Water Source

As the consumer areas are relatively distributed and demands are relatively small, spring water and groundwater are suitable for water sources in these areas. Water sources shall be developed at the upstream locations from consumer area to distribute water by gravity. As the Multipurpose Benel Dam project is already registered in the National Development Program and the preparation has started, the project plan prepared by the Bali Government is entered into the Master Plan. The current use and potential of spring and groundwater are shown in Table-4.11. In these areas, spring water and groundwater are well utilized. However, few spring water is used in Jembrana and few groundwater is used in Bangli.

Table-4.11 Spring/Groundwater Use and Potential (Northern Bali Area)

Items / Regency	Spring (lit/s)			Groundwater (lit/s)		
	Potential	Current Use	Remaining	Potential	Current Use	Remaining
Jembrana	119	3	116	1,126	581	545
Buleleng	6,173	2,934	3,239	2,093	411	1,682
Bangli	3,393	692	2,701	1,551	9	1,542
Karangasem	9,956	4,533	5,423	2,090	206	1,884
Total	19,641	8,162	11,479	6,860	1,207	5,656

Proposed Water Supply Plan in Northern Bali Area

The outline of the propose water supply plan by regency is shown in Table-4.12.

Table-4.12 Outline of Water Supply Plans for Northern Bali Area

Items / Regency	Current Capacity (lit/s)	Extention Capacity (lit/s)	Water Source (lit/s)			Explanation
			Surface Water	Ground Water	Spring Water	
Jembrana	139	260	160	100		Benel Dama (2@50lit/s) and Well (2@50lit/s)
Buleleng	394	450		150	300	Well (3@50lit/s)＋Spring (3@100lit/s)
Bangli	120	170			170	Spring (20lit/s + 3@50lit/s)
Karangasem	224	320		20	300	Well (20lit/s)＋Spring (3@100lit/s)
Total	877	1,200	160	270	770	

4.2.3 Water Supply for Remote and Isolated Areas

Generally, people in urban areas and rural areas are receiving water supply service through water distribution network. However, some people in remote and isolated areas can not receive this service through the public water supply system. In these cases, organization responsible for public water supply has to examine the method and to distribute domestic water to those who are waiting service and living in the remote and isolated areas. As examples, there are two cases: 1) Kubu in Kalangasem and 2) Penida Island in Klungkung In both cases, water source is located at the limited area, and far from the service areas

<Kubu Area>

Water sources and volumes in the area are limited. There is no perennial river in the areas. There are few springs in number and the yields of springs are small and limited. Groundwater table is very deep in the high altitude area. Main water sources are production wells located in the coastal areas. Townships are distributed along the coastal line. These conditions explained above are caused by the hydro-geological and topographical features of the area. New village users in the mountain slopes (far from water source near coastal area) are waiting public water supply not to suffer from water shortage in dry season. Usually those people are using spring water with small capacities. To reply the request, PDAM has to select feasible method comparing the two options: 1) Expansion of existing network and 2) Water delivery by Water-Tank-Car. (See Figure-4.7)

