4.3.2 Benel Dam Development Plan

Shortage of irrigation water with area of about 966 ha and local water supply in Mekarsari and Manistutu located at downstream of Aya Barat river in Jembrana Regency was very severe especially during dry seasons in recent years. Small reservoir at upstream of Aya Barat River was planned for the supply of water by Bali Water Resources Development and Management Project. In addition, this reservoir planned to be providing raw water supply for domestic use of about 64 l/sec for Melaya district and Negara district in Jembrana Regency.

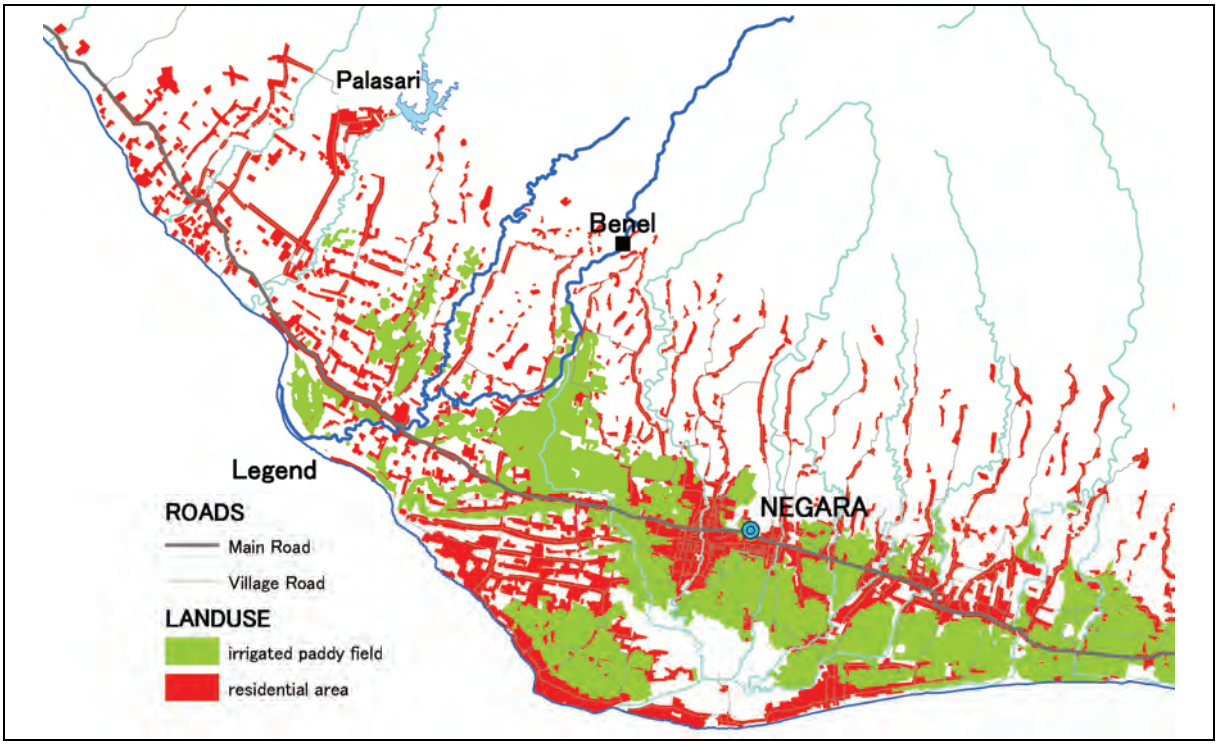


Figure-II-4.40 Location of Benel Dam

Main objectives of the Project are shown as follows;

- Irrigation water for irrigated area 966.0 ha with 1.59 m^3/sec.
- Irrigation water for Intake II (Upstream) irrigated to area of 42 ha with 0.069 m^3/sec
- Raw water supply for domestic use of about 64 l/sec for Melaya and Negara in Jembrana Regency.

Considering the above matters, a planning on Integrated Development Plan for Aya Barat River will be prepared. Specifications of Benel dam are shown in Table-II-4.34.

Table-II-4.34 Specifications for Benel Dam

Classifications	Items	Specifications
1. Reservoir	1)Location	Aya Barat River (Desa Manistutu)
	2)Catchments Area	18.3 km^2
	3)Full Supply Level(FSL)	EL 171.5 m
	4)Low Water Level(LWL) Minimum Operation Level(MOL)	EL 151.0 m
	5)Active Storage	1,618,000 m^3
	6)Sedimentation Storage	305,000 m^3
	7)Total Storage	1,923,000 m^3
2. Dam	1)Type of Dam	Rockfill Type (Central Core Type)
	2)Crest Elevation	EL 175.5 m
	3)Dam Basement	EL 138.0 m
	4)Dam Height	37.5 m
	5)Construction Cost	JP¥ 850.8 mill.

Plan and Typical Section are shown in Figure-II-4.41 and Figure-II-4.42.

