3.3.2 Engineering Geology of Ayung Dam

(1) Geological Features of Ayung Dam Site

The bedrocks of the Ayung dam site are composed of tuff breccia, welded tuff, pumiceous tuff breccia and volcanic ash in ascendant order.

Rock Type		Height from the Riverbed (m)
Welded tuff	:	0-30
Pumiceous tuff (moderately hard)	:	30-60
Pumiceous tuff (soft)	:	60-100
Volcanic ash	:	100+

The following drilling core data indicates an old valley covered by welded tuff beneath the recent valley.

- Basement of welded tuff layer rises gradually on both banks.
- Completely weathered tuff breccia beneath the welded tuff was observed in the drilling core DA-1(existing hole) and DA-6 on the left bank, and DA-8 and DA-10 on the right bank.
- Old river deposits beneath the welded tuff were observed in the drilling core DA-2(exisiting hole), DA-7 of riverbed and DA-4(existing hole) on right bank. The surface of the old river deposits were approximately 240 m in elevation.

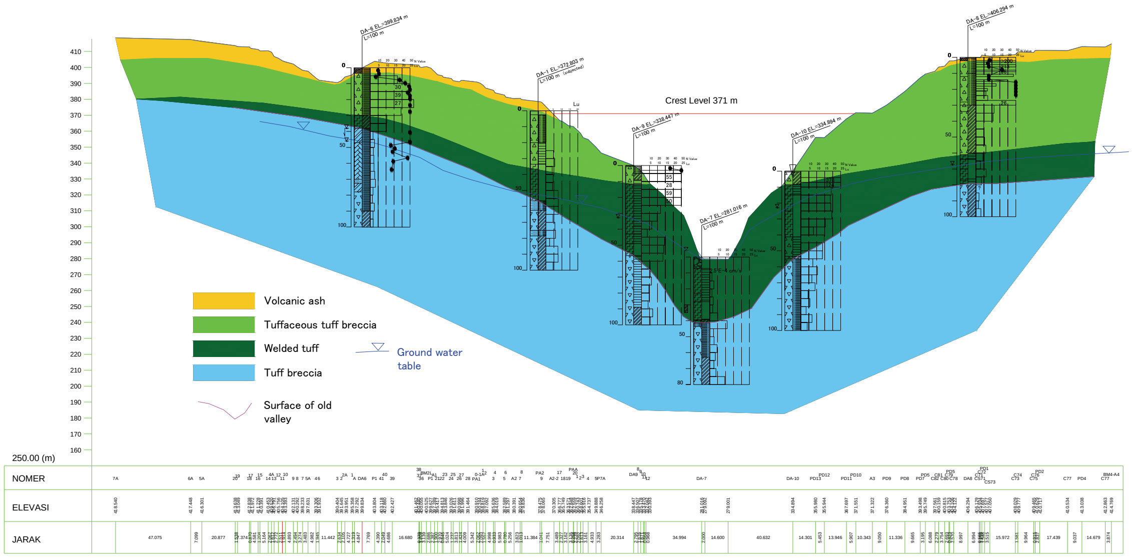

Figure-III-3.4 Geological Section along Dam Axis

(2) Rock Condition

The bedrocks of the proposed dam site are composed of welded tuff classified into CH-CM class and tuff breccia classified into CL-CM class on the basis of the criteria developed by Central Research Institute of Electric Power Industry (CRIEPI), Japan (Rock Mass Classification in Japan, 1992) as shown in Table-III-3.3. The features and expectable physico-mechanical properties of the rock classes are also shown in Table-III-3.3.

Table-III-3.3 Criteria of Rock Mass Classification by the CRIEPI, Japan

Rock Class	Discription of Outcrop Condition	Drilling Core Condition (Expectable)
CH	- The rock mass is relatively solid. - There is no opening joint and crack in general. Slightly contaminated by limonite, etc in partly. - The rock forming minerals and grains undergo a little weathering and alteration in partly. - Sound by hammer brow is clear	- Fresh and hard - Crack spacing larger than 50 cm - Cracks are closely adhered, no deterioration nor discoloration in general, limonite adhered along cracks in partly
CM	- The rock mass is somewhat soft. The rock forming minerals and grains are somewhat softened by weathering, expect for quartz. - The rock is contaminated by limonite etc. - Sound by hammer brow is somewhat dim	- Somewhat soft - Crack spacing about 30cm - Thin clay is sandwiched along the opening.
CL	- The rock is soft. The rock forming minerals and grains are softened by weathering. - Sound by hummer blow is dim	- Soft rock fragments with clayey to sandy materials - Crack spacing smaller than 10 cm
D	- The rock mass is remarkably soft. The rock forming minerals and grains are softened by weathering. - Easy to dig by a pick hummer.	- Clayey and sandy materials with soft rock fragments

Reference: Rock Mass Classification in Japan (Japan Society of Engineering Geology, 1992)

The rock condition along the dam axis of Ayung Dam is shown in Figure-III-3.5.

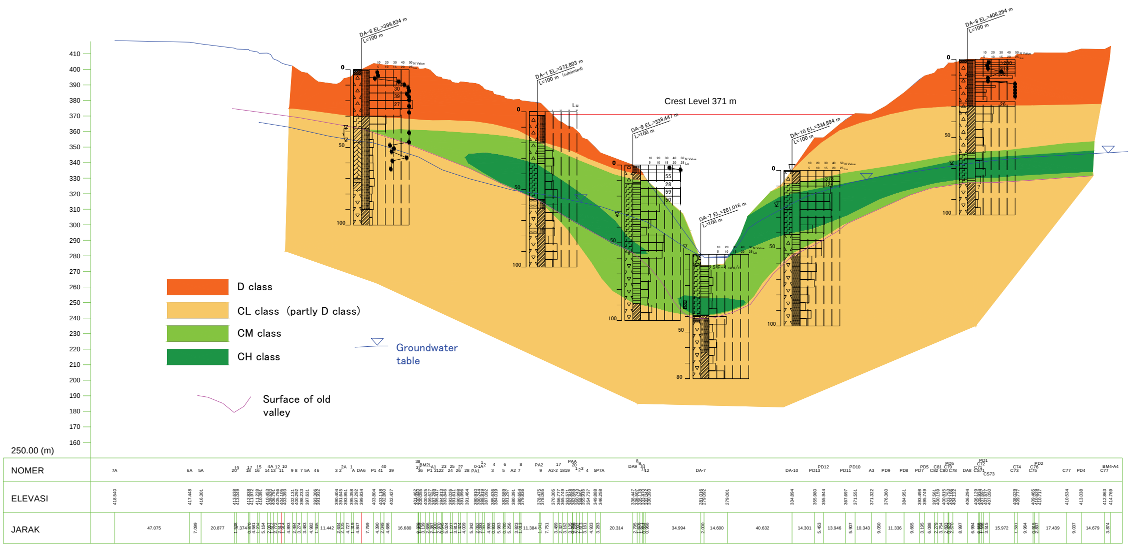

Figure-III-3.5 Rock Condition along Dam Axis

Expected shear strength of each rock class is shown as follows:

CH class : $\tau_0 = 160$ tf/m^2

CM class : $\tau_0 = 80$ tf/m^2

CL class : $\tau_0 = 40$ tf/m^2

The bed rocks distributed around the proposed dam site shows intermediate characteristic between volcanic rocks and volcanic sedimentary rocks according to the past experience in Japan.

These engineering properties were estimated based on limited data of laboratory tests and observations of outcrops at the site. The above rock classification and engineering properties will be revised in the course of the geological investigation.

In-situ rock tests will be necessary to determine engineering properties in the detailed design study. Additional investigation including core drillings is necessary for the detail design of proposed dam and its foundation treatment.

(3) Permeability

Based on the survey results, permeability coefficient of the bedrocks shows the order of 10^{-5} to 10^{-4} cm/s (2-10 Lu) except for the surface weathered zone (within about 20 m in depth) and some parts of welded tuff layer.

Ground water level of the right bank is approximately EL 340 m (about 25 m lower than HWL). Spring water from the confined aquifer in welded tuff layer was observed at drilling hole DA-7. Old river deposits are covered by welded tuff.

Additional investigation including core drillings shall be curried out for the design of foundation treatment.

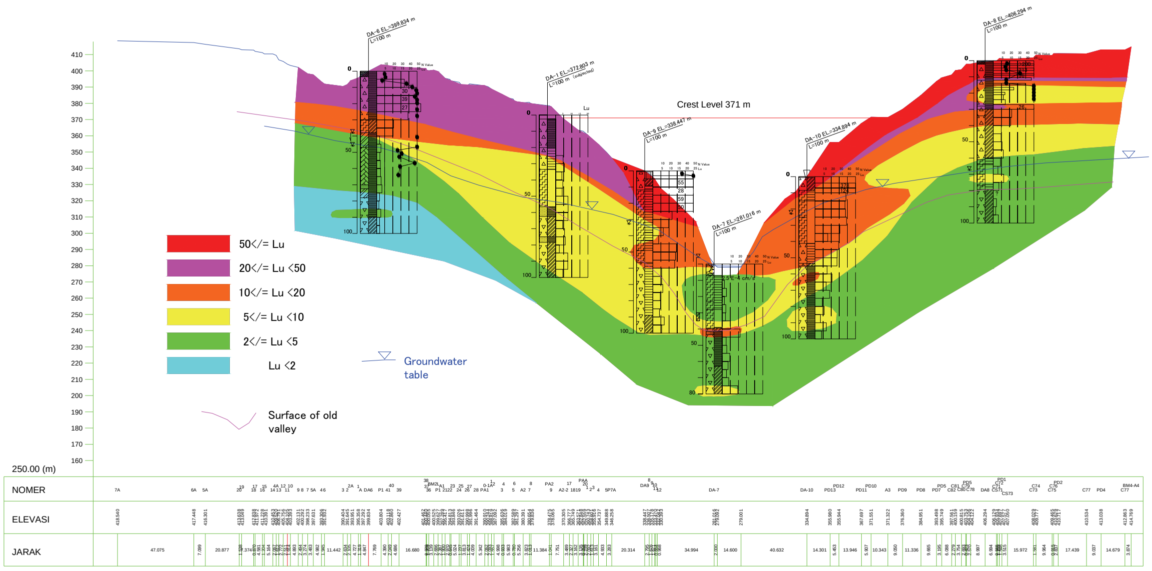

Figure-III-3.6 Lugeon Value along Dam Axis

3.3.3 Engineering Geology of Reservoir Area of Ayung Dam

The Siap River, a main turbidity of the Ayung River, flows together at approximately 400 m upstream of the proposed dam site. The reservoir area forms a V-shaped and relatively straight valley extending N-S.

(1) Potential of Slope Failure

Water impounding in a reservoir sometimes causes slope failures such as landslide, rock mass failure, collapse etc. Reactivation of old landslide is the most possible slope failure.

The potential slopes of the slope failure have classic character traits for shown in Table-III-3.4. These characteristics are helpful for identification in aerial photo inspection and ground mapping. Location of suspicious landslide is shown in Figure-III-3.7.

Table-III-3.4 Classifications and Characters of Slope Failure

Type of Failure	Geomorphic Feature	Geology
Existing Landslide	Head cliff and horseshoe depression at the top of slope, convex prominence at the toe of the slope etc.	Thick loose materials, spring at the toe of the slope
Rock mass failure	Overhang, turriculate feature and escarpment etc.	Collapse-prone bedding plane, open crack
Failure of thick talus deposits	Gentle slope at the base of a steep cliff, conical slope etc.	Thick talus deposits

Figure-III-3.7 Location of Suspicious Landslide

Results of aerial photograph inspection and ground mapping are summarized as follows:

- There are no obvious landslides in the planned reservoir. However, a suspicious landslide was observed in the proposed disposal site at the right bank approximately 500 m upstream of the proposed dam site.
- No suspicious slopes, which have potential of large-scale rock mass failure, are detected.
- No thick unconsolidated deposits including residual soil, talus deposits and volcanic ash in the proposed Ayung dam reservoir are observed.
- Although pumiceous tuff breccia forming small gully on the both bank about 40-50 m above the riverbed seems to be erosive and collapse-prone, it is indeed well cemented and relatively stable. The SPT values performed in drilling holes at the dam site are 30-50 and over even in highly weathered sections. However, rapid rise or declination of reservoir water level can trigger slope failure. In long-term bank erosion might be caused by surface wave of the reservoir.

According to the results of aerial photograph inspection and ground mapping, there are no obvious landslides in the planned reservoir. However, geological study including core drillings and stability analysis for suspicios land slide at the right bank shall be recommended in detail design phase.

(2) Leakage Risk

Two caves were observed at the right bank approximately 500 m upstream of the proposed dam site as shown in Figure-III-3.7. One of them strikes downstream of the river. According to local inhabitants there, they had lived in the cave had excavated widely about 60 years ago, and there were small holes of 50 cm in diameter stretching inside, although approximately 15 m inside of the cave has been collapsed.

