BW - __999__

DRAFT
BRINE WELL STRATEGY
TALKING POINTS

BRINE WELL WORK GROUP

3/26/09 - Present

New Mexico Oil Conservation Division
UIC Class III Brine Well Strategy

INTRODUCTION

The New Mexico Oil Conservation Division (OCD) developed this brine well strategy subsequent to two brine well collapses that occurred in July of 2008 (Jims Water Service) about 14 miles SE of Artesia, and another one (Loco Hills) that occurred in November of 2008 about 25 miles east of Artesia. They were isolated incidents and there were no injuries. The county road near Loco Hills was impacted, while the county road near Jims Water Service is threatened.

The OCD recognizes based on the age of production from a majority of permitted brine wells that a BW Strategy is needed going forward. Consequently, the OCD incorporated many of the brine work group member agenda recommendations and thoughts into this draft brine well strategy document, which may serve as topics to facilitate brainstorming. It is hoped that the work group may formulate solutions and ideas based on what happened, why it may have happened, and what the OCD may start doing now and in the future to prevent salt formation collapses and protect public health and safety. It is hoped that other states with EPA UIC Class II HC Storage and Class III Brine Well programs may learn from New Mexico. ***The OCD intends to update this document throughout the brine group process and use it as a brainstorming tool to flesh out thoughts and ideas from the brine well work group for the report to the Oil Conservation Commission due May 1, 2009. Therefore, Work Group Members are encouraged to continue sending in your thoughts and ideas at any time throughout this process.***

GENERAL

1. According to Wayne Price (OCD), the BLM, NMED and OCD agreed several years ago (early 1980s) that injecting fresh water down the annulus and extracting 10# brine from the tubing was most protective of USDW in the event of a leak. There is no EPA Guidance recommending or requiring fresh water to be injected down the annulus. Brine could be produced through the annual as brine wells are constructed with steel casing that is tested for leaks and cement is placed between the borehole and steel casing to protect any USDW.

2. Injecting fresh water down the annulus of brine wells with casing shoes set at the top of the salt formation as observed in New Mexico results in aggressive dissolution of the salt laterally outward expanding the top of cavern roof outward at the contact between rock and top of salt formations. The work group recommends reversal of flow to inject fresh water down the tubing and extract brine from the annulus. UIC Class III brine wells are designed with steel and cement to prevent impacts to the USDW. This is recommended at operating brine wells regardless of knowing the size of the cavern roof at this time,

until sonar work or other investigation methods determine the size and configuration of operational brine wells.

3. The present configuration of OCD brine well salt caverns looks like an upside down Christmas tree based on fresh water injection through the annulus. Injection of fresh water down the annulus would not be of as much concern if the casing shoes of brine wells had been set 50 to 100 feet into the salt. However, two-well brine well systems are preferred to single well systems by the work group. The injection of fresh water down the annulus results in a broader roof cavern configuration, while injection of brine results in a preferred arched roof design or roof with a "back".

4. The majority of OCD brine wells are 25 to 30 years old and were never permitted under the current WQCC Underground Injection Control Regulations. Many were initially designed for oil and gas exploration and production, and later converted into brine wells regardless of the depth and setting of the casing shoe. Unless existing oil and gas wells are seated 100 feet into the salt, they should not be approved for conversion into a brine well.

APPLICATIONS

1. The C-108 Form used for brine wells does not have a check-off for brine extraction facilities and other pertinent criteria as specified in the WQCC Regulations. Needs to be amended to include Class III information or the unnumbered form for brine extraction facilities needs to be amended.

2. The unnumbered "Discharge Plan for Brine Extraction Facilities" form is too generic and should include more questions commensurate with WQCC Regulations for a UIC Class III brine well application. Does there need to be a separate C-108 Form that needs to be filled out?

DISCHARGE PERMIT

1. The permit does not have a definitive date for sonar testing or calculations based on brine production to ensure cavern size is assessed by the OCD.

2. The permit does not have language for determining when a salt cavern is at maturity and in need of PA. The work group indicated that the OCD may not want to PA brine wells, but continue to keep them full of brine water and to monitor fluid level on a regular basis to assess possible roof collapse anomalies?

3. The permits are renewed every 5-yrs. and this would be the time for the OCD to assess the maturity of a brine well or system.

4. Discharge permits may not be followed as in the case of BW-021 where a well was being fractured nearby the brine well. There is a concern if brine fluid in the cavern escapes resulting in a potential collapse of the cavern, and even though the permit requires

notification to the OCD when wells are drilled within the Area of Review (AOR), this was not followed by the owner/operator of the brine well. There are also concerns about Class II hydrocarbon storage wells and AOR as water floods and nearby wells could encounter gas and result in an explosion or public health concern.

REGULATIONS

1. Kansas has a 10-yr. life expectancy for its brine wells with option to renew the permit at that time.

2. Kansas and Texas appear to incorporate Federal EPA UIC Regulations into their state regulations. Could NM do this too? Currently, NM WQCC 20.6.2 NMAC does not appear to reference Federal UIC Regulations, but is comprehensive and as stringent as the Federal regulations.

3. A change to NM WQCC Regulations may require a major process involving multiple agencies and programs working from the current WQCC Regulations. The OCD may be better served by developing "Guidelines" in reference to the general intent of the WQCC Regulations and the concerns raised by the Brine Well Work Group as it applies to UIC Class III wells. The "Guidelines" would contain construction, siting, operations, monitoring, and other applicable sections to ensure the protection of public health and the environment and fulfill the intent of the State and Federal UIC Regulations.

4. UIC Class II hydrocarbon storage wells may be addressed via the Oil & Gas Act and/or "Guidelines" similar to the Class III wells.

5. TX RR Commission has greater power to require things. Rules can come up from staff or legislature down (guaranteed usually). Top down approach from the Governor.

SITING REQUIREMENTS

8:00 – 9:00 a.m. Siting Criteria (Work Group)

Proximity of populated development
Proximity of public roadways
Proximity of utilities including water supply wells: No burden placed on operators on siting to address this. Changes to rules would be needed for issuing APDs, which is a BLM issue too.
Pipelines and all infrastructure, pipelines, utilities....
Oil & gas production
Potash mining (Richard Miller): Object to big caverns in potash. Covered under potash rules, would never happen. No BWs W of Pecos would affect potash.
Other brine wells/caverns
Easements

WIPP (Chuck Byrum): OCD proposed placing a 5 mile OCD internal APD Area of Review around WIPP so DOE, EPA, OCD & WIPP can scrutinize Class II SWD Well APDs and/or other types of wells drilled near WIPP. Class II SWD Wells are of high concern at WIPP Site according to Chuck. OCD notices that gas storage wells from other states have significant AOR distance to prevent gas migration into potash mines, nearby caverns, etc.
Other infrastructure
Disposition of protectable ground water
Thickness of salt ore layer
Interbedding

Presently, OCD has caverns that should be taken out of service now.
There is an inability to deal with Grandfathered facilities. Require that all operators reapply.

1) Siting requirements (establish top & bottom of salt w/ min. depth to top of salt). Are there current resources that can be used that may be accurate? Presence of anhydrites above salt is uncertain and requires site specific logging to determine. TX requires that operators ensure confinement not so much salt. Drill it log or core it to minimum standards. Got enough off-set to get minimum standards to construct. Must meet minimum standards. Can't solution mine < 1000 ft.? Don't know for certain? May never know? Key Energy Services, L.L.C. (Key) is looking to drill new BWs around Hobbs and Carlsbad near trucking business. Key recently PA'd a BW in Carlsbad and wants to drill a 2-well brine system at the same facility.

2) Establish relationship between Salado salt cavern and ground water. USDW top and bottom needs to be known. Mud logging? Set casing after knowing this? Would push BWs E of Pecos River? Well construction required under UIC Program already covers this concern, and protects USDW regardless of whether fresh water is present.

3) Should all new BWs going forward be required to be new? Or, should C-103 Sundry notices for conversion of oil/gas wells into brine wells? If existing well can meet minimum BW requirement, may be ok? Each case is site-specific.

4) The top-of-salt section must be at least 1000 ft. bgl and salt section must be at least 500 ft. thick. No BWs W of Pecos River. Want thick layer of salt. Beam (geotechnical sense) theory we want anhydrite above salt to provide some strength. You are not going to find this geologic scenario in NM. No domal salt in NM. Depth is a function of size and shape of cavern. Single string can achieve shape, but what if leaks occur in surface casing? Dual-string probably best method. 100 ft. of roof salt, oil blanket or pad, etc. should not require the min. 1000 ft. Should be site-specific. Intent is not to allow brine caverns to coalesce (dog bone shape), but this may not be a big issue if roof of caverns aren't big. There is still a pillar of support between caverns that helps support systems. Two well systems should minimize size of cavern when salt is produced without dead oil cap on brine fluid or padded system.

5) The well must be located at least ¼ mile from nearby residences and/or quarter mile away from public roadways, transportation and drainage features. Permitting in existing populated areas, roads, waterways, buildings, and railways. Probably a ½ mile or greater at least..... Not in city limits.

6) Contingency Plan-CP (should include collapse considerations in addition to abatement of surface and ground water). Incorporate collapses into CP and reassess bond or financial assurance amount accordingly.

7) Formation depth- overlying & underlying rock

8) Brine well re-drilling on facility is not allowed. No BWs within a municipality. Don't allow in cities where there are population centers.

9) Cavity setback distance from 300 ft. from lease line- encroachment issues to mineral rights owners. Similar to recent Part 17 Siting Criteria, but greater distances. Cavity is eventual cavity size at closure. Life of mine issue? Thief zones and offset operators may drill into thief zone(s) that was unpredicted? Reporting to OCD has to be updated and monitored on a daily basis. If operator injects more fresh water than brine coming out- you have a leak problem (1:7 Rule: every 7 bbls. pump in you lose 1 bbl.) Variation or differential > 14% injection vs. production, need to see what's going on with brine well.

