GLOBAL EARTHQUAKE MODEL 2018
A Step Toward Earthquake Resilience
5th of December 2018 | 0900h - 1800h | CAR College, Pavia, Italy

IMPACTS AND LESSONS FROM THE RECENT INDONESIAN EARTHQUAKE IN LOMBOK AND PALU 2018

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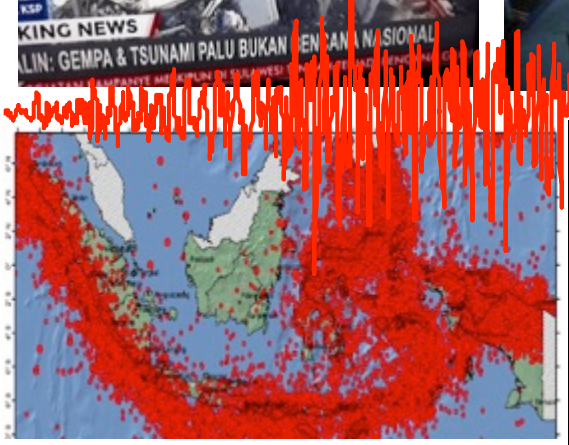
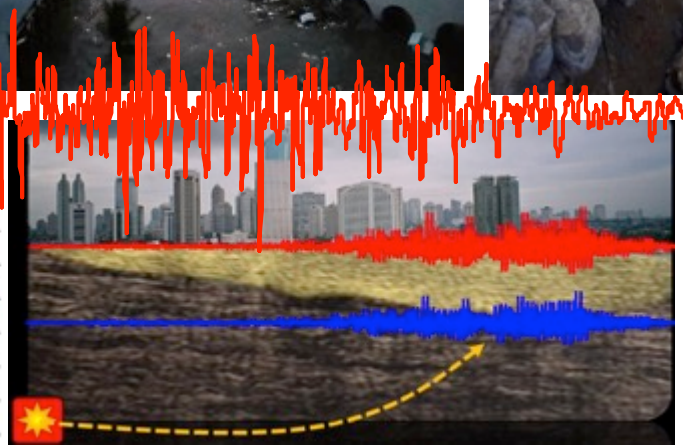
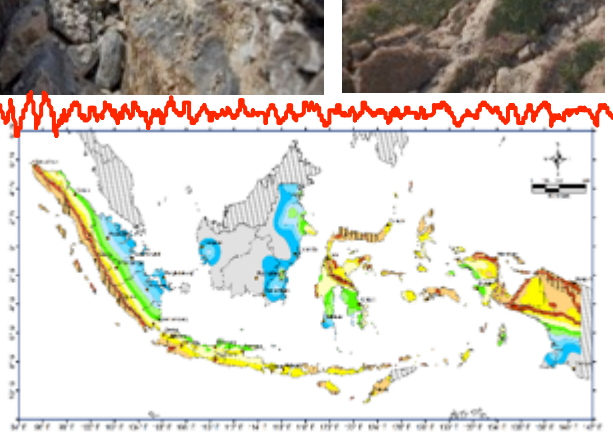
*) Pusat Studi Gempa Nasional (PuSGeN) - National Research Center for Earthquake
Team for Updating of Sesimic Hazard Maps of Indonesia 2010 and 2017
Lecturer ISTN Jakarta







On behalf of:

Pusat Studi Gempa Nasional (PuSGeN)
National Research Center for Earthquake

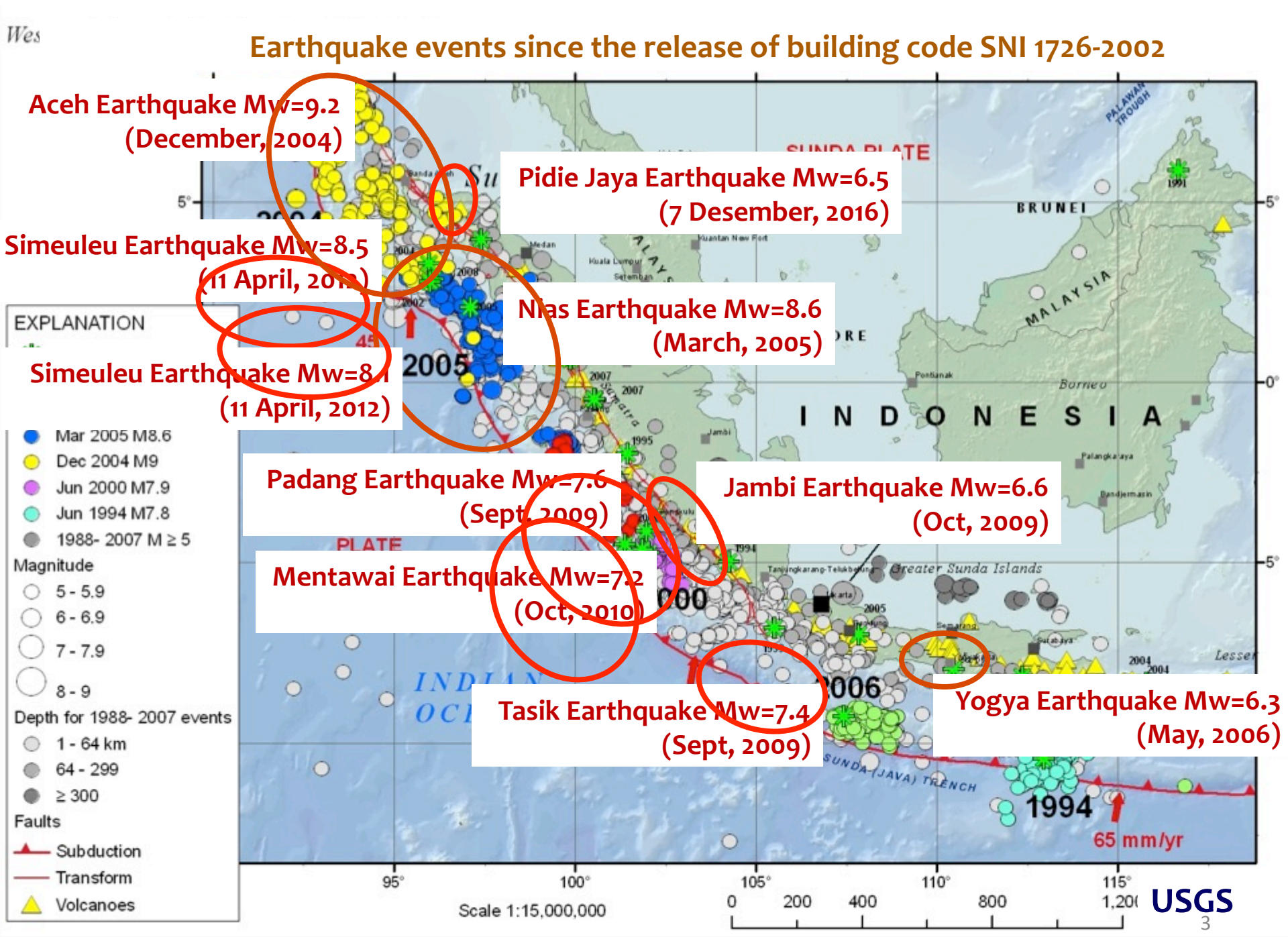
Ministry of Public Works

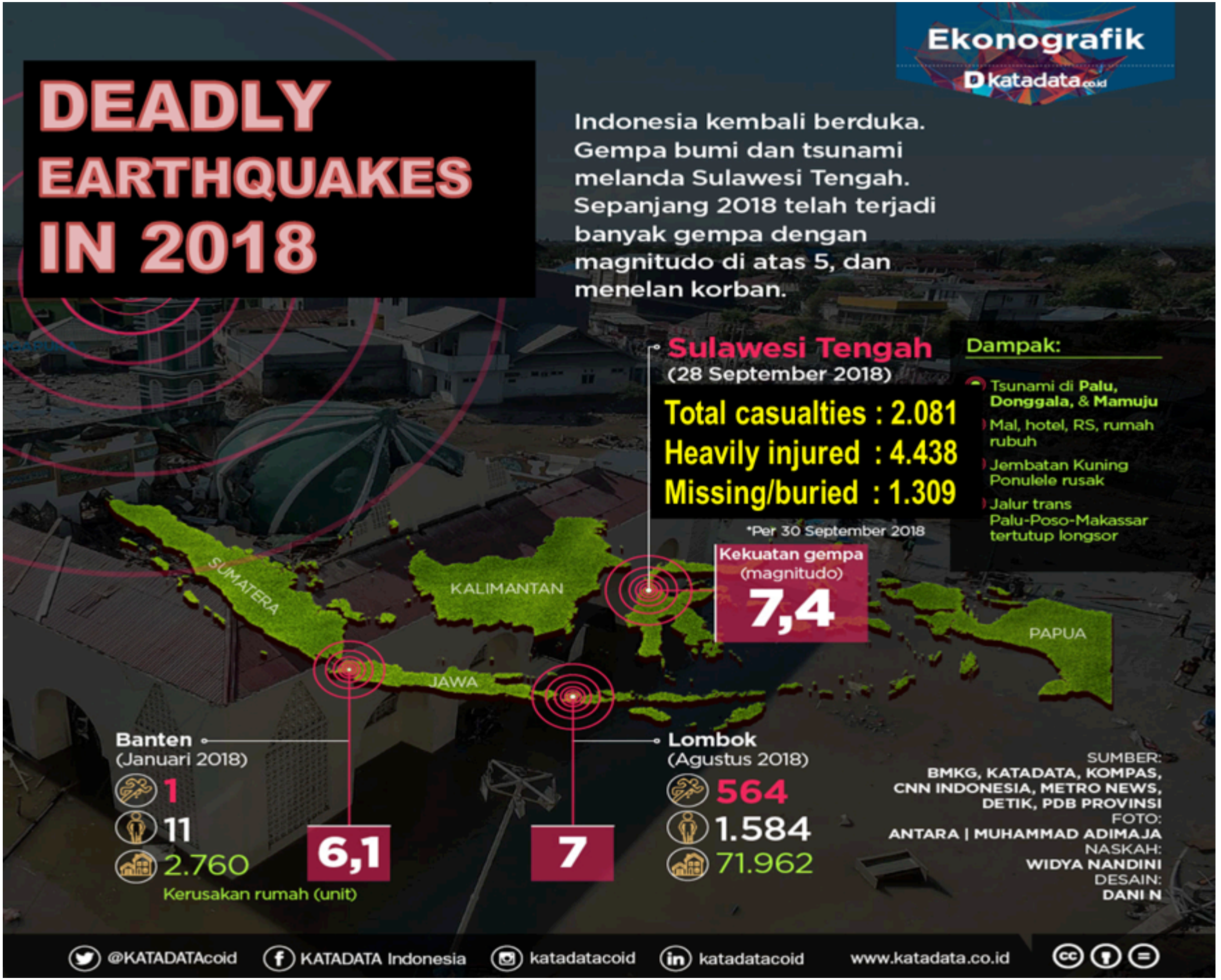
PuSGeN

Acknowledgement:

GEM
GLOBAL EARTHQUAKE MODEL
working together to assess risk

Earthquake events since the release of building code SNI 1726-2002



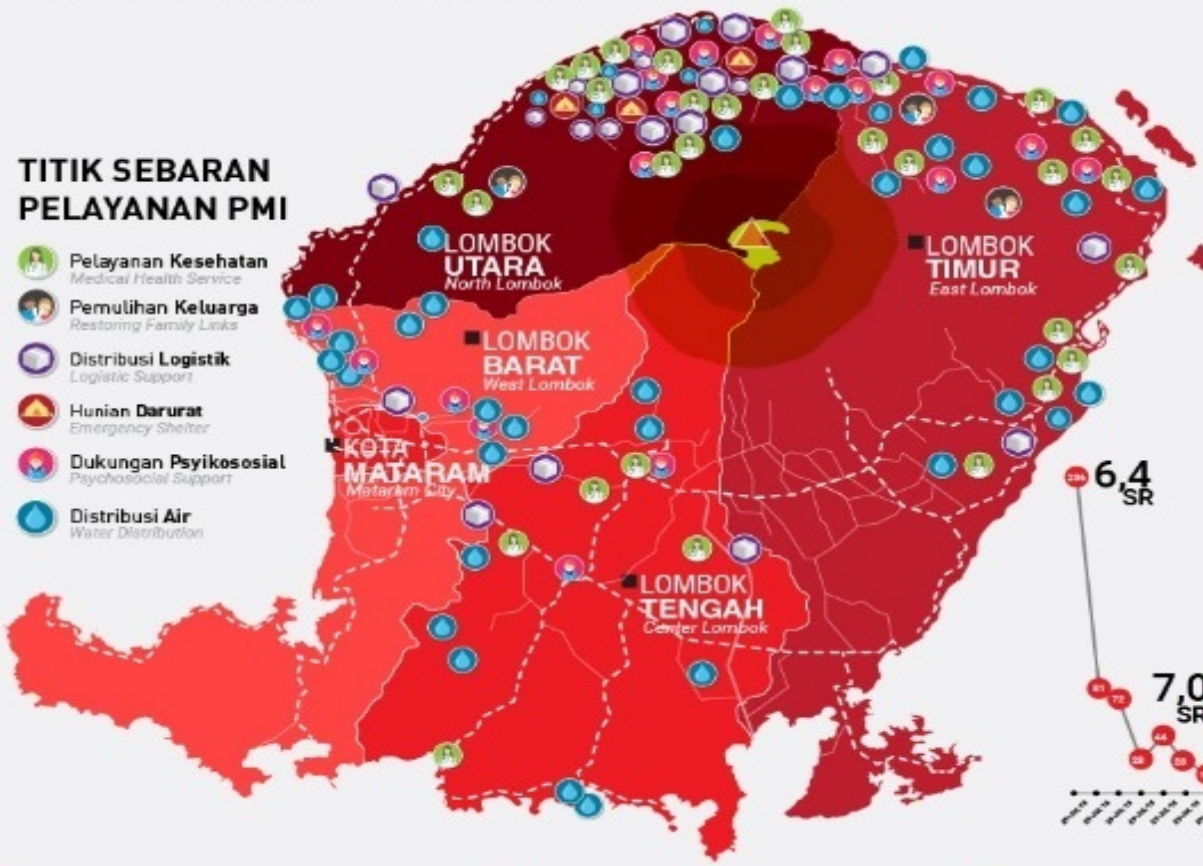

Ekonografik
katadata.co.id
DEADLY EARTHQUAKES IN 2018
Indonesia kembali berduka. Gempa bumi dan tsunami melanda Sulawesi Tengah. Sepanjang 2018 telah terjadi banyak gempa dengan magnitudo di atas 5, dan menelan korban.
Sulawesi Tengah
(28 September 2018)
Total casualties : 2.081
Heavily injured : 4.438
Missing/buried : 1.309
*Per 30 September 2018
Dampak:
Tsunami di Palu, Donggala, & Mamuju
Mal, hotel, RS, rumah rubuh
Jembatan Kuning Ponulele rusak
Jalur trans Palu-Poso-Makassar tertutup longsor
Kekuatan gempa (magnitudo)
7,4
SUMATERA
KALIMANTAN
JAWA
PAPUA
Banten
(Januari 2018)
1
11
2.760
Kerusakan rumah (unit)
6,1
7
Lombok
(Agustus 2018)
564
1.584
71.962
SUMBER:
BMKG, KATADATA, KOMPAS, CNN INDONESIA, METRO NEWS, DETIK, PDB PROVINSI
FOTO:
ANTARA | MUHAMMAD ADIMAJA
NASKAH:
WIDYA NANDINI
DESAIN:
DANI N
@KATADATAcoid
KATADATA Indonesia
katadatacoid
katadatacoid
www.katadata.co.id

infografis
GEMPA BUMI NTB

LAPORAN SITUASI 33
Situation Report of 33

Minggu, 2 September 2018
Sunday, 2 September 2018

infographic ***EARTHQUAKE WEST NUSA TENGGARA***



TITIK SEBARAN PELAYANAN PMI

- Pelayanan **Kesehatan** — *Medical Health Service*
- Pemulihan **Keluarga** — *Restoring Family Links*
- Distribusi **Logistik** — *Logistic Support*
- Hunian **Darurat** — *Emergency Shelter*
- Dukungan **Psyikososial** — *Psychosocial Support*
- Distribusi **Air** — *Water Distribution*

DAMPAK GEMPA
earthquake impact

- **TERDAMPAK** — *People Affected*: **509.677** JIWA
- **MENGUNGSI/** — *People Displaced*: **390.529** JIWA
- **MENINGGAL** — *number of death*: **555** JIWA
- **LUKA-LUKA** — *People Injured*: **7.757** JIWA
- **RUMAH RUSAK** — *House Damaged*: **81.022**
- **FASILITAS UMUM RUSAK** — *Public Facilities Destroyed*: **1.154**

GEMPA SUSULAN
Aftershock Earthquake

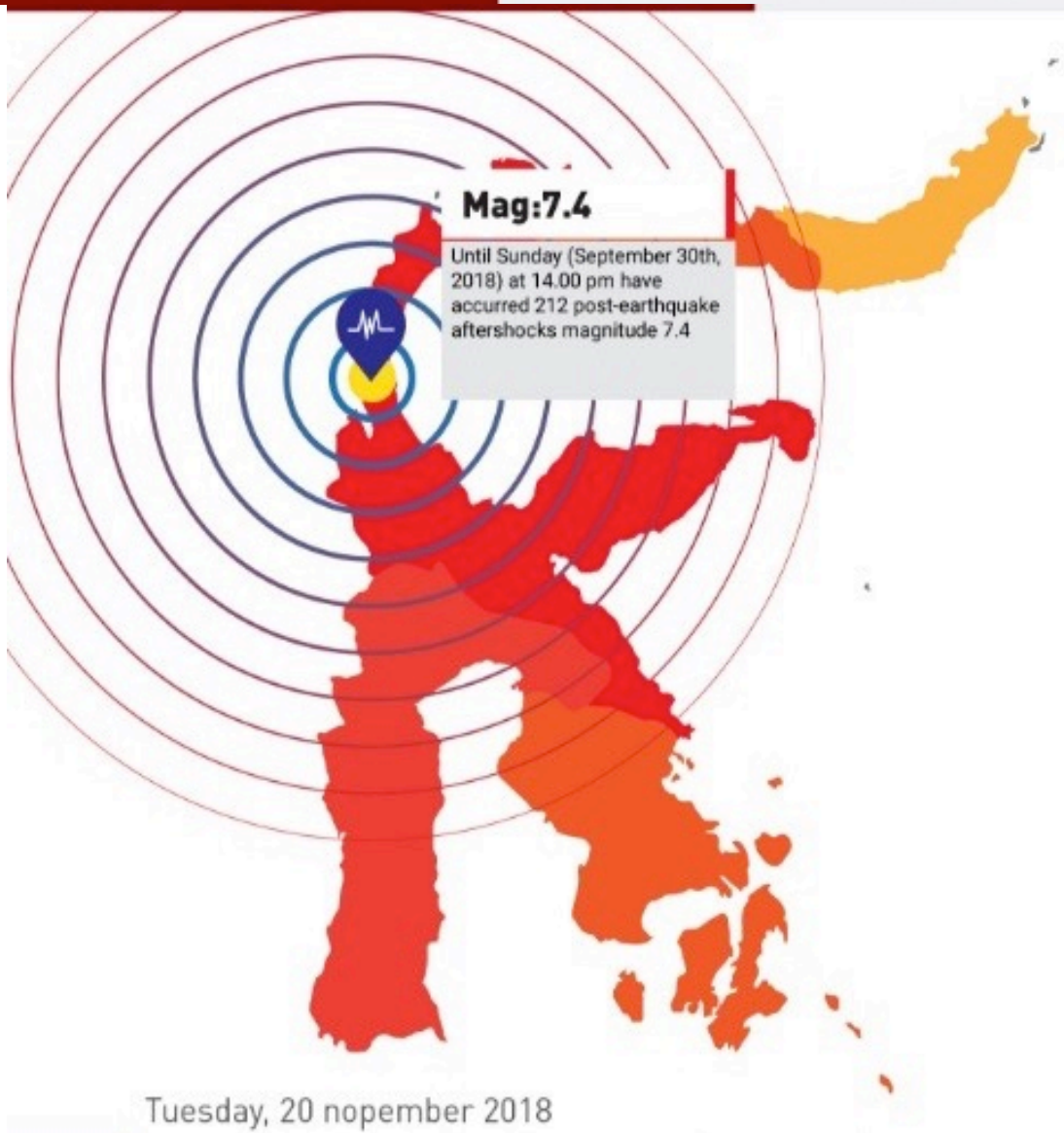
1.644 kali

infographics

SITUATION REPORT

EARTHQUAKE & TSUNAMI
DONGGALA-PALU-SIGI CENTRAL SULAWESI

Palang Merah Indonesia



Disater: **EARTHQUAKE & TSUNAMI**
Location : **CENTRAL SULAWESI**
FRIDAY, 28 sept 2018 5 PM

UPDATE Friday, 30 Nopember 2018

DATA VICTIM & DAMAGED

INTERNALLY DISPLACED PERSON
214.925 | 122

NUMBER OF DEAD
2,081

PEOPLE INJURED
12.568

MISSING
1.309

HOUSE DAMAGED
67.310

SCHOOL BUILDING DAMAGED
2.736

familylinks.icrc.org/indonesia

Data Website until 29 November 2018
I AM ALIVE = **54**
I AM LOOKING FOR = **1445**
SATPHONE = **2**
CLOSE = **223**
HANDPHONE = **58**
RED CROSS MESSAGE **(RCM) = 7**

