4	5	6	7	8	9	10	11	12
Preparatory Works	1	← Dry Season →												← Dry Season →												← Dry Season →											
Detour	1	[Bar]												[Bar]												[Bar]											
Temporary Bridge	3	[Bar]												[Bar]												[Bar]											
Removing Existing Superstructure	4	[Bar]												[Bar]												[Bar]											
Abutments Works	2	[Bar]												[Bar]												[Bar]											
Removing Existing Abutments	1	[Bar]												[Bar]												[Bar]											
Coffering Works	1	[Bar]												[Bar]												[Bar]											
Removing Existing P3 Pier	0.5	[Bar]												[Bar]												[Bar]											
Construction P2 Pier	2.5	[Bar]												[Bar]												[Bar]											
Revetment Works Right Bank	1	[Bar]												[Bar]												[Bar]											
Coffering Works	1	[Bar]												[Bar]												[Bar]											
Removing Existing P1 & P2 Pier	1	[Bar]												[Bar]												[Bar]											
Construction P1 Pier	2.5	[Bar]												[Bar]												[Bar]											
Revetment Works Left Bank	1	[Bar]												[Bar]												[Bar]											
Superstructure Erection Works	10	[Bar]												[Bar]												[Bar]											
Removing Temporary Bridge	1.5	[Bar]												[Bar]												[Bar]											
Removing Detour	0.5	[Bar]												[Bar]												[Bar]											
Clear Works	0.5	[Bar]												[Bar]												[Bar]											

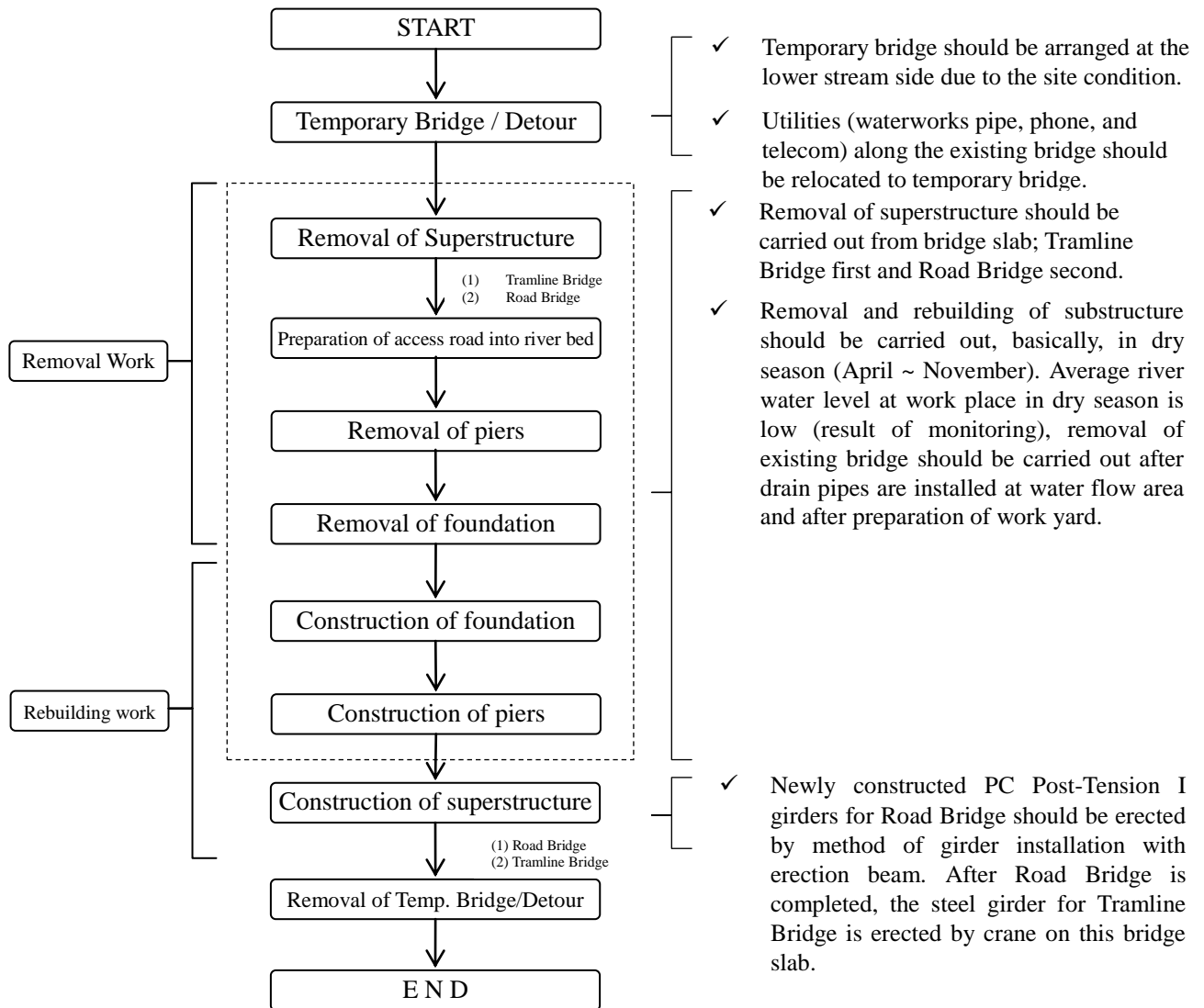
Source: JICA Study Team

(2) Old Queens Road Bridge

A2 Abutment of Old Queens Road Bridge is located adjacent to the cement factory and private houses along the existing road, and the Old Nadi Back Road, which include this bridge, is the primary road of this region. This road connects Queens Road and Nadi Back Road, and the traffic volume is high. The flow of bridge rebuilding, principle of construction at each step, and typical construction period are explained hereunder, considering the above-mentioned site conditions.

1) Construction Process

The construction process of this road bridge and tramline bridge, are shown in Figure 15-29 respectively.

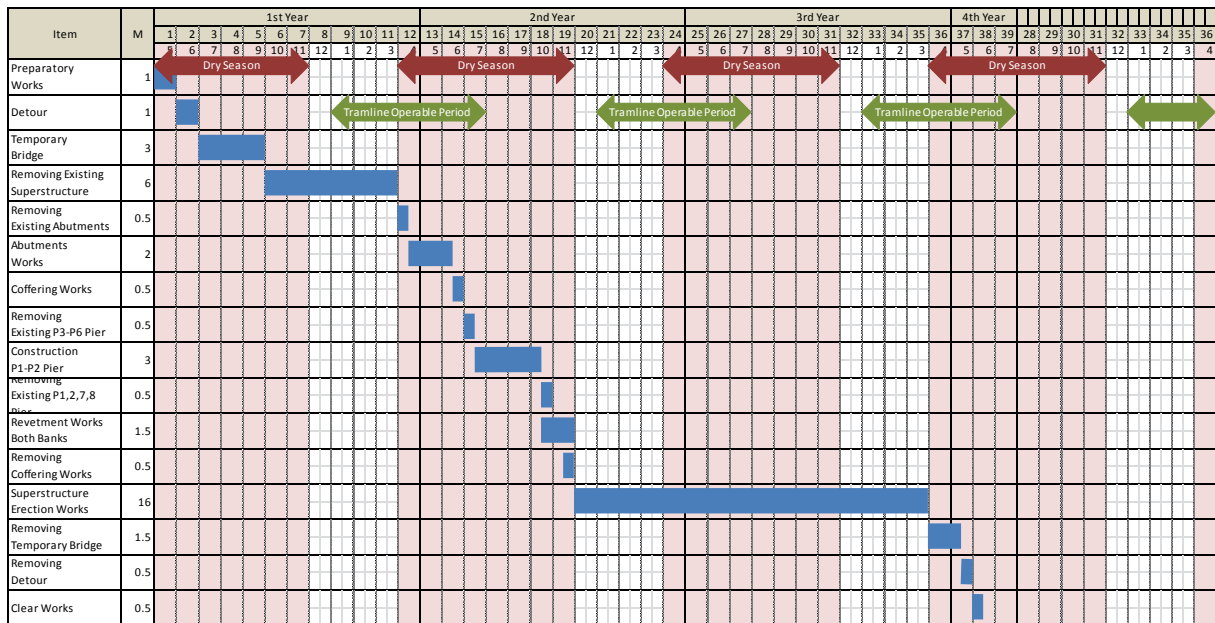


Source: JICA Study Team

Figure 15-29 Construction Flow (Old Queens Road Bridge)

2) Work Schedule

Table 15-12 Process Scheduling (Old Queens Road Bridge)



Source: JICA Study Team

15.8.3 Whole Construction Work Schedule

Whole Construction Work Schedule of this project, which is combines river work and bridge work, is as described in Table 15-13.

Chapter 16 Land Acquisition and House Compensation

16.1 Land Acquisition

In this project, land acquisition is required for Package-1 (River Widening), Package-2 (Retarding basin A, B), Package-3 (Ring Dike), Package-4 (Surrounding Dike and Shortcuts of tributaries), and Package-5 (Rebuilding of Bridges). Approximate area of required land acquisition is as shown in Table 16-1. This area is calculated by Department of Land in Fiji.

Table 16-1 Land Acquisition Area

This document is a preceding summary for the Public Consultation. Therefore, it does not contain the information that can be inferred a project cost.

16.2 Compensation

Relocation of houses for river widening and construction of embankment is required in Package-1 (River Widening) and Package-2 (Retarding Basin A, B). The number of houses that should be relocated is as shown in Table 19-27.

In addition, there are some downstream houses which are to be affected negatively by the Priority Project but not affected directly. The number of affected houses is also as shown in Table 16-2.

Table 16-2 Number of houses to be affected and relocated

This document is a preceding summary for the Public Consultation. Therefore, it does not contain the information that can be inferred a project cost.

Chapter 17 Project Cost Estimation

17.1 Project Cost Estimation System

The following items were considered in the project cost estimation:

1. Direct construction cost
2. Consulting service (CS) cost
3. Work site compensation cost
4. Administrative cost
5. Price increase
6. Contingency
7. Taxes

This document is a preceding summary for the Public Consultation. Therefore, it does not contain the information that can be inferred a project cost.