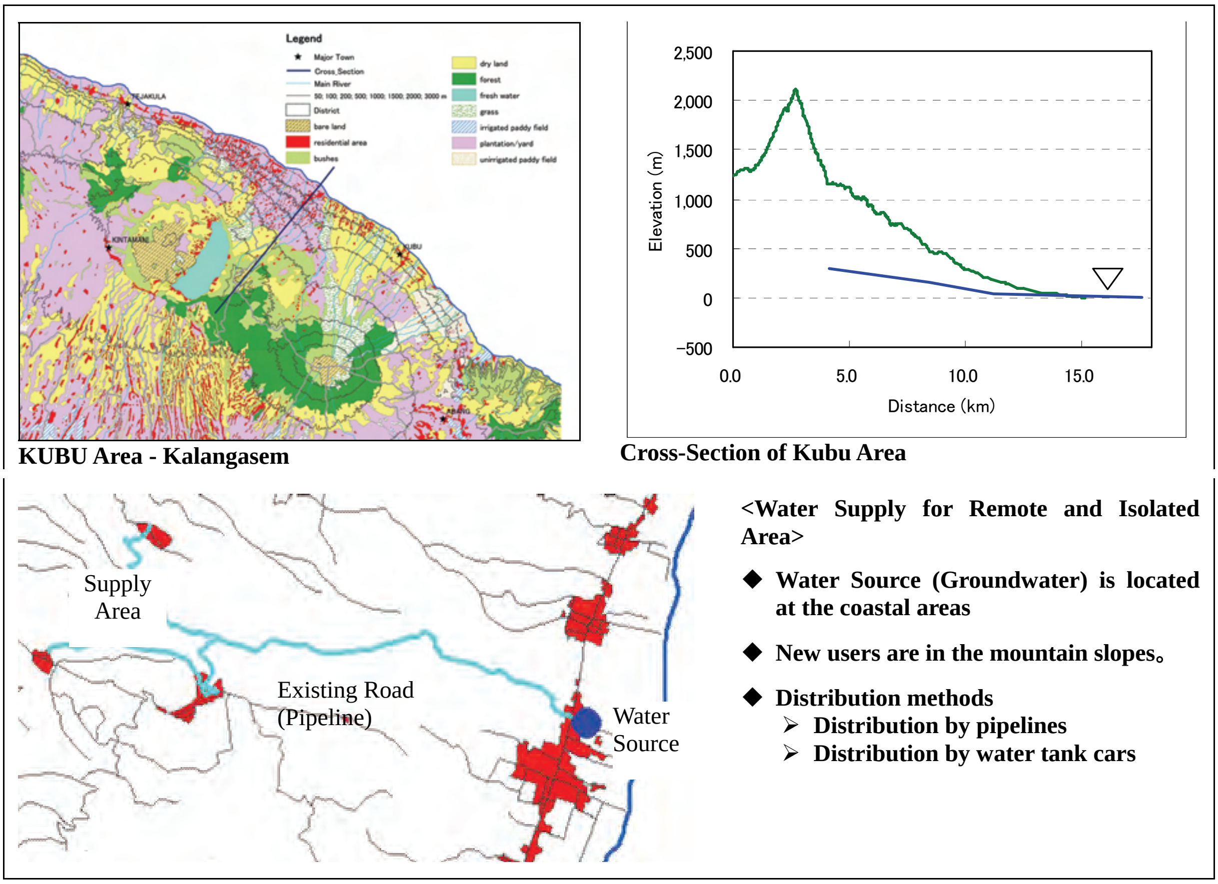


Figure-4.7 Water Supply Plan for Kubu Area

<Penida Island >

The service areas in Penida are located in the relatively high land. Main water source is spring. It is confirmed that the total capacity of these springs is more than 500 lit/s. However, almost springs discharge at the middle of the cliff (of 100m height). To expand the water supply service, spring water has to be pumped up to the reservoir in the high land.

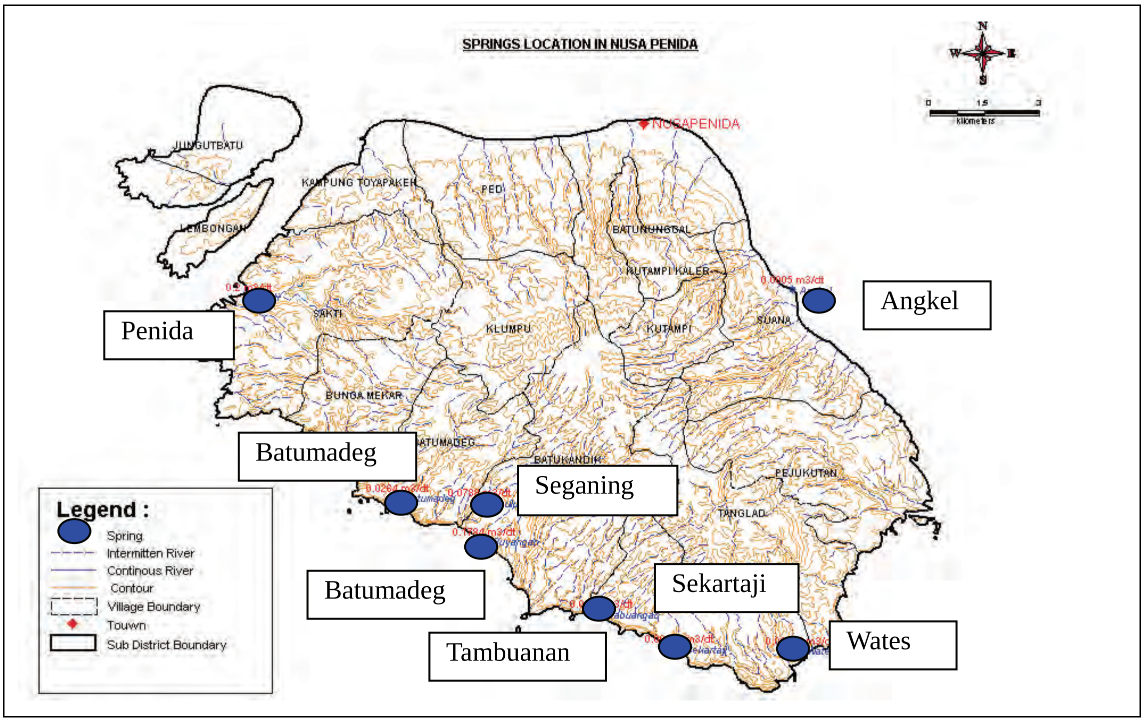


Figure-4.8 Water Spring Plan for Penida Area

4.2.4 Irrigation Plan

(1) Alternative Plans for Water Supply

<Issues Associated with Present Irrigation System>

Although the paddy culture in Bali has already achieved high crop intensities and high productivity with intensive and extensive irrigation, there are still some issues as summarized below. These issues need to be mitigated for the future irrigation.

Irrigation Efficiency

The excess use of water resources should be mitigated by improving the irrigation efficiency so that the residual water can be utilized to increase productivity/production of crops. 14 % of irrigation area (paddy field) equipped with primitive irrigation facilities are the first priority for an improvement of irrigation efficiency.

Volume Control of Intake Discharge

Technical irrigation schemes, which measure and regulate the intake discharge, cover only 32 % of the irrigation area in Bali. Therefore, the volume of water cannot be controlled in the rest of irrigation schemes, 68 % of the irrigation area. Considering effective and efficient water use, the irrigation schemes require to be upgraded to the technical irrigation system so as to control the volume of water, particularly the irrigation system in Tabanan Regency, where the technical irrigation system is rare despite its superiority of paddy irrigation.

Unit of Irrigation Water

Subak uses the flow area (tektek) for allocation and distribution of water, instead of discharge. This unit of irrigation water makes hard to optimize the water use with other sectors and introduce the concept of water right. As the water balance between demand and supply is already tight, particularly in urban areas, a common sense to measure water by discharge needs to be understood by Subak with detailed technical assessment of exact irrigation water requirement and promotion through public consultation meetings.

Irrigation Management

Subak is a model of the water users association in terms of O/M of irrigation facilities and water allocation. However, the optimization of water use among all water sectors requires more precise volume control of water because the tight water balance between demand and supply is anticipated.

For the precise volume control, it is necessary to identify the location and area of irrigation schemes with a network from intake to drainage, discharges from an intake to field inlets, volumes of drained water/return flow and so on. However, the availability of those data is very limited. Public Works Service of Bali Province is recently conducting a study for identification of irrigation schemes by regency. This study is expected to cover the whole Bali Province and target to identify the above factors in details.

Decrease in Paddy Field

The recent decreasing tendency of paddy field needs to be mitigated and controlled because the paddy field benefits not only self-sufficiency of staple food (paddy) but also many factors, such as flood control, groundwater recharge, stabilization of river flow, water quality control, eco-system and tourism. Besides, the paddy culture is associated with tradition and religion through Subak. Thus, the rapid decrease in the paddy field will affect the Balinese culture and tradition.

