An Update on the Earthquake Hazards and Risk Assessment of Greater Metropolitan Manila Area

November 14, 2013

Renato U. Solidum Jr.

Philippine Institute of Volcanology and Seismology

Department of Science and Technology

Key Messages

- Metropolitan Manila and surrounding provinces are prone to earthquake hazards.

- A Magnitude 7.2 or even a Magnitude 6.5 earthquake from the West Valley Fault can cause severe damage to Metropolitan Manila and vicinity.

- Collectively, we can reduce the risk from earthquake to save lives, property, assets and businesses.

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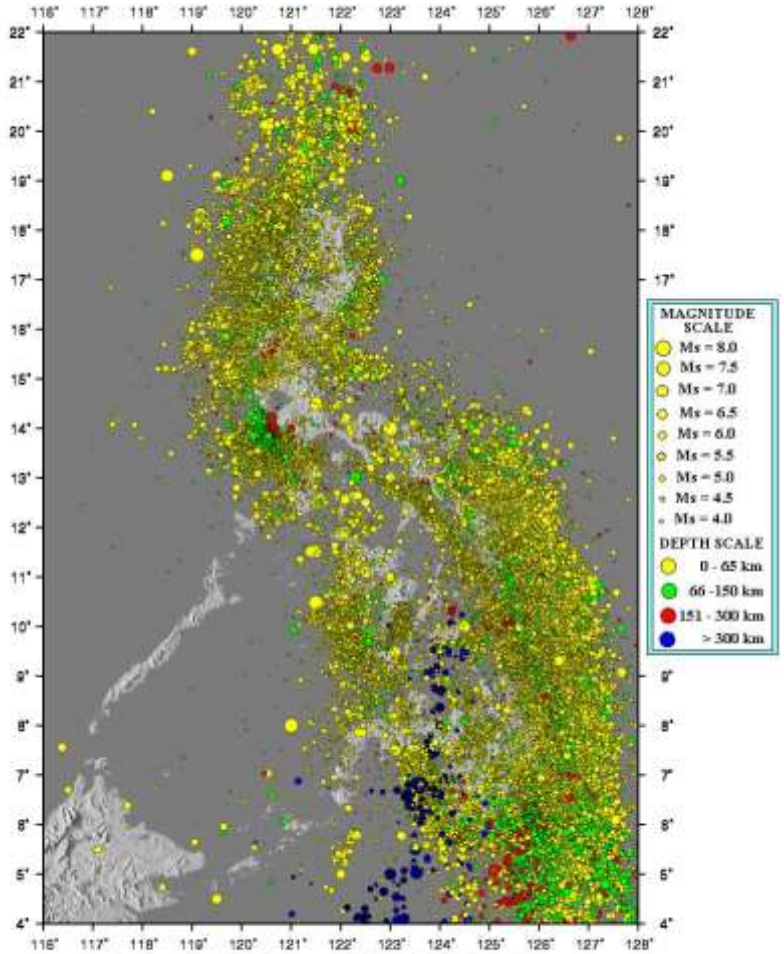
Earthquake Activity in the Philippines

(~90 destructive earthquakes for past 400 years)



Seismicity Map of the Philippines
1907-2012

M7.8 1990 Luzon Earthquake

M6.9 2012 Negros Or Earthquake

15 October 2013 M7.2 Bohol Earthquake

RT @PhilstarNews

Collapsed structure in Barangay Mambaling, Cebu City | via @jajarama pic.twitter.com/qd0mqT3jnC

RT @rapplerdotcom

San Pedro Church in Loboc, Bohol collapsed. http://rplr.co/19JU8Mk via @tokyodrastic pic.twitter.com/qdaGNyOGyN

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Can large earthquakes affect Metro Manila and vicinity?

YES

Greater Metro Manila Area Exposed to Earthquakes


Ruby Tower (Manila)

- M 7.3 Casiguran, Aurora Earthquake, 02 August 1968
- Ruby Tower in Manila collapsed – 268 killed, 260 injured

- Metro Manila and vicinity affected by several major earthquakes in the past

- Recent quake that caused significant casualty in Metro Manila – 1968 M7.3 Casiguran (Aurora) Earthquake

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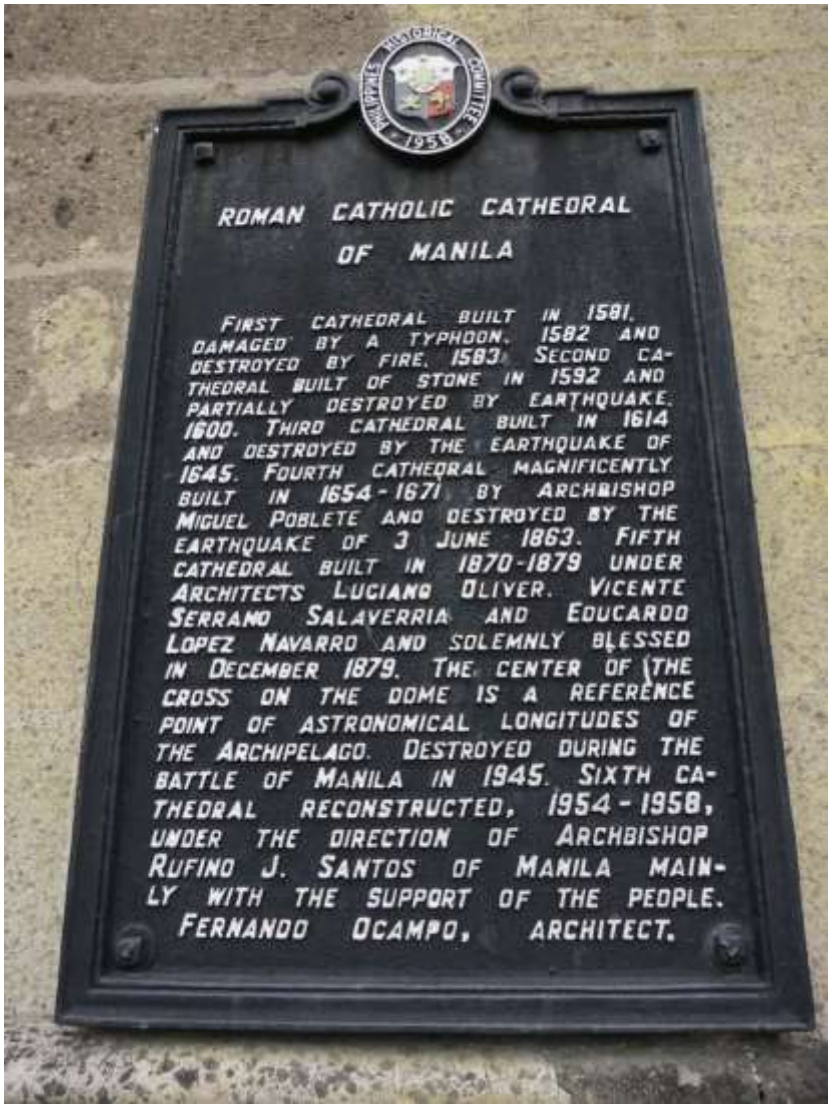
Some Historical Churches in Metro Manila

with earthquake accounts



Roman Catholic Cathedral of Manila

"partially destroyed by earthquake, 1600"
"destroyed by the earthquake of 1645"
"destroyed by the earthquake of 3 June 1863"