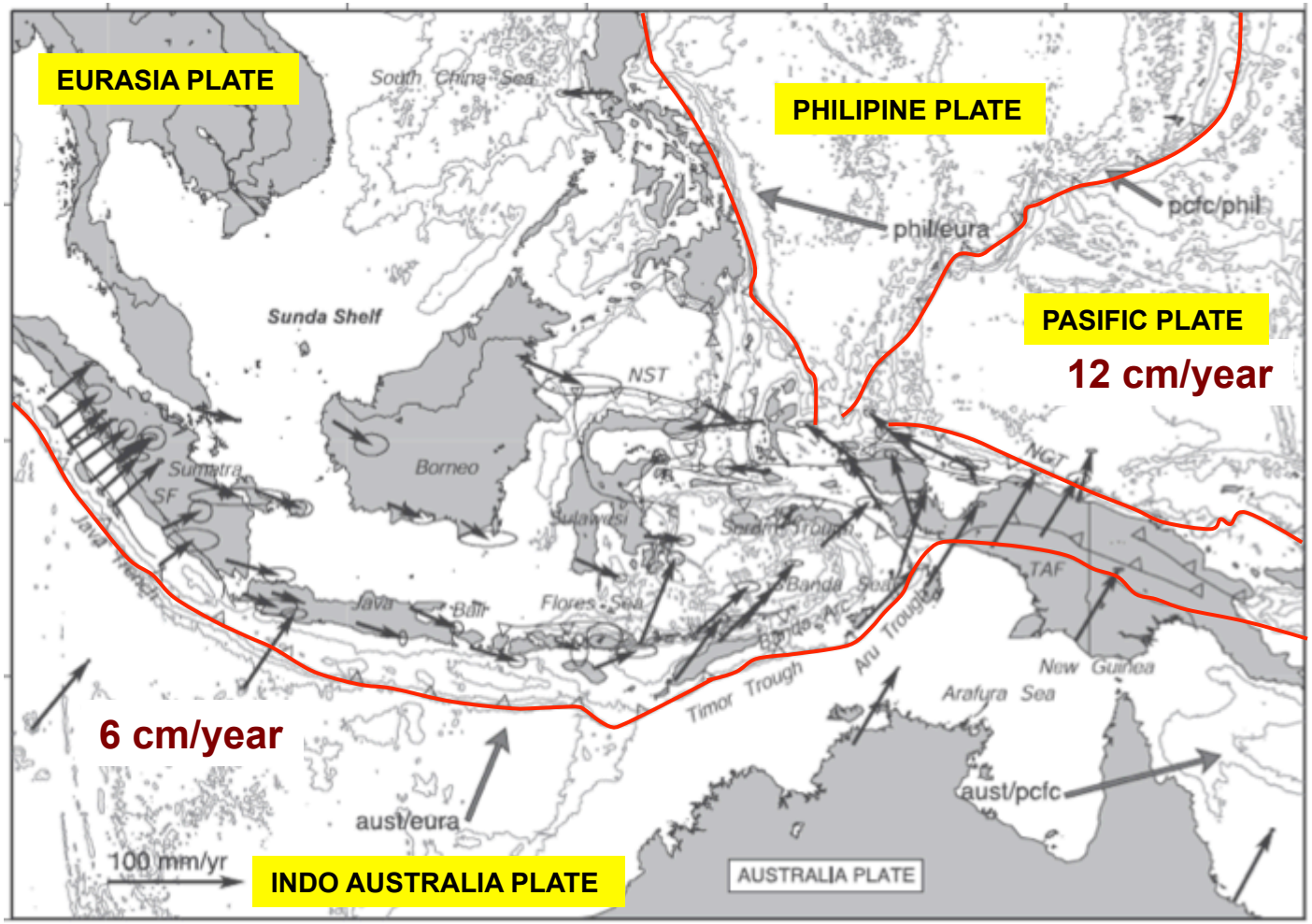
Tribute to Lombok & Palu:

Our thoughts and prayers are with victims, families, and whoever impacted by Lombok & Palu Earthquake.

We wish the community for a quickly complete recovery.

OUTLINE:

- Tectonic Condition of Indonesia
- Indonesian Seismic Hazard Map
- Active Faults & Earthquakes in Lombok & Palu
- Impacts & Lessons from The Recent Earthquake in Lombok & Palu 2018
- Closing



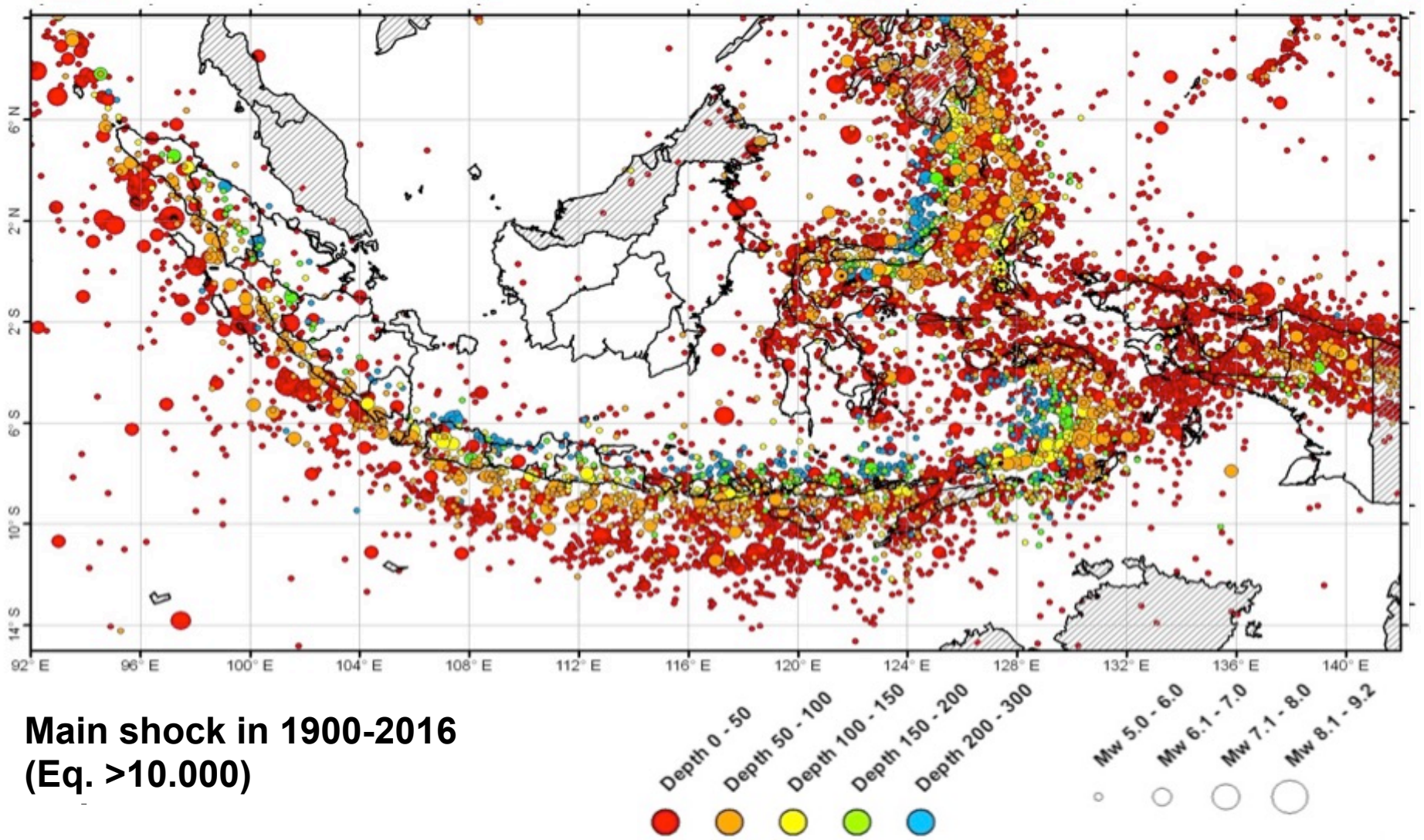
Major Tectonics around Indonesia (Bock *et al.*, 2003)

- There are 4 major tectonic plates in this region: Eurasia, Indoaustralia, Pacific and Philipine.
- Indoaustralia and Philipine/pacific plates subduct beneath the Eursia plate with the rate of 6cm/year and 12 cm/year

Stories about earthquakes in Indonesia as a realization of the dynamics of Plate Tectonic

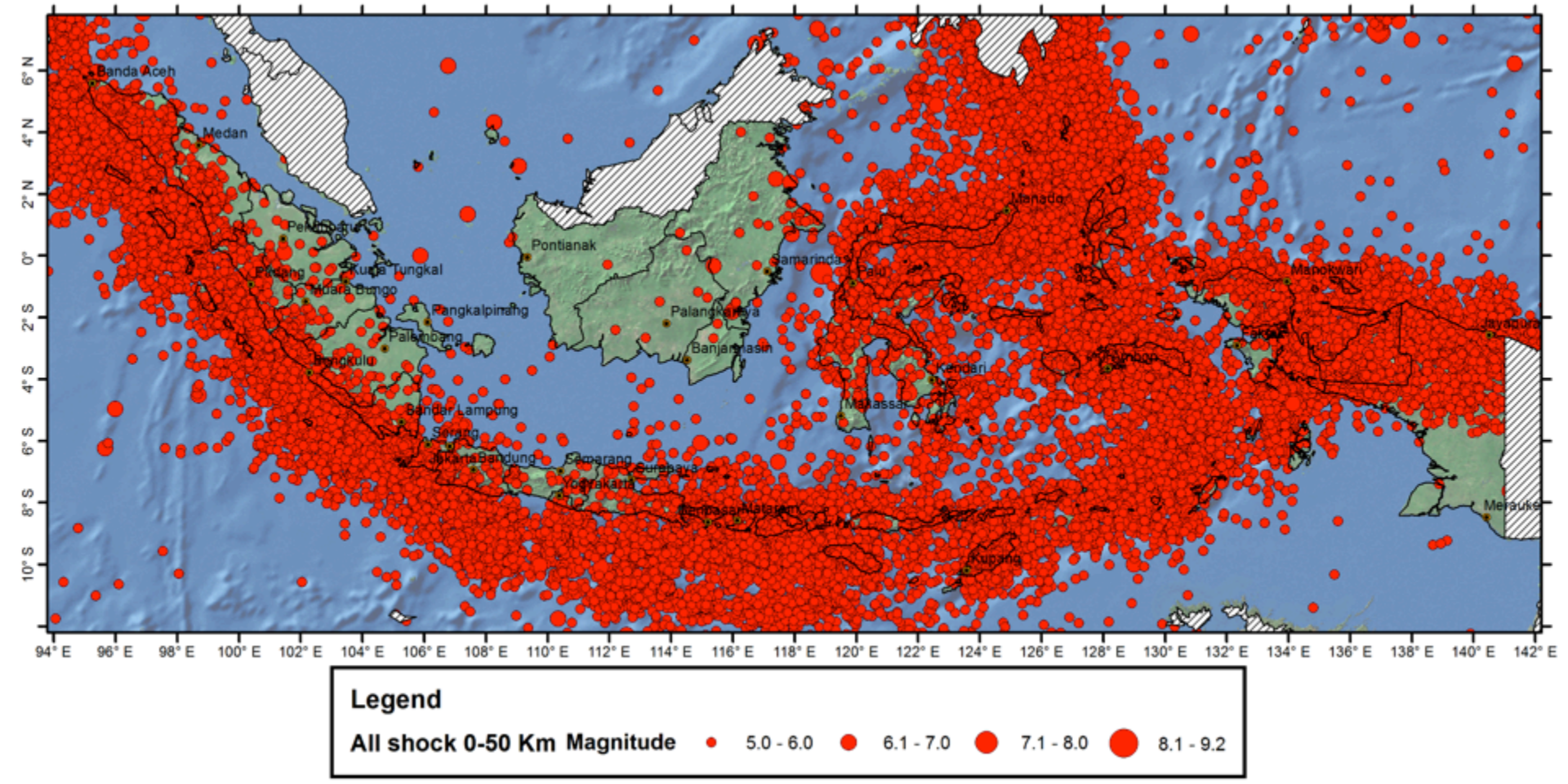
(Referring The Work Of Robert Hall)

Indonesia is one of the most seismically active countries in the world, it is epicenter all shock situation Indonesia tectonic regime.



Main shock in 1900-2016 (Eq. >10.000)

Shallow Earthquake 1900-2016



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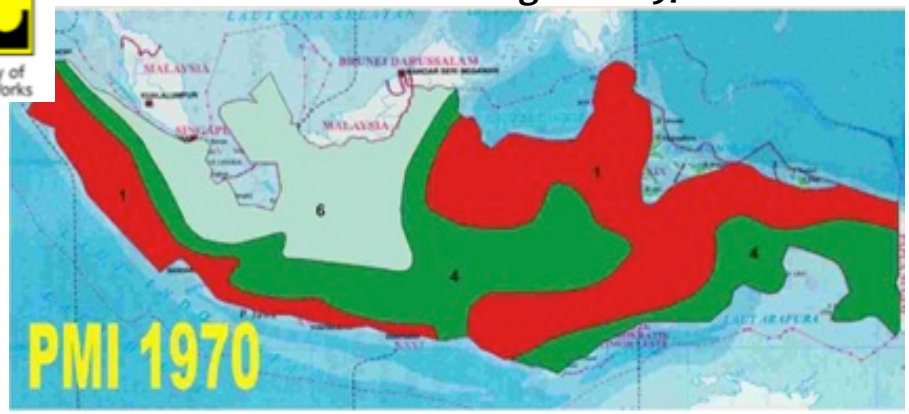
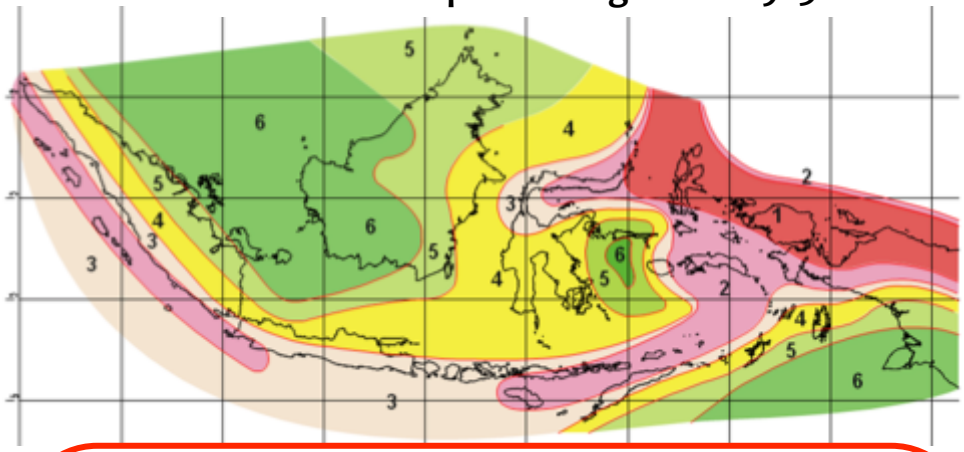
Indonesian Conrete Design Code 1966

Ministry of Public Works

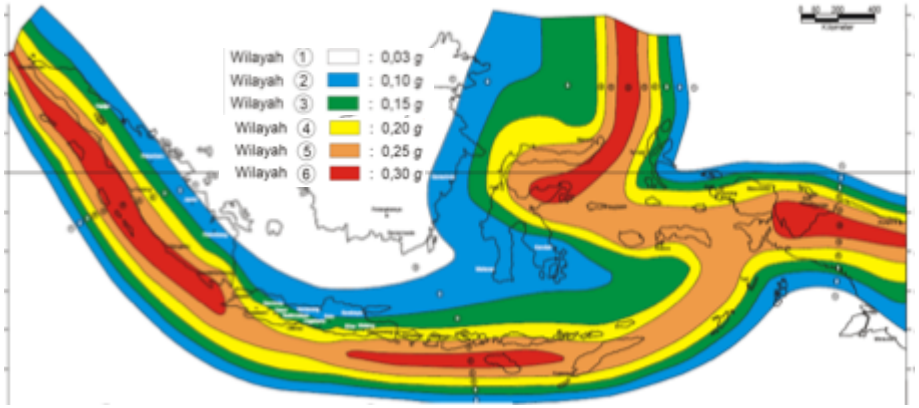
Indonesian Loading Code 1970



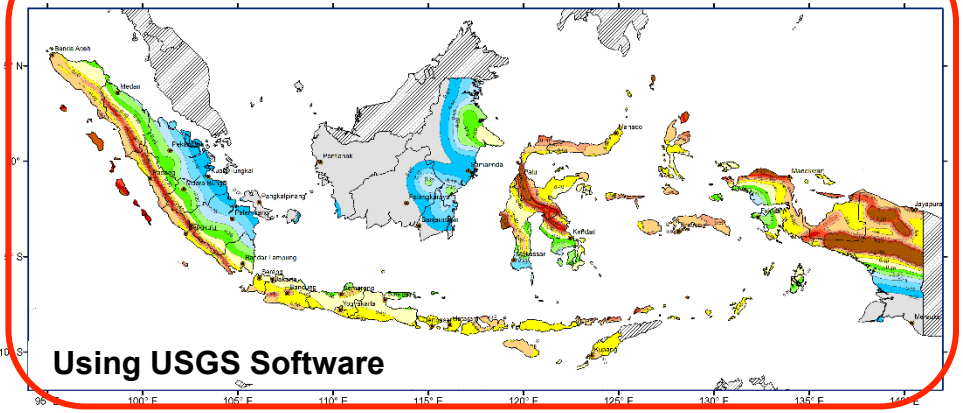
Indonesian Earthquake Design Code 1983



Indonesian Earthquake Building Code SNI 1726-2002

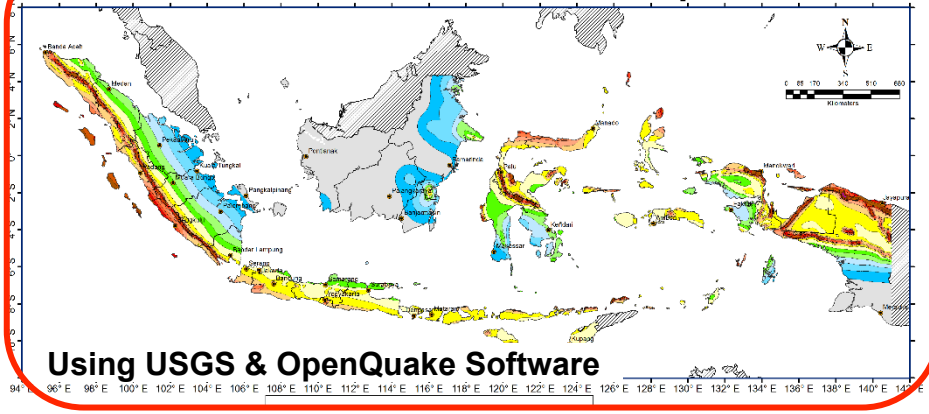


Indonesian Seismic Hazard Maps 2010



Using USGS Software

New National Seismic Hazard Maps 2017



Using USGS & OpenQuake Software

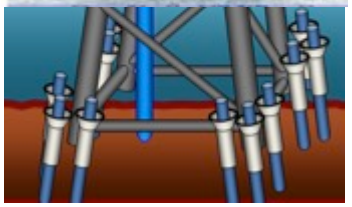
The National Hazard Maps Have been Implemented in Earthquake Resistance Building and Infrastructure Design Codes in Indonesia

Buildings
Return period of earthquake 2,500 yrs and 1% risk of collapse in 50 yrs

Bridges
Return period of earthquake 1,000 yrs

Metro Tunnels 1,000 yrs

Dams: 2,500-10,000 yrs

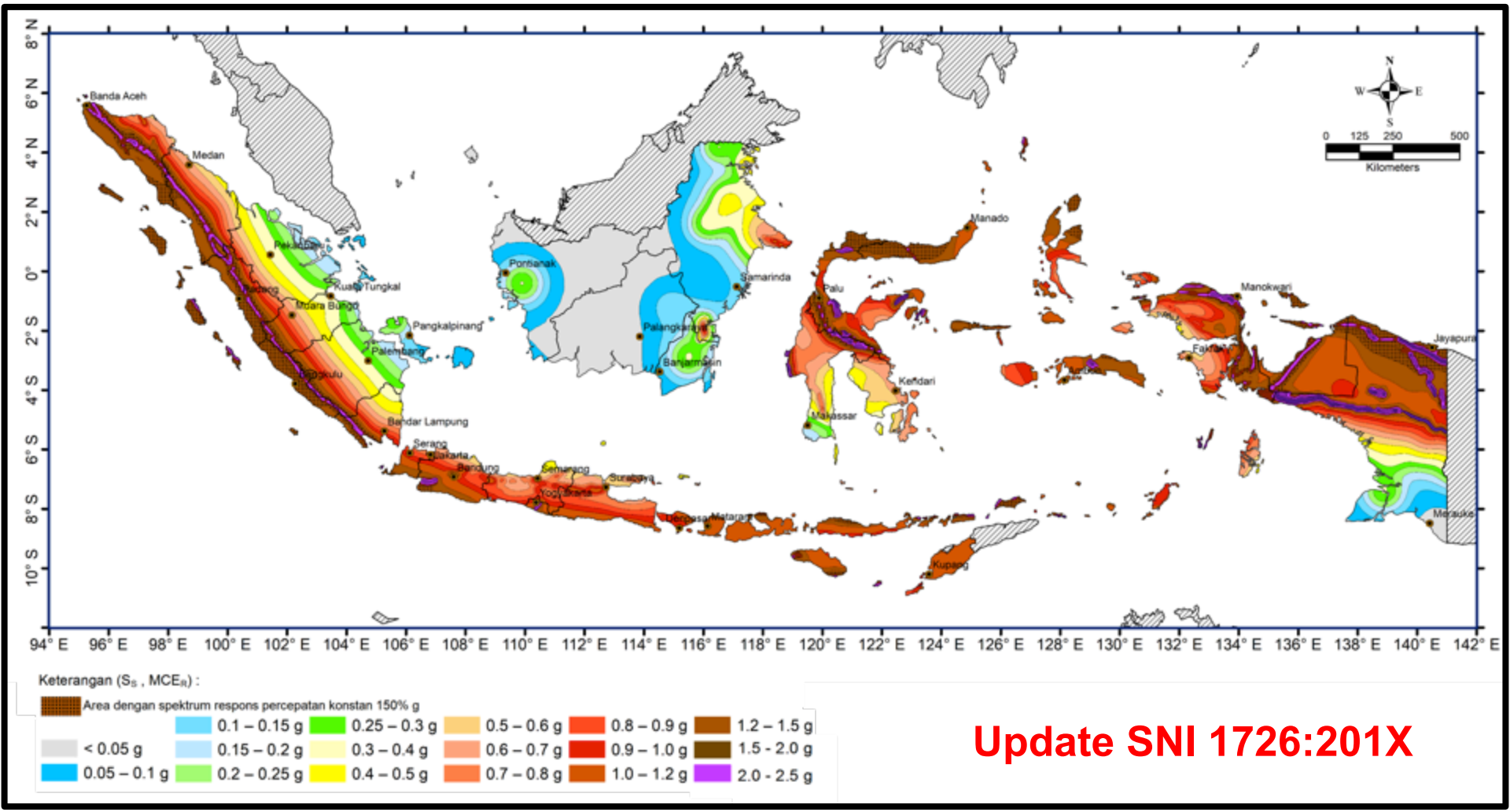


Offshore Platforms: 500 - 2,500 yrs

Railway Bridges: 500-1000 yrs

Port and Airport

Ss Risk-Adjusted Maximum Considered Earthquake (MCE_R) Ground Motion Parameter for Indonesia for 0.2-s Spectral Response Acceleration (5% of Critical Damping), Site Class BC

