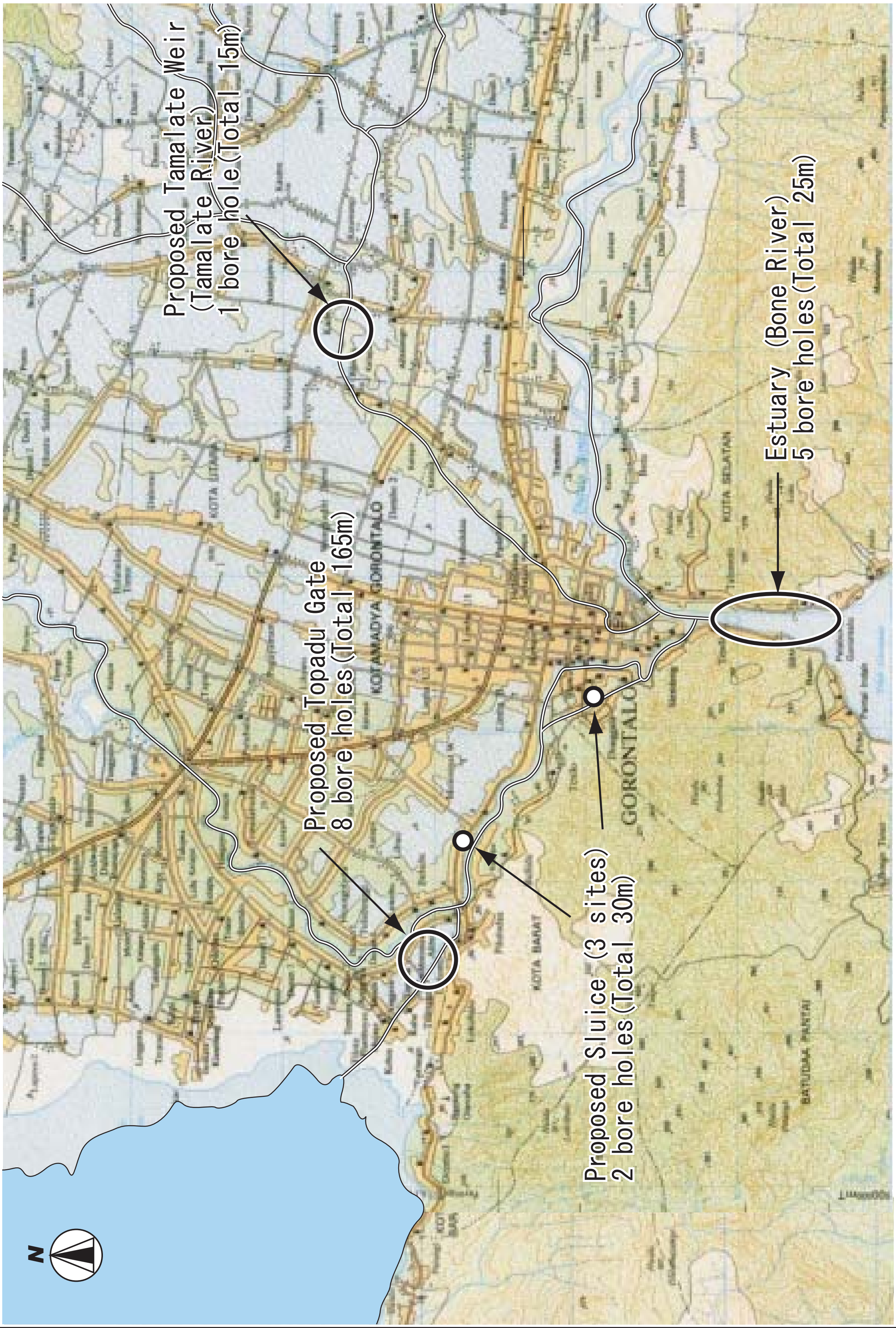
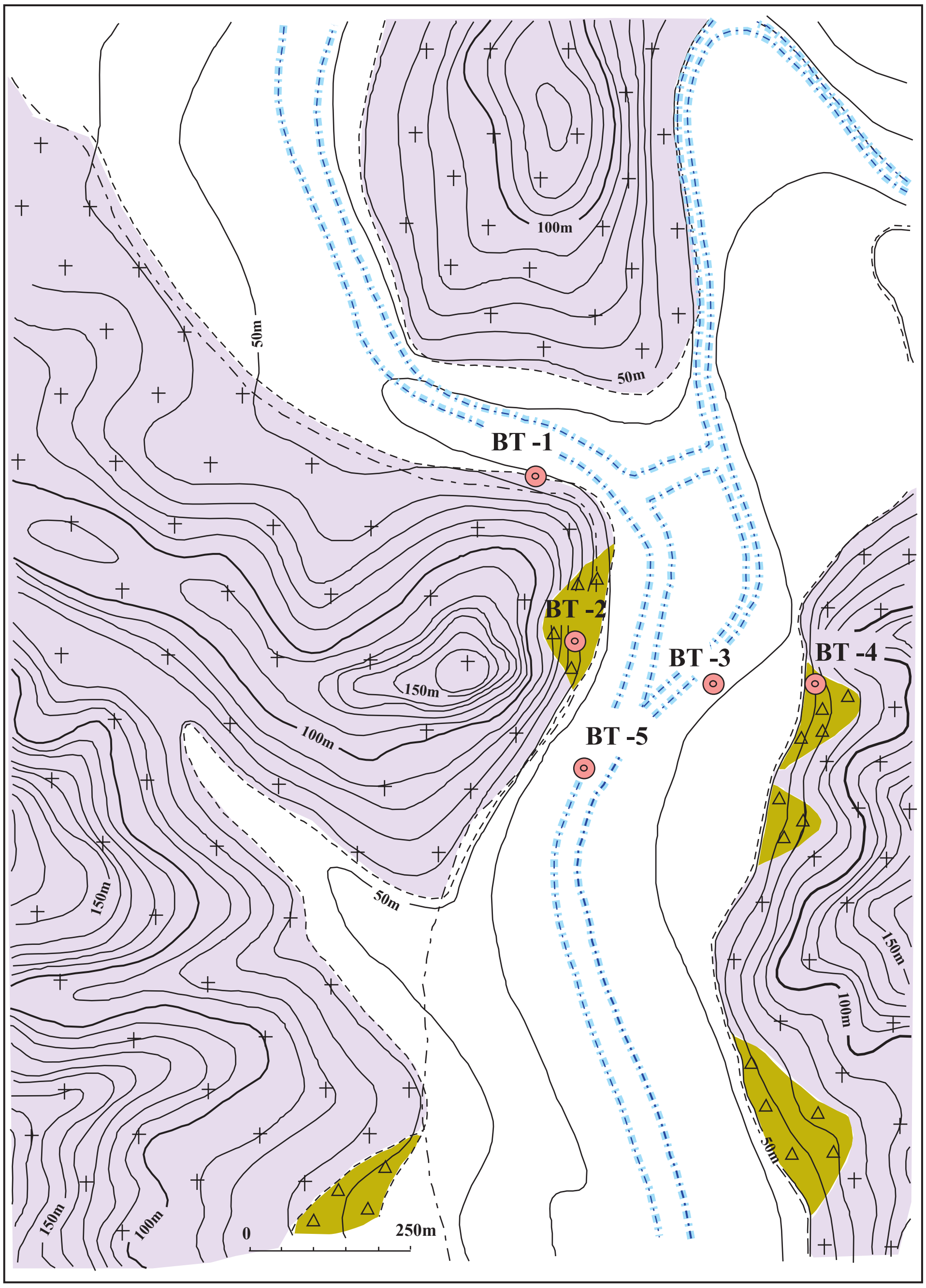