10) OCD APD ½ mile AOR Internal Review of all new wells drilled near brine well locations

11) Relationship of secondary recovery techniques in the oil and gas industry relative to the sodium well failures. Upon arriving at the Loco Hills sinkhole (BW-021), on the day of the collapse, noticed a Halliburton crew was fracturing an adjacent well (BLM). Concerns about fracturing within shallow oil fields just below the potash basin and ramifications to mine workings. Concern that nearby well drilling could encounter flow and dewater the brine well salt cavern and induce a BW collapse. Is there a relationship of breccia solution chimneys just south of the area and is there a connection? Water ascends up into formation and dissolves salt resulting in a collapse. North of Eddy Mine there are breccia chimneys south of ? Breccia chimneys more common than people suspect. No significant issues for BWs. Unstable area already listed under WQCC regulations. A few studies in TX show concentrations of breccia pipes discovered in cores. Boundary breccias embed in natural halites. Finds avenue for migration via fractures. Salt could move up from bottom of Salado Fm. W flank of Capitan Reef structure is where breccia pipes could outcrop. Lots of natural salt sinks in the area like the Wink Sink in TX. Finding sinks on Capitan Reef and away in TX.

Work w/ BLM on this too. OCD-EB Santa Fe may need to talk further with District Offices to heighten awareness. Place AOR on every BW closed and open. It will include nearby well workovers too.

CONSTRUCTION REQUIREMENTS

9:00 – 9:30 a.m. Construction Characteristics (Loren Molleur)

Re-entry of former oil and gas wells
Thickness and lithology of overburden
Borehole geophysical logging
Well Materials
Casing penetration into salt
Cementation of casing
Multi-well operation

1) Brine wells need to be constructed with bigger borehole. Double string and cement to surface. Double tubing. No more single tubing. Double tubing w/ double tubing packer would work better. Put packer fluid in annulus monitored by external tank fluid level monitoring device. Problem casing size is too small to be BWs and not optimized to be BWs. Also, need dead oil roof layer.

2) Minimum logging requirements (logging to surface). State of the art dual tool cement bond log (internal bonding and external bonding to surface. Open hole log, gamma-ray log- standard suite (pick interbedding layers, i.e., anhydrite, salt, etc.). Temperature log accompanies gamma-ray log. Log suitable to pick water bearing formations. Know lithology and water. Standard SP may pick up water zones?

3) Must drill salt section w/ brine mud.

4) APDs to drill new Class III Wells on facilities with PA'd Brine Wells (i.e., dual string within one casing completions). Beam (geotechnical sense) theory we want anhydrite above salt to provide some strength. You are not going to find this geologic scenario in NM. No domal salt in NM. Depth is a function of size and shape of cavern. Single string can achieve shape, but what if leaks occur in surface casing? Dual-string probably best method. 100 ft. of roof salt, oil blanket or pad, etc. should not require the min. 1000 ft. Should be site-specific. Intent is not to allow brine caverns to coalesce (dog bone shape), but this may not be a big issue if roof of caverns aren't big. There is still a pillar of support between caverns that helps support systems. Two well systems should minimize size of cavern when salt is produced without dead oil cap on brine fluid or padded system.

5) APD or C-103 conversion of O & G wells into BWs, internal AOR min. ½ mile around all BWs? Must meet fundamental brine well construction requirement of casing shoe set at least 100 ft. into the salt formation.

6) The top-of-salt section must be at least 1000 ft. bgl and salt section must be at least 500 ft. thick. Same as number 4 above.

7) No conversions from oil & gas to Class III well unless well casing shoe is at least 100 ft. into the salt section. Double strings required? Must meet fundamental brine well

construction requirement of casing shoe set at least 100 ft. into the salt formation. May determine that two-well system is the requirement too.

8) At least 100 ft. of salt shall be present above any brine extraction cavern

9) Relationships to drilling & fracturing activities? AOR concept here? Permit provides for AOR around brine wells, but operators not notifying OCD, i.e., BW-021.

MONITORING REQUIREMENTS

10:15 – 10:45 a.m. Monitoring (Work Group)

Subsidence monitoring
Mechanical integrity testing of casing and cavern (Carl Chavez)
Surface assessment
Geophysical methods for determination of cavern size and geometry (Andreas Reitze)
Groundwater quality monitoring

OPERATIONAL REQUIREMENTS

9:30 – 10:00 a.m. Operations (Mark Cartwright)
Tubing placement
On-site pumping of fresh water
Modes of fresh water injection/brine extraction
Production pressures and rates
Operational lifetime
Closure including possible backfilling of cavern with solid materials

1) Fresh water shall be injected down the annulus with brine extracted through tubing at all brine wells with casing shoes constructed at least 100 ft. into the salt section. No, brine extraction through the annulus is preferred due to the preferred arch shape, configuration and stability of the cavern roof. Besides, steel casing and cement along with MITs are designed to protect the USDW. It was thought by the State of New Mexico that injection of fresh water down the annulus was more environmentally protective, since a leak in the casing would result in fresh water leaking into the USDW instead of brine. However, based on the location of casing shoes near the top of the salt, this flow regime is not appropriate as lateral dissolution of salt at the contact of salt and rock will occur enlarging the cavern roof and increasing the potential for collapse.

2) Operational wells with casing shoes near the top of the salt section shall inject brine water down the annulus to minimize dissolution of the roof of the salt cavern and shall inject dead oil (diesel preferred, mineral oil, bunker oil, low gravity & no VOCs due to explosion and environmental concerns) cap to minimize dissolution of the salt. These

wells shall be sonar tested at a frequency determined from past sonar testing to monitor the potential for collapse and/or the operator may choose to PA the well. May not want to PA any brine well, but continue to monitor head in cavern on a routine basis in the event anomalous head fluctuations may signal a collapsing roof scenario and serve as an early warning indicator. Should keep cavern full of brine water for ground stability purposes. If you PA the brine well, there could be natural fluid loss in the cavern over times.

3) On new brine wells with casing shoes set at least 100 ft. into the top of the salt section, the first sonar test shall be conducted on the 10^{th} year of brine production and every 5 years thereafter. If the well casing shoe is set at the top of the salt section, then the frequency of sonar testing may be more frequent. Tie sonar logs to production limit rather than life of the well. Brine well cavities larger during beginning of production and decreases when they are larger due to the increased surface area.

4) When problems occur conducting a sonar test, the well must be drilled out with the largest bit size that can be run in the casing due to the salt section moving or there is build in the casing. Any bit size used must be run with a scraper. A gauge ring shall be run before the next bit run- Tim Gum BW-27 Sonar problem case study. Map w/ density tools that are smaller through pinched areas down hole. Gravity survey map to 3000 ft. in Andrews County, TX. Does GPR go down deep enough? No. Shallow tool. Socons small tool costs 3 – 4 times more for insurance to use at a well. If you knocked off bottom of casing where kink is, could you go back in and deepen? Dog leg instances. Casing issues not resolved from recollection? Drill pipe down hole, placed explosive down hole, blow off casing, went back in to deepen. This is a common down hole technique today. Operators could do something to run neutron log. Ledges of anhydrite still a problem. Sacrifice bit to get tubing down. Doesn't help with imaging. Old BWs have 5 1/2" casing and can't place large tubing in them except 2 7/8". Tried in Carlsbad at Key BW, didn't work. Can you run an under reamer? Yes. If you have small casing, can you under ream and make the bore hole bigger? Problem shallow depth < 2000 ft. tough to get weight on bit to do it. Run 10 ¾" surface pipe or 13 3/8" 100 ft. into salt, place pad or dead oil layer, last string should be a suspended liner in 10 ¾" then go back down into salt fm. Considered air drilling w/ air hammer? No. In Virginia much straighter hole, less weight on bit, chiseling w/ air worked. Cable tool drilling results in the straightest hole. Less expensive to drill an offset hole than to fix a down hole problem? Better to abandon facility. If you're going to have to drill a larger hole, may as well drill one at a new facility. If you could get sonar tool 100 ft. below casing shoe, and shoot upward and downward, could determine maturity of cavern to be plugged and abandoned. Drawback with sonar tool stuck at minimum depth from casing shoe is you may view only the cavern roof and top section of the cavern when the cavern may be much larger with depth. There is a false sense of security if you're only looking upward at the roof and are unable to sonar the entire cavern. One brine well cavern looked like a spider well....

5) A well maturity status designation shall be declared upon obtaining a cavern roof radius of 150 ft maximum (safety factor) or a total volume of salt removed.

6) OCD shall place MIT Guidance on website for brine wells. OCD shall work to develop an automated reporting system for fresh water and brine production to facilitate a more efficient method of reporting and to track operator reporting.

7) Drilling to emplace tubing to TD and encountering well problems, i.e., tubing hits ledge & kinks affecting the ability to sonar or log the well must be approved by the OCD for continued operation or to PA the well.

8) Seismic monitoring shall be required in addition to subsidence monitoring at locations where public health is threatened. Any surface movement may shut down BW operation? Concern that seismic monitoring noise may pose problem during high traffic periods.

9) Subsidence monitoring shall be required at all brine production wells. Require sonar testing required too.

10) Ground water monitoring program, seasonal piezometric and hydraulic gradient monitoring. Should obtain this information if NM requires monitor well installation for every BW installation. Can monitor down gradient from well.