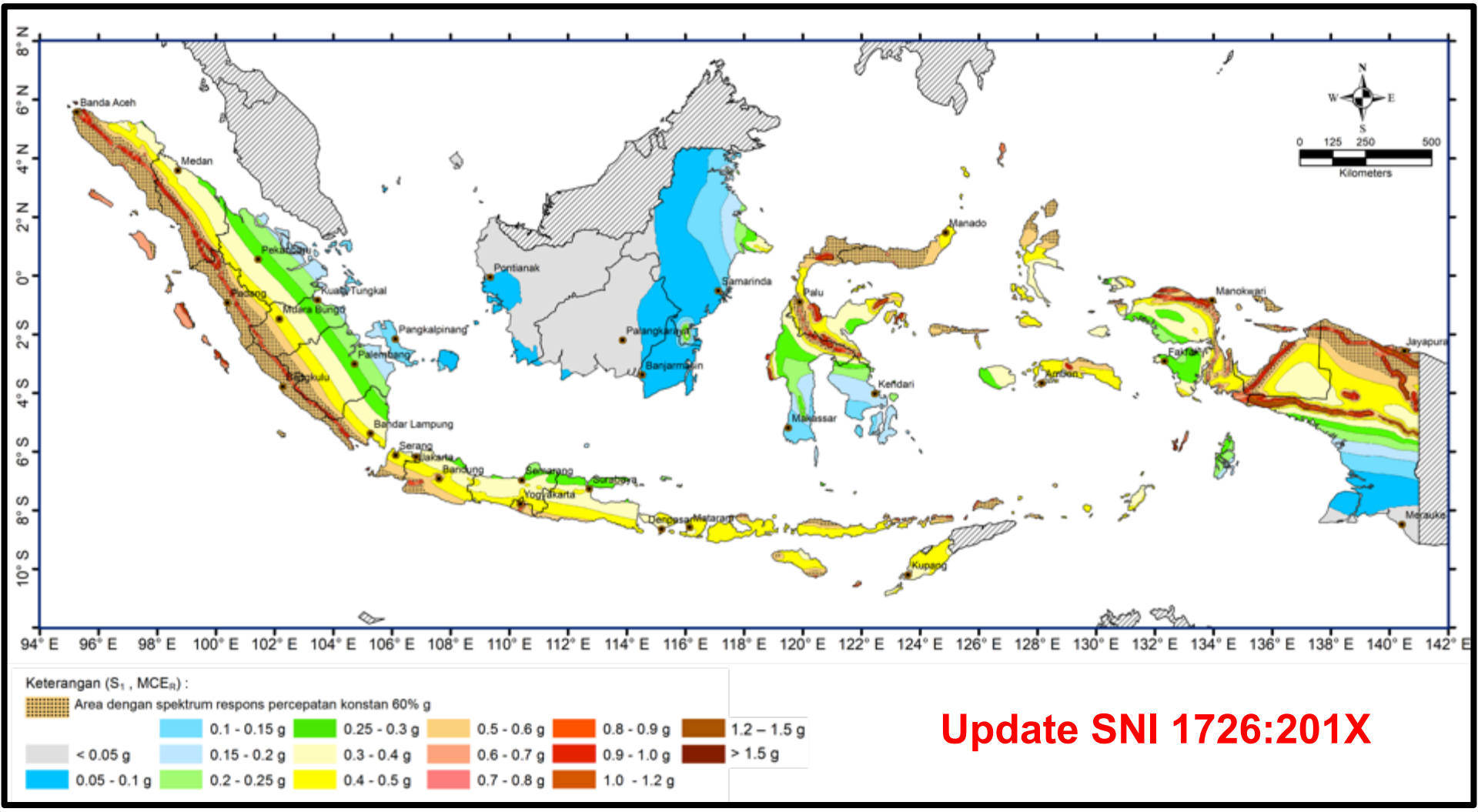


Update SNI 1726:201X

Using USGS & OpenQuake Software for Analysis

asrurifak@gmail.com

Ss Risk-Adjusted Maximum Considered Earthquake (MCE_R) Ground Motion Parameter for Indonesia for 1.0-s Spectral Response Acceleration (5% of Critical Damping), Site Class BC



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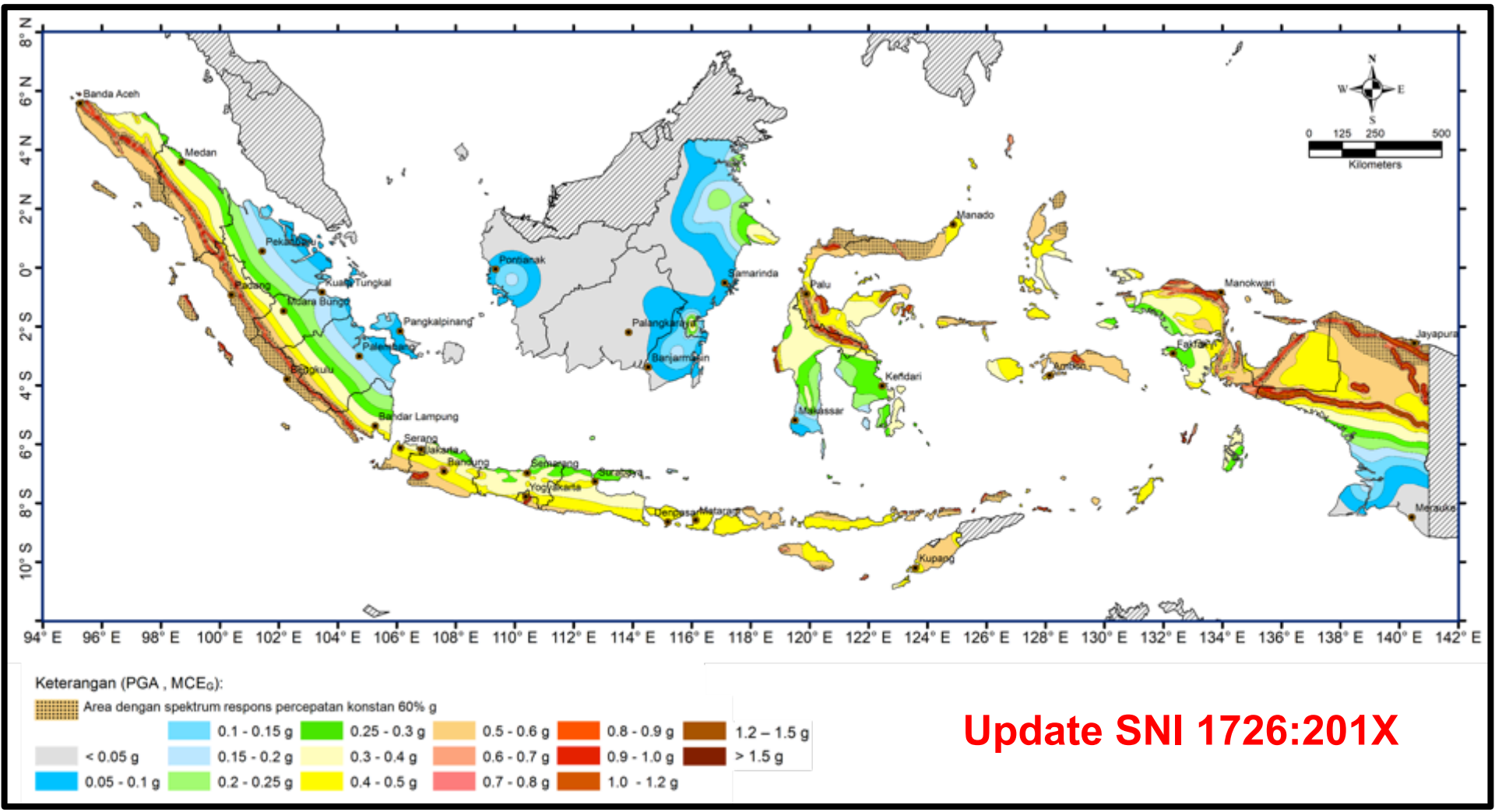
Maximum Considered Earthquake Geometric mean (MCE_G) PGA



Update SNI 1726:201X

Using USGS & OpenQuake Software for Analysis

asrurifak@gmail.com

Efforts to Enhance the 2017 National Seismic Hazard Maps

- Enhancement is conducted by updating earthquake sources data including geology, seismology, geodesy, and earthquake catalog.
- Updating data is based upon the latest studies such as recent active-fault studies utilizing trenching, carbon dating, epicenter relocation, strain analysis from GPS data, availability of basic data including the SRTM-30, IFSAR, LiDAr, and earthquake catalog up to 2016.
- Improvement of tomography using 3D velocity model.
- Adding several active faults that were not quantified before.
- Considering the latest GMPE published after Tohoku earthquake and latest NGA.
- Adding OpenQuake software for comparison and verification to USGS and EZFRisk software.

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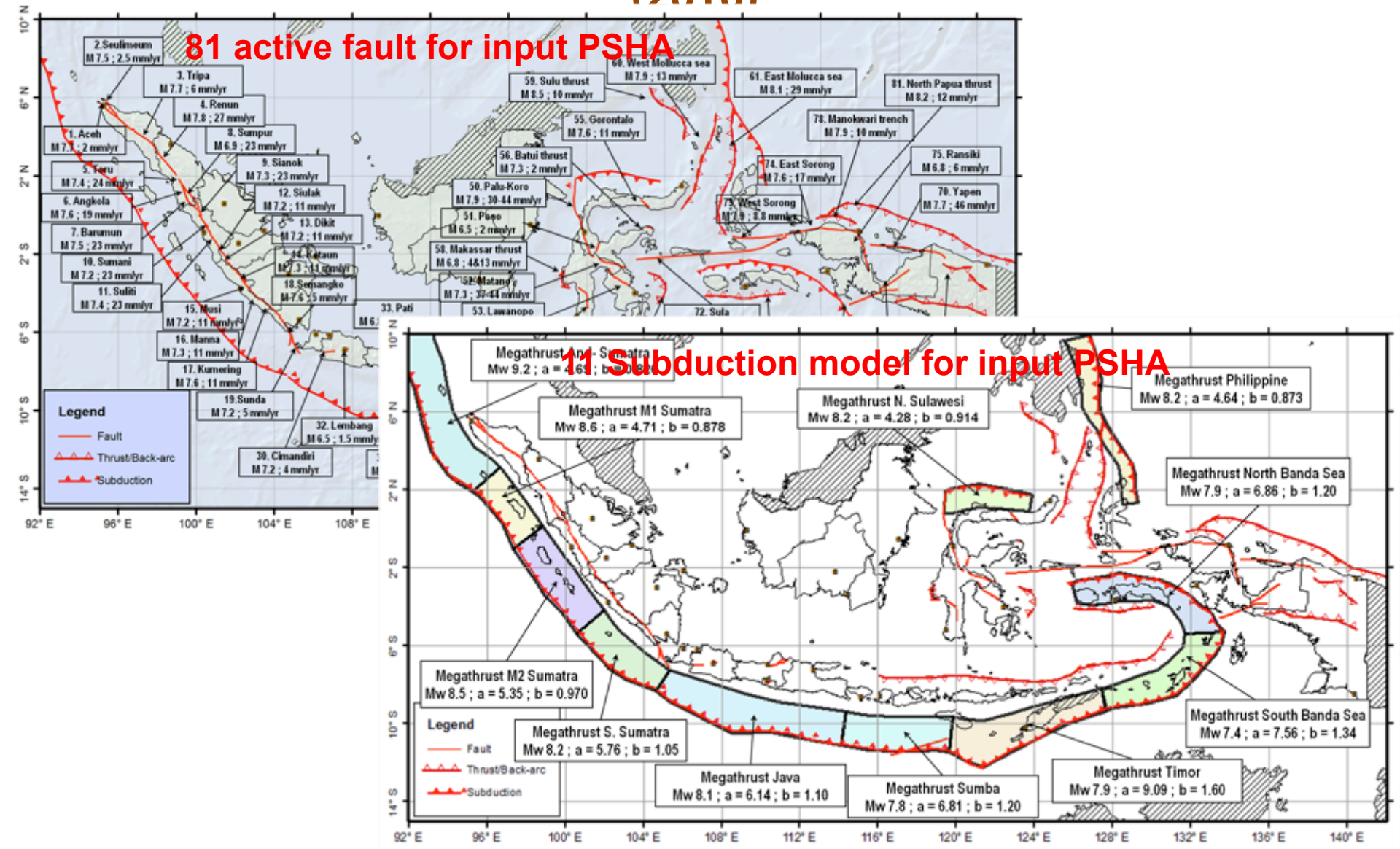
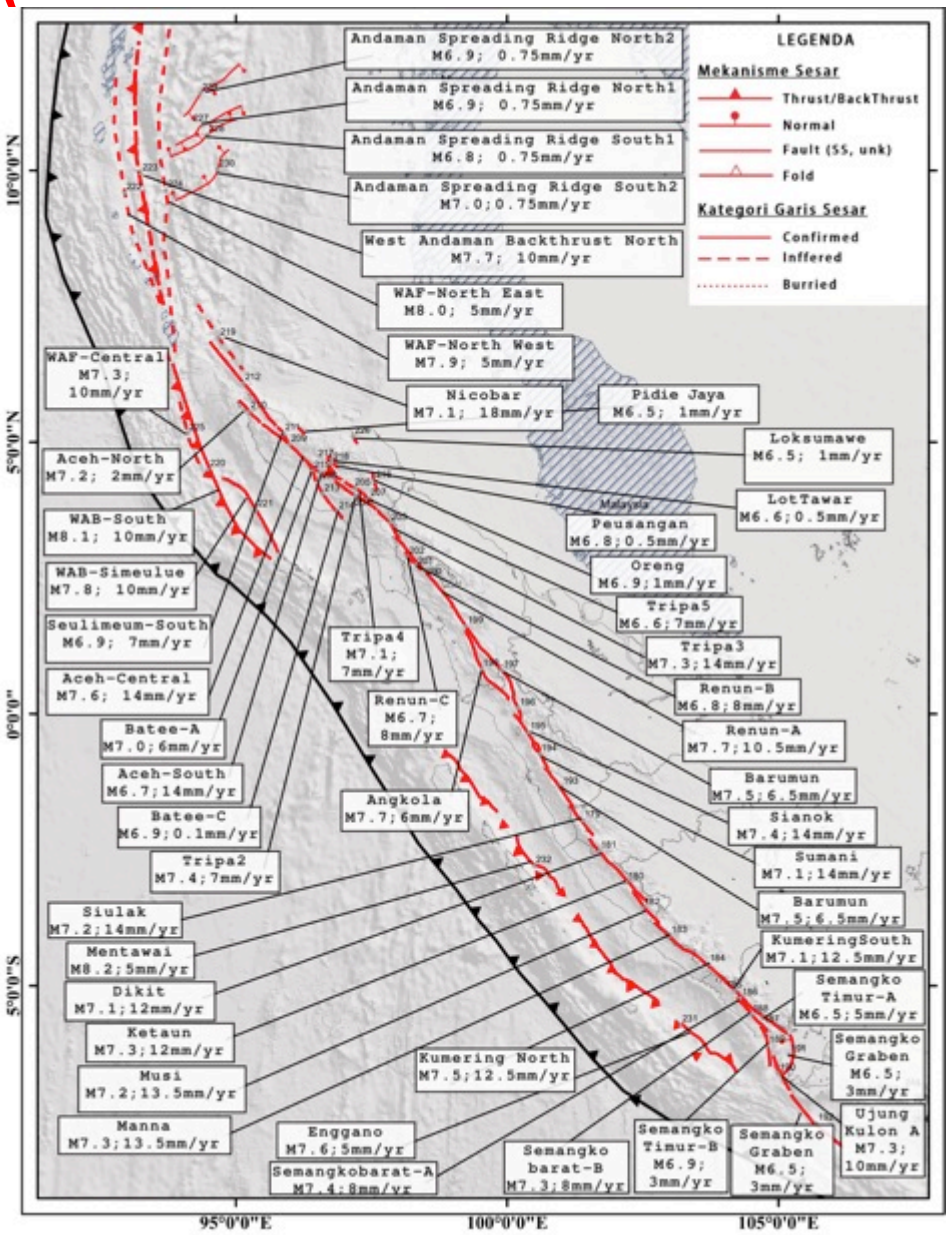
LATEST INFORMATION ON SEISMIC SOURCES PARAMETERS THAT HAVE NOT BEEN ACCOMMODED IN OLD HAZARD MAP (2010)



Input Parameters Indonesian hazard map, 2010

NEW PARAMETER FOR SEISMIC SOURCES 2017

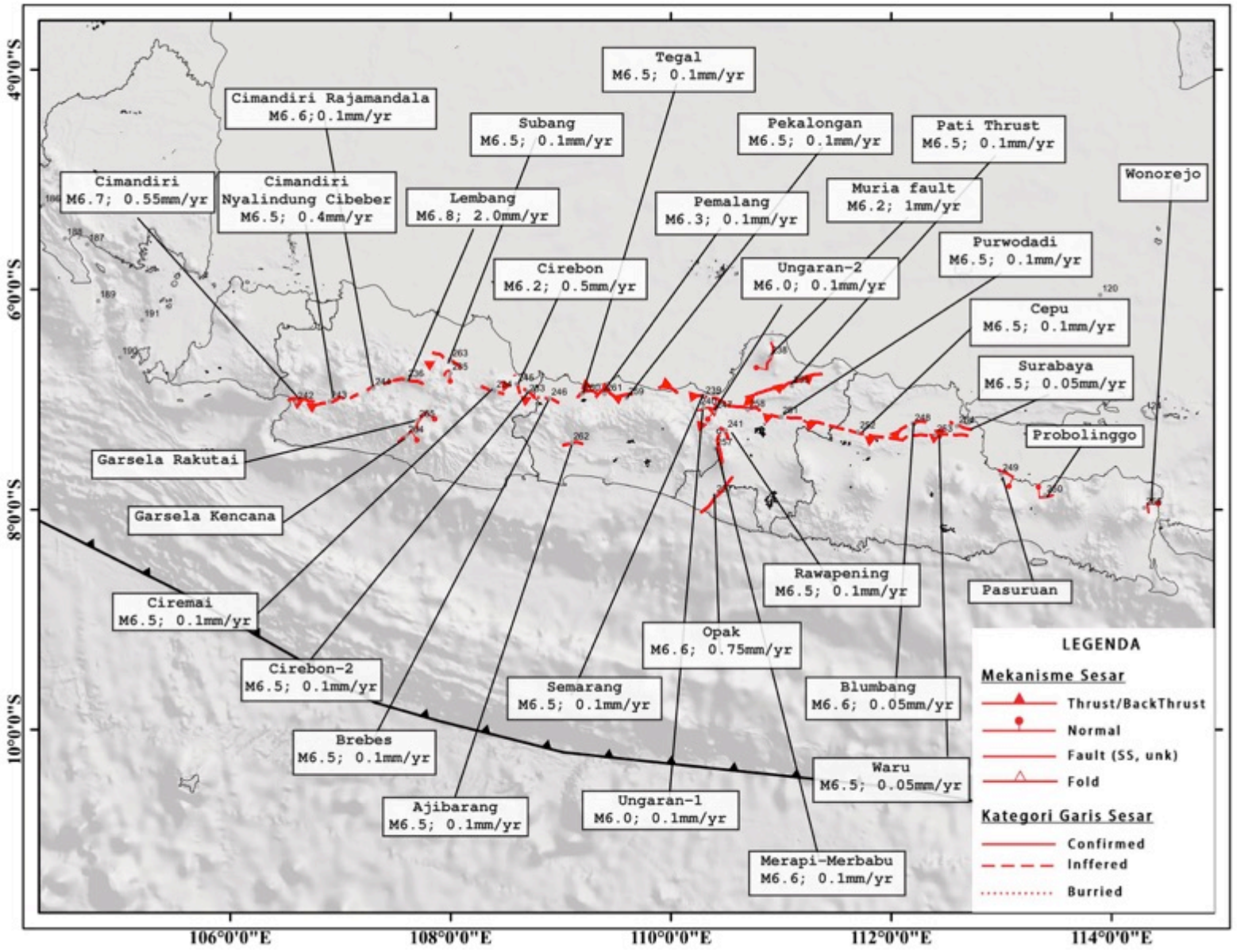
(251 ACTIVE FAULT FOR INPUT PSHA)



