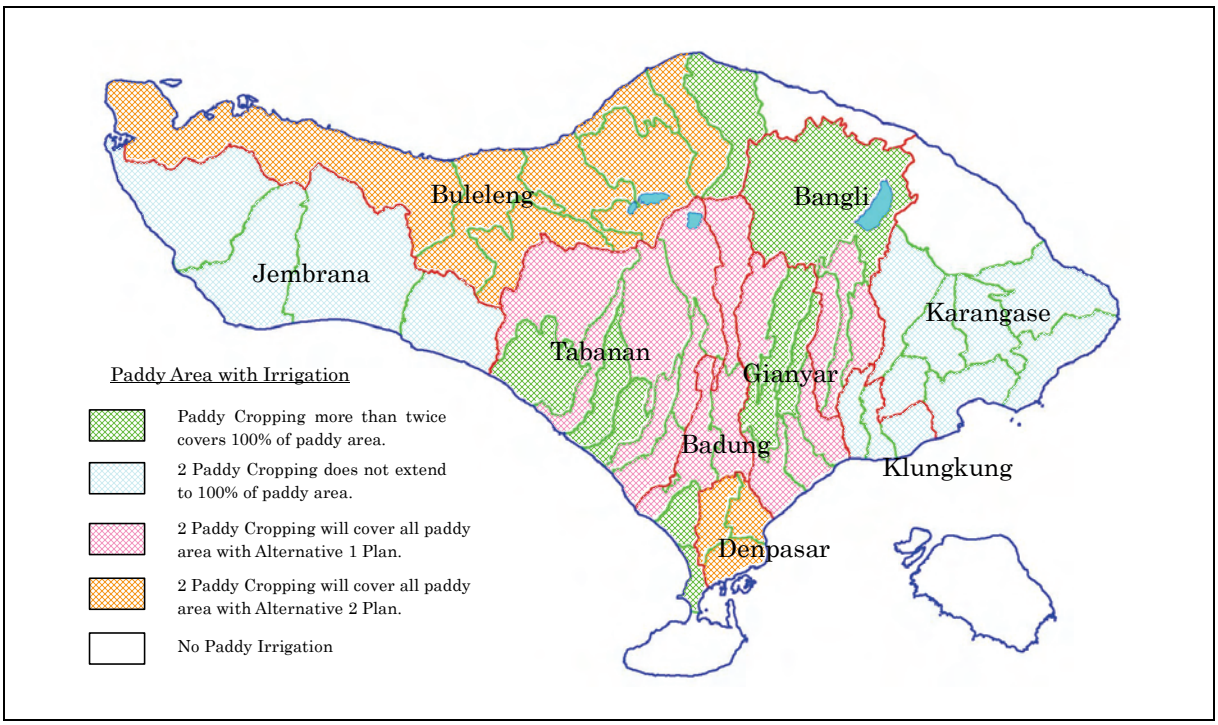


Figure-II-4.19 Potential Area for Improvement of Crop Intensities

4.3 Dam Development Facility Plan

There are two multipurpose dam Projects that is Ayung Dam planned in Ayun River and Benel Dam planned in Aya Barat River in Bali Province. The Ayung dam (Buangga dam) Project was studied as one scheme in the hydroelectric power development projects by JICA. Detail design on Ayung dam with purpose of irrigation, water supply and power generation was carried out in 2002 by Indonesian Government. Benel dam project was planned for the purpose of irrigation and water supply and already took place in registration to National Development Plan (Blue Book). Review of detail design on Benel dam was carried out in 2004 by Indonesian Government.

4.3.1 Ayung Dam Development Plan

(1) General

Due to population growth, industrial developments and advanced urbanization in Southern Bali area (Badung Regency and Gianyar Regency), the water demand which target year of 2025 is projected to 6,050 l/sec in total, or 2.6 times of current demand. To fulfill the water demand of target year 2025, the development of water resources such as river water, springs and deep wells shall be required.

Judging from the remained water potential in future in Denpasar and its surrounding area, river water was recommended for the development method of water resources with comparing water sources such as springs and wells which were supposed to almost exhausted for production.

With aim at water supply for drinking water and irrigation water as well as river maintenance water, Ayung River was selected for the development river of water resources in feasible from the result of flow regime analysis. Ayung Dam project shall be situated for water resource as central water supply system. By using the differential head of water stored by reservoir of Ayung dam, electric power shall be generated.

Ayung River originated in Mt. Mangu (El. 2,020m), flows to the south direction and flows into Indian Sea going through the east of Denpasar City with it catchments area of 302 km^2(based on GIS data) and river length about 62 km(based on GIS data).

The construction purpose of Ayung dam is shown as follows:

- ◆ Development for Municipal Water 1,800 l/sec (155,500m^3/day）

- Water supply for the Irrigation Water and Unspecified River Maintenance Water
- Electric Power Generation (7,900 kW)

(2) Flow Characteristic and Water Use in Ayung River

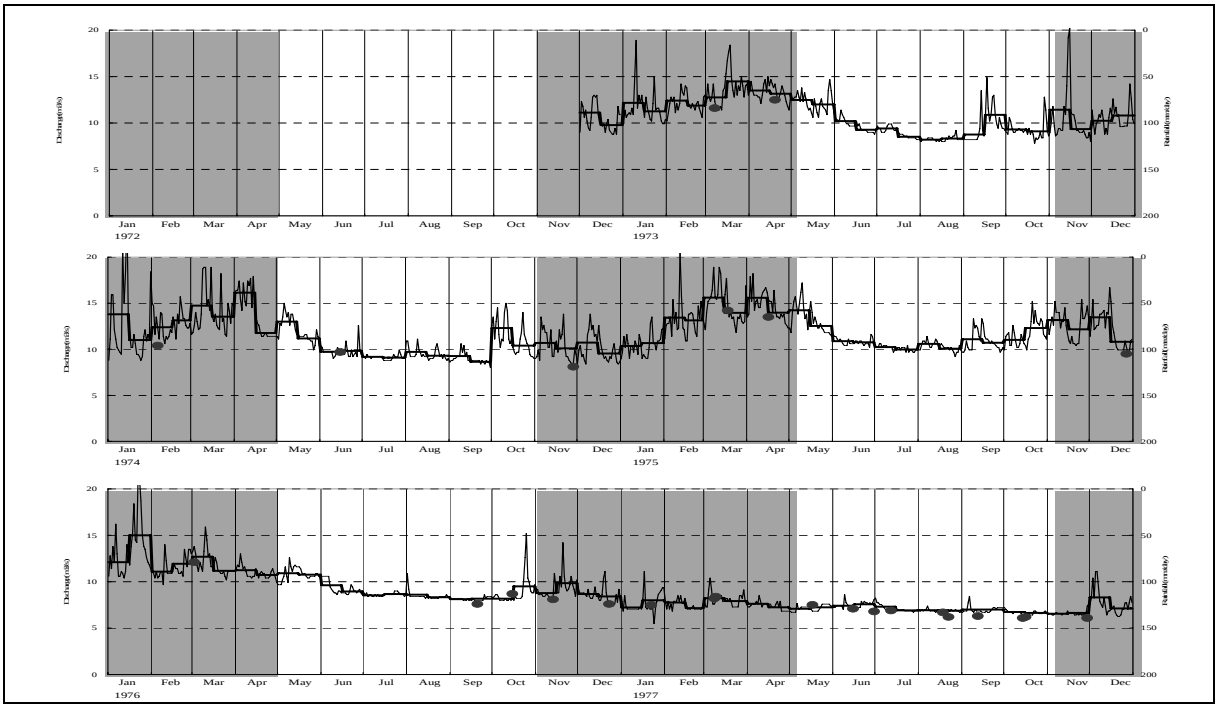
There are two water level observation stations which are Sidang station and Buannga station observing for 14 yeas started from 1973 as shown in Table-II-4.21.

Table-II-4.21 Observation for Water Level Observation Stations in Ayung River

Name of Station	Catchment's Area (km^2)	Data	1970's	1980's	1990's	2000's
Sidang	217.00	WL	1973-1979	1980-1986	N.A	N.A
		Q	1973-1979	1980-1986	N.A	N.A
Buangga(Old)	178.80	WL	1973-1979	1980-1986	N.A	N.A
		Q	1973-1979	1980-1986	N.A	N.A
Buangga(New)	178.80	WL	N.A	N.A	N.A	2000-2001
		Q	N.A	N.A	N.A	N.A

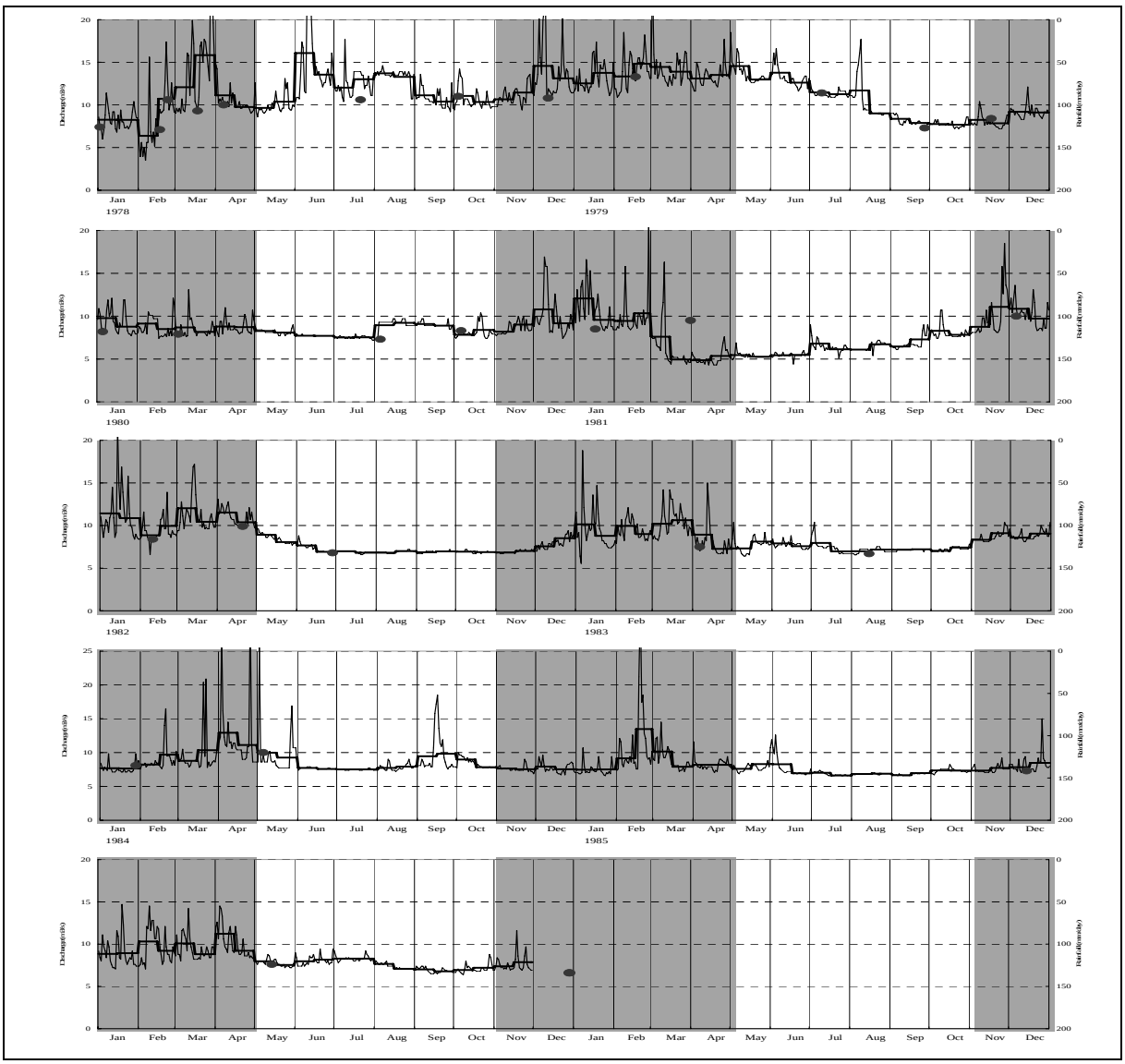
Note) WL: Water Level, Q: Discharge

Based on the data arrangement of daily discharge at Buanngga stations which located near the proposed Ayung dam site, daily discharge and 15 days average discharge are shown in Figure-II-4.20. Regarding with tendency of discharge every rainy season and dry season for 14 years, discharge shows regular fluctuation, namely, with showing increase in rainy season and decrease in dry season. Minimum discharge during dry season shows from 5.0 to 7.0 m^3/sec.



Note) Red mark shows observed discharge.

Figure-II-4.20 Daily Discharge and 15 days Discharge at Buangga Station (1/2)



Note) Red mark shows observed discharge.

Figure-II-4.20 Daily Discharge and 15 days Discharge at Buangga Station (2/2)

Flow regime at Buangga station is shown in Table-II-4.22, based on the analysis of discharge duration curve from 1973 to 1986 as shown in Figure-II-4.21.

