JAPAN INTERNATIONAL COOPERATION AGENCY

Republic of the Philippines
DEPARTMENT OF
PUBLIC WORKS AND HIGHWAYS

THE STUDY
ON
THE IMPROVEMENT OF EXISTING BRIDGES ALONG PASIG RIVER AND MARIKINA RIVER
IN
THE REPUBLIC OF THE PHILIPPINES

FINAL REPORT
APPENDICES

JULY 2004

KATAHIRA & ENGINEERS INTERNATIONAL

CTI ENGINEERING INTERNATIONAL CO. LTD.

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PART I

GENERAL

CHAPTER 2

PROFILE OF THE STUDY AREA

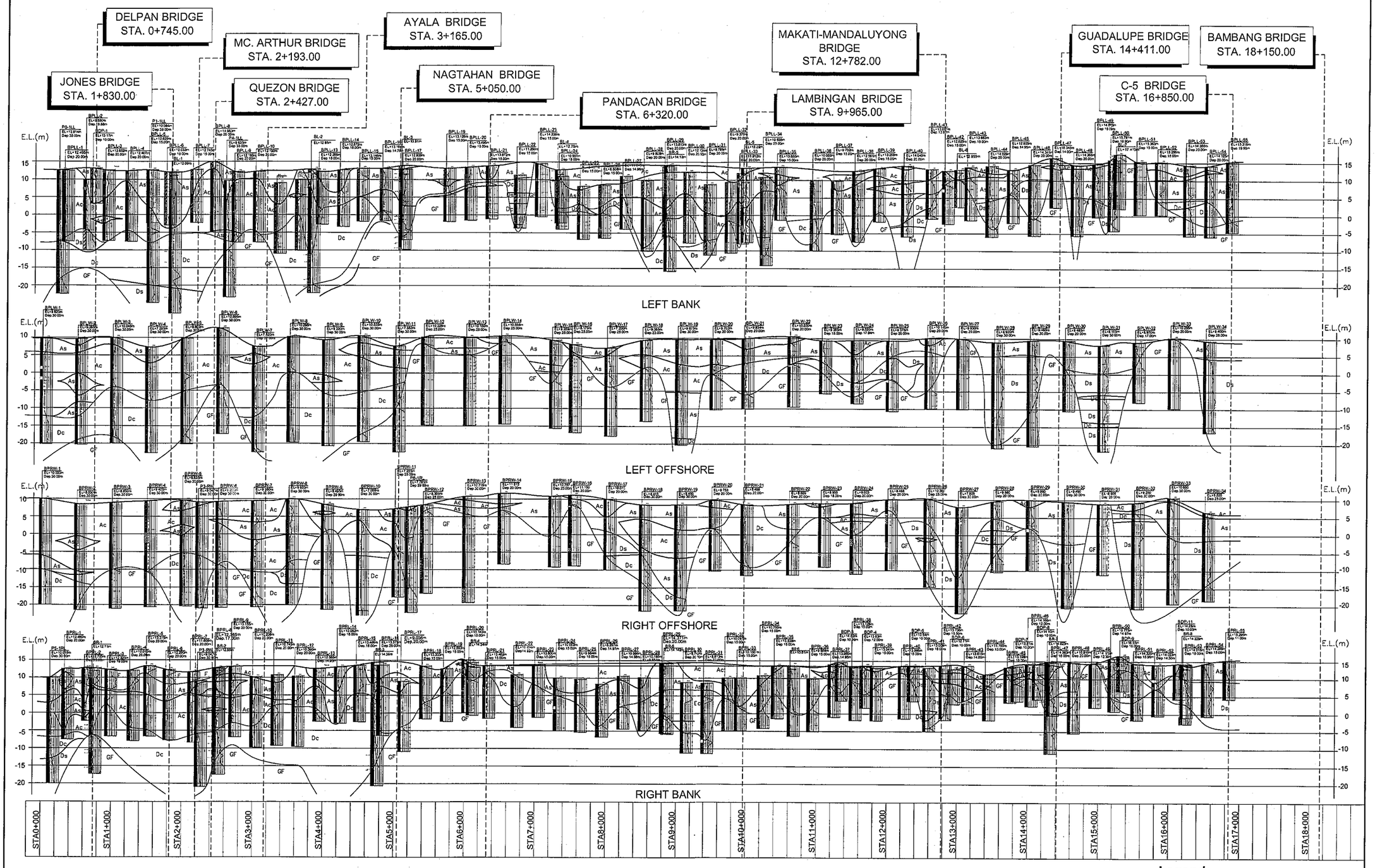
Appendix 2.1.1-1

Earthquakes which affect Metro Manila Area from 1589 to 1999

Date	Affected Area(s)	Epicenter & Magnitude	Intensity in Metro Manila	Damages in Metro Manila
June 1589	Metro Manila		(Not available)	A fort (La Guia Fort) while being constructed cracked in many places.
June 21, 1599	Metro Manila (Intramuros)	(Not available)	VIII	Many buildings damaged specifically two sections of a school and arch and stone vault of Jesuit Church; Wooden frame and walls of Santo Domingo Church was damaged; These were located in the Intramuros Area.
January 01, 1601	Metro Manila (Intramuros)	(Not Available)	VIII	A great portion of the city was ruined; Many churches and houses were damaged; Two lateral vaults of the Jesuit Church were cracked; The Cathedral was damaged; Damage reports confined to Intramuros area.
November 30, 1645	Metro Manila (Binondo)	(15.70 N. lat.; 121.20 E. long.) Ms. 7.9	IX	One of the most destructive earthquakes over to hit Manila; Most buildings in the city were ruined including the Manila Cathedral's tower roofs and chapels fell to their foundations; 150 principal houses collapsed especially those near Pasig River.
October 26, 1824	Metro Manila	(14.20 N. lat.; 121.90 E. long.) Ms. 7.6	VIII	Some churches were demolished; A portion of the San Francisco bell tower was destroyed; Cracks were formed at the Santo Domingo Church and on the Arch of a bridge in Manila (which was constructed between 1626-1632); Explosions were heard upstream of the river and after which, dead sea fishes were seen floating on the river.
September 16, 1852	Metro Manila Parañaque Las Piñas	(14.20 N. lat.; 120.10 E. long) Ms. 7.6	IX VII VII	Public and private buildings, monasteries and churches, principal gates, walls, arches and columns of some palatial houses cracked dangerously and several tiles knocked down; Roof and two galleries of an old Jesuit church/monastery despite strong arches collapsed. Large cracks at Fort Santiago, Cathedral- 2 arches of lat. Naves broke and badly cracked; San Agustin Church-stairway walls cracked, a dome section cracked and old crack increased in size; San Francisco Church – almost all of the arches of the monastery were weakened and the church is badly damaged. San Miguel tower destroyed and some walls cracked. Beaterio of Santa Rosa greatly damaged and nuns must be evacuated to another place.
June 03, 1863	Metro Manila Tondo, Binondo, Santa Cruz, Quiapo, Pandacan, Santa Ana, Navotas, Pasig, Calnta	(14.70 N. lat.; 120.901 E. long.) Ms. 6.5	IX	Shook down strongest edifices and most houses; Almost all buildings in Tondo called "possesiones" collapsed; Section of Divisoria Market fell; Binondo Church tower and a part of the church fell; Binondo Cigar Factory partially damaged; Santa Cruz and most of the buildings in Quaipo including Quaipo Church partially damaged; Walls of the Santa Ana and Pandacan Churches cracked while their tower were demolished.
October 01, 1869	Metro Manila	(14.30 N.lat; 120.5. E. long) Ms. 6.6	VII	Façade of San Agustin Church cracked, parts of roof collapsed, windows and doors damaged in the Administration of Rents, one wall in Smith, Bell and Co., three houses, one shop and Cuartel de Arroceros damaged.
July 15-20 1880 15th - series of quakes started 18th - biggest event of quakes 20th - the biggest aftershock	Metro Manila Las PiñasParañaque, Pateros, Pasig, Pandacan, Binondo, Tondo, Quaipo, Sampaloc, Santa Ana, Paco, Malate, Mandaluyong, Malabon, Marikina, Makati, Kalookan, Taguig	(14.40 N. lat.; 121.50 E. long) Ms. 7.6	VIII	Buildings inside the Intramuros area and 14 churches either lost their tower or sustained damages; Entrances to Intramuros collapsed; Virtually all tile roofed houses collapsed inside Intramuros; Many buildings in Manila area near Pasig River sustained severe damages.
