SCENARIO DESIGN ON THE IMPACT OF A HIGH-MAGNITUDE EARTHQUAKE IN THE CITY OF LIMA, PERU




Methodology

- Determination of the characteristics of the probable earthquake (magnitude, intensity, acceleration).
- Seismic geotechnical soil characterization Metropolitan Lima.
- Estimation of the seismic vulnerability of buildings.
- Seismic Risk Assessment.
- Tsunami hazard assessment.
- Impact Assessment (Damages).

Document Features

- An instrument to support basic performance protocol for humanitarian response to seismic disasters in Lima-Callao.

- Done in a short period of time (two months) based on secondary information available.

- Allows estimation of impacts and the preliminary analysis of seismic risk.

- It provides the basis for creation of more precise and detailed products.

- Could be easily modified based on updated data.

- Shows the simulation scenario of earthquake damages in urban areas, representing results spatially using a geographic information system (GIS).

Study Area

Lima and the Constitutional Province of Callao. 41 districts assessed in the study of vulnerability and seismic risk by CISMID (April 2005) were identified as the study area, as the CISMID study is the main source in the field of seismic hazard estimation.

Parameters to be effective:

Due to the vastness and the information available, the level of detail selected was the district level, and in very large districts, the planning sectors level (homogeneous urban areas identified in the majority of the District Development Plans).

Seismic Hazard Estimation

Determining the probable characteristics of earthquake.

- Depth: 33 km.
- Epicenter: In front of Lima.
- Magnitude: 8.0 Mw.
- Intensity: VIII (MM).
- Imax Area: Chimbote City and Metropolitan Lima
- Average Maximum Acceleration: 350-400 cm/seg^2.

Source: Dr. H. TAVERA (IGP)
SEISMIC HAZARD ESTIMATION

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Seismic Zoning Lima and Callao

ZONE I:
Rocky outcrops of rigid behavior
Natural Vibration periods: Vn 0.1 and 0.3 seconds.
Seismic amplification factor S = 1.0
Soil natural period Tp = 0.4 seconds.

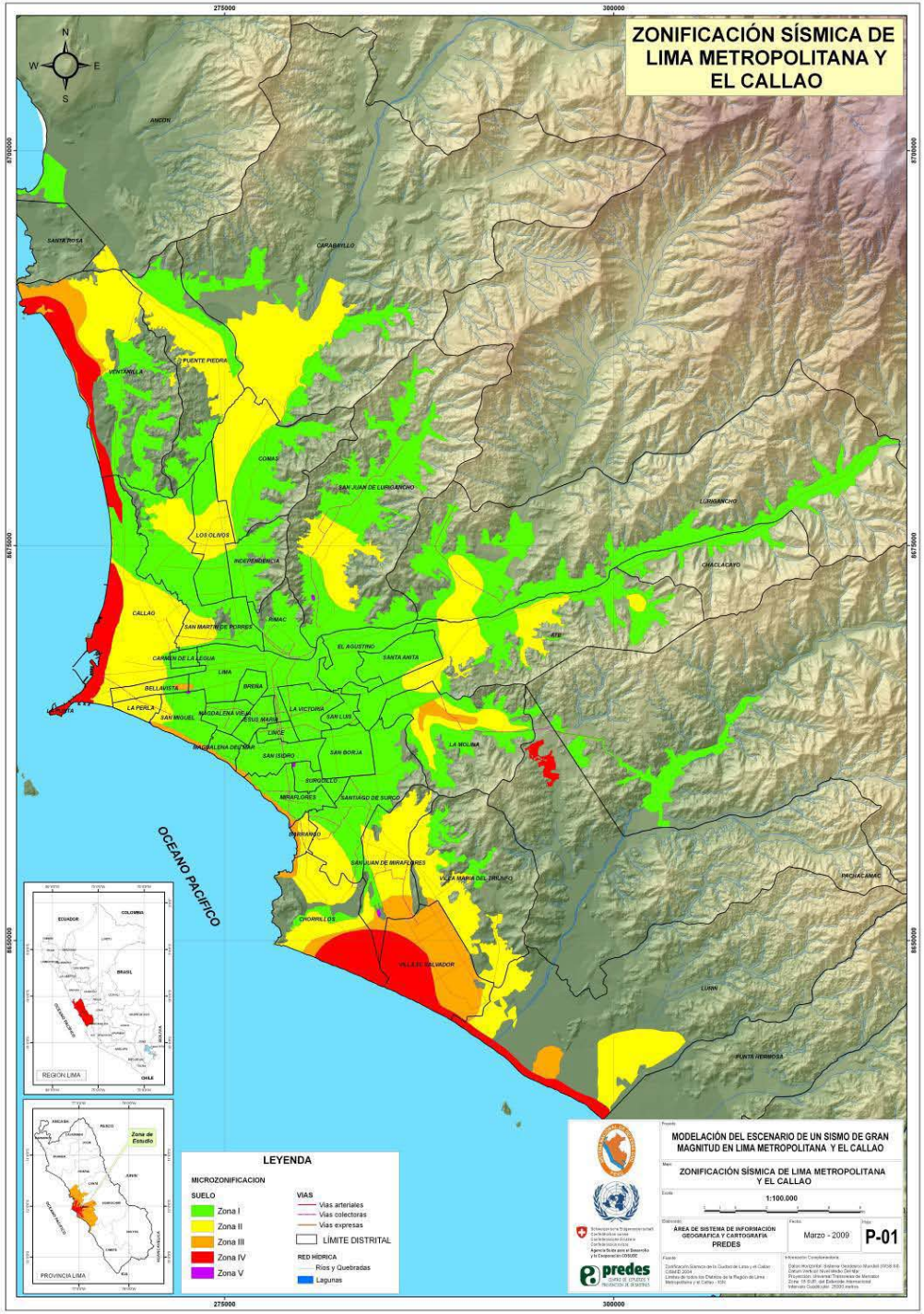
ZONE II:
Surface layer of fine granular soils and clay soils Vn: 0.3 and 0.5 seconds S = 1.2.Tp = 0.6 seconds.

ZONE III:
Deposits of fine soil and sand, thick ground state.
Vn: = 1.4.Tp = 0.9 seconds 0.5 and 0.7 seconds.

ZONE IV:
Aeolian sand deposits of thick, loose, muddy soil and marine deposits Vn: 0.7segundos, S = 1.6, Tp = 1.2 seconds.