The Study on Flood Control and Water Management in Limboto-Bolango-Bone Basin in the Republic of Indonesia

Japan International Cooperation Agency

Figure A1.3.1
LOCATION MAP OF DRILLING HOLES (2/2 : F/S STAGE)



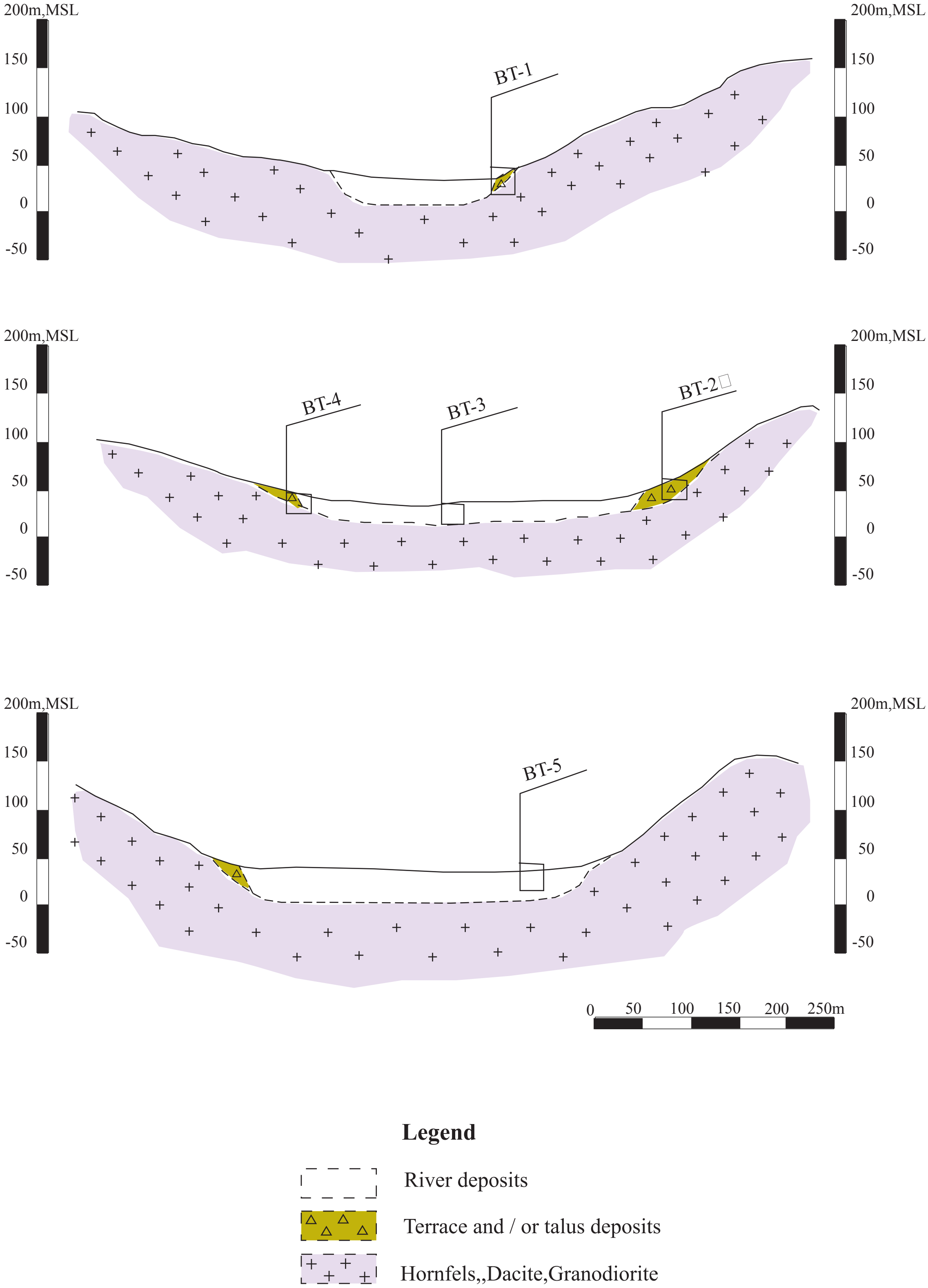
Legend

	River deposits		Road
	Terrace and / or talus deposits		Geologic Boundary
	Hornfels,,Dacite,Granodiorite		River in dry season
	Drilling Hole		

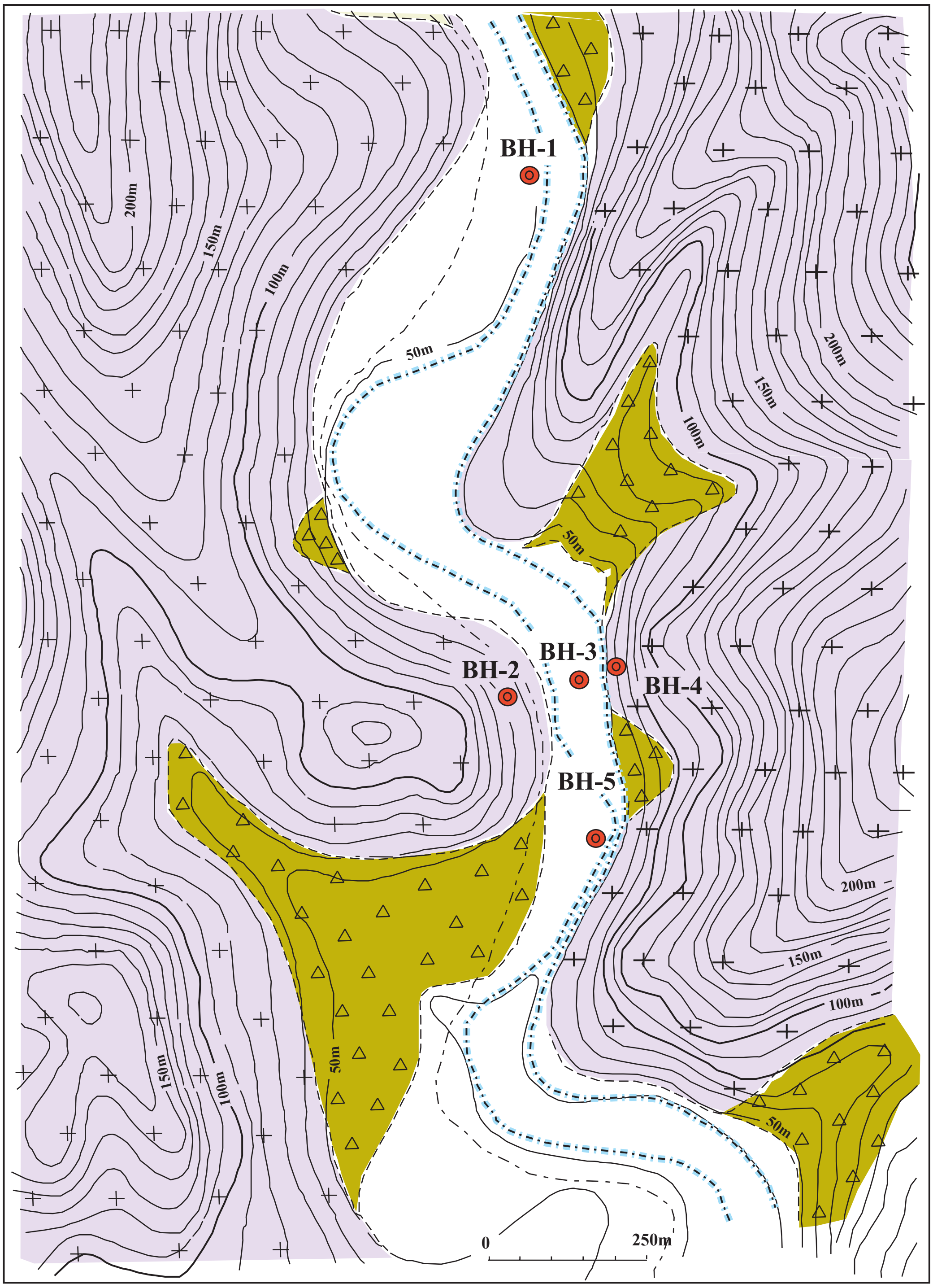
The Study on Flood Control and Water Management in Limboto-Bolango-Bone Basin in the Republic of Indonesia

