5.6 Tuganay River Basin

5.6.1 Basin Conditions

(1) Natural Conditions

1) 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 5.83 and Figure 5.34.

Table 5.83 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.

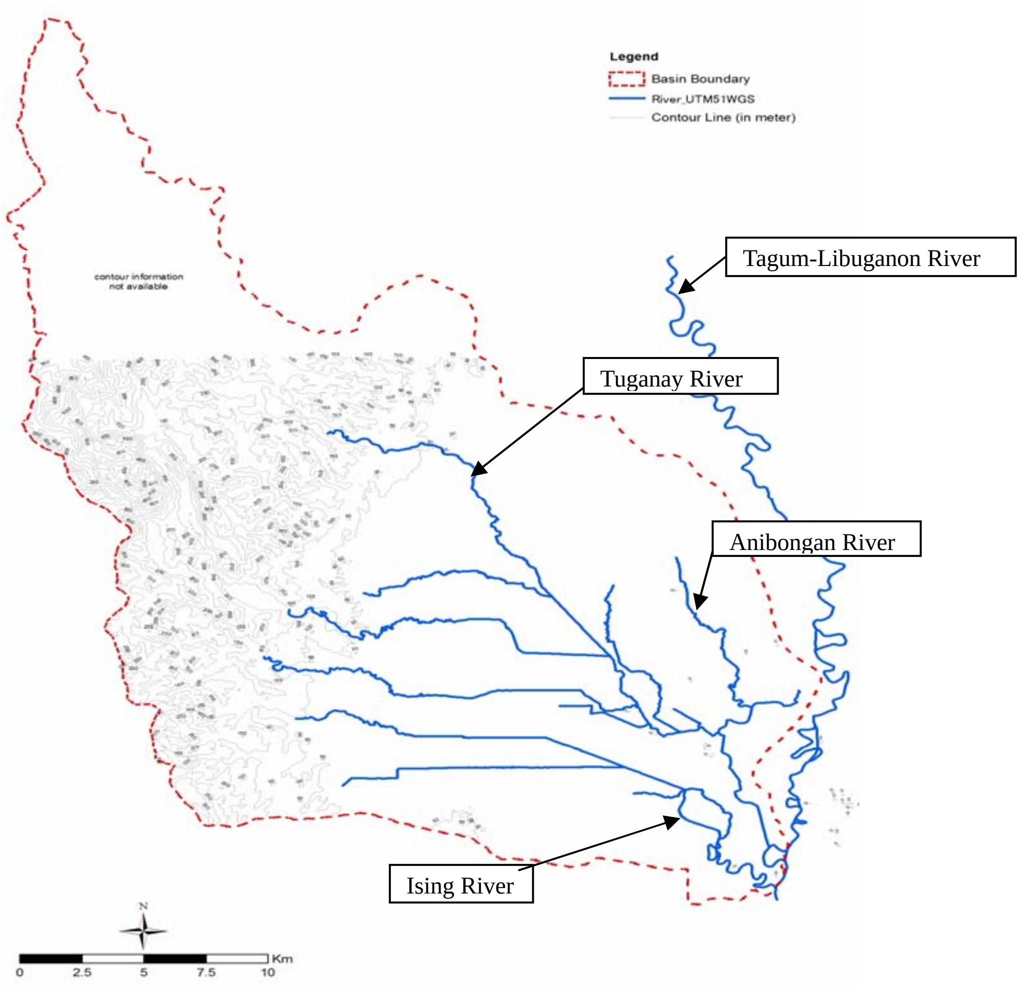


Figure 5.34 Topographic Map of the Tuganay River Basin

2) 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 5.35.

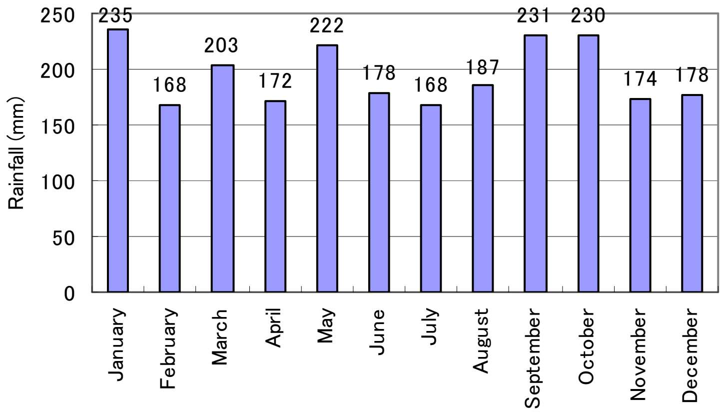


Figure 5.35 Monthly Rainfall Distributions at PAGASA Synoptic Station, 1996-2005

(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

a) 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 5.36 shows the land use map of the basin (2002/03).

