Chapter 9. Urban Conditions

CHAPTER 9. URBAN CONDITIONS

9.1 Buildings

1) Characteristics of NSO data, Distribution of Residential Buildings

(1) General

In order to estimate building damage against earthquake occurrence, detailed information on each building is indispensable. Therefore, the Study Team visited relevant organizations to find the best resources for the Study. Fortunately, the “2000 Census of Population and Housing” was implemented by National Statistics Office (hereinafter referred to as “NSO”) and results will be published soon. Therefore, the Study Team officially requested to receive the data in a form that could be converted to building units, since the original data is in the form of each dwelling unit. Because damage estimation of buildings is calculated for each building, the Study Team requested to include building serial number in the data.

The Study Team received data in early January 2003 consisting of various information, such as 1) Number of Households, 2) Number of Habitants, 3) Type of Building, 4) Construction Materials of the Outer Wall, and 5) Construction Year.

In general, for the damage estimation of buildings, the fundamental information is: 1) Structure, 2) Construction Year, and 3) Number of Story. However, from the Census, number of story information cannot be gathered. The Study Team will consider how to assume this information in the later stage, or how to make the fragility function of the buildings without the number of story information.

Table 9.1.1 shows the general information on buildings by district. According to the Census 2000, total number of buildings in Metropolitan Manila is counted as 1,325,896 buildings and its building density is 22 buildings/hectare.

Figure 9.1.1 shows building distribution by Barangay and Figure 9.1.2 shows Building density distribution by Barangay. In detail, Quezon City has the largest number of buildings in Metropolitan Manila, counted as 302,818. However, area of Quezon City is rather large compared to other cities in Metropolitan Manila and its building density is 18 buildings /ha, which is less than average.

Pateros and Manila have the largest building density at 45 buildings/ha and 41 buldings/ha respectively. On the contrary, Valenzuela City, Muntinlupa City, Makati City, and Paranaque City have the lowest building density at 14 buildings/ha, 15 buildings/ha, 16 buildings/ha, and 16 buildings/ha respectively. However, this argument is focused on LGU level, therefore, in Barangay level, more detailed special characteristics can be found.

Table 9.1.1 General Information on Building by LGU

LGU Name	Area (ha)	Total No. of Building	Building Density (buildings/ha)	Total No. of Household	Total No. of Habitant	Total Floor Area (m2)
Manila	4,130	168,528	41	333,546	1,569,581	11,475,903
Mandaluyong City	1,107	32,942	30	59,681	275,106	2,149,173
Marikina City	2,265	53,422	24	80,159	389,758	4,217,033
Pasig City	3,189	72,143	23	107,834	503,674	4,856,306
Quezon City	16,539	302,818	18	480,623	2,166,314	22,194,266
San Juan	588	11,793	20	24,604	117,392	1,253,073
Kalookan City	5,314	168,480	32	249,566	1,174,669	9,116,205
Malabon	1,597	51,694	32	74,136	336,511	2,498,690
Navotas	1,095	35,124	32	49,449	229,710	1,537,689
Valenzuela City	4,454	62,778	14	106,381	481,039	3,866,230
Las Pinas City	3,228	73,919	23	97,961	471,764	5,600,672
Makati City	3,197	50,381	16	103,980	470,304	5,031,045
Muntinlupa City	3,814	55,522	15	78,015	370,329	3,398,054
Paranaque City	4,563	72,230	16	94,108	447,901	6,084,705
Pasay City	1,779	39,968	22	78,179	354,011	2,597,026
Pateros	195	8,726	45	12,028	57,389	470,536
Taguig	2,753	65,428	24	102,722	464,552	3,825,264
MM: Total	59,809	1,325,896	22	2,132,972	9,880,004	90,171,870

Source: NSO, 2002

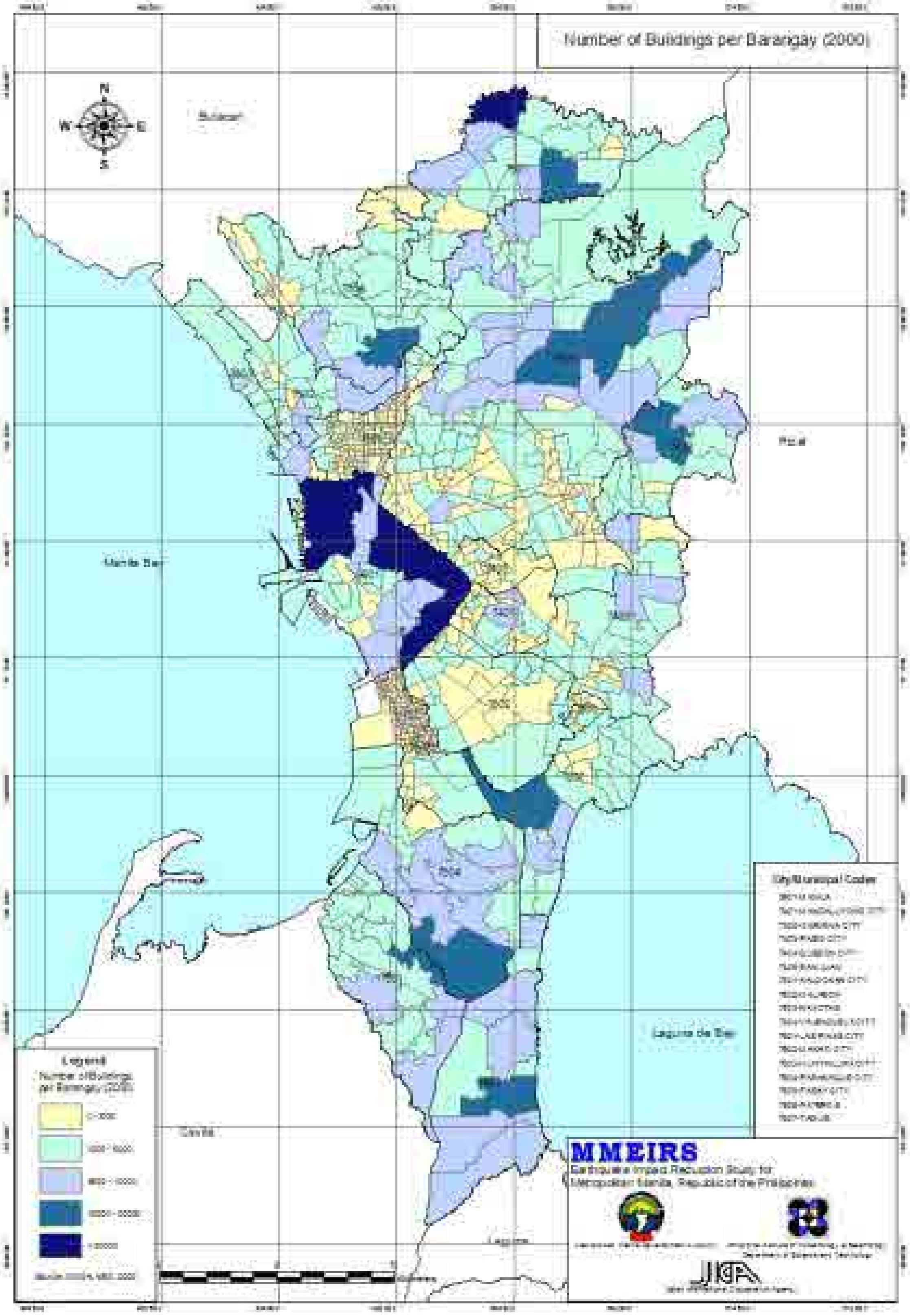


Figure 9.1.1 Number of Buildings per Barangay

Figure 9.1.2 Building Density per Barangay

(2) Building Type

In the Census 2000, type of building is indicated to identify scale of building. Type of building is classified into 6 categories, 1) Single House, 2) Duplex, 3) Multi-Unit Residential (3 or more units), 4) Commercial/Industrial/Agricultural, 5) Institutional living quarters, and 6) Other housing units. The definition of each category is shown in Table 9.1.2.

Table 9.1.2 Definition of Building Type

No.	Type of Building	Definition
1	Single House	This is an independent structure intended for one household separated by an open space or walls from all other structures.
2	Duplex	This is a structure intended for two households, with complete living facilities for each. It is divided vertically or horizontally into two separate housing units, which are usually identical.
3	Multi-Unit Residential (3 or more units)	This is a building intended for residential use only, consisting of 3 or more housing units.
4	Commercial/Industrial/Agricultural	These buildings are not intended mainly for human habitation but used as living quarters of households at the time of the pilot census.
5	Institutional living quarters	hotel, lodging house, dormitory, hospital, convent, school, penal institution, refugee camp, military camp, etc.
6	Other housing units	This refers to living quarters which are not intended for human habitation nor located in permanent buildings but which are nevertheless, used as living quarters at the time of the pilot census.

Source: NSO, Census 2000

Since Census 2000 does not include number of story information, this building type can be used to identify scale of building to estimate building story. For instance, Single house and Duplex can be a one or two story buildings and Multi-Unit Residential can be considered as rather high story buildings. However, it has been cleared that this type of building are not correctly answered at the time of survey. Table 9.1.3 shows counts of households in each category of building type. As indicated in the definition of building type, Single houses are occupied by one household which should be only available in “1” in the table (74,559 households). However, sometimes there are more than 2 households existing in this category. Likewise, duplex should have only “2 households”. However, these are sometimes occupied by only 1 household or more than 3 households. Therefore, this information cannot be used to assume building story, unfortunately.

Table 9.1.3 Number of Household by Type of Building

LGU	Type	1	2	3	4	5-10	11-20	21-50	51-100	101-200	200-
MANILA	Single house	74,559	14,860	6,307	3,098	3,661	253	38	4	3	0
MANILA	Duplex	6,263	3,910	1,000	416	461	31	9	1	0	0
MANILA	Multi-unit residential	21,374	7,189	6,464	4,024	6,220	795	248	63	21	3
MANILA	Commercial/industrial/Agricultural	1,013	190	96	52	109	28	15	2	0	0
MANILA	Others	5,132	335	104	62	96	10	9	0	0	0

Source: NSO, Census 2000

Table 9.1.4 Building Type Distribution by District

	No of Buildings								Percentage (%)						
LGU Name	1	2	3	4	5	6	9	LGU: Total	1	2	3	4	5	6	9
Manila	102,783	12,091	46,401	1,505	153	1,547	4,048	168,528	61.0	7.2	27.5	0.9	0.1	0.9	2.4
Mandaluyong City	21,215	2,493	8,487	157	18	40	532	32,942	64.4	7.6	25.8	0.5	0.1	0.1	1.6
Marikina City	41,370	4,204	6,456	206	21	180	985	53,422	77.4	7.9	12.1	0.4	0.0	0.3	1.8
Pasig City	53,956	6,398	10,115	245	15	38	1,376	72,143	74.8	8.9	14.0	0.3	0.0	0.1	1.9
Quezon City	207,345	24,364	60,574	1,535	201	1,709	7,090	302,818	68.5	8.0	20.0	0.5	0.1	0.6	2.3
San Juan	6,322	718	4,189	122	8	65	369	11,793	53.6	6.1	35.5	1.0	0.1	0.6	3.1
Kalookan City	122,133	14,662	26,441	1,023	66	269	3,886	168,480	72.5	8.7	15.7	0.6	0.0	0.2	2.3
Malabon	38,183	5,072	6,945	295	26	76	1,097	51,694	73.9	9.8	13.4	0.6	0.1	0.1	2.1
Navotas	28,084	2,564	3,483	179	10	102	702	35,124	80.0	7.3	9.9	0.5	0.0	0.3	2.0
Valenzuela City	41,040	6,971	13,044	485	32	81	1,125	62,778	65.4	11.1	20.8	0.8	0.1	0.1	1.8
Las Pinas City	60,904	4,097	6,784	265	26	127	1,716	73,919	82.4	5.5	9.2	0.4	0.0	0.2	2.3
Makati City	29,652	4,838	14,251	271	37	247	1,085	50,381	58.9	9.6	28.3	0.5	0.1	0.5	2.2
Muntinlupa City	41,781	5,190	7,385	97	17	40	1,012	55,522	75.3	9.3	13.3	0.2	0.0	0.1	1.8
Paranaque City	58,310	4,950	7,097	275	26	139	1,433	72,230	80.7	6.9	9.8	0.4	0.0	0.2	2.0
Pasay City	25,607	3,097	10,035	275	39	231	684	39,968	64.1	7.7	25.1	0.7	0.1	0.6	1.7
Pateros	6,624	859	1,016	30		14	183	8,726	75.9	9.8	11.6	0.3	0.0	0.2	2.1
Taguig	48,312	7,012	8,975	148	19	28	934	65,428	73.8	10.7	13.7	0.2	0.0	0.0	1.4
MM: Total	933,621	109,580	241,678	7,113	714	4,933	28,257	1,325,896	70.4	8.3	18.2	0.5	0.1	0.4	2.1

Source: NSO, Census 2000

Note: 1. Single house, 2.Duplex, 3.Multi-unit residential (three units or more), 4.Commercial/industrial/agricultural (office, factory, rice mill, etc.), 5.institutional living quarters (hotel, hospital, etc.), 6.Other housing unit (boat, cave, etc.), 9.Not Reported

(3) Outer Wall Material

In Census 2000, Building Outer Wall Material is classified into 10 types, 1) Concrete/brick/stone, 2)Wood, 3) Half concrete/brick/stone/ and half wood, 4) Galvanized iron/aluminum, 5) Bamboo/sawali/cogon/nipa, 6) Asbestos, 7) Glass, 8) Makeshift/salvaged/improvised materials, 9) Others, and 10) No walls. This information is used to identify type of structure of each building.

Table 9.1.5 shows building outer wall material distribution in each LGU. As a whole for Metropolitan Manila, 44.4 % of buildings are constructed with Concrete/brick/stone, 30.1% Half concrete/brick/stone/ and half wood, and 18.6% Wood. Those three types of structure occupies 93.1% of buildings existing in Metropolitan Manila.

Focusing on each LGU, buildings in Marikina City, Kalookan City, Valenzuela City, Las Pinas City, Taguig are mostly constructed with Concrete/brick/stone, which comprises 56.2%, 53.5%, 54.6%, 53.5%, and 54.3 respectively. For the buildings constructed with Wood, these are remarkably distributed in Malabon and Navotas, which occupies 32.4%, and 36.2 respectively. However, most of LGU have more than 15% of buildings constructed with Wood. In addition, buildings in Manila, Mandaluyong City, and Pasay City are constructed with Half concrete/brick/stone/ and half wood, which comprises 41.7%, 45.4%, and 39.1% respectively.

In Barangay level, characteristics of building distribution by structure is different. Therefore, data were prepared in Barangay level as well and these data are attached in the end of this report. To understand the distribution visually, several GIS maps are prepared. Figure 9.1.3 illustrates Concrete/brick/stone Structure Distribution by Barangay, Figure 9.1.4 illustrates Wood Structure Distribution by Barangay, and Figure 9.1.5 illustrates Half concrete/brick/stone/ and half wood Structure Distribution by Barangay.

