GW - 226

GENERAL CORRESPONDENCE

YEAR(S):

1997 - 1978

RISK ANALYSES FOR DISPOSING NONHAZARDOUS OIL FIELD WASTES IN SALT CAVERNS

Prepared for: **U.S. Department of Energy**
Office of Fossil Energy
Under Contract W-31-109-ENG-38

Prepared by: **David Tomasko, Deborah Elcock, John Veil, and Dan Caudle**
Argonne National Laboratory
Argonne, IL

December 1997

Acknowledgments

The authors wish to express their appreciation to those individuals who gave their time to review the draft version of this report and provide us with comments. In particular we thank H.W. Diamond of the Solution Mining Research Institute, who coordinated an extensive review of the draft report. The review panel consisted of the following persons:

Pierre Berest	Ecole Polytechnique
Benoit Brouard	Ecole Polytechnique
Ph. Cosenza	Ecole Polytechnique
Dennis Crist	Ohio Department of Natural Resources
Fritz Crotogino	Kavernen Bau- und Betriebs GmbH
Ken E. Davis	Envirocorp Services & Technology, Inc.
Anna Dombrowski	Envirocorp Services & Technology, Inc.
H.W. Diamond	Solution Mining Research Institute
Norbert Heitmann	PB-KBB, Inc.
Gordon Kiddoo	consultant
James Linn	Sandia National Laboratories
Jeff McCartney	Texas Brine Corp.
James Oswald	Morton Salt
Joe L. Ratigan	RE/SPEC, Inc.
Robert Thoms	AGM, Inc.

Additional comments were received separately from the following persons:

Richard Ginn	Railroad Commission of Texas
Susan Hovorka	Texas Bureau of Economic Geology

The final report reflects the contributions of each of these persons.

We also wish to thank Nancy Johnson of the Office of Fossil Energy at DOE headquarters and John Ford of DOE's National Petroleum Technology Office for their continued encouragement and support of our salt cavern research program.

Risk Analyses for Disposing Nonhazardous Oil Field Wastes in Salt Caverns

D. Tomasko, D. Elcock, J. Veil, and D. Caudle

Executive Summary

Salt caverns have been used for several decades to store various hydrocarbon products. In the past few years, four facilities in the United States have been permitted to dispose nonhazardous oil field wastes in salt caverns. Several other disposal caverns have been permitted in Canada and in Europe. This report evaluates the possibility that adverse human health effects (carcinogenic and noncarcinogenic) could result from exposure to contaminants released from the caverns in domal salt formations used for nonhazardous oil field waste disposal. The evaluation assumes normal operations but considers the possibility of leaks in cavern seals and cavern walls during the post-closure phase of operation. In this assessment, several steps were followed to identify possible human health risks. At the broadest level, these steps include identifying a reasonable set of contaminants of possible concern, identifying how humans could be exposed to these contaminants, assessing the toxicities of these contaminants, estimating their intakes, and characterizing their associated human health risks.

The contaminants of concern for the assessment are benzene, cadmium, arsenic, and chromium. These were selected as being components of oil field waste and having a likelihood to remain in solution for a long enough time to reach a human receptor.

Post-closure releases of fluids from the caverns can be classified under the following scenarios for the present study: inadvertent intrusion by unintentionally drilling a new well into a closed cavern; failure of the cavern seal due to increased pressure from salt creep and geothermal heating; release of contaminated fluid through cracks, leaky interbeds, or nonhomogeneous zones composed of higher permeability material; and partial cavern roof fall. Most releases would be to deep aquifers at or near the top of the cavern, although under several scenarios, released contaminants can move upward through the well casing and leak out into shallow aquifers.

For the inadvertent intrusion scenario, up to 2,000 gallons (gal) of contaminated fluids would move quickly to the surface where, if not contained by the drilling blowout-prevention system, would most likely form a pool on the ground surface. These materials would not penetrate very far into the ground and could be readily cleaned up. Because the volume of released fluid for this scenario would be small, the effects would be of very short duration, the liquid would not be potable, and such a spill would be quickly remediated, the scenario was eliminated from further analyses.

In most of the other scenarios, the release pattern would be to have the pressure build up in the cavern to a level that causes seal failure or cracks. A small amount of contaminated fluids (assumed to be 2,000 gal) would be released and the internal cavern pressure would decrease. The cracks or leaks could self-heal after the release because of additional salt creep. With repressurization of the cavern, the cracks or leaks could once again open, producing a series of short contaminant pulses (probably on the order of hours to days in duration). Under the remaining scenarios, releases would be gradual and long-term seeps through cracks, leaky interbeds, or other nonhomogeneous zones composed of higher permeability material.

Not every closed cavern is expected to undergo releases, so some measure of the probability of failure must be incorporated into the analyses. Because experience with disposal caverns is limited and they have not been in operation for very many years, virtually no information exists about the accident or release rates from disposal caverns. In order to estimate the range of the probabilities of occurrence, a questionnaire was distributed to experts in the field of salt caverns. The panel of experts was asked to provide both a "best-estimate" and a "worst-case" estimate of the probability of occurrence for each of the release scenarios. The estimates from each expert were averaged. Averaged best-estimates for the different scenarios ranged from 0.006 for partial roof fall plus cavern seal failure and fluid release at shallow depth to 0.1 for partial roof fall plus fluid release at depth. Averaged worst-case estimates ranged from 0.04 for seal failure with fluid release at shallow depth to 0.29 for partial roof fall plus fluid release at depth.

Once contaminated fluids leave the cavern, they are expected to migrate laterally and vertically through different formations and aquifers. During the time the fluids travel from the point of release to the receptor site (assumed to be 1,000 ft laterally from the cavern) various physical, chemical, and biological processes occur that reduce the concentration of the contaminants. Fate and transport modeling was used estimate the contaminant concentrations at the receptor point (exposure point concentrations).

Risk calculations were conducted using the exposure point concentrations, assumed drinking water intake rates, and standard assumptions regarding exposure time, duration, and frequency. Based on assumptions that were developed for a generic cavern and generic oil field wastes, the estimated human health risks for worst-case conditions are very low (excess cancer risks of between 1.1×10^{-8} and 2.0×10^{-17}) and hazard indices (referring to noncancer health effects) of between 6×10^{-5} and 1.0×10^{-7}. Normally, risk managers consider risks of 1×10^{-6} and less and hazard indices of less than 1 to be acceptable. For best-estimate conditions, the excess cancer risks were calculated to be between 1.3×10^{-9} and 3.8×10^{-18} and the hazard indices were between 1.4×10^{-5} and 1.9×10^{-8}.

Caveats regarding the use of the results of this report include the following. First, the assessment does not address risks to workers at the cavern disposal site. Such risks would be comparable to or less than worker risks associated with hydrocarbon cavern storage operations. Second, the assessment does not determine whether any health effects will occur in the future; it only estimates cancer risk and potential for noncarcinogenic effects. Third, risks have only been estimated for contaminants for which toxicity values were available; just because there is no toxicity value does not mean there is no risk. Finally, the assessment is limited to human health effects produced by nonradioactive contamination; it does not address the possible ecological risks associated with salt cavern disposal, nor does it estimate risks associated with NORM that may be included in oil field wastes.

1. Introduction

In 1996, the U.S. Department of Energy (DOE), Office of Fossil Energy, asked Argonne National Laboratory (ANL) to conduct a preliminary technical and legal evaluation of disposing of nonhazardous oil field wastes (NOW) into salt caverns. The conclusions of that study, based on preliminary research, were that disposal of oil field wastes into salt caverns is feasible and legal. If caverns are sited and designed well, operated carefully, closed properly, and monitored routinely, they can be a suitable means for disposing of oil field waste (Veil et al. 1996). Considering these findings and the increased U.S. interest in using salt caverns for nonhazardous oil field waste disposal, the Office of Fossil Energy asked ANL to conduct a preliminary identification and investigation of the risks associated with such disposal.

The purpose of this report is to evaluate the possibility that adverse human health effects (carcinogenic and noncarcinogenic) could result from exposure to contaminants released from the caverns in domal salt formations used for nonhazardous oil field waste disposal. The evaluation assumes normal operations but considers the possibility of leaks in cavern seals and cavern walls during the post-closure phase of operation. It does not consider the risks associated with emissions from surface equipment operating at the site, nor does it consider the risks associated with surface oil leaks or other equipment-related spills or accidents.

The study focuses on possible long-term risks to human health. It does not address potential ecological effects, although such effects could result. Also, risks associated with naturally occurring radioactive materials (NORM) are not addressed. This preliminary assessment estimates risks associated with disposal in a single generic cavern only. No attempt has been made to address the possibly or likelihood that several caverns may be located in relatively close proximity and that more than one cavern could be a source of contamination to a given receptor. Also, no attempt has been made to evaluate the possible impacts of synergistic effects of multiple contaminants on a single receptor.

Because the history of salt cavern use for solid waste disposal is very limited, no readily available data could be accessed for this study. As a result, data from similar operations and professional judgment were used to develop the possible release mechanisms assumed in this hypothetical, generic analysis. The validity of the results would be enhanced if real data could be used. As data are generated on the use and post-closure operations of salt caverns used for solid waste disposal, they should be incorporated to update this study.

In this assessment, several steps were followed to identify possible human health risks. At the broadest level, these steps include identifying a reasonable set of contaminants of possible concern, identifying how humans could be exposed to these contaminants, assessing the toxicities of these contaminants, estimating their intakes, and characterizing their associated human health risks. The risk assessment methodology and techniques used in this report are based in large part on two documents. The first document is a training manual that was developed for a risk assessment workshop sponsored by DOE (DOE 1996). The second is the Risk Assessment Guidance for Superfund (U.S. Environmental Protection Agency [EPA] 1989).

The remainder of this report consists of nine sections. Section 2 provides background on the development, use, and closure of salt caverns that may be used for disposal of nonhazardous oil field wastes and possible cavern release scenarios. Section 3 identifies contaminants of potential concern that could cause harm to human health. Sections 4, 5, and 6 provide information for assessing potential exposure pathways that the contaminants of concern could take to reach human populations. Specifically, Section 4 describes fate and transport mechanisms of the contaminants of concern; Section 5 describes specific hydrogeologic conditions of locations where salt caverns are most likely to be used for oil field disposal (Gulf Coast, Texas, and New Mexico); and Section 6 describes potential release modes that could cause contaminants to leak from the cavern and be transported to areas where human populations may be exposed. Section 6 also estimates possible concentrations of the contaminants to which humans could be exposed under various release scenarios. Section 7 describes the toxicity of those contaminants that could come in contact with humans, given the fate and transport mechanisms identified in Section 5 combined with the potential exposure pathways described in Section 6. Section 8 estimates the potential intakes of those contaminants by humans and characterizes the risks to which those humans may be subjected on the basis of the intake of the contaminants (the potential for harm), their toxicities, and the release assumptions. Section 9 addresses the sensitivity of the estimated risks to operating procedures and potential regulatory structures, and Section 10 summarizes the results of the analyses.

2. Salt Cavern Background

The following section discusses the origins and development of salt caverns in the United States, waste disposal in caverns, sealing and abandoning salt caverns, and scenarios under which cavern contents could leave the cavern.

2.1 Origins and Development

As discussed in Veil et al. (1996), subsurface salt deposits occur in two major forms in the United States: bedded salt and salt domes. Although salt deposits occur in many parts of the United States, the occurrence of salt in quantities and locations that would promote commercial development is limited. There are 16 states in which salt occurs in sufficient quantity to be mined by either excavation or solution mining or to be recovered through solar evaporation. States having major salt deposits are Alabama, Arizona, Colorado, Kansas, Louisiana, Michigan, Mississippi, Montana, New Mexico, New York, North Dakota, Ohio, Oklahoma, Pennsylvania, Texas, and Utah. Of these states, those with the most significant salt mining are Kansas, Louisiana, Michigan, New Mexico, New York, Ohio, and Texas (Veil et al. 1996).

Bedded salt formations occur in layers interspersed with such sedimentary materials as anhydrite, shale, dolomite, and other more soluble salts (e.g., potassium chloride). These materials have varying degrees of permeability, but all are generally low (Freeze and Cherry 1979). The bedded salt deposits are tabular and can contain significant quantities of impurities.

Salt domes are large, nearly homogeneous formations of sodium chloride, although they may contain nonhomogeneous zones. Pfeifle et al. (1995) report that the typical anhydrite ($CaSO_4$) content of Gulf Coast salt domes averages less than 5%. These domes were created by geological processes that spanned millions of years (Chilingarian et al. 1989). About 30 million years ago, salt buried by more dense materials flowed to form pillows. Because of its lower density, salt flowed upward to form diapirs (domes or anticlinal folds whose overlying rocks have been ruptured by the squeezing-up of the more plastic salt core) and piercing overlying units.

As the salt passed up through the overlying sediments, long, finger-like projections developed. The depth of the intruded salt (sedimentary piercements) can be greater than 10,000 ft (Whiting 1981a), and the top width of the salt domes ranges from about 0.5 to 2.5 miles (Chilingarian et al. 1989). If the intruded salt contacted undersaturated water, dissolution would occur. Through a complex interaction of dissolution, recrystallization, hydration of anhydrite to form gypsum, sulfate reduction, cementation, etc., a caprock was often formed. Although caprocks are common in the vicinity of salt domes, they do not always exist there (Linn 1997).

At the top of the caprock, a region of limestone frequently developed. This limestone may have been formed by a number of processes, including reduction of the calcium-sulfate caprock, and precipitation from calcium-sulfate-rich water (Werner 1986).

As the salt intruded the Cenozoic sediments along the Gulf Coast, various minerals were often precipitated in the vicinity of the caprock. Along with the minerals, oil was frequently trapped under the edge of the caprock. Because of the high probability of finding oil and other valuable minerals, salt domes have been extensively explored and mined for more than 100 years.

Starting in the late 1800s, salt domes were commercially mined for salt by using various leaching techniques. The shapes of the resulting caverns were often irregular because of the techniques applied, but a number of caverns, such as West Hackberry Cavern 11, are nearly symmetrical (Tomasko 1985).

Salt caverns are used for storing hydrocarbons. The earliest cavern storage in salt domes for liquified petroleum gas (LPG) started in 1951; LPG storage in bedded salt started somewhat sooner, in the early 1940s (Querio 1980). Some of the liquified products stored include propane, butane, ethane, fuel oil, gas, and crude oil.

DOE acquired the rights to some existing caverns for the Early Storage Reserve (ESR) of the Strategic Petroleum Reserve (SPR). The ESR was designed to store 250 million barrels of oil of which about two thirds were to be placed in solution-mined caverns and one third in a conventional rock salt mine. Acquisitions for the ESR were made about 1977. SPR now has a capacity of 680 million barrels, and the rock salt mine has been removed from the program (SMRI 1997).

Private industry in the United States operates a large number of caverns for storing liquid petroleum products, petrochemicals, and natural gas. European countries have also used salt caverns as containment sites for the disposal of drilling muds and cuttings from deep oil and gas wells (Testa 1994).

Nearly all salt caverns in the SPR are 2,000 ft tall and have a cavern roof that is at a depth of about 2,000 ft. The diameters of the caverns vary greatly, but a typical value is about 300 ft (Biringer 1984). The distance between caverns is variable, but a typical separation distance from center-to-center is more than 600 ft (Whiting 1981b). Volumetrically, SPR caverns are large, and each cavern contains about 10 million barrels (420 million gallons) of crude oil. Private sector caverns are generally smaller than the SPR caverns and have various sizes, shapes, and depths (Hickerson 1995).

To create salt caverns, water that is not fully salt-saturated is injected into a salt stock and the resulting brine solution is withdrawn. This method is referred to as solution mining (Testa 1994). The development and shape of the salt cavern can be controlled by the method used for construction. In the direct circulation method, fresh water is injected through a tubing string from the surface, and brine is withdrawn through an annular space between the tubing and final casing. In the reverse circulation method, fresh water enters through the annulus, and brine is removed through the tubing string. A combination of these two methods, or other more complicated methods, can be used to obtain the desired cavern shape. The American Petroleum Institute (API) provides illustrations and more details on these methods (API 1994).

2.2 Waste Disposal in Caverns

Use of salt caverns for waste disposal in the United States has been limited. A summary of current disposal practices is given in Veil et al. (1996) along with a discussion on using caverns for waste disposal in Canada, the United Kingdom, Germany, the Netherlands, and Mexico.

In this study, we consider the disposal of nonhazardous oil field wastes in salt caverns. As discussed in Section 3, the majority of material disposed of would be tank bottom wastes (waste material from washing tanks, heater tanks, and stock tanks). This solid or sludge-like waste consists of accumulated heavy hydrocarbons, paraffins, inorganic solids, and heavy emulsions (EPA 1994b). Physically, the waste consists of approximately 50% water, 15% clay, 10% scale, 10% corrosion products, 10% oil, and 5% sand. Its specific gravity ranges from about 1.5 to 2.0. The principal contaminants of concern in the waste include benzene, lead, arsenic, cadmium, chromium, and boron (see Section 3).

Initially, the caverns would be filled with brine. Wastes would then be introduced as a slurry of waste and a fluid carrier (brine or fresh water). Three scenarios are possible for introducing the waste material: (1) the waste can be pumped down tubing to the bottom of the cavern and the displaced brine can be withdrawn through an annulus; (2) the waste can be pumped down an annulus and the displaced brine can be withdrawn through the tubing; and (3) the waste can be injected through one well and the brine withdrawn from another well. The first scenario is the most likely method because of associated costs and ease of use (Veil et al. 1996).

As the slurry is injected, the cavern acts as an oil/water/solids separator. The heavier solids sink to the bottom of the cavern and form a pile. Any free oils and hydrocarbons float to the top of the cavern, because they are less dense than water. An organic blanket could be injected into the cavern to prevent additional leaching of the cavern's roof by water that is not fully saturated with salt. Clays in the slurry can mix with the brine, forming a suspension above a brine/waste interface. Clean brine displaced by the incoming slurry would be removed from the cavern and either sold as a product or disposed of in an injection well.

Early in the life of the disposal cavern, clean brine is withdrawn from hundreds of feet above the surface of the waste pile or interface. As the cavern fills, the brine becomes dirtier (i.e., it will have a higher clay and oil content). This dirty brine can produce operational difficulties (e.g., clogging of pumps) and additional expenses (Veil et al. 1996). The cavern is considered to be "full" of waste when disposed material being returned with the displaced fluid becomes a problem. When the cavern is full, the operator seals the cavern.

2.3 Post-Closure Cavern Behavior

Once the cavern has been filled with waste, the cavern would be sealed and the borehole plugged with cement. Bridge plugs would be placed in the well bore above and below water-bearing intervals to isolate these intervals permanently. This procedure is often used in the oil and gas industry to abandon wells.

A waste-filled cavern that has been sealed is subject to a number of complex physical processes: reduction in cavern volume caused by salt creep (the process by which salt surrounding the cavern flows into the cavern space as a pseudo-fluid [Bishop 1986, Freeze et al. 1995]); convective mixing in the upper, brine-filled portion of the cavern; differential settling and compaction of solids; chemical reaction and compaction of the waste material; and an increase in pressure produced by the combined effects of salt creep and the addition of sensible heat (heat derived from the geothermal gradient vertically across the cavern — approximately 13°F per 1,000 ft at a depth of 1,000 ft [Tomasko 1985]);

During a transient period of several years after closure of a cavern filled with brine, pressure can exceed the lithostatic value (pressure in surrounding salt) because of thermal expansion of the brine. The amount of over-pressurization is a function of cavern size (Berest and Brouard 1995). Similarly, cavern pressure can exceed the lithostatic value after a longer time period when, due to salt creep, brine pressure will balance average lithostatic pressure, resulting in a slight excess of brine pressure at the top of the cavern (Langer et al. 1984; Wallner 1986). This occurs because lithostatic pressure increases linearly with depth, while brine pressure is constant within the cavern.

The presence of a small quantity of gas in the sealed cavern can mitigate the effects of pressure buildup because the gas drastically increases the cavern compressibility or decreases the cavern stiffness (Berest et al. 1997a). Gases can be produced in a sealed disposal cavern in a number of ways, including bacterial degradation of the waste, corrosion, and natural releases from the salt formation itself (e.g., carbon dioxide, hydrogen sulfide, hydrogen, methane, etc.). Bacterial degradation of organic material in the waste can generate such gases as carbon dioxide, hydrogen sulfide, and methane. However, for several reasons, bacterial action would not generate a large quantity of gas. For example, because many bacteria have a limited tolerance for salt, conditions in the cavern would not be conducive for bacterial growth and reproduction (Stanier et al. 1963; and Postgate 1965). Even if the bacteria could survive in brine, there are other natural curbs on their activity. For aerobic bacteria, the supply of oxygen would be limited (only 8 parts per million [ppm] of oxygen are in the fresh water that is in contact with air at 25°C). For anaerobic conditions, bacteria could produce hydrogen sulfide gas if the waste contains sulfate. The hydrogen sulfide produced would, however, be water soluble and would dissolve in the brine. As the pressure in the cavern increased with time, the solubility of the hydrogen sulfide would also increase and minimize free-gas production.

Metal components of the waste material could corrode and generate hydrogen gas, especially at low pH conditions (acid environment). Such processes are common causes for equipment failures in oil and gas production systems. In a waste cavern, pH would be controlled by the partial pressure of carbon dioxide. Ambient carbon dioxide levels in the cavern would not support a significant corrosion rate, and hydrogen gas would not be generated. The only other source of acid in oil field waste would be spent acid from well stimulations (Bradley 1992). If the pH of such wastes is adjusted to six or above prior to disposal, no significant gas production would occur. Because the principal waste material for this study is tank bottom material and not spent acids, little acid would be present and the production of hydrogen gas would be negligible.

Gas production in caverns is also controlled by pressure effects. As the pressure in a cavern builds up, the gas production rates would fall correspondingly. This process would limit the volume of any gases produced.

A recent study of the behavior of brine-filled, sealed caverns suggests that the permeability of the material surrounding the cavern can also influence pressure buildup (Wallner and Paar 1997). Because of a very slow pressure increase within a sealed salt cavern, the pressure at the top of the cavern would only exceed the lithostatic value after a long time (on the order of thousands of years for a 1,000-ft tall cavern). Because the rock salt formation becomes permeable if the fluid pressure exceeds the stress in the salt, small leakage rates of fluids from the top of the cavern are predicted. This leakage would compensate for the overpressurization at the top of the cavern and return the system to an equilibrium condition.

Details on the pressurization of a sealed cavern that is filled with NOW are currently unavailable, although the behavior is expected to be similar to that discussed above with the exception that the compressibility of the wastes may alter the time scale and magnitude of the system response. More study of actual waste disposal caverns would help to clarify this issue.

2.4 Cavern Release Scenarios

In assessing risks to the public from disposing of NOW in caverns, potential release modes must be determined. At the present time, there is little information on accidents for cavern disposal systems because there are only a few disposal caverns in operation and they have not been operating for very many years. However, what little accident information exists from disposal and storage caverns indicates that the caverns are safe and that the only accidents that have occurred were associated with surface facilities. Because insufficient information exists for quantifying release probabilities for cavern disposal, results from the liquid petroleum gas (LPG) storage industry and the Strategic Petroleum Reserve (SPR) are used in this study as a basis for identifying potential release scenarios.

Although LPG industries and the SPR have a long history of safe operations, a statistically meaningful data base for risk analysis is absent. To overcome this difficulty, a subjective, semiquantitative methodology was developed by Radian Corporation to evaluate risks for the LPG industry (Radian Corporation 1995). This methodology, developed by a panel of experts in the field of salt-cavern conversion for LPG storage, was based on a modified-Delphi approach (Brown and Helmer 1964) in which variability of the estimated parameters are reduced through group interaction.

The Radian study identified 22 accident scenarios that could lead to releases to the environment. These accident scenarios can be grouped into three general categories: (1) cavern development and conversion, (2) cavern filling, and (3) post-closure releases. In this study, impacts were analyzed for only the last of the accident scenarios identified, post-closure releases. Impacts from the first two scenarios are better addressed in a second tier assessment, in which site-specific information would be used and more detailed design parameters would be defined.

Post-closure releases can be classified under the following categories for the present study: inadvertent intrusion; failure of the cavern seal; release of contaminated fluid through cracks, leaky interbeds, or nonhomogeneous zones composed of higher permeability material; and partial cavern roof fall.

3. Contaminants of Potential Concern

In a standard risk assessment, the first step is collecting and evaluating data. One result of the data collection exercise is the identification of contaminants of potential concern. Contaminants of potential concern at a site are those that may be hazardous to human health and/or the environment under current or future site conditions. Selecting contaminants of potential concern helps focus the risk assessment on those contaminants that may be of potential significance to human health.

It is important to select contaminants of potential concern for several reasons. If all possible contaminants were considered, the risks associated with naturally occurring contaminants could drive the assessment. For example, high background levels of particular contaminants, such as manganese, could obscure risks related to oil field wastes. Also, the level of effort and the cost of analysis increase with the number of contaminants being evaluated. Probably hundreds of contaminants associated with nonhazardous oil field wastes could be identified, depending on the types of crude that were produced, the types of drilling muds used, and the geochemistry of the formation from which the oils were extracted.

As the risk assessment is conducted, it may be determined that the risks associated with some potential contaminants are insignificant and can be dropped from further consideration. For example, the ability of some potential contaminants to be transported may be insufficient to allow them to come in contact with humans. In such cases, the contaminant would not be considered further in the risk assessment.

The term nonhazardous oil-field waste should not be interpreted to mean that no hazardous substances are found in oil-field wastes. In 1988, EPA made a determination that exempted wastes from the exploration, development, and production of crude oil, natural gas, and geothermal energy from regulation as hazardous under Subtitle C of the Resource Conservation and Recovery Act (RCRA). In 1993, EPA added many other wastes that were uniquely associated with exploration and production operations to those already exempted from RCRA Subtitle C requirements. Thus, exempt wastes include drilling fluids, produced water, and other wastes associated with the exploration, development, or production of crude oil, natural gas, or geothermal energy. However, even though a waste is exempted from Subtitle C requirements, it may still contain hazardous contaminants. In its regulatory determination, EPA concluded that the wastes exempted from regulation under Subtitle C could be better controlled through improvements to existing state and Federal regulatory programs.

The current study is a preliminary, generic risk assessment; collecting the primary data needed to identify contaminants of potential concern is beyond its intended scope. Rather, results of the analysis presented in EPA's 1987 Report to Congress (EPA 1987) and a later draft pertaining to Selected Associated Wastes (EPA 1994b) were used to identify contaminants of potential concern.

As described in its Report to Congress, EPA used waste sampling and analysis data to characterize drilling wastes and produced water for quantitative risk modeling. Limited available data prohibited the EPA from developing separate waste-stream characterizations for various geographic zones; as a result, one set of waste characteristics was used to represent the nation. The major factors EPA used in selecting contaminants of concern were (1) median and maximum concentrations in the waste samples, (2) frequency of detection in the waste samples, (3) mobility in groundwater, and (4) concentrations at which human health effects, aquatic toxicity, or resource damage start to occur. By using this screening process, EPA selected several chemicals considered likely to dominate risk estimates. These chemicals included arsenic, benzene, boron, cadmium, and chromium (VI).

The 1987 Report to Congress focused primarily on produced water and drilling muds. Because the EPA estimated that these two types of waste constituted over 98% of the industry waste stream in 1988, the EPA began evaluating the relative hazards posed by various associated waste streams, including tank bottoms, oily debris, workover fluids, produced sand, and emulsions. It found that tank bottom samples exceeded the RCRA toxicity characteristics for benzene and lead. On the basis of these two EPA studies, the contaminants of concern for salt cavern disposal are arsenic, benzene, boron, cadmium, chromium, and lead.

Because these contaminants may behave differently in the environment than in the laboratory, an evaluation of the fate and transport mechanisms for each contaminant is presented in Section 4. On the basis of that evaluation, combined with a consideration of the hydrogeologic conditions in areas where cavern disposal is likely to occur (Section 5) and an assessment of potential release modes and exposure pathways (Section 6), a subset of the contaminants listed above that have the ability to produce human health risks was identified. Because risk is a function not only of the probability of exposure, but also of the potential for harm due to the chemical, the toxicity of these contaminants must also be assessed. Section 7 addresses the toxicity of this subset of contaminants, and in Section 8, the risks associated with exposure to releases of those contaminants considered dangerous to humans are estimated.

4. Fate and Transport for Contaminants of Potential Concern

In this section, the fate and transport of the contaminants of potential concern for salt cavern disposal is described. Specific information is provided for benzene, lead, arsenic, cadmium, chromium, and boron. This information is used in estimating contaminant concentrations at the location of a receptor for risk assessment.

4.1 Benzene

Benzene (C_6H_6) is the most important aromatic hydrocarbon in this study because of its physical properties. Benzene is unsaturated and reacts to add hydrogen and other elements to its ring of six carbon atoms.

Benzene, also known as annulene, carbon oil, and coal naphtha, is a clear, colorless to light yellow, watery liquid with an aromatic or gasoline-like odor. Benzene has a density less than that of water (0.8765 g/cm^3) (Mackay et al. 1992).

Benzene is a Class A carcinogen that has an EPA maximum contaminant level (MCL) of 0.005 mg/L (EPA 1994a). It is soluble in water (1.780 g/L at 20°C for fresh water) and readily volatilizes (changes from the aqueous to the gas phase) with a dimensionless Henry's Law constant of 0.2199 (Montgomery 1991; Montgomery and Welkom 1991). The Henry's Law constant gives the ratio of a compound's saturated vapor concentration to its concentration in the associated liquid phase and is an index of partitioning between dissolved and gaseous phases (Hern and Melancon 1987). For benzene, the effective half-life for volatilization is about 4.8 hours (Montgomery 1991; Montgomery and Welkom 1991). In saline water, the solubility of benzene decreases (Stumm and Morgan 1981).

In water, benzene has a distribution coefficient (mass of solute sorbed on solid surfaces per solid mass divided by the mass of solute per volume of solute [Freeze and Cherry 1979]), K_d, of 0.62 mL/g (Lyman et al. 1992). Sorption of benzene onto a solid surface produces a retardation of benzene's transport velocity in groundwater; that is, the velocity of the center of mass of a contaminant plume of benzene, V_c, will move at a retarded velocity of V/R, where V is the velocity of groundwater and R is a retardation coefficient. Retardation coefficients can be estimated by using the following relationship (Freeze and Cherry 1979):

$$R = 1 + \frac{\rho_b K_d}{\Phi} \tag{1}$$

where ρ_b is the bulk density of the matrix material, and Φ is its porosity (Freeze and Cherry 1979). For a bulk density of 1.7 g/cm^3 and a porosity of 0.1 (typical values for this study [Freeze and Cherry 1979]), the retardation coefficient for benzene is about 10.

Under aerobic conditions, benzene has an effective biodegradation half-life of about 10 days; for anaerobic conditions, its half-life is about 2 years (Howard et al. 1991). If exposed to air and sunlight, benzene undergoes photo-oxidation, with an effective half-life of 5-16 days; however, it does not apparently undergo hydrolysis (i.e., it does not react with water to form another compound [Mackay et al. 1992]).

As the above data show, benzene is very soluble in water, and once in a groundwater system, it is very mobile. Because of biodegradation and volatilization, however, it would have a somewhat limited range of travel in an aquifer. When biodegrading, benzene would be mineralized to form water (H_2O) and carbon dioxide (CO_2). Possible transformation products include cis-benzene glycol accompanied by partial dehydrogenation, yielding catechol, or cis,cis-muconic acid and α-hydroxymuconic semialdehyde (Montgomery and Welkom 1991). Because little information is available on the toxicity or fate and transport of these intermediate products, and their behavior can be site-specific, complete biodegradation of the decay products of benzene is assumed for this study.

4.2 Lead

Lead is generally found in the divalent form and tends to form relatively insoluble compounds with such common anions as hydroxide and sulfate. An insoluble precipitate can also form with sulfide, which can be present under reducing conditions. Lead can also form insoluble complexes with carbonate at pH values higher than 5.4 (Adriano 1986). In the presence of clays, lead is very immobile. An approximate K_d for lead is 900 mL/g (Baes and Sharp 1983; Baes et al. 1984). By using Equation 1 with a bulk density of 1.7 g/cm^3 and a porosity of 0.1, the retardation coefficient for lead would exceed 15,000. The maximum recommended concentration of lead in drinking water is 0.015 mg/L (EPA 1994a).

Because of its low solubility, large distribution coefficient, and very large retardation coefficient, further analyses of lead-associated risks are not presented in this study.

4.3 Arsenic

Arsenic generally forms insoluble complexes, typically reacting with hydrous oxide coatings and various anions. For example, the solubility of pentavalent arsenic sulfide (As_2S_5) is 0.000136 g/L in cold, fresh water (CRC 1968). In brine, the solubility of arsenic would be less (Stumm and Morgan 1981). Arsenic readily adsorbs onto clays, iron or manganese compounds, or aluminum complexes. Arsenic can also be immobilized by forming complexes or chelates with iron or calcium (Callahan et al. 1979). The distribution coefficient for trivalent arsenic reported for agricultural soils and clay ranges from about 1- 8 mL/g; for pentavalent arsenic, the range is approximately 2 - 18 mL/g (Baes and Sharp 1983). For this study, a K_d of 10 mL/g was assumed. By using Equation 1 with a bulk density of 1.7 g/cm^3 and a porosity of 0.1, the retardation coefficient for arsenic would be about 170 (rounded to 200). The MCL for arsenic is 0.05 mg/L (EPA 1994a).

Because of the low solubility and large distribution coefficient of arsenic, its concentration and mobility in groundwater would be very low.

4.4 Cadmium

Cadmium can exist as soluble or insoluble species or can be immobilized by sorption onto clays or iron oxides. Cadmium forms soluble complexes and insoluble precipitates with carbonates and hydroxide ions, and it can also exist as the hydrated ion (Baker and Amacher 1982). Under acidic conditions, cadmium can be relatively mobile, with its mobility decreasing as increasing pH and ion exchange capacity increase (Lu et al. 1975). In soil that contains clay and iron hydroxides, cadmium has a low mobility and commonly coprecipitates with iron and manganese hydroxides.

The solubility of cadmium is generally low; however, the solubility of cadmium chloride is about 140 g/L in cold, fresh water, and that of cadmium hydroxide is about 0.00026 g/L (CRC 1968). In brine, this solubility would be less (Stumm and Morgan 1981). The K_d values for cadmium in soil and clay range from about 1.3 to 27 mL/g (Baes and Sharp 1983). For this study, a K_d value of 3 mL/g was used. By using Equation 1 with a bulk density of 1.7 g/cm^3 and a porosity of 0.1, the retardation coefficient for cadmium would be about 50. Cadmium has an MCL of 0.005 mg/L (EPA 1994a).

Because of the presence of iron in the tank bottom wastes, cadmium is likely to precipitate out as a hydroxide. Given the low solubility of cadmium hydroxide and its moderate rate of sorption, the mobility of cadmium in groundwater would be low.

4.5 Chromium

The predominant form of chromium likely to occur in the vicinity of a failed salt cavern would be insoluble, trivalent chromate (Cr_2O_3) (ATSDR 1989). Soluble chromate generally forms precipitates, with hexavalent chromium undergoing anion adsorption and reduction, and trivalent chromium undergoing adsorption, hydrolysis, and chelation (Reisenauer 1982). Manganese and iron oxides can affect chromium adsorption. Adsorption of all chromium species can occur in substrates in the pH range of 6 to 7.5, making the chromium fairly immobile. Adsorption of the hexavalent form can decrease with increasing pH, while adsorption of the more predominant trivalent form can increase with increasing pH, probably as a result of cation exchange (Adriano 1986). In the presence of organic matter, hexavalent chromium is converted to the more insoluble trivalent form. The hydrated form of trivalent chromium sulfate [$Cr_2(SO_4)_3$] has a solubility of about 120 g/L in cold, fresh water (CRC 1968). Brine conditions would be expected to reduce this solubility. The K_d values reported for soil and clay range from about 1.2 - 1,800 mL/g for the hexavalent form and 470 - 150,000 mL/g for the trivalent form (Baes and Sharp 1983). A K_d value of 30 mL/g was assumed for this study. By using Equation 1 with a bulk density of 1.7 g/cm^3 and a porosity of 0.1, the retardation coefficient for chromium would be about 500. Total chromium has an MCL of 0.1 mg/L (EPA 1994a).

Because of low solubility and high distribution coefficients, both trivalent and hexavalent forms of chromium are expected to have low concentrations and mobilities in groundwater. The mobility of the hexavalent form, however, is expected to be greater than that of the trivalent form.

4.6 Boron

Boron is a nonvolatile metalloid that occurs in combination with most of the other elements. Boron readily hydrolyzes in water to form the electrically neutral, weak monobasic acid H_3BO_3 and the monovalent ion $B(OH)_4$ (ATSDR 1990). Although most boron compounds are highly soluble in water (Rai et al. 1986), boron may be precipitated with aluminum, silicon, or iron in the form of fairly insoluble hydroxyborate compounds on the surfaces of minerals. In elemental form, boron is insoluble in water (Windholz et al. 1983). The adsorption of boron may not be reversible in some media. This irreversibility may be the result of solid-phase formation on mineral surfaces. Little information is available on boron sorption; however, for clays, K_d may be as high as 20 mL/g, with a range for soils of 0 to 10 mL/g (Sheppard et al. 1984). For this study, a K_d value of 8 mL/g was assumed. By using Equation 1 and values for bulk density of 1.7 g/cm^3 and for porosity of 0.1, the retardation coefficient for boron would be about 150. As of 1994, the EPA did not have any defined drinking water standards for boron, although its lifetime health advisory is 0.6 mg/L for a 70-kg adult (EPA 1994a).

It is likely that boron would precipitate to form insoluble hydroxyborate compounds on mineral surfaces because of the iron and silicon content of the tank bottoms component of the wastes. Because of this precipitation, further analyses of boron-associated risks are not presented in this study.

5. Hydrogeology

As discussed in Section 2, the majority of salt formations of interest for waste disposal occur along the Gulf Coast and in Texas and New Mexico, although other states, such as Kansas and Michigan, could also be considered as potential candidate states for NOW disposal in salt caverns. The following sections discuss hydrogeological conditions for the Gulf Coast, the western Texas panhandle, and New Mexico. A composite of these areas is then used for a generic analysis of disposing of NOW in a hypothetical salt cavern in domal salt. Additional site-specific calculations are recommended for future studies in other states and bedded salt formations.

5.1 Gulf Coast Hydrogeology

Salt caverns along the Gulf Coast of the United States are located in the Coastal Plain Physiographic Province (Back et al. 1988). This province is underlain by a gulfward thickening wedge of unconsolidated to semiconsolidated sedimentary rocks (sand, silt, and clay derived from erosion of nearby continental upland areas). These sediments overlie consolidated rocks of Mesozoic Age and range in thickness from a few feet near their landward limit to more than 30,000 ft in southern Louisiana.

As part of the Gulf Coast Regional Aquifer-System Analysis (GCC RASA) program, the depth to groundwater was evaluated for a 230,000-mi^2 study area that included coastal regions in Texas, Louisiana, Mississippi, and Florida (Williams and Williamson 1989). Based on data from 6,825 wells, the depth to the water table ranges from 0 to 74 ft, with a median value of 20 ft. This shallow groundwater system is primarily composed of sands interbedded with deposits of silt and clay. Where the silts and clay have been eroded and the aquifer is in communication with the atmosphere, the aquifer is unconfined. Confined to semiconfined conditions exist where low-permeability clays and silt overlay the more permeable sands (Hanor 1993). Beneath the shallow groundwater system are other sequences of clays and silts, interspersed with beds of sand. The sand areas constitute other potential aquifers that are predominantly confined (Capuano and Jan 1996).

Recharge to the shallow groundwater system is derived from precipitation. The majority of recharge occurs in areas where the clay and silt layers are absent. Discharge of this aquifer occurs to surface waters, underlying deeper aquifers, and pumping wells.

5.2 Texas and New Mexico Hydrogeology

Bedded salt occurs in the Texas panhandle area and West Texas, as well as in central and southeastern New Mexico. These bedded salts are located, for the most part, in deep formations (the top of salt occurs at a depth of 500 to 2,000 ft below the land surface, and the salt thickness is about 1,000 to 3,000 ft thick). Although most of these bedded salts occur below 1,000 ft, some of the bedded salts in west Texas can be much shallower (e.g., one of the Permian Brine Sales' caverns starts at a depth of about 700 ft [Hickerson 1995]).

Overlying the bedded salt layers are the Ogallala fluvial aquifer, which is composed of stream and river deposits, and the Dockum aquifer, which is composed of fluvial and lacustrine (lake) deposits (Bassett and Bentley 1982). These aquifers make up a shallow, fresh-water system that is used for domestic, municipal, industrial, and agricultural purposes. The combined thickness of these two aquifers can be as great as 2,300 ft (Bair et al. 1985). The Ogallala is the shallower of the two aquifers and occurs at a depth that ranges between 20 and 400 ft (Wood and Sanford 1995). It has a thickness that ranges from 0 to 800 ft (Seni 1980), and it underlies about 134,000 mi^2 of land that extends from Nebraska to New Mexico (Back et al. 1988). Its principal composition is sand and gravel.

The Dockum aquifer lies below the Ogallala aquifer. Locally, its depth is variable; it can outcrop at the surface or occur as deep as 800 ft below the ground. It is typically composed of a sandstone and conglomerate unit (fluvial) overlying a fine silt and clay unit (lacustrine). The thick Permian evaporite-bearing unit beneath the Dockum is an aquitard and a barrier to vertical groundwater flow. Depth to bedded salt ranges from about 500 to 2,000 ft. The uppermost extensive salt is the Salado Formation. Where this unit has been dissolved, various older formations (e.g., Seven Rivers, Grayburg, San Andres, and Castile) contain the uppermost salt units. In some areas, salt has been completely removed.

Bedded salts are being developed for low-level nuclear waste disposal at the Waste Isolation Pilot Plant (WIPP) in New Mexico. The facility has been constructed and will shortly begin operation. It is located at a depth of 2,150 ft below the ground surface in the Salado Formation (DOE 1990). The Ogallala and Dockum aquifers are absent in this area of New Mexico, and the shallowest groundwater of consequence occurs in the Culebra Dolomite of the Rustler Formation at a depth of about 750 ft.

Recharge to the shallow groundwater system in the semi-arid Texas/New Mexico environment is derived from precipitation. Wood and Sanford (1995) estimate the annual recharge to be 11±2 mm/yr. Recharge is small because of high potential evaporation, plant transpiration, limited precipitation, and runoff. In the past, discharge was to springs; other, deeper, groundwater systems; and pumps. Because of heavy pumping, most of the discharge springs are now dry, and the only discharge is to deeper aquifers.

In general, water quality in Texas and New Mexico decreases with depth. For example, the Rustler Formation water quality is generally poor, with total dissolved solids ranging from 286 mg/L in Ward County to 157,000 mg/L in Winkler County. Chloride concentrations can be as high as 89,700 mg/L in Winkler County, Texas (Richey et al. 1985). Because of this poor water quality, water for public water supply, irrigation, industry, livestock, and rural domestic use is often obtained from overlying aquifers, such as the Santa Rosa Sandstone Formation in the Dockum and from the Cenozoic alluvium in the Delaware basin (including the Ogallala Aquifer, if present). In the Texas panhandle area, similar observations have been made on groundwater quality (Bair 1987); i.e., total dissolved solids and the concentration of brine increase with depth.

6. Release Calculations

Impact analyses were performed for the general categories of cavern-release scenarios discussed in Section 2: inadvertent intrusion; failure of the cavern seal; release of contaminated fluid through cracks, leaky interbeds, or nonhomogeneous zones of higher impermeability; and partial cavern roof fall. Details on these analyses are presented in Section 6.2. Concentrations for the contaminants of potential concern presented in these sections are used for risk analyses in Section 8.

For all of the release scenarios, the initial concentrations of contaminants leaving the cavern must be known. These concentrations are discussed in Section 6.1.

6.1 Initial Concentrations for Contaminants Released from a Cavern

In the event of a release, some of the brine overlying the waste would leave the cavern. This brine will contain dissolved contaminants of potential concern. No data are available to show the chemical characteristics of the cavern brine at the time of release, because no disposal cavern has yet been closed. After the cavern is closed, the chemical constituents of the waste will reach an equilibrium solubility with the overlying brine. Theoretical solubility values for the four constituents of potential concern (benzene, arsenic, cadmium, and chromium) are available in the literature (e.g., ATSDR 1989; CRC 1968; Montgomery 1991; and Montgomery and Welkom 1991), but these values are based on the solubility of the contaminants in cool, fresh water using pure laboratory-grade chemicals and are not relevant for in-cavern conditions.

The conditions found in a closed cavern will have a significant effect on final solubility. Two factors that are especially important are the salt content and the pH of the water in the cavern. Fresh water will dissolve more organic materials (e.g., benzene) than brine. Consequently, the brine will reach an equilibrium benzene concentration with the waste that is lower than the theoretical fresh water solubility. In addition, the brine in the cavern will contain chloride, sulfate, sodium, calcium, and hydroxide. Many toxic metals form insoluble precipitates with one or more of these ions, which will limit the solubility of the metals. Also some ions of arsenic form insoluble calcium compounds.

One of the main types of waste disposed of in salt caverns is drilling waste, which tends to be alkaline. The presence of a high-pH waste will cause the cavern brine to have a pH higher than neutral. The solubility of metals is much higher at low pH values than at the higher pH values expected in the cavern brine. Therefore, the brine will reach equilibrium metals concentrations with the waste that are somewhat lower than the theoretical fresh-water solubilities.

One way of estimating the chemical characteristics of the cavern brine is to look at other brines that have been in contact with both crude oil and many of the solid materials that will be in the wastes for a long enough time to reach equilibrium values. Perhaps the best example of such brines is produced water. Produced water characteristics vary somewhat, but extensive data are available to estimate chemical concentrations. The following analyses contain data on concentrations of chemical constituents in produced water:

- As part of its proposed effluent limitations guidelines for the coastal oil and gas industry, EPA sampled ten coastal oil and gas facilities for produced water constituents (SAIC 1994).
- EPA summarized several produced water studies covering 55 facilities as part of its final effluent limitations guidelines for the offshore oil and gas industry (EPA 1993).
- EPA (1987) selected median and upper 90th percentile concentrations for arsenic and benzene in produced water as inputs to a risk assessment model.

Concentration ranges for the constituents of concern cited in these three studies are given in Table 6-1.

Another approach for estimating fully saturated brine concentrations is to look at the relative proportions and concentrations of the major waste types that are placed into the caverns and to estimate how much of those wastes will leach into the cavern brine. The operators of the four disposal caverns in Texas were asked to provide qualitative estimates of the proportions of different types of wastes entering the caverns. Depending on the operator, drilling wastes make up from 20-50% and tank bottoms make up about 50-60% of the total incoming waste stream[1]. Miscellaneous wastes make up the remainder. In many cases, the solids in the wastes contain chemical concentrations much higher than those reported for produced water. However, under conditions where wastes are in contact with water, concentrations of chemicals in the surrounding water are typically much lower than those in the waste. The amounts of chemicals likely to leach out of the waste when it is exposed to water have been estimated by EPA.

The EPA (1987) provides comparative data on both drilling waste solids and solids that have undergone the toxicity characteristic leaching procedure or TCLP (40 CFR 261, Appendix II). The TCLP test measures a waste's tendency to leach into water. The TCLP can serve as an analog of the extent to which wastes in a cavern will leach into the overlying brine. In the TCLP, solids samples are extracted by mixing them for 18 hours in a flask containing water adjusted to an acidic pH. Because metals are more likely to leach out of a solid under low pH conditions, the TCLP test is more conservative than leaching at a neutral pH. Under these conservative, low-pH conditions, the upper 90th percentile TCLP results are much lower than the results from analysis of drilling waste solids, which had been measured without being subjected to leaching (see Table 6-1). These data support the premise that only a small fraction of the total waste is likely to leach into water or the cavern brine.

The other major type of waste disposed of in caverns is tank bottoms. The EPA (1994b)

---

[1]Telephone conversations between John Veil, Argonne National Laboratory, Washington, DC, and Russ Hickerson, Permian Brine Sales, Odessa, TX; Grady Moore, Taylor Disposal Operating, Inc., Carthage, TX; and Tom Voskamp, Voskamp Exploration, Midland, TX, on March 12, 1997.

provides extensive characterization of tank bottoms. The range of TCLP values and analysis of samples as reported in EPA (1994b) for tank bottoms at production facilities (the predominant source of tank bottoms likely to go to the caverns) are shown in Table 6-1. Only a small fraction of the total tank bottom chemical concentration is likely to leach into water or the cavern brine.

For the initial concentrations of constituents to be used in the fate and transport modeling in this report, we have chosen the highest concentration for each constituent of concern from the (a) produced water data, (b) drilling waste TCLP data, and (c) tank bottoms TCLP data. In each of these data sets, we already are looking at the maximum concentrations, which typically are many times higher than average values. The concentrations of the contaminants of potential concern in brine when they leave the cavern under different release modes are as follows: benzene, 20.4 mg/L; arsenic, 1.7 mg/L; cadmium, 0.29 mg/L; and chromium, 0.85 mg/L.

6.2 Cavern Release Scenarios

Five release scenarios are discussed in this section: inadvertent intrusion, which could produce a release of cavern fluid to the ground surface; failure of the cavern seal, which could release contaminated fluid to the groundwater (the release could be either at the depth of the cavern or at more shallow depths); release of contaminated fluid through cavern cracks; release of contaminated fluid through leaky interbeds or non-homogeneous zones of higher permeability material; and a partial cavern roof fall, which could release contaminated fluid to deep or shallow groundwater depending on the condition of the cavern seal. Calculations for these release scenarios are discussed below.

6.2.1 Inadvertent Intrusion

In the inadvertent intrusion scenario, an exploratory well for oil or minerals penetrates a hypothetical waste disposal cavern that has an initial brine volume of one million ft^3 (about 7.5 million gallons). Assuming that the cavern contains 750,000 ft^3 of NOW when full, approximately 2 million gallons of brine lie above the NOW. Groundwater wells probably would not reach the cavern because drinking or irrigation water could be obtained at shallower depths, and groundwater at the depth of the cavern would probably not be potable because of brine (Section 5). Based on an average modulus of elasticity of 337,000 psi (Streeter 1961), a depth of 1,500 ft, and an initial pressure in the cavern equal to the lithostatic pressure (about 1,500 psi for a depth of 1,500 ft assuming a lithostatic pressure gradient of 1 psi per ft [SMRI 1997]), a maximum of about 2,000 gallons of contaminated fluid would flow from the cavern toward the surface. This value is about 0.1% of the fluid present in the cavern. In addition to brine and dissolved waste constituents, drilling muds and other associated fluids would also flow toward the surface.

If the blowout-protection system of the well failed, fluids from the cavern could spill onto the ground surface and form a pool in the vicinity of the well pad or be discharged into a lined pond. If the discharge occurs directly to the ground and the local topography is depressed, a small surface pond would form. If the pond has a radius of 25 ft, the depth of the spill would be about 1 inch without considering evaporative losses. For a spill this small, fluids from the cavern would not reach the underlying unconfined aquifer that occurs at a median depth of 20 ft (Section 5.1), but would form a contaminated zone in the unsaturated soil. If the porosity of the soil is 0.3 (Freeze and Cherry 1979), a mass-conservation calculation shows that the penetration depth of the fluids from the cavern would be less than 6 inches. Mobilization of contaminants out of the contaminated zone could then occur by leaching. However, remediation activities at the site (e.g., removal of contaminated soil) would occur before the contaminants could dissolve and be transported by advection and dispersion to the water table.

In addition to lasting for a short duration, the pond water would be very unappetizing for ingestion (i.e., the water would have a very high turbidity because of the drilling mud, it would be very salty [saturated brine], it would be oily because of the presence of organic materials, and it would probably have an unpleasant odor). Because the volume of released fluid for this scenario would be small, the effects would be of very short duration, the liquid would not be potable, and such a spill would be quickly remediated, the scenario was eliminated from further analyses.

6.2.2 Release through the Cavern Seal

For this scenario, the seal that keeps liquids within the cavern is assumed to fail and release brine and contaminants to the well bore. As discussed in Section 2.4, the well bore would have cement plugs installed during cavern closure and abandonment. With time, the well casing may deteriorate because of the presence of brine in the vicinity of the caprock or the top of the cavern if a caprock is not present. For anticipated conditions, the well casing will corrode and fail near the top of the cavern first. With additional time, the well casing will fail at shallower depths.

Once the cavern is full of waste, it would be sealed and abandoned. At the time of sealing, the cavern would be mostly filled with solids and semisolids that are not fully compacted. Brine would remain between the top of the cavern and the top of the waste mass.

As discussed in Section 2.4, the pressure in the cavern would increase because of the combined effects of the addition of sensible heat from the surrounding salt and salt creep. Although the pressurization of sealed caverns containing liquids or dry granular wastes is currently under investigation (e.g., Langer et al. 1984; Wallner 1986; Berest and Brouard 1995; Wallner and Paar 1997; and Berest et al. 1997a), little research has been directed at predicting pressure behavior in caverns containing NOW. Future work should be performed to reduce the uncertainty in this process.

For this scenario, the pressure in the cavern is assumed to reach a high enough value that the cavern seal fails because of a crack in the plug, dissolution of salt around the seal, or by some other means. Contaminated fluid then moves up the well bore toward the ground as the pressure in the cavern is reduced to the hydrostatic value.

Assuming that the cavern had an initial brine volume of 1,000,000 ft^3, and that it was filled to three-quarters of its capacity with NOW, about 250,000 ft^3 of free brine and 750,000 ft^3 of waste would be present. If the cavern failed at a pressure equal to the lithostatic value (approximately 1,500 psi for a cavern located at a depth of 1,500 ft), a maximum of only about 0.1% of the free liquid (about 2,000 gal) would exit the cavern because of the effects of compressibility (Streeter 1961), if the well bore was free of liquid and at atmospheric pressure. If the well bore contained water, or if the released volume was greater than the volume of the well bore up to the location of the deepest bridge plug, less than 0.1% of the fluid would escape from the cavern. For conservative results, this study assumes that the full 0.1% volume would be released.

Flow of the released fluid would be greatly restricted in the well bore at the locations of the cement bridge plugs. Flow through the bridge plugs would resemble flow through a porous medium having a low hydraulic conductivity (about 1×10^{-8} to 1×10^{-5} cm/s), similar to that of cemented sandstone (Maidment 1993). If the cavern fluid moves up the borehole at a rate equal to the saturated hydraulic conductivity of the cement (Freeze and Cherry 1979), it would have a velocity between 3×10^{-5} and 0.03 ft/d. For a cavern at a depth of 1,500 ft, fluid would not reach the surface for about 140 years if the well casing remained intact, and evapotranspiration did not deplete the volume of free liquid near the ground surface.

While moving up the borehole, fluid from the cavern could also move laterally into adjoining formations if the well casing had failed. Because the casing would probably be made of ordinary steel, there is a high probability that the casing would fail when exposed to groundwater containing brine over a time period ranging into the thousands of years. Two possible cases are considered under this scenario: (1) the casing fails at the depth of the cavern (at or near the cavern roof) and contaminated fluid is released to a deep aquifer, and (2) the casing fails at a shallow depth and releases fluid to a near-surface aquifer. Because of hydrogeological differences between the aquifers considered, these scenarios are discussed separately below.

For a deep casing failure, fluid moving up the well bore would move into the deep aquifer and be transported laterally. The presence of low-permeability beds at shallower depths would prevent vertical transport of the contaminated fluid to overlying aquifers and the ground surface. Assuming that the well bore has a diameter of 2 ft and that the ambient groundwater velocity is 10 ft/year, contaminated water would enter the surrounding porous medium for a period of about 0.2 years.

The extent and magnitude of contamination created by this type of release would depend on the hydrological properties of the material in the vicinity of the failed casing, the volume of fluid that is released, the duration of the discharge, and the transport properties of the contaminants. In the vicinity of the cavern, hydrological properties are unlikely to favor rapid transport of the contaminants. For example, the groundwater velocity at depth is estimated on the basis of engineering judgment to be less than 10 ft/yr. Because of adsorption and subsequent retardation (Section 4.1), contaminants (particularly metals) would be transported at even lower velocities. For example, cadmium, which has a distribution coefficient of 3 mL/g (Section 4.4), would have a retardation coefficient, R, of about 50 for an assumed bulk density of 1.7 g/cm^3 and a porosity of 0.10 (Equation 1). Therefore, the center of mass velocity of cadmium would be 50 times less than that of the groundwater (0.2 ft/yr). In 100 years, cadmium would travel about 20 ft.

Benzene would move much more quickly than the dissolved metals because of its greater mobility. As discussed in Section 4.1, benzene has a distribution coefficient of about 0.6 mL/g and a retardation coefficient of about 10. In 100 years benzene would, therefore, move about 100 ft. Unlike the metals, however, benzene would be likely to degrade biologically with time. For the calculations presented in this study, benzene was assumed to have an effective half-life of 2 years, the upper end of the values for anaerobic conditions presented in Section 4.1. In 100 years, its concentration would decrease by a factor of about 1.0×10^{15} (50 half-lives).

In addition to the extent of contamination created by the release, the contaminant's concentration is also needed for risk assessment. In general, the downstream concentrations of contaminants depend on the length of time that the cavern acts as source of contaminated fluid. For either a release at the depth of the cavern or to a shallow aquifer, the cavern is assumed to depressurize to conditions in the well bore within one day. Fluid released during the depressurization would then be swept into adjacent aquifers by moving groundwater (10 ft/yr at the depth of the cavern and 100 ft/yr for a shallow release). Under these conditions, a two-foot well bore would act as a source of contamination for 0.2 and 0.02 years at the depth of the cavern and in a shallow aquifer, respectively. After the system depressurizes, salt creep would once again occur and the pressure in the cavern would increase, particularly if the point of failure self-heals. Because of this repressurization, the seal may again fail, and the process can then repeat itself as a series of short, pulsed releases. Because the time between releases would be long (repressurization is a slow process), the pulses would not interact with each other along the flow path.

Contaminant concentrations in the exiting fluid are discussed in Section 6.1 and are listed in Table 6-1. Because of the short duration time of a pulse release scenario, little dilution would occur because of mixing with uncontaminated groundwater. The contaminant concentrations in the water adjacent to the failure point would, therefore, be the same as in the cavern.

After release, the aqueous phase contaminants would be transported in the direction of lower hydraulic head (pressure) and would undergo sorption (loss of material to particle surfaces), dispersion (reduction in concentration produced by non-uniform fluid velocities), and degradation (decrease in concentration produced by chemical or biological interactions). Transport calculations were performed with a one-dimensional analytical solution to the governing partial differential equation incorporating advection, dispersion, and biodegradation (Tomasko 1991; 1994) to estimate the concentrations of benzene, cadmium, arsenic, and chromium at a lateral distance of 1,000 ft from the location of the casing failure, the assumed location of the nearest human receptor.

For transport calculations, the groundwater velocity was assumed to be 10 ft/yr and dispersion was assumed to be scale dependent, with dispersivity set equal to one-tenth of the travel distance (Lallemand-Barres and Peaudecerf 1978). Contaminant concentrations in the groundwater were evaluated at the location of a potential receptor at a time of 1,000 years in the future, a typical value for risk analyses. In the case of cadmium released to shallow aquifers, the maximum estimated concentration would reach the receptor after 334 years. This value is noted, where applicable, in the tables associated with Section 8 and is used in the risk calculations. A compilation of contaminant concentrations for these conditions is given in Table 6.2. As shown in Table 6.2, the concentration of benzene would be 0.0 mg/L at 1,000 years because of degradation along the flow path (approximately 500 half-lives). Values for arsenic and chromium would both be very small because of retardation along the flow path and the short duration of the release (0.2 yr).

For the second alternative considered for this release scenario, the cavern seal is again assumed to fail; however, the well bore casing at depth is assumed to be intact. Contaminated fluid then flows up the well bore and exits the casing at a failure point adjacent to a shallow groundwater aquifer such as the Dockum or the Ogallala. The initial concentration of the contaminants entering the system would be the same as for the scenarios discussed above (Table 6-1), and there would be no substantial dilution. The duration of the source term would be ten times less than that used at depth because of the higher groundwater velocity in the shallow groundwater system (100 ft/yr). For a release to shallow groundwater, the concentrations (Table 6.2) would be larger than those discussed above because of shorter travel time. The concentration of benzene, however, is still at 0.0 mg/L because of its biological degradation. In spite of the higher velocity and shorter travel time for a shallow groundwater release, the contaminant concentrations at the receptor 1,000 years after the release would all be much less than their MCLs discussed in Section 4 (Table 6.2).

6.2.3 Release of Contaminated Fluid through Cracks

During pressurization of the cavern because of the combined effects of thermal heating and salt creep, cracks might develop that would release fluid into the surrounding material, thereby reducing the pressure in the cavern. The volume of fluid released would be a function of the pressure in the cavern, the volume of the cracks, and the crack pressure. If the pressure in the cracks is atmospheric, the volume of fluid released would be the same as that discussed under the inadvertent intrusion scenario (2,000 gallons). However, the actual volume released could be much less than this value if the cracks are at the local hydrostatic or lithostatic pressure. For conservative results, the volume of released fluid is assumed to be 2,000 gallons.

Depending on the pressure in the cracks, they could self-heal after the release because of additional salt creep. With repressurization of the cavern, the cracks could once again open, producing a series of short contaminant pulses (probably on the order of hours to days in duration) that would not interact with one another because of the time needed to repressurize the cavern to a value that approaches or exceeds the local lithostatic value. Because of gradients in the lithostatic pressure, cracks would open in a vertically upward direction (SMRI 1997). With time, the contaminated fluid in the cracks could reach a deep underground aquifer and be transported laterally to the location of a potential receptor (1,000 ft away from the point of release).