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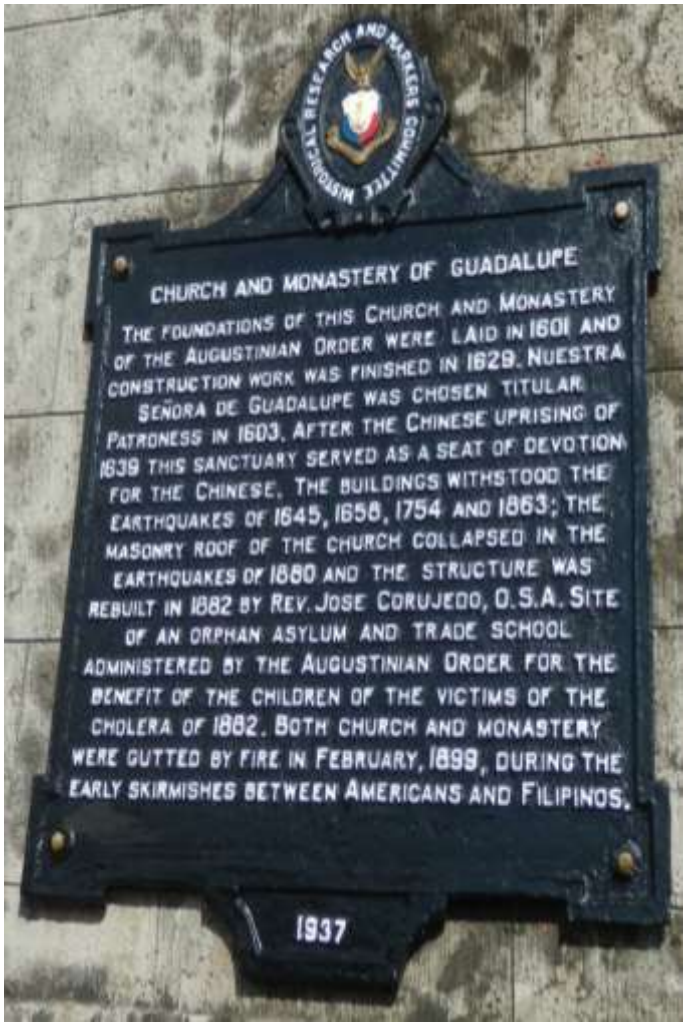
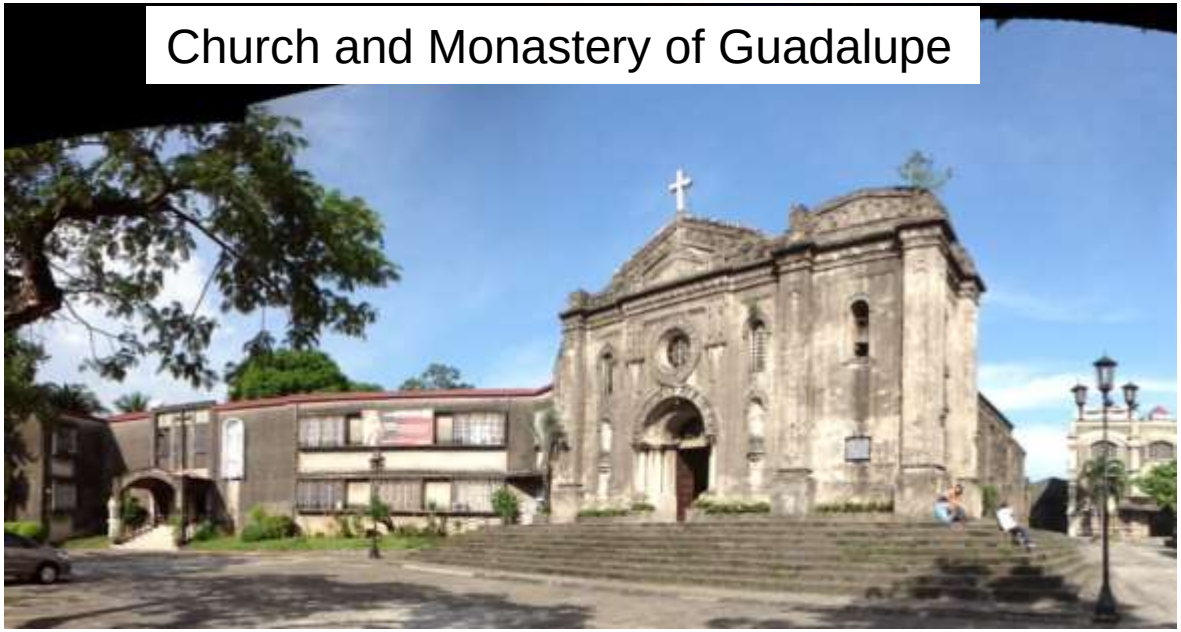
Some Historical Churches in Metro Manila

with earthquake accounts





"withstood the earthquakes of 1645, 1658, 1754, and 1863"
"the masonry roof of the Church collapsed in the earthquake of 1880"

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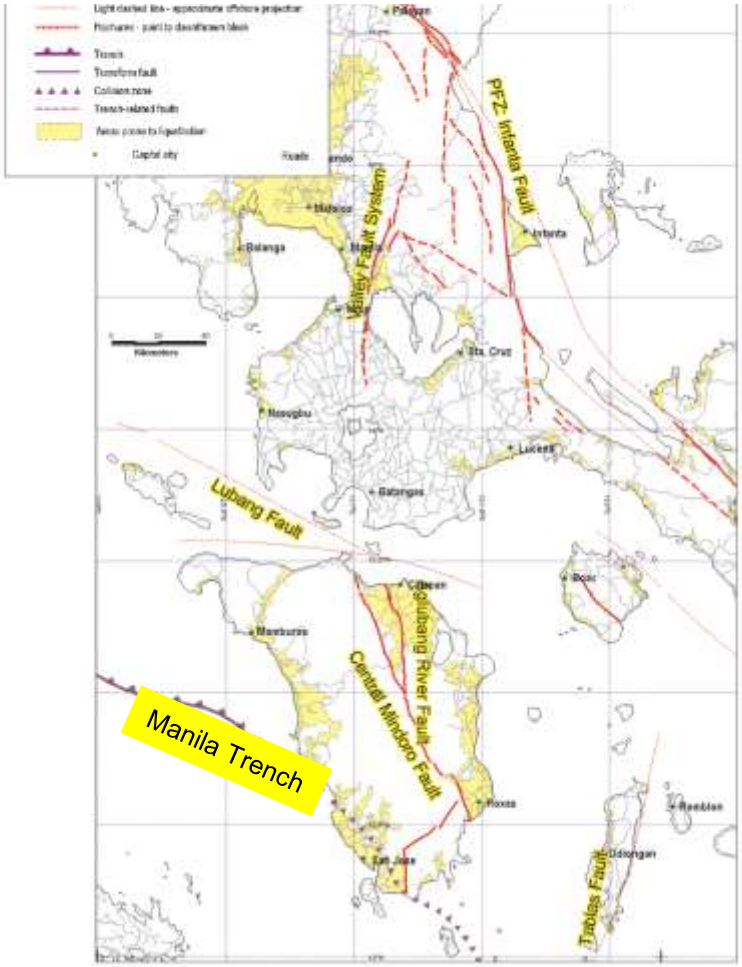
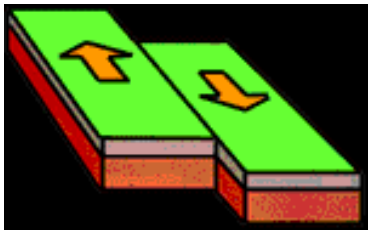
Earthquake Generators: Active Faults and Trenches in Metro Manila and Vicinity





Active Faults

Trenches

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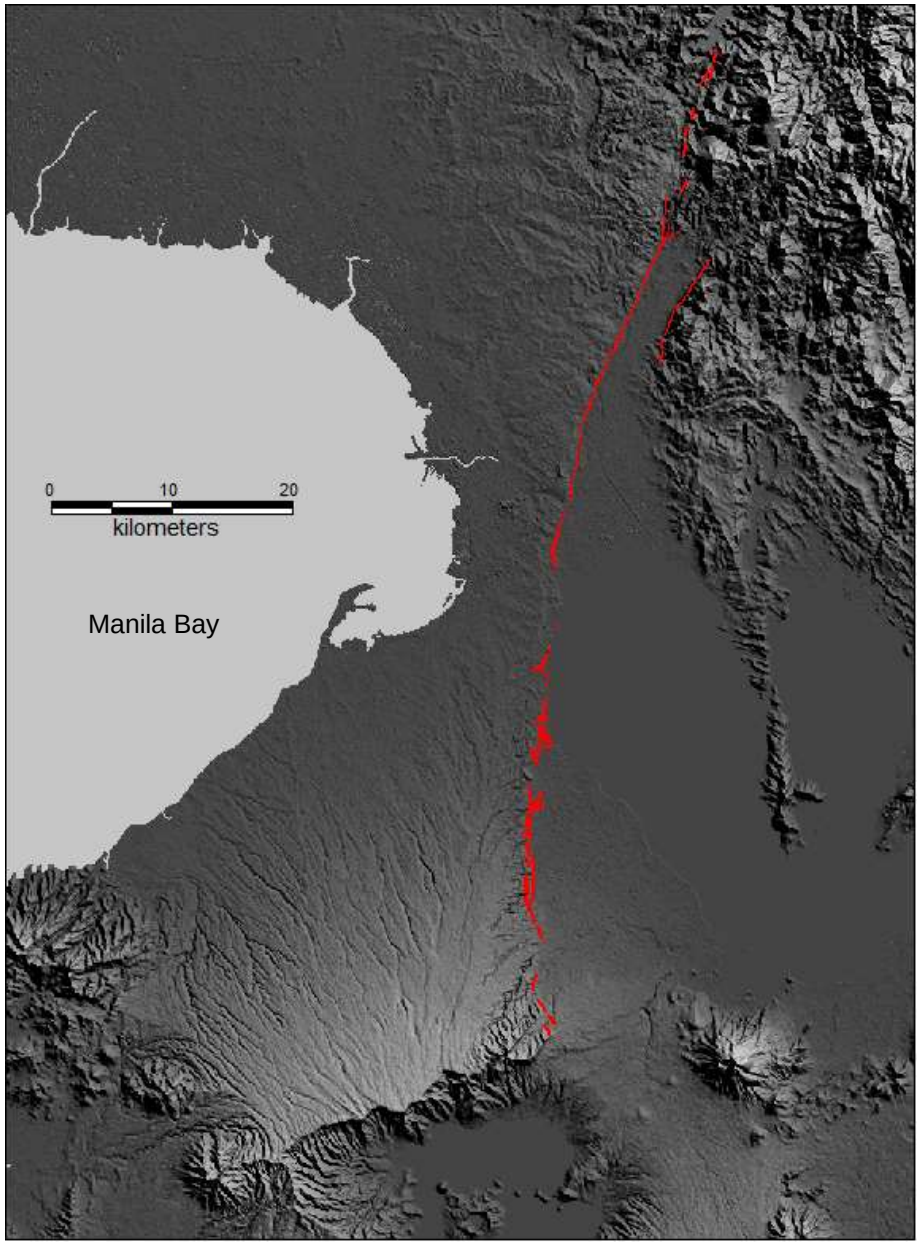
The Valley Fault System



