

# OVERVIEW OF EARTHQUAKE RISK IN METRO MANILA AND DEVELOPING EARTHQUAKE PREPAREDNESS

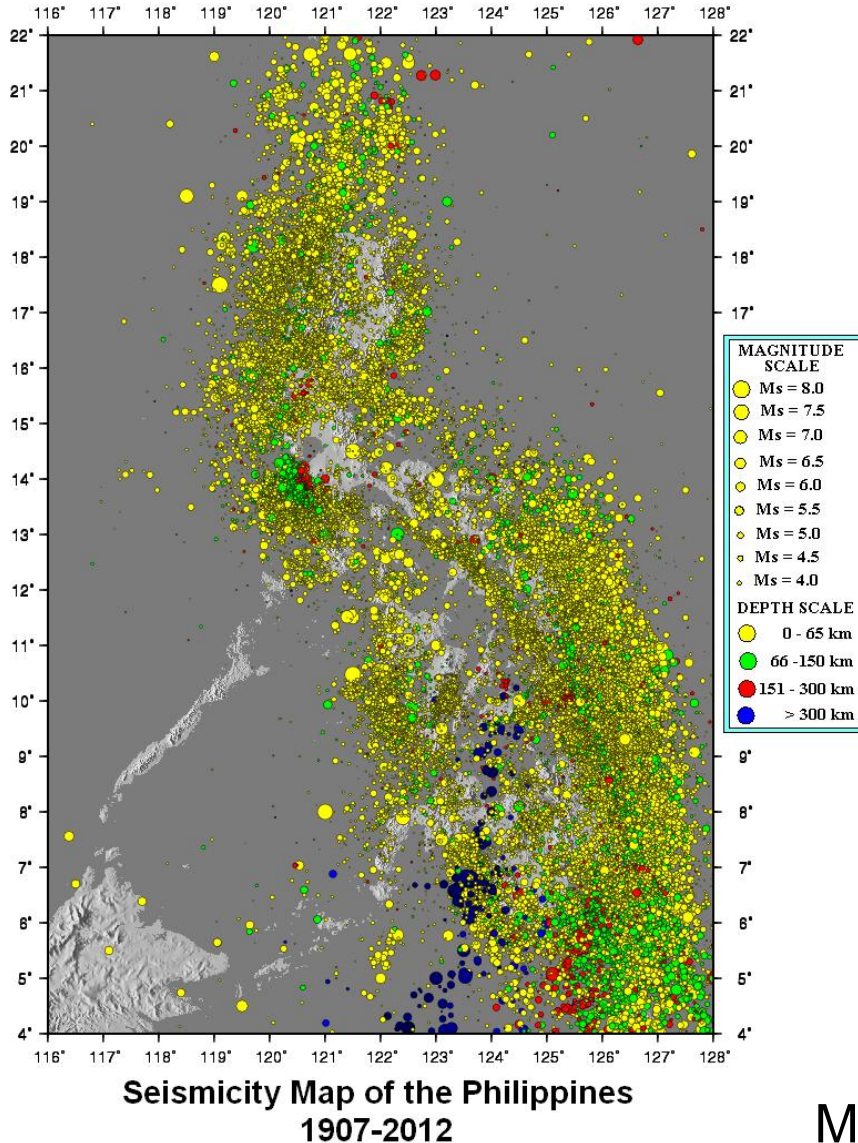
Asian Development Bank  
May 28, 2013

Renato U. Solidum Jr.  
*Philippine Institute of Volcanology and Seismology-  
Department of Science and Technology*



# Earthquake Activity in the Philippines

(~90 destructive earthquakes for past 400 years – 1 in 5 years)



M7.8 1990 Luzon Earthquake



M6.9 2012 Negros Or Earthquake

# Some destructive Philippine earthquakes

<b>Year</b>	<b>M</b>	<b>Location</b>	<b>Dead/Missing</b>	<b>Effects</b>
<b>1863</b>		Manila	876	Collapse, tsunami
1918	8.3	S. Cotabato	100	Collapse, tsunami
1955	7.5	Lanao	291	Collapse
<b>1968</b>	7.3	Aurora	270	Collapse in Manila
1976	7.9	Mindanao	3792/1937	Collapse, tsunami
<b>1990</b>	7.8	C. Luzon	1283 /321	Collapse, landslide, liquefaction, rupture
<b>1994</b>	7.1	Mindoro	83/8	Collapse, tsunami, liquefaction, rupture
2012	6.9	Negros Or.	58/62	Collapse, landslide liquefaction, tsunami

\* Earthquakes felt in Manila in bold

# Earthquake-related Hazards



**Fault (Ground) Rupture**



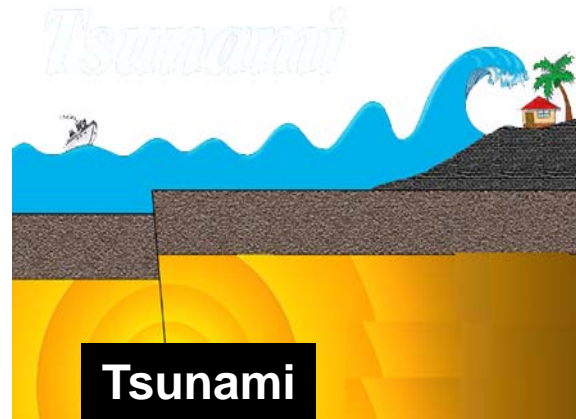
**Ground Shaking –  
Collapse of Building**



**Liquefaction**



**Landslide**



**Tsunami**

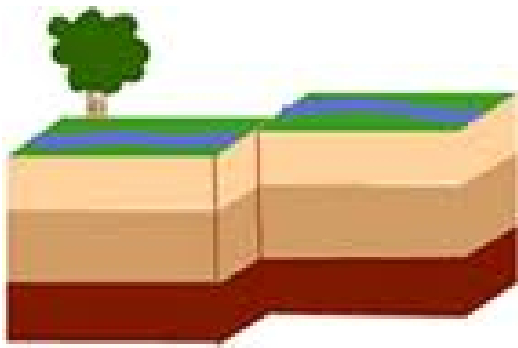


**Fire**

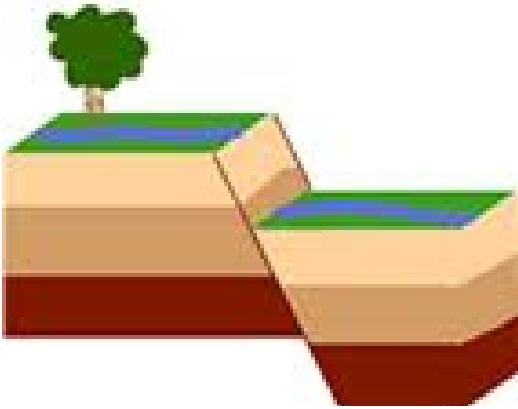
# Faults

- fractures where rock movement has taken place and earthquakes have been produced