<Strategy for Future Irrigation>

Based on the two agricultural plans (the spatial plan and RENSTRA) and present issues regarding irrigation, the following is the strategy for the future irrigation development in Bali.

- ◆ Considering the importance of paddy in Bali, the surplus water due to decreasing of paddy field shall be used for following items:
  - Increasing of cropping pattern intensity to 300%
  - Water supply stabilization for draught period

- Upgrading of irrigation efficiency

- ◆ Considering three items shown in above, surplus water shall be used for water supply to SURBAGITAKU area by mean of negotiation between stakeholders.
- ◆ Surplus irrigation water shall be used for countermeasures to poverty people and development of rural communities.
- ◆ Rehabilitation works of irrigation facilities will be applied continuously to improve irrigation efficiency, resulting in mitigation of water loss, improvement of crop intensities and improvement of O/M of irrigation facilities.
- ◆ Irrigation water shall be developed mainly by dams and small pond.

<Evaluation of Alternative Irrigation Plans for Water Supply>

The residual water in the year of 2025 amounts to approximately 387 million m^3 because of improvement in irrigation efficiency and area decrease in paddy field. Improvement in irrigation efficiency and area decrease in paddy field contribute to 247 million m^3 and 140 million m^3 reduction of irrigation water respectively. Besides, 10% increase in irrigation efficiency (from 50% to 60%) save 17% of water compared to the irrigation water requirement in 2025 with 50% efficiency.

<Proposed Plans for Water Supply>

Based on evaluation of two alternative plans, proposed plans for water supply are summarized as follows. Proposed plans are basically applicable to the whole Bali but particularly areas that require the Alternative 2 Plan for improvement of crop intensities as shown in Figure-4.9. Those areas extend in Buleleng, Karangasem, Klungkung, Denpasar and Jembrana.

- ◆ Small ponds are useful for maximum use of residual water and drought countermeasures.
- ◆ Crop diversification might require the irrigation system for fruit culture ad horticulture on the dry land. In this case, the residual water is the first priority to be used.
- ◆ The surface water development just for irrigation is not economically feasible. Therefore, the surface water development with multiple purposes including irrigation should be considered for improvement of crop intensities and drought countermeasures.
- ◆ The groundwater development is applicable to extend new irrigation schemes for fruit/vegetables culture.
- ◆ For the poverty alleviation, mitigation of economic disparity in region and rural development, irrigation is effective but requires a subsidy. Since those purposes are subject to social matters, they cannot be examined by economic aspects.

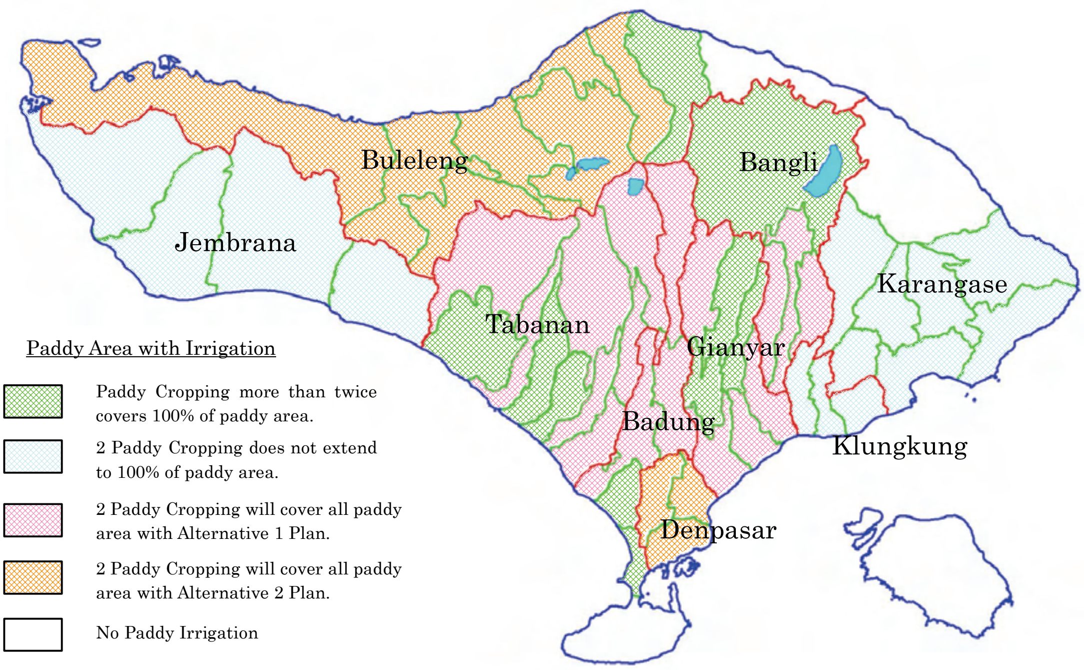


Figure-4.9 Potential Area for Improvement of Crop Intensities

4.3 Dam Development Facility Plan

4.3.1 Ayung Dam Development Plan

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. 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 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)

(1) 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 years started from 1973. Flow regime at Buangga station is shown in Table-4.13.

Table-4.13 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

Current state of water use for irrigation water and municipal water is shown in Figure-4.10.

