SDCI | Director’s Rule 2-2023

Applicant: City of Seattle Department of Construction and Inspections	**Page** 1 of 5	**Supersedes:** N/A
	Publication: 7/20/2023	**Effective:** 8/30/2023
Subject: Update of ECA Liquefaction-Prone Areas Map	**Code and Section Reference:** SMC 25.09.012, SMC 25.09.030	
	Type of Rule: Code Interpretation	
	Ordinance Authority: SMC 3.06.040	
Index: Regulations for Critical Areas	**Approved** **Date** (Signature on file 8/25/23) Nathan Torgelson, Director, SDCI	

Purpose

This rule updates the advisory map for Liquefaction-Prone Environmentally Critical Areas (ECA) (25.09.012.A.2). The authority for updating the map is Seattle Municipal Code (SMC) 25.09.030.A, Regulations for Environmentally Critical Areas, which states that “The Director may update or amend maps by Director’s Rule”.

Background

Liquefaction occurs when loose, saturated soils lose their strength due to strong ground shaking. Liquefaction can cause severe damage to structures and infrastructure due to total and differential settlement of the ground, lateral spreading, and loss of bearing capacity. Earthquake-induced liquefaction and damage were observed in Seattle during the 1949, 1965 and 2001 earthquakes.

The current liquefaction-prone area map of Seattle was adopted in 1992. It is based upon work documented in “Evaluation of Liquefaction Potential, Seattle, Washington,” USGS

Open-File Report 91-441-T (Grant et al., 1991) and the geologic map for Seattle by Waldron et al. (1962).

Grant et al. (1991 and 1998) identified geologic units susceptible to liquefaction using the "simplified procedure" (Seed and Idriss, 1971 and Seed et al., 1983 and 1984) for liquefaction triggering to analyze representative soil borings in each geologic unit. Geologic units containing a majority of soil samples with moderate to high liquefaction hazard were classified as liquefiable.

Grant et al. (1991 and 1998) also describes a parallel study by Perkins (1991) who evaluated liquefaction potential using thickness criteria. A geologic unit was considered liquefiable if more than 25% of borings in that unit contained a minimum of 10 feet of soil that would liquefy with pga=0.3g or 1 foot of soil would liquefy with pga=0.15g. The results of both research efforts were similar and combined into the single liquefaction hazard map described in Grant et al. (1991 and 1998) and adopted in 1992.

Basis for Updated Liquefaction-prone Area Map

The new liquefaction-prone area map for Seattle is based upon work documented in "Mapping Earthquake-Induced Liquefaction Potential of Quaternary Late Glacial and Post Glacial Deposits in Seattle, Washington" by Tunnelle (2021) and "The Geologic Map of Seattle—A Progress Report: USGS Open-File Report 2005-1252" (Troost et al., 2005). The primary differences between the two mapping studies are summarized in the table below:

	Reference	**Number of borings**	**Geologic Map**	**Ground motions for liquefaction evaluation**	**Liquefaction evaluation method**
Current map	Grant et al., 1991	350+	Waldron et al., 1962	pga=0.3g, M=7.5 (475-year return period consistent with 1991 Uniform Building Code)	Methodology from (1) "simplified method" for liquefaction triggering and (2) thickness criteria
Updated map	Tunnelle, 2021	3,157	Troost et al., 2005	pga=0.66g, M=7.5 from 2014 USGS NSHMP*, 2475-year return period consistent with ASCE 7-16, SBC** 2018 and SBC 2021	Liquefaction Potential Index (Iwasaki, 1978) that considers "simplified method" for liquefaction triggering, thickness, and depth of liquefiable layers

*U.S. Geological Survey National Seismic Hazard Mapping Project
**Seattle Building Code

The updated geologic map by Troost et al. (2005), based on 35,000 geotechnical borings and LiDAR analysis "identified several new geologic units and increased the spatial extent of normally consolidated materials that may be susceptible to liquefaction," (Tunnelle, 2021). The new geologic map shows a 22% increase in areas mapped as late glacial and post-glacial deposits compared to Waldron et al. (1962). These deposits are typically loose to medium dense soils.

