SOIL HAZARD MAP OF THE LOWER MAINLAND OF BRITISH COLUMBIA FOR ASSESSING THE EARTHQUAKE HAZARD DUE TO LATERAL GROUND SHAKING

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Southwest British Columbia is located in the most seismically active region of Canada. However, the strength of ground shaking during an earthquake varies considerably due to local geological conditions, and is generally greater at sites located on deposits of soft soil than at sites located on bedrock. For example, during the 1989 Loma Prieta Earthquake, ground shaking in San Francisco was commonly two to three times stronger on soft soil sites than on bedrock sites nearby.

The objective this map is to delineate the different soil types in the Lower Mainland of British Columbia, from West Vancouver to Chilliwack, for use in determining the earthquake hazard due to lateral ground shaking. **The map is intended to be used for planning purposes, such as land use planning, emergency response planning, and prioritization of seismic retrofit candidates. It is not intended to replace site-specific investigations where these are normally required. Furthermore, other earthquake hazards, such as liquefaction, landslides and tsunamis have not been considered in the preparation of this map.** ***Appropriate use of this map requires careful reading and understanding of the accompanying report and the following text.***

For more details on the preparation of this map, including references and acknowledgments, the reader is referred to the accompanying report.

Geological Mapping

This map is based mainly on the Geological Survey of Canada surficial geological maps of the Lower Mainland, which reflect primarily surface geological conditions and were prepared to support a variety of engineering and environmental applications. The Geological Survey of Canada mapping has been locally modified here on the basis of borehole data and recent subsurface geological investigations conducted by the author. In the City of Chilliwack, this map is based on the British Columbia Geological Survey preliminary earthquake hazard map of the Chilliwack area, which was based on a large body of borehole data as well as surficial geological data.

Definition of Soil Types

The soil types are defined here primarily by assigning NEHRP site classes to the various geological map units shown on the source maps. These site classes, which are being incorporated into the current national building code, are defined fundamentally on the basis of the average shear-wave velocity in the upper 30 metres (V_{30}). However, other criteria can be used where shear-wave velocity data are lacking (Table 1). In general, the intensity of ground shaking increases from site class A to E.

Table 1. NEHRP Site Classes

Site Class	General Description	Definition (V_{s30}=average shear-wave velocity in upper 30 m, m/sec; N_{30}=average N in the upper 30 m)
A	Hard rock	V_{s30}>1500
B	Rock	760<V_{s30}<1500
C	Very dense soil and soft rock	360<V_{s30}<760; or N_{30} >50; or >3 m of soil over bedrock, where V_{s30}>760 m/sec
D	Stiff soils	180<V_{s30}<360; 15<N_{30}<50
E	Soft soils, or soil profile with >3 m soft silt and clay	V_{s30}< 180; or N_{30}<15; or >3 m silt and clay with plasticity index >20, moisture content >40%, and undrained shear strength <25 kPa)

Assigning the NEHRP site classes to the geological map units requires both geotechnical borehole and shear-wave velocity data. The geotechnical borehole data obtained for the preparation of this map is limited to what could be obtained from a few readily accessible sources with large volumes of regionally distributed data, such as the British Columbia Ministry of Highways. These borehole data were used to determine the vertical profiles present within the geological map units. However, the volume of borehole data obtained was insufficient to significantly revise geological boundaries. Shear-wave velocity data available for this map are unevenly distributed in the Lower Mainland, with significant concentrations available in the Fraser River delta and adjoining parts of Vancouver and North Delta and in Chilliwack. The shear-wave velocity data were used to update a shear-wave velocity model of the principal surficial geological units of southwest British Columbia. This model permits the estimation of the V_{s30} at sites where shear-wave data are not available, but where the stratigraphy is known. However, there are many parts of the map that are poorly characterized by geotechnical and shear-wave velocity data, so that the site classes in these areas have been estimated by comparison with areas with similar geological materials and similar geological histories. Site Classes A and B, which both pertain to bedrock, have been combined on this map

High Amplification Zone

A zone of potentially high amplification is shown here around the margins of the Fraser River delta. Several phenomena, some of which are earthquake-specific, can combine to cause particularly high amplification around the margins of sedimentary basins. Consistent with this, the strongest ground motions recorded in the delta during several recent earthquakes commonly occurred at the delta margin, albeit at low levels of ground shaking. Although the modelling to fully define a zone of potentially high amplification is beyond the scope of this project, it is approximated on this map by the area in which resonance due to the thickness of deltaic deposits would occur at a period of one second or less. This period corresponds to thicknesses of 50 metres or less. The area forms a narrow band around the delta margin, and follows a buried Pleistocene ridge tending southeast across central Richmond. The high amplification zone includes areas that would otherwise be assigned to both Sites Classes D and E. Although high amplification and resonance may occur around other basins in the Lower Mainland, a high amplification zones is only mapped around the Fraser delta, because high amplification is a complex process, and it has only been observed in this one setting.

Limitations of this map

This map is intended for regional planning purposes only, such as prioritizing seismic retrofits and land use and emergency response planning, and should not replace site-specific evaluations where normally required.

This map is based on limited subsurface geological and geotechnical information. In most of the map area, the distribution of borehole data was insufficient to define the geological boundaries. Consequently these boundaries are for the most part based on the surface distribution of geological material, not their subsurface distribution. The geological boundaries shown here are in most cases taken from previous geological mapping. The Geological Survey of Canada mapping was initially conducted at a scale of 1:50,000, but these maps have been digitized from paper copies, resulting in a further loss of accuracy. Furthermore geological boundaries are generally gradational and geological materials are variable, so that deposits of a particular deposit may locally have unusual properties. For these reasons, geological boundaries are *approximate*, areas assigned to one site class may enclose smaller occurrences of other site classes, and the mapping is subject to revision as more borehole data become available. **Consequently, the hazard *at a specific site* could be either higher or lower than that indicated by these maps.**

This map does not address man-made alterations to ground conditions, whether the changes lower or increase the hazard at a site. Furthermore, the map does not consider the effect of fill on the shear-wave velocity profile, except in those areas where fill is identified on the source map. The principal area of fill thus shown is in False Creek in Vancouver. However, other areas of fill occur present, and new areas of fill will be developed in the future.

The stability of dams under earthquake shaking, and hazards due to the failures of dams or other man-made structures have not been addressed.

This map shows the distribution of soil classes, which largely reflect the variation in the ground-shaking hazard in an earthquake. However, a low hazard indicated on the map does not mean freedom from earthquake hazards, because all areas could be subjected to significant ground shaking during an earthquake. Furthermore, the map does not address the variation in the ground-shaking hazard due to topography, or, except in the potential high amplification zone in the Fraser delta, due to resonance or subsurface structure.

The map does not address other earthquake hazards, such as liquefaction, landslides, tsunamis, land subsidence and ground rupture.

Site Class

- AB
- C
- D
- DE
- E
- High Amplification

0 1 2 4 6 8
Kilometres

Map layout prepared by:
AXYS Environmental Consulting Ltd.
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The road network displayed on the map is at a scale of 1:250,000 and is accurate to +/- 125 metres.