17.2 Project Cost Unit Price Estimation

This document is a preceding summary for the Public Consultation. Therefore, it does not contain the information that can be inferred a project cost.

17.3 Quantity of Each Work Item

Table 17-1 Quantity of Each Work Item of River Improvement

This document is a preceding summary for the Public Consultation. Therefore, it does not contain the information that can be inferred a project cost.

Table 17-2 Quantity of Each Work Item of Bridge work

This document is a preceding summary for the Public Consultation. Therefore, it does not contain the information that can be inferred a project cost.

Table 17-3 Quantity of Each Work Item of Site acquisition

This document is a preceding summary for the Public Consultation. Therefore, it does not contain the information that can be inferred a project cost.

Table 17-4 Number of houses to be affected and relocated by the project

This document is a preceding summary for the Public Consultation. Therefore, it does not contain the information that can be inferred a project cost.

17.4 Project Cost Estimation

This document is a preceding summary for the Public Consultation. Therefore, it does not contain the information that can be inferred a project cost.

Chapter 18 Project Implementation Plan

18.1 Purpose of the Project

The Project is to improve flood control measures in the Nadi River basin, which has been seriously flooded, through infrastructure improvement including river improvement, and thus contribute to the reduction of flood damage and the improvement of the living environment of the local residents.

18.2 Target Area

Purpose of the Priority Project is preferentially to mitigate inundation of Important Protected Area.

Figure 18.1 shows the components of structure measures of the priority project.

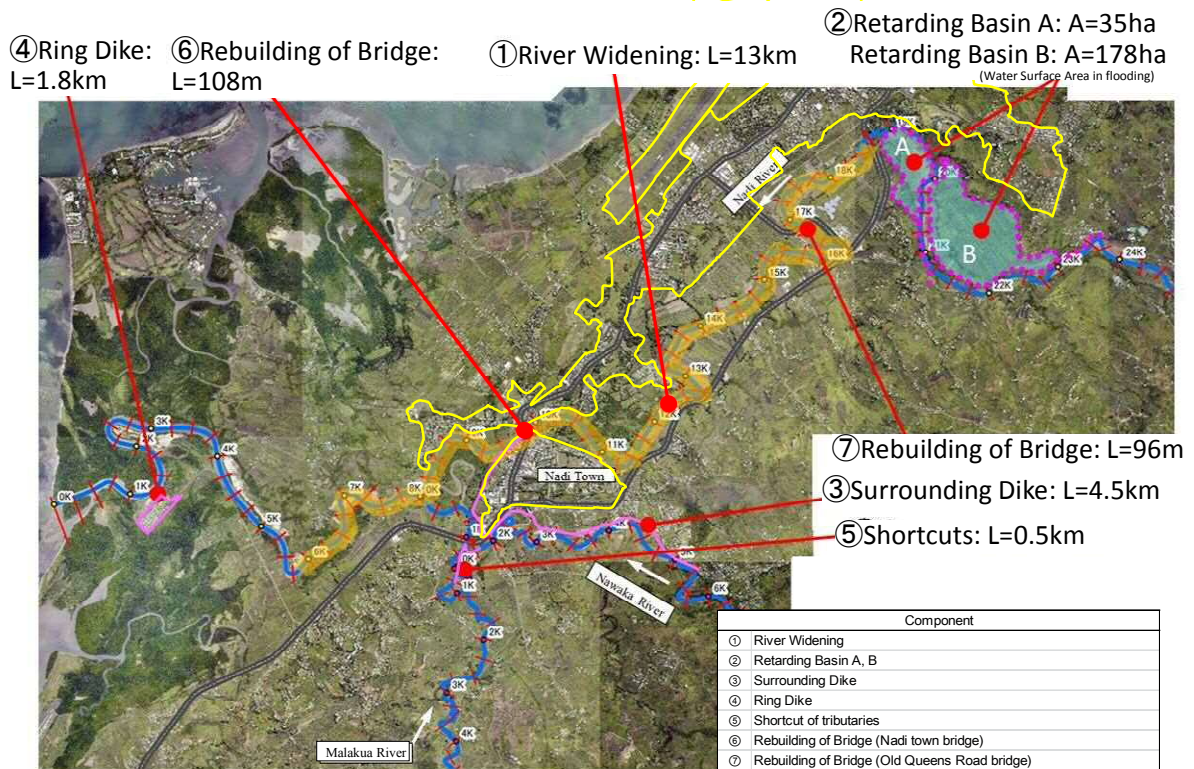


Figure 18-1 Components of structure measures of the priority project

18.3 Project Overview

18.3.1 Contents of Construction Works

(1) The Nadi River Flood Control Structures

For the Nadi River projects, sufficient cross-sectional area has been secured for the design flow of $1,800\text{m}^3/\text{s}$ with a design scale based on the return period of 50 years in condition of full flow¹ in the section at the Back Road Bridge. The structural measures of the Priority Project are river improvements (levee construction and river-bed excavation) necessary for the design flow, construction of two retarding basins for storage of design flood discharge, construction of ring dike for protecting the downstream community, construction of surrounding dike for protecting Nadi town, and shortcut in Malakua River for reducing negative impact. These components are included in the Master Plan as the Priority Project to be implemented in advance. Two bridges exist in the river widening section, and they have to be rebuilt.

¹ When the Master Plan will be completed, since the upstream dam will be constructed, the discharge of $1,800\text{ m}^3/\text{s}$ can flow down in the cross section considered free-board. In the Priority Project the discharge is permitted to flow down with water level between HWL and top of dike.

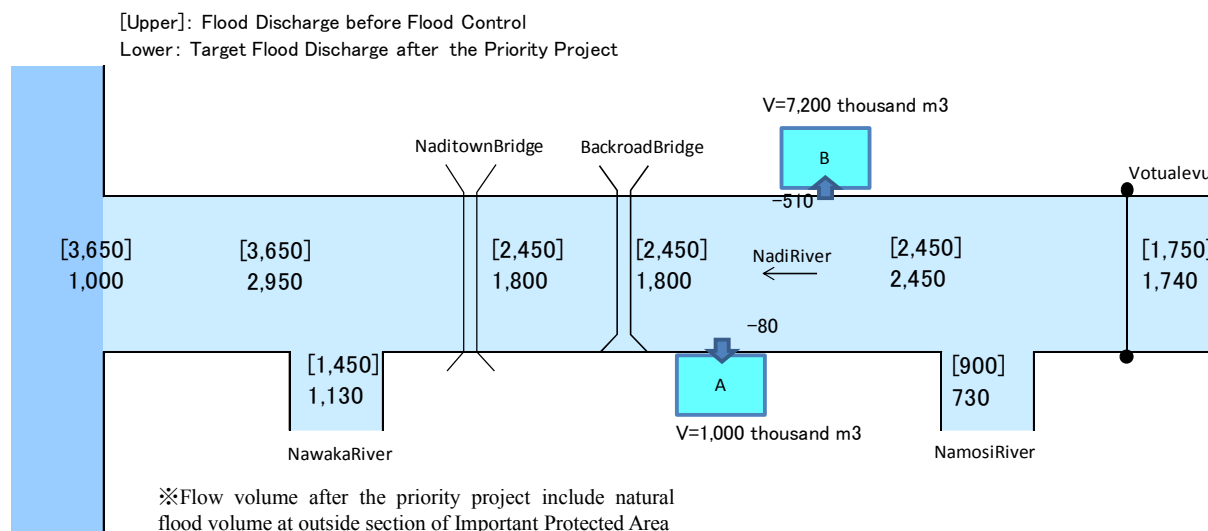


Figure 18-2 Design Flood Discharge of The Priority Project

Table 18-1 Summary of Structure Measures in the Priority Project

This document is a preceding summary for the Public Consultation. Therefore, it does not contain the information that can be inferred a project cost.

18.3.2 Contents of Consulting Services

Consulting services are for overall project management, detailed design (D/D), assistance in preparation of bidding documents (tender assistance), construction supervision, environmental/ social impact monitoring. The consulting services are also for planning for the above-described river improvements, construction of retarding basins and rebuilding bridge.

18.4 Project Implementing Schedule

We set the project implementation schedule after considering the major processes. Table 18-2 shows the processes and times required for each process. In addition, we assumed that the pledge will be made in March 2017 and 25 months will be required for the selection of the consultant.

Table 18-2 Time Periods Required for Major Processes and their Contents

No.	Process	Required time period	Contents
1	Yen loan procedures	-	Mar 2017 Pledge
2	Land acquisition	35 months	After Pledge and before the start of construction
3	Selection of consultants	12 months	Creation of RFP and short list and consent of JICA Invitation and submission of proposal Evaluation of the proposal and consent of JICA Contract negotiation Preparation and conclusion of contract Consent of JICA on contract and notice to commence
4	Detailed design	12 months	Location survey and research Detailed design related to river improvement, bridges and river structures

			Volume calculation and estimation of accumulation Preparation of bidding documents
5	Selection of contractors	12 months	Prequalification of bidders, creation of bidding documents and consent of JICA Bidding Bidding evaluation Consent of JICA Negotiation and conclusion of contract JICA's consent to contract, opening of L/C and issue of L/Com
6	Implementation of main construction works	48 months	River improvement, Rebuilding of Bridge, Retarding basins, Ring dike, Surrounding dike, Shortcut
7	Completion of construction and delivery	-	Completion of construction and delivery

Note: The time period required for JICA's consent on procurement differs depending on the type (of consultant or contractor) and the amount.

Table 18-3 below shows the implementation schedule of the Project under the above-described conditions.

Land acquisition has to be completed before the initiation of the Project.

18.5 Project Implementing Structure

For the Implementation of the Projects, the establishment of a Project Management Unit (PMU) will be considered. A draft of the project implementing structure is shown below.

