Gas Processing, LPG Recovery Plant and Allied Facilities at Nashpa Field

Geological Hazard Assessment

(Report)

Geotechnical Investigation & Survey of Gas Processing, LPG Recovery Plant and Allied Facilities at NASHPA Oil Field

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Zealcon Engineering (Pvt) Ltd.

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NASHPA GAS PROCESSING AND LPG RECOVERY PLANT

GEOLOGICAL HAZARD ASSESMENT REPORT

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1.0 INTRODUCTION

This report represents the results of a geological hazard evaluation of Nashpa area Kohat, conducted by Zealcon Engineering (Pvt.) Ltd. The primary purpose of our investigation is to assess existing and potential geologic hazards that may affect the structure and facilities in project area, and is not intended to be applied to any new developments.

Zealcon Engineering (Pvt.) Ltd conducted an evaluation of geologic and geotechnical conditions at site. The scope of our investigation was limited to the following items:

Compilation and review of pertinent literature, maps, aerial photographs, and previously prepared reports and evaluation of existing geologic and soils data for the site.

2.0 SITE CONDITIONS

Project area is located about 70 km from Kohat city. In general the relief of the area is moderate with alternate valleys and ridges. The ridges have been formed by resistant limestone and sandstone beds whereas the valley are formed by the deep cuts by erosion of shale/clay of various units in the area.

At site the elevation is increasing from north to south direction. There are alternate beds of clay and sandstone which are present at site and sandstone is dipping in the direction of SW. Dipping angle varies from 30 to 50 degree.

2.1 Site Soils

Soil descriptions were compiled from logs. Excavation methods for these logs included straight rotary rigs and test pits.

As previously mentioned, most of project area is located on alternates beds of sandstone, clay and subordinate conglomerates. Clay of this site is silty and brownish in