ZONE V:
Areas formed by deposits of loose, heterogeneous fill that have been placed in natural depressions or excavations made in the past, with powers between 5 and 15 m. Also included are landfills that were once located outside of urban areas, but are now urbanized. The dynamic behavior of these fills is uncertain and requires a specific study.

Source: CISMID.



ESTIMATES OF TSUNAMI HAZARD

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Seismic Zoning Lima and Callao

TSUNAMI HAZARD CHARACTERIZATION

It is assumed that plane of subduction would be in the same direction as the subduction axis caused by the earthquake proposed for the seismic scenario.

Ellipse Axes

$$\log_{10} a = \frac{2}{3}M - 2.93 \xrightarrow{M=8} a = 253.12km$$

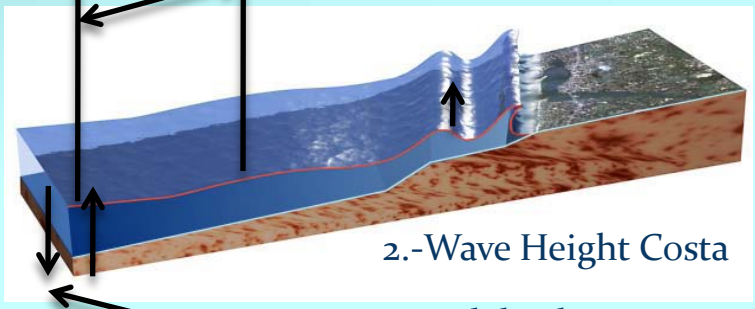
$$\frac{b}{a} = 3.77 - 0.42 * M \xrightarrow{M=8} b = 103.78km$$

