B3. STUDIES ON COMPONENT SCHEMES

B3.1 Component Schemes for Studies

Applicable Measures and Schemes: The Flood Mitigation Master Plan (the FM-MP) to be discussed here shall cover structural and non-structural measures to cope with flood and sediment induced disasters in the Study Area. Applicable measures and schemes would be (1) river improvement, (2) flood and sediment retention, (3) watershed management, and (4) flood plain management. These measures are schematically illustrated in Figure B3.1.1. The structural measures to be discussed here in the FM-MP are limited to the primary facilities to mitigate flood and sediment damages of the basin.

River Improvement: River improvement includes works for channel normalization, dike, bank protection and flood diversion. The channel normalization work aims to secure smooth drainage and passage of floodwater, by means of smoothening channel alignment, widening and deepening channel section, and normalizing sections at constriction due to river crossing structures and natural obstacles. The dike work is intended to prevent floodwater from spilling over the riverbank, and the bank protection work to prevent river erosion and to stabilize the river course. The flood diversion work includes construction of floodway and intercepting channel to lead floodwater away from the area to be protected. The following schemes were selected for the Study:

1) Bone-Bolango system: Improvement of the Bone, Tamalate and Bolango Rivers
2) Lake Limboto system: Improvement of the Biyonga, Meluopo, Marisa, Alo-Pohu and Rintenga rivers
3) Floodway: Tamalate floodway scheme to divert the Tamalate floodwater to the Bone River bypassing the urban area of Gorontalo, and Bolango-Limboto floodway scheme to divert the Bolango floodwater to Lake Limboto.

Flood Runoff Retention: Flood control dam and flood retardation pond are conceivable to retain floodwater so as to lower the flood peak in the lower reaches. Following three schemes were selected for the study:

1) Kayu-Merah dam scheme on the Biyonga river to alleviate flood peak in Limboto City

2) Toheti-Dehua dam scheme on the Bolango river to alleviate flood peak in Gorontalo City
3) Lake Limboto management scheme to regulate discharge at the outlet so as to mitigate flooding in Gorontalo City. The scheme may include improvement of outlet channel (the Tapodu River) with construction of hydraulic control gate (Tapodu Gate), construction of ring dike, etc.

Watershed Management: Watershed management is the activities to manage watershed area so as to retain rainwater in the watershed area and alleviate flood and sediment runoff to the lower basin. Main activities for the watershed management include:

1) Afforestation,
2) Conservation of existing forest,
3) Regulation of deforestation,
4) Conservation of natural flood retardation areas, and
5) Guidance to local people for appropriate forest use and conservation of mountain slope.

Flood Plain Management: The flood plain management is the activities to manage flood plain area so as to reduce and avoid occurrence of flood damages. Main activities for the flood plain management include:

1) Land use adjustment to reduce damageable properties in flood vulnerable areas,
2) Encouragement of peoples' water-proofing activities,
3) Establishment of flood forecasting and warning system, and
4) Promotion of flood fighting activities by community organization.

B3.2 River Improvement Schemes

Outline of Scheme: Existing channels of the Bone, Tamalate and Bolango rivers of the Bone-Bolango river system; and the Biyonga, Meluopo, Marisa, Alo-Pohu and Rintenga rivers of the Lake Limboto system are improved so as to have enough capacity to carry flood water of 20 year return period. The river improvement includes the works for channel excavation, dike embankment, bank protection, and drainage sluice across the dike.

Channel Design: River Channel was designed as follows:

1) Design discharges applied to the channel design are shown in Figure B3.2.1 based on 20-year flood.
2) Design high water level was set as low as possible considering the surrounding ground elevation and design high water levels (MHWL) at the river mouth (MHWH: +0.673 m,MSL) and at Lake Limboto (+5.50 m,MSL).
3) Minimum river width between the dikes and dike section are assumed tentatively for the Master Plan as shown in Figure B3.2.2 according to the standards and practice in Japan.
4) The low water channel is improved by means of excavation, so that the river channel has enough capacity to carry 20-year flood discharge below the design high water level set in the above.
5) Channel flow calculation was made assuming the coefficient of roughness n = 0.030 for low water channel and n = 0.060 for high water channel.
6) Bank protection works are necessary at the sections where the low water channel is close to the dike and/or important properties to be protected are located. For the purpose of overall cost estimate for the Master Plan, bank protection works were assumed for the whole river banks, since rivers in the Study Area are steep located on and adjacent to the alluvial fan.

Relationship with Other Alternatives: Quantity of works for river improvement of respective rivers are summarized in Table B3.2.1. The river improvement schemes set forth here are fundamental solution to attain flood mitigation in the Study Area. The scheme may be replace with other alternatives discussed below after comparison from overall viewpoint.

B3.3 Floodway Schemes

Two floodway schemes were considered for the Study, i.e., Tamalate floodway and Bolango-Limboto floodway schemes.

(1) Tamalate Floodway Scheme

Outline of Scheme: The Tamalate River has a total basin area of 70 km^2 including mountainous basin. Floodwater from the basin flows down to the urban area of Gorontalo City and drained into the Bone River just upstream of the Bone-Bolango

junction. The Tamalate River is one of cause of flooding in southern part of Gorontalo City. In order to protect of the urban area from the Tamalate floodwater, Tamalate floodway scheme was considered. The floodway will divert all the flood runoff from the upper basin (about 42 km^2) to the Bone River, alleviating the flood runoff in the lower reaches of the lower Tamalate River. The existing Tamalate River downstream from the floodway divergence will serve as a trunk drainage channel of the urban area. The Tamalate floodway scheme includes works of construction of new floodway, diversion weir for the floodway, and closing dike of the existing Tamalate River with intake sluice to supply water during dry season.

Floodway Design: The floodway and the related facilities were designed as follows:

1) Design discharge: Design discharge distributions without and with floodway are shown in Figure B3.3.1.
2) Floodway route: The route connecting Alitalango of the Tamalate and Oluhuta of the Bone River was proposed as shown in the Figure B3.3.1. The floodway length is the shortest at this site (1.5 km) and the land is mostly farmland.
3) Floodway Channel: Open channel with low dike embankment was designed in the same procedures as channel design mentioned in the previous sub-section.
4) Closing Dike: The Tamalate River is divided into the upper and lower Tamalate River by a closing dike at Alitalango section. During flood season the flood water from the upper Tamalate will be diverted to the Bone River via floodway and the lower Tamalate will serve as a trunk drainage channel of the Gorontalo City. An intake gate will be provided with the closing dike to supply water to the urban area during dry season for water use and maintenance purposes.

Selection of Alternative: The Tamalate floodway will reduces the improvement works of the lower Tamalate River. For the selection of the optimum scheme following alternatives were established for comparison:

1) Alternative [Ch]: Channel improvement of the existing Tamalate River
2) Alternative [Fw＋Ch]: Construction of Tamalate floodway with minor channel improvement of the lower Tamalate River

Project features and merit/demerit of these schemes were compared from technical, financial, economic, social and environmental aspects as shown in Table B3.3.1. In conclusion, Alternative [Fw＋Ch] was selected mainly due to lower cost and firm flood

mitigation effects.

(2) Bolango-Limboto Floodway Scheme

The Bolango River passes through the urban area of Gorontalo City. The Bolango River flooded frequently in the urban area since the channel capacity of the lower Bolango River is low. In order to reduce flood discharges to the urban area, Bolango-Limboto floodway scheme was considered. The floodway will divert major part of floodwater exceeding the existing capacity of the Bolango River (100 m^3/s) to Lake Limboto.

Floodway Design: The floodway and the related facilities were designed as follows:

1) Design discharge: Design discharge distributions without and with floodway are shown in Figure B3.3.2.
2) Floodway route: The floodway divert from the Bolango River at Batato to Lake Limboto near Lupoyo 1, taking route on the paddy field with less settlements as shown in the Figure B3.3.2. The total floodway length is 6.3 km.
3) Floodway Channel: Open channel with low dike embankment was designed in the same procedures as channel design mentioned in the previous sub-section.
4) Diversion Structures: In order to divert 650 m^3/s of flood water to floodway and 100 m^3/s to lower reaches of the Bolango River under 20-year flood conditions, culvert was designed across the Bolango River and fixed weir at the inlet of the floodway.

Selection of Alternative: The floodway scheme will reduce the improvement works of the Bolango River in the downstream reaches. For the selection of the optimum scheme, following alternatives were established for comparison:

1) Alternative [Ch]: Channel improvement of the existing Bolango River up to the Bone confluence.
2) Alternative [Fw+Ch]: Construction of Bolango-Limboto floodway with minor channel improvement of the existing Bolango River

Project features and merit /demerit of these schemes were compared from technical, financial, economic, social and environmental aspects as shown in Table B3.3.2. In conclusion, Alternative [Ch] was selected mainly due to lower cost and less sediment

and environmental problems.

B3.4 Flood and Sediment Retention Schemes

Within the frame of the LBB Basin Water Management Master Plan (WM-MP) formulated in March 1999 with technical assistance of CIDA, two multi-purpose dams have been proposed. Objectives of these dams are as follows:

1) Toheti-Dehua multi-purpose reservoir on the Borango River: To provide a reliable water supply for irrigation, domestic, and industrial supplies; to augment water supply to Lake Limboto; to provide flood control facilities, hydropower; and retention of sediment in order to improve agricultural production, increase farmers' incomes, improve health standards and the Lake Limboto environment, and reduce flooding in Gorontalo City.
2) Kayu-Merah multi-purpose reservoir on the Biyonga River: To construct a small multi-purpose reservoir for irrigation, domestic water supply, flood control, and retention of sediment, in order to increase agricultural production, reduce flood damage in the city of Limboto, provide a more reliable source of water for domestic use, and reduce the amounts of sediment being deposited in Lake Limboto and the downstream irrigation system.

Besides these dam schemes, the WM-MP has also proposed Lake Limboto management Scheme. These schemes are expected to serve for flood control as one of the multi-purpose functions. Therefore, these schemes were adopted for the present study as alternative flood mitigation measures.

