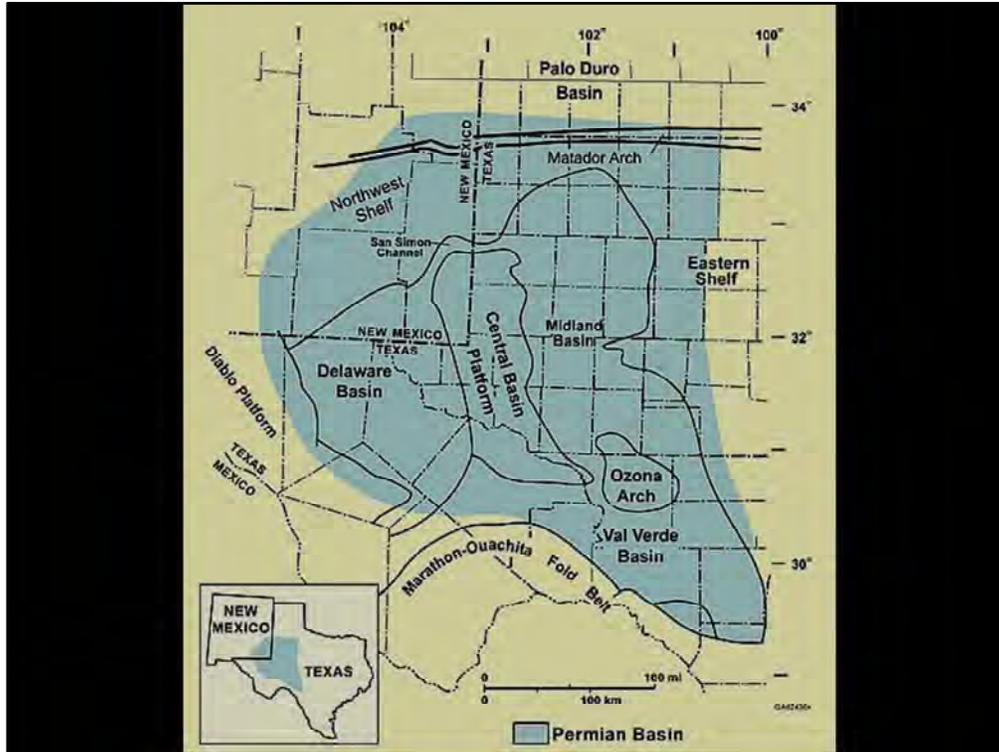




Carlsbad Brine Well Update

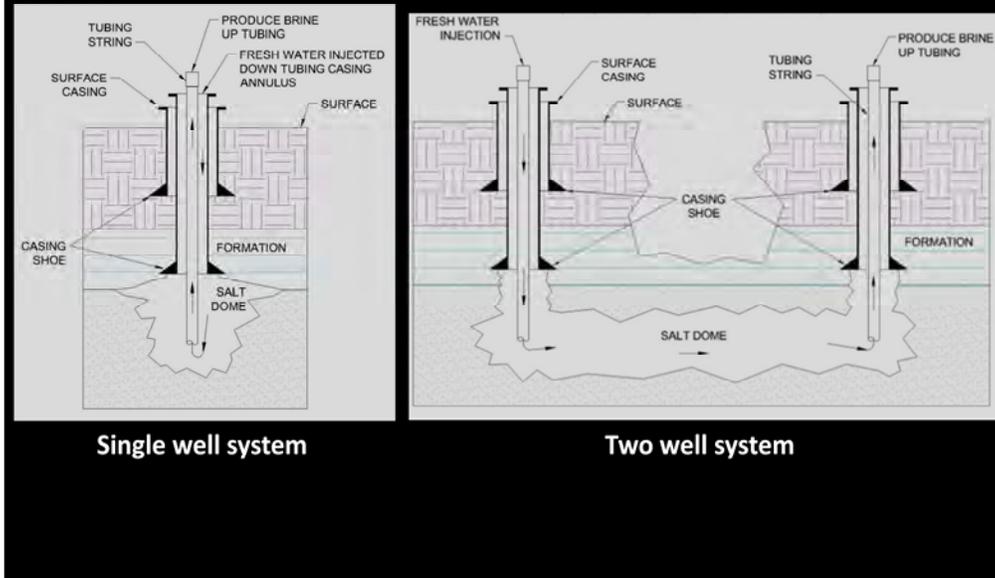
October 13, 2011



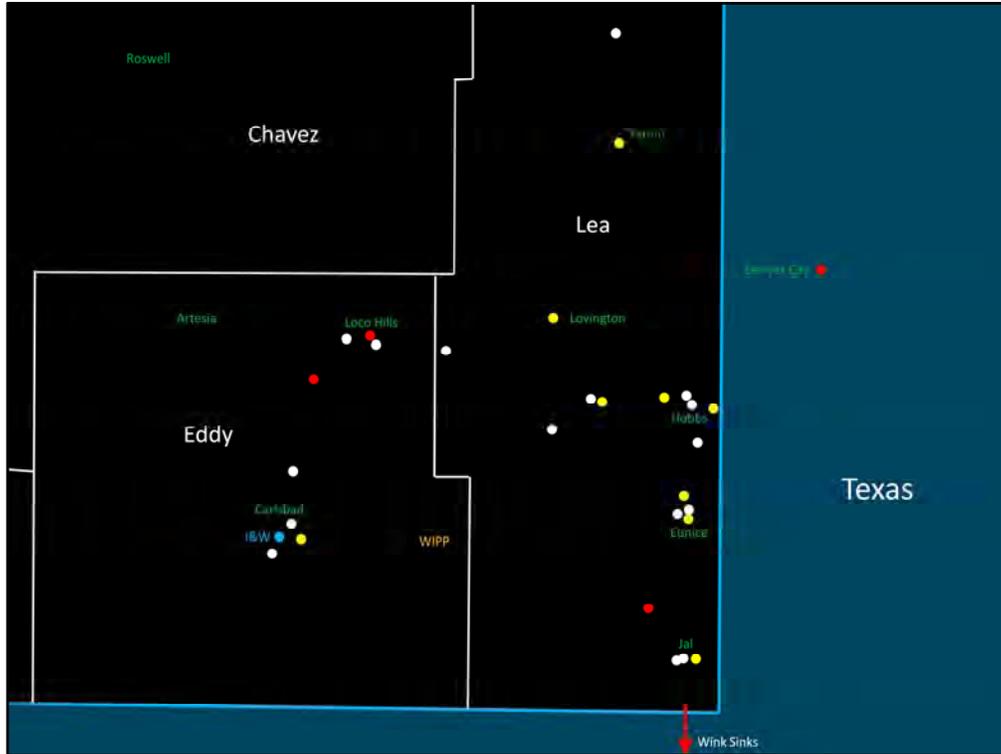


The Permian Basin (the area shaded in blue) spans southeast New Mexico into west Texas and is internationally known for its reserves of crude oil and natural gas. Overlying these valuable reserves are significant layers of salt left behind millions of years ago as an ancient ocean receded. That salt benefits us not only via potash mining, but is also the material providing for the safe disposal of the nation's defense-related transuranic waste at the Waste Isolation Pilot Plant. As one proceeds west-to-east across the basin, not only do the salt layers become thicker, the top of the salt is also deeper (shallowest and thinnest near Carlsbad, thicker and deeper near Hobbs). When drilling through the salt layers to extract the underlying oil and gas, drilling fluids need to be pre-saturated with salt to prevent washouts and ensure borehole integrity. As such, a source of brine (salt-laden water) is required. Brine is also used to mitigate existing downhole pressures during well workover operations due to its higher density.

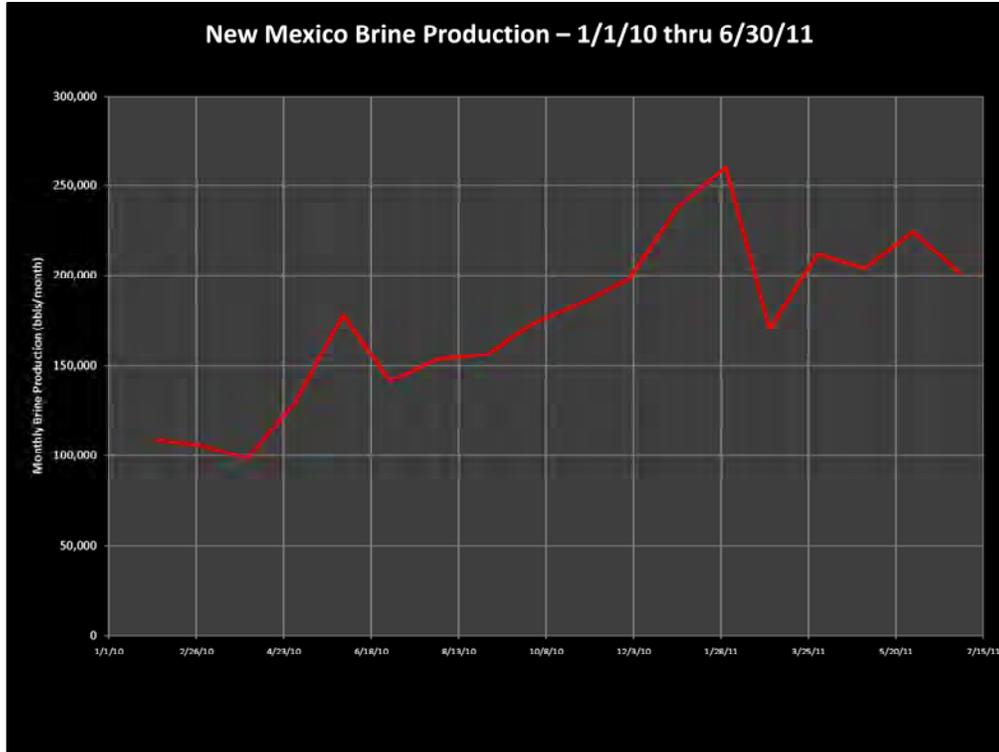
Brine well configurations



A “brine well” is a solution mining operation. Fresh water is introduced into the subsurface through a well casing or tubing, thereby dissolving the salt. The brine is then pumped out and trucked to wellsites for use.



There are a total of 32 historically permitted brine well operations in New Mexico associated with oil and gas development. The oldest of these wells date back to 1963. At present, there remain nine active brine facilities.



The market value of brine is relatively low (less than two dollars per barrel) and brine operations have almost exclusively been owned by trucking companies. Monthly statewide brine production for 2011 is exceeding 200,000 barrels per month.

Oversight of brine wells by the Oil Conservation Division is accomplished under provisions of the federal Underground Injection Control program and the New Mexico Water Quality Control Commission regulations. Both these enforcement mechanisms are primarily concerned with the protection of groundwater.

Factors Affecting Stability

Depth to Cavern

Width of Cavern

Strength of Roof Material

