(1) Weir

The intake construction is suggested in permanent weir type with dam body's height that is possible to lead gravitational flow to the storage tank. The using of pump machine is only implemented if the river topography and water treatment facilities position are impossible to be flowed gravitationally.

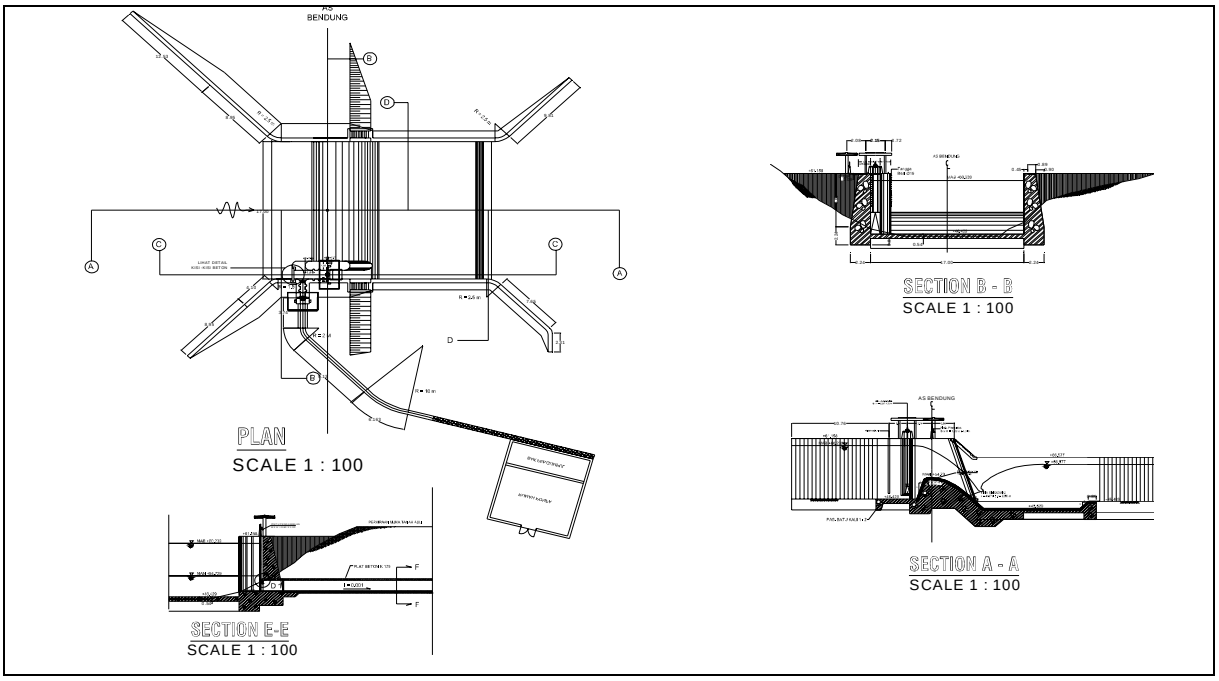


Figure-III-2.5 Weir of Central Water Supply System in Ayung River

(2) Water Treatment Plant (WTP)

The structure of sedimentation tank and pump house position are designed to be built in the south/downstream of the Ayung WTP III's pump house. WTP facilities position for these three units were planned in the east of Ayung Installation III, north of the road, while the Sludge Drying Bed (SBD) was in the south of the road in a row with the WTP.

Nowadays, the land use condition which shall be used for the building of Water Treatment Plant is dry field and rice field owned by the surrounding peoples.

