Geologic and geomorphic influence on the spatial extent of lateral spreading in Christchurch, New Zealand

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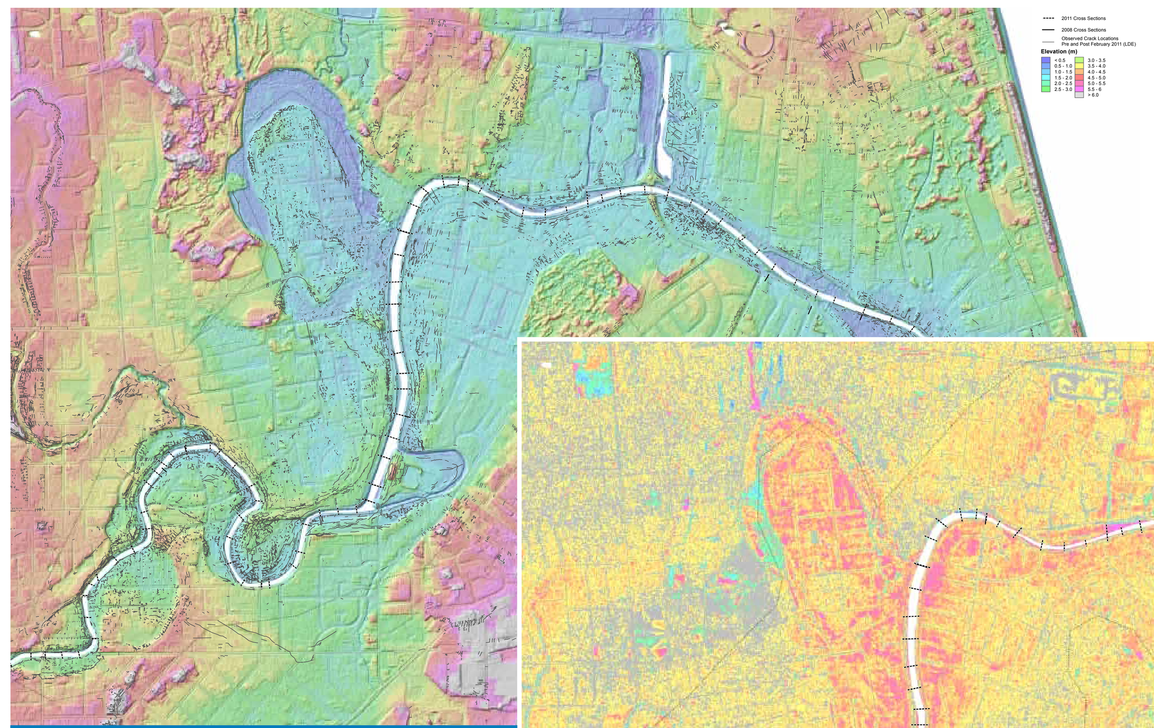
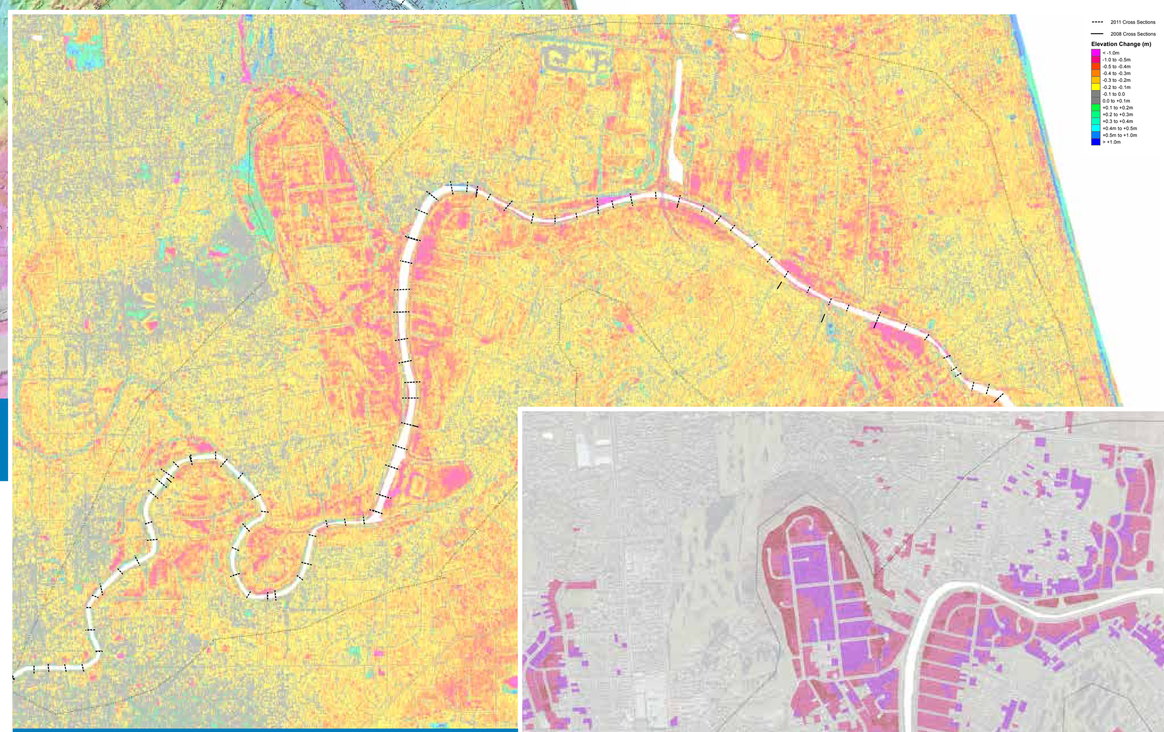
Background