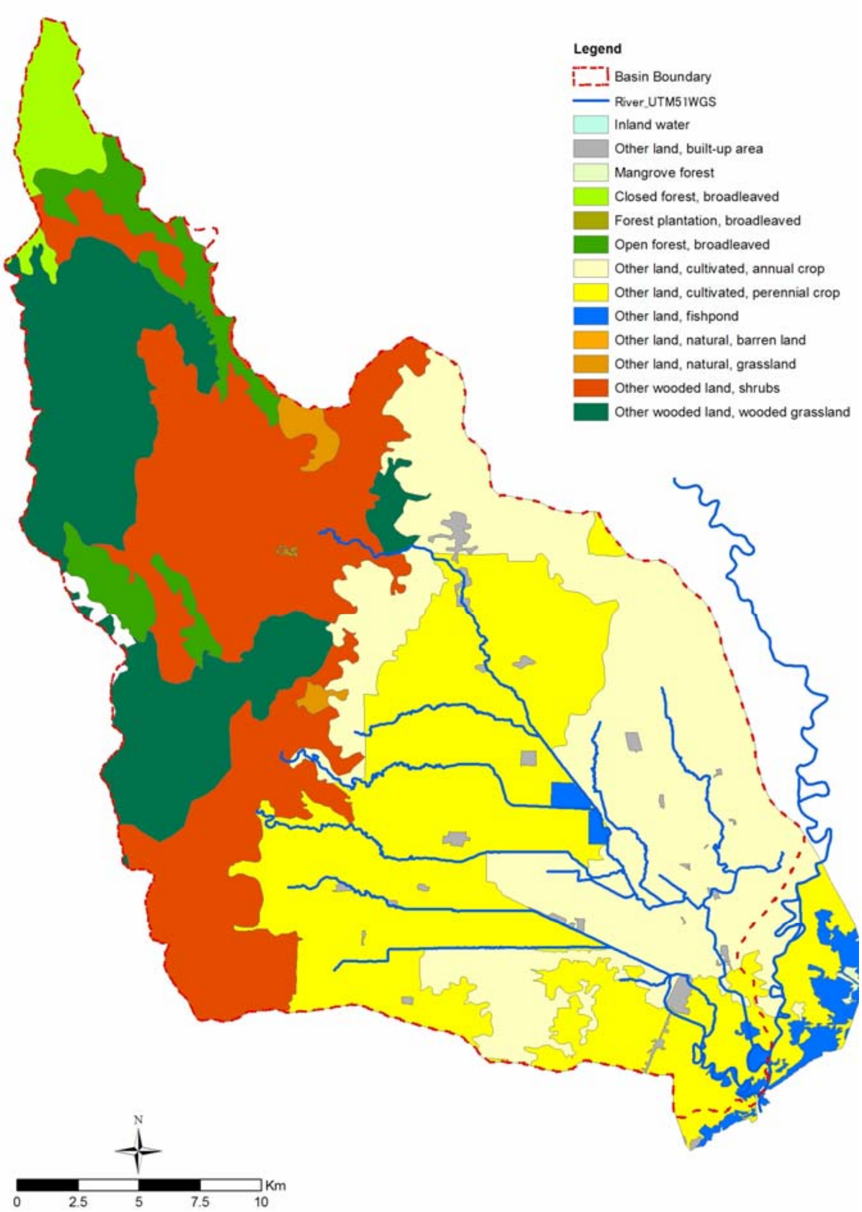


Figure 5.36 Existing Land Use in the Tuganay River Basin

b) 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 5.84 and Table 5.85 show the existing and projected land use of the both Municipalities.

Table 5.84 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 5.85 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

a) 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.

b) 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.

c) 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.

(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 5.86 shows the number of affected persons and the damage on infrastructure in the Carmen Municipality during 1995-2006. On the other hand, Table 5.87 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 5.86 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 5.87 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.

(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 5.37 and Table 5.88.
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.

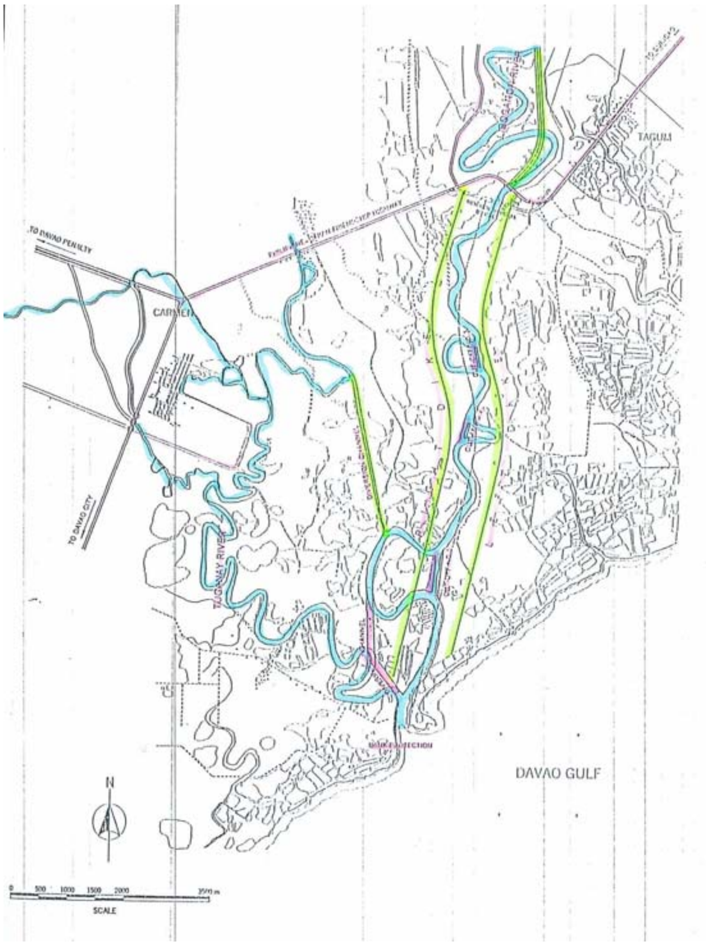


Figure 5.37 Recommended Flood Protection Dikes along Tagum River

Table 5.88 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	

5.6.2 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 5.38.

