5. KINANLIMAN RIVER BASIN

5.1 Basin Conditions

5.1.1 Natural Conditions

(1) Topography

The Kinanliman River Basin is mountainous with steep slopes in the northern peaks of the surrounding Mt. Binangona. Table G.5.1 shows share of elevation zones in the Kinanliman River Basin. The average elevation is 367 m. About 80% of the catchment area is higher than 200 m above MSL. Only 2 % is less than 20 m above MSL, which is relatively flat. The topographic map of the basin is shown in Figure G.5.1. The most downstream reach with about 1km has relatively mild slope, at which build-up area is developed.

Table G.5.1 Elevation Zone of the Kinanliman River

Elevation (m)	0-20	20-100	100-200	200-400	400-600	600-800	800-1000	Total
Area (km^2)	0.22	0.75	1.18	4.30	2.32	1.04	0.30	10.11
Percentage (%)	2.17	7.39	11.70	42.53	22.99	10.29	2.94	100.00

(2) Existing River System and Structure

The catchment area of the Kinanliman River Basin is 10 km^2. Reflecting its small catchment area, total river length is about 5km. Kinanliman River is typical mountainous river. The gradient of the main stream is summarized as shown below.

Table G.5.2 River Gradient of Kinanliman River

Reach	Slope
0 - 0.9 km	1/50
0.9 - 2.3 km	1/30
2.3 - 5.0 km	1/15

Sediment size of the riverbed is very large in general. Even in the most downstream reach, rock with more than 0.5m can be often observed in the riverbed.

The existing structures relating to flood control are, as follows:

- Kinanliman Bridge
- Revetment works constructed mainly around Kinanliman Bridge

On the other hand, there is a water intake along Kinanliman River. This is one of main sources of portable water for Municipality of Real. Figure G.5.1 shows the topographic map of the basin.

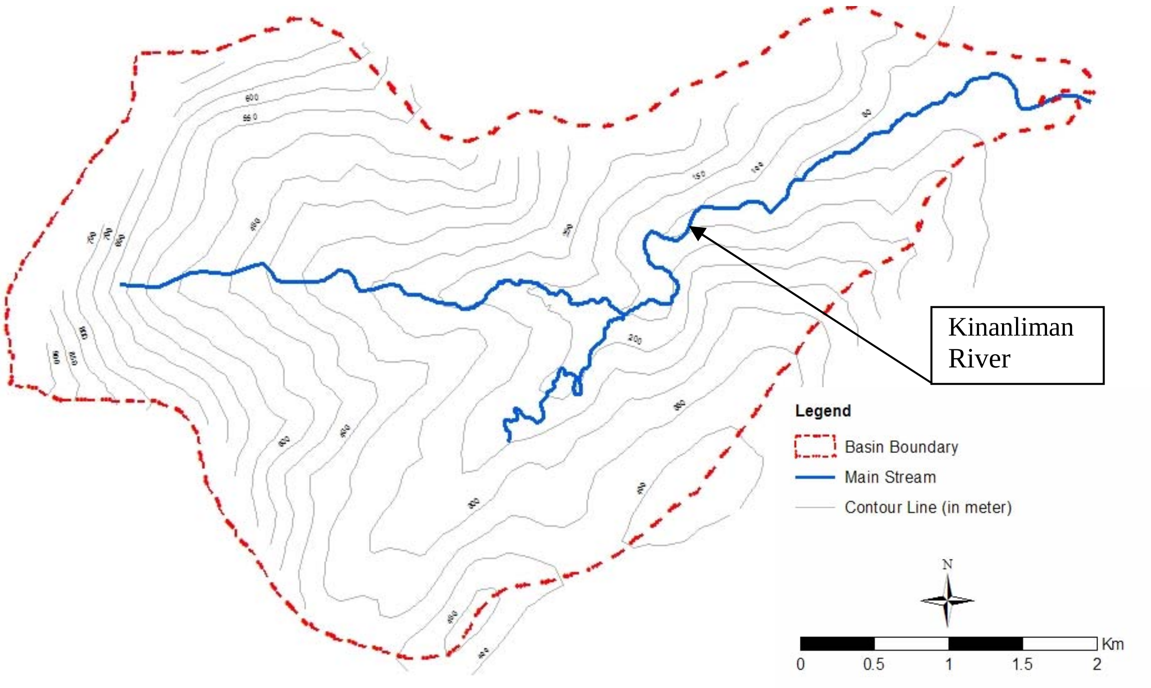


Figure G.5.1 Topographic Map of the Kinanliman River Basin

(3) Meteorology and Hydrology

The Kinanliman River Basin falls under Type IV of the modified Corona's climate classification. Rainfall is more or less evenly distributed throughout the year. This part of the country is exposed to the northeast monsoon, which brings strong winds and torrential rains during half of the year.

Because of small total catchment area and steep gradient of the river, time of concentration of flood is estimated at about 50 minutes. This hydrological characteristic can cause flash flood in the Kinanliman River Basin even in the most downstream reach.

(4) Regional Geology

The distribution of rocks in this river basin includes limestone, diorite and andesite, which are also common to other municipalities of the Province of Quezon.

5.1.2 Social and Economic Conditions

(1) Population and its Growth

The total population of the municipality based on the 2000 NSO Census is 30,684, in which about 63% is found in the rural areas. The population by 2020 is projected to reach 61,000 assuming the current growth rate of 2.11%. The aggregate population density for the urban area is 222 persons/km^2, while for the rural area, the population density is 38 persons/km^2.

(2) Land Use

1) General Feature

In Municipality of Real, only 16% of the total land area is relatively flat and suitable for urban expansion. Further, the municipal territory of Real is covered by several presidential proclamations (Buriquela National Park, UP Land Grant, DAR Reservation Lot1, etc.) that reserve huge tract of land for specific purposes. Nearly half of the land area of Real falls under these proclamations. In terms of land uses, the Municipal Land Use Plan has identified four types of settlement areas for its urban growth areas: urban settlements; agrarian reform communities (ARC); non-ARC rural communities; and indigenous people’s settlements.

2) Land use in the Kinanliman River Basin

Figure G.5.2 shows the land use map of the basin (2002/03). Share of each land use based on the above map is shown in Table G.5.3. Based on this table, built-up area is 1.3% of the total catchment area and is located at around the most downstream reach of the river. More than 80% of the total catchment area is covered by broadleaved forest, while 10% is shrub land, which may have relatively high erosion risk.

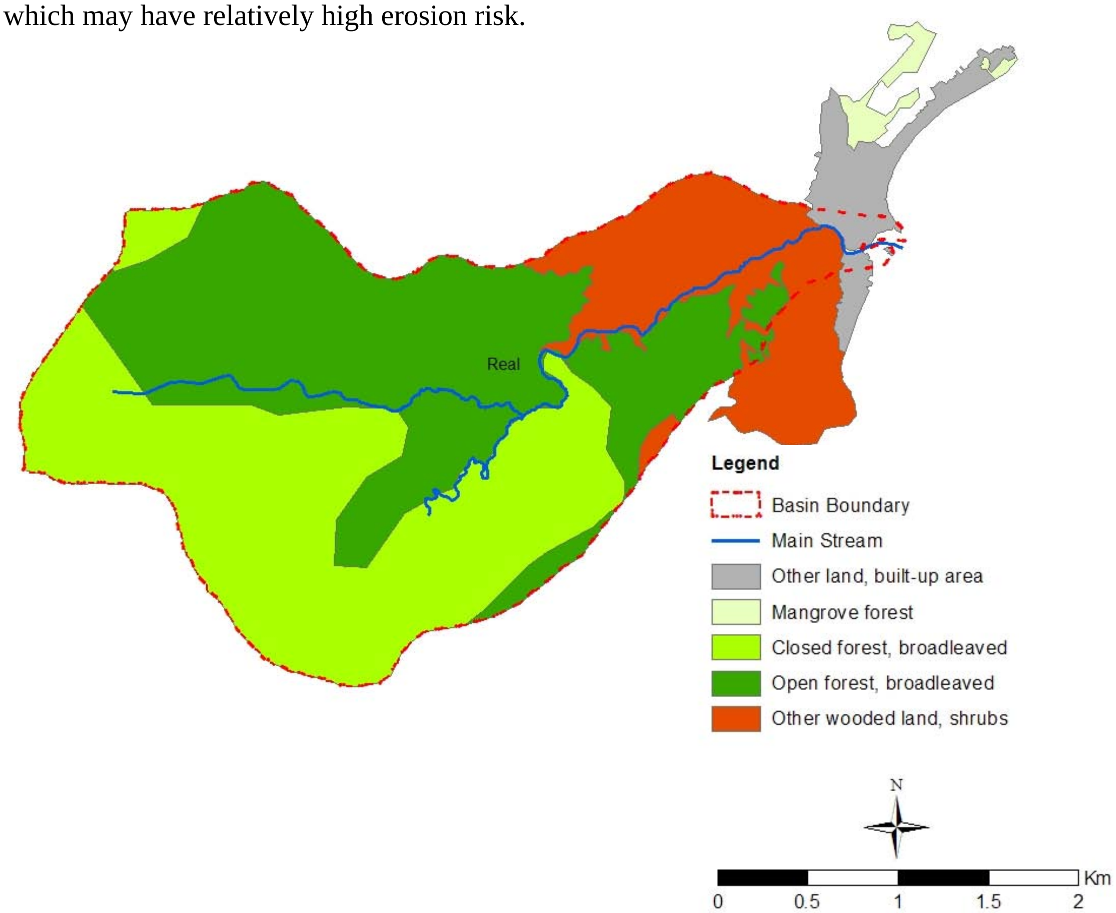


Figure G.5.2 Existing Land Use in the Kinanliman River Basin

Table G.5.3 Share of Land Use in the Kinanliman River Basin

Class	Area (km^2)	Percentage
Closed forest, broadleaved	4.24	41.9
Forest plantation, broadleaved	0.00	0.0
Inland water	0.00	0.0
Mangrove forest	0.00	0.0
Open forest, broadleaved	4.47	44.2
Other land, built-up area	0.13	1.3
Other land, cultivated, annual crop	0.00	0.0
Other land, cultivated, perennial crop	0.00	0.0
Other land, fishpond	0.00	0.0
Other land, natural, barren land	0.00	0.0
Other land, natural, grassland	0.00	0.0
Other wooded land, shrubs	1.27	12.6
Other wooded land, wooded grassland	0.00	0.0
Total	10.11	100.0

(3) Local Economy

1) Agriculture

Agricultural production is focused mainly on rice (107 ha, irrigated), coconut, rootcrops and vegetables. There are 8 commercial broiler farms in the Municipality. On the other hand, the Municipality has fishponds of 282 ha. However, fishponds are economically unattractive due to difficulty in market outlets.

2) Commerce and Trade

A central business district, where most of the commercial establishments are located, can be found at the Poblacion and other three growth centers. Commercial activities include trading, banking and finance services, cottage industries and tourism. As per records gathered, there are about 205 convenience stores, 30 resorts and hotels, 10 construction/electronic supplies, 20 tourism and tourism-related business services.

3) Industry

Industrial activities in the Municipality consist of small-scale quarrying of sand and gravel. It also has a flourishing cottage industry.

4) Tourism

Tourism activity is one of the key economic drivers identified by the LGU in resource generation. Endowed with natural resource diversity, the LGU has numerous natural waterfalls, caves and other natural attraction.

(4) Floods and Flood Damage

1) Floods and Flood Damage

The Kinanliman River Basin experienced devastating flash flood damage at November 29, 2004. This is caused by typhoon Winnie and Yoyong. Summary of families with dead members by this disaster are shown below. In the Kinanliman River Basin, the causality is concentrated to Barangay Poblacion 01.

Table G.5.4 Casualties by Flash Flood (November 29, 2004)

	No. of Families	No. of Dead Persons	Missing
Barangay Poblacion 01	30	58	1
Barangay Poblacion 61	1	1	0
Barangay Ungos	N/A	N/A	N/A
Total in Real	129	241	3

Source: "Profile of Real" provided by Municipality of Real

The daily rainfall amount was more than 400 mm at Infanta. It is said that the probability of the extreme event could be more than 100-year return period.

According to the interview, water level of Kinanliman River started to rise at around 7pm and reached to maximum at around 10pm. People could not evacuate because it was too rapid. Flood depth was about 150 cm in the inland area, at the location of 50 m from the left riverbank. The floodwater overflowed from Kinanliman River reached to the center of the built-up area near the elementary school. However, duration was less than an hour. Around 1km upstream of the Kinanliman Bridge, there were houses of Purok Long Pond. However, almost all of the houses were washed out by floodwater and sediment.

In 2006, high water level around the Kinanliman Bridge appeared again, although damage was not so severe. It is still at risk for flood and debris flow in the Kinanliman River Basin.

2) Major Causes of Floods

Major causes of floods in the Kinanliman River Basin are heavy rainfall and consequent rapid runoff. Flood type is flash flood due to very short time of concentration of flood wave. Sudden and severe sediment load caused by landslides can happen in the Kinanliman River Basin. In this case, the flash flood may accompany with much sediment. This causes rapid aggradations of riverbed, which reduces flow capacity of the existing channel drastically. There is also risk of debris flow.

According to results of the interview in the field survey, formulation of natural dams caused by landslides and woody debris and those corruptions may bring about devastating flash flood. Actually, many people pointed out that it occurred during the 2004 flood.

Another important point is that woody debris accumulated at the Kinanliman Bridge caused backwater toward upstream of the bridge, resulting in overflow from Kinanliman River to the built-up area.

(5) Previous Related Study

After the very severe flood damage in 2004, FCSEC conducted the “Detailed Design Report for the Pilot Project for Kinanliman River, Real, Quezon, March 2007”. Based on the study, training dike in the left bank of Kinanliman River, 490m in total length from the Kinanliman Bridge toward upstream, was proposed as urgent measures, and detailed design has been completed. The location and plan of the proposed dike are shown in Figure G.5.3. The necessity of sabo dam was also preliminary examined and typical drawing of the sabo dam was prepared during the study, although it is not included in the implementation of the urgent works.