CLOSURE REQUIREMENTS

10:45 – 11:15 a.m. **Plug & Abandonment (Work Group)**
Fill brine cavern w/ brine water & cement casing to surface. Would industry be interested in taking over caverns for gas storage to recycle or reuse existing brine caverns? WRSW- Yes, if sound and there are no other problems nearby. May not want to PA brine wells, but monitor keep them filled and routinely monitor head for any sign of roof collapse, etc.

11:15 – Noon **Collapse Response (James Rutley- BLM)**
Pre-positioning of emergency materials
Immediate public safety
Longer term restriction of access
Property damage
Groundwater contamination
Backfilling

1) Plug and abandonment method(s) (salt creep theory- theoretical)
Fill brine cavern up with brine water to stabilize cavern, scrape casing & cement from casing shoe to surface, install marker, and keep at least 50 psi of pressure on well at all times. Continue subsidence monitoring and/or seismic monitoring for at least ? years.

Industry is undecided at this moment. There is no such thing as permanent abandonment. There are two SMRI research papers in the works to predict the behavior of brine caverns for years or decades down the road. In the 1980s in TX, UIC Director's opinion (Railroad Commission) to plug and abandon (PA) BWs may not be best method to PA a BW? Once PA'd, well can't be used and can't see what's going on down hole. Wait for SMRI research papers to determine best professional judgment. It may be best to do nothing until we know more from upcoming SMRI research information.

EPA had experience 10 yrs. ago in TX where applicant wanted to dispose of Hazardous Waste into Class III Well near Bowing, TX. EPA required disposal modeling to show containment for 10K yrs. EPA reviewed preliminary proposals to inject hazardous waste into a salt cavern. In salt domes, and deep caverns, creep forms near closure and creates high pressure at the top of the cavern. Application was stopped by Legislators. These type of disposal operations were banned in TX. A preliminary review by EPA indicated that the well bore should remain open during post closure care period and extended for 50 yrs. after disposal ceased or maybe longer. Keep well open because cavern needs to off-gas. The minimum assumption in modeling is that the cavern be considered structurally stable. If all information indicates it's stable, PA procedures may be implemented. But if not, filling w/ solids may be feasible? Intrepid has huge volumes of salt that could be used to dispose or fill up caverns. The WIPP Facility may also have huge volumes of salt that could be used to fill up caverns.

If concerned about collapse, may want to look at slurry fill method. Re-enter cavern through new borehole? Directionally drill wells into bottom of cavern? Circulate slurry. What size of bit would you use? Sand could be fluidized. Cost of sand? BLM land, city land may be available. Wait for SMRI research papers due within the year. Shallow well scenario is in draft and may be finalized within year. Could set retrievable bridge plug in the interim? PA well to protect USDW. Class II program in TX a well was temporarily abandoned 25 yrs. ago and monitored. It may have had bridge plug in it while operator continued to MIT well. Temporary removable of plug emplaced in well and monitored pressure at surface to verify cavern was not loosing fluids, or not creating a problem. Keep well open. EPA requires plugging and abandoning of wells at some point. Who will pay to PA in 30 years? Post closure care period w/ FAM to PA well required- EPA. If a well is constructed properly, then it can be reused. Wells in urban settings? PA procedures may need to be flexible? Depends on location and the type of well.

2) Plugging & abandonment (chemistry of fluid in cavity, oil or other impermeable layer on top of fluid in cavity- BLM comment. Should oil cap or pad be placed in it? What happens to cavern after PA. SMRI research in progress. Shallow research due within next year maybe? Before any PA policy, wait to see SMRI research on shallow wells. SNL feeling to wait for SMRI research to be finished. At most BWs there is a concern

about collapse even after wells were PA'd. What's cost of moving road, moving residences, and maybe you want to artificially collapse an area? Irrigation canal near I&W BW-006 means you must prevent collapse.

3) Maximum allowable amount of salt removed from formation (max. allowable diameter for underground cavity as a function of depth).

4) 1 M ft^3/50 ft. overburden or 178,107.6 bbls./50 ft. overburden- Historical API Correspondence and/or Wayne Price's (OCD) Questionnaire Algorithm below:

Calculation: Please divide your estimated total volume of produced brine by 180,000 and multiply by 50. Example: If you have produced a total of 18,000,000 bbls of brine in the life time of the well then your calculation would be 18,000,000/180,000 = 100 x 50 = 5000.

1. Provide the calculated number above here:_____
2. Now provide the depth (ft) from the surface to your casing shoe:_____

Is the calculated number found in #1 above greater than #2? Yes _ No_

CONSERVATION OF BRINE USE

1) Use brine only for drilling operations through salt formations to decrease waste Problem wells- bedded salt w/ collapse features or ledges. Issues w/ pit rule issues. Why do drillers need such large pits? Not using brine to drill through Salado. Using brine in overpressured zones and use brine just in case. Can drilling be done differently to minimize waste? In TX do things in tanks. Desilt mud, tanks worked better. Stop practice of large brine flows to be flowed into reserve pits. There are cases when brine is actually needed. The use of brine may be more of a gas storage operations issue? There are significant zones of pressurized brine in the Loco Hills area. Top of Rustler- high pressure blow-out condition could exist? Hit this zone all the time. Water and nitrogen flows suspected. Drill in and lose control. No fires associated with them to date.

SALT CAVERN USE FOR SLURRY WASTE DISPOSAL

1) Legacy issues- UIC Class I well slurry (well cuttings, other wastes) disposal into brine caverns- interest in NM. Might be solution for I & W BW-006 in Carlsbad? Suspect Owner/Operator of I&W would not be able to afford a collapse. There is a $50K bond. OCD has Reclamation Fund and has to be done before it collapses. This should be a high priority of the OCD..... Turn into slurry and inject down tubing, let settle, bring liquid out and recycle saturated brine. Mud cuttings may be disposed in BW-006? Know BLM may be able to get rid of tailing piles. About 1 M bbls roughly estimated to fill

BW-6 cavern. Approximately 3 $M of materials may be needed. How would you ship it to the brine well site. How many truck loads? Could run a slurry pipeline to I&W from Intrepid or WIPP or DOE and fill hole. Potash mine has a rail that goes by I&W. Bring a 100 yd. car by rail road to location. Approximately 34K truckloads? A M bbls of void space is a big volume.

Two situations: 1) An average hazardous waste permit from EPA to inject may cost from $ 0.25 M to $ 0.5 M. If OCD allows oilfield waste to be disposed, companies may save $ if non hazardous. In lieu of backfilling salt cavern, don't know if this type of disposal would qualify. Have permit for back filling mine tailings back into mine bore underground. Could qualify as a Class V Well if waste non-hazardous? Not disposal, but to restore surface so not a waste, but don't know if this would fly- EPA?

2) Similar issues w/ brine well collapse potential, i.e, thickness and depth to top of salt, well construction, conversion of conventional well into Class I slurry injection well, dissolution of salt, cavern size, etc.

OTHER WORK GROUP COMMENTS

- Basic configuration of brine wells in NM presently vs. how they could be configured to prevent upper end growth of the cavern rather lower growth within the cavern to prevent collapses of overburden

- Cavern monitoring through sonic surveys

- Seismic monitoring for early detection of subsidence

Has seismic proved anything? What can you do in 6 hours if you have early warning of collapse? I & W may have to move their yard? Spilling water on surface there is a concern as fresh water may dissolute the salt in sediments or find natural conduits or channels to salt formation in the area. May want to talk to Rick Asper at NM Tech? Could we filter background noise at seismographs to see if they are a feasible tool at brine wells? May give early warning over several days or several hours to react and protect public safety? OCD should require subsidence monitoring at all BWs at a minimum. The closer you are to a brine well with a monitor, there is a high probability that you're going to detect something if it happens. Bore hole used to place seismic monitor down hole? Good benefit to re-entering well w/ device to hang in well that may give hours or days worth of warning. Evacuate homes, traffic, etc... Simple mechanical device low cost may be effective, place a string at the base of cavern in tension, record tension at well head, in the event of failure, i.e., roof is collapsing. Roof falls first right? Early warning systems.... small boreholes w/ lines to roof cavern to monitor? Any exist wells nearby, could use them? Fluid level monitoring could watch any disruption in cap rock that would affect fluid level in cavern. A work group member attending an annual geophysics meeting discovered that you can detect earthquakes around the world from the cap

rock on salt dome. At I & W BW-006 do something in the short term, and in the long term consider backfilling the cavern? WIPP funds may be available to the City of Carlsbad (contact Mayor) to see if WIPP funds may be available to do some joint monitoring. May want to include the local university? Explore opportunity to obtain DOE funds to City of Carlsbad for something like monitoring. Would DOE agree that a collapse at BW-006 is a concern that city could use DOE funds for? Don't know stipulations on use of the funds.

- How do the brine well issues apply to Class II hydrocarbon storage well discharge permits?
- Research that should be conducted to better evaluate the potential for collapses
- Sources to fund study that we can match item with state funds or work in partnership w/ the state to maximize results of efforts

Width to overburden thickness- diameter is important and is a function of the overburden thickness. Well produced with little oversight and control. There is a minimum salt back (anhydrite- KS) or beam (geotechnical sense) separating overburden from the top of the salt cavern. KS limits size and vol. of brine produced (roof as f(depth)) from a well.
Reverse flow immediately. Require annual test of casing as simple as injection of fresh water column into annulus for short period. An operator can perform daily MITs of the well casing annulus by connecting the annulus to a tank and monitoring fluid column fluctuations (temperature vs. pressure differentials). The OCD already does this at UIC Class I Wells. CFR Code: Water Brine Interface Test. Don't do it in TX, but VA yes. Well tested during completion. Standard casing test drill out.
Require for future wells. Get away from single-well production from casing. Use bigger casing to hang 2 strings in casing (one shallow-one deeper) to produce brine from well. Production and injection into one well casing will help control cavern size and shape better. If breach in casing, you're not loosing brine, but loosing annular fluid.
Old brine wells with small casing too small to place multi strings into it and have more problems with completing sonar tests later.
Need inert insoluble pad or oil blanket to control dissolution at salt cavern roof. Diesel is the most common type of pad used. Bunker oil is not preferred since it will solidify and can't be recovered. Pad pressure always highest pressure and should read constant pressure under static and dynamic conditions. The differential is the same. Western Refining L.P. (GW-007) is already doing this.
Do not re-enter old wells unless constructed properly and verified. 7 or 42 wells were re-entered by United Brine? It is possible to drill through a PA'd well.
Any oil and gas well converted will have penetrated the Salado. How well were they cased, cemented?