Japan International Cooperation Agency

Figure A1.3.2
GEOLOGICAL MAP OF TOHETI-DEHUA DAM SITE



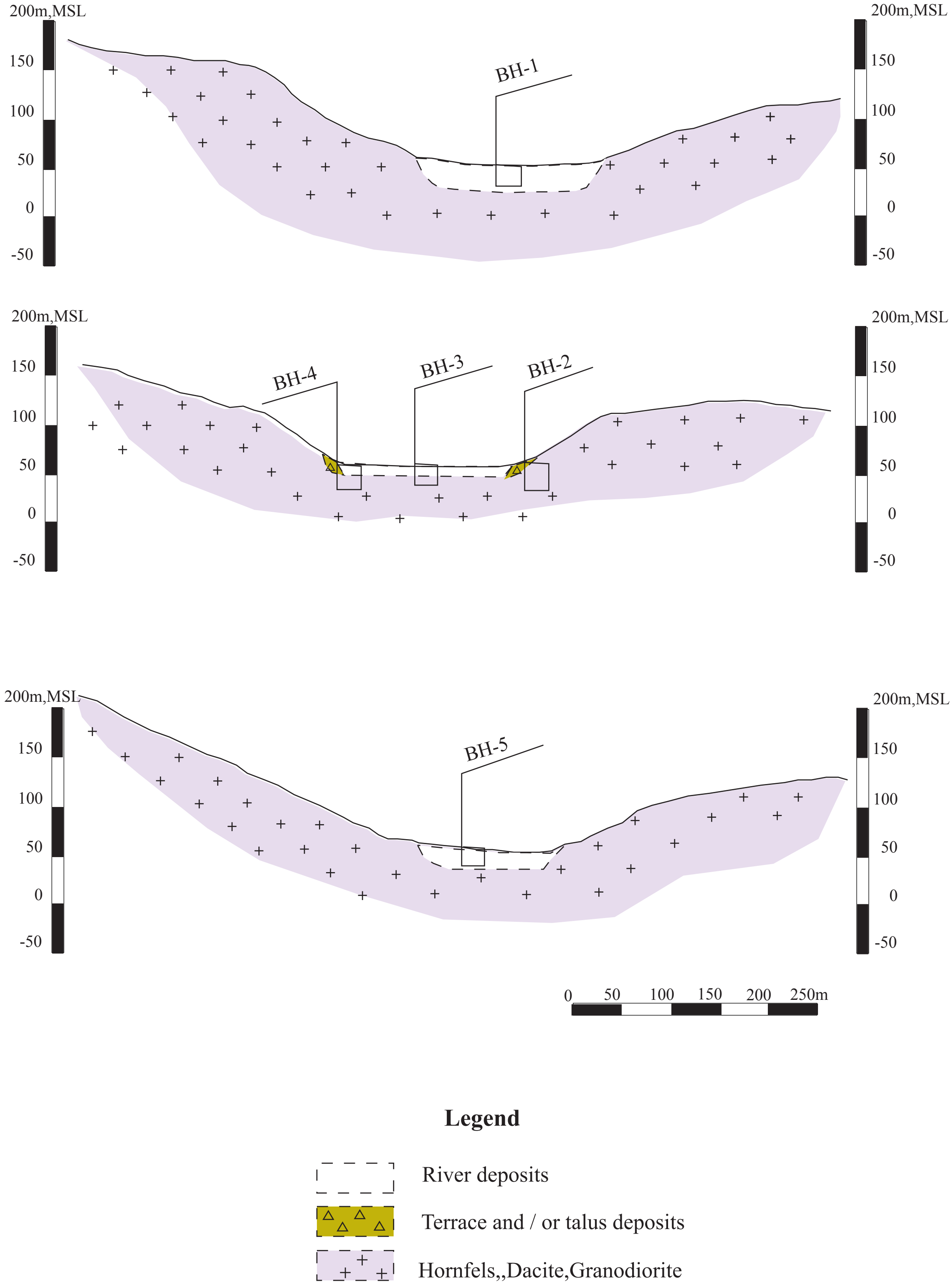
The Study on Flood Control and Water Management in Limboto-Bolango-Bone Basin in the Republic of Indonesia	**Figure A1.3.3**
Japan International Cooperation Agency	**GEOLOGICAL PROFILE OF TOHETI-DEHUA DAM SITE**



Legend

	River deposits		Road
	Terrace and / or talus deposits		Geologic Boundary
	Hornfels,,Dacite,Granodiorite		River in dry season
	Drilling Hole		

The Study on Flood Control and Water Management in Limboto-Bolango-Bone Basin in the Republic of Indonesia	**Figure A1.3.4**
Japan International Cooperation Agency	**GEOLOGICAL MAP OF KAYU MERAH DAM SITE**



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

Japan International Cooperation Agency

Figure A1.3.5
GEOLOGICAL PROFILE OF KAYU MERAH DAM SITE

A2. HYDRO-METEOROLOGY

A2.1 Overview of Basin and River System

The LBB basin, with a total catchment area is about 2,700 km^2, consists of three main drainage basins as listed below:

1) Lake Limboto basin: 890 km^2 including the lake area
2) Bolango river basin: 490 km^2
3) Bone river basin: 1,320 km^2

Three basins join in the City of Gorontalo where a flood and inundation frequently occurred in the past. The Lake Limboto functions as a regulation reservoir in the case of flood. The area of the confluence is located near to the sea that also affects tidally on flood flows from three rivers and inundation.

(1) Lake Limboto Basin

The Lake Limboto basin is situated in the western part of the Study Area. The major catchment area aspect is northwest to southeast, with the northern and southern extremities dominated by hilly terrain. The large central portion is an alluvial plain where Lake Limboto, Limboto City, towns and villages, and irrigation areas are located.

The headwater elevations of the Lake Limboto basin range from 500 to 800 m along the coastal divide on the south, 200 to 500 m along the western basin divide, and 800 to 1,300 m along the northern divide. The elevation of the inland plain ranges from 5 to 25 m and the combined average basin elevation is less than 150 m.

The Lake Limboto has an approximate surface area of 25 km^2 during the dry season and about 50 km^2 during flood. About 20 tributaries drain into the lake. Among tributaries in the basin, the Biyonga River draining a moderately small drainage area of 58 km^2 is the only perennial stream. This sub-basin drains the higher elevation range to the north and has permanent springs.

Tributary basins are all extensively developed with about 66 % of the total area mainly consisting of agricultural land use. Only about 20 % of the basin remain forested.