Percentage of Liquid in Cavern

Depth into Salt of Casing Shoe

Use of a "Blanket" Liquid

Production Flow Pattern

The solution mining of the salt results in an underground cavern. The stability of these caverns is dependent upon their depth, their width, the strength of the materials above the cavern, and the liquid within.

Since July of 2008, three large sinkholes associated with brine wells in the Permian Basin have catastrophically developed; two in New Mexico, and one in Texas. Both the sinkholes in New Mexico are at locations where the depth to the salt-bearing formation is less than 500 feet and more than five million barrels of brine were historically produced.



Jim's Water Service Brine Well Collapse

On July 16, 2008 the OCD received a phone call from a representative of Jim's Water Service of New Mexico (JWS) asking about the permitting process for a new brine well. During that conversation the OCD inquired as to the need for a new well as JWS already had an active brine well in Eddy County approximately 17 miles southeast of Artesia. Their initial response was to say they had "lost the well". After several more minutes of discussion, the OCD was informed that at approximately 8:15 that morning during a routine inspection an employee was approaching the well when he observed a significant amount of dust. He stopped, got out of his truck, and immediately noticed severe ground movement and a crack propagating toward him. Within minutes he observed a sinkhole centered on the former location of the wellhead.



Jim's Water Service Brine Well Collapse - July 16, 2008. The sinkhole contains brine that migrated upward from the cavern as the roof and overburden moved down. There is no significant groundwater in this area.



Jim's Water Service Brine Well - July 25, 2008; nine days after collapse. Brine has begun to drain into the surrounding soil and the sidewalls are eroding to a natural angle of repose.



Jim's Water Service Brine Well Collapse -This sinkhole has since grown to a diameter of about 400 feet with a depth greater than 100 feet. Numerous concentric surface cracks appeared immediately after the collapse and identified as far as 300 feet away from the sinkhole's edges.



Jim's Water Service Brine Well Collapse –These cracks can be more than 80 feet in length, more than one foot in width, and of an unverified depth.