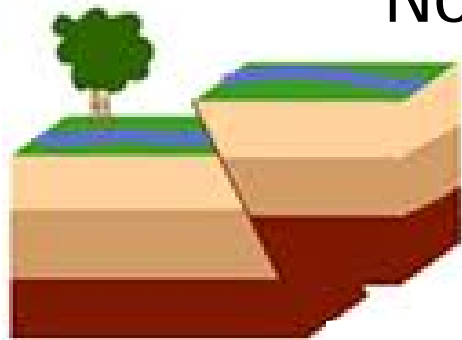
- active faults are those that moved in the last 10,000 years



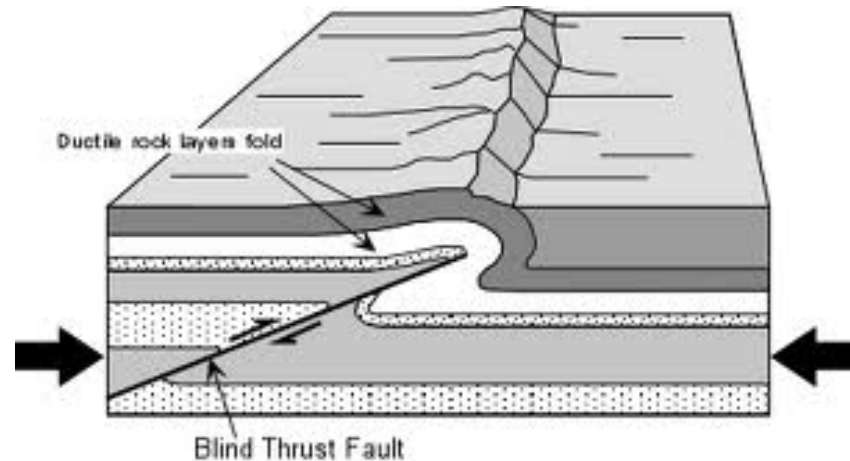
Strike Slip



Normal

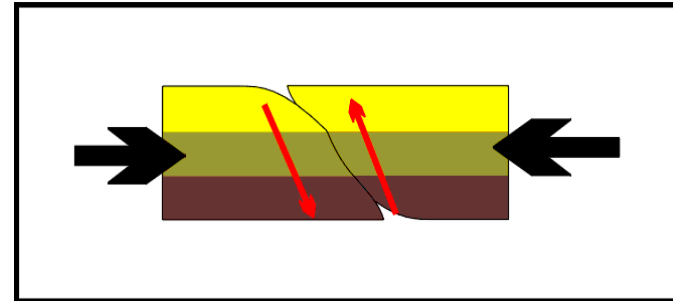
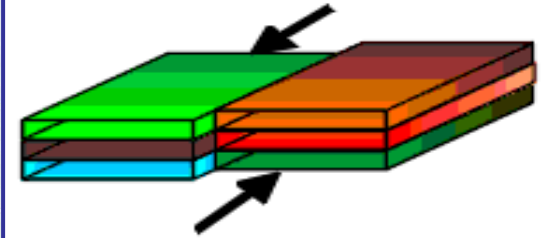
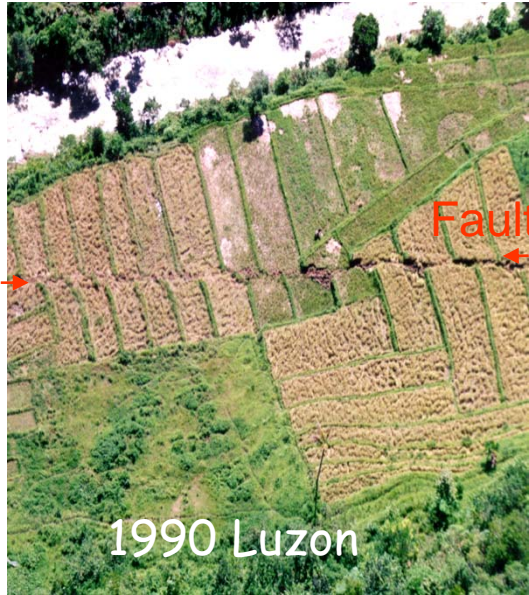


Thrust



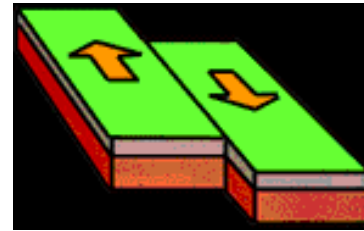
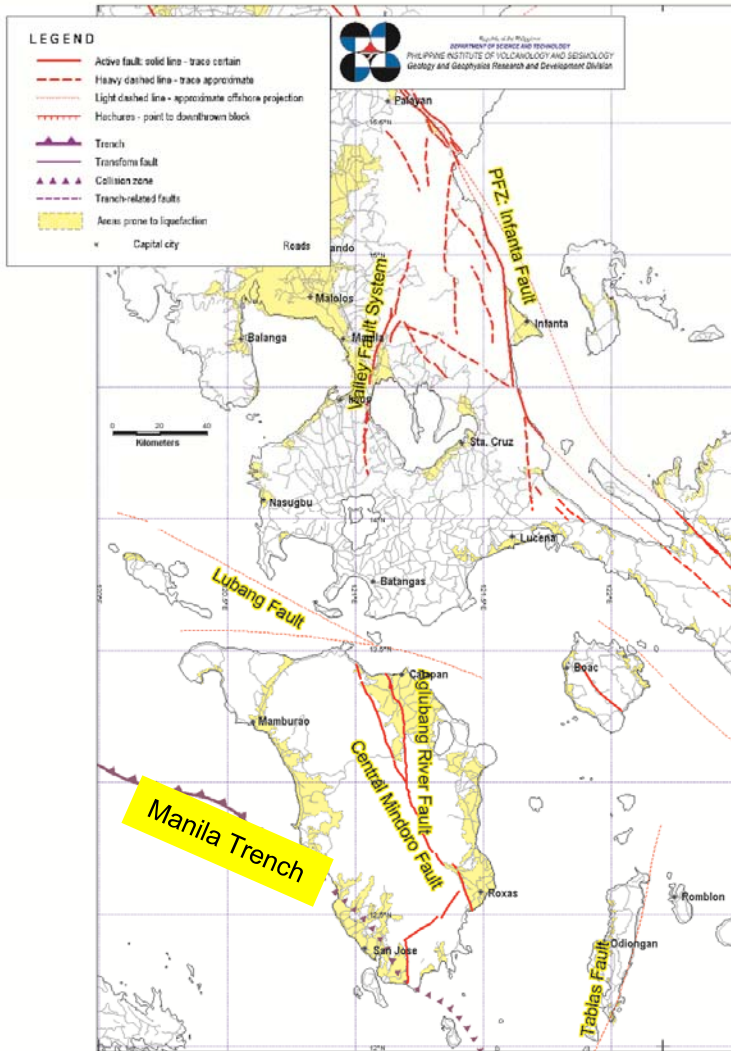
Blind Fault