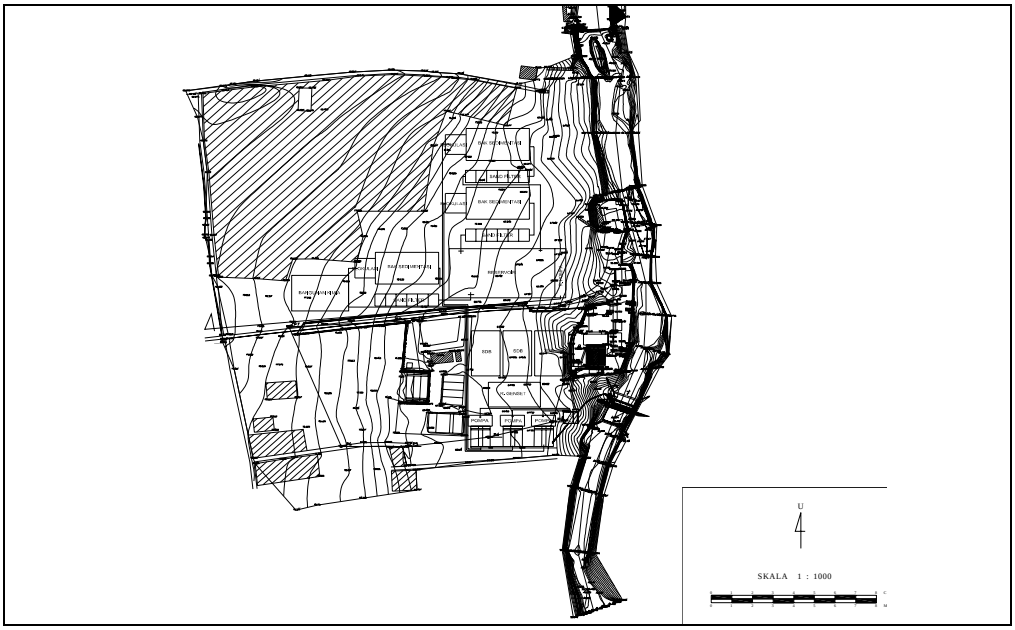


Figure-III-2.6 General Plan for Ayung Water Treatment in Ayung River

2.3 Eastern Water Suppy System

The raw water shall be taken at the downstream area of Petanu River, about 1,5 km from the coast line. The WTP location was selected at Glumpang sub-village, Sukawati Sub district, Gianyar Regency by taking into account hydraulic condition such as salinity intrusion as well as magnitude of effect against the existing springs located at upstream from planned weir along Petanu River. The production capacity for eastern system shall be planned to 300 l/sec (25,920 m^3/day).

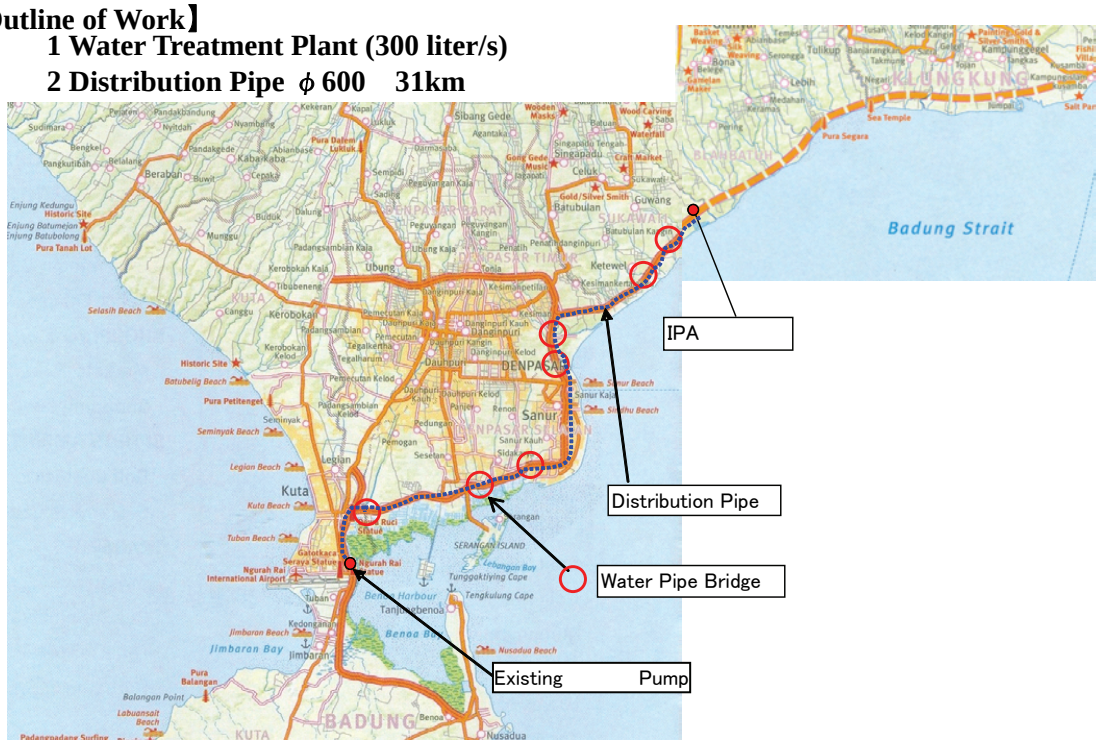
<Eastern Water Supply System>

East System (River Petanu Water Treatment Plant)