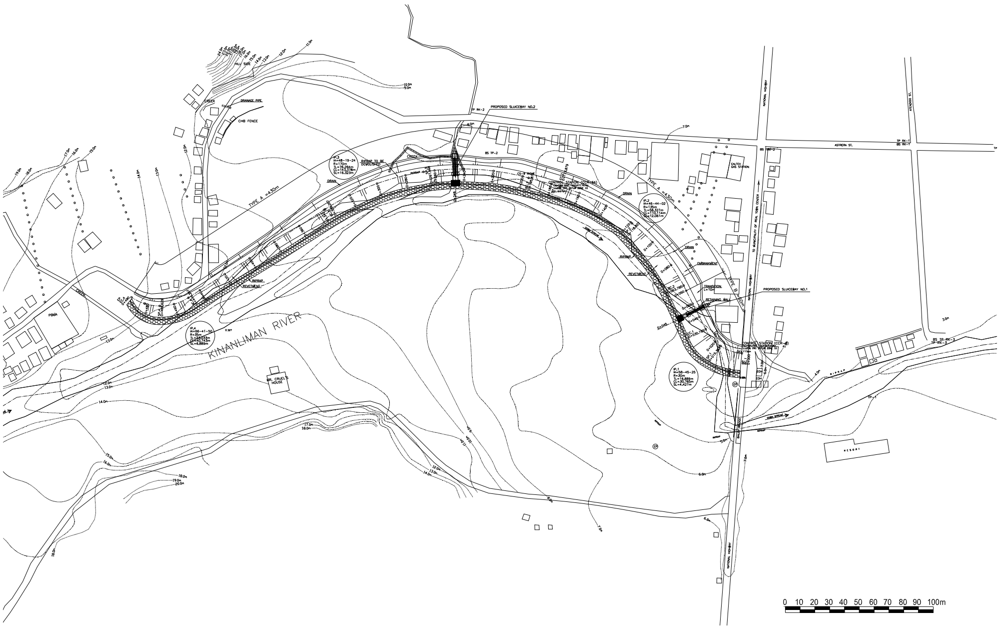


Figure G.5.3 Proposed Training Dike by FCSEC Study in 2007

5.2 Hydrologic Analysis

5.2.1 Design Flood Discharge

The design flood discharge is set with reference to the study in 2007 by FCSEC, in which rational formula is applied. Furthermore, since this river is a debris flow stream, the design flood discharge is increased 1.5 times. Distribution of design flood discharge for 25-year return period is shown in Figure G.5.4.

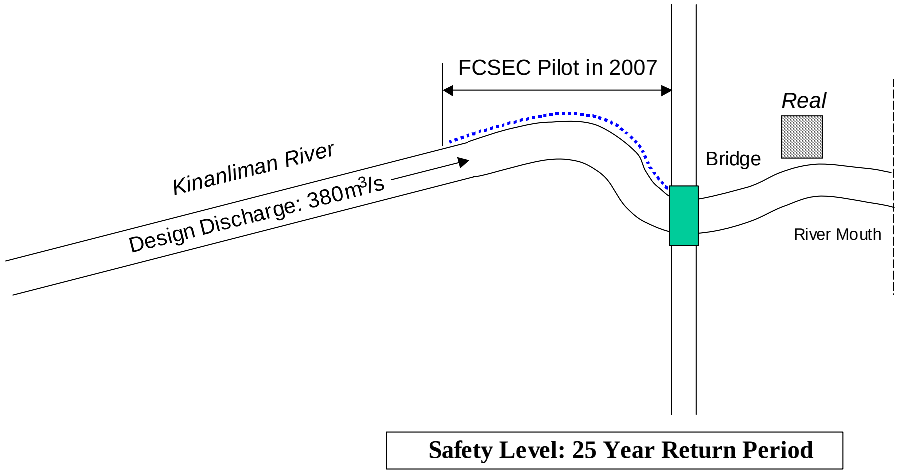


Figure G.5.4 Design Discharge Distribution in the Kinanliman River Basin

5.3 Flood Inundation Analysis

5.3.1 Flow Capacity

The flow capacity of the existing river channel is analyzed with HEC-RAS using the river cross sections newly obtained in the survey. The flow capacity of Kinanliman River at the Kinanliman Bridge is estimated as shown below.

Table G.5.5 Flow Capacity of Existing River Channel in the Kinanliman River Basin

Location of Calculation	Flow Capacity (m^3/sec)
Kinanliman River (Kinanliman Bridge)	190

5.3.2 Flood Inundation Area

Flood inundation area is analyzed with HEC-RAS and HEC-GeoRAS using the river cross sections newly obtained. In the analysis, the altitude data of SRTM is adjusted by comparison with the river cross sectional survey data. As a result, the floods over flow around the Kinanliman Bridge, and the floods flow into the built-up area of Real. The total inundation area is estimated at 13 ha with 25-year return period flood, as tabulated below. Figure G.5.5 shows the inundation area of the basin.

Table G.5.6 Area of Flood Inundation of the Kinanliman River Basin

(Unit: ha)

Land Use	Flood Scale (Return Period)
	25-year
Built-up Area	8.4
Fishpond	0.0
Cultivated, Annual Crop	0.0
Other	4.2
Total	12.6

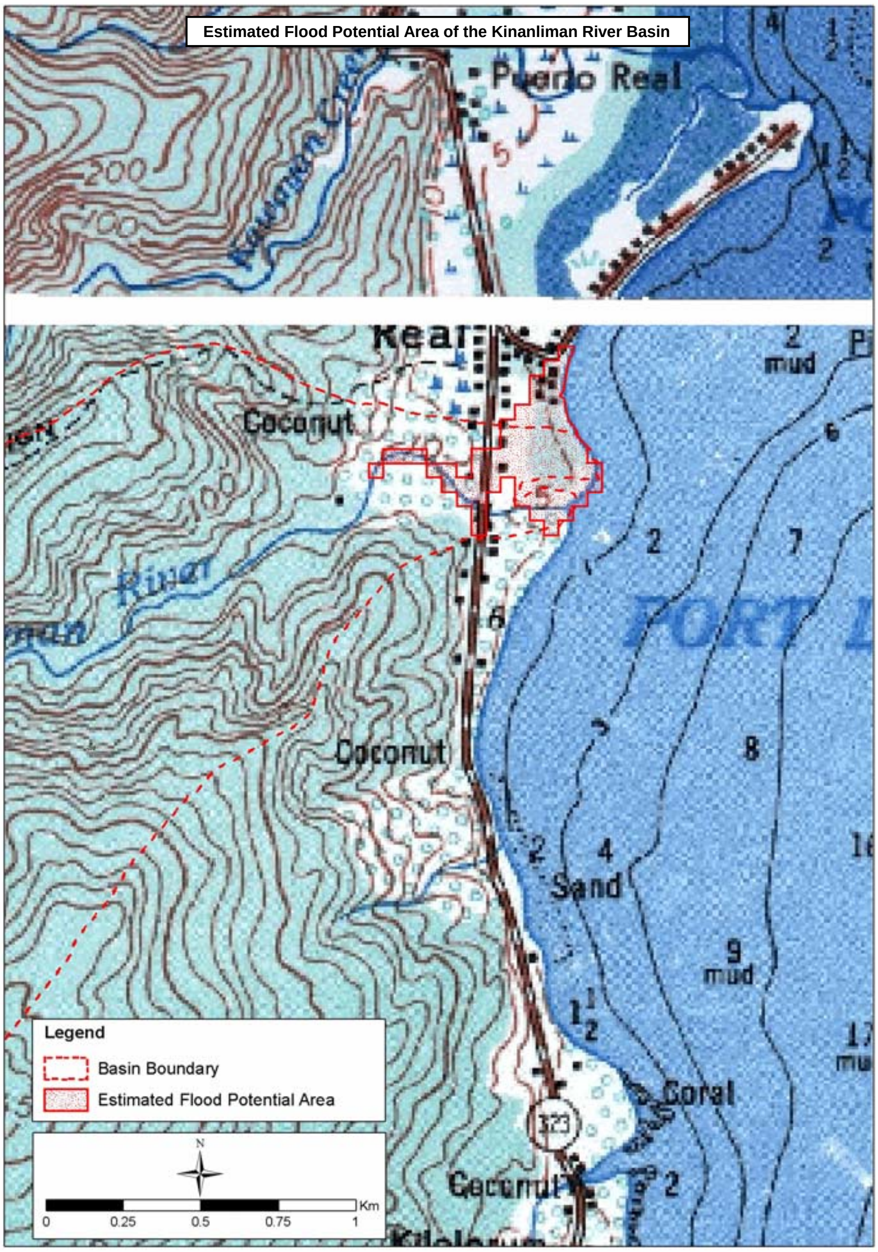


Figure G.5.5 Flood Inundation Area of the Kinanliman River Basin

5.4 Basic Layout of Main Structural Measures

5.4.1 Applicable Structural Measures

The flood type of the Kinanliman River Basin is F+O+I+ B/F+I (Group 4). Comparing with the flood type of this basin, the following structural measures are considered as the applicable ones:

Table G.5.7 Basic Applicable Structural Measures for Flood Type in the Kinanliman River Basin

Flood Type	Applicable Measures				
	River Channel Improvement	Dam and Reservoir and/or Sabo dam	Retarding Basin	Diversion Channel	Drainage Facilities
Flash Flood (F)	O	O			
Over Flow (O)	O	O	O	O	O
Inland Flooding (I)	O				O
Bank Erosion (B)	O				

Judging from the river basin conditions, among these applicable measures, the flood control dam, retarding basin, diversion channel and drainage facilities are not applicable or not necessary to the basin considering the topographic and land use conditions. Hence, applicable measures are the river channel improvement and sabo dam as described below.

Table G.5.8 Applicable Structural Measures in the Kinanliman River Basin

Flood Type	Applicable Measures				
	River Channel Improvement	Sabo dam	Retarding Basin	Diversion Channel	Drainage Facilities
F+O+I+B	O	O			

5.4.2 Basic Idea of Structural Measures

(1) Target Area of Flood Mitigation

Target area of flood mitigation is a potential flood area along the most downstream reach of Kinanliman River, in which built-up area of Real exists along the river. Based on the ocular observation during the filed survey and the result of workshop, the target reach has been set at 0 – 1.05km: 0.4km downstream from the Kinanliman Bridge and 0.65km upstream from the Bridge.

(2) Safety Level

Study by FCSEC has already set the safety level for Kinanliman River to 1/25, although it is said that the probability of the 2004 flood, which may be the past maximum flood, is at more than 1/100. The present Study basically follows the idea by the FCSEC study. Therefore, the safety level is set at 1/25.

(3) Relationship between the Present Study and the FCSEC study

The study by FCSEC focused on only very urgent measures considering limitation of budget. In the present Study, more comprehensive measures for longer-term implementation is planned considering the urgent work proposed by FCSEC.

(4) River Channel Improvement

On the left bank of Kinanliman River, construction of new dike was proposed by the FCSEC study as urgent measures. Detailed design has been completed and construction work will start soon. In addition to the urgent measures proposed by FCSEC study, it is judged that the following river channel improvement is necessary to ensure more safety condition for the target area for long-term perspective.

1) Extension of dike

- It is proposed to extend the dike about 160m toward upstream to protect residential area there.
- Along right bank, construction of dike, which starts from the Kinanliman Bridge toward upstream to connect existing road, is proposed.
- At the downstream portion of the Kinanliman Bridge to river mouth, construction of new dike for both banks is proposed.

2) Spur dike

Along the dike proposed by FCSEC study, it is recommended to set a series of spur dikes to protect the dike and to make channel alignment straighter so that flood flow can pass smoothly.

3) Excavation

To keep necessary flow capacity and to make channel alignment more straight, excavation of sand bar is proposed

4) Bridge

The existing Kinanliman Bridge makes significant contraction effect for flow because of its small cross-section area for flow. It is clearly understood that the bridge is obstacle for smooth flow during flood. It is recommended to reconstruct the bridge with widening and heightening in order to reduce future risk for flood, especially for flood caused by clogging of woody debris.

5) Sabo dam

In many cases, flash floods and/or debris flows cause severe damages including loss of human lives although its damage area is limited.

For the river basins like Kinanliman, where debris flow was occurred or is expected, it is necessary to provide countermeasures such as sabo dams against sediment discharges.

The effects of sabo dam are to reduce risks for:

- Sediment disaster due to debris flows,
- Flooding caused by severe aggradation of river bed due to heavy and sudden sediment load, and

- Flooding caused by backwater at structures such as bridges due to clogging of woody debris, etc.

In the previous study conducted by FCSEC in 2006, the transportable sediment in the Kinanliman River Basin was estimated at 215,836 m^3. In principle, it is desirable to construct necessary sabo works, which total capacity is corresponding to the total sediment discharges, in order to eradicate the sediment disasters. For this achievement, it is required to construct a number of sabo dams, and it will cost considerably.

In this regard, the minimum number of sabo dam, one sabo dam, is preliminary proposed in this plan. The main purposes of this sabo dam are to catch the front of debris flow, the most dangerous portion of debris flow, in order to weaken its destructive power, and to reduce the risk of clogging at the downstream bridge by the control of woody debris at the sabo dam.

Actually in this Study, estimation of benefit does not include intangible damages such as casualties because of difficulty of counting value of human lives. This is another aspect of planning the minimum number of sabo dam. However, in the further studies, the number of sabo dams will be increased so as to make the plan more safety, if this will be judged to be necessary from the viewpoint of the stability of communities and others. On the other hand, it is also important to improve the accuracy of planning by the monitoring of sediment discharges and others.

As for the maintenance of the sabo dam, it is necessary to remove rocks and/or woody debris after floods.

5.4.3 Recommended Structural Measures

(1) Recommended Structural Measures

Based on the basic idea above mentioned, the recommended structural measures are the above river channel improvement and the sabo dam, as shown in Table G.5.9 and Figure G.5.6.

Table G.5.9 Summary of Recommended Structural Measures in the Kinanliman River Basin

	Components	Work item	Description	Quantity
1	Kinanliman River Improvement	Revetment, Foot protection Embankment, Excavation	Embankment: 1.0～3.5m high	Left: 1,045m Right: 565m
2	Spur Dike	Hydraulic jump spur dike	Length: 10m Height: 3m	6 sites
3	Re-Construction of Bridge	Concrete bridge	Length: 60m Width: 7m	1 site
4	Sabo Dam	Permeable Type Dam	Width: 85m Effective height: 3m	1 site

The proposed flood discharge distribution is shown in Figure 5.7.

