BW - __999__

GENERAL CORRESPONDENCE

BRINE WELL WORK GROUP

3/26/09 - Present

Operator: Salty Brine Inc.

Permit: No. 522854
Lease: Lease 68605

Activity: Class III Commercial Brine Mining
Location: Yoakum County
Wells: No. 3, 4, & 4A

Salty Brine Inc. Well Nos. 3, 4 and 4A were selected for review as a result of a sinkhole collapse which occurred in the summer of 2009. The sinkhole, which is located on the outskirts of Denver City, Texas, appears to be centered on brine Well No. 3. Well No. 3, originally drilled in 1958, mined brine from the Salado, a regional bedded salt formation approximately 2100' to 2800' below subsurface at that location. The base of useable quality water at the location is set at 375'. Well No. 3 initially began brine mining in 1974 (pre primacy). The current operator, Salty Brine Inc., acquired the well in 1984. In 1986 the Texas legislature transferred authority over Class III brine mining wells to the RRC from the Texas Natural Resource Conservation Commission (TNRCC). TNRCC has not yet permitted the well and the RRC kept it on inventory, issuing an interim permit with plans to issue a final permit after EPA's approval of the program transfer. However, in 1997, prior to Class III program approval, Well No. 3 suffered a casing collapse at approximately 700'. In July of that year, during plugging operations, Well No. 3 began venting natural gas at an estimated 25 thousand cubic feet per day (mcfd) between its long string casing and surface casing. A well bore diagram in the file suggests the cement along the 9 5/8" long string casing topped out at 1740', well below the base of the surface casing at 335' subsurface. This length of uncemented casing is the suspected avenue for the gas to reach the surface.

Well No. 3 was plugged up to 300' subsurface at that time. Efforts to identify the source of the gas were inconclusive. The RRC allowed the well to vent, flaring the gas to an open pit, in hope of depleting the water sand. It never depleted. Efforts to gain operator agreements to capture the gas for sale fell through and in February 2000 Well No. 3 was plugged from a depth of 295' to surface with all three casing strings remaining in the ground.

During this time period the operator reported brine mining on the lease continued through Well No. 4, which was authorized under the same permit as Well No. 3. Well No. 4 continued brine mining until July 2002 when it failed an MIT. Well No. 4 was shut in and plugged that following August. In October 2002 Well No. 4A, was constructed approximately 100 yards away from Well No. 3 and 50 feet from Well No. 4. Well No. 4A was completed with surface casing and long string set to 398' and 2150' respectively with both casings cemented to surface. Injection is through 4 ½"tubing hanging to a depth of 2468'. There is no packer. The application reflects fresh water is injected with a pressure not to exceed 1000 psi into the cavern and brine is produced up the tubing /casing annulus. MI is to be demonstrated annually by means of a hydrostatic fluid pressure test. Cavern size is limited to 1,300,000 barrels, a 300,000 barrel increase from the permit for Well Nos. 3 and 4 issued in 1997. Well No. 4A is completed into the same cavern as was mined by Well No. 4.

To protect USDWs there is a State and federal requirement to require a monitoring well at Class III brine mining facilities. Monthly sampling of the monitor well for specific conductance provides a warning system that salt may be entering fresh water zones due to injection. Should a brine mining monitoring well exceed a stated upper limit of specific conductance, the operator is required to cease injection immediately and notify the RRC. If the permittee demonstrates to the satisfaction of the Director that any changed detected is not the result of injection, the Director may authorize injection to continue.

Between 1986 and 1998, Salty Brine, Inc. sporadically reported the results of monthly ground water monitoring for conductance from monitoring wells (MWs) near brine Wells No. 3 and 4 and MWs 1 and 2 on an adjacent lease associated with two other brine wells. Records indicate all four monitoring wells were approximately 160' deep. From 1985 through 1993 Salty Brine, Inc. reported conductance only on MWs Nos. 1 and 2. At that time the RRC associated these MWs to brine Wells Nos. 3 and 4 respectively. The results were fairly consistent with conductance ranging from 1125 – 1145 μmhos, within the permitted limits. However, beginning in 1993 Salty Brine Inc. began reporting conductance for MWs Nos. 3 and 4. From the beginning, the conductance in MWs Nos. 3 and 4 were above the permitted upper limit. In 1993 the values ranged from 6800 to 9500 μmhos, eventually spiking to 192,000 μmhos in June of 1998. During that time span confusion developed as to which MWs were providing these results. In March 1998 the RRC concluded in a letter that while the RRC initially associated MW Nos. 1 and 2 with brine Wells Nos. 3 and 4, Salty Brine associated the MWs with brine Wells Nos. 1 and 2 of an adjacent lease. The RRC further concluded it was "likely the MW Nos.3 and 4 were impacted with brine before Salty Brine's ownership of the wells". Other correspondence in the record implied that a company called Vulcan Materials once occupied the location and that unlined pits in the area may be the source of brine in the area. The record implies as a result of this conclusion, the RRC allowed Well No. 4 to continue to inject until it developed MI problems in 2002.

The basis for this conclusion was not found in the record. In August 1998 a tally of the results from MWs 1, 2, 3, and 4 from 1986 to 1998 was compiled. The compilation reveals that the monitoring results at brine Wells Nos. 3 and 4, which began to be reported in 1993, exceeded the permit's conductance upper limit from the outset. Further the conductance had increased into the 33,000 μmhos range and had plateaud until June of 1998 when it spiked to 192,000 μmhos.

This review can make no definitive conclusion regarding the cause of the sinkhole centered around brine Well No. 3, but some theories can be offered. Sinkholes form when the structural integrity of the overburden is overcome by stress due to gravity. The integrity of the overburden is a function of many factors. Of primary influence is the span of the cavern roof and its structural integrity. The depth of the salt cavern mined by Well No. 3 is relatively deep (2150') compared to many other such mining operations in this Region. The overburden is largely alluvium, providing reduced resistance to shear forces. Sinkholes appearing at the surface from deep cavern collapse may be created as a result of a domino effect, layer-by-layer cavern roof collapse, eventually reaching the surface. These types of collapses are well documented and the resulting debris column is referred to as the chimney. The shear walled appearance of the sinkhole at the surface shortly after its appearance on the surface would appear to support a well formed columnar style collapse.

Another observation is the possibility brine Well No. 3 may have played a key role in diminishing the integrity of the cavern roof. None of the permits found in the record specified a circulation scheme. Injection of fresh water through the tubing-casing annulus maximizes dissolution at the casing shoe. This condition was found to be a potential contributor to cavern collapse at brine wells mining the Salado formation in New Mexico. The record indicates that fresh water injection through the tubing-casing annulus may be an option. Although a wellbore diagram indicates injection through tubing hung into the salt formation. However, in what appears to be an applicant record for calculating the allowable injection pressure for the most recently permitted Well No. 4A, the tubing depth for the calculation was set equal to the depth of the casing shoe. The subsequent use of the hydrostatic pressure of fresh water at that depth implies fresh water will be injected into the cavern at the casing shoe.

Well No. 3's casing was clearly visible and nearly center of the sinkhole. The record shows the casing collapsed at approximately 700' in 1997. Casing collapse may be caused by compaction forces and aging pipe. If a cavern roof's span remains essentially constant as roof collapse travels up the chimney, compaction stresses increase as the height of cavern roof is diminished. It is feasible increasing horizontal stresses due to a collapsing cavern roof may have been the cause for the casing collapse in 1997. Gas, venting from within the well's outer casing annulus at significant and sustained rate is also an indication that an avenue, such as offered by an unconsolidated debris chimney, began feeding the vent from deeper gas bearing zones. It is also feasible that the continued migration of gas next to and through the well's tubulars further weakened the overburden until the well was plugged to surface in 2000.

In summary, there are numerous significant concerns revealed in this review that may have attributed to the formation of the sinkhole. The increasing salinity found in the monitoring wells would appear to indicate containment of injected fluids within the Salado formation was not occurring. The circulation scheme is not dictated in the permit and therefore can be conducted in a manner detrimental to cavern roof integrity. The casing collapse of Well No. 3 may be an indication that the cavern roof was deteriorating as was the gas production between the long string casing and surface casing.

In response to a review of a draft of this report, the RRC has provided the following response and a letter dated July 6, 2010 requesting the operator provide records describing: the cumulative volumes of brine produced from Well Nos. 3 and 4, the reason for plugging Well No. 4, records demonstrating whether or not Well No. 4A encountered the cavern created by mining in Well No. 4 and the results of a sonar caliper survey of the open hole interval in Well No. 4. Salty Brine Inc. has recently responded to the request providing they had no record of volumes produced by Wells No. 3 and 4, Well No. 4 was plugged due to junk in the hole, Well No. 4A does encounter the cavern created by Well No. 4 and the results of a sonar survey of that cavern. That sonar survey reflects a flat roof in the immediate vicinity of the well bore penetration into the Salado indicating total dissolution of the salt at the top of the cavern. The RRC provides the estimated cavern volume to be approximately 885,000 bbls.

The RRC response

Although staff do not dispute that the operation of Well No. 3 ultimately led to the development of the sinkhole, unfortunately – the information necessary to diagnose exactly what those operations were, and how they ultimately led to sinkhole development, does not exist because those operations occurred so long ago. However, staff believes the most plausible explanation is that the cavern developed while Vulcan Chemicals operated the well was much larger than the typical Salado salt cavern in Texas. Vulcan operated the cavern for over 20 years to produce saturated brine as plant feed stock in a Chlor-alkali process at its nearby plant. All of these operations occurred prior to the RRC primacy and the Vulcan operations occurred prior to the RRC having even state jurisdiction over brine mining.

Salty Brine took over operation of the well in the 1980's but it is unreasonable to assume that Salty Brine would have substantially enlarged the cavern while generating brine for drilling and workover operations as compared to rates likely generated by Vulcan in its Chlor-alkali process. Nevertheless, Salty Brine's records also do not exist because the well was plugged 10 years before the sinkhole occurred.

Similarly, the fact that Well No. 3 is known to have had a casing failure at around 700 feet deep or less, and ultimately was plugged to a depth of only about 300 feet, when the nominal mining elevation was much deeper could be an indication that dissolution of much shallower evaporates had been occurring for a extended period of time before the gas venting problems manifested themselves. The sinkholes that occurred during 2009 in New Mexico are attributed to brine mining at much shallower elevations than typically occurs in Texas.

Because of the relative hazard presented by the gas venting, Commission staff focused their efforts on this issue rather than the casing defect in Well No. 3. Commission staff believed there was a possible connection between the two and that casing head gas from a casing leak in an offset producing well was likely migrating through the Ogallala aquifer and venting through the bradenhead of Well No. 3. So the well was allowed to continue venting gas in a controlled manner while the offset casing leak scenario was investigated. No obvious connection was ever identified, so Well No. 3 was eventually plugged – albeit in a manner that left much unknown about the condition of the casing and subsurface below the deepest plug. Again, practically all operations that could be attributable to whatever led to the sinkhole, occurred before there were any applicable state regulations.

Staff disagrees with EPA's conclusions concerning the water quality monitoring. There was historically inconsistent water quality monitoring efforts in this area. It has been well-documented that the groundwater has been impacted by historic oil field operations and continuing to receive the water quality data enables a means of monitoring the abatement of these pre-primacy impacts.

Moreover, the elevated salinity in the baseline value for the permit granted to Well 4A was established based on Staff's knowledge that historic evaporation pits had impacted the Ogallala in this immediate vicinity that had been operated both by Vulcan and the oil and gas producers in the area. As the monitor wells were the same wells used as a source of "freshwater" for brine production, continuing to monitor the quality of the produced water also served as a means of "remediating" the impacted groundwater.

Section 6 Recommendations

Salty Brine

In reviewing the files on the Salty Brine operation in Denver City several findings are notable. Permit conditions protecting the cavern roof in Well No 4A would be prudent. These would include defining a circulation scheme in the permit that would prohibit or minimize the opportunity for dissolution to occur at the cavern roof. Another recommendation would be to require a protective layer such as a diesel blanket in the permit to protect the cavern roof from further dissolution. Both of these concerns appear to have contributed to the weakening of the cavern roofs that collapsed in New Mexico.

In addition the review found significant concern with the manner in which the monitoring wells were being utilized. Acknowledging the historical activities impacting ground water quality prior to the RRC's involvement, the actions with respect to the monitoring well results for brine Wells Nos. 3 and 4 are questionable. The upper limit for conductance of 1300μmhos in the permit issued in 1986 and reissued again in 1997, for both Wells Nos. 3 and 4, was exceeded regularly beginning in 1993. The permit condition specifies that should the upper limit be exceeded, the operator is to cease injection and seek approval of a plan to fix the problem and restore the ground water. However, the permit also allows that if the operator demonstrates to the satisfaction of the Director that the change in water quality is not the result of the injection, the Director may authorize the operator to resume injection. As previously discussed, in 1998, a conclusion that the chlorides present in the analyses predates the activities of Salty Brine Inc. apparently justified continuation of injection into brine Well No. 4. That conclusion also appears to have justified the issuance of a new permit for its replacement, Well No. 4A, in 2004. In the most recent permit the lower limit value for specific conductance in the 2004 permit is placed at 44,300 μmhos and sets an upper limit of 55,400 μmhos. The lower limit indicates an approximate equivalent to 22,150 ppm TDS, well above the 10,000 TDS used to identify the base of all USDWs. Well No. 4A currently produces approximately 40,000 barrels of brine a month. Monthly monitoring results from Well No. 4A's MW in 2006 – 2008 reflect conductance values ranging from 17,890 – 43,500 μmhos. Moving the limits for monitoring ground water quality to above that necessary to protect water quality defeats the purpose of the monitoring well.

The RRC requires annual mechanical integrity testing of their Class III brine wells. This exceeds the federal five year requirement. Throughout this extensive file review, records on MITs were found intermittently. Compliance with the annual requirement could not be determined. The Class III program is not computer based at this time, but is managed manually. This has likely had an impact of the program's ability to track and enforce it's permit and program requirements. The RRC is encouraged to expedite the incorporation of its Class III brine mining program into the main frame computer program used to administer the Class II program.

Chavez, Carl J, EMNRD

From: john.o.voigt@gmail.com
Sent: Wednesday, October 07, 2009 10:49 AM
To: Chavez, Carl J, EMNRD
Subject: 2009 SMRI Research survey results
Attachments: 2009_SMRI_Research_quest_results.pdf

Dear Carl_Chavez,

Research Coordinator Gérard Durup has collected and compiled the results of the 2009 SMRI research needs questionnaires many of you completed. We thank those of you for helping determine the research subject priorities that are important to you and your industry, and for helping Gérard and the Research Committee focus attention on subjects of greatest importance.

The pdf file of the survey results is attached, but is also available on the website at http://www.solutionmining.org/smri.cfm?a=cms,c,12,3

Other items of importance:

e-mail vote by member representatives will be during November, to handle several items, such as approving the 2010 budget, approving Joe Ratigan as 2010 Secretary Treasurer, possibly a research project vote addressing RFP 2009-1 (proposals are due 15 October, to Gérard), and approval of a By-laws change to create a new member class for government regulators(with zero dues and no vote).

More to come later, and your new SMRI website is progressing, slower than I'd prefer, but looking like late October testing and November start-up.

Have a great October,
...John

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Sent Via Solution Mining Research Institute's Website http://www.solutionmining.org/

SOLUTION MINING RESEARCH INSTITUTE
www.solutionmining.org

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To: **SMRI Membership**

C/: **SMRI 2009 Research Committee Members**
Jeff Langinais
Fritz Wilke
Jeff McCartney
Paul Grönefeld
Ron Benefield
Patrick De Laguerie

From: Gérard Durup
SMRI Research Coordinator

Date: October 07, 2009

Subject: Results of the 2009 SMRI Research Priorities Survey

In 2003 and 2005, the SMRI sent out the first written questionnaires regarding research priorities to SMRI members and industry representatives. In spring 2009, the SMRI sent out another survey questionnaire to individuals on the SMRI mailing list. Thirty-two responses to the questionnaire were received, compared to about 40 responses in the previous surveys. All of the responses received this time were exclusively from SMRI member companies.

The purpose of this memorandum is to summarize the 2009 questionnaire responses and to provide some recommendations relative to the responses.

Who responded to the questionnaire?

All the responses were SMRI members. Some of the questionnaire respondents were involved in more than one line of business. However, approximately 50% of the respondents were in the hydrocarbon storage business, 35% were involved with solution mining, and the remainder was engineering company employees or researchers. Compared to previous surveys, the percentage of respondents from the storage business increased in 2009 by about 10%.

Of the questionnaire respondents with storage or mining operations, approximately 50% had operations in bedded deposits and 50% had operations in salt domes. Some respondents had operations in both domes and bedded deposits. The number of respondents in each category is quite consistent with the previous survey responses.

How did the questionnaire respondents feel the SMRI was performing?

Generally speaking, the respondents appear to be pleased with the SMRI research performance. The results of the 2009 survey as well as the two previous surveys are summarized in Figure 1. In the areas where the SMRI scored extremely well in 2005, the 2009 scores have remained very high (equal scores or almost as high). I think it is important to note that the respondents have very consistently since 2003 the same feeling that the SMRI does not issue too many RFPs. In my opinion that means that they would like to see more SMRI projects. This would require less money per project or more money for all project funding. It might be interesting to determine if the membership would be willing to increase dues so as to fund more research.

The category "Research results are easy to access" was not as high as it should be, and SMRI is currently developing our new website to improve substantially research and paper member search and access.

How did the questionnaire respondents prioritize future research areas?

The ranking priority assigned by the 2009 questionnaire respondents is summarized in Figure 2. It is encouraging that the respondents still ranked abandonment as highest, as that is where we have been spending most of our research funds over recent years. Fields of clearly stronger interest compared to previous surveys are (1) simulation capabilities for leaching bedded salt, (2) drilling, completion, workovers, and (3) behavior of tubulars. In spring 2009, the membership approved a research contract to better understand the deformation of hanging tubulars in caverns.

What specific research projects were suggested by the questionnaire respondents?

In 2009, the respondents listed 50 specific research topics, compared to about 65 specific research interests noted in the previous surveys. Some of the research topics have already been undertaken and some of the suggested topics have overlap and/or are near duplicates from another respondent. Table 1 provides a categorized listing of the specific research topics noted by the questionnaire responders.

Table 1. Research Topics Suggested by Respondents to the 2009 SMRI Questionnaire

Topic Category	Suggested Topic
Logging	Software for interpreting various logs
	Definition of cavern shapes with external geophysics
Salt Mechanics	More domal salt geomechanics (the geomechanics is well documented, but geological variation may be a limiting aspect)
	Coupling of cavern mechanics, thermodynamics and hydraulics
	Control of cavern convergence
	Creep vs. high insoluble content
	Salt micro-permeability
	Comprehension of subsidence-induced stresses at casing shoe (2x)
Gas Storage	Software for cavern thermodynamics
	Safe design of high-frequency cycled caverns
	Economics of high frequency cycling of caverns
	Thermodynamics of high frequency cycling
	Use of bedded salt caverns for gas storage
	Improved gas cavern operations
	Hydrate-blocking kinetics
	Effects of thermally induced pressure differentials
	Gas cavern MIT evaluation
Cavern/Well Lifetime Studies	Determination of the long-term evolution of casing cementations
	Increasing the long-term reliability of cementations
Standards	Report summary in German
Safety and Rick Assessment	Long term effects of subsidence
	Safe abandonment of deep caverns
	Development of safe cavern abandonment procedures
	Plugging of big diameter cavern necks
	Cavern abandonment manual
	Behavior of last casing and its cementation
Site Characterization	Software for geological modeling of salt structures
	Improved salt characterization
	High resolution geophysics for geologic detail
Practical Technologies	Control of the vibration of hanging tubulars
	Software for well and cavern planning
	More friendly SMRI website
	Development of new cavern utilizations (2x)
	Development of offshore cavern utilizations
	Corrosion control of cavern tubulars

	Continued development of TOOLBOX
	Energy storage in caverns
	CO2 storage in caverns
	Metallurgy of valves
	Behavior of packers under cyclic loadings
	Drilling, completions, workovers
Solution Mining	Blanket medium controlling technology (2x)
	Improved solution mining simulations
	Brine disposal technology
	Effects of calcium sulfate on leaching strings
	Case histories of bedded salt caverns
	Optimization of cavern design
	New solution mining techniques

Figure 1. Summary of Survey Respondents' Rating of SMRI Performance

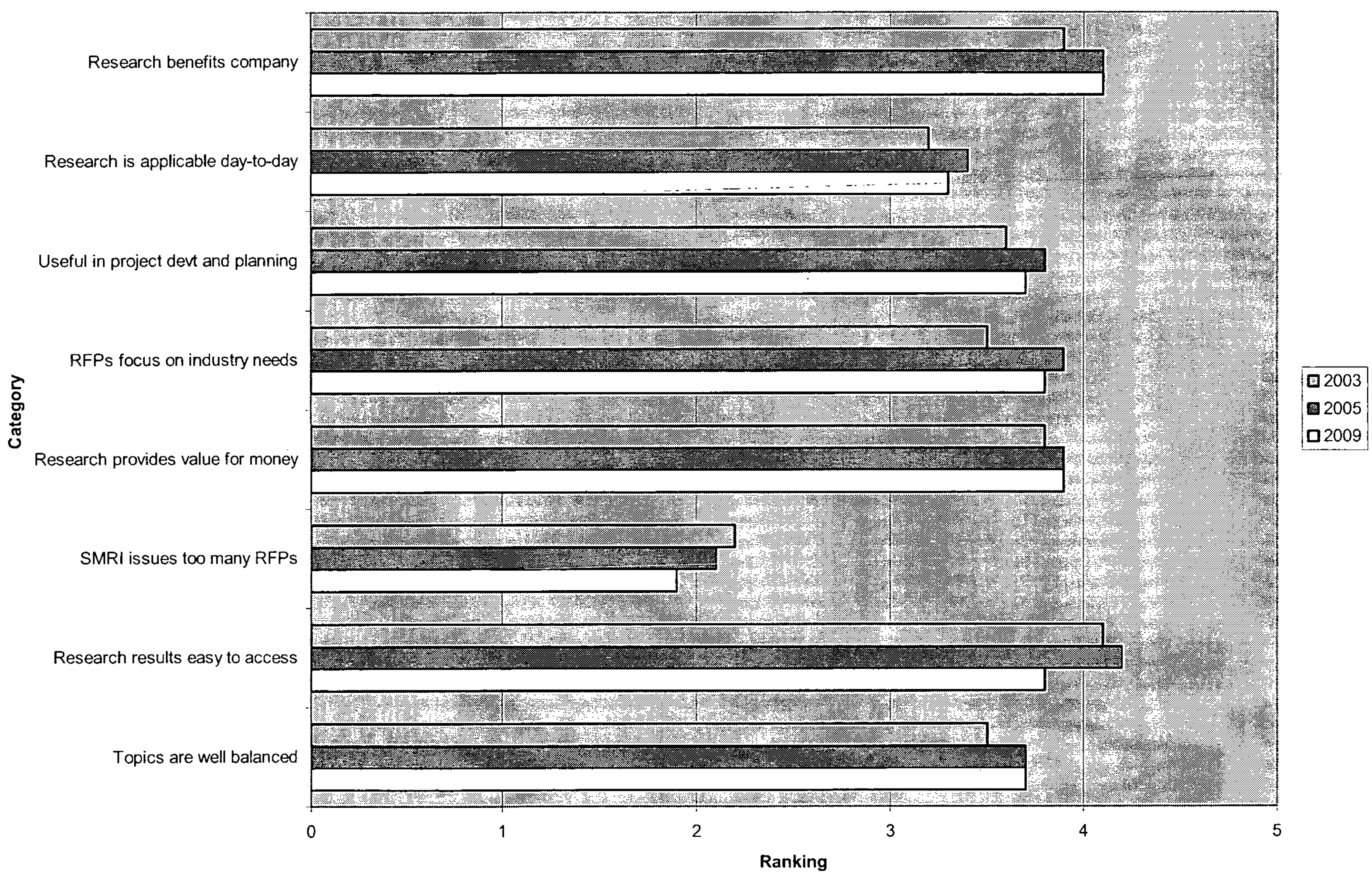
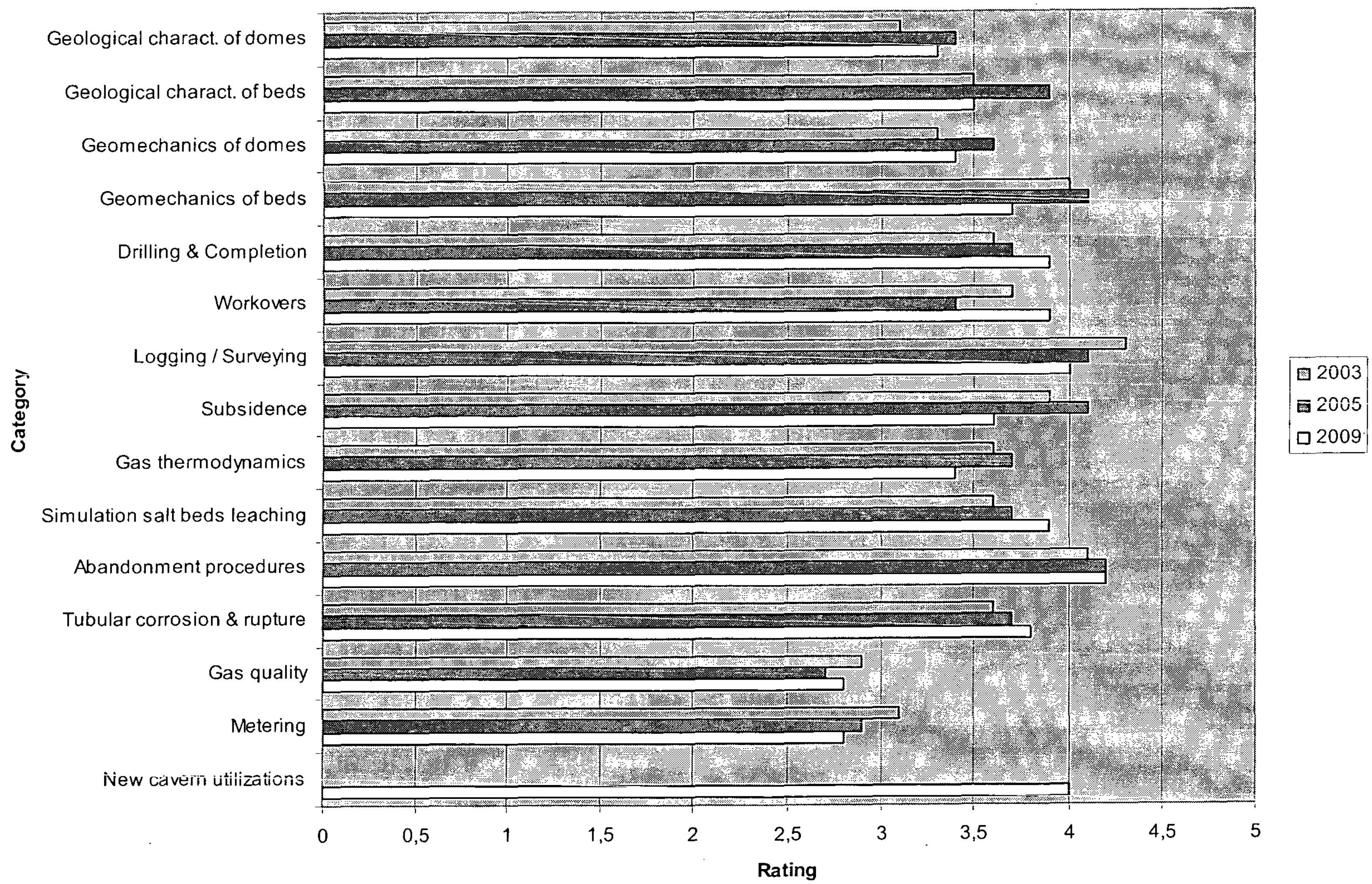


Figure 2. Summary of Survey Respondents' Ranking of Research Priorities



UNITED STATES ENVIRONMENTAL PROTECTION AGENCY
REGION 6
1445 ROSS AVENUE, SUITE 1200
DALLAS, TX 75202-2733

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JUL 23 2009

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Ms. Joanna Prukop
Secretary
Energy, Minerals and Natural Resources Department
1220 South St. Francis Drive
Santa Fe, NM 87505

Dear Ms. Prukop:

This letter is in reference to the recently released Brine Well Collapse Evaluation Report issued by the Oil Conservation Division. We believe the report provides valuable recommendations to prevent sinkholes in the future. The Environmental Protection Agency (EPA), Region 6 wishes to thank the OCD for the opportunity to participate in the workgroup organized to develop the report and your staff's efforts in compiling it's findings and recommendations. The records made available to the workgroup by OCD gave us opportunity to review the UIC program's administration for the wells in question. It is from this review and the report that we wish to provide recommendations.

The report holds several recommendations we think prudent in the prevention of any more collapses. The report recommends a risk assessment for collapse potential for all current and former brine wells. This assessment would utilize the workgroup's findings that collapse is unlikely in caverns whose roof span does not remotely approach a two-thirds ratio between maximum span and depth of overburden. In order to assure that the program does not allow a cavern to remotely approach this threshold we support the report's suggestion that the roof span to depth threshold ratio for limiting solution mining activity be set at one-half. Further, by defining a one-half ratio threshold in the regulations, NMOCD would be setting a clear, definable and enforceable requirement, preventing caverns from remotely approaching the two-thirds ratio associated with the potential for collapse.

The report also recommends that operators propose criteria for determining when production must be altered or stopped. We agree operators should provide any criteria they wish to propose. We suggest that any criteria, utilized by the State for periodically determining a brine well's remaining viable lifespan, be incorporated as permit conditions. Diligently followed and enforced, such permit conditions should be effective in providing the margin of safety discussed above.

The report recognizes an incomplete record for production activity exists for the two brine well operations that resulted in sinkholes and for the brine well in Carlsbad. A similar record deficit appears to exist for appropriate and periodic cavern delineation.

This lack of critical information prevents timely characterization of the caverns' configurations. The Region recommends emphasis be placed on the management of all records required to be periodically reported by brine well operators for compliance purposes.

The report includes many of the good technical recommendations made by the workgroup, but not all. For instance the report identifies using permit modification to reverse flow in current mining operations and implementing requirements such as a diesel blanket or pad to prevent dissolution from the top of the cavern. These are good. The report was unclear if consideration will be given to require new brine wells to allow a salt back or salt layer to remain between the dissolutioned salt cavern roof and the overlying overburden. We understand 50' – 100' salt back requirements are practiced elsewhere in the country and are widely accepted as protecting the bottom of the overburden from erosional effects of circulating water.

I hope you find these comments beneficial in your efforts to improve New Mexico's Class III brine mining program. As the report acknowledges, the NM UIC program is approved by EPA. The federal Class III UIC program protects underground sources of drinking water (USDW) from contamination due to injection. The program was not designed to provide requirements for the prevention of surface collapse, although such events impact USDWs. Therefore, these recommendations are for your consideration. Region 6 stands ready to assist you in your efforts. Should you or your staff have any questions or wish to discuss this matter further, please contact me or Mr. Larry Wright, Associate Director for Drinking Water and Ground Water Protection at (214) 665-7150.

Sincerely yours,

Bill Luthans

Bill Luthans
Acting Director
Water Quality Protection Division

cc: Mark Fesmire, NMOCD
Daniel Sanchez, NMOCD
Carl Chavez, NMOCD

Chavez, Carl J, EMNRD

From: john.o.voigt@gmail.com
Sent: Thursday, July 23, 2009 11:15 PM
To: Chavez, Carl J, EMNRD
Subject: New Research Report and New RFP
Attachments: SMRI_RFP2009-1_Aban_Shal_Cav.pdf

Dear Carl_Chavez,

Hello SMRI members,

I hope your summer is going well and has included some well-earned vacation time. We have 2 major research items and general news for you:

1) COMPLETED RESEARCH REPORT is available for you (logged in members only) to download from SMRI website. RR2009-01 "Stassfurt Shallow Cavern Abandonment Field Tests" by ESK RWE, Bannach and Klafki, was posted 23 July 2009 for SMRI member download. PDF is 77 pages, file is about 2 MB, too large to send as an attachment.
TO DOWNLOAD from website, go to Research, Latest Research, then scroll to bottom of page, click on file.

2) NEW RFP: Gérard Durup and the Research Committee have issued the attached Request for Proposal (RFP 2009-1) to Synthesize the SMRI sponsored research to date on Shallow Cavern Abandonment Tests. If you cannot receive the attached file and are interested, please go to the Research page and scroll to bottom of page, select the RFP file. Please direct questions to Gérard at gerardd@solutionmining.org and remember that proposals are due 31 August 2009.

World Salt 2009 is coming together nicely for Beijing, all authors should have received verification and a schedule by now. If not contact info@worldsalt2009.com quickly.

The new SMRI website is finally coming together, with new project manager KeyTech Group... I sure hope you will find it was worth waiting for!!!

Best regards,
...John

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Sent Via Solution Mining Research Institute's Website http://www.solutionmining.org/

SOLUTION MINING RESEARCH INSTITUTE
www.solutionmining.org

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Gérard Durup, Research Coordinator
July 13, 2009

Request for Proposals
RFP 2009-1 for a
Synthesis of SMRI sponsored Shallow Cavern Abandonment Tests

Background

The Solution Mining Research Institute (SMRI) has developed a major, multi-project research program addressing Cavern Sealing and Abandonment of solution-mined caverns in salt formations. Several research reports are already available on the SMRI website. The SMRI research program concluded that for many caverns, abandonment and sealing could be accomplished effectively provided (1) the temperature of the cavern brine rises to a level reasonably near the pre-mining salt temperature and (2) the salt formation has adequate micro-permeability properties to relieve subsequent brine pressure increases associated with salt creep and residual thermal effects.

To further advance the understanding of the technical aspects of the process and to validate the research program results, the SMRI has sponsored a number of in-situ abandonment field tests, both in shallow and deep (over 1000 m) caverns, and in various rock salt formations.

The testing in deep caverns will be still ongoing for some more years, but the testing effort on shallow caverns has been completed on Etrez, Carresse and Stassfurt cavern sites. SMRI is solicitating a report which will collect and interpret the data from all the shallow cavern field tests and research reports which have been completed to date. Completion of the deep cavern testing and results will be several years ahead, and is not part of this RFP.

Scope of Work

The SMRI is soliciting proposals to perform a general synthesis of the shallow cavern abandonment field tests that it has sponsored. The synthesis will include a thorough analysis of all the SMRI published research reports relative to the Etrez, Carresse and Stassfurt abandonment field tests. Below is a list of the research reports to be included; proposals should include a list of major, additional references that will be analysed during the proposed work.

The scope of work does not require that all the computations and simulations performed in the research reports need to be necessarily re-calculated.

The party submitting a selected proposal and awarded a contract in response to this RFP will develop a draft document for review and comment by the SMRI Research Committee and Leadership and other SMRI members selected by the Research Coordinator. Following receipt of comments, a final version of the document will be finalized and submitted to the SMRI.

Proposal Instructions

Respondents to this RFP should provide a reasonably brief proposal (less than 7 pages) describing the proposed effort, a specific discussion of the technical approach, the project schedule, the project cost, and the proposer's qualifications for executing the effort.

Proposals should include an option for presenting semi-annual progress reports and final project results to the SMRI membership at future SMRI meetings. Proposals should clearly state the cost for performing the proposed work and a separate cost for the presentations noted. Proposals should be submitted in electronic form via email to Gérard Durup (gerardd@solutionmining.org), SMRI Research Coordinator, by 5 PM (EST) August 31, 2009. Any questions relating to the RFP should be directed in writing, (e-mail is OK,) to Mr. Durup, the SMRI Research Coordinator. The SMRI will follow established procedures to review proposals and determine those proposal(s) to be chosen.

Contract Award

The SMRI expects to award one or more fixed price contracts for this effort on or before October 31, 2009 if an acceptable proposal(s) is submitted.

The contract(s) will require submittal of a draft report on a date to be supplied in the proposal. The SMRI will provide comments on the draft report within four weeks, and a final report responding to the review comments will be due within four weeks following receipt of the SMRI comments on the draft report. The SMRI prefers to pay for the contracted effort in one payment following acceptance of the final report.

Relevant SMRI Research Reports:

1998-4 Berest, Long-Term Evolution of a Sealed Cavern, Etrez.

1998-5 Staudtmeister, Pressure build-up in the Etzel Cavern.

2003-3 Ratigan, Summary Report- The SMRI Cavern Sealing and Abandonment Program 1996 Through 2002.

2006-1 Brouard, Carresse SPR-2 final report, cavern abandonment field testing.

2009-1 ESK – RWE, Shallow Cavern Abandonment testing at Stassfurt.

Chavez, Carl J, EMNRD

From:	Chavez, Carl J, EMNRD
Sent:	Tuesday, July 21, 2009 2:19 PM
To:	'Leissner.Ray@epamail.epa.gov'
Cc:	VonGonten, Glenn, EMNRD; Griswold, Jim, EMNRD; Sanchez, Daniel J., EMNRD
Subject:	RE: Use of Tires as erosion control with ground water monitoring

Thanks Ray. This is yet another option to consider for filling up the collapsed caverns as a beneficial use, reuse and recycling option. Yeah, I saw this application be done on roadway projects in Michigan and worked quite well. Thank you.

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E-mail: CarlJ.Chavez@state.nm.us
Website: http://www.emnrd.state.nm.us/ocd/index.htm
(Pollution Prevention Guidance is under "Publications")

From: Leissner.Ray@epamail.epa.gov [mailto:Leissner.Ray@epamail.epa.gov]
Sent: Tuesday, July 21, 2009 1:56 PM
To: Chavez, Carl J, EMNRD
Subject: Fw: Use of Tires as erosion control with ground water monitoring

Carl,

Our Branch Chief invites personnel from other programs to come give a talk at our branch meetings. Its a good way to see the other programs EPA has. Today we had a speaker on the tire issues along the U. S. / Mexico border. It suffices to say there are a lot of used tires in huge piles along both sides of the border that EPA is trying to deal with. Even though they are used as fuel in cement kilns, and for rubberized asphalt, what to do with them is still an issue as there are millions of them. Well later I joked that perhaps used tires could be used to fill the sinkholes in NM. Phil thought perhaps shredded tires could help fill the Carlsbad cavern. A co-worker who has dealt with used tire piles for a state agency provided the report below that indicates shredded tires mixed with soil and used to construct an experimental embankment for a state highway, were not all that bad for GW. I don't know if ya'll are still looking at ways to fill these things but there may be some feasibility in this idea. It seems like a better place for them than in piles on the surface.

Ray Leissner, Env. Eng.
Ground Water / UIC Section (6WQ-SG)
(214) 665 - 7183
USEPA, Region 6

----- Forwarded by Ray Leissner/R6/USEPA/US on 07/21/2009 02:19 PM -----

Use of Tires as erosion control with ground water monitoring

Ken-E Johnson to: Ray Leissner, Philip Dellinger 07/21/2009 12:37 PM

Look at the ground water issues from this project http://www.vdot.virginia.gov/vtrc/main/online_reports/pdf/04-r20.pdf

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6WQ-SG
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Chavez, Carl J, EMNRD

From: Mark Cartwright [mcartwright@unitedbrine.com]
Sent: Monday, April 27, 2009 6:10 AM
To: Chavez, Carl J, EMNRD
Cc: Allen.Hains@wnr.com; balch@prrc.nmt.edu; Olson, Bill, NMENV; Jones, Brad A., EMNRD; byrum.charles@epa.gov; Chavez, Carl J, EMNRD; cgherri@sandia.gov; Sanchez, Daniel J., EMNRD; dave.hughes@wipp.ws; david_herrell@blm.gov; douglas.johnson@rrc.state.tx.us; dwpowers@evaporites.com; dwsnow@lotusllc.com; gary.wallace@crihobbs.com; VonGonten, Glenn, EMNRD; grkirke@sandia.gov; gveni@nckri.org; hugh.harvey@intrepidpotash.com; James_Rutley@blm.gov; jhand@kdhe.state.ks.us; Griswold, Jim, EMNRD; joeb@dnr.state.la.us; Hall, John, NMENV; jvoigt@solutionmining.org; kdavis@subsurfacegroup.com; ken.parker@wnr.com; khoeffner@kdheks.gov; Leissner.Ray@epamail.epa.gov; leo.vansambeek@respec.com; lland@gis.nmt.edu; lmolleur@keyenergy.com; lyn.sockwell@basicenergyservices.com; mcochran@kdheks.gov; psbriggs@gw.dec.state.ny.us; reitze@socon.com; RichardM@intrepidpotash.com; rlbeauh@sandia.gov; Ron.Weaver@wnr.com; Kostrubala, Thaddeus; Veronica.Waldram@wipp.ws; reitze@socon.com; v.tryller@socon.com
Subject: Re: FW: UIC Class III Brine Evaluation Work Group Draft Report Attached
Attachments: filltechniquediag.pdf

Greetings Carl -

With regard to the options OCD has identified for addressing the Carlsbad situation, I believe the first two are most attractive. The first phase must include steps to characterize the cavern and overburden. You should be aware of a technique which may have some value in this process. I am currently attending the SMRI conference in Krakow, Poland, and after describing conditions in New Mexico to the Executive Committee, I was approached by Dr. Hartmut von Tryller, the owner of Socon. Hartmut told of a technique used early in his career, (with caverns approximately 600 meters below the surface) for characterizing cavern dimensions where conventional sonar techniques were not possible. This technique involved induced current in the brine of a cavern and the use of surface equipment for delineating the boundary between the brine, (cavern) and surrounding bedrock. Although not completely precise, this method was effective at roughly delineating the maximum diameter of a shallow cavern. I am including Dr. Harmut and his principal, Dr. Reitze, in this email. Perhaps you can contact either of these men for more information.

Regards,
Mark

"Chavez, Carl J, EMNRD" <CarlJ.Chavez@state.nm.us>

04/24/2009 12:11 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" <brad.a.jones@state.nm.us>, "Chavez, Carl J, EMNRD" <CarlJ.Chavez@state.nm.us>, "VonGonten, Glenn, EMNRD" <Glenn.VonGonten@state.nm.us>, "Griswold, Jim, EMNRD" <Jim.Griswold@state.nm.us>, "Kostrubala, Thaddeus" <tkostrubala@slo.state.nm.us>, <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>, "Sanchez, Daniel J., EMNRD" <daniel.sanchez@state.nm.us>

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" <john.hall@state.nm.us>, "Olson, Bill, NMENV" <bill.olson@state.nm.us>, <kdavis@subsurfacegroup.com>
Subject FW: UIC Class III Brine Evaluation Work Group Draft Report Attached

Thanks Richard.

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Website: http://www.emnrd.state.nm.us/ocd/index.htm
(Pollution Prevention Guidance is under "Publications")

From: Richard Miller [mailto:RichardM@intrepidpotash.com]
Sent: Friday, April 24, 2009 11:08 AM
To: Chavez, Carl J, EMNRD
Subject: RE: UIC Class III Brine Evaluation Work Group Draft Report Attached

Carl,

My vote is for #2) below. Solid salt deposited by pumped slurry into this cavern will settle and adhere into a near solid but porous brick that will provide compressive strength to minimize collapse. The strength of salt mass can be observed at our tails piles in various locations.

The fill technique diagram proposed by others (and attached here) seems like a feasible method. Depending upon evaluation of recent sonar surveys multiple wells may be necessary for adequate cavern fill.

Richard Miller

Please note our new address as of March 16, 2009
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303-296-3006
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From: Chavez, Carl J, EMNRD [mailto:CarlJ.Chavez@state.nm.us]
Sent: Monday, April 20, 2009 6:10 PM
To: Chavez, Carl J, EMNRD; James_Rutley@blm.gov; byrum.charles@epa.gov; Leissner.Ray@epamail.epa.gov; Hugh Harvey; lmolleur@keyenergy.com; gveni@nckri.org; Jones, Brad A., 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; Richard Miller; cgherri@sandia.gov; dwsnow@lotusllc.com; lyn.sockwell@basicenergyservices.com; dwpowers@evaporites.com; Sanchez, Daniel J., EMNRD
Cc: jhand@kdhe.state.ks.us; khoeffner@kdheks.gov; mcochran@kdheks.gov; jvoigt@solutionmining.org;

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Subject: RE: UIC Class III Brine Evaluation Work Group Draft Report Attached

Ladies and Gentlemen:

Please find attached a copy of the Microsoft Word draft report. The report is still in very rough draft form as the OCD attempted to capture the essence of the comments recorded in the Brine Strategy Document from March 27, 2009. The OCD attempted to capture the Work Group comments in the recommendations for a path forward section near the end of the report. The OCD will ultimately have to comb over the sections to refine, add and/or delete items for the final report.

The OCD notices that there was some concepts and ideas sent in e-mails for a solution to the I&W Brine Well #6 problem in Carlsbad and your final input would be appreciated for finding a solution to this problem. Although the solution appears to be on a fast track with the Office of Homeland Security, OCD, DOT, and other stakeholders in the area, I think the Work Group should chime in with recommendations at this point on a possible solution or you could cast a vote on the solutions *below?. The solutions proposed thus far appear to be:*

1) Restrict access as it could collapse at any moment, implement monitoring (laser level on well head, could include re-drilling into abandoned well to monitor fluid level and keep cavern filled), create safe zone in area (remove persons or businesses if necessary), and work on contingency plan for if and when well collapses. Could sink $5 Million into project and could collapse anyway....?
2) Pipe in salt waste slurry from Intrepid Potash at nominal fee per bbl. (~ 1 Million barrels) to fill salt cavern or via rail cars or trucks.
3) Induce collapse of cavern and fill up with solids, including special polymers, cement, etc. using heavy earth moving equipment?
4) EPA *proposal to drill wells into bottom of cavern, seek operator to manage the injection of acceptable oilfield non-*hazardous wastes (i.e., BLM tailings, salt wastes from potash companies, drill cuttings, slurry sand, solids, etc.) into cavern over long-term.
5) Salt bath steam concept from bottom to top of cavern?
6) Other?

The OCD looks forward to your comments. Please save the document under your name and track changes if you wish to send it back with your comments. The OCD requests your comments by COB this Friday, April 24, 2009 or sooner if possible. The OCD will issue one last draft on COB Tuesday April 28, 2009. The above dates are tentative, but we hope to give you a chance to comment before issuing the final report, which you will be copied on to the Secretary of the EMNRD. Yes, it appears that the report is to the Secretary and not the Oil Conservation Commission.

Please contact me if you have questions. Thank you.

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Oil Conservation Division, Environmental Bureau
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Office: (505) 476-3490
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'Veronica.Waldram@wipp.ws'; 'RichardM@intrepidpotash.com'; 'cgherri@sandia.gov'; 'dwsnow@lotusllc.com'; 'lyn.sockwell@basicenergyservices.com'; 'dwpowers@evaporites.com'; Sanchez, Daniel J., EMNRD
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Ladies and Gentlemen:

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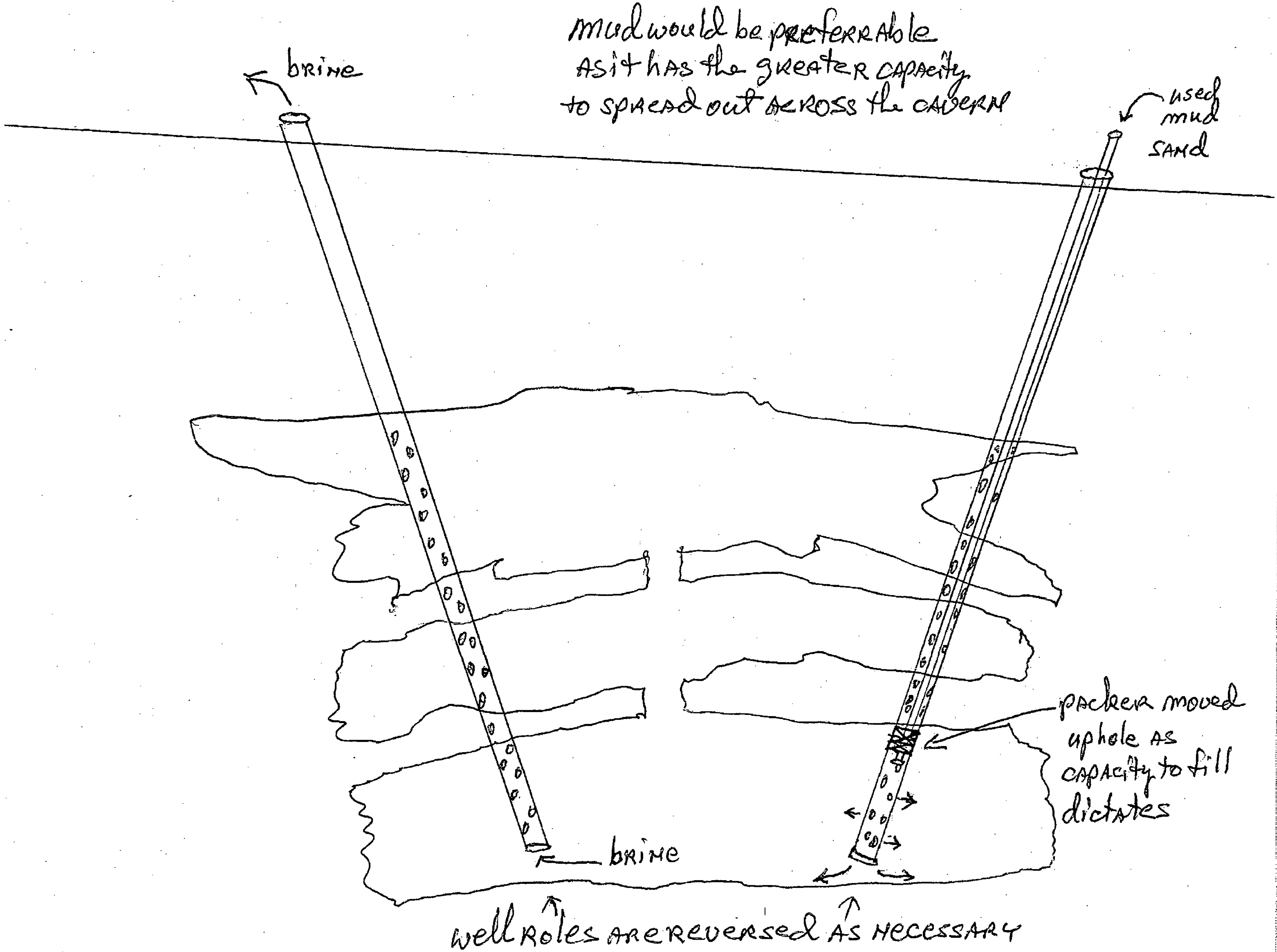
mud would be preferrable
as it has the greater capacity
to spread out across the cavern
brine
used
mud
sand
brine
packer moved
uphole as
capacity to fill
dictates
well roles are reversed as necessary

Chavez, Carl J, EMNRD

From: Chavez, Carl J, EMNRD
Sent: Friday, April 24, 2009 1:54 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'; Sanchez, Daniel J., EMNRD
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Subject: FW: FW: UIC Class III Brine Evaluation Work Group Draft Report Attached

FYI. Thanks David.

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From: David_Herrell@blm.gov [mailto:David_Herrell@blm.gov]
Sent: Friday, April 24, 2009 1:26 PM
To: Chavez, Carl J, EMNRD
Cc: Jim_Stovall@nm.blm.gov; James_Rutley@blm.gov; Dave_D_Evans@blm.gov; Don_Peterson@nm.blm.gov
Subject: Re: FW: UIC Class III Brine Evaluation Work Group Draft Report Attached

Carl, I mostly agree with option 1 in which we plan and prepare for a catastrophic collapse; however, perhaps we should consider the possibility of **carbon dioxide sequestration.**

Two Department of Interior Secretarial Orders have been issued since January of this year regarding Climate Change and Energy. In these, one of our tasks within the Department of Interior is to characterize public lands for possible carbon dioxide sequestration, which includes both vegatative and geologic sequestration. In the ladder, we are our looking for suitable underground geologic formations and "pore space" (parameters are not yet defined) that can support the sequestration of carbon dioxide for a geological amount of time.

In general, the kind of geology considered most are deep underground acquifiers, coal deposits, and depleted oil fields. An industry is developing around the ideas of sequestration, and perhaps our hole can be a viable commercial pursuit while at the same time ensuring against a catastrophic collapse within the city limits of Carlsbad, NM.

Thanks, Dave.

Chavez, Carl J, EMNRD

From: Ken Davis [kdavis@subsurfacegroup.com]
Sent: Friday, April 24, 2009 12:53 PM
To: Chavez, Carl J, EMNRD; 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; 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; Sanchez, Daniel J., EMNRD
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Subject: RE: UIC Class III Brine Evaluation Work Group Draft Report Attached

Carl:
I think it would be appropriate to investigate #2 & #4 (listed below) and a combination of both. This would allow for some reimbursment of the costs to fill the cavern plus get rid of some Oil Field Waste. The Oil Field Waste could be limited to only non-hazardous materials if necessary.

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Thanks Richard.

Carl J. Chavez, CHMM
New Mexico Energy, Minerals & Natural Resources Dept.

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Richard Miller

*****Please note our new address as of March 16, 2009*****

Intrepid Potash, Inc.
707 17th Street, Suite 4200
Denver, CO 80202

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Sent: Monday, April 20, 2009 6:10 PM
To: Chavez, Carl J, EMNRD; James_Rutley@blm.gov; byrum.charles@epa.gov; Leissner.Ray@epamail.epa.gov; Hugh Harvey; lmolleur@keyenergy.com; gveni@nckri.org; Jones, Brad A., 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; Richard Miller; cgherri@sandia.gov; dwsnow@lotusllc.com; lyn.sockwell@basicenergyservices.com; dwpowers@evaporites.com; Sanchez, Daniel J., EMNRD
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; kdavis@subsurfacegroup.com
Subject: RE: UIC Class III Brine Evaluation Work Group Draft Report Attached

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1) Restrict access as it could collapse at any moment, implement monitoring (laser level on well head, could include re-drilling into abandoned well to monitor fluid level and keep cavern filled), create safe zone in area (remove persons or businesses if necessary), and work on contingency plan for if and when well collapses. Could sink $5 Million into project and could collapse anyway....?
2) Pipe in salt waste slurry from Intrepid Potash at nominal fee per bbl. (~ 1 Million barrels) to fill salt cavern or via rail cars or trucks.
3) Induce collapse of cavern and fill up with solids, including special polymers, cement, etc. using heavy earth moving equipment?
4) EPA proposal to drill wells into bottom of cavern, seek operator to manage the injection of acceptable oilfield non-hazardous wastes (i.e., BLM tailings, salt wastes from potash companies, drill cuttings, slurry sand, solids, etc.) into cavern over long-term.
5) Salt bath steam concept from bottom to top of cavern?
6) Other?

The OCD looks forward to your comments. Please save the document under your name and track changes if you wish to send it back with your comments. The OCD requests your comments by COB this Friday, April 24, 2009 or sooner if possible. The OCD will issue one last draft on COB Tuesday April 28, 2009. The above dates are tentative, but we hope to give you a chance to comment before issuing the final report, which you will be copied on to the Secretary of the EMNRD. Yes, it appears that the report is to the Secretary and not the Oil Conservation Commission.

Please contact me if you have questions. Thank you.

Carl J. Chavez, CHMM
New Mexico Energy, Minerals & Natural Resources Dept.
Oil Conservation Division, Environmental Bureau
1220 South St. Francis Dr., Santa Fe, New Mexico 87505
Office: (505) 476-3490
Fax: (505) 476-3462
E-mail: CarlJ.Chavez@state.nm.us
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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; 'kdavis@subsurfacegroup.com'
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Chavez, Carl J, EMNRD

From: Richard Miller [RichardM@intrepidpotash.com]
Sent: Friday, April 24, 2009 11:08 AM
To: Chavez, Carl J, EMNRD
Subject: RE: UIC Class III Brine Evaluation Work Group Draft Report Attached
Attachments: filltechniquediag.pdf

Carl,

My vote is for #2) below. Solid salt deposited by pumped slurry into this cavern will settle and adhere into a near solid but porous brick that will provide compressive strength to minimize collapse. The strength of salt mass can be observed at our tails piles in various locations.

The fill technique diagram proposed by others (and attached here) seems like a feasible method. Depending upon evaluation of recent sonar surveys multiple wells may be necessary for adequate cavern fill.

Richard Miller

Please note our new address as of March 16, 2009
Intrepid Potash, Inc.
707 17th Street, Suite 4200
Denver, CO 80202

Intrepid Potash Inc.
700 17th Street, Suite 1700
Denver, CO 80202
Cell 303-881-5440
303-296-3006
Fx 303-298-7502

From: Chavez, Carl J, EMNRD [mailto:CarlJ.Chavez@state.nm.us]
Sent: Monday, April 20, 2009 6:10 PM
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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; kdavis@subsurfacegroup.com
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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; 'kdavis@subsurfacegroup.com'
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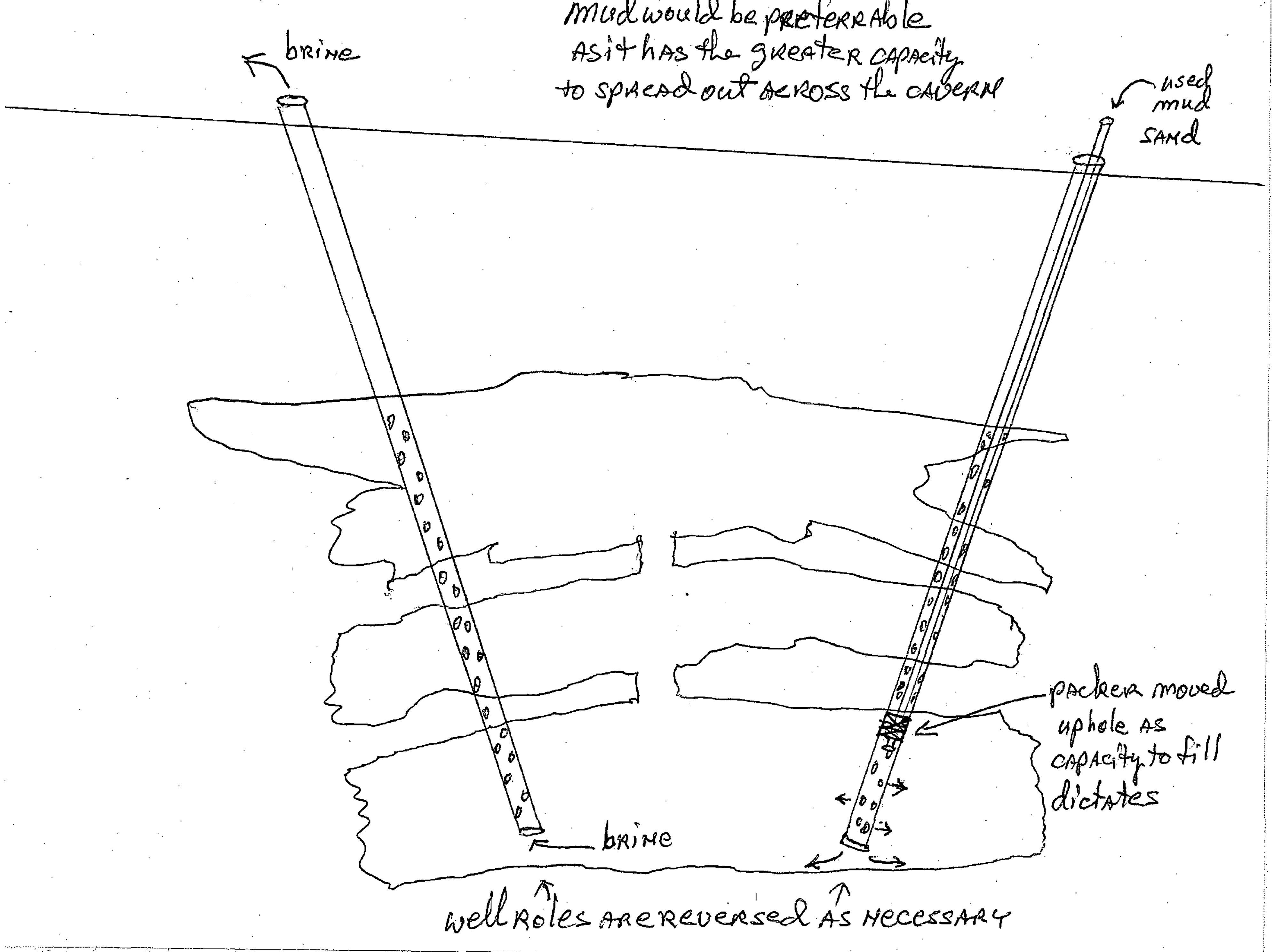

mud would be preferrable
as it has the greater capacity
to spread out across the cavern
brine
used
mud
sand
packer moved
uphole as
capacity to fill
dictates
brine
well roles are reversed as necessary

Chavez, Carl J, EMNRD

From: Mark Cartwright [mcartwright@unitedbrine.com]
Sent: Tuesday, April 07, 2009 12:49 PM
To: Chavez, Carl J, EMNRD
Subject: Re: FW: I & W Brine Well (BW-6) Carlsbad, NM

Greetings Carl -

For some reason I cannot open the files contained in this link. How are things going and how did your meeting with the feds go?

Mark

"Chavez, Carl J, EMNRD" <CarlJ.Chavez@state.nm.us>

04/01/2009 07:10 PM

To <MCartwright@unitedbrine.com>
cc
Subject FW: I & W Brine Well (BW-6) Carlsbad, NM

Carl J. Chavez, CHMM
New Mexico Energy, Minerals & Natural Resources Dept.
Oil Conservation Division, Environmental Bureau
1220 South St. Francis Dr., Santa Fe, New Mexico 87505
Office: (505) 476-3490
Fax: (505) 476-3462
E-mail: CarlJ.Chavez@state.nm.us
Website: http://www.emnrd.state.nm.us/ocd/index.htm
(Pollution Prevention Guidance is under "Publications")

From: Chavez, Carl J, EMNRD
Sent: Wednesday, April 01, 2009 6:10 PM
To: Griswold, Jim, EMNRD
Cc: VonGonten, Glenn, EMNRD
Subject: FW: I & W Brine Well (BW-6) Carlsbad, NM

Jim:

Can you send your white paper to Mark Cartwright ASAP. Thanks.

I am providing a link to the OCD Online file “Subsidence Monitoring Thumbnail” and “Permits” and “Gen. Correspondence (early info.) for well info., history that may help Mark. Thanks.

OCD Online BW-6 (click on “Subsidence Monitoring Reports” thumbnail)
http://ocdimage.emnrd.state.nm.us/imaging/AEOrderFileView.aspx?appNo=pENV0000BW0007

Thanks.

Carl J. Chavez, CHMM
New Mexico Energy, Minerals & Natural Resources Dept.
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Office: (505) 476-3490
Fax: (505) 476-3462
E-mail: CarlJ.Chavez@state.nm.us
Website: http://www.emnrd.state.nm.us/ocd/index.htm
(Pollution Prevention Guidance is under "Publications")

From: MCartwright@unitedbrine.com [mailto:MCartwright@unitedbrine.com]
Sent: Wednesday, April 01, 2009 5:51 PM
To: Chavez, Carl J, EMNRD
Subject: Re: I & W Brine Well (BW-6) Carlsbad, NM

Can you send history?
Mark J. Cartwright
713.877.2634
www.texasbrine.com

From: "Chavez, Carl J, EMNRD" [CarlJ.Chavez@state.nm.us]
Sent: 04/01/2009 05:46 PM CST
To: Mark Cartwright
Cc: "VonGonten, Glenn, EMNRD" <Glenn.VonGonten@state.nm.us>; "Griswold, Jim, EMNRD" <Jim.Griswold@state.nm.us>
Subject: RE: I & W Brine Well (BW-6) Carlsbad, NM

Thanks Mark. When you approached me after the meeting on Friday, there was an immediate sense of urgency to act quickly instead of later. Consequently, the OCD was looking for immediate action indications from you so we may act immediately if necessary. We are meeting with the Office of Homeland Security tomorrow morning and based on your response below, taking immediate measures may not transpire. Will keep you posted..... Thanks.

Carl J. Chavez, CHMM
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From: MCartwright@unitedbrine.com [mailto:MCartwright@unitedbrine.com]
Sent: Wednesday, April 01, 2009 5:31 PM
To: VonGonten, Glenn, EMNRD; Chavez, Carl J, EMNRD
Cc: Sanchez, Daniel J., EMNRD; Griswold, Jim, EMNRD
Subject: Re: I & W Brine Well (BW-6) Carlsbad, NM

Glenn -

I just landed in Charlotte. Please forgive this late reply. As to urgency, it's difficult to gauge without more information. Please forward anything available and I will give you my opinion. Much of my initial response has simply to do with the cavern's size and depth. I think another important factor would be the length of time, and percent of production, since the early 80's change in mining mode, (direct to reverse).

It should be clear, there are professionals far more qualified than I, to consult OCD on the risk of collapse. I am happy to help in any way possible, but a much better assessment can be made by either of those gentlemen referred to you in my previous email. Nonetheless, I would like to review the history, particularly as it compares to the other problem wells.

Regards,
Mark J. Cartwright
713.877.2634
www.texasbrine.com

From: "VonGonten, Glenn, EMNRD" [Glenn.VonGonten@state.nm.us]
Sent: 04/01/2009 03:20 PM CST
To: Mark Cartwright; "Chavez, Carl J, EMNRD" <CarlJ.Chavez@state.nm.us>
Cc: "Sanchez, Daniel J., EMNRD" <daniel.sanchez@state.nm.us>; "Griswold, Jim, EMNRD" <Jim.Griswold@state.nm.us>
Subject: RE: I & W Brine Well (BW-6) Carlsbad, NM

Mark,

This afternoon was the first time that I have been able to speak with our boss, Director Mark Fesmire. Jim Griswold put together a history of the I&W brine well. He decided to bring the I&W situation immediately to the attention of the Secretary of the Energy, Minerals and Natural Resources Department, Johanna Prukop. I presented the site history and gave her a copy of your email. She is very concerned about the possibility of a collapse, as we all are. She requested that I get in touch with you ASAP to find out how urgent that you feel the situation may be and whether you would be willing to talk about it with us.

Please give me a call at 505-476-3488 at your earliest convenience. Carl Chavez may be reached at 505-476-3490.

Thanks,

Glenn von Gonten
505-476-3488

From: Mark Cartwright [mailto:mcartwright@unitedbrine.com]
Sent: Wednesday, April 01, 2009 10:10 AM
To: Chavez, Carl J, EMNRD
Cc: Sanchez, Daniel J., EMNRD; VonGonten, Glenn, EMNRD; Griswold, Jim, EMNRD
Subject: Re: I & W Brine Well (BW-6) Carlsbad, NM

Hello folks - some quick thoughts and recommendations on the Carlsbad brine well.

- Emergency response/contingency plan involving State/County/City
- Every attempt should be made to characterize the cavern
  - Well construction
  - Production history
  - Estimated dimensions

- Local/regional geology, (stratigraphy and structure)
- Stability model - Geomechanical study by Respec or PB-ESS, (Dr. Van Sambeek and Dr. Ratigan, respectively)
- Given cavern's sensitive location, several steps might be considered
    - High resolution seismic survey
    - Subsidence monitoring
    - Re-entry for direct monitoring
        - Seismic probe
        - Pressure probe
        - Well and cavern logging
        - If risk is found intolerable, develop concepts for possible backfilling
            - Sand
            - Crushed limestone
            - Salt from potash mine
            - If backfilling or other stabilization methods are prohibitive, consider ultimate failure with marginal impact
                - Reroute roadways and utilities
                - Reroute irrigation canal
                - Relocate homeowners and businesses

It was a pleasure meeting you. I wish you all the best and look forward to any future opportunities.

Mark

"Chavez, Carl J, EMNRD" <CarlJ.Chavez@state.nm.us>

03/27/2009 06:08 PM

To <mcartwright@unitedbrine.com>

cc "Sanchez, Daniel J., EMNRD" <daniel.sa EMNRD" <Glenn.VonGonten@state.nm.ı <Jim.Griswold@state.nm.us>

Subject I & W Brine Well (BW-6) Carlsbad, NM

Mark:

Could you please send me an e-mail on the immediate concerns you have with the I & W brine well that you discussed with me after the meeting on Friday, March 27, 2009?

Also, any other immediate concerns that you have.

Thank you.

Carl J. Chavez, CHMM
New Mexico Energy, Minerals & Natural Resources Dept.

Oil Conservation Division, Environmental Bureau
1220 South St. Francis Dr., Santa Fe, New Mexico 87505
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Chavez, Carl J, EMNRD

From: Ken Davis [kdavis@subsurfacegroup.com]
Sent: Wednesday, April 22, 2009 9:35 AM
To: Chavez, Carl J, EMNRD

Subject: Link to Louisiana Regulations for E&P Waste Disposal in Salt Caverns.
Attachments: 43v17.pdf

Carl:
Here is the link to the Louisiana regulations you requested.
Ken E. Davis

http://dnr.louisiana.gov/title43/43v17.pdf#page=61

Table of Contents

Title 43
NATURAL RESOURCES
Part XVII. Office of Conservation—Injection and Mining

Subpart 1. Statewide Order No. 29-N-1

Subpart 2. Statewide Order No. 29-N-2

Subpart 3. Statewide Order No. 29-M

Subpart 4. Statewide Order No. 29-M-2

Title 43
NATURAL RESOURCES
Part XVII. Office of Conservation—Injection and Mining
Subpart 1. Statewide Order No. 29-N-1

Chapter 1. Class I, III, IV and V Injection Wells

§101. Definitions

A. The following definitions apply to all regulations following hereafter. Terms not defined in this Section have the meaning given by R.S. (1950) Title 30, Section 3.

Abandoned Well—a well whose use has been permanently discontinued or which is in a state of disrepair such that it cannot be used for its intended purpose or for observation purposes.

Act—Part I, Chapter 1 of Title 30 of the Louisiana Revised Statutes.

Application—the filing by a person on the Office of Conservation forms for applying for an underground injection permit, including any additions, revisions or modifications to the forms.

Aquifer—a geological formation, group of formations, or part of a formation that is capable of yielding a significant amount of water to a well or spring.

Area of Review—the area surrounding an "injection well" as described in §109.A.2 for Class I and §109.B.2 for Class III.

Casing—a metallic or nonmetallic tubing or pipe of varying diameter and weight, lowered into a borehole during or after drilling in order to support the sides of the hole and thus prevent the walls form caving, to prevent loss of drilling mud into porous ground, or to prevent water, gas or other fluid from entering the hole.

Catastrophic Collapse—the sudden and utter failure of overlying *strata* caused by removal of underlying materials.

Cementing—the operation whereby a cement slurry is pumped into a drilled hole and/or forced behind the casing.

Cesspool—a drywell that receives untreated sanitary waste containing human excreta, and which sometimes has an open bottom and/or perforated sides.

Confining Bed—a body of impermeable or distinctly less permeable material stratigraphically adjacent to one or more aquifers.

Confining Zone—a geological formation, group of formations, or part of a formation that is capable of limiting fluid movement above an injection zone.

Contaminant—any physical, chemical, biological, or radiological substance or matter in water.

Commissioner—the Assistant Secretary of the Office of Conservation, Department of Natural Resources.

Disposal Well—a well used for the disposal of waste into a subsurface stratum.

Drilling Mud—heavy suspension used in drilling an injection well introduced down the drill pipe and through the drill bit.

Drywell—a well, other than an improved sinkhole or subsurface fluid distribution system, completed above the water table so that its bottom and sides are typically dry except when receiving fluids.

Effective Date—the date that the Louisiana State UIC Program is approved by the Environmental Protection Agency.

Emergency Permit—a UIC permit issued in accordance with §115.

Exempted Aquifer—an aquifer or its portion that meets the criteria of the definition of underground source of drinking water but which has been exempted according to the procedures set forth in §103.H.

Existing Injection Well or Project—an injection well or project other than a new injection well or project.

Experimental Technology—a technology which has not been proven feasible under the conditions in which it is being tested.

Facility or Activity—any facility or activity, including land or appurtenances thereto, that is subject to these regulations.

Fault—a surface or zone of rock fracture along which there has been displacement.

Flow Rate—the volume per time unit given to the flow of fluid substance which emerges from an orifice, pump, turbine or passes along a conduit or channel.

Fluid—any material or substance which flows or moves whether in a semisolid, liquid, sludge, gas or any other form or state.

Formation—a body of rock characterized by a degree of lithologic homogeneity revealingly, but not necessarily, tabular and is mappable on the earth's surface or traceable in the subsurface.

Formation Fluid—fluid present in a formation under natural conditions as opposed to introduced fluids, such as drilling muds.

Generator—any person, by site location, whose act or process produces hazardous waste identified or listed in the Louisiana Hazardous Waste Management Program.

Ground Water—water below the land surface in a zone of saturation.

Hazardous Waste—a hazardous waste as defined in the Louisiana Hazardous Waste Management Program.

Hazardous Waste Management (HWM) Facility—all contiguous land, and structures, other appurtenances, and improvements on the land, used for treating, storing or disposing of hazardous waste.

Improved Sinkhole—a naturally occurring karst depression or other natural crevice found in volcanic terrain and other geologic settings which have been modified by man for the purpose of directing and emplacing fluids into the subsurface.

Injection Well—a well into which fluids are being injected other than fluids associated with active drilling operations.

Injection Zone—a geological formation, group of formations or part of a formation receiving fluids through a well.

Ionizing Radiation—any electromagnetic or particulate radiation capable of producing ions, directly or indirectly, in its passage through matter. It includes any or all of the following: alpha rays, beta rays, gamma rays, X-rays, neutrons, high-speed electrons, high-speed protons, and other atomic particles; but not sound or radio waves, or visible, infrared or ultraviolet light.

Lithology—the description of rocks on the basis of their physical and chemical characteristics.

Major Facility—any Class I or IV hazardous waste injection well facility or activity.

Manifest—the shipping document originated and signed by the generator which contains the information required by the Hazardous Waste Management Program.

New Injection Well—a well which began injection after the Louisiana Underground Injection Control program is approved and the applicable (Office of Conservation) rules and regulations are promulgated.

Owner or Operator—the owner or operator of any facility or activity subject to regulation under the UIC program.

Packer—a device lowered into a well to produce a fluid tight seal within the casing.

Permit—an authorization, license, or equivalent control document issued by the commissioner to implement the requirements of these regulations. Permit includes, but it is not limited to, area permits and emergency permits. Permit does not include UIC authorization by rule or any permit which has not yet been the subject of final agency action, such as a draft permit.

Person—an individual, association, partnership, corporation, municipality, state or federal agency, or an agent or employee thereof.

Plugging—the act or process of stopping the flow of water, oil or gas into or out of a formation through a borehole or well penetrating that formation.

Plugging Record—a systematic listing of permanent or temporary abandonment of water, oil, gas, test, exploration, and waste injection wells.

Point of Injection—the last accessible sampling point prior to waste fluids being released into the subsurface environment through a Class V injection well. For example, the point of injection of a Class V septic system might be the distribution box, the last accessible sampling point before the waste fluids drain into the underlying soils. For a dry well, it is likely to be the well bore itself

Pressure—the total load or force per unit area acting on a surface.

Project—a group of wells in a single operation.

Public Water System—a system for the provision to the public of piped water for human consumption, if such system has at least 15 service connections or regularly serves at least 25 individuals. Such term includes:

a. any collection, treatment, storage, and distribution facilities under control of the operator of such system and used primarily in connection with such system; and

b. any collection or pretreatment storage facilities not under such control which are used primarily in connection with such system.

Radiation—any electromagnetic or ionizing radiation including gamma rays and X-rays, alpha and beta particles, high-speed electrons, neutrons, protons and other nuclear particles; but not sound waves. Unless specifically stated otherwise, these regulations apply only to ionizing radiation.

Radioactive Material—any material, whether solid, liquid, or gas, which emits radiation spontaneously.

Radioactive Waste—any waste which contains radioactive material for which no use or reuse is intended and which is to be discarded.

RCRA—the Solid Waste Disposal Act as amended by the Resource Conservation and Recovery Act of 1976 (P.L. 94-580 as amended by P.L. 95-609, 42 U.S.C. 6901 et seq.).

Sanitary Waste—liquid or solid wastes originating solely from humans and human activities, such as wastes collected from toilets, showers, wash basins, sinks used for cleaning domestic areas, sinks used for food preparation, clothes washing operations, and sinks or washing machines where food and beverage serving dishes, glasses, and utensils are cleaned. Sources of these wastes may include single or multiple residences, hotels and motels, restaurants, bunkhouses, schools, ranger stations, crew quarters, guard stations, campgrounds, picnic grounds, day-use recreation areas, other commercial facilities, and industrial facilities provided the waste is not mixed with industrial waste.

Schedule of Compliance—a schedule or remedial measures included in a permit, including an enforceable sequence of interim requirements (for example, actions, operations, or milestone events) leading to compliance with the act and these regulations.

Septic System—a well that is used to emplace sanitary waste below the surface and is typically comprised of a septic tank and subsurface fluid distribution system or disposal system.

Site—the land or water area where any facility or activity is physically located or conducted including adjacent land used in connection with the facility or activity.

Skin Effect—the blockage or plugging of the well perforations or near wellbore formation face from solids in the waste stream that results in increased injection pressures and can be measured by accepted engineering test procedures.

Sole or Principal Source Aquifer—an aquifer which is the sole or principal drinking water source for an area and which, if contaminated, would create a significant hazard to public health.

State—the state of Louisiana.

Stratum (plural *Strata*)—a single sedimentary bed or layer, regardless of thickness, that consists of generally the same kind of rock material.

Subsurface Fluid Distribution System—an assemblage of perforated pipes, drain tiles, or other similar mechanisms intended to distribute fluids below the surface of the ground.

Surface Casing—the first string of casing to be installed in the well, excluding conductor casing.

Total Dissolved Solids—the total dissolved filterable solids as determined by use of the method specified in the 14th edition, pp. 91-92, of *Standard Methods for the Examination of Water and Waste Water*.

UIC—the Louisiana State Underground Injection Control Program.

Underground Injection—a well injection.

Underground Source of Drinking Water (USDW)—an aquifer or its portion:

a. which supplies any public water system; or

b. which contains a sufficient quantity of ground water to supply a public water system; and

i. currently supplies drinking water for human consumption; or

ii. contains fewer than 10,000 mg/l total dissolved solids; and which is not an exempted aquifer.

USDW—Underground Source of Drinking Water.

Well—a bored, drilled, or driven shaft whose depth is greater than the largest surface dimension; or, a dug hole whose depth is greater than the largest surface dimension; or, an improved sinkhole; or, a subsurface fluid distribution system.

Well Injection—the subsurface emplacement of fluids through an injection well.

Well Plug—a fluid-tight seal installed in a borehole or well to prevent movement of fluids.

Well Stimulation—several processes used to clean the well bore, enlarge channels, and increase pore space in the interval to be injected thus making it possible for wastewater to move more readily into the formation, and includes:

a. surging;

b. jetting;

c. blasting;

d. acidizing; or

e. hydraulic fracturing.

Workover—to perform one or more of a variety of remedial operations on an injection well, such as cleaning, perforation, change tubing, deepening, squeezing, plugging back, etc. (see §109.A.8.b).

AUTHORITY NOTE: Promulgated in accordance with R.S. 30:ID and 4C(16), and 4.1.

HISTORICAL NOTE: Promulgated by the Department of Natural Resources, Office of Conservation, LR 8:83 (February 1982), amended LR 12:26 (January 1986), LR 27:1698 (October 2001).

§103. General Provisions

A. Applicability. These rules and regulations apply to all owners and operators of proposed and existing Class I, III, IV, and V injection wells in the state of Louisiana. For Class I wells, these rules shall only apply to nonhazardous waste disposal as described in §103.C.1.b. and c. below. Applicable rules for Class I hazardous waste disposal is in Statewide Order No. 29-N-2 (LAC 43:XVII.Chapter 2).

B. Prohibition of Unauthorized Injection. Any underground injection, except as authorized by a permit or rule, is prohibited after the effective date of these regulations. Construction of any well required to have a permit under these regulations is prohibited until the permit has been issued.

C. Classification of Injection Wells

1. Class I

a. Wells used by generators of hazardous wastes or owners or operators of hazardous waste management facilities to inject hazardous waste beneath the lowermost formation containing, within 1/4 mile radius of the well bore, an underground source of drinking water.

b. Other industrial and municipal disposal wells which inject fluids beneath the lowermost formation containing an underground source of drinking water within 1/4 mile radius of the well bore.

c. Radioactive waste disposal wells which inject fluids below the lowermost formation containing an underground source of drinking water within 1/4 mile of the well bore. This classification of radioactive waste disposal wells does not affect the disposal of naturally occurring radioactive material (NORM) in Class II wells as part of oil and gas exploration and production operations. The injection of wastes associated with oil and natural gas exploration and production, including such wastes containing NORM, are regulated under the appropriate Class II regulations.

2. Class II. Wells which inject fluids:

a. which are brought to the surface in connection with conventional oil or natural gas production and may be commingled with waste waters from gas plants which are an integral part of production operations, unless those waters are classified as a hazardous waste at the time of injection;

b. for enhanced recovery of oil and natural gas; and

c. for storage of hydrocarbons which are liquid at standard temperature and pressure.

3. Class III. Wells which inject for extraction of minerals or energy, including:

a. mining of sulfur by the Frasch process;

b. in situ production of uranium or other metals. This category includes only in situ production from ore bodies which have not been conventionally mined. Solution mining of conventional mines such as stopes leaching is included in Class V; and

c. solution mining of salts or potash.

4. Class IV

a. Wells used by generators of hazardous wastes or of radioactive wastes, by owners or operators of hazardous waste management facilities, or by owners or operators of radioactive waste disposal sites to dispose of hazardous wastes or radioactive wastes into a formation which within 1/4 mile of the well contains an underground source of drinking water. This includes the disposal of hazardous waste into what would otherwise be septic systems and cesspools, regardless of their capacity.

b. Wells used by generators of hazardous wastes or of radioactive wastes, by owners or operators of hazardous wastes management facilities, or by owners or operators of radioactive waste disposal sites to dispose of hazardous wastes or radioactive waste above a formation which within 1/4 mile of the well contains an underground source of drinking water. This includes the disposal of hazardous waste into what would otherwise be septic systems and cesspools, regardless of their capacity.

c. Wells used by generators of hazardous wastes or by owners or operators of hazardous waste management facilities, to dispose of hazardous wastes which cannot be classified under §103.C.1.a or 103.C.4.a and b (e.g., wells used to dispose of hazardous wastes into or above a formation which contains an aquifer which has been exempted pursuant to §103.H). This includes the disposal of hazardous waste into what would otherwise be septic systems and cesspools, regardless of their capacity.

5. Class V. Injection wells not included in Class I, II, III, or IV. Typically, Class V wells are shallow wells used to place a variety of fluids directly below the land surface. However, if the fluids placed in the ground qualify as a hazardous waste under the Resource Conservation and Recovery Act (RCRA), the well is either a Class I or Class IV well. Class V wells include:

a. air conditioning return flow wells used to return to the supply aquifer the water used for heating or cooling in a heat pump;

b. large-capacity cesspools, including multiple dwelling, community or regional cesspools, or other devices that receive sanitary wastes, containing human excreta, which have an open bottom and sometimes have perforated sides (see §109.D.2). The UIC requirements do not apply to single family residential cesspools or to nonresidential cesspools which receive solely sanitary waste and have the capacity to serve fewer than 20 persons a day;

c. cooling water return flow wells used to inject water previously used for cooling;

d. drainage wells used to drain surface fluid, primarily storm runoff, into a subsurface formation;

e. dry wells used for the injection of wastes into a subsurface formation;

f. recharge wells used to replenish the water in an aquifer;

g. salt water intrusion barrier wells used to inject water into a USDW to prevent the intrusion of salt water into the USDW;

h. sand backfill and other backfill wells used to inject a mixture of water and sand, mill tailings or other solids into mined out portions of subsurface mines, whether what is injected is radioactive or not;

i. septic system wells used to inject the waste or effluent from a multiple dwelling, business establishment, community or regional business establishment septic tank (see §103.C.6). The UIC requirements do not apply to single family residential septic system wells, or to nonresidential septic system wells which are used solely for the disposal of sanitary waste and have the capacity to serve fewer than 20 persons a day;

j. subsidence control wells (not used for the purpose of oil or natural gas production) used to inject fluids into a non-oil or gas producing zone to reduce or eliminate subsidence associated with the overdraft of a USDW;

k. injection wells associated with the recovery of geothermal energy for heating, aquaculture and production of electric power;

l. wells used for solution mining of conventional mines such as stopes leaching;

m. injection wells used for in situ recovery of lignite, coal, tar, sands, and oil shale;

n. wells used to inject spent brine into the same formation from which it was withdrawn after extraction of halogens or their salts; and

o. injection wells used in experimental technologies;

p. motor vehicle waste disposal wells that receive or have received fluids from vehicular repair or maintenance activities, such as an auto body repair shop, automotive repair shop, new and used car dealership, specialty repair shop (e.g., transmission and muffler repair shop), or any facility that does any vehicular repair work. Fluids disposed in these wells may contain organic and inorganic chemicals in concentrations that exceed the maximum contaminant levels (MCLs) established by the primary drinking water regulations. These fluids also may include waste petroleum products and may contain contaminants, such as heavy metals and volatile organic compounds, which pose risks to human health.

6. Specific Exclusions. The following are not covered by these regulations:

a. individual or single family residential or nonresidential cesspools, septic systems or similar waste disposal systems, if such systems:

i. are used solely for the disposal of sanitary waste; and

ii. have the capacity to serve fewer than 20 persons a day;

b. injection wells located on a drilling platform or other site that is beyond the state's territorial waters; and

c. any dug hole, drilled hole, or bored shaft which is not used for emplacement of fluids underground.

D. Prohibition of Movement of Fluid into Underground Sources of Drinking Water

1. No authorization by permit or rule shall allow the movement of fluid containing any contaminant into underground sources of drinking water, if the presence of that contaminant may cause a violation of the Louisiana Drinking Water Regulations, Chapter VIII of the State Sanitary Code or may otherwise adversely affect the health of persons. The applicant for a permit shall have the burden of showing that the requirements of this Section are met.

2. For Class I and III wells, if any water quality monitoring of a USDW indicates the movement of any contaminant into the USDW, except as authorized under §109, the commissioner shall prescribe such additional requirements for construction, corrective action, operation, monitoring, or reporting (including closure of the injection well) as are necessary to prevent such movement. In the case of wells authorized by permit, these additional requirements shall be imposed by modifying the permit in accordance with §113.C, or the permit may be terminated under §113.E if cause exists, or appropriate enforcement action may be taken if the permit has been violated. In the case of wells authorized by rule, see §103.E.1.

3. If at any time the commissioner learns that a Class V well may cause a violation of the Louisiana Drinking Water Regulations, Chapter XII of the State Sanitary Code or may be otherwise adversely affecting the health of persons, he shall:

a. require the injector to obtain a permit;

b. order the injector to take such actions (including, where required, closure of the injection well) as may be necessary to prevent the violation or adverse effect; or

c. take enforcement action.

4. Notwithstanding any other provision of this Section, the commissioner may take emergency action upon receipt of information that a contaminant which is present in or likely to enter a public water system may present an imminent and substantial endangerment to the health or safety of persons.

E. Authorization of Underground Injection by Rule

1. The commissioner may authorize underground injection by rule as outlined in this Section.

a. Injection into existing Class I and III wells or Class III projects may be authorized by rule for up to five years from the effective date of the Louisiana UIC program. Except for commercial Class I wells in §103.F, all such wells must apply for a permit within four years of the effective date and receive a permit within five years of the effective date. The commissioner will establish a schedule for repermitting prior to the effective date.

i. Rules under §103.E.1 shall specify that the authorization to inject shall expire:

(a). upon the effective date of the permit or permit denial, if a permit application has been filed in a timely manner as specified in §105.B;

(b). if a permit application has not been filed in a timely manner as specified in §105.B; or

(c). unless a complete permit application is pending, not later than five years after the effective date.

ii. Notwithstanding the prohibition in §103.B, rules which under §103.E.1.a authorizing Class III wells or projects in existing fields or projects may allow them to continue normal operations until permitted, including construction, operation, and plugging and abandonment of wells provided the owner or operator maintains compliance with all applicable requirements.

iii. Rules under §103.E.1 shall require compliance no later than one year after authorization with the following requirements applicable to permittee, except the terms permit and permittee shall be read to include rules and those authorized by rule:

(a). requirements for commercial wells injecting hazardous waste accompanied by a manifest: §103.F;

(b). financial responsibility: §107.C;

(c). notice of abandonment: §107.L;

(d). 24-hour reporting on noncompliance: §107.L.6;

(e). operating, monitoring, and reporting requirements (except mechanical integrity): §109.A.6, 7, and 8 (Class I) and §109.B.6, 7, and 8 (Class III);

(f). plugging and abandonment: §109.A.10, §109.B.10;

(g). record keeping requirements: §109.A.11, §109.B.12; and

(h). exemption from rule where authorized by temporary permit: §115.B.

b.i. Injection into existing Class IV wells as defined in §103.C.4.a may be authorized for a period not to exceed six months after approval or promulgation of the UIC program. Such rules shall apply the requirements of §103.F.3.

ii. Injection into existing Class IV wells as defined in §103.C.4.b and c may be authorized until six months after approval or promulgation of a UIC program incorporating criteria and standards under §109.C applicable to Class IV injection wells. Such rules shall apply the requirements of §103.F.3.

iii. notwithstanding the requirements of Clauses i and ii above, wells used to inject contaminated ground water that has been treated and is being injected into the same formation from which it was drawn are authorized by rule for the life of the well if such subsurface emplacement of fluids is approved by appropriate state or federal agencies pursuant to provisions for cleanup of releases under the Comprehensive Environmental Response, Compensation, and Liability Act of 1980 (CERCLA) or pursuant to requirements and provisions under the Resource Conservation and Recovery Act (RCRA).

c. Injection into Class V wells may be authorized by rule until requirements under future regulations become applicable to the specific type of Class V well. However, the owner or operator of a Class V well authorized by rule shall provide an inventory of the Class V well(s) to the commissioner. At a minimum, the inventory shall include the following information for each Class V well:

i. well and/or facility name and location;

ii. name and address of legal contact;

iii. ownership of well and/or facility;

iv. date of well installation/completion;

v. nature and type of injection well(s);

vi. depth and operating status of injection well(s); and

vii. any additional information required by the commissioner.

d. Class V well authorization by rule shall expire upon the effective date of a permit issued pursuant to these rules or upon proper closure of the well.

e. An owner or operator of a Class V well which is authorized by rule is prohibited from injecting into the well:

i. upon the effective date of an applicable permit denial;

ii. upon failure to submit inventory information pursuant to §103.E.1.c. above;

iii. upon failure to submit a permit application pursuant to §103.E.2.b. below; or

iv. upon failure to comply with the commissioner's request for any additional information.

2. Requiring a Permit

a. The commissioner may require any Class I, III, or V injection well or project authorized by a rule to apply for and obtain a UIC permit. Cases where UIC permits may be required include:

i. the injection well is not in compliance with any requirements of the rule;

(Note: Any underground injection which violates any rule under this Section is subject to appropriate enforcement action.)

ii. the injection well is not or no longer is within the category of wells and types of wells operations authorized in the rule; and

iii. the protection of USDW requires that the injection operation be regulated by requirements, such as for corrective action, monitoring and reporting, or operation, which are not contained in the rule.

b. The commissioner may require the owner or operator authorized by a rule to apply for a UIC permit by sending the owner or operator a letter containing a brief statement of the reasons, an application form, a statement setting a time for the owner or operator to file the application, and a statement that upon the effective date of the UIC permit the rule no longer applies to the activities regulated under the UIC program.

c. Any owner or operator authorized by a rule may request to be excluded from the coverage of the rule by applying for a UIC permit. The owner or operator shall submit an application under §105.B with reasons supporting the request, to the commissioner. The commissioner may grant any such request.

d. A Class V well satisfying any of the requirements of Clauses i through iv below is no longer authorized by rule; therefore, the owner or operator of the well shall apply for and obtain a UIC permit or permanently close the well:

i. the Class V well does not comply with the prohibition of fluid movement standard in §103.D;

ii. the Class V well is an existing large-capacity cesspool (in which case, the well shall be permanently closed by April 5, 2005) or an existing Class V motor vehicle waste disposal well (in which case, the well shall be permanently closed by January 1, 2005). These rules prohibit the permitting and construction start-up of new motor vehicle waste disposal wells and new large-capacity cesspools on and after April 5, 2000;

iii. the commissioner specifically requires the Class V well be permitted (in which case, rule authorization expires upon the effective date of the permit, or you are prohibited from injecting into your well upon failure to submit a permit application in a timely manner as specified by the commissioner; or upon the effective date of permit denial);

iv. the owner or operator of the Class V well failed to submit inventory information as described in §103.E.1.c (in which case, injection into the well is prohibited until the inventory requirements are met).

F. Requirements for Commercial Wells Injecting Hazardous Waste Accompanied by a Manifest

1. Applicability. The regulations in this Section apply to all generators of hazardous waste, and to owners or operators of all commercial hazardous waste management facilities, using any class of well to inject hazardous wastes accompanied by a manifest.

2. Authorization. The owner or operator of any commercial injection well that is used to inject hazardous wastes accompanied by a manifest or delivery document shall apply for authorization to inject as specified in §105.B within six months after the effective date of the Louisiana UIC Program.

3. Requirements. In addition to requiring compliance with the applicable requirements of this Section and §109, the commissioner shall, for each facility meeting the requirements of §103.F.2, require that the owner or operator comply with the applicable requirements of the Louisiana Hazardous Waste Management program.

G. Prohibition of Class IV Wells. The following activities are prohibited:

1. the construction, operation, or maintenance of any Class IV well is prohibited except for wells used to inject contaminated ground water that has been treated and is being reinjected into the same formation from which it was drawn as part of a clean-up plan approved by appropriate state and federal agencies; however, this prohibition does not apply to the following:

a. wells used to inject hazardous waste into aquifers or portions thereof which have been exempted pursuant to §103.H, provided the exempted aquifer into which waste is injected underlies the lowermost formation containing a USDW; and

b. wells used to inject hazardous waste where no USDW exists within 1/4 mile of the well bore in any underground formation, provided that a determination is made that such injection is into a formation sufficiently isolated to ensure that injected fluids do not migrate from the injection zone.

H. Identification of Underground Sources of Drinking Water and Exempted Aquifers

1. The commissioner may identify (by narrative description, illustrations, maps, or other means) and shall protect, except where exempted under §103.H.2, as an underground source of drinking water, all aquifers or parts of aquifers which meet the definition of an underground source of drinking water. Even if an aquifer has not been specifically identified by the commissioner, it is an underground source of drinking water if it meets the definition.

2. After notice and opportunity for a public hearing the commissioner may identify (by narrative description, illustrations, maps, or other means) and describe in geographic and/or geometric terms (such as vertical and lateral limits and gradient) which are clear and definite, all aquifers or parts thereof which the commissioner proposes to designate as exempted aquifers if they meet the following criteria:

a. the aquifer does not currently serve as a source of drinking water; and

b. the aquifer cannot now and will not in the future serve as a source of drinking water because:

i. it is mineral, hydrocarbon or geothermal energy producing or can be demonstrated by a permit applicant as part of a permit application for a Class III operation to contain minerals or hydrocarbons that considering their quantity and location are expected to be commercially producible;

ii. it is situated at a depth or location which makes recovery of water for drinking water purposes economically or technologically impractical;

iii. it is so contaminated that it would be economically or technologically impractical to render that water fit for human consumption; or

iv. it is located over a Class III well mining area subject to subsidence or catastrophic collapse; or

c. the total dissolved solids content of the ground water is more than 3,000 and less than 10,000 mg/l and it is not reasonably expected to supply a public water system.

