HOQUIAM FIRE DEPARTMENT

HOQUIAM, GRAYS HARBOR COUNTY, WA

WASHINGTON 2019–2021 SCHOOL SEISMIC SAFETY PROJECT SITE CLASS ASSESSMENT

WHAT IS SITE CLASS?

Site class estimates how local soils amplify earthquake-induced ground shaking, and is based on how fast seismic (shear) waves travel through the upper 30 m (100 ft) of the soil (Vs30). Site class has been approximated for the entire State of Washington, but these predictions aren't always accurate where geology is complex. The site class measured for this project accounts for geologic complexity and is therefore more accurate.

HOW DID WE MEASURE SITE CLASS?

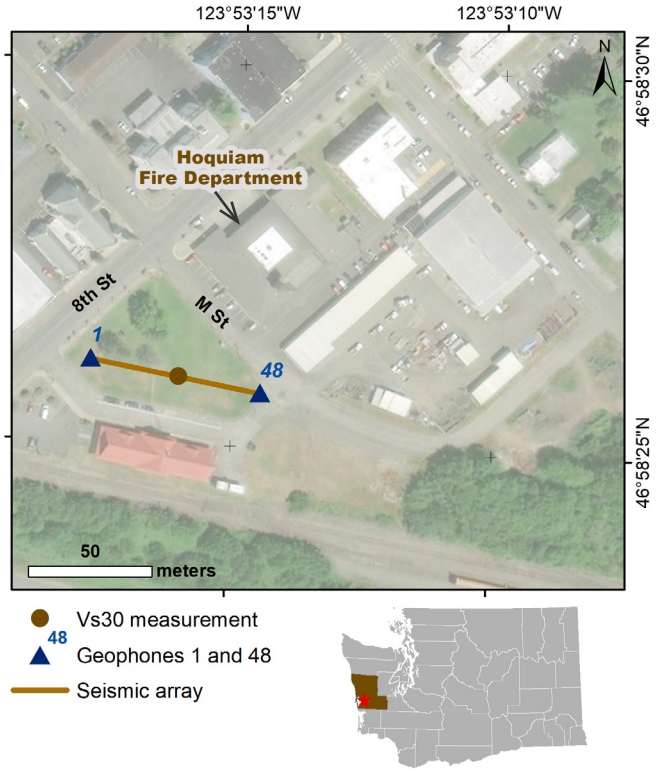
On October 21, 2020, a team from the Washington Geological Survey conducted a seismic survey at the Hoquiam Fire Department. We measured Vs30 by laying out 48 geophones (ground motion sensors) in a 70.5 m (231 ft) array. Then we conducted (1) an active survey in which a sledgehammer was struck against the ground to generate seismic waves; and (2) a passive survey where we measured ambient seismic noise. These surveys let us calculate Vs30 at the center of the array, which is then correlated to site class using the table below. It is generally accurate to assume the site class is the same under the array and the fire department.

WHAT DID WE LEARN?

- The fire department is built on soft soil, which would amplify ground shaking relative to rock.
- Site class is within the predicted site class of D–E.

Site class	Description	Vs30 (m/sec)	Ground shaking amplification
A	Hard rock	>1,500	Low
B	Rock	760–1,500	
C	Soft rock or very dense soil	360–760	
D	Stiff soil	180–360	
E	Soft soil	<180	High

MEASURED SITE CLASS **E**



Location of seismic array at the school campus.

WHAT SOILS ARE UNDER THE DEPARTMENT?

The fire department is sitting on Quaternary alluvium; river sediments consisting mostly of boulder, cobble, and pebble gravel and sand.

GEOLOGIC HAZARDS AT THE DEPARTMENT

Liquefaction
Moderate to high

Ground Shaking
Extreme

Tsunami
In a mapped tsunami hazard zone

See Washington Geological Survey Open File Report 2019-01 for more information.

TECHNICAL OVERVIEW OF RESULTS

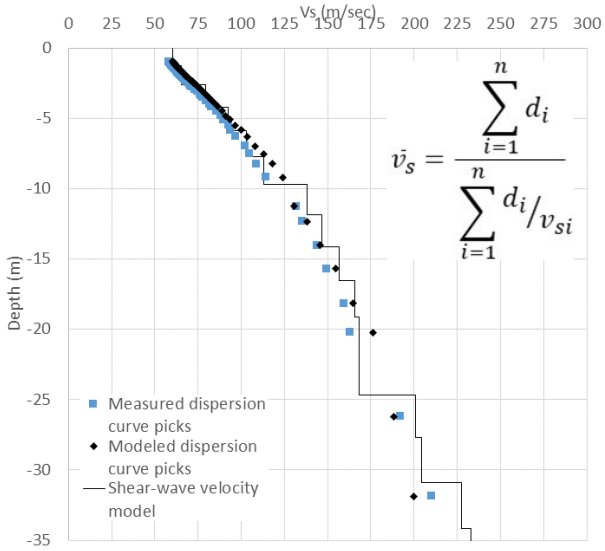
This section provides a technical overview of the geophysical methods and results of the seismic site characterization.

DISPERSION CURVE

The term dispersion image refers to the image of phase velocity versus frequency of a record. Dispersion curve refers to the manually picked fundamental mode in a dispersion image. The multi-channel analysis of surface wave (MASW) dispersion images from the forward and reverse directions are excellent quality so that the fundamental mode can be picked with high confidence. However, the MASW dispersion curves do not sample down to 30 m (100 ft). The microtremor analysis method (MAM) dispersion image is also excellent quality. MAM and the forward and reverse MASW dispersion curves correlate well, depicting similar trends. Therefore the three dispersion curves are combined into a single model.

VELOCITY MODEL

An initial model was generated using the 1/3 wavelength approximation and the combined dispersion curves. The initial model had an RMSE of 11.1 percent. The inversion was carried out for six iterations and resulted in a final model with an RMSE of 5.0 percent. The final model is unconstrained in the top 1 m (3 ft), and below this shows generally increasing velocity to 17 m (56 ft), then nearly constant velocity down to 25 m (82 ft), and then generally increasing velocity down to 30 m (100 ft). Our best Vs30 measurement is 128 m/sec, which places the site solidly in the E site class. With the clear coherence in the dispersion images and all initial and inverted models placing this site in the E site class, this site can be confidently classified. This is within the predicted site class of D–E.



Final inverted velocity model with measured dispersion curve and modeled dispersion curve. The equation used to calculate the average shear wave velocity (V_S) for the upper 30 m is shown in the upper right corner. d_i = thickness of any layer between 0 and 30 m. V_{si} = shear wave velocity in m/sec of the layer.