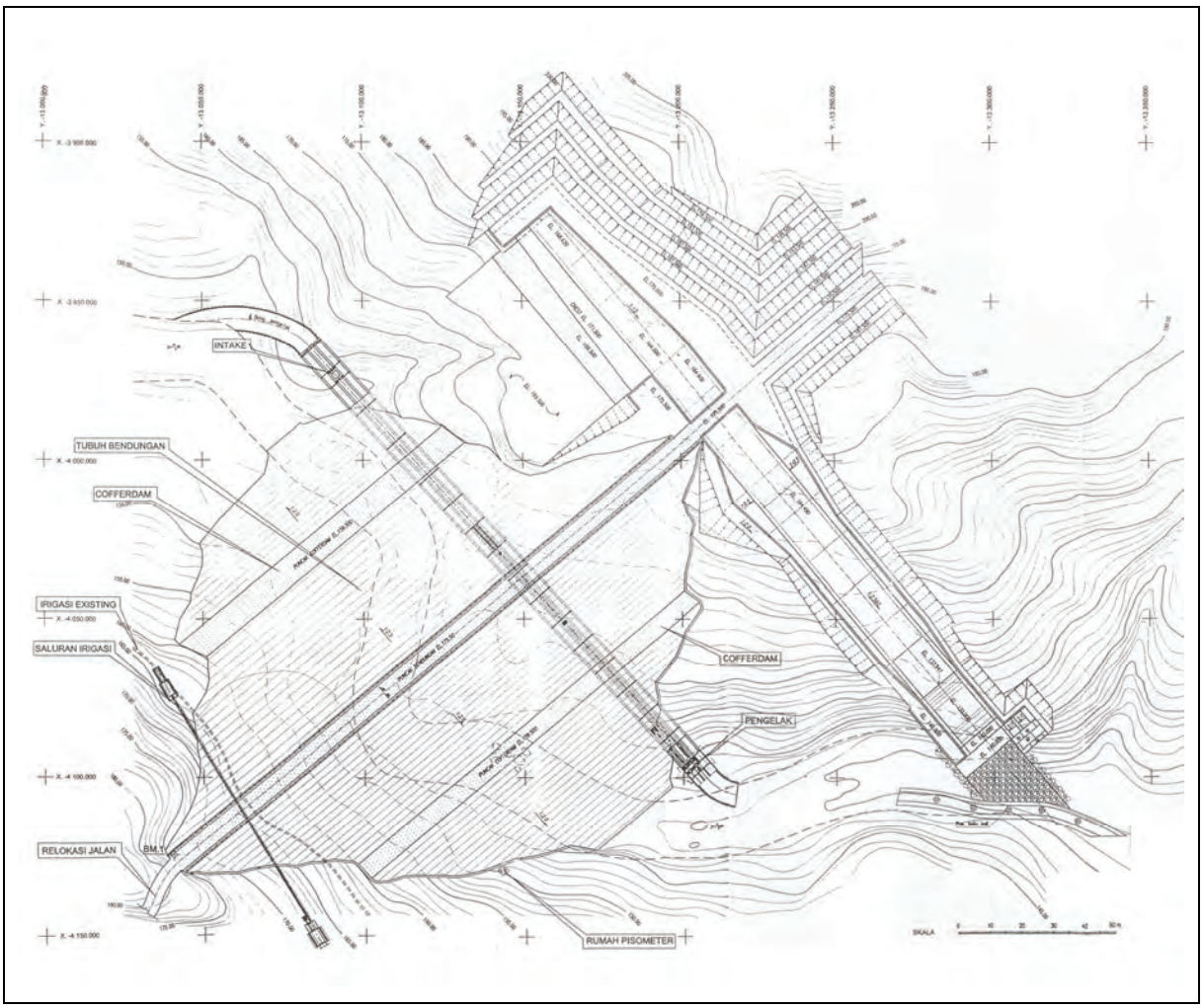


Figure-II-4.41 Plan

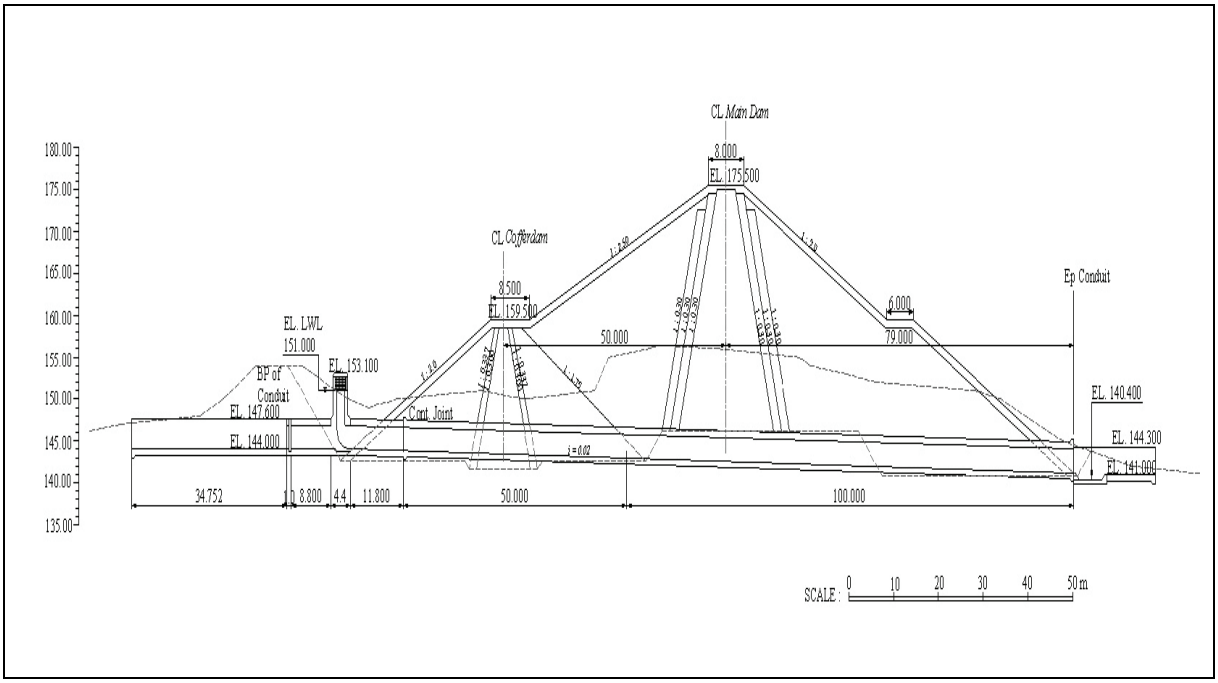


Figure-II-4.42 Typical Cross Section

CHAPTER 5 FLOOD CONTROL PLAN

5.1 Countermeasures against Flood Control

As described in Sub Section 3.4.2 in this report, flood control countermeasures which include not only structural measures but also non-structural measures are to be applied on the basis of the policy of "*STAY HARMONY WITH WATER*".

A system of comprehensive flood control countermeasures is shown in Table-II-5.1.

Table-II-5.1 System of Comprehensive Flood Control Countermeasures

Classifications	Contents of Countermeasures		Non-structural
1.River Improvement	1.1River improvement(Dykes, Revetment, Excavation)		
	1.2Construction of Retarding area, Diversion water way, and so on		
2.Countermeasures for Catchments Areas	2.1Retention Areas	2.1.1 Land use restriction	○
		2.1.2 Vegetation control & Greenery conservation	○
		2.1.3 Detention pond	
		2.1.4 Rain water storage(off-site, on-site)	
		2.1.5 Permeable pavement, Infiltration pit	
	2.2 Retarding Areas	2.2.1 Land use restriction	○
		2.2.2 Land banking restriction	○
		2.2.3 Farm environment improvement	○
	2.3 Low land Areas	2.3.1 Landside drainage system	○
		2.3.2 Storing Pond	