Table 9.1.5 Building Outer Wall Material Distribution by LGU

	No of Buildings											
LGU	1	2	3	4	5	6	7	8	9	10	99	LGU: Total
Manila	45,489	42,013	70,319	1,193	84	55	59	3,828	89	245	5,154	168,528
Mandaluyong City	9,796	6,449	14,947	282	24	19	16	599	4	17	789	32,942
Marikina City	30,015	6,795	13,276	683	64	23	42	876	18	62	1,568	53,422
Pasig City	32,391	16,422	19,387	381	112	37	40	1,139	14	128	2,092	72,143
Quezon City	141,864	42,181	94,089	3,676	594	162	204	9,024	122	497	10,405	302,818
San Juan	4,340	2,670	4,002	79	4	3	3	88	6	15	583	11,793
Kalookan City	90,085	20,961	45,754	1,721	670	99	60	3,406	183	240	5,301	168,480
Malabon	16,324	16,729	15,889	411	64	17	31	595	5	78	1,551	51,694
Navotas	9,295	12,718	10,979	210	55	13	13	769	34	56	982	35,124
Valenzuela City	34,307	9,672	15,567	448	109	30	40	1,067	24	102	1,412	62,778
Las Pinas City	39,558	14,425	13,151	374	356	13	49	3,397	18	81	2,497	73,919
Makati City	23,825	7,497	15,370	276	34	10	34	1,746	32	142	1,415	50,381
Muntinlupa City	25,552	10,765	14,783	649	398	18	49	1,593	22	66	1,627	55,522
Paranaque City	33,669	15,763	17,740	597	140	27	76	1,730	9	87	2,392	72,230
Pasay City	13,324	8,516	15,645	302	15	8	26	1,098	37	64	933	39,968
Pateros	3,670	1,866	2,676	52	5	1	2	152	0	6	296	8,726
Taguig	35,552	10,886	14,893	751	237	21	31	1,443	12	80	1,522	65,428
MM: Total	589,056	246,328	398,467	12,085	2,965	556	775	32,550	629	1,966	40,519	1,325,896
	Percentage (%)											
LGU	1	2	3	4	5	6	7	8	9	10	99	LGU: Total
Manila	27.0	24.9	41.7	0.7	0.0	0.0	0.0	2.3	0.1	0.1	3.1	100
Mandaluyong City	29.7	19.6	45.4	0.9	0.1	0.1	0.0	1.8	0.0	0.1	2.4	100
Marikina City	56.2	12.7	24.9	1.3	0.1	0.0	0.1	1.6	0.0	0.1	2.9	100
Pasig City	44.9	22.8	26.9	0.5	0.2	0.1	0.1	1.6	0.0	0.2	2.9	100
Quezon City	46.8	13.9	31.1	1.2	0.2	0.1	0.1	3.0	0.0	0.2	3.4	100
San Juan	36.8	22.6	33.9	0.7	0.0	0.0	0.0	0.7	0.1	0.1	4.9	100
Kalookan City	53.5	12.4	27.2	1.0	0.4	0.1	0.0	2.0	0.1	0.1	3.1	100
Malabon	31.6	32.4	30.7	0.8	0.1	0.0	0.1	1.2	0.0	0.2	3.0	100
Navotas	26.5	36.2	31.3	0.6	0.2	0.0	0.0	2.2	0.1	0.2	2.8	100
Valenzuela City	54.6	15.4	24.8	0.7	0.2	0.0	0.1	1.7	0.0	0.2	2.2	100
Las Pinas City	53.5	19.5	17.8	0.5	0.5	0.0	0.1	4.6	0.0	0.1	3.4	100
Makati City	47.3	14.9	30.5	0.5	0.1	0.0	0.1	3.5	0.1	0.3	2.8	100
Muntinlupa City	46.0	19.4	26.6	1.2	0.7	0.0	0.1	2.9	0.0	0.1	2.9	100
Paranaque City	46.6	21.8	24.6	0.8	0.2	0.0	0.1	2.4	0.0	0.1	3.3	100
Pasay City	33.3	21.3	39.1	0.8	0.0	0.0	0.1	2.7	0.1	0.2	2.3	100
Pateros	42.1	21.4	30.7	0.6	0.1	0.0	0.0	1.7	0.0	0.1	3.4	100
Taguig	54.3	16.6	22.8	1.1	0.4	0.0	0.0	2.2	0.0	0.1	2.3	100
MM: Total	44.4	18.6	30.1	0.9	0.2	0.0	0.1	2.5	0.0	0.1	3.1	100

Source: NSO, Census 2000

Note: 1. Concrete/brick/stone, 2.Wood, 3.Half concrete/brick/stone/and half wood, 4.Galvanized iron/aluminum, 5.Bamboo/sawali/cogon/nipa, 6.Asbestos, 7.Glass, 8.Makeshift/salvaged/improvised materials, 9.Others, 10.No walls, 99.Not Reported

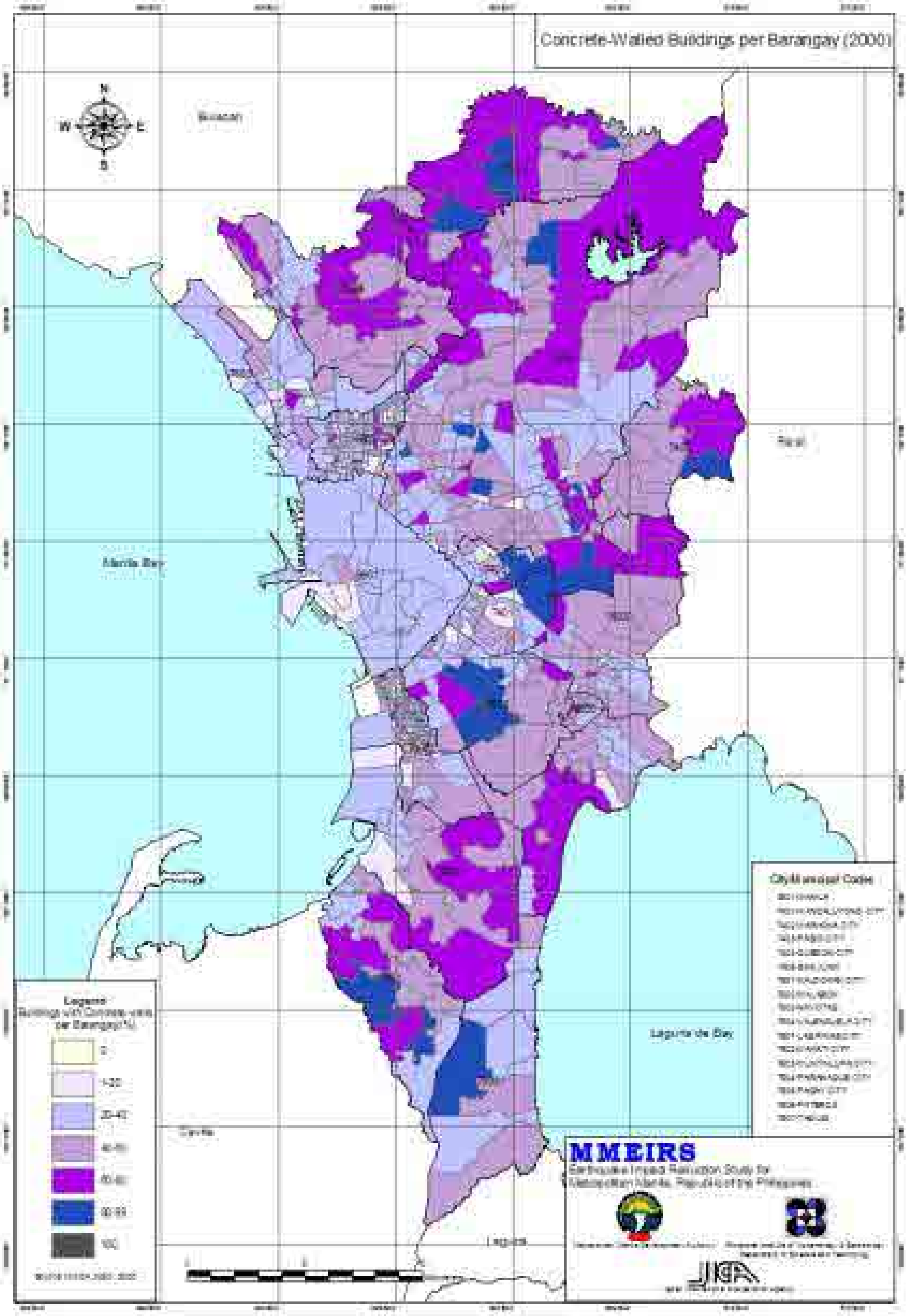


Figure 9.1.3 Concrete-Walled Buildings per Barangay (2000)

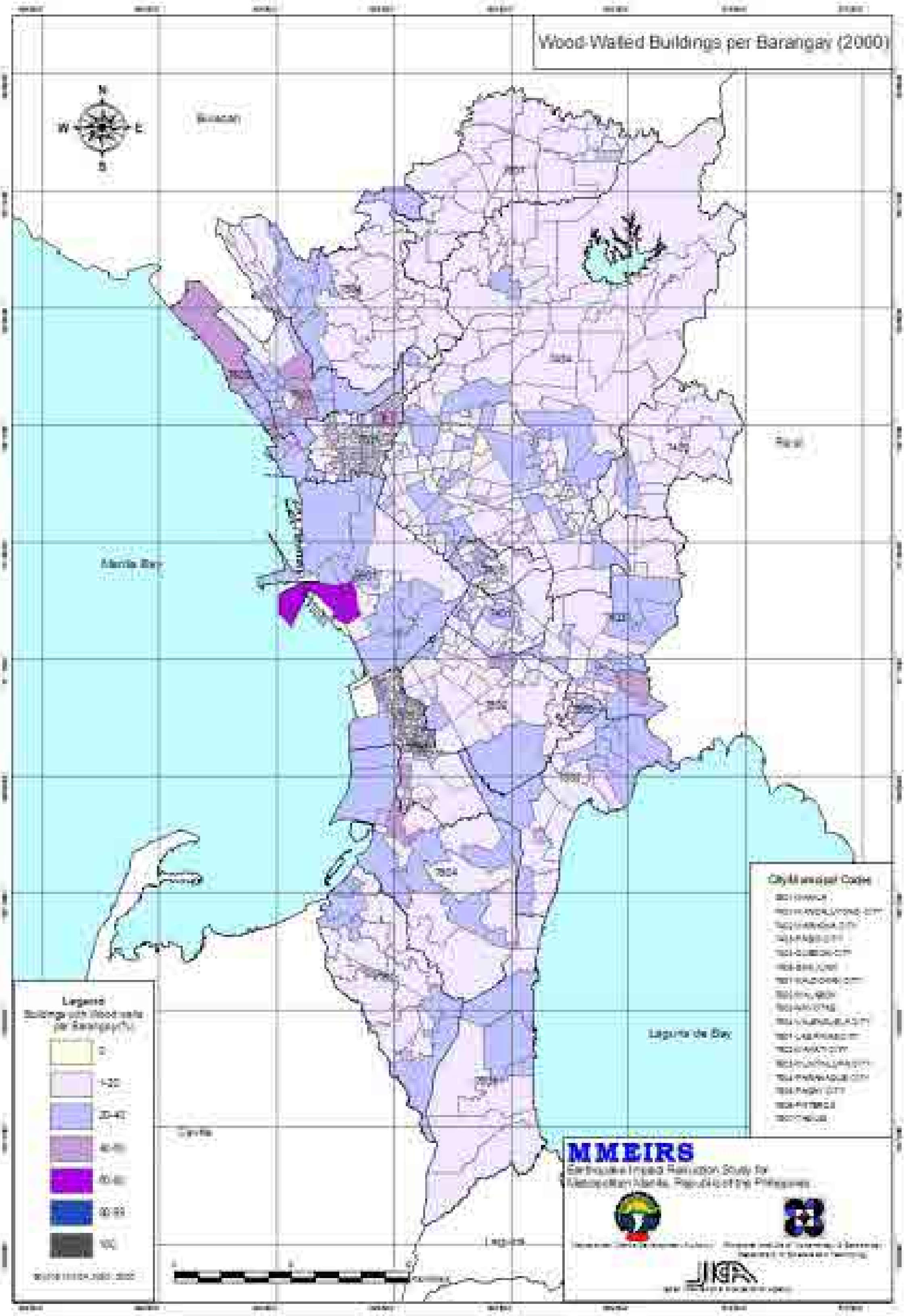


Figure 9.1.4 Wood-Walled Buildings per Barangay (2000)

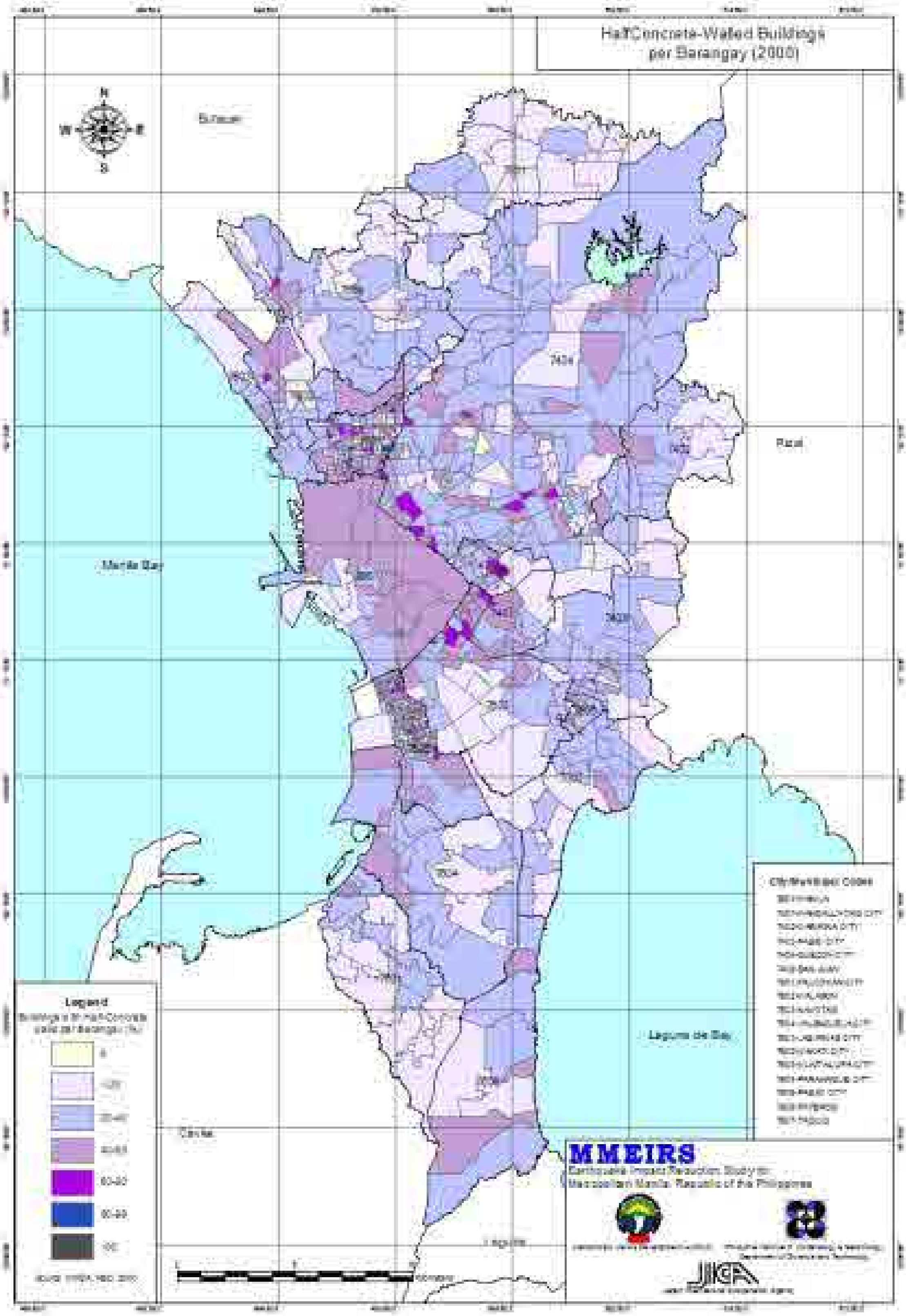


Figure 9.1.5 Half Concrete-Walled Buildings per Barangay (2000)

(4) Construction Year

In Census 2000, Construction Year is divided into 10 categories, 1) 2000, 2) 1999, 3) 1998, 4) 1997, 5) 1996, 6) 1991-1995, 7) 1981-1990, 8) 1971-1980, 9) 1961-1970, and 10) 1960 and earlier. From the original data, to understand urban development pattern clearly, data have been re-categorized into 5 categories, 1) 1960 and earlier, 2) 1961-1970, 3) 1971-1980, 4) 1981-1990, and 5) 1991-2000. Table 9.1.6 is a summarized table of construction year distribution by LGU.