SUMATRA ACTIVE FAULT AND SURROUNDING

NEW PARAMETER FOR SEISMIC SOURCES 2017

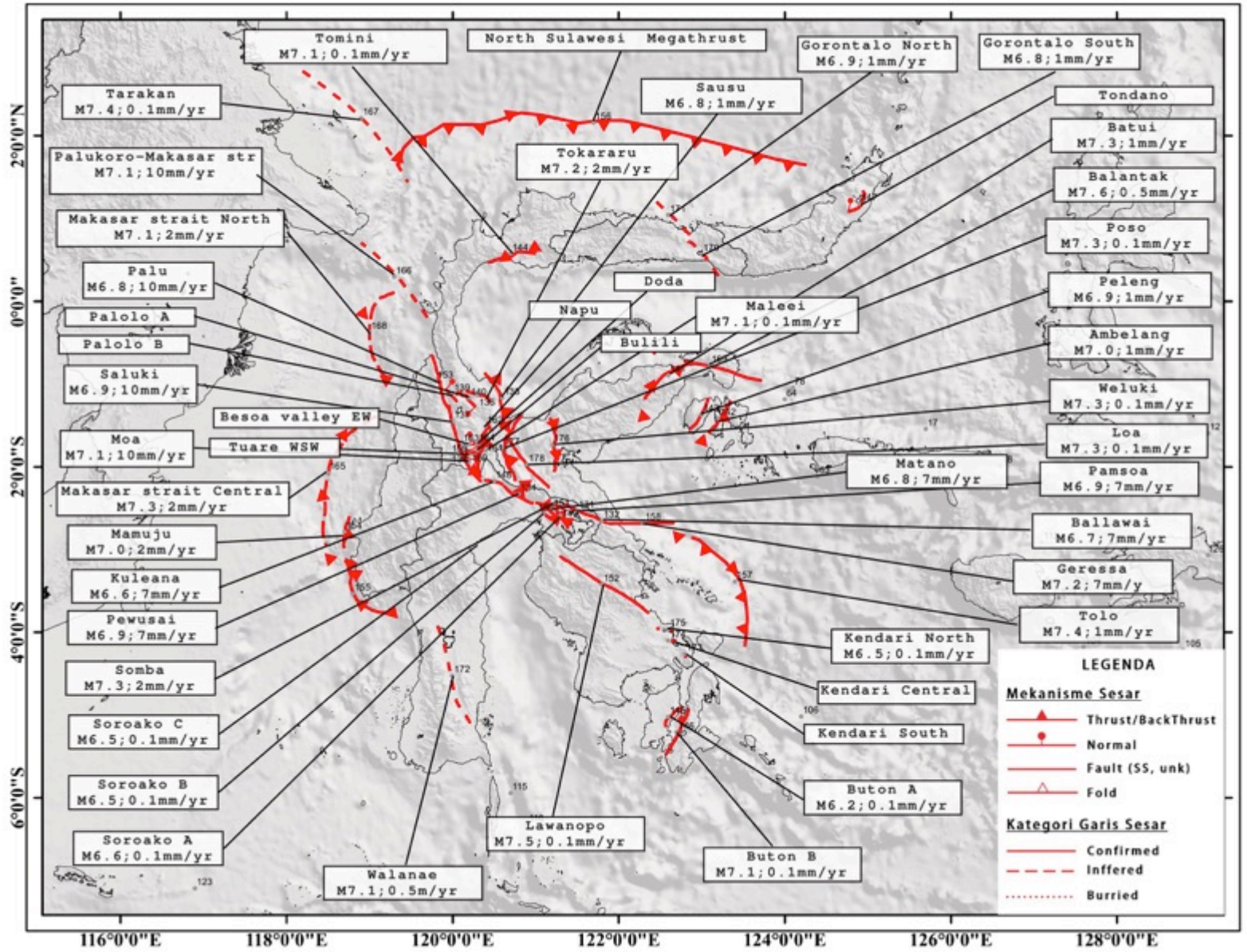
(251 ACTIVE FAULT FOR INPUT PSHA)



JAVA ACTIVE FAULT AND SURROUNDING

NEW PARAMETER FOR SEISMIC SOURCES 2017

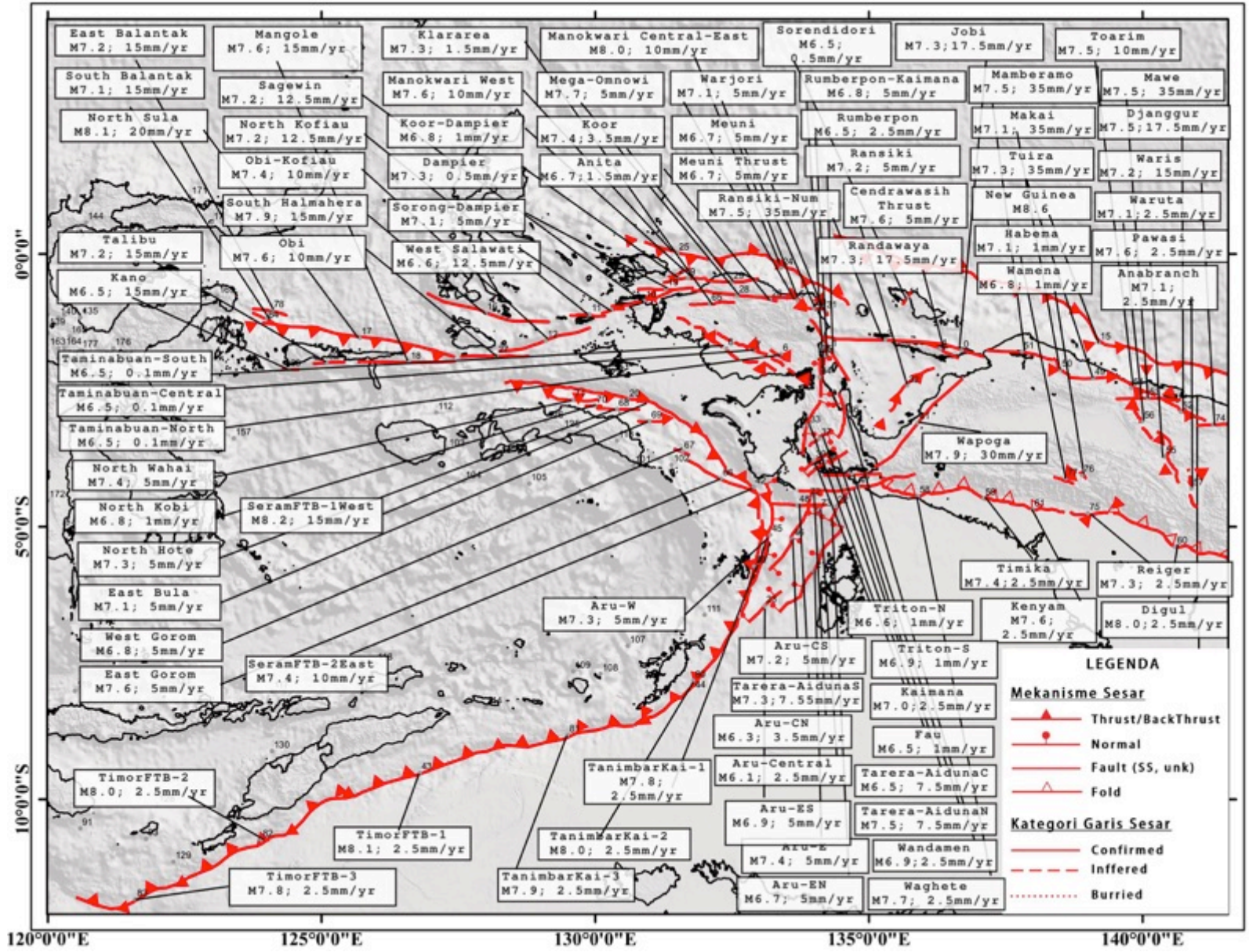
(251 ACTIVE FAULT FOR INPUT PSHA)



SULAWESI ACTIVE FAULT AND SURROUNDING

NEW PARAMETER FOR SEISMIC SOURCES 2017

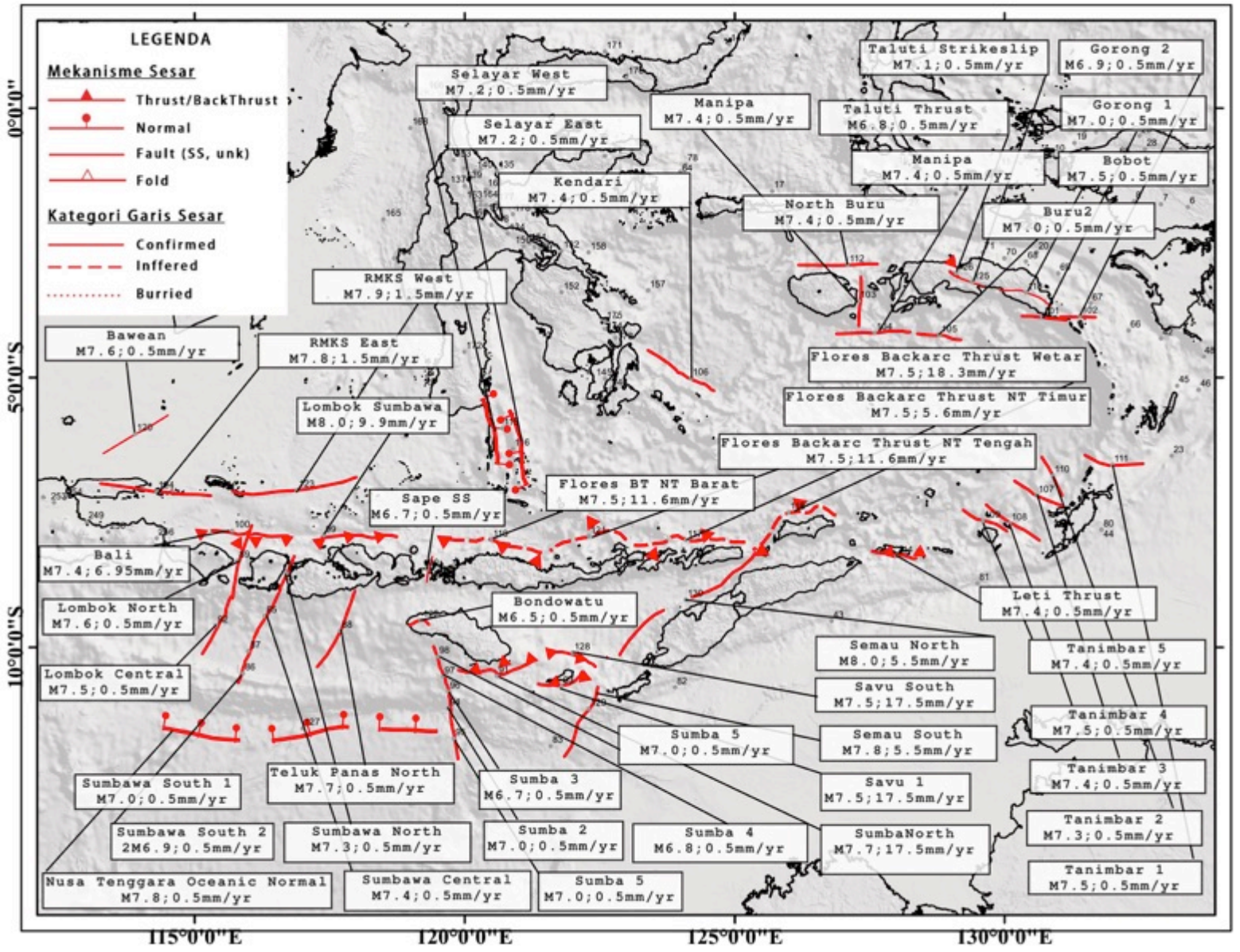
(251 ACTIVE FAULT FOR INPUT PSHA)



PAPUA ACTIVE FAULT AND SURROUNDING

NEW PARAMETER FOR SEISMIC SOURCES 2017

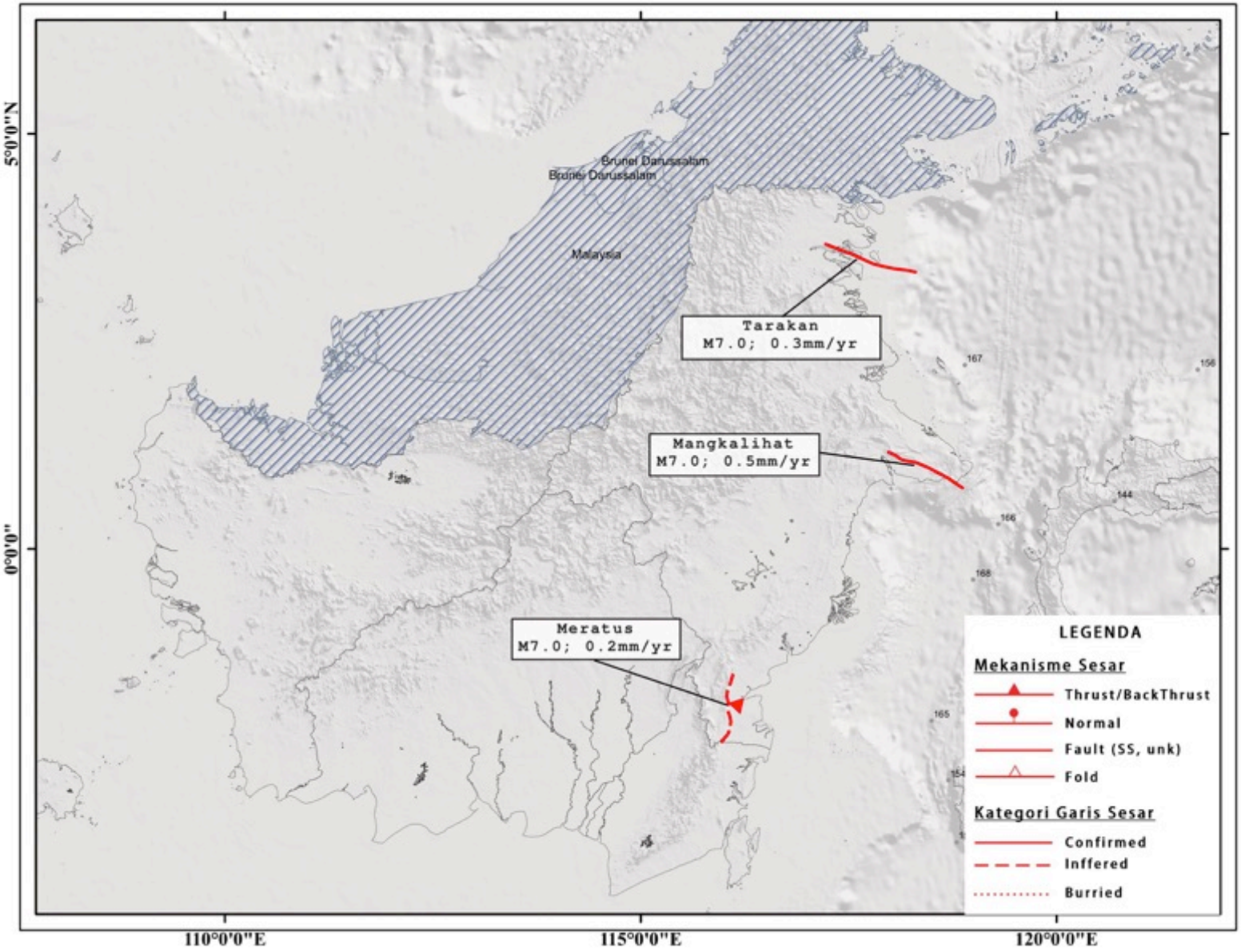
(251 ACTIVE FAULT FOR INPUT PSHA)



NUSATENGGARA-BANDA ACTIVE FAULT AND SURROUNDING

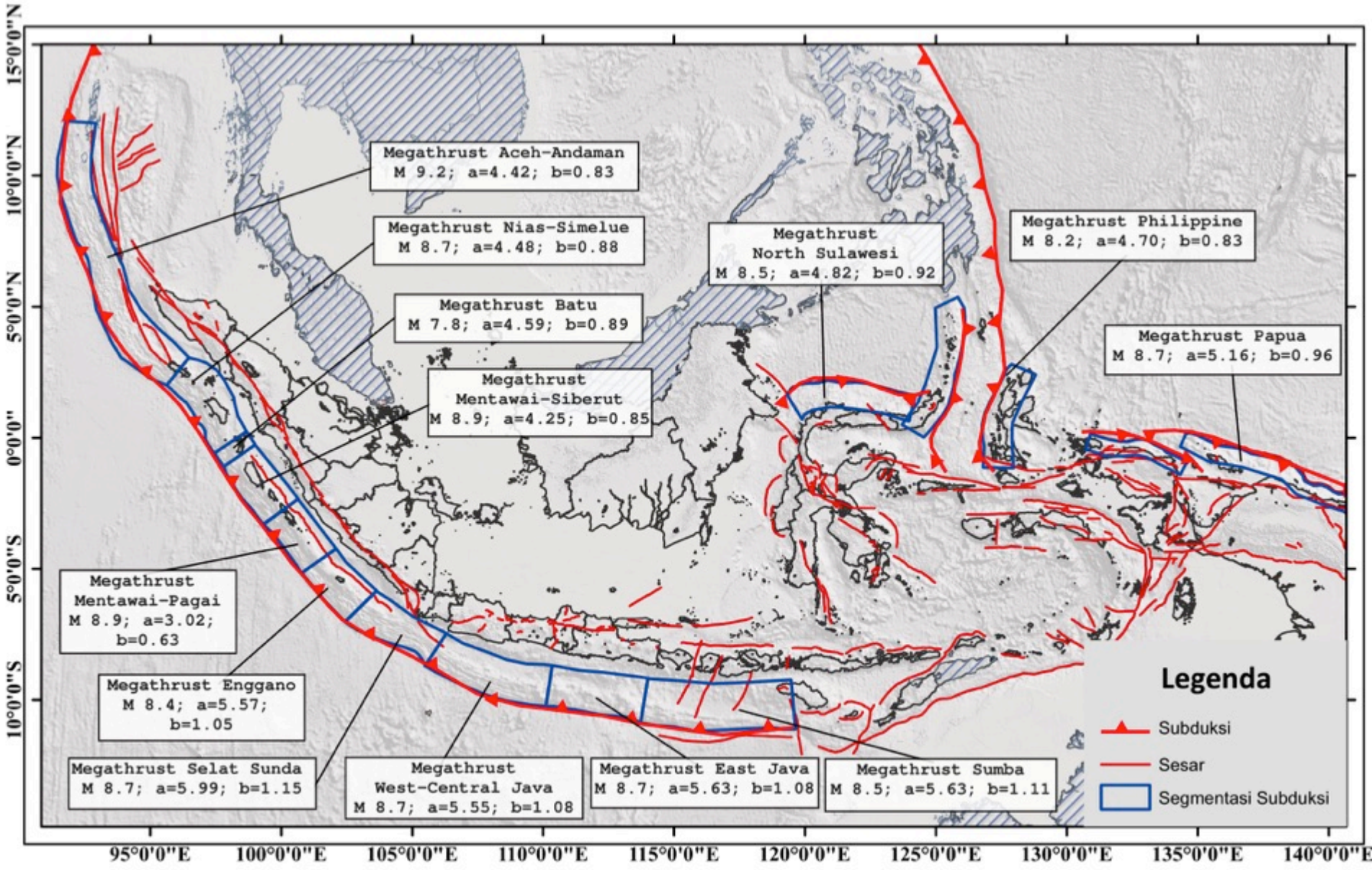
NEW PARAMETER FOR SEISMIC SOURCES 2017

(251 ACTIVE FAULT FOR INPUT PSHA)