【Outline of Work】

1 Water Treatment Plant (300 liter/s)

2 Distribution Pipe ϕ 600 31km



Distribution Pipe Rout
(Sanur Kusumba Bypass)

Site for New Water Treatment Plant
(Petanu River)

Figure-III-2.7 Eastern Water Supply System and Current Condition of planned WTP

(1) Weir

For the intake type selection, permanent type weir was selected with dam body height that is possible to lead gravitational flow to the storage tank. The using of pump machine shall be only implemented in case of river topography condition and water treatment facilities position shall be impossible for flowing due to gravitation.

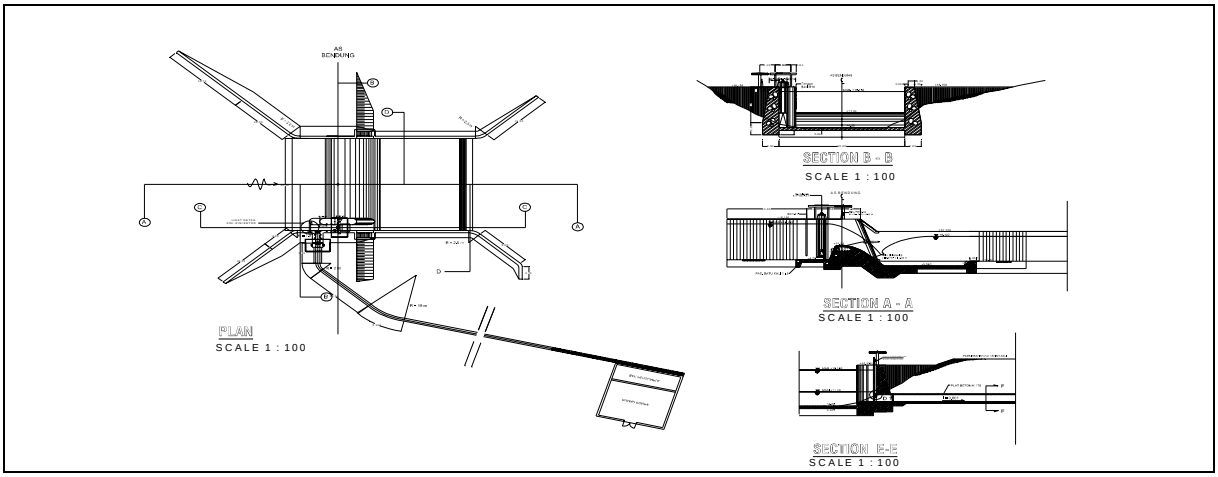


Figure-III-2.8 Weir of Eastern Water Supply System in Petanu River

(2) Water Treatment Plant(WTP)

Layout of WTP building is designed around 300 m in the north of Petanu Bridge, in the west side of the Petanu River. The location choosing was exerted to be far from the side of By Pass Prof. Ida Bagus Mantra and close to the riverside, so that land acquisition cost will be lower. Area planed for WTP buildings is now functioned as rice field owned by surrounding people. Land level is a little bit higher than river course for which gravitation flows is possible to be implemented.

(3) Transmission Pipe

The transmission pipe shall be installed along the side of By Pass Prof. Dr. Ida Bagus Mantra runs between Sunur and Kesamba and By Pass Ngurah Rai runs between Kuta and Sunur, and it shall be connected with the reservoir at the IPA Estuary Dam location.

The pipe position shall be planned at the shoulder of the road, in the northern side for By Pass Prof .Dr. Ida Bagus Mantra and in the eastern side for By Pass Ngurah Rai.