3. For Class III wells, the commissioner shall require an applicant for a permit, which necessitates an aquifer exemption under §103.H.2.b above, to furnish the data necessary to demonstrate that the aquifer is expected to be mineral or hydrocarbon producing. Information contained in the mining plan for the proposed project, such as a map and

general description of the mining zone, general information on the mineralogy and geochemistry of the mining zone, analysis of the amenability of the mining zone to the proposed mining method, and a time-table of planned development of the mining zone shall be considered by the commissioner in addition to the information required in the well or area permit application.

AUTHORITY NOTE: Promulgated in accordance with R.S. 30:1D, 4C(16), and 4.1.

HISTORICAL NOTE: Promulgated by the Department of Natural Resources, Office of Conservation, LR 8:83 (February 1982), amended LR 11:640 (June 1985), LR 27:1698 (October 2001).

§105. Permit Application Requirements

A. Applicability. The rules and regulations of this Section apply to all Class I and III injection wells or project applications required to be filed with the Department of Natural Resources (Office of Conservation) for authorization under R.S. 1950 Title 30.

B. Application Required

1. Permit Application. New applicants, permittees with expiring permits, and any person required to have a permit shall complete, sign, and submit an application in triplicate to the commissioner as described in this Section. Persons currently authorized with interim status under the Resource Conservation and Recovery Act (RCRA) or authorized by rule shall apply for permits when required by the commissioner (see §105.B.2).

2. Time to Apply. Any person who performs or proposes an underground injection for which a permit is or will be required shall submit an application to the commissioner as follows:

a. for existing Class I and III wells or projects no later than four years after inauguration of the UIC program and according to the schedule of repermitting established by the commissioner;

b. for existing Class I commercial facilities injecting hazardous waste, within six months of the effective date of the UIC program;

c. for new Class I injection wells, a reasonable time before construction is expected to begin; or

d. for new Class III injection wells, except new wells covered by an existing area permit, a reasonable time before construction is expected to begin.

C. Who Applies. It is the duty of the owner of a facility or activity to submit an application for permit. When a facility is owned by one person and operated by another, it is the operator's duty to obtain a permit.

D. Signature Requirements for Applications

1. All permit applications shall be signed as follows:

a. for a corporation: by a principal executive officer of at least the level of vice-president, or a duly authorized representative of that person if the representative performs similar policy-making functions for the corporation. A person is a duly authorized representative only if:

i. the authorization is made in writing by a principal executive officer of at least the level of vice-president;

ii. the authorization specifies either an individual or a position have responsibility for the overall operation of the regulated facility or activity, such as the position of plant manager, operator of a well or a well field, superintendent, or position of equivalent responsibility. (A duly authorized representative may thus be either a named individual or any individual occupying a named position); and

iii. the written authorization is submitted to the commissioner;

b. for partnership or sole proprietorship, by a general partner or the proprietor, respectively; or

c. for a municipality, state, federal, or other public agency: by either a principal executive officer or ranking elected official.

2. If an authorization under §105.D.1 is no longer accurate because a different individual or position has responsibility for the overall operation of the facility, a new authorization satisfying the signature requirements must be submitted to the commissioner prior to or together with any reports, information or applications to be signed by an authorized representative.

3. Certification. Any person signing a document under §105.D.1 shall make the following certification:

> I certify under penalty of law that I have personally examined and am familiar with the information submitted in this document and all attachments and that, based on my inquiry of those individuals immediately responsible for obtaining the information, I believe that the information is true, accurate, and complete. I am aware that there are significant penalties for submitting false information, including the possibility of fine and imprisonment.

E. Application Contents for Class I Wells. All applicants for Class I permits shall provide the following information to the commissioner, using the application form provided:

1. administrative information;

a. the name, mailing address, and location of the facility for which the application is submitted;

b. ownership status as federal, state, private, public, or other entity;

c. the operator's name, address and telephone number;

d. a brief description of the nature of the business associated with the facility;

e. the activity or activities conducted by the applicant which require the applicant to obtain a permit under these regulations;

f. up to four SIC Codes which best reflect the principle products or services provided by the facility;

g. a listing of all permits or construction approvals which the applicant has received or applied for under any of the following programs and which specifically affect the legal or technical ability of the applicant to undertake the activity or activities to be conducted under the permit filed here for:

i. the Louisiana Hazardous Waste Management Program;

ii. this or any other Underground Injection Control Program;

iii. NPDES Program under the Clean Water Act;

iv. Prevention of Significant Deterioration (PSD) Program under the Clean Air Act;

v. Nonattainment Program under the Clean Air Act;

vi. National Emission Standards for Hazardous Pollutants (NESHAPS) preconstruction approval under the Clean Air Act;

vii. Ocean Dumping Permit under the Marine Protection Research and Sanctuaries Act;

viii. dredge or fill permits under Section 404 of the Clean Water Act; and

ix. other relevant environmental permits, including, but not limited to any state permits issued under the Louisiana Coastal Resources Program, the Louisiana Surface Mining Program or the Louisiana Natural and Scenic Streams System;

h. jurisdiction:

i. whether the facility is located on Indian lands or other lands under the jurisdiction or protection of the federal government;

ii. whether the facility is located on state water bottoms or other lands owned by or under the jurisdiction or protection of the state;

2. maps and related information for new and existing wells;

a. one or more maps, preferably USGS topographic map(s), with a scale of 1:24,000 showing the property boundaries of the facility, each injection well for which a permit is sought and the area of review as described in §109.A.2;

i. the map(s) must show the section, township and range of the area in which the activity is located and any parish, city or municipality boundary lines within 1 mile of the injection well;

ii. within the area of review the map(s) must show the name and/or number and location of all injection wells, producing wells, abandoned wells, dry holes, surface bodies of water, springs, mines (surface and subsurface), quarries, public water systems, water wells (public and private) and other pertinent surface features including residences and roads;

iii. the map(s) should also show faults if known or projected;

iv. only information of public record is required to be included on the map(s); however, the applicant is required to undertake a diligent search to locate all water wells not listed in the public record;

b. generalized maps and cross sections illustrating the regional geology and hydrology;

c. maps and cross-sections to the necessary scale to detail the local geology and hydrology (2-mile radius of well minimum);

d. any other information required by the commissioner to evaluate the proposed well;

3. technical information for new wells, and:

a. a tabulation of data on all wells within the area of review which penetrate the proposed injection zone. Such data shall include a description of each well's type, construction, date drilled, location, depth, record of plugging and/or completion, and any additional information the commissioner may require;

b. proposed operating data:

i. average and maximum daily rate and volume of the injection fluid;

ii. average and maximum injection pressure; and

iii. source and an analysis of the chemical, physical, and biological characteristics of the injection fluid;

c. proposed formation testing program to obtain an analysis of the physical and chemical characteristics of the receiving formation;

d. proposed stimulation program;

e. proposed injection procedures (including storage and pre-injection treatment of the waste stream, and well use schedule);

f. schematic or other appropriate drawings of the surface (well head and related appurtenances) and subsurface construction details of the system;

g. plans (including maps) for meeting the monitoring requirements of §109.A.7;

h. construction procedures including a cementing and casing program, logging procedures, deviation checks, and a drilling, testing, and coring program;

i. contingency plans to cope with all shut-ins or well failures so as to prevent the migration of the contaminating fluids into underground sources of drinking water;

j. a certificate that the applicant has assured, through a performance bond or other appropriate means, the resources necessary to close, plug or abandon the well as required by §§109.A.10 and 107.C;

k. for wells within the area of review which penetrate the injection zone but are not properly completed or plugged, the corrective action proposed to be taken under §109.A.3;

l. calculation of the pressure increase in the proposed injection zone for a time period equal to the expected life of the well, preferably using Matthews and Russell, 1967 *Pressure Buildup and Flow Tests in Wells*, American Institute of Mining, Met. Eng. Monograph, Vol. 1);

m. calculation of the expected waste front travel using a model acceptable to the commissioner. A conservative value can be calculated by using the following formula:

$$r = \sqrt{\frac{v}{\pi b \phi}}$$

where:

r = radial distance of wastewater front from well;

v = cumulative volume of injected wastewater;

b = effective reservoir thickness;

ø = average effective porosity;

(Warner, D.L. and Lehr, J.H., *An Introduction to the Technology of Subsurface Wastewater Injection*, Robert S. Kerr Environmental Research Laboratory (EPA) Research Report, 1977)

n. any other information required by the commissioner to evaluate the proposed well;

4. technical information for existing wells:

a. a tabulation of data on all wells within the area of review and which penetrate the injection zone, (see §105.E.3.a);

b. operating data as required in §105.E.3.b;

c. formation testing results if performed prior to well operation;

d. stimulation program;

e. description of injection procedures (including storage and pre-injection treatment of the waste stream and well use schedule);

f. schematic or other appropriate drawings of the surface (wellhead and related appurtenances) and subsurface construction details of the system;

g. monitoring equipment as required in §109;

h. contingency plans as required in §105.E.3;

i. a plugging and abandonment certificate as required in §105.E.3;

j. proposed corrective action as required in §105.E.3.k;

k. calculation of the pressure increase in the injection zone as required in §105.E.3;

l. calculation of the waste front travel as required in §105.E.3;

m. measurement of bottomhole pressure and temperature at the time of repermitting or during the next workover operation;

n. a graphic presentation of the well's operational history consisting of the following:

i. a plot of representative values of injection pressure and injection rate versus time, from date of initial injection to the present (indicate cumulative volume);

ii. a plot of measured bottomhole pressure versus date if such measurements were made;

iii. indications of any workovers and associated problems, stimulations, waste stream changes and other events that would have a bearing on the well's performance, especially:

(a). any change of injection interval; or

(b). any other information the permittee or commissioner may consider useful;

o. copies of all logs and tests run during construction and subsequent operation of the well, including mechanical integrity tests;

p. a summary analysis of the data provided in §105.E.4; and

q. any other information required by the commissioner to evaluate the existing well.

F. Application Content for Class III Wells. Prior to the issuance of a permit for an existing Class III well or area to operate or the construction of a new Class III well the commissioner shall consider the following information (provided on the application form):

1. administrative information:

a. the name, mailing address, and location of the facility for which the application is submitted;

b. ownership status as federal, state, private, public, or other entity;

c. the operator's name, address and telephone number;

d. a brief description of the nature of the business associated with the activity;

e. the activity or activities conducted by the applicant which require the applicant to obtain a permit under these regulations;

f. up to four SIC Codes which best reflect the principal products or services provided by the facility;

g. a listing of all permits or construction approvals which the applicant has received or applied for under any of the following programs and which specifically affect the legal or technical ability of the applicant to undertake the activity or activities to be conducted by the applicant under the permit filed here for:

i. the Louisiana Hazardous Waste Management Program;

ii. this or any other Underground Injection Control Program;

iii. NPDES Program under the Clean Water Act;

iv. Prevention of Significant Deterioration (PSD) Program under the Clean Air Act;

v. Nonattainment Program under the Clean Air Act;

vi. National Emission Standards for Hazardous Pollutants (NESHAPS) preconstruction approval under the Clean Air Act;

vii. Ocean Dumping Permit under the Marine Protection Research and Sanctuaries Act;

viii. dredge or fill permits under Section 404 of the Clean Water Act; and

ix. other relevant environmental permits, including, but not limited to any state permits issued under the Louisiana Coastal Resources Program, the Louisiana Surface Mining Program or the Louisiana Natural and Scenic Streams System;

h. jurisdiction:

i. whether the facility is located on Indian lands or other lands under the jurisdiction or protection of the federal government; or

ii. whether the facility is located on state water bottoms or other lands owned by or under the jurisdiction or protection of the state;

2. maps and related information:

a. a topographic or other map extending 1 mile beyond the property boundaries, depicting the facility and each well where fluids are injected underground; and those wells, springs, or surface water bodies, and drinking water wells listed in public records or otherwise known to the applicant in the map area;

b. the section, township and range of the area in which the activity is located and any parish, city or municipality boundary lines within 1 mile of the activity location;

c. a map showing the injection well or project area for which the permit is sought and the applicable area of review. Within the area of review, the map must show the number, or name, and location of all existing producing wells, injection wells, abandoned wells and dry holes, public water systems and water wells. The map may also show surface bodies of water, mines (surface and subsurface), quarries, and other pertinent surface features including residences and roads, and faults if known or projected. Only information of public record and pertinent information known to the applicant is required to be included on this map;

d. maps and cross sections indicating the vertical limits of all underground sources of drinking water within the area of review, their position relative to the injection formation, and the direction of water movement, where known, in every underground source of drinking water which may be affected by the proposed injection;

e. generalized map and cross sections illustrating the regional geologic setting;

f. maps and cross sections detailing the geologic structure of the local area; and

g. any other information required by the commissioner to evaluate the proposed well or project;

3. technical information for new wells:

a. a tabulation of data reasonably available from public records or otherwise known to the applicant on all wells within the area of review which penetrate the proposed injection zone. Such data shall include a description of each well's type, construction, date drilled, location, depth, record of plugging and/or completion, and any additional information the commissioner may require. In cases where the information would be repetitive and the wells are of similar age, type, and construction, the commissioner may elect to only require data on a representative number of wells;

b.i. proposed operating data:

(a). average and maximum daily rate and volume of fluid to be injected;

(b). average and maximum injection pressure; and

(c). qualitative analysis and ranges in concentrations of all constituents of injected fluids. The applicant may request confidentiality;

ii. if the information is proprietary an applicant may, in lieu of the ranges in concentrations, choose to submit maximum concentrations which shall not be exceeded. In such a case the applicant shall retain records of the undisclosed concentrations and provide them upon request to the commissioner as part of any enforcement investigation;

c. proposed formation testing program to obtain the information required by §109.B.4.c and d;

d. proposed stimulation program;

e. proposed injection procedure;

f. schematic or other appropriate drawings of the surface and subsurface construction details of the system;

g. plans (including maps) for meeting the monitoring requirements of §109.B.7;

h. expected changes in pressure, native fluid displacement, and direction of movement of injection fluid;

i. contingency plans to cope with all shut-ins or well failures so as to prevent the migration of the contaminating fluids into underground sources of drinking water;

j. a certificate that the applicant has assured, through a performance bond or other appropriate means, the resources necessary to close, plug or abandon the well as required by §§109.B.10 and 107.C; and

k. for wells within the area of review which penetrate the injection zone but are not properly completed or plugged, the corrective action proposed to be taken under §109.B.3.

G. Recordkeeping of Application Information. The applicant shall keep records of all pertinent data used to complete the permit applications and any supplemental information submitted under these regulations for a period of at least three years from the date the application is signed.

H. Confidentiality of Information. Information obtained by any rule, regulations, order, or permit term or condition adopted or issued here-under, or by any investigation authorized thereby, shall be available to the public, unless nondisclosure is requested in writing and such information is determined by the commissioner to require confidentiality to protect trade secrets, processes, operations, style of work, apparatus, statistical data, income, profits, losses, or in order to protect any plan, process, tool, mechanism, or compound; provided that such nondisclosure shall not apply to information that is necessary for use by duly authorized officers or employees of state or federal government in carrying out their responsibilities under these regulations or applicable federal or state law. If no claim is made at the time of submission, the commissioner may make the information available to the public without further notice.

1. Claims of confidentiality for the following information will be denied:

a. the name and address of any permit applicant or permittee; and

b. information which deals with the existence, absence, or level of contaminants in drinking water.

I. Filing Fee. Each application shall be accompanied by a per well, nonrefundable filing fee as required by Statewide Order No. 29-R-00/01 (LAC XIX.Chapter 7) or successor document.

AUTHORITY NOTE: Promulgated in accordance with R.S. 30:1D, 4C(16), and 4.1.

HISTORICAL NOTE: Promulgated by the Department of Natural Resources, Office of Conservation, LR 8:83 (February 1982), LR 27:1699 (October 2001).

§107. Legal Permit Conditions

A. Applicability. The rules and regulations of this Section set forth legal conditions for Class I, III, IV and V well permits.

B. Signatories. All reports required by permits and other information requested by the commissioner shall be signed as in applications by a person described in §105.D.

C. Financial Responsibility. The permit shall require the permittee to maintain financial responsibility and resources to close, plug, and abandon the underground injection wells in a manner prescribed by the commissioner. The permittee must show evidence of financial responsibility to the commissioner by the submission of a surety bond, or other adequate assurance, such as financial statements or other materials acceptable to the commissioner.

D. Duty to Comply. The permittee must comply with all conditions of a permit. Any permit noncompliance constitutes a violation of the act and is grounds for enforcement action, or permit termination, revocation and reissuance, or modification; or for denial of a permit renewal application if the commissioner determines that such noncompliance endangers underground sources of drinking water. The permittee need not comply with the provisions of his permit to the extent and for the duration such noncompliance is authorized in a (temporary) emergency permit under §115.

E. Duty to Reapply. If the permittee wishes to continue an activity regulated by a permit after the expiration date of this permit, the permittee must apply for and obtain a new permit.

F. Duty to Halt or Reduce Activity. It shall not be a defense for a permittee in an enforcement action that it would have been necessary to halt or reduce the permitted activity in order to maintain compliance with the conditions of this permit.

G. Duty to Mitigate. The permittee shall take all reasonable steps to minimize or correct any adverse impact on the environment such as the contamination of underground sources of drinking water resulting from noncompliance with this permit.

H. Proper Operation and Maintenance. The permittee shall at all times properly operate and maintain all facilities and systems of treatment and control (and related appurtenances) which are installed or used by the permittee to achieve compliance with the conditions of his permit. Proper operation and maintenance includes effective performance, adequate funding, adequate operation staffing and training, and adequate laboratory process controls, including appropriate quality assurance procedures. This provision requires the operation of back-up or auxiliary facilities or similar systems only when necessary to achieve compliance with the conditions of the permit.

I. Inspection and Entry. Inspection and entry shall be allowed as prescribed in R.S. of 1950, Title 30, Section 4.

J. Compliance. Except for Class III wells, compliance with a permit during its term constitutes compliance, for purposes of enforcement, with the act and these regulations.

K. Property Rights. The issuance of a permit does not convey any property rights of any sort, or any exclusive privilege or servitude.

L. Notification Requirements

1. Planned Changes. The permittee shall give notice to the commissioner as soon as possible of any planned physical alterations or additions to the permitted facility which may constitute a major modification of the permit.

2. Notice of Well Completion

a. A new injection well may not commence injection until construction is complete, a notice of completion has been submitted to the commissioner, and except for wells authorized by area permit or rule, the commissioner has inspected or otherwise reviewed the injection well and finds it is in compliance with the conditions of the permit.

b. The commissioner shall inspect the well within 10 working days of the notice of completion required in §107.L.2.a.

c. If the permittee has not received notice from the commissioner of his intent to inspect or review the well or if the commissioner has not inspected or otherwise reviewed the new injection well within 10 working days of the notice of completion in §107.L.2.a, prior inspection or review is waived and the permittee may commence injection.

3. Anticipated Noncompliance. The permittee shall give advance notice to the commissioner of any planned changes in the permitted facility or activity which may result in noncompliance with permit requirements.

4. Transfers. A permit is not transferable to any person except after notice to the commissioner. The commissioner may require modification or revocation and reissuance of the permit to change the name of the permittee and incorporate such other requirements as may be necessary. (See §113.)

5. Compliance Schedules. Report of compliance or noncompliance with, or any progress reports on, interim and final requirements contained in any compliance schedule in these regulations shall be submitted to the commissioner no later than 14 days following each schedule date.

6. Twenty-Four Hour Reporting

a. The permittee shall report to the commissioner any noncompliance which may endanger health or the environment. Any information pertinent to the noncompliance shall be reported by telephone at (225) 342-5515 within 24 hours from the time the permittee becomes aware of the circumstances. A written submission shall also be provided within five days of the time the permittee becomes aware of the circumstances and shall contain a description of the noncompliance and its cause; the period of noncompliance, including exact dates and times, and if the noncompliance has not been corrected, the anticipated time it is expected to continue; and steps taken or planned to reduce, eliminate, and prevent reoccurrence of the non-compliance.

b. The following additional information must be reported within the 24-hour period provided above:

i. any monitoring or other information which indicates that any contaminant may cause an endangerment to a USDW;

ii. any noncompliance with a permit condition or malfunction of the injection system which may cause fluid migration into or between USDW's.

7. The permittee shall notify the commissioner at such times as the permit requires before conversion or abandonment of the well or in the case of area permits before closure of the project.

8. Other Noncompliance. The permittee shall report all instances of noncompliance not reported under §107.L.5 and 6, at the time quarterly reports are submitted. The reports shall contain the information listed in §107.L.6.

9. Other Information. Where the permittee becomes aware that it failed to submit any relevant facts in a permit application, or submitted incorrect information in a permit application or in any report to the commissioner, it shall promptly submit such facts or information.

M. Duration of Permits

1. UIC permits for Class I and Class V wells shall be effective for a fixed term not to exceed 10 years. Permits for Class III wells shall be issued for a period up to the operating life of the facility. The commissioner shall review each issued Class III well or area permit at least once every five years to determine whether it should be modified, revoked and reissued, terminated, or a minor modification made.

2. The term of a permit shall not be extended by modification beyond the maximum duration specified in this Section, except as provided in §107.M.4 below.

3. The commissioner may issue, for cause, any permit for a duration that is less than the full allowable term under this Section.

4. The conditions of an expired permit may continue in force until the effective date of a new permit if the permittee has submitted a timely and a complete application for a new permit, and the commissioner, through no fault of the permittee, does not issue a new permit with an effective date on or before the expiration date of the previous permit (e.g., when issuance is impracticable due to time or resource constraints).

a. Permits continued under this Section remain fully effective and enforceable.

b. When the permittee is not in compliance with the conditions of the expiring or expired permit, the commissioner may choose to do any or all of the following:

i. initiate enforcement action based upon the permit which has been continued;

ii. issue a notice of intent to deny the new permit. If the permit is denied, the owner or operator would then be required to cease the activities authorized by the continued permit or be subject to enforcement action for operating without a permit;

iii. issue a new permit under the requirements of these rules for issuing a new permit with appropriate conditions; or

iv. take other actions authorized by these regulations.

N. Schedules of Compliance. The permit may, when appropriate, specify a schedule of compliance leading to compliance with the act and these regulations.

1. Time for Compliance. Any schedules of compliance under this Section shall require compliance as soon as possible but not later than three years after the effective date of the permit.

2. Interim Dates. Except as provided in §107.N.2.b, if a permit establishes a schedule of compliance which exceeds one year from the date of permit issuance, the schedule shall set forth interim requirements and the dates for their achievement.

a. The time between interim dates shall not exceed one year.

b. If the time necessary for completion of any interim requirements (such as the construction of a control facility) is more than one year and is not readily divisible into stages for completion, the permit shall specify interim dates for submission of reports of progress toward completion of the interim requirements and indicate a projected completion date.

3. Reporting. The permit shall be written to require that progress reports be submitted no later than 30 days following each interim date and the final date of compliance.

O. Additional Conditions. The commissioner shall impose on a case-by-case basis such additional conditions as are necessary to protect underground sources of drinking water.

AUTHORITY NOTE: Promulgated in accordance with R.S. 30:1D, 4C(16), and 4.1.

HISTORICAL NOTE: Promulgated by the Department of Natural Resources, Office of Conservation, LR 8:83 (February 1982), amended LR 11:640 (June 1985), LR 27:1700 (October 2001).

§109. Technical Criteria and Standards

A. Class I Wells

1. Applicability. This Subsection establishes technical criteria and standards for regulation of Class I wells which possess a permit or are authorized by rule.

2. Area of Review

a. The area of review for each Class I injection well shall be a fixed radius around the well of not less than 2 miles.

b. All known unplugged or improperly plugged and abandoned wells in the area of review which penetrate the injection zone are subject to the corrective action requirements of §109.A.3.

3. Corrective Action

a. Coverage. Applicants for Class I injection well permits shall identify the location of all known wells within the area of review which penetrate the injection zone. For such wells which are improperly sealed, completed or abandoned, the applicant shall also submit a plan consisting of such steps or modifications as are necessary to prevent movement of fluid into underground sources of drinking water ("corrective action"). Where the plan is adequate, the commissioner shall incorporate it into the permit as a condition. Where the commissioner's review of an application indicates that the permittee's plan is inadequate (based on the factors in §109.A.3.c) the commissioner shall require the applicant to revise the plan, prescribe a plan for corrective action as a condition of the permit under §109.A.3.b, or deny the application.

b. Requirements

i. Existing Injection Wells. Any permit issued for an existing injection well requiring corrective action shall include a compliance schedule requiring any corrective action accepted or prescribed under §109.A.3.a to be completed as soon as possible.

ii. New Injection Wells. No permit for a new injection well may authorize injection until all required correction action has been taken.

iii. Injection Pressure Limitation. The commissioner may require as a permit condition that injection pressure be so limited that pressure in the injection zone does not cause the movement of fluids into a USDW through any improperly completed or abandoned will within the area of review. This pressure limitation shall satisfy the corrective action requirement. Alternatively, such injection pressure limitation can be part of a compliance schedule and last until all other required corrective action has been taken.

c. In determining the adequacy of corrective action proposed by an application for a well requiring such action and in determining the additional steps needed to prevent fluid movement into underground sources of drinking water, the following criteria and factors shall be considered by the commissioner:

i. nature and volume of the injected fluid;

ii. nature of native fluids or by-products of injection;

iii. potentially affected population;

iv. geology;

v. hydrology;

vi. history of the injection operation;

vii. completion and plugging records;

viii. abandonment procedures in effect at the time the well was abandoned; and

ix. hydraulic connections with underground sources of drinking water.

4. Construction Requirements

a. Siting. All Class I wells shall be sited in such a fashion that they inject into a formation which is beneath the lower most formation containing an underground source of drinking water within 1/4 mile radius of the well bore.

b. Casing and Cementing

i. All Class I wells shall be cased and cemented to prevent the movement of fluids into or between USDWs.

ii. Cementing shall be by the pump and plug or other method approved by the commissioner and sufficient amount of cement shall be used to fill the annular space between the hole and casing and between casing strings to the surface of the ground.

iii. The casing and cement used in the construction of each new injection well shall be designed for the life expectancy of the well.

iv. Surface casing shall be set to a minimum subsurface depth determined by the commissioner to properly protect underground sources of drinking water and cemented to the surface. If the long string or intermediate casing is to be perforated, the approved casing shall be set to a depth below the injection zone and cemented to the surface. If an approved alternate method is used, such as the setting of a screen, the casing shall be set to the top of the injection zone and cemented back to the surface.

v. In determining and specifying casing and cementing requirements, the following factors shall be considered:

(a). depth to the injection zone;

(b). injection pressure, external pressure, internal pressure, and axial loading;

(c). hole size;

(d). size and grade of all casing strings (wall thickness, diameter, nominal weight, length, joint specification, and construction material);

(e). corrosive effects of injected fluid, formation fluids, and temperatures;

(f). lithology of injection and confining intervals; and

(g). types and grades of cement.

c. Tubing and Packer

i. All Class I injection wells shall inject fluids through tubing with either a packer set above the injection zone or a fluid seal system approved by the commissioner. In determining and specifying requirements for tubing, packer or fluid seal system, the following factors shall be considered:

(a). depth of setting;

(b). characteristics of injection fluid;

(c). injection pressure;

(d). annular pressure;

(e). rate, temperature, and volume of injected fluid; and

(f). size of casing.

ii. The use of other alternatives to a packer may be allowed with the written approval of the commissioner. To obtain approval, the operator shall submit a written request to the commissioner, which shall set forth the proposed alternative and all technical data supporting its use. The commissioner shall approve the request if the alternative method will reliably provide a comparable level of protection to underground sources of drinking water. The commissioner may approve an alternative method for an individual well or for general use.

iii. A corrosion resistant fluid shall be placed under pressure into the tubing-long string casing annulus. The annulus pressure shall be monitored in accordance with §109.A.7.d and 9.b.

d. Logs and Tests. Appropriate logs and other tests shall be conducted during the drilling and construction of new Class I wells. All logs and tests shall be interpreted by the service company which processed the logs or conducted the test, or by other qualified persons. A minimum of the following logs and tests shall be conducted.

i. Deviation checks on all holes constructed by first drilling a pilot hole, and then enlarging the pilot hole by reaming or another method. Such checks shall be at sufficiently frequent intervals to assure that avenues for fluid migration in the form of diverging holes are not created during drilling.

ii. For surface casing:

(a). spontaneous potential, resistivity or gamma-resistivity, and caliper logs before the casing is installed; and

(b). a cement bond, temperature, or density log after the casing is set and cemented.

iii. For intermediate and long string casing:

(a). spontaneous potential, resistivity or gamma-resistivity, and caliper logs before the casing is installed;

(b). a fracture finder log when applicable; and

(c). a cement bond log, a gamma-ray (full hole) log, and an inclination survey after the casing is set and cemented.

iv. All casing strings shall be pressure tested at conditions specified by the commissioner and reported on form CSG.T.

v. If core data is not available from nearby wells full-hole cores shall be taken from selected intervals of the injection zone and lowermost confining zone; or, if full-hole coring is not feasible or adequate core recovery is not achieved, side-wall cores shall be taken at sufficient intervals to yield representative data for selected parts of the injection zone and lowermost confining zone. Core analysis shall include a determination of permeability, porosity, bulk density, and other necessary tests.

e. Injectivity Tests. After completion of the well, injectivity tests shall be performed to determine the well capacity and reservoir characteristics. Surveys shall be performed to establish preferred injection zones. Prior to performing injectivity tests, the bottom hole pressure, bottom hole temperature, and static fluid level shall be determined, and a representative sample of formation fluid shall be obtained for chemical analysis.

f. Construction Supervision. All phases of well construction and all phases of any well workover shall be supervised by a person who is knowledgeable and experienced in practical drilling engineering and who is familiar with the special conditions and requirements of injection well construction.

5. Pre-Operation Requirements. In order to receive approval to start operation of a new well, the permittee must supply the following to the commissioner within 30 days of well completion.

a. A completion report containing, at a minimum, the following:

i. the drilling and complete and accurate record of the depth, thickness, and character of the strata penetrated;

ii. casing and cement records;

iii. well logs;

iv. injectivity test data;

v. measured bottomhole temperature and pressure;

vi. core sample testing results;

vii. formation fluid analysis;

viii. compatibility testing results;

ix. test data which provides a demonstration of mechanical integrity pursuant to §109.A.9;

x. a descriptive report interpreting the results of all logs and tests;

xi. a revised formation pressure build-up calculation in accordance with §105.E.3.l;

xii. a revised waste front travel calculation (§105.E.3.m); and

xiii. revised cross sections of the injection zone using pertinent data above.

b. For commercial Class I wells, written notification that a copy of the permit has been filed with the appropriate authorities where the well is located.

c. Written Notification of the Anticipated Well Startup Date. Compliance with all pre-operation terms of the permit must occur and approval to start operation must be received from the commissioner prior to beginning injection operations (see §107.L).

d. The commissioner may give permission to commence injection for an interim period of 30 days following the inspection required in §107.L.2.b. Final permission to inject will be given only upon receipt and approval of the completion report required in §109.A.5.

6. Operating Requirements

a.i. Except during well stimulation, the Maximum Surface Injection Pressure (MSIP) shall not exceed the surface injection pressure needed to initiate fracture of the injection or confining zone(s) and shall be calculated by following the formula:

$$MSIP = 0.85\ [BHP_F - H] + TF + SE$$

where:

BHP_F = bottomhole fracture pressure established by gradients for the area the well is located in or actual testing

H = hydrostatic pressure

TF = frictional loss in the tubing during maximum injection rate

SE = skin effects as established by accepted engineering test procedures as described in "Pressure Buildup and Flow Tests in Wells", by C.S. Matthews and D.G. Russell or approved alternate tests (optional variable)

ii. In no case shall the calculated maximum surface injection pressure exceed the surface injection pressure needed to initiate fractures in the confining or injection zone(s) or cause movement of injection or formation fluids into a USDW.

b. Injection between the outermost casing protecting underground sources of drinking water and the well bore is prohibited.

c. Unless an alternative to a packer has been approved by the commissioner, the tubing-long string casing annulus shall be filled with a corrosion resistant fluid approved by the commissioner. A positive pressure, also approved by the commissioner, shall be maintained on the annulus to detect well malfunctions.

d. A protective barrier shall be maintained around the wellhead and related appurtenances during all normal in-service and out-of-service periods for protection against mechanical damage.

e. A sign shall be maintained on the protective barrier of each injection well identifying the well class (Class I) operator, well name and/or number, UIC permit number, and any other information required by the commissioner.

f. Approval by the commissioner shall be obtained before the permittee may begin any workover operation (see §109.A.8.b.i). All fluids and materials (sand, etc.) removed from a well during any workover operation shall be contained and disposed of properly.

7. Monitoring Requirements

a. Samples and measurements taken for the purpose of monitoring shall be representative of the monitored activity.

b. Records of monitoring information shall include:

i. the date, exact place, and time of sampling or measurements;

ii. the individual(s) who performed the sampling or measurements;

iii. the date(s) analyses were performed;

iv. the individual(s) who performed the analyses;

v. the analytical techniques or methods used; and

vi. the results of such analyses.

c. Injection fluids shall be sampled and analyzed with a frequency sufficient to yield data representative of their characteristics.

d. Pressure gauges shall be installed and properly maintained on the injection tubing and on the annulus at the wellhead.

e. Continuous recording devices shall be installed and maintained in proper operating condition at all times to monitor and record injection tubing pressures, injection flow rates, injection volumes, tubing-long string casing annulus pressure, and any other specified data. The instruments shall be housed in weatherproof enclosures.

f. Any wells within the area of review selected for the observation of water quality, formation pressure, or any parameter, shall be monitored at a frequency sufficient to protect USDWs.

g. Mechanical integrity shall be demonstrated and reported according to the procedures, and at the frequency, specified in §109.A.9.

8. Reporting Requirements

a. Quarterly Reports to the Commissioner

i. This report shall include:

(a). the physical, chemical, and other relevant characteristics of the injection stream;

(b). monthly average, maximum, and minimum values for injection pressure, flow rate and volume, cumulative volume, and annular pressure;

(c). the results of any mechanical integrity tests performed during the quarter;

(d). the results of any other well test performed during the quarter;

(e). the results of monitoring prescribed in §109.A.7.f; and

(f). the results of any well workover performed during the quarter including minor well maintenance.

ii. This report shall be filed four times a year within 30 days after the quarter end and if not received as required, the commissioner may commence appropriate enforcement action.

b. Workover Reports

i. Notification of Workover. The permittee shall notify the commissioner by telephone at (225) 342-5515 before commencing any workover operation which requires the use of a rig. In addition, the operator must obtain a work permit prior to any workover operation such as plug and abandon, deepen, perforate, squeeze, plugback, side-track, pull casing, pull tubing, or change zone of completion (disposal).

ii. Completed Workover Report. The first quarterly report after the completion of a workover shall include the reason for the well workover and the details of all work performed.

iii. Bottom Hole Pressure Report. During major workovers, the bottom hole pressure shall be determined either by direct measurement by conventional techniques or by calculation using specific gravity of fluid in the well bore and the static fluid level as specified by the commissioner.

9. Mechanical Integrity Testing

a. Mechanical integrity of Class I injection wells shall be defined as:

i. no significant leak(s) in the casing, tubing or packer; and

ii. no significant fluid movement into an underground source of drinking water through vertical channels adjacent to the injection well bore.

b. One of the following tests must be used to demonstrate the absence of significant leaks in §109.A.9.a.i above:

i. a fluid pressure test of the annular space witnessed by an Office of Conservation representative; or

ii. review of the continuous monitoring records required in §109.A.7 by an Office of Conservation representative.

c. One of the following tests may be used to demonstrate absence of significant vertical fluid movement in §109.A.9.a.ii above:

i. radioactive tracer survey;

ii. high resolution temperature survey;

iii. audio Log; and/or

iv. other test accepted by the industry may be allowed with prior written approval from the commissioner.

d. Frequency of Mechanical Integrity Tests

i. Mechanical integrity tests under §109.A.9.b shall be performed on an alternative basis unless otherwise ordered by the commissioner or his representative. The frequency of this mechanical integrity testing shall be quarterly for commercial Class I wells and semiannually for on-site Class I wells.

ii. For new wells, mechanical integrity tests under §109.A.9.c shall be performed annually during the first two years of the well permit period and no less than once every five years thereafter. For existing wells, mechanical integrity tests under §109.A.9.c shall be performed at the time of repermitting and no less than once every five years thereafter.

e. The commissioner or his representative reserves the right to specifically require more frequent integrity testing as well as the right to specify the method of testing in specific instances.

f. Except during workovers or routine maintenance, any well which is not operational shall conform to the mechanical integrity requirements of this Section and shall sustain a positive pressure on the annulus during the period of non-use. When an operator plans to take a well out of operation, he shall submit a plan to the commissioner to assure the mechanical integrity of the well during non-use. If a well cannot meet the mechanical integrity requirements of this Section, the operator shall submit a plan to the commissioner within 30 days of the test, to properly bring the facility into compliance. If a plan is not submitted within 30 days or if the plan is considered inadequate, the operator will be given six months to plug and abandon the well as required in §109.A.10.

10. Plugging and Abandonment

a. Prior to plugging and abandoning a Class I well, the permittee shall submit to the commissioner a plan of plugging and abandonment which will include location, depth of plugs, type of cement and the general procedure for plugging. After receipt of this information, the commissioner may approve, modify or deny the plan of abandonment; the commissioner additionally may require the applicant to revise the plan.

b. Any Class I permit shall include conditions to ensure that plugging and abandonment of the well will not allow the movement of fluids either into an underground source of drinking water or from one USDW to another.

11. Recordkeeping Requirements

a. The permittee shall keep complete and accurate records of:

i. all monitoring required by the permit, including:

(a). continuous records of surface injection pressures;

(b). continuous records of the tubing-long string annulus pressures;

(c). continuous records of injection flow rates; and

(d). monthly total volume of injected fluids.

ii. all periodic well tests, including but not limited to:

(a). injection fluid analyses;

(b). bottom hole pressure determinations; and

(c). mechanical integrity.

b. The permittee shall retain records of all information resulting from any monitoring activities for a period of at least three years from the date of the sample or measurement. This period may be extended by request of the commissioner at any time.

c. In addition to Paragraph 11.b above, the permittee shall retain all records concerning the nature, composition, and volume of injected fluids until three years after completion of any plugging and abandonment procedures. The commissioner may require the owner or operator to deliver the records to the Office of Conservation at the conclusion of the retention period.

d. All records shall be made available for review upon request from a representative of the commissioner.

12. Waiver of Requirements

a. When injection does not occur into, through, or above an underground source of drinking water, the commissioner may authorize a Class I well with less stringent requirements for area of review, construction, mechanical integrity, operation, monitoring and reporting than required in this Section, to the extent that the reduction in requirements will not result in an increased risk of movement of fluids into a USDW.

b. When reducing requirements under this Section, the commissioner shall issue an order explaining the reasons for the action.

13. Additional Requirements. The commissioner may prescribe additional requirements for Class I wells in order to protect underground sources of drinking water.

B. Class III Wells

1. Applicability. This Subpart establishes criteria and standards for regulation of Class III wells or projects which possess a permit or are authorized by rule.

2. Area of Review

a. For individual Class III wells, the area of review shall be a fixed radius around the well of not less than 1/4 mile.

b. For wells in a Class III project, the area of review shall be the project area plus a circumscribing area the width of which is not less than 1/4 mile.

3. Corrective Action

a. Coverage. Applicants for class III injection well permits shall identify the location of all known wells within the injection well's area of review which penetrate the injection zone. For such wells which are improperly sealed, completed, or abandoned, the applicant shall also submit a plan consisting of such steps or modifications as are necessary to prevent movement of fluid into underground sources of drinking water corrective action. Where the plan is adequate, the commissioner shall incorporate it into the permit as a condition. Where the commissioner's review of an application indicates that the permittee's plan is inadequate (based on the factors in Subparagraph c below) the commissioner shall require the applicant to revise the plan, prescribe a plan for corrective action as a condition of the permit or deny the application.

b. Requirements

i. Existing Injection Wells. Any permit issued for an existing injection well requiring corrective action shall include a compliance schedule requiring any corrective action accepted or prescribed under §109.B.3.a to be completed as soon as possible.

ii. New Injection Wells. No permit for a new injection well may authorize injection until all required correction action has been taken.

iii. Injection Pressure Limitation. The commissioner may require as a permit condition that injection pressure be so limited that pressure in the injection zone does not cause the movement of fluids into a USDW through any improperly completed or abandoned well within the area of review. This pressure limitation shall satisfy the corrective action requirement. Alternatively, such injection pressure limitation can be part of a compliance schedule and last until all other required corrective action has been taken.

c. When setting corrective action requirements for Class III wells, the commissioner shall consider the overall effect of the project on the hydraulic gradient in potentially affected USDWs, and the corresponding changes in potentiometric surface(s) and flow direction(s) rather than the discrete effect of each well. If a decision is made that corrective action is not necessary based on the determinations above, the monitoring program required in §109.B.7 shall be designed to verify the validity of such determination.

d. In determining the adequacy of corrective action proposed by the applicant under §109.B.3.a above and in determining the additional steps needed to prevent fluid movement into underground sources of drinking water, the following criteria and factors shall be considered by the commissioner:

i. nature and volume of injected fluid;

ii. nature of native fluids or by-products of injection;

iii. potentially affected population;

iv. geology;

v. hydrology;

vi. history of the injection operation;

vii. completion and plugging records;

viii. abandonment procedures in effect at the time the well was abandoned; and

ix. hydraulic connections with underground sources of drinking water.

4. Construction Requirements

a. All new Class III wells shall be cased and cemented to prevent the migration of fluids into or between underground sources of drinking water. The commissioner may waive the cementing requirement for new wells in existing projects or portions of existing projects where he has substantial evidence that no contamination of underground sources of drinking water would result. The casing and cement used in the construction of each newly drilled well shall be designed for the life expectancy of the well. In determining and specifying casing and cementing requirements, the following factors shall be considered:

i. depth to the injection zone;

ii. injection pressure, external pressure, internal pressure, axial loading, etc.;

iii. hole size;

iv. size and grade of all casing strings (wall thickness, diameter, nominal weight, length, joint specification, and construction material);

v. corrosiveness of injected fluids and formation fluids;

vi. lithology of injection and confining zones; and

vii. type and grade of cement.

b. Appropriate logs and other tests shall be conducted of new Class III wells. A descriptive report interpreting the results of such logs and tests shall be prepared by a knowledgeable log analyst and submitted to the commissioner. The logs and tests appropriate to each type of Class III well shall be determined based on the intended function, depth, construction, and other characteristics of the well, availability of similar data in the area of the drilling site and the need for additional information that may arise from time to time as the construction of the well progresses. Deviation checks shall be conducted on all holes where pilot holes and reaming are used, unless the hole will be cased and cemented by circulating cement to the surface. Where deviation checks are necessary, they shall be conducted at sufficiently frequent intervals to assure that vertical avenues for fluid migration in the form of diverging holes are not created during drilling.

c. Where the injection zone is a water bearing formation, the following information concerning the injection zone shall be determined or calculated for new Class III wells or projects:

i. fluid pressure;

ii. fracture pressure; and

iii. physical and chemical characteristics of the formation fluids.

d. Where the injection formation is not a water bearing formation, the information in §109.B.4.c.ii must be submitted.

e. Where injection is into a formation which contains water with less than 10,000 mg/l TDS, monitoring wells shall be completed into the injection zone and into any underground sources of drinking water above the injection zone which could be affected by the mining operation. These wells shall be located in such a fashion as to detect any excursion of injected fluids, process by-products, or formation fluids outside the mining area or zone. If the operation may be affected by subsidence or catastrophic collapse the monitoring wells shall be located so that they will not be physically affected.

f. Where injection is into a formation which does not contain water with less than 10,000 mg/l TDS, no monitoring wells are necessary in the injection stratum.

g. Where the injection wells penetrate a USDW in an area subject to subsidence or catastrophic collapse an adequate number of monitoring wells shall be completed into the USDW to detect any movement of injected fluids, process by-products or formation fluids into the USDW. The monitoring wells shall be located outside the physical influence of the subsidence or catastrophic collapse.

h. In determining the number, location, construction and frequency of monitoring of the monitoring wells the following criteria shall be considered:

i. the population relying on the USDW affected or potentially affected by the injection operation;

ii. the proximity of the injection operation to points of withdrawal of drinking water;

iii. the local geology and hydrology;

iv. the operating pressures and whether a negative pressure gradient is being maintained;

v. the nature and volume of the injected fluid, the formation water, and the process by-products; and

vi. the injection well density.

5. Pre-Operation Requirements. Prior to granting approval for the operation of an individual Class III well, except for wells drilled under an area permit, the commissioner shall consider the following information:

a. all available logging and testing data on individual wells; representative logs on Class III projects;

b. a satisfactory demonstration of mechanical integrity for all new wells and for all existing salt solution wells;

c. the results of the formation testing program;

d. the status of corrective action on defective wells in the area of review;

e. the proposed operating data; and

f. the proposed injection procedures.

6. Operating Requirements. Operating requirements prescribed shall, at a minimum, specify that:

a. except during well stimulation injection pressure at the well-head shall be calculated so as to assure that the pressure in the injection zone during injection does not initiate new fractures or propagate existing fractures in the injection zone. In no case shall injection pressure initiate fractures in the confining zone or cause the migration of injection or formation fluids into an underground source of drinking water; and

b. injection between the outermost casing protecting underground sources of drinking water and the well bore is prohibited.

7. Monitoring Requirements. Monitoring requirements shall, at a minimum, specify:

a. monitoring of the nature of injected fluids with sufficient frequency to yield representative data on its characteristics. Whenever the injection fluid is modified to the extent that the analysis required by §105.F.3.b is incorrect or incomplete, a new analysis shall be provided to the commissioner;

b. monitoring of injection pressure and either flow rate or volume semi-monthly, or metering and daily recording of injected and produced fluid volumes as appropriate;

c. demonstration of mechanical integrity pursuant to §109.B.9 at least once every five years during the life of the well for salt solution mining;

d. monitoring of the fluid level in the injection zone semi-monthly, where appropriate, and monitoring of the parameters chosen to measure water quality in the monitoring wells required by §109.B.4.c, semi-monthly;

e. quarterly monitoring of wells required by §109.B.4.g; and

f. all Class III wells may be monitored on a field or project basis rather than an individual well basis by manifold monitoring. Manifold monitoring may be used in cases of facilities consisting of more than one injection well, operating with a common manifold. Separate monitoring systems for each well are not required provided the owner/operator demonstrates that manifold monitoring is comparable to individual well monitoring.

8. Reporting Requirements. Reporting requirements shall, at a minimum, include:

a. quarterly reporting to the commissioner on required monitoring;

b. results of mechanical integrity and any other periodic test required by the commissioner reported with the first regular quarterly report after the completion of the test; and

c. monitoring may be reported on a project or field basis rather than individual well basis where manifold monitoring is used.

9. Mechanical Integrity

a. An injection well has mechanical integrity if:

i. there is no significant leak in the casing, tubing, or packer; and

ii. there is no significant fluid movement into an underground source of drinking water through vertical channels adjacent to the injection well bore.

b. One of the following methods must be used to evaluate the absence of significant leaks under §109.B.9.a.i:

i. monitoring of annulus pressure; or

ii. pressure test with liquid or gas.

c. One of the following methods must be used to determine the absence of significant fluid movement under §109.B.9.a.ii:

i. for Class III wells where the nature of the casing precludes the use of the logging techniques prescribed in §109.B.9.c.iii, cementing records demonstrating the presence of adequate cement to prevent such migration; or

ii. the results of a temperature or noise log;

iii. for Class III wells where the commissioner elects to rely on cementing records to demonstrate the absence of significant fluid movement, the monitoring program prescribed by §109.B.7 shall be designed to verify the absence of significant fluid movement.

d. The commissioner may allow the use of a test to demonstrate mechanical integrity other than those listed in §109.B.9.b and c.ii.

e. In conducting and evaluating the tests enumerated in this Section or others to be allowed by the commissioner, the owner or operator and the commissioner shall apply methods and standards generally accepted in the industry. When the owner or operator reports the results of mechanical integrity tests to the commissioner, he shall include a description of the test(s) and the method(s) used. In making his evaluation, the commissioner shall review monitoring and other test data submitted since the previous evaluation.

10. Plugging and Abandonment

a. Any Class III permit shall include conditions to ensure that plugging and abandonment of the well will not allow the movement of fluids either into an underground source of drinking water or from one underground source of drinking water to another. Any applicant for a UIC permit shall be required to submit a plan for plugging and abandonment. Where the plan meets the requirements of this Section, the commissioner shall incorporate it into the permit as a condition. Where the commissioner's review of an application indicates that the permittee's plan is inadequate, the commissioner shall require the applicant to revise the plan, prescribe the conditions meeting the requirements of this Section, or deny the application. For purposes of this Section, temporary intermittent cessation of injection operations is not abandonment.

b. The permittee shall notify the commissioner at such time as the permit requires before conversion or abandonment of the well or in the case of area permits before closure of the project.

c. Prior to the abandoning Class III wells, the well shall be plugged with cement in a manner which will not allow the movement of fluids either into or between underground sources of drinking water. The commissioner may allow Class III wells to use other plugging materials if he is satisfied that such materials will prevent movement of fluids into or between underground sources of drinking water.

d. Placement of the cement plugs shall be accomplished by one of the following:

i. the Balance Method;

ii. the Dump Bailer Method; or

iii. the Two-Plug Method.

e. The well to be abandoned shall be in a state of static equilibrium with the mud weight equalized top to bottom, either by circulating the mud in the well at least once or by a comparable method prescribed by the commissioner, prior to the placement of the cement plug(s).

f. The plugging and abandonment plan required in §109.B.10.a above shall, in the case of a Class III project which underlies or is in an aquifer which has been exempted under §103.H also demonstrate adequate protection of USDWs. The commissioner shall prescribe aquifer cleanup and monitoring where he deems it necessary and feasible to insure adequate protection of USDWs.

11. Area or Project Permit Authorization

a. The commissioner may issue a permit on an area basis, rather than for each well individually, provided that the permit is for injection wells:

i. described and identified by location in permit application(s) if they are existing wells, except that the commissioner may accept a single description of wells with substantially the same characteristics;

ii. within the same well field, facility site, reservoir, project, or similar unit in the state;

iii. operated by a single owner or operator; and

iv. used to inject other than hazardous waste.

b. Area permits shall specify:

i. the area within which underground injections are authorized; and

ii. the requirements for construction, monitoring, reporting, operation, and abandonment, for all wells authorized by the permit.

c. The area permit may authorize the permittee to construct and operate, convert, or plug and abandon wells within the permit area provided:

i. the permittee notifies the commissioner at such time as the permit requires;

ii. the additional well satisfies the criteria in §109.B.11.a and meets the requirements specified in the permit under §109.B.11.b; and

iii. the cumulative effects of drilling and operation of additional injection wells are considered by the commissioner during evaluation of the area permit application and are acceptable to the commissioner.

d. If the commissioner determines that any well constructed pursuant to §109.B.11.c does not satisfy any of the requirements of §109.B.11.c.i and c.ii, the commissioner may modify the permit under §113.C, terminate under §113.E, or take enforcement action. If the commissioner determines that cumulative effects are unacceptable, the permit may be modified under §113.C.

12. Recordkeeping Requirements

a. The permittee shall keep complete and accurate records of:

i. all monitoring required by the permit; and

ii. all periodic well tests.

b. The permittee shall retain records of all information resulting from any monitoring activities for a period of at least three years from the date of the sample or measurement. This period may be extended by request of the commissioner at any time.

c. In addition to §109.B.12.b above, the permittee shall retain all records concerning the nature and composition of injected fluids until three years after completion of any plugging and abandonment procedures. The commissioner may require the owner or operator to deliver the records to the Office of Conservation at the conclusion of the retention period.

d. All records shall be made available for review upon request from a representative of the commissioner.

13. Waiver of Requirements by Commissioner

a. When injection does not occur into, through, or above an underground source of drinking water, the commissioner may authorize a Class III well or project with less stringent requirements for area of review, construction, mechanical integrity, operation, monitoring, and reporting than required in this Subsection to the extent that the reduction in requirements will not result in an increased risk of movements of fluids into an underground source of drinking water.

b. When reducing requirements under this Section, the commissioner shall issue an order explaining the reasons for the action.

14. Additional Requirements. The commissioner may prescribe additional requirements for Class III wells or projects in order to protect USDWs.

C. Class IV Wells (Reserved)

D. Class V Wells

1. Applicability. This Subsection sets forth technical criteria and standards for the regulation of all underground injection practices not regulated in Subsections A, B, and C.

a. Generally, wells covered by this Subsection inject nonhazardous fluids into or above formations that contain underground sources of drinking water. It includes all wells listed in §103.C.5, but is not limited to those types of injection wells.

b. It also includes wells not covered in Class IV that inject radioactive materials listed in the Louisiana Radiation Regulations (October 20, 1980), Part D (Standards for Protection Against Radiation), Appendix A, Table II, Column 2.

2. Large-Capacity Cesspools

a. The permitting and construction start-up of new or converted large-capacity cesspools are prohibited on and after April 5, 2000.

b. Existing large-capacity cesspools that were in operation or were under construction before April 5, 2000, shall be permanently close by April 5, 2005.

3. Motor Vehicle Waste Disposal Wells

a. The permitting and construction start-up of new or converted motor vehicle waste disposal wells are prohibited on and after April 5, 2000.

b. Existing motor vehicle waste disposal wells that were in operation or were under construction before April 5, 2000, shall be permanently closed by January 1, 2005.

4. Well Abandonment (Closure). Before permanently closing a Class V well, the owner or operator shall submit to the commissioner a plan detailing the method and procedure for closure. The commissioner may either approve the plan or require the applicant to revise the plan. The closure plan shall include conditions to ensure that permanent closure will comply with the prohibition of fluid movement standard in §103.D by not allowing the movement of additional fluids into an underground source of drinking water or from one USDW to another.

AUTHORITY NOTE: Promulgated in accordance with R.S. 30:1D, 4C(16), and 4.1.

HISTORICAL NOTE: Promulgated by the Department of Natural Resources, Office of Conservation, LR 8:83 (February 1982), amended LR 11:640 (June 1985), LR 12:26 (January 1986), LR 27:1700 (October 2001).

§111. Permitting Process

A. Applicability. This Section contains procedures for issuing all UIC permits other than emergency (temporary) permits. UIC authorizations by rule are not permits and are covered by specific provisions in §103.E.

B. Application Submission and Review

1. Any person required to have a UIC permit shall submit an application to the Office of Conservation, UIC Section, as outlined in §105.

2. Check for completeness:

a. the commissioner shall not issue a permit before receiving an application form and any required supplemental information which are completed to his satisfaction;

b. each application for a permit submitted for a new UIC injection well will be reviewed for completeness by the commissioner and the applicant will be notified of the commissioner's decision within 30 days of its receipt. Each application for a permit submitted for an existing injection well will be reviewed for completeness and the applicant will be notified of the commissioner's decision within 60 days of receipt. Upon completing the review, the commissioner shall notify the applicant in writing whether the application is complete; and

c. for each application for a new Class I injection well or a new Class III well or project, the commissioner shall, no later than the date the application is ruled complete, prepare and mail to the applicant a project decision schedule. The schedule shall specify target dates by which the commissioner intends to:

i. prepare a draft permit;

ii. give public notice;

iii. complete the public comment period, including any public hearing; and

iv. issue a final permit.

3. Incomplete Applications

a. If the application is incomplete, the commissioner shall list in the notification in §111.B.2.b above, the information necessary to make the application complete. When the application is for an existing UIC injection well, the commissioner shall specify in the notice a date for submitting the necessary information. The commissioner shall notify the applicant that the application is complete upon receiving this information. The commissioner may request additional information from an applicant only when necessary to clarify, modify, or supplement previously submitted material. Requests for such additional information will not render an application incomplete.

b. If an applicant fails or refuses to correct deficiencies found in the application, the permit may be denied and, for existing wells, appropriate enforcement actions may be taken under the applicable statutory provision.

4. If the commissioner decides that a site visit is necessary for any reason in conjunction with the processing of an application, he shall notify the applicant, state the reason for the visit, and a date shall be scheduled.

C. Draft Permits

1. Once an application is complete, the commissioner shall prepare a draft permit or deny the application.

2. The applicant may appeal the decision to deny the application in a letter to the commissioner who may then call a public hearing through §111.G.1.

3. If the commissioner prepares a draft permit, it shall contain the following information where appropriate:

a. all conditions under §107 and §109;

b. all compliance schedules under §107.N; and

c. all monitoring requirements under applicable Paragraphs in §109.

4. All draft permits prepared under this Section may be accompanied by a fact sheet pursuant to §111.D, and shall be publicly noticed in accordance with §111.E, and made available for public comment pursuant to §111.F.

D. Fact Sheet

1. A fact sheet shall be prepared for every draft permit for all major UIC facilities or activities and for every draft permit which the commissioner finds is the subject of wide-spread public interest or raises major issues. The fact sheet shall briefly set forth the principal facts and the significant factual, legal, methodological and policy questions considered in preparing the draft permits. The commissioner shall send this fact sheet to the applicant and, on request, to any other person.

2. The fact sheet shall include, when applicable:

a. a brief description of the type of facility or activity which is the subject of the draft permit;

b. the type and quantity of wastes, fluids, or pollutants which are proposed to be or are being injected;

c. a brief summary of the basis for the draft permit conditions including references to applicable statutory or regulatory provisions;

d. reasons why any requested variances or alternatives to required standards do or do not appear justified;

e. a description of the procedures for reaching a final decision on the draft permit including:

i. the beginning and ending dates of the comment period under §111.F and the address where comments will be received;

ii. procedures for requesting a hearing and the nature of that hearing; and

iii. any other procedures by which the public may participate in the final decision;

f. name and telephone number of a person to contact for information.

3. A copy of the fact sheet shall be mailed to all persons identified in §111.E.3.a.i, ii, and iii.

E. Public Notice of Permit Actions and Public Comment Period

1. Scope

a. The commissioner shall give public notice that the following actions have occurred:

i. a draft permit has been prepared under §111.C; and

ii. a hearing has been scheduled under §111.G.

b. No public notice is required when a request for permit modification, revocation and reissuance, or termination is denied under §113. Written notice of that denial shall be given to the requester and to the permittee.

c. Public notices may describe more than one permit or permit action.

2. Timing

a. Public notice of the preparation of a draft permit required under §111.E.1 shall allow 30 days for public comment.

b. Public notice of a public hearing shall be given 30 days before the hearing. (Public notice of the hearing may be given at the same time as public notice of the draft permit and the two notices may be combined).

3. Methods. Public notice of activities described in §111.E.1.a shall be given by the following methods:

a. by mailing a copy of a notice to the following persons (any person otherwise entitled to receive notice under this Section may waive his rights to receive notice for any classes and categories of permits):

i. the applicant;

ii. any other agency which the commissioner knows has issued or is required to issue a permit for the same facility or activity (including EPA);

iii. federal and state agencies with jurisdiction over fish, shellfish, and wildlife resources and over coastal zone management plans, the Advisory Council on Historic Preservation, the State Archeological Survey and Antiquities Commission, and other appropriate government authorities, including any affected states; and

iv. persons on a UIC mailing list.

b. for Class I permits, publication of a notice in a daily or weekly newspaper within the area affected by the facility or activity;

c. in a manner constituting legal notice to the public under state law; and

d. any other method reasonably calculated to give actual notice of the action in question to the persons potentially affected by it, including press releases or any other form or medium to elicit public participation.

4. Contents

a. All Public Notices. Public notices issued under this Section shall contain the following information:

i. name and address of the Division of the Office of Conservation processing the permit action for which notice is being given;

ii. name and address of the permittee or permit applicant and, if different, of the facility or activity regulated by the permit;

iii. a brief description of the business conducted at the facility or activity described in the permit application;

iv. name, address, and telephone number of a person from whom interested persons may obtain copies of the draft permit, and the fact sheet, and further information concerning the application;

v. a brief description of the comment procedures required by §111.F and the time and place of any hearing that will be held, including a brief statement of procedures to request a hearing (unless a hearing has already been scheduled) and other procedures by which the public may participate in the final permit decision; and

vi. any additional information considered necessary or proper.

b. Public Notices for Hearings. In addition to the general public notice described in §111.E.4.a, the public notice of a hearing under §111.G shall contain the following information:

i. reference to the date of previous public notices relating to the permit;

ii. date, time, and place of the hearing; and

iii. a brief description of the nature and purpose of the hearing, including the applicable rules and procedures.

F. Public Comments and Requests for Public Hearings. During the public comment period provided under §111.G, any interested person may submit written comments on the draft permit and may request a public hearing, if no hearing has already been scheduled. A request for a public hearing shall be in writing and shall state the nature of the issues proposed to be raised in the hearing. All comments shall be considered in making the final decision and shall be answered as provided in §111.H.

G. Public Hearings

1. The commissioner shall hold a public hearing whenever he finds, on the basis of requests, a significant degree of public interest in (a) draft permit(s). The commissioner also may hold a public hearing at his discretion, whenever, for instance, such a hearing might clarify one or more issues involved in the permit decision.

Public notice of the hearing shall be given as specified in §111.G.

2. Any person may submit oral or written statements and data concerning the draft permit. Reasonable limits may be set upon the time allowed for oral statements, and the submission of statements in writing may be required. The public comment period under §111.G shall automatically be extended to the close of any public hearing under this Section. The hearing officer may also extend the comment period by so stating at the hearing.

3. A tape recording or written transcript of the hearing shall be made available to the public.

H. Response to Comments

1. At the time that any final permit is issued the commissioner shall issue a response to comments. This response shall:

a. specify which provisions; if any, of the draft permit have been changed in the final permit decision, and the reasons for the change; and

b. briefly describe and respond to all significant comments on the draft permit or the permit application raised during the public comment period, or during any hearing.

2. The response to comments shall be available to the public.

I. Permit Issuance and Effective Date

1. After closure of the public comment period, including any public hearing, under §111.G on a draft permit, the commissioner shall issue a final permit decision within 30 days.

2. A final permit decision shall become effective on the date of issuance.

3. Approval or the granting of a permit to construct a Class I or III well shall be valid for a period of one year and if not begun in that time, the permit shall be null and void. The permittee may request an extension of this one-year requirement; however, the commissioner shall approve the request for extenuating circumstances only.

AUTHORITY NOTE: Promulgated in accordance with R.S. 30:1D, 4C(16), and 4.1.

HISTORICAL NOTE: Promulgated by the Department of Natural Resources, Office of Conservation, LR 8:83 (February 1982).

§113. Permit Modification, Revocation and Reissuance, Termination, Transfer or Renewal

A. Applicability. The rules of this Section set forth the standards and requirements for applications and actions concerning modification, revocation and reissuance, termination, transfer and renewal of permits.

B. Permit Actions

1. The permit may be modified, revoked and reissued, or terminated for cause.

2. The permittee shall furnish to the commissioner, within 30 days, any information which the commissioner may request to determine whether cause exists for modifying, revoking and reissuing, or terminating a permit, or to determine compliance with the permit. The permittee shall also furnish to the commissioner, upon request, copies of records required to be kept by the permit.

3. The commissioner may, upon his own initiative or at the request of any interested person, review any permit to determine if cause exists to modify, revoke and reissue, or terminate the permit for the reasons specified in §113.C, D, and E. All requests shall be in writing and shall contain facts or reasons supporting the request.

4. If the commissioner decides the request is not justified, he shall send the person making the request a brief written response giving a reason for the decision. Denials of requests for modification, revocation and reissuance, or termination are not subject to public notice, comment, or hearings.

5. If the commissioner decides to modify or revoke and reissue a permit under §113.C, D, and E, he shall prepare a draft permit under §111.C incorporating the proposed changes. The commissioner may request additional information and, in the case of a modified permit, may require the submission of an updated permit application. In the case of revoked and reissued permits, the commissioner shall require, if necessary, the submission of a new application.

C. Modification or Revocation and Reissuance of Permits

1. The following are causes for modification and may be causes for revocation and reissuance of permits.

a. Alterations. There are material and substantial alterations or additions to the permitted facility or activity which occurred after permit issuance which justify the application of permit conditions that are different or absent in the existing permit.

b. Information. The commissioner has received information pertinent to the permit. Permits for Class I or V wells may be modified during their terms for this cause only if the information was not available at the time of permit issuance (other than revised regulations, guidance, or test methods) and would have justified the application of different permit conditions at the time of issuance. For area or project permits (§109.B.11) cause shall include any information indicating that cumulative effects on the environment are unacceptable.

c. New Regulations

i. The standards or regulations on which the permit was based have been changed by promulgation of amended standards or regulations or by judicial decision after the permit was issued and conformance with the changed standards or regulations is necessary for the protection of the health or safety of the public or the environment. Permits for Class I or V wells may be modified during their terms when:

(a). the permit condition requested to be modified was based on a promulgated regulation or guideline;

(b). there has been a revision, withdrawal, or modification of that portion of the regulation or guideline on which the permit condition was based; and

(c). a permittee requests modification within 90 days after *Louisiana Register* notice of the action on which the request is based.

ii. When standards or regulations on which the permit was based have been changed by withdrawal of standards or regulations or by promulgation of amended standards or regulations which impose less stringent requirements on the permitted activity or facility and the permittee requests to have permit conditions based on the withdrawn or revised standards or regulations deleted from his permit, the permit may be modified as a minor modification without providing for public comment.

iii. For judicial decisions, a court of competent jurisdiction has remanded and stayed Office of Conservation regulations or guidelines and all appeals have been exhausted, if the remand and stay concern that portion of the regulations or guidelines on which the permit condition was based and a request is filed by the permittee to have permit conditions based on the remanded or stayed standards or regulations deleted from his permit.

d. Compliance Schedules. The commissioner determines good cause exists for modification of a compliance schedule, such as an act of God, strike, flood, or materials shortage or other events over which the permittee has little or no control and for which there is no reasonable available remedy.

2. Causes for modification or revocation and reissuance. The following are causes to modify or, alternatively, revoke and reissue a permit:

a. cause exists for termination under §113.D, and the commissioner determines that modification or revocation and reissuance is appropriate; or

b. the commissioner has received notification of a proposed transfer of the permit and the transfer is determined not to be a minor modification (see §113.D.4). A permit may be modified to reflect a transfer after the effective date (§113.F.2.b) but will not be revoked and reissued after the effective date except upon the request of the new permittee.

3. Facility Siting. Suitability of an existing facility location will not be considered at the time of permit modification or revocation and reissuance unless new information or standards indicate that continued operations at the site pose a threat to the health or safety of persons or the environment which was unknown at the time of permit issuance. A change of injection site or facility location may require modification or revocation and issuance as determined to be appropriate by the commissioner.

4. If a permit modification satisfies the criteria of this Section, a draft permit must be prepared and other applicable procedures must be followed.

D. Minor Modifications of Permits. Upon the consent of the permittee, the commissioner may modify a permit to make the corrections or allowances for changes in the permitted activity listed in this Section without issuing a draft permit and providing for public comment. Minor modifications may only:

1. correct typographical errors;

2. require more frequent monitoring or reporting by the permittee;

3. change an interim compliance date in a schedule of compliance, provided the new date does not interfere with attainment of the final compliance date requirement;

4. allow for a change in ownership or operational control of a facility where the commissioner determines that no other change in the permit is necessary, provided that a written agreement containing a specific date for transfer of permit responsibility, coverage, and liability between the current and new permittees has been submitted to the commissioner (see §113.F);

5. change quantities or types of fluids injected which are within the capacity of the facility as permitted and, in the judgment of the commissioner, would not interfere with the operation of the facility or its ability to meet conditions prescribed in the permit, and would not change its classification;

6. change construction requirements or plans approved by the commissioner provided that any such alteration shall comply with the requirements of this Section and §109. No such changes may be physically incorporated into construction of the well prior to approval; or

7. amend a plugging and abandonment plan which has been updated under §109.A.7.f.

E. Termination of Permits

1. The commissioner may terminate a permit during its term for the following causes:

a. noncompliance by the permittee with any condition of the permit;

b. the permittee's intentional failure in the application or during the permit issuance process to disclose fully all relevant facts, or the permittee's misrepresentation of any relevant facts at any time; or

c. a determination that the permitted activity endangers the health or safety of persons or the environment which activity cannot be regulated to acceptable levels by permit modification and can only be regulated to acceptable levels by permit termination.

2. If the commissioner decides to terminate a permit, he shall issue a notice of intent to terminate. A notice of intent to terminate is a type of draft permit which follows the same procedures as any draft permit prepared under §111.C.

3. The commissioner may alternatively decide to modify or revoke and reissue a permit for the causes in §113.E.1 (see §113.C.2.a).

F. Transfers of Permits

1. A permit may be transferred to a new owner or operator upon approval by the commissioner.

2. The current permittee shall submit an application for transfer at least 30 days before the proposed transfer date. The application shall contain the following:

a. name and address of the transferee;

b. date of proposed transfer; and

c. a written agreement between the existing and new permittees containing a specific date for transfer of permit responsibility, coverage and liability between them. The agreement should also demonstrate to the satisfaction of the commissioner that the financial responsibility requirements of §107.C will be met by the new permittee.

3. If the commissioner does not notify the existing permittee and the proposed new permittee of his intent to modify or revoke and reissue the permit under §113.C.2.b the transfer is effective on the date specified in the agreement mentioned in §113.F.2.c.

4. If no agreement described in §113.F.2.c is provided, responsibility for compliance with the terms and conditions of the permit and liability for any violation will shift from the existing permittee to the new permittee on the date the transfer is approved.

5. If a person attempting to acquire a permit causes or allows operation of the facility before approval by the commissioner, it shall be considered a violation of these rules for operating without a permit or other authorization.

AUTHORITY NOTE: Promulgated in accordance with R.S. 30:1D, 4C(16), and 4.1.

HISTORICAL NOTE: Promulgated by the Department of Natural Resources, Office of Conservation, LR 8:83 (February 1982), amended LR 11:640 (June 1985).

§115. Emergency or Temporary Permits

A. Applicability. The provisions for this Section set the standards applicable to emergency or temporary permits for all Class I, III, IV, and V wells.

B. Coverage. Notwithstanding any other provision of this Section, the commissioner may temporarily permit a specific underground injection which has not otherwise been authorized by rule or permit if an imminent and substantial endangerment to the health of persons will result unless a temporary emergency permit is granted. The permittee need not comply with the provisions of the permit to the extent and for the duration that noncompliance is authorized in a temporary emergency permit.

C. Requirements for Issuance

1. Any temporary permit under this Section shall be for no longer term than required to prevent the hazard.

2. Notice of any temporary permit under this Section shall be published in accordance with §111.E within 10 days of the issuance of the permit.

3. The temporary permit under this Section may be either oral or written. If oral, it must be followed within five calendar days by a written temporary emergency permit.

4. The commissioner shall condition the temporary permit in any manner he determines is necessary to ensure that the injection will not result in the movement of fluids into an underground source of drinking water.

D. Duration

1. A temporary permit shall not exceed a maximum of 90 days.

2. That the rules and regulations provide for environmental safety, protection and nonendangerment of underground sources of drinking water.

AUTHORITY NOTE: Promulgated in accordance with R.22S. 30:1D, 4C(16), and 4.1.

HISTORICAL NOTE: Promulgated by the Department of Natural Resources, Office of Conservation, LR 8:83 (February 1982).

Title 43
NATURAL RESOURCES
Part XVII. Office of Conservation—Injection and Mining
Subpart 2. Statewide Order No. 29-N-2

Chapter 2. Class I Hazardous Waste Injection Wells

§201. Definitions

A. The following definitions apply to all regulations following hereafter. Terms not defined in this Section have the meaning given by R.S. (1950) Title 30, Section 3.

Abandoned Well—a well whose use has been permanently discontinued or which is in a state of disrepair such that it cannot be used for its intended purpose or for observation purposes.

Act—Part I, Chapter I of Title 30 of the Louisiana Revised Statutes.

Application—the filing by a person on the Office of Conservation forms for applying for an underground injection permit, including any additions, revisions or modifications to the forms.

Aquifer—a geological formation, group of formations, or part of a formation that is capable of yielding a significant amount of water to a well or spring.

Area of Review—the area surrounding an injection well as described in §209.B.

Casing—a metallic or nonmetallic tubing or pipe of varying diameter and weight, lowered into a borehole during or after drilling in order to support the sides of the hole and thus prevent the walls from caving, to prevent loss of drilling mud into porous ground, or to prevent water, gas or other fluid from entering the hole.

Catastrophic Collapse—the sudden and utter failure of overlying *strata* caused by removal of underlying materials.

Cementing—the operation whereby a cement slurry is pumped into a drilled hole and/or forced behind the casing.

Cone of Influence—that area around the well within which increased injection zone pressures caused by injection into the hazardous waste injection well would be sufficient to drive fluids into an underground source of drinking water (USDW).

Confining Bed—a body of impermeable or distinctly less permeable material stratigraphically adjacent to one or more aquifers.

Confining Zone—a geological formation, group of formations, or part of a formation that is capable of limiting fluid movements above an injection zone.

Contaminant—any physical, chemical, biological, or radiological substance or matter in water.

Commissioner—the Assistant Secretary of the Office of Conservation, Department of Natural Resources.

Disposal Well—a well used for the disposal of waste into a subsurface stratum.

Drilling Mud—heavy suspension used in a drilling an injection well introduced down the drill pipe and through the drill bit.

Effective Date—the date that Statewide Order 29-N-2 is promulgated in accordance with the Louisiana Administrative Procedure Act.

Emergency Permit—a UIC permit issued in accordance with §215.

Exempted Aquifer—an aquifer or its portion that meets the criteria of the definition of *underground source of drinking water* but which has been exempted according to the procedures set forth in §203.F.

Existing Well—a Class I hazardous waste injection well which was authorized prior to August 25, 1988, by the Louisiana Underground Injection Control Program or a well which has become a Class I well as a result of a change in the definition of the injected waste which would render the waste hazardous.

Experimental Technology—a technology which has not been proven feasible under the conditions in which it is being tested.

Facility or Activity—any facility or activity (including land or appurtenances thereto) that is subject to these regulations.

Fault—a surface or zone of rock fracture along which there has been displacement. (Also see *transmissive fault or fracture*).

Flow Rate—the volume per time unit given to the flow of fluid substance which emerged from an orifice, pump, turbine or passes along a conduit or channel.

Fluid—any material or substance which flows or moves whether in a semisolid, liquid, sludge, gas or any other form or state.

Formation—a body of rock characterized by a degree of lithologic homogeneity which is prevailing, but not necessarily, tabular and is mappable on the earth's surface or traceable in the subsurface.

Formation Fluid—fluid present in a formation under natural conditions as opposed to introduced fluids, such as drilling muds.

Generator—any person, by site location, whose act or process produces hazardous waste identified or listed in the Louisiana Hazardous Waste Management Program.

Ground Water—water below the land surface in a zone of saturation.

Hazardous Waste—a hazardous waste as defined in the Louisiana Hazardous Waste Management Program.

Hazardous Waste Management (HWM) Facility—all contiguous land, and structures, other appurtenances, and improvements on the land, used for treating, storing or disposing of hazardous waste.

Injection Interval—that part of the injection zone in which the well is screened, or in which the waste is otherwise directly emplaced.

Injection Well—a well into which fluids are being injected other than fluids associated with active drilling operations.

Injection Zone—a geological formation, group of formations or part of a formation receiving fluids through a well.

Ionizing Radiation—any electromagnetic or particulate radiation capable of producing ions, directly or indirectly, in its passage through matter. It includes any or all of the following: alpha rays, beta rays, gamma rays, X-rays, neutrons, high-speed electrons, high-speed protons, and other atomic particles; but not sound or radio waves, or visible, infrared or ultraviolet light.

Lithology—the description of rocks on the basis of their physical and chemical characteristics.

Major Facility—any Class I hazardous waste injection well facility or activity.

Manifest—the shipping document originated and signed by the generator which contains the information required by the Hazardous Waste Management Program.

New Well—any Class I hazardous waste injection well which is not an existing well.

Owner or Operator—the owner or operator of any facility or activity subject to regulation under the UIC program.

Packer—a device lowered into a well to produce a fluid-tight seal within the casing.

Permit—an authorization, license, or equivalent control document issued by the commissioner to implement the requirement of these regulations. Permit includes, but it is not limited to, area permits and emergency permits. Permit does not include UIC authorization by rule or any permit which has not yet been the subject of final agency action, such as a draft permit.

Person—an individual, association, partnership, corporation, municipality, state or federal agency, or an agent or employee thereof.

Plugging—the act or process of stopping the flow of water, oil or gas into or out of a formation through a borehole or well penetrating that formation.

Plugging Record—a systematic listing of permanent or temporary abandonment of water, oil, gas, test, exploration, and waste injection wells.

Pressure—the total load or force per unit area acting on a surface.

Project—a group of wells in a single operation.

Public Water System—a system for the provision to the public of piped water for human consumption, if such system has at least 15 service connections or regularly serves at least 25 individuals. Such term includes:

a. any collection, treatment, storage, and distinction facilities under control of the operator of such system and used primarily in connection with such system; and

b. any collection or pretreatment storage facilities not under such control which are used primarily in connection with such system.

Radiation—any electromagnetic or ionizing radiation including gamma rays and X-rays, alpha and beta particles, high-speed electrons, neutrons, protons and other nuclear particles: but not sound waves. Unless specifically stated otherwise, these regulations apply only to ionizing radiation.

Radioactive Material—any material, whether solid, liquid, or gas, which emits radiation spontaneously.

Radioactive Waste—any waste which contains *radioactive material* for which no use or reuse is intended and which is to be discarded.

RCRA—the Solid Waste Disposal Act as amended by the Resource Conservation and Recovery Act of 1976 (Pub. L. 94-580 as amended by Pub. L. 95-609, 42 U.S.C. 6901 et seq.).

Schedule of Compliance—a schedule or remedial measures included in a permit, including an enforceable sequence of interim requirements (for example, actions, operations, or milestone events) leading to compliance with the act and these regulations.

Site—the land or water area where any facility or activity is physically located or conducted including adjacent land used in connection with the facility or activity.

Skin Effect—the blockage or plugging of the well perforations or formation face from solids in the waste stream that results in increased injection pressures and can be measured by accepted engineering test procedures.

Sole or Principal Source Aquifer—an aquifer which is the sole or principal drinking water source for an area and which, if contaminated, would create a significant hazard to public health.

State—the state of Louisiana.

Stratum (plural *Strata*)—a single sedimentary bed or layer, regardless of thickness, that consists of generally the same kind of rock material.

Surface Casing—the first string of casing to be installed in the well, excluding conductor casing.

Total Dissolved Solids—the total dissolved filterable solids as determined by use of the method specified in the 14th edition, pp. 91-92, of "Standard Methods for the Examination of Water and Waste Water."

Transmissive Fault or Fracture—a fault of fracture that has sufficient permeability and vertical extent to allow fluids to move between formations.

UIC—the Louisiana State Underground Injection Control Program.

Underground Injection—a well injection.

Underground Source of Drinking Water (USDW)—an aquifer or its portion: which supplies any public water system or which contains a sufficient quantity of ground water to supply water system; and currently supplies drinking water for human consumption or contains fewer than 10,000 mg/l total dissolved solids; and which is not an exempted aquifer.

USDW—Underground Source of Drinking Water.

Well—a bored, drilled or driven shaft, or a dug hole, whose depth is greater than the largest surface dimension.

Well Injection—the subsurface emplacement of fluids through an injection well.

Well Plug—a fluid tight seal installed in a borehole or well to prevent movement of fluids.

Well Stimulation—several processes used to clean the well bore, enlarge channels, and increase pore space in the interval to be injected thus making it possible for wastewater to move more readily into the formation, and includes:

a. surging;

b. jetting;

c. blasting;

d. acidizing; or

e. hydraulic fracturing.

Workover—to perform one or more of a variety of remedial operations on an injection well, such as cleaning, perforation, change tubing, deepening, squeezing, plugging back, etc.

AUTHORITY NOTE: Promulgated in accordance with R.S. 30:1D and 4C(16), and 4.1.

HISTORICAL NOTE: Promulgated by the Department of Natural Resources, Office of Conservation, LR 15:978 (November 1989).

§203. General Provisions

A. Applicability. The rules and regulations of this Section apply to all owners and operators of proposed and existing Class I hazardous waste injection wells in the state of Louisiana.

B. Prohibition of Unauthorized Injection. Any underground injection, except as authorized by a permit, is prohibited after the effective date of these regulations. Construction of any well required to have a permit under these regulations is prohibited until the permit has been issued.

C. Classification of Class I Wells

1. Class I Hazardous Waste Injection Wells. Wells used by generators of hazardous wastes or owners or operators of hazardous waste management facilities to inject hazardous waste beneath the lowermost formation containing, within 1/4 mile radius of the well bore, an underground source of drinking water.

2. Class I Nonhazardous Waste Injection Wells. Other industrial and municipal disposal wells which inject fluids beneath the lowermost formation containing an underground source of drinking water within 1/4 mile radius of the well bore.

D. Prohibition of Movement of Fluid into Underground Sources of Drinking Water of Outside of the Approved Injection Zone

1. No authorization by permit shall allow the movement of fluid containing any contaminant into underground sources of drinking water or outside the injection zone. The applicant for a permit shall have the burden of showing that the requirements of this Paragraph are met.

2. For Class I hazardous waste injection wells, if any water quality monitoring indicates the movement of any contaminant into a USDW or outside of the injection zone, except as authorized under §209, the commissioner shall prescribe such additional requirements for construction, corrective action, operation, monitoring, or reporting (including closure of the injection well) as are necessary to prevent such movement. In the case of wells authorized by permit, these additional requirements shall be imposed by modifying the permit in accordance with §213.C, or the permit may be terminated under §213.E if the cause exists, or appropriate enforcement action may be taken if the permit has been violated.

3. Notwithstanding any other provision of §203.D, the commissioner may take emergency action upon receipt of information that a contaminant which is present in or likely to enter a public water supply or may present an imminent and substantial endangerment to the health or safety of persons, or may threaten oil or gas deposits.

E. Requirements for Commercial Wells Injecting Hazardous Waste Accompanied by a Manifest. All generators of hazardous waste, and owners or operators of all commercial hazardous waste management facilities, who use any Class I hazardous waste injection well to inject hazardous waste shall comply with all the applicable requirements of the Louisiana Hazardous Waste Management program.

F. Identification of Underground Sources of Drinking Water and Exempted Aquifers

1. The commissioner may identify (by narrative description, illustrations, maps, or other means) and shall protect, except where exempted under §203.F.2, as an underground source of drinking water, all aquifers or parts of aquifers which meet the definition of an *underground source of drinking water*. Even if an aquifer has not been specifically identified by the commissioner, it is an underground source of drinking water if it meets the definition.

2. After notice and opportunity for a public hearing the commissioner may identify (by narrative description, illustrations, maps, or other means) and describe in geographic and/or geometric terms (such as vertical and lateral limits and gradient) which are clear and definite, all aquifers or parts thereof which the commissioner proposes to designate as exempted aquifers if they meet the following criteria:

a. the aquifer does not currently serve as a source of drinking water; and

b. the aquifer cannot now and will not in the future serve as a source of drinking water because:

i. it is mineral, hydrocarbon or geothermal energy producing or can be demonstrated by a permit applicant as part of a permit application for a Class III operation to contain minerals or hydrocarbons that considering their quantity and location are expected to be commercially producible;

ii. it is situated at a depth or location which makes recovery of water for drinking water purposes economically or technologically impractical;

iii. it is so contaminated that it would be economically or technologically impractical to render that water fit for human consumption; or

iv. it is located over a Class III well mining area subject to subsidence or catastrophic collapse; or

c. the total dissolved solids content of the ground water is more than 3,000 and less than 10,000 mg/l and it is not reasonably expected to supply a public water system.

AUTHORITY NOTE: Promulgated is accordance with R.S. 30:1D and 4C(16), and 4.1.

HISTORICAL NOTE: Promulgated by the Department of Natural Resources, Office of Conservation, LR 15:978 (November 1989).

§205. Permit Application Requirements

A. Applicability. The rules and regulations of this Section apply to all Class I hazardous waste injection wells required to be filed with the Department of Natural Resources, Office of Conservation, for authorization under R.S. 1950 Title 30.

B. Application Required

1. Permit Application. New applicants, permittees with expiring permits, and any person required to have a permit shall complete, sign, and submit an application in triplicate to the commissioner as described in this Section.

2. Time to Apply. Any person who performs or proposes a Class I hazardous waste injection well for which a permit is or will be required shall submit an application to the commissioner a reasonable time before construction of the new well is expected to begin.

3. All applicants for a new Class I hazardous waste injection well shall comply with and submit to the commissioner, as part of the permit application, all the information listed in §205.A, B, C, D and E concerning new wells including those applicable amended portions of the aforementioned paragraphs as listed below. This information shall be submitted in conjunction with the appropriate application form.

4. For an existing Class I hazardous waste injection well, the applicant shall comply with and submit to the commissioner, as part of the permit application, all the information listed in §205.A, B, C, D and E concerning existing wells including those applicable amended portions of the aforementioned paragraphs as listed below except for those items of information which are current, accurate, and available in the existing permit file. This information shall be submitted in conjunction with the appropriate application form.

5. For both new and existing Class I hazardous waste injection wells, certain maps, cross-sections, tabulations of wells within the area of review and other data may be included in the application by reference provided they are current and readily available to the commissioner and sufficiently identifiable to be retrieved.

C. Who Applies. It is the duty of the owner of a facility or activity to submit an application for permit. When a facility is owned by one person and operated by another, it is the operator's duty to obtain a permit.

D. Signature Requirements for Applications

1. All permit applications shall be signed as follows:

a. for a corporation: by a principal executive officer of at least the level of vice-president, or duly authorized representative of that person if the representative performs similar policy-making functions for the corporation. A person is a duly authorized representative only if:

i. the authorization is made in writing by a principal executive officer of at least the level of vice-president;

ii. the authorization specifies either an individual or a position have responsibility for the overall operation of the regulated facility or activity, such as the position of plant manager, operator of a well or a well field, superintendent, or position of equivalent responsibility. (A duly authorized representative may thus be either a named individual or any individual occupying a name position); and

iii. the written authorization is submitted to the commissioner;

b. for partnership or sole proprietorship, by a general partner or the proprietor, respectively; or

c. for a municipality, state, federal, or other public agency by either a principal executive officer or ranking elected official.

2. If an authorization under §205.D.1 is no longer accurate because a different individual or position has responsibility for the overall operation of the facility, a new authorization satisfying the signature requirements must be submitted to the commissioner prior to or together with any reports, information or applications to be signed by an authorized representative.

3. Certification. Any person signing a document under §205.D shall make the following certification:

> "I certify under penalty of law that I have personally examined and am familiar with the information submitted in this document and all attachments and that, based on my inquiry of those individuals immediately responsible for obtaining the information, I believe that the information is true, accurate, and complete. I am aware that there are significant penalties for submitting false information, including the possibility of fine and imprisonment."

4. Any permit application for a Class I hazardous waste injection well for disposal on the premises where the waste is generated shall contain a certification by the owner or operator that:

a. the generator of the hazardous waste has a program to reduce the volume or quantity and toxicity of such waste to the degree determined by the generator to be economically practicable; and

b. injection of the waste is that practicable method of disposal currently available to the generator which minimizes the present and future threat to human health and the environment.

E. Application Contents for Class I Hazardous Waste Injection Wells. All applicants for Class I hazardous waste injection well permits shall provide the following information to the commissioner, using the application form provided:

1. administrative information:

a. the name, mailing address, and location of the facility for which the application is submitted;

b. ownership status as federal, state, private, public, or other entity;

c. the operator's name, address and telephone number;

d. a brief description of the nature of the business associated with the facility;

e. the activity or activities conducted by the applicant which require the application to obtain a permit under these regulations;

f. up to four SIC Codes which best reflect the principle products or services provided by the facility;

g. a listing of all permits or construction approvals which the applicant has received or applied for under any of the following programs and which specifically affect the legal or technical ability of the applicant to undertake the activity or activities to be conducted under the permit filed herefor:

i. the Louisiana Hazardous Waste Management Program;

ii. this or any other Underground Injection Control Program;

iii. NPDES Program under the Clean Water Act;

iv. Prevention of Significant Deterioration (PSD) Program under the Clean Air Act;

v. Nonattainment Program under the Clean Air Act;

vi. National Emission Standards for Hazardous Pollutants (NESHAPS) Preconstruction approval under the Clean Air Act;

vii. Ocean Dumping Permit under the Marine Protection Research and Sanctuaries Act;

viii. Dredge or Fill Permits under Section 404 of the Clean Water Act; and

ix. other relevant Environmental Permits, including but not limited to any state permits issued under the Louisiana Coastal Resources Program, the Louisiana Surface Mining Program or the Louisiana Natural and Scenic Streams System;

h. jurisdiction:

i. whether the facility is located on Indian lands or other lands under the jurisdiction or protection of the federal government;

ii. whether the facility is located on state waterbottoms or other lands owned by or under the jurisdiction or protection of the state;

i. describe the waste to be injected along with its corresponding EPA Hazardous Waste Code Number.

2. Maps and Related Information for New and Existing Wells

a. One or more maps, preferably USGS topographic map(s), with a scale of 1:24,000 showing the property boundaries of the facility, each injection well for which a permit is sought and the area of review as described in §209.B.

i. The map(s) must show the section, township and range of the area in which the activity is located and any parish, city or municipality boundary lines within 1 mile of the injection well.

ii. Within the area of review the map(s) must show the name and/or number and location of all injection wells, producing wells, abandoned wells, dry holes, surface bodies of water, springs, mines (surface and subsurface), quarries, public water systems, water wells (public and private) and other pertinent surface features including residences and roads.

iii. The map(s) should also show faults if known or projected.

iv. Only information of public record is required to be included on the map(s): however, the applicant is required to undertake a diligent search to locate all water wells not listed in the public record.

v. For water wells on the facility property and adjacent property, submit a tabulation of well depth, water level, owner, chemical analysis, and other pertinent data. If these wells do not exist, submit this information for a minimum of three other wells in the area of review or a statement why this information was not included.

vi. The protocol followed to identify, locate, and ascertain the condition of all wells within the area of review which penetrate the injection or confining zone.

b. Generalized maps and cross-sections illustrating the regional geology and hydrology.

c. Maps and cross-sections to the necessary scale to detail the local geology and hydrology (2-mile radius of well minimum).

d. Maps and cross-sections indicating the general vertical and lateral limits of all underground sources of drinking water (USDW) within the area of review, their position relative to the injection formation and the direction of water movement, if known, in each aquifer containing a USDW which may be effected by the proposed injection.

e. In areas with limited subsurface well control or where the subsurface geology is in doubt and cannot be adequately described by conventional methods, the commissioner may request an applicant to provide geophysical seismic data to reinforce the geologic interpretation.

f. Any other information required by the commissioner to evaluate the proposed well.

3. Technical Information for New Wells

a. A tabulation on all wells within the area of review which penetrate the proposed injection zone or confining zone. Such data shall include a description of each well's type, construction, date drilled, location, depth, record of plugging and/or completion and any additional information the commissioner may require. For wells within a 1/2 mile radius of the injection well, include:

i. copies of all casing and cementing records (including cementing affidavits);

ii. copies of plugging and/or completion records; and

iii. schematic diagrams of each well;

b. proposed operating data:

i. average and maximum daily rate and volume of the injection fluids;

ii. average and maximum injection pressure; and

iii. source and an analysis of the chemical, physical, and biological characteristics of the injection fluid;

c. proposed formation testing program to obtain an analysis of the chemical, physical, and radiological characteristics of and other information on the injection and the confining zone;

d. proposed stimulation program;

e. proposed injection procedures (including storage and pre-injection treatment of the waste stream, and well use schedule);

f. schematic or other appropriate drawings of the surface (well-head and related appurtenances) and subsurface construction details of the system;

g. plans (including maps) for meeting the monitoring requirements of §209.1;

h. construction procedures including a cementing and casing program (include cementer's recommendation), well material specifications and their life expectancy, logging procedures, deviation checks, and a drilling, testing, and coring program;

i. contingency plans to cope with all shut-ins or well failures so as to prevent the migration of the contaminating fluids into underground sources of drinking water;

j. a certificate that the applicant has assured, through a performance bond or other appropriate means, the resources necessary to close, plug or abandon the well and for post-closure care as required in §§207.C and 209.O;

k. for wells within the area of review which penetrate the injection zone of the confining zone but are not properly completed or plugged, the corrective action proposed to be taken under §209.C;

l. calculation of the pressure increase in the proposed injection zone for a time period equal to the expected life of the well, preferably using Matthews and Russell, 1967 ('Pressure Buildup and Flow Tests in Wells', American Institute of Mining, Met. Eng. Monograph, Vol. 1);

m. calculation of the expected waste front travel using a model acceptable to the commissioner. A conservative value can be calculated by using the following formula:

$$r = \sqrt{\frac{v}{\pi b \phi}}$$

where:

r = radial distance of wastewater front from well

v = cumulative volume of injected wastewater

b = effective reservoir thickness

ø = average effective porosity

(Warner, D.L. and Lehr, J.H., 'An Introduction to the Technology of Subsurface Wastewater Injection', Robert S. Kerr Environmental Research Laboratory (EPA) Research Report, 1977);

n. information required under §§209.L.1 and M.1 concerning the applicant's plans for closure (plug and abandonment) and post-closure care of the well; and

o. any other information required by the commissioner to evaluate the proposed well.

4. Technical information for existing wells:

a. a tabulation of data on all wells within the area of review which penetrate the injection zone (see §205.E.3.a);

b. operating data as required in §205.E.3.b;

c. formation testing results if performed prior to well operation;

d. stimulation program;

e. description of injection procedures (including storage and pre-injection treatment of the waste stream and well use schedule);

f. schematic or other appropriate drawings of the surface (well-head and related appurtenances) and subsurface construction details of the system;

g. monitoring equipment as required in §209;

h. contingency plans as required in §205.E.3.i;

i. a demonstration of the resources for closure and post-closure as required in §205.E.3.j;

j. proposed corrective action as required in §205.E.3.k;

k. calculation of the pressure increase in the injection zone as required in §205.E.3.1;

l. calculation of the waste front travel as required in §205.E.3.m;

m. measurement of bottom hole pressure and temperature at the time of repermitting or during the next workover operation;

n. a graphic presentation of the well's operational history consisting of the following:

i. a plot of representative values of injection pressure and injection rate versus time, from date of initial injection to the present (indicate cumulative volume);

ii. a plot of measured bottom-hole pressure versus date if such measurements were made;

iii. indications of any workovers and associated problems, stimulations, waste stream changes and other events that would have a bearing on the well's performance, especially:

(a) any change of injection interval; and

(b) any other information the permittee or commissioner may consider useful;

o. copies of all logs and tests run during construction and subsequent operation of the well, including mechanical integrity tests;

p. a summary analysis of the data provided in §205.E.4.o;

q. plans for closure and post-closure required in §205.E.3.n; and

r. any other information required by the commissioner to evaluate the existing well.

F. Recordkeeping of Application Information. The applicant shall retain records of all pertinent data used to complete the permit application and any supplemental information submitted under these regulations for a period of three years following well closure or until the time of next repermitting, whichever is less.

G. Confidentiality of Information. Information obtained by any rule, regulations, order, or permit term or condition adopted or issued here-under, or by any investigation authorized thereby, shall be available to the public, unless nondisclosure is requested in writing and such information is determined by the commissioner to require confidentiality to protect trade secrets, processes, operations, style of work, apparatus, statistical data, income, profits, losses, or in order to protect any plan, process, tool, mechanism, or compound: provided that such nondisclosure shall not apply to information that is necessary for use by duly authorized officers or employees of state or federal government in carrying out their responsibilities under these regulations or applicable federal or state law. If no claim is made at the time of submission, the commissioner may make the information available to the public without further notice. Claims of confidentiality for the following information will be denied:

1. the name and address of any permit applicant or permittee; and

2. information which deals with the existence, absence, or level of contaminants in drinking water or zones other than the approved injection zone.