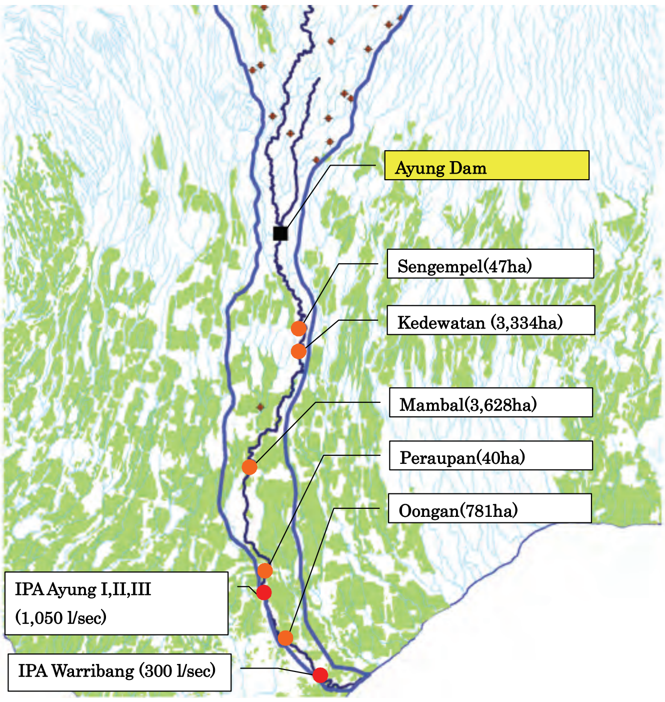


Figure-4.10 Existing Weirs along Ayung River

(2) 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 shall be generated for the purpose of contribution for electric demand in Bali.
- In the river flowing to Denpasar City, water quality shall be improved due to the water conveyance of purification water developed by dam reservoir.

(3) Calculation for Water Use Capacity of Ayung Dam

<Calculation Condition>

Conditions for calculation of capacity are shown in Table-4.14.

Table-4.14 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	400 lit/sec	At Wariban

<Requirement Capacity Based on the Calculation Results>

Calculation result for the requirement of each capacity is as shown in Table-4.15.

Table-4.15 Requirement Capacity Based on the Calculation Results

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

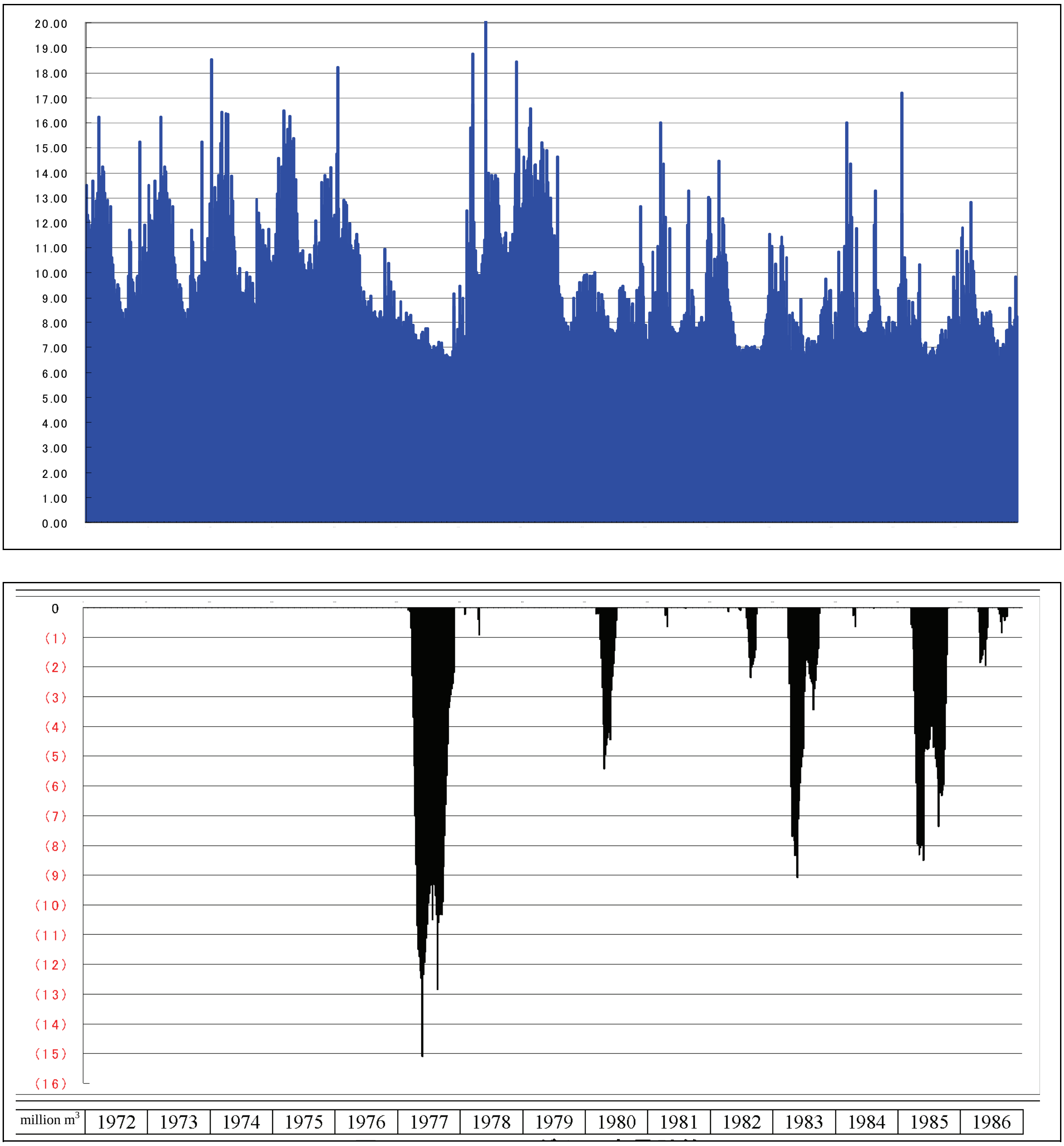


Figure-4.11 Calculation Result of Requirement Capacity for Ayung Dam

(4) Sediment Capacity

With reference to design sediment capacity for Ayung dam, based on the detail design of Ayung dam in 2002, 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 × 218.4 km^2 × 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.