Table 9.1.6 Building Construction Year Distribution by LGU

	No of Buildings							Percentage (%)					
LGU Name	1	2	3	4	5	6	LGU: Total	1	2	3	4	5	6
Manila	32,651	20,061	25,156	33,269	32,507	24,884	168,528	19.4	11.9	14.9	19.7	19.3	14.8
Mandaluyong City	2,959	3,471	5,175	7,627	9,809	3,901	32,942	9.0	10.5	15.7	23.2	29.8	11.8
Marikina City	2,632	4,249	8,562	15,065	18,314	4,600	53,422	4.9	8.0	16.0	28.2	34.3	8.6
Pasig City	3,147	4,700	10,290	18,756	27,283	7,967	72,143	4.4	6.5	14.3	26.0	37.8	11.0
Quezon City	15,709	18,636	41,915	82,085	109,616	34,857	302,818	5.2	6.2	13.8	27.1	36.2	11.5
San Juan	2,672	1,652	1,642	1,659	1,931	2,237	11,793	22.7	14.0	13.9	14.1	16.4	19.0
Kalookan City	7,702	8,356	14,865	51,013	71,864	14,680	168,480	4.6	5.0	8.8	30.3	42.7	8.7
Malabon	4,162	4,713	8,260	13,960	15,119	5,480	51,694	8.1	9.1	16.0	27.0	29.2	10.6
Navotas	2,726	2,317	6,326	9,995	11,293	2,467	35,124	7.8	6.6	18.0	28.5	32.2	7.0
Valenzuela City	2,290	3,703	8,920	16,880	23,176	7,809	62,778	3.6	5.9	14.2	26.9	36.9	12.4
Las Pinas City	1,072	2,852	11,451	23,351	29,925	5,268	73,919	1.5	3.9	15.5	31.6	40.5	7.1
Makati City	5,764	6,070	7,235	11,813	12,406	7,093	50,381	11.4	12.0	14.4	23.4	24.6	14.1
Muntinlupa City	1,506	2,485	8,290	18,522	19,979	4,740	55,522	2.7	4.5	14.9	33.4	36.0	8.5
Paranaque City	2,935	3,522	9,242	21,432	28,051	7,048	72,230	4.1	4.9	12.8	29.7	38.8	9.8
Pasay City	4,693	4,567	7,114	9,894	8,089	5,611	39,968	11.7	11.4	17.8	24.8	20.2	14.0
Pateros	912	1,124	1,756	2,071	2,242	621	8,726	10.5	12.9	20.1	23.7	25.7	7.1
Taguig	1,485	2,193	7,855	19,439	29,508	4,948	65,428	2.3	3.4	12.0	29.7	45.1	7.6
MM: Total	95,017	94,671	184,054	356,831	451,112	144,211	1,325,896	7.2	7.1	13.9	26.9	34.0	10.9

Source: NSO, Census 2000

Note: 1. 1960 or earlier, 2.1961-1970, 3.1971-1980, 4.1981-1990, 5.1991-2000, 6. Unknown

According to the original data, up to Year 1960, number of buildings in Metropolitan Manila was only 95,017 (7.2% of total number of buildings in year 2000). Development in Metropolitan Manila rapidly increased from 1980's. Old town like City of Manila is almost equally developed and even from 1981-1990, new construction increased only to 19.3%. Other LGU constructed more than 30% of the buildings in this decade, except for San Juan, Makati City, Pasay, and Pateros. However, Makati City mostly constructed high-rise buildings. Therefore, from the statistical table, this trend cannot be observed clearly.

In this study, construction year data is used to visualize the urban development pattern in Metropolitan Manila (Figure 9.1.6 to Figure 9.1.10). These figures clearly show the urban development trend in Metropolitan Manila in each Barangay. Data table for each Barangay is attached in the last part of this report.

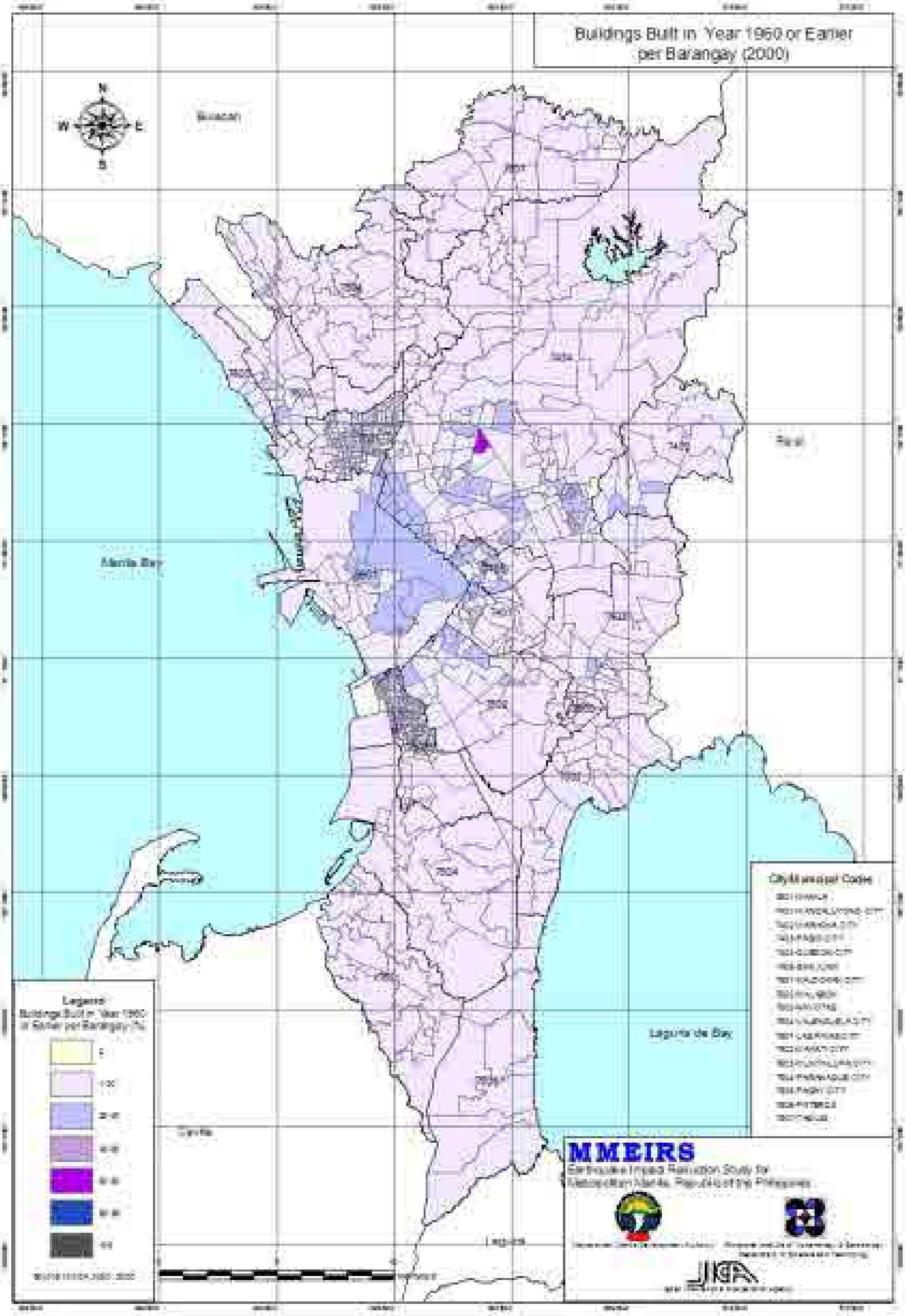


Figure 9.1.6 Buildings Built in Year 1960 or Earlier per Barangay (2000)

Figure 9.1.7 Building Built in Year 1961-1970 per Barangay (2000)

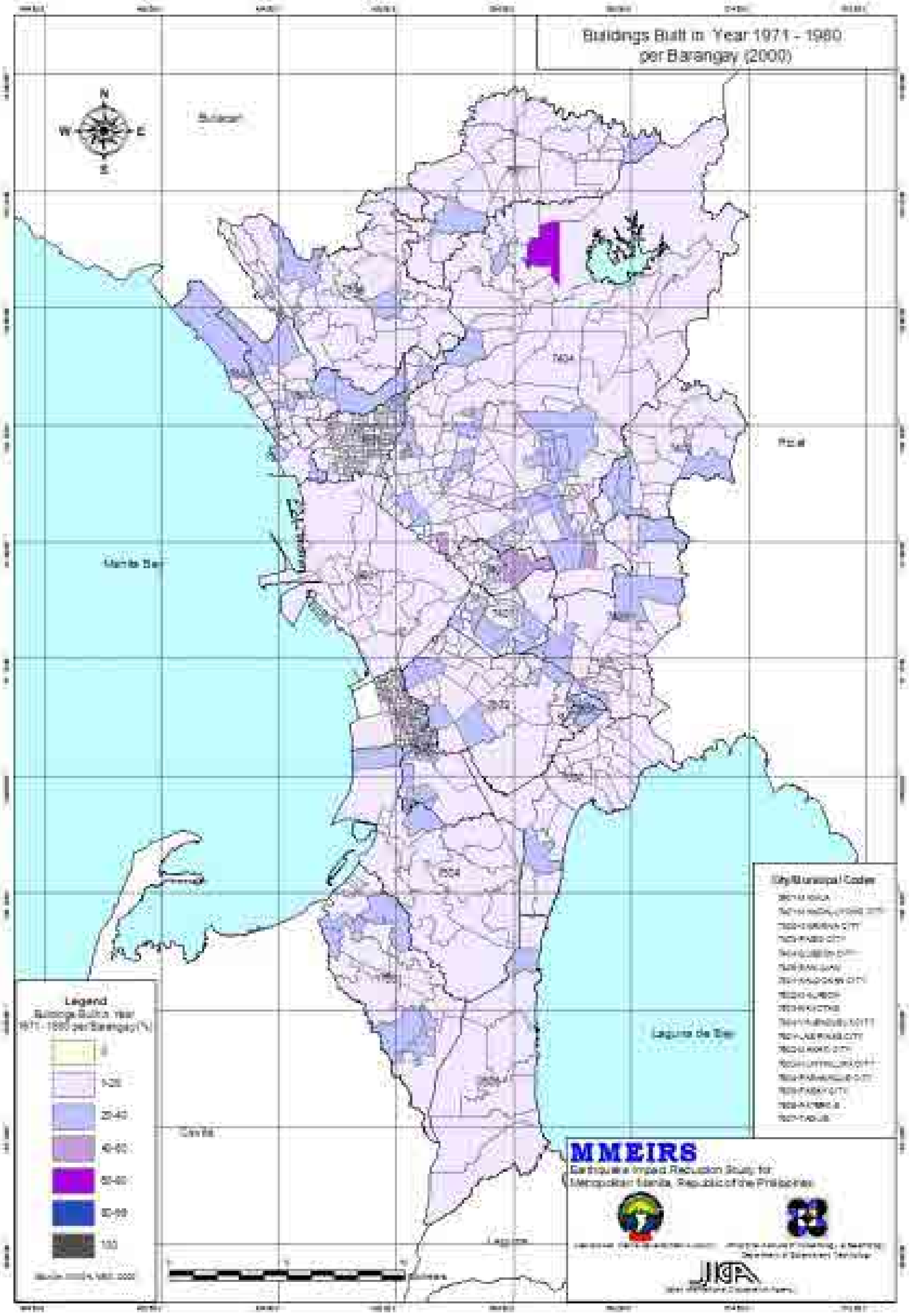


Figure 9.1.8 Building Built in Year 1971 – 1980 per Barangay (2000)

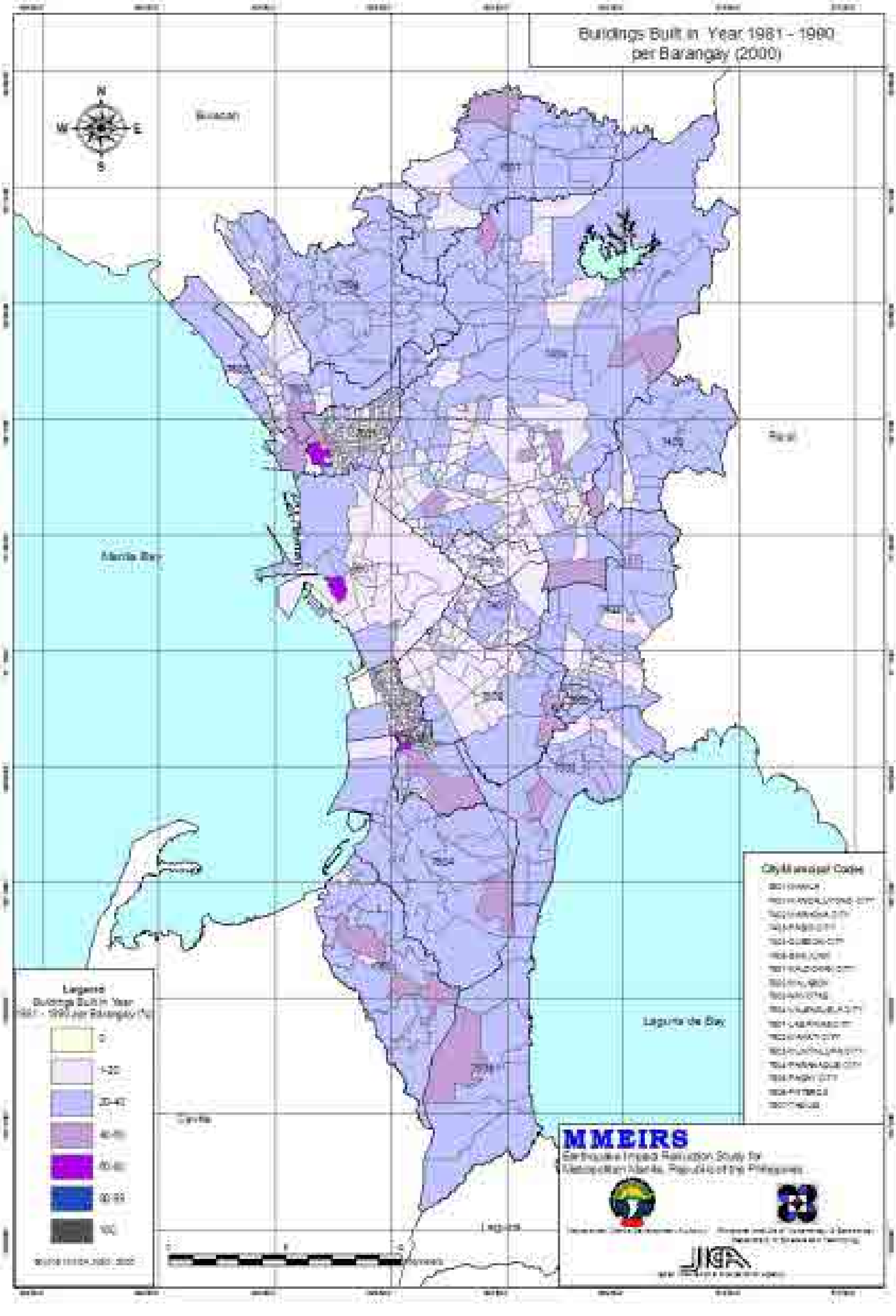


Figure 9.1.9 Building Built in Year 1981 – 1990 per Barangay (2000)