(1) Toheti-Dehua Flood Control Dam

General features: Candidate site of the dam is located on the Bolango River, immediately downstream of its confluence with the Mongillo River. Basin area upstream of the dam is 357 km^2.

Dam: In order to estimate the cost for flood mitigation function, the dam exclusive for flood mitigation was assumed for the study. Stage-area-volume (H-A-V) curves are shown in Figure B3.4.1. The dam scheme was planned and designed based on the design for the WM-MP, adjusting for storage capacity. Design discharge distributions without and with dam are shown in the Figure B3.4.1.

Selection of Alternative: The dam scheme will reduce the improvement works of the Bolango River in the lower reaches. For the selection of the optimum scheme, following alternatives were established for comparison:

1) Alternative [Ch]: Channel improvement of the existing Bolango River up to the Bone confluence.
2) Alternative [Dm + Ch]: Construction of Toheti-Dahua flood control dam with channel improvement of the existing Bolango River.

Project features and merit/demerit of these schemes were compared from technical, financial, economic, social and environmental aspects as shown in Table B3.4.1. In conclusion, Alternative [Ch] was selected mainly due to lower cost and immediate realization of the flood mitigation effects.

(2) Kayu-Merah Flood Control Dam

General features: Candidate site of the dam is located on the Biyonga River with basin area of 58 km^2 at dam site.

Dam: In order to estimate the cost for flood mitigation function, the dam exclusive for flood mitigation was assumed for the study. Stage-area-volume (H-A-V) curves are shown in Figure B3.4.2. The dam scheme was planned and designed based on the design for the WM-MP, adjusting for storage capacity. Design discharge distributions without and with dam are shown in the Figure B3.4.2.

Selection of Alternative: The dam scheme is an alternative measure for the Biyonga River improvement scheme. For the selection of the optimum scheme, following alternatives were established for comparison:

1) Alternative [Ch]: Channel improvement of the existing Biyonga River up to Lake Limboto.
2) Alternative [Dm＋Ch]: Construction of Kayu-Merah flood control dam with channel improvement of the existing Biyonga River.

Project features and merit/demerit of these schemes were compared from technical, financial, economic, social and environmental aspects as shown in Table B3.4.2. In

conclusion Alternative [Ch] was selected mainly due to lower cost and immediate realization of the flood mitigation effects.

(3) Multipurpose Dams

Flood Control Dam: According to the alternative studies in the previous sub-sections, Toheti-Dahua and Kayu-Merah flood control dams were not adopted to the FM-MP. This decision, however, does not mean to deny the proposed multi-purpose dam schemes.

Multi-purpose Dam: The multi-purpose dam, notwithstanding with flood control component or without, serves for flood peak reduction and sediment control in the lower river reaches. In view of this the construction of multi-purpose dam is favorably accepted from flood and sediment control viewpoint.

Uncertainty of Time of Implementation: Primary component of Toheti-Dahua and Kayu-Merah multi-purpose dams would not be flood control and implementation of dam schemes depend on the programs of other sectors, which makes difficult to incorporate these multi-purpose dams into the FW-MP.

(4) Lake Limboto Management

The flood mitigation function of the lake should be maintained and the sound development of lake side area and other existing functions of the lake should be secured. From this viewpoint, Lake Limboto management scheme was proposed mainly for flood and sediment disaster mitigation. The Lake Limboto management scheme includes realignment of the Biyonga and Alo-Pohu rivers with sediment traps, lake dikes, and the Tapodu River improvement with gate.

Sediment Trap Works: Major sources of sediment of the Lake Limboto are the Biyonga, Alo-Pohu, Meluopo and Marisa rivers. In order to prevent the sediment spread over the lake, sedimentation area was specified in the northern part of the lake bounded by sediment trap works. Lower reaches of the Biyonga and the Alo-Pohu rivers are realigned to lead the sediment to the specified area. The sediment trap works consist of palm piles and bamboo net to trap sediment with crest elevation of +4.0 m,MSL.

Lake Dikes: Lake dikes were proposed primarily to protect low-lying land adjacent to the lake and secondarily to demarcate the lake area. The dike was designed with crown elevation of 6.5 m,MSL taking free board of 1 m, crown width of 4.0 m considering future use as rural road, and side slope of 1 on 3. Drainage sluices were also considered for the local drainage.

Tapodu River Improvement with Gate: The Tapodu River is the only outlet of the lake. The river channel is improved with gate at the confluence with the Bolango River. The gate (Tapodu gate) shall have dual function, i.e., (1) to prevent Bolango flood water from flowing into the lake and (2) to maintain lake water level at +4.0 m,MSL at the lowest.

B3.5 Watershed Management Schemes

Watershed management is the activities to encourage following activities by the government agencies concerned and relevant local communities so as to retain rain water in the watershed area and alleviate flood and sediment runoff in the lower basin:

1) Construction of erosion control facilities
2) Afforestation and land use control
   - Afforestation
   - Conservation of existing forest
   - Regulation of deforestation
   - Conservation of natural flood retardation areas
3) Publicity activities: Guidance to government agencies concerned and local community people for appropriate forest use and conservation of mountain slope, etc.

B3.6 Flood Plain Management Schemes

The flood plain management is the activities to support and guide the community people in the flood prone areas so as to reduce and avoid occurrence of flood damages. The activities for the flood damage deduction in the flood prone areas would include the following:

1) Community mobilization: To organize the community peoples to cope with the floods.

2) Local coping measures: To support and guide the community people to reduce actual flood damages from self-help viewpoint through:
   - Land use adjustment to reduce damages in flood vulnerable areas,
   - Encouragement of peoples' water-proofing activities, and
   - Promotion of flood fighting activities by community organization.
3) Community-based sustainable measures: To encourage and support community people to develop and carry out flood mitigation works/activities in sustainable manners, by deriving additional benefits for improving their livelihoods

B3.7 Proposed Flood Mitigation Master Plan

As a result of studies on component schemes, the proposed flood mitigation master plan is summarized below.

(1) Flood and Sediment Disasters

Suffering Areas: Major areas suffering from flood and sediment disasters in the Study Area are southern part of Gorontalo City, middle reaches of the Bolango River, Limboto area, Isim-Pohu area, and western area of Lake Limboto. Among these, problems are more serious in the southern part of Gorontalo City near the confluence of the Bolango and Bone rivers. Major types of flood disaster in the Study Area are flooding and inundation, and those of sediment disasters are bank erosion, silting-up of riverbeds, and sedimentation of Lake Limboto.

Roles of Flood Mitigation: Per capita GRDP of the Study Area is far low comparing with the national average. Flood mitigation is one of the basic infrastructures of the basin and is duly necessary to support sound economic development of the basin and to stabilize people's livelihood, accordingly to alleviate poverty of the region.

(2) Principles for Planning

Flood Mitigation Master Plan (FM-MP) for the LBB basin will be formulated along the following principles:

1) **Objective of Master Plan:** The FM-MP aims to direct or guide the flood mitigation activities that will be conducted by various agencies and organizations concerned.

2) **Scope:** The FM-MP shall cover structural and non-structural measures. The structural measures discussed in the master plan are limited to the primary facilities to mitigate flood and sediment damages of the area, and the secondary facilities to be connected to the primary facilities will not be included in principle.
3) **Target Year:** In line with the phasing of National Five-Year Plan, target year of the FM-MP was set at the end of Tenth Five-Year Plan in 2019. The proposed project will be implemented to support basin's socio-economic conditions at the target year.
4) **Design Scale:** Facilities for the FM-MP are planned and designed based on 20-year flood.

(3) Component Works of FM-MP

Figure B3.7.1 shows general location map of the component works for the FM-MP.

1) Bolango-Bone River System:
   - River improvement: Bone, Bolango and lower Tamalate rivers (Figures B3.7.2 through B3.7.4)
   - Tamalate floodway (Figure B3.7.5)

2) Lake Limboto System:
   - River improvement: Biyonga, Meluopo, Marisa, Alo-Pohu and Rintenga rivers (Figures B3.7.6 through B3.7.10)
   - Lake Limboto management (Figure B3.7.11 for general plan and Figure B3.7.12 for Tapodu River)

3) Watershed Management: To encourage;
   - Construction of erosion control facilities,
   - Afforestation and land use control, and
   - Publicity activities.

4) Flood Plain Management: To promote and guide for the community people to take activities for;
   - Community mobilization,
   - Local coping measures, and
   - Community-based sustainable measures.

Table B3.2.1 BASIC QUANTITY OF CHANNEL IMPROVEMENT WORKS

No.	Work Item	Unit	BOLANGO-BONE RIVER SYSTEM			LAKE LIMBOTO SYSTEM				
			Bone River Improvement	Tamalate River Improvement	Bolango River Improvement	Biyonga River Improvement	Meluopo River Improvement	Marisa River Improvement	Alopohu River Improvement	Rintenga River Improvement
1	Earth Work									
	- Excavation	m3	0	470,000	1,560,000	85,000	18,000	260,000	1,600,000	290,000
	- Embankment	m3	533,000	82,000	600,000	110,000	50,000	58,000	181,000	50,000
2	Concrete Work									
	- Concrete	m3	0	0	0	0	0	0	0	0
3	Stone Works									
	- Wetrubble masonry	m3	104,000	51,000	180,000	231,000	23,000	39,000	110,000	38,000
4	Bridge									
	- Bridge type 1 (w = 4.0 m)	m	0	450	0	450	240	150	750	150
	- Bridge type 2 (w = 7.0 m)	m	250	90	690	780	0		250	
5	Sluiceway									
	- Sluiceway type 1 (1m x 1m)	pcs	0	14	5	0	0	0	0	0
	- Sluiceway type 2 (3m x 3m)	pcs	0	0	1	0	0	0	0	0
6	Metal Works									
	- Steel Gate	set	0	0	0	0	0	0	0	0

Note: The above quantities of channel improvement works are the basic quantities without consideration of alternatives such as dam and floodway schemes, and subject to change incorporating the alternatives.