# Fault (Ground) Rupture



1999 Taiwan

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

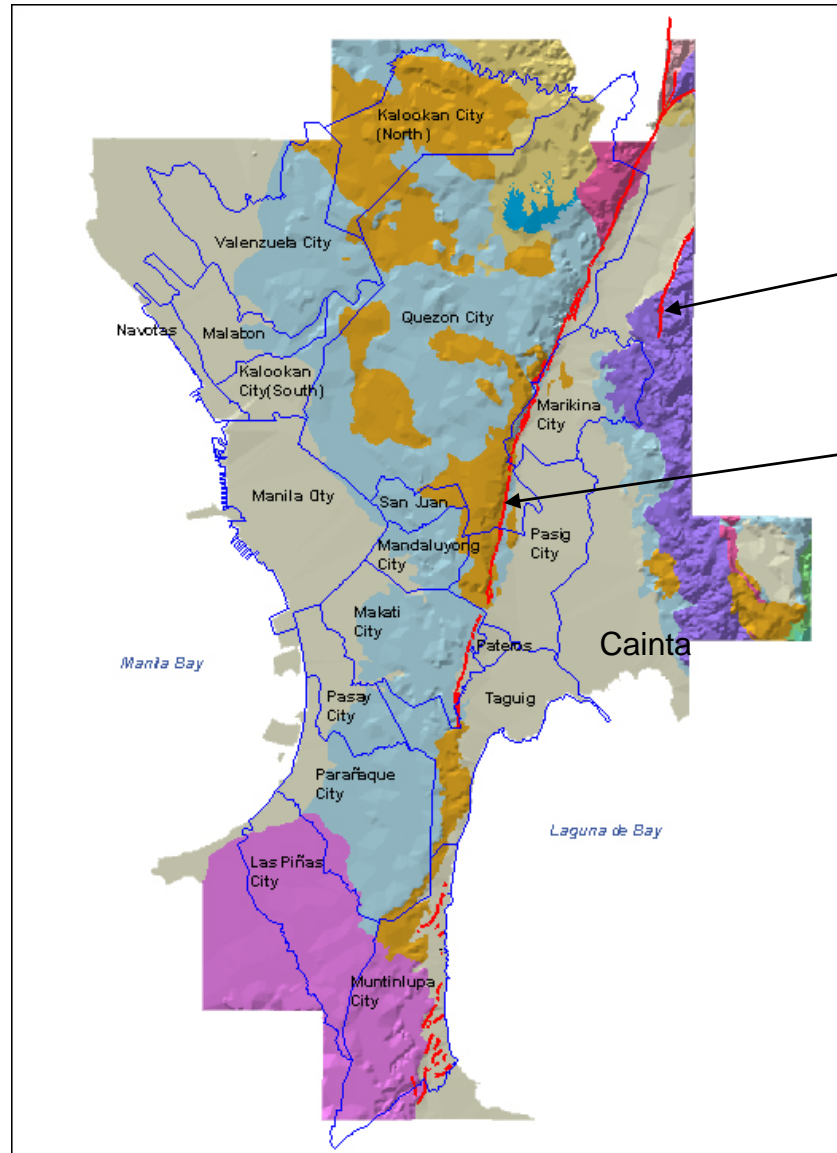


Active Faults



Trenches

# Geology of Metro Manila and Vicinity



East Valley Fault

West Valley Fault

Alluvium – liquefaction prone

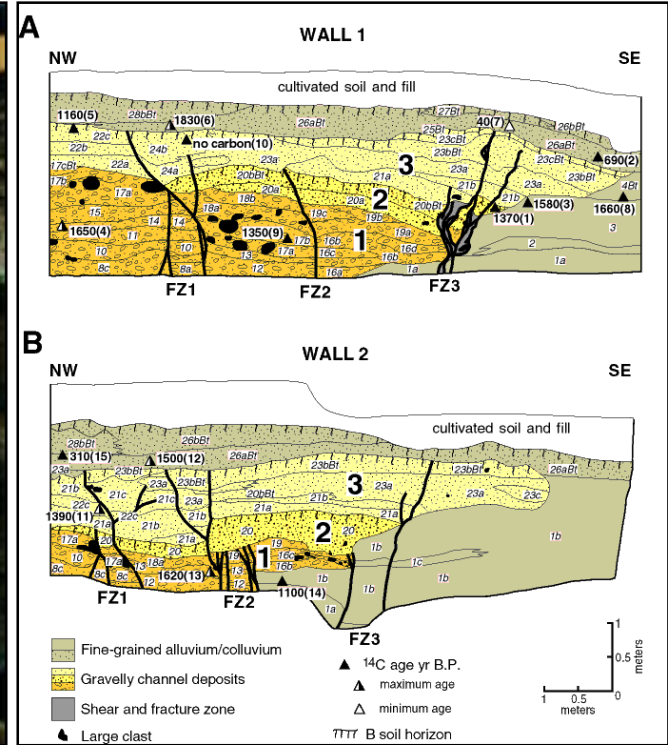
	Quaternary alluvium		Basement complex
	Tuff and tuffaceous sediment		Limestone
	Pyroclastic flow deposit adobe		Diorite
	Lava flow		La Mesa Dam
	Taal pyroclastic		Fault trace
	Conglomerate		Municipal/City boundary
	Volcaniclastics		

Note:  
Surface geology draped over digital elevation model with 2x vertical exaggeration. (As of May 2001)