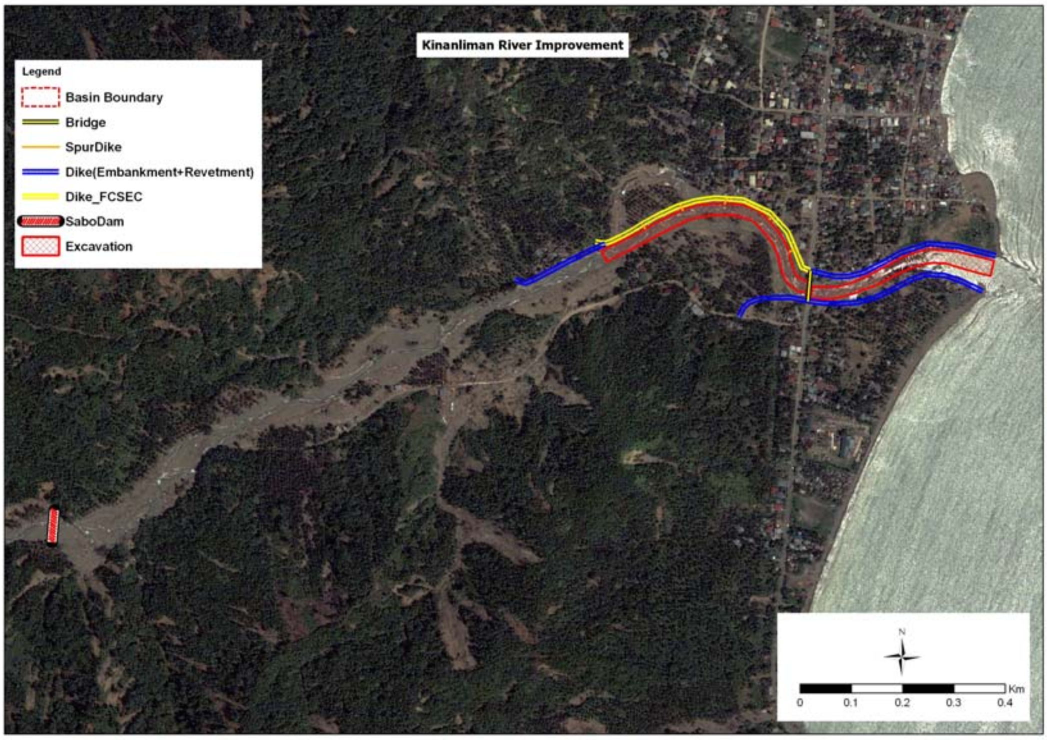


Figure G.5.6 Recommended Structural Measures in the Kinanliman River Basin

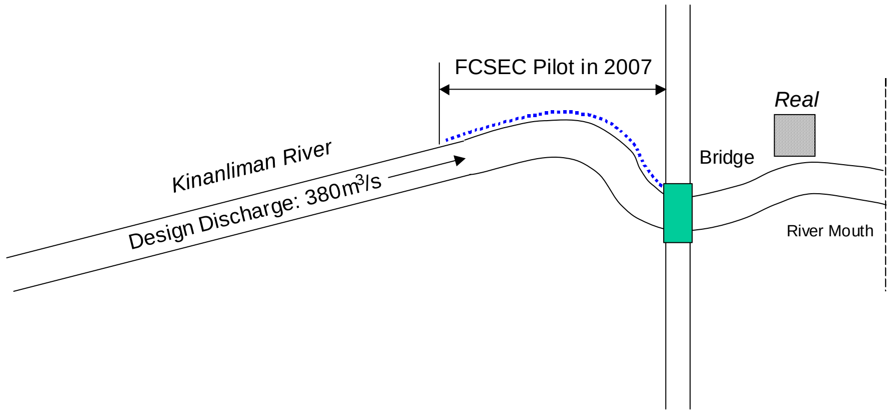


Figure G.5.7 Design Discharge Distribution with Proposed Structural Measures in the Kinanliman River Basin

6. TUGANAY RIVER BASIN

6.1 Basin Conditions

6.1.1 Natural Conditions

(1) Topography

The Tuganay River Basin faces Davao Gulf to the southeast. The basin is characterized by extensive flat terrain in the central and northeastern areas, and hilly and mountainous areas in the northwestern side. The elevation of lowland, downstream of the Davao-Agusan National Highway, is 2-3 meters above mean sea level. On the other hand, the highland of this basin has an elevation of less than 1,300 meters above mean sea level. In the southeastern part of the basin along Davao Gulf, the Tuganay River and the Tagum-Libuganon River merge just upstream of the river mouth. The topography of the Basin is shown in Figure G. 6.1.

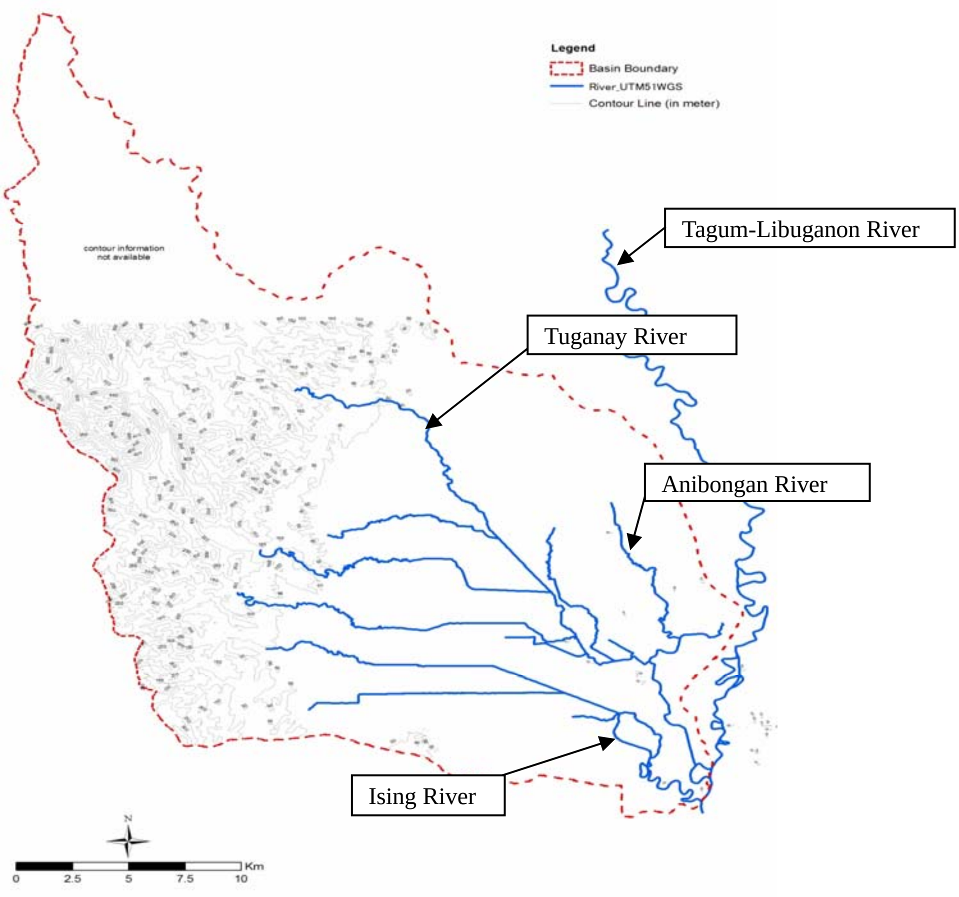


Figure G.6.1 Topographic Map of the Tuganay River Basin

(2) Existing River System and Structures

The Tuganay River system is composed mainly of Tuganay River, Anibongan River and Ising River. Tuganay River, with a length about 101 km, is the main drainage of this basin. The basin has the total area of 747 km^2. The riverbed gradient of Tuganay River ranges from 1/20 to 1/3,700. The existing river system of the Tuganay River Basin is shown in Table G.6.1.

Table G.6.1 Rivers in the Tuganay River Basin

River	Catchment Area (km^2)	Length (m)	Remarks
Tuganay	747	101,400*	*Excluding Tributaries
Anibongan	145	45,000	Tributary
Ising (new)	144	27,600	

The major river structures relating to flood control are, as follows:

- The New Ising River was constructed in the south of Old Ising River. At present, the floods flow through New Ising River.
- At the crosses with the Davao-Agusan National Highway, bridge was constructed for Tuganay and Old Ising Rivers, and culvert was constructed for New Ising River.

(3) Meteorology and Hydrology

The Tuganay River Basin falls in Type IV of the modified Corona's climate classification. For this type of climate, rainfall is more or less evenly distributed throughout the year. The average annual rainfall in the locality is about 2,400 mm. Monthly rainfall distribution in the basin is shown in Figure G.6.2.

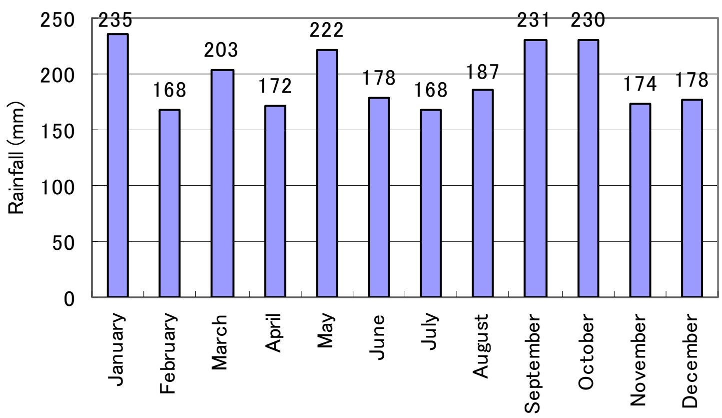


Figure G.6.2 Monthly Rainfall Distribution at PAGASA Synoptic Station, 1996-2005

(4) Regional Geology

The basin is categorized as quarternary, alluvial, lacustrine, beach and residual deposits. Alluvial plains landscape occupies the broad valley floors of Carmen Municipality and Tagum City. The alluvial deposits generally consist of unsorted heterogeneous, consolidated detrital fragments of clay, silt and sand pebble and angular to rounded gravel size fragments mixed into a sandy to clayey matrix deposited along stream beds and banks, floodplains, flat aras and abandoned segments of meander cut-offs. These material show mixed characteristics from volcanic to sedimentary origin, being transported and eroded from the surrounding hills and mountains.

6.1.2 Social and Economic Conditions

(1) Population and its Growth

The total population of the Carmen Municipality based on the 2000 NSO Census is 55,144. The growth rate between 1995 and 2000 was 1.55% even for the separation of the two comprising barangays. The bulk of municipal population resides in barangay Ising with a total population of 15.5%. The average population density is 332 persons/km^2.

On the other hand, for the Municipality of Braulio E. Dujali, the 1995 NSO record shows that the Municipality had a total population of 25,100, of which 18.3% is residing in the urban area. The growth rate between 1990 and 1995 was 2.00%. The average population density is 293 persons/km^2.

(2) Land Use

1) Existing Land Use

The Municipality of Carmen covers a total land area of 16,625 ha, of which 91.7% is devoted to agriculture, and 2.2% and 2.1% is infrastructure/road network and creeks/rivers, respectively.

On the other hand, the Municipality of Braulio E. Dujali covers a total land area of 9,100 ha, of which 85.6% is devoted to agriculture, while 3.7% and 2.5% is utilized for fishponds (inland) and swampland/marshland, respectively. These swampland/marshland are potential for fish and bird sanctuary.

Figure G.6.3 shows the land use map of the basin (2002/03).

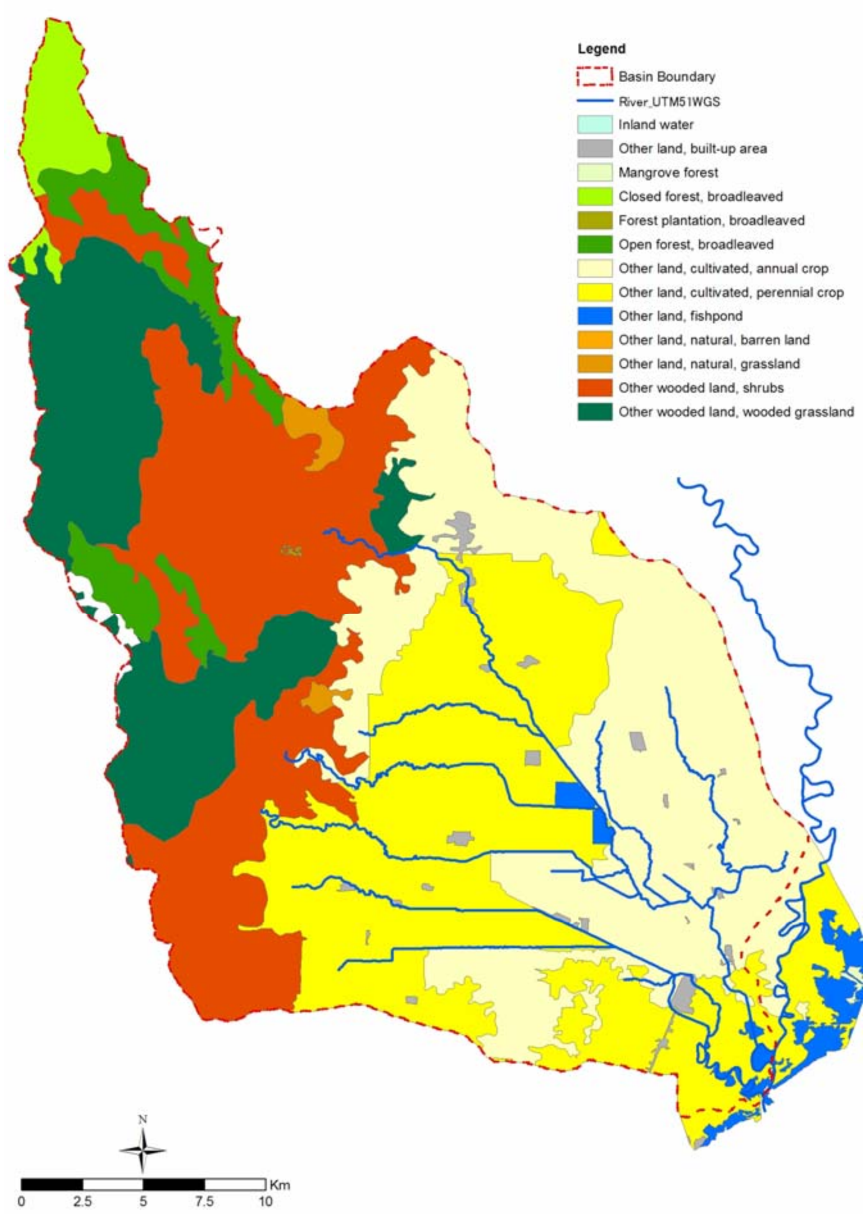


Figure G.6.3 Existing Land Use in the Tuganay River Basin

2) Projected Land Use

The year of projection for the Carmen Municipality is 2015. The major changes in the land use are; increase of built-up area (561 ha), swamp/marshland (31 ha) and fishponds (15 ha): and decrease of only agricultural area (622 ha).