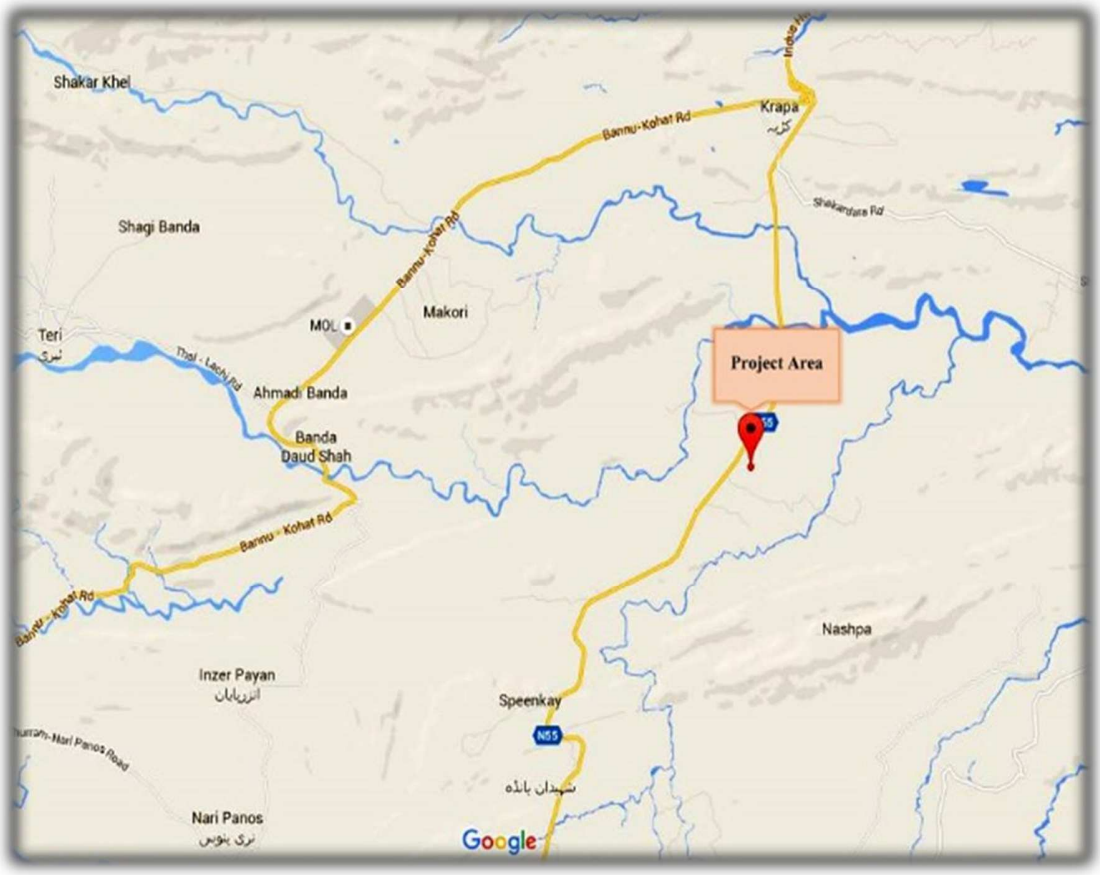

Figure 1. Location Map of the Project Area

color. Sandstone is grayish in color and dense in nature. The silts and clays are typically sandy, medium stiff to stiff. Occasionally sandier layers are intermixed with silt and clay.

2.2 Seismic Setting

2.2.1 Regional Tectonic Setting

Pakistan lies on three tectonic plates which are Arabian, Eurasian and Indian plate. It is mostly experiencing compressional and transpressional forces. The compressional

forces are believed to be a result of the ongoing collision of the Eurasian and Indo- Pak continental plates that started in the late Eocene to Early Oligocene with the formation of the Himalayan ranges. The Indo-Pak plate, relative to the Eurasian plate is still moving northwards at a rate of about 3.7 cm/yr near 73' longitude east (Molnar & Toppomier,

1975). The major portion of this convergence was taken up by deformation along the northern collision * boundary involving folding and thrusting of the upper crustal layers (Seeber &~rmbruster, 1979) in the shape of MKT (Main Karakoram Thrust), MMT (Main Mantle Thrust), MBT (Main Boundary Thrust) and SRT (Salt Range Thrust). Transpression is prevalent at the western boundary of the Indo-Pakistan plate with the 800 to 900km long Chaman fault, a transform boundary (Lawrence & Yeats, 1979. On the regional scale project area is situated in the Himalayan fold-and-thrust belt, which covers the area between the MMT and the SRT.

2.2.2 Local Tectonic Setting

The kohat plateau forms the western margin of the Himalayan forland fold and thrust belt. It is bounded to the north by the Main Boundary Thrust (MBT) and to the south by the Surghar Range Thrust (SRT) and kohat plateau boundary zone (Fig 2). The eastern side continuation of surghar range thrust is called the Salt Range Trust which is affected by right lateral movement along Kalabagh Fault. On the eastern side indus river separates kohat plateau from the Potwar plateau. On the western side the kohat plateau is bounded by the Kurran Fault.

The Himalayan forland fold and the thrust belt of northern Pakistan is being under thrust belt by crystalline basement along a single detachment surface (Seebar et al, 1981;

Lilli et al 1987). The Main Boundary Thrust (MBT) is a regional fault that bought the Mesozoic- Cenozoic shelf sediments to the Hill Ranges (Margalla, Kalachitta, Kohat, Samna and Safed Koh) against a pile of mollase sediments deposited in the foreland basin

of Potwar and Kohat (Yeats and Hussain. 1984). Discruption along the MBT zone started probably around early Miocene times as suggested by the involment of Miocene Murree Formation in deformation (Burbank, 1983; Yeats and Huassain, 1987). Structure associated with this major fault includes duplex systems, back thrusts (Ghauri et al. In press) fore thrusts and fan folds (Khan et al, 1990).

The project area is surrounded by active faults. The PGA value predicted by (Monalisa et al, 2007) for 475-years return using attenuation relation is 0.20 to 0.21g.

2.3 Liquefaction

Liquefaction occurs when seismic shaking of loose sands results in the upward migration of water through the pore spaces in the sand. If cracks are present above such liquefied layers, the saturated sediment can erupt to the ground surface, forming a sand blow. Structures built above liquefiable sands can sustain significant damage. Liquefaction typically occurs in young alluvial sands on an active floodplain. Most of the sediments are silts /clays and sandstone, and it is prone to liquefaction. Boring logs indicate these sands are typically dense. The variable nature of molasse deposits allows the possibility for perched water tables in these less cohesive sandy layers, and the potential for liquefaction can be ruled out.