H. Filing Fee. Each application shall be accompanied by a filing fee established by Statewide Order 29-Q as amended, or subsequent applicable regulations.

AUTHORITY NOTE: Promulgated in accordance with R.S. 30:1D and 4C(16), and 4.1.

HISTORICAL NOTE: Promulgated by the Department of Natural Resources, Office of Conservation, LR 15:978 (November 1989).

§207. Legal Permit Conditions

A. Applicability. The rules and regulations of this Section set forth legal conditions for all Class I hazardous waste injection well permits.

B. Signatories. All reports required by permits and other information requested by the commissioner shall be signed as in applications by a person described in §205.D.

C. Financial Responsibility. The permit shall require the permittee to maintain financial responsibility and resources to close, plug and abandon and for post-closure care of the Class I hazardous waste injection wells in a manner prescribed by the commissioner. The permittee must show evidence of financial responsibility to the commissioner by the submission or a surety bond, or other adequate assurance, such as financial statements or other materials acceptable to the commissioner (see §209.O).

D. Duty to Comply. The permittee must comply with all conditions of a permit. Any permit noncompliance constitutes a violation of the act and is grounds for enforcement action, or permit termination, revocation and reissuance, or modification; or for denial of a permit renewal application if the commissioner determines that such noncompliance endangers underground sources of drinking water. The permittee need not comply with the provisions of his permit to the extent and for the duration such noncompliance is authorized in an (temporary) emergency permit under §215.

E. Duty to Reapply. If the permittee wishes to continue an activity regulated by permit after the expiration date of the permit, the permittee must apply for and obtain a new permit.

F. Duty to Halt or Reduce Activity. It shall not be a defense for a permittee in an enforcement action that it would have been necessary to halt or reduce the permitted activity in order to maintain compliance with the conditions of this permit.

G. Duty to Mitigate. The permittee shall take all reasonable steps to minimize or correct any adverse impact on the environment such as the contamination of underground sources of drinking water or zones outside of the approved injection zone resulting from noncompliance with this permit.

H. Proper Operation and Maintenance. The permittee shall at all times properly operate and maintain all facilities and systems of treatment and control (and related appurtenances) which are installed or used by the permittee to achieve compliance with the conditions of his permit. Proper operation and maintenance includes effective performance, adequate funding, adequate operation staffing and training, and adequate laboratory process controls, including appropriate quality assurance procedures. This provision requires the operation of back-up or auxiliary facilities or similar systems only when necessary to achieve compliance with the conditions of the permit.

I. Inspection and Entry. Inspection and entry shall be allowed as prescribed in R.S. of 1950, Title 30, Section 4.

J. Compliance. Compliance with a permit during its term constitutes compliance, for purposes of enforcement, with the act and these regulations.

K. Property Rights. The issuance of a permit does not convey any property rights or any sort, or any exclusive privilege or servitude.

L. Notification Requirements

1. Planned Changes. The permittee shall give notice to the commissioner as soon as possible of any planned physical alterations or additions to the permitted facility which may constitute a major modification of the permit.

2. Notice of Well Completion

a. A new Class I hazardous waste injection well may not commence injection until construction is complete, a notice of completion has been submitted to the commissioner and the commissioner has inspected or otherwise reviewed the injection well and finds it is in compliance with the conditions of the permit.

b. The commissioner shall inspect the well within 10 working days of the notice of completion required in §207.L.2.a.

c. If the permittee has not received notice from the commissioner of his intent to inspect or review the well or if the commissioner has not inspected or otherwise reviewed the new Class I hazardous waste injection well within 10 working days of the notice of completion in §207.L.2.a, prior inspection or review is waived and the permittee may commence injection.

3. Anticipated Noncompliance. The permittee shall give advance notice to the commissioner of any planned changes in the permitted facility or activity which may result in noncompliance with permit requirements.

4. Transfers. A permit is not transferable to any person except after notice to the commissioner. The commissioner may require modification or revocation and reissuance of the permit to change the name of the permittee and incorporate such other requirements as may be necessary (see §213).

5. Compliance Schedules. Report of compliance or noncompliance with, or any progress reports on, interim and final requirements contained in any compliance schedule in these regulations shall be submitted to the commissioner no later than 14 days following each schedule date.

6. Twenty-Four Hour Reporting

a. The permittee shall report to the commissioner any noncompliance which may endanger health or the environment. Any information pertinent to the noncompliance shall be reported by telephone within 24 hours from the time the permittee becomes aware of the circumstances. A written submission shall also be provided within five days of the time the permittee becomes aware of the circumstances and shall contain a description of the noncompliance and its cause, the period of noncompliance, including exact dates and times, and if the noncompliance has not been corrected, the anticipated time it is expected to continue; and steps taken or plannned to reduce, eliminate, and prevent reoccurrence of the noncompliance.

b. The following additional information must be reported within the 24-hour period provided above:

i. any monitoring or other information which indicates that any contaminant may cause an endangerment to a USDW or zone outside of the injection zone;

ii. any noncompliance with a permit condition or malfunction of the injection system which may cause fluid migration into or between USDW's or outside of the injection zone.

7. The permittee shall notify the commissioner at such times as the permit requires before abandonment of the Class I hazardous waste injection well (see §209.L.2).

8. Other Noncompliance. The permittee shall report all instances of noncompliance not reported under §207.L.5 and 6 at the time quarterly reports are submitted. The reports shall contain the information listed in §207.L.6.

9. Other Information. Where the permittee becomes aware that it failed to submit any relevant facts in a permit application, or submitted incorrect information in a permit application or in any report to the commissioner, it shall promptly submit such facts or information.

M. Duration of Permits

1. Permits for the operation of a Class I hazardous waste injection well shall be effective for a fixed term not to exceed ten years (see §211.I.3).

2. The term of a permit shall not be extended by modification beyond the maximum duration specified in this Subsection.

3. The commissioner may issue, for cause, any permit for duration that is less than the full allowable term under this Subsection.

N. Schedules of Compliance. The permit may, when appropriate, specify a schedule of compliance leading to compliance with the act and these regulations.

1. Time for Compliance. Any schedules of compliance under this Subsection shall require compliance as soon as possible but not later than two years after the effective date of the permit.

2. Interim Dates. Except as provided in Paragraph 2.b of this Subsection, if a permit establishes a schedule of compliance which exceeds one year from the date of permit issuance, the schedule shall set forth interim requirements and the dates for their achievement.

a. The time between interim dates shall not exceed one year.

b. If the time necessary for completion of any interim requirements (such as the construction of a control facility) is more than one year and is not readily divisible into stages for completion, the permit shall specify interim dates for submission of reports of progress toward completion or the interim requirements and indicate a projected completion date.

3. Reporting. The permit shall be written to require that progress reports be submitted no later than 30 days following each interim date and the final date of compliance.

O. Additional Conditions. The commissioner shall impose on a case-by-case basis such additional conditions as are necessary to protect underground sources of drinking water.

AUTHORITY NOTE: Promulgated in accordance with R.S. 30:1D and 4C(16), and 4.1.

HISTORICAL NOTE: Promulgated by the Department of Natural Resources, Office of Conservation, LR 15:978 (November 1989).

§209. Technical Criteria and Standards

A. Applicability. This Section establishes technical criteria and standards for the regulation of Class I hazardous waste injection wells.

B. Area of Review

1. The area of review for each Class I hazardous waste injection well shall be a fixed radius of no less than 2 miles around the well or shall be determined by the calculated cone of influence of the well, whichever is greater.

2. All known unplugged, improperly plugged and abandoned, or improperly constructed wells in the area of review which penetrate the confining of injection zone are subject to the corrective action requirements of §209.C.

C. Corrective Action

1. Coverage. Applicants for Class I hazardous waste injection well permits shall submit a plan outlining the protocol used to:

a. identify all wells which penetrate the confining or injection zone within the area of review; and

b. determine whether these wells are adequately completed or plugged.

2. Applicants for Class I hazardous waste injection well permits shall identify the location of all wells within the area of review that penetrate the injection or confining zone and shall submit as required in §205.E.2, 3, and 4:

a. a tabulation of all wells within the area of review that penetrate the injection or the confining zone; and

b. a description of each well or type of well and any records of its plugging or completion.

3. For wells determined to be improperly plugged, completed, or abandoned, or for which plugging or completion information is unavailable, the applicant shall also submit a plan consisting of such steps or modifications

as are necessary to prevent movement of fluids into or between underground sources of drinking water or outside of the injection zone. Where the plan is adequate, the commissioner shall incorporate it into the permit as a condition. Where the commissioner's review of the application indicates that the permittee's plan is inadequate (based at a minimum on the factors in §209.C.5), the commissioner shall:

a. require the applicant to revise the plan;

b. prescribe a plan for the corrective action as a condition of the permit; or

c. deny the application.

4. Requirements

a. Existing Injection Wells. Any permit issued for an existing Class I hazardous waste injection well requiring corrective action other than pressure limitations shall include a compliance schedule requiring any corrective action accepted or prescribed under §209.C.3. Any such compliance schedule shall provide for compliance as soon as possible but not later than two years following issuance of the permit. It shall also require observance of appropriate pressure limitations under §209.C.4.c until all other corrective action measures have been implemented.

b. New Injection Wells. No permit for any Class I hazardous waste injection well may authorize injection until all corrective actions required under this Section have been taken.

c. Injection Pressure Limitations. The commissioner may require pressure limitations in lieu of plugging. If so, then the commissioner shall require as a permit condition that injection pressure be so limited that pressure in the injection zone at the site of any improperly completed or abandoned well within the area of review would not be sufficient to drive fluids into or between USDW's or outside of the injection zone. This pressure limitation shall satisfy the corrective action requirement. Alternatively, such injection pressure limitation can be made part of a compliance schedule and last until all other corrective actions have been implemented.

5. In determining the adequacy of corrective action proposed by the applicant under §209.C.3 and in determining the additional steps needed to prevent fluid movement into and between USDW's or outside of the injection zone, the following criteria and factors shall be considered by the commissioner:

a. nature and volume of the injected fluids;

b. nature of native fluids or by-products of injection;

c. geology;

d. hydrology;

e. potentially affected population;

f. history of the injection operation;

g. completion and plugging records;

h. closure procedures in effect at the time the well was closed;

i. hydraulic connections with USDW's or zones outside of the injection zone;

j. reliability of the procedures used to identify abandoned wells;

k. any other factors which might affect the movement of fluids into or between USDW's or outside of the injection zone.

D. Minimum Criteria for Siting

1. All Class I hazardous waste injection wells shall be sited such that they inject into a formation that is beneath the lowermost formation containing within 1/4 mile of the wellbore an underground source of drinking water (USDW).

2. The siting of Class I hazardous waste injection wells shall be limited to areas that are geologically suitable. The commissioner shall determine geologic suitability based upon:

a. an analysis of the structural and stratigraphic geology, the hydrogeology, and the seismicity of the region;

b. an analysis of the local geology and hydrogeology of the well site, including at a minimum, detailed information regarding stratigraphy, structure and rock properties, aquifer hydrodynamics and mineral resources; and

c. a determination that the geology of the area can be described confidently and that the limits of waste fate and transport can be accurately predicted through the use of models.

3. Class I hazardous waste injection wells shall be sited such that:

a. the injection zone has sufficient permeability, porosity, thickness, and a real extent to prevent migration of fluids into USDW's or outside of the injection zone;

b. the confining zone:

i. is laterally continuous and free of transecting, transmissive faults or fractures over an area sufficient to prevent the movement of fluids into USDW or outside the injection zone; and

ii. contains at least one formation of sufficient thickness and with lithologic and stress characteristics capable of preventing vertical propagation of fractures.

4. The owner or operator shall demonstrate to the satisfaction of the commissioner that:

a. the confining zone is separated from the base of the lower-most USDW by at least one sequence of permeable and less permeable strata that will provide an added layer of protection for the USDW in the event of fluid movement in an unlocated borehole or transmissive fault; or

b. within the area of review, the piezometric surface of the fluid in the injection zone is less than the piezometric surface of the lower-most USDW, considering density effects, injection pressures and any significant pumping in the overlying USDW; or

c. there is no USDW present;

d. the commissioner may approve a site which does not meet the requirements in §209.D.4.a, b or c if the applicant can demonstrate to the commissioner that because of the geology, nature of the waste, or other considerations, abandoned boreholes or other conduits would not cause endangerment of USDW's.

E. Construction Requirements

1. General. All existing and new Class I hazardous waste injection wells shall be constructed and completed to:

a. prevent the movement of fluids into or between USDW's or into any unauthorized zones;

b. permit the use of appropriate testing devices and workover tools; and

c. permit continuous monitoring of injection tubing and long string casing as required pursuant to §209.H.10.

2. Compatibility. All well materials must be compatible with fluids with which the materials may be expected to come into contact. A well shall be deemed to have compatibility as long as the materials used in the construction of the well meet or exceeds standards developed for such materials by the American Petroleum Institute, The American Society for Testing Materials, or comparable standards acceptable to the commissioner.

3. Casing and Cementing of New Wells

a. Casing and cement used in the construction of each newly drilled well shall be designed for the life expectancy of the well, including the post-closure care period. The casing and cementing program shall be designed to prevent the movement of fluids into or between USDW's, or outside the injection zone, and to prevent potential leaks of fluids from the well. In determining and specifying casing and cementing requirements, the commissioner shall consider the following information as required by §205.E:

i. depth to the injection zone;

ii. injection pressure, external and internal pressure, and axial loading;

iii. hole size;

iv. size and grade of all casing strings (wall thickness, diameter, nominal weight, length, joint specification, and construction material);

v. corrosiveness of injected fluid, formation fluids, and temperature;

vi. lithology of injection and confining zones;

vii. type or class of cement including slurry weight (lb/gal) and yield (cu. ft./sack); and

viii. quantity and chemical composition of injected fluid.

b. One surface casing string shall, at a minimum, extend into the confining bed below the lowest formation that contains a USDW and be cemented by circulating cement from the base of the casing to the surface, using a minimum of 150 percent of the calculated annular volume. The commissioner may require more than 150 percent when it is warranted by the geology or by other circumstances.

c. At least one long string casing and/or intermediate casing string, using a sufficient number of centralizers, shall be utilized in the well. If either casing string is to be perforated, then the approved casing shall extend through the base of the injection zone. If an approved alternate construction method is used, such as the setting of a screen, the casing shall be set to the top of the injection interval. Regardless of the construction method utilized, the casing strings shall be cemented by circulating cement from the casing shoe to the surface in one or more stages:

i. of sufficient quantity and quality to withstand the maximum operating pressure; and

ii. in a quantity no less than 120 percent of the calculated volume necessary to fill the annular space. The commissioner may require more than 120 percent when it is warranted by the geology or other circumstances.

d. Circulation of cement may be accomplished by staging. The commissioner may approve an alternative method of cementing in cases where the cement cannot be circulated to the surface, provided the owner or operator can demonstrate by using logs that the cement is continuous across and sufficiently above the injection zone so as to provide for zonal isolation and does not allow fluid movement behind the casing.

e. Casing, including any casing connections, must be rated to have sufficient structural strength to withstand, for the design life of the well, the maximum burst and collapse pressures and the maximum tensile stress which may be experienced during the construction, operation, and closure of the well.

f. At a minimum, cement and cement additives must be of sufficient quality and quantity to maintain integrity over the design life of the well.

4. Tubing and Packer

a. All Class I hazardous waste injection wells, except as in §209.E.4.d below, shall inject fluids through tubing with a packer set at a depth specified by the commissioner. Where multiple injection intervals exist, the packer setting depth will be as close as practicable to the top of the primary injection interval. The commissioner shall have the authority to adjust the packer setting depth as required on a case-by-case basis.

b. In determining and specifying requirements for tubing and packer, the following factors shall be considered:

i. depth of setting;

ii. characteristics of injection fluid (chemical content, corrosiveness, temperature, and density);

iii. injection pressure;

iv. annular pressure;

v. rate (intermittent or continuous), temperature, and volume of injected fluids;

vi. size of casing; and

vii. tubing tensile, burst, and collapse strengths.

c. A corrosion resistant or noncorrosive fluid shall be placed under pressure into the tubing/long string casing annulus. The annulus pressure shall be monitored in accordance with §209.H.9 and 10.

d. The commissioner may approve the use of a fluid seal system as an alternative to a mechanical packer if he determines that the following conditions are met:

i. the operator demonstrates that the seal will provide a level of protection comparable to a packer;

ii. the operators staff is, and will remain, adequately trained to operate and maintain the well and to identify and interpret variations in parameters of concern;

iii. the permit contains specific limitations on variations in annular pressure and loss of annular fluid;

iv. the design and construction of the well allows continuous monitoring of the annular pressure and mass balance of annular fluid; and

v. a secondary system is used to monitor the interface between the injection fluid and the annulus fluid and the permit contains requirements for testing the system every three months and recording the results with the submission of the appropriate quarterly report.

5. Disposal of Drill Material. The subsurface material (cuttings) such as sand, clay, shale, etc. removed from the wellbore during the drilling of a Class I hazardous waste injection well may be disposed at a properly permitted municipal landfill or a hazardous waste landfill provided the disposal of such material at such facilities complies with all applicable regulations.

F. Logging, Testing and Sampling Prior to New Well Operation

1. During the drilling and construction of a new Class I hazardous waste injection well, appropriate logs and tests shall be run to determine or verify the depth, thickness, porosity, permeability, and rock type of, and the salinity of any entrained fluids in all relevant geologic units to assure conformance with performance standards in §209.E, and to establish accurate baseline data against which future measurements may be compared. A descriptive report interpreting results of such logs and tests shall be prepared by a knowledgeable log analyst and submitted to the commissioner as part of the completion report described in §209.G.1. At a minimum, such logs and tests shall include:

a. deviation checks during drilling on all holes constructed by drilling a pilot hole which are enlarged by reaming or another method. Such checks shall be at sufficient frequent intervals to determine the location of the borehole and to assure that vertical avenues for fluid movement in the form of diverging holes are not created during drilling; and

b. such other logs and tests as may be needed after taking into account the availability of similar data in the area of the drilling site, the construction plan, and the need for additional information that may arise from time to time as the construction of the well progresses. At a minimum, the following logs shall be required in the following situations:

i. for surface casing:

(a) spontaneous potential, resistivity or gamma-resistivity, and caliper logs before casing is installed; and

(b) a cement bond and variable density log, and a temperature log after casing is set and cemented;

ii. for intermediate and long string casing:

(a) resistivity, spontaneous potential, gamma-ray, porosity, caliper and fracture finder logs before the casing is installed; and

(b) a cement bond and variable density log, and a temperature log after the casing is cemented;

iii. the commissioner may allow the use of an alternative to the above logs when an alternative will provide equivalent or better information, and:

(a) all casing strings shall be pressure tested at conditions specified by the commissioner and reported on the appropriate form; and

(b) a mechanical integrity test consisting of:

(i). a pressure test with liquid or gas;

(ii). a radioactive tracer survey;

(iii). a temperature or noise log;

(iv). a casing inspection log, if required by the commissioner; and

(v). any other test required by the commissioner.

2. Whole cores or sidewall cores of the confining and injection zones and formation fluid samples from the injection zone shall be taken. Cores from nearby wells may be accepted if the owner or operator can demonstrate that core retrieval is not possible and that such cores are representative of the conditions at the well. The commissioner may require coring of other formations in the borehole.

3. The fluid temperature, pH, conductivity, pressure, and the static fluid level of the injection zone must be recorded.

4. At a minimum, the following information concerning the injection and confining zones shall be

determined or calculated for Class I hazardous waste injection wells:

a. fracture pressure;

b. other physical and chemical characteristics of the formation fluids in the injection zone; and

c. physical and chemical characteristics of the confining and injection zones.

5. Upon completion, but prior to operation, the owner or operator shall conduct the following tests to verify hydrogeologic characteristics of the injection zone:

a. a pump test; or

b. injectivity tests.

6. The commissioner shall have the opportunity to witness all logging and testing required by §209.F. The owner or operator shall submit a schedule of such activities to the commissioner 30 days prior to conducting the first test.

7. Construction Supervision. All phases of well construction and any well workover shall be supervised by a person who is knowledgeable and experienced in practical drilling engineering and who is familiar with the special conditions and requirements of injection well construction.

G. Pre-Operation Requirements. Prior to the commissioner granting final approval for the operation of a Class I hazardous waste injection well, the owner or operator shall submit the following information to the commissioner for review and approval.

1. A completion report containing at a minimum:

a. the drilling and complete and accurate record of the depth, thickness, and character of the strata penetrated;

b. casing and cement records;

c. all available logs and testing program data on the well and a descriptive report interpreting the results of all logs and tests;

d. measured bottomhole temperature and pressure;

e. a demonstration of mechanical integrity pursuant to §209.F.1.d;

f. the results of the injection zone and confining zone testing program as required in §205.E.3.c;

g. compatibility of the injected waste with fluids in the injection zone and minerals in both the injection zone and confining zone and with the materials used to construct the well;

h. core sample testing results;

i. injectivity test data;

j. the anticipated maximum pressure and flow rate under which the well will operate;

k. the actual injection procedure;

l. revised calculated area of review based on data obtained during logging and testing of the well and formation, and where necessary revisions to the information submitted under §205.E.2.a.ii and E.3.a;

m. revised formation pressure build-up calculation, §205.E.3.1;

n. revised waste front travel calculation, §205.E.3.m;

o. revised maps and cross sections of the injection zone using pertinent data above;

p. the status of corrective action on wells identified under §205.E.3.k;

q. as built diagram of the well with construction information;

r. submit a certified location plat indicating the surveyed surface and bottom-hole location of the well, the latitude and longitude as well as the Lambert (X-Y) coordinates of the surface and bottom-hole. Also include the directional survey and directional profile drawing of the well.

2. For all Class I injection wells, file one copy of the permit in the conveyance records of the parish courthouse where the well is located. Within 15 days from the date of filing, forward a certified copy of the permit with recording references to the division within the Office of Conservation that issued the permit.

3. For all Class I injection wells, written notification that a copy of the permit has been filed with the appropriate oil and gas regulatory division within the Office of Conservation.

4. Compliance with all pre-operating terms of the permit must occur and approval to commence operation must be received from the commissioner prior to beginning injection operations (see §207.L).

5. The commissioner may give permission to commence injection for an interim period not to exceed 30 calendar days following the inspection required in §207.L.2.b. Final permission to inject will be given only upon receipt and approval of the completion report required in §209.G.1.

H. Operating Requirements

1. Except during well stimulation, the injection pressure at the wellhead shall not exceed the calculated maximum surface injection pressure (MSIP) so as to assure that the pressure in the injection zone during injection operations will not initiate new fractures or propagate existing fractures in the injection or confining zone nor cause the movement of injection or formation fluids into USDW or outside the injection zone. The MSIP shall be calculated by using the following formula.

$$MSIP = 0.85\ (BHP_F - H) + TF + SE$$

where:

BHP_F = bottom-hole fracture pressure established by gradients for the area the well is located in or actual testing.

H = hydrostatic pressure.

TF = frictional loss in the tubing during maximum injection rate.

SE = skin effects as established by accepted engineering test procedures as described in "Pressure Buildup and Flow Tests in Wells", by C.S. Matthews and D G. Russell or approved alternate tests (optional variable).

2. Injection between the outermost casing protecting USDW's and the wellbore is prohibited.

3. The owner or operator shall maintain an annulus pressure that exceeds the operating injection pressure, unless the commissioner determines that such a requirement might harm the integrity of the well. The fluid in the annulus shall be noncorrosive or contain a corrosion inhibitor.

4. A protective barrier shall be maintained around the wellhead and related appurtenances during all normal in-service and out-of-service periods for protection against mechanical damage.

5. A sign shall be maintained on the protective barrier of each injection well identifying the well class and type, well name and number, Serial Number, section-township-range, and any other information required by the commissioner.

6. The owner or operator shall maintain mechanical integrity of the well at all times. Integrity shall be demonstrated and reported according to the procedures and at the frequency specified in §209.I.

7. Approval by the commissioner must be obtained before conducting any workover operations on the well (see §209.J.2). All fluids and materials (sand, etc.) removed from the well during workovers shall be contained and disposed of properly.

8. Permit requirements for owners or operators of hazardous waste wells which inject wastes that have the potential to react with the injection formation to generate gases shall include:

a. conditions limiting the temperature, pH or acidity of the injected waste; and

b. procedures necessary to assure that pressure imbalances which might cause a backflow or blowout do not occur.

9. Pressure gauges shall be installed at the wellhead and properly maintained which will indicate the pressure on the injection tubing and on the tubing-casing annulus.

10. The owner or operator shall install, use, and maintain in proper operating condition continuous recording devices to monitor injection pressure, flow rate, volume, and temperature of injected fluids; and the pressure on the annulus between the injection tubing and the long string casing, and any other specified data. The instruments shall be housed in weatherproof enclosures.

11. The owner or operator shall install, use, and maintain in proper operating condition:

a. automatic alarm and automatic shut-off systems, designed to sound and shut-in the well when pressures and flow rates or other parameters approved by the commissioner exceed a range and/or gradient specified in the permit; or

b. automatic alarms, designed to sound when the pressures and flow rates or other parameters approved by the commissioner exceed a rate and/or gradient specified in the permit, in cases where the owner or operator certifies that a trained operator will be on site at all times when the well is operating.

12. If an automatic alarm or shutdown is triggered, the owner or operator shall immediately investigate and identify as expeditiously as possible the cause of the alarm or shutoff. If upon such investigation the well appears to be lacking mechanical integrity or if the monitoring required under §209.H.10 of this Section otherwise indicates that the well may be lacking mechanical integrity, the owner or operator shall:

a. cease injection of waste fluids unless authorized by the commissioner to continue or resume injection;

b. take all necessary steps to determine the presence or absence of a leak; and

c. notify the commissioner within 24 hours after the alarm or shutdown in person or by telephone as required in §207.L.6.

13. If a loss of mechanical integrity is discovered pursuant to Paragraph 12 of this Subsection or during periodic mechanical integrity testing, the owner or operator shall:

a. immediately cease injection of waste fluids;

b. take all steps reasonably necessary to determine whether there may have been a release of hazardous waste constituents into any unauthorized zone;

c. notify the commissioner within 24 hours as in §209.H.12.c after loss of mechanical integrity is discovered;

d. notify the commissioner when injection can be resumed; and

e. restore and demonstrate mechanical integrity to the satisfaction of the commissioner prior to resumption of injection operations.

14. Whenever the owner or operator obtains evidence that there may have been a release of injected waste into an unauthorized zone, immediately cease injection of waste fluids, and:

a. notify the commissioner within 24 hours of obtaining such evidence as in §209.H.12.c;

b. take all necessary steps to identify and characterize the extent of any release;

c. comply with and implement any remediation plan specified and approved by the commissioner; and

d. where such release is into a USDW currently serving as a water supply, place a notice in the official parish journal where the facility is located and the official state journal; notify local governing authorities in the affected area, all water well users within 2 miles of the release, and the Secretary of the Department of Environmental Quality.

15. Where there is evidence that there may have been a release of injected waste into an unauthorized zone, the commissioner may allow the operator to resume injection prior to completing cleanup action if the owner or operator demonstrates that the injection operation will not endanger USDW's or allow the movement of fluids outside the injection zone.

I. Testing and Monitoring Requirements. Samples and measurements taken for the purposes of testing and monitoring shall be representative of the monitored activity and shall include at a minimum:

1. Monitoring of the Injected Waste

a. The owner or operator shall develop and follow an approved written waste analysis plan that describes the procedures to be carried out to obtain a detailed chemical and physical analysis of a representative sample of the waste, including the quality assurance procedures used. At a minimum the plan shall specify:

i. the parameters for which the waste will be analyzed and the rationale for the selection of these parameters;

ii. the test methods that will be used to test for these parameters;

iii. the sampling method that will be used to obtain a representative sample of the waste being analyzed;

iv. the date, exact place and time of sampling or measurement;

v. the individual(s) who performed the sampling or measurement;

vi. the date(s) analyses were performed;

vii. the individual(s) who performed the analyses; and

viii. the results of such analyses.

b. The analysis of the injected waste as described in the waste analysis plan shall be repeated at frequencies specified in the waste analysis plan and when process or operating changes occur that may significantly alter the characteristics of the waste stream.

c. The owner or operator shall conduct continuous or periodic monitoring of selected parameters as required by the commissioner.

d. The owner or operator shall assure that the plan remains accurate and the analysis remain representative.

2. Hydrogeologic Compatibility Determination. The owner or operator shall submit information demonstrating to the satisfaction of the commissioner that the waste stream and its anticipated reaction products will not alter the permeability, thickness or other relevant characteristics of the confining or injection zone such that they would no longer meet the requirements specified in §209.D.

3. Compatibility of Well Materials

a. The owner or operator shall demonstrate that the waste stream will be compatible with the well materials with which the waste is expected to come into contact, and submit to the commissioner a description of the methodology used to make that determination. Compatibility for the purposes of this requirement is established if contact with injected fluids will not cause the well materials to fail to satisfy any design requirement imposed under §209.E.2.

b. The commissioner shall require continuous corrosion monitoring of the construction materials used in the well for wells injection corrosive waste, and may require such monitoring for other waste by:

i. placing coupons of the well construction materials in contact with the waste stream; or

ii. routing the waste stream through a loop constructed with the material used in the well; or

iii. using an alternative method approved by the commissioner.

c. If a corrosion monitoring program is required:

i. the test shall use materials identical to those used in the construction of the well, and such materials must be continuously exposed to the operating pressures and temperatures (measured at the wellhead) and flow rates of the injection operation; and

ii. the owner or operator shall monitor the materials for loss of mass, thickness, cracking, pitting, and other signs of corrosion on a quarterly basis to ensure that the well components meet the minimum standards for material strength and performance set forth in §209.E.2.

4. Periodic Mechanical Integrity Testing. The owner or operator of a Class I hazardous waste injection well shall conduct mechanical integrity testing as follows:

a. the long string casing, injecting tubing, and annular seal shall be tested by means of an approved pressure test with a liquid or gas annually and whenever there has been a well workover involving the unseating or disturbing of the injection tubing or annular seal system;

b. the bottom-hole cement shall be tested by means of an approved Radioactive Tracer Survey annually;

c. an approved temperature, noise, or other approved log shall be run at least once every five years to test for movement of fluid along the borehole. The commissioner may require such test whenever the well is worked over;

d. casing inspection logs shall be run once every five years unless the commissioner waives this requirement due to well construction or other factors which limit the test's reliability; and

e. any other test approved by the commissioner.

5. Mechanical Integrity Testing by Conservation Representative

a. One of the following tests shall be witnessed or reviewed onsite by a Louisiana Office of Conservation representative to verify mechanical integrity:

i. a fluid pressure test of the annular space; or

ii. review of the continuous monitoring records required in §209.J.

b. Verification of mechanical integrity under this Paragraph may be performed on an alternating basis. The frequency of integrity verification shall be quarterly for commercial Class I hazardous waste injection wells and semi-annually for onsite Class I hazardous waste injection wells. The commissioner or his representative reserves the right to specifically require more frequent testing as well as the right to specify the method of testing in specific instances.

6. Mechanical Integrity during Periods of Non-Use. Except during workovers or routine maintenance, any well which is not operational shall conform to the mechanical integrity requirements of §209.I.4 and 5 and shall sustain a positive pressure on the annulus during the period of non-use. When an operator takes a well out of operation, the operator shall assure the mechanical integrity of the well during non-use (see §209.K). If a well cannot meet mechanical integrity requirements the operator shall submit a plan to the commissioner within 30 days of the integrity test, to properly bring the facility into compliance. If a plan is not submitted within 30 days or if the plan is considered inadequate, the owner or operator will be given six months to plug and abandon the well as required in §209.L.

7. Ambient Monitoring. This Paragraph sets forth ambient monitoring criteria for all Class I injection wells. Based on a site-specific assessment of the potential for fluid movement from the well or injection zone, and on the potential value of monitoring wells to detect such movement, the commissioner shall:

a. require the owner or operator to develop a monitoring program. At a minimum, the commissioner shall require monitoring of the pressure buildup in the injection zone annually, including at a minimum, a shut down of the well for a time sufficient to conduct a valid observation of the pressure fall-off curve;

b. when prescribing a monitoring system the commissioner may also require:

i. continuous monitoring for pressure changes in the first aquifer overlying the confining zone. When such a well(s) is/are installed, the owner or operator shall, on a quarterly basis, sample the aquifer and analyze for constituents specified by the commissioner;

ii. the use of indirect geophysical techniques to determine the position of the waste front, the water quality in a formation designated by the commissioner, or to provide other site specific data;

iii. periodic monitoring of the groundwater, quality in the first aquifer overlying the injection zone;

iv. periodic monitoring of the groundwater quality in the lowermost USDW; or

v. any additional monitoring necessary to determine whether fluids are moving into or between USDW's or outside the injection zone.

8. The commissioner may require seismicity monitoring when he has reason to believe that the injection activity may have the capacity to cause seismic disturbances.

J. Reporting Requirements. Reporting requirements shall, at a minimum, include:

1. quarterly reports to the commissioner containing the following information. Quarterly reports are due no later than 30 days following the end of the quarter for which it is being submitted:

a. the physical, chemical, and other relevant characteristics of the injection stream;

b. monthly average, maximum and minimum values for injection pressure, flow rate and volume, cumulative volume of fluids, and annular pressure;

c. any changes in the annular fluid volume;

d. a description of any event which triggers an alarm or shutdown device required pursuant to §209.H.10 and 11 and the response taken;

e. a description of any event that exceeds operating parameters for annulus pressure or injection pressure as specified in the permit; and

f. the results of monitoring prescribed under §209.I;

g. periodic test of mechanical integrity;

h. any other test of the injection well conducted by the permittee if required by the commissioner; and

i. any well workover performed during the quarter including minor well maintenance.

2. Workover Reporting

a. The owner or operator shall notify the commissioner and obtain a work permit prior to commencing any workover operation on the well. Workovers include, but are not limited to, plug and abandon, deepen, perforate, squeeze, plugback, sidetrack, pull tubulars, unseat packer, backwash, change interval of completion (disposal) within the approved injection zone, etc.

b. All work permits must be requested in writing by use of the appropriate form. If an unforseen situation arises which requires immediate attention, the permittee may request a verbal work permit by phoning the Office of Conservation. The permittee must then submit to the commissioner a completed work permit application within five days of obtaining the verbal permit.

c. Within 20 days following the completion of the authorized work, the permittee must submit to the Office of Conservation, one original and two copies of the well history and work resume report.

d. With the first quarterly report after the conclusion of the workover submit, to the aforementioned office, a completion report which not only includes the reason for the workover but also a detailed description and analysis of the work performed.

K. Temporarily Cease Injection

1. The owner or operator of a Class I hazardous waste injection well who temporarily ceases injection, except for periods of workovers or routine maintenance, may keep the well open provided the well is kept in compliance with the technical requirements applicable to active injection wells such as maintaining mechanical integrity, positive annular pressure, monitoring, etc. This is to ensure that the waste will not migrate out of the injection zone or endanger USDW's during the period of temporary disuse.

2. If a well has been out-of-service for a period of one year or longer, the owner or operator must inform the commissioner of intentions for the continued use of the well.

3. The owner or operator of a well that has ceased injection operations for more than two years shall notify the commissioner 30 days prior to resuming operation of the well.

L. Closure (Plug and Abandon)

1. Closure Plan. The owner or operator of a Class I hazardous waste injection well shall prepare, maintain, and comply with a plan for closure of the well that meets the requirements of §209.L.4 and is acceptable to the commissioner. The obligation to implement the closure plan survives the termination of a permit or the cessation of injection activities. The requirement to maintain and implement an approved plan is directly enforceable regardless of whether the requirement is a condition of the permit.

a. The owner or operator shall submit the plan as part of the permit application, and upon approval by the commissioner, shall be a condition of any permit issued.

b. Any proposed significant revision to the method of closure reflected in the plan shall be submitted for approval by the commissioner no later than the date on which notice of closure is required to be submitted under §209.L.2.

c. The plan shall assure financial responsibility as required in §209.O and also include the following information:

i. the type, number, and placement of each plug including the elevation of the top and bottom of each plug;

ii. the type, grade, and quantity of material to be used in plugging;

iii. the method of placement of the plugs as required in §209.L.4.e;

iv. any proposed test or measurement to be made;

v. the amount, size, and location (by depth) of casing and any other materials to be left in the well;

vi. the method and location where casing is to be parted, if applicable; and

vii. the estimated cost of closure expressed in future dollars for a time period equal to the duration of a Class I injection well permit.

d. The commissioner may modify a closure plan where necessary.

2. Notice of Intent to Close. The owner or operator shall notify the commissioner by submission of an appropriate work permit at least 60 days before closure of a well. At the discretion of the commissioner, a shorter notice period may be allowed.

3. Closure Report. Within 60 days after closure or at the time of the next quarterly report (whichever is less) the owner or operator shall submit a closure report to the commissioner. If the quarterly report is due less than 15 days after completion of closure, then the closure report shall be submitted within 60 days of closure. The report shall be certified as accurate by the owner or operator and by the person who performed the closure operation (if other than the owner or operator). Such report shall consist of:

a. a statement that the well was closed in accordance with the closure plan previously submitted and approved by the commissioner; or

b. where actual closure differed from the plan previously submitted, a written statement specifying the differences between the previous plan and the actual closure.

4. Standards for Well Closure

a. Prior to closing the well, the owner or operator shall observe and record the pressure decay for an appropriate time period or a time specified by the commissioner. The commissioner shall review the pressure decay and transient pressure observations conducted pursuant to §209.I.7.a and determine whether the injection activity has conformed with predicted values.

b. Prior to closure, appropriate mechanical integrity testing shall be conducted to ensure the integrity of that portion of the long string casing and cement that will be left in the ground after closure. Testing methods may include:

i. pressure testing with liquid or gas;

ii. radioactive tracer surveys;

iii. noise, temperature, pipe evaluation, or cement bond logs; or

iv. any other test required by the commissioner.

c. Prior to well closure, the well shall be flushed with a buffer fluid.

d. Upon closure, the well shall be plugged with cement in a manner that will not allow the movement of fluids into or between USDW's or outside the injection zone.

e. Placement of cement plugs shall be accomplished by one of the following:

i. the Balance Method;

ii. the Dump Bailer Method;

iii. the Two-Plug Method; or

iv. an alternate method approved by the commissioner that will reliably provide a comparable level of protection.

f. Each plug shall be appropriately tagged and tested for seal and stability before closure is completed.

g. The well to be closed is to be in a state of static equilibrium with the mud weight equalized top to bottom, either by circulating the mud in the well at least once or by a comparable method prescribed by the commissioner, prior to the placement of the cement plug(s).

h. Upon successful completion of the closure, the surface location of the abandoned well shall be identified with a permanent marker inscribed with the operator's name, well class, well name and number, serial number, section-township-range, parish, and date plugged and abandoned.

M. Post-Closure Care

1. The owner or operator of a Class I hazardous waste injection well shall prepare, maintain, and comply with a plan for post-closure care that meets the requirements of §209.M.2 and is acceptable to the commissioner. The obligation to implement the post-closure plan survives the termination of a permit or the cessation of injection activities. The requirement to maintain an approved plan is directly enforceable regardless of whether the requirement is a condition of the permit.

a. The owner or operator shall submit the plan as part of the permit application and, upon approval by the commissioner, such plan will be a condition of any permit issued.

b. The owner or operator shall submit any proposed significant revision to the plan as appropriate over the life of the well, but no later than the date of the closure report required under §209.L.3.

c. The plan shall assure financial responsibility as required in §209.O.

d. The plan shall include the following information:

i. the pressure in the injection zone before injection began. Where a direct measurement of initial pressure is not available, then reasonable estimates may be used, provided they are acceptable to the commissioner;

ii. the anticipated pressure in the injection zone at the time of closure;

iii. the predicted time until pressure in the injection zone decays to the point that the well's cone of influence no longer intersects the base of the lowermost USDW;

iv. predicted position of the waste front at closure;

v. the status of any cleanups required under §209.C; and

vi. the estimated cost of proposed post-closure care at a time equal to the duration of a Class I injection well permit expressed in terms of future dollars.

e. At the request of the owner or operator, or on his own initiative, the commissioner may modify the post-closure plan after submission of the closure report.

2. To provide for post-closure care, the owner or operator shall:

a. continue and complete any cleanup action required under §209.C, if applicable;

b. continue to conduct any groundwater monitoring required under the permit until pressure in the injection zone decays to the point that the well's cone of influence no longer intersect the base of the lowermost USDW. The commissioner may extend the period of post-closure monitoring if he determines that the well may endanger a USDW;

c. submit a survey plat to the local zoning authority designated by the commissioner. The plat shall indicate the location of the well relative to permanently surveyed benchmarks. A copy of the plat shall be submitted to the appropriate Regional Administrator, Environmental Protection Agency;

d. provide appropriate notification and information to such state and local authorities as have cognizance over drilling activities to enable such state and local authorities to impose appropriate conditions on subsequent drilling activities that may penetrate the well's confining or injection zone.

3. Each owner of a Class I hazardous waste injection well and the owner of the surface or subsurface property on or in which a Class I hazardous waste injection well is located, must record a notation on the deed to the facility property or on some other instrument which is normally examined during title search that will in perpetuity provide any potential purchaser of the property the following information:

a. the fact that the land has been used to manage hazardous waste;

b. the name of the state agency or local authority with which the plat was filed, as well as the address of the Regional Environmental Protection Agency Office to which it was submitted;

c. the type and volume of waste injected, the injection interval(s) into which it was injected, and the period over which injection occurred.

N. Recordkeeping Requirements

1. The owner or operator shall keep complete and accurate records of all phases of the injection operation from application through post-closure. This includes, but is in no way limited to:

a. area of review and corrective action requirements;

b. construction and completion information including logging and testing;

c. complete data on all monitoring requirements specified in the permit and/or by the commissioner for the injection well(s) and any associated monitoring well(s);

d. all periodic measurements and well test such as injection fluid analyses, bottom-hole pressure data, mechanical integrity records, etc.;

e. records reflecting the nature, composition, and volume of all injected fluids; and

f. closure (plug and abandon) and post-closure information.

2. The owner or operator shall retain all records of the well's operation described in Paragraph 1 above for a period of three years following well closure. The commissioner may require the owner or operator to deliver the records to the Louisiana Office of Conservation at the conclusion of the retention period. If so, then the records shall thereafter be retained at a location designated by the commissioner for that purpose.

3. All records shall be made available for review upon request from a representative of the commissioner.

O. Financial Responsibility

1. The permit shall require the owner or operator to demonstrate and maintain financial responsibility for closure (plug and abandon) and post-closure care by using a trust fund, surety bond, letter of credit, financial statement, insurance, or corporate guarantee, or other materials acceptable to the commissioner. The amount of the funds available shall be no less than the amount identified in §209.L.1.c.vii and §209.M.1.d.vi.

2. The obligation to maintain financial responsibility for post-closure care survives the termination of a permit or the cessation of injection activities. The requirement to maintain financial responsibility is enforceable regardless of whether the requirement is a condition of the permit.

P. Waiver of Requirements

1. Where applicable on a case-by-case basis, the commissioner may alter requirements for a Class I hazardous waste injection well from those set forth in this Section provided any reduction in requirements will not result in an increased risk for movement of fluids into an underground source of drinking water or outside of the injection zone.

2. When reducing requirements under this Subsection, the commissioner shall issue an order either separately or as part of the permit explaining the reasons for the action.

Q. Additional Requirements. The commissioner may prescribe additional requirements for a Class I hazardous waste injection well than those described in these regulations in order to protect underground sources of drinking water or prevent the movement of fluids outside of the injection zone.

AUTHORITY NOTE: Promulgated in accordance with R.S. 30:1D and 4C(16), and 4.1.

HISTORICAL NOTE: Promulgated by the Department of Natural Resources, Office of Conservation, LR 15:978 (November 1989).

§211. Permitting Process

A. Applicability. This Section contains procedures for issuing UIC permits for Class I hazardous waste injection wells other than emergency (temporary) permits.

B. Application Submission and Review

1. Any person required to have a UIC permit shall submit an application to the Office of Conservation as outlined in §205.

2. Check for completeness:

a. the commissioner shall not issue a permit before receiving an application form and any required supplemental information which are completed to his satisfaction;

b. each application for a permit submitted for a Class I hazardous waste injection well will be reviewed for completeness by the commissioner and the applicant will be notified of the commissioner's decision within 90 days of its receipt; and

c. for each application for a Class I hazardous waste injection well permit, the commissioner shall, no later than the date the application is ruled complete, prepare and mail to the applicant a project decision schedule. The schedule shall specify target dates by which the commissioner intends to:

i. prepare a draft permit;

ii. give public notice;

iii. complete the public comment period, including any public hearing; and

iv. issue a final permit.

3. Incomplete Applications

a. If the application is incomplete, the commissioner shall list in the notification in §211.B.2.b, the information necessary to make the application complete. The commissioner shall notify the applicant when an application is complete. The commissioner may request additional information from an applicant only when necessary to clarify, modify, or supplement previously submitted material. Requests for such additional information will not render an application incomplete.

b. If an applicant fails or refuses to correct deficiencies found in the application, the permit may be denied and, for existing wells, appropriate enforcement actions may be taken under the applicable statutory provision.

4. If the commissioner decides that a site visit is necessary for any reason in conjunction with the processing of an application, he shall notify the applicant, state the reason for the visit, and a date shall be scheduled.

C. Draft Permits

1. Once an application is complete, the commissioner shall prepare a draft permit or deny the application.

2. The applicant may appeal the decision to deny an application in a letter to the commissioner who may then call a public hearing through the provisions of §211.G.l.

3. If the commissioner prepares a draft permit, it shall contain the following information where appropriate:

a. all conditions under §§207 and 209;

b. all compliance schedules under §207.N; and

c. all monitoring requirements under applicable paragraphs in §209.

4. All draft permits prepared under this Section may be accompanied by a fact sheet (§211.D), and shall be publicly noticed (§211.E), and made available for public comment (§211.F).

D. Fact Sheet

1. A fact sheet shall be prepared for every draft permit for all major facilities or activities and for every draft permit which the commissioner finds is the subject of wide-spread public interest or raises major issues. The fact sheet shall briefly set forth the principal facts and the significant factual, legal, methodological and policy questions considered in preparing the draft permits. The commissioner shall send this fact sheet to the applicant and, on request, to any other person.

2. The fact sheet shall include, when applicable:

a. a brief description of the type of facility or activity which is the subject of the draft permit;

b. the type and quantity of wastes, fluids, or pollutants which are proposed to be or are being injected;

c. a brief summary of the basis for the draft permit conditions including references to applicable statutory or regulatory provisions;

d. reasons why any requested variances or alternatives to required standards do or do not appear justified;

e. a description of the procedures for reaching a final decision on the draft permit including:

i. the beginning and ending dates of the comment period under §211.F and the address where comments will be received;

ii. procedures for requesting a hearing and the nature of that hearing; and

iii. any other procedures by which the public may participate in the final decision;

f. name and telephone number of a person to contact for information.

3. A copy of the fact sheet shall be mailed to all persons identified in §211.E.a.i, ii and iii.

E. Public Notice of Permit Actions and Public Comment Period

1. Scope

a. The commissioner shall give public notice that the following actions have occurred:

i. a draft permit has been prepared under §211.C; and

ii. a hearing has been scheduled under §211.G.

b. No public notice is required when a request for permit modification, revocation and reissuance, or termination is denied under §213. Written notice of that denial shall be given to the requester and to the permittee.

c. Public notices may describe more than one permit or permit action.

2. Timing

a. Public notice of the preparation of a draft permit required under §211.E shall allow 30 days for public comment.

b. Public notice of a public hearing shall be given 30 days before the hearing. Public notice of the hearing may be given at the same time as public notice of the draft permit and the two notices may be combined.

3. Methods. Public notice of activities described in §211.E.l.a shall be given by the following methods:

a. by mailing a copy of a notice to the following persons (any person otherwise entitled to receive notice under this Paragraph may waive his rights to receive notice):

i. the applicant;

ii. any other agency which the commissioner knows has issued or is required to issue a permit for the same facility or activity (including EPA);

iii. federal and state agencies with jurisdiction over fish, shellfish, and wildlife resources and over coastal zone management plans, the Advisory Council on Historic Preservation, the State Archeological Survey and Antiquities Commission, the Department of Environmental Quality, the Department of Justice, and other appropriate government authorities, including any affected states; and

iv. persons on a UIC mailing list;

b. for noncommercial Class I hazardous waste injection well permits, publication of a notice in a daily or weekly newspaper within the area affected by the facility or activity;

c. in a manner constituting legal notice to the public under state law; and

d. any other method reasonably calculated to give actual notice of the action in question to the persons potentially affected by it, including press releases or any other forum or medium to elicit public participation.

4. Contents

a. All Public Notices. Public notices issued under this Section shall contain the following information:

i. name and address of the Division of the Office of Conservation processing the permit action for which notice is being given;

ii. name and address of the permittee or permit applicant and, if different, of the facility or activity regulated by the permit;

iii. a brief description of the business conducted at the facility or activity described in the permit application;

iv. name, address, and telephone number of a person from whom interested persons may obtain copies of the draft permit, and the fact sheet, and further information concerning the application;

v. a brief description of the comment procedures required by §211.F and the time and place of any hearing that will be held, including a brief statement of procedures to request a hearing (unless a hearing has already been scheduled) and other procedures by which the public may participate in the final permit decision; and

vi. location of the proposed injection well or activity, the depth of the proposed injection zone, the depth of the base of the lowermost underground source of drinking water, and the list of waste and volumes proposed to be injected;

vii. any additional information considered necessary or proper.

b. Public Notices for Hearings. In addition to the general public notice described in §211.E.4.a, the public notice of a hearing under §211.G shall contain the following information:

i. reference to the date of previous public notices relating to the permit;

ii. date, time, and place of the hearing; and

iii. a brief description of the nature and purpose of the hearing including the applicable rules and procedures.

c. Public hearings are required for all applications for new commercial Class I hazardous waste injection wells. The method and content of public notices for such hearings are as follows.

i. Applicants for new commercial Class I hazardous waste injection wells shall give public notice of a scheduled and required public hearing on three separate days within a period of 30 days prior to the scheduled hearing, with at least five days between each publication of notice, both in the official state journal and in the official journal of the parish in which the well is located.

ii. Applicants for commercial Class I hazardous waste injection wells shall also be required to place an advertisement in the official state journal and in the official journal of the parish in which the well is to be located, but not in the classified or public notice section of the newspapers, in a form which shall not be less than one-half page in size and printed in bold face type. Such notice shall inform the public that application for a permit has been made to the Office of Conservation for a new commercial Class I hazardous waste injection well. The notice shall also contain the information required in §211.E.4.a and b.

F. Public Comments and Requests for Public Hearings. During the public comment period provided under §211.E any interested person may submit written comments on the draft permit and may request a public hearing, if no hearing has already been scheduled. A request for a public hearing shall be in writing and shall state the nature of the issues proposed to be raised in the hearing. All comments shall be considered in making the final decision and shall be answered as provided in §211.H.

G. Public Hearings

1. The commissioner shall hold a public hearing whenever he finds, on the basis of requests, a significant degree of public interest in (a) draft permit(s). The commissioner also may hold a public hearing at his discretion, whenever, for instance, such a hearing might clarify one or more issues involved in the permit decision. Public notice of the hearing shall be given as specified in §211.E.

2. Any person may submit oral or written statements and data concerning the draft permit. Reasonable limits may be set upon the time allowed for oral statements, and the submission of statements in writing may be required. The public comment period under §211.E shall automatically be extended to the close of any public hearing under this Subsection. The hearing officer may also extend the comment period by so stating at the hearing.

3. A tape recording or written transcript of the hearing shall be made available to the public.

H. Response to Comments

1. At the time that any final permit is issued the commissioner shall issue a response to comments. This response shall:

a. specify which provisions if any, of the draft permit have been changed in the permit decision and the reasons for the change; and

b. briefly describe and respond to all significant comments on the draft permit or the permit application raised during the public comment period, or during any hearing.

2. The response to comments shall be available to the public.

I. Permit Issuance and Effective Date

1. After closure of the public comment period, including any public hearing, under §211.E on a draft permit, the commissioner shall issue a final permit decision within 90 days.

2. A final permit decision shall become effective on the date of issuance.

3. Approval or the granting of a permit to drill and construct a Class I hazardous waste injection well shall be valid for a period of one year and if construction has not been completed in that time, then the permit shall be null and void. The permittee may request an extension of this one year requirement; however, the commissioner shall approve the request for extenuating circumstances only.

AUTHORITY NOTE: Promulgated in accordance with R.S. 30:1D and 4C(16), and 4.1.

HISTORICAL NOTE: Promulgated by the Department of Natural Resources, Office of Conservation, LR 15:978 (November 1989).

§213. Permit Modification, Revocation and Reissuance, Termination, Transfer or Renewal

A. Applicability. The rules of this Section set forth the standards and requirements for applications and actions concerning modification, revocation and reissuance, termination, transfer and renewal of permits.

B. Permit Actions

1. The permit may be modified, revoked and reissued, or terminated for cause.

2. The permittee shall furnish to the commissioner, within 30 days, any information which the commissioner may request to determine whether cause exists for modifying, revoking and reissuing, or terminating a permit, or to determine compliance with the permit. The permittee shall also furnish to the commissioner, upon request, copies of records required to be kept by the permit.

3. The commissioner may, upon his own initiative or at the request of any interested person, review any permit to determine if cause exists to modify, revoke and reissue, or terminate the permit for the reasons specified in §213.C, D and E. All requests shall be in writing and shall contain facts or reasons supporting the request.

4. If the commissioner decides the request is not justified, he shall send the person making the request a brief written response giving a reason for the decision. Denials of requests for modification, revocation and reissuance, or termination are not subject to public notice, comment, or hearings.

5. If the commissioner decides to modify or revoke and reissue a permit under §213.C, D or E, he shall prepare a draft permit under §211.C incorporating the proposed changes. The commissioner may request additional information and, in the case of a modified permit, may require the submission of an updated permit application. In the case of revoked and reissued permits, the commissioner shall require, if necessary, the submission of a new application.

C. Modification or Revocation and Reissuance of Permits

1. The following are causes for modification and may be causes for revocation and reissuance of permits.

a. Alterations. There are material and substantial alterations or additions to the permitted facility or activity which occurred after permit issuance which justify the application of permit conditions that are different or absent in the existing permit.

b. Information. The commissioner has received information pertinent to the permit. Permits for Class I hazardous waste injection wells may be modified during their terms for this cause only if the information was not available at the time of permit issuance (other than revised regulations, guidance, or test methods) and would have justified the application of different permit conditions at the time of issuance. Cause shall include any information indicating that cumulative effects on the environment are unacceptable.

c. New Regulations

i. The standards or regulations on which the permit was based have been changed by promulgation of new or amended standards or regulations or by judicial decision after the permit was issued and conformance with the changed standards or regulations is necessary for the protection of the health or safety of the public or the environment. Permits for Class I hazardous waste injection wells may be modified during their terms when:

(a) the permit condition requested to be modified was based on a promulgated regulation or guideline;

(b) there has been a revision, withdrawal, or modification of that portion of the regulation or guideline on which the permit condition was based; and

(c) a permittee requests modification within 90 days after *Louisiana Register* notice of the action on which the request is based.

ii. When standards or regulations on which the permit was based have been changed by withdrawal of standards or regulations or by promulgation of amended standards or regulations which impose less stringent requirements on the permitted activity or facility and the permittee requests to have permit conditions based on the withdrawn or revised standards or regulations deleted from his permit, the permit may be modified as a minor modification without providing for public comment.

iii. For judicial decisions, a court of competent jurisdiction has remanded and stayed Office of Conservation regulations or guidelines and all appeals have been exhausted, if the remand and stay concern that portion of the regulations or guidelines on which the permit condition was based and a request is filed by the permittee to have permit conditions based on the remanded or stayed standards or regulations deleted from his permit.

d. Compliance Schedules. The commissioner determines good cause exists for modification of a compliance schedule, such as an act of God, strike, flood, or materials shortage or other events over which the permittee has little or no control and for which there is no reasonable available remedy.

2. Causes for Modification or Revocation and Reissuance. The following are causes to modify or, alternatively, revoke and reissue a permit.

a. Cause exists for termination under §213.E, and the commissioner determines that modification or revocation and reissuance is appropriate.

b. The commissioner has received notification of a proposed transfer of the permit and the transfer is determined not to be a minor modification (see §213.D.4). A permit may be modified to reflect a transfer after the effective date (§213.F.2.b) but will not be revoked and reissued after the effective date except upon the request of the new permittee.

c. A determination that the waste being injected is a hazardous waste as defined in the Louisiana Hazardous Waste Management Program either because the definition has been revised or because a previous determination has been changed.

3. Facility Siting. Suitability of an existing facility location will not be considered at the time of permit modification or revocation and reissuance unless new information or standards indicate that continued operations at the site pose a threat to the health or safety of persons or the environment which was unknown at the time of permit issuance. A change of injection site or facility location may require modification or revocation and issuance as determined to be appropriate by the commissioner.

4. If a permit modification satisfies the criteria of this Section, a draft permit must be prepared and other applicable procedures must be followed.

D. Minor Modifications of Permits. Upon the consent of the permittee, the commissioner may modify a permit to make the corrections or allowances for changes in the permitted activity listed in this Section without issuing a draft permit and providing for public comment. Minor modifications may only:

1. correct typographical errors;

2. require more frequent monitoring or reporting by the permittee;

3. change an interim compliance date in a schedule of compliance, provided the new date does not interfere with attainment of the final compliance date requirement;

4. allow for a change in ownership or operational control of a facility where the commissioner determines that no other change in the permit is necessary, provided that a written agreement containing a specific date for transfer of permit responsibility, coverage, and liability between the current and new permittees has been submitted to the commissioner (see §213.F);

5. change quantities or types of fluids injected which are within the capacity of the facility as permitted and, in the judgment of the commissioner, would not interfere with the operation of the facility or its ability to meet conditions prescribed in the permit, and would not change its classification;

6. change construction requirements or plans approved by the commissioner provided that any such alteration shall comply with the requirements of this Section and §209. No such changes may be physically incorporated into construction of the well prior to approval; or

7. amend a plugging and abandonment plan which has been updated under §209.L.

E. Termination of Permits

1. The commissioner may terminate a permit during its term for the following causes:

a. noncompliance by the permittee with any condition of the permit;

b. the permittee's failure in the application or during the permit issuance process to disclose fully all relevant facts, or the permittee's misrepresentation of any relevant facts at any time; or

c. a determination that the permitted activity endangers the health or safety of persons or the environment which activity cannot be regulated to acceptable levels by permit modification and can only be regulated to acceptable levels by permit termination.

2. If the commissioner decides to terminate a permit, he shall issue a notice of intent to terminate. A notice of intent to terminate is a type of draft permit which follows the same procedures as any draft permit prepared under §211.C.

3. The commissioner may alternatively decide to modify or revoke and reissue a permit for the causes in §213.E (see §213.C.2.a).

F. Transfers of Permits

1. A permit may be transferred to a new owner or operator upon approval by the commissioner.

2. The current permittee shall submit an application for transfer at least 30 days before the proposed transfer date. The application shall contain the following:

a. name and address of the transferee;

b. date of proposed transfer; and

c. a written agreement between the existing and new permittees containing a specific date for transfer of permit responsibility, coverage and liability between them. The agreement should also demonstrate to the satisfaction of the commissioner that the financial responsibility requirements of §207.C will be met by the new permittee.

3. If the commissioner does not notify the existing permittee and the proposed new permittee of his intent to modify or revoke and reissue the permit under §213.C.2.b the transfer is effective on the date specified in the agreement mentioned in Paragraph 2.c above.

4. If no agreement described in §213.F.2 is provided, responsibility for compliance with the terms and conditions of the permit and liability for any violation will shift from the existing permittee to the new permittee on the date the transfer is approved.

5. If a person attempting to acquire a permit causes or allows operation of the facility before approval by the commissioner, it shall be considered a violation of these rules for operating without a permit or other authorization.

AUTHORITY NOTE: Promulgated in accordance with R.S. 30:1D and 4C(16), and 4.1.

HISTORICAL NOTE: Promulgated by the Department of Natural Resources, Office of Conservation, LR 15:978 (November 1989).

§215. Emergency or Temporary Permits

A. Applicability. The provisions for this Section set the standards applicable to emergency or temporary permits for Class I hazardous waste injection wells.

B. Coverage. Notwithstanding any other provision of this Section, the commissioner may temporarily permit a specific underground injection which has not otherwise been authorized by rule or permit if an imminent and substantial endangerment to the health of persons will result unless a temporary emergency permit is granted. The permittee need not comply with the provisions of the permit to the extent and for the duration that noncompliance is authorized in a temporary emergency permit.

C. Requirements for Issuance

1. Any temporary permit under this Section shall be for no longer term than required to prevent the hazard.

2. Notice of any temporary permit under this Subsection shall be published in accordance with §211.E within 10 days of the issuance of the permit.

3. The temporary permit under this Subsection may be either oral or written. If oral, it must be followed within five calendar days by a written temporary emergency permit.

4. The commissioner shall condition the temporary permit in any manner he determines is necessary to ensure that the injection will not result in the movement of fluids into an underground source of drinking water or outside of the injection zone.

D. Duration. A temporary permit shall not exceed a maximum of 90 days.

AUTHORITY NOTE: Promulgated in accordance with R.S. 30:1D and 4C(16), and 4.1.

HISTORICAL NOTE: Promulgated by the Department of Natural Resources, Office of Conservation, LR 15:978 (November 1989).

Title 43
NATURAL RESOURCES
Part XVII. Office of Conservation—Injection and Mining
Subpart 3. Statewide Order No. 29-M

Chapter 3. Hydrocarbon Storage Wells in Salt Dome Cavities

Editor's Note: Further policies can be found in "Commissioner's Order Second Supplement to Statewide Order 29-M," dated June 8, 1979.

§301. Findings of Fact—the Commissioner of Conservation Finds as Follows

A. That rules and regulations should be established governing the use and/or development of salt dome caverns for storage of liquid and/or gaseous hydrocarbons under those certain conditions as set forth herein below where it is shown that such use and/or storage will carry out the purpose and intent of the laws of this state.

B. That except as to liquid and/or gaseous hydrocarbon storage projects begun before October 1, 1976, no such project to develop and/or use a salt dome in the state of Louisiana for the injection, storage and withdrawal of liquid and/or gaseous hydrocarbons shall be permitted until the commissioner has issued an order following a public hearing after 10 days notice, under the rules covering such matters, which order shall include the following findings of fact:

1. that the salt dome sought to be used for the injection, storage and withdrawal of liquid and/or gaseous hydrocarbons is suitable and feasible for such use as to area, salt volume, depth, and other physical characteristics;

2. that the use of salt dome cavity for the storage of liquid and/or gaseous hydrocarbons will not contaminate other formations containing fresh water, oil, gas or other commercial mineral deposits, except salt; and

3. that the proposed storage, including all surface pits and surface storage facilities incidental thereto which are used in connection with the salt dome cavity storage operation, will not endanger lives or property and is environmentally compatible with existing uses of the salt dome area, and which order shall provide that:

a. liquid and/or gaseous hydrocarbons, which are injected and stored in a salt dome cavity, shall at all times be deemed the property of the injector, his successors or assigns, subject to the provisions of any contract with the affected land or mineral owners; and

b. in no event shall the owner of the surface of the lands or water bottoms or of any mineral interest under or adjacent to which the salt dome cavity may lie, or any other person, be entitled to any right of claim in or to such liquid and/or gaseous hydrocarbons stored unless permitted by the injector.

C. That in presenting evidence to the commissioner to enable him to make the findings described in Subsection B above, the applicant shall demonstrate that the proposed storage of liquid and/or gaseous hydrocarbons will be conducted in a manner consistent with established practices to preserve the integrity of the salt deposit and the overlying sediments. This shall include an assessment of the stability of the proposed cavity design, particularly with regard to the size, shape and depth of cavity, the amount of separation among cavities, and the amount of separation between the outer-most cavity wall and the periphery of the salt deposit.

D. That all projects for the storage of liquid and/or gaseous hydrocarbons approved by the commissioner pursuant to Subsection B above, should be designed, located, equipped, and operated in accordance with the following standards.

1. Design of underground storage chamber:

a. prior to the design and construction of an underground storage chamber, a qualified engineer and geologist shall perform an investigation to determine the feasibility of such a storage system at a particular site; and

b. the data obtained during the feasibility investigation shall be considered in the design of a solution mined underground storage system. Design shall be performed by or under the supervision of an engineer or geologist qualified for this type of work, and shall include such factors, among others, as: type of storage use, location of the cavity(ies), number of cavities, cavity capacity, and maximum development diameter of the cavity(ies). The design shall assure that project development can be conducted in a reasonable, prudent and systematic manner; and shall stress physical and environmental safety and the prevention of waste. The design and solutioning shall be continually reviewed throughout the construction phase to take into consideration pertinent additional detailed subsurface information; and shall include provisions for protection from damage caused by hydraulic shock. The original development and operational plans shall be modified to conform with good engineering practices, if necessary.

2. Location of underground storage chamber:

a. the wellhead and borehole shall be located so that the storage chamber at maximum development diameter shall not extend closer than 100 feet to the property of others who have not consented to subsurface storage under their land;

b. the minimum separation of adjacent walls of storage chambers as measured in any direction shall be established by a qualified engineer, considering:

i. the salt properties;

ii. the elevation of the top and bottom of the adjacent cavities;

iii. their maximum development diameter relative to the spacing of the cavities; and

iv. other considerations deemed appropriate for the specific site; but, in no case shall such separation at any time during the storage project be less than 200 feet. The walls of storage chambers shall be no less than 100 feet from the boundary of the lands included in the storage project on which the chambers are located; and

c. if the design should involve the intentional subsurface connection between two adjacent storage chambers under one property (e.g., a U tube storage chamber system) the minimum separation between cavities specified in Subparagraph b above, shall not apply.

3. Casing Program

a. The bore of a storage chamber access hole shall be cased and completed in accordance with rules, regulations, and good engineering practices pertaining to oil and/or gas wells of comparable depth applicable in the same area in which the chamber is located as established by the commissioner, except as specifically provided below.

b. The borehole shall be dually cased from the surface into the salt, one casing string being an intermediate string, the other being the final cemented string. Exceptions to this procedure will be processed under Subsection G.

c. The intermediate cemented casing string shall have adequate tensile and collapse strengths as established by the commissioner for the setting depth. This string shall be cemented from casing seat (bottom of casing) to ground surface when practicable; however, in every case it shall be cemented a sufficient distance to prevent migration of the stored products into zones of porosity or permeability in the overburden.

d. The final cemented string shall have adequate tensile and collapse strengths as established by the commissioner for the setting depth. This string shall be cemented from casing seat (bottom of string) to ground surface and shall be set a minimum of 300 feet into the salt.

e. The final (production) cemented casing string shall be hydrostatically pressure tested before drilling out the plug (shoe). The test pressure applied at the surface shall be a minimum of 200 psi. However, the test pressure when measured at the surface shall not cause pressure at the casing seat to exceed 0.9 psi. per foot of depth. The test pressure shall be maintained for a minimum of one hour to verify casing integrity and absence of thread leaks.

f. The casing seat and cement of final cemented casing string shall be hydrostatically tested after drilling out. At least 10 feet of salt below the casing shall be penetrated prior to this test. The test pressure calculated at the casing seat shall equal the maximum operating pressure at that point.

g. After the wellhead has been installed and prior to storing products, the system shall be hydrostatically pressure tested as a unit.

h. All tests required by this Section shall be prepared and supervised by a qualified engineer.

4. Operating Pressure on Solution Mined Storage Chamber

a. The maximum and minimum operating pressure of a storage chamber shall be determined by a qualified engineer after considering the geological characteristics of the dome. The maximum operating pressure (gauge) at the casing seat or chamber ceiling, whichever is the shallowest, shall not exceed 0.9 psi per foot of overburden.

b. The storage chamber shall not be subjected to pressures in excess of the maximum operating pressure even for short periods of time (including pressure pulsation peaks, abnormal operating condition, etc.).

5. Wellhead and Flowlines

a. All wellhead components (casinghead, tubinghead, etc.), valves and fittings shall be of steel. The water side of the wellhead shall have the same pressure rating as the products side. Each flowline connected to the wellhead shall be equipped with a remotely operated shut-off valve as well as a manually operated positive shut-off valve located on the wellhead. The wellhead, flowlines, valves, and all related connections shall have a test pressure rating at least equivalent to 125 percent of the maximum pressure which could be exerted at the surface. All valves shall be periodically inspected and maintained in good working order.

b. The wellhead and storage chamber shall be protected with safety devices to prevent pressures in excess of maximum operating pressure from being exerted on the storage chamber, and to prevent backflow of stored products in event of flowline rupture.

c. The brine flow line(s) shall be equipped with a safety device(s) to prevent the escape of product.

d. A continuous flare or other safety system shall be installed at or near each brine pit or at any other location where the uncontrollable escape of liquefied gases are likely to occur and the flare shall be burned continuously when a liquefied gas is being injected into a cavern.

e. Caverns containing hydrocarbons that exist as liquids at ambient conditions shall be surrounded by levees, booms, or other containment devices suitable for retention of liquids released by accidental spillage.

f. Competent personnel shall be at either the well or other control sites during injection or withdrawal from any storage well. An automated system approved by the commissioner may be employed in lieu of the above.

g. The wellhead shall be protected from mechanical damage by trespassers and/or accidental physical damage.

6. Saltwater Disposal and Brine Storage. Saltwater disposal wells shall be drilled and completed in accordance with existing statewide rules and regulations of the commissioner. Brine disposal reservoirs shall be designed to prevent the contamination of air, fresh water or soil, or as directed by appropriate state agencies.

E. That all hydrocarbon storage projects conducted in the state of Louisiana should comply with the following requirements pertaining to inspection, record keeping, safety and abandonment.

1. Safety Inspections

a.i. Each operator of a solution cavern storage well shall conduct semi-annual safety inspections of such facility, and file with the commissioner a written report consisting of the inspection procedures and results within 30 days following the inspection. Such inspections shall be conducted during the months of January and July of each year. The operator shall notify the commissioner at least five days prior to such inspections so that his representative may be present to witness the inspections. Inspections shall include, but not be limited to, the following:

(a). operations of all manual valves;

(b). operation of all automatic shut-in safety valves, including sounding or alarm devices;

(c). flare system installation, or hydrocarbon filters;

(d). earthen brine pits, tanks, firewalls and related equipment;

(e). flowlines, manifolds, and related equipment; and

(f). warning signs, safety fences, etc.

ii. Additional inspections may be made by representatives of the department at any time during regular working hours and upon reasonable notice to the cavern owner.

b. A capacity determination for each storage chamber shall be made and filed with the commissioner prior to operation of those projects begun after October 1, 1976. The latest available determination for each storage chamber existing on or begun prior to October 1, 1976 shall be filed within 90 days of the effective date of Statewide Order No. 29-M. These determinations shall be verified every five years, or as soon as possible thereafter; but in no event shall this period exceed 10 years.

c. A complete inspection of the Christmas tree and casing shall be conducted every five years or as soon as possible thereafter.

2. Design and Construction Records. Records pertaining to project design and construction shall be retained for the life of the storage chamber. (Such data shall include well drilling logs, electrical logs, directional surveys, completion and cementing data, pressure test records, geophysical records, washing records, surveys, photographs, inspection, reports, permits, certified location plat, etc.)

3. Safety Warnings. Appropriate safety precaution signs shall be displayed and unauthorized personnel kept out of the storage area. Each storage wellhead shall be visibly marked with an appropriate identifying sign.

4. Abandonment Procedure. Prior to the commencement of plugging operations on any project well or the abandonment of any storage cavity, an application describing the method to be used shall be filed with and approved by the commissioner. Unless the commissioner specifies to the contrary, wells shall be plugged in accordance with Statewide Order No. 29-B, §137.

F. That should the commissioner determine that the continued operation of a storage chamber and/or the product storage well or associated wellhead facilities (wellhead, valves, brine tanks or pits and flares) would cause unsafe operating conditions, waste pollution, or contamination of air, fresh water or soil, or encroachment on adjacent property, he may immediately prohibit further operation of the well or associated wellhead facilities until such time as he has determined that the project can and will be conducted in a physically and environmentally safe manner.

G. That exceptions to the guidelines and requirements set forth in Subsections D and E above, should be granted by the commissioner only upon proper showing by the applicant at a public hearing that such exception is reasonable, justified by the particular circumstances, and consistent with the intent of this order regarding physical and environmental safety and the prevention of waste.

AUTHORITY NOTE: Promulgated in accordance with R.S. 30:23(C).

HISTORICAL NOTE: Promulgated by the Department of Natural Resources, Office of Conservation, LR 3:310 (July 1977).

§303. Compliance

A. Now, therefore, it is ordered that from and after July 20, 1977, any applicant for approval of the use and/or development of cavities in a salt dome for storage of liquid and/or gaseous hydrocarbons in the state of Louisiana shall comply with the provisions §301.B, C, D and E;

B. from and after July 20, 1977, all operators of solution cavern storage wells shall comply with the provisions of §301.E hereof;

C. if it is determined by the commissioner that any unsafe operating condition, waste, pollution, or contamination of air, fresh water, or soil is imminent (reference §301.F above), further operation of any affected storage chamber and/or product storage well and associated facilities shall be discontinued until such time as it is determined that the project will be conducted in a physically and environmentally safe manner; and

D. exceptions to the guidelines set forth in §301.D and E shall be granted pursuant to §301.G above.

AUTHORITY NOTE: Promulgated in accordance with R.S. 30:23(C).

HISTORICAL NOTE: Promulgated by the Department of Natural Resources, Office of Conservation, LR 3:310 (July 1977).

Title 43
NATURAL RESOURCES
Part XVII. Office of Conservation—Injection and Mining
Subpart 4. Statewide Order No. 29-M-2

Chapter 31. Disposal of Exploration and Production Waste in Solution-Mined Salt Caverns

§3101. Definitions

Application—the filing on the appropriate Office of Conservation form(s), including any additions, revisions, modifications, or required attachments to the form(s), for a permit to operate a salt cavern waste disposal facility or parts thereof.

Aquifer—a geologic formation, groups of formations, or part of a formation that is capable of yielding a significant amount of water to a well or spring.

Blanket Material—sometimes referred to as a "pad." The blanket material is a fluid placed within a salt cavern that is lighter than the water in the cavern and will not dissolve the salt or any mineral impurities that may be contained within the salt. The function of the blanket is to prevent unwanted leaching of the salt cavern roof, prevent leaching of salt from around the cemented casing, and to protect the cemented casing from internal corrosion. Blanket material typically consists of crude oil, diesel, mineral oil, or some fluid possessing similar noncorrosive, nonsoluble, low density properties. The blanket material is placed between the salt cavern's outermost hanging string and innermost cemented casing.

Brine—water within a salt cavern that is completely or partially saturated with salt.

Cap Rock—the porous and permeable strata immediately overlying all or part of the salt stock of some salt structures typically composed of anhydrite, gypsum, limestone, and occasionally sulfur.

Casing—metallic pipe placed and cemented in the wellbore for the purpose of supporting the sides of the wellbore and to act as a barrier preventing subsurface migration of fluids out of or into the wellbore.

Catastrophic Collapse—the sudden or utter failure of the overlying strata caused by the removal or otherwise weakening of underlying sediments.

Cementing—the operation (either primary, secondary, or squeeze) whereby a cement slurry is pumped into a drilled hole and/or forced behind the casing.

Circulate to the Surface—the observing of actual cement returns to the surface during the primary cementing operation.

Commercial Salt Cavern Facility—a legally permitted salt cavern waste disposal facility that disposes of exploration and production waste off the site where produced by others for a fee or other consideration.

Commissioner—the Commissioner of Conservation for the State of Louisiana.

Contamination—the introduction of substances or contaminants into a groundwater aquifer, a USDW or soil in such quantities as to render them unusable of their intended purposes.

Discharge—the placing, releasing, spilling, percolating, draining, pumping, leaking, mixing, migrating, seeping, emitting, disposing, by-passing, or other escaping of pollutants on or into the air, ground, or waters of the state. A discharge shall not include that which is allowed through a federal or state permit.

E&P Waste—exploration and production waste.

Effective Date—the date of final promulgation of these rules and regulations.

Emergency Shutdown Valve—a valve that automatically closes to isolate a salt cavern well from surface piping in the event of a specified condition that, if uncontrolled, may cause an emergency.

Exempted Aquifer—an aquifer or its portion that meets the criteria of the definition of underground source of drinking water but which has been exempted according to the procedures set forth in §3103.E.2.

Existing Salt Cavern—a salt cavern originally permitted by the Office of Conservation for use other than E&P waste disposal.

Existing Well—a wellbore originally permitted by the Office of Conservation for use other than to facilitate E&P waste disposal into a salt cavern.

Exploration and Production Waste (E&P Waste)—drilling wastes, salt water, and other wastes associated with the exploration, development, or production of crude oil or natural gas wells and which is not regulated by the provisions of, and, therefore, exempt from the Louisiana Hazardous Waste Regulations and the Federal Resource Conservation and Recovery Act, as amended. E&P Wastes include, but are not limited to, those wastes listed in the definition for E&P Waste located in LAC 43:XIX.501 (Definitions).

Fluid—any material or substance which flows or moves whether in a semisolid, liquid, sludge, gas or any other form or state.

Generator—a person or corporate entity who creates or causes to be created any E&P waste.

Ground Subsidence—the downward settling of the Earth's surface with little or no horizontal motion in response to natural or manmade subsurface actions.

Groundwater Aquifer—water in the saturated zone beneath the land surface that contains less than 10,000 mg/l total dissolved solids.

Groundwater Contamination—the degradation of naturally occurring groundwater quality either directly or indirectly as a result of human activities.

Hanging String—casing whose weight is supported at the wellhead and hangs vertically in a larger cemented casing or another larger hanging string.

Injection and Mining Division—the Injection and Mining Division of the Louisiana Office of Conservation within the Department of Natural Resources.

Leaching—the process whereby an undersaturated fluid is introduced into a salt cavern thereby dissolving additional salt and increasing the volume of the salt cavern.

Migrating—any movement of fluids by leaching, spilling, discharging, or any other uncontained or uncontrolled manner, except as allowed by law, regulation, or permit.

New Well—a wellbore permitted by the Office of Conservation after the effective date of these rules and regulations to be completed into an existing salt cavern to facilitate E&P waste disposal.

Non-Commercial Salt Cavern Facility—a legally permitted salt cavern waste disposal facility that disposes of only E&P waste generated by the owner of the facility during oil and gas exploration and production activities.

Office of Conservation—the Louisiana Office of Conservation within the Department of Natural Resources.

Oil-Based Drilling Muds—any oil-based drilling fluid composed of a water in oil emulsion, organophillic clays, drilled solids and additives for down-hole rheology and stability such as fluid loss control materials, thinners, weighting agents, etc.

Operator—the person recognized by the Office of Conservation as being responsible for the physical operation of the facility or activity subject to regulatory authority under these rules and regulations.

Owner—the person recognized by the Office of Conservation as owning the facility or activity subject to regulatory authority under these rules and regulations.

Person—an individual, association, partnership, public or private corporation, firm, municipality, state or federal agency and any agent or employee thereof, or any other juridical person.

Produced Water—liquids and suspended particulate matter that is obtained by processing fluids brought to the surface in conjunction with the recovery of oil and gas from underground geologic formations, with underground storage of hydrocarbons, or with solution mining for brine.

Public Water System—a system for the provision to the public of piped water for human consumption, if such system has at least 15 service connections or regularly serves at least 25 individuals. Such term includes:

1. any collection, treatment, storage, and distribution facilities under control of the operator of such system and used primarily in connection with such system; and

2. any collection or pretreatment storage facilities not under such control which are used primarily in connection with such system.

Release—the accidental or intentional spilling, pumping, leaking, pouring, emitting, leaching, escaping, or dumping of pollutants into or on any air, land, groundwater, or waters of the state. A release shall not include that which is allowed through a federal or state permit.

Salt Cavern—see *solution-mined salt cavern*

Salt Cavern Roof—the uppermost part of a salt cavern being just below the neck of the wellbore. The shape of the salt cavern roof may be flat or domed.

Salt Cavern Waste Disposal Facility—any public, private, or commercial property, including surface and subsurface lands and appurtenances thereto, used for receiving, storing, and/or processing E&P waste for disposal into a solution-mined salt cavern.

Salt Cavern Well—a well extending into the salt stock to facilitate the disposal of waste or other fluids into a salt cavern.

Salt Dome—a diapiric, typically circular structure that penetrates, uplifts, and deforms overlying sediments as a result of the upward movement of a salt stock in the subsurface. Collectively, the salt dome includes the salt stock and any overlying uplifted sediments.

Salt Stock—a typically cylindrical formation composed chiefly of an evaporite mineral that forms the core of a salt dome. The most common form of the evaporite mineral is halite known chemically as sodium chloride (NaCl). Cap rock shall not be considered a part of the salt stock.

Solution-Mined Salt Cavern—a cavity created within the salt stock by dissolution with water.

State—the state of Louisiana.

Subsidence—see *ground subsidence*.

Surface Casing—the first string of casing installed in a well, excluding conductor casing.

Transport Vehicle—a motor vehicle, rail freight car, freight container, cargo tank, portable tank, or vessel used for the transportation of E&P wastes or other materials for use or disposal at a salt cavern waste disposal facility.

Transportation—the movement of wastes or other materials from the point of generation or storage to the salt cavern waste disposal facility by means of commercial or private transport vehicle.

Unauthorized Discharge—a continuous, intermittent, or one-time discharge, whether intentional or unintentional, anticipated or unanticipated, from any permitted or unpermitted source which is in contravention of any provision of the Louisiana Environmental Quality Act (R.S. 30:2001 et seq.) or of any permit or license terms and conditions, or of any applicable regulation, compliance schedule, variance, or exception of the Commissioner of Conservation.

Underground Source of Drinking Water—an aquifer or its portion:

1. which supplies any public water system; or

2. which contains a sufficient quantity of groundwater to supply a public water system; and

a. currently supplies drinking water for human consumption; or

b. contains fewer than 10,000 mg/l total dissolved solids; and which is not an exempted aquifer.

Waters of the State—both surface and underground waters within the state of Louisiana including all rivers, streams, lakes, groundwaters, and all other water courses and waters within the confines of the state, and all bordering waters, and the Gulf of Mexico.

AUTHORITY NOTE: Promulgated in accordance with R.S. 30:4 et seq.

HISTORICAL NOTE: Promulgated by the Department of Natural Resources, Office of Conservation, LR 29:914 (June 2003).

§3103. General Provisions

A. Applicability

1. These rules and regulations shall apply to all applicants, owners and/or operators of non-commercial salt cavern waste disposal facilities for disposal or proposed for disposal of E&P waste. However, where indicated, certain criteria found herein will also apply to commercial facility operators, in addition to the requirements of LAC 43:XIX.501 et seq.

2. These rules and regulations do not address creation of a salt cavern, rather, only the disposal of E&P waste into a salt cavern. Rules governing the permitting, drilling, constructing, operating, and maintaining of a Class III brine solution mining well and cavern are codified in applicable sections of Statewide Order No. 29-N-1 (LAC 43:XVII, Subpart 1) or successor documents.

3. An applicant, owner and/or operator of a salt cavern being solution-mined for conversion to E&P waste disposal should become familiar with these rules and regulations to assure that the well and salt cavern shall comply with these rules and regulations.

B. Prohibition of Unauthorized Disposal of Exploration and Production Waste

1. Construction, conversion and/or operation of a salt cavern for disposal of E&P waste without obtaining a permit from the Office of Conservation is a violation of these rules and regulations and applicable laws of the state of Louisiana.

2. Any salt cavern well or salt cavern existing before the effective date of these rules must comply with the requirements of these rules and regulations before converting the existing well and salt cavern to E&P waste disposal.

C. Prohibition on Movement of Fluids into Underground Sources of Drinking Water

1. No authorization by permit shall allow the movement of injected or disposed fluids into underground sources of drinking water or outside the salt stock. The owner or operator of the salt cavern waste disposal facility shall have the burden of showing that this requirement is met.

2. The Office of Conservation may take emergency action upon receiving information that injected or disposed fluid is present in or likely to enter an underground source of drinking water or may present an imminent and substantial endangerment to the environment, or the health, safety and welfare of the public.

D. Prohibition of Surface Discharges. The intentional, accidental, or otherwise unauthorized discharge of fluids, wastes, or process materials into manmade or natural drainage systems or directly into waters of the state is strictly prohibited.

E. Identification of Underground Sources of Drinking Water and Exempted Aquifers

1. The Office of Conservation may identify (by narrative description, illustrations, maps, or other means) and shall protect as an underground source of drinking water, except where exempted under §3103.E.2 all aquifers or parts of aquifers that meet the definition of an underground source of drinking water. Even if an aquifer has not been specifically identified by the Office of Conservation, it is an underground source of drinking water if it meets the definition.

2. After notice and opportunity for a public hearing, the Office of Conservation may identify (by narrative description, illustrations, maps, or other means) and describe in geographic and/or geometric terms (such as vertical and lateral limits and gradient) that are clear and definite, all aquifers or parts thereof that the Office of Conservation proposes to denote as exempted aquifers if they meet the following criteria:

a. the aquifer does not currently serve as a source of drinking water; and

b. the aquifer cannot now and shall not in the future serve as a source of drinking water because:

i. it is mineral, hydrocarbon, or geothermal energy producing or can be demonstrated to contain minerals or hydrocarbons that when considering their quantity and location are expected to be commercially producible;

ii. it is situated at a depth or location that makes recovery of water for drinking water purposes economically or technologically impractical;

iii. it is so contaminated that it would be economically or technologically impractical to render said water fit for human consumption; or

iv. it is located in an area subject to severe subsidence or catastrophic collapse; or

c. the total dissolved solids content of the groundwater is more than 3,000 mg/l and less than 10,000 mg/l and it is not reasonably expected to supply a public water system.

F. Exceptions/Variances

1. Except where noted in specific provisions of these rules and regulations, the Office of Conservation may allow, on a case-by-case basis, exceptions or variances to these rules and regulations. It shall be the obligation of the applicant, owner, or operator to show that the requested exception or variance shall not create an increased endangerment to the environment, or the health, safety and welfare of the public. The applicant, owner, or operator shall submit a written request to the Office of Conservation detailing the reason for the requested exception or variance. No deviation from the requirements of these rules or regulations shall be undertaken by the applicant, owner, or operator without prior written authorization from the Office of Conservation.

2. Granting of exceptions or variances to these rules and regulations shall only be considered upon proper showing by the applicant, owner, or operator at a public hearing that such exception or variance is reasonable, justified by the particular circumstances, and consistent with the intent of these rules and regulations regarding physical and environmental safety and the prevention of waste. The requester of the exception or variance shall be responsible for all costs associated with a public hearing.

G. Prohibition through Oilfield Site Restoration Fund. Without exception or variance to these rules and regulations, no solution-mined salt cavern or associated well shall be used for exploration and production waste disposal if the well or salt cavern was previously plugged and abandoned by or where site restoration has occurred pursuant to funding provided through the Oilfield Site Restoration Fund, R.S. 30:80 et seq. (Act 404 of 1993).

AUTHORITY NOTE: Promulgated in accordance with R.S. 30:4 et seq.

HISTORICAL NOTE: Promulgated by the Department of Natural Resources, Office of Conservation, LR 29:916 (June 2003).

§3105. Permit Requirements

A. Applicability. No person shall convert or operate a non-commercial salt cavern waste disposal facility without first obtaining written authorization (permit) from the Office of Conservation.

B. Application Required. Applicants for a non-commercial salt cavern waste disposal facility, permittees with expiring permits, or any person required to have a permit shall complete, sign, and submit one original application form with required attachments and documentation and two copies of the same to the Office of Conservation. The complete application shall contain all information necessary to show compliance with applicable state laws and these regulations.

C. Who Applies. It is the duty of the owner or proposed owner of a facility or activity to submit a permit application and obtain a permit. When a facility or activity is owned by one person and operated by another, it is the duty of the operator to file and obtain a permit.

D. Signature Requirements. All permit applications shall be signed as follows.

1. Corporations. By a principle executive officer of at least the level of vice-president, or duly authorized representative of that person if the representative performs similar policy making functions for the corporation. A person is a duly authorized representative only if:

a. the authorization is made in writing by a principle executive officer of at least the level of vice-president;

b. the authorization specifies either an individual or position having responsibility for the overall operation of the salt cavern waste disposal facility, such as the position of plant manager, superintendent, or position of equivalent responsibility. A duly authorized representative may thus be either a named individual or any individual occupying a named position; and

c. the written authorization is submitted to the Office of Conservation.

2. Partnership or Sole Proprietorship. By a general partner or proprietor, respectively; or

3. Public Agency. By either a principle executive officer or a ranking elected official of a municipality, state, federal, or other public agency.

E. Signature Reauthorization. If an authorization under §3105.D is no longer accurate because a different individual or position has responsibility for the overall operation of the salt cavern waste disposal facility, a new authorization satisfying the signature requirements must be submitted to the Office of Conservation before or concurrent with any reports, information, or applications required to be signed by an authorized representative.

F. Certification. Any person signing a document under §3105.D shall make the following certification on the application:

"I certify under penalty of law that I have personally examined and am familiar with the information submitted in this document and all attachments and that based on my

> inquiry of those individuals immediately responsible for obtaining the information, I believe that the information is true, accurate, and complete. I am aware that there are significant penalties for submitting false information, including the possibility of fine and/or imprisonment."

AUTHORITY NOTE: Promulgated in accordance with R.S. 30:4 et seq.

HISTORICAL NOTE: Promulgated by the Department of Natural Resources, Office of Conservation, LR 29:917 (June 2003).

§3107. Application Content

A. The following minimum information required in §3107 shall be submitted in a permit application for a non-commercial salt cavern E&P waste disposal facility. The applicant shall also refer to the appropriate application form for any additional information that may be required.

B. Administrative Information:

1. all required state application form(s);

2. the nonrefundable application fee(s) and public hearing fee;

3. the name, mailing address, and physical address of the salt cavern waste disposal facility;

4. the operator's name, address and telephone number;

5. ownership status as federal, state, private, public, or other entity;

6. a brief description of the nature of the business associated with the activity;

7. list of all permits or construction approvals that the applicant has received or applied for and which specifically affect the legal or technical ability of the applicant to undertake the activity or activities to be conducted by the applicant under the permit being sought;

8. a copy of the title to the property for the salt cavern waste disposal facility. If a lease, option to lease, or other agreement is in effect on the property, a copy of this instrument shall be included with the application;

9. acknowledgment as to whether the facility is located on Indian lands or other lands under the jurisdiction or protection of the federal government, or whether the facility is located on state water bottoms or other lands owned by or under the jurisdiction or protection of the state of Louisiana;

10. documentation of financial responsibility and insurance or documentation of the method by which proof of financial responsibility and insurance will be provided as required in §3109.B. Where applicable, include copies of a draft letter of credit, bond, or any other evidence of financial responsibility acceptable to the Office of Conservation. Before making a final permit decision, final (official) documentation of financial responsibility and insurance must be submitted to and approved by the Office of Conservation;

11. names and addresses of all property owners within a 1/2 mile radius of the property boundary of the salt cavern waste disposal facility.

C. Maps and Related Information—

1. a location plat of the salt cavern well prepared and certified by a registered civil engineer or registered land surveyor. The location plat shall be prepared according to standards of the Office of Conservation;

2. a topographic or other map extending at least 1 mile beyond the property boundaries of the salt cavern waste disposal facility depicting the facility and each well where fluids are injected underground; and those wells, springs, or surface water bodies, and drinking water wells listed in public records or otherwise known to the applicant in the map area;

3. the section, township and range of the area in which the salt cavern waste disposal facility is located and any parish, city or municipality boundary lines within 1 mile of the facility location;

4. a map showing the salt cavern well for which the permit is sought, the property boundaries of the salt cavern waste disposal facility, and the area of review. Within the area of review, the map shall show the number, name, and location of all existing producing wells, injection wells, abandoned wells and dry holes, public water systems and water wells. The map shall also show surface bodies of water, mines (surface and subsurface), quarries, and other pertinent surface features including residences and roads, and faults if known or projected;

5. maps and cross sections indicating the vertical limits of all underground sources of drinking water within the area of review, their position relative to the disposal formation, and the direction of water movement, where known, in every underground source of drinking water which may be affected by the proposed project;

6. generalized maps and cross sections illustrating the regional geologic setting;

7. structure contour mapping of the top-of-salt on a scale no smaller than 1 inch to 500 feet;

8. vertical cross sections detailing the geologic structure of the local area. The cross sections shall be structural (as opposed to stratigraphic cross sections), be referenced to sea level, show the salt cavern well and the salt cavern being permitted, all surrounding salt caverns regardless of use and current status, conventional (room and pillar) mines, and all other bore holes and wells that penetrate the salt stock. Cross sections should be oriented to indicate the closest approach to surrounding salt caverns, bore holes, wells, etc., and shall extend at least 1-mile beyond the edge of the salt stock. Any faulting in the area shall be illustrated on the cross sections such that the displacement of subsurface formations is accurately depicted; and

9. any other information required by the Office of Conservation to evaluate the salt cavern well, salt cavern, and related surface facility.

D. Area of Review Information. Refer to §3115.E for area of review boundaries and exceptions. Only information of public record need be researched or submitted with the application, however, a diligent effort must be made to identify all wells and other manmade structures in response to the area of review requirements. The applicant shall provide the following information on all wells or structures within the defined area of review:

1. a discussion of the protocol used by the applicant to identify wells and manmade structures in the defined area of review;

2. a tabular listing of all known water wells in the area of review to include the name of the operator, well location, well depth, well use (domestic, irrigation, public, etc), and current well status (active, abandoned, etc.);

3. a tabular listing of all known wells (excluding water wells) in the area of review with penetrations into the cap rock or salt stock to include at a minimum:

a. operator name, well name and number, state serial number (if assigned), and well location;

b. well type and current well status (producing, disposal, storage, solution mining, shut-in, plugged and abandoned), date the well was drilled, and the date the current well status was assigned;

c. well depth, construction, completion (including completion depths), plug and abandonment data;

4. the following information shall be provided on manmade structures within the salt stock regardless of use, depth of penetration, or distance to the salt cavern well or salt cavern being the subject of the application:

a. a tabular listing of all salt caverns to include:

i. operator name, well name and number, state serial number, and well location;

ii. current or previous use of the salt cavern (waste disposal, hydrocarbon storage, solution mining), current status of the salt cavern (active, shut-in, plugged and abandoned), date the salt cavern well was drilled, and the date the current salt cavern status was assigned;

iii. salt cavern depth, construction, completion (including completion depths), plug and abandonment data;

b. a tabular listing of all conventional (dry or room and pillar) mining activities, whether active or abandoned. The listing shall include the following minimum items:

i. owner or operator name and address;

ii. current mine status (active, abandoned);

iii. depth and boundaries of mined levels;

iv. the closest distance of the mine in any direction to the salt cavern well and salt cavern.