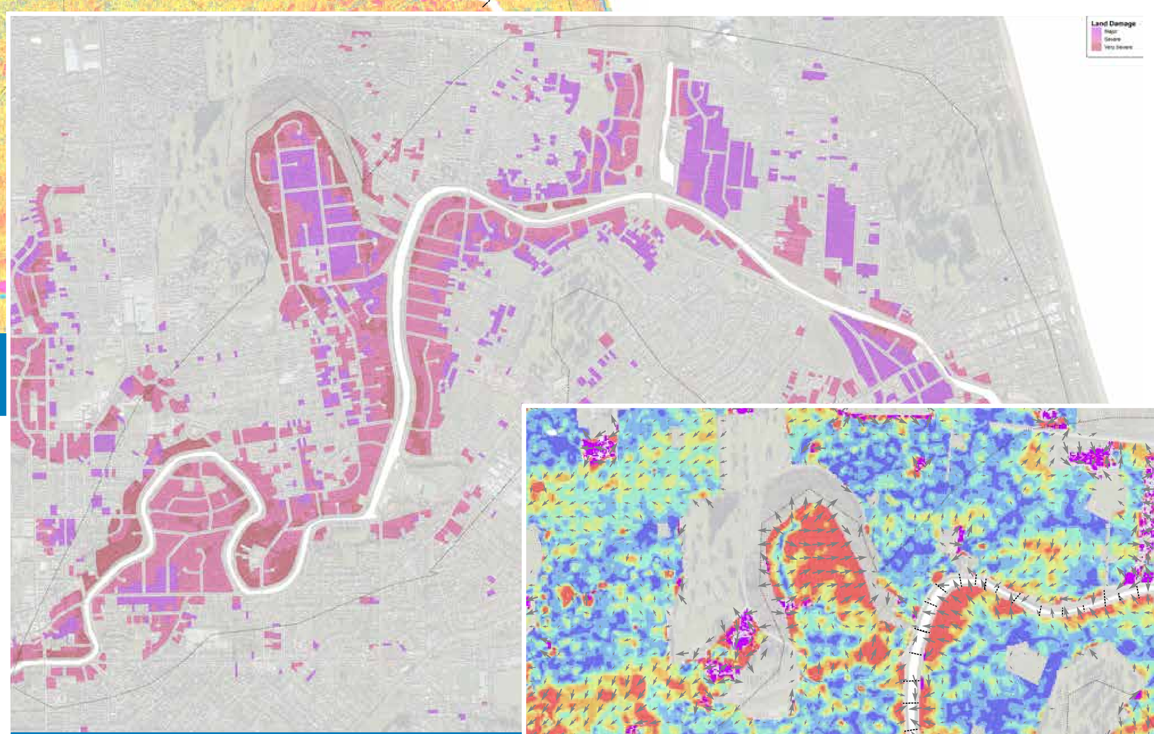
Liquefaction-induced lateral spreading during earthquakes poses a significant hazard to the built environment, as observed in Christchurch during the 2010 to 2011 Canterbury Earthquake Sequence (CES). It is critical that geotechnical earthquake engineers are able to adequately predict both the spatial extent of lateral spreads and magnitudes of associated ground movements for design purposes. Published empirical and semi-empirical models for predicting lateral spread displacements have been shown to vary by a factor of <0.5 to >2 from those measured in parts of Christchurch during CES. Comprehensive post-CES lateral spreading studies have clearly indicated that the spatial distribution of the horizontal displacements and extent of lateral spreading along the Avon River in eastern Christchurch were strongly influenced by geologic, stratigraphic and topographic features.



