CHAPTER 2

PROFILE OF THE STUDY AREA

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2.1 PHYSICAL PROFILE

2.1.1 Topography

(1) Terrain

The general topography of Metro Manila is characterized as flat to rolling. Elevation is low and predominantly flat along the coastal area. Towards the east, the landscape gradually rises and assumes a rolling characteristic. Ground elevation ranges between 10-30 meters above mean sea level (AMSL), with gradients ranging from 0% to 15%. The Guadalupe Plateau makes up the eastem portion of the metropolis, which is topographically high. This feature covers a large portion of Metro Manila, which starts from Novaliches to the north and extends as far as Parañaque to the south (ECOSYS Corporation 1997).

The Municipality of Rodriguez in the Province of Rizal is characterized by very rough topography. Approximately 83% of its land area is composed of uplands, hills, and mountain ranges with steep slopes and rugged terrain. Only a small portion has low-lying level and landscape to moderately sloping and rolling lands, which includes Brgy. San Jose.

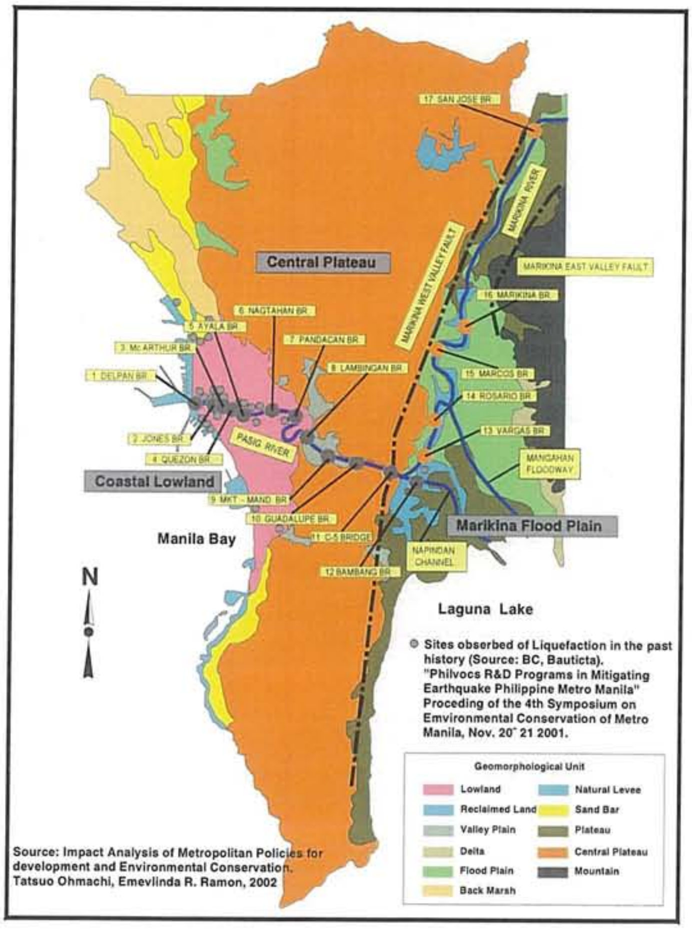


Figure 2.1.1-1 Topography of Metro Manila

(2) Geomorphology

The geomorphological units in Metro Manila can be subdivided into three (3) major types as shown in **Figure 2.1.1-1**. These are (i) the Central Plateau; (ii) the Marikina Flood Plain; and (iii) the Coastal Lowland. Metro

Manila is bounded in the east by the Sierra Madre Mountain Range, and the Laguna de Bay and the Taal Ignimbrite Plain to the south.

The Central Plateau is composed of welded tuffaceous materials. The Marikina Flood Plain on the other hand, consists of soft, unconsolidated Fluvial deposits due to the active deposition of the Marikina River and Deltaic deposits as it nears Laguna de Bay. The Deltaic deposits of Pasig River along Manila Bay shoreline blend well with coralline and other coastal deposits forming a significant part of the Coastal Lowland.

The eastern part of the metropolis is transversed by an active fault system, the Marikina East Valley Fault (EVF) and West Valley Fault (WVF). The present instrumentation does not record any event generated by this fault system. However, based on C-14 dating of organic materials found along major displacements in trench sites along the fault, four major events were inferred to have occurred in the past, approximately 400 years apart (Narag, et al., 2000).

(3) Destructive Earthquakes That Affected Metro Manila

Many earthquakes affected Metro Manila area at varying intensities from 1589 to 1999, as summarized in **Appendix 2.1.1-1.**

2.1.2 Geology

Naturally, there are some connections between geological features and geological history. Landform should be determined by geological features and changed by geological history. The varied deposited soil has been influenced by its background.

Quaternary Alluvium is composed of soft clay, silt and loose sand. All of them are transported and deposited. They are mainly divided into two (2) classes, namely, the continental sediment and the marine sediment.

In post-glacial age, about 7,000 years ago, the low land named "Central Valley" distributed from Lingayen Bay to Manila Bay and Central Plateau were under the sea due to the marine regression. Most marine sediments are composed of thick and soft clay around coastal areas, which was deposited in the said age. After the marine regression, the Laguna de Bay was separated from the sea. The present flood plain around the Pasig and Marikina Rivers, the coastal plain and the delta are still evolving up to the present.

Geological profiles along the Pasig and Marikina Rivers are presented in **Appendix 2.1.1-2.**

(1) Pasig River mouth to Makati-Mandaluyong Bridge

The area is composed of coastal plain, delta and flood plain. Consequently, the ground is formed with loosed sand, soft silt and soft clay. The hard soil or rock layers are generally distributed in the deeper portion. The depth of hard layers, however, is not even. Accordingly the thickness of the soft ground also varies.

Alluvial layers are composed mainly of clay and sand, which is classified as marine deposit, deltaic deposit and sediment of flood plain for the area.

The thick and soft marine clay are distributed to the lower stream of the Pasig River from Nagtahan Bridge to the river mouth. There are six bridges crossing the river along their area, namely Jones Bridge, Delpan Bridge, Mac Arthur Bridge, Quezon Bridge, Ayala Bridge and Nagtahan Bridge. Moreover, there is a large drowned valley between Nagtahan Bridge and Quezon Bridge. The area where Ayala Bridge is built.

In this area, the surface of the ground is covered with deltaic loose sand where the bottom of the alluvial layer is deeper than Elev.-12.0m with about 20.0m thick soft clay.

On the other hand, in the upstream area of Pandacan Bridge, the alluvial layer is mainly sand and marine clay distributed to around Elev. 0.0m to -2.0m. The sedimentary setting is different at the lower stream area around Pandacan Bridge, because the base rock rises high it separates from the area. There are also few clayey deposits between Lambingan Bridge and Makati-Mandaluyong Bridge. There bridges exist in this area including Pandacan Bridge, Lambingan Bridge and Makati-Mandaluyong Bridge.

Diluvial layer is composed of firm to very hard clay and dense to very dense sand. Clay has more deposits than sand and gravel at some locations.

(2) Makati-Mandaluyong Bridge to Pasig City Area

This area is mainly a narrow valley between hilly regions. It is divided into two (2) sections, the Makati-Mandaluyong area and the Pasig City area. The ground surface is mainly covered by loose gravel in the former area, while the Pasig City area is an extension of the flood plain along the Marikina Valley with the ground surface mainly covered by clayey soil. Guadalupe Bridge, C-5 Bridge and Bambang Bridge exist in this area.

Diluvial layer is sandy at both of these areas. The boundary between alluvia and diluvia is from EL. 0.0m to +5.0m.

(3) Marikina River from Pasig City Area to San Jose Bridge

The Marikina Valley is mainly a floodplain along the river. However, its geological structure is not uniform so that the area is divided into different regions.

The thickness of the alluvial layer is generally thinner than the one at the Pasig River area, except for the downstream area of the Vargas Bridge. The thickness of the alluvia ranges from 3.0m to 5.0m upstream of the Rosario Weir.

In the downstream area of Vargas Bridge, the bottom of the alluvia is at an elevation ranging from Elev. +6.0m to Elev. -4.0m because of the presence of an underground drowned valley. The Alluvia is mainly composed of loose sand in the shallow portion. However, the drowned valley is filled with clayey deposit. Occasionally, clayey deposits are observed covering the ground surface or filling the sunken place like a former river.

The area between Vargas Bridge and Rosario Bridge has a similar geological structure with the downstream area. The thickness of alluvia are, however, are thicker than the downstream area. The bottom of the drowned valley formed by the encroached base rock might be even deeper.

The Alluvia are composed of clayey soil in the said area. Sand is distributed in small portion, mainly at the ground surface and the riverbed. Diluvia are composed of clayey soil similar to the downstream area.

Between the Rosario Bridge and the Rosario Weir, the base rock rises high up to around Elev. +3.0m with the diluvia encroachind deeply at some portions. For this reason, the thickness of alluvia changes in this area and are mainly composed of clayey soil.

Upstream of the Rosario Weir, the Diluvia increases its thickness. However, the thickness of the alluvia is almost constant and relatively thin (about 3 to 7m.) at some regions. The depth of the base rock is unclear because it is covered by a thick diluvia. The diluvia are composed of stiff to very hard clay and dense sand. Gravel is not found in the diluvia. The alluvia are composed of sand and clay. Sand seems to be the main material of the alluvia. However, clay is distributed and found covering the ground and filling sunken places.

A total of five bridges exit in this area, including Vargas Bridge, Rosario Bridge, Marcos Bridge, Marikina Bridge and San Jose Bridge.

2.1.3 Climate

The Philippines is located southeast of the big Asian continent, with an almost north to south orientation (4.7ºN to 21.5ºN latitude and from 117ºE to 127ºE longitude). The climate over any particular locality in the country is due to the so-called climatic controls acting with various intensities and in different combinations. These climatic controls are the topography and geography of the place, the prevailing wind regimes (the northeast monsoon, the southwest monsoon and the North Pacific trades), the semi-permanent cyclones which produce and cause the wind regimes over the country, the ocean currents, the various linear systems and tropical cyclones affecting the country.