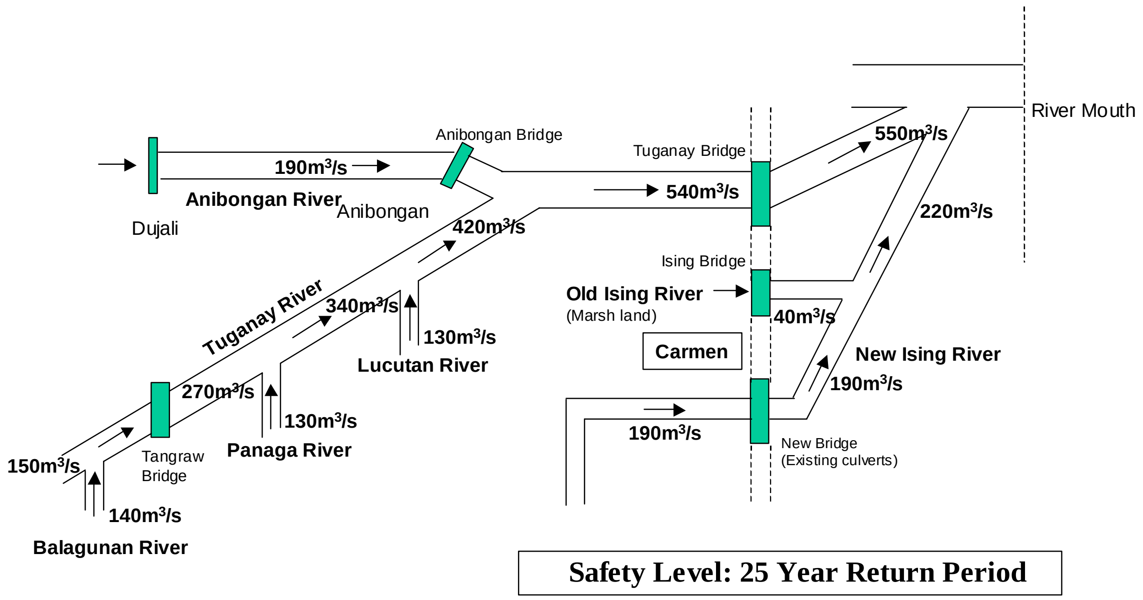


Figure 5.38 Design Discharge Distribution in the Tuganay River Basin

5.6.3 Flood Inundation Analysis

(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 5.89 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

(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 5.90. Figure 5.39 shows the flood inundation area.

Table 5.90 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

5.6.4 Basic Layout of Main Structural Measures

(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 5.91 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.

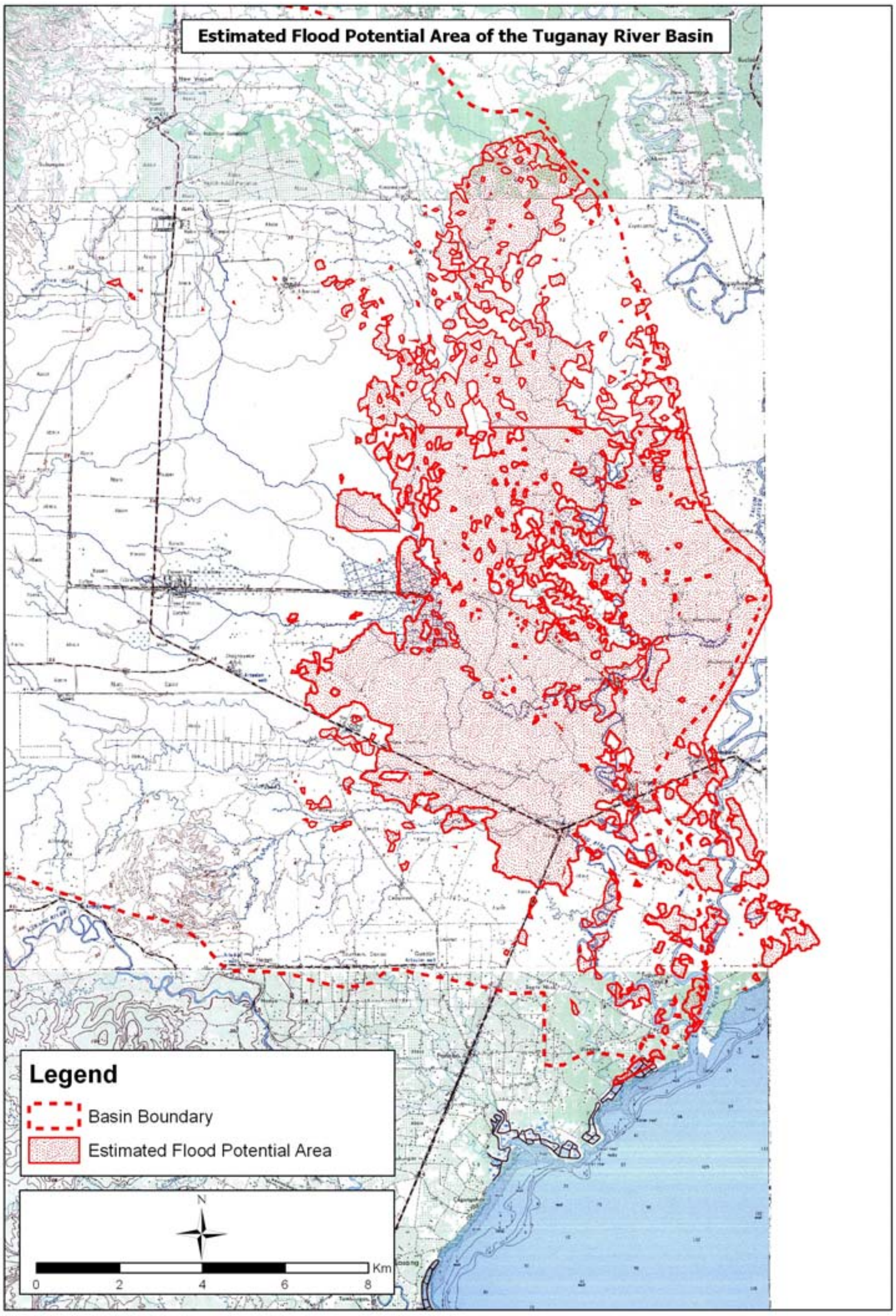


Figure 5.39 Flood Inundation Area of the Tuganay River Basin

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:

a) 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.

b) 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.

c) 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:

a) 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.

b) 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.

c) Diversion Channel

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

d) 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.

a) 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.

b) 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 5.92 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		

(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 5.39.