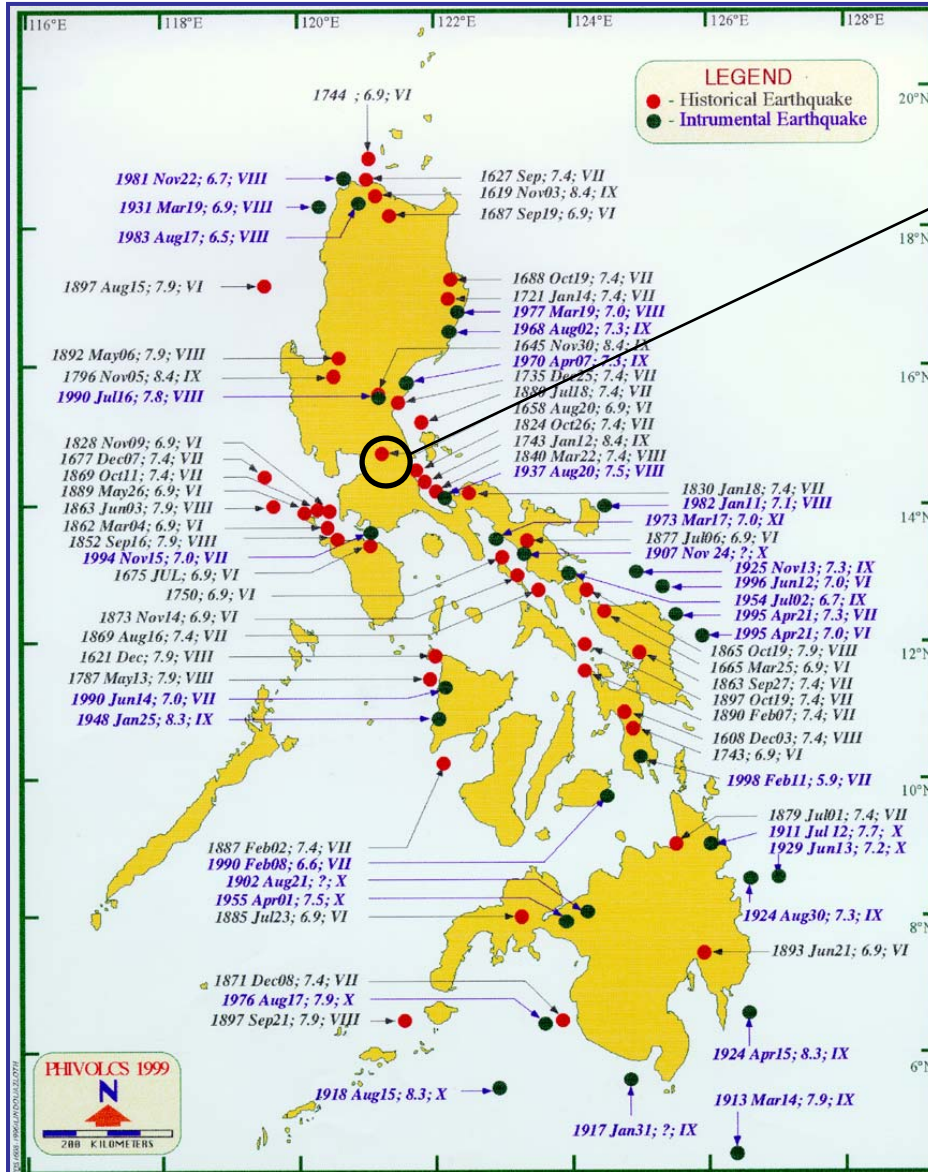


# Valley Fault System

- Paleo-seismological studies indicate that West Valley Fault moved 4 times for past 1400 years generating earthquakes of ~Magnitude 7



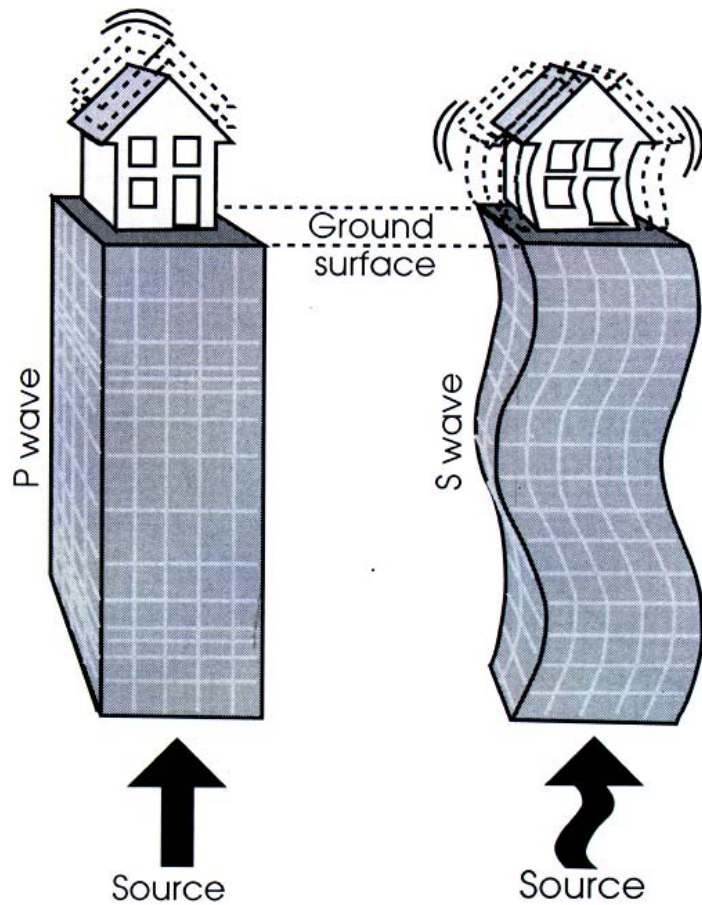
# Destructive Earthquake From West Valley Fault



August 20, 1658 3pm M6.9

- Maybe related to movement of West Valley Fault
- Affected southern Luzon, Manila and neighbouring provinces: Manila - wiped out not only what had been damaged by the previous earthquake (1645) but also what appeared very solid. (SEASEE)

# Ground Shaking



**Primary (P-) and Secondary (S-) waves. P-waves are transmitted as a compressional disturbance, while S-waves are transmitted as a transverse disturbance.**

# Ground Shaking

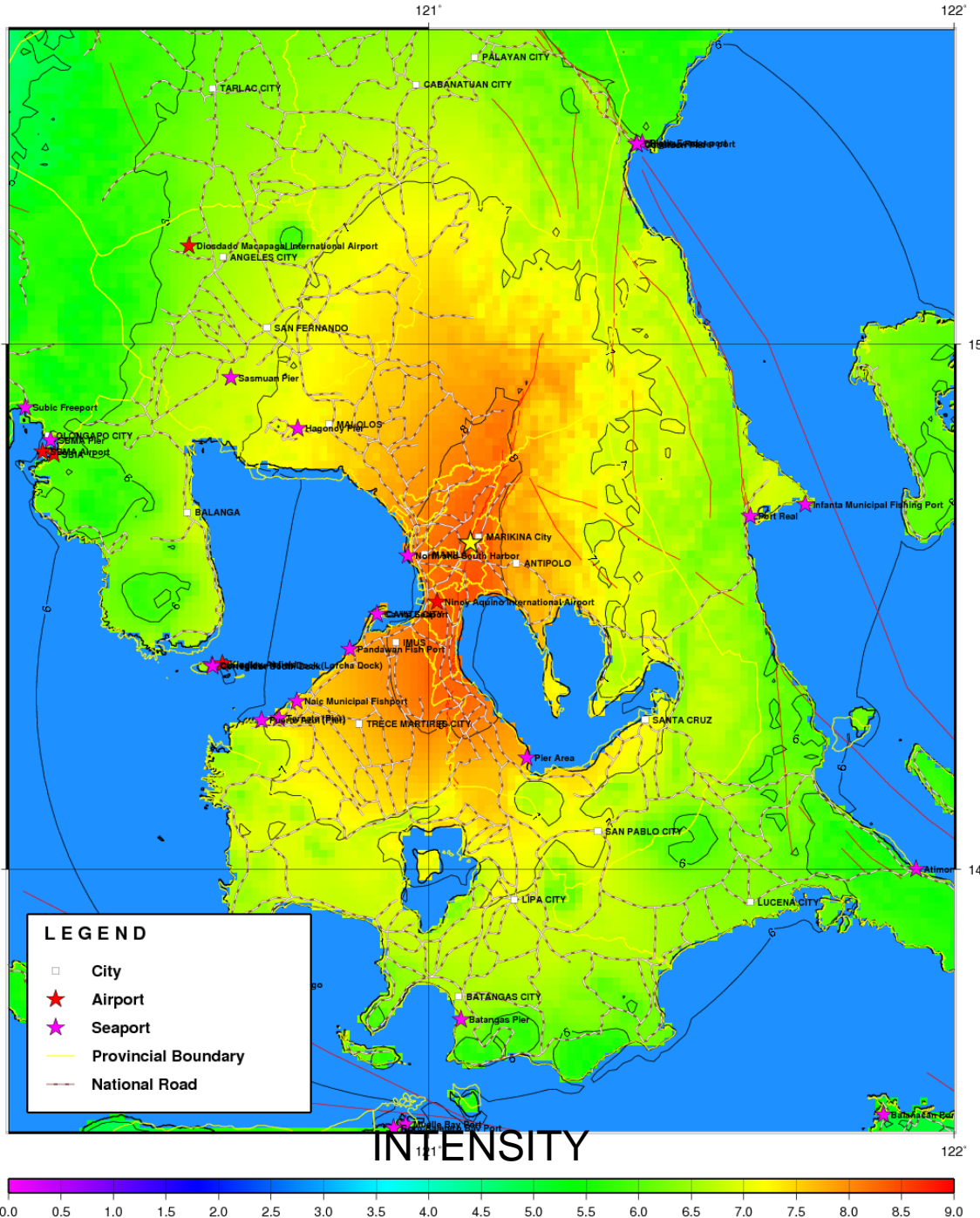


17sec. video recorded by a convenience store's surveillance camera in Kobe City, Japan due to M6.9 earthquake