Climate in the Philippines has been described in terms of rainfall distribution received in a locality. One such climatic classification is the Modified Coronas classification. With the use of the average monthly distribution of rainfall at different stations, four types such rainfall distributions in the Philippines are defined as shown in Figure 2.1.3-1.

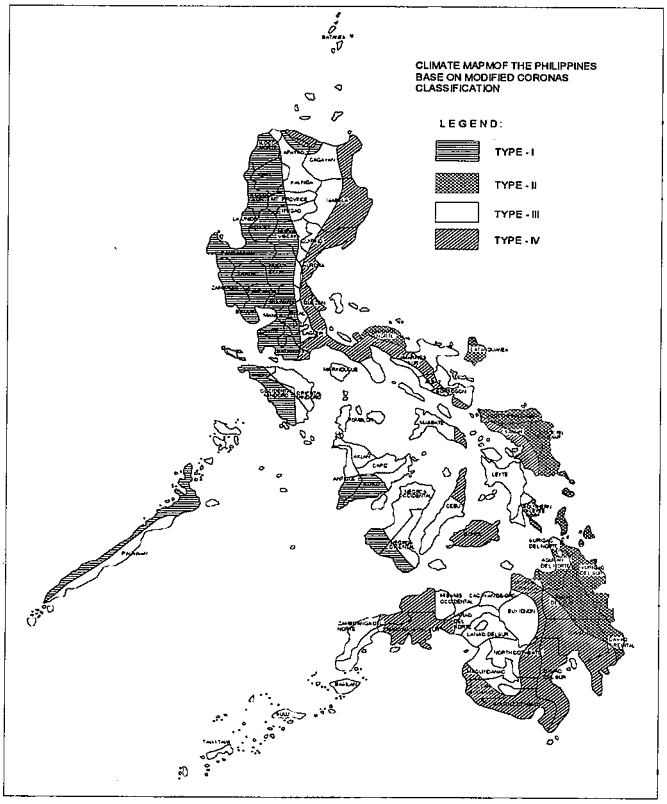


Figure 2.1.3-1 Climate Map of the Philippines Based on Modified Coronas Classification

Details of the climatic data are presented in **Appendix 2.1.3-1**.

2.1.4 River Morphology

(1) Fluvial Geomorphology

The river channel from the river mouth (draining in Manila Bay) to the confluence point of the Napindan Channel is called the Pasig River, and the upstream reaches from the Napindan junction is called the Marikina River. The Marikina River is also connected to the

Laguna Lake through the Mangahan Floodway, which was completed in 1985. The San Juan River is the largest tributary merging into the Pasig River at the north bank. **Figure 2.1.4-1** shows the Pasig-Marikina river system in the Study Area. The Pasig-Marikina River is divided into four (4) sections according to the features of river course, as given in **Table 2.1.4-1.**

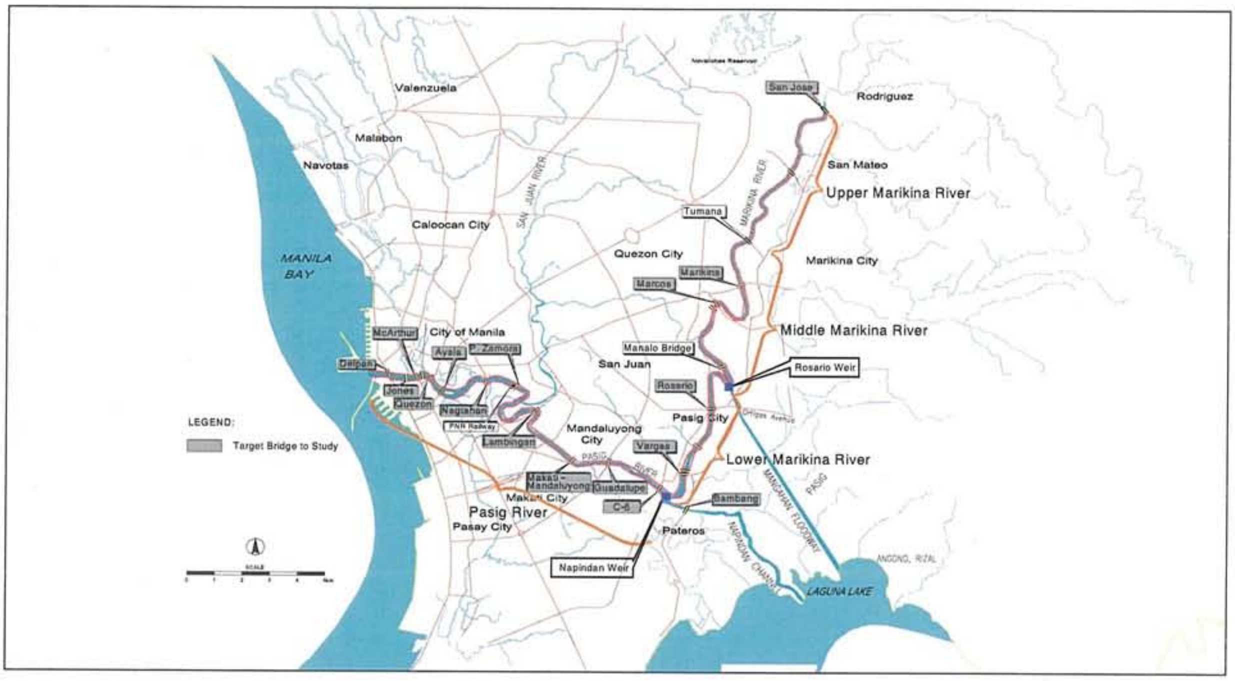


Figure 2.1.4-1 Pasig Marikina River System in the Study Area

Table 2.1.4-1 River Section and Riverbed Gradient

Name	Sections	Length	Gradient of Riverbed
Pasig River	River Mouth to Napindan Weir	17 km	1/10,000 to 1/30,000
Lower Marikina River	Napindan Weir to Rosario Weir	7 km	1/5,000 to 1/10,000
Middle Marikina River	Rosario Weir to Tumana Spillway	9 km	1/2,000 to 1/3,000
Upper Marikina River	Tumana Spillway to San Jose Bridge	11 km	1/1,000 to 1/2.,000

The Pasig River, with the total length 17km, runs through the center of densely populated areas in Metro Manila. The river course meanders at the confluence with the San Juan River, and the river alignment could not be straightened because of social and financial implications. The gradient of the riverbed is almost flat, from the 1/10,000 to 1/30,000. The river width ranges from 60m to 250m and the depths varies from 6 m to 12 m.

The narrower sections are located at Jones Bridge, Quezon Bridge and Nagtahan Bridge. The channel is a single cross-section type and most sections have revetment and concrete wall structures with the sheet piles on both sides. The river width along this area varies between 50m and 150m.

The Lower Marikina River is aligned straightly and smoothly from north to south for a length of 7 km. This stretch is very gentle with river gradient of 1/5,000 to 1/10,000.

The river width ranges from 50 to 110 m and the depth varies from 4.2 to 9.5 m. The channel is a single cross-section type with natural banks at both sides. Unlike the riverbanks of the Pasig River, the riverbanks of the Lower Marikina River do not have river protection walls along the majority of the river stretch. Generally, sods only protect the slopes of the riverbanks. Most of the areas of the riverbanks immediately adjacent to the river are already occupied. Industrial buildings and small houses occupy some of the stretches.

(2) Hydrology

(a) Rainfall Characteristics

The Pasig-Marikina river basin has a catchment area of 621 km^2. The schematic configuration of the river basin and location of hydrological gauging stations are shown in **Appendix 2.1.4-1.**

The meteo-hydrological characteristics of the study area are governed mainly by seasonal dominant monsoons, trade winds and typhoons. This area has two prominent seasons; namely, the wet season from May to October and the dry season from November to April. The pan evaporation ranges from 1,300 to 1,600 mm/year.

Heavy rainfalls are brought about by typhoons, tropical depressions and southwest monsoon. The monthly rainfall pattern is shown in **Appendix 2.1.4-2**, which clarifies the prominent wet season. Annual rainfall in the Pasig-Marikina river basin ranges from 2,100 to 2,600 mm/year. The tendency to have more rainfall amount in mountainous areas than in the lowlands is not so apparent.

The probable rainfall intensities have been estimated by the Gumbel-Chow method in the Detailed Engineering Design of Pasig-Marikina River Channel Improvement Project. The calculation results are given in **Table 2.1.4-2.** The rainfall intensities for 1-hour and 1-day at 30-year return period, which is the flood control scale for urgent projects, are 93.6 mm/hour and 315.9 mm/day, respectively.

(b) Probable Runoff Discharge in the Pasig-Marikina River

Probable flood runoff discharges of 2-year, 5-year, 10-year, 20-year, 30-year, 50-year and 100-year have been estimated under the Detailed Engineering Design of Pasig-Marikina River Channel Improvement Project. The estimated probable flood runoff discharges are shown in **Appendix 2.1.4-3.** The flood water level at bridges in the Pasig-Marikina River calculated by the probable flood discharges is given in **Appendix 2.1.4-4.**

Table 2.1.4-2 Probable Rainfall Intensity in the Study Area

Year	Rainfall (mm/hr)						Rainfall (mm/day)	
T	5 min.	10 min.	20 min.	30 min.	60 min.	120 min.	1 day	2 day
2	147.4	118.0	93.6	77.7	53.3	38.8	147.2	105.0
3	166.6	133.3	105.7	88.2	60.4	44.2	177.2	129.8
5	187.9	150.3	119.3	100.0	68.4	50.3	210.6	157.4
8	206.2	165.0	130.9	110.1	75.3	55.5	239.3	181.1
10	214.7	171.8	136.3	114.8	78.4	57.9	252.5	192.1
20	240.3	192.3	152.6	129.0	88.1	65.1	292.7	225.4
30	255.1	204.2	162.0	137.1	93.6	69.3	315.9	244.5
40	265.5	212.5	168.6	142.9	97.5	72.3	332.2	258.0
50	273.6	219.0	173.8	147.3	100.5	74.6	344.8	268.4
60	280.1	224.2	177.9	150.9	103.0	76.4	355.1	276.9
80	290.5	232.5	184.5	156.6	106.8	79.4	371.3	290.3
100	298.5	238.9	189.6	161.1	109.8	81.6	383.8	300.7

(c) Tidal Level in Manila Bay

The tide gauge is located at Pier 15 of the Manila South Harbor, which is about 1.7 km southwest of the Pasig River mouth. The gauge is under the responsibility of the Bureau of Coast and Geodetic Survey (BCGS). Principal tide levels are summarized below:

Highest Tide Level (HTL)	=	DL+12.1 m
Mean Springs High Water Level (MSHW)	=	DL+11.4 m
Mean Higher High Water (MHHW)	=	DL+11.1 m
Mean Sea Level (MSL)	=	DL+10.6 m
Datum Level	=	DL+10.0 m

(d) Water Level in Laguna Lake

The water level of Laguna Lake is planned to be regulated within 10.5 m to 12.5 m in elevation, although the average water level was estimated at 11.2 m in the Detailed Engineering Design of the North Laguna Lakeshore Urgent Flood Control and Drainage Project. A flood control dike for the Laguna Lake Basin, including the Napindan Channel, is being constructed with a 13.8 m design water level that is equivalent to the recorded highest flood water level in Laguna Lake.