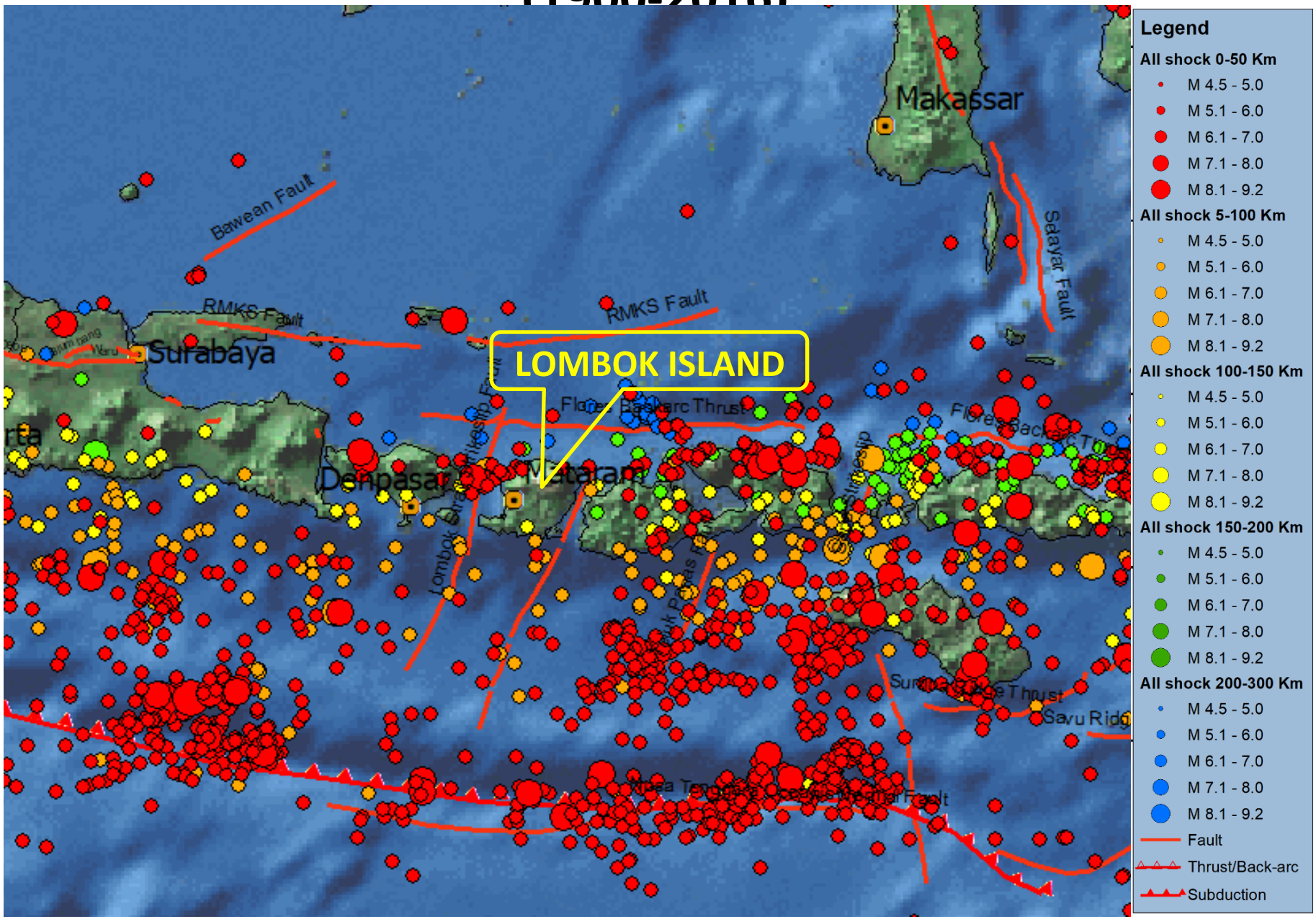


KALIMANTAN ACTIVE FAULT AND SURROUNDING

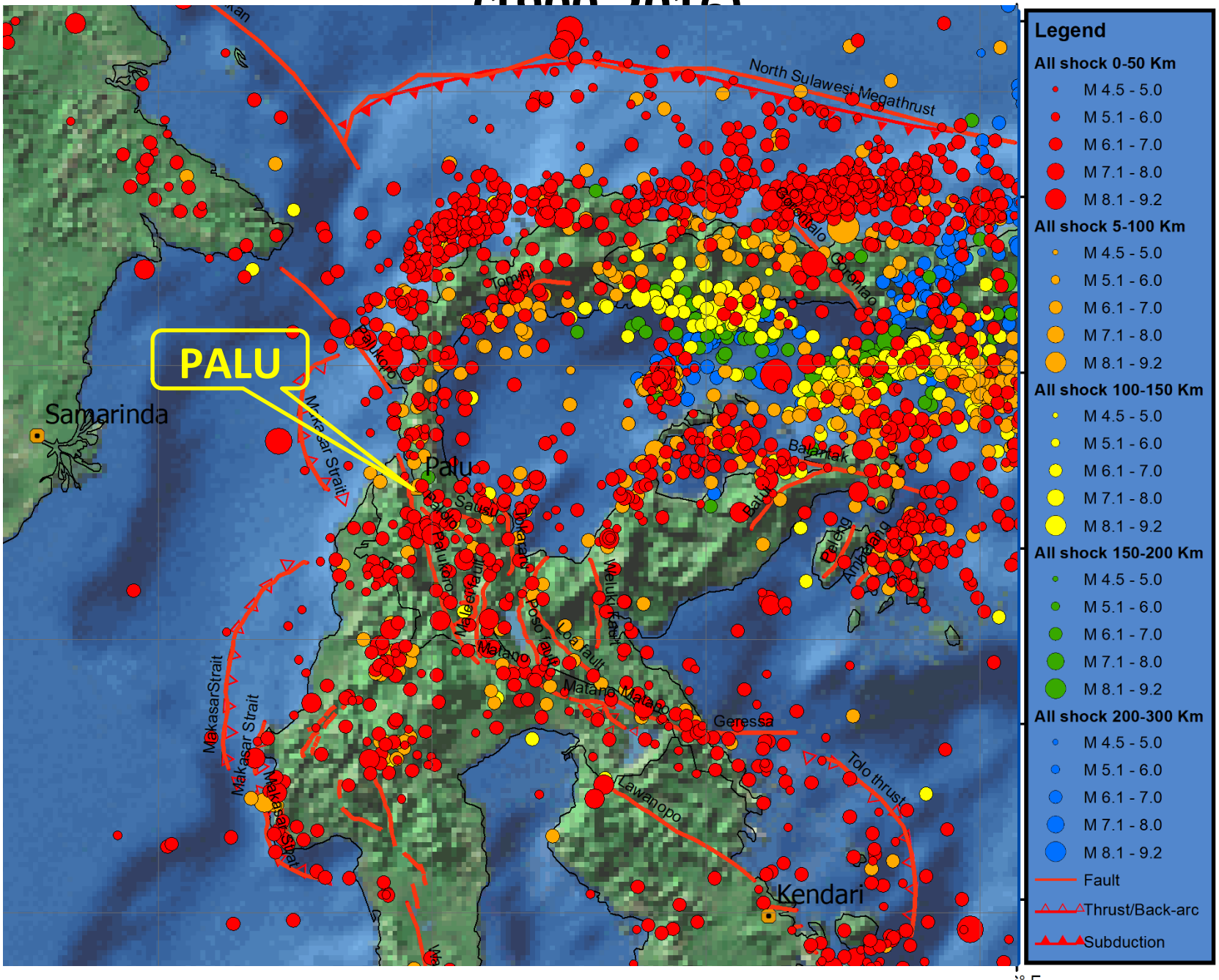
MEGATHRUST PARAMETERS FOR INPUT PSHA 2017



EQ EPICENTER FROM PUSGEN CATALOG (1900-2016)



EQ EPICENTER FROM PUSGEN CATALOG (1900-2016)



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Impact Lombok Eq. 2018

Buildings Collapse
Lombok Eq. 2018

“STRONG COLUMN WEAK BEAM” CONSEPT
NOT YET APPLIED

MINIMUM STANDARD OF REINFORCEMENT


Detailing of joint

LANDSLIDE

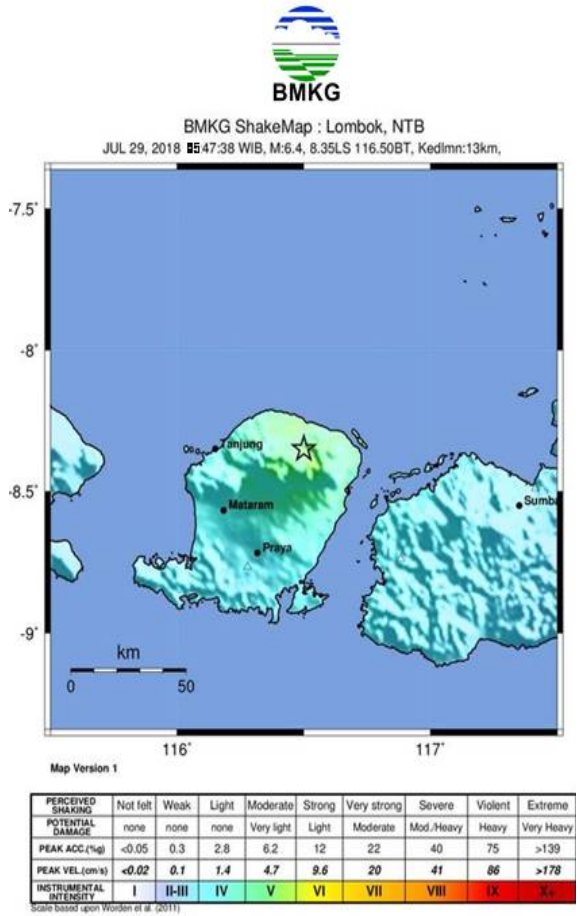
Lombok Eq. 2018

LIQUIFACTION & GROUND CRACKING

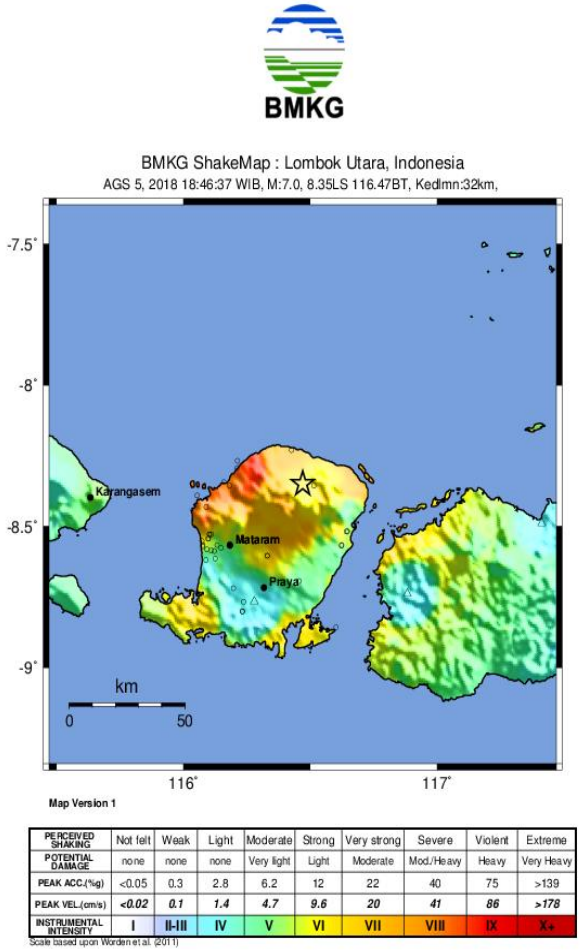
Lombok Eq. 2018

LESSONS LEARNED FROM LOMBOK EARTHQUAKE

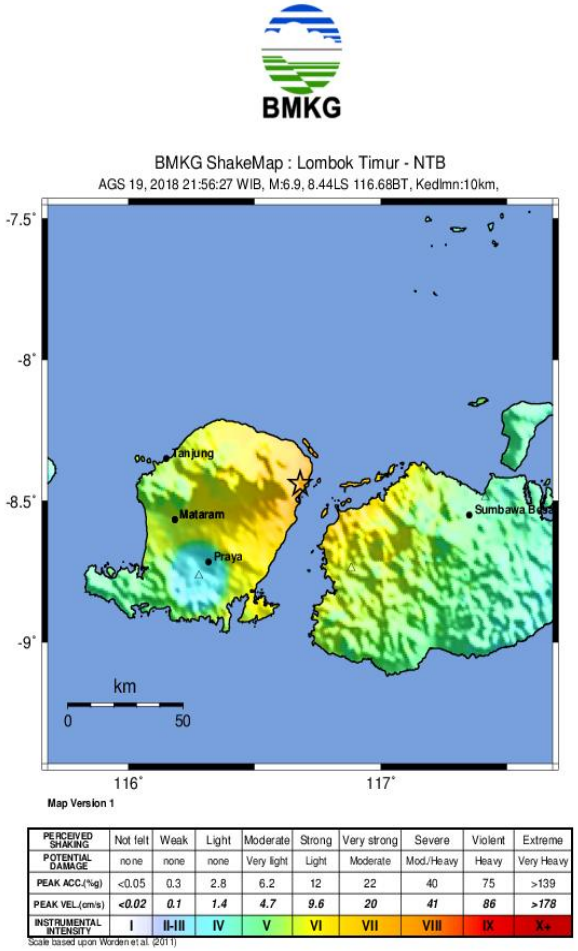
Lombok Earthquake Intensity Map in MMI by BMKG



M6.4, 29 Juli 2018



M7.0, 5 Agustus 2018

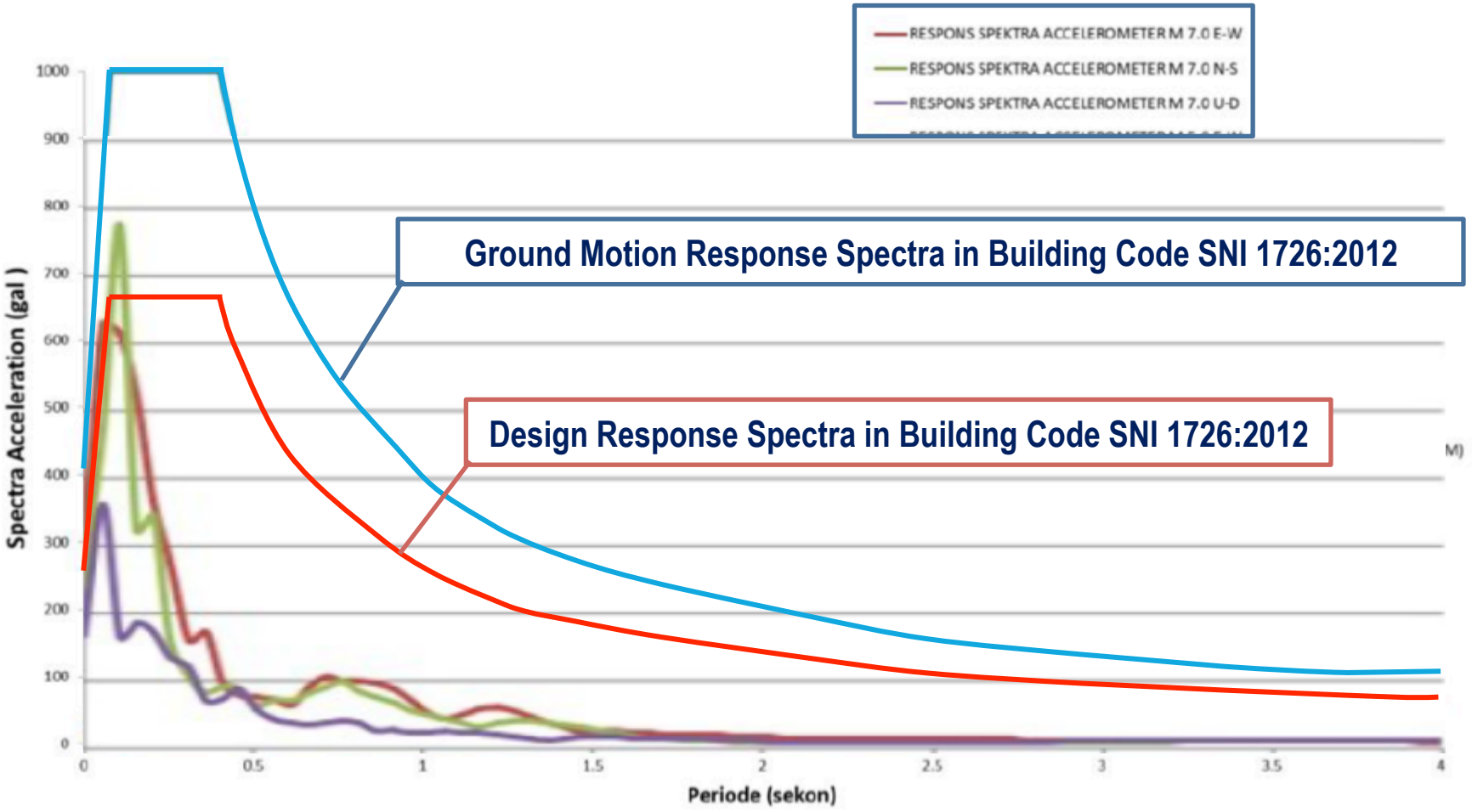


M6.9, 19 Agustus 2018

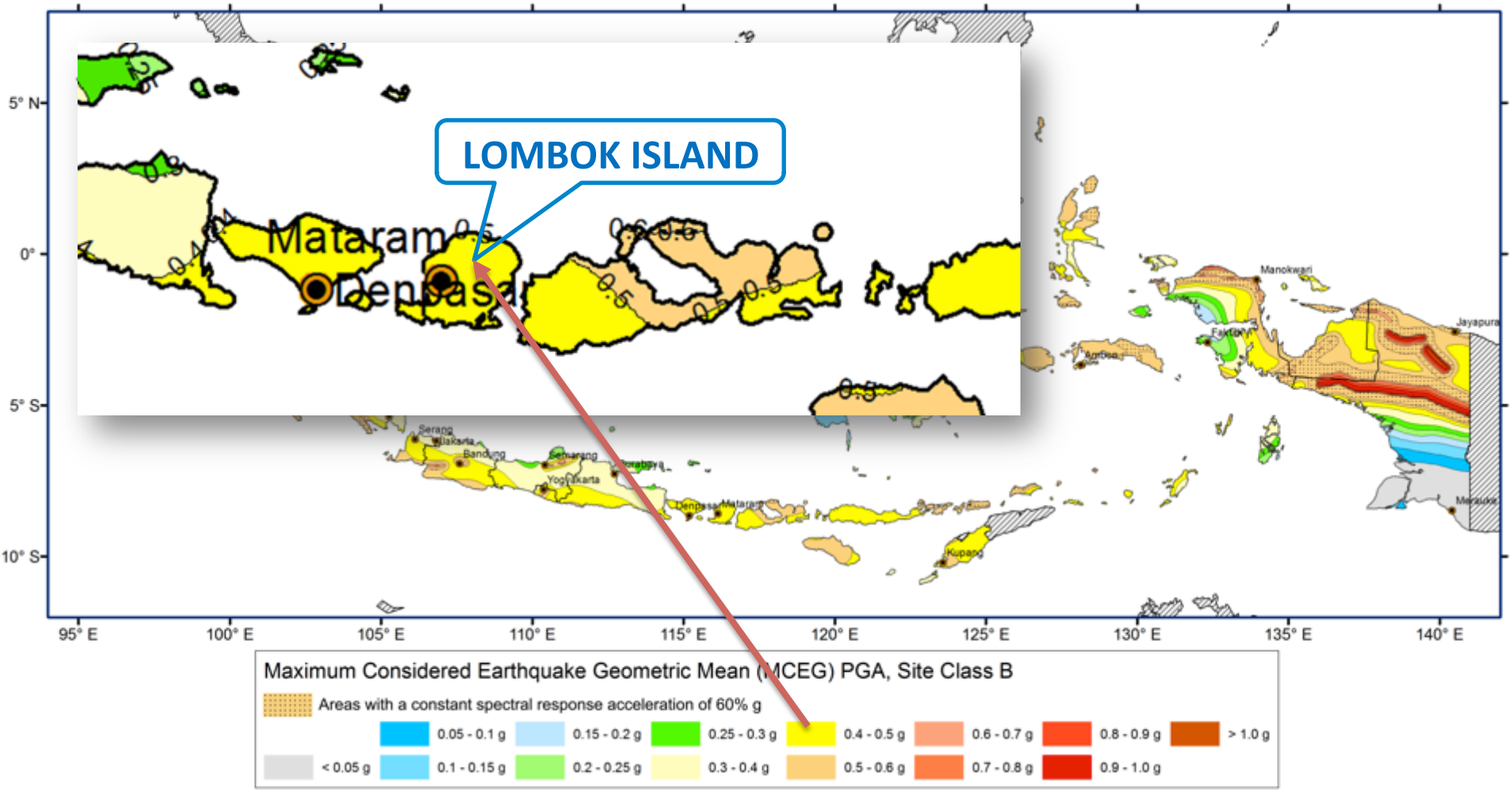
Value of MMI about VII

BMKG

Design and Recorded Response Spectra at Geophysics Taliwang Station
M 7.0 Lombok Earthquake 2018



Maximum Considered Earthquake Geometric mean (MCE_G) PGA in Building Code SNI-1726-2012



LESSONS LEARNED EATHQUKAE IMPACT TO BUILDING

CASE STUDY: LOMBOK Eq. 2018

VII MMI scale ➔ converted to PGA about 0.18-0.34g (Actual G Motion)

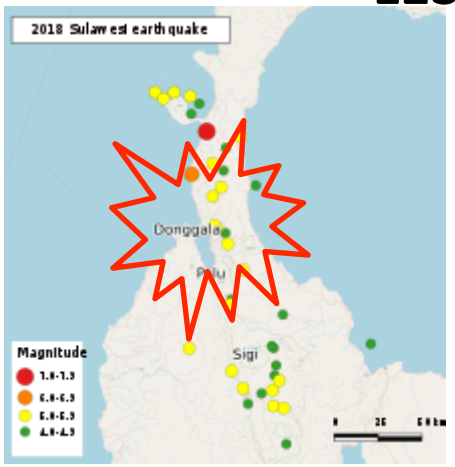
Indonesian Risk Map (MCE_G) SNI 1726:2012 for Lombok ➔ 0.4-0.5g (bedrock)

on surface, Peak Surface Acceleration (PSA) ➔ the value will be multiply with amplification factor depend on site class condition

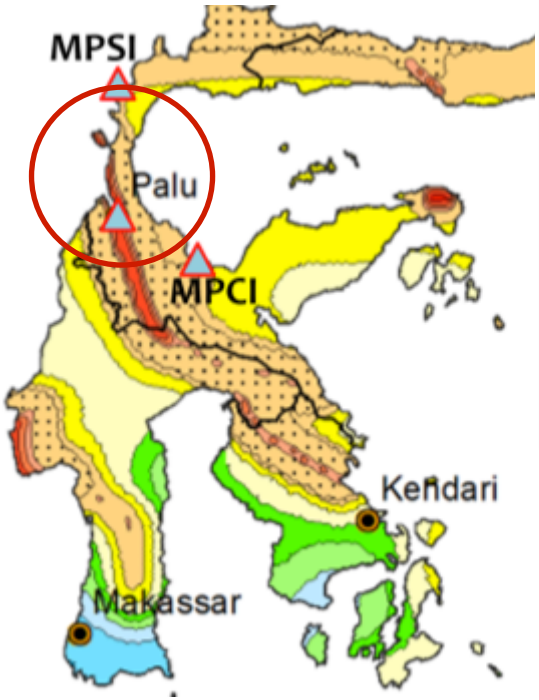
In fact ➔ many buildings that have structural damage (from medium to heavy), even to collapse due to the earthquake that occurred

