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Water disposal induced seismicity in Alberta: requirements from Directive 065 and application of earthquake iso-nuisance and iso-damage mapping

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ABSTRACT

In recent times, there has been an increasing number of induced seismicity cases linked to wastewater disposal in Alberta. The seismic hazard has increased to such an extent that multiple earthquakes exceeding magnitude M>5 have been recorded, including events in the Peace River region (M = 5.59 in November 2022 and M = 5.09 in March 2023) and south of Grande Prairie (M = 5.08 in February 2025). To address the increased seismic hazard, the Alberta Energy Regulator (AER) updated Directive 065: Resources Applications for Oil and Gas Reservoirs, to include provisions for managing disposal-induced seismicity. Under the updated Directive 065, operators of disposal wells are required to conduct seismic hazard assessments before submitting an application. If a new disposal well is identified as potentially seismogenic through a seismic hazard assessment, or if an existing well is deemed seismogenic, the operator must conduct a seismic risk assessment and submit a Monitoring, Mitigation, and Response (MMR) plan that includes real-time seismic monitoring, event thresholds, and a traffic-light protocol (TLP). The TLP outlined in Directive 065 establishes three response levels (Green, Yellow, and Red-light) based on defined earthquake magnitude thresholds. Green-stage events require only routine monitoring, yellow-light events require notification to the AER and mitigation to reduce the magnitude and frequency of events, while red-light events require mitigation aimed toward seismicity cessation. A site-specific seismic risk assessment should inform the magnitude thresholds defined in the TLPs. As a guideline, the Alberta Geological Survey has developed earthquake iso-nuisance and iso-damage maps in Alberta. These maps show the earthquake magnitudes required at any given location to exceed a particular threshold of nuisance and damage, taking into account human exposure factors and surficial geological conditions. By defining an adequate trailing seismicity factor, which accounts for subsequent seismicity after a substantial change or end of the seismogenic operations, it is possible to derive examples of red-light threshold maps for hydraulic fracturing and disposal activities in Alberta. These maps represent the first step in defining the magnitude threshold for induced seismicity, enabling consistent tolerance levels throughout the province.