Table-4.16 Design Sediment Capacity for Ayung Dam and Check Dams

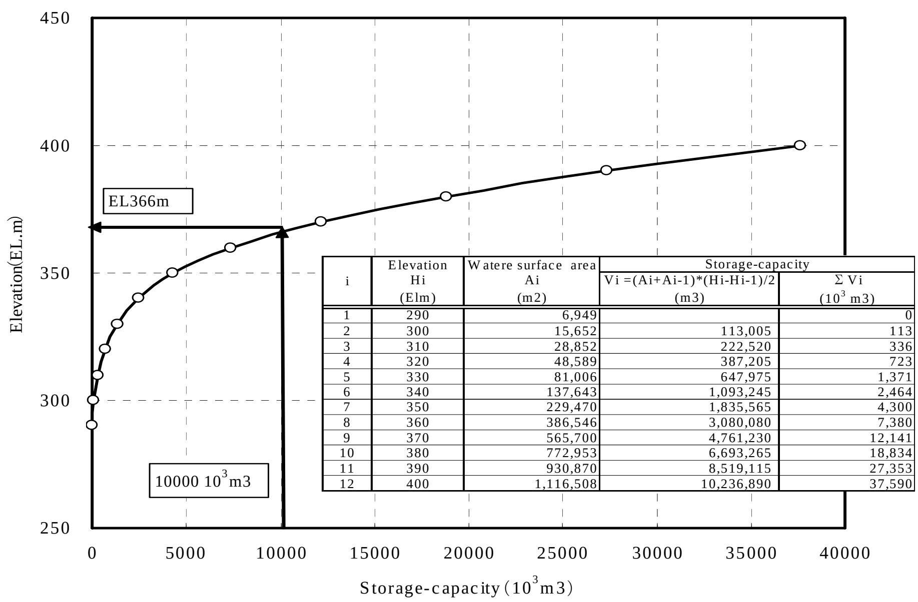
Method of Secure	Sediment Capacity for Facility	Planned Location of Facility
Ayung Dam	**1,000,000**	Ayung Dam
2 Check Dams	3,600,000	Near upstream edge of reservoir located in Ayung River and Siap River

(5) Storage Capacity Distribution

Due to above mentioned study results storage capacity distribution is shown in Table-4.17.

Table-4.17 Design Capacity Distribution for Ayung Dam

Purpose	Capacity(m^3)	Water level	Remarks
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-4.12 Reservoir Capacity Curve for Ayung Dam

(6) Selection of 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-4.13).

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.

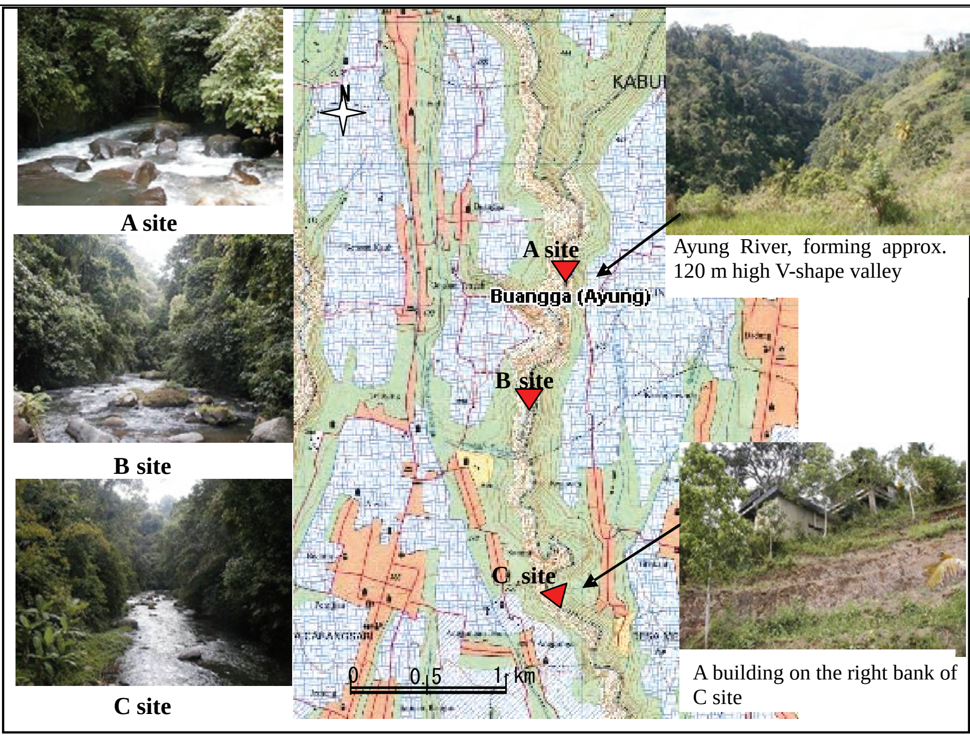
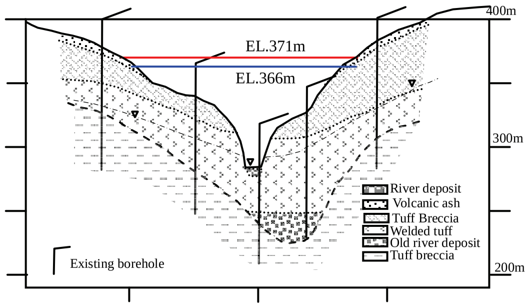
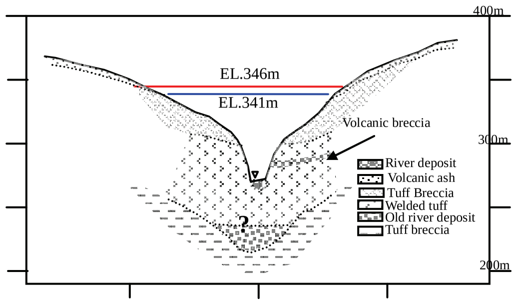
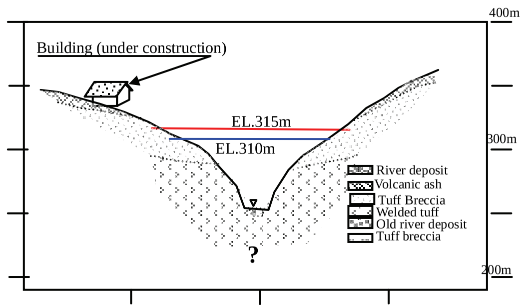


Figure-4.13 Location Map of Alternative Dam Sites

Table-4.18 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

(7) Topographic and Geological Outlines

<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-4.14 Topography around Proposed of Ayung Dam Site

<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.