(2) Bolango River Basin

The Bolango River basin drains central portion of the Study Area and flows to the south joining with its main tributary, Mongiilo on the east just upstream of Lomaya Weir.

The maximum elevation is 1,745 m in the eastern headwaters. The inland east-west divide forms the northern headwaters and ranges from 900 m to nearly 1,600 m in elevation. The average basin elevation is approximately 400 m.

The lower 33 % of the watershed are developed with dry land, irrigation and urban land use. Approximately 46 % of the basin are forested.

(3) Bone River Basin

The Bone river basin drains the eastern portion of the Study Area. The watershed is 90 percent forested and mainly consists of uplands and mountainous terrain. This watershed encompasses a part of Dumoga National Park consisting of approximately 800 km^2 of protected forest within the Bone River basin.

The average basin elevation is approximately 700 m with the maximum basin elevation of 1,984 m at the Mount Matabulawa in the eastern headwaters.

A2.2 Review of Previous Hydrological Studies

The major hydrological studies in the LBB basin were carried out in the master plan studies through the North Sulawesi Water Resources Institutional Development Project funded by Canadian International development Agency (CIDA) as summarized below:

1) LBB Water Resources Development Master Plan, 1994 (the 1994-Study)
2) LBB Basin Water Management Master Plan, 1999 (the 1999-Study)

The review and evaluation of the previously estimated parameters on storm and flood events in the LBB basin were conducted through the additional collection of rainfall and runoff data from the related agencies.

(1) LBB Water Resources Development Master Plan

The 1994-Study covers the following basic study items:

1) Climate,
2) Basins and rivers,
3) Rainfall,
4) Runoff,
5) Water balance, and
6) Design flood.

In relation to the flood control study, the estimate of design floods was carried out. The estimates of critical floods at each potential diversion sites were required for the outline design and subsequent costing of irrigation weirs and reservoir spillways.

No long-term flood flow records were available in the LBB basin. Therefore, the empirical methods such as Haspers and Mononobe were adopted for assessing flood peaks with return periods up to 1,000 years, based on the maximum daily rainfall and the catchment characteristics such as catchment area, river length and height. These methods provide the estimates of instantaneous flood peaks and are not concerned with the prediction of flood volume and hydrograph.

To determine the design flood for the Lake Limboto, a synthetic hydrograph method was applied. The peak design floods for each tributary with return periods of 50 and 100 years have been derived from the basin characteristics and calculation of unit hydrograph.

(2) LBB Basin Water Management Master Plan

The 1999-Study additionally covers the following specific study items:

1) Flood discharges, and
2) Probable flood peak

In relation to the difficulty of storm and flood analyses, this study made the following remarks:

1) Because of the extreme spatial variations in rainfall and the lack of rainfall data at higher elevations, any form of basin-wide hydrological analysis based on rainfall data should be applied with caution.
2) Longer duration rainfalls of 3 to 5 days are in fact probably more critical for determining flood magnitudes in the main rivers in the Study Area of the LBB basin.
3) Greater data regarding rainfall at higher elevations are also required for any runoff analyses based upon rainfall-runoff.
4) The application of the daily storm rainfall is therefore recommended to be limited to small watersheds within the low plain area.

An attempt was made to estimate the actual flood discharges, to analyze the probable flood peaks and to carry out the regional flood frequency analysis in the LBB basin.

The 1999-study was not also concerned with the prediction of flood volume and its hydrograph because of the extreme lack of rainfall and runoff records.

A2.3 Characteristics of Rainfall and Runoff

In order to outline the basin's rainfall and runoff characteristics, several important hydrological parameters ever estimated by the previous studies were reviewed here. In the descriptions below, drainage areas of the original documents were used and may not always accord with those of the present study.

A2.3.1 Climate

The climate of the Limboto-Bolango-Bone (LBB) basin is generally classified as humid tropical. On the Oldeman classification, the climate falls into category E1 and E2 with five or six months classified as wet, with three or less months comprising a dry season. On the Koppen system of classification, the Study area falls into class Af. This climate group is defined as having a tropical rainy climate with no definite dry period, with a temperature exceeding 18℃ in the coolest month.

Figure A2.3.1 shows the monthly average temperature, monthly average relative humidity and monthly rainfall at Jalaludin Airport as representative climatic features of the Study Area. The Study Area is equatorial and characterized by high temperature with insignificant seasonal variation (26.3 to 27.0℃), high humidity throughout the year

(75.4 to 83.6%) and two main seasonal wind directions with rarely high wind speed. Rainfall in the Study Area is typical of areas close to the equator. The bimodal peak is caused by the double passage of the inter-tropical convergence zone following the overhead passage of the sun.

A2.3.2 Rainfall

Rainfall in the Study area is typical of areas close to the equator; the bimodal peak is caused by the double passage of the inter-tropical convergence zone following the overhead passage of the sun.

(1) Mean Annual Rainfall l

The long-term mean annual rainfall was able to estimate at the following two rain gauge stations located in the plain areas of the Study Area.

(Long-term Mean Annual Rainfall: 1975-1997)

Station name	Mean annual rainfall (mm)	Location	Organization
Boidu	1,286	Lomaya Weir, Bolango River basin	CDG
Jalaludin	1,240	Jalaludin Airport, Lake Limboto Basin	BMG

The above table indicates the similar rainfall amount at two stations over long periods. The mean annual rainfall is 1,240 mm/yr at Jalaludin Airport in the Lake Limboto basin. The mean annual rainfall at Boidu/Lomaya Weir of the Bolango River is reported as 1,286 mm/yr, indicating similar rainfall amount with the Jalaludin. At Boidu the maximum annual rainfall was 2,249 mm in 1997 and the minimum 471 mm in 1972.

Though the long-term rainfall data are not available, for the other stations, the annual rainfall in the central portion of the LBB basin (below 100 m, MSL) ranges from less than 1,000 mm to 1,280 mm. The annual rainfall increases to over 1,300 mm on the eastern side of the plain. The annual rainfall approaches or may exceed 2,000 mm at the higher elevations in the north and eastern portions of the LBB basin.

The detailed isohyetal lines of mean annual rainfall are also difficult to construct in the Study area because of the extreme spatial variations in rainfall and the lack of rainfall at higher elevations.

(2) Monthly Variation of Rainfall

Monthly rainfall peaks in May (165 mm) with a secondary peak typically occurring in November (138 mm). The dry season with less than 100 mm of monthly rainfall extends from July to September. February is also a dry month with less than 100 mm rainfall in between the two short wet seasons.

Distribution of monthly rainfall at Jalaludin Airport shown below is typical of areas close to the equator exhibiting a bimodal peak.

(Monthly Distribution of Rainfall at Jalaluddin: 1974-1993)

Month	Rainfall (mm)	Distribution (%)
January	100.1	8.1
February	82.8	6.7
March	101.5	8.2
April	114.9	9.3
May	**164.7**	**13.3**
June	118.0	9.5
July	98.4	7.9
August	52.0	4.2
September	52.8	4.3
October	103.1	8.3
November	**138.2**	**11.1**
December	113.9	9.2
Total (annual rainfall)	1,240	100

(3) Storm Rainfall Patterns

The storm rainfall patterns and intensity were not examined by the previous studies because of the extreme lack of hourly rainfall data in the LBB River basin. It is preliminarily identified at the site that the critical rainfall that caused the past floods in the region seemed to last for more than 3 days in the main river basins.

(4) Probable Storm Rainfall

An attempt to estimate the probable storm rainfall was made in the 1999-Study. A frequency analysis of daily rainfall at Boidu station was only conducted based on the recorded annual maximum for 36 years using the Extreme Value Distribution.

