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Interpreting and Understanding Signatures of Measurements from Monitoring System at I&W Brine Cavern, Carlsbad, New Mexico

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Abstract

Being at risk of catastrophic collapse, the I&W Brine Cavern located within the city limits of Carlsbad, New Mexico, has been continuously monitored since 2009. Continuous monitoring is accomplished using instrument arrays measuring primarily brine cavern fluid pressure, ground tilt, and micro-seismicity. Ground water elevations, barometric pressure, precipitation, air and shallow ground temperature, and depth of water in an adjacent irrigation water delivery canal are also monitored. Monitoring results are internet accessible and are automatically communicated to selected personnel in a daily report. If preset alarm levels are exceeded, notifications to local authorities and selected personnel are made automatically. Collapse of the similarly designed and constructed Loco Hills and Jim's Water Services brine facilities north of Carlsbad in 2008 prompted closure and investigation of the I&W facility by 2008, and installation of pressure, ground tilt and weather monitoring instrumentation by 2009. In conjunction with subsurface site characterization, a micro-seismicity network was installed and became operational in 2014.

Interpreting and understanding of the monitoring results is a process that has developed over time. Alarm thresholds need to be sufficiently sensitive to trigger on potential real problems, but not trigger an inordinate number of false alarms. Since the initial top of the I&W cavern was set at the top of salt at a relatively shallow depth of 456 ft (139 m) below ground surface, daily and significant seasonal variations in measurements have been documented. Barometric pressure alone appears to generate a constant, yet not quite consistent, background response signal (noise) in the various pressure, groundwater level, and ground tilt measurements. Daily peak to peak barometric pressure changes of about 0.1 psi (0.7 kpa) correlate with similar magnitude daily shallow groundwater level changes, reduced magnitude deep groundwater level and cavern pressure changes, and daily tilt changes in some borehole tiltmeters of up to two micro-radians. The long-term measurement record at one tiltmeter includes an annual cyclic pattern magnitude of about 40 micro-radians. The irrigation canal is used seasonally; nearby tiltmeters respond significantly in a complex pattern as the canal fills and empties. Micro-seismic events are located in distinct patterns in the near vicinity of the cavern. Alarm levels must address these 'normal' measurements. A cavern entrance event to perform a sonar scan in 2010 provided a test case for the monitoring system; 16 psi (110 kpa) of brine pressure and about 8,100 ft^3 (229 m^3) of brine was lost at the wellhead, and tiltmeter deflections were quantified.

Three events with rapid loss of 0.2 to 0.5 psi (1.4 to 3.4 kpa) cavern pressure occurred in 2014 and 2015. These events were approximately located above or in the near vicinity of the cavern by the micro-seismic network. Possible change in the relationship of deep groundwater pressure to cavern pressure was noted after one of these events.

Key words: brine well, brine cavern, cavern collapse, instrumentation, tilt meters, micro-seismicity