- Formerly known as the Marikina Valley Fault System
- West Valley Fault (WVF)
  - ~90 km long (PHIVOLCS, 2000; READY, 2008; JSP & MLPM, 2009)
- East Valley Fault (EVF)
  - ~10 km long (PHIVOLCS,2000)
- WVF moved 4 times in past 1400 years; movement interval ~ 400 yrs
- Last major earthquake from West Valley Fault in 1658

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What are the effects of a strong earthquake from the West Valley Fault?

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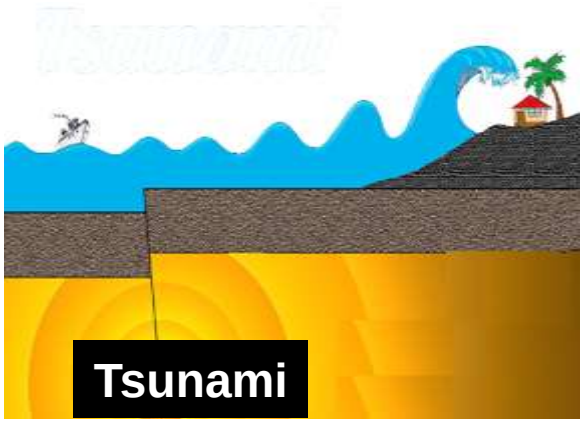
Earthquake-related Hazards

Fault (Ground) Rupture

Ground Shaking – Collapse of Building

Liquefaction

Landslide



Tsunami

Fire

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"Enhancing Risk Analysis Capacities for Flood, Tropical Cyclone Severe Wind and Earthquake for Greater Metro Manila Area" Or Risk Analysis Project – RAP (2010-2013)

- A 3-year collaborative project among CSCAND agencies (PHIVOLCS, PAGASA, MGB, NAMRIA, OCD) in partnership with Geoscience Australia (GA) and Australian Agency for International Development (AusAID)

- Project started in response to Cyclone Ondoy (Ketsana) in 2009 and is part of a broader AusAID initiative known as BRACE (Building Resilience and Awareness of Metro Manila Communities to Natural Disasters and Climate Change Impacts)

- Objective is to assess the potential impact from flood, cyclone and earthquake in the Greater Metro Manila Area by developing fundamental datasets and information on hazard, exposure and vulnerability

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Philippine Organizations Involved in RAP

- Philippine Institute of Volcanology and Seismology (PHIVOLCS)
- Philippine Atmospheric, Geopysical and Astronomical Services Administration (PAGASA)
- National Mapping and Resource Information Authority (NAMRIA)
- Mines and Geoscience Bureau (MGB)
- Office of Civil Defense (OCD)

* University of the Philippines Diliman – Institute of Civil Engineering

Risk Assessment

Earthquake
Floods
Tropical Cyclones
(Severe Wind)
- - - - -

EXTENT and INTENSITY

People, Buildings,
Businesses,
Infrastructure, Other
Critical Facilities
- - - - -

LOCATION and ATTRIBUTES

Engineering
Economic
Social
- - - -

RESPONSE and BEHAVIOUR

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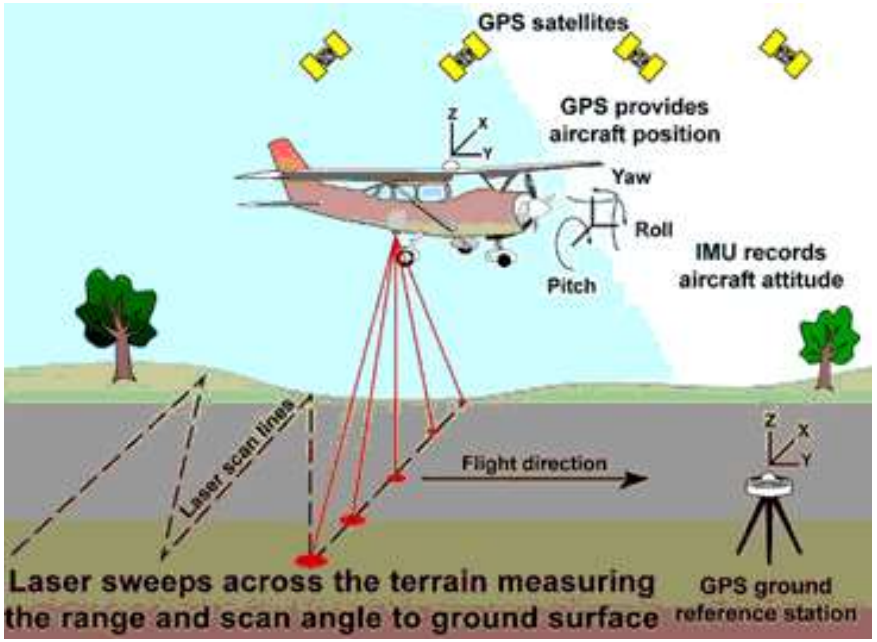
Risk Analysis Project Components

- High Resolution Digital Elevation Model and Imagery – LiDAR - *Lead Agency: NAMRIA*
- Exposure Information - *Lead Agency: PHIVOLCS*
- Flood Risk Modelling - *Lead Agency: PAGASA*
- Tropical Cyclone Severe Wind Risk Modelling - *Lead Agency: PAGASA*
- Earthquake Risk Modelling - *Lead Agency: PHIVOLCS*
- Information, Education and Communication - *Lead Agency: OCD*

COMPONENT 1: Digital Elevation Model for Greater Metro Manila Area (GMMA)

- High-resolution digital elevation model was produced in the Greater Metro Manila Area for the analysis of natural hazard risk and climate change impacts.



Source: http://www.beg.utexas.edu

- With funding from AusAID, a LiDAR dataset was acquired in April 2011 and transmitted to the Philippine Government in September 2011; 1 meter resolution

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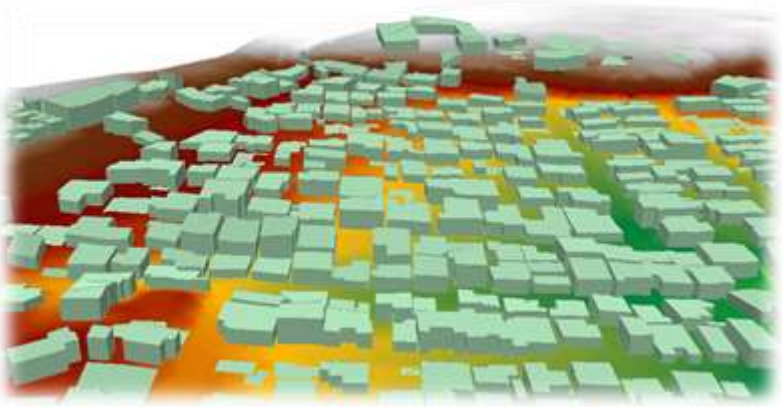
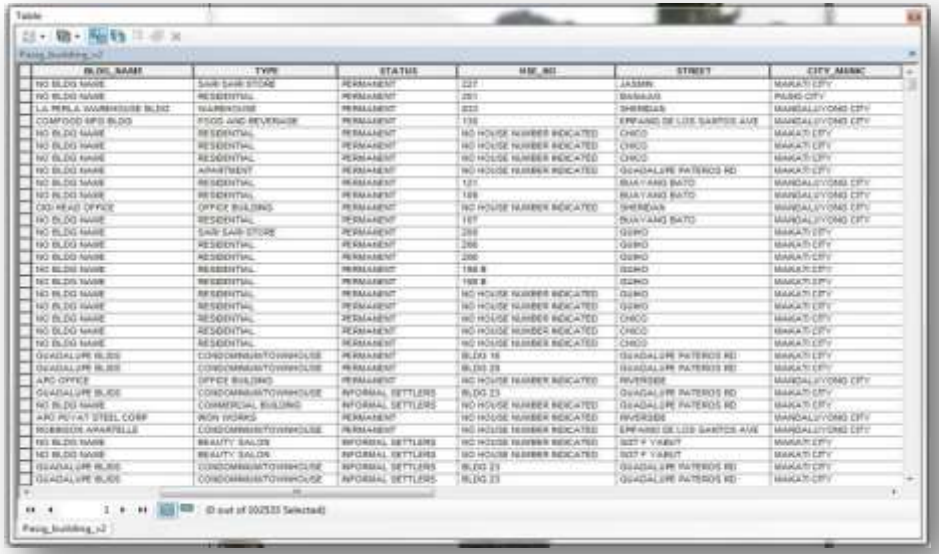
High resolution Digital Elevation Model and Imagery - LiDAR