August 20,1937	Metro Manila Ermita, Tondo, Quiapo, Pandacan, Santa Ana, Pasig	(14.50 N. lat., 121.50 E. long) Ms. 7.5	VII	The church tower of Pandacan fell; School buildings were damaged; Water pipelines in Santa Ana areas as well as near the Ayala Bridge in Santa Cruz areas burst and telephone and power lines also disrupted; A 12 inch main pipe at Ayala Bridge broke, also an 8 inch pipe at Pier No.3 and 5 which flooded a warehouse damaging hundreds of sacks of flour; Crane derailed at Pier 7; Ayala and Santa Cruz Bridges were badly shaken that they had to closed for inspection.
April 09, 1942	Metro Manila	120 km southwest of Manila Ms. 7.5	(Not available)	Ten buildings slightly damaged in Manila Corridors of Phil. General Hospital's 2nd floor cracked, window panes of Heacock Bldg. Previously damaged in the 1937 quake cracked, Paris and Filipinas buildings cracked; Fragments of concrete fell from the Phil. National Bank building.
August 02, 1968	Metro Manila Quezon City, Makati	130 km away from Manila Ms. 7.3	VII	Ruby Tower collapsed (a 60 storey building located in the Binondo area); Don Petra building in Quezon Blvd. Showed cracks on concrete walls and large fractures on the east and west side of the 3rd and 4th floors; Glass panes in a chapel broke; cracks on the DENR bldg. In Quezon circle.
April 07, 1971	Metro Manila Binondo, Escolta, Recoletos, Intramuros, Quiapo, Morayta, Taft Aveneu and Kalaw Streets	(15.671 N. lat.; 121.717 E. long) 120 km from Manila	(Not available)	Six buildings were condemned, five were rendered unsafe for occupancy and 250 more sustained varying level of damages.
April 26, 1972	Metro Manila	(13.370 N. lat., 120.309 E. long) 120 km from Manila Ms. 7.2	VII	City Library of Manila in Aroceros was heavily damaged; Other buildings damaged were the Manila City Hall, Bayview Hotel, Hilton Hotel, VIP Bldg., Torres Hotel, Manufacturer's bank in Santa Cruz, Corriman Bldg. In Escolta, Amparo Bldg. In España, Dom Mariano Bldg. In Sampaloc.
July 16, 1990	Metro Manila	100 km from Manila Ms. 7.8	VII	Some buildings in Binondo and in the reclaimed area of Pasay City sustained minor cracks; Telephone and power lines went out for one hour after the quake.
December 12, 1999	Metro Manila Pasay	180 km from Manila Ms. 6.8	(Not available)	Damages sustained by the PGH building, San Sebastian College, Chinatown, Steel Tower Condominium, PICC building, Manila Film Center and Golden Bay Hotel in Pasay City.

Earthquake Intensity in Metro Manila
The Modified Mercalli Scale

INTENSITY	EFFECT
I	Not felt
II	Felt by persons at rest on upper floors
III	Felt indoors. Hanging object swing. Vibration like passing of light trucks.
IV	Vibration like passing of heavy trucks. Standing automobiles rock. Windows, dishes, doors rattle; Wooden walls or frame may creak.
V	Felt outdoors. Sleepers wakened. Liquid disturbed, some spilled. Small objects may be moved or upset. Doors swing; shutters and pictures move.
VI	Felt by all; many frightened. People walk unsteadily. Windows, dishes broken. Objects knocked off shelves, pictures off walls. Furniture moved or overturned. Weak plaster cracked. Small bells ring. Trees, bushes shaken
VII	Difficult to stand. Furniture broken. Damage to weak materials, such as adobe; some cracking of ordinary masonry. Fall of plaster, loose bricks, and tile. Waves on ponds; water muddy; small slides along sand or gravel banks. Large bells ring.
VIII	Steering of automobiles affected. Damage to, partial collapse of ordinary masonry. Fall of chimneys, towers. Frame houses moved on foundations if not bolted down. Changes in flow of springs and wells.
IX	General panic. Frame structures shifted off foundations if not bolted down; frames cracked. Serious damage even to partially reinforced masonry. Underground pipes broken; reservoirs damaged. Conspicious cracks in ground.
X	Most masonry and frame structures destroyed with their foundations. Serious damage to dams, dikes. Large landslides. Rails bent slightly.
XI	Rails bent greatly. Underground pipelines out of service
XII	Damage nearly total. Large rock masses shifted. Objects thrown into the air.