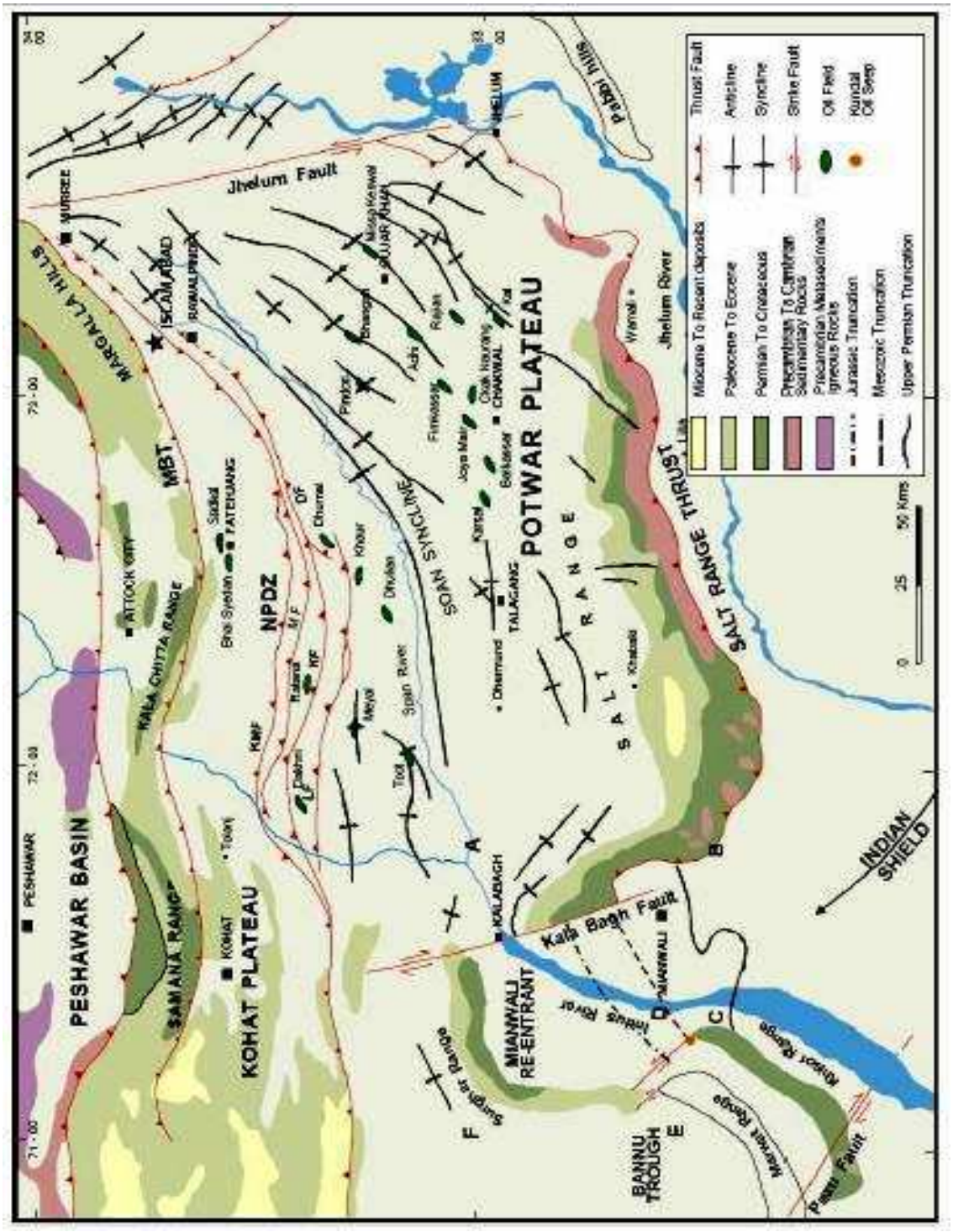

Figure 2. Structural Map of Kohat Potwar Depression (Kazmi and Jan 1997).