E. Technical Information. The applicant shall submit, as an attachment to the application form, the following minimum information in technical report format:

1. results of a current salt cavern sonar survey and mechanical integrity pressure and leak tests;

2. corrective action plan required by §3115.F for wells or other manmade structures within the area of review that penetrate the salt stock but are not properly constructed, completed or plugged and abandoned;

3. plans for performing the geological and hydrogeological studies of §3115.B, C, and D. If such studies have already been done, submit the results obtained along with an interpretation of the results;

4. properly labeled schematic of the surface construction details of the salt cavern well to include the wellhead, gauges, flowlines, and any other pertinent details;

5. properly labeled schematic of the subsurface construction and completion details of the salt cavern well and salt cavern to include borehole diameters (bit size or calipered); all cemented casings with cement specifications, casing specifications (size, depths, etc.); all hanging strings showing sizes and depths set; total depth of well; top, bottom, and diameter of cavern; and any other pertinent details;

6. surface site diagram(s) drawn to scale to include details and locations of the entire salt cavern waste disposal facility layout (surface pumps, piping and instrumentation, controlled access roads, fenced boundaries, waste offloading, storage, treatment and processing areas, field office, monitoring and safety equipment and location of such equipment, required curbed or other retaining wall heights, etc.);

7. detailed plans and procedures to operate the salt cavern well, salt cavern, and related surface facilities in accordance with the following requirements:

a. the cavern and surface facility design requirements of §3117, including, but not limited to cavern spacing requirements and cavern coalescence;

b. the well construction and completion requirements of §3119, including, but not limited to open borehole surveys, casing and cementing, casing and casing seat tests, cased borehole surveys, hanging strings, and wellhead components and related connections;

c. the operating requirements of §3121, including, but not limited to cavern roof restrictions, blanket material, remedial work, well recompletion, multiple well caverns, cavern allowable operating pressure and rates, cavern displacement fluid management, and E&P waste storage;

d. the safety requirements of §3123, including, but not limited to an emergency action plan, controlled site access, facility identification, personnel, wellhead protection and identification, valves and flowlines, alarm systems, emergency shutdown valves, vapor monitoring and leak detection, gaseous vapor control, fire detection and suppression, systems test and inspections, and surface facility retaining walls and spill containment, as well as contingency plans to cope with all shut-ins or well failures to prevent the migration of contaminating fluids into underground sources of drinking water;

e. the monitoring requirements of §3125, including, but not limited to equipment requirements such as pressure gauges, pressure sensors and flow sensors, continuous recording instruments, vapor monitoring and leak detection, subsidence monitoring, and weather conditions (wind sock), as well as a description of methods that will be undertaken to monitor salt cavern growth due to undersaturated fluid injection. The plan shall incorporate method(s) for monitoring the salinity of all wastes disposed and the carrier fluid used in aiding the disposal of wastes;

f. the pre-operating requirements of §3127, specifically the submission of a completion report, and the information required therein, prior to accepting, storing, treating, processing or otherwise initiating waste disposal activities;

g. the mechanical integrity pressure and leak test requirements of §3129, including, but not limited to frequency of tests, test methods, submission of pressure and leak test results, notification of test failures and prohibition of waste acceptance during mechanical integrity failure;

h. the cavern configuration and capacity measurement procedures of §3131, including, but not limited to sonar caliper surveys, frequency of surveys, and submission of survey results;

i. the cavern waste disposal capacity exceedance requirements of §3133;

j. the requirements for inactive caverns in §3135;

k. the reporting requirements of §3137, including, but not limited to the information required in monthly waste receipts and operation reports;

l. the record retention requirements of §3139;

m. the closure and post-closure requirements of §3141, including, but not limited to closure plan requirements, notice of intent to close, standards for closure, and post-closure requirements; and

n. any other information pertinent to operation of the salt cavern E&P waste disposal facility, including, but not limited to procedures for waste characterization and testing, waste acceptance, waste storage, waste processing, waste disposal, any waiver for surface siting, monitoring equipment and safety procedures.

AUTHORITY NOTE: Promulgated in accordance with R.S. 30:4 et seq.

HISTORICAL NOTE: Promulgated by the Department of Natural Resources, Office of Conservation, LR 29:918 (June 2003).

§3109. Legal Permit Conditions

A. Signatories. All reports required by permit or regulation and other information requested by the Office of Conservation shall be signed as in applications by a person described in §3105.D or §3105.E.

B. Financial Responsibility

1. Closure and Post-Closure. The owner or operator of a non-commercial salt cavern E&P waste disposal facility shall maintain financial responsibility and the resources to close, plug and abandon and, where necessary, for post-closure care of the salt cavern well, salt cavern, and related facility as prescribed by the Office of Conservation. Evidence of financial responsibility shall be by submission of a surety bond, a letter of credit, certificate of deposit, or other instruments acceptable to the Office of Conservation. The amount of funds available shall be no less than the amount identified in the cost estimate of the closure plan of §3141.A and, if required, post-closure plan of §3141.B. Any financial instrument filed in satisfaction of these financial responsibility requirements shall be issued by and drawn on a bank or other financial institution authorized under state or federal law to operate in the state of Louisiana.

2. Insurance. All owners or operators of a salt cavern waste disposal facility shall provide evidence of sudden and accidental pollution liability insurance coverage for damages that may be caused to any property and party by the escape or discharge of any material or waste from the facility. Such evidence shall be provided to the Office of Conservation before the issuance of a permit for a salt cavern waste disposal facility.

a. Insurance responsibility may be evidenced by filing a certificate of sudden and accidental pollution liability insurance (indicating the required coverage is in effect and all deductible amounts applicable to the coverage), a letter of credit, bond, certificate of deposits issued by and drawn on Louisiana banks, or any other evidence of equivalent financial responsibility acceptable to the Office of Conservation.

b. The amount and extent of such sudden and accidental pollution liability insurance responsibility shall not be less than the face amounts per occurrence and/or aggregate occurrences as set by the Office of Conservation. The minimum coverage for sudden and accidental pollution liability insurance shall be $5,000,000. The Office of Conservation retains the right to increase the minimum amount of insurance coverage as needed to prevent waste and to protect the environment, or the health, safety and welfare of the public.

c. Insurance coverage shall be issued by a company licensed to operate in the state of Louisiana. A copy of the insurance policy subsequently issued with any certificate of insurance is to be immediately filed with the Office of Conservation upon receipt by the operator.

3. Renewal of Financial Responsibility and Insurance. Any approved instrument of financial responsibility and insurance coverage shall be renewable yearly. Documentation of renewals shall be submitted to the Office of Conservation.

C. Duty to Comply. The operator must comply with all conditions of a permit. Any permit noncompliance is a violation of the permit and these rules and regulations and is grounds for enforcement action, permit termination, revocation and possible reissuance, modification, or denial of any future permit renewal applications. It shall be the duty of the operator to prove that continued operation of the salt cavern waste disposal facility shall not endanger the environment, or the health, safety and welfare of the public.

D. Duty to Halt or Reduce Activity. It shall not be a defense for an owner or operator in an enforcement action to claim it would have been necessary to halt or reduce the permitted activity to maintain compliance with the conditions of the permit.

E. Duty to Mitigate. The owner or operator shall take all reasonable steps to minimize or correct any adverse impact on the environment resulting from a noncompliance with the permit or these rules and regulations.

F. Proper Operation and Maintenance

1. The operator shall always properly operate and maintain all facilities and systems of storage, treatment, disposal, injection, withdrawal, and control (and related appurtenances) installed or used to achieve compliance with the permit or these rules and regulations. Proper operation and maintenance include effective performance (including well/cavern mechanical integrity), adequate funding, adequate operation, staffing and training, and adequate controls. This provision requires the operation of back-up, auxiliary facilities, or similar systems when necessary to achieve compliance with the conditions of the permit or these rules and regulations.

2. The operator shall address any unauthorized escape, discharge, or release of any material or waste from the salt cavern waste disposal facility, or part thereof, with a corrective action plan. The plan shall address the cause, delineate the extent, and determine the overall effects on the environment resulting from the escape, discharge, or release. The Office of Conservation shall require the operator to formulate a plan to remediate the escaped, discharged, or released material or waste if the material or waste is thought to have entered or has the possibility of entering an underground source of drinking water.

3. The Office of Conservation may immediately prohibit further operations if it determines that continued operations at a salt cavern waste disposal facility, or part thereof, may cause unsafe operating conditions, or endanger the environment, or the health, safety and welfare of the public. The prohibition shall remain in effect until it is determined that continued operations can and shall be conducted safely. It shall be the duty of the operator to prove that continued operation of the salt cavern waste disposal facility, or part thereof, shall not endanger the environment, or the health, safety and welfare of the public.

G. Inspection and Entry. Inspection and entry at a salt cavern waste disposal facility by Office of Conservation personnel shall be allowed as prescribed in R.S. of 1950, Title 30, Section 4.

H. Notification Requirements. The operator shall give written, and where required, verbal notice to the Office of Conservation concerning activities indicated in this Subsection.

1. Any change in the principal officers, management, owner or operator of the salt cavern waste disposal facility shall be reported to the Office of Conservation in writing within 10 days of the change.

2. Planned physical alterations or additions to the salt cavern well, salt cavern, surface facility or parts thereof that may constitute a modification or amendment of the permit.

3. Whenever there has been no disposal of waste into a salt cavern for 30 consecutive days or more, the operator shall notify the Office of Conservation in writing within seven days following the thirtieth day of the salt cavern becoming inactive (out of service). The notification shall include the date on which the salt cavern was removed from service, the reason for taking the salt cavern out of service, and the expected date that the salt cavern shall be returned to waste disposal service. See §3135 for additional requirements for inactive caverns.

4. The operator of a new or converted salt cavern well or salt cavern shall not begin waste disposal operations until the Office of Conservation has been notified of the following:

a. well construction or conversion is complete, including submission of the completion report and all supporting information (e.g., as-built diagrams, records, sampling and testing results, well and cavern tests, logs, etc.) required in §3127;

b. a representative of the commissioner has inspected the well and/or facility; and

c. the operator has received written approval from the Office of Conservation clearly stating salt cavern waste disposal operations may begin.

5. Noncompliance or anticipated noncompliance with the permit or applicable regulations including a failed mechanical integrity pressure and leak test of §3129.

6. Permit Transfer. A permit is not transferable to any person except after giving written notice to and receiving written approval from the Office of Conservation clearly stating that the permit has been transferred. This action may require modification or revocation and re-issuance of the permit to change the name of the operator and incorporate other requirements as may be necessary, including but not limited to financial responsibility.

7. Twenty-Four Hour Reporting

a. The operator shall report any noncompliance that may endanger the environment, or the health, safety and welfare of the public. Any information pertinent to the noncompliance shall be reported to the Office of Conservation by telephone within 24 hours from when the operator becomes aware of the circumstances. A written submission shall also be provided within five days from when the operator becomes aware of the circumstances. The written notification shall contain a description of the noncompliance and its cause, the periods of noncompliance including exact times and dates, and if the noncompliance has not been corrected, the anticipated time it is expected to continue, and steps taken or planned to reduce, eliminate and prevent recurrence of the noncompliance.

b. The following additional information must also be reported within the 24-hour period:

i. monitoring or other information (including a failed mechanical integrity test of §3129) that suggests the waste disposal operation or disposed waste may cause an endangerment to underground sources of drinking waters, oil, gas, other commercial mineral deposits (excluding the salt), neighboring salt operations of any kind, or movement outside the salt stock or salt cavern;

ii. any noncompliance with a regulatory or permit condition or malfunction of the waste injection/withdrawal system (including a failed mechanical integrity test of §3129) that may cause fluid migration into or between underground sources of drinking waters or outside the salt stock or salt cavern.

8. The operator shall give written notification to the Office of Conservation upon permanent conclusion of waste disposal operations into a salt cavern. Notification shall be given within seven days after concluding disposal operations.

9. The operator shall give written notification before abandonment (closure) of the salt cavern, salt cavern well, or related surface facility. Abandonment (closure) shall not begin before receiving written authorization from the Office of Conservation.

10. When the operator becomes aware that it failed to submit any relevant facts in a permit application or submitted incorrect information in a permit application or in any report to the Office of Conservation, the operator shall promptly submit such facts and information.

I. Duration of Permits

1. Authorization to Operate. Authorization by permit to operate a salt cavern waste disposal facility shall be valid for the life of the facility, unless suspended, modified, revoked and reissued, or terminated for cause as described in §3111.K.

2. Authorization to Drill and Complete. Authorization by permit to drill and complete a new salt cavern well into an existing salt cavern shall be valid for one year from the effective date of the permit. If drilling and well completion is not completed in that time, the permit shall be null and void and the operator must obtain a new permit.

3. Authorization to Convert. Authorization by permit to convert an existing salt cavern well or salt cavern to waste disposal shall remain in effect for six months from the effective date of the conversion permit. If conversion has not begun within that time, the permit shall be null and void and the operator must obtain a new permit.

4. Extensions. The operator shall submit to the Office of Conservation a written request for an extension of the times of §3109.I.2 and §3109.I.3; however, the Office of Conservation shall approve the request only for extenuating circumstances. The operator shall have the burden of proving claims of extenuating circumstances.

J. Compliance Review. Cavern disposal facility permits shall be reviewed at least once every five years to determine compliance with applicable permit requirements and conditions. Commencement of the permit review process for each facility shall proceed as authorized by the Commissioner of Conservation.

K. Additional Conditions. The Office of Conservation may, on a case-by-case basis, impose any additional conditions or requirements as are necessary to protect the environment, the health, safety and welfare of the public, underground sources of drinking waters, oil, gas, or other mineral deposits (excluding the salt), and preserve the integrity of the salt dome.

AUTHORITY NOTE: Promulgated in accordance with R.S. 30:4 et seq.

HISTORICAL NOTE: Promulgated by the Department of Natural Resources, Office of Conservation, LR 29:920 (June 2003).

§3111. Permitting Process

A. Applicability. This Section contains procedures for issuing and transferring permits to operate a non-commercial salt cavern waste disposal facility. Any person required to have a permit shall apply to the Office of Conservation as stipulated in §3105. The Office of Conservation shall not issue a permit before receiving an application form and any required supplemental information showing compliance with these rules and regulations and that is administratively and technically completed to the satisfaction of the Office of Conservation.

B. Notice of Intent to File Application

1. The applicant shall make public notice that a permit application is to be filed with the Office of Conservation. A notice of intent shall be published at least 30 days but not more than 120 days before filing the permit application with the Office of Conservation. The applicant shall publish a new notice of intent if the application is not received by the Office of Conservation within the filing period.

2. The notice shall be published once in the official state journal, the official journal of the parish of the proposed project location, and, if different from the official parish journal, in a journal of general circulation in the area of the proposed project location. The cost for publishing the notice of intent shall be the responsibility of the applicant. The notice shall be published in bold-faced type, be not less than 1/4 page in size, and shall contain the following minimum information:

a. name and address of the permit applicant and, if different, the facility to be regulated by the permit;

b. the geographic location of the proposed project;

c. name and address of the regulatory agency to process the permit action where interested persons may obtain information concerning the application or permit action;

d. a brief description of the business conducted at the facility or activity described in the permit application including the method of storage, treatment, and/or disposal; and

e. the nature and content of the proposed waste stream(s).

C. Application Submission and Review

1. The applicant shall complete, sign, and submit one original application form, with required attachments and documentation, and two copies of the same to the Office of Conservation. The complete application shall contain all information to show compliance with applicable state laws and these rules and regulations.

2. The applicant shall be notified if a representative of the Office of Conservation decides that a site visit is necessary for any reason in conjunction with the processing of the application. Notification may be either oral or written and shall state the reason for the visit.

3. If the Office of Conservation deems an application to be incomplete, deficient of information, or requires additional data, a notice of application deficiency indicating the information necessary to make the application complete shall be transmitted to the applicant.

4. The Office of Conservation shall deny an application if an applicant fails, refuses, is unable to respond adequately to the notice of application deficiency, or if the Office of Conservation determines that the proposed activity cannot be conducted safely. The Office of Conservation shall notify the applicant by certified mail of the decision denying the application.

D. Public Hearing Requirements. A public hearing is required for new applications and shall not be scheduled until administrative and technical review of an application has been completed to the satisfaction of the Office of Conservation.

1. Notice by Office of Conservation

a. Upon acceptance of a permit application as complete and meeting the administrative and technical requirements of these rules and regulations, the Office of Conservation shall fix a time, date, and location for a public hearing. The public hearing shall be held in the parish of the proposed project location. The cost of the public hearing shall be set by LAC 43:XIX.Chapter 7 (Fees, as amended) and is the responsibility of the applicant.

b. The Office of Conservation shall provide notice of a scheduled hearing by mailing a copy of the notice to the applicant, property owners immediately adjacent to the proposed project, operators of existing projects located on or within the salt stock of the proposed project; United States Environmental Protection Agency; Louisiana Department of Wildlife and Fisheries; Louisiana Department of Environmental Quality; Louisiana Office of Coastal Management; Louisiana Office of Conservation, Pipeline Division, Louisiana Department of Culture, Recreation and Tourism, Division of Archaeology; the governing authority for the parish of the proposed project; and any other interested parties.

2. Notice by Applicant

a. Public notice of a hearing shall be published by the applicant in the legal ad section of the official state journal, the official journal of the parish of the proposed project location, and, if different from the official parish journal, in a journal of general circulation in the area of the proposed project location, not less than 30 days before the scheduled hearing.

b. The applicant shall file at least one copy of the complete permit application with the local governing authority of the parish of the proposed project location at least 30 days before the scheduled public hearing to be available for public review.

c. One additional copy of the complete permit application shall be filed by the applicant in a public library in the parish and in close proximity to the proposed project location.

3. Contents. Public notices shall contain the following minimum information:

a. name and address of the permit applicant and, if different, the facility or activity regulated by the permit;

b. name and address of the regulatory agency processing the permit action;

c. name, address, and phone number of a person within the regulatory agency where interested persons may obtain information concerning the application or permit action;

d. a brief description of the business conducted at the facility or activity described in the permit application;

e. a brief description of the public comment procedures and the time and place of the public hearing;

f. a brief description of the nature and purpose of the public hearing.

E. Draft Permit. The Office of Conservation shall prepare a draft permit (Order) after accepting a permit application as meeting the administrative and technical requirements of these rules and regulations. Draft permits shall be accompanied by a fact sheet, be publicly noticed, and made available for public comment.

F. Fact Sheet. The Office of Conservation shall prepare a fact sheet for every draft permit. It shall briefly set forth principal facts and significant factual, legal, and policy questions considered in preparing the draft permit.

1. The fact sheet may include:

a. a brief description of the type of facility or activity that is the subject of the draft permit or application;

b. the type and proposed quantity of material to be injected;

c. a brief summary of the basis for the draft permit conditions including references to applicable statutory or regulatory provision;

d. a description of the procedures for reaching a final decision on the draft permit or application including the ending date of the public comment period of §3111.H, the address where comments shall be received, and any other procedures whereby the public may participate in the final decision;

e. the name and telephone number of a person within the permitting agency to contact for additional information.

2. The fact sheet shall be distributed to the permit applicant and, on request, to any interested person.

G. Public Hearing. Public hearings for permitting activities shall be held in the parish of the proposed project location. The cost of the public hearing shall be the responsibility of the applicant.

1. The public hearing shall be fact finding in nature and not subject to the procedural requirements of the Louisiana Administrative Procedure Act. All public hearings shall be publicly noticed as required by these rules and regulations.

2. At the hearing, any person may make oral statements or submit written statements and data concerning the application or permit action being the basis of the hearing. Reasonable limits may be set upon the time allowed for oral statements; therefore, submission of written statements may be required. The hearing officer may extend the comment period by so stating before the close of the hearing.

3. A transcript shall be made of the hearing and such transcript shall be available for public review.

H. Public Comments, Response to Comments, and Permit Issuance

1. Any interested person may submit written comments concerning the permitting activity during the public comment period. All comments pertinent and significant to the permitting activity shall be considered in making the final permit decision.

2. The Office of Conservation shall issue a response to all pertinent and significant comments as an attachment to and at the time of final permit decision. The final permit with response to comments shall be made available to the public.

3. The Office of Conservation shall issue a final permit decision within 90 days following the close of the public comment period; however, this time may be extended due to the nature, complexity, and volume of public comments received.

4. A final permit decision shall be effective on the date of issuance.

5. Approval or the granting of a permit to construct a salt cavern waste disposal facility or salt cavern well shall not become final until a certified copy of a lease or proof of ownership of the property of the proposed project location is submitted to the Office of Conservation.

I. Permit Application Denial

1. The Office of Conservation may refuse to issue, reissue, or reinstate a permit or authorization if an applicant or operator has delinquent, finally determined violations of the Office of Conservation or unpaid penalties or fees, or if a history of past violations demonstrates the applicant's or operator's unwillingness to comply with permit or regulatory requirements.

2. If a permit application is denied, the applicant may request a review of the Office of Conservation's decision to deny the permit application. Such request shall be made in writing and shall contain facts or reasons supporting the request for review.

3. Grounds for permit application denial review shall be limited to the following reasons:

a. the decision is contrary to the laws of the state, applicable regulations, or evidence presented in or as a supplement to the permit application;

b. the applicant has discovered since the permit application public hearing or permit denial, evidence important to the issues that the applicant could not with due diligence have obtained before or during the initial permit application review;

c. there is a showing that issues not previously considered should be examined so as to dispose of the matter; or

d. there is other good ground for further consideration of the issues and evidence in the public interest.

J. Permit Transfer

1. Applicability. A permit may be transferred to a new owner or operator only upon written approval from the Office of Conservation. Written approval must clearly read that the permit has been transferred. It is a violation of these rules and regulations to operate a salt cavern waste disposal facility without a permit or other authorization if a person attempting to acquire a permit transfer allows operation of the salt cavern waste disposal facility before receiving written approval from the Office of Conservation.

2. Procedures

a. The proposed new owner or operator must apply for and receive an operator code by submitting a completed Organization Report (Form OR-1), or subsequent form, to the Office of Conservation.

b. The current operator shall submit an application for permit transfer at least 30 days before the proposed permit transfer date. The application shall contain the following:

i. name and address of the proposed new owner or operator;

ii. date of proposed permit transfer; and

iii. a written agreement between the existing and new owner or operator containing a specific date for transfer of permit responsibility, insurance coverage, financial responsibility, and liability between them.

c. If no agreement described in §3111.J.2.b.iii above is provided, responsibility for compliance with the terms and conditions of the permit and liability for any violation will shift from the existing operator to the new operator on the date the transfer is approved.

d. The new operator shall submit an application for a change of operator using Form MD-10-R-A, or subsequent form, to the Office of Conservation containing the signatories of §3105.D and E along with the appropriate filing fee.

e. The new operator shall submit evidence of financial responsibility under §3109.B.

f. Any additional information as may be required to be submitted by these regulations or the Office of Conservation.

K. Permit Suspension, Modification, Revocation and Reissuance, Termination. This subsection sets forth the standards and requirements for applications and actions concerning suspension, modification, revocation and reissuance, termination, and renewal of permits. A draft permit must be prepared and other applicable procedures must be followed if a permit modification satisfies the criteria of this subsection. A draft permit, public notification, or public participation is not required for minor permit modifications of §3111.K.5.

1. Permit Actions

a. The permit may be suspended, modified, revoked and reissued, or terminated for cause.

b. The operator shall furnish the Office of Conservation within a predetermined time any information that the Office of Conservation may request to determine whether cause exists for suspending, modifying, revoking and reissuing, or terminating a permit, or to determine compliance with the permit. Upon request, the operator shall furnish the Office of Conservation with copies of records required to be kept by the permit.

c. The Office of Conservation may, upon its own initiative or at the request of any interested person, review any permit to determine if cause exists to suspend, modify, revoke and reissue, or terminate the permit for the reasons specified in §§3111.K.2, 3, 4, 5, and 6. All requests shall be in writing and shall contain facts or reasons supporting the request.

d. If the Office of Conservation decides the request is not justified, the person making the request shall be sent a brief written response giving a reason for the decision. Denials of requests for suspension, modification, revocation and reissuance, or termination are not subject to public notice, public comment, or public hearings.

e. If the Office of Conservation decides to suspend, modify or revoke and reissue a permit under §3111.K.2, 3, 4, 5, and 6, additional information may be requested and, in the case of a modified permit, may require the submission of an updated permit application. In the case of revoked and reissued permits, the Office of Conservation shall require the submission of a new application.

f. The suitability of an existing salt cavern well, salt cavern, or salt cavern waste disposal facility location shall not be considered at the time of permit modification or revocation and reissuance unless new information or standards suggest continued operation at the site endangers the environment, or the health, safety and welfare of the public which was unknown at the time of permit issuance. If the salt cavern well, salt cavern, or salt cavern waste disposal facility location is no longer suitable for its intended purpose, it shall be closed according to applicable sections of these rules and regulations.

2. Suspension of Permit. The Office of Conservation may suspend the operator's right to accept additional E&P wastes, or to treat, process, store, or dispose such waste until violations are corrected. If violations are corrected, the Office of Conservation may lift the suspension. Suspension of a permit and/or subsequent corrections of the causes for the suspension by the operator shall not preclude the Office of Conservation from terminating the permit, if necessary. The Office of Conservation shall issue a Notice of Violation (NOV) to the operator, by certified mail, return receipt requested, of violations of the permit or these regulations that list the specific violations. If the operator fails to comply with the NOV by correcting the cited violations within the date specified in the NOV, the Office of Conservation shall issue a Compliance Order requiring the violations to be corrected within a specified time and may include an assessment of civil penalties. If the operator fails to take corrective action within the time specified in the Compliance Order, the Office of Conservation shall assess a civil penalty, and shall suspend, revoke, or terminate the permit.

3. Modification or Revocation and Reissuance of Permits. The following are causes for modification and may be causes for revocation and reissuance of permits.

a. Alterations. There are material and substantial alterations or additions to the permitted facility or activity which occurred after permit issuance which justify the application of permit conditions that are different or absent in the existing permit.

b. Information. The Office of Conservation has received information pertinent to the permit. Permits may be modified during their terms for this cause only if the information was not available at the time of permit issuance (other than revised regulations, guidance, or test methods) and would have justified the application of different permit conditions at the time of issuance. Cause shall include any information indicating that cumulative effects on the environment, or the health, safety and welfare of the public are unacceptable.

c. New Regulations

i. The standards or regulations on which the permit was based have been changed by promulgation of new or amended standards or regulations or by judicial decision after the permit was issued and conformance with the changed standards or regulations is necessary for the protection of the environment, or the health, safety and welfare of the public. Permits may be modified during their terms when:

(a). the permit condition requested to be modified was based on a promulgated regulation or guideline;

(b). there has been a revision, withdrawal, or modification of that portion of the regulation or guideline on which the permit condition was based; or

(c). an operator requests modification within 90 days after Louisiana Register notice of the action on which the request is based.

ii. The permit may be modified as a minor modification without providing for public comment when standards or regulations on which the permit was based have been changed by withdrawal of standards or regulations or by promulgation of amended standards or regulations which impose less stringent requirements on the permitted activity or facility and the operator requests to have permit conditions based on the withdrawn or revised standards or regulations deleted from his permit.

iii. For judicial decisions, a court of competent jurisdiction has remanded and stayed Office of Conservation regulations or guidelines and all appeals have been exhausted, if the remand and stay concern that portion of the regulations or guidelines on which the permit condition was based and a request is filed by the operator to have permit conditions based on the remanded or stayed standards or regulations deleted from his permit.

d. Compliance Schedules. The Office of Conservation determines good cause exists for modification of a compliance schedule, such as an act of God, strike, flood, or materials shortage or other events over which the operator has little or no control and for which there is no reasonable available remedy.

4. Causes for Modification or Revocation and Reissuance. The following are causes to modify or, alternatively, revoke and reissue a permit.

a. Cause exists for termination under §3111.K.6, and the Office of Conservation determines that modification or revocation and reissuance is appropriate.

b. The Office of Conservation has received notification of a proposed transfer of the permit and the transfer is determined not to be a minor permit modification.

c. A determination that the waste being disposed into a salt cavern is not E&P waste as defined in §3101 or LAC 43:XIX.501, or subsequent revisions, either because the definition has been revised or because a previous determination has been changed.

5. Minor Modifications of Permits. The Office of Conservation may modify a permit to make corrections or allowances for changes in the permitted activity listed in this subsection without issuing a draft permit and providing for public participation. Minor modifications may only:

a. correct administrative or make informational changes;

b. correct typographical errors;

c. amend the frequency of or procedures for monitoring, reporting, sampling, or maintenance activities;

d. change an interim compliance date in a schedule of compliance, provided the new date does not interfere with attainment of the final compliance date requirement;

e. allow for a change in ownership or operational control of a salt cavern waste disposal facility where the Office of Conservation determines that no other change in the permit is necessary, provided that a written agreement containing a specific date for transfer of permit responsibility, coverage, and liability between the current and new permittees has been submitted to the Office of Conservation;

f. change quantities or types of waste or other material disposed into the salt cavern which are within the capacity of the salt cavern waste disposal facility and, in the judgement of the Office of Conservation, would not interfere with the operation of the facility or its ability to meet other conditions prescribed in the permit, and would not change the waste classification of the disposed material;

g. change construction requirements or plans approved by the Office of Conservation provided that any such alteration is in compliance with these rules and regulations. No such changes may be physically incorporated into construction of the salt cavern well, salt cavern, or surface facility before written approval from the Office of Conservation; or

h. amend a closure or post-closure plan.

6. Termination of Permits

a. The Office of Conservation may terminate a permit during its term for the following causes:

i. noncompliance by the operator with any condition of the permit;

ii. the operator's failure in the application or during the permit issuance process to fully disclose all relevant facts, or the operator's misrepresentation of any relevant facts at any time; or

iii. a determination that continued operation of the permitted activity cannot be conducted in a way that is protective of the environment, or the health, safety and welfare of the public.

b. If the Office of Conservation decides to terminate a permit, such shall only be done after a public hearing.

c. The Office of Conservation may alternatively decide to modify or revoke and reissue a permit for the causes in §3111.K.6.

AUTHORITY NOTE: Promulgated in accordance with R.S. 30:4 et seq.

HISTORICAL NOTE: Promulgated by the Department of Natural Resources, Office of Conservation, LR 29:922 (June 2003).

§3113. Location Criteria

A. No physical structure at a salt cavern waste disposal facility shall be located within 500 feet of a residential, commercial, or public building. Adherence to this requirement may be waived by the owner of the building. For a public building, the waiver shall be provided by the responsible administrative body. Any such waiver shall be in writing and be made part of the permit application. Examples of physical structures include, but are not limited to, the wellhead of the salt cavern well, waste storage, waste transfer and waste processing areas, onsite buildings, pumps, etc. An exception to the 500-foot restriction may be granted upon request for the placement of instruments or equipment required for safety or environmental monitoring.

AUTHORITY NOTE: Promulgated in accordance with R.S. 30:4 et seq.

HISTORICAL NOTE: Promulgated by the Department of Natural Resources, Office of Conservation, LR 29:925 (June 2003).

§3115. Site Assessment

A. Applicability. This Section applies to all applicants, owners and/or operators of salt cavern waste disposal facilities. The applicant, owner and/or operator shall be responsible for showing that disposal of E&P wastes into the salt cavern shall be accomplished using good engineering and geologic practices for salt cavern operations to preserve the integrity of the salt stock and overlying sediments. This shall include, but not be limited to:

1. an assessment of the geological, geomechanical, geochemical, geophysical properties of the salt stock;

2. stability of the salt cavern design (particularly regarding its size, shape, depth, and operating parameters);

3. physical and chemical characteristics of the waste;

4. the amount of separation between the salt cavern of interest and adjacent caverns and structures within the salt stock; and

5. the amount of separation between the outermost salt cavern wall and the periphery of the salt stock.

B. Geological Studies and Evaluations. The applicant shall do a thorough geological, geophysical, geomechanical, and geochemical evaluation of the salt stock to determine its suitability for waste disposal, stability of the salt cavern under the proposed set of operating conditions, and where applicable, the structural integrity of the salt stock between an adjacent cavern and salt periphery under the proposed set of operating conditions. The applicant shall provide a listing of data or information used to characterize the structure and geometry of the salt stock.

1. Where applicable, the geologic evaluation shall include, but should not be limited to:

a. geologic mapping of the structure of the salt stock and any cap rock;

b. geologic history of salt movement;

c. an assessment of the impact of possible anomalous zones (salt spines, shear planes, etc.) on the salt cavern well or salt cavern;

d. deformation of the cap rock and strata overlying the salt stock;

e. investigation of the upper salt surface and adjacent areas involved with salt dissolution;

f. cap rock formation and any non-vertical salt movement.

2. The applicant shall perform a thorough hydrogeological study on strata overlying the salt stock to determine the occurrence of the lowermost underground source of drinking water immediately above and in the vicinity of the salt stock.

3. The applicant shall investigate regional tectonic activity and the potential impact (including ground subsidence) of the waste disposal project on surface and subsurface resources.

C. Core Sampling

1. At least one well at the site of the salt cavern waste disposal facility (or the salt dome) shall be or shall have been cored over sufficient depth intervals to yield representative samples of the subsurface geologic environment. This shall include coring of the salt stock and may include coring of overlying formations, including any cap rock. Cores should be obtained using the whole core method. Core acquisition, core handling, and core preservation shall be done according to standard field sampling practices considered acceptable for laboratory tests of recovered cores.

2. Data from previous coring projects may be used instead of actual core sampling provided the data is specific to the salt dome of interest. If site-specific data is unavailable, data may be obtained from sources that are not specific to the area as long as the data can be shown to closely approximate the properties of the salt dome of interest. It shall be the responsibility of the applicant to make a satisfactory demonstration that data obtained from other sources are applicable to the salt dome of interest.

D. Core Analyses and Laboratory Tests. Analyses and tests shall consider the characteristics of the injected materials and should provide data on the salt's geomechanical, geophysical, geochemical, mineralogical properties, microstructure, and where necessary, potential for adjacent salt cavern connectivity, with emphasis on salt cavern shape and the operating conditions. All laboratory tests, experimentation, and numeric modeling shall be conducted using methods that simulate the proposed operating conditions of the salt cavern. Test methods shall be selected to define the deformation and strength properties and characteristics of the salt stock under salt cavern operating conditions.

E. Area of Review. A thorough evaluation shall be undertaken of both surface and subsurface activities in the defined area of review of the individual salt cavern well or project area that may influence the integrity of the salt stock, salt cavern well, and salt cavern, or contribute to the movement of injected fluids outside the salt cavern, wellbore, or salt stock.

1. Surface Delineation. The area of review for a salt cavern well shall be a fixed radius around the wellbore of not less than 1/2 mile. Exception shall be noted as shown in §§3115.E.2.c and d below.

2. Subsurface Delineation. At a minimum, the following shall be identified within the area of review:

a. all known active, inactive, and abandoned wells within the area of review with known depth of penetration into the cap rock or salt stock;

b. all known water wells within the area of review;

c. all salt caverns within the salt stock regardless of usage, depth of penetration, or distance to the proposed salt cavern well or salt cavern;

d. all conventional (dry or room and pillar) mining activity either active or abandoned occurring anywhere within the salt stock regardless of distance to the proposed salt cavern well or salt cavern.

F. Corrective Action

1. For manmade structures identified in the area of review that are not properly constructed, completed, or plugged and abandoned, the applicant shall submit a corrective action plan consisting of such steps, procedures, or modifications as are necessary to prevent the movement of fluids outside the salt cavern or into underground sources of drinking water.

a. Where the plan is adequate, the provisions of the corrective action plan shall be incorporated into the permit as a condition.

b. Where the plan is inadequate, the Office of Conservation shall require the applicant to revise the plan or the application shall be denied.

2. Any permit issued for an existing salt cavern well or salt cavern for which corrective action is required shall include a schedule of compliance for complete fulfillment of the approved corrective action procedures. If the required corrective action is not completed as prescribed in the schedule of compliance, the permit shall be suspended, modified, revoked and possibly reissued, or terminated according to these rules and regulations.

3. No permit shall be issued for a new salt cavern well until all required corrective action obligations have been fulfilled.

4. The Office of Conservation may prescribe additional requirements for corrective action beyond those submitted by the applicant.

AUTHORITY NOTE: Promulgated in accordance with R.S. 30:4 et seq.

HISTORICAL NOTE: Promulgated by the Department of Natural Resources, Office of Conservation, LR 29:926 (June 2003).

§3117. Cavern and Surface Facility Design Requirements

A. This Section provides general standards for design of salt caverns to assure that project development can be conducted in a reasonable, prudent, and a systematic manner and shall stress physical and environmental safety. The cavern design shall be modified where necessary to conform with good engineering and geologic practices.

B. Cavern Spacing Requirements

1. Property Boundary. The wellhead and borehole shall be located such that the salt cavern at its maximum diameter shall not extend closer than 100 feet to the property boundary of the salt cavern waste disposal facility.

2. Adjacent Structures within the Salt. As measured in any direction, the minimum separation between walls of adjacent salt caverns or between the walls of the salt cavern and any manmade structure within the salt stock shall not be less than 200 feet.

3. Salt Periphery. Without exception or variance to these rules and regulations, the minimum separation between the walls of a salt cavern at any point and the periphery of the salt stock shall not be less than 300 feet.

C. Cavern Coalescence. The Office of Conservation may permit the use of coalesced salt caverns for waste disposal. It shall be the duty of the applicant, owner or operator to demonstrate that operation of coalesced salt caverns under the proposed cavern operating conditions can be accomplished in a physical and environmentally safe manner. The intentional subsurface coalescing of adjacent salt caverns must be requested by the applicant, owner or operator in writing and be approved by the Office of Conservation before beginning or resumption of salt cavern waste disposal operations. Approval for salt cavern coalescence shall only be considered upon a showing by the applicant, owner or operator that the stability and integrity of the salt cavern and salt stock shall not be compromised and that salt cavern waste disposal operations can be conducted in a physical and environmentally safe manner. If the design of adjacent salt caverns should include approval for the subsurface coalescing of adjacent salt caverns, the minimum spacing requirement of §3117.B.2 above shall not apply to the coalesced salt caverns.

AUTHORITY NOTE: Promulgated in accordance with R.S. 30:4 et seq.

HISTORICAL NOTE: Promulgated by the Department of Natural Resources, Office of Conservation, LR 29:927 (June 2003).

§3119. Well Construction and Completion

A. General Requirements

1. All materials and equipment used in the construction of the salt cavern well and related appurtenances shall be designed and manufactured to exceed the operating requirements of the specific project. Consideration shall be given to depth and lithology of all subsurface geologic zones, corrosiveness of formation fluids, hole size, anticipated ranges and extremes of operating conditions, physical and behavioral characteristics of the injected and disposed material under the specific range of operating conditions, subsurface temperatures and pressures, type and grade of cement, and projected life of the salt cavern well.

2. All salt cavern wells and salt caverns shall be designed, constructed, completed, and operated to prevent the escape of injected or disposed materials out of the salt stock, into an underground source of drinking water, or otherwise create or cause pollution or endanger the environment or public safety. All phases of design, construction, completion, and testing shall be prepared and supervised by qualified personnel.

B. Open Borehole Surveys

1. Open hole wireline surveys that delineate subsurface lithologies, formation tops (including top of cap rock and salt), formation fluids, formation porosity, and fluid resistivities shall be done on wells from total well depth to either ground surface or base of conductor pipe. Wireline surveys shall be presented with gamma-ray and, where applicable, spontaneous potential curves. All surveys shall be presented on a scale of 1 inch to 100 feet and a scale of 5 inches to 100 feet.

2. Gyroscopic multi-shot surveys of the borehole shall be taken at intervals not to exceed every 100 feet of drilled borehole.

3. Where practicable, caliper logging to determine borehole size for cement volume calculations shall be done before running casings.

C. Casing and Cementing. Except as specified below, the wellbore of the salt cavern shall be cased, completed, and cemented according to rules and regulations of the Office of Conservation and good petroleum industry engineering practices for wells of comparable depth that are applicable to the same locality of the salt cavern. Design considerations for casings and cementing materials and methods shall address the nature and characteristics of the subsurface environment, the nature of injected and disposed materials, the range of conditions under which the well, cavern, and facility shall be operated, and the expected life of the well including closure and post-closure.

1. Cementing shall be by the pump-and-plug method or another method approved by the Office of Conservation and shall be circulated to the surface. Circulation of cement may be done by staging.

a. For purposes of these rules and regulations, circulated (cemented) to the surface shall mean that actual cement returns to the surface were observed during the primary cementing operation. A copy of the cementing company's job summary or cementing ticket indicating returns to the surface shall be submitted as part of the pre-operating requirements of §3127.

b. If returns are lost during cementing, the owner or operator shall have the burden of showing that sufficient cement isolation is present to prevent the upward movement of injected or disposed material into zones of porosity or transmissive permeability in the overburden along the wellbore and to protect underground sources of drinking water.

2. Surface casing shall be set to a depth into a confining bed below the base of the lowermost underground source of drinking water. Surface casing shall be cemented to surface where practicable.

3. All salt cavern wells shall be cased with a minimum of two casings cemented into the salt. The surface casing shall not be considered one of the two casings of this Subparagraph.

4. New wells drilled into an existing salt cavern shall have an intermediate casing and a final cemented casing set into the salt. The final cemented casing shall be set a minimum distance of 300 feet into the salt and shall make use of a sufficient number of casing centralizers.

5. The following applies to wells existing in salt caverns before the effective date of these rules and regulations and are being converted to salt cavern waste disposal. If the design of the well or cavern precludes having distinct intermediate and final casing seats cemented into the salt, the wellbore shall be cased with two concentric casings run from the surface of the well to a minimum distance of 300 feet into the salt. The inner casing shall be cemented from its base to surface.

6. The intermediate and final casings shall be cemented from their respective casing seats to the surface when practicable.

D. Casing and Casing Seat Tests. When doing tests under this paragraph, the owner or operator shall monitor and record the tests by use of a surface readout pressure gauge and a chart or a digital recorder. All instruments shall be properly calibrated and in good working order. If there is a failure of the required tests, the owner or operator shall take necessary corrective action to obtain a passing test.

1. Casing. After cementing each casing, but before drilling out the respective casing shoe, all casings shall be hydrostatically pressure tested to verify casing integrity and the absence of leaks. For surface casing, the stabilized test pressure applied at the surface shall be a minimum of 500 pounds per square inch gauge (PSIG). The stabilized test pressure applied at the surface for all other casings shall be a minimum of 1,000 PSIG. All casing test pressures shall be maintained for one hour after stabilization. Allowable

pressure loss is limited to five percent of the test pressure over the stabilized test duration.

2. Casing Seat. The casing seat and cement of intermediate and production casings shall each be hydrostatically pressure tested after drilling out the casing shoe. At least 10 feet of formation below the respective casing shoes shall be drilled before the test. The test pressure applied at the surface shall be the greater of 1,000 PSIG or 125 percent of the maximum predicted salt cavern operating pressure. The appropriate test pressure shall be maintained for one hour after pressure stabilization. Allowable pressure loss is limited to 5 percent of the test pressure over the stabilized test duration.

3. Casing or casing seat test pressures shall never exceed a pressure gradient equivalent to 0.80 PSI per foot of vertical depth at the respective casing seat or exceed the known or calculated fracture gradient of the appropriate subsurface formation. The test pressure shall never exceed the rated burst or collapse pressures of the respective casings.

E. Cased Borehole Surveys. A cement bond with variable density log (or similar cement evaluation tool) and a temperature log shall be run on all casings. The Office of Conservation may consider requests for allowances for wireline logging in large diameter casings or justifiable special conditions.

1. It shall be the duty of the well applicant, owner or operator to prove adequate cement isolation on all cemented casings. Remedial cementing shall be done before proceeding with further well construction, completion, or conversion if adequate cement isolation between the salt cavern well and other subsurface zones cannot be demonstrated.

2. A casing inspection log (or similar log) shall be run on the final cemented casing.

F. Hanging Strings. Without exception or variance to these rules and regulations, all salt cavern wells shall be completed with at least two hanging strings. One hanging string shall be for waste injection; the second hanging string shall be for displacing fluid out of the salt cavern from below the blanket material. Hanging strings shall be designed with a collapse, burst, and tensile strength rating conforming to all expected operating conditions, including flow induced vibrations. The design shall also consider the physical and chemical characteristics of fluids placed into and/or withdrawn from the salt cavern.

G. Wellhead Components and Related Connections. All wellhead components, valves, flanges, fittings, flowlines, and related connections shall be manufactured of steel. All components shall be designed with a test pressure rating of at least 125 percent of the maximum pressure that could be exerted at the surface. Selection and design criteria for components shall consider the physical and chemical characteristics of fluids placed into and/or withdrawn from the salt cavern under the specific range of operating conditions, including flow induced vibrations. The fluid withdrawal side of the wellhead (if applicable) shall be rated for the same pressure as the waste injection side. All components and related connections shall be maintained in good working order and shall be periodically inspected by the operator.

AUTHORITY NOTE: Promulgated in accordance with R.S. 30:4 et seq.

HISTORICAL NOTE: Promulgated by the Department of Natural Resources, Office of Conservation, LR 29:927 (June 2003).

§3121. Operating Requirements

A. Cavern Roof

1. Without exception or variance to these rules and regulations, no salt cavern shall be used for E&P waste disposal if the salt cavern roof has grown above the top of the salt stock. The operation of an already permitted salt cavern shall cease and shall not be allowed to continue if information becomes available that shows this condition exist. The Office of Conservation may order the well and salt cavern closed according to an approved closure and post-closure plan.

2. The Office of Conservation may consider the use of a salt cavern for waste disposal if information exists that shows the salt cavern roof has grown vertically above the depth of the salt cavern well's deepest cemented casing seat. However, the salt cavern roof shall be below the top of the salt stock, the owner/operator shall meet the provisions for proving well/cavern mechanical integrity of §3129 and cavern configuration and capacity of §3131, and the owner/operator shall submit and carry out a plan for doing cavern roof monitoring. It shall be the duty of the well applicant or owner or operator to prove that operation of the salt cavern under this condition shall not endanger the environment, or the health, safety and welfare of the public.

B. Blanket Material. Before beginning waste disposal operations, a blanket material shall be placed into the salt cavern to prevent unwanted leaching of the cavern roof. The blanket material shall consist of crude oil, diesel, mineral oil, or other fluid possessing similar noncorrosive, nonsoluble, low-density properties. The blanket material shall be placed between the outermost hanging string and innermost cemented casing of the salt cavern and shall be of sufficient volume to coat the entire cavern roof. The cavern roof and level of the blanket material shall be monitored at least once every five years by running a density interface survey or using an alternative method approved by the Office of Conservation.

C. Remedial Work. No remedial work or repair work of any kind shall be done on the salt cavern well or salt cavern without prior authorization from the Office of Conservation. The provision for prior authorization shall also extend to doing mechanical integrity pressure and leak tests and sonar caliper surveys. The owner or operator or its agent shall submit a valid work permit request form (Form UIC-17 or successor). Before beginning well or cavern remedial work, the pressure in the salt cavern shall be relieved, as practicable, to zero pounds per square inch as measured at the surface.

D. Well Recompletion—Casing Repair. The following applies to salt cavern wells where remedial work results from well upgrade, casing wear, or similar condition. For each paragraph below, a casing inspection log shall be done on the entire length of the innermost cemented casing in the well before doing any casing upgrade or repair. Authorization from the Office of Conservation shall be obtained before beginning any well recompletion, repair, upgrade, or closure. A salt cavern well that cannot be repaired or upgraded shall be properly closed according to §3141.

1. Liner. A liner may be used to recomplete or repair a well with severe casing damage. The liner shall be run from the well surface to the base of the innermost cemented casing. The liner shall be cemented over its entire length and shall be successfully pressure tested.

2. Casing Patch. Internal casing patches shall not be used to repair severely corroded or damaged casing. Casing patches shall only be used for repairing or covering isolated pitting, corrosion, or similar localized damage. The casing patch shall extend a minimum of 10 feet above and below the area being repaired. The entire casing shall be successfully pressure tested.

E. Multiple Well Caverns. No newly permitted well shall be drilled into a existing salt cavern until the cavern pressure has been relieved, as practicable, to zero pounds per square inch as measured at the surface.

F. Cavern Allowable Operating Pressure.

1. The maximum allowable salt cavern injection pressure shall be calculated at a depth referenced to the shallower of either the salt cavern roof or the well's deepest cemented casing seat. When measured at the surface and calculated with respect to the appropriate reference depth, the maximum allowable salt cavern injection pressure shall never exceed a pressure gradient of 0.80 PSI per foot of vertical depth.

2. The salt cavern shall never be operated at pressures over the maximum allowable injection pressure defined above, exceed the maximum allowable pressure as may be established by permit, or exceed the rated burst or collapse pressure of all well tubulars (cemented or hanging strings) even for short periods, including pressure pulsation peaks, abnormal operating conditions, well or cavern tests.

3. The maximum injection pressure for a salt cavern shall be determined after considering the properties of all injected fluids, the physical properties of the salt stock, well and cavern design, neighboring activities within and above the salt stock, etc.

4. Shut-in pressure at the surface on the fluid withdrawal string or any annulus shall not be greater than 200 PSIG.

G. Cavern Displaced Fluid Management. The operator shall maintain a strict accounting of the fluid volume displaced from the salt cavern. Fluid displaced from a salt cavern shall be managed in a way that is protective of the environment. Such methods may include subsurface disposal via a properly permitted Class II disposal well, onsite storage for recycling as a waste carrier fluid, or any other method approved by the appropriate regulatory authority.

H. Waste Storage. Without exception or variance to these rules and regulations, all E&P wastes shall be stored in aboveground storage tanks. Storing wastes in open pits, cells, or similar earthen or open structures is strictly prohibited. Storage tanks shall be constructed of fiberglass, metal, or other similar material. All waste storage areas shall be built on concrete slabs/pads, be enclosed by retaining walls of required construction, and possess a means for the collection of spilled fluids.

I. Time Limits for Onsite Waste Storage. E&P waste accepted for disposal shall not be held in storage at the facility for more than 14 consecutive days. The Office of Conservation may grant a wavier to this requirement for extenuating circumstances only.

AUTHORITY NOTE: Promulgated in accordance with R.S. 30:4 et seq.

HISTORICAL NOTE: Promulgated by the Department of Natural Resources, Office of Conservation, LR 29:928 (June 2003).

§3123. Safety

A. Emergency Action Plan. A plan outlining procedures for personnel at the facility to follow in case of an emergency shall be prepared and submitted as part of the permit application. The plan shall contain emergency contact telephone numbers, procedures and specific information for facility personnel to respond to a release, upset, incident, accident, or other site emergency. A copy of the plan shall be kept at the facility and shall be reviewed and updated as needed.

B. Controlled Site Access. All operators of salt cavern waste disposal facilities shall install and maintain a chain link fence of at least 6 feet in height around the entire facility property. All points of entry into the facility shall be through by a lockable gate system. All gates of entry shall be locked except during hours of operation.

C. Facility Identification. An identification sign shall be placed at all gated entrances to the salt cavern waste disposal facility. All lettering on the sign shall be of at least 1-inch dimensions and kept in a legible condition. The sign shall be of durable construction. Minimum information to include on the sign shall be the facility name, site address, daytime and nighttime telephone numbers, and shall be made applicable to the activity of the facility according to the following statement.

> "This facility is authorized by the Office of Conservation, Injection and Mining Division to receive, store, treat, process, and/or dispose of E&P wastes into a salt cavern by means of subsurface injection. Improper operations, spills/or violations at this facility should be reported to the Office of Conservation at (225) 342-5515."

D. Personnel. Trained and competent personnel shall be on duty and stationed as appropriate at the salt cavern waste disposal facility during all hours and phases of facility operation. Facility operation includes, but shall not be limited to, periods of waste acceptance, waste offloading, waste transfer, waste transport vehicle washing, waste storage, waste treatment, waste processing, and waste injection/disposal.

E. Wellhead Protection and Identification

1. A protective barrier shall be installed and maintained around wellheads, pipings, and above ground structures that may be vulnerable to physical or accidental damage by mobile equipment or trespassers.

2. An identifying sign shall be placed at the wellhead of each salt cavern well and shall include at a minimum the operator's name, well/cavern name and number, well serial number, section-township-range, and any other information required by the Office of Conservation. The sign shall be of durable construction with all lettering kept in a legible condition.

F. Valves and Flowlines

1. All valves, flowlines, flanges, fittings, and related connections shall be manufactured of steel. All components shall be designed with a test pressure rating of at least 125 percent of the maximum pressure that could be exerted at the surface. All components and related connections shall be maintained in good working order and shall be periodically inspected by the operator.

2. All valves, flowlines for waste injection, fluid withdrawal, and any other flowlines shall be designed to prevent pressures over maximum operating pressure from being exerted on the salt cavern well and salt cavern and prevent backflow or escape of injected waste material. The fluid withdrawal side of the wellhead shall have the same pressure rating as the waste injection side.

3. All flowlines for injection and withdrawal connected to the wellhead of the salt cavern well shall be equipped with remotely operated shut-off valves and shall also have manually operated positive shut-off valves at the wellhead. All remotely operated shut-off valves shall be fail-safe and tested and inspected according to §3123.L.

G. Alarm Systems. Manual and automatically activated alarms shall be installed at all salt cavern waste disposal facilities. All alarms shall be audible and visible from any normal work location within the facility. The alarms shall always be maintained in proper working order. Automatic alarms designed to activate an audible and a visible signal shall be integrated with all pressure, flow, heat, fire, cavern overfill, leak sensors and detectors, emergency shutdown systems, or any other safety system. The circuitry shall be designed such that failure of a detector or sensor shall activate a warning.

H. Emergency Shutdown Valves. Manual and automatically actuated emergency shutdown valves shall be installed on all systems of salt cavern injection and withdrawal and any other flowline going into or out from each salt cavern wellhead. All emergency shutdown valves shall be fail-safe and shall be tested and inspected according to §3123.L.

1. Manual controls for emergency shutdown valves shall be designed for operation from a local control room, at the salt cavern well, any remote monitoring and control location, and at a location that is likely to be accessible to emergency response personnel.

2. Automatic emergency shutdown valves shall be designed to actuate on detection of abnormal pressuring of the waste injection system, abnormal increases in flow rates, responses to any heat, fire, cavern overfill, leak sensors and detectors, loss of pressure or power to the salt cavern well, salt cavern, or valves, or any abnormal operating condition.

I. Vapor Monitoring and Leak Detection. The operator shall develop a vapor monitoring and leak detection plan as required in §3125.C below to detect the presence of noxious vapors, combustible gases, or any potentially ignitable substances.

J. Gaseous Vapor Control. Where necessary, the operator shall install and maintain in good working order a system for managing the uncontrolled escape of noxious vapors, combustible gases, or any potentially ignitable substances within the salt cavern waste disposal facility. Any vapor control system shall be in use continuously during facility operation.

K. Fire Detection/Suppression. All salt cavern waste disposal facilities shall have a system or method of fire detection and fire control or suppression. Emphasis for fire detection shall be at waste transfer, waste storage, waste process areas, and any area where combustible materials or vapors might exist. The fire detection system shall be integrated into the automatic alarm and emergency shut down systems of the facility.

L. Systems Test and Inspection

1. Safety Systems Test. The operator shall function-test all critical systems of control and safety at least once every six months. This includes testing of alarms, test tripping of emergency shutdown valves ensuring their closure times are within design specifications, and ensuring the integrity of all electrical, pneumatic, and/or hydraulic circuits. Tests results shall be documented and keep onsite for inspection by an agent of the Office of Conservation.

2. Visual Facility Inspections. Visual inspections of the entire salt cavern waste disposal facility shall be conducted each day the facility is operating. At a minimum, this shall include inspections of the wellhead, flowlines, valves, waste transfer areas, waste storage areas, waste processing areas, signs, perimeter fencing, and all other areas of the facility. Problems discovered during the inspections shall be corrected timely.

M. Retaining Walls and Spill Containment

1. Retaining walls, curbs, or other spill containment systems shall be designed, built, and maintained around appropriate areas of the facility to collect, retain, and/or otherwise prevent the escape of wastes or other materials that may be released through facility upset or accidental spillage. Retaining walls shall be constructed of reinforced

concrete. All retaining walls shall be built to a level that will provide sufficient capacity for holding at least 110 percent of the volume of each tank. All storage areas shall be kept free of debris, trash, or other materials that may constitute a fire hazard.

2. At a minimum, the following areas shall be protected by retaining walls and/or spill containment:

a. waste acceptance areas;

b. waste unloading and waste transfer areas;

c. waste storage areas;

d. waste transport vehicle and transport container decontamination/washout areas;

e. waste treatment and waste processing areas;

f. curbed area around the wellhead of each salt cavern well; and

g. any other areas of the facility the Office of Conservation deems necessary.

AUTHORITY NOTE: Promulgated in accordance with R.S. 30:4 et seq.

HISTORICAL NOTE: Promulgated by the Department of Natural Resources, Office of Conservation, LR 29:929 (June 2003).

§3125. Monitoring Requirements

A. Pressure Gauges, Pressure Sensors, Flow Sensors

1. Pressure gauges that show pressure on the fluid injection string, fluid withdrawal string, and any annulus of the well, including the blanket material annulus, shall be installed at each wellhead. Gauges shall be designed to read in 10 PSI increments. All gauges shall be properly calibrated and shall always be maintained in good working order. The pressure valves onto which the pressure gauges are affixed shall have 1/2 inch female fittings.

2. Pressure sensors designed to automatically close all emergency shutdown valves in response to a preset pressure (high/low) shall be installed and properly maintained for all fluid injection and fluid withdrawal strings, and blanket material annulus.

3. Flow sensors designed to automatically close all emergency shutdown valves in response to abnormal increases in cavern injection and withdrawal flow rates shall be installed and properly maintained on each salt cavern well.

B. Continuous Recording Instruments. Continuous recording instrumentation shall be installed and properly maintained for each salt cavern well. Continuous recordings may consist of circular charts, digital recordings, or similar type. Mechanical charts shall not exceed a clock period of 24-hour duration. The chart shall be selected such that its scaling is of sufficient sensitivity to record all fluctuations of pressure or any other parameter being monitored. The chart shall be scaled such that the parameter being recorded is 30 percent to 70 percent of full scale. Instruments shall be housed in weatherproof enclosures when located in areas exposed to climatic conditions. All fluid volumes shall be determined by metering or an alternate method approved by the Office of Conservation. Minimum data recorded shall include the following:

1. wellhead pressures on both the fluid injection and fluid withdrawal strings;

2. wellhead pressure on the blanket material annulus;

3. volume and flow rate of waste injected;

4. volume of fluid withdrawn;

5. salinity of injected material including the carrier fluid; and

6. density of injected material.

C. Vapor Monitoring and Leak Detection

1. Without exception or variance to these rules and regulations, the operator shall develop a monitoring plan designed to detect the presence of a buildup of noxious vapors, combustible gases, or any potentially ignitable substances in the atmosphere resulting from the storage, treatment, processing, and disposal of waste at the facility. Variations in topography, atmospheric conditions typical to the area, characteristics of the wastes, nearness of the facility to homes, schools, commercial establishments, etc. shall be considered in developing the monitoring plan. The plan shall be submitted as part of the permit application and should include provisions for the strategic placement of detection devices at various areas of the facility such as:

a. waste transfer, waste storage, and waste process areas;

b. salt cavern wellhead(s). An exception may be allowed for salt cavern wells in close proximity to each other, thus, the monitoring plan may include installation of detection devices around the perimeter of the well field; and

c. any other areas of the facility where may be appropriate.

2. All detection devices or systems identified in the monitoring plan shall include their integration into the facility's automatic alarm system. Activation of a detection device or system alarm shall cause a cessation of all waste acceptance, waste transfer, waste processing, and waste injection until the reason for the alarm activation has been determined and corrected.

D. Subsidence Monitoring. The owner or operator shall prepare and carry out a plan to monitor ground subsidence at and in the vicinity of the waste disposal cavern(s). Frequency of subsidence monitoring shall be scheduled to occur annually during the same period. A monitoring report shall be prepared and submitted to the Office of Conservation after completion of each monitoring event.

E. Wind Sock. At least one wind sock shall be installed at all salt cavern waste disposal facilities. The wind sock shall be visible from any normal work location within the facility.

AUTHORITY NOTE: Promulgated in accordance with R.S. 30:4 et seq.

HISTORICAL NOTE: Promulgated by the Department of Natural Resources, Office of Conservation, LR 29:931 (June 2003).

§3127. Pre-Operating Requirements—Completion Report

A. The operator of a salt cavern waste disposal facility shall not accept, store, treat, process, or otherwise initiate waste disposal operations until all required information has been submitted to the Office of Conservation and the operator has received written authorization from the Office of Conservation clearly stating waste disposal operations may begin.

B. The operator shall submit a report to the Office of Conservation that describes, in detail, the work performed resulting from any approved permitted activity. A report shall include all information relating to the work and information that documents compliance with these rules and the approved permitted activity. The report shall be prepared and submitted for any approved work relating to the construction, installation and completion of the surface portion of the facility and information on the construction, conversion, or workover of the salt cavern well or salt cavern.

C. Where applicable to the approved permitted activity, information in a completion report shall include:

1. all required state reporting forms containing original signatures;

2. revisions to any operation or construction plans since approval of the permit application;

3. as-built schematics of the layout of the surface portion of the facility;

4. as-built piping and instrumentation diagram(s);

5. copies of applicable records associated with drilling, completing, working over, or converting the salt cavern well and/or salt cavern including a daily chronology of such activities;

6. revised certified location plat of the salt cavern well if the actual location of the well differs from the location plat submitted with the salt cavern well application;

7. as-built subsurface diagram of the salt cavern well and salt cavern labeled with appropriate construction, completion, or conversion information, i.e., depth and diameter of all tubulars, depths of top of cap rock and salt, and top and bottom of the cavern;

8. as-built diagram of the surface wellhead labeled with appropriate construction, completion, or conversion information, i.e., valves, gauges, and flowlines;

9. results of any core sampling and testing;

10. results of well or cavern tests such as casing and casing seat tests, well/cavern mechanical integrity pressure and leak tests;

11. copies of any wireline logging such as open hole and/or cased hole logs, cavern sonar survey;

12. any additional data documenting the work performed for the permitted activity, information requested by the Office of Conservation, or any additional reporting requirements imposed by the approved permit.

AUTHORITY NOTE: Promulgated in accordance with R.S. 30:4 et seq.

HISTORICAL NOTE: Promulgated by the Department of Natural Resources, Office of Conservation, LR 29:932 (June 2003).

§3129. Well and Salt Cavern Mechanical Integrity Pressure and Leak Tests

A. The operator of the salt cavern well and cavern shall have the burden of meeting the requirements for well and cavern mechanical integrity. The Office of Conservation shall be notified in writing at least seven days before any scheduled mechanical integrity test. The test may be witnessed by Office of Conservation personnel but must be witnessed by a qualified third party.

B. Frequency of Tests. Without exception or variance to these rules and regulations, all salt cavern wells and salt caverns shall be tested for and satisfactorily prove mechanical integrity before being placed into initial waste disposal service. After the initial test for well and cavern mechanical integrity, all subsequent tests shall occur at least once every five years. Additionally, mechanical integrity testing shall be done for the following reasons regardless of test frequency:

1. after any alteration to any cemented casing or cemented liner;

2. after performing any remedial work to reestablish well or cavern integrity;

3. before suspending salt cavern waste disposal operations for reasons other than a lack of well/cavern mechanical integrity if it has been more than three years since the last mechanical integrity test;

4. before well/cavern closure; or

5. whenever the Office of Conservation believes a test is warranted.

C. Test Method

1. All mechanical integrity pressure and leak tests shall demonstrate no significant leak in the salt cavern, wellbore, casing seat, and wellhead. Test schedules and methods shall consider neighboring activities occurring at the salt dome to reduce any influences those neighboring activities may have on the salt cavern being tested.

2. Tests shall be conducted using the nitrogen-brine interface method with density interface and temperature logging. An alternative test method may be used if the alternative test can reliably demonstrate well/cavern mechanical integrity and with prior written approval from the Office of Conservation.

3. The salt cavern pressure shall be stabilized before beginning the test. Stabilization shall be reached when the rate of cavern pressure change is no more than 10 PSIG during 24 hours.

4. The stabilized test pressure applied at the surface shall be a minimum of 125 percent of the maximum cavern surface operating pressure or 500 PSIG whichever is greater. However, at no time shall the test pressure calculated with respect to the shallowest occurrence of either the cavern roof or deepest cemented casing seat and as measured at the surface exceed a pressure gradient of 0.80 PSI per foot of vertical depth. The salt cavern well or salt cavern shall never be subjected to pressures over the maximum allowable operating pressure or exceed the rated burst or collapse pressure of all well tubulars (cemented or hanging strings) even for short periods during testing.

5. A mechanical integrity pressure and leak test shall be run for at least 24 hours after cavern pressure stabilization and must be of sufficient time duration to ensure a sensitive test. All pressures shall be monitored and recorded continuously throughout the test. Continuous pressure recordings may be achieved through mechanical charts or may be recorded digitally. Mechanical charts shall not exceed a clock period of 24-hour duration. The chart shall be scaled such that the test pressure is 30 percent to 70 percent of full scale. All charts shall be selected such that its scaling is of sufficient sensitivity to record all fluctuations of pressure, temperature, or any other monitored parameter.

D. Submission of Pressure and Leak Test Results. One complete copy of the mechanical integrity pressure and leak test results shall be submitted to the Office of Conservation within 30 days of test completion. The report shall include the following minimum information:

1. current well and cavern completion data;

2. description of the test procedure including pretest preparation;

3. copies of all wireline logs performed during testing;

4. tabulation of measurements for pressure, volume, temperature, etc.;

5. interpreted test results showing all calculations including error analysis and calculated leak rates; and

6. any information the owner or operator of the salt cavern determines is relevant to explain the test procedure or results.

E. Mechanical Integrity Test Failure

1. Without exception or variance to these rules and regulations, a salt cavern well or salt cavern that fails a test for mechanical integrity shall be immediately taken out of waste disposal service. The failure shall be reported to the Office of Conservation according to the Notification Requirements of §3109.H. The owner or operator shall investigate the reason for the failure and shall take appropriate steps to return the salt cavern well or salt cavern to a full state of mechanical integrity. A salt cavern well or salt cavern is considered to have failed a test for mechanical integrity for the following reasons:

a. failure to maintain a change in test pressure of no more than 10 PSIG over a 24-hour period;

b. not maintaining nitrogen-brine interface levels according to standards applied in the salt cavern storage industry; or

c. fluids are determined to have escaped from the salt cavern well or salt cavern during waste disposal operations.

2. Written procedures for rehabilitation of the salt cavern well or salt cavern, extended salt cavern monitoring, or abandonment (closure and post-closure) of the salt cavern well or salt cavern shall be submitted to the Office of Conservation within 30 days of mechanical integrity test failure.

3. Upon reestablishment of mechanical integrity of the salt cavern well or salt cavern and before returning either to waste disposal service, a new mechanical integrity pressure and leak test shall be performed that demonstrates mechanical integrity of the salt cavern well or salt cavern. The owner or operator shall submit the new test results to the Office of Conservation for written approval before resuming waste disposal operations.

4. If a salt cavern well or salt cavern fails to demonstrate mechanical integrity and where mechanical integrity cannot be reestablished, the Office of Conservation may require the owner or operator to begin closure of the well or cavern within six months according to an approved closure and post-closure plan.

5. If a salt cavern fails mechanical integrity and where rehabilitation cannot be accomplished within six months, the Office of Conservation may waive the six-month closure requirement if the owner or operator is engaged in a salt cavern remediation study and implements an interim salt cavern monitoring plan. The owner or operator must seek written approval from the Office of Conservation before implementing a salt cavern monitoring program. The basis for the Office of Conservation's approval shall be that any waiver granted shall not endanger the environment, or the health, safety and welfare of the public. The Office of Conservation may establish a time schedule for salt cavern rehabilitation, cessation of interim salt cavern monitoring, and eventual salt cavern closure and post-closure activities.

F. Prohibition of Waste Acceptance During Mechanical Integrity Failure

1. Salt cavern waste disposal facilities with a single cavern are prohibited from accepting E&P wastes at the facility until mechanical integrity of the salt cavern well or salt cavern is documented to the satisfaction of the Office of Conservation.

2. Salt cavern waste disposal facilities with multiple salt caverns may continue accepting E&P wastes if the other cavern(s) at the facility exhibit mechanical integrity.

AUTHORITY NOTE: Promulgated in accordance with R.S. 30:4 et seq.

HISTORICAL NOTE: Promulgated by the Department of Natural Resources, Office of Conservation, LR 29:932 (June 2003).

§3131. Cavern Configuration and Capacity Measurements

A. Sonar caliper surveys shall be performed on all salt caverns. With prior approval of the Office of Conservation, the operator may use another similar proven technology designed to determine cavern configuration and measure cavern capacity as a substitute for a sonar survey.

B. Frequency of Surveys. A sonar caliper survey shall be performed and submitted as part of the salt cavern waste disposal permit application. All subsequent surveys shall occur at least once every five years. Additional surveys shall be done for any of the following reasons regardless of frequency:

1. before commencing salt cavern closure operations;

2. whenever leakage into or out of the salt cavern is suspected;

3. after performing any remedial work to reestablish salt cavern well or salt cavern integrity; or

4. whenever the Office of Conservation believes a survey is warranted.

C. Submission of Survey Results. One complete copy of each survey shall be submitted to the Office of Conservation within 30 days of survey completion.

1. Survey readings shall be taken a minimum of every 10 feet of vertical depth. Sonar reports shall contain the following minimum information and presentations:

a. tabulation of incremental and total salt cavern volume for every survey reading;

b. tabulation of the salt cavern radii at various azimuths for every survey reading;

c. tabulation of the maximum salt cavern radii at various azimuths;

d. graphical plot of Cavern Depth versus Volume;

e. graphical plot of the maximum salt cavern radii;

f. vertical cross sections of the salt cavern at various azimuths drawn to an appropriate horizontal and vertical scale;

g. vertical cross section overlays comparing results of current survey and previous surveys;

h. (optional)-isometric or 3-D shade profile of the salt cavern at various azimuths and rotations.

2. The information submitted resulting from use of an approved alternative survey method to determine cavern configuration and measure cavern capacity shall be determined based on the method or type of survey.

AUTHORITY NOTE: Promulgated in accordance with R.S. 30:4 et seq.

HISTORICAL NOTE: Promulgated by the Department of Natural Resources, Office of Conservation, LR 29:933 (June 2003).

§3133. Cavern Capacity Limits

A. The waste volume permitted for disposal into a salt cavern may not exceed 90 percent of the salt cavern volume measured from the sonar caliper survey submitted as part of the permit application. Upon reaching the permitted waste volume, the owner or operator shall remove the salt cavern from further waste disposal service and within seven days notify the Office of Conservation of such. Due to the potential for salt cavern enlargement resulting from disposal of undersaturated fluids, the operator may request a modification to the permit to allow for a continued waste disposal based on the findings of a new cavern capacity survey. If the Office of Conservation denies the request for permit modification, the operator shall begin preparations for salt cavern closure per approved updated closure and post-closure plan. The operator shall maintain a strict accounting of the waste volume disposed into the salt cavern, the fluid volume displaced from the salt cavern, and the salt cavern volume.

AUTHORITY NOTE: Promulgated in accordance with R.S. 30:4 et seq.

HISTORICAL NOTE: Promulgated by the Department of Natural Resources, Office of Conservation, LR 29:934 (June 2003).

§3135. Inactive Caverns

A. The operator shall comply with the following minimum requirements when there has been no disposal of waste into a salt cavern for 30 consecutive days or more, regardless of the reason:

1. notify the Office of Conservation as per the requirements of §3109.H.3;

2. disconnect all flowlines for injection to the salt cavern well;

3. maintain continuous monitoring of salt cavern pressure, fluid withdrawal, and other parameters required by the permit;

4. maintain and demonstrate salt cavern well and salt cavern mechanical integrity if disposal operations were suspended for reasons other than a lack of mechanical integrity;

5. maintain compliance with financial responsibility requirements of these rules and regulations;

6. any additional requirements of the Office of Conservation to document the salt cavern well and salt cavern shall not endanger the environment, or the health, safety and welfare of the public during the period of salt cavern inactivity.

AUTHORITY NOTE: Promulgated in accordance with R.S. 30:4 et seq.

HISTORICAL NOTE: Promulgated by the Department of Natural Resources, Office of Conservation, LR 29:934 (June 2003).

§3137. Monthly Operating Reports

A. The operator shall submit monthly waste receipts and operation reports to the Office of Conservation. Monthly reports are due no later than 15 days following the end of the reporting month.

B. The operator shall have the option of submitting monthly reports by any of the following methods:

1. the appropriate Office of Conservation supplied form;

2. an operator generated form of the same format and containing the same data fields as the Office of Conservation's form; or

3. electronically in a format meeting the Office of Conservation's requirements for electronic data submission.

C. Monthly reports shall contain the following minimum information:

1. name and location of the salt cavern waste disposal facility;

2. source and type of waste disposed;

3. wellhead pressures (PSIG) on all injection and withdrawal hanging strings;

4. wellhead pressure (PSIG) on the blanket material annulus;

5. density in pounds per gallon (PPG) of injected material;

6. volume in barrels (BBLS) and flow rate in barrels per minute (BPM) of injected material;

7. volume (BBLS) and disposition of all fluids withdrawn or displaced from the salt cavern;

8. chloride concentration in milligrams per liter (Mg/L) of injected materials including the carrier fluid;

9. changes in the blanket material fluid volume;

10. results of any monitoring program required by permit or compliance action;

11. summary of any test of the salt cavern well or salt cavern;

12. summary of any workover performed during the month including minor well maintenance;

13. description of any event which triggers an alarm or shutdown device and the response taken;

14. description of any event that exceeds operating parameters for annulus pressure or injection pressure as may be specified in the permit.

AUTHORITY NOTE: Promulgated in accordance with R.S. 30:4 et seq.

HISTORICAL NOTE: Promulgated by the Department of Natural Resources, Office of Conservation, LR 29:934 (June 2003).

§3139. Record Retention

A. The owner or operator shall retain copies of all records, data, and information concerning the design, permitting, construction, and operation of the salt cavern well, salt cavern, and related surface facility. Records shall be retained throughout the operating life of the salt cavern waste disposal facility and for five years following conclusion of any post-closure care requirements. Records, data, and information shall include, but shall not be limited to the permit application, cementing (primary and remedial), wireline logs, drill records, casing records, casing pressure tests, well recompletion records, well/cavern mechanical integrity tests, cavern capacity and configuration surveys, surface construction, sources of wastes disposed, waste manifests, waste testing results, post-closure activities, corrective action, etc. All documents relating to any waste accepted and rejected for disposal shall be kept at the facility and shall be available for inspection by agents of the Office of Conservation at any time.

B. Should there be a change in the owner or operator of the salt cavern waste disposal facility, copies of all records identified in the previous paragraph shall be transferred to the new owner or operator. The new owner or operator shall then have the responsibility of maintaining such records.

C. The Office of Conservation may require the owner or operator to deliver the records to the Office of Conservation at the conclusion of the retention period. If so, the records shall be retained at a location designated by the Office of Conservation.

AUTHORITY NOTE: Promulgated in accordance with R.S. 30:4 et seq.

HISTORICAL NOTE: Promulgated by the Department of Natural Resources, Office of Conservation, LR 29:934 (June 2003).

§3141. Closure and Post-Closure

A. Closure. The owner or operator shall close the salt cavern well, salt cavern, surface facility or parts thereof as approved by the Office of Conservation. Closure shall not begin without written authorization from the Office of Conservation.

1. Closure Plan. Plans for closure of the salt cavern well, salt cavern, and related surface facility shall be submitted as part of the permit application. The closure plan shall meet the requirements of these rules and regulations and be acceptable to the Office of Conservation. The obligation to implement the closure plan survives the termination of a permit or the cessation of salt cavern waste disposal operations or related activities. The requirement to maintain and implement an approved plan is directly enforceable regardless of whether the requirement is a condition of the permit. The Office of Conservation may modify a closure plan where necessary.

2. Closure Plan Requirements. The owner or operator shall review the closure plan annually to determine if the conditions for closure are still applicable to the actual conditions of the salt cavern well, salt cavern, or surface facility. Any revision to the plan shall be submitted to the

Office of Conservation for approval. At a minimum, a closure plan shall address the following:

a. assurance of financial responsibility as required in §3109.B.1. All instruments of financial responsibility shall be reviewed each year before its renewal date according to the following process:

i. a detailed cost estimate for adequate closure of the entire salt cavern waste disposal facility (salt cavern well, salt cavern, surface appurtenances, etc.) shall be prepared by a qualified, independent third party and submitted to the Office of Conservation by the date specified in the permit;

ii. the closure plan and cost estimate shall include provisions for closure acceptable to the Office of Conservation and shall reflect the costs for the Office of Conservation to complete the approved closure of the facility;

iii. after reviewing the closure cost estimate, the Office of Conservation may increase, decrease or allow the amount to remain the same;

iv. documentation from the operator showing that the required financial instrument has been renewed shall be received each year by the date specified in the permit. When an operator is delinquent in submitting documentation of financial instrument renewal, the Office of Conservation shall initiate procedures to take possession of funds guaranteed by the financial instrument and suspend or revoke the operating permit. Permit suspensions shall remain in effect until renewal documentation is received and accepted by the Office of Conservation;

b. a prediction of the pressure build-up in the salt cavern following closure;

c. an analysis of potential pathways for leakage from the salt cavern, cemented casing shoe, and wellbore. Consideration shall be given to site specific elements of geology, waste characteristics, salt cavern geometry and depth, salt cavern pressure build-up over time due to salt creep and other factors inherent to the salt stock and/or salt dome;

d. procedures for determining the mechanical integrity of the salt cavern well and salt cavern before closure;

e. removal and proper disposal of any waste or other materials remaining at the facility;

f. closing, dismantling, and removing all equipment and structures located at the surface (including site restoration) if such equipment and structures will not be used for another purpose at the same disposal facility;

g. the type, number, and placement of each wellbore or salt cavern plug including the elevation of the top and bottom of each plug and the method of placement of the plugs;

h. the type, grade, and quantity of material to be used in plugging;

i. a description of the amount, size, and location (by depth) of casing and any other well construction materials to be left in the salt cavern well;

j. any proposed test or measurement to be made before or during closure.

3. Notice of Intent to Close

a. The operator shall review the closure plan before seeking authorization to begin closure activities to determine if the conditions for closure are still relevant to the actual conditions of the salt cavern well, salt cavern, or surface facility. Revisions to the method of closure reflected in the plan shall be submitted to the Office of Conservation for approval no later than the date on which the notice of closure is required to be submitted as shown in the subparagraph below.

b. The operator shall notify the Office of Conservation in writing at least 30 days before the expected closure of a salt cavern well, salt cavern, or surface facility. Notification shall be by submission of a request for a work permit. At the discretion of the Office of Conservation, a shorter notice period may be allowed.

4. Standards for Closure. The following are minimum standards for closing the salt cavern well or salt cavern. The Office of Conservation may require additional standards prior to actual closure.

a. After permanently concluding waste disposal operations into the salt cavern but before closing the salt cavern well or salt cavern, the owner or operator shall:

i. observe and accurately record the shut-in salt cavern pressures and salt cavern fluid volume for an appropriate time or a time specified by the Office of Conservation to provide information regarding the salt cavern's natural closure characteristics and any resulting pressure buildup;

ii. using actual pre-closure monitoring data, show and provide predictions that closing the salt cavern well or salt cavern as described in the closure plan will not result in any pressure buildup within the salt cavern that could adversely effect the integrity of the salt cavern well, salt cavern, or any seal of the system.

b. Before closure, the owner or operator shall do mechanical integrity pressure and leak tests to ensure the integrity of both the salt cavern well and salt cavern.

c. Before closure, the owner or operator shall remove and properly dispose of any free oil or blanket material remaining in the salt cavern well or salt cavern.

d. Upon permanent closure, the owner or operator shall plug the salt cavern well with cement in a way that will not allow the movement of fluids into or between underground sources of drinking water or outside the salt stock. Placement of cement plugs shall be accomplished by using standard petroleum industry practices for downhole well abandonment. Each plug shall be appropriately tagged and pressure tested for seal and stability before closure is completed.

e. Upon successful completion of the closure, the owner or operator shall identify the surface location of the abandoned well with a permanent marker inscribed with the operator's name, well name and number, serial number, section-township-range, date plugged and abandoned, and acknowledgment that the well and salt cavern were used for disposal of E&P waste.

5. Closure Report. The owner or operator shall submit a closure report to the Office of Conservation within 30 days after closure of the salt cavern well, salt cavern, surface facility, or part thereof. The report shall be certified as accurate by the owner or operator and by the person charged with overseeing the closure operation (if other than the owner or operator). The report shall contain the following information:

a. detailed procedures of the closure operation. Where actual closure differed from the plan previously approved, the report shall include a written statement specifying the differences between the previous plan and the actual closure;

b. all state regulatory reporting forms relating to the closure activity; and

c. any information pertinent to the closure activity including test or monitoring data.

B. Post-Closure. Plans for post-closure care of the salt cavern well, salt cavern, and related surface facility shall be submitted as part of the permit application. The post-closure plan shall meet the requirements of these rules and regulations and be acceptable to the Office of Conservation. The obligation to implement the post-closure plan survives the termination of a permit or the cessation of salt cavern waste disposal operations or related activities. The requirement to maintain and implement an approved post-closure plan is directly enforceable regardless of whether the requirement is a condition of the permit. The Office of Conservation may modify a post-closure plan where necessary.

1. The owner or operator shall review the post-closure plan annually to determine if the conditions for post-closure are still applicable to actual conditions. Any revision to the plan shall be submitted to the Office of Conservation for approval. At a minimum, a post-closure plan shall address the following:

a. assurance of financial responsibility as required in §3109.B.1. All instruments of financial responsibility shall be reviewed each year before its renewal date according to the following process:

i. a detailed cost estimate for adequate post-closure care of the entire salt cavern waste disposal facility shall be prepared by a qualified, independent third party and submitted to the Office of Conservation by the date specified in the permit;

ii. the post-closure care plan and cost estimate shall include provisions acceptable to the Office of Conservation and shall reflect the costs for the Office of Conservation to complete the approved post-closure care of the facility;

iii. after reviewing the post-closure cost estimate, the Office of Conservation may increase, decrease or allow the amount to remain the same;

iv. documentation from the operator showing that the required financial instrument has been renewed must be received each year by the date specified in the permit. When an operator is delinquent in submitting documentation of financial instrument renewal, the Office of Conservation shall initiate procedures to take possession of the funds guaranteed by the financial instrument and suspend or revoke the operating permit. Any permit suspension shall remain in effect until renewal documentation is received and accepted by the Office of Conservation;

b. any plans for monitoring, corrective action, site remediation, site restoration, etc., as may be necessary.

2. Where necessary and as an ongoing part of post-closure care, the owner or operator shall continue the following activities:

a. complete any corrective action or site remediation resulting from the operation of a salt cavern waste disposal facility;

b. conduct any groundwater monitoring or subsidence monitoring required by the permit until pressure in the salt cavern displays a trend of behavior that can be shown to pose no threat to salt cavern integrity, underground sources of drinking water, or other natural resources of the state;

c. complete any site restoration.

3. The owner or operator shall retain all records as required in §3139 for five years following conclusion of post-closure requirements.

AUTHORITY NOTE: Promulgated in accordance with R.S. 30:4 et seq.

HISTORICAL NOTE: Promulgated by the Department of Natural Resources, Office of Conservation, LR 29:935 (June 2003).

Chavez, Carl J, EMNRD

From: Chavez, Carl J, EMNRD
Sent: Wednesday, April 22, 2009 9:18 AM
To: 'Mike Cochran'
Cc: Jeffrey Hand; Kirk Hoeffner; 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; kdavis@subsurfacegroup.com; 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; 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; Sanchez, Daniel J., EMNRD
Subject: RE: UIC Class III Brine Evaluation Work Group Draft Report Attached

Thanks Mike. FYI, the OCD has hired RESPEC (Engineering Firm) who has geotechnical experience with caverns on all of the Work Group ideas or concepts for the brine well in Carlsbad. In addition, the OCD in conjunction with the State Department of Homeland Security and Emergency Management is proceeding with installation of an early warning detection system along with imaging of the subsurface cavern with possible backfilling.

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(Pollution Prevention Guidance is under "Publications")

From: Mike Cochran [mailto:mcochran@kdheks.gov]
Sent: Wednesday, April 22, 2009 8:28 AM
To: Chavez, Carl J, EMNRD
Cc: Jeffrey Hand; Kirk Hoeffner; 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; kdavis@subsurfacegroup.com; 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; 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; Sanchez, Daniel J., EMNRD
Subject: RE: UIC Class III Brine Evaluation Work Group Draft Report Attached

Good morning Carl,

In regards to well # I & W Brine well #6, based on our experiences we would probably follow the path of implementing #1 and then consider filling the cavern with some type of material since as we understand this well is located in a sensitive area with transportation arteries, water canal, etc. close by plus possibly other human activities. One needs to have information on the cavern configuration and dimensions though if at all possible if this is pursued, otherwise the most efficient, effective fill method will be difficult to implement and there may be cavern conditions that essentially prevent filling. Also, one has to consider how stabile it is believed the cavern is before getting any material and equipment out over the cavern. If this is an issue, then it would have to be evaluated if this could be accomplished through slant borings into the cavern. One is basically shooting in the dark without the cavern information.

The more solid the nature of the material that can placed into the cavern the better since the material emplaced will tend to settle and compact. There will be less of this with a solid material and the solid material will provide added support. We have found though it is very difficult to get material up against the roof all the way across to provide complete support. The more solid the material the more likely it will want to form a cone when placed into the cavern and will not spread completely beneath the entire roof. We have some experience where actually gravel has been emplaced in a limestone cavern through wells constructed for the purpose and a friction reducer used in the gravel slurry mix to assist in more even distribution. Has power plant flyash been considered? This has been used successfully in our area to fill limestone caverns. It spreads out and then sets up providing reasonable support. Flyash is expensive to bring in and would have to be tested to make sure it is not hazardous.

It will be very helpful if the cavern filling progress can be periodically monitored. Another issue is you have to have a good slurry mix so that the tubing or casing it is being injected down does not bridge off. We would use brine for the mixing the slurry in most cases.

We concur with George Veni that if material is placed into the cavern it may not prevent collapse, but it would probably limit the catastrophic nature of a collapse.

The collapse contingency plan is important also. We believe elements that should be included in such a plan are: securing of the sight and address safety issues; notification procedure; prepare press release shell; traffic control; evacuation and relocation of people plan; and go ahead and install groundwater monitoring wells strategically located prior to the collapse if there is a usable aquifer present, including plans for groundwater remediation.

What have found that each cavern collapse or potential collapse does present its own set of variables to deal with.

Mike,

Michael H. Cochran, Licensed Geologist
Chief, Geology Section
Kansas Department of Health & Environment
1000 SW Jackson Street, Suite 420
Topeka, KS 66612-1367
Telephone = 785.296.5560
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Website = www.kdheks.gov/geo

"A good plan today is better than a great plan tomorrow." -General George S. Patton

From: Chavez, Carl J, EMNRD [mailto:CarlJ.Chavez@state.nm.us]
Sent: Monday, April 20, 2009 7:10 PM
To: Chavez, Carl J, EMNRD; 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; 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; Sanchez, Daniel J., EMNRD
Cc: Jeffrey Hand; Kirk Hoeffner; Mike Cochran; 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; kdavis@subsurfacegroup.com
Subject: RE: UIC Class III Brine Evaluation Work Group Draft Report Attached

Ladies and Gentlemen:

Please find attached a copy of the Microsoft Word draft report. The report is still in very rough draft form as the OCD attempted to capture the essence of the comments recorded in the Brine Strategy Document from March 27, 2009. The OCD attempted to capture the Work Group comments in the recommendations for a path forward section near the end of the report. The OCD will ultimately have to comb over the sections to refine, add and/or delete items for the final report.

The OCD notices that there was some concepts and ideas sent in e-mails for a solution to the I&W Brine Well #6 problem in Carlsbad and your final input would be appreciated for finding a solution to this problem. Although the solution appears to be on a fast track with the Office of Homeland Security, OCD, DOT, and other stakeholders in the area, I think the Work Group should chime in with recommendations at this point on a possible solution or you could cast a vote on the solutions below?. The solutions proposed thus far appear to be:

1) Restrict access as it could collapse at any moment, implement monitoring (laser level on well head, could include re-drilling into abandoned well to monitor fluid level and keep cavern filled), create safe zone in area (remove persons or businesses if necessary), and work on contingency plan for if and when well collapses. Could sink $5 Million into project and could collapse anyway....?
2) Pipe in salt waste slurry from Intrepid Potash at nominal fee per bbl. (~ 1 Million barrels) to fill salt cavern or via rail cars or trucks.
3) Induce collapse of cavern and fill up with solids, including special polymers, cement, etc. using heavy earth moving equipment?
4) EPA proposal to drill wells into bottom of cavern, seek operator to manage the injection of acceptable oilfield non-hazardous wastes (i.e., BLM tailings, salt wastes from potash companies, drill cuttings, slurry sand, solids, etc.) into cavern over long-term.
5) Salt bath steam concept from bottom to top of cavern?
6) Other?

The OCD looks forward to your comments. Please save the document under your name and track changes if you wish to send it back with your comments. The OCD requests your comments by COB this Friday, April 24, 2009 or sooner if possible. The OCD will issue one last draft on COB Tuesday April 28, 2009. The above dates are tentative, but we hope to give you a chance to comment before issuing the final report, which you will be copied on to the Secretary of the EMNRD. Yes, it appears that the report is to the Secretary and not the Oil Conservation Commission.

Please contact me if you have questions. Thank you.

Carl J. Chavez, CHMM
New Mexico Energy, Minerals & Natural Resources Dept.
Oil Conservation Division, Environmental Bureau
1220 South St. Francis Dr., Santa Fe, New Mexico 87505
Office: (505) 476-3490
Fax: (505) 476-3462
E-mail: CarlJ.Chavez@state.nm.us
Website: http://www.emnrd.state.nm.us/ocd/index.htm
(Pollution Prevention Guidance is under "Publications")

From: Chavez, Carl J, EMNRD
Sent: Monday, April 20, 2009 5:46 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'; Sanchez, Daniel J., EMNRD
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; 'kdavis@subsurfacegroup.com'
Subject: UIC Class III Brine Evaluation Work Group Draft Report Attached

Ladies and Gentlemen:

Please find attached a copy of the Microsoft Word draft report. The report is still in very rough draft form as the OCD attempted to capture the essence from the Brine Strategy Document from March 27, 2009 in the recommendations for a path forward section.

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

Chavez, Carl J, EMNRD

From: dan [dwsnow@lotusllc.com]
Sent: Wednesday, April 22, 2009 6:33 AM
To: Chavez, Carl J, EMNRD
Cc: dan
Subject: I&W

Carl,
On the email last night I may have overestimated the $ cost of electricity. If the right brine lagoon makeup was located the cost would be ideally one complete circulation of the cavern volume which I have been told may be 1 Million bbls and if so the cost would be 1/7 of what I submitted which would be about$70000 per mile of distance from the lagoon to the cavern. Also the time to complete would be reduced by 7 to about 40-50days.
Dan Snow cell 432 661 5828

Chavez, Carl J, EMNRD

From: Chavez, Carl J, EMNRD
Sent: Wednesday, April 22, 2009 8:48 AM
To: 'dan'; George Veni
Cc: 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; VonGonten, Glenn, EMNRD; Griswold, Jim, EMNRD; Kostrubala, Thaddeus; balch@prrc.nmt.edu; 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; gary.wallace@crihobbs.com; Hall, John, NMENV; Olson, Bill, NMENV; kdavis@subsurfacegroup.com; 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; lyn.sockwell@basicenergyservices.com; dwpowers@evaporites.com; Sanchez, Daniel J., EMNRD
Subject: RE: UIC Class III Brine Evaluation Work Group Draft Report Attached

Thanks Dan.

As you indicated from your telephone call this morning, the Work Group can view the Patent (4,692,061) by googling the US Patent Office and entering this number into the patent & search link. Could call patent office in Germany after hours (time difference) if necessary in Germany as they probably speak English.

The basic concept is: Circulation loop between boreholes or concentric strings per well bores, return effluent brine into lagoon where saturated MgCl or $MgSO_4$ or both brines are added to complete loop and keep cavern filled while recirculating saturated Mg (could be sodium, but Mg is believe to crystallize out better) based brine into the 1Mbbl cavern and cavern solidification or crystallation within the cavern could occur within 50 days, but must pump in hypersaline brine at temperature below equilibrium temperature to prevent damage or further dissolution to the cavern. Surrounding walls pull heat from salt, it will crystallize. The process would be much faster than injecting mud cuttings, certain solids, etc....

Need chemical engr. to find equilibrium temp. of salts (Mg vs Na) to enhance the crystallization process to eliminate solution mining and enhance crystallization process. Intrepid Potash could condition brine to be hypersaline Mg based. Issue would be the lagoon size needed to sustain the flow rate into the 4 wells to maintain an equilibrium flow rate in the recirculation process keeping cavern full while recirculating.......

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Website: http://www.emnrd.state.nm.us/ocd/index.htm
(Pollution Prevention Guidance is under "Publications")

From: dan [mailto:dwsnow@lotusllc.com]
Sent: Tuesday, April 21, 2009 10:11 PM
To: Chavez, Carl J, EMNRD; George Veni
Cc: 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; 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; gary.wallace@crihobbs.com; Hall, John, NMENV; Olson, Bill, NMENV; kdavis@subsurfacegroup.com; leo.vansambeek@respec.com; rlbeauh@sandia.gov; grkirke@sandia.gov; reitze@socon.com; mcartwright@unitedbrine.com; dave.hughes@wipp.ws; Allen.Hains@wnr.com;

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Subject: Re: UIC Class III Brine Evaluation Work Group Draft Report Attached

Hello all---Carl, as promised I dug up the info on the foreign patent, which I believe from previous conversation with Wintershall to be public domain, containing information in part to the hypersaline crystallization of the supernatent portion of a salt cavern. The patent is

Title TI [DE] Verfahren zum Ein- bzw. Endlagern von pumpfähigen Abfallstoffen in Salzkavernen
[EN] Process for storage or ultimate storage of pumpable waste materials in salt caverns
Applicant PA Wintershall AG, 3100 Celle, DE
Inventor IN Lindörfer, Walter, Dr., 3500 Kassel, DE ; Jahn-Held, Wilhelm, Dr., 3513 Staufenberg, DE
Application date AD 25.06.1984
Application number AN 3423387
Country of application AC DE
Publication date PUB 10.10.1985

Registered in the USA as
United States Patent 4,692,061 Lindorfer , et al. September 8, 1987
and ignoring the part of the process pertaining to waste disposal, I quote

"...the water contained in the supernatant liquid phase of the contents of the salt cavern is bound chemically in the form of water of crystallization or in the form of hydroxides or physically by means of absorption through the addition of suitable compounds or substances.

It has proved useful for this purpose to introduce salts containing magnesium chloride and/or magnesium sulfate, such as are obtained in the processing of raw potash, into the supernatant liquid phase of the contents of the salt cavern. The system NaCl-MgCl.sub.2 -H.sub.2 O then forms in the liquid phase of the contents of the salt cavern, from which at the temperature of the deposit the solid salt 1880 g MgCl.sub.2 +1000 g H.sub.2 O, or the system NaCl-MgSO.sub.4 -H.sub.2 O, crystallizes out, from which the salts 3156 g Na.sub.2 SO.sub.4 +3124 g MgSO.sub.4 +1000 g H.sub.2 O or 1972 g Na.sub.2 SO.sub.4 +1673 g MgSO.sub.4 +1000 g H.sub.2 O crystallize. Because of the binding of the water of crystallization, these crystallization processes increase not only the solids content of the contents of the salt cavern, but also the concentration of the sodium chloride in the liquid phase to above the saturation concentration so that sodium chloride additionally crystallizes which in turn also increases the solids content of the contents of the salt caverns.