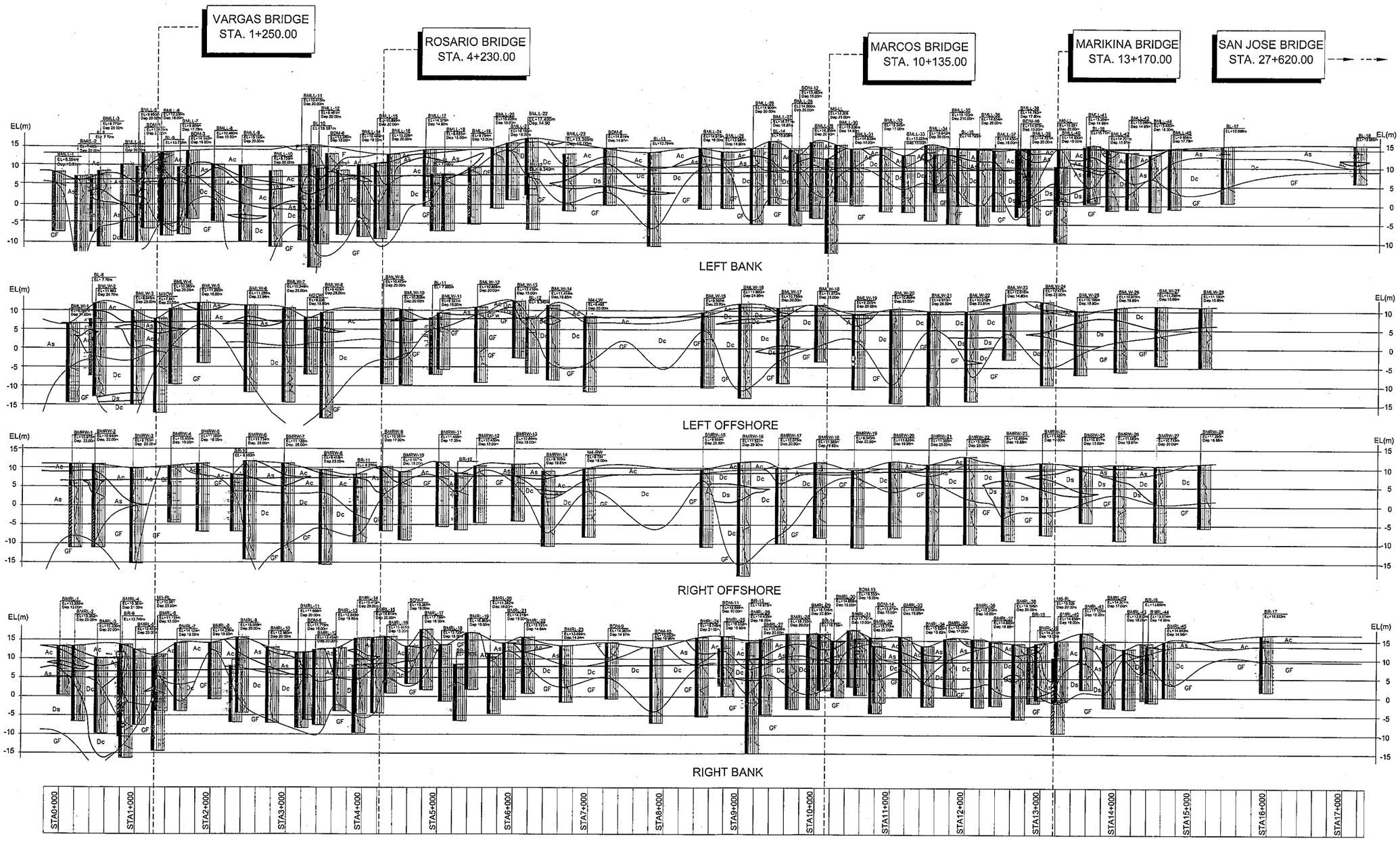


GEOLOGICAL PROFILES ALONG PASIG RIVER

HORIZONTAL SCALE : 1:550
VERTICAL SCALE : 1:1000

Legend:

F	:	Filled Soil
Bs	:	Boulder Stone
As	:	Alluvial Sand
Ac	:	Alluvial Clay
Ds	:	Diluvial Sand
Dc	:	Diluvial Clay
GF	:	Guadalupe Formation and Weathered Portion



GEOLOGICAL PROFILES ALONG MARIKINA RIVER

HORIZONTAL SCALE : 1:550
VERTICAL SCALE : 1:1000

Legend:

F	:	Filled Soil
Bs	:	Boulder Stone
As	:	Alluvial Sand
Ac	:	Alluvial Clay
Ds	:	Diluvial Sand
Dc	:	Diluvial Clay
GF	:	Guadalupe Formation and Weathered Portion

1. CLIMATOLOGICAL BASIC DATA

(1) Climatological Basic Data at Port Area, Manila

Latitude : 14º 35' N Longitude : 120º 59' E
Elevation : 16.0 m Period : 1961 - 1995

Climatological Normals, Port Area (MCO), Manila (Station 425)

MONTH	RAIN - FALL MM	NO. OF RD	TEMPERATURE DEG. C			RH %	MSLP MBS	WIND		DAYS TSTM	WITH LTNG.
			MAX.	MIN.	MEAN			DIR	SPD MPS		
JAN.	16.2	4	29.4	23.0	26.2	71	1013.2	NE	3	0	0
FEB.	5.5	2	30.3	23.2	26.8	68	1013.2	SE	3	0	0
MAR.	9.5	2	32.0	24.5	28.2	65	1012.4	SE	3	0	0
APR.	16.4	2	33.4	25.7	29.6	64	1010.9	SE	3	1	2
MAY	133.3	9	33.3	26.4	29.8	69	1009.2	SE	3	8	11
JUNE	289.1	17	32.1	25.8	29.0	76	1008.5	SW	4	11	13
JULY	406.7	22	31.1	25.4	28.2	79	1008.1	SW	4	12	11
AUG.	463.5	22	30.5	25.1	27.8	82	1007.8	SW	4	10	8
SEPT.	353.4	20	30.7	25.1	27.9	81	1008.6	SW	3	12	11
OCT.	232.9	17	30.9	25.0	28.0	78	1009.4	W	3	7	8
NOV.	124.5	11	30.6	24.4	27.5	75	1010.8	NE	3	2	2
DEC.	54.1	8	29.7	23.6	26.6	74	1012.3	NE	3	0	0
ANNUAL	2105.0	136	31.2	24.8	28.0	74	1010.4	SE	3	63	66

LEGEND
NO. OF RD. - Number of Rainy Days
RH - Relative Humidity (%)
MSLP - Mean Sea Level Pressure (millibars)
REFERENCE : PAGASA / CAB / CDS
SPD - Wind Speed, (m/s)
DAYS TSTM - Days with Thunderstorm
WITH LTNG. - With Lightning

Climatological Extremes, Port Area, Manila (Year – As of 1997)

MONTH	TEMPERATURE, DEG C				GREATEST DAILY RAINFALL, MM		HIGHEST WIND, MPS			SEA LEVEL PRESSURE, MBS			
	HIGH	DATE	LOW	DATE	AMOUNT	DATE	SPD	DIR	DATE	HIGH	DATE	LOW	DATE
JAN.	36.5	30 – 84	14.5	11 - 14	36.2	16 – 88	18	E	15 -87	1022.4	9 - 14	1003.4	2 - 16
FEB.	35.6	25 – 6	15.6	18 - 20	46.4	3 – 86	25	SE	26 - 62	1021.4	1 - 62	1002.7	18 - 98
MAR.	36.8	23 – 66	16.2	10 - 11	42.0	1 – 64	27	SSE	16 - 62	1020.5	30 - 58	997.3	27 - 91
APR.	38.0	30 – 15	17.2	2 - 23	143.0	29 – 5	24	WSW	18 - 62	1018.8	1 - 58	998.1	29 - 5
MAY	38.6	17 – 15	20.0	1 - 21	371.4	19 – 76	35	E	17 - 89	1015.9	9 -37	987.4	23 - 22
JUNE	37.6	4 – 12	20.1	4 - 73	252.8	27 – 85	47	SW	29 - 64	1021.6	28 - 93	974.6	29 - 64
JULY	36.5	2 – 73	19.4	14 - 70	293.6	29 – 19	31	WSW	24 - 68	1014.9	29 - 87	991.7	4 - 21
AUG.	35.6	9 – 64	18.0	14 - 74	323.9	10 – 47	34	S	4 - 89	1015.2	12 - 58	990.8	31 - 20
SEPT.	35.3	18 – 3	20.2	2 - 70	403.1	1 – 70	34	SW	13 - 61	1015.2	20 - 65	986.7	27 - 6
OCT.	35.8	1 – 68	19.5	26 - 13	194.3	15 – 18	41	W	26 - 78	1017.0	28 - 60	977.9	14 - 70
NOV.	35.6	4 – 66	16.8	30 - 11	278.4	18 – 23	56	WNW	19 - 70	1019.0	29 - 85	966.5	19 - 70
DEC.	34.6	14 – 47	15.7	31 = 92	128.3	18 – 39	41	W	14 - 64	1020.9	8 - 60	971.1	26 - 47
ANNUAL	38.6	5 – 17 1915	14.5	1 – 11 1914	403.1	9 – 1 1970	56	WNW	11 – 19 1970	1022.4	1 – 9 1914	966.5	11 –19 1970
PERIOD OF RECORD	1885 – 1997				1865 – 1997		1948-1997			1885 - 1997			