Tunnelle evaluated over 3,000 representative soil borings in various geologic units based on the Troost et al. (2005) map. Based on the boring information, she calculated a liquefaction potential index (LPI) (Iwasaki, 1978) and assigned a liquefaction hazard rating ranging from very low to high for each boring. The LPI method includes the "simplified method" to evaluate liquefaction triggering (Boulanger and Idriss, 2014) and also includes a depth-weighting function. Geologic units containing a majority of borings with moderate to high liquefaction hazard ratings were included in the updated liquefaction-prone areas map.

Tunnelle's findings are "generally consistent with the results from the liquefaction study by Grant et al. (1991 and 1998)." In general, both studies assign moderate to high liquefaction potential to Holocene-aged deposits. Grant et al. (1991 and 1998) generally assigned low liquefaction potential to Pleistocene-aged deposits. However, Tunnelle identified some areas of Pleistocene-aged deposits with moderate to high liquefaction potential and included those areas in the map.

The updated liquefaction-prone area map contains about 25% more land designated as potentially liquefiable than the previous map. The increase in mapped liquefiable area is primarily due to the changes in geologic mapping (i.e., the extent of geologic units deemed liquefiable) and not the increase in ground motions used to evaluate liquefiable zones in the soil borings.

The liquefaction prone areas map is called "advisory" because the mapping is used for initial information and screening. Whether or not a site is treated as an environmentally critical area is based on site specific subsurface data and analysis.

Rule

This rule adopts the map titled figure 1, "Liquefaction-Prone Areas Map," dated March 16, 2021. You can view the updated advisory map layer at: Seattle Department of Construction & Inspections GIS (arcgis.com)