Instead of the salts containing magnesium chloride and/or magnesium sulfate or in addition to these, layer lattice minerals can be introduced into the supernatant liquid phase of the contents of the salt cavern after they have been chemically or thermally expanded. Expanded layer lattice minerals of this kind are, for example, expanded vermiculites and/or perlites and/or light expanded clay aggregates which are distinguished by their high absorptive capacity for liquids. In this way the supernatant liquid phase of the contents of the salt cavern is solidified at least to a major extent. "

Italics and emphasis added and cutting to the point, a system could be installed drawing liquid hypersaline potash brines from the nearest lagoon and pumping via black poly pipe to the I&W site during the upcoming desert summer heat cycle the cavern to crystallization. While this may need some crystallization expertise and some study into the transient heat transfer of the whole process, an automated system, duly tuned to the necessary parameters, could solidify the 1Million BBL +cavern brine without the placement of solids and could be done fairly quickly using standard off the shelf oilfield equipment.

I propose if Mg salts/sulphates are presently available nearby:
1. Immediately set necessary monitoring equipment in place and establish an emergency response plan for rapid evacuation in the event of premature cavern failure.
2. Drill at least one observation borehole to document areal extent of cavern(s) while maintaining increased emergency response plans of preparedness. This wellbore drilling operation would need pressure control capability in the event of subsidence pressurization above hydrostatic.

3.Perform analysis of crystallization and transient heat transfer based upon samples taken from the brine cavity.
4. Locate suitable lagoon salinity and chemical makeup with the potential of adding raw potash salts to balance the reaction.
5. Install additional boreholes adequately sized, equipment and automation for the pressure placement of the hypersaline liquid brine taking into account all necessary mass heat balance issues.
6.Pump the cavern volume to chemical-heat crystallization equilibrium while minimizing or eliminating additional solution mining using a closed loop black poly pipe system.(Most likely a summer daytime operation only and with 4 wellbores at 4 BPM /well pumping operations would take approximately 300 cavern ambient equilibrium pumping days at an project electrical cost of about $216000 per mile lagoon to I&W. This number should be a maximum cost per mile)
7 Monitor cavern crystallization equilibrium parameters in a static steady-state mode and perform tests to determine strength of crystallization.
8. Determine additional procedures for the closure of boreholes and ultimate use of the original potential surface collapse radius.
9 Set up permanent monitoring equipment and observe until ultimate site remediation termination is determined.

As an alternate to lack of suitable lagoon brines locate and install virgin salt solution mining boreholes nearby and augment crystallization using Mg salts/sulphates trucked in.(added costs)

Respectfully submitted and subject to review, Dan Snow LotusLLC cell 432 661 5828

----- Original Message -----
From: Chavez, Carl J, EMNRD
To: George Veni
Cc: 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 ; 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 ; kdavis@subsurfacegroup.com ; 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 ; Sanchez, Daniel J., EMNRD
Sent: Tuesday, April 21, 2009 9:54 AM
Subject: RE: UIC Class III Brine Evaluation Work Group Draft Report Attached

Thanks for the input George. It is now critical that the Work Group begin chiming in with any recommendation or ideas on the Carlsbad BW. Stay tuned......

Carl J. Chavez, CHMM
New Mexico Energy, Minerals & Natural Resources Dept.
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1220 South St. Francis Dr., Santa Fe, New Mexico 87505
Office: (505) 476-3490
Fax: (505) 476-3462
E-mail: CarlJ.Chavez@state.nm.us
Website: http://www.emnrd.state.nm.us/ocd/index.htm
(Pollution Prevention Guidance is under "Publications")

From: George Veni [mailto:gveni@nckri.org]
Sent: Monday, April 20, 2009 8:49 PM

To: Chavez, Carl J, EMNRD
Subject: RE: UIC Class III Brine Evaluation Work Group Draft Report Attached

Carl,

Here is my vote on the options: 1, 2, and 4. They are not mutually exclusive. #1 protects everyone while #2 and 4 (which is a reasonable variation of #2) go into effect. #3 and 5 are not options in my opinion. #3 induces the problem and there is guarantee it will be "controlled." A large hole would still result that will necessitate rerouting the canal and probably one of the highways. #5 may induce the collapse accidentally instead of stopping it.

#1, 2, and 4 do not guarantee a collapse will be prevented, but they will minimize the impact by keeping the potentially affected public at a safe distance. By filling the cavern as much as possible, if they don't stop the collapse, will reduce the depth and diameter of any sinkhole that would develop. Perhaps a catastrophic sinkhole would be reduced to a more manageable and non-life threatening subsidence.

I'll be out for the rest of week but will monitor messages on my Blackberry.

George

From: Chavez, Carl J, EMNRD [mailto:CarlJ.Chavez@state.nm.us]
Sent: Monday, April 20, 2009 6:10 PM
To: Chavez, Carl J, EMNRD; 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; 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; Sanchez, Daniel J., EMNRD
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Please contact me if you have questions. Thank you.

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Office: (505) 476-3490
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1220 South St. Francis Dr., Santa Fe, New Mexico 87505
Office: (505) 476-3490
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Chavez, Carl J, EMNRD

From: Chavez, Carl J, EMNRD
Sent: Tuesday, April 21, 2009 5:16 PM
To: 'Ken Davis'; 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; 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; Sanchez, Daniel J., EMNRD
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Subject: RE: UIC Class III Brine Evaluation Work Group Draft Report Attached
Attachments: TXRRC Oilfield Wastes.pdf

Ken:

Thank you for your input and information submittal. I think the concern of the OCD is the UIC Class I Disposal Well designation and was based on comments from the EPA during the Work Group meeting regarding an application in TX where RCRA Subtitle "C" Hazardous Wastes was being proposed for disposal in a salt cavern. The application was eventually denied or prohibited and the discussion of the costs for any applicant may have to incur to model and address all of the Federal concerns with such a proposal seemed to be costly.

You will note that the brine well strategy indicated that there was interest for UIC Class I Waste Disposal into salt caverns. Similar to the EPA concerns with RCRA Hazardous Waste, the OCD regards oilfield non-exempt non-hazardous wastes, while being exempt from the hazardous Subtitle "C" RCRA Classification, to be inherently similar to it with similar concerns as the EPA when reviewing the aforementioned application in TX. I have attached a chapter on waste from the TX Railroad Commission (Waste Minimization Program) that clarifies the type of wastes that are oilfield non-exempt and oilfield wastes that are indeed considered hazardous for background for the Work Group.

The OCD will review the publication you attached to your e-mail in consideration of the final report related to your e-mail, but may not yield to a UIC Class I disposal well designation, but may consider these wells for oilfield exempt type wastes in our final report? The EPA had also mentioned the fact that brine wells that are backfilled may be classified as UIC Class V Wells; thus, the removal of the Class I Disposal Well nomenclature?

Also, please provide the Work Group with links for documentation on the LA Regulations and info. that may be pertinent to consider; however, LA has a different salt depositional environment (salt dome) than the bedded salt in SE NM.

Thanks again.

Carl J. Chavez, CHMM
New Mexico Energy, Minerals & Natural Resources Dept.
Oil Conservation Division, Environmental Bureau
1220 South St. Francis Dr., Santa Fe, New Mexico 87505
Office: (505) 476-3490
Fax: (505) 476-3462
E-mail: CarlJ.Chavez@state.nm.us
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From: Ken Davis [mailto:kdavis@subsurfacegroup.com]
Sent: Tuesday, April 21, 2009 4:05 PM

To: Chavez, Carl J, EMNRD; 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; 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; Sanchez, Daniel J., EMNRD
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Subject: RE: UIC Class III Brine Evaluation Work Group Draft Report Attached

Carl:
I reviewed the NMOCD Class III Brine Well Draft Report that was originally attached to this e-mail and suggest you might want to review the results of an Argonne National Laboratory Study. They developed a report titled "An Introduction to Salt Caverns & Their Use for Disposal of Oil Field Wastes". I have attached a scanned copy of the report for every-ones convenience.

The report indicates their findings were favorable to disposing of Oil Field Wastes in Salt Caverns. Additionally, the state of Louisiana developed very stringent regulations allowing this methodology that should also be considered. I suggest the OCD review these documents before banning Oil Field Waste Disposal in Salt Caverns.

I agree we should also consider the SMRI ongoing P&A research results.

Hope this information will be helpful.
Ken E. Davis

From: Chavez, Carl J, EMNRD [mailto:CarlJ.Chavez@state.nm.us]
Sent: Monday, April 20, 2009 7:10 PM
To: Chavez, Carl J, EMNRD; 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; 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; Sanchez, Daniel J., EMNRD
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3

HAZARDOUS AND NONHAZARDOUS OIL AND GAS WASTE

OIL AND GAS WASTES

The Railroad Commission has jurisdiction over oil and gas wastes, which include all wastes generated in association with the following activities:

- drilling, operation, and plugging of wells associated with the exploration, development, or production of oil and gas, including oil and gas wells, fluid injection wells used in enhanced recovery projects, and disposal wells;
- separation and treatment of produced fluids in the field or at natural gas processing plants;
- storage of crude oil before it enters a refinery;
- underground storage of hydrocarbons and natural gas;
- transportation of crude oil or natural gas by pipeline;
- solution mining of brine; and
- storage, hauling, disposal, or reclamation of wastes generated by these activities.

The Railroad Commission regulates *all* oil and gas waste in Texas, both hazardous and nonhazardous. Statewide Rule 30, "Memorandum of Understanding Between the Railroad Commission of Texas (RRC) and the Texas Natural Resource Conservation Commission (TNRCC)," provides additional guidance for determining jurisdiction over waste in Texas.

RCRA AND THE E&P EXEMPTION

The federal Resource Conservation and Recovery Act (RCRA), originally enacted in 1976, authorizes EPA to regulate the management of wastes resulting from industrial, commercial, mining, agricultural, and community activities. RCRA Subtitle C contains a comprehensive program for the regulation of hazardous wastes. Nonhazardous wastes are subject to regulation under RCRA Subtitle D. Railroad Commission Statewide Rule 98, "Standards for Management of Hazardous Oil and Gas Wastes," establishes equivalent requirements for generators and transporters of hazardous oil and gas waste.

Recognizing the unique characteristics of oil and gas wastes, in 1980, Congress specifically exempted "drilling fluids, produced waters, and other wastes associated with the exploration, development, or production of crude oil or natural gas or geothermal energy"[5] from regulation under RCRA Subtitle C as hazardous wastes. This exemption is commonly called the "E&P Exemption." Statewide Rule 98 also provides the E&P exemption. The E&P exemption is explained in the following section.

Produced waters make up about 98% of all oil and gas wastes. In Texas, we estimate that 98% of these produced waters are injected in wells regulated under the federally approved underground injection control program administered by the Railroad Commission. Drilling fluids and other associated wastes make up about 1.6% and 0.4% of oil and gas wastes, respectively.

The exempt oil and gas wastes are unique, which is the rational for the exemption. They are generated in large quantities, but are relatively low in toxicity. Exempt oil and gas wastes are generated by a large number of individual oil and gas operations—around 250,000 wells and 12,500 operators in Texas. Oil and gas wastes are generated in diverse operational and environmental settings—compare the Gulf Coast to the Panhandle, or the Permian Basin to the East Texas Field. Finally, exempt oil and gas wastes are adequately regulated under state and federal programs (other than RCRA Subtitle C) that have evolved over the years.

SCOPE OF THE E&P EXEMPTION

On July 6, 1988, after performing the study of oil and gas wastes mandated by Congress, EPA published its regulatory determination[6] (see Appendix A). In its regulatory determination, EPA concluded that the exemption for produced water, drilling fluids, and associated wastes should continue. EPA also made its first efforts to define the scope of the exemption. EPA reviewed both the statutory language and the legislative history and determined that the exemption for wastes associated with the exploration, development, and production of oil and gas covers only those wastes **uniquely associated** with **primary field operations**. Primary field operations include primary, secondary, and tertiary production of oil or gas.

With respect to **oil production**, primary field operations include activities occurring at or near the wellhead or production facility, but before the point where the custody of the oil is transferred from an individual field facility or a centrally located facility to a carrier for transport to a refiner. In the event no custody transfer occurs, the primary field operation ends at the last point of separation. Crude oil stock tanks are considered separation devices for the purpose of defining areas of primary field operations.

With respect to **natural gas production**, primary field operations are those activities occurring at or near the wellhead, production facility, or gas plant (including gathering lines to the plant), but before the point of transfer of the gas from an individual field facility, a centrally located facility, or a gas plant to a carrier for transport to market, or before the point of the use of natural gas in a manufacturing process.

In order to be covered under the E&P exemption, wastes from primary field operations must also be unique to E&P operations. Clearly, wastes such as produced water and drilling fluid are unique. However, other wastes commonly generated in E&P operations are used in other types of industries. For example, cleaning wastes, painting wastes, and waste lubricating oil are commonly generated in activities other than E&P activities (i.e., are not unique) and are, therefore, not covered by the E&P exemption.

In March 1993[7], EPA provided clarification of the regulatory determination regarding the status of certain oil and gas wastes (see Appendix B). In that clarification, exempt waste was more precisely defined:

> In particular, for a waste to be exempt from regulation as a hazardous waste under RCRA Subtitle C, it must be associated with operations to locate or remove oil and gas from the ground or to remove impurities from such substances and it must be intrinsic to and uniquely associated with oil and gas exploration, development or production operations (commonly referred to as exploration and production or E&P); the waste must not be generated by transportation or manufacturing

> operations ... One common belief is that any wastes generated by, in support of, or intended for use by the oil and gas E&P industry ... are exempt. This is not the case; in fact, only wastes generated by activities uniquely associated with the exploration, development or production of crude oil or natural gas ... (i.e., wastes from down-hole or wastes that have otherwise been generated by contact with the production stream during the removal of produced water or other contaminants from the product) are exempt from regulation under RCRA Subtitle C ...

In its March 1993 clarification, EPA addressed the applicability of the E&P exemption to wastes generated by crude oil reclaimers, service companies, gas plants and feeder pipelines, crude oil pipelines, and underground gas storage fields. The clarification included the following explanations of the E&P exemption.

- For the purpose of defining primary field operations, the change of custody criterion refers to <u>product</u> (e.g., crude oil and natural gas), not waste.

- The off-site transport of exempt waste from a primary field site for treatment, reclamation, or disposal does not negate the exemption.

- Wastes derived from the treatment of an exempt waste, including any recovery of product from an exempt waste (e.g., crude oil reclamation from tank bottoms), generally remain exempt from the requirements of RCRA Subtitle C.

- Vacuum truck and drum rinsate from trucks and drums transporting or containing exempt waste is exempt, provided that the trucks or drums only contain E&P exempt wastes and that the water or fluid used in the rinsing is not subject to RCRA Subtitle C (i.e., is itself nonhazardous).

- Wastes generated by a service company that do not meet the basic criteria listed in the regulatory determinations (i.e., are not uniquely associated with oil and gas E&P operations) are not exempt from Rule 98 and Subtitle C. However, an oil and gas waste generated by a service company in primary field operations, and that is also uniquely associated with E&P, is an exempt oil and gas waste.

- The removal of elemental sulfur from hydrogen sulfide gas at a gas plant is considered treatment of an exempt waste.

- Wastes uniquely associated with operations to recover natural gas from underground gas storage fields are covered by the exemption.

EPA included a list of exempt wastes and a list of nonexempt wastes in its regulatory determination. These lists are not comprehensive. They were intended only to provide examples of the types of wastes that fall under the exempt and nonexempt categories. Generators will need to make individual determinations regarding the status of a number of other incidental wastes. The Railroad Commission or the EPA should be contacted for guidance in the event the regulatory status of a waste is in doubt.

Exempt Wastes

Exempt wastes make up the bulk (over 99.9%) of all wastes that are regulated by the Railroad Commission. Table 1 is a list of wastes designated as exempt in EPA's regulatory determination dated July 6, 1988[6]. It is a listing of most, but not all, oil and gas wastes that are exempt from hazardous waste regulation.

> Although many oil and gas wastes are exempt from hazardous waste regulation, other regulations will apply, such as Railroad Commission Statewide Rule 8.

Nonexempt Wastes

The wastes that EPA has determined are not covered under the exemption may be hazardous wastes subject to regulation under Rule 98 and RCRA Subtitle C. Nonexempt wastes include, no matter where generated, those wastes that *are not uniquely associated* with an exploration and production activity, such as cleaning wastes or lubricating oil. Further, *all* wastes that are not associated with primary field operations, such as wastes associated with pipeline transportation or manufacturing (e.g., refining) activities, are nonexempt. Table 2 provides the list of nonexempt wastes in EPA's regulatory determination[6]. This is a listing of most, but not all, oil and gas wastes that are not exempt from regulation as hazardous wastes.

Not all nonexempt wastes are hazardous wastes. For example, empty drums and insulation will probably not be hazardous waste. However, some wastes, such as paint wastes, spent solvents, unused fracturing materials that can no longer be used for their intended purpose, and contaminated media resulting from a spill from a transportation pipeline, may be hazardous. The following section, "Hazardous Oil and Gas Wastes," explains how an operator may identify a nonexempt waste as hazardous or nonhazardous.

TABLE 1. OIL AND GAS WASTES EXEMPT FROM RCRA HAZARDOUS WASTE REGULATION*

- Produced water
- Drilling fluids and drill cuttings
- Drilling fluids and cuttings from offshore operations disposed on-shore
- Rigwash
- Well completion, treatment, and stimulation fluids
- Workover wastes
- Basic sediment and water and other tank bottom sludge from storage facilities that hold product and exempt waste
- Accumulated materials such as hydrocarbons, solids, sand , and emulsion from production separators, fluid treating vessels, and production impoundments
- Pit sludges and contaminated bottoms from storage or disposal exempt wastes
- Gas plant dehydration wastes, including glycol-based compounds, glycol filters, filter media, backwash, and molecular sieves
- Gas plant sweetening wastes for sulfur removal, including amine, amine filters, amine filter media, backwash, precipitated amine sludge, iron sponge, and hydrogen sulfide scrubber liquid and sludge
- Cooling tower blowdown
- Spent filters, filter media, and backwash (assuming the filter itself is not hazardous and the residue in it is from an exempt waste stream)
- Packing fluids
- Produced sand
- Pipe scale, hydrocarbon solids, hydrates, and other deposits removed from piping and equipment prior to transportation
- Hydrocarbon-bearing soil
- Pigging wastes from gathering lines
- Wastes from subsurface gas storage and retrieval, except for the listed nonexempt wastes
- Constituents removed from produced water before it is injected or otherwise disposed of
- Liquid hydrocarbons removed from the production stream but not from oil refining
- Gases removed from the production stream, such as hydrogen sulfide and carbon dioxide, and volatilized hydrocarbons
- Materials ejected from a producing well during blowdown
- Waste crude oil from primary field operations and production
- Light organics volatilized from exempt wastes in reserve pits or impoundments or production equipment

*Note: All exempt waste *must* be generated in primary field operations. A more descriptive listing of exempt wastes, as well as lists of wastes subject to laws other than RCRA, is provide in Appendix C.

TABLE 2. RCRA NONEXEMPT OIL AND GAS WASTES*

- Unused fracturing fluids or acids
- Gas plant cooling tower cleaning wastes
- Painting wastes
- Oil and gas service company wastes, such as empty drums, drum rinsate, vacuum truck rinsate, sandblast media, painting wastes, spent solvents, spilled chemicals, and waste acids
- Vacuum truck and drum rinsate from trucks and drums transporting or containing nonexempt waste
- Liquid and solid wastes generated by crude oil and tank bottom reclaimers**
- Used equipment lubrication oils
- Waste compressor oil, filters, and blowdown
- Used hydraulic fluids
- Waste solvents
- Waste in transportation pipeline-related pits
- Caustic or acid cleaners
- Boiler cleaning wastes
- Boiler refractory bricks
- Boiler scrubber fluids, sludges, and ash
- Incinerator ash
- Laboratory wastes
- Sanitary wastes
- Pesticide wastes
- Radioactive tracer wastes
- Drums, insulation, and miscellaneous solids

(EPA also included refinery wastes in this list. However, refinery wastes are not under the jurisdiction of the Railroad Commission.)

*NOTE: A more descriptive listing of nonexempt wastes, as well as lists of wastes subject to laws other than RCRA, is provided in Appendix C.

**NOTE: Residual material from reclamation of crude oil from exempt waste is also exempt (see third bullet item on page 3-4).

Implementing a waste minimization program can simplify compliance with the requirements of Rule 98 and RCRA and may reduce costs and future liability for the disposal of hazardous and nonhazardous wastes.

HAZARDOUS OIL AND GAS WASTE

RCRA required EPA to establish procedures for identifying wastes as either hazardous or nonhazardous, and promulgate requirements for the management of both. In order for a waste to be a hazardous waste, it must also be a solid waste as defined under federal law (40 CFR 261.2). A solid waste may be solid, semi-solid, liquid, or a contained gas. A nonexempt solid waste is classified as a hazardous waste if EPA has specifically listed it as such or if it tests positive for one of four hazardous waste characteristics. Rule 98 adopts the federal hazardous waste identification rules.

Nonexempt Listed Hazardous Oil and Gas Wastes

EPA has listed numerous solid wastes as hazardous wastes because they:

- typically exhibit one or more of the characteristics of hazardous waste (described below);
- have been shown to meet certain human toxicity criteria; or
- contain any one of the chemical compounds or substances listed by EPA as hazardous constituents.

EPA's regulations contain four lists of hazardous wastes (refer to Table 3, Listed RCRA Hazardous Oil and Gas Wastes). These lists contain over 400 hazardous wastes. Some are considered acutely hazardous wastes, which are wastes that EPA has determined to be so dangerous that small amounts of them are regulated the same way as larger amounts of other hazardous wastes.

If a nonexempt oil and gas waste is identified on any of these four lists, the waste must be managed as a listed hazardous waste. For example, waste solvent from use of the solvent as a degreaser on surface equipment is nonexempt; and if it is found to be a "listed" hazardous waste, it must be managed as such. Remember, however, that the same solvent used to remove paraffin in a well is an exempt oil and gas waste when it is recovered. If an oil and gas waste is exempt, it is an exempt waste even if it appears on one of the four lists. Though the waste is not subject to regulation as a hazardous waste, other regulations apply and good waste management practices (including waste minimization) should be employed.

TABLE 3: LISTED RCRA HAZARDOUS OIL AND GAS WASTES

EPA LIST	TYPE OF WASTE	EXAMPLES OF OIL AND GAS WASTES THAT MIGHT BE FOUND ON EPA LISTS *
F List	Hazardous wastes from non-specific sources	Spent solvents (trichloroethylene, methylene chloride, tetrachloroethylene, xylene, acetone, benzene, ethyl benzene, methyl ethyl ketone, nbutyl alcohol, methanol, toluene, and solvent mixtures/blends that contain more than 10% of these solvents
K List	Hazardous wastes from specific sources	None identified
P List	Acute hazardous wastes (Commercial chemical products that become acute hazardous waste when disposed of)	Acrolein, beryllium, carbon disulfide, parathion, vanadium pentoxide
U List	Toxic hazardous wastes (Commercial chemical products that become toxic hazardous wastes when disposed of)	Acetone, benzene, carbon tetrachloride, chloroform, chrysene, formaldehyde, formic acid, hydrogen fluoride, hydrogen sulfide, lindane, mercury, methanol, methyl ethyl ketone, methyl isolbutyl ketone, methylene chloride, naphthalene, toluene, xylene

* Note: The examples given are not a complete list. Additional oil and gas wastes may be found on one of the four lists, depending upon the operations.

Nonexempt Characteristically Hazardous Oil and Gas Wastes

If a nonexempt oil and gas waste is not listed, it must be determined if the waste exhibits a hazardous waste characteristic. Typically, characteristically hazardous oil and gas wastes are a more common concern to operators of E&P facilities. A nonexempt oil and gas waste is classified as hazardous if it exhibits any one of following four hazardous waste characteristics:

- ignitability,
- corrosivity,
- reactivity, and
- toxicity.

Table 4 provides a description of the four hazardous waste characteristics.

The generator can either test the waste material using an accepted EPA analytical method or can apply process knowledge in determining whether the waste in question is characteristically hazardous. A generator who relies on process knowledge in determining if a waste is characteristically hazardous should be prepared to demonstrate that this determination is reasonable in terms of the materials and process used. If there is any reasonable doubt as to whether a nonexempt oil and gas waste exhibits one or more hazardous waste characteristics, the generator is encouraged to verify the waste classification by testing so that the waste may be properly managed. It is prudent to determine whether or not a waste exhibits hazardous characteristics any time a change is made in process or materials. The generator is subject to civil and criminal penalties if a hazardous waste is misidentified and, thus not managed according to hazardous waste regulations.

A characteristically hazardous waste may be decharacterized; however, it will probably remain subject to land disposal restrictions of 40 CFR Part 268. As a general rule, the dilution of a hazardous waste for the purpose of eliminating the characteristic is prohibited. Dilution is not considered by EPA to be an acceptable treatment method for characteristically hazardous waste.

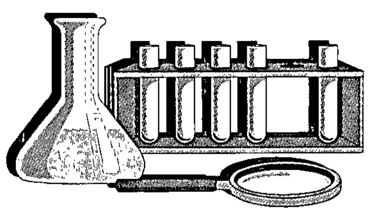

TABLE 4: RCRA AND RULE 98 HAZARDOUS WASTE CHARACTERISTICS

➤ IGNITABILITY

- Liquids with a flash point less than 140°F
- Ignitable compressed gas
- Materials other than liquids that at standard conditions are capable of causing fire by spontaneous chemical changes, by absorption of moisture, or through friction.

Examples: certain cleaning solvents (may also be listed hazardous wastes), certain degreasers, certain transportation-pipeline pigging wastes, certain paint wastes

➤ CORROSIVITY

- Aqueous materials with a pH of less than or equal to 2.0 or greater than or equal to 12.5.
- Liquid materials that corrode steel (SAE 1020) at a rate greater than 0.250 inch per year at a test temperature of 130°F.

Examples: certain acid or caustic cleaning wastes, unused well acidizing fluids (that have not been down the borehole), certain rust removers, waste battery acid

➤ REACTIVITY

- Any waste that reacts violently with water, forms explosive mixtures with water, or generates any toxic fumes with water
- Any waste that is explosive at standard conditions or if heated
- Any waste that contains cyanide or sulfide at a concentration that will emit toxic cyanide or sulfide gases when exposed to a pH of 2.0 to 12.5.

Examples: certain waste oxidizers

➤ TOXICITY

Potential to contaminate ground water by leaching as determined in a laboratory using the Toxicity Characteristic Leaching Procedure (TCLP) Test.

Table 4 continues on the next page.

TABLE 4: RCRA HAZARDOUS WASTE CHARACTERISTICS (CONTINUED)

TCLP leachable components* that cause a waste to test hazardous are:

Organics:	Benzene	0.5 mg/l
	Carbon tetrachloride	0.5 mg/l
	Chlordane	0.03 mg/l
	Chlorobenzene	100.0 mg/l
	Chloroform	6.0 mg/l
	o-Cresol	200.0 mg/l
	m-Cresol	200.0 mg/l
	p-Cresol	200.0 mg/l
	Cresol	200.0 mg/l
	2,4-D	10.0 mg/l
	1,4-Dichlorobenzene	7.5 mg/l
	1,2-Dichloroethane	0.5 mg/l
	1,1-Dichloroethylene	0.7 mg/l
	2,4-Dininitrotoluene	0.13 mg/l
	Endrin	0.02 mg/l
	Heptachlor (and its epoxide)	0.008 mg/l
	Hexachlorobenzene	0.13 mg/l
	Hexachlorobutadiene	0.5 mg/l
	Hexachloroethane	3.0 mg/l
	Lindane	0.4 mg/l
	Methoxychlor	10.0 mg/l
	Methyl ethyl ketone	200.0 mg/l
	Nitrobenzene	2.0 mg/l
	Pentachlorophenol	100.0 mg/l
	Pyridine	5.0 mg/l
	Tetrachloroethylene	0.7 mg/l
	Toxaphene	0.5 mg/l
	Trichloroethylene	0.5 mg/l
	2,4,5-Trichlorophenol	400.0 mg/l
	2,4,6-Trichlorophenol	2.0 mg/l
	2,4,5-TP (Silvex)	1.0 mg/l
	Vinyl chloride	0.2 mg/l
Metals:	Arsenic	5.0 mg/l
	Barium	100.0 mg/l
	Cadmium	1.0 mg/l
	Chromium	5.0 mg/l
	Lead	5.0 mg/l
	Mercury	0.2 mg/l
	Selenium	1.0 mg/l
	Silver	5.0 mg/l

Examples of types of wastes that may test hazardous include:
- unused pipe dope (lead)
- unused biocides (chromium)
- cleaning wastes or solvents (benzene)
- transportation pipeline pigging wastes (benzene)

* Note: When at concentrations equal to or greater than the respective value given in the table.

MIXING EXEMPT AND NONEXEMPT WASTES

Mixing exempt and nonexempt wastes creates a special set of problems. Whenever possible, mixing nonexempt wastes with exempt wastes should be avoided because the resulting mixture may become a hazardous waste and require management under RCRA Subtitle C regulations. Furthermore, mixing a characteristically hazardous waste with a nonhazardous or exempt waste *for the purpose of rendering the hazardous waste nonhazardous or less hazardous* is considered by EPA to be a treatment process; which is subject to the appropriate RCRA Subtitle C hazardous waste regulations, including permitting requirements.

Below are some basic guidelines for determining the status of a mixture of exempt and nonexempt wastes.

- Mixing a nonhazardous (exempt or nonexempt) waste with an exempt waste results in a mixture that is nonhazardous.

  Example: If nonhazardous wash water from rinsing road dust off equipment or vehicles is mixed with the contents of a reserve pit containing exempt drilling waste, the wastes in the pit are not subject to hazardous waste regulations regardless of the characteristics of the waste mixture in the pit.

- If, after mixing a nonexempt characteristically hazardous waste with an exempt waste, the resulting mixture exhibits any of the same hazardous characteristics as the hazardous waste (ignitability, corrosivity, reactivity, or toxicity due to a particular constituent), then the mixture is a nonexempt hazardous waste.

  Example: If nonexempt caustic soda (corrosive) is mixed with exempt waste and the resultant mixture exhibits the hazardous characteristics of corrosivity as determined from pH or steel corrosion tests, then the entire mixture becomes a nonexempt hazardous waste.

  Example: If a nonexempt solvent that is characteristically hazardous because of benzene toxicity is mixed with an exempt waste, and the resultant mixture exhibits the hazardous characteristic of benzene toxicity, then the entire mixture becomes a nonexempt hazardous waste.

- If, after mixing a nonexempt characteristically hazardous waste with an exempt waste, the resulting mixture does not exhibit any of the same hazardous characteristics as the hazardous waste, the mixture is not subject to regulation as a hazardous waste. Even if it exhibits some other characteristic of a hazardous waste, it is still not subject to regulation as a hazardous waste. However, remember that the elimination of the hazardous characteristic(s) exhibited by the nonexempt waste as a result of mixing may be considered treatment. Treatment of a hazardous waste is strictly regulated under RCRA Subtitle C and may require a permit.

Example: If, after mixing nonexempt hydrochloric acid (corrosive characteristic only) with an exempt waste, the resultant mixture does *not* exhibit the hazardous characteristic of corrosivity, then the mixture is not subject to hazardous waste regulations (even if it exhibits some *other* hazardous characteristic, such as toxicity). Note, however, that such a mixture may be made only under specific hazardous waste regulation provisions.

Example: If, after mixing a nonexempt waste exhibiting the hazardous characteristic of lead toxicity with an exempt waste exhibiting the hazardous characteristic of benzene toxicity, the resultant mixture exhibits the hazardous characteristic for benzene but not for lead, then the mixture is not subject to hazardous waste regulations. Such a mixture may be made only under specific provisions of the hazardous waste regulations.

- Generally, if a *listed* hazardous waste is mixed with an exempt waste, regardless of the proportions, the mixture is a nonexempt hazardous waste.

Example: Adding collected nonhazardous stormwater to a partially filled drum of vanadium peroxide solution would result in a mixture that is the listed hazardous waste, vanadium peroxide.

As illustrated above, an operator's waste management practices should preclude mixing exempt and nonexempt nonhazardous oil and gas waste with any hazardous oil and gas waste. Such practice will help an operator avoid stricter regulatory control and higher waste management costs.

EPA's regulations also state that a solid waste (such as sludge or ash) *derived from* a listed hazardous waste is a hazardous waste. In addition, EPA's regulations require that a waste (such as soil or absorbent material) that *contains* a listed hazardous waste be managed as if it *were* a hazardous waste. Therefore, if an operator spills a listed hazardous waste, such as unused methanol, the contaminated soil "contains" a listed hazardous waste and must itself be managed as a hazardous waste.

MANAGEMENT OF NONHAZARDOUS OIL AND GAS WASTES

The Railroad Commission regulates both exempt and nonexempt oil and gas wastes. In Texas, oil and gas wastes must be managed in accordance with the Railroad Commission's rules and guidelines. Statewide Rule 8 governs the transportation, storage, and disposal (other than by underground injection) of exempt and nonexempt nonhazardous oil and gas wastes. Cleanup requirements for crude oil spills into soil in nonsensitive areas are contained in Statewide Rule 91. Statewide Rules 9 and 46 establish permitting requirements for underground injection. Reclamation of E&P tank bottoms and other exempt hydrocarbon wastes is regulated under Statewide Rule 57. The Water Protection Manual and Underground Injection Control Manual, both available from the Commission, contain the Commission's waste management rules and guidelines.

Some oil and gas wastes may be managed at facilities permitted by the Texas Natural Resource Conservation Commission (TNRCC). Appendix D provides, for your reference, a description of TNRCC waste classifications and the TNRCC and Railroad Commission's joint guidelines for disposal of oil and gas wastes in municipal landfills permitted by the TNRCC.

MANAGEMENT OF HAZARDOUS OIL AND GAS WASTES

As you now know, hazardous oil and gas wastes are those oil and gas wastes that are not RCRA-exempt and that are listed hazardous wastes or characteristically hazardous under RCRA Subtitle C and Rule 98. Because the Railroad Commission has not yet been delegated RCRA authority by the Environmental Protection Agency (EPA), these wastes are regulated both by the Railroad Commission under Rule 98 and by EPA under federal law. The Commission intends to obtain authorization from EPA to administer the federal hazardous waste program for hazardous oil and gas waste. (Note that until EPA's delegation of RCRA Subtitle C authority to the Railroad Commission, hazardous waste generated at natural gas processing plants, pressure maintenance plants, and repressurization plants are excluded from the definition of "oil and gas waste" and are solid waste subject to TNRCC jurisdiction.)

RCRA Subtitle C mandated that EPA develop and adopt regulations for management of hazardous wastes. The regulations adopted by EPA under RCRA Subtitle C are very complex and lengthy. These regulations are contained in 40 Code of Federal

Regulations (CFR) Parts 260 through 270. These regulations apply to the generation, transportation, treatment, storage and disposal of hazardous waste.

The Railroad Commission's Statewide Rule 98 establishes regulations for generators and transporters of hazardous oil and gas wastes. The Commission's hazardous waste rule tracks certain parts of EPA's hazardous waste regulations. The definition of hazardous waste and the standards applicable to generators and transporters of hazardous waste are prime examples. However, because the management of hazardous oil and gas wastes presents some special challenges, the Commission has tailored its hazardous waste rules accordingly.

An operator's status as a hazardous waste generator and the applicable hazardous waste management requirements will depend on the quantity of hazardous oil and gas waste generated. In general, the less nonexempt hazardous oil and gas waste generated, the less imposing the requirements and operational limitations of the hazardous waste regulations.

Chavez, Carl J, EMNRD

From:	Ken Davis [kdavis@subsurfacegroup.com]
Sent:	Tuesday, April 21, 2009 4:05 PM
To:	Chavez, Carl J, EMNRD; 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; 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; Sanchez, Daniel J., EMNRD
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
Subject:	RE: UIC Class III Brine Evaluation Work Group Draft Report Attached
Attachments:	20090421163055246.pdf

Carl:
I reviewed the NMOCD Class III Brine Well Draft Report that was originally attached to this e-mail and suggest you might want to review the results of an Argonne National Laboratory Study. They developed a report titled "An Introduction to Salt Caverns & Their Use for Disposal of Oil Field Wastes". I have attached a scanned copy of the report for every-ones convenience.

The report indicates their findings were favorable to disposing of Oil Field Wastes in Salt Caverns. Additionally, the state of Louisiana developed very stringent regulations allowing this methodology that should also be considered. I suggest the OCD review these documents before banning Oil Field Waste Disposal in Salt Caverns.

I agree we should also consider the SMRI ongoing P&A research results.

Hope this information will be helpful.
Ken E. Davis

From: Chavez, Carl J, EMNRD [mailto:CarlJ.Chavez@state.nm.us]
Sent: Monday, April 20, 2009 7:10 PM
To: Chavez, Carl J, EMNRD; 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; 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; Sanchez, Daniel J., EMNRD
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: RE: UIC Class III Brine Evaluation Work Group Draft Report Attached

Ladies and Gentlemen:

Please find attached a copy of the Microsoft Word draft report. The report is still in very rough draft form as the OCD attempted to capture the essence of the comments recorded in the Brine Strategy Document from March 27, 2009. The OCD attempted to capture the Work Group comments in the recommendations for a path forward section near the end of the report. The OCD will ultimately have to comb over the sections to refine, add and/or delete items for the final report.

The OCD notices that there was some concepts and ideas sent in e-mails for a solution to the I&W Brine Well #6 problem in Carlsbad and your final input would be appreciated for finding a solution to this problem. Although the solution appears to be on a fast track with the Office of Homeland Security, OCD, DOT, and other stakeholders in the area, I think the Work Group should chime in with recommendations at this point on a possible solution or you could cast a vote on the solutions below?. The solutions proposed thus far appear to be:

1) Restrict access as it could collapse at any moment, implement monitoring (laser level on well head, could include re-drilling into abandoned well to monitor fluid level and keep cavern filled), create safe zone in area (remove persons or businesses if necessary), and work on contingency plan for if and when well collapses. Could sink $5 Million into project and could collapse anyway....?
2) Pipe in salt waste slurry from Intrepid Potash at nominal fee per bbl. (~ 1 Million barrels) to fill salt cavern or via rail cars or trucks.
3) Induce collapse of cavern and fill up with solids, including special polymers, cement, etc. using heavy earth moving equipment?
4) EPA proposal to drill wells into bottom of cavern, seek operator to manage the injection of acceptable oilfield non-hazardous wastes (i.e., BLM tailings, salt wastes from potash companies, drill cuttings, slurry sand, solids, etc.) into cavern over long-term.
5) Salt bath steam concept from bottom to top of cavern?
6) Other?

The OCD looks forward to your comments. Please save the document under your name and track changes if you wish to send it back with your comments. The OCD requests your comments by COB this Friday, April 24, 2009 or sooner if possible. The OCD will issue one last draft on COB Tuesday April 28, 2009. The above dates are tentative, but we hope to give you a chance to comment before issuing the final report, which you will be copied on to the Secretary of the EMNRD. Yes, it appears that the report is to the Secretary and not the Oil Conservation Commission.

Please contact me if you have questions. Thank you.

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

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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'; Sanchez, Daniel J., EMNRD
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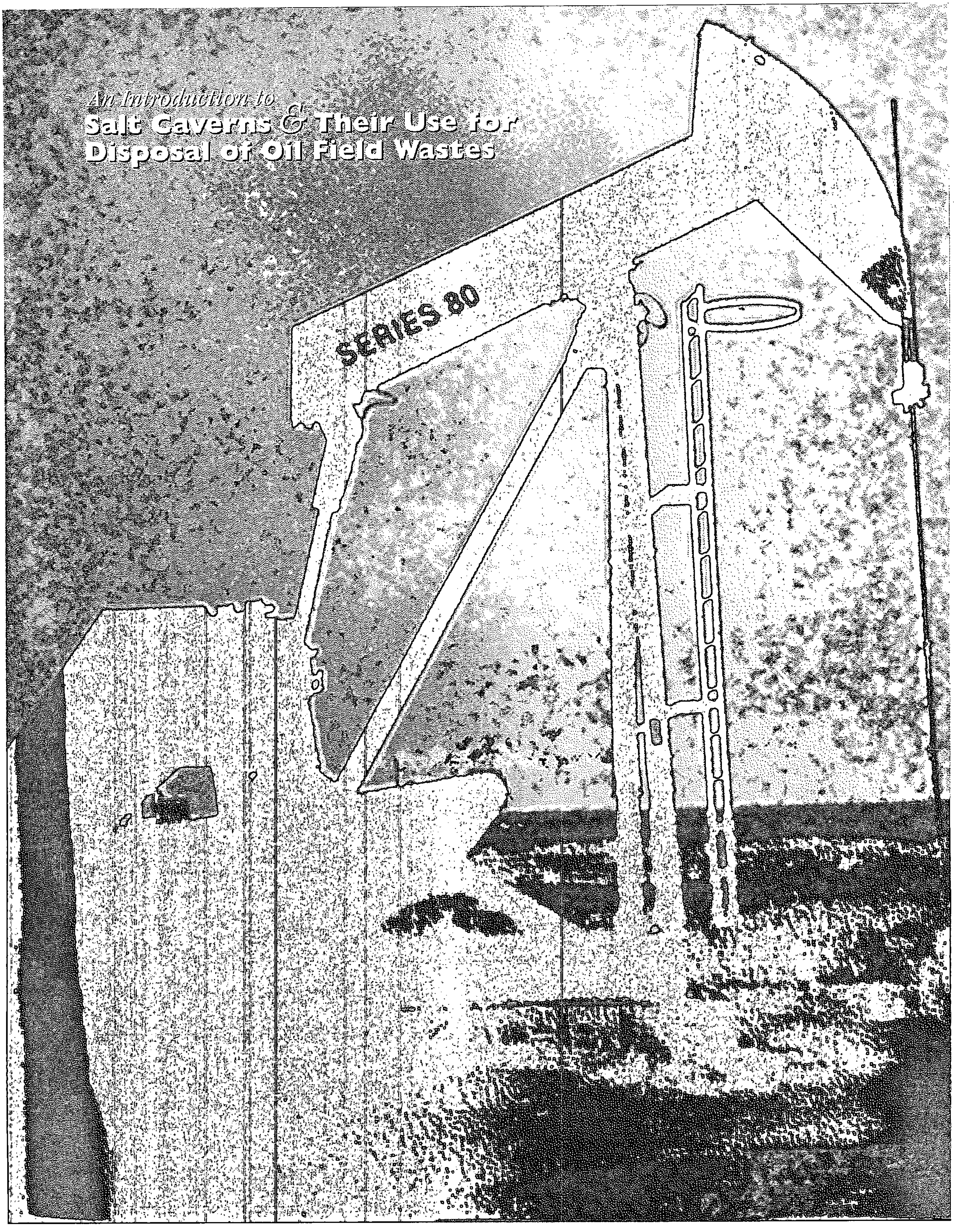
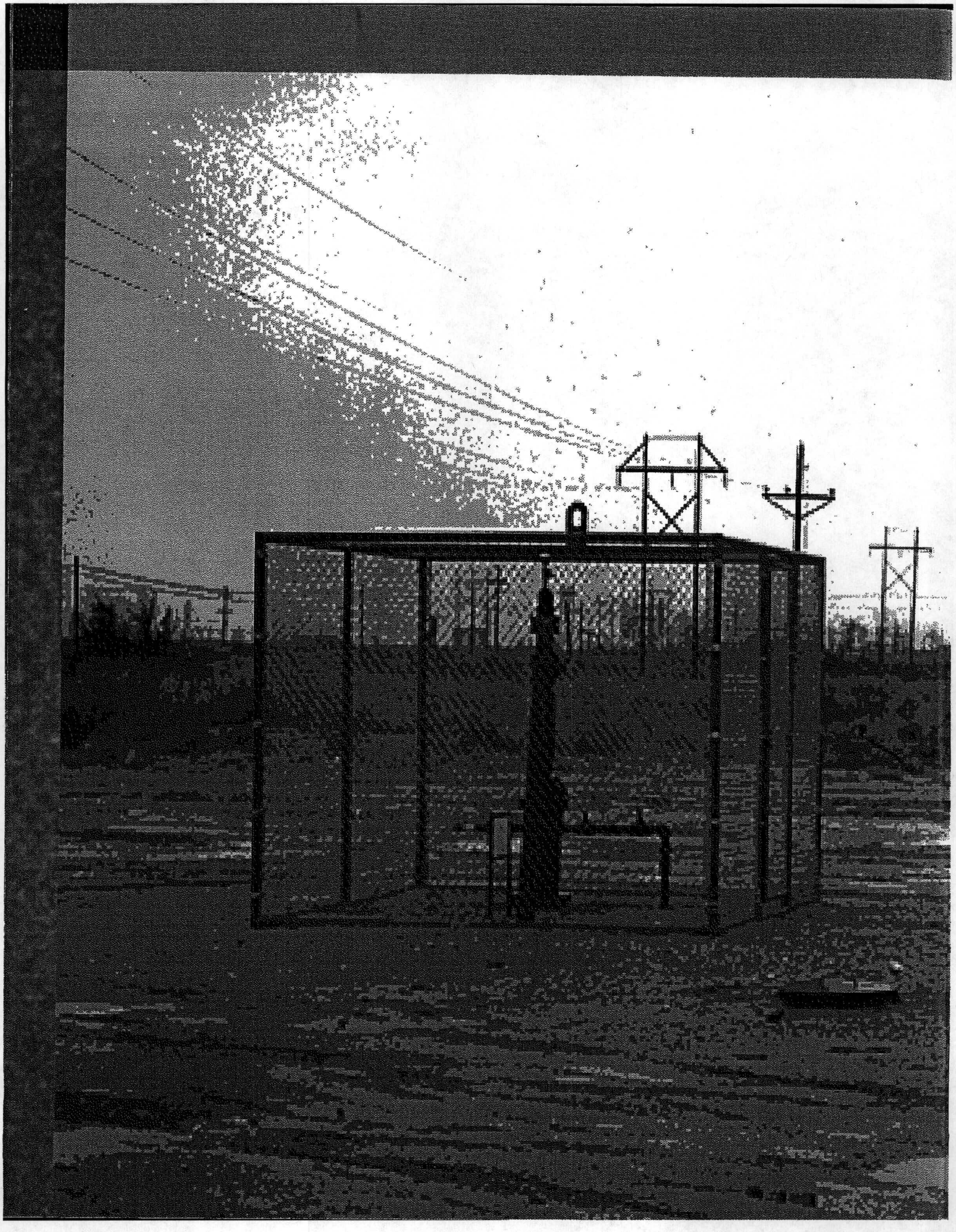
An Introduction to

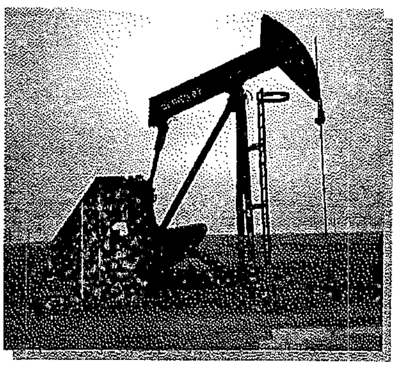
Salt Caverns & Their Use for Disposal of Oil Field Wastes





An Introduction to
Salt Caverns & Their Use for Disposal of Oil Field Wastes

Table of Contents



Inside Cover:
Well Head at a West Texas Oil Field
Waste Disposal Cavern

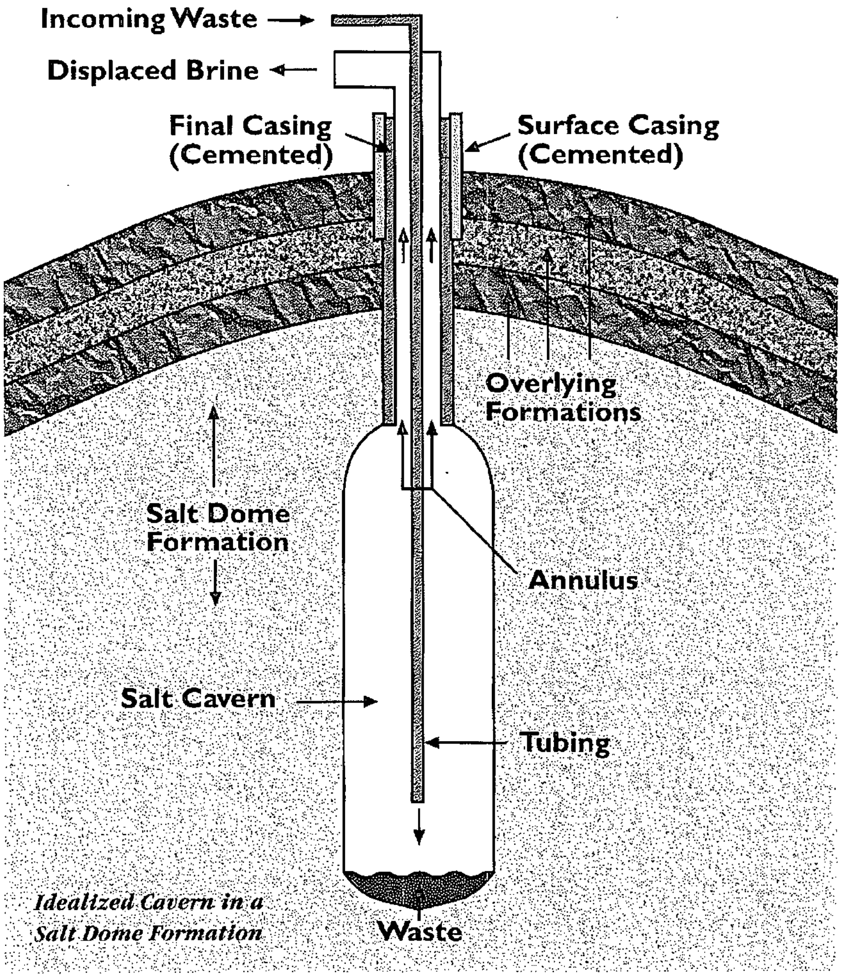
About the Cover:
West Texas Oil Field
Pumping Unit

What Are Salt Caverns?

Salt caverns are cavities or chambers formed in underground salt deposits. Although cavities may naturally form in salt deposits, this brochure discusses caverns that have been intentionally created by humans for specific purposes, such as for storage of petroleum products or disposal of wastes.

Why Are Salt Caverns Important?

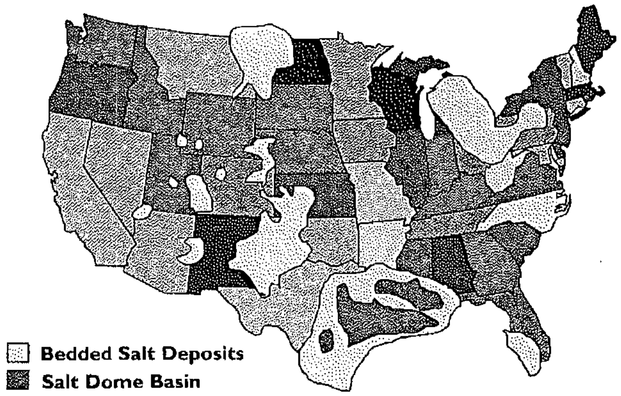
Because of the degree of protection they provide, salt caverns are used for hydrocarbon storage and are beginning to be used for disposal of oil field wastes. This brochure provides basic information on salt caverns and gives sources for additional information.



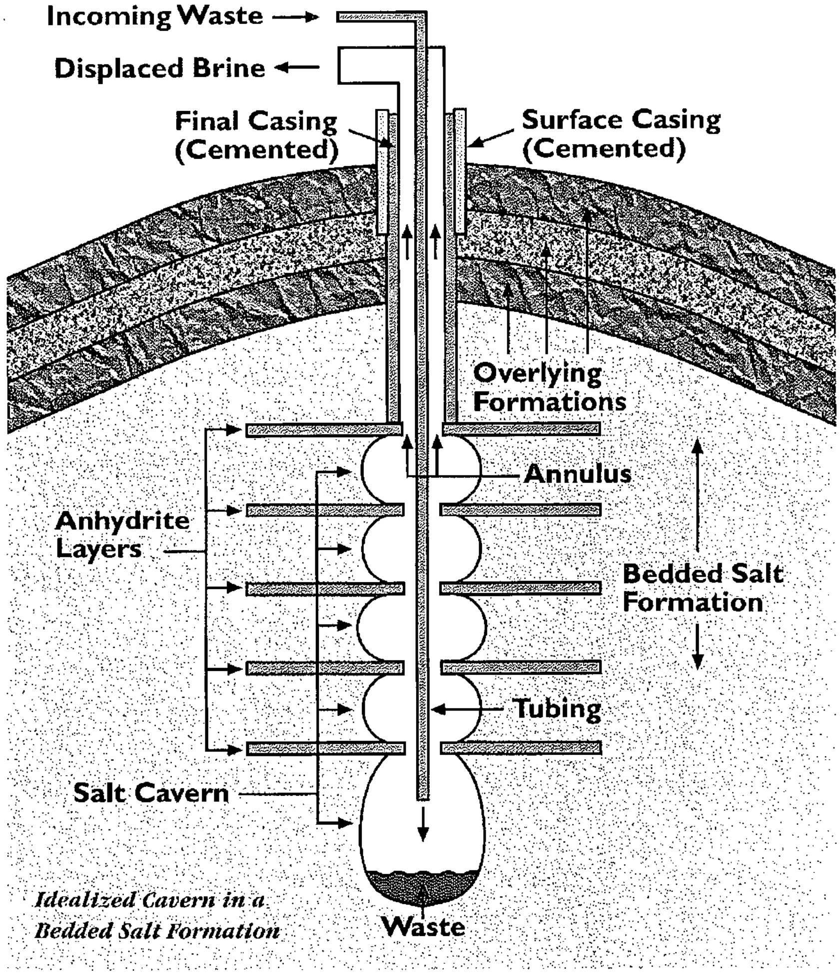
Idealized Cavern in a Salt Dome Formation

Where Are Salt Deposits and Caverns Found?

Underground salt deposits were formed naturally over millions of years and are found in many parts of the world. The map at right shows the locations of major salt deposits in the United States. Salt and other minerals precipitated when small oceans or seas evaporated, leaving behind bedded salt formations. Salt is a relatively weak and light rock. If buried by heavy overlying rock formations, salt will slowly flow and form salt domes. Salt domes are large, fingerlike projections of nearly pure salt that have risen to near the surface. As salt domes are formed, they often trap oil and gas and other minerals around their edges. The tops of salt domes can reach the surface or may be thousands of feet below the surface. Salt domes range in width from 0.5 to almost 5 miles. In the United States, salt domes are found in Texas, Louisiana, and Mississippi, and in the Gulf of Mexico.



Major U.S. Salt Deposit Locations



Idealized Cavern in a Bedded Salt Formation

Bedded salt formations typically contain multiple layers of salt separated by layers of other rocks, such as shales, sandstones, dolomite, and anhydrite. Bedded salts often contain impurities. Salt beds occur at depths of 500 to 6,000 feet below the surface and are up to 3,000 feet thick. In the United States, bedded salts are primarily found along the Gulf Coast, through the central part of the country, and in the Great Lakes region.

More than 1,000 salt caverns have been intentionally created in these salt deposits in the United States. The intended use of a cavern and the nature of the salt formation in which it is formed determine a cavern's shape and size. Some caverns in salt domes are very tall and narrow, while some caverns in bedded salt formations may be short and wide or long tubes.

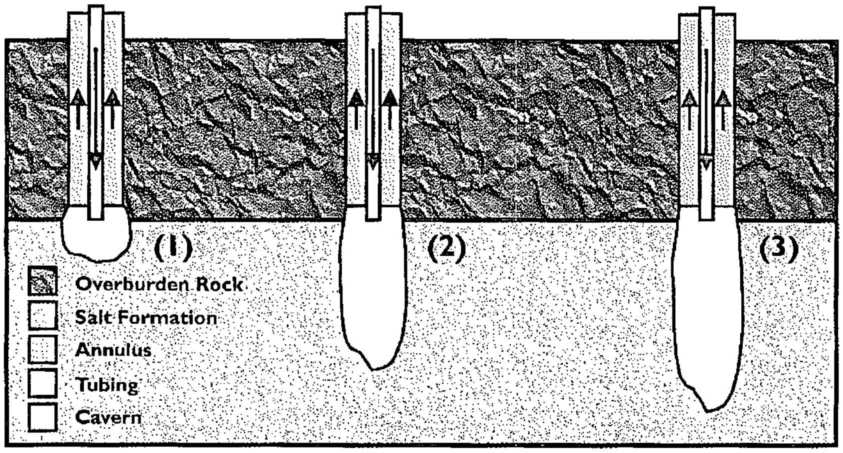
How Are Caverns Formed?

Man-made salt caverns are formed through a process called solution mining. First, well-drilling equipment is used to drill a hole from the surface to the depth of the salt formation. The portion of the well above the salt formation is supported by several concentric layers of pipe known as casing to protect drinking water zones and to prevent collapse of the hole. A smaller-diameter pipe called tubing is lowered through the middle of the well. This arrangement creates two pathways into and out of the well – the hollow tubing itself and the open space between the tubing and the final casing (the annulus). To visualize how this works, think of a straw in a soft drink bottle. The straw represents the tubing, and the space between the straw and the bottle represents the annulus. Liquid can flow in or out of the bottle through both the straw and the annulus.

To form a salt cavern, the well operator pumps fresh water through one of the pipes. As the fresh water comes in contact with the salt formation, the salt dissolves until the water becomes saturated with salt. The salty brine is then pumped to the surface through the second of the two pipes. Cavern space is created by the removal of salt as brine. Operators typically use a combination of direct and reverse circulation, as shown in the figures to the right, at different times to create the desired cavern shape. Some operators install two wells in their caverns and can alternate injection of fresh water and brine withdrawal between the two wells to achieve the desired size and shape of the cavern.

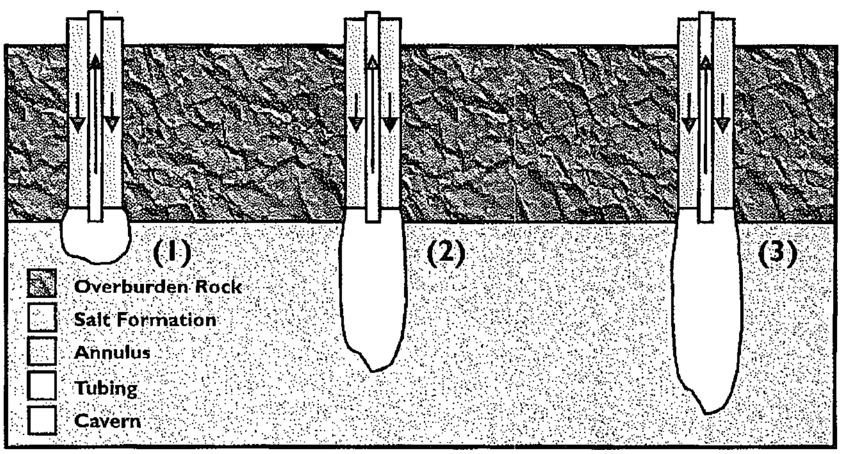
Direct Circulation

Fresh Water Is Injected through Tubing, and Brine Is Withdrawn through the Annular Space between the Tubing and the Final Well Casing



Reverse Circulation

Fresh Water Is Injected through the Annulus, and Brine Is Withdrawn through the Tubing



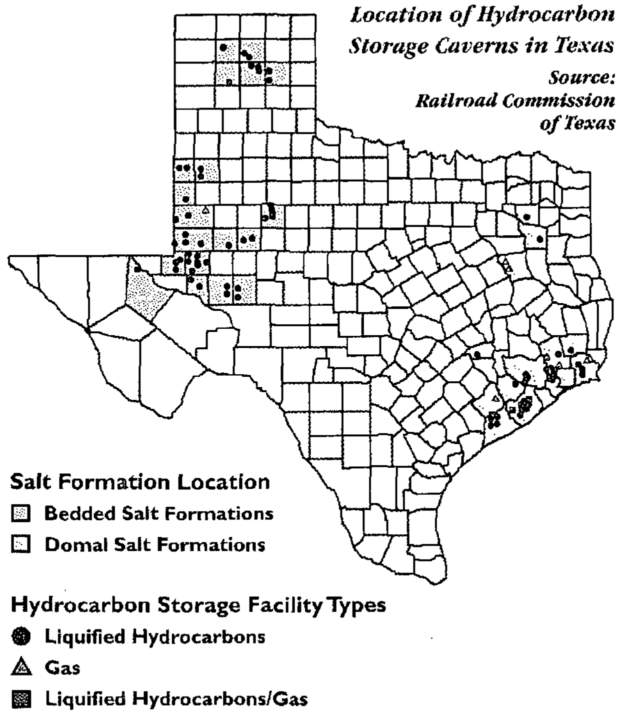
How Are Caverns Used?

Brine Production: In this case, caverns are a by-product of brine production. As brine is produced, a cavern is created and enlarged. The solution mining process is regulated by federal and state agencies through the Underground Injection Control program. Brine can be sold for use in drilling fluids for drilling oil and gas wells or can be used to make salt or other chemicals. Once caverns have reached their maximum permitted size or can no longer be operated efficiently, brine production stops, and the caverns are either left filled with brine or are used for other purposes, such as storage or disposal.

Hydrocarbon Storage: Salt caverns have been used to store various types of hydrocarbons since the 1940s. The types of products that have been stored in these caverns include liquefied petroleum gas (LPG), propane, butane, ethane, ethylene, fuel oil, gasoline, natural gas, and crude oil. The largest underground storage operations in the United States are part of the U.S. Department of Energy's (DOE's) Strategic Petroleum Reserve (SPR). The SPR currently stores about 560 million barrels of crude oil in 62 caverns located at four sites in Louisiana and Texas. Efforts are underway to add another 28 million barrels of crude oil to these sites.

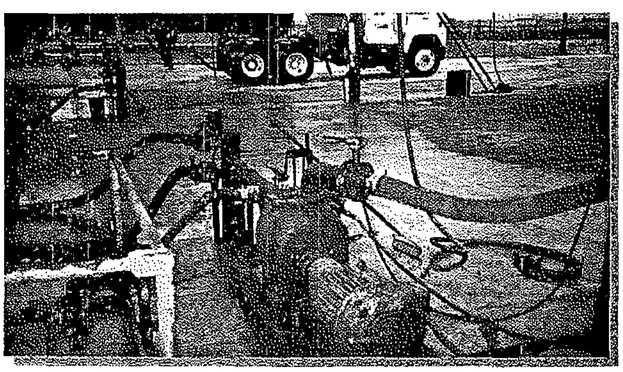
Waste Disposal: Salt caverns represent secure repositories located far below the earth's surface. Several proposals have been made in the United States, Mexico, and Europe to dispose of hazardous chemical wastes in salt caverns, but as of 1999, none have received regulatory approval. In the United States, the DOE, after years of careful study, opened its Waste Isolation Pilot Plant (WIPP), in a bedded salt formation in New Mexico. Although the WIPP was created through conventional mining techniques rather than through solution mining, DOE's decision to place a nuclear waste disposal facility in bedded salt is an indication of the protection offered by salt formations.

Location of Hydrocarbon Storage Caverns in Texas
Source: Railroad Commission of Texas



In several countries, brine producers are allowed to dispose of impurities from the brine processing operations back into the caverns. One British company is authorized to dispose of inorganic and organic wastes from specific industrial processes into caverns.

This brochure is primarily focused on the use of salt caverns for disposing of oil field wastes. The following sections summarize information from a series of four reports prepared for DOE by Argonne National Laboratory. The four reports cover (a) technical feasibility and legal issues, (b) costs, (c) risk, and (d) disposal of naturally occurring radioactive materials associated with oil field waste. Copies of these reports are available on Argonne's website at www.ead.anl.gov.

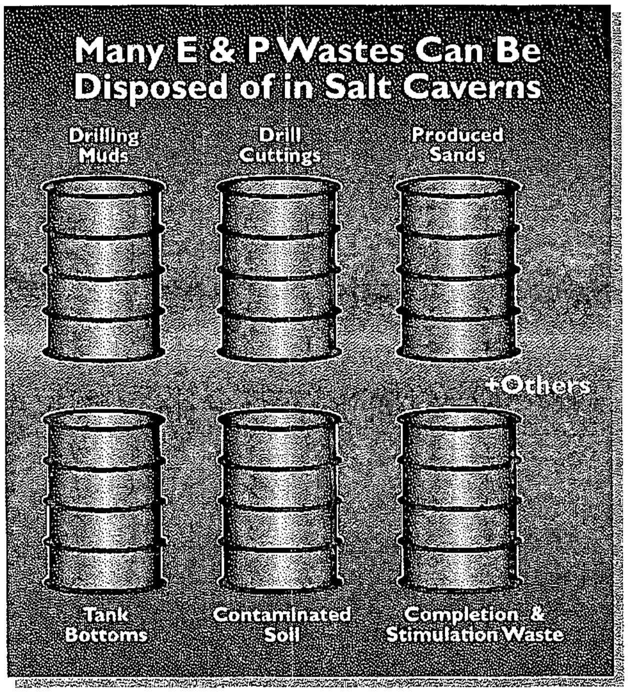


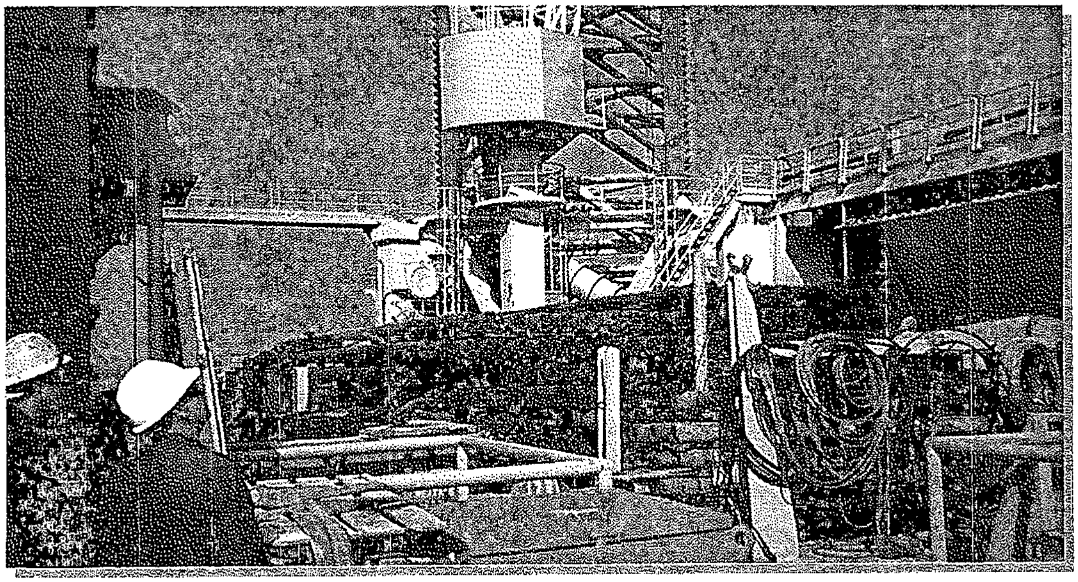
Oil Field Waste Is Pumped into a West Texas Disposal Cavern

What Types of Wastes Are Considered to Be Oil Field Wastes?

The process of drilling oil and gas wells and pumping or producing oil and gas to the surface generates various types of wastes that must be disposed of in an environmentally secure manner. One such waste is the salty water that is brought to the surface along with oil and gas. Much of this "produced water" is reinjected to underground formations through injection wells. Other types of wastes that contain more oil or solids are less suitable for injection and are handled in different types of surface facilities. The types of wastes handled in this manner include drilling fluids, drill cuttings, produced sands, tank bottoms (solids or semisolids that settle in the bottoms of storage tanks), and soil contaminated by small leaks of crude oil. Many agencies refer to these various materials as "nonhazardous oil field wastes," or NOW. Other agencies refer to them as E&P (exploration and production) wastes.

Some oil field wastes become contaminated with naturally occurring radioactive material (NORM). Produced water often becomes contaminated with the natural radiation in the formations holding oil and gas. As the produced water is brought to the surface and is handled there, radioactive pipe scale and sludge form, and soil may be contaminated by leaks of produced water. These NORM wastes have the same chemical and physical makeup as NOW, but also contain measurable radioactivity.

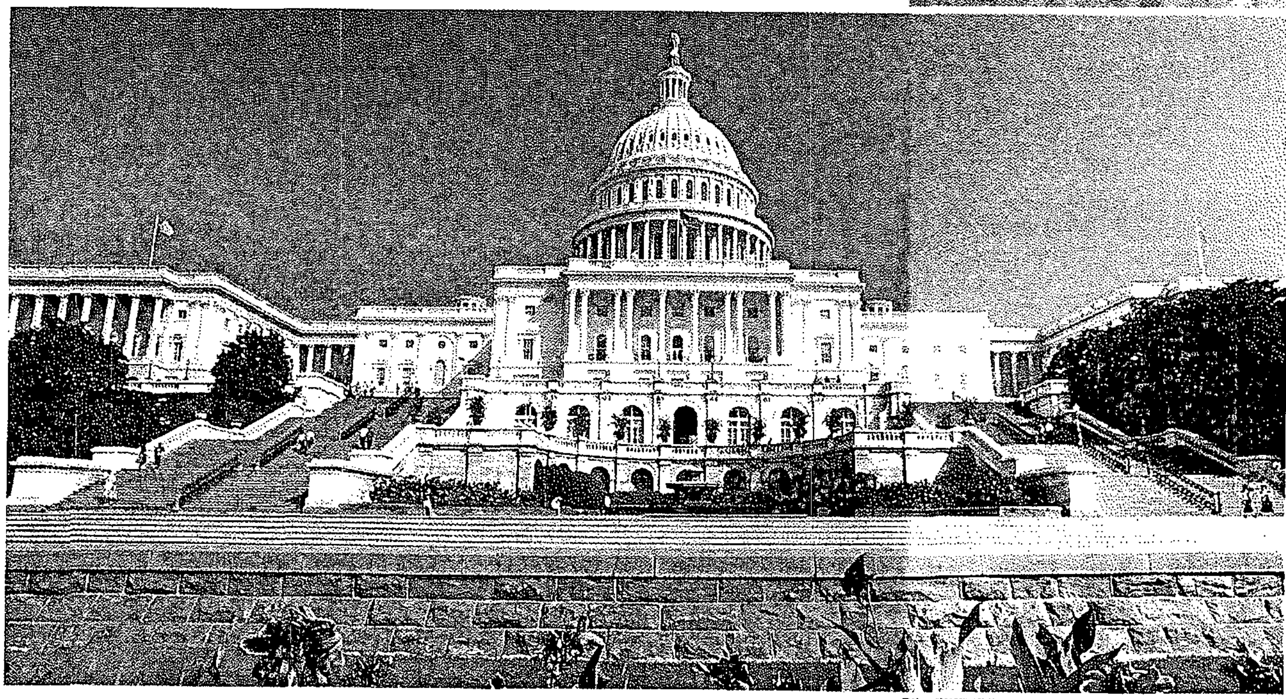




Oil Field Pipe May Contain NORM Scale

What Are the Legal Requirements Governing Disposal of Oil Field Wastes into Salt Caverns?

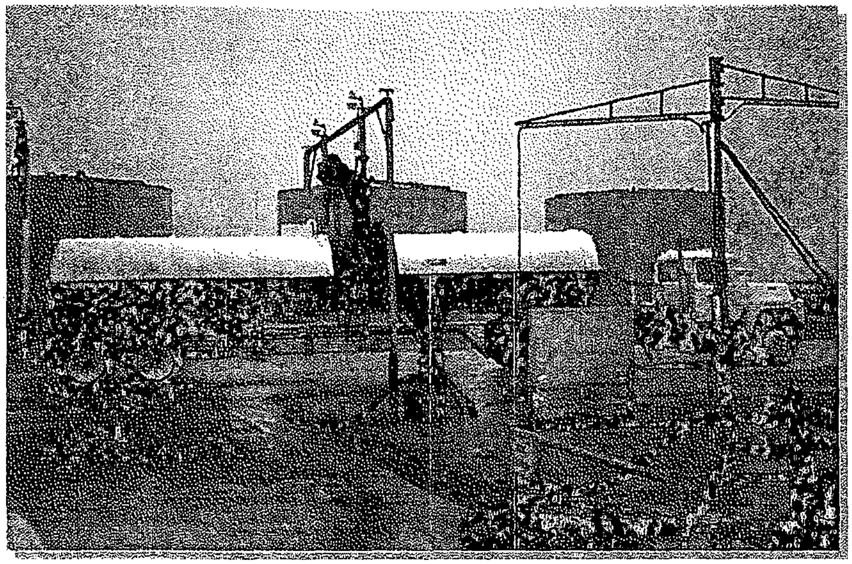
State agencies have the lead responsibility for managing oil field wastes. The federal law covering waste management is the Resource Conservation and Recovery Act (RCRA). Under provisions of RCRA, the U.S. Environmental Protection Agency (EPA) establishes regulations to manage hazardous wastes. In 1988, EPA announced that wastes resulting from exploration and production of oil and gas were exempted from the hazardous waste requirements of RCRA. In other words, these wastes were considered to be nonhazardous. EPA concluded that existing state regulatory programs were generally adequate to control oil field wastes. Since 1988, state waste management programs have been strengthened. All state oil and gas agencies have NOW management requirements, and a few states also have NORM management requirements.



The Underground Injection Control (UIC) program, under the Safe Drinking Water Act, is a federal program that governs disposal of oil field wastes into salt caverns. Wells into which wastes and other fluids are injected are considered to be UIC wells. Injection wells used for disposal of oil field wastes are called Class II injection wells. Many state oil and gas agencies have assumed the authority from EPA to administer Class II injection well programs. These agencies develop state regulations and issue permits or other authorizations for oil field waste disposal. Texas, New Mexico, and Louisiana are currently developing regulations that will specifically govern disposal of oil field wastes into caverns.

Are NOW or NORM Wastes Currently Being Disposed of into Caverns?

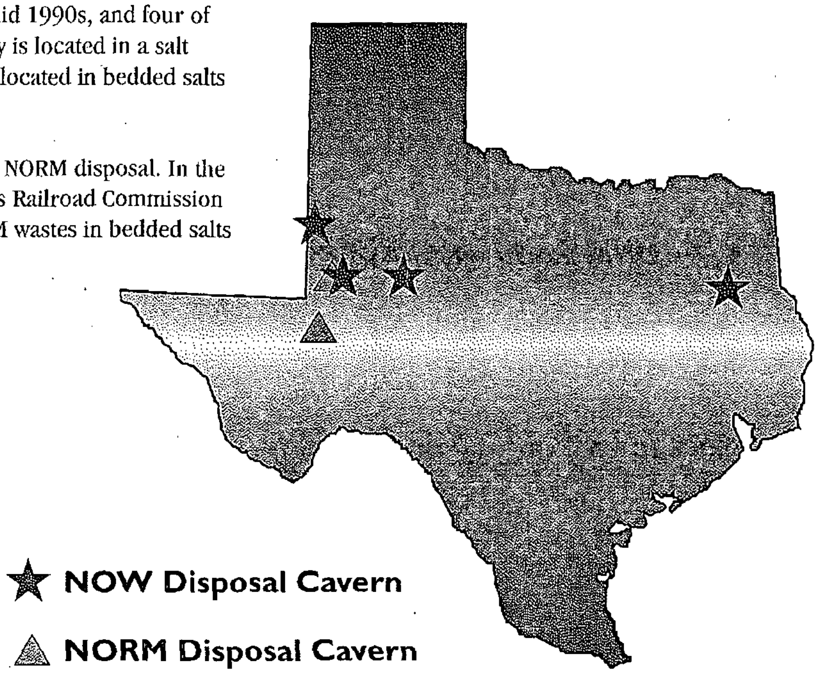
Some caverns have been approved for disposal of NOW and NORM wastes, but a number of conditions must be met. First, there must be a site with suitable salt formations. Second, the appropriate regulatory agency must give approval for the disposal cavern. Finally, the chosen site must be relatively close to where the waste is being generated. The cost of hauling NOW waste more than 50 to 100 miles becomes prohibitive. There are fewer approved NORM disposal sites, and the disposal costs are much higher; therefore, the cost of hauling in relation to the disposal cost is less important, and hauling distances can be greater.



Tanker Loading Brine at a West Texas Cavern facility

Several countries have authorized disposal of NOW into salt caverns. Saskatchewan and Alberta, Canada, have approved several caverns for NOW disposal. Germany has reportedly authorized NOW disposal caverns, and the Netherlands is considering allowing cavern disposal of oil field wastes. In the United States, the Texas Railroad Commission issued permits for six disposal caverns in the mid 1990s, and four of these went into operation. One operating facility is located in a salt dome in eastern Texas, and the other three are located in bedded salts in western Texas.

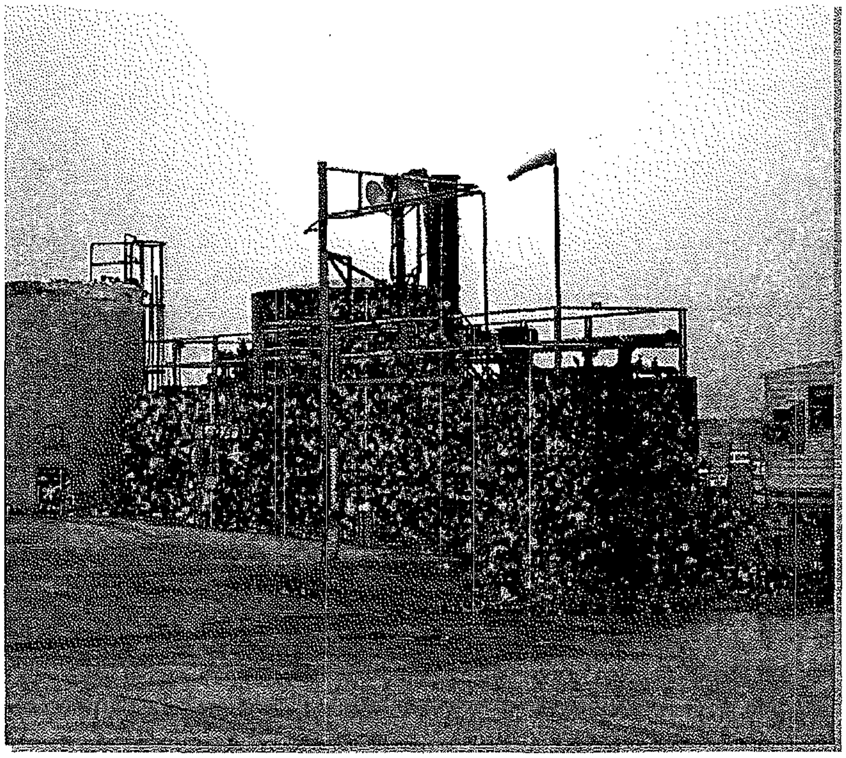
Until early 1999, no caverns were approved for NORM disposal. In the spring and summer of 1999, however, the Texas Railroad Commission issued two permits for cavern disposal of NORM wastes in bedded salts in western Texas.



Location of NOW and NORM Disposal Caverns in Texas (As of September 1999)

How Are Wastes Put into Caverns?

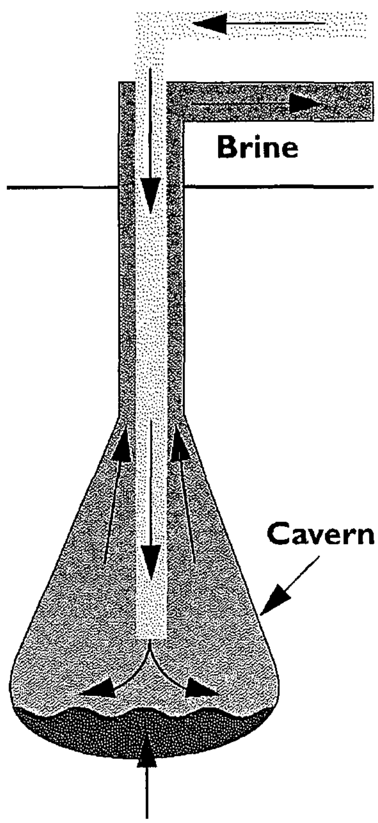
The process that creates caverns leaves them filled with brine. Wastes are brought to the cavern site in trucks and unloaded into mixing tanks, where they are blended with water or brine to make a slurry. Grinding equipment may be used to reduce particle size. The waste slurry is then pumped into the caverns. Each barrel of waste slurry pumped into the cavern displaces a barrel of brine back to the surface. This brine can be sold, if a market exists and the state regulatory agency allows such sales, or can be injected underground in a Class II disposal well.



Waste Blending and Mixing at a West Texas Disposal Cavern

Among the four operating disposal caverns in Texas, three different waste loading practices are followed. Two caverns are operated by injecting wastes through the well tubing and withdrawing brine through the annulus. One cavern operator injects wastes through the annulus and withdraws brine through the tubing. The fourth cavern uses two wells – one to inject waste and the other to remove brine.

Inside the cavern, the solids, oils, and other liquids separate into distinct layers, much like in a bottle of Italian salad dressing. The solids fall to the bottom and form a pile, the oily materials float to the top where they form a protective pad, preventing unwanted dissolving of the cavern roof. The brine and other watery fluids remain in a middle layer.



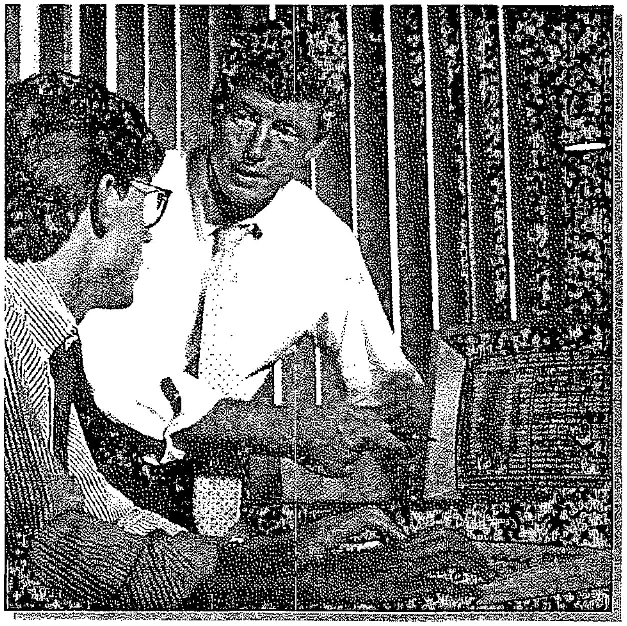
Waste Emplacement Process

What Types of Monitoring Are Appropriate for Disposal Caverns?

To ensure the safe and efficient use of a disposal cavern, it is important to have information on the volume and types of waste that are placed into the cavern, including information on the levels of solids, oil, and water. The water content is important because any water that is not already fully saturated with salt will dissolve away some of the salt from the cavern walls, thereby enlarging the cavern. Cavern enlargement is not a problem, as long as the cavern operator keeps track of how much water is added and how much space is created.

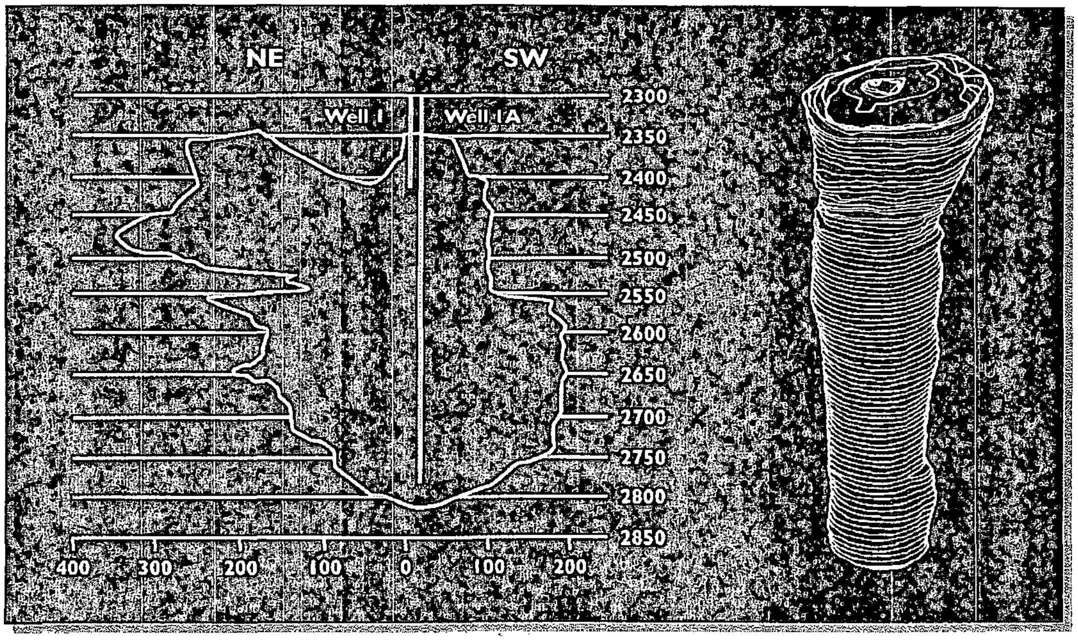
It is also useful to have information about the cavern shape and size. Such information can be obtained by various monitoring methods, such as sonar, that give an indication of the interior dimensions of the cavern.

Another important parameter for monitoring is the internal cavern pressure. Pressure should be monitored before the cavern is filled with waste, while the cavern is being filled, and after the cavern is filled.



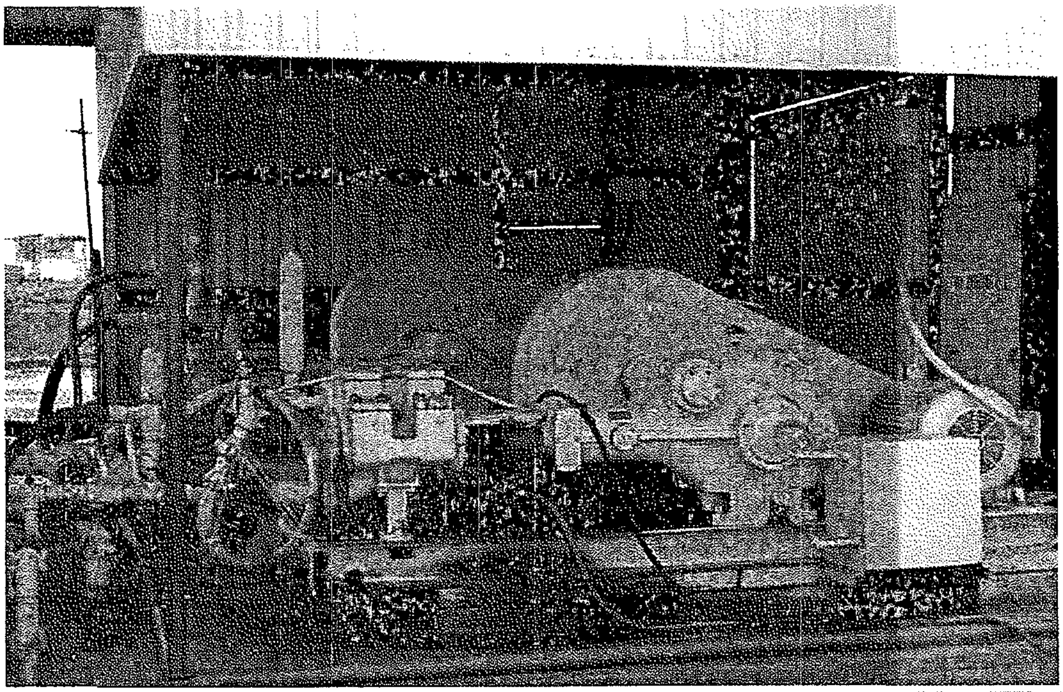
Review of Monitoring Data Helps to Ensure Safe Cavern Operations

Sonar Monitoring Provides Two- and Three-Dimensional Views of Cavern Size and Shape
(Note: These Images Come from Two Different Caverns)



What Happens to the Cavern When It Is Full?

Once the cavern has been filled with waste, the operator will remove the oily layer floating at the top of the cavern, plug the well leading to the cavern, and permanently seal the cavern. During the cavern filling process, the pressure used to inject the waste into the cavern is relatively low. However, once the cavern has been sealed, internal cavern pressure will increase for two reasons. First, the weight of the overlying rock causes the salt formations surrounding the caverns to deform and press against the cavern walls. The salt then slowly flows into the cavern, reducing its volume. This process is known as salt creep. Second, because the temperature of the rocks surrounding the cavern increases with depth, geothermal energy heats the cavern contents, causing them to expand.



Both of these processes cause the internal cavern fluid pressure to rise. Some researchers have suggested that the pressure will increase to a point that the cavern walls crack or leak. Limited field data indicate that even though salt is very nonporous under normal circumstances, when it is subjected to very high pressures, small quantities of fluids from the caverns may migrate into the salt formation surrounding the cavern, thereby relieving the cavern pressure. Since no disposal caverns have been closed anywhere in the world, no actual data exist to show how a disposal cavern will behave following closure. Additional laboratory and field research is underway that will define the extent and effects of the pressure rise.

Injection Pump at a West Texas Disposal Cavern Facility

What Would Happen If Caverns Leak?

Because the issue of whether caverns will leak after they are closed has not been resolved, DOE asked Argonne to predict how caverns might leak and what would be the effects on humans who might drink water contaminated by wastes from cavern leaks.

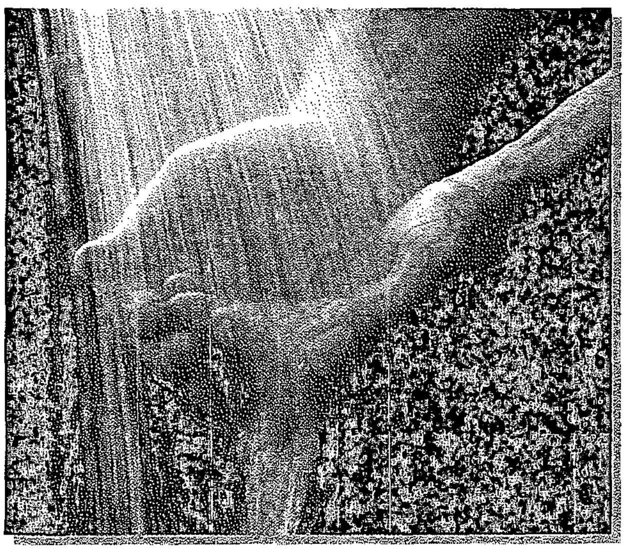
How Might Caverns Leak?

1. A new well could inadvertently be drilled into an old, closed disposal cavern. Some portion of the cavern fluids might mix with the drilling fluids of the well being drilled and be circulated to the surface pit or tank. They might then overflow to the land surface.

2. The plug in the closed cavern well could fail, and fluids could begin moving up the well bore. Fluids could escape if they moved upward behind the well casing or out through holes in the casing either near the depth of the cavern or nearer the surface.

3. Fluids could escape through the sides of the caverns through cracks or, in bedded salts, through the more permeable rock layers between the salt layers.

4. The roof of the cavern could collapse, allowing the cavern fluids to escape. Fluids could move up the well bore and be released at the top of the cavern or nearer the surface.



How Often Will Caverns Leak?

No information is available on the likelihood that any of these events might happen. A group of experts was asked to estimate, on the basis of their knowledge and experience, the probability of each type of failure. These numbers were averaged. To give an indication of the absolutely worst possible situation, Argonne also evaluated a case under which all caverns were assumed to fail.

Type of Leak Event	Probability	
	Most Likely	Least Likely
Inadvertent Intrusion	0.008	0.017
Plug Failure – Deep Leak	0.031	0.120
Plug Failure – Shallow Leak	0.012	0.040
Cracks/Leaky Interbeds	0.022	0.120
Roof Collapse – Deep Leak	0.062	0.163
Roof Collapse – Shallow Leak	0.006	0.051
Roof Collapse – Deep Leak, Plug Intact	0.100	0.290

What Would Happen to Fluids after They Left the Cavern?

If fluids actually left the cavern, it is assumed that they would begin migrating horizontally away from the cavern and could mix with groundwater used for drinking water. Argonne assumed that the first point of human contact would be at a drinking water well located 1,000 feet away from the cavern. Assumptions were made about how rapidly the groundwater would flow toward the well. As the cavern fluids passed through the soils and rocks, various chemical, biological, and physical processes would change the concentration and makeup of the groundwater such that the water eventually reaching the drinking water well would contain a much lower concentration of contaminants than was originally present in the fluids leaving the cavern. Most of the radiological components of NORM wastes would become bound up by soils and rocks such that only very low concentrations of those components would ever reach the drinking water well.

Disposal Cavern Operations Must Protect Drinking Water Quality

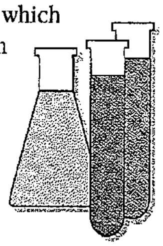
What Are the Risks Posed by Leaks from Caverns?

Argonne estimated the cancer and noncancer risks to humans from drinking water contaminated by fluids leaked from disposal caverns.

Well Heads at a West Texas Disposal Cavern

Cancer Risks

The EPA has established an acceptable cancer risk level of 10^{-4} to 10^{-6}. Risks lower than these levels are considered to be safe. A risk of 10^{-6} means that the event causes one additional cancer case per 1 million persons exposed. As an example of how to interpret these numbers, an event with a risk of 10^{-4} is 100 times more risky than an event with a risk of 10^{-6}. Using the very worst case situation, in which all caverns fail, the estimated cancer risk from NOW and NORM wastes is only 10^{-7} to 10^{-16}. The risk from the radiological components of NORM waste is many times lower at 10^{-13} to 10^{-22}. These levels are all below the EPA's acceptable risk range.



Noncancer Risks

Leaks from disposal caverns might pose additional health risks through causes other than cancer. EPA uses a different methodology, the hazard index, to evaluate these noncancer risks. In this case, EPA's acceptable risk level is a hazard index of less than 1.0. Using the scenario in which all caverns fail, the estimated noncancer risk from NOW and NORM wastes is a hazard index of 10^{-3} to 10^{-7}.

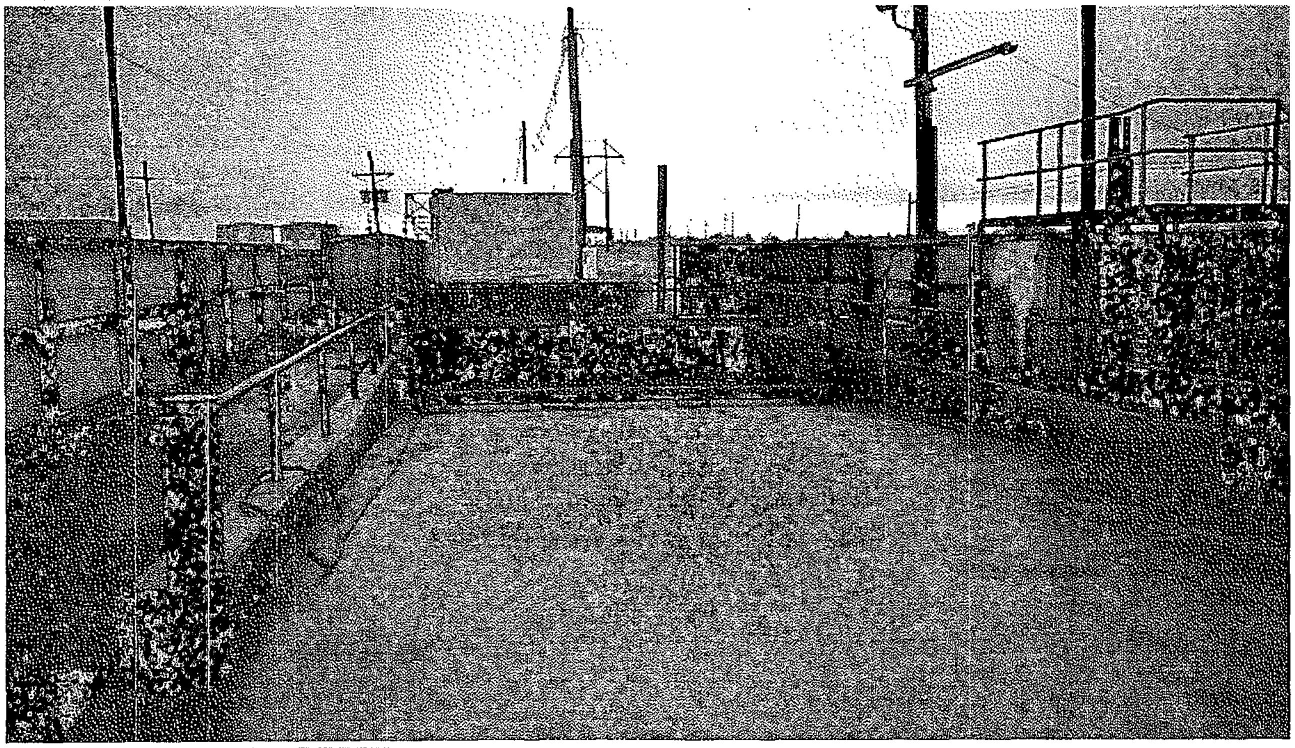
These estimates suggest that cavern disposal poses very low human health risks, even if all caverns leak. The radiological risk, while perceived by the public to be more serious, is actually many orders of magnitude lower than the already low chemical risk.