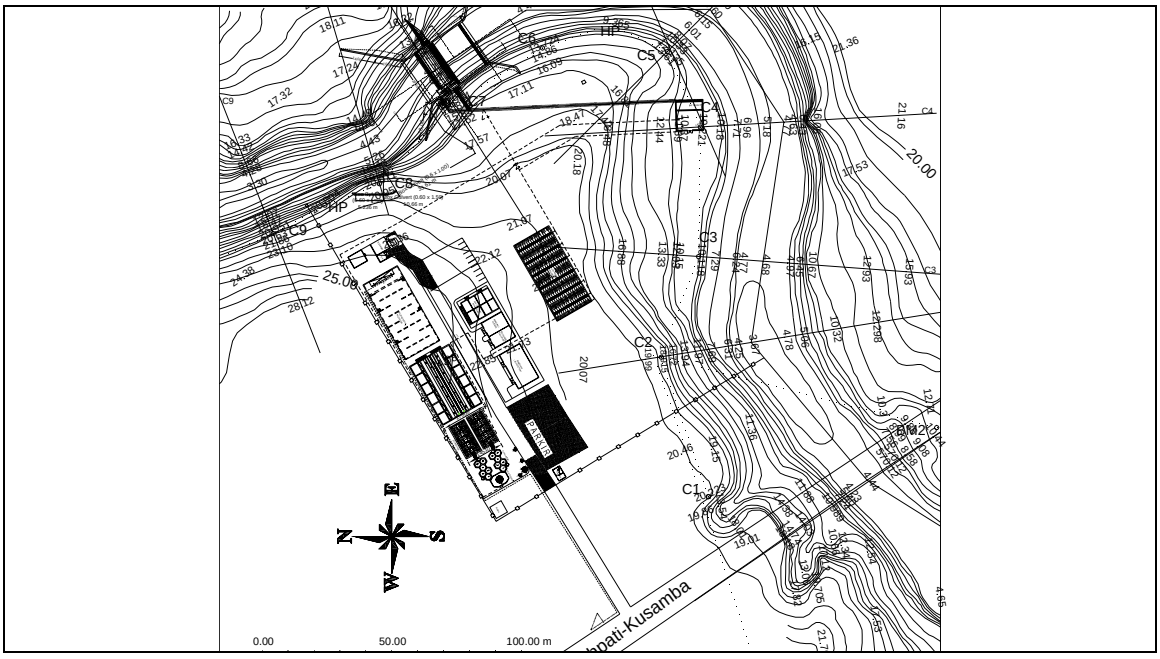


Figure-III-2.9 General Plan for PetanuWater Treatment in Petanu River

2.4 Work Quantities

Works for southern Bali water supply system are shown in Table-III-2.3.

Table-III-2.3 Main Construction Works of South Bali Area Water Supply Project

System Name		Unit	Western System	Eastern System	Central System
River Name			Penet river	Petanu River	Ayung River
Intake weir			Height×Wide×Length 7.3m×19m×28m	Height×Wide×Length 7.8m×20m×30m	Height×Wide×Length 6.6m×17m×25m
Treatment Plant (Water Supply Capacity)		liter／sec	300	300	600
Waterline Pipe φ600		k m	8.8	31.0	non
Water Pipe Bridge	L=10m	site	1	1	non
	L=15m	〃	1	—	
	L=20m	〃	3	3	
	L=25m	〃	—	5	
	L=35m	〃	—	2	
	L=50m	〃	—	1	
	L=95m	〃	—	1	
	L=100m	〃	—	1	

Work quantities in detail for each system are shown in following Table-III-2.4.

Table-III-2.4 Work Quantities for Western Water Supply System

Works Description	Works Item		Unit	Quantity	Remarks
Common Temporary Work			Ls	1.0	
Intake & Conduit					Height×Wide×Length
	Intake Weir& Pump Pit	Temporary Work	Ls	1.0	7.3m×19m×28m
		Earths Works(Excavation)	m^3	2400.0	
		Earths Works(Backfill)	m^3	1300.0	
		Earths Works(Bank)	m^3	3400.0	
		Concrete Works	m^3	500.0	
		Masonry Works	m^3	1800.0	
		Intake(Pump Pit)	m^2	110.0	10m×11m×4.0m
	Waterline Pipe φ600		m	200.0	
		Other（Mechanical Equipment）	Ls	1.0	
Treatment Plant Facilities					
	Treatment Plant(Civil Works) Other Building Work	Temporary Work	Ls	1.0	
		Earths Works(Excavation)	m^3	4579	
		Earths Works(Bank・Backfill)	m^3	1585	
		Concrete Works	m^3	1870	
		Wall Structure Works: Receiving well：35 m^2	m^2	35.0	5m×7m
		Wall Structure Works: Flocculation Tank	m^2	110.0	9m×6m×2sites
		Wall Structure Works: Chemical Reservoir	m^2	200.0	14m×7m×2sites
		Wall Structure Works: Sand Filter	m^2	445.0	25.5m×17.5m
		Wall Structure Works: Clear Water Reservoir	m^2	495.0	33m×15m
		Wall Structure Works: Sludge Drying Bed	m^2	495.0	33m×15m
		Wall Structure Works: Other（Mechanical Equipment）	Ls	1.0	
		Wall Structure Works: Pipes Setting	Ls	1.0	
		Office & Laboratory	m^2	165.0	15m×11m×7.6m
		Chemical Room	m^2	235.0	20m×9m×3.9m
					11m×5m×7.6m
		Mechanical & Electric Room	m^2	120.0	11m×11m×5.3m
		Workshop	m^2	50.0	8m×6m
		Guard House	m^2	15.0	3m×4.5m
Transmission Facility					
	Waterline Pipeφ600 Water Pipe Bridge		m	8800.0	
		L=10m	Site	1.0	
		L=15m	Site	1.0	
		L=20m	Site	3.0	
Electrical & Mechanical Cost (E & M)			Ls	1.0	