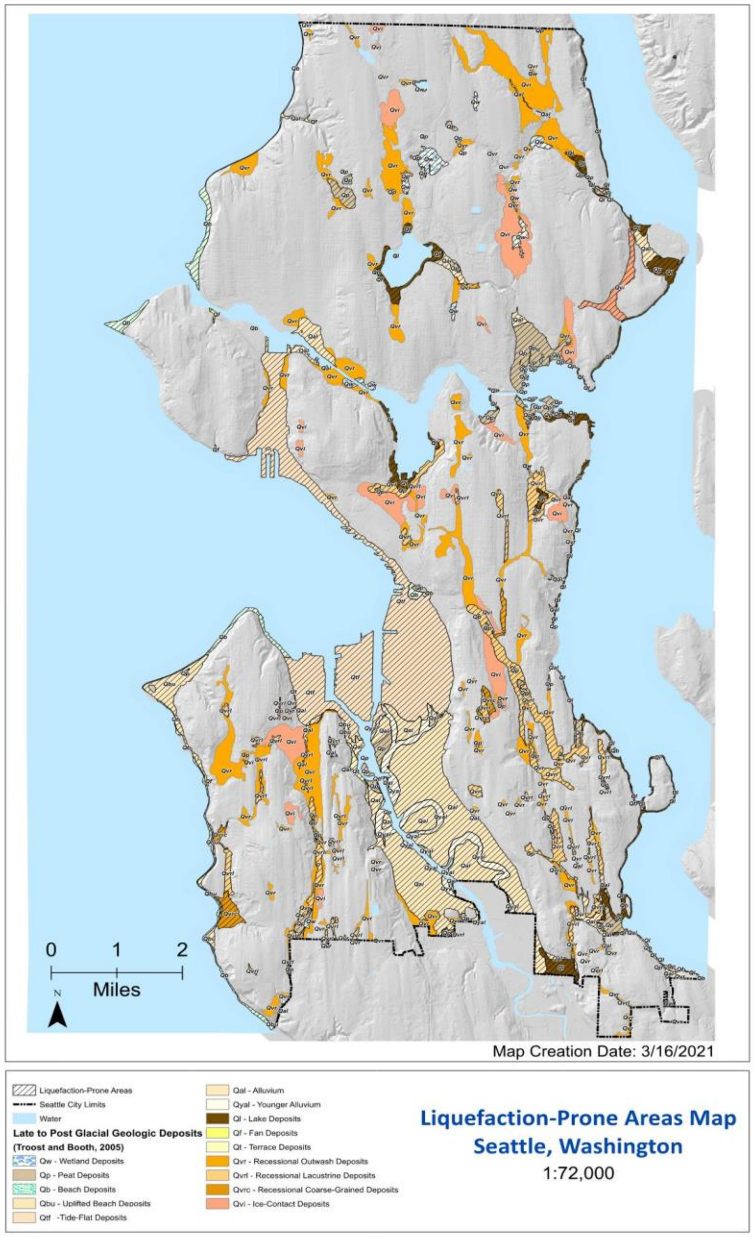

Figure 1. Liquefaction-Prone Areas Map

References

Boulanger, R.W. and Idriss, I.M., 2014, CPT and SPT Based Liquefaction Triggering Procedures, Report UCD/CGM 14/01, Department of Civil and Environmental Engineering, University of California, Davis, CA 138 p.

Grant, W. P., Perkins, W. J., Youd, T. L., 1991, Evaluation of Liquefaction Potential in Seattle, Washington: U.S. Geological Survey Open-File Report 91-441, 44 p.

Grant, W. P., Perkins, W. J., Youd, T. L., 1998, Evaluation of Liquefaction Potential in Seattle, Washington, in Rogers, A. M., Walsh, T. J., and Priest, G. R., eds., Assessing Earthquake Hazards and Reducing Risk in the Pacific Northwest, Volume 2: U.S. Geological Survey Professional Paper 1560, p. 441-473, 1 plate.

Iwasaki, T., Tatsuoka, F., Tokida, K., and Yasuda, S, 1978, A practical method for assessing soil liquefaction potential based on case studies at various sites in Japan, Proc., 2nd Int. Conf. on Microzonation, National Science Foundation, Washington, DC, 10 p.

Perkins, W.J., 1991, Evaluation of liquefaction potential, Seattle, Washington, M.S. Thesis: Provo, Utah, Brigham Young University, 71 p.

Seed, H.B. and Idriss, I.M., 1971, Simplified Procedure for Evaluating Soil Liquefaction Potential: Journal of the Soils Mechanics and Foundation Division, American Society of Civil Engineers, v. 97, p. 1249-1273

Seed, H.B., Idriss, I.M., and Arango, I., 1983, Evaluation of liquefaction potential using field performance data: Journal of Geotechnical Engienering, American Society of Civil Engineers, v. 109, p. 458-482

Seed, H.B., Tokimatsu, K., Harder, L.F., and Chung, R.M., 1984 The Influence of SPT procedures in soil liquefaction resistance evaluations: Berkeley, California, University of California UCB/EERC-84-15

Troost, K.G., Booth, D.B., Wisher, A.P., and Shimel, S.A., 2005, The Geologic Map of Seattle – A Progress Report: U.S. Geological Survey Open-File Report 2005-1252, scale 1:24,000.

Tunnelle, A., 2021, Mapping Earthquake-Induced Liquefaction Potential of Quaternary Late Glacial and Post Glacial Deposits in Seattle, Washington, a report prepared in partial fulfillment of the requirements for the degree of Master of Science, University of Washington, Earth and Space Sciences: Applied Geosciences

Waldron, H.H., Liesch, B.A., Mullineaux, D.R., and Crandell, D.R., 1962, Preliminary geologic map of Seattle and vicinity, Washington: U.S. Geological Survey Miscellaneous Investigations Map I-354, accessed at: **https://pubs.er.usgs.gov/publication/i354**