KS rules for new BWs, before cement casing in place, clean rock interface, rinse and get mud cake off rock to get good cement bond. Cemented w/ 5.5" through Salado w/ constant barrier between salt .... Perforating may not always work. States put together wish list package that dwindles with exception process of states. Hold fast to dual tubing scenario, requires a new well. Size and shape of cavern shall be considered.

Problems with reporting production volumes and submit annual reports in New Mexico. Could require the placement of a low cost data logger w/ solar panel that transmits injection and production data directly to the OCD?

Fresh water and brine water production must be known for owner/operator sales information, etc. Why do owners/operators claim their files are incomplete?

Totalizer required on well to verify accuracy by operator. TX recently, annual report all Class II Operators. Volume must be monitored at least once a month. It is labor intensive. Lately, internet web used to send production data automatically without all the labor costs. The data goes immediately into TX database and computer issues warning letter automatically when operators don't report. Online reporting good!

Annual report, operators in NM supposed to report sonar and cavity examination (calc. based on production data to estimate cavern size). Owner/operator must get professional to interpret the data and summarize it in a report to agency for operator if they can't do it. New Mexico sinkhole operator annual reports don't correspond with sonar of cavity. Someone needed on regulatory end to see problem. Need guidance on when to shut-in or PA the well.

There should be maximum roof cavern diameter established, i.e. ~200 ft. Inputting production data into a computer database or program will help to monitor the cavern size. Automated data does not exceed parameter that is required to be monitored. Use words like maximum diameter of cavern in future discharge permits. What about void space being created (size and shape). Operator should do this and when approaches the limit the operation must be shut down.

Depends on location on how thick salt has to be, depth, etc. Maximum diameter may be 50 ft based on the location. Put BW in urban areas? In town, shouldn't have them there. OCD siting requirements will definitely be in guidelines. SMRI has simulation program just revised last year and is much more specific to examine salt in Europe? One change is plug allowed in non-salt intervals. This works very effectively. Software price and cost of consultant, require simulation for planned life of well. There is software available right now that can be used to satisfy the above. Certain cases, TX may want to look at injection pressure and have information submitted by a Certified Professional Engineer. Permit authority to review information submitted by applicant and operator must ensure QA/QC of certification of engineer submitting accurate date to agency.

Transfer of wells five times even. First guy already knows it's risky, getting out by selling well. BWs don't make $ unless you have trucks to haul it. Less profitable business if you don't have trucks to transport brine. The price of brine right now is about $1 to $1.20/ bbl.

Verification during transfer of well, require sonar test and testing to ensure buyer is not liable or else well is not transferrable. New owner has to file a new application, etc.? New permit is

issued that is non-transferrable and buyer knows this up front? Like buying a car and not selling it? New rules w/ higher standards may make this unnecessary.
Notification of sale and transfer requirements are already included in WQCC Regulations.
Quantity of production for any well will address maturity and closure of a well.
Identify a maximum quantity or volume, but a more important consideration is the roof diameter.
Volume of production works in a one-well scenario, but not in a dual tubing well.
What about horizontal wells or two-well systems and what would oil blanket be like for these types of wells? This is more complicated. In NM would know how to do. Requiring a two-well system may be too extreme? Guidelines needed for dual tubing in one well vs. two well systems that meets performance standards.
Research will address long-term risk. How do you stop wells from being drilled too close to each other. Recommend OCD get w/ NMED and put all information on brine well vulnerability into a GIS as a resource. Labor intensive up front, but when finished, may work.

Chavez, Carl J, EMNRD

From: Chavez, Carl J, EMNRD
Sent: Wednesday, April 15, 2009 1:47 PM
To: 'James_Rutley@blm.gov'; 'byrum.charles@epa.gov'; 'Leissner.Ray@epamail.epa.gov'; 'hugh.harvey@intrepidpotash.com'; 'lmolleur@keyenergy.com'; 'gveni@nckri.org'; Jones, Brad A., EMNRD; Chavez, Carl J, EMNRD; VonGonten, Glenn, EMNRD; Griswold, Jim, EMNRD; Kostrubala, Thaddeus; 'balch@prrc.nmt.edu'; 'leo.vansambeek@respec.com'; 'rlbeauh@sandia.gov'; 'grkirke@sandia.gov'; 'reitze@socon.com'; 'mcartwright@unitedbrine.com'; 'dave.hughes@wipp.ws'; 'Allen.Hains@wnr.com'; 'ken.parker@wnr.com'; 'Ron.Weaver@wnr.com'; 'Veronica.Waldram@wipp.ws'; 'RichardM@intrepidpotash.com'; 'cgherri@sandia.gov'; 'dwsnow@lotusllc.com'; 'lyn.sockwell@basicenergyservices.com'; 'dwpowers@evaporites.com'
Cc: 'jhand@kdhe.state.ks.us'; 'khoeffner@kdheks.gov'; 'mcochran@kdheks.gov'; 'jvoigt@solutionmining.org'; 'douglas.johnson@rrc.state.tx.us'; 'joeb@dnr.state.la.us'; 'psbriggs@gw.dec.state.ny.us'; 'david_herrell@blm.gov'; 'lland@gis.nmt.edu'; 'douglas.johnson@rrc.state.tx.us'; 'gary.wallace@crihobbs.com'; Hall, John, NMENV; Olson, Bill, NMENV; 'Ken Davis'
Subject: UIC Class III Brine Well Evaluation Work Group Request for Comments
Attachments: BW Strategy 3-27-09.docx

Ladies and Gentlemen:

Please find attached the brine well strategy document updated from Friday, March 27, 2009. I am also scanning this document into OCD Online "BW-999" today at http://ocdimage.emnrd.state.nm.us/imaging/AEOrderFileView.aspx?appNo=pCJC0906359521. This document may help you to re-focus on our meeting and recall details that you may wish to elaborate on further or items that you missed commenting on during the meeting. I anticipate creating one last final brine well strategy document to place in the file after the report is completed. Therefore, your comments are crucial at this stage. You may also wait to view the draft report to make sure that the OCD considers your comments at that time. Please review the document and provide any comments to me at your earliest convenience.

The OCD is using the attached brine well strategy document in preparation of the final draft report that you will also be allowed to review and comment on next week. The OCD hopes to have a draft report to you by COB Monday, April 20, 2009 or sooner if possible. The final report is due May 1, 2009.

Please contact me if you have questions or if you wish to verbally convey key comments. Thank you.

Carl J. Chavez, CHMM
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(Pollution Prevention Guidance is under "Publications")

DRAFT

New Mexico Oil Conservation Division
UIC Class III Brine Well Strategy (3/27/2009)

INTRODUCTION

The New Mexico Oil Conservation Division (OCD) developed this brine well strategy subsequent to two brine well collapses that occurred in July of 2008 (Jims Water Service) about 14 miles SE of Artesia, and another one (Loco Hills) that occurred in November of 2008 about 25 miles east of Artesia. They were isolated incidents and there were no injuries. The county road near Loco Hills was impacted, while the county road near Jims Water Service is threatened.

The OCD recognizes based on the age of production from a majority of permitted brine wells that a BW Strategy is needed going forward. Consequently, the OCD incorporated many of the brine work group member agenda recommendations and thoughts into this draft brine well strategy document, which may serve as topics to facilitate brainstorming. It is hoped that the work group may formulate solutions and ideas based on what happened, why it may have happened, and what the OCD may start doing now and in the future to prevent salt formation collapses and protect public health and safety. It is hoped that other states with EPA UIC Class II HC Storage and Class III Brine Well programs may learn from New Mexico. ***The OCD intends to update this document throughout the brine group process and use it as a brainstorming tool to flesh out thoughts and ideas from the brine well work group for the report to the Oil Conservation Commission due May 1, 2009. Therefore, Work Group Members are encouraged to continue sending in your thoughts and ideas at any time throughout this process.***

GENERAL

1. According to Wayne Price (OCD), the BLM, NMED and OCD agreed several years ago (early 1980s) that injecting fresh water down the annulus and extracting 10# brine from the tubing was most protective of USDW in the event of a leak. There is no EPA Guidance recommending or requiring fresh water to be injected down the annulus. Brine could be produced through the annual as brine wells are constructed with steel casing that is tested for leaks and cement is placed between the borehole and steel casing to protect any USDW.

2. Injecting fresh water down the annulus of brine wells with casing shoes set at the top of the salt formation as observed in New Mexico results in aggressive dissolution of the salt laterally outward expanding the top of cavern roof outward at the contact between rock and top of salt formations. The work group recommends reversal of flow to inject fresh water down the tubing and extract brine from the annulus. UIC Class III brine wells are designed with steel and cement to prevent impacts to the USDW. This is recommended

at operating brine wells regardless of knowing the size of the cavern roof at this time, until sonar work or other investigation methods determine the size and configuration of operational brine wells.