The contaminant concentrations at the location of the receptor 1,000 years after the release into the underground aquifer would be the same as those presented above for failure of the cavern seal with a subsequent pulsed release at the depth of the cavern (Table 6.2). The resulting contaminant concentrations would all be much less than their associated MCLs (Section 4).

6.2.4 Release of Contaminated Fluid through Leaky Interbeds or Nonhomogeneous Zones

In this scenario, the cavern is assumed to have a leaky interbed or heterogeneity that allows communication with the outside environment. As the cavern pressure rises because of thermal effects and salt creep, fluid would be discharged into the interbed where it would be laterally transported under existing gradients. Fluid velocity in the interbed is assumed to be 10 ft/yr. In this way, the entire fluid volume of the cavern would eventually be discharged into the surrounding material.

Van Sambeek (1993) gives the following formula for the steady-state volumetric creep rate for a cylindrical cavern:

$$\frac{\frac{dV}{dt}}{V} = -\sqrt{3}\left(\frac{\sqrt{3}}{n}\left(P_\infty - P_i\right)\right)^n A\, e^{-\frac{Q}{RT}} \qquad (2)$$

where

n, A, and Q/R = Model calibration parameters,
P = Lithostatic pressure,
P_i = Internal pressure of the cavern,
t = Time, and
T = Temperature in degrees Kelvin.

Parameters for the above equation are compiled in Berest et al. (1997b). For this analysis, the following values were selected as typical: n = 5, T=304K, Q/R=7,500, and A=100,000. For a brine-filled cavern,

$$P_\infty - P_i = 0.01\ H \qquad (3)$$

where H is the depth of the cavern (Berest et al. 1997b).

Using a value of 533 m for H (top of cavern at a depth of 1,500 ft plus 250 ft of free brine), and the above parameters, the steady-state volumetric creep rate from Equation 2 expressed as a percent would be about -0.007% per year. At this rate, it would take about

14,000 yr to discharge the cavern fluid to the interbed. For 2 million gallons of free brine in the cavern, the steady-state leak rate would, therefore, be about 150 gal/yr.

The leaking brine would mix with in-situ water and be transported down-gradient. Because of this mixing, the contaminant concentrations would be reduced by dilution. Dilution, D_f, can be expressed by the following expression (Tomasko 1991):

$$D_f = \frac{Q_{gw}}{Q_{cav}} + 1 \tag{4}$$

where Q_{cav} is the volumetric leak rate of the cavern and Q_{gw} is the volumetric flow in the interbed. For a cavern that has a diameter of 100 ft, an interbed thickness of 20 ft, and a groundwater velocity of 10 ft/yr, the dilution factor would be 1,000.

Table 6-2 lists the contaminant concentrations at the receptor for this scenario at a time of 1,000 years after the cavern has begun to leak. All of the concentrations are small compared to their MCLs.

6.2.5 Partial Cavern Roof Fall

Loss of cavern integrity through a partial roof fall coupled with failure of the cavern seal could produce impacts similar to those described in Section 6.2.2. Under these scenarios, the cavern would discharge fluid in a series of short pulses separated by periods of low to no discharge when the pressure in the cavern is increasing because of salt creep. If a partial roof fall occurs without failure of the cavern seal, the release of contaminated fluid would occur as a series of short pulses. A partial roof fall coupled with a release through leaky interbeds or non-homogeneous zones of higher permeability material would be manifested as a long slow release. Contaminant concentrations for these various scenarios are given in Table 6-2.

6.2.6 Probabilities of Occurrence

In performing a risk assessment, besides the concentrations of the contaminants of concern being required, the probability that a given scenario would occur also needs to be known. Because there is no operational history for disposing of NOW in salt caverns, the probabilities of occurrence for the release scenarios described above are uncertain. Under the most optimistic conditions, no releases would ever occur, and the associated probabilities of occurrence would be 0.0. For the most pessimistic conditions, releases would always occur and the probabilities of occurrence would be 1.0.

In order to reduce the uncertainty in the range of the probabilities of occurrence, a questionnaire was distributed to experts in the field of salt disposal. The panel of experts was asked to provide both a “best-estimate” and a “worst-case” estimate of the probability of occurrence for each of the release scenarios. In the context of this questionnaire and study, best estimate did not refer to the "best-case" or the best or least risky case, but rather it referred to the probability of occurrence that was most likely in the best judgment of the expert. Similarly, "worst-case" referred to the least likely probability of occurrence in the best judgment of the expert rather than to the most risky case.

Following the receipt of responses from the expert panel, the estimates were aggregated to form consensus values for each of the probabilities of occurrence. A number of procedures can be used to form the consensus values from the individual estimates. These include behavioral and mechanical approaches (Winkler and Sarin 1981). In behavioral aggregation, some contact is required between the experts. The range in estimates provided is then reduced through intensive group interaction. This methodology is typically followed in the Delphi approach of Brown and Helmer (Brown and Helmer 1964). With mechanical aggregation, a mechanical rule is used to combine the estimates of the probabilities. For example, the aggregate value can be the arithmetic mean, median, weighted average, or some other weighting that uses Bayesian estimation by incorporating *a priori* information (Winkler 1968; Winkler 1977; Makridakis and Winkler 1983). For the present study, an arithmetic average was used to represent the aggregate value for the probabilities of occurrence. This method was selected because of the difficulties and time constraints of using a Delphi approach, the lack of appropriate weighting functions for the experts (there is no cavern release data available that could be used to rank the ability of the experts according to past predictions [Winkler and Clemen 1992]), and the average value of the data performs as well as any of the other mechanical rules (Winkler 1968).

Table 6-3 lists the best-estimate and worst-case aggregated probabilities of occurrence for the release scenarios previously discussed and their ranges. For all cases, the highest probabilities of occurrence were for a partial fall of the roof (0.10 and 0.29, respectively). The smallest probabilities of occurrence were for a partial roof fall with a cavern seal failure and release to a shallow aquifer (0.006 and 0.051, respectively), and a cavern seal failure with subsequent release to a shallow aquifer (0.012 and 0.040, respectively).

7. Toxicity of Contaminants of Potential Concern

Toxicity assessment is a key component in risk assessment. It weighs available evidence regarding the potential for the contaminants of concern to cause adverse effects in exposed individuals. It consists of two parts: hazard identification and dose-response evaluation. The hazard identification process determines whether exposure to a contaminant can cause an increase in the incidence of a particular adverse health effect (e.g., cancer, birth defect) and whether that effect is likely to occur in humans. Section 7.1 describes the potential health hazards associated with the contaminants discussed in Section 4, that is, those contaminants to which humans could be exposed under various salt cavern release scenarios and exposure pathways.

Toxicity assessment also provides an estimate of the relationship between the extent of exposure to a contaminant and the increased likelihood or severity of adverse effects. Dose-response evaluation is the process of evaluating, in a quantitative manner, the toxicity information and characterizing the relationship between the dose of the contaminant received and the incidence of adverse health effects in an exposed individual. Dose-response relationships provide toxicity values that are used to estimate the incidence or potential for adverse effects as a function of human exposure to the contaminant. Section 7.2 describes dose-response relationships for the contaminants of concern and provides toxicity values, where available, for each of those contaminants. These toxicity values are used in combination with contaminant intake information to estimate the potential for human health risks associated with salt cavern disposal of NOW.

7.1 Hazard Identification

Typically, two categories of toxicity are addressed in human health risk assessments: carcinogenic and noncarcinogenic. Carcinogens are believed to act via a "nonthreshold" mechanism of action; that is, a risk would be associated with any exposure level, no matter how small. Noncarcinogens are believed to act via a "threshold" mechanism of action; that is, there is some level of exposure (the threshold) below which the contaminant is unlikely to have an effect.

The following paragraphs describe the hazards associated with the contaminants of concern identified in the previous sections (i.e., arsenic, benzene, cadmium, and chromium). As noted in Section 4, contaminants such as boron and lead would form insoluble precipitates and would not migrate to areas where they could come in contact with humans. The information presented comes from the Agency for Toxic Substances and Disease Registry (ATSDR) Fact Sheets. These fact sheets are available on the Internet and summarize information about various hazardous substances, including their health effects (ATSDR 1993).

Arsenic. Arsenic is a metal usually found in compounds with oxygen, chlorine, sulfur, carbon, or hydrogen. Some arsenic compounds can dissolve in water. Arsenic can change from one form to another, but it does not break down. Exposure comes from ingesting contaminated water, soil, or air. Other exposure routes include breathing workplace air or burning smoke from wood containing arsenic. High levels (60 ppm [mg/L]) in food or water can be fatal; lower levels can cause nausea, decreased production of blood cells, and abnormal heart rhythms. Arsenic is a known carcinogen; ingesting inorganic arsenic increases the risk of skin cancer and tumors of the bladder, kidney, liver, and lung. The EPA has set a limit of 0.05 ppm for arsenic in drinking water (EPA 1994a).

Benzene. Benzene is a colorless liquid with a sweet odor that is found in crude oil and gasoline. In liquid form, benzene mixes easily in water. In water, benzene can change quickly into a vapor and mix readily with the air. In air, it reacts with other chemicals and breaks down within a few days. It can move from soil to groundwater. Plants and animals do not store high levels of benzene. The most common exposure route is inhalation, but benzene can also be ingested. Most exposure comes from tobacco smoke, auto exhaust, and industrial emissions. Benzene is a known human carcinogen and is associated with leukemia. EPA has set a maximum permissible level of benzene in drinking water of five parts per billion (ppb) (5×10^{-9}) per day for a lifetime of exposure. The EPA has set a goal of 0 ppb for drinking water and rivers and lakes. The maximum permissible level of benzene in water for children for short-term exposures (10 days) is 235 ppb.

Cadmium. Cadmium is found naturally in the earth's crust. It is usually combined with other elements (e.g., oxygen, chlorine, sulfur), and it has no definite taste or odor. Cadmium binds strongly to soil particles, and some cadmium dissolves in water. It can change form in the environment but does not break down. Cadmium can accumulate in the human body from many years of low-level exposure. Exposure comes from eating foods that contain cadmium and drinking contaminated water. Other sources include breathing contaminated workplace air, cigarette smoke, or air near the burning of fossil fuels or municipal waste. On the basis of weak evidence of lung cancer in humans from breathing cadmium and strong evidence from animal studies, cadmium and cadmium compounds may be reasonably anticipated to cause cancer in humans. It is not known whether cadmium causes cancer from eating or drinking contaminated food or water. The EPA has set a limit of 5 ppb for cadmium in drinking water.

Chromium. Chromium occurs naturally in rocks, soils, plants, and animals. It has three main forms. These are chromium 0, which does not occur naturally; chromium III, the compounds of which are stable and occur naturally; and chromium VI, which rarely occurs. Chromium III is an essential nutrient in the human diet, but only small amounts are needed. Chromium adheres strongly to soil particles, but small amounts of chromium move from soil to groundwater. In surface water, most chromium sticks to dirt particles that settle to the bottom; only a small amount dissolves. Human exposure comes from ingestion or inhalation, especially breathing contaminated workplace air or sawdust from chromium-treated wood. At high levels, all forms of chromium can be toxic, but chromium VI is more toxic than chromium III. Long-term exposure to high or moderate levels of chromium VI can damage the nose and lungs. Ingesting large amounts of chromium can cause stomach upsets and ulcers, convulsions, kidney and liver damage, and death. Certain chromium VI compounds are known carcinogens. ATSDR has insufficient data to determine if chromium 0 or chromium III are carcinogens. The EPA has set an MCL for total chromium of 0.1 mg/L.

7.2 Dose-Response Relationships for Contaminants of Concern

Toxicity values are used to translate a dose of a contaminant (the intake) into a risk for cancer or a hazard index for noncancer effects. There are of two types of toxicity values: slope factors and reference doses. Section 7.2.1 describes slope factors for the contaminants of concern; Section 7.2.2 describes reference doses for the contaminants of concern.

7.2.1 Slope Factors

Slope factors are used to estimate the toxicities of carcinogens. A slope factor is defined as a plausible upper-bound estimate of the probability of a response per unit intake of a chemical over a lifetime. It is used to estimate an upper-bound probability of an individual developing cancer as a result of a lifetime of exposure to a particular level of a potential carcinogen. A curve representing the response per unit intake for a given chemical is known as a dose-response curve. This curve is developed by evaluating toxicity information and characterizing the relationship between the dose of a contaminant received and the incidence of adverse health effects.

Dose-response curves and slope factors are developed for various exposure routes (e.g., oral, inhalation). Because the potential exposure pathways identified for salt cavern release modes is always ingestion of groundwater, the oral slope factor is used. The slope factor is the upper 95% confidence limit of the slope of the dose-response curve. Because it represents the upper 95% confidence limit of the slope of the curve and because the slope is determined using very conservative models, the slope factor itself is conservative. As a result, the risks calculated using slope factors tend to be upper-bound estimates of the "true" risks. The oral slope factors for the contaminants of concern come from EPA's Integrated Risk Information System (IRIS) and are shown in Table 7-1.

7.2.2 Reference Doses

Reference doses (RfD) are used to estimate the toxicities of noncarcinogens. An RfD is an estimate of the "safe dose" of a contaminant for humans. A variety of RfDs are available, depending on the exposure route (e.g., oral, inhalation), the critical effect (e.g., developmental) and the length of exposure being evaluated (e.g., chronic [long time] event, or acute [a single, short-time event]). Because the only potential exposure pathway to humans for salt caverns is ingestion of groundwater, only the oral RfDs are used in calculating noncarcinogenic hazards. RfDs are conservative because EPA applies order-of-magnitude safety factors to allow for uncertainty. As a result, the hazards estimated using RfDs tend to be upper-bound estimates of the "true" hazards. RfDs for the contaminants of concern come from IRIS and are listed in Table 7-2.

Often the data needed to develop toxicity values are weak or unavailable; typically, data from animal studies are extrapolated to human studies. Also, a number of uncertainties are associated with the models used to derive toxicity values, and safety factors are incorporated into the derivation of toxicity factors. Because EPA continually reviews and revises its toxicity values, they may change over time. Toxicity values provide the major source of uncertainty in risk assessments.

8. Risk Characterization

Human health risks from contaminants at waste disposal caverns may be carcinogenic or noncarcinogenic. This section describes these two types of risks and uses the information derived from Section 6 on exposure pathways and exposure-point concentrations and the toxicity values described in Section 7 to develop risk estimates for the contaminants of concern. Section 8.1 reviews the information developed in Section 6 to produce exposure-point concentrations for the release scenarios. Section 8.2 describes potential cancer risks from those scenarios, and Section 8.3 describes their potential noncancer risks.

8.1 Exposure Scenarios

Section 6 described the potential release modes. These were (1) failure of the cavern seal, resulting in contaminated fluid entering the groundwater at the depth of the cavern or at more shallow depths; (2) release of contaminated fluid through a crack in the salt; (3) release of contaminated fluid through a leaky interbed or higher permeability nonhomogeneous zone; and (4) a partial cavern roof fall, resulting in the release of contaminated fluids to deep or shallow groundwater. For all of the release modes, the exposure pathway would be ingestion of contaminated groundwater by residents living near the salt caverns. Table 8.1 summarizes the potential release modes.

The concentrations of the contaminants reaching the water that humans may drink depend on the location of the release, i.e., release to a shallow aquifer or release to a deep aquifer (see Table 6-2). Exposure-point concentrations are the concentrations of the contaminants in groundwater (shallow or deep) at the point of contact with a human receptor. Estimated exposure-point concentrations derived in Section 6 for the contaminants of concern are summarized in Tables 8-2 through 8-7. Note that in estimating the exposure-point concentrations, assumptions were made about the probability that the release event would actually occur. Thus, the concentrations in Section 6 were calculated assuming that the release would occur. These concentrations need to be adjusted for the likelihood of actual occurrence. Tables 8-2 through 8-7 show the exposure-point concentrations assuming release occurs, the probability that the release would occur based on the discussion in Section 6.2.6, and the resulting exposure-point concentrations used for estimating risk. Note that the exposure-point concentrations for benzene would be zero for all scenarios because of biodegradation along the flow path.

To estimate the amount of contaminant actually received from drinking contaminated water, assumptions must be made regarding time, frequency, and duration of exposure to that water. These assumptions are presented in Table 8-7. Unless otherwise indicated, standard EPA default exposure factors are used in the assumptions (EPA 1991).

Using these assumptions and the exposure-point concentrations, an intake rate for each contaminant of concern can be calculated with the following equation:

$$I_i = \frac{C_i \times IR \times ET \times EF \times ED \times CF}{BW \times AT} \qquad (5)$$

where

I_i = Intake of contaminant *I*
C_i = Exposure point concentration of contaminant *I*, in g/L
IR = Intake rate in L/day
ET = Exposure time, in h/d
EF = Exposure frequency in d/yr
ED = Exposure duration, in yr
CF = Conversion factor of 1 d/24 h
BW = Body weight of the receptor, in kg, and
AT = Averaging time, in d (for carcinogens, AT = 25,550 d (70 years); for noncarcinogens, AT = 365 d/y x ED)

Tables 8-9 through 8-14 show the intake rates in milligrams per kilogram-day for each contaminant of concern for the release scenarios for best-estimate and worst-case conditions.

8.2 Cancer Risks

Cancer risk is the likelihood of getting cancer. It is expressed as a probability (e.g., 1 in 100,000, which equals 10^{-5}). A 10^{-5} risk is a one-in-one hundred thousand excess risk of cancer from a given level of exposure to a particular contaminant. In other words, each individual exposed to that contaminant at that level over his/her lifetime has a one-in-one-hundred-thousand chance of getting cancer from that particular exposure. Cancer risk is described as excess because it is above the existing background risk of cancer. (In a population of one million people, the number of background cancer cases is roughly between 250,000 and 333,000.) An alternative interpretation is that one additional case of cancer would be expected to occur in a population of one million people who are all exposed under the same circumstances to a particular contaminant.

Cancer risks were calculated for each contaminant and for each exposure route for that contaminant and were then summed over all contaminants and exposure routes. Because the only exposure pathway for potential contaminant releases from a disposal cavern would be groundwater, the only exposure route is ingestion.

Human cancer risks associated with disposal of nonhazardous oil-field wastes in salt caverns are estimated for the release scenarios using the following equation:

$$R_i = I_i \times SF_i \qquad (6)$$

where

R_i = Risk from contaminant I,
I_i = Intake of contaminant I, and
Sf_i = Slope factor for contaminant I.

Using Equation 6 and the data in Tables 8-9 through 8-14 (intake estimates) and Table 7-1 (oral slope factors), cancer risks were estimated for each of the individual contaminants for the release scenarios for best-estimate and worst-case conditions. The results are presented in Tables 8-15 and 8-16. The total cancer risk for the release scenarios is the sum of the individual cancer risks for all contaminants of concern. Because there are no slope factors available for cadmium and chromium, and the exposure-point concentration of benzene would be 0.0 for all of the release scenarios, the total cancer risk is thus equal to the risk estimate for arsenic.

For worst-case conditions, the total cancer risks range from 2.0×10^{-17} for failure of the cavern seal with a fluid release at the depth of the cavern and for cracks releasing fluid at the depth of the cavern to 1.1×10^{-8} for a release scenario in which there is a partial roof fall and cavern seal failure with a failed casing at a shallow depth that releases contaminated fluid to the shallow aquifer (Table 8-16). Even under worst-case conditions, the excess cancer risks would lie well below the acceptable target risk range (1×10^{-4} to 1×10^{-6}) of the EPA that was established for remedial action goals for National Priority List (NPL) sites (40 CFR300.430(e)(2)(I)(A)(2)). For best-estimate conditions, the estimated cancer risks would be less (Table 8-15). For best-estimate conditions, the estimated cancer risks would be less.

8.3 Noncancer Risks

Risks associated with noncarcinogens are expressed as hazard quotients, which is the intake of a particular contaminant divided by its RfD. Because the RfD is the estimated "safe" dose for humans, when a hazard quotient exceeds 1, there is a potential for adverse noncarcinogenic effects. Hazard quotients are not probabilities. A hazard quotient that is less than one indicates a very low potential for noncarcinogenic effects. A hazard quotient that is greater than one indicates that the information on the exposure should be reviewed to determine the significance of the finding. Like carcinogenic risks, hazard quotients are summed over contaminants and exposure routes. However, for salt caverns, the only exposure route would be the oral pathway (ingestion of groundwater). Also, hazard quotients for multiple contaminants may not be strictly additive because different chemicals may affect different organs.

For a single contaminant, *I*, the hazard quotient is calculated according to the equation,

$$HQ_i = \frac{I_i}{RfD_i} \qquad (7)$$

where

Hq_i = Hazard quotient from contaminant I,
I_i = Intake of contaminant I, and
RfD_i = Reference dose for contaminant I.

Using Equation 7 and the data in Tables 8-9 through 8-14 (intake estimates) and Table 7-2 (oral RfDs), noncancer risks are estimated for each of the individual contaminants for the release scenarios for both best-estimate and worst-case conditions. The results are shown in Tables 8-17 and 8-18. All of the contaminants of concern would have hazard quotients that are much less than one. Even when the hazard quotients are summed for all contaminants in a given release scenario, the greatest hazard index (sum of the individual hazard quotients) under worst-case conditions would be 6×10^{-5}, which is much less than one (Table 8-18). For best-estimate conditions, the largest total hazard index would be less (1.4×10^{-5}) (Table 8-17).

9. Sensitivity of Risks to Operating Procedures and Regulatory Structures

The risk estimates calculated in Section 8 indicate that the potential for human health risks associated with disposal of nonhazardous oil field wastes in salt caverns is very low. These risks were estimated assuming normal operating conditions and standard operating procedures for cavern closure. Any relaxation in design, monitoring, or operating practices could increase these risks.

At the same time, because the projected risks from failure of the cavern seal or cavern walls are low, the results of this preliminary assessment would not appear to support the imposition of additional safety regulations (i.e., regulations beyond those assumed to be used under normal operational and post-operational conditions). For example, the health risks estimated for release of contaminants into a deep or shallow aquifer assume that the residents who drink the water would be at a lateral distance of 1,000 ft from the edge of the disposal cavern. Risks would be lower if the population drinking the water were further away. Therefore, based on the estimates of cancer and noncancer risks presented in Section 8, it would not be necessary to implement any new requirements for residents living in the vicinity of waste caverns.

Although the risks associated with spills, accidents, and equipment leaks during normal operations were not evaluated in this study, it is likely that contaminants released from such occurrences would present greater risks than those derived from the cavern itself. Consequently, care should be taken to ensure that operating practices continue to be monitored in a way that minimizes the occurrence of surface accidents.

10. Summary

This report investigated the potential for human health risks associated with the use of salt caverns for nonhazardous oil-field waste disposal. Based on assumptions that were developed for a generic cavern and generic oil-field wastes, the estimated human health risks for worst-case conditions are very low (excess cancer risks of between 1.1×10^{-8} and 2.0×10^{-17}) and hazard indices (referring to noncancer health effects) of between 6×10^{-5} and 1.0×10^{-7}. Normally, risk managers consider risks of 1×10^{-6} and less and hazard indices of less than 1 to be acceptable. For best-estimate conditions, the excess cancer risks and hazard indices would be less.

Because these risks were developed for a hypothetical cavern, and site-specific conditions related to cavern type, location, and characteristics of the waste being disposed will vary, it would be prudent to conduct a site-specific risk assessment for an actual cavern, perhaps for an existing cavern currently in use for waste disposal. Such an assessment would provide a more realistic and useful assessment than the generic one described in this report.

A few comments on the use of the results of this report are in order. First, the assessment does not address risks to workers at the cavern disposal site. Such risks would be comparable to or less than worker risks associated with hydrocarbon cavern storage operations. (Because of the potential for explosions at hydrocarbon storage operations, worker risks for nonhazardous oil-field waste disposal may be less than for hydrocarbon storage.) Second, the assessment does not determine whether any health effects will occur in the future; it only estimates cancer risk and potential for noncarcinogenic effects. Third, risks have only been estimated for contaminants for which toxicity values were available; just because there is no toxicity value does not mean there is no risk. Finally, the assessment is limited to human health effects produced by nonradioactive contamination; it does not address the possible ecological risks associated with salt cavern disposal, nor does it estimate risks associated with NORM that may be included in oil field wastes.

11. References

Adriano, D.C., 1986, *Trace Elements in the Terrestrial Environment*, Springer-Verlag, New York.

Agency for Toxic Substances and Disease Registry, 1989, "Toxicological Profile for Chromium," ATSDR/TP-88/10, prepared by Syracuse Research Corporation for Toxic Substances and Disease Registry, U.S. Public Health Service, July.

Agency for Toxic Substances and Disease Registry, 1990, "Draft Toxicological Profile for Boron," prepared by Life Systems, Inc., for Toxic Substances and Disease Registry, U.S. Public Health Service, October.

Agency for Toxic Substances and Disease Registry, 1993, ToxFAQs fact sheets, available from the Internet at http://atsdr1.atsdr.cdc.gov:8080/tfacts2.html.

API, 1994, "Design of Solution-Mined Underground Storage Practices," API Recommended Practice 1114, American Petroleum Institute, Washington, D.C., June.

ATSDR = see Agency for Toxic Substances and Disease Registry.

Back, W., J.S. Rosenshein, and P.R. Seaber, 1988, *The Geology of North America*, Volume O-2, The Geological Society of America, Inc., Boulder, Colorado, 524p.

Baes, C.F., and R.D. Sharp, 1983, "A Proposal for Estimation of Soil Leaching and Leaching Constants for Use in Assessment Models," *Journal of Environmental Quality*, 12(1):17-28.

Baes, C.F., et al., 1984, "A Review and Analysis of Parameters for Assessing Transport of Environmentally Released Radionuclides through Agriculture," ORNL-5786, prepared by Oak Ridge National Laboratory, Oak Ridge, Tennessee, for the U.S. Department of Energy, Oak Ridge Operations, Oak Ridge, Tennessee.

Bair, E.S., 1987, "Analysis of Hydraulic Gradients Across the Host Rock at the Proposed Texas Panhandle Nuclear-Waste Repository Site," *Ground Water*, 25(4):440-447.

Bair, E.S., T.P.O. O'Donnell, and L.W. Picking, 1985, Potentiometric Mapping from Incomplete Drill-Stem Test Data: Palo Duro Basin Area, Texas and New Mexico.

Baker, D.E., and M.C. Amacher, 1982, Nickel, Copper, Zinc, and Cadmium, in Methods of Soil Analysis, Part 2: Chemical and Microbiological Properties, Second Edition, A.L. Page et al. (editors), American Society of Agronomy, Inc., Madison, Wisconsin.

Bassett, R.L., and M.E. Bentley, 1982, "Geochemistry and Hydrodynamics of Deep Formation Brines in the Palo Duro and Dalhart Basins, Texas, U.S.A.," *Journal of Hydrology*, 59:331-372.

Berest, P., and B. Brouard, 1995, "Behavior of Sealed Solution-Mined Caverns," presented at the Spring Meeting of the Solution Mining Research Institute, New Orleans, Louisiana, April.

Berest, P., B. Brouard, J. Bergues, J. Frelat, and G. Durup, 1997a, "Salt Caverns and the Compressibility Factor," presented at the Fall Meeting of the Solution Mining Research Institute, El Paso, Texas, October.

Berest, P., B. Brouard, F. Beugin, and J. Goldberg, 1997b, "Storage of Tritiated Water in Salt Caverns," presented at the Fall Meeting of the Solution Mining Research Institute, El Paso, Texas, October.

Biringer, K.L., 1984, "Strategic Petroleum Reserve Cavern, Geotechnical Data Base," SAND84-1500, Sandia National Laboratories, Albuquerque, New Mexico.

Bishop, W.M., 1986, "Long-Term Disposition of SPR Caverns Not Used for Petroleum Storage, A Draft Plan," unpublished report, employed by PB-KBB, Houston, TX, October.

Bradley, H.B., 1992, *Petroleum Engineering Handbook*, Society of Petroleum Engineers, Richardson, Texas.

Brown, B., and O. Helmer, 1964, "Improving the Reliability of Estimates Obtained from a Consensus of Experts," P-2986, The RAND Corporation.

Callahan, M.A., et al., 1979, "Water-Related Environmental Fate of 129 Priority Pollutants," EPA 440/4-79-029A, Office of Water Planning and Standards, Washington, D.C.

Capuano, R.M., and R.Z. Jan, 1996, "In-Situ Hydraulic Conductivity of Clay and Silt-Clay Fluvial-Deltaic Sediments, Texas Gulf Coast," *Ground Water*, 34(3):545-551.

CRC, 1968, *Handbook of Chemistry and Physics*, The Chemical Rubber Company, Cleveland, Ohio.

Chilingarian, G.V., J.O. Robertson, Jr., and S. Kumar, 1989, *Surface Operations in Petroleum Production, II*, Elsevier, New York, 562p.

EPA: see U.S. Environmental Protection Agency.

Freeze, R.A., and J.A Cherry, 1979, *Groundwater*, Prentice-Hall, Inc., Englewood Cliffs, New Jersey, 604p.

Freeze, G.A., K.W. Larson, P.B. Davies, and S.W. Webb, 1995, "Using a Multiphase Flow Code to Model the Coupled Effects of Repository Consolidation and Multiphase Brine and Gas Flow at the Waste Isolation Pilot Plant," AIChE Heat Transfer Symposium, Portland, Oregon, E.L. Gaden, Jr., Series Editor, Volume 91, Number 306, American Institute of Chemical Engineers, New York.

Hanor, J.S., 1993, "Effective Hydraulic Conductivity of Fractured Clay Beds at a Hazardous Waste Landfill, Louisiana Gulf Coast," *Water Resources Research*, 29 (11): 3691-3698.

Hern, S.C., and S.M. Melancon, 1987, *Vadose Zone Modeling of Organic Pollutants*, Lewis Publishers, Chelsea, Michigan, 295p.

Hickerson, R., 1995, "Oilfield Waste Disposal in a Salt Cavern," in Proceedings of the Annual Underground Injection Control and Ground Water Protection Forum, Kansas City, Missouri, October.

Howard, P.H., R.S. Boethling, W.F. Jarvis, W.M. Meylan, and E.M. Michalenko, 1991, *Handbook of Environmental Degradation Rates*, Lewis Publishers, Inc., Chelsea, Michigan, 225p.

Lallemand-Barres, A., and P. Peaudecerf, 1978, "Recherche des Relations Entre la Valeur de la Dispersivite Macroscopique d'un Milieu Aquifere, Ses Autres Caracteristiques et les Conditions de Mesure," *Bulletin Bureau Geologique Minieres*, Sect. 3, Vol. 4, p277-284.

Langer, M., M. Wallner, and H. Wassman, 1984, "Gebirgsmechanische Bearbeitung von Stabilatsfragen bei Deponiekaverenen im Salzgebirge" (Geoengineering with Respect to Stability of Cavities Used for Disposal Purposes, in German), *Kali und Steinsalz*, 2, p66-76.

Linn, J., 1997, personal communication, February.

Lu, P.Y., et al., 1975, "Model Ecosystem Studies of Lead and Cadmium and of Urban Sewage Sludge Containing These Elements," *Journal of Environmental Quality*, 4:505-509.

Lyman, W.J., P.J. Reidy, and B. Levy, 1992, *Mobility and Degradation of Organic Contaminants in Subsurface Environments*, C.K. Smoley, Inc., Chelsea, Michigan, 395p.

Mackay, D., W.Y. Shiu, and K.C. Ma, 1992, *Illustrated Handbook of Physical-Chemical Properties and Environmental Fate for Organic Chemicals, Volume 1, Monoaromatic Hydrocarbons, Chlorobenzenes, and PCBs*, Lewis Publishers, Chelsea, Michigan, 697p.

Maidment, D.R., 1993, *Handbook of Hydrology*, McGraw-Hill, Inc., New York.

Makridakis, S., and R.L. Winkler, 1983, "Averages of Forecasts: Some Empirical Results," *Management Science*, 29(9):987-996.

Montgomery, J.H., 1991, *Groundwater Chemicals Desk Reference Volume 2*, Lewis Publishers, Chelsea, Michigan, 944p.

Montgomery, J.H., and L.M. Welkom, 1991, *Groundwater Chemicals Desk Reference*, Lewis Publishers, Chelsea, Michigan, 640p.

Pfeifle, T.W., T.J. Vogt, and G.A. Brekken, 1995, "Correlation of Chemical, Mineralogic, and Physical Characteristics of Gulf Coast Dome Salt to Deformation and Strength Properties," Solution Mining Research Institute Research Project Report 94-0004-S, January.

Postgate, J.K., 1965, "Recent Advances in the Study of Sulfate-Reducing Bacteria," *Bacteriological Reviews*, 29(4):December.

Querio, C.W., 1980, "Design and Construction of Solution-Mined Caverns for LPG Storage," presented at the Fall Meeting of the Solution Mining Research Institute, Minneapolis, Minnesota, October.

Radian Corporation, 1995, "Risk Assessment of Converting Salt Caverns to Natural Gas Storage, Final Report," GRI-95/0377, prepared for the Gas Research Institute, Austin, Texas, October.

Rai, D., J.M. Zachara, A.P. Schwab, et al., 1986, "Chemical Attenuation Rates, Coefficients, and Constants in Leachate Migration, Volume 1," A Critical Review, Report to Electric Power Research Institute, Palo Alto, California by Battelle, Pacific Northwest Laboratories, Richland, Washington, Research Project 2198-1.

Reisenauer, H.M., 1982, "Chromium," *in Methods of Soil Analysis, Part 2: Chemical and Microbiological Properties*, Second Edition, A.L. Page et al. (editors), American Society of Agronomy, Inc., Madison, Wisconsin.

Richey, S.F., J.G. Wells, and K.T. Stephens, 1985, "Geohydrology of the Delaware Basin and Vicinity, Texas and New Mexico," U.S. Geological Survey, Water Resources Investigations Report 84-4077, Albuquerque, New Mexico.

SAIC, 1994, "Statistical Analysis of Effluent from Coastal Oil and Gas Extraction Facilities," prepared by Science Applications International Corporation, Falls Church, Virginia, for U.S. Environmental Protection Agency, Office of Science and Technology, September 30.

Seni, S.J., 1980, "Sand-Body Geometry and Depositional Systems, Ogallalla Formation, Texas," The University of Texas at Austin, Bureau of Economic Geology Report of Investigation No. 5, Austin, Texas, 35p.

Sheppard, M.I., D.I. Beals, D.H. Thibault, and P. O'Connor, 1984, "Soil Nuclide Distribution Coefficients and Their Statistical Distributions," AECL-8364, Whiteshell Nuclear Research Establishment, Atomic Energy of Canada Limited, Pinawa, Manitoba, December.

SMRI: see Solution Mining Research Institute.

Solution Mining Research Institute (SMRI), 1997, Letter to J. Veil, Argonne National Laboratory, August 6.

Stanier, R.Y., et al., 1963, *The Microbial World,* Second Edition, Prentice Hall, Englewood Cliffs, New Jersey.

Streeter, V.L., 1961, *Handbook of Fluid Dynamics*, McGraw-Hill Book Company, Inc., New York.

Stumm, W., and J.J. Morgan, 1981, *Aquatic Chemistry, An Introduction Emphasizing Chemical Equilibria in Natural Waters*, John Wiley and Sons, New York, 780p.

Testa, S.A., 1994, *Geological Aspects of Hazardous Waste Management*, CRC Press, Boca Raton, Florida, 537p.

Tomasko, D., 1985, "A Numerical Model for Predicting the Thermal Behavior of Caverns in the Strategic Petroleum Reserve," Dissertation submitted in partial fulfillment of the requirements for the degree of Doctor of Philosophy, the University of New Mexico, Albuquerque, New Mexico.

Tomasko, D., 1991, "Modeling Vertical and Horizontal Solute Transport," American Geophysical Union Fall Meeting, San Francisco, California, December.

Tomasko, D., 1994, "An Analytical Model for LNAPL Transport in the Vadose Zone," Geological Society of America Fall Meeting, Seattle, Washington, December.

U.S. Department of Energy, 1990, "Final Supplemental Environmental Impact Statement Waste Isolation Pilot Plant," DOE/EIS-0026-FS, Office of Environmental Restoration and Waste Management, January.

U.S. Department of Energy, 1996, "Workshop on Managing Human Health and Ecological Risk Assessment Projects under CERCLA and RCRA," Office of Environment Safety and Health, prepared by Argonne National Laboratory, May.

U.S. Environmental Protection Agency, 1987, "Report to Congress, Management of Wastes from the Exploration, Development, and Production of Crude Oil, Natural Gas, and Geothermal Energy, Volume 1 of 3," EPA/530-SW-88-003, Office of Solid Waste and Emergency Response, Washington, D.C., December.

U.S. Environmental Protection Agency, 1989, "Risk Assessment Guidance for Superfund, Volume I, Human Health Evaluation Manual (Part A)," EPA/540/1-89/002, Office of Emergency and Remedial Response, December.

U.S. Environmental Protection Agency, 1991, "Human Health Evaluation Manual, Supplemental Guidance: Standard Default Exposure Factors," OSWER Directive 9285.6-03, Office of Solid Waste and Emergency Response, Washington, D.C., March 25.

U.S. Environmental Protection Agency, 1993, "Development Document for Effluent Limitations Guidelines and New Source Performance Standards for the Offshore Subcategory of the Oil and

Gas Extraction Point Source Category," EPA 821-R-93-003, Office of Water, Washington, D.C., January.

U.S. Environmental Protection Agency, 1994a, "Drinking Water Regulations and Health Advisories," Office of Water, Washington, D.C., May.

U.S. Environmental Protection Agency, 1994b, "Associated Waste Report: Crude Oil Tank Bottoms and Oily Debris," Office of Solid Waste, Special Waste Branch, Washington, D.C., March.

Van Sambeek, L. L., 1993, "Evaluating Cavern Tests and Subsurface Subsidence Using Simple Numerical Models," presented at the 7th Symposium on Salt, Vol. I.

Veil, J., D. Elcock, M. Raivel, D. Caudle, R.C. Ayers, Jr., and B. Grunewald, 1996, "Preliminary Technical and Legal Evaluation of Disposing of Nonhazardous Oil Field Waste into Salt Caverns," prepared for the U.S. Department of Energy, Office of Fossil Energy under contract W-31-109-ENG-38, Argonne National Laboratory, Argonne, Illinois, June.

Wallner, M., 1986, "Frac-Pressure Risk in Rock Salt," presented at the Fall Meeting of the Solution Mining Research Institute, Amsterdam.

Wallner, M., and W.A. Paar, 1997, "Risk of Progressive Pressure Build Up in a Sealed Cavern," presented at the Fall Meeting of the Solution Mining Research Institute, El Paso, Texas, October.

Werner, M.L, 1986, "Structure and Mineralization of the Richton Dome Caprock Boring MRIG-9 Technical Report," BMI/ONWI-610, Office of Nuclear Waste Isolation, Columbus, Ohio.

Whiting, G.H., 1981a, "Strategic Petroleum Reserve (SPR) Geologic Site Characterization Report, Sulphur Mines Salt Dome," SAND80-7141, Sandia National Laboratories, Albuquerque, New Mexico, March.

Whiting, G.H., 1981b, "Strategic Petroleum Reserve (SPR) Geologic Site Characterization Report, West Hackberry Salt Dome," SAND80-7131, Sandia National Laboratories, Albuquerque, New Mexico, January.

Williams, T.A., and A.K. Williamson, 1989, "Estimating Water-Table Altitudes for Regional Ground-Water Flow Modeling, U.S. Gulf Coast," *Ground Water*. 27(3):333-340.

Windholz, M., S. Budavari, R.F. Blumetti, and E.S. Otterbein, 1983, *The Merck Index, An Encyclopedia of Chemicals, Drugs, and Biologicals*, Merck & Company, Rahway, New Jersey.

Winkler, R.L., 1968, "The Consensus of Subjective Probability Distributions," *Management Science*, 15(2): B-61—B-75.

Winkler, R.L., 1977, "The Consensus of Subjective Probability Forecasts: Are Two, Three, ... Heads Better Than One?," Fifth Conference on Probability and Statistics, Las Vegas, Nevada, November.

Winkler, R.L., and R.T. Clemen, 1992, "Sensitivity of Weights in Combining Forecasts," Technical Notes, *Operations Research*, 40(3):609-614.

Winkler, R.L., and R.K. Sarin, 1981, "Risk Assessment: Consulting the Experts," *The Environmental Professional*, 3:265-276.

Wood, W.W., and W.E. Sanford, 1995, "Chemical and Isotopic Methods for Quantifying Ground-Water Recharge in a Regional, Semiarid Environment," *Ground Water*, 33(3):458-468.

Tables

(Note: Numbers presented in these tables have been rounded)

Table 6-1 Chemical Constituent Concentrations Assumed for Cavern Brine at the Time of Release

Type of Waste/Reference	Concentration Range (mg/L unless otherwise noted)			
	Benzene	Arsenic	Cadmium	Chromium
Produced water				
SAIC (1994)	0.08-14	BDL[a] -0.032	BDL-0.098	BDL-0.85
EPA (1993)[b]	0.052-20.4	0.017-0.31	0.0012-0.098	--
EPA (1987)[b]	0.47-2.9	0.02-1.7	--	--
Drilling Waste				
EPA (1987)[b] TCLP data[c]	--[d]	BDL-0.002	0.011-0.29	BDL-0.78
EPA (1987)[a] analysis of waste itself	--[d]	BDL-0.01 mg/kg	2 - 5.4 mg/kg	22-190 mg/kg
Tank Bottoms				
EPA (1994b) TCLP data	BDL-13	BDL-0.06	BDL- 0.008	BDL-0.14
EPA (1994b) analysis of waste itself	0.175-2,686 mg/kg	0.47-166 mg/kg	0.32-6,500 mg/kg	1.7-1,170 mg/kg
Selected Concentrations[e]	20.4	1.7	0.29	0.85

[a] BDL = value is below detection limit.
[b] Range is from the median to the upper 90th percentile.
[c] TCLP = toxicity characteristic leaching procedure.
[d] No data reported in this reference.
[e] Highest value for each constituent in TCLP samples for produced water, drilling waste, and tank bottoms.

Table 6-2 Summary Table of Release Calculations

Release Scenario	Contaminant	Retardation	Initial Conc. (mg/L)	Concentration at 1,000 yrs (mg/L)[a]	Concentration at 1,000 yrs (mg/L)[b]	MCL (mg/L)
Cavern seal fails and releases fluid at depth	Benzene	10	20.4	0.0		0.005
	Cadmium	50	0.29	4.1×10^{-8}		0.005
	Arsenic	200	1.7	9.5×10^{-15}		0.05
	Chromium	500	0.85	7.7×10^{-15}		0.1
Cavern seal fails and releases fluid to shallow aquifer	Benzene	10	20.4	0.0		0.005
	Cadmium	50	0.29	1.0×10^{-6}[c]		0.005
	Arsenic	200	1.7	1.2×10^{-5}		0.05
	Chromium	500	0.85	1.2×10^{-8}		0.1

Table 6.2 Summary Table of Failure Calculations (continued)

Release Scenario	Contaminant	Retardation	Initial Conc. (mg/L)	Concentration at 1,000 yrs (mg/L)[a]	Concentration at 1,000 yrs (mg/L)[b]	MCL (mg/L)
Release from crack	Benzene	10	20.4	0.0		0.005
	Cadmium	50	0.29	4.1×10^{-8}		0.005
	Arsenic	200	1.7	9.5×10^{-15}		0.05
	Chromium	500	0.85	7.7×10^{-15}		0.1
Release from leaky interbed	Benzene	10	20.4		0.0	0.005
	Cadmium	50	0.29		1.6×10^{-8}	0.005
	Arsenic	200	1.7		6.1×10^{-13}	0.05
	Chromium	500	0.85		5.2×10^{-13}	0.1
Roof fall + release at depth	Benzene	10	20.4	0.0		0.005
	Cadmium	50	0.29	4.1×10^{-8}		0.005
	Arsenic	200	1.7	9.5×10^{-15}		0.05
	Chromium	500	0.85	7.7×10^{-15}		0.1

Table 6.2 Summary Table of Failure Calculations (continued)

Release Scenario	Contaminant	Retardation	Initial Conc. (mg/L)	Concentration at 1,000 yrs (mg/L)[a]	Concentration at 1,000 yrs (mg/L)[b]	MCL (mg/L)
Roof fall + cavern seal failure + release at depth	Benzene	10	20.4	0.0		0.005
	Cadmium	50	0.29	4.1×10^{-8}		0.005
	Arsenic	200	1.7	9.5×10^{-15}		0.05
	Chromium	500	0.85	7.7×10^{-15}		0.1
Roof fall + cavern seal failure + release at shallow depth	Benzene	10	20.4	0.0		0.005
	Cadmium	50	0.29	1.0×10^{-6}[c]		0.005
	Arsenic	200	1.7	1.2×10^{-5}		0.05
	Chromium	500	0.85	1.2×10^{-8}		0.1
Roof fall + release through leaky interbed	Benzene	10	20.4		0.0	
	Cadmium	50	0.29		1.6×10^{-8}	0.005
	Arsenic	200	1.7		6.1×10^{-13}	0.05
	Chromium	500	0.85		5.2×10^{-13}	0.1

[a] Short, pulsed release.
[b] Long, slow release.
[c] Maximum concentration of 1.3×10^{-5} occurs at 334 yrs.

Table 6-3 Probabilities of Occurrence for Specified Release Scenarios

Release Scenario	No. of Responses	Best Estimate	Range	Worst Case	Range
Seal fails and releases fluid at depth	5	0.031	0.0005 to 0.1	0.12	0.002 to 0.25
Seal fails and releases fluid at shallow depth	5	0.012	0.0001 to 0.05	0.040	0.001 to 0.10
Cracks release fluid at depth	5	0.022	0.0001 to 0.10	0.120	0.001 to 0.35
Leaky interbeds release fluid at depth	5	0.022	0.0001 to 0.10	0.120	0.001 to 0.35
Roof fall plus fluid released at depth	5	0.100	10^{-6} to 0.50	0.290	10^{-5} to 1.0
Roof fall plus cavern seal fails and releases fluid at depth	5	0.062	5×10^{-6} to 0.2	0.163	2×10^{-5} to 0.35
Roof fall plus cavern seal fails and releases fluid at shallow depth	5	0.006	1×10^{-7} to 0.02	0.051	1×10^{-6} to 0.10
Roof fall plus release through leaky interbed	5	0.062	5×10^{-6} to 0.20	0.163	2×10^{-5} to 0.35

Table 7-1 Oral Slope Factors for Contaminants of Concern

Contaminant of Concern	Oral Slope Factor (1/ (mg/kg-day))
Arsenic	1.5
Benzene	0.029
Cadmium	NA
Chromium	NA

NA = Not available

Table 7-2 Oral Reference Doses for Contaminants of Concern

Contaminant of Concern	Oral RfD (mg/kg/day)
Arsenic	0.0003
Benzene	NA
Cadmium	0.0005
Chromium (III)	1.0
Chromium (VI)	0.005

NA = Not available

Table 8-1 Scenarios for Risk Calculations

Release Location	Release Modes
Release to shallow aquifer	- Cavern seal failure with casing failure at shallow depth - Cavern roof fall with cavern seal failure and casing failure at shallow depth
Release to deep aquifer	- Cavern seal failure with casing failure at depth of cavern - Cracks - Leaky interbeds - Roof fall with intact cavern seal - Roof fall with cavern seal failure and casing failure at depth of cavern - Roof fall with release through exposed leaky interbed

Table 8-2 Exposure-Point Concentrations for Deep, Best-Estimate Aquifer Release Scenarios

Contaminant	Conc. at 1,000 yr (mg/L)	Best-Estimate Probability of Occurrence				Best-Estimate Exposure-Point Concentrations (mg/L)			
		Seal fails and releases fluid at depth	Crack releases fluid at depth	Roof fall + fluid released at depth	Roof fall + seal fails and fluid released at depth	Seal fails and releases fluid at depth	Crack releases fluid at depth	Roof fall + fluid released at depth	Roof fall + seal fails and fluid released at depth
Benzene	0.0	0.031	0.022	0.1	0.062	0.0	0.0	0.0	0.0
Cadmium	4.1×10^{-8}	0.031	0.022	0.1	0.062	1.3×10^{-9}	9.0×10^{-10}	4.1×10^{-9}	2.5×10^{-9}
Arsenic	9.5×10^{-15}	0.031	0.022	0.1	0.062	3.0×10^{-16}	2.1×10^{-16}	9.5×10^{-16}	5.9×10^{-16}
Chromium	7.7×10^{-15}	0.031	0.022	0.1	0.062	2.4×10^{-16}	1.7×10^{-16}	7.7×10^{-16}	4.8×10^{-16}

Table 8-3 Exposure-Point Concentrations for Deep, Worst-Case Aquifer Release Scenarios

Contaminant	Conc. at 1,000 yr (mg/L)	Worst-Case Probability of Occurrence				Worst-Case Exposure-Point Concentrations (mg/L)			
		Seal fails and releases fluid at depth	Crack releases fluid at depth	Roof fall + fluid released at depth	Roof fall + seal fails and fluid released at depth	Seal fails and releases fluid at depth	Crack releases fluid at depth	Roof fall + fluid released at depth	Roof fall + seal fails and fluid released at depth
Benzene	0.0	0.120	0.120	0.290	0.163	0.0	0.0	0.0	0.0
Cadmium	4.1×10^{-8}	0.120	0.120	0.290	0.163	4.9×10^{-9}	4.9×10^{-9}	1.2×10^{-8}	6.7×10^{-9}
Arsenic	9.5×10^{-15}	0.120	0.120	0.290	0.163	1.1×10^{-15}	1.1×10^{-15}	2.8×10^{-15}	1.6×10^{-15}
Chromium	7.7×10^{-15}	0.120	0.120	0.290	0.163	9.2×10^{-16}	9.2×10^{-16}	2.2×10^{-15}	1.3×10^{-15}

Table 8-4 Exposure-Point Concentrations for Shallow, Best-Estimate Aquifer Release Scenarios

Contaminant	Conc. at 1,000 yr (mg/L)	Best-Estimate Probability of Occurrence		Best-Estimate Exposure-Point Concentrations (mg/L)	
		Seal fails, casing fails, and fluid released to shallow aquifer	Roof fall + seal fails, + casing fails and releases fluid to shallow aquifer	Seal fails, casing fails, and fluid released to shallow aquifer	Roof fall + seal fails + casing fails and releases fluid to shallow aquifer
Benzene	0.0	0.012	0.006	0.0	0.0
Cadmium	1.0×10^{-6}	0.012	0.006	1.2×10^{-8}[a]	6.0×10^{-9}
Arsenic	1.2×10^{-5}	0.012	0.006	1.4×10^{-7}	7.2×10^{-8}
Chromium	1.2×10^{-8}	0.012	0.006	1.4×10^{-10}	7.2×10^{-11}

[a] Maximum concentration of 1.6×10^{-7} mg/L occurs at 334 years.

Table 8-5 Exposure-Point Concentrations for Shallow, Worst-Case Aquifer Release Scenarios

Contaminant	Conc. at 1,000 yr (mg/L)	Worst-Case Probability of Occurrence		Worst-Case Exposure-Point Concentrations (mg/L)	
		Seal fails, casing fails, and fluid released to shallow aquifer	Roof fall + seal fails + casing fails and releases fluid to shallow aquifer	Seal fails, casing fails, and fluid released to shallow aquifer	Roof fall + seal fails + casing fails and releases fluid to shallow aquifer
Benzene	0.0	0.040	0.051	0.0	0.0
Cadmium	1.0×10^{-6}	0.040	0.051	4.0×10^{-8}[a]	5.1×10^{-8}
Arsenic	1.2×10^{-5}	0.040	0.051	4.8×10^{-7}	6.1×10^{-7}
Chromium	1.2×10^{-8}	0.040	0.051	4.8×10^{-10}	6.1×10^{-10}

[a] Maximum concentration of 5.2×10^{-7} mg/L occurs at 334 years.

Table 8-6 Exposure-Point Concentrations for Additional Best-Estimate Releases at Depth

Contaminant	Conc. at 1,000 yr (mg/L)	Best-Estimate Probability of Occurrence		Best-Estimate Exposure-Point Concentrations (mg/L)	
		Leaky interbed releases fluid at depth	Roof fall + long slow release through leaky interbed at depth	Leaky interbed releases fluid at depth	Roof fall + release through leaky interbed at depth
Benzene	0.0	0.022	0.062	0.0	0.0
Cadmium	1.6×10^{-8}	0.022	0.062	3.5×10^{-10}	9.9×10^{-10}
Arsenic	6.1×10^{-13}	0.022	0.062	1.3×10^{-14}	3.8×10^{-14}
Chromium	5.2×10^{-13}	0.022	0.062	1.1×10^{-14}	3.2×10^{-14}

Table 8-7 Exposure-Point Concentrations for Additional Worst-Case Releases at Depth

Contaminant	Conc. at 1,000 yr (mg/L)	Worst-Case Probability of Occurrence		Worst-Case Exposure-Point Concentrations (mg/L)	
		Leaky interbed releases fluid at depth	Roof fall + long slow release through leaky interbed at depth	Leaky interbed releases fluid at depth	Roof fall + release through leaky interbed at depth
Benzene	0.0	0.120	0.163	0.0	0.0
Cadmium	1.6×10^{-8}	0.120	0.163	1.9×10^{-9}	2.6×10^{-9}
Arsenic	6.1×10^{-13}	0.120	0.163	7.3×10^{-14}	9.9×10^{-14}
Chromium	5.2×10^{-13}	0.120	0.163	6.2×10^{-14}	8.5×10^{-14}

Table 8-8 Exposure Scenario Assumptions for Ingestion of Groundwater

Parameter	Value
Daily intake rate	2 L/d
Exposure time	24 h/d
Exposure frequency[a]	350 d/yr
Exposure duration[a]	30 yr
Body weight of human receptor	70 kg
Averaging time Carcinogens (70 yr) Noncarcinogens (365 d/yr × ED)[b]	 25,550 d 10,950 d

[a] Exposure frequency and exposure duration based on specifics of failure mode.
[b] ED = exposure duration.

Table 8-9 Estimated Intake Rates for Deep, Best-Estimate Aquifer Release Scenarios

	Intake Rate (mg/kg-day)							
	Seal fails and releases fluid at depth		Crack releases fluid at depth		Roof fall and fluid released at depth		Roof fall plus seal fails and fluid released at depth	
Contaminant	Carcinogen	Non-carcinogen	Carcinogen	Non-carcinogen	Carcinogen	Non-carcinogen	Carcinogen	Non-carcinogen
Benzene	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
Cadmium	1.6×10^{-11}	3.5×10^{-11}	1.1×10^{-11}	2.4×10^{-11}	4.9×10^{-11}	1.1×10^{-10}	3.0×10^{-11}	6.8×10^{-11}
Arsenic	3.6×10^{-18}	8.1×10^{-18}	2.5×10^{-18}	5.7×10^{-18}	1.1×10^{-17}	2.6×10^{-17}	7.1×10^{-18}	1.6×10^{-17}
Chromium	2.9×10^{-18}	6.5×10^{-18}	2.0×10^{-18}	4.6×10^{-18}	9.2×10^{-18}	2.1×10^{-17}	5.8×10^{-18}	1.3×10^{-17}

Table 8-10 Estimated Intake Rates for Deep, Worst-Case Aquifer Release Scenarios

	Intake Rate (mg/kg-day)							
	Seal fails and releases fluid at depth		Crack releases fluid at depth		Roof fall and fluid released at depth		Roof fall plus seal fails and fluid released at depth	
Contaminant	Carcinogen	Non-carcinogen	Carcinogen	Non-carcinogen	Carcinogen	Non-carcinogen	Carcinogen	Non-carcinogen
Benzene	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
Cadmium	5.9×10^{-11}	1.3×10^{-10}	5.9×10^{-11}	1.3×10^{-10}	1.4×10^{-10}	3.2×10^{-10}	8.0×10^{-11}	1.8×10^{-10}
Arsenic	1.3×10^{-17}	3.0×10^{-17}	1.3×10^{-17}	3.0×10^{-17}	3.4×10^{-17}	7.6×10^{-17}	1.9×10^{-17}	4.3×10^{-17}
Chromium	1.1×10^{-17}	2.5×10^{-17}	1.1×10^{-17}	2.5×10^{-17}	2.6×10^{-17}	5.9×10^{-17}	1.6×10^{-17}	3.5×10^{-17}

Table 8-11 Estimated Intake Rates for Shallow, Best-Estimate Aquifer Release Scenarios

	Intake Rate (mg/kg-day)			
	Seal fails, casing fails, and fluid released to shallow aquifer		Roof fall + seal fails + casing fails and releases fluid to shallow aquifer	
Contaminant	Carcinogen	Noncarcinogen	Carcinogen	Noncarcinogen
Benzene	0.0	0.0	0.0	0.0
Cadmium	1.4×10^{-10}[a]	3.2×10^{-10}[b]	7.2×10^{-11}	1.6×10^{-10}
Arsenic	1.7×10^{-9}	3.8×10^{-9}	8.6×10^{-10}	1.9×10^{-9}
Chromium	1.7×10^{-12}	3.8×10^{-12}	8.6×10^{-13}	1.9×10^{-12}

[a] Maximum concentration of 1.9×10^{-9} mg/kg-day occurs at 334 years.
[b] Maximum concentration of 4.2×10^{-9} mg/kg-day occurs at 334 years.

Table 8-12 Estimated Intake Rates for Shallow, Worst-Case Aquifer Release Scenarios

	Intake Rate (mg/kg-day)			
	Seal fails, casing fails, and fluid released to shallow aquifer		Roof fall + seal fails + casing fails and releases fluid to shallow aquifer	
Contaminant	Carcinogen	Noncarcinogen	Carcinogen	Noncarcinogen
Benzene	0.0	0.0	0.0	0.0
Cadmium	4.8×10^{-10}[a]	1.1×10^{-9}[b]	6.1×10^{-10}	1.4×10^{-9}
Arsenic	5.8×10^{-9}	1.3×10^{-8}	7.3×10^{-9}	1.7×10^{-8}
Chromium	5.8×10^{-12}	1.3×10^{-11}	7.3×10^{-12}	1.7×10^{-11}

[a] Maximum concentration of 6.2×10^{-9} mg/kg-day occurs at 334 years.
[b] Maximum concentration of 1.4×10^{-8} mg/kg-day occurs at 334 years.

Table 8-13 Estimated Intake Rates for Additional, Best-Estimate Aquifer Release Scenarios

	Intake Rate (mg/kg-day)			
	Leaky interbed releases fluid at depth		Roof fall + release thorough leaky interbed at depth	
Contaminant	Carcinogen	Noncarcinogen	Carcinogen	Noncarcinogen
Benzene	0.0	0.0	0.0	0.0
Cadmium	4.2×10^{-12}	9.5×10^{-12}	1.2×10^{-11}	2.7×10^{-11}
Arsenic	1.6×10^{-16}	3.5×10^{-16}	4.6×10^{-16}	1.0×10^{-15}
Chromium	1.3×10^{-16}	3.0×10^{-16}	3.8×10^{-16}	8.6×10^{-16}

Table 8-14 Estimated Intake Rates for Additional, Worst-Case Aquifer Release Scenarios

	Intake Rate (mg/kg-day)			
	Leaky interbed releases fluid at depth		Roof fall + release through leaky interbed at depth	
Contaminant	Carcinogen	Noncarcinogen	Carcinogen	Noncarcinogen
Benzene	0.0	0.0	0.0	0.0
Cadmium	2.3×10^{-11}	5.1×10^{-11}	3.1×10^{-11}	7.0×10^{-11}
Arsenic	8.8×10^{-16}	2.0×10^{-15}	1.2×10^{-15}	2.7×10^{-15}
Chromium	7.4×10^{-16}	1.7×10^{-15}	1.0×10^{-15}	2.3×10^{-15}

Table 8-15 Estimated Cancer Risks for Best-Estimate Aquifer Release Scenarios

	Release Scenario							
Contaminant	Seal fails and releases fluid at depth	Crack releases fluid at depth	Roof fall and fluid released at depth	Roof fall plus seal fails and fluid released at depth	Seal fails, casing fails, and fluid released to shallow aquifer	Roof fall + seal fails + casing fails and releases fluid to shallow aquifer	Leaky interbed releases fluid at depth	Roof fall + release through leaky interbed at depth
Arsenic	5.4×10^{-18}	3.8×10^{-18}	1.7×10^{-17}	1.1×10^{-17}	2.6×10^{-9}	1.3×10^{-9}	2.4×10^{-16}	6.9×10^{-16}
Benzene	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
Cadmium	NA	NA	NA	NA	NA	NA	NA	NA
Chromium III	NA	NA	NA	NA	NA	NA	NA	NA
Chromium VI	NA	NA	NA	NA	NA	NA	NA	NA
Total	5.4×10^{-18}	3.8×10^{-18}	1.7×10^{-17}	1.1×10^{-17}	2.6×10^{-9}	1.3×10^{-9}	2.4×10^{-16}	6.9×10^{-16}

NA = Not available

Table 8-16 Estimated Cancer Risks for Worst-Case Aquifer Release Scenarios

	Release Scenario							
Contaminant	Seal fails and releases fluid at depth	Crack releases fluid at depth	Roof fall and fluid released at depth	Roof fall plus seal fails and fluid released at depth	Seal fails, casing fails, and fluid released to shallow aquifer	Roof fall + seal fails + casing fails and releases fluid to shallow aquifer	Leaky interbed releases fluid at depth	Roof fall + release through leaky interbed at depth
Arsenic	2.0×10^{-17}	2.0×10^{-17}	5.1×10^{-17}	2.9×10^{-17}	8.7×10^{-9}	1.1×10^{-8}	1.3×10^{-15}	1.8×10^{-15}
Benzene	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
Cadmium	NA	NA	NA	NA	NA	NA	NA	NA
Chromium III	NA	NA	NA	NA	NA	NA	NA	NA
Chromium VI	NA	NA	NA	NA	NA	NA	NA	NA
Total	2.0×10^{-17}	2.0×10^{-17}	5.1×10^{-17}	2.9×10^{-17}	8.7×10^{-9}	1.1×10^{-8}	1.3×10^{-15}	1.8×10^{-15}

NA = Not available

Table 8-17 Estimated Noncancer Risks for Best-Estimate Aquifer Release Scenarios

	Release Scenario							
Contaminant	Seal fails and releases fluid at depth	Crack releases fluid at depth	Roof fall and fluid released at depth	Roof fall plus seal fails and fluid released at depth	Seal fails, casing fails, and fluid released to shallow aquifer	Roof fall + seal fails + casing fails and releases fluid to shallow aquifer	Leaky interbed releases fluid at depth	Roof fall + release through leaky interbed at depth
Arsenic	2.7×10^{-14}	1.9×10^{-14}	8.7×10^{-14}	5.3×10^{-14}	1.3×10^{-5}	6.3×10^{-6}	1.2×10^{-12}	3.3×10^{-12}
Benzene	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
Cadmium	7.0×10^{-8}	4.8×10^{-8}	2.2×10^{-7}	1.4×10^{-7}	6.4×10^{-7}[a]	3.2×10^{-7}	1.9×10^{-8}	5.4×10^{-8}
Chromium III	6.5×10^{-18}	4.6×10^{-18}	2.1×10^{-17}	1.3×10^{-17}	3.8×10^{-12}	1.9×10^{-12}	3.0×10^{-16}	8.6×10^{-16}
Chromium VI	1.3×10^{-15}	9.2×10^{-16}	4.2×10^{-15}	2.6×10^{-15}	7.6×10^{-10}	3.8×10^{-10}	6.0×10^{-14}	1.7×10^{-13}
Total	7.0×10^{-8}	4.8×10^{-8}	2.2×10^{-7}	1.4×10^{-7}	1.4×10^{-5}	6.6×10^{-6}	1.9×10^{-8}	5.4×10^{-8}

[a] 8.4×10^{-6} Maximum concentration occurs at 334 years.