Table B3.3.1 COMPARISON OF ALTERNATIVES: TAMALATE FLOODWAY SCHEME

Descriptions	Alternative [Ch] (Tamalate River improvement)	Alternative [Fw+Ch] (Tamalate Floodway)
SCHEME DESCRIPTION	Improvement of existing channel	Constraction of Floodway(1.5km) + improvement of existing channel
TECHNICAL ASPECT		
- Major quantity of work	- New channel: None - Excavation: 686,000 m^3 - Embankment: 63,300 m^3 - Concrete: None - Dam: None	- New channel: 1.5 km - Excavation: 340,000 m^3 - Embankment: 62,000 m^3 - Concrete: 5,000 m^3 - Dam: None
- Difficulty in work	Works in populated urban area	Works in farm lands
- Ranking (Wt=0.15)	2 (0.30)	0 (0)
FINANCIAL ASPECT		
- Project cost - Maintenance cost	Rp 35.8 billion	Rp 29.2 billion
- Ranking (Wt=0.40)	2 (0.80)	0 (0)
ECONOMIC ASPECT		
- Project effects	- Same as other scheme	- Same as other scheme
- Other positive/negative effects	- None	- None
- Ranking (Wt=0.15)	1 (0.15)	1 (0.15)
SOCIAL ASPECT		
- Relocation of houses	Medium	Medium
- Land acquisition	43 ha	33 ha
- Ranking (Wt=0.15)	1 (0.15)	1 (0.15)
ENVIRONMENTAL ASPECT		
- Negative impact	Public pollution along lower Tamalate	Water pollution and sedimentation in Bone
- Positive impact	Reduction of bank erosion in lower Tamalate	Reduction of bank erosion in lower Tamalate
- Ranking (Wt=0.15)	2 (0.30)	0 (0)
OVERALL EVALUATION		
- Summary of ranking	1.70	0.30
- Special remarks		Lower cost and firm effects
- Evaluation	Not selected	**SELECTED**

(Remarks) Wt: Weight for overall evaluation 0: Advantageous/better, 1: Moderate/no difference, 2: Disadvantageous/worse

Table B3.3.2 COMPARISON OF ALTERNATIVES: BOLANGO-LIMBOTO FLOODWAY SCHEME

Descriptions	Alternative [Ch] (Bolango River improvement)	Alternative [Fw+Ch] (Bolango - Limboto Floodway)
SCHEME DESCRIPTION	Improvement of existing channel	Constraction of Floodway(6.3km) + improvement of existing channel
TECHNICAL ASPECT		
- Major quantity of work	- New channel: None - Excavation: 1,560,000 m^3 - Embankment: 600,000 m^3 - Concrete: None - Dam: None	- New channel: None - Excavation: 2,900,000 m^3 - Embankment: 170,000 m^3 - Concrete: 15,000 m^3 - Dam: None
- Difficulty in work	Works in populated urban area	Works in farm lands
- Ranking (Wt=0.15)	2 (0.30)	0 (0)
FINANCIAL ASPECT		
- Project cost - Maintenance cost	Rp 107.7 billion	Rp 126.9 billion
- Ranking (Wt=0.40)	0 (0)	2 (0.80)
ECONOMIC ASPECT		
- Project effects	- Same as other scheme	- Same as other scheme
- Other positive/negative effects	- None	- None
- Ranking (Wt=0.15)	1 (0.15)	1 (0.15)
SOCIAL ASPECT		
- Relocation of houses	Medium	Medium
- Land acquisition	301 ha	108 ha
- Ranking (Wt=0.15)	2 (0.30)	0 (0)
ENVIRONMENTAL ASPECT		
- Negative impact	Public pollution along lower Bolango	Sedimentation in Lake Limboto
- Positive impact	Reduction of bank erosion in lower Bolango	Reduction of bank erosion in lower Bolango
- Ranking (Wt=0.15)	1 (0.15)	2 (0.30)
OVERALL EVALUATION	0.90	1.25
- Summary of ranking	Lower cost and less sediment and environmental preblems	
- Special remarks		
- Evaluation	**SELECTED**	Not selected

(Remarks) Wt: Weight for overall evaluation 0: Advantageous/better, 1: Moderate/no difference, 2: Disadvantageous/worse

Table B3.4.1 COMPARISON OF ALTERNATIVES: TOHETI-DEHUA DAM SCHEME

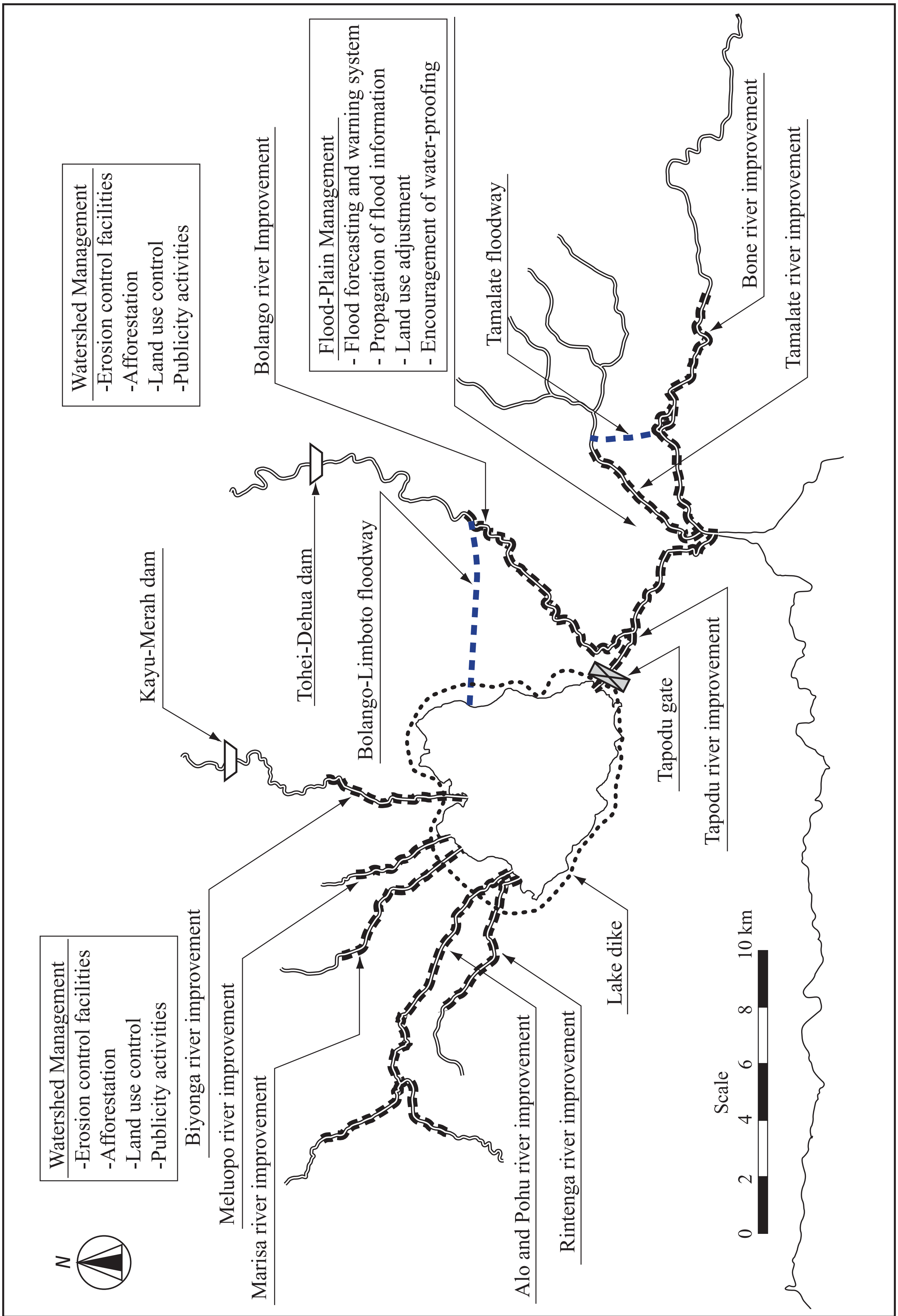
Descriptions	Alternative [Ch] (Bolango River improvement)	Alternative [Dm+Ch] (Toheti-Dehua Dam)
SCHEME DESCRIPTION	Improvement of existing channel	Constraction of Dam + improvement of existing channel
TECHNICAL ASPECT		
- Major quantity of work	- New channel: None - Excavation: 1,560,000 m^3 - Embankment: 600,000 m^3 - Concrete: None - Dam: None	- New channel: None - Excavation: 1,560,000 m^3 - Embankment: 420,000 m^3 - Concrete: None - Dam: 1 nos
- Difficulty in work	Traditional earth work	Dam need sophisticated technology
- Ranking (Wt=0.15)	0 (0)	2 (0.30)
FINANCIAL ASPECT		
- Project cost - Maintenance cost	Rp 107.7 billion	Rp 198.5 billion
- Ranking (Wt=0.40)	0 (0)	2 (0.80)
ECONOMIC ASPECT		
- Project effects	- Same as other scheme	- Same as other scheme
- Other positive/negative effects	- None	- None
- Ranking (Wt=0.15)	1 (0.15)	1 (0.15)
SOCIAL ASPECT		
- Relocation of houses	Medium	Medium
- Land acquisition	301 ha	492 ha
- Ranking (Wt=0.15)	1 (0.15)	2 (0.30)
ENVIRONMENTAL ASPECT		
- Negative impact	Public pollution along lower Bolango	Negative impacts on flora and fauna
- Positive impact	Reduction of bank erosion in lower Bolango	Not identified
- Ranking (Wt=0.15)	1 (0.15)	2 (0.30)
OVERALL EVALUATION		
- Summary of ranking	0.45	1.85
- Special remarks	Lower cost and immediate effects	
- Evaluation	**SELECTED**	Not selected