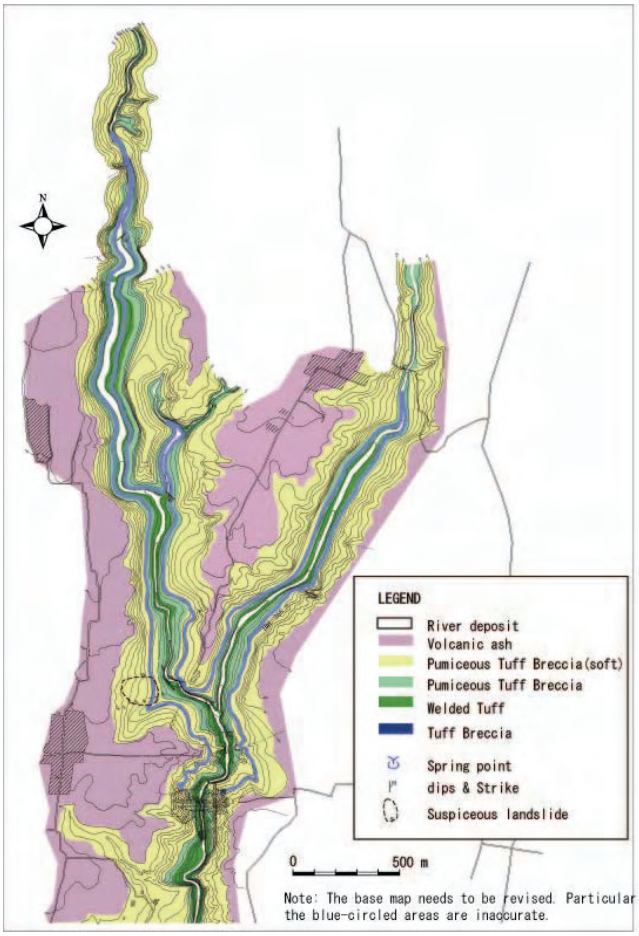
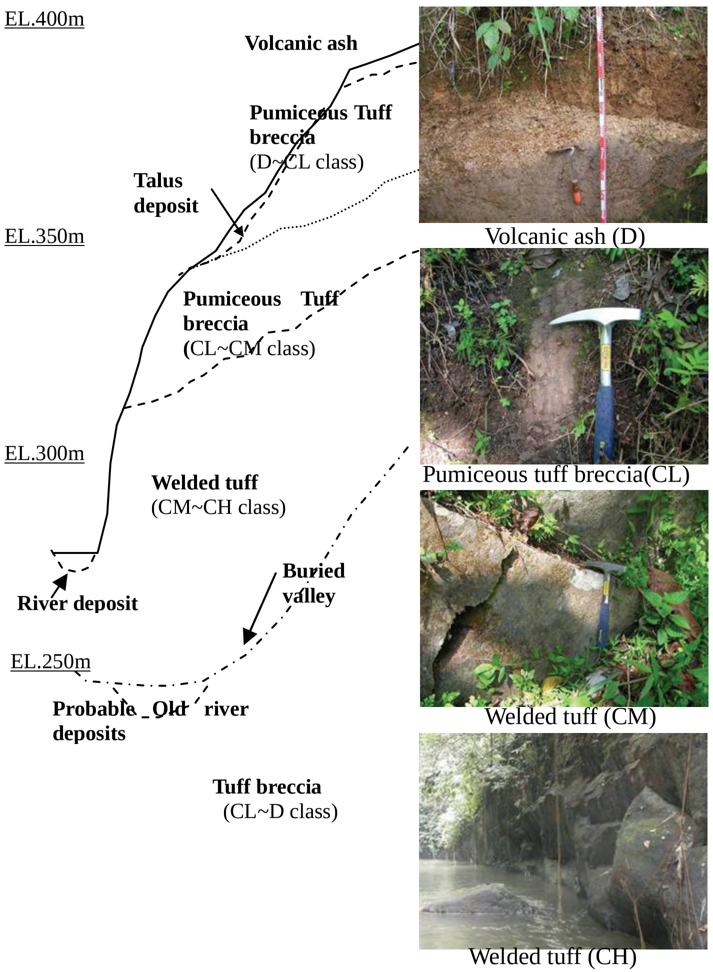


Figure-4.15 Geological Map of Ayung Dam Reservoir Area (Source: JICA Study Team)

Table-4.19 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	50~8 0 100~ 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<

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).