Table-II-4.22 Flow Regime at Buangga Station in Ayung River (m^3/s)

Max.	75-day (High)	185-day (Normal)	275-day (Low)	355-day (Droughty)	Min.	Remarks
22.55	10.47	8.98	8.01	7.18	6.58	Data 1973-1985

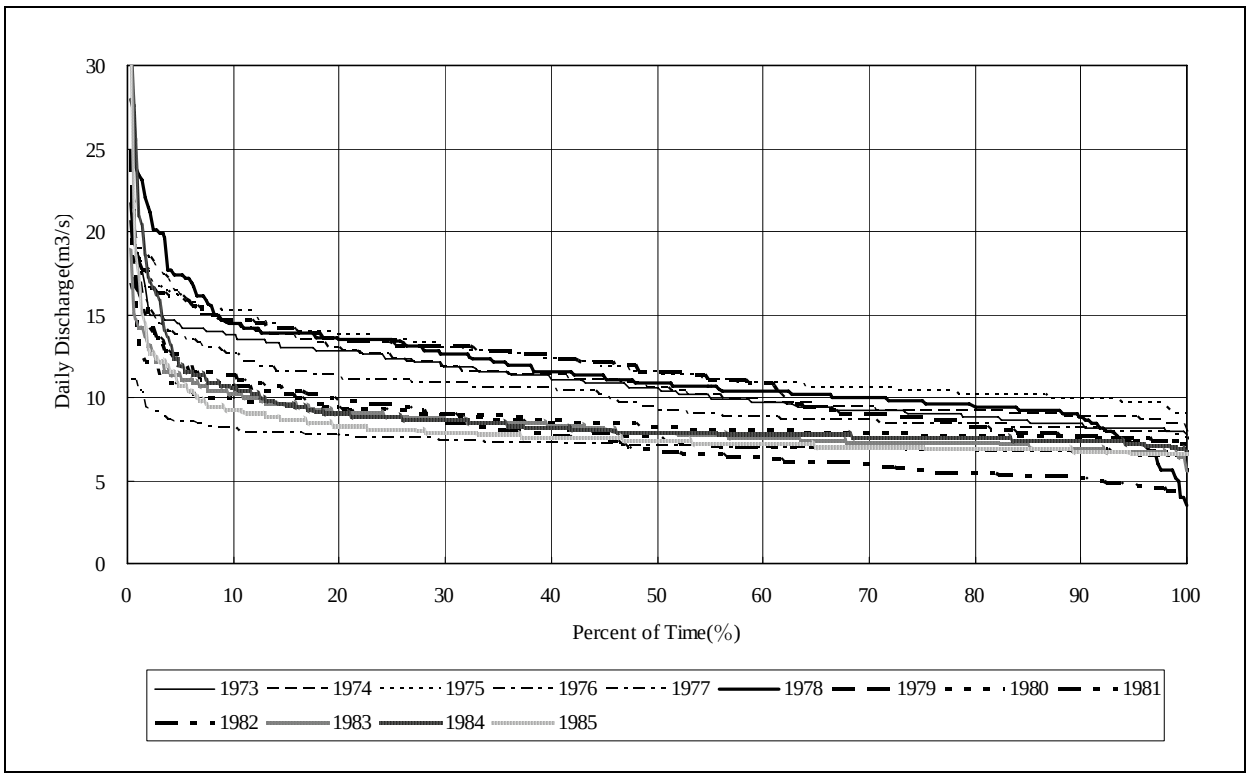


Figure-II-4.21 Discharge Duration Curve at Buangga Station (1973-1985)

Current state of water use for irrigation water and municipal water is shown in Table-II-4.23. There are 6 weirs for irrigation with total irrigated area 8,800 ha and 2 weirs for municipal with total 1,350 l/sec along Ayung River.

Table-II-4.23 Existing Weirs for Water Use along Ayung River

Name of Facilities	Purpose	Remarks
1)GERANA	Irrigation	Area:997ha (for Badung Regency)
2)SENGENPEL	Irrigation	Area:47ha (for Badung Regency)
3)KEDEWATAN	Irrigation	Area: 3,334 ha (for Badung Regency,Denpasar City,Ginyar Regency)
4)MAMBAL	Irrigation	Ares:3,628ha(for Badung Regency, Denpasar City)
5)PERAUPAN	Irrigation	Area:25ha(for Denpasar City)
6)IPA AYUNG	Municipal	Intake Rate:1,050 1/s (for Badung Regency, Denpasar City)
7)OONGAN	Irrigation	Area:781ha(for Denpasar City
8)WARRIBANG	Municipal	Intake Rate:150 1/s (Plan 300 l/s)
Total	Irrigated Area:8,812 ha (Excluding GERANA 7,815 ha) Intake Rate: 1,350 1/s (Excluding Plan WARIBANG: 1,200 l/s)	

The location of weirs as mentioned above Table is shown in Figure-II-4.22.

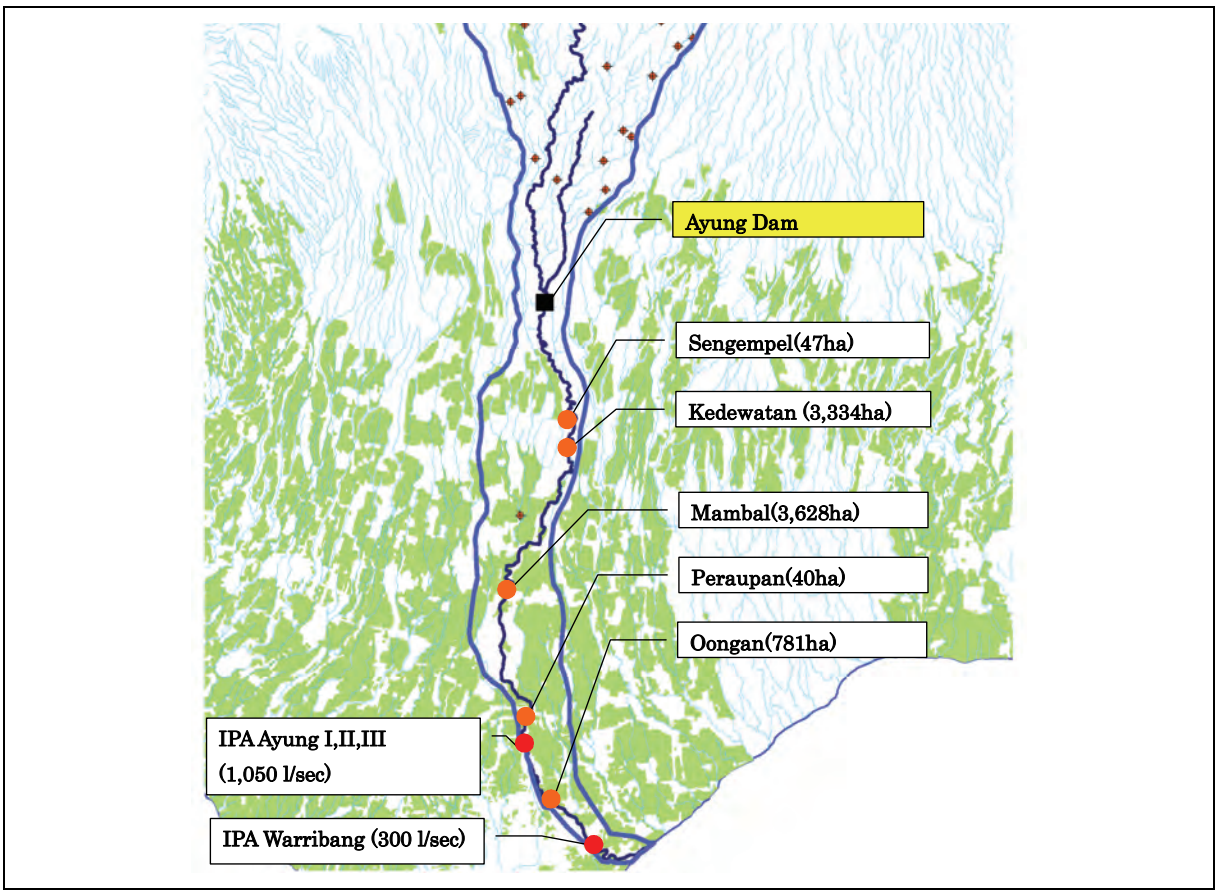


Figure-II-4.22 Existing Weirs along Ayung River

(3) Methodology for Water Resources Development in Ayung River

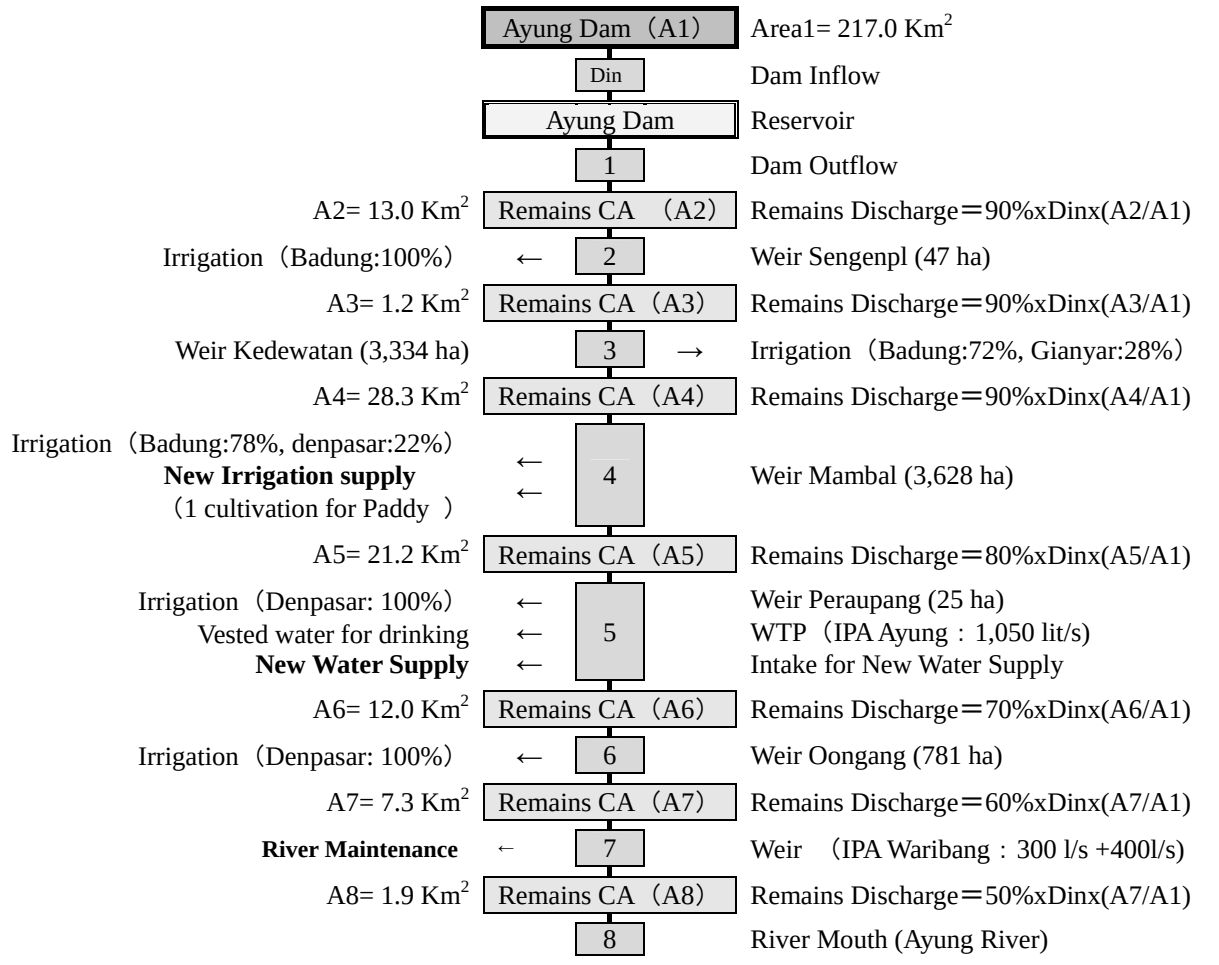
Basic Policy for the development of water resources depending on Ayung dam reservoir is summarized as follows:

- For the municipal water supply, to cope with increasing of demand targeted 2025 in Denpasar urban area, water of 1,800 l/sec shall be developed. Water supply plan was aimed at probability with 1 year for ten yeas during dry season.
- For the irrigation water supply, to keep up current cropping pattern in irrigated area, unspecified water shall be developed. Water supply plan was aimed at probability 1 year for 5 yeas. Cultivation area of paddy from single cropping to double cropping shall be expanded even during the drought season for the purpose of income increase.
- For the electric generation, by using the differential head of water stored in Ayung reservoir, electric power of 7,900 kW shall be generated for the purpose of contribution for electric demand in Bali.
- For the environmental maintenance water of river, by outflow discharge stored by Ayung dam, existing habitat for fauna and flora as well as natural landscape shall be conserved or improved. In the river flowing to Denpasar City, water quality shall be improved due to the water conveyance of purification water developed by dam reservoir.