How Do Disposal Caverns Compare in Cost?

Disposal costs at the four operating NOW disposal caverns in Texas are comparable to or lower than the costs at other types of commercial NOW disposal facilities. The 1997 cavern disposal costs ranged from $1.95 to $6.00 per barrel (bbl) of waste. The 1997 costs at competing Texas and New Mexico commercial treatment facilities are shown below:

Disposal Method	Cost (bbl)
Land Spreading	$5.50 – $16.00
Landfill or Pit Disposal	$2.25 – $3.25
Evaporation	$2.50 – $2.75
Treatment and Injection	$8.50 – $11.00
Cavern Disposal	**$1.95 – $6.00**

Unloading Area at a West Texas Cavern Facility



Most oil field NORM is sent to commercial disposal companies that charge more than $100/bbl to dispose of NORM wastes. It is likely that cavern operators can charge that amount or less for NORM disposal and still be profitable.

Where Can You Get More Information about Salt Caverns?

U.S. Department of Energy

DOE's National Petroleum Technology Office (NPTO) has established a Salt Cavern Information section on its website. The address for that website is: http://www.npto.doe.gov/saltcaverns.

The website provides more detailed information on the topics covered in this brochure and provides links to other useful websites. The NPTO official responsible for salt cavern issues is John Ford; he can be reached by telephone at 918-699-2061 and by e-mail at jford@npto.doe.gov.

DOE's Strategic Petroleum Reserve (SPR) office operates large salt caverns for crude oil storage. Information on SPR's operations is available at http://www.spr.doe.gov.

The State Agencies that Are Developing Salt Cavern Regulations Are:

RAILROAD COMMISSION of TEXAS

Railroad Commission of Texas
Oil and Gas Division
P.O. Box 12967
Austin, TX 78711-2967
www.rrc.state.tx.us

New Mexico Energy, Minerals, and
Natural Resources Department
Oil Conservation Division
2040 S. Pacheco Street
Santa Fe, NM 87505
http://www.emnrd.state.nm.us/ocd/

Louisiana Department of Natural Resources
Office of Conservation
P.O. Box 94275
Baton Rouge, LA 70804-9275
http://www.dnr.state.la.us/CONS/Conserv.ssi

Research Organizations

Several leading research organizations – Argonne National Laboratory, Sandia National Laboratories, the Solution Mining Research Institute (SMRI), and the University of Texas - Bureau of Economic Geology (BEG) – formed the Salt Cavern Research Partnership. For more information about those organizations' salt cavern research programs, contact the following persons:

Organization	Name	Phone	E-mail
Argonne	John Veil	202-488-2450	jveil@anl.gov
Sandia	Jim Linn	505-844-6813	jklinn@sandia.gov
SMRI	Bill Diamond	858-759-7532	smri@solutionmining.org
BEG	Jerry Mullican	512-471-9262	mullicanj@begv.beg.utexas.edu

The Argonne National Laboratory reports that provide much of the baseline information on oil field waste disposal in salt caverns discussed here can be downloaded from the Argonne website at http://www.ead.anl.gov or obtained by calling 202-488-2450.

The other three research organizations have also compiled an extensive body of geological and engineering research on various aspects of salt formations and salt caverns.

National
Petroleum
Technology
Office NPTO

This brochure was produced by Argonne National Laboratory for the U.S. Department of Energy, National Petroleum Technology Office, Under Contract W-31-109-Eng-38 and is intended for educational purposes.

Inside Cover:
Well Head at a West Texas
Oil Field Waste Disposal Cavern

Chavez, Carl J, EMNRD

From:	Chavez, Carl J, EMNRD
Sent:	Tuesday, April 21, 2009 9:57 AM
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; Sanchez, Daniel J., EMNRD
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; kdavis@subsurfacegroup.com
Subject:	FW: Brine well No 6 updated sonar image?

FYI. Thanks Jim.

Carl J. Chavez, CHMM
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1220 South St. Francis Dr., Santa Fe, New Mexico 87505
Office: (505) 476-3490
Fax: (505) 476-3462
E-mail: CarlJ.Chavez@state.nm.us
Website: http://www.emnrd.state.nm.us/ocd/index.htm
(Pollution Prevention Guidance is under "Publications")

From: James_Rutley@blm.gov [mailto:James_Rutley@blm.gov]
Sent: Tuesday, April 21, 2009 9:41 AM
To: Chavez, Carl J, EMNRD
Subject: Brine well No 6 updated sonar image?

Good Morning Carl,

Last Friday, as I was lazily approaching the office after a jalapeno-hot breakfast, my drive was interrupted by the suggestion that an updated sonar revealed that the Cavern at South Y was much larger than originally imaged? Is this true, or are they pulling my leg down here? I heard that they ordered I & W to remove all of their vehicles from the lease? David Herrell and I were asked to inspect an adjacent building to the I & W lease, the Kingdom of Jehovah's Hall on Wednesday, April 15th. They reported to us that the SW part of their building had been developing cracks and were concerned that it was because of the salt cavern 300 feet to the west. Dave and I looked for surface disturbances that we have seen with two previous sinkholes but all we found were gopher holes. They did have cracks in their building and it was on the SW corner, but we did not see any concentric cracks leading back towards the cavern. There was no evidence we could see that related their cracks to the cavern.

I & W has covered their brine location with gravel and there is no way to observe cracks now unless they were obvious ring fractures. The surface near the well does have an undulating feature just to the northeast but no conclusive evidence that is related to the sinkhole. Plus, Dave and I were viewing this feature from about 300 feet. I did walk along the CID right of way behind I & W along the canal. I walked from one east side to the west side of where the potential outermost ring fractures might appear and saw nothing that would alert me. I was surprised that I wasn't met by I & W personnel since I was taking pictures.

In regards to the vote? I am curious about whether this cavern is larger than the 2007 image? If so, its not a matter of if it collapses but when. I would like to see a couple of things, I like the laser idea for the well head and I would also like to see a seismograph installed in a location that can alert authorities in a timely fashion rather than catastrophically. I would like to see the immediate widest circumference of the cavern below fenced off at the surface and a second fence or monuments to mark the angle of repose for that respective cavern size. If the cavern size now compromises the canal, then I would like to see a mitigation plan to divert the water immediately. This cavern could be a monster if they are irrigating and it takes 6 to 10 hours to cut off the flow. I can't imagine the collateral damage that we would incur if that were to happen. When skyscrapers are deemed hazardous, engineers implode the building rather than attempt to repair the aging building? I like the idea of filling the cavern with a material whether its sand, tailings, etc, and being prepared if the disturbance decides to collapse anyway. We are going to have to backfill eventually, might as well attempt to reduce the surface failure by filling it prematurely.

My first concern, as I am sure it is everyone's is protecting the public. I would rather the trigger be us trying to mitigate the collapse rather than the collapse occurring without notice and compromising public safety. If this cavern is allowed to catastrophically fail without our mitigation, the infrastructure that would be compromised, well, I'm not telling you anything you don't know already.

Thanks Carl for your outstanding leadership for this very controversial subject.

Jim

James S. Rutley
Bureau of Land Management
Solid Minerals Geologist
620 East Greene Street
Carlsbad, New Mexico USA
575-234-5904
james_rutley@blm.gov

Chavez, Carl J, EMNRD

From: Chavez, Carl J, EMNRD
Sent: Tuesday, April 21, 2009 8:54 AM
To: George Veni
Cc: 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; 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; kdavis@subsurfacegroup.com; 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; Sanchez, Daniel J., EMNRD
Subject: RE: UIC Class III Brine Evaluation Work Group Draft Report Attached

Thanks for the input George. It is now critical that the Work Group begin chiming in with any recommendation or ideas on the Carlsbad BW. Stay tuned......

Carl J. Chavez, CHMM
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E-mail: CarlJ.Chavez@state.nm.us
Website: http://www.emnrd.state.nm.us/ocd/index.htm
(Pollution Prevention Guidance is under "Publications")

From: George Veni [mailto:gveni@nckri.org]
Sent: Monday, April 20, 2009 8:49 PM
To: Chavez, Carl J, EMNRD
Subject: RE: UIC Class III Brine Evaluation Work Group Draft Report Attached

Carl,

Here is my vote on the options: 1, 2, and 4. They are not mutually exclusive. #1 protects everyone while #2 and 4 (which is a reasonable variation of #2) go into effect. #3 and 5 are not options in my opinion. #3 induces the problem and there is guarantee it will be "controlled." A large hole would still result that will necessitate rerouting the canal and probably one of the highways. #5 may induce the collapse accidentally instead of stopping it.

#1, 2, and 4 do not guarantee a collapse will be prevented, but they will minimize the impact by keeping the potentially affected public at a safe distance. By filling the cavern as much as possible, if they don't stop the collapse, will reduce the depth and diameter of any sinkhole that would develop. Perhaps a catastrophic sinkhole would be reduced to a more manageable and non-life threatening subsidence.

I'll be out for the rest of week but will monitor messages on my Blackberry.

George

From: Chavez, Carl J, EMNRD [mailto:CarlJ.Chavez@state.nm.us]
Sent: Monday, April 20, 2009 6:10 PM
To: Chavez, Carl J, EMNRD; 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; 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; Sanchez, Daniel J., EMNRD
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4) EPA proposal to drill wells into bottom of cavern, seek operator to manage the injection of acceptable oilfield non-hazardous wastes (i.e., BLM tailings, salt wastes from potash companies, drill cuttings, slurry sand, solids, etc.) into cavern over long-term.
5) Salt bath steam concept from bottom to top of cavern?
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Please contact me if you have questions. Thank you.

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New Mexico Energy, Minerals & Natural Resources Dept.
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Office: (505) 476-3490
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E-mail: CarlJ.Chavez@state.nm.us
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From: Chavez, Carl J, EMNRD
Sent: Monday, April 20, 2009 5:46 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'; Sanchez, Daniel J., EMNRD
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Subject: RE: UIC Class III Brine Evaluation Work Group Draft Report Attached
Attachments: NMOCD Class III Brine Well Draft Report 4-20-09.doc

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Chavez, Carl J, EMNRD

From:	Dennis Powers [dwpowers@evaporites.com]
Sent:	Thursday, April 16, 2009 4:40 PM
To:	Lewis Land
Cc:	VonGonten, Glenn, EMNRD; Chavez, Carl J, EMNRD; 'George Veni'; James_Rutley@blm.gov; byrum.charles@epa.gov; Leissner.Ray@epamail.epa.gov; Jones, Brad A., EMNRD; Griswold, Jim, EMNRD; balch@prrc.nmt.edu; rlbeauh@sandia.gov; grkirke@sandia.gov; Veronica.Waldram@wipp.ws; cgherri@sandia.gov; Sanchez, Daniel J., EMNRD; david_herrell@blm.gov; Hall, John, NMENV; Olson, Bill, NMENV
Subject:	Re: Need for Top of Salt Map

The highest halite-bearing formation in southeastern New Mexico and west Texas is the Rustler Formation. While a top of Rustler structure contour map, such as Resource Map 7, is a very useful map, it doesn't directly indicate depth to the top of Rustler nor to the top of salt. As a first approximation, the first salt currently found in the Rustler is generally a little west of the Lea-Eddy County line. It varies for two reasons: 1) limits of original deposition, and 2) more recent dissolution along the margin. With Bob Holt, I have published articles and DOE reports that illustrate this, although I have not drawn a line across all of southeastern New Mexico to delineate the margin of any halite in the Rustler Formation.

The Salado is the next lower salt-bearing formation, and salt exists over all of Lea and most of Eddy County in this unit. The uppermost halites in the Salado are being dissolved across a significant portion of Eddy County, west of the area where Rustler halite is present. Notable examples of the consequences this dissolution include Nash Draw, where the margin of dissolution is narrowly defined (less than 1/2 mile). Most brine wells are developed in the Salado.

Below the Salado is the Castile Formation. Within the Delaware Basin, west of the Pecos River, this formation is at relatively shallow depths. Some brine production has come from this unit I believe, in the past. The Castile famously crops out on US 62/180 near the NM-TX border.

Rick Beauheim presented a contour map of depth to top of Salado (overburden) that I prepared for him from my database. It incorporated more than 1900 data points, but they are not equally distributed. They are very much skewed to the WIPP site and Delaware Basin. I made a few comments about the map and data on Thursday at the meeting.

This map provides a broad view of depth to first salt in eastern Eddy County. It is not perfect by any means, for several reasons: 1) the top of Salado is a stratigraphic concept that is not based on "top of salt". West of the Eddy-Lea county lines, however, it's a fair approximation because there is Rustler halite mainly near the county line. In some areas, however, salt can be quite a bit deeper because of the accumulation of solution residue at the top of the Salado, and this residue includes no salt.

East of the Lea-Eddy County line the uppermost salt is normally in the Rustler Formation. Net salt thickness can be more than 200 ft, although most of it is in the middle member

(Tamarisk). Nevertheless, upper Salado is more likely a favorable target because of the purity and thickness of halite units.

A good map of depth to top of salt or depth to top of Salado is not difficult to do, as Bob Holt and I have provided the means of interpreting the Rustler halite reasonably well from geophysical logs. The detail required for such a map needs to be carefully considered, however, because the amount of work required differs signficantly. My map required a few hours to develop and contour, but I only used my available data. And, as mentioned, it is less detailed toward the west. Given the known solution and collapse features along the Pecos Valley, I would expect a map along the valley to be very complicated. Given the resource the river provides, I would suggest that any proposed brine well within the immediate Pecos Valley be made a special case with special study of the particular location to determine suitability.

All that said, I would enjoy preparing such a map, under the right circumstances, because it would be a natural extension of what I already do and have done. I cannot afford on my own to do an extended and much more detailed map, however, so I would imagine the most useful thing I can do is offer encouragement and try to accommodate requests if someone else needs help in how to interpret geophysical logs to obtain a more detailed map.

A pdf file (oversize format) of the figure presented by Rick Beauheim is available at the following url:

http://www.evaporites.com/OCDbrinewells/Saladodepth.pdf

The file is ~2 MB. In includes the layer with contours, a layer showing the data point locations and distribution, a layer with some road and "culture", and a layer with a background topographic map that also has some scaling lines that haven't been removed. If you open it with a recent Acrobat Reader, you should be able to click on the layer icon (left side, third from top) and turn on or off some of the background. It is set for simple map view without data locations or the topo background.

****

Dennis W. Powers, Ph.D.
Consulting Geologist
140 Hemley Road
Anthony, TX 79821

TEL: 915.877.3929
CELL: 915.588.7901

Licensed Professional Geologist (IL)
Professional Geologist (TX)

Some things get better with age . . .
I'm approaching magnificent!

Lewis Land wrote:

Hi Glenn. I contacted Ron Broadhead, our petroleum geologist at the Bureau, and he advised me that the closest thing we have to a regional Salado structure map is Resource Map 7, Structure contours on the top of the Rustler Formation. I don't think a digital version is available, but you can purchase the paper copy from the Bureau's publications office (I have a paper copy in front of me right now). Disclaimer: The map is about 30 years old, and the Rustler formation top I got from the first collapsed brine well (220 ft bgl, or 3300 ft asl, based on the drillers log, since there was no geophysical log available for that well) is not in good agreement with the structural contours on the map.

The structural discrepancy is so great - more than 200 ft low relative to a couple of wells 1 mile east that should be downdip - that I would have mapped the Jim's water service well as a closed low on the structure map. Bill Hiss, the guy who made the original map in 1976, probably didn't include this well on his map because it didn't have a geophysical log. However, if you study the map you'll see quite a few anomalous closed lows, which probably reflect subsurface dissolution and subsidence in the underlying Salado formation in the geologic past. The JWS well and sinkhole are in line with a NNW trending chain of depressions on the top of the Rustler that roughly parallels the Pecos River. Let me be clear on this point (to paraphrase our new pres), I have no doubt that Jim's sinkhole is anthropogenic, but its location with respect to the subsidence trough to the southeast invites speculation about the relationship of the collapse to pre-existing subsidence features.

Lewis Land

NMBGMR/NCKRI

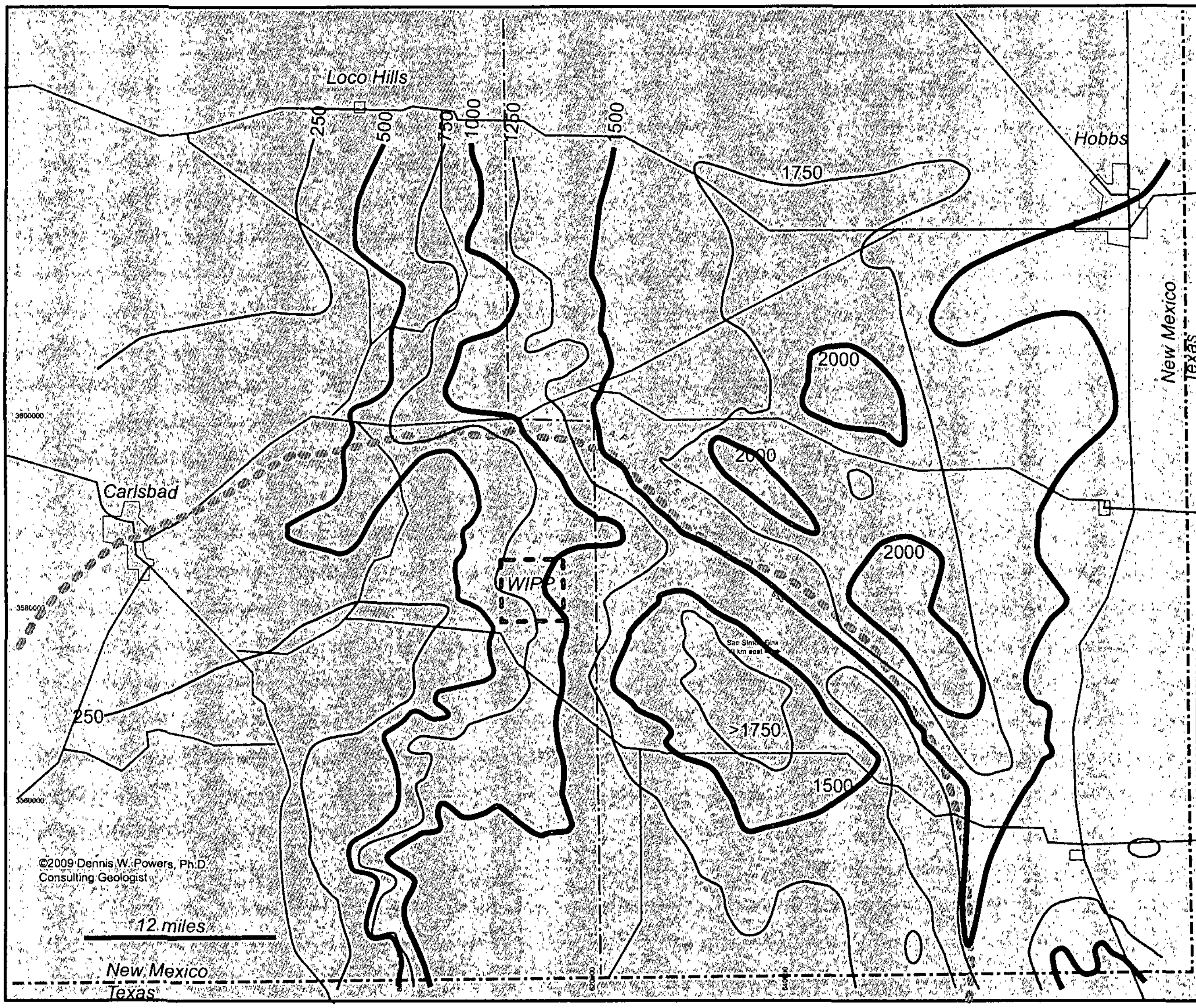
From: VonGonten, Glenn, EMNRD [mailto:Glenn.VonGonten@state.nm.us]
Sent: Thursday, April 16, 2009 10:36 AM
To: Chavez, Carl J, EMNRD; George Veni; James Rutley@blm.gov; byrum.charles@epa.gov; Leissner.Ray@epamail.epa.gov; hugh.harvey@intrepidpotash.com; lmolleur@keyenergy.com; Jones, Brad A., EMNRD; 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; Sanchez, Daniel J., EMNRD
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
Subject: RE: Brine Well Work Group Update - Need for Top of Salt Map

All,

If you have any regional scale Top of Salt maps, please send them to us to place on the BW999 file. This may be very critical information for OCD to consider.

Thanks,

Glenn von Gonten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New Mexico
Texas
New Mexico
Texas
©2009 Dennis W. Powers, Ph.D.
Consulting Geologist
12 miles

From: Lewis Land [lland@nckri.org]
Sent: Thursday, April 16, 2009 2:47 PM
To: VonGonten, Glenn, EMNRD; Chavez, Carl J, EMNRD; 'George Veni'; James_Rutley@blm.gov; byrum.charles@epa.gov; Leissner.Ray@epamail.epa.gov; Jones, Brad A., EMNRD; Griswold, Jim, EMNRD; balch@prrc.nmt.edu; rlbeauh@sandia.gov; grkirke@sandia.gov; Veronica.Waldram@wipp.ws; cgherri@sandia.gov; dwpowers@evaporites.com; Sanchez, Daniel J., EMNRD
Cc: david_herrell@blm.gov; Hall, John, NMENV; Olson, Bill, NMENV
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Lewis Land
NMBGMR/NCKRI

From: VonGonten, Glenn, EMNRD [mailto:Glenn.VonGonten@state.nm.us]
Sent: Thursday, April 16, 2009 10:36 AM
To: Chavez, Carl J, EMNRD; George Veni; James_Rutley@blm.gov; byrum.charles@epa.gov; Leissner.Ray@epamail.epa.gov; hugh.harvey@intrepidpotash.com; lmolleur@keyenergy.com; Jones, Brad A., 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; Sanchez, Daniel J., EMNRD
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
Subject: RE: Brine Well Work Group Update - Need for Top of Salt Map

All,

If you have any regional scale Top of Salt maps, please send them to us to place on the BW999 file. This may be very critical information for OCD to consider.

Thanks,

Glenn von Gonten

This inbound email has been scanned by the MessageLabs Email Security System.

Chavez, Carl J, EMNRD

From: Mike Cochran [mcochran@kdheks.gov]
Sent: Thursday, April 16, 2009 12:27 PM
To: Chavez, Carl J, EMNRD; George Veni; James_Rutley@blm.gov; byrum.charles@epa.gov; Leissner.Ray@epamail.epa.gov; hugh.harvey@intrepidpotash.com; lmolleur@keyenergy.com; Jones, Brad A., 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; Sanchez, Daniel J., EMNRD
Cc: Jeffrey Hand; Kirk Hoeffner; 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
Subject: RE: Brine Well Work Group Update

Good afternoon all.

We will try and make some comments tomorrow or at least within the next few days on some of the material that has been distributed, based on our experiences in Kansas. One experience though is that trying to fill a cavern with a material other than saturated brine is a difficult, if not impossible task, and if not filled completely to support the roof does not really accomplish much.

Mike,

I have a new e-mail address: mcochran@kdheks.gov

Michael H. Cochran, Licensed Geologist
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Website = www.kdheks.gov/geo

"A good plan today is better than a great plan tomorrow." -General George S. Patton

---

From: Chavez, Carl J, EMNRD [mailto:CarlJ.Chavez@state.nm.us]
Sent: Thursday, April 16, 2009 11:23 AM
To: George Veni; James_Rutley@blm.gov; byrum.charles@epa.gov; Leissner.Ray@epamail.epa.gov; hugh.harvey@intrepidpotash.com; lmolleur@keyenergy.com; Jones, Brad A., 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;

Sanchez, Daniel J., EMNRD
Cc: Jeffrey Hand; Kirk Hoeffner; Mike Cochran; 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
Subject: RE: Brine Well Work Group Update

Thanks George for commenting and promoting dialogue on Mr. Ken Parker's (Western Refining L.P.) idea about the steam bath to precipitate out brine in the salt cavern to fill it up.

Some comments below provided by Mr. John Voigt (Solution Mining Research Institute) Ken's idea or concept are:

1) It would be a very slow process to address immediate needs. Could introduce brine from evaporation ponds at 120F with pumps and circulate cooler brine out while introducing 120F brine from solar heated ponds into the well, but again long process that needs engineering........
2) If there is concern about a collapse of the cavern, may want to keep away from it.
3) Filling up the cavern with this process is going to be extremely expensive from an energy standpoint.

Another idea that we discussed may be to induce a collapse under controlled conditions. New Mexico Tech may offer advice on controlled explosives placed downhole to make it happen safely. However, as I recall the work group was concerned about surface water and conduits for fresh water to further dissolve the salt at the surface and inducing a collapse would allow a fresh recharge condition to occur directly into the salt and may cause other fresh water dissolution of salt problems .

My thoughts, sometimes, besides taking precautions to restrict access and keep trespassers away (also act to assess the risk to the nearby population and take steps based on safety) from the area of concern, it may be best to focus on restricting access, initiate monitoring techniques (may drill back into well), keep brine cavern full, and collect data and think about it more. Sometimes, the best solution is to do nothing and focus on restricting access and creating a safe zone in the area coupled with monitoring and early detection. Maybe in addition to addressing public safety, we need to focus on a contingency plan for what we need to do after it collapses with safe zone considerations?

Thanks.

Carl J. Chavez, CHMM
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E-mail: CarlJ.Chavez@state.nm.us
Website: http://www.emnrd.state.nm.us/ocd/index.htm
(Pollution Prevention Guidance is under "Publications")

From: George Veni [mailto:gveni@nckri.org]
Sent: Wednesday, April 15, 2009 10:34 PM
To: Chavez, Carl J, EMNRD; James_Rutley@blm.gov; byrum.charles@epa.gov; Leissner.Ray@epamail.epa.gov; hugh.harvey@intrepidpotash.com; lmolleur@keyenergy.com; Jones, Brad A., 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; Sanchez, Daniel J., EMNRD
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Subject: RE: Brine Well Work Group Update

Carl,

The idea below makes me nervous. Heated water will increase the ability of the water to dissolve more salt. Assuming it is carefully controlled to not produce an undersaturated solution, I then wonder about steam produced. Steam is more likely to be undersaturated. While the intent will be to release it up the well, it may also collect along the cavern roof, inject itself into any fractures, and as an undersaturated solution it would dissolve more salt along the roof and increase the risk of collapse. A blanket would certainly reduce this possibility, but how much might the cavern be widened below a blanket and again increase the risk of collapse?

Assuming the above concerns are adequately addressed, I expect the amount of energy needed to heat that volume of water, and the surrounding rock mass to maintain the temperature for the desired effect, will be substantial and expensive. When considered with the price of bringing in brine, or water and salt to create brine, I suspect that simply bringing in salt to fill the cavern will be cheaper, easier, and with a lower risk of triggering a collapse. It would be good if someone could provide actual cost figures for the various scenarios for real comparisons.

George

****

George Veni, Ph.D.
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From: Chavez, Carl J, EMNRD [mailto:CarlJ.Chavez@state.nm.us]
Sent: Tuesday, April 14, 2009 2:23 PM

Concept or Idea:

Introduce hot brine water into salt cavern and raise temperature causing the evaporation of water and formation of solid salt from vaporization. Keep adding hot brine water that turns into steam. Calculate shrinkage and add more brine water during process. When solidified, shut off and let cavern cool. The salt fluid will become solid. A salt water bath heater would allow operator to run at a higher temperature.

How could you heat so much water? Could run 2-strings of tubing and work 2-3 ft. sections at a time from bottom to top of cavern; thus, heating a more localized area than the entire cavern at once.

I have used salt water baths to bring up temperature slowly to get molten or super heated salt. At atmospheric temperatures, I had to achieve >300 F or more for solidification or evaporation of salt to occur. Release steam out of water to condense the salt. Temperature is hot enough to solidify. If too big of a cavern volume with fluids, must work in increments from bottom to top. A 2-well system may work fine for this?

If you attempt to pump in salt slurry waste through tubing to fill salt cavern, solids may bulk near tubing at the bottom of the hole, but may not bulk evenly up the cavern as you fill salt slurry or solids into the cavern. Using sand when I worked for a frac company required > 10,000 psi to inject 1M lbs of sand into the formation, but this is an open cavern so the pressure may not be an issue and sand may work?

Boil fresh water out of salt. Slowly heat up entire volume of fluid in cavern or do it incrementally from bottom to top to solidify upward applying heat in 4-5 ft. increments. Allow bottom zone to cool down and evaporate salt. Example, brine pond where solid salt on top of pond falls to bottom of pond in sunlight and effect would be similar at the bottom of the salt cavern. Salt flakes create a solid salt bottom.

Engineers may find comprehensive pros and cons that may make this process infeasible?

Pros:

Using the existing brine water in the cavern.
Wouldn't have to use as much tailings waste from other companies fill void.

Cons:

Shrinkage as brine fluid is evaporated in salt cavern
Brine water or make-up water needed to continue process
Scale of bath water heater large w/ gas burner energy source,
Evaporating fluid source in brine cavern during the process, which may require make-up water for process to work.
Have to drill a 2-well system above salt cavern, which may collapse.

Let the work group know if you have any comments or recommendations on this idea? Also, if you have any ideas to share with the group in plugging a brine well cavern, we would like to know.

Please contact me if you have questions. Thank you.

Carl J. Chavez, CHMM
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1220 South St. Francis Dr., Santa Fe, New Mexico 87505
Office: (505) 476-3490
Fax: (505) 476-3462
E-mail: CarlJ.Chavez@state.nm.us
Website: http://www.emnrd.state.nm.us/ocd/index.htm
(Pollution Prevention Guidance is under "Publications")

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Chavez, Carl J, EMNRD

From: Chavez, Carl J, EMNRD
Sent: Thursday, April 16, 2009 11:48 AM
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'; Sanchez, Daniel J., EMNRD
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; 'kdavis@subsurfacegroup.com'
Subject: FW: Brine Well Work Group Update

FYI.

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E-mail: CarlJ.Chavez@state.nm.us
Website: http://www.emnrd.state.nm.us/ocd/index.htm
(Pollution Prevention Guidance is under "Publications")

From: john.o.voigt@gmail.com [mailto:john.o.voigt@gmail.com] **On Behalf Of** John Voigt
Sent: Thursday, April 16, 2009 11:34 AM
To: Chavez, Carl J, EMNRD
Subject: Re: Brine Well Work Group Update

Well done Carl, Thanks for writing the thoughts up, without stepping on any toes...
It was good to actually discuss this in person with you anyway. The unique situation of a given cavern can determine what is best or most practical: is risk perceived as short term serious threat, or pretty stable for now (which might allow the long time necessary for backfilling or even longer recrystallization).

Only additional thing I mentioned - Heat: is that the hotter the cavern/salt, the faster the salt creep/closure, so it could accelerate the process, even towards failure if it is close.

...John

On Thu, Apr 16, 2009 at 12:22 PM, Chavez, Carl J, EMNRD <CarlJ.Chavez@state.nm.us> wrote:

Thanks George for commenting and promoting dialogue on Mr. Ken Parker's (Western Refining L.P.) idea about the steam bath to precipitate out brine in the salt cavern to fill it up.

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Thanks.

Carl J. Chavez, CHMM

New Mexico Energy, Minerals & Natural Resources Dept.

Oil Conservation Division, Environmental Bureau

1220 South St. Francis Dr., Santa Fe, New Mexico 87505

Office: (505) 476-3490

Fax: (505) 476-3462

E-mail: CarlJ.Chavez@state.nm.us

Website: http://www.emnrd.state.nm.us/ocd/index.htm

(Pollution Prevention Guidance is under "Publications")

From: George Veni [mailto:gveni@nckri.org]
Sent: Wednesday, April 15, 2009 10:34 PM
To: Chavez, Carl J, EMNRD; James_Rutley@blm.gov; byrum.charles@epa.gov; Leissner.Ray@epamail.epa.gov; hugh.harvey@intrepidpotash.com; lmolleur@keyenergy.com; Jones, Brad A., 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; Sanchez, Daniel J., EMNRD
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
Subject: RE: Brine Well Work Group Update

Carl,

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Assuming the above concerns are adequately addressed, I expect the amount of energy needed to heat that volume of water, and the surrounding rock mass to maintain the temperature for the desired effect, will be substantial and expensive. When considered with the price of bringing in brine, or water and salt to create brine, I suspect that simply bringing in salt to fill the cavern will be cheaper, easier, and with a lower risk of triggering a collapse. It would be good if someone could provide actual cost figures for the various scenarios for real comparisons.

George

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George Veni, Ph.D.

Executive Director

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001-210-863-5919 (mobile)

001-413-383-2276 (fax)

From: Chavez, Carl J, EMNRD [mailto:CarlJ.Chavez@state.nm.us]
Sent: Tuesday, April 14, 2009 2:23 PM

Concept or Idea:

Introduce hot brine water into salt cavern and raise temperature causing the evaporation of water and formation of solid salt from vaporization. Keep adding hot brine water that turns into steam. Calculate shrinkage and add more brine water during process. When solidified, shut off and let cavern cool. The salt fluid will become solid. A salt water bath heater would allow operator to run at a higher temperature.

How could you heat so much water? Could run 2-strings of tubing and work 2-3 ft. sections at a time from bottom to top of cavern; thus, heating a more localized area than the entire cavern at once.

I have used salt water baths to bring up temperature slowly to get molten or super heated salt. At atmospheric temperatures, I had to achieve >300 F or more for solidification or evaporation of salt to occur. Release steam out of water to condense the salt. Temperature is hot enough to solidify. If too big of a cavern volume with fluids, must work in increments from bottom to top. A 2-well system may work fine for this?

If you attempt to pump in salt slurry waste through tubing to fill salt cavern, solids may bulk near tubing at the bottom of the hole, but may not bulk evenly up the cavern as you fill salt slurry or solids into the cavern. Using sand when I worked for a frac company required > 10,000 psi to inject 1M lbs of sand into the formation, but this is an open cavern so the pressure may not be an issue and sand may work?

Boil fresh water out of salt. Slowly heat up entire volume of fluid in cavern or do it incrementally from bottom to top to solidify upward applying heat in 4-5 ft. increments. Allow bottom zone to cool down and evaporate salt. Example, brine pond where solid salt on top of pond falls to bottom of pond in sunlight and effect would be similar at the bottom of the salt cavern. Salt flakes create a solid salt bottom.

Engineers may find comprehensive pros and cons that may make this process infeasible?

Pros:

Using the existing brine water in the cavern.

Wouldn't have to use as much tailings waste from other companies fill void.

Cons:

Shrinkage as brine fluid is evaporated in salt cavern

Brine water or make-up water needed to continue process

Scale of bath water heater large w/ gas burner energy source,

Evaporating fluid source in brine cavern during the process, which may require make-up water for process to work.

Have to drill a 2-well system above salt cavern, which may collapse.

Let the work group know if you have any comments or recommendations on this idea? Also, if you have any ideas to share with the group in plugging a brine well cavern, we would like to know.

Please contact me if you have questions. Thank you.

Carl J. Chavez, CHMM

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John O. Voigt
Executive Director
Solution Mining Research Institute
105 Apple Valley Circle
Clarks Summit, PA 18411 USA

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e-mail: jvoigt@solutionmining.org
john.o.voigt@gmail.com

This inbound email has been scanned by the MessageLabs Email Security System.

Chavez, Carl J, EMNRD

From:	VonGonten, Glenn, EMNRD
Sent:	Thursday, April 16, 2009 10:36 AM
To:	Chavez, Carl J, EMNRD; 'George Veni'; 'James_Rutley@blm.gov'; 'byrum.charles@epa.gov'; 'Leissner.Ray@epamail.epa.gov'; 'hugh.harvey@intrepidpotash.com'; 'lmolleur@keyenergy.com'; Jones, Brad A., 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'; Sanchez, Daniel J., EMNRD
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
Subject:	RE: Brine Well Work Group Update - Need for Top of Salt Map

All,

If you have any regional scale Top of Salt maps, please send them to us to place on the BW999 file. This may be very critical information for OCD to consider.

Thanks,

Glenn von Gonten

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Sent: Thursday, April 16, 2009 10:23 AM
To: George Veni; James_Rutley@blm.gov; byrum.charles@epa.gov; Leissner.Ray@epamail.epa.gov; hugh.harvey@intrepidpotash.com; lmolleur@keyenergy.com; Jones, Brad A., 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; Sanchez, Daniel J., EMNRD
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From: Chavez, Carl J, EMNRD [mailto:CarlJ.Chavez@state.nm.us]
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Introduce hot brine water into salt cavern and raise temperature causing the evaporation of water and formation of solid salt from vaporization. Keep adding hot brine water that turns into steam. Calculate shrinkage and add more brine water

recommendations to the Oil Conservation Commission for a safe path forward. The report should be completed by May 1, 2009.

"The moratorium will provide time to properly evaluate the causes of the recent collapses and to discuss the development of new rules or guidelines to ensure the safety and stability of brine well systems," added Secretary Prukop.

The moratorium will only aflect new wells and will not impact existing wells and facilities.

Brine Well Salt Cavern Plug Concept or Idea: Ken Parker (Western Refining L.P.) wants to share a possible brine well cavern plug concept or idea with the work group, which may be considered for filling the void space in brine well salt caverns like BW-6 in Carlsbad. This is just an idea that may be feasible to consider by the work group. Anyone else with a possible options may reply to this e-mail and provide the concept to the rest of the work group.

Concept or Idea:

Introduce hot brine water into salt cavern and raise temperature causing the evaporation of water and formation of solid salt from vaporization. Keep adding hot brine water that turns into steam. Calculate shrinkage and add more brine water during process. When solidified, shut off and let cavern cool. The salt fluid will become solid. A salt water bath heater would allow operator to run at a higher temperature.

How could you heat so much water? Could run 2-strings of tubing and work 2-3 ft. sections at a time from bottom to top of cavern; thus, heating a more localized area than the entire cavern at once.

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Engineers may find comprehensive pros and cons that may make this process infeasible?

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Using the existing brine water in the cavern.
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Scale of bath water heater large w/ gas burner energy source,
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Have to drill a 2-well system above salt cavern, which may collapse.

Let the work group know if you have any comments or recommendations on this idea? Also, if you have any ideas to share with the group in plugging a brine well cavern, we would like to know.

Please contact me if you have questions. Thank you.

Carl J. Chavez, CHMM
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[attachment "OCD Press Release 1.pdf" deleted by Ray Leissner/R6/USEPA/US] [attachment "OCD Press Release 2.pdf" deleted by Ray Leissner/R6/USEPA/US]

Chavez, Carl J, EMNRD

From: Leissner.Ray@epamail.epa.gov
Sent: Thursday, April 16, 2009 7:20 AM
To: Chavez, Carl J, EMNRD
Cc: Dellinger.Philip@EPA.GOV; Wright.Larry@EPA.GOV
Subject: Proposal
Attachments: filltechniquediag.pdf

Carl,

Thanks for keeping us updated. As a group we tend to think that the evaporation process described below would be cost prohibitive due to BTU consumption, take too long to complete, and increase the risk of collapse by removing existing brine from the cavern.

We agree with NM's desire to fill the cavern if a feasible means can be obtained. We have a proposal. But before we describe it, we suggest that before a closure plan for the cavern can be truly considered, the dimensions and shape of the cavern needs to be determined as best as possible. This data will more than likely drive NM's decision to fill the cavern and the technique to do so.

Drawing from our current "vision" of the cavern's structure, we suspect the cavern to have multiple beds or "plates" of anhydrite extending into the cavern's central area. This is a reasonable conclusion given the reports that anhydrite beds hindered the sonar logging. If this vision is confirmed by the initial cavern characterization, we propose the cavern might be filled satisfactorily by using four+ wells, offset and encircling the cavern's perimeter, drilled at a slant into the base of the cavern. These wells could be constructed with perforated or slotted casing through all anhydrite beds extending into the cavern. One could use tubing and packer to ensure used salt-based drilling muds could be distributed as much as possible below and behind all beds before moving up hole to fill the next target zone. We believe used drilling muds are the best candidate for the purpose as they would be cheap and have good gel strength, low compressibility, ability to spread and will eventually solidify. Polymer enhancement could be considered as well. The four wells' effectiveness could be enhanced by using them in partnership, allowing one well to inject while another acts as a "bleed" thus helping to distribute the drilling muds throughout the zone. The wells should be drilled at a slant to keep the rig off of shaky ground, another reason to determine the dimensions. To convey our thought, see the idealized rough sketch diagram I've attached.

There are unknowns with this idea as well but the use of "free" used drilling mud from an industry who I'm sure would like the opportunity to turn this into a positive public perception rather than a negative one seems plausible. If implemented this proposal could take years to complete but there might be a means to encourage out-of-state participation as well. I envision that the State could utilize supplemental environmental projects rather than monetary fines to bring more drilling muds to the project. Another incentive, the operator could take ownership of the brine his used drilling fluids displaced. Perhaps a mud manufacturing facility could be engaged in the process, taking the displaced brine to make new mud. It's a process that could take some time and that's a factor to be considered but I suspect the up-front cost might be palatable and get the ball rolling. Once the initial investment is absorbed, the operation might prove fairly low cost to maintain until the job is complete.

If NMOCD finds merit in this proposal, feel free to share it with the group. Thanks

Ray Leissner, Env. Eng.
Ground Water / UIC Section (6WQ-SG)
(214) 665 - 7183
USEPA, Region 6

Brine Well Work Group Update

Chavez, Carl J, EMNRD	to:	James_Rutley, Charles Byrum, Ray Leissner, hugh.harvey, lmolleur, gveni, Jones, Brad A., EMNRD, Chavez, Carl J, EMNRD, VonGonten, Glenn, EMNRD, Griswold, Jim, EMNRD, Kostrubala, Thaddeus, balch, leo.vansambeek, rlbeauh, grkirke, reitze, mcartwright, dave.hughes, Allen.Hains, ken.parker, Ron.Weaver, Veronica.Waldram, RichardM, cgherri, dwsnow, lyn.sockwell, dwpowers, Sanchez, Daniel J., EMNRD	04/14/2009 03:23 PM

Cc: jhand, khoeffner, mcochran, jvoigt, douglas.johnson, joeb, psbriggs, david_herrell, lland, douglas.johnson, gary.wallace, "Hall, John, NMENV", "Olson, Bill, NMENV"

Ladies & Gentlemen:

Good afternoon. Sorry for not getting the brine strategy document updated sooner. Please find attached some recent developments on the I&W brine well (BW-006) in Carlsbad, NM which took place shortly after the brine well work group meeting on 3/26-27/2009. The work group's concerns and presentations were instrumental and guided the OCD through presentations with Homeland Security, NMDOT, Eddy County, and other entities to drive a path forward with respect to those brine well group concerns we discussed during the meetings. In addition, brine well operators have been contacted and instructed to produce brine through the annulus until further notice. Thank you for your valuable input.

Brine Well Strategy:

I am working on sending out the brine well strategy document from March 27, 2009 in the very near future (today or tomorrow). I will place the brine well strategy under the "Brine Well Strategy" thumbnail at "BW-999." I hope that you will take some time to look it over and provide any additional comments/recommendations to consider for the strategy and that the work group can consider in the final report.

Draft Report:

As you know, the OCD is working on a report to the Oil Conservation Commission due May 1, 2009. The final report date is fast approaching. I will place an OCD draft report in the "Draft Report" thumbnail at "BW-999" on OCD Online (see Moratorium Press Release below on report objectives). This will require the work group to work fast to provide any final comments or recommendations on the report to the OCD.

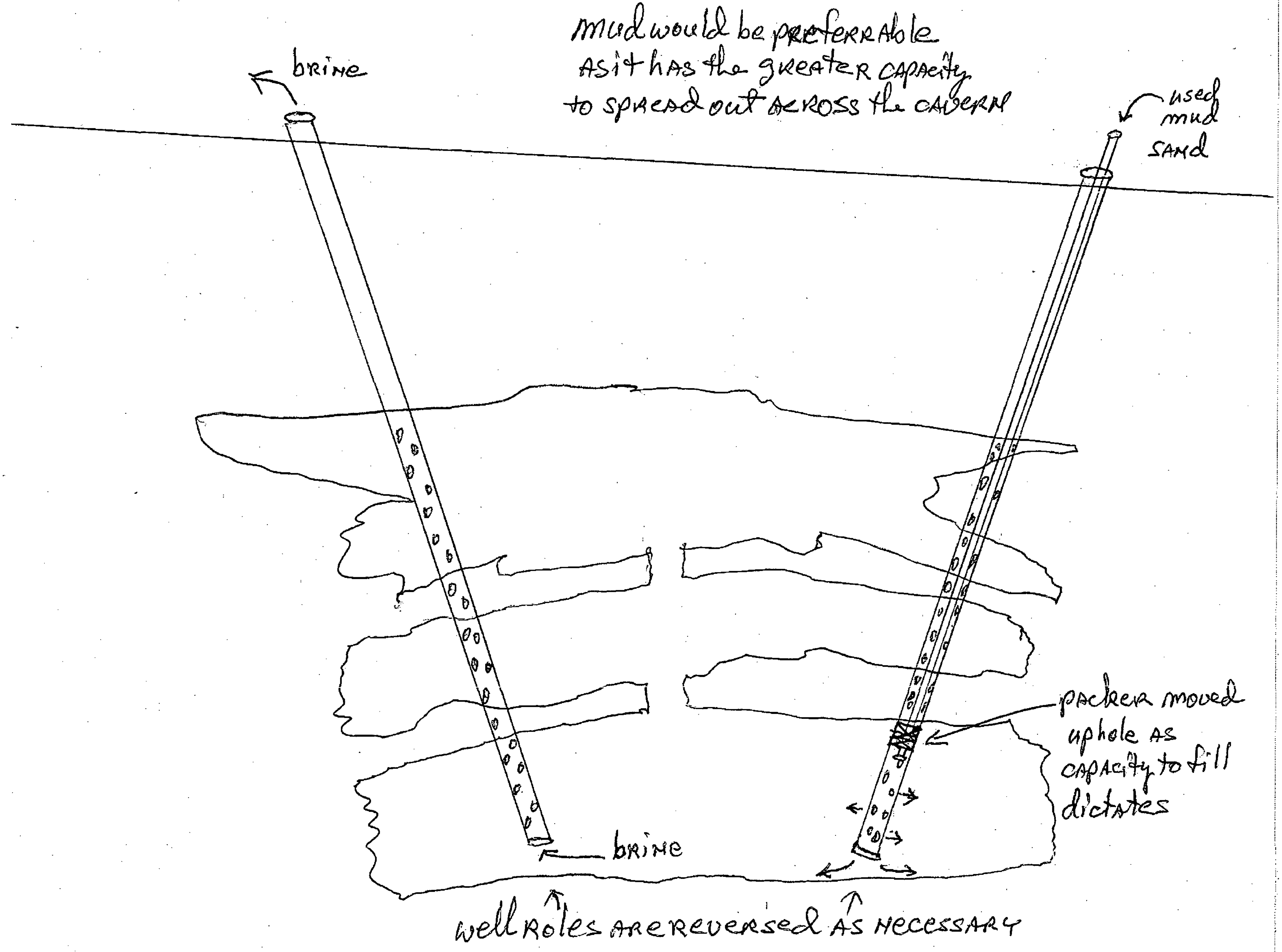
November 14, 2008 NEWS RELEASE

Contact: Jodi McGinnis Porter,

Pubjic Information Officei 505.476.3226

Energy, Minerals and Natural Resources Cabinet Secretary Prukop Orders a Six Month Moratorium on New Brine Wells
Oil Conservation Division to Investigate Brine Well Collapses and Provide Recommendations

SANTA FE, NM - Secretary Joanna Prukop today ordered the Oil Conservation Division to place a six month moratorium on any new brine well applications located in geologically sensitive areas. Secretary Prukop's action comes following the second brine well collapse in less than four months in southeastern New Mexico. **The Secretary has also directed the Oil Conservation Division to work with the Environmental Protection Agency, other states, technical experts and oil and gas industry representatives to examine the causes of recent collapses, and provide a report with**


mud would be preferrable
as it has the greater capacity
to spread out across the cavern
brine
used
mud
sand
brine
packer moved
uphole as
capacity to fill
dictates
well roles are reversed as necessary

Chavez, Carl J, EMNRD

From: Chavez, Carl J, EMNRD
Sent: Thursday, April 16, 2009 10:23 AM
To: 'George Veni'; James_Rutley@blm.gov; byrum.charles@epa.gov; Leissner.Ray@epamail.epa.gov; hugh.harvey@intrepidpotash.com; lmolleur@keyenergy.com; Jones, Brad A., 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; Sanchez, Daniel J., EMNRD
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Subject: RE: Brine Well Work Group Update

Thanks George for commenting and promoting dialogue on Mr. Ken Parker's (Western Refining L.P.) idea about the steam bath to precipitate out brine in the salt cavern to fill it up.

Some comments below provided by Mr. John Voigt (Solution Mining Research Institute) Ken's idea or concept are:

1) It would be a very slow process to address immediate needs. Could introduce brine from evaporation ponds at 120F with pumps and circulate cooler brine out while introducing 120F brine from solar heated ponds into the well, but again long process that needs engineering........
2) If there is concern about a collapse of the cavern, may want to keep away from it.
3) Filling up the cavern with this process is going to be extremely expensive from an energy standpoint.

Another idea that we discussed may be to induce a collapse under controlled conditions. New Mexico Tech may offer advice on controlled explosives placed downhole to make it happen safely. However, as I recall the work group was concerned about surface water and conduits for fresh water to further dissolve the salt at the surface and inducing a collapse would allow a fresh recharge condition to occur directly into the salt and may cause other fresh water dissolution of salt problems .

My thoughts, sometimes, besides taking precautions to restrict access and keep trespassers away (also act to assess the risk to the nearby population and take steps based on safety) from the area of concern, it may be best to focus on restricting access, initiate monitoring techniques (may drill back into well), keep brine cavern full, and collect data and think about it more. Sometimes, the best solution is to do nothing and focus on restricting access and creating a safe zone in the area coupled with monitoring and early detection. Maybe in addition to addressing public safety, we need to focus on a contingency plan for what we need to do after it collapses with safe zone considerations?

Thanks.

Carl J. Chavez, CHMM
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Oil Conservation Division, Environmental Bureau
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E-mail: CarlJ.Chavez@state.nm.us
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(Pollution Prevention Guidance is under "Publications")

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Carl,

The idea below makes me nervous. Heated water will increase the ability of the water to dissolve more salt. Assuming it is carefully controlled to not produce an undersaturated solution, I then wonder about steam produced. Steam is more likely to be undersaturated. While the intent will be to release it up the well, it may also collect along the cavern roof, inject itself into any fractures, and as an undersaturated solution it would dissolve more salt along the roof and increase the risk of collapse. A blanket would certainly reduce this possibility, but how much might the cavern be widened below a blanket and again increase the risk of collapse?

Assuming the above concerns are adequately addressed, I expect the amount of energy needed to heat that volume of water, and the surrounding rock mass to maintain the temperature for the desired effect, will be substantial and expensive. When considered with the price of bringing in brine, or water and salt to create brine, I suspect that simply bringing in salt to fill the cavern will be cheaper, easier, and with a lower risk of triggering a collapse. It would be good if someone could provide actual cost figures for the various scenarios for real comparisons.

George

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www.nckri.org
001-575-887-5517 (office)
001-210-863-5919 (mobile)
001-413-383-2276 (fax)

From: Chavez, Carl J, EMNRD [mailto:CarlJ.Chavez@state.nm.us]
Sent: Tuesday, April 14, 2009 2:23 PM

Concept or Idea:

Introduce hot brine water into salt cavern and raise temperature causing the evaporation of water and formation of solid salt from vaporization. Keep adding hot brine water that turns into steam. Calculate shrinkage and add more brine water during process. When solidified, shut off and let cavern cool. The salt fluid will become solid. A salt water bath heater would allow operator to run at a higher temperature.

How could you heat so much water? Could run 2-strings of tubing and work 2-3 ft. sections at a time from bottom to top of cavern; thus, heating a more localized area than the entire cavern at once.

I have used salt water baths to bring up temperature slowly to get molten or super heated salt. At atmospheric temperatures, I had to achieve >300 F or more for solidification or evaporation of salt to occur. Release steam out of water to condense the salt. Temperature is hot enough to solidify. If too big of a cavern volume with fluids, must work in increments from bottom to top. A 2-well system may work fine for this?

If you attempt to pump in salt slurry waste through tubing to fill salt cavern, solids may bulk near tubing at the bottom of the hole, but may not bulk evenly up the cavern as you fill salt slurry or solids into the cavern. Using sand when I worked for a frac company required > 10,000 psi to inject 1M lbs of sand into the formation, but this is an open cavern so the pressure may not be an issue and sand may work?

Boil fresh water out of salt. Slowly heat up entire volume of fluid in cavern or do it incrementally from bottom to top to solidify upward applying heat in 4-5 ft. increments. Allow bottom zone to cool down and evaporate salt. Example, brine pond where solid salt on top of pond falls to bottom of pond in sunlight and effect would be similar at the bottom of the salt cavern. Salt flakes create a solid salt bottom.

Engineers may find comprehensive pros and cons that may make this process infeasible?

Pros:

Using the existing brine water in the cavern.
Wouldn't have to use as much tailings waste from other companies fill void.

Cons:

Shrinkage as brine fluid is evaporated in salt cavern
Brine water or make-up water needed to continue process
Scale of bath water heater large w/ gas burner energy source,
Evaporating fluid source in brine cavern during the process, which may require make-up water for process to work.
Have to drill a 2-well system above salt cavern, which may collapse.

Let the work group know if you have any comments or recommendations on this idea? Also, if you have any ideas to share with the group in plugging a brine well cavern, we would like to know.

Please contact me if you have questions. Thank you.

Carl J. Chavez, CHMM
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Chavez, Carl J, EMNRD

From: George Veni [gveni@nckri.org]
Sent: Wednesday, April 15, 2009 10:16 PM
To: Chavez, Carl J, EMNRD
Subject: RE: UIC Class III Brine Well Evaluation Work Group Request for Comments

Carl,

I've been hit by a different sudden crisis that is eating most of my time this week and next (and then I leave town for a week), but I've tried to do at least a careful skim of the meeting minutes. I may have missed it, but I didn't see anything on the point I presented on and which Wayne supported on the need for further research to better characterize the collapse risk with the remaining existing wells. This is not on-point relative to upgrading the current regs, but having such a notation of such a recognized need in the minutes may be important at a later day to making such a research plan and risk characterization a reality.

Thanks,

George

From: Chavez, Carl J, EMNRD [mailto:CarlJ.Chavez@state.nm.us]
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
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Subject: UIC Class III Brine Well Evaluation Work Group Request for Comments

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.

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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

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(Pollution Prevention Guidance is under "Publications")

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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

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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)

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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.

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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.

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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.

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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.

Chavez, Carl J, EMNRD

From:	Overbay.Michael@epamail.epa.gov
Sent:	Wednesday, April 15, 2009 9:04 AM
To:	Leissner.Ray@epamail.epa.gov; Dellinger.Philip@epamail.epa.gov
Cc:	Chavez, Carl J, EMNRD
Subject:	New Mexico Tech information
Attachments:	LAND-2009 SAGEEP paper.pdf

Here is the information the guy from NM Tech sent me about his projects for the Carlsbad site. He also told me the state intends to put up "tilt meters" to provide real time monitoring of subsidence. I made plans with him that when he does his fieldwork in May, if we have the travel money, we would like to come out to the site and meet him and the site owners. I would expect the state OCD folks would also be interested in attending, too.

Mike

Michael Overbay, P.G.
Regional Ground Water Center Coordinator
U.S. Environmental Protection Agency - Region 6
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Visit the Ground Water Center on the web at:

www.epa.gov/earth1r6/6wq/swp/groundwater/gw.htm

----- Forwarded by Michael Overbay/R6/USEPA/US on 04/15/2009 09:53 AM -----

sinkhole investigations

Lewis Land to: Michael Overbay 04/14/2009 04:38 PM

Cc: "'George Veni'"

Dear Mr. Overbay, thanks for your call earlier. I'm attaching a pdf of a paper I had published recently discussing the recent sinkhole activity in the Carlsbad area. The full citation is

Land, L. and Aster, R., 2009, *Seismic recordings of an anthropogenic sinkhole collapse*, *in* Proceedings of the Symposium on the Application of Geophysics to Engineering and Environmental Problems: Environmental and Engineering Geophysical Society, 2009 Annual Meeting, Fort Worth, Texas, p. 511-519.

There's a lot of concern at the state level about the potential for additional sinkholes to form in this area, but not much funding at the moment to support research, although we are still inquiring about that. I have a couple of small-scale projects in the works. Wade Kress, a geophysicist in the USGS San Angelo, TX office, has expressed an interest in spending a couple of days with me in the Carlsbad area running DC resistivity lines adjacent to some of our existing sinkholes and over areas where we have some concern about future sinkholes forming. I have also contacted Dr. Sean Buckley at the Center for Space Research, UT-Austin, about the possibility of using satellite-based radar interferometry (InSAR) to detect recent vertical movement in the vicinity of existing brine wells in southeastern New Mexico. Other geophysical methods I'd be interested in applying are microgravity surveys and FEM (conductivity) profiling. I have also been conducting aerial observations of the two existing sinkholes since they formed last year, with assistance from a local pilot who has been willing to make his plane and pilot services available for free. It goes without saying that additional funds would be very helpful in supporting a broader and more sustained investigation of sinkhole formation in this part of the southwest. In the meantime, these are the projects I'm able to proceed with.

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New Mexico Bureau of Geology and Mineral Resources
And the National Cave & Karst Research Institute
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Carlsbad, NM 88220
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SEISMIC RECORDINGS OF AN ANTHROPOGENIC SINKHOLE COLLAPSE

Lewis Land, New Mexico Institute of Mining and Technology, Carlsbad, NM
Richard Aster, New Mexico Institute of Mining and Technology, Socorro, NM

Abstract

On July 16, 2008, a sinkhole several tens of meters in diameter formed abruptly at the site of a brine well in Eddy Co., NM. The well operator had been injecting fresh water into salt beds of the Permian Salado Formation and pumping out the resulting brine for use as oil field drilling fluid. Borehole problems had prevented the operator from conducting required downhole sonar surveys to assess the dimensions of the resulting subsurface void and the collapse was unanticipated. EarthScope USArray Transportable Array three-component broadband seismograph TA126, located ~13 km southeast of the well, recorded ground motion associated with the sinkhole formation. Approximately 6 hours before surface disruption occurred, short period seismic signals became visible at the station, probably reflecting subsurface spalling and upward stoping of the cavern roof. This may be the first documented seismologic record of catastrophic sinkhole formation, and demonstrates that precursory seismic activity related to sinkholes of this size may be readily detectable at such ranges.

Introduction

Sinkholes formed in evaporitic rocks are common features of the lower Pecos region of southeastern New Mexico and west Texas (e.g., Martinez et al., 1998; Land, 2003a; Johnson et al., 2003; Powers, 2003). In more humid environments, such as the eastern U.S., sinkholes commonly form in carbonate bedrock. In those areas evaporites are usually dissolved or removed by erosion to depths of several meters to hundreds of meters below ground level. However, in the semi-arid southwest, where mean annual precipitation is commonly less than 50 cm/yr, evaporites are more readily preserved at the land surface (Johnson, 2002). In these areas, sinkholes tend to form in or above evaporitic bedrock such as gypsum or halite, mineralogies that are orders of magnitude more soluble than limestone (Klimchouk, 1996; Martinez et al., 1998).

Geologic setting

The lower Pecos region includes the city of Carlsbad in Eddy County, New Mexico. Evaporitic rocks, primarily gypsum, are widely distributed in the Carlsbad region both at the surface and subsurface (Bachman, 1984; Hill, 1996). Carlsbad is located on the Northwest Shelf of the Delaware Basin, a large hydrocarbon-producing sedimentary basin containing >7300 m of Paleozoic rock and occupying over 44,000 km^2 in west Texas and southeastern New Mexico (Land, 2003b). The uppermost part of the Delaware Basin section is comprised of ~1700 m of redbeds and evaporites of upper Permian (Lopingian) age (Lucas, 2006a; 2006b). This section includes the Salado Formation (Figure 1), which in the subsurface of the Delaware Basin consists of ~710 m of bedded halite and argillaceous halite, with lesser amounts of anhydrite and polyhalite. Rare amounts of potassium salts (sylvite and langbeinite) occur in the the McNutt potash zone near the center of the formation (Cheeseman, 1978). Clastic material makes up less than 4% of the Salado (Kelley, 1971). Potash ore is mined from the McNutt Potash Zone in underground mines a few kilometers east of Carlsbad. The formation is also the host rock for the Waste Isolation Pilot Plant (WIPP), a repository for transuranic radioactive waste in eastern Eddy County.

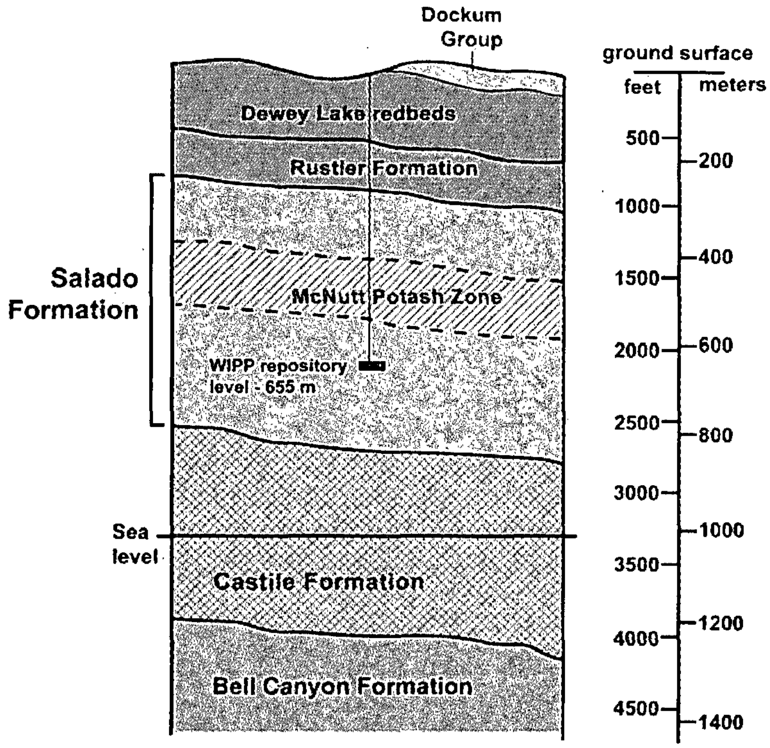

Figure 1: Upper Permian stratigraphy of WIPP Site, Carlsbad area, southeastern New Mexico.

The Salado Formation thins to the north and west by erosion, halite dissolution, and onlap onto the Northwest Shelf of the basin. Because of the soluble nature of Salado rocks, the unit is very poorly exposed in an outcrop belt ~5 km east of the Pecos River valley (Figure 2). In that area the Salado is represented by 10 to 30 m of insoluble residue consisting of reddish-brown siltstone, occasional gypsum, and greenish and reddish clay in chaotic outcrops. In most areas the Salado outcrop is covered by a few meters to tens of meters of pediment gravels and windblown sand (Kelley, 1971; McCraw and Land, 2008).

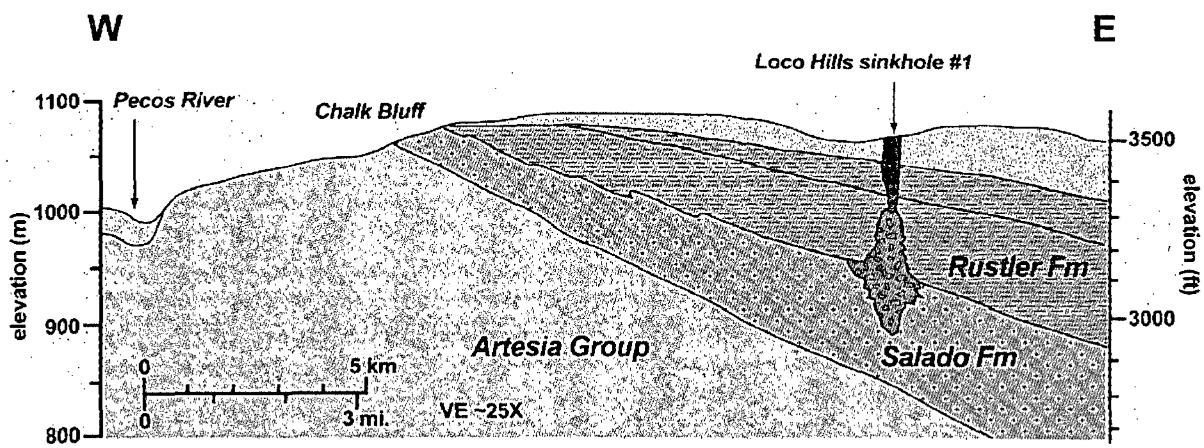

Figure 2: West-east cross-section showing stratigraphic section penetrated by Loco Hills Sinkhole #1.

Observations

Around 8:15 on the morning of July 16th, 2008, a driver for a local water service company was inspecting a brine well located on state trust land ~ 35 km northeast of Carlsbad. While on location the driver noticed a rumbling noise and quickly vacated the site. Minutes later, a large sinkhole abruptly formed, engulfing the brine well and associated structures. The well operator had been solution mining the Salado Formation by injecting fresh water and circulating it through the 86 m thick section of halite until the water reached saturation. The resulting brine was then sold as oil field drilling fluid. The brine well was being operated under permit from the New Mexico Oil Conservation Division (NMOCD).

This sinkhole, referred to as Loco Hills Sinkhole #1 because of proximity to the nearby community of Loco Hills (Figure 3), was originally several tens of meters in diameter and filled with water to a depth of ~12 m below land surface (Figure 4). Large concentric fractures developed around the perimeter of the sink, threatening the integrity of County Road 217, 100 m to the south. By July 24 the originally vertical walls of the sinkhole had begun to collapse, and the sink continued to grow in diameter over the course of the next two weeks. By July 28, the walls of the sink had developed an angle of about 45° to within ~30 m below ground level, above which the sides of the sink were vertical, and the water originally present had subsided into the subsurface (Figure 5). There are no significant sources of groundwater at shallow depths in the immediate vicinity of the sink, so the water was solution mining fluid that had presumably been forced up the debris chimney in the initial stages of collapse, and was now stored in pore space in the resulting collapse breccia in the subsurface cavern. By this time the sinkhole had attained a diameter of ~111 m, based on air photo interpretation. Representatives of the State Land Office used a range finder to estimate a maximum depth of 64 m.

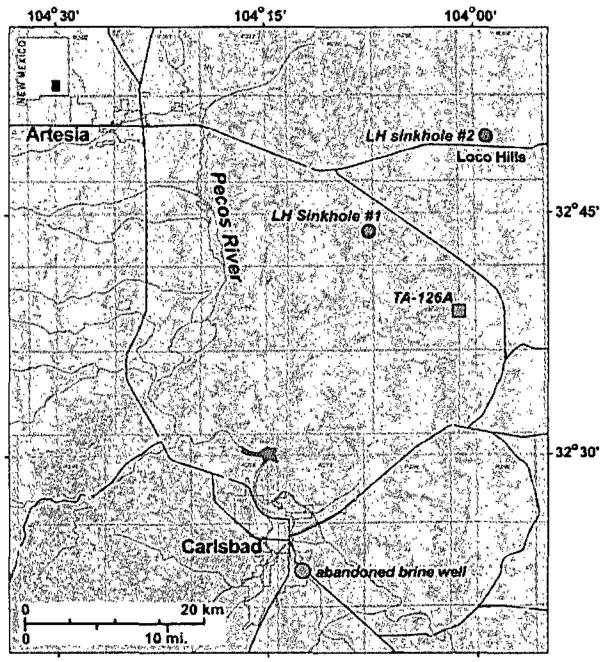

Figure 3: Map of study area in Eddy Co., NM, showing locations of the two Loco Hills sinkholes with respect to the Transportable Array seismograph TA126. Orange dot shows location of an abandoned brine well within Carlsbad city limits.

Figure 4: Loco Hills Sinkhole #1 on 7/19/2008, three days after initial catastrophic collapse. Water in sink is ~12 m below ground level. View to south, with County Road 217 in background.

Figure 5: Loco Hills Sinkhole #1 on 7/28/2008, showing post collapse draining and broadening.

Seismic recordings

On March 15, 2008, an EarthScope Transportable Array three-component broadband seismograph TA126 was installed near the Intrepid potash mine ~13 km southeast of Loco Hills sinkhole #1 (Figure 3). This transportable seismograph is a component of the National Science Foundation's EarthScope USArray continental seismic investigation program that is presently imaging the North American continent at a mean station spacing of approximately 75 km. EathScope TA seismographs are installed in subsurface (approximately 2 m-deep) vaults and record three-component ground motion from hundreds of seconds to approximately 20 Hz. Data are openly available in near real-time from the IRIS Consortium Data Management System. About 6 hours before surface disruption at the site of the brine well, TA126 began recording high frequency (>5 Hz) seismic signals, with vertical ground motion velocity amplitudes of ~5 microns/s (Figure 7). These seismic events probably reflect subsurface spalling during upward stoping of the cavern roof, with seismic energy resulting from the fall of material into the solution cavity. Another transportable array seismograph 50 km west of the site showed no obvious record of the sinkhole formation, indicating that these high-frequency seismic waves do not travel very far due to the shallow source of the seismic event and high near-surface attenuation.

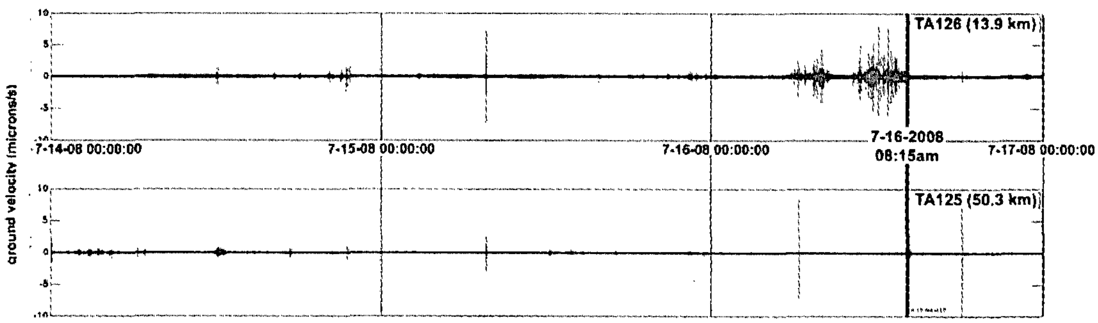

Figure 7: Transportable Array seismograph TA126 3-day high-pass (filtered above 5 Hz) record of vertical ground velocity (top), located 13.9 km from the sinkhole, showing more than 6 hours of apparent precursory ground motion associated with formation of Loco Hills sinkhole #1. The estimated time of sinkhole surface formation (8:15 MST) is indicated by the red line. Seismograph TA125 (lower plot), located 50.3 km from the site showed no such obvious candidate precursory signals.

Subsequent events

In the aftermath of formation of Loco Hills Sinkhole #1, another water supply company voluntarily abandoned an injection brine well located within the city limits of Carlsbad (Figure 3). NMOCD ordered a review of regulations covering all brine wells across the state. Then, on November 3, 2008, a new sinkhole formed ~17 km northeast of Loco Hills Sinkhole #1 (Figure 3). This sinkhole, referred to as Loco Hills Sinkhole #2, is also associated with a brine well that was shut in 3 months earlier after it failed a mechanical integrity test as part of the statewide review. At the time of this writing, nearby structures and a large water storage tank have fallen into the hole and large concentric fractures are threatening an adjacent county road. Aerial observations of Loco Hills sinkhole #2 indicate that it is presently ~80 m in diameter. Downhole surveys conducted in 2001 showed three stacked voids. The uppermost cavern was ~150 m below land surface, the deepest cavern was ~180 m in diameter, and the upper two caverns about one-third that size. The caverns were probably larger when the collapse

Solution mining

During solution mining operations a subsurface cavern is excavated. Most cavern excavation occurs at the top of the void space, since the injected fresh water floats on top of the denser brine. Thus, caverns produced by solution mining tend to approximate the shape of an inverted cone. Typically, a cushion of crude oil or diesel fuel is injected into the void to protect the cavern roof and ensure that cavern excavation occurs outward rather than upward. To prevent surface subsidence and collapse, brine well operators in New Mexico are required to conduct annual pressure tests and downhole sonar surveys to assess the size and proportions of the cavern being excavated. However, borehole problems prevented the operator from conducting these surveys, and the resulting collapse was unanticipated.

In the absence of precise borehole geophysical surveys, a rough estimate can be made of the volume of the subsurface void beneath the Loco Hills Sinkhole based on volume of fluid injected. Brine well operations were approved by NMOCD in 1982, with a production rate of 900 barrels of 10 pound brine per day. Over a 25 year period, this production rate would yield ~5.8 million barrels of brine. Each seven barrels of brine produced dissolves approximately one "barrel" of cavern space (Hickerson, 1991, unpublished report), indicating a cavern volume of ~133,000 m^3 (1 barrel = 5.61 ft^3 = 0.16 m^3), corresponding to an equivalent spherical radius of about 32 m, consistent with the observed sinkhole radius.

The top of the Salado Formation is 121 m below ground level and the formation is 86 m thick at the site of Loco Hills Sinkhole #1 (Figure 6). The brine well operator had set casing 6 m below the top of salt and suspended tubing for open-hole fresh water injection down to the base of the salt section. Assuming the resulting cavern was 80 m in vertical dimension and originally shaped like an inverted cone, simple volumetric calculations indicate a roof diameter of 80 m. This figure is consistent with the ~111 m diameter of the sinkhole that later formed above the cavern. Apparently, the mechanical strength of the mudstone and gypsum in the overlying Rustler and Dewey Lake Formations was insufficient to prevent upward stoping of the cavern roof, causing eventual catastrophic surface collapse (Figure 6).

Johnson (2002) observed that "most solution-mining collapses result from cavities formed 50-100 years ago, before modern-day engineering safeguards were developed. Proper, modern design has virtually eliminated this problem in new facilities." It would appear that developing engineering safeguards for solution mining is still an evolving science.

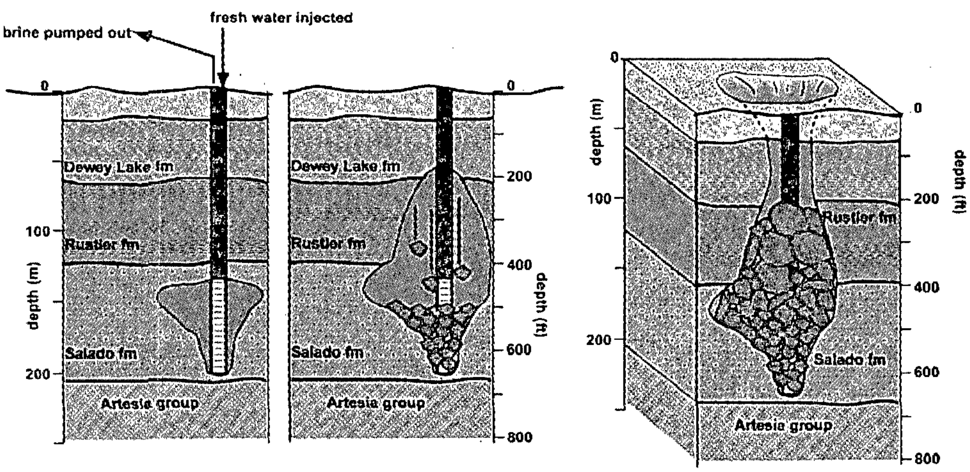

Figure 6: Sequence of events associated with solution mining that led to development of Loco Hills Sinkhole #1. Unnamed uppermost section consists of ~20 m of Quaternary sand, gravel and caliche.

occurred. The New Mexico cabinet secretary for Energy, Minerals and Natural Resources has ordered NMOCD to impose a 6 month moratorium on new brine well applications located in geologically sensitive areas. The closest EarthScope Transportable Array seismic station to Loco Hills sinkhole #2 was again TA126A (20.5 km), and no obvious precursor candidates have been detected to date.

Conclusions

Seismic recordings have been used in the past in a forensic capacity to analyze catastrophic events in southeastern New Mexico, such as pipeline exposions (e.g., Koper et al., 2000). However, this may be the first documented seismologic record of catastrophic sinkhole formation, and suggests that precursory seismic activity related to collapse events of this size may be detectable at ranges up to approximately 10 km.

Figure 8: Loco Hills Sinkhole #1 on 11/18/2008. Note continued presence of concentric fractures. Boulders visible on left flank of sinkhole are approximately car-size.

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Chavez, Carl J, EMNRD

From: Chavez, Carl J, EMNRD
Sent: Tuesday, April 14, 2009 2:58 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
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Subject: Intrepid Potash, inc. Glad to Sell Their Brine and/or Tailings Salt Authorized by NMED
Attachments: OCD - Brine Well Strategy.doc

FYI.

Carl J. Chavez, CHMM
New Mexico Energy, Minerals & Natural Resources Dept.
Oil Conservation Division, Environmental Bureau
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(Pollution Prevention Guidance is under "Publications")

From: Richard Miller [mailto:RichardM@intrepidpotash.com]
Sent: Tuesday, April 14, 2009 2:50 PM
To: Chavez, Carl J, EMNRD
Subject:

Carl,

I have discussed the issues with management and we will be happy to sell our brine and or tails salt to any distributor authorized by the NMED.

I hope this helps.

Richard Miller

*****Please note our new address as of March 16, 2009*****
Intrepid Potash, Inc.
707 17th Street, Suite 4200
Denver, CO 80202

Intrepid Potash Inc.
700 17th Street, Suite 1700
Denver, CO 80202
Cell 303-881-5440
303-296-3006
Fx 303-298-7502

OCD – Brine Well Strategy

Re: MINE TAILS SALES

During the OCD Meeting on Brine Well Strategy in Santa Fe on 3/27/2009, I was asked if Intrepid Potash would be willing to consider selling our tails salt and water products to reduce the demand from brine wells or to fill existing brine wells. My answer was vague and uncertain because I did not know:

1. the position of management;
2. insurance and indemnity requirements that our company may require from purchasers;
3. environmental or regulatory requirements that dictate the disposition of our products; and
4. Intrepid's exposure in the event a purchaser intentionally or unintentionally disposes of our products improperly.

Regarding item 3 above, we will need the buyer to obtain a certification from the NMED to allow this use and disposal of our tails and that they don't constitute solid waste or hazardous waste.

After talking with management and legal counsel we feel that our concerns can be addressed in a negotiated sales agreement.

Intrepid will begin working with any interested purchasers in order to implement a sales agreement in the near future.

Richard Miller

Intrepid Potash, Inc.
707 17th Street, Suite 4200
Denver, CO 80202
303-296-3006

Chavez, Carl J, EMNRD

From: Chavez, Carl J, EMNRD
Sent: Tuesday, April 14, 2009 2:23 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'; Sanchez, Daniel J., EMNRD
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
Subject: Brine Well Work Group Update
Attachments: OCD Press Release 1.pdf; OCD Press Release 2.pdf

Ladies & Gentlemen:

Good afternoon. Sorry for not getting the brine strategy document updated sooner. Please find attached some recent developments on the I&W brine well (BW-006) in Carlsbad, NM which took place shortly after the brine well work group meeting on 3/26-27/2009. The work group's concerns and presentations were instrumental and guided the OCD through presentations with Homeland Security, NMDOT, Eddy County, and other entities to drive a path forward with respect to those brine well group concerns we discussed during the meetings. In addition, brine well operators have been contacted and instructed to produce brine through the annulus until further notice. Thank you for your valuable input.

Brine Well Strategy:

I am working on sending out the brine well strategy document from March 27, 2009 in the very near future (today or tomorrow). I will place the brine well strategy under the "Brine Well Strategy" thumbnail at "BW-999." I hope that you will take some time to look it over and provide any additional comments/recommendations to consider for the strategy and that the work group can consider in the final report.

Draft Report:

As you know, the OCD is working on a report to the Oil Conservation Commission due May 1, 2009. The final report date is fast approaching. I will place an OCD draft report in the "Draft Report" thumbnail at "BW-999" on OCD Online (see Moratorium Press Release below on report objectives). This will require the work group to work fast to provide any final comments or recommendations on the report to the OCD.

November 14, 2008 NEWS RELEASE

Contact: Jodi McGinnis Porter,

Pubjic Information Officei 505.476.3226

Energy, Minerals and Natural Resources Cabinet Secretary Prukop Orders a Six Month Moratorium on New Brine Wells

Oil Conservation Division to Investigate Brine Well Collapses and Provide Recommendations

SANTA FE, NM - Secretary Joanna Prukop today ordered the Oil Conservation Division to place a six month moratorium on any new brine well applications located in geologically sensitive areas.
Secretary Prukop's action comes following the second brine well collapse in less than four months in southeastern New Mexico. **The Secretary has also directed the Oil Conservation Division to work with**

the Environmental Protection Agency, other states, technical experts and oil and gas industry representatives to examine the causes of recent collapses, and provide a report with recommendations to the Oil Conservation Commission for a safe path forward. The report should be completed by May 1, 2009.

'The moratorium will provide time to properly evaluate the causes of the recent collapses and to discuss the development of new rules or guidelines to ensure the safety and stability of brine well systems," added Secretary Prukop.

The moratorium will only aflect new wells and will not impact existing wells and facilities.

Brine Well Salt Cavern Plug Concept or Idea: Ken Parker (Western Refining L.P.) wants to share a possible brine well cavern plug concept or idea with the work group, which may be considered for filling the void space in brine well salt caverns like BW-6 in Carlsbad. This is just an idea that may be feasible to consider by the work group. Anyone else with a possible options may reply to this e-mail and provide the concept to the rest of the work group.

Concept or Idea:

Introduce hot brine water into salt cavern and raise temperature causing the evaporation of water and formation of solid salt from vaporization. Keep adding hot brine water that turns into steam. Calculate shrinkage and add more brine water during process. When solidified, shut off and let cavern cool. The salt fluid will become solid. A salt water bath heater would allow operator to run at a higher temperature.

How could you heat so much water? Could run 2-strings of tubing and work 2-3 ft. sections at a time from bottom to top of cavern; thus, heating a more localized area than the entire cavern at once.

I have used salt water baths to bring up temperature slowly to get molten or super heated salt. At atmospheric temperatures, I had to achieve >300 F or more for solidification or evaporation of salt to occur. Release steam out of water to condense the salt. Temperature is hot enough to solidify. If too big of a cavern volume with fluids, must work in increments from bottom to top. A 2-well system may work fine for this?

If you attempt to pump in salt slurry waste through tubing to fill salt cavern, solids may bulk near tubing at the bottom of the hole, but may not bulk evenly up the cavern as you fill salt slurry or solids into the cavern. Using sand when I worked for a frac company required > 10,000 psi to inject 1M lbs of sand into the formation, but this is an open cavern so the pressure may not be an issue and sand may work?

Boil fresh water out of salt. Slowly heat up entire volume of fluid in cavern or do it incrementally from bottom to top to solidify upward applying heat in 4-5 ft. increments. Allow bottom zone to cool down and evaporate salt. Example, brine pond where solid salt on top of pond falls to bottom of pond in sunlight and effect would be similar at the bottom of the salt cavern. Salt flakes create a solid salt bottom.

Engineers may find comprehensive pros and cons that may make this process infeasible?

Pros:

Using the existing brine water in the cavern.
Wouldn't have to use as much tailings waste from other companies fill void.

Cons:

Shrinkage as brine fluid is evaporated in salt cavern
Brine water or make-up water needed to continue process
Scale of bath water heater large w/ gas burner energy source,
Evaporating fluid source in brine cavern during the process, which may require make-up water for process to work.
Have to drill a 2-well system above salt cavern, which may collapse.

Let the work group know if you have any comments or recommendations on this idea? Also, if you have any ideas to share with the group in plugging a brine well cavern, we would like to know.

Please contact me if you have questions. Thank you.

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(Pollution Prevention Guidance is under "Publications")

Chavez, Carl J, EMNRD

From: Porter, Jodi, EMNRD
Sent: Thursday, April 09, 2009 4:33 PM
Subject: PR-Oil Conservation Division Requests Carlsbad Brine Well Operator I&W to Take Common-Sense Precautions
Attachments: PR-OCD.Brine.Well.Carlsbad.pdf

New Mexico Energy, Minerals and Natural Resources Department

Mark Fesmire
Division Director
Oil Conservation Division

April 9, 2009

NEWS RELEASE

Contact: Jodi McGinnis Porter,
Public Information Officer 505.476.3226

Oil Conservation Division Requests Carlsbad Brine Well Operator I&W to Take Common-Sense Precautions

State and Eddy County Preparing Emergency Action Plan

CARLSBAD, NM – The Oil Conservation Division put Carlsbad brine well operator I&W, Inc on notice for unsafe conditions that pose a serious risk to human life and property, and is asking the operator to take reasonable actions to mitigate that risk. The division is considering legal action forcing safety precautions, if they are not voluntarily met by the operator. The location of I&W's brine operation poses special dangers in the event of collapse. The facility where the brine operations are located is in the city of Carlsbad, between US 285 and US 180/62 where those two highways meet at a "Y"-shaped intersection.

"Ensuring the public safety of citizens, protecting adjacent properties, roadways and the Carlsbad Irrigation District Canal demands our immediate attention," stated Mark Fesmire, Oil Conservation Division Director.

Today, the Oil Conservation Division met with Department of Homeland Security and Emergency Management, Department of Transportation, the National Cave and Karst Research Institute, Department of Energy, the Bureau of Land Management, Eddy County Emergency Management, fire and police officials from Carlsbad, representatives from the Carlsbad Irrigation District and local elected officials to prepare an action plan in the event the I&W brine well collapses.

"We are prepared to assist the Carlsbad community in organizing their law enforcement, fire, and emergency management agencies as they continue to protect the state and its citizens," said John Wheeler incoming Cabinet Secretary, for the Department of Homeland Security and Emergency Management.

The Oil Conservation Division requests that I&W voluntarily and immediately take the following common-sense precautions:

Cease truck traffic at the facility. The concern is that vibrations from heavy truck traffic over the cavern could trigger a collapse.

Remove the contents of tanks at the facility, if removal can be accomplished safely. Removal of liquids will reduce weight on the overburden, and hazardous liquids should be removed to prevent leakage should a collapse occur. The concern is also about tanks at the site that containing propane, which could spark an explosion in the event of a collapse.

Restrict all public access to the facility.

Cooperate with monitoring requirements. The division has been working with I&W to establish a monitoring program for the site, but has not seen proof that the monitoring is in place, and has not received monitoring data from I&W. The division's experience is that weekly or daily monitoring will not provide adequate warning of a collapse. The division is working to determine if a real-time monitoring system can be designed that will provide sufficient warning to prevent loss of life or property; if so, it will require I&W's cooperation in implementing that monitoring program.

On July 18, 2008, a brine well located approximately 25 miles north of Carlsbad collapsed forming a sinkhole several hundred feet across. Straight away, staff from the Oil Conservation Division began closely monitoring the brine well operated by I & W, Inc located in Carlsbad. Following ongoing inquiries from the division, the operator voluntarily agreed to stop operation of the well. Division staff had concerns then, because I&W's brine well operations share physical features with the Artesia brine well that had just collapsed.

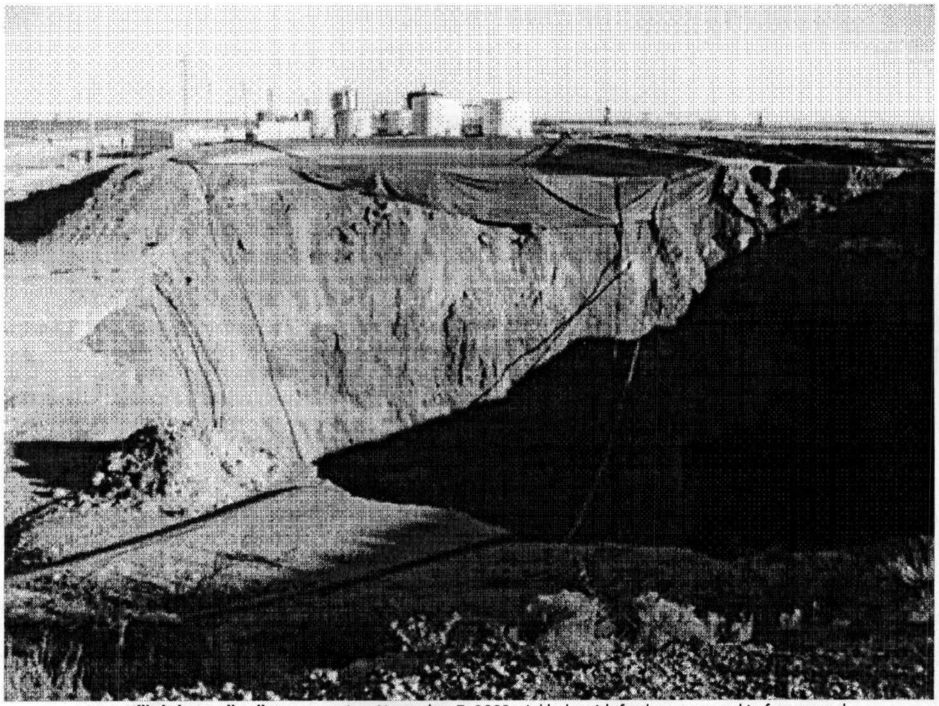
Also in July of 2008, Energy, Minerals and Natural Resources Cabinet Secretary, Joanna Prukop ordered the Oil Conservation Division to conduct a complete evaluation of the rules and regulations concerning brine wells. The evaluation included an internal audit and inspection of all existing brine wells in New Mexico.

Last November 2008, after a second brine well collapse in less than four months in southeastern New Mexico, Secretary Prukop issued a six month moratorium on any new brine well applications located in geologically sensitive areas. Secretary Prukop also directed the Oil Conservation Division to work with the federal Environmental Protection Agency, other states, technical experts and oil and gas industry representatives to examine the causes of recent collapses, and provide a report with recommendations to the Oil Conservation Commission for a safe path forward.

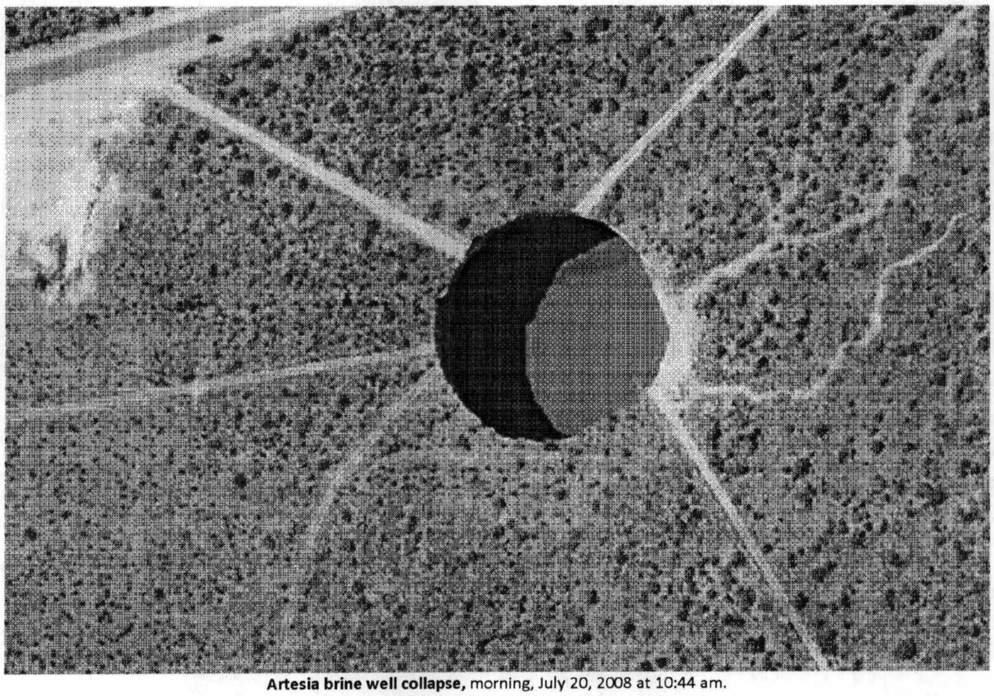
Two weeks ago the Oil Conservation Division hosted a 2-day brine well workgroup meeting. Participants included the Environmental Protection Agency, the Department of Energy, the National Cave and Karst Research Institute, the Solution Mining Research Institute, and New Mexico industry representatives. The workgroup discussed the two collapses, the collapse potential of existing brine wells in New Mexico, and what could be done in future operations to avoid collapses. During the workgroup, participants discussed I&W's operations. The members of the workgroup were extremely concerned because I&W's operations share physical features with the two brine wells that had collapsed and because the facility is located in a developed area, posing special risks to life and property in the event of a collapse.

Production of brine is essential part of the oil and gas drilling industry, particularly in the southeastern part of the state. Oil and gas operators use brine water in the drilling process. Brine is saturated salt water which can be more salty than sea water. Because it is more economical that using above ground tanks, brine is typically produced by injecting fresh water into underground salt formations, allowing the water to absorb the salt and then pumping it out of the well. This method creates an underground cavity.

Below are photographs of the two brine well collapses that took place last year:



Loco Hills brine well collapse, morning, November 7, 2008, sinkhole with fresh water pond in foreground.
Photo courtesy of Oil Conservation Division



Artesia brine well collapse, morning, July 20, 2008 at 10:44 am.
Photo courtesy of National Cave and Karst Research Institute

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The Energy, Minerals and Natural Resources Department provides resource protection and renewable energy resource development services to the public and other state agencies.

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Chavez, Carl J, EMNRD

From: Porter, Jodi, EMNRD
Sent: Thursday, April 09, 2009 6:11 PM
To: Prukop, Joanna, EMNRD; EMNRD-OCD - SANTA FE; EMNRD-DIV. DIRECTORS
Cc: Gallegos, Gilbert, GOV; Shipley, Pahl, GOV; Cottrell, Sarah, GOV; Wheeler, John, DPS
Subject: AP Story-Brine Well Story: NM makes demands of brine well operator

Apr 9, 7:57 PM EDT

NM makes demands of brine well operator

CARLSBAD, N.M. (AP) -- The state Oil Conservation Division is asking a brine well operator to take action to limit the risk of another brine well collapse in southeastern New Mexico.

The division announced Thursday that it will consider legal action if I&W Inc. fails to take safety precautions. The division claims the company's location - near the intersection of two highways in Carlsbad - would pose special dangers in the event of a collapse.