High-resolution imagery draped over Digital Elevation Model

Location and Attributes of Buildings





BLDG_NAME	TYPE	STATUS	HSE_NO	STREET	CITY_MUNIC
NO BLDG NAME	SARI SARI STORE	PERMANENT	227	JASMIN	MAKATI CITY
NO BLDG NAME	RESIDENTIAL	PERMANENT	251	BANAUG	PASIG CITY
LA PERLA WAREHOUSE BLDG	WAREHOUSE	PERMANENT	833	SHERIDAN	MANDALUYONG CITY
COMFOOD MFG BLDG	FOOD AND BEVERAGE	PERMANENT	130	EMPANG DE LOS SANTOS AVE	MANDALUYONG CITY
NO BLDG NAME	RESIDENTIAL	PERMANENT	NO HOUSE NUMBER INDICATED	CHICO	MAKATI CITY
NO BLDG NAME	RESIDENTIAL	PERMANENT	NO HOUSE NUMBER INDICATED	CHICO	MAKATI CITY
NO BLDG NAME	RESIDENTIAL	PERMANENT	NO HOUSE NUMBER INDICATED	CHICO	MAKATI CITY
NO BLDG NAME	APARTMENT	PERMANENT	NO HOUSE NUMBER INDICATED	GUADALUPE PATEROS RD	MAKATI CITY
NO BLDG NAME	RESIDENTIAL	PERMANENT	121	BUAYANG BATO	MANDALUYONG CITY
NO BLDG NAME	RESIDENTIAL	PERMANENT	109	BUAYANG BATO	MANDALUYONG CITY
CBD HEAD OFFICE	OFFICE BUILDING	PERMANENT	NO HOUSE NUMBER INDICATED	SHERIDAN	MANDALUYONG CITY
NO BLDG NAME	RESIDENTIAL	PERMANENT	107	BUAYANG BATO	MANDALUYONG CITY
NO BLDG NAME	SARI SARI STORE	PERMANENT	258	GUMO	MAKATI CITY
NO BLDG NAME	RESIDENTIAL	PERMANENT	266	GUMO	MAKATI CITY
NO BLDG NAME	RESIDENTIAL	PERMANENT	268	GUMO	MAKATI CITY
NO BLDG NAME	RESIDENTIAL	PERMANENT	198 B	GUMO	MAKATI CITY
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NO BLDG NAME	RESIDENTIAL	PERMANENT	NO HOUSE NUMBER INDICATED	CHICO	MAKATI CITY
GUADALUPE BLDG	CONDOMINIUM/TOWNHOUSE	PERMANENT	BLDG 16	GUADALUPE PATEROS RD	MAKATI CITY
GUADALUPE BLDG	CONDOMINIUM/TOWNHOUSE	PERMANENT	BLDG 23	GUADALUPE PATEROS RD	MAKATI CITY
APO OFFICE	OFFICE BUILDING	PERMANENT	NO HOUSE NUMBER INDICATED	RIVERSIDE	MANDALUYONG CITY
GUADALUPE BLDG	CONDOMINIUM/TOWNHOUSE	INFORMAL SETTLERS	BLDG 23	GUADALUPE PATEROS RD	MAKATI CITY
NO BLDG NAME	COMMERCIAL BUILDING	INFORMAL SETTLERS	NO HOUSE NUMBER INDICATED	GUADALUPE PATEROS RD	MAKATI CITY
APO PUYAT STEEL CORP	IRON WORKS	PERMANENT	NO HOUSE NUMBER INDICATED	RIVERSIDE	MANDALUYONG CITY
ROBINSON APARTELLE	CONDOMINIUM/TOWNHOUSE	PERMANENT	NO HOUSE NUMBER INDICATED	EMPANG DE LOS SANTOS AVE	MANDALUYONG CITY
NO BLDG NAME	BEAUTY SALON	INFORMAL SETTLERS	NO HOUSE NUMBER INDICATED	SIOT F YABUT	MAKATI CITY
NO BLDG NAME	BEAUTY SALON	INFORMAL SETTLERS	NO HOUSE NUMBER INDICATED	SIOT F YABUT	MAKATI CITY
GUADALUPE BLDG	CONDOMINIUM/TOWNHOUSE	INFORMAL SETTLERS	BLDG 23	GUADALUPE PATEROS RD	MAKATI CITY
GUADALUPE BLDG	CONDOMINIUM/TOWNHOUSE	INFORMAL SETTLERS	BLDG 23	GUADALUPE PATEROS RD	MAKATI CITY

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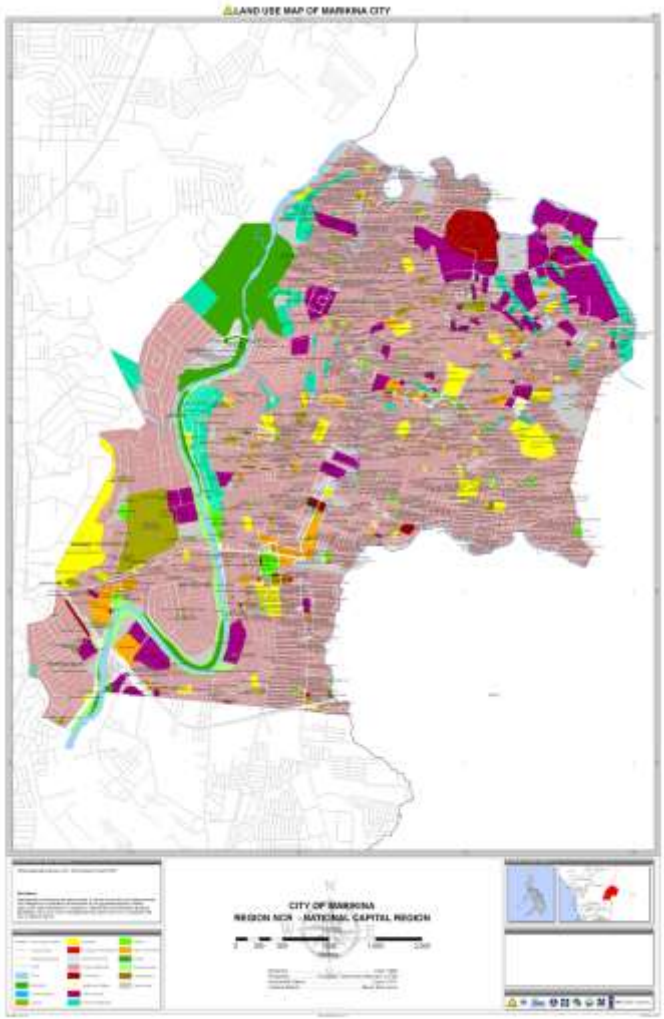
COMPONENT 2: Development of an Exposure Database for Greater Metro Manila Area (GMMA)

- Exposure information was obtained in the Greater Metro Manila Area for the analysis of natural hazard risk and climate change impacts.

- Exposure information can include details about:
  - Physical Location, Size and Shape
  - Administrative Area
  - Land Ownership
  - Land Use
  - Construction Period
  - Structural Characteristics
  - Demographic or Social Characteristics
  - Economic Characteristics

Exposure Information

- Area-Based Approach:
  - Divide land areas by their actual use
  - Develop statistical information about buildings, population etc.
  - Suitable for extensive urban and rural areas
- Feature-Based Approach:
  - Record location of individual features (buildings, structures etc)
  - Record specific attributes for each feature
  - Suitable for infrastructure
- Database can contain both Area-Based and Feature-Based data
- Area-Based Approach is being adopted for much of the first generation exposure data for this Project



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Exposure Information: Building Types and Year of Construction

CONCRETE

Material	Type	Sub-Type	Description	Year of Construction		
				Pre-1972	1972-1992	Post-1992
Concrete	CWS	CWS-L	Half-RC Frame/Half-Wood/Metal (1-2 storeys)		√	
	C1	C1-L	Moment Frame (1-2 storeys)		√	
		C1-M	Moment Frame (3-7 storeys)	√	√	√
		C1-H	Moment Frame (8-15 storeys)	√	√	√
	C2	C2-L	Shear Walls (1-2 storeys)		√	
		C2-M	Shear Walls (3-7 storeys)	√	√	√
		C2-H	Shear Walls (8-15 storeys)	√	√	√
		C2-V	Shear Walls (16-25 storeys)		√	√
		C2-E	Shear Walls (26-35 storeys)		√	√
		C2-S	Shear Walls (36+ storeys)		√	√
		C4-M	Shear Walls and Frames (3-7 storeys)	√	√	√
		C4-H	Shear Walls and Frames (8-15 storeys)	√	√	√
		PC1-L	Precast Tilt-up (1-2 storeys)	√	√	√
		PC2-L	Precast Frame (1-2 storeys)	?	?	√
		PC2-M	Precast Frame (3-7 storeys)	?	?	√