(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:

a) 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.

b) 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; and
- ➢ 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.

(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; and
(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.

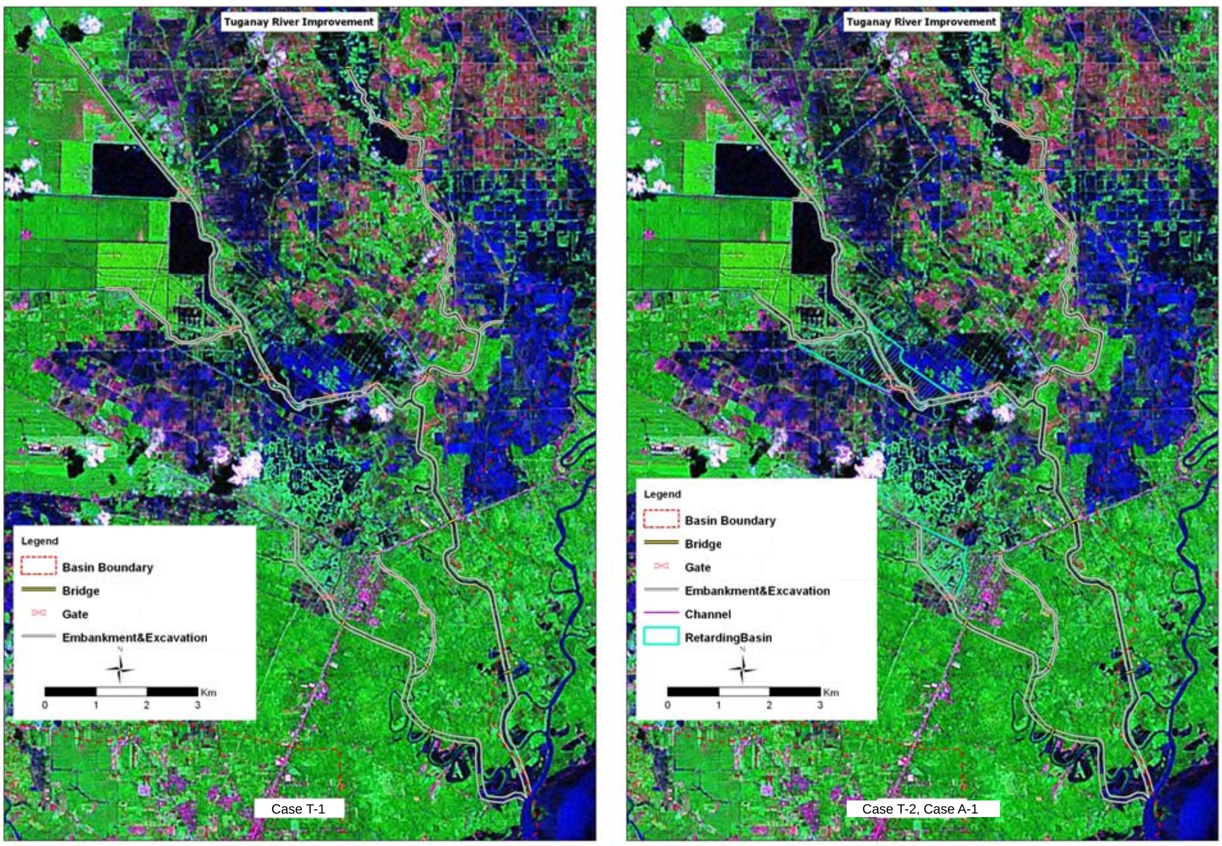
Table 5.93 Preliminary Dimension of Dam

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 5.94. Figure 5.40 shows the plans of these cases.

Table 5.94 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 5.40 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 5.95. Figure 5.41 shows the plans of these cases.

