TECHNICAL SUPPLEMENT

Methodology for Liquefaction Hazard Assessment for the RCFZ Earthquake Scenario

San Diego Earthquake Planning Scenario - M6.9 Earthquake on the Rose Canyon Fault Zone

Liquefaction Susceptibility

The Liquefaction Susceptibility (LS) map developed as part of the San Andreas fault ShakeOut Scenario (Ponti et al., 2008) was used as a base map for this study. This LS map was developed from various groundwater depth (GD) and geologic maps with relative LS categories assigned to each geologic unit using the criteria set forth in Youd and Perkins (1978) and the estimated site-specific groundwater depth.

The Youd and Perkins (1978) relative material susceptibility criteria was developed based on empirical data from past global earthquakes in which geologic conditions such as sedimentation process, deposition age, grain-size distribution, and density were considered. Table A-1 provides the material susceptibility criteria from Youd and Perkins (1978) based on these geologic factors and assigns various geologic deposits to categories of none, very low, low, moderate, high, and very high relative LS based on material classifications only. The LS material categories are assigned numeric scores that vary from 0 for LS category of "None" to 5 for LS category of "Very High".

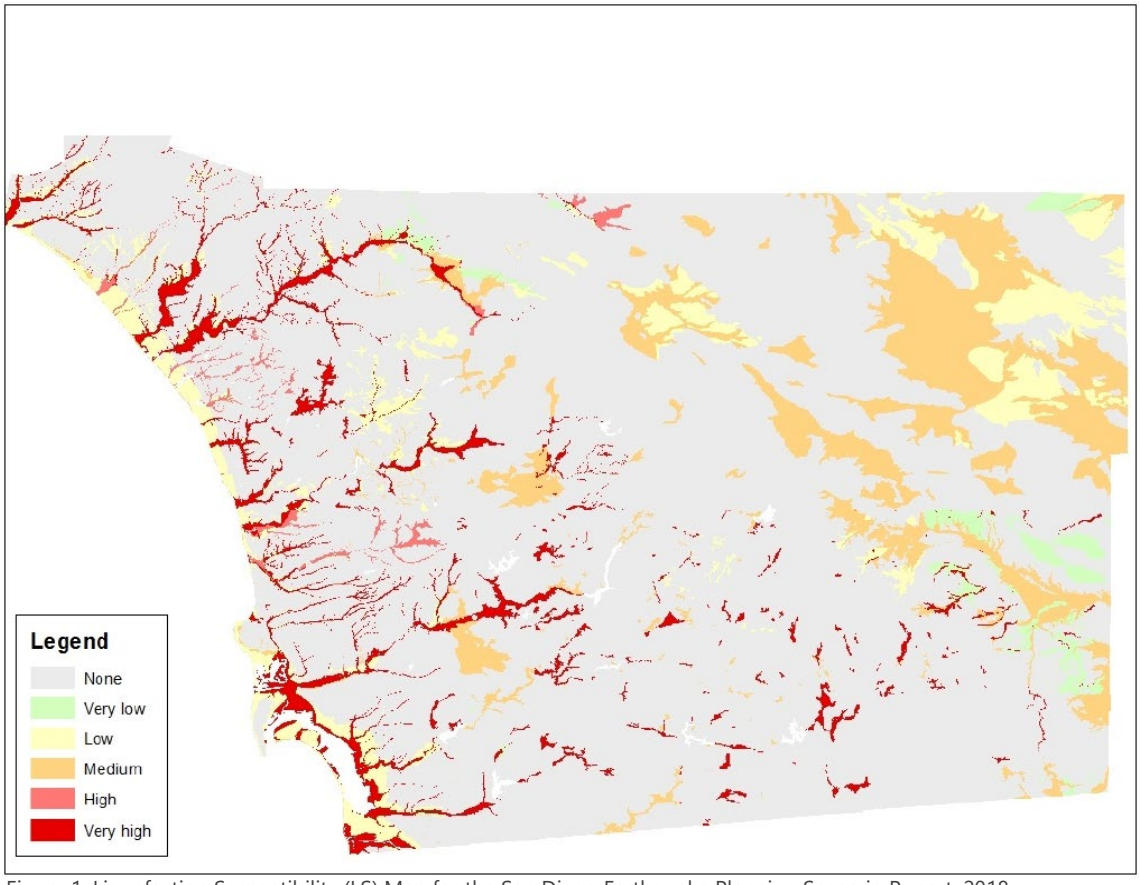

Figure 1. Liquefaction Susceptibility (LS) Map for the San Diego Earthquake Planning Scenario Report, 2018.