The year of projection for the Municipality of Braulio E. Dujali is 2009. Significant increase is expected for residential area (19 ha), road networks (18 ha) and agro-industrial area (8 ha). On the other hand, only agricultural area will be decreased (50 ha).

Table G.6.2 and Table G.6.3 show the existing and projected land use of the both Municipalities.

Table G.6.2 Existing and Projected Land Use in Carmen Municipality

Land Use	Existing (2006)		Projected (2015)		Area Change (ha)
	Area (ha)	Percent to Total (%)	Area (ha)	Percent to Total (%)	
Built-up Area	363.23	2.2	923.74	5.6	+560.51
- Residential	167.23	1.0	333.38	2.0	+166.15
- Commercial	16.00	0.1	20.84	0.1	+4.84
- Institutional	75.00	0.5	104.18	0.6	+29.18
- Industrial	31.50	0.2	166.69	1.0	+135.19
- Agro-Industrial	26.00	0.2	55.56	0.3	+29.56
- Park & Open Space/Buffer	47.50	0.3	243.09	1.5	+195.59
Infrastructure Facilities	372.98	2.2	382.00	2.3	+9.02
Agricultural	15,247.89	91.7	14,626.26	88.0	-621.63
Forest	31.00	0.2	31.00	0.2	0
Swamp/Marshland	-	-	31.00	0.2	+31.00
Mangrove	2.00	0.0	2.00	0.0	0
Quarrying Area	41.00	0.3	41.00	0.3	0
Rivers/Creeks	342.00	2.1	340.00	2.1	-2.00
Fishponds	222.4	1.3	237.00	1.4	+14.60
Special Use	2.50	0.0	11.00	0.1	+8.50
- Cemetery	2.50	0.0	8.50	0.1	+6.00
- Cockpit	-	-	0.50	0.0	+0.50
- Ecological Waste D. S.	-	-	2.00	0.0	+2.00
TOTAL	16,625.00	100.0	16,625.00	100.00	0

Source) Comprehensive Local Development Plan, 2006-2015, Municipality of Carmen

Table G.6.3 Existing and Projected Land Use in Braulio E. Dujali Municipality

Land Use	Existing (1998)		Projected (2009)		Area Change (ha)
	Area (ha)	Percent to Total (%)	Area (ha)	Percent to Total (%)	
Residential	86.25	0.9	105.21	1.2	+18.96
Commercial	13.58	0.1	13.57	0.1	0
Institutional	23.59	0.3	23.59	0.3	0
Agro-Industrial	38.75	0.4	47.12	0.5	+8.37
Industrial	1.00	0.0	2.00	0.0	+1.00
Agricultural	8,050.30	88.5	8,000.35	87.9	-49.95
Fishponds	324.00	3.6	324.00	3.6	0
Open Space/Parks & Playgrounds	0.78	0.0	0.94	0.0	+0.16
Wild Life Sanctuary	227.87	2.5	227.87	2.5	0
Special Use	5.00	0.1	6.00	0.1	+1.00
- Cockpit	1.00	0.0	1.00	0.0	0
- Cemetery	4.00	0.0	5.00	0.1	+1.00
Road Networks	214.45	2.4	232.74	2.6	+18.29
Rivers/Creeks	113.90	1.3	113.90	1.3	0
TOTAL	9,100	100.0	9,100	100	0

Source) Comprehensive Land Use Plan, CY 1998-2009, Municipality of Braulio E. Dujali

(3) Local Economy

1) Agriculture

The Municipality of Carmen is greatly dependent on agriculture. In the Municipality, the crops produced from the agricultural lands are banana (4,805 ha), rice (3,889 ha), coconut (2,736 ha), mango (548 ha), corn (256 ha) and various fruit and vegetables. Banana is the major exportable that generates employment for the Municipality. Rice is the major staple crop in the Municipality.

The Municipality of Braulio E. Dujali is also greatly dependent on agriculture. In the Municipality, the produced agricultural crops are rice (4,333 ha), banana (3,163 ha), coconut (123 ha), vegetables (43 ha), corn (36 ha) and others. Out of rice area, 3,783 ha are irrigated and 550 ha are rainfed. Banana became the second major crop of the Municipality. This is a result of the continuing expansion of the banana plantations operating in the Municipality.

2) Commerce and Trade

Presently the Carmen Municipality has a total of 366 commercial establishments classified into: wholesalers (21), retailers (230), agro-industry (25), industrial establishment (5), financial institution (2) and other miscellaneous services. The existing commercial area in the Poblacion is approximately 3 ha.

In the Municipality of Braulio E. Dujali, trade and commerce activities are taking place in the Poblacion especially at existing 0.5 ha market site. In the locality, a total of 199 establishments are operating sari-sari stores, rice trading, fish selling, eateries and others. At present, the municipal government is negotiating for the possible acquisition of 2 ha of land for establishment of its Central Business District.

3) Industry

The most common industries that exist in the Carmen Municipality are classified as agro-industries. The Municipality has 34 industries mostly composed of rice and corn mills, banana packing plants. Among the top list in terms of capitalization are DOLE Philippines and Diamond Farms Inc. The total existing industrial area of the Municipality are 41.61 ha.

In the Municipality of Braulio E. Dujali, the existing industries are a few rice mills, auto repair and welding shop in the Poblacion proper.

6.1.3 Floods and Flood Damage

(1) Floods and Flood Damage

In the lowlands along Tuganay River system, floods occur 2-3 times per year. The depth of floods ranges from 0.2 to 2.0 m, and the period of floods from 1 to 7 days. These are varying in areas due to topography and elevation. Generally, the flows of rivers are hampered by heavy siltation coming from the upstream. On the other hand, up rooted trees in flood flows are minimal in the basin.

In the basin, the flood damages on casualties are minimal but on built-up area, agriculture and infrastructure are large. Table G.6.4 shows the number of affected persons and the damage on infrastructure in the Carmen Municipality during 1995-2006. On the other hand, Table G.6.5 shows the flood damages of 2007 January flood. This table indicates 23.2 million pesos of crop damage, 17.4 million pesos of infrastructure damage, 1.7 million pesos of fishery damage and 2 totally damaged houses.

Table G.6.4 Flood Damages in Carmen Municipality

Year	No. of Affected Persons	Infrastructure Damage (mil. Pesos)
1995	No Data	1.7
1996	No Data	7.2
1997	No Data	4.8
1998	No Data	2.5
1999	11,650	7.4
2000	12,340	3.8
2001	8,950	10.0
2002	8,950	4.5
2003	33,920	13.8
2004	19,312	16.1
2005	0	0
2006	27,164	23.2

Source) No of affected persons: Office of the Social Welfare and Development, Municipality of Carmen
Infrastructure Damages: Office of the Municipal Engineer, Municipality of Carmen

Table G.6.5 Flood Damages during January 9-10, 2007 Flood

Municipalities Affected	No. of Families Affected	No. of Dependents	Damages			
			Houses, Total Damaged	Crop (Pesos)	Infrastructure (Pesos)	Fishery (Pesos)
B. E. Dujali	1,015	5,075	0	3,475,300	2,800,000	1,630,000
Sto. Tomas	1,665	6,660	0	4,051,345	7,050,000	15,000
Carmen	2,515	10,298	2	15,720,000	7,550,000	35,000
Total	5,195	22,033	2	23,246,645	17,400,000	1,680,000

Note) Table shows the damages occurred in the Tuganay River Basin only.

(2) Major Causes of Floods

Heavy local rainfall in the upstream causes flash floods and overflows in the downstream of the Tuganay River system, especially Anibongan and New Ising Rivers, due to lack of their flow capacities. Local rainfall generally does not occur in the entire basin at the same time, therefore, the timing of floods is different for each river basin.

The lack of flow capacity of drainage facilities is also another factor of flooding of this basin. However, this is secondary factor of the flooding. Hence, the flood mitigation plan of this basin is formulated from the viewpoint of avoiding overflow as mentioned above. In the future, however, the drainage improvement should be carried out.

6.1.4 Previous Related Study

Philippine-Japan Highway Loan Project Office, DPWH prepared “the Report on Preliminary Design of Liboganon River Dike Extension, December 1998” for the Philippine-Japan Friendship Highway Mindanao Section Rehabilitation Project (I). One of the main purposes of this report was to conduct preliminary design of the extended dike between the Highway at Governor Miranda Bridge and the Davao Gulf. In this report, alternative plans on the dike extension were studied and the following plan was recommended considering the least construction cost and minimum land acquisition cost and the technical difficulty in the construction:

(Recommended Plan)
The construction of flood protection dikes along Tagum River from the Governor Miranda Bridge to the Davao Gulf, and the diversion channels near Tuganay River mouth in order to prevent flooding of Tagum River to both banks, especially to protect outflow of flooding to the Tuganay area which has own flooding from the Tuganay and Ising Rivers.

In this plan, the design discharge of 25-year return period was adopted. The salient features of the recommended dike extension works are shown in Figure G.6.4 and Table G.6.6.
Considering the above situation, the flood mitigation plan for the Tuganay River Basin is formulated under the condition of the construction of this dike extension.

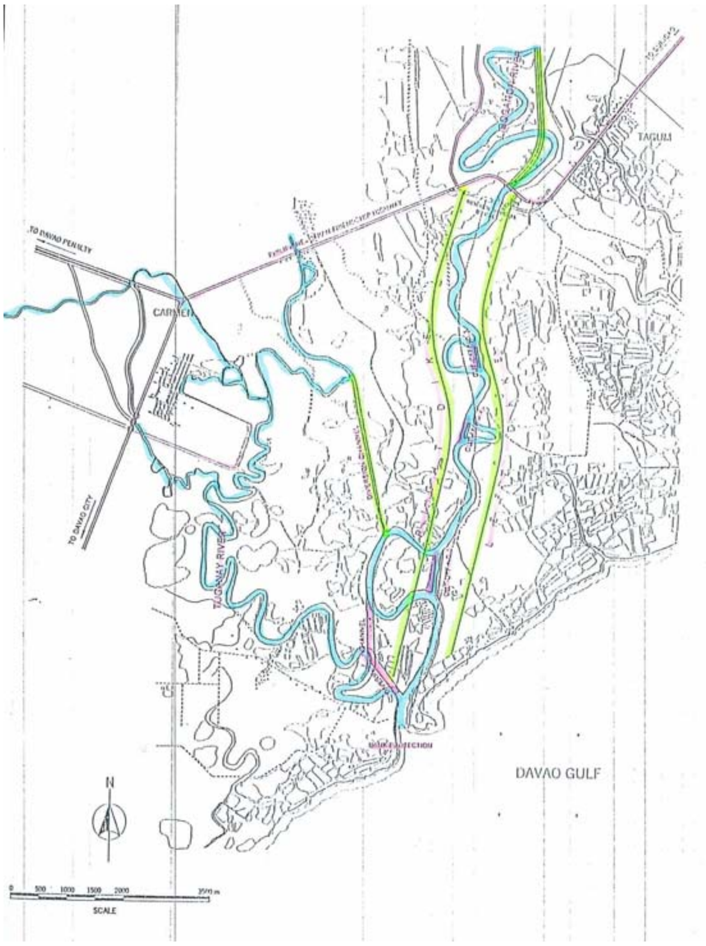


Figure G.6.4 Recommended Flood Protection Dikes along Tagum River

Table G.6.6 Salient Features of Recommended Dike Extension Works

Dike	Length (km)	Dike Height (m)	Side Slope	Remarks
Left Dike	5.6	2.6-5.1	1:3.0	Width between left and right banks is 700 m.
Right Dike	6.3	2.0-5.1	1:3.0	

6.2 Hydrologic Analysis

The design discharges are estimated referring to the Preliminary Design. Distribution of the design discharges for 25-year return period is shown in Figure G.6.5.

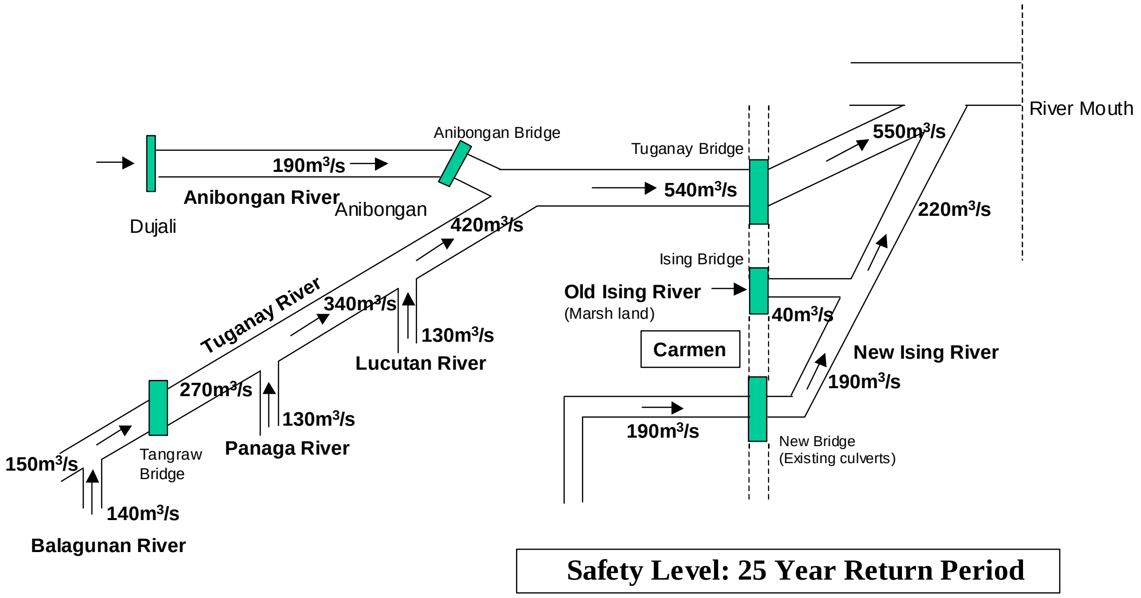


Figure G.6.5 Design Discharge Distribution in the Tuganay River Basin

6.3 Flood Inundation Analysis

6.3.1 Flow Capacity

The flow capacity of the existing river channel is analyzed with HEC-RAS using the river cross sections newly obtained in the survey. The flow capacities of the Tuganay River system are calculated as shown below.

