Priority List for Nevada Fault Investigations for EHP FY2016

March 2015, Nevada Bureau of Mines and Geology

Nevada is the third most seismically active state in the country. Most of the historical earthquakes have occurred in western Nevada, where GPS geodetic strain rates are highest (as much as 1 cm/yr) due primarily to dextral shear within the Walker Lane, which accommodates about 20% of the motion between the North American and Pacific plates. Nevada is also the most urban state in the country, in that a greater proportion of its residents live in major metropolitan areas (Reno-Carson City and Las Vegas) than in any other state. The Reno-Carson City area has much greater present-day strain rates than the Las Vegas area, as it contains active segments of both the Walker Lane and Sierra Nevada frontal fault systems. However, more than 2.0 million of the state’s 2.7 million residents live in the Las Vegas metropolitan area (including the large cities of Las Vegas, North Las Vegas, and Henderson, and adjacent urbanized areas of Clark County). Moreover, the Las Vegas area is riddled with poorly understood Quaternary faults, many of which have the potential to produce a damaging earthquake (>M6.0).

The Nevada Bureau of Mines and Geology has therefore concluded that both the Las Vegas and Reno-Carson City areas are in critical need of additional Quaternary fault studies. In consultation with groups throughout Nevada, we have established the following list of fault systems in these areas for which we recommend that the U.S. Geological Survey support fault investigations. Faults are listed in order of priority, from 1 (highest) to 4 (still high in priority). In generating this list, we considered several factors such as:

- previous fault investigations;
- detail of available fault maps;
- likelihood of finding dateable materials in fault trenches, mapped stratigraphic units, and geomorphic surfaces; and
- earthquake risk, based on a combination of nearness to population centers, loss-estimation modeling, and current knowledge of earthquake frequency and severity.

We believe that the prioritization process would benefit from having detailed science plans, including five-year priorities, for the Reno-Carson City and Las Vegas areas. These plans should include the consensus and breadth of the professionals working in these areas. This planning would lead to an enhancement of the seismic hazard characterization in these regions.

We strongly support the efforts by the U.S. Geological Survey to obtain better seismologic, geologic, and geodetic information about earthquake hazards in the Reno-Carson City urban corridor. Ten earthquakes of magnitude 6 or greater have struck the urban corridor within its 150 year recorded history and there is a greater than 70% chance of a magnitude 6 or greater earthquake striking the area within the next 50 years. A comprehensive seismic hazard characterization is imperative for appropriate building design and construction and community planning.

In the Las Vegas metropolitan area, there is an urgent need for paleoseismic studies on mapped late Quaternary faults, which lack detailed studies or are not currently included in the National Seismic Hazard Map. Studies by the University of Nevada, Las Vegas indicate that ground-motion levels in Las Vegas Valley could be as much as 70% larger than currently used values (Lamichhane et al., BSSA, 2014). HAZUS modeling in 2009 of a magnitude 6 earthquake in the Las Vegas Valley estimated potential losses of $7.2 billion, which would be devastating to the economy of Nevada. The uncertainties of the seismic hazard potential of the faults in this metropolitan area need to be resolved as soon as possible to assure the accuracy of building codes. Similar to the Reno-Carson City urban corridor, the Las Vegas metropolitan area should be the focus of
a series of comprehensive studies that characterize its earthquake hazard. We therefore consider these studies to be a high priority.

A high-priority is also given to studies that collaborate with the USGS and other agencies or research groups, advancing the quality, quantity, and timing of earthquake hazard research. Geodetic data are increasingly used as input and constraint for seismic hazard characterization. Studies that evaluate resolution, reliability, and stability of strain maps, block models, block rotation, and the geometry of the faults used in those models are important. Areas with geodetic deformation rates that exceed local fault slip rates or components of strike-slip or normal motion should be examined for unrecognized, buried, or blind faults, as well as under-represented fault hazards.

LiDAR data provide critical information that can be used to document the existing landscape, identify new faults and fault traces, and make measurements of geomorphic features along faults that can help define their slip rates. LiDAR should be flown in high resolution in the Reno-Carson City urban corridor region and over the Las Vegas metropolitan region to facilitate detailed studies of Quaternary faults.

