COUNTY OF LOS ANGELES

DEPARTMENT OF PUBLIC WORKS

"To Enrich Lives Through Effective and Caring Service"

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IN REPLY PLEASE
REFER TO FILE: GME-3

REVIEW OF GEOTECHNICAL REPORTS ADDRESSING LIQUEFACTION

Although the Seismic Hazard Mapping Act became operative on April 1, 1991, the County still receives submittals with liquefaction analyses that do not meet the established requirements To assist in facilitating the processing of your reports, we have enclosed a summary of our review requirements for liquefaction analyses and a list of common areas requiring additional information. This information is being circulated in an effort to provide applicants with information regarding our requirements and standards, to reduce the number of required addendum reports, and to increase our efficiency

Beginning April 15, 2009, the County will require all reports dated April 15, 2009, and later, to abide by the requirements and guidelines set forth in the attached document. Reports dated prior to April 15, 2009, shall continue to be reviewed per the guidelines set forth in the 1997 Special Publications 117 and 1999 Recommended Procedures for Implementation of DMG Special Publication 117 Guidelines for Analyzing and Mitigating Liquefaction in California documents until April 15, 2010 After April 16, 2010, all reports and addenda with new or revised liquefaction analyses, regardless of the initial submittal date, will be held to the requirements and guidelines described in the attached document.

If you have any questions or concerns, please contact Mr Michael Montgomery at (626) 458-4923.

Very truly yours,

GAIL FARBER
Director of Public Works

Greg Kelley

GREG KELLEY
Assistant Deputy Director
Geotechnical and Materials Engineering Division

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REVIEW OF GEOTECHNICAL REPORTS ADDRESSING LIQUEFACTION

BACKGROUND

In response to damaging earthquakes in California, in 1990 the State Legislature passed the Seismic Hazards Mapping Act. The Governor signed the Act, codified in the Public Resources Code as Division 2, Chapter 7.8, which became operative on April 1, 1991.

The purpose of the Act is to protect public safety from the effects of strong ground shaking, liquefaction, landslides, ground failures, and other hazards caused by earthquakes. The Act requires that City, County, and State agencies use seismic hazard zone maps developed by the California Department of Conservation, Division of Mines and Geology (DMG) in their land use and permitting process. The Act requires "Projects" within seismic hazard zones to have site-specific geotechnical investigations conducted and mitigation measures, if any, incorporated into the plans. The term "Project" is defined by the Seismic Hazard Mapping Act in Public Resources Code 2693 (see attached Table 1).

Guidelines for evaluating and mitigating seismic hazards in California were published in 1997 by the DMG as Special Publication 117 (SP117). These guidelines were revised and readopted September 11, 2008, and published by the California Department of Conservation, California Geological Survey (CGS), formerly known as DMG. In 1999, the Southern California Earthquake Center published the *Recommended Procedures for Implementation of DMG Special Publication 117 Guidelines for Analyzing and Mitigating Liquefaction in California* (1999 Recommended Procedures). These guidelines and procedures have been adopted by the County of Los Angeles Department of Public Works (Public Works) with some minor modifications and requirements. These modifications and requirements are detailed in the Public Works *Manual for the Preparation of Geotechnical Reports*, which is available online at http://dpw.lacounty.gov/gmed/manual.pdf. It should be noted that changes have been made from the 1997 SP117 to the 2008 SP117, in particular the screening criteria for liquefaction assessment.

REVIEW CRITERIA

The Public Works permitting/reviewing sections have received several geotechnical reports that did not comply with the guidelines and procedures set forth in the 1997 SP117 and/or 1999 Recommended Procedures. This noncompliance generated many review comments and resulted in unnecessary project permitting delays and associated costs.

REVIEW OF GEOTECHNICAL REPORTS ADDRESSING LIQUEFACTION

In an effort to clarify the permitting requirements and reduce future permit delays and associated costs, please note the following:

The Public Works permitting/reviewing sections will be utilizing the guidelines and procedures set forth in the following to review the assessment and analysis of liquefaction hazards:

- 2008 SP117
- 1999 Recommended Procedures
- California Building Code - California Code of Regulations (CCR) Title 14, Division 2, Chapter 8, Article 10, Section 3724 (State's minimum criteria for project approval) and CCR Title 24 (requirements for hospitals, public schools, and other essential buildings)
- Most recent version of the Public Works *Manual for the Preparation of Geotechnical Reports*

Where there is a conflict between the commentary in the 2008 SP117 and 1999 Recommended Procedures documents, the 2008 SP117 commentary supersedes the 1999 Recommended Procedures information.