Table 8-18 Estimated Noncancer Risks for Worst-Case Aquifer Release Scenarios

	Release Scenario							
Contaminant	Seal fails and releases fluid at depth	Crack releases fluid at depth	Roof fall and fluid released at depth	Roof fall plus seal fails and fluid released at depth	Seal fails, casing fails, and fluid released to shallow aquifer	Roof fall + seal fails + casing fails and releases fluid to shallow aquifer	Leaky interbed releases fluid at depth	Roof fall + release through leaky interbed at depth
Arsenic	1.0×10^{-13}	1.0×10^{-13}	2.5×10^{-13}	1.4×10^{-13}	4.3×10^{-5}	5.7×10^{-5}	6.7×10^{-12}	9.0×10^{-12}
Benzene	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
Cadmium	2.6×10^{-7}	2.6×10^{-7}	6.4×10^{-7}	3.6×10^{-7}	2.2×10^{-6a}	2.8×10^{-6}	1.0×10^{-7}	1.4×10^{-7}
Chromium III	2.5×10^{-17}	2.5×10^{-17}	5.9×10^{-17}	3.5×10^{-17}	1.3×10^{-11}	1.7×10^{-11}	1.7×10^{-15}	2.3×10^{-15}
Chromium VI	5.0×10^{-15}	5.0×10^{-15}	1.2×10^{-14}	7.0×10^{-15}	2.6×10^{-9}	3.4×10^{-9}	3.4×10^{-13}	4.6×10^{-13}
Total	2.6×10^{-7}	2.6×10^{-7}	6.4×10^{-7}	3.6×10^{-7}	$4.5 \times 10^{-5*}$	6.0×10^{-5}	1.0×10^{-7}	1.4×10^{-7}

[a] Maximum concentration of 2.8×10^{-5} occurs at 334 years.

B. QUICK, Inc.

9535 Forest Lane, Suite 123, Dallas, Texas 75243
Office: (972) 644-4259 * FAX: (972) 669-3911

AUG 18

August 15, 1997

Mr. Roger Anderson
Oil Conservation Division
2040 S. Pacheco
Santa Fe, New Mexico 87505

RE: Request for brine well permit and for non-hazardous oilfield waste disposal permit in abandoned Climas salt wells in S/2 of S/2 of Section 34, T-19-S, R-36-E, in Lea County

This letter is intended to inform you of our situation regarding the above referenced project and our intentions for the future of this lease.

Mr. Hickerson and Permian Brine Sales, Inc. have endeavored to obtain the appropriate permits for the past two years. As of August 14, 1997, B. Quick, Inc. assumed control of the lease and will utilize Mr. Hickerson as a consultant to B. Quick, Inc. Attached is Permian Brine Sales, Inc. termination of lease agreement dated August 14, 1997.

Our intentions are to go forward with the process of obtaining the appropriate permits in compliance with NMOCD and EPA regulations. We feel that these salt dome cavern disposal systems are environmentally superior to any surface disposal system. This system of deep salt dome disposal has been used in many areas with no surrounding contamination. In Texas alone there have been five such facilities in operation for a number of years. Historical and engineering studies can be provided as part of our anticipated permit application.

With the past two year duration of the permit process and the current assignment of the lease to B. Quick, Inc. we request the status of the application. We would like to facilitate this process and as such would be agreeable to your suggestions by mail, telephone or in a sit- down meeting with you or your people in Santa Fe.

In closing I would like to re-emphasize our belief in the safety of this disposal project. We are anticipating your response so we can move forward with this project.

Cordially,

Bill Quick

Bill Quick

B. QUICK, Inc.

9535 Forest Lane, Suite 123, Dallas, Texas 75243
Office: (972) 644-4259 * FAX: (972) 669-3911

RECEIVED
SEP 10 1997
CONSERVATION DIVISION

August 15, 1997

Mr. Roger Anderson
Oil Conservation Division
2040 S. Pacheco
Santa Fe, New Mexico 87505

RE: Request for brine well permit and for non-hazardous oilfield waste disposal permit in abandoned Climas salt wells in S/2 of S/2 of Section 34, T-19-S, R-36-E, in Lea County

This letter is intended to inform you of our situation regarding the above referenced project and our intentions for the future of this lease.

Mr. Hickerson and Permian Brine Sales, Inc. have endeavored to obtain the appropriate permits for the past two years. As of August 14, 1997, B. Quick, Inc. assumed control of the lease and will utilize Mr. Hickerson as a consultant to B. Quick, Inc. Attached is Permian Brine Sales, Inc. termination of lease agreement dated August 14, 1997.

Our intentions are to go forward with the process of obtaining the appropriate permits in compliance with NMOCD and EPA regulations. We feel that these salt dome cavern disposal systems are environmentally superior to any surface disposal system. This system of deep salt dome disposal has been used in many areas with no surrounding contamination. In Texas alone there have been five such facilities in operation for a number of years. Historical and engineering studies can be provided as part of our anticipated permit application.

With the past two year duration of the permit process and the current assignment of the lease to B. Quick, Inc. we request the status of the application. We would like to facilitate this process and as such would be agreeable to your suggestions by mail, telephone or in a sit- down meeting with you or your people in Santa Fe.

In closing I would like to re-emphasize our belief in the safety of this disposal project. We are anticipating your response so we can move forward with this project.

Cordially,

Bill Quick

PERMIAN BRINE SALES, INC.

BRINE - FRESHWATER - WATER DISPOSAL - SOLIDS DISPOSAL

WEB SITE: http://www2.basinlink.com/us/permbrin/main.htm
E-MAIL: Permbrine@basinlink.com

6067 W. TENTH ST. • ODESSA, TEXAS 79763
OFF. (915) 381-0531 FAX (915) 381-9316

August 14, 1997

Mr. Roger Anderson
Oil Conservation Division
2040 S Pacheco
Santa Fe, New Mexico 87505

18

Re: Request for brine well permit and for non-hazardous oilfield waste disposal permit in abandoned Climas salt wells in S/2 of S/2 of Section 34, T-19-S, R-36-E, in Lea County.

Original request dated September 18, 1995

Dear Sirs:

We made the original request based on a farm-out agreement we had from B-Quick Inc. They are the holder of a lease from the land owner, Mr. James A. Foster.

I hereby terminate our agreement with Mr. Bill Quick and authorize him to assume the Permian Brine Sales, Inc. subject in his name. He proposes to actively pursue the procurement of NMOCD's approval.

We are still actively involved only as a consultant in the proposal, and will be available for consultation.

Your cooperation with Mr. Quick will be greatly appreciated. Thanks for all the help that you and Mark Ashley have given us.

If you have any further questions or are in need of any further information, you can contact me at (915)381-0531.

Very truly yours,
PERMIAN BRINE SALES, INC.

A. L. Hickerson

A.L. Hickerson
CEO

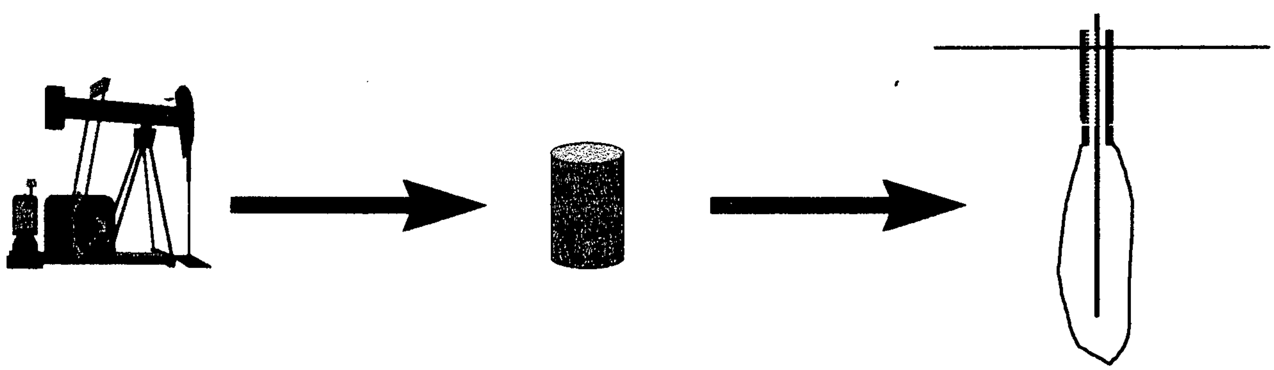
ALH/bjk

Preliminary Technical and Legal Evaluation of Disposing of Nonhazardous Oil Field Waste into Salt Caverns

Prepared for: U.S. Department of Energy
Office of Fossil Energy
under Contract W-31-109-ENG-38

Prepared by: Argonne National Laboratory
Washington, DC

John Veil
Deborah Elcock
Mary Raivel
Dan Caudle
Robert C. Ayers, Jr.
Ben Grunewald



June 1996

Table of Contents

List of Tables

List of Figures

Acknowledgements

The authors wish to express their appreciation for the many persons who provided copies of reports and papers, spoke with us about various salt cavern issues, and provided comments on the two drafts of the report. We particularly extend thanks to Richard Ginn of the Railroad Commission of Texas, R.D. Hickerson of Permian Brine Sales, Inc., and H.W. Diamond of the Solution Mining Research Institute. Mr. Diamond coordinated an extensive review of the second draft report. The review panel consisted of the following persons:

William Barlow	Texas Brine
Charles Chabannes	Sofregaz US Inc.
Dennis Crist	Ohio Department of Natural Resources
Fritz Crotogino	Kavernen Bau- und Betriebs GmbH
Ken E. Davis	Envirocorp Services & Technology, Inc.
H.W. Diamond	Solution Mining Research Institute
Norbert Heitmann	PB-KBB, Inc.
James Linn	Sandia National Laboratories
Joe L. Ratigan	RE/SPEC, Inc.
Robert Thoms	AGM, Inc.
Frank Whelpy	Sonar and Well Testing Service
Scott Whitelaw	Texas Brine

The final report reflects the contributions of each of these persons.

Preliminary Technical and Legal Evaluation of Disposing of Nonhazardous Oil Field Waste into Salt Caverns

by

J. Veil, D.Elcock, M. Raivel, D. Caudle, R.C. Ayers, Jr., and B. Grunewald

Executive Summary

Bedded and domal salt deposits occur in many states. If salt deposits are thick enough, salt caverns can be formed through solution mining. These caverns are either created incidentally as a result of salt recovery or intentionally to create an underground chamber that can be used for storing hydrocarbon products or compressed air or for disposing of wastes. This report evaluates the suitability, feasibility, and legality of disposing of nonhazardous oil and gas exploration, development, and production wastes (hereafter referred to as oil field wastes, unless otherwise noted) in salt caverns.

In 1988, the U.S. Environmental Protection Agency (EPA) published a list of those oil field wastes that were exempt from regulation as hazardous wastes under Subtitle C of the Resource Conservation and Recovery Act (RCRA). EPA's Underground Injection Control (UIC) regulations allow most of those oil field wastes to be injected into Class II UIC wells. Efforts are currently under way to obtain clarification from EPA whether all exempted oil field wastes can be injected into Class II wells. At the state level, only the Railroad Commission of Texas (TRC) has formally authorized disposal of oil field wastes into salt caverns. The TRC has issued permits for six facilities, but as of May 1996, only four of these were active. In April 1996, the TRC released draft proposed amendments to TRC Rule 9, the regulation that governs injection into a formation not productive of oil, gas, or geothermal resources. Ten other states were contacted about their interest in disposing of oil field waste into salt caverns. Many of these states were interested in following the TRC program to see how it worked, but at this time, only New Mexico has received an application for disposal of oil field wastes into salt caverns. There are no apparent regulatory barriers to the use of salt caverns for disposal of most types of oil field wastes at either the federal level or in the eleven states discussed in this analysis.

The types of oil field waste that are planned for disposal in salt caverns are those that are most troublesome to dispose of through regular Class II injection wells, because they contain excessive levels of solids. The solids-containing oil field wastes most likely to be disposed of in salt caverns include used drilling fluids, drill cuttings, completion and stimulation waste, produced sand, tank bottoms, and soil contaminated by crude oil or produced water.

The location and design of waste disposal caverns play an important role in ensuring long-term waste isolation from the surface water or groundwater resources. Hundreds of caverns have been used safely for storing hydrocarbons. The hydrocarbon storage industry has developed useful, detailed standards and guidance for designing and constructing storage caverns that are also

appropriate for creating solution-mined caverns for other uses. Several factors should be considered in selecting sites for disposal of oil field wastes in caverns, including distance to populated areas; proximity to other industrial facilities; current and future use of adjacent properties; handling of brine or other displaced fluid; proximity to environmentally sensitive wetlands, waters, and fresh water aquifers; proximity to the salt boundary; and proximity to other existing and abandoned subsurface activities, such as neighboring caverns for brine or hydrocarbon storage. Detailed knowledge of the geology should be supported by adequate documentation. Operators should be able to demonstrate that the caverns they plan to use — either new caverns developed specifically for oil field waste disposal, or existing caverns that are being converted — will remain stable in the future.

Disposal caverns act like large oil/water/solids separators. The solids in the incoming waste settle to the bottom of the cavern while the lighter oils and hydrocarbons rise to the top of the cavern, where they can be removed. When placing waste in a cavern, the cavern space is best utilized by filling evenly and uniformly, with no large voids. One method for emplacing the waste in the cavern is to inject it through the tubing to the bottom of the cavern. Under this scenario, an operator of an oil field waste disposal cavern would inject waste until the end of the tubing is covered or the back pressure from the accumulated waste precludes further injection. At this point, the operator would use a small controlled explosive charge to cut off the end of the tubing further up the cavern. Another Texas operator prefers to inject waste through the tubing/casing annulus into the top of the cavern and allow the waste to settle to the bottom. A third Texas operator has installed two wells in the cavern, one for injection and the other for brine withdrawal. Under any of these waste emplacement scenarios, cavern pressure should be monitored and controlled before the cavern is filled with oil field waste, throughout the waste emplacement cycle, and optimally, for some period of time after waste emplacement has ended.

There is no actual field experience on the long-term impacts that might arise from salt cavern disposal of oil field wastes. The literature contains many theoretical studies that speculate what might happen following closure of a cavern. Although different authors agree that pressures will build in a closed brine-filled cavern due to salt creep (domal salt only) and geothermal heating, they do not specifically address caverns filled with oil field wastes. Caverns filled with oil field wastes having specific gravities greater than that of brine will have a lower likelihood of failure than caverns filled with brine. More field research on pressure buildup in closed caverns is desirable.

Based on this preliminary research, we believe that disposal of oil field wastes into salt caverns is feasible and legal. If caverns are sited and designed well, operated carefully, closed properly, and monitored routinely, they represent a suitable means of disposing of oil field wastes.

Chapter 1 - Introduction

Content and Purpose of Report

Caverns can be readily formed in salt formations through solution mining. The caverns may be formed incidentally, as a result of salt recovery, or intentionally to create an underground chamber that can be used for storing hydrocarbon products or compressed air or disposing of wastes. The purpose of this report is to evaluate the feasibility, suitability, and legality of disposing of nonhazardous oil and gas exploration, development, and production wastes (hereafter referred to as oil field wastes, unless otherwise noted) in salt caverns.

Chapter 2 provides background information on

- Types and locations of U.S. subsurface salt deposits;
- Basic solution mining techniques used to create caverns; and
- Ways in which salt caverns are used.

Later chapters provide discussion of

- Federal and state regulatory requirements concerning disposal of oil field waste, including which wastes are considered eligible for cavern disposal;
- Waste streams that are considered to be oil field waste; and
- An evaluation of technical issues concerning the suitability of using salt caverns for disposing of oil field waste. Separate chapters present
    - Types of oil field wastes suitable for cavern disposal;
    - Cavern design and location;
    - Disposal operations; and
    - Closure and remediation.

This report does not suggest specific numerical limits for such factors or variables as distance to neighboring activities, depths for casings, pressure testing, or size and shape of cavern. The intent is to raise issues and general approaches that will contribute to the growing body of information on this subject.

Chapter 2 - Background

Types and Locations of U.S. Subsurface Salt Deposits

Figure 1 (from Johnson and Gonzales 1978) shows the location of the major U.S. subsurface salt deposits. There are two types of subsurface salt deposits in the United States: salt domes and bedded salt. Salt domes are large, generally homogeneous formations of salt that are formed when a column of salt migrates upward from a deep salt bed, passing through the overlying sediments. Pfeifle et al. (1995) report that the typical anhydrite (calcium sulfate) content of Gulf Coast salt domes averages less than 5 percent. Salt dome deposits are found in the Gulf Coast region of Texas, Louisiana, Mississippi, and Alabama. Figures 2 through 5 (taken from Jirik and Weaver 1976) show the specific locations of many onshore and offshore salt domes.

Bedded salt formations occur in layers bounded on the top and bottom by impermeable formations and interspersed with nonsalt sedimentary materials having varying levels of impermeability, such as anhydrite, shale, and dolomite. Unlike salt domes, bedded salt deposits are tabular deposits of sodium chloride that can contain significant quantities of impurities. Major bedded salt deposits occur in several parts of the United States.

Although salt deposits occur in many parts of the United States, in most states, the occurrence of salt in the quantities and locations that would promote commercial mining is limited. There are 16 states in which salt occurs in sufficient quantity to be mined by either excavation or solution mining, or recovered through solar evaporation. The states where these major salt deposits occur are: Alabama, Arizona, Colorado, Kansas, Louisiana, Michigan, Mississippi, Montana, New Mexico, New York, North Dakota, Ohio, Oklahoma, Pennsylvania, Texas, and Utah.

Of the states listed above, those with the most significant salt mining operations are: Kansas, Louisiana, Michigan, New Mexico, New York, Ohio, and Texas. These states, either currently or in the future, could contain caverns suitable for oil and gas waste disposal. Pennsylvania contains caverns that are currently permitted for hydrocarbon storage that could potentially be converted to waste disposal caverns. Utah has some potential for future disposal cavern operations, although it is a relatively small oil and gas waste generator. The remaining states have only a limited number of salt production sites and are not likely candidates for future cavern disposal operations.

Formation of Salt Caverns

Salt caverns are formed by injecting water that is not fully salt-saturated into a salt formation and withdrawing the resulting brine solution. Figures 6 and 7 show the main features of salt cavern construction for caverns in domal salt and bedded salt, respectively. These figures are not drawn to scale or intended to show detailed construction features.

The first step in creating a salt cavern is drilling a borehole. Near the surface, the borehole is larger in diameter to allow for installation of several concentric layers of casing, which are cemented in place to protect against contamination of drinking water sources. The outermost layer of casing is known as the surface casing. Typically, it does not extend all the way to the cavern roof. The final casing (or long string casing), which is also cemented, is set at a depth below the top of the salt formation. Generally, a non-cemented casing string, the tubing string, is placed in an open hole which has been drilled to a depth approximately where the bottom of the cavern will be, although some interconnected multi-well caverns may not have a non-cemented string in each well. In some caverns, two non-cemented casing strings may extend to a depth approximately where the bottom of the cavern will be. Under this design scenario, one string is used to inject water and the other is used to withdraw brine.

There are several methods used for developing and shaping the cavern. In the direct circulation method, fresh water is injected through the tubing string, and brine is withdrawn through the annular space between the tubing string and the final casing. In the reverse-circulation method, fresh water enters through the annulus and the brine is withdrawn through the tubing string. A combination of these two methods or other more complicated methods can be used to obtain the desired cavern geometry. API (1994) describes and provides illustrations of these methods.

During cavern formation, a rubble bed of impurities such as anhydrite can form on the bottom of the cavern. Depending on the size of the cavern and the amount of impurities present, more than 50 feet of impurities can sit on the bottom of the cavern (Tomasko 1985).

The petroleum industry has constructed many salt caverns for storing hydrocarbons. In an attempt to provide guidance for designing and operating hydrocarbon storage salt caverns, several organizations have developed standards and guidance documents (CSA 1993, API 1994, and IOGCC 1995). Readers desiring more details on design, location, and construction of salt caverns are referred to these reports.

Use of Salt Caverns

The most common use of salt caverns is production of salt, which in turn, enlarges the caverns. The post-mining uses of caverns are hydrocarbon storage, compressed air storage, and waste disposal.

Hydrocarbon Storage - Salt caverns are commonly used for storing hydrocarbons. The earliest cavern storage for liquified petroleum gas (LPG) in bedded salts occurred in the 1940s, with storage in salt dome caverns beginning in 1951. Some of the products that have been stored are propane, butane, ethane, ethylene, fuel oil, gasoline, natural gas, and crude oil (Querio 1980). In 1975, the U.S. Congress created the Strategic Petroleum Reserve (SPR) program to provide the country with sufficient petroleum reserves to reduce the impacts of future oil supply interruptions. The SPR consists of 62 leached caverns in domal salt with a total capacity of 680 million barrels. The U.S. Department of Energy (DOE) has prepared a plan for, but is not currently pursuing, the development of an additional 250 million barrels of storage capacity.

Waste Disposal - A second use of salt caverns is disposing of various types of wastes. Several examples of actual or proposed waste disposal projects are presented below. These examples are based on limited and not completely up-to-date information from foreign countries. The current extent of cavern waste disposal may be larger now.

United States - In the United States, only limited waste disposal into salt caverns has occurred. In Texas, the Railroad Commission of Texas (TRC) issued six permits between 1991 and 1994 for disposing of oil field waste into salt caverns. As of May 1995, nearly half a million barrels of oil field waste had been disposed of in this manner (Fuller and Boyt 1995). Ten other states with significant solution mining and oil and gas production activity were asked if they currently used salt caverns for disposing of oil field waste. None of these states currently have approved any such disposal projects, although several states reported an interest in the subject. New Mexico has received an application to site and operate a disposal cavern but had made no decision on it as of May 1996. A summary of the contacts with these states is provided in Table 1.

Several proposals for storing hazardous wastes in Texas salt dome caverns were made during the past 10 years, but none have been approved by the Texas state government (Thoms and Gehle 1994). In the early 1980s, a Houston-based waste disposal company proposed to dispose of toxic wastes in the Vinton salt dome in southwest Louisiana. A vertically aligned series of caverns, separated by salt intervals, was to be solution-mined from a single well. The deepest would be mined first, filled with wastes, and then plugged with salt. The next deepest cavern would then be filled and sealed. The process would be continued until the usable salt interval for that well was fully occupied with stacked "mini-caverns". This design was referred to as the "string of pearls" concept and reportedly was patented (Thoms 1995). By minimizing the vertical extent of any particular mini-cavern, pressure differential problems could be reduced.

The DOE constructed the Waste Isolation Pilot Plant (WIPP), an underground repository for radioactive waste, in a bedded salt formation in southeastern New Mexico. Although the WIPP was excavated rather than formed through solution mining, its concept of safely disposing of wastes in a salt formation applies equally well to oil field waste disposal caverns.

The U.S. salt mining industry disposes of impurities removed during the brine purification process into caverns[1].

---

[1] Personal communication between Bill Diamond, Executive Director, Solution Mining Research Institute, Deerfield, IL, and John Veil, Argonne National Laboratory, Washington, DC, on August 22, 1995.

Canada - In 1995, a U.S. patent was granted to Canadian inventors for a method of refuse disposal in solution-mined salt cavities (Pearson and Alseth 1995), but their process has not yet been used in the United States.

The Province of Alberta has authorized disposal of oil field wastes into several caverns near Edmonton[2].

United Kingdom - In the United Kingdom, various wastes are being disposed of into caverns at the Holford Brinefield (Hoather and Challinor 1994). The brinefield operator is authorized to dispose of 200 tons per day of brine mud solids from the purification of crude brine, and 250 tons per day of alkali wastes from local soda ash production, into salt caverns. The brine displaced from the caverns by the solids is used to slurry additional solids back to the caverns. In addition, the operator is authorized to dispose of organic residues from the production of perchloroethylene, trichloroethylene, and other related chlorohydrocarbons into specially designated caverns that contain alkaline material that will neutralize any free acid in the wastes.

Feasibility studies for disposing of hazardous or other wastes in salt caverns have been conducted in several European countries. Hoather and Challinor (1994) report on a proposal to dispose of contaminated soils, domestic and commercial solid waste (trash), and sewage sludge into the Holford Brinefield in the United Kingdom.

Germany - Germany has adopted technical regulations on hazardous waste management, TA Sonderabfall. These regulations require that all waste that cannot be stored for extended periods above ground without posing a serious threat to the biosphere, even after undergoing treatment, shall be stored underground in suitable geologic formations. The German government and the Lower Saxony Company for the Final Disposal of Hazardous Waste (NGS) co-sponsored a study of the feasibility of storing hazardous waste in salt caverns (NGS date unspecified, Crotogino 1990). The TA Sonderabfall requires that brine be removed from the caverns before emplacing wastes. The NGS study found that by adapting existing technologies for waste conditioning, waste emplacement, and cavern engineering, the requirements of TA Sonderabfall could be met. At this time, however, no hazardous wastes have been disposed of in German salt caverns.

Crotogino (1994) reports that salt-bearing drilling fluids and cuttings arising from deep drilling for natural gas, oil, and salt caverns are disposed of in salt caverns. At the time Crotogino presented this paper, projects were in the planning stage for disposing of various mineral bulk residues (e.g., contaminated soil, ashes, dusts, and sand blasting residues) in salt caverns. More recently, Germany is planning to dispose of sediments contaminated with

---

[2] Personal communication between Brenda Austin, Alberta Energy and Utilities Board, Calgary, Alberta, Canada, and John Veil, Argonne National Laboratory, Washington, DC, on May 17, 1996.

mercury from the harbor in Hamburg into salt caverns[3].

Netherlands - Wassman (1983) reports that the Dutch have disposed of wastes from a brine purification plant in a salt cavern. At that time, the Dutch were making plans to dispose of drilling fluids and drill cuttings in salt caverns. Concentrated magnesium chloride brine has also been stored in caverns.

Mexico - In Mexico, sulfate purged from salt evaporators is being disposed of into salt caverns[4].

[3]Personal communication between Fritz Crotogino, Kavernen Bau- und Betriebs-Gmbh, Hannover, Germany, and John Veil, Argonne National Laboratory, Washington, DC, on August 25, 1995.

[4]Personal communication between Jose Pereira, PB-KBB, Houston, TX, and John Veil, Argonne National Laboratory, Washington, DC, on October 3, 1995.

Chapter 3 - Regulatory Considerations

Extent of Evaluation

This chapter evaluates the state and federal environmental requirements as they apply to disposal of oil field wastes into salt caverns. No attempt is made to encompass all types of permits, licenses, or approvals that must be obtained by an operator, including zoning approvals, mineral rights, and construction, safety, and fire code requirements.

Description of Nonhazardous Oil Field Wastes

On July 6, 1988, the U.S. Environmental Protection Agency (EPA) issued a regulatory determination that exempted wastes from the exploration, development, and production of crude oil, natural gas, and geothermal energy from regulation as hazardous wastes under the Resource Conservation and Recovery Act (RCRA) Subtitle C (53 FR 25477). The list of wastes exempted from RCRA Subtitle C is reproduced in Table 2. On March 22, 1993, EPA issued clarification of the 1988 determination, adding that many other wastes that were uniquely associated with exploration and production operations were also exempted from RCRA Subtitle C requirements (58 FR 15284). The clarification of the RCRA exemption restates EPA's position that wastes derived from treatment of an exempted waste generally remain exempt, and that off-site transportation does not negate the exemption. Some wastes derived from treatment of an exempt waste may not be exempt, however. For example, if a treatment facility uses acid to treat an exempt waste, the waste material derived from the exempt waste remains exempt, but the spent acid is not exempt.

EPA has emphasized the need to work with states to encourage changes in their regulations to improve management of oil and gas exploration and production wastes. For example, although RCRA Subtitle C specifically exempts produced water, drilling fluids, and "other wastes associated" with exploration, development, and production activities, most state regulations exempt produced water and drilling fluids from hazardous waste regulation (allowing for their disposal into Class II injection wells) but are often silent on the requirements for the "associated wastes". EPA specifically identified in its 1988 regulatory determination many "associated wastes" that are exempt under RCRA Subtitle C (see Table 2).

Consideration of Salt Caverns Used for Disposing of Oil Field Waste as Class II Injection Wells

Under the authority of the Safe Drinking Water Act (SDWA), EPA established regulations for the Underground Injection Control (UIC) program. All injection wells are assigned to five classes. Salt caverns used for disposing of oil field waste are Class II wells. States seeking authority to administer the UIC program can seek primacy in two ways. Under §1422 of the SDWA, states must demonstrate that their state regulations are at least as stringent as those adopted by EPA. To provide greater flexibility for states administering Class II programs, Congress added §1425 to the SDWA, which requires states seeking delegation to have an underground injection program that meets the requirements of §1421(b)(1)(A)-(D) and represents an effective program to prevent underground injection that endangers drinking water sources. A brief discussion of the relevant federal UIC regulations follows. References to state responsibilities in the following sections are those that would apply to states seeking delegation under §1422.

40 CFR Part 144 - These regulations establish the minimum requirements for the UIC program. Each state must meet these requirements in order to obtain primary enforcement authority for the UIC program in that state. These regulations also are part of the UIC programs in states where the program is administered directly by EPA. The SDWA provides that all underground injections are unlawful and subject to penalties unless authorized by permit or by rule. Part 144 sets forth the permitting and other program requirements that must be met by UIC Programs, whether run by a state or by EPA. Class II injection wells are defined as "wells which inject fluids:

> (1) Which are brought to the surface in connection with natural gas storage operations, or 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.
>
> (2) For enhanced recovery of oil or natural gas; and
>
> (3) For storage of hydrocarbons which are liquid at standard temperature and pressure." (40 CFR 144.6(b))

EPA defines well as a "bored, drilled or driven shaft, or a dug hole, whose depth is greater than the largest surface dimension," and fluids as "any material or substance which flows or moves whether in a semisolid, liquid, sludge, gas, or other any other form or state" (both from 40 CFR 144.3).

The requirements in Part 144 that may affect the proposed use of salt caverns as Class II injection wells for disposal include the prohibition of movement of fluid into underground sources of drinking water (§144.12) and the compliance with a plan for plugging and abandonment of the well which meets the requirements of §146.10.

40 CFR Part 145 - These regulations specify the procedures EPA will follow in approving, revising, and withdrawing state programs under the UIC provisions of the SDWA, and include the elements that must be part of submissions to EPA for program approval and the substantive provisions that must be present in state programs for them to be approved. EPA has established UIC programs in states that do not comply with elements of a state program submission set forth in §145.22. When a state UIC program is fully approved by EPA to regulate all classes of injections, the state assumes primary enforcement authority under section 1422(b)(3) of the SDWA. States are not precluded, however, from omitting or modifying any provisions to impose more stringent requirements.

40 CFR Part 146 - These regulations set forth technical criteria and standards for the UIC Program. Part 146 standards in the following areas may affect the proposed use of salt caverns as Class II injection wells for disposal: the area of review for each injection well, mechanical integrity, plugging and abandonment, construction of new and some existing wells, and operating and monitoring.

Comparison between RCRA and UIC Regulations

Salt caverns used for disposing of nonhazardous oil and gas waste brought to the surface in connection with conventional oil and natural gas production activities clearly would fit into the section (1) category of Class II wells. Most, but not all of the wastes exempted by the 1988 RCRA regulatory determination would meet the UIC program's "in connection with" oil and gas production criterion. Some wastes (e.g., hydrocarbon-contaminated soil) would not meet the UIC criterion, however. Although EPA's description of wastes that are "uniquely associated" with oil and gas production under RCRA (58 FR 15284) cannot be clearly applied to determining whether such wastes have been brought to the surface "in connection with" oil and gas production under the UIC Class II regulations, the waste in question (i.e., the soil) has been contaminated by wastes that have been brought to the surface. In February 1996, the Ground Water Protection Council asked EPA to clarify that all exempted oil field wastes can be injected into Class II wells. As of May 1996, EPA had not issued the requested clarification.

This potential gap is somewhat clarified by a draft 1993 memorandum from James Elder, then EPA's Director of the Office of Ground Water and Drinking Water (the part of EPA that oversees the UIC program), to EPA Regional Water Management Division directors (Elder 1993). In that memorandum, EPA headquarters states:

> "The key concepts that have been used by the UIC program to determine whether waste fluids could be injected in Class II wells were that they had to be **non hazardous** and **integrally associated** with oil and gas production .... we believe that all exempt E&P [exploration and production] wastes under RCRA can be injected in Class II wells as long as their physical state allows it."

Although that memorandum has apparently never been issued in final form, it has been used as the basis of at least one letter from EPA Region VI to the State of Louisiana outlining the policy on waste types eligible for Class II well disposal (Knudson 1993). In that letter, Myron Knudson, the Director of Region VI's Water Management Division, states:

> "Under the new guidance, all exploration and production (E&P) wastes exempted under Section 3001(b)(2)(A) of the Resource Conservation and Recovery Act (RCRA) will be eligible for injection into Class II disposal wells."

EPA's position from 1993 is clearly indicated, but since the guidance from EPA headquarters is in draft form, clear guidance is needed to determine which types of exploration and production wastes may be disposed into Class II wells. Of course, those wastes determined by EPA not to be exempt from RCRA Subtitle C (i.e., hazardous oil and gas production wastes) could not be legally injected into a salt cavern permitted as a Class II injection well. The section (1) category of injection well is often referred to in state regulations as a "disposal well."

State UIC Regulations

As described earlier, regulatory agencies in eleven oil-producing states where salt caverns exist were consulted with regard to the possible use of salt caverns for disposal of oil field wastes. Most of the contact persons in each state felt that, were salt caverns to be used for this purpose, they would be considered Class II injection wells. However, with the exception of one state, Texas, these state officials said that salt caverns were not being used in such a manner in their state. Moreover, most said that such an idea has never been formally proposed in their state. These same officials, however, generally thought there were no existing provisions in their states' Class II injection well or other regulations which would specifically prohibit the practice of disposing of oil field wastes in salt caverns. Three of the eleven states, Michigan, New York, and Pennsylvania, do not have "primacy" to administer and enforce their own Class II injection well programs. Applicants in these states must therefore apply directly to EPA for Class II permits.

Relevant Differences from EPA UIC Regulations - In the three states that do not have primacy, Michigan, New York, and Pennsylvania, a person wishing to receive a permit to use salt caverns as Class II injection wells for disposal of oil field wastes must comply with the applicable EPA regulations[5]. Ohio's oil and gas law states that the Ohio injection well regulations are to be interpreted as no more stringent than the SDWA UIC regulations, unless a stricter interpretation is essential to ensure that underground sources of drinking water will not be endangered (Ohio Revised Code §1509.22(D)). Oklahoma's salt deposits are not suitable for extensive solution mining or salt cavern disposal, so no detailed analysis of that state's UIC regulations was conducted.

---

[5] Michigan, New York, and Pennsylvania require state-level permits, in addition to UIC permits issued by EPA, to drill or alter an existing oil or gas well. Michigan requires a permit to drill a well for disposal of brine or other oil field wastes (Michigan Act 61, §319.23. Pennsylvania requires the applicant to submit a copy of the EPA UIC permit and EPA UIC application, as well as the related documentation required by EPA. Pennsylvania requires the applicant to submit both a control and disposal plan and an erosion and sedimentation plan, in order to comply with state water pollution, erosion, and erosion sedimentation control regulations (Pennsylvania Code, Title 25, §78.18). New York requires a "conversion permit" for the construction involved in converting a solution-mining or storage well to a disposal well (New York Department of Environmental Conservation Regulations, Title 6, Chapter V, Subchapter B, Part 552).

In the six remaining states whose regulations were analyzed, the applicable state regulations may vary from EPA regulations in the extent to which they would allow salt caverns to be used for oil field waste disposal. The relevant provisions of those states' regulations are discussed below, followed by a discussion of the Texas program.

Kansas - The Kansas General Rules and Regulations for Conservation of Crude Oil and Natural Gas set forth permit requirements for injection and disposal wells (§82-3-400 through 499). Section 82-3-101 defines disposal well as a well in which those fluids brought to the surface in connection with oil and natural gas production are injected for purposes other than enhanced recovery. The definition of fluid is identical to that in the EPA UIC regulations.

A possible impediment to the use of salt cavern disposal wells in Kansas is the existence of well location and spacing requirements (§82-3-108 and 109). Although these requirements were not specifically mentioned as impediments in discussions with the Kansas contact person, this official did express concerns about the additional dissolution of cavern walls that might occur if caverns are used for disposal of oil and gas waste. The dissolution of the caverns could affect the spacing between caverns.

It should be noted that §82-3-100 allows the state to grant an exception to any of these oil and natural gas conservation regulations.

Louisiana - The Louisiana Department of Natural Resources Regulations, §43:XIX.129, contain Class II injection well requirements, including wells for disposal of nonhazardous oil field waste generated from drilling and production of oil and gas wells at §43:XIX.129.M, which apply to the disposal of nonhazardous oil and gas waste by a commercial facility. These regulations define nonhazardous oil field waste (NOW) similarly to the description of wastes suitable for disposal under EPA's Class II injection well regulations. The Louisiana regulations also list all wastes included in the definition of NOW. The wastes listed are similar to those listed in EPA's 1988 regulatory determination on the exemption of oil and gas wastes from RCRA Subtitle C.

As in the Kansas regulations, Louisiana's regulations require the subsurface geology of any proposed injection zone to exhibit adequate thickness and areal extent. Dissolution of salt cavern disposal well walls may impede compliance with this requirement.

Mississippi - Mississippi Rule 63, governing underground injection wells, contains a description of the materials that may be injected into Class II disposal wells that is identical to that contained in 40 CFR Part 144 for Class II disposal wells. Most of the requirements of Rule 63 that are stricter than EPA's regulations are administrative and monitoring requirements. Rule 63 also contains criteria for establishing minimum distances between wells, which are not required by EPA regulations. Such minimum distance requirements would need to be carefully considered when siting caverns for disposal of the oil and gas wastes. Incoming wastes that were not fully saturated with salt could dissolve the walls of the caverns, thereby affecting the wall thickness[6]. Rule 63 does allow for exceptions to be granted for any construction or operating requirement contained in the Rule.

New Mexico - The New Mexico Oil Conservation Division's Rules 701-711 set forth the new requirements for Class II injection and disposal wells that allow disposal of saltwater and produced water in Class II disposal wells. The Rules contain construction, operating, testing, and monitoring requirements. The New Mexico contact person felt that the process for disposal of nonhazardous oil and gas wastes into salt caverns was unclear, but that it would likely be regulated under the Class II well regulations. He stated that certain requirements of the New Mexico regulations are more stringent than the EPA regulations, including the area of review, injection pressure, and construction requirements. He could not foresee, however, that these stricter requirements would be more difficult to comply with for operators of salt cavern disposal wells than for operators of other Class II disposal wells. He stressed, however, that his opinion was qualified due to uncertainty about the process[7].

North Dakota - The North Dakota Injection Control Regulations, Chapter 43-02-05, contain a definition of underground injection identical to that contained in 40 CFR Part 144 for disposal wells. There do not appear to be any requirements in the North Dakota regulations beyond the minimum EPA requirements that would impede the use of salt caverns as Class II injection wells in North Dakota. However, North Dakota's UIC coordinator explained that salt formations in the state are very deep. Consequently, the engineering problems and associated costs suggest that cavern disposal is probably not a realistic option for North Dakota[8].

The Texas Program - The Texas regulation applicable to use of salt caverns as Class II injection wells for disposal of nonhazardous oil and gas waste, ~~Texas Statewide Rule 9~~ (§3.9), allows disposal of saltwater or other oil and gas waste by injection into a porous formation not productive of oil, gas, or geothermal resources. The TRC is the agency responsible for administering this regulation. To date, six permits under Rule 9 have been issued for disposal of oil field waste in salt caverns. Rule 9 also sets forth monitoring and reporting requirements, which require the operator to monitor the injection pressure and injection rate of each disposal well on at least a monthly basis.

[6] Personal communication between Fred Hille, State Oil and Gas Board, Jackson, MS, and Mary Raivel, Argonne National Laboratory, Washington, DC, on August 23, 1995.

[7] Personal communication between David Catanach, New Mexico Oil Conservation Division, Santa Fe, NM, and Mary Raivel, Argonne National Laboratory, Washington, DC, on August 31, 1995.

[8] Personal communication between Charles Koch, North Dakota Industrial Commission, Oil and Gas Division, Bismark, ND, and John Veil, Argonne National Laboratory, Washington, DC, on May 14, 1996.

There are also requirements for pressure testing the well, the area of review, casing, special equipment, and plugging of wells.

In April 1996, the TRC released draft proposed amendments to Rule 9 that set forth requirements specifically for disposal of oil and gas wastes in solution-mined salt caverns. Cavern disposal wells may be created, operated, or maintained only in impermeable salt formations so that they do not cause surface water or groundwater pollution or danger to life or property. The draft proposed amendments would require the applicant to submit

- A list of the types and maximum volume of the oil and gas wastes to be disposed of;
- Geologic information concerning the overlying and surrounding formations and the size and shape of the cavern;
- A list of all wells within one-quarter mile of the proposed cavern disposal well that penetrate the salt formation and any adjacent disposal, mining, or storage cavern wells or caverns;
- Topographic maps;
- An operating plan that describes facilities, equipment, brine management, and cavern monitoring;
- A closure plan that addresses monitoring of pressures after shut-in and demonstrates that post-plugging pressure increases will not affect the well's ability to confine the injected fluids; and
- Financial security information.

The draft proposed amendments also describe standards applicable to operation of a cavern disposal well, including

- Maintaining records of the fluids used to slurry the wastes into the cavern and the type, volume, and characteristics of the wastes that are injected;
- Setting maximum injection pressure of a cavern disposal well; and
- Establishing monitoring, financial security, and recordkeeping requirements.

The amendments also establish testing, monitoring, surveying, and closure requirements for cavern disposal wells.

Regulatory Conclusions

Other than the draft proposed amendments to the Texas regulations, there are no specific regulations addressing disposal of oil field wastes in salt caverns at either the federal level or in the states discussed in this analysis. EPA's Class II well requirements do not specifically address oil and gas wastes generated on the surface (not brought to the surface in connection with conventional oil and natural gas production activities). It would be useful if EPA would explicitly address such wastes under the UIC program. Some of the types of wastes that are currently going into the four operating Texas cavern disposal wells are in this category (e.g., contaminated soils).

Another potential barrier to allowing the practice of disposal of oil field wastes in salt caverns is the general nature of a state's existing applicable regulations. States would need to make a decision about whether to allow the practice under existing regulations, amend the existing regulations to more specifically address and permit salt cavern disposal wells, or amend the regulations to specifically prohibit the practice.

Given the current level of support at the state level for the use of salt caverns for disposal of oil field waste, and the general consensus that this practice is possible and feasible, it seems entirely reasonable that oil-producing states in which salt caverns are located could allow salt cavern disposal of oil field waste where appropriate. Moreover, these states could use the Texas salt cavern disposal program as a model. Contact persons from several of the other states indicated that they were interested in seeing how the TRC program worked out.

Chapter 4 - Types of Oil Field Wastes Suitable for Cavern Disposal

Chapters 4-7 present technical issues associated with disposing of nonhazardous oil field wastes into salt caverns.

Types of Wastes to be Accepted

The types of oil field waste proposed for disposal in salt caverns are those that are most troublesome to dispose of through regular Class II injection wells because they contain higher levels of solids. Wastes containing water that is not fully saturated with salt may increase the size of caverns because the unsaturated water will leach salt from the cavern walls. The presence of fresh water in wastes should not preclude their disposal in salt caverns, but the operator must account for the increased volume of the cavern and what effect it will have on such cavern siting parameters as distance to adjacent caverns and roof span or thickness. The solids-containing oil field wastes most likely to be disposed of in salt caverns include

- Used drilling fluids,
- Drill cuttings,
- Completion and stimulation waste,
- Produced sand,
- Tank bottoms, and
- Crude oil- or salt-contaminated soil.

Each of these wastes is described below.

Used Water-Based Drilling Fluids - Water-based fluids are suspensions of drilling fluid additives and formation solids in water. They usually contain many of the following ingredients: barite, clay, chromium lignosulfonate, lignite, polymers, caustic soda, and formation solids. They may also contain low concentrations of specialty chemicals added to treat a specific problem (e.g., aluminum stearate - defoamer, zinc carbonate - hydrogen sulfide scavenger). Water-based fluids may also contain 0 - 5 percent emulsified diesel or mineral oil. The water in water-based fluids may be relatively fresh or may contain high concentrations of sodium, potassium, or calcium chloride.

Used Oil-Based Drilling Fluids - Oil-based drilling fluids are water-in-oil emulsions. They contain a base oil (diesel or mineral oil), barite, clays, emulsifiers, water, calcium chloride, lignite, and lime. Oil-based fluids are more expensive than water-based fluids and are normally recovered and cleaned up for reuse; however, in some situations salt cavern disposal might be economically viable. Oil-based fluids are dense, viscous, exhibit low vapor pressure, do not dissolve cavern walls, and are immiscible with brine. One would expect excellent cavern integrity and minimum disturbance of the displaced brine from this type of waste.

Drill Cuttings - Cuttings consist of formation solids (shale, sandstone, chert, etc.) and associated drilling fluid liquid (water or oil and fluid additives - barite, clay, lignite, polymers, etc). Cuttings contain trace amounts of heavy metals; however, these are present as insoluble inorganic salts in concentrations comparable to those found in surface soils.

The nature of the associated fluid is the most important characteristic that distinguishes cuttings for disposal. Thus, cuttings may be classified as either water-based or oil-based. Water-based cuttings may be further classified as salt-water-based or fresh-water-based. Normally, fresh-water-based cuttings would not be candidates for cavern disposal, because in most cases it is permissible to dispose of them on site either through land farming or direct pit closure.

Waste from Completion and Stimulation Operations - Various completion and stimulation processes on oil and gas wells result in solids-containing waste. Excess cement after setting plugs or cementing casing may result in cement waste. Washing sand out of tubing will result in silicon dioxide and other formation solids. Acid stimulation wastes may contain solids or neutralized wastes may deposit solids. There are a number of other, similar waste sources. All these would be candidates for disposal in a salt cavern.

Produced Sand - Many formations composed of sandstone break down, and fine particles of the formation are produced along with oil, gas, and water. These siliceous materials are much heavier than the liquid portions of the produced stream and settle out in piping, separators, and other treatment vessels. This material is distinct from tank bottoms because it collects rapidly in large amounts and is fairly uniform in composition, mostly as particles of silicon dioxide (sand). Other small impurities in produced sand can be water-formed scales and clays. Water-formed scales tend to contain radium as a co-precipitant in the scale. At times, the naturally occurring radioactive materials (NORM) concentration can be high enough to cause this waste to fall under NORM waste disposal regulations.

Tank Bottoms - Solids accumulate in the bottom of tanks and treating vessels. These solids usually contain oil and are dispersed in a water continuous phase. The solids content is composed of clays and other formation fines, corrosion products such as iron sulfide and iron oxide, water-formed scales such as calcium carbonate or calcium sulfate, and bacterial bodies (biomass). Trace constituents might include treating chemicals, live bacterial cultures, dissolved gases such as carbon dioxide, and hydrogen sulfide. Water-formed scales tend to contain radium as a co-precipitant in the scale. At times, the NORM concentration can be high enough to cause this waste to fall under NORM waste disposal regulations.

In physical form, such wastes range from soft, flocculent materials composed of small amounts of solids dispersed in water and oil to hard, cemented masses that are almost entirely solid materials. Typically, this waste is a watery sludge, and it is collected and transported by vacuum truck. Solids entrained in the waste are of small particle size and may be almost neutrally buoyant in water.

Crude Oil-Contaminated Soil - Surface soil may become contaminated with crude oil because of spills or leaks. Crude oil-contaminated soil would be a potential candidate for cavern storage if reclamation were not economically feasible.

Salt-Contaminated Soil- Surface soils may become contaminated with salt due to brine or produced water spills or leaks. Salt-contaminated soil would be a potential candidate for cavern storage if reclamation were uneconomical.

Monitoring and Recordkeeping Considerations

It is the best interest of both the regulator and the operator to know what types of wastes have been placed in the disposal cavern. This report does not propose specific monitoring requirements; rather the reader is referred to IOGCC (1994), which puts forth criteria that are intended to guide states in assessing and improving their regulatory programs for oil field waste management. While the IOGCC criteria do not specifically apply to disposal of oil field wastes by injection (which logically includes cavern disposal), they should be considered as a useful starting point for establishing monitoring requirements. In particular, Section 5.2 - Waste Characterization should be consulted.

It is appropriate to maintain long-term records of the source, quantity, and type of each batch of waste brought to the disposal facility.

Chapter 5 - Cavern Design and Location Considerations

Hundreds of salt caverns have been constructed and operated around the world. Most of these have been structurally sound and completely free from leakage or collapse. If cavern failure does occur, however, it can lead to contamination of surface water and groundwater. This chapter discusses several potential failure modes or areas of concern and approaches for mitigating or at least addressing the concerns.

Potential Failure Modes

Salt Creep - Salt is a material that creeps or flows under stress. Creep closure is an active process in any salt cavity where stresses or pressure differentials exist. Scientists have studied the behavior of rock salt, and the subject remains a topic of investigation. Agreement exists among most scientists that salt behaves as a fluid (it flows under even small deviatoric stresses) and that the creep rate of a cavern is a highly nonlinear function of its internal pressure and is strongly influenced by temperature (Berest and Brouard 1995). These factors provide for the "self-healing" of salt. In caverns used for gas storage, for example, fractures resulting from excessive operating pressures will close when the pressures return to normal. However, creep also results in loss of volume or closure of caverns. The effort required to obtain site-specific data may be very large, and modeling of salt is quite specialized, although models are available to do these types of calculations.

Cavern Roof Collapse and Subsidence - Cavern roof collapse would most likely occur in caverns with minimal or no salt roofs or other weight-supporting roof structure, in caverns with excessive roof spans, or in caverns with minimal internal pressure. Under such conditions, lithostatic pressure (the pressure attributable to the weight of the overlying rock) could exceed the load-carrying capability of the roof support and the roof could collapse. Collapse of a cavern roof may result in sudden major subsidence at the surface and formation of sinkholes extending for hundreds of feet around the cavern well. Nieto-Pescetto and Hendron (1977) suggest that sinkholes are less likely to occur when the thickness of the overburden is greater than ten times the thickness of the salt layer.

Failure will also depend on size of the roof span and strength of the strata overlying the salt. As salt is leached from the walls or roof of the cavern, load is transferred to the strata above the salt, increasing the stress in these less ductile layers. The cavity roof begins to fail when the stress exceeds the strength of these layers. There are several documented cases of cavern roof collapse, including solution-mined brine caverns in Grosse Ile, Michigan, and solution-mined caverns in Windsor, Ontario (Coates et al. 1983). While the potential for roof collapse exists for any cavern, the likelihood of roof collapse is very small for most caverns.

Impacts from a general collapse would occur from the dispersion of the waste that had been disposed of in the cavern or from displaced brine. The final environmental impact statement (EIS) for the Seaway Group Salt Domes prepared for the SPR described the process of general collapse for an oil-filled cavern (DOE 1978). If the waste materials in the cavern were in a liquid or semi-liquid form, the process described by DOE for collapse into an oil-filled cavern could be similar for collapse into a waste-filled cavern, assuming the properties of the waste were similar to the properties of the oil. In the DOE collapse model, the contents (a nearly incompressible fluid such as brine or oil) would be displaced volume for volume by the falling caprock and overlying sediment. If the entire column of sediment above a cavern entered it in a manner analogous to a piston in a cylinder, and if the cavern contents were completely displaced by percolation through the sediments of the piston, rather than compressed, there would be a surface depression equal in volume to the original cavern, filled but not overflowing with the displaced fluid.

A more realistic result would reflect various mechanisms (imperfect packing of falling particles, adsorption, absorption, dissolution, and trapping of the displaced fluid), which would reduce the amount of fluid that would continue to rise through the cone of influence and emerge to the surface or that would migrate into aquifers between the surface and the top of the cavern. Under these mechanisms, the oil would probably reach the surface as small seeps, and as sediment settled into the place formerly occupied by the oil, a small surface depression would form. Subsidence could also occur without surface emergence of oil. Using the piston analogy, and assuming that the oil percolates up through water-saturated sediments that have zero empty pore space, there would be a volume for volume displacement of oil, and the combined volume of waste and saturated sediments would remain constant. If the oil moved up from the saturated layer into the empty pores of an unsaturated layer, the volume of the unsaturated layer would remain constant as long as the oil filled only empty space. Oil would not emerge on the surface until all the pore space near a potential seep was filled with oil. This would permit the possible formation of an oil slick on top of the water table surface in the unsaturated layer (DOE 1978).

Subsidence due to cavern roof collapse could affect the surface environment as well as surface facilities, buildings, equipment, and piping. Subsidence caused by salt creep and cavern closure is generally limited and slow. In shallow caverns, for example, subsidence rates of 0.5 mm per year are common (Wassmann 1993). However, Wassmann has reported several contributing factors to surface subsidence above salt caverns. For example, one particular salt cavern in the Hegelo brine field in the Netherlands subsided due to both overmining (1,100-mm subsidence in 1 year) and disintegration of the cavern roof, which was further weakened by geologic faulting. Eventually, the brine penetrated the roof, causing it to cave in slowly and steadily and ultimately creating a 35-meter crater within a couple of hours (Wassmann 1993).

It is important to note that in a disposal cavern the oil field waste will be in the form of a solid or semi-solid. Even if the roof of a disposal cavern should collapse, the solid or semi-solid wastes will not be displaced from the cavern to the extent that the fluids considered in the DOE collapse model would be. Therefore, the consequences of a roof collapse in a disposal cavern, in the event it should occur, would be less damaging than a roof collapse in a fluid-filled cavern.

Cavern Integrity - Although caverns can and should be designed to minimize the chance for collapse and subsidence, the use of caverns historically developed for other purposes and used today for disposal of oil field wastes must be carefully assessed. Although permitted at their time of development for hydrocarbon storage or brine production, their use specifically for disposal should consider location, size and shape, and proximity to nearby caverns and other activities that could in any way be affected in the longer term.

Location of cavern - A major factor in determining cavern stability is cavern depth. Deep cavities subjected to large overburden stresses are more likely to suffer excessive closure because the potential for large shear stress is greater than for shallow cavities (Coates et al. 1983). Nearness to salt formation boundaries and to other caverns within the salt formation also affects cavern stability — caverns near salt formation boundaries may induce high deviatoric stresses in more brittle rock outside the salt.

Cavern size and shape - Cavern size and shape affect in-situ stress changes, which in turn influence stress concentrations around the cavern. Short, wide caverns tend to produce larger stresses than high, narrow cavities of equal volume. Thus, for caverns of equal volume, those with relatively high height-to-diameter ratios are considered to be less subject to roof collapse than those with lower ratios.

Proximity to other caverns - When multiple cavities are created in salt domes, a primary consideration is the thickness of the walls between cavities required to maintain system stability. This design consideration is similar to that involved in designing supporting pillars for room and pillar mining and is two-fold. First, the initial design or spacing of multiple caverns must be such that the roofs will be adequately supported. Second, there is a potential for cavern diameter to increase. This increase could occur if there were unsaturated water in the wastes that could dissolve salt from the surrounding walls, thereby increasing the size of the existing caverns and further reducing the thickness of the salt wall between them. This process could be accelerated if seams of salt more soluble than sodium chloride were present in the formation. This concern can generally be addressed by basing the original cavern design on the anticipated increase in cavern diameter caused by additional leaching. Communication between caverns, or the passage of material through porous and permeable connections from one cavern to another, may also result from activities outside the cavern and outside the control of the cavern operator, especially when the disposal cavern is near other caverns that could expand.

By using comprehensive geotechnical computations, Wallner and van Vliet (1993) assessed changes in cavity stability and surface subsidence expected to result from enlarging several brine caverns in a salt dome in the Netherlands. Salt field operators planned to enlarge cavity diameters from 100 to 200 meters, leading to an increased volume and an increased ratio of cavity spacing-to-diameter approaching 2:1. The model indicated that the existing formation is stable because of a bridging effect– the inner region of the cavity array relaxes and the outer region of the dome receives the transferred stresses. The model also indicated that for this particular array, the stability of the cavities and the pillars would not be endangered by enlarging the cavity diameter, although the enlarged diameters resulted in slightly increased surface subsidence. The model predicted continued stability as the spacing-to-diameter ratio approached 2:1, although several published standards or regulatory requirements for hydrocarbon storage caverns require a spacing-to-diameter ratio of no less than 2:1 (CSA 1993; TNRCC 1995). The CSA standards allow alternate spacing if geological studies show that caverns may be closer. Another recent reference recommends a spacing-to-diameter ratio of 4:1 for hydrocarbon storage caverns unless site-specific geomechanical studies show that caverns may be closer (IOGCC 1995).

The Netherlands study also assumed that the cavities were open and subject to hydrostatic brine pressure only. The study suggested that long-term subsidence forecasts will depend on cavity abandonment and sealing criteria, which need to be developed and tested, and which "need substantial research effort and study in the years to come" (Wallner and van Vliet 1993).

Leakage of Cavern Contents - Although salt is by nature a creeping material and will theoretically seal under normal conditions, leaks from caverns have been encountered. DOE's SPR found one cavern at Sulphur Mines, Louisiana, that when tested, leaked at a rate of several hundred barrels per year. Other operations have occasionally experienced similar leaks. Such leaks are normally attributed to poor or deteriorated cement jobs on the entry well to the caverns. In the Sulphur Mines case, sacrificial nitrogen was maintained on the cavern roof during crude oil storage to preclude product loss. Additionally there has been at least one case in southern Louisiana of a cavern being accidentally leached through at the edge of the dome. It is important to note, however, that the vast majority of the hundreds of storage caverns in use have served as secure storage chambers and have not leaked.

Solubility of salt - All materials found in salt formations do not dissolve at the same rate. Certain nonsalt constituents (e.g., anhydrite) may dissolve at slower rates than sodium chloride, thereby leaving ledges, while other types of salts may dissolve more quickly than sodium chloride, creating unanticipated channels or enlarged areas within a cavern.

Type of salt formation - The type of formation in which the salt cavern is located may affect the potential for leakage. There are two general types of salt formations: bedded and domal, and there are significant variations in salt properties and characteristics within these two categories as well as within individual beds or domes. Bedded salt, which has historically been used for brine mining in west Texas, is often characterized by insoluble shale and anhydrite zones that jut into the cavern (see Figure 7). A concern has been raised that salt may be interbedded with porous or fractured rock layers, and that liquid waste might migrate out of the cavern through these layers, if such layers are present. However, this mechanism of migration is considered highly unlikely, because these layers would be expected to be plugged with salt. Mechanical integrity testing of disposal caverns would determine whether fluid migration through these layers is occurring.

Generally, salt domes contain salt that is relatively free of shale and anhydrite layers. The relative purity of the salt in the deeper domal areas allows uniform dissolution and the formation of regular caverns, although domal salt can also vary from formation to formation, and even within a formation. Physical tests conducted for the Solution Mining Research Institute to determine hydrofrac gradients (pressure gradients that will cause formations to physically fracture) of Gulf Coast salt domes showed that in-situ fracturing characteristics and containment properties of salt can vary greatly. The results also demonstrate that the hydraulic fracture gradient typically assumed for Gulf Coast domes leads to conservative practices in solution mining and storage (Thoms and Gehle 1990).