The comparison of 20 years of annual maximum daily rainfalls between Jalaluddin Airport and Boidu indicates that the values at Boidu are only 1 % higher than that at Jalaluddin on the average.

A2.3.3 Runoff

(1) Mean Annual Runoff

Historical runoff data at six locations were analyzed in the 1999-Study based on a detailed review of the entire database of the HYMOS. The correlation of annual values was applied where necessary to develop the common period. The estimated mean annual runoffs in the LBB basin are summarized below:

(Mean Annual Runoff in LBB Basin: 1983-1997)

River	Location	Drainage Area (km^2)	Mean Annual Runoff		
			(mm)	(m^3/s)	($m^3/s/km^2$)
Bone	Alale Weir	1,060	1038	34.9	0.033
Bolango	Lomaya Weir	388	955	11.7	0.030
Biyonga	Huludupitango Weir	57	691	1.24	0.022
Meluopo	Pone Staff Gauge	24	372	0.28	0.012
Molamahu	Molamahu Weir	87	283	0.78	0.009
Pohu	Pohu Weir	134	395	1.68	0.013

Looking into the specific discharges, there is a definite trend of decreasing runoff from basins in the east to basins in the west, which is similar to the rainfall trend. A trend of decreasing runoff with decreasing drainage area is also indicated. It is also identified that the larger basin yields higher mean annual specific runoff.

(2) Monthly Variation of Runoff

The monthly runoff distributions are shown in Figure A2.3.2 for the Bone River at Lombongo/Alale Weir and the Bolango River at Boidu Tapa/Lomaya Weir. The monthly runoff distribution is almost similar to the rainfall distribution with peaks occurring in January and in May/June. The highest average annual runoff period is usually from late-May to early-June. Low runoff occurs from August to October with minimums usually occurring in October. A brief low flow period also occurs in late February to early March.

The variation index of the specific monthly runoff height worked out for the Bone River is smaller than that of the Bolango River, though the specific runoff heights for the month of maximum runoff are the same. This may come from better vegetation and larger basin size of the Bone River.

(3) Flood Discharges

The comparatively long annual flood data are available only at the following stations on a daily basis in the Bone and Bolango rivers.

1) Lombongo (Bone River)
2) Pinogu (Bone River)
3) Boidu Tapa/Lomaya Weir (Bolango River)
4) Longalo (Bolango River)

At Lombongo and Longalo stations, the instantaneous flood data are also available. The flashy nature of flood peaks can be indicated with the ratio of instantaneous and daily average runoffs. The ratios were worked out at 1.87 for the Bone River at Lombongo and about 5.0 for the Bolango River at Longalo.

The recent major flooding occurred in 1995 and 1996 in the LBB basin. The instantaneous flood peak of 1,200 m3/s was recorded in July 1995 at the Pinogu station in the Bone River. In the Bolango River basin at the Lomaya Weir, two peak historic flood levels on July 31, 1931 and on February 26, 1971 have been noted on the existing weir structure. The hydraulic calculations approximately estimate these peak events at 350 m^3/s for 1931-flood and 700 m^3/s for 1971-flood.

A2.4 Existing Hydro-Meteorological Observatory

A2.4.1 Rainfall Observation

(1) Relevant Agencies

The rainfall observation in the LBB basin is operated by the following five agencies:

1) BMG: Badan Meteorologi dan Geofisika (Meteorology and Geophysics Board)
2) Bagpro PDSA: Bagian Proyek Pengembangan Data Sumber Air (Water Resources Data Development Project)
3) CDG: Cabang Dinas PU Gorontalo (Publics Works, Gorontalo Branch Office)
4) PLN: Perusahaan Listrik Negara (National Electric Power Corporation)

(2) Type of Recording

As of September 2001, there exist at least nineteen (19) rainfall stations that are registered by each organization. The automatic rain gauges (Hellmann type) were installed at eight (8) rainfall stations. Other stations were equipped with a manual gauge.

(3) Recording Period

In terms of recording period and completeness, there is a high variation among stations. The majority of stations started their observations in 80's or 90's. All but two stations (those operated by BMG or CDG) have a recorded period less than 20 years with some missing periods.

(4) Spatial Distribution

Reflecting on the several geographical constraints in the LBB basin, there are a few rainfall stations situated in the mountainside. No stations are located above an elevation of 500 m. Several of the existing stations, located at the lowland, provide repetitive data due to their close proximity.

Figure A2.4.1 shows the location of the rainfall stations ever installed in the LBB basin as of 1999. The location map of rainfall stations in the LBB River basin will precisely be constructed later after collecting the updated information from various related agencies.

(5) Operation and Maintenance

It was acknowledged that three (3) of four automatic rain gauges operated by Bagpro PDSA have not properly been functioned by the broken recorders.

A2.4.2 Flow Measurement

(1) Relevant Agencies

The river discharge measurement in the LBB basin is performed by the following three agencies:

1) Bagpro PDSA: Bagian Proyek Pengembangan Data Sumber Air (Publics Works, Gorontalo Branch Office)
2) CDG: Cabang Dinas PU Gorontalo (Water Resources Data Development Project)
3) PLN: Perusahaan Listrik Negara (National Electric Power Corporation)

Figure A2.4.1 shows the location of water level gauging stations installed in the LBB basin as of 1999.

(2) Type of Recording

As of September 2001, there exist at least twenty (20) discharge stations that are registered by each organization. The automatic water level gauges (horizontal A. OTT type X variety or SEBA strip-chart type) were installed at four (4) stations of Bagpro PDSA and at two (2) stations of PLN. Other stations were equipped with only staff gauges.

(3) Recording Periods

In terms of recording period and completeness, there is a high variation among stations. The majority of stations started observation in 90's. All but three stations (those operated by Bagpro PDSA or CDG) have a record period less than 10 years with some missing periods.

(4) Operation and Maintenance

It was acknowledged that three of four automatic water level gauges operated by Bagpro PDSA have been deactivated by severe damage of foundation and recorder caused by the past floods.

A2.4.3 Availability of Data

The extreme lack of data for the flood hydrological study in the LBB basin has already emphasized by the previous studies by CIDA as mentioned in the previous sections. The major objective of the previous studies was comparatively limited to estimate hydrological design values for the potential diversion projects for irrigation and water supply.

On the other hand, the present JICA Study is much concerned with the prediction of flood hydrograph and volume to benefit for the basin-wide flood control plan and management in the LBB basin. Therefore, more efforts shall be made to collect data and information regarding measured storm and flood records. However, regarding the data acquisition by the Bagpro PDSA, the following facts were unfortunately identified:

1) The HYMOS (hydro-meteorological database and analysis system software developed by the Delft Hydraulics) had been used at the Bagpro PDSA (Hydrological Unit in Manado) during the period of 1993-1997. All rainfall and discharge data published during the period were compiled by the HYMOS. After 1997, the usage of the HYMOS has been halted due to software problems.
2) A flood inundation event occurred on 30 November 2000 and lasted for two days at the Bagpro PDSA office in Manado. This event caused some damages on the collected but not processed hydro-meteorological data kept in the office.
3) Because of the above situations, database or any other back data collected, processed and analyzed for the previous hydrological studies by the Bagpro PDSA are not totally available for the Study.

(1) Storm Rainfall Data

Availability of daily and hourly rainfall data which can be used for the estimate spatial distribution of storm rainfall in the Study Area is shown in Table A2.4.1.