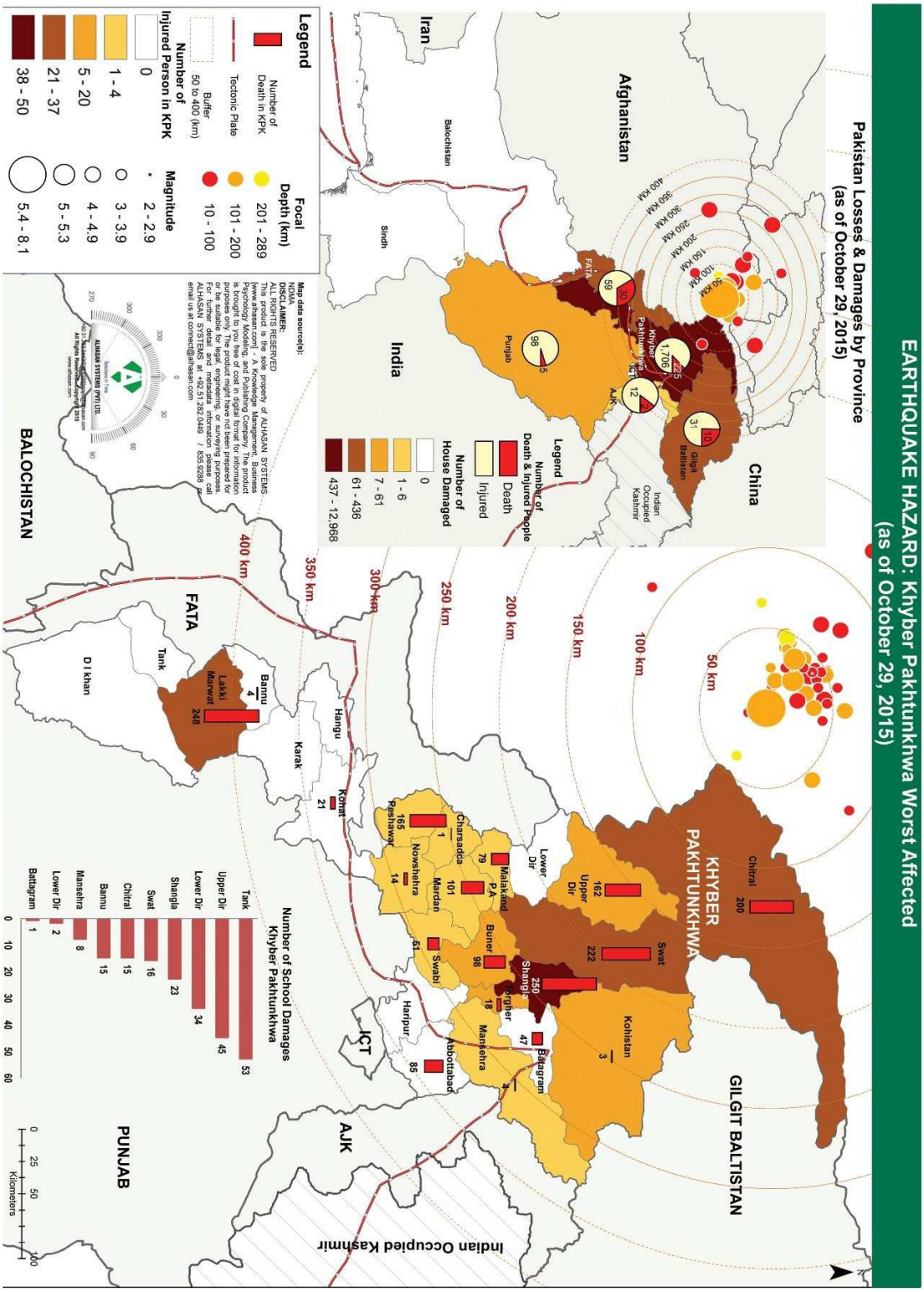

Figure 3. Earthquake hazard KPK worst affected map as of Oct, 2015.

2.4 Flood Hazard

The Kohat plateau is located in close proximity to the Sindh River. In August of 2010, an exceptionally large flood inundated from the heavy rain fall, resulting in the loss of many homes. Flood affected areas of 2010 shown in (Figure 4).