Construction and operating practices - During construction of a salt cavern for waste disposal, it will be necessary to avoid any serious damage (fracture, rupture) that might compromise cavern stability and long-term capacity for containment. Operating conditions and practices can lead to leakage if the integrity of the final cemented casing or the casing seat (a cemented base placed at the bottom of the casing) is compromised. Factors affecting the pressure of the casing seat include disposal injection rate, casing and tubular configuration, and system back pressure. A specific example of how system piping, wellheads, and the cavern formation can be damaged is through excessive pressure surges caused by the sudden stoppage of a flowing stream. This can happen if (in the case of hydrocarbon storage wells) product is injected or withdrawn at very high flow rates (API 1993). API reports that brine, fresh water, and some relatively non-compressible materials can cause pressure shock waves severe enough to damage piping, wellheads, and the cavern formation. Thus, it is possible that injection of oil field wastes at pressures that are too high could lead to sudden stoppages, or "water hammer" effects. The disposal caverns permitted in Texas operate at much lower injection pressures than most hydrocarbon storage caverns. Consequently, water hammer effects should not be a problem.

Approaches for Mitigating Potential Failure Modes

The concerns raised above can be addressed through appropriate design, construction, operating, and closure procedures. Presented below are suggestions for mitigating potential adverse consequences associated with using salt domes for disposing oil field waste.

Computer Modeling - Many of the concerns described above can be predicted with computer programs that forecast closure and subsidence rates. Cavern design and operating procedures can then be modified, if necessary, on the basis of the results. However, because each situation is different, such programs must be calibrated to the special circumstances of each location and not all phenomena can be modeled accurately. Thus, while modeling is valuable for helping to mitigate potential adverse effects, empirical data and actual measurements are also useful.

Site Selection Criteria - Several factors should be considered in selecting sites for disposal of oil field wastes. These include many suggested by the Interstate Oil and Gas Compact Commission for siting natural gas storage caverns (IOGCC 1995):

- Distance to populated areas;
- Proximity to other industrial facilities;
- Current and future use of adjacent properties, including agriculture, which may withdraw large amounts of groundwater and potentially increase subsidence rates;
- Handling of brine or other displaced fluid;
- Proximity to environmentally sensitive wetlands, waters, and fresh water aquifers;
- Proximity to the salt boundary; and
- Proximity to other existing and abandoned subsurface activities, e.g., neighboring caverns for brine, gas, or hydrocarbons.

Another consideration for siting is the potential for seismic activity.

Design Considerations - To minimize the chance for failure due to closure, collapse, or leakage, acceptable designs should be based on a geological review of the location that covers all features capable of affecting the cavern. Adequate studies should address regional stresses and strains; mechanical, chemical, and containment properties of the salt and confining rock formations; and structural anomalies, including faulting (IOGCC 1995). The design should also consider potentially associated low-permeability zones and the effects of those zones on disposal operations (CSA 1993). Detailed knowledge of the geology should be supported by adequate documentation. Operators should be able to demonstrate that the caverns they plan to use — either new caverns developed specifically for oil field waste disposal or existing caverns that are being converted — will remain stable in the future.

Construction Considerations - Following cavern construction and before waste disposal begins, inspection and testing should be conducted to verify the tightness of the cavern, and to ensure that there is no hydraulic communication between the cavern and other caverns or elsewhere outside the salt formation.

Operating Considerations - During disposal operations, records of operation as well as measurements of subsidence and cavern integrity should be made periodically. Care must be taken to ensure against conditions that would cause the pressure at the cemented casing seat to exceed the fracture pressure. Emergency planning should also be undertaken to address accidental releases of brine or oily substances.

Chapter 6 - Disposal Operations

The Disposal Process

Initially, caverns are filled with clean brine. Wastes are introduced as a slurry of waste and a carrier fluid (brine or fresh water). A carrier fluid that is not fully saturated with salt will eventually leach salt from the cavern walls or roof. Expansion of cavern diameter is generally not a problem as long as the anticipated degree of expansion is accounted for when designing the caverns. To avoid excessive leaching of the cavern roof, operators may intentionally introduce a hydrocarbon pad that, by virtue of its lower density, will float to the top of the cavern and keep the unsaturated carrier fluid from coming in contact with the cavern roof.

As the waste slurry is injected, the cavern acts as a oil/water/solids separator. The heavier solids fall to the bottom of the cavern, forming a pile. Any free oils or hydrocarbons that are associated with the waste float to the top of the cavern. Clean brine displaced by the incoming slurry is removed from the cavern and either sold as a product or disposed of in an injection well. When the cavern is filled, the operator removes the hydrocarbon pad and plugs the cavern. The remainder of this chapter provides greater detail on the disposal process and discusses issues relating to disposal.

Carrier Fluid Considerations

Fully saturated brine is a good carrier fluid, but it may not always be available or may be too costly. Using fresh water or brines that are not fully saturated as carrier fluids does not present major difficulties, however. Under this scenario, the operator would need to be aware of the effect the carrier fluids would have on additional salt leaching. Although the presence of fresh water should cause only a relatively small change in the diameter or height through leaching, under certain circumstances, the amount of additional leaching could reduce the intra-cavern distance, the distance to the edge of the salt formation, or the cavern roof thickness to a degree that would be considered undesirable. Therefore, if the waste contains fresh water or less than fully saturated brine, the operator and the regulatory agency would need to agree in advance on the extent of additional leaching that would be allowed at that particular site and how that leaching rate could be controlled.

While caverns will expand if carrier fluids are not fully saturated, the extent of expansion is generally not particularly large. For example, if a cavern is filled completely with fresh water, which subsequently dissolves enough salt to become fully saturated, the cavern volume is expected to increase by only one-sixth and the diameter is expected to increase by only 8 percent (Diamond 1996).

Waste Emplacement Considerations

There are three potential ways to fill the cavern:

1. The waste can be pumped down the tubing and the displaced brine withdrawn from the annulus;

2. The waste can be pumped down the annulus and the displaced brine can be withdrawn from the tubing; and

3. The waste can be pumped down one well and the displaced brine can be withdrawn through a second well.

The first scenario described above is the one most likely to be used. The heavier solids in the incoming waste will be introduced near the bottom of the cavern and will have a good chance of settling and remaining in the cavern. Some of the hydrocarbons rising through the cavern may become entrained in the displaced brine that is leaving the cavern, although most hydrocarbons will accumulate in a pad or layer near the roof.

One operator in Texas follows the second scenario. Waste is introduced near the top of the cavern. The lighter material will remain at the top of the cavern while the heavier solids must fall through many feet of brine before reaching the cavern bottom. The heavier solids are moving in the same direction as the displaced brine and may mix with the displaced brine and be carried out of the cavern.

Another Texas disposal cavern operator started disposal operations with a single well and injected waste through the tubing. The cross-sectional area of the tubing and the annulus limited the rate at which the cavern could be filled. To provide additional cross-sectional area to enhance the rate of filling, the operator recently drilled a second well and is now operating the cavern using one well for injection and the other well for brine withdrawal.

Injection at the bottom of the cavern presents the problem of changing the injection tubing depth as the cavern fills. Operators of oil field waste disposal caverns using injection through the tubing inject waste until the end of the tubing is covered or the back pressure from the accumulated waste precludes further injection. At this point, the operators use a small controlled explosive charge to cut off the end of the tubing further up the cavern and then can resume filling the cavern.

Displaced Fluids Considerations

As the solid components of the incoming waste fill the bottom of the cavern, an interface forms between the accumulated waste and the overlying brine, including a transition zone of brine that is mixed with the waste. Early in the life of a disposal cavern, brine is withdrawn hundreds of feet above the surface of the waste pile or the transition zone. The vast majority of the displaced brine will be clean. As the cavern fills, however, the transition zone brine may make up a larger proportion of the remaining cavern volume. At some later time, the brine withdrawn from the cavern will consist partially or completely of brine from the transition zone. The transition zone brine will be noticeably dirtier than the clean brine that was originally displaced from the cavern. The waste/brine interaction in the transition zone should have no effect on the nonhazardous classification of the brine or on the environmental suitability of cavern disposal. However, there may be unanticipated operational concerns and expenses.

Displaced brine is generally sold as a product or injected into brine disposal wells. As long as the brine is clean, either method of managing displaced brine can be practiced without additional treatment or handling. However, as the transition zone brine is displaced from the cavern, the operator may be faced with additional expense to clean up the brine before it can be injected underground for disposal. Solids-laden brine could clog the formation into which it was injected; typically such wastes are filtered prior to injection. Since most of the brine that is sold is used as a constituent of drilling fluids to drill additional oil and gas wells, the presence of waste components in the brine may not affect its salability.

An alternative to cleaning up the displaced fluid for disposal is early abandonment of the cavern, before it is completely full. This results in less disposal volume than was initially planned, with a resultant loss in revenue. Yet another alternative is to fill a cavern until the displaced brine shows characteristics of the transition zone. At that point the operator could discontinue disposal for a period of time, allowing the solid wastes to more completely settle and minimizing the extent of the transition zone.

Displaced brine that is sold should not contain excessive levels of contaminants. Regulatory criteria for acceptable levels of contaminants or on the projected end use may be appropriate.

Other Considerations

Monitoring of cavern pressure should be done before the cavern is filled with oil field waste, throughout the waste emplacement cycle, and optimally, for some period of time after the cavern has been closed. In order to monitor cavern pressure after closure, a pressure transducer must be installed in the cavern at the time it is closed.

The types and volumes of wastes emplaced should be recorded on a regular basis and the records should be maintained for several years following closure of the cavern.

Since there is very limited experience with operating salt caverns for disposal of oil field waste, certain facets of operation could benefit from additional research. The few oil field waste disposal caverns in operation have not yet become full. There will be differences in brine quality as the caverns fill. Research could provide information useful to operators on how to control brine quality and when brine will have to be treated prior to disposal or sale.

Chapter 7 - Closure and Remediation

Although various industries have been operating storage and production caverns for years, the long-term behavior of caverns filled with oil field waste is unknown. Scientists have modeled cavern behavior and engineers have conducted limited tests of closed brine-filled caverns. Most have studied liquid-filled salt caverns, although some have modeled hazardous waste disposal in dry caverns. The extent to which preliminary findings in these areas relate to the behavior of caverns used for oil-field wastes is not known. However, it will depend at least in part on the ratio of brine (or other liquid waste contents) to solids and on the densities of the solid wastes relative to those of the surrounding salt. To present the current thinking regarding closure and abandonment and to highlight some of the issues associated with such activities, the status of knowledge related to closing and abandoning caverns is addressed in this chapter.

Concerns with Sealing and Abandoning Caverns

Sealing and Abandonment of Liquid-Filled Caverns

The general concern with sealing and abandoning a fluid-filled salt cavern is that the continued creep of the cavern can raise the fluid pressure at the top of the cavern to a value greater than that of the lithostatic pressure at that point (Bishop 1986). This condition can lead to a possible fracture in the area of the wellbore, allowing brine to be forced out of the cavern.

The SPR has only cursorily addressed the abandonment of SPR caverns. Saline aquifers or impermeable caprock overlay the salt around the SPR salt domes. When the SPR caverns are closed, they will be sealed as state law requires. However, even state concerns relative to brine escaping into saturated aquifers or caprock are minimal for SPR caverns. Other sites for existing or potential waste disposal caverns may be located in areas that pose greater risks. Each site should be individually evaluated for its risk potential.

In 1984, the Solution Mining Research Institute sponsored a study using computer simulations combined with knowledge of the material properties of rock salt and with comparisons with actual pressure buildup data obtained in field operations to analyze the long-term behavior of a solution cavern sealed with a cement plug (Serata 1984a). While the simulations showed the plugged cavern to steadily approach structural equilibrium with permanent stability, they also disclosed a potential danger resulting from cavern pressure buildup. If the cavern pressure buildup were to exceed the surrounding ground pressure at the cavern top or at the wellbore below the cement plug, the excess pressure could lead to brittle fracture or plastic yield, depending on the strength of materials and initial stress states at the elevation of the cement plug. Factors contributing to the magnitude of cavern pressure buildup include bottom depth, thickness and size of salt mass behind the cavern wall, proximity to cavern boundaries, influence of neighboring caverns, cavern geometry, and the initial stress state at the cavern bottom (Serata 1984b).

Serata (1984a) hypothesizes a critical depth of 1,000 feet. If the cavern top is higher than the critical depth, then the cavern roof may crack and leak. Likewise, if the wellbore plug is set above the critical depth, the wellbore would be fractured, creating a direct conduit for cavern contents to reach the surface. However, more recent research suggests that this hypothesis cannot be supported (Linn 1995).

Bishop (1994) calculates that the salt strength of domes and the compressive strength of the cement plug in the wellbore is typically much greater than the lithostatic pressure. Consequently, Bishop believes that fracturing is unlikely.

In 1994, anticipating eventual sealing and abandonment of SPR caverns, DOE sponsored a series of modeling efforts to gain insight into the long-term behavior of a typical SPR cavern (Ehgartner and Linn 1994). To predict the speed and extent of cavern pressurization, the individual and combined effects of salt creep, salt dissolution, and geothermal heating of brine on the pressures generated after plugging were modeled. The models showed that after plugging, the internal fluid pressures in a brine-filled cavern eventually exceed lithostatic pressure in the upper portion of the cavern, resulting in enlargement and increased potential for leakage. The time needed for the brine pressure to exceed the lithostatic pressure varies with brine temperature and salinity. Assuming no salt dissolution after plugging the cavern, the predicted time for geothermally heated brine to reach lithostatic pressure at the casing seat was only about two years; without geothermal heating of the brine, the predicted time was over 200 years. Salt dissolution had the effect of nearly doubling the time needed to reach lithostatic pressure. The authors suggested that the sensitivity of cavern brine pressures to temperature and salt dissolution can be used to increase the time before the casing seat exceeds lithostatic pressure and decrease the maximum fluid pressure exerted on the casing seat. Thus, heating the brine and using brine of lower salinities could help decrease fluid pressure on the casing seat. The authors conclude, however, that even without heating the brine or delaying installation of the plug, the predicted rate of brine pressurization is not high enough to result in fracturing of the salt.

A more recent study of the behavior of sealed solution-mined caverns suggests that the factors affecting cavern closure include not only brine heating and cavern creep, but also rock salt permeability. More importantly, rock salt permeability, even if very small, allows some pressure release and leads to a final equilibrium pressure that can be substantially lower than the lithostatic pressure (Berest and Brouard 1995). The authors reported three test cases. The first concerned shallow brine production caverns in France and showed that during the test measurement period, the predominant effect was thermal expansion (neither percolation nor creep played major roles). The second case was a cavern operated by Gaz de France that was closed roughly one year after leaching had ended and was kept closed for about 7½ months. Tests showed that thermal expansion remained active and could be considered responsible for 80 to 90 percent of the observed brine outflow. The third test was conducted in much deeper caverns (rock salt layers between 1,800 meters and 2,500 meters) and showed that for deep caverns, cavern creep is much more important than thermal expansion. However, when the gap between lithostatic pressure and brine pressure becomes very small, creep is ineffective and thermal expansion becomes the primary contributor to pressure buildup.

Berest and Brouard (1995) found that pressure buildup generated by salt creep and brine heating in a sealed cavern leads to a final equilibrium pressure that is smaller than lithostatic pressure, provided that surrounding rock salt exhibits some permeability. They suggest that cavern operators consider such permeability in order to evaluate the area, especially prior to leaching. However, they acknowledge that salt permeability may not be sufficient to avoid a transient period in which the pressure in the cavern exceeds the lithostatic pressure. They suggest that this problem can be mitigated by injecting nitrogen or air into the cavern prior to plugging to modify cavern compressibility and reduce pressure buildup rate and also by delaying plug installation until the salt has heated the brine.

The temperature differential between the bottom and top of a tall cavern can lead to convective mixing of the fluids in the cavern. For oil field waste disposal caverns, the convection is unlikely to disturb the solid or semi-solid waste layer at the bottom of the cavern, but it could mix the overlying brine. This is not anticipated to lead to cavern failure[9].

The current literature cited above, whose conclusions are based on modeling, suggests that brine-filled caverns will not leak. However, no empirical tests of these suggestions have been reported in the literature to date.

Sealing and Abandonment of Waste-Filled Caverns

It is not known how these findings for brine-filled caverns will translate to caverns filled with oil field waste. Presumably there will be some brine remaining in a waste disposal cavern at the time of closure, because the likelihood of the displaced brine coming from the transition zone increases as the amount of waste disposed increases. Therefore, the disposal process will likely reach a point at which the displaced brine can no longer be economically extracted and treated or disposed of. Further, there will be brine or other fluids in the pore spaces surrounding the solid waste particles and the rubble at the bottom of the cavern deposited during cavern formation. The wastes near the bottom of the cavern may contain less pore fluids because the increased pressure at that depth will have packed the particles more tightly. Although the solids portion of the waste mass will resist salt creep, the brine portion is likely to be subjected to creep and geothermal heating.

The effect of geothermal heating may not be as significant for waste-filled caverns as for fluid-filled caverns because the anticipated filling rate is slower than for fluid-filled caverns.

---

[9] Personal communication between David Tomasko, Argonne National Laboratory, Argonne, IL, and John Veil, Argonne National Laboratory, Washington, DC, on January 24, 1996.

The oil field wastes will have a longer time to reach formation temperatures before the cavern is sealed.

Because no caverns filled with solid waste have been sealed, most of the information on the behavior of sealed, solid-waste-filled caverns is based on modeling and theory. The two studies cited below both consider disposal of predominantly dry wastes into dry caverns. It is not known how their conclusions relate to the scenario of disposing of a slurried solid/semi-solid waste into a fluid-filled cavern.

One preliminary study (Tinucci et al. 1988) modeled the response of a hazardous waste-disposal cavern in three stages over a 200-year modeling period. The stages consisted of a 5-year period for cavern creation through solution mining, a 2-year waste emplacement period (in the first 2 years the cavern was assumed to be empty, then filling occurred at the end of the 2-year period), and a 193-year sealed period. The waste material was assumed to be a weak compressible solid of high porosity in a pelletized form with low shear strength. The modeling results indicated that most deformation occurred when the cavern was empty, with a cavern volume reduction of 1.1 percent in the first 7 years, and less than 0.2 percent thereafter. However, depending on the creep equations, the results could be 3 to 5 times higher. Upon sealing, the model predicted rapid pressure buildup within 6 months, and then a levelling off. While the pressure at the top of the cavern did not significantly exceed the original lithostatic pressure, the cavern pressure was expected to exceed lithostatic pressure eventually if the stresses came to equilibrium and the cavern did not leak off pressure. Modeled deformations were large enough to fracture several of the zones, but fracturing diminished over time.

Crotogino (1990), while studying disposal of hazardous wastes into dry, empty caverns, identified at least two particular concerns for closure of caverns filled with solid wastes. The first relates to the possibility of fluid-like pressure buildup. To avoid this, the mechanical properties of the waste should be such that shear stress will be absorbed. The other concern is the possible subsidence of the surface due to the porosity of the waste materials. Upon introduction, waste materials have a porosity of 30 to 40 percent, a factor which is subsequently reduced by the impinging rock pressure. To predict cavity convergence, lab tests can be used to project compaction behavior. The objective is to achieve elastoplastic behavior of the waste by undertaking corresponding conditioning.

Approaches for Addressing Concerns

Because neither the behavior nor the impacts of a breach of cavern integrity after closure are well understood, it is difficult to suggest mitigating approaches. It can be argued that because of the unknown factors, the approaches should be conservative. However, if the impacts of actual breach of containment are low (as would be the case for caverns located away from aquifers and human activity), then it could be argued that the regulatory approach should not entail overly prescriptive and conservative requirements. Argonne National Laboratory has received funding from DOE to conduct a preliminary risk and cost analysis of salt caverns compared to other methods for disposing of oil field wastes during 1996. The findings of this study will contribute to a better understanding of the risks and impacts associated with cavern disposal.

The following issues should be considered when establishing regulatory requirements.

Testing and Analysis - Plugging and abandonment requirements should incorporate such tests as

- Geomechanical analyses of stability of the cavern and its roof prior to abandonment; and
- Pressure tests to ensure integrity of the cavern, wellbore, and cement prior to setting plugs or to demonstrate that the waste will remain in the cavern.

Plug Design - The standards developed for plugging hydrocarbon storage caverns are applicable for disposal caverns too. For example, the IOGCC (1995) standards call for installation of a drillable bridge plug within 30 feet of the casing shoe (a reinforcing collar of steel attached to the bottom of the casing) or the end of the casing if no casing shoe is present. The bridge plug is then capped with a plug of salt-saturated, sulfate-resistant cement to a depth sufficient to cover two casing collars. Additional plugs should be located within the wellbore to cover all porous or permeable zones between the casing shoe and the surface.

Some of the research into hazardous waste disposal has considered alternative plugging designs and materials. Crotogino (1990) suggests that both long-term and short-term sealing needs must be met. Long-term sealing requires a material that compacts under the effects of pressure, temperature, and humidity. Crushed rock salt appears to meet those requirements and should be considered as a component of the borehole plug. Over time, it recrystallizes to a homogeneous material that is barely distinguishable from naturally occurring rock salt, and it can be introduced as a bulk material, which gradually joins with the surrounding rock over the long term. However, since salt fines do not produce a fully functioning seal in the intermediate term, it may be necessary to seal part of the uncased section with low-permeability grout plugs (e.g., salt concrete or bitumen). Research regarding the use of plugs of designed viscosity to achieve a permanent seal is under way. A plug should have a viscosity high enough to act as a pressure seal and low enough to allow existing pressures to force it against the salt, enhancing the ability of the highly viscous salt to conform exactly to the perimeter of the plug (Bishop 1986).

Pressure Relief - One approach to relieving pressure created by cavern closure after sealing would be to bleed off brine as necessary. Under this approach, operators would need to demonstrate that there was sufficient brine remaining in the cavern after closure to allow bleeding and would have to maintain monitoring and responsibility for several years following cavern closure.

Summary Opinions of Independent Experts

To better assess the significance of these reports and findings, the authors interviewed several experienced researchers in the field to learn their opinions. Dr. James Linn of Sandia National Laboratories suggests that for liquid-filled caverns, researchers don't know what will happen, although if cavern pressure buildup is slow, the caverns should not fail. Dr. Linn also suggests that solids-filled caverns will not transmit pressure like fluid-filled caverns and consequently will not fail. Caverns filled with noncompressible solids with porosity are more stable than caverns filled with brine, but lighter, more compressible solids provide less stability than noncompressible solids. The relative stability depends on the nature of the waste[10].

Dr. Joe Ratigan of RE/SPEC Inc. suggests that researchers have a good knowledge of fluid-filled cavern behavior up to internal pressures of 0.8-0.9 times lithostatic pressure, but they disagree as to what will occur beyond that point. The potential weak links where fractures could occur include the casing plug, the cement filling the annulus, and the rock itself. Another avenue for waste leakage from the cavern would be for the cavern contents to diffuse into the rock mass[11].

Dr. Robert Thoms of AGM Inc. suggests that very tall liquid-filled caverns could experience leakage problems at the top due to increased pressure following closure, but caverns that are shorter would be less likely to leak. Caverns filled with solids that have sufficient shear strength and adequate void spaces should have little chance of leakage. The weight of the waste pile will exert lateral pressure on the cavern walls and provide additional stability. Dr. Thoms suggests that one additional safeguard that could be employed is to fill the cavern, monitor pressure for several years, and then permanently seal the cavern[12].

As part of the Solution Mining Research Institute's comments on the second draft of this report (Diamond 1996, comment 96), two persons experienced in the salt cavern industry added additional insights on the stability of caverns filled with solids versus caverns filled with brine. Fritz Crotogino of Kavernen Bau- und Betriebs GmbH commented that his research found that solids can have a porosity exceeding 40 percent and that significant cavern pressure reduction only occurs after compaction of over 20 percent (Crotogino 1990). Mr. Crotogino expects that slurried oil field wastes introduced to a brine-filled cavern will behave in the same manner as primarily dry solids introduced into a dry cavern, the situation on which he reported in Crotogino (1990). Mr. Crotogino suggests that compaction of 20 percent can only be expected after a long period of time at the internal

---

[10]Personal communication between James Linn, Sandia National Laboratories, Albuquerque, NM, and John Veil, Argonne National Laboratory, Washington, DC, on December 8, 1995 and May 14, 1996.

[11]Personal communication between Joe L. Ratigan, RE/SPEC Inc., Rapid City, SD, and John Veil, Argonne National Laboratory, Washington, DC, on December 7, 1995 and May 14, 1996.

[12]Personal communication between Robert L. Thoms, AGM Inc., College Station, TX, and Joh n Veil, Argonne National Laboratory, Washington, DC, on December 11, 1995.

pressure corresponding to a brine column and as long as the waste material has not been compacted to a considerable extent, there will be no increase in internal pressure.

The second person who expressed an opinion on this issue is Charles Chabannes of Sofregaz US Inc. Mr. Chabannes suggests that solid particles in the waste pile will probably not offer structural support until nearly all the pore space has been eliminated by creep-induced compaction (Diamond 1996, comment 96).

Although the comments from Mr. Crotogino and Mr. Chabannes may appear to disagree with the statements attributed to the other experienced researchers, Dr. Thoms suggests that different experts have focused on different aspects of the fill material issue and that all of their comments are valid. He offers the following summary (Thoms 1996). As a general rule, the stability of liquid-filled caverns increases with the density of the filling liquid. Caverns that are filled by displacing brine with materials more dense than brine will be more stable than those filled with brine alone. As solid particles are injected into a cavern, they introduce additional lateral forces that reinforce the stabilizing effect of the brine pressure acting outward against the cavern walls. The lateral forces have two components. The first component is lateral confinement of the solid particles by the cavern walls, which is influenced by the weight and interlocking characteristics of the solids. The second component is a propping resistance of the solids matrix in response to inward creep of the cavern walls; it tends to increase over time. If the waste pile contains large void spaces (e.g., Crotogino's 40 percent porosity), significant wall movements may be necessary to incur any propping effects.

Dr. Thoms indicates that Mr. Crotogino's and Mr. Chabannes' comments are consistent with the concept that a brine cavern that exhibits little salt creep before waste introduction will initially gain little additional stability from the propping resistance of a solid waste pile with considerable porosity. However, the presence of the solids in the cavern represents a measure of insurance against long-term creep effects. If the nature of the incoming waste is such that it deforms readily, as would a brine/oil field waste slurry, there will be an immediate gain due to confinement effects. In summary, disposal of solids into brine-filled caverns will generally tend to enhance the stability of caverns. The degree of stability enhancement depends on the nature of the material (Thoms 1996).

The experts are in agreement that disposal caverns are likely to be stable, if designed and operated properly. Even if waste-filled caverns are no more stable than brine-filled caverns, they still are very stable, as indicated by literature studies. If waste-filled caverns prove to be more stable than brine-filled caverns, either initially or at a later point following creep-induced compaction, the additional margin of safety further reduces the likelihood of cavern leakage.

Remediation Considerations

There appears to be undue concern about escape of waste from a cavern if its structural integrity is breached. Most oil field wastes that would be placed in a cavern for disposal are solids or semi-solids and would not move an appreciable distance even if the cavern ruptured. All that remains to cause concern is oil and brine. The movement of oil would be limited if it were not accompanied by water. It would tend to adsorb on rock or soil and its movement would be minimized. The most significant danger from a waste disposal cavern failure is the escape of brine. If a failure occurred that allowed brine to escape, it would pose the greatest threat if it reached formations containing fresh water.

If brine were to escape from the cavern, the proper remediation would consist of recovery wells that could capture the escaped brine before it reached fresh water formations, assuming that the leak was detected before fresh water contamination occurred. If a drinking water aquifer becomes contaminated with brine, there are a variety of techniques that can be used for remediating the aquifer. Most state groundwater protection or waste site cleanup agencies have extensive experience with these techniques.

Matalucci (1993) provides a thorough review of techniques that could be used to repair leaks in the SPR caverns. The same techniques are applicable to the borehole and casings of disposal caverns too. The techniques reviewed by Matalucci include

- Inner full-length cemented liner;
- Inner uncemented liner options using external casing packers;
- Internal steel liner casing patch (HOMCO patch); and
- Various squeeze cementing options using small-particle-size cementing materials.

It would seem more prudent to design for low risk than to have to counteract failure. A viscous waste containing little brine, that kept all its constituents in a contiguous mass and that filled the cavern completely before closure would appear to pose the least risk.

Areas for Further Research

The current state of knowledge about the long-term behavior of closed waste-filled caverns is incomplete. Research in several key areas would improve our understanding of what happens in closed caverns and the risks that closed caverns pose relative to other disposal mechanisms. These areas include:

- Defining ways to conduct long-term monitoring of closed caverns (particularly caverns filled with oil field wastes) to ensure that leaks are discovered in a timely manner, including defining parameters to be monitored and how the monitoring would be done;
- Identifying and evaluating the risks associated with waste disposal cavern behavior following closure and the impacts of a containment breach should it occur;

- Estimating the relative risk of disposing of oil field wastes in salt caverns compared to other existing disposal methods; and

- Identifying and assessing the costs and benefits of various methods for disposing of oil field wastes.

Chapter 8 - Conclusions

This report presents an initial evaluation of the suitability, feasibility, and legality of using salt caverns for disposal of nonhazardous oil field wastes. Given the preliminary and general nature of this report, we recognize that some of our findings and conclusions may be speculative and subject to change upon further research on this topic.

- This particular mode of disposal is in its infancy. At the time this report was prepared, we could identify only six U.S. facilities permitted for this type of disposal, and only four of those were in an active status as of May 1996. While there appears to be interest from several oil-producing states in considering this method of oil field waste disposal, no other state has approved any project yet and only New Mexico has received an application for siting and operating a disposal cavern.

- There are no apparent regulatory barriers to the use of salt caverns for disposal of oil field wastes at either the federal level or in the eleven states discussed in this analysis. One area that would benefit from clarification is further EPA guidance on what types of wastes may be disposed of into Class II wells.

- The types of oil field wastes that are exempted from RCRA hazardous wastes requirements are generally suitable for disposal in salt caverns. Many of these wastes are now disposed of in landfills or are land-farmed; these disposal methods pose environmental risks of their own.

- There are many variables to consider when siting, constructing, and operating a waste disposal cavern. The hydrocarbon storage industry has developed useful, detailed standards, guidance, and criteria for designing and constructing caverns; these are appropriate for waste disposal caverns, too. Hundreds of storage caverns have successfully been operated worldwide for several decades.

- There is no actual field experience on the long-term impacts that might arise from salt cavern storage of oil field wastes. The literature contains many theoretical studies that estimate what might happen following closure of a cavern. Although different authors agree that pressures will build in a closed cavern due to salt creep and geothermal heating, they do not specifically address caverns filled with oil field wastes. Several experienced researchers in the field interviewed by the authors believed that caverns filled with oil field wastes presented much less likelihood of leakage than fluid-filled caverns, although other experienced researchers believed that until the pore space of the waste pile is reduced through creep-induced compaction, a solids-filled cavern will behave in the same way as a fluid-filled cavern. More field research on the effects of pressure buildup in closed caverns would aid our understanding of this subject.

- No attempt was made in this study to evaluate the cost effectiveness of cavern disposal of oil field wastes. Additional research in the areas of risk assessment and costs of cavern disposal compared to other alternatives for oil field waste disposal, some of which will be conducted by Argonne National Laboratory during 1996, will facilitate the development of efficient and effective policy.

- On the basis of this preliminary research, we believe that disposal of oil field wastes into salt caverns is feasible and legal. If caverns are well-sited and designed, operated carefully, closed properly, and monitored routinely, they represent a suitable means of disposing of oil field wastes.

References

API, 1993, "Operation of Solution Mined Storage," API Recommended Practice 1115, American Petroleum Institute, Washington, DC, August 5.

API, 1994, "Design of Solution-Mined Underground Storage Practices," API Recommended Practice 1114, American Petroleum Institute, Washington, DC, June.

Berest, P., and B. Brouard, 1995, "Behavior of Sealed Solution-Mined Caverns," presented at 1995 Solution Mining Research Institute's Spring Meeting, New Orleans, LA, April 30-May 3.

Bishop, W.M., 1986, "Long-Term Disposition of SPR Caverns Not Used for Petroleum Storage, A Draft Plan," unpublished report, October 27.

Bishop, W.M., 1994, letter from Bishop, PB-KBB, Houston, TX, to R. Taylor, Taylor SWD Operating, Inc., concerning "Fracture Potential for Taylor #2 during Long Term Closure," August 11.

Coates, G.K., C.A. Lee, W.C. McClain, and P.E. Senseny, 1983, "Closure and Collapse of Man-Made Cavities in Salt," in Proceedings of Sixth International Symposium on Salt, pp. 139-157.

Crotogino, F., 1990, "Technical Concept for a Hazardous Waste Cavern in Salt in Accordance with the German Regulations on Hazardous Waste," presented at the Solution Mining Research Institute's Fall Meeting, Paris, France, October.

Crotogino, F., 1994, "Waste Disposal in Salt Caverns - The Situation in Germany," presented at Spectrum '94, Atlanta, GA, August 14-18.

CSA, 1993, "Storage of Hydrocarbons in Underground Formations - Oil and Gas Industry Systems and Materials," CSA Standard Z341-93, Canadian Standards Association, Rexdale, Ontario, Canada, July.

Diamond, H.W., 1996, letter containing Solution Mining Research Institute's comments on 2nd draft of Argonne National Laboratory report, "Preliminary Technical and Legal Evaluation of Disposing of Nonhazaradous Oil Field Waste into Salt Caverns (February 14, 1996)," from Diamond, Solution Mining Research Institute, Deerfield, IL, to J.A. Veil, Argonne National Laboratory, Washington, DC, April 30.

DOE, 1978, "Final Environmental Impact Statement, Strategic Petroleum Reserve, Seaway Group Salt Domes (Bryan Mound Expansion, Allen, Nash, Damon Mound, and West Columbia), Brazoria County Texas," U.S. Department of Energy, DOE/EIA-0021, June.

Ehgartner, B.L., and J.K. Linn, 1994, "Mechanical Behavior of Sealed SPR Caverns", paper presented at Solution Mining Research Institute's Spring Meeting, Houston, TX, April 25-27.

Elder, J.R., 1993, draft memorandum from Elder, Director of EPA's Office of Ground Water and Drinking Water to Water Management Division Directors, Region II-X, "RCRA-Exempt Oil and Gas Exploration and Production Wastes and Authorization for Injection into Class II Wells - Underground Injection Control Program Guidance #XX," March 17.

Fuller, J., and J. Boyt, 1995, internal Oil and Gas Division memorandum to B. Williamson, C.K. Rylander, and C.R. Matthews, Railroad Commission of Texas, on "Cavern Disposal Wells," May 1.

Hoather, H.A., and D. Challinor, 1994, "The Use of Salt Cavities for the Disposal of Waste," presented at the Solution Mining Research Institute's Fall Meeting, Hannover, Germany, September 25-October 1.

IOGCC, 1994, "IOGCC Environmental Guidelines for State Oil & Gas Regulatory Programs," the Interstate Oil and Gas Compact Commission, Oklahoma City, OK, May.

IOGCC, 1995, "Natural Gas Storage in Salt Caverns - A Guide for State Regulators," the Interstate Oil and Gas Compact Commission, Oklahoma City, OK, October.

Jirik, C.J., and L.K. Weaver, 1976, "A Survey of Salt Deposits and Salt Caverns - Their Relevance to the Strategic Petroleum Reserve," U.S. Federal Energy Administration, FEA/S-76/310.

Johnson, K.S., and S. Gonzales, 1978, "Salt Deposits in the United States and Regional Geologic Characteristics Important for Storage of Radioactive Wastes," prepared for Office of Waste Isolation, U.S. Department of Energy, by Earth Resource Associates, Y/OWI/SUB-7414/1, March.

Knudson, M.O., 1993, letter from Knudson, Water Management Division, EPA Region 6, Dallas, TX, to H.W. Thompson, Louisiana Department of Natural Resources, Baton Rouge, LA, about Class II Wastestream Classification, April 20.

Linn, J.K., 1995, memorandum containing comments on draft salt cavern report from Linn, Sandia National Laboratories, Albuquerque, NM, to J. Veil, Argonne National Laboratory, Washington, DC, September 15.

Matalucci, R.V., 1993, "A Review of Alternative Techniques for Repairing Leaks in Strategic Petroleum Reserve (SPR) Cavern Wells," Sandia National Laboratories, Albuquerque, NM, SAND92-2475, August.

NGS, date unspecified, "Experimentaluntersuchungen zur Ablagerung von Abfallen in Salzkavernen (Experimental Studies into the Disposal of Wastes in Salt Caverns)," prepared by Niedersachsische Gesellschaft zur Endlagerung von Sonderabfall mbH (Lower Saxony Company for the Final Disposal of Hazardous Waste), Hannover, Germany.

Nieto-Pescetto, A.S., and A.J. Hendron, Jr., 1977, "Study of Sinkholes Related to Bedded Salt Production in the Area of Detroit, Michigan," published by Solution Mining Research Institute, Flossmoor, IL, November.

Pearson, A.G.A., and A. Alseth, 1995, U.S. Patent No. 5,433,553, "Method for Refuse Disposal in Solution-Mined Salt Cavities," July 18.

Pfeifle, T.W., T.J. Vogt, and G.A. Brekken, 1995, "Correlation of Chemical, Mineralogic, and Physical Characteristics of Gulf Coast Dome Salt to Deformation and Strength Properties," Solution Mining Research Institute Research Project Report 94-0004-S, Deerfield, IL, January.

Querio, C.W., 1980, "Design and Construction of Solution-Mined Caverns for LPG Storage," presented at Solution Mining Research Institute's Fall Meeting, Minneapolis, MN, October 12-15.

Serata, S., 1984a, "Ultimate Stress in the Salt Envelope of a Sealed Liquid-Filled Solution Cavern," Vol. 1, prepared for Solution Mining Research Institute, Woodstock, IL, by Serata Geomechanics, August 15.

Serata, S., 1984b, "Follow-Up Proposal for Practical Application: Ultimate Stress in the Salt Envelope of a Sealed Liquid-Filled Solution Cavern," prepared for Solution Mining Research Institute, Woodstock, IL, by Serata Geomechanics, October 15.

Thoms, R.L., 1995, memorandum containing comments on draft salt cavern report from Thoms, AGM, Inc., College Station, TX, to J. Veil, Argonne National Laboratory, Washington, DC, October 3.

Thoms, R.L., 1996, memorandum containing opinions on cavern stability from Thoms, AGM, Inc., College Station, TX, to J. Veil, Argonne National Laboratory, Washington, DC, and H.W. Diamond, Solution Mining Research Institute, Deerfield, IL, May 21.

Thoms, R.L. and R.M. Gehle, 1990, "Hydrofrac Gradient in Gulf Coast Salt Domes - Phase 2," Research Project Report for the Solution Mining Research Institute, October 31.

Thoms, R.L., and R.M. Gehle, 1994, "Analysis of a Solidified-Wastes Disposal Cavern in a Gulf Coast Salt Dome," presented at the Solution Mining Research Institute's Fall Meeting, Hannover, Germany, September 25-October 1.

Tinucci, J.P., S.-J. Chern, W.C. Yeung, and B. Dial, 1988, "A Study of Hazardous Waste Disposal in Salt," presented at the Solution Mining Research Institute's Spring Meeting, Mobile, AL, April 25.

TNRCC, 1995, Texas Natural Resource Conservation Commission, T.A.C., Title 30, Chapter 331, Subchapter J, Standards for Class I Salt Cavern Solid Waste Disposal Rules, §331.164.

Tomasko, D., 1985, "A Numerical Model for Predicting the Thermal Behavior of Caverns in the Strategic Petroleum Reserve", dissertation submitted in partial fulfillment of the requirements of the degree of Doctor of Philosophy in Civil Engineering, the University of New Mexico, Albuquerque, New Mexico.

Wallner, M., and A. van Vliet, 1993, "Assessment of Surface Subsidence above a Cavity Field Resulting from Cavity Diameter Enlargement, presented at the Seventh Symposium on Salt, Vol. I, pp. 489-496, Elsevier Science Publishers B.V., Amsterdam, Netherlands.

Wassman, T.H., 1983, "Cavity Utilization in the Netherlands," presented at the Sixth International Symposium on Salt, Vol. II, pp.191-201, Toronto, Canada, May.

Wassmann, T.H., 1993, "Mining Subsidence above Cavities Created by Solution Mining of Rocksalt," presented at the Seventh Symposium on Salt, Vol. I, pp. 425-431, Elsevier Science Publishers B.V., Amsterdam, Netherlands.

Table 1 - State Activities Regarding Disposal of Oil Field Waste into Salt Caverns

State	Contact	Are salt caverns being used in your state for disposal of oil industry waste?	Has this practice ever been considered?	Are there any state regulations specifically addressing disposal of oil field waste into salt caverns?	Comments
TX	Richard Ginn Texas Railroad Comm. Austin, TX 78711-2967 512/463-6796 or Jeb Boyt 512/463-7562	Yes Texas has four salt caverns that accept O&G production wastes.	N/A	Proposed regulations have been drafted.	The first facility was established four years ago. The wastes that are being disposed of in these caverns have a high solids content (suspended solids), which make them less suitable for typical Class II injection. The salt brine that is displaced from the cavern to make space for the O&G waste is disposed of in Class II wells.
LA	James Welsh LA Department of Natural Resources P.O. Box 94275 Baton Rouge, LA 70804 504/342-5515	No	Yes	No	No hazardous waste can be disposed of via injection wells in Louisiana. He indicated that injection of production waste streams with a high solids content (cuttings, drilling fluids, etc.) are not much of an issue with injection into Class II wells when the technology (ball mills or grinders) is used to grind the solids into fine particles. They are open to the idea.
MI	R. Thomas Segall MI Dept. of Natural Resources P.O. Box 30028 Lansing, MI 48909 517/334-6923 or Raymond Ellis 517/334-6923	No	Yes	No	Michigan is interested in knowing what the other states are considering. They currently permit cavern use for liquid natural gas storage.
OH	Dennis Crist OH DNR Fountain Square Columbus, OH 43224 614/265-6926	No	Yes	No	He thinks it is a good idea for the disposal of solid wastes (drilling fluids) not typically disposed of in Class II wells. He feels that a Federal Advisory Committee on the subject should be considered.
KS	Richard Hestermann KS Corp. Comm. Colorado Derby Bldg., Rm 200 Wichita, KS 67202 316/337-6200	No	No	No	He indicated that he was not aware of any discussions about permitting such activity in the state of Kansas. Some of the older solution mines that had been abandoned and injection wells that had gone through these salt deposits have been assumed responsible for sink holes that have occurred in Kansas. It is thought that fluid traveling down hole along the casing through the salt deposit displaced the salt and created a void that eventually collapsed.

Table 1 - State Activities Regarding Disposal of Oil Field Waste into Salt Caverns

State	Contact	Are salt caverns being used in your state for disposal of oil industry waste?	Has this practice ever been considered?	Are there any state regulations specifically addressing disposal of oil field waste into salt caverns?	Comments
OK	Bruce Langhus OK Corp. Comm. Jim Thorpe Building Oklahoma City, OK 73105 405/521-2500	No	No	No	The salt deposits in Oklahoma are not thick and conducive to solution mining. There is only one solution mine in the state.
MS	Fred Hille State O&G Board 500 Greymont Ave., Suite E Jackson, MS 39202 601/354-7127 or James Crawford Dept. of Env. Quality P.O. Box 10385 Jackson, MS 39289 601/961-5354	No	Yes	He indicated that the existing state regulations do not prohibit this practice. No state regulations would need to be changed to allow this practice.	They had been thinking that the disposal of Naturally Occurring Radioactive Material (NORM) wastes from O&G production might be effectively disposed of in salt caverns. Mississippi is very interested in what other states are thinking.
ND	Charles A. Koch ND Industrial Comm. 600 E. Boulevard Ave. Bismarck, ND 58505 701/328-5357 or Wesley Norton 701/328-2969	No	No	No	North Dakota only has one solution mine. It is in an O&G production area. Several years ago the state considered using salt caverns for storage but made the decision not to. O&G drillers have experienced many casing problems through the salt section which is approximately 600 feet thick. He did not feel that North Dakota would likely utilize salt caverns for O&G waste disposal since the salt formations are very deep.
NM	David Catanach NM Oil. Conserv. Div. P.O. Box 2088 Santa Fe, NM 87504 505/827-7131	No	Yes	No	NM Oil Conservation Division has received an application from a company interested in developing a commercial oil field waste disposal facility in NM. The NM Oil Conservation Division will be handling the application. The existing state regulations are silent on the subject.

Table 1 - State Activities Regarding Disposal of Oil Field Waste into Salt Caverns

State	Contact	Are salt caverns being used in your state for disposal of oil industry waste?	Has this practice ever been considered?	Are there any state regulations specifically addressing disposal of oil field waste into salt caverns?	Comments
NY	John C. Harmon NY Dept. of Env. Cons. 50 Wolf Road, Rm 202 Albany, NY 12233 518/457-9633 or Bradley Field 518/457-0100	No	No	No	Several years ago, there was some consideration of permitting disposal of municipal fly ash into a large conventional salt mine. However, a roof collapsed in a portion of the mine, causing flooding of the cavern, and the permit was never granted. He stated that injection of O&G waste into salt caverns is not likely in New York. There is little need for the disposal of solid drilling waste because most of the wells are air drilled (not utilizing drilling fluids).
PA	James Erb PA Dept. of Envir. Resources P.O. Box 2357 Harrisburg, PA 17120 717/772-2199	No	No	No (See Comments)	The Division of O&G has rules to permit the use of caverns for gas storage, but the Bureau of Labor and Industry regulates caverns. There are several storage caverns permitted.

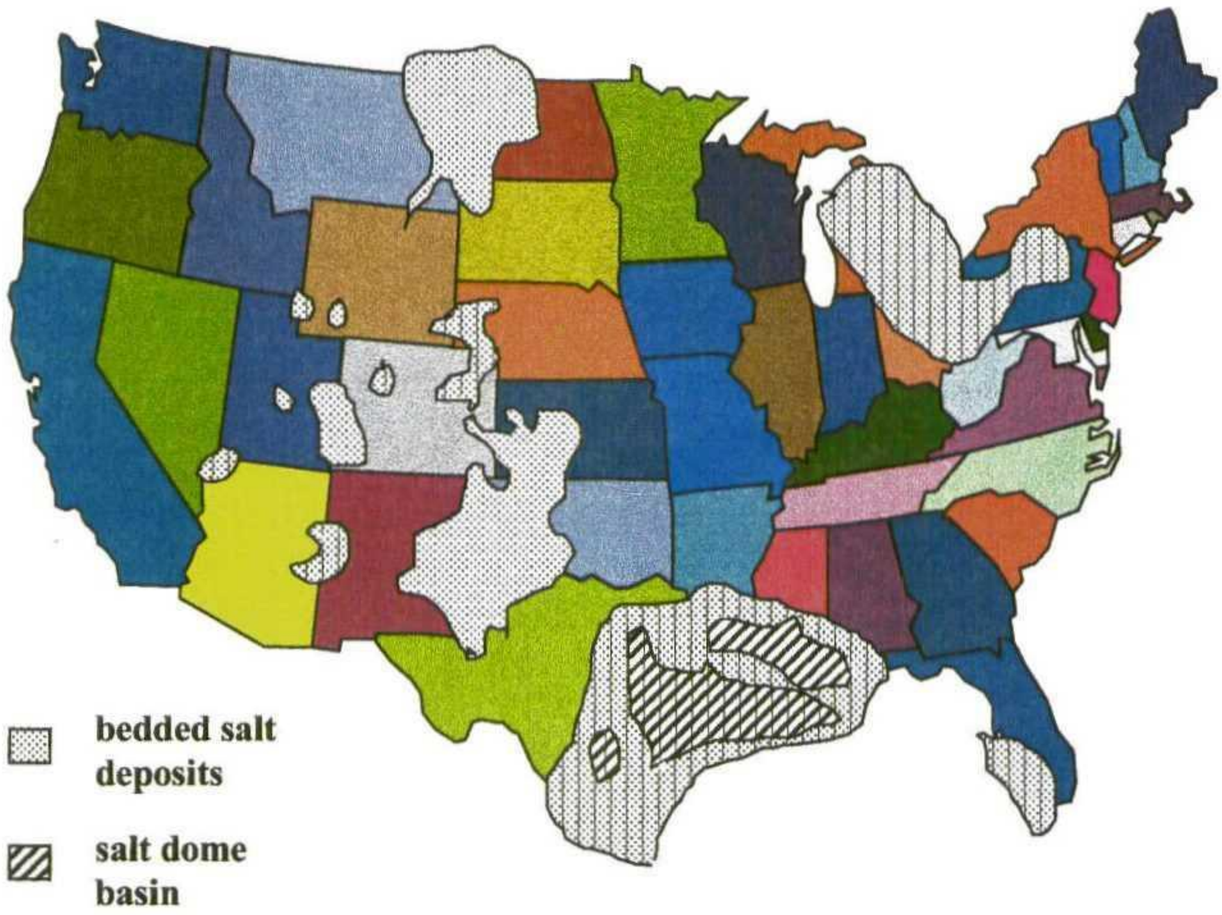
Table 2 - Oil and Gas Wastes Exempted from RCRA Hazardous Waste Requirements (53 FR 25446, July 6, 1988)

- Produced water;
- Drilling fluids;
- Drill cuttings;
- Rigwash;
- Drilling fluids and cuttings from offshore operations disposed of onshore;
- Well completion, treatment, and stimulation fluids;
- Basic sediment and water and other tank bottoms 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 of exempt wastes;
- Workover 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 amines, 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;
- 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 from the production stream, such as hydrogen sulfide and carbon dioxide, and volatilized hydrocarbons;
- Materials ejected from a producing well during the process known as blowdown;
- Waste crude oil from primary field operations and production; and
- Light organics volatilized from exempt wastes in reserve pits or impoundments or production equipment.

FIGURE 1 Major U.S. Subsurface Salt Deposits

(redrawn from Johnson and Gonzales 1978)



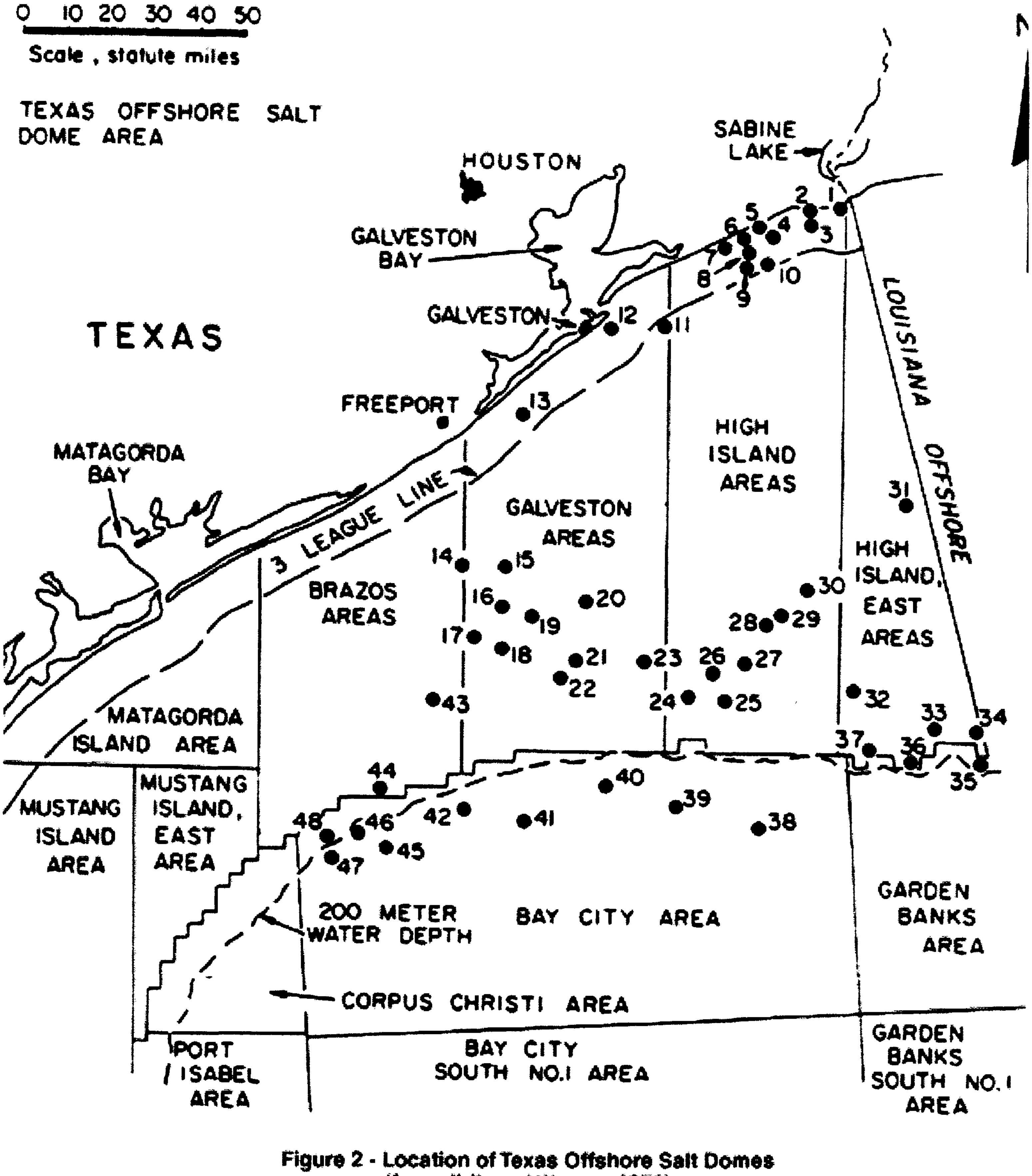


Figure 2 - Location of Texas Offshore Salt Domes (from Jirik and Weaver 1976)

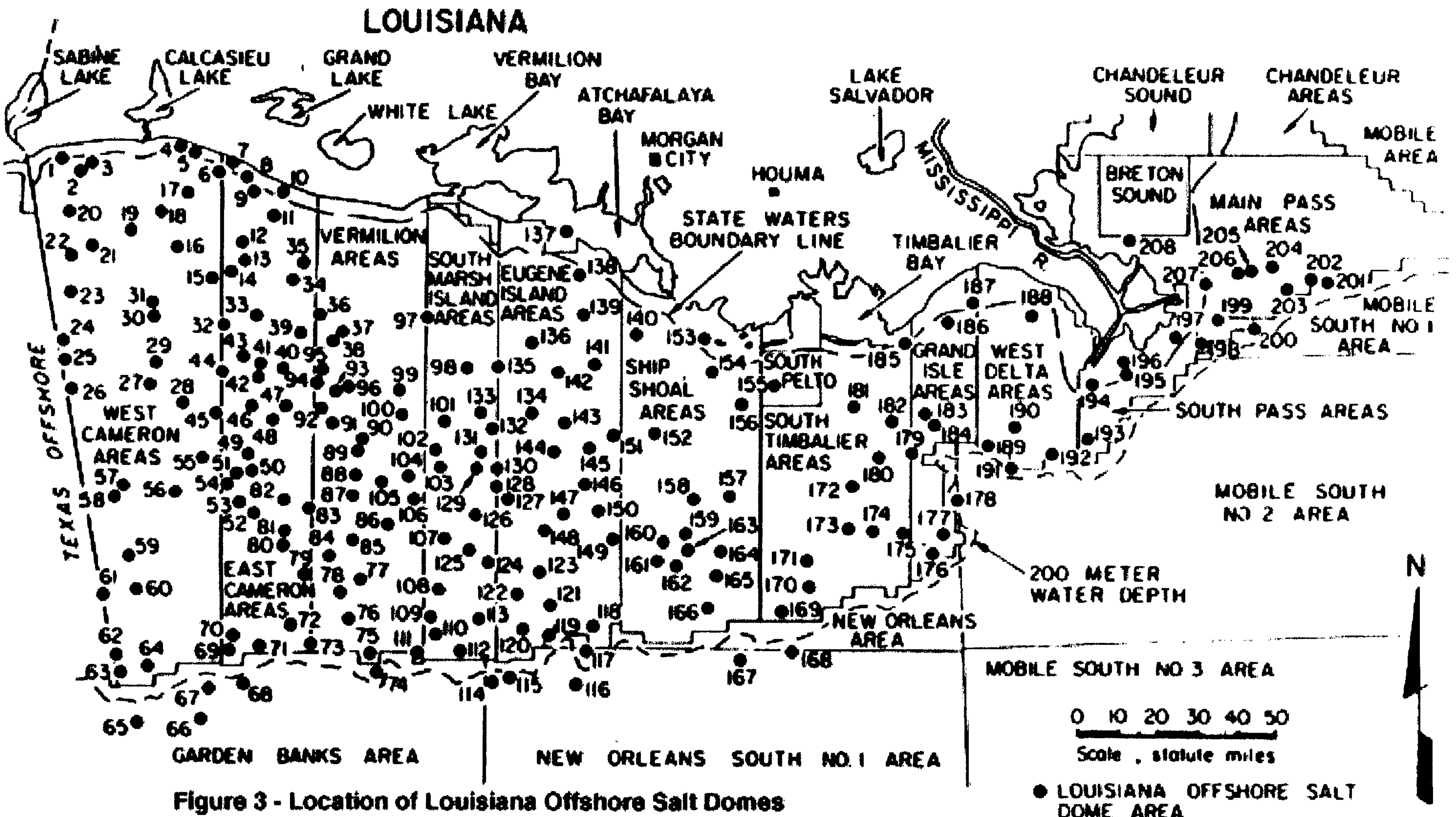


Figure 3 - Location of Louisiana Offshore Salt Domes (from Jirik and Weaver 1976)

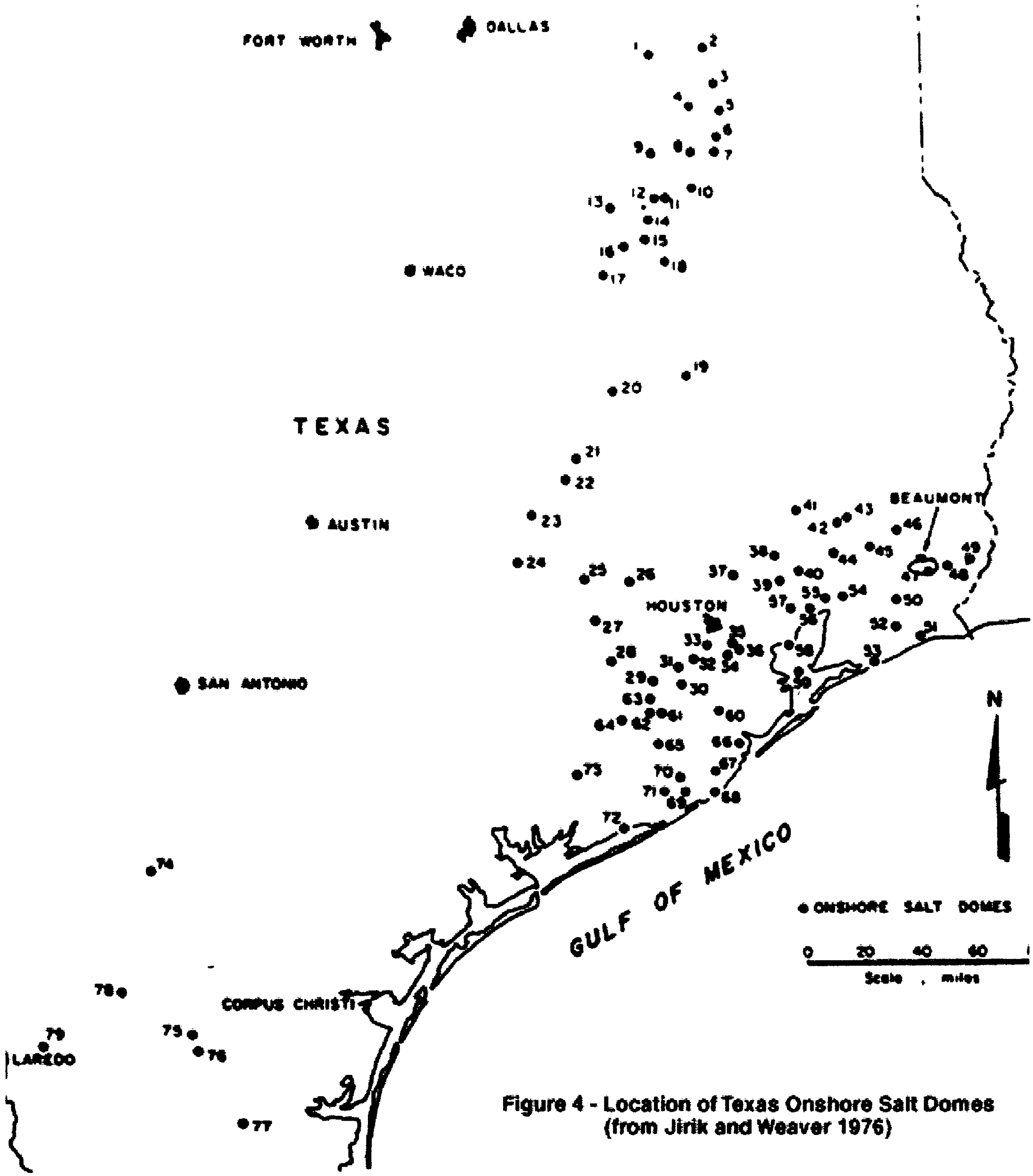


Figure 4 - Location of Texas Onshore Salt Domes (from Jirik and Weaver 1976)