1.- Time

V

3 .- Flood level

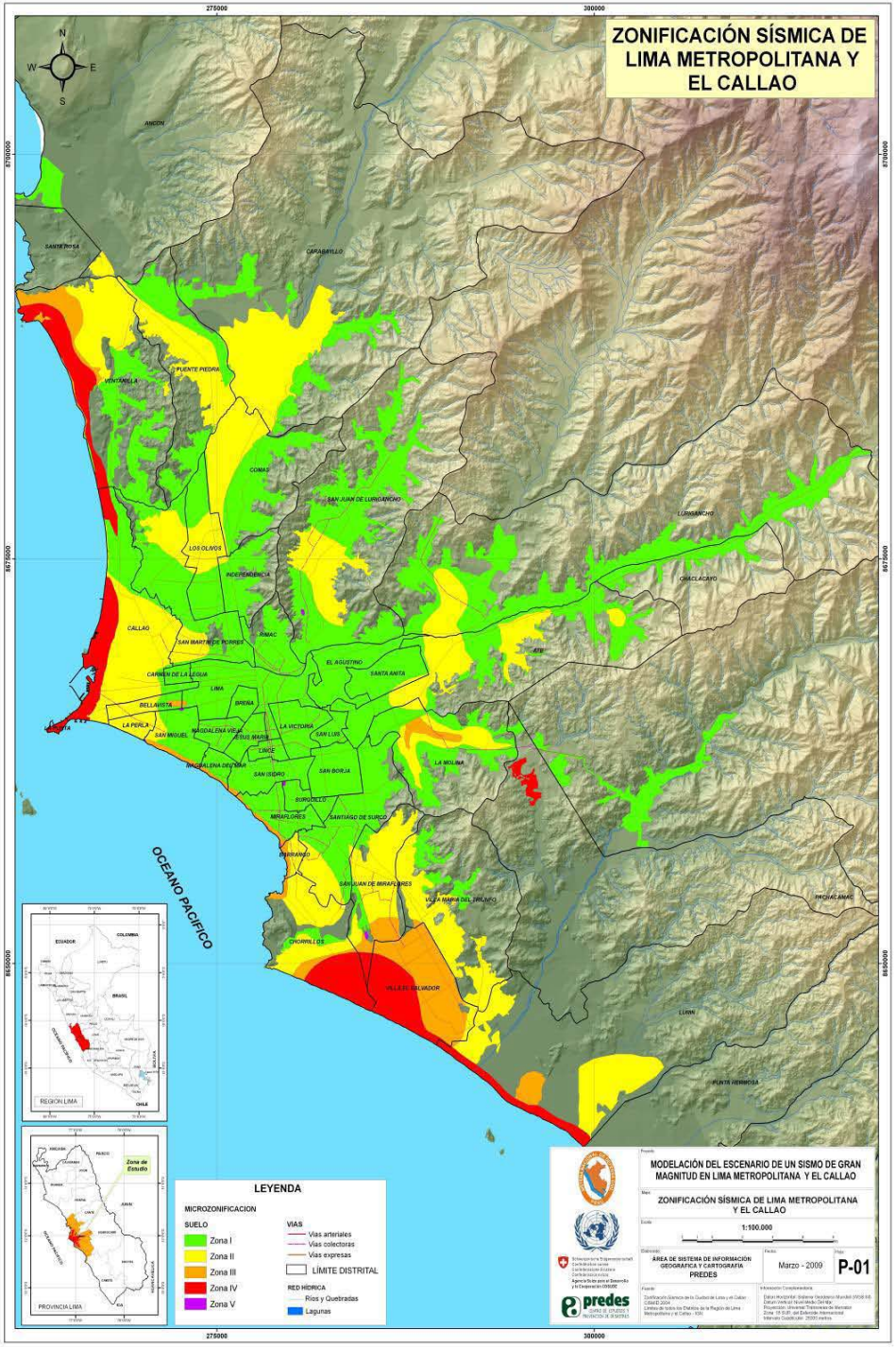
L



Failure

2.-Wave Height Costa

Epicenter. Vertical displacement and alteration of the water column



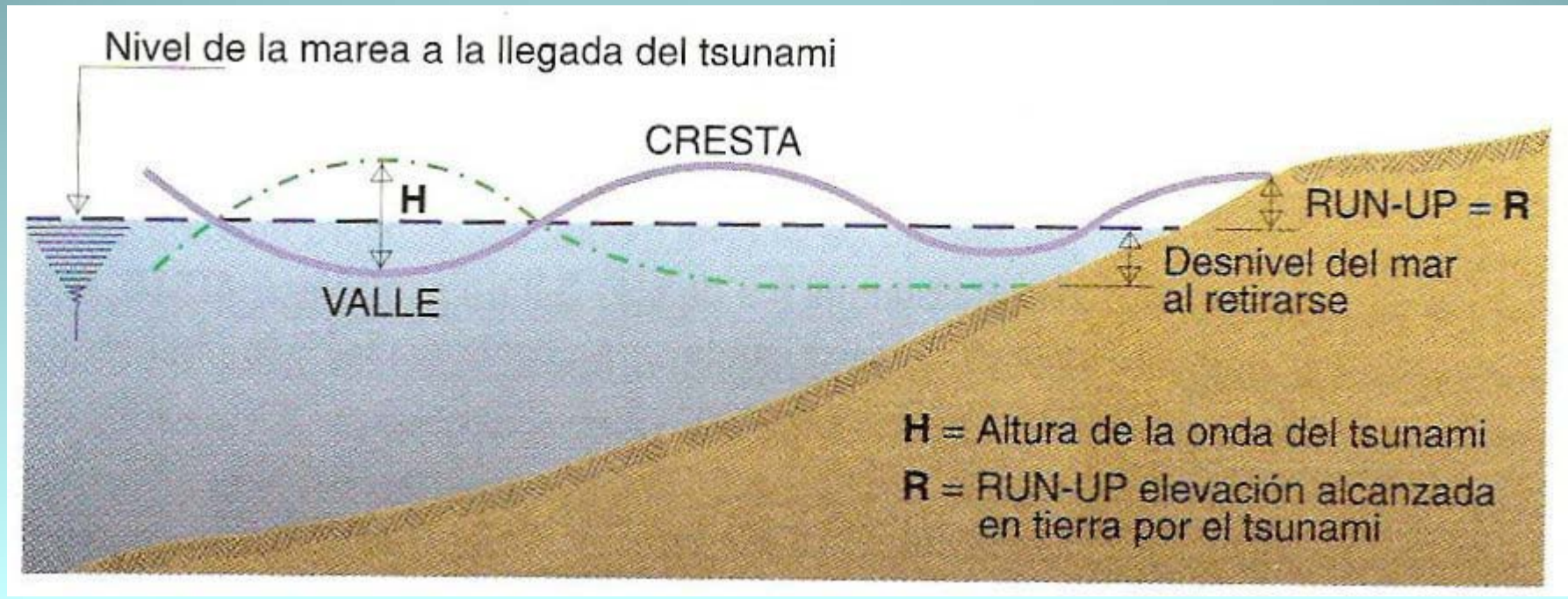
2 .- WAVE HEIGHT

Silgado formula. (Zapata, 2004)

$$Log\,(H) = 0.79M - 5.7$$

Yamaguchi formula. (Garcia, 1994)