Table G.6.7 Flow Capacity of Existing River in the Tuganay River Basin

Location of Calculation	Flow Capacity (m^3/sec)
Tuganay River (Upstream Portion)	75
Tuganay River (Tuganay Bridge)	175
Anibongan River	20
Ising River	8

6.3.2 Flood Inundation Area

(1) Flood Inundation Area

The flood inundation area is analyzed with HEC-RAS and HEC-GeoRAS using the river cross sections newly obtained. In the analysis, the altitude data of SRTM is adjusted by comparison with the river cross sectional survey data. As a result, the flood inundation area spreads out in the low flat area, which includes the downstream of the Tuganay, Anibongan and Ising Rivers.

The total inundation area is estimated at 7,711ha with 25-year return period flood, as shown in Table G.6.8. Figure G.6.6 shows the flood inundation area.

Table G.6.8 Area of Flood Inundation of the Tuganay River Basin

(Unit: ha)

Land Use	Flood Scale (Return Period)
	25-year
Built-up Area	154.5
Fishpond	391.2
Cultivated, Annual Crop	6,857.5
Other	307.4
Total	7,710.6

6.4 Basic Layout of Main Structural Measures

6.4.1 Applicable Structural Measures

The flood type of the Tuganay River Basin is F+O+I/F+I+B/F+I (Group 5). Comparing with the flood type of this basin, the following structural measures are considered as the applicable ones:

Table G.6.9 Basic Applicable Structural Measures for Flood Type in the Tuganay River Basin

Flood Type	Applicable Measures				
	River Channel Improvement	Dam and Reservoir and/or Sabo dam	Retarding Basin	Diversion Channel	Drainage Facilities
Flash Flood (F)	O	O			
Over Flow (O)	O	O	O	O	O
Bank Erosion (B)	O				
Inland Flooding (I)	O				O

Note) Flash flood and bank erosion are not major flood types based on the field survey.

The low flat area of the Tuganay River system comprises mainly the downstream basins of the Tuganay, Anibongan and Ising Rivers. Since the topographical and land use conditions of these rivers are different from each other, the applicable structural measures are studied respectively as described below.

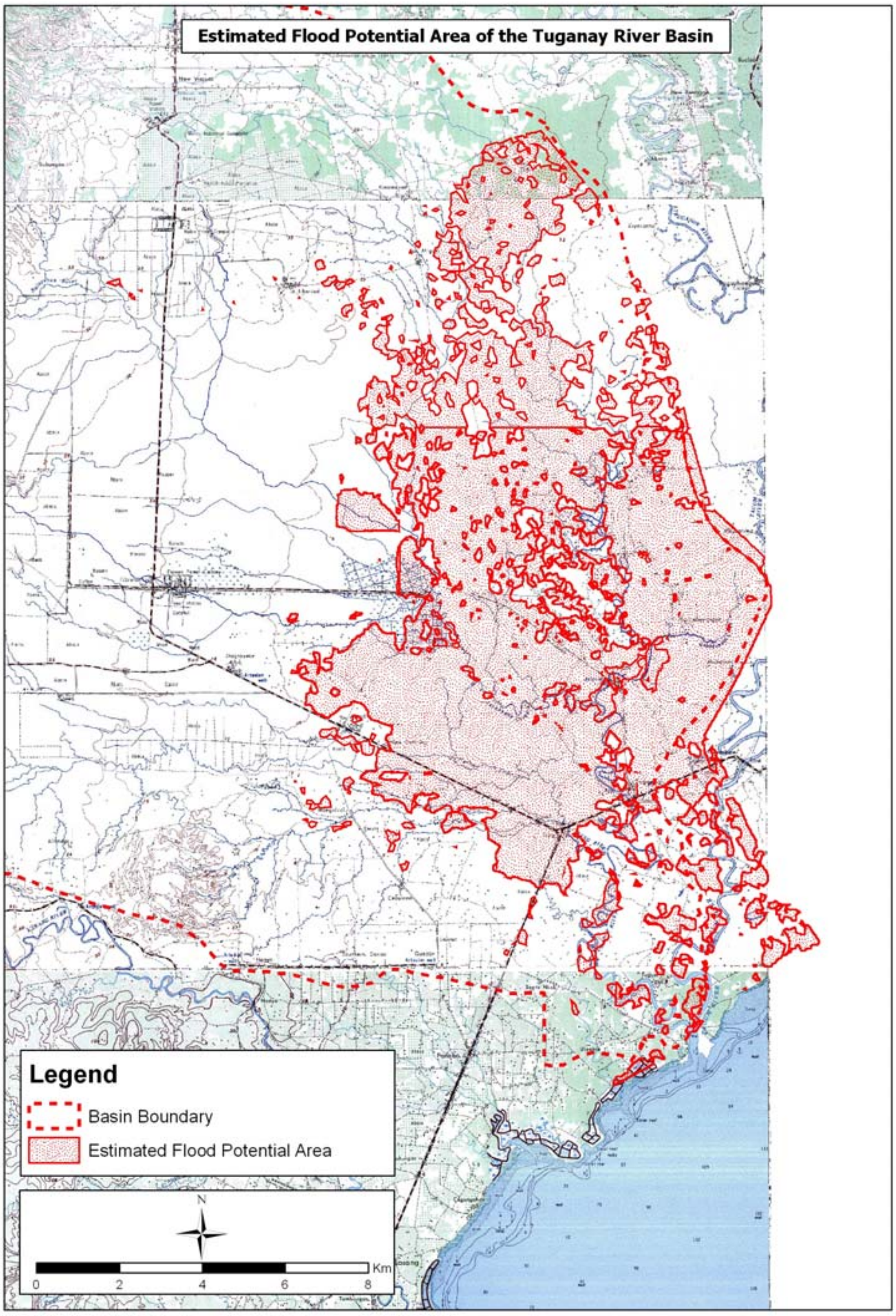


Figure G.6.6 Flood Inundation Area of the Tuganay River Basin

(1) Tuganay River

Judging from the topographic and land use conditions of the basin, three main structural measures are applicable, namely, river channel improvement, retarding basin and dam and reservoir, as follows:

1) River Channel Improvement

A river channel improvement is principally applicable to confine and carry the design discharge towards the Davao Gulf. The existing river alignment is adopted basically.

2) Retarding Basin

The location of the retarding basin is preliminary determined at around the confluence with the Lucutan River. The present land use of the site is marshland. The stored water will drain by gravity.

3) Dam and Reservoir

Dam site is preliminarily selected at the upper Tuganay River, approximately 6 km upstream from the Poblacion of Santo Tomas, considering its location, storage capacity and geological conditions. This dam is planned as a single-purpose dam based on the field survey, etc.

(2) Anibongan River

Considering the adjustment of river confluence with Tuganay River (as described later) in due consideration of the field survey results, four main structural measures are applicable, namely, river channel improvement, retarding basin, diversion channel and drainage facilities (gate and pump), as follows:

1) River Channel Improvement

A river channel improvement is applicable to confine and carry the design discharge to Tuganay River. The existing river alignment is adopted basically.

2) Retarding Basin

The location of the retarding basin is preliminary determined at the upstream of the confluence with Tuganay River. The present land use of the site is marshland. The stored water will drain by gravity.

3) Diversion Channel

The location of the diversion channel is preliminary determined linking the lower reaches of Anibongan River and Tuganay River.

4) Drainage Facilities

Gate facilities are planned in order to stop the backwater from Tuganay River. On the other hand, pump facilities are planned in order to discharge the floods from the upstream.

(3) Ising River

Judging from the topographic and land use conditions of the basin, two main structural measures are applicable, namely, river channel improvement and retarding basin, as described below.

1) River Channel Improvement

The river channel improvement for the New and Old Ising Rivers is principally applicable to confine and carry the design discharge to the Davao Gulf. The improvement of Old Ising

River is planned to protect the Carmen Poblacion. Cut-off channel is planned for the meandering portion in downstream of Ising River.

2) Retarding Basin

The location of the retarding basin is preliminary determined at the west-southern area of the intersection at Carmen. Considering its location, the flood regulation effect by the retarding basin is expected only for New Ising River. The present land use of the site is marshland. The stored water will drain by gravity.

As a result, the applicable structural measures for the Tuganay River Basin are summarized below.

Table G.6.10 Applicable Structural Measures in the Tuganay River Basin

River	Applicable Measures				
	River Channel Improvement	Dam and Reservoir	Retarding Basin	Diversion Channel	Drainage Facilities
Tuganay	O	O	O		
Anibongan	O		O	O	O
Ising	O		O		

6.4.2 Target Area of Flood Mitigation

Target area of flood mitigation is the low flat area of the Tuganay River system mainly comprising the downstream portions of the Tuganay, Anibongan and Ising Rivers. The area covers the built-up areas of Carmen and Dujali, and large agricultural areas. The location of the target area is shown in Figure G.6.6.

6.4.3 Basic Idea of Layout

(1) Tuganay River

The excess water over its existing flow capacity of Tuganay River is to be confined by means of the river channel improvement, retarding basin and/or dam and reservoir.

(2) Anibongan River

In the formulation of the basic layout for Anibongan River, the adjustment of river confluence with Tuganay River is considered. The elevation of Anibongan River in the lower reaches is lower than that of Tuganay River. Thus, the high water level from Tuganay River backs into Anibongan River, and this raises the dike height of Anibongan River. Based on this idea, the following alternatives are considered:

1) Allowing Backwater from Tuganay to Anibongan River

In this case, the dike height of Anibongan River is designed higher due to the backwater from Tuganay River.

2) Not Allowing Backwater from Tuganay to Anibongan River

In this case, the backwater from Tuganay River is stopped with gate. Thus, the dike height of Anibongan River is designed lower. Regarding to the floods from the upstream, the following structural measures are applicable:

- Retarding basin which stores the floods from the upstream temporally
- Diversion channel which discharges the floods from the upstream
- Pump facilities which discharge the floods from the upstream

(3) Ising River

The excess water of New Ising River is to be confined by means of the river channel improvement and retarding basin. On the other hand, the excess water of Old Ising River is to be confined by means of the river channel improvement only.

6.4.4 Possible Alternative Cases

In line with the above idea, the alternative cases are studied, as described below.

(1) Tuganay River

Basic alternative cases are formulated as the combination of the applicable structural measures as described below.

(1) River channel improvement only
(2) Retarding basin only
(3) Dam and reservoir only
(4) Combination of river channel improvement and retarding basin
(5) Combination of river channel improvement and dam and reservoir
(6) Combination of retarding basin and dam and reservoir
(7) Combination of river channel improvement, retarding basin and dam and reservoir

Among these alternatives, the cases of (2), (3) and (6) are eliminated from the possible alternative cases, because even dam regulates all the flood discharge from the upstream and/or retarding basin regulates floods at full capacity, flood damage still occurs in the downstream.

Based on this, then, the dam size is preliminary designed as shown below, and its construction cost is roughly estimated at 270 million pesos. Based on this figure, the costs for alternatives which include dam are compared with the costs which do not include dam. Result is the former is more expensive than the latter about 15-20%. In addition to this, single purpose dam for flood control will be economically disadvantageous. Hence, the cases (5) and (7) are eliminated.

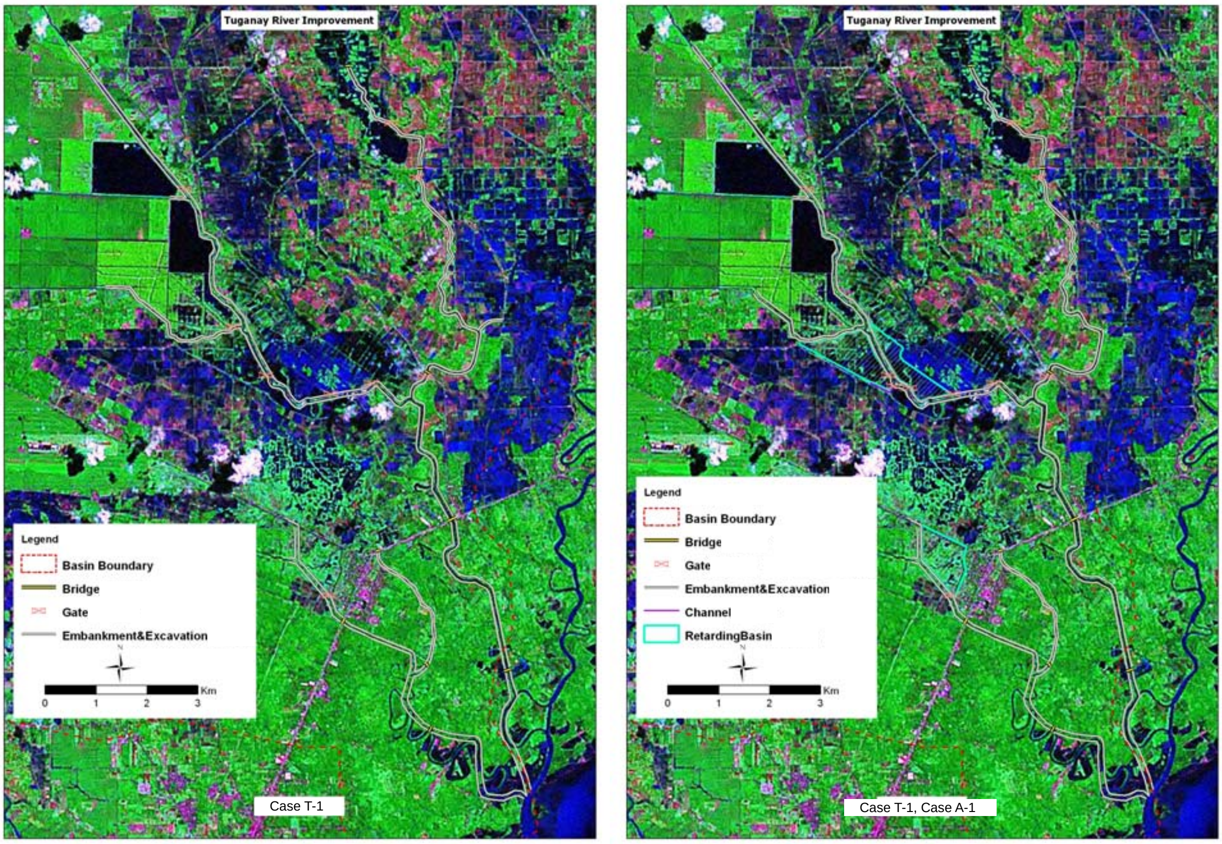
Table G.6.11 Preliminary Dimension of Dam

Item	Dimensions
Dam Type	Rockfill
Peak Discharge Cut at Dam Site (m^3/s)	130 (All cut at the dam site)
Total Storage Capacity (MCM) Flood Control Dead Water	10.4 4.0 6.4
Dam Height (m)	25.0
Dam Length (m)	220

Consequently, the possible alternative study cases are (1) and (4), as shown in Table G.6.12. Figure G.6.7 shows the plans of these cases.

