SCREENING INVESTIGATIONS FOR LIQUEFACTION POTENTIAL IN THE LAS VEGAS VALLEY, NEVADA

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ABSTRACT

The presence of Quaternary faults in the Las Vegas Valley and the potential for basin amplification of ground motion from significant seismic sources 100-200 km (62-124 mi.) from the valley (Death Valley Fault System) could provide sufficient energy to cause liquefaction in the valley. The important criteria, liquefiable soils and shallow groundwater table (less than 15 m (50 ft)) are met at some sites in the Las Vegas Valley. Basic lowlands in the valley consist of Holocene and Pleistocene alluvial and playa deposits of sand and silt with low SPT blow counts. The groundwater table is very shallow in more than half of the urbanized area of the Las Vegas Valley. A preliminary screening investigation has been conducted to determine whether there are any indicators of liquefaction potential in the Las Vegas Valley. This preliminary screening investigation was implemented according to the guidelines for evaluating liquefaction hazards in Nevada, which rely upon the *Guidelines for Evaluating and Mitigating Seismic Hazards in California, Special Publication 117.* The investigation was carried out in three steps: survey of liquefiable soils in the valley, evaluation of local seismicity, and finally, evaluation of liquefaction hazard in the Las Vegas Valley.

INTRODUCTION

Guidelines for Evaluating Liquefaction Hazards in Nevada were recently prepared and endorsed by the Nevada Earthquake Safety Council, which is affiliated with the Nevada Division of Emergency Management, Department of Motor Vehicles and Public Safety, and Division of Special Services. The purpose of the guidelines is described in the following excerpt:

> "Significant seismic hazards are present in Nevada. With the increase in population, the evaluation of liquefaction [potential] is becoming more

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important for land use planning and development. The intent of these guidelines is to provide a standardized minimum level of investigation for liquefaction in Nevada. They were prepared using established guidelines for liquefaction evaluation in California, and the current standard of practice in the greater metro Las Vegas, Reno, Sparks and Carson City areas.

This document provides general guidelines for evaluating, mitigating, and reporting of liquefaction hazards in Nevada. It is intended as a guide for performing liquefaction investigations and analyses, not as a prescriptive "standard." Liquefaction hazard assessment requires considerable engineering and professional judgment. This document, therefore, should only be treated as a general guide. It is the consensus of the authors that the use of new or innovative practices should be encouraged and not be limited by this document."

This paper presents the results of a preliminary screening investigation conducted to determine whether there are any indicators of liquefaction potential in the Las Vegas Valley. This preliminary screening investigation was implemented according to the new guidelines. The Nevada guidelines generally relied upon *Guidelines for Evaluating and Mitigating Seismic Hazards in California, Special Publication 117* and a recent accompanying California publication entitled *Recommended Procedures for Implementation of DMG Special Publication 117 – Guidelines for Analyzing and Mitigating Liquefaction in California* (Martin et al., 1999). The investigation was carried out in three steps: survey of liquefiable soils in the valley, evaluation of local seismicity, and finally, evaluation of liquefaction hazard in the Las Vegas Valley.

GEOLOGIC AND HYDROLOGIC SETTING

The Las Vegas Valley lies in the Basin and Range Physiographic Province of the United States, characterized by near parallel tilted fault blocks forming north to south trending mountain ranges with broad intervening basins. The valley consists of a 900 to 1,200 meter (3,000 to 4,000 ft) thick sediment-filled bedrock basin.

Coarse sand and gravel deposits contain cobbles and boulders near the base of the Valley's perimeter mountains and grade to fine sand, silt, and clay towards the center of the valley. Older sedimentary sequences, exposed at the central and eastern portions of the valley include playa or dry lake deposits consisting of fine sand, silt, clay, as well as evaporates such as gypsum. Alluvial washes crossing the lowlands generally from west to east have deposited sand and gravel lenses within the playa deposits. Eolian or windblown deposits are commonly found intercalated in both the alluvial and playa

sediments in the valley and generally consist of fine silty sand. The near-surface deposits in the valley are Holocene and Pleistocene in age.

Drainage in the Las Vegas Valley is characterized by the confluence of several main ephemeral washes including the Las Vegas Creek, Flamingo Wash, Tropicana Wash, and Duck Creek into the Las Vegas Wash. Las Vegas Wash is a perennial stream fed by both groundwater discharge and treated wastewater effluent and flows into Lake Mead southeast of the valley.

Groundwater in the valley is generally divided into two main aquifer types: deep and shallow. The deep groundwater aquifer is located at depths of 60 to 365 meters (200 to 1,200 feet). The shallow aquifer is found within 9 m (30 feet) of the surface in the central part of the valley (including portions of Las Vegas Boulevard) and along the washes in the east part of the valley and may be as shallow as 1.5 meters (5 feet) below the ground surface. Shallow groundwater conditions are discussed further in the following section.

LIQUEFACTION SUSCEPTIBLE CONDITIONS

The term *liquefaction* describes a phenomenon in which a saturated cohesionless earth material loses strength and acquires a degree of mobility because of strong ground shaking during an earthquake. Research has shown that earth materials having the greatest susceptibility to seismically induced liquefaction appear to be clean sands and fine silty sands.

As discussed in the GEOLOGIC AND HYDROLOGIC SETTING, the Las Vegas Valley contains Holocene and Pleistocene alluvial and playa deposits. Present within these deposits are fine silty sand deposits of eolian origin. For the most part, these silty sands are found throughout the valley but are more abundant in the lower parts of the valley especially along Las Vegas Wash where possible reworking of these deposits has made them more fluvial in nature.