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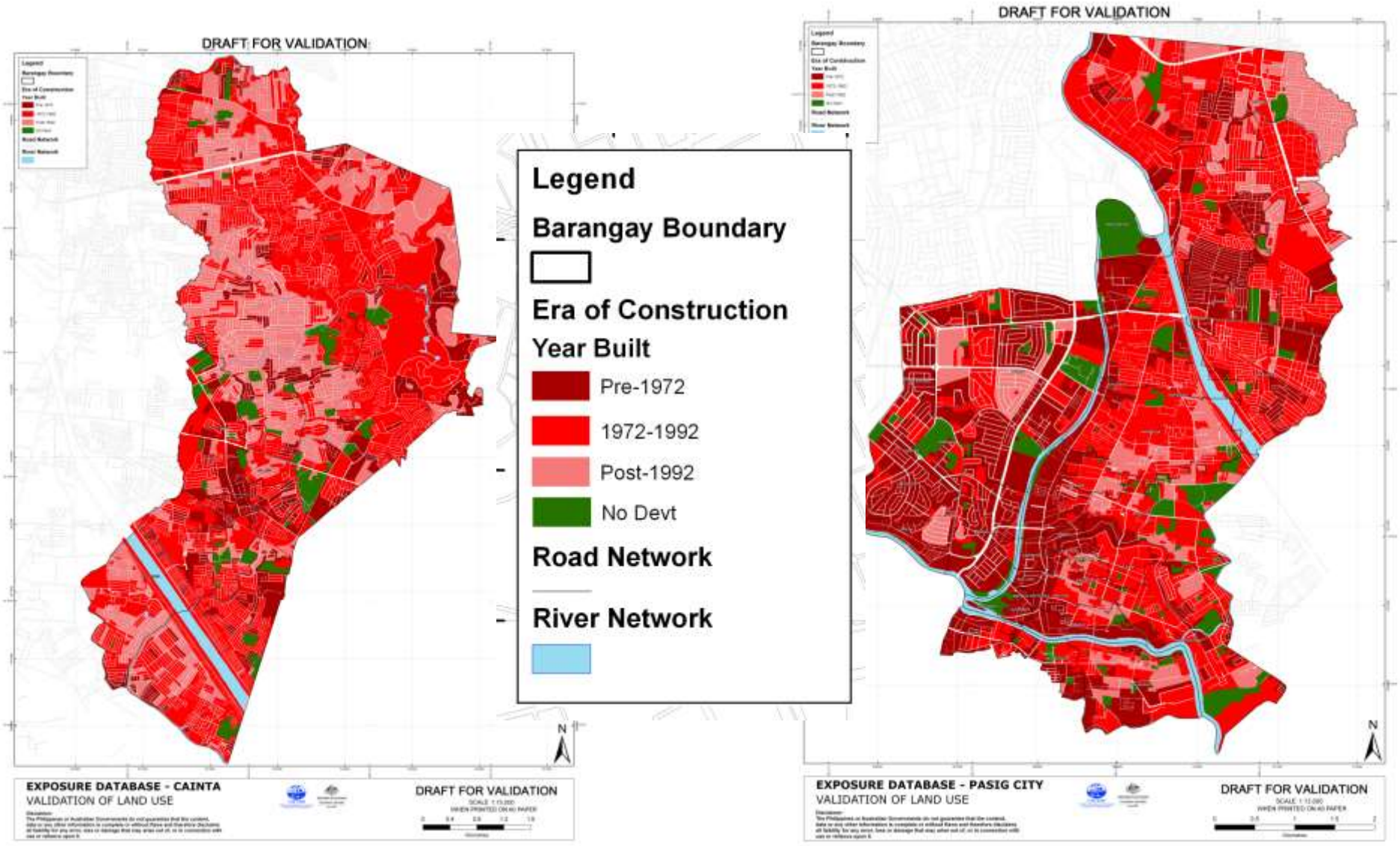
Exposure Information: Year of Construction



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COMPONENT 5: Earthquake Risk Modelling in Greater Metro Manila

Sub-component

- 1: Paleoseismic
- 2: Geotechnical
- 3: Ground Motion
- 4: Probabilistic Seismic Hazard Analysis (PSHA)
- 5: Impact Modelling

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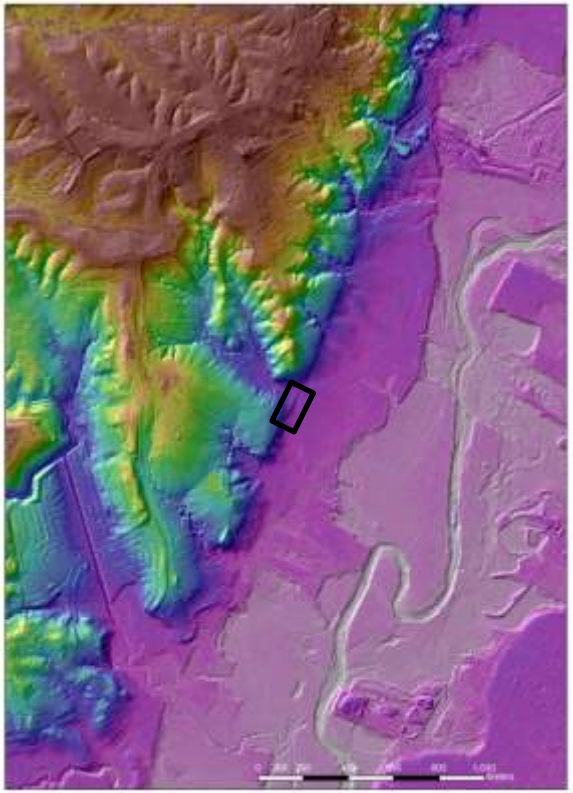
Paleoseismic activity - trenching

Bagong Silangan Trench Site



LiDAR-derived DEM (courtesy of AusAID)

Results

- at least 3 surface rupturing events in northern segment
- at least 3 to 5 rupturing events in southern segment