(2) Flood Runoff Data

Table A2.4.2 shows the daily discharge data available for the Study. Discharge data available for the Study are very limited. No hourly discharge data are obtained for the Study.

Table A2.4.1 RAINFALL DATA AVAILABLE FOR STUDY

NO	Station No.	Station Name	Owner Status	Data Type	Record	Coordinate Position		Year (1975 - 2001)																										
					From/To	N.L.	E.L.	75	76	77	78	79	80	81	82	83	84	85	86	87	88	89	90	91	92	93	94	95	96	97	98	99	00	01
1	03 13 15	Bandara Jalaluddin	BMG	Clim	1975/2001	00 38 19	122 51 10	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	2	2	2	2	2	2	2	2	2	2	2
2	03 15 03	Bone-Kabila	PDSA	Clim	1993/	00 32 11	123 10 32																			2	2	2	2			2		
3	03 13 02	Alo-Alo	PDSA	MRG	1993/	00 39 11	122 51 28																			3	2	2	2	2	2	2		
4	03 13 03	Bionga-Huludupitango	PDSA	MRG	1993/	00 41 16	122 59 23																			2	2	2	2	2	2	2		
5	03 13 07	DAS Limboto-Dembe II	CDG	MRG	1981/	00 32 31	122 58 48								1	1	1	1	1	1	1	1	1	1	1	2	2	2						
6	03 14 05	Bolango-Longalo	PDSA	MRG	1979/	00 39 45	123 04 49					1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1		
7	03 15 02	Bone-Lombongo	PDSA	MRG	1985/	00 32 02	123 10 20											1	1	1	1	1	1	1	1	1	3	1	1	1	1	1		
8	03 15 11	Bone-Pinogu	PLN	ARR	1991/	00 30 41	123 25 42																	1	1	1								
9	03 15 13	Pohulongo	PLN	ARR	1991/	00 31 18	123 22 12																											
10	03 13 06	Kayumerah-Limboto	CDG	MRG	1983/	00 37 59	122 58 48									1	1	1	1	1	1	1	1	1	1									
11	03 13 09	UPP Tibawa	BMG	MRG	1986/	00 38 27	122 51 23												1	1			1	1	1	1	1							
12	03 13 10	UPP Batudaa	BMG	MRG	1990/	00 33 39	122 57 24																1	1	1	1								
13	03 13 11	UPP Limboto	BMG	MRG	1987/	00 37 13	122 58 25																											
14	03 14 06	Boidu-Tapa	CDG	MRG	1975/	00 37 41	123 04 58	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1
15	03 14 07	UPP Telaga	BMG	MRG	1976/	00 35 41	123 04 14												1	1			1		1	1								
16	03 15 12	Lonuo-Kabila	CDG	MRG	1981/	00 35 37	123 07 18						1	1	1	1	1	1	1	1	1	1	1	1	1		1	1	1	1	1	1	1	
17	03 15 14	UPP Suwawa	BMG	MRG	1986/	00 32 01	123 08 31												1	1			1	1	1	1								
18	03 13 17	Bionga Kayubulan	PDSA	ARR	1990/																													1
19	03 15 16	Butahu-Datahu	PDSA	ARR	?/																				1	1	1							
20	03 12 21	Bulota-Hepuhulawa	PDSA	ARR	?/																							1	1	1	1	1		

Remarks : 1.Daily data ; 2.Hourly data ; 3.Daily data incomplete
BMG: Badan Meteorologi dan Geofisica
PDSA: Pengembangan Data Sumber Air
CDG: Cabang Dinas PU Gorontalo
PLN: Perusahan Listrik Negara

N.L.: North latitude ; E.L.: East longitude
Clim: Climatological station
ARR: Automatic rainfall recorder
MRG: Manual rainfall gauge

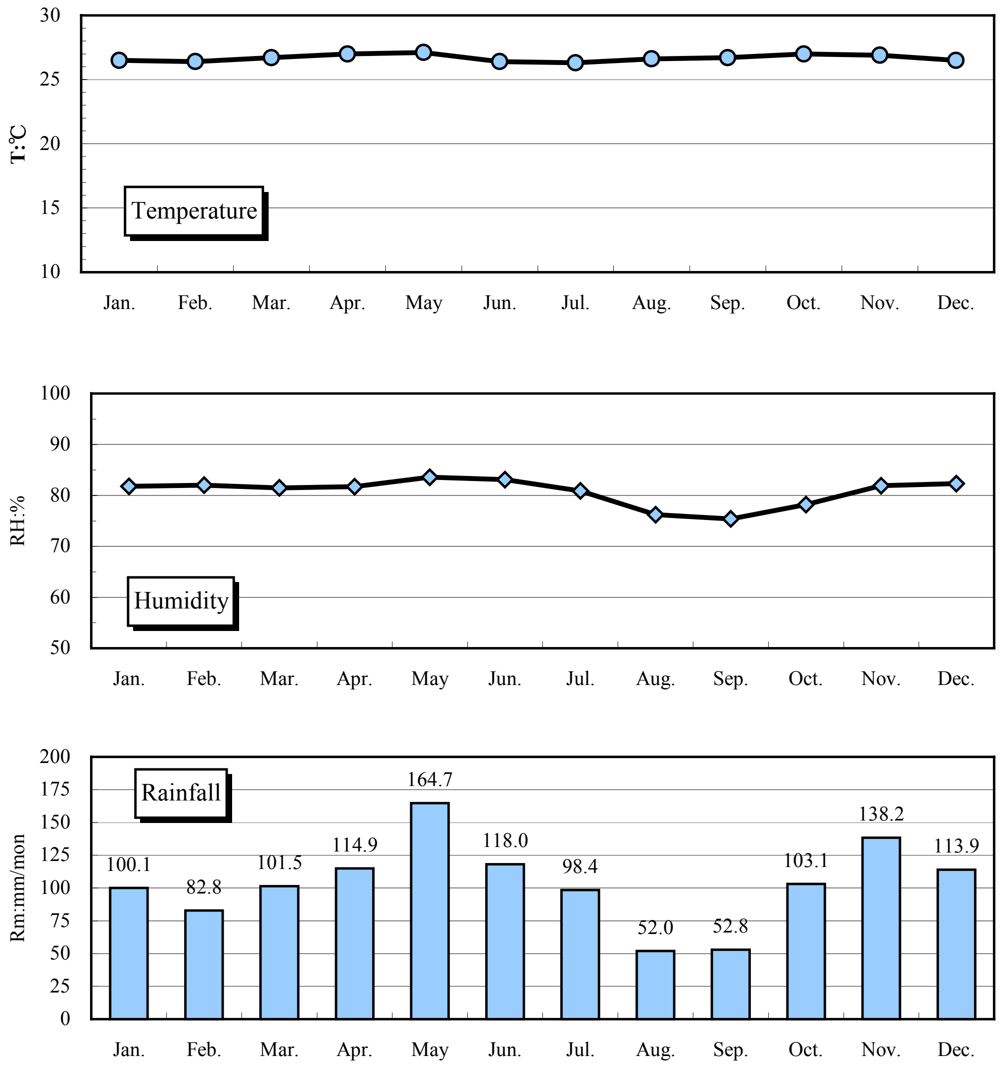
Table A2.4.2 RUNOFF DATA AVAILABLE FOR STUDY