		2.3.3 Water proof houses, buildings, facilities	
3.Damage Mitigation	3.1 Evacuation and warning system		○
	3.2 Flood defense activities		○
	3.3 Hazard map(Flood, Sediment)		○
	3.4 General river management(sedimentation, facilities, deposits, etc)		○
	3.5 Public relations, awareness		○
	3.6 Flood insurance		○

Of these countermeasures shown in Tabele-II-5.1, countermeasures on off-site storage and low land infiltration, land use regulation, flood proof facilities and flood fighting systems, etc are summarized as below.

(1) Off-site Storage (Countermeasure 2.1.4)

To meet the recent population expansion in Denpasar, large scale land development for residential areas is currently being carried out in the catchments area. This kind of land development usually causes an increase of runoff and sediment discharge. To maintain former condition of the runoff system, regulation reservoirs to store increasing flood and sediment discharge are essential.

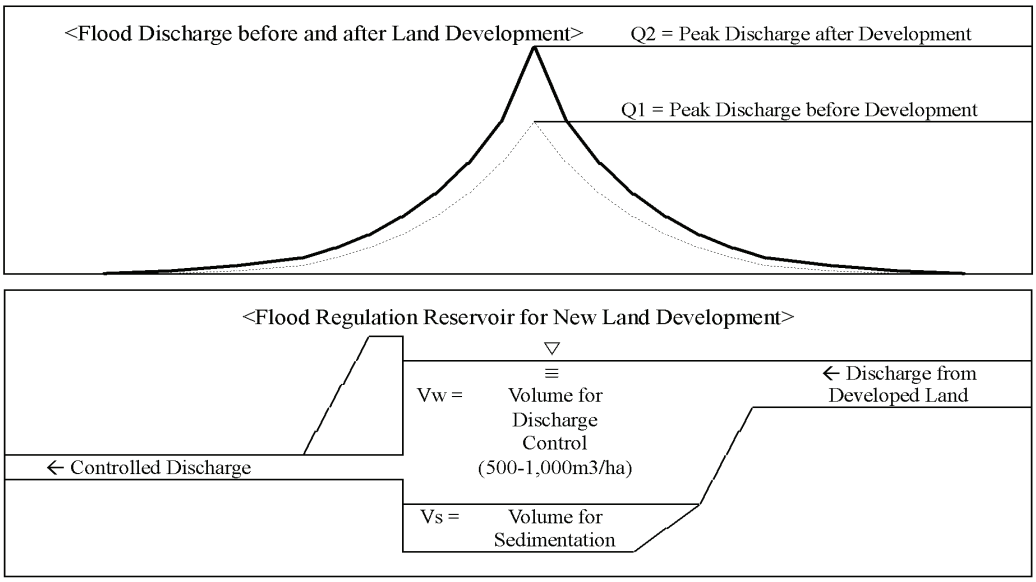


Figure-II-5.1 Schematic Off-site Storage System for New Land Development

(2) Lowland Infiltration (Countermeasure 2.1.5)

In the densely populated lowland areas which are the targets of flood protection, infiltration of rain water using the following methods is useful to decrease rain water discharge.