# Ground Shaking Intensity Distribution for Metro Manila and Surrounding Provinces

## M7.2 West Valley Fault Scenario

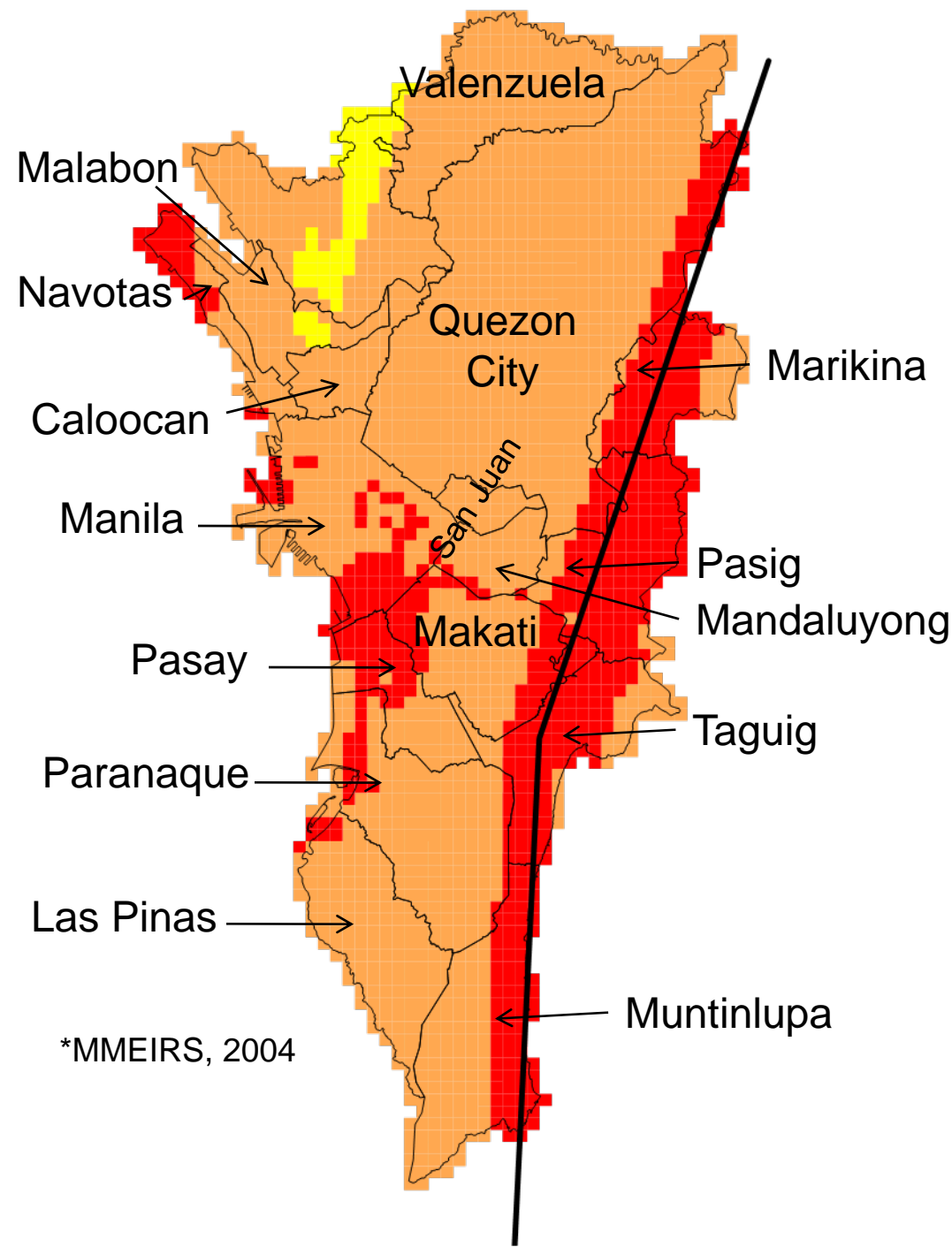
**REDAS Simulation**



# Ground Shaking Hazard for Metro Manila

Magnitude 7.2

West Valley Fault Scenario

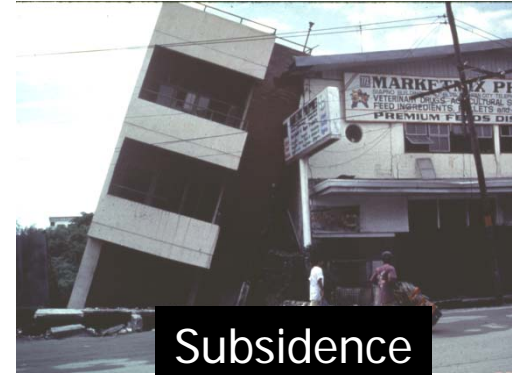


Intensity (PEIS)



\*MMEIRS, 2004

# Liquefaction



Subsidence



Rise of buried pipes, tanks

Loose, water-rich sediments like liquid during strong ground shaking and sediments are rearranged into a more compact state.



