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Advancement of 3D modeling methodologies for seismic hazard assessment: a study of potential site effects in the Lower Hutt Basin, New Zealand

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A new interpretation of the 3D geology of the Lower Hutt Valley Basin in New Zealand has been created for seismic hazard studies using 3D geological modeling methods. A model was created as part of the 2009/2010 'It's Our Fault' programme by combining data from 800 drillholes, geophysical profiles and geological mapping; synthesized using the Geological Surveying and Investigation (GSI3D) software program and workflow methodology developed by the British Geological Survey. The resulting model is presented in a seven-layer digital geological framework model. A key requirement of the 3D model for advanced site effect studies is accurate spatial representation of the 3D geology, particularly the sediment/bedrock interface, and representation of the active Wellington Fault scarp in the subsurface. The fault scarp was illustrated as a near-vertical northeast trending step in the bedrock. Correlation of Hutt Formation stratigraphic units between drillholes was based on comparison of marine and non-marine sequences with International Oxygen Isotope Stages. Analyses of geological, geotechnical and geophysical datasets through the modeling process provided valuable new insights into the geological and geotechnical characteristics of the Lower Hutt Valley Basin Quaternary sediments. An empirical relationship between shear-wave velocity and lithostratigraphy was developed through model visualization and geophysical measurements allowing characterization of the shear-wave velocity structure of the basin for use in advanced ground motion and liquefaction potential studies. The derived model data, geotechnical data and local expert knowledge have been combined in a GIS to create new applied geological maps for land use planning, which include: depth to bedrock, site period, Vs30, and Site Subsoil Class determined in accordance with the New Zealand Standard NZS 1170.5:2004. Importantly, the digital capture of three-dimensional geology enabled preliminary Site Subsoil Class determination for sites where detailed ground investigation data were not yet available. The study highlighted the importance of developing 3D geological framework models to inform seismic hazard zoning and land use planning worldwide.