$$H = 12.3e^{0.067D}$$



Different levels of flood

ESTIMATION OF THE SEISMIC VULNERABILITY

SCENARIO DESIGN ON THE IMPACT OF A HIGH-MAGNITUDE EARTHQUAKE IN THE CITY OF LIMA, PERU

HEIGHT OF BUILDING

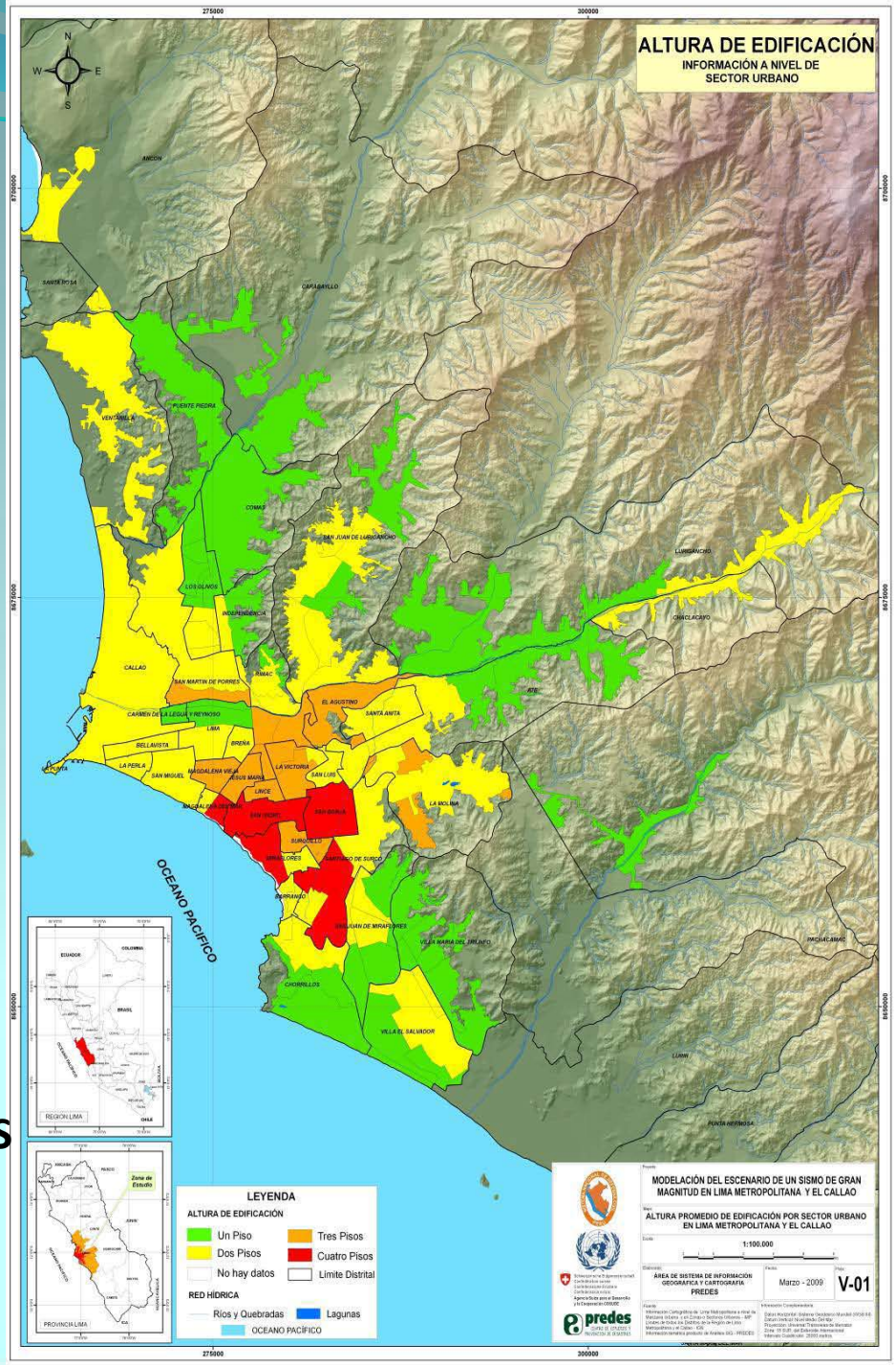
ONE FLOOR

TWO FLOORS

THREE FLOORS

FOUR OR MORE FLOORS

SOURCE:
INEI / PREDES



SCENARIO DESIGN ON THE IMPACT OF A HIGH-MAGNITUDE EARTHQUAKE IN THE CITY OF LIMA, PERU

CONDITION OF CONSERVATION

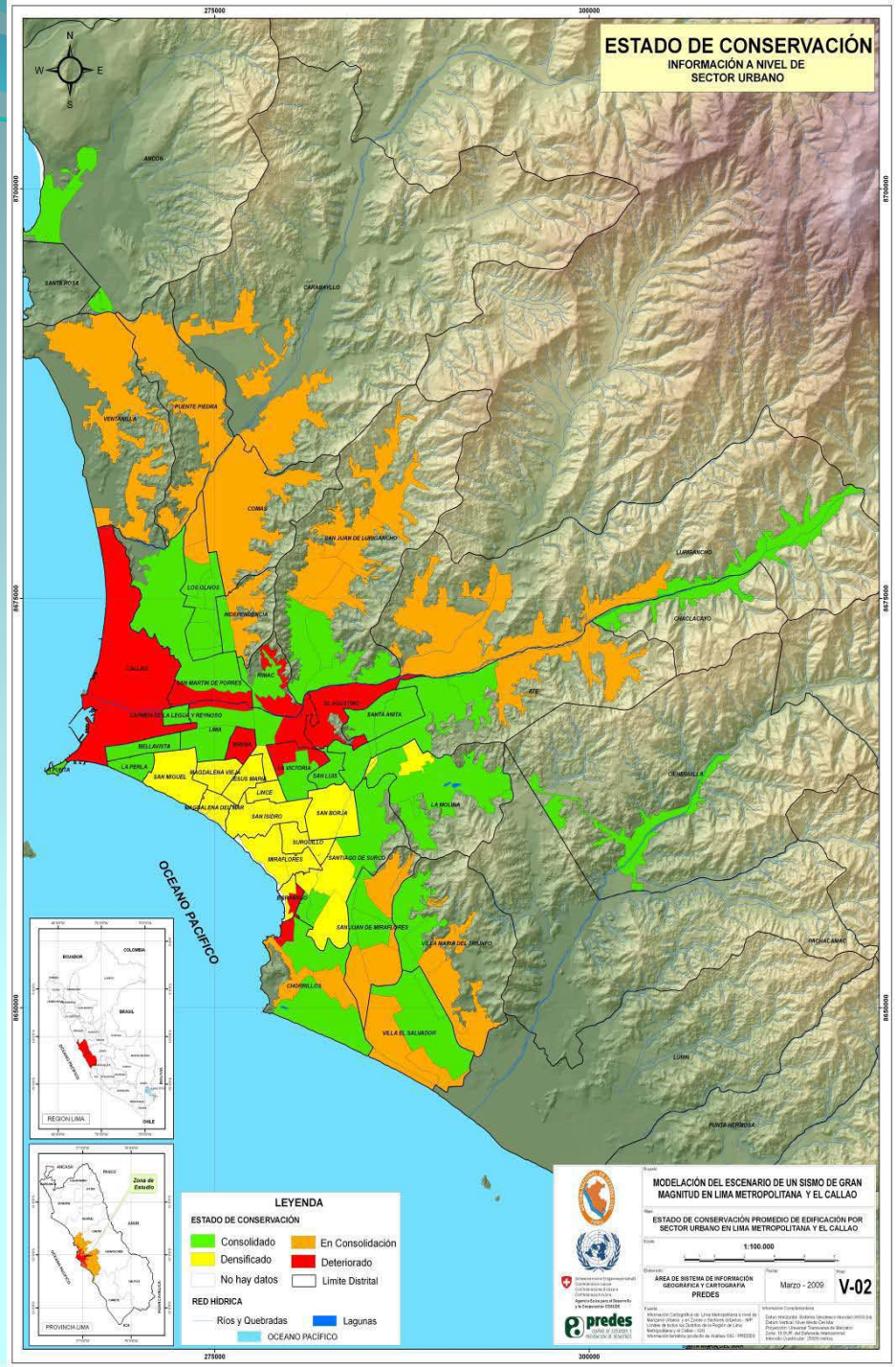
DETERIORATED

IN CONSOLIDATION

CONSOLIDATED

DENSIFIED

SOURCE:
INEI / PREDES



SCENARIO DESIGN ON THE IMPACT OF A HIGH-MAGNITUDE EARTHQUAKE IN THE CITY OF LIMA, PERU

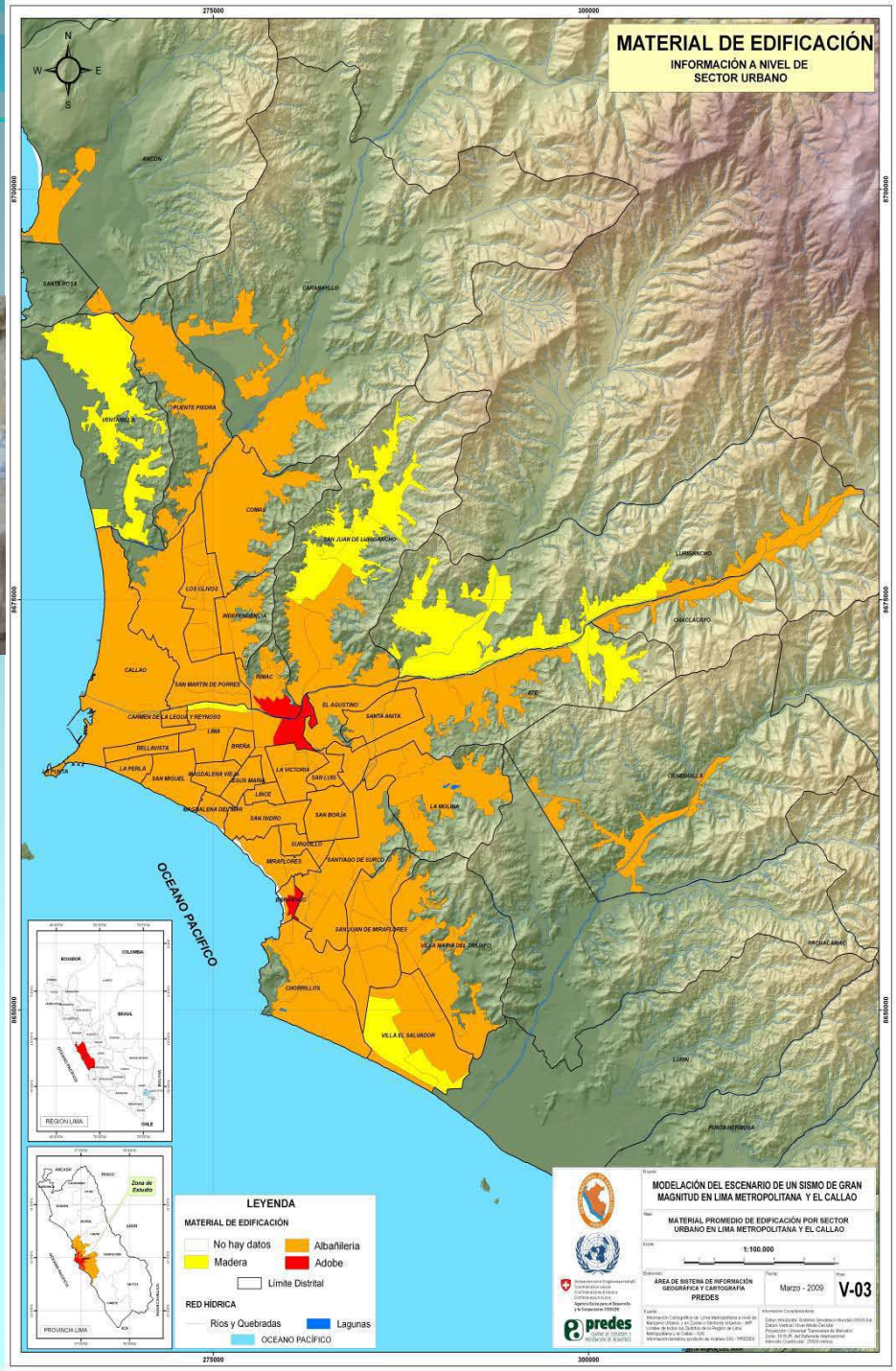
MATERIAL OF BUILDING

BRICK OR CEMENT BLOCK

ADOBE

WOOD / MAT

SOURCE:
INEI / PREDES



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TYPE OF HOUSING

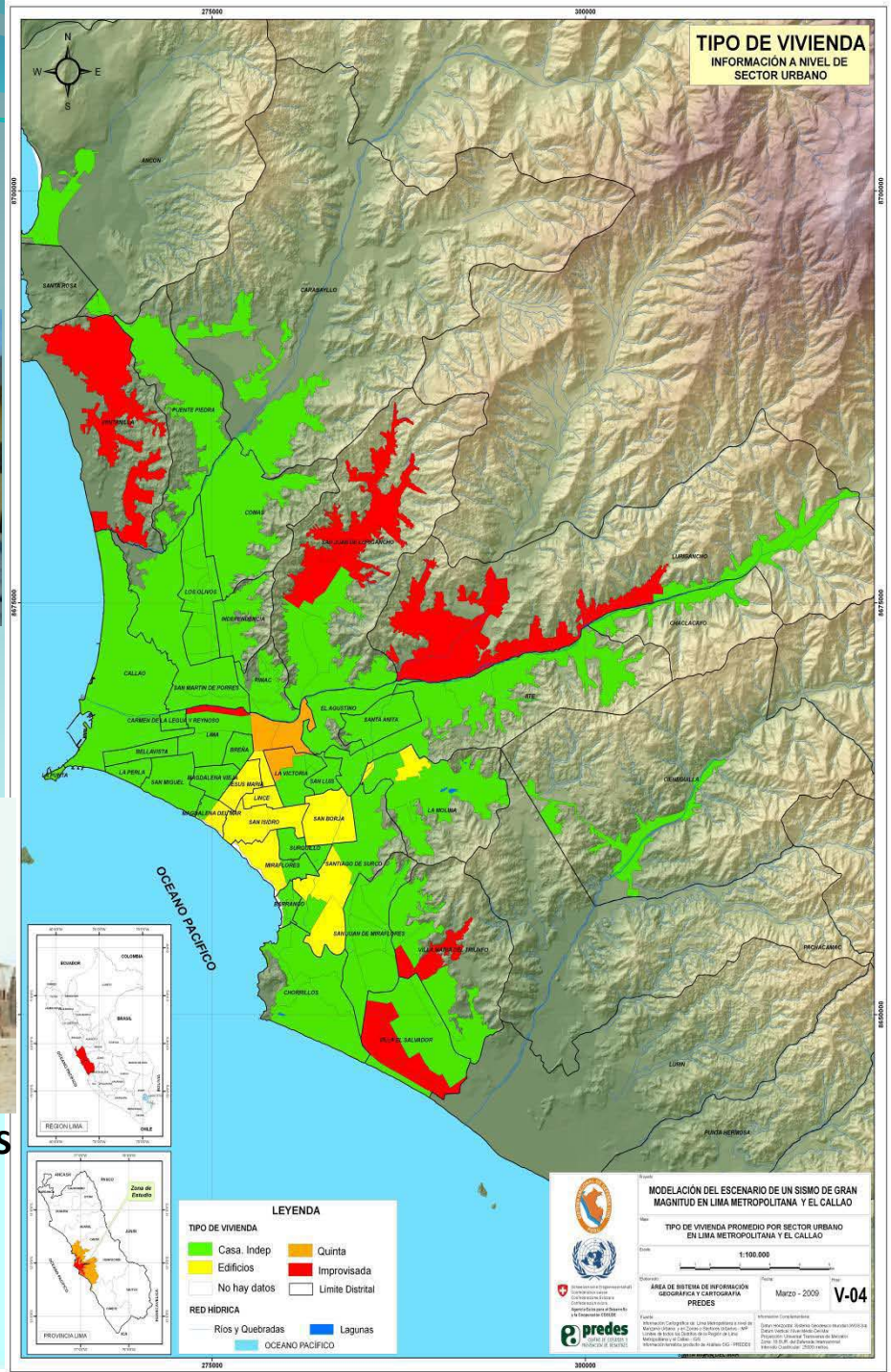
INDEPENDENT HOUSE

VILLA

APARTMENT IN BUILDING

SPONTANEOUS SETTLEMENTS

SOURCE:
INEI / PREDES



ESTIMATION OF RISK SCENARIO AND MAGNITUDE OF IMPACT

SCENARIO DESIGN ON THE IMPACT OF A HIGH-MAGNITUDE EARTHQUAKE IN THE CITY OF LIMA, PERU

SEISMIC EVENT PROBABLE MAXIMUM	Magnitude. 8,0Mw (15,26-28). Maximum intensity: VII on the Modified Mercalli Scale, between Metropolitan Lima and Chimbote. Average maximum acceleration: 350-400gals, 22,23. Epicentre. Opposite to Lima. Focus: Depth, 33km. Extent of affected area: This study considers only to Metropolitan Lima and the Constitutional Province of the Callao. Nevertheless a real event will affect the departments of Lima, Ancash, Ica, Huánuco, Junín, Pasco, Huancavelica.
PROBABLE TSUNAMI Hypothesis sustained on the basis of the study of the tsunami of October 3, 1974	Characteristics. Train of waves of approximately six meters of height. Direction of the waves: west – east or west - south-east. Speed of displacement: 837 km/h. Width of the waves: up to 200 km. Height of the waves: 6 meters Experimental average time of arrival to the coast: 18 minutes. Measured time of arrival: 11 minutes to The Top. Zone of flood: Variable, in agreement to the level of the area, with ranges of impact for the height of the maximum foreseen flood. Extent of affected area: The littoral of Metropolitan Lima, the port and the coastal band of the Constitutional Province of the Callao.