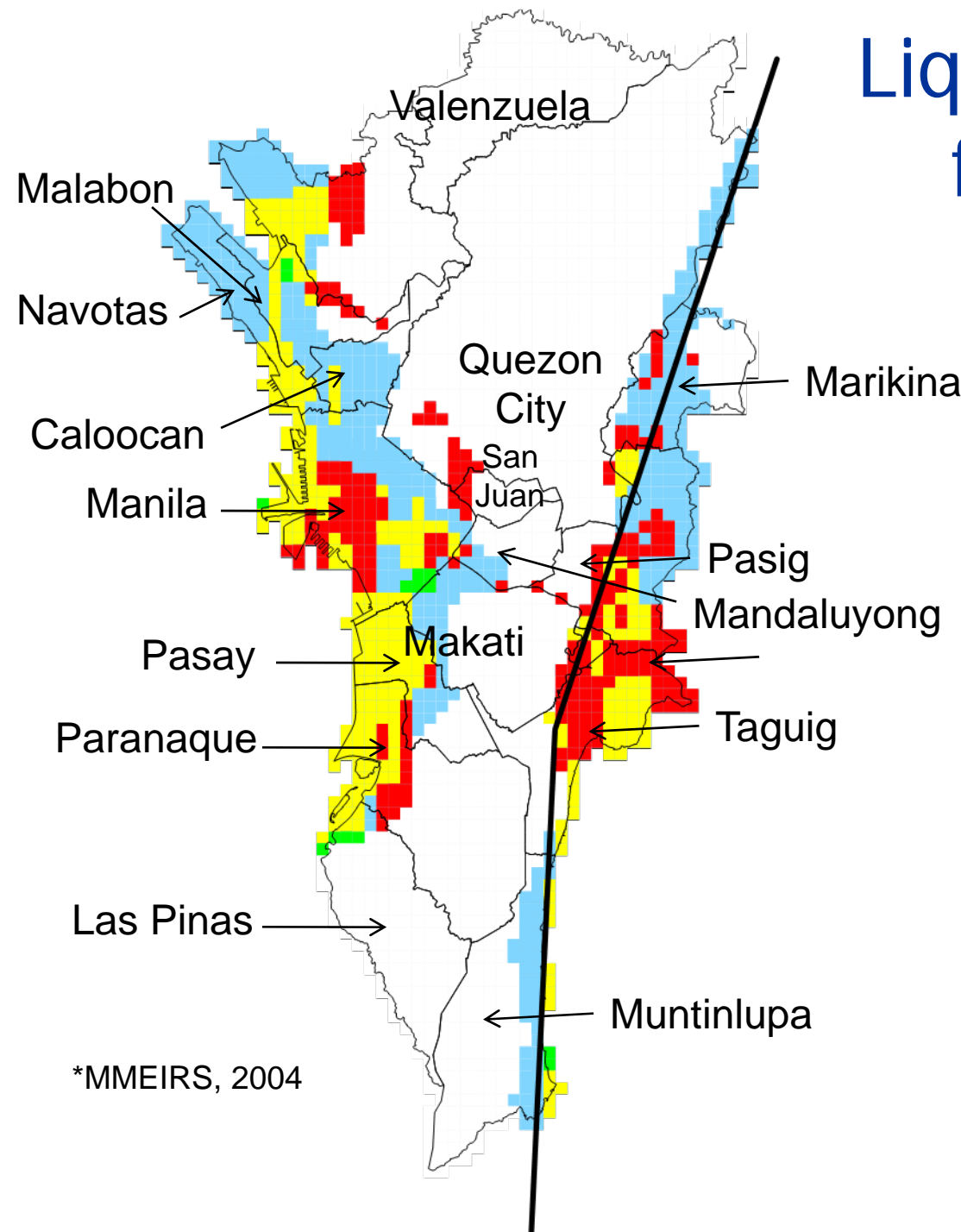
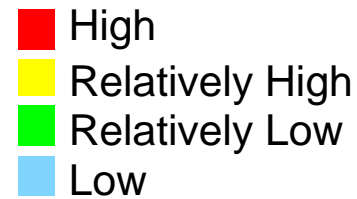
Lateral spreading