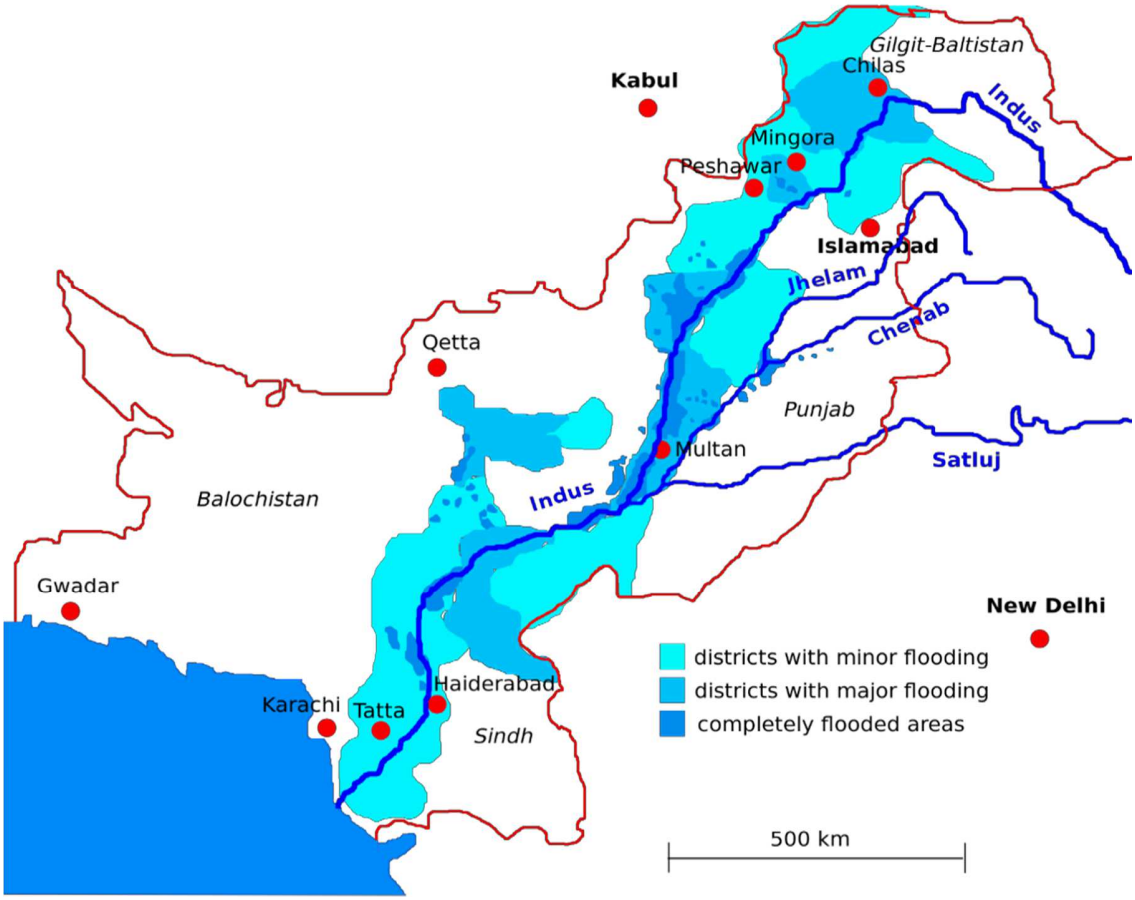

Figure 4. Flood affected areas map as of 26 August 2010.

2.5 Slope Stability

No active landslides are mapped in the study area, and most of the town lies on low gradient ground. Khyber Pakhtoon .Strong seismic shaking may destabilize the banks along the road.