No continuing volcanic holes, which might cause leakage from the reservoir, were observed in the ground mapping or the drilling core survey at the dam site. Risk of leakage from the reservoir to another river close to Ayung River will be small due to the direction of the holes, if any.

Entrance: Approximately 12 m in height from the riverbed, 4m wide, 2-3 m high, 15 m long, collapsed inside
Left side (hanging wall): A fracture and alteration zone of 20 cm in thickness, N25W86E)
Right side (foot wall): Tuff breccia (geological boundaryN35W68E), spring 2-3L/min

Figure-III-3.8 Photo of Cave Located in Right Bank of Reservoir Area

3.4 Design for Ayung Dam

Design criteria applied for design of Ayung Dam are as follows.

(1) Design Discharge

Based on "Several Criteria of Dam Plans" in a national seminar of dams on May, 2003, design flood for spillway shall be adopted return period from 500 years to 1,000 years instead of probable maximum flood(PMF) with 2,300 m3/s. For Ayung Dam, 1,000 years of return period shall be adopted and 1,270m^3/s shall be applied as design discharge. This value is corresponding to about 1.2 times of the discharge with 200 years return period (Refer to Table-III-3.5)

Table-III-3.5 Discharge for Each Return Period (Snyder Method)

Return Period	Discharge(m^3/s)
2	440
10	680
50	890
100	980
200	1,070
500	1,180
1,000	1,270(adopted)

Data) JICA Team

(2) Design Seismic Coefficient

Design seismic coefficient of Kh = 0.15, which corresponding to the value for strong earth quake region in Japan.

(3) Stability Condition

In order to construct a concrete gravity dam, the following 3 conditions pertaining to the external loads must be satisfied to secure the dam's stability.

- The resultant force consisting of the dam's self-weight and external forces work within the range of the middle 1/3 of the base of section. This condition needs to be satisfied in order to prevent the creation on tensile stress at the upstream end of the base of dam section.
- Sliding between the dam base and the subgrade need to be prevented.
- The maximum stress created in the dam body must not exceed the material's allowable stress. The maximum pressure that the subgrade receives must not exceed the allowable bearing capacity of the subgrade.

Basic conditions for stability analysis are summarized in Table-III-3.6.

Table-III-3.6 Calculation Conditions for Stability Analysis

Item		Design Value	Remarks
Basic Dimension	Dam crest elevation	EL.371.0m	
	Dam foundation elevation	EL.305.0m	
	Dam height	66.0m	
Water Level	Design flood level	EL.369.0m	
	Surcharge level	EL.366.0m	
	Full reservoir level	EL.366.0m	
	Sedimentation level	EL.325.0m	
Downstream Water Level	Design flood	EL.315.0m	water level at downstream of sub-dam
	Surcharge level	EL.307.0m	
	Full reservoir	EL.307.0m	

Other Conditions	Design seismic coefficient	Design flood — Surcharge level 0.075 Full reservoir 0.15 Empty 0.075	
	Unit weight	Concrete 2.30t/m³ Water 1.00t/m³ Sediment in water 1.10t/m³	
	Coefficient of sediment pressure	0.50	
	Wave height	Wind wave 1.0m Seismic wave 0.6m	
	Shear strength Friction coefficient *f* Horizontal shear strength *τ0*	*F*: CM0.84 τ_0: CH 1.00 160tf/m² CM0.84 80tf/m² CL 0.57 40tf/m²	
	Location of foundation drain well	Downstream of 4.5 m from upper surface	

(4) Result of Stability Analysis

Among the stability analysis, the condition of normal water level showed the most critical situation. Result of stability analysis is summarized in Table-III-3.7.

Table-III-3.7 Result of Stability Analysis

Downstream Slope	Fillet		Maximum Cross Section			
	height (m)	Upstream Slope	Upstream Edge Stress (tf/m2)	Safety Factor	Required Shear Stress (tf/m2)	Cross Section Area (m2)
1 : 0.70	349.00	1 : 0.40	5.3	4.9	118	1,930
1 : 0.72	347.00	1 : 0.40	7.1	4.9	118	1,938
1: 0.74	343.00	1 : 0.40	6.8	4.9	119	1,917
1 : 0.76	337.00	1 : 0.40	4.6	4.8	123	1,877
1: 0.78	329.00	1 : 0.40	1.5	4.7	128	1,830
1: 0.80	315.00	1 : 0.40	0.7	4.4	140	1,778
1 : 0.82	0	0	2.4	4.2	150	1,801

Based on the stability analysis, basic dimension of Ayung dam which minimizes dam volume is shown as follows:

- Downstream Slope 1 : 0.80
- Height of Fillet 10 m
- Upstream Slope of Fillet 1 : 0.4

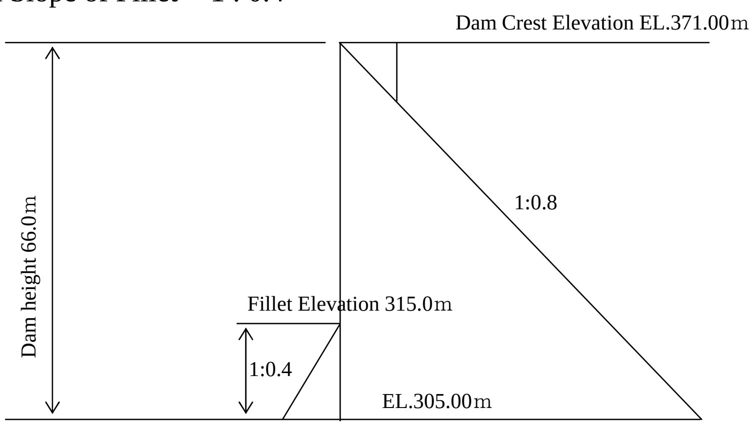

Figure-III-3.9 Basic Dimension of Dam

Required shear stresses in the dam body of each elevation are as shown in Table-III-3.8.

Table-III-3.8 Required Shear Stress

Elevation (m)	Upstream Edge (tf/m²)	Downstream Edge (tf/m²)	Required Shear Strength (tf/m²)

EL.350.00	10.4	34.2	39.2
EL.340.00	7.3	56.5	66.4
EL.330.00	4.4	79.4	87.1
EL.320.00	1.7	102.5	112.9
EL.315.00	0.4	114.1	126.0
EL.310.00	0.5	122.7	132.1
EL.305.00	0.7	128.5	140.2

(5) Spillway

Since Ayung Dam does not have flood control function, spillway with capacity of 1,270m^3/sec discharge has to be installed in more than normal water level 366m in elevation. Taking into consideration with dam operation and maintenance, type of spillway for Ayung Dam shall be designed as toe guide wall type with no gates. Relations between overflow depth and width of overflow section to discharge 1,270m^3/sec are calculated applying the following formula, and the results are summarized in Table-III-3.9.

$$Q = CBH^{3/2} \tag{3.1}$$

where, Q: Discharge (m^3)
C: Discharge Coefficient (= 2.0)
B: Overflow Width (m)
H: Overflow Depth (m)

Table-III-3.9 Relation between Overflow Depth and Width

Overflow Depth (m)	*2.0*	*3.0*	*4.0*	*5.0*	*6.0*
Unit Width Discharge (m^3/s)	*5.7*	*10.4*	*16.0*	*22.4*	*29.4*
Overflow Width (m)	*223*	*182*	*123*	*97*	*80*
Number of Gates	*18*	*15*	*10*	*8*	*7*

Considering the river width and spillway width, overflow depth of spillway shall be adopted as 3.0m. Dam top elevation shall be 371m in elevation by adding normal water level 366m in elevation, overflow depth 3.0m, bridge clearance of 1.5m and bridge beam height of 0.5m.

(6) Artificial Concrete Plug

Base rock of Ayung Dam has the strength of CM class rocks (shearing strength 80 tf/m^2). Based on the stability analysis for CM class rock strength, requirement of dam basement length was calculated as more than 234m and downstream slope of dam was set to as 1:2.3. It is wasteful for adopting this dam shape; artificial concrete plug method was adopted. From the economical point of view for the decreasing of dam concrete volume, the height of 35m above riverbed basement with showing narrow width, artificial concrete plug method was adopted.

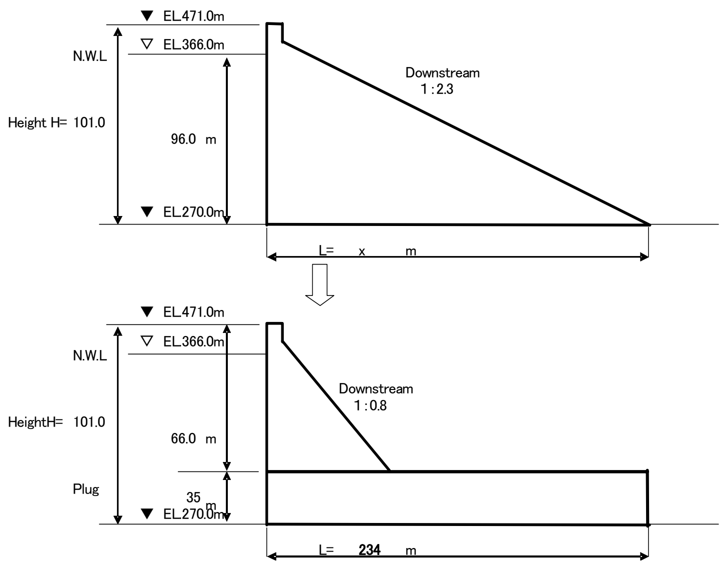

Figure-III-3.10 Comparison with Dam Shape Without Plug and With Plug

(7) Diversion Channel

Design flood for design of diversion tunnel is 440m^3/sec, which corresponding to the probable discharge of 2 years return period. Necessary dimension of diversion tunnel is calculated as shown in Table-III-3.10, assuming the following conditions.

(1) Horseshoe shape is applied as sectional from
(2) Longitudinal slope of diversion tunnel is assumed as 1/50.
(3) Design depth of diversion tunnel is 80 % of full depth.
(4) Manning's formula with roughness coefficient of 0.018 is applied for calculations.

Table-III-3.10 Necessary Dimension of Diversion Tunnel

Diameter(m)	Cross Section Area (m^2)	Hydraulic Mean Depth (m)	$I^{1/2}$	$R^{2/3}$	Vm/s	Qm^3/s
5.0	19.5	1.477	0.1414	1.297	10.2	198.9
6.0	28.1	1.772	0.1414	1.464	11.5	323.2
7.0	38.3	2.068	0.1414	1.623	12.7	486.4
8.0	50.0	2.363	0.1414	1.774	13.9	695.0

As the result of above calculation, basic dimension of diversion tunnel is as shown in Figure-III-3.11.

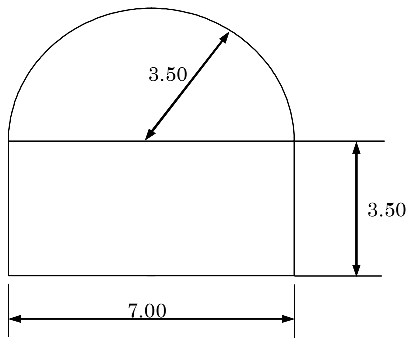

Figure-III-3.11 Typical Section for Diversion Channel

(8) Drawings

Specifications for dam and resourvoir of Ayung Dam is shown in Table-III-3.11.