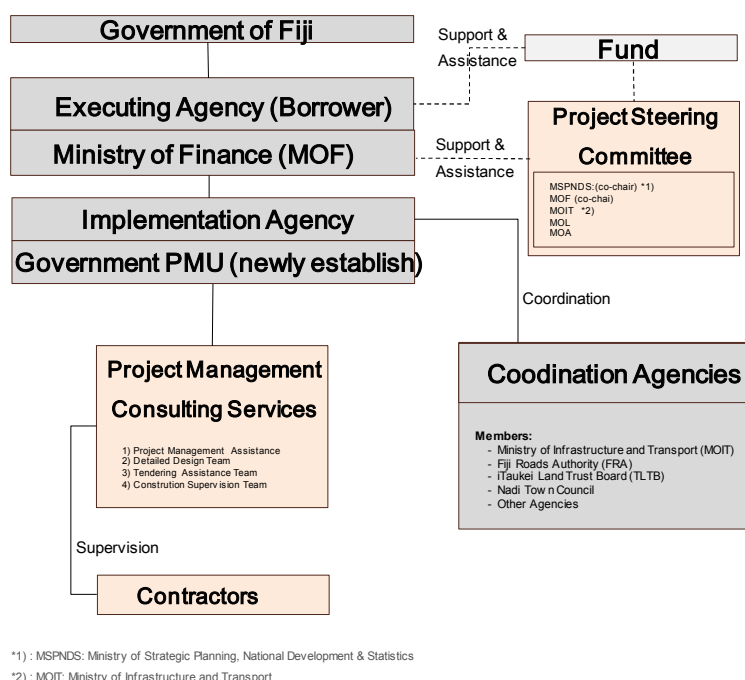


Figure 18-3 Draft project implementing structure

18.6 Performance Indicators

The annual maximum flow amount is selected as operation index, and the annual maximum flood area and annual maximum number of flooded houses due to dike breakage or overflow is selected as effect index for evaluating the operational effect of this project quantitatively and qualitatively. A reference value and target value of two (2) years after the completion of project are shown in Table 18-4.

Table 18-4 Operation and Effect Indicators of the Project

Operation and effect indicators		Reference level (50-year flood)	2027 target (2 years after the project completion) (50-year flood)
Operation indicator	Annual maximum water level (m) *1	2,450 m ³ /s (Calculated flood discharge before flood control)	1,800 m ³ /s (Channel Full Flow) (Design Discharge: Q50)
Effect indicator	Annual maximum inundation area (km ²) *2	9,137 ha	0 km ²
	Annual maximum flood damage (houses) *2	10,975 houses	0 houses

*1: Discharge in Nadi Town Bridge

*2: Due to destruction or overflow of dike (river water inundation) except inland inundation by rainfall

Chapter 19 Economic Feasibility of the Project

19.1 Preconditions

19.1.1 Evaluation Period

The evaluation period for the project is 50 years from 2026 to 2075. Expected schedule of the project implementation is as follows:

2016 - 2017: land acquisition

2018 - 2023: construction

2024: residual payment

2026 - 2075: evaluation period

The year means here the fiscal year of Fiji, from August 1 to July 30 of next year

19.1.2 Price level, price escalation

Economic value is set at 2015 price level. Foreign exchange rate is set as follows, using JICA rate of April 2016:

1JPY=0.01835FJD, 1FJD=JPY54.50

Forecasting the long-term inflation rate involves many uncertainties and not reliable. Price escalation of benefit and cost will balance out if the escalation rate is the same for the both of them in this investment plan.

And it is necessary to avoid introduction of assumption which is price escalation rate during long project period, and to secure the logical consistency the EIRR estimated by the present value and capital opportunity cost.

Therefore, the analysis is based on 2015 price, and price escalation in evaluation period is not considered.

19.1.3 Economic Price

Market price is converted to economic price for the project valuation. The following items are considered in calculating the economic price of the project.

(1) Tax and public dues

Tax and public dues are not included in the economic price. Value added tax that is 9% is not included in the calculation of the benefits and costs.

(2) Land price

Land price is calculated through deducting the cash flows from land usage when there is a big gap between market and economic price. Market price of land is used for the project valuation as such price gap does not exist in project area.

(3) Standard Conversion Factor (SCF)

SCF is used to convert domestic price to market price. The SCR used by ADB for development projects in Fiji is 0.986, which shows very small difference between domestic and market prices. Therefore, SCF of 1.0 is used for this project.

19.1.4 Social Discount Rate (SDR)

Social Discount Rate (SDR) is set at cut off line of 10–12% level in the economic analysis guidelines of the World Bank, Asian Development Bank and Inter-American Development Bank. The discount rate applied to the project is set at 10% as this rate is often applied to Fiji aid projects by Asian Development Bank, the World Bank and other international aid agencies.

19.1.5 Project Cost

The project cost does not include tax, price escalations and public dues. Operational and maintenance cost is set at 0.5% of the capital expenditure in reference to the cases of other countries.

19.2 Economic evaluation

The result of the economic evaluation is shown in Table 19-1.

The result confirms the cost-effectiveness and the positive economic effect of the project.

Table 19-1 Result of Economic Evaluation

Economic indicator	Result	Evaluation
Economic internal rate of return (EIRR)	12.0%	Since EIRR is well over 10% , a rate applied to the development assistance project in Fiji, the economic effectiveness is high.
Benefit-cost (B/C) ratio	1.20	Since the B/C ratio is over 1.0, the cost-effectiveness is high.

Source: JICA study team

This document is a preceding summary for the Public Consultation. Therefore, it does not contain the information that can be inferred a project cost.

19.3 Sensitivity analysis

Sensitivity analysis is conducted with fluctuating benefits and costs for analyzing changes of EIRR. As shown in Table 19-2, the EIRR of Case 1 (5% benefit decrease and 5% cost increase) is 10.7%, 9.60% for Case 2 (10% benefit decrease and 10% cost increase), and 8.5% for Case 3(15% benefit decrease and 55% cost increase). Although, these EIRR results of Case 2 and Case 3 are slightly below the target rate of 10%, their possibility possibilities are estimated to be low based on the prospect of increase of the benefits by economic growth in Nadi area.

Table 19-2 Result of sensitivity analysis

	Case 1	Case 2	Case 3
Benefit	-5%	-10%	-15%
Cost	+5%	+10%	+15%
EIRR	10.7%	9.6%	8.5%

Source: JICA Study Team

Chapter 20 Environmental and Social Considerations

20.1 Impact Assessment

20.1.1 Comparison of Scoping and Impact Assessment based on Survey Results

Based on the survey on baseline environmental conditions, impact prediction as well as the mitigation measures to be incorporated in the project, the environmental and social impacts of the project are evaluated as listed in Table 20 1.

20.1.2 Conclusion of Environmental Impact Assessment

(1) Pollution

Among eight (8) components of pollution related components, there is no component of which potential impact is evaluated as A- (Significant negative impact is expected.). Five (5) components are evaluated as B- (Negative impact is expected to some extent.) based on the survey results, including 1) Air pollution, 2) Water pollution, 3) Wastes, 4) Soil Contamination, and 5) Noise and vibration. The impacts on these components are to be caused by the construction works. Regarding the other components, the potential impacts are evaluated as D (No impact is expected.) during both construction and operation phases.

(2) Natural Environment

Among six (6) components of natural environment components, there is no component of which potential impact is evaluated as A- (Significant negative impact is expected.). Three (3) components are evaluated as B- (Negative impact is expected to some extent.) based on the survey results, including 10) Hydrological Situation, 12) Ecosystem and 14) Topography and Geographical Features. The impacts on these components are to be caused by the construction works.

As to 12) Ecosystem and 14) Topography and Geographical Features, the conditions will be continuously changed during operation phase. These components require continuous monitoring and implementation of countermeasures. Therefore, these components are evaluated as B+/-.

Regarding the other components, the potential impacts are evaluated as D (No impact is expected.) during both construction and operation phases.

(3) Social Environment

Among the social components, the most considerable impact by the project is in voluntary settlement. Number of involuntary settlement households by the Project is six (6) based on the social and economic survey.

During construction phase, the Project gives positive and negative impact to the local society and economy. Therefore, to monitor and implement mitigation measures adequately, comprehensive management scheme is required. The Resettlement Action Plan (RAP) prepared for the Project to provide a policy and a plan for the mitigation measures among resettlement and land acquisitions.