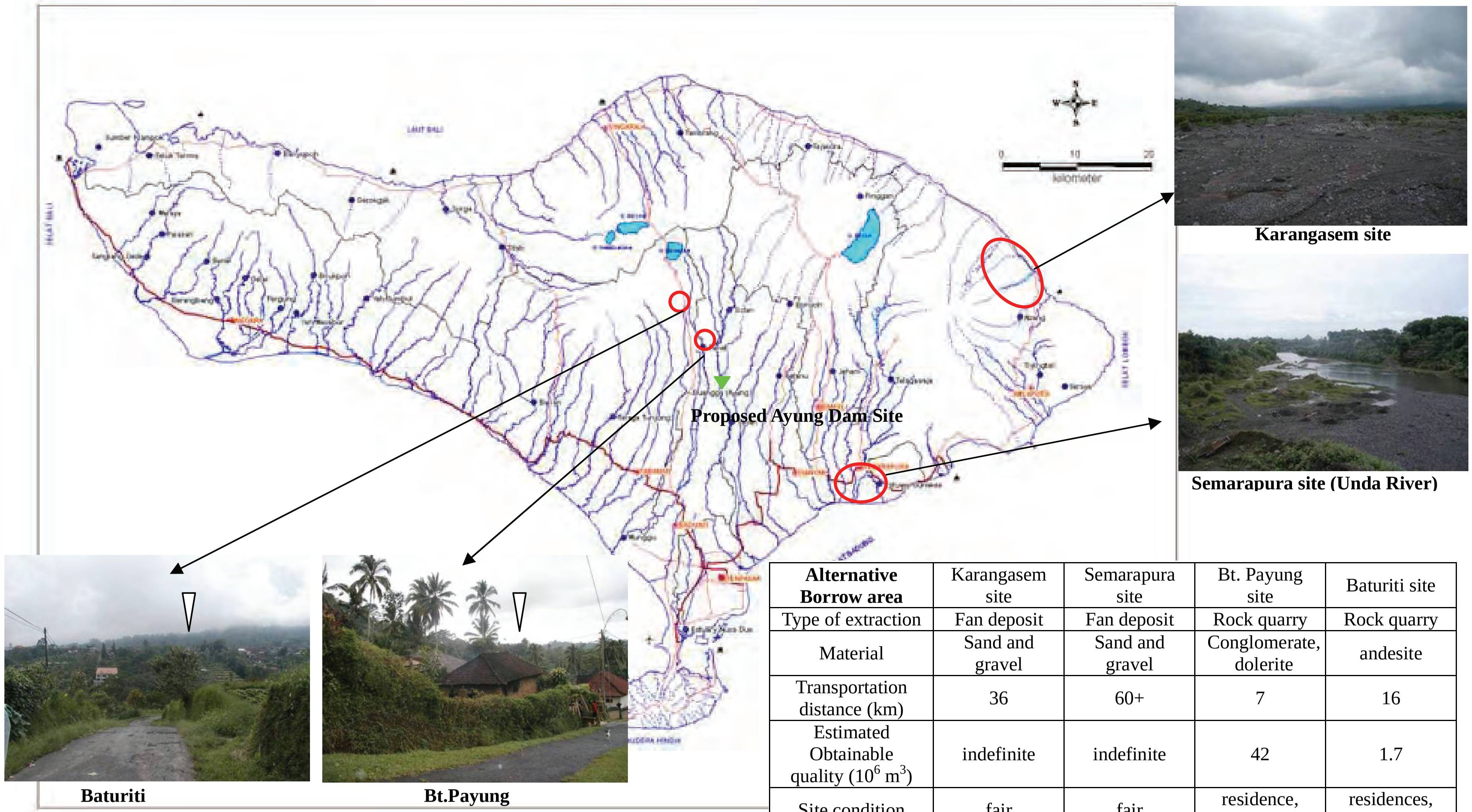
(8) Construction Materials

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.

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.



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-4.16 Location Map of Alternative Construction Material Sources

(9) Comparison of Dam Type

Concrete gravity dam is applied for Ayung Dam by the following comparison results.
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-4.17to Figure-4.18, respectively.

Table-4.20 Comparison between Concrete Gravity Dam and Zoned Rock-fill Dam

Dam Type	Concrete Gravity Dam		Zoned Rock-fill Dam	
Specifications	Dam height Non overflow section elevation Crest elevation Foundation elevation Crest length Crest width Dam volume Min. water level Full reservoir water level Surcharge water level Design flood water level Reservoir area	66.0m EL.371.0m EL.371.0m EL.305.0m 235.0m 5.00m 296,000m^3 EL.325.0m EL.366.0m EL.366.0m EL.369.0m 0.49km^2	Dam height Non overflow section elevation Crest elevation Foundation elevation Crest length Crest width Dam volume Min. water level Full reservoir water level Surcharge water level Design flood water level Reservoir area	67.0m EL.372.0m EL.372.0m EL.305.0m 235.0m 10.00m 1,500,000m^3 EL.325.0m EL.366.0m EL.366.0m EL.369.0m 0.49km^2
Rough 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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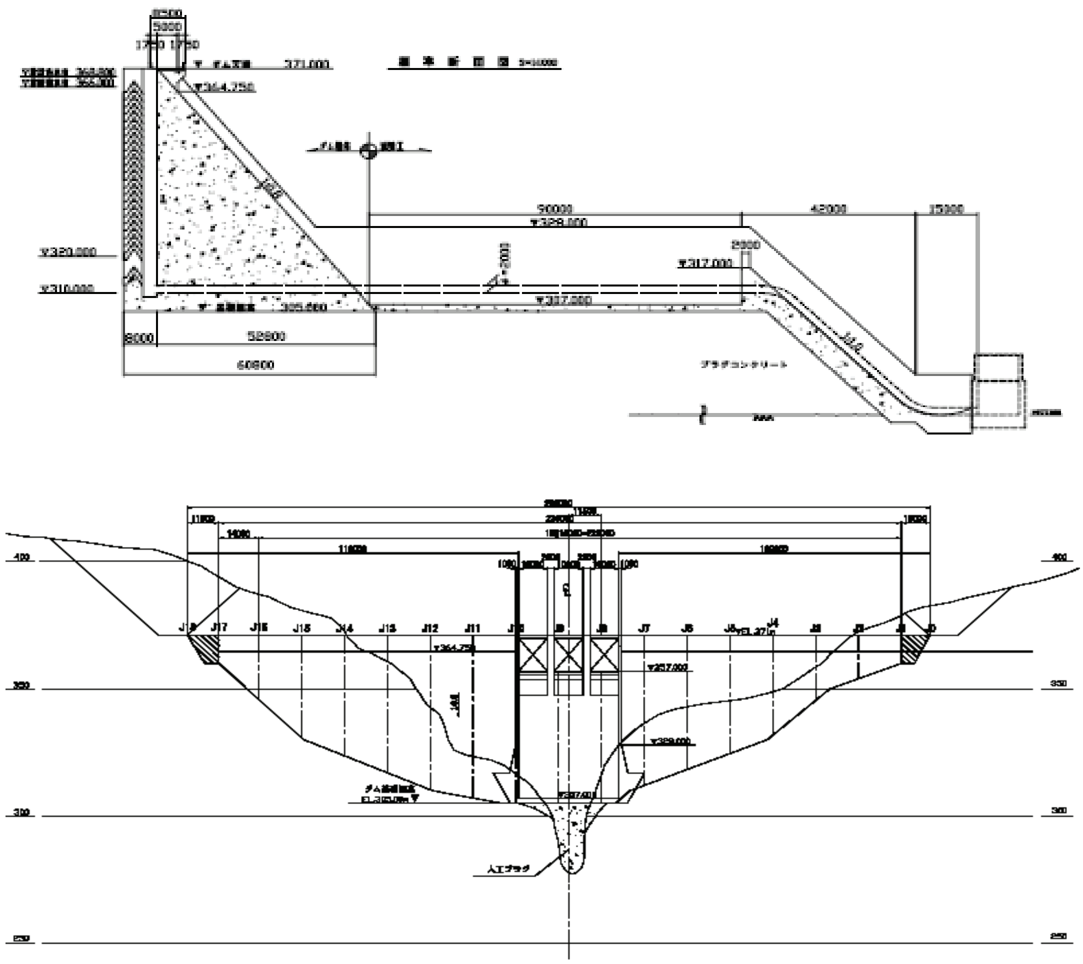