"Ensuring the public safety of citizens, protecting adjacent properties, roadways and the Carlsbad Irrigation District Canal demands our immediate attention," Mark Fesmire, director of the Oil Conservation Division, said in a statement.

The division met Thursday with state homeland security and emergency management officials, Eddy County officials, the Carlsbad police and fire departments, the Carlsbad Irrigation District and others to prepare an action plan in the event the brine well collapses. Such wells are used to create saturated salt water used in oil and natural gas production.

Kevin Wilson, I&W operations manager, said Thursday the company does not believe the well is in danger of collapsing like the two that collapsed last year in northern Eddy County.

"We don't want to take it lightly and say we're not concerned about ourselves or the public but if we felt like there was an immediate danger we wouldn't be here," Wilson said. "We live and work here."

The division requested that I&W cease truck traffic at the facility; remove the contents of tanks at the facility if it can be done safely; restrict all public access; and cooperate with monitoring requirements.

Wilson said the company plugged the brine well, emptied the tanks at the yard and is monitoring the site on a weekly basis.

"We've tried to do everything we could," he said. "As far as restricting access, up to this point we are still operating our business out of this facility but we're trying to work something out to get out of there."

A brine well north of Carlsbad collapsed in July, leaving a sinkhole several hundred feet across. As a result, Energy, Minerals and Natural Resources Secretary Joanna Prukop ordered the Oil Conservation Division to conduct a complete evaluation of brine well rules and regulations. The evaluation included an audit and inspection of all existing brine wells in New Mexico.

In November, after a second brine well collapsed, Prukop issued a six-month moratorium on any new brine well applications located in geologically sensitive areas.

State officials said they were concerned about I&W's operation because it shared physical features with the two wells that collapsed and because the facility is located in a developed area.

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LPG Storage at Mont Belvieu, Texas: A Case History

J.L. Ratigan, SPE, and **T.J. Vogt,** RE/SPEC Inc.

Summary. The Barbers Hill salt dome contains 124 solution-mined, liquified-petroleum-gas (LPG) storage wells with a capacity of 200×10^6 bbl. A geomechanics evaluation of the facility is described that includes mechanical testing of salt and caprock core, structural evaluation of the storage and brine disposal wells, and development of a subsidence evaluation network.

Introduction

History. U.S. gulf coast salt domes have been used for underground LPG storage since 1951.[1] The largest U.S. gulf coast underground LPG storage facility is in the Barbers Hill salt dome at Mont Belvieu, TX. LPG production from 1,200 Texas oil and gas fields are upstream from the Barbers Hill storage facility. Fourteen large petrochemical plants, which in turn are connected to many derivative plants, are downstream.[2]

The dome has 124 solution-mined storage wells operated by nine companies: Conoco Inc., Enterprise, Exxon Co. U.S.A., Diamond Shamrock, Offshore Partners LP, Lyondell Petrochemical Co., Tenneco (now Enron Natural Gas Liquids Corp.), Texas Eastern Products Pipeline Co., Warren Petroleum Co., XRAL Storage & Terminaling Co. **Table 1** shows the number of wells and storage capacities for each operator and **Fig. 1** shows the wellhead locations.

In 1987, the Mont Belvieu storage operators commissioned a geomechanics investigation of the facility. Conclusions from this investigation were presented during the summer of 1989 to the Texas Railroad Commission, the regulatory body responsible for underground LPG storage at Mont Belvieu.[2,3] The investigation included core drilling and rock-mechanics testing of caprock and salt core; evaluation of the LPG storage wells; structural evaluations of brine disposal wells; and design, installation, and monitoring of a subsidence evaluation network.

Geology. The Barbers Hill salt dome is about 20 miles east of Houston and is one of several domes composing the Houston diapir province of the tertiary U.S. gulf coast basin. The dome is slightly elongated, with the long axis oriented northwest-southeast. The maximum cross-sectional area occurs about 2,000 ft below sea level. At that level, the long axis is about 2.2 miles long and the short axis is about 1.7 miles long. All sides, except the southwest, have a well-developed overhang, particularly the eastern side. The top of the salt is fairly flat, forming a planar surface about 1,300 ft below sea level.

The caprock is about 900 ft thick near the center of the dome and thins irregularly to the edges. A zone of gypsum, 40 to 200 ft thick, includes variable amounts of anhydrite and secondary calcite. The deepest caprock zone is anhydrite, 500 ft thick near the center to 25 ft thick near the edges. In places, minor cavities are found at the anhydrite/salt contact.[4] Areas of high porosity and permeability are present within the caprock, particularly in the gypsum zone. Diapiric processes have fractured and brecciated portions of the caprock, leaving vuggy and sometimes cavernous zones.

Barbers Hill is surrounded by thick Mesozoic and Cenozoic sediments. The uppermost Holocene and Pleistocene sands are called the Chicot aquifer, locally differentiated into the upper and lower units of the Chicot. The Chicot thins and becomes less sandy where it overlies the salt dome. The Miocene Evangeline aquifer and the Miocene Burkeville aquitard underlie the Chicot aquifer. Only a small portion of the Evangeline is found on top of the dome. The remaining portion of the Evangeline, the Burkeville, and the sediments below are upturned as they approach the dome. Below the Burkeville aquitard are saltwater-bearing sands of Miocene Age.[5]

Operations. Underground storage space at Mont Belvieu is used for LPG for two principal reasons: safety and economics. Underground storage is considerably safer than surface storage, and the cost of creating storage space through solution mining of dome salts can be as little as one-tenth the cost of surface-storage space. A typical storage well at Mont Belvieu is cylindrical and has a storage volume of $>1.5 \times 10^6$ bbl, a height of $>1{,}000$ ft, and a maximum diameter of ≈ 150 ft and is located between depths of 2,000 and 4,000 ft.

LPG products are moved in or out of storage wells depending on market demand. Products are displaced from storage wells with salt-saturated brine. Similarly, brine is displaced from storage wells when products are moved into them. Depending on the movement of products through Mont Belvieu, there can be considerable demand for or surplus of brine. Large surface-storage ponds have been constructed at Mont Belvieu in an attempt to meet the supply or disposal cycles. Additionally, some of the operators manage brine disposal through sales to chemical plants. The storage ponds and brine sales, however, are not sufficient to handle the peak requirements for brine disposal at Mont Belvieu.

Since the mid-1970's, excess brine has been disposed of in brine disposal wells completed in lost-circulation zones encountered in the caprock. Nearly 2×10^9 bbl of brine has been disposed of through approximately 15 wells. Currently, off-dome brine disposal is being evaluated. As of June 1989, however, 12 brine disposal wells were permitted by the Texas Railroad Commission. Fig. 1 shows the locations of the brine disposal wellheads.

Rock Properties

As part of the geomechanics investigation of the Barbers Hill salt dome, rock core was drilled in early 1987. The caprock was reported to have three structural components consisting of calcite, gypsum, and anhydrite. Thus, the coring program was designed to obtain rock from each of the postulated caprock lithologic units. The upper portion of the caprock (reported to be calcite) was sampled by extending Well WR-15 on the Warren Petroleum property from 487.9 to 496.0 ft. The middle and lower portions of the caprock (reported to be gypsum and anhydrite, respectively) were sampled by extending the Warren Petroleum Well SWD-4 from a depth of 998.1 to 1,369.0 ft. This well was extended farther by coring salt from 1,369.0 to 1,450 ft, and 3.5-in. core was obtained in both wells.

Caprock. Testing of the caprock core from Wells WR-15 and SWD-4 included 17 unconfined-compression tests and 38 Brazilian indirect-tension tests. The mineralogic composition and density were determined for all caprock specimens tested in compression. **Table 2** summarizes the unconfined compressive strength, Brazilian tensile strength, and elastic properties of the caprock for the upper caprock and the upper and middle portions of the lower caprock. The caprock strength and stiffness increase with increasing depth. The increases can be attributed to the increase in anhydrite content with depth, which is typical for U.S. gulf coast salt domes.

Each caprock specimen tested in compression was subjected to laboratory determination of gypsum/anhydrite content and density. The upper caprock (core from Well WR-15) is essentially gypsum. The caprock from the upper portion of the lower caprock is approximately 60% anhydrite and 40% gypsum. The rock from the middle portion of the lower caprock is essentially anhydrite.

TABLE 1—SUMMARY OF STORAGE AND CAPROCK BRINE DISPOSAL WELLS AT MONT BELVIEU, TX

Property	Number of Storage Wells	Approximate Storage Well Volume (10^6 bbl)	Number of Caprock Brine Disposal Wells
Lyondell Petrochemical Co.	14	13.5	1
Conoco Inc.	3	4.6	2
Diamond Shamrock Offshore Partners LP	14	69.3	—
Enterprise	8	11.8	2
Exxon Co. U.S.A.	6	6.5	—
Tenneco (now Enron Natural Gas Liquids Corp.)			
East	10	10.1	1
West	3	2.3	1
Texas Eastern Products Pipeline Co.			
North	10	11.6	—
South	13	22.4	1
Warren Petroleum Co.	28	51.1	3
XRAL Storage & Terminaling Co.	15	25.3	1
Total	124	228.5	12

TABLE 2—SUMMARY OF MECHANICAL PROPERTIES OF BARBERS HILL CAPROCK

Core		Unconfined Compressive Strength	Brazilian Tensile Strength	Young's Modulus	Poisson's Ratio
Location	Depth (ft)	(psi)	(psi)	(10^6 psi)	
Upper Caprock	≈490	2,585 ± 230	289 ± 48	5.11 ± 0.15	0.39 ± 0.05
Upper Portion of Lower Caprock	≈1,000	3,840 ± 1,050	464 ± 127	5.44 ± 2.58	0.31 ± 0.01
Middle Portion of Lower Caprock	≈1,300	8,435 ± 1,000	668 ± 218	9.35 ± 1.21	0.35 ± 0.03

The density of the caprock (determined by X-ray defraction) can be directly correlated to the anhydrite/gypsum composition. Caprock that is 100% anhydrite has a density of 3.00 g/cm^3, and caprock composed entirely of gypsum has a density of 2.31 g/cm^3. The density and anhydrite/gypsum content of all the caprock specimens are linearly correlated with a coefficient of multiple determination greater than 0.99.

More than 70 specific unconfined-compressive-strength tests of anhydrite appear in the literature for caprock from the Richton and Vacherie domes[6] and for anhydrite from bedded deposits throughout the U.S.[7-11] The unconfined compressive strength in these tests ranged from 3,320 to 25,810 psi, with an average of 13,430±5,290 psi. The average value of the unconfined compressive strength for the Vacherie and Richton domes is 11,240±1,900 psi. The Barbers Hill anhydrite is not as strong in unconfined compression as these other anhydrites. The mean unconfined compressive strength of the Barbers Hill anhydrite, however, is nearly within a standard deviation of the mean strength of the anhydrite from the Vacherie and Richton domes.

The average value of Young's modulus for all the anhydrite tests found in the literature is $9.3 \pm 2.6 \times 10^6$ psi. The Barbers Hill anhydrite has essentially the same stiffness, with a mean Young's modulus of 9.35×10^6 psi.

The Brazilian indirect tensile strength of the Vacherie and Richton caprock is approximately 900 psi, which is slightly higher than the indirect tensile strength of the middle portion of the lower caprock at Barbers Hill. The middle portion of the lower caprock at Barbers Hill has an indirect tensile strength of about 700 psi.

Salt. Fifteen unconfined-compression, ten Brazilian indirect-tension, seven unconfined-creep, and four confined-creep tests were performed on the Barbers Hill salt. The Barbers Hill salt also has undergone petrofabric examination and chemical analyses.[3]

Quasistatic-compression experiments were completed on salt from three different depths: shallow (≈1,400 ft), middle (≈1,450 ft), and deep (≈1,500 ft) zones, where shallow, middle, and deep indicate the relative depth of the salt core. **Table 3** presents the test data.

Overall, the elastic properties are consistent between all three sets of salt samples. The unconfined compressive strength, on the other hand, is appreciably different between each set. All the salt is much stronger than other natural salts, which have an unconfined compressive strength of about 3,000 psi.

The unconfined compressive strength for nine other salt domes and five bedded deposits in the U.S. has been reported.[12-21] On the basis of our literature survey, the Barbers Hill salt dome is the strongest domal salt (in compression) ever tested and is stronger in indirect tension than the majority of other salts (**Fig. 2**).

Seven unconfined-creep and four confined-creep tests were performed on the Barbers Hill salt. Two unconfined-creep tests were performed at each of three axial stress differences (1,500, 2,250, and 3,000 psi). The seventh unconfined-creep test was performed at the highest axial stress difference. **Fig. 3** shows the axial creep for these seven unconfined tests. Note that Fig. 3 does not show the deformation associated with the application of the stress difference. The repeatability or reproducibility of the axial deformation decreases as the axial stress difference increases. This occurs because salt creep depends on the axial stress difference raised to a power (usually 3 to 6), and small variations in the stress control can result in large variations in the deformation rate. Lateral creep strains for the unconfined-creep tests are comparable with the axial strains, indicating dilation, which is typical for unconfined-creep tests.

Confined-creep tests were performed at axial stress differences of 1,500, 2,250, and 3,000 psi. The confining pressure for all these tests was maintained at 1,500 psi. Brittle deformation mechanisms were essentially suppressed at this confining pressure. **Fig. 4** shows the axial creep strain for the confined-creep tests. Clearly, the confining pressure has reduced the deformation at a given axial stress difference. At an axial stress difference of 3,000 psi, confining pres-

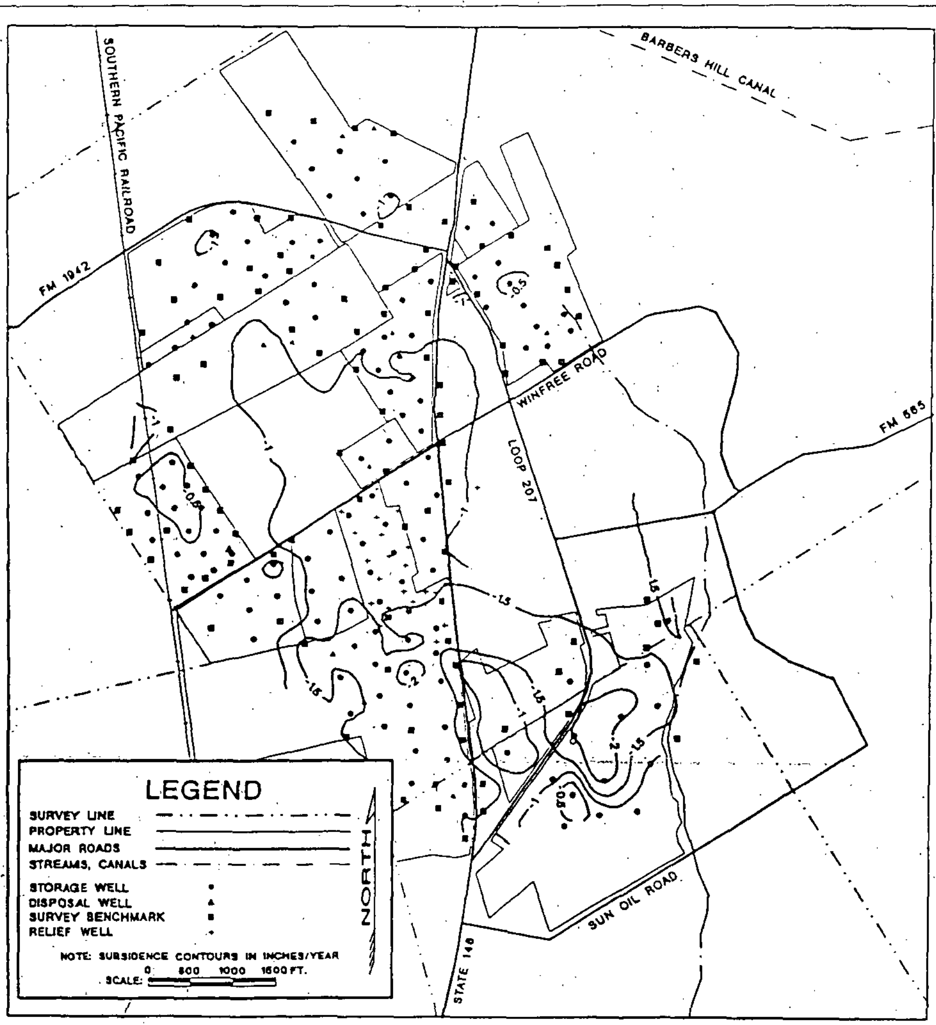

Fig. 1—LPG storage well complex at Mont Belvieu, TX.

TABLE 3—SUMMARY OF MECHANICAL PROPERTIES OF BARBERS HILL SALT

Core		Unconfined Compressive Strength (psi)	Brazilian Tensile Strength (psi)	Young's Modulus (10^6 psi)	Poisson's Ratio
Location	Depth (ft)				
Shallow	≈1,400	4,595 ± 105	—	3.32 ± 0.10	0.28 ± 0.05
Middle	≈1,450	4,290 ± 105	293 ± 26	3.06 ± 0.08	0.30 ± 0.05
Deep	≈1,500	3,780 ± 170	—	3.29 ± 0.18	0.42 ± 0.02

sure reduces the axial strain by about 40% and the lateral strain by a factor of about three.

The axial strain rate and subsequent strain are larger in an unconfined-creep test on rock salt than in a confined-creep test because the brittle deformation mechanisms contributing to the axial strain in the unconfined-creep test are essentially suppressed in the confined-creep test.

The axial strain from the Barbers Hill creep tests was compared with similar tests on Avery Island[22] and Jefferson Island[14] salts. For an axial stress difference of 1,500 psi, the axial creep deformation for the Barbers Hill salt is slightly greater than the Avery Island salt and less than the Jefferson Island salt. The axial strain from the Barbers Hill creep tests performed at an axial stress difference of 3,000 psi is essentially the same as the Avery Island salt and less than the Jefferson Island salt.

Two representative samples of Barbers Hill domal salt were examined with well-documented optical techniques. The samples were taken from the residual end pieces cut from specimens tested in unconfined compression. When tested in uniaxial compression, these specimens failed at 4,225 and 4,390 psi, respectively. The strength of this material is abnormally high compared with other natural salts from within the U.S. (Fig. 2).

In general, it is almost impossible to make unequivocal statements about why the strength and deformational characteristics of salts vary. For example, many investigators suggest that mineralogical variability causes behavioral differences. We have examined the mineralogy (impurities) of other salts extensively and can state only that increased anhydrite content reduces creep deformation. The Barbers Hill salt contains *approximately* 3% anhydrite, which is substantially more than Avery Island domal salt (0.5% anhydrite), but to say that 3% anhydrite content accounts for the magnitudes of strengths encountered in Barbers Hill salt is not justified scientifically. In fact, increasing anhydrite content may result in decreasing unconfined compressive strength despite the fact that it results in decreasing deformation in confined-creep tests. Other petrological explanations of strength differences are less quantitative. For example, an increase in water content can reduce strength and accentuate deformability. The Barbers Hill salt appears to be dry (typi-

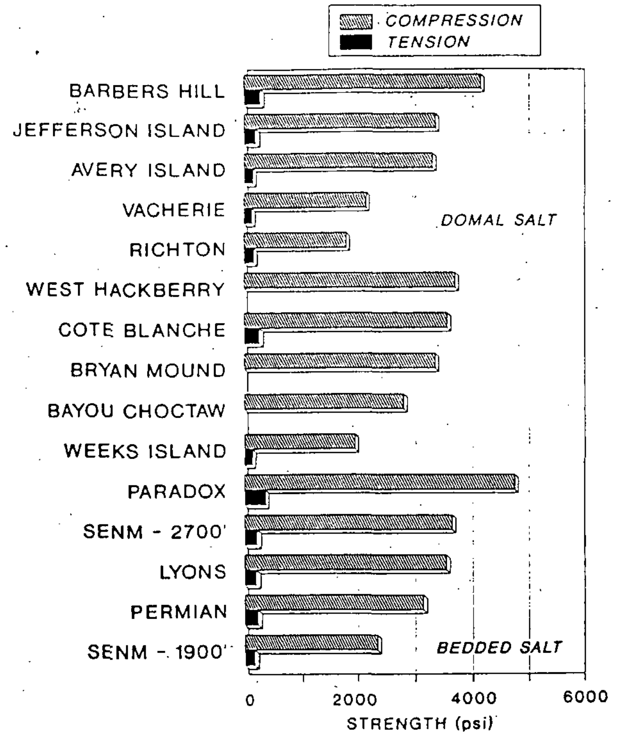

Fig. 2—Comparison of strength of Barbers Hill salt with other salts.

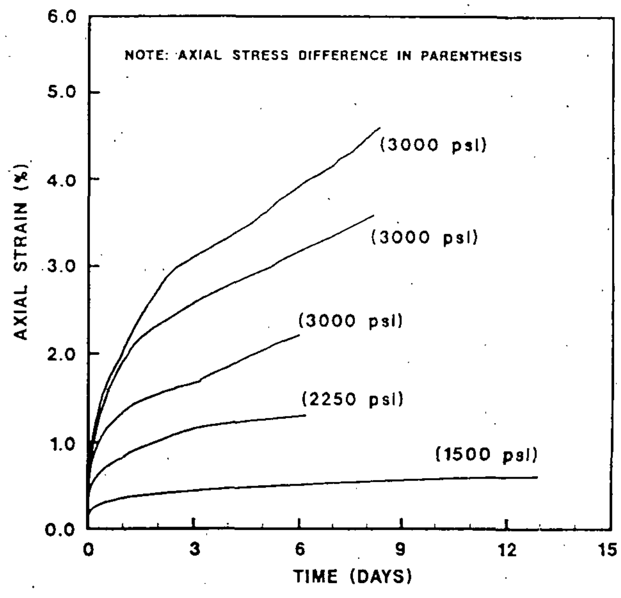

Fig. 3—Unconfined axial creep strain response of Barbers Hill salt at three axial stress differences. (After Ratigan.[3])

cal of domal salt), which also is consistent with greater strength and rigidity.

Other features that greatly influence the way salt deforms are the microstructures or substructures. Much of salt deformation is accounted for by movement of crystal imperfections (dislocations) in the lattice. As salt deforms, the substructure of the material changes—usually, it gets increasingly difficult for the dislocations to move and the salt hardens as a result. The substructures were examined and nothing abnormal or outstanding was found within the Barbers Hill salt.

One clue regarding paleostress comes from the subgrains within the salt substructure. Many of these features were measured on numerous salts, and a means exists for comparing other salts with that of Barbers Hill. Subgrain sizes are inversely related to stress. Subgrain size of Barbers Hill salt is slightly smaller than other typical salts, but the difference is not substantial.

Free dislocation density is another quantifiable substructural feature. Usually, a natural salt has from 6×10^7 to 32×10^7 dislocations/in.^{2}. The average for one Barbers Hill sample is 10.3×10^7 dislocations/in.^{2}, which is typical.

Such features as photoelastic effects and glide bands were not present in Barbers Hill salt. On the basis of these preliminary microscopic studies, no definitive cause was found for the abnormally high strength.

Storage Wells

Currently, 124 petroleum-product storage wells are operating in the Barbers Hill salt dome at Mont Belvieu. The storage wells store light hydrocarbons. At any given time, 5 to 10 storage wells are not used for product storage because of market conditions, well workovers, or other maintenance-related conditions.

Solution Cavities. During well workovers (typically performed on a 5-year schedule), an extensive series of tests is performed to evaluate the condition of the casing string connecting the storage well cavity with the surface. A sonar caliper survey of the solution-mined well cavity is also performed during the well workovers. These periodic sonar surveys enable assessments of the progressive shape and size changes (if any) of the well cavity that may be occurring because of the inward creep of the salt and/or any continued leaching of the cavity occurring during product movement. **Fig.** 5 illustrates the storage-cavity shapes obtained through sonar caliper surveys of the 28 storage wells on the Warren Petroleum property. The first Warren storage wells were developed more than 30 years ago. The first wells (those with the lowest well numbers) are in the central portion of the well field and typically are bell-shaped rather than more cylindrically shaped like later storage wells. The bell shapes resulted from the early practice of displacing products with fresh water or undersaturated brine instead of saturated brine. Current practice is to displace products with saturated brine.

Wellfield Geometries. The State of Texas generally approves the design and construction of underground hydrocarbon storage wells in salt on a well-by-well basis. Design criteria have been suggested[23] for the Strategic Petroleum Reserve (SPR) program, and several of these criteria are addressed in the literature[24,25] with regard to aptness. The State of Louisiana also has a design-related rule relating to the structural integrity of storage wells. Design criteria for the storage wells in the SPR program were developed by Boeing Petroleum Services Inc.[23] The quantitative criteria developed by Boeing include (1) a maximum well diameter, d, of <270 ft; (2) a minimum well center-to-center spacing of 750 ft; (3) a minimum web between adjacent wells, L, >480 ft; (4) a minimum web between a well and the dome edge >300 ft; (5) a minimum web between a well and the closest property line >100 ft; (6) a distance from the well roof peak to the top of the salt, L_S, >450 ft; (7) an L_S/d ratio >1.0; and (8) a L/d ratio >1.78.

Criteria 1, 2, and 8 are not independent. In fact, only two of the three criteria are independent. Criteria 6 and 7 were not intended to be independent. The distance from the well roof peak to the top of the salt is intended to be the greater of 450 ft or the maximum well diameter. Criteria 5 is obviously not a structural criterion but is included in the SPR document, nonetheless. Note that all the storage wells used in the SPR program do not satisfy all these design criteria.

The Louisiana State Dept. of Conservation enacted Statewide Order No. 29-M, which says that the minimum web between adjacent storage wells should be greater than 200 ft.

The applicability and aptness of several of the design criteria and guidelines stated above are addressed elsewhere. For example, the SPR guidelines for proximity of a storage well to the top of the salt, proximity to the edge of the dome, and the Louisiana guideline for the minimum web between storage wells are addressed in may be considered acceptable when site-specific details are considered. This report also states that Statewide Order No. 29-M requires a minimum of 200 ft between adjacent caverns and that, although this conservative criterion would be appropriate in most applications, a safe absolute minimum wall thickness of 100 ft is considered adequate. The report further says that this 100 ft minimum is considered to be an adequate distance between the cavern edge and the dome flank.[24]

Preece and Wawersik[25] addressed the SPR guideline for L/d. These investigators evaluated a storage well complex (located between depths of 2,500 and 3,500 ft) while allowing L/d to vary from 0.6 to 1.8. They state that all pillar widths are predicted to be stable, the volume loss from the caverns is within acceptable limits when L/d is reduced, and moderate reductions of L/d from 1.8 should not result in cavern collapse.[25]

The guidelines of the SPR and the State of Louisiana do not recognize the importance of storage well depth. The in-situ or virgin stress and temperature are directly related to depth. The deformation of salt is strongly correlated to both temperature and stress. The steady-state creep deformation of salt depends on the maximum principal stress difference raised to a power of between 3 and 6 and depends exponentially on the absolute temperature.

Note that SPR storage caverns have nearly 10 times the volume of a typical storage cavern in the Barbers Hill dome. Also, product movement in the Mont Belvieu wells is accomplished with saturated brine, whereas product movement in the SPR wells is designed intentionally to increase the storage well volume through leaching.

Criteria for storage cavern design in domal salt from the SPR program and the State of Louisiana do not apply to the LPG storage caverns at Mont Belvieu. Nonetheless, the 124 storage wells at Mont Belvieu were evaluated with these guidelines for comparison purposes. Approximately one-third of the storage wells do not conform to the State of Louisiana guideline relating to the minimum web thickness between adjacent storage wells. Only nine of the wells have web thicknesses <100 ft.

The majority of the storage wells at Mont Belvieu do not follow the SPR design guidelines relating to the minimum distance to adjacent wellheads or the minimum web thickness to adjacent storage wells. Nine of the wells have maximum diameters >270 ft. None of the storage wells is closer than 300 ft to the dome edge, but 43 of the wells are closer than 100 ft to the nearest property line. Fifteen of the storage wells are less than 450 ft from the top of the salt, but only one storage well has an L_S/d ratio <1. Approximately 60% of the storage wells have L/d <1.78, and 28 of these wells have L/d <1.

The purpose of the SPR design guidelines is to "ensure cavern structural integrity," and the geometric criteria are "derived from cavern integrity and area subsidence considerations."[23] The integrity of the storage caverns (wells) at Mont Belvieu is monitored continually through periodic testing. The area subsidence also is monitored continually and is discussed later in this paper.

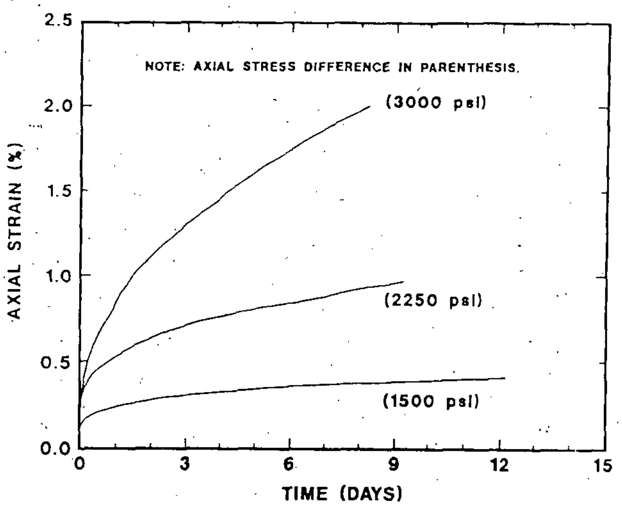

Fig. 4—Confined axial creep strain response of Barbers Hill salt at three axial stress differences. (After Ratigan.[3])

Brine Disposal Wells

Well Cavities. In Aug. 1988, sonar caliper, x-y caliper, and uncalibrated density surveys were performed on a series of brine disposal wells owned by storage operators at Barbers Hill. The purpose of the sonar surveys was to assess the size and shape of the lost-circulation zone in each brine disposal well as part of an overall effort to determine the structural integrity of these lost-circulation cavities.

Each disposal well was generally found to be shorter vertically than when it was originally drilled. Lower portions of the disposal wells had obviously filled. Each disposal well is cased to a region of the borehole that includes the disposal horizon. The disposal horizon occasionally appears to include most of the uncased portion of the drillhole.

The caprock voids in most of the brine disposal wells have similar geometric characteristics. The exception is the Texas Eastern well, which is about an order of magnitude larger than the others. **Fig. 6** shows the sizes and locations of several disposal well voids

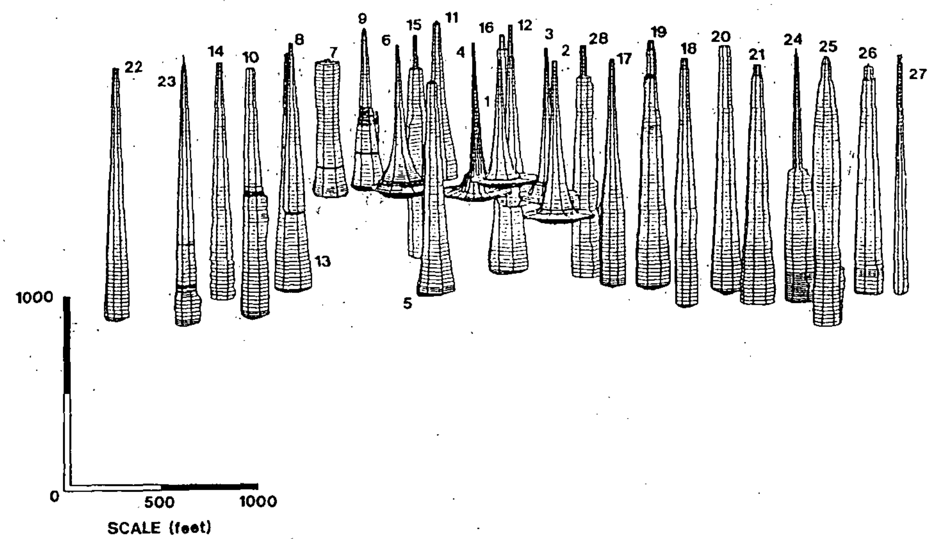

Fig. 5—Isometric view of 28 Warren Petroleum LPG storage wells at Mont Belvieu, TX.

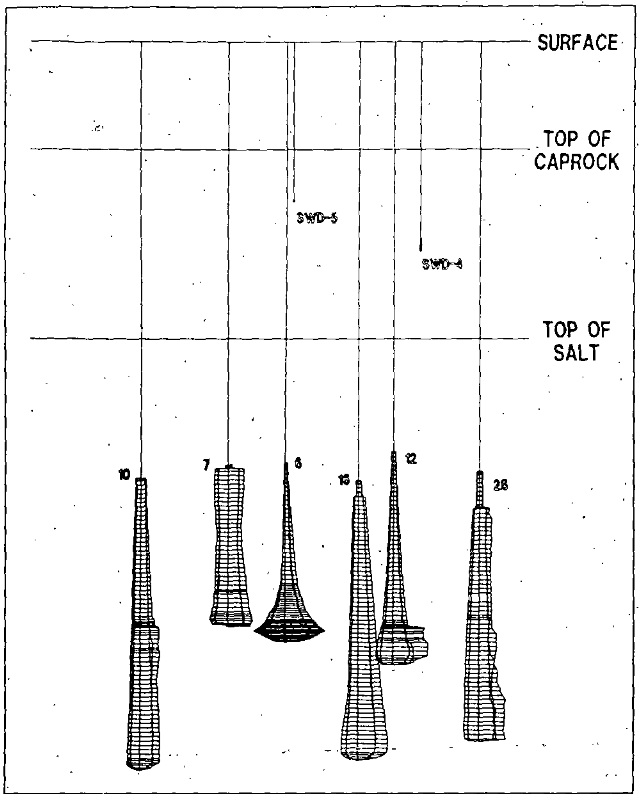

Fig. 6—Two brine disposal well cavities and several LPG wells on the Warren Petroleum property.

relative to several LPG storage wells. The horizon-void volume of the disposal wells ranges from 100 to >37,000/bbl, as determined from the sonar survey.

Structural Stability. An analysis was performed to determine the maximum span of a cavity or opening that could exist in the Barbers Hill caprock without any artificial support. The methods used to determine the maximum unsupported span are those used in the design of underground openings for such civil engineering projects as underground powerhouses, railroad or highway tunnels, and subway tunnels. Hoek and Brown[26] describe the analysis methods for determining the maximum unsupported span.

The characteristics of the Barbers Hill caprock used in the analysis are determined from core taken from Wells WR-15 and SWD-4 on the Warren Petroleum property. The caprock ranges from essentially gypsum (Well WR-15), with a compressive strength of ≈2,600 psi, to essentially anhydrite (Well SWD-4), with a compressive strength of ≈8,500 psi. The rock-quality designation (RQD),[27] Q_f, for the core from both wells was essentially the same (94%). All discontinuities in the core were assumed to be either joints or features that developed because of the presence of a joint. With this assumption, the average spacing of jointing sampled in the vertical holes is 2.1 ft. On the basis of core examination, the jointing is believed to be discontinuous with rough-surfaced joint walls.

A range in the value of the tunneling quality can be calculated with the caprock characteristics. **Fig. 7** shows that tunneling quality ranges from 7 to 37.6 for the Barbers Hill caprock.

If we assume that the underground openings in the caprock should be supported in a manner equivalent to "permanent mine openings, water tunnels for hydropower, pilot tunnels, and drifts and headings for large excavations,"[28,29] then the maximum unsupported span for tunneling quality ranges from 26 to 110 ft. All caprock cavities associated with brine disposal wells can be demonstrated to be stable without artificial support, except for the Texas Eastern brine disposal well. The Texas Eastern well cavity was filled with a sand/grout mixture in 1989, and brine disposal in the well was terminated.

Well Cavities and Brine Disposal. The size of the voids associated with the brine disposal wells in the Barbers Hill caprock may be related to the amount of brine disposed of in the well and the location of the void within the caprock. The amount of brine that enters each disposal well is difficult to determine precisely because accurate records were not always maintained until recently. Therefore, the amount of brine disposed of in a well is assumed to be proportional to the storage volume it services. For example, Texas Eastern has a storage capacity that is 2.5 times greater than the storage capacity at Lyondell. Therefore, the assumption implies that Texas Eastern has disposed of 2.5 times more brine in its disposal well than Lyondell has disposed of in its well. In situations where an operator has more than one disposal well, the wells are assumed to have had equal disposal volumes; e.g., 50% of the disposal at Conoco is assumed to have been in Disposal Well No. 1 and the

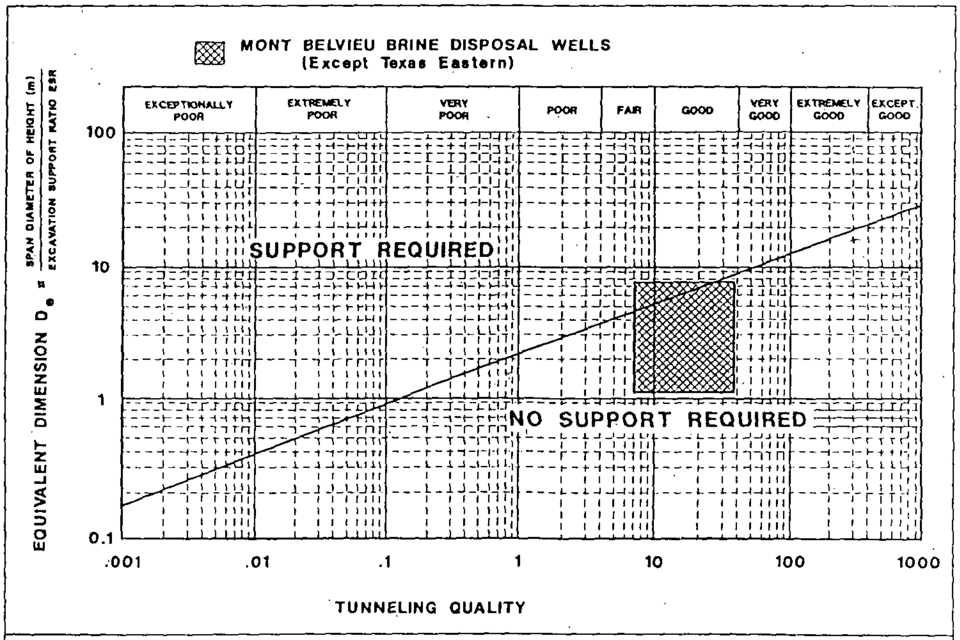

Fig. 7—Relationship between the maximum equivalent dimension, D_e, of an unsupported underground excavation and I_Q. (After Barton, Lien, and Lunde.[28])

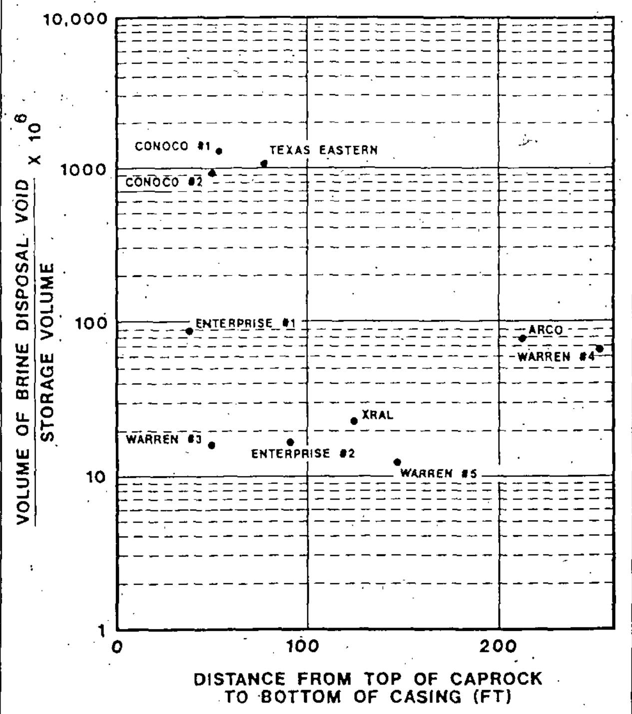

Fig. 8—Normalized void volumes in brine disposal wells as a function of distance into caprock.

other 50% in Disposal Well No. 2. At the Warren property, one-third of the total brine disposal is assumed to have occurred in each of three disposal wells.

In **Fig. 8**, the volume of the void associated with each disposal well normalized with the LPG storage volume (see Table 1) serviced by the disposal well is plotted as a function of distance into the caprock. A correlation seems to exist between these two quantities. The deeper into the caprock, the smaller the cavity volume per unit of brine disposed of. The apparent correlation implies that 1 bbl of brine injected 200 ft into the caprock will result in a void $<1\%$ the size of a void resulting from a similar injection a few feet into the caprock.

Ground Subsidence

Subsidence at Mont Belvieu is determined by comparing the results of two or more precision-level surveys of a series of benchmarks. The benchmarks at Mont Belvieu consist of storage wells, saltwater disposal wells, Warren relief wells, and a series of McClelland benchmarks designed and installed in 1987. **Table 4** shows the number of each benchmark type.

Benchmark and Network Design. Several subsidence benchmark designs are available in the literature.[30] At Mont Belvieu, the design for the sleeved Class A rod mark[30] was selected. The depth of the benchmark (≈ 30 ft) results from the design specifications and the local geologic conditions.

The subsidence network at Mont Belvieu was designed to enable measurement of the vertical ground movement occurring at the surface from the gradual creep closure of the LPG storage wells. The benchmark spacing at Mont Belvieu is not uniform. Many benchmarks are placed over regions with larger LPG storage well capacities or regions with a higher density of storage wells. The average spacing of the benchmarks in the Mont Belvieu network is about 250 ft.

The subsidence network is tied to Coast & Geodetic Survey's Benchmark No. D 1148. Benchmark D 1148 is located on F.M. 1942, 3.0 miles west of its intersection with Loop 207 in Mont Belvieu. This reference benchmark is subsiding at an approximate rate of 1 in./yr from information supplied by the Coast & Geodetic Survey.

TABLE 4—PERMANENT SUBSIDENCE-SURVEY BENCHMARKS AT MONT BELVIEU

Benchmark	Number of Benchmarks
Storage wells	124
Saltwater disposal wells	12
Warren relief wells	25
McClelland benchmarks	101
Total	262

Survey Results. Subsidence rates at Mont Belvieu above the Barbers Hill salt dome were calculated with data from four level surveys performed between Dec. 1987 and July 1989. Evaluation of the data included consideration of the subsidence occurring during the level surveys.[31] All subsidence rates are with respect to a stationary mean sea level.

Fig. 1 shows the contours of the subsidence rates occurring over the Barbers Hill salt dome. The measured subsidence rate is influenced by the volume of the storage wells below the surface, the depths of the wells, the products being stored (or equivalently, the product-side wellhead pressures), and the storage well density.

The average subsidence rate for the 124 storage wells at Mont Belvieu is -1.04 ± 0.40 in./yr. The average subsidence rate for the 101 McClelland benchmarks is -1.06 ± 0.35 in./yr. The remarkable similarity in rates indicates that subsidence on the dome resulting from groundwater withdrawal at Mont Belvieu is negligible. The average subsidence rate of the 12 brine disposal wells is -1.05 ± 0.32 in./yr. All these measured rates tend to confirm that ground subsidence at Mont Belvieu only results from creep closure of the storage wells. A negligible amount of aquifer deformation above the Barbers Hill dome is associated with groundwater withdrawal, and there is no indication of deformation in the caprock other than that associated with the creep closure of the storage wells.

The subsidence rate at the five SPR sites is reported by Goin and Neal[32] for the period from Dec. 1982 to Jan. 1988. During this time, the maximum subsidence rates range from -0.72 in./yr at the Bryan Mound site to -3.6 in./yr at the West Hackberry site.[32] All their subsidence rates are believed to reflect the respective level-survey reference benchmarks and not the stationary mean sea level. The average subsidence rate for all the SPR sites is approximately 25% greater than the average rate at Mont Belvieu.

Conclusions

A comprehensive geomechanics evaluation of the underground LPG storage facility at Mont Belvieu was reported. The salt core of the Barbers Hill dome exhibits very high compressive and tensile strengths. The creep characteristics of the Barbers Hill salt are typical of other U.S. gulf coast salt domes. The storage wells within the salt dome have relatively uniform shapes and an average storage capacity of about 1.5×10^6 bbl. The caprock strength is comparable with other domes and is sufficiently strong and fracture-free to ensure stability of the cavities associated with caprock brine disposal at all currently existing brine wells.

Subsidence rates at Mont Belvieu are moderate, relatively uniform, and attributable to the gradual creep closure of the LPG storage wells. Continued storage well monitoring and subsidence measurements should ensure continued safe and economical operation of the Mont Belvieu complex.

Nomenclature

d = well diameter, ft
I_Q = index of tunneling quality
J_a = joint alteration number
J_n = joint set number
J_r = joint roughness number
J_w = joint water-reduction factor
L = web between adjacent wells, ft
L_S = distance from well roof peak to top of salt, ft

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Q_f = rock quality, %
SRF = Stress Reduction Factor
x,y = Cartesian coordinates, ft

Acknowledgments

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SI Metric Conversion Factors

bbl	× 1.589 873	E−01	=	m^3
ft	× 3.048*	E−01	=	m
in.	× 2.54*	E+00	=	cm
in.^{2}	× 6.451 6*	E+00	=	cm^2
miles	× 1.609 344*	E+00	=	km
psi	× 6.894 757	E+00	=	kPa

*Conversion factor is exact.

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Development of the Wink Sink in west Texas due to salt dissolution and collapse

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ABSTRACT

The Wink Sink, in Winkler County, Texas, is a collapse feature that formed in June 1980 when an underground dissolution cavity migrated upward by successive roof failures until it breached the land surface. The original cavity developed in the Permian Salado Formation salt beds more than 400 m (1,300 ft) below ground level. Natural dissolution of salt occurred in the vicinity of the Wink Sink in several episodes that began as early as Salado time and recurred in later Permian, Triassic, and Cenozoic times. Although natural dissolution occurred in the past below the Wink Sink, it appears likely that the dissolution cavity and resultant collapse described in this report were influenced by petroleum-production activity in the immediate area. Drilling, completion, and plugging procedures used on an abandoned oil well at the site of the sink appear to have created a conduit that enabled water to circulate down the borehole and dissolve the salt. When the dissolution cavity became large enough, the roof failed and the overlying rocks collapsed into the cavity. Similar collapse features exist where underground salt beds have been intentionally dissolved during solution mining or accidentally dissolved as a result of petroleum-production activity.

Introduction

The Wink Sink, located 3.2 km (2 miles) north of the town of Wink in Winkler County, Texas (Figure 1), formed on June 3, 1980, and within 24 hours it had expanded to a maximum width of 110 m (360 ft) (Baumgardner et al., 1982). Two days later, the maximum depth of the sinkhole was 34 m (110 ft) and the volume was estimated at about 159,000 cubic m (5.6 million cubic ft). The collapse occurred near the middle of Hendrick Field, a giant oilfield that has been operating since 1926; one abandoned oil well was incorporated within the sink itself, and a second oil well was plugged and abandoned because of its proximity to the sinkhole. There appears to be no doubt that the Wink Sink resulted from an underground dissolution cavity that migrated upward by successive roof failures, thereby producing a collapse chimney filled with brecciated rock (Baumgardner et al., 1982). The dissolution cavity had developed in salt beds of the Permian Salado Formation, which is about 260 m (850 ft) thick and lies about 400 to 655 m (1,300 to 2,150 ft) beneath the Wink Sink. Natural dissolution of salt beds in the Salado Formation in Winkler County and other areas of West Texas and New Mexico is well known, but the dissolution and collapse associated with the Wink Sink apparently resulted from, or at least was accelerated by, oilfield activity in the immediate vicinity of the sink. Whether the dissolution is due to natural causes or oilfield activity, there are four distinct requirements for salt dissolution to occur (Johnson, 1981): (1) a deposit of salt through which water can flow, (2) a supply of water unsaturated with respect to NaCl, (3) an outlet whereby the resulting brine can escape, and (4) energy (such as hydrostatic head or density gradient) to cause the flow of water through the system.

Previous reports on the Wink Sink include widely distributed articles by Baumgardner et al. (1980, 1982) and a limited-distribution government document by Johnson (1986). The current report is a summary of data presented by Johnson (1986).

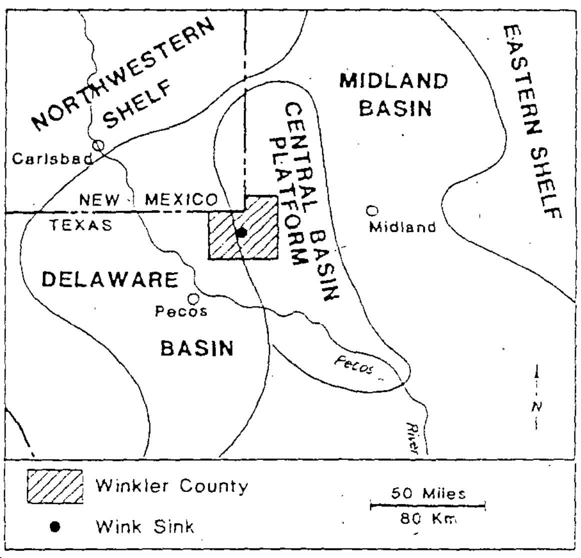

Figure 1: Map of west Texas and southeast New Mexico showing major geologic provinces and location of Wink Sink in Winkler County.

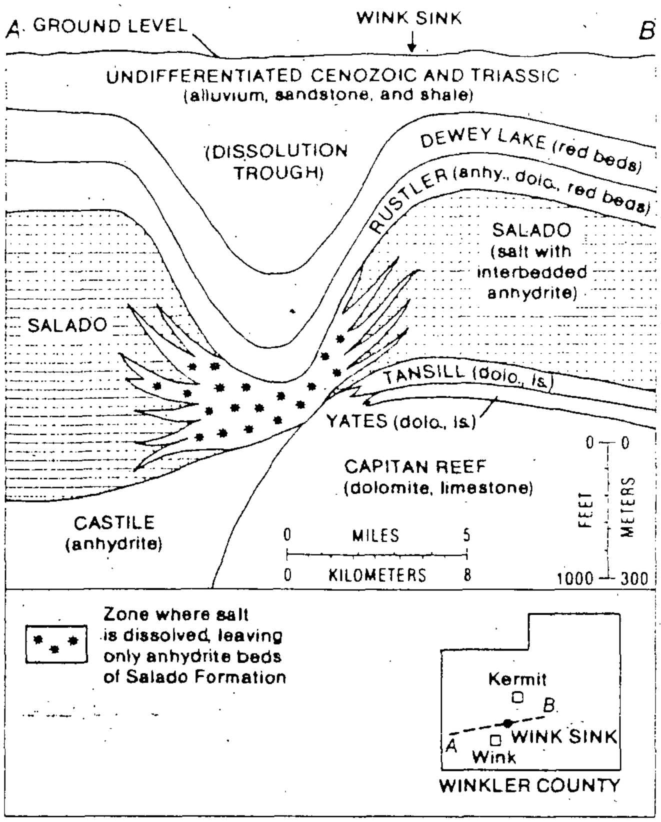

Figure 2: Schematic east-west cross section in Winkler County showing natural dissolution of Salado Formation salts on the eastern edge of the Delaware Basin (modified from Baumgardner et al., 1982). All strata below the "Undifferentiated Cenozoic and Triassic" are Permian in age.

Geologic History and Stratigraphy

Winkler County is located astride the boundary between the Delaware Basin on the west and the Central Basin Platform on the east (Figure 1). These major structural provinces are both part of the greater Permian Basin of West Texas and southeast New Mexico and are characterized by different sequences of Permian-age strata. The provinces are separated by the Capitan Reef, a massive limestone and dolomite reef that fringed the Delaware Basin during Guadalupian time when different suites of sediment were deposited on either side of the reef.

Rock units of principal concern in the vicinity of the Wink Sink are all of sedimentary origin and are of Permian, Triassic, or Cenozoic age (Figure 2). The Capitan Reef, the oldest Permian unit of interest, is a massive sequence of limestone and dolomite about 457 to 610 m (1,500 to 2,000 ft) thick and 13 to 16 km (8 to 10 miles) wide in western Winkler County (Garza and Wesselman, 1959). Carbonate rocks in the Capitan typically have a high porosity and permeability. The Capitan grades eastward into contemporaneous back-reef carbonates and clastics of the Artesia Group; the two uppermost formations of the Artesia (the Yates and Tansill Formations) are present above the Capitan beneath the Wink Sink.

The Yates Formation consists of light-gray, white, and flesh-colored dolomite and limestone with some interbeds of fine-grained gray sandstone and shale (Ackers et al., 1930). The Yates is about 85 m (280 ft) thick in the vicinity of the Wink Sink (Baumgardner et al., 1982). Porosity occurs in the form of irregular solution cavities as large as 5 cm (2 in) in diameter, and also as interstitial voids in the granular rocks. Solution cavities lined with calcite are commonly found in the oil-producing horizons.

The overlying Tansill Formation consists mainly of dolomite and limestone, interbedded with dolomitic shales, and a persistent bed of anhydrite that overlies the dolomitic sequence (Ackers et al., 1930; Baumgardner et al., 1982). The Tansill Formation is about 50 m (160 ft) thick beneath the Wink Sink, and the anhydrite in the upper part of the Tansill is generally 9 to 15 m (30 to 50 ft) thick. The top of the formation is at the base of the lowest salt unit in the Salado Formation (Baumgardner et al., 1982).

The Salado Formation is a thick sequence of interbedded salt (halite) and anhydrite. The formation is about 260 m (850 ft) thick beneath the Wink Sink, but it is as much as 400 m (1,300 ft) thick just to the east and only about 180 m (600 ft) thick just to the west (Figure 2). Individual Salado anhydrite units in the area typically are 3 to 15 m (10 to 50 ft) thick, whereas the intervening salt units commonly are 3 to 30 m (10 to 100 ft) thick. Variations in thickness of the Salado Formation and of the individual salt units are largely due to dissolution of one or more of the salt units during Salado and post-Salado times. Dissolution of the salts in the Salado has been noted several times in earlier literature (Ackers et al., 1930; Maley and Huffington, 1953; Anderson and Kirkland, 1980), and, most recently, Baumgardner et al. (1982) and Johnson (1986) have shown that dissolution has occurred in each of the Salado salt units in the vicinity of the Wink Sink.

Overlying the Salado is the Rustler Formation, which consists of interbedded anhydrite, dolomite, limestone, shale (or mudstone), and sandstone (Ackers et al., 1930; Baumgardner et al., 1982). The Rustler is about 82 m (270 ft) thick beneath the sink, but locally it is as much as 95 m (310 ft) thick where it apparently thickens due to dissolution and collapse of underlying Salado salt units prior to or during Rustler deposition. The Dewey Lake Formation consists of interbedded red-brown shale, sandy shale, and siltstone overlying the Rustler (Ackers et al., 1930; Baumgardner et al., 1982). The thickness of Dewey Lake strata in the area ranges from about 110 to 146 m (360 to 480 ft), and is about 137 m (450 ft) beneath the Wink Sink. The local sharp increase in thickness of the Dewey Lake indicates the likelihood that some of the dissolution of salt in the Salado occurred prior to or during Dewey Lake deposition.

Unconformably above the Dewey Lake Formation lies a sequence of Triassic shales and sandstones overlain by unconsolidated Cenozoic clastics; these strata are not readily differentiable in the area, and thus have been referred to as "undifferentiated Cenozoic and Triassic" strata (Figure 2). This undifferentiated sequence increases in thickness markedly across the area from about 120 m (400 ft) on the east to as much as 457 m (1,500 ft) in the dissolution trough west of Wink Sink (Figure 2). The abrupt thickening of these strata in the same area where the Salado salts reach minimum thickness supports the interpretation of salt dissolution and concurrent (or subsequent) basin filling during Triassic and Cenozoic times.

Natural dissolution of salt beds of the Salado Formation in western Winkler County began during Late Permian time and still may be going on today (Baumgardner et al., 1982). Abnormal thinning and thickening of individual salt units in the Salado, as well as local thickening of each of the overlying formations of Permian, Triassic, and Cenozoic age, indicate that this process of dissolution and subsidence has occurred intermittently in the Wink area and began even before the end of Salado deposition (Johnson, 1986).

Petroleum Activity in the Hendrick Field

The Hendrick Field, which includes the location of the Wink Sink (Figure 3), is one of the giant oilfields of Texas. More than 1,400 wells have been drilled in the field since its discovery in 1926, and these wells have yielded a cumulative total of about 40.55 million cubic m (255 million barrels) of oil (one metric ton of crude oil equals 1.166 cubic m). Drilling activity and oil production were phenomenally high in the first few years after the discovery well was drilled, but by the early 1930s, the activity was reduced greatly and has continued to decline to a relatively low level today. One of the major problems in the Hendrick Field since its beginnings is the great volume of oifield brine that has been produced along with the oil and has required disposal.

Several articles were published during the early boom period of the Hendrick Field (Vance, 1928; Bignell, 1929, 1930; Ackers et al., 1930; Heithecker, 1932; Carpenter and Hill, 1936), and these documents provide valuable insight into the methods of drilling, well completion, oil production, brine production, and brine disposal used in the field.

Production in the Hendrick Field has been predominantly oil, with small amounts of natural gas. Most of the oil has come from the Yates Formation, although some is produced from the overlying Tansill Formation. Initial daily production of individual wells, based on short-time gages, ranged from 48 to 15,583 cubic m (300 to 98,000 barrels) of oil per day, and pilot-tube measurements of natural-gas production on some wells indicated as much as 2 million cubic m (70 million cubic ft) per day. Most wells were drilled only 201 m (660 ft) from neighboring wells, with spacing throughout the field typically being one well per 4 or 8 hectares (10 or 20 acres) (Figure 4). In parts of the field explosives were used to fracture the producing zones and thereby increase production of some of the wells with low yields (Vance, 1928).

Many crooked boreholes were drilled in the early years of development of the Hendrick Field (Carpenter and Hill, 1936). As a result, the lower part of some boreholes is shifted a hundred meters (several hundred feet) or more laterally away from the surface location. In surveys of some of the boreholes, it was found that the deflection of the holes at various depths was as much as 20 to 40 degrees from the vertical. In some of these boreholes where the deviation was excessive, such as in the Hendrick well 10-A at the Wink Sink, explosives were used to fracture the rock and allow realignment of the hole.

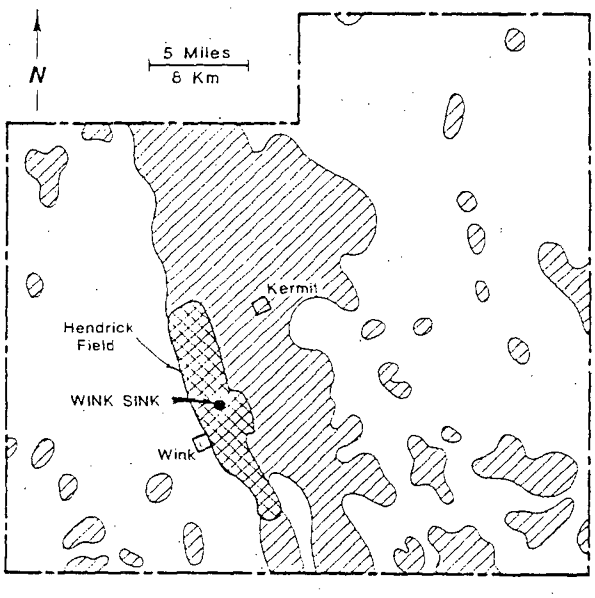

Figure 3: Winkler County, Texas, showing oil- and gas-producing areas (diagonal lines) and location of Hendrick Field and Wink Sink.

Oilfield Brines in the Hendrick Field

Production and disposal of oilfield brines has been a serious problem in the Hendrick Field since shortly after the field was discovered. The vugs and fractures within the Tansill and Yates carbonate reservoirs yield saline formation waters along with the oil, and, in most cases, large amounts of brine were produced shortly after completion of an oil well. The brines generally contain from 5,000 to 48,000 parts per million dissolved solids. Water production ranged from about 95,400 to 139,000 cubic m (600,000 to 875,000 barrels) per day in the 1930s, and the water-oil ratio for the producing wells increased from about 16 to 1 in 1930 to as much as 50 to 1 in 1934 (Carpenter and Hill, 1936).

Although no accurate totals are available, it is clear that a tremendous quantity of water has been produced in the Hendrick Field. By assuming an average production of 135,000 cubic m (850,000 barrels) of water per day from 1929 through 1957 (Garza and Wesselman, 1959) and an average of 47,700 cubic m (300,000 barrels) per day from 1958 through 1982 (Johnson, 1986), it is herein estimated that the cumulative production of water has amounted to about 1.86 billion cubic m (11.7 billion barrels, or 1.5 million acre-feet).

The principal means for handling the great quantity of water produced with oil in the Hendrick Field consisted of disposal in unlined, natural and artificial earthen "evaporation" pits (Heithecker, 1932). In some places, dynamite was used to blast caliche or other hard rock units present in the floor of a pit. It was realized from the outset that most of the water disposed of in the earthen pits was in fact lost through seepage into the ground (Heithecker, 1932). The ground surface in most parts of the Hendrick Field consists of loose sand, and this covers the unconsolidated sand, gravel, silt, and clay in the Cenozoic alluvium. Therefore, waters (including oilfield brines) were able to percolate down easily through the porous and permeable surface materials to reach and recharge the ground water.

No public records have been kept of the location of these earthen pits, the period of their use, or the quantity of wastewater that was discarded into individual pits or into all pits combined. However, a series of aerial photographs taken in 1942, 1946, 1954, and 1968 show the location of a great many natural and artificial earthen pits that were used intermittently or continuously for disposal of water. By stereoscopic study of these photographs, I have established that nearly 50 separate areas, ranging in size from 0.4 to 12 hectares (1 to 30 acres), were used at one time or another as disposal pits in the vicinity of the Wink Sink (Figure 5). In fact, the largest pit, located in the northeast quarter of section 34, is just 300 m (1,000 ft) south-southeast of the Wink Sink; portions of this pit

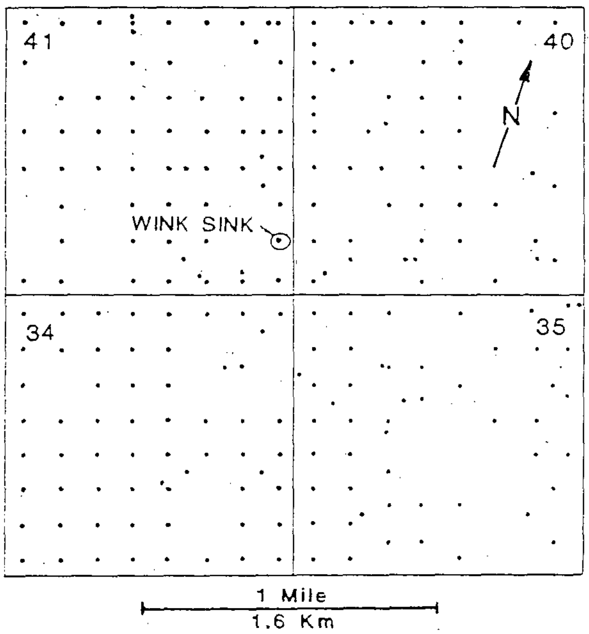

Figure 4: Location of the 227 petroleum tests and other boreholes drilled near Wink Sink in sections 34, 35, 40, and 41 of Block B-5, Public School Land Survey, Winkler County.

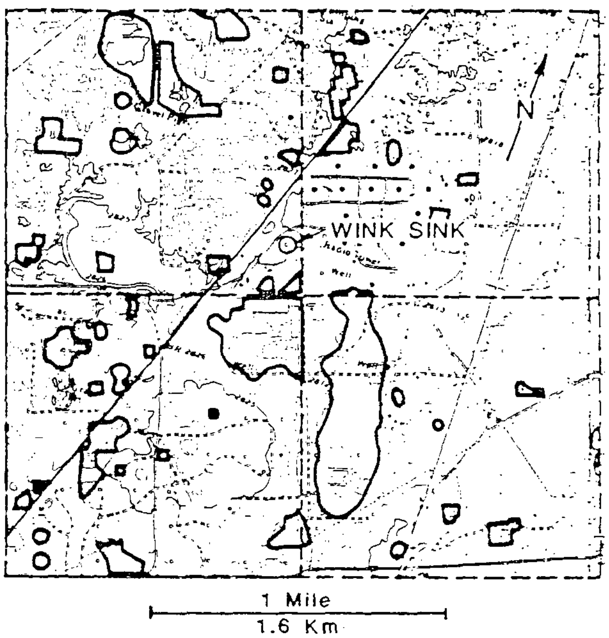

Figure 5: Map showing location of earthern ponds and pits (heavy lines) used for disposal of oilfield brines in four-section area surrounding the Wink Sink in Winkler County.

have been used continuously from 1942 through 1968, and the pit may have been put in use as early as the early 1930s. Several smaller pits, located in the southeast quarter of section 41 (Figure 5), are even closer to the Wink Sink, but have been in use for shorter periods of time.

Within the Hendrick Field the shallow, fresh-water aquifers have been recharged substantially by leakage of wastewater from the disposal pits (Garza and Wesselman, 1959). Great volumes of water have seeped down through permeable, sandy soil in the central part of the field, including the location of the Wink Sink, creating a large ground-water mound that in 1956 extended about 13 km (8 miles) north-south and 6.5 km (4 miles) east-west (Garza and Wesselman, 1959). It appears that the water table in the mound may have been raised some 15 to 30 m (50 to 100 ft) by that time. In 1956 the water table at the site of the Wink Sink was about 9 m (30 ft) below ground level.

History of Hendrick Well 10-A

An abandoned oil well, the Hendrick well 10-A, is located within the circumference of the Wink Sink. The sink apparently did not breach the surface at the location of the borehole, but reportedly appeared to one side of the borehole (Baumgardner et al., 1982). As the sink enlarged by slumping and caving of the sides, the surface casing of the well apparently was incorporated in the slump material, although no eyewitnesses reported sighting the surface casing. The following discussion on the history of the Hendrick well 10-A is modified slightly from an original discussion by Baumgardner et al. (1982) based largely on data filed with the Texas Railroad Commission.

Republic Production Company began drilling the Hendrick well 10-A on June 29, 1928, and completed it on October 25, 1928. The driller's log and the borehole representation (Figure 6) show drilling, casing, and plugging procedures reported to the Texas Railroad Commission during the life of the well. The well was drilled with rotary tools to the top of "brown lime of the Tansill Formation" at a depth of 668 m (2,193 ft), and cable tools were used to complete the well in the Yates Formation at a depth of 778 m (2,552 ft). Initial daily production from the well was estimated to be 159 cubic m (1,000 barrels) of oil and 636 cubic m (4,000 barrels) of water. The casing program consisted first of setting surface pipe, 39.4 cm (15.5 in) in diameter, at a depth of 122 m (400 ft) and cementing it with 300 sacks of cement. Second, 25.4-cm (10-in) casing was set at a depth of 669 m (2,196 ft) and cemented with 800 sacks of cement. Finally, casing 21 cm (8.25 in) in diameter was set at a depth of 744 m (2,440 ft) but was not cemented. No casing was set below 744 m (2,440 ft). The Hendrick well 10-A was a crooked borehole that deviated too much from the vertical; it was straightened at a depth of 701 m (2,300 ft) by exploding 151 liters (160 quarts) of nitroglycerine in the borehole.

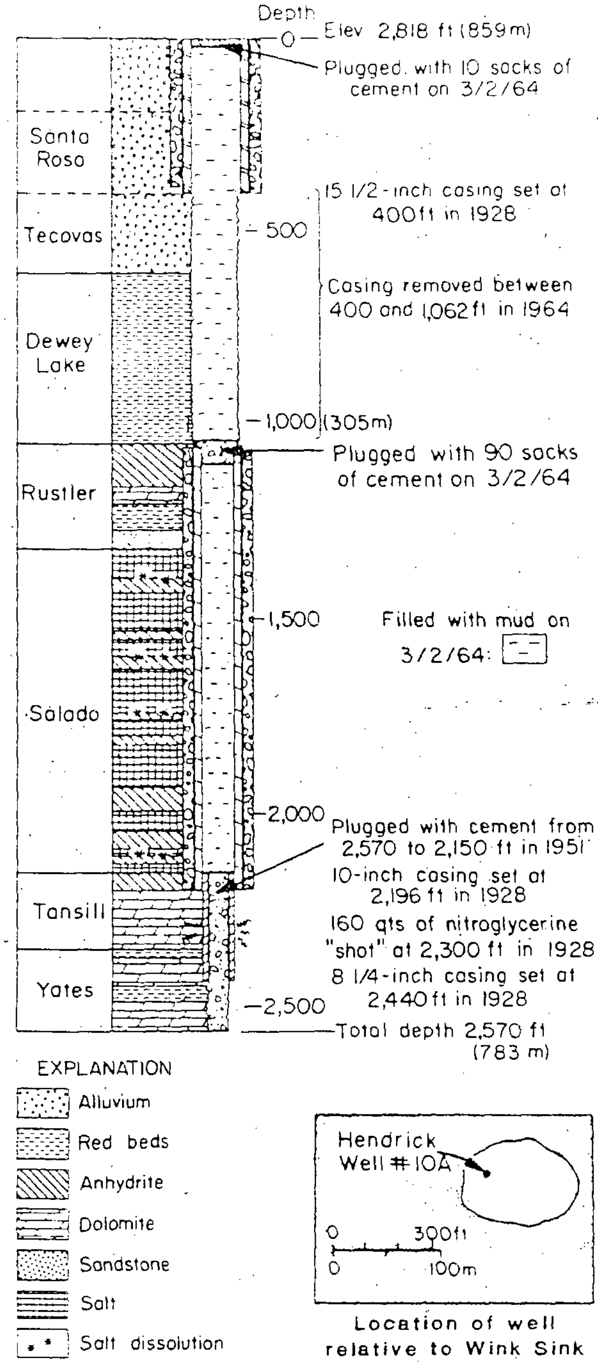

Figure 6: Stratigraphic section of Hendrick well 10-A, section 41, Block B-5, Public School Land Survey, Winkler County, Texas (modified from Baumgardner et al., 1982).

The Republic Production Company later deepened the well to 783 m (2,570 ft) in January 1930. They then filed an application to again deepen the well to 945 m (3,100 ft) in December 1931, but no data are on file with the Texas Railroad Commission to indicate that the well was drilled deeper than 783 m (2,570 ft). The Bradberry and Sasser Company later filed a plugging record for the well in July 1951, referring to the well as being on the T. G. Hendrick "A" lease. The record stated that the well was shot "to part casing," but the depth (or depths) of these shots and their effect on the casing were not reported. The record did show, however, that the well was plugged with cement at depths from 783 to 655 m (2,570 to 2,150 ft). The wellbore above this was filled with mud and plugged at depths from 122 to 113 m (400 to 370 ft) with 25 sacks of cement, and then plugged at the surface with 15 sacks of cement. The well was then abandoned for 13 years.

In 1964, the Mallard Petroleum Company removed the shallow cement plugs and attempted to deepen the well. However, the drillers were unable to reenter the hole "because of junk" in the borehole. The well was then replugged in March 1964 with 90 sacks of cement at a depth of 323 m (1,060 ft), and with 10 sacks of cement at the surface. During this reentry attempt, the company removed more than 183 m (600 ft) of 25.4-cm (10-in) diameter casing, leaving an unlined borehole (presumably filled with mud) between 324 and 122 m (1,062 and 400 ft), or from the upper part of the Rustler Formation to just below the Santa Rosa Formation.

Salt Dissolution by Natural Causes in the Wink Sink Area

A number of studies have been conducted on salt dissolution in various parts of the Delaware Basin and nearby areas, including work by Ackers et al. (1930), Adams (1944), Maley and Huffington (1953), Hills (1970), Bachman (1976), Kirkland and Evans (1976), Anderson et al. (1978), Mercer and Hiss (1978), Anderson and Kirkland (1980), Baumgardner et al. (1980; 1982), Lambert (1983), and Johnson (1986). There is, in addition, overwhelming evidence that salt has been partly dissolved by natural processes in the vicinity of the Wink Sink (Baumgardner et al., 1982; Johnson, 1986). Abnormal and abrupt thinning of salt units with concurrent thickening of overlying rock units in the same area is major proof for this natural dissolution (Figure 2). The dissolution has been episodic in various parts of the Wink area, with evidence that it began as early as Salado time and then recurred during later Permian, Triassic, and Cenozoic time. Some natural dissolution of Salado salts may be going on at the present time, but there is no evidence currently available to confirm or refute this.

There is no evidence that a natural cavern existed in the vicinity of the Wink Sink prior to drilling of the Hendrick well 10-A. No cavities were reported in 1928 during drilling of the well, and subsurface conditions at and near the sink have not been examined by boreholes or other methods since development of the sink. The presence of permeable fracture zones or cavities in the area is indicated by the loss of fluids during the drilling of four of the oil wells located within 1.6 km (1 mile) of the Wink Sink (Baumgardner et al., 1982). The wells, drilled in 1927 and 1928, lost circulation at depths ranging from 291 to 699 m (956 to 2,293 ft). One well lost circulation during drilling in sand and red beds of the Dewey Lake Formation; one well lost circulation in dolomite of the Tansill Formation; and the other two wells lost circulation during drilling in the Salado Formation. These lost-circulation zones are permeable pathways that can allow for the movement of fluids within, above, and below the Salado Formation.

Salt Dissolution Related to Petroleum Activity in the Wink Sink Area

Although it is clear that most of the salt dissolution in the Wink area (including the dissolution trough) has resulted from natural processes, it is equally clear that some of the early-day oilfield practices employed during the boom period of the Hendrick Field may have contributed to the accelerated dissolution of salt in the vicinity of the Hendrick well 10-A and this may have caused the collapse of the Wink Sink. Similar collapse features have developed in the past above caverns that resulted from solution mining of salt or from unplanned borehole enlargement in salt beds penetrated during oil and gas operations.

Drilling and completion of the Hendrick well 10-A apparently were consistent with standard industry practices of West Texas during the late 1920s. In retrospect, however, several factors and events can be identified that may have contributed to development of a dissolution cavern in the Salado salt around this borehole. These include the probable use of a fresh-water drilling fluid, use of nitroglycerine to straighten the hole, the possibility of poor cement jobs inadequately sealing off the salt beds behind the casing, possible corrosion of casing by salt water, and removing some of the casing upon final plugging of the borehole. Such factors and events may have assisted in making the borehole a pathway whereby shallow ground water could have flowed down to and through the Salado salts.

Data are not available on the nature of drilling fluids used in drilling the Hendrick well 10-A, but in all probability the fluid consisted of fresh water (from local water wells) mixed with clays to increase its weight and viscosity. Such a fresh-water fluid would have dissolved some of the salt adjacent to the borehole during drilling operations, and thus would have enlarged or "washed out" the hole within the Salado salt sequence. Walters (1978) points out that oil wells drilled by similar rotary methods in central Kansas during the 1930s were enlarged considerably through the Hutchinson salt beds; holes drilled with 23-cm (9-in) bits were washed out to 1.5 m (5 ft) or more in the salt section. Therefore, it is quite likely that the Hendrick well 10-A borehole was at least somewhat enlarged and washed out within the Salado salt section during drilling.

Baumgardner et al. (1982) indicate that the 800 sacks of cement used to set the 25.4-cm (10-in) casing at 669 m (2,196 ft) in the Hendrick well 10-A had filled all the annular space in the hole behind the casing from a depth of 669 m (2,196 ft) up to about 328 m (1,075 ft) (Figure 6). This does not seem likely, however, because if the 800 sacks of cement had filled the annulus for this entire 342 m (1,121 ft) of hole, it would average about 2.33 sacks of cement per meter (0.71 sack of cement per foot) of hole; that would indicate a very narrow space behind the casing and account for little or no hole enlargement through the salt section. Walters (1978) reported that 1,000 sacks of cement filled only 46 m (150 ft) of hole that had been washed out to about a 1.4-m (4.5-ft) diameter in the Hutchinson salt at the Panning Sink in central Kansas. Therefore, it seems likely that the 800 sacks of cement used in the 10-A well were sufficient to cement the 25.4-cm (10-in) casing only in the lower part of the hole, leaving most of the salt section uncemented behind the casing.

The explosion of 151 liters (160 quarts) of nitroglycerine to realign the hole at a depth of 701 m (2,300 ft) may have fractured the cement lining of the borehole, and thus may have created pathways for water movement adjacent to the Salado salt (Baumgardner et al., 1982). The explosion certainly fractured the Tansill Formation and/or other rock units near the bottom of the hole and thereby increased their permeability to circulating brines. Also, the need to straighten the hole with explosives shows that the Hendrick well 10-A deviated from the vertical, and the lower part of the hole had shifted some distance away from the surface location of the borehole. The direction and magnitude of that shift were not reported, but it is possible that the borehole penetrated the top of the Salado Formation at a distance some 15 to 30 m (50 to 100 ft) east of its surface location, at a site directly below the center of the present Wink Sink (Figure 7, part A). This would be a borehole deviation of only 2 to 4 degrees from the vertical at the top of the Salado.

Poor cement jobs or fractures in the cement lining of the Hendrick well 10-A may have opened pathways for movement of water either up or down the borehole, thus allowing the water to come in contact with the Salado salts (Baumgardner et al., 1982). Surface casing was set at a depth of 122 m (400 ft), approximately at the base of the Santa Rosa fresh-water aquifer. If this casing were set too shallow to seal off the aquifer, or if water also were present in some of the siltstone or sandstone beds of the underlying Tecovas Formation, it would be possible for fresh water to leak into and down the borehole outside the casing (Figure 7, part B, upper part). Also, a poor cement job at the base of this surface casing in 1928, or fracturing of the cement during later workover, reentry, or plugging operations, could have allowed fresh water from the Santa Rosa to leak down the borehole outside the casing. Baumgardner et al. (1982) also point out that the absence of cement plugs or cement lining in the borehole below a depth of 669 m (2,196 ft) during the period from 1928 to 1951 may have allowed water to move upward under artesian pressure to near the base of the Salado Formation.

Casing in the well may have been perforated by corrosion, thus permitting water to circulate outside the casing where it could encounter the Salado salts (Baumgardner et al., 1982). Pumping large amounts of saline water (Hendrick Field brines range from 5,000 to 48,000 parts per million dissolved solids) from this well from 1928 to 1951 may have caused excessive corrosion of the casing. Baumgardner et al. (1982) report leaks in the casing of a nearby well of similar age: the Hendrick well 3-A, drilled 201 m (660 ft) south-southeast of the well 10-A, was drilled and cased in 1928 and also had an initial fluid production of about 795 cubic m (5,000 barrels) per day (it yielded 90 percent water, whereas the well 10-A yielded 80 percent water). An attempt to circulate cement behind the casing in well 3-A in early June 1980 (prior to formation of the Wink Sink) had failed because of leaks in the casing, and presumably these leaks were caused by corrosion. The similar ages and production histories of both wells suggest that the casing in well 10-A may also have been perforated by corrosion (Baumgardner et al., 1982).

Removal of 25.4-cm (10-in) casing between the depths of 324 and 122 m (1,062 and 400 ft) in 1964 left an unlined borehole in the interval extending from near the base of the Santa Rosa to the top of the Rustler for a period of 16 years, until development of the Wink Sink. This would have enhanced the access of fresh water to the upper part of the borehole, particularly if water from the Santa Rosa aquifer could enter the borehole below the surface casing or through fractured cement at the base of the surface casing. The well was plugged in 1964 at a depth of 323 m (1,060 ft), and therefore this should have prevented any water in the upper part of the borehole from migrating deeper into the Salado salts. However, fractures or other imperfections in the cement plug, or the presence of fractures, cavities, or other permeable pathways in the upper part of the Rustler Formation, may have allowed water in the upper part of the borehole to bypass this plug and enter the salt beds in the lower part of the well.

Regardless of conditions of the cement or casing in the upper part of the borehole, or whether water could enter the borehole from any aquifer above the Salado and gain access to the salt sequence, it still was necessary for an outlet to exist, whereby the resulting brine could escape, and energy to cause flow of water through the system for extensive dissolution to occur (Johnson, 1981). The lower part of the Hendrick well 10-A contained several outlets whereby brine could have escaped the borehole, and the energy required to force the water down

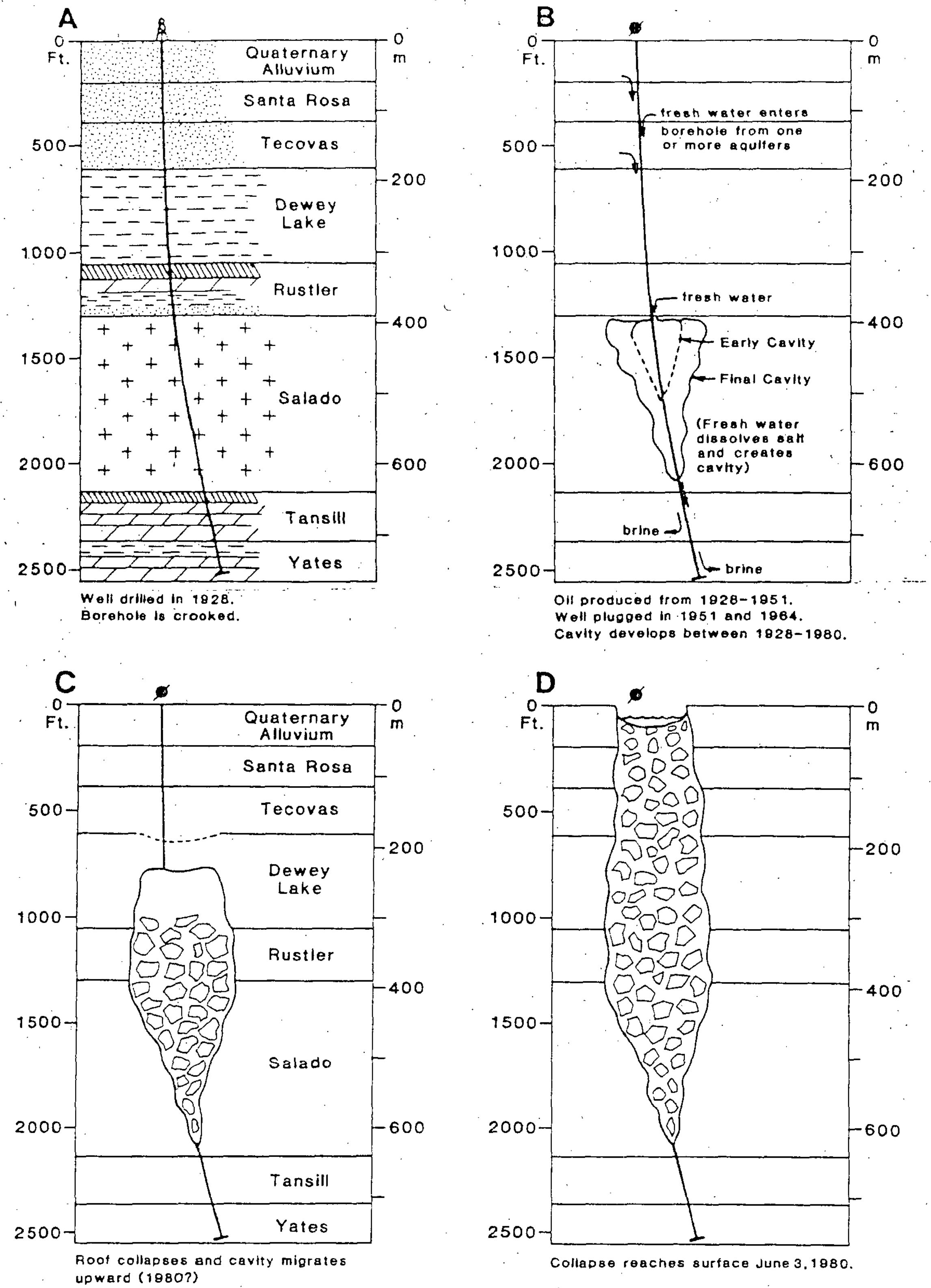

Figure 7: East-west cross section through the Hendrick well 10-A showing possible relationship of well to development of the Wink Sink. Fresh water may have circulated down the borehole to dissolve the salt and create a cavity; by successive roof failures, the cavity migrated upward to the land surface.

the borehole was the hydraulic-head difference between the shallow aquifers and permeable strata below the salt sequence.

All three formations underlying the Salado salts in the Hendrick Field have moderate to high porosity and permeability. The Tansill, Yates, and Capitan carbonates typically contain vugs and irregular solution cavities, whereas the sandstones commonly have interstitial porosity; the various formations and rock types also are well interconnected by fracture systems. The high porosity and permability of these formations are substantiated by the large yields of oil and water from wells drilled into these reservoirs: initially 795 cubic m (5,000 barrels) of oil and water were produced per day from the Hendrick well 10-A. Furthermore, the natural porosity and permeability of pre-Salado strata in the Hendrick well 10-A were undoubtedly increased by exploding 151 liters (160 quarts) of nitroglycerine in the Tansill Formation in 1928.

It is also possible for brine to escape the borehole by moving laterally through preexisting dissolution channels that may have existed in the salt, anhydrite, or dolomite beds of the Salado Formation. There is no question that some of the Salado salt units have been partially or totally dissolved by natural processes in various parts of the Hendrick Field, and the Hendrick well 10-A probably penetrated one or several of these preexisting dissolution zones. Solution channels, brecciated rock, and other openings that conducted fluids through the various Salado salt beds in the past would still be potential pathways for movement of fluids away from a dissolution cavern such as may have developed around the Hendrick well 10-A. The ultimate outlet for brines that may have escaped the borehole through preexisting Salado dissolution channels probably would still be the highly porous and permeable carbonates that underlie the Salado. Access of the brines to these pre-Salado strata would be through preexisting natural pathways or through other boreholes in the area that might permit open communication between the dissolution channels and the pre-Salado strata.

The energy necessary to drive shallow fresh water down to the salt in the Hendrick well 10-A, and to drive the resultant brine into underlying pre-Salado strata would be the hydraulic-head difference between water-bearing strata above and below the Salado Formation. Drill-stem tests from wells near the Wink Sink in 1975 show that the hydraulic head in the Santa Rosa Formation was higher than that in the Tansill, Yates, or Capitan Formation (Baumgardner et al., 1982). Therefore, if the Santa Rosa aquifer were connected with the permeable pre-Salado strata by pathways through or near the Hendrick 10-A borehole, then downward flow into the deep reservoirs would result (Figure 7, part B).

Other shallow aquifers, such as the Cenozoic alluvium and perhaps even the Rustler Formation, also have hydraulic heads higher than those of the pre-Salado reservoirs; thus, waters in these shallow aquifers would also flow down through the borehole if they were interconnected with the deep reservoirs (Figure 7, part B). The Cenozoic alluvium is an unconfined aquifer well above the hydraulic heads of the Tansill, Yates, and Capitan Formations, and clearly would have yielded water to the Hendrick well 10-A. However, data on the Rustler aquifer in the vicinity of the Wink Sink are lacking. Water yields and permeabililty of the Rustler are highly variable, and therefore it is uncertain whether the Rustler might have yielded much water to the Hendrick well 10-A in the past. Furthermore, although the Rustler had static water levels higher than those of the Tansill and Yates Formations north and northwest of Kermit in the mid 1950s (Garza and Wesselman, 1959), there are no data to prove that a similar situation has existed in the vicinity of the Wink Sink.

Most of the estimated 1.86 billion cubic m (11.7 billion barrels) of brine produced with oil in the Hendrick Field were eventually returned to the subsurface by seepage from unlined earthen pits or by injection wells. This brine was unsaturated with respect to salt, and thus it would have increased the supply of shallow ground water that could flow down to and dissolve the Salado salts if these shallow aquifers were interconnected with the deep reservoirs by an open borehole. The amount of oilfield brine that has been disposed of in the vicinity of the Wink Sink is unknown, but available data indicate that it must have been a considerable amount. Aerial photographs taken between 1942 and 1968 show that several earthen pits 213 to 305 m (700 to 1,000 ft) away from the Wink Sink must have contributed large amounts of water to the local ground-water system. Also, a large ground-water mound created by seepage of oilfield brines in the central part of the Hendrick Field embraced the location of the Wink Sink. The water table in the mound may have been raised some 15 to 30 m (50 to 100 ft) by that time.

If downward flow of undersaturated water into and through the Salado salts in the Hendrick well 10-A had occurred, a dissolution cavity might well have developed, probably in the upper part of the salt sequence (Figure 7, part B). The period of cavity development is unknown, but it may have occurred at any time between 1928 and 1980. Eventually (probably shortly before June 3, 1980), the cavity became sufficiently large that the roof collapsed and, by successive roof failures, the cavity migrated upward (Figure 7, part C) until it finally reached the surface on June 3, 1980, causing development of the Wink Sink (Figure 7, part D).

Conclusions

Natural dissolution of salt in the Salado Formation has occurred in many parts of the Delaware Basin from Permian time up through the Cenozoic. It is attested by the abrupt thinning of Salado salt units above and just to the west of the buried Capitan Reef and also by the presence of a great, sediment-filled dissolution trough directly above the area where the Salado is anomalously thin. Although natural dissolution of portions of several of the Salado salt units has occurred within short distances of the Wink Sink, and may have occurred immediately below the sink itself, it is highly likely that petroleum activities were instrumental in bringing about the dissolution cavity and the collapse that created the sink.

The Hendrick well 10-A, an abandoned oil well, was located at the site of the sinkhole, and it appears likely that it was a pathway for water to come in contact with the Salado salt. Drilling and brine-disposal procedures, although consistent with standard industry practices during the life of Hendrick well 10-A, would have aided in conducting fresh water from shallow aquifers down the borehole to the salt beds. Outlets for high-salinity brine formed by dissolution of salt in the borehole included the porous and permeable strata underlying the Salado Formation, as well as possible preexisting dissolution channels within the Salado. Thus, a dissolution cavity may well have been formed around well 10-A, probably in the upper part of the salt sequence, and this cavity eventually would have become sufficiently large to permit collapse of the roof. By successive roof failures, the cavity then migrated upward until it finally reached the land surface and created the Wink Sink.

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How To Test Saltwater Disposal Wells

Part 1 – Conventional Hydrostatic Packer Test

by John D. Herlihy, *John W. McGowan*, and Raymond S. Chapman, *Ray Chapman and Associates*

Packerless well completions are an economically and technologically viable means to dispose of produced salt water. Previous articles by John D. Herlihy and Lizabeth A. Champlin in the May and June 1987 issues of PETROLEUM ENGINEER INTERNATIONAL described the concept, installation, and advantages of a packerless saltwater disposal well. This two-part series will discuss how to analyze hydrostatic and gas mechanical integrity tests for saltwater disposal wells. In part 1 of this article, the authors will analyze and mathematically model the conventional hydrostatic packer test in an attempt to identify what constitutes a minimum failure or significant leak and establish criteria for equivalence between liquid and gas pressure testing techniques. In the concluding part of this article, the authors will analyze the mechanics of the equivalent gas pressure technique with respect to identifying a minimum failure or significant leak and establish the applicability of the gas pressure test and develop a practical methodology for its use.

If properly completed, a packerless saltwater disposal well can be operated on a gravity feed, thus eliminating the need for forced injection. Operation of a gravity feed system allows larger volumes of salt water to be disposed of with a decrease in cost, corrosion potential, and the potential to do harm to the Underground Source of Drinking Water (USDW).

An important aspect of operating a saltwater disposal well on gravity feed is that the bottomhole cavity must be maintained by means of periodic swabbing. As earlier discussed (PEI, May 1987, p. 18), adequate swabbing of the bottomhole cavity requires that the saltwater disposal well must be completed without a packer. As a consequence, use of conventional hydrostatic mechanical integrity tests are not practical.

In an attempt to develop a mechanical integrity test for packerless saltwater disposal wells that satisfied regulatory guidelines, the Environmental Protection Agency (EPA) Title 40 CFR Section 146.9 was consulted. This regulation states that mechanical integrity can be demonstrated with a liquid or gas pressure test. Given that the use of gas in the mechanical integrity test is acceptable to the EPA, efforts were directed toward the development and standardization of a gas pressure mechanical integrity test.

Basic Principles

The basic principle behind a gas pressure test is simple fluid statics. Specifically, the annular pressure at any depth can be calculated by summing the pressure contributions of the fluids (gas or liquids) above that depth.

For example, Fig. 1A illustrates a well with a 40-psi

[illegible]

annular gas pressure and a fluid level 200 ft below the surface. The annular pressure at a depth of 2,000 ft is obtained by adding the pressure of the 1,800-ft fluid column, which is 810 psi (given a fluid gradient of 0.45 psi/ft), and the annular gas pressure of 40 psi, yielding a total pressure of 850 psi. If the 40 psi of annular gas pressure is bled off and the bottomhole pressure remains constant, the pressure at 2,000 ft would remain at 850 psi but the fluid level would rise to 111 ft (Fig. 1B). Conversely, if the annular gas pressure was increased to 500 psi, the fluid level would be forced down to a depth of 1,222 ft (Fig. 1C).

The concept shows that the annular fluid level in a well without a packer is directly related to annular pressure. The ability to displace the annular fluid level with gas pressure is the physical foundation which allows one to conduct a gas pressure mechanical integrity test.

Air or Nitrogen

Recognizing that gas pressure testing offers a means of testing the mechanical integrity of saltwater disposal wells with packerless completions, air and nitrogen were considered as potential test gases. The circumstances as to whether air or nitrogen is most desirable for the gas pressure test depends on economics and the potential for methane combustion.

As far as potential for methane combustion is concerned, nitrogen would be the test gas of choice because it is inert and does not support combustion. However, the quantity of methane in the annular space above the fluid level in a saltwater disposal well is sufficiently small that when air is used as the test gas, the risk of combustion of the air-methane mix is insignificant.

The elements that must be considered when evaluating the economics with respect to the selection of a particular test gas are: (1) number of wells to be tested, (2) maximum test depth, and (3) annular volume. Specifically, it becomes more economical to use compressed air (that is, purchasing an air compressor) when a large number of wells requiring large volumes of gas are to be tested. An evaluation of John McGowan's operations using the above criteria concluded that air should be selected as the test gas.

A preliminary methodology for air pressure testing originated in discussions with Dr. Tola Moffett, formerly with the Alabama Oil and Gas Board in 1984. The air pressure test developed at that time consisted of the following procedure:

- Determine the annular fluid level.
- Determine annular fluid gradient.
- Determine confining depth beneath the base of the USDW.
- Calculate air pressure required to displace the fluid level below the confining depth.
- Apply air pressure to saltwater disposal well annulus until the calculated pressure is achieved.
- Monitor pressure and fluid levels for 48 hours.

Under the supervision of James McGowan, Dr. Tola Moffett, and Gene Coker of the EPA's Region IV, air pressure tests were conducted on the Pollard WWS No.1 Well No. 3 and the Pollard WWS No.2 Well No. 1 during May 1985.

The Pollard WWS No.1 Well No.3 was pressured up in approximately 16 hours. The fluid level stabilized at 2,274 ft with a 957-psi pressure. At that time the air compressor was shut down and the pressure and fluid level were monitored for 48 hours. During that period of time no pressure loss or fluid level change was observed.

The Pollard WWS No. 2 Well No.1 was pressured up in approximately 20 hours. In this case, the fluid level stabilized at 2,033 ft with a 900-psi pressure. The pressure and fluid level were again observed for 48 hours with no change.

Since the original air pressure tests were conducted in 1985, over 30 gas pressure tests of packerless saltwater disposal wells have been conducted in Alabama, Louisiana, and Mississippi. Given the present state of knowledge of gas pressure testing, Louisiana and Alabama have adopted preliminary testing criteria for conducting gas pressure tests on John McGowan's packerless saltwater disposal wells. Although over 20 successful air pressure tests have been conducted in the state of Mississippi since 1986, the Mississippi State Oil and Gas Board has yet to adopt regulations which specify a gas pressure test methodology.