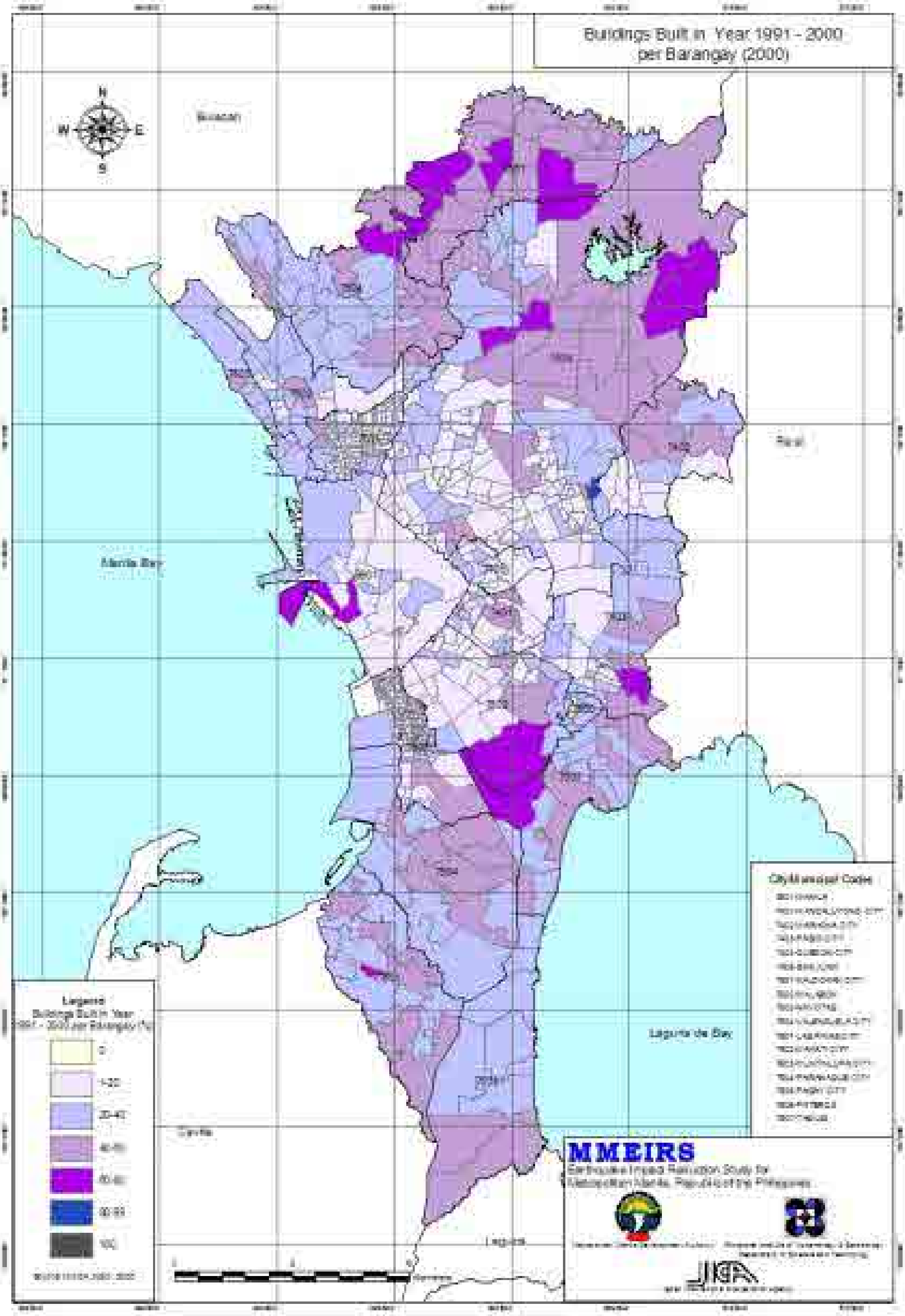


Figure 9.1.10 Building Built in Year 1991 – 2000 per Barangay (2000)

2) Distribution of Mid-rise and High-rise Buildings

The Study Team identified locations and heights of each building, with height over 12m, using the aerophoto taken in 2003. These include commercial and residential buildings. Table 9.1.7 shows the summary of mid-rise and high-rise buildings in Metropolitan Manila.

Table 9.1.7 Mid-rise and High-rise Buildings in Metropolitan Manila

Number of Stories	Building Count
10-30 Stories	981
Over 30 Stories	119

3) Distribution of Major Public Facility Buildings

Public and governmental facility buildings examined in the Study are described here and shown in Table 9.1.8. Data source are shown in the table. Number of facilities in each LGU is summarized in Table 9.1.8 to Table 9.1.12. Location maps are shown in Figure 9.1.11 to Figure 9.1.15.

Table 9.1.8 Contents of Public and Governmental Facility Buildings

Type	Data	Data Source (year)
Police Station	Location of Police Regional,District HQ & Stations Police Districts in Metropolitan Manila	ROD, NCRPO (2003)
Fire Fighting Station	Location of Fire District HQ, Stations & Substations Fire Districts in Metropolitan Manila Location of Fire Hydrants in Metropolitan Manila	BFP (2003)
Hospitals	Location of Hospitals Hospital Districts	DOH (2003)
Public schools Private Schools	Location of Public Elementary and High Schools Location of Private Elementary and High Schools Department of Education Divisions Location of Higher Educational Institutions	DepED(2003) CHED(2003)
17 LGU City and Municipality Hall MMDCC organizing Department and Agencies	Building Location	The Study Team (2003)

Table 9.1.9 Police Stations in Metropolitan Manila

LGU Code	LGU	No. of Police Stations			
		Stations	District HQ	Regional HQ	Total
390	Manila	11	1	0	12
741	Mandaluyong	1	0	0	1
742	Marikina	1	0	0	1
743	Pasig	1	1	0	2
744	Quezon	11	1	0	12
745	San Juan	1	0	0	1
751	Valenzuela	1	0	0	1
752	Kalookan	1	1	0	2
753	Malabon	1	0	0	1
754	Navotas	1	0	0	1
761	Las Pinas	1	0	0	1
762	Makati	1	1	0	2
763	Muntinlupa	1	0	0	1
764	Paranaque	1	0	0	1
765	Pasay	1	0	0	1
766	Pateros	1	0	0	1
767	Taguig	1	0	1	2
Total		37	5	1	43

Table 9.1.10 Fire Stations in Metropolitan Manila

LGU Code	LGU	No. of Fire Station			
		Head Quarter	Station	Sub - station	Total
390	Manila	1	1	13	15
741	Mandaluyong	0	1	2	3
742	Marikina	0	1	6	7
743	Pasig	1	1	9	11
744	Quezon	1	0	17	18
745	San Juan	0	1	1	2
751	Valenzuela	0	1	6	7
752	Kalookan	0	1	10	11
753	Malabon	0	1	3	4
754	Navotas	0	1	6	7
761	Las Pinas	0	1	8	9
762	Makati	1	0	10	11
763	Muntinlupa	0	1	3	4
764	Paranaque	0	1	6	7
765	Pasay	0	1	2	3
766	Pateros	0	1	0	1
767	Taguig	0	1	3	4
Total		4	15	105	124

Table 9.1.11 Hospitals in Metropolitan Manila

LGU Code	LGU	No. of Hospitals			
		Primary	Secondary	Tertiary	Total
390	Manila	1	11	20	32
741	Mandaluyong	0	2	3	5
742	Marikina	0	5	1	6
743	Pasig	4	6	4	14
744	Quezon	12	12	25	49
745	San Juan	0	1	2	3
751	Valenzuela	4	3	1	8
752	Kalookan	6	7	2	15
753	Malabon	3	1	0	4
754	Navotas	1	0	0	1
761	Las Pinas	2	5	3	10
762	Makati	1	1	4	6
763	Muntinlupa	2	3	3	8
764	Paranaque	0	4	1	5
765	Pasay	3	1	4	8
766	Pateros	0	0	0	0
767	Taguig	1	2	0	3
Total		40	64	73	177

Table 9.1.12 Schools in Metropolitan Manila

LGU Code	LGU	No. of Public Schools				No. of Private Schools		
		Elementary School	High School	CHED	Total	All Category	CHED	Total
390	Manila	71	31	7	109	81	67	148
741	Mandaluyong	15	5	1	21	10	4	14
742	Marikina	18	8	1	27	19	6	25
743	Pasig	27	10	1	38	39	7	46
744	Quezon	98	42	3	143	82	61	143
745	San Juan	9	1	0	10	13	7	20
751	Valenzuela	36	11	0	47	27	7	34
752	Kalookan	50	23	1	74	23	19	42
753	Malabon	28	6	1	35	20	1	21
754	Navotas	15	6	1	22	6	1	7
761	Las Pinas	20	6	1	27	32	8	40
762	Makati	30	7	2	39	21	16	37
763	Muntinlupa	17	4	1	22	27	7	34
764	Paranaque	20	6	0	26	38	5	43
765	Pasay	19	8	3	30	17	11	28
766	Pateros	6	2	0	8	3	0	3
767	Taguig	22	6	2	30	15	2	17
Total		501	182	25	708	473	229	702