(4) Calculation for Water Use Capacity

(a) Water Use Calculation Model

Water use calculation on capacity for municipal water and unspecified water such as river maintenance water and purification shall be proceeded in accordance with calculation flow as shown below:



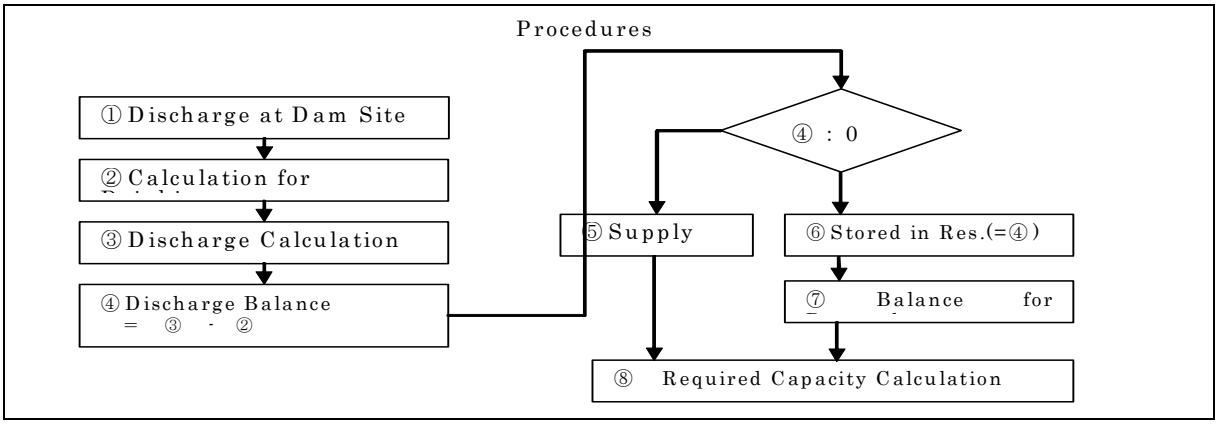


Figure-II-4.23 Calculation Flow for Municipal Water and Unspecified Water

(b) Conditions for Calculation

Conditions for calculation of capacity are shown in Table-II-4.24.

Table-II-4.24 Conditions for Calculation

Items	Contents	Remarks
Duration	1972～1986	15 years
Discharge Unit	5 days discharge	
Intake Rate for Irrigation	Unit Intake Rate per Ha × Area Rainy season: 300-4,700l/s in total Dry season : 4,200-12,000l/s in total	Depend on cropping pattern
Intake Rate for Current Drinking Water	1,350 lit/sec	Water Treatment Plant IPA AYUNG ;1,050 lit/s IPA WARIBANG; 300 lit/s
New Intake Rate for Municipal Water	1,800 lit/sec	At Praupan
New Intake Rate for River Maintenance	Max. 400 lit/sec	At Wariban

(c) Requirement Capacity Based on the Calculation Results

Calculation result for the requirement of each capacity is as shown in Table-II-4.25.

Table-II-4.25 Requirement Capacity Based on the Calculation Results

Ranking	Required Capacity (x 1,000m^3)	Year Occurred
1	15,000	1977
2(adopted)	**9,000**	**1983**
3	8,400	1985
4	5,300	1980
5	2,200	1982

On the basis of the calculation results of requirement capacity, the second capacity with 9,000,000m^3 for 15 years shall be adopted in consideration of safety for water supply, reservoir scale and frequency of drought occurrence, etc.

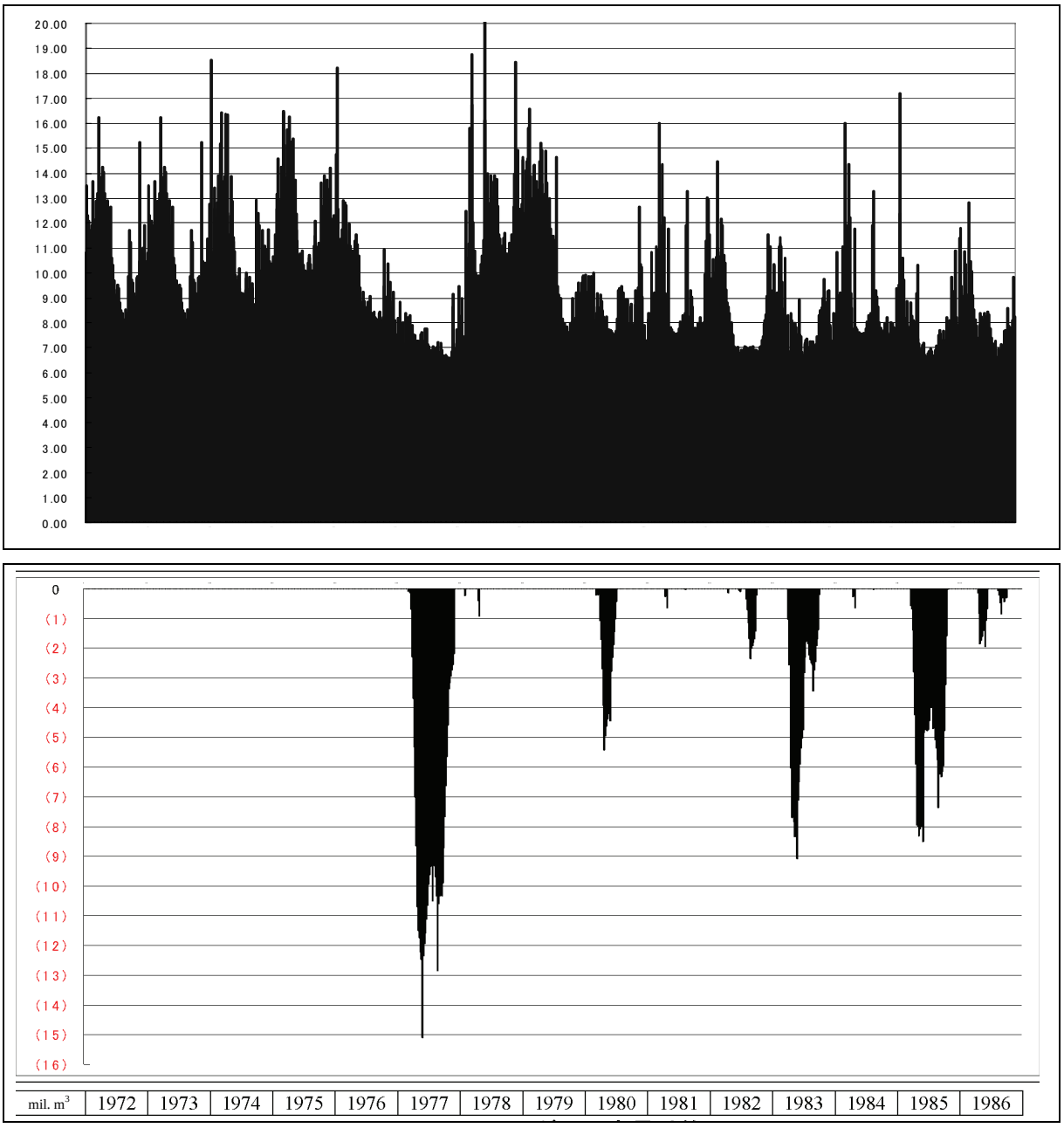


Figure-II-4.24 Calculation Result of Requirement Capacity for Ayung Dam

(5) Ayung Dam Reservoir Operation

A reservoir operation simulation which shows reservoir water level at Ayung reservoir, river in-flow and out-flows at weir along Ayung River in benchmark year of 1983 is shown in Figure-II-4.25 and Figure-II-4.26. According to the Figures, due to supply by outflow of Ayung dam, river discharge after reservoir operation exceed to water requirement for irrigation and municipal water at each weir.

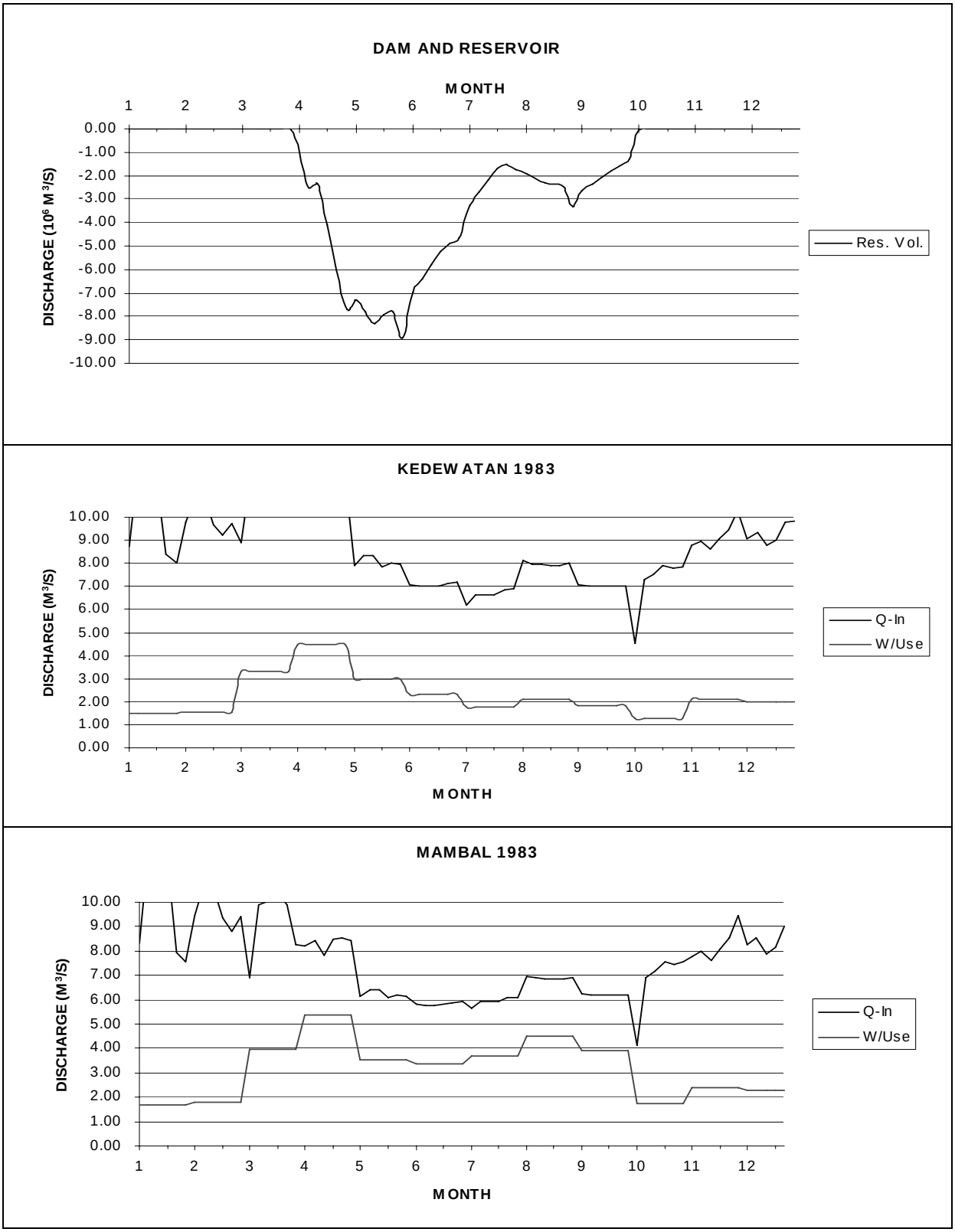


Figure-II-4.25 Simulation Results at Ayung Dam, Kedewatan Weir, Mambal Weir

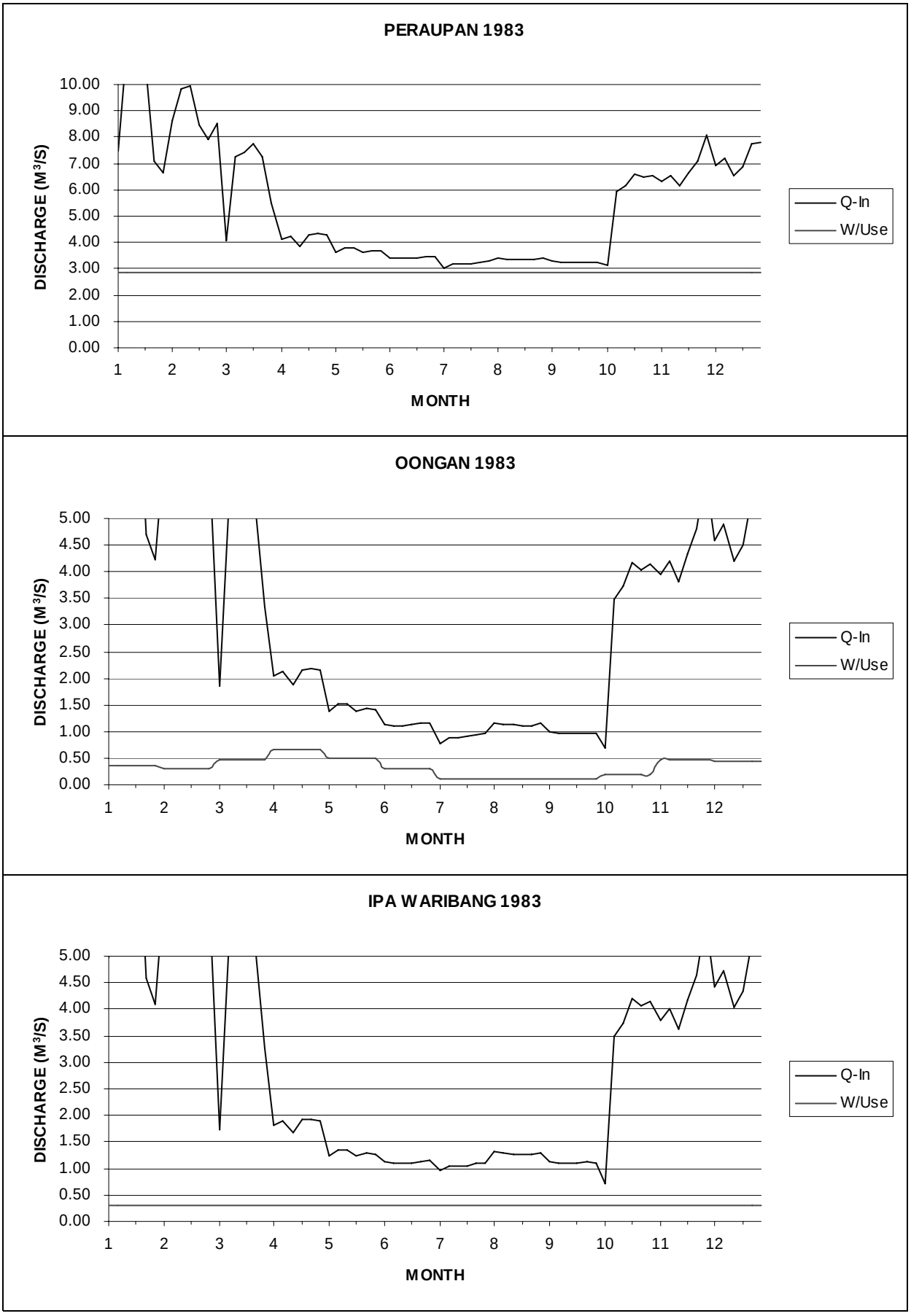


Figure-II-4.26 Reservoir Operation Simulation Results at Puraupan Weir, Oongan Weir, Waribang Weir

(6) Requirement Capacity for Water Use of Ayung Dam

Above mentioned consideration results, requirement capacity for water use of Ayung dam shall be set up to 9,000,000 m^3.