SCENARIO DESIGN ON THE IMPACT OF A HIGH-MAGNITUDE EARTHQUAKE IN THE CITY OF LIMA, PERU

SOIL TYPE

SEISMIC AMPLIFICATION

MOVEMENT

SEISMIC HAZARD

TSUNAMI

LIQUEFACTION

SLIDING

FLOOD

CHARACTERISTICS THAT INCREASE LIKELIHOOD OF PERSONAL INJURY AND DAMAGE TO INFRASTRUCTURE

SEISMIC VULNERABILITY

EARTHQUAKE SCENARIO

LOSS OF LIVES AND INFRASTRUCTURE

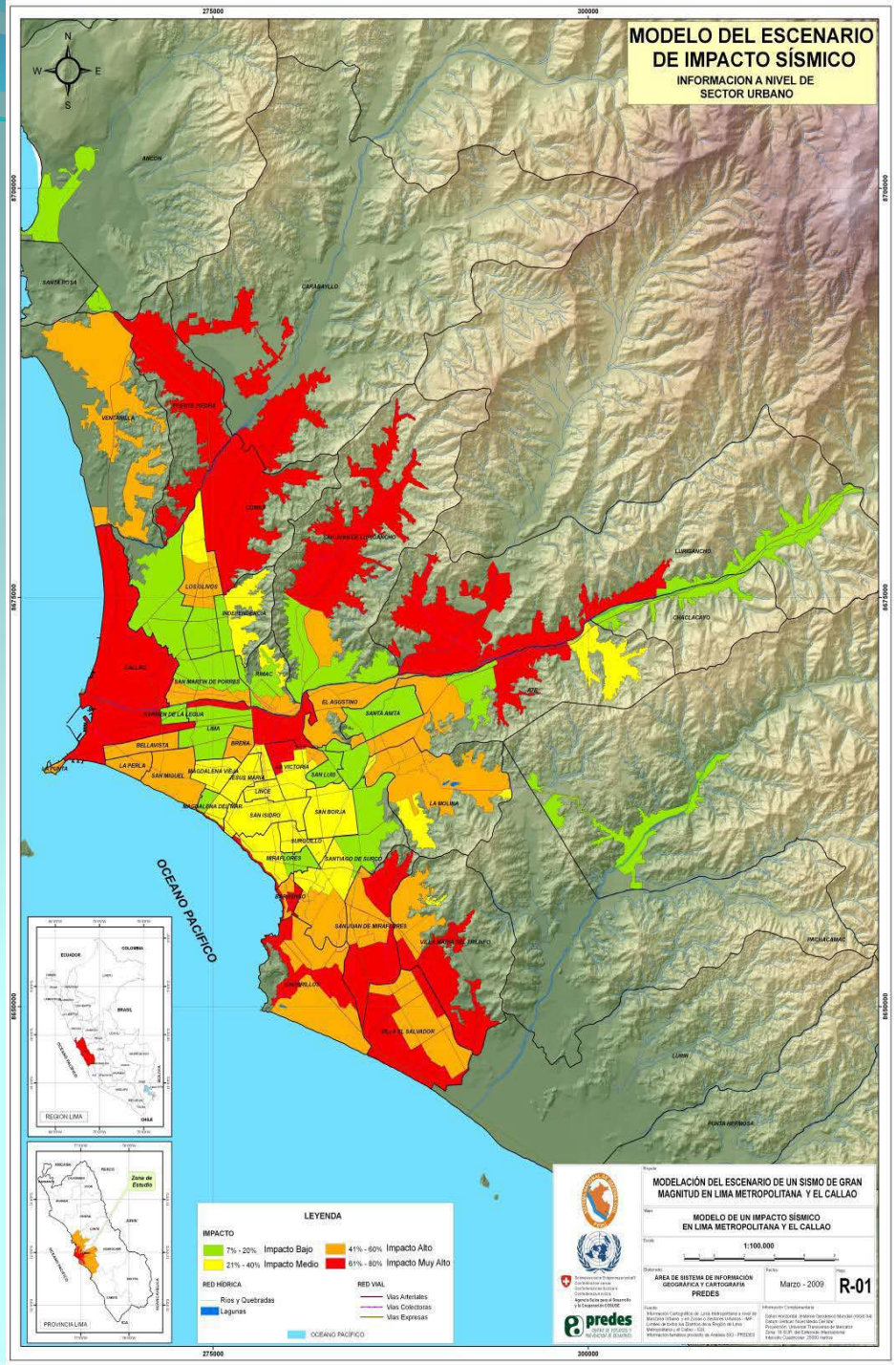
SEISMIC RISK

SCENARIO DESIGN ON THE IMPACT OF A HIGH-MAGNITUDE EARTHQUAKE IN THE CITY OF LIMA, PERU

PICTURE OF SEISMIC IMPACT IN THE CITY OF LIME

POPULATION	
DEAD	*51,019*
INJURED	*686,105*
NOT AFFECTED	*7 548,603*
TOTAL	*8 285,727*

HOUSING	
DESTROYED	*200,347*
UNINHABITABLE	*348,328*