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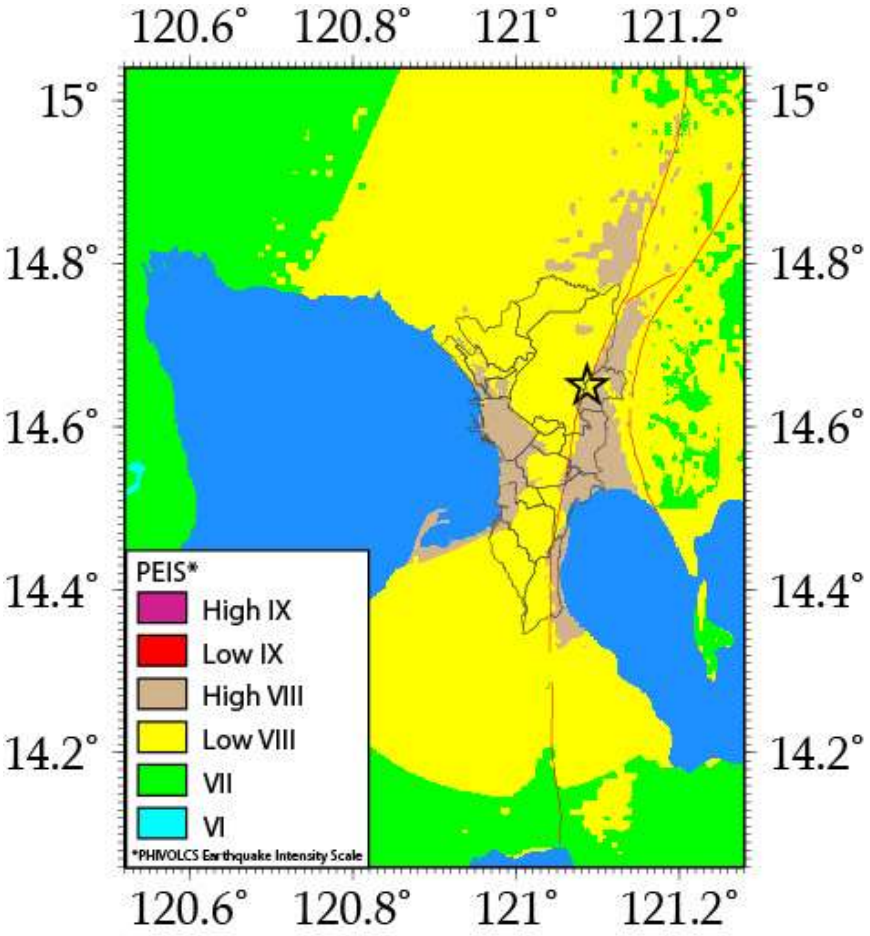
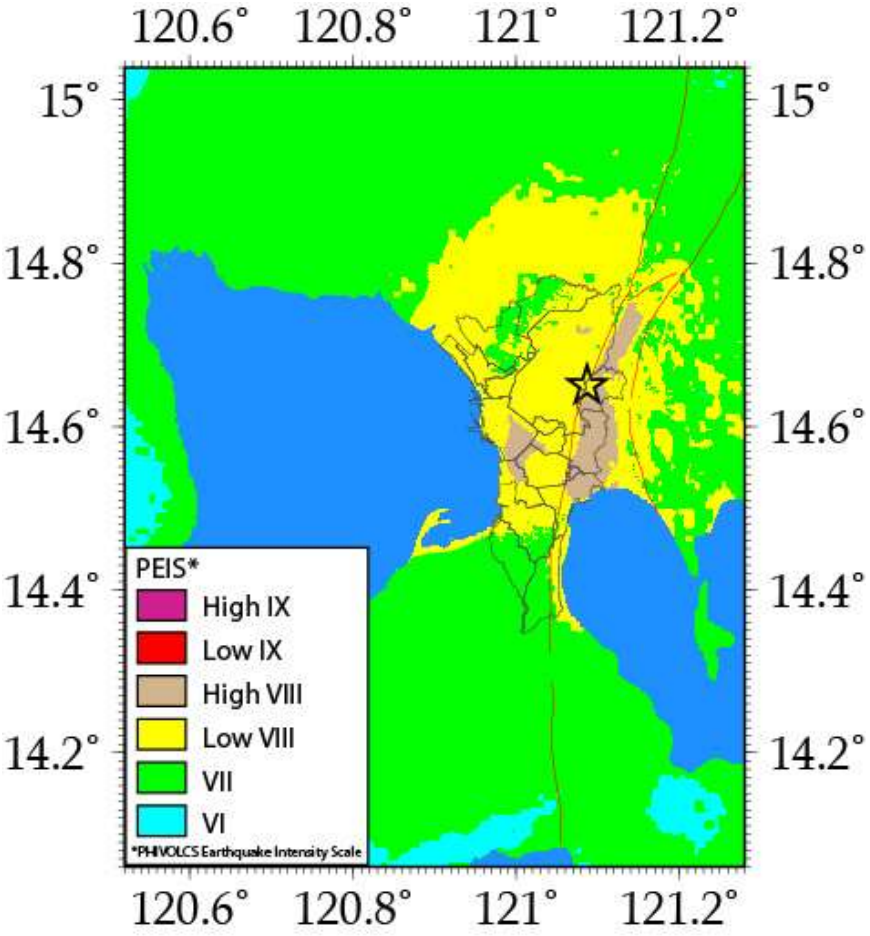
Ground Shaking Hazard Map for Greater Metro Manila



(M7.2, Depth = 5km)



(M6.5, Depth = 5km)

Risk Analysis Project, 2013)