(Remarks) Wt: Weight for overall evaluation 0: Advantageous/better, 1: Moderate/no difference, 2: Disadvantageous/worse

Table B3.4.2 COMPARISON OF ALTERNATIVES: KAYU-MERAH DAM SCHEME

Descriptions	Alternative [Ch] (Biyonga River improvement)	Alternative [Dm+Ch] (Kayu-Merah Dam)
SCHEME DESCRIPTION	Improvement of existing channel	Constraction of Dam + improvement of existing channel
TECHNICAL ASPECT		
- Major quantity of work	- New channel: None - Excavation: 85,000 m^3 - Embankment: 110,000 m^3 - Concrete: None - Dam: None	- New channel: None - Excavation: None - Embankment: 26,000 m^3 - Concrete: None - Dam: 1 nos
- Difficulty in work	Traditional earth work	Dam needs sophisticated technology
- Ranking (Wt=0.15)	0 (0)	2 (0.30)
FINANCIAL ASPECT		
- Project cost - Maintenance cost	Rp 19.7 billion	Rp 47.3 billion
- Ranking (Wt=0.40)	0 (0)	2 (0.80)
ECONOMIC ASPECT		
- Project effects	- Same as other scheme	- Same as other scheme
- Other positive/negative effects	- None	- None
- Ranking (Wt=0.15)	1 (0.15)	1 (0.15)
SOCIAL ASPECT		
- Relocation of houses	Medium	Medium
- Land acquisition	31 ha	29 ha
- Ranking (Wt=0.15)	1 (0.15)	1 (0.15)
ENVIRONMENTAL ASPECT		
- Negative impact	Public pollution along lower Biyonga	Impacts on both terrestrial and aquatic ecology
- Positive impact	Reduction of bank erosion in lower Biyonga	Not identified
- Ranking (Wt=0.15)	1 (0.15)	2 (0.30)
OVERALL EVALUATION		
- Summary of ranking	0.45	1.70
- Special remarks	Lower cost and immediate effects	
- Evaluation	**SELECTED**	Not selected

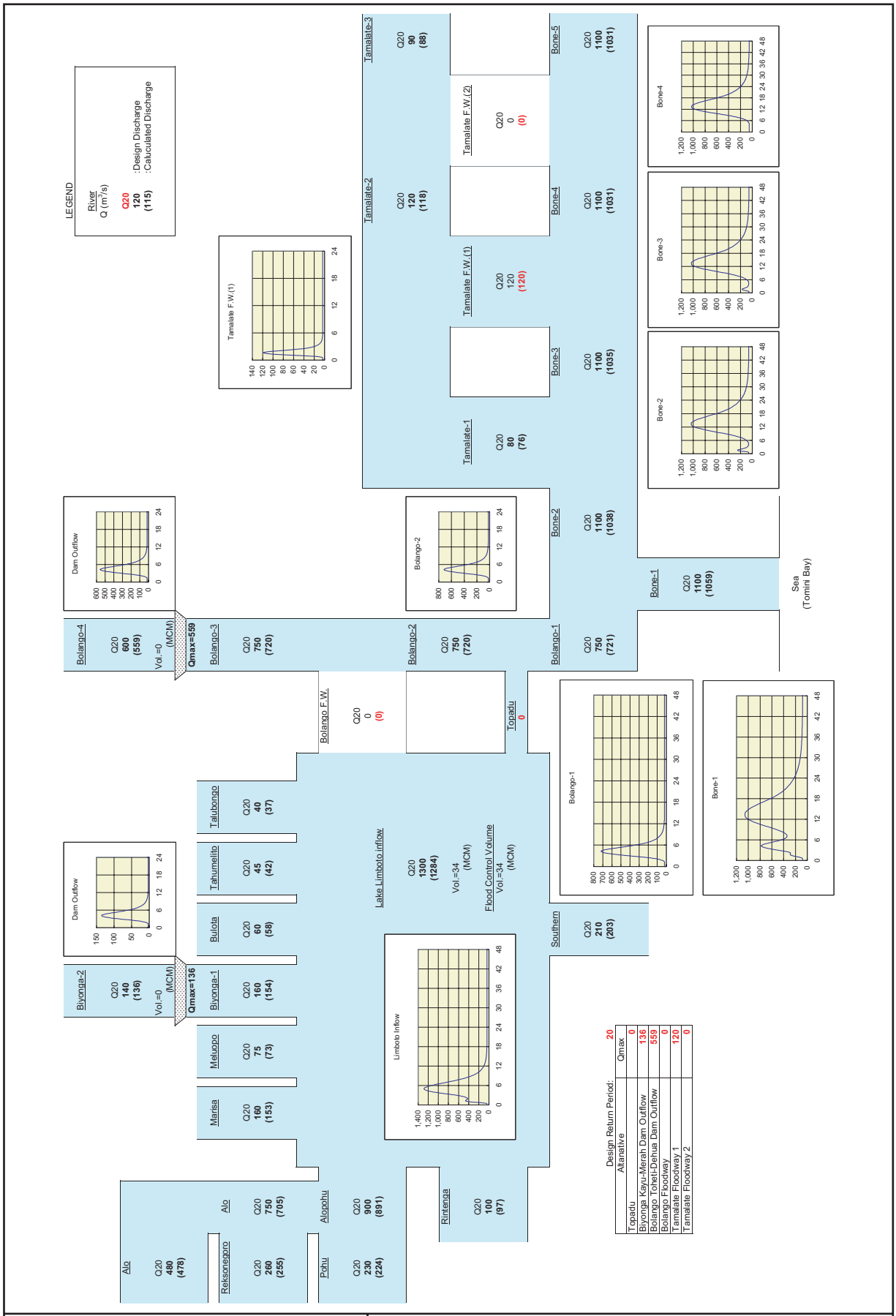
(Remarks) Wt: Weight for overall evaluation 0: Advantageous/better, 1: Moderate/no difference, 2: Disadvantageous/worse



The Study on Flood Control and Water Management in Limboto-Bolango-Bone Basin in the Republic of Indonesia

Japan International Cooperation Agency

Figure B3.1.1
COMPONENT SCHEMES FOR FLOOD MITIGATION STUDIES



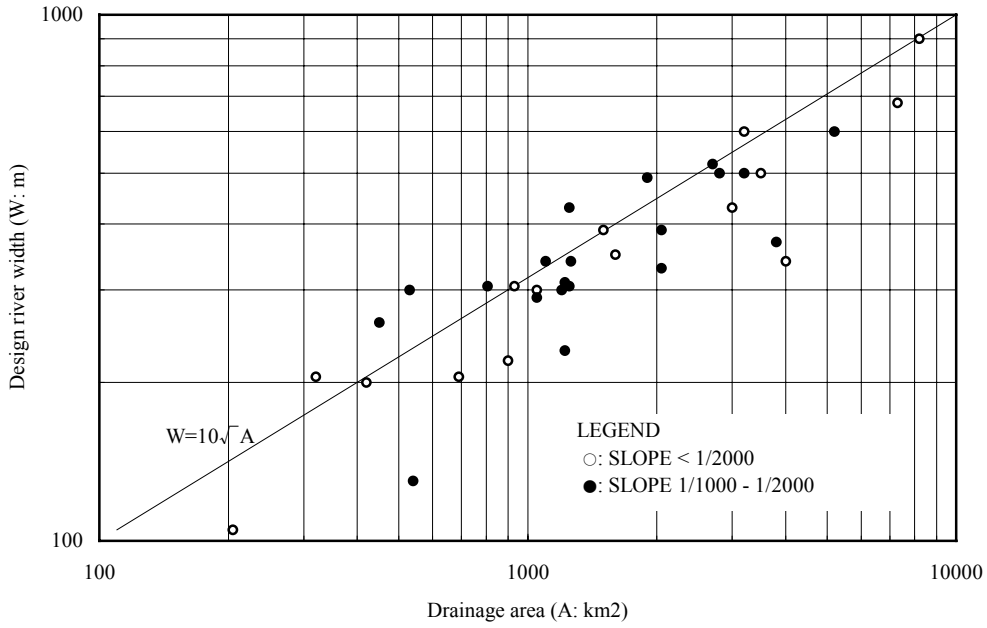
The Study on Flood Control and Water Management in Limboto-Bolango-Bone Basin in the Republic of Indonesia

Japan International Cooperation Agency

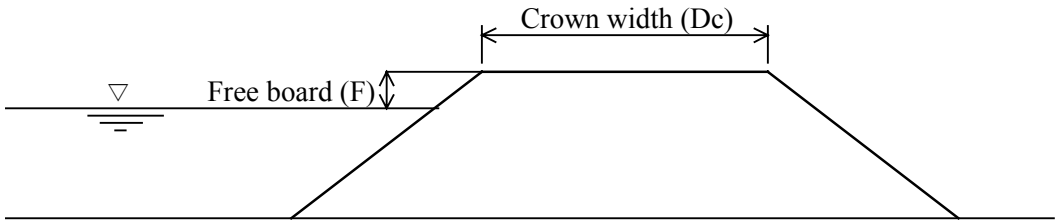
Figure B3.2.1

DESIGN DISCHARGE DISTRIBUTION (20-YEAR FLOOD)