(7) Sediment

(a) Design Sediment Capacity in Bali

Based on the existing report concerning with design sediment volume of dams in Bali, Specific sediment volume per year is arranged as shown in Table-II-4.26. There are two kinds of data for Ayung dam, that is, study result of JICA Study Team in 1989 and study result of Indonesian government in 2002.

Table-II-4.26 Specific Sediment Volume for Each Dam in Bali

Name of Dams	Catchment Area (Km^2)	Design Sediment Capacity (10 x 3)	Specific Sediment Volume (m^3/km^2)	Working Life (years)	Specific Sediment Volume per year (m3/km2/year)	Remarks
Ayung(1)	217.0	8,800	40,550	50	811	Planned ,JICA 1989
Ayung(2)	218.4	5,924	27,120	65	417	Planned Indonesia (2002)
Titab	69.5	1,090	15,680	100	157	Planned
Telaga Tunjung	81.5	522	60	50	128	Under construction (as of 2005)
Bunel	18.3	305	16,670	30	556	Planned
Palasari	42.3	1,500	35,460	50	710	In operation
Grokgak	20.0	1,250	62,500	50	1,250	In operation
Average	-	-	-	-	575	In operation

Sources: 1. Feasibility Study on Ayung Hydroelectric Power Development Project (1989)
2. Detail Desain Waduk ayung Di kabupaten Badung(2002)
3. Kajian dan Perubahan Desain Bendungan Telaga Tunjung(2004)

According to Table-II-4.26, design specific sediment volume per year discharge varies from 128 to 1,250. For Palasari dam and Grokgak dam, there was no data for the actual sediment accumulation since in operation.

(8) Design Sediment Capacity for Ayung Dam

With reference to design sediment capacity for Ayung dam, based on the detail design of Ayung dam in 2002 as shown in Table-II-4.27, specific sediment volume per year was set up as 417m^3/km^2/year. As compared Ayung dam with another dam in Bali, this value is classified as average.

Design sediment capacity for 50 working life is calculated as shown in below:

$$417\ m^3/km^2/year \times 218.4\ km^2 \times 50\ years = 4{,}553{,}640\ m^3 = 4{,}600{,}000\ m^3$$

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.

Table-II-4.27 Design Sediment Capacity for Ayung Dam and Check Dams

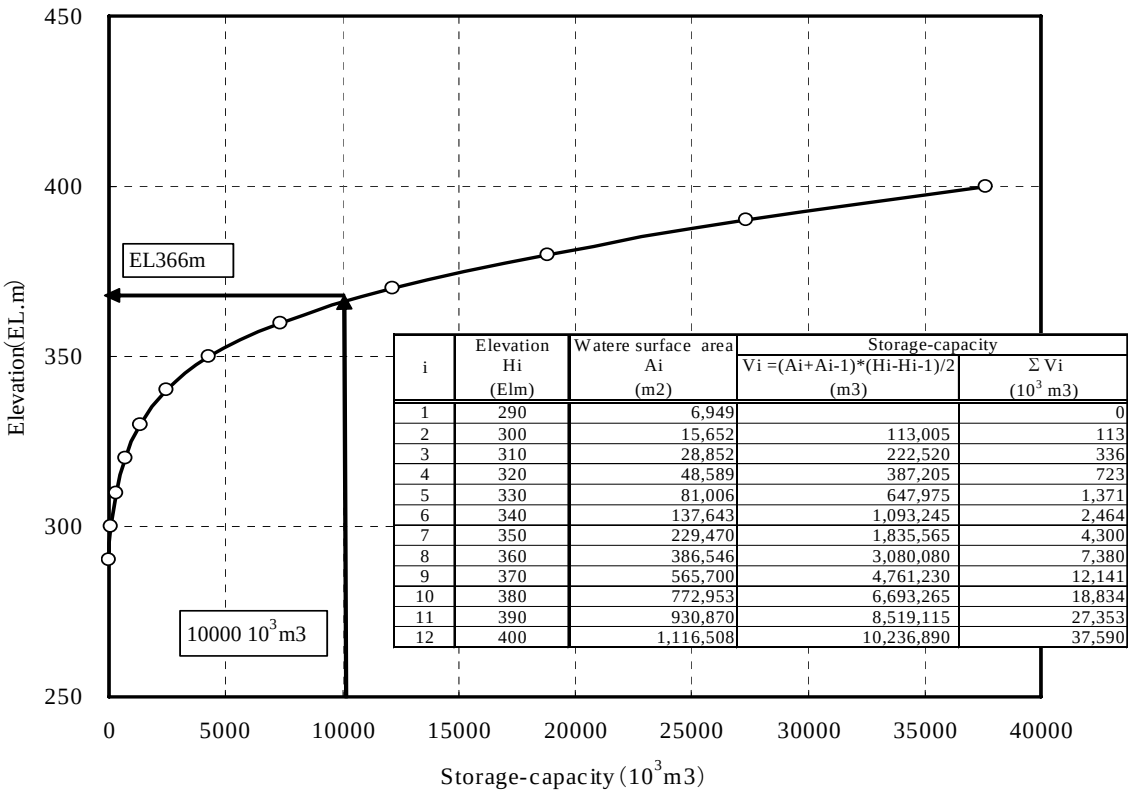
Method of Secure	Sediment Capacity for Facility	Planned Location of Facility
Reservoir	**1,000,000**	Ayung Dam Reservoir
2 Check Dams	3,600,000	Near upstream edge of reservoir located in Ayung River and Siap River

(9) Storage Capacity Distribution

Due to above mentioned study results storage capacity distribution is shown in Table-II-4.28. Normal water level and low water level were fixed from accumulated capacity of each purpose by using reservoir capacity curve as shown in Figure-II-4.27, are also shown in Table-II-4.28.

Table-II-4.28 Design Capacity Distribution for Ayung Dam

Purpose	Capacity(m^3)	Water level	Remaarks
Effective Capacity 1) Municipal 2) Irrigation 3)River Maintenance	9,000,000	**Normal Water Level** EL 366.0 m (Capacity of 10,000,000 m^3)	Drinking:1,800 l/s Irrigation: : 7,720ha Cultivated Area Expansion:1,000 ha
Sediment Capacity	1,000,000	**Low Water Level** EL 325.0 m	For 10 years
Total	10,000,000	-	



i	Elevation Hi (Elm)	Watere surface area Ai (m2)	Storage-capacity Vi =(Ai+Ai-1)*(Hi-Hi-1)/2 (m3)	Storage-capacity Σ Vi (10^3 m3)
1	290	6,949		0
2	300	15,652	113,005	113
3	310	28,852	222,520	336
4	320	48,589	387,205	723
5	330	81,006	647,975	1,371
6	340	137,643	1,093,245	2,464
7	350	229,470	1,835,565	4,300
8	360	386,546	3,080,080	7,380
9	370	565,700	4,761,230	12,141
10	380	772,953	6,693,265	18,834
11	390	930,870	8,519,115	27,353
12	400	1,116,508	10,236,890	37,590

Normal Water Level: EL 366.0 m (Accumulated Capacity 10,000,000 m^3)
Low Water Level : EL 325.0 m (Accumulated Capacity 1,000,000m^3)

Figure-II-4.27 Reservoir Capacity Curve for Ayung Dam

(10) Existing Geological Survey

The Ayung dam (Buangga dam) was studied feasibility as one scheme in the hydroelectric power development projects by Jica in 1989, when core-drilling, seismic refraction prospecting and laboratory tests were carried out. In the study, two alternative dam sites, the upstream site for a concrete gravity dam of 40 m in height and the downstream site for a rock fill dam of 100 m in height were compared. Additional geological investigation including core-drilling, electric resistance prospecting and laboratory tests were executed at the downstream site by PKSA in 2003, and a concrete gravity dam of 100 m in height was designed. Quantities of the existing survey carried out in Buangga dam (Ayung dam) are listed in Table-II-4.29.

Table-II-4.29 Existing Geological Survey

Survey Item	Quantities	Executing Body	Remarks
Feasibility study on Ayung Hydroelectric Power Development Project (1989)			
Mapping	20 ha, 1:1000 in scale	PLN	upstream & downstream site
Core drilling	4 holes, total 362 m	PLN	upstream & downstream site
Seismic refraction prospecting	6 lines, total 2310 m	JICA	upstream & downstream site
Laboratory test			upstream & downstream site
Detail Design Ayung Multipurpose Dam, Payangan & Buangga - Bali (2003)			
Core drilling	5 holes, total 480 m	PKSA	downstream site
Electric resistance prospecting	20 points	PKSA	downstream site
Test pit	4 pits	PKSA	downstream site
Trench cut	4 points	PKSA	downstream site
Laboratory test		PKSA	downstream site

(11) Selection of Dam Site

(a) Alternatives for Planned Dam Site

Three alternative dam sites of more than 10 M m^3 in storage capacity were proposed on the Ayung River from the confluence of the Ayung River and Pungsa River to its approximately 3 km downstream in the preliminary study based on 1:25,000 scale topographic maps. The three sites, A, B and C in sequence from the upstream, were compared through the follow-up site investigations (See Figure-II-4.28).

(b) Selection of Dam Site for Ayung Dam

C site is excluded due to its unsuitable social environmental impact, since the right bank of the C site was extensively developed for new hotel buildings. Although no significant differences between A site and B site in topographic feature and economical efficiency, the plan of A site can minimize impacts of commercial rafting and has advantages of available topographic maps and geological data. A Chinese cemetery located on the left bank of A site is avoidable by the layout design of the proposed dam. Consequently A site has been selected as the optimum site. The summary of the comparison is presented in Figure-II-4.28.