3. The present configuration of OCD brine well salt caverns looks like an upside down Christmas tree based on fresh water injection through the annulus. Injection of fresh water down the annulus would not be of as much concern if the casing shoes of brine wells had been set 50 to 100 feet into the salt. However, two-well brine well systems are preferred to single well systems by the work group. The injection of fresh water down the annulus results in a broader roof cavern configuration, while injection of brine results in a preferred arched roof design or roof with a "back".

4. The majority of OCD brine wells are 25 to 30 years old and were never permitted under the current WQCC Underground Injection Control Regulations. Many were initially designed for oil and gas exploration and production, and later converted into brine wells regardless of the depth and setting of the casing shoe. Unless existing oil and gas wells are seated 100 feet into the salt, they should not be approved for conversion into a brine well.

APPLICATIONS

1. The C-108 Form used for brine wells does not have a check-off for brine extraction facilities and other pertinent criteria as specified in the WQCC Regulations. Needs to be amended to include Class III information or the unnumbered form for brine extraction facilities needs to be amended.

2. The unnumbered "Discharge Plan for Brine Extraction Facilities" form is too generic and should include more questions commensurate with WQCC Regulations for a UIC Class III brine well application. Does there need to be a separate C-108 Form that needs to be filled out?

DISCHARGE PERMIT

1. The permit does not have a definitive date for sonar testing or calculations based on brine production to ensure cavern size is assessed by the OCD.

2. The permit does not have language for determining when a salt cavern is at maturity and in need of PA. The work group indicated that the OCD may not want to PA brine wells, but continue to keep them full of brine water and to monitor fluid level on a regular basis to assess possible roof collapse anomalies?

3. The permits are renewed every 5-yrs. and this would be the time for the OCD to assess the maturity of a brine well or system.

4. Discharge permits may not be followed as in the case of BW-021 where a well was being fractured nearby the brine well. There is a concern if brine fluid in the cavern escapes

resulting in a potential collapse of the cavern, and even though the permit requires notification to the OCD when wells are drilled within the Area of Review (AOR), this was not followed by the owner/operator of the brine well. There are also concerns about Class II hydrocarbon storage wells and AOR as water floods and nearby wells could encounter gas and result in an explosion or public health concern.

REGULATIONS

1. Kansas has a 10-yr. life expectancy for its brine wells with option to renew the permit at that time.

2. Kansas and Texas appear to incorporate Federal EPA UIC Regulations into their state regulations. Could NM do this too? Currently, NM WQCC 20.6.2 NMAC does not appear to reference Federal UIC Regulations, but is comprehensive and as stringent as the Federal regulations.

3. A change to NM WQCC Regulations may require a major process involving multiple agencies and programs working from the current WQCC Regulations. The OCD may be better served by developing "Guidelines" in reference to the general intent of the WQCC Regulations and the concerns raised by the Brine Well Work Group as it applies to UIC Class III wells. The "Guidelines" would contain construction, siting, operations, monitoring, and other applicable sections to ensure the protection of public health and the environment and fulfill the intent of the State and Federal UIC Regulations.

4. UIC Class II hydrocarbon storage wells may be addressed via the Oil & Gas Act and/or "Guidelines" similar to the Class III wells.

SITING REQUIREMENTS

8:00 – 9:00 a.m. Siting Criteria (Work Group)

Proximity of populated development
Proximity of public roadways
Proximity of utilities including water supply wells No burden placed on operators on siting to address this. Changes to rules would be needed for issuing APDs, which is a BLM issue too.
Pipelines and all infrastructure, pipelines, utilities....
Oil & gas production
Potash mining (Hugh Harvey) Object to big caverns in potash. Covered under potash rules, would never happen. No BWs W of Pecos would affect potash.
Other brine wells/caverns
Easements

DRAFT

WIPP (Chuck Byrum) OCD proposed placing a 5 mile OCD internal APD Area of Review around WIPP so OCD, DOE & WIPP can scrutinize Class II SWD Well APDs near WIPP. Class II SWD Wells are of high concern at WIPP Site according to Chuck.
Other infrastructure
Disposition of protectable ground water
Thickness of salt ore layer
Interbedding

Presently, OCD has caverns that should be taken out of service now.
Inability to deal with Grandfathered facilities. Require that all operators reapply.

1) Siting requirements (establish top & bottom of salt w/ min. depth to top of salt). Are there current resources that can be used that may be accurate? Presence of anhydrites above salt is uncertain and requires site specific logging to determine. TX requires that operators ensure confinement not so much salt. Drill it log or core it to minimum standards. Got enough off-set to get minimum standards to construct. Must meet minimum standards. Can't solution mine < 1000 ft.? Don't know for certain? May never know? Key Energy Services, L.L.C. (Key) is looking to drill new BWs around Hobbs and Carlsbad near trucking business. Key recently PA'd a BW in Carlsbad and wants to drill a 2-well brine system at the same facility.

2) Establish relationship between Salado salt cavern and ground water. USDW top and bottom needs to be known. Mud logging? Set casing after knowing this? Would push BWs E of Pecos River? Well construction required under UIC Program already covers this concern, and protects USDW regardless of whether fresh water is present.

3) Should all new BWs going forward be required to be new? Or, should C-103 Sundry notices for conversion of oil/gas wells into brine wells? If existing well can meet minimum BW requirement, may be ok? Each case is site-specific.

4) The top-of-salt section must be at least 1000 ft. bgl and salt section must be at least 500 ft. thick. No BWs W of Pecos River. Want thick layer of salt. Beam (geotechnical sense) theory we want anhydrite above salt to provide some strength. You are not going to find this geologic scenario in NM. No domal salt in NM. Depth is a function of size and shape of cavern. Single string can achieve shape, but what if leaks occur in surface casing? Dual-string probably best method. 100 ft. of roof salt, oil blanket or pad, etc. should not require the min. 1000 ft. Should be site-specific. Intent is not to allow brine caverns to coalesce (dog bone shape), but this may not be a big issue if roof of caverns aren't big. There is still a pillar of support between caverns that helps support systems. Two well systems should minimize size of cavern when salt is produced without dead oil cap on brine fluid or padded system.

5) The well must be located at least ¼ mile from nearby residences and/or quarter mile away from public roadways, transportation and drainage features. Permitting in existing

populated areas, roads, waterways, buildings, and railways. Probably a ½ mile or greater at least..... Not in city limits.

6) Contingency Plan-CP (should include collapse considerations in addition to abatement of surface and ground water). Incorporate collapses into CP and reassess bond or financial assurance amount accordingly.

7) Formation depth- overlying & underlying rock

8) Brine well re-drilling on facility is not allowed. No BWs within a municipality. Don't allow in cities where there are population centers.

9) Cavity setback distance from 300 ft. from lease line- encroachment issues to mineral rights owners. Similar to recent Part 17 Siting Criteria, but greater distances. Cavity is eventual cavity size at closure. Life of mine issue? Thief zones and offset operators may drill into thief zone(s) that was unpredicted? Reporting to OCD has to be updated and monitored on a daily basis. If operator injects more fresh water than brine coming out- you have a leak problem (1:7 Rule: every 7 bbls. pump in you lose 1 bbl.) Variation or differential > 5% injection vs. production, need to see what's going on with brine well.

10) OCD APD ½ mile AOR Internal Review of all new wells drilled near brine well locations

11) Relationship of secondary recovery techniques in the oil and gas industry relative to the sodium well failures. Upon arriving at the Loco Hills sinkhole (BW-021), on the day of the collapse, noticed a Halliburton crew was fracturing an adjacent well (BLM). Concerns about fracturing within shallow oil fields just below the potash basin and ramifications to mine workings. Concern that nearby well drilling could encounter flow and dewater the brine well salt cavern and induce a BW collapse. Is there a relationship of breccia solution chimneys just south of the area and is there a connection? Water ascends up into formation and dissolves salt resulting in a collapse. North of Eddy Mine there are breccia chimneys. S of ? Breccia chimneys more common than people suspect. No significant issues for BWs. Unstable area already listed under WQCC regulations. A few studies in TX show concentrations of breccia pipes discovered in cores. Boundary breccias embed in natural halites. Finds avenue for migration via fractures. Salt could move up from bottom of Salado Fm. W flank of Capitan Reef structure is where breccia pipes could outcrop. Lots of natural salt sinks in the area like the Wink Sink in TX. Finding sinks on Capitan Reef and away in TX.

Work w/ BLM on this too. OCD-EB Santa Fe may need to talk further with District Offices to heighten awareness. Place AOR on every BW closed and open. Would include nearby well workovers too.

CONSTRUCTION REQUIREMENTS

9:00 – 9:30 a.m. Construction Characteristics (Loren Molleur)

Re-entry of former oil and gas wells
Thickness and lithology of overburden
Borehole geophysical logging
Well Materials
Casing penetration into salt
Cementation of casing
Multi-well operation

1) Brine wells need to be constructed with bigger borehole. Double string and cement to surface. Double tubing. No more single tubing. Double tubing w/ double tubing packer would work better. Put packer fluid in annulus monitored by external tank fluid level monitoring device. Problem casing size is too small to be BWs and not optimized to be BWs. Also, need dead oil roof layer.

2) Minimum logging requirements (logging to surface). State of the art dual tool cement bond log (internal bonding and external bonding to surface. Open hole log, gamma-ray log- standard suite (pick interbedding layers, i.e., anhydrite, salt, etc.). Temperature log accompanies gamma-ray log. Log suitable to pick water bearing formations. Know lithology and water. Standard SP may pick up water zones?

3) Must drill salt section w/ brine mud.

