Best Available Science

Seismic Hazard Areas

Prepared for the City of Sammamish
by AMEC Environment & Infrastructure, Inc.

Introduction

In the City of Sammamish Critical Areas Ordinance (CAO), “Seismic hazard areas means those areas in the City subject to severe risk of earthquake damage as a result of soil liquefaction in areas underlain by cohesionless soils of low density, and usually in association with a shallow groundwater table or other seismically induced settlement” (Sammamish Municipal Code 21A.15.1045). The two components that cause earthquake damage are strong ground motions and ground conditions that lose strength during ground motion.

Puget Sound-Wide Issues

All of western Washington is generally at risk of strong ground motions resulting from movement of tectonic plates in the Cascadia Subduction Zone. Geologic studies have documented large earthquakes in the past, such as the estimated magnitude 9.0 earthquake that occurred approximately 300 years ago. This earthquake was located near the Washington coast and relatively deep below the surface (DNR 2012). Another source of strong ground motion is the potential for shallow crustal movement along the Seattle Fault. The Seattle Fault crosses the City of Sammamish in an east-west direction, in a zone that extends south of Pine Lake to the southern City limits (Johnson et al. 2004). Geologic studies indicate that surface movement along the Seattle Fault caused an earthquake approximately 1,000 years ago with an estimated magnitude 7.5 (DNR 2012). An earthquake from the Seattle Fault could cause ground motions that are just as strong as that caused by a subduction zone earthquake because the fault is closer to the City and closer to the ground surface. Ground motions could also derive from other crustal faults, such as the magnitude 6.0 Nisqually Earthquake in 2001.

Some land areas are more susceptible to earthquake damage due to local ground conditions. Loose, saturated, cohesionless soils tend to experience the most severe ground shaking during an earthquake. When shaken, these soils lose strength and will settle, crack, and deform. Some soils will lose strength to the point of acting like a liquid, in a process called liquefaction. The loss of soil strength damages structures that had been supported by these soils. (King County 2012)

These ground conditions are usually located in low-lying areas with recent deposits of unconsolidated soils (alluvial or fluvial soils, or artificial fills) combined with shallow groundwater. Areas with peat deposits are also a hazard because ground motions can cause large permanent deformations of peat deposits. (Palmer et al. 2004)

Unique Conditions in Sammamish

The most significant BAS document for seismic hazard areas is the Liquefaction Susceptibility and Site Class Maps of Washington State, By County (Palmer et al. 2004). These maps and report were prepared by the Washington State Department of Natural Resources (DNR) primarily to describe the location and extent of earthquake hazards in Washington State. One of the stated purposes of the maps was so that:

> local jurisdictions can use these maps to delineate earthquake hazard areas and enforce critical areas ordinances as required by the State Growth Management Act. Also, local building officials will be able to use these maps to help delineate areas requiring thorough geotechnical investigation in their enforcement of state and local building codes. (Palmer et al. 2004)

Most of the City of Sammamish is within the area of detailed study on the Liquefaction Susceptibility Map of King County, Washington (Figure 1). The detailed map area is based on 1:24,000-scale geologic mapping; and quantitative engineering analysis was utilized to characterize the risk of liquefaction. The analytical methods have been validated by reports of liquefaction during previous earthquakes in the Puget Sound region. More recent and improved engineering analytical methods were used for the detailed map area, as compared to previously published maps.

Another important document is the 2008 U.S. Geological Survey (USGS) National Seismic Hazard Maps (Peterson et al. 2008). These maps provide several different probabilities of earthquake ground motions, which are used in seismic provisions of building codes, insurance rate structures, risk assessments, and other public policy. The abstract and web site states, "The national seismic maps represent our assessment of the 'best available science' in earthquake hazards estimation for the United States." (Peterson et al. 2008)

The following engineering manuals are routinely updated to address potential seismic ground motions for the design of buildings and other structures. They provide engineering design values based on the 2008 USGS National Seismic Hazard Maps probabilistic and deterministic ground motion parameters for designing structures.

- 2009 NEHRP Recommended Seismic Provisions for New Buildings and Other Structures, FEMA P-750 ("2009 NEHRP Provisions");
- 2010 Minimum Design Loads for Buildings and Other Structures, ASCE 7-10 ("2010 ASCE-7 Standard"); and
- 2012 International Building Code.