NOTE : 1. EQUAL SIGN (=) MEANS YEAR 1800
2. NO RECORD FOR THE PERIOD 1941 – 1945

(2) Climatological Basic Data at Science Garden, Quezon City

Latitude : 14° 39' N Longitude : 121° 03'
Elevation : 43.0 m Period : 1961 - 1995

Climatogological Normals, Science Garden, Quezon City (Station 430)

MONTH	RAIN - FALL MM	NO. OF RD	TEMPERATURE DEG. C			RH %	MSLP MBS	WIND		DAYS TSTM	WITH LTNG.
			MAX	MIN.	MEAN			DIR	SPD MPS		
JAN.	18.7	4	30.2	20.1	25.2	76	1012.5	NE	2	0	0
FEB.	7.4	2	31.4	20.2	25.8	70	1012.4	NE	2	0	0
MAR.	16.7	3	33.2	21.4	27.3	67	1011.8	SE	2	1	1
APR.	28.5	4	34.8	22.9	28.9	65	1010.3	SE	2	3	3
MAY	141.0	11	34.6	24.1	29.3	71	1008.6	SE	2	12	13
JUNE	344.6	18	32.5	24.0	28.3	80	1008.0	SW	2	16	13
JULY	478.6	22	31.3	23.6	27.5	84	1007.6	SW	2	17	13
AUG.	517.1	24	30.8	23.6	27.2	84	1006.5	SW	2	14	9
SEPT.	402.2	22	31.1	23.4	27.3	85	1008.1	SW	2	15	12
OCT.	268.2	18	31.1	22.8	27.0	83	1009.0	N	2	10	8
NOV.	147.2	13	30.9	22.0	26.4	81	1010.3	N	2	4	3
DEC.	61.9	8	30.2	21.0	25.6	79	1011.7	NE	2	1	1
ANNUAL	2431.9	149	31.8	22.4	27.1	77	1009.8	SW	2	93	76

LEGEND
NO. OF RD. - Number of Rainy Days
RH - Relative Humidity (%)
MSLP - Mean Sea Level Pressure (millibars)
REFERENCE : PAGASA / CAB / CDS
SPD - Wind Speed, (m/s)
DAYS TSTM - Days with Thunderstorm
WITH LTNG. - With Lightning

Climatological Extremes, Quezon City (Year – As of 1997)

MONTH	TEMPERATURE, DEG C				GREATEST DAILY RAINFALL, MM		HIGHEST WIND, MPS			SEA LEVEL PRESSURE, MBS			
	HIGH	DATE	LOW	DATE	AMOUNT	DATE	SPD	DIR	DATE	HIGH	DATE	LOW	DATE
JAN.	34.2	29 - 88	15.5	27 -87	55.8	16 – 88	24	ESE	17 - 72	1020.6	30 - 73	998.8	22 - 89
FEB.	35.6	24 - 67	15.1	4 - 87	30.7	12 – 74	22	SSE	2 - 92	1020.1	8 - 73	1002.3	9 – 85
MAR.	36.8	26 - 83	14.9	1 - 63	44.8	15 – 89	26	S	16 – 92	1019.0	2 - 87	997.8	28 – 88
APR.	38.0	30 - 88	17.2	5 - 63	47.2	16 – 79	26	SSE	7 – 92	1016.3	11 - 72	1002.1	26 – 71
MAY	38.5	14 - 87	17.8	3 - 62	166.0	20 – 96	40	N	10 – 92	1015.1	28 - 86	992.4	17 – 89
JUNE	38.0	2 - 93	18.1	27 - 61	334.5	7 – 67	37	SW	25 – 72	1014.9	7 - 97	978.7	26 – 93
JULY	36.1	9 - 92	17.7	23 - 61	218.0	31 – 72	36	NNW	9 – 77	1015.0	1 - 79	989.2	15 – 78
AUG.	35.8	10 - 62	17.8	23 - 64	223.0	15 – 79	30	WSW	18 – 92	1014.1	11 - 97	994.2	24 – 78
SEPT.	35.4	4 - 88	20.0	8 - 64	276.5	1 – 70	30	SSW	20 – 92	1016.0	28 - 97	987.4	30 – 95
OCT.	35.0	20 - 89	18.6	31 - 67	209.3	18 – 75	30	SE	11 – 89	1016.0	25 - 86	978.7	23 – 88
NOV.	34.2	5 - 87	15.6	12 - 62	169.9	20 - 66	50	NNW	3 – 95	1019.1	18 - 79	883.1	2 – 95
DEC.	34.7	15 - 97	15.1	13 - 88	87.2	22 - 94	22	SE	22 – 97	1019.1	21 - 81	998.1	5 – 93
ANNUAL	38.5	3 – 14 1987	14.9	3 – 1 1963	334.5	6 – 7 1967	50	NNW	11 – 3 1995	1020.6	1 – 30 1973	883.1	11 – 2 1995
PERIOD OF RECORD	1961 – 1997				1961 – 1997		1961 - 1997			1961 – 1997			

NOTE : 1. EQUAL SIGN (=) MEANS YEAR 1800
2. NO RECORD FOR THE PERIOD 1941 – 1945

(3) Rainfall

a) Rainfall at Port area in Manila City.

Amount of annual rainfall is 2105 mm. The season of strong rainfall more than 300 mm/month is between July and September. The season of small rainfall less than 100 mm/month is between December and April. The amount of the greatest daily rainfall is 403.1 mm, recorded on Sept. 1 in 1970.

b) Rainfall at Science Garden, Quezon City

Amount of annual rainfall is 2431.9 mm. The season of strong rainfall more than 300 mm/ month is between June to September. The season of small rainfall less than 100 mm/month is between December to April. The amount of this greatest daily rainfall is 334.5 mm recorded on June 7 in 1967.

(4) Temperature

a) Temperature at Port area in Manila City.

Temperature change is very small. Average of maximum temperature is 31.2 ºC and minimum temperature is 24.8 ºC. The difference is only 6.4 ºC, mean temperature is 28.0 ºC. The maximum temperature is 38.6 ºC, recorded on May 17 in 1915 and the minimum temperature is 14.5 ºC, recorded on Jan. 11 in 1914.

b) Temperature at Science Garden in Quezon City

The average of maximum temperature is 31.8 ºC and minimum 22.4 ºC. The difference is only 9.4 ºC. The maximum temperature is 38.5 ºC, recorded on May 14 in 1987 while the minimum temperature is 14.9 ºC, recorded on March 1 in 1963.

(5) Relative Humidity

a) Relative humidity at Port Area in Manila City

Relative humidity at Port area in Manila City is 74 %, maximum value shows 82 % and minimum value shows 64 %, difference is only 18 %.

b) Relative humidity at Science Garden, Quezon City

Relative humidity at Science Garden, Quezon City is 77 %, maximum 85 %, minimum 65 %, difference is only 20 %.

(6) Wind

a) Wind at Port Area in Manila City

Direction of wind in South-East to South-West during Feb. to Sept. and West to North-East in October to January. Wind speed is 3 ~ 4 m/s.

b) Wind at Science Garden in Quezon City.