Table 20-1 Comparison of Scoping and Impact Assessment based on Survey Results

Environmental Components	River Widening / River short cutting / Construction of Bridges				Surrounding Dike				Ring Dike				Retarding Basin				
	Assessment at scoping		Assessment based on survey results		Assessment at scoping		Assessment based on survey results		Assessment at scoping		Assessment based on survey results		Assessment at scoping		Assessment based on survey results		
	Period I & II	Period III	Period I & II	Period III	Period I & II	Period III	Period I & II	Period III	Period I & II	Period III	Period I & II	Period III	Period I & II	Period III	Period I & II	Period III	
Physical-Chemical Environment (Pollution)	1	Air Pollution	B-	D	B-	D	[Construction] Air pollution due to dust and emission gas by construction equipment and vehicles as well as earth works will occur. [Operation] No air pollution which is attributed to the project components will occur because the project facilities are not pollution source.	B-	D	B-	D	[Construction] Air pollution due to dust and emission gas by construction equipment and vehicles as well as earth works will occur. [Operation] No air pollution which is attributed to the project components will occur because the project facilities are not pollution source.	B-	D	B-	D	[Construction] Air pollution due to dust and emission gas by construction equipment and vehicles as well as earth works will occur. [Operation] No air pollution which is attributed to the project components will occur because the project facilities are not pollution source.
	2	Water Pollution	B-	D	B-	D	[Construction] Suspension of sediments and release of sediment pollutants will occur as a result of excavation/dredging for river widening, river short cutting and construction of bridges. Creation of bare land and waste water from contractor base camp and/or office would also cause water pollution in the river. [Operation] There will be no pollution source of water.	B-	D	B-	D	[Construction] Creation of bare land and waste water from contractor base camp and/or office would also cause water pollution in the river. [Operation] There will be no pollution source of water.	B-	D	B-	D	[Construction] Suspension of sediments and release of sediment pollutants will occur as a result of construction a facilities and excavation/dredging in the river. Creation of bare land and waste water from contractor base camp and/or office would also cause water pollution in the river. [Operation] There will be no pollution source of water.
	3	Wastes (including Dredged Material)	A-	D	B-	D	[Construction] Dredged material would be generated as a result of river widening, river short cutting and bridge construction. Part of the dredged material would be use as material for dikes. General wastes from contractor office and base camp and demolished structures would be generated. [Operation] There will be no wastes from flood control facilities.	B-	D	B-	D	[Construction] General wastes from contractor office and base camp and demolished structures would be generated. [Operation] There will be no wastes from flood control facilities.	B-	D	A-	D	[Construction] Dredged material would be generated. Part of the dredged material would be use as material for dikes. General wastes from contractor office and base camp and demolished structures would be generated. [Operation] There will be no wastes from flood control facilities.
	4	Soil Contamination	B-	D	B-	D	[Construction] Survey results of the water and riverbed sediment quality indicate that the riverbed sediment is non-hazardous materials, and hazardous level of heavy metals is not detected. Spilled oil from construction equipment would also cause soil contamination. [Operation] There will be no pollution source of soil contamination.	B-	D	B-	D	[Construction] Spilled oil from construction equipment would also cause soil contamination. [Operation] There will be no pollution source of soil contamination.	B-	D	B-	D	[Construction] Spilled oil from construction equipment would also cause soil contamination. [Operation] There will be no pollution source of soil contamination.
	5	Noise and Vibration	B-	D	B-	D	[Construction] Noise and vibration caused by construction activities and transportation will occur. [Operation] There will be no source of noise or vibration from the project facilities.	B-	D	B-	D	[Construction] Noise and vibration caused by construction activities and transportation will occur. [Operation] There will be no source of noise or vibration from the project facilities.	B-	D	B-	D	[Construction] Noise and vibration caused by construction activities and transportation will occur. [Operation] There will be no source of noise or vibration from the project facilities.
	6	Land Subsidence	D	D	D	D	No land subsidence is anticipated during both construction and operation stage because pumping of groundwater, deep excavation work, or tunneling work is not included in the project activities.	D	D	D	D	No land subsidence is anticipated during both construction and operation stage because pumping of groundwater, deep excavation work, or tunneling work is not included in the project activities.	D	D	D	D	No land subsidence is anticipated during both construction and operation stage because pumping of groundwater, deep excavation work, or tunneling work is not included in the project activities.
	7	Offensive	B-	B-	D	D	[Construction] Offensive odor during	D	D	D	D	No occurrence of offensive odor is	D	D	D	D	No occurrence of offensive odor is

Environmental Components	River Widening / River short cutting / Construction of Bridges				Surrounding Dike				Ring Dike				Retarding Basin				
	Assessment at scoping		Assessment based on survey results		Explanation for the evaluation	Assessment at scoping		Assessment based on survey results		Explanation for the evaluation	Assessment at scoping		Assessment based on survey results		Explanation for the evaluation		
	Period I & II	Period III	Period I & II	Period III		Period I & II	Period III	Period I & II	Period III		Period I & II	Period III	Period I & II	Period III			
					[Operation] In case of flood situation, mangrove forests located in Nadi River mouse would be inundated, however, this phenomenon is also observed in this area before the project. So, the impact of the project is not anticipated.												
	14	Topography and Geographical Features	B-	C+/-	B-	B+/-	[Construction] River widening would cause the change of topographical features along the Nadi River. [Operation] From the long term point of view, sand accumulation and bank erosion will occur. Adequate monitoring activities will be needed to grasp accurate conditions.	B-	D	B-	D	[Construction] Construction of dike would cause the change of topographical features. [Operation] No impact to topography and geographical features is anticipated.	B-	D	B-	D	[Construction] Construction of dike would cause the change of topographical features. [Operation] No impact to topography and geographical features is anticipated.
Social Environment	15	Involuntary Resettlement	B-	D	B-	D	[Pre-Construction / Construction] There will be a total of 6 households of involuntary resettlement required by river widening. Resettlement of the affected households needs to be completed before construction is commenced. [Operation] There is no impact to involuntary resettlement.	B-	D	D	D	[Pre-Construction / Construction] No involuntary resettlement is anticipated in the surrounding dike construction area. [Operation] There is no impact to involuntary resettlement.	B-	D	D	D	[Pre-Construction / Construction] No involuntary resettlement is anticipated in the surrounding dike construction area. [Operation] There is no impact to involuntary resettlement.
	16	Poverty Group	C-	C-	B-	B-	[Pre-Construction/Construction] As the result of survey, 41% of households (4 households are required for involuntary resettlement) are living with less than 5,000FJD income per annum. Measures aimed to improving standard of living need to be provided to project affected households before construction begins. [Operation] There is possibility of inflow of informal settlers to Nadi River side.	C-	C-	B-	B-	[Pre-Construction/Construction] As the result of survey, 41% of households are living with less than 5,000FJD income per annum. Measures aimed to improving standard of living need to be provided to project affected households before construction begins. [Operation] There is possibility of inflow of informal settlers to Nadi River side and dike side.	C-	C-	B-	B-	[Pre-Construction/Construction] As the result of survey, 41% of households are living with less than 5,000FJD income per annum. Measures aimed to improving standard of living need to be provided to project affected households before construction begins. [Operation] There is possibility of inflow of informal settlers to inside of retarding basins.
	17	Indigenous Peoples	C+/-	C+/-	D	D	Fiji's indigenous people, Fijian is one of the major ethnic group in Fiji. There is no indigenous groups are observed in the project area.	C+/-	C+/-	D	D	Fiji's indigenous people, Fijian is one of the major ethnic group in Fiji. There is no indigenous groups are observed in the project area.	C+/-	C+/-	D	D	Fiji's indigenous people, Fijian is one of the major ethnic group in Fiji. There is no indigenous groups are observed in the project area.
	18	Local Economy such as Employment and Livelihood	C+/-	A+	B+/-	A+	[Pre-Construction/Construction] Agricultural production might be affected by construction works. However, the project would contribute for temporary job creation and accelerate local economy such as tourism industry. The result of type of employment shows farming in 15 %, tourism in 35%. [Operation] Development of flood control facilities would decrease a vulnerability of flood and contribute for developing of industries.	C+/-	A+	B+/-	A+	[Pre-Construction/Construction] Agricultural production might be affected by construction works. However, the project would contribute for temporary job creation and accelerate local economy such as tourism industry. The result of type of employment shows farming in 15 %, tourism in 35%. [Operation] Development of flood control facilities would decrease a vulnerability of flood and contribute for developing of industries.	C+/-	A+	B+/-	A+	[Pre-Construction/Construction] Agricultural production might be affected by construction works. However, the project would contribute for temporary job creation and accelerate local economy such as tourism industry. The result of type of employment shows farming in 15 %, tourism in 35%. [Operation] Development of flood control facilities would decrease a vulnerability of flood and contribute for developing of industries.
	19	Land Use and	B-	C+/-	B-	B-	[Pre-Construction / Construction] Land use and utilization of local resources will	B-	C+/-	B-	B-	[Pre-Construction / Construction] Land use and utilization of local resources will	B-	C+/-	B-	B-	[Pre-Construction / Construction] Land use and utilization of local resources will

Environmental Components	River Widening / River short cutting / Construction of Bridges				Surrounding Dike				Ring Dike				Retarding Basin			
	Assessment at scoping		Assessment based on survey results		Explanation for the evaluation	Assessment at scoping		Assessment based on survey results		Explanation for the evaluation	Assessment at scoping		Assessment based on survey results		Explanation for the evaluation	
	Period I & II	Period III	Period I & II	Period III		Period I & II	Period III	Period I & II	Period III		Period I & II	Period III	Period I & II	Period III		
					who do not need along the river when land acquisition is required for the project facilities. [Operation] There is possibility of generation of local conflicts of interest between priority project area and other areas, inside and outside of dykes etc.					acquisition and not. [Operation] There is possibility of generation of local conflicts of interest between priority project area and other areas, inside and outside of dykes etc.					acquisition and not. [Operation] There is possibility of generation of local conflicts of interest between priority project area and other areas, inside and outside of dykes etc.	
25	Cultural Heritage	C-	D	D	D	[Pre-Construction/Construction] As the result of the survey, there is no cultural facilities, sensitive facilities such as grave site, shrine etc. in the project area. However, during project implementation, it is required to observe the actual situations. [Operation] There is no possibility of influence for cultural heritage.	C-	D	C-	D	[Pre-Construction/Construction] As the result of the survey, there is no cultural facilities, sensitive facilities such as grave site, shrine etc. in the project area. However, during project implementation, it is required to observe the actual situations. [Operation] There is no possibility of influence for cultural heritage.	C-	D	C-	D	[Pre-Construction/Construction] As the result of the survey, there is no cultural facilities, sensitive facilities such as grave site, shrine etc. in the project area. However, during project implementation, it is required to observe the actual situations. [Operation] There is no possibility of influence for cultural heritage.
26	Landscape	C-	B+/-	B-	B-	[Construction] Change of landscape is evaluated by the generation of bare lands and movement of construction equipment during construction works. [Operation] River widening would be changed. However, river itself is part of nature scenery. So that negative impact to social and economy is limited. In addition, there is positive impact for urban design by re-construction of bridges.	C-	B-	B-	B-	[Construction] Change of landscape is evaluated by the situation of after construction phase. [Operation] Existence of dike would cause obstruction to landscape views especially at the vicinity where the dike is relatively high.	C-	B-	B-	B-	[Construction] Change of landscape is evaluated by the situation of after construction phase. [Operation] Existence of dike would cause obstruction to landscape views especially at the vicinity where the dike is relatively high.
27	Gender / Socially Vulnerable Groups	C-	C+/-	D	D	Negative impact for gender is not anticipated in this project. The results of survey indicate that very few number of disability persons are identified, and they are not included to resettlement households.	C-	C+/-	D	D	Negative impact for gender is not anticipated in this project. Results of survey indicate that very few number of disability persons are identified, and they are not included to resettlement households.	C-	C+/-	D	D	Negative impact for gender is not anticipated in this project. Results of survey indicate that very few number of disability persons are identified, and they are not included to resettlement households.
28	Rights of Children	C-	D	D	D	Negative impact to the children rights is not anticipated by the project. The results of survey did not find the any issues regarding children's rights.	C-	D	D	D	Negative impact to the children rights is not anticipated by the project. The results of survey did not find the any issues regarding children's rights.	C-	D	D	D	Negative impact to the children rights is not anticipated by the project. The results of survey did not find the any issues regarding children's rights.
29	Infectious Diseases such as HIV/AIDS	C-	D	B-	D	[Construction] Number of infected person in Fiji is increasing. So that there is possibility of HIV infected worker would participate to the construction works.	C-	D	B-	D	[Construction] Number of infected person in Fiji is increasing. So that there is possibility of HIV infected worker would participate to the construction works.	C-	D	B-	D	[Construction] Number of infected person in Fiji is increasing. So that there is possibility of HIV infected worker would participate to the construction works.
30	Labor Environment (Including Occupational Safety)	B-	D	B-	D	[Pre-Construction/ Construction] The construction works of the Project is in a certain scale. So that it is required to consider safety and work environment.	B-	D	B-	D	[Pre-Construction/ Construction] The construction works of the Project is in a certain scale. So that it is required to consider safety and work environment.	B-	D	B-	D	[Pre-Construction/ Construction] The construction works of the Project is in a certain scale. So that it is required to consider safety and work environment.
31	Accidents	B-	B-	B-	B-	[Construction] Construction related accidents by heavy equipment and transportation vehicles might occur. [Operation] There is a possibility to occur of accidents in the maintenance road along the river.	B-	B-	B-	B-	[Construction] Construction related accidents by heavy equipment and transportation vehicles might occur. [Operation] There is a possibility to occur of accidents in the maintenance road along the river.	B-	B-	B-	B-	[Construction] Construction related accidents by heavy equipment and transportation vehicles might occur. [Operation] There is a possibility to occur of accidents in the maintenance road along the river.
32	Global Warming	D	D	D	D	The scale of changes are large. However, the project will be conducted in the river	D	D	D	D	The scale of changes are large. However, the project will be conducted in the river	D	D	D	D	The scale of changes are large. However, the project will be conducted in the river