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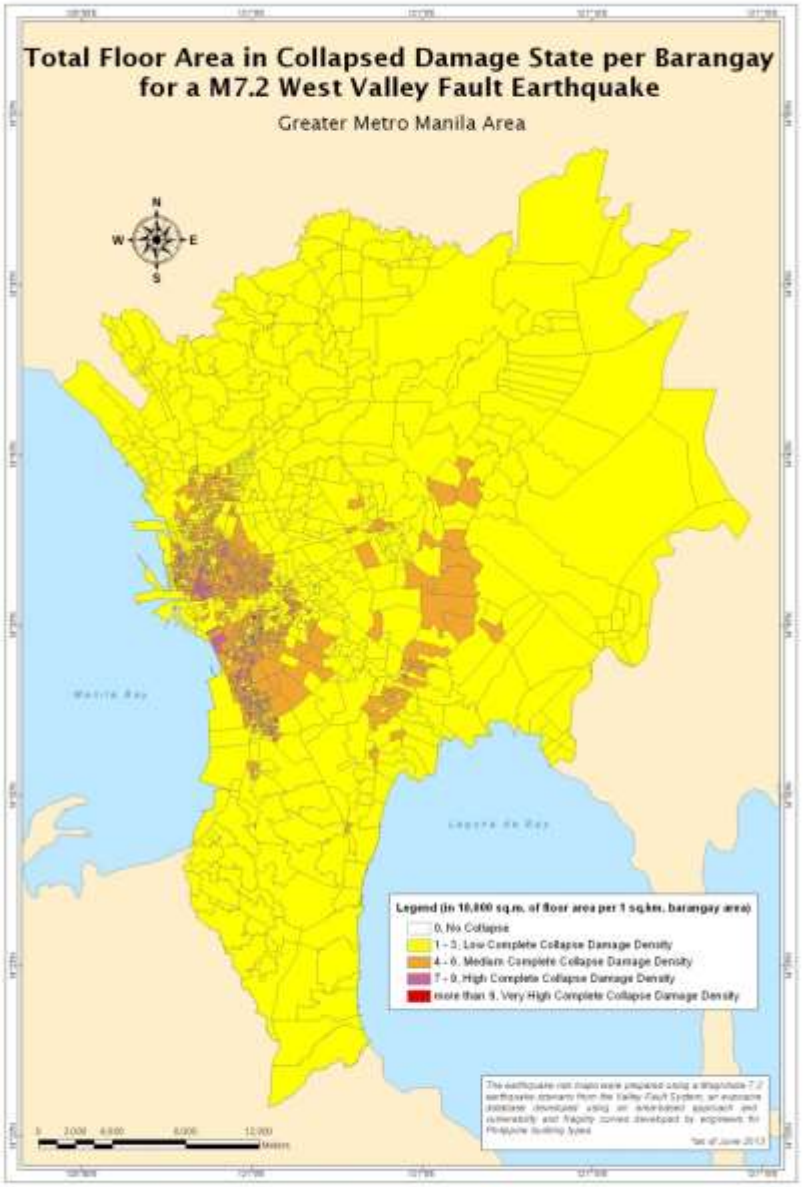
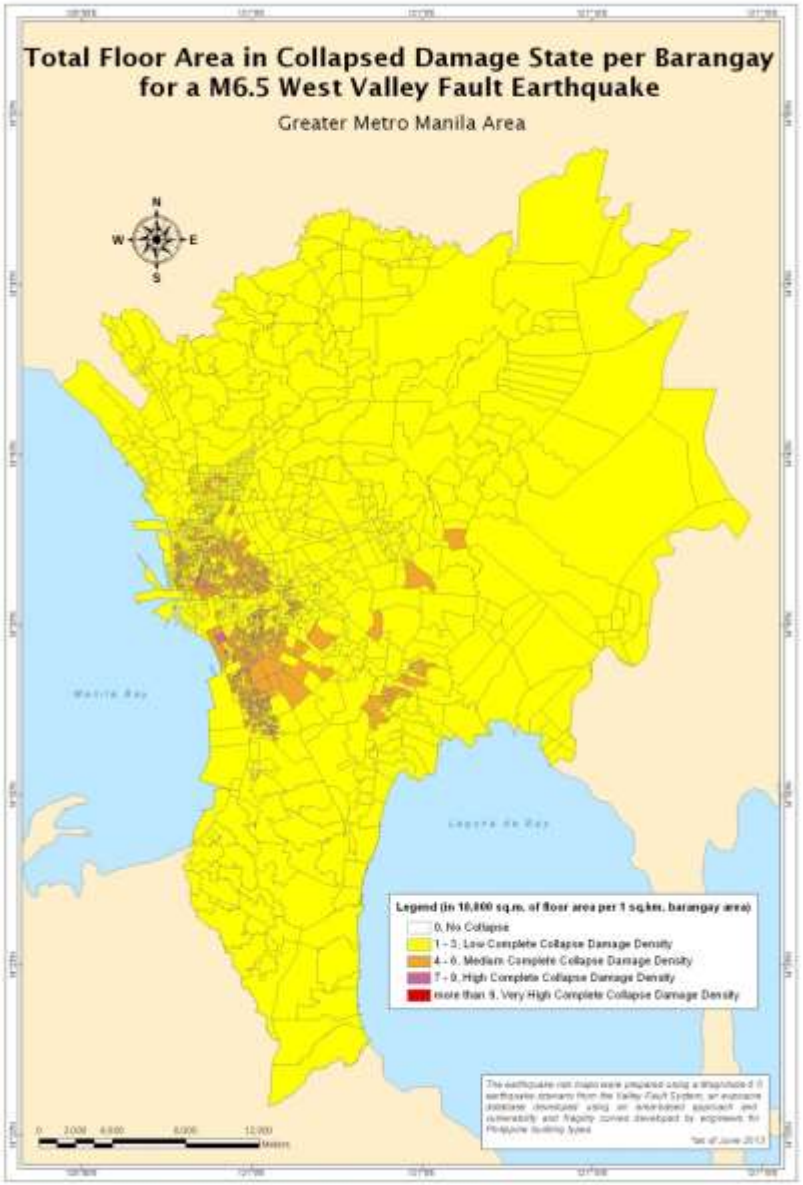
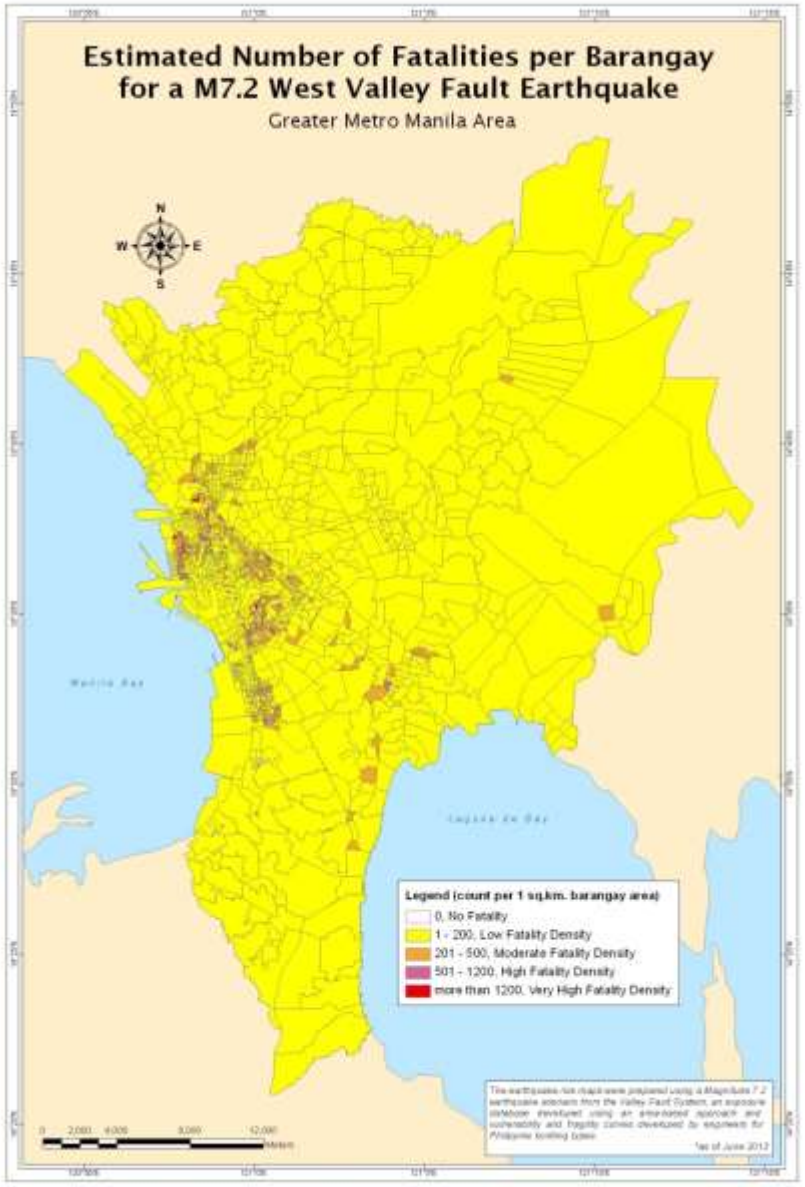
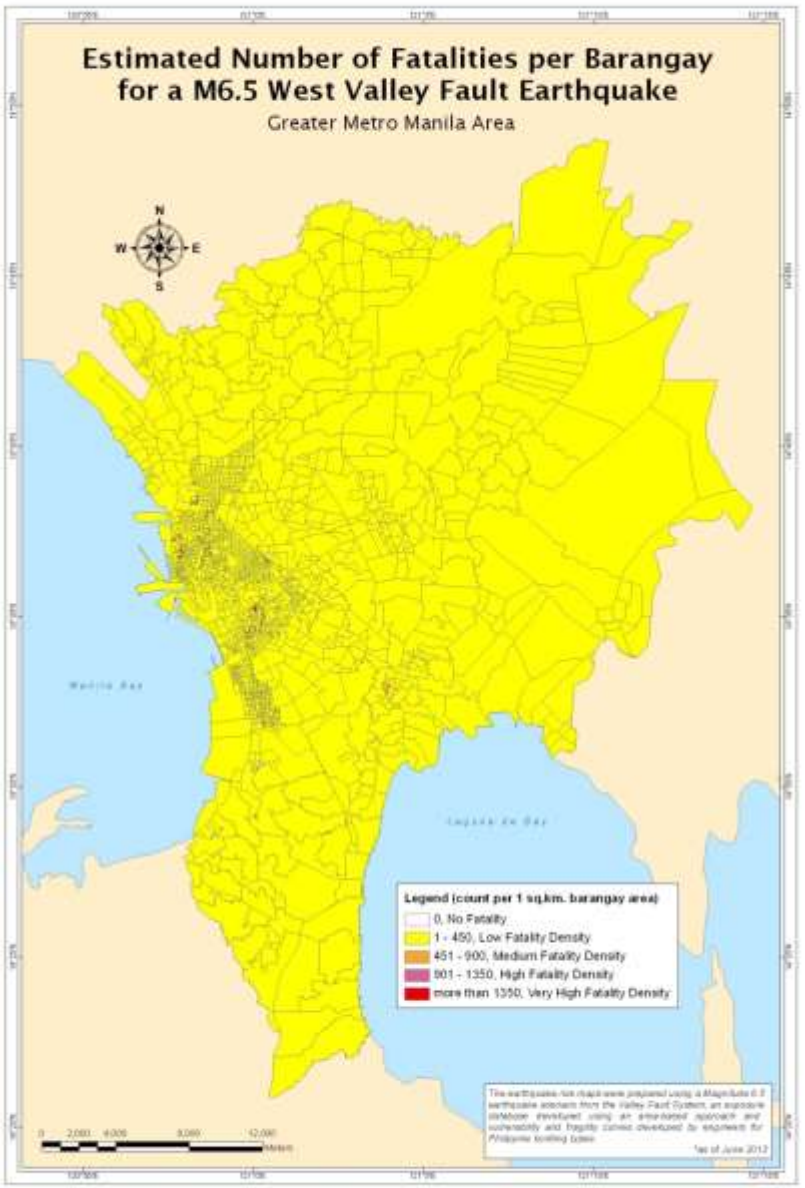
Total Floor Area Damage State Per Barangay