Areas of the Las Vegas Valley having depths to water less than 9 m (30 feet) are shown on Figure 1. In general, the depth to shallow groundwater decreases following the flow gradient from northwest to southeast (Zikmund, 1996). These areas have been growing in extent over the last few decades. Recharge to the near-surface groundwater system in the valley is thought to be increasing due the effects of urbanization, including increased infiltration from landscape watering. Typically, the shallow groundwater elevations increase through recharge until an equilibrium between recharge and discharge is reached. Currently in Las Vegas Valley, this equilibrium has been reached in the eastern and southeastern portions of the valley with rising conditions and new

occurrences of near-surface ground water in areas west and northwest of the Las Vegas "Strip" and downtown. With this in mind, future groundwater levels should also be considered for liquefaction analysis purposes.

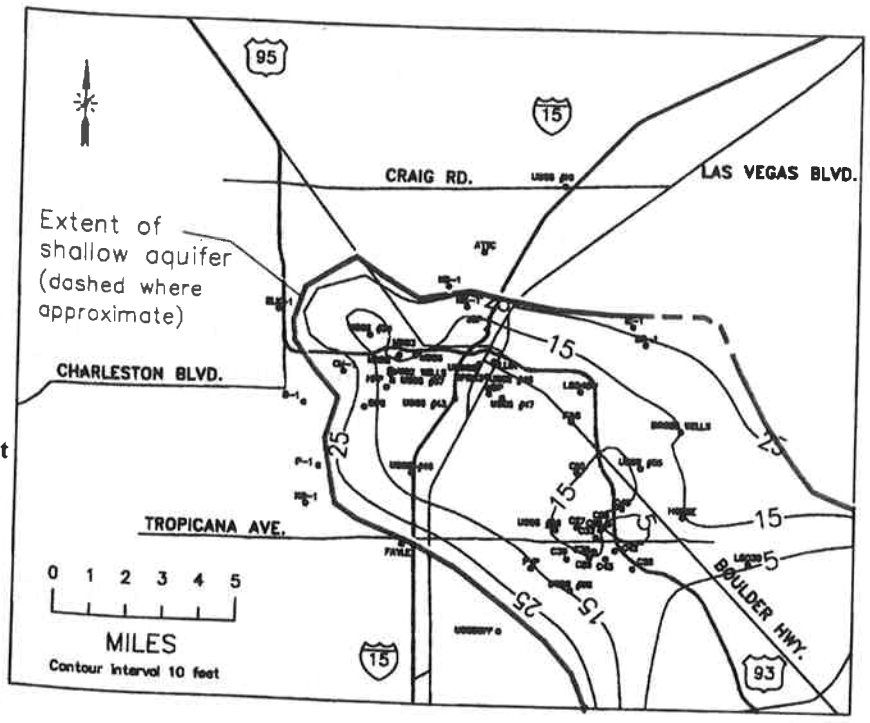

Figure 1 – Depth to water contour in feet below land surface (Zikmund, 1996).

As described above, the important criteria for liquefaction susceptibility - liquefiable soils and shallow groundwater table - are met at some sites in the Las Vegas Valley. The groundwater table is very shallow in more than half of the urbanized area of the Las Vegas Valley. Much of the valley consists of Holocene and Pleistocene alluvial and playa deposits of sand and silt. Some sites within these areas have deposits with low SPT blow counts.

SEISMIC SOURCES

In order for a liquefaction hazard to exist, there must be a real potential for significant ground shaking. The following describes the seismicity of the Las Vegas area as it applies to liquefaction potential.

Faulting and Seismicity

Uniform Building Code

The Las Vegas Valley is located in Seismic Zone 2B, as categorized in the 1997 Uniform Building Code (UBC). Zone 2B represents a low to moderately active seismic area.

Local Geologic Faults

Several north-trending fault scarps extend through the center of the Las Vegas Valley and are believed to be of late Quaternary age. The scarps are more than 30 meters (100 feet) high (Bell, 1981). The origin of these fault scarps is still debated. One theory suggests the scarps are the surface expressions of prehistoric differential consolidation or compaction of alluvial and playa-like sediments having dissimilar grain-size and compressibility characteristics (Maxey & Jameson, 1948 and Cibor, 1983). The second theory states the fault escarpments are tectonic in origin from faults extending up from the bedrock basement underlying the valley. The latter interpretation implies that these faults would be capable of generating seismic events (Bell & Price, 1991). This fault system is roughly regarded to be between 14,000 and 35,000 years old.

The Frenchman Mountain Fault runs along the eastern margins of the valley. Morphologic dating techniques show the last movement on the Frenchman Mountain fault system to be greater than 50,000 years old (Linnert & Werle, 1998). Younger (and therefore possibly more active) faults can be found in the adjoining valleys to the south and northeast. The Black Hills Fault in El Dorado Valley (Werle & Knight, 1998) and the California Wash Fault in Garnet Valley are both considered to be Holocene or less than 10,000 years old. Of the two, the Black Hills Fault located just south of Las Vegas Valley could generate an earthquake with significant ground motion to cause liquefaction in susceptible sediments the valley.

Regional Seismic Sources

The Death Valley Fault System (DVFS) is the largest and potentially most active seismic source in the Basin and Range Province (Sawyer, et. al., 1998). This fault system is located 100-200 km (62-124 mi.) from Las Vegas Valley. Faults that make up DVFS are capable of producing maximum earthquakes of M_w 7 to M_w 7.5. The recurrence interval is about 500 to 1,100 years or at least an order of magnitude more frequent than the local faults described previously.

In 1992, the Little Skull Mountain earthquake, M_L 5.6 and 100 km (62 mi.) induced significant basin response and site effects in Las Vegas (Su et. al., 1998). This suggests that the DVFS may pose a significant long period ground motion hazard for Las Vegas