Table G.6.12 Alternative Cases in Tuganay River

Alternative Cases	Basic Layout of Main Structural Measures
Case T-1	• River channel improvement for the downstream of the confluence with Balagunan River
Case T-2	• Combination of the river channel improvement and the retarding basin



Case T-1, Case A-1

Case T-2, Case A-1

Figure G.6.7 Comparison of Alternative Cases in Tuganay River

(2) Anibongan River

The possible alternative cases for Anibongan River are formulated based on the "Basic Idea of Layout "above mentioned. As the result, the possible alternative study cases are formulated, as shown in Table G.6.13. Figure G.6.8 shows the plans of these cases.

Table G.6.13 Alternative Cases in Anibongan River

Alternative Cases	Adjustment Method of the Confluence	Basic Layout of Main Structural Measures
Case A-1	Allowing backwater from Tuganay to Anibongan River	River channel improvement without gate facilities
Case A-2	Stopping the backwater by gate facilities, and storing the floodwater into retarding basin	Combination of river channel improvement, gate facilities and retarding basin
Case A-3	Stopping the backwater by gate facilities, and discharging the floodwater through diversion channel	Combination of river channel improvement, gate facilities and diversion channel
Case A-4	Stopping the backwater by gate facilities, and discharging the floodwater by pump facilities	Combination of river channel improvement, gate and pump facilities

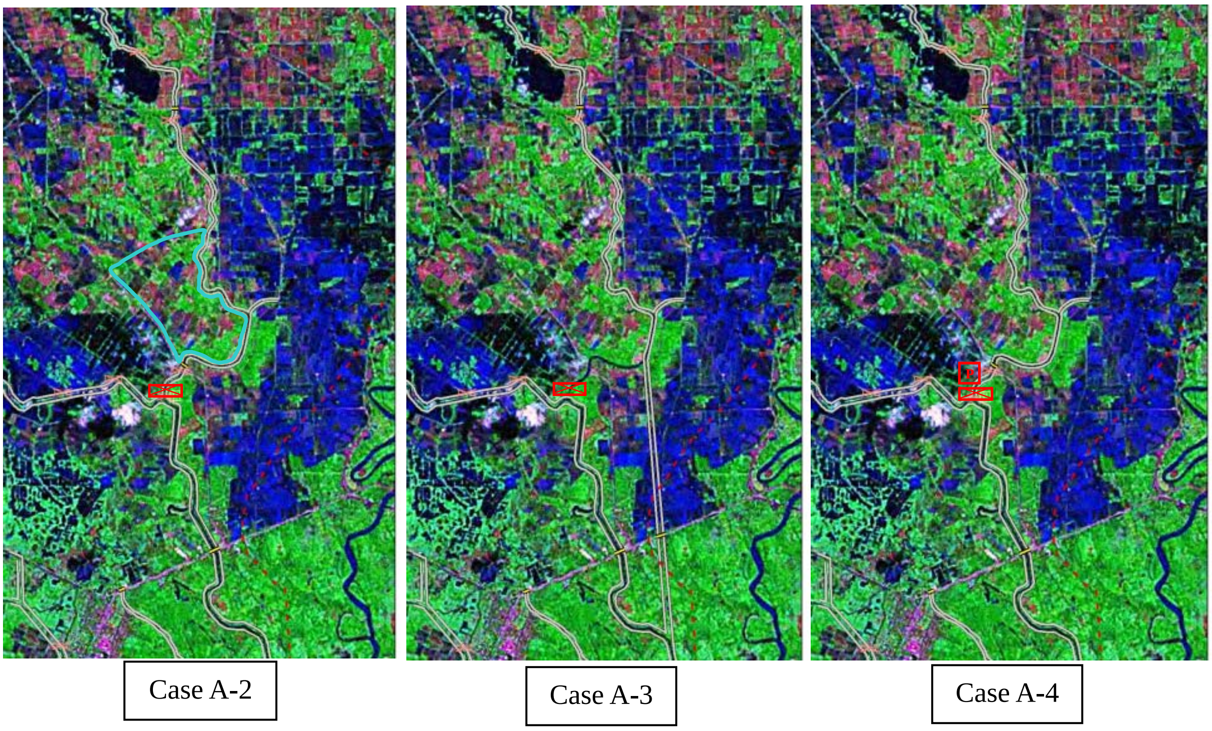


Figure G.6.8 Comparison of Alternative Cases in Anibongan River

(3) Ising River

Basic alternative cases are formulated as the combination of the applicable structural measures as described below.

(1) River channel improvement only

(2) Retarding basin only

(3) Combination of river channel improvement and retarding basin

Among these alternative cases, the case of "(2) Retarding basin only" is eliminated from the possible alternative cases, because even retarding basin regulates all the flood discharge from the upstream, flood damage still occurs in the downstream of New Ising River. Consequently, the possible alternative study cases are formulated as shown in Table G.6.14. Figure G.6.9 shows the plans of these cases.

Table G.6.14 Alternative Cases in Ising River

Alternative Cases	Basic Layout of Main Structural Measures
Case I-1	• River channel improvement for New Ising River for the downstream of the Hiway to Davao Penalty • River channel improvement for Old Ising River for the downstream of the Ising Bridge
Case I-2	• Combination of the river channel improvement and the retarding basin for New Ising River • Above river channel improvement for Old Ising River

Case I-1

Case I-2

Figure G.6.9 Comparison of Alternative Cases in Ising River

6.4.5 Recommended Structural Measures

(1) Optimum Case

Based on the cases of the alternative study, the optimum case for the respective rivers can be determined through cost comparison. In this cost comparison, the combination of the alternative cases of Tuganay and Anibongan Rivers are considered. The cost for each alternative case is roughly estimated, and the results of the cost comparison are shown in Table G.6.15.

Based on the comparison, Case T-2, Case A-1 and Case I-2 become the lowest for Tuganay, Anibongan and Ising, respectively. However, the differences between the lowest and the second lowest are around 5%. Therefore, the said cases are preliminary selected as the optimum ones from the viewpoint of economic advantage. The total cost is estimated at 2,669 million pesos.

Table G.6.15 Result of Cost Comparison of Alternative Cases in the Tuganay River Basin

Tuganay and Anibongan Rivers

Alternative Cases		Cost (mil. Pesos)		
Tuganay	Anibongan	Tuganay	Anibongan	Total
Case T-1	Case A-1	1,668.2	899.6	2,567.8
	Case A-2	1,668.2	781.9	2,450.1
	Case A-3	1,668.2	879.5	2,547.7
	Case A-4	1,668.2	7,321.8	8,990.0
Case T-2	Case A-1	1,537.4	674.2	2,211.6
	Case A-2	1,537.4	781.9	2,319.3
	Case A-3	1,537.4	879.5	2,416.9
	Case A-4	1,537.4	7,321.8	8,859.2

Note) In Case T-1, there are differences in the Tuganay cost in accordance with the alternative cases of Anibongan. For Case T-2, this situation is same. However, these cost differences are judged to be negligible.

Ising River

Alternative Cases	Cost (mil. Pesos)
Case I-1	475.9
Case I-2	457.4

With the recommended structural measures, the design discharge of 25-year return period will be distributed as shown in Figure G.6.10.

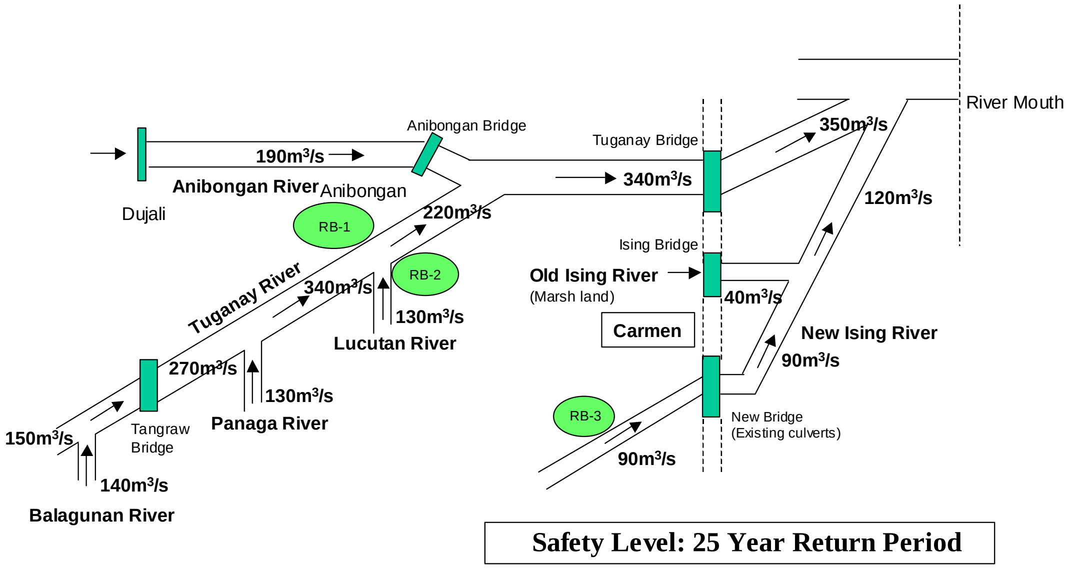


Figure G.6.10 Design Discharge Distribution with Optimum Structural Measures in the Tuganay River Basin

7. DINANGGASAN RIVER BASIN

7.1 Basin Conditions

7.1.1 Natural Conditions

(1) Topography

The Dinanggasan River Basin is mountainous with steep slopes in the southern peak of the Catarman and Tempoong Mountain Ranges in Camiguin Island.

The topography can best be described as one composed of narrow and slightly undulating plains from the coast, which gradually rise landward to pyroclastic hills, then to steep volcanic mountains.

Table G.7.1 shows share of elevations in the Dinanggasan River Basin. The highest elevations reach above 1,200 m above MSL, where they form part of the Catarman and Tempoong Mountain Ranges. About 80% of the basin is higher than 800 m above MSL. On the other hand, about 2% is less than 20 m above MAL. The Dinanggasan River is dry near the coast and has waters only during rainfall. The topographic map of the basin is shown in Figure G.7.1.

Table G.7.1 Elevation Zone of the Dinanggasan River Basin

Elevation (m)	0-20	20-100	100-200	200-400	400-600	600-800	800-1000	1000-1200	1200-	Total
Area (km^2)	0.64	2.35	2.96	6.20	5.85	5.87	2.99	1.43	0.97	29.28
Percentage(%)	2.20	8.03	10.12	21.17	20.00	20.03	10.22	4.89	3.33	100.00

(2) Existing River System and Structures

Dinanggasan River originates from the slopes of Hibok-Hibok volcano and drains towards Macajalar Bay of Mindanao Sea. The closest river is the Compol River to the east, however, is almost buried. The Dinanggasan River Basin has a catchment area of around 29 km^2, and is composed mainly of two rivers; Dinanggasan River with a length of about 9.3 km, and Tag-Ibo River with a length of about 3.8 km. The existing river system is shown in Table G. 7.2.

Table G. 7.2 Rivers in the Dinanggasan River Basin

River	Catchment Area (km^2)	Length (m)	Remarks
Dinanggasan	29.0	9,300*	*Excluding Tributary
Tag-Ibo	2.9	3,800	Tributary

Dinanggasan River is typical torrential stream. The gradient of the mainstream is summarized as shown in Table G.7.3. Sediment size of the riverbed is very large in general.