Figure 9.1.11 Location Map of Police Station

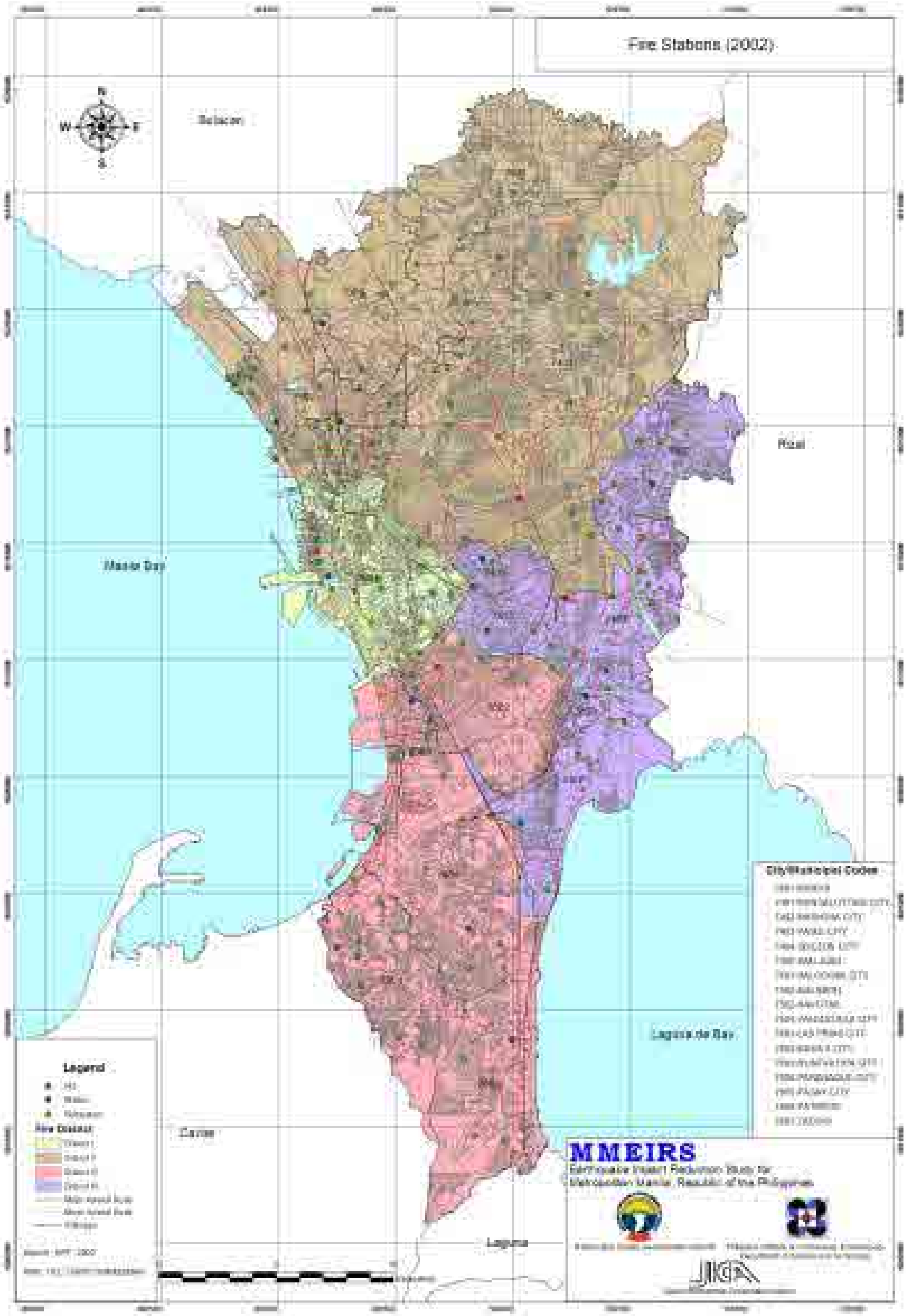


Figure 9.1.12 Location Map of Fire Fighting Station

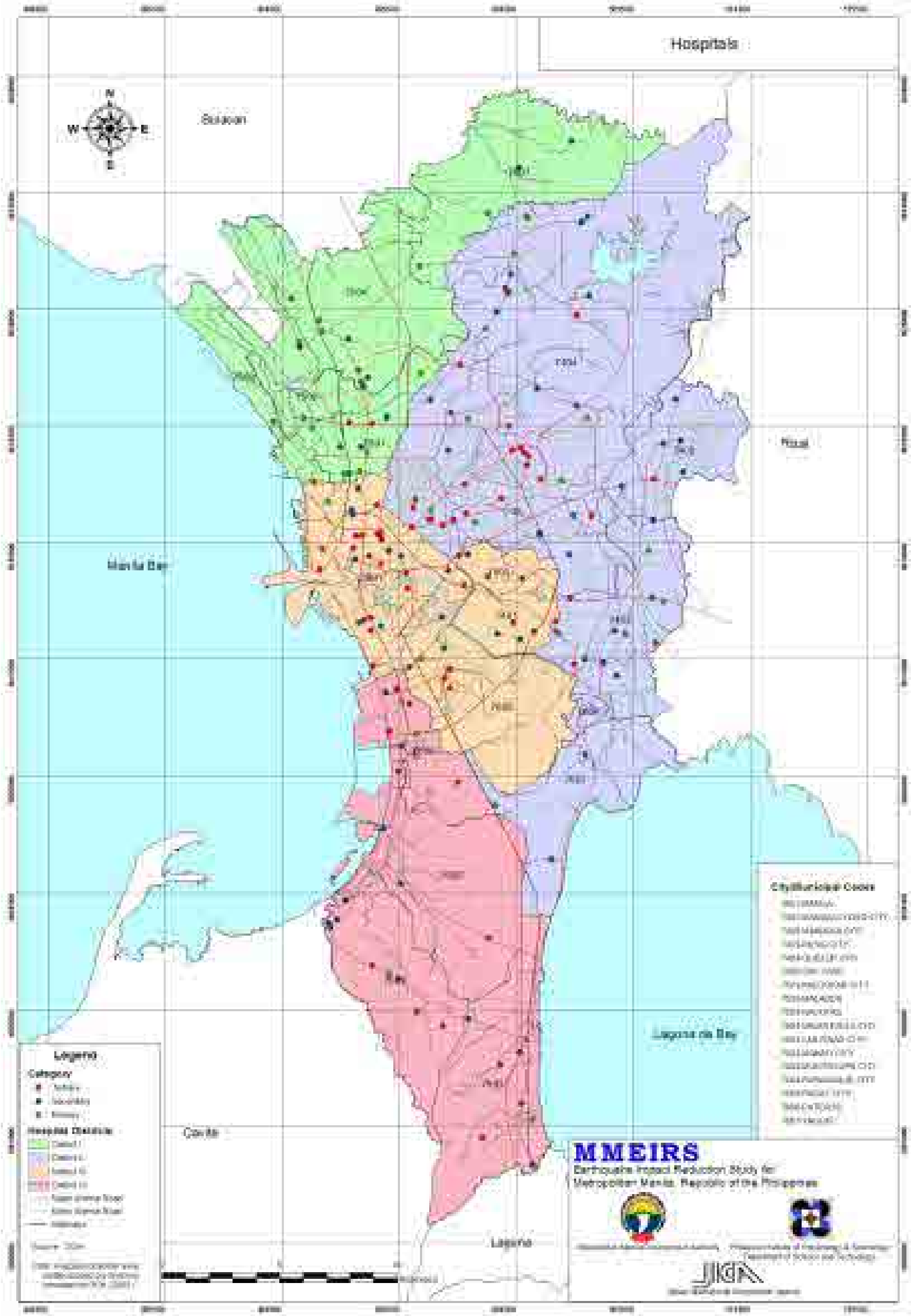


Figure 9.1.13 Location Map of Hospitals

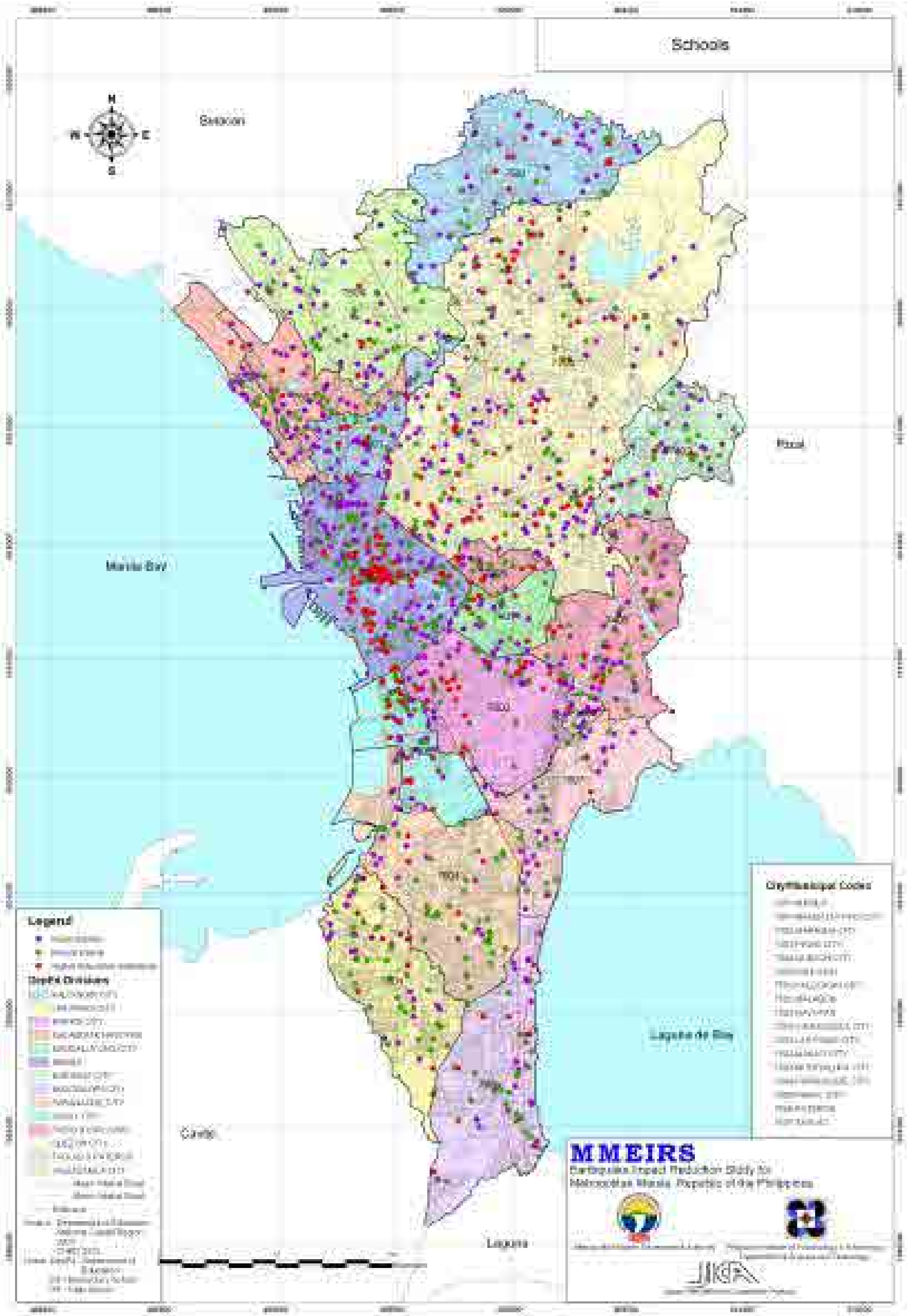


Figure 9.1.14 Location Map of Public Schools and Private Schools

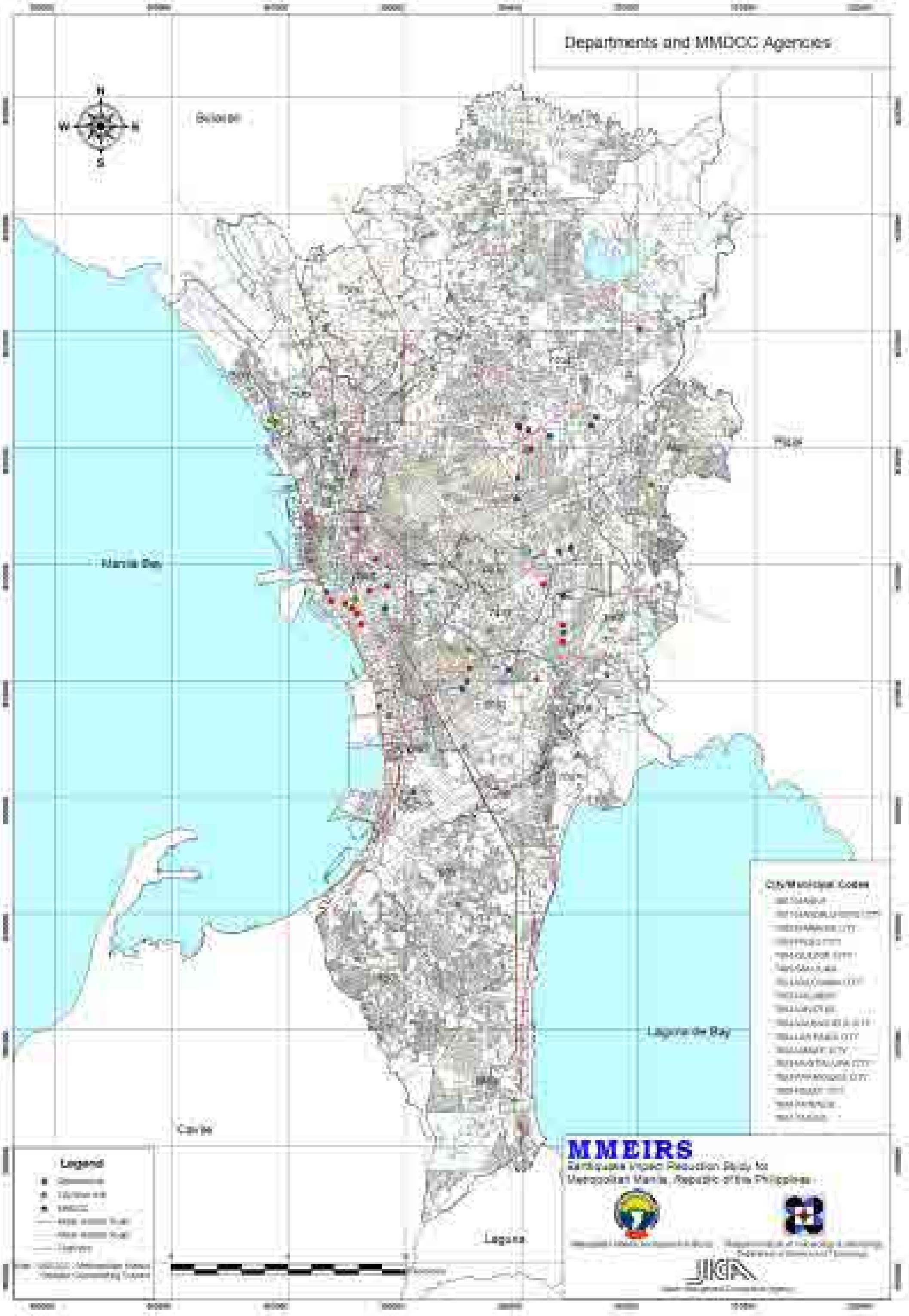


Figure 9.1.15 Location Map of 17 LGU City and Municipality Hall, MMDCC Departments and Agencies

4) Structural Features of Residential Buildings

(1) Classification of Residential Buildings

In Metropolitan Manila, qualities of the residential buildings have wide variety. Few buildings are well designed, well constructed and well maintained while almost all buildings are of moderate and/or low quality. Although NSO (National Statistics Office) gives building and population census, data regarding the buildings' structural classification and its quality are limited to several items. They are;

1. Floor area of housing unit
2. Construction materials of the outer walls
3. Year of construction
4. Construction materials of the roof

From the site observation, it is found that the residential buildings have the façade that uses the same material as that of the structure. Therefore it is reasonable to classify the residential buildings by using the classification of construction materials of the outer walls. Construction materials of the outer walls are categorized into four groups by Census data. They are as shown in the photographs;

1. Concrete/brick/stone
2. Half concrete/brick/stone and half wood
3. Wood
4. Others (Galvanized iron, Bamboo, Makeshift etc)

Through the observation in the study area, many residential buildings are of concrete frames with reinforcing bars that are very often filled with C.H.B (Concrete Hollow Brick). Exceptionally, very few and new tall condominium buildings are made of reinforced concrete shear wall structures.

Concrete

Half concrete and half wood

Wood

(2) Construction Material

Concrete structure

Individual house: Regarding the concrete residential buildings in Metropolitan Manila, it is usual that the house owner himself constructs his house with low-engineered construction method. For example, concrete is mixed by human laborers without proper mixing criteria. Sometimes, mere sand is used as aggregate material and the non-skilled laborers often ignore to mix coarse aggregate, which means that the constructor is never concerned with the proper mix proportioning of concrete. Very often, the in-filled CHB wall is first constructed, and then a portion of the CHB wall is used as form to make concrete column. The column depth is, in general, equal to that of the CHB. Although the reinforcing bars of column are placed with ties, the spacing is not strictly defined. It was not found that design and construction code is enforced during the construction of this type of structure.

Large condominium: On the other hand, few large-scale residential buildings such as condominium buildings apply proper construction methods. A mixer mixes concrete with appropriate mix proportioning practice. Sometimes most updated techniques such as Jumping forms for structural wall and Flying shores for floor systems are used. Even the concrete strength of 8000 psi for core concrete and 6000 psi for floor slab is sometimes allocated in the structural design. In order to pour the concrete, concrete bucket by crane for vertical members is used while pumping is used for horizontal members such as beams and slabs. Concrete test specimen are taken and cured for the strength verification. In general, quality assurances in the large-scale building construction are rather in a good condition.

Individual house

Large condominium (Good Quality)

Wood Structure

Wood structure is composed of lumber, wooden structural panel, particleboard, end-jointed lumber, fiberboard sheathing and hardboard siding (if latter two materials are used structurally). It is observed in Metropolitan Manila that structural quality of this type is widely scattered due to their conditions for design, construction and maintenance. For example, low-cost house lacks structural component to resist earthquake forces while, in a subdivision area, the large wooden structure looks much stronger than the badly constructed concrete structure.

(3) Legal Procedure of Building Construction

Construction approval

All the private buildings are to be constructed after getting the construction approval (Construction Permit) from the Building Officials in LGU. Building officials in LGU have to check the legality on the light of the use of the land and other items.

Role of Building officials

However, the building officials do not review the design of the applied buildings, which means that, although structural code exists for implementation, only law-abiding designer and/or owner of the building can assure the safeness of the building structure. Building officials have to check the legality at the time of completion of the building

(4) Supply of Construction Material

Study Team visited factories for Rebar, Ready mixed concrete and Concrete Hollow Brick (CHB) for understanding of the present condition of building industry in view of structural and earthquake engineering. Names of the factory are STEEL ASIA Company, DAROMAR Ready Mix Industries Inc., and ALLIED Concrete Products, Inc. respectively. Through the visit and interview with local engineers and/or with those who are involved in the building industry, study team could, to some extent, clarify the overall conditions regarding the building construction. It is to be pointed out that, in all the factories, the product machines are under good operational conditions with proper quality assurance process. The produced building materials are kept under appropriate quality control even after the delivery to the construction sites. Therefore, it was found so far that the quality of the building material products in the factory is as good as in Japan.

Rebar Factory

Concrete Hollow Brick Factory

On the other hand, many of concrete hollow bricks, those are actually supplied at construction sites, have very low strength. These are hand-made brick, often prepared at construction site. Some construction site manager said that there are serious strength problem even with factory-made bricks.

5) Structural Features of Major Public Facilities

(1) Design and Construction of Public Building Facilities

All the public buildings such as school, hospital and other governmental facilities are designed and constructed by DPWH. The organizational chart is shown in the Figure 9.1.16.

For instance, engineers in BOD (Bureau of Design) are in charge of review and check of designed structures. The engineers in DPWH are strictly referring to the national building code. On the other hand, buildings, which belong to the LGU, such as city hall and barangay hall, are designed and constructed through the building officials in LGU.

(2) Seismic Performance of Public Buildings in View of Seismic Diagnosis

A. Procedure of Building Diagnosis

a) For Reinforced Concrete Buildings with Medium Heights

According to the Japanese practice in order to briefly estimate seismic performance of existing medium heights' reinforced concrete (RC) buildings, basic structural index Is is used as diagnosis index by using following equation(s).

$Is = \beta\ (C_2+0.7C_3) \cdot 1.0$ ---- (1)

$Is = \beta\ (C_1+0.7C_2+0.5C_3) \cdot 0.8$ ---- (2)

Larger Is value are adopted

Where $\beta=(n+1)/(n+i)$

n=total number of stories

i= story level under consideration

$Cj = \Sigma Q_j / \Sigma w_k$ (j=1 Extremely short column, j=2 Column, j=3 Wall)

ΣQ_j=sum of story shear of Group-j at ultimate stage

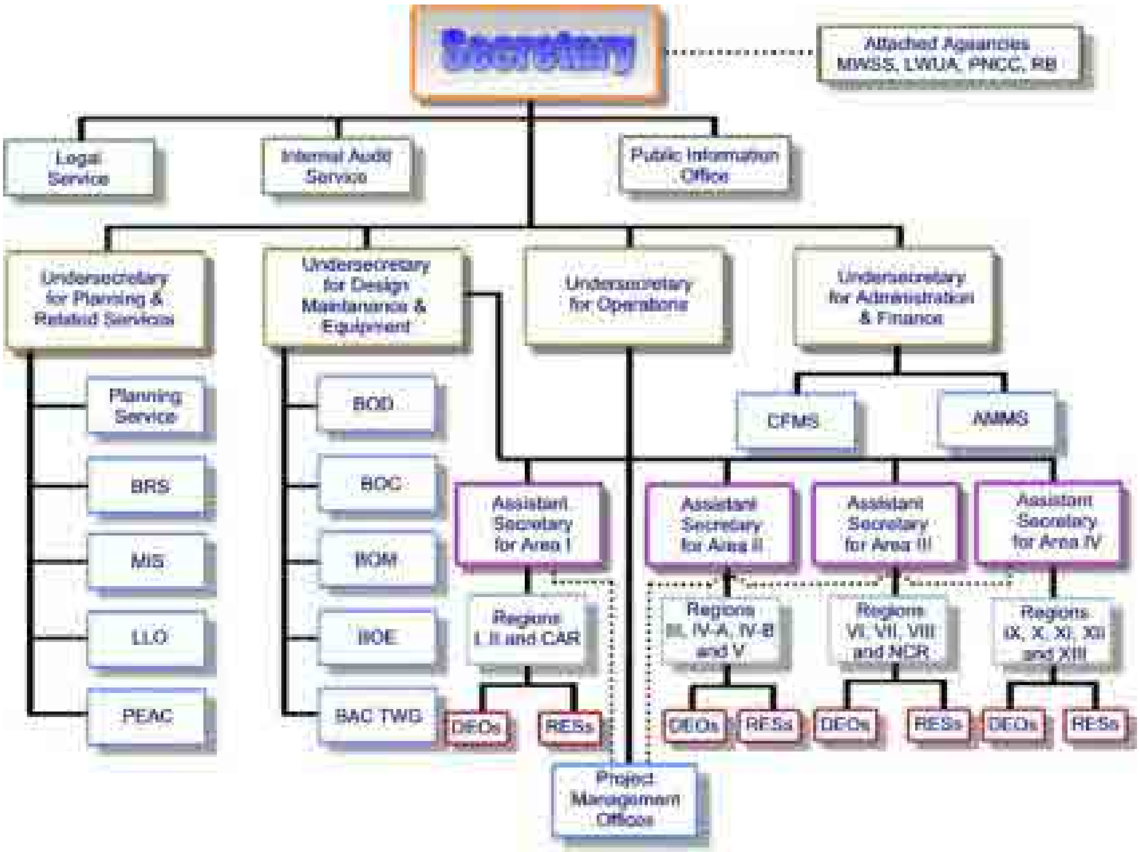
Σw_k=building weight above the story

$Q_j = \tau \cdot A$

τ=Shear Stress

A= cross sectional area

During calculation of the equation above, the building weight should be assumed as, for instance, 1 ton per square meter. Is value is obtained for each story level, but the ground floor level's Is is the most important. Threshold value of Is is more or less 0.6 if the building would be located in Japan.