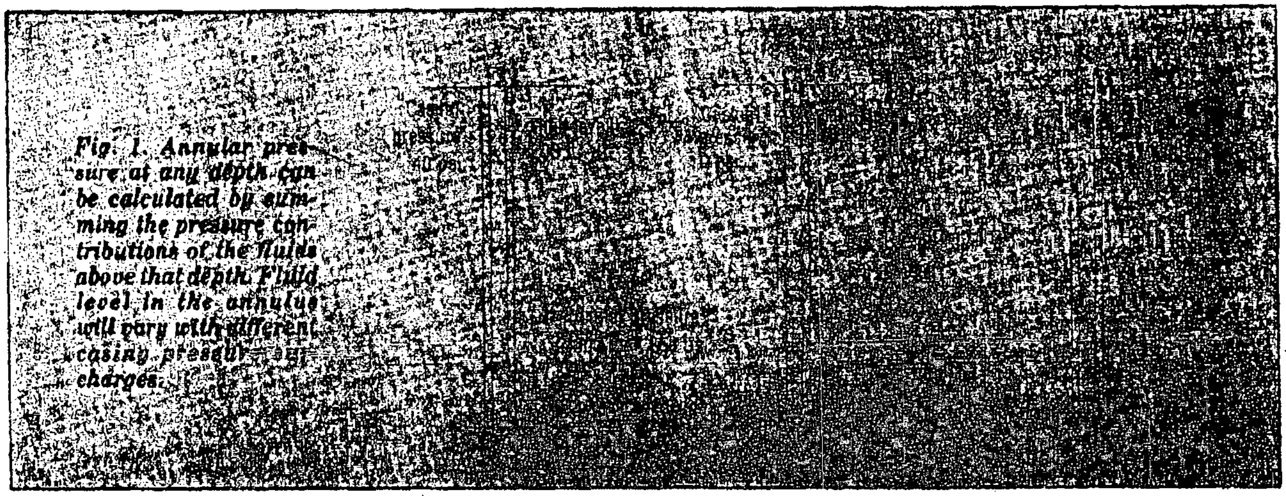

Fig. 1. Annular pressure at any depth can be calculated by summing the pressure contributions of the fluids above that depth. Fluid level in the annulus will vary with different casing pressure surcharges.

Hydrostatic Packer Tests

Discussions with the Mississippi Oil and Gas Board led to questions concerning the equivalence of the gas pressure test with conventional hydrostatic packer tests. This resulted primarily from the fact that in all of the saltwater disposal wells tested with a liquid or gas pressure test no casing failures occurred. Consequently, data was not available to define a gas pressure test that was equivalent to a hydrostatic packer test.

In the present context, an equivalent test means both test methods can detect the same failure. To establish equivalence between a hydrostatic pressure and gas pressure test it is necessary to adopt some standard criteria for the hydrostatic pressure test.

According to the Mississippi Oil and Gas Board rules, saltwater disposal wells operating with tubing pressures less than 300 psi must pass a 300-psi annular mechanical integrity test. The criteria for passing the 300-psi test is that the well shall not lose more than 10% of the initial test pressure or 30 psi during a 30-minute test period. For the sake of illustration, this test criteria will be defined as a minimum failure, which, intentionally or unintentionally, quantifies the EPA's regulatory concept of a significant leak. Given this definition of a minimum failure, the next step was to perform detailed analysis of the hydrostatic packer pressure test so that an equivalent gas pressure test could be specified.

Hydrostatic Pressure Test Modeling

When a hydrostatic pressure test is performed for purposes of detecting casing, tubing, or packer leaks, a surcharge of water is pumped into the annulus to achieve a desired pressure increase. The capacity to detect a leak or failure is generated when the pressure inside the annulus is greater than external hydrostatic pressure (outside the casing) such that a differential pressure exists.

(Continued)

As a general rule, the external pressure is calculated by multiplying the freshwater gradient of 0.433 psi/ft by the depth. This assumes the water table is located at the surface and all aquifers have normal pressures. This assumption defines external pressures greater than would actually be encountered and therefore provides conservative differential pressures. In a hydrostatic packer test, this differential pressure is approximately equal to the test pressure surcharge because the internal and external hydrostatic pressure gradients are roughly equal.

As water was pumped into the annulus, the air pocket had to be compressed before the compression of the water column. This effect clearly is seen in the Mean Lake test data where the linear relationship between fluid surcharge and pressure is displaced vertically away from the origin. Given a rough estimate of 0.25 cu ft for the volume of the air pocket before the beginning of the packer test, the data was corrected for the volume of water required to compress the air and replotted. The packer test corrected for air is represented by squares in Fig. 2. Given the crude nature of the correction for air pocket compression and the marked difference in the casing and tubing sizes, the corrected Mean Lake data and the Cranfield data show reasonable agreement.

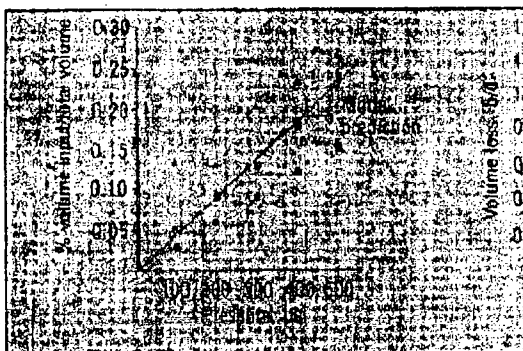

Fig. 2 Hydrostatic packer field tests were performed with different packer depths and casing-tubing configurations.

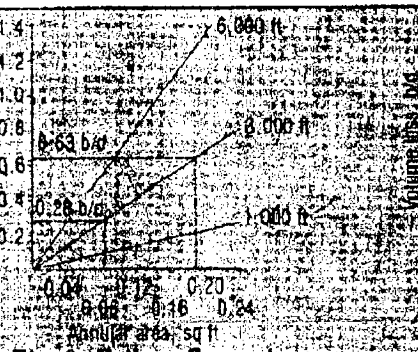

Fig. 3 Failure flow rate varies with different annular areas (casing-tubing configurations).

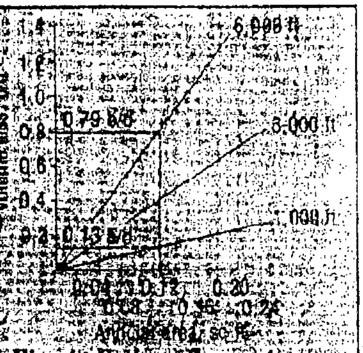

Fig. 4 Failure flow rate varies with different packer depths.

During a test, when the annulus is exposed to a pressure surcharge, the concept of conservation of water mass requires that for a leak-free system the additional water mass pumped into the annulus must be accommodated by a combination of casing expansion, tubing compression, and fluid compression. Furthermore, if the amount of surcharge water mass is relatively small with respect to the annular volume, then the variation in the casing diameter and water density will be both small and linear with water-mass increase. In other words, the pressure within the annulus will be a linear function of water-mass surcharge.

This concept was tested in the field using two hydrostatic pressure tests performed with different packer depth and casing-tubing configurations. The results of the field experiments are summarized in Fig. 2.

In this figure the data represented by triangles corresponds to a packer test performed on the H. W. Wright No. 4 well in Mean Lake field, La. This well has 5½-in., 15.5-lb/ft casing and 2⅜-in. tubing with the packer set at 1,994 ft. The data represented by the circles corresponds to a test run on the E. G. Lees No. 32 SWDW in Cranfield field, Miss. This well has 7-in., 23-lb/ft and 26-lb/ft casing and 4½-in., 11.6-lb/ft tubing with the packer set at 3,380 ft. The data represented by the squares and the dashed line will be discussed shortly.

Note that when measurements of relative water volume input and the resulting pressure are plotted, a linear relationship results. The Cranfield data represented by circles are considered to be very reliable because practically no air was in the wellhead above the test connections before the beginning of the packer test.

The important conclusion to draw from the field data is that the amount of fluid surcharge does vary linearly with pressure. As a consequence, the development and application of a reliable mathematical model to simulate a hydrostatic pressure test becomes a relatively straightforward task.

Model Formulations

Assume that water and tubing compression and casing expansion must account for the water-mass surcharge–that is, pressure–entering the annulus in some time increment Δt_w. The principle of conservation of mass for a leak free system requires that

$$\rho_w Q_w \Delta t_w = \rho_w V \left(\frac{D_c}{t_c} + \frac{D_t}{t_t} \right) \frac{\Delta P}{E_p} + \rho_w V \frac{\Delta P}{E_w} \qquad (1)$$

where

ρ_w = density of water
Q_w = volume flow rate entering the annulus during the time increment Δt_w
V = annular volume
D_c = casing diameter
D_t = tubing diameter
t_c = casing thickness
t_t = tubing thickness
ΔP = pressure increase during the time increment Δt_w
E_p = modulus of elasticity of the casing
E_w = bulk modulus of water.

Physically, the left-hand side of Eq. 1 represents the increase or surcharge in water mass during time increment Δt_w. The two terms on the right-hand side of the equation represent the amount of casing expansion and tubing and water compression during the same time increment, respectively.

The accuracy of the mathematical packer test model was verified against the Cranfield measurements described in the previous section and presented in Fig. 2. The results of this comparison also are presented in Fig. 2 where the dashed line represents the model predictions. Close agreement between the observed and predicted results suggests that the model equation (Eq. 1) does, in fact, properly describe a packer test and that all significant physical mechanisms are represented in the model formulations.

To see how Eq. 1 can be used to simulate a minimum casing failure of a hydrostatic packer test, recall that by previous definition, a failure is said to exist when greater than 10% or 30 psi of a 300-psi initial surcharge pressure is lost in a 30-minute test period. If a casing or tubing leak is present, as the annulus is being pressurized, surcharged water mass is lost due to outflow through one or more holes. As a result, when the annulus pressure reaches 300 psi and the pump is shut down, a gradual pressure drop will be registered.

Specifically, if we are looking for a minimum failure, the pressure will drop exactly 30 psi in 30 minutes. Using this information, Eq. 1 can be used to determine the average failure flow rate, Q_w, packer test and that all significant physical mechanisms are represented in the model formulations.

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Specifically, if we are looking for a minimum failure, the pressure will drop exactly 30 psi in 30 minutes. Using this information, Eq. 1 can be used to determine the average failure flow rate, Q_w, in a 30-minute test period, which corresponds to a minimum failure.

Rewriting Eq. 1, we obtain

$$Q_w = \left(\frac{30\text{ psi}}{1{,}800\text{ sec}}\right)\left(\frac{V}{E_w}\right)\left[\left(\left(\frac{D_c}{t_c} + \frac{D_t}{t_t}\right)\frac{E_w}{E_p}\right) + 1\right] \qquad (2)$$

Given the physical characteristics of the annulus (that is, diameter, area, thickness, strength, and depth to packer) Eq. 2 defines the average flow rate through a leak, which results in the minimum failure of a hydrostatic pressure test. Within the regulatory context of a minimum failure or significant leak, a flow rate that equals or exceeds that given by Eq. 2 constitutes a failure.

Given the predictable relationship between pressure and fluid loss, one would think that the specification of 10% pressure surcharge loss in 30 minutes would represent a reasonably unambiguous and reliable way to specify failures. To investigate this point, a series of hydrostatic packer test simulations were performed.

Examples of the results of these tests are presented in Table 1 and Figs. 3 and 4. Figs. 3 and 4 show the failure flow rate or hole area varies significantly with packer depth and annular area. The terms failure flow rate or hole area can be used interchangeably, because the failure flow rate is directly proportional to the casing or tubing leak hole area. These large variations in failure flow rates lead to substantial differences in the volumetric definition of a minimum failure or significant leak.

For example, if we look at Fig. 4, the minimum failure results have been plotted for hydrostatic pressure test with 1,000-, 3,000-, and 6,000-ft packer depths. In this figure, the flow rate (in barrels per day) of fluid lost during a minimum failure is plotted as a function of annular area and depth. The dashed lines on Fig. 3 illustrate that a 300-psi test, with a 3,000-ft packer depth, fails with a 0.28 b/d flow rate from a 7-in. casing and 5-in. tubing configuration. However, if the 5-in. tubing was replaced with 2⅜-in. tubing, a 0.63-b/d flow rate would have to occur for the same 7-in. casing to fail the test. In other words, the failure hole area in the 7-in. casing with 2⅜-in. tubing can be more than twice as large as the failure hole area with 5-in. tubing and still pass the hydrostatic pressure test.

Also, if the packer depth is increased in the same well, the allowable failure hole size also increases (Fig. 4). For the particular case illustrated, moving the packer from 1,000 to 6,000 ft in a well with an annular area of 0.12 sq ft results in a fivefold increase in size of the hole required to fail the 300-psi test.

The obvious conclusion here is that the ambiguous nature of the packer test results does not allow a uniform quantified definition of a failure hole size or a significant leak.

TO BE CONTINUED. The final article in this series analyzes the mechanics of the equivalent gas pressure technique with respect to identifying a minimum failure or significant leak and establish the applicability of the gas pressure test and develop a practical methodology for its use.

About the Authors

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How To Test Saltwater Disposal Wells

Part 2—Gas Pressure Test

by John D. Herlihy, *John W. McGowan*, and Raymond S. Chapman, *Ray Chapman and Associates*

An important aspect in the use of packerless saltwater disposal wells is testing the wells for mechanical integrity. In the first part of this article, the authors analyzed and mathematically modeled the conventional hydrostatic packer test in an attempt to identify what constitutes a minimum failure or significant leak.

In this concluding part of the article, the authors will:

- Establish criteria for equivalence between liquid and gas pressure testing techniques.
- Analyze the mechanics of the equivalent gas pressure technique with respect to identifying a minimum failure or significant leak.
- Establish the applicability of the gas pressure test.
- Develop a practical methodology for its use.

As discussed in the first part of this article, leak detection capacity of a hydrostatic pressure test simply boils down to determining if a failure flow rate or hole area (significant leak) exists in a given annulus. Further, the 10% pressure loss specification during a hydrostatic pressure test is an ambiguous indicator of a failure flow rate.

The only clear way to define equivalence in any fluid pressure test method is to require each test to have the same leak detection capability. In other words, equal leak detection capacity means that both methods under a specified set of conditions will identify the same failure flow rate or failure area size. Viewed in this manner, the volumetric definition of a significant leak must be standardized to ensure that pressure test criteria—whether hydrostatic or gas—will be uniform.

Furthermore, there is no requirement that equivalent pressure testing methods have the same test duration. The duration of a given test method is governed by the length of time required for a measurable pressure drop to be observed under minimum failure conditions. In addition, there is no practical reason for equivalent tests to require equal differential pressures. The magnitude of the annular pressure differential needs only be large enough to be observable using conventional pressure gauges and ensure equal leak detection capacity.

As previously mentioned, the economic evaluation of gas pressure testing of John McGowan's saltwater disposal wells led to the conclusion that air was the appropriate test gas. As a result the analysis presented hereafter will be specifically concerned with air pressure testing techniques.

In the same way that the pressure surcharge was applied to the annulus during a hydrostatic pressure test, an air pressure surcharge can be applied. In an air pressure test, sufficient air pressure must be applied to force the fluid level below the maximum test depth so that a pressure differential capable of detecting a leak will exist.

The pressure differential and test duration required to detect an equivalent failure or leak will be addressed next. Using the same conservation of mass principle as in the hydrostatic test analysis, an analogous mathematical model for air pressure tests and failure flow rates is written as

$$\rho_a Q_a \Delta t_a = \frac{V\Delta P_a}{KRT}\left[\left(\left(\frac{D_c}{t_c}+\frac{D_t}{t_t}\right)\frac{\rho_a KRT}{E_p}\right)+1\right] \quad (1)$$

where K and R are gas constants and T is temperature, R. As stated in the previous section, hydrostatic and air pressure tests are equivalent only when each test exhibits the same leak detection capability. In other words, each test must identify the same failure flow rate or hole size.

The equivalence between air pressure testing and hydrostatic testing is established when an identifiable flow rate through a failure hole size is detectable by a specified pressure drop during some test period. To relate the hydrostatic pressure test failure flow rate to the air pressure test failure flow rate it is necessary to examine the dynamics of flow through the failure hole size.

Applying conservation of energy across a failure hole area, a, the volume flow rates for water and air, respectively are given by

$$Q_w = C_w a\sqrt{\frac{2PE_w}{\rho_w}} \quad (2)$$

and

$$Q_a = C_a a\sqrt{\frac{2PE_a}{\rho_a}} \quad (3)$$

where the excess pressures PE_w and PE_a are the difference in internal and external casing pressure, and C_w and C_a are orifice coefficients for water and air, respectively.

Taking the ratio of Eqs. 2 and 3 and solving for Q_a we obtain

$$Q_a = Q_w\left(\frac{C_a}{C_w}\right)\frac{\sqrt{\frac{2PE_a}{\rho_a}}}{\sqrt{\frac{2PE_w}{\rho_w}}} \quad (4)$$

Experimental measurements suggest that orifice coefficients for water are less than that for air under similar flows. In the present analysis it is assumed that $C_w = C_a$. This will result in a slight underprediction of the failure flow rate for air which is a conservative assumption.

Refering to Eq. 1, the failure flow rate on the left-hand side of the equation can be calculated, using Eq. 4, in terms of the failure flow rate of water and a specified excess pressure (PE_w). When specifying the excess pressure PE_a in Eq. 4, keep in mind that the weight of the column of compressed air must be added to the surface gauge pressure to correctly specify the total excess pressure. To see the effect of air column weight on the total pressure, the contribution of air column weight as a function of surface pressure P_s is written as

$$P_z = P_s e^{3.1274 \times 10^{-5} z} \quad (5)$$

Where P_z is pressure at any depth $_z$ and P_s is the absolute surface pressure.

As an example, consider a case where the air-water interface has been depressed to 2,000 ft. In this case, the pressure at test depth is 6.5% greater than the pressure read on a surface gauge. If, for example, the surface gauge pressure was 1,000 psia, the pressure at depth is 1,065 psia, which results in a greater excess pressure differential.

For purposes of standardizing an equivalent air pressure test, test durations of 3, 6 and 9 hours with a 100-psi differential at maximum test depth were selected. Furthermore, a failure flow rate of 2 b/d was adopted. Using Eqs. 1, 4, and 5, the pressure losses corresponding to the 3-, 6-, and 9-hour test durations and the 100-psi pressure excess were determined. These results, presented in Figs. 1, 2, and 3 show that the failure pressure loss varies from 20 to 100 psi. The application of these results in defining a uniform and equivalent gas test is described in the next section.

Although air pressure testing offers a practical means of determining the mechanical integrity of the majority of saltwater disposal wells with packerless completions, there are specific cases where it is not recommended. For example, the gas pressure test is not recommended to test wells with confining depths greater than 3,000 ft. This is because the pressure required to depress the fluid level would exceed the working pressure of most conventional wellheads.

Another example in which the gas pressure test is not applicable is where a saltwater disposal well has a low bottomhole pressure or operating fluid level. John McGowan operates two such wells in Tinsley field, Mississippi, in the West Segment South waterflood unit. The confining depth in these wells is 2,590 ft, with an external pressure of approximately 1,120 psi. The fluid level in one well stands at 1,140 ft so that the internal pressure at 2,590 ft is approximately 696 psi. This generates an external 420-psi pressure differential such that the freshwater would flow into the annulus if a leak developed.

It is not possible for a well of this type – one that has greater external pressure at the base of the Underground Source of Drinking Water (USDW) – to contaminate a freshwater aquifer. As a result, depending on the magnitude of the bottomhole pressure, it may not be necessary to run an air pressure test.

For example, if a 150-psi external differential pressure existed at the base of the USDW, in a well with low bottomhole pressure, the annulus would in fact be under a constant state of mechanical integrity testing. This is because, as previously stated, freshwater would flow into the annulus thus drastically altering the operating fluid level of the well.

The air pressure test requirements established in Alabama were preliminary and compared with the detailed analysis of the air pressure test are rather conservative. The air pressure test results presented in Figs. 1, 2, and 3 allow the development of a refined methodology that is relatively easy to apply. Table 1 is a cross section of the complete air pressure test design tables that were used to generate these figures.

The information required to determine test pressures and durations for the purpose of conducting an air pressure test follows:

- Fluid level.
- Annular fluid gradient.

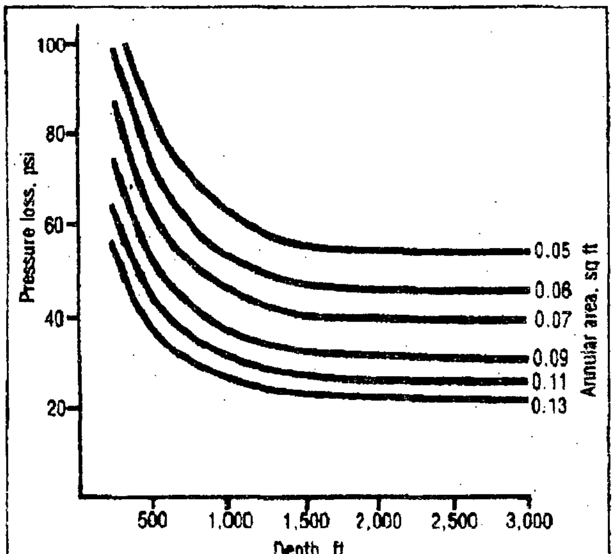

Fig. 1. Pressure losses during a 3-hour air pressure test.

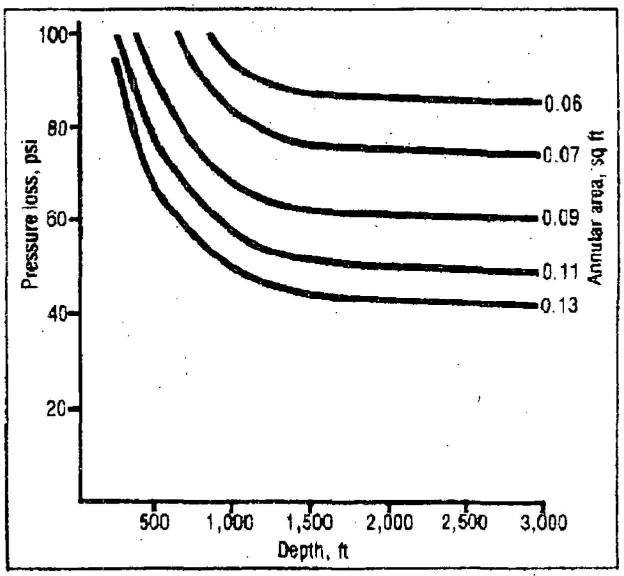

Fig. 2. Pressure losses during a 6-hour air pressure test.

TABLE 1. Air pressure test—pressure loss per test period information

Differential pressure			100 psi	Compressed water			320,000 psi
Fluid density			66.2 lb/cu ft	Modulus of elasticity			2.9×10^7
Temperature			140 F	Test time			3 hours
Casing OD, in.	Tubing OD, in.	Annular area, sq ft	Differential pressure, psi	Test depth, ft	Surface pressure, psi	Test pressure, psi	Pressure loss, psi
7.00	5.00	0.0846	105	500	317	322	54
7.00	5.00	0.0846	136	1,500	750	786	34
7.00	5.00	0.0846	196	2,500	1,183	1,280	32
7.00	4.50	0.1106	105	500	317	322	43
7.00	4.50	0.1106	136	1,500	750	786	27
7.00	4.50	0.1106	196	2,500	1,183	1,280	25
5.50	4.00	0.0464	105	500	317	322	87
5.50	4.00	0.0464	136	1,500	750	786	59
5.50	4.00	0.0464	196	2,500	1,183	1,280	57

- Test depth or USDW confining depth.
- Annular area in square feet.

The test pressure is obtained by adding 100 psi to the test depth multiplied by the external gradient of 0.433 psi/ft. The approximate fluid level at test pressure can be obtained by dividing the test pressure by annular fluid gradient and adding the fluid level. To determine the test duration and corresponding failure pressure loss for a 100-psi differential test Figs. 1, 2, and 3 are used. The shortest test period that generates an observable pressure loss is recommended.

For example, consider a well that has 5½-in. casing with 4-in. tubing and a confining depth of 2,270 ft. The annular area for this casing-tubing configuration is 0.0464 sq ft or approximately 0.05 sq ft. The operating fluid level stands at 19 ft and the annular fluid gradient is 0.46 psi/ft. Based on these parameters, the test pressure would be 2,270 ft x 0.433 psi/ft plus 100 psi or approximately 1,100 psi. Fig. 3 shows that during a 3-hour test the maximum acceptable pressure loss would be 53 psi. The fluid level at test pressure can be obtained by dividing the test pressure of 1,100 psi by the annular fluid gradient of 0.46 psi/ft and adding the operating fluid level. This fluid level would be approximately 2,580 ft or 310 ft below the confining depth.

A second example has a well with a confining depth of

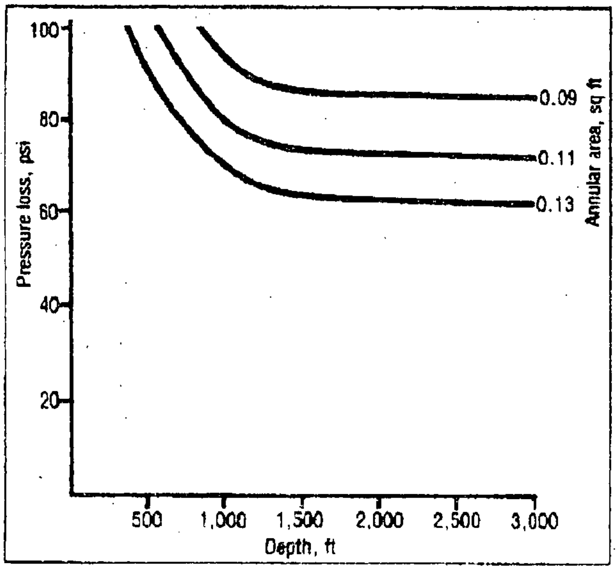

Fig. 3. Pressure losses during a 9-hour air pressure test.

800 ft with 7-in. casing and 5-in. tubing. The annular area is 0.085 sq ft or approximately 0.09 sq ft. The operating fluid level is 80 ft with a gradient of 0.45 psi/ft. Based on these parameters the test pressure would be 450 psi. The 3- and 6-hour curves show that 41 psi is the maximum allowable loss for the 3-hour test and 74 psi for the 6-hour test. The fluid level at test pressure would be approximately 1,080 ft or 280 ft below the confining depth.

Based on the information presented previously the following conclusions have been drawn:

- The hydrostatic pressure test as it is used does not allow for a uniform volumetric definition of a significant leak and therefore does not afford fair and uniform testing requirements to all operators.
- Equivalent pressure testing, whether hydrostatic or gas, requires a fixed value of the failure flow rate or volumetrical definition of a significant leak be adopted. Given this set criteria for volume loss of a minimum failure, then all pressure test methods can be applied uniformly.
- An equivalent gas pressure test methodology has been developed and has been shown to be more than adequate for the testing of saltwater disposal wells with packerless completions.

This final point is based on two factors. First, the assumption that the air and water orifice coefficients are equal is conservative. Consequently, in the analysis used to design the air pressure test, the air failure flow rates and pressure losses are underpredicted. Within the spirit of mechanical integrity pressure testing, the air pressure test developed here is, in fact, more strict than an equivalent hydrostatic packer test.

Second, the uphole decrease in air pressure is insignificant with respect to the corresponding decrease in the external hydrostatic pressure. This means that the leak detection capacity of the air pressure test increases uphole from the maximum test depth.

As a result, if a well passes an air pressure test it has, in reality, been subjected to a much more stringent test than that of an equivalent hydrostatic packer test. If however, a well fails the air pressure test, further testing can be used to determine the location of a possible failure hole. The air pressure test can then be repeated at that new maximum test depth to determine if, in fact, a significant leak occurs. Otherwise a radioactive tracer survey or packer test could be performed to verify the failure. ■

Charles A. Caswell

Underground waste disposal: C

Waste injection wells are becoming popular but the field is still plagued by some fundamental misunderstandings

Deep-well disposal has become a controversial topic, at least to the environmental control engineer, his associates, and much of the general public. However, in view of the wide potential for useful application of subsurface fluid, gas, and solid handling techniques to water and air resource conservation problems, the subject should be of interest to every practicing engineer, as well as to those engaged in other phases of environmental control work. Deep-well disposal of liquid wastes is really only one small part of a wider field—the application of subsurface geologic technology to natural resource conservation.

While there will be some simple arithmetic presented here, I will not attempt the usual translation of logic into extensive engineering mathematics for computerized application. Unquestionably, computer technology is a tremendous asset to the engineer and enables us to construct, almost instantaneously, a massive, inverted, pyramid of rapidly expanding confusion balanced neatly upon any initial point of irrelevancy that can be expressed by a numerical symbol. But it will be my purpose here only to point out some of the broader, overall aspects of the subject of subsurface considerations. A few points of technical relevancy will be illustrated, and thereafter those who so desire will be free to construct their own pyramids.

Practically speaking, deep-well disposal is, at the moment, the one facet of subsurface technology that most engineers are probably familiar with, and my discussion will start with some comments on this specific method, particularly regarding areas in which a review of current literature indicates some fundamental misconceptions.

Origins

The process actually originated in the petroleum industry over 40 years ago as a means of disposing of salt water that commonly accompanies oil taken from producing wells. The original reason for this was probably the well-known fact, at least in the oil field, that salt water has an amazing affinity for any expensive cows! Later, the concept of using this water to increase oil recoveries developed and then the process of "secondary recovery," or "water-flooding," was born. Geologists then developed a broad spectrum of engineering data regarding the injection of fluids into subsurface geologic formations of various lithologic character. Concurrently the concepts of repressuring exhausted oil fields with gas came along, and once again a backlog of engineering data on injecting gases into geologic formations began to develop. This has been further accelerated by the development of underground gas storage facilities. Both these techniques may well have application in alleviating air pollution problems in the future, and research should be initiated on this possibility.

Within the last 15 years, with the growing problems of industrial waste, the use of these subsurface techniques for industrial and municipal waste disposal began to develop. The first industry outside the petroleum companies to use this technique was the chemical process industry, probably because operation of specialized oil field service divisions allowed chemical process engineers to become acquainted with these concepts. By about 1965, the boom was on. Because of a rapid proliferation of waste disposal problems, particularly with toxic or difficult-to-treat wastes, underground disposal was attempted by industries of all types. Some of these attempts were successful, others were not.

No accurate figures are available, due to variations between different states and companies in reporting requirements, but it appears there are about 40,000 saltwater injection wells operated by the petroleum industry in the U.S. either for brine disposal or secondary recovery purposes. There may be another 1100 fluid injection wells involving waste disposal, groundwater recharge, and protection against saltwater invasion operated by various industries and municipalities. In addition, the petroleum industry uses about 20,000 gas injection wells for reservoir maintenance purposes, secondary recovery, or underground gas storage.

If we consider the additional tens of thousands of wells that have been involved in extracting oil, water, gas, sulfur, and salt from beneath the earth's surface, it's apparent that the massive backlog of data regarding subsurface geologic techniques can be of primary interest and a useful tool to all involved in the problems of natural resource protection under many combinations of circumstances.

Pros and cons

As is true of any engineering system, there are advantages and disadvantages involved in the use of these methods. It is the engineer's job to weigh the factors involved in coming up with a workable solution. Advantages of subsurface techniques to water resource problems under good geologic circumstances are:

- A potential method of ultimate disposal, in the sense that wastes untreatable by other means may feature

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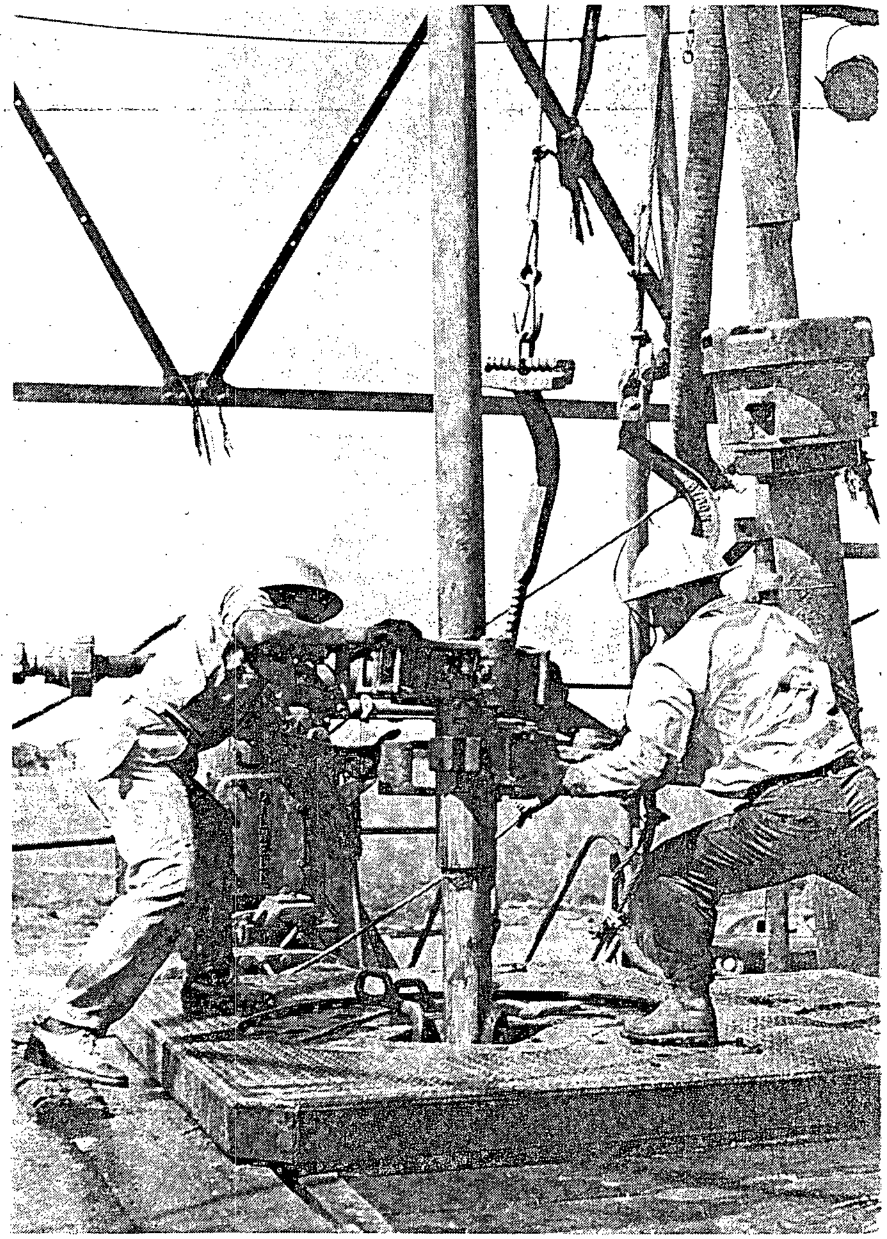
- Protection of fresh groundwater supplies from saltwater invasion.
- Underground storage of fresh water in arid regions to reduce evaporation losses, or to store intermittent freshwater supplies.
- Groundwater recharge in areas heavily dependent upon groundwater sources as a water supply.
- Solids storage and disposal under some conditions.
- Effective use in conjunction with other water supply or waste disposal processes. This may be particularly true when a waste of small volume is highly dangerous or toxic, and the cost of treating the waste by usual means may make effective treatment of the total flow impossible. In such cases, it is frequently feasible to separate the high pollutant level waste stream from the main waste flow and dispose of it underground at less cost than trying to pay for treating the entire flow on the basis of the combined pollutant levels. Where the water supply problem is more critical than waste disposal, it is frequently feasible to apply additional treatment to effluent from a secondary waste treatment plant and inject it back for later use.
- Potential solution to some air pol-



Drilling. *Oilfield technology often can be used for natural resource protection* lution problems, as injection of toxic or otherwise obnoxious fumes into underground storage reservoirs.

The foregoing advantages are sometimes offset by several disadvantages, the most important of which might be:

- Existence of unfavorable geologic circumstances in the vicinity of the problem. This factor alone places some rather severe limitations in many areas.
- Fluid incompatability, in case of liquid injections, between the natural formation fluid and the fluid being injected.
- Possible loss of control of the waste liquids after injection.
- Legal problems that may arise from such activity. For example: when does underground trespass start? What are the degree and extent of the injector's liability in the event of surface or subsurface damage to nearby properties? Who owns water injected in groundwater recharge? There are, of course, many other problems of this type that will arise as usage of these methods increases. Obviously, the use of subsurface techniques for industrial wastes has not been widespread enough to have built up much in the way of legal precedent; many of the petroleum and water rights laws on the books are rarely precisely applicable to the industrial waste disposal problem.

Finally, there is a tremendous problem involved in educating regulatory bodies, the body politic, and the industrial users to understanding the design and operational principles and limitations inherent in the application of these subsurface techniques to the field of water and air resources. Sometimes it seems that the necessity for the application of a certain amount of thought and intelligence to utilization of underground techniques is probably their greatest disadvantage.

Well design

The field of underground fluid or gas handling has two major divisions—the surface factors and the subsurface factors. To put it simply, the first basic requirement for underground disposal is a usable hole in the ground. This involves a geologic study for determination of a specific location and the operation of drilling equipment. In most cases, these factors can be handled much more effectively by independent contractors intimately familiar with them, than by the usual design and construction engineer who normally specializes in surface structure construction. The drilling, testing, and casing program of a well, if properly done, will establish the volumes of fluid it can effectively accept and the pressures required to maintain these acceptable volumes at the desired rates of injection. Supervision of these phases of the project should be handled by a consulting geologist familiar with subsurface conditions. Once these data are acquired, the design of the treating and pumping equipment to prepare and handle the fluid at the surface, prior to injection, and the additional surface pumping equipment necessary to inject the fluid into the formation, can be handled by any capable engineer familiar with the basic principles of handling waste fluids or gases.

However, in the consideration of the subsurface factors, the average industrial project engineer is, usually, at somewhat of a disadvantage by virtue of background training and normal experience. For this reason, illustration of a few basic principles involved in the subsurface functions of the fluid handling system might be of both interest and value to the engineer involved in the overall supervision of any environmental control problem involving underground disposal, even though this phase of the project should normally be handled by a consultant.

The areas in which current literature indicates some misunderstandings are injection pressure requirements, hydraulic fracturing techniques, formation fluid capacities, and fluid migration conditions. An attempt will be made to use, as illustrations, examples involved in these areas. So we must go "down the hole," so to speak, and take a worm's eye view of this system in order to discuss some of the mechanics involved at the bottom end of our "usable hole in the ground."

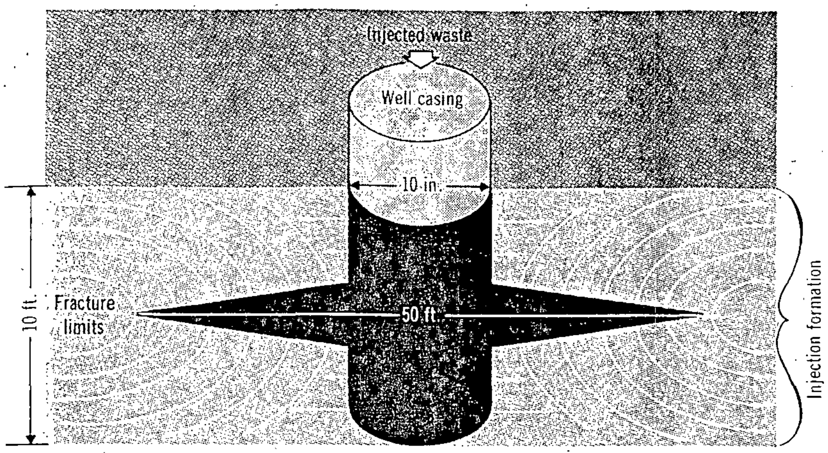
Migration rates

First, let's consider briefly the question of fluid well capacities and fluid migration in the geological formations. By assuming some typical parameters for a disposal well (*see inserts*), it can be calculated that a square mile of formation around the well could contain as much as 5,217,200,000 gallons of fluid. If a waste fluid were injected at a rate of 10,000 gallons per day, it would take 521,720 days, or about 1429 years to fill up this space—and still move only one-half mile from the well site. By assuming a 50% saturation of the well by the original formation fluid, these figures would, of course, be cut in half.

Since a finely engineered disposal well would not use a receptor formation that outcrops nearby, it's apparent that under normal conditions of fluid migration it would take a long, long time for this material to reach the surface. Let us take, for example, an improbable situation in which our hypothetical formation might outcrop, or come to the surface, ten miles away from the disposal well. Using the 50% formation saturation figure, so that we only need 714.5 years to move the first half mile, we then find we still need 14,290 years for the injection fluid to arrive at the surface of the outcrop. Going one step further, just to be conservative, we might say that these figures are in error by 90% due to unknown factors affecting the migration rate, and that the actual migration occurs in 10% of our computed time. We still have a little over 71 years to move the first half mile and 1429 years to reach the outcrop.

If we add a dilution factor to account for mixing waste with the formation fluid, we are forced to conclude that it will take an extremely long-lived waste to reach an outcrop only ten miles away in its original form. In view of these factors above, it would seem wise to give more consideration to the use of underground formation space for storage, treatment, and ultimate reduction of some types of pollutants.

Obviously, this total available space may not be available for storage at any particular location having these assumed porosity conditions. The determining factors here will be the percentage of saturation of the formation by naturally occurring fluid, and whether the acceptance of the injected fluid is achieved by displacement, diffusion, or a combination of both. The original formation fluid hydraulic conditions, hydrostatic or hydrodynamic, will also affect this factor of ultimate usable storage volume. It might be added here that observation of many core analyses and electric log data taken from drilling wells,



This simplified sketch illustrates several salient points about injection wells.

Well capacity: A formation of the dimensions indicated and with typical porosity (25%) and permeability (10 millidarcies) has a tremendous storage capacity, up to 8.2×10^6 gallons per acre of formation. As mentioned in the text, such a formation, in the absence of large amounts of naturally occurring fluids, can receive significant amounts of waste for literally hundreds of years without the fluid advancing more than a few miles from the well site.

Injection pressure: Injection pressure is a function of the effective pore space exposed to the advancing front of the injection fluid. As the fluid moves radially outward from the well, the surface area exposed to the fluid front (effective porosity) per unit volume of injected fluid increases. As a result, there is a rapid decrease in the injection pressure per given injected fluid volume and rate.

Fracturing techniques: If the formation surrounding the original bore hole is fractured, the net effect is to increase the initial surface area available for injection. For the 50-foot fracture indicated, each face of the fracture becomes a disk having 282,000 sq. in. of surface area. When this is compared with the initial surface area of 3768 sq. in. for the original 10-in. bore hole, it is easy to see why injection wells frequently "go on a vacuum" when fractured. The arrows show the fluid dispersion patterns around the fracture, from which it can be seen that channeling induced by fracturing will normally occur far beyond the limits of the original fracture.

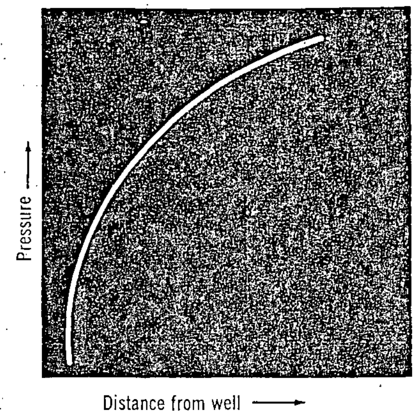
ranging in depth from 1000 to 24,000 ft., has rarely shown formation fluid saturations in the 100% range.

The original formation bottom hole pressure will also have an effect on both injection pressure and the ultimate usable storage volume by virtue of the effect on the injection pressures required. Observation of many hundred drill stem tests at varying depths and across most of the Mid-Continent region has rarely indicated bottom hole pressures that even approached theoretical calculated hydrostatic heads for the depths involved. However, frequently in the unconsolidated sediments along the Gulf Coast, we do find theoretical hydrostatic and theoretical overburden pressures close to recorded pressures.

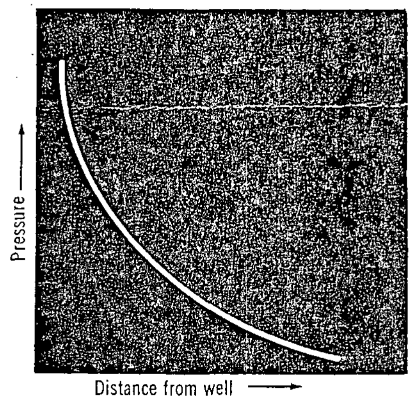
Fluid flow

Permeability, in practical terms, refers to the ability of the fluid to move through existing porosity, and thus into, or out of, the bore hole and on through the formation. This, in turn, tends to become a direct function of pore geometry by virtue of the normal friction resistance to fluid flow. Damage to the formation face in the bore hole by action of the drilling bit may also cause considerable modification of pore geometry as it affects fluid flow. As a matter of fact, in most cases most of the pressure required to inject fluid into a porous and permeable formation is really being used to overcome this combination of factors, causing high friction resistance only near the bore hole. This total friction resistance to flow is referred to as the "skin effect."

One of the great advantages of fracturing techniques lies in their use to alleviate this skin effect. Most of you are, no doubt, familiar with the appearance of the drawdown curve on a water well, which looks something like this:



In other words, pressure required for a given fluid volume to flow at a given rate increases with decreasing distance from the well. The pressure curve for an injection well appears reversed but actually expresses the operation of the same physical factors:



Here the greatest pressure required for flow is nearest the bore hole with a rapid decrease in required pressure away from the bore. To demonstrate the skin effect let us consider the fluid as moving through a series of ever-enlarging concentric cylinders as distance from the bore hole increases. If we assume an initial bore hole cylinder of 10 in. in diameter and a formation depth of 10 ft., the surface area of the bore hole cylinder is 3768 sq. in.

By the time the fluid has moved to a diameter of 20 in. from the axis of the bore hole, the total surface has become 7536 sq. in.; at 30 in. from the axis we have acquired an area of 11,304 sq. in. It can easily be seen that the steady increase in the cross-sectional area available to carry the fluid results in a very rapid decrease

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Water injection

The only place where water is normally injected into the same formation from which oil is produced is in the case of "water-floods" and these are only used to recover oil from reservoirs that contain no natural water drive. As a matter of fact, they normally contain very little or no waste at all. The water produced is that which has been previously injected. In this case water for flooding has to be obtained by drilling water supply wells to horizons other than the producing formation.

A misunderstanding of this key point seems to have led to many erroneous computations in the literature regarding available storage space and required injection pressures. It might well be said, as mentioned earlier, that failure to differentiate among some of these basic conditions appears to have led to the creation of some interesting pyramids of confusion, based on initial points of irrelevancy, with respect to the use of fracturing, available storage space, and calculated injection pressure requirements. There are various techniques of perforating, "shooting," acidizing, and hydraulic fracturing that can be used both to overcome the skin effect and to improve and maintain injective capability. It is, however, important to realize that the pressure required initially to inject fluid into an untreated formation is not necessarily a good index, of itself, of the pressure ultimately required for fluid disposal into that formation.

Of course, getting the fluid into the formation is only part of the problem—then comes the question of who is responsible for it. Although a considerable body of law has been built up regarding underground fluids and their migration, most of it has developed from our frontier day concepts of riparian rights and private property that have since been held to be applicable to petroleum and subsurface waters. Since underground waste disposal is a very new concept in legal terms, there has been little as yet in the way of precedents established for degrees of responsibility concerning migrated industrial waste.

There are, however, several mechanical factors known to be involved in any consideration of fluid migration in subsurface formations:

- Degree of formation cementation and formation porosity.
- Lateral extent of effective permeability and porosity.
- Characteristics of beds overlying and underlying the injection formation.
- The presence of faults and (or) fracture patterns in the area.
- Earthquake occurrence, frequency, and intensity in the area.
- Freshwater–saltwater contact levels are important in groundwater recharge, underground water storage, prevention of saltwater invasion, and finally, in regard to decisions specifying depth for projected waste disposal wells.
- Structural attitude of the injection formation.
- Hydrological characteristics of the disposal formation.
- Effectiveness of casing and casing cementing program.

It might be well to point out that this last factor is a point in injection well planning where great care must be exercised. While also true for producing wells, it is far more critical in injection wells due to pressure gradients resulting from the reversal of the direction of flow which the normal well casing program is designed to handle. The case of a disposal well "blow-out" at Lake Erie is well-known.

A review of published literature indicates that many disposal wells allow only for an inch of diameter differential between hole size and casing size. For example, 7.5- or 8-inch casing will frequently be set in a 9-inch hole. This allows a thin half inch film of cement between the casing and the formation. Since the cement-to-casing bond and the cement-to-formation bond usually represent the weakest link in the pressure retention chain, it would be well to specify, as a minimum, at least 2 inches of diameter differential between the casing collar o.d. and the hole for waste injection wells.

More knowledge

With regard to the present state-of-the-art of application of subsurface techniques to water resource problems and planning, there is an urgency for additional research in the foregoing areas to assist in establishing logical legal and operational principles by people familiar with both petroleum technology and industrial waste disposal techniques. For example, the field of suspended solids injection, an entirely new utilization of subsurface techniques, is an area in which there is still much to be learned. Some techniques have been evolved for the disposal of radioactive wastes, but even here much improvement is needed.

In addition, some successful experimentation is being done on the injection of sewage sludge solids into certain favorably constituted formations. The types of porosity and permeability required for high solids content fluid injection need to be further defined and determined. For example, the "lost circulation" zones, which oil well drillers unhappily experience, might well be feasible for waste sludge or slurry injection programs.

We might sum up by saying that subsurface injection has been used, either experimentally or on a large scale with varying degrees of success for a wide range of applications, shows that subsurface geologic techniques are important tools for the environmental engineer in his continuing struggle to meet the needs of society. It will pay him well to recognize the circumstances under which he may increase the effectiveness of his natural resource control and protection programs. After all, man is a very unique animal, the only one that is capable of destroying his own environment—and with it, himself. Whether he does this, or not, will ultimately depend upon engineers, scientists, and political leaders who must create, design, and build society's structures to protect the environment.

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of pressure required to move a given volume of fluid, at any given rate, into the formation. This condition will continue until the limits of the formation's geographic dimensions are reached or as long as the fluid is moving. Also, note that the pressure, volume, and velocity effects on the fluid flow are going to be constantly changing with the changing radius of flow around the bore hole. This point is very significant in terms of the potential of a disposal well to trigger earthquakes. Due to this rapid pressure drop it would take a very special set of circumstances for a disposal well to trigger a quake.

There are other factors involved in the flow mechanics that are pertinent to the skin effect, since they affect permeability, or "transmissibility:"

- Pore geometry as it relates to turbulence near the bore hole, and surface tension and viscosity of the fluid.
- Botton hole pressure of the original formation, which in some cases, exerts a back pressure on the injected fluid.
- Hydrologic conditions, whether static or dynamic.
- Percentage saturation of the original porosity by the in-place fluid, if any.
- Damage to the formation face by the original drill bit or infiltration of drilling fluid.

An interesting example of the combined effects on these factors occurred at the recent completion of a 3500-ft. well. In this case, an attempt was being made to hydraulically fracture a potential producing formation after a pipe had been set on top of the formation. The hole had been cleaned out, washed with mud acid, and the fracturing procedure instituted. Pressure against the formation increased to 8000 p.s.i. before the geologist gave the word to shut down because of the possibility of equipment damage. Not one drop of fluid had moved into the formation. The electric log and microlog indicated suitable porosity and permeability, and a drill stem test recovered only a few feet of oil-cut drilling mud, with no salt water. Thus, because a good shut-in-bottom hole pressure built up from 0 to 200 p.s.i., it was felt that the possibility of a blocked formation face existed.

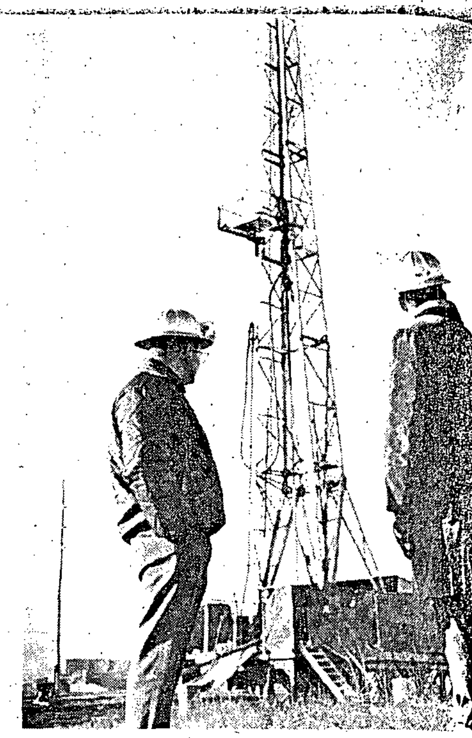
For these reasons, it was decided to attempt an open hole perforation with large caliber expendable jet charges. The fracturing equipment was removed from the well, and when the perforating job was completed, another attempt made to fracture the formation was successful. The formation began to take fluid slowly at 900 p.s.i., fractured at 1650 p.s.i., and then took 2000 g.p.m. of sand slurry at an injection pressure of 300 p.s.i. The well was completed as a good pumping oil well for about 10 b.b.l. per hour with an operating bottom hole pressure of 420 p.s.i.g. Obviously the initial failure to pump into, or "fracture," the formation effectively was one due entirely to skin effect factors.

Misleading tests

The foregoing case is merely cited as an example of how great the effect of these factors can be when they are present in just the right combination. Pump tests on an injection well can also be misleading if initial pressure is simply accepted at face value, as evidence of the ability of a formation to accept fluids or the operating injection pressures required. In general, fracturing can cause a tremendous increase in fluid acceptability of a formation.

Unfortunately, hydraulic fracturing and its effects seem to be misunderstood factors in the underground disposal field. When interest in underground disposal began to spread, the first thing engineers apparently did was to research the petroleum field with respect to water injection wells. But there is a great deal of difference between a water injection well and a disposal well. The requirements are entirely different. The water injection well is used only in water-flooding for the purpose of secondary recovery. Under these conditions, the advance of the flood face must be kept as uniform as possible to provide a clean sweep of the in-place oil. This usually requires relatively low initial injection pressures, slow injection rates, and the absence of fracturing to avoid channeling and consequent bypassing of the oil in place in the vicinity of the well bore.

A saltwater disposal well is very different. Here it makes no difference whether or not the flood front is kept uniform; the problem here is simply to put as much fluid as possible into the formation at as low a cost as possible. This condition is much more similar to waste disposal than is water flooding. Under these conditions hydraulic fracturing is commonly used to increase formation fluid acceptability and reduce required injection pressures. Saltwater disposal wells are almost routinely fractured, and in the first year or two operate on a vacuum or gravity flow, and injection pressure buildup thereafter is at a very slow rate. In a waste disposal well a uniformly advancing floodfront is not needed, and the greatly increased expense required to maintain it can hardly be justified. (It should be added that hydraulically induced fractures do not close if the pressure drops. They are kept open by propping agents, such as sand or small beads, injected in a slurry as a part of the fracturing process.) Another very important misconception shows up in the often repeated comment that water produced with oil is usually injected back into the producing formation, thus more space is available. Quite the contrary is true, which points up how the difference in terminology between petroleum technologists and those not so familiar with the field can create misunderstanding. Where significant amounts of water are produced with oil, the oil is coming from a water-driven reservoir, already under natural flood, and injecting additional water into these sands would only cause possible channeling and consequent loss of oil. Thus, rather than waste money to gild the lily, water produced with oil from these reservoirs



Derrick. *Drilling tests are critical steps in planning for waste disposal wells*

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DISPOSAL OF RADIOACTIVE WASTES IN SALT DOMES*

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Abstract—Diapiric salt structures, which are caused by the plastic deformation of thick salt beds, have been proposed as possible locations for the disposal of radioactive wastes requiring long-term containment. There are, however, several important questions concerning tectonic stability, salt dissolution, and reliability of long-term containment that would have to be satisfactorily answered before this scheme of waste disposal could be considered feasible.

Several concepts have been proposed for the emplacement of radioactive wastes in diapiric salt structures. The most promising of these are: (1) a mechanical mine, and (2) the mixing of granular waste and crushed salt in deep solution cavities.

In comparison with a mechanical mine, the granular mixture in solution cavities would require the mining of larger volumes of salt and would be feasible only with wastes aged significantly more than 10 yr; on the other hand, it could offer greater reliability of long-term containment because of the increased isolation provided by the greater depth.

INTRODUCTION

THE LONG-LIVED radionuclides present in radioactive wastes must be kept isolated from the biosphere for geologic time periods. The alphaemitters for example, which are responsible for most of the long-term hazard, decay to nonhazardous levels of activity in a time period that might vary between several tens of thousands of years and several million years, depending on definitions of acceptable levels of activity at the time of containment failure. Current best estimates of the required duration of containment of long-lived radioactive wastes are in the order of 100,000–200,000 yr (CLAIBORNE, 1972; BELL and DILLON, 1971; GERA, 1975).

It is clear that it is impossible to provide a realistic scheme of waste containment over geologic time periods based on man-made structures and human surveillance. The only feasible way to assure containment of the wastes for the required length of time is to enclose them in deep geologic formations with suitable properties. The most important characteristics of a suitable disposal formation are the extremely low permeability and the high plasticity. Consequently the most promising geologic environments for the disposal of long-lived radioactive wastes are thick formations of rock salt and argillaceous materials (GERA and JACOBS, 1972).

The advantages of rock salt as a natural containment medium for radioactive wastes have been recognized for a number of years. The Oak Ridge National Laboratory is primarily responsible for the well-known concept of the salt mine respository. To date, ORNL has emphasized only bedded salt formations, despite the fact that many salt structures in the Gulf Coast area and in the Paradox basin constitute extensive masses of excellent-quality halite. This preference for bedded salt is due to the early recognition that the demonstration of the reliability of long-term containment in a salt dome would require the solution of several potentially difficult geologic problems.

SALT DIAPIRISM

Diapiric salt structures are due to the intrusion of large masses of salt through the overlying sediments. The forces responsible for the typical diapiric deformation of salt are mainly gravitational in nature. Locally tectonic forces can be active and squeeze the salt along lines of minimum resistance, but the phenomenon of

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diapirism is essentially caused by the flow of salt under the differential load of the overburden (GERA, 1972).

The source bed must be assumed to be of great original thickness and is usually located at great depth. In the Gulf Coast area of the U. S. the depth of the mother bed is in the order of 10,000–15,000 m, while in the basins of northeast Texas, north Louisiana, and Mississippi, the depth of the Louann salt ranges from 3000 to more than 5000 m (MURRAY, 1968).

The upper portion of a typical Gulf Coast salt dome has a horizontal section that ranges from circular to oval, and an average diameter that can vary from less than one to several kilometers. The shape in depth is either cylindrical or conical, or a combination of the two. Occasionally, overhanging flanks are observed. In several cases it is known that individual domes merge at depth to form huge structures that have been named "salt massifs" (ATWATER and FORMAN, 1959).

In relation to disposal of radioactive waste in salt, the most important aspect of salt diapirism is the rate of the process in its various stages. The rate of salt movement is not the same in all phases of salt deformation; it is probably at a maximum in the late stage, when diapirs are approaching or reaching the surface. In fact, in this phase, the pressure difference due to the salt-sediment density contrast is close to its maximum, and the resistance offered by the overburden to the rising salt is reduced, or even nil, when salt is exposed at the surface.

The available evidence seems to indicate that typical growth rates for domes approaching the surface are on the order of a few millimeters per year (GERA, 1972; BORCHERT and MUIR, 1964; BALK, 1949).

LONG-TERM WASTE CONTAINMENT

Several problems would have to be satisfactorily solved before the disposal of high-level radioactive waste in a salt structure could be seriously considered:

(1) *Tectonic stability of the structure*

Salt domes and anticlines have been formed by the upward migration of large masses of salt. Reasonable confidence exists that our present understanding of salt diapirism is essentially correct; however, there are still several unanswered questions concerning the termination of domal growth and the possibility of rejuvenated movements. Before a particular dome could be considered suitable for waste disposal, it would be necessary to demonstrate that it is not currently moving and that future rejuvenated movement could not occur. Alternatively, it would have to be demonstrated that, even if the dome did move, waste containment would not be affected; however, in consideration of the known rates of domal growth, this argument would best be left as a second line of defense.

(2) *Hydrologic regime around the structure*

Domes are intruded through a great thickness of sediments and usually intercept several aquifers. It can often be shown that the domes have undergone dissolution by ground water. In fact, the "cap rock" formation immediately overlying many domes is generally interpreted as the accumulation of insoluble residues previously dispersed in the salt mass (BODENLOS, 1970).

The ground-water hydrology in proximity of salt domes is usually complicated by the faulting and extensive disturbance that the sediments have undergone as a consequence of the salt intrusion itself. It has been reported that, in the Gulf Coast region, water in wells located down the hydrologic gradient from salt domes is not consistently more saline than the average water in the area; in some cases, ground water around domes is actually *less* saline than the average water at the same depth (ANDERSON *et al.*, 1973). This apparently anomalous situation may be a result of the faulting and deformation of strata above and around the domes, which permit the access of fresh water to the naturally saline aquifers and produces a locally enhanced flushing action (ROLLO, 1960). In the face of the overwhelming geologic evidence pointing to past salt dissolution, the logical conclusion is that salt dissolution must be taking place in many cases; however, its mechanism and average rate are imperfectly known, and an adequate understanding of the entire problem of the interactions between salt domes and ground water would require additional extensive investigation.

Before a particular structure could be considered acceptable for waste disposal, it would be necessary to define in considerable detail the characteristics of the ground-water flow around the salt structure and the present rate of salt dissolution. In addition, it would be necessary to demonstrate that the waste containment would be preserved even in the event of a future increase in dissolution rate, regardless of whether it was due to man-made or natural changes (GERA and JACOBS, 1972).

(3) *Effects of heat on the salt structure*

A particular type of problem is related to the heat generation in the radioactive waste. Extensive heating of the salt structure would be limited to a fairly small volume and, in a geological sense, would be of very short duration. It has been calculated that in a few thousand years the temperature in the disposal zone would return to approximately the original value. The thermal effects at a few hundred meters from the disposal zone would be limited to a maximum temperature rise of a few degrees (CHEVERTON and TURNER, 1971). Nevertheless, several questions are raised by the prospect of adding significant amounts of energy to a geologic structure that is the result of original conditions of gravitational instability and, possibly, is in a status of precarious equilibrium. Therefore, a thorough appraisal of the effects arising from the generation of decay heat, both on the salt structure and on the surrounding sediments, would be required.

(4) *Effects of cavity closure on the salt structure*

The analyses that have been performed for a bedded salt repository indicate that the initial subsidence due to the closure of mined cavities is almost exactly counterbalanced by the thermal expansion of the column of sediments. Therefore, subsidence is considerably delayed and takes place slowly over several thousand years, reaching a maximum uniform value of $\sim$1.2 m over the entire respository area (McCLAIN, 1971). If the shape of the original salt dome cavity were different (as a result of a different emplacement concept), subsidence might effect a smaller area with a larger total displacement. While the movement in the salt mass would be plastic and would not result in zones of significant permeability, this might not be the case for the overlying and surrounding sediments; consequently, a careful assessment of the effects of these movements on the hydrologic regime above and around the salt structure would be required.

However it seems reasonable to assume that none of the above difficulties would be disqualifying, and that salt structures suitable for radioactive waste disposal could eventually be identified if the necessary extensive investigations were performed. It is, therefore, interesting to analyze the various concepts that have been proposed for the emplacement of radioactive wastes in salt structures.

WASTE EMPLACEMENT CONCEPTS

(1) *Mechanical mine*

An obvious possibility is a concept similar to the one developed by the Oak Ridge National Laboratory for bedded salt formations, involving a horizontal planar array of long pillars with the wastes placed in the floor of the intervening rooms (McCLAIN and BRADSHAW, 1970; GILBERT and PILCHER, 1970); however, in the case of diapiric salt structures, this scheme does not make the best use of the shape of the salt mass. The maximum development of a salt dome occurs in a vertical direction, while a conventional mine is developed horizontally; hence the mined openings would approach the dome boundary more closely than if the disposal cavities had a predominantly vertical development.

In Germany the demonstration disposal of high-level waste is planned to begin in a few years in the Asse II mine, which is located in a large salt anticline. In this case, the plan calls for fairly deep boreholes reaching down from the deepest mined level, and for the stacking of several waste containers in each borehole (KÜHN, 1972). This concept, entailing a greater vertical development, is more suited to the geometry of a salt structure than the strictly horizontal Oak Ridge mine concept.

A conventional mine in salt could not be operated conveniently at depths below about 1000 m, and it would be economically advantageous not to exceed the depth of 600–700 m; in conjunction with the requirement for a sizable buffer zone, this means that only those domes which rise to fairly shallow depths could be considered as potential sites for the disposal of radioactive waste through the mechanical mine concept.

(2) *Drilled matrix holes*

This concept implies drilling holes from the surface to the disposal horizon and lowering one or more waste containers into each hole. Obviously, the plugging problem would be exacerbated in direct proportion to the number of holes. Man-made penetrations of the salt are presently considered a potential cause of future increases of the rates of salt dissolution. The conclusion, of course, is that it would be advantageous to limit the number of holes to as few as possible. For these and other reasons, it seems that the matrix concept would result in increased probability of salt dissolution and would increase the hazard associated with disposal in salt.

(3) *Liquid waste in a large cavity*

In this concept, it is proposed that a cavity would be produced by either mechanical mining, solution mining, or nuclear explosive (COHEN *et al.*, 1972).

A conventionally mined cavity would share the depth limitations mentioned for the mechanical mine; on the other hand, it would permit engineered improvements designed to improve the characteristics and properties of the cavity.

A nuclear chimney would be significantly more expensive than a solution cavity (ATKINSON and WARD, 1966). Solution cavities, some of which have capacities in the order of hundreds of thousands of cubic meters, are routinely produced in salt structures for LPG storage (ANONYMOUS, 1966). There is no doubt that solution mining would be the most convenient technique to produce large, deep cavities in salt.

Regardless of the method of developing the cavity, the basic difficulty with this disposal concept is related to the liquid state of the waste. A heat-generating liquid in salt constitutes a dynamic system, and prevention of the thermally driven migration of the cavity would pose unresolved problems. It is envisioned that the wastes would be allowed to boil to dryness before plugging the connections with the surface. However, in this procedure there is no way in which the final distribution of radioactive nuclides could be controlled. During the liquid stage, differentiation and sedimentation processes might lead to accumulation of particular elements. Creation of hot spots and accumulation of actinides, with the related criticality hazard, would be theoretical possibilities. After sealing of the cavity, very high temperatures would be reached in the waste mass, and the subsequent melting would again introduce elements of unpredictability and create potential problems.

(4) *Self-burying waste containers*

Still another idea that has been advanced with regard to storage in salt is to introduce waste containers that have a heat generating capacity sufficiently high that they would bury themselves to a great depth by melting their way down through the salt structure (DONEA, 1971; DONEA *et al.*, 1972). In addition to the strictly technical problems that have not been analyzed in detail, and might or might not be solvable, there is again the basic objection to a dynamic disposal system that, by its own nature, has a high degree of unpredictability.

(5) *Mixture of granular waste and crushed salt in a solution cavity*

A solution cavity having a volume in the order of a few hundred thousand cubic meters could be produced in a salt structure at a depth compatible with solution mining requirements and the design life of the facility. The depth would be limited by the rate of plastic deformation of the salt, but it is believed that operation at depths in the order of 2500 m or greater would be possible.

After mining, the cavity would be pumped dry and further dried by circulation of hot air. The waste would then be introduced into the cavity by pneumatic transport as a mixture of granular waste and crushed salt. The mixture could contain small quantities of additives for the purpose of collecting and fixing the small amounts of moisture dispersed throughout the salt mass and attracted to the cavity by the thermal gradient. The waste granules could be either oxide granules (as produced by a fluid-bed solidification process), crushed borosilicate glass, or some other low-leachability solid.

This waste emplacement concept would seem to take better advantage of the favorable features and geometry of salt structures and, at the same time, circumvent some of the difficulties associated with the previous schemes.

The waste/salt ratio, and hence the volume of waste that could be disposed of in the cavity, is a function of the total power density that could be tolerated in the waste–salt mixture. The main objective should be to avoid melting and thereby ensure the maintenance of a relatively uniform dispersion of the waste in the salt.

The fairly high plastic flow rates prevailing at great depth, further accelerated by the high temperature, would rapidly close the cavity and cause reconsolidation and recrystallization of the salt. The result would be a mass of salt having a volume equivalent to the original cavity minus the pore volume in the original waste–salt mixture, and containing the waste granules as uniformly dispersed inclusions. The potential advantages of this concept could be significant, and can be summarized as follows:

(1) Great depth with the related remoteness from the biosphere.

(2) Great reliability of containment as a result of the increased plasticity of salt.

(3) Relatively small cavity located in the center of a massive salt structure; therefore, a great thickness of undisturbed salt would exist between the waste and the salt boundary in *all directions*, as shown in Fig. 1.

Of course, retrievability of the waste, would be extremely difficult; it is, therefore, obvious that disposal of long-lived wastes by this technique could be chosen only after all doubts about the desirability of irretrievable geologic disposal had been eliminated.

The main question about the feasibility of the concept under consideration is the acceptable waste/salt ratio and, thus, the volume of waste that could be accommodated in a single cavity. Some very preliminary calculations have indicated that large dilution factors are necessary to prevent the peak temperature from reaching the melting point of halite (TURNER and SIMAN-TOV, 1971). In these calculations, a

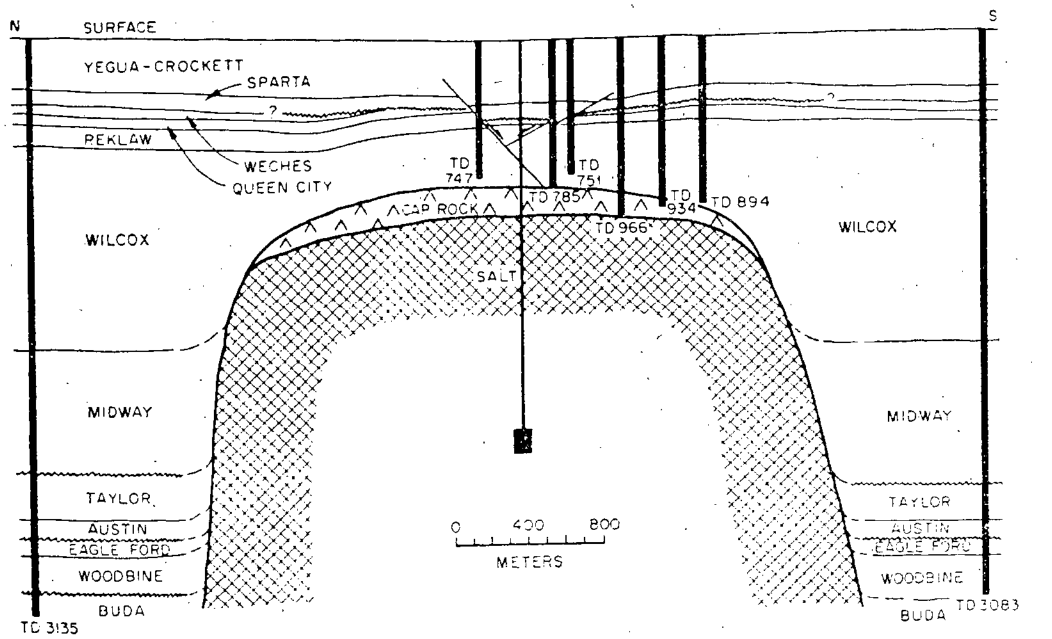

FIG. 1. North–south structural cross-section through Day Dome, Madison County, Texas. The 400,000-m³ cavity is drawn to scale to illustrate the typical size relationship. Obviously, a salt dome could accommodate several cavities. The choice of Day Dome for this figure is due to convenience of drawing, and it implies no interest in that particular dome for radioactive waste disposal. No vertical exaggeration. TD = total depth of wells in meters.

cavity of cylindrical shape, with a height of 120 m, a diameter of 65 m, and a volume of $\sim$400,000 m^3 is assumed. The cavity is filled with crushed salt (porosity $\sim$30%). The thermal conductivity in crushed salt is assumed to be about one-sixteenth that of solid salt. Under these conditions, a power density in the waste–salt mixture of only $\sim$1.4 W/m^3 would result in a peak temperature rise of about 700°C, reached 50 yr after disposal, assuming that the waste were 100 yr old at the time of emplacement.

With the assumption of 1 m^3 of high-level solid waste produced by the reprocessing of 10 tons of fuel, the volume of 100-yr-old waste that could be emplaced in the cavity is about 500 m^3. If the waste were aged for 10 yr, the volume that could be accommodated in a 400,000-m^3 cavity is slightly more than 50 m^3. Obviously, only an exceedingly small fraction of the cavity volume would be utilized for waste disposal; many cavities would be required to accommodate the amount of high-level solid waste projected for the end of the century.

Additional studies might show that the concept is more attractive than this preliminary assessment seems to indicate. For example, several cavities might be located in a single salt dome; in addition, the thermal conductivity of crushed salt could be increased rapidly by self-compaction inside a large mass. In this last case, a proportionally higher power density in the waste–salt mixture would become acceptable.

CONCLUSIONS

This review seems to confirm that several geologic questions still exist concerning disposal of high-level radioactive wastes in diapiric salt structures, but none of the problems appear to be basically unsolvable.

If suitable diapiric salt structures were identified, disposal of high-level waste through a mechanical mine concept would certainly be feasible. Among the alternative waste emplacement concepts, that of the mixture of granular waste and crushed salt in large solution cavities appears to be promising and seems to offer maximum intrinsic safety.

The granular mixture in solution cavities would require a total mined volume twice as large as would be the case with the Oak Ridge mechanical mine concept; in addition, waste in the first case should be aged 100 yr, while waste in the mechanical mine would be only 10 yr old. From an economic point of view, it is anticipated that the lower cost of solution mining—about ten times cheaper than mechanical mining (Mead, 1960)—would be more than offset by the increased volume requirements, the significant number of required cavities, and the more extended interim storage time. However, if a decision were made to use extended interim storage on the basis of other considerations and wastes were allowed to age for significantly longer than 10 yr, the concept of the granular mixture in solution cavities would become more attractive.

In conclusion, it is believed that the disposal of radioactive waste as a dispersion of granular waste in crushed salt in deep solution cavities in salt structures could very well be a safe and attractive disposal option, but it would be practicable only for wastes aged significantly more than 10 yr.

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From: Charles Byrum [byrum.charles@epa.gov]
Sent: Thursday, March 12, 2009 12:18 PM
To: Chavez, Carl J, EMNRD
Cc: Russ Patterson; David Hughes
Subject: Interesting modeling article
Attachments: cc5.pdf

Carl, Russ,

I found a, hard to read, article from China about structural modeling done to study salt cavities. I found it interesting.

Chuck Byrum

STABILITY ANALYSES ON THE DISSOLVED CAVITIES OF QIAOHOU SALT MINE

ANÁLISES DA ESTABILIDADE NAS CAVIDADES DISSOLVIDAS DA MINA DE SAL DE QIAOHOU

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ABSTRACT

Qiaohou is a mine located in sedimentary-metamorphic salt deposits at the Yunnan province of China. Since the 1960's, a technique named "drilling well dissolution" was adopted in the mine to exploit rock salt by supplying fresh water into the cavities and transporting the saline solution to surface. In 1989, the drilling well having the maximum diameter collapsed and produced many losses on properties, making further exploitation difficult.
In this paper, numerical simulations were performed to analyse the stability of the dissolved cavities of this mine with the code Phase 2, a finite element program with elasto-plastic functions. The relationship between the underground cavity sizes and their stability was investigated and is described.

RESUMO

A mina de sal de Qiauhou está situada em formações sedimentares metamorfisadas da província de Yunnan, China. Desde 1960, tem sido utilizada na mina, a técnica de dissolução para explorar o sal, injectando água fresca por furos de sonda nas cavidades subterrâneas e transportando a salmoura para o exterior. Em 1989 ocorreu um colapso na extracção de salmoura que ocasionou muitos danos à superfície, num poço perfurado de grande diâmetro.
Neste artigo descrevem-se simulações numéricas que foram executadas para analisar a estabilidade das cavidades dissolvidas da mina, com o programa Phase 2, elementos finitos que tem funções elasto-plásticas. A relação entre as dimensões das cavidades e a sua estabilidade foi investigada e é objecto desta descrição.

1. INTRODUCTION

Qiaohou is a sedimentary-metamorphic deposited salt mine, located at Yunnan province, south-west of China. The deposit appeared to be approximately a layer with changeable width and the average thickness of the orebody (rock salt) is about 30 meters. However, its vertical thickness at the local area of mining is as high as 60 to 100 meters. Salt contained in the rock salt is a little more than 50%.

It has been several hundred years that people took rock salt from the deposit and made it into salt, although the mining operation had always been conducted by manual works and so the outputs were always very small. Beginning from 1950's, some modern equipment and underground mining system were adopted to extract rock salt from underground stopes with a room and pillar method, a system been called "dry mining" in this mine. In 1960's, a dissolution technique named "cave dissolution" was adopted. With the new technique, the rock salt was no longer mined and transported, the transportation of the ore was replaced by transportation of the saline solution. Water was pumped into the rock caves and then saline solution was pumped out to the plant to make salt. However, with the cave dissolution, the shape of the dissolved cave was developed naturally and could not be controlled, making the roof area of the stopes more and more large and the dissolved cavities unstable. Roof failure happened during the following period of the exploitation. A few years later another technique named "drilling well dissolution" was then employed, with which the geometry of the cavities can be controlled and dissolved into cylinders. With the drilling well technique, the solved cylinder cavities are more stable, and the production has higher extraction recovery and higher efficiency, making the mining cost decreased and the output increased. This technique is then employed until present time. As water is employed in dissolution process, the technique is called "water mining" in this mine.

At the beginning period of drilling well mining, the diameters of the well were only 15 meters. Later, the diameters were increased to 30 to 50 meters. For drilling well No. 12, the diameter reached to a high value of 77 meters.

When exploited with room and pillar system, the stopes kept stable and collapse was hardly appeared, because both the span and the volume of the stopes were relatively small and the ore recovery was quite low. With the dissolution technique, the volumes of the cavities were much bigger. For some cavities of the cave dissolution, the exposed areas of the cavity roof were as high as 1500m^2 to 2000m^2; for the cavities of the drilling wells, the exposed roof area was even larger. So local collapses had happened several times.

In December 1989, a large collapse arisen at drilling well No. 12, the main production drilling well during late 1980's. At the moment of the collapse, 80,000 m^3 of the saline solution was driven away from the cavity of the drilling well. The saline solution emerged out to surface through level 4, and went passed the salt plant. Some equipment in the plant was damaged. Fortunately the collapse happened during the night and no people were injured. After that, a cave with a geometry of approximately cylinder appeared on the surface with the diameter of about 40m and depth about 15m.

In this paper, numerical simulations are conducted with the finite element program Phase 2 to analyse the stability of the drilling wells of Qiaohou salt mine, to investigate the best geometry of the drilling well cavities.

2. GEOLOGY AND SIMULATION MODELS

The rock salt and the country rocks are composed of the Jurassic strata. Rock salt is stable and support is unnecessary when underground drifts are excavated in it. Most of the country rocks are composed of mud-conglomerate containing richly gypsum and salt, and are usually very weak, especially exposed to air after drifts have been excavated through them. So supports are necessary for all drifts excavated in the country rocks. Usually the deformation of the drifts in country rocks is quite large, making the supports fail gradually, thus, the supports have to be renewed every 1 or 2 years.

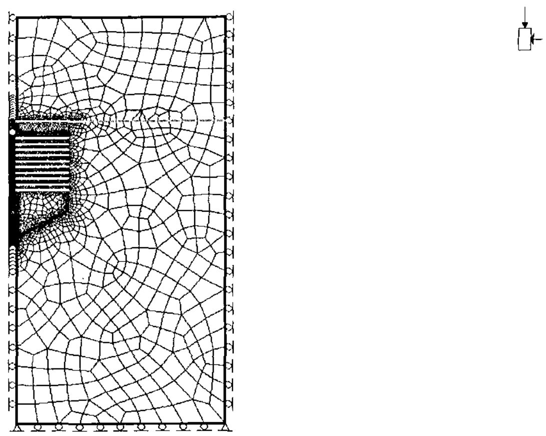
In the exploitation of this mine, the dissolved cavities must be well controlled and cannot reach roof rocks since the roof is so week, or else failure would appear immediately, making the following excavation difficult. Therefore, for the sake of keeping working safety, the operation cave of the drilling well, where the exploitation equipment is installed, has to be excavated in rock salt. Then the roof of the dissolved cavity cannot reach overlying of the rock salt during the upward dissolution, some rock salt have to be remained unsolved to protect the stability of the cave and then the stability of the equipment and working people. The rock salt remaining on the roof of cavities (i.e., the rock salt between cavity roof and the overlying rock), is called "floor" (roof pillar). Obviously, with the reason of economy, the thickness of the "floor" should be as low as possible; however, for the sake of safety, the thickness should have enough thickness. For the purpose of keeping balance between economy and safety, investigations on the suitable value of the "floor" thickness are important. Unfortunately, such a work has not been conducted up till now and the thickness values of the "floor" adopted are completely experience values without supported by further investigations. The authors believe that this was the most important reason that produced the accident of 1989.

Measurement results of convergence (relative deformation) and settlements were conducted and continued during several years in the underground drifts of Qiuaohou salt mine. The obtained results shown that the vertical convergence in these drifts were larger than the horizontal one and the ratios between the vertical and the horizontal convergence are between 1.65 and 7.86 (Yu et al. 1994). Considering the influence of the excavated cavities near by, the largest ratio value should be removed and the average ratio between vertical and horizontal convergence should be approximately 2. This number means that the stress field in the rock mass of the mine is of the gravity type and vertical component of the initial stress is larger than the horizontal component. Such a result supplies an important data for the numerical simulation concerned with this paper.

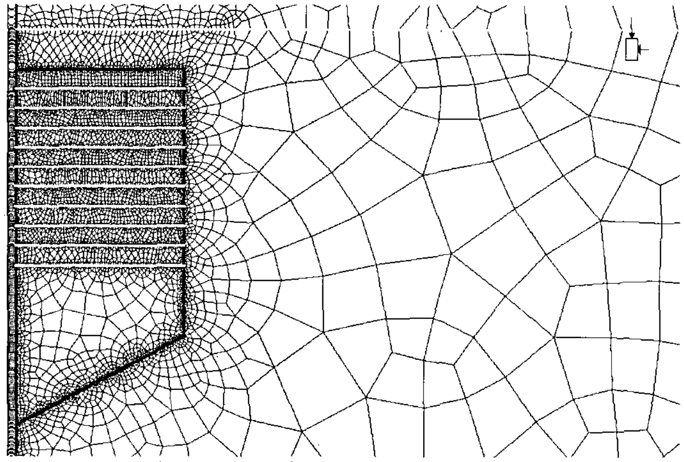
Finite element program phase 2 was adopted to make the numerical simulations. Since the geometry of the dissolved wells is cylindrical, non-linear axial symmetry simulations were performed.

Simulations were performed to analyse the stress distribution and stability of the drilling wells with different diameters, mainly the diameters of 40 m, 50, 60 m and 77 m. Fig.1 shows the mesh and the boundary conditions of a simulation model, of which the diameter was 77 m (drilling well No.12). Two materials are existed in this model: mud-conglomerate (on upper part) and rock salt (situated below). In the simulations, pressure normal to the tangent direction was acted on the inner surface of the dissolved cavity, to simulate the air pressure used to make the dissolved solution out of the cavity automatically. The other models were similar.

In the simulations, the elements at the lower part of the cavity were supposed to be dissolved first, then dissolution continued upward in the following simulation stages, to observe the results of the excavation process.



(a) Simulation model and the boundary conditions



(b) Detail mesh around the cavity

Fig.1 – Simulation model with the mesh

3. MAIN RESULTS AND DISCUSSION

After a dissolution cavity is formed, stress concentration with large values appears at the sharp corner of the cavity and would cause local failure there. However, the stress concentration area (volume) of such compressive stress is small and is not important to the total stability of a cavity. Tensile stress is more important and needs detail investigation.

Fig.2 presented contours of tensile stresses (s_3) appeared in the rocks after the first excavation stage was finished under the condition that the diameter of the drilling well is 77m. At this moment, the vertical distance between the top of dissolved cavity and the overlying rock is 50m, and the maximum tensile stresses appeared at the central roof of the cavity, (s_{tmax}), is 1.18MPa.

With the development of dissolution, the cavity roof raises, and then s_{tmax} raised. When the cavity top is near the roof rock (mud-conglomerate), tensile stresses appear not only at the top, but also at the rock salt below the overburden (mud-conglomerate). When the floor thickness is 15m, the maximum tensile tress at the cavity roof is 5.4MPa. Such a result is quite different from that of a cavity where no week rock on above of rock salt.

With the further decrease of the floor thickness, the values of tensile stress raised rapidly. When the floor thickness is 10m, the maximum tensile stress at the cavity top is as 7.38MPa, and the maximum tensile stress appeared at rock salt joining to overburden (mud-conglomerate) with a value of 6.06MPa (tension). When the floor thickness is 5m, the maximum tensile stress at the cavity top is 14.06MPa, and the maximum tensile stress appeared at rock salt joining to overburden is as high as 16.11MPa, as shown in Fig.3.

Fig.4 shows the contours of tensile stress where the stress values are greater than 1MPa. Test results in laboratory with rock samples show that the compressive and tensile strengths of the rock salt are respectively 4-12MPa and 0.5-2.5MPa [3]. Although there is hardly discontinuities exist in rock salt, the strength of rock mass should be smaller than that of rock samples. So failure is unavoidable with the upward of the dissolution until the floor thickness is less than 15m.

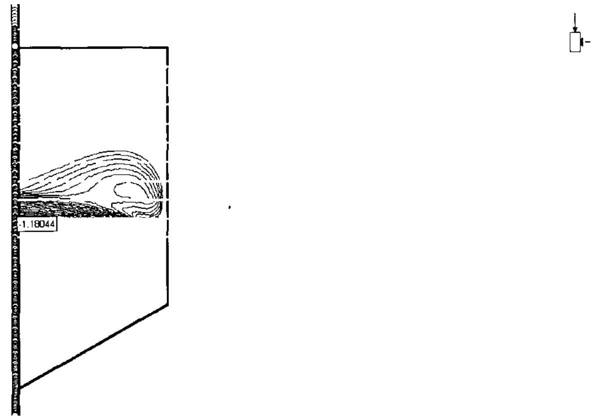


Fig.2 – Contours of tensile stresses (s_3) around the dissolved cavity when floor thickness is 50m (white colour outside the cavity represents the area of compressive stress)

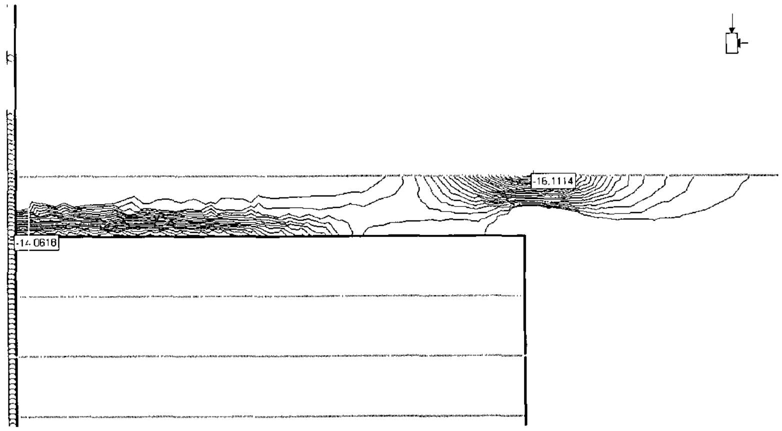


Fig.3 – Contours of tensile stresses around the dissolved cavity when floor thickness is 5m.

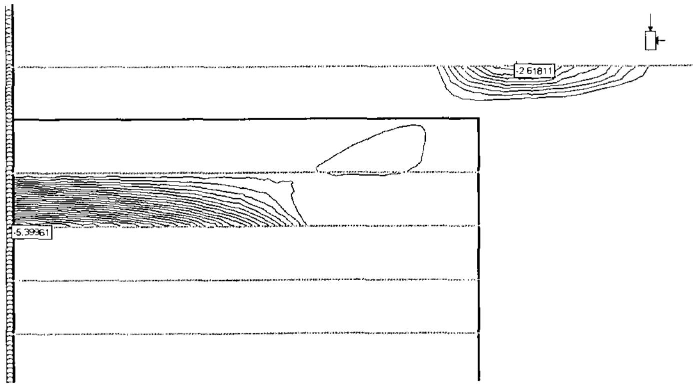


Fig.4 – Contours of tensile stresses around the dissolved cavity when floor thickness is 15m (contours shown the area where tensile stress values greater than 1MPa)

Fig.5 presented the relationship between the maximum tensile stress in the roof and the depth of the floor under the condition of diameter 77m obtained from the simulations. When the floor thickness (t) decreased from 60m to 30m, the maximum tensile stress (s_{tmax}) increased from 0.96MPa to 1.41MPa; when t is 20m, s_{tmax} increased to 2.14MPa. When t is 10m, s_{tmax} is as high as 4.38MPa; When t is 5m, s_{tmax} is as high as 11.45MPa.

It should be noticed that tensile stress values below and next to the mud-conglomerate is independent of the maximum tensile stress at top of rock salt. When the "floor" thickness is greater than 25m, no tensile stress appeared there. When the "floor" thickness is 15m, the maximum value of tensile stress next to mud-conglomerate is 1.35MPa, about 50% of the maximum tensile stress appearing at the cavity roof. When the "floor" depth is 10m, the maximum value of tensile stress next to mud-conglomerate is 3.52MPa, about 20% lower than that appears at the cavity top. When the "floor" depth is 5m, the maximum value of tensile stress next to mud-conglomerate is 12.15MPa, about 6% greater than that appearing at the cavity roof. Obviously, the tensile stress appearing at the rock salt adjacent to mud-conglomerate will decrease the cavity stability very much when the "floor" thickness is thin enough.

Since the tensile strength of the samples of rock salt is usually less than 2MPa, failure is unavoidable when the "floor" thickness is less than 20m. With the raising of the cavity top, failure zone would develop continually and may produce a large circle, and causing collapse at last. The authors believe that this is the main reason that produced the accident of 1989.

Above results were obtained for the condition that the diameter of the drilling well is 77m. For the purpose to know the influences of the drilling diameter to stability of the cavities, more simulations were conducted. The results were presented in Fig.6. These results show that the drilling diameter has great influence on the tensile stresses appeared in the rock salt. For example, when the "floor" thickness is 5m, the maximum tensile stress at the cavity top is 2.68MPa for the condition of diameter 40m and is 7.82MPa as for the condition of diameter 50m.

For different cavity diameters, the safety floor thickness is quite different. For example, when the diameter is 40m and the floor thickness is 5m, the maximum tensile stress in the rock salt is 2.68MPa meaning that some part of the cavity may fail. However, the scope of the rock salt where tensile stresses exceed strength value is relatively small, so the cavity of the drilling well can keep stable although local failure may appear. When the diameter is 60m, failure would be more serious even when the floor thickness is 10m, because the maximum tensile stress at this moment is higher than the condition when the diameter is 40m and the floor thickness is 5m.

In the mine exploitation, diameter of the drilling well is very important. From the consideration of economy, larger value of diameter is better, since it would promote higher recovery and produce better benefits. However, larger diameter also means lower safety factor of the cavity. To improve the safety factor, the "floor" should have enough thickness, or else accidents like what happened at drilling well No.12 are unavoidable.

To keep balance between safety and economy, the minimum floor thickness should be different when the cavity diameter is different. It is suggested to considering the results shown in Figs 5 and 6 in the following drilling well design.

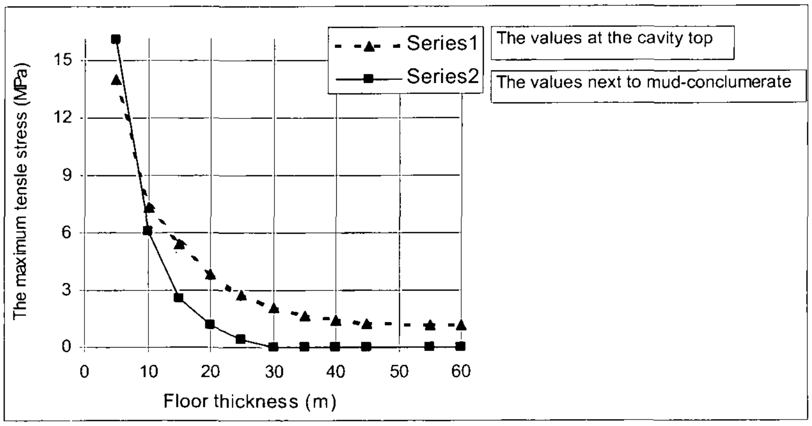


Fig. 5 – The maximum tensile stress in the roof vs. floor thickness when the cavity diameter is 77m.

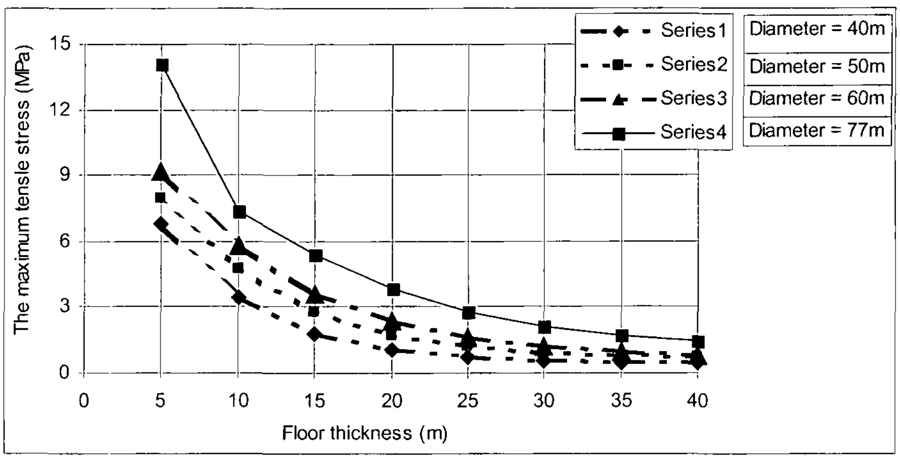


Fig.6 – Floor thickness vs. the maximum tensile stresses in the rock

It is well known that rock salt is a rock type that has typical behaviour of rheology, i.e., the deformation is connected with time. In Qiaohou salt mine, measurement results from underground openings has shown that rheology deformation does exist [2]. Since the excavation of a drilling well continues usually several years, rheology behaviour will influence the stress distribution and the stability of the drilling cavities. Test results with the samples of rock salt of this mine also shown that non-linear stage exists on the stress-strain curves with the raising of stress values, where the slope of the curve is much smaller than the initial linear stage. Unfortunately, no test results on rheology behaviour are available and the related analyses cannot be conducted. The results of this paper are then some primary ones.

4. CONCLUSIONS

(a) Tensile stress appeared in the cavity top was the main reason of making the cavities' failure and collapse.

(b) The thickness of the "floor", or the vertical distance between the cavity top and the overlying rock (mud-conglomerate), and the cavity diameter are the main factors of influencing the tensile stress values. With the decrease of the "floor" thickness and increase of the diameter, the values of tensile stresses increase rapidly.

(c) For a drilling well of which the diameter is as high as 77m, like drilling well No.12, the "floor" thickness should be larger than 15m or else collapse is unavoidable.

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