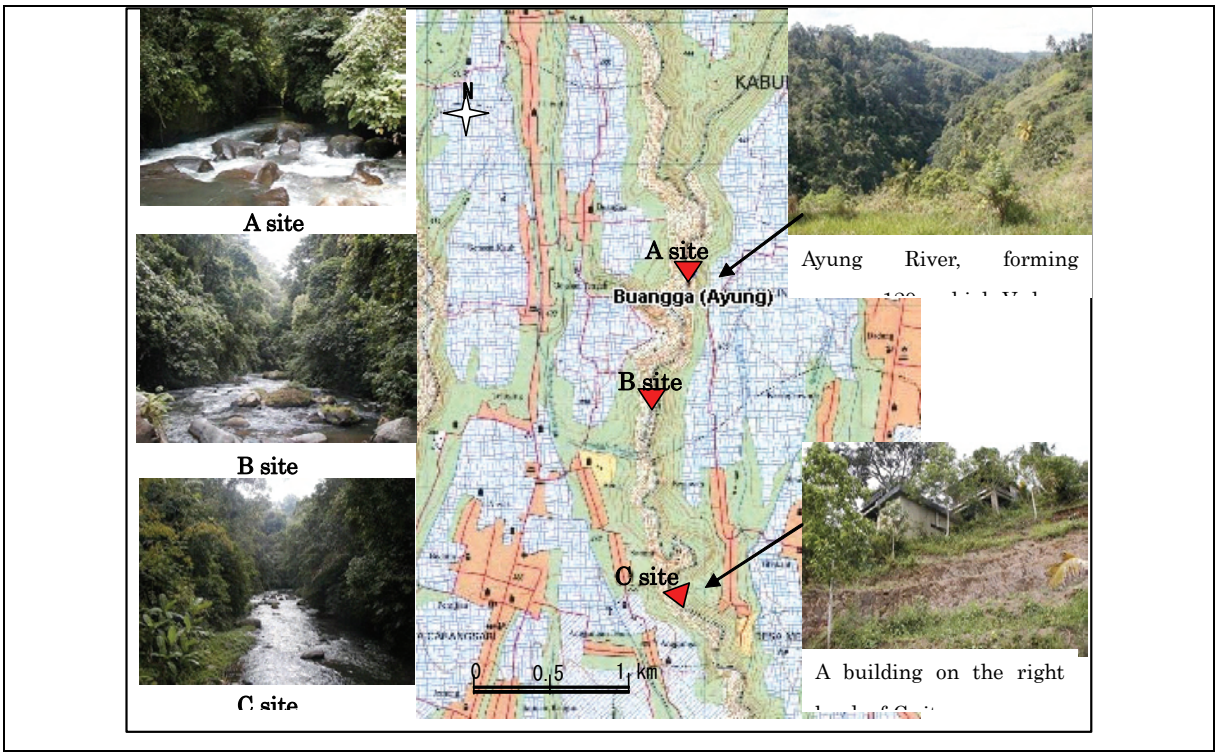
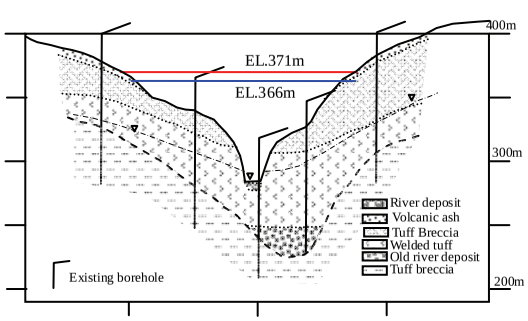
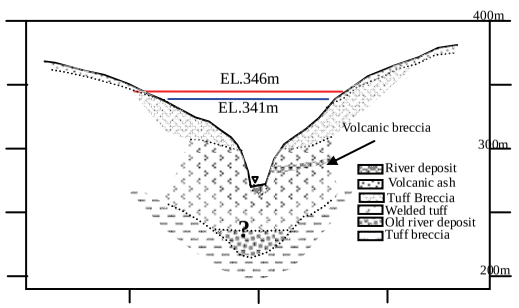
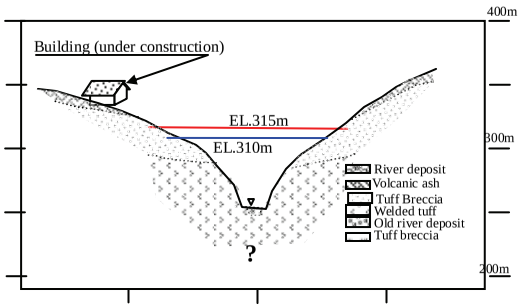


Figure-II-4.28 Location Map of Alternative Dam Sites

Table-II-4.30 Summary of Planned Alternative Dam Site Evaluation

Alternative Dam Site	A Site		B Site		C Site	
Schematic Profile of dam axis					
Dam Design	Storage Capacity 10,000,000 m^3 Effective Storage Capacity 9,000,000 m^3 Sediment Capacity 1,000,000 m^3 Normal Water Level 366.00 m Dam Top Level 371.00 m Foundation Level 305.00 m Dam Height 66 m (on the plug of 30 m high)		Storage Capacity 10,000,000 m^3 Effective Storage Capacity 9,000,000 m^3 Sediment Capacity 1,000,000 m^3 Normal Water Level 341.00 m Dam Top Level 346.00 m Foundation Level 279.00 m Dam Height 67 m (on the plug of 30 m high)		Storage Capacity 10,000,000 m^3 Effective Storage Capacity 9,000,000 m^3 Sediment Capacity 1,000,000 m^3 Normal Water Level 310.00 m Dam Top Level 315.00 m Foundation Level 263.00 m Dam Height 52 m (on the plug of 30 m high)	
Topology/Geology	EL. 390 m ~ <20°, EL. 340-390 m 30-40° EL. 280 m-340 m 50-60°, Riverbed 20 m wide Bedrock: Welded tuff: CH~CM class Tuff breccia: CL~CM class Riverbed: sand and gravel within 5 m thick A buried valley of old Ayung River is assumed.	F	EL. 390 m ~ <20°, EL. 300-390 m 30-40° EL. 270 m-300 m 50-60°, Riverbed 20 m wide Bedrock: Welded tuff: CH~CM class Tuff breccia: CL~CM class Riverbed: sand and gravel within 5 m thick A buried valley of old Ayung River is assumed.	F	EL. 350 m ~ <20°, EL. 300-350 m 30-40° (right bank: EL.320 m~ 20-30°), EL. 250 m-300 m 45-50°, Riverbed 20 m wide Bedrock: Welded tuff: CH~CM class Tuff breccia: CL~CM class Riverbed: sand and gravel within 5 m thick A buried valley of old Ayung River is assumed.	F
Social Aspects	No residence in proposed reservoir area Commercial rafting Chinese Cemetery on the left bank	F~P	No residence in proposed reservoir area A start point of commercial rafting and some facilities	F~P	Buildings of hotel on the left bank Commercial rafting	U
Available Survey Data	Topographic map (1:5,000), 5 drilling holes（480 m）, 1 seismic line (500 m) and laboratory tests etc.	F	None	P	None	P
Conclusion	F		F~P		U	

Note: Evaluation F: fair, P: poor or not recommended, U: unsuitable

(12) Topographic and Geological Outlines

(a) Topography

The Ayung River, forming a deep valley at the project area, runs southward. The Pungsa River flows into the Ayung River at approximately 400 m upstream of the proposed dam site. The riverbed with 20 m in width is at an elevation of approximately 280 m at the proposed dam site and rises up to the tableland gently dipping southward of approximately 420 m in elevation. The inclinations of the both banks of 280-340 m, 340-390 m and 390-420 m in elevation are 50-60 degrees, 30-40 degrees and 20 degrees respectively.

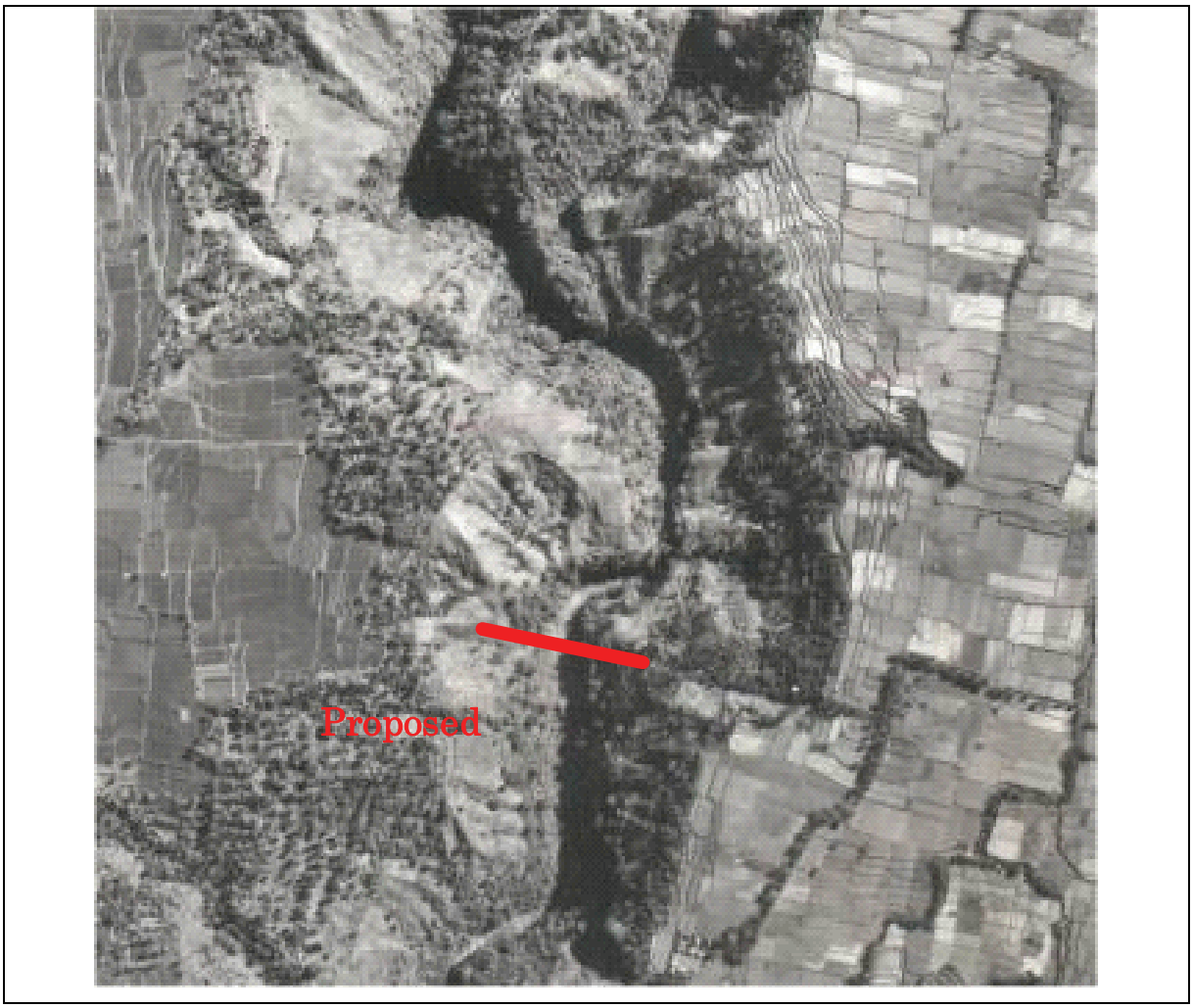


Figure-II-4.29 Proposed of Dam Site

(b) Geology

According to the previous study, the basement of the site is tuff breccia with gravel, volcanic breccia and volcanic sandstone. The welded tuff flowed and deposited along the present river course. The welded tuff is well cemented and forms 10-20 high cliffs along the river. On the both banks of the river the welded tuff is overlain by thick layers of pumiceous tuff and volcanic ash. Pumiceous tuff and volcanic ash are moderately soft and easily eroded and small gullies are formed on the relatively gentle slopes of 340-390 m in elevation at the proposed dam site. Talus deposits, less than 2 m in thickness, are composed of sandy clay including some pumiceous fragments. River deposits, less than 5 m in thickness, are composed mainly of sand including some pebbles.

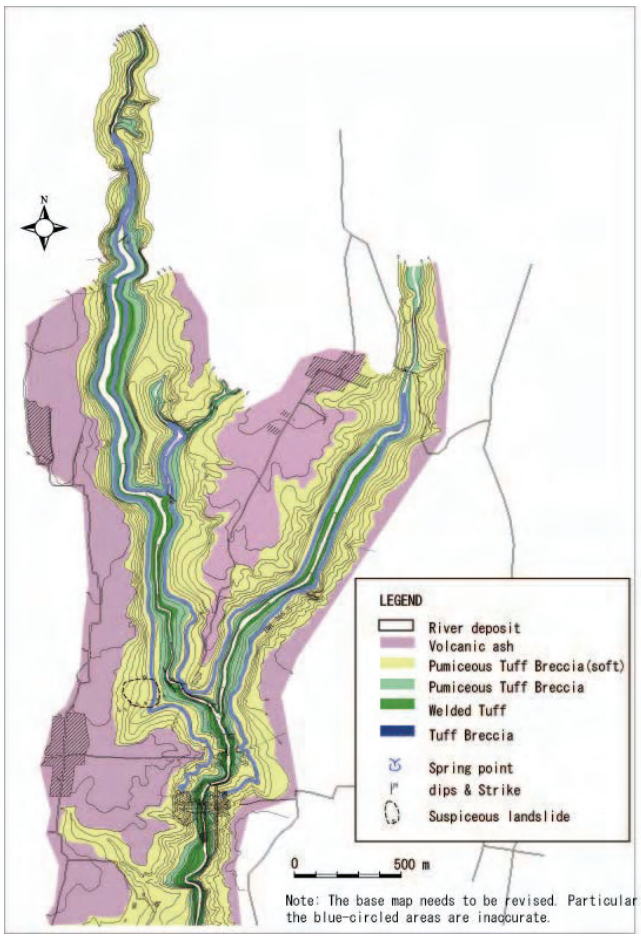
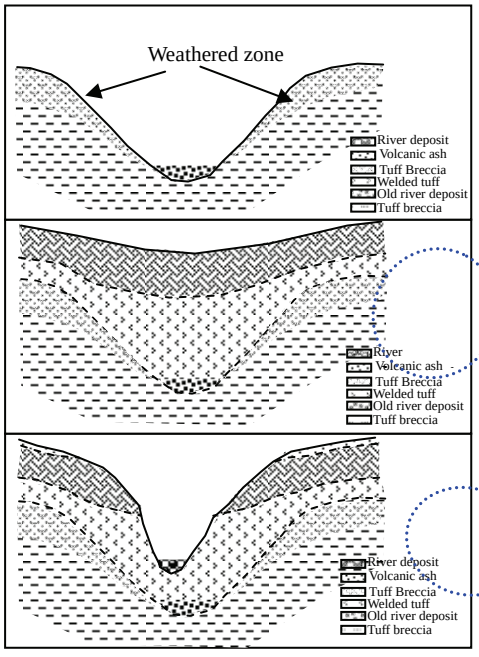


Figure-II- 4.30 Geological Map of Ayung Dam Reservoir Area (Source: JICA Study Team)

The following development process inferred from the review of the previous study.