Table 5.95 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

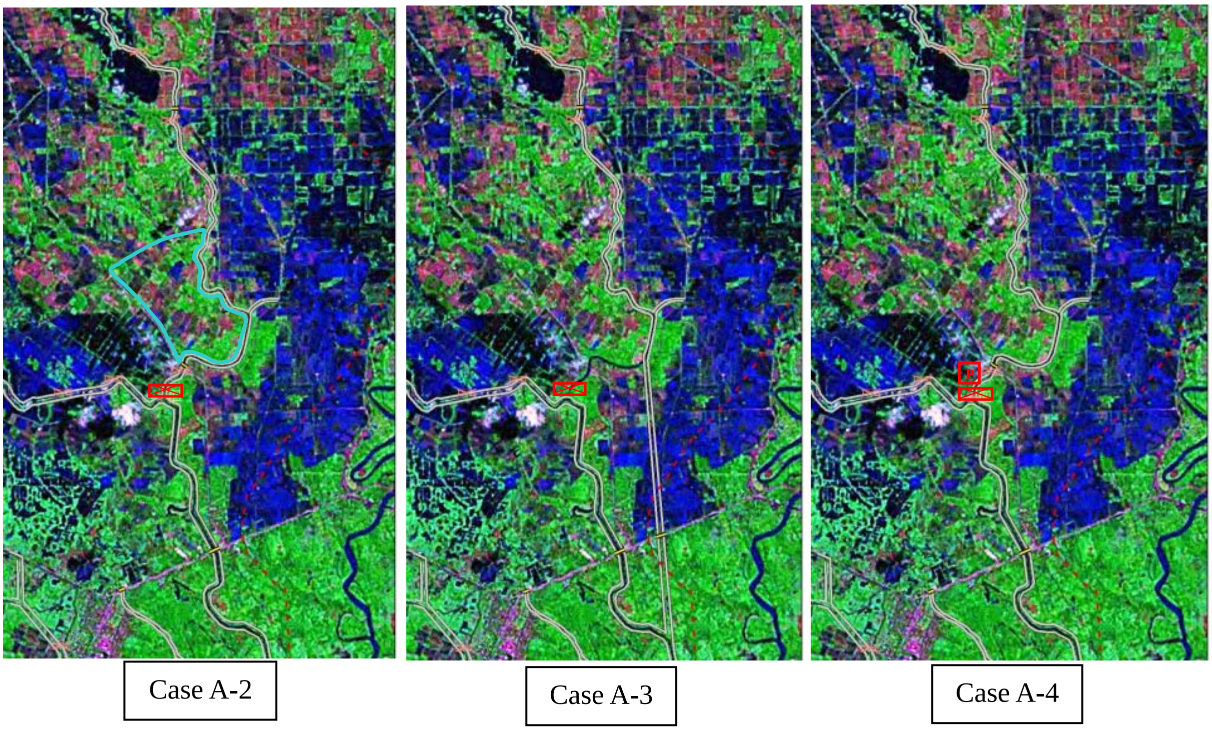


Figure 5.41 Comparison of Alternative Cases in Anibongan River

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 5.96. Figure 5.42 shows the plans of these cases.

Table 5.96 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 5.42 Comparison of Alternative Cases in Ising River

(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 5.97.

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 5.97 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 5.43.

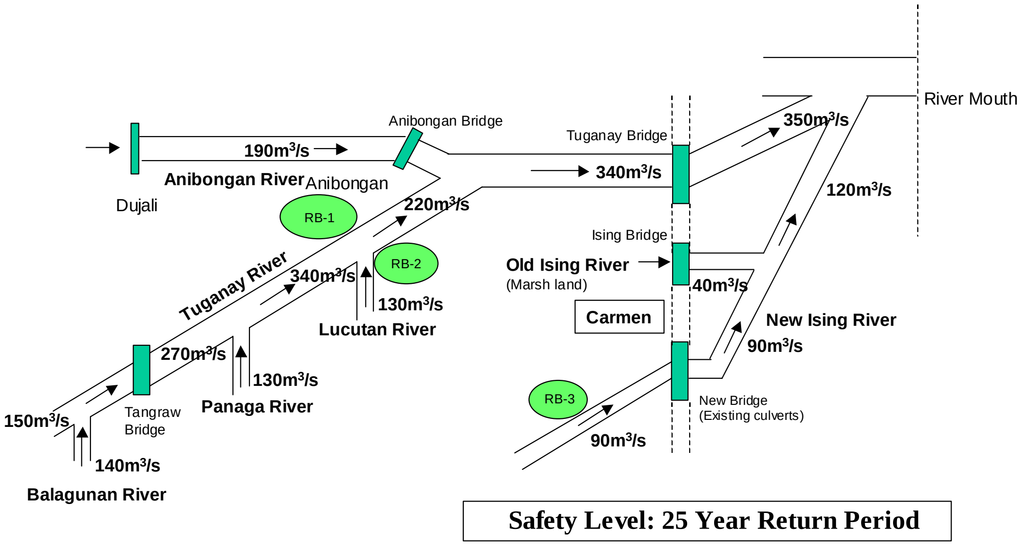


Figure 5.43 Design Discharge Distribution with Optimum Structural Measures in the Tuganay River Basin

2) Preliminary Design of Main Structural Measures

The preliminary design of the river channel improvement and retarding basin is presented below.

a) River Channel Improvement

The improvement works will be required the following rivers in order to attain the flood mitigation against the project scale of 25-year return period. The length and section for the improvement are tabulated in Table 5.98. On the other hand, longitudinal profile and typical cross sections of the improvement are shown in Fig.5-6, Fig.5-7 and Fig.5-8.

Table 5.98 Improvement Plan in the Tuganay River Basin

Tuganay River

Stretch	Station Number		Design Discharge (m^3/s)	Length (km)	Width (m)
	From	To			
1	0	9.0	340 - 350	9.0	60
2	9.0	15.0	220	6.0	60
3	15.0	21.0	270 - 340	6.0	55
Total				21.0	

Anibongan River

Stretch	Station Number		Design Discharge (m^3/s)	Length (km)	Width (m)
	From	To			
1	0	6.5	190	6.5	65
2	6.5	10.0	190	3.5	60
Total				10.0	

New Ising River

Stretch	Station Number		Design Discharge (m^3/s)	Length (km)	Width (m)
	From	To			
1	0	6.0	90 ~ 130	6.0	100
2	6.0	9.0	90	3.0	50
Total				9.0	

Old Ising River

Stretch	Station Number		Design Discharge (m^3/s)	Length (km)	Width (m)
	From	To			
1	0	3.0	40	3.0	25
Total				3.0	

b) Retarding Basin

The retarding basins are planned for Tuganay and Ising Rivers. With the design discharge of 25-year return period, the regulation function is examined to estimate the required capacity of the retarding basins. As a result, the required volumes and dike heights are preliminarily designed as shown below.

Table 5.99 Dimension of Retarding Basins in the Tuganay River Basin

Dimensions	Tuganay River	Ising River
Area of Retarding Basin (ha)	200	75
Storage Volume (MCM)	5.00	1.50
Required Capacity (MCM)	4.99	1.42
Surface Elevation (EL. m)	7.6	6.0
Dike Height (m)	3.1	2.3
Dike Length (m)	11,000	4,100

Based on the above design, the basic layout of the main structures is presented in Figure 5.44.