- **Permeable Drainage System:**
  During heavy rainfall, lowland areas suffer from inundation caused by rain water falling on such areas due to shortage of drainage system. Final solution for this problem is to establish an appropriate system. This permeable drainage system includes underground infiltration trench, infiltration pit, infiltration well and so on.
- **Pervious Pavement Road:**

  To decrease discharge from roads which are usually paved with impervious materials such as concrete and asphalt, pervious pavement road is effective.

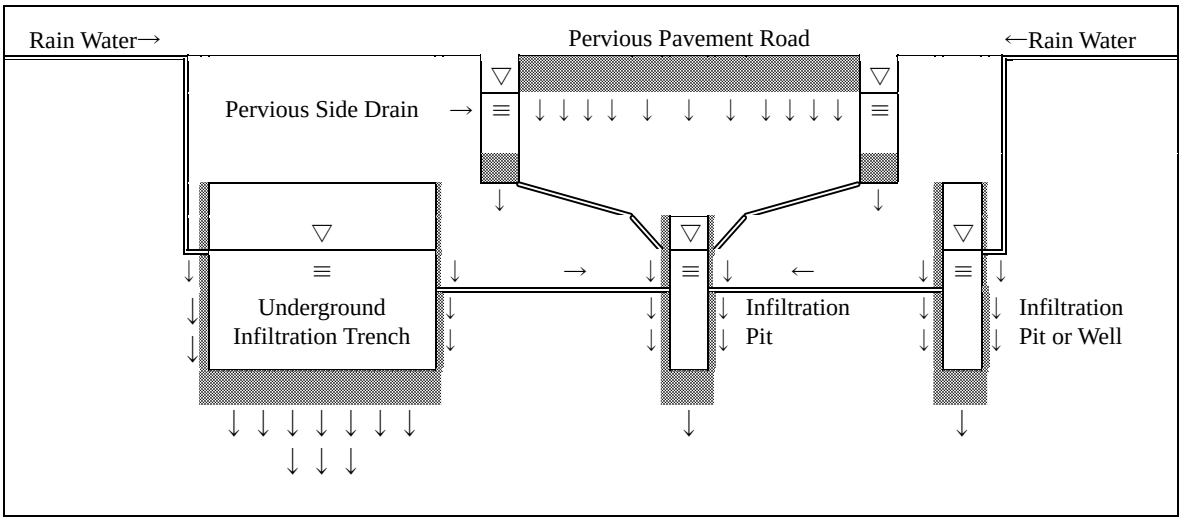


Figure-II-5.2 Infiltration System in Lowland Areas

(3) Land Use Regulation (Countermeasure 2.1.1)

In the upstream flood prone areas where the river improvement work is not yet completed, land use along the river shall be restricted by authorized regulation. Along the river side belt zones, construction of building shall be prohibited. To prevent flood damage, soil erosion and water pollution, this regulation shall be implemented completely.

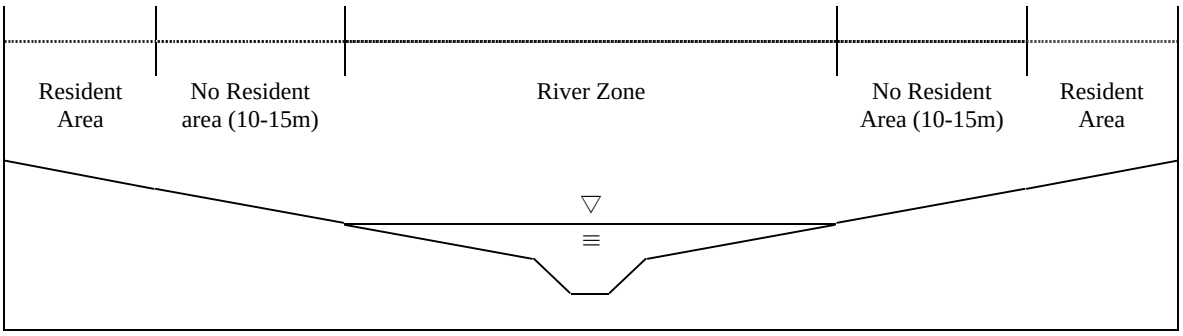


Figure-II-5.3 Land Use Regulation along River Channel

(4) Flood Proof Facilities (Countermeasure 2.3.3)

To minimize inundation damage to private and public assets during flood time, flood proof facilities such as raised sidewalks and lowered roads, as shown in Figure-5.4, are recommendable. Also, important public facilities shall be independently protected against inundation with protecting walls, gates etc., if necessary.