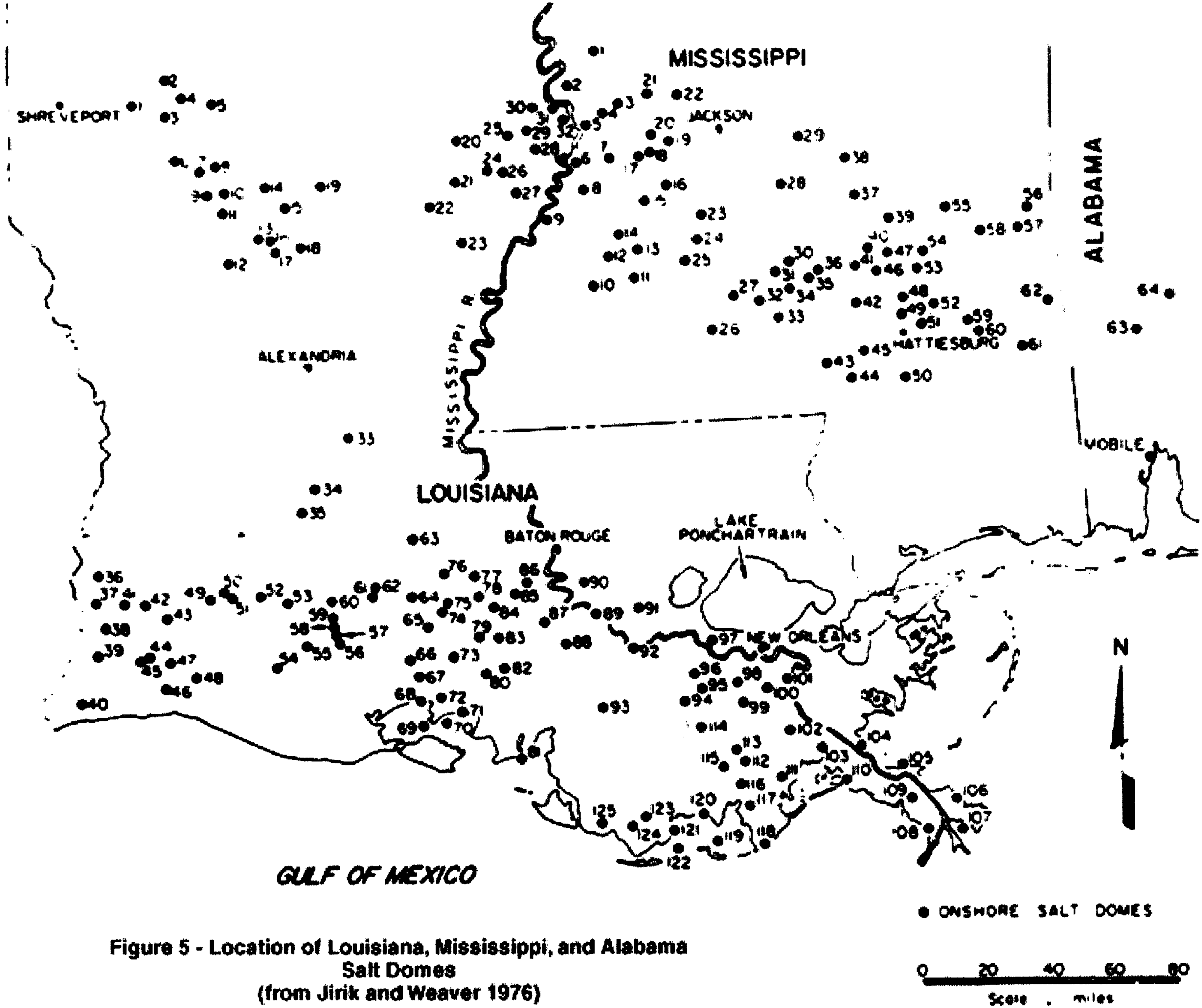


Figure 5 - Location of Louisiana, Mississippi, and Alabama Salt Domes
(from Jirik and Weaver 1976)

FIGURE 6 Idealized Cavern in a Salt Dome Formation

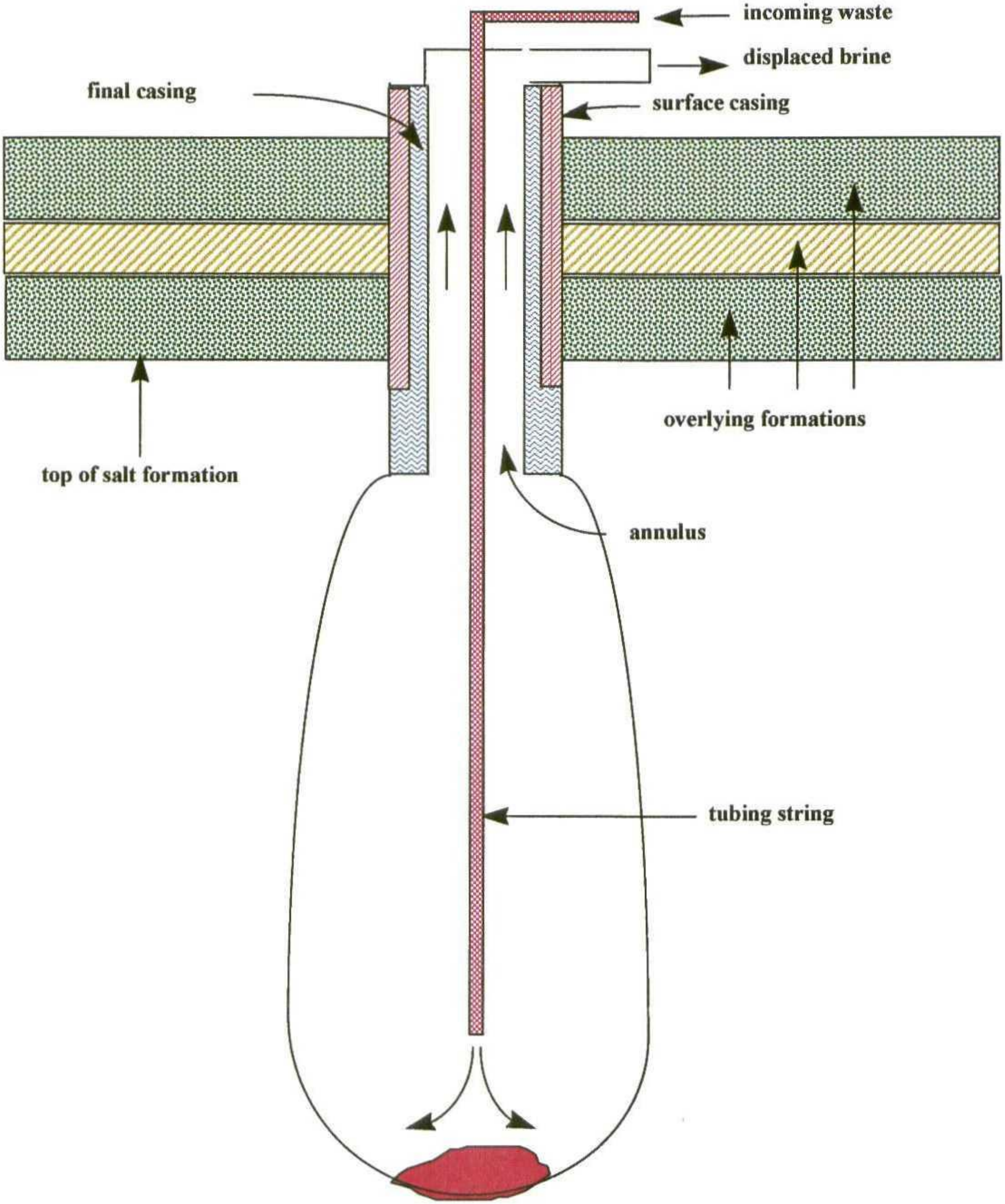
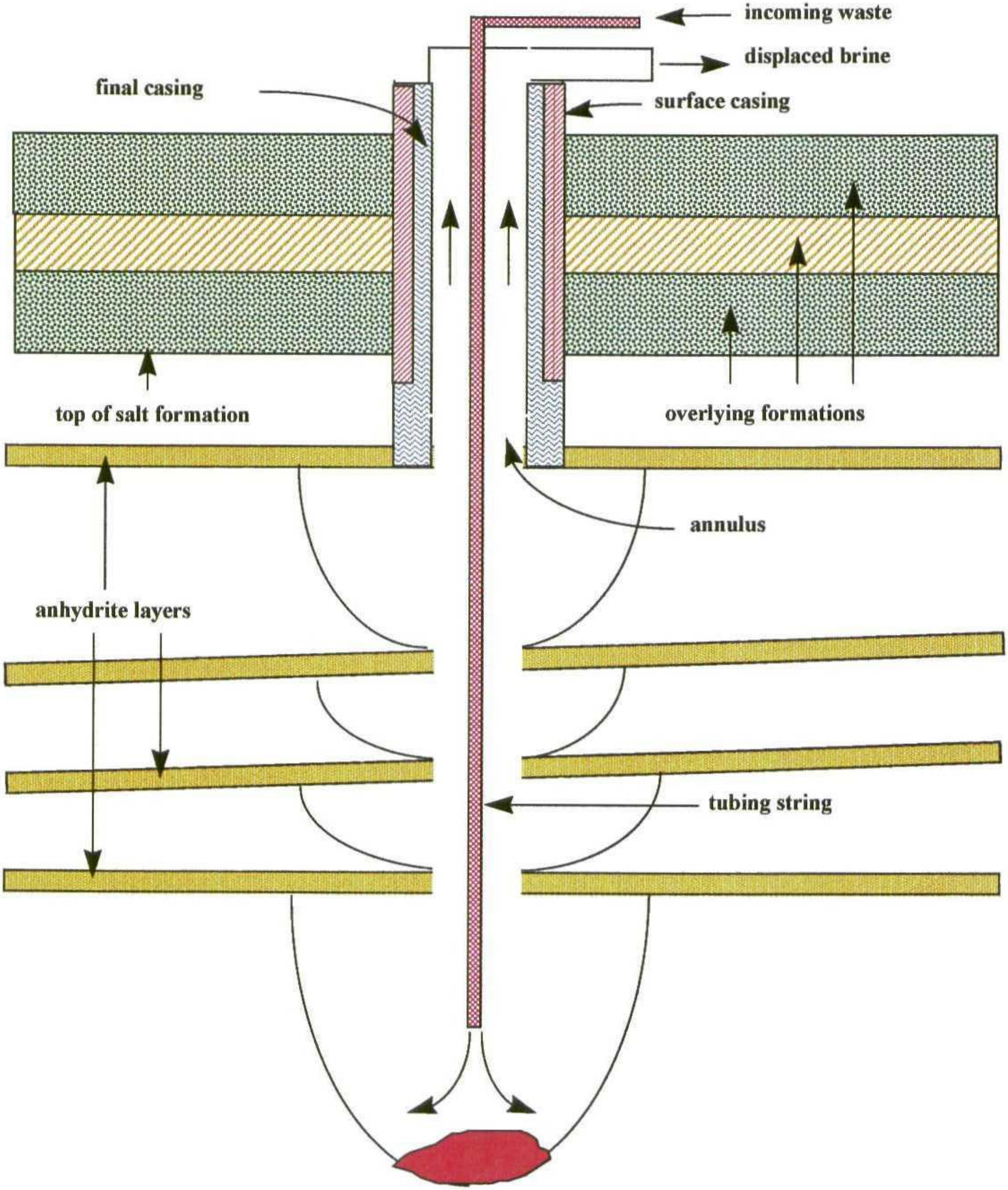


FIGURE 7 Idealized Cavern in a Bedded Salt Formation



Permian Brine Sales, Inc.

6067 West 10 th Street
Odessa, Texas 79763
(915) 381-0531
Fax: (915) 381-9316

FAX TRANSMISSION COVER SHEET

Date: *August 6, 1996*

To: *Mr. Mark Ashley*

Fax: *505-827-8177*

Re: *Rule 9*

Sender: *A.L. Hickerson*

YOU SHOULD RECEIVE 10 PAGE(S), INCLUDING THIS COVER SHEET. IF YOU DO NOT RECEIVE ALL THE PAGES, PLEASE CALL (915) 381-0531.

TEXAS MID-CONTINENT OIL & GAS ASSOCIATION

June 4, 1996

Mr. Jeb Boyt, Staff Attorney
Environmental Section
Office of General Counsel
Railroad Commission of Texas
P. O. Box 12967
Austin, Texas 78711-2967

Re: <u>Draft Proposed Amendments to Rule 9, Disposal Wells</u>

Dear Mr. Boyt:

Texas Mid-Continent Oil & Gas Association (TMOGA) appreciates your giving us this opportunity to comment on the Railroad Commission's proposed draft amendments to Statewide Rules 9 and 81 pertaining to disposal of oil and gas wastes in solution-mined salt caverns and brine mining injection wells, respectively.

The changes which have been made to the draft amendments since the September 13, 1995, conference are very positive. The commission has focused more on defining the expectations as opposed to setting prescriptive requirements. This approach will allow the specific conditions at each cavern disposal well to be considered and will require the operator to prepare a properly engineered design, operating plan and closure plan.

We do recommend that the revisions set out in this draft proposal be written into a new rule rather than as amendments to existing Statewide Rule 9. We feel that cavern disposal wells and the application of cavern disposal are so rare compared to regular disposal wells that Rule 9 ought to be left alone. However, to distinguish Rule 9 from Rule 46 and Rule "New" it would be appropriate to revise the title of Rule 9 to something like, "Disposal Wells in Non-Productive Reservoirs". We also recommend that existing approved permits for cavern disposal be administratively converted to the new rule.

Our membership strongly believes that acceptance of existing and newly created solution-mined salt caverns for disposal of exempt oil and gas wastes is a positive step. In recognizing this as a viable, environmentally safe method of disposal and providing for its proper permitting, the Commission can give industry another efficiency tool with which to reduce operating costs, thus extending the lives of producible hydrocarbon reserves while maintaining or even lowering the risk to precious underground sources of drinking water. Simultaneously, you are creating a valuable "new lease on life" for many existing solution-mined caverns formerly used for hydrocarbon product storage.

There is a long history of safe, contained storage in underground salt caverns which we feel is the ultimate performance-driven data needed to prove the viability of salt caverns as a sealed, safe container into which to place oil and gas waste.

Our specific comments are detailed in the attached table showing your proposed amended language on the left and our recommendations on the right. The italicized annotations provide some thoughts on why we made certain specific recommendations. These comments have been prepared in the context of the proposed Rule 9 structure. If a new rule is written as we suggest, it would be necessary to adjust the rule structure and adapt into the new rule from Rule 9 subsections (a)(4), Notice and opportunity for hearing, (a)(5), Subsequent Commission action, (a)(7), Casing, (a)(9) - (10), Well record and Monitoring and reporting, and (a)(13), Penalties.

We appreciate the opportunity to comment on this draft and would be pleased to discuss our comments with you in more detail. If you would like to discuss our comments, please contact Jim Collier with Amoco at (713) 366-3371 or Gene Montgomery with Shell at (713) 544-3426.

Sincerely,

Rob Looney

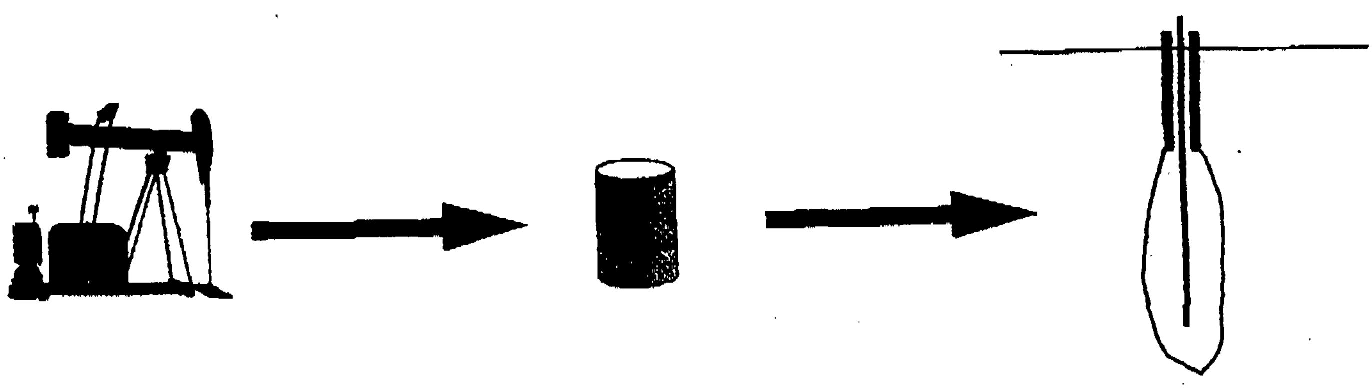
RL:ad
Attachment

Preliminary Technical and Legal Evaluation of Disposing of Nonhazardous Oil Field Waste into Salt Caverns

Prepared for: U.S. Department of Energy
Office of Fossil Energy
under Contract W-31-109-ENG-38

Prepared by: Argonne National Laboratory
Washington, DC

John Veil
Deborah Elcock
Mary Raivel
Dan Caudle
Robert C. Ayers, Jr.
Ben Grunewald



June 1996

Table of Contents

List of Tables

List of Figures

Acknowledgements

The authors wish to express their appreciation for the many persons who provided copies of reports and papers, spoke with us about various salt cavern issues, and provided comments on the two drafts of the report. We particularly extend thanks to Richard Ginn of the Railroad Commission of Texas, R.D. Hickerson of Permian Brine Sales, Inc., and H.W. Diamond of the Solution Mining Research Institute. Mr. Diamond coordinated an extensive review of the second draft report. The review panel consisted of the following persons:

William Barlow	Texas Brine
Charles Chabannes	Sofregaz US Inc.
Dennis Crist	Ohio Department of Natural Resources
Fritz Crotogino	Kavernen Bau- und Betriebs GmbH
Ken E. Davis	Envirocorp Services & Technology, Inc.
H.W. Diamond	Solution Mining Research Institute
Norbert Heitmann	PB-KBB, Inc.
James Linn	Sandia National Laboratories
Joe L. Ratigan	RE/SPEC, Inc.
Robert Thoms	AGM, Inc.
Frank Whelpy	Sonar and Well Testing Service
Scott Whitelaw	Texas Brine

The final report reflects the contributions of each of these persons.

Preliminary Technical and Legal Evaluation of Disposing of Nonhazardous Oil Field Waste into Salt Caverns

by

J. Veil, D.Elcock, M. Raivel, D. Caudle, R.C. Ayers, Jr., and B. Grunewald

Executive Summary

Bedded and domal salt deposits occur in many states. If salt deposits are thick enough, salt caverns can be formed through solution mining. These caverns are either created incidentally as a result of salt recovery or intentionally to create an underground chamber that can be used for storing hydrocarbon products or compressed air or for disposing of wastes. This report evaluates the suitability, feasibility, and legality of disposing of nonhazardous oil and gas exploration, development, and production wastes (hereafter referred to as oil field wastes, unless otherwise noted) in salt caverns.

In 1988, the U.S. Environmental Protection Agency (EPA) published a list of those oil field wastes that were exempt from regulation as hazardous wastes under Subtitle C of the Resource Conservation and Recovery Act (RCRA). EPA's Underground Injection Control (UIC) regulations allow most of those oil field wastes to be injected into Class II UIC wells. Efforts are currently under way to obtain clarification from EPA whether all exempted oil field wastes can be injected into Class II wells. At the state level, only the Railroad Commission of Texas (TRC) has formally authorized disposal of oil field wastes into salt caverns. The TRC has issued permits for six facilities, but as of May 1996, only four of these were active. In April 1996, the TRC released draft proposed amendments to TRC Rule 9, the regulation that governs injection into a formation not productive of oil, gas, or geothermal resources. Ten other states were contacted about their interest in disposing of oil field waste into salt caverns. Many of these states were interested in following the TRC program to see how it worked, but at this time, only New Mexico has received an application for disposal of oil field wastes into salt caverns. There are no apparent regulatory barriers to the use of salt caverns for disposal of most types of oil field wastes at either the federal level or in the eleven states discussed in this analysis.

The types of oil field waste that are planned for disposal in salt caverns are those that are most troublesome to dispose of through regular Class II injection wells, because they contain excessive levels of solids. The solids-containing oil field wastes most likely to be disposed of in salt caverns include used drilling fluids, drill cuttings, completion and stimulation waste, produced sand, tank bottoms, and soil contaminated by crude oil or produced water.

The location and design of waste disposal caverns play an important role in ensuring long-term waste isolation from the surface water or groundwater resources. Hundreds of caverns have been used safely for storing hydrocarbons. The hydrocarbon storage industry has developed useful, detailed standards and guidance for designing and constructing storage caverns

that are also appropriate for creating solution-mined caverns for other uses. Several factors should be considered in selecting sites for disposal of oil field wastes in caverns, including distance to populated areas; proximity to other industrial facilities; current and future use of adjacent properties; handling of brine or other displaced fluid; proximity to environmentally sensitive wetlands, waters, and fresh water aquifers; proximity to the salt boundary; and proximity to other existing and abandoned subsurface activities, such as neighboring caverns for brine or hydrocarbon storage. Detailed knowledge of the geology should be supported by adequate documentation. Operators should be able to demonstrate that the caverns they plan to use — either new caverns developed specifically for oil field waste disposal, or existing caverns that are being converted — will remain stable in the future.

Disposal caverns act like large oil/water/solids separators. The solids in the incoming waste settle to the bottom of the cavern while the lighter oils and hydrocarbons rise to the top of the cavern, where they can be removed. When placing waste in a cavern, the cavern space is best utilized by filling evenly and uniformly, with no large voids. One method for emplacing the waste in the cavern is to inject it through the tubing to the bottom of the cavern. Under this scenario, an operator of an oil field waste disposal cavern would inject waste until the end of the tubing is covered or the back pressure from the accumulated waste precludes further injection. At this point, the operator would use a small controlled explosive charge to cut off the end of the tubing further up the cavern. Another Texas operator prefers to inject waste through the tubing/casing annulus into the top of the cavern and allow the waste to settle to the bottom. A third Texas operator has installed two wells in the cavern, one for injection and the other for brine withdrawal. Under any of these waste emplacement scenarios, cavern pressure should be monitored and controlled before the cavern is filled with oil field waste, throughout the waste emplacement cycle, and optimally, for some period of time after waste emplacement has ended.

There is no actual field experience on the long-term impacts that might arise from salt cavern disposal of oil field wastes. The literature contains many theoretical studies that speculate what might happen following closure of a cavern. Although different authors agree that pressures will build in a closed brine-filled cavern due to salt creep (domal salt only) and geothermal heating, they do not specifically address caverns filled with oil field wastes. Caverns filled with oil field wastes having specific gravities greater than that of brine will have a lower likelihood of failure than caverns filled with brine. More field research on pressure buildup in closed caverns is desirable.

Based on this preliminary research, we believe that disposal of oil field wastes into salt caverns is feasible and legal. If caverns are sited and designed well, operated carefully, closed properly, and monitored routinely, they represent a suitable means of disposing of oil field wastes.

CRI

CONTROLLED RECOVERY INC.

P.O. BOX 369, HOBBS, NM 88241 (505) 393-1079

OIL CONSERVATION DIVISION RECEIVED
'96 APR 22 AM 8 52

April 19, 1996

RECEIVED
APR 22 1996
Environmental Bureau
Oil Conservation Division

MR. WILLIAM J. LEMAY
State of New Mexico
Energy, Minerals and Natural
Resources Department
Oil Conservation Division
2040 South Pacheco
Santa Fe, New Mexico 87505

Re: (GW-226) Permian Brine Sales
(UIC-CL1-006) P & S Brine Sales

Dear Mr. LeMay:

I am enclosing additional information regarding referenced permit applications. Hopefully, this documentation will encourage denial of referenced.

Thank you.

Sincerely,

Gail Power

Gail Power

GP/jh

Enclosures: 1. RRC of Texas Proposed Amendments April 4, 1996
2. Exxon Newsletter April 8, 1996
3. Midland Reporter-Telegram Article August 23, 1995
4. CRI Letter Dated March 15, 1996

Carole Keeton Rylander, Chairman
Barry Williamson, Commissioner
Charles R. Matthews, Commissioner

Lindil C. Fowler, Jr., General Counsel
Terri Eaton, Asst. Director
Environmental Section

RAILROAD COMMISSION OF TEXAS
OFFICE OF GENERAL COUNSEL

April 4, 1996

Notice of Draft Proposed Amendments to Rule 9, Disposal Wells, and a Conforming Amendment to Rule 81, Brine Mining Injection Wells

Attached for review and comment is a draft of proposed amendments to Rule 9, Disposal Wells, and a conforming amendment to Rule 81, Brine Mining Injection Wells. The draft amendments specify requirements for the disposal of oil and gas waste in solution-mined salt caverns.

Please submit your written comments on the draft of proposed amendments to Rule 9 and the conforming amendment to Rule 81 by 5:00 p.m. on June 4, 1996. Comments should be addressed to Jeb Boyt, Staff Attorney, Environmental Section, Office of General Counsel, Railroad Commission of Texas, P.O. Box 12967, Austin, Texas 78711-2967.

If you have any questions regarding the draft amendments, please contact Jeb Boyt at 512/463-7562 or Richard Ginn, Deputy Assistant Director for Underground Injection Control, at 512/463-6796.

Jeb Boyt, Staff Attorney
Environmental Section

The Railroad Commission of Texas (commission) proposes to amend §3.9, concerning disposal wells. The proposed amendments to §3.9 specify requirements for the disposal of oil and gas wastes in solution-mined salt caverns and modify provisions of §3.9 relating to modification, suspension, or termination of permits. The commission also proposes a conforming amendment to §3.77, concerning brine mining injection wells, to clarify that a well used to solution-mine a cavern for the disposal of oil and gas waste is subject to regulation as a brine mining injection well during active solution-mining operations.

The proposed amendments would apply to wells used to dispose of oil and gas wastes in solution-mined salt caverns. Such salt caverns may be located in either salt domes or bedded salt formations. Under the proposed rule amendments, an existing salt cavern may be converted for use as a cavern disposal well if the requirements of these proposed rules and the applicable requirements of §3.9(a) are met.

The commission proposes to amend §3.9(a) by adding the title "General requirements" and by amending paragraph (5)(A) to clarify that the commission may modify, suspend, or terminate a disposal well permit if operation of the well is dangerous to life or property.

Proposed §3.9(b) addresses issues specific to the disposal of oil and gas waste in salt caverns. Subsection (b) defines a "cavern disposal well" as a well used to dispose of oil and gas waste, as that term is defined in Chapter 27 of the Texas Water

Code, in a solution-mined salt cavern. "Oil and gas waste" as defined under §27.002(6) of the Texas Water Code means "waste arising out of or incidental to drilling for or producing oil, gas, or geothermal resources, waste arising out of or incidental to the underground storage of hydrocarbons other than storage in artificial tanks or containers, or waste arising out of or incidental to the operation of gasoline plants, natural gas processing plants, or pressure maintenance or repressurizing plants. The term includes but is not limited to salt water, brine, sludge, drilling mud, and other liquid or semi-liquid waste material."

Proposed §3.9(b)(1)(A) specifies the following requirements of subsection (a) that apply to cavern disposal wells in addition to the provisions of subsection (b): paragraph (4), relating to notice and opportunity for hearing; paragraph (5), relating to subsequent commission action; paragraph (7), relating to casing; paragraph (9), relating to well record; paragraph (10), relating to monitoring and reporting; and paragraph (13), relating to penalties. The remaining provisions of subsection (a) do not apply to cavern disposal wells.

Proposed §3.9(b)(1)(B) describes notice requirements for cavern disposal wells that supplement the requirements described under subsection (a)(4)(A). An applicant for a cavern disposal well permit must give notice of the application to each salt leaseholder of the tract on which the cavern disposal well will be located or of any tract adjoining the tract on which the cavern disposal well will be located. Also, when publishing a notice of application, the notice must indicate that the proposed cavern disposal well will be used to dispose of oil and gas waste in an underground salt cavern.

Proposed §3.9(b)(1)(C) provides that persons who propose to dispose of oil and gas waste in a cavern disposal well must obtain a permit from the commission. Proposed §3.9(b)(1)(D) provides that existing permits for cavern disposal wells will remain in effect unless revoked, modified, or suspended by the commission.

Proposed §3.9(b)(2) provides that a cavern disposal well may not pollute surface or subsurface water or endanger life or property. Paragraph (2) also requires that an applicant submit a letter from the Texas Natural Resource Conservation Commission stating that the creation or use of the salt cavern for the disposal of oil and gas waste and the injection of oil and gas waste into the cavern disposal well will not endanger the freshwater strata in that area and that the formation used for disposal is not freshwater sand. This letter is required by Texas Water Code, §27.033.

Proposed §3.9(b)(3) identifies information that must be included in a cavern disposal well permit application. Proposed §3.9(b)(3)(A) requires that an application include a list of the types of oil and gas wastes to be disposed of in the salt cavern; the maximum volume of oil and gas waste to be disposed of in the salt cavern; the substances that will be mixed with the oil and gas waste to facilitate disposal; the size and shape of the cavern as

determined by a recent sonar survey or an estimate of the size and shape of the cavern upon completion, if solution-mining has not been completed, including a description of the model or method used to prepare the estimate; and an estimate of the cavern's size after disposal operations cease, including a description of the model or method used to prepare the estimate.

Proposed §3.9(b)(3)(B) requires that an application include specific geologic information relating to the proposed cavern disposal well. There are separate information requirements for caverns in salt domes and those in bedded salt formations. For caverns in salt domes, an applicant must submit specific information regarding the salt stock, caprock, and surrounding formations. For caverns in bedded salt formations, an applicant must submit specified information regarding the bedded salt formation, anhydrite layers, and the formations above and below the bedded salt formation. This information will be used in a site-specific evaluation of the suitability of the location for the proposed cavern disposal well.

Proposed §3.9(b)(3)(C) requires that an application for a cavern disposal well permit include information on wells and surface features in the area of the proposed cavern disposal well. This information is required to determine if there are any nearby wells, caverns, or other excavations of the salt formation or any subsidence or other dissolution features that may compromise the integrity of the solution-mined cavern. An applicant must provide a list of all wells within a 1/4 mile radius of the proposed cavern disposal well and identify any wells that are unplugged or improperly plugged. The application must include information on the depth, diameter, and volume, and a map indicating the location of any hydrocarbon storage caverns, disposal caverns, brine mining caverns, salt mines, or other excavations of the salt formation and the location and depth of any sulphur mining wells within one-quarter of a mile of the proposed cavern disposal well. An application must also include a topographic map or other map showing surface water bodies and subsidence features within one mile of the property boundaries of the proposed cavern disposal facility.

Proposed §3.9(b)(3)(D) requires that an applicant submit an operating plan for a proposed cavern disposal well. The operating plan must describe the surface facilities, downhole equipment, whether an oil pad will be used in the cavern, the proposed injection methods, and plans for the disposal, use, or sale of the displaced brine. If the displaced brine is to be sold for non-oilfield use, the operating plan must include a plan for monitoring the chemical constituents in the brine. The operating plan must also include a plan for monitoring any affect that disposal operations may have on the size of the cavern, due to incidental dissolution of the cavern, and a description of the methods or models that will be used for monitoring such affect.

Proposed §3.9(b)(3)(E) requires an applicant to provide a plan for the closure of the proposed cavern disposal well. The closure plan must provide for monitoring the shut-in pressure and releasing

any pressure that may accumulate in a shut-in cavern disposal well during the time between cessation of disposal operations and plugging.

For a cavern disposal well in a salt dome, the closure plan must demonstrate that any pressure increase in the cavern after the well is plugged will not affect the ability of the well or cavern to confine the injected fluids. The post-closure pressure increase is predicted by multiplying the difference between the lithostatic and hydrostatic pressure gradients by the height of the cavern. This is expressed as a formula where the pressure increase equals (A - B)(C - D), where A is the lithostatic pressure gradient between the top and bottom of the cavern, B is the hydrostatic pressure gradient between the top and the bottom of the cavern, C is the depth to the bottom of the cavern, and D is the depth to the top of the cavern. A post-closure pressure increase calculation is not required for caverns in bedded salt formations because caverns in bedded salt are not as tall as caverns in domal salt and because the rate of salt creep (the rate at which the salt moves to close a cavern) is much less for bedded salt than for domal salt.

Proposed §3.9(b)(3)(F) provides that an application for a cavern disposal well permit must include the financial security information required under proposed §3.9(c)(1).

Proposed §3.9(b)(3)(G) provides that the commission or its delegate may establish, on a case-by-case basis, permit conditions including conditions to provide for compliance with any requirements of the proposed operating plan, as required under paragraph (3)(D), or proposed closure plan, as required under paragraph (3)(E).

Proposed §3.9(b)(3)(H) provides that the commission or its delegate may request that an applicant submit additional information necessary to demonstrate that the creation, operation, or maintenance of the cavern disposal well will not result in pollution of surface or subsurface water or danger to life or property.

Proposed §3.9(b)(4) describes standards applicable to the operation of a cavern disposal well. Persons holding existing cavern disposal well permits must also comply with the requirements of this paragraph. Under subparagraph (A) of this paragraph, active solution mining of the cavern must cease and the operator must request cancellation of any brine mining or hydrocarbon storage permit prior to beginning disposal operations. Subparagraph (B) of this paragraph requires that the wellhead of a cavern disposal well be equipped with a pressure observation valve on the tubing and each annulus of the well.

Proposed §3.9(b)(4)(C) requires that the operator keep a record of the volume of any substance, including fresh water, that is used to facilitate disposal or that is injected downhole and the purpose for which the substance is used. An operator must also record information sufficient to determine the salinity of substances that are mixed with the waste to facilitate disposal, other than brine that weighs ten pounds per gallon, because if undersaturated fluids are used to facilitate disposal, further

dissolution of the salt may occur, thereby increasing the cavern's capacity.

Proposed §3.9(b)(4)(D)-(F) prohibit the disposal of any wastes other than non-hazardous oil and gas wastes; require that an operator maintain a record until the cavern disposal well is plugged, unless otherwise specified in the permit or commission order, of the generator, type, volume, and percent solids of waste disposed of; limit the maximum injection and shut-in pressure of a cavern disposal well; and require that an operator monitor the size of the cavern. Any increase in the cavern's size must be consistent with the estimate of the cavern's ultimate size submitted with the permit application, as required under §3.9(b)(3)(A)(v), using the methods or models described in §3.9(b)(3)(D)(iii). Persons holding existing cavern disposal well permits will be required to submit to the commission a plan for monitoring any effect that disposal operations may have on the size of the cavern and a description of the methods or models that will be used for monitoring such effect. If a cavern exceeds the estimate of the cavern's ultimate size by twenty percent or more, the operator must notify the commission in writing. The commission or its delegate may then require that the operator amend the cavern disposal well permit. Alternatively, the commission may modify, cancel, or suspend the permit as described in §3.9(a)(5) or take enforcement action against the operator.

Proposed §3.9(b)(4)(G) requires that an operator of a cavern disposal well maintain financial security as required under proposed §3.9(c).

Proposed §3.9(b)(4)(H) requires the operator to retain any records required to be maintained by the operator under subsections (a)(9)-(10) and (b)(4)(C) and (F) of this section for at least three years after the operator ceases to own or control the cavern disposal well. The operator must maintain the waste record required under proposed §3.9(b)(4)(D) for three years after the cavern disposal well is plugged. If the operator transfers the cavern disposal well to another person, the original operator must maintain a copy of the record required under §3.9(b)(4)(D) and provide the original record to the new operator.

Proposed §3.9(b)(4)(I) requires that any revisions or amendments to an operating plan must be submitted to the commission at least 15 days prior to any change in operations. The commission may require that the operator file an application for an amended permit if the revised operating plan deviates materially from the permitted operating conditions.

Proposed §3.9(b)(4)(J) requires that the operator of an existing cavern disposal well demonstrate the maximum lateral extent of the disposal cavern by means of a sonar survey, three-dimensional seismic survey, use of perimeter monitoring wells, or another approved method within 180 days after the effective date of these rule amendments.

Proposed §3.9(b)(5) establishes testing and surveying requirements for cavern disposal wells. Persons holding existing cavern disposal well permits must also comply with the requirements

of this paragraph. Operators must pressure test each well and cavern before disposal operations begin and annually thereafter. The operator must monitor the status of the salt cavern roof by running a density interface survey or alternate monitoring method approved by the commission or its delegate at least once every five years.

Proposed §3.9(b)(5)(C) and (D) incorporate the provisions of §3.9(a)(11)(D)-(E), which require the operator to notify the district office at least 48 hours prior to running any test or survey and that a complete record of all tests must be filed with the district office within 30 days after the testing.

Proposed §3.9(b)(6) requires an operator to notify the district office immediately if a fluid loss or pressure decrease occurs during the operation of a cavern disposal well. The operator must then pressure test the well and cavern in accordance with proposed §3.9(b)(5) unless otherwise instructed by the district office. Persons holding existing cavern disposal well permits must also comply with the requirements of this paragraph.

Proposed §3.9(b)(7) requires that, upon permanent abandonment of a cavern disposal well, all oil and gas waste remaining at the surface must be disposed of, all surface equipment and facilities must be closed or removed, and the well must be plugged. An operator must also monitor shut-in well pressures after disposal operations are completed and prior to plugging the well and remove any hydrocarbon pad from the cavern before closing a cavern disposal well. Prior to plugging a cavern disposal well, an operator must evaluate the need for any changes to the closure plan that was submitted with the application and submit to the commission's Environmental Services section either a revised closure plan or a reasoned justification stating why the closure plan does not need to be revised. A cavern disposal well may not be plugged until the commission or its delegate has reviewed the revised plan or reasoned justification and approved the final closure plan. Persons holding existing cavern disposal well permits must also comply with the requirements of proposed §3.9(b)(7).

The commission proposes to further amend §3.9 by adding a new subsection (c) which would require that financial security be filed for any cavern disposal well.

Proposed §3.9(c)(1) and (2) describe requirements for submission of financial security information to the commission for review for both new and existing cavern disposal wells and provide for notice and hearing in certain situations.

Proposed §3.9(c)(3) requires that a bond or letter of credit, in an amount approved by the commission or its delegate and meeting the requirements of the subsection as to form and issuer, be filed with the commission prior to receipt of waste at a new cavern disposal well. After one year from the effective date of the subsection, an existing cavern disposal well may not continue to receive waste unless financial security has been filed with the commission. An extension of the time for filing financial security may be granted upon written request and for good cause shown. In

addition, the time period for filing financial security is automatically extended pending final commission action on review of proposed financial security.

Proposed §3.9(c)(4) specifies that the amount of financial security be estimated by or under supervision of a registered professional engineer. The amount of financial security must be equal to or greater than the maximum amount necessary to close the cavern disposal well at any time during the permit term, exclusive of plugging costs, but no less than $10,000. The amount of financial security required may be reduced by $25,000, an amount equivalent to the minimum P-5 financial assurance amount.

Proposed §3.9(c)(5) specifies that bonds and letters of credit must be issued by a corporate surety or bank, respectively, authorized to do business in the State of Texas.

A conforming amendment to §3.77 is proposed that will amend the definition of "brine mining injection well" to provide that such a well includes a well used to actively solution-mine a cavern for the disposal of oil and gas wastes. Section 3.77 will become effective upon delegation to the commission by the U.S. Environmental Protection Agency of the authority to regulate brine mining injection wells under the Federal Safe Drinking Water Act.

[Fiscal Note to be provided at a later date.]

[Public Benefit/Cost Note to be provided at a later date.]

Comments on the proposed amendments may be submitted in writing to Jeb Boyt, Staff Attorney, Office of General Counsel, Railroad Commission of Texas, P.O. Box 12967, Austin, Texas 78711-

2967. Comments must be submitted by ________________________.

The commission proposes these amendments under Texas Natural Resources Code, §85.042(b), which authorizes the commission to adopt rules for the prevention of operations in the field dangerous to life or property; Texas Natural Resource Code, §91.101, which authorizes the commission to adopt rules and issue permits to prevent pollution of surface and subsurface waters, including rules and permits relating to the disposal of oil and gas wastes; Texas Natural Resources Code, §91.109, which authorizes the commission to require performance bonds or other forms of financial security from a person permitted to manage oil and gas waste; Texas Water Code, §27.031, which authorizes the commission to issue permits for injection wells used to dispose of oil and gas waste; Texas Water Code, §27.034, which authorizes the commission to develop rules and procedures reasonably required for the performance of its duties under Chapter 27 of the Water Code; and Texas Water Code, §27.036, which grants the commission jurisdiction over brine mining and authorizes the commission to issue permits for injection wells used for brine mining and adopt rules necessary to administer and regulate brine mining.

The following statutes, articles, or codes are affected by the proposal:

§3.9 -- Texas Natural Resources Code, §§85.042(b), 91.101 and 91.109; Texas Water Code, §27.031 and §27.034.

§3.77 -- Texas Water Code §27.036.

§3.9 Disposal Wells

(a) <u>General requirements.</u> Any person who disposes of saltwater or other oil and gas waste by injection into a porous formation not productive of oil, gas, or geothermal resources shall be responsible for complying with this section, Texas Water Code, chapter 27, and Title 3 of the Natural Resources Code.

(1)-(4) (No change.)

(5) Subsequent commission action.

A permit for saltwater or other oil and gas waste disposal may be modified, suspended, or terminated by the Commission for just cause after notice and opportunity for hearing, if:

(i)-(iii) (No change.)

(iv) the applicant has misrepresented any material facts during the permit issuance process; [or]

(v) injected fluids are escaping from the permitted disposal zone<u>; or</u> [.]

<u>(vi) operation of the disposal well presents a danger to life or property.</u>

(6)-(13) (No change.)

<u>(b) Cavern disposal wells. Notwithstanding the requirements of subsection (a) of this section, any person who proposes to dispose of oil and gas wastes in a solution-mined salt cavern must obtain a permit from the commission authorizing such disposal in accordance with this section. For purposes of this section, "cavern disposal well" means an injection well used to dispose of</u>

oil and gas waste, as that term is defined in chapter 27 of the Texas Water Code, in a solution-mined salt cavern. The provisions of this subsection (b) apply only to cavern disposal wells.

(1) General.

(A) Applicable requirements of subsection (a). The provisions of subsection (a)(4)-(5), (7), (9)-(10), and (13) of this section also apply to cavern disposal wells. The remaining provisions of subsection (a) do not apply to cavern disposal wells.

(B) Additional notice requirements. In addition to the notice required under subsection (a)(4)(A) of this section, the applicant shall also give notice, in the manner required under subsection (a)(4)(B) of this section, to each salt leaseholder of the tract on which the cavern disposal well will be located and of any tract adjoining the tract on which the cavern disposal well will be located. In addition to the provisions for publication of notice of the application under subsection (a)(4)(B) of this section, the following statement shall be included in the published notice of application: "The proposed cavern disposal well will be used to dispose of oil and gas waste in an underground salt cavern."

(C) Cavern disposal well permit. Oil and gas waste, as that term is defined in chapter 27 of the Texas Water Code, may be disposed of, upon application to and approval by the commission or its delegate, by injection into a solution-mined salt cavern. Every applicant who proposes to dispose of oil and gas waste into a solution-mined salt cavern must obtain a permit from the

commission or its delegate authorizing the disposal in accordance with this section.

(D) Existing permits. Permits for cavern disposal wells issued by the commission before the effective date of this subsection shall continue in effect until revoked, modified, or suspended by the commission or its delegate. Persons holding cavern disposal well permits issued before the effective date of this subsection shall comply with the provisions of subsections (b)(4)-(7) and (c).

(2) Geological requirements. A cavern disposal well may be created, operated, or maintained only in an impermeable salt formation in a manner that will not cause pollution of surface or subsurface water or danger to life or property. The applicant must submit a letter from the Texas Natural Resource Conservation Commission, Austin, Texas, stating that the creation or use of the salt cavern for disposal of oil and gas waste and the injection of oil and gas waste into the cavern will not endanger the freshwater strata in that area and that the formation used for disposal is not freshwater sand.

(3) Application. The application to dispose of oil and gas waste by injection into a solution-mined salt cavern shall be filed with the commission in Austin. On the same date, one copy shall be filed with the appropriate district office.

(A) An application shall include the following information regarding the operation of the proposed cavern disposal well:

(i) a list of the types of oil and gas wastes to be disposed of in the salt cavern;

(ii) the maximum volume of oil and gas waste to be disposed of in the salt cavern prior to any mixing to facilitate disposal;

(iii) a list of the substances that will be mixed with the oil and gas waste to facilitate disposal;

(iv) the size and shape of the salt cavern as determined by:

(I) the most recent sonar survey of the cavern, if solution-mining of the salt cavern has been completed; or

(II) if solution-mining of the salt cavern has not been completed, an estimate of the size and shape of the cavern upon completion of solution-mining operations and a description of the model or method used in preparing this estimate; and

(v) an estimate of the cavern's size after disposal operations cease and a description of the model or method used in preparing this estimate.

(B) An application for a cavern disposal well shall include the following geologic information:

(i) for a cavern located in a salt dome:

(I) a cross-section of the salt dome in the area of the proposed cavern disposal well showing the stratigraphy and lithology of the salt stock, caprock, and

surrounding formations;

(II) a description of the geometry of the salt stock showing its boundaries and any salt and caprock overhangs;

(III) any available seismic surveys or other geophysical information characterizing the salt dome;

(IV) information on the depth of the top of the cavern and the thickness of the salt roof above the cavern; and

(V) a log of the cavern disposal well showing the salt stock, caprock, and overlying formations, or, if the well has not yet been drilled, a log of a nearby well or test hole showing the same features; or

(ii) for a cavern located in a bedded salt formation:

(I) geologic information on the stratigraphy and lithology of the formations from the land surface to the underlying formations showing the bedded salt, anhydrite layers, and formations above the bedded salt and, in particular, identifying the confinement strata using a log of the cavern disposal well or, if the well has not yet been drilled, a log of a nearby well or test hole showing the same features;

(II) the actual depth of the top of the cavern based on a density log or alternative method approved by the commission or its delegate, or, if the cavern has not yet been created, the projected depth of the top of the cavern; and

(III) information on the thickness and other characteristics of the salt or other strata sufficient to demonstrate the integrity of the cavern roof.

(C) An application shall include the following siting information:

(i) a list of all wells, within a 1/4 mile radius of the proposed cavern disposal well, that penetrate the salt formation in which the cavern disposal well will be located. The list must identify any wells:

(I) that the applicant actually knows to be unplugged or improperly plugged; or

(II) that appear, from a review of the data of public record, to be unplugged or improperly plugged;

(ii) information on the depth, diameter, and volume of any hydrocarbon storage caverns, disposal caverns, brine mining caverns, salt mines, or any other excavations of the salt formation and information on the depth of any sulphur mining wells within a 1/4 mile radius of the proposed cavern disposal well;

(iii) a map indicating the location of any sulphur mining wells, hydrocarbon storage caverns, disposal caverns, brine mining caverns, salt mines, or any other excavations of the salt formation within a 1/4 mile radius of the proposed cavern disposal well;

(iv) a topographic or other map depicting the surface that extends one mile beyond the property boundaries of the proposed cavern disposal facility and that depicts the facility,

surface water bodies, and any subsidence or other dissolution features;

(D) An application shall include an operating plan for the proposed cavern disposal well that:

(i) describes the surface facilities, downhole equipment, any oil pad that will be maintained during disposal operations, proposed injection methods, and plans for the disposal, use, or sale of displaced brine;

(ii) addresses the management of the displaced brine and, if the displaced brine will be sold for non-oilfield use, provides for monitoring of the chemical constituents in the brine;

(iii) includes a plan for monitoring any effect that disposal operations may have on the size of the cavern and a description of the methods or models that will be used for monitoring such effect.

(E) An application shall include a closure plan for the proposed cavern disposal well that:

(i) addresses the monitoring of the shut-in pressure and the release of any pressure that may accumulate in a shut-in cavern disposal well during the period between cessation of disposal operations and the plugging of the cavern disposal well; and

(ii) if the cavern is located in a salt dome, demonstrates that post-plugging pressure increases will not affect the ability of the well and cavern to confine the injected fluids.

The applicant shall calculate post-closure pressure increases using the following formula:

Pressure Increase = (A - B)(C - D)

Where:

A = Lithostatic pressure gradient between the top and bottom of the cavern;

B = Hydrostatic pressure gradient between the top and bottom of the cavern;

C = Depth to the bottom of the cavern; and

D = Depth to the top of the cavern.

(F) An application shall include the financial security information required under subsection (c)(1) of this section.

(G) The commission or its delegate may establish permit conditions, as required on a case-by-case basis, including conditions to provide for and assure compliance with any requirements of the proposed operating plan or proposed closure plan.

(H) The commission or its delegate may require additional information necessary to demonstrate that creation, operation, or maintenance of the cavern disposal well will meet the requirements of paragraph (2) of this subsection.

(4) Operating requirements.

(A) Prior to beginning disposal operations, the operator shall cease active solution-mining operations, if any, and shall request cancellation of any existing brine mining or

hydrocarbon storage permit for the well. For any cavern disposal well that begins disposal operations after the effective date of this subparagraph, a sonar survey of the completed cavern shall be filed with the commission in Austin prior to the start of disposal operations.

(B) The wellhead shall be equipped with a pressure observation valve on the tubing and each annulus of the well.

(C) The operator shall keep a record of the volume of any substance, including fresh water, that is used to facilitate disposal or that is injected downhole and the purpose for which the substance is used. The operator shall record information sufficient to determine the salinity of substances, other than brine that weighs ten pounds per gallon, that are mixed with the oil and gas waste to form a slurry for injection into the cavern disposal well.

(D) No waste other than non-hazardous oil and gas waste may be injected into a cavern disposal well. Until the cavern disposal well is plugged, or unless otherwise specified by the permit or Commission order, the operator shall maintain a record of all waste received at the facility. For each waste received, the record shall indicate the generator, type, volume, salinity, and percent solids of such waste.

(E) The maximum injection pressure at the shoe of the lowermost casing shall not exceed 0.8 psi per foot of depth. Shut-in pressure at the surface on the brine withdrawal string or annulus shall not be greater than 100 psig.

(F) The operator shall monitor and record the size of the cavern in accordance with the methods or models described in subsection (b)(3)(D)(iii) of this section. Persons holding cavern disposal well permits issued before the effective date of this subsection shall submit, within 90 days of the effective date of these amendments, a plan for monitoring any effect that disposal operations may have on the size of the cavern and a description of the methods or models that will be used for monitoring such effect. The operator shall notify the commission if information indicates that the size of the cavern exceeds its permitted size by 20% or more. Such notice shall be made in writing to the commission in Austin within 10 days after the operator knows or has reason to know that the cavern disposal well has exceeded its permitted size by twenty percent or more. The notice shall include a description of the information that indicates that the permitted cavern capacity has been exceeded, and an estimate of the current cavern capacity. Upon receipt of such information, the commission or its delegate may take any one or more of the following actions:

(i) require the operator to file an application to amend the cavern disposal well permit;

(ii) modify, cancel, or suspend the permit as provided in subsection (a)(5)(A) of this section; or

(iii) take enforcement action.

(G) The operator of a cavern disposal well shall maintain financial security as required under subsection (c) of this section.

(H) For at least three years after the operator ceases to own or control the cavern disposal well, the operator shall retain all records that contain the information specified under subsections (a)(9)-(10) and (b)(4)(C) and (F) of this section. In addition, the operator shall maintain the waste record required under subsection (b)(4)(D) for three years after the cavern disposal well is plugged. If the operator transfers ownership or control of the cavern disposal well before it is plugged, he or she shall maintain a copy of the record required under subsection (b)(4)(D) and shall provide the original record to the transferee.

(I) Any revisions or amendments to an operating plan shall be submitted to the commission in Austin at least 15 days in advance of any change in operations. If the commission or its delegate determines that the revised or amended operating plan deviates materially from the permitted operating conditions, the operator shall file an application for an amended permit.

(J) 180 days after the effective date of this subsection, any person holding a cavern disposal well permit issued before the effective date of this subsection shall demonstrate the maximum lateral extent of the disposal cavern by means of a sonar survey, three-dimensional seismic survey, use of perimeter monitoring wells, or other methods approved by the commission or its delegate.

(5) Testing and surveying.

(A) Before disposal operations begin and annually thereafter, and after any workover involving physical changes to any cemented casing string, the operator shall perform a pressure test on the well and cavern. The test pressure must equal 1.5 times the average operating pressure or 200 psig, whichever is greater, and shall be maintained for a minimum of two hours. Cavern disposal well pressures shall be allowed to stabilize to a rate of change of less than 10 psig in 24 hours before the testing period begins. If the well or cavern fails the pressure test, the operator shall immediately shut-in the well and file a remedial action plan with the district office.

(B) Within five years of the date of permit issuance and at least once every five years thereafter, the operator shall monitor the status of the salt cavern roof by running a density interface survey or using an alternative method approved by the commission or its delegate.

(C) The operator shall notify the appropriate district office at least 48 hours prior to performing a test or survey. Testing or surveying shall not commence before the end of the 48-hour period unless authorized by the district office.

(D) A complete record of all tests and surveys shall be filed in duplicate in the district office on the appropriate form within 30 days after the testing and surveying.

(6) Fluid loss or pressure decrease. In the event of a fluid loss or an abnormal pressure decrease, the operator shall shut-in and pressure test the well and cavern in accordance with paragraph (5)(A) of this subsection unless otherwise instructed by

the district office.

(7) Closure and plugging. Upon permanent abandonment of a cavern disposal well, all oil and gas waste remaining at the surface shall be disposed of in accordance with applicable commission rules, permits, or orders; all equipment and facilities located at the surface shall be closed, dismantled, or removed in accordance with applicable commission rules, permits, or orders; and the well shall be plugged in a manner approved by the commission or its delegate.

(A) Prior to closing a cavern disposal well, the operator shall remove any hydrocarbon pad that is present in the cavern.

(B) After disposal operations are completed and prior to plugging a cavern disposal well, the operator shall monitor shut-in well pressures in accordance with the closure plan described in paragraph (3)(E) of this subsection or an amended closure plan.

(C) Prior to plugging a cavern disposal well, the operator shall review the proposed closure plan submitted with the permit application, as required by paragraph (3)(E) of this subsection, to determine whether the proposed closure plan should be revised.

(D) Prior to plugging, the operator shall submit to the commission in Austin either a revised closure plan or a reasoned justification as to why the proposed closure plan does not need to be revised.

(E) The operator shall not plug the cavern disposal well prior to receiving final approval of the plugging procedures from the commission or its delegate.

(F) The operator shall file a notice of intent to plug with the district office at least five days prior to commencement of plugging operations.

(G) A plugging report shall be filed with the commission in Austin within 30 days after plugging.

(c) Financial security for cavern disposal wells. In addition to the financial security required under §3.76(c) of this title, the holder of a cavern disposal well permit shall file financial security in an amount approved by the commission or its delegate as provided in this subsection and meeting the requirements of this subsection as to form and issuer. The provisions of this subsection (c) apply only to cavern disposal wells.

(1) Application.

(A) New permits. Any application for a new or amended cavern disposal well permit filed after the effective date of this subsection shall include:

(i) a written estimate of the maximum amount necessary to close the cavern disposal well prepared in accordance with the provisions of paragraph (4) of this subsection that shows all assumptions and calculations used to develop the estimate;

(ii) a copy of the form of the bond or letter of credit that will be filed with the commission; and

(iii) information concerning the issuer of the

bond or letter of credit as required under paragraph (5) of this subsection including the issuer's name and address and evidence of authority to issue bonds or letters of credit in Texas.

(B) Existing permits. Within 180 days of the effective date of this subsection, the holder of any cavern disposal well permit issued on or before the effective date of this subsection shall file with the commission the information specified in subparagraph (A) of this paragraph.

(2) Notice and Hearing.

(A) New Permits. For cavern disposal well permits issued after the effective date of this subsection, the provisions of subsection (a)(4) of this section, regarding notice and opportunity for hearing, shall apply to review and approval of financial security proposed to be filed to meet the requirements of this subsection.

(B) Existing Permits. Notice of filing of information required under paragraph (1)(B) of this subsection shall not be required. In the event approval of the financial security proposed to be filed for a cavern disposal well operating under a permit in effect as of the effective date of this subsection is denied administratively, the applicant shall have the right to a hearing upon written request. After hearing, the examiner shall recommend a final action by the commission.

(3) Filing of Instrument.

(A) New Permits. Except as provided in subparagraphs (B) or (C) of this paragraph, a cavern disposal well may not receive oil and gas waste after the effective date of this paragraph until a bond or letter of credit in an amount approved by the commission or its delegate under this subsection and meeting the requirements of this subsection as to form and issuer has been filed with the commission.

(B) Existing Permits. Except as otherwise provided in subparagraph (C) of this paragraph, after **(a date one year after effective date of subsection)**, a cavern disposal well permitted on or before the effective date of this subsection may not continue to receive oil and gas waste unless a bond or letter of credit in an amount approved by the commission or its delegate under this subsection and meeting the requirements of this subsection as to form and issuer has been filed with the commission.

(C) Extensions for Existing Permits. On written request and for good cause shown, the commission or its delegate may authorize a cavern disposal well permitted before the effective date of this subsection to continue to receive oil and gas waste after **(a date one year after the date of this subsection)** even though financial security required under this subsection has not been filed. In the event the commission or its delegate has not taken final action to approve or disapprove the amount of financial security proposed to be filed by the owner or operator under this subsection by **(a date one year after the effective date of the subsection)**, the period for filing financial security under this subsection is automatically extended to a date 45 days after such final action.

(4) Amount.

(A) Except as provided in subparagraphs (B) or (C) of this paragraph, the amount of financial security required to be filed under this subsection shall be an amount approved by the commission or its delegate as being equal to or greater than the maximum amount necessary to close the cavern disposal well, exclusive of plugging costs, at any time during the permit term in accordance with all applicable state laws, commission rules and orders, and the permit, but shall in no event be less than $10,000.

(B) The owner or operator of a cavern disposal well may reduce the amount of financial security required under this subsection by $25,000 if he or she holds only one cavern disposal well permit.

(C) The owner or operator of more than one cavern disposal well may reduce the amount of financial security required under this subsection for one such cavern disposal well by $25,000. The full amount of financial security required under subparagraph (A) of this paragraph shall be required for the remaining cavern disposal wells.

(D) A qualified registered professional engineer shall prepare or supervise the preparation of a written estimate of the maximum amount necessary to close the cavern disposal well as provided in subparagraph (A) of this paragraph. The written estimate shall be submitted under seal of a qualified registered professional engineer to the commission as required under paragraph (1) of this subsection.

(E) Notwithstanding the fact that the maximum amount necessary to close the cavern disposal well as determined under this paragraph is exclusive of plugging costs, the proceeds of financial security filed under this subsection may be used by the commission to pay the costs of plugging any well or wells at the facility if the financial security for plugging costs filed with the commission under subsection (c) of this section is insufficient to pay for the plugging of such well or wells.

(5) Issuer and Form.

(A) Bond. The issuer of any cavern disposal well bond filed in satisfaction of the requirements of this subsection shall be a corporate surety authorized to do business in Texas. The form of bond filed under this subsection shall provide that the bond be renewed and continued in effect until the conditions of the bond have been met or its release is authorized by the commission or its delegate.

(B) Letter of Credit. Any letter of credit filed in satisfaction of the requirements of this subsection shall be issued by and drawn on a bank authorized under state or federal law to operate in Texas. The letter of credit shall be an irrevocable, standby letter of credit subject to the requirements of Chapter 5 of the Texas Business and Commerce Code. The letter of credit shall provide that it will be renewed and continued in effect until the conditions of the letter of credit have been met or its release is authorized by the commission or its delegate.

§3.77. Brine Mining Injection Wells

(a) Definitions. The following words and terms when used in this section, shall have the following meanings, unless the context clearly indicates otherwise.

(1)-(2) (No Change.)

(3) Brine mining injection well--A well used to inject fluid for the purpose of extracting brine by the solution of a subsurface salt formation. The term "brine mining injection well" does not include a well used to inject fluid for the purpose of leaching a cavern for the underground storage of hydrocarbons or the disposal of waste other than oil and gas waste, or a well used to inject fluid for the purpose of extracting sulphur by the thermofluid mining process.

(4)-(11) (No Change.)

(b)-(1) (No Change.)

Meet Neal the Wheel
Page 8

West Texas field doubles production
Page 3

Exxon Ventures aids Russian orphans
Page 7

Exxon Today

About the people and the business of Exxon

Volume 5 • Number 5

April 8, 1996

VIEWPOINT

Reserve sales not an answer

Some Washington policy makers think that selling some of our country's stored oil reserves is a way to reduce the federal deficit. Their plan is to sell oil from the nation's emergency stockpile known as the Strategic Petroleum Reserve.

The public paid for and owns nearly 600 million barrels of oil, stored in salt domes in Louisiana and Texas, as insurance against any dramatic supply loss.

Budget negotiators hope to sell 39 million barrels from a storage facility at Weeks Island, Louisiana. Thirty-two million barrels would be sold to reduce the deficit and 7 million barrels would be used to cover the costs of transferring oil and shutting down the facility, ~~which is closing because of technical problems.~~

In 1994, our national oil stockpile equaled a 75-day supply of net oil imports. Because imports are rising, the level is expected to be down to a 57-day supply by 2000. Any oil that is sold will further cut the number of days that our country can operate during an emergency.

Selling any of the reserves to address budgetary issues undermines their purpose: to replace disrupted supplies and sustain confidence in the economy while government leaders work through a crisis. The message to allies and potential aggressors alike is that federal government leaders are willing to increase the country's vulnerability to a potential crisis in return for short-term political gain.

The Strategic Petroleum Reserve plays a vital role in U.S. national security. Draining the volumes lowers that security.

Exxon strongly supports the goal of cutting the deficit. But the culprit is spending growth, not income that's too low. The best way to control the federal deficit is for the government to stop spending more than it takes in.

Midland Telegram August 23, 1995

POSTED
Today $17.00
Previous Close $16.75
Year Ago $15.25

Prices jump

NEW YORK — Crude oil prices jumped to another two-month high Tuesday as the contract for September delivery expired.