Minimum River Width



Dike Section



Crown Width of Dike

Q (m^3/s)	Dc (m)
< 500	3
< 2000	4

Free Board

Q (m^3/s)	F (m)
< 200	0.6
< 500	0.8
< 2000	1.0

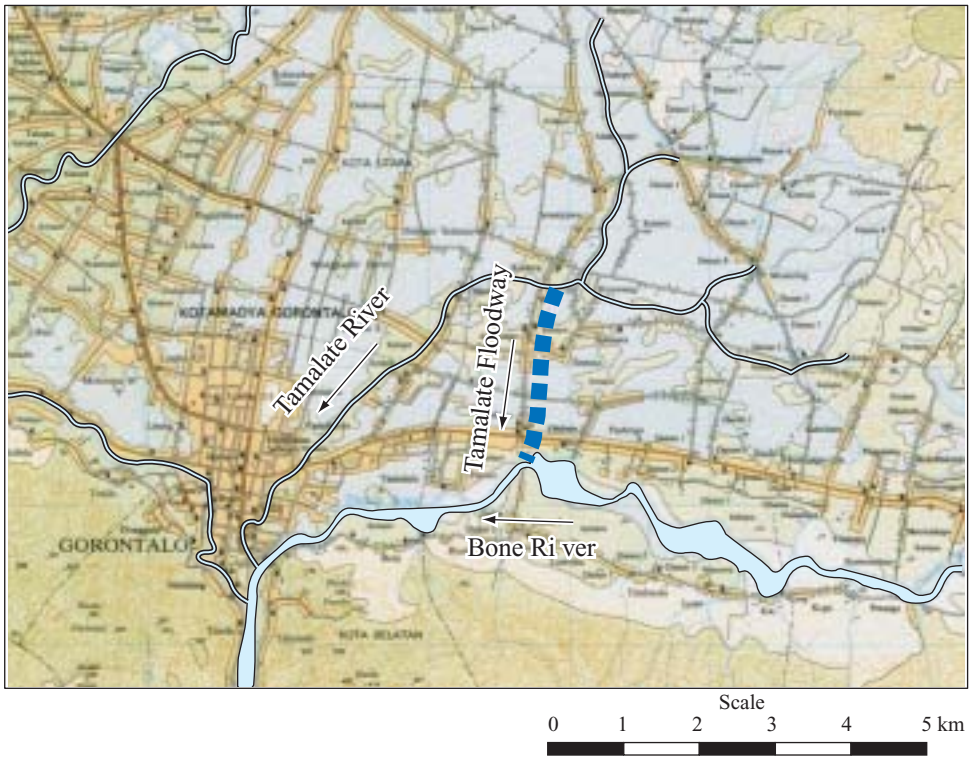
The Study on Flood Control and Water Management in Limboto-Bolango-Bone Basin in the Republic of Indonesia

Japan International Cooperation Agency

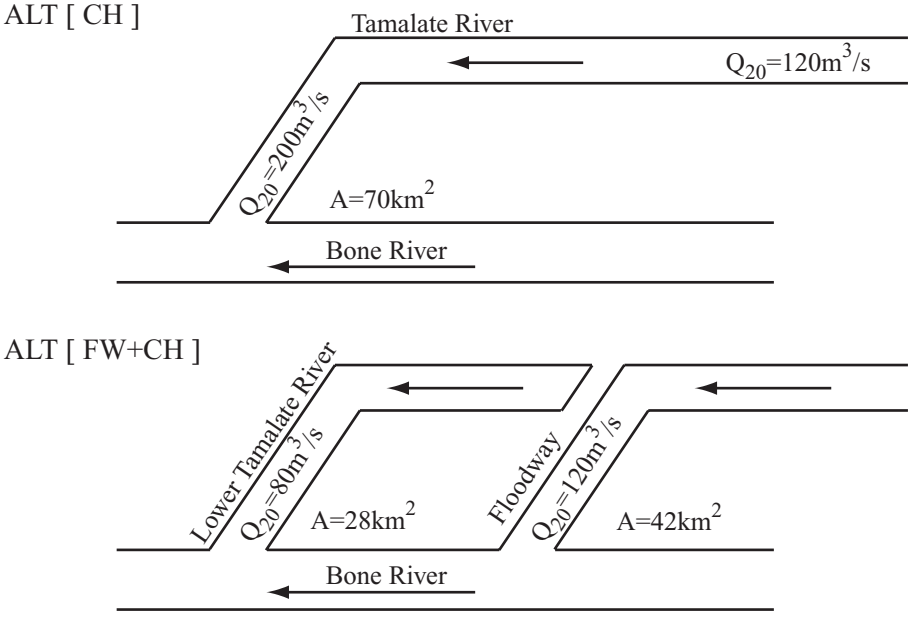
Figure B3.2.2

DESIGN OF DIKE

Route of Tamalate Floodway

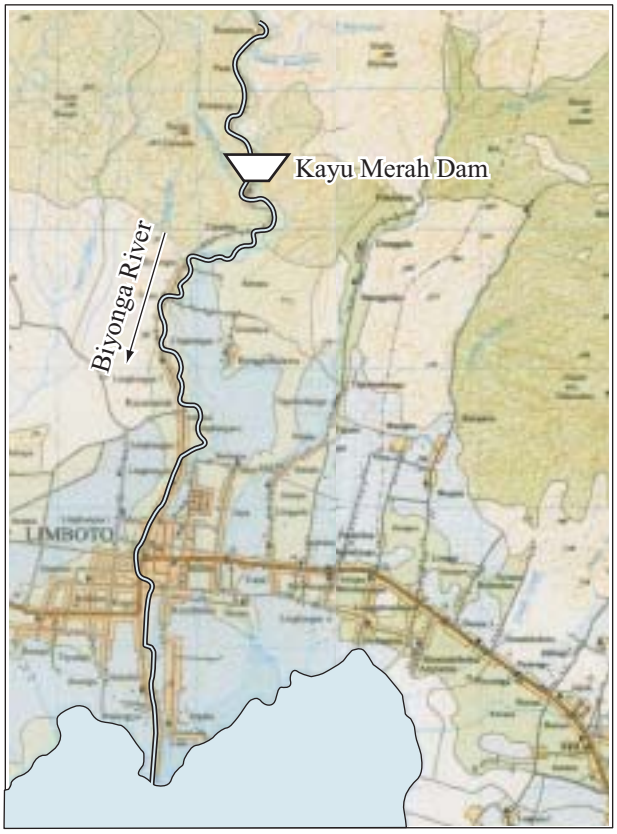


Design Discharge Distribution

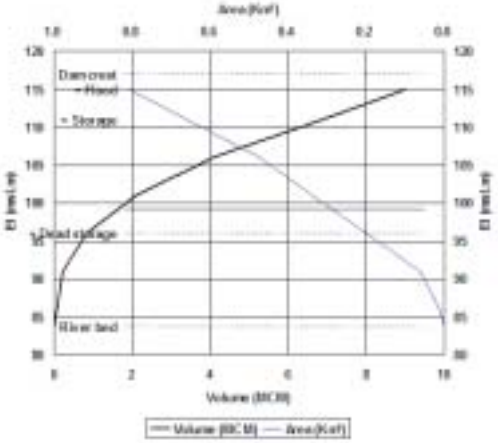


The Study on Flood Control and Water Management in Limboto-Bolango-Bone Basin in the Republic of Indonesia	**Figure B3.3.1**
Japan International Cooperation Agency	**TAMALATE FLOODWAY SCHEME**

Location Map of Kayu Merah Dam

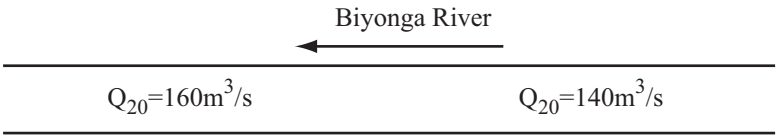


H-A-V Curve of Reservoir

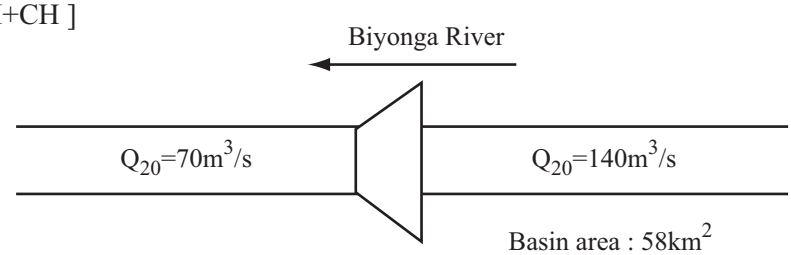


Design Discharge Distribution

ALT [CH]

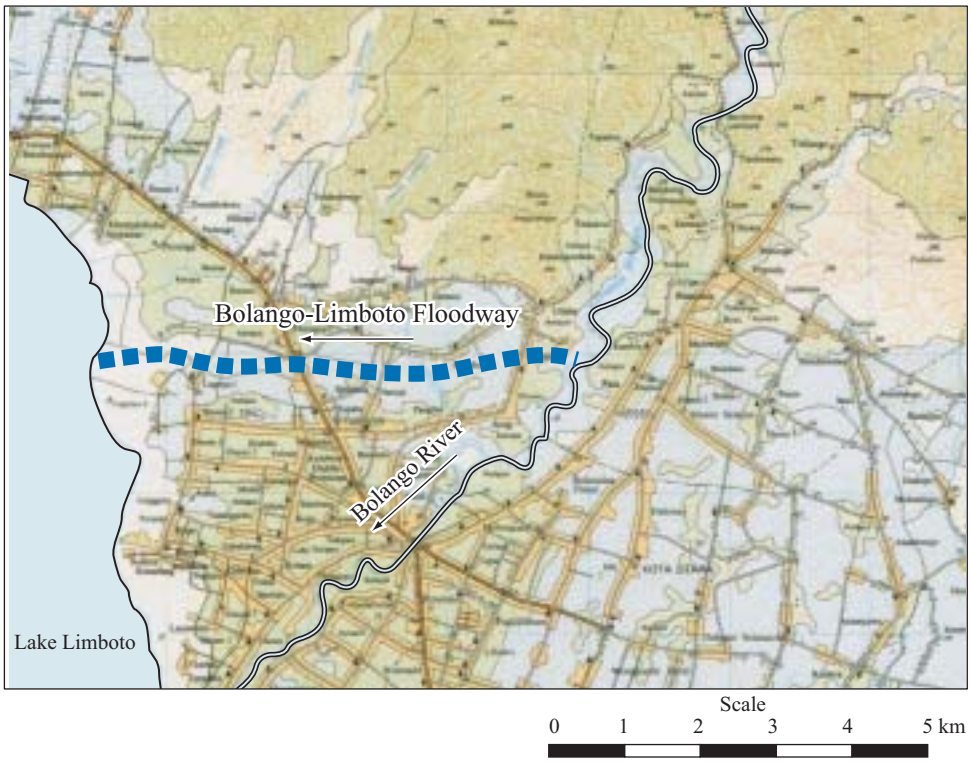


ALT [DM+CH]