Prior to performing a quantitative assessment, a screening investigation should be conducted in accordance with the 2008 SP117. If the screening investigation clearly demonstrates the absence of a liquefaction hazard at a "Project" site and the Public Works reviewers concur, then the screening investigation will satisfy the site investigation report requirement. Otherwise, a quantitative evaluation is required to assess the liquefaction hazard at the "Project" site (see attached Table 1).

The following screening criteria may be applied to determine if the entire depth or specific layers may be excluded from further quantitative evaluation of liquefaction hazard:

1. Estimated maximum past, current, and future groundwater levels are determined to be deeper than 50 feet below the existing ground surface, finished grade, or 20 feet below the proposed bottom of foundations, whichever is deepest.

2. If bedrock or other similar lithified formational material underlies the site, those materials need not be considered liquefiable and no analysis of their liquefaction potential is necessary. The presence of bedrock or other similar lithified formational material must be substantiated by either refusal encountered or

boring log(s) showing that at least 5 feet of such materials have been logged. It should be noted that hand augered refusals will not be accepted as adequate exploratory effort.

3. Corrected standard penetration test (SPT) blow counts $(N_1)_{60}$, greater than or equal to 30. A sufficient numbers of tests shall be conducted to provide at least one SPT blow count record for every 5 feet of depth explored. If nonstandard samplers or penetration tests are used, conversion to SPT blow counts shall incorporate conservative conversion factors (e.g., conversion from California modified split spoon to field SPT blow counts is typically 0.67 to 0.7). If cone penetration test soundings are made, the corrected cone penetration test tip resistance (q_{c1N}) should be greater than or equal to 160 tsf (156 kg/cm^2 or 16 MPa) in all soundings in coarse-grained soils.

4. Soils that behave like clays and do not undergo severe strength loss during ground shaking may be generally considered not susceptible to liquefaction. To determine if soils are susceptible to liquefaction, the Plasticity Index (PI) and in-situ moisture content must be determined. Soils considered to be potentially susceptible to undergo seismically induced deformation during liquefaction are classified in the following manner: (**1**) PI<12 and moisture content greater than 85 percent of the liquid limit, or (**2**) sensitive soils with a PI>18.

   If a soil has a PI>18, additional information will be required to show that it is not a sensitive soil. This may include data such as consolidated undrained triaxial stress relaxation tests, ratio of undisturbed to remolded shear strength, or determination of the degree of sensitivity (for reference see *Soil Mechanics in Engineering Practice* 3rd Edition by Terzaghi, Peck, and Mesri or *An Introduction to Geotechnical Engineering* by Holtz and Kovacs).

The following is a list of the most common reasons for (and solutions to) the Public Works permitting/reviewing sections not accepting liquefaction analyses and associated dynamic settlement calculations:

1. Submitted geotechnical reports lack sufficient laboratory data to substantiate the nonliquefiable soil layers. Specific commentary and supporting data (see 2008 SP117 and 1999 Recommended Procedures) must be provided before a layer or layers will be accepted for exclusion in the liquefaction assessment and settlement analyses.

2. The depth of exploration is inadequate. It is required that subsurface data be collected and analyzed to a minimum depth of 50 feet below ground surface or finished grade, whichever is deeper. When a structure may have subterranean construction or deep foundations, the minimum depth of exploration must be extended to a minimum of 20 feet below the lowest expected foundation level (bottom of caisson or pile), or 50 feet below ground surface, whichever is deeper.

3. Subsurface conditions are not confirmed by a confirmation boring when using Cone Penetration Testing (CPT). If CPTs are utilized to assess liquefaction hazard, at least one boring is required to confirm the subsurface conditions with samples taken at a minimum of every 2½ feet of depth explored. Sampling and testing is performed to confirm the CPT-soil behavior type interpretations. The confirmation boring must be performed to meet the minimum required depth of exploration (see Item No. 2 above). The CPT and confirmation boring shall be conducted in close proximity to each other, but not be spaced so closely that stress relief would significantly affect the results.