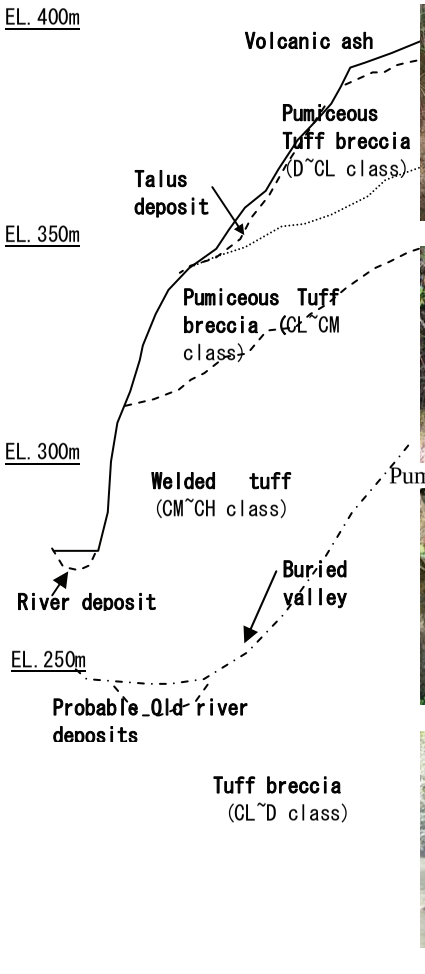
1. Pleistocene (~approx. 20,000 years ago)
Old river valley was underlain by tuff breccia (including lahar deposit and tuff facies). Surface of the tuff breccia was weathered and softened.

2. Approx. 20,000 years ago
Welded tuff and pumiceous tuff breccia covered the old valley.

3. Recent event
Volcanic ash covered the surface, and the plateau composed of welded tuff and pumiceous tuff breccia was deeply dissected by the recent river valley.

The stratigraphy of the Ayung dam site is shown in Table-II-4.31

Table-II-4.31 Stratigraphy of Proposed Ayung Dam Site

Schematic Profile	Geology	Characteristics*							Thick-Ness (m)
		hardness	Vp (km/s)	N value	Γt (t/m^3)	σ_c(t/m^2)	Es (t/m^2)	k (cm/s)	
	**River deposit:** Grey, sand and gravel	Loose							<5
	Talus deposit: Light brown soft gravels, sand and clay.	Loose							<2
	Volcanic ash: Brown loam, and light-brown pumice	Very Soft, relatively compact and stable	0.3~ 0.5	5~10	1.4	3	3		1~2
	Pumiceous tuff breccia: grey to light grey, including pumices, andesite, volcanic detritus and volcanic bomb, and sandy tuff matrix	Soft — moderately hard	0.7~ 0.8,	50<	1.5~	2	2,		30+/-
	Welded tuff: Grey to purplish grey, including welded pumice fragments (0.5 cm thick, 2-3 cm long), Vertically variable facies and hardness. Low cemented welded tuff, High-cemented welded tuff, Lappli tuff of sandy tuff matrix, and andestic facies (at some places) occur in descendant order.	Hard — moderately hard	1.4~ 1.6 3.2~ 3.5		1.8 2.0	50~80 100~ 120	8 20		30+/-
	Old river deposit: Grey, clayey(?) sand with cobbles of andesite	(Loose?)							20
	Tuff breccia: Yellow brown to bluish-grey color, the breccias consists mainly of angular to subrounded fragments of 2 to 10 cm dia.	Moderately soft							40<


Volcanic ash (D)


Pumiceous tuff breccia (CL)


Welded tuff (CM)


Welded tuff (CH)

Source: JICA 1989 Feasibility study on Ayung Hydroelectric Power Development Project. The above engineering properties will be revised in the course of the study (Phase 3 study).

(c) Geological Engineering Specifications

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 a criteria developed by CRIEP (Tanaka, 1964) (See Figure-II-4.31). Expected shear strength of each rock class is 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

These engineering properties were estimated based on limited data of laboratory tests and naked observations of surface geological conditions. 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.

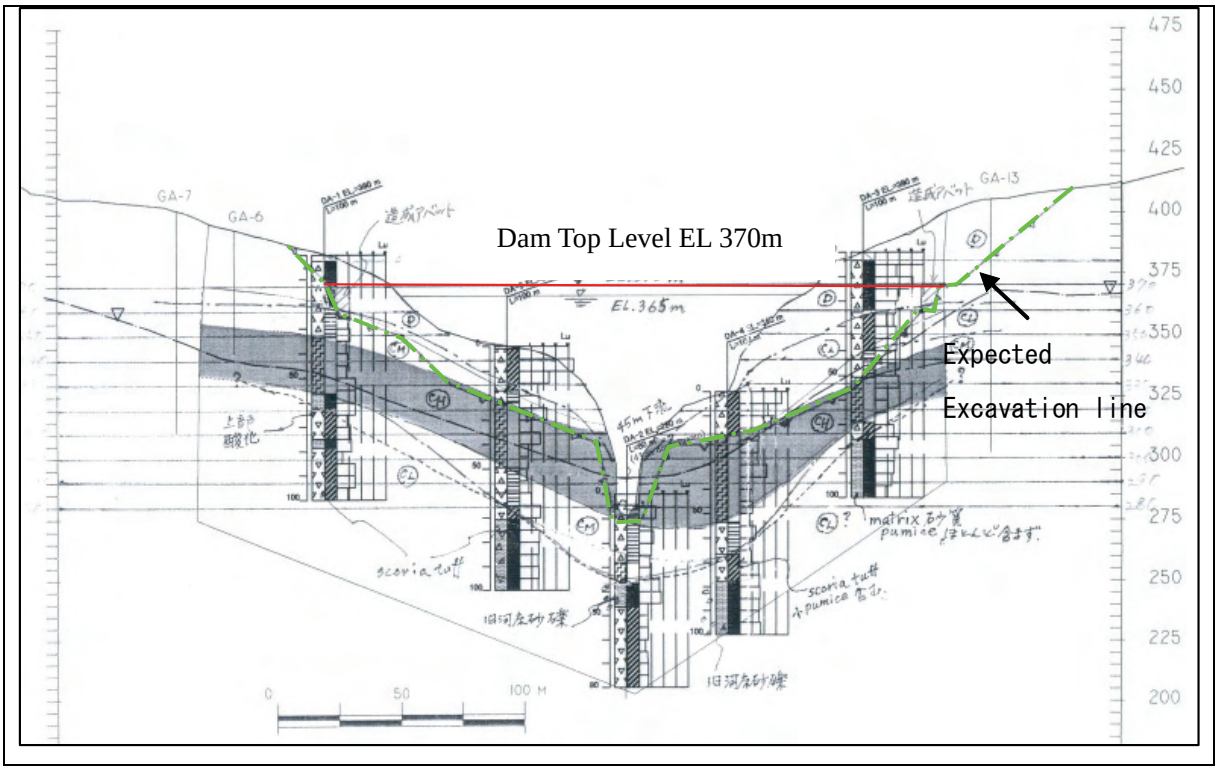


Figure-II-4.31 Geological Profile of Proposed Dam Axis

Permeability

According to previous study, permeability coefficient of the bedrocks shows the order of 10^{-5} to 10^{-4} cm/s. Permeability of the dam site and ground water condition will be studied in the Phase 3 study. 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. Leakage risk of the reservoir and potential of landslides will be studied in Feasibility Study phase.

(13) Construction Materials

In the previous study (JICA1989), two alternative quarry sites, Bt. Payang site and Baturiti site, were proposed within 20 km from the proposed dam site (See Figure-II-4.32). Two core drillings were carried out in each quarry site. Bt. Payang site and Baturiti site were environmentally unsuitable for exploitation of construction material resources based on field investigations in this phase, since either site was located in vicinity of residences and religious facilities.

River deposits of the Ayung River are insufficient in quantity for the material resources. Although usable sound rocks forming 20 m high cliffs occur along the riverbed, the exploitation for the quarry of reservoir area is economically handicapped, since 70-80 m thick soil covering the rocks has to be removed and considerable low-quality portions were contained in the sound rocks.

Procurement of the rock materials for the rock fill type dam of 100 m high is difficult in economical and environmental aspects. At the present moment, Karangasum site and Semarapuna site, which are located in approximately 60 km and 40 km from the dam site respectively, are economically considerable for material resources. A concrete gravity type dam is recommendable for the Ayung dam site in aspect of construction material procurement, since its required construction materials will be almost one to ten of required for rock fill type of same height and the transportation cost will be reduced.

(14) Comparison of Dam Type

Concrete gravity dam is applied by the following reasons.

- Dam height can be reduced to below than 70 m by applying artificial foundation method. CH class foundation, which is dominant in the dam site, is suitable for concrete dam less than 70 m heights.
- Concrete gravity dam is more efficient water storage than that of rock-fill dam, and easy to install spillway and decelerating works.
- For the above reason, dam height of rock-fill dam becomes higher than concrete gravity dam to keep same storage capacity. Therefore, concrete gravity dam is less required land.
- Concrete gravity dam is easy to acquire materials
- Concrete dam is superior to rock-fill dam in the financial aspect as shown in Table-II-4.32.

Comparison between concrete gravity dam and zoned rock-fill dam is shown in Table-II-4.32. Typical sections of concrete gravity dam, typical longitudinal section of zoned rock-fill dam and typical cross section of artificial foundation are shown in Figure-II-4.33 to Figure-II-4.35, respectively.

Table-II-4.32 Comparison between Concrete Gravity Dam and Zoned Rock-fill Dam

Dam Type	Concrete Gravity Dam		Zoned Rock-fill Dam	
Specifications	Dam height	66.0m	Dam height	67.0m
	Non overflow section elevation	EL.371.0m	Non overflow section elevation	EL.372.0m
	Crest elevation	EL.371.0m	Crest elevation	EL.372.0m
	Foundation elevation	EL.305.0m	Foundation elevation	EL.305.0m
	Crest length	235.0m	Crest length	235.0m
	Crest width	5.00m	Crest width	10.00m
	Dam volume	296,000m^3	Dam volume	1,500,000m^3
	Min. water level	EL.325.0m	Min. water level	EL.325.0m
	Full reservoir water level	EL.366.0m	Full reservoir water level	EL.366.0m
	Surcharge water level	EL.366.0m	Surcharge water level	EL.366.0m
	Design flood water level	EL.369.0m	Design flood water level	EL.369.0m
	Reservoir area	0.49km^2	Reservoir area	0.49km^2
Cost	JPY 10.6 billion (100%)		JPY 12.6 billion (119%)	
Overall Evaluation	(1) Construction of concrete dam is available according to the topographical and geological condition of the site. (2) Concrete dam is easy to layout facilities such as spillway and decelerating works. (3) Scale of dam can be reduced by concrete dam. (4) Concrete dam is easy to acquire materials (5) For above reasons, concrete dam is superior to rock-fill dam in economical and technical aspects.			
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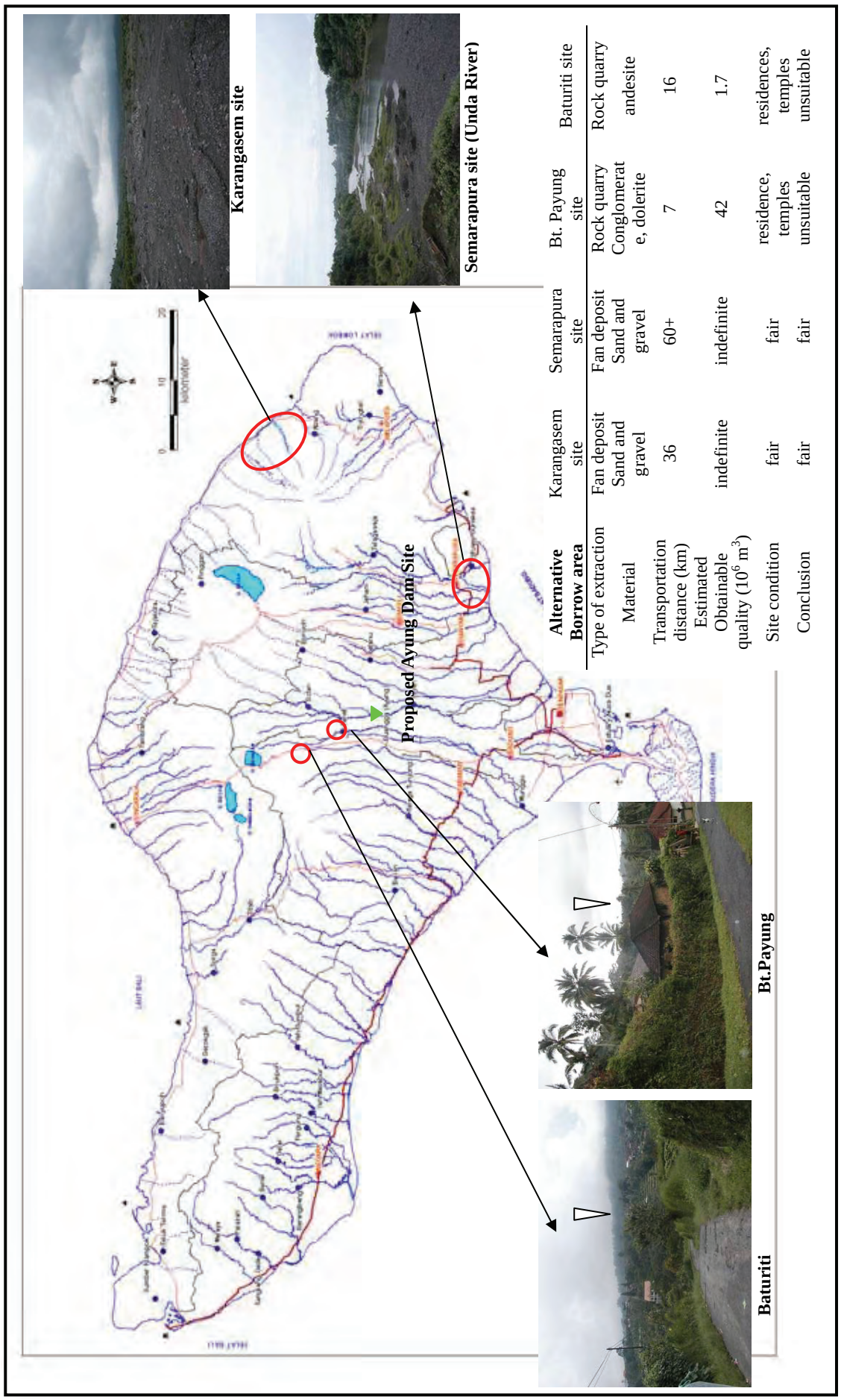