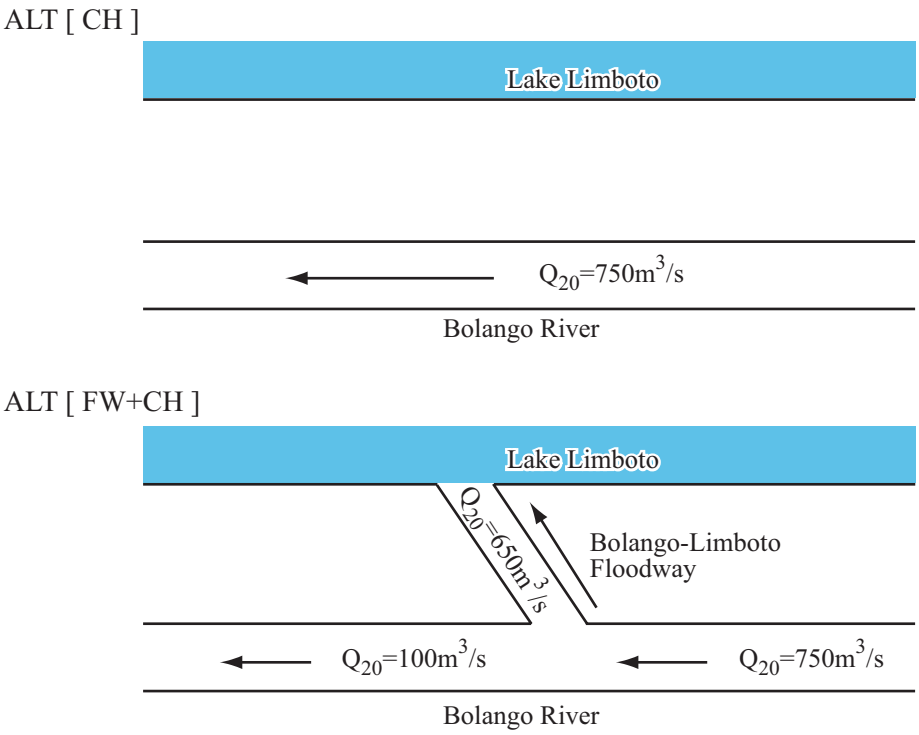


The Study on Flood Control and Water Management in Limboto-Bolango-Bone Basin in the Republic of Indonesia	**Figure B3.4.2**
Japan International Cooperation Agency	**KAYU MERAH DAM SCHEME**

Route of Bolango-Limboto Floodway



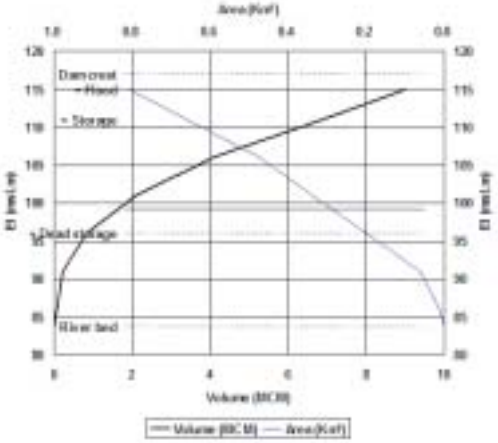
Design Discharge Distribution



The Study on Flood Control and Water Management in Limboto-Bolango-Bone Basin in the Republic of Indonesia *Japan International Cooperation Agency*	**Figure B3.3.2** **BOLANGO-LIMBOTO FLOODWAY SCHEME**

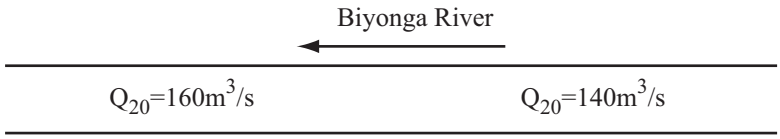
Location Map of Kayu Merah Dam

H-A-V Curve of Reservoir



Design Discharge Distribution

ALT [CH]



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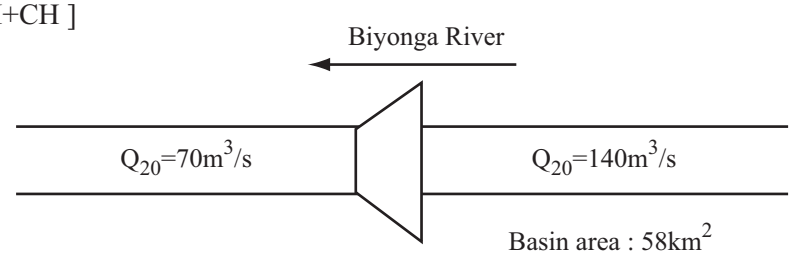

The Study on Flood Control and Water Management in Limboto-Bolango-Bone Basin in the Republic of Indonesia	**Figure B3.4.2**
Japan International Cooperation Agency	**KAYU MERAH DAM SCHEME**

The Study on Flood Control and Water Management in Limboto-Bolango-Bone Basin in the Republic of Indonesia

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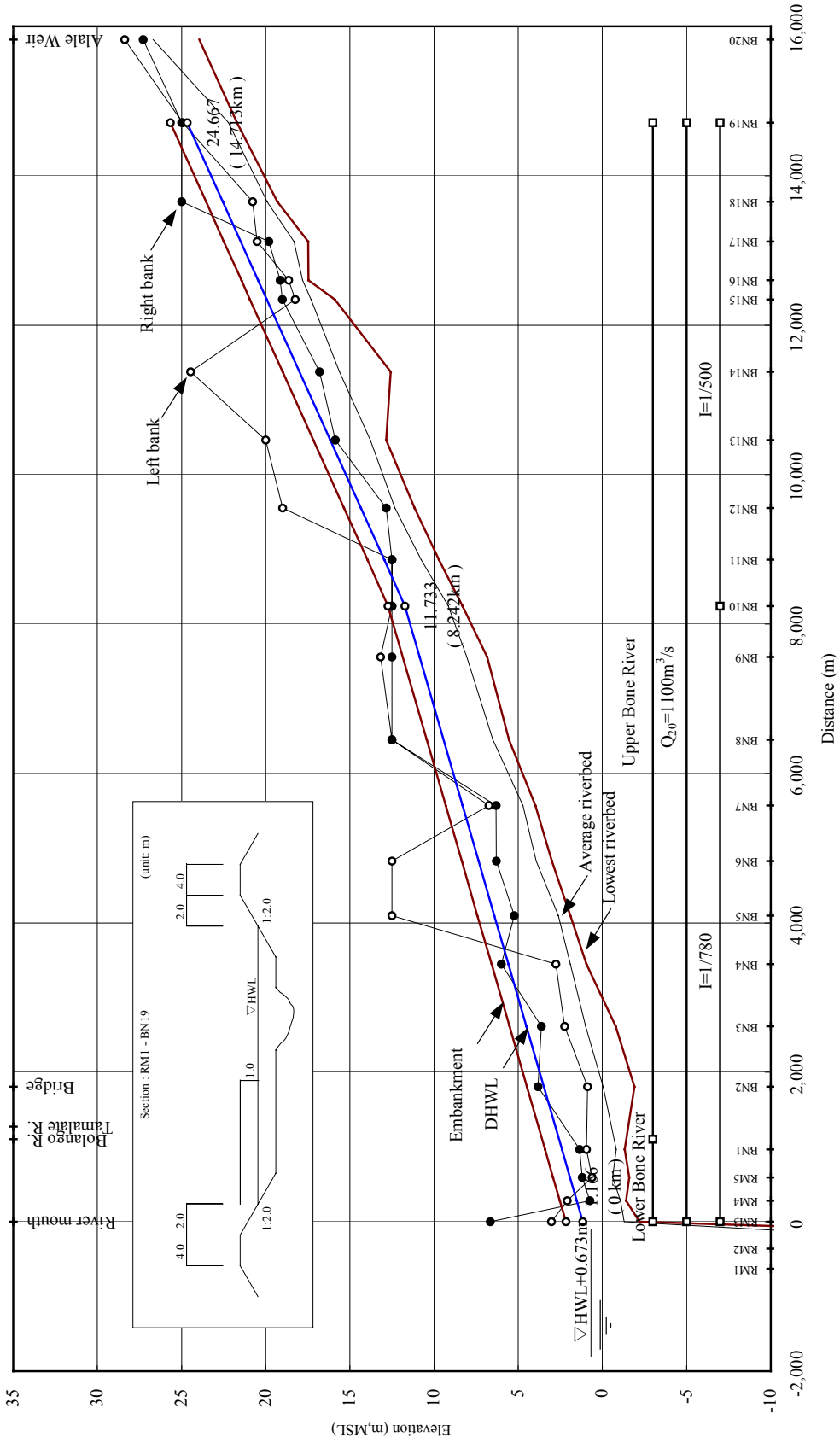
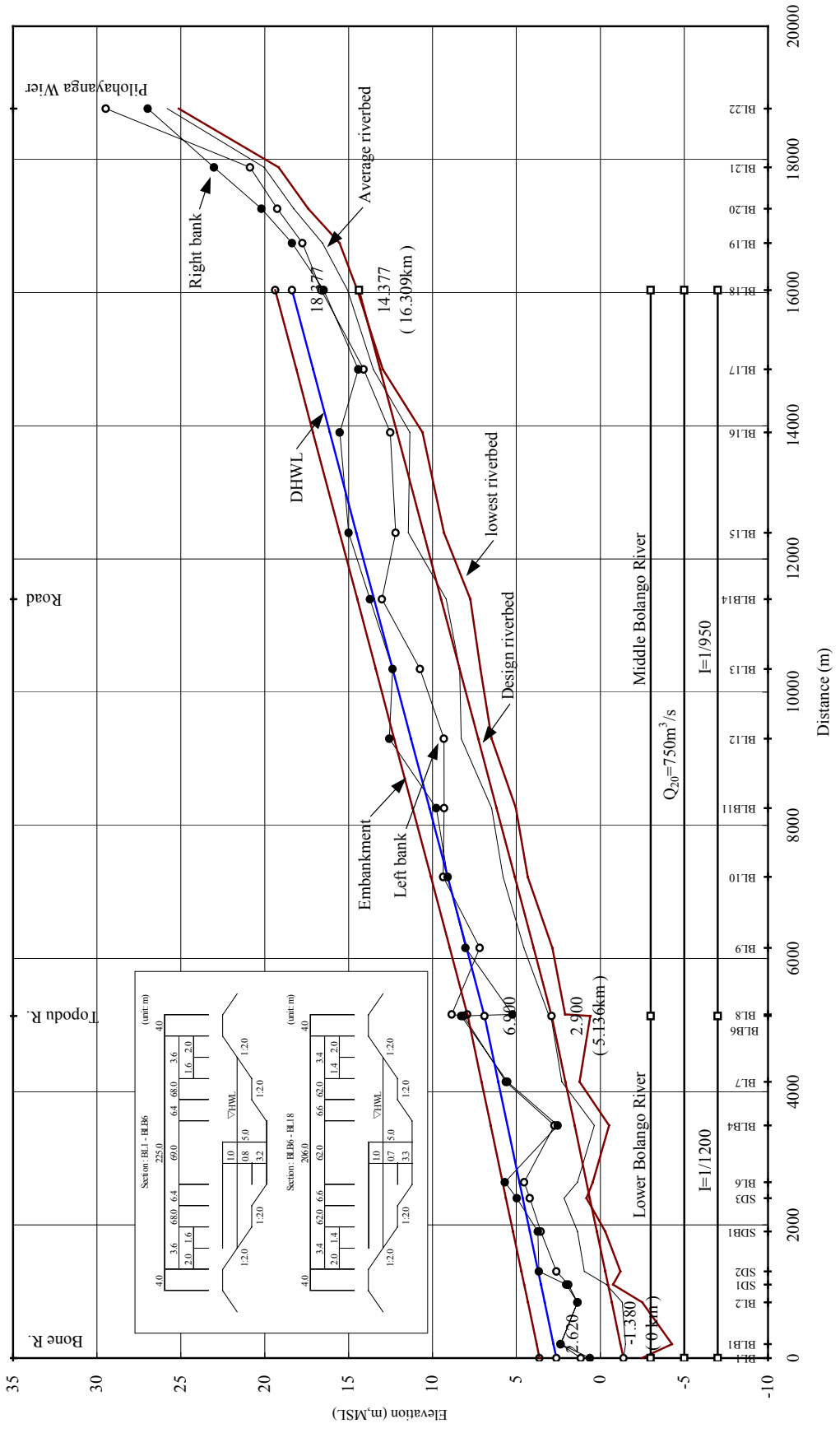
Figure B3.7.1
FLOOD MITIGATION MASTER PLAN FOR LIMBOTO-BOLANGO-BONE BASIN