4. Lateral extents of areas subject to liquefaction are not clearly identified. Typically this is a problem limited to projects that cover large acreage, such as a tract development. The liquefaction hazard assessment shall indicate the areas/zones that are subject to liquefaction hazards and provide the associated liquefaction analyses as appropriate. If the lateral extents of the liquefaction are not supported with substantiating data, the entire project site will be evaluated as having the same liquefaction hazard and/or most critical liquefaction hazard assessed at that site.

5. Layers have been excluded from quantitative liquefaction hazard evaluation due to the Soil Behavior Type Index value assessed during the CPT sounding(s). Use of Soil Behavior Type Index (I_c) value greater than 2.4 to exclude layers from the quantitative liquefaction hazard evaluation, is not an acceptable method to Public Works at this time. However a conversion of the corrected tip resistance (q_c) to equivalent $(N_1)_{60}$ values is acceptable.

6. Factors of safety of some layers do not meet the County minimum standard in the quantitative assessment; nevertheless, the layers have been excluded from the settlement calculations. Factor of safety against the occurrence of liquefaction (adopted by Public Works) is 1.30 or greater in the quantitative assessment of the potential liquefaction hazard. Every layer in the analysis, not precluded by screening criteria, must meet this factor of safety requirement or be included in the seismically induced settlement calculations. NOTE: The factor of safety is determined as the ratio of magnitude corrected cyclic resistance ratio ($CRR_{7.5}$) to the cyclic stress ratio (CSR).

7. Input parameters (such as magnitude, acceleration, and depth of historically high groundwater table) used for liquefaction analyses are less conservative than the values in the CGS Seismic Hazard Zone Reports and have not been fully justified. For the purpose of performing liquefaction analysis, the use of Simple Prescribed Parameter Values (SPPV) for the magnitude and acceleration of the site are recommended. SPPV maps and historically high groundwater depths are available within the CGS Seismic Hazard Zone Reports prepared for each quadrangle. These reports are online at the CGS website (http://gmw.consrv.ca.gov/shmp/html/eval_rpts_so.html).

8. Acceleration values used in the liquefaction analyses do not appear to include the magnitude scaling factor. All acceleration values must be magnitude weighted in accordance with magnitude scaling factors after Youd and Idriss, 1997.

9. All correction factors applied to raw SPT blow counts are not fully discussed and justified. Provide justification for SPT correction factors. For example, the inside diameter of the hollow stem shall be provided in order to use the C_B correction factor.

10. Values utilized in multiple liquefaction analyses for the same site do not use consistent values when applicable. Consistent values must be used throughout the analyses, or adequately explain the inconsistent values and have them supported by substantiating data.

11. Values reported in the boring logs are not utilized in the liquefaction analyses. Adequate explanation and substantiating data are required to justify using values in the analyses that are different from those reported in the boring logs.

12. Report indicates that only a portion of the predicted seismically induced settlement will manifest to the surface or proposed foundation will not experience the same amount of settlement as predicted in the analyses. At this time, bridging of nonliquefiable soil layers above liquefiable layers is not considered an adequate explanation or justification for a reduction of ground surface settlement manifestation.

13. Seismically induced settlements of unsaturated soil layers are not calculated or included in the total settlement calculations. Total seismically induced settlement must be the sum of seismically induced settlements of both the saturated and unsaturated soils. For liquefaction analyses, soil layers below the historically high groundwater level shall be considered saturated.

14. The distance over which the differential settlement will occur is not specified. If the total seismically induced settlement is determined based on only one exploratory boring or CPT, differential settlement shall be taken as half of the total seismically induced settlement over a horizontal distance of 30 feet. For a horizontal distance reference greater than 30 feet, more than one exploratory boring or CPT must be conducted, or an extensive justification must be provided and agreed to by the Public Works reviewer.

15. Differential settlement is not equal to at least half of the total settlement or there is insufficient site investigation to justify the reduced differential settlement vertical displacement. Also, a shallow removal and recompaction recommendation (e.g., 5 feet of removal and recompaction below foundation and footings) is not considered by Public Works to be an adequate justification by itself for a reduction of the differential settlement. In order to use less than half of the total settlement, there must be additional borings or CPTs onsite that confirm the uniformity of the soil stratigraphy and relative densities.