Table-III-3.11 Specifications of Ayung Dam and Reservoir

Classification	Items	Specifications
1. Reservoir		
	1)Location (River)	Ayung River
	2)Catchments Area	219.4 km^2
	3)Lake Area	0.57 km2(EL370m)
	4)Normal Water Level(NWL)	EL 366 m
	5)Low water Level(LWL)	EL 325 m
	6)Effective Volume	9,000,000 m^3
	7)Sediment Volume	1,000,000 m^3
	8)Total Reservoir Volume	10,000,000 m^3
2. Dam		
	1)Dam Type	Concrete Gravity Dam
	2)Dam Top	EL 371 m
	3)Top Length	239 m
	3)Dam Basement	EL 305 m
	4)Dam Height	66 m
	5)Artificial Basement(Plug)	EL 270 m～305m(Plug Treatment)
	6)Total Dam Volume(Inclu. Plug)	290,000 m^3

3. Spillway		
	1)Type	Toe guide wall type with no gates
	2)Design Discharge	1,270 m^3/s (1/1,000)
	3)Depth	3.0 m
	4)Width	113 m(Net width)

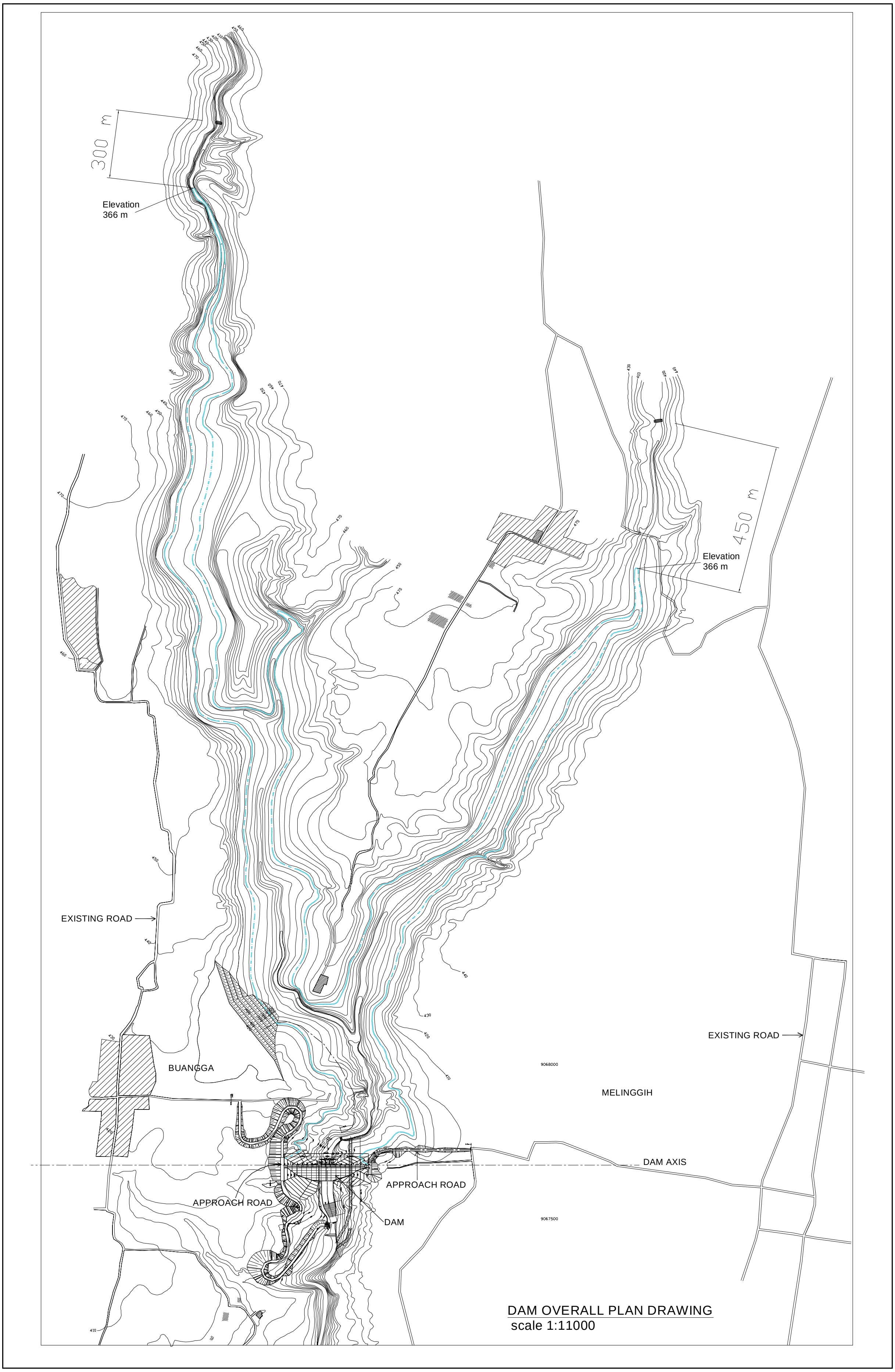

Figure-III-3.12 Genaral Plan of Ayung Dam and Reservoir

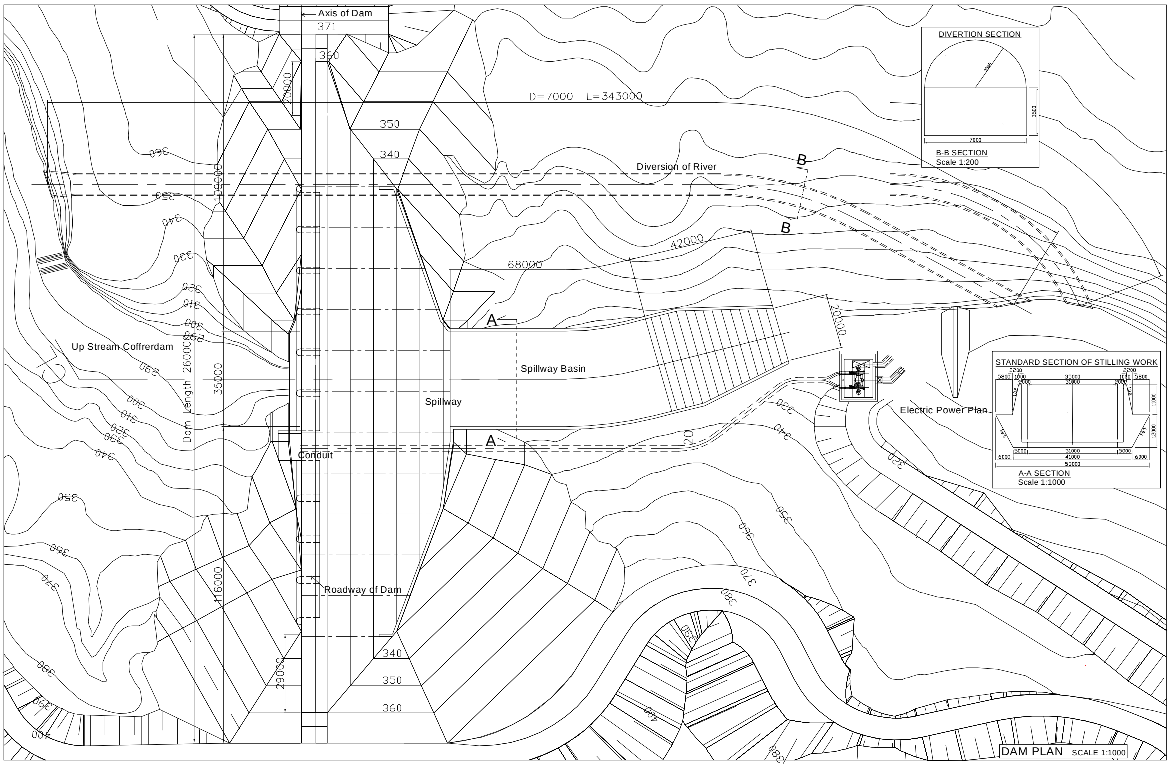

Figure-III-3.13 Plan of Ayung Dam

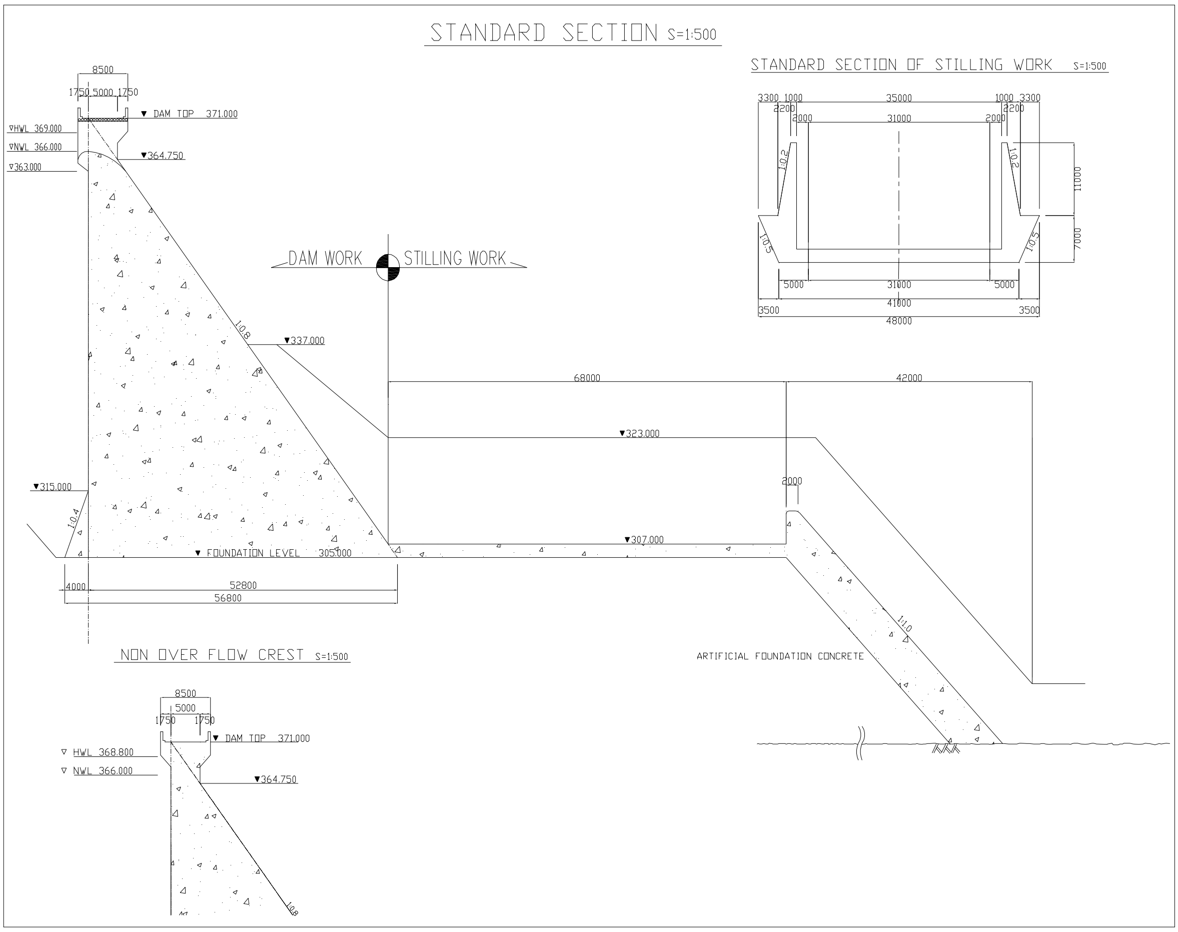

Figure-III-3.14 Typical Cross Section of Ayung Dam

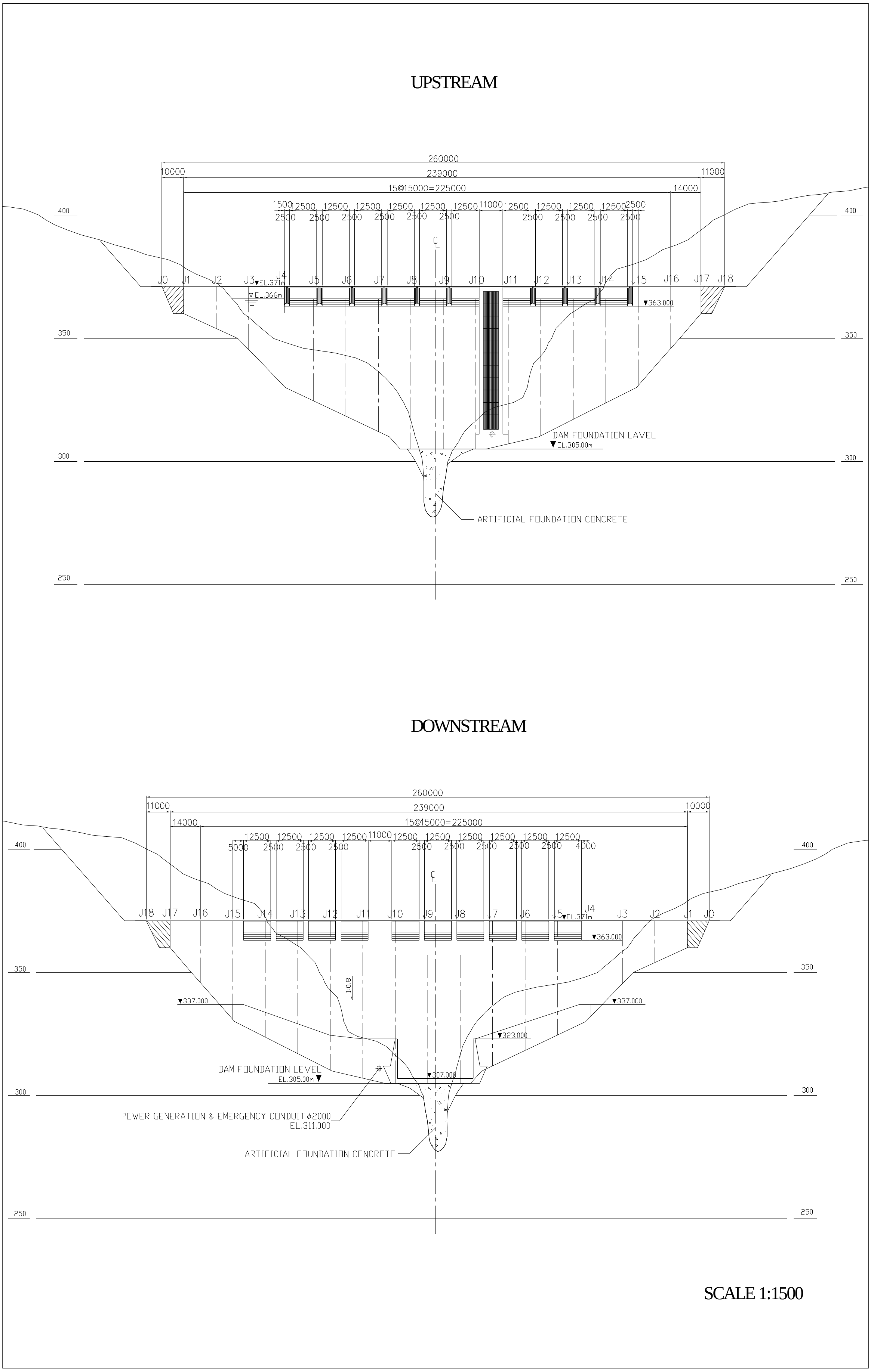

Figure-III-3.15 Upstream and Downstream View

3.5 Design for Check Dam

In consideration of the relationship between possible dam height and reservoir volume, design sediment capacity for Ayung dam shall be secured by dividing into capacity with 1,000,000m^3 stored in reservoir and capacity with 3,600,000 m^3 stored or controlled by check dams constructed at upstream in Ayung River and Siap River. As of sediment inflow, proportion of suspended load and bed load is estimated as 1:3.6, suspended load with volume of 1,000,000 m3(equivalent to 22% of total sediment volume) which passing the check dams shall be accumulated in dam reservoir. Remaining bed load, equivalent to 78% of total sediment volume, shall be trapped and excavated periodically in check dams located both Ayung River and Siap.

(1) Design Sediment Volume

Design sediment volume for check dams was calculated by estimating the storing volume of bed load for 1 year. Design sediment volume is shown in Table-III-3.12.

Table-III-3.12 Design Sediment Volume for Check Dams

River	Area	Annual Sediment Inflow	Design Sediment Volume	Remarks
Ayung River	153.9 km^2	64,200 m^3	50,300 m^3	equivalent to 78% of total sediment inflow volume
Siap river	64.5 km^2	26,900 m^3	21,100 m^3	

Note）: Anuual Sediment Inflow :Specific Inflow417 m^3/km2/year X area (km2)

(2) Waterway

Based on the probable discharge analysis, design discharge for waterway with return period of 25 years was calculated as 570 m^3/s for check dam in Ayung River and 240 m^3/s for check dam in Siap River. Depth of overflowing is calculated by formula as shown in below:

$$Q = (0.71h3 + 1.77B1)\ h^{3\ 3/2} \qquad (3.2)$$

Where, Q : Discharege（m^3/sec） C : Coefficient (0.60～0.66) C=0.6
g : Gravity (9.8m/sec^2） B_1 : Base width (m)
B_2 : Water width (m) m_2 : Slope Gradient (m_2=0.5)