Figure-4.17 Typical Sections of Concrete Gravity Dam

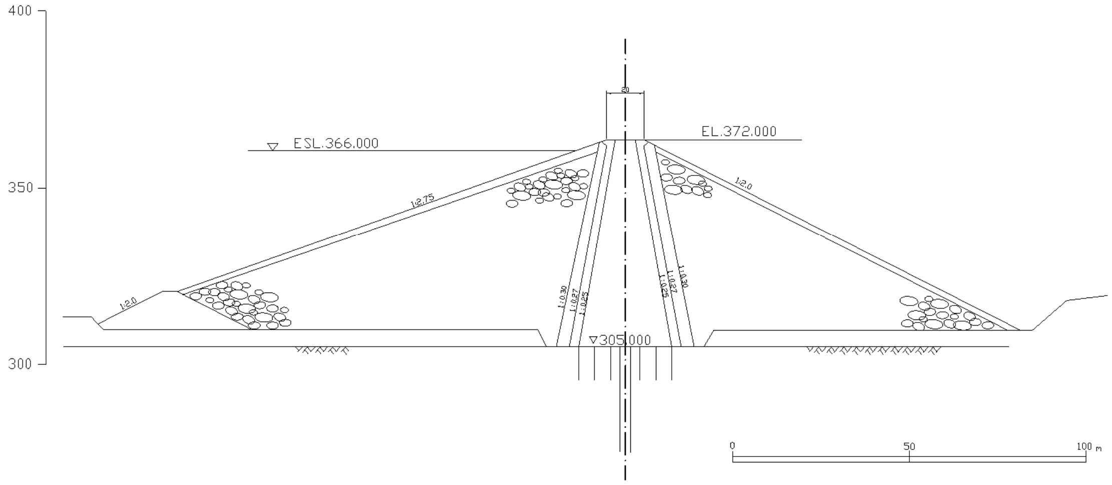

Figure-4.18 Typical Cross Section of Zoned Rock-fill Dam

(10) Preliminary Power Generation Plan

Preliminary Power Generation Plan based on the dam specification are shown in Table-4.21.

Table-4.21 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

Drawings of Ayung dam are shown in Figure-4.19 and Figure-4.20.

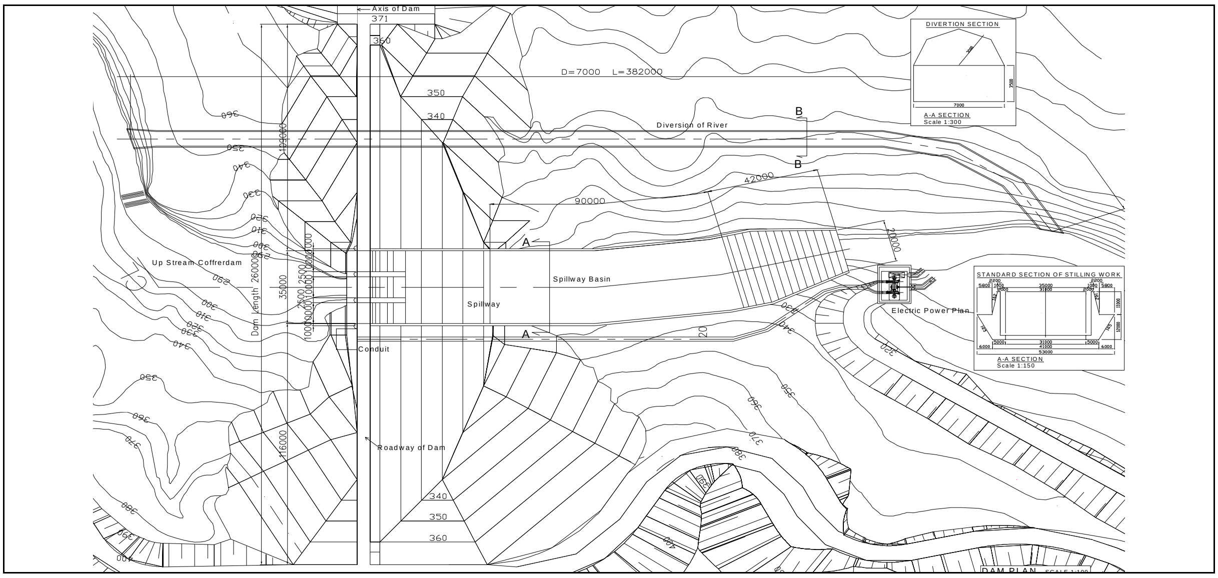

Figure-4.19 Plan of Ayung Dam