Table-III-2.5 Work Quantities for Central Water Supply System

Works Description		Works Item		Unit	Quantity	Remarks
Common Temporary Work				Ls	1.0	
Intake & Conduit						Height×Wide×Length
	Intake Weir& Pump Pit	Temporary Work		Ls	1.0	11.5×60×30m
		Earths Works(Excavation)		m^3	10,800	
		Earths Works(Backfill)		m^3	5,850	
		Earths Works(Bank)		m^3	15,300	
		Concrete Works		m^3	2,250	
		Masonry Works		m^3	8,100	
		Intake(Pump Pit)		m^2	495	10m×11m×4.0m
	Waterline Pipe φ600			m	250.0	
		Other (Mechanical Equipment)		Ls	1.0	
Treatment Plant Facilities						
	Treatment Plant(Civil Works)	Temporary Work		Ls	1.0	
		Earths Works(Excavation)		m^3	4579	
		Earths Works(Bank・Backfill)		m^3	1585	
		Concrete Works		m^3	1870	
		Wall Structure Works	Receiving well：35 ㎡	m^2	35.0	5m×7m
			Flocculation Tank	m^2	110.0	9m×6m×2sites
			Chemical Reservoir	m^2	200.0	14m×7m×2sites
			Sand Filter	m^2	445.0	25.5m×17.5m
			Clear Water Reservoir	m^2	495.0	33m×15m
			Sludge Drying Bed	m^2	495.0	33m×15m
			Other (Mechanical Equipment)	Ls	1.0	
			Pipes Setting	Ls	1.0	
	Other Building Work	Office & Laboratory		m^2	165.0	15m×11m×7.6m
		Chemical Room		m^2	235.0	20m×9m×3.9m
						11m×5m×7.6m
		Mechanical & Electric Room		m^2	120.0	11m×11m×5.3m
		Workshop		m^2	50.0	8m×6m
		Guard House		m^2	15.0	3m×4.5m
Eleectrical & Mechanical Cost (E & M)				Ls	1.0	

Table-III-2.6 Work Quantities for Eastern Water Supply System

Works Description		Works Item		Unit	Quantity	Remarks
Common Temporary Work				Ls	1.0	
Intake & Conduit						Height×Wide×Length
	Intake Weir& Pump Pit	Temporary Work		Ls	1.0	7.8×20×30m
		Earths Works(Excavation)		m^3	3300.0	
		Earths Works(Backfill)		m^3	2000.0	
		Earths Works(Bank)		m^3	5200.0	
		Concrete Works		m^3	650.0	
		Masonry Works		m^3	2700.0	
		Intake(Pump Pit)		m^2	110.0	10m×11m×4.0m
	Waterline Pipe φ600			m	200.0	
		Other (Mechanical Equipment)		Ls	1.0	
Treatment Plant Facilities						
	Treatment Plant(Civil Works)	Temporary Work		Ls	1.0	
		Earths Works(Excavation)		m^3	4579	
		Earths Works(Bank・Backfill)		m^3	1585	
		Concrete Works		m^3	1870	
		Wall Structure Works	Receiving well：35 ㎡	m^2	35.0	5m×7m
			Flocculation Tank	m^2	110.0	9m×6m×2sites