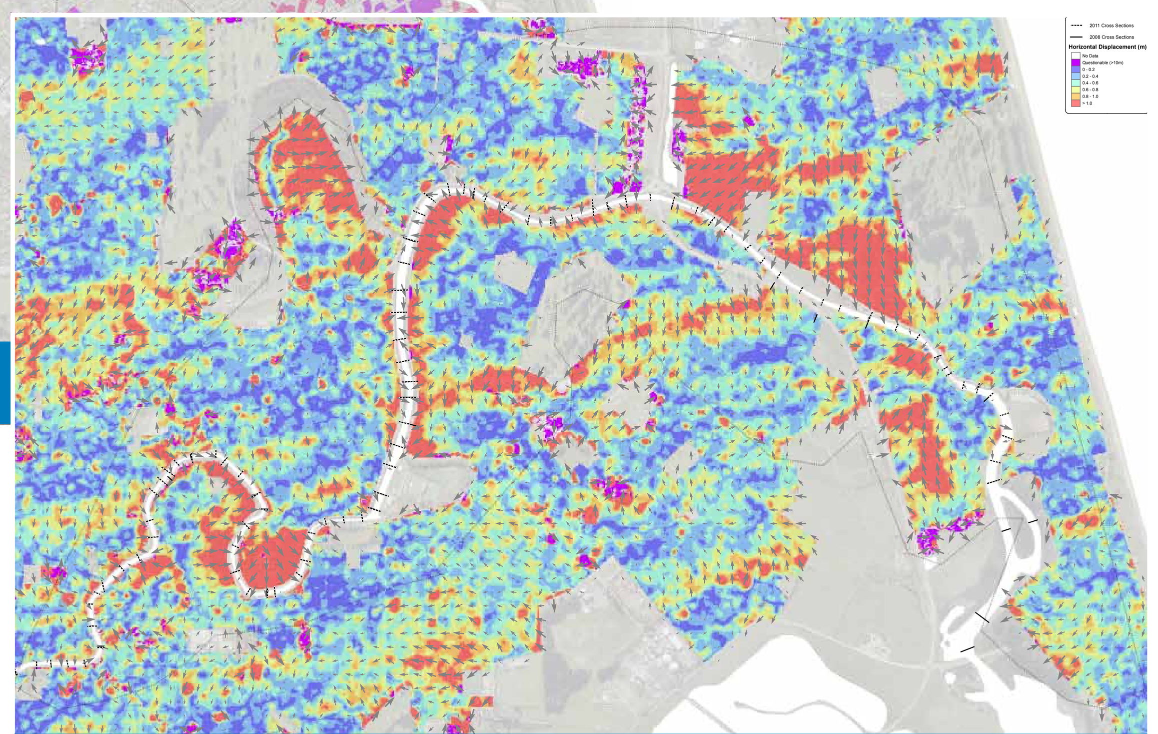
Mapped cracks



Liquefaction subsidence



Land damage observations



Horizontal movement - LiDAR

Background *(continued)*

These effects are not explicitly accounted for in the current predictive models and likely account for some of the discrepancy between predicted and measured spreading displacements. The objective of this study is to examine the combined influence of geologic and geomorphic features on both the spatial extent of lateral spreading and the magnitude of associated ground movement.

Datasets

Extensive LiDAR and satellite derived horizontal displacement datasets are available for Christchurch following the main CES earthquakes, including permanent ground displacements observed after the major CES events. These datasets provide an indication of the maximum extent of lateral spreading, the magnitude of horizontal displacements, and the direction of ground movement. However each dataset has inherent limitations including their spatial resolution, accuracy, and acquisition errors (i.e. flight line offset). Additional datasets indicating the maximum extent of lateral spreading include the summation of measured crack widths along transects from field surveys, LiDAR derived ground surface subsidence, documented land damage, and details of cracking features observed from post-event high resolution aerial photography.