Jim's Water Service Brine Well Collapse – Cracks nine months after collapse. This picture was taken on the northeast side of the sinkhole approximately 60 feet from the edge. The central block has fallen about two feet vertically.

The site is located on State Trust land otherwise used for grazing. The area was fenced by JWS and is monitored to see if subsidence is adversely affecting the adjacent roadway (NM 217). This brine well first came into production in March 1979 under the ownership of Permian Brine Sales. The well was constructed by re-entering a former oil well. Depth to salt in the area is 397 feet below surface. Production records are incomplete, but an estimate of total brine production is in excess of 5 million barrels resulting in a mined cavern greater than 750,000 barrels in volume.

On July 23rd, 2008, then EMNRD Cabinet Secretary Joanna Prukop requested a state-wide review of all brine wells including an internal OCD audit and daily well inspections by all operators of active facilities. What precipitated the cavern collapse at the JWS facility is not definitively known. Based on the diameter of the surface hole, the subsurface cavern was at least 300 feet across. Thus, the ratio of cavern diameter to overburden thickness is $300/397$ or 0.76. A general "rule of thumb" in rock mechanics and solution mining says that caverns appear to be stable if this ratio is less than 0.67 (two-thirds).



Loco Hills Water Disposal Co. Brine Well Collapse

In June of 2008, a brine well failed a casing integrity test located at the Loco Hills Water Disposal facility immediately north of the town of Loco Hills, in Eddy County east of Artesia (also on State Trust land). The well was thereafter plugged. This brine well had been in operation since late-1985, depth to salt in the area is 470 feet, and produced approximately 8 million barrels of brine throughout its lifetime. This would have resulted in a cavern nearly 1.2 million barrels in volume.

On November 3rd, 2008 as one of the owners of the Loco Hills facility was returning from lunch, he saw what he thought was a dust devil in the vicinity of the plugged brine well. As he got closer he noticed the dust particles were not swirling, but rather traveling vertically. The brine cavern was collapsing.



Loco Hills Water Disposal Co. Brine Well Collapse

This picture was taken during the evening of November 3rd, 2008.

On November 14th, 2008 the Cabinet Secretary placed a six month moratorium on new brine well permits in geologically sensitive areas and tasked the OCD with continuing its investigation of the brine well collapses and providing recommendations for the future. As part of that effort, a working group was established with members of state regulatory agencies beyond New Mexico, the EPA, the DOE, Sandia Labs, WIPP, the solution mining industry, and oil & gas service companies.



Loco Hills Water Disposal Co. Brine Well Collapse – 15 days after collapse, and still growing eventually to over 300 feet in diameter.



Loco Hills Water Disposal Co. Brine Well Collapse – Cracks formed in outlying areas as also occurred at the JWS sinkhole. These cracks immediately decimated the adjacent public roadway and eventually placed future operation of the disposal facility at risk.



Loco Hills Water Disposal Co. Brine Well Collapse – This crack broke a 4-inch thick reinforced concrete slab.



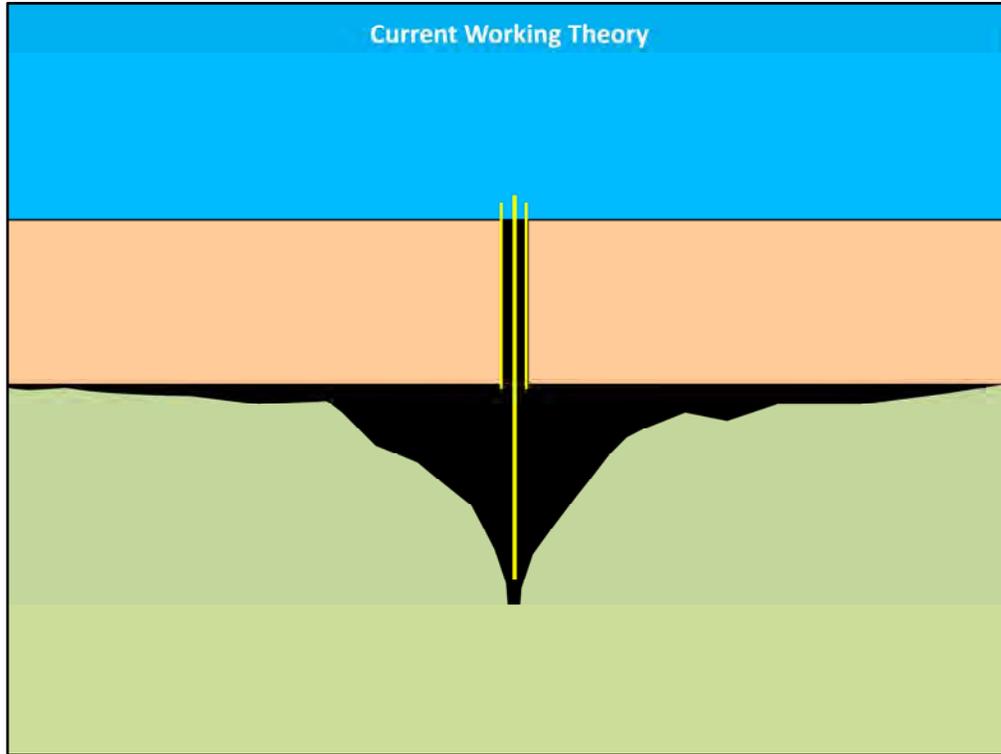
Loco Hills Water Disposal Co. Brine Well Collapse – Due to the continued risk to operations at the water disposal facility in Loco Hills, the operator decided to backfill the sinkhole. This endeavor took several months to complete and cost approximately \$1.3 million. Based on sonar logging of the brine cavern undertaken in February of 2001, the maximum cavern diameter was 310 feet. This placed the ratio of diameter to overburden thickness at $310/470$ or 0.66, right at the “rule of thumb” limit discussed previously.