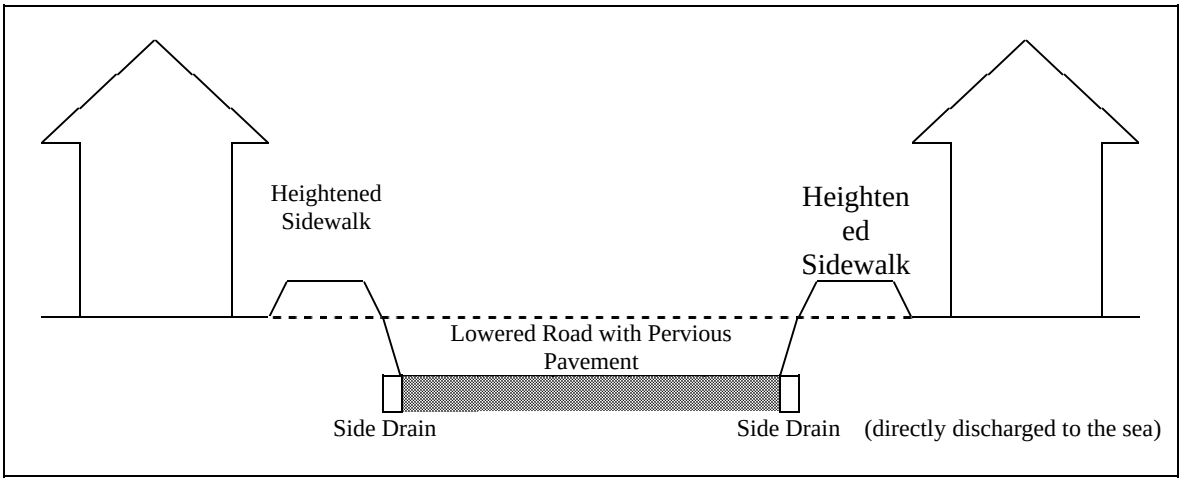
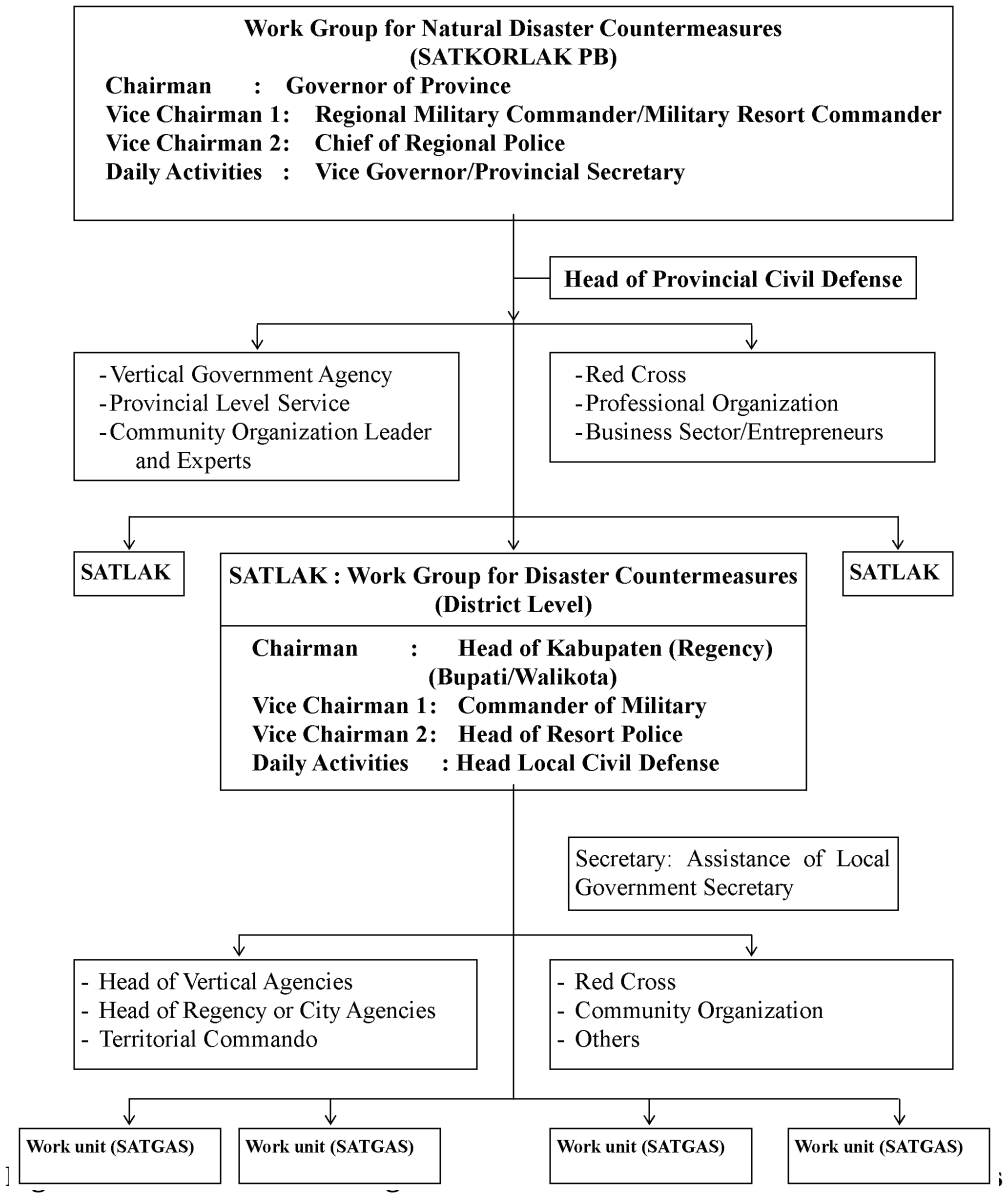