2.1.5 Considerations on Bridge Improvement

The Pasig-Marikina River Channel Improvement Project is to be carried out to confine the flood discharges into the existing river channel and solve the perennial inundation by floods in Metro Manila. The location of abutment and pier, as well as pier width, is the main issue on bridge improvement that would affect the river flow condition during flood time.

Riverbed fluctuation is another factor that could affect the design of bridge foundation. The required conditions of these main factors on bridge and river improvement are hereinafter described.

(a) Location of Abutment and Pier

The Detailed Engineering Design of the Pasig-Marikina River Channel Improvement Project was completed by the DPWH in March 2002. The river improvement plans to maintain the existing river width and the spaces between bridge piers/abutments so as not to increase the flood water level. The bridge abutment/pier should be placed not to encroach on the existing river flow area, as shown in **Figure 2.1.5-1**

With regard to the location of abutment and pier, the minimum span length (L1, L2 and L3 in **Figure 2.1.5-1**) has to be in proportion to the design discharge of the Pasig-Marikina River, as expressed in Equation 2-1. Then, the design discharge is estimated from the discharge of 100-year return period for the master plan, which was taken from the Detailed Engineering Design of the Pasig-Marikina River Channel Improvement Project.

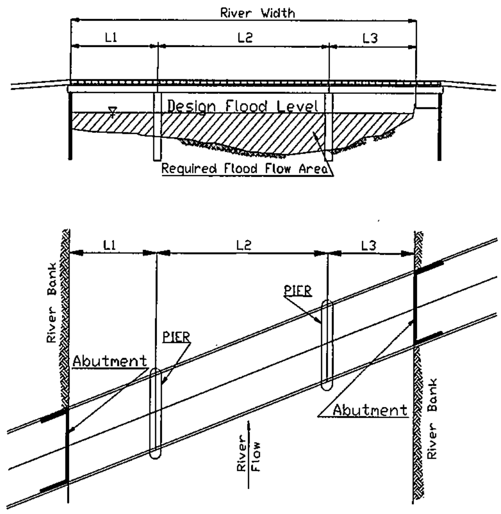


Figure 2.1.5-1 Location of Abutment and Pier in the River Channel

L = 20 + 0.005 x Q —— (201.5-1)

Where

L: Minimum Bridge Span Length

Q: Design discharge of 100-year return period (m^3/s)

Table 2.1.5-1 gives the minimum bridge span length computed.

Table 2.1.5-1 Minimum Span Length of the Bridges

Bridge in the River Stretch	Design Discharge	Minimum Span Length
Pasig River (Manila Bay to San Juan River): Delpan Bridge, Jones Bridge, Mc Arthur Bridge, Quezon Bridge, Ayala Bridge, Nagtahan Bridge, Pandacan Bridge	1,300 m^3/s	26.5 m
Pasig River (San Juan River to Napindan Weir): Lambingan Bridge, Makati-Mandaluyong Bridge, Guadalupe Bridge, C-5 Bridge	650 m^3/s	23.3 m
Napindan Channel (Napindan Weir to Laguna Lake): Bambang Bridge	400 m^3/s	22.0 m
Marikina River (Napindan Weir to Rosario Weir): Vargas Bridge Rosario Bridge	550 m^3/s	22.8 m
Marikina River (Rosario Weir to Nangka River): Marcos Bridge Marikina Bridge	2,900 m^3/s	34.5 m
Marikina River (Nangka River to San Jose Bridge): San Jose Bridge	2,400 m^3/s	32.0 m

(b) Width of Bridge Pier

The area obstructed by the bridge pier in the river channel should be the same or less than the existing one. The target obstruction ratio of piers within the flood flow area should be less than five percent (5%) so as not to affect the flood flow condition, according to the experimental regulation in Japan. The obstruction ratio of the Nagtahan, Guadalupe, Vargas, Rosario and Marikina bridges ranges from 5.2% to 6.7% which more than 5%. It is desirable to secure the ratio of 5% for the improvement of bridges.

(c) Riverbed Fluctuation

Figure 2.1.5-2 shows the lowest riverbed elevation profiles for the 1988 and 2000 surveys. The survey in 1988 was conducted under the Study of Flood Control and Drainage Project in Metro Manila, JICA. The 2000 survey was carried out by the DPWH for the Detailed Engineering Design of Pasig-Marikina River Channel Improvement Project.

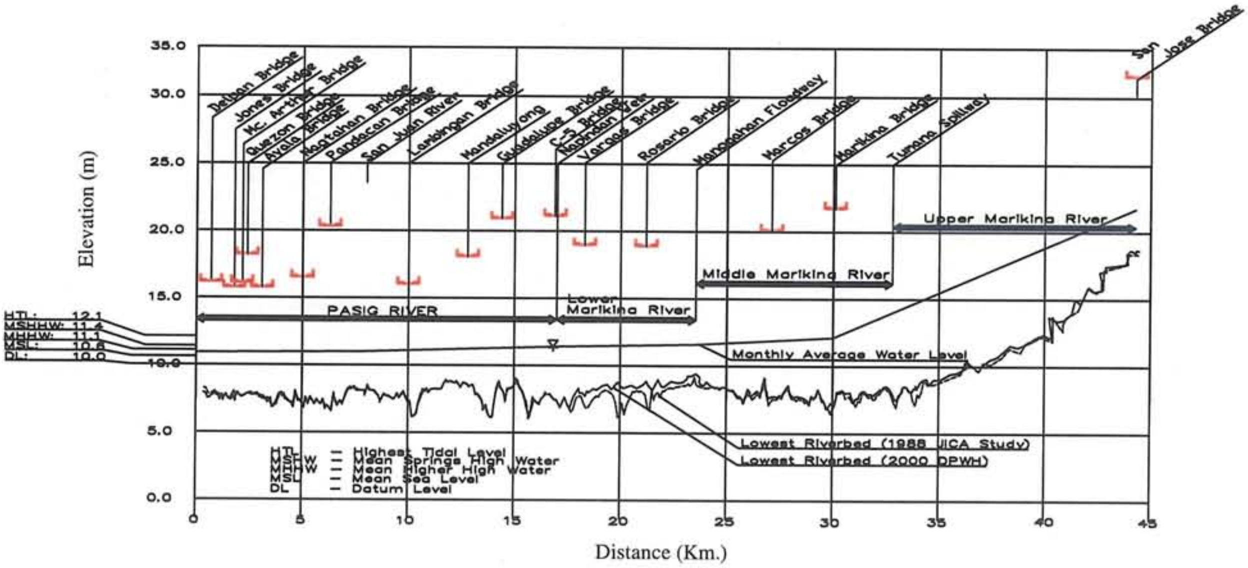


Figure 2.1.5-2 Lowest River Profiles for the 1988 and 2000 Survey

Riverbed materials in the Upper Marikina River are predominantly coarse to fine gravel, while riverbed materials in the downstream of the Tumana Spillway up to the Marcos Bridge are generally fine to medium sand.

Riverbed materials downstream of the Marcos Bridge up to the Napindan Weir in Marikina River is composed of fine sand to silty clay. Bank erosion exists in this stretch of the Marikina River and it is still uncertain as to the ratio of the bed materials coming from the upstream and those due to bank erosion. Further downstream in the Pasig River from the confluence with Napindan to its mouth in Manila Bay, riverbed materials are also composed of fine sand and silt.

In the Upper and Middle Marikina River, the present riverbed elevation had increased slightly during the past decade. Aggradation in the Lower Marikina River is predominant, ranging from 0.5 to 2 m due to bank erosion and sediment yield within the watershed. The riverbed elevation in the Pasig River has remained almost the same for the past decade, which means that the river channel is fairly stable except for local sedimentation and scouring. The local scouring depth could be due to the physical feature of riverbed materials and the flow velocity.

2.2 SOCIO ECONOMIC PROFILE

2.2.1 Demography

Metro Manila or the National Capital Region (NCR), with an area of about 636 sq km, has been constantly growing rapidly. The effect of its rapid urbanization spilled over to the adjoining municipalities with areas of about 3,670 sq km. The actual densely populated urbanized area had reached about 800 sq km in 1996 as shown in **Figure 2.2.1-1**, far exceeding the administrative area of Metro Manila.