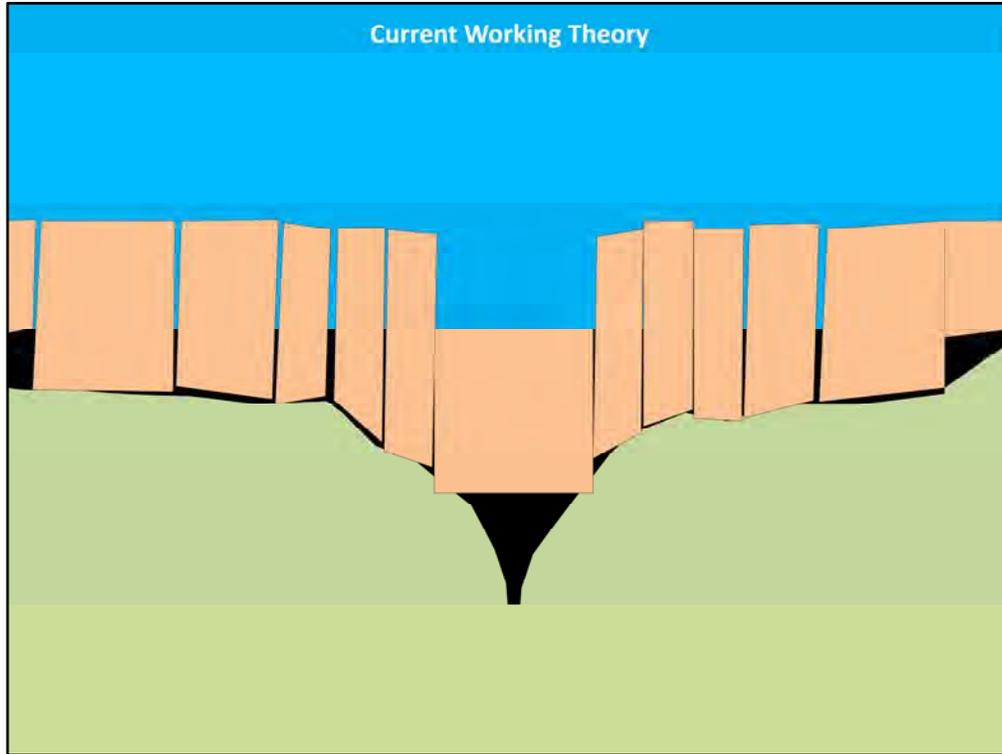
Denver City, Texas Brine Well Collapse

On July 27th, 2009 just over one year after the JWS brine well collapse, another sinkhole associated with brine production appeared overnight in the Permian Basin. This time just east of Denver City, Texas in Yoakum County about 15 miles from the Texas/New Mexico border.

This brine well came into production in 1974 but was completed as a re-entry into an oil and gas well originally drilled in 1958 and mined salt from the same geologic salt formation (Salado) as all brine wells in New Mexico. The depth to this formation in that area is approximately 2,150 feet. Complete information on the well and associated activities is not yet available but the well did experience a casing failure at a depth of 700 feet in 1997 and began venting an estimated 25,000 cubic feet per day of natural gas. The gas was allowed to vent and was flared in hopes of depleting the gas zone, which never occurred. Solution mining of salt continued in the immediate area via adjacent brine wells. An estimate of cavern volume by the Texas Railroad Commission is approximately 885,000 barrels.



OCD's current working hypothesis is that due to historic setting of the casing shoe at or very near the salt/overburden contact, along with the federal requirement for fresh water injection thru the annular space, has resulted in laterally large solution caverns with deeper central cores in the area of the production tubing. This geometry is a recipe for structural failure and subsidence.



Consequently, when catastrophic failure occurs a deep sinkhole is formed in the immediate area of the well where the cavern height is greater, but the observed concentric fractures are indicative of broader roof collapse in those areas where the cavern height is substantially less.