16. Mitigation measures recommended by the consultant are inadequate. Structural mitigation is acceptable for up to 4 inches of total seismically induced settlement. Calculated seismically induced settlement greater than 4 inches requires ground modification and/or pile supported foundations. A combination of ground modification, piles, and structural mitigation may be acceptable for sites with more than 4 inches of total seismically induced settlement.

17. Lateral spreading is inadequately addressed by geotechnical consultants when warranted. Lateral spreading on gently sloping ground or along free face surfaces (e.g., marina sea walls, flood protection channels) is the most pervasive and damaging type of liquefaction failure. Soil layers having equivalent $(N_1)_{60}$ blow counts less than 15 should be evaluated to assess the lateral spreading hazard. Structural mitigation is acceptable for up to 12 inches of horizontal displacement. Calculated lateral displacement greater than 12 inches requires ground modification. A combination of ground modification, piles, and structural mitigation may be acceptable for sites with more than 12 inches of lateral displacement.

18. Lastly and most importantly, Public Works often receives geotechnical reports addressing “Projects” that do not address liquefaction. A “Project” will be approved only when the nature and severity of the liquefaction potential at the site has been evaluated in a geotechnical report and appropriate mitigation measures have been proposed and incorporated into the plans for the “Project”. The approved report will be submitted to the State Geologist within 30 days of the approval of the “Project.”

REVIEW OF GEOTECHNICAL REPORTS ADDRESSING LIQUEFACTION

SUMMARY

There are many procedures and guidelines that must be met before an assessment and/or analysis of liquefaction hazards can be accepted by the Public Works permitting/reviewing sections. We have discussed the reviewing criteria and typical problems, and provided solutions to resolve the majority of those issues. We anticipate that this letter will provide a better understanding of how our reviewers approach, review, and accept the assessment, analyses, and mitigation measures for liquefaction hazards.

We acknowledge that we have not discussed the actual geotechnical mitigation methods that may be utilized at a site to address potential liquefaction hazards. However, the reason for this is that Chapter 7 of 2008 SP117 did an excellent job of detailing several methods and we will not attempt to reiterate its extensive commentary. Please remember that either some or all of the following may be required before a particular mitigation recommendation is accepted at a project site: calculations, supporting data, additional commentary, and post-mitigation plan for quality assurance testing. The reason for the post-mitigation quality assurance (e.g., CPTs, shear wave velocity testing) is to verify that the mitigation measures have adequately addressed the reduction of the potential liquefaction hazard.

We understand that some of the items in this letter will need to be discussed in greater depth in order for all to become accustomed to how we review potential liquefaction hazards. To this effect we would like to set up some discussion groups so that our reviewers can meet and discuss these policies with those preparing reports for submittal to the County. We will be updating our webpage (http://dpw.lacounty.gov/gmed/permits/index.cfm) with more information regarding the anticipated dates for these discussion groups. For information on how to contact us, please visit us at http://dpw.lacounty.gov/gmed/permits/index.cfm?p=contact_us, or we can be reached at (626) 458-4923. Attachment 1 contains a **general** list of key items that should be addressed in the assessment and analysis of liquefaction hazards.

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ATTACHMENT 1

General Screening Criteria Assessment of Liquefaction Hazard

1. Groundwater deeper than 50 feet.

2. Bedrock encountered at a shallow depth below proposed foundations.

3. SPT $(N_1)_{60}$ blow counts greater than or equal to 30 and/or CPT tip resistance (q_{c1N}), greater than or equal to 160 tsf.

4. Soils with a **(1)** PI<12 and moisture content greater than 85 percent of the liquid limit, or **(2)** sensitive soils with a PI>18 are considered to be susceptible to undergo seismically induced deformation during liquefaction.

General Guidelines for Analysis of Liquefaction Hazard

1. Specific commentary and supporting data provided for every layer excluded from liquefaction assessment and settlement analyses.

2. Depth of exploration to a minimum of 50 feet below ground surface, finished grade, or 20 feet below the lowest expected foundation level (bottom of caisson or pile), whichever is deepest.

3. When using Cone Penetration Testing (CPT), provide a confirmation boring to meet the minimum required depth of exploration (see Item No. 2 above). The CPT and confirmation boring shall be conducted in close proximity to each other, but not be spaced so closely that stress relief would significantly affect the results.

4. Soil Behavior Type Index (I_c) values may not be used to exclude layers from the quantitative liquefaction hazard evaluation.