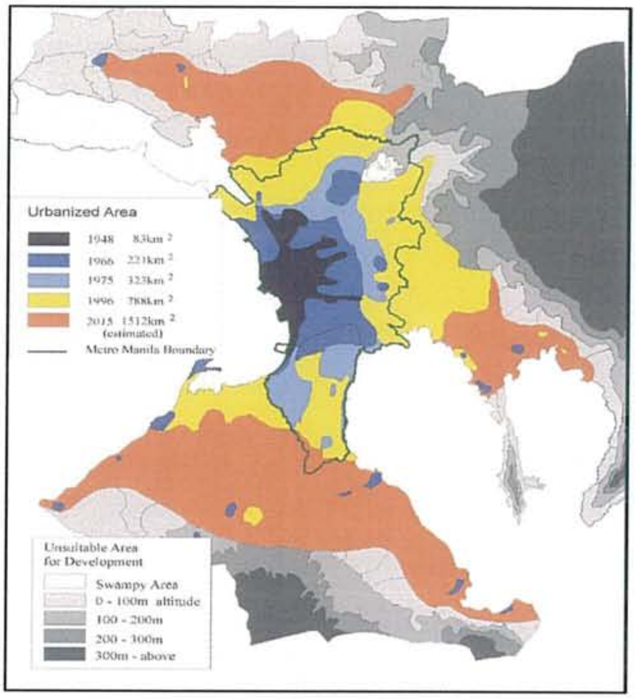


Figure 2.2.1-1 Expansion of the Urban with in MMUTIS Study Area

The population of Metro Manila of less than two million in 1950 increased to 5.9 million in 1980, 7.0 million in 1990 and 9.9 million in 2000. The total population of the MMUTIS Study Area including adjoining areas of 16.3 million residents in 2000 takes more than 20% of the country's population and its share is constantly increasing (Refer to **Tables 2.2.1-1, 2.2.1-2** and **Figure 2.2.1-2**).

The population of Metro Manila is expected to increase from 9.9 million in 2000 to 12.6 million in 2015 with an average annual growth rate of 1.6%. On the other hand, the population increase of the adjoining provinces is expected to increase from 6.3 million to 11.1 million in 2015.

Table 2.2.1-1 Demography Data of MMUTIS Study Area, 2000

Item		Metro Manila	Adjoining Municipalities					Total
			Bulacan	Rizal	Cavite	Laguna	Sub-Total	
MMUTIS Study Area	Population: 000 (%)	9,933 (61%)	1,734 (11%)	1,707 (10%)	1,797 (11%)	1,088 (7%)	6,326 (39%)	16,259 (100%)
	No. of Household: 000 (%)	2,133 (62%)	362 (10%)	357 (10%)	375 (11%)	232 (7%)	1,326 (38%)	3,459 (100%)
Whole Cities/ Municipalities	Population: 000 (%)	9,933 (55%)	2,234 (12%)	1,707 (10%)	2,063 (12%)	1,966 (11%)	7,970 (45%)	17,903 (100%)
	No. of Household: 000 (%)	2,133 (56%)	463 (12%)	357 (9%)	429 (11%)	418 (11%)	1,667 (44%)	3,800 (100%)

Table 2.2.1-2 Changes of Population of MMUTIS Study Area as of 2000

(Unit 1,000)

	Population					Annual Growth Rate (w/o Year)		
	1980	1990	1995	2000	2015	'80 – '90	'90 – '00	'00 – '15
Philippines	48,098	60,703	68,617	76,499	122,700	2.35	2.34	2.32
(1) Metro Manila	5,926	7,929	9,454	9,933	12,579	2.95	2.28	1.59
(2) Adjoining Provinces	2,434	3,773	4,914	6,326	11,133	4.48	5.30	3.84
Bulacan	-	-	1,354	1,734	3,589	-	2.50	4.97
Rizal	-	-	1,312	1,707	2,173	-	2.67	1.62
Cavite/Laguna	-	-	2,248	2,885	5,371	-	2.52	4.23
(3) Study Area [(1)+(2)]	8,360	11,702	14,368	16,259	23,712	3.42	3.34	2.55

Source: MMUTIS, Census 2000

Note: Refer to MMUTIS Study Area for Adjoining Municipalities

However, enrolment in higher educational levels and employment opportunities have not followed the urban sprawl. Most are still located in the inner urban core (refer to **Table 2.2.1-3**): About 72% of total jobs and 65% of total enrolments (secondary level and above) are within Metro Manila in 1995.

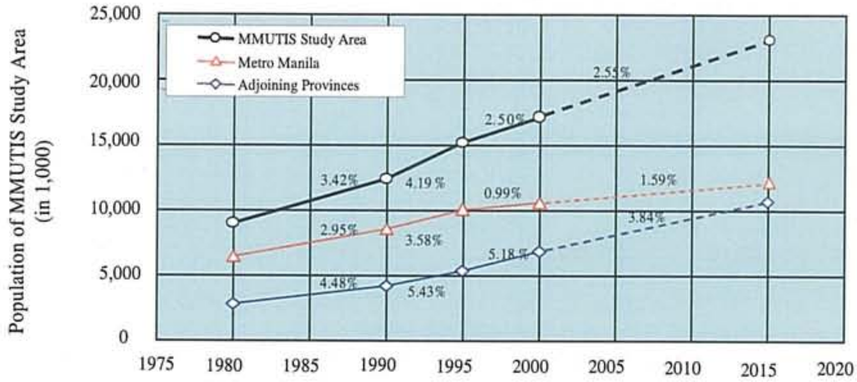


Figure 2.2.1-2 Changes of Population of MMUTIS Study Area as of 2000

The socio-economic profile of Metro Manila is considerably different than that of the adjoining areas. While the former provides more employment opportunities in the tertiary sector, the latter is more in the secondary sector

Table 2.2.1-3 Employment and School Attendance, 1995 and 2015

	1995	2015	Annual Growth Rate (%/year)
Employment at Workplace			
2-1 Secondary Sector			
(1) Metro Manila	837	1,393	2,57
(2) Adjoining Provinces	426	1,074	4.73
Bulacan	86	261	5.71
Rizal	89	197	4.05
Cavite/Laguna	251	616	4.59
(3) Study Area [(1) + (2)]	1,263	2,467	3.40
2-2 Tertiary Sector			
(1) Metro Manila	2,853	3,899	1.57
(2) Adjoining Provinces	890	1,848	3.72
Bulacan	272	597	4.00
Rizal	213	318	2.02
Cavite/Laguna	405	933	4.26
(3) Study Area [(1) + (2)]	3,743	5,747	2.17
Student at School Place			
(1) Metro Manila	1,385	1,866	1.50
(2) Adjoining Provinces	508	1,321	4.89
Bulacan	143	391	5.16
Rizal	111	286	4.85
Cavite/Laguna	254	644	4.76
(3) Study Area [(1) + (2)]	1,893	3,187	2.64

Source: MMUTIS

2.2.2 Economy

The Gross Regional Domestic Product (GRDP) and GRDP per capita are summarized in **Table 2.2.2-1** and **2.2.2-2.** GRDP per capita of Metro Manila is higher roughly more than twice than that of the Philippines. At the same time Future GDD, GRDP and GRDP per Capita are shown in the same table.

Table 2.2.2-1 Gross Regional Domestic Product (GRDP)

(Unit: Million Peso)

		1990	1995	2000	2015	Annual Growth Rate (%)	
						'90 – '00	'00 – '15
At Current Prices	Philippines	1,077,237	1,905,951	3,308,318	10,396,000	11.9%	9.9%
	NCR	347,609	623,939	1,169,989	3,815,400	12.9%	8.2%
At Constant 1985 Prices	Philippines	720,691	802,224	958,411	1,935,900	2.9%	4.8%
	NCR	221,753	242,167	294,390	594,800	4.0%	4.8%

Source: National Statistical Coordination Board, MMUTIS
Note: Data posted are as of July 2000 and at constant 1985 prices, NCR: National Capital Region

Table 2.2.2-2 Gross Regional Domestic Product (GRDP) per Capita

(Unit: Million Peso)

		1990	1995	2000	2015	Annual Growth Rate (%)	
						'90 – '00	'00 – '15
At Current Prices	Philippines	17,522	27,670	42,190	84,700	9.2%	4.8%
	NCR	43,593	68,429	116,568	160,900	10.3%	2.2%
At Constant 1985 Prices	Philippines	11,722	11,417	12,528	15,800	0.4%	1.6%
	NCR	18,950	16,854	18,106	25,100	0.5%	2.5%

Source: National Statistical Coordination Board, MMUTIS
Note: Data posted are as of July 2000 and at constant 1985 prices, NCR: National Capital Region

2.2.3 Industry

Data on the industrial sector provide vital information on the extent to which an economy has attained progress in its industrial development program.

The industrial sector, manufacturing in particular, leads the country in its thrust toward a more accelerated pace of development. By giving emphasis on the development of its indigenous industries, a country could broaden the base of its development, generate more employment opportunities for the populace, and expand aggregate production.

Table 2.2.3-1 shows that the Index of the total manufacturing of Philippines is 177 in 2000, 193 in 2001 (Year of 1994 = 100).

Table 2.2.3-1 Index of Value of Production of Key Manufacturing Enterprises in the Philippines by Industry, 2000 to 2001 (1994=100)

Products	Year		Percent Change (2000 - 2001)
	2000	2001	
Total Manufacturing	177.3	193.4	9.1
Food	120.6	135.0	11.9
Beverage	186.3	191.8	3.0
Tobacco	150.1	156.0	3.9
Footwear & Wearing Apparel	74.1	85.9	15.9
Wood and Wood Products	100.2	100.6	0.4
Furniture and Fixtures	94.4	96.8	2.5
Paper and Paper Products	195.7	170.1	-13.1
Chemical and Chemical Products	258.6	278.1	7.5
Rubber Products	70.9	57.8	-18.5
Petroleum Products	250.8	271.2	8.2
Non-metallic Mineral Products	107.1	108.7	1.5
Basic Materials	75.8	89.5	18.1
Transport Equipment	108.6	114.6	5.5
Electrical Machinery	253.9	265.3	4.5
Miscellaneous	100.3	110.4	10.1

Source: Philippine Statistical Year Book 2002, National Statistical Coordination Board, October 2002

2.2.4 Car Ownership

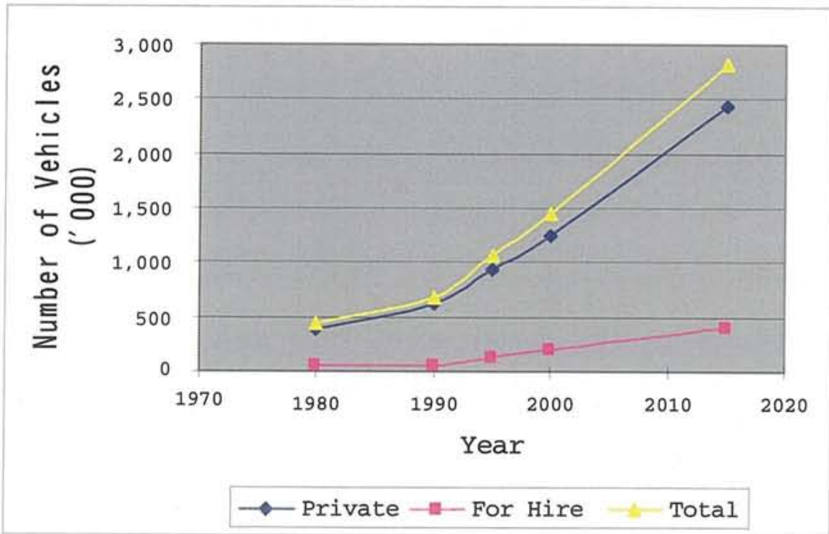


Figure 2.2.4-1 Trend and Forecast of Car Ownership

Motorization has increased rapidly. During the period 1980-1995, the number of registered vehicles, both private and for hire, has increased at an average rate of about 6% a year. The increase in private utility vehicle, private trailer and for-hire motorcycles (termed tricycles) was especially high. More than 40% of all vehicles registered in the Philippines are concentrated in Metro Manila (refer to **Figure 2.2.4-1** and **Table 2.2.4-1**). The estimated future car ownership in MMUTIS Study Area is expected to increase from 1.4 million in 2000 to 2.8 million in 2015 with an average annual growth rate of 4.6%.