Figure-II-5.4 Flood Proof for Town Street

(5) Flood Fighting System (Countermeasure 3.2)

In Indonesia, the emergency relief system for natural disaster is already well established and functions as shown in Figure-II.5.5. This figure shows the organization of work group committee for national disaster countermeasures in province level(SATKORLAK) to in district level called ”SATLAK” with smallest work unit so called “SATGAS ”. In the broad sense, this system is a kind of flood fighting system.

As shown in Figure, establishment of the flood fighting team as a work unit “SATGAS” under SATLAK is recommended. The targets of the team are: 1) to implement urgent rehabilitation of flood control works during flood time, 2) to monitor constructed flood control works on a regular basis, and 3) to establish evacuation route for each flood prone area and to facilitate services for evacuation of inhabitants. A storage facility for emergency relief is required to store emergency equipment and materials for civil works.



(6) River Management Zone (Countermeasure 3.4)

To maintain the flood control facilities along the river channel, the establishment of river management zone(s) of width 5 - 10 meters is recommended. This river management zone shall be implemented simultaneously with the construction of river improvement works. However, it will be carried out step by step according to authorized city planning, including land use plan and road plan, as land acquisition along the densely populated river side is currently very difficult.

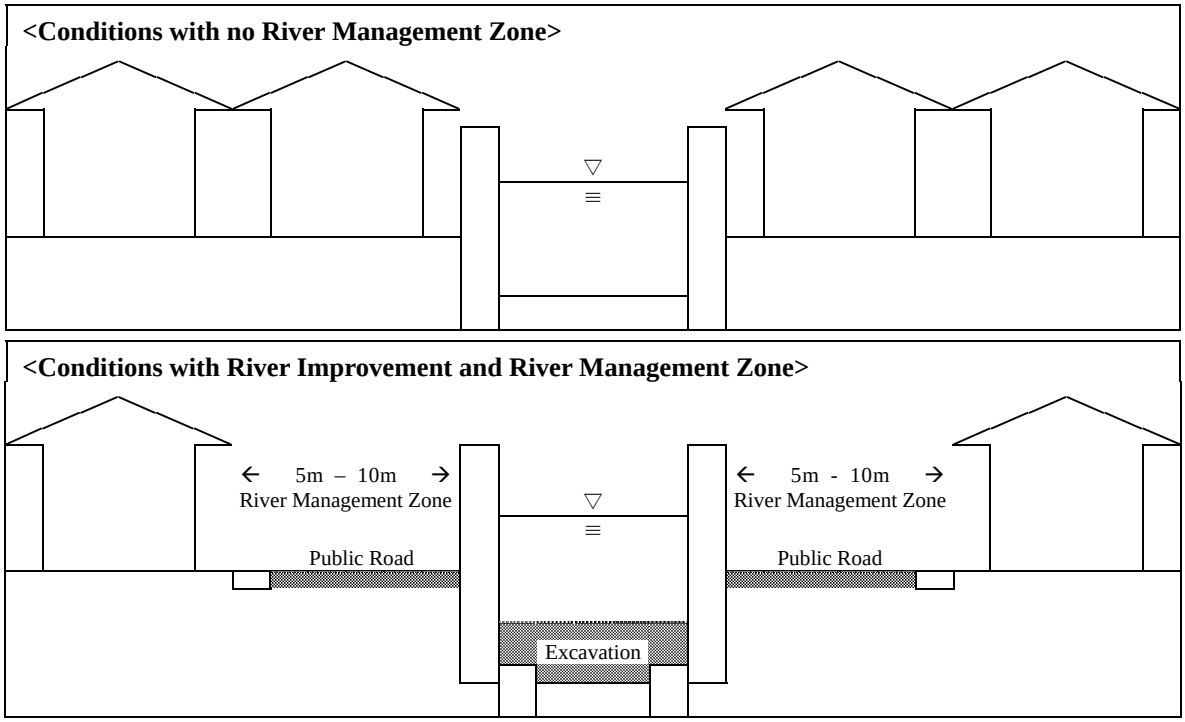


Figure-II-5.6 River Management Zone

Flood control plan for Badung River in the master plan, river improvement was adopted, whereas river improvement plan and construction of retarding area with land use restriction were adopted for Mati River. Flood defense activities by the reorganization of work unit SATGAS shall be found to be useful in the area of Badung River and Mati River. Lowland infiltration with storage function shall be adopted in the area of motor pool, ground and park in Badung and Mati Catchments areas.

5.2 Flood Control Plan

5.2.1 Current Conditions and Problems on Flood Occurrences

There are 111 records of flood occurrence in Bali Province during 23 years starting from 1982. Of these records, the occurrences of flood concentrate in Denpasar City, Buleleng Regency, Jembrana Regency and Karangasem Regency. Among them, the river basins where floods are happened many times are Badung River in Denpasar City, Mati River in Badung Regency, Buleleng River in Buleleng Regency and Sowan River in Jembrana Regency.