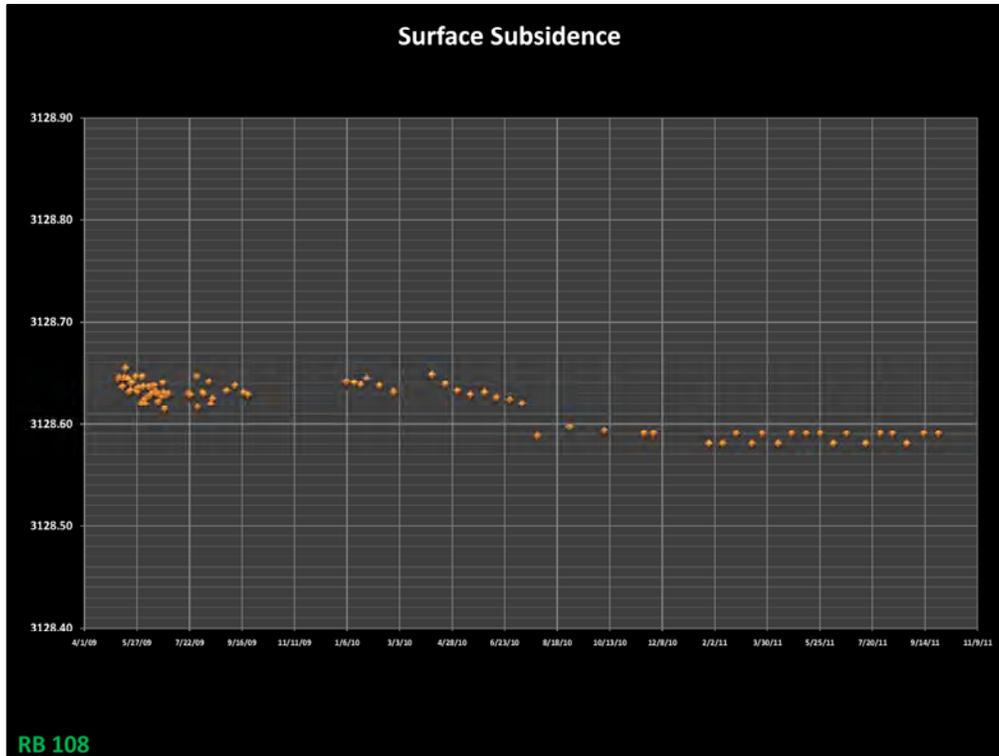


I&W, Inc. Brine Well in Carlsbad

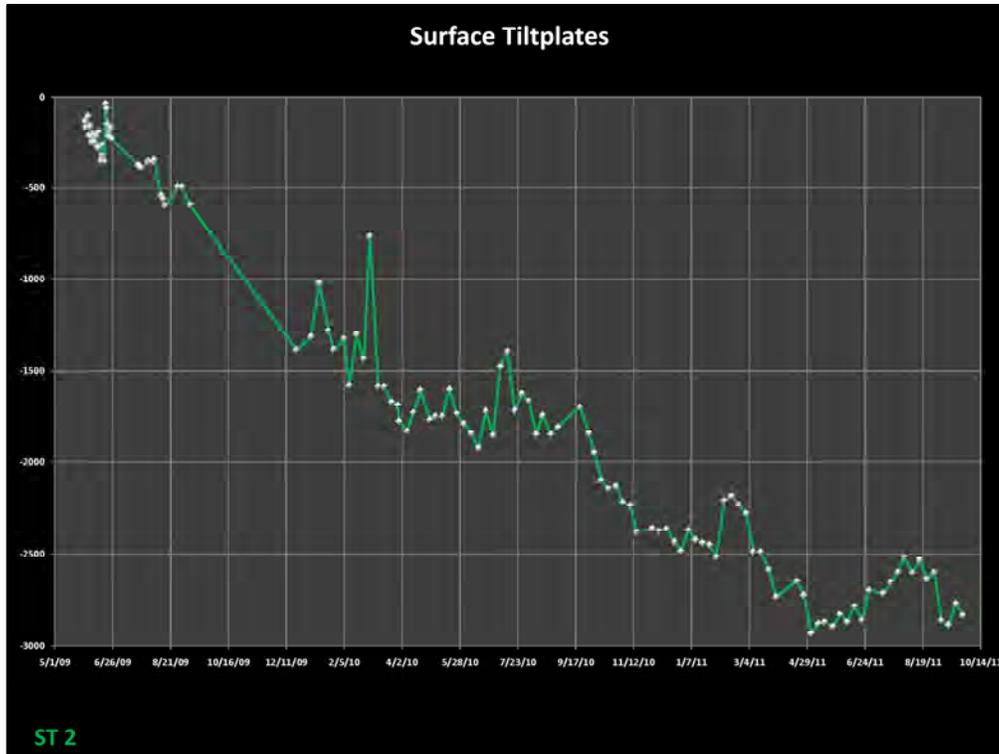
Within days of the first brine well collapse at the JWS facility southeast of Artesia in July 2008 division personnel became concerned about an oilfield trucking operation in Carlsbad owned by I&W, Inc. which included an active brine well of similar depth and production history. This facility is located amidst two major roadways, a vital irrigation canal, a trailer park, a church, a feed store, an agricultural dry goods facility, a truck stop, and a railway servicing the potash industry.

On July 22, 2008 brine production from the remaining operational well was terminated at OCD's direction and the well was plugged in October of that year. On March 11, 2009 OCD recommended the operator consider shutting down remaining operations and submit contingency planning for a possible collapse including discussions with their neighbors. On March 26th and 27th of 2009, a gathering of the brine well working group was held in Santa Fe to discuss overall brine well safety during which a consensus developed that the brine cavern in Carlsbad had a high probability for collapse.

Beginning in April of 2009, the division briefed emergency response organizations, local government, the Departments of Transportation, Public Safety, and the Environment, along with the public about the situation on numerous occasions.



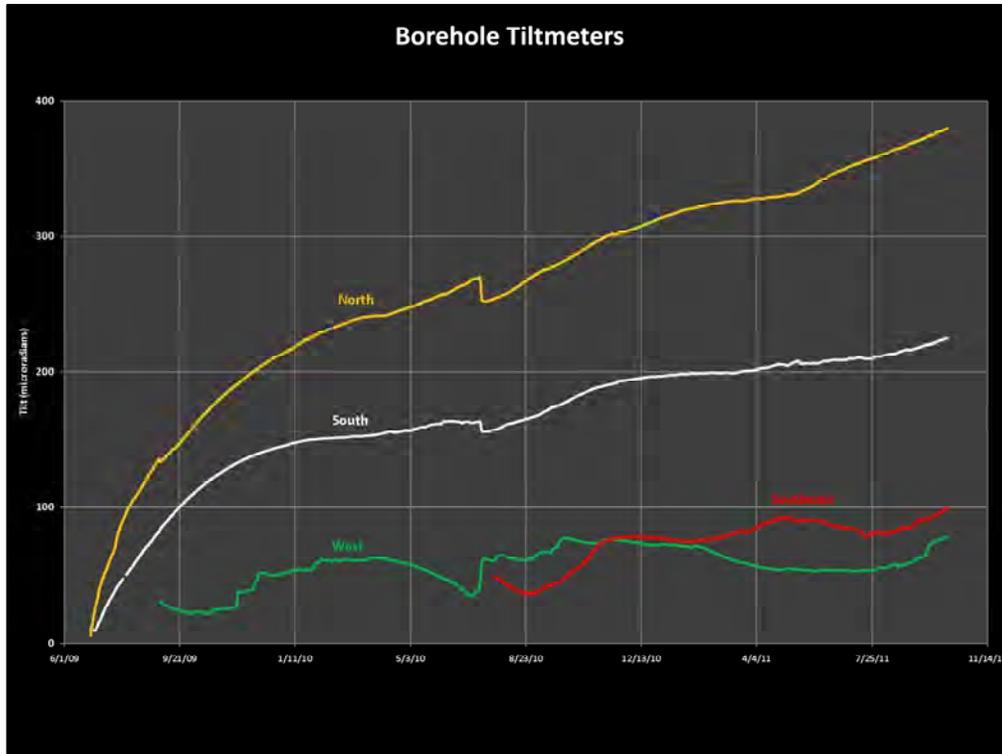
OCD also contracted with a knowledgeable engineering firm to undertake characterization of the brine cavern and install an automated system to detect ground movement. The graph above provides historic surface survey data for one of 71 benchmarks established atop the presumed brine cavern and surveyed on a regular basis. This particular location is above the center of the cavern and has subsided about three-quarters of an inch over the past two years. Approximately half that subsidence occurred during July of 2010 when less than one percent of the brine was allowed to flow from the cavern during a re-entry procedure.