Table 2.2.4-1 Trend of Car Ownership of MMUTIS Study Area as of 2000

(x 1,000)

Type		1980	1990	1995	2000	2015	%/Yr (80-90)	%/Yr (90-2000)	%/Yr(2000-15)
Private	Motorcycles	36.9	50.2	73.0	130.1	-	7.80%	10.00%	-
	Cars	219.0	297.1	410.8	486.0	-	6.70%	5.00%	-
	Utility Vehicle1/	36.8	224.0	368.0	515.1	-	10.40%	87%	-
	Busses	-	0.9	0.5	0.5	-	-11.80%	-6.20%	-
	Trucks/Trailers	97.6	51.4	86.1	105.6	-	8.20%	7.50%	-
	Sub-Total	390.2	623.5	938.4	1,237.3	2,429.2	8.30%	7.10%	4.60%
For Hire	Motorcycles	4.8	16.5	34.5	59.3	-	16.00%	13.60%	-
	Taxis	10.1	1.7	21.7	41.9	-	66.10%	37.60%	-
	Cars	1.5	8.2	5.6	10.8	-	-7.20%	2.90%	-
	Utility Vehicle1/	27.2	27.7	53.4	72.3	-	14.00%	10.10%	-
	Busses	3.6	4.3	7.8	9.7	-	12.60%	9.40%	-
	Trucks/Trailers	8.8	3.0	4.3	7.2	-	7.60%	9.10%	-
	Sub-Total	56.0	61.3	127.3	201.3	395.2	15.70%	12.60%	4.60%
Total		446.1	684.8	1,065.7	1,438.6	2,824.4	9.00%	7.70%	4.60%

Sources : 1) 1980-1995 MMUTIS
2) Annual growth rate from 2000 to 2015 was estimated by MMUTIS

2.2.5 Environmental Consideration on Bridge Improvement

Environmental impacts of construction activities associated with the rehabilitation and improvement of the 17 bridges under the present study would naturally be on Pasig River, Marikina River, and its immediate vicinities. As such a general overview of the existing condition of these river systems in terms of environmental aspects are presented below.

(1) The Pasig River System: A General Overview

In one of the reports of the Pasig River Rehabilitation Commission (PRRC), the Pasig River system, which includes the Pasig River and its major tributaries, San Juan River and Marikina River, was described as "*an environmentally sensitive water course with a limited capacity to assimilate wastewater discharges*". This statement tells of the excessively high levels of pollutants that presently contaminate the said river system. In the same report, it was mentioned that there are even times of a year (i.e., during the dry season) when the river is considered biologically "dead", since the flow mostly comes from wastewater discharges. During these times, BOD[1] levels are as high as 80 to 120 mg/l, DO[2] levels drop to zero, and coliform counts increase the Department of Environment and Natural Resources (DENR) limit by several hundred to several thousand degrees. Major sources of pollutants identified

1 Biological Oxygen Demand
2 Dissolved Oxygen

consist of (i) domestic liquid waste, (ii) commercial and industrial waste (in terms of wastewater and sewage), and (iii) solid waste (garbage).

Aside from water quality, other important aspects of the PRRC's rehabilitation program for the Pasig River system are to make it more orderly, aesthetically pleasing, and economically productive. The PRRC, in cooperation with other government agencies such as the DPWH, Philippine Ports Authority (PPA), Philippine Coast Guard (PCG), Maritime Industry Authority (MARINA), Office of the Solicitor General (OSG), Metro Manila Development Authority (MMDA), National Housing Authority (NHA), and the Local Government Units (LGUs) of Marikina, Manila, Makati, and Mandaluyong cited some of its plans to achieve this goal. These are:

- Improvement of the waterways – dredging and construction/repair of river walls, and flood control projects by DPWH, PPA, and LGUs
- Removal of river obstructions – removal of sunken derelicts (tug boats, barges, passenger boats and tankers) that illegally block and pose serious hazards to navigation
- Greening and urban renewal of adjacent areas – development of linear parks and other leisure areas along the river (e.g., Marikina Riverpark in Marikina City, Poblacion Park and Guadalupe-Pateros Promenade in Makati City, and Community Park and Pioneer-EDSA Shaw Triangle Project in Mandaluyong City).
- Resettling of informal dwellers – relocation of illegal dwellers who occupy danger zones---low lying areas and river banks that are highly prone to flooding and vulnerable to poor sanitation-related diseases, into safer environments

(2) Environmental Impacts

In support of the Philippine government's thrust to rehabilitate the Pasig River system through the PRRC, it is important to ensure that the improvement of the 17 bridges under the present study will NOT contribute to the existing water quality problems, and instead help realize its goal to make the river system more orderly, aesthetically pleasing, and economically productive. To achieve these, the following positive impacts must be enhanced, and the adverse ones mitigated.

Positive impacts envisioned on the one hand consist of:

- Improvement of the safety of vehicular traffic as a result of the physical strengthening of the bridges;

- Increase in traffic capacity for bridge sites where widening will be undertaken, which would in turn ease the traffic flow along the bridge, together with the main thoroughfares that it connects;

- Safer river navigation because of improvements in the design of pier columns;

- Relocation of unlawful occupants of danger areas, particularly at the bridge abutments and some portions of the river banks into safer sites; and

- Better aesthetics as a result of the replacement of deteriorated parts and the landscaping and greening of portions of approach roads.

On the other hand, **adverse impacts** expected are:

- Disturbance to the day-to-day activities of communities who live "under" the bridges, particularly at abutment areas;

- Temporary increase in turbidity of water as a result of excavation, boring, and other related substructure construction/improvement activities;

- Possible increase in the "existing very high" domestic waste load;

- Possible increase in the solid waste (garbage) content of the river systems;

- Possible increase in the number of informal settlers if construction workers are allowed to build makeshift houses near the construction sites; and

- Possible increase in siltation rates, which would further decrease the depth of the rivers if construction debris and spoils are not properly hauled and disposed of.

(3) Enhancement and Mitigation Measures

The following enhancement and mitigation measures are recommended to ensure that positive and adverse impacts are properly addressed.

- Adoption of the state-of-the-art technology in the design of the bridges to be constructed/improved;

- Adoption of the state-of-the-art and at the same time, economical construction methodology that would minimize disturbance of the mud, sediments and other substances on the riverbed so as not to further aggravate siltation problems, depth reduction of the river, and flooding;

- Preparation of a comprehensive Resettlement Action Plan that shall include just compensation and rehabilitation assistance to project affected persons, in accordance with existing Philippine laws, implementing rules and regulations, and executive and administrative orders;

- Provision of portable toilets and other solid waste management tools, such as garbage bins for construction workers and other crews;

- Prohibition of "shanty" type of dwellings for construction workers; and
- Proper stockpiling, regular hauling, and disposal of construction debris and other spoils at DENR approved sites.

2.3 REVIEW OF EXISTING STUDY AND PLAN

2.3.1 Development Plan

(1) National Development Plan

The National Development Plans are summarized as follows:

- New Transport Policy Direction

  : A new paradigm in urban transport planning and management has emerged, emphasizing sustainability and private-public partnership.

- Infrastructure Development and Management

  : Alternative methods to the current practice in ROW acquisition need to seriously look into closer integration of resettlement with the projects, strengthening city planning/land-use.

- Integrated Transport Planning and Development

  : Planning capabilities need to be strengthened and supported with good and reliable database and decision support system.

- Public Transport Operations

  : Public transport operation in Metro Manila are facing needs for change. Mass transit strategy requires purposeful planning by the government, scrutiny of the system/line integration and effective participation of the private sector.

- Traffic Management and Demand Management

  : Traffic management and low-cost measures can greatly contribute to the transport improvement.

- Attracting the Private Sector

  : This will entail more intensive promotional efforts to actively package and bid out road projects to private proponents and to advance expenditures on securing ROW.

- National Transport Issues

  : The framework for private sector participation is clearly not just a metropolitan issue but a national one. Principal benefits of creation of a dedicated fund will be the early ROWs, better road maintenance and better coordination of project implementation.

- Air Pollution

  : Improvement of traffic flows will have the salutary effect of reducing pollution from motor vehicles.

(2) Metro Manila Development Plan

In the study area of MMUTIS, there are a number of on-going/proposed road projects for ordinary roads which are implemented by DPWH-URPO and a number of toll road projects by joint venture companies between government agencies such as PNCC, PEA, and many others and private sector investors under Build-Operate-Transfer (BOT) scheme arrangement.

The MMUTIS Inter-Agency Committee is monitoring the activity of the Medium Term Development Plan of MMUTIS (1994-2004).