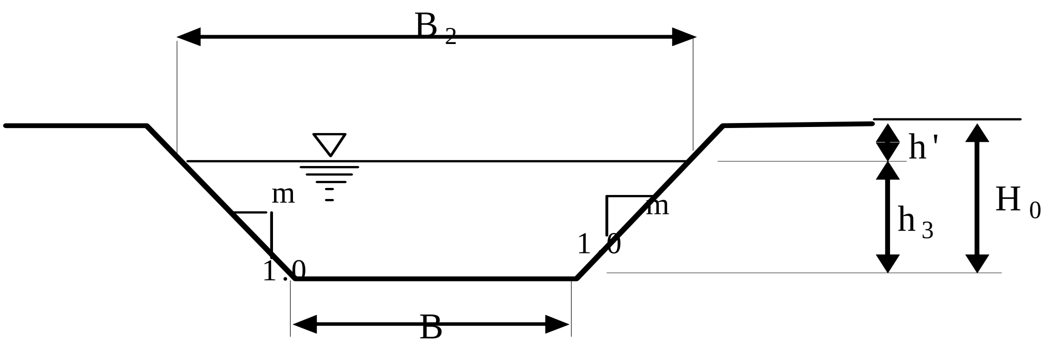

Figure-III-3.16 Calculation of Overflow Depth for Waterway

Specifications of waterways are summarized as shown in Table-III-3.13.

Table-III-3.13 Specifications of Waterways

Dam	Design Discharge	Base Width	Overflow Depth
Ayung River	570 m^3/s	20 m	6.0 m
Siap River	240 m^3/s	10 m	5.2 m

(3) Dam Height

Location of dam sites was fixed by taking into account the water level 366m in elevation of reservoir. Storing volume by check dam was calculated by the estimation of 1/2 sediment gradient for river gradient

Storing volume V = 1/3・W・H・X (3.3)

W : Width

H : Dam Height → H = (I - I') ・ X

X : Length (I' = I/2)

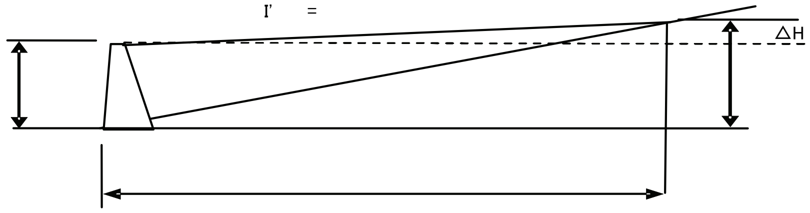

Figure-III-3.17 Calculation for Storing Volume of Check Dam

Specifications of check dam are summarized as shown in Table-III-3.14.

Table-III-3.14 Specifications of Check Dams

Items	Ayung River	Siap River
1. Name of River	Ayung	Siap
2. Catichments Area(km^2)	159.3	64.5
3. Design Sediment Volume(m^3)	50,300	21,100
4. Design Discharge(m^3/s)	570	240
5. Waterway Base Length(m)	20	10
6. Over flow Width(m)	6.0	5.2
7. Dam Height(m)	13.0	7.0
8. Design Storing Sediment Lenght(m)	1,220	990
9. Sediment Volime (m^3)	50,300	21,100

(4) Drawings

Drawings of check dam are summarized as shown in Figure-III-3.18 - Figure-III-3.19.

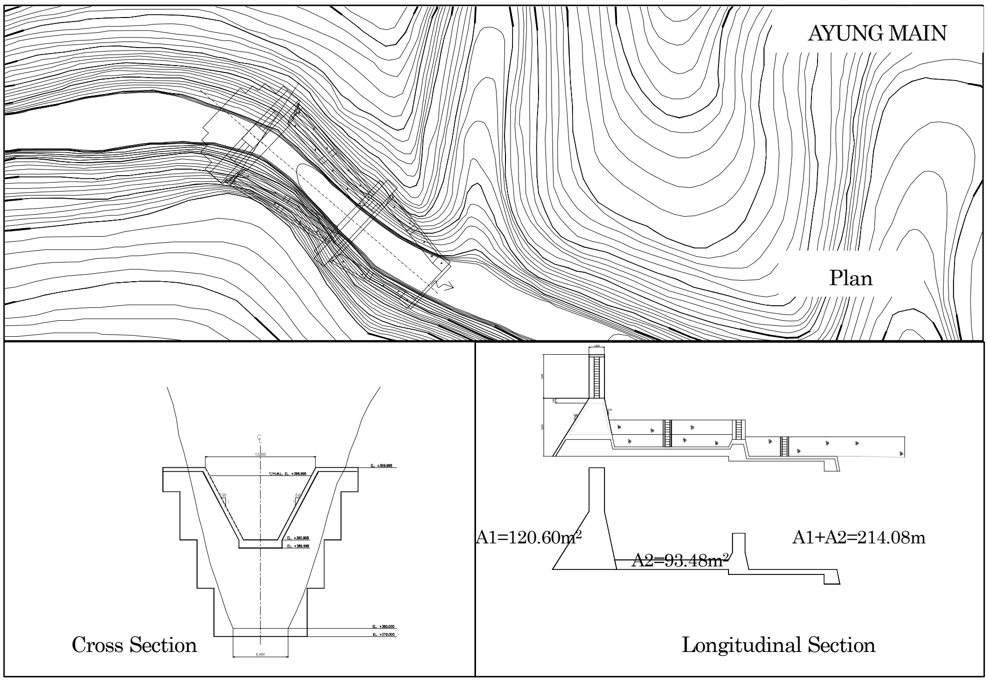

Figure-III-3.18 Check Dam in Ayung River

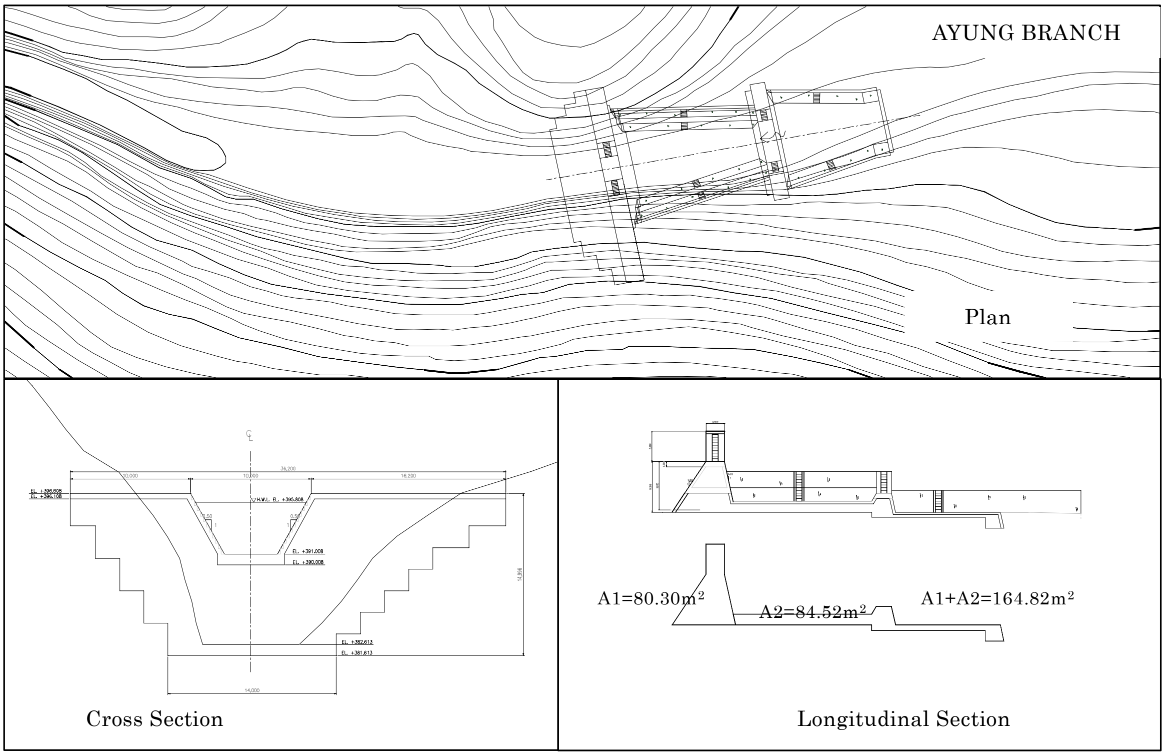

Figure-III-3.19 Check Dam in Siap River

3.6 Reservoir Area Development Plan

In consideration of characteristics of dam location, communities near Ayung Dam, temples and holy places as well as tourism area of Ubud, development themes were stated as shown in follows:

Concept 1. «Travel Destination for Adults»

- The construction of Ayung dam and the reservoir should have positive effects on the economic condition of the local people. The project focuses on tourism, putting more emphasis on the improvement of their lives.
- Tourists visiting Ubud is expecting a peaceful moment in the beautiful scenery of paddy field and forest as the top priority, away from the hustle and bustle of the cities.
- The project actualizes the elements such as 'experiencing/learning Balinese culture' and 'interacting with residents at life/cultural level,' in addition to the existing places of interest including 'watch (dances, etc.),' 'play (rafting, surfing, golf),' and 'shop and heal (hotel, spa, etc.).' It will provide tourists more opportunities to learn the deep part of Balinese culture.

Concept 2. «Respect for Balinese Culture»

- The location of the planned site is the back part of Ubud town, to be connected to the town of Ubud. The reservoir to be constructed in the future should take the idea of Balinese cosmology, considering the fact that the construction site is a 'sacred place' for praising water which is the symbol of religious belief in Bali.