Alternative Borrow area	Karangasem site	Semarapura site	Bt. Payung site	Baturiti site
Type of extraction	Fan deposit	Fan deposit	Rock quarry	Rock quarry
Material	Sand and gravel	Sand and gravel	Conglomerate, dolerite	andesite
Transportation distance (km)	36	60+	7	16
Estimated Obtainable quality (10^6 m^3)	indefinite	indefinite	42	1.7
Site condition	fair	fair	residence, temples	residences, temples
Conclusion	fair	fair	unsuitable	unsuitable

Figure-II-4.32 Location Map of Alternative Construction Material Sources

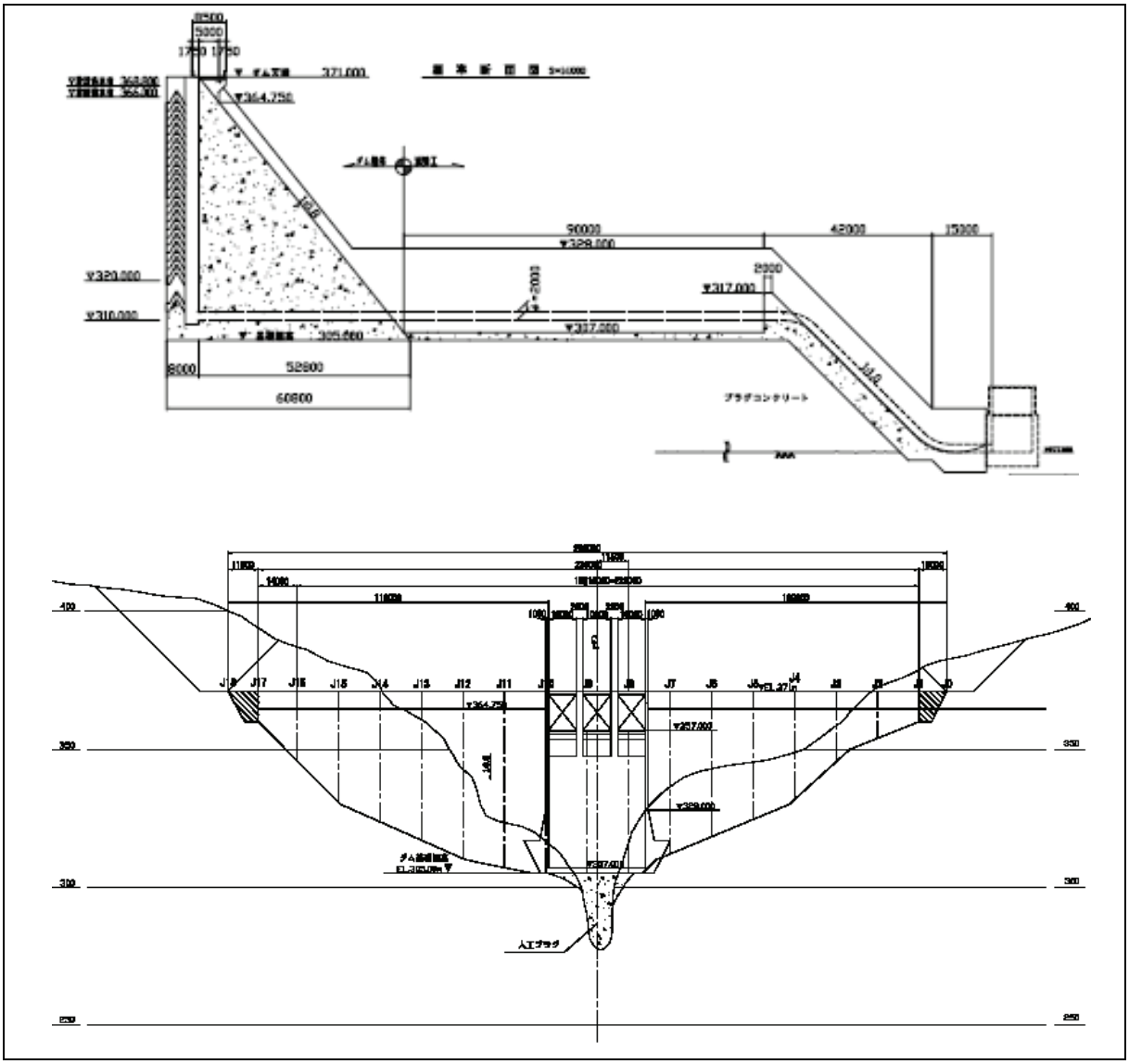

Figure-II-4.33 Typical Sections of Concrete Gravity Dam

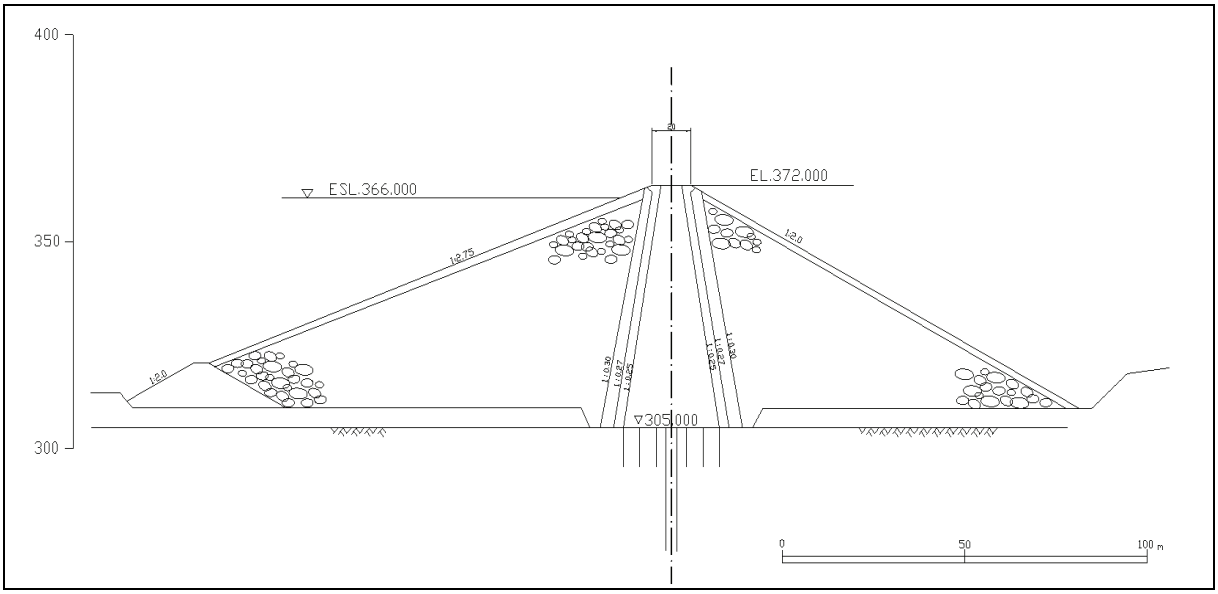

Figure-II-4.34 Typical Cross Section of Zoned Rock-fill Dam

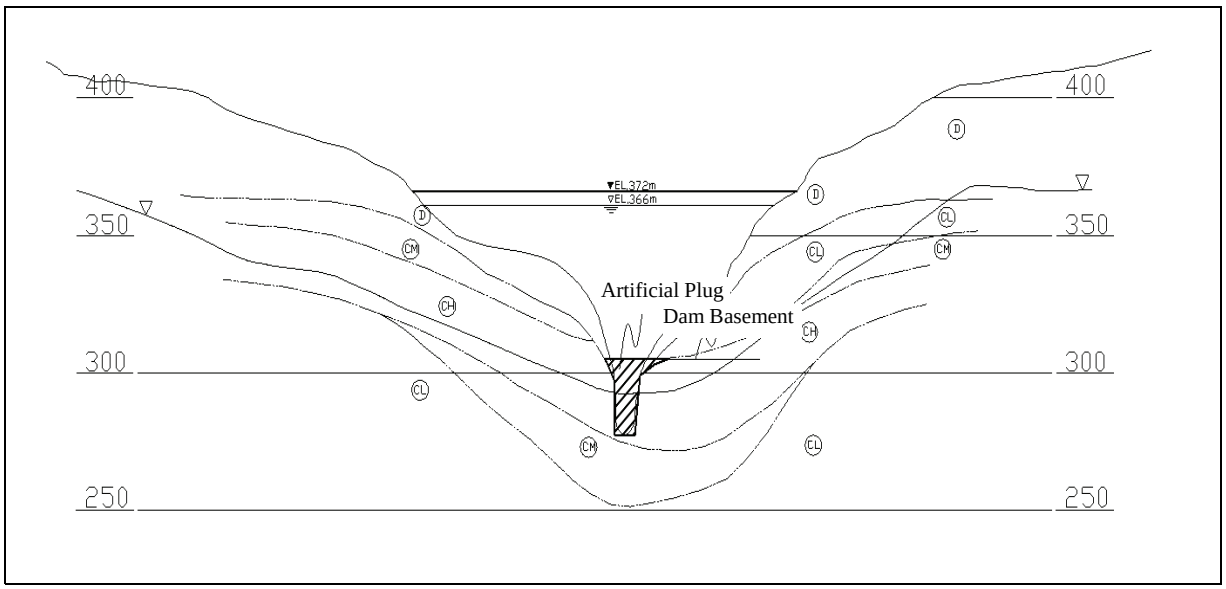

Figure-II-4.35 Typical Cross Section of Artificial Foundation

(15) Preliminary Power Generation Plan

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 365m in elevation
- Tail water level was set up as 283m in elevation by taking into account with riverbed elevation, river width, basement level of power plan.
- Turbine discharge for power generation was set up as 13 m3/sec based on the 2 times from the average minimum discharge 6.5 m3/s by taking into consideration of efficiency of hydraulic turbine and generator.

Specifications for power generation are shown in Table-II-4.33

Table-II-4.33 Specifications for Power Generation of Ayung Dan

Items	Specifications	Explanations
Generation Method	Dependent for Outflow	No capacity for power genaration
Intake water level	EL 366 m	Normal water level
Tail water level	EL 285 m	Setting up from river bed level
Total head (Max.)	81.0 m	=Intake-Tail = EL366m-285m = 81 m
Effective head (Max.)	72.9 m	=Total head×0.9=72.9m
Total head (regular)	60.0 m	=(NWL+LWL)-intake= EL345m –285m = 60 m
Effective head(regural)	54.0 m	=Total×0.9=54.0m
Max. discharge	13.0 m^3/s	
Min. discharge	6.5 m^3/s	
Max. Power	7.6 Mw	P= 9.8 ×Head × Discharge × Efficiency(0.82)= 9.8× 72.9m × 13.0 × 0.82 = 7,615 Kw
Regular power	1.9 Mw	= 9.8 ×Head × Discharge × E(0.50)= 9.8× 60.0m × 6.5 × 0.50 = 1,910 Kw
Electric Energy (Year)	41,610 Mwh	=(Max.+Regular)/2 ×24 × 365 =(7.6+1.9)/2× 8,760 = 41, 610 MWh

(16) Drawings

Drawings of Ayung dam are shown in Figure-II-4.36–Figure-II-4.39.