5. Every layer in the analysis, not precluded by screening criteria, must meet the factor of safety against the occurrence of liquefaction of 1.30 or greater.

6. For the purpose of performing liquefaction analysis, the use of Simple Prescribed Parameter Values (SPPV) for the magnitude and acceleration of the site are recommended.

7. All acceleration values must be magnitude weighted in accordance with magnitude scaling factors after Youd and Idriss, 1997.

8. All correction factors applied to raw SPT blow counts shall be discussed and justified.

9. Consistent values must be used throughout the analyses, or adequately explain the inconsistent values and have them supported by substantiating data.

10. Bridging of nonliquefiable soil layers above liquefiable layers is not considered an adequate explanation or justification for exclusion of those layers in the seismically induced settlement calculations.

11. Total seismically induced settlement must be the sum of seismically induced settlements of both the saturated and unsaturated soils.

12. Differential settlement shall be taken as half of the total seismically induced settlement over a horizontal distance of 30 feet. In order to use less than half of the total settlement, there must be additional borings onsite that confirm the uniformity of the soil stratigraphy and relative density.

13. Assessment of lateral spreading must be conducted when gently sloping ground or free faces (e.g., marina seawalls, drainage channels) are within or in close proximity to the site. Soil layers having equivalent $(N_1)_{60}$ blow counts less than 15 should be evaluated to assess the lateral spreading hazard.

14. Structural mitigation is acceptable for **(1)** up to 1 inch of seismically induced differential vertical displacement over a horizontal distance of 30 feet, **(2)** up to 4 inches of total seismically induced settlement, and **(3)** up to 12 horizontal inches of lateral ground displacement. Anything in excess of the aforementioned values requires ground modification. A combination of ground modification, piles, and structural mitigation may be acceptable.

15. Liquefaction hazard assessment shall indicate the areas/zones subject to liquefaction hazards and provide the associated liquefaction analyses as appropriate. If the limits of the liquefaction are not supported with substantiating data, the entire project site will be evaluated as having the same liquefaction hazard.

16. A “Project” will be approved only when the nature and severity of the liquefaction potential at the site has been evaluated in a geotechnical report and appropriate mitigation measures have been proposed and incorporated into the plans for the “Project”.

TABLE 1. Definition of "Project"

Public Resources Code Section 2693.

As used in [Chapter 7.8, the Seismic Hazards Mapping Act]:

d) "Project" has the same meaning as in Chapter 7.5 (commencing with Section 2621), except as follows:

(1) A single-family dwelling otherwise qualifying as a project may be exempted by the city or county having jurisdiction of the project.

(2) "Project" does not include alterations or additions to any structure within a seismic hazard zone which do not exceed either 50 percent of the value of the structure or 50 percent of the existing floor area of the structure.

Public Resources Code Section 2621.6.

(a) As used in (Chapter 7.5, the Alquist-Priolo Earthquake Fault Zoning Hazard Act), "project" means either of the following:

(1) Any subdivision of land which is subject to the Subdivision Map Act (Division 2 (commencing with Section 66410) of Title 7 of the Government Code), and which contemplates the eventual construction of structures for human occupancy.

(2) Structures for human occupancy, with the exception of either of the following:

(A) Single-family wood-frame or steel-frame dwellings to be built on parcels of land for which geologic reports have been approved pursuant to paragraph (1).

(B) A single-family wood-frame or steel-frame dwelling not exceeding two stories when that dwelling is not part of a development of four or more dwellings.

(b) For the purposes of this chapter, a mobile home whose body width exceeds eight feet shall be considered to be a single-family wood-frame dwelling not exceeding two stories.

California Code of Regulations Section 3601 (Policies and Criteria of the State Mining and Geology Board, With Reference to the Alquist-Priolo Earthquake Fault Zoning Act).

The following definitions as used within the Act and herein shall apply:

(e) A "structure for human occupancy" is any structure used or intended for supporting or sheltering any use of occupancy, which is expected to have a human occupancy rate of more than 2,000 person-hours per year.

(f) Story" is that portion of a building included between the upper surface of any floor and the upper surface of the floor next above, except that the topmost story shall be that portion of the building included between the upper surface of the topmost floor and the ceiling or roof above. For the purpose of the Act and this subchapter, the number of stories in a building is equal to the number of distinct floor levels, provided that any levels that differ from each other by less than two feet shall be considered as one distinct level."