➔ Buildings not designed in accordance with seismic design standards

LESSONS LEARNED FROM PALU EARTHQUAKE

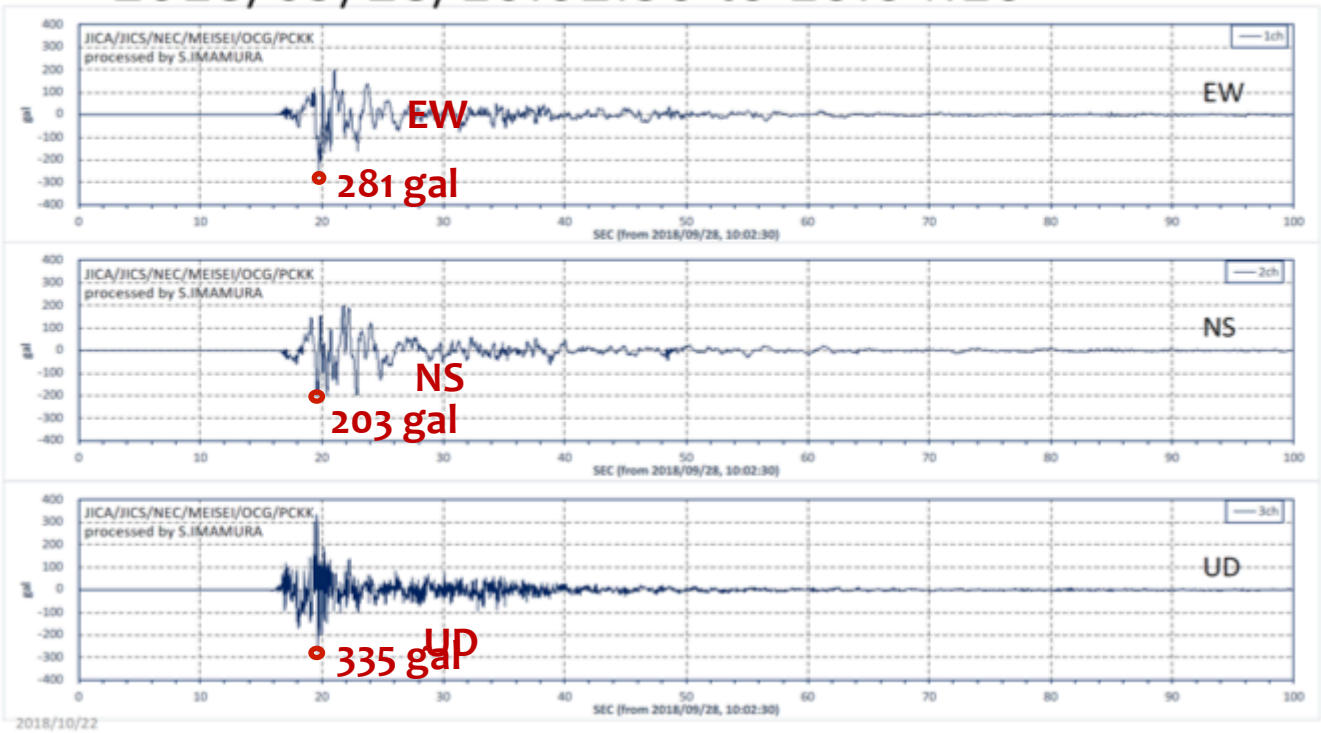


MCE_G (SNI 1726:2012)



BMKG

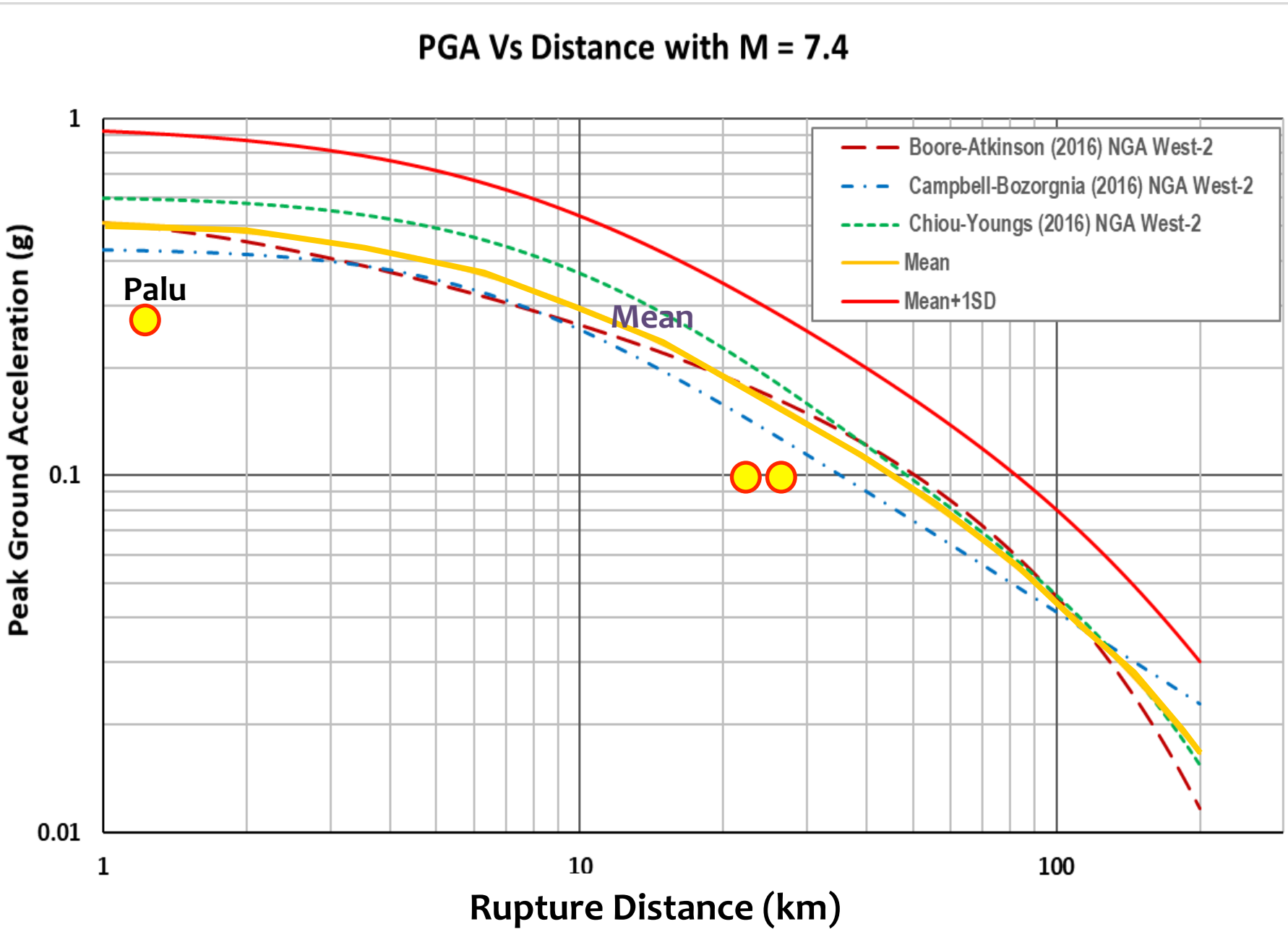
Acceleration waveform from 2018/09/28/10:02:30 to 10:04:10



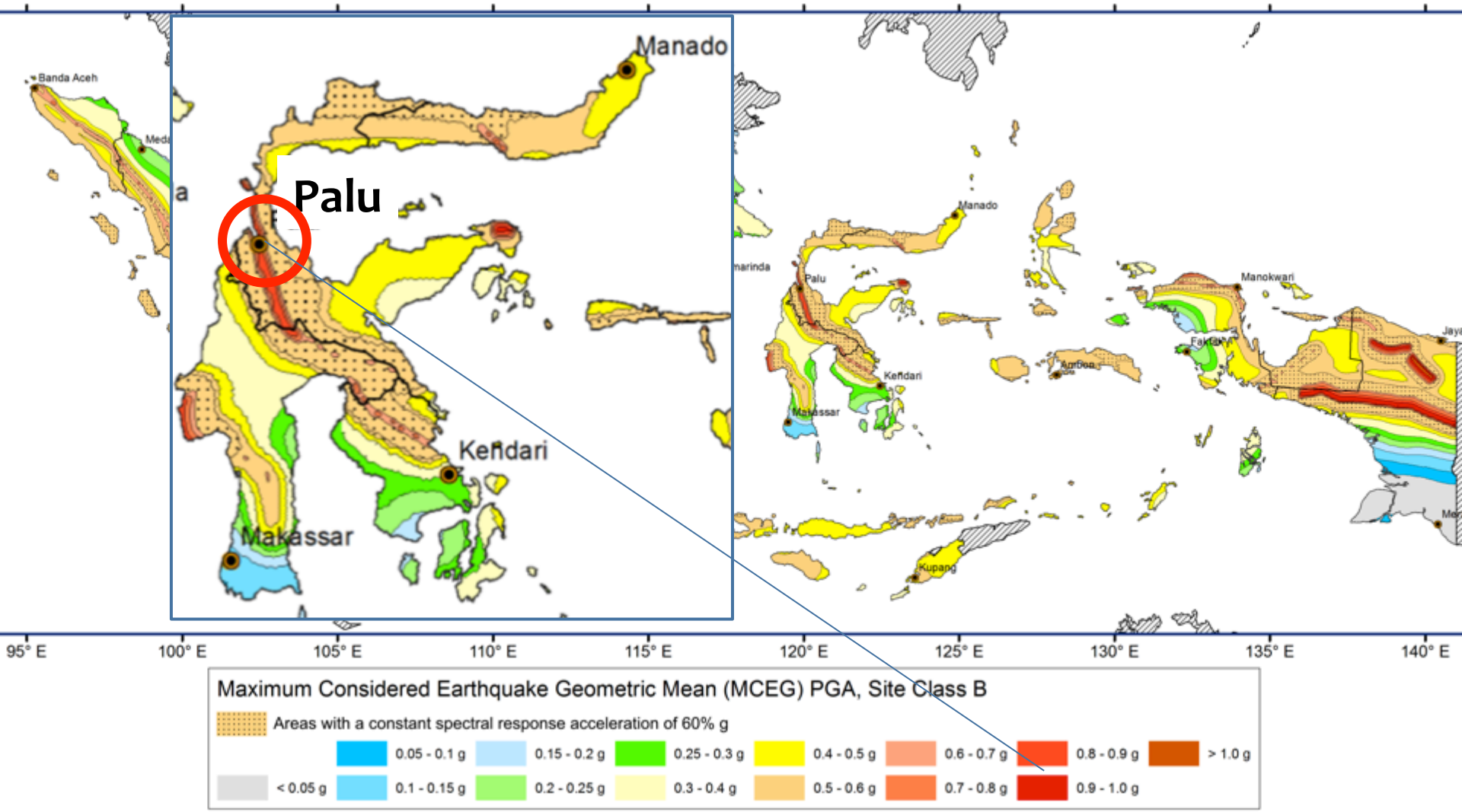
PGA & MMI

- EW: 281gal VII, NS: 203gal VII, UD: 335gal VI
- Horizontal vector: 333gal VIII
- 3 component vector: 400gal VIII

(Sigit Pramono, 2018)


PGA Vs Distance with M = 7.4
Peak Ground Acceleration (g)
1
0.1
0.01
1
10
100
Rupture Distance (km)
Boore-Atkinson (2016) NGA West-2
Campbell-Bozorgnia (2016) NGA West-2
Chiou-Youngs (2016) NGA West-2
Mean
Mean+1SD
Palu
Mean

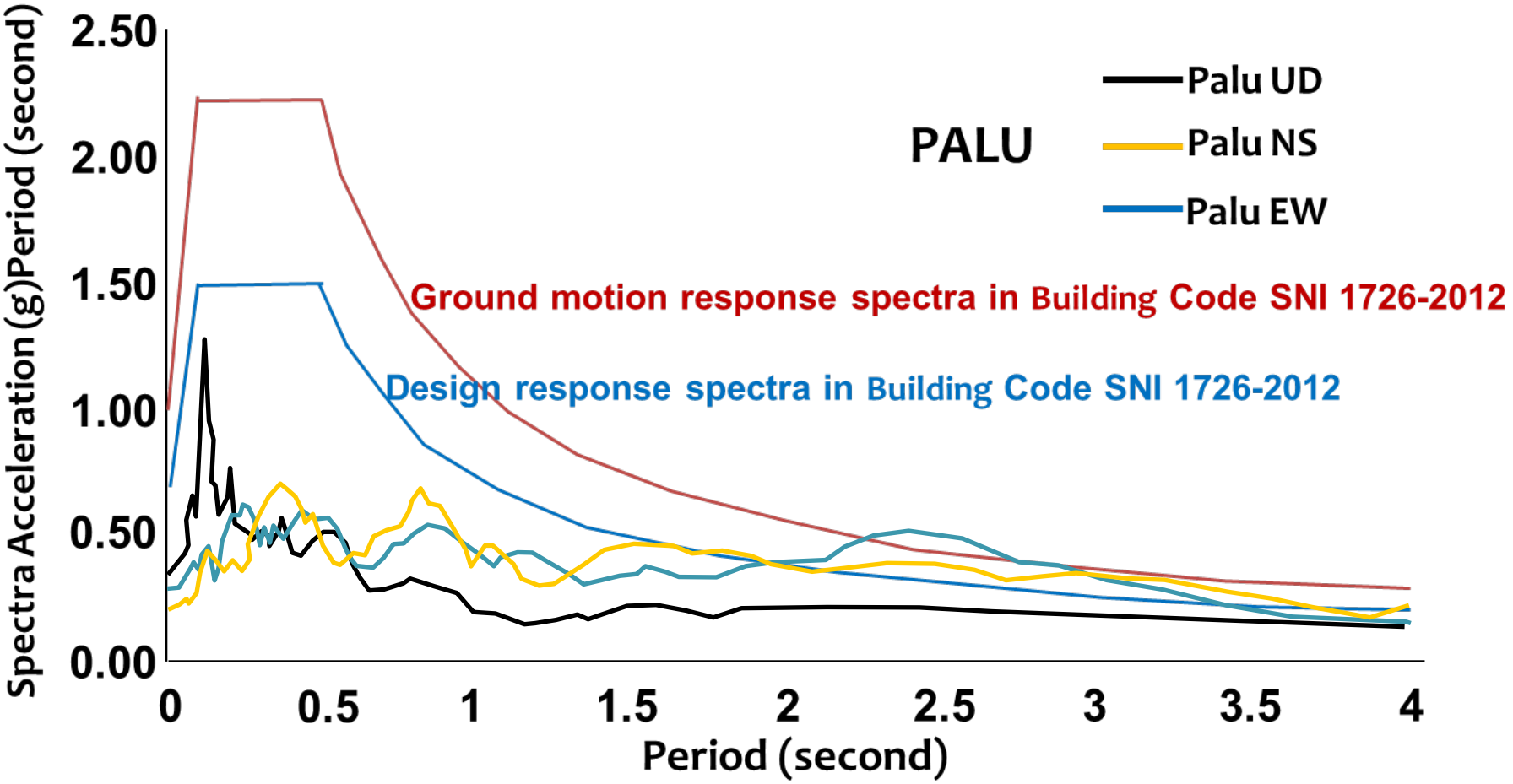
Maximum Considered Earthquake Geometric mean (MCE_G) PGA in Building Code SNI-1726-2012



BMKG

(Sigit Pramono)

Design and Recorded Response Spectra at Geophysics Station of Palu



Same case with Lombok Eq

PALU EQ ➔ Actual GM < Design GM ➔ but, many buildings collapse

LESSONS LEARNED FROM PALU/DONGGALA EARTHQUAKE

BUILDINGS COLLAPSE
Palu Eq. 2018

BUILDINGS COLLAPSE
Palu Eq. 2018

DAMAGE & LIQUIFACTION

Palu Eq. 2018

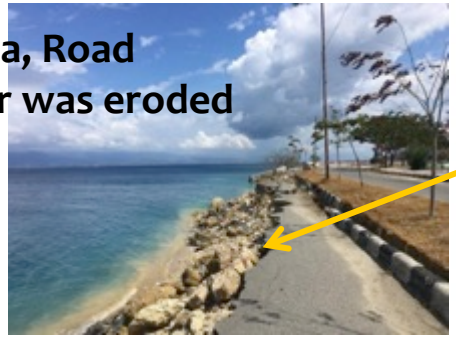
Hotel Roa Roa di kawasan Maesa di Kelurahan Lolu Timur, Kota Palu, luluh lantak dihantam rangkaian gempa yang melanda Sulawesi Tengah. Puluhan tamu belum diketahui nasibnya. **(KOMPAS.com/ROSYID A AZHAR)**

Tim SAR menemukan salah satu korban meninggal dunia dari reruntuhan Hotel Roa Roa Palu akibat gempa, Minggu (30/9/2018). **(Dok Humas Kantor SAR Palu)**