**Priority List for Fault Investigations in Western Nevada:**

1. **Late Quaternary faults within and adjacent to urban centers in western Nevada.** Large urban areas include Reno-Sparks, Carson City, Minden-Gardnerville, South Lake Tahoe, and Incline Village. Several faults in these areas pose some of the highest earthquake risks in the region, even from events with lower magnitudes than the maximum values (e.g., M5+). In general, most of these faults have not had detailed paleoseismic investigations and have not been included in the National Seismic Hazard Maps. Faults within this group considered a high priority include:
   a. Apparent normal faults (e.g., Vista fault zone) along the east side of the Truckee Meadows basin in Reno-Sparks.
   b. Probable oblique-slip (dextral-normal) faults within the central part of the Truckee Meadows.
   c. Major normal to normal-dextral faults in the northern part of the Reno-Sparks area, bounding Long Valley, Peterson Mountain, and Spanish Springs Valley.
   d. The Verdi fault on the west side of Reno.

2. **Carson Range fault system** (generally east-dipping normal faults on the eastern side of the Carson Range that are close to and dipping below the communities of Reno, Carson City, Minden, and Gardnerville). These include the main north-striking frontal faults (Genoa, Washoe Valley, and Mount Rose faults), three northeast-striking faults in the Carson City area (Indian Hill, Carson City, and Kings Canyon faults), and synthetic faults within the range (Little Valley fault and unnamed faults in the northern Carson Range). These faults form the main seismic hazard to western Nevada and are among the most studied faults in the area, but large uncertainties remain about the frequency and timing of events and about segmented earthquake behavior along these faults.

3. **Late Quaternary faults within other designated urban expansion areas.** Such areas include the Dayton-Silver Springs corridor, central Carson Valley, Lake Tahoe basin, and the Fernley area. In general, faults in these areas have not been well-documented and not included in the National Seismic Hazard Maps. There are opportunities to trench and otherwise investigate these faults prior to urban development.
4. **Right-lateral fault zones in the northern Walker Lane belt.** These include the Pyramid Lake, Warm Springs Valley, Honey Lake, and Mohawk Valley fault zones. Understanding the slip rates and earthquake characteristics of these faults are key for resolving the apparent discrepancy between geodetic and geologic rates, but they are generally farther from the urban areas than the previously mentioned fault systems, and all have received some initial paleoseismic studies.

**Priority List for Fault Investigations in Southern Nevada:**

1. **Las Vegas Valley faults.** The seismic potential of the late Quaternary faults within Las Vegas Valley is poorly understood, but all of these faults can have a large potential impact on the estimated strong ground-motion levels within Las Vegas Valley, a highly urbanized region. Studies that show evidence for surface-rupturing earthquakes along these faults and/or strong ground motion within the basin are of the highest priority. Studies that define multiple paleoseismic events along these faults or better establish their slip rates through dating of earthquake deposits and the displaced alluvial fan deposits are critical to establishing the seismic hazard. The major Quaternary faults within Las Vegas are primarily normal faults. Whether or not there is the potential for strike-slip faults within Las Vegas Valley is poorly understood, although it is well accepted that the Las Vegas Valley shear zone is a buried Miocene right-lateral fault zone within the northern part of the valley and that much of Las Vegas Valley was originally shaped by movement on this shear zone. Notable Quaternary faults within Las Vegas Valley (collectively known as the Las Vegas Valley fault system) include the following:
   a. Eglington fault,
   b. Valley View fault,
   c. Decatur fault,
   d. Cashman Field fault zone,
   e. Whitney Mesa fault zone, and
   e. West Charleston fault.

2. **Frenchman Mountain fault.** The recent history of events along the Frenchman Mountain fault is poorly understood. Studies that help define these parameters are thus considered a high priority. The subsurface geometry of the Frenchman Mountain fault and where it intersects faults within Las Vegas Valley and/or the Las Vegas Valley shear zone are important parameters to define for characterizing the seismic potential of faults within the valley.

3. **Pahrump Valley fault zone and other regional strike-slip fault zones.** A major earthquake along the Pahrump Valley fault system could strongly shake the Las Vegas metropolitan area. Initial studies have been conducted, but more are needed to characterize this fault system. Pahrump Valley is a bedroom community and expansion area of the Las Vegas Valley. The date of the most recent event, the recent paleoseismic history, and possible earthquake segmentation need to be better defined. These studies are considered a high priority.

4. **Other regional late Quaternary faults.** Other regional faults, such as the Black Hills fault zone and the California Wash fault need to have their paleoseismic histories and seismic potential better defined and documented. In addition to being regional hazards for Las Vegas, these faults pose local risks as well to the communities of Moapa and Boulder City, respectively.