2.3.2 Metro Manila Urban Transportation Integration Study (MMUTIS)

(1) Study Area

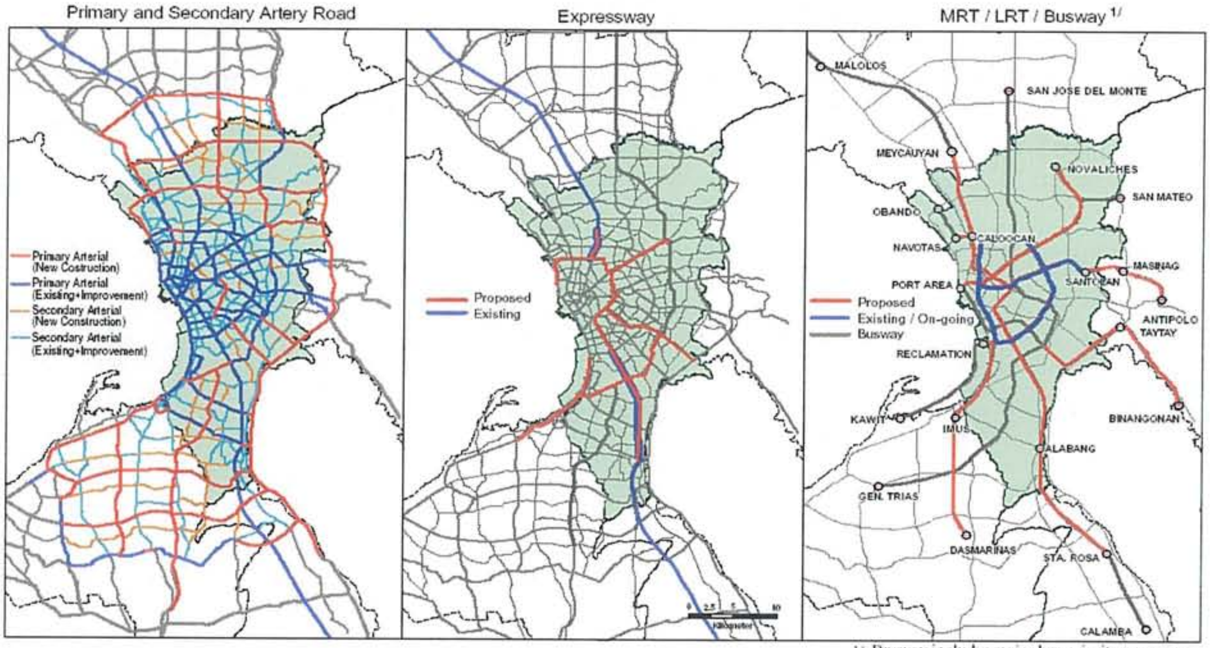
The MMUTIS study area covers Metro Manila and the adjoining municipalities/ cities in Bulacan, Rizal, Cavite, and Laguna Provinces as shown in **Figure 2.3.2-1.**

Source: MMUTIS

Figure 2.3.2-1 MMUTIS Study Area

(2) Master Plan Formulation

The Master Plan network has been formulated by initially developing the "Do-maximum" network which can meet the future demand in terms of infrastructure capacity at an improved level of traffic situation than the present. The entire "Do-maximum" network could unrealistically be implemented, this provides national agencies and local government units (LGUs) with a basis for city planning direction beyond 2015. On the basis of the assessment of the "Do-maximum" network by corridor and area, the Master Plan network has been formulated more or less within the constraint of the budget envelope (Refer to **Figure 2.3.2-2**).



Source: MMUTIS

1/ Busway includes major bus priority measures

Figure 2.3.2-2 MMUTIS Master Plan Network, 2015

(3) Medium-term Transport Development Plan (MTDP)

The MTDP has been formulated, basically forming the essential components of the Master Plan.

Investment priorities in the MTDP have been broadly set forth as follows:

- Management and low-cost measures such as traffic management, minor road widening and rehabilitation, public transport priorities, terminals, intersection improvements, etc.
- At-grade road improvements/construction, particularly primary arterial roads (missing links in the central area and those to promote north-south urban expansion) and secondary roads to strengthen road network connections. The role of at-grade roads in the Study Area is extremely important for effective urban expansion and to provide space to accommodate elevated expressways and the MRT.
- The MRT and urban expressways which are to become more and more important to sustain mobility in large urban areas. These projects require effective participation of the private sector to become implementable.

2.3.3 Asian Development Bank 6th Road Project

(1) Objective

The project is a part of the RIMSS project that has the overall objective to improve the quality and delivery of DPWH services in the provision and management of the road system.

The specific goals of the project titled "CO7 Pavement Management Systems/Bridge Management Systems" are as follows:

- A pavement management application to support needs analysis, multi-year programming and annual budgeting for the preservation of road pavements on the national road network, customized to local conditions, integrated with RIMMS, supported by technical upgrades, and supporting DPWH asset management processes.

- A bridge management application to support needs analysis, multi-year programming and annual budgeting for the preservation of the national bridge stock, customized for local conditions and integrated with RIMMS, supported by technical upgrades, and supporting DPWH asset management processes.

- A comprehensive and sustainable bridge inspection program to provide sufficiently accurate, consistent and timely information to planner and maintenance personnel for all bridges which are part of national highway network, utilizing computer application(s) being procured by DPWH.

(2) Policies and Targets

It is proposed that the following policies are put forward for further consideration within the DPWH:

- Policy 1 : The new bridge inventory and BMS will be implemented and completed for all bridges on national road.

- Policy 2 : All bridges on national roads will receive an annual routine inspection and condition assessment to enable the BMS to be updated and maintained.

- Policy 3 : Separate funding allocations will be provided in the DPWH budget to cover the following bridge activities:

  - Routine maintenance (RMMS)
  - Major maintenance
  - Capital works including bridge replacement and upgrading

- Policy 4 : The description of bridges shall be amended to include flyovers and viaducts.

- Policy 5 : Bridge descriptions shall be revised to a simplified standard description and delete any reference to temporary or permanent bridges.

It is proposed that the following targets are put forward for further consideration within the DPWH.

- Target 1 : All bridges have a major maintenance requirement identified in the annual routine inspections shall receive an engineering inspection within six months of the need being identified.

- Target 2 : 50% of bridges having a major maintenance requirement confirmed by an engineering inspection shall have the major maintenance work commenced within one year of the engineering inspection; the work on the remaining 50% shall be completed within five years.

- Target 3 : All bridges identified as requiring partial reconstruction or replacement shall have the work completed within ten years.

These policies and targets are proposed to ensure that the following outcomes are achieved:

- The BMS is established,
- The BMS is provided with sufficient resources to enable it to be utilized as an efficient planning and bridge management tool,
- Efficient bridge management plans are developed, and
- Funding will be made available to implement the major repair, upgrading and replacement programs identified through use of the BMS.

(3) Bridge Management Data Requirements

Four types of data are required for the establishment and operation of the BMS as listed below:

- Location
- Inventory
- Condition
- Operation

The Location Data identifies the bridges on the national road network and includes basic location data such as name, road, location, region, district, etc. The Location Data for national bridges in the Philippines is being developed under the CO2b project and is not yet available. This data will ultimately be installed in the Confirm database. This data will be obtained once and only updated when bridges are constructed, replaced or abandoned.

The Inventory Data contains data on the geometry and type of construction of the bridges including detailed data on a standardized set of bridge elements which make up a "bridge" in terms of the need to maintain, classify and report on the bridges. The Inventory Data for national bridges is being developed under the CO2a project and is not yet available. This data will also ultimately be installed in the Confirm database. This data will be obtained once and updated when bridges are modified, constructed, replaced or abandoned.

The Condition Data includes data on the condition and required work to the standardized set of bridge elements included in the Inventory Data. Data will be obtained annually during routine bride inspection and will be separately recorded in the BMS for each inspection.

The operation data includes cost information for the routine maintenance, major repairs, emergency maintenance, upgrading or replacement work undertaken to each bridge in each financial year. This data will be separately recorded for each financial year.

The objective is to collect information on sufficient data fields to be able to run the prioritization algorithms and to store basic data about the bridge.

(4) Bridge Inventory Data Requirements

Inventory information relates to four main part of the bridge:

- Spans
- Abutments
- Piers
- Bridge

It is proposed that the list is structured to match the Confirm software terminology. The column headings are:

- Element type
- Attribute type
- Parameter type
- Pick list
- Range

The range is the validation range for numeric fields such as 'span length'. The proposed inventory is typical of the international norm.

(5) Bridge Condition Data Requirements

The condition information is obtained during routine inspection of the bridge. Each main element and component of the bridge is to be assessed using a simple four point scale. This scale expresses the condition in terms of the need to maintenance:

- Scale Point 0 (State 0) – no maintenance required in the foreseeable future, implying that the element or component is in good condition.
- Scale Point 1 (State 1) – maintenance may be required within 10 years implying that there is some superficial deterioration but maintenance can be safely deferred for a significant period.
- Scale Point 2 (State 2) – maintenance required within 2 years implying significant deterioration that could soon lead to a safety problem or a substantial increase in the rate of deterioration.

- Scale Point 3 (State 3) – maintenance required within the next year implying that there is an immediate serious problem.

(6) Bridge Expenditure Data Requirements

Every time routine maintenance or major repair are proposed to be carried out on a bridge, the following information should be recorded in the database for each element and component maintained:

- Type of maintenance
- Cost and quantity of maintenance
- Date maintenance need was identified (inspection date)
- Date maintenance work is stated
- Date maintenance work is completed
- Traffic management needed during the maintenance work

(7) Bridge Records

The records maintained in the new facility are listed in **Table 2.3.3-1.**

Table 2.3.3-1 Types of Bridge Records

Type of Record	Comment	Data Use
Geotechnical investigation reports	Provides information on foundation conditions at the site	Assessment of settlement
Design drawings	Provides the original design for the bridge	Assessment of bridge structural conditions
As-Built Construction drawings	Provides data on changes to the bridge design construction	Assessments of bridge changes and movements

Procedures will be developed to collect and store this data if required by DPWH.

2.3.4 Pasig River Rehabilitation Plan (PRRP)

(1) PRRC and the Master Plan

In January 1999, the Pasig River Rehabilitation Commission (PRRC) was created by virtue of Executive Order No. 54 and took over the responsibilities of the Presidential Force which was created for the Rehabilitation of the Pasig River. The role of the PRRC is to ensure that the waterway is rehabilitated to its historically pristine condition conducive to transport, recreation and tourism. In order to achieve this mandate the Commission was vested with necessary powers and functions among which is to draw up an updated and integrated Pasig River Rehabilitation Master Plan. The Master Plan shall guide the Commission in its function to integrate and coordinate all programs related to the rehabilitation of the Pasig River.