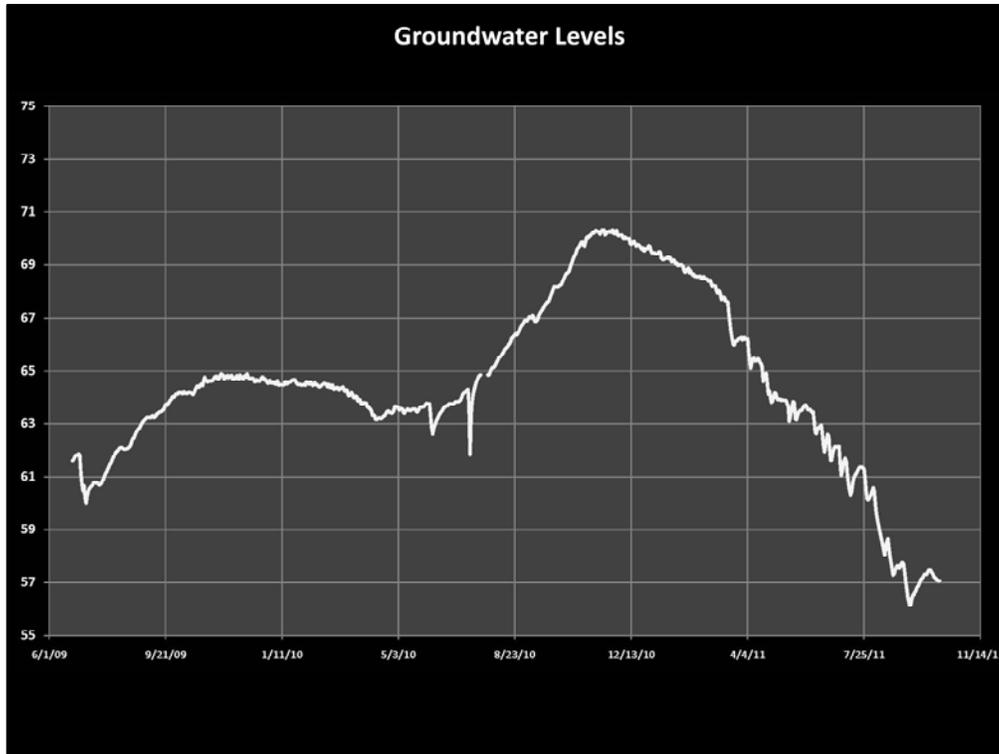
A group of X surface tiltplates were also installed in the area. The graph above presents data from one such plate located within a highway median along US 285 northeast of the I&W facility. The measured displacement indicates a change in tilt of not quite one-quarter of one degree.



The early warning system became operational on June 23, 2009 and consists of four borehole tiltmeters, two pressure transducers monitoring groundwater levels, and two pressure transducers monitoring brine cavern pressure. Data is logged from all sensors every minute, uploaded to an offsite server every five minutes, and automatically checked against preset alarm levels. If an alarm condition is observed, the system digitally alerts the Eddy County Emergency Response infrastructure and the OCD.



Data from the borehole tiltmeters has shown almost continual ground movement since July of 2009. The rate of movement accelerates during the irrigation season due to losses of water from the unlined canal. The distinct movement recorded in July of 2010 on 3 of the four meters is associated with brine flow from the cavern during re-entry for sonar logging.



Groundwater levels in the aquifer situated several hundred feet above the brine cavern vary based on precipitation, regional pumping, and canal losses. If the brine cavern were to fail, upward movement of brine into this freshwater aquifer would render a large amount of the groundwater unusable.



In August of 2009, a two-dimensional seismic reflection survey was completed to determine the lateral extents of the cavern.



The area shaded in yellow represents an interpretation of the seismic data which likely indicates brine cavern heights in excess of 25 feet. The area shaded in red is indicative of the salt being completely removed.

In September 2009 as part of the legislature's efforts to close the State's budget gap, the unencumbered balance of OCD's Reclamation Fund was swept. Thereafter, a local technical committee was established in November of 2009 by the City of Carlsbad and Eddy County tasked with developing a means of mitigating a cavern collapse. Funding for this effort relied on local monies.

In December of 2009 the owners of the neighboring feedstore filed a civil suit against I&W for loss of property and business value. In January 2010 the OCD issued a Compliance Order to I&W seeking reimbursement of State expenses and a fine for violations of their operating permit and the Water Quality Act. At the same time the City of Carlsbad filed suit against I&W to compel the firm to pay for ongoing and future characterization, monitoring, and reclamation efforts. On March 9th, 2010 Governor Richardson signed legislation to enact an additional conditional severance on crude oil to enhance the OCD's ability to properly deal with such matters. On May 9th, 2010 I&W filed for bankruptcy protection.



Re-entry of one of the brine wells for purposes of sonar logging was attempted by contractors for the city during July and September of 2010. This is a photo of the Eugenie #1 well with the P&A marker removed and a small pit excavated around the wellhead.



A bradenhead flange was then welded to the casing.



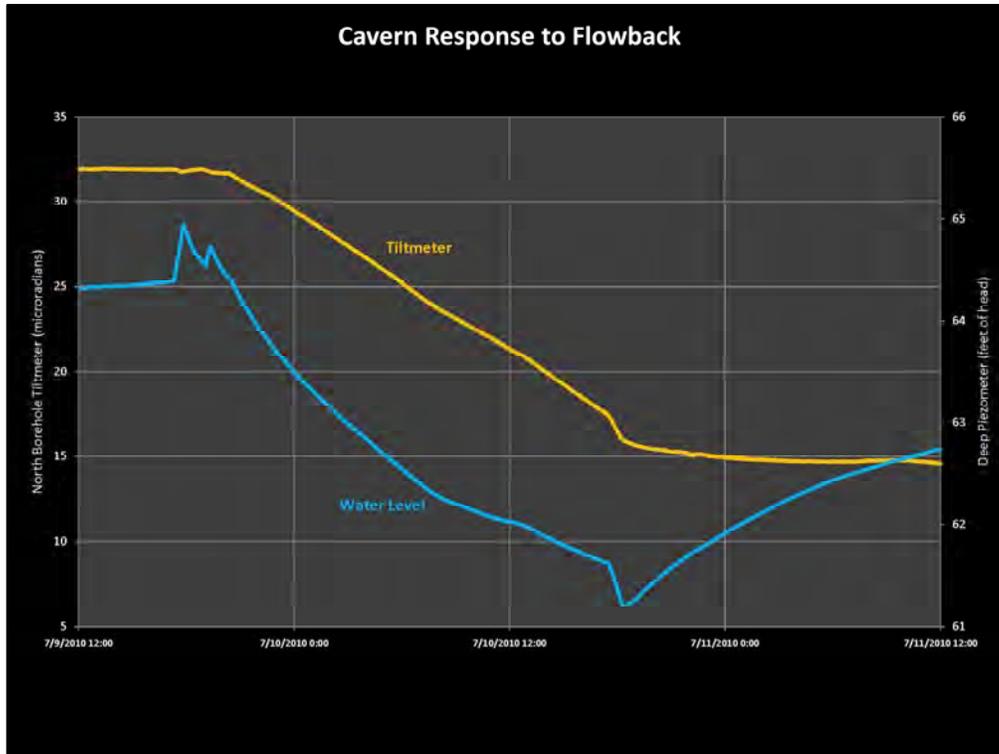
A blowout preventer was fastened to the bradenhead flange.