Table G. 7.3 River Gradient of Dinanggasan River

Reach	Slope
0 – 2.5 km	1/30
2.5 – 7.8 km	1/20
7.8 – 9.3 km	1/7

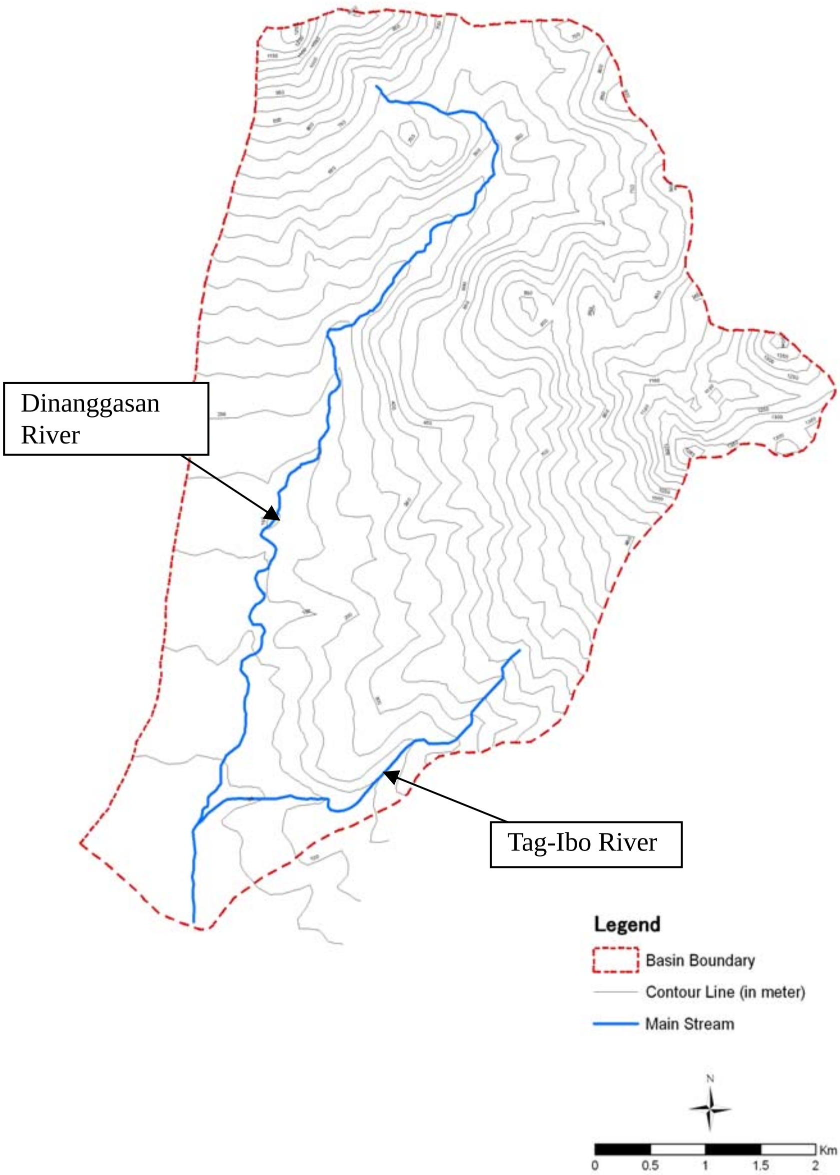


Figure G.7.1 Topographic Map of the Dinanggasan River Basin

The major river structures relating to flood control are, as follows:

- Boulder dike with rubble concrete surface stretching 650 m around the river mouth on the left side of Dinanggasan River
- Boulder dike with rubble concrete surface stretching 80 m around the river mouth on the right side of Dinanggasan River

Figure G.7.1 shows topographic map of the basin.

(3) Meteorology and Hydrology

The Catarman Municipality, that covers almost all of the Dinanggasan River Basin, falls under the Type II of the Corona climate classification. This climate type is characterized by a very pronounced rainy period during the months of December to February and the absence of a definite dry season.

There is only one rainfall station located in Camiguin Island, and this station is operated by the PHIVOLCS. The daily rainfall data has been collected since 1990.

(4) Regional Geology

Volcanic rocks underlay in the Dinanggasan River Basin. These include lava flows, pyroclastic flows and lahars. Alluvial deposits at the river deltas and beaches are likewise of volcanic composition. The volcanic rocks are better classed as rock-dependent units than time-dependent units because of the very young age of the island.

7.1.2 Social and Economic Conditions

(1) Population and its Growth

The total population of the Catarman Municipality based on the 2000 NSO Census is 15,386, an increase of 864 individuals from the 1995 NSO Census. The average annual growth rate from 1995 to 2000 is 1.21%. It is noteworthy that there is a steady and modest increase in population from 1980 to 2000. Based on the Municipality CLUP, the population by 2008 is projected to reach 17,099.

(2) Land Use

The total land area of the Catarman Municipality is about 5,690 ha. The dominant land use in the Municipality can be categorized into built-up areas, agro-industrial area, forestland, grassland and other uses, such as quarry and tourist areas, as follows:

1) Built-up Areas

Urban built-up area is 44.33 ha, while the aggregate total of other barangays is 202.90 ha.

2) Agri-industrial areas

Agri-industrial area is generally coconut plantation with inter crops of lanzones, mango, cultivated crops and other fruit trees. This covers 3,818.62 ha or roughly 71.04 % of the total area of the Municipality.

3) Grassland

The grassland area of 412.83 ha is generally located in the slopes of Mt. Catarman and Mt. Vulcan, while 186.50 ha are located within the alienable and disposable (A & D) classification.

4) Forestland

Forestland is mostly secondary growth forest. Forestland still covers 888.80 ha. Total open canopy forest covers 745 ha, while close canopy forest covers 143.80 ha.

5) Quarry

Quarry sites for sand and gravel locate in two rivers and are used as tourist spots. These are small areas but they have impact on the economy of the Municipality.

6) Other Uses

Rice land covers 29 ha mostly found in Barangay Mainit and Liloan.

Figure G.7.2 shows the land use of the basin (2002/03) and Table G. 7.4 shows the specific details of the land use.

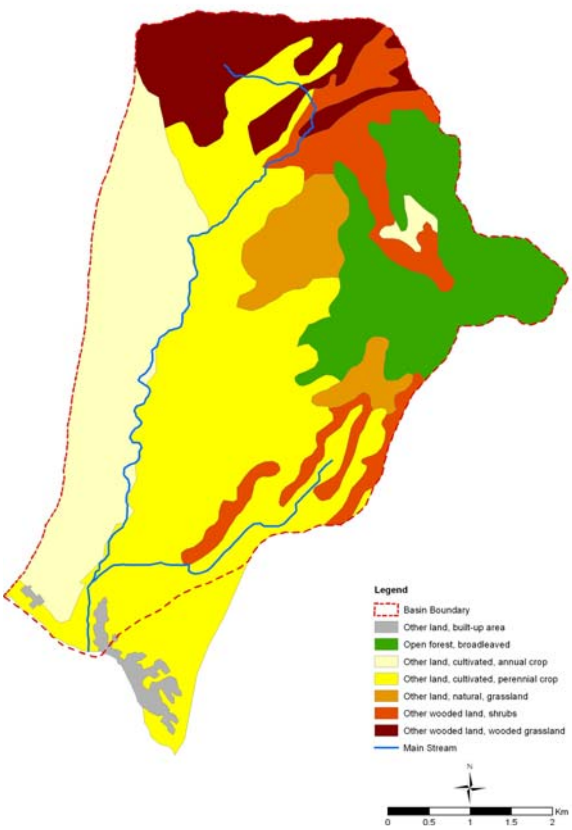


Figure G.7.2 Land Use in the Dinanggasan River Basin

Table G. 7.4 Share of Land Use in the Dinanggasan River Basin

Land Use	Land Area (km^2)	Percent of Total (%)
Open Land, Built-up	0.1	0.4
Other Land, Cultivated, Annual Crop	6.0	20.5
Other Land, Cultivated, Perennial Crop	10.6	36.2
Other Land, Natural, Grassland	1.8	6.2
Other Wooded Land, Wooded Grassland	3.0	10.1
Other Wooded Land, Shrubs	3.0	10.2
Open Forest, Broadleaved	4.8	16.4
Total	29.3	100.0

(3) Local Economy

1) Agriculture

Coconut is the dominant crop planted in the Catarman Municipality covering 5,355 ha. Inside this area, lanzones, banana, root crops, vegetables and other fruit trees are planted as inter-crop. Within this multi-storey cropping, the coconut and lanzones area covers 107 ha; coconut and banana area covers 119 ha; coconut and mango covers 143 ha; coconut and corn area covers 261 ha; coconut and root crops/vegetables covers 91 hectares; and the remaining area of 4,605 ha is dominantly planted with coconuts.

Having a shoreline of 16.35 kilometers, this municipal water is the richest fishing ground in terms of pelagic fisheries.

2) Commerce and Trade

The Central Business District in the Catarman Municipality is host to major business establishments, banking and financial institutions, and convention and conference centers.

The business establishments in the Municipality are mostly general merchandise stores, small town drugstores, banks, restaurants and fuel stations.

3) Industry

The Catarman Municipality has a couple of industries, such as wood appliance industries, bamboo craft industries and “nito” industries. These products are mainly sold locally.

Dinanggasan River has been declared as the only quarry area in the province. The extracted volume serves the requirement for the concreting of road pavements and low stress infrastructures.

7.1.3 Floods and Flood Damage

(1) Floods and Flood Damage

The Dinanggasan River Basin experienced severe floods on November 2001 when the tropical typhoon “Nanang” passed northern Mindanao through the islands of Cebu and Panay. A total of 166 persons died, 84 missing and 146 injured in the whole Camiguin Island due to Typhoon Nanang.

Regarding to the casualties of the Dinanggasan River Basin under Typhoon Nanang, the DPWH regional officer said that the flood had killed three (3) persons and damaged almost the entire portion of the rubble concrete on the surface of the existing dike. The damage was evaluated at 11 million pesos. The major flood type of this river basin is debris flows and flash flood.

(2) Major Causes of Floods

The basin is generally underlain by volcanic rocks, and covered by the pyroclastic sedimentation and large rocks. Especially, large volcanic rocks are observed in the upstream area with steep slope. Under these river conditions, heavy rainfall and consequent rapid runoff resulted in debris flows.

7.1.4 Previous Related Study

Disaster caused by Typhoon Nanang pushed forward the "Basic Study on Disaster Prevention and Reconstruction Project for Camiguin Island, Mindanao, Philippines, December 2003, JICA". The purposes of this study were to (1) analyze and evaluate the present flooding characteristics and sediment conditions of Camiguin Island, (2) formulate a basic plan for disaster prevention and reconstruction; and (3) prepare an action plan for urgent undertaking.
Based on this analysis, the characteristics of the basin are, as follows:

- Population in the Basin: 2,241 persons which is the largest population among the 28 river basins in Camiguin Island
- Population in Dangerous Area: 124 persons which is the 10th largest population among the river basins in Camiguin Island
- Volume of Specific Movable Sediment: 48,082 m^3/km^2 which is the 5^{th} largest among the river basins in Camiguin Island

The Dinanggasan River Basin was not included in the action plan.

7.2 Hydrologic Analysis

7.2.1 Specific Discharge Formula

The design discharge of the Dinanggasan River Basin is computed with the following Specific Discharge Formula. Furthermore, since this river is a debris flow stream, the design discharge is increased by 1.5 times.

$$\mathbf{q = c \cdot A^{(A^{-0.048}-1)}}$$

Where, q = specific discharge ($m^3/s/km^2$)
c = constant (11.29, decided by region and return period)
A = catchment area (km^2)

7.2.2 Design Discharge Distribution

Distribution of design discharge for 20-year return period is shown in Figure G.7.3.

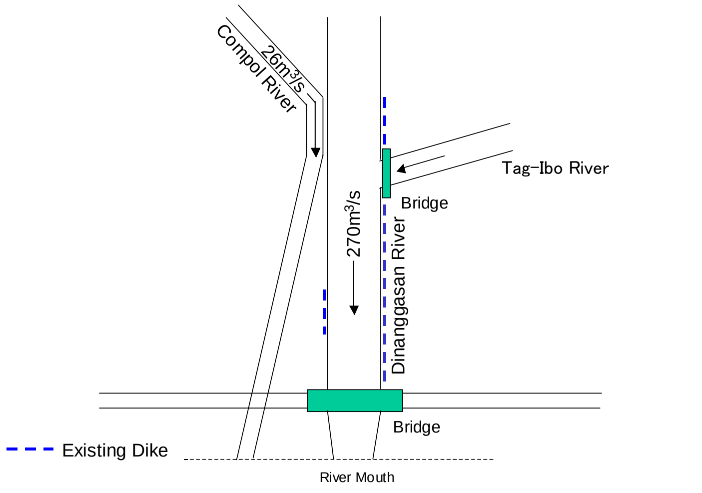


Figure G.7.3 Design Discharge Distribution in the Dinanggasan River Basin

7.3 Flood Inundation Analysis

7.3.1 Flow Capacity

The flow capacity of the existing river channel is analyzed with HEC-RAS using the river cross sections newly obtained in the survey. The flow capacity is estimated as shown below.

Table G. 7.5 Flow Capacity of Existing River Channel in the Dinanggasan River Basin

Location of Calculation	Flow Capacity (m^3/sec)
Dinanggasan River (Upstream Portion)	180

7.3.2 Flood Inundation Area

The upper stream from 500m from the river mouth is the debris flow section with the riverbed gradient of 1/30 or more. Based on these characteristics, it is considered that the flood damage is mainly caused by sand and rock with water. Therefore, the damage area is estimated based on the potential area of debris flows shown in the previous Basic Study in due consideration of the topography and river conditions. The flood inundation area is preliminary estimated at Compol area in the right bank and Catarman area in the left bank, as shown in Figure G.7.4. The total inundation area is estimated at around 147 ha as shown below.