Based on the newspaper and disaster records arranged by Provincial Public Works Service Office(Dinas PU-PROP), the times of occurrence of flood, inundation, debris flow and landslide for each Regency are shown in Table-II-5.2. Locations of these disasters are shown in Figure-II-5.7.

Table-II-5.2 Number of Flood and Sediment Disasters in Bali Province

Regency	Flood and Inundation	Debris Flow	Slope Failure	Landslide	Total
Jembrana	13	1	0	2	16
Tabanan	0	1	0	7	8
Badung	5	0	0	1	6
Denpasar	26	0	0	0	26
Gianyar	1	0	1	4	6
Bangli	0	0	4	4	8
Klungkung	5	1	0	0	6
Karangasem	9	2	0	5	16
Buleleng	52	0	1	47	100
Total	111	5	6	70	192

Note) Data from Dinas-PU and Newspaper

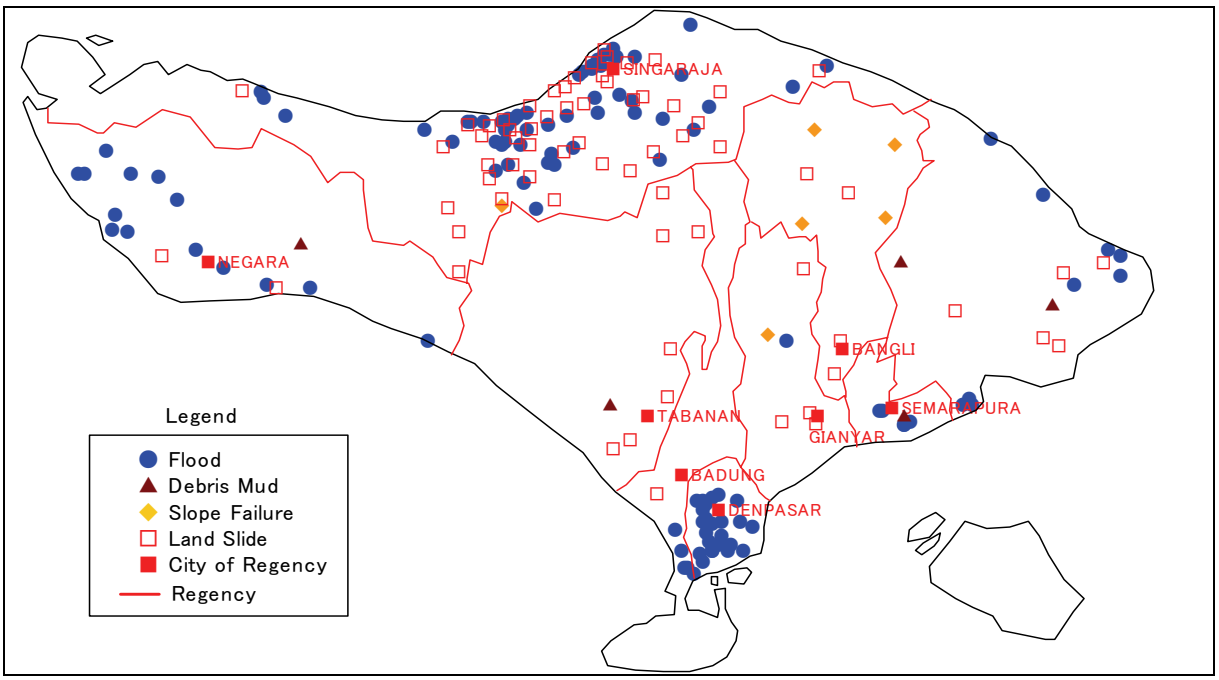
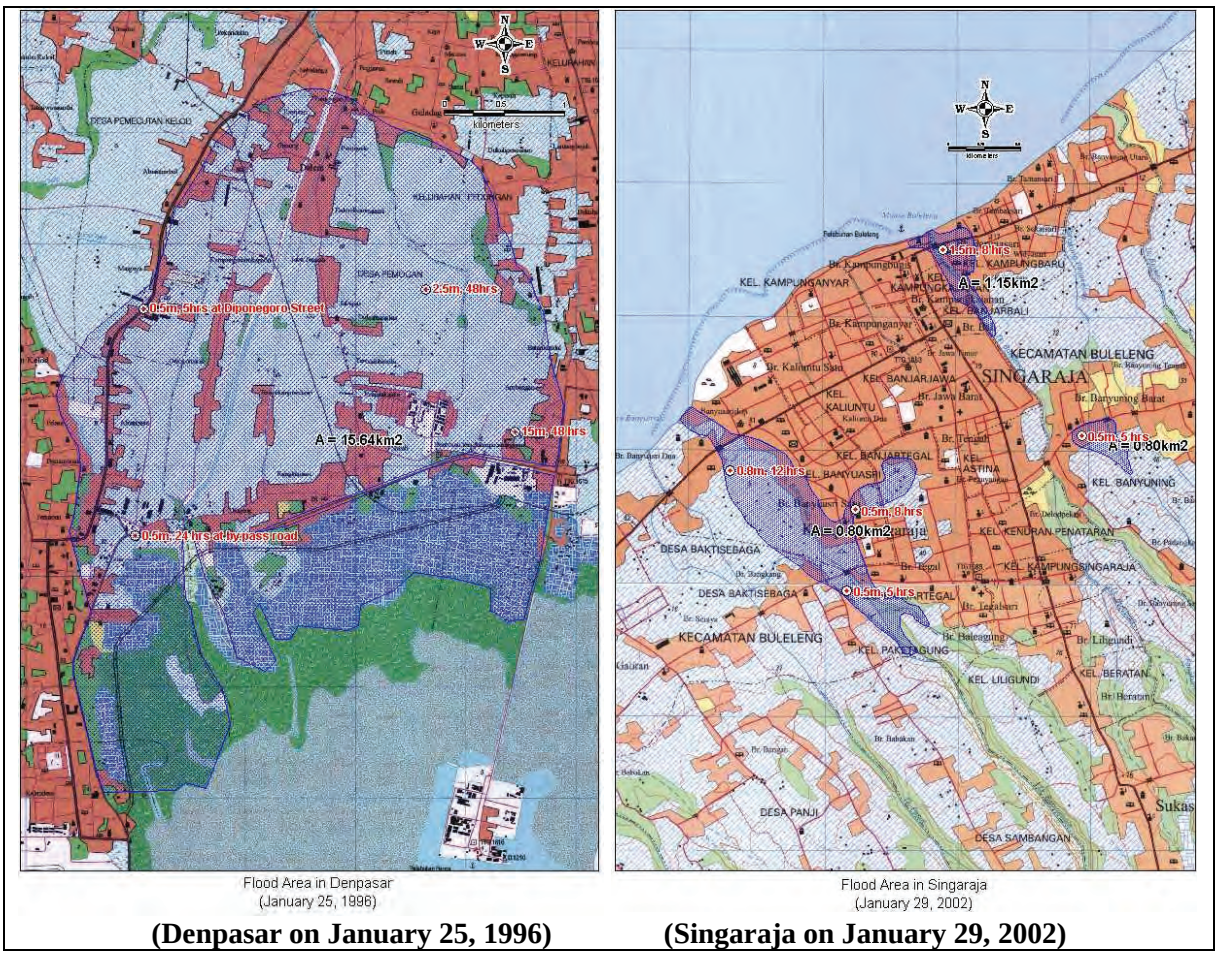