The previously cemented well casing was then drilled out using a coiled tubing system to prevent excessive weight being placed on the potentially fragile wellbore. Drilling thru the cement and cast iron bridge plug only took a few hours.



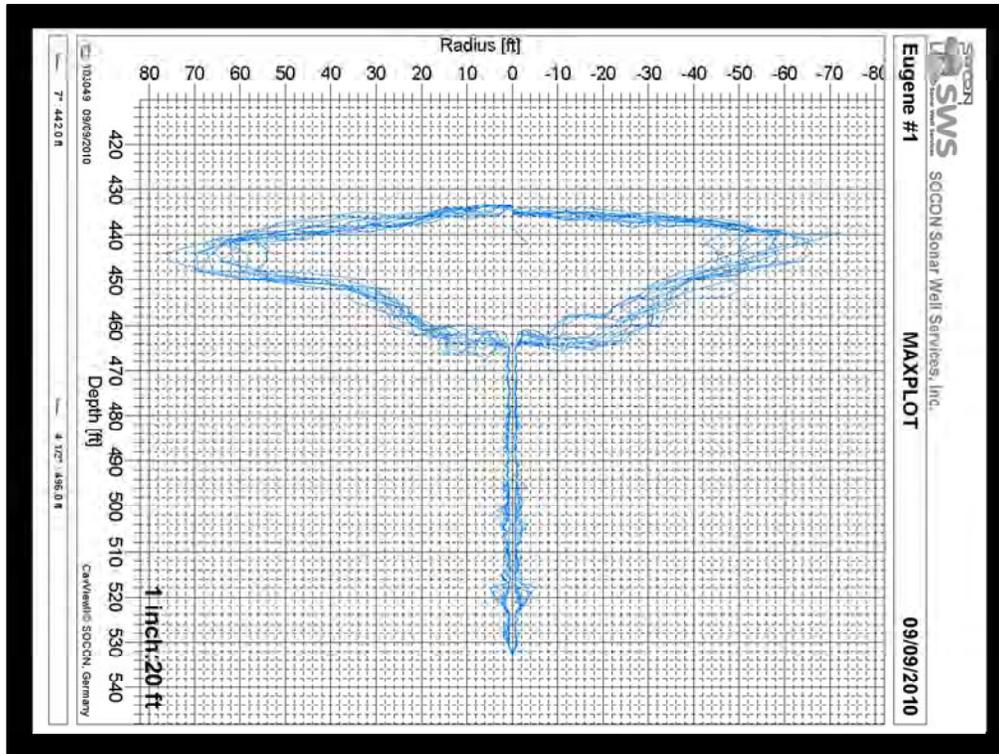
Once the cement and plug had been drilled out, the well was allowed to flow back brine thru the bradenhead and choke lines into on-site tanks while the upper cavern was logged using a sonar tool. This photograph shows the logging crew assembling a lubricator and the downhole sonar equipment prior to logging.



During the period in which brine was allowed to leave the cavern the borehole tiltmeters indicated ground movement and even the deeper water levels showed a response presumably due to an elastoporosity response in the overburden above the brine cavern. When the rate of flowback was temporarily increased, the earth movement and groundwater decline increased as well. When flow from the cavern was terminated, the ground immediately ceased moving and the water level began to return to its original state. This data is strongly indicative of an unstable cavern roof and the presence of brine within the cavern is likely the only remaining support.



With a desire to still sonar log the cavern, the effort was put off until September of 2010 when a snubbing unit could be deployed to prevent loss of brine.



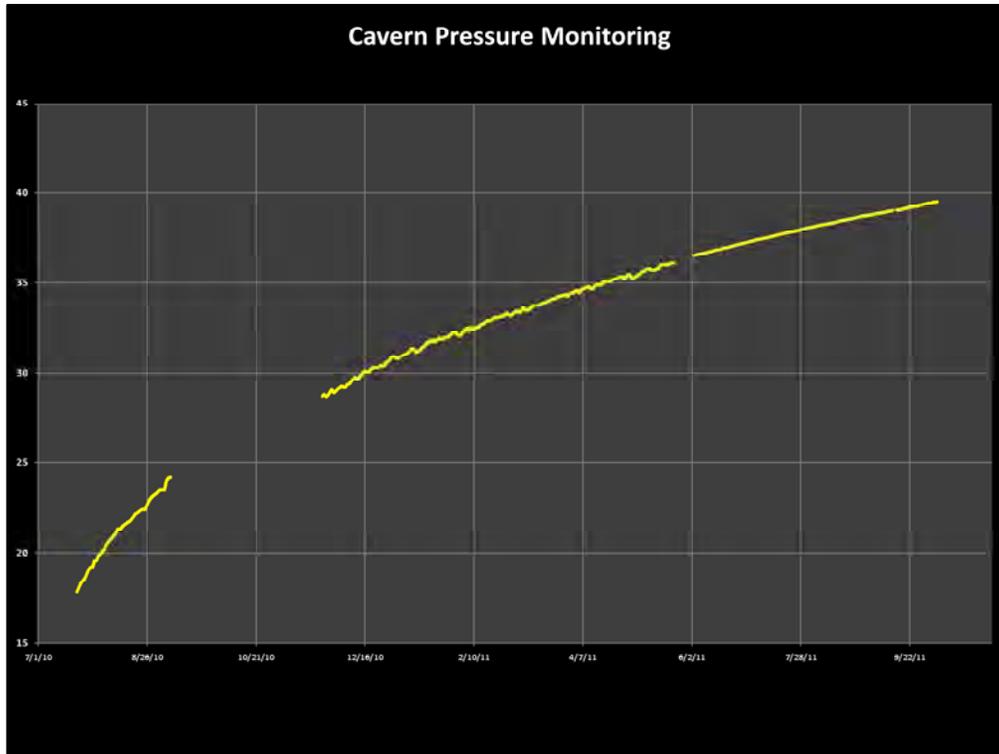
Those efforts did not yield a sonar picture of the larger cavern as had been hoped. A relatively small upper cavern was imaged, but what is most likely a rubble pile of broken material was observed at greater depth. Furthermore, those efforts in large part depleted available funding from the City of Carlsbad.