Environmental Components	River Widening / River short cutting / Construction of Bridges				Surrounding Dike				Ring Dike				Retarding Basin			
	Assessment at scoping		Assessment based on survey results		Explanation for the evaluation	Assessment at scoping		Assessment based on survey results		Explanation for the evaluation	Assessment at scoping		Assessment based on survey results		Explanation for the evaluation	
	Period I & II	Period III	Period I & II	Period III		Period I & II	Period III	Period I & II	Period III		Period I & II	Period III	Period I & II	Period III		
					area. The impact will not exceeding the area. In addition, no impact for global warming is anticipated.						area. The impact will not exceeding the area. In addition, no impact for global warming is anticipated.					area. The impact will not exceeding the area. In addition, no impact for global warming is anticipated.

A+/-: Significant positive/negative impact is expected.

B+/-: Positive/negative impact is expected to some extent.

C+/-: Possibility of impact and its magnitude are unknown.

(A further examination is needed, and the impact could be clarified as the study progresses.)

D: No impact is expected.

Period I: Pre-construction, Period II: Construction, Period III: Operation

20.2 Environmental Management Plan

20.2.1 Pollution

Environmental impacts and mitigation measures for pollution related components are described in Environmental Management Plan shown in Table 20-2.

Table 20-2 Environmental Management Plan for Pollution Related Components

Project Phase	Potential Impact	Mitigation Measures / Perspective on Impact Mitigation	Implementation Organization / Responsible organization	Cost
1) Air Pollution				
Constriction	Air pollution by dust due to earth works for dike and excavation, etc.	<ul style="list-style-type: none"> Excavation materials must be properly stockpiled and properly disposed of immediately from the construction site when not needed. Provision of covers to stockpiles that will be left idle for a long time, Dust generation will be mitigated with watering at dusty place and covering the load of trucks by tarpaulin, Periodical and timely cleaning of the spilled materials on road or other public space along the transportation route of construction materials and spoil materials 	<p><u>Implementation:</u> Contractor,</p> <p><u>Responsible Org.:</u> Proponent , Consultant and DOE(Department of Environment)</p>	Included in the construction cost
	Air pollution by emission gas due to the operation of construction equipment and vehicles	<ul style="list-style-type: none"> Using a low emission type construction equipment and vehicles, Regular maintenance of construction equipment and vehicles, Consideration of operation manner of the equipment due to the regular education to the operators. 	<p><u>Implementation:</u> Contractor,</p> <p><u>Responsible Org.:</u> Proponent , Consultant and DOE(Department of Environment)</p>	Included in the construction cost
2) Water Pollution				
Constriction	Water pollution of the river water due to earth works near the river bank, excavation and dredging works in the river	<ul style="list-style-type: none"> Installation of temporary embankment and drainage at the boundary of periphery of project site, Installation of sedimentation pond at appropriate location to avoid the turbid water discharge 	<p><u>Implementation:</u> Contractor,</p> <p><u>Responsible Org.:</u> Proponent , Consultant and DOE(Department of Environment)</p>	Included in the construction cost

Project Phase	Potential Impact	Mitigation Measures / Perspective on Impact Mitigation	Implementation Organization / Responsible organization	Cost
		<ul style="list-style-type: none"> • Selection of less agitation method of dredging and its proper implementation. 		
	Water pollution by waste water (effluent and used oil) from construction yards and offices, and accidental oil spill	<ul style="list-style-type: none"> • To ensure not to directly drain the waste water from construction yard and offices to the river, • Waste water is to be properly treated and disposed using septic tank or other appropriate treatment method • Provision of portable toilet for the workers at the construction work sites. • To ensure not to cause accidental oil spill and other chemicals. 	<p><u>Implementation:</u> Contractor,</p> <p><u>Responsible Org.:</u> Proponent , Consultant and DOE(Department of Environment)</p>	Included in the construction cost
3) Wastes (including Dredged Material)				
Constriction	Waste generation associated with demolition of buildings and structures	<ul style="list-style-type: none"> • Reduction of wastes generation by segregation, re-use and recycle of the materials used in the demolished buildings and structures in the affected areas. • Appropriate treatment and disposal of the wastes from demolished structures by delegating to the accredited waste contractor. 	<p><u>Implementation:</u> Contractor,</p> <p><u>Responsible Org.:</u> Proponent , Consultant and DOE(Department of Environment)</p>	Included in the construction cost
	Dredged material generation associated with dredging and excavating	<ul style="list-style-type: none"> • Dredged material can be facilitated through the DMR (Department of Mineral Resources) direction. • Temporary disposal area for dredged materials can be prepared through the coordination among native land owners (LOU: Land Owning Unit). Received dredged materials by a landowner can be sold based on the permission from DMR. Gain on sale of dredged material can be used for public purpose in LOU by landowners. 	<p><u>Implementation:</u> Contractor,</p> <p><u>Responsible Org.:</u> Proponent, Consultant, DOE (Department of Environment) and DMR (Department of Mineral Resources).</p>	Included in the construction cost
4) Soil Contamination				
Constriction	Soil contamination at the construction site by oil leaking from	<ul style="list-style-type: none"> • Regular maintenance of construction equipment and 	<p><u>Implementation:</u> Contractor,</p>	Included in the construction

Project Phase	Potential Impact	Mitigation Measures / Perspective on Impact Mitigation	Implementation Organization / Responsible organization	Cost
	construction equipment and vehicles.	<p>vehicles.</p> <ul style="list-style-type: none"> • Consideration of operation manner of the equipment due to the regular education to the operators. 	<p><u>Responsible Org.:</u> Proponent , Consultant and DOE(Department of Environment)</p>	cost
5) Noise and Vibration				
Construction	Noise and vibration during construction works due to operation of construction equipment and vehicles	<ul style="list-style-type: none"> • Using a low noise and vibration type construction equipment and vehicles, • Regular maintenance of construction equipment and vehicles, • Consideration of operation manner of the equipment due to the regular education to the operators. • Regular communication with local residents about the methodology and implementation schedule of construction works. • Adjustments in the operation time of construction equipment and dump trucks, transportation route, etc. • Installation of sound abatement wall during construction work in the vicinity of residents and sensitive facilities such as schools or settlement areas, if necessary. 	<p><u>Implementation:</u> Contractor,</p> <p><u>Responsible Org.:</u> Proponent , Consultant and DOE(Department of Environment)</p>	Included in the construction cost

20.2.2 Natural Environment

Environmental impacts and mitigation measures for natural environment related components are described in Environmental Management Plan shown in Table 20-3.

Table 20-3 Environmental Management Plan for Natural Environment Related Components

Project Phase	Potential Impact	Mitigation Measures / Perspective on Impact Mitigation	Implementation Organization / Responsible organization	Cost
10) Hydrological Situation (River flow)				
Constriction	Variation of river water flow by temporary closure works	<ul style="list-style-type: none"> To mitigate turbid water generation from closure works by steel sheet pile. Transfer/rescue of aquatic organism from closed water area before dredging. 	<p><u>Implementation:</u> Contractor,</p> <p><u>Responsible Org.:</u> Proponent , Consultant and DOE(Department of Environment)</p>	Included in the construction cost
Operation	Reduction of average water depth by river widening.	<ul style="list-style-type: none"> To consider the water route for initial condition of cross sections. After operation, initial water route can be helped to create original the river flow by river power. Regular maintenance cross section survey to inspect the condition of river bed maintained adequately. 	<p><u>Implementation:</u> Contractor,</p> <p><u>Responsible Org.:</u> Proponent and DOE(Department of Environment)</p>	included in the operation cost
12) Ecosystem				
Construction	Loss of vegetation cover and change of habitat of wildlife	<ul style="list-style-type: none"> Limiting land and vegetation clearance as much as possible by considering the construction method. Appropriate plant species for greening and compensation should be planted. 	<p><u>Implementation:</u> Contractor,</p> <p><u>Responsible Org.:</u> Proponent , Consultant and DOE(Department of Environment)</p>	Included in the construction cost
Operation	Change of frequency of flood and river velocity	<ul style="list-style-type: none"> Cross section design should consider the creation and maintenance of habitat of wild life by river power. 	<p><u>Implementation:</u> Consultant (detailed design) and Proponent (operation)</p> <p><u>Responsible Org.:</u> Proponent and DOE(Department of Environment)</p>	Design is included in the detailed design study included in the operation cost

20.3 Abbreviated Resettlement Action Plan

The Abbreviated Resettlement Action Plan (RAP) for this project will be prepared based on JICA Environmental and Social Considerations, April 2010 and World Bank Safeguard Policy.