4) APDs to drill new Class III Wells on facilities with PA'd Brine Wells (i.e., dual string within one casing completions). Beam (geotechnical sense) theory we want anhydrite above salt to provide some strength. You are not going to find this geologic scenario in NM. No domal salt in NM. Depth is a function of size and shape of cavern. Single string can achieve shape, but what if leaks occur in surface casing? Dual-string probably best method. 100 ft. of roof salt, oil blanket or pad, etc. should not require the min. 1000 ft. Should be site-specific. Intent is not to allow brine caverns to coalesce (dog bone shape), but this may not be a big issue if roof of caverns aren't big. There is still a pillar of support between caverns that helps support systems. Two well systems should minimize size of cavern when salt is produced without dead oil cap on brine fluid or padded system.

5) APD or C-103 conversion of O & G wells into BWs, internal AOR min. ½ mile around all BWs? Must meet fundamental brine well construction requirement of casing shoe set at least 100 ft. into the salt formation.

6) The top-of-salt section must be at least 1000 ft. bgl and salt section must be at least 500 ft. thick. Same as number 4 above.

7) No conversions from oil & gas to Class III well unless well casing shoe is at least 100 ft. into the salt section. Double strings required? Must meet fundamental brine well construction requirement of casing shoe set at least 100 ft. into the salt formation. May determine that two-well system is the requirement too.

8) At least 100 ft. of salt shall be present above any brine extraction cavern

9) Relationships to drilling & fracturing activities? AOR concept here? Permit provides for AOR around brine wells, but operators not notifying OCD, i.e., BW-021.

MONITORING REQUIREMENTS

10:15 – 10:45 a.m. Monitoring (Work Group)

Subsidence monitoring
Mechanical integrity testing of casing and cavern (Carl Chavez)
Surface assessment
Geophysical methods for determination of cavern size and geometry (Andreas Reitze)
Groundwater quality monitoring

OPERATIONAL REQUIREMENTS

9:30 – 10:00 a.m. Operations (Mark Cartwright)
Tubing placement
On-site pumping of fresh water
Modes of fresh water injection/brine extraction
Production pressures and rates
Operational lifetime
Closure including possible backfilling of cavern with solid materials

1) Fresh water shall be injected down the annulus with brine extracted through tubing at all brine wells with casing shoes constructed at least 100 ft. into the salt section. No, brine extraction through the annulus is preferred due to the preferred arch shape, configuration and stability of the cavern roof. Besides, steel casing and cement along with MITs are designed to protect the USDW. It was thought by the State of New Mexico that injection of fresh water down the annulus was more environmentally protective, since a leak in the casing would result in fresh water leaking into the USDW instead of brine. However, based on the location of casing shoes near the top of the salt, this flow regime is not appropriate as lateral dissolution of salt at the contact of salt and rock will occur enlarging the cavern roof and increasing the potential for collapse.

2) Operational wells with casing shoes near the top of the salt section shall inject brine water down the annulus to minimize dissolution of the roof of the salt cavern and shall inject dead oil (diesel preferred, mineral oil, bunker oil, low gravity & no VOCs due to explosion and environmental concerns) cap to minimize dissolution of the salt. These wells shall be sonar tested at a frequency determined from past sonar testing to monitor

the potential for collapse and/or the operator may choose to PA the well. May not want to PA any brine well, but continue to monitor head in cavern on a routine basis in the event anomalous head fluctuations may signal a collapsing roof scenario and serve as an early warning indicator. Should keep cavern full of brine water for ground stability purposes. If you PA the brine well, there could be natural fluid loss in the cavern over times.

3) On new brine wells with casing shoes set at least 100 ft. into the top of the salt section, the first sonar test shall be conducted on the 10th year of brine production and every 5 years thereafter. If the well casing shoe is set at the top of the salt section, then the frequency of sonar testing may be more frequent. Tie sonar logs to production limit rather than life of the well. Brine well cavities larger during beginning of production and decreases when they are larger due to the increased surface area.

4) When problems occur conducting a sonar test, the well must be drilled out with the largest bit size that can be run in the casing due to the salt section moving or there is build in the casing. Any bit size used must be run with a scraper. A gauge ring shall be run before the next bit run- Tim Gum BW-27 Sonar problem case study. Map w/ density tools that are smaller through pinched areas down hole. Gravity survey map to 3000 ft. in Andrews County, TX. Does GPR go down deep enough? No. Shallow tool. Socons small tool costs 3 – 4 times more for insurance to use at a well. If you knocked off bottom of casing where kink is, could you go back in and deepen? Dog leg instances. Casing issues not resolved from recollection? Drill pipe down hole, placed explosive down hole, blow off casing, went back in to deepen. This is a common down hole technique today. Operators could do something to run neutron log. Ledges of anhydrite still a problem. Sacrifice bit to get tubing down. Doesn't help with imaging. Old BWs have 5 1/2" casing and can't place large tubing in them except 2 7/8". Tried in Carlsbad at Key BW, didn't work. Can you run an under reamer? Yes. If you have small casing, can you under ream and make the bore hole bigger? Problem shallow depth < 2000 ft. tough to get weight on bit to do it. Run 10 ¾" surface pipe or 13 3/8" 100 ft. into salt, place pad or dead oil layer, last string should be a suspended liner in 10 ¾" then go back down into salt fm. Considered air drilling w/ air hammer? No. In Virginia much straighter hole, less weight on bit, chiseling w/ air worked. Cable tool drilling results in the straightest hole. Less expensive to drill an offset hole than to fix a down hole problem? Better to abandon facility. If you're going to have to drill a larger hole, may as well drill one at a new facility. If you could get sonar tool 100 ft. below casing shoe, and shoot upward and downward, could determine maturity of cavern to be plugged and abandoned. Drawback with sonar tool stuck at minimum depth from casing shoe is you may view only the cavern roof and top section of the cavern when the cavern may be much larger with depth. There is a false sense of security if you're only looking upward at the roof and are unable to sonar the entire cavern. One brine well cavern looked like a spider well....

5) A well maturity status designation shall be declared upon obtaining a cavern roof radius of 150 ft maximum (safety factor) or a total volume of salt removed.

6) OCD shall place MIT Guidance on website for brine wells. OCD shall work to develop an automated reporting system for fresh water and brine production to facilitate a more efficient method of reporting and to track operator reporting.

7) Drilling to emplace tubing to TD and encountering well problems, i.e., tubing hits ledge & kinks affecting the ability to sonar or log the well must be approved by the OCD for continued operation or to PA the well.

8) Seismic monitoring shall be required in addition to subsidence monitoring at locations where public health is threatened. Any surface movement may shut down BW operation? Concern that seismic monitoring noise may pose problem during high traffic periods.

9) Subsidence monitoring shall be required at all brine production wells. Require sonar testing required too.

10) Ground water monitoring program, seasonal piezometric and hydraulic gradient monitoring. Should obtain this info. if NM requires monitor well installation for every BW installation. Can monitor down gradient from well.

CLOSURE REQUIREMENTS

10:45 – 11:15 a.m. **Plug & Abandonment (Work Group)**

Fill brine cavern w/ brine water & cement casing to surface. Would industry be interested in taking over caverns for gas storage to recycle or reuse existing brine caverns? WRSW- Yes, if sound and there are no other problems nearby. May not want to PA brine wells, but monitor keep them filled and routinely monitor head for any sign of roof collapse, etc.

11:15 – Noon **Collapse Response (James Rutley- BLM)**

Pre-positioning of emergency materials
Immediate public safety
Longer term restriction of access
Property damage
Groundwater contamination
Backfilling

1) Plug and abandonment method(s) (salt creep theory- theoretical)
Fill brine cavern up with brine water to stabilize cavern, scrape casing & cement from casing shoe to surface, install marker, and keep at least 50 psi of pressure on well at all times. Continue subsidence monitoring and/or seismic monitoring for at least ? years.

Industry undecided at this moment. Permanent abandonment, no such thing. There are two SMRI research papers in the works to predict the behavior of brine caverns for years

or decades down the road. In the 1980s in TX, UIC Director's opinion (Railroad Commission) to PA BWs. May not be best method to PA a BW? Once PA'd, well can't be used and can't see what's going on down hole. Wait for SMRI research papers to determine best professional judgment. May be best to do nothing until we know more from upcoming SMRI info.

EPA had experience 10 yrs. ago. TX dispose of Haz. Waste near Bowing? TX. EPA disposal modeling to show containment for 10K yrs. EPA reviewed preliminary proposals to inject haz. Waste into salt. In salt dome, deep caverns, creep near closure that creates high pressure at top of cavern. Killed by Legis. TX banned it in TX. Prelim. Review by EPA, well bore should remain open during post closure care period and extended for 50 yrs. after disposal ceased and maybe longer. Keep well open because cavern would want to burp. Assumption is that cavern structurally stable. If all information indicates its stable, PA procedures. But if not, outlining filling w/ solids may be feasible. Intrepid has huge volumes of salt that could be used to dispose or fill up caverns.

If concerned about collapse, may want to look at slurry fill method. Re-enter cavern through new borehole? Circulate slurry. Size of bit? Sand could be fluidized. Cost of sand? BLM land, city land may be available. Wait for SMRI research papers due within the year. Shallow well scenario is in draft and may be finalized within year. Could set retrievable bridge plug in the interim? PA well to protect USDW. Class II program in TX a well was temporarily abandoned 25 yrs. ago and monitored. May have bridge plug. Continued to MIT well. Temporary removable plug emplaced in well and monitored pressure at surface to verify not loosing fluids, or not creating problem. Keep well open. EPA didn't say this!!! Who will pay to PA in 30 years? Post closure care period w/ FAM to PA well required- EPA. If well constructed properly, can reuse. Wells in urban settings, PA procedures may need to be flexible. Depends on location and the type of well.