Much of the buying appeared to originate from refiners looking to stock up amid declining supplies nationwide and from market speculators who were reversing previous bets that prices would fall from Monday's two-month high.

West Texas Intermediate for delivery in September settled at $18.54 per barrel, up 29 cents on the New York Mercantile Exchange. The October contract gained 4 cents to $17.88 per barrel. Local crude purchasers raised their posted price 25 cents to $17.

Natural gas contracts for delivery in September settled at $1.567 per 1,000 cubic feet, down 5.1 cents.

After trading concluded, the American Petroleum Institute issued its supply figures for the week ending last Friday that showed further declines.

Crude oil stocks fell 8.38 million barrels to 301.38 million. Gasoline stocks fell 3.84 million barrels to 199.4 million. Distillate stocks, including heating oil, fell 15,000 barrels to 124.60 million. The percentage of refinery capacity in operation fell 0.1 point to 93.5 percent.

Marketing seminar

An announcement from the University of Texas of the Permian Basin Small Business Development Center about Thursday's seminar, "Marketing and Your Business" gave a wrong location.

The seminar will be held at the Center for Energy and Economic Diversification, Highway 191 and FM 1788 in Midland from 8 a.m. to 8:30 a.m. to noon.

Cost is $30 and reservations can be made by calling 5520-2455.

Dollar steady

NEW YORK — The dollar was little changed Tuesday as the Federal Reserve left interest rates alone, as expected and the market held steady as it focused on possible rate easing by the German central bank.

By late Tuesday in New York the dollar was quoted at 96.85 Japanese yen, just down from 96.87 yen late Monday. The dollar also was changing hands at 1.4875 German marks, up from 1.4771 marks.

Other late dollar rates in New York, compared with late Monday: 1.2335 Swiss francs, up from 1.2260; 5.0845 French francs, up from 5.0585; 1,619 Italian lire, down from 1,623; and 1.3576 Canadian dollars, down from 1.3593.

The British pound was quoted at $1.5320, down from $1.5405.

Markets hold

NEW YORK— The stock market reaped scattered gains Tuesday while Wall Street registered little reaction to news that federal policy makers refrained from lowering interest rates.

The Dow Jones industrial average finished up 5.64 at 4,620.42.

The NYSE composite index crawled ahead 0.25 to 300.16 and Standard & Poor's 500 list logged an increase of 1.41 to close at 559.52. The American Stock Exchange market value index

DOE races clock to empty SPR cavern

By N.Y. Times News Service

New Iberia, Louisiana — U.S. energy officials are battling the clock to empty a salt cavern holding 12 percent of the nation's Strategic Petroleum Reserve before a crevice gives way and causes a massive oil spill.

The project can't move forward until the Department of Energy gets congressional approval to sell 7 million of the 72 million barrels of oil in Louisiana's Weeks Island salt mine. That will raise the $100 million needed to move the oil to other reserve caverns in Texas and Louisiana.

Timing is critical because ground water is leaking into the storage area through a crevice. If the fracture enlarges, water could surge into the mine, forcing the oil out of the cavern and into nearby marshes, threatening shrimp, crab and fish.

If all 3 billion gallons escaped, the spill would be 275 times greater than the 1989 Exxon Valdez spill of 11 million gallons.

"Without question, the longer we delay, the higher the probability goes that we will have an environmental catastrophe," said Bob Porter, spokesman for the DOE's office of fossil energy.

That prospect frightens neighbors of the mine, many of whom make their living in the environmentally sensitive central Louisiana industries of shrimping, agriculture, tourism and commercial and recreational fishing.

"It would have a tremendous impact economically," said Mike Richard, a wholesale nursery owner in Iberia Parish.

Added resident Wilma Subra of Subra Co., a consulting firm donating its services to a local environmental advocacy group: "Any release of oil or concentrated brine into that ecosystem will have a tremendous detrimental effect, not only instantaneously but long term."

The Strategic Petroleum Reserve was authorized by Congress in 1976 to amass crude oil that could protect the U.S. from a shortage similar to the one that occurred in 1973 during the Arab oil embargo.

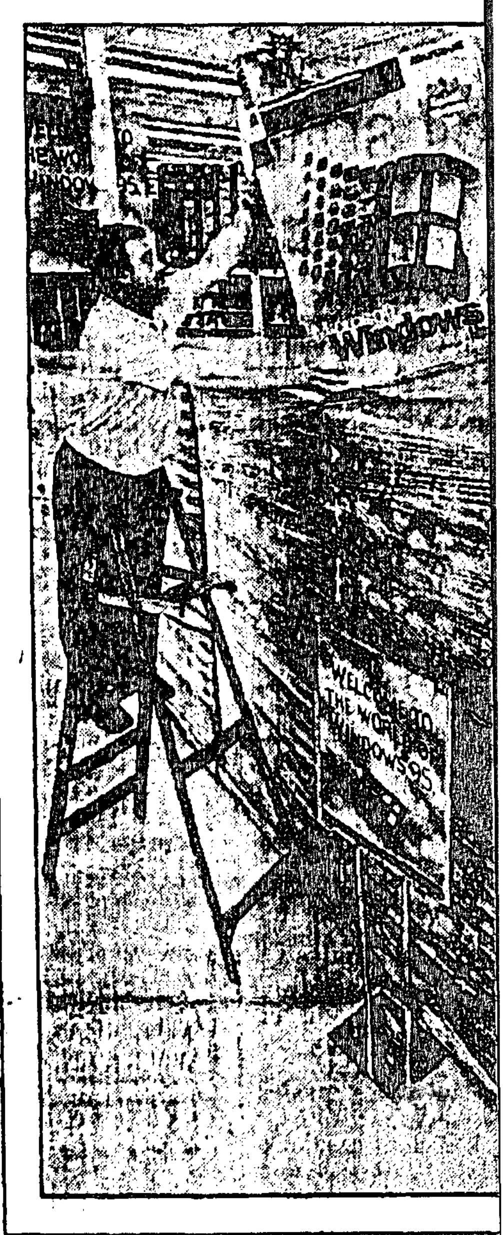
The reserve, housed in five massive underground salt caverns, contains 592 million barrels of oil. The caverns could hold as much as 750 million barrels.

The fracture at Weeks Island, a former Morton Salt Co. mine, was detected in 1992 after a security guard found a 35-foot-diameter sinkhole at the edge of the mine. Below the sinkhole, a fracture split the wall of the salt cavern.

Since then, more sinkholes have developed around the mine boundaries, and a second fracture has been found.

To stabilize the structure, the DOE has drilled 55 small wells around the first sinkhole and filled them with cryogenically cooled brine that froze the water

Please see SPR/2C



Motorola oper

By Associated Press

AUSTIN — Motorola Inc. opened a $1 billion microchip complex Tuesday, with company officials saying the fabrication plant and research lab will take it to a new era of technology.

With the finishing touches put on the facility, the company can begin making chips and finding new ways to build them.

The complex will turn out Motorola's latest microprocessors and be home for researchers who will invent the "recipes" for at least four future generations of advanced microchips.

Motorola officials and city leaders Tuesday dedicated the complex, which is called MOS 13 and the Advanced Products Research and Development Laboratory.

"MOS 13 and APRDL are our pathfinders to the next generations of technology," said Barry Waite, the Motorola executive whose business group designs and sells the circuits that will be produced in the new complex.

MOS 13 is the company's most

BUSINESS SCENE

Austin mortgage company

By Mella McEwen

An Austin-based mortgage company has opened a branch in Midland's Mission Square shopping center, 4400 N. Big Spring, Suite 122.

Branch manager of HARRIS TRUST COMPANY is Dayna Belkirch, who lived in Midland for 22

loans for 15 or 30-year mortgages. Fixed rate or adjustable rate mortgages are available.

Appointments are requested to make applications, which are taken Monday through Friday from 7:30 a.m. to 6 p.m. and from noon to 2 p.m. Saturday.

***

Midlanders Michael and Jackie Waters have opened IN HOME CARE version. Union Pacific could

cal refineries in Texas and Louisiana could be a particular

says, the best solution is to give Justice an advisory role — but give the final decision on rail

1994 sales of Burlington ern and Santa Fe would been about $1.8 billion

SPR: Fractures threaten to let oil spill

(From 1C)

inside, creating a dam of ice to block any flow through the crevice.

The measure is only temporary. In September 1994, the Strategic Petroleum Reserve project manager recommended Weeks Island be abandoned as an oil storage site.

The report by William C. Gibson Jr. said there is "a high probability of additional stress fractures" and "the integrity of the Weeks Island mine cannot be assured."

The Department of Energy hopes to begin moving the oil in October. The House of Representatives and a Senate committee have approved the sale of 7 million barrels from the reserve to pay for shutting down the site and moving the oil as part of the $12 billion appropriations bill for the Energy and Interior departments.

The spending plan must be approved by the entire Senate and then go to a conference committee in September to resolve differences between the two versions before it is sent to President Clinton. The differences don't involve the Weeks Island plan.

Some congressmen, including Rep. Billy Tauzin, R-Louisiana, and Rep. Don Schaefer, R-Colorado, oppose the sale of reserve oil, saying it sets a dangerous precedent for the government to sell more of the critical reserve to cover funding shortfalls.

The DOE said the Weeks Island problem is an unforeseeable emergency, and wouldn't be a precedent for more sales.

Tauzin and others also have questioned the wisdom of selling the crude at prices significantly below the average cost of the stored oil. The reserve's 592 million barrels were acquired at an average price of $27.50 a barrel, and the cost of the reserve caverns and maintenance boost the price to about $30 a barrel.

During the past three months, benchmark West Texas Intermediate crude has sold for an average $18.01 a barrel.

Porter said the last 7 million barrels bought for the reserves were purchased at a price of about $17 a barrel. "We don't, quite frankly, buy the argument we will be incurring a tremendous loss," he said.

The marketability of the oil is another issue. The Weeks Island oil is a "heavy crude" that is less desirable because it is harder to refine. If DOE can't sell the Weeks Island oil, it will considering selling the 7 million barrels from another reserve site, Porter said.

The Weeks Island situation raises the question of whether the remaining reserve caverns could develop similar problems. Weeks Island will be the second original storage site to be abandoned because of the potential for leaks.

In 1991, the DOE decided to empty the Sulphur Mines cavern near Lake Charles, Louisiana, saying that the 26-million-barrel cavern was the least economical of the reserve sites to operate.

The DOE later acknowledged that the Sulphur Mines site had "inherent storage risks" because its geological characteristics posed the risk of leaks.

"They're all going to face similar problems," Subra said. "The others have subsidence problems, just not as severe as these" at Weeks Island, she said.

The DOE said Weeks Island is unique, partly because its structure — two chambers supported by pillars — makes settling inevitable. In addition, the mine's top lies just 700 feet below the surface.

In the other reserve caverns, wells were drilled in underground salt domes as much as 2,000 feet below the surface. Water then was pumped in to leach out huge caverns as much as 2,000 feet deeper, large enough to hold New York's World Trade Center.

"At that depth, the natural geologic pressure on the salt is enough to heal any fracture that develops," Porter said. "We do not see the potential for a Weeks Island-type of problem to develop at any of our other sites."

Louis Dellwig, a retired University of Kansas geologist who has worked as a salt dome consultant to government and industry, said caverns that were leached out shouldn't develop cracks that won't heal themselves, and should be deep enough underground to escape subsidence.

Porter, the DOE spokesman, said the department's geologists were aware of the potential for sinkholes and subsidence at the Weeks Island when it was chosen as a reserve site. The risks were outweighed by the rush to stockpile oil after the Arab embargo, when Americans saw prices soar and stood in gas station lines.

"Americans saw oil prices quadruple over several months," Porter said. "The clear guidance was to find places to store oil and move oil into those places very rapidly."

GTE, unio keep talkir

IRVING, Texas (AP Southwest and the Co tions Workers of Ame agreed to continue "e contract negotiations af of recurrent midnight the company said Tues

GTE spokesman Dav said the two sides have keep talking until th reach an agreement or negotiations. "That way have to go through the deadline extensions," h

The union, which has authorize a walkout, has give the company 24-hou it intends to wage a strik said.

The union represents s workers in Texas, Oklal Arkansas.

The Irving, Texas-ba telephone company's with the union expired A negotiations have contir then. The union is seekin security in the wake o GTE layoffs in recent y

PUBLIC NOTIFICATION OF NONDISCRIMINATION IN MIDLAND INDEPENDENT SCHOOL DISTRICT'S CAREER AND TECHNOLOGY EDUCATION PROGRAMS

Midland Independent School District offers career and technology education programs in Agriculture, Business, Cosmetology, Health Occupations, Home Economics, Industrial Technology, Marketing Education, and Trade and Industry. Admission to these programs is based on the student's needs, aptitudes, abilities, and course selection.

CRI
CONTROLLED RECOVERY INC.

P.O. BOX 369, HOBBS, NM 88241 (505) 393-1079

March 15, 1996

MR. WILLIAM J. LEMAY
State of New Mexico
Energy, Minerals and Natural
Resources Department
Oil Conservation Division
2040 South Pacheco
Santa Fe, New Mexico 87505

Re: (GW-226) Permian Brine Sales
(UIC-CL1-006) P & S Brine Sales

Dear Mr. LeMay:

On behalf of Controlled Recovery, Inc. I respectfully request the referenced permit applications be denied.

As a Lea County business owner and taxpayer, Controlled Recovery, Inc. is extremely concerned about the possibility of waste disposal into a salt cavern. I believe this disposal method would have a negative impact on surrounding property owners in Lea County, New Mexico. The salt cavern(s) could develop leaks and possibly collapse allowing migration of waste into the precious and irreplaceable water aquifer. Any damage to the underground water supply would most likely cause health and safety risks for all persons in this region of New Mexico.

If my request to deny these applications is not implemented, I respectfully request a public hearing to review these applications be conducted by the Oil Conservation Commission. Please enter Controlled Recovery, Inc. (Gail Power) as a registered protestant in these cases.

CRI

CONTROLLED RECOVERY INC.

P.O. BOX 369, HOBBS, NM 88241 (505) 393-1079

May 28, 1996

State of New Mexico
Energy, Minerals and Natural Resources Department
Oil Conservation Division
Santa Fe, New Mexico 87505

Re: (UIC-CL1-006) P. & S. Brine Sales-Sec. 16, T-25-S, R-37-E
(GW-226) Permian Brine Sales-Sec. 34, T-29-S, R-36-E
OCD Hearing, May 28, 1996, Hobbs, New Mexico

Dear Madam or Sir:

Thank you for permitting me to speak at this hearing today.

My name is Gail Power. I am employed by Controlled Recovery, Inc. of Hobbs, New Mexico. CRI is in the surface waste disposal business and crude oil reclamation business. I will stipulate at this time Permian and P&S would be competition to CRI if their permit applications are approved. Additional competition is not the issue and purpose of this hearing.

We are all present today to listen to various statements from interested parties in order that the OCD can accept and review all testimony pro and con to determine if the applications for salt cavern disposal operations should be permitted and allow Permian and P&S to accept for disposal permitted waste into brine-mined salt cavities.

Before the New Mexico OCD considers the issuance of these permits several factors should be considered. These factors are:

1. Applicants should be required to provide thorough geologic information about the characteristics of the salt stock, including sufficient data to image underneath all overhangs and to delineate the edge of the salt stock.

2. Applicants should be required to provide adequate financial assurance to indemnify all parties that could be adversely effected by a leak of waste into surface waters or underground water aquifers. Obviously as waste volumes increase the financial assurance should be expanded proportionately.

3. Applicants should be required to demonstrate public necessity exists for the permitting of waste injection into salt cavities.

4. Applicants should be required to explain and prove that all safety considerations have been met to the satisfaction of the New Mexico OCD to include:
   a. Waste will not migrate (applicants should be able to prove the no-escape performance standard will be continuously met).
   b. Gas pressure and liquids will not build up in the salt cavern.
   c. All waste received will be properly classified.

5. Applicants should be required to satisfy the OCD that the public interest will be served and protected if the permits are issued. Possibly, the OCD should consider including the State of New Mexico Department of Health in the review process to ascertain all risks associated with this disposal method.

6. Applicants should be required to demonstrate proven waste containment and retrieval procedures in the event of a collapse, shift or leak in the sub-surface salt cavities.

7. The OCD may consider verification that no conflicts exist that are contrary or in violation of 40 CFR, Parts 144, 145, 146, 241, 243, 256, 257 and 268.

I respectfully request the OCD to consider all of my aforementioned recommendations.

In recent years the New Mexico Oil and Gas Industry, with the support, advise and regulatory assistance of the OCD has devoted great effort to reverse a long standing distrust and unfavorable image by the farming and ranching interest coupled with very poor ratings in the media and inferior regard among the general citizenry. The Oil and Gas Industry and the OCD have made great strides to improve this overall sub-standard profile by adhering to safe and prudent operations with specific concern for environmental issues.

With all the progress heretofore to improve the Oil and Gas Industry public standing, now is not the time to allow any wavering of these past gains and improvements by permitting any operations that are vulnerable to public safety, health and environmental risks and questions which could be counter-productive and, in fact, would adversely effect the entire Oil and Gas Industry in New Mexico and its Regulatory Agency. The honorable and dedicated commitment of the Oil and Gas Industry and the OCD should not be impugnable by authorizing high risk and unnecessary endeavors.

I respectfully request my remarks be included and made a part of the record of this hearing. A written transcript of my testimony is available for the record.

Thank you again for granting me time to address this hearing.

Sincerely,

Gail Power

Gail Power

GP/jh

FOSSIL ENERGY

DOE/BC/W-31-109-Eng-38-2

COSTS FOR OFF-SITE DISPOSAL OF NONHAZARDOUS OIL FIELD WASTES: SALT CAVERNS VERSUS OTHER DISPOSAL METHODS

Topical Report

By
John A. Veil

September 1997

Performed Under Contract No. W-31-109-Eng-38

Argonne National Laboratory
Environmental Assessment Division
Argonne, IL

National Petroleum Technology Office
U. S. DEPARTMENT OF ENERGY
Tulsa, Oklahoma

Available to DOE and DOE contractors from the Office of Scientific and Technical Information, P.O. Box 62, Oak Ridge, TN 37831; prices available from (615) 576-8401.

Available to the public from the National Technical Information Service, U.S. Department of Commerce, 5285 Port Royal Rd., Springfield VA 22161

DOE/BC/W-31-109-Eng-38-2
Distribution Category UC-122

Costs For Off-Site Disposal Of Nonhazardous Oil Field Wastes: *Salt Caverns Versus Other Disposal Methods*

Topical Report

By
John A. Veil

September 1997

Work Performed Under Contract No. W-31-109-Eng-38

Prepared for
BDM-Oklahoma/
U.S. Department of Energy
Assistant Secretary for Fossil Energy

Rhonda Lindsey, Project Manager
National Petroleum Technology Office
P.O. Box 3628
Tulsa, OK 74101

Prepared by:
Argonne National Laboratory
Environmental Assessment Division
9700 S. Cass Avenue
Argonne, IL 60439

CONTENTS

CONTENTS

TABLES

FIGURES

ACKNOWLEDGMENTS

I wish to express appreciation for the assistance received from many state officials and commercial disposal company officials who participated in the survey described in this report. Their willingness to share technical and cost information enabled me to compile a meaningful database on commercial waste disposal methods and costs. I also acknowledge Nancy Johnson, U.S. Department of Energy, Office of Fossil Energy, without whose support and guidance the project would not have taken place.

COSTS FOR OFF-SITE DISPOSAL OF NONHAZARDOUS OIL FIELD WASTES: SALT CAVERNS VERSUS OTHER DISPOSAL METHODS

by

John A. Veil
Argonne National Laboratory

SUMMARY

According to an American Petroleum Institute production waste survey reported on by P.G. Wakim in 1987 and 1988, the exploration and production segment of the U.S. oil and gas industry generated more than 360 million barrels (bbl) of drilling wastes, more than 20 billion bbl of produced water, and nearly 12 million bbl of associated wastes in 1985. Current exploration and production activities are believed to be generating comparable quantities of these oil field wastes. Wakim estimates that 28% of drilling wastes, less than 2% of produced water, and 52% of associated wastes are disposed of in off-site commercial facilities. In recent years, interest in disposing of oil field wastes in solution-mined salt caverns has been growing. This report provides information on the availability of commercial disposal companies in oil-and gas-producing states, the treatment and disposal methods they employ, and the amounts they charge. It also compares cavern disposal costs with the costs of other forms of waste disposal.

At the federal level, the majority of oil field wastes are considered to be exempt from the hazardous waste provisions of the Resource Conservation and Recovery Act (RCRA). These wastes are instead regulated at the state level. All oil- and gas-producing states allow some oil field wastes to be disposed of on-site. The commonly used on-site disposal methods include underground injection, on-site burial, land spreading or other land treatment, evaporation, surface discharge, and recycling. Argonne National Laboratory conducted interviews with oil and gas officials in 31 oil- and gas-producing states to learn how oil field wastes are disposed of in their states and to identify commercial off-site disposal companies. Argonne then surveyed these disposal companies to learn what types of wastes they disposed of, what disposal methods they used, and how much they charged their customers.

There appear to be two major trends in off-site disposal. The first trend is exemplified in nine oil- and gas-producing states, where many commercial disposal companies are dedicated to handling oil field wastes. They use the same disposal methods as those used for on-site disposal. In addition, in one of these states — Texas — the Railroad Commission has issued permits to allow several salt caverns to be used for disposal of oil field wastes. The second trend is exemplified by

22 other oil- and gas-producing states, where few or no companies are dedicated to disposing of oil and gas industry waste. The off-site commercial disposal companies available either handle only general industrial wastes or operate sanitary landfills.

In most cases, operators can dispose of their oil field wastes for a lower cost on-site than off-site; thus, they choose on-site disposal. In other cases, operators send their wastes off-site. The cost of off-site commercial disposal varies, depending on the disposal method used, the state in which the disposal company is located, and the degree of competition in the area. This report contains tables that provide cost data for disposing of three waste categories: (1) solid and oily wastes, which correspond to associated (small-volume wastes related to oil and gas exploration and production that are not drilling or water wastes) and oil-based drilling wastes; (2) produced water, rain water, and other types of dirty-water wastes; and (3) water-based drilling wastes. Disposal costs for solid and oily wastes range from $0 to $57/bbl, $6.50 to $50/yd, and $12 to $150/ton. Disposal costs for produced water, rain water, and other types of dirty-water wastes range from $0.01 to $8/bbl, although most costs fall in the $0.25 to $1.50/bbl range. Disposal costs for water-based drilling wastes range from $0.20 to $14.70/bbl, $5 to $37.50/yd, and $15 to $55/ton.

Solution-mined salt cavern disposal costs are presently competitive in the Texas waste disposal market. However, they are likely to rise in the near future as the Railroad Commission of Texas adopts regulations governing cavern disposal. It is unclear how the increased costs will affect the competitiveness of these disposal caverns in the future, since costs for disposal at competing facilities will likely change. The use of commercial disposal caverns for oil field waste could spread to other states, but it will be limited by the availability of suitable salt formations and the size of the off-site commercial disposal market in those states. The market, in turn, is affected by the stringency of state regulations on disposing of oil field waste. Thus, future changes to state regulations on disposal of oil field waste will act as an a important catalyst to stimulate new cavern disposal operations.

1 INTRODUCTION

As companies explore for and produce oil and gas, they generate various nonhazardous liquid, semisolid, and solid wastes. When on-site disposal of these wastes is allowed, it is generally the least expensive disposal option. Consequently, the majority of nonhazardous wastes are disposed of on-site. The term "on-site" includes waste disposal that occurs (1) on the same lease site as the one occupied by the oil and gas operation that generates the wastes and (2) at a location that is off the lease site but is owned or operated by the same company that operates the well that generates the wastes. Wastes are handled by off-site commercial disposal companies if state regulations preclude on-site disposal or if operators elect to avoid the responsibility of on-site waste disposal.

Works by Wakim (1987, 1988) summarize the results of a major, industrywide survey on waste production volumes and disposal methods conducted by the American Petroleum Institute (API) in 1985. Wakim (1987) found that more than 102 million barrels (bbl) or about 28% of drilling wastes and only a small fraction of produced water (less than 2%) were disposed of off-site. Wakim (1988) found that more than 6 million bbl or about 52% of other wastes associated with oil and gas production were disposed of off-site. The Wakim studies provide good information on waste generation and disposal practices in the mid-1980s. To get more current information, API sent out a new waste management survey in the fall of 1996. Results are expected to be available in 1997.

Little information has been compiled on the number, location, type, and cost of commercial oil and gas waste disposal facilities. This report provides information on the commercial disposal options available to operators in selected oil- and gas-producing states. The costs of different disposal options are also provided.

Interest in using solution-mined salt caverns to dispose of oil field wastes has been growing. Recently, Argonne National Laboratory (ANL), under a U.S. Department of Energy (DOE) contract, evaluated the suitability, feasibility, and legality of disposing of nonhazardous oil field wastes in salt caverns (Veil et al. 1996). That report, which examined only solution-mined salt caverns and not excavated caverns, concluded that using salt caverns to dispose of oil field wastes is technically feasible and legal under both federal and state regulations. If caverns are well-sited and well-designed, operated carefully, closed properly, and monitored routinely, they represent a suitable means of disposing of oil field wastes. ANL is also conducting a qualitative risk assessment of salt caverns used to dispose of nonhazardous oil field wastes. Because DOE has a continuing interest in exploring new and alternative waste disposal methods, especially those that are less costly or risky than existing methods, this report compares cavern disposal costs with the costs of other forms of waste disposal.

2 OIL FIELD WASTES AND DISPOSAL METHODS

2.1 TYPES OF OIL FIELD WASTE

Most oil field wastes that arise from or are associated with oil and gas exploration and production are considered to be nonhazardous by virtue of being specifically exempted from federal hazardous waste requirements. A more detailed discussion of this subject is found in Section 4. Table 1 is a list of oil field wastes exempted from the federal hazardous waste requirements of the Resource Conservation and Recovery Act (RCRA). These nonhazardous oil field wastes can be assigned to several categories: drilling wastes, produced water, and associated wastes. The categories are described below.

2.1.1 Drilling Wastes

Drilling wastes include drilling muds, drill cuttings, wash water, and other related wastes.

- Drilling muds are used in the drilling process to lubricate the drill bit, control wellbore pressure, and remove cuttings from the well. Mud systems can be freshwater-based (65%), saltwater-based (23%), oil-based (3%), or other (Wakim 1987). Wakim found that in 1985, drilling muds made up nearly 62% of drilling wastes.

- Drill cuttings are the particles of rock that are ground up by the drill bit during the drilling process. Cuttings are mixed with and covered with drilling muds. They made up about 10% of the volume of drilling wastes (Wakim 1987).

- Water used to wash the drilling rig and for other drilling-related purposes made up about 24% of the volume of drilling wastes (Wakim 1987).

- Drilling wastes may contain oil and grease, inorganic salts, or other components of concern, depending on the type of mud system and additives used. These constituents can affect the way in which the wastes are disposed of. For example, most freshwater-based muds and cuttings are disposed of on-site, while oil-based muds may need to be sent off-site for disposal.

TABLE 1 Oil and Gas Wastes Exempted from RCRA Hazardous Waste Requirements (53 FR 25446, July 6, 1988)

Produced water
Drilling fluids
Drill cuttings
Rigwash
Drilling fluids and cuttings from offshore operations disposed of onshore
Well completion, treatment, and stimulation fluids
Basic sediment and water and other tank bottoms 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 of exempt wastes
Workover 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 amines, 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
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 from the production stream, such as hydrogen sulfide and carbon dioxide, and volatilized hydrocarbons
Materials ejected from a producing well during the process known as blowdown
Waste crude oil from primary field operations and production
Light organics volatilized from exempt wastes in reserve pits or impoundments or production equipment

2.1.2 Produced Water

Produced water is the water brought to the surface along with the oil and gas. It occurs naturally in the formations where oil and gas are found and is typically salty or brackish. The ratio of produced water to oil and gas increases over the life of the well. Produced water contains inorganic salts, oil and grease, and organics.

2.1.3 Associated Wastes

Associated wastes are small-volume wastes that are generated as a result of activities related to oil and gas exploration and production but are not drilling wastes or produced water. Wakim (1988) estimated that in 1985, the U.S. oil and gas industry generated about 11.8 million bbl of associated wastes. Nearly half of that total (48%) consisted of well treatment fluids (e.g., workover fluids, completion fluids). Other waste classes that contributed significantly to the volume of associated wastes include oil debris and contaminated soils (11%), produced sands (11%), and tank bottoms (10%).

2.2 AVAILABLE DISPOSAL METHODS

Several methods to dispose of oil field wastes are available to operators. The most commonly used options are listed here:

- Underground injection (disposal wells, enhanced oil recovery wells, annular injection, salt caverns);
- On-site burial (pits, landfills);
- Land treatment (land spreading, land farming, road spreading);
- Evaporation;
- Surface discharge;
- Recycling; or
- Sending waste off-site for commercial disposal (the off-site facility would use one of the same methods as those used by the operator, as described above);

Operators select a disposal option after considering the characteristics of the waste, federal and state regulations, and the availability and cost of commercial off-site disposal.

The following sections summarize information on disposal option preferences taken from Wakim's studies (1987 and 1988) and a more recent study sponsored by DOE and the Interstate Oil and Gas Compact Commission (DOE/IOGCC 1993). The data from DOE/IOGCC (1993) were not intended to be statistically representative of actual waste management practices but rather were determined on the basis of the best judgment of state regulators. Each study groups the potential disposal options somewhat differently, so the results cannot be exactly compared. Nevertheless, these studies provide a good indication of how operators disposed of wastes in the mid-1980s and early 1990s.

2.2.1 Drilling Wastes

Wakim (1987) provides detailed information, by state, on the percentages of drilling wastes managed by means of different disposal methods. Table 2 summarizes these data. In the United States, 29% of drilling wastes were evaporated, 28% were hauled off-site to a commercial disposal facility, 13% were injected, 12% were buried on-site, 10% were discharged to surface waters, and 7% were land spread. Most states followed this trend, but in some states, one disposal method predominated (e.g., off-site burial in California, Michigan, and Ohio; land spreading in West Virginia; surface discharge in Arkansas; evaporation in Colorado, Kansas, and New Mexico; and annular injection in Alaska and Mississippi).

Table 3 is taken from DOE/IOGCC (1993). Since the table does not provide data for all states, no quantitative estimate of national disposal options selected in 1992 could be calculated. A qualitative analysis indicates that on-site burial was the most commonly selected option, with subsurface injection, land treatment, annular disposal, and off-site commercial disposal being selected in many other cases. Evaporation, the most commonly selected option found in Wakim (1987), was rarely used in the opinion of the state regulators surveyed by DOE/IOGCC (1993).

2.2.2 Produced Water

Table 4, which shows the proportion of produced water disposed of by means of different methods in 1985, is taken from Wakim (1987). The vast majority of produced water was injected; 62% was injected into enhanced oil recovery projects and 30% into disposal wells. About 6% of produced water was discharged to surface waters. In Louisiana, surface discharge was an important disposal mechanism. In California, 16% of produced water was disposed of by means of some other process, probably evaporation.

TABLE 2 Percentage of Drilling Waste Volumes for Each Disposal Method in 1985 Estimated in Wakim (1987)

State	Off-Site Disposal	Buried On-Site	Land Spread	Surface Discharge	Evaporation	Annular Injection	Solidification
Alabama	28	10	5	13	30	14	0
Alaska	18	13	0	18	0	51	0
Arkansas	20	3	0	63	14	0	0
California	75	17	1	0	5	0	2
Colorado	17	18	0	13	51	0	0
Florida	25	10	3	23	15	24	0
Illinois	71	16	13	0	0	0	0
Indiana	36	15	5	2	40	1	1
Kansas	12	21	6	6	55	0	0
Kentucky	39	9	5	2	43	2	1
Louisiana	16	4	4	43	1	33	0
Michigan	88	9	0	0	2	0	1
Mississippi	1	6	0	17	1	75	0
Montana	39	29	0	0	10	23	0
Nebraska	23	18	8	6	42	3	1
Nevada	29	10	6	7	35	13	0
New Mexico	6	12	0	1	81	0	1
New York	37	10	5	3	42	2	1
North Dakota	55	22	0	1	19	2	0
Ohio	84	15	0	0	1	0	0
Oklahoma	43	16	0	0	30	11	0
Pennsylvania	57	17	0	14	5	7	0
Texas	25	11	13	2	39	10	0
Utah	39	14	0	11	34	2	0
West Virginia	3	12	77	8	0	0	0
Wyoming	36	15	0	2	44	3	0
Total[a]	28	12	7	10	29	13	0

[a] Total also includes minor contributions from several other states not shown.

TABLE 3 Percentage of Drilling Waste Volumes for Each Disposal Method Estimated in DOE/IOGCC (1993)[a]

State	Off-Site Disposal	Buried On-Site	Land Spread	Surface Discharge	Evaporation	Annular and Subsurface Injection[b]	Recycling/Closed Drilling System
Alabama	c					c	c
California	c	c	c	c		c	c
Colorado	c	c	c		c		c
Kansas	20	75			3	1	1
Louisiana	22		51			27	c
Michigan		65			3	32	c
Mississippi			c	50		c	c
Montana	c	75-85	c		c	c	c
New Mexico		c	c				c
North Dakota	3	42				54	1
Ohio	3-4	27-36				60-70	<1
Oklahoma	54		12			33	c
Pennsylvania	<1	60	38	<1			<1
Texas	2	83	<4	<0.5		11	
Utah	c	c					
West Virginia	3	13	77	7			
Wyoming	c	c	c			c	5

[a] Based on best judgment of state regulators.

[b] DOE/IOGCC (1993) provides separate categories for subsurface injection and annular injection but provides no explanation for that distinction; both categories are combined here.

[c] Indicated practice is allowable and may be used in the state; no other data are available.

TABLE 4 Percentage of Produced Water Volumes for Each Disposal Method in 1985 Estimated in Wakim (1987)

State	Disposal Wells	Enhanced Oil Recovery	Surface Discharge	Other
Alabama	85	15	0	0
Alaska	29	71	0	0
Arkansas	46	54	0	0
California	23	54	6	16
Colorado	8	92	0	0
Illinois	5	95	0	0
Kansas	60	39	0	0
Kentucky	100	0	0	0
Louisiana	46	10	44	1
Michigan	35	65	0	0
Mississippi	96	4	0	0
Montana	16	83	1	0
Nebraska	60	39	0	1
New Mexico	17	83	0	0
North Dakota	72	28	0	0
Oklahoma	9	91	0	0
Texas	31	64	3	2
Utah	36	63	1	0
West Virginia	100	0	0	0
Wyoming	55	28	17	0
Total[a]	30	62	6	3

[a] Total also includes minor contributions from several other states not shown.

Results shown in Table 5, taken from DOE/IOGCC (1993), are very similar to those shown in Table 4. In most states, a high percentage of produced water was reinjected. Several states discharged a significant quantity of produced water to surface waters, although the volume of produced water discharged to surface waters is declining. In California, an estimated 20% of produced water was evaporated.

2.2.3 Associated Wastes

Table 6, which shows the proportion of associated wastes disposed of by means of different methods in 1985, is taken from Wakim (1988). Nationally, more than half of the associated waste (52%) was taken to off-site commercial facilities, 14% was spread on roads, 9% was land spread, 7% was recycled, 7% was injected, and 5% was buried on-site. States showed substantial variation in their use of the most commonly selected options.

Table 7, which lists data from DOE/IOGCC (1993) on disposal of associated wastes, reveals no clear trends. Subsurface injection, commercial off-site disposal, land treatment, and on-site burial all are used to dispose of more than 95% of the associated wastes in at least one state.

TABLE 5 Percentage of Produced Water Volumes for Each Disposal Method Estimated in DOE/IOGCC (1993)[a]

State	Disposal Wells	Enhanced Oil Recovery	Surface Discharge	Evaporation	Off-Site Disposal	Annular Injection	Road Spreading	Other
Alabama, oil/conventional gas								b
Alabama, coalbed methane gas	b		b					b
California	25	32	9	20				14
Colorado			b	b	b			b
Kansas	60	39					<1	
Louisiana	46	8	44			2		
Michigan	63	37					<1	
Mississippi	b	b				b		
Montana	16	83	<1	<1				
New Mexico			b	b				
North Dakota	72	28						
Ohio						2	4	
Oklahoma	28	72	<1					
Pennsylvania	b	b	b		b		b	b
Texas	37	61	1.6	0.2	0.2			
Utah	22	51	25	2				
West Virginia								
Wyoming	9	58	31	2				

[a] Based on best judgment of state regulators.

[b] Indicated practice is allowable and may be used in the state; no other data are available.

TABLE 6 Percentage of Associated Waste Volumes for Each Disposal Method in 1985 Estimated in Wakim (1988)

State	Off-Site Disposal	Buried On-Site	Land Spread	Surface Discharge	Evaporation	Annular Injection	Recycled	Road Spreading	Other
Alabama	1	3	2	0	10	41	38	2	2
Alaska	19	0	0	0	12	69	0	0	0
Arkansas	13	9	2	1	8	13	45	10	0
California	40	0	5	0	1	0	2	51	1
Colorado	4	45	0	0	1	46	2	2	1
Florida	94	0	0	0	2	0	4	0	0
Illinois	1	0	16	0	0	0	65	18	0
Kansas	21	19	1	0	5	3	15	37	0
Louisiana	59	1	0	4	10	1	20	1	4
Michigan	85	0	0	0	2	7	5	0	1
Mississippi	3	3	1	0	15	8	68	1	0
Montana	97	2	0	0	0	0	0	0	0
Nebraska	75	5	0	0	1	1	5	11	0
New Mexico	94	1	0	0	1	1	4	0	0
North Dakota	98	0	0	0	0	0	2	0	0
Oklahoma	69	2	0	2	2	11	4	2	7
Texas	57	3	17	0	5	1	9	5	2
Utah	33	14	9	0	31	1	7	0	5
West Virginia	1	0	97	0	2	0	1	0	0
Wyoming	39	5	1	0	28	0	23	6	2
Total[a]	52	5	9	1	3	7	7	14	2

[a] Total also includes minor contributions from several other states not shown.

TABLE 7 Percentage of Associated Waste Volumes for Each Disposal Method Estimated in DOE/IOGCC (1993)[a]

State	Off-Site Disposal	Buried On-Site	Land Spread	Surface Discharge	Subsurface Injection	Recycled	Road Spreading	Other
Alabama	b				b			
California	b				b			
Colorado	b		95		b			
Kansas	17	30			1	20	32	
Louisiana	b							
Michigan	97					3		
Mississippi	100			b	b		b	b
Montana	b	>50	b			7	5	
New Mexico		b	b		b	b		b
North Dakota	b					20		
Ohio	b	90-95			b			
Oklahoma	>80	b	b		b	3	b	
Pennsylvania	b	b	b					b
Texas								
Workover/completion wastes		5			95			
Basic sediments	1	93	1				5	
Other oily wastes	1	1	97		1			
Utah	b	20				b		
West Virginia	42	18				40		
Wyoming	24% is recycled; of the remaining volume, 90% is disposed of on-site and 10% is disposed of off-site.							

[a] Based on best judgment of state regulators.

[b] Indicated practice is allowable and may be used in the state; no other data are available.

3 BACKGROUND ON SALT CAVERNS

Veil et al. (1996) discusses many aspects of salt formations and salt caverns. Relevant portions of that information are summarized in this section. Both Veil et al. (1996) and this report consider only solution-mined salt caverns. Underground chambers or caverns can also be formed in salt deposits through room-and-pillar mining, which involves mechanical excavation of the salt deposits. To the author's knowledge, only solution-mined caverns have been proposed for use as disposal caverns for nonhazardous oil and gas wastes. Room-and-pillar mining is not discussed further in this report.

3.1 TYPES AND LOCATIONS OF U.S. SUBSURFACE SALT DEPOSITS

Figure 1 (redrawn from Johnson and Gonzales 1978) shows the locations of the major U.S. subsurface salt deposits. There are two types of subsurface salt deposits in the United States: salt domes and bedded salt. Salt domes are large, generally homogeneous formations of salt that are

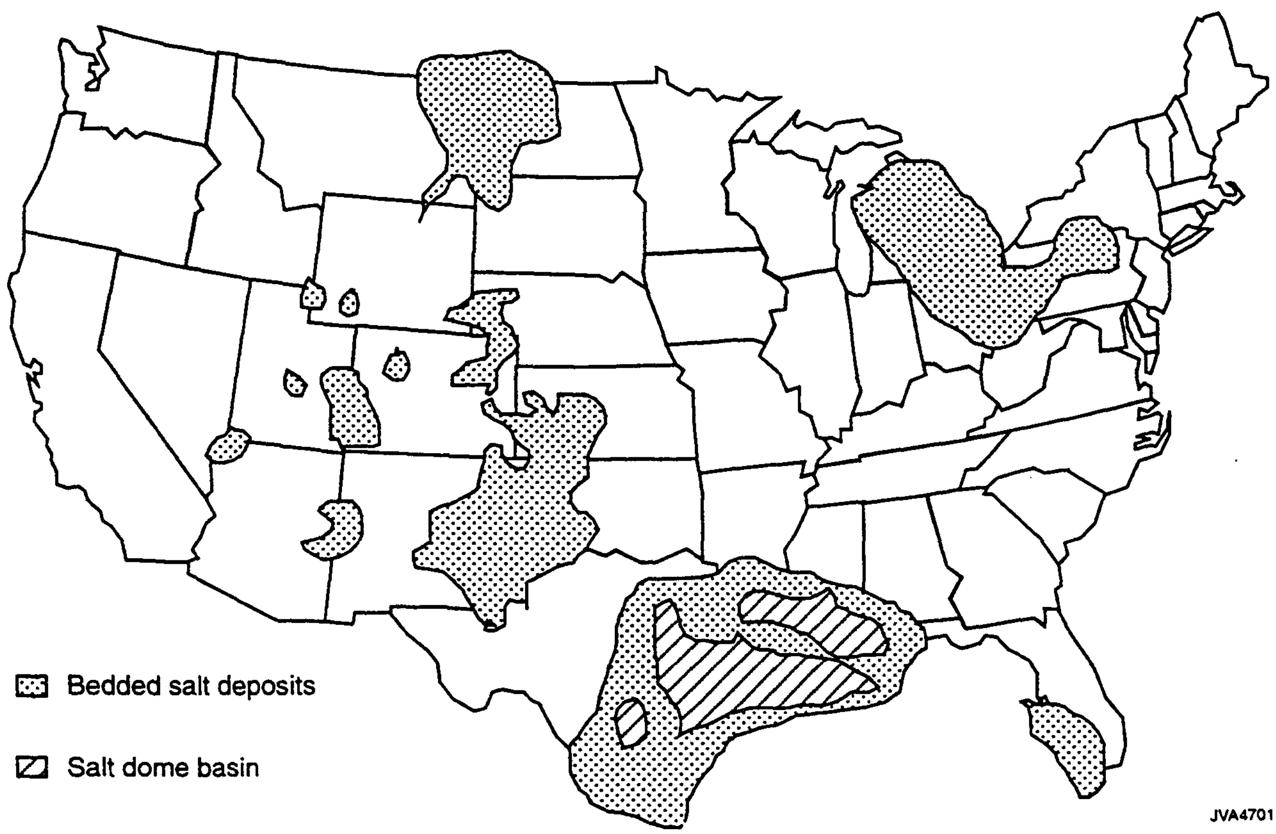


FIGURE 1 Map Showing Major U.S. Rock Salt Deposits

formed when a column of salt migrates upward from a deep salt bed, passing through the overlying sediments. Salt dome deposits are found in the Gulf Coast region of Texas, Louisiana, Mississippi, and Alabama.

Bedded salt formations occur in layers bounded on the top and bottom by impermeable formations and are interspersed with nonsalt, sedimentary materials having varying levels of impermeability, such as anhydrite, shale, and dolomite. Unlike salt domes, which are large masses of relatively pure sodium chloride, bedded salt deposits are tabular deposits of sodium chloride that can contain significant quantities of impurities. Major bedded salt deposits occur in several parts of the United States.

Although salt deposits occur in many parts of the United States, in most states, the occurrence of salt in the quantities and locations that would promote commercial mining is very limited. There are 16 states in which salt occurs in sufficient quantity to be mined by either excavation, solution mining, or solar evaporation: Alabama, Arizona, Colorado, Kansas, Louisiana, Michigan, Mississippi, Montana, New Mexico, New York, North Dakota, Ohio, Oklahoma, Pennsylvania, Texas, and Utah.

Of the states listed above, Kansas, Louisiana, Michigan, New Mexico, New York, Ohio, and Texas have the most significant salt mining operations. These states either now contain or have the potential to contain a cavern suitable for oil and gas waste disposal. Pennsylvania contains caverns that are currently permitted for hydrocarbon storage but could be converted to waste disposal caverns. Utah has some potential for future disposal cavern operations, although it is a relatively small oil and gas waste generator. The remaining states have only a limited number of salt production sites and are not likely candidates for future cavern storage operations.

3.2 CREATION OF SALT CAVERNS

Salt caverns are created by injecting fresh water into a salt formation and withdrawing the resulting brine solution. Figures 2 and 3 show the idealized construction for caverns in domal salt and bedded salt, respectively. The petroleum industry has constructed many salt caverns to store hydrocarbons. To provide guidance for designing and operating hydrocarbon storage salt caverns, several organizations have developed standards documents (CSA 1993; API 1994; IOGCC 1995). Details on the design, location, and construction of salt caverns are provided in these reports.

3.3 USE OF SALT CAVERNS

The most common use for salt caverns is to store hydrocarbons such as propane, butane, ethane, ethylene, fuel oil, gasoline, natural gas, and crude oil (Querio 1980). In 1975, the

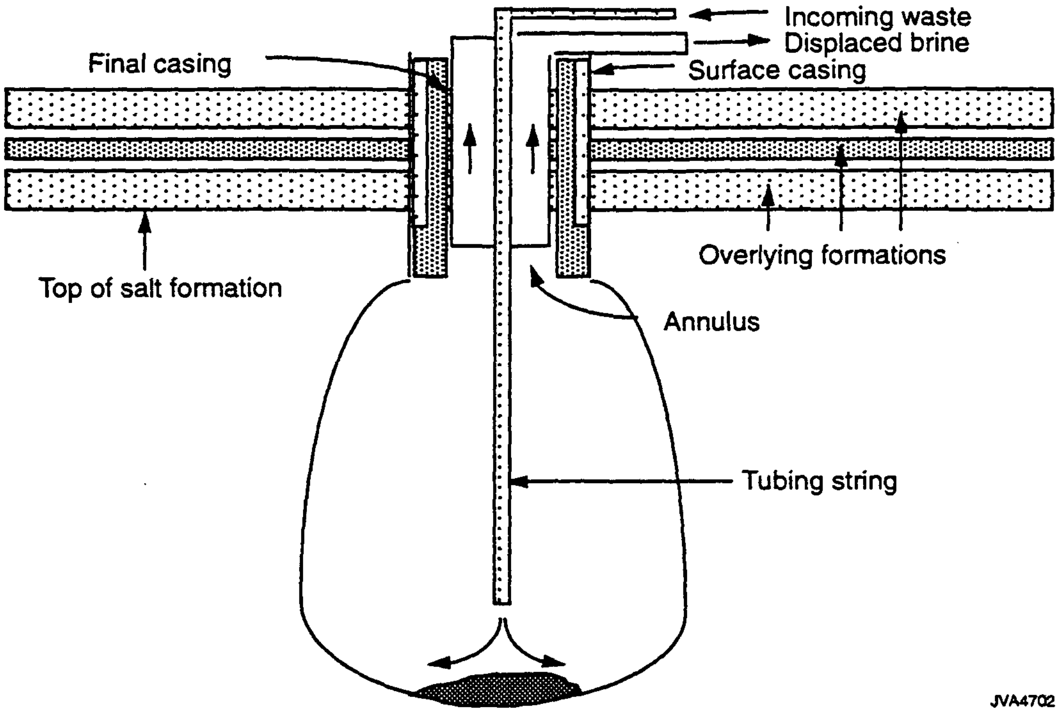


FIGURE 2 Idealized Cavern in a Salt Dome Formation

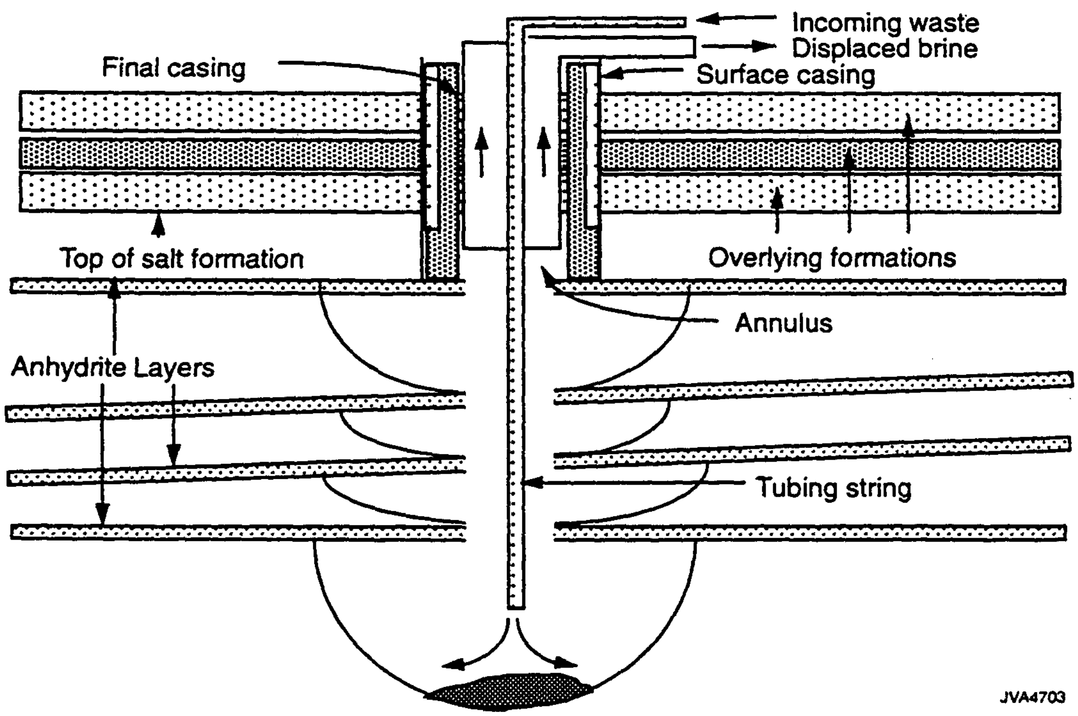


FIGURE 3 Idealized Cavern in a Bedded Salt Formation

U.S. Congress created the Strategic Petroleum Reserve (SPR) program to provide the country with sufficient petroleum reserves to reduce any impacts that might be caused by future interruptions in the oil supply. The SPR consists of 62 leached caverns in domal salt with a total capacity of 680 million bbl. DOE has prepared a plan for, but is not currently pursuing, the development of an additional 250 million bbl of storage capacity. Highly compressed air has also been stored in some caverns, where it can later be withdrawn to generate electricity.

A second use for salt caverns is to dispose of various wastes. In the United States and other countries, only a limited number of salt caverns have been issued permits for waste disposal. The Railroad Commission of Texas has issued permits for disposal of nonhazardous oil field waste in six caverns. Four of these are presently operating as disposal caverns. At least two caverns in Canada have been permitted for disposal of nonhazardous oil field waste. Veil et al. (1996) describes other types of cavern disposal activities in the United Kingdom, Germany, the Netherlands, and Mexico.

3.4 WASTE DISPOSAL PROCESS

Initially, caverns are filled with clean brine. Wastes are introduced as a slurry of waste and a carrier fluid (brine or fresh water). A carrier fluid that is not fully saturated with salt will eventually leach salt from the cavern walls or roof. Expansion of cavern diameter is generally not a problem as long as the anticipated degree of expansion is accounted for in the cavern design and the actual degree of expansion is monitored throughout the waste emplacement cycle. To avoid excessive leaching of the cavern roof, operators may intentionally introduce a hydrocarbon pad that, by virtue of its lower density, will float to the top of the cavern and keep the unsaturated carrier fluid from coming in contact with the cavern roof.

As the waste slurry is injected, the cavern acts as an oil/water/solids separator. The heavier solids fall to the bottom of the cavern, forming a pile. Any free oils or hydrocarbons that are associated with the waste float to the top of the cavern. Clean brine displaced by the incoming slurry is removed from the cavern and either sold as a product or disposed of in an injection well. When the cavern is filled, the operator removes the hydrocarbon pad and plugs the cavern.

3.5 CAVERN CLOSURE

There is no actual field experience on the long-term impacts from disposing of oil field wastes in salt caverns. Theoretical studies estimate what might happen after such a cavern is closed. Various authors agree that pressures will build up in a closed cavern because of salt creep and geothermal heating. However, these authors do not specifically address caverns filled with oil field wastes. Several experienced researchers in the field interviewed by the authors of Veil et al. (1996) believe that caverns filled with oil field wastes would be much less likely to leak than would caverns filled with less dense liquids. However, other experienced researchers believe that until the pore space of the waste pile is reduced through creep-induced compaction, a solids-filled cavern will behave in the same way as a fluid-filled cavern.

Some disposal caverns might leak after closure because of elevated pressures; however, the time needed for pressures to build to the point of cavern failure is not defined. Argonne's risk assessment of disposal caverns, due to be completed in late 1997, may shed some light on the consequences of cavern failure. Additional research on the likelihood and rates of cavern failure following closure would be useful to better understand this issue.

4 REGULATORY CONSIDERATIONS

This section describes the federal and state requirements that apply to the disposal of oil field wastes. Three federal statutes govern disposal of oil field wastes — the Resource Conservation and Recovery Act (RCRA), Safe Drinking Water Act (SDWA), and Clean Water Act (CWA).

4.1 RCRA EXEMPTS OIL FIELD WASTES FROM HAZARDOUS WASTE REQUIREMENTS

The most important distinction between oil field wastes and many other types of industrial wastes is that the former are exempted from the hazardous waste requirements of RCRA. On July 6, 1988, the U.S. Environmental Protection Agency (EPA) issued a regulatory determination that exempted any wastes arising from the exploration, development, and production of crude oil, natural gas, and geothermal energy from regulation as hazardous wastes under RCRA Subtitle C (53 FR 25477). The list of wastes exempted from RCRA Subtitle C is reproduced in Table 1. On March 22, 1993, the EPA clarified the 1988 determination and exempted many other wastes that were uniquely associated with exploration and production operations from RCRA Subtitle C requirements (58 FR 15284). The clarification restates the EPA's position that wastes derived from treatment of an exempted waste generally remain exempt, and that off-site transportation does not negate the exemption. Some wastes derived from treatment of an exempt waste may not be exempt, however.

The EPA has emphasized the need to work with states to encourage changes in their regulations to improve the management of wastes from oil and gas exploration and production. Given the federal exemption from RCRA for oil field wastes, the waste management requirements faced by most operators will be state requirements.

4.2 SDWA REGULATES SALT CAVERNS FOR OIL FIELD WASTE DISPOSAL AS CLASS II INJECTION WELLS

Unlike most other methods for disposing of nonhazardous oil field waste, salt caverns and injection wells are subject to the requirements of the SDWA's Underground Injection Control (UIC) program. All injection wells are assigned to five classes. Salt caverns for disposing of oil field waste and wells for disposing of produced water are Class II wells.

States seeking authority to administer the UIC program may obtain primacy in two ways. Under Section 1422 of the SDWA, states must demonstrate that their regulations are at least as stringent as those adopted by the EPA. To provide greater flexibility for states administering Class II programs, Congress added Section 1425 to the SDWA, which requires states seeking delegation to have an underground injection program that meets the requirements of Section 1421(b)(1)(A)-(D) and would be effective enough to prevent any underground injection that would endanger drinking water sources.

4.3 CWA REGULATES DISCHARGES OF OIL FIELD WASTES INTO SURFACE WATER

Under the CWA, the EPA must establish effluent limitations guidelines (ELGs) for most major industrial categories. The ELGs prohibit the majority of oil and gas exploration and production wells from discharging oil field wastes. However, offshore wells and wells in Cook Inlet, Alaska, are allowed to discharge most types of oil field wastes, subject to the requirements of National Pollutant Discharge Elimination System (NPDES) permits. The ELGs also do not establish any requirements for stripper oil wells (wells producing less than 10 bbl per day of oil). Wells in the agricultural and wildlife use subcategory may discharge produced water to surface water under the requirements of an NPDES permit. Some western U.S. operators can dispose of their relatively fresh produced waters to irrigation ditches under this subcategory.

Surface water discharge is not an available option for onshore wells, other than those in the stripper well and agricultural and wildlife use subcategories, and onshore wells make up the largest segment of U.S. oil and gas wells. Onshore wells must dispose of oil field wastes on-site or off-site at land-based or underground facilities. Some onshore wells may discharge produced water or other aqueous wastes to sanitary sewer systems.

4.4 STATES REGULATE WASTE MANAGEMENT

The DOE/IOGCC (1993) study provides a thorough overview of the waste management requirements of 17 oil- and gas-producing states. Some regulatory changes have occurred since 1993, but the majority of the information in that report remains accurate. As of 1992 (the year in which data for a 1993 report would have been collected), all of the 17 states surveyed allowed most types of oil field wastes to be disposed of on-site by means of a variety of methods. Not every state allows all disposal methods (e.g., Kansas does not allow land spreading of drilling wastes; Louisiana does not allow pits in coastal areas; and Michigan and North Dakota prohibit annular injection), but each state allows several disposal options. Appendix B of DOE/IOGCC (1993) provides a detailed state-by-state discussion of oil and gas waste management requirements and approved disposal methods.

Most states follow the EPA's determination to exempt oil field wastes from hazardous waste requirements. California is an exception to this policy; it does not offer a blanket exemption from hazardous waste requirements. California requires testing of all wastes; wastes that test as hazardous, regardless of their source, must be handled as hazardous wastes.

The IOGCC has also developed waste management guidelines for state oil and gas regulatory programs that recognize and support on-site disposal of nonhazardous oil and gas wastes (IOGCC 1994). Individual states are not bound by the IOGCC guidelines, but the guidelines serve as a good indication of what types of practices states do allow. IOGCC (1994) contains general and administrative criteria and technical criteria for on-site pits, land spreading, burial and landfilling, road spreading, tanks, and off-site commercial and centralized disposal facilities.

5 AVAILABILITY AND COST OF OFF-SITE COMMERCIAL DISPOSAL FACILITIES

Section 2 documented that much of the associated wastes and some drilling wastes are sent to off-site commercial facilities for disposal. However, the references cited in that section do not provide information on the types of disposal methods employed by the commercial disposal facilities or the price an operator must pay for disposal at those facilities. This section describes the results of a survey conducted by Argonne National Laboratory from July 1996 to March 1997 that collected such information. The information contained here is derived from either written materials provided by commercial disposal companies or telephone interviews between the author and the disposal companies.

5.1 APPROACH AND FOCUS OF THE SURVEY

The initial intent of the survey was to compare the disposal costs at the four salt cavern disposal facilities currently in operation in Texas with the costs of other, more established disposal methods. The findings were then to be used to assess whether cavern disposal could compete on a cost basis with the other disposal methods. Consequently, the survey was initially limited to those states that both produced significant levels of oil and gas and contained salt formations that were thick enough and near enough to the surface to be economically used for cavern disposal.

The resulting data were sparse enough that the survey was expanded to include commercial disposal activities in all other major oil- and gas-producing states. Thus the survey developed a second focus; it was the basis for assembling a national database on commercial waste disposal costs.

Commercial off-site produced water disposal wells are found in many of the oil- and gas-producing states. The survey was not initially intended to consider commercial off-site disposal facilities for produced water. However, some commercial disposal companies operate separate facilities — some for disposal of solid or semisolid wastes like drilling wastes or associated wastes, and others for disposal of produced water. Those companies provided information on disposal costs for both categories of waste. Therefore, the survey was expanded to include some information on a limited number of commercial companies that dispose of produced water. The data presented here are believed to be a reasonable representation of commercial disposal costs for the states in which those disposal companies are located. Those costs may or may not be transferable to other oil- and gas-producing states.

Data were collected in two steps. First, representatives of state oil and gas regulatory agencies were contacted to determine if a list of permitted commercial disposal companies was available. Then, if such a list existed, each company on the list was contacted by phone. If a state agency had no list of commercial disposal companies, state officials were asked to describe how operators in that state disposed of their nonhazardous oil field waste. Commercial disposal companies were asked what type of wastes they accepted, what type of disposal method they employed, and how much they charged for disposal, exclusive of transportation costs. The majority of companies surveyed willingly provided information. A few companies elected not to participate, primarily out of concern that the cost information might be used to their competitive disadvantage. These companies are not discussed in the following sections or listed in the tables on disposal companies. The resulting information on the availability and cost of off-site commercial disposal companies is provided by state in the following sections.

5.2 STATES WITH INDUSTRY-SPECIFIC OFF-SITE COMMERCIAL DISPOSAL

In several states, there are many off-site commercial disposal companies that are dedicated to accepting only oil field wastes. In these states, this type of facility handles most of the oil field waste that is sent off-site. In other states, a combination of oil-industry-specific disposal facilities and other more general industrial waste disposal facilities receive oil field waste that is sent off-site. This section describes the availability of off-site disposal and the disposal methods used at these commercial sites. Table 8 lists companies that dispose of solid and oily wastes (which correspond to associated wastes and oil-based drilling wastes). Table 9 lists companies that dispose of produced water, rain water, and other dirty-water-type wastes. Table 10 lists companies that dispose of water-based drilling wastes. As noted in the previous section, only a few off-site commercial companies for disposal of produced water are included in the discussion.