Concept 3. «Trend of Tourism»

- The construction of tourist site should meet the purpose of trips as refers to shown in Table-III-3.15.

Table-III-3.15 Purposes of Trip and General Descriptions

Purpose of Trip	Overview
Spectator - Planner	Image-confirmation (go/watch/photograph) type of trip has been reduced. The purpose of trip has been shifting from 'observation/participation' to 'real experience.'
Lifelong Study	Demand for 'intellectual asset' has been growing as people's lives stabilize, especially among adults/senior generations who are capable of taking enough time for acquiring such asset. Traveling provides lifelong study as well.
Social Contribution	Concerns of mentally-matured tourists are shifting to conservation and improvement of natural/social environment. Sustainable tours will be recognized as the latest styles of traveling. Environment-friendly trips as well as social action tours where visitors can learn conservation/betterment of the environment and participate in such activities will be active with public support.

Source: "Tourist busines supporting travel industry" (Kishimitsu Sato, Doyukan, 2002, Japan)

Table-III-3.16 Development Zone and Images, Plans

Zone	Locations	Symbol color & Images	Development Plans
A Zone ■Dancing Stage & Circle in Lake	Meeting Point of Ayung River and Siap River	Symbol Color: (Black)（Vishnu=Water） Image : (Water)(Silent)(Dance)(Sanctification)(Feminale)	1)Dancing Stage in Lake 2)Audience Seat 3)Boat for Moving and Fishing 4)Dock 5)Fish Breeding in Lake
B Zone ■Culuture Village & Exchange Village	Ayung River Right Bank	Symbol Color: (White) (Amalgamation and Harmony) Image: (Mother Earth & Water) (Response & Motion) (Bisexual)	1)House for each theme 2)Cottage for each theme 3)Pool such like a rice field 4)Cattle cart
C Zone ■Entrance & Transit	Siap River Left Bank	Symbol Color: (Red) Image: (Fire) (Motion) (Manlike)	1)Car Space 2)Transit Zone for moving to lake 3)Observation Deck

According to development plant as shown in Table-III-3.16, image landscape design with atmosphere of Bali is shown in Figure-III-3.20.

Figure-III-3.20 Landscape Design with Atmosphere of Bali

3.7 Power Genaration Plan

The discharge of Ayung dam site during dry season is larger than among the rivers flowing to central area of Bali. Due to abundant discharge of Ayung River, the utilization of released water (hereinafter defined as 'outflow') and water level (hereinafter defined as 'hydraulic head') by Ayung dam was planned.

Water for irrigation and raw water as well as unspecified water for river environmental conservation shall be supplied through the outlets. Outflow of dam contains not only effective flow for water use but also flow for no use (hereinafter defined as 'unavailable flow') due to excess capacity above normal water level based on reservoir operation plan.

For hydro power plan of Ayung dam, however, turbine discharge for power generation can be used from minimum discharge for water use to maximum discharge with containing unavailable water flowing through the outlets. Turbine discharge shall be turn out from outlets.

(1) Basic Condition

<Power Generation Facilities Route and Location of Power Plant>

Due to usage of outflow of reservoir, the power generation facilities route was set up with conduit and pipeline route of Ayung Dam. The location of power plant was planned to right side.

<Discharge for Generation>

Maximum and minimum discharge for calculation of power generation was shown in Table-III-3.17.

Table-III-3.17 Maximum and Minimum Discharge for Calculation Case of Power Generation

Case	Max. Discharge	Min. Discharge
1	12.0 m^3/s	6.5 m^3/s
2	14.0	6.5
3	16.0	6.5
4	18.0	6.5

<Water level and Head>

Based on the dam specifications such as normal water level, location of pipeline and electric power plant, river water level, power generation plan by Ayung dam was studied as shown in following condition:

- Intake water level was set up as 366m in elevation
- Tail water level was set up as 282m in elevation by taking into account with riverbed elevation, river width, basement level of power plan.

Table-III-3.18 Calculation Conditions for Power Generation

Items	Specifications	Remarks
Intake water level	EL 366.0 m	Normal water level
Tail water level	EL 282.0 m	
Maximum head	84.0 m	
Effective head	79.8m	5% of loss head =4.2m

(2) Culculation Results

Based on the reservoir operation simulation, calculation results of power generation for Ayung Dam are as shown in Table-III-3.19.

Table-III-3.19 Ｌ5 Output and Annual Output (Average :1976-1985)

Discharge	L5Output(Kw)	Gross Output for Year(Mwh)	Utilization factor for Year (%)
8 m^3/s	4,402	39,828	85
10 m^3/s	4,729	44,253	76
12 m^3/s	４,782	45,896	66
14 m^3/s	４,687	45,885	56
16 m^3/s	４,551	45,070	48
18 m^3/s	４,404	43,951	28

Note) Utilization factor : (GO / Max. output × 24 hours × 365 days) × 100 (%)

(3) Optimal Scale

Economic evaluation results by C/V method are shown in Table-III-3.20 and Figure-III-3.21.

Table-III-3.20 Economic Evaluation by C/V Method (V-C, C/V)

Case		Turbine Discharge （m^3/s）					Remarks
		8.0	10.0	11.0	12.0 (Adopted)	14.0	
Max. Output (KW)	1)	5,320	6,650	7,310	7,980	9,310	
Ｌ5output capacity (KW)	2)	4,402	4,729	4,756	4,782	4,687	
Gross Output(MWh)	3)	39,828	44,253	45,100	45,896	45,885	
Effective Output Capacity (KW)	4)	4,204	4,516	4,542	4,567	4,476	2)×(1-Stop Factor)
Net Output(MWh)	5)	38,036	42,262	43,071	43,831	43,820	3)× Utilization Factor
Value for KW (1000yen	6)	138,115	148,375	149,222	150,038	147,057	4)×KW
Value for KWh(1000 yen)	7)	464,036	515,592	525,460	534,734	534,606	5)×KWh
Benefit(1000yen)(V)	8)	602,151	663,967	674,682	684,772	681,663	6)＋7)
Construction Cost(1000 yen) (V)	9)	793,000	916,000	979,000	1,031,000	1,139,000	
Operation Cost(1000 yen) (C)	10)	97,539	112,668	120,417	126,813	140,097	9)× Expense Rate
Ｖ－Ｃ(1000 yen)	11)	504,612	551,299	554,265	557,959	541,566	8)－10)
Ｃ／Ｖ	12)	0.162	0.170	0.178	0.185	0.206	10)／8)
Cost per Kw (1000yen/KW)		149.1	137.7	133.9	129.2	122.3	9)／1)
Cost per Kwh(1000 yen /KWh)		19.9	20.7	21.7	22.5	24.8	9)／3)
Utilization Factor (%)		85	76	70	66	56	(3)/(1)×24×365/1000)) ×100

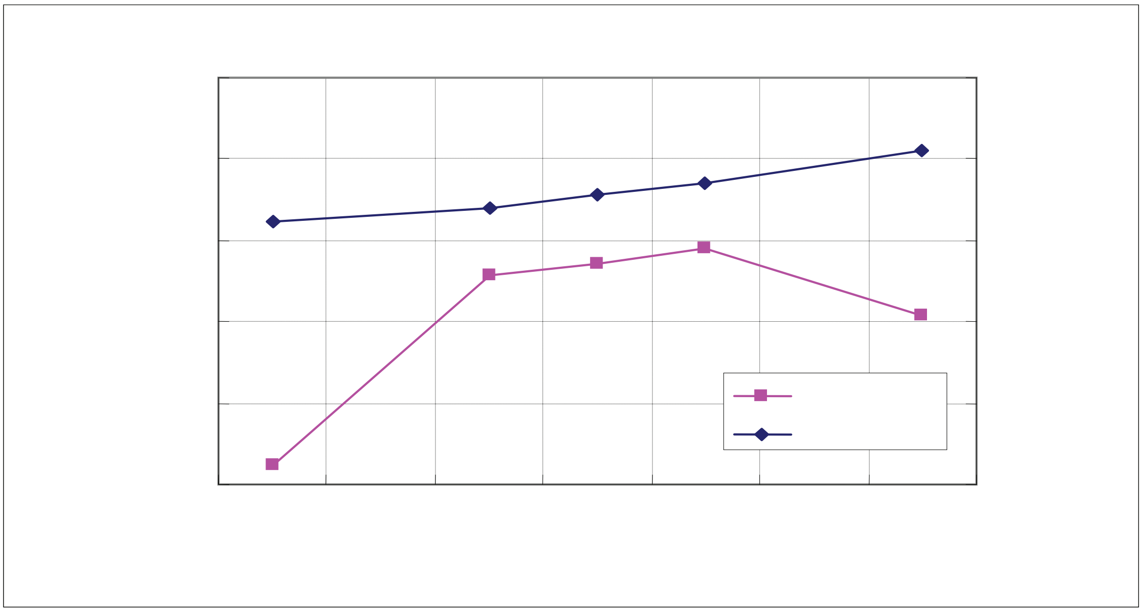

Figure-III-3.21 Relationship Between Discharge V-C,C/V

Optimal scale for discharge was selected as discharge case of 12m^3/s with showing highest value of (V-C). Specifications of Ayung power plant are shown as Table-III-3.21.

Table-III-3.21 Specifications of Ayung Power Plant

Items	Specifications	Remarks
Intake water level	EL.366.000 m	Normal water level
Tail water level	EL.282.000 m	
Gross head	84.0 m	
Net head	79.8 m	Loss= 4.2 m
Discharge	12.0 m^3/s	
Output capacity	7,980 KW	
Net output capacity	4,570 KW	L5Output×Stop Factor
Firm Capacity	4,570 KW	Same as above
Gross output (year)	45,900 MWh	

3.8 Construction Quantities

Construction quantities for Ayung Dam are shown as Table-III-3.22.

Table-III-3.22 Construction Quantities for Ayung Dam

Works Description		Unit	Quantity
1	Preparatory Works (Clearing and Grubbing etc)		
	1.1 Mobilization	Ls	1.0
	1.2 Temporary Road of Disposal Area	m	550.0
	1.3 Road works	m	2,080.0
2	Diversion Works(L=340m)		
	2.1 Diversion Length	m	340.0
	(Figure：7.5m×7.5m Semi-Horse Shaped Tunnel)		
	2.2 Open Inlet・Outlet	site	2.0
	2.3 Coffer Dam	site	2.0
3	Permanent Works（Concrete Gravity Dam）		
	3.1 Excavation	m^3	514,000.0
	3.2 Artificial Plug	m^3	50,000.0
	3.3 Concrete Works	m^3	240,000.0
	3.4 Artificial Concrete Abutment	m^3	750.0
	3.5 Grout Works		
	1) Consolidation Grout	m	2,600.0
	2) Curtain Grout	m	29,500.0
	3) Rim Grout	m	500.0
	3.6 Crown Road of Dam	site	10.0
4	Temporary Equipment		
	1) Concrete Plant	t	750.0
	2) Tower Crane （13.5t×75m)	set	1.0
	3) Feed Plant	t/hr	150.0
5	Power Station		
	Excavation	m^3	14,000.0
	Concrete Structure	m^3	3,000.0
	Power Station(7900kwｖ)	set	1.0
6	Sabo Dam		
	Excavation	m^3	1,000.0
	Concrete Works	m^3	12,000.0
7	Road Works		
	1) Earth Works ＆ Pavement	m^2	18,550.0
	2) Excavation(Rock)	m^3	5,000.0
	3) Surface Course(Concrete:25cm)	m^2	18,550.0
	5) Beacon・Signal etc	m	1,667.0
	6) Steel bridge	t	390.0
8	Disporsal Area		
	Left bank	m^3	1,250,000.0
	Right bnak	m^3	250,000.0
	Embankment (Backfulling)	m^3	1,495,000.0
9	Outlet＆Electric Power Gate		
	1) Intake Gate	t	540.0
	2) Conduit Pressure Pipe	t	110.0

3.9 Construction Plan

Out line of Construction Method

The outline of construction method and work item based on the construction quantity is shown in Table-III-3.23.