Works Description		Works Item		Unit	Quantity	Remarks
			Chemical Reservoir	㎡	200.0	14m×7m×2sites
			Sand Filter	㎡	445.0	25.5m×17.5m
			Clear Water Reservoir	㎡	495.0	33m×15m
			Sludge Drying Bed	㎡	495.0	33m×15m
			Other（Mechanical Equipment）	Ls	1.0	
			Pipes Setting	Ls	1.0	
	Other Building Work	Office ＆ Laboratory		㎡	165.0	15m×11m×7.6m
		Chemical Room		㎡	235.0	20m×9m×3.9m
						11m×5m×7.6m
		Mechanical & Electric Room		㎡	120.0	11m×11m×5.3m
		Workshop		㎡	50.0	8m×6m
		Guard House		㎡	15.0	3m×4.5m
Transmission Facility						
	Waterline Pipeφ600			m	31,000.0	
	Water Pipe Bridge	L=10m,50m,95m,100m		Site	1	
		L=20m		Site	3	
		L=25m		Site	5	
		L=35m		Site	2	
Electrical ＆ Mechanical Cost (E ＆ M)				Ls	1.0	

2.5 Construction Plan

(1) Works Description for Water Supply System

Work description for southern Bali area water supply system is shown in Table-III-2.7.

Table-III-2.7 Contents of Works for South Bali Area Water Supply Project

Facility Name	Intake River	Content of Works	Remark
West System	Penet river	1.New Water Treatment Facilities（300 liter/sec）	
		2.Waterline Pipeφ600　8.8 km	
East System	Petanu River	1.New Water Treatment Facilities（300 liter/sec）	
		2.Waterline Pipeφ600　31.0 km	
Central system	Ayung River	1.New Water Treatment Facilities（1800 liter/sec）	･Existing Water Treatment Plant
		2.Waterline Pipe　non	･Capacity：1000 liter/sec

(2) Construction Site

Construction site for each water supply system is shown in Table-III-2.8.

Table-III-2.8 Construction Site of each Water Supply System

Facility Name	Construction Site	Site Area
West System	The Facility is located on the left side on the upper reach from the mouth of Penet River about 2km.	About 5,000 ㎡
East System	The Facility is located on the right side on the upper reach from the mouth of Petanu River about 1km.	About 5,000㎡
Central system	The Facility adjoins existing Ayung Water Treatment Plant on the upper reach from the　Mouth of Ayung River about 10km, and it is located in the right bank side .	About 30,000 ㎡

(3) Construction Method

Construction method for main facilities is shown in Table-III-2.9.

Table-III-2.9 Construction Method of Main Facility

Facility	Construction Method or Construction Sequence	Remark
1)Intake Weir	・Because it becomes work inside the river, it is done in dry season (in May, - October). ・Execution is done with method of the half-river deadline.	Intake weir of the central system should be constructed in the final scale (1.8m ^{3}/s).
2)Water Treatment Plant	・It is planned by a grade-like execution along water-demand. Western system does for 1 year and eastern system does for 2-3 years next. ・As for the central system of big capacity(1800 liters/sec), it is divided in the facility of the water ability of 600 liter/sec, and constructed.	
3) Water Pipe	・Adjustment with the road administrator is necessary before the execution. ・The construction of water pipe is presumed at the 60m/ day. ・The execution of the western system is done for six months(8,800m／60m／25day／month). ・The execution of the eastern system is done for six months(3,100m／60m／25day／month).	

(4) Construction Schedule

Construction Schedule for southern Bali area water supply system is shown in Table-III-2.10. It takes four years for both western system and eastern system. After completion of these systems, central system shall be started at the fifth year.

Table-III-2.10 Construction Schedule for Southern Bali Area Water Supply System

System Name and River Name	Works Description	1 yesr		2 year		3 year		4 year		5 year		6-8 year		9 year		10-12 year		13 year	
		dry	wet	dry	wet	dry	wet	dry	wet	dry	wet	dry	wet	dry	wet	dry	wet	dry	wet
West System	Intake weir	*																	
Penet River	Treatment Plant	*	*																
Water Supply Capacity 300 liter/s	Waterline Pipe	*	*																
Intake weir	Water Pipe Bridge	*	*																
East System	Intake weir			*															
Petanu River	Treatment Plant			*	*														
Water Supply Capacity 300 liter/s	Waterline Pipe			*	*	*	*	*	*										
Intake weir	Water Pipe Bridge			*	*	*	*	*	*										
Central System	Intake weir									*				*				*	
Ayung River	Treatment Plant									*	*			*	*			*	*