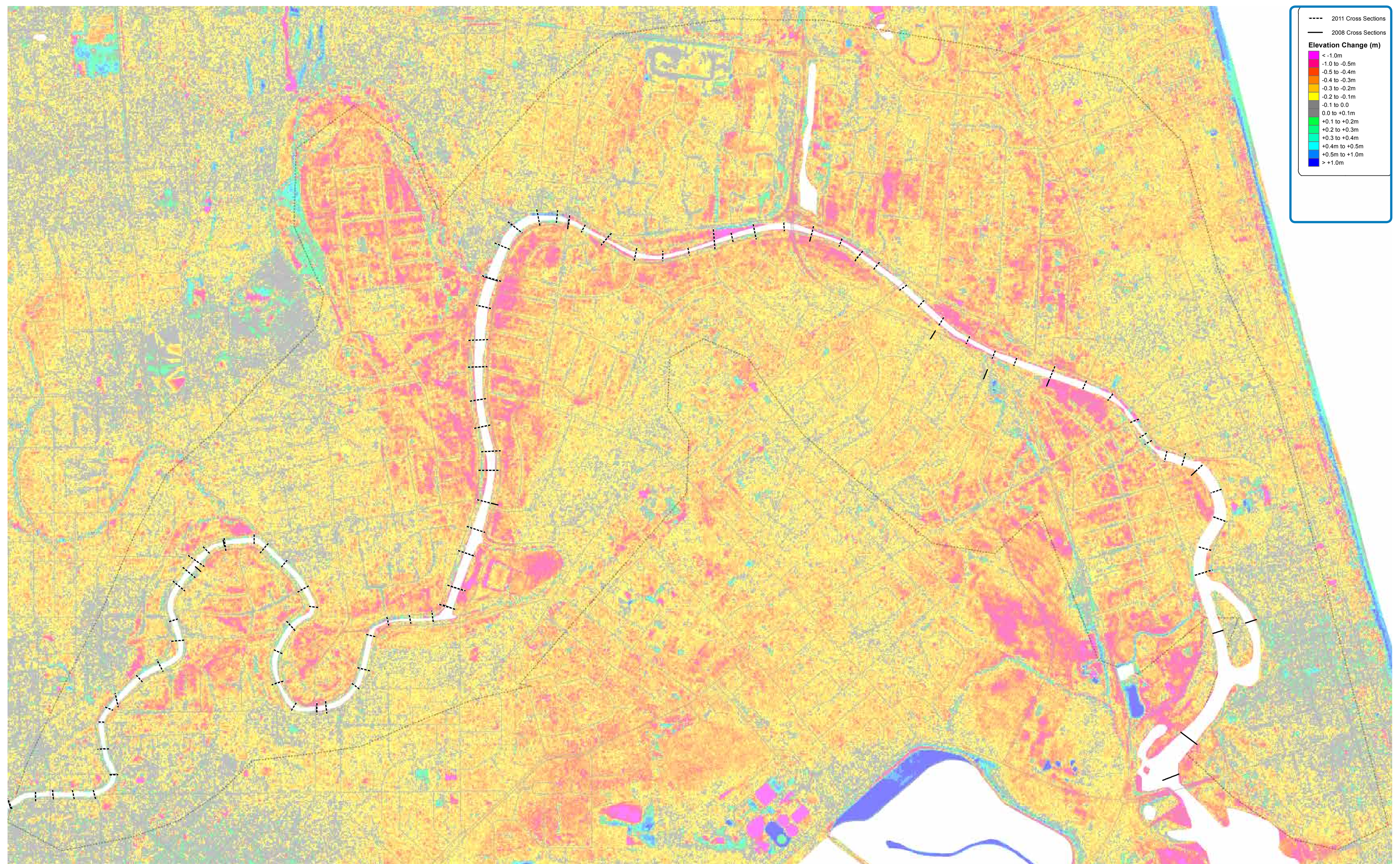
Analysis

Methodology and preliminary results

Using each of these datasets, the maximum extent of lateral spreading and the magnitude of maximum displacement was estimated along the Avon River. Relatively narrow zones of lateral spreading were identified along the Avon River ranging between 0 and 300 m inland with associated maximum horizontal movements ranging between 0 and 2.5 m. These zones of observed lateral spreads are spatially correlated with geologic and geomorphic maps to directly examine the influence of these factors on the extent and severity of lateral spreading. Detailed geotechnical characterization of the subsurface sediments will then be undertaken for each geologic and geomorphic area to identify characteristic soil profiles, prevalent soil types and stratification, and the thicknesses and lateral extent of critical layers.

Anticipated Outcomes

This study aims to combine geomorphic mapping and geotechnical characterization with lateral spreading extents in an effort to enhance engineering evaluation of lateral spreading, based on the exceptional datasets available from the CES.



Preliminary zero movement lines overlaid on a geomorphic map