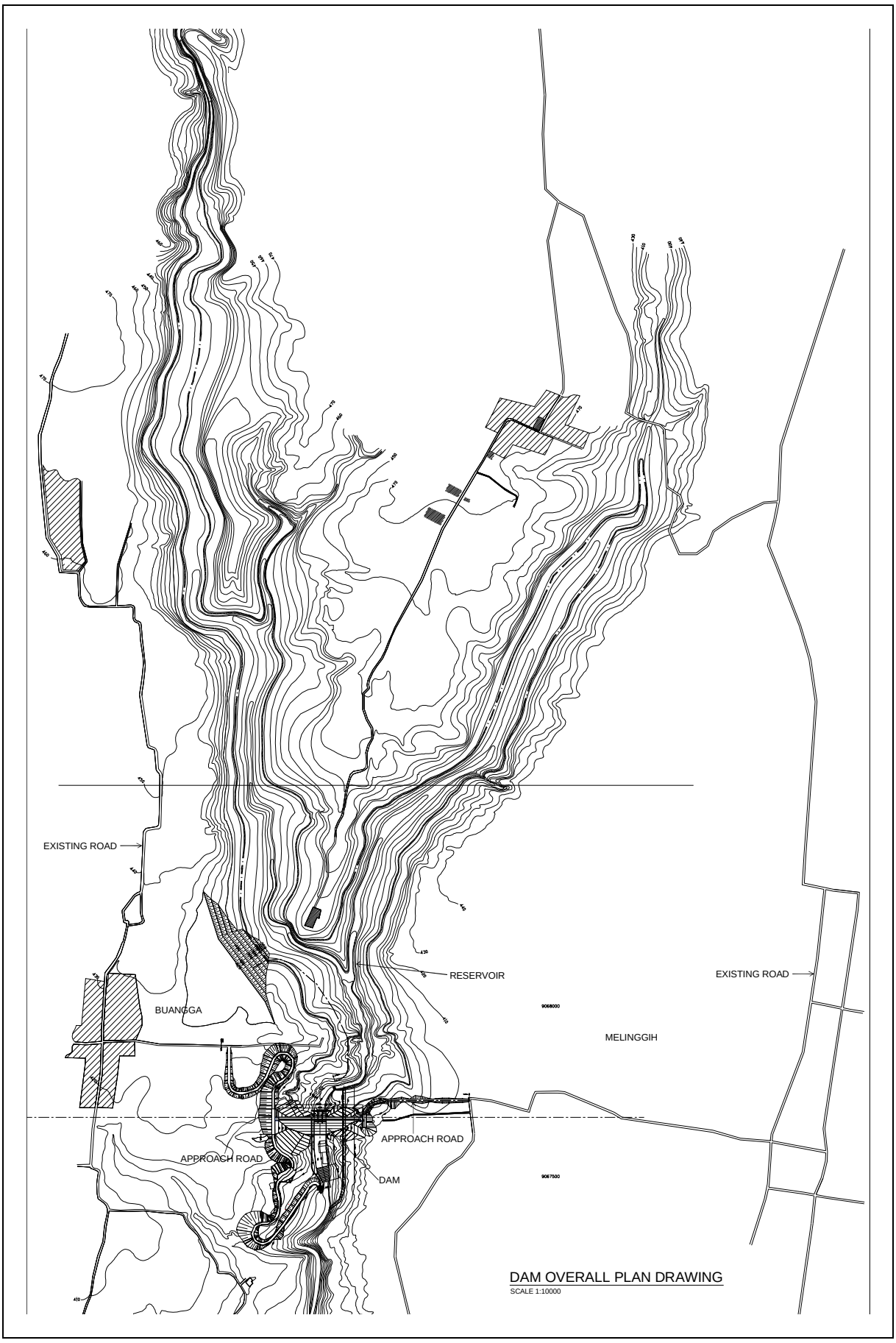

Figure-II-4.36 Plan of Reservoir of Ayung Dam

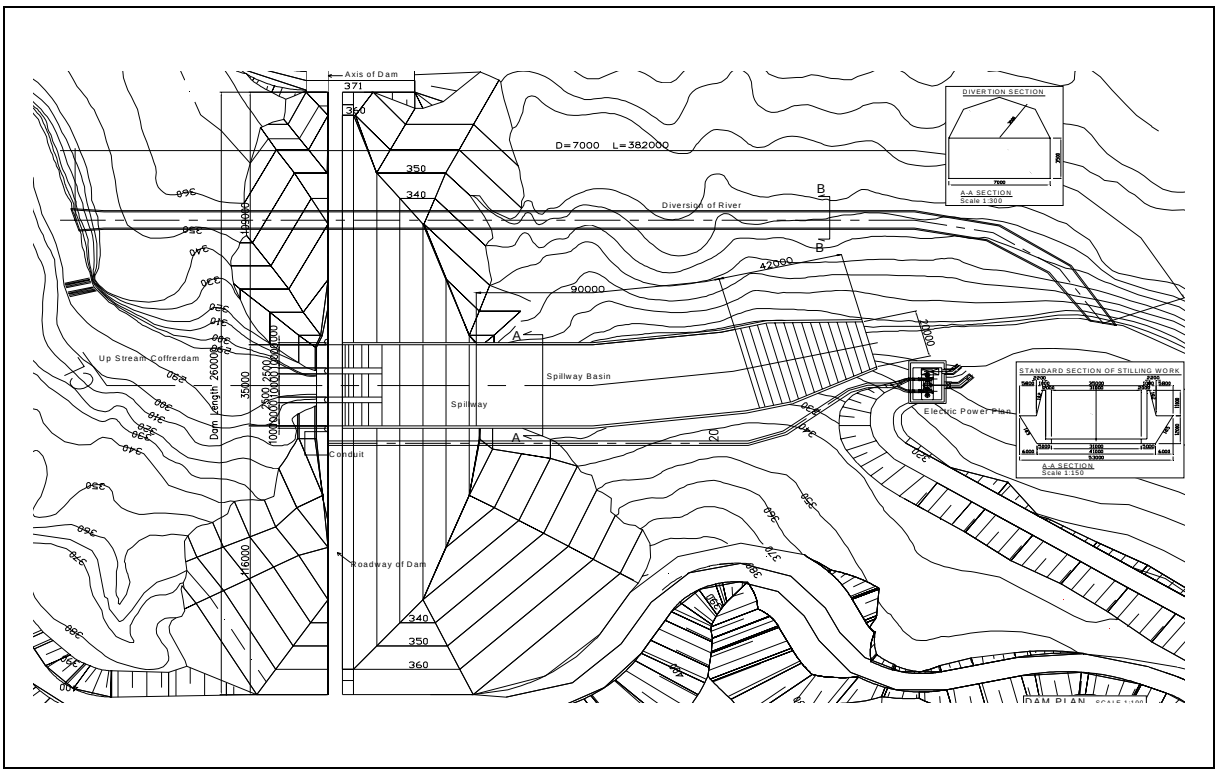

Figure-II-4.37 Plan of Ayung Dam

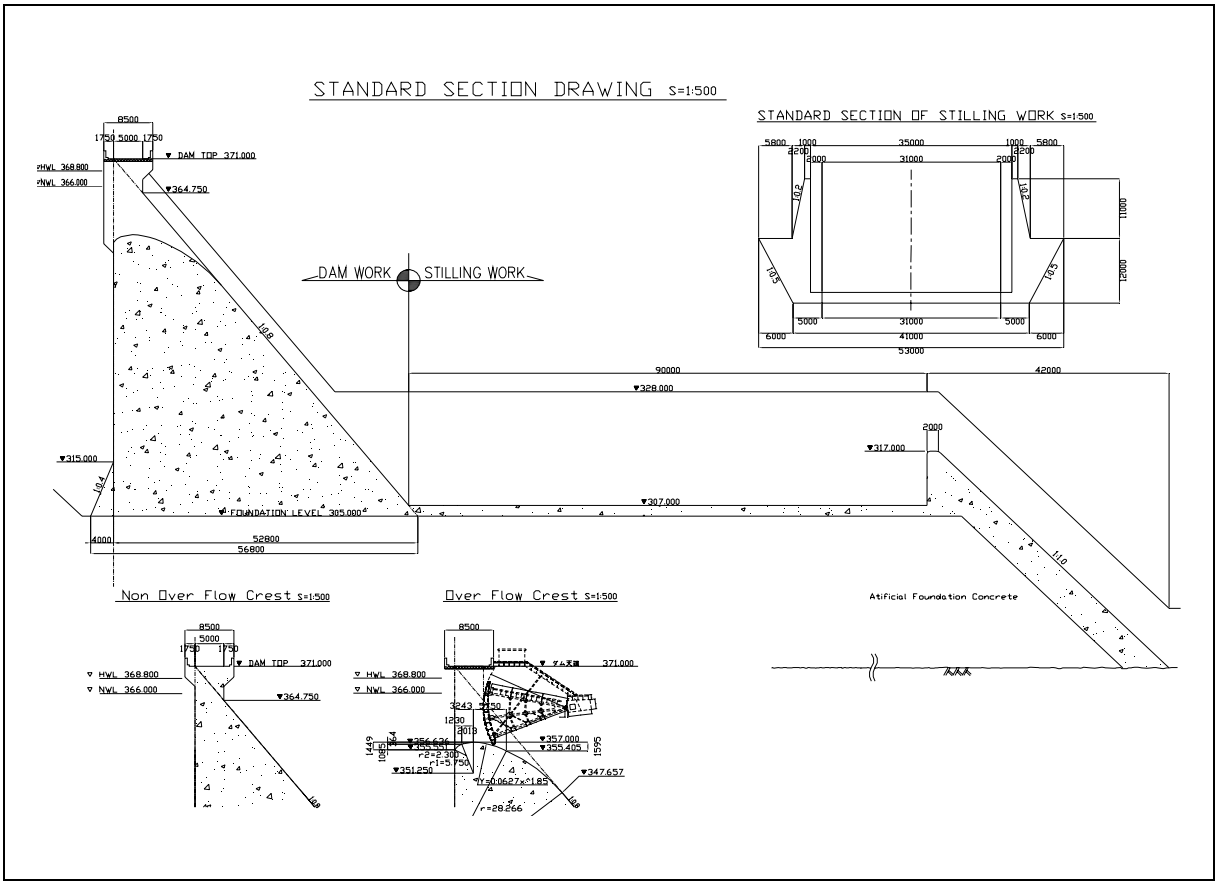

Figure-II-4.38 Typical Section of Ayung Dam

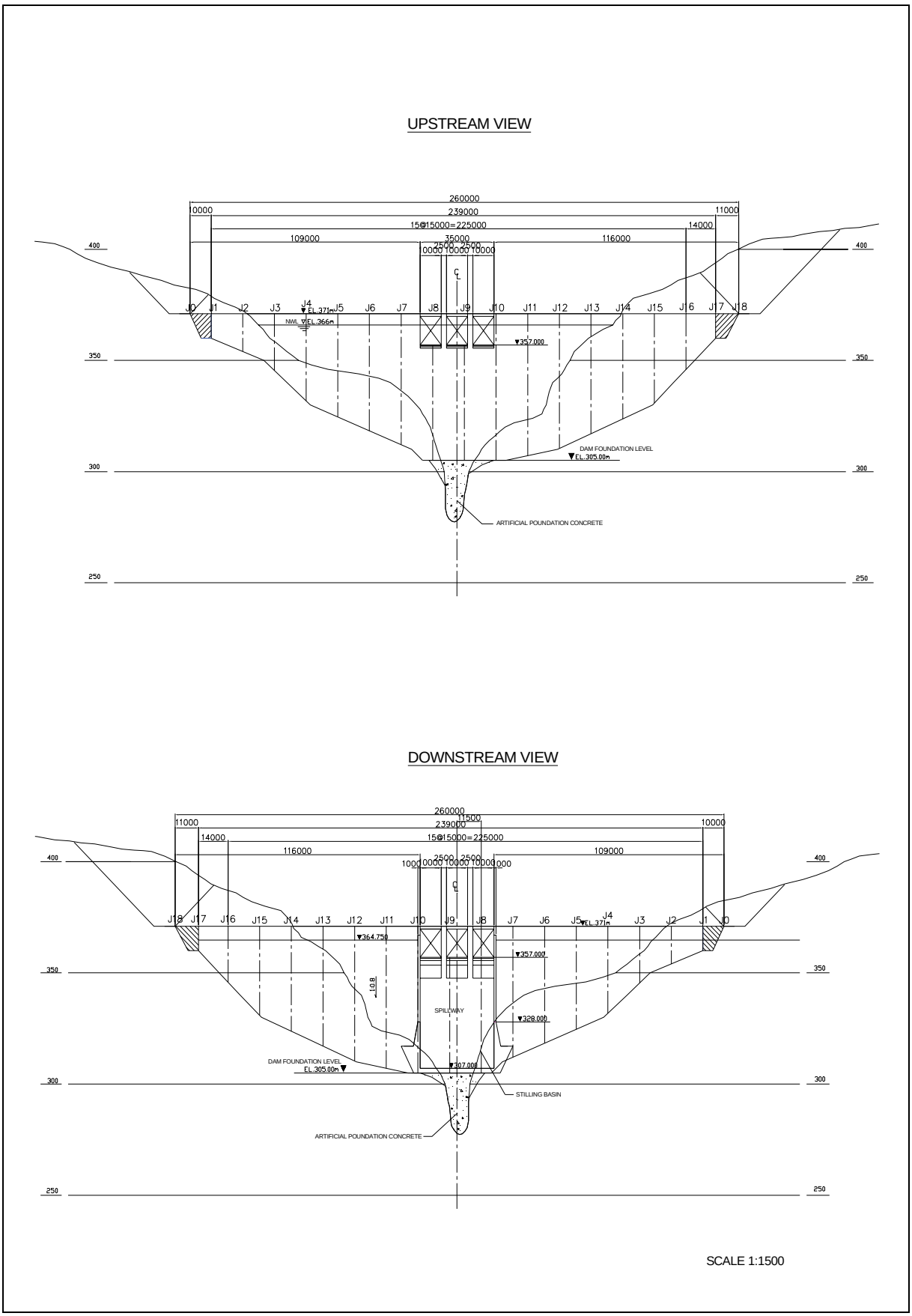

Figure-II-4.39 Upstream and Downstream Section of Ayung Dam