The Study on Flood Control and Water Management in Limboto-Bolango-Bone Basin in the Republic of Indonesia *Japan International Cooperation Agency*	**Figure B3.7.2** **DESIGN LONGITUDINAL PROFILE (BONE RIVER)**



The Study on Flood Control and Water Management in Limboto-Bolango-Bone Basin in the Republic of Indonesia

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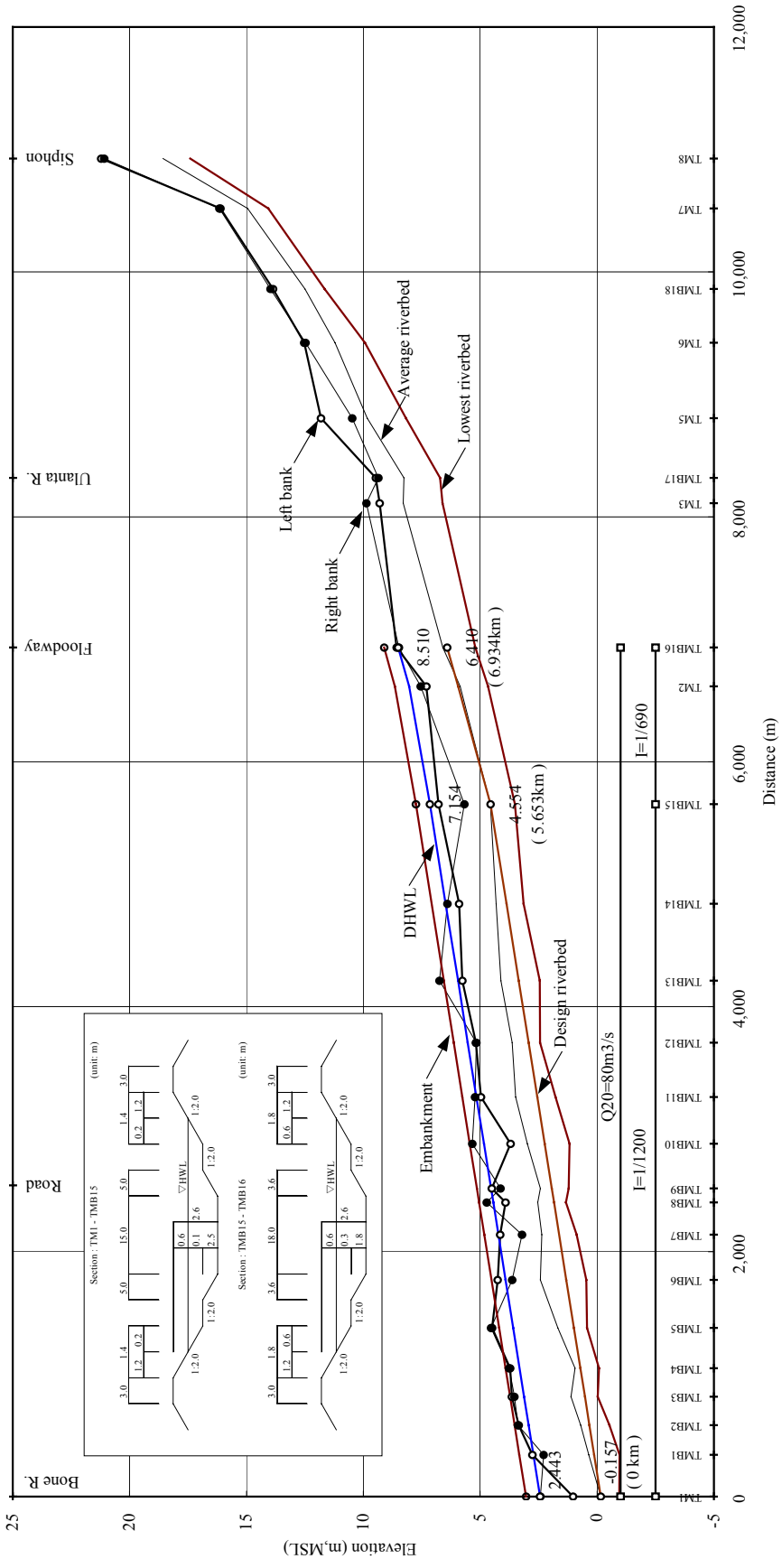
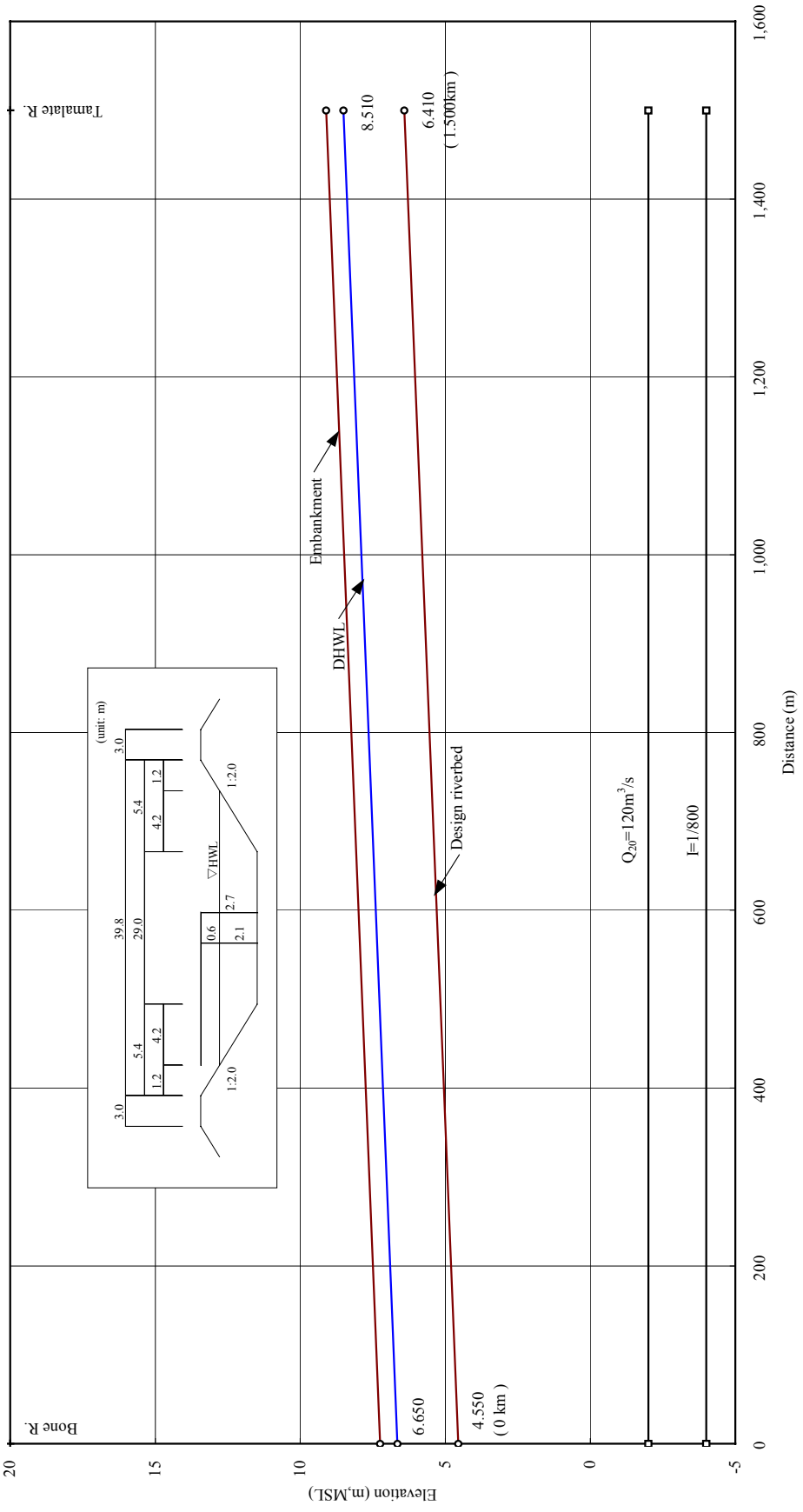
Figure B3.7.3
DESIGN LONGITUDINAL PROFILE (BOLANGO RIVER)