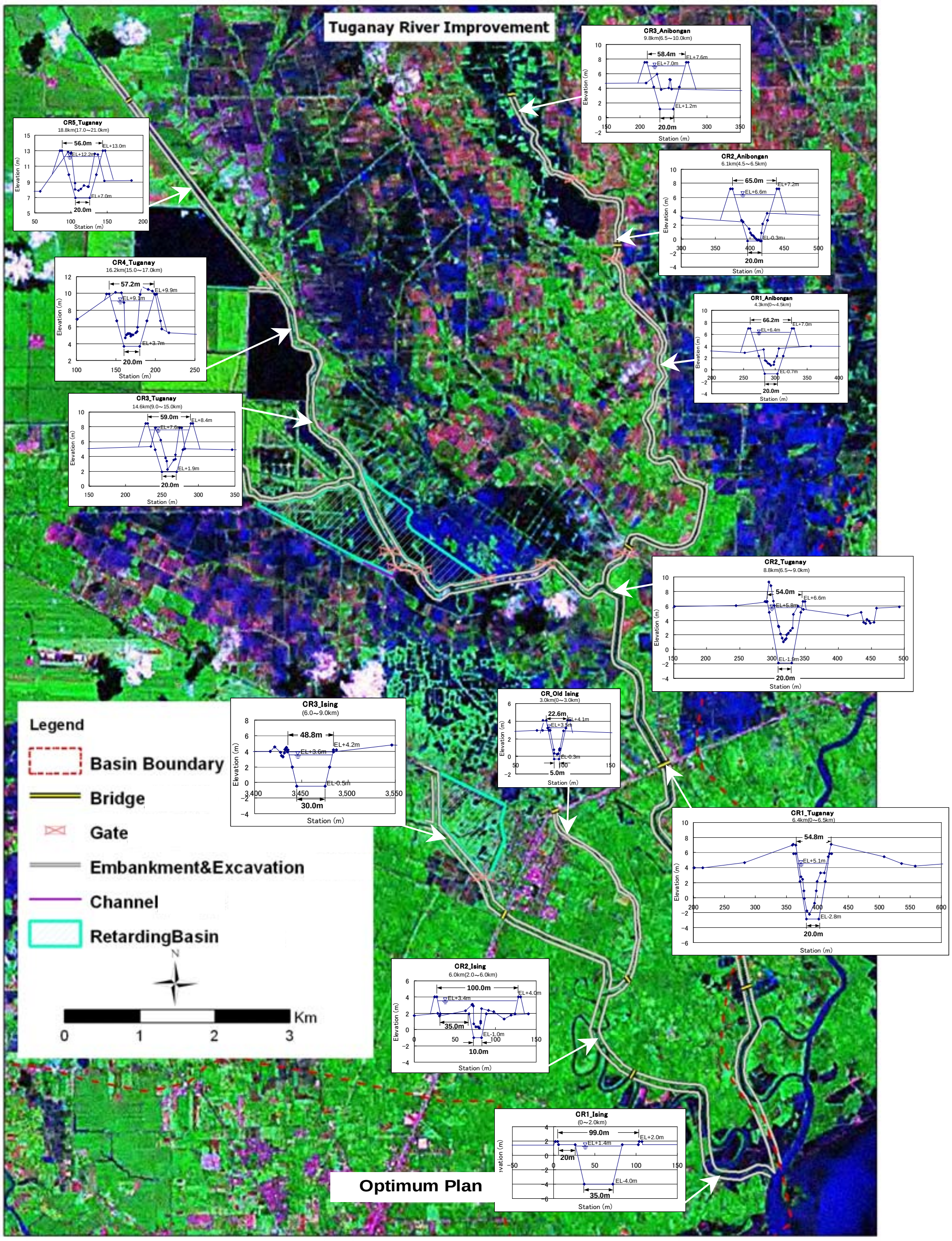


Figure 5.44 Proposed Works of the Optimum Plan of the Tuganay River Basin

(6) Estimation of Cost for Structural Measures

1) Construction Cost of Structural Measures

The construction cost of the recommended structural measures is estimated at 1,754.7 million pesos as shown below.

Table 5.100 Main Construction Cost for Structural Measures of the Tuganay River Basin

No.	Work Item	Unit	Quantity	Unit Cost (Pesos)	Amount (thousand Pesos)
1	Channel Excavation	m^3	4,384,692.0	150	657,704
2	Embankment	m^3	1,967,386.0	130	255,760
3	Revetment	m^2	92,509.5	1,100	101,760
4	Foot Protection	m	2,325.0	3,350	7,789
5	Sodding	m^2	1,872,042.5	30	56,161
6	Gate	m^2	275.0	1,040,000	286,000
7	Bridge	m^2	8,260.0	-	389,500
	Total				1,754,674

2) Project Cost

The project cost is estimated at 2,669.0 million pesos in total as shown below.

Table 5.101 Project Cost for Structural Measures of the Tuganay River Basin

No.	Description	Amount (thousand Pesos)
1	Construction Cost	2,017,875
(1)	Preparatory Works	263,201
(2)	Main Construction Cost	1,754,674
2	Administration Cost	60,536
3	Engineering Services	322,860
4	Compensation Cost	25,067
5	Physical Contingency	242,634
	Total	2,668,972

3) Economic Cost

The economic project cost is estimated as shown below.

Table 5.102 Financial and Economic Costs of the Project of the Tuganay River Basin

	Financial (mil. Pesos)	Economic (mil. Pesos)
Project Cost	2,669.0	1,948.4

(7) Estimation of Benefit of Structural Measures

1) Estimation of Flood Damage

Inundation areas under the project scale are calculated in the flood inundation analysis, and are applied to estimate the flood damage. The flood damage is estimated considering with and without project conditions as shown below.

Table 5.103 Flood Damage in the Tuganay River Basin

Item		Area Inundated (ha)	Assets Inundated (mil. Pesos)	Flood Damage (mil. Pesos)
I.	Direct Damage			616.5
	Built-up Area	154.5	1,406.0	421.8
	Irrigated paddy	6,857.5	83.7	41.9
	Fishponds	391.2	11.7	10.5
	Infrastructure			142.3
II.	Indirect Damage			123.3
III.	Total			739.8

2) Annual Average Benefit

Based on the estimated flood damage, the annual average benefit under present condition is computed at 266.3 million pesos. The future benefit is shown in Tab.5-9.