Table-III-3.23 Work Item of Construction Plan, Method and Quantity

No.	Work Item	Content and Construction Method	Construction Quantity
1	Temporary road and Improvement Work.	Construction of Temporary road	L=2,630m, B=7～8m
2	Diversion Work	Diversion tunnel shall be constructed on the left bank side to do excavation of the river bed. It shall be set up cofferdam at mouth and outflow of diversion tunnel and a river bed shall be made dry work.	L＝340m (Half-horse-shoe :7.5m×7.5m)
3	Dam Excavation	Before the diversion of river, it shall be made to finish excavation beyond the crown of dam. After the diversion of river, it shall be made to finish excavation under the crown of dam . Excavation shall be begun from the top, and onboard work and conveyance work shall be done on the river bed.	Excavation Quantity = 520,000 m^3
4	Gravity Dam (Concrete Works）	Gravity Dam shall be constructed with ELCM (Extended Layer construction method)	Concrete Works = 291,000 m^3
5	Drilling and Grouting Works	Consolidation grouting, curtain grouting and rim grouting shall be carried out.	Consolidation Grouting = 2,600m Curtain Grouting = 29,500m
6	Slope Protection Works	Protection work shall be done for cut slope of the temporary road, cut slope of dam excavation and temporary cut slope of other excavation.	
7	Disposal Area Works	It shall be thrown away in the place beyond EL370, and soil shall be done. Disposal area shall be set up in the dam right bank upper reaches part, and it shall be placed beyond EL370.	Capacity of Disposal Area = 1,450,000m^3

Excavation Work and Concrete Work for Main Dam are as shown in followins:

Excavation Work (Main Dam)

Excavation volume is estimated as 520,000m^3. Image figure of excavation work is shown in Figure-III-3.22.

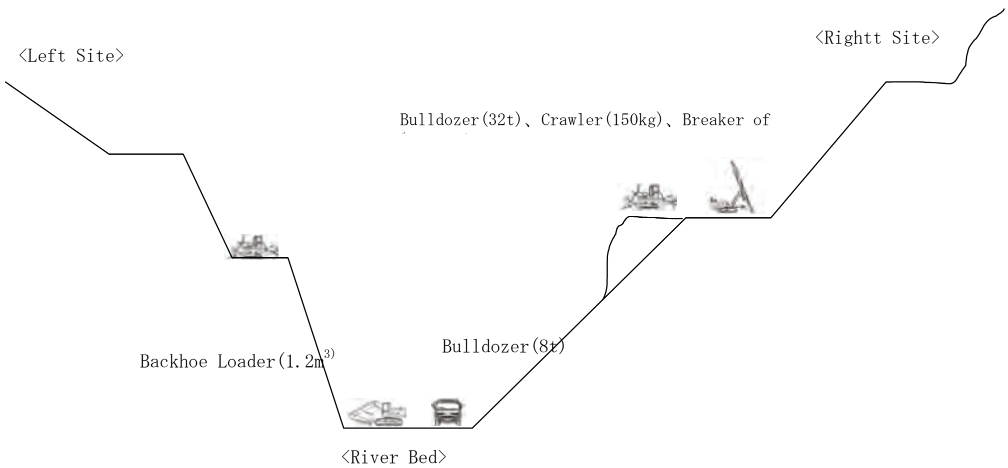

Figure-III-3.22 Image figure of Dam Excavation Work

Concrete Work（Main Dam Work）

Dam concrete works are consists of main dam work(EL.305m upper), artificial concrete plug(EL.275m～305m) and artificial concrete abutment work (around dam crown). Concrete volumes are estimated as about 291,000m^3. Outline of concrete works are shown in the Table-III-3.24.

Table-III-3.24 Outline of Concrete Work (for Main Dam).

Item	Concrete Lift	Placement Schedule	Monthly Construction acceptable day	Total months of Construction Work	Mean monthly placement quantity	Remark
Dam body concrete	1.5m	312 day	16 day	21.5 month	11,500 m^3	River bed 2 months
Artificial concrete plug	ditto	108	ditto	7.0	7,150	
Abutment on either bank	2.5	80	25	3.2	125	Placement is quantity /one-time

Construction Schedule

Concrete Work is calculated as 312 days in total. As for items, placements days of concrete are 222days, suspensions by the structure thing execution inside dam are 60 days and placements of concrete form are 30 days.

If acceptable days for placement of concrete are made 16 days. Total months of construction works are 21. 5 months and the amount of average placement for a month becomes 11,500 m^3. Specifications of Production equipment, the amount of bone material stock and a conveyance equipment are shown as the following Table-III-3.25.

Table-III-3.25 Outline of Construction for Dam Body Works（Concrete Work）

Equipment classification.	Item
1) Production equipment	・16 hours(Day and night execution.) ・Maximum one-day quantity = 1,200m^3（around EL.332.0 m） ・Maximum one-hour quantity=75 m ^{3}/ hr
2) Stock and Supply of Aggregate	・Daily Necessary Maximum Quantity.Coarse Aggregate ＝2.860m^3/day、 Fine Aggregate＝360m^3/day ・The bin which can keep capacity on 3 days of a maximum quantity is set up.
3) Conveying Equipment for Dam body execution	・Main placement and Conveying Equipment：Tower Crane (13.5ｔ×75m） 1 set. ・4.5m^3 Vessel Dump ・9m^3 Gland Hopper ・10ｔDamp Truck

The construction schedule of Ayung Dam Project is shown in the Table-III-3.26 from the above examination.

Table-III-3.26 Construction Schedule of Ayung Dam

	Details of Work	Qty	1 (J F M A M J J A S O N D)	2 (J F M A M J J A S O N D)	3 (J F M A M J J A S O N D)	4 (J F M A M J J A S O N D)	5 (J F M A M J J A S O N D)	Remarks
1	Preparatory Works							
	Clearing & Grubbing	Ls						
	Temporary Roads	L=595m						
	Permanent Roads	L=2120m						
	Mobilization	Ls						
2	Diversion Works							
	Excavation	340m						
	Concrete Lining	340m						
	Inlet/Outlet Structure	2site						
	Coffer Dams	2site						
3	Main Dams Works							
	Abutment	375m						
	Plug	50,000m^3						
	Excavation	514,000m^3						
	Concreting	240,000m^3						
	Drilling & Grouting	Ls						
	Intake	Ls						
	Crest Bridge	10						
4	Temporary Facilities							
	Main Concrete Plant	2.25x2						
	Tower Crane Installation	13.5tx75m						
	Water Treatment Plant	150t/hr						
5	Power Station							
	Excavation	6000m^3						
	Foundation Treatment	Ls						
	Structural Concrete	3,000m^3						
	Architectural $ Equipment Works	7900kw						
6	Sabo Dams							
	Excavation	2site						
	Concrete	2site						
7	Spoil Bank							
	Right site	1,250,000m^3						
	Left site	250,000m^3						
	Remark							

CHAPTER 4 FLOOD CONTROL FACILITY FOR BADUNG RIVER AND MATI RIVER

4.1 General

Badung River originated in hillside with 150m in elevation runs north to south throurgh the center of Denpasar City on the way and flows into Benoa Straight. Area of basin is about 37.7 km^2, length is approximately 30km and rounded river gradient is about 1/500. There are houses and stores densely in the some sections which show insufficient height of dikes or narrow width along the river. Badung River is one of the typical urban rivers judging from the urbanization ratio of 55% in the river basin at present. However, due to good location for business as well as residences, it is forecasted to reach about 80% of river basin in the future. Buagan Weir located in the downstream is the main river facility for irrigation use as well as domestic use.

Mati River originated in hillside with 80m in elevation near Sempide runs north to south, joining to Tebe River at downstream near Kuta, and flows into the Benoa Straight. Mati River is also one of typical urban river with catchments area 38.4km^2 , length 20km, and river gradient I=1/400. There are no dikes or narrow channel from Ulun Tanjung Weir in downstream to Umadui Weir in upstream. According to river improvement plan by Indonesian Government, the area which surrounded both Mati River and its right tributary Lebakmudin River in the upstream of Umadui Weir shall be designed for retarding basin for flood control.

Same as Badung River basin, the ratio of urbanization in river basin currently reaches to about 50% and estimated as 80 % in the future, the need for more land development for housing is very strong due to the good location, and in the future it will be 80% of river basin.

Many flooding have been repeating along the area in Badung River and Mati River since 1979 which recrded. In March 4^{th},1984, Monang Manning, Suwung and Pamecutan area located in Mati River Basin were inundated at the estimated area of 700 ha and depth of 0.3m for about two days. More than 200 houses and stores near Kumbasari market located along Badung River also damaged in January 8, 1980. Lately, December 12, 2005, the section between Maruti Street located in upstream and Pulau Misol Street located in downstream along Badung River hit and damaged by flood. (Refer to Figure-III-4.1)

To prevent these damages by flood, flood control plan shall be settled and river improvement such as excavation of riverbed, revetment and normalization shall be designed during feasibility study.

<Upstream Section at JL. G. Kering Street(From Right Bank Side)>

<Bank Slope Failure near Upstream of JL. P. Misol (From Left Bank Side)>

Figure-III-4.1 Photos of Damage Condition by Flood December 12, 2005

4.2 Criteria for Plan and Design

For the flood control plan and river planning, referring to not only Indonesian standards and criteria but also the Japanese standard for flood control plan and design, the following items were settled:

- ◆ Based on the recommended minimum return period of Design Flood as shown in the Flood Control Manual, return period of flood control plan for both Badung River and Mati River shall be adopted **for 25 years.**
- ◆ For the following items, Japanese Standard for River Planning and Design was adopted by referring to Flood Control Manual of Indonesian government.

1) Design Rainfall
2) Run-off Calculation Method
3) Design Flood
4) Flood Control Measures
5) Hydraulic Calculation
6) River Engineering
7) River Facilities and Bridges

4.3 Flood Control Plan

4.3.1 Badung River

(1) Flow Capacity of Current Condition

1) Calculation Method and Conditions

Based on the topographic survey results, current river flow capacity was calculated by using non-uniform flow method. The conditions for calculation are shown in Table-III-4.1.

Table-III-4.1 Calculation Method and Conditions

Items		Conditions, Contents	Remarks
Calculation Method		Non-uniform Flow	
Calculation Condition	Section	Buagan Weir (Downstream) - Gajamada Street (Upstream)	
	Coefficient of Roughness	n=0.025	Refer to PU plan
	Evaluation	Top of the Bank with No Freeboard	
	Cross Section	Topographic Survey Result	

2) Calculation of River flow Capacity

The result of river flow calculation is shown in Figure-III-4.2. According to this result, minimum flow capacity of current river flow is estimated as 120 m^3/sec - 200 m^3/sec, except some section showing less than 50 m^3/sec.

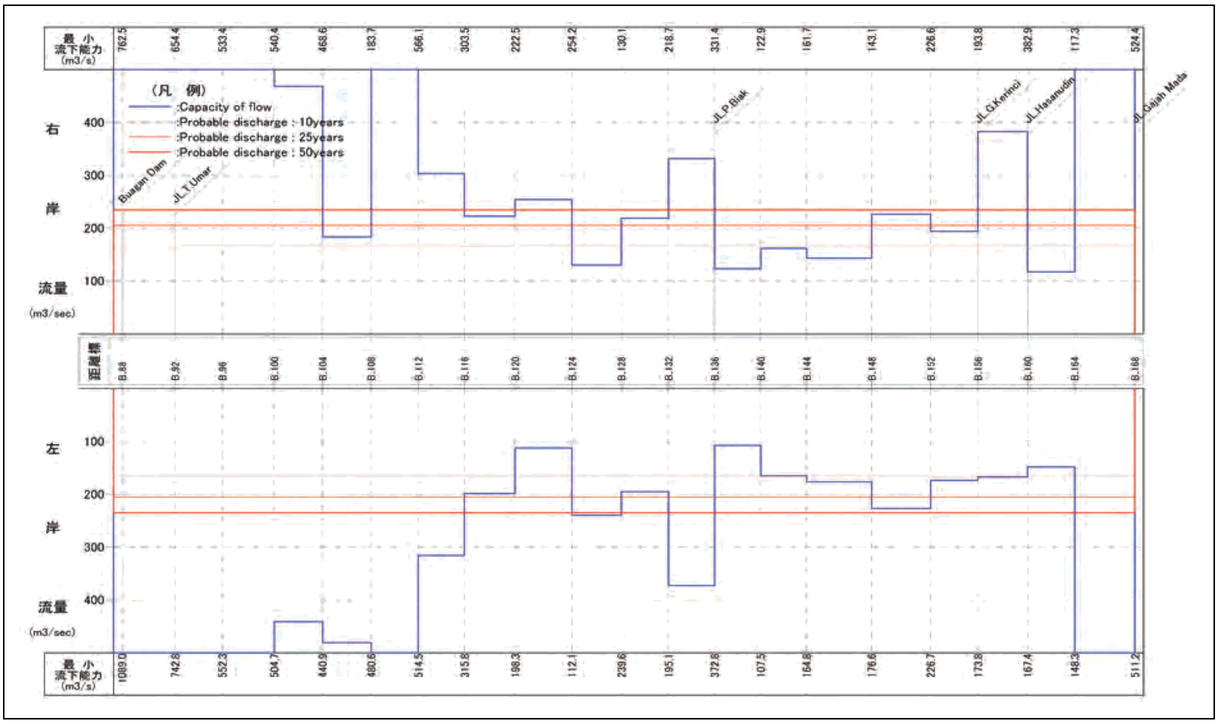

Figure-III-4.2 Calculation Result for Current River Flow Capacity (Badung River)

(2) Design Flood Calculation

1) Run-off Calculation Method

Run-off analysis for the design flood of Badung River was executed by using rational formula in consideration with following reasons:

- ◆ The analysis model is to be required to calculate the change of land use due to urbanization in basin.
- ◆ The analysis model has applicability for calculation even in case of no discharge observation.