NOT AFFECTED	*1 331,583*
TOTAL	*1 880,257*



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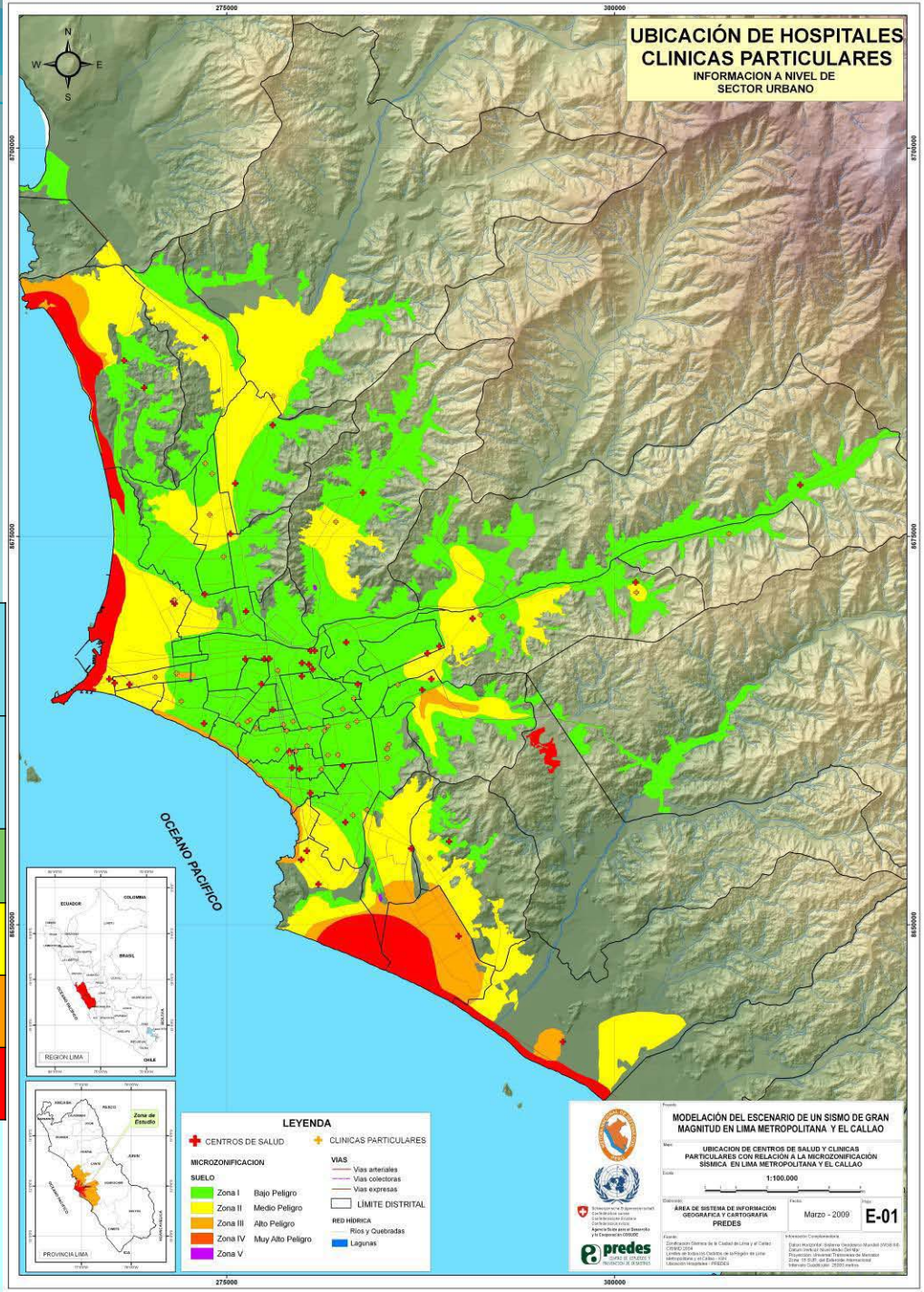
LOCATION OF HOSPITALS AND PRIVATE CLINICS

The most important health facilities with major capacity were considered. The analysis showed that approximately 68% of hospitals and 81% of clinics are located on Soil Type I. This type presents minor seismic danger.

SOIL TYPE	*HEALTH ESTABLISHMENTS*	
	HOSPITALS	*CLINICS*
SOIL I	***32***	***35***
SOIL II	***14***	***7***
SOIL III	***1***	***1***
SOIL IV	***0***	***0***

SOURCE:
INEI / PREDES



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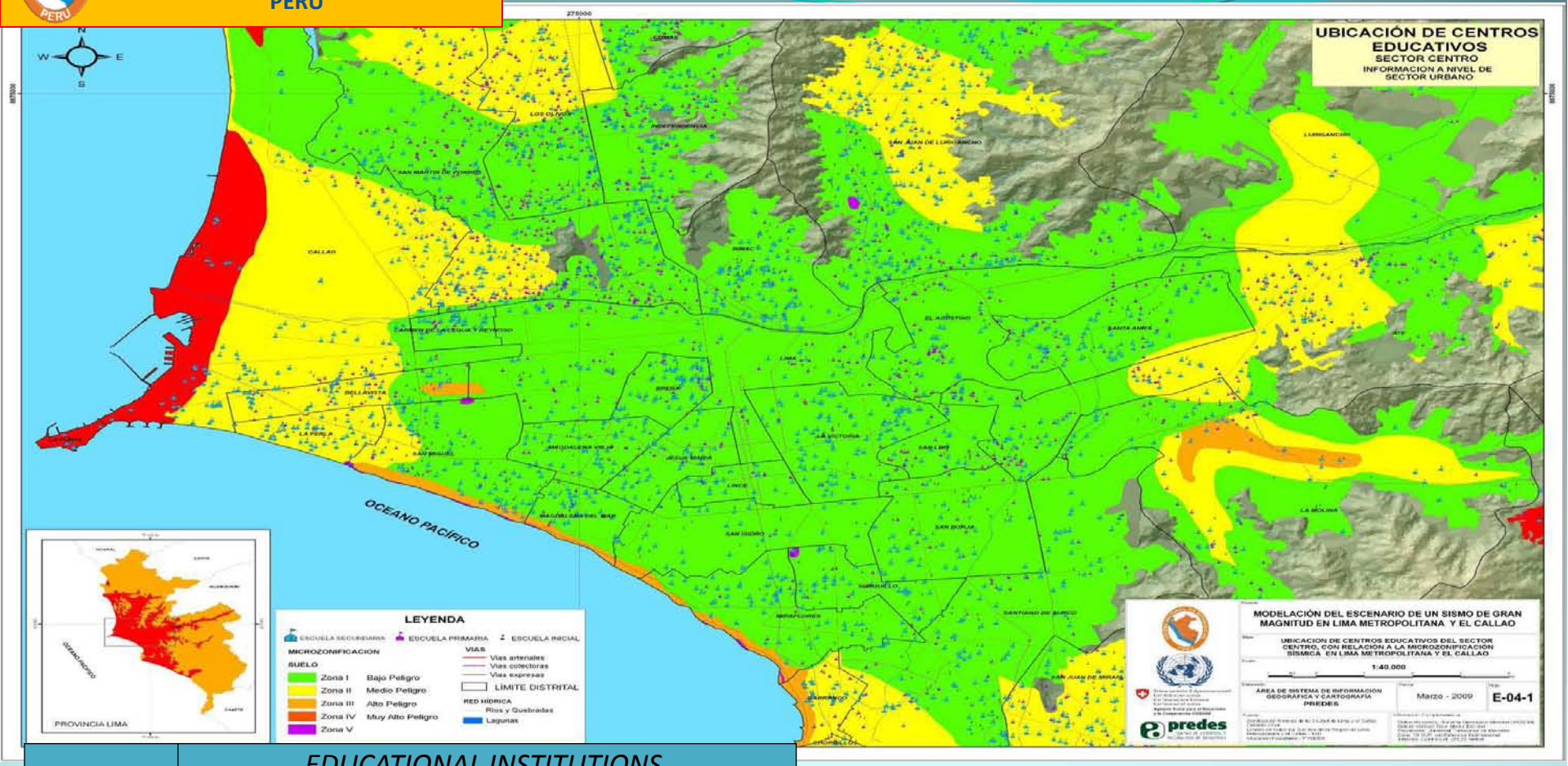