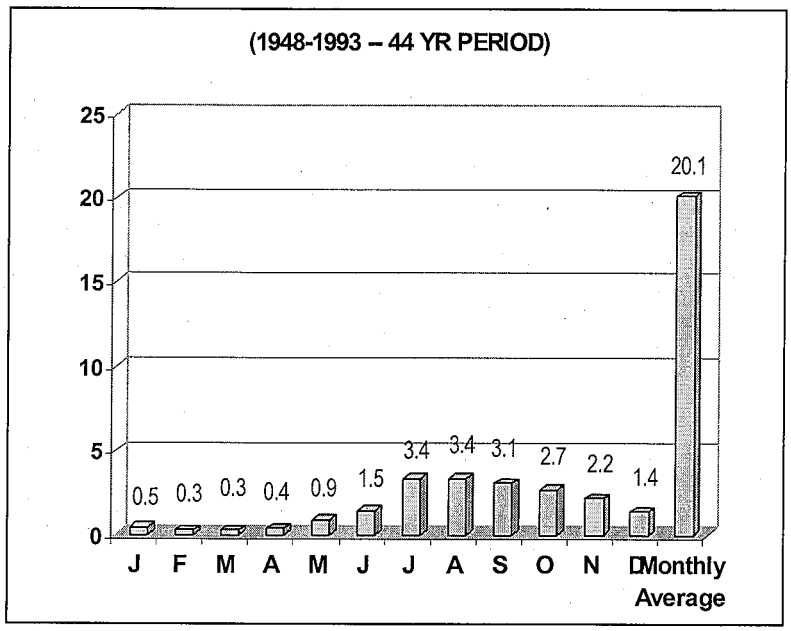
Direction of wind is South-East to South-West from March to September and North to North-East from October to February. Wind speed is 2 m/s.

(7) Tropical Cyclone

Tropical cyclones including typhoon are the most destructive weather disturbances because of the accompanying strong winds, besides the voluminous rains which they release. They are characterized by a low pressure center called the "eye" of the storm with no clouds and no wind. The winds of a tropical cyclone blow around this low pressure center in a counterclockwise direction in the northern hemisphere with increasing magnitude as one approaches the eye. The maximum winds can be found near the eye wall of a storm.

a) Frequency of the typhoon

The typhoon season in the Philippines begins during the month of May and lasts until December. Tropical cyclones may form as early as January to April but these are relatively few in number (**Appendix 2.1-2-1)**). Actually, no month is spared. Most typhoons form during the months of July, August and September.



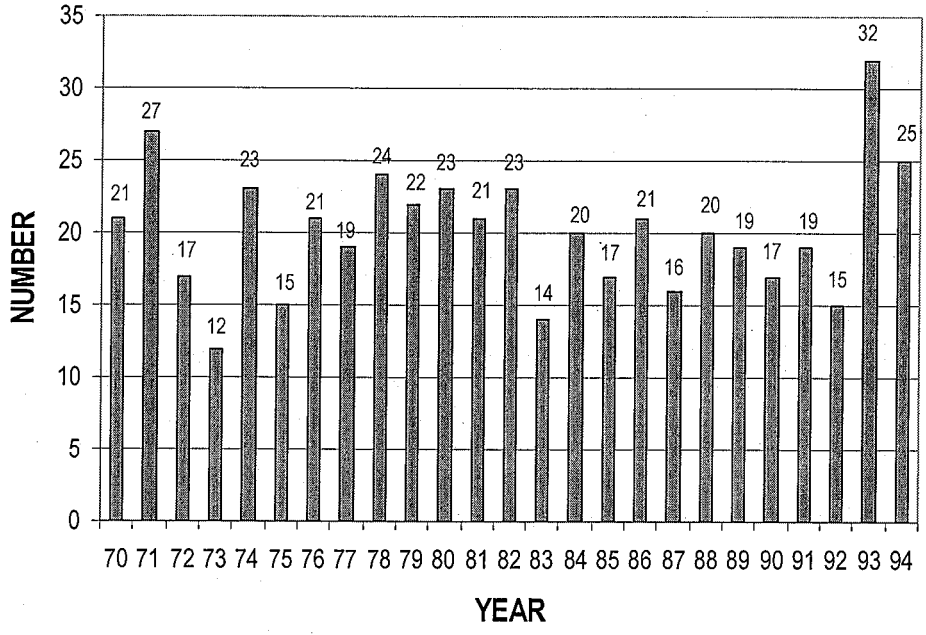
Appendix 2.1-2-1) Tropical cyclone in the PAR Average monthly frequency

(PAGASA Natural Mitigation Disaster in the Philippines)

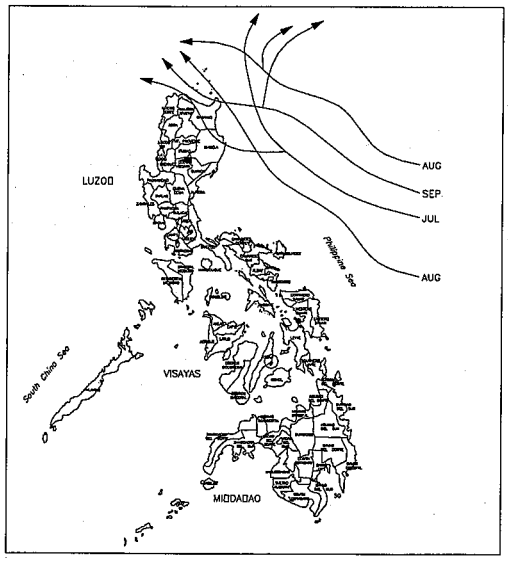
The number of tropical cyclones that occur in the Philippine Area of Responsibility (PAR) is not the same every year. **Appendix 2.1-2-2)** shows that in terms of annual occurrence, the year 1997 has the least. (12 cases).

Tropical cyclones which affect the Philippines usually form in the Pacific Ocean between the Philippines and the Marianas-Carolines Islands above 5 degrees latitude. They move generally in a west-northwest direction at 15 kph on the average, intensifying as they approach the Philippine area. Winds of 200 kph or more can be observed in typhoons approaching the shores. Tropical cyclone tracks vary with season. **Appendix 2.1-2-3)** shows the representative average tropical cyclone tracks.

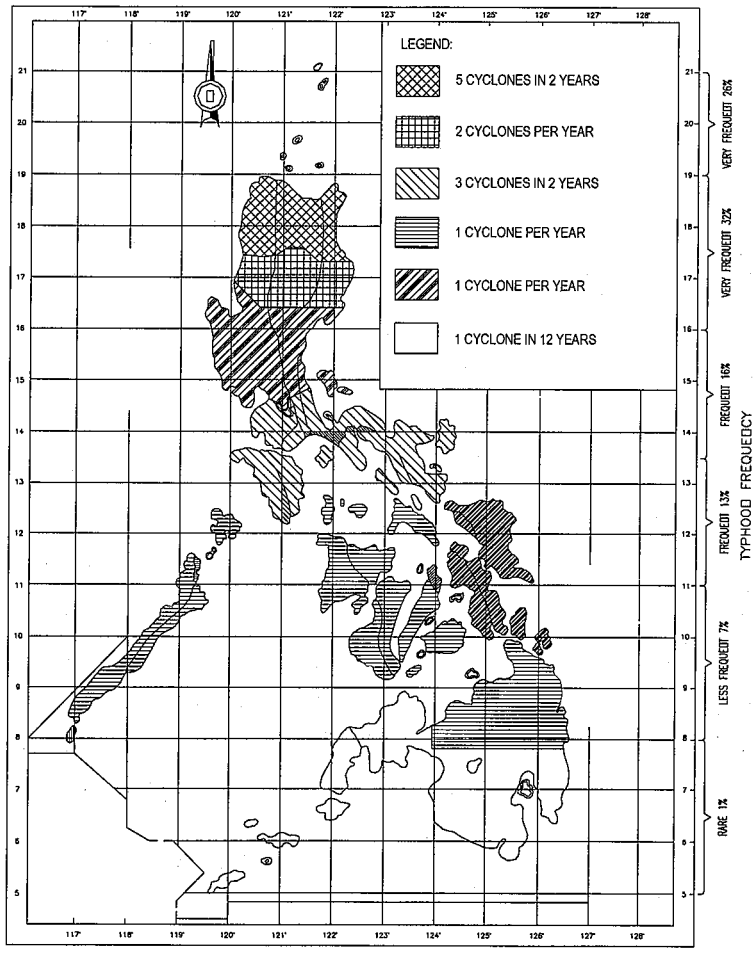
Appendix 2.1-2-4) shows the frequency of tropical cyclone passage over each of the geographical zones in the Philippines. Zone 2 has the most frequent passage of tropical cyclones of 5 cases in 2 years. It is located in the northern Philippines. Zone 12, which is situated in the southern portion of the Philippines, has the least number of tropical cyclone passages, with an occurrence of 1 cyclone in 12 years.