BRS - Bureau of Research and Standards

MIS - Monitoring and Information

LLO - Legislative Liaison Office

PEAC - Pre-Qualification, Evaluation and Awards Committee for Consultancy

BOD - Bureau of Design

BOC - Bureau of Construction

BOM - Bureau of Maintenance

BOE - Bureau of Equipment

BAC TWG - Bids and Awards Committee Technical Working Group

CAR - Cordillera Administrative Region

NCR - National Capital Region

DEOs - District Engineering Office

RESs - Regional Equipment Services

CFMS - Comptrollership & Financial Management Service

AMMS - Administrative & Manpower Management Service

MWSS - Metropolitan Waterworks & Sewerage System

LWUA - Local Water Utilities Administration

PNCC - Phil. National Construction Corp.

RB - Road Board

Figure 9.1.16 Organization Chart of DPWH

b) Tall RC Buildings and Steel Buildings and Others

Except medium height RC buildings described above, taller RC buildings and Steel (S) buildings and others are not possibly estimated by numerical procedure. Therefore, Study Team uses a rapid visual screening (RVS) method developed by FEMA as a brief diagnosis for the existing buildings.

RVS was designed to be a procedure in which no structural analysis calculations are performed. The judgment whether the building is safe or not is based on the scoring system. In this RVS, the inspection, data collection and decision making process typically will occur at the building site. Threshold score value of this scoring system is 2.0, which means that the buildings with score higher than 2 is considered potentially safe at the time of earthquake.

c) Combination of two diagnosis methods

As described above, Japanese and FEMA methods' threshold value is 0.6 and 2.0 respectively. Therefore, by using factor 0.3, FEMA results are adjusted to be compatible to Japanese method.

B. Buildings to be Inspected

Study Team conducted the diagnostic survey of existing public buildings located in Metropolitan Manila composed of 17 LGUs. The number of the building inspected by diagnosis is total 80. Selection of 68 buildings was done by MMDA based on the requests from 17 each LGU. The rest of 12 buildings were selected by MMDA and PHIVOLCS.

C. Results of Diagnostic Inspection and discussion

Result of diagnostic inspection is summarized in Table 9.1.13, Figure 9.1.17.

Table 9.1.13 Results of Building Diagnosis for Public Buildings

Type	Total	Evaluation		
		Low	Moderate	High
Government Building	11	3	2	6
City Hall	16	2	7	7
School Building	27	4	6	17
Hospital Building	19	4	7	8
Barangay Hall	7	0	1	6
Total	80	13	23	44

In this figure, low seismic performance buildings have Is values less than 0.6, moderate ones have Is values between 0.6 and 0.8 and high performance buildings have Is values larger than 0.8.

The correlation between Is and the degrees of structural damage was examined by Umemura (1980) and others applying it to the case of 1968 Tokachi-oki earthquake and 1978 Miyagiken earthquake both in Japan, and it is suggested that the value of Is of 0.6 is the border between damaged and undamaged buildings experienced 25-30 %.g level ground motion. It is noteworthy that 55% of the inspected buildings have high performance.

Low performance buildings have, in general, small number of columns in comparison of the occupant area. There are very few concrete shear walls. Although the construction year was not identified, it was observed that these buildings were possibly constructed before and during the 1960s before the establishment of structural code.

High performance buildings have, on the contrary, large sized concrete columns and sometimes sufficient shear walls. They are relatively new buildings and maintenance condition is good. According to the Japanese experience, these buildings are supposed to resist to the earthquake strong motion with 0.3g maximum acceleration without any damage. It is difficult to predict ultimate strength of these buildings. However, considering the Japanese experiences, it is also supposed that these buildings would survive the severer earthquake strong motion with 0.6g maximum acceleration.

It is also difficult to how to judge the seismic performance of Moderate performance buildings. It is desired to inspect by using more accurate method, and, if any, some strengthening therapy may be necessary to avoid fatal damages.

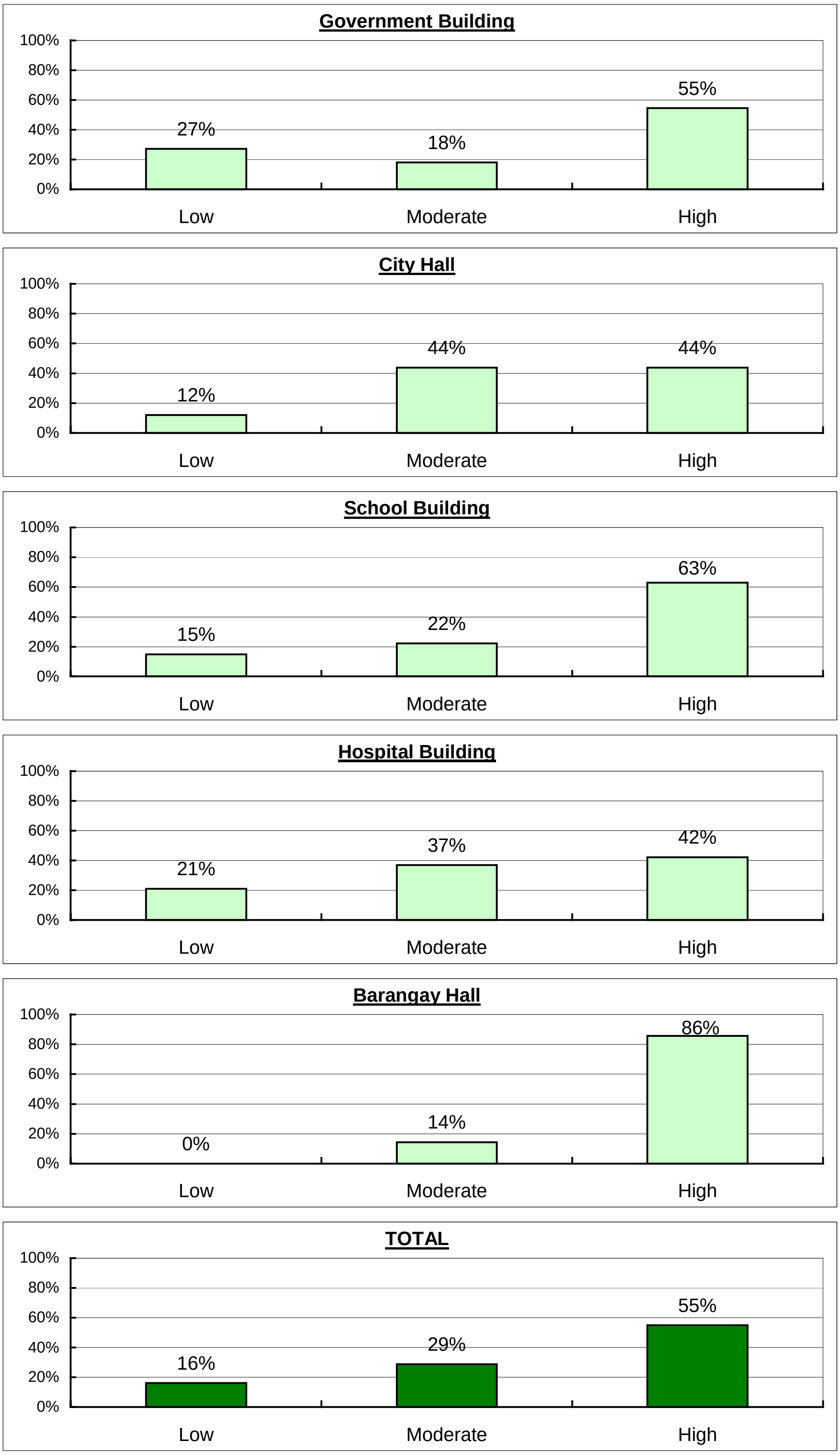


Figure 9.1.17 Results of Building Diagnosis for Public Building

6) Structural Code

(1) Chronology of Changes in the Seismic base Shear Formula

Since 1977, the National Building Code of the Philippines (NBCP) promulgated as Presidential Decree (PD) 1096, has been adopting by referral the National Structure Code for Buildings (NSCB) (previously developed by the Association of Structural Engineers of the Philippines (ASEP) and Philippines Association of Civil Engineers (PICE) in 1972) or its successors codes.

The referral code NSCB has since metamorphosed into the National Structure Code of the Philippines (NSCP) Volume 1 – Buildings, Towers and Other Vertical Structures.

The various editions of the NSCP, now in its 5th edition are reviewed to provide historical insights into the seismic design practices and experiences in the Philippines. A comparison of pertinent seismic provisions of the codes from the NSCB 1972 to NSCP 2001 is presented in Table 9.1.14. Table 9.1.14 is a comparison of the general procedure in computing for the base shear coefficient by the static lateral force procedure.

The static lateral force procedure, and most features of Philippine seismic codes for buildings, has been patterned after the Uniform Building Code (UBC) and/or the Bluebook of the Structural Engineers Association of California (SEAOC). In terms of seismic zone, Metropolitan Manila has always been categorized as one zone – the highest zone. In 2001, near-source factors have been introduced that add to the design requirement for buildings within 15 km of such known sources as the West Valley Fault.

Historically, the effect of changes in the several factors that contribute to seismic base shear is such as to generally increase the base shear according to NSCB 1981, and to reduce (back to almost NBCP 1977 level) according to NSCP 1992. By NSCP 2001, design base shear increases again when within 15 km of known major earthquake source. It is noteworthy that design base shear is not necessarily bigger in NSCP 1992 than previously, even after the 1990 Luzon Earthquake. The increase by NSCP 2001 (associated mainly with near source factors) is mainly motivated by observations in the 1994 Northridge Earthquake and 1995 Kobe Earthquake. What the NSCP 1992 edition has strengthened are the additional requirements for reinforced concrete members that are part of the earthquake lateral-force resisting systems.

The more important change between NSCP 1992 and NSCB 1972 are summarized below:

The minimum concrete compressive strength f'c is changed to 20 MPa (NSCP 1992) from 21 MPa (NSCB 1972).

Minimum width to depth ratio the flexural members is changed to 0.3 (NSCP 1992) from 0.4 (NSCB 1972).

Additional maximum longitudinal steel ratio (r = 0.025) in beams is added in NSCP 1992.

Additional requirement to assure a strong column, weak beam behavior in NSCP 1992 is given by the condition.

Maximum spacing of hoops in beams is replaced by 8*smallest longitudinal bar (NSCP 1992) from 16*smallest longitudinal bar (NSCB 1972).

Maximum longitudinal steel ratio for columns is replaced by 0.06 (NSCP 1992) from 0.08 (NSCB 1972).

Additional requirement in transverse reinforcement spacing in columns in NSCP 1992 states that tie spacing should be spaced no more than ¼ minimum member dimension or 100 mm. New equations for development length is defined in NSCP 1992.

Table 9.1.14 Chronologies of Coefficients and Factors in Seismic Design

		(1)	*(2)*	*(3)*	*(4)*	*(5)*
		NSCB 1972, NBCP 1977	**NSCB 1981**	**NSCP Vol.1 1986**	**NSCP Vol.1 1992**	**NSCP Vol.1 2001**
	Item	**(1st Edition)**	**(2nd Edition)**	**(3rd Edition)**	**(4th Edition)**	**(5th Edition)**
(a)	Formula for design base shear by static lateral force procedure	V = ZKC W	V = ZIKCS W	V = ZIKCS W	V = (ZIC/R_w) W	V = (C_vI/RT) W V = (0.8 ZN_vI/R) W V = 0.11 C_aI W V = (2.5C_aI/R) W *max.*
(b)	Zone designation			Zone 4	Zone 4	Zone 4
(c)	Zone seismicity coefficient	Z = 1.0 rock Z = 1.2 intermediate Z = 1.4 alluv. or poor	Z = 1.0 rock Z = 1.2 intermediate Z = 1.4 alluv. or poor	Z = 1.0	Z = 0.4	Z = 0.4
(d)	Near-source factors					N_v = 1.0 beyond 15 km N_v = 1.2 about 10 km N_v = 1.6 within 5 km N_a = 1.0 about 10 km N_a = 1.2 within 5 km
(e)	Site and structure resonance coeff.		S = 1.0 ~ 1.5	S = 1.0 ~ 1.5	S = 1.0 ~ 2.0	
(f)	C coefficient	C = (0.05) / $(T)^{1/3}$ C = 0.10 *max.*	C = (1.0) / (15 $(T)^{1/2}$) C = 0.12 *max.* CS = 0.14 *max.*	C = (1.0) / (15 $(T)^{1/2}$) C = 0.12 *max.* CS = 0.14 *max.*	C = (1.25 S) / $(T)^{2/3}$ C = 2.75 *max.*	C_v = 0.32 N_v for soil S_A C_v = 0.40 N_v for soil S_B C_v = 0.56 N_v for soil S_C C_v = 0.64 N_v for soil S_D C_v = 0.96 N_v for soil S_E C_v = site-specific for S_F C_a = 0.32 N_a for soil S_A C_a = 0.40 N_a for soil S_B C_a = 0.40 N_a for soil S_C C_a = 0.44 N_a for soil S_D C_a = 0.36 N_a for soil S_E C_a = site-specific for S_F
(g)	Fundamental (elastic) period of vibration of the building (in seconds) based on height and base width (in meters)	T = (0.0906 h_n) / $(D)^{1/2}$	T = (0.0906 h_n) / $(D)^{1/2}$	T = (0.09 h_n) / $(D)^{1/2}$	T = 0.050 $(h_n)^{3/4}$	T = 0.0488 $(h_n)^{3/4}$
(h)	Fundamental (elastic) period of vibration of the moment-resisting space frame building (in seconds) based on number of stories or height (in meters)	T = 0.10 N	T = 0.10 N	T = 0.10 N	T = 0.075 $(h_n)^{3/4}$ *Conc.* T = 0.085 $(h_n)^{3/4}$ *Steel*	T = 0.0731 $(h_n)^{3/4}$ *Conc.* T = 0.0853 $(h_n)^{3/4}$ Steel
(I)	Structural system K or R_w or R	K = 0.67 ~ 1.33	K = 0.67 ~ 1.33	K = 0.67 ~ 1.33	R_w = 12 ~ 4	R = 8.5 ~ 2.8
(j)	Importance factor		I = 1.0 ~ 1.5	I = 1.0 ~ 1.5	I = 1.0 ~ 1.25	I = 1.0 ~ 1.25

(2) National Structural code of Philippines and its comparison with Japanese Code

Present national structural code of Philippines, Volume 1 covering Buildings, Towers, and Other Vertical Structures, is the fifth edition following to, in turn, the first (1972), second (1981), third (1986) and fourth (1992) edition. The code itself is composed of 7(seven) chapters; 1.General Requirements, 2.Minimum Design Loads and Lateral Forces, 3.Foundations and Excavations, 4.Structural Concrete, 5 Structural Steel, 6 Wood, and 7. Masonry. Volume II of National Structural Code of the Philippines covers Bridges and issued in 1997 as 2nd Edition. Seismic items such as Seismic Criteria, Earthquake loadings and Computational procedures are described in the Section 208 of Chapter 2 as Earthquake Design. Besides, special seismic provisions for each structure are described in several sections. For example, Section 421 of Chapter 4. Structural Concrete describes the Special Provisions For Seismic Design. By comparison of the main factors that constitute the seismic code provisions of Building Standard Low in Japan and National Structural Code of Philippines, it is pointed out that while the two codes differ in detail, they have essential common features and are comparable. Both codes include the effect of seismic risk, spectral content, structural behavior and soil/foundation effect for seismic load. The force levels to be applied to the building structure are almost compatible in the 5th edition.

However, in the actual design practice, design earthquake force by NSCP become to small in comparison with Japanese Code. This is because large ductility factor (R) is applied to the structure in case of NSCP. For instance, in case of concrete structure, although the detail of column and beam connection does not allow high ductility factor (R), the code of the Philippines specifies the R value up to 8.5. The ductility of this grade is not assured even in Japanese.