Figure-II-5.7 Location of Floods and Sediment Disasters during 1982-2004

In the severe floods-prone areas of Denpasar, Singaraja and Negara, the inundation conditions of the past floods are investigated based on government reports and interview surveys, and are shown in Table-II-5.2**.** The inundation maps of Denpasar and Singaraja are shown in Table-II-5.3**.**

Table-II-5.3 Inundation Conditions of the Past Floods

City	Date	Inundation Area (ha)	Maximum Inundation Depth (cm)	Maximum Inundation Period (hr)	Note
Denpasar	Jan. 25, 1996	1,506	250	48	Bypass road was being blocked for 24hrs
	Mar. 4, 1984	1,850	100	24	
	Oct. 15, 1999	1,720	100	24	
	Dec. 18, 2003	1,179	100	48	
Negara	Oct. 14, 1998	5,090	100	48	
Singaraja	Jan. 10, 1981	115	150	24	
	Jan. 11, 1987	115	100	24	
	Jan. 29, 2002	275	150	12	
	Feb. 3, 2004	37	150	12	



(Denpasar on January 25, 1996) **(Singaraja on January 29, 2002)**

Figure-II-5.8 Past Flood Inundation Area

Current issues on disasters by flood based on the arrangement of past flood analysis is summarized as follows:

- Due to urbanization in urban area, run-off volume has been increasing in recent years in Denpasar City and its surrounding area. Increasing of runoff volume make disasters repeatedly in Badung River of Denpasar City and in Mati River of Badung Regency. There are many housing and buildings lined so close in both banks of rivers flowing in urban area. Taking into consideration of these current conditions, it is impossible to execute large-scale works of widening and banking for river improvement plan. It would be appear that land acquisition is impossible due to rising land price.
- Many water channels which converted from irrigation channels of the paddy field in the past flows in Denpasar City. Almost of these channels show a shortage of flow capacity for large rainfall intensity.
- There was inundation disaster caused to mistake by gate operation of weirs in Denpasar City. For the disaster prevention, guidance for gate operation shall be required.
- The river improvement projects caused to inundation by 1998 flooding in progress are Sowan River and its tributaries near Negara in Jembrana Regency. In Sigaraja area, drainage countermeasures for inland low-lying area in Buleleng River and riverbed excavation as well as banking in Banumala River should be required.

（Upsream View from Hasanudin Street,　Downstream view from Misol Bridges）

Figure-II-5.9 Badung River in Denpasar

(Umadui Weir for Irrigation,　Mati River near Kuta Area)

Figure-II-5.10 Mati River in Badung Regency

(Upstream View from ErlangaStreet : Buleleng River in Singaraja)

(Negara:River Mouth of Sowan River)

Figure-II-5.11 River Condition in Singaraja and Negara Area