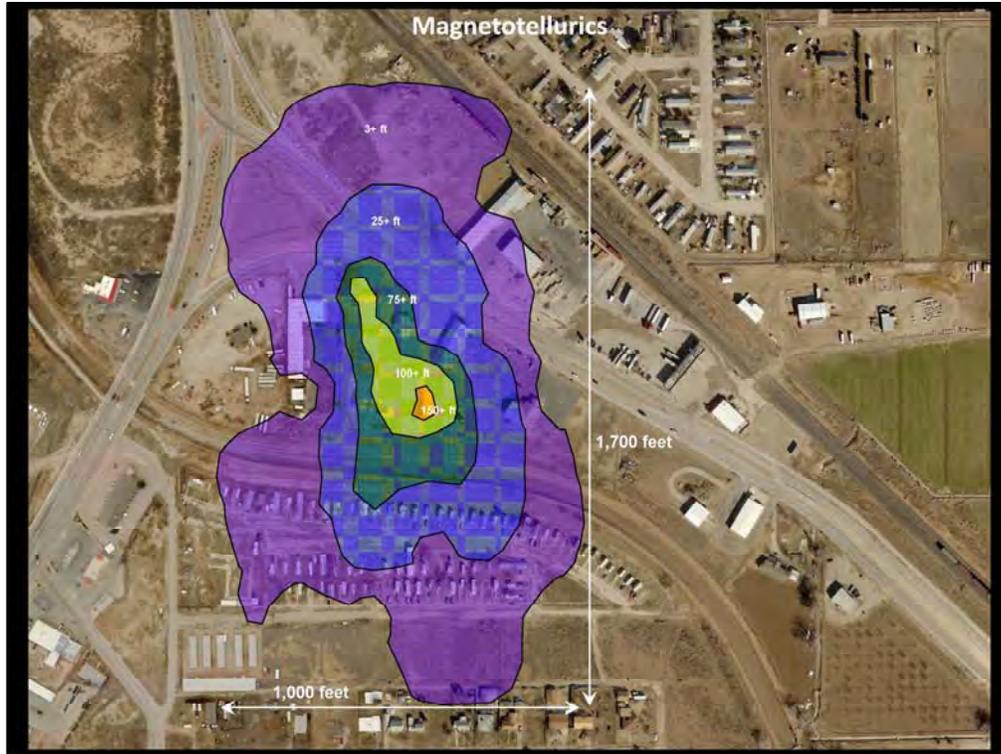
The image above provides the sonar footprint of the upper cavern (in white) overlain upon the seismic interpretation previously presented.



A master valve was fitted to the wellhead and integrated with pressure transducers to gauge the cavern pressure as part of the early warning system.



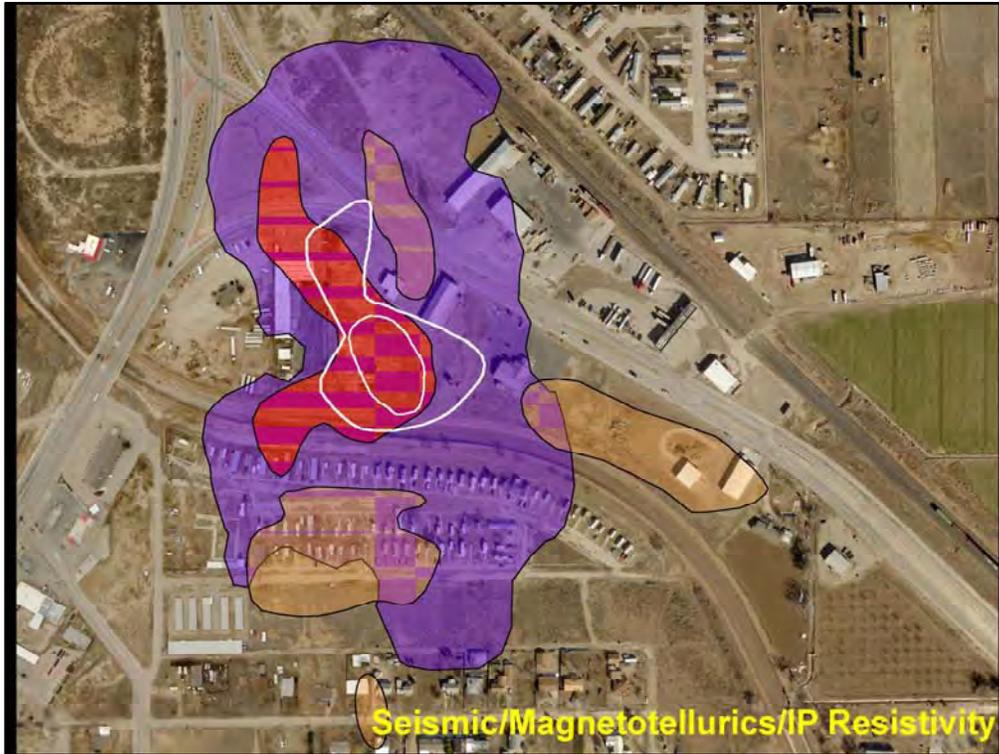
That pressure data shows a continuous climb in cavern pressure which indicates the cavern is hydraulically “tight” at present, but the observed increase could also be indicative of thermal instability, salt creep, and downward overburden movement.



The OCD resumed fiscal and technical oversight of the characterization and early warning efforts in the winter of 2010 supported by the Reclamation Fund. Additional geophysical techniques have been used including digital magnetotelluric imaging. The image presented provides an overlay of the inferred cavern footprint atop an aerial photograph of the area. The area in purple defines disturbed salt and overburden thickness of at least three feet. The area in blue 25 feet. The dark green 75 feet. The lime green 100 feet and the orange greater than 150 feet in disturbed thickness. The potentially impacted zone spans about 1,700 feet North to South and 1,000 feet East to West.



The National Cave & Karst Research Institute in Carlsbad was contracted by the OCD to undertake an induced polarization resistivity survey of the subsurface in the area and those results are partially presented above. The area shaded in red indicates low resistivity (brine) which is likely associated with the cavern. The areas shaded in orange represent low resistivity (brine and/or fresh groundwater) within the overburden.



This image provides a combination of the seismic, magnetotelluric, and resistivity profiles. It may not look like it, but there is reasonable agreement between the techniques from a remote geophysical point of view.

Path Forward

Magnetotelluric Survey on Tightened Spacing

Coring Program

Re-interpretation of Existing Seismic Data
(new synthetic)

Continued Monitoring and Upgrade of Early
Warning System

Feasibility Study