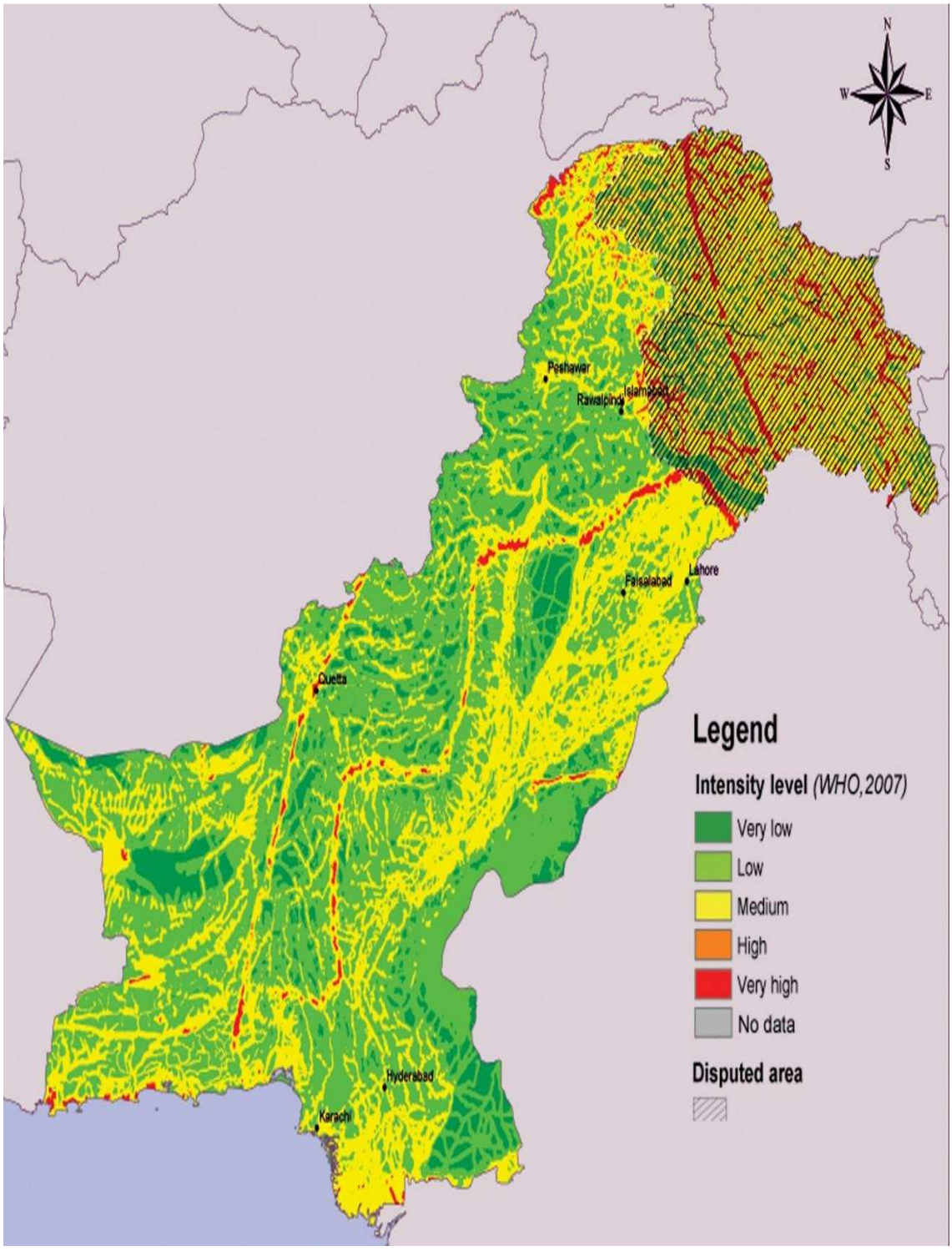

Figure 5. Map showing landslide hazard distribution map (WHO, 2007)

3.0 CONCLUTIONS

1. The primary geologic hazard in project area is seismic shaking.
2. Study area comprised of molasses deposits clay and sandstone liquefaction remains a moderate hazard.
3. Lower elevation areas in project are subject to inundation by large floods. Historically only the northern portion of kohat plateau has been inundated, and this area is at risk for large flood events in the future. Most of project area is located on ground high enough to be unaffected by the largest historical floods.
4. Slope failure is a low level hazard in Scotia. No historical landslides have occurred within the area, and there is no geologic no geomorphic evidence for large, catastrophic

4.0 References

Burbank. D.W., 1983, The chroeology of intermontane-basin development in the north western Himalaya and evolution of the Northwest Syntaxis: Earth and Planetary Science Letters, v.64, p.77-92.

Khan, S. R., M.A. Khan, R. Nawaz and T. Karim, 1990, Stratigraphic control for the age of Peshawar plain magmatism, northern Pakistan. Geol. Bull. Univ. Peshawar, 23: p.253-263.

Lawrence, R.D. and Yeats, R.S., 1979, Geological reconnaissance of the Chaman Fault in Pakistan. In: Farah, A. & DeJong, K.A. (eds.). Geodynamics of Pakistan. Geol.Surv.Pak. Quetta, Pp. 351-357.

Molnar, P. &Tapponier, P., 1975. Cenozoic tectonics of Asia: effects of a continental1 collision. Science, 189, 419-426.

Seeber, L. and Armbruster. J., 1979. Seismicity of Hazara Arc in Northern Pakistan: Decollement vs. Basement Faulting. In: Farah, A. and DeJong, K.A. (eds.), Geodynamics of Pakistan. Geol.Surv.Pak, Pp. 131-142.

Seeber, L., Armbruster, J.G. and Quittmeyer, R., 1981, Seismicity and continental subduction in the Himalayan Arc. In Zagros, Hindu Kush, Himalaya Geodynamic Evolution, H.K. Gupta and F.M. Delany (Eds), Geodynamics Series, vol. 4, pp. 215–242 (Washington, DC: American Geographical Union)

Yeats, R.S., and Lawrence, R.D., 1984. Tectonics of the Himalayan Thrust Belt in Northern Pakistan. In: Haq, B.U., and Milliman, J.D (eds), *Marine Von Nostrand*, New York, 177-198.

Yeats, R.S., Hussain, A., 1987. Timing of structural events in the Himalayan foothills of Northwestern Pakistan. Geological Society of America Bulletin, 99, 161-176.