# Liquefaction Potential for Metro Manila

Magnitude 7.2

West Valley Fault Scenario

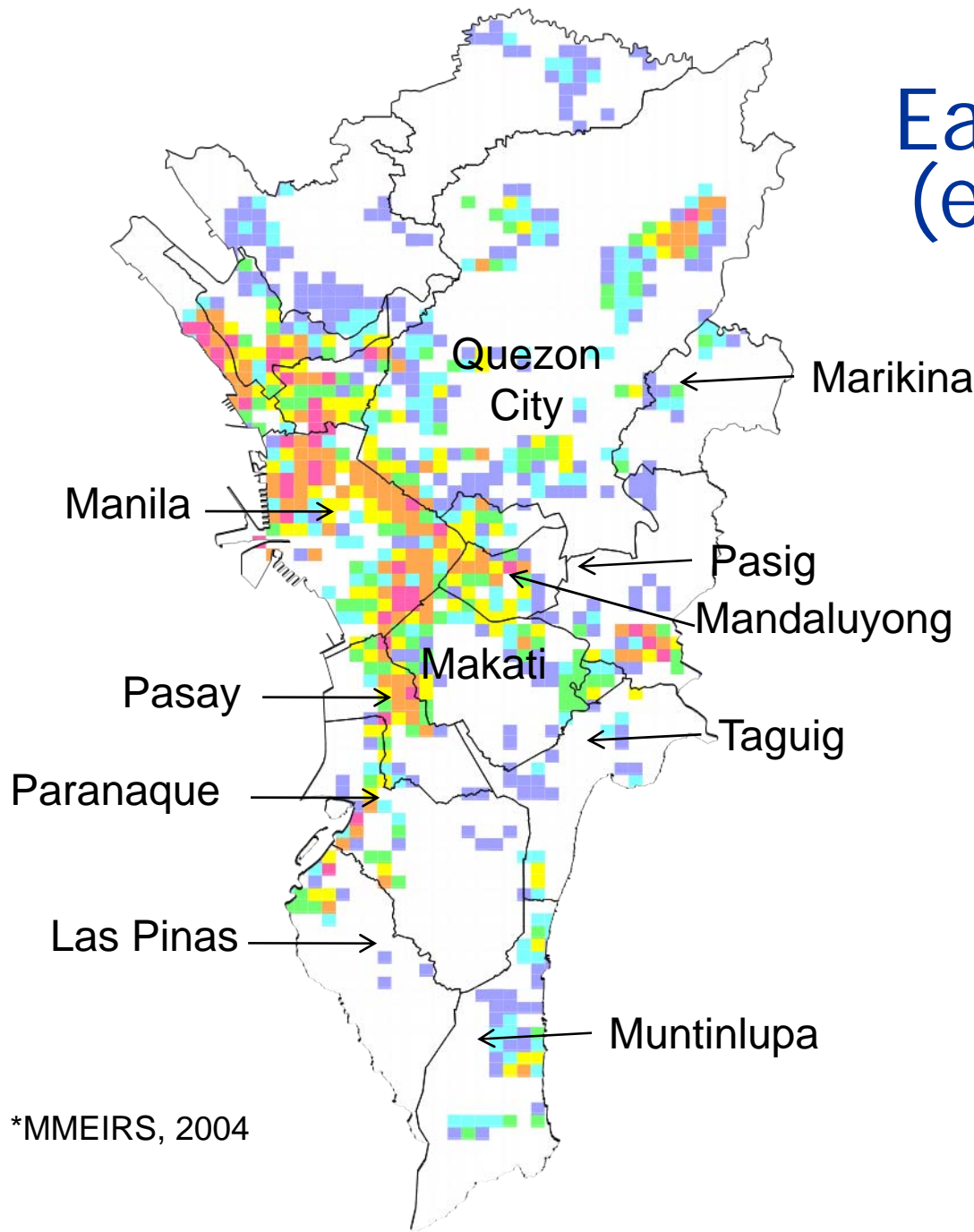
Liquefaction Potential



\*MMEIRS, 2004



# Fire After Earthquake Hazard (ex. Metro Manila)



Fire outbreak by electrical short circuit; toppling of lamps, candles

Explosion of petroleum, gas tanks may cause spreading of fire

\*MMEIRS, 2004

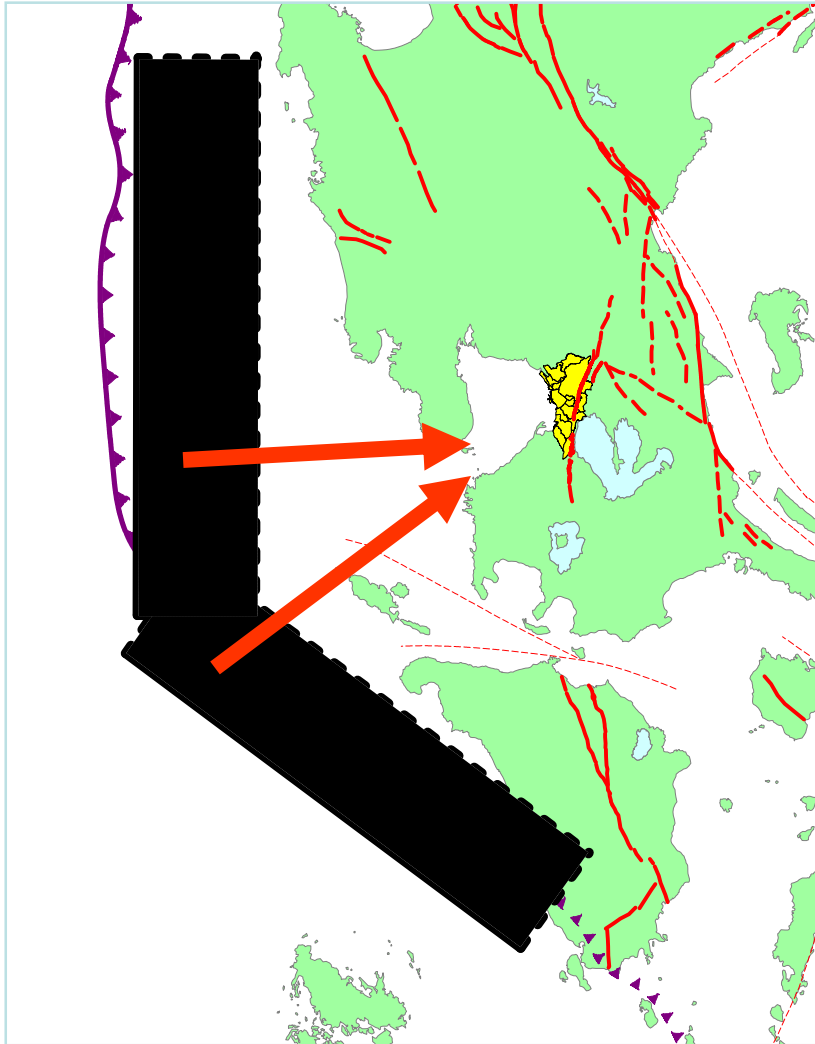
# Tsunami

Sea waves resulting from 1) vertical displacement of ocean floor associated with earthquake, 2) submarine landslides, 3) submarine eruption, 4) meteor impact

- Flooding of coastal areas
- Drowning of people
- Damage to properties



# Tsunami



- Model 13 (Manila Trench)
  - Average height... 2 m
  - Maximum..... 4 m
  - Arrival time .....~ 1 hour

\*MMEIRS, 2004

# Building Damage and Human Casualty for Metro Manila

## West Valley Fault M7.2

### Residential Building (1,325,896)

Damage	Heavy	168,300 (12.7%)
	Partly	339,800 (25.6%)

### Public Buildings

Damage	Heavy	8-10%
	Partly	20-25%

### 10-30 Storey

Damage	Heavy	11%
	Partly	27%

### 30-60 Storey

Damage	Heavy	2%
	Partly	12%

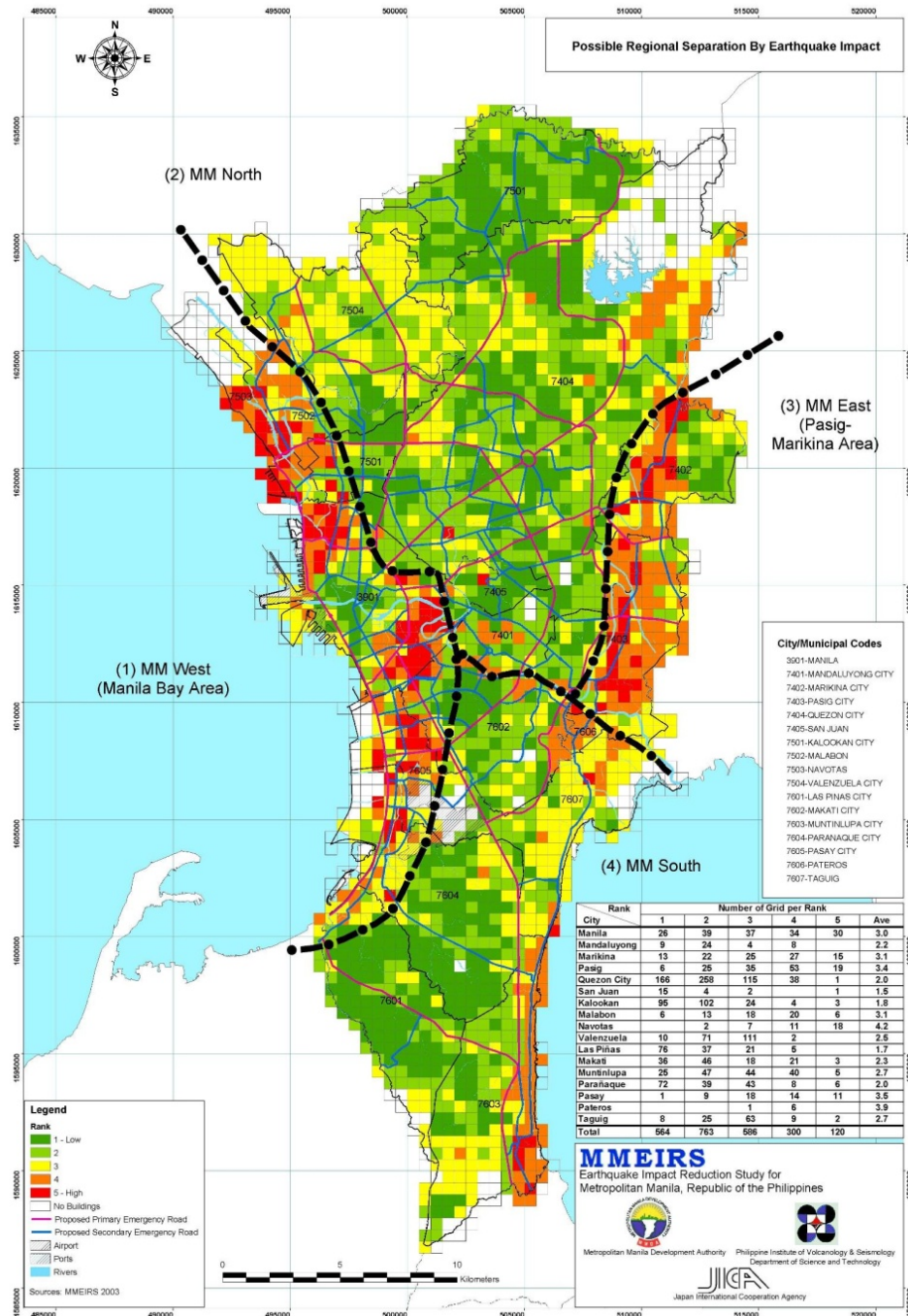
### Population (9,932,560)