2) Calculation method

Peak discharge flow calculated by Rational Formula is given as follows:

$$Qp = 1/3.6 \cdot f \cdot R \cdot A \qquad (4.1)$$

where, Qp：Maximum Discharge (m^3/sec),
f：Dimensionless Runoff Coefficient,
R： Average rainfall intensity within arrival time of flood(mm/hr)
A：Catchments Area (km^2)

3) Runoff Coefficient

For flood plan, taking into account of land cover condition, land use and urbanization, runoff coefficient for Badung River basin should be calculated by weighted average method corresponding with classified coefficient of land use condition

a) Densely residential Area : 0.9
b) Residential Area : 0.9
c) Cropping field ,Waste land : 0.6
d) Paddy field : 0.8
e) Mountain area : 0.7

4) Arrival Time of Flood

Kraven's Formula was used for calculation of arrival time of flood.

$$T = L/W \qquad (4.2)$$

I	Less than 1/100	1/100～1/200	More than1/200
W	3.5m/s	3.0m/s	2.1m/s

where I：Watercourse gradient
W：Velocity of flood
L：Length of watercourse
T：arrival time of flood

5) Rainfall Intensity

Rainfall intensity was calculated by using daily rain fall intensity formula as shown in below,

$$r_t = R_{24}/24(24/T)^{2/3} \qquad (4.3)$$

where r_t：Rainfall Intensity (mm/hr)
T：Arrival time of flood (hr),
R_{24}：24 hours rainfall (= daily rainfall, m)

6) Watershed Division and Specifications

Watershed division for the runoff model of Badung basin is shown in Figure-III-4.3 by taking into consideration with confluences of tributaries, control point for river planning and main river facilities. Land use condition for each divided area is shown in Table-III-4.2

Table-III-4.2 Watershed Division and Land Use

Ite	Land Use	1		2				3			
		JL.GATO SUBUROTO		JL.GAJAMADA				Tukad Badung			
		a		b		c=a+b		d		e=c+d	
		(km2)	(%)	(km2)	(%)	(km2)	(%)	(km2)	(%)	(km2)	(%)
High density city area	building			0.04	0.5	0.04	0.2	0.25	2.2	0.29	0.8
General city area	residential area	6.66	35.6	4.21	55.4	10.87	41.3	8.12	71.2	18.99	50.4
Paddy field	irrigated paddy field	10.49	56.1	2.83	37.2	13.32	50.6	2.10	18.4	15.42	40.9
A field and a land	bushes							0.13	1.1	0.13	0.3
	dry land			0.03	0.4	0.03	0.1	0.04	0.2	0.07	0.2
	grass	0.02	0.2	0.04	0.7	0.06	0.2	0.32	2.8	0.38	1.0
	plantation/yard	1.50	8.0	0.44	5.8	1.94	7.4	0.44	3.9	2.38	6.3
	unirrigated paddy field	0.03	0.2			0.03	0.1			0.03	0.1
	bare land										
Mountain land	forest										
∑A		18.7	100.0	7.6	100.0	26.3	100.0	11.4	100.0	37.7	100.0

Note) Total catchments area of 37.7 km^2 is based on the report "PERENCANAAN PENGELOLAAN SEDIME TUKAD BADUNG DI KOTA DENPASAR, 2001"

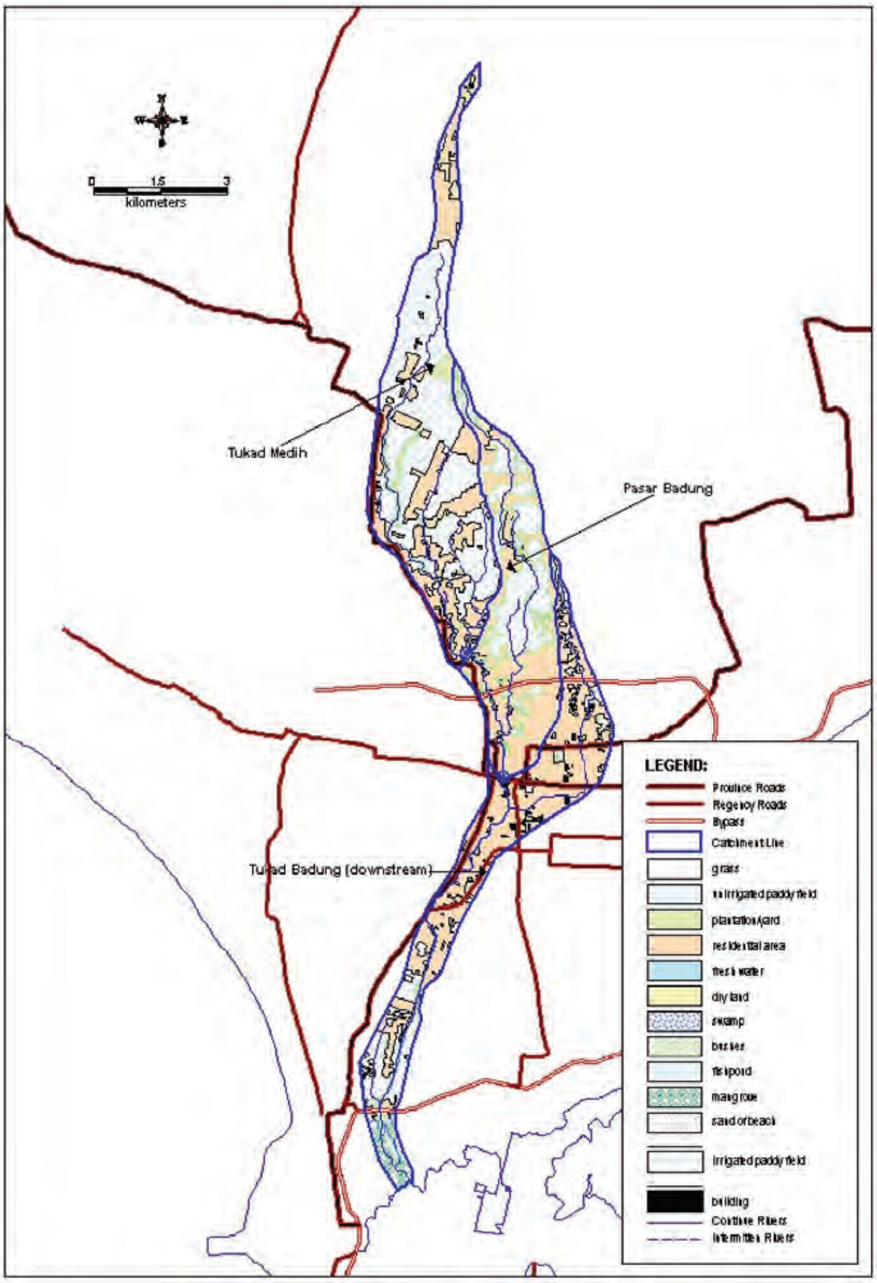

Figure-III-4.3 Watershed Division for Badung River Basin

7) Run-off Calculation

<u>Conditions for Run-off Calculation</u>

Return Period: As scale of return period 5, 10, 20, 25, 30, 50, 100 years are adopted for the calculation.

Run-off Co-efficient: Two cases of co-efficient were set up for the runoff calculation; the one is for current land use, another one is for future land use by taking into urbanization in Badung river basin. In this calculation, percentage of 80% in river basin will be presumed to be developed.

Probable Daily Rainfal: 24 hours rainfall data for each return period are used.

Result of Run-off Calculation: **Result of run-off calculation is shown in** Figure-III-4.4**.**

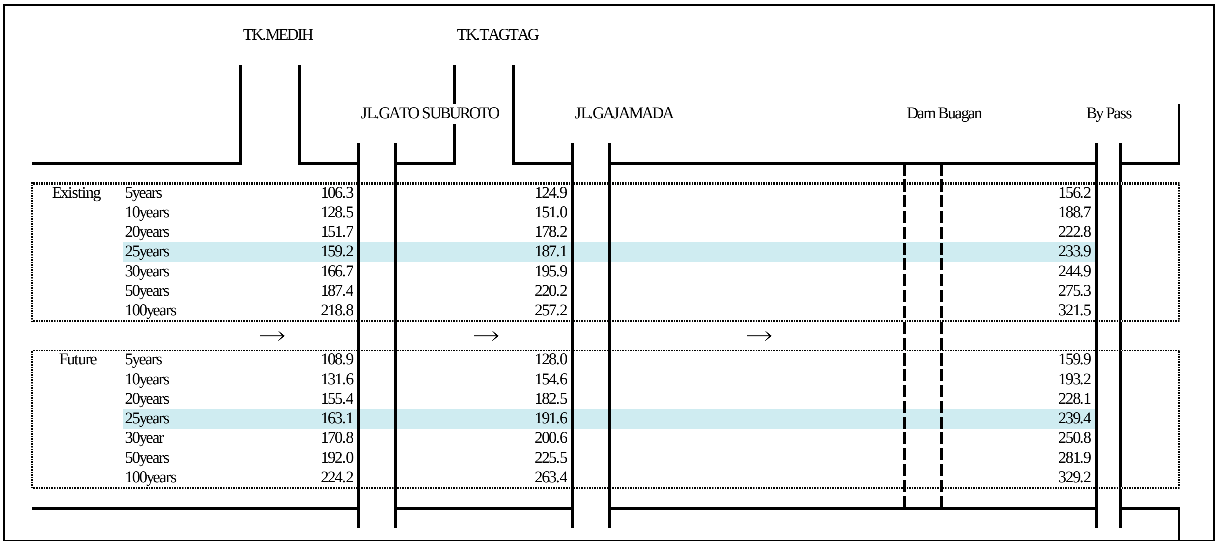

Figure-III-4.4 Discharge for Each Return Period at Base Point

Table-III-4.3 List of Discharge for Each Return Period

Return period	Site	Catchment area (km2)	Stream length (km)	Runoff coefficient		Arrival time of food (min)	R24 (mm)	Rainfall rate (mm/hr)	Probable discharge		
				Existing	Future				Existing (m3/s)	Future (m3/s)	Rate of increase (%)
1/5	1	18.7	10.3	0.82	0.84	60	72.0	25.0	106.32	108.91	
	2	26.3	21.9	0.83	0.85	80	72.0	20.6	124.94	127.95	
	3	37.7	33.5	0.84	0.86	100	72.0	17.8	156.20	159.92	
1/10	1	18.7	10.3	0.82	0.84	60	87.0	30.2	128.47	131.60	
	2	26.3	21.9	0.83	0.85	80	87.0	24.9	150.97	154.61	
	3	37.7	33.5	0.84	0.86	100	87.0	21.5	188.74	193.24	
1/20	1	18.7	10.3	0.82	0.84	60	102.7	35.6	151.65	155.35	
	2	26.3	21.9	0.83	0.85	80	102.7	29.4	178.21	182.51	
	3	37.7	33.5	0.84	0.86	100	102.7	25.3	222.80	228.11	
1/25	1	18.7	10.3	0.82	0.84	60	107.8	37.4	159.18	163.07	2.4
	2	26.3	21.9	0.83	0.85	80	107.8	30.9	187.06	191.57	2.4
	3	37.7	33.5	0.84	0.86	100	107.8	26.6	233.87	239.43	2.4
1/30	1	18.7	10.3	0.82	0.84	60	112.9	39.1	166.72	170.78	
	2	26.3	21.9	0.83	0.85	80	112.9	32.3	195.91	200.63	
	3	37.7	33.5	0.84	0.86	100	112.9	27.8	244.93	250.76	
1/50	1	18.7	10.3	0.82	0.84	60	126.9	44.0	187.39	191.96	
	2	26.3	21.9	0.83	0.85	80	126.9	36.3	220.21	225.51	
	3	37.7	33.5	0.84	0.86	100	126.9	31.3	275.30	281.86	
1/100	1	18.7	10.3	0.82	0.84	60	148.2	51.4	218.84	224.18	
	2	26.3	21.9	0.83	0.85	80	148.2	42.4	257.17	263.36	
	3	37.7	33.5	0.84	0.86	100	148.2	36.5	321.51	329.17	

From the Table-III-4.3, discharge with 25 years return period at river mouth is 233.9m^3/sec on the basis of current land use condition, and 239.4m^3/sec with increasing 5.5m^3/sec due to developing ratio with 80% of urbanization for watershed area.

