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Applications of Geophysics, Rock Mechanics and Historical Perspectives for Reanalysis of the 1954 Windsor Subsidence Event

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Abstract

The search for a new crossing of the Detroit River between the highways of Ontario and Michigan led to three possible bridge location sites near a former salt solution mining site in Windsor, Ontario. Solution mining, beginning in the early 1900's using wells that were uncased across several of the Salina Formation salt beds, resulted in limited control of cavern development and a significant sinkhole in 1954. Given the uncertainties in cavern location and geometry, the question that had to be answered by the Canadian search team was "How close is too close?" The nature of the previously unknown dimensions of the solution-mined cavities when intact, remnant subsurface collapse features or voids, and the integrity of the surrounding rock mass were all uncertain. Multiple hypothetical explanations have been published related to upward propagation of the collapse, though little field evidence was available to support the suspected collapse mechanisms. To confirm whether or not the sites might be suitable for the new crossing, a study was undertaken that included twelve 500 m deep boreholes, surface seismic reflection surveys, down-hole geophysics, use of oil reservoir cross-hole seismic reflection survey techniques, development of a 3D geologic model, and distinct element rock mechanics modeling. This paper describes the methods and the results of this unique investigation that highlights the difficulty in defining cavern geometry once well access is lost, sheds new light on an enigmatic surface sinkhole arising from deep solution mining, and describes the techniques for exploring and evaluating unknown conditions near historic solution mining sites.

Key words: Sinkholes, Solution Mining and Salt History, Geophysics, Computer Modeling, Rock Mechanics, Bedded Salt Deposits.

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