Reference to Section 9.1

Applied Technology Council, Rapid Visual Screening of Buildings for Potential Seismic Hazards: A Handbook, FEMA-154, ATC-21, 1988.

Applied Technology Council, Rapid Visual Screening of Buildings for Potential Seismic Hazards: Supporting Documentation, FEMA-155, ATC-21-1, 1988.

Association of structural engineers of the Philippines (ASEP); National Structural Code of the Philippines 2001,Volume 1, Buildings, Towers, and Other Vertical Structures.

Umemura; Hajime, A guideline to evaluate seismic performance of existing medium-and low-rise reinforced concrete buildings and its application; Proceedings of the 7th World conference on Earthquake Engineering, 1980.

9.2 Infrastructures

9.2.1 Roads

Road network in Metropolitan Manila is the most important infrastructure for transportation that maintains urban lives. The road network also has a function as lifelines and communication since lifelines and communication facilities are buried under it. Therefore, there are two aspects on earthquake disaster of the road network as follows:,

1) Damages on each individual structure
2) Dysfunction of the whole network system due to damage of individual structure.

Furthermore, road plays important roles for evacuation, fire fighting operation and medical service as well as transportation of relief goods and rehabilitation activity.

In this point of view, it is essential to seize current status and function of the road network in order to carry out planning of earthquake disaster prevention and reconstruction. It is also important for this purpose to foresee damages of the road network by earthquake.

Table 9.2.1 shows distribution of road network in each category of road in Metropolitan Manila. Road width less than 6.5 meters are considered as narrow roads which will have serious difficulty to enter the area surrounded by narrow streets at the time of seismic disaster to do rescue activities and emergency goods delivery and so on. Therefore, pointing out such area will help to prepare for widening roads to keep safer area against seismic disaster.

Table 9.2.1 Distribution of Road Network in Metropolitan Manila

LGU	All Roads					Outside Subdivisions Roads				
	Road (6.5m or over)		Narrow Road (3 - 6.5m)			Road (6.5m or over)		Narrow Road (3 - 6.5m)		
	Length (m)	Density (m/Ha)	Length (m)	Density (m/Ha)	Ratio (%)	Length (m)	Density (m/Ha)	Length (m)	Density (m/Ha)	Ratio (%)
KALOOKAN CITY	650,012.69	122.38	39,078.81	7.36	6.01	398,158.19	74.96	28,789.96	5.42	7.23
LAS PINAS CITY	461,672.68	143.09	97.85	0.03	0.02	185,781.92	57.58	97.85	0.03	0.05
MAKATI CITY	512,744.28	160.43	921.63	0.29	0.18	394,737.07	123.51	340.34	0.11	0.09
MALABON	170,300.65	106.69	10,571.40	6.62	6.21	146,300.43	91.65	9,475.83	5.94	6.48
MANDALUYONG CITY	144,509.22	130.56	2,006.69	1.81	1.39	125,608.89	113.48	2,006.69	1.81	1.60
MANILA	746,599.79	180.85	36,037.06	8.73	4.83	696,995.10	168.83	35,713.41	8.65	5.12
MARIKINA CITY	350,735.66	154.88	3,155.52	1.39	0.90	179,758.28	79.38	2,754.59	1.22	1.53
MUNTINLUPA CITY	396,029.18	103.87	7,988.58	2.10	2.02	203,699.96	53.42	6,049.11	1.59	2.97
NAVOTAS	91,968.52	84.00	14,049.11	12.83	15.28	84,425.11	77.11	13,908.33	12.70	16.47
PARANAQUE CITY	593,826.98	130.21	813.73	0.18	0.14	327,514.52	71.81	710.09	0.16	0.22
PASAY CITY	195,883.72	110.18	789.63	0.44	0.40	194,352.43	109.32	789.63	0.44	0.41
PASIG CITY	399,651.73	125.35	2,282.78	0.72	0.57	303,010.54	95.04	1,612.68	0.51	0.53
PATEROS	19,232.89	98.60	982.49	5.04	5.11	18,439.02	94.53	982.49	5.04	5.33
QUEZON CITY	1,902,123.52	115.05	56,420.52	3.41	2.97	1,141,286.13	69.03	45,760.75	2.77	4.01
SAN JUAN	102,500.83	174.33	-	-	-	82,266.63	139.92	-	-	-
TAGUIG	259,954.90	94.46	1,041.51	0.38	0.40	221,326.98	80.42	1,041.51	0.38	0.47
VALENZUELA CITY	332,740.37	74.74	27,511.67	6.18	8.27	262,868.09	59.05	25,908.35	5.82	9.86
Total	7,330,487.61	122.61	203,748.98	3.41	8.27	4,966,529.29	109.19	175,941.61	3.87	3.54

Figure 9.2.1 Road Network

9.2.2 Bridges and Flyovers

1) Introduction

A bridge, in general, is a structure carrying a pathway or roadway over a depression or obstacles such as rivers or creeks and roads in the case of a flyover bridge. These structures are basically vulnerable to earthquakes. Collapse or damage to these structures would make it non-functional and would prohibit the movement of emergency vehicles such as ambulance, fire trucks, police, etc. In this study, data for bridges around the National Capital Region (NCR) were collected to analyze vulnerability of these structures.

For this study, it was necessary to get vital information on the bridges in the NCR especially the year of construction, number of lanes, length, girder type, bearing type, height of abutment, retrofitting or strengthening works, etc to prepare database. The Study Team prepared a data table from the original data received from the Department of Public Works and Highways (DPWH) Bridge Inspection of 1995, to characterize these bridges. Of all the bridges in the NCR, 189 bridges and 38 flyovers were inspected and described as per the engineering data requirements.

It must be noted that in parallel to this study, another JICA Study called "The Study on the Improvement of Existing Bridges along Pasig River and Marikina River in the Republic of the Philippines" is in progress. This study is only focused on the bridges along Pasig and Marikina River, however, very much detailed information is collected for each bridge. Therefore, results of mentioned study must be considered to be in higher priority.

2) Relevant Organizations/Divisions pertaining to Bridges

DPWH is the governing body that designs, constructs, manages and maintains the bridges in the NCR. Municipalities are responsible for monitoring the status of these structures.

3) Data Set up

The data received from DPWH were very limited for purposes of this study as the list of bridges is not complete, and some needed data were missing. The Study Team conducted its own inventory of the existing bridges in the National Capital Region (NCR). The Team, however, used the data received from DPWH as a guide for naming, locating and dating the year of construction of the bridges.

Table 9.2.2 is the summary of bridge inventory implemented in the Study. Figure 9.2.2 shows location of 189 bridges and 38 flyovers. The field investigation undertaken by the study team covers most of major bridges and flyovers, however, due to time limitation, not all of the bridges and flyovers that exist in Metropolitan Manila can be investigated, therefore, bridge data must be updated in the future. It is to be noted that most of bridges were investigated but flyover data is limited.

Table 9.2.2 Summary of Bridges and Flyovers Inventory in NCR

Municipality	No of Bridges / Flyovers	Girder Type			Type of Bearing			Max. Height of Abut./Pier			Material of Abut./Pier		Number of Spans		Foundation type		Minimum Seat Width	
		Arch or Rigid Frame	Continuous Girder	Simple Girder	With Specific Device	Bearing (with clear design concept)	Movable	less than 5 m	5 to 10 m	More than 10m	Reinforced Concrete	Plain Concrete / Others	1 span	2 or more spans	Pile	Others	Wide	Narrow
Manila	59	10	11	38	11	43	5	52	7	0	56	3	35	24	7	52	18	41
		59			59			59			59		59		59		59	
Mandaluyong	2	0	1	1	2	0	0	0	2	0	2	0	0	2	1	1	1	1
		2			2			2			2		2		2		2	
Marikina	5	0	3	2	2	2	1	1	3	1	5	0	1	4	0	5	3	2
		5			5			5			5		5		5		5	
Pasig	9	0	1	8	2	7	0	3	6	0	9	0	1	8	3	6	7	2
		9			9			9			9		9		9		9	
Quezon City	56	2	19	35	16	40	0	28	24	4	56	0	31	25	1	55	8	48
		56			56			56			56		56		56		56	
San Juan	3	0	2	1	2	1	0	1	2	0	3	0	0	3	1	2	2	1
		3			3			3			3		3		3		3	
Kaloocan	8	1	1	6	3	5	0	5	3	0	8	0	4	4	0	8	3	5
		8			8			8			8		8		8		8	
Malabon	10	1	4	5	3	6	1	8	2	0	10	0	2	8	0	10	3	7
		10			10			10			10		10		10		10	
Navotas	7	0	3	4	1	3	3	6	1	0	7	0	0	7	0	3	3	4
		7			7			7			7		7		3		7	
Valenzuela	23	7	3	13	3	20	0	21	2	0	23	0	18	5	0	23	6	17
		23			23			23			23		23		23		23	
Las Piñas	6	2	0	4	3	3	0	6	0	0	6	0	3	3	1	5	0	6
		6			6			6			6		6		6		6	
Makati	18	1	12	5	7	8	3	7	10	1	16	2	2	16	0	18	13	5
		18			18			18			18		18		18		18	
Muntinlupa	8	0	6	2	0	7	1	7	1	0	8	0	1	7	0	8	5	3
		8			8			8			8		8		8		8	
Parañaque	5	0	1	4	0	2	3	4	1	0	5	0	0	5	0	5	1	4
		5			5			5			5		5		5		5	
Pasay	4	0	0	4	1	1	2	3	1	0	4	0	1	3	0	4	1	3
		4			4			4			4		4		4		4	
Pateros	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
		0			0			0			0		0		0		0	
Taguig	4	0	1	3	1	3	0	4	0	0	4	0	1	3	1	3	2	2
		4			4			4			4		4		4		4	
Total	227																	

Source: JICA Study Team, 2003

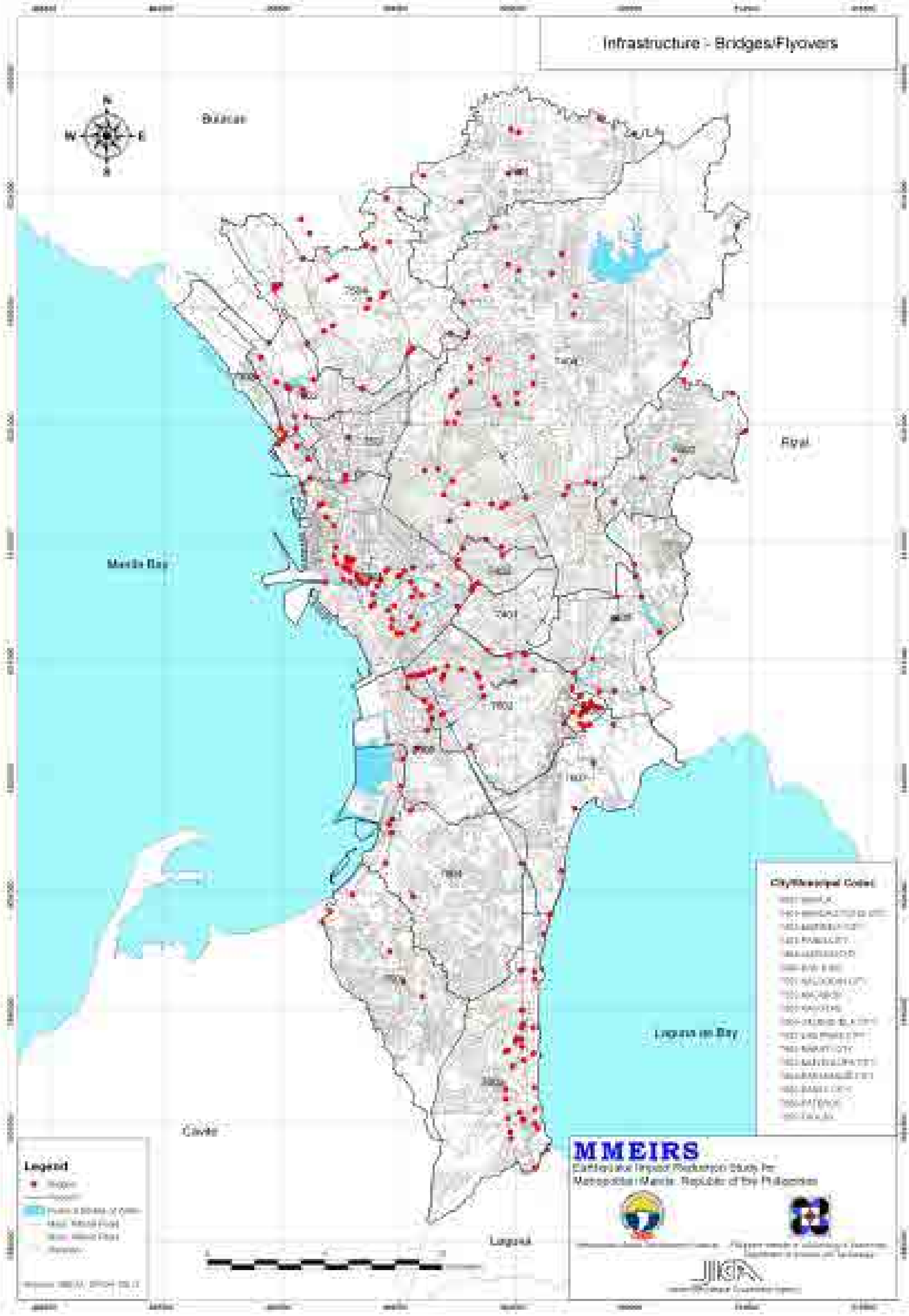


Figure 9.2.2 Bridge Distribution in Metropolitan Manila

4) General Features of the Bridge in the National Capital Region (NCR)

(1) Superstructure

The superstructure of most of the bridges in the National Capital Region which were inspected are pre-stressed concrete girders which is expected due to construction limitations at the bridge site and the volume of traffic in the area. The use of pre-cast AASHTO girders has been a trend in the National Capital Region since installation of these girders are easier and reduces construction time as compared to reinforced concrete deck girder and other types of superstructure. However, there are still some bridges with RCDG superstructures. It is also noticeable that there are only few bridges with steel superstructures. These few old bridges have steel beams, which are already severely corroded. In contrast to this, recently constructed bridges/flyovers with longer spans have resorted to the use of steel superstructure specially if horizontal curves cannot be avoided.

From the bridge survey, old bridges have simply supported girders even if they are multi-span while recently built bridges were made continuous through diaphragms at the piers or through continuous slabs over the piers.

Because of the July 1990 earthquake, restrainers were attached to the superstructures of some major bridges/flyovers, which were constructed before the release of the latest AASHTO Code and DPWH requirements. In addition, bridge seats were extended and shear keys were installed between girders as part of seismic retrofitting.

(2) Substructure

The hammerhead type T pier was observed in most of the bridges in the National Capital Region since it poses the least obstruction to traffic (as in the case of flyovers) and is cheaper than the solid wall type. However the number of solid wall piers does not lag behind that of the hammerhead as observed during the survey. For massive superstructures and very tall piers, the double hammerhead or multi-column piers were adopted. It is only in few old bridges that one can find pier pile bents.

Seismic retrofitting or strengthening works on the piers have already started with the major bridges and flyovers.

The type of abutment generally adopted in the bridges cannot be ascertained because of the presence of slope protection or shanties totally covering a portion of the coping down to the foundation.

(3) Foundation

The type of foundation for most of the bridges inspected could not be determined because they are not exposed except for one bridge, which has a pile bent pier. In general, for the new bridges /

flyovers constructed in the late 1980’s, bored pile were used because they eliminate huge excavation and construction of massive footings which obstruct traffic flow.

Spread footing was adopted in the municipalities located on stable and hard soil foundation such as Quezon City.

It can be assumed that pile foundation is predominant since most of the municipalities are located in alluvial deposits and in low lying areas where the presence of water table is a problem.

A detailed breakdown of the types and features of the bridges per municipality is discussed in the next section.