8) Basic Design Flood for Badung River

Based on the calculation result as shown in Figure-III-4.5, basic design flood for Badung River should be determined to be **235 m^3/sec at the base point as well as 205 m^3/sec at Buagan Weir.** Comment for the calculation results for basic design flood is summarized as follows:

- ◆ Basic design discharge for urbanization of 80 % shall be 239.4m^3/sec
- ◆ Result of calculated discharge by JICA is almost same as existing plan discharge 231.7m^3/sec which had formulated by Indonesian Government.
- ◆ Specific flow is to be 6.2 m^3/sec/km^2 from its basin area of 37.7km^2 at river mouth.

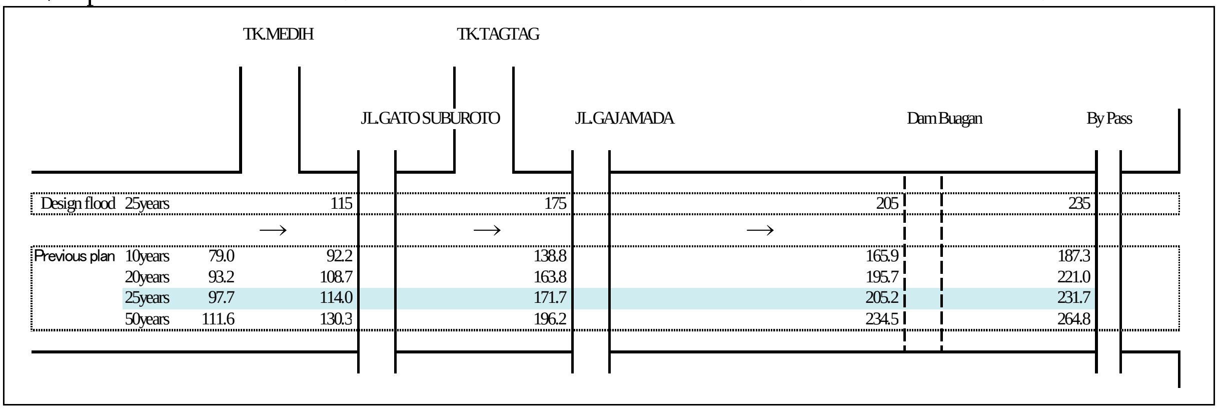

Figure-III-4.5 Distribution of Basic Design Discharge (Badung River)

(3) Flood Prevention Project for Badung River

Flood control plan for Basic Design Discharge of Badung River is shown as follows:

1) Distribution of Design Discharge for River Improvement

Comparing with the result between flow capacity of current river condition and planning river condition, only river course improvement including riverbed excavation and bank heightening, etc shall be adopted for Badung River. Design discharge is shown in Figure-III-4.5.

2) Selection of for River Improvement Section

Section of river improvement plan is indicated on Figure-III-4.6.

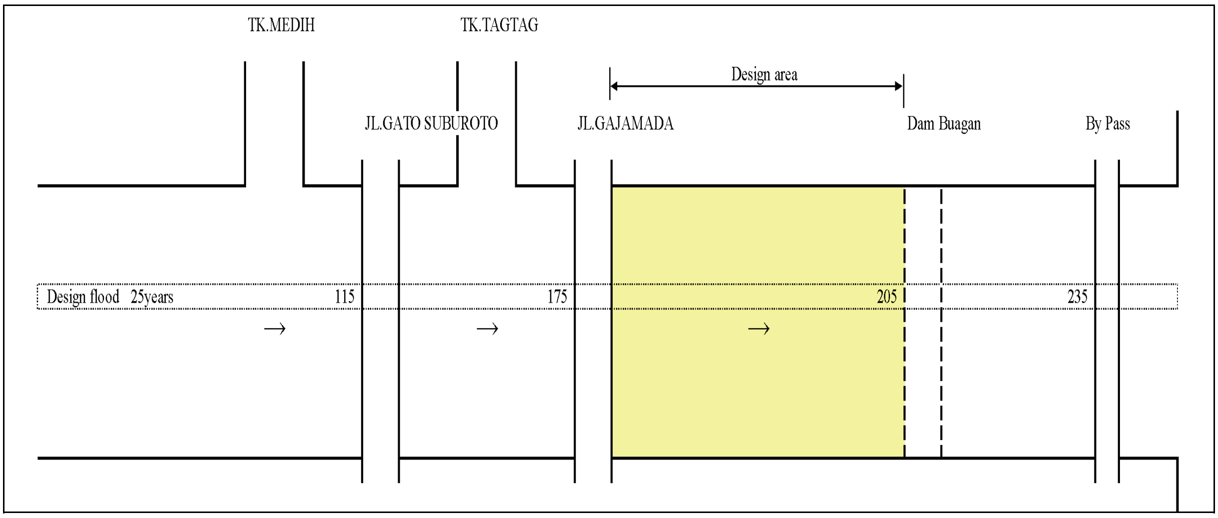

Figure-III-4.6 River Improvement Section for Badung River

(4) Basic Facility Plan for River Improvement

As regarding current condition of Badung River, masonry revetments whose slope is 1:0.5 – 1:1.0 are installed on both river bank. River width ranging from 20m to 25m on average, however partially narrow river course with its width 20m is left at a bridge near B.K Tunggal Street, which would to be constrained pass for the river flow. Due to density of housing, small factories and stores located along the river, it is difficult to widen the river width.

As mentioned above, Badung River runs thorough the massed housing area as well as business area, there are no space for the widening of river. Therefore, typical cross section with the riverbed excavation and parapet wall should be adopted. Longitudinal profile should be designed to be steeper slope due to riverbed excavation. Repair work for Buagan Weir mainly operating to irrigate paddy field located in the downstream is also adopted based on the flow capacity calculation.

Land use regulations or flood control reservoir such as retarding basin are not to be planned on this river improvement plan.

1) Section for River Improvement

Section for river improvement should be designated from just upstream of Buagan weir (Distance mark No.88-50) to NO.194 distance mark near Maruti Street with about 5,700 m as shown in Figure-III-4.7

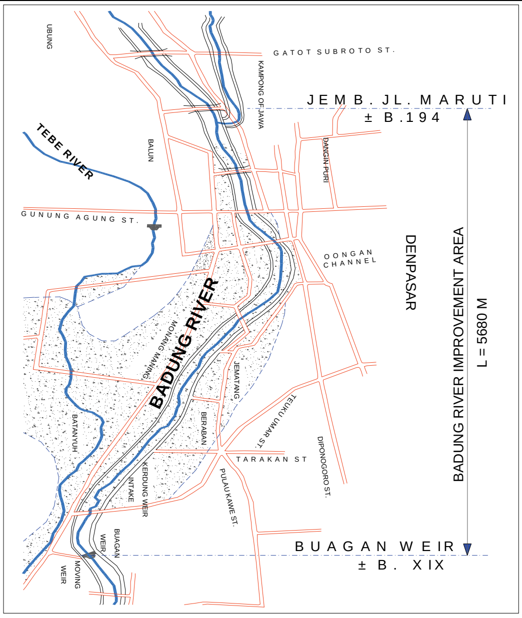

Figure-III-4.7 Plan for Section of River Improvement for Badung River

2) Adopted Method for River Improvement

An adopted method for river improvement in Badung River is shown as follows;

- ◆ Riverbed excavation
- ◆ Parapet Wall on the Dike
- ◆ Repair of Existing Buagan Weir
- ◆ Plan for Longitudinal Profile

3) Plan for Longitudinal Profile

Longitudinal profile plan was set to by taking into consideration with current profile prepared by topographic survey results by JICA Study Team. Longitudinal profile of current river is shown in Figure-III-4.8. Rounded river gradient of the section from Buagan weir to upstream with distance of 2,260m is to be I=1/450, and to be more than I=1/830 for upstream section of 1,770 m.

To increase river flow capacity, river excavation should be adopted. The planned gradient of section from Buagan Weir located in downstream to distance mark No.194 located in Maruti Street with distance of 5,700m was designed to be I=1/650. The gradient of upstream section from this mark gradually approached to actual riverbed.

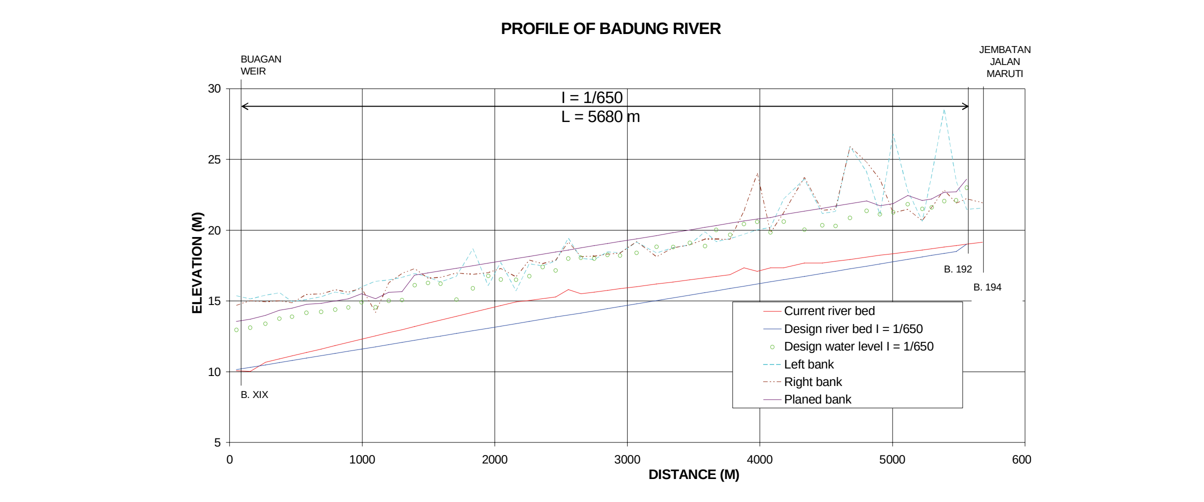

Figure-III-4.8 Designed Longitudinal Profile for Badung River

4) Typical Cross Section

Revetments had already lain down on both river banks and 18.5m to 37m river width have secured in the extent of river improvement. Therefore, excavation of riverbed and installment of parapet wall should be provided on current river condition. Riverbed excavation should be implemented in low water channel. Specifications for river improvement works are shown in Table-III-4.4 and typical cross section is shown in Figure-III-4.9.

Table-III-4.4 Specifications for River Improvement of Badung River

Items	Specifications	Remarks
1)River Improvement Section and its Length	Buagan Weir (Downstream) to Mariti Street(Upstream) L=5,680 m	
2)Design Flood	205 m3/sec	220 m^3/sec in future
3)Designed River Gradient	I=1/650	Upstream section: gradually approach to actual riverbed
4)River Width & Cross Section Shape	B= 18.5-37.5m, b=11-32 m (Trapezoid Shape with slope 1:0.5)	
5) Adopted Works	◆ Riverbed Excavation ◆ Parapet Placement ◆ Revetment	
1) Improvement Facility Works	Buagan Weir	

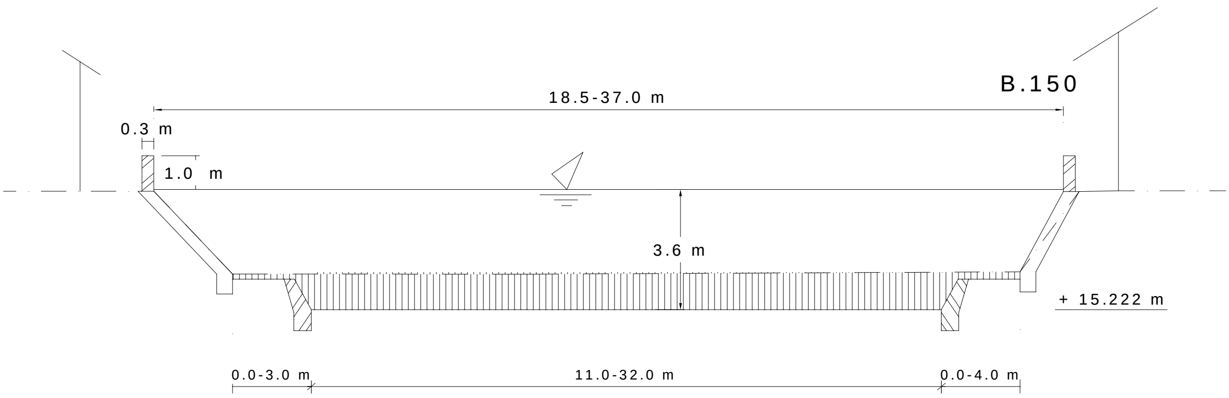

Figure-III-4.9 Typical Cross Section for Badung River

General plan of flood prevention project for Badung River is shown in Figure-III-4.10.