1. Necessity of Land Acquisition and Resettlement
2. Regal Framework for Land Acquisition and Resettlement
3. JICA's policy for Resettlement
4. Gaps between JICA Guideline and Fiji's legal Frameworks
5. Policy for Land Acquisition and Resettlement for the Project
6. Scope of Resettlement Impact
7. Concrete Measures for Compensation and Support
 - 7.1 Impact and Compensations by the Project
 - 7.2 Compensation for Loss of Assets
 - 7.3 Assistance on Entitlements for land acquisition and resettlement
 - 7.4 Countermeasures for Restoring of Living
 - 7.5 Relocation Land
 - 7.6 Entitlement Matrix
 - 7.7 Responsible Institutions of Land Acquisition and Resettlement
 - 7.8 Land Acquisition Procedures
 - 7.9 Responsible Institutions and Mechanism of Grievance Redress
 - 7.10 Resettlement Implementation Schedule
 - 7.11 Cost and Fund Source of Land Acquisition and Resettlement
 - 7.12 Monitoring Framework by Implementation Institutions

20.4 Public Consultations and Stake Holders Meetings

20.4.1 Outline

Three (3) Public Consultations are held to inform the situation of project examination and collect an opinion and comment from residents. The dates of public consultations are follows;

1st Public Consultation: 2 July, 2015 (Tuesdays)

2nd Public Consultation: 12 September, 2015 (Wednesday)

3rd Public Consultation: 5 April, 2016 (Tuesday)

20.4.2 Participants and major opinions

(1) 1st Public Consultation

The number of participants of 1st Public Consultation are 46. Name and organization of participants are shown below.

1. IntazHussain (Lands – Lautoka)
2. Neel Chandra (Fiji Police Force)
3. P. Bainivalu (Fiji Military Force)

4. EpineriDalituicama (Ministry of Agriculture)
5. UmendraPratap (Ministry of Agriculture)
6. Mahendra K. (Ministry of Agriculture)
7. Shiri N (Agriculture Department)
8. ViliameMomoivalu (Department of Environment)
9. Vinod Kumar (Min. of Primary Ind.)
10. Albert Queet (SCOPE Pacific)
11. Melissa Toro (SCOPE Pacific)
12. Neela Prasad (JICA)
13. Ifereimi (Nadi Rural Local Authority/Ministry of Health)
14. Robin Anganu (Nadi Town Council)
15. IliesaRakaseta (Housing Authority)
16. JoneMataiqe (Housing Authority)
17. IliesaTaivei (Housing Authority)
18. Sekove Q (Housing Authority)
19. Vishnu (Sheraton Resort)
20. John Ross (Fiji Sun)
21. SaloteQalubau(Fiji Sun)
22. ArujDevia(Devia Bookshop)
23. Pravin (Brij& Co)
24. Yeh Chang Wai (PIL Foodhall Supermarket)
25. ManojJeet(VIB)
26. Charles Dewan(ANZ)
27. R. Sanday (Nadi Sports Council)
28. B. McElrath (McDonalds)
29. Jeff Wang (EMEI)
30. Rapek (Avon Store)
31. Marsh (Jet tex S P L)
32. Sunt Kumar (Farmer)
33. P. Watson (Landowner)
34. Norman Yee (NadiResident)
35. ApenisaVuki (Nadi Resident)
36. TevitaRatu (Nakovacake)
37. IliaseriVano (Nakovacake)
38. TomasiNaulumatua (Natoqocake)
39. Egi T. Dodd (Businessman)
40. Anil Gounder (Businessman)
41. Ash Yam(Namotourio)

42. Nacanieli V (MH Nadi)
43. Nikan K (Nadi Resident)
44. M. W
45. VilimoniTabuanitoga (Narewa Village)
46. KapilBhagwan (Unknown)

Major opinions from participants are shown below.

- What type of embankment are considered along with the river (Resident in Nakovacake)
- What kind of impact will be anticipated due to the river widening? In Nakovacake, we are worry for Landslide. (Resident in Nakovacake)
- More than 77 year living in Nadi Basin, a planting in upstream area is needed. (person in charge of agriculture sector)
- Construction of Diversion channel needs huge cost and may it make several impacts to the area. The idea of river widening is simple and acceptable. (Resident in Namotomoto)
- Under the low tide condition, estuary of Nadi river is very shallow. Not to navigate by the boat. Is there (Resident in Nacovi)
- Can house owners which are affected by the river widening receive the proper assistance? (Nakomorake Development Trust)

(2) 2nd Public Consultation

The number of participants of 2nd Public Consultation are 22. Name and organization of participants are shown below.

1. Khin Maung Cho (LWRM/MOA)
2. Josefa Nawai (LWRM/MOA)
3. Jonetani B (LWRM/MOA)
4. Vinesh (LWRM/MOA)
5. Sauri Mitchell (SDC)
6. Netani Qicatabua (Consulting Engineer, Netts Planning & Infrastructure)
7. Peceli Nakavulevu (Min of Lands)
8. Robin Ali (Nadi Town Council)
9. Jone Mataitoga (Housing Authority)
10. IliesaTaivei (Housing Authority)
11. Tevita King (SCOPE Pacific)
12. Nina Sikiti (SCOPE Pacific)
13. Joseva Rokocoko (Yavusania Village)
14. Sakiasi Radibi (Yavusania Village)
15. Ilisoni R (Moala Village)
16. Vuniani L (Moala Village)
17. Takashi Toyoda (JICA Study Team)
18. Hajime Watanabe (JICA Study Team)

19. Metuisela Mua (JICA Study Team)
20. Ashok Kumar (JICA Study Team)
21. Joe Waqavakatoga (JICA Study Team)
22. Amelina Ratubuli (JICA Study Team)

Major opinions from participants are shown below.

- The examination done by JICA is based on the evaluation which the frequency of flood in 2015 is 1/50. Do you conduct the calculation for the 1/100, 1/25 flood? Can we review the draft report? (Civil Engineer)
- How many years are needed for completion of the Project? (Housing Authority)

(3) 3rd Public Consultation

The number of participants of 2nd Public Consultation are approximately 30 (this number including person who are not record the name on attendance list). Name and organization of participants are shown below.

1. Rita Pickering (Air New Zealand)
2. Samisoni Vouratukula (Waqadra Residence)
3. Daya Lal - (Waqadra Residence)
4. Palpana Nand (Waqadra Residence)
5. V. Ramani (Unknown)
6. Kamlesh Chandra - (Qeleloa Settlement)
7. Mahesh Khatri (ACME Garments)
8. Jitendra Singh (Deo Street, Namaka)
9. Ana Dugulele (Rustic Pathways)
10. Laupaama (Unknown)
11. Ravin Devia (Devia Bookshop)
12. Jainendra Vikash - (Mega Paper Power)
13. Naseer Khan (Khans Service Station)
14. Roneel Deo (Sharma Design)
15. Aung Yi (MOA)
16. Josefa Nawai (MOA)
17. Sant Pratap (MOA)
18. Filimoni Vananalagi (MOA)
19. Vinesh Kumar (MOA)
20. Hideki Sawada (JICA)
21. Nila Prasad (JICA)
22. Takashi Toyoda (JST)
23. Yoshio Nakagawa (JST)
24. Metuisela Mua (JST)
25. Ashok Kumar (JST)

26. Amelina Ratubuli (JST)

Major opinions from participants are shown below.

- Where is the starting point of river widening? In case of the flood happen in upstream, the area around Novotel inundated? (Waqadra Residence)
- In case of flood in Nadi river, the water going to the sea with out any flooding? (unknown)
- After the development of retarding basin and river widening, the amount of water which flow into the ocean is changed? How to drain the water from retarding basins (Unknown)
- Dam construction is included to the Project? (Khans Service Station)
- In case of collapse of Vaturu Dam, what kind of even is anticipated? (Rustic Pathways)

Chapter 21 Project Evaluation and Recommendations

21.1 Project Evaluation

21.1.1 Economic Valuation

Result of economic valuation are EIRR of 12.0% and B/C of 1.2. This investment rate of return is above the target investment rate of return of 10% in Fiji and show the positive economic effect.

21.1.2 Environmental Impact Evaluation

By the implementation of the Project, the inundation area and period will be reduced significantly, and as a result the direct and indirect damages caused by flooding will be reduced. This will have large positive impacts on the social economic development and peoples' welfare.

Although the various countermeasures will be able to cope sufficiently with the negative impacts on the social and natural environment as described in this report, the items which will relatively have important effect are shown below.

(1) Relocation of housing

Seventeen households have to be relocated in the Priority Project. Sufficient negotiation on land acquisition and compensation will be required from now on. In addition to the above 17 households, there are other 17 households scattered in the retarding basin area planned in the Master Plan; these households will be affected by the negative impact of the river channel widening in the middle stream of Nadi River, and as a result compensation negotiation of will be necessary.

(2) Change of topography and landscape

Since the river width will be widened approximately by 2 times of its present width after implementation of the Project, the topography and landscape will be change. Therefore, it is desirable to implement the land use planning and town planning along the river, facilitating such as building parks and walking trails in parallel with the Project.