Dry Season May-October, Wet Season November-April

CHAPTER 3 AYUNG MULTIPURPOSE DAM

3.1 General

With aim at water supply for drinking water, irrigation water, river maintenance water and power generation, Ayung Multipurpose Dam was selected for the water resource of the central system as a part of Southern Bali Water Supply Project based on the Master Plan Study. Dam site for Ayung multipurpose dam with catchments area of 218km^2, reservoir volume of 1,000 thousand m^3 and dam height of 66m is located at the downstream of meeting points of Ayung River and Siap River, belong to Buangga village Petang District in Badung Regency in right side and Payangan village Payangan District Gianyar Regency in the left bank.

Figure-III-3.1 Ayung Damsite from Downstream

The construction purpose of Ayung dam is shown as follows:

Development of Water Supply for Municipal Water

Depend primarily on use of stored water by Ayung Dam, municipal water of 1,800 l/sec (155,500m^3/day) shall be developed and taken at the water treatment plant IPA AYUNG. Due to development of water resource, the prospective shortage of water supply for drinking in Southern Bali Area such as Denpasar City, Badung Regency and Gianyar Regency shall be eliminated.

Expansion of Cultivation Area during Dry Season

By outflow discharge stored by Ayung dam, existing cropping pattern in irrigated area of 9,000 ha located in downstream shall be maintained, cultivation area of paddy from single cropping to double cropping shall be expanded even during the drought season which has occurred with the probability of 1 year for 5 years.

Maintenance and Improvement of River Environment

By outflow discharge stored by Ayung dam, river environment so as to maintain 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.

Hydro-power Generation

By using the differential head of water stored by Ayung dam, electric power of 8,000 Kw shall be generated.

As part of local development, the development program for the reservoir area of 60 ha and the road crossing dam body available for passage between Buangga in Badung Regency and Payangan in Gianyar Regency shall be introduced.

The Ayung River, forming a deep valley at the project area, runs southward. 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.

According to the previous study, the basement of the site is volcanic sandstone with gravel, volcanic breccia. 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 310m in elevation. 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.

Geological survey including core-drilling for 5 holes with total length of 500m and laboratory tests were executed along the dam site for the purpose of collection of geological condition, rock conditions and permeability and ground water level. Based on the geological study, gravity dam for Ayung dam was designed and the project cost was estimated.

3.2 Criteria for Dam Design

For the dam design, referring to not only Indonesian Standards May, International Commission on Large Dams Standards but also the Japanese Standards, the following items were settled:

Criteria for dam design are as shown in Table-III-3.1.

Table-III-3.1 Criteria for Dam Design

Item	Specifications
Location	Ayung River Buangga village Petang District in Badung Regency in right side, Payangan village Payangan District Gianyar Regency in left side
Design standard	Design Standard authorized by International Commission on Large Dams (ICOLD)
Material values of Dam Foundation	Design shear stresses are as follows. - CH class $\tau = 160tf/m^2 + \tan 45°$ - CM class $\tau = 80tf/m^2 + \tan 40°$ - CL class $\tau = 40tf/m^2 + \tan 30°$
Design Discharge for Spillway	- Catchment Area : 218.4 km^2 - Design Discharge : 1,270 m^3/s (Return Period: 1,000 years) - Specific Discharge : 5.81 $m^3/s/km^2$
Design Sediment Amount	1,000,000m^3 (Storage capacity for sedimentation of Dam) 3,600,000m^3 (controlled sediment volume by 2 Check Dams to be constructed in upstream)
Storage Capacity	- Gross storage capacity : 10,000,000 m^3 - Water use capacity : 9,000,000 m^3 - Storage capacity for sedimentation : 1,000,000 m^3