Appendix 2.1-2-2) Annual occurrence of tropical cyclones in the Philippines (PAGASA)



Appendix 2.1-2-3) Representative Average monthly paths of tropical cyclones entering the Philippine Area of Responsibility (PAR) – 4th Quarter (Valenzuela 1989).



Appendix 2.1-2-4) Frequency of tropical cyclone passage over each geographical zone in the Philippines (PAGASA)

b) Frequency of typhoon passage in Metro Manila

The tropical cyclone consists of Tropical Depression (TD), Tropical Storm (TS) and Typhoon (TY). The frequency of Tropical Cyclone passage in Metro Manila is shown in **Appendix 2.1-2-5)**. In the past ten years, five (5) Tropical Cyclones mainly Typhoon have come over to Metro Manila.

Appendix 2.1-2-5) - Frequency of Tropical Cyclone Passage in Metro Manila (From 1948 to 2000 – 53 Year Period)

(PAGASA)

YEAR	CENTER OVER/VERY CLOSE TO MM	CENTER WITHIN 50 KM FR. MM	CENTER WITHIN 50-100 KM FR. MM	TD	TS	TY	TOTAL
1948		TD (NOV-S)		1	0	0	1
1949		TD (AUG-N)		1	0	0	1
1950	TY FRAN (DEC)			0	0	1	1
1951		TY IRIS (MAY-SW)		0	0	1	1
1953		TS BETTY (OCT-NE)		0	1	0	1
1957		TD (OCT-NE)		1	0	0	1
1960		TD GLORIA (SEP-S)		2	0	1	3
		TY OLIVE (JUN-NE)					
		TD LUCILLE (MAY-NE)					
1961			TS RUBY (SEP-NE)	0	1	0	1
1962		TD (SEP-N)		1	0	0	1
1963	TY DADING (JUN)	TS LUSING (JUL-NE)		0	2	1	3
		TS KAYANG (SEP-N)					
1966		TD LOLENG (JUL-S)	TD UDING (NOV-NE)	2	0	0	2
1967	TY WELING (NOV)			0	0	1	1
1970	TY SENING (OCT)		TS WENING (NOV-S)	0	1	2	3
	TY YOLING (NOV)						
1971			TY HERMING(MAY-S)				
			TD ONIANG (JUL-N)	1	1	1	3
			TS DADANG (OCT-S)				
1972	TY KONSING (JUN)			0	0	1	1
1974		TS YANING (NOV-S)	TY BIDANG (NOV-N)	0	1	1	2
1975		TD PEPANG(NOV-SE)		1	0	0	1
1977		TY UNDING (NOV-NE)	TS ELANG (JUN-NE)	0	1	1	2
1978		TY YAYANG (OCT-N)	TY WELING (SEP-SE)	0	1	3	4
			TS SUSANG (OCT-N)				
			TY KADING (OCT-NE)				
1979	TD SISANG (OCT)	TS KARING (MAY-S)		1	2	0	3
		TS PEPANG (SEP-SE)					
1980		TD ISANG (JUL-S)	TD MARING (JUL-N)	2	0	0	2
1981			TD SALING (SEP-SE)	2	0	1	3
			TD YEYENG (NOV-S)				
			TY ANDING (NOV-NE)				
1983	TY BEBENG (JUL)			0	0	1	1
1985			TD ELANG (JUL-ENE)	1	0	0	1
1986			TS OYANG (OCT-N)	0	1	0	1
1988			TY ASIANG (JAN-S)	0	0	2	2
			TY UNSANG (OCT-N)				
1989	TY BINING (MAY)			0	0	2	2
	TY SALING (OCT)						
1991	TS YAYANG (NOV)			0	1	0	1
1992		TY PARING (OCT-N)		0	0	1	1
1993			TS HULING (JUL-S)	0	1	0	1
1994	TY KATRING (OCT)			0	0	1	1
1995	TS MAMENG (SEP)			0	1	1	2
	TY ROSING (OCT)						
2000	TY REMING (OCT)			0	0	2	2
	TY SENIANG (OCT)						
			TOTAL	16	15	25	56
			RANK	2	3	1	

Note: TD – Tropical Depression, TS – Tropical Storm, TY - Typhoon

c) Peak Gust of Typhoon

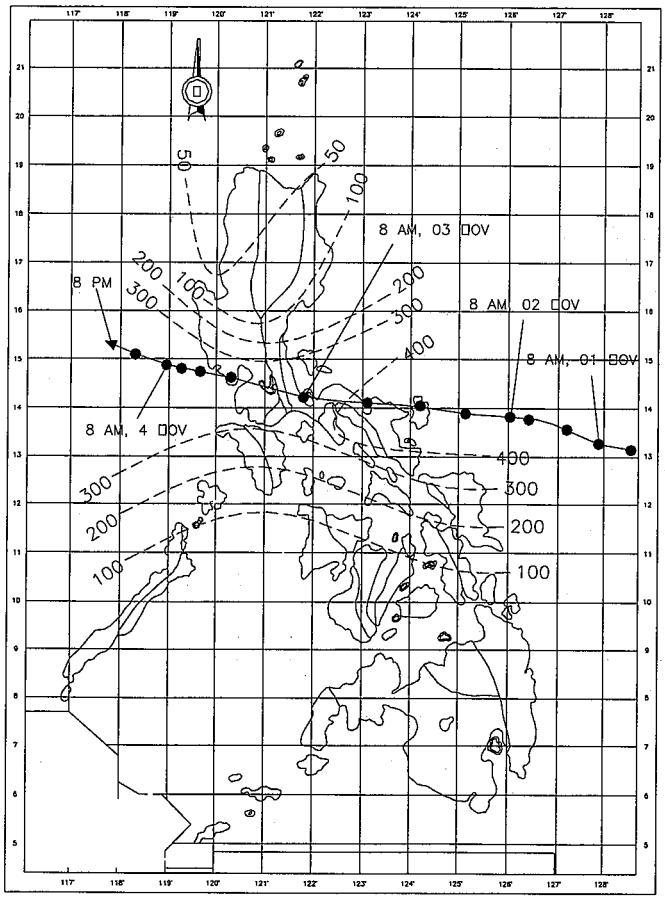
The wind velocity is an important parameter in bridge engineering design, especially for Suspension Bridge, Cable Stay Bridge and extra-dozed bridges. The record of tropical cyclone affecting Metro Manila is shown in **Appendix 2.1-2-6).** In this table, the maximum center wind velocity is 70.8 m/s gust during Typhoon Rosing in 1995.