(3) Influence on tourism

During implementation of the Project, vehicles and heavy construction equipment may frequently move here and there including dump trucks transporting soil. Such traffic may pass through main road together with that of tourism vehicles, and there is some risk that the river channel excavation may cause turbid water. The reduction of such minus impacts on tourism should be considered by planning adopting a construction method avoiding such impacts on tourism and environment. However, after completion of the Project a large plus impact on tourism is expected by reducing remarkably direct and indirect damage of flooding.

21.2 Recommendations for the Implementation of the Project

21.2.1 Recommendations for the Implementation of the project

(1) Implementation of the Priority Project

The recommended Priority Project has large economic effect and sufficient financial feasibility. The implementation of the Project will present a great benefit to social and economic development and peoples' welfare. Therefore, the Project should be implemented as soon as possible to avoid repeated flood damage.

(2) Consensus building

Consensus should be built among the stakeholders of the government on the implementation of the project. Moreover, the understanding and consensus of the residents that may be affected by the project are required.

(3) Commencement of loan procedure for project fund

The major part of the fund for implementation of the Project is likely to be procured by foreign loan. Such loan process requires long period, and it is necessary to start the loan process as early as possible. Since the government has to cover part of the cost, the project should be included in the government budget, and the process necessary to realize this should commence immediately.

(4) Commencement of negotiation for land acquisition and compensation

Since the negotiation of land acquisition and compensation requires generally long time, the explanation to residents and negotiation should commence as early as possible so that there will be enough time for discussion after which the agreement of the residents should be obtained.

(5) Commencement of consultant procurement and environmental monitoring

Prior to the construction of flood control counter measures, the detail design is necessary. Therefore, after the decision of Project implementation, the consultant is procured immediately to prepare the detail design of the Project.

And in order to assess the natural and social impact of the implementation of the Project, various types of monitoring of environmental factors should be started.

(6) Establishment of flood control legislation

The legislation of flood control in Fiji is not yet accomplished; it should be established on various items including definition of river area (boundary of river) and compensation method of retarding basin and so on.

(7) Establishment of organization responsible for flood control and capacity building

At present the organization responsible for flood control is not clearly defined in the legislation. The Ministry of Agriculture (MOA), which is a counterpart agency of this Study, is and only responsible for flood control of agricultural village and land; however flood control of urban area and examination of influence of climate change and so on are out of its responsibility.

The number of engineers in LWRM of MOA is few and very limited. The establishment and strengthening of the organization responsible for flood control is urgently required, including increase of engineers and capacity building, and budget allocating.

(8) Preparation of criteria and standard

The preparation of criteria and standard as well as organization and legislation concerning flood control is necessary. It is understood from a discussion with LWRM that since there are no specific criteria and standard in Fiji, at present engineers rely on their own knowledge, experience and information obtained from internet. The criteria and standard matching to the natural, social and environmental situation of Fiji should be prepared.

(9) Securing of maintenance budget for flood control

At present, the maintenance budget for flood control is not always secured, and as a result, the maintenance of flood control facilities is not carried out sufficiently. The maintenance work of flood control facilities to be constructed by the Project is inevitable; therefore, yearly budget has to be secured for continuous maintenance work.

(10) Establishment of flood control master plan for overall Fiji and implementation

The flood control master plan in the Nadi River basin was established in this Study; however, there are 4 large river basins in Viti Levu island in addition to Nadi River, which are Rewa River, Navua River, Sigatoka River and Ba River, without master plans. Master plans for these rivers is to be established and the implementation of flood control facilities of it should be implemented step by step.

21.2.2 Recommendations for Inland water Drainage

(1) Present situation and issues of inland water drainage

Although the inundation phenomena by river water is the objective of this study, inundation damage by inland water occurs often due to insufficient capacity of drainage system for rainfall in the central area of Nadi town, which is included in the Important Protected Area defined in the Project. Therefore it is impossible to protect completely the inundation in the city center area by only the counter measures against river water. Therefore, the improvement of the inland water drainage system is an urgent issue that should be carried out soon.

Figure 21-1 shows the current situation of the rainfall water (inland water) drainage system. The central area of Nadi town is often inundated due to slight topography depression and insufficient drainage system.

There is a drainage plan promoted by Nadi town (discussed later in Section (2),2), which is not concrete plan, but the maintenance of drainage channel is carried out partly limited to removing rubbish.

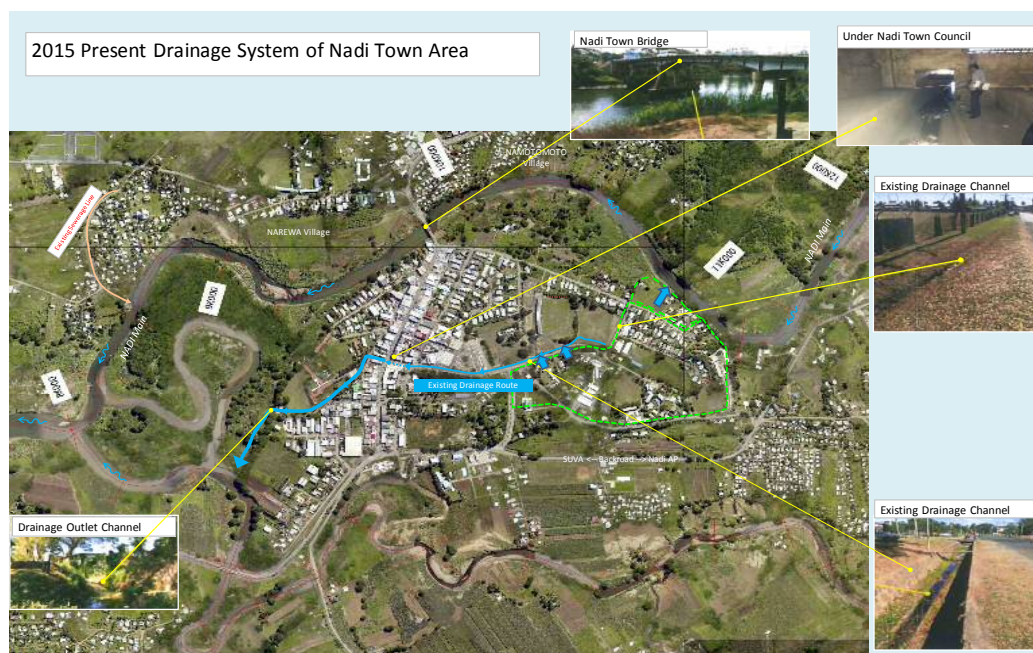


Figure 21-1 Drainage system of rainfall water in the central area of Nadi town

(2) Drainage counter measures for inland water

1) Mitigation method of inundation by inland water in the Project

In the Project, the river channel widening is to be implemented. In the flood control plan the design high water level (HWL) is planned to be equal to or lower than the ground height of the river side land so that the increase of inundation by inland water is restrained. In addition, depression area besides the dike is recommended to be filled to the top of bank so that there will be no depression area.

2) Review of Nadi Town Drainage Plan

Nadi Town Drainage Plan was completed for the solution of drainage problems and reduction of flood damage of Nadi town in August 2000 by the Department of Town and Country Planning, Nadi Town Council, LWRM, Western Drainage Board, National Disaster Management Committee, Nadi Rural Local Authority.

In the plan, present situation and issues were studied, and the long-term, and short- and medium-term plans were recommended to solve the issues (refer to Table23-1). However, the plan was studied without demarcation of inland water and river water, without hydraulic analysis and verification, and scientific ground.

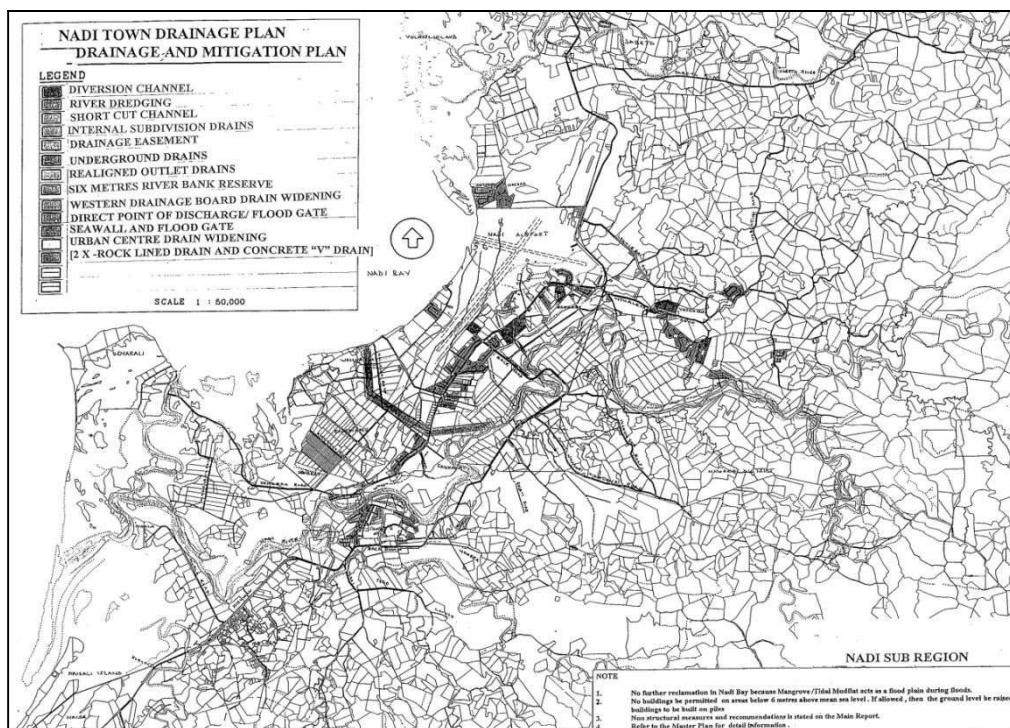
In addition to the above, the plan included the diversion channel and short cut recommended by JICA study carried out from 1996–1998, titled as [*The study on watershed management and flood control for the four major vitilevu rivers*](herein after referred to as Development Study1998)

As the progress of Nadi Town Drainage Plan, although the retention dams are constructed by LWRM separately, the other facilities are not confirmed remarkable progress in the investigation carried out by JICA study team in 2016.