Table A-1. Liquefaction Susceptibility Criteria as given in Youd and Perkins (1978)

Type of Deposit		General Distribution of Cohesionless Sediments in Deposits	Liquefaction Susceptibility of Cohesionless Sediments When Saturated (by Age of Deposit)			
			<500 years	Holocene	Pleistocene	Pre-Pleistocene
Continental Deposits	River Channel	Locally Variable	Very High	High	Low	Very Low
	Flood Plain	Locally Variable	High	Moderate	Low	Very Low
	Alluvial Fan and Plain	Widespread	Moderate	Low	Low	Very Low
	Marine Terraces and Plains	Widespread	N/A	Low	Very Low	Very Low
	Delta and Fan-Delta	Widespread	High	Moderate	Low	Very Low
	Lacustrine and Playa	Variable	High	Moderate	Low	Very Low
	Colluvium	Variable	High	Moderate	Low	Very Low
	Talus	Widespread	Low	Low	Very Low	Very Low
	Dunes	Widespread	High	Moderate	Low	Very Low
	Loess	Variable	High	High	High	Unknown
	Glacial Till	Variable	Low	Low	Very Low	Very Low
	Tuff	Rare	Low	Low	Very Low	Very Low
	Tephra	Widespread	High	High	Unknown	Unknown
	Residual Soils	Rare	Low	Low	Very Low	Very Low
	Sebka	Locally Variable	High	Moderate	Low	Very Low
Coastal Deposits	Delta	Widespread	Very High	High	Low	Very Low
	Estuarine	Locally Variable	High	Moderate	Low	Very Low
	Beach – High Wave Energy	Widespread	Moderate	Low	Very Low	Very Low
	Beach – Low Wave Energy	Widespread	High	Moderate	Low	Very Low
	Lagoonal	Locally Variable	High	Moderate	Low	Very Low
	Fore Shore	Locally Variable	High	Moderate	Low	Very Low
Artificial Material	Uncompacted Fill	Variable	Very High	N/A	N/A	N/A
	Compacted Fill	Variable	Low	N/A	N/A	N/A

It should be noted that geologic units characterized with a potential to liquefy in Table A-1 indicates there may be liquefiable sediments at some, not necessarily all, locations within that unit.

For the current scenario study, the Ponti et al. map (2008) was reviewed and adjusted to account for local geologic materials and is provided in Figure 1 pictured above, (refer to Figure 4-6 in the San Diego Earthquake Planning Scenario Report). For example, the Ponti et al. (2008) regional map conservatively classified all fill materials to the "Very High" LS category and did not differentiate between compacted fill ("Low" LS classification) and uncompacted fills ("Very High" LS classification) per Youd and Perkins (1978). Based on local geologic experience, areas known to have compacted fills were adjusted to the "Low" LS category.

Groundwater Depth

As discussed in Section 4.2 of the report, the new GIS-based GD map, as shown in Figure 2 (refer to Figure 4-7 in the report), was used in conjunction with the LS map and was developed using the data collection and analytical methods used for the 2008 ShakeOut report with some modifications.

Data collected in August through December for the years of 2007 through 2017 was used for development of the new GD map. The August through December collection period focuses the groundwater depth analysis on the months prior to the rainy season which are historically confined to the months of January and February in San Diego.

Groundwater data for San Diego County was collected from groundwater monitoring well sites using the following three online sources:

1. **USGS National Water Information System (NWIS) -** https://waterdata.usgs.gov/nwis
2. **California Statewide Groundwater Elevation Monitoring Program (CASGEM) -** http://www.water.ca.gov/groundwater/casgem/
3. **California State Water Resources Control Board -** https://geotracker.waterboards.ca.gov/

Groundwater measurement data relevant to liquefaction susceptibility was the focus for this groundwater depth investigation; therefore, only groundwater data from wells with listed screen depths within 100 feet (30 meters) of the ground surface were used. If screen depths were not specified, groundwater measurement data from wells with listed total depths no deeper than 100 feet (30 meters) were also used. Data from wells where screen depth or total depth could not be verified were not used. Individual groundwater measurements were removed if: there was any indication of nearby or recent pumping when the measurement was taken; there were noted issues during sampling of the well (such as an obstruction); or the well is considered "Dry". Based on these criteria, a total of 33,074 groundwater measurements from 4,550 sites were used. Depth to groundwater statistics (mean, minimum, maximum, and standard deviation of GD) were calculated.

Depth to groundwater was estimated for all LS material classifications of "Very Low" or higher to further refine the LS map. The average of all minimum (deepest) depth to groundwater values from well sites within each mapped liquefaction susceptibility GIS-based polygon was calculated and used to represent the depth to groundwater for that polygon. The use of minimum groundwater levels is consistent with the methodology of Ponti et al. (2008) and provides a sense of the relative risk of liquefaction. There may be a greater risk of liquefaction if the minimum groundwater level is consistently shallow whereas deep, or fluctuating, groundwater levels might indicate a lower likelihood of liquefaction. Where no well sites were present in a given polygon, the reported depth to groundwater value from the 2008 Shakeout report was used. Like the 2008 report, the depth to groundwater data in this revised map contains considerable uncertainties due to disparities in the distribution of data in time and space. Depth to groundwater estimates from only a few sites are likely to have greater uncertainties than estimates with a substantial number of sites.