9.2.3 Ports and Harbors

As Metropolitan Manila faces the Manila Bay, several important Ports and Harbors facilities exists along the Manila Bay. Role of Ports and Harbors facilities are also important at the time of earthquake events. Therefore, to understand existing condition of those facilities are necessary for future preparedness against earthquake. Mainly, at the time of earthquake, ports and harbors will function as major transport and stock facility from outside Metropolitan Manila and neighboring country. Therefore, maintain the function will be important to keep smooth transportation from outside.

In Metropolitan Manila, there are three main harbors, as follows;

- Manila North Harbor,
- Manila International Container Terminal, and
- Manila South Harbor

Those Ports and Harbors are operated by 2 private enterprises under control of the Philippine Ports Authority (hereinafter referred to as “PPA”) and another one is directly operated by PPA. PPA is the main government agency concerned with the planning and development of the country's seaports, a vital link in both domestic and international trade. Established in 1974, the PPA’s charter was amended by Executive Order 857 which expanded its functions to cover the integration and coordination of port development nationwide while promoting the creation of autonomous port development bodies in trading centers in the region.

In the Philippines, Ports and Harbors are basically classified by the Port Authority namely Government and Private Ports, and importance is recognized but no official declaration of the classification according to importance.

According to the interview and meeting with PPA, ICTSI, ATI, regarding countermeasures against possible earthquakes, there are no specific preparations, unfortunately.

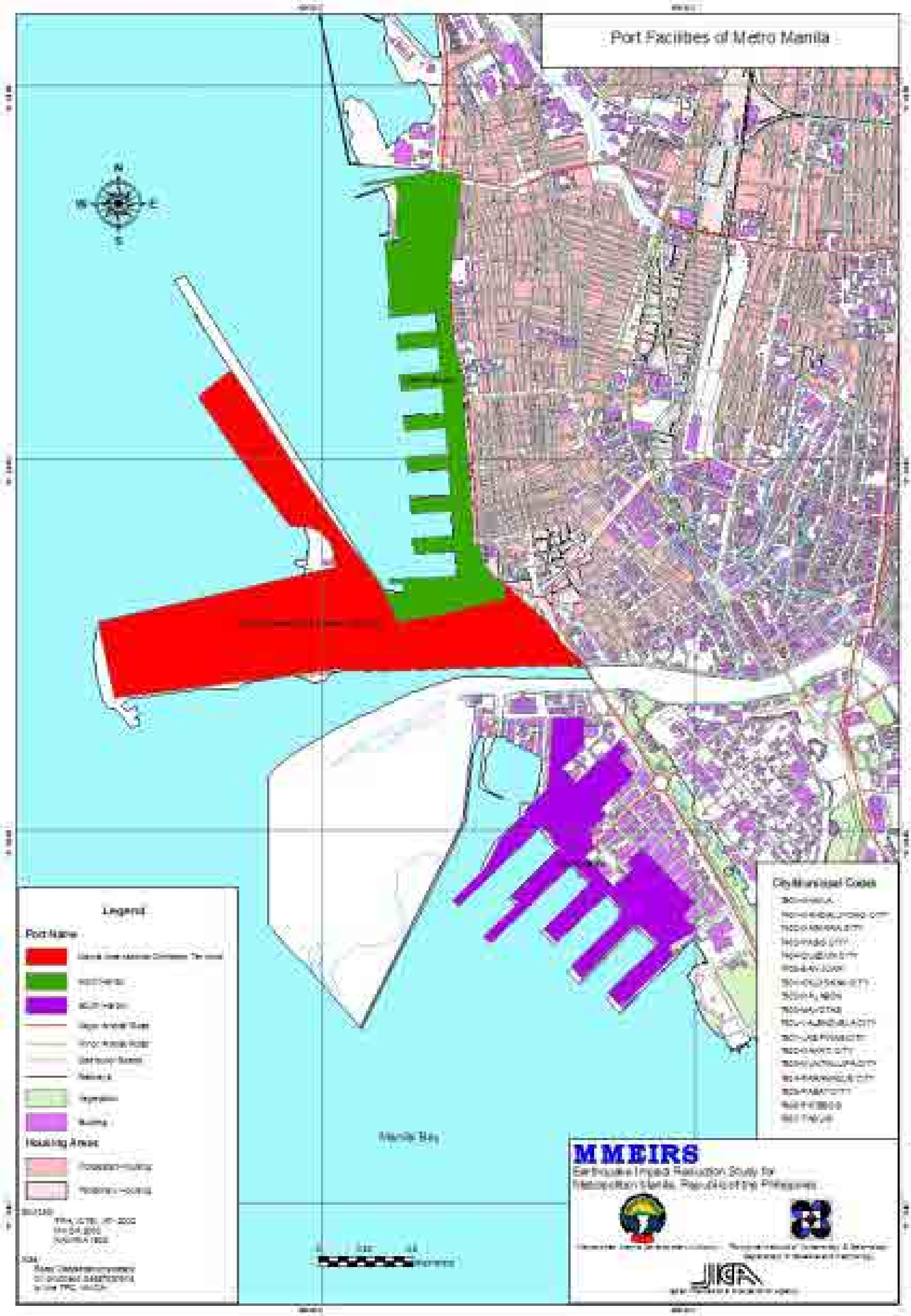


Figure 9.2.3 Port Facilities of Metropolitan Manila

1) Manila North Harbor

Manila North Harbor is function as Domestic Vessels Passenger Terminal, Domestic Container Terminal, Domestic Non-container Terminal directly operated by PPA. This Harbor has eleven (11) facilities as shown in Table 9.2.3.

Table 9.2.3 Facilities of Manila North Harbor

Facility	Function	Berth Length (m)	No. of Berths	Pier Area (m^2)	Back-up Area (m^2)	Passenger Terminal Building (m^2)	Controlling Draft (m)	Transit Shed (m^2)	Fendering System	Mooring Facilities
Pier 2	Wharf type structure with one side being used for berthing purposes.	579	3	35,200	-	2,250	5 - 6	-	Rubber Fenders	Bollards, Bits & Cleats
Pier 4	Finger pier type facility with two parallel berthing sides for large vessels and one small vessel berth at the tip of the pier.	654	6	17,641	-	-	5 - 6	1,200	-	-
Pier 6	Finger Pier with 3 berthing sides.	652	6	17,410	-	-	5 - 6	-	-	-
Pier 8	-	661	6	18,180	-	-	5 - 6	1,960	-	-
Pier 10	Finger Pier type facility with two parallel berthing sides for large vessels and one small vessel berth at the tip of the pier.	661	6	18,180	-	-	5 - 6	1,960	-	-
Pier 12	Finger pier with 3 berthing sides.	661	6	17,832	-	-	5 - 6	1,520	-	-
Pier 14	Finger pier type facility with two parallel berthing sides for large vessels and one berthing side occupying small vessel.	623	6	17,124	-	-	5 - 6	-	-	-
Pier 16	Wharf type structures which recently constructed connecting Pier 16.	665	5	108,675	54,536	-	5 - 6	3,390	-	-
Marine Slipway (MSW)	Facilities equivalent to 1 berth which is at present used by vessel temporarily.	97	3	54,536	-	-	5 - 6	-	-	-
Pier 18	Caters to small boats, trampers and other similar vessels.	383	-	2,949	1,700	-	5 - 6	-	-	-
Isla Putting Bato (IBP)	-	650			500					

Source: PPA, 2002

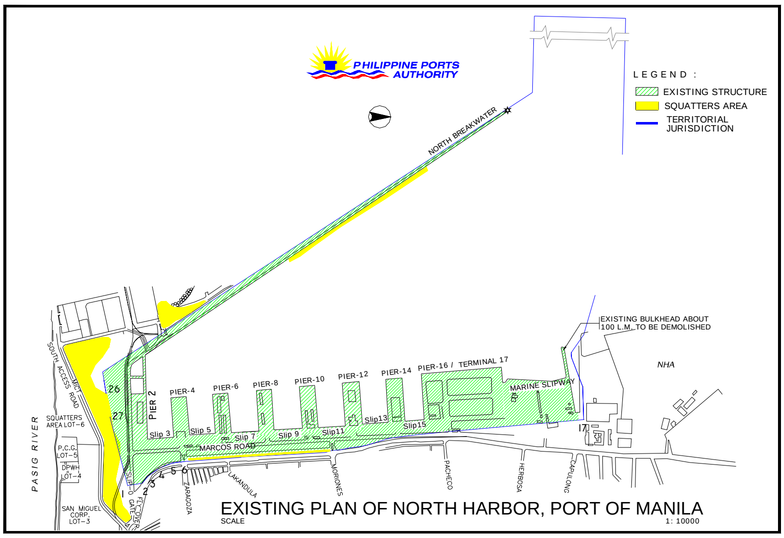


Figure 9.2.4 Existing Plan of North Harbor, Port of Manila

Source: PPA, 2002

2) Manila International Container Terminal

Manila International Container Terminal (MICT) has function of International Container and Non-container Terminal operated by private enterprise named International Container Terminal Services, Inc (ICTSI). The MICT is located in Manila, which lies between the North Harbor and the South Harbor, protruding westward into the Manila Bay with total port area of 606,740 m^2. It is situated just north of the mouth of Pasig River off Pier 2 of the PMO-North Harbor. The MICT has a 1,300 meter wharf divided into five berths as shown detail in Table 9.2.4.

Table 9.2.4 List of Berths in MICT

Berth	Length (m.)	Controlling Depth (m)
1	250	10.0
2	250	10.0
3	250	10.0
4	250	10.0
5	300	10.0 – 11.0

Source: ICTSI, 2002

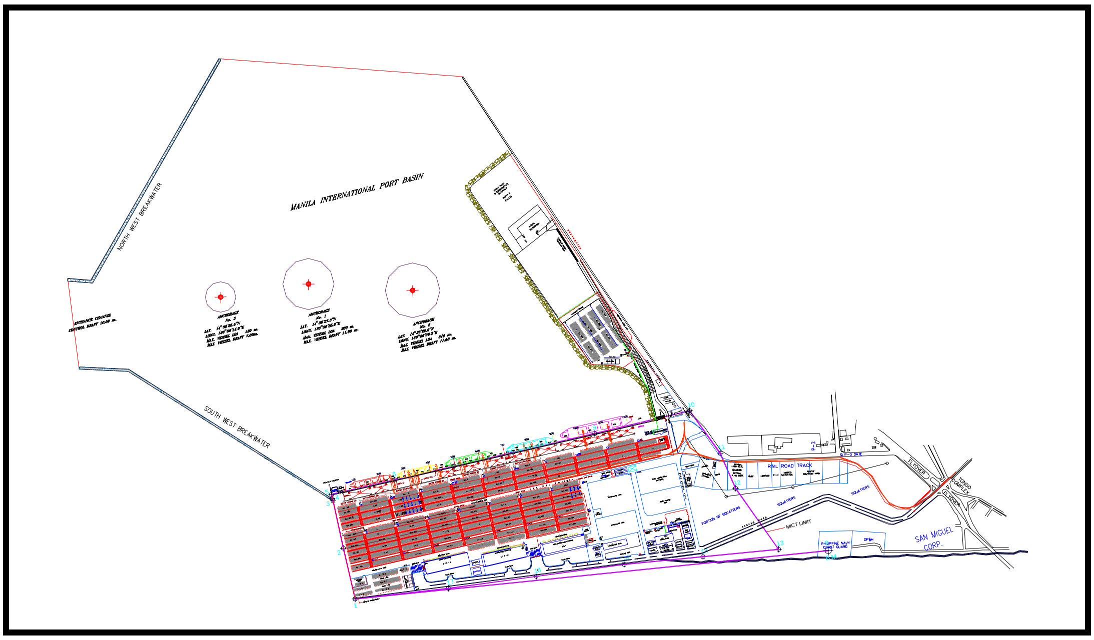


Figure 9.2.5 Existing Plan of MICT, Port of Manila

Source: ICTSI, 2002

3) Manila South Harbor

Manila South Harbor has function of International Cargo and Container Terminal operated by a private enterprise named Asia Terminal Incorporated (ATI), located South of International Container Terminal. Manila South Harbor has 3 functions as follows;

Container Terminal (900m Berth-Pier 3, 5)

General Stevedoring (9 Berths, Pier 5, 9, and 15)

Domestic Cargo Terminal (5 Berths, Pier 15)

According to ATI personal, regarding strengthening of Piers, Pier 3, 5, 9 and 15 are old piers constructed 30 to 40 years ago with the old design code. The Pier 5 extension was design and constructed with seismic standard code of 1995.

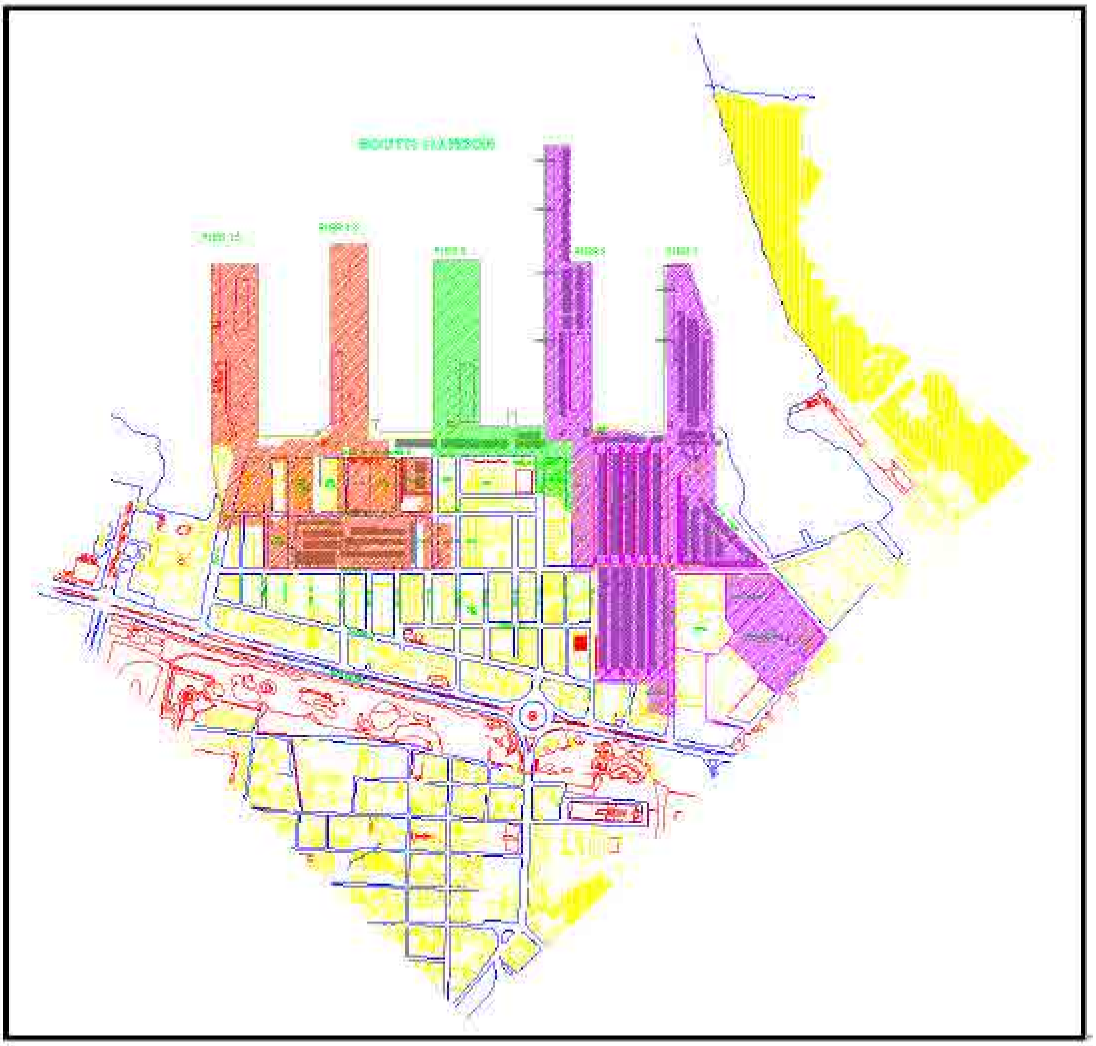


Figure 9.2.6 Existing Plan of International Container Terminal, Port of Manila

Source: ATI, 2002