5.6.5 Non-Structural Measures

(1) General

Non-structural measures are examined on the basis of filed survey and preliminary studies on flood warning system and soil loss related to reforestation. The methodology and detailed results of the study are described in Supporting Report H. It should be reminded that the Study is preliminary level because of limited time frame and resources. The Study concentrated to discuss general direction of flood mitigation using currently available information. Further detailed study toward implementation of flood mitigation measures is recommended at the next stage such as feasibility study. The recommended non-structural measures at this stage are summarized below.

(2) Recommendation on Non-Structural Measures

1) Recommended Flood Warning System

Community Based Flood Early Warning System (CBFEWS), which PAGASA is now introducing, is recommended. Basically same scheme as PAGASAs system can be applied.

However, special treatment of mountain area belonging to another province (Davao) should be considered when the warning system is established.

After initial introduction of the warning system, it is recommended to refine the system every 3 years using the accumulated data and knowledge. Equipment introduced should also be checked at the same time.

2) Recommendation on Baseline Activities on Watershed Management

Watershed management includes many aspects than flood mitigation. In the present Study, it is recommended that at least minimum necessary activities related to flood mitigation be implemented as baseline activities on watershed management. The following activities are recommended.

- To prepare watershed characterization and watershed management plan
  - ➢ Watershed Management Plan for the part of Davao Del Norte is going to be finalized soon. Using this, watershed characterization and watershed management plan should be prepared for the entire river basin including a part of Davao province.
  - ➢ The watershed characterization and watershed management plan should be reviewed and revised every 5 years to reflect the watershed situation properly.
- Reforestation with at least same rate as current national average
  - ➢ In order to keep at least current condition of watershed so that sediment load from catchment will not increase drastically in future, reforestation should be continued with at least same rate as current national average, e.g. reforestation of grass land (Total area in 26 years = 5.7% of land without forest in the basin).
- Supporting of River Basin Council
  - ➢ To enhance more communication within a basin, it is recommended to prepare budget to support activities of river basin council.

3) Recommendation on Other Measures

Issues and recommendations for further improvement for disaster management activity for the Tuganay River Basins based on the result of field survey are summarized.

General recommendations are, as follows:

- Enhancement of disaster management activities at community level;
- Necessity of periodical refinement of disaster management plan; and
- Necessity of preparation and dissemination of hazard map for excess flood after completion of structural measures.

Recommended other measures for the Tuganay River Basin are, as follows:

- Assessment of existing dike system & Hazard map which shows danger of breach of dike
  - ➢ Tuganay river basin, especially lower reach, is well-known as flood prone area. People have already known that they area living in flood prone area. The nature of the flood is that the water level gradually increases. Therefore, people can adapt to slowly changing flood with almost no causality. However, if the dike system collapses, very rapid flow and sudden increase of water level can occur, which people have not yet experienced. In this case, it is very high risk for causality. Many new dikes are constructed not only by governmental organization but also private companies. The updated condition of the dike system should be investigated and those risks against flood should be assessed. Based on the assessment, hazard map

should be prepared to show potential risk as if dike system collapses. Preparedness plan should also be prepared against the dike collapse.

- Landuse regulation for banana plantation
    - ➢ Banana plantation supports regional economic growth. However, it could bring about more rapid run-off than before, although more scientific observation may be required. The first thing to do is to monitor the possible change of run-off pattern by introduction of banana plantation. Then, if change of the run-off pattern is scientifically detected, proper land use regulation should be considered to prevent further increase of peak discharge.
- Enhancement of communication between neighboring LGUs
    - ➢ MDCC/CDCC workshop to establish communication and support from neighboring LGUs is recommended. Exchange of know-how of disaster management each other is also recommended.

(3) Rough Estimation of Cost and Benefit for Reference

As a reference, rough cost estimation is made for the flood warning system and the baseline activity on watershed management.

Cost for flood warning system is roughly estimated as follows. O&M cost for 26 years includes 1) cost for refinement of the system every 3 years and 2) cost for observer.

Table 5.104 Rough Cost Estimation for Flood Warning System for 26 years in the Tuganay River Basin (2009 to 2034)

Cost for Initial Setting (mil. Pesos)	Total Cost for O&M for 26 years (mil. Pesos)	Total Cost for 26 years (mil. Pesos)
1.5	3.6	5.1

Cost for recommended baseline activities on watershed management for 26 years (2009 to 2034) is roughly estimated as shown in the following table.

Table 5.105 Rough Cost Estimation for Recommended Baseline Activities on Watershed Management for 26 years in the Tuganay River Basin (2009 to 2034)

Cost			
Preparation of Watershed Characterization & Watershed Management Plan (mil. Pesos)	Reforestation (mil. Pesos)	Supporting of River Basin Council (mil. Pesos)	Total Cost (mil. Pesos)
6.00	40.31	5.20	51.51

The breakdown of the estimated costs is shown in Supporting Report H.

Possible benefit by flood forecasting and warning system is preliminary estimated to examine appropriate flood forecasting and warning system in this river basin. Based on it, the above-mentioned flood warning system is recommended. The detail discussion is presented in Supporting Report H.

5.6.6 Initial Environmental Examination

(1) Result of the IEE

The IEE for the structural measures was carried out based on the information and data collected during this Study and consultation with concerned government and stakeholders.

In the Matrix (refer to Tab.5-10), the major environmental resources are shown in the horizontal line, and the activities for implementation of the proposed plan are shown in the vertical line. The assessment of impacts was made in terms of magnitude (e.g., significant, moderate, and negligible) of the negative or positive affecting the environmental elements.