Table 21-1 Contents of the 2000 Nadi Town Drainage Plan

Period	Contents of Plan
Short- and medium-term plan	Widening drainage channel and review of the alignment
Long-term plan	Construction of retention dam, embankment, diversion channel, short cut and so on

Source : Nadi Town Drainage Plan (2000)



Source: Nadi Town Council, Department of Town and Country Planning

Figure 21-2 Nadi Town Drainage Plan (2000)

21.2.3 Recommendations for Mitigation and Management of Disaster Risk

The present conditions and issues of flood control and the mitigation measures of disaster damage is as described in “ VolumeII Main Report, Part I: Master Plan Study, Chapter 4 Present Conditions and issues of Flood control and Basin Management

The flood control and flood damage mitigation measures executed up to now are limited to local river bank protection works, small scale retention dam construction, and introduction of early flood warning system and so on, which are not systematic measures for overall river basin. Considering the above situation the following recommendations are made.

(1) Background of mitigation and management of disaster risk

The inundation analysis was carried out for the maximum flood recorded in the past, and the predicted inundation area was presented. However, it is necessary to envisage possibility of new disaster risk resulting from extraordinary flood and different rainfall pattern, and to promote the counter measures by recognition of occurrence frequency, possible damage, by the government agencies, municipalities and residents.

Accurate and comprehensive information on frequency of inundation, risk of loss of human life, capacity and condition of facilities should be presented by the related agencies using hazard map or other appropriate means. The measures reducing the disaster risk should be promoted by sharing disaster risk information among agencies.

(2) Basic concept of implementation of adaptive measures

On the other hand, the increase of impact and risk of frequent and severe disasters of flood, sedimentation, high tide and drought by climate change has become a major concern in recent years. The importance of adaptive measures to the adverse effect of the climate change as well as mitigation measures is pointed out in the Conference of the Parties to the United Nations Framework Convention on Climate Change (COP). The measures were proposed considering change of future socioeconomic situation and uncertainty of risk such as climate change and movement of population, economy, and technology level and so on. In order to mitigate such disaster risk, it is important that adaptive measures are to be applied.

When adaptive measures are implemented as risk mitigation measures, the measures have to be promoted based on the concept listed below. And the measures have to be implemented adaptively and verified and

reviewed based on the knowledge and experience of not only upgrading the basic technology on the hydrology, which is based on scientific ground, but also promoting continuous monitoring of climate change, prediction, investigation and research, technological development of climate change.

The basic concept of implementation of adaptive measures is as follows:

- Adaptive management based on uncertainty
- Coping with existing phenomena
- Consideration of impact on future
- Comprehensive structural and non-structural measures
- Consideration of climate change for each project plan
- Symbiosis with nature and conformity with environment
- Consideration of regional characteristics and promotion of activity in each level

1) Adaptive management based on uncertainty

The prediction of future impact of climate change (timing of occurrence, place, and extent) is accompanied by uncertainty. When the adaptive measures are to be promoted, adaptive management has to be applied. Moreover, appropriate measures have to be selected when necessary with continuous monitoring of climate change, progress of climate change, up-to-date climate data, socio-economic regional variation, effect of the existing and new risk reduction measures.

2) Coping with existing phenomena at present

The influence of climate change has not been observed clearly in Nadi River basin, but if the climate change will be observed and becomes obvious by observation and monitoring, the measures in the Priority Project in this Study is basically to be adopted and promoted.

3) Consideration of impact on future

Although the extent of impact and time of occurrence of climate change is uncertain, the phenomena at present may become worse and cause the large disaster in progress of climate change. Therefore, the study on adaptive measures for various phenomena is to be carried out taking into consideration the change of the frequency of occurrence of phenomena.

4) Structural and non-structural aspects of measures

The adaptive measures include structural measures such as construction of facilities and non-structural measures such as early flood warning, town and land use planning based on the disaster risk. The comprehensive measures have to be implemented immediately by appropriately combining the structural and non-structural measures.

5) Consideration of adaptive measures and disaster prevention of each project plan

In order to implement the adaptive measures effectively and efficiently, the concept of adaptation to the impact of climate change and disaster prevention should be involved in each project plan. If necessary, concept of adaptive measures and disaster prevention should be considered in the design of facilities, maintenance, renewal of infrastructure and systems.

6) Prevention and reduction of disaster based on symbiosis with nature, conformity with environment and ecosystem

It is important to look at nature closely, utilize natural function and conform to nature in the development of infrastructure. Similarly, in the implementation of adaptive measures and disaster prevention measures, it is necessary to consider conservation, renewal and creation of natural environment.

The restoration and conservation of water conservation forest by watershed management not only strengthen the function of water conservation area but also increase regional toughness, and contribute to the prevention and reduction of disaster in community, and mangrove forest, natural retarding basin and swamp mitigate flooding. The ecosystem has various functions for prevention and reduction of disaster, and Eco-DRR (Ecosystem-based Solutions for Disaster Risk Reduction) is to be promoted.

A forestation in the upstream of Nadi River has been carried out by MOA, and this is expected to conserve the basin and protect the sediment run off. The downstream area on left bank side of Nadi River is natural

retarding basin where mangroves make their habitat. This area will be planned as an artificial retarding basin in the future in the Master Plan and will contribute to conservation of natural environment as well as reduction of disaster.

7) Consideration of regional characteristics and promotion of activity in each level

In promotion of the accommodated measures, the scenario of measures and implementation timing is to be assumed beforehand, and the preparation of flexible measures is to be considered. The Government is required to assist sufficiently the regions to understand the impact of climate change and the adaptive measures.

(3) Recommendation for adaptive measures in Nadi River basin

Based on the present situation of Nadi River basin and the Master Plan presented in this Study and the basic concept of adaptive measures above, the following measures are recommended.

1) Disaster prevention measures for floods with relatively low occurrence probability

a) Immediate implementation of Priority Project

The damage caused by the floods with relatively low occurrence probability such as once in two or three years will be eliminated by the implementation of the Priority Project targeting flood with occurrence probability of 1/50. Therefore, the Priority Project has to be implemented immediately.

b) Upgrading function of existing facilities

Upgrading the function of the existing facilities is to be carried out by strengthening drainage facilities and construction of reservoir for rainfall water.

c) Full execution of maintenance and renewal

The maintenance and renewal of existing facilities are to be fully executed after preparing the inventory of existing facilities and understanding the present condition of the facilities.

d) Expanding and upgrading hydrological observation network

The hydrological network such as rainfall observation and water level observation is to be expanded and upgraded and the information on flood and inland water is to be collected and integrated with river basin management

e) Comprehensive sediment management

In the entire sediment transport system, the target of sustainable sediment management is to be studied, and comprehensive sediment management is to be promoted for monitoring sediment yield, mitigation of sediment discharge by watershed conservation like planting in upstream area and planning maintenance works like dredging.

f) Upgrading of flood forecasting technique for plan and design of facilities

The flood forecasting technique is to be upgraded not only for reduction of disaster risk but also for reflecting it to the plan and design of facilities.

g) Integrated preparation and operation of river and rainfall drainage systems

Although the flood control is executed by the implementation of the Priority Project and the Master Plan, in order to eliminate the inundation damage in Nadi town, rainfall water drainage system should be facilitated; moreover, an integrated operation of the river and rainfall drainage systems is necessary for inundation caused by river water and rainfall water. Therefore, a system connecting river and rainfall water drainage systems is to be established to strengthen their function, and rainfall water reservoirs are to be promoted.

2) Disaster reduction measures for extraordinary floods

a) Enhancement hydrological observation network

The hydrological observation network is to be enhanced not only for rainfall and river water level but also for inland water level and tide level (high tide) by improvement of observation equipment and promotion of flood forecasting technique. Assistance to the related organizations and support system should be enhanced so that the appropriate evacuation recommendation is possible in extraordinary flood situations, and in normal time the detail information on disaster risk of dangerous location is to be supplied.

b) Evaluation of disaster risk for various external forces

The Master Plan for the external force of the maximum flood recorded in the past was established in this

Study. However, in the long-term, after continuous hydrological observation and monitoring is carried out, it is necessary to estimate the external force of not only the recorded maximum flood, but also for that of extraordinary floods that may result from exceptionally different rainfall pattern. And the occurrence frequency of inundation above floor level and risk of loss of human life, capacity and conditions of facilities are to be evaluated.

c) Structural inspection of Vaturu Dam

As for the Vaturu Dam located in the most upstream of Nadi River, the study is to be carried out on the safety such as structural damage and its influence in case the external force exceeds the design capacity of the dam, and counter measures are to be implemented, if necessary.

d) Restraining inundation area collaborated to town and regional planning

The embankment and rising of road in Back Road is examined to restrain development of the inundation area collaborated to town and regional planning and respond to extraordinary flood.

e) Drainage of inundation water

It is very important in the large scale flood disaster to drain the inundation water as soon as possible to prevent the expansion of inundation area, and for early restoration and rehabilitation. Therefore, the drainage plan is to be examined beforehand and all necessary preparation regarding drainage water gate, pumping station, secure of access road to supply fuel, reserve power, stock fuel and so on is to be promoted.

f) Enhancement of emergency evacuation system

The number of the dead and isolated persons including travelers is estimated in case of large scale flood disaster, based on this assumed damage, the timeline (action plan in time series) will be prepared in cooperation with related organizations so that the evacuation, first aid service, emergency transportation will be possible. The emergency evacuation system should include allocating boat, preparing evacuation place, securing evacuation route, preparing stock of supplies and so on.

g) Presentation of understandable information to urge evacuation

Simple and easily understandable information on the approaching danger, such as flooding and high tide, should be provided to the public.

Moreover, hazard map which is can be easily understood by residents and travelers has to be prepared, and the installation of notice board in the town, on which the estimated inundation depth and the elevation at the place, direction of evacuation, name and distance to the evacuation place are indicated, has to be promoted.

Appendix

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Appendix-1

Implementation Schedule of the Study

Appendix-2

Staffing Plan