NO	Station No.	Station Name	River Name	Owner Status	Data Type	Catchment Area(km^2)	Record	Coordinate Position		Year (1988 - 2001)													
							From/To	N.L.	E.L.	88	89	90	91	92	93	94	95	96	97	98	99	00	01
1	03 12 01	at outlet	Bolango	PDSA			1975/2001								1								
2	03 13 01	Tapodu	Tapodu	P3SU	AWLR		1993/	00 32 52	123 01 46							1	1	1	1				
3	03 13 04	Dembe I		CDG	SG			00 33 07	122 59 49														
4	03 13 16	Lingkubulan IV	Bionga Up	P3SU	SG	53	1993/1997	00 40 50	122 59 20								1						
5	03 13 17	Kayubulan	Bionga	P3SU	SG	68.1	1985/1997	00 37 36	122 58 39								1	1	1				
6	03 13 21	weir at Ilomanga	Alo Pohu	P3SU	SG		1981/	00 36 20	122 56 26								1	1					
7	03 13 22	Alo Pohu Weir	Alo Pohu	P3SU	SG		1979/	00 36 25	122 55 44								1	1					
8	03 13 23	Alilumayonga-Jem.Bongo		P3SU	SG																		
9	03 13 24	Hepuhulawa	Bulota	P3SU	SG	14.8	1994/1997	00 37 45	122 59 13								1	1					
10	03 13 25	Pone	Meluupo	P3SU	SG	23.7	1994/1997	00 37 50	122 57 18								1	1					
11	03 13 26	Pilolalenga	Pohu	P3SU	SG	134	1994/1997	00 35 57	122 52 15								1	1	1				
12	03 13 27	Marisa-Tenilo		P3SU	SG			00 36 42	122 57 17														
13	03 13 28	Datahu	Molalahu	P3SU	SG	83	1994/1997	00 39 55	122 49 54								1						
14	03 14 01	Longalo	Bolango	DPMA	AWLR	120	1985/1997	00 40 00	123 04 44				1	1	1	1	1	1	1				
15	03 14 02	Pilohayanga	Bolango	PDSA	SG	392	1991/1997	00 37 10	123 04 23						1	1		1					
16	03 14 03	Boidu Tapa	Bolango	DPMA	SG	388	1985/1997	00 37 59	123 05 56				1	1	1	1	1						
17	03 14 04	Tengalla Lowuo	Bolango	PDSA	AWLR	487	1985/1997	00 34 22	123 02 05				1	1	1	1	1						
18	03 14 08	Bolango-Bendung Pilohayanga		PDSA	SG			00 37 10	123 04 23														
19	03 15 01	Lombongo	Bone	PDSA	AWLR	1060	1985/1994	00 30 03	123 14 00				1	1	1								
20	-	PLN-Tulabolo	Bone	PLN			1981/																
21	-	PLN-Pohulongo	Bone	PLN			1986/																
22	20.102.108	Pinogu-PLN	Bone		AWLR	727	1991/1998																
23		Lomaya Weir	Bolango		SG-Weir	388	1978/1997																
24		Pilohayanga W.	Bolango		SG-Weir	392	1977/1997																
25		Alale Weir	Bone		SG-Weir	1060	1983/1997																
26		Huludupitango	Bionga		SG-Weir	56.6	1983/1997																
27		Alo-Weir	Alo		SG-Weir	196	1983/1997																
28		Pohu Weir	Pohu		SG-Weir	134	1983/1997																
29		Molalahu Weir	Molalahu		SG-Weir	87	1983/1997																
30		AloPohu-Weir	AloPohu		SG-Weir	475	1989/1997																

Remarks : 1.Daily data ; 2.Hourly data ; 3.Daily data incomplete
PDSA: Pengembangan Data Sumber Air
P3SU: Proyek Pembinaan Pengairan Sulawesi Utara
DPMA:
PLN: Perusahan Listrik Negara

N.L.: North latitude ; E.L.: East longitude
AWLR: Automatic water level recorder
SG: Staff gauge
SG-weir: Staff gauge at weir site

STATION : JALALUDDIN AIRPORT

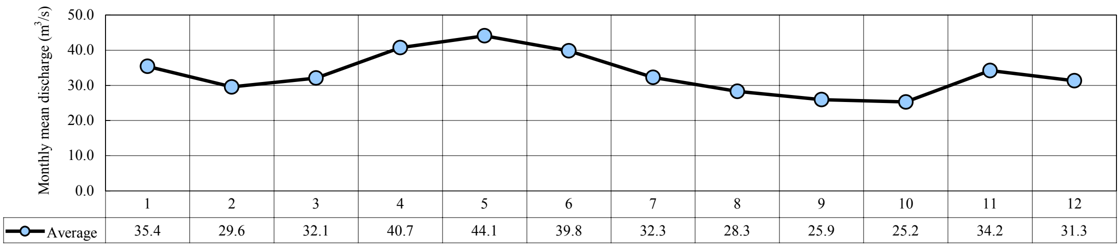


Month	Temperature (T:℃)	Humidity (RH:%)	Rainfall (Rm:mm/mon)
Jan.	26.5	81.8	100.1
Feb.	26.4	82.0	82.8
Mar.	26.7	81.5	101.5
Apr.	27.0	81.7	114.9
May	27.1	83.6	164.7
Jun.	26.4	83.1	118.0
Jul.	26.3	80.9	98.4
Aug.	26.6	76.2	52.0
Sep.	26.7	75.4	52.8
Oct.	27.0	78.2	103.1
Nov.	26.9	81.9	138.2
Dec.	26.5	82.3	113.9
Ave/Total	26.7	80.7	1240.4

Figure A2.3.1

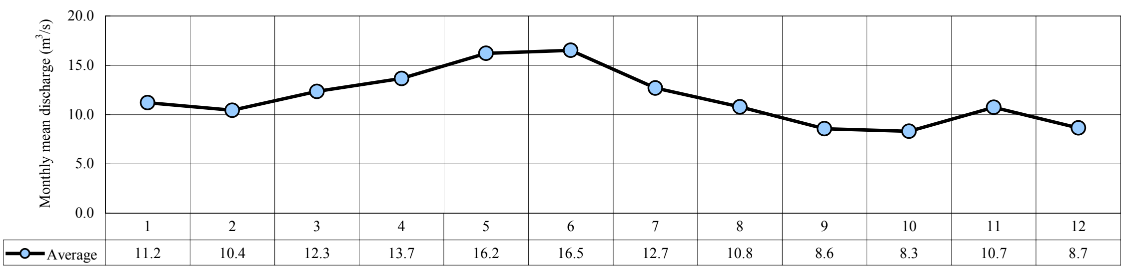
METEOROLOGICAL CONDITIONS

Bone River: Lombongo/Alale Weir (1,060 km²)



Year	Monthly Discharge (m^3/s)												Annual	
	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec	m^3/s	mm/yr
1985	-	-	28.3	29.6	38.5	34.6	33.1	42.8	40.2	42.1	62.4	48.9	-	-
1986	47.6	43.2	42.9	46.9	45.3	41.9	38.6	31.1	26.6	31.0	38.3	33.3	38.9	1157
1987	27.2	27.2	24.5	28.6	34.8	24.1	17.0	17.1	15.0	17.5	20.4	19.8	22.8	677
1988	34.2	35.1	44.5	38.9	65.4	50.7	52.3	57.5	49.7	-	-	-	-	-
1989	-	-	38.0	73.6	25.6	28.0	52.9	41.4	57.3	42.5	44.6	27.4	-	-
1990	53.7	31.3	30.4	49.0	39.5	32.7	16.5	24.1	18.5	32.6	38.3	26.4	32.8	974
1991	47.9	17.3	19.9	46.4	26.5	35.3	22.6	20.5	14.7	14.2	18.4	32.9	26.4	785
1992	23.4	17.4	14.5	14.2	51.5	39.6	26.8	15.6	11.1	19.5	25.0	36.2	24.6	731
1993	26.1	25.4	33.1	35.7	65.9	53.0	25.5	13.5	11.3	12.5	19.6	19.4	28.4	846
1994	23.0	39.9	47.1	44.2	48.0	57.9	37.8	19.2	15.1	15.2	40.6	37.6	35.5	1055
Average	35.4	29.6	32.1	40.7	44.1	39.8	32.3	28.3	25.9	25.2	34.2	31.3	33.2	989
$m^3/s/km^2$	0.033	0.028	0.030	0.038	0.042	0.038	0.030	0.027	0.024	0.024	0.032	0.030	0.031	$m^3/s/km^2$
mm/mon	89	67	81	100	111	97	82	71	63	64	84	79	989	mm/yr
												Cv=	0.57	%