The inclusion of disposal companies in Tables 8-10 does not constitute an endorsement of those companies or provide any indication of their performance capabilities. The companies are included solely to provide an indication of the types of commercial disposal options available to operators in the 1996-1997 time frame.

5.2.1 Arkansas

Hampton Bussey of the Arkansas Oil and Gas Commission indicated that if sufficient surface casing has been set to satisfy state and EPA requirements, drilling fluids are injected into wells on-site. Drilling fluids that are not injected into the wellbore are either recycled or buried

TABLE 8 Disposal Costs for Solid and Oily Nonhazardous Oil Field Wastes

State	Company	Type	Cost[a]	Comments
AR	B&C Oilfield Construction	Recycle	\$0-\$40/hour	Tank bottoms only; no charge for first 4 hours, \$40/hour after that; they clean tanks, accumulate tank bottoms, and sell to a refinery
AR	Arkansas Service Company	Recycle	\$45/hour	Tank bottoms only; they clean tanks, accumulate tank bottoms, and sell to a refinery
CA	VenVirotek	Chem. treat/reuse	\$15-\$25/ton	After treatment, used for landfill cover
CA	Terrain Technology	Chem. treat/reuse	\$12-\$25/ton	Make dust control product; drilling muds are evaporated and reused, \$3-\$6/bbl
CA	Morton Recycling	Bio. treat/reuse	\$12.50–\$28.50/yd^3	After treatment, used for fill dirt
CA	Crosby and Overton	Thermal treat/reuse	\$10.50/bbl	Cost is for bulk liquids; solids are \$50/drum (\$38/bbl); used as soil
CA	Demeno Kerdoon	Treat/reuse	\$0 -\$4.20/bbl	Cost is based on % of water; only takes liquids and sludges; no solids
CA	Liquid Waste Mgmt.-McKittrick	Treat/reuse	\$45/ton	Used for road base material
CA	Evergreen Oil	Reuse	\$52-\$77/bbl	Tank bottoms only; collects other wastes but sends to a third party for disposal
CA	Laidlaw-Lokern	Landfill	\$30-\$60/ton	\$4.20-\$18.90/bbl for liquids
CA	Laidlaw-Imperial Valley	Landfill	\$45/ton	Liquids can be solidified and landfilled at \$150/ton
CA	Simi Valley Landfill	Landfill	\$30-\$40/ton	
CA	Rollins OPC	Landfill - haz.waste	\$150/ton	Cost is for contam. soil; no treatment at this site, sent off-site
CA	Chem. Waste Mgmt.-Kettleman	Landfill - haz.waste	\$125/ton	
CA	Filter Recycling	Landspread	\$95/ton	\$38/bbl; no treatment at this site; it packages in bulk and sends off-site
CO	Waste Management-Aurora	Landfill	\$12-\$20/yd3	Some waste is biologically treated to speed up breakdown of hydrocarbons
CO	Conservation Services	Landfill	\$12-\$22/yd^3	Some waste is landspread at \$10.50-\$18.90/bbl
CO	Laidlaw-Erie	Landfill	\$10.80/yd^3	
CO	Strategic Environ. Solutions	Thermal treatment	\$30-\$100/ton	Operated as stationary or mobile units; may incorporate wastes into asphalt

TABLE 8 (Cont.)

State	Company	Type	Cost[a]	Comments
FL	Rinker-Miami	Incinerator	\$26-\$30/ton	Costs are for tank bottoms or contaminated soils
LA	Campbell Wells-Mermentau	Land spread	\$9.50/bbl	
LA	Campbell Wells-Elm Grove	Land spread	\$9.50/bbl	
LA	Campbell Wells-Bourg	Land spread	\$9.50/bbl	
LA	Campbell Wells-Bateman Island	Land spread	\$9.50/bbl	
LA	Newpark-Morgan City	Treat/injection	\$8.50-\$11/bbl	Depends on oil and gas (o&g) content; treated solids sold for landfill cover material
LA	Newpark-Fourchon	Treat/injection	\$8.50-\$11/bbl	Depends on o&g content; treated solids sold for landfill cover material
LA	Newpark-Venice	Treat/injection	\$8.50-\$11/bbl	Depends on o&g content; treated solids sold for landfill cover material
LA	Newpark-Intracoastal City	Treat/injection	\$8.50-\$11/bbl	Depends on o&g content; treated solids sold for landfill cover material
LA	Newpark-Cameron	Treat/injection	\$8.50-\$11/bbl	Depends on o&g content; treated solids sold for landfill cover material
MS	BFI-Gulf Pines	Landfill	\$20-\$25/ton	
MS	BFI-Big River	Landfill	\$19-\$25/yd^3	
MS	BFI-Little Dixie	Landfill	\$20-\$25/ton	\$23-\$36/bbl for liquids
MS	BFI-Three Rivers	Landfill	\$20/ton	
MS	Transamerican Central	Landfill	\$18.50-\$24/ton	
MS	WMI-Plantation Oaks	Landfill	\$35/ton	
MS	WMI-Prairie Bluff	Landfill	\$35/ton	
MS	WMI-Pecan Grove	Landfill	\$35/ton	
MS	WMI-Pine Ridge	Landfill	\$35/ton	
MS	Chambers-Clearview	Landfill	\$26.50/ton	\$18.90/bbl for liquids
NM	C&C	Land spread	\$24/yd3	Contaminated soils only
NM	Goo-Yea	Land spread	\$20/ton	Contaminated solid only

TABLE 8 (Cont.)

State	Company	Type	Cost[a]	Comments
NM	Gandy-Marley	Land spread	$14/yd^3$	Reclamation plant for tank bottoms, $2.50-$5/bbl
NM	Envirotech	Land spread	$18/yd^3$	
NM	TNT Construction	Land spread	$20/yd^3$	
NM	Tierra	Land spread	$16-$18/yd^3$	
NM	Sundance	Evap.& landfill	$2.75/bbl	
NM	CRI	Evap. & landfill	$2.50/bbl	$14/yd^3$ for solids
NV	Nevada Hydrocarbon	Thermal treat/reuse	$40-$50/ton	Contaminated soils only; after treatment, soils are used for construction
NV	Las Vegas Paving	Incinerator	$20-$22/ton	Contaminated soils only
NV	Environ. Technol. of Nevada	Landfill	$31/ton or $31/yd^3$	Also must pay a $650 profile fee
OH	Athens Hocking	Landfill	$17-$26/ton	
OH	Mahoning Landfill	Landfill	$22.5-$24/ton	
OH	Suburban South Landfill	Landfill	$22-$29/ton	
OH	Countywide Recycling	Landfill	$23-$24/ton	
OH	Mt. Eaton East	Landfill	$22.50/ton	
TX	Permian Brine Sales-Andrews	Cavern	$1.95-$2.85/bbl	Depends on solids & o&g content; discounts of $1-$1.5/bbl for high oil content
TX	Permian Brine Sales-Big Springs	Cavern	$1.95-$2.85/bbl	Depends on solids & o&g content; discounts of $1-$1.5/bbl for high oil content
TX	Taylor Service Co.	Cavern	$6/bbl	$50/yd^3$ for contam. soils
TX	Voskamp Exploration	Cavern	$2.75/bbl	
TX	Newpark-Port Arthur	Treat/injection	$8.50-$11/bbl	Depends on o&g content; treated solids sold for landfill cover material
TX	Newpark-Ingleside	Treat/injection	$8.50-$11/bbl	Depends on o&g content; treated solids sold for landfill cover material
TX	PSL, Inc.	Land spread	$20/yd^3$	
TX	Waste Facilities, Inc.	Land spread	$9-$16/bbl	For oil-based muds and tank bottoms; $25/yd^3$ for contam. soil or oil-based muds

TABLE 8 (Cont.)

State	Company	Type	Cost[a]	Comments
TX	Campbell Well-Zapata	Land spread	\$6.67-\$8.25/bbl	
TX	RCM Oil	Land spread	\$22.50/yd^3	Contaminated soils only
TX	Soil Recovery Systems	Land spread	\$57/bbl	\$30-\$40/yd^3
TX	Basic Remediation	Land spread	\$18/yd^3	
TX	J. Moss	Land spread/landfill	\$5.50-\$7/bbl	Solids - \$25/yd^3
TX	Westex Notrees	Landfill	\$3.25/bbl	\$15.50/yd^3
TX	Westex Sacroc	Landfill	\$3.25/bbl	\$15.50/yd^3
TX	Williams Oil Field Disposal	Pits/landfill	\$2.25/bbl	Dry solids - \$6.50/yd^3
TX	Eco Mud Disposal	Chem. treat/pit	\$9-\$12/bbl	\$30/yd^3; chemical stabilization of waste, then fill in caliche pit
UT	Lapoint Recycle and Storage	Pit	\$15/yd^3	Cost is for contaminated soil; tank bottoms at \$0.55/bbl
UT	Nick Stevenson	Pit	\$7/yd^3	Contaminated soils
UT	Water Disposal	Biol. treat./pit	\$0.50/bbl	Contaminated soils and tank bottoms
WY	Waste Inc.- Evanston	Pit	\$37.50/yd^3	Drilling wastes
WY	Waste Inc.-LaBarge	Pit	\$37.50/yd^3	Drilling wastes
WY	Sierra Construction	Pit	\$6/bbl	
WY	Jim's Water Service-Blakes Pit	Pit	\$10.50/bbl	
WY	Jim's Water Service-Cannon Land	Pit	\$10.50/bbl	
WY	Jim's Water Service-McBeth Pits	Pit	\$10.50/bbl	
WY	Jim's Water Service-Werner Ranch	Pit	\$10.50/bbl	
WY	Oilfield Disposal Service	Recycle	\$6/bbl	Tank bottoms
WY	Great Plains Environmental	Treat/injection or NPDES	\$2-\$5/bbl	This is a general industrial wastewater treatment facility
WY	Sweetwater Co. Solid Waste	Landspread	\$50-\$55/ton	Contaminated soils and drilling wastes

[a] Costs were provided by disposal companies between June 1996 and March 1997 and may not reflect current costs.

TABLE 9 Disposal Costs for Produced Water, Rain Water, and Other Water-Type Wastes

State	Company	Type	Cost[a]	Comments
CA	Valley Waste Disposal	Evap./injection	$0.01-$0.09/bbl	Produced water; injection cost is $0.06/bbl; this company is nonprofit
KY	Magnum Drilling	Injection	$1/bbl	
LA	L&S Service	Injection	$0.40/bbl	Produced water
LA	Pool Company	Injection	$0.20/bbl	Produced water
LA	J&R Systems-Lafayette	Injection	$0.35/bbl	Cost is for produced water; $0.45-$0.95 for rainwater
LA	J&R Systems-Vermillion	Injection	$0.40/bbl	Produced water and rainwater
LA	Venvirotek	Injection	$0.50-$0.75/bbl	Produced water
LA	SWD Inc.	Injection	$0.50/bbl	Produced water
LA	Saline Injection Systems	Injection	$0.31/bbl	Produced water
LA	Oil Field Brine Disposal	Injection	$0.36-$0.42/bbl	Produced water
LA	FAS Services	Injection	$0.35/bbl	Produced water and other water-type wastes
LA	Habetz Oilfield Saltwater Service	Injection	$0.29/bbl	Produced water and rainwater
LA	Hallar Enterprises	Injection	$0.75/bbl	Produced water
LA	Houma Salt Water Disposal	Injection	$0.50-$0.75/bbl	For prod. water and other water-type wastes; dirty water up to $3/bbl
LA	Louisiana Tank	Injection	$0.60/bbl	Produced water
LA	Teutsch	Injection	$0.50/bbl	Cost is for produced water; $0.75 for other water-type wastes
LA	Campbell Wells-Mermentau	Injection	$0.40/bbl	Cost is for produced water; dirty water and rainwater = $3-$6.50/bbl
LA	Campbell Wells-Elm Grove	Injection	$0.40/bbl	Cost is for produced water; dirty water and rainwater = $3-$6.50/bbl
LA	Campbell Wells-Bourg	Injection	$0.50/bbl	Cost is for produced water; dirty water and rainwater = $3-$6.50/bbl
LA	Campbell Wells-Bateman Island	Injection		Do not take produced water; dirty water and rainwater = 3-9.50/bbl
LA	Newpark-Morgan City	Injection	$4.50/bbl	Produced water, dirty water, and rainwater
LA	Newpark-Fourchon	Injection	$4.50/bbl	Produced water, dirty water, and rainwater
LA	Newpark-Venice	Injection	$4.50/bbl	Produced water, dirty water, and rainwater
LA	Newpark-Intracoastal City	Injection	$4.50/bbl	Produced water, dirty water, and rainwater
LA	Newpark-Cameron	Injection	$4.50/bbl	Produced water, dirty water, and rainwater

TABLE 9 (Cont.)

State	Company	Type	Cost[a]	Comments
NM	CRI	Evaporation	$0.25/bbl	Produced water
NM	Sundance	Evaporation	$0.25/bbl	Produced water
NM	TNT Construction	Evaporation	$0.81/bbl	Produced water
NM	Loco Hills	Evaporation	$0.35/bbl	Produced water
NM	Sunco	Evap./injection	$0.69/bbl	Produced water
NM	Basin Disposal	Injection	$0.69/bbl	Produced water
OK	Eola Muds	Injection	$0.30/bbl	Produced water
PA	Franklin Brine Treatment	Treat/NPDES	$1-$1.50/bbl	Produced water and other water-type wastes
PA	Hart Chemical	Treat/NPDES	$1.80-$2.10/bbl	$2.10/bbl for produced water; $1.80/bbl for nonsalty water
PA	Waste Treatment	Treat/NPDES	$1.50/bbl	Produced water and other water-type wastes
PA	Allegheny Liquid Systems	Treat/POTW	$1.25-$1.80/bbl	Produced water and other water-type wastes
PA	Keystone Vacuum Services	POTW/road spread	$1.30-$4.20/bbl	Produced water is roadspread in summer; other water-type wastes go to POTW
PA	Moshannon Valley Treatment Plant	POTW	$0.65/bbl	Other water-type wastes
PA	Bellefonte Treatment Plant	POTW	$1.50/bbl	Other water-type wastes
TX	Williams Oil Field Disposal	Injection	$0.30/bbl	Produced water
TX	Permian Brine Sales-Big Springs	Injection	$0.32-$0.50/bbl	Produced water
TX	Taylor Service Company	Injection	$0.35/bbl	Produced water
TX	Lundy Vacuum Services-Armour	Injection	$0.30/bbl	Produced water
TX	Lundy Vacuum Services-Wittig	Injection	$0.30/bbl	Produced water
TX	Mo-Vac Service	Injection	$0.35/bbl	Produced water
TX	Basic Remediation	Injection	$0.23-$0.35/bbl	Produced water
TX	Newpark-Port Arthur	Injection	$4.50/bbl	Produced water, dirty water, and rainwater
TX	Newpark-Ingleside	Injection	$4.50/bbl	Produced water, dirty water, and rainwater

TABLE 9 (Cont.)

State	Company	Type	Cost[a]	Comments
UT	Lapoint Recycle and Storage	Evaporation	$0.55/bbl	Produced water
UT	Ace Disposal	Evaporation	$0.75/bbl	Produced water
UT	Hansen Disposal	Evaporation	$0.50/bbl	Produced water
UT	Water Disposal	Evaporation	$0.50/bbl	Produced water
UT	Montezuma Well Service	Evaporation	$0.65-$0.75/bbl	Produced water; costs are based on truck loads
WY	D&B Disposal	Evaporation	$1.50//bbl	condensates
WY	Waste Inc.- Evanston	Evaporation	$1.75-$2.50/bbl	$1.75/bbl for produced water; $2.50 for other water-type wastes
WY	Waste Inc.-LaBarge	Evaporation	$1.10-$2.50/bbl	$1.10/bbl for produced water; $2.50 for other water-type wastes
WY	Sierra Construction	Evaporation	$0.60/bbl	Produced water
WY	Jim's Water Service-Blakes Pit	Evaporation	$1/bbl	Produced water
WY	Jim's Water Service-Cannon Land	Evaporation	$1/bbl	Produced water
WY	Jim's Water Service-McBeth Pits	Evaporation	$1/bbl	Produced water
WY	Jim's Water Service-Werner Ranch	Evaporation	$1/bbl	Produced water
WY	Oilfield Disposal Service	Evaporation	$0.75-$1.25/bbl	Produced water
WY	Mexican Flats Water Disposal	Evaporation	$1.95/bbl	Produced water
WY	Great Plains Environmental	Treat/injection or NPDES	$0.96/bbl	Produced water
WY	Wyoming Waste Water Disposal	Injection	$1-$2.50/bbl	Produced water
WY	Prima Exploration	Injection	$0.60/bbl	Produced water
WY	Cortez Energy	Injection	$0.75-$8/bbl	Produced water and other water-type wastes

[a] Costs were provided by disposal companies from June 1996 to March 1997 and may not reflect current costs.

TABLE 10 Disposal Costs for Water-Based Drilling Wastes

State	Company	Type	Cost	Comments
CA	VenVirotek	Chem.treat/reuse	\$15-\$25/ton	After treatment, used for landfill cover
LA	Campbell Wells-Mermentau	Land spread	\$7.50-\$9.50/bbl	
LA	Campbell Wells-Elm Grove	Land spread	\$7.50-\$9.50/bbl	
LA	Campbell Wells-Bourg	Land spread	\$7.50-\$9.50/bbl	
LA	Campbell Wells-Bateman Island	Land spread	\$7.50-\$9.50/bbl	
LA	Newpark-Morgan City	Treat/injection	\$7.50/bbl	Treated solids sold for landfill cover material
LA	Newpark-Fourchon	Treat/injection	\$7.50/bbl	Treated solids sold for landfill cover material
LA	Newpark-Venice	Treat/injection	\$7.50/bbl	Treated solids sold for landfill cover material
LA	Newpark-Intracoastal City	Treat/injection	\$7.50/bbl	Treated solids sold for landfill cover material
LA	Newpark-Cameron	Treat/injection	\$7.50/bbl	Treated solids sold for landfill cover material
NM	CRI	Evaporation/landfill	\$2.50/bbl	\$14/yd^3 for solids
NM	Sundance	Evaporation/landfill	\$2.75/bbl	
NM	Gandy-Marley	Land spread	\$14/yd3	
NM	Envirotech	Land spread	\$18/yd3	
NM	TNT Construction	Land spread	\$20/yd3	
NM	Tierra	Land spread	\$16-\$18/yd^3	
OK	Briggett	Pit	\$0.90/bbl	
OK	FPC Disposal	Pit	\$0.35/bbl	
OK	Gray	Pit	\$0.75/bbl	Cost for solids - \$5.20-\$6.25/yd^3
OK	Eola Mud	Pit	\$0.75/bbl	
OK	Guard-Giles	Pit	\$0.60-\$0.75/bbl	
OK	Guard	Pit	\$0.60-\$0.75/bbl	
OK	Smith	Pit	\$0.88/bbl	
OK	O'Daniel Gravel	Pit	\$0.50/bbl	
OK	Safe Earth	Pit	\$0.75-\$1.75/bbl	Cost for muds depends on chloride content; cuttings - \$8.30-10/yd^3
OK	Poteet Oil	Pit	\$0.67-\$1/bbl	

TABLE 10 (Cont.)

State	Company	Type	Cost	Comments
PA	Franklin Brine Treatment	Treat/NPDES	\$2.50-\$3.50/bbl	
PA	Allegheny Liquid Systems	Treat/POTW	\$1.25-\$14.70/bbl	Surcharges for solids and oil
PA	Hart Chemical	Treat/NPDES	\$3.40-\$8.40/bbl	
PA	Waste Treatment	Treat/NPDES	\$2.50-\$12.60/bbl	
PA	Bellefonte Treatment Plant	POTW	\$1.50/bbl	
PA	Moshannon Valley Treatment Plant	POTW	\$0.65/bbl	
TX	Permian Brine Sales-Andrews	Cavern	\$1.95-\$2.85/bbl	Depends on solids & o&g content; discounts of \$1-\$1.5/bbl for high oil content
TX	Permian Brine Sales-Big Springs	Cavern	\$1.95-\$2.85/bbl	Depends on solids & o&g content; discounts of \$1-\$1.5/bbl for high oil content
TX	Taylor Service Co.	Cavern	\$6/bbl	
TX	Voskamp Exploration	Cavern	\$2.75/bbl	
TX	Lundy Vacuum Service-Beasley	Land spread	\$0.31-\$0.80/bbl	
TX	Lundy Vacuum Service-Humphreys	Land spread	\$0.31-\$0.80/bbl	
TX	F. W. Fontenot	Land spread	\$0.38/bbl	
TX	Waste Facilities, Inc.	Land spread	\$5/bbl	
TX	Karon Smith	Land spread	\$1/bbl	\$10/yd3 for solids
TX	Earl Nunneley	Land spread	\$0.20/bbl	Cost is for muds; cuttings - \$5/yd^3
TX	Keith Overby	Land spread	\$0.38/bbl	
TX	Goetz Services	Land spread	\$0.19/bbl	
TX	Campbell Wells-Zapata	Land spread	\$1.50-\$7/bbl	Depends on oil and chlorides content
TX	*Mo-Vac Service*	Pit	\$1/bbl	
TX	J. Moss	Pit	\$2/bbl	Cost is for muds; cuttings - \$6.50 /yd^3; soil - 15/yd^3
TX	Newpark-Port Arthur	Treat/injection	\$7.50/bbl	Treated solids sold for landfill cover material
TX	Newpark-Ingleside	Treat/injection	\$7.50/bbl	Treated solids sold for landfill cover material
UT	Ace Disposal	Pit	\$1.50/bbl	

TABLE 10 (Cont.)

State	Company	Type	Cost	Comments
WY	Waste Inc.- Evanston	Pit	$37.50/yd^3$	
WY	Waste Inc.-LaBarge	Pit	$37.50/yd^3$	
WY	Sierra Construction	Pit	$1-$2/bbl	
WY	Jim's Water Service-Blakes Pit	Pit	$10.50/bbl	
WY	Jim's Water Service-Cannon Land	Pit	$10.50/bbl	
WY	Jim's Water Service-McBeth Pits	Pit	$10.50/bbl	
WY	Jim's Water Service-Werner Ranch	Pit	$10.50/bbl	
WY	Great Plains Environmental	Treat/injection or NPDES	$2-$5/bbl	This is a general industrial wastewater treatment facility
WY	Sweetwater Co. Solid Waste	Landspread	$50-$55/ton	

a Costs were provided by disposal companies from June 1996 to March 1997 and may not reflect current costs.

on-site. He also stated that tank bottoms are handled by commercial reclaimers.[1] Dennis Endel of the Oil and Gas Commission provided a list of several reclaimers. All were contacted, but only two provided information. These two are listed in Table 8. The reclaimers come to the oil field site and clean out tank bottoms. They then take the tank bottoms back to their facility, where the bottoms accumulate until their volume is sufficient to be sold to a refinery.

5.2.2 California

William Guerard and Hal Bopp of the California Department of Conservation indicated that although there are commercial oil field waste disposal companies in California, no formal comprehensive list of them is available. They provided the names of several companies, who, in turn, provided the names of other companies. M.G. Mefferd of the Conservation Committee of California Oil and Gas Producers provided an additional list of disposal companies. All facilities identified through this process were contacted. Facilities that provided information are listed in Tables 8-10. Table 8 lists five hazardous and nonhazardous waste landfills that accept oil field waste and six facilities that chemically, biologically, or thermally treat solid and oily wastes and convert them into usable by-products. One of these facilities also treats water-based drilling wastes for reuse, as shown in Table 10. Table 8 also identifies a facility that receives oil field wastes, assembles them in bulk, and transports them to an off-site land spreading operation. Table 9 identifies one facility that disposes of produced water through injection and evaporation and fresh water through irrigation.

5.2.3 Louisiana

Carroll Wascom of the Department of Natural Resources provided a list of approved commercial disposal facilities. Every facility on the list was contacted. Those facilities that provided information are listed in Tables 8-10. Tables 8 and 10 identify four land spreading sites and five sites that treat the wastes, inject the liquids, and recycle the solids as landfill cover material. Table 9 shows 23 commercial injection wells operated by 15 companies.

---

[1] Although the practice of reclaiming tank bottoms may occur throughout a large portion of the United States, the data collected for this study are not adequate to draw nationwide conclusions. Many of the state representatives we interviewed did not provide information on reclaiming activities in their states. When reclaimers were identified, they were contacted, and if they provided information, it is included in Table 8. In EPA (1994), there is a table (Table B-1) that summarizes a study by the Interstate Oil and Gas Compact Commission and identifies reclaimers in 15 oil- and gas-producing states.

5.2.4 New Mexico

Mark Ashley and Denny Faust of the New Mexico Oil Conservation Division provided a list of approved commercial disposal facilities. Every facility on the list was contacted. Facilities that provided information are listed in Tables 8-10. Table 8 identifies six land spreading operations and two facilities that use evaporation and landfills for disposing of solid and oily wastes. Table 9 shows that four facilities use evaporation, one uses injection, and another uses both evaporation and injection for disposing of produced water. Table 10 identifies four land spreading operations and two facilities that use evaporation and landfills for disposing of water-based drilling wastes.

5.2.5 Oklahoma

Bruce Langhus of the Oklahoma Corporation Commission provided a list of active commercial disposal pits that are authorized to accept only water-based drilling wastes. All facilities on that list were contacted. The 10 facilities that provided information are listed in Table 10. One of these facilities also operates a injection well for produced water disposal, as shown in Table 8. A lengthy list of commercial well companies for disposal of produced water was also provided. These companies were not contacted and are not shown on Table 9.

5.2.6 Pennsylvania

James Erb of the Pennsylvania Department of Environmental Protection indicated that most nonhazardous oil field wastes are disposed of on-site. Although operators could take wastes to landfills, he was not aware of any operators that did. Ron Gilius, also of the Department of Environmental Protection, provided a list of commercial facilities that receive oil field waste. Most of these disposal facilities dispose of only produced water and were not contacted. Several other facilities that dispose of both produced water and drilling and frac fluids were contacted. Table 9 lists one facility that treats the waste and then discharges it to a publicly owned treatment works (POTW), two facilities that are POTWs, and three facilities that treat the waste and then discharge it to surface waters through in a National Pollutant Discharge Elimination System (NPDES) permit. All of these facilities also dispose of water-based drilling wastes and are listed in Table 10.

One other company, referred to by Mr. Gilius as a service company, collects wastes and transports them to a POTW. This company also spreads produced water on roads during the summer, which is considered a beneficial use of a waste material by the Department of Environmental Protection. There are other service companies operating in Pennsylvania, but they were not identified or contacted.

5.2.7 Texas

Jill Hibner of the Railroad Commission of Texas provided a list of approved commercial disposal facilities. Every facility on the list was contacted. Facilities that provided information are listed in Tables 8-10. Table 8 identifies 17 facilities that dispose of solid and oily wastes, including seven land spreading operations, four facilities that use salt caverns, four that use pits or landfills (one of which chemically stabilizes the waste first), and two that process solid wastes for reuse and inject liquid wastes.

Table 9 identifies nine facilities that employ injection for disposing of produced water, rain water, and other water-type wastes. Table 10 identifies 17 facilities for disposing of water-based drilling wastes, including nine land spreading operations, four facilities that use salt caverns, two that use pits or landfills, and two that process solid wastes for reuse and inject liquid wastes.

5.2.8 Utah

Gil Hunt of the Utah Department of Natural Resources provided a list of approved disposal pits. Every facility on the list was contacted. Facilities that provided information are listed in Tables 8-10. Table 8 identifies three facilities that accept contaminated soils. Two of those facilities also accept tank bottoms. Table 9 lists five facilities that dispose of produced water through evaporation in pits. Table 10 lists one facility that disposes of water-based drilling wastes.

5.2.9 Wyoming

Bob Lucht and Larry Robinson of the Wyoming Department of Environmental Quality provided a list of approved disposal pits. Every facility on the list was contacted. Facilities that provided information are listed in Tables 8-10. Table 8 identifies seven facilities that dispose of solid and oily wastes in pits, one that land spreads, and one that recycles tank bottoms. Table 9 identifies 10 facilities that evaporate produced water and other water-type wastes, three that employ injection, and the industrial treatment facility described above. Table 10 lists seven facilities that dispose of water-based drilling wastes in pits and one that land spreads. One additional facility, which treats the waste in an industrial treatment plant and then either injects it to a well or discharges it to surface waters through an NPDES permit, is listed in all three tables.

5.3 STATES WITHOUT INDUSTRY-SPECIFIC OFF-SITE COMMERCIAL DISPOSAL

Some oil- and gas-producing states support a network of industry-specific commercial disposal facilities; these are described in the previous section. Most other oil-and gas-producing states are unable to support this type of network. In this second group of states, most nonhazardous oil field wastes are disposed of on-site. The wastes that must go off-site for disposal are sent to local sanitary landfills, industrial disposal facilities not specific to the oil and gas industry, or out of state. The information obtained through interviews with representatives of these states is described below. Since sanitary landfills represent the primary off-site disposal option for operators in many of these states, information on landfill availability and cost was gathered from several states that represent different parts of the country: California, Colorado, Mississippi, and Ohio.

5.3.1 Alabama

David Bolin of the Alabama Oil and Gas Board indicated that most nonhazardous oil field waste is disposed of on-site. Tank bottoms are generally sent off-site to a commercial disposal facility. He was unable to identify any disposal facilities that specifically handle oil and gas industry wastes. Tank bottoms and other wastes that are sent off-site probably go to a local landfill or hazardous waste disposal facility or to an out-of-state facility for disposal.

5.3.2 Alaska

Jack Hartz of the Alaska Oil and Gas Conservation Commission indicated that all nonhazardous oil field wastes in Alaska are disposed of on-site.

5.3.3 Arizona

Steve Rauzi of the Arizona Geological Survey, which provides staff support for the Oil and Gas Conservation Commission, reported that all oil field wastes are either disposed of on-site or sent to disposal facilities in neighboring states.

5.3.4 Colorado

Robin Reade of the Colorado Oil and Gas Conservation Commission indicated that much of Colorado's oil and gas waste is disposed of on-site or at off-site land farms owned and operated by the oil companies for their own wastes. Table 8 lists three sanitary landfills that accept oil field wastes. One landfill offers biological treatment before landfilling to speed up degradation. A second landfill also offers land spreading. A fourth company provides thermal treatment for contaminated soils but does not treat or dispose of other types of oil field wastes.

5.3.5 Florida

Don Hargrove, Paul Attwood, and Ed Garrett of the Florida Geological Survey indicated that drilling wastes are disposed of on-site. Contaminated soils and tank bottoms are incinerated. One commercial incinerator is identified in Table 8.

5.3.6 Illinois

Lawrence Bengal of the Illinois Department of Natural Resources reported that Illinois has 12 commercial produced water disposal wells. These companies were not contacted and do not appear in Table 9. Most other oil field wastes are disposed of on-site. Those wastes that are sent off-site are taken to sanitary landfills or sent out of state.

5.3.7 Indiana

Mike Nickolaus of the Indiana Department of Natural Resources reported that most wastes are disposed of on-site. Some wastes may be sent to "special waste" landfills.

5.3.8 Kansas

William Bryson of the Kansas Geological Survey and Richard Bronaugh and Joe Cronin of the Kansas Department of Health and Environment were interviewed. They suggested that most oil field wastes generated in Kansas are disposed of on-site. None of these officials were aware of any commercial waste disposal facilities in Kansas that are operated solely for handling oil field wastes, although there might be some commercial disposal wells for produced water. Wastes that cannot be disposed of on-site are probably sent to local sanitary or industrial landfills or to commercial disposal facilities in other states.

5.3.9 Kentucky

James Hale and Dan Juett of the Kentucky Department for Environmental Protection indicated that drilling wastes are disposed of on-site by land spreading. Produced water is disposed of through underground injection, enhanced evaporation, or NPDES-permitted discharge. Tank bottoms and other nonhazardous wastes are sent to landfills permitted to accept such wastes. Hale and Juett reported that two commercial injection wells dispose of produced water. One of these companies is identified in Table 9. The other company could not be contacted.

5.3.10 Maryland

Molly Gary of the Maryland Department of the Environment reported that cuttings are disposed of on-site but that drilling fluids are taken to an out-of-state disposal facility.

5.3.11 Michigan

Tom Segall and Joan Peck of the Michigan Department of Environmental Quality were interviewed. Neither official was aware of any commercial waste disposal facilities in Michigan that are operated solely to handle oil field wastes. Wastes that cannot be disposed of on-site are probably sent to local sanitary or industrial landfills or commercial disposal facilities in other states.

5.3.12 Mississippi

Fred Hille of the Mississippi Oil and Gas Board indicated that there are presently no commercial waste disposal companies in Mississippi that are operated solely for handling nonhazardous oil field wastes. Several facilities are licensed to handle naturally occurring radioactive material (NORM) associated with oil and gas activities. This report does not focus on NORM disposal, so those facilities were not identified. Jeff Lundy, also of the Oil and Gas Board, indicated that in early 1997, an oil field waste disposal company had expressed interest in operating a disposal facility in Mississippi. This facility is not currently licensed or operational and is therefore not included in Tables 8-10.

Wastes that cannot be disposed of on-site are sent to local sanitary or industrial landfills or to commercial disposal facilities in other states. Because Mississippi was selected as an example of a Gulf Coast state in which solid waste landfills are used for oil field waste disposal, additional data on landfills were collected. Mark Williams and James Crawford of the Mississippi Department of Environmental Quality provided a list of Mississippi's 17 active municipal solid waste landfills. Eleven of those facilities, located in oil- and gas-producing parts of the state, were contacted. One of these landfills does not accept oil field wastes. The remaining 10 landfills are listed in Table 8.

5.3.13 Missouri

Evan Kifer of the Missouri Department of Natural Resources indicated that drilling wastes are disposed of on-site but that contaminated soils are sent to landfills. James Williams, also of the Department of Natural Resources, reported that some coal bed methane production wastewater has been transported out of state for disposal.

5.3.14 Montana

Tom Richmond of the Montana Board of Oil and Gas Conservation reported that the majority of oil field wastes are disposed of on-site. There is one special landfill in Montana that can accept oil field wastes if necessary.

5.3.15 Nebraska

Stan Belieu of the Nebraska Oil and Gas Commission suggested that most oil field wastes generated in Nebraska are disposed of on-site. He was unaware of any commercial waste disposal facilities in Nebraska that are operated solely for handling oil field wastes. Wastes that cannot be disposed of on-site are probably sent to local sanitary or industrial landfills or to commercial disposal facilities in other states.

5.3.16 Nevada

Russ Land of the Nevada Department of Conservation and Natural Resources indicated that all produced waters are disposed of through injection wells and all nonhazardous drilling and associated wastes are disposed of on-site. John Snow of the Nevada Division of Minerals reported that heavily contaminated soils and tank bottoms are sent to two thermal treatment facilities or a hazardous waste landfill, as listed in Table 8.

5.3.17 New York

Brad Field of the New York Department of Environmental Conservation indicated that some wastes are disposed of on-site but that many oil field wastes are sent either to sanitary landfills or to out-of-state disposal facilities.

5.3.18 North Dakota

Charles Koch of the North Dakota Industrial Commission reported that most wastes are disposed of on-site but contaminated soils are taken to an approved landfill for disposal. North Dakota has numerous commercial disposal wells. These were not identified or contacted and do not appear in Table 9.

5.3.19 Ohio

Dennis Crist of the Ohio Department of Natural Resources indicated that there are no commercial waste disposal companies in Ohio operated solely for handling nonhazardous oil field wastes. Most oil field wastes generated in Ohio are disposed of on-site. Wastes that cannot be disposed of on-site are sent to local sanitary or industrial landfills or to commercial disposal facilities in other states. Because Ohio was selected as an example of a northern state in which solid waste landfills are used for oil field waste disposal, additional data on landfills were collected. George Kaiser of the Ohio Environmental Protection Agency provided a list of Ohio's licensed solid waste landfills. Five of those landfills, located in oil- and gas-producing parts of the state, were contacted and are listed in Table 8.

5.3.20 South Dakota

Mac MacGillivray of the South Dakota Department of Environment and Natural Resources reported that most oil field wastes are disposed of on-site or by neighboring operators. If wastes need to go off-site, they are sent to sanitary landfills or taken out of state.

5.3.21 Virginia

Bob Wilson of the Virginia Department of Mines, Minerals, and Energy indicated that drill cuttings are disposed of on-site but other solid wastes are sent off-site to approved landfills or other general waste disposal facilities. Liquid wastes are disposed of in injection wells or taken out of state to licensed facilities for disposal.

5.3.22 West Virginia

Jamie Sturm of the West Virginia Department of Natural Resources indicated that most nonhazardous oil field waste is disposed of on-site. Tank bottoms are generally sent off-site to a commercial disposal facility. He identified three Pennsylvania facilities that handle oil field wastes.

Other West Virginia operators may send their wastes to local landfills. Gene Smith, also of the Department of Natural Resources, reported that West Virginia has six commercial disposal wells for produced water. These companies were not contacted and do not appear in Table 9.

5.4 COSTS OF OFF-SITE COMMERCIAL DISPOSAL

Tables 8-10 list the costs for the off-site commercial disposal of solid and oily wastes, produced water (including rain water and other water-type wastes), and water-based drilling wastes, respectively. These costs are discussed by waste type and disposal method in the text that follows. The costs represent only the cost for disposal and do not include other costs associated with transportation or vehicle washout. Many companies indicated they would offer discounts from their standard rates for large volumes of waste.

The costs included in Tables 8-10 are those that were provided by each disposal company to the author during June 1996 and March 1997. They are included in this report for comparative purposes at one point in time. There is no guarantee that those costs reflect the actual costs that would be charged to customers or that these companies still charge the same costs.

Costs are expressed in different units of measurement. Most costs are expressed as \$/bbl, but others are expressed as \$/cubic yard (\$/yd^3) and \$/ton. The \$/yd^3 unit is often used when the wastes are predominantly solids, and the \$/ton unit is commonly used by landfills because costs for disposal of municipal solid waste are based on \$/ton. For the sake of comparison, one can convert the latter two units into \$/bbl, although the result is only an approximation, at best. To convert a volume-based unit (barrels or cubic yards) to a weight-based unit (tons), the specific gravity of the waste must be considered. If one assumes that oil field waste has a specific gravity that is 1.5 times that of water, the conversion factors are 1 yd^3 = 4.81 bbl and 1 ton = 3.81 bbl. The conversions are not shown in Tables 8-10 but are provided in several places in the following sections to describe overall cost patterns.

5.4.1 Solid and Oily Waste

Costs for these wastes are found in Table 8. Overall, disposal costs range from \$0-\$57/bbl, \$6.50-\$50/yd^3 (comparable to \$1.35-\$10.40/converted bbl), and \$12-\$150/ton (comparable to \$3.15-\$39.40/converted bbl). The highest cost per bbl, \$57/bbl, appears to be a true outlier. At the facility that charges that price, it costs less to dispose of a cubic yard of waste than a barrel of waste. This apparent anomaly can be attributed to the facility's reluctance to handle individual barrels rather than handling bulk wastes. After removing that anomalous value, the range becomes \$1.95-\$38/bbl. Several of the facilities that charge high per-ton rates are facilities that also accept hazardous wastes for disposal.

Land spreading operations have a significant share of the commercial disposal market. Prices are \$5.50-\$57/bbl and \$14-\$40/yd^3, with most costs falling in the range of \$7-\$9.50/bbl and \$18-\$25/yd^3. Two land spreading facilities quoted a per-ton rate of \$20-\$95/ton.

Landfills and pits represent another important disposal option for solid and oily wastes. Prices in Texas are \$2.25-\$3.25/bbl and \$6.50-\$25/yd^3, while Wyoming prices are \$6-\$10.50/bbl and \$37.50/yd^3. Two Utah facilities charge \$7-\$15/yd^3, and another charges \$0.50/bbl. Two New Mexico facilities evaporate the liquid fraction of the waste and then send the solids to landfills. They charge \$2.50-\$2.75/bbl and \$14/yd^3 for solids.

The Texas, Wyoming, Utah, and New Mexico landfills and pits in Table 8 are dedicated to receiving just oil field wastes, while the landfills in the other states are general solid waste or hazardous waste landfills that typically charge by the ton. Costs for disposing of solid wastes at landfills vary somewhat, depending on the state. For example, weight-based rates in Mississippi are \$18.50-\$35/ton; those in Ohio are \$17-\$29/ton; and those in California are \$30-\$40/ton at nonhazardous landfills and \$30-\$150/ton at hazardous waste landfills. One Nevada landfill charges \$31/ton. Three Colorado landfills charge \$10.80-\$22/yd^3. Two Mississippi landfills will accept liquids at a much higher rate of \$18.90-\$36/bbl, and one Mississippi landfill charges \$19-\$25/yd^3.

Several other disposal facilities treat the wastes before disposing of or reusing them. Five Louisiana facilities and two Texas facilities treat and reuse the solid part of the waste and inject the liquid part at a cost of \$8.50-\$11/bbl. Another Texas facility first chemically stabilizes the waste and then landfills it at a cost of \$9-\$12/bbl and \$30/ton. Five California facilities biologically or chemically treat waste and then reuse it at a cost of \$12-\$45/ton, \$12.50-\$28.50/yd^3, and \$0-\$6/bbl. One of these facilities charges \$0-4.20/bbl but only accepts liquids and sludges.

Several facilities use thermal treatment or incineration followed by reuse or disposal of the residues. Costs are \$10.50-\$38/bbl and \$20-\$100/ton.

One California commercial facility evaporates liquid wastes in a surface impoundment at a cost of \$4.20-\$18.90/yd^3.

Several companies identified in this survey reclaim tank bottoms. Two Arkansas reclaimers charge by the hour. One charges \$45/hour, and the other charges nothing for the first four hours and \$40/hour for each additional hour. One New Mexico company and one Wyoming company reclaim tank bottoms at costs from \$2.50-\$6/bbl.

A Wyoming company operates a sophisticated industrial wastewater treatment plant that either injects the treated waste or discharges it to the sanitary sewer. This plant charges \$2-\$5/bbl.

The remaining disposal method for solid and oily wastes, salt caverns, appears to be among the least costly off-site disposal options at this time. Disposal at three cavern facilities located in west Texas costs $1.95-$2.85/bbl. Disposal at the fourth operating disposal cavern, located in east Texas, costs $6/bbl or $50/yd^3 for contaminated soils. One reason the salt caverns cost less is that the Railroad Commission of Texas does not yet have regulations specifically targeted at disposal caverns. The four Texas disposal caverns are operating under permits issued by the Commission. However, in April 1996, the Commission proposed draft regulations. Most observers agree that when the regulations become final, the requirements placed on cavern operators will be more stringent than those currently specified by their permits. At that time, cavern siting, operating, monitoring, and closure costs are likely to increase, and the cavern operators will pass the increased costs to their customers. It is not possible to estimate the magnitude of the increase in costs that will follow final cavern disposal regulations.

The costs shown in Tables 8-10 do not include transportation costs, which can be substantial. Limited data collected during the survey indicate that trucking costs are $42-$63/hour. There are economic incentives for operators to send their wastes to disposal facilities located within a reasonably short distance from the oil and gas production site. Generally, operators will not transport waste more than 50-75 miles unless no other alternatives are available. Although disposal costs are important to an operator when determining which commercial waste disposal company to choose, the total of disposal costs, transportation costs, and other costs weigh heavily in the operator's final decision.

Examination of the data from a geographic perspective provides additional insights into disposal costs. As noted above, the disposal caverns in west Texas are much less costly than the disposal cavern in east Texas. One possible explanation for this cost dichotomy is competition. Figure 4 shows the locations of the four disposal caverns, with 75-mile-radius circles drawn around them. There are no other commercial disposal companies within the 75-mile-radius circle of the east Texas disposal cavern. There are several other commercial disposal companies within the 75-mile-radius circle of the three west Texas disposal caverns. All three facilities rank among the lowest-cost facilities for their disposal method.

5.4.2 Produced Water, Including Rain Water and Other Water-Type Wastes

Costs for disposing of these wastes are listed in Table 9. Overall, disposal costs are $0.01-$8/bbl, although most are $0.25-$1.50/bbl. The highest cost, $8/bbl, is charged at one facility for particularly dirty wastes that need pretreatment before injection. The same facility charges as low as $0.75/bbl for cleaner wastes. The lowest cost is charged by a nonprofit facility in California that operates as a cooperative for several member users.

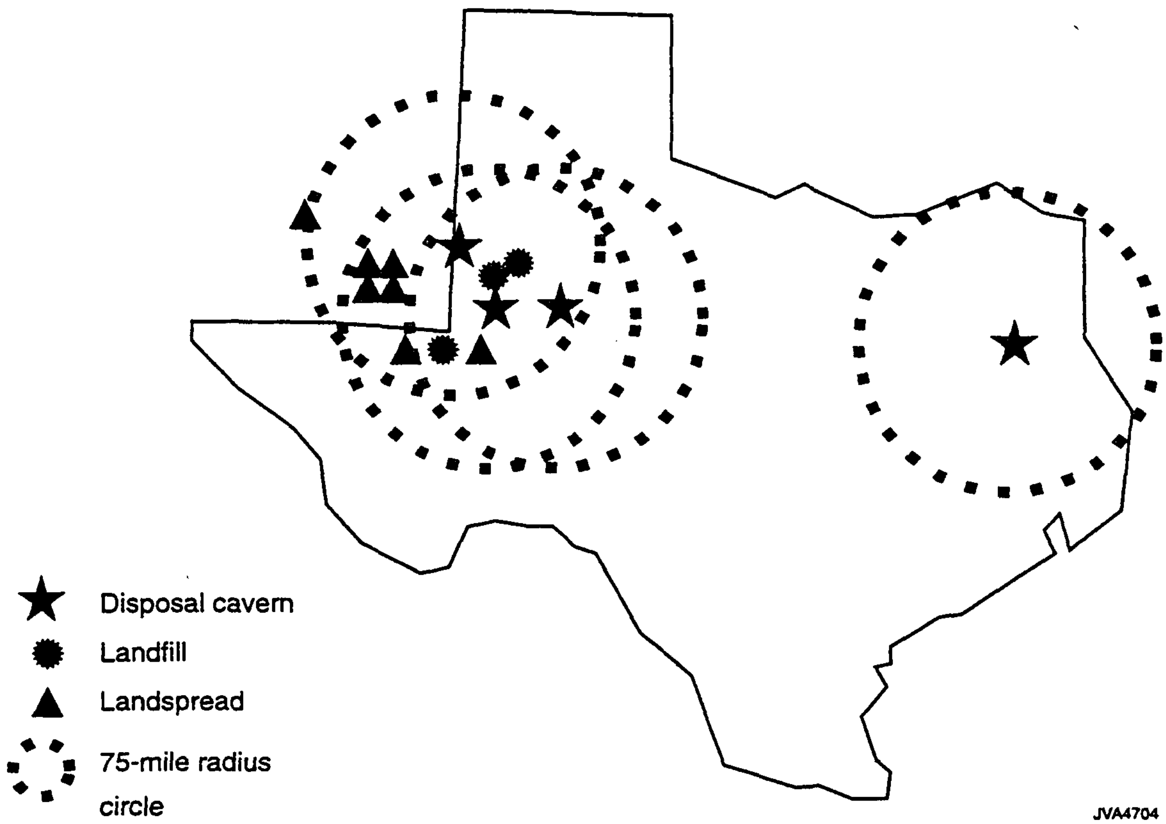


FIGURE 4 Locations of Disposal Caverns and Other Commercial Solid and Oily Waste Disposal Facilities within 75-Mile Radiuses

By far, the most common commercial disposal method for produced water is injection. As mentioned previously, the waste disposal cost survey did not focus on produced water disposal costs, and no attempt was made to obtain costs from most or all commercial produced water disposal companies. The range of costs for injection is the same as that described in the previous paragraph.

Ten companies in Wyoming, five companies in Utah, and four companies in New Mexico use evaporation to dispose of produced water. The cost is \$0.25-\$2.50/bbl. Another New Mexico company uses a combination of evaporation and injection, at a cost of \$0.69/bbl. The nonprofit California company described above, which also uses a combination of evaporation and injection, charges \$0.01-\$0.09/bbl.

Six companies in Pennsylvania utilize surface water discharge options. Three of these companies treat and blend produced water and discharge it directly through an NPDES permit. Another company treats the waste and discharges it to a sanitary sewer that leads to a municipal wastewater treatment plant. They charge \$1-\$2.10. Two municipal wastewater treatment plants accept water-type wastes but not produced water. They charge \$0.65-\$1.50/bbl. Another company in Pennsylvania spreads produced water on roads in the summer and discharges to a municipal wastewater treatment plant in the winter. This company charges \$1.30-4.20/bbl.

Salt caverns have not been used for commercial produced water disposal because they are more costly than the other available produced water disposal options. Caverns are not likely to be used in the future, either, partly because a barrel of brine is brought to the surface for each barrel of produced water that is placed into the cavern. Unless there is a market for the brine, the costs will become prohibitive when compared with those of other locally available options.

5.4.3 Water-Based Drilling Wastes

Costs for these wastes are found in Table 8. Overall, disposal costs are \$0.20-\$14.70/bbl, \$5-\$37.50/yd^3 (comparable to \$1.04-\$7.80/converted bbl), and \$15-\$55/ton (comparable to \$3.93-\$14.43/converted bbl).

Land spreading appears to be the most common commercial disposal method for water-based drilling wastes. Prices vary in different states. In Texas, land spreading costs are \$0.20-\$7/bbl and \$5-\$10/yd^3. In Louisiana, land spreading costs are somewhat higher — \$7.50-\$9.50/bbl. New Mexico's commercial land spreading companies charge \$14-\$20/yd^3. One Wyoming company charges \$50-\$55.

Another common commercial disposal method for water-based drilling waste is disposal pits. Ten Oklahoma pits charge \$0.35-\$1.75/bbl, and two Texas pits charge \$1-\$2/bbl. Solids are handled at several of the pits; costs are \$5.20-\$15/yd^3. One Utah pit charges \$1.50/bbl. Seven Wyoming pits charge \$1-\$10.50/bbl and \$37.50/yd^3.

Several other commercial disposal companies use a combination of treatment and disposal methods. Five Louisiana facilities and two Texas facilities treat the waste, reuse the solids as landfill cover, and inject the liquid, at a cost of \$7.50/bbl. Two New Mexico companies evaporate the liquids and landfill the solids at a cost of \$2.50-\$2.75/bbl or \$14/yd^3 for solids.

Three Pennsylvania companies treat water-based drilling wastes and discharge them to surface waters under an NPDES permit. A fourth company treats the wastes and then discharges them to a local sanitary sewer that leads to a municipal wastewater treatment plant. These companies charge \$2.50-\$14.70/bbl. Two municipal wastewater treatment plants accept water-based drilling wastes and charge \$0.65-\$1.50/bbl. A Wyoming company operates a sophisticated industrial wastewater treatment plant that either injects the treated waste or discharges it to the sanitary sewer. This plant charges \$2-\$5/bbl.

One California company treats the wastes and reuses the solids as landfill cover at a cost of \$15-\$25/ton.

Salt caverns can be used to dispose of water-based drilling wastes. Cavern disposal costs are \$1.95-\$6/bbl.

6 CONCLUSIONS

According to Wakim (1987, 1988), in 1985, the U.S. exploration and production segment of the oil and gas industry generated more than 360 million bbl of drilling wastes, more than 20 billion bbl of produced water, and nearly 12 million bbl of associated wastes. Current exploration and production activities are believed to be generating comparable quantities of waste. Wakim estimates that 28% of drilling wastes, less than 2% of produced water, and 52% of associated wastes are sent to off-site commercial facilities for disposal. Little has been published on the availability of commercial disposal companies in different states. This report provides information on the availability of commercial disposal companies, the treatment and disposal methods they employ, and the amounts they charge. The conclusions are summarized below.

- At the federal level, the majority of oil field wastes are considered to be exempt from the hazardous waste provisions of RCRA. This nonhazardous classification simplifies the disposal of oil field waste and allows for reduced disposal costs. All oil- and gas-producing states except California accept this nonhazardous classification. California tests each waste for hazardous characteristics; if the waste fails, it is considered hazardous.

- Oil field wastes are regulated at the state level. All oil- and gas-producing states allow some on-site disposal of oil field wastes. Commonly used methods include underground injection, on-site burial, land spreading or other land treatment, evaporation, surface discharge, and recycling.

- Many drilling wastes and associated wastes are sent to off-site commercial disposal facilities. Interviews with oil and gas officials in 31 oil- and gas-producing states suggest that there are two off-site disposal trends.

    1. Nine states contain numerous commercial disposal companies dedicated to handling only oil field wastes. These companies use the same disposal methods as those used for on-site disposal. In addition, the Railroad Commission of Texas has issued permits allowing several salt caverns to be used for disposal of oil field wastes.

    2. Twenty-two other oil- and gas-producing states contain few or no disposal companies dedicated to oil and gas industry waste. The only off-site commercial disposal companies available are general industrial waste disposal facilities or sanitary landfills.

- The cost of off-site commercial disposal varies, depending on the disposal method used, the state in which the disposal company is located, and the degree of competition in the area.

- In most cases, companies can dispose of their oil field wastes at a lower cost on-site than off-site and therefore choose on-site disposal. When wastes must be sent off-site for regulatory, economic, or other reasons, operators closely examine the total cost of off-site disposal. The total cost includes transportation and vehicle washout costs as well as disposal costs.

- Disposal caverns are presently cost-competitive in the Texas waste disposal market. However, disposal cavern costs are likely to increase in the near future as the Railroad Commission of Texas adopts regulations governing cavern disposal. It is unclear how the increased costs will affect the competitiveness of disposal caverns in the future, since costs at competing waste disposal facilities are likely to change.

- Regulatory officials in Louisiana, New Mexico, and Mississippi are presently considering how to manage cavern disposal in their states. The use of caverns to dispose of oil field waste will spread to other states, depending on the availability of suitable salt formations and the size of the off-site commercial disposal market in those states. The market, in turn, is affected by the stringency of state regulations on disposal of oil field wastes. Thus, future changes to state oil field waste disposal regulations will be an important catalyst to encourage new cavern disposal operations.

- This report does not evaluate the economic feasibility of using salt caverns to dispose of oil field wastes on-site. The author is not aware of any U.S. proposals to operate on-site disposal caverns, but one such project for Husky Oil in Saskatchewan, Canada, to dispose of its own wastes has been approved.

7 REFERENCES

API, 1994, "Design of Solution-Mined Underground Storage Practices," Recommended Practice 1114, American Petroleum Institute, Washington, D.C., June.

CSA, 1993, "Storage of Hydrocarbons in Underground Formations — Oil and Gas Industry Systems and Materials," Standard Z341-93, Canadian Standards Association, Rexdale, Ontario, Canada, July.

DOE/IOGCC, 1993, *Oil and Gas Exploration and Production Waste Management: A 17-State Study*, DOE/FE-62017-H1, prepared by ICF Resources, Inc., Washington, D.C., for U.S. Department of Energy, Washington, D.C., and Interstate Oil and Gas Compact Commission, Oklahoma City, Okla., June.

EPA, 1994, *Associated Waste Report: Crude Oil Tank Bottoms and Oily Debris*, draft, U.S. Environmental Protection Agency, Washington, D.C., March.

IOGCC, 1994, *IOGCC Environmental Guidelines for State Oil & Gas Regulatory Programs*, Interstate Oil and Gas Compact Commission, Oklahoma City, Okla., May.

IOGCC, 1995, *Natural Gas Storage in Salt Caverns — A Guide for State Regulators*, Interstate Oil and Gas Compact Commission, Oklahoma City, Okla., Oct.

Johnson, K.S., and S. Gonzales, 1978, *Salt Deposits in the United States and Regional Geologic Characteristics Important for Storage of Radioactive Wastes*, Y/OWI/SUB-7414/1, prepared by Earth Resources Associates, Inc., Athens, Ga., for U.S. Department of Energy, Office of Waste Isolation, March.

Querio, C.W., 1980, "Design and Construction of Solution-Mined Caverns for LPG Storage," presented at Solution Mining Research Institute's fall meeting, Minneapolis, Minn., Oct. 12-15.

Veil, J. et al., 1996, *Preliminary Technical and Legal Evaluation of Disposing of Nonhazardous Oil Field Waste into Salt Caverns*, prepared by Argonne National Laboratory, Washington, D.C., for the U.S. Department of Energy, June.

Wakim, P.G., 1987, *API 1985 Production Waste Survey, Statistical Analysis and Survey Results*, American Petroleum Institute, Washington, D.C., Oct.

Wakim, P.G., 1988, *API 1985 Production Waste Survey, Part II — Associated and Other Wastes, Statistical Analysis and Survey Results*, American Petroleum Institute, Washington, D.C., June.

GUIDELINES FOR THE PREPARATION OF DISCHARGE PLANS AT BRINE EXTRACTION FACILITIES

(Revised 05-91)

Introduction

The New Mexico Oil Conservation Division (OCD) regulates brine extraction activities and disposal of non-domestic wastes resulting from this industry pursuant to authority granted in the New Mexico Water Quality Act and the Oil and Gas Act. OCD administers, through delegation by the New Mexico Water Quality Control Commission (WQCC), all Water Quality Act regulations pertaining to surface and ground water except sewage. However, if the sewage is in a combined waste stream, the OCD will have jurisdiction.

Sections 3-104 and 3-106 of the WQCC Regulations stipulate that, unless otherwise provided for by the regulations, no person shall cause or allow effluent or leachate to discharge so that it may move directly or indirectly into the ground water unless such discharge is pursuant to a discharge plan approved by the director. Additionally, Section 5-101 requires in situ extraction wells, including those extracting brine, to have approved discharge plans prior to operation. The Oil and Gas Act (Section 70-2-12.B(22)) authorizes the OCD to regulate the disposition of non-domestic, non-hazardous wastes at oil field facilities to protect public health and the environment. The OCD has combined these requirements into one document, (a "discharge plan") that will provide protection to ground water, surface water and the environment through proper regulation of brine extraction facilities and associated transfer, storage, and disposal of materials at the facility.

A proposed discharge plan shall set forth in detail the methods or techniques the discharger proposes to use which will ensure compliance with WQCC regulations and the Oil and Gas Act. The proposed discharge plan must provide the technical staff and the director of the regulating agency (in this case, the OCD) with sufficient information about the operation to demonstrate that the discharger's activities will not cause state regulations or ground water standards (WQCC Section 3-103) to be violated.

In addition to meeting the Part 5 WQCC requirements for injection wells, the discharge plan must address surface facility operations including storage pits, tankage and loading areas. Inadvertent discharges of liquids (ie. leaks and spills, or any type of accidental discharge of contaminants) or improper disposal of waste solids still have a potential to cause ground water contamination or threaten public health and the environment.

For existing brine extraction facilities presently operating under an approved discharge plan, WQCC UIC regulation 5-101.G stipulates that the expiration date of the plan shall be extended provided the following conditions are met: (1) A discharge plan renewal application should be submitted to the OCD at least 180 days prior to plan expiration, and (2) the discharger is in compliance with the existing plan on the original date of expiration. The extension of the existing plan is effective until the OCD approves or disapproves the renewal application. The renewal application should follow the attached guidelines with emphasis on the items that are not included in the original plan.

After a discharge application plan has been received, the OCD must publish a public notice pursuant to Section 3-108 of the regulations, and allow 30 days for public comment before a discharge plan may be approved or otherwise resolved. If significant public interest is indicated, a public hearing will be held which will delay a decision on plan approval.

Once a plan has been approved, discharges must be consistent with the terms and conditions of the plan. Similarly, if there is any facility expansion or process change that would result in any significant modification of the approved discharge of water contaminants, the discharger is required to notify this agency, and have the modification approved prior to implementation. Approval of a discharge plan application by OCD will not relieve the operator of the necessity to become familiar with other applicable state and federal regulations.

The review of a proposed discharge plan often requires several months depending on complexity. This includes time for requests to the discharger for additional information and clarification, in-house information gathering and analysis, and field investigations of the discharge site, and a public notice and comment period. Review time will, to a large extent, be dependent on the extent to which a facility has generally self-contained processes to prevent movement of fluids and leaching of solids from the work area into the environment.

For example, the review process will be expedited when effluent, process or other fluids are routed to tanks, or lined pits with underdrains for leak detection, when accurate monitoring of fluid volumes and pressure and/or integrity testing is performed for leak detection in below grade or underground tanks, and when the possibility of accidental spills and leaks is addressed by adequate contingency plans (e.g. containment by curbing and drainage to properly constructed sumps). Other examples allowing faster review include recycling of waste oils, proper disposal of dried sludges to minimize potential ground water contamination, and closure of previously used ponds. A more rapid review of discharge plans for such facilities is possible because much less geologic and hydrologic study of the site is required in order to delineate impact.

Similarly, longer review times will be required for operators seeking to continue to use unlined ponds or to utilize other procedures that have a high probability of allowing infiltration and movement of effluent and leachate to the subsurface. For these instances large amounts of technical data generally will be required including: 1) detailed information on site hydrogeology, natural and current water quality, and movement of contaminants; 2) processes expected to occur in the vadose and saturated zones to attenuate constituents to meet WQCC standards at a place of present or reasonably foreseeable future use of ground water; and 3) monitoring of ground water (including post operational monitoring as necessary).

If an operator desires to change or modify effluent or solid waste disposal practices it is not necessary to have completed all such changes prior to plan approval. A commitment to make the changes together with submittal of proposed modification details and a timely completion schedule can be included in the plan. These become plan requirements after the plan is approved.

The following discharge plan application guidelines have been prepared for use by the discharger to aid in fulfilling the requirements of Sections 3-106, 3-107 and Part 5 (UIC) of the WQCC regulations and to expedite the review process by minimizing OCD requests for additional information. It sets up a logical sequence in which to present the information required in a discharge plan for this type of facility. It is suggested that you read the entire document before preparing your application. Not all information discussed in the guidelines may be applicable to your facility. However, all sections of the application form must be completed for new or renewal discharge plan applications.