The Pasig River Rehabilitation Master Plan has the following objectives:

- To integrate and update the sectoral development plans of government and non-government agencies. This includes the analysis and synthesis of existing plans and programs in the sectors of environmental management, riverbank development, transportation, tourism, housing and resettlement, livelihood, information and advocacy.
- To develop a Riverbank Physical Development Plan which shall propose a land use program for the area approximately 500 meters north and south of the Pasig River. The plan shall identify potential development areas where the private sector shall be encouraged to invest to complement public infrastructure improvements.
- To formulate design guidelines for the Environmental Preservation Areas or the 10-meter easement
- To recommend policies and strategies for the effective implementation of the plan.

(2) Study Area

The Master Plan follows an ecosystems approach to the rehabilitation of the Pasig River. Its scope covers all the five sub-basins of the Pasig River Basin Area with a total land area of 570 sq. km. Although most of the discharge into the Pasig River comes from the Laguna Lake, this area (3.580 sq. km.) is not included in the PRRMP area since the Plan focuses on the most environmentally critical portion of the entire basin to make it more manageable. The rehabilitation of Laguna Lake is equally complex and is handled by a separate but inter-related multi-sectoral program.

The study area of the Pasig Riverbanks Physical Development Plan covers an area approximately 500 meters from the riverbanks on both sides of the river for the entire length of the Pasig River from Manila Bay to Laguna Lake – the area being bounded by the barangay limits. The 310 barangays and 8 cities and municipalities cover a total area of 5.959.85 hectares. The City of Manila has the largest area covering 39% of the total area, followed by Pasig City with 22% and Taguig with 13%.

2.3.5 Pasig-Marikina River Improvement Project

(1) Background

"The Study on Flood Control and Drainage Project in Metro Manila" that consisted of the master plan formulation and the feasibility study was carried out with technical assistance from the JICA from January 1988 to March 1990. In this study, the master plan of

Pasig-Marikina River Channel Improvement was premised on the project scale of a 100-year return period.

In 1993, a flagship project named the PRRP was implemented as a multi-agency undertaking to retrieve the beauty and lush greenery of the Pasig River as it used to be as early as the 15th century. The DPWH was tasked with the civil works for flood mitigation, especially channel improvement.

In January 1998, the Government endorsed to the OECF (now JBIC) the request for assistance to update/review the feasibility study results of the Project under OECF's Special Assistance for Project Formation (OECF-SAPROF). The SAPROF study was completed in June 1998 with the conclusion that the Project is technically sound and economically viable for immediate implementation. Following the SAPROF study, the Government of Japan through JBIC decided to extend a loan to finance the Project under the 23rd Loan Package in June 1999. The detailed engineering design of the Project was thus started in October 2000 and completed in March 2002.

(2) Master Plan for River Improvement

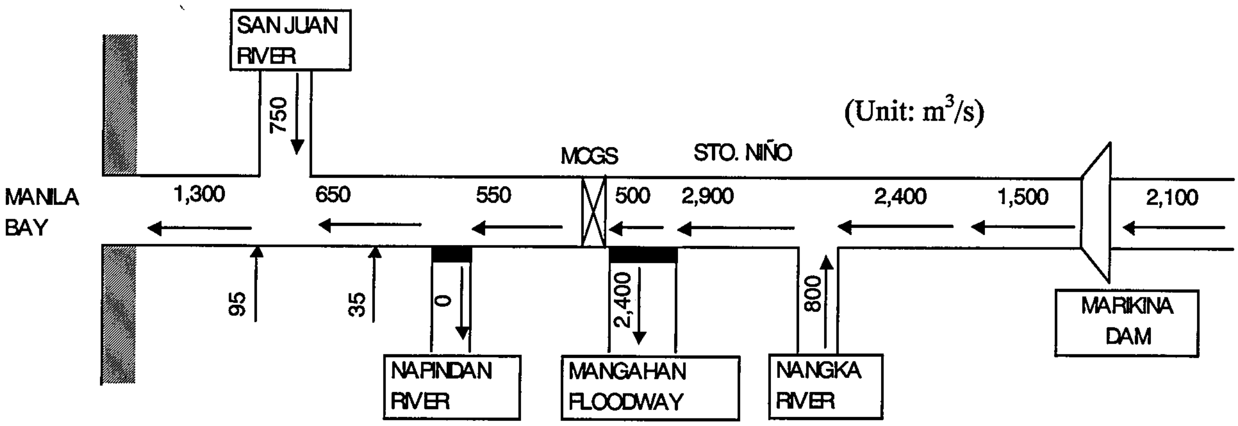


Figure 2.3.5-1 Discharge Distribution of Master Plan

The design flood discharge distribution at a 100-year return period for the master plan is as illustrated in **Figure 2.3.5-1.**

The master plan is structurally composed of river improvement works and the construction of Marikina Control Gate Structure (MCGS) and the Marikina Multipurpose Dam. The river improvement comprises improvement works for the Pasig, Marikina and San Juan rivers.

The Marikina Dam is proposed to be a concrete gravity type with the height of 70 m to impound the water of 25,000,000 m^3 and to regulate the inflow flood of 2,100 m^3/s to as low as 1,500 m^3/s.

(3) Urgent Project for River Improvement

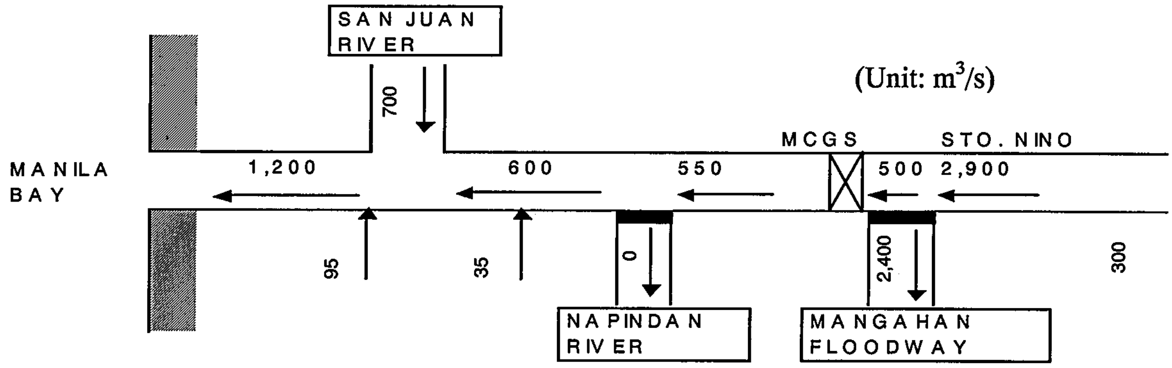


Figure 2.3.5-2 Discharge Distribution of Urgent Project

Based on the master plan, the feasibility study has been conducted for an urgent project against a 30-year return period flood.

The design flood water level for urgent project is shown in **Figure 2.3.5-3.** Major works consist of the improvement of the Pasig and Lower Marikina rivers and a part of the Middle Marikina River, and construction of the MCGS. The San Juan River Improvement Works and Construction of the Marikina Multipurpose Dam have been excluded.

(4) Flood Control Works of Urgent Project

To increase the flow capacity of the Pasig-Marikina River, the channel is to be improved for a stretch of about 30 m from the river mouth up to Sto. Niño. For the urgent flood control project with the scale of 30-year return period, the construction of MCGS is indispensable. River improvement of the Upper Marikina River is also required in line with the construction of MCGS.

All of the river stretches are to be improved by raising the existing parapet wall and rehabilitation of revetment, dredging/excavation and raising of embankment to secure each design discharge as shown in **Figure 2.3.5-2.**

(a) Construction of MCGS

The MCGS, which is a flood control weir, is to be constructed at the immediate downstream from the confluence point of Mangahan Floodway to regulate the design discharge of 2,400 m^3 into the Laguna Lake through the Mangahan Floodway. Thus, the design discharge towards the downstream of MCGS (500 m^3/s) is to be regulated to secure Metro Manila against a 30-year return period flood in combination with the flood scale of Rosario Weir and the Mangahan Floodway.