Appendix 2.1-2-6) Tropical Cyclone Affecting Metro Manila (PAGASA)

	NAME OF TYPHOON	MAX. CENTER WIND (KPH)	MAX. CENTER WIND (M/S)
1	TY Katring 1994 Oct. 18-23	165 / 95 Gust	45.8 / 54.2 Gust
2	TS Mameng 1995 Sept. 27-Oct. 2	95 / 105 Gust	26.4 / 29.2 Gust
3	TY Rosing 1995 Oct. 30-Nov. 4	225 / 255 Gust	62.5 / 70.8 Gust
4	TY Reming 2000 Oct. 25-Nov. 1	130 / 160 Gust	36.6 / 44.4 Gust
5	TY Seniang 2000 Oct. 31-Nov. 5	130 / 160 Gust	36.1 / 44.4 Gust

d) Record of Typhoon Rosing

The track coordinates and intensity for typhoon Rosing in 1995 is shown in **Appendix 2.1.2-7)** and **Appendix 2.1-2-8)** The direction of wind was east to west and the maximum velocity of wind was 225 kph (62.5 m/s).



Appendix 2.1-2-7)

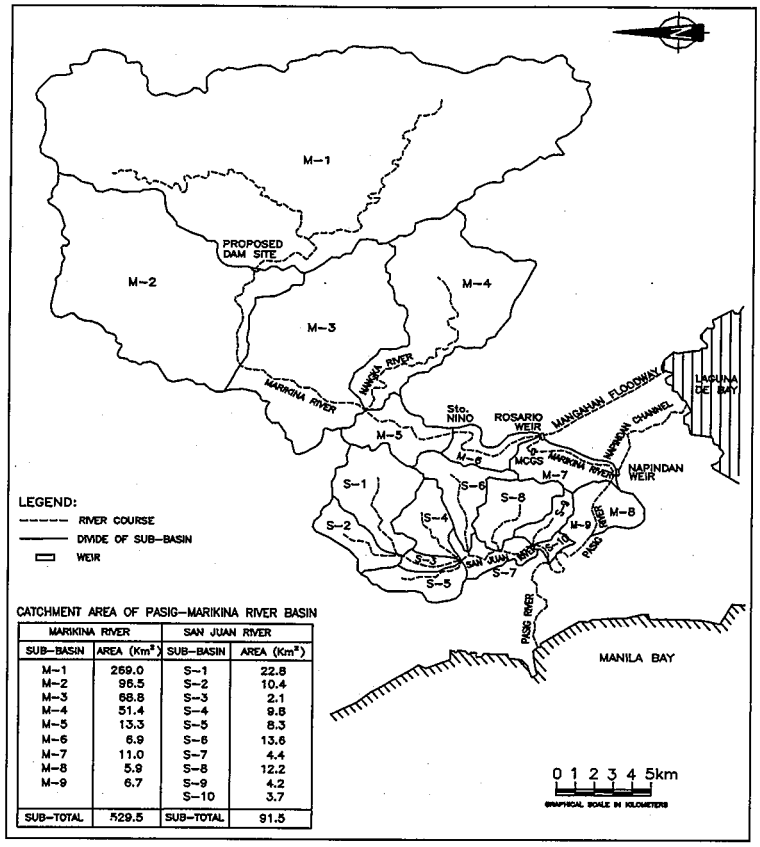
Appendix 2.1-2-8)

T. ROSING { ANGELA { [9520] OCT. 30 - NOV. 4, 1995 (PAGASA)

MO/DAY/HR	STATUS	COORDINATES		INTENSITY	
		LAT	LONG	MSLP (hPa)	MWS (kph)
10301800	TS	11.8	134.8	980.0	110
310000	TY	12.0	133.7	967.0	140
0600	TY	12.3	132.8	967.0	140
1200	TY	12.5	131.4	967.0	140
1800	TY	12.7	130.5	965.0	145
11010000	TY	12.8	129.7	954.0	165
0600	TY	13.3	129.0	946.0	185
1200	TY	14.0	128.2	946.0	185
1800	TY	14.2	126.8	935.0	205
020000	TY	14.2	126.1	935.0	205
0600	TY	14.2	125.1	935.0	205
1200	TY	14.0	124.3	919.0	225
1800	TY	14.2	123.0	938.0	195
030000	TY	14.3	121.8	938.0	195
0600	TY	14.4	120.3	951.0	170
1200	TY	14.6	118.8	951.0	170
1800	TY	14.7	118.0	951.0	170
040000	TY	14.7	117.4	951.0	170
0600	TY	15.0	116.2	951.0	170
1200	TY	15.3	114.9	951.0	170

Typhoon Rosing (1995)