Table 5.106 Activities for Each Project Phase in the Tuganay River Basin

Phase	Project Activity
Pre-construction Phase	Resettlement of Project affected Persons/Families
	Land Acquisition
	Project Mobilization
Construction Phase	Reconstruction of Existing Dike and River Improvement Works
	Demolition and Reconstruction of Existing Dike
	Upgrading/Construction of Approximately 10 Bridge affected by the River Improvement Works
	Installation/Construction of Gates and Drainage Facility
	Construction of Diversion Channel
	Construction of Retarding Basins
O & M Phase	Dredging and Excavation

Positive impacts are not considered in the cumulative quantification of the environmental impact score for each alternative since they would not lead to any hindrance in decisions of whether or not to proceed with the project. On the other hand, negative environmental impacts remain critical in so far as decisions in the proper selection of project alternatives.

As the result of the assessment, it is evaluated that the dredging, excavation and removal of debris (construction and demolition) for the river improvement works and the development of land as retarding basins are considered to cause the potential adverse impact for this area. The particular evaluations for these impacts are described below (for details, refer to Supporting Report I).

1) Social Environment

a) Resettlement

Potential conflict in land use may arise with the proposal to utilize the 225 hectares of land as retarding basins (e.g., agricultural activities and the displacement of PAPs/PAFs). Such condition will entail approval from the LGU of Carmen, Davao del Norte and permit from the Department of Agriculture (DA) for the land to be converted into special use from an agricultural use.

The preparation and implementation of resettlement plan will have to be immediately engaged to address the needs of more than 34 residential households living within the proposed retarding basins. Similar mitigating measure is needed for the more than 15 residential households which will be affected by the re-construction of the dike located in Barangay Anibongan.

As such, the IEE report shall be substantiated to include social preparation activities like community/stakeholders consultation, preparation of framework for resettlement and preparation of resettlement plans. Only upon the completion of such activities can the project satisfy the provision of DAO 2003-30 regarding social acceptability as well as the project's compliance to the compensation requirement of Philippine Republic Act 7279 or the 1992 Urban Development and Housing Act (UDHA).

b) Disruption of Existing Infrastructure

Another environmental impact that was identified in the IEE study is the disruption in local transport and water utility line crossing the bridge deck. Such instance would lead to the temporary disruption of the said facilities and inconvenience which may be experience to last until the completion of the newly constructed bridge. Based on the thresholds set by DAO 2003-30, the expansion/rehabilitation works may be covered by the permitting process once the capacity of the bridge exceeds 80 meters in length or an equivalent 50% increase in capacity in terms of length/width. In the event the proposed bridge rehabilitation falls outside the coverage of the Philippine EIS system, it is still recommended that a traffic management plan should be prepared in collaboration with the local traffic bureau considering the minimum number (approximately 5) of bridges that will be affected by the river improvement works.

2) Natural Environment

a) Removal of plants and the mangrove

No adverse impacts on the animals were expected. The project covers the river channel, where a habitat of any animal species was not found.

3) Public Hazard

During the construction stage, the changes in the local air quality conditions, noise level and river water quality resulting from the demolition/excavation of the existing dike including its reconstruction will likely occur.

a) Turbidity and Total Suspended Particulates

Since more than 42 kilometer length of dike is proposed to be reconstructed, an increase in Total Suspended Particulates (TSP) will likely occur in the working areas. Corresponding increase in noise level will also happen with the operation of construction equipment and the use of construction materials. Such alteration in air quality and noise level however have short-term effect and can be mitigated by means of regular watering of work areas, controlled (speed <10kph) vehicular/equipment movement, covering of stockpiled construction materials, installation of enclosure in work areas and the regular maintenance of construction equipment. The potential increase in turbidity along Ising River and Tuganay River can be mitigated with the immediate removal of spoils/dredged materials, installation of silt ponds and the proper handling of wastes.

(2) Management/Mitigation Plan

Overall, environmental management and mitigation plan shall be closely exercised during the development phase of these major project components in order to minimize if not totally eradicated the negative environmental impacts. Several potential adverse impacts identified in the evaluation were concluded that the Environmental Impact Assessment (EIA) is required in the succeeding study period.

5.6.7 Project Evaluation

(1) Technical Feasibility

The Philippines has experienced the construction of river channel improvement many times. On the other hand, the construction of retarding basin is similar to that of river channel improvement. Thus, no difficulty would be encountered in the actual construction of the river channel improvement and retarding basin. The recommended non-structural measures have also been experienced in the country. This project is, therefore, evaluated to have a technical feasibility

(2) Economical Viability

The economic viability is assessed based on the economic cost and benefit stream of the proposed structural measures. As for the assessment of the non-structural measures, this is not carried out based on the situation as discussed before.

Tab. 5-9 shows the economic cost and benefit stream. As the results, the economic viability is figured out as follows:

Table 5.107 Economic Viability of the Optimum Plan in the Tuganay River Basin

Viability Index	
EIRR (%)	19.1
NPV (mil. Pesos)	363.7
B/C	1.33

Based on the above results, EIRR becomes higher than the opportunity cost of capital of 15%. Therefore, the project is evaluated to have an adequate economic viability.

(3) Environmental and Social Acceptance

As the social environmental impacts, the resettlement and reconstruction of the bridge deck are expected for the project implementation. However, these environmental issues can be settled down through the coordination with local authorities as well as stakeholders. As the natural environmental impacts, no significant issue is expected except cutting or removal of plants, which can be accepted judging from the magnitude of impact. As the public hazard, the disposal of dredge materials and spoils for the channel improvement is expected. This issue can be settled down through preparation of the appropriate disposal site prior to construction work.

Overall, environmental management and mitigation plan shall be closely exercised during the development phase of these major project components in order to minimize if not totally eradicated the negative environmental impacts.

The project plan was explained and discussed with the stakeholders through the stakeholder meetings at each end of the field survey and workshop in the site. Through these experiences and activities, it is concluded that, at this stage, implementation of this project is socially and environmentally accepted by the stakeholders.