2) Plugging & abandonment (chemistry of fluid in cavity, oil or other impermeable layer on top of fluid in cavity- BLM comment. Should oil cap or pad be placed in it? What happens to cavern after PA. SMRI research in progress. Shallow research due within next year maybe? Before any PA policy, wait to see SMRI research on shallow wells. SNL feeling to wait for SMRI research to be finished. At most BWs there is a concern about collapse even after wells were PA'd. What's cost of moving road, moving residences, and maybe you want to artificially collapse an area? Irrigation canal near I&W BW-006 means you must prevent collapse.

3) Maximum allowable amount of salt removed from formation (max. allowable diameter for underground cavity as a function of depth).

4) 1 M ft^3/50 ft. overburden or 178,107.6 bbls./50 ft. overburden- Historical API Correspondence and/or Wayne Price's (OCD) Questionnaire Algorithm below:

Calculation: Please divide your estimated total volume of produced brine by 180,000 and multiply by 50. Example: If you have produced a total of 18,000,000 bbls of brine in the life time of the well then your calculation would be 18,000,000/180,000 = 100 x 50 = 5000.

1. Provide the calculated number above here:_____
2. Now provide the depth (ft) from the surface to your casing shoe:_____

Is the calculated number found in #1 above greater than #2? Yes _ No_

CONSERVATION OF BRINE USE

1) Use brine only for drilling operations through salt formations to decrease waste Problem wells- bedded salt w/ collapse features or ledges. Issues w/ pit rule issues. Why do drillers need such large pits? Not using brine to drill through Salado. Using brine in overpressured zones and use brine just in case. Can drilling be done differently to minimize waste? In TX do things in tanks. Desilt mud, tanks worked better. Stop practice of large brine flows to be flowed into reserve pits. There are cases when brine is actually needed. May be more of a gas operations issue. There is allot of pressurized brine in the Loco Hills area. Top of Rustler- high pressure blow-out condition could exist? Hit this zone all the time. Water and nitrogen flows suspected. Drill in and lose control. No fires associated with them to date.

SALT CAVERN USE FOR SLURRY WASTE DISPOSAL

1) Legacy issues- UIC Class I well slurry (well cuttings, other wastes) disposal into brine caverns- interest in NM. Might be solution for I & W BW-006 in Carlsbad? Suspect Owner/Operator of I&W would not be able to afford a collapse. There is a $50K bond. OCD has Reclamation Fund and has to be done before it collapses. This should be a high priority of the OCD..... Turn into slurry and inject down tubing, let settle, bring liquid out and recycle saturated brine. Mud cuttings may be disposed in BW-006? Know BLM may be able to get rid of tailing piles. About 1 M bbls roughly estimated to fill BW-6 cavern. Approximately 3 $M of materials may be needed. How would you ship it to the brine well site. How many truck loads? Could run a slurry pipeline to I&W from Intrepid or WIPP or DOE and fill hole. Potash mine has a rail that goes by I&W. Bring a 100 yd. car by rail road to location. Approximately 34K truckloads? A M bbls of void space is a big volume.

EPA had experience 10 yrs. ago. TX disposed of hazardous waste near Bowing, TX. EPA disposal modeling required containment for 10K yrs. EPA reviewed preliminary proposals to inject hazardous waste into salt. In salt dome, deep caverns, creep near closure that creates high pressure at top of cavern. This use of a salt cavern for hazardous waste disposal was stopped by legislation. TX banned it. Preliminary review by EPA, determined that well bore should remain open during post closure care period and extended for 50 yrs. after disposal ceased and maybe longer. Keep well open because cavern would want to degas or burp due to pressure buildup. Assumption is that cavern is structurally stable. If all information indicates that it is stable, may implement PA procedures. But if not, outlining filling w/ solids. Intrepid has huge volumes of salt in which to dispose. Two situations: 1) An average hazardous waste permit from EPA to inject may cost from ¼ M$ to 0.5 M $. If OCD allows oilfield waste to be disposed, companies may save $ if non hazardous. In lieu of backfilling salt cavern, don't know if this type of disposal would qualify. Have permit for back filling mine tailings back into mine bore underground. Could qualify as a Class V Well if waste non-hazardous? Not disposal, but to restore surface so not a waste, but don't know if this would fly- EPA?

2) Similar issues w/ brine well collapse potential, i.e, thickness and depth to top of salt, well construction, conversion of conventional well into Class I slurry injection well, dissolution of salt, cavern size, etc.

OTHER WORK GROUP COMMENTS

- Basic configuration of brine wells in NM presently vs. how they could be configured to prevent upper end growth of the cavern rather lower growth within the cavern to prevent collapses of overburden

- Cavern monitoring through sonic surveys

- Seismic monitoring for early detection of subsidence

Has seismic proved anything? What can you do in 6 hours if you have early warning of collapse? I & W may have to move their yard? Spilling water on surface there is a concern as fresh water may dissolute the salt in sediments or find natural conduits or channels to salt formation in the area. Talk to Rick Asper at NM Tech? Could we filter background noise at seismographs to see if they are a feasible tool at brine wells? May give early warning over several days or several hours to react and protect public safety? Should have subsidence monitoring at all BWs at a minimum. The closer you are to a brine well with a monitor, there is a high probability that you're going to detect something if it happens. Bore hole used to place seismic monitor down hole? Good benefit to re-entering well w/ device to hang in well that may give hours or days worth of warning. Evacuate homes, traffic, etc... Simple mechanical device low cost may be effective, place a string at the base of cavern in tension, record tension at well

head, in the event of failure, i.e., roof is collapsing. Roof falls first right? Early warning systems.... small boreholes w/ lines to roof cavern to monitor? Any exist wells nearby, could use them? Fluid level monitoring could watch any disruption in cap rock that would affect fluid level in cavern. A work group member attending an annual geophysics meeting discovered that you can detect earthquakes around the world from the cap rock on salt dome. At I & W BW-006 do something in the short term, and in the long term consider backfilling the cavern? WIPP funds may be available to the City of Carlsbad (contact Mayor) to see if WIPP funds may be available to do some joint monitoring. May want to include the local university. Explore opportunity to obtain DOE funds to City of Carlsbad for something like monitoring. Would DOE agree that a collapse at BW-006 is a concern that city could use DOE funds for? Don't know stipulations on use of the funds.

- How do the brine well issues apply to Class II hydrocarbon storage well discharge permits?

- Research that should be conducted to better evaluate the potential for collapses

- Sources to fund study that we can match item with state funds or work in partnership w/ the state to max. results of efforts

TX RR Commission has greater power to require things. Rules can come up from staff or legislature down (guaranteed usually). Top down approach from the Governor.

Width to height- diameter is important and is a function of the overburden thickness. Well produced with little oversight and control. Minimum salt back (KS) separating overburden from salt cavern. KS limits size and vol. of brine produced (roof as f(depth)) from a well.

Reverse flow immediately. Require annual test of casing as simple as injection of fresh water column into annulus for short period. Fresh water column w/ temperature and pressure differentials. CFR Code: Water Brine Interface Test. Don't do it in TX, but VA yes. Well tested during completion. Standard casing test drill out.

Require for future wells. Get away from production from casing. Big casing to place 2 strings in casing (one shallow-one deeper) to produce brine from well. Production and injection into one well casing. Can control cavern shape better. If breach in casing, you're not loosing brine just loosing annular fluid.

Old brine wells with small casing too small to place multi strings into.

Need inert insoluble pad or oil blanket to control dissolution at salt cavern roof. Diesel is the most common type of pad used. Dead oil or oil without VOCs. Bunker oil is not preferred since it will solidify and can't be recovered.

Pad pressure always highest pressure and should read constant pressure under static and dynamic conditions. Differential the same. Western Refining L.P. (GW-007) is already doing this.

Do not re-enter old wells unless constructed properly and verified. 7 or 42 wells were re-entered by United Brine? It is possible to drill through a PA'd well.

Any oil and gas well converted will have penetrated the Salado. How well were they cased, cemented?

KS rules for new BWs, before cement casing in place, clean rock interface, rinse and get mud cake off rock to get good cement bond. Cemented w/ 5.5" through Salado w/ constant barrier between salt .... Perforating may not always work. States put together wish list package that dwindles with exception process of states. Hold fast to dual tubing scenario, requires a new well.

Size and shape of cavern shall be considered.

Problems with reporting production volumes and submit annual reports in New Mexico. Could require the placement of a low cost data logger w/ solar panel that transmits injection and production data directly to the OCD?

Fresh water and brine water production must be known for owner/operator sales info. etc. Why do owners/operators claim their files are incomplete?

Totalizer required on well to verify accuracy by operator. TX recently, annual report all Class II Operators. Volume once a month. Labor intensive. Lately, internet web used to send production data automatically without all the labor costs. Goes immediately into TX database and computer issues warning letter automatically when operators don't report. Online reporting good!

Annual report, operators in NM supposed to report sonar and cavity examination (calc. based on production data to estimate cavern size). Owner/operator must get professional to interpret the data and summarize it in a report to agency for operator if they can't do it. New Mexico sinkhole operator annual reports don't correspond with sonar of cavity. Someone needed on regulatory end to see problem. Need guidance on when to shut-in or PA the well.

There should be maximum roof cavern diameter established, i.e. ~200 ft. Input production data into computer to help monitor cavern size. Automated data does not exceed parameter that is required to be monitored. Use words like maximum diameter of cavern in future discharge permits. What about void space being created (size and shape). Operator should do this and when approaches the limit the operation must be shut down.