These three similar manuals represent the best available engineering for seismic design of structures.

The 2006 Geologic Map of King County is another BAS document. (Booth & Wisher 2006). It shows detailed soil types and the zone of the Seattle Fault. The purpose of the map is for more general geology uses, but it appears to be consistent with 2004 Liquefaction Susceptibility Map in terms of the location of soil types susceptible to liquefaction and the location of peat deposits.

Implications for Existing City Regulations

- *Definition*: The current CAO definition of seismic hazard areas provides a general description of the type of ground conditions mapped as seismic hazard areas. However, the terminology is not consistent with geologic maps of these hazards. For example, the use of the word "severe" could cause some interpretive arguments since that word is not used on the maps. It would be more specific and legally defendable to use a definition that correlates directly with the BAS geologic map, such as "Those areas mapped as moderate to high and high liquefaction susceptibility and peat deposits on the Liquefaction Susceptibility Map of King County, Washington, Washington Division of Geology and Earth Sciences, OFR 2004-20, Palmer et al., September, 2004."
- *Map*: Currently the City uses King County's Environmentally Sensitive Areas Map, in which the source data is from 1990. AMEC recommends using the 2004 DNR Liquefaction Susceptibility Map for mapping the seismic hazard areas in the City of Sammamish. It is based on more detailed geologic mapping and improved engineering analysis (BAS) as compared to previous maps, including the King County Environmentally Sensitive Areas Map. The main difference in the location and extent of the seismic hazard areas would be that the new map includes areas of peat deposits. The geospatial data for the map is available from the DNR web site, so this information could be incorporated into the City's geographic information systems (GIS).
- *Standards*: The City of Sammamish CAO states that development proposals in seismic hazard areas must follow the applicable building codes. By linking the CAO to the current building codes, the City has maintained BAS in the CAO for seismic hazard areas. This is because building permits in seismic hazard areas require detailed, site-specific investigation (best available science) and project specific mitigation measures (best available engineering) to reduce the risk of damage to the structures.

Research or Monitoring Needs

None noted.

Attachment: 2004 Liquefaction Susceptibility Map

Specific References

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General References

City of Everett Municipal Code Chapter 37 Critical Areas, 37.080 Geologically hazardous areas. A. 2.b. http://www.mrsc.org/mc/everett/everet19/everet1937.html#37.080.