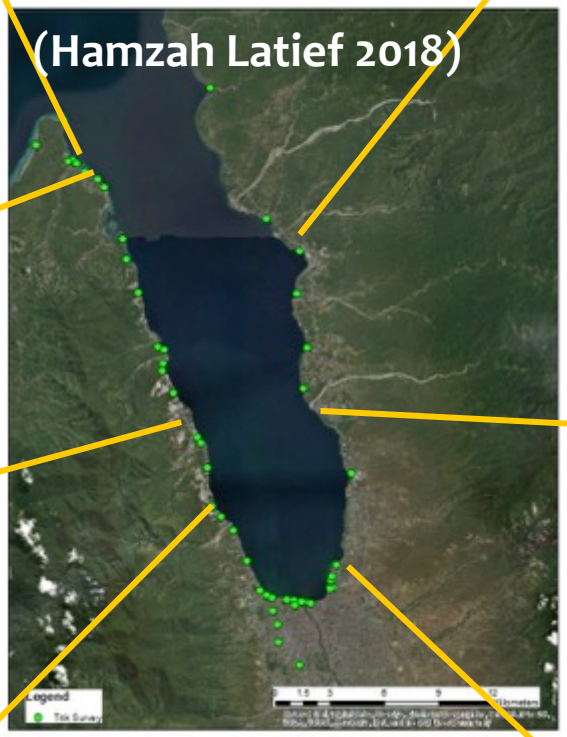
BRIDGE COLLAPSE

SURVEY OF PALU TSUNAMI

Donggal, house slided



Donggala, Road
Shoulder was eroded



Port Wani 2

Tondo Maboro

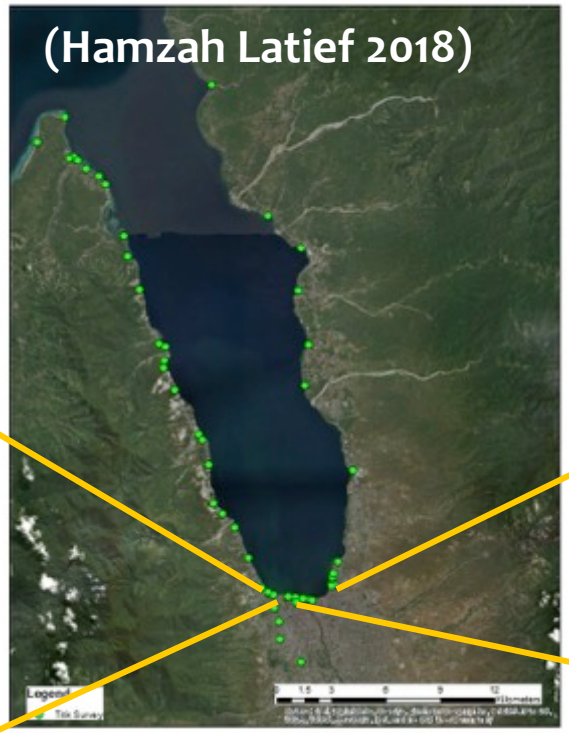
Lolipesua

Citra land

Buluri

Landslide Talise Beach

SURVEY OF PALU TSUNAMI



Wood and car transported by Tsunami

Datokarama Beach

Mosque in front of the Gas Station

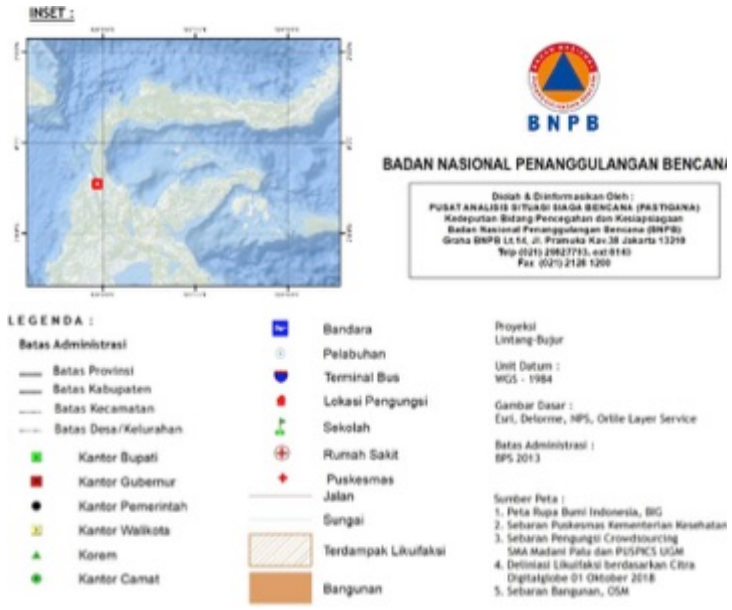
Yellow Bridge

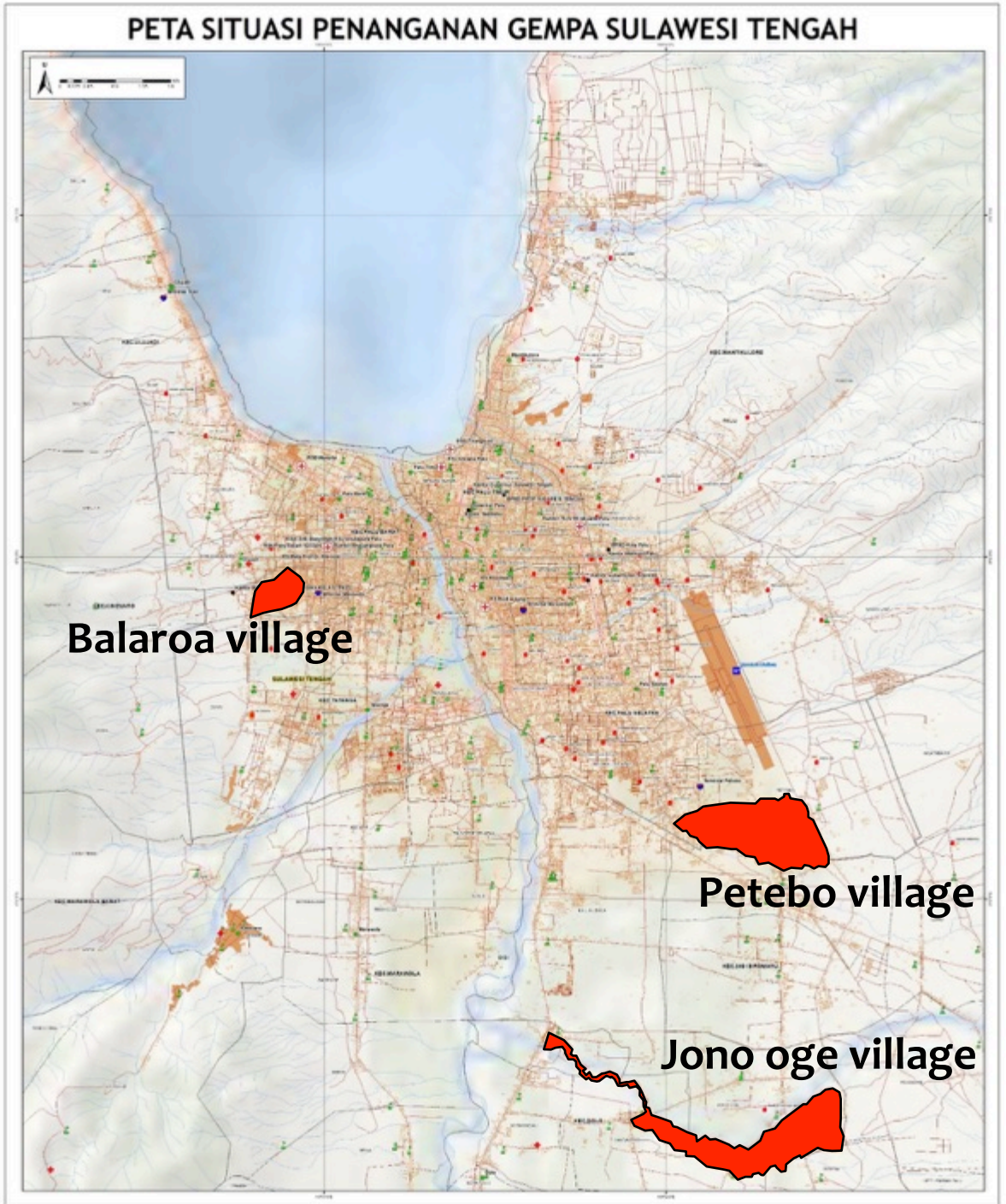
Ground Cracking

Ground Cracking at Palu Airport

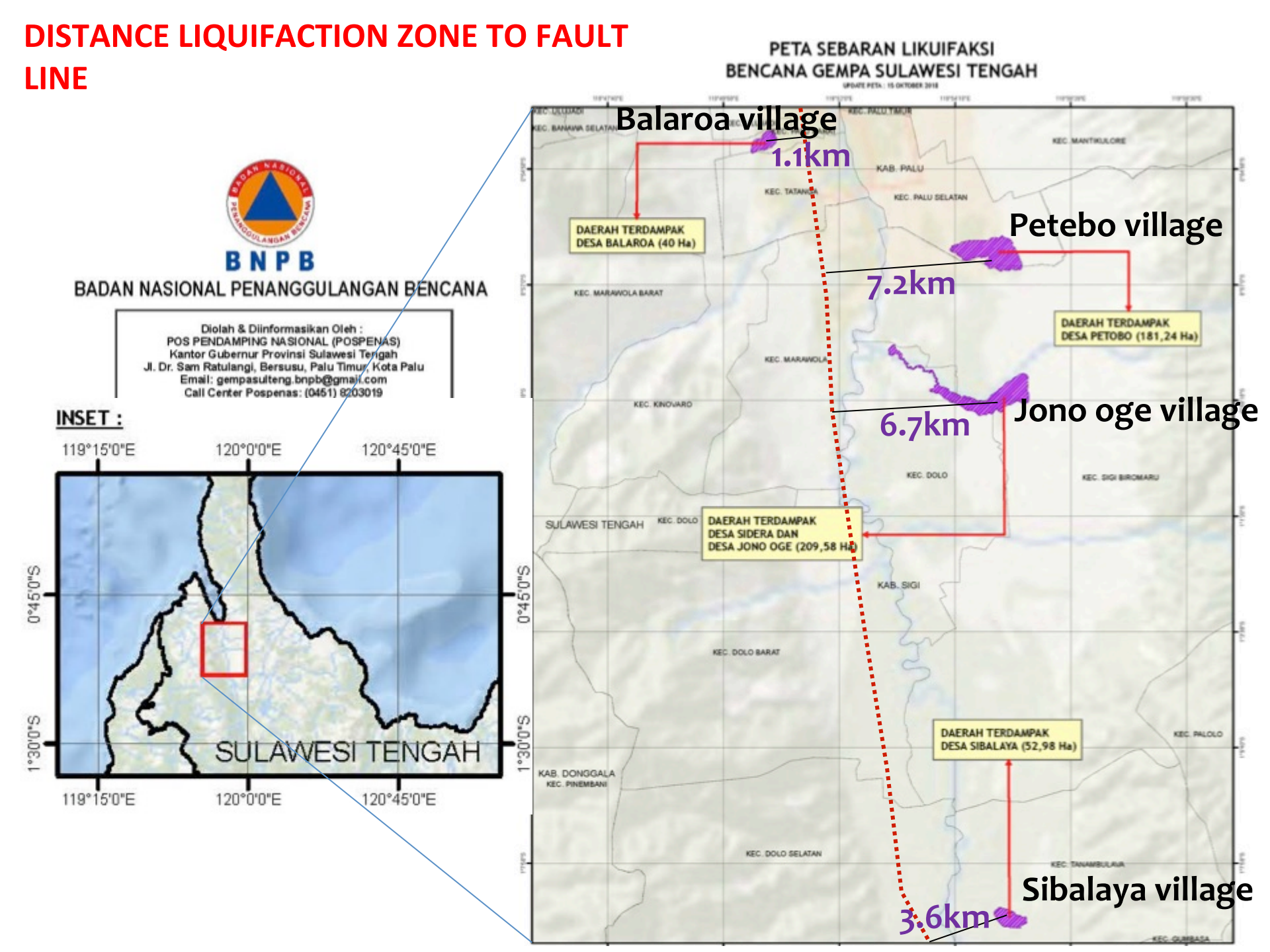
Ground Cracking, Jono oge village

Soil Condition, Liquefaction, and Landslide



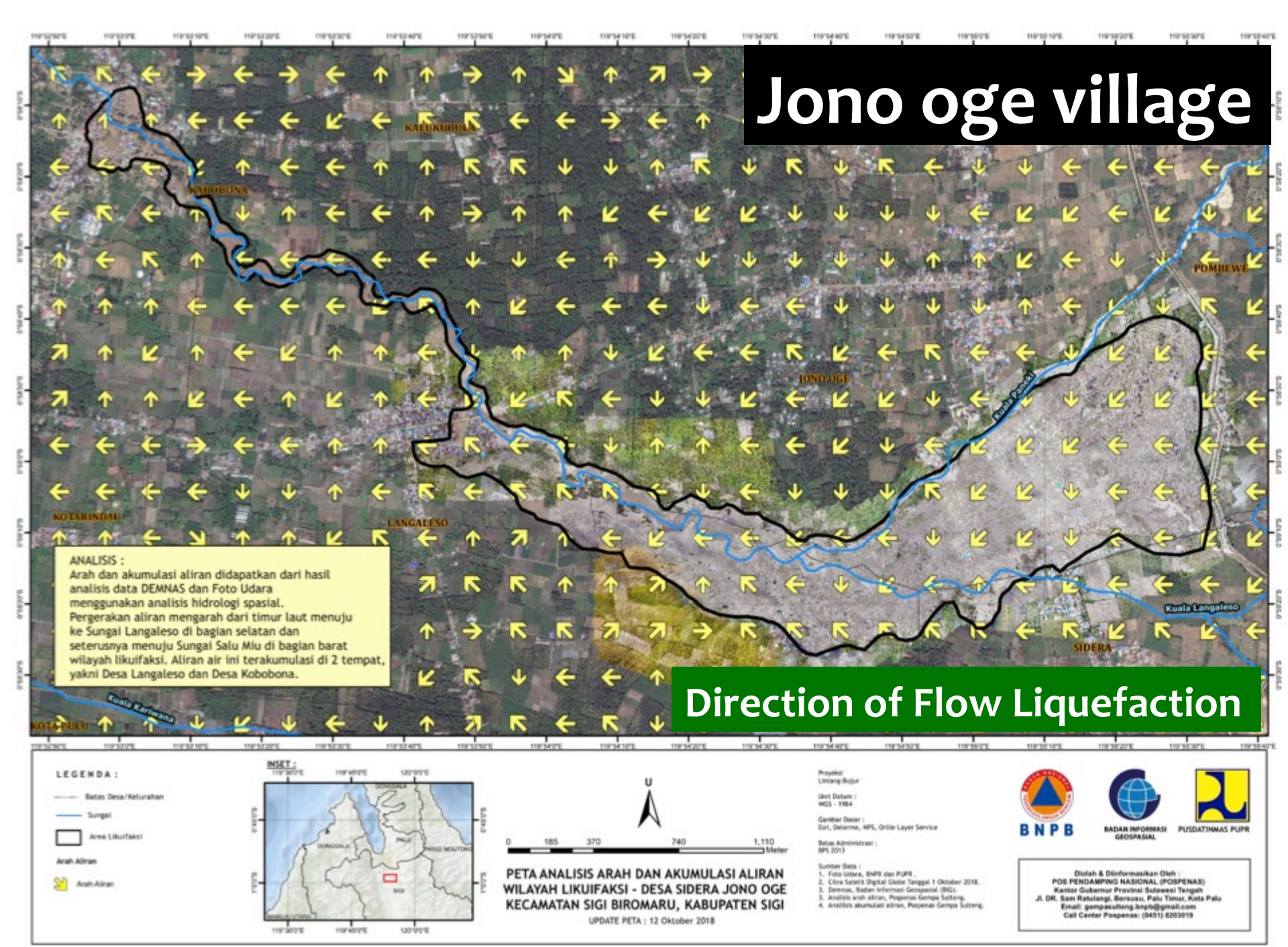


DISTANCE LIQUIFACTION ZONE TO FAULT LINE



Jono oge village

(Youtube, 2018)


Jono oge village
KALUKUBULA
KOBOBONA
POMBEWE
JONO OGE
Kuala Paneki
KOTARINDAU
LANGALESO
Kuala Langaleso
SIDERA
Kuala Karawana
KOTA PULU
ANALISIS :
Arah dan akumulasi aliran didapatkan dari hasil analisis data DEMNAS dan Foto Udara menggunakan analisis hidrologi spasial.
Pergerakan aliran mengarah dari timur laut menuju ke Sungai Langaleso di bagian selatan dan seterusnya menuju Sungai Salu Miu di bagian barat wilayah likuifaksi. Aliran air ini terakumulasi di 2 tempat, yakni Desa Langaleso dan Desa Kobobona.
Direction of Flow Liquefaction
LEGENDA :
Batas Desa/Kelurahan
Sungai
Area Likuifaksi
Arah Aliran
Arah Aliran
INSET :
U
0 185 370 740 1,110 Meter
PETA ANALISIS ARAH DAN AKUMULASI ALIRAN WILAYAH LIKUIFAKSI - DESA SIDERA JONO OGE KECAMATAN SIGI BIROMARU, KABUPATEN SIGI
UPDATE PETA : 12 Oktober 2018
Proyeksi :
Lintang-Bujur
Unit Datum :
WGS - 1984
Gambar Dasar :
Esri, Delorme, NPS, Ortle Layer Service
Batas Administrasi :
BPS 2013
Sumber Data :
1. Foto Udara, BNPB dan PUPR .
2. Citra Satelit Digital Globe Tanggal 1 Oktober 2018.
3. Demnas, Badan Informasi Geospasial (BIG).
3. Analisis arah aliran, Pospenas Gempa Sulteng.
4. Analisis akumulasi aliran, Pospenas Gempa Sulteng.
BNPB
BADAN INFORMASI GEOSPASIAL
PUSDATINMAS PUPR
Diolah & Diinformasikan Oleh :
POS PENDAMPING NASIONAL (POSPENAS)
Kantor Gubernur Provinsi Sulawesi Tengah
Jl. DR. Sam Ratulangi, Bersusu, Palu Timur, Kota Palu
Email: gempasulteng.bnpb@gmail.com
Call Center Pospenas: (0451) 8203019

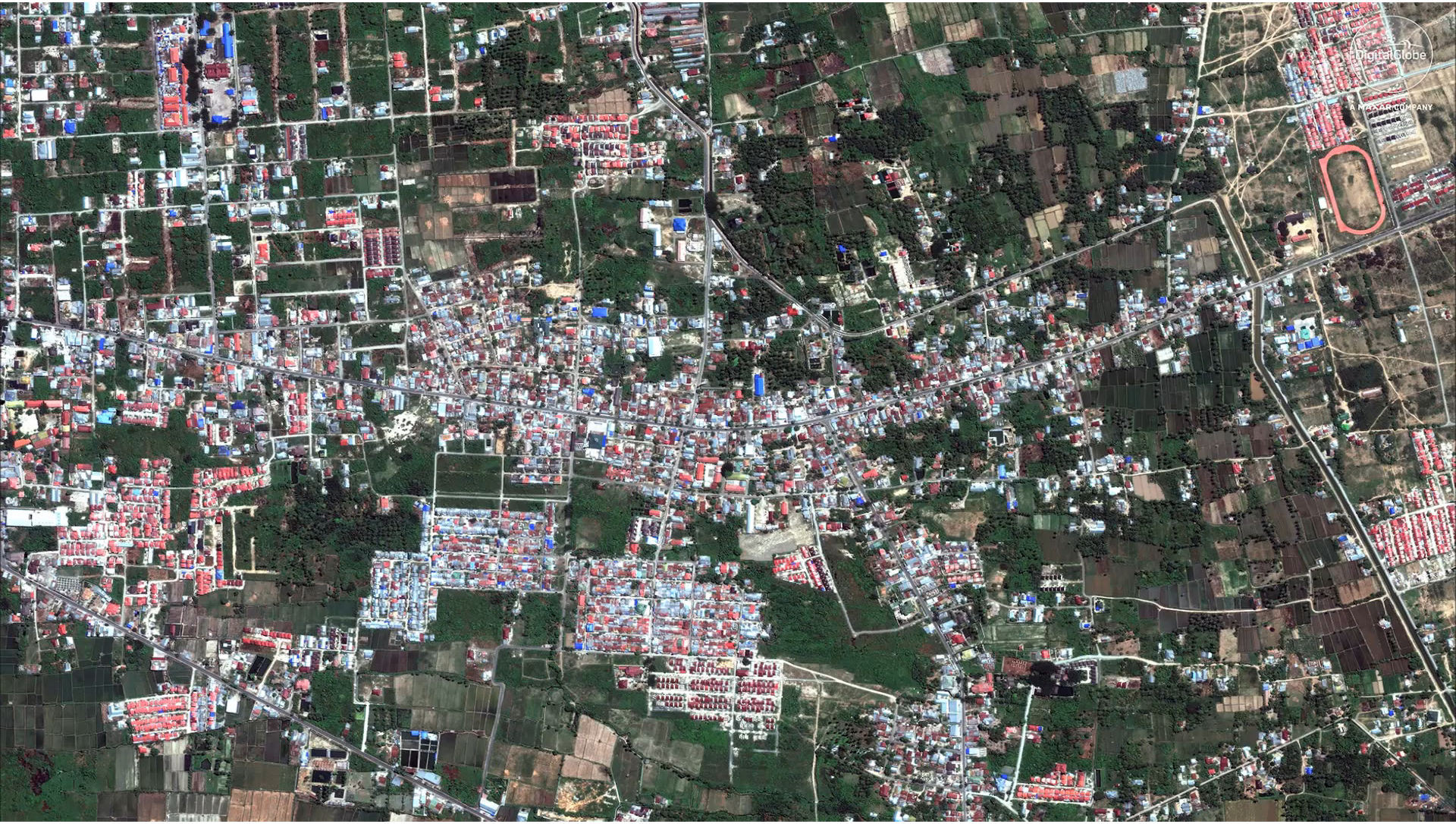
Soil Condition & Liquefaction

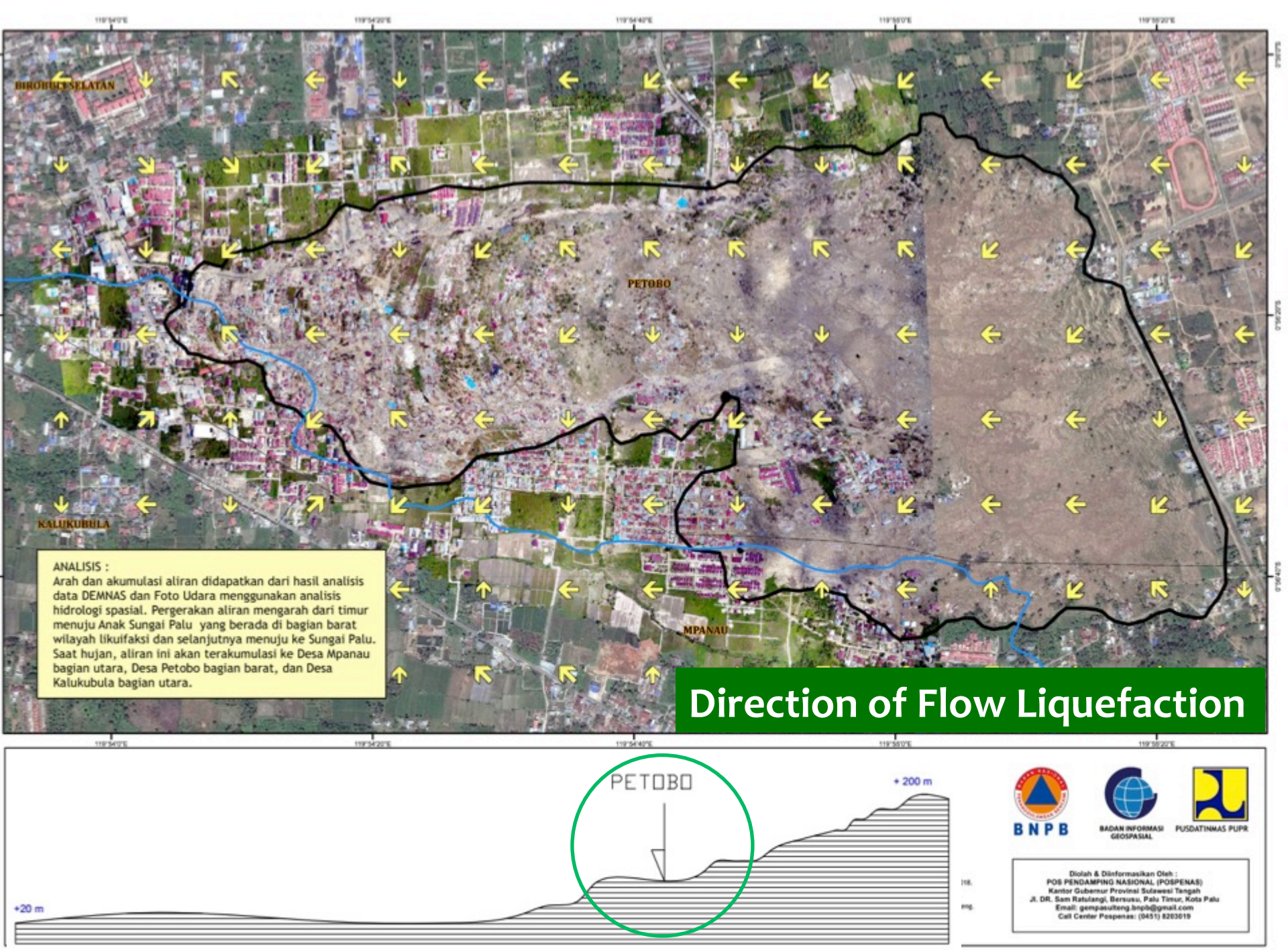
Petobo village

(Youtube, 2018)

Flow Liquefaction Failure

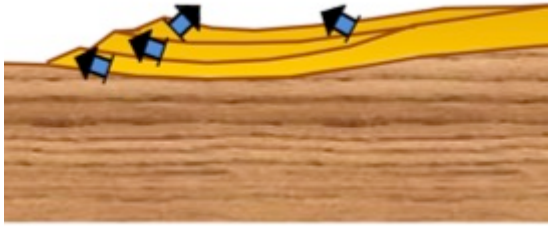
Petobo village
(Youtube, 2018)




BIROBULI SELATAN
PETOBO
KALUKUBULA
MPANAU
ANALISIS :
Arah dan akumulasi aliran didapatkan dari hasil analisis data DEMNAS dan Foto Udara menggunakan analisis hidrologi spasial. Pergerakan aliran mengarah dari timur menuju Anak Sungai Palu yang berada di bagian barat wilayah likuifaksi dan selanjutnya menuju ke Sungai Palu. Saat hujan, aliran ini akan terakumulasi ke Desa Mpanau bagian utara, Desa Petobo bagian barat, dan Desa Kalukubula bagian utara.
Direction of Flow Liquefaction

PETOBO
+ 200 m
+20 m
BNPB
BADAN INFORMASI GEOSPASIAL
PUSDATINMAS PUPR
Diolah & Diinformasikan Oleh :
POS PENDAMPING NASIONAL (POSPENAS)
Kantor Gubernur Provinsi Sulawesi Tengah
Jl. DR. Sam Ratulangi, Bersusu, Palu Timur, Kota Palu
Email: gempasulteng.bnpb@gmail.com
Call Center Pospenas: (0451) 8203019