Depends on location on how thick salt has to be, depth, etc. Maximum diameter may be 50 ft based on the location. Put BW in urban areas? In town, shouldn't have them there. OCD siting requirements will definitely be in guidelines. SMRI has simulation program just revised last year and is much more specific to examine salt in Europe? One change plug in non-salt

intervals. Works very effectively. Software price and cost of consultant, require simulation for planned life of well. Software available right now. Certain cases, TX may want to look at injection pressure and have information submitted by a Certified Professional Engineer. Permit authority to review information submitted by applicant and operator must ensure QA/QC of certification of engineer submitting accurate date to agency.

Transfer of wells five times even. First guy already knows it's risky, getting out by selling well. BWs don't make $ unless you have trucks to haul it. Less profitable business if you don't have trucks to transport brine. Price of brine $1 to $1.20/ bbl. right now.

Verification during transfer of well, require sonar test and testing to ensure buyer is not liable or else well is not transferrable. New owner has to file a new application, etc.? New permit is issued that is non-transferrable and buyer knows this up front? Like buying a car and not selling it? New rules w/ higher standards may make this unnecessary.

Notification of sale and transfers.

Quantity of production for any well will address maturity and closure of a well.

Identify a maximum quantity or volume, but a more important consideration is the roof diameter. Volume of production works in a one-well scenario, but not in a dual tubing well.

Horizontal well with cap or limit? More complicated. In NM would know how to do. Requiring a two-well system may be too extreme? Guidelines needed for dual tubing in one well vs. two well systems that meets performance standards.

Research will address long-term risk. How do you stop wells from being drilled too close to each other. Recommend OCD get w/ NMED and put all information on brine well vulnerability into a GIS as a resource. Labor intensive up front, but when finished, may work.

New Mexico Oil Conservation Division
UIC Class III DRAFT Brine Well Strategy (2/25/2009)

INTRODUCTION

The New Mexico Oil Conservation Division (NMOCD) developed this brine well strategy subsequent to two brine well collapses that occurred in July of 2008 (Jims Water Service) about 14 miles SE of Artesia, and another one (Loco Hills) that occurred in November of 2008 about 25 miles east of Artesia. They were isolated incidents and there were no injuries. The county road near Loco Hills was impacted, while the county road near Jims Water Service is threatened.

The NMOCD recognizes based on the age of production from permitted brine wells that a BW Strategy is needed going forward. Consequently, the NMOCD in consideration of Brine Work Group agenda recommendations developed this draft brine well strategy as talking points for a path forward in consideration of what happened, why it happened, and what the agency can start doing now and in the future to prevent by identifying existing brine wells that may pose the most risk to public health and safety.

Should similar guidance be developed for Class II HC and/or Natural Gas Storage Wells as for brine wells, since the salt cavern scenario may be similar? OCD plans to work on operational and public safety regulations for Class II HC Wells in the future. According to OCD UIC Guidance Manual, the EPA dropped natural gas storage wells from being tracked under the EPA UIC Program. However, Class II HC Wells are tracked under the program. Currently, the only permitted facility where the OCD is tracking LPG Storage Wells is at Western Refining L.P.'s (GW-007) Facility. Four LPG Storage Wells are located at the facility.

SITING REQUIREMENTS

1) Siting requirements (establish top & bottom of salt w/ min. depth to top of salt)

2) Establish relationship between Salado salt cavern and ground water. USDW top and bottom needs to be known. Mud logging? Set casing after knowing this?

3) Should all new BWs going forward be required to be new? Or, should C-103 Sundry notices for conversion of oil/gas wells into brine wells? If existing well can meet minimum BW requirement, may be ok?

4) The top-of-salt section must be at least 1000 ft. bgl and salt section must be at least 500 ft. thick. No BWs W of Pecos River. Want thick layer of salt w/o anhydrite.

5) The well must be located at least ¼ mile from nearby residences and/or quarter mile away from public roadways, transportation and drainage features. Permitting in existing populated areas, roads, waterways, buildings, and railways.

6) Contingency Planning

7) Formation depth- overlying & underlying rock

8) Brine well re-drilling on Facility is not allowed. No BWs within a municipality.

9) Cavity setback distance from 300 ft. from lease line- encroachment issues to mineral rights owners. Similar to recent Part 17 Siting Criteria; but greater distances. Cavity is eventual cavity size at closure. Life of mine issue?

10) NMOCD APD ½ mile AOR Internal Review of all new wells drilled near brine well locations

11) Relationship of secondary recovery techniques in the oil and gas industry relative to the sodium well failures. Upon arriving at the Loco Hills sinkhole, on the day of the collapse, noticed a Halliburton crew was fracturing an adjacent well. Concerns about fracturing within shallow oil fields just below the potash basin and ramifications to mine workings. Is there a relationship of breccia solution chimneys just south of the area and is there a connection?

CONSTRUCTION REQUIREMENTS

1) Brine wells need to be constructed with bigger borehole. Double string and cement to surface. Double tubing. No more single tubing. Double tubing w/ double tubing packer would work better. Put packer fluid in annulus monitored by external tank fluid level monitoring device. Problem casing size is too small to be BWs and not optimized to be BWs. Also, need dead oil roof layer.

2) Minimum logging requirements (logging to surface). State of the art dual tool cement bond log (internal bonding and external bonding to surface. Open hole log, gamma-ray log- standard suite (pick interbedding layers, i.e., anhydrite, salt, etc.). Temperature log accompanies gamma-ray log. Log suitable to pick water bearing formations. Know lithology and water. Standard SP may pick up water zones?

3) Must drill salt section w/ brine mud.

4) APDs to drill new Class III Wells on facilities with PA'd Brine Wells (i.e., dual string within one casing completions).

5) APD or C-103 conversion of O & G wells into BWs, internal AOR min. ½ mile around all BWs?

6) The top-of-salt section must be at least 1000 ft. bgl and salt section must be at least 500 ft. thick.

7) No conversions from oil & gas to Class III well unless well casing shoe is at least 100 ft. into the salt section. Double strings required?

8) At least 100 ft. of salt shall be present above any brine extraction cavern

9) Relationships to drilling & fracturing activities? AOR concept here?

OPERATIONAL REQUIREMENTS

1) Fresh water shall be injected down the annulus with brine extracted through tubing at all brine wells with casing shoes constructed at least 100 ft. into the salt section.

2) Operational wells with casing shoes near the top of the salt section shall inject brine water down the annulus to minimize dissolution of the roof of the salt cavern and shall inject dead oil (mineral oil, bunker oil, low gravity & no VOCs explosion concerns & not soluble in water) cap to minimize dissolution of the salt. These wells shall be sonar tested at a frequency determined from past sonar testing to monitor the potential for collapse and/or the operator may choose to PA the well.

3) On new brine wells with casing shoes set at least 100 ft. into the top of the salt section, the first sonar test shall be conducted on the 10th year of brine production and every 5 year thereafter. If the well casing shoe is set at the top of the salt section, then the frequency of sonar testing may be more frequent. Tie sonar logs to production limit rather than life of the well. Brine well cavities larger during beginning of production and decreases when they are larger due to the increased surface area.

4) When problems occur conducting a sonar test, the well must be drilled out with the largest bit size that can be run in the casing due to the salt section moving or there is build in the casing. Any bit size used must be run with a scraper. A gauge ring shall be run before the next bit run- Tim Gum BW-27 Sonar problem case study.

5) A well maturity status designation shall be declared upon obtaining a cavern roof radius of 150 ft maximum (safety factor) or a total volume of salt removed.

6) OCD shall place MIT Guidance on website for brine wells. NMOCD shall work to develop an automated reporting system for fresh water and brine production to facilitate more efficient method of reporting and to track operator reporting.

7) Drilling to emplace tubing to TD and encountering well problems, i.e., tubing hits ledge & kinks affecting the ability to sonar or log the well must be approved by the OCD for continued operation or to PA the well.

8) Seismic monitoring shall be required in addition to subsidence monitoring at locations where public health is threatened. Any surface movement may shut down BW operation?

9) Subsidence monitoring shall be required at all brine production wells

10) Ground water monitoring program, seasonal piezometric and hydraulic gradient monitoring.

CLOSURE REQUIREMENTS

1) Plug and abandonment method(s) (salt creep theory- theoretical)
Fill brine cavern up with brine water to stabilize cavern, scrape casing & cement from casing shoe to surface, install marker, and keep at least 50 psi of pressure on well at all times. Continue subsidence monitoring and/or seismic monitoring for at least ? years.

2) Plugging & abandonment (chemistry of fluid in cavity, oil or other impermeable layer on top of fluid in cavity- BLM comment.

3) Maximum allowable amount of salt removed from Fm. (max. allowable diameter for underground cavity as a function of depth).

4) 1 M ft^3/50 ft. overburden or 178,107.6 bbls./50 ft. overburden- Historical API Correspondence and/or Wayne Price's (OCD) Questionnaire Algorithm below:

Calculation: Please divide your estimated total volume of produced brine by 180,000 and multiply by 50. Example: If you have produced a total of 18,000,000 bbls of brine in the life time of the well then your calculation would be 18,000,000/180,000 = 100 x 50 = 5000.

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2) Similar issues w/ brine well collapse potential, i.e, thickness and depth to top of salt, well construction, conversion of conventional well into Class I slurry injection well, dissolution of salt, cavern size, etc.

OTHER WORK GROUP COMMENTS

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- Cavern monitoring through sonic surveys- Loren Moulleur
- Seismic monitoring for early detection of subsidence- Loren Moulleur
- How does the brine well issues apply to Class II hydrocarbon storage well discharge permits?- Western Refining L.P.
- Research that should be conducted to better evaluate the potential for collapses- George Veni
- Sources to fund study that we can match item with state funds or work in partnership w/ the state to max. results of efforts- George Veni