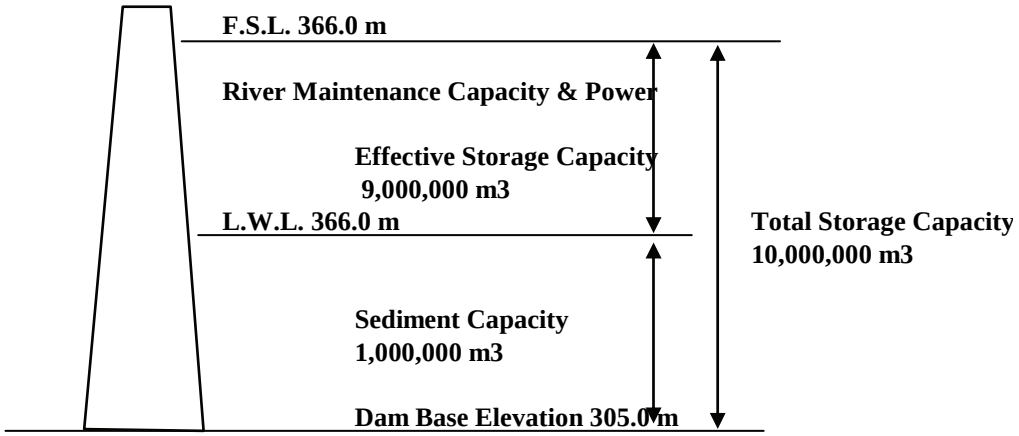


Figure-III-3.2 Distribution of Storage Capacity and Water Level of Reservoir

3.3 Geological Conditions

3.3.1 Geological Survey Results

Topographic survey and geological investigation were executed at the dam site of Ayung Dam. Quantities and location of the survey are shown in Table-III-3.2 and Figure-III-3.3.

Table-III-3.2 Discription of Topographic Surveys and Geological Investigation

Classifications	Items	Quantities
1) Topographic survey	Longitudinal profile survey	10 lines L= 3,650m
	Cross section survey	11 lines L= 5,275m
2) Geological survey	Core drilling	5 holes (DA-6,7,8,9,10) L= 480m
	Permeability Test (constant head test, Lugeon test)	102 nos.
	Standard penetration test	32 nos.
	Installation of screen pipes	400m
	Laboratory tests	1 set

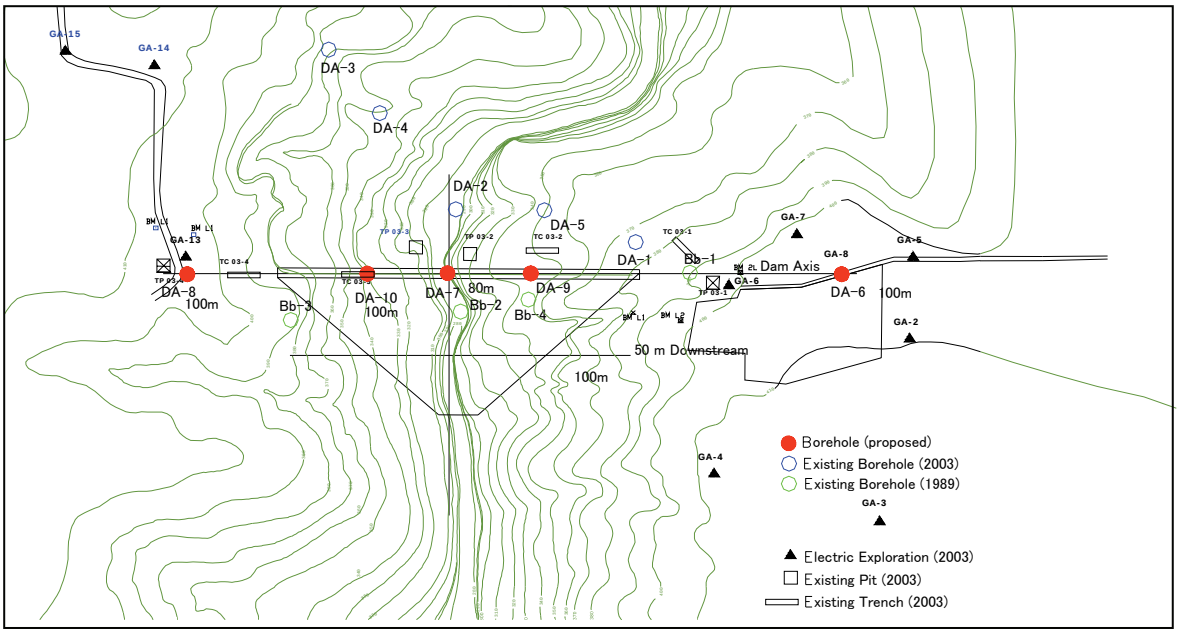


Figure-III-3.3 Location Map of Geological Investigation (Source: JICA Study Team)