Table G. 7.6 Area of Flood Inundation of the Dinanggasan River Basin

(Unit: ha)

Land Use	Inundation Area
Built-up area	6.0
Fishpond	0.0
Cultivated, Annual Crop	91.5
Other	49.3
Total	146.8

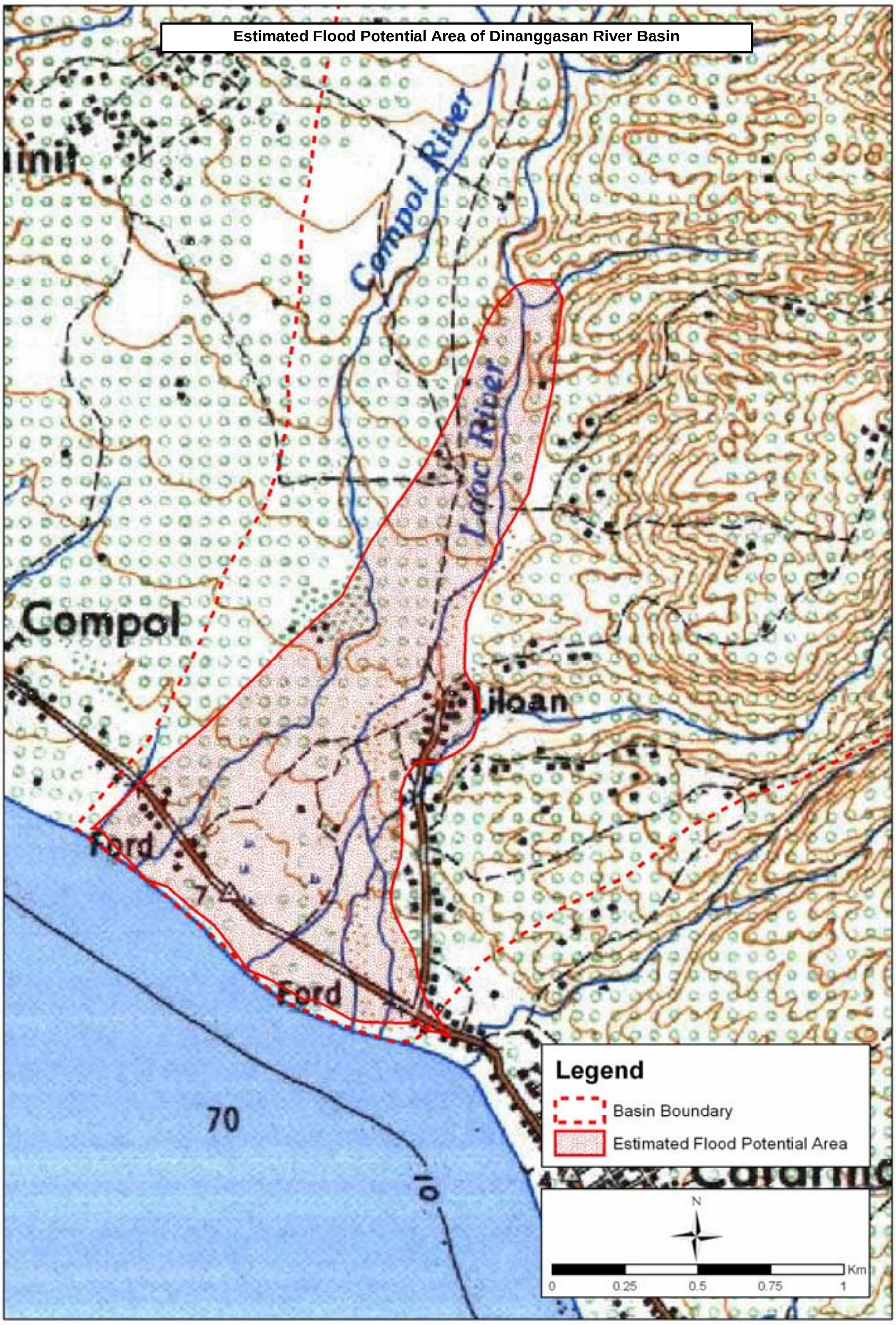


Figure G.7.4 Flood Inundation Area of the Dinanggasan River Basin

7.4 Basic Layout of Main Structural Measures

7.4.1 Applicable Structural Measures

The flood type of the Dinanggasan River Basin is F+O+B+I+L (Group 6). Comparing with the flood type of this basin, the following structural measures are considered as the applicable ones:

Table G. 7.7 Basic Applicable Structural Measures for Flood Type in the Dinanggasan River Basin

Flood Type	Applicable Measures				
	River Channel Improvement	Dam and Reservoir and/or Sabo Dam	Retarding Basin	Diversion Channel	Drainage Facilities
Flash Flow (F)	O	O			
Over Flow (O)	O	O	O	O	O
Bank Erosion (B)	O				
Inland Flooding (I)	O				O
Lahar / Debris Flow (L)	O	O			

Judging from the river basin conditions, retarding basin, diversion channel and drainage facilities are not applicable to the basin considering the topographic and land use conditions. Hence, applicable measures are river channel improvement and sabo facilities as described below.

(1) River Channel Improvement

River channel improvement for Dinanggasan River is applicable to confine and carry the design discharge. For this river channel improvement, alignment of the existing dikes is adopted in principle.

(2) Sabo Dam and Sand Pocket

Observing the riverbed gradient, river width and riverbed materials and other conditions along Dinanggasan River, sabo dam and sand pocket sites were preliminarily selected at around 5 km and 2.5 km upstream from the river mouth, respectively.

Based on the study above mentioned, the following structural measures are recommended as the applicable structural measures for the basin:

Table G. 7.8 Applicable Structural Measures in the Dinanggasan River Basin

Flood Type	Applicable Measures				
	River Channel Improvement	Sabo Facilities	Retarding Basin	Diversion Channel	Drainage Facilities
F+O+B+I+L	O	O			

7.4.2 Basic Idea of Layout

(1) Relationship with the Compol River

The Compol River lies in the right bank of Dinanggasan River. The shortest distance between the both rivers is around 300m. Based on the field survey, the overflow from Dinanggasan River to Compol River has been observed during Typhoon Nanang at around 1.5 – 2 km from the river mouth. On the other hand, there was a information that the floods from the upper stream of the Compol River flow into Dinanggasan River. Therefore, the flood mitigation of Dinanggasan River only will not solve the flood problems in this basin. Hence, in this Study, the both river basins are studied for the formulation of the plan. However, due to the period of this Study, the available data and information are limited, therefore, further investigations are necessary.

(2) Target Area of Flood Mitigation

Based on the idea above mentioned, the target area of flood mitigation is a potential flood area of the rivers. Based on the results of the previous Basic Study, the target area has been set at 0 – 2.5 km. In this target area, the following damageable assets are located:

- Built-up areas of Catarman and Compol
- Houses located around the river mouth and the confluence with Tag-Ibo River
- Annual crop area

(3) Sabo Facilities

In many cases, flash floods and/or debris flows cause severe damages including loss of human lives although its damage area is limited.

Based on the previous Basic Study, the debris flows in this area are classified into two types, one is debris flow with mainly boulder in the upstream, and the other is with mainly sand and gravel in the lower stream. The sabo facilities are planned against the boulders flown in debris flow in the upstream.

The effects of sabo facilities are to reduce risks for:

- Sediment disaster due to debris flows,
- Flooding caused by severe aggradation of river bed due to heavy and sudden sediment load, and
- Flooding caused by backwater at structures such as bridges due to clogging of woody debris, etc.

In the previous Basic Study in 2003, the specific movable sediment in the Dinanggasan River Basin was estimated at 48,082 m^3/km^2. In principle, it is desirable to construct necessary sabo works, which total capacity is corresponding to the total sediment discharges, in order to eradicate the sediment disasters. For this achievement, it is required to construct a number of sabo facilities, and it will cost considerably.

In this regard, one sabo dam and one sand pocket are preliminary proposed in this plan. The main purpose of these sabo facilities is to catch the front of debris flow, the most dangerous portion of debris flow, in order to weaken its destructive power.

Actually in this Study, estimation of benefit does not include intangible damages such as casualties because of difficulty of counting value of human lives. This is another aspect of planning the minimum size of sabo facilities. However, in the further studies, the number of sabo facilities will be increased so as to make the plan more safety, if this will be judged to be necessary from the viewpoint of the stability of communities and others. On the other hand, it is also important to improve the accuracy of planning by the monitoring of sediment discharges and others.

(4) River Channel Improvement

Around the downstream of the confluence with Tag-Ibo River, the main component of sediments in debris flows is sand and gravel. Under this condition, as mentioned before, the boulder dikes with rubble concrete surface were constructed in this downstream in order to protect built-up and agricultural areas. Based on the field survey, these dikes are judged to be well functioned against debris flows here. Therefore, river channel improvement with the same dike type is planned for the remaining portion (other than the existing dike portion) in order to mitigate the risks of flooding caused by the debris and flash flows.

(5) Treatment of the Compol River

There are two alternatives regarding to the treatment of the Compol River, as follows:

1) Connecting Compol River to Dinanggasan River

The river channel improvement is proposed to confine and carry the design discharge flows of Dinanggasan River and Compol River.

2) Separating Compol River from Dinanggasan River

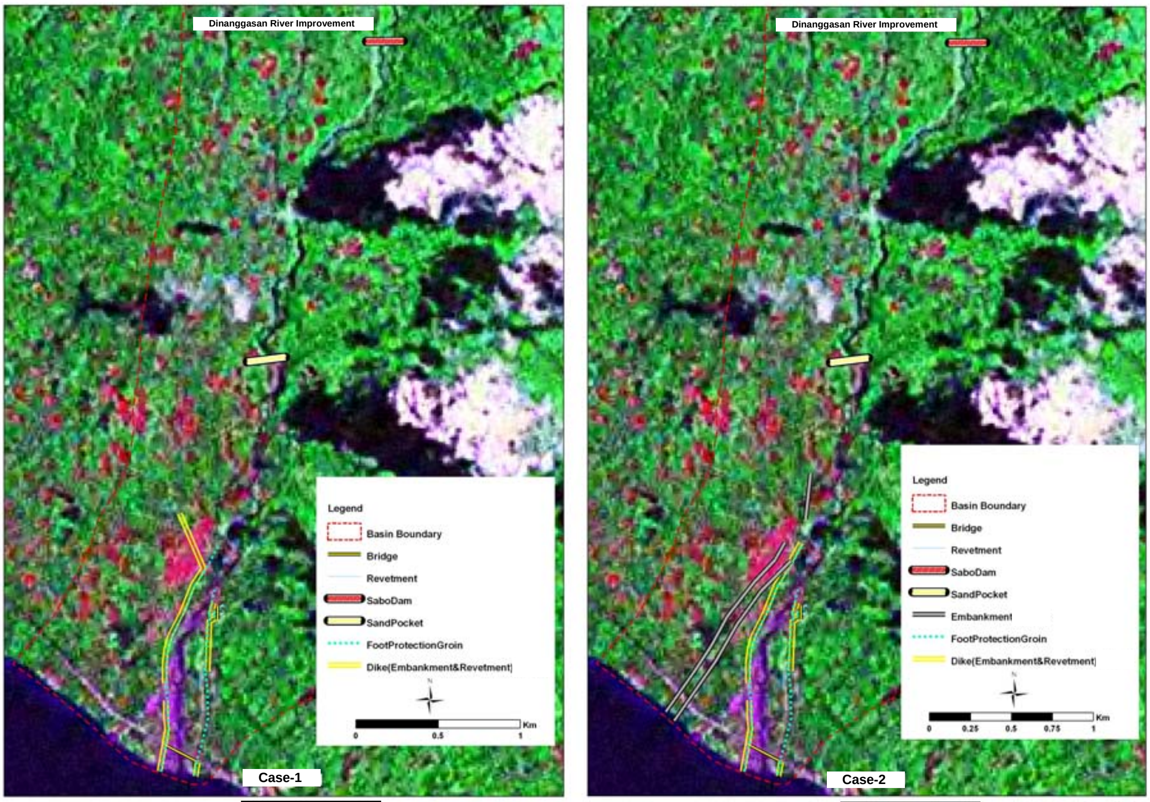
The river channel improvement is proposed to confine and carry the design discharge flows of Dinanggasan River only. For this treatment, training dike and a channel are planned in order to separate both rivers. With these measures, the flooding of Compol River will be avoided, which may cause severe damages to the Dinanggasan River Basin.

7.4.3 Possible Alternative Cases

Considering the above idea, two alternative cases are conceivable as shown in Table G. 7.9 and Figure G.7.5.

Table G. 7.9 Alternative Cases in the Dinanggasan River Basin

Alternative Cases	Basic Layout of Main Structural Measures
Case-1	• River channel improvement in the lower reach of Dinanggasan River • Training dike guiding the flow of Compol Rive into Dinanggasan River • A sand pocket and a sabo dam in the middle reach of Dinanggasan River
Case-2	• River channel improvement in the lower reach of Dinanggasan River • Training dike avoiding the over flow from Dinanggasan River to Compol River • A channel along Compol Rive to flow down its flood • A sand pocket and a sabo dam in the middle reach of Dinanggasan River



Case-1 Case-2

Figure G.7.5 Comparison of Alternative Cases in the Dinanggasan River Basin

7.4.4 Recommended Structural Measures

(1) Optimum Case

The cost for each alternative case is roughly estimated as shown in Table G. 7.10. Based on the estimation results, the difference in the costs is very small. However, because of the economical advantage, Case-1 is preliminarily recommended as the main structural measures for the time being. It is recommended that the selection of the optimum case and the specifications of the structural measures should be reviewed in the further study.

Table G. 7.10 Result of Cost Comparison for Alternative Cases in the Dinanggasan River Basin

Alternative Cases	Cost (mil. Pesos)
Case-1	147.5
Case-2	149.8

Based on the above, the main structural measures are proposed as shown in Table G.7.11. Figure G.7.6 shows the design discharge distribution with the proposed structure measures.

Table G. 7.11 Major Work Items in the Dinanggasan River Basin

	Components	Work Item	Quantity
1	Dinanggasan River Improvement	Dike, Foot Protection, Excavation, Training Dike	Around 1.6 km
2	Sabo Dam	Impermeable Type Dam	1 no.
3	Sand Pocket	Impermeable Type Dam	1 no.
4	Re-Construction of Bridge	Concrete Bridge	1 no.

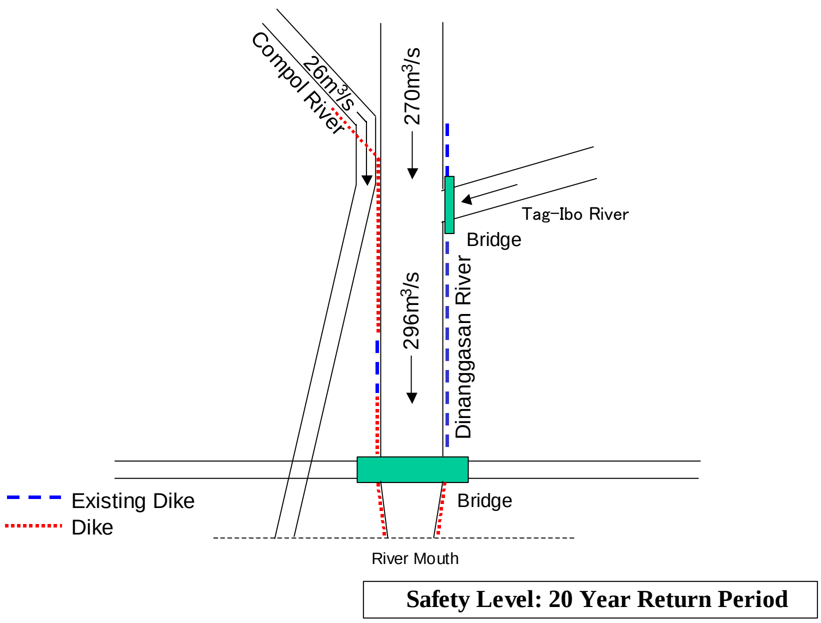


Figure G.7.6 Design Discharge Distribution with Optimum Structural Measures in the Dinanggasan River Basin