Casualty	Dead	33,500 (0.3%)
	Injured	113,600 (1.1%)

\*MMEIRS, 2004



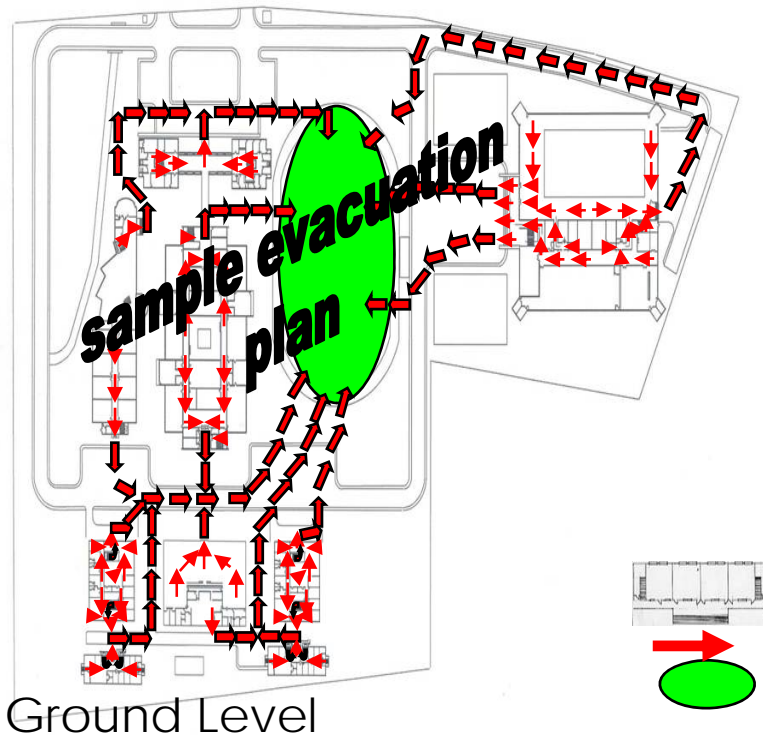
# Possible Isolation due to Earthquake Impacts (West Valley Fault Scenario)



- *West*
  - Fire, Building Damage
- *North*
  - Bridge Damage
- *South*
  - Bridge Damage
- *East*
  - Building Damage, Bridge Damage

\*MMEIRS, 2004

# Earthquake Preparedness and Risk Reduction



What to do?  
BEFORE  
DURING (Drop, Cover, Hold)  
AFTER  
an EARTHQUAKE

- Develop plans
- Mitigation
  - Awareness and Preparedness
  - Evacuation
  - Immediate Response
  - Business Continuity
- Test the plan: Conduct Simulation Exercises
  - Table top
  - Functional/Drill

# What to do Before HAZARD AND RISK ASSESSMENT



- **Assess potential hazards** in facilities, lifelines (water, power, transport systems) used, houses of employees
- **Assess risks** to facilities and operations, especially critical ones
- **Assess structural integrity** of buildings and facilities

# What to do Before

## PLANNING AND IMPLEMENTATION OF ACTIONS FOR RISK REDUCTION

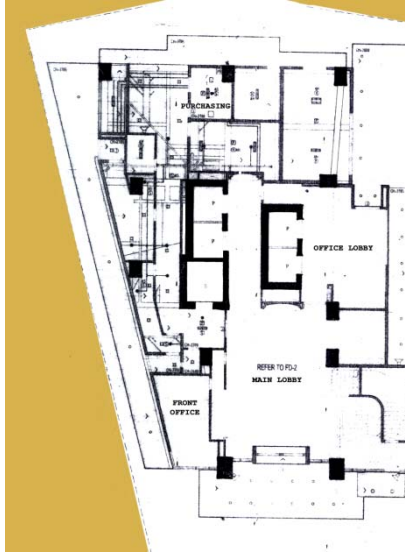


- Plan and implement actions to reduce risks of assets and operations
- Select “**safe**” **location** and follow **proper** structural design and **construction** practices for buildings, facilities, houses
- Retrofit already constructed buildings and facilities if necessary and cost-effective
- Secure critical equipment



# What to do Before

## AWARENESS AND PREPAREDNESS OF OFFICIALS, EMPLOYEES -> FAMILIES



- **Roles** before, during and after a hazardous event
- Know **safe and dangerous spots** and what to do during an event
- Know **response procedures** during earthquakes, fire, first aid
- Familiarize with **evacuation plan** and the responses after the event
- Prepare **emergency bags/kits**
- **Conduct drills**

## Safe Zones

- under sturdy tables
- inside corner of rooms;  
columns/beams
- load-bearing doorway
- outside elevator shafts
- open/clear area

## Danger Zones

- windows and glass
- book shelves
- cabinets and furniture that may topple or slide
- hanging objects
- inside elevators
- power lines; poles; trees; narrow alleys between tall buildings
- bridges and flyovers

Identify Safe and dangerous areas

# What to do Before

## Prepare an emergency kit/earthquake survival kit



- First Aid Kit with Water Purification Tablets
- AM/FM Radio
- Water & High-energy Food
- Tools & Ropes
- Candles & Flashlights
- Blankets
- Tissue Paper & Waste Bags
- Pencil and Paper
- Whistle
- others



# What to do During

- When inside a structurally sound building

**DROP!**

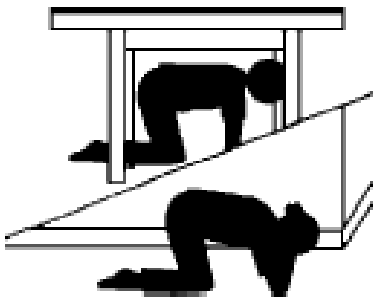


-duck under a sturdy table and hold on to it

- go to safe spot and protect your head with your arms

- Stay away from glass windows, shelves, cabinets and other heavy objects

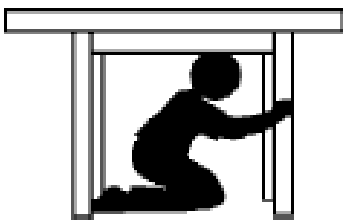
**COVER!**



-Turn-off anything that might cause fire

- Guide others (customers) on what to do

**HOLD!**



If outside

- Go to an open area. Stay away from posts, power lines, tall objects, structures

- Move away from steep slopes (possible landslide), from coastlines (in case of tsunami)

- Stop driving, do not cross bridges, overpasses

# What to do After

- **Be prepared for aftershocks.** After the shaking, **get out in an orderly manner** taking designated fastest and safest way out **to evacuation area.** Assist others in need.
- Check for and treat injuries if possible, check for missing persons.
- Coordinate with authorities.
- Evaluate effect to assets and surrounding areas.
- Implement response plan,



## **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

# Contact Us:

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



/phivolcs\_dost



Philippine Institute  
of Volcanology and  
Seismology  
(PHIVOLCS-DOST)