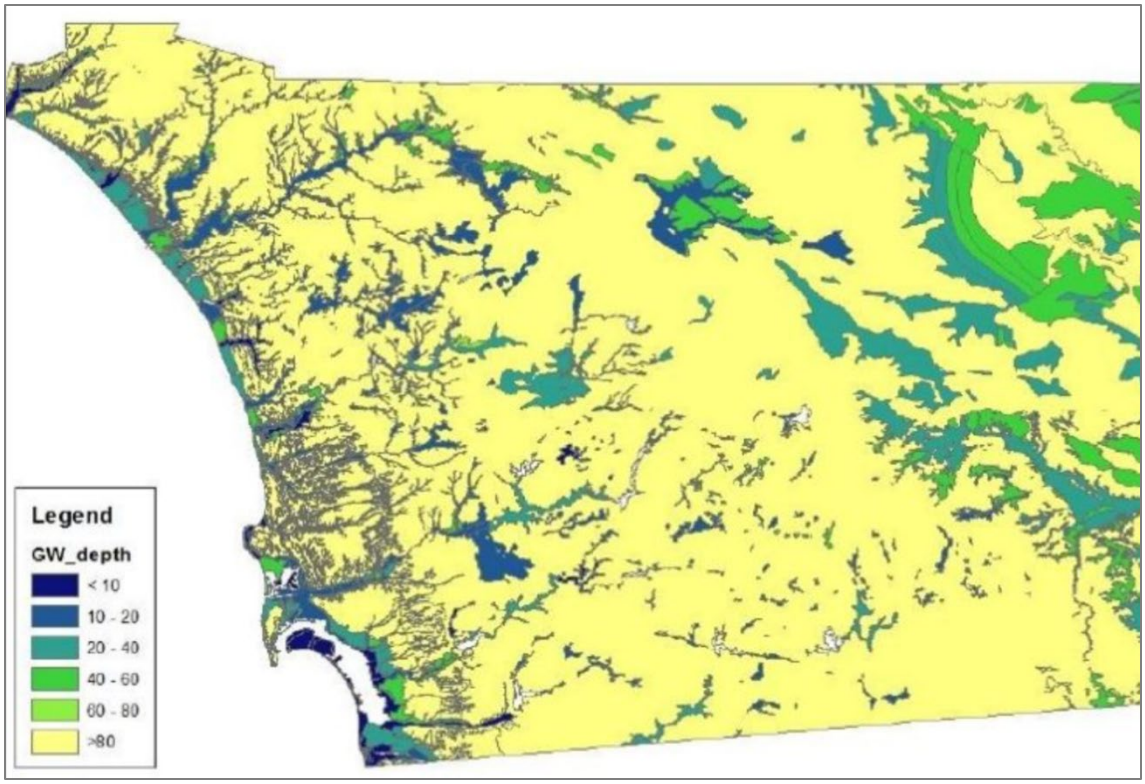

Figure 2. Groundwater Depth in Meters for Scenario Earthquake, 2017.

Ground Motion Intensity

As discussed in Section 4.2 of this report, the scenario PGA map, Figure 3 (refer to Figure 4-4 in the report), was used as the GMI map in conjunction with the LS and GD maps to assess the potential for liquefaction triggering.

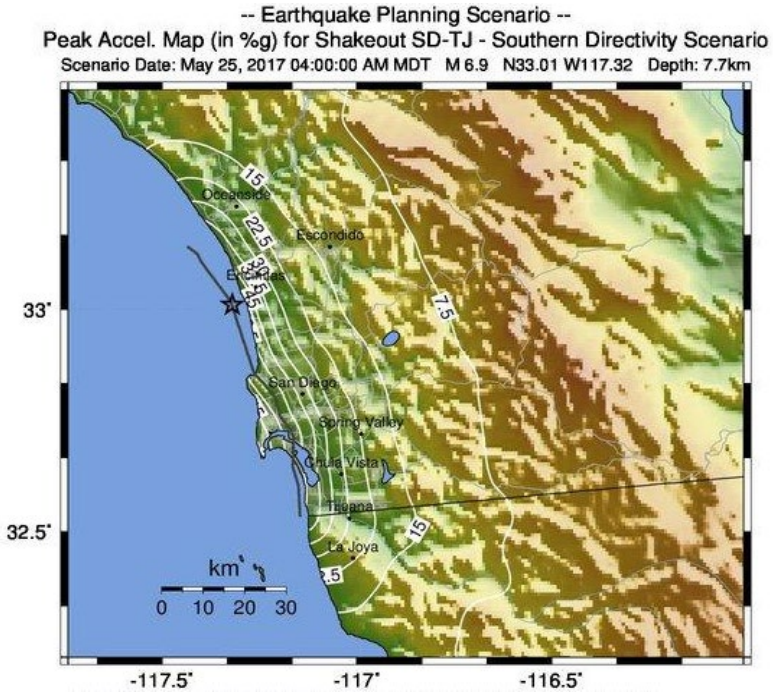

Figure 3. Earthquake Scenario Peak Ground Acceleration Map (USGS, 2017)