The Study on Flood Control and Water Management in Limboto-Bolango-Bone Basin in the Republic of Indonesia	**Figure B3.7.4 DESIGN LONGITUDINAL PROFILE (LOWER TAMALATE RIVER WITH FLOODWAY)**
Japan International Cooperation Agency	



The Study on Flood Control and Water Management in Limboto-Bolango-Bone Basin in the Republic of Indonesia

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Figure B3.7.5
DESIGN LONGITUDINAL PROFILE (TAMALATE FLOODWAY)

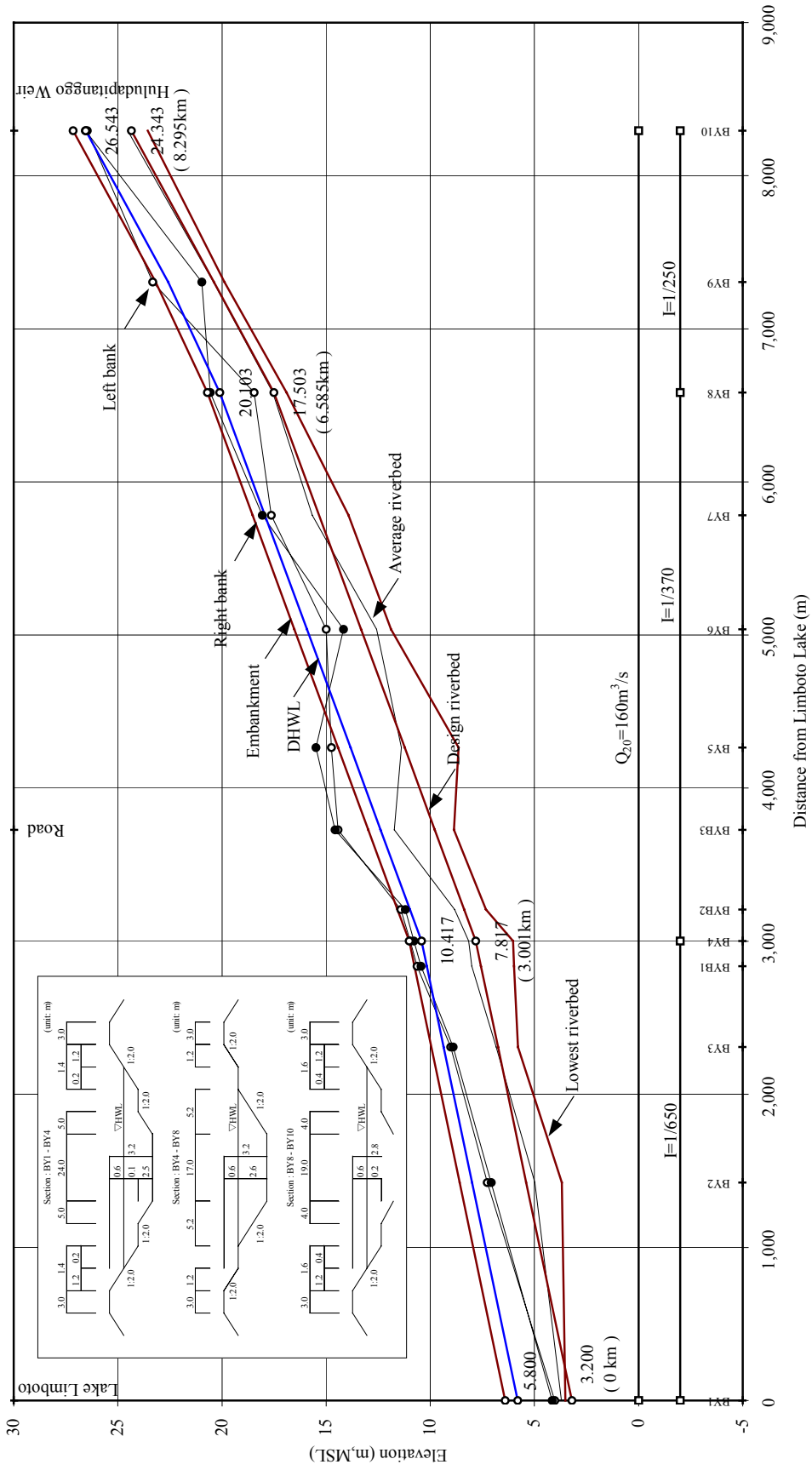

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Figure B3.7.6
DESIGN LONGITUDINAL PROFILE (BIYONGA RIVER)

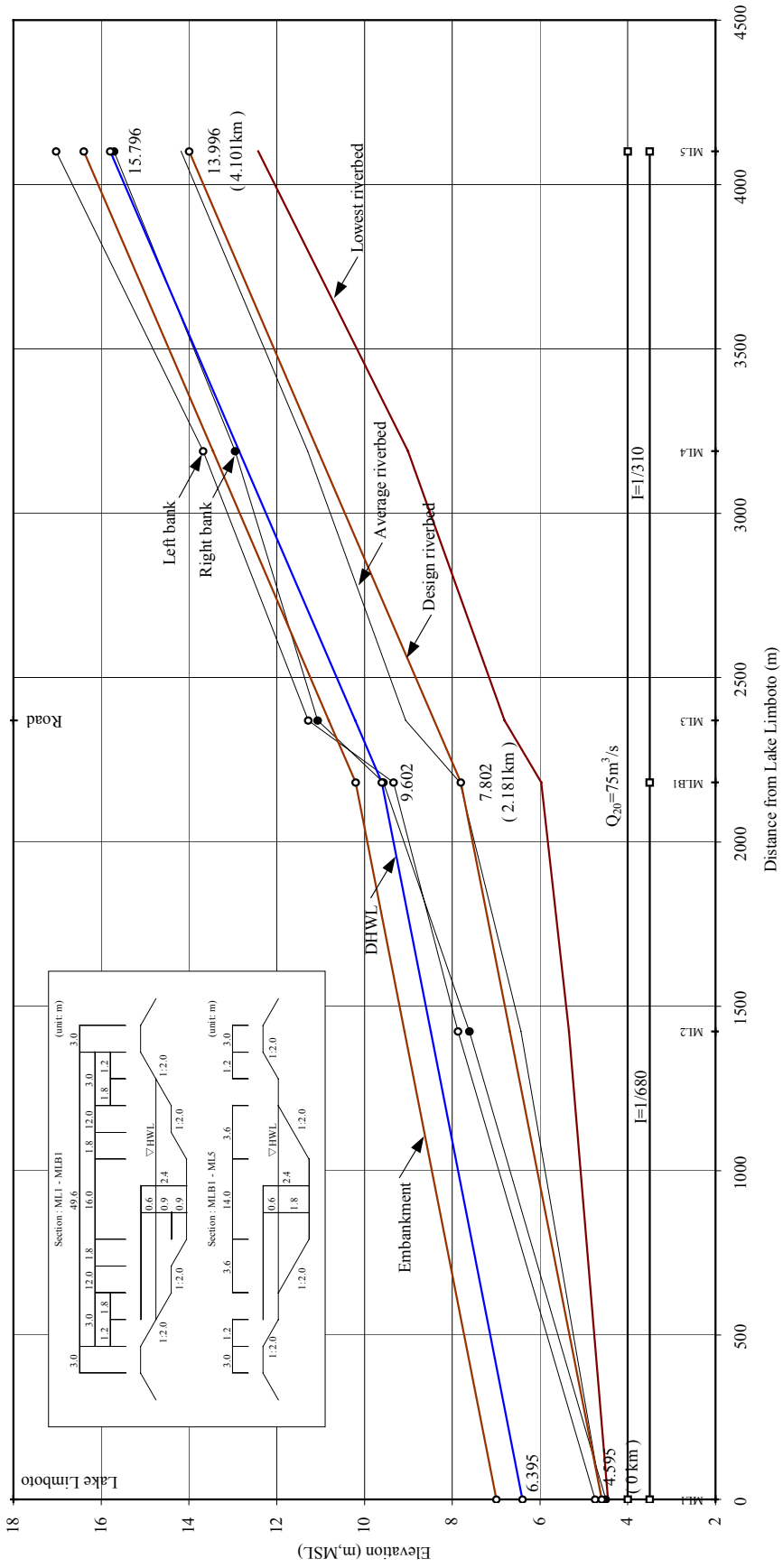

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Figure B3.7.7
DESIGN LONGITUDINAL PROFILE (MELUOPO RIVER)