SOIL TYPE	EDUCATIONAL INSTITUTIONS		
	INITIAL	PRIMARY	PRIMARY SECONDARY
SOIL I	931	1218	1909
SOIL II	479	734	1134
SOIL III	118	58	254
SOIL IV	29	38	78

LOCATION OF EDUCATIONAL INSTITUTIONS

In order to better identify the points, it was necessary to divide the representation of this vulnerable asset type into four areas: Central, North, South and East. The results show that 22% of educational centers are of the initial level, 29% are of primary level and 48% are of secondary primary level.

SOURCE: CISMID, MINEDU

CONCLUSIONS

- Of the 106 urban areas analyzed, 34 are in very high risk, 29 high risk, 20 medium and 23 in low risk.

- As a result of scenario analysis, it is estimated that there will be a maximum of approximately 51019 deaths, 686105 wounded, 200347 houses collapsed and 348329 houses affected.

- It has been determined that the wave height would affect the coastal zone is 6 feet, flooding major areas, especially La Punta.

- Arrival time is critical for La Punta, this being 11 minutes after the quake occurred. For other areas the average is 18 minutes.

- The following facilities have been identified as located in low competency soil (soil type III and IV): 569 educational institutions; 2 health establishments with inpatient facilities

RECOMMENDATIONS (1/2)

•The existing information on geotechnical microzonation is coarse. More detailed studies are needed, particularly for the identification of less competent soils.

•The study established a maximum impact level. A range that also establishes a minimum impact level should also be analyzed.

• Incorporate the analysis regarding damages caused to gas, water and electricity networks.

• Refine details of study in regards to physical vulnerability

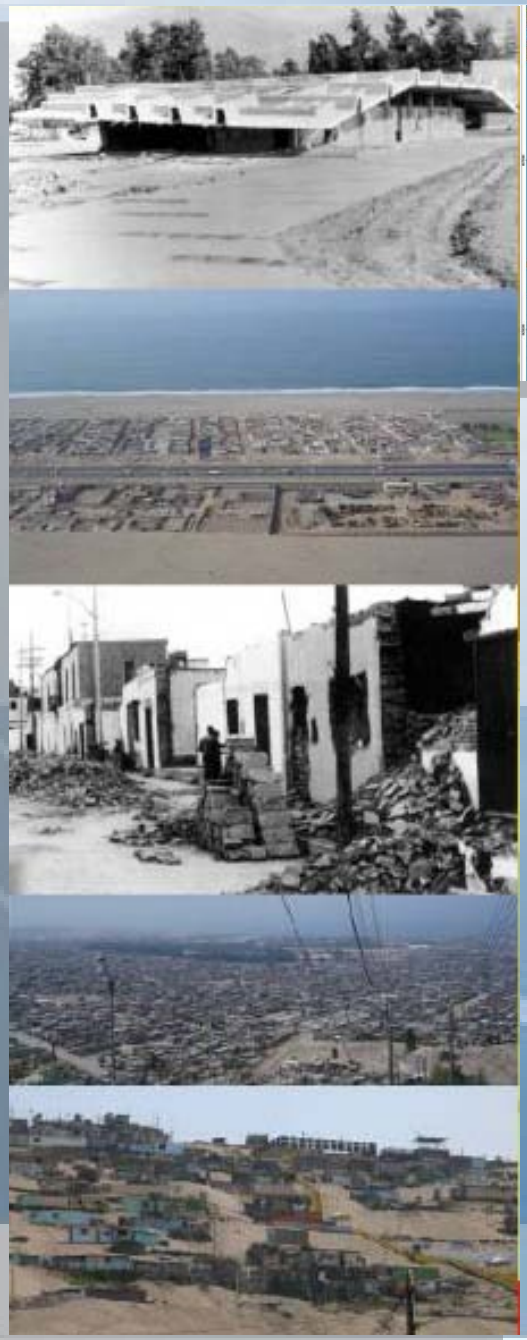
• Represent the risk of Lima at the block level. The indicators of vulnerability must be obtained through census data and field verification.

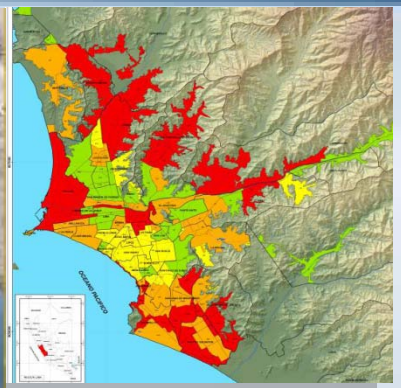
RECOMMENDATIONS (2/2)

- Improve mechanisms for cooperation and information exchange through an institution coordinating agency, avoiding duplication of effort in the creation of information base.

- Perform risk analysis at the sectoral level and its subsequent integration into an integrated risk map for purposes of preparation.

- Awareness of local government level for risk studies are considered in development planning and integrate with the other levels of government.





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