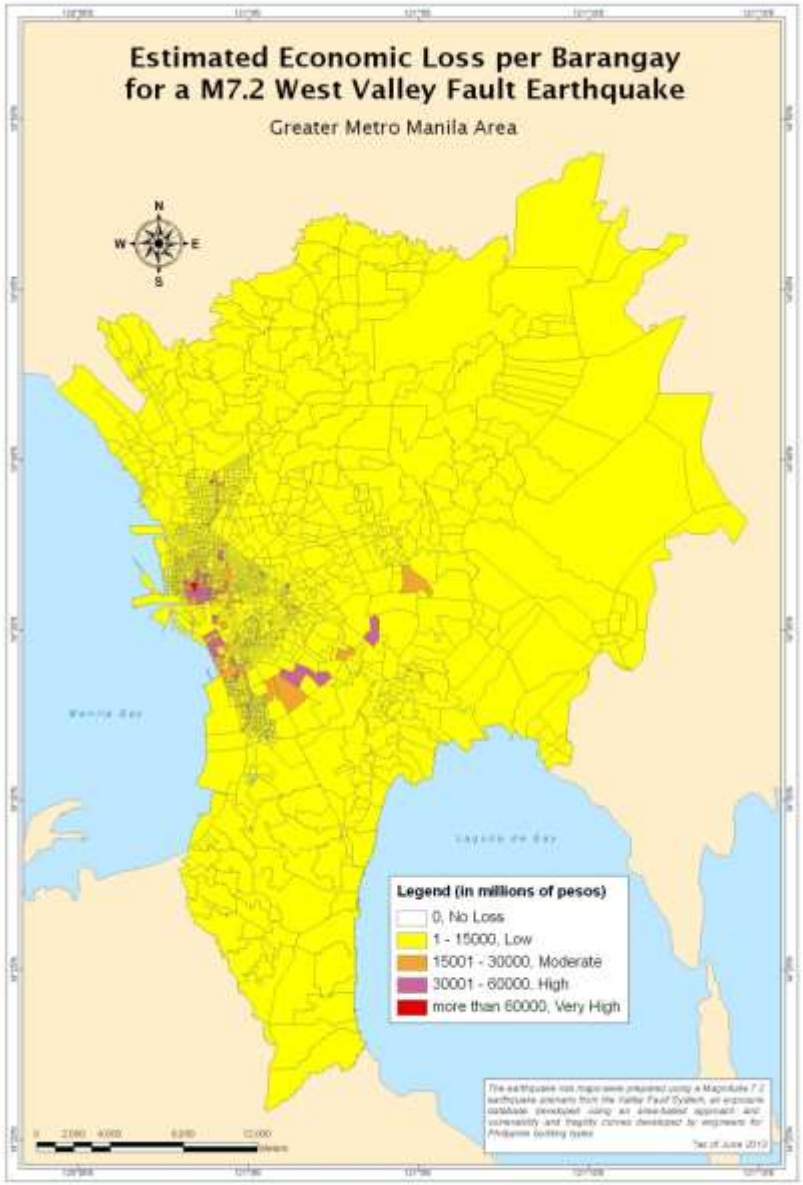


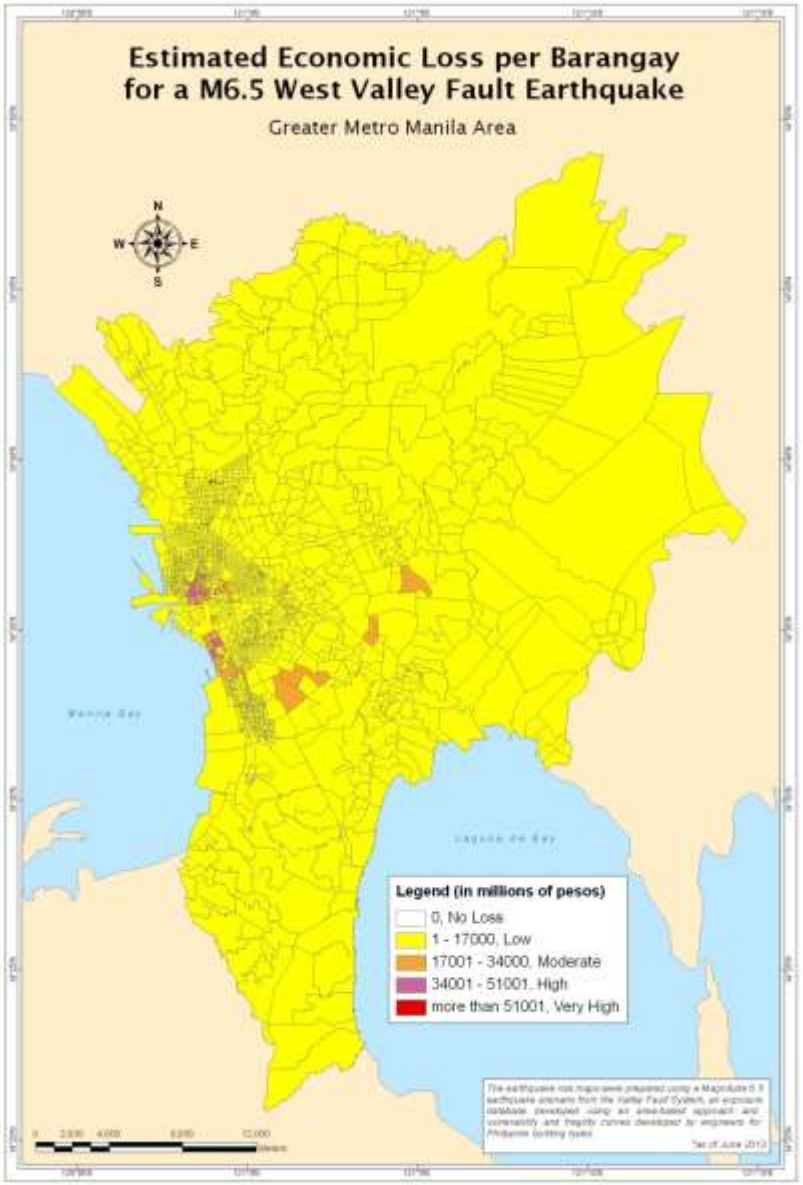
Fatalities Per Barangay





Estimated Economic Loss Per Barangay





Summary of Risk Analysis Project Results for GMMA

(Metro Manila + 5 LGUs of Rizal – Rodriguez, San Mateo, Antipolo, Cainta, Taytay)

		M7.2	M6.5
Total Floor Area in Collapsed Damage (sqm)		11,053,000	8,169,000
Total Floor Area in Complete Damage (sqm)		89,089,000	66,646,000
Total Floor Area in Extensive Damage (sqm)		70,490,000	57,082,000
Total Floor Area in Moderate Damage (sqm)		76,704,000	73,819,000
Total Floor Area in Slight Damage (sqm)		44,804,000	50,218,000
Total Fatalities		37,000	27,000
Total Injuries	Very Serious	16,000	12,000
	Serious	132,000	102,000
	Slight	456,000	359,000
Total Economic Losses (millions of PhP)		2,473,000	1,940,000

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Summary of Risk Analysis Project Results – Metro Manila

		M7.2	M6.5
Total Floor Area in Collapsed Damage (sqm)		9,642,000	7,068,000
Total Floor Area in Complete Damage (sqm)		78,500,000	58,339,000
Total Floor Area in Extensive Damage (sqm)		63,511,000	50,998,000
Total Floor Area in Moderate Damage (sqm)		68,849,000	66,457,000
Total Floor Area in Slight Damage (sqm)		40,564,000	45,344,000
Total Fatalities		31,000	23,000
Total Injuries	Very Serious	14,000	10,000
	Serious	112,000	85,171
	Slight	385,000	302,000
Total Economic Losses (millions of PhP)		2,269,000	1,773,000

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Risk Analysis Per City/Municipality in Metro Manila

M7.2 Scenario from the West Valley Fault

MUNICIPALITY	AREA (sqm)	Slight Damage (sqm)	Moderate Damage (sqm)	Extensive Damage (sqm)	Complete Damage (sqm)	Complete Collapse (sqm)	Loss (millions of pesos)	Slight Injuries	Serious Injuries	Life-threatening Injuries	Fatalities
Caloocan	53201841	3479806	5232422	4087406	5072855	625656	119027	41243	11567	1295	3114
Manila	42882803	4010957	8103927	9825526	11969904	1385187	400031	62895	18845	2775	5449
Las Piñas	32020293	1898996	3036596	2420619	2990543	405359	70436	19231	5582	616	1491
Makati	21731876	2239323	4291520	4261247	6223243	638784	234339	15458	4670	609	1427
Malabon	15963229	1012122	1670251	1477221	1960091	227640	41751	10325	3046	403	874
Mandaluyong	11067798	1199782	2063208	1912450	2249883	253941	76352	10271	3001	392	817
Marikina	22646526	1214505	2396756	2707179	4003510	548329	87926	18129	5511	657	1617
Muntinlupa	41676056	1736660	3020253	2877665	3845083	476436	101281	16259	4677	514	1206
Navotas	11518069	394736	707097	709673	1016382	117412	20429	9344	2733	354	740
Parañaque	47289915	2897909	4893277	4307947	5149340	681479	131392	18616	5396	496	1385
Pasay	18645496	1096852	2129076	2479783	3062884	368315	100406	12977	3641	565	1117
Pasig	31464095	2213476	4156819	4708861	6922002	856014	190686	25649	7908	1135	2387
Pateros	1764233	83141	167761	222650	472378	58103	7263	2747	834	117	239
Quezon	165330829	11049945	17663877	14187637	15414694	1997221	449214	73549	20871	2232	5524
San Juan	5879834	699746	1156132	951902	920029	114219	31760	3667	1046	105	306
Taguig	45183558	2014723	3373491	3300500	4594379	532398	118643	29529	8700	1018	2366
Valenzuela	45751216	3321678	4786840	3073094	2633301	356300	87908	15656	4398	468	1169
SUM		40,564,357	68,849,303	63,511,360	78,500,501	9,642,793	2,268,844	385,545	112,426	13,751	31,228

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How do we prepare for and reduce risks from major earthquakes?

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Earthquake Preparedness and Impact Reduction

–

Public Help	**Legislations, Building Regulations Land Use Planning**
	Construction & Retrofitting Public Buildings and Infrastructure
	Emergency Shelter & Operation Disaster Information System
Mutual Help	**Community Emergency Response Plan & Drill** **Evacuation, Fire, First Aid** **Information Management**
Self Help	**Individual Preparation Safer House**

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Contact Us:

Earthquake & Tsunami (24/7):

Tel. Numbers

- +632 929-9254
- +632 426-1468 loc 124 / 125

Fax number

- +632 927-1087

Volcano (24/7):

Tel. Numbers

- +632 426-1468 loc 127

Telefax number

- +632 927-1095

IEC materials:

- +632 426-1468 loc 128
- +632 927-4524

http://www.phivolcs.dost.gov.ph

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