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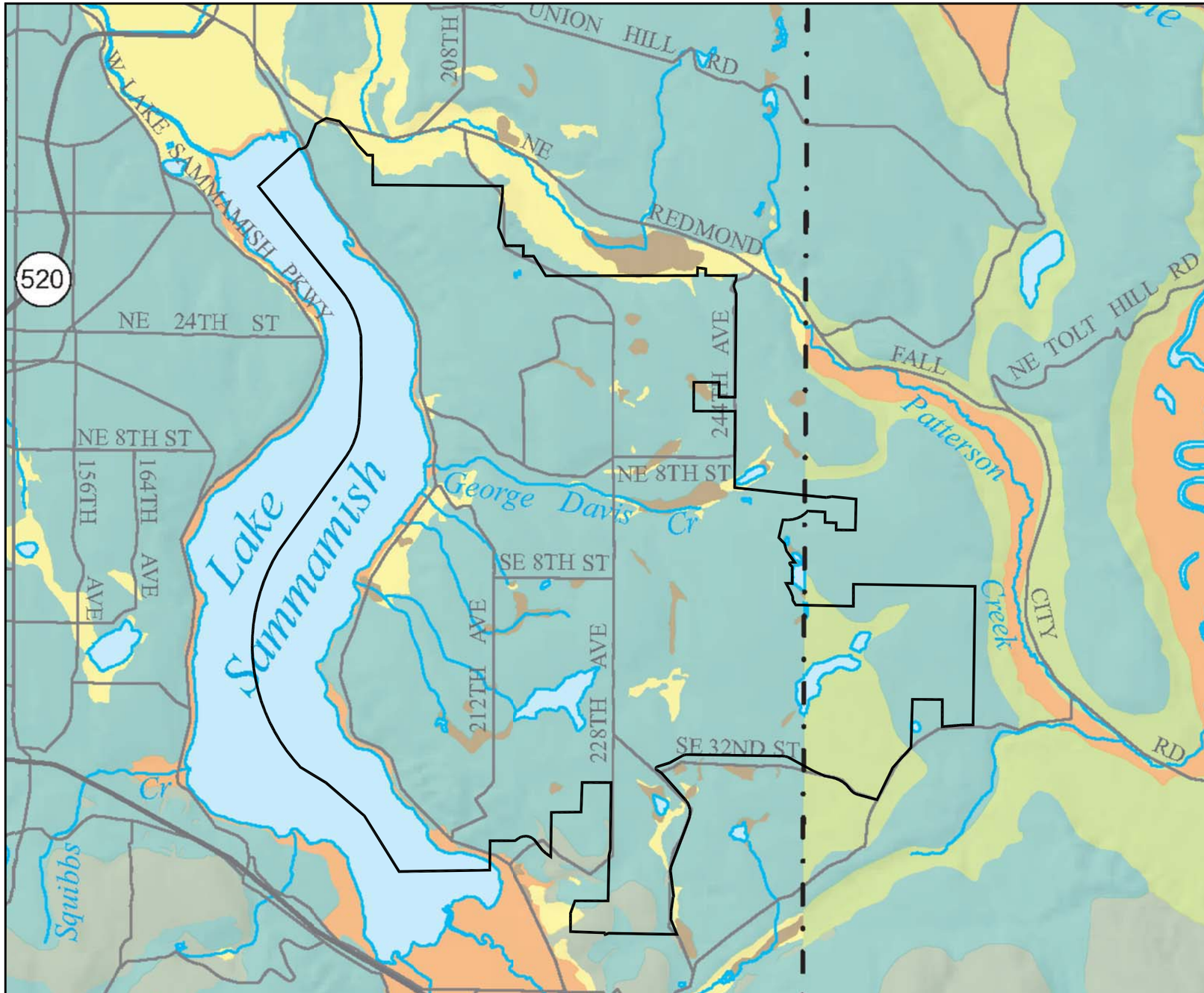
Pacific Northwest Center for Geologic Mapping Studies. 2006. Geologic map of King County, Washington: D.B. Booth and A. P. Wisher, compilers. Scale 1:100,000. http://geomapnw.ess.washington.edu/services/publications/map/data/KingCo_composite.pdf



EXPLANATION

- Liquefaction susceptibility: HIGH
- Liquefaction susceptibility: MODERATE to HIGH
- Liquefaction susceptibility: MODERATE
- Liquefaction susceptibility: LOW to MODERATE
- Liquefaction susceptibility: LOW
- Liquefaction susceptibility: VERY LOW to LOW
- Liquefaction susceptibility: VERY LOW
- Bedrock
- Peat deposit — Peat is not susceptible to liquefaction but may undergo permanent displacement or loss of strength as a result of earthquake shaking.
- Water
- Ice
- Extent of detailed study

This explanation is standardized for this series of county-based liquefaction maps; some categories may not appear on this map.

0 200 400
SCALE IN FEET
Scale 1"=416 Ft.

SOURCE: STEPHEN P. PALMER, SAMMANTHA L. MAGSINO, ERIC L. BILDERBACK, JAMES L. POELSTRA, DEREK S. FOLGER, AND REBECCA A. NIGGEMANN, SEPTEMBER 2004. "*LIQUEFACTION SUSCEPTIBILITY MAP OF KING COUNTY, WASHINGTON*". OPEN FILE REPORT 2004-20.

	CLIENT LOGO	CLIENT: CITY OF SAMMAMISH	DWN BY: JRS	PROJECT: ENVIRONMENTAL CRITICAL AREAS STUDY	DATE: MARCH 2012
			CHK'D BY: TDW		PROJECT NO: 2-915-17374-0
		AMEC Environment & Infrastucture, 11810 North Creek Parkway North, Bothell, WA, U.S.A. 98011-8201	DATUM: NONE	TITLE: LIQUEFACTION SUSCEPTIBILITY MAP 2004	REV. NO.:
			PROJECTION: NONE		FIGURE No. 1
			SCALE: AS SHOWN		

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