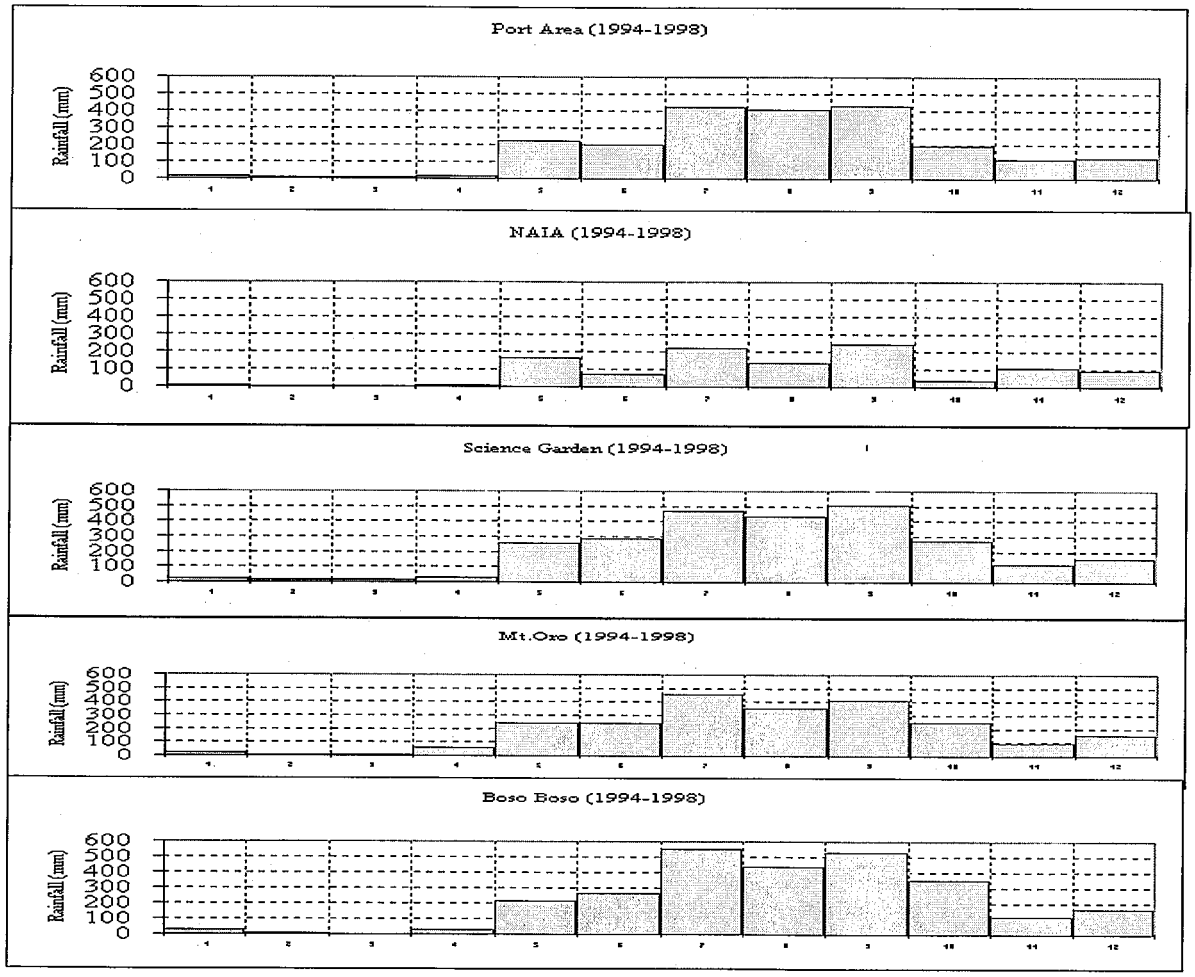
Appendix 2.1.4-1 & 2.1.4-2



CATCHMENT AREA OF PASIG-MARIKINA RIVER BASIN

MARIKINA RIVER		SAN JUAN RIVER	
SUB-BASIN	AREA (Km²)	SUB-BASIN	AREA (Km²)
M-1	269.0	S-1	22.8
M-2	95.5	S-2	10.4
M-3	68.8	S-3	2.1
M-4	51.4	S-4	9.8
M-5	13.3	S-5	8.3
M-6	6.9	S-6	13.6
M-7	11.0	S-7	4.4
M-8	5.9	S-8	12.2
M-9	6.7	S-9	4.2
		S-10	3.7
SUB-TOTAL	529.5	SUB-TOTAL	91.5

Location of Hydrological Gauging Stations

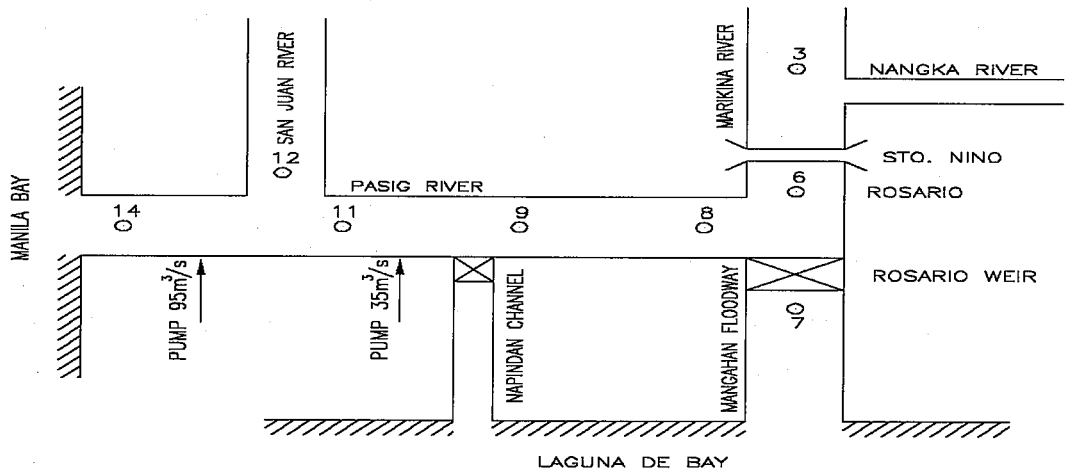


Monthly Rainfall Pattern at 5 Stations for Recent 5 Years

Appendix 2.1.4-3 and 2.1.4-4

Probable Discharge Distribution of Pasig-Marikina River

Point No.	Probable Discharge (m3/s) for Each Return Period							Remarks
	2-year	5-year	10-year	20-year	30-year	50-year	100-year	
(3)	1,270	1,750	2,030	2,370	2,520	2,710	2,980	Before Nangka River
(6)	1,480	2,000	2,320	2,720	2,890	3,070	3,440	Before Diversion
(7)	800	1,170	1,400	1,690	1,810	1,930	2,210	Mangahan = (6)-(8)
(8)	680	830	920	1,030	1,080	1,140	1,230	Into Lower Marikina
(9)	690	840	940	1,050	1,100	1,160	1,260	Before Napindan
(11)	725	885	975	1,095	1,155	1,215	1,315	Including Pump 35m3/s
(12)	490	560	600	660	680	710	750	San Juan River
(14)	910	1,110	1230	1,370	1,430	1,520	1,640	Including Pump 95m3/s



Probable Water Level in Existing River Channel

Bridge Name	Station No.	2-year		5-year		10-year		20-year		30-year		50-year		100-year	
		Q(m3/s)	H (m)	Q(m3/s)	H (m)	Q(m4/s)	H (m)	Q(m5/s)	H (m)	Q(m6/s)	H (m)	Q(m7/s)	H (m)	Q(m8/s)	H (m)
PASIG RIVER															
1 Delpan Bridge	P+0.705 km	950	11.7	1200	11.8	1300	11.9	1400	11.9	1500	12.0	1600	12.0	1700	12.1
2 Jones Bridge	P+1.8km	950	11.8	1200	12.0	1300	12.1	1400	12.2	1500	12.2	1600	12.3	1700	12.4
3 Mac Arthur	P+2.165 km	950	11.9	1200	12.1	1300	12.2	1400	12.3	1500	12.5	1600	12.6	1700	12.7
Bridge															
4 Quezon Bridge	P+2.400 km	950	11.9	1200	12.1	1300	12.2	1400	12.3	1500	12.5	1600	12.6	1700	12.7
5 Ayala Bridge	P+3.092 km	950	12.1	1200	12.4	1300	12.6	1400	12.7	1500	12.8	1600	13.0	1700	13.1
6 Nagtahan	P+5.010 km	950	12.4	1200	12.9	1300	13.0	1400	13.2	1500	13.4	1600	13.5	1700	13.7
Bridge															
7 Pandacan	P+6.320 km	950	12.7	1200	13.2	1300	13.4	1400	13.5	1500	13.7	1600	13.9	1700	14.1
Bridge															
8 Lambingan	P+9.950 km	750	13.3	900	13.9	1000	14.1	1100	14.4	1200	14.6	1300	14.9	1400	15.1
Bridge															
9 Makati-	P+12.776 km	750	13.6	900	14.2	1000	14.5	1100	14.8	1200	15.0	1300	15.3	1400	15.6
Mandaluyong															
10 Guadalupe	P+14.400 km	750	13.9	900	14.6	1000	14.9	1100	15.2	1200	15.5	1300	15.8	1400	16.1
Bridge															
11 C-5 Bridge	P+16.850 km	750	14.2	900	14.9	1000	15.3	1100	15.6	1200	15.9	1300	16.3	1400	16.6
MARIKINA RIVER															
12 Vargas Bridge	M+1.263 km	700	14.4	850	15.1	950	15.4	1100	15.8	1100	16.1	1200	16.5	1300	16.8
13 Rosario Bridge	M+4.230 km	700	15.2	850	15.8	950	16.2	1100	16.6	1100	16.8	1200	17.1	1300	17.5
14 Marcos Bridge	M+10.130 km	1500	17.6	2000	18.5	2400	19.1	2800	19.7	2900	19.8	3100	20.2	3500	20.7
15 Marikina Bridge	M+13.108 km	1500	19.2	2000	20.2	2400	20.9	2800	21.5	2900	21.7	3100	21.9	3500	22.5
16 Quezon Bridge	P+2.400 km	1122	17.8	1453	18.8	1740	19.4	2051	20.0	2105	20.2	2267	20.6	2554	21.2