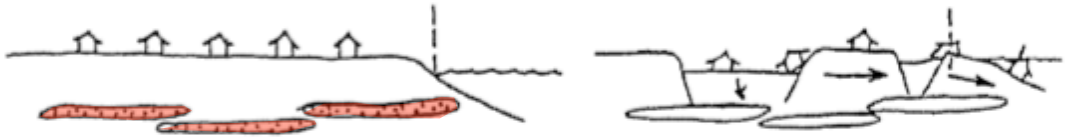

Petobo village



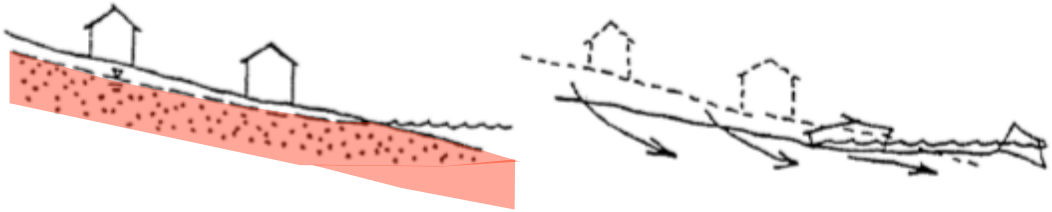
Toe of failure

Liquefied zone with low residual undrained strength

(a) Edge Failure/Lateral Spreading by Flow

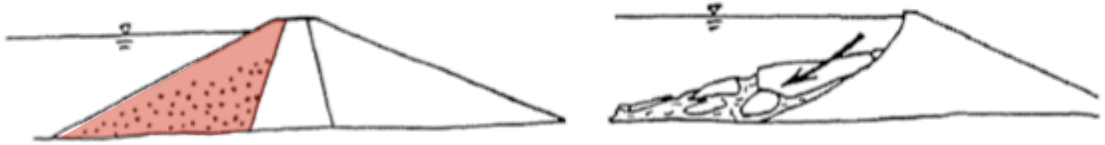


(b) Edge Failure/Lateral Spreading by Translation



(c) Flow Failure

(d) Translational Displacement

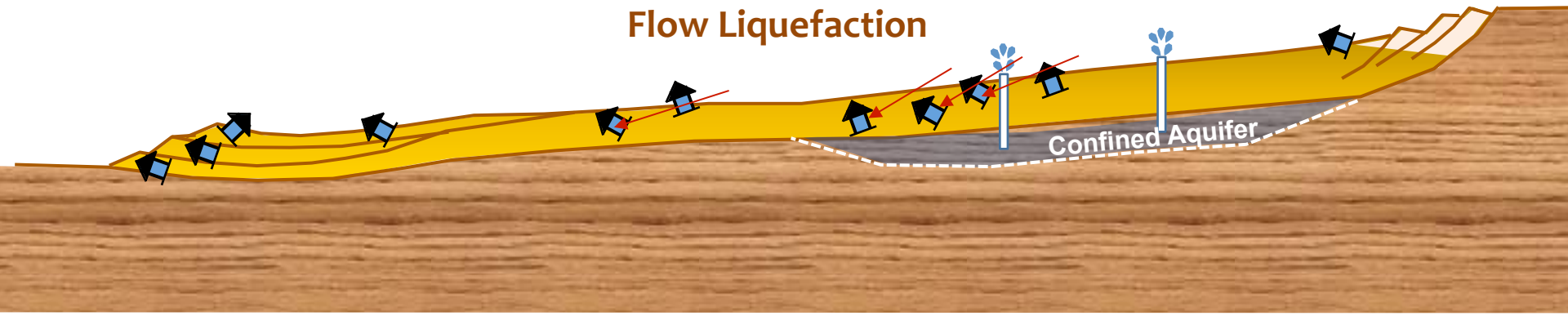


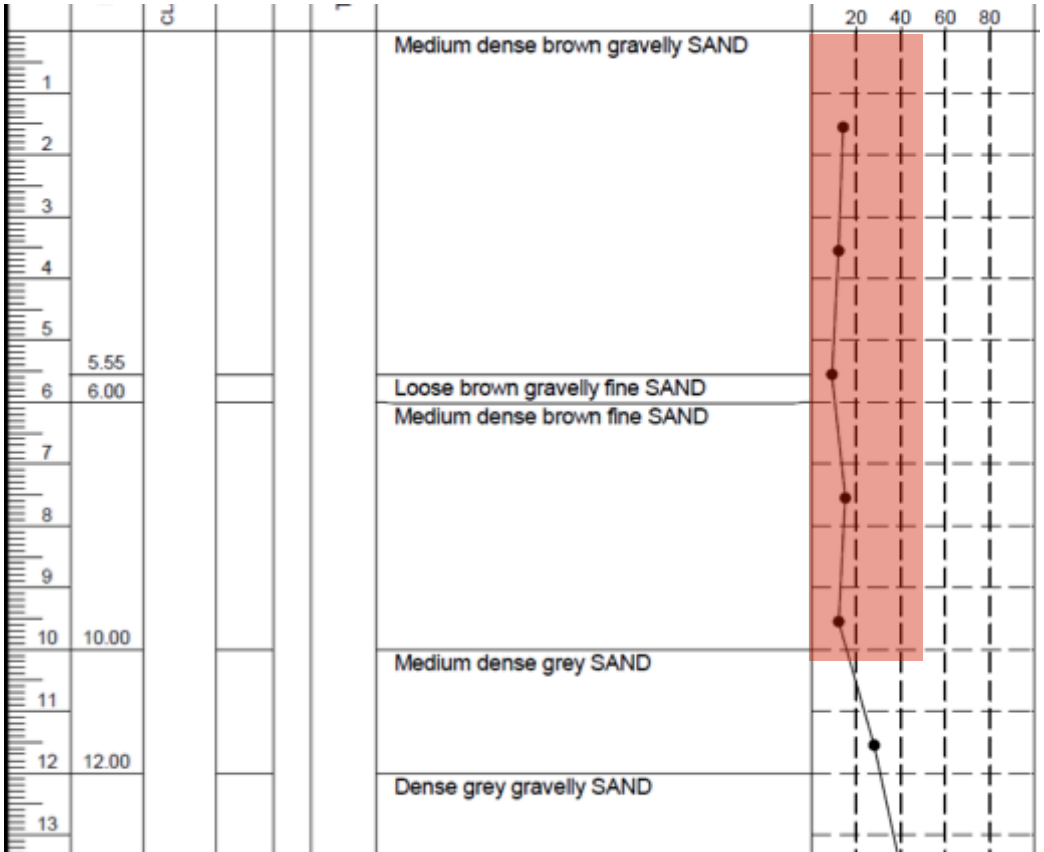
(e) Rotational and/or Translational Sliding

Schematic Examples of Liquefaction-Induced Global Site Instability and/or "Large" Displacement Lateral Spreading (Seed et al., 2001)

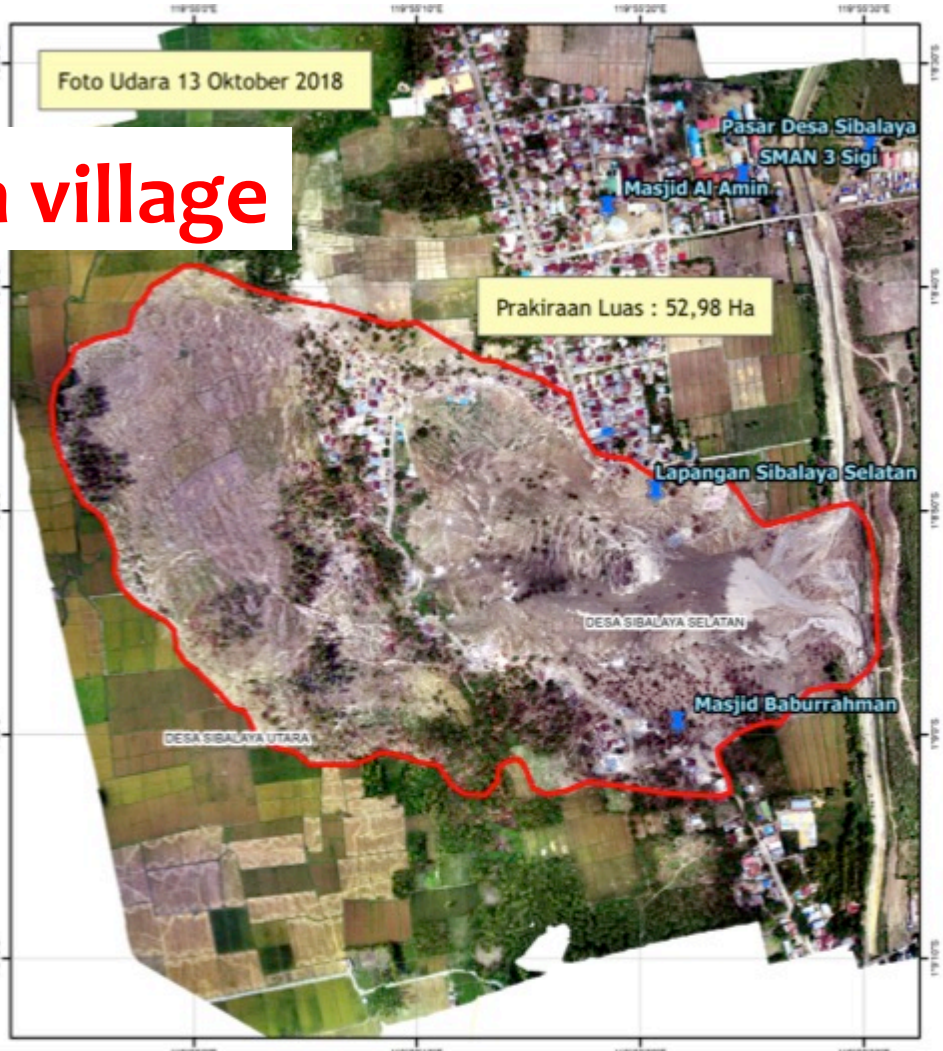
Petebo village

Flow Liquefaction





Sibalaya village



LEGENDA :

Batas Administrasi

- Titik-titik Penting
- Batas Desa/Kelurahan
- Area Likuifaksi

INSET :

U

0 70 140 280 420 Meter

PETA TERDAMPAK LIKUIFAKSI DESA SIBALAYA
KECAMATAN TANAMBULAVA
KABUPATEN SIGI

UPDATE PETA : 17 Oktober 2018

Proyeksi
Lintang-Bujur

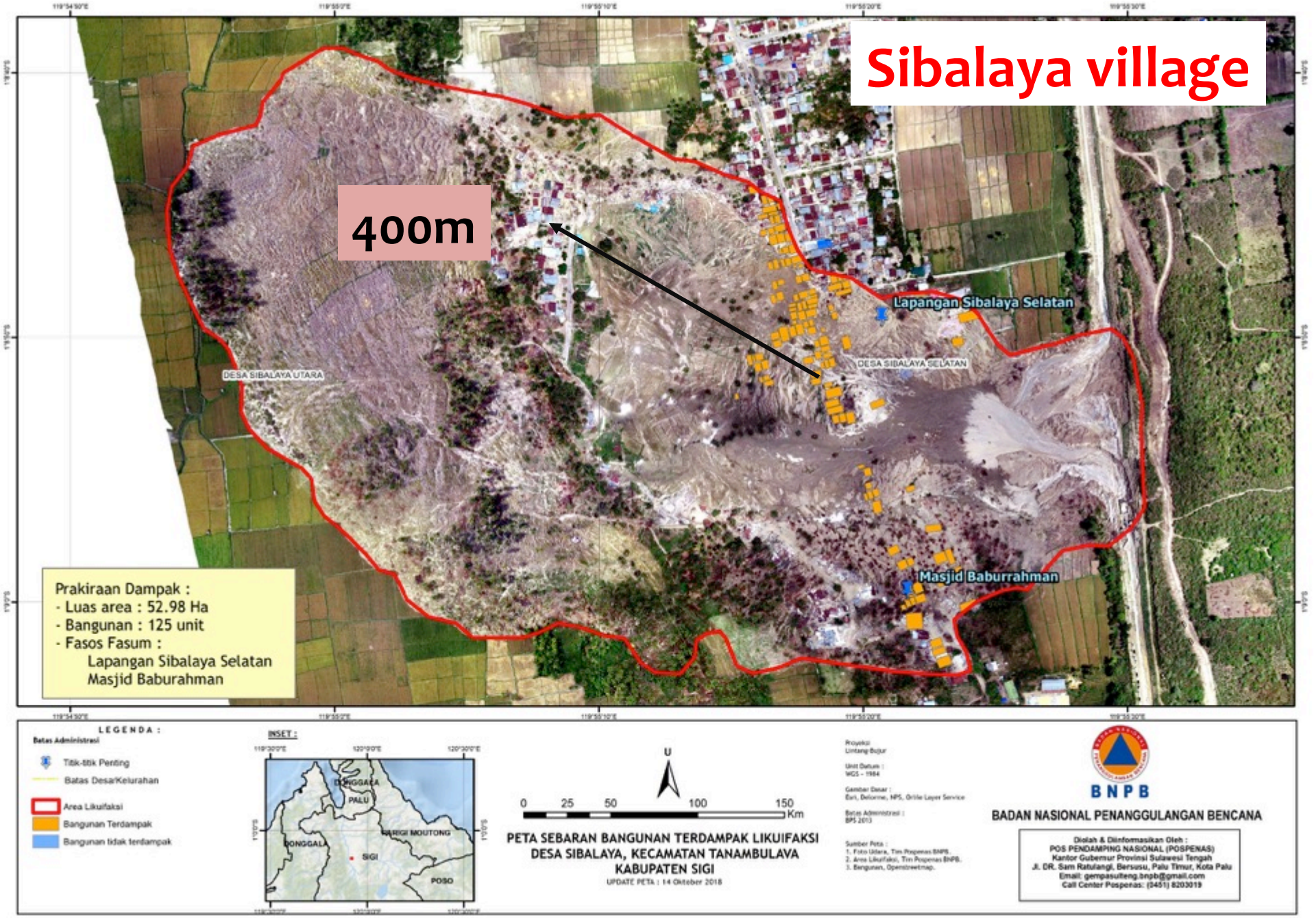
Unit Datum :
WGS - 1984

Sumber Peta :
1. Area Likuifaksi, Tim Pospenas BNPB.
2. Foto Udara, Tim Pospenas BNPB.
3. Citra Planet Tanggal 8 September 2018

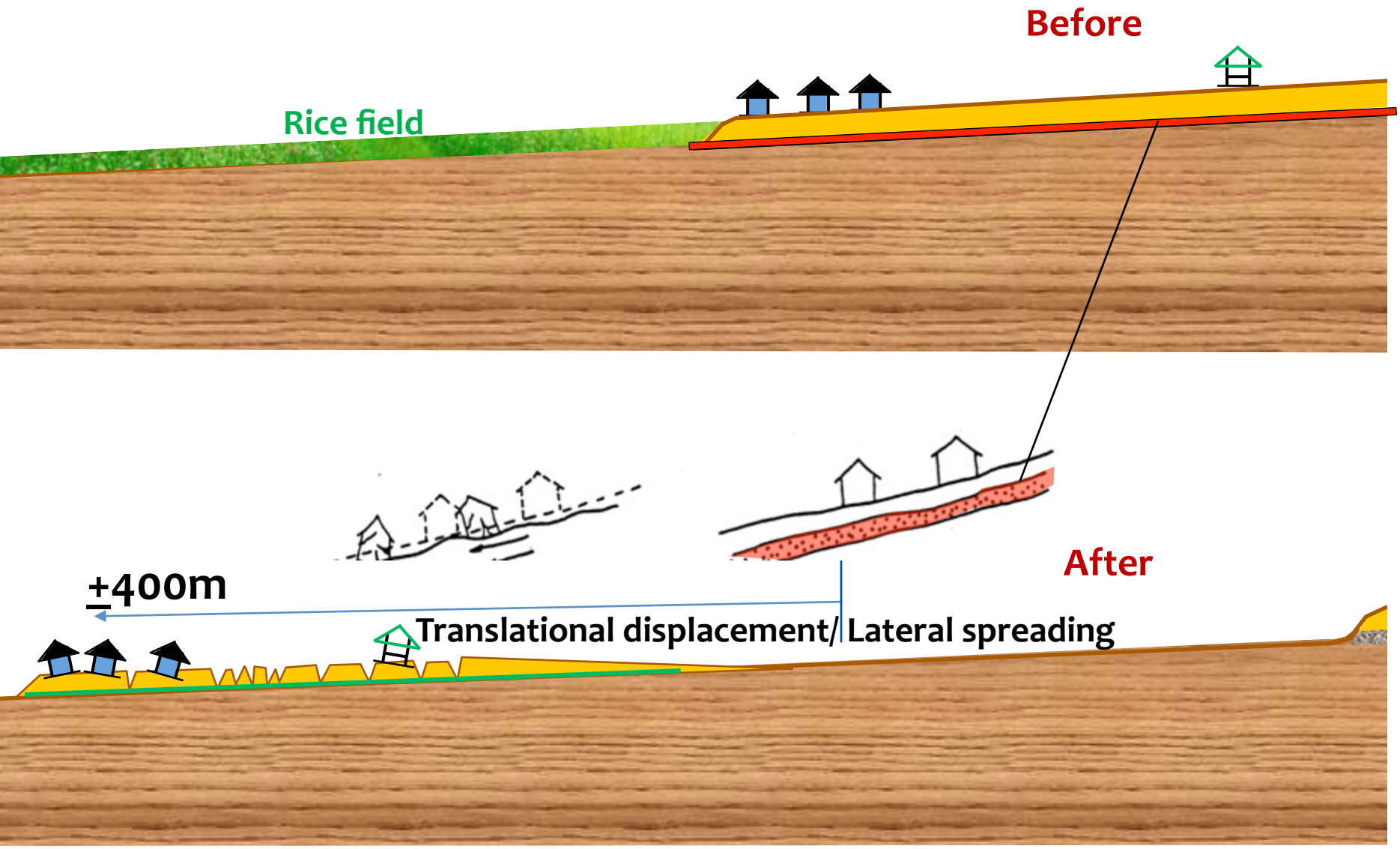
BNPB

BADAN NASIONAL PENANGGULANGAN BENCANA

Diolah & Diinformasikan Oleh :
POS PENDAMPING NASIONAL (POSPENAS)
Kantor Gubernur Provinsi Sulawesi Tengah
Jl. DR. Sam Ratulangi, Bersusu, Palu Timur, Kota Palu
Email: gempasulteng.bnpb@gmail.com
Call Center Pospenas: (0451) 8203019


Sibalaya village
400m
Lapangan Sibalaya Selatan
DESA SIBALAYA UTARA
DESA SIBALAYA SELATAN
Masjid Baburrahman
Prakiraan Dampak :
- Luas area : 52.98 Ha
- Bangunan : 125 unit
- Fasos Fasum :
Lapangan Sibalaya Selatan
Masjid Baburahman
LEGENDA :
Batas Administrasi
Titik-titik Penting
Batas Desa/Kelurahan
Area Likuifaksi
Bangunan Terdampak
Bangunan tidak terdampak
INSET :
DONGGALA
PALU
SIGI
BIRIGI MOUTONG
POSO
U
0 25 50 100 150
Km
PETA SEBARAN BANGUNAN TERDAMPAK LIKUIFAKSI
DESA SIBALAYA, KECAMATAN TANAMBULAVA
KABUPATEN SIGI
UPDATE PETA : 14 Oktober 2018
Proyeksi
Lintang-Bujur
Unit Datum :
WGS - 1984
Gambar Dasar :
Esri, DeLorme, NPS, Ortho Layer Service
Batas Administrasi :
BPS 2013
Sumber Peta :
1. Foto Udara, Tim Pospenas BNPB.
2. Area Likuifaksi, Tim Pospenas BNPB.
3. Bangunan, Openstreetmap.
BNPB
BADAN NASIONAL PENANGGULANGAN BENCANA
Diolah & Diinfomasikan Oleh :
POS PENDAMPING NASIONAL (POSPENAS)
Kantor Gubernur Provinsi Sulawesi Tengah
Jl. DR. Sam Ratulangi, Bersusu, Palu Timur, Kota Palu
Email: gempasulteng.bnpb@gmail.com
Call Center Pospenas: (0451) 8203019

SIBALAYA VILLAGE



KEMENTERIAN PEKERJAAN UMUM DAN PERUMAHAN RAKYAT
BADAN PENELITIAN DAN PENGEMBANGAN
PUSAT PENELITIAN DAN PENGEMBANGAN JALAN DAN JEMBATAN
Jl.A.H. Nasution No. 264 PO BOX 2 Bandung 40294 Indonesia Telp. (022) 7802251 Fax (022) 7802726 email:info@pusjatan.pu.go.id

Gambar 6 Penyelidikan Geofisika Menggunakan Metode Geolistrik Daerah Terdampak Likuifaksi Sibalaya

Houses have moved approximately 400m

LAND SUBSIDENCE

CLOSING

- We are still mourning the victims of the earthquake in Lombok and Palu, hoping that people will recover quickly.
- Recorded PGA at Lombok range 180-340 gal & Palu range from 200-350 gal.
- Impact of Palu Eq: ground cracking, tsunami, landslide, liquefaction, and ground shaking are a huge natural disaster event and will be a future learning ➔ This is a huge laboratory for natural disasters
- Palu Eq: the rupture offset was found as large as 4-6 meters horizontal sinistral offset and about half meter vertical offset.
- Liquefaction has resulted in extreme flow liquefaction and lateral spreading.
- Material losses and injuries or death are usually not caused by earthquakes directly, but because buildings or infrastructure are designed not to follow seismic design building standards (Earthquake doesn't kill)
- Stakeholders in the construction sector must seriously pay attention to the rules of building seismic resistance based on the current code provisions.

Thank you for the continuous support from:

Ministry of Public Works

RISTEKDIKTI

Ministry of Energy+ Mineral Resources

Ministry of Transportation

National Disaster Management Authority

Bureau of Meteorology, Climatology, Geophysics

Indonesia Research Institute

Geospatial Information Agency

Australian Government
Geoscience Australia

GEM
GLOBAL EARTHQUAKE MODEL
working together to assess risk

USGS
science for a changing world

To:

PuSGeN
Pusat Studi Gempabumi Nasional
The National Research Center for Earthquake

SALUTI E GRAZIE

asrurifak@gmail.com