Bolango River: Boidu Tapa/Lomaya Weir (388 km²)

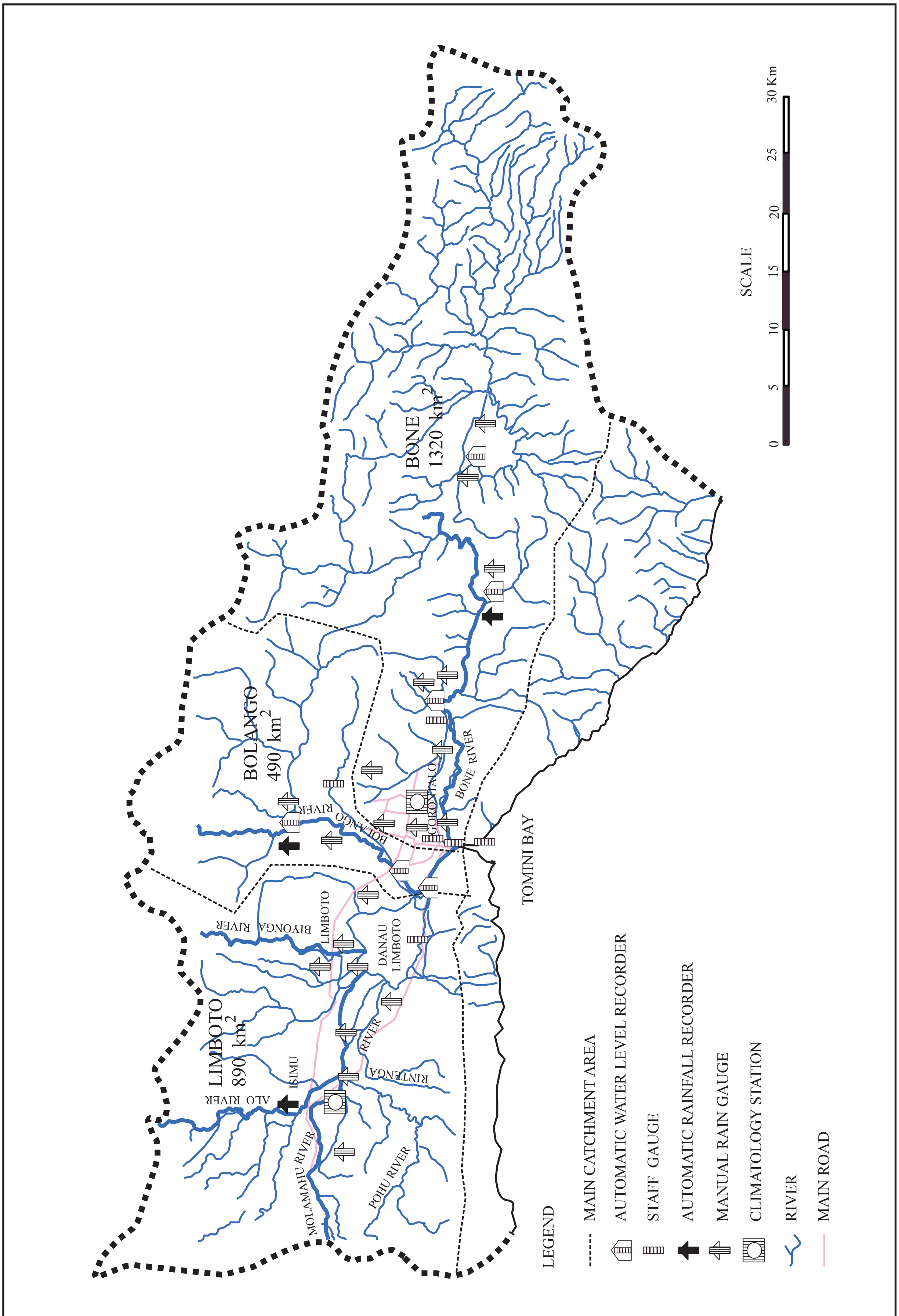


Year	Month												Annual	
	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec	m^3/s	mm/yr
1985	-	9.2	8.4	5.4	24.3	19.4	6.8	5.2	6.6	8.5	19.6	11.3	-	-
1986	9.4	9.2	17.3	15.2	22.8	12.7	7.8	5.2	5.7	6.5	11.3	4.0	10.6	862
1987	10.9	6.3	7.1	7.2	7.5	5.7	3.0	2.2	2.3	4.3	7.2	4.1	5.7	460
1988	4.5	11.0	10.2	16.4	21.3	10.5	8.5	17.0	15.8	13.9	14.4	10.3	12.8	1043
1989	19.1	11.6	15.5	15.9	10.8	13.8	15.9	10.2	14.2	15.2	13.4	8.7	13.7	1113
1990	13.6	10.7	12.4	23.8	15.9	10.6	8.6	6.9	13.0	9.9	10.9	4.8	11.8	956
1991	13.2	7.5	6.2	12.8	16.2	15.2	6.5	4.1	2.0	1.9	3.1	7.2	8.0	649
1992	3.8	4.5	2.6	4.3	10.7	14.8	5.0	4.0	2.1	5.4	7.4	14.2	6.6	534
1993	9.6	5.2	4.5	5.2	15.9	21.5	10.7	4.2	3.4	4.0	8.7	5.5	8.2	666
1994	8.3	14.1	26.0	14.7	18.1	25.5	11.8	4.7	2.6	2.9	7.1	7.5	11.9	971
1995	17.0	14.0	13.1	13.1	17.8	26.4	33.9	47.7	20.2	14.6	15.0	11.7	20.4	1656
1996	11.3	20.3	25.7	12.8	7.0	29.4	39.4	25.4	21.1	18.7	15.3	15.4	20.2	1639
1997	13.7	11.8	11.6	30.7	22.4	9.4	7.1	3.4	2.3	2.3	6.3	7.7	10.7	870
Average	11.2	10.4	12.3	13.7	16.2	16.5	12.7	10.8	8.6	8.3	10.7	8.7	11.7	949
$m^3/s/km^2$	0.029	0.027	0.032	0.035	0.042	0.043	0.033	0.028	0.022	0.021	0.028	0.022	0.030	$m^3/s/km^2$
mm/mon	77	65	85	91	112	110	88	74	57	57	72	60	950	mm/yr
												Cv=	0.70	%

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

Figure A2.3.2

MONTHLY DISCHARGES



The Study on Flood Control and Water Management in Limboto-Bolango-Bone Basin in the Republic of Indonesia	**Figure A2.4.1**
Japan International Cooperation Agency	**LOCATION OF HYDROLOGICAL STATIONS IN LBB BASIN**