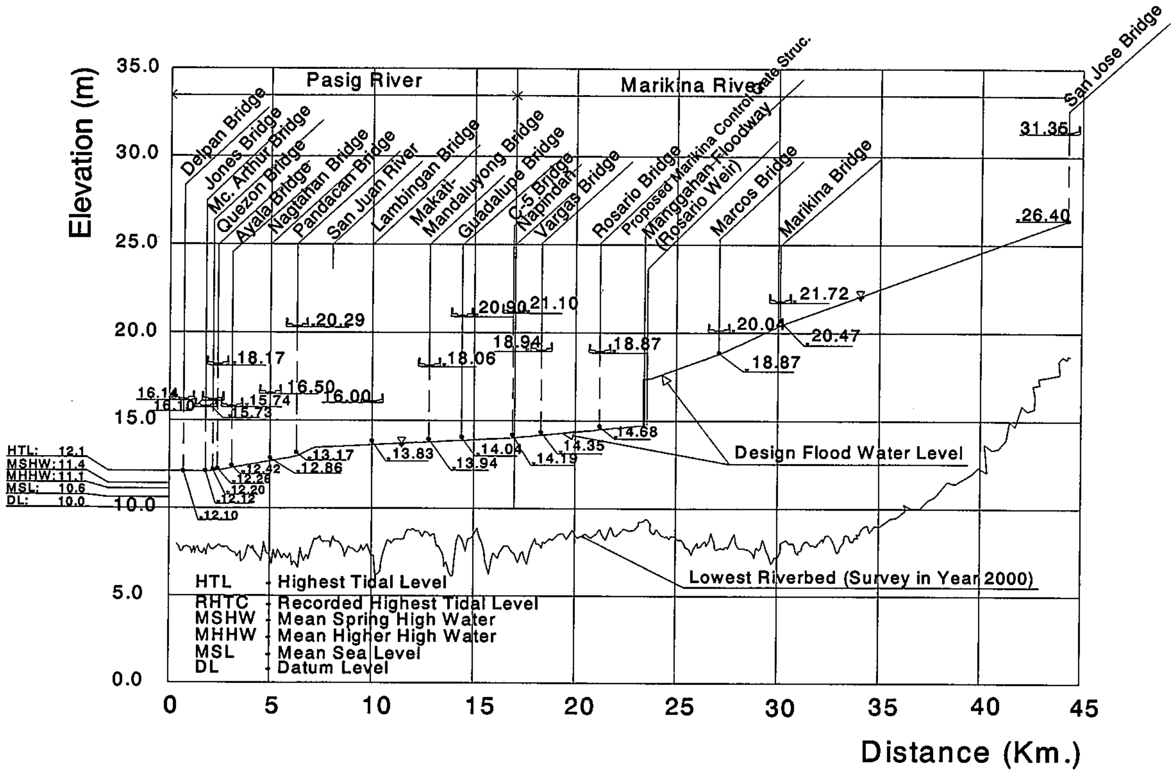


Figure 2.3.5-3 Design Flood Water Level for Urgent Project

2.3.6 Earthquake Impact Reduction Study

In parallel to the Study, another JICA Study entitled "Earthquake Impact Reduction Study for Metropolitan Manila, Republic of the Philippines" (hereinafter referred to as "the Earthquake Study") is being implemented focusing on the overall main infrastructures, the scope of which is a more comprehensive and extensive study on the vulnerability to an earthquake than that of the Study.

The Study reviews therefore the Earthquake Study, introducing the major works related to the Study and the differences in the methods and results between both Studies

(1) Major Works Related to the Study

The major works of the Earthquake Study related to the Study are as follows:

- Disaster management system,
- Consideration of scenario and earthquakes and hazards,
  - Ground motion estimation
  - Tsunami height estimation
  - Slope stability potential estimation
- Earthquake damage estimation,
  - Building damages
  - Human casualties
  - Fire

- Lifelines
- **Bridges and flyovers**
- Transportation
- Angat Dam

- Urban spatial analysis on vulnerability to earthquake, and
- Legal and institutional arrangements for disaster management.

(2) Estimation Methods for Bridge Vulnerability to Earthquake

The Earthquake Study utilized Katayama's method which had been established in Japan. The method was developed employing statistical procedure based on the cases of falling-off bridges or bridge damages under earthquakes in Japan.

In Katayama's method, 10 items, which are likely to affect the falling-off probability of the girder, were studied as indicated in **Figure 2.3.6-1.** Each items consist of a few categories, which can be selected without complex calculations. Score chart for bridges/flyovers stability analysis is shown in **Table 2.3.6-1.** The category-score is given to each category as a weighting factor. The category score, which is modified by taking into account the bridges in Metropolitan Manila, is shown in **Table 2.3.6-1.** Almost necessary data were obtained by observing the bridges in sites.

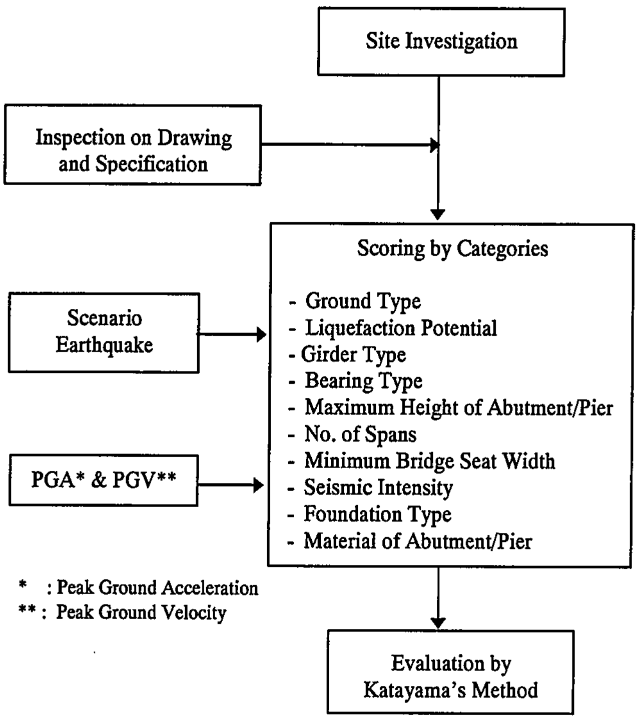


Figure 2.3.6-1 Flowchart of Stability Analysis of bridges/flyovers

Table 2.3.6-1 Score Chart for Stability Analysis of Bridges/Flyovers

Item	Category	Category Score
Ground type	Stiff	0.5
	Medium	1.0
	Soft	1.5
	Very Soft	1.8
Probability of Liquefaction	Nothing	1.0
	Fear	1.5
	Having	2.0
Girder Type	Arch or Rigid Frame	1.0
	Continuous	2.0
	Simple	3.0
Bearing Type	with Specific Device (prevent falling-off of the girder)	0.6
	Bearing (with clear design concept)	1.0
	exist two bearing that can move axial direction	1.15
Max. Height of Abut./Pier	less than 5m	1.0
	5 to 10m	1.35
	more than 10m	1.7
Number of Span	1 span	1.0
	2 spans or more	1.75
Min. Bridge Seat Width	Wide	0.8
	Narrow	1.2
JMA seismic intensity scale	5 (4.5 to less than 5.0)	1.0
	5.5 (5.0 to less than 5.5)	1.7
	6.0 (5.5 to less than 6.0)	2.4
	6.5 (6.0 to less than 6.5)	3.0
	7.0 (6.5 and more than 6.5)	3.5
Foundation Type	Spread	1.0
	Pile	0.9
Material of Abut./Pier	Plain Concrete or others	1.4
	Reinforced Concrete	1.0

(3) Difference in Methods between Both Studies

The following are the features of the methods used in both Studies.

The Earthquake Study

- Structural analysis was not carried out for the estimation of bridge damages.
- Statistical and experimental method was used for the estimation of bridge damages, focusing on whether the superstructures are falling down or not.
- According to **Table 2.3.6-1** the extent of structural deterioration and damages was not considered.
- The seismic intensity was estimated with seismic motion analysis anticipated in Metro Manila.
- The advantage of this estimation is to grasp extensively the safety of bridges under an earthquake.

The Study

- Retrofitting previously made under ADB Project, discussed in **Chapter 10**, was considered.
- Whether the substructures meet the requirements specified in the latest seismic code was studied.
- The 3-D rigid frame model was employed for the analysis of seismic capacity based on the In-Depth Bridge Condition Survey results that include structural damages, deterioration and defects, and geotechnical survey results performed in the Study.
- However, considering that the Study is under Master Plan and Feasibility Study levels, the vulnerability to earthquakes was judged as follows:
  - High Vulnerability : Capacity-Demand Ratio (C/D) ≦ 0.5
  - Moderate Vulnerability : 0.5 < C/D ≦ 1.5
  - Low Vulnerability : C/D > 1.5

(3) Comparison on Vulnerability to Earthquake between Both Studies

Table 2.3.6-2 shows differences in the results between both Studies. As discussed earlier, the study methods and information on each bridge are considerably different, thus producing differences in the results.

Table 2.3.6-2 Comparison on Vulnerability to Earthquake

No	Bridge Study Reference No.	MMEIRS Bridge Code	Bridge Name	Construction Year	The Study Vulnerability	The Earthquake Study Class of Damage Degree	Difference
1	Pa1.1	NC-NM-D201	Delpan Bridge – Upstream	1965	Moderate	A	Small
	Pa1.2	NC-NM-D201	Delpan Bridge - Downstream	1988	Moderate		
2	Pa2	NC-NM-J301	Jones Bridge	1948	High	C	Big
3	Pa3	NC-NM-M201	McArthur Bridge	1948	High	C	Big
4	Pa4	NC-NM-Q101	Quezon Bridge	1946	Moderate	C	Small
5	Pa5	NC-SM-A201	Ayala Bridge	1935/1950	High	C	Big
6	Pa6	NC-NM-N102	Nagtahan Bridge	1966	High	C	Big
7	Pa7	NC-NM-P201	Pandacan Bridge	1997	Low	C	None
8	Pa8	NC-SM-N101	Lambingan Bridge	1975	Moderate	C	Small
9	Pa9	NC-2M-M101	Makati-Mandaluyong Bridge	1986	Moderate	C	Small
10	Pa10.1	NC-1M-E105	Guadalupe Bridge (Central)	1962	Moderate	C	Big
	Pa10.2	NC-1M-E105	Guadalupe Bridge (Both Sides)	1979	High		
11	Pa11	NC-2M-C201	C-5 Bridge	1998	Moderate	C	Small
12	Pa12	NC-1M-P101	Bambang Bridge	1991	Low	C	None
13	Ma1.1	NC-1M-S304	Vargas Bridge – Upstream	1992	Low	A	Big
	Ma1.2	NC-1M-S304	Vargas Bridge – Downstream	1973	Moderate		
14	Ma2	NC-1M-O101	Rosario Bridge	1952	Moderate	C	Small
15	Ma3	NC-1M-M301	Marcos Bridge	1978	Moderate	C	Small
16	Ma4	NC-2M-A102	Marikina Bridge	1980	Moderate	C	Small
17	Ma5	NC-QC-S301	San Jose Bridge	1980	High	C	Big

Definition of Vulnerability

- Low Vulnerability ($C/D > 1.5$) : When exposure to shaking from large earthquake should not cause collapse of all or part of the bridge. Where possible, damage that does not occur should be readily detectable and accessible for inspection.
- Moderate Vulnerability ($0.5 \leqq C/D < 1.5$) : Total collapse of the bridge is not expected but damages to bridges would take time and difficult to restore.
- High Vulnerability ($C/D \leqq 0.5$) : Probability of collapse under large earthquake could not be overruled, restoration to capacity under present code requirements will be very costly and impractical.

Class and Boundary values of Damage Degree

A : Large probability of falling-off (Boundary Values (BV) $\geqq 30$)
B : Moderate probability of falling-off ($26 \leqq BV < 30$)
C : Less probability of falling-off ($BV < 26$)