If there are any questions on the preparation of a discharge plan, please contact OCD's Environmental Bureau (P. O. Box 2088, Santa Fe, New Mexico 87501-2088 or by telephone at (505) 827-5812).

DISCHARGE PLAN GUIDELINES

I. Name of Facility

Provide complete name. Indicate whether this is a new or renewal application.

II. Name of Operator or Legally Responsible Party and Local Representative

Include address and telephone number.

III. Location of Facility

Give a legal description of the location (i.e. 1/4. 1/4, Section, Township, Range) and county. Use state coordinates or latitude/longitude on unsurveyed land. Submit a large scale topographic map, facility site plan, or detailed aerial photograph for use in conjunction with the written material. It should depict the location of the injection well, storage tanks and/or ponds, process equipment, relevant objects, facility property boundaries, and other site information required in Sections V through IX below. If within an incorporated city, town or village provide a street location and map.

IV. Landowners

Attach the name and address of the landowner(s) of record of the facility site.

V. Type and Quantities of Fluids Stored or Used at the Facility

List all fluids stored or used at the facility (e.g. High TDS salt water, hydrocarbons, etc.). Include source, average daily volume produced, estimated volume stored, location, and type of containers.

VI. Transfer, Storage and Disposal of Fluids and Solids

A. Provide sufficient information to determine what water contaminants may be discharged to the surface and subsurface within the facility. Information desired includes whether tanks, piping, and pipelines are pressurized, above ground or buried. If fluids are drained to surface impoundments, skimmer pits, emergency pits, sumps, etc. for further transfer and processing, provide size and show if these units are lined or unlined. Provide fluid flow schematics with sufficient detail to show individual units.

1. Tankage and Chemical Storage Areas - Storage tanks for fluids other than fresh water must be bermed to contain a volume one-third more than the largest tank. If tanks are interconnected, the berm must be designed to contain a volume one-third more than the total volume of the interconnected tanks. Chemical and drum storage areas must be paved, curbed and drained such than spills or leaks from drums are contained on the pads or in lined sumps.

2. Surface impoundments - Date built, use, type and volume of materials stored, area, volume, depth, slope of pond sides, sub-grade description, liner type and thickness, compatibility of liner and stored materials, installation methods, leak detection methods, freeboard, runoff/runon protection.

3. Leach fields - Type and volume of effluents, leach field area and design layout. If non-sewage or mixed flow from any process units or internal drains is, or has been, sent to the leach fields, include dates of use and disposition of septic tank sludges.

4. Solids disposal - Describe types volumes frequency and location of on-site solids dried disposal. Typical solids include sands, sludges, filters, containers, cans and drums.

B. For each of the transfer/storage/disposal methods listed above:

1. Describe the existing and proposed measures to prevent or retard seepage such that ground water at any place of present or future use will meet the WQCC Standards of Section 3-103, and not contain any toxic pollutant as defined in Section 1-101.UU.

2. Provide the location and design of site(s) and method(s) to be available for sampling, and for measurement or calculation of flow.

3. Describe the monitoring system existing or proposed in the plan to detect leakage or failure of any discharge system. If ground water monitoring exists or is proposed, provide information on the number, location, design, and installation of monitoring wells.

C. Off-Site Disposal

If wastewaters, sludges, solids etc. are pumped or shipped off-site, indicate general composition (e.g. waste oils), method of shipment (e.g. pipeline, trucked), and final disposition (e.g. recycling plant, OCD-permitted or domestic landfill, Class II disposal well). Include name, address, and location of receiving facility. If receiving facility is a sanitary or modified domestic landfill show operator approval for disposal of the shipped wastes.

D. Proposed Modifications

1. If protection of ground water cannot be demonstrated pursuant to Section B.1. above, describe what modification (including closure) is proposed to meet the requirements of the Regulations. Describe in detail the proposed changes. Provide the information requested in A. and B. above for the proposed modified facility and a proposed time schedule for construction and completion. (Note: OCD has developed specific guidelines for lined surface impoundments that are available on request.)

2. For ponds, pits, leach fields, etc. where protection of ground water cannot be demonstrated, describe the proposed closure of such units so that existing fluids are removed, and emplacement of additional fluids and runoff/runon of precipitation are prevented. Provide a proposed time schedule for closure.

E. If the facility contains underground piping, the age and specification (i.e., wall thickness, fabrication material, etc.) of said piping should be submitted. Upon evaluation of such information, mechanical integrity testing of piping may be necessary as a condition for discharge plan approval. If such testing (e.g. hydrostatic tests) has already been conducted, details of the program should be submitted.

F. Inspection, Maintenance and Reporting

1. Describe proposed routine inspection procedures for surface impoundments and other transfer, storage, or disposal units including leak detection systems. Include frequency of inspection, how records are to be maintained and OCD notification in the event of leaks.

2. If ground water monitoring is used to detect leakage or failure of the surface impoundments, leach fields, or other approved transfer/storage/disposal systems provide:

a. The frequency of sampling, and constituents to be analyzed.

b. The proposed periodic reporting of the results of the monitoring and sampling.

c. The proposed actions and procedures (including OCD notification) to be undertaken by the discharger in the event of detecting leaks or failure of the discharge system.

3. Discuss general procedures for containment of precipitation and runoff such that water in contact with process areas does not leave the facility, or is released only after testing for hazardous constituents. Include information on curbings, drainage, disposition, notification, etc.

4. Describe methods used to detect leaks and ensure integrity of above and below ground tanks, and piping. Discuss frequency of inspection and procedures to be undertaken if significant leaks are detected.

5. Submit a general closure plan describing what actions are to be taken when the facility discontinues operations. These actions must include:

   1. Removal of all fluids, contaminants and equipment.

   2. Grading of facility to as close to the original contour as is practical.

   3. Proper disposal of fluids, sludges and solids pursuant to rules and regulations in effect at the time of closure.

VII. Brine Extraction Well(s)

Insitu brine extraction wells must meet the requirements of Part 5 of the Water Quality Control Commission Regulations in addition to other applicable requirements of WQCC and Oil Conservation Division Rules and Regulations.

A. Drilling, Deepening, or Plug Back Operations

Before drilling, deepening, or plug back operations, the operator of the well must file the following plans, specifications, and pertinent documents with the Oil Conservation Division 90 days prior to start-up of the planned operation.

1. Form C-101 "Application for Permit to Drill, Deepen, or Plug Back" (OCD Rule 1101).

2. A "Notice of Intent to Discharge" in accordance with WQCC regulation 1-201 (New facilities only).

3. A map showing the number, name, and location of all producing oil and gas wells, injection wells, abandoned holes, surface bodies of water, watercourses, springs, mines, quarries, water wells, and other pertinent surface features within 1/4 mile from the wellbore(s).

4. Maps and cross-sections indicating the general vertical and lateral limits of all ground water having 10,000 mg/l or less TDS within one mile of the site. Show the position of such ground water within this area relative to the injection formation. Indicate the direction of water movement, where known, for each zone of ground water.

5. List all abandoned wells/shafts or other conduits in the area of review which penetrate the injection zone. Identify those which may provide a pathway for migration of contaminant through being improperly sealed, completed or abandoned. Detail what corrective action will be taken prior to start up of operations to prevent any movement of contaminants into ground water of less than/equal to 10,000 mg/l TDS through such conduits due to the proposed injection activity (e.g. plugging open holes). Include completion and plugging records.

   If information becomes available after operations have begun, which indicates the presence of a conduit that will require plugging then the injection pressure will be limited to avoid movement of contaminants through such a conduit into protected groundwater.

6. Maps and cross-sections detailing the geology and geologic structure of the local area.

7. A proposed formation testing program to obtain an analysis or description of fluids in the receiving formation.

8. Schematic drawings of the surface and subsurface construction details.

9. The proposed drilling, evaluation, and testing, programs. Include logging procedures, coring program, and deviation checks.

10. The proposed stimulation, injection, and operation procedures (Note WQCC 5-206 limitations).

11. A plan for plugging and abandonment of the well that meets the requirements of WQCC regulations section 5-209. **A plugging bond pursuant to OCD Rule 101 is required prior to commencement of any new well drilling operations.**

B. Workover Operations

Before performing remedial work, altering or pulling casing, plugging or abandonment, or any other workover, approval of OCD must be obtained. Approval should be requested on OCD Form C-103 "Sundry Notices and Reports on Wells" (OCD Rule 1103-A).

C. Additional Information Required with Discharge Plan

In addition to all of the information required above in Part VII.A. (Drilling, Deepening, or Plug Back Operations), include the following with your discharge plan application.

1. Provide evaluation, completion and well workover information. Include all logs, test results, completion reports and workover descriptions.

2. Provide the proposed maximum and average injection pressures and injection volume. If one well is to be used for injection and extraction, fresh water must be injected down the annulus and brine must be recovered up the tubing. Reverse flow will be allowed for up to once a month for 24 hours for clean out. If an alternative operating method is desired then a written request must be submitted to the OCD which describes the proposed operating procedures and how the mechanical integrity of the casing will be guaranteed.

3. Submit a proposed mechanical integrity testing program. OCD requires a casing pressure test isolating the casing from the formation using either a bridge plug or packer prior to start of operation, and repeated at least once every five years or during well work over. In addition, OCD requires an open hole pressure test to 500 PSI for 4 hours on an annual basis.

4. Provide an analysis of the injection fluid and brine. Include location and design of site(s) and method(s) of sampling. Analysis will be for concentrations of Total Dissolved Solids, Sodium, Calcium, Potassium, Magnesium, Bromide, Carbonate/Bicarbonate, Chloride and Sulfate.

5. Compare volumes of fresh water injected to volume of brine to detect underground losses and specify method by which volumes are determined. After approval, submittal of a quarterly report listing, by month, the volume of fluids injected and produced will be required.

6. For renewal application for facilities in operation in excess of 15 years, provide information on the size and extent of the solution cavern and geologic/engineering data demonstrating that continued brine extraction will not cause surface subsidence of catastrophic collapse.

VIII. Spill/Leak Prevention and Reporting Procedures (Contingency Plans)

It is necessary to include in the discharge plan submittal a contingency plan that anticipates where any leaks or spills might occur. It must describe how the discharger proposes to guard against such accidents and detect them when they have occurred. The contingency plan also must describe the steps proposed to contain and remove the spilled substance or mitigate the damage caused by the discharge such that ground water is protected, or movement into surface waters is prevented. The discharger will be required to notify the OCD Director in the event of significant leaks and spills. This commitment and proposed notification threshold levels must be included in the contingency plan.

A. Prevention

Describe how spills and leaks will be prevented at the facility. Include specifically how spillage/leakage will be prevented during truck loading and at major transfer points within the facility. Discuss general "housekeeping" procedures for areas not directly associated with the above major processes.

B. Containment and Cleanup

Describe procedures for containment and cleanup of major and minor spills at the facility. Include information as to whether areas are curbed, paved, and drained to sumps; final disposition of spill materials; etc.

C. Notification

Propose a schedule for OCD notification of spills. OCD requires immediate notification at major spills or within 24 hours and written subsequent notification of minor spills or within 10 days (OCD Rule 116).

IX. Site Characteristics

A. The following hydrologic/geologic information is required to be submitted with all discharge plan applications. Some information already may be included in this application or may be on file with OCD and can be provided to the applicant on request.

1. Provide the name, description, and location of any bodies of water, streams (indicate perennial or intermittent), or other watercourses (arroyos, canals, drains, etc.); and ground water discharges sites (seeps, springs, marshes, swamps) within one mile of the outside perimeter of the facility. For water wells, locate wells within one-quarter mile and specify use of water (e.g. public supply, domestic, stock, etc.).

2. Provide the depth to and total dissolved solids (TDS) concentration (in mg/l) of the ground water most likely to be affected by any discharge (planned or unplanned). Include the source of the information and how it was determined. Provide a recent water quality analysis of the ground water, if available, including name of analyzing laboratory and sample date.

3. Provide the following information and attach or reference source information as available (e.g. driller's logs):

   a. Soil type(s) (sand, clay, loam, caliche);

   b. Name of aquifer(s);

   c. Composition of aquifer material (e.g. alluvium, sandstone, basalt, etc.); and

   d. Depth to rock at base of alluvium (if available).

4. Provide information on:

   a. The flooding potential at the discharge site with respect to major precipitation and/or run-off events; and

   b. Flood protection measures (berms, channels, etc.), if applicable.

B. Additional Information

Provide any additional information necessary to demonstrate that approval of the discharge plan will not result in concentrations in excess of the standards of WQCC Section 3-103 or the presence of any toxic pollutant (Section 1-101.UU.) at any place of withdrawal of water for present or reasonably foreseeable future use. Depending on the method and location of discharge, detailed technical information on site hydrologic and geologic conditions may be required to be submitted for discharge plan evaluation. This material is most likely to be required for unlined surface impoundments and pits, and leach fields. **Check with OCD before providing this information.** However, if required it could include but not be limited to:

1. Stratigraphic information including formation and member names, thickness, lithologies, lateral extent, etc.

2. Generalized maps and cross-sections;

3. Potentiometric maps for aquifers potentially affected;

4. Porosity, hydraulic conductivity, storactivity and other hydrologic parameters of the aquifer;

5. Specific information on the water quality of the receiving aquifer; and

6. Information on expected alteration of contaminants due to sorption, precipitation or chemical reaction in the unsaturated zone, and expected reactions and/or dilution in the aquifer.

X. Other Compliance Information

Attach such other information as is necessary to demonstrate compliance with any other OCD rules, regulations and/or orders. Examples include previous Division orders or letters authorizing operation of the facility or any surface impoundments at the location.

State of New Mexico
Energy, Minerals and Natural Resources Department
OIL CONSERVATION DIVISION
P.O. Box 2088
Santa Fe, NM 87501

DISCHARGE PLAN APPLICATION FOR BRINE EXTRACTION FACILITIES

(Refer to OCD Guidelines for assistance in completing the application.)

☐ NEW ☐ RENEWAL

I. FACILITY NAME: ____________________

II. OPERATOR: ____________________
ADDRESS: ____________________
CONTACT PERSON: ____________________ PHONE: __________

III. LOCATION: ____/4 ____/4 Section _____ Township _________ Range _________
Submit large scale topographic map showing exact location.

IV. Attach the name and address of the landowner of the facility site.

V. Attach a description of the types and quantities of fluids at the facility.

VI. Attach a description of all fluid transfer and storage and fluid and solid disposal facilities.

VII. Attach a description of underground facilities (i.e. brine extraction well).

VIII. Attach a contingency plan for reporting and clean-up of spills or releases.

IX. Attach geological/hydrological evidence demonstrating that brine extraction operations will not adversely impact fresh water.

X. Attach such other information as is necessary to demonstrate compliance with any other OCD rules, regulations and/or orders.

XI. CERTIFICATION

I hereby certify under penalty of law that I have personnaly 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.

Name: ____________________ Title: ____________________

Signature: ____________________ Date: ____________________

DISTRIBUTION: Original and one copy to Santa Fe with one copy to appropriate Division District Office.

ONSERV RECEIVED 96 JUL 15 AM 8 52

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

JUL 1 1 1996

Mr. George Rauscher
John Gandy Corporation
Texas Commerce Bank Plaza
200 River Pointe Dr. Suite 310
Conroe, TX 77304-2718

Dear Mr. Rauscher:

This letter is in response to your Freedom of Information request for a list of all names, addresses, and contacts for Class I well operators in the Region. Region 6 does not actively maintain this information for each state and/or tribe. In Region 6, each state administers the underground injection control (UIC) program and the Environmental Protection Agency administers the UIC program for certain Indian lands. Therefore, to assist you in obtaining this information, we have enclosed a list of state UIC program contacts and the address for the only Class I well operator on Indian lands in the region.

Control number 6RIN-01160-96 has been assigned to your request. Please reference this number if any further information is needed. In addition, you may contact Ray Leissner of my staff at (214) 665-7183.

Sincerely yours,

Larry Wright

Larry Wright
Acting Chief
Source Water Protection Branch

Enclosure

cc: Mr. Gerald Delavan, ADPC&E
Mr. Carroll Wascom, LDNR, OC
Mr. Preston Manning, NMED
Mr. Roger Anderson, NMOCD
Mr. Rod Horton, ODEQ
Mr. Ben Knape, TNRCC

CRI

CONTROLLED RECOVERY INC.

P.O. BOX 369, HOBBS, NM 88241 (505) 393-1079

May 28, 1996

State of New Mexico
Energy, Minerals and Natural Resources Department
Oil Conservation Division
Santa Fe, New Mexico 87505

Re: (UIC-CL1-006) P. & S. Brine Sales-Sec. 16, T-25-S, R-37-E
(GW-226) Permian Brine Sales-Sec. 34, T-29-S, R-36-E
OCD Hearing, May 28, 1996, Hobbs, New Mexico

Dear Madam or Sir:

Thank you for permitting me to speak at this hearing today.

My name is Gail Power. I am employed by Controlled Recovery, Inc. of Hobbs, New Mexico. CRI is in the surface waste disposal business and crude oil reclamation business. I will stipulate at this time Permian and P&S would be competition to CRI if their permit applications are approved. Additional competition is not the issue and purpose of this hearing.

We are all present today to listen to various statements from interested parties in order that the OCD can accept and review all testimony pro and con to determine if the applications for salt cavern disposal operations should be permitted and allow Permian and P&S to accept for disposal permitted waste into brine-mined salt cavities.

Before the New Mexico OCD considers the issuance of these permits several factors should be considered. These factors are:

1. Applicants should be required to provide thorough geologic information about the characteristics of the salt stock, including sufficient data to image underneath all overhangs and to delineate the edge of the salt stock.

2. Applicants should be required to provide adequate financial assurance to indemnify all parties that could be adversely effected by a leak of waste into surface waters or underground water aquifers. Obviously as waste volumes increase the financial assurance should be expanded proportionately.

3. Applicants should be required to demonstrate public necessity exists for the permitting of waste injection into salt cavities.

4. Applicants should be required to explain and prove that all safety considerations have been met to the satisfaction of the New Mexico OCD to include:
   a. Waste will not migrate (applicants should be able to prove the no-escape performance standard will be continuously met).
   b. Gas pressure and liquids will not build up in the salt cavern.
   c. All waste received will be properly classified.

5. Applicants should be required to satisfy the OCD that the public interest will be served and protected if the permits are issued. Possibly, the OCD should consider including the State of New Mexico Department of Health in the review process to ascertain all risks associated with this disposal method.

6. Applicants should be required to demonstrate proven waste containment and retrieval procedures in the event of a collapse, shift or leak in the sub-surface salt cavities.

7. The OCD may consider verification that no conflicts exist that are contrary or in violation of 40 CFR, Parts 144, 145, 146, 241, 243, 256, 257 and 268.

I respectfully request the OCD to consider all of my aforementioned recommendations.

In recent years the New Mexico Oil and Gas Industry, with the support, advise and regulatory assistance of the OCD has devoted great effort to reverse a long standing distrust and unfavorable image by the farming and ranching interest coupled with very poor ratings in the media and inferior regard among the general citizenry. The Oil and Gas Industry and the OCD have made great strides to improve this overall sub-standard profile by adhering to safe and prudent operations with specific concern for environmental issues.

With all the progress heretofore to improve the Oil and Gas Industry public standing, now is not the time to allow any wavering of these past gains and improvements by permitting any operations that are vulnerable to public safety, health and environmental risks and questions which could be counter-productive and, in fact, would adversely effect the entire Oil and Gas Industry in New Mexico and its Regulatory Agency. The honorable and dedicated commitment of the Oil and Gas Industry and the OCD should not be impugnable by authorizing high risk and unnecessary endeavors.

I respectfully request my remarks be included and made a part of the record of this hearing. A written transcript of my testimony is available for the record.

Thank you again for granting me time to address this hearing.

Sincerely,

Gail Power

Gail Power

GP/jh

QUESTIONS FOR OCD HEARING

MAY 28, 1996-HOBBS, NEW MEXICO

RE: (UIC-CL1-006) P. & S. BRINE SALES-SEC. 16, T-25-S, R-37-E
(GW-226) PERMIAN BRINE SALES-SEC. 34, T-19-S, R-36-E

1. CAN BRINE-MINED CAVERNS (CAVITIES) GUARANTEE THE CONTAINMENT OF AQUEOUS E&P WASTE?

2. HOW ARE ACCIDENTAL E&P AND NON-E&P WASTE EVENTS HANDLED?

3. HOW CAN THE DIMENSIONS OF THE CAVITIES BE CERTIFIED BEFORE AND AFTER DISPOSAL OPERATIONS?

4. HOW WILL COMPATIBILITY OF THE WASTE STREAM WITH THE INJECTION FORMATION BE DETERMINED?

5. HOW WILL WASTE BE RETRIEVED IN THE EVENT OF BREACH OF THE CAVITY?

6. WHAT WILL BE METHOD OF LOCATING LEAKS?

7. HOW WILL THE INTEGRITY OF THE CAVITY BE CERTIFIED BOTH BEFORE AND AFTER DISPOSAL OPERATIONS?

8. WHAT WILL BE THE LENGTH OF PERMITTED OPERATIONS?

9. WHAT VOLUME OF WASTE INJECTIONS WILL BE PERMITTED?

10. WHAT WILL BE THE OPERATIONAL REQUIREMENTS?

11. WHAT IS THE POTENTIAL FOR SUBSIDENCE AND COLLAPSE?

12. WHO WILL CONDUCT ENVIRONMENTAL IMPACT STUDY TO DETERMINE RISK TO PUBLIC HEALTH AND ENVIRONMENT?

13. WHAT CONSIDERATION WILL BE GIVEN TO HISTORICAL OPERATIONAL PROBLEMS INCLUDING LOSS-CIRCULATION IN THE AREA?

14. WHY IS BRINE WELL #3 AT CLIMAX LOCATION IN PERMIAN APPLICATION NOT IDENTIFIED AS HAVING SUB-SURFACE COMMUNICATION WITH WELLS #1 AND #2?

15 HOW DOES DISPOSAL INTO SALT CAVERNS OR SALT CAVITIES COMPARE WITH DISPOSAL INTO SURFACE DISPOSAL FACILITIES?

16. WHAT PROCEDURE WILL BE USED TO CLOSE A BRINE DISPOSAL CAVITY AND WHAT GUARANTEE WILL INSURE THE LONG-TERM STABILITY OF THE WASTE?

17. WHAT ARE THE OPERATIONAL CLOSURE AND POST-CLOSURE MONITORING REQUIREMENTS?

18. WHAT WILL BE THE CAVITY DEGRADATION AFTER CLOSURE?

19. HOW CAN NO MIGRATION OF WASTE BE CERTIFIED AFTER CLOSURE?

20. WILL A CLOSURE PLAN, INCLUDING COST ESTIMATES SUFFICIENT TO CLOSE FACILITY TO PROTECT PUBLIC HEALTH AND ENVIRONMENT, BE REQUIRED?

21. WILL THERE BE FINANCIAL ASSURANCE REQUIRED TO COVER CLOSURE PLAN AND AT WHAT INTERVALS WILL CLOSURE PLAN AND RELATED COSTS BE REVIEWED AND UPDATED?

22. WHAT MEASURES WILL BE TAKEN TO MONITOR AND CONTROL PRESSURE AND TEMPERATURE INCREASES OVER THE YEARS THAT MAY CAUSE UNKNOWN PROBLEMS IN THE FUTURE?

23. HOW DOES THE STATE OF NEW MEXICO OIL CONSERVATION DIVISION PERMITTING OF BRINE-MINED DISPOSAL SITES COMPARE TO THE PERMITTING OF OTHER SUBSURFACE WASTE DISPOSAL FACILITIES BY OTHER STATE OF NEW MEXICO AGENCIES?

24. HAS THE STATE OF NEW MEXICO OIL CONSERVATION COMMISSION DETERMINED IF CURRENT PERMITS/APPLICATIONS FOR BRINE-MINED WASTE DISPOSAL FACILITIES VIOLATE ANY FEDERAL STATUTES OR REGULATIONS?

25. WILL THE SALT CAVERN APPLICANTS BE OBLIGATED TO COMPLY WITH ALL REQUIREMENTS OF OCD RULE 711?

26. WILL THE BUREAU OF LAND MANAGEMENT AND/OR STATE OF NEW MEXICO PERMIT WASTE FROM FEDERAL LEASES TO BE INJECTED INTO THE DISPOSAL CAVITIES?

27. WILL THE BUREAU OF LAND MANAGEMENT AND/OR STATE OF NEW MEXICO ALLOW THE BRINE MIXED WITH WASTE TO BE USED ON FEDERAL LEASES?

28. IF EITHER OF THESE PERMITS ARE GRANTED, WILL THIS ESTABLISH A PRECEDENT FOR OTHER BRINE WELLS IN THE STATE OF NEW MEXICO TO BE CONVERTED INTO DISPOSAL SITES?
    a. HOW MANY DIFFERENT SALT STRUCTURES ARE LOCATED IN NEW MEXICO?
    b. IS THE DISPOSAL RISK THE SAME FOR DIFFERENT TYPE SALT STRUCTURES?

29. WILL THE BRINE PRODUCED BE A NON-EXEMPT INDUSTRIAL WASTE?

30. WHAT TESTING WILL BE DONE ON THE MIXED WASTE BEFORE DISTRIBUTION TO OTHER WELLS AND IN THE ENVIRONMENT?

31. WHAT RECORDS AND WASTE MANIFEST WILL BE REQUIRED PERTAINING TO BRINE DISTRIBUTION?

32. WHAT WILL BE IMPACT ON SURROUNDING LAND OWNERS AND RESIDENTS?

33. WHAT WILL BE IMPACT ON AREA MINERAL OWNERS?

34. ARE THE SALT FORMATIONS A NATURAL RESOURCE?

35. IS THIS DISPOSAL METHOD A DILUTION OF A WASTE STREAM?

36. ARE VALUABLE RECOVERABLE HYDROCARBONS BEING WASTED?

United States Department of the Interior

BUREAU OF LAND MANAGEMENT
ROSWELL DISTRICT OFFICE
1717 West Second Street
Roswell, New Mexico 88202

IN REPLY REFER TO:
1703 (06010)

MAY 28 1996

William J. LeMay, Director
New Mexico Oil Conservation Division
2040 South Pacheco
Santa Fe, New Mexico 87505

Dear Mr. LeMay:

Please accept the following comments and questions from the Bureau of Land Management (BLM) regarding the proposed discharge plans GW-226 and UIC-CLI-006. The BLM requests admission of these comments and questions during the hearing scheduled for 3:00 p.m. May 28, 1996 in Hobbs, New Mexico. These comments and questions are in addition to the comments presented in our letter dated May 9, 1996. The comments and questions in this letter apply equally to both proposals.

Questions

1. What on-site testing requirements will the Oil Conservation Division (OCD) impose to ensure the waste delivered to the proposed facilities for disposal meets all the Resource Conservation and Recovery Act (RCRA) subtitle C requirements for the oil field waste exemptions?

2. Does the brine proposed for use in the disposal process constitute a mixing of a waste stream with a usable product?

3. Do the proposed disposal processes negate the assumed RCRA exempt status of the waste?

4. Do the proposed processes constitute waste treatment as defined by RCRA?

5. How does the OCD plan to ensure the proposed waste streams meet the RCRA requirements for exempt status?

6. How does the OCD plan to define the size, shape and integrity of the proposed containers (salt caverns)? If the OCD does not plan to define the size, shape and integrity of the containers, how do the operators of the disposal processes plan to define the size, shape and integrity of the proposed containers?

7. Do the proposed disposal processes and containers meet or exceed the requirements for waste disposal as defined by RCRA subtitles C and D and the New Mexico Solid Waste regulations? Please provide specific regulatory citations and precisely how the proposals meet or exceed these requirements.

8. Do the processes and approval processes include mining a natural resource (salt)?

9. Do the proposals adequately protect available groundwater resources?

10. Do the processes and proposals include spill prevention plans that concur with regulations.

Comments

1. Both sites are adjacent to public lands and natural resources managed by the BLM. The proposals do not adequately address potential impact to the adjacent land or natural resources.

2. The size, shape and integrity of the proposed containers is not defined. The size and shape of the containers may impact public land or resources. Since the processes described recovery of brine and implied additional solution of salt, the size and shape of the container may change over time. If federal lands or resources are impacted by the proposed processes, the proposals constitute a violation of the Federal Land Policy and Management Act (FLPMA).

3. The proposals may not meet BLM disposal standards established by Onshore Order Number 7 and BLM New Mexico policy. Disposal processes that do not meet these standards are not authorized for use by federal lessees.

4. The National Environmental Policy Act (NEPA) requires completion of an Environmental Assessment (EA) or Environmental Impact Statement (EIS) if the processes meet or exceed the disposal standards established by Onshore Order Number 7 and BLM New Mexico policy. BLM requires this documentation before BLM approves transfer or disposal of any waste from federal leases at the proposed facilities.

Please contact Al Collar at 505-627-0272 if you have any questions.

Sincerely,

Leslie M. Cone

Leslie M. Cone
District Manager

cc:
Coby Muckelroy
NM Environment Department
HRMB
2044 Galisteo Dr
Santa Fe, NM 87502

Linda Freedman
NM State Land Office
P.O. Box 1148
Santa Fe, NM 87504-1148

BUSINESS

Stocks/8-9C

Second round of SPR oil sales ends

■ Three bids accepted Wednesday brought $21 million in revenues.

By N.Y. Times News Service

Washington — The Energy Department ended the second round of sales of oil from the nation's strategic reserves without accepting any additional bids.

"The latest round of 'best and finals' did not produce additional offers that met the government's acceptable price threshold," the DOE said.

The department began the sale Wednesday, holding it open an additional day to see if it would produce additional offers. The DOE rejected all the bids in the first round of sales on May 16, saying they were too low.

Wednesday's bidding, in which three bidders bought a total of 1.075 million barrels, produced $21.02 million in revenue, the DOE said Thursday.

The department also disclosed the names of the bidders and details of the sales:

■ Exxon Co. USA bought 200,000 barrels at $19.65 a barrel, for a total of $3.93 million. The oil will be delivered by pipeline in May or June.

■ Basis Petroleum Inc. bought 475,000 barrels at $19.61 a barrel, for a total of $9.31 million. The oil will be delivered by tanker in May.

■ Coastal Corp.'s Coastal States Trading Inc. subsidiary bought 400,000 barrels at $19.45 each, for a total of $7.78 million. Delivery will be by tanker in June.

A third round of bids will be accepted June 3, and additional rounds will be scheduled if necessary, the DOE said.

The three bids produced about one-tenth of the $227 million the government plans to raise from the sale of the reserve oil.

The department hopes to sell a total of 12 million barrels during fiscal 1996 for an average price of $18.91 a barrel.

Congress ordered the sale as part of budget legislation. The Clinton administration expedited the sale, saying it hoped the extra oil on the market would depress prices and stem a rise in gasoline prices at the pump.

The sale is viewed by market watchers as an election-year political move. Twelve million barrels is less than one day's worth of domestic consumption, experts say. The White House has also come under fire for using the nation's emergency reserves in a time of non-emergency.

The sale is the government's largest single reserve sale since a 17 million-barrel offering during the Persian Gulf war. That sale, combined with U.S. actions in the region, drove the price of oil about $10 a barrel lower, an Energy Department official said.

The oil is coming out of the department's Weeks Island storage facility in Louisiana, which is being decommissioned because of a structural fault.

Crude prices have fallen in the weeks since the strategic petroleum reserve sale was announced on April 29. Imports and production have picked up, easing concern that supply would be too low to meet demand in the summer driving season. In addition, Iraq is resuming oil sales for the first time since 1990, when the United Nations imposed sanctions following Iraq's invasion of Kuwait.

[redacted]

[redacted]

BUSINESS

Stocks/8-9C

Second round of SPR oil sales ends

■ Three bids accepted Wednesday brought $21 million in revenues.

By N.Y. Times News Service

Washington — The Energy Department ended the second round of sales of oil from the nation's strategic reserves without accepting any additional bids.

"The latest round of 'best and finals' did not produce additional offers that met the government's acceptable price threshold," the DOE said.

The department began the sale Wednesday, holding it open an additional day to see if it would produce additional offers. The DOE rejected all the bids in the first round of sales on May 16, saying they were too low.

Wednesday's bidding, in which three bidders bought a total of 1.075 million barrels, produced $21.02 million in revenue, the DOE said Thursday.

The department also disclosed the names of the bidders and details of the sales:

■ Exxon Co. USA bought 200,000 barrels at $19.65 a barrel, for a total of $3.93 million. The oil will be delivered by pipeline in May or June.

■ Basis Petroleum Inc. bought 475,000 barrels at $19.61 a barrel, for a total of $9.31 million. The oil will be delivered by tanker in May.

■ Coastal Corp.'s Coastal States Trading Inc. subsidiary bought 400,000 barrels at $19.45 each, for a total of $7.78 million. Delivery will be by tanker in June.

A third round of bids will be accepted June 3, and additional rounds will be scheduled if necessary, the DOE said.

The three bids produced about one-tenth of the $227 million the government plans to raise from the sale of the reserve oil.

The department hopes to sell a total of 12 million barrels during fiscal 1996 for an average price of $18.91 a barrel.

Congress ordered the sale as part of budget legislation. The Clinton administration expedited the sale, saying it hoped the extra oil on the market would depress prices and stem a rise in gasoline prices at the pump.

The sale is viewed by market watchers as an election-year political move. Twelve million barrels is less than one day's worth of domestic consumption, experts say. The White House has also come under fire for using the nation's emergency reserves in a time of non-emergency.

The sale is the government's largest single reserve sale since a 17 million-barrel offering during the Persian Gulf war. That sale, combined with U.S. actions in the region, drove the price of oil about $10 a barrel lower, an Energy Department official said.

The oil is coming out of the department's Weeks Island storage facility in Louisiana, which is being decommissioned because of a structural fault.

Crude prices have fallen in the weeks since the strategic petroleum reserve sale was announced on April 29. Imports and production have picked up, easing concern that supply would be too low to meet demand in the summer driving season. In addition, Iraq is resuming oil sales for the first time since 1990, when the United Nations imposed sanctions following Iraq's invasion of Kuwait.

[redacted]

[redacted]

State of New Mexico
Commissioner of Public Lands

RAY POWELL, M.S., D.V.M.
COMMISSIONER

310 OLD SANTA FE TRAIL P.O. BOX 1148
SANTA FE, NEW MEXICO 87504-1148

(505) 827-5760
FAX (505) 827-5766

July 3, 1996

Permian Brine Sales, Inc.
6067 West Tenth
Odessa, Texas 79763

Attn: A.L. Hickerson

Re: Application for Disposal of Nonhazardous Oilfield Waste in Salt Cavern

Dear Mr. Hickerson:

Thank you for your letter of June 24 and the packet of information on disposal of nonhazardous oilfield waste in salt caverns. As you also suggested, the State Land Office intends to send personnel to the Petroleum Environmental Conference in Albuquerque in September.

In your letter was a request that the Commissioner of Public Lands withdraw his objection to approval of your application to dispose of waste material in a salt cavern in Section 34, Township 19 South, Range 36 East. This section is adjacent to State Trust lands which could be impacted by these activities.

At this time, the Commissioner of Public Lands objects to the approval of nonhazardous oilfield waste in salt caverns based on the following factors:

1. Current Oil Conservation Division (OCD) rules contain no design standards for qualification of salt caverns for waste disposal. Standards should be developed prior to approval of applications, and should address siting, operation, maintenance, and performance requirements for waste disposal. These standards must be developed to prevent migration of waste or contamination of brine produced for sale from the operations.

2. OCD rules currently do not require a closure plan that includes a demonstration of stability for the abandoned cavern or sonar surveys for determination of the initial and final shapes, and areal extent of the caverns.

3. There is a lack of understanding of fluid dynamics within the waste injection formation, where previous studies have indicated transient high-pressure waterflows along distinct horizons of bedding planes at clastic-evaporite interfaces.

Until new rules, which must be grounded on a sound technical foundation, are enacted through a public hearing process, and until specific studies on fluid flow within the Salado Formation in this area are completed, the Commissioner is reluctant to withdraw his objection to the operation. Please do, however, continue to send us information on new methods of oilfield solids disposal.

Sincerely,

Larry Kehoe, Assistant Commissioner
Mineral Resources

cc: William J. LeMay - NMOCD
Mark Schmidt

LK/jb

Figure 3 - Idealized Cavern in a Bedded Salt Formation (from Veil et al. 1996)

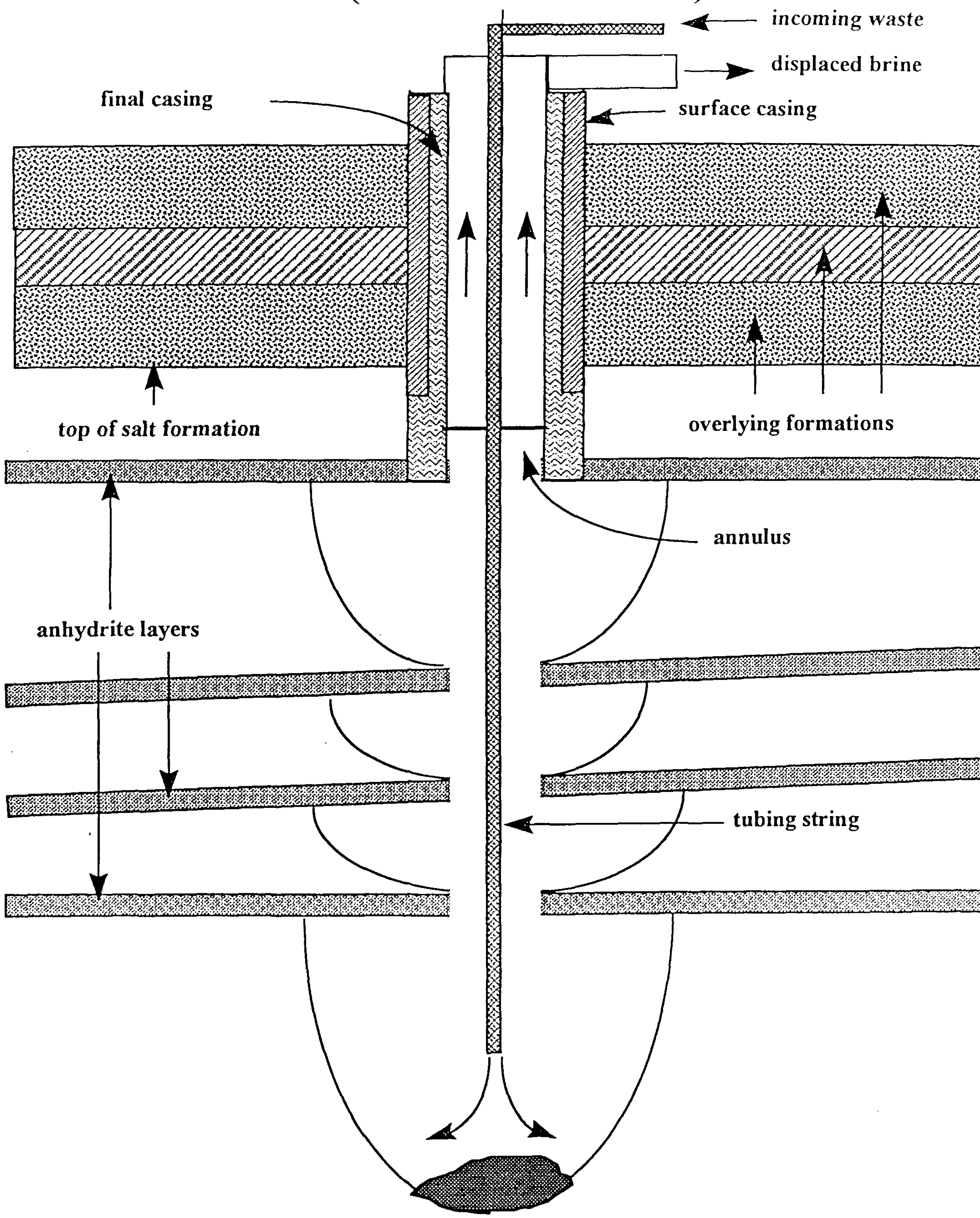
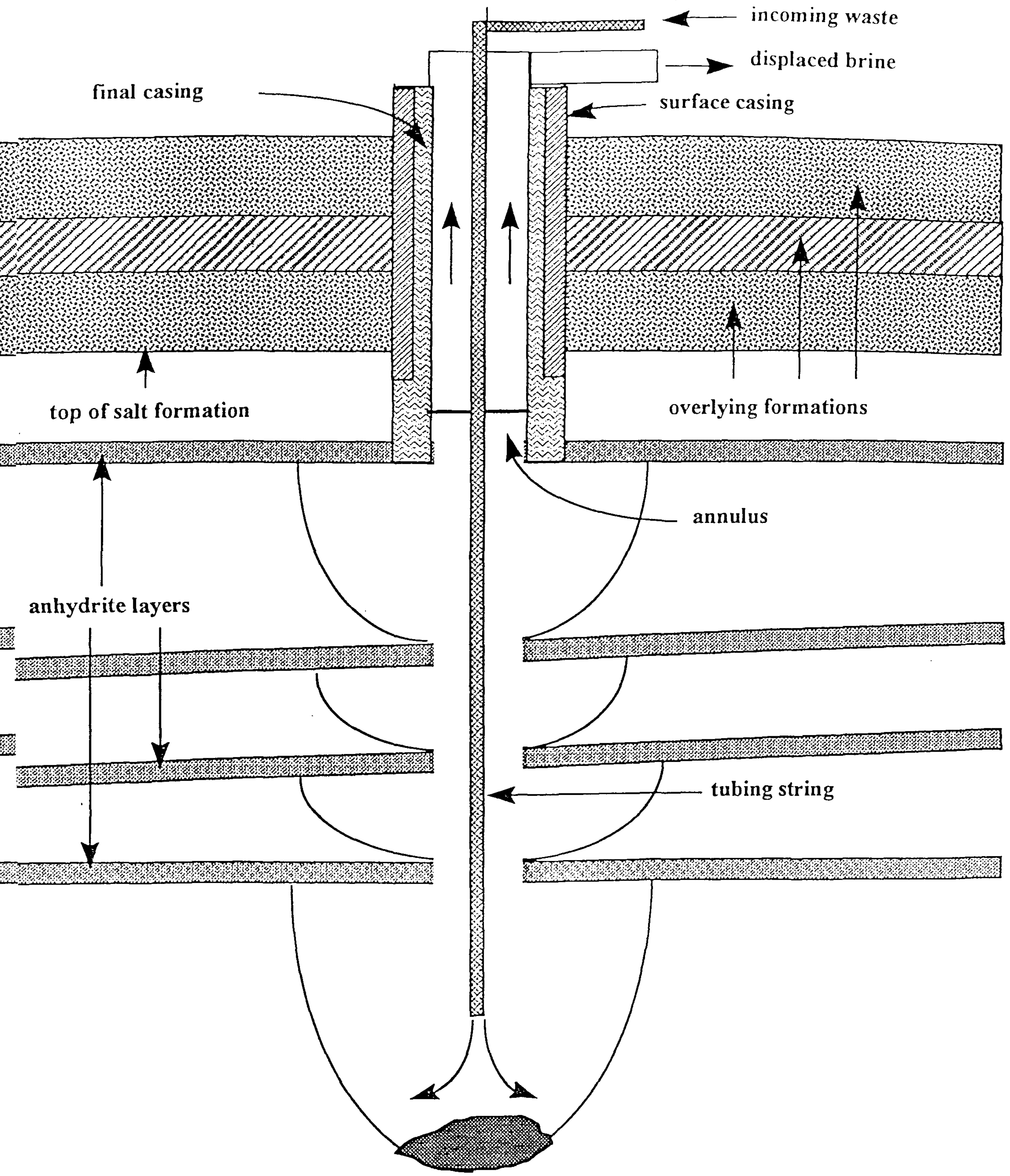


Figure 3 - Idealized Cavern in a Bedded Salt Formation (from Veil et al. 1996)



RECEIVED
MAY 3 1 1996

United States Department of the Interior

BUREAU OF LAND MANAGEMENT
ROSWELL DISTRICT OFFICE
1717 West Second Street
Roswell, New Mexico 88202

IN REPLY REFER TO:
1703 (06010)

MAY 28 1996

William J. LeMay, Director
New Mexico Oil Conservation Division
2040 South Pacheco
Santa Fe, New Mexico 87505

Dear Mr. LeMay:

Please accept the following comments and questions from the Bureau of Land Management (BLM) regarding the proposed discharge plans GW-226 and UIC-CLI-006. The BLM requests admission of these comments and questions during the hearing scheduled for 3:00 p.m. May 28, 1996 in Hobbs, New Mexico. These comments and questions are in addition to the comments presented in our letter dated May 9, 1996. The comments and questions in this letter apply equally to both proposals.

Questions

1. What on-site testing requirements will the Oil Conservation Division (OCD) impose to ensure the waste delivered to the proposed facilities for disposal meets all the Resource Conservation and Recovery Act (RCRA) subtitle C requirements for the oil field waste exemptions?

2. Does the brine proposed for use in the disposal process constitute a mixing of a waste stream with a usable product?

3. Do the proposed disposal processes negate the assumed RCRA exempt status of the waste?

4. Do the proposed processes constitute waste treatment as defined by RCRA?

5. How does the OCD plan to ensure the proposed waste streams meet the RCRA requirements for exempt status?

6. How does the OCD plan to define the size, shape and integrity of the proposed containers (salt caverns)? If the OCD does not plan to define the size, shape and integrity of the containers, how do the operators of the disposal processes plan to define the size, shape and integrity of the proposed containers?

7. Do the proposed disposal processes and containers meet or exceed the requirements for waste disposal as defined by RCRA subtitles C and D and the New Mexico Solid Waste regulations? Please provide specific regulatory citations and precisely how the proposals meet or exceed these requirements.

8. Do the processes and approval processes include mining a natural resource (salt)?

9. Do the proposals adequately protect available groundwater resources?

10. Do the processes and proposals include spill prevention plans that concur with regulations.

Comments

1. Both sites are adjacent to public lands and natural resources managed by the BLM. The proposals do not adequately address potential impact to the adjacent land or natural resources.

2. The size, shape and integrity of the proposed containers is not defined. The size and shape of the containers may impact public land or resources. Since the processes described recovery of brine and implied additional solution of salt, the size and shape of the container may change over time. If federal lands or resources are impacted by the proposed processes, the proposals constitute a violation of the Federal Land Policy and Management Act (FLPMA).

3. The proposals may not meet BLM disposal standards established by Onshore Order Number 7 and BLM New Mexico policy. Disposal processes that do not meet these standards are not authorized for use by federal lessees.

4. The National Environmental Policy Act (NEPA) requires completion of an Environmental Assessment (EA) or Environmental Impact Statement (EIS) if the processes meet or exceed the disposal standards established by Onshore Order Number 7 and BLM New Mexico policy. BLM requires this documentation before BLM approves transfer or disposal of any waste from federal leases at the proposed facilities.

Please contact Al Collar at 505-627-0272 if you have any questions.

Sincerely,

Leslie M. Cone

Leslie M. Cone
District Manager

cc:
Coby Muckelroy
NM Environment Department
HRMB
2044 Galisteo Dr
Santa Fe, NM 87502

Linda Freedman
NM State Land Office
P.O. Box 1148
Santa Fe, NM 87504-1148

NEWS RELEASE

May 21, 1996
Santa Fe, New Mexico

Contact: Lester Swindle
505-827-1375

PUBLIC MEETING ON DISPOSAL APPLICATIONS SET

The Oil Conservation Division of the Energy, Minerals and Natural Resources Department has received two applications for disposal of oil field wastes. The applications involve plans for utilizing abandoned drilling operations' tubing or casing for injection of non-hazardous oil field waste into salt caverns. The applications also include such items as construction, operation and monitoring of the wells along with plans for emergencies such as spills, leaks and other accidents. The Division has called a public meeting at the New Mexico Junior College in Hobbs, New Mexico, on May 28, 1996 at 3:00 PM.

Permian Brine Sales has submitted an application for disposal of waste into a salt cavern located west of Monument, New Mexico. Approximately 5,000 barrels per day of non-hazardous oil field waste slurry will be injected into an abandoned well to the bottom of the salt cavern, approximately 2,500 feet. P. & S. Brine Sales has submitted an application for disposal into a salt cavern located northeast of Jal, New Mexico. Approximately 2,500 barrels per day of slurry will be injected down the tubing of a previously plugged brine well to a depth of approximately 1,582 feet.

The operations would cause brine to be pushed to the surface as a result of the injection. Both applicants are in the business of selling the brine to other companies as an agent to facilitate the drilling process.

Any interested person may attend the meeting to be held in the Bob Moran Multi-Purpose meeting room at the school, or written comments may be submitted to: Director, New Mexico Oil Conservation Division, 2040 South Pacheco, Santa Fe, New Mexico 87505.

END

RECEIVED
JUN - 3 1996
CONSERVATION [illegible]

Becky Jo Doom
HCR 68 Box 188
Jal, New Mexico 88252
(505) 395-2877

May 28, 1996

Mr. William J. Lemay
State of New Mexico
Energy, Minerals and
Natural Resources Division
2040 South Pacheco
Santa Fe, N. M. 87505

Re.: (GW-226) Permian Brine Sales
(UIC-CL1) P & S Brine Sales

Dear Mr. LeMay:

I respectfully enter my opposition to the granting of the two above listed requests for permits for the disposal of oil field waste into the salt caverns. The disposal of any type of waste is too dangerous to the precious, scarce fresh waters of our area.

Not too long after Climax Chemical facility was first built, our 35 foot deep water well near the mid-point of section 12, township 24 south, range 37 east became contaminated. This well is located in the Monument Draw and is in the same stream as Climax Chemical. I do not recall exactly what measures were taken at the source as my father, J. J. Smith, was then alive and running the ranch. However I do know that it was many years before the water cleared up. We have not had it tested in the past two years, but will again this year.

My parents bought land in Lea County in 1934, but my aunt and her husband homesteaded 86 years ago on land that is a part of our current ranch. In fact, our ranch has recently been designated as a Heritage Ranch.

There is already too much oil field related water contamination without allowing such a dangerous addition disposal method.

What will this area be without potable water?

Sincerely,

Becky Jo Doom

Becky Jo Doom

RECEIVED

MAY 14 1996

OIL CONSERVATION DIVISION

United States Department of the Interior

BUREAU OF LAND MANAGEMENT
ROSWELL DISTRICT OFFICE
1717 West Second Street
Roswell, New Mexico 88202

IN REPLY REFER TO:
1703 (06010)

MAY 09 1996

William J. LeMay, Director
New Mexico Oil Conservation Division
2040 South Pacheco
Santa Fe, New Mexico 87505

Dear Mr. LeMay:

This letter provides written comments and concerns on the proposed discharge plans GW-226 and UIC-CLI-006. The Bureau of Land Management (BLM) first expressed comments on March 14, 1996, during a phone conversation between Mr. Roger Anderson of your office and Al Collar, the Carlsbad Resource Area Hazardous Materials Specialist.

Both proposed discharge plans involve injection and underground disposal of oilfield waste in salt caverns located in Lea County, New Mexico. Our comments and concerns apply equally to both proposals.

1. The proposals suggest the injection and disposal process involves only non-hazardous oilfield waste. The BLM is not certain there is adequate testing of the waste before disposal to establish the waste status as non-hazardous. The proposal may involve waste defined in the Resource Conservation and Recovery Act (RCRA) as exempt from regulation as a hazardous waste, but that does mean it is non-hazardous. The BLM is also concerned there is a lack of adequate protection or process that guarantees the disposal process involves only RCRA exempt oilfield waste.

2. Both sites are adjacent to public land and resources managed by the BLM. The proposals do not contain language, techniques, or processes that ensure protection of the public lands and resources from adverse impact should an accidental release occur at the proposed facility. The National Environmental Policy Act (NEPA) and Federal Land Policy and Management Act (FLPMA) require prior approval for processes that impact public land or resources.

3. The techniques and processes do not provide apparent protection of federal resources from subsurface migration of contaminants.

4. The techniques and processes described in the proposals indicate there is potential for solution mining of adjacent federal resources (salt). NEPA and FLPMA require prior approval for processes that impact public land or resources.

The BLM respectfully requests that New Mexico Oil Conservation Division hold a public hearing for these proposals.

Sincerely,

Leslie M. Cone

Leslie M. Cone
District Manager

Affidavit of Publication

STATE OF NEW MEXICO)
) ss.
COUNTY OF LEA)

Joyce Clemens being first duly sworn on oath deposes and says that he is Adv. Director of THE LOVINGTON DAILY LEADER, a daily newspaper of general paid circulation published in the English language at Lovington, Lea County, New Mexico; that said newspaper has been so published in such county continuously and uninterruptedly for a period in excess of Twenty-six (26) consecutive weeks next prior to the first publication of the notice hereto attached as hereinafter shown; and that said newspaper is in all things duly qualified to publish legal notices within the meaning of Chapter 167 of the 1937 Session Laws of the State of New Mexico.

That the notice which is hereto attached, entitled

Notice Of Publication

~~and numbered~~ .... ~~in the~~

.... ~~County of Lea~~

~~Court of Lea County, New Mexico~~ was published in a regular and entire issue of THE LOVINGTON DAILY LEADER and not in any supplement thereof, ~~once each week on the~~

~~same day of the week~~, for one (1) day

~~consecutive weeks~~, beginning with the issue of

May 15, 1996

and ending with the issue of

May 15, 1996

And that the cost of publishing said notice is the sum of $53.60

which sum has been (Paid) (~~Assessed~~) as Court Costs

Joyce Clemens

Subscribed and sworn to before me this 16th

day of May, 1996

Jean Sewer

Notary Public, Lea County, New Mexico

My Commission Expires Sept. 28, 1998

LEGAL NOTICE
NOTICE OF PUBLICATION
STATE OF NEW MEXICO
ENERGY, MINERALS AND
NATURAL RESOURCES DEPARTMENT
OIL CONSERVATION DIVISION

Notice is hereby given that a public meeting will be held to solicit input regarding the following discharge plan applications, for disposal of oil field waste into the Salado Formation, that have been submitted to the Director of the Oil Conservation Division, 2040 South Pacheco, Santa Fe, New Mexico 87505, Telephone (505) 827-7131:

(GW-226) - Permian Brine Sales, A.L. Hickerson, 6067 W Tenth, Odessa, Texas 79763, has submitted a discharge plan application for disposal of non-hazardous semi-solid oil field waste in abandoned salt caverns located in the SE/4 SE/4 of Section 34, Township 19 South, Range 36 East, NMPM, Lea County, New Mexico. Approximately 5,000 barrels per day of non-hazardous oil field waste slurry will be injected down the tubing of the abandoned Climax Chemical Company Foster No. 1 to the bottom of the salt cavern, approximately 2,500 feet, and brine will be produced up the annulus for sale. Ground water most likely to be affected in the event of an accidental discharge is at a depth of approximately 35 to 60 feet with a total dissolved solids concentration ranging from 500 to 3000 mg/l. The discharge plan addresses construction, operation and monitoring of the well and associated surface facilities and how spills, leaks, and other accidental discharges to the surface will be managed.

(UIC-CL1-006) - P. & S. Brine Sales, Paul Prather, P.O. Box 1768, Eunice, New Mexico, 88231 has submitted a discharge plan application for disposal of non-hazardous oil field waste in salt caverns located in Section 16, Township 25 South, Range 37 East, NMPM, Lea County, New Mexico. Currently, under discharge plan BW-007, fresh water is injected through the casing of the Arnott Ramsey State No. 4 into the Salado Formation at an approximate depth of 1,260 feet and brine is extracted through the tubing. The average total dissolved solids concentration of the brine is approximately 290,000 mg/l. The discharge plan application proposes to reenter the previously plugged Arnott Ramsey State No. 5 brine well to allow for the injection of approximately 2,500 barrels per day of non-hazardous oil field waste slurry. Injection will be through the tubing into the existing salt cavern to approximately 1,582 feet. The Arnott Ramsey State No. 4 will be used for brine returns through the tubing. Ground water most likely to be affected by any accidental discharge is at a depth of approximately 400 feet with a total dissolved solids concentration of approximately 1,025 mg/l. Pockets of ground water may exist in the area at depths as shallow as 50 feet, with higher or lower total dissolved solids concentrations. The discharge plan addresses construction, operation and monitoring of the well and associated surface facilities and provides a contingency plan in the event of accidental spills, leaks and other accidental discharges to the ground surface.

The public meeting will be held at the New Mexico Junior College, Bob Moran Multi-Purpose meeting room, on May 28, 1996 at 3:00 PM. Any interested person may attend to present comments. Written requests may be submitted to the Director of the Oil Conservation Division at the address given above.

Published in the Lovington Daily Leader May 15, 1996.

AFFIDAVIT OF PUBLICATION

State of New Mexico,
County of Lea.

I, Kathi Bearden

Publisher

of the Hobbs Daily News-Sun, a daily newspaper published at Hobbs, New Mexico, do solemnly swear that the clipping attached hereto was published once a week in the regular and entire issue of said paper, and not a supplement thereof for a period.

of

1 weeks.

Beginning with the issue dated

May 19, 1996

and ending with the issue dated

May 19, 1996

Kathi Bearden

Publisher

Sworn and subscribed to before

me this 22 day of

May, 1996

Sandra Calbett

Notary Public.

My Commission expires
August 29, 1999
(Seal)

This newspaper is duly qualified to publish legal notices or advertisements within the meaning of Section 3, Chapter 167, Laws of 1937, and payment of fees for said publication has been made.

LEGAL NOTICE
May 19, 1996
PUBLIC NOTICE
STATE OF NEW MEXICO
ENERGY, MINERALS AND NATURAL RESOURCES DEPARTMENT
OIL CONSERVATION DIVISION

Notice is hereby given that a public meeting will be held to solicit input regarding the following discharge plan applications, for disposal of oil field waste into the Salado Formation, that have been submitted to the Director of the Oil Conservation Division, 2040 South Pacheco, Santa Fe, New Mexico 87505, Telephone (505) 827-7131:

(GW-228) - Permian Brine Sales, A. L. Hickerson, 6067 W Tenth, Odessa, Texas 79763, has submitted a discharge plan application for disposal of non-hazardous semi-solid oil field waste in abandoned salt caverns located in the SE/4 SE/4 of Section 34, Township 19 South, Range 36 East, NMPM, Lea County, New Mexico. Approximately 5,000 barrels per day of non-hazardous oil field waste slurry will be injected down the tubing of the salt cavern, approximately 2,500 feet, and brine will be produced up the annulus for sale. Ground water most likely to be affected in the event of an accidental discharge is at a depth of approximately 35 to 60 feet with a total dissolved solids concentration ranging from 500 to 3000 mg/l. The discharge plan addresses construction, operation and monitoring of the well and associated surface facilities and how spills, leaks, and other accidental discharges to the surface will be managed.

(UIC-CL1-006) - P. & S. Brine Sales, Paul Prather, P.O. Box 1768, Eunice, New Mexico, 88231 has submitted a discharge plan application for disposal of non-hazardous oil field waste in salt caverns located in Section 16, Township 25 South, Range 37 East, NMPM, Lea County, New Mexico. Currently, under discharge plan BW-007, fresh water is injected through the casing of the Arnott Ramsey State No.4 into the Salado Formation at an approximate depth of 1,260 feet and brine is extracted through the tubing. The average total dissolved solids concentration of the brine is approximately 290,000 mg/l. The discharge plan application proposes to reenter the previously plugged Arnott Ramsey State No. 5 brine well to allow for the injection of approximately 2,500 barrels per day of non-hazardous oil field waste slurry. Injection will be through the tubing into the existing salt cavern to approximately 1,582 feet. The Arnott Ramsey State No. 4 will be used for brine returns through the tubing. Ground water most likely to be affected by any accidental discharge is at a depth of approximately 400 feet with a total dissolved solids concentration of approximately 1,025 mg/l. Pockets of ground water may exist in the area at depths as shallow as 50 feet, with higher or lower total dissolved solids concentrations. The discharge plan addresses construction, operation and monitoring of the well and associated surface facilities and provides a contingency plan in the event of accidental spills, leaks and other accidental discharges to the ground surface.

The public meeting will be held at the New Mexico Junior College, Bob Moran Multi-Purpose meeting room, on May 28, 1996 at 3:00 PM. Any interested person may attend to present comments. Written requests may be submitted to the Director of the Oil Conservation Division at the address given above.
#14562

The Santa Fe New Mexican
Since 1849. We Read You.

NEW MEXICO OIL CONSERVATION
ATTN: SALLY MARTINEZ
2040 S. PACHECO ST.
SANTA FE, NM 87505

AD NUMBER: 502095 ACCOUNT: 56689
LEGAL NO: 59651 P.O. #: 96199002997

207 LINES once at $ 82.80
Affidavits: 5.25
Tax: 5.50
Total: $ 93.55

RECEIVED
MAY 17 1996
OIL CONSERVATION DIVISION

AFFIDAVIT OF PUBLICATION

STATE OF NEW MEXICO
COUNTY OF SANTA FE

I, BETSY PERNER being first duly sworn declare and say that I am Legal Advertising Representative of THE SANTA FE NEW MEXICAN, a daily news paper published in the English language, and having a general circulation in the Counties of Santa Fe and Los Alamos, State of New Mexico and being a Newspaper duly qualified to publish legal notices and advertisements under the provisions of Chapter 167 on Session Laws of 1937; that the publication #59651 a copy of which is hereto attached was published in said newspaper once each week for one consecutive week(s) and that the notice was published in the newspaper proper and not in any supplement; the first publication being on the 15th day of MAY 1996 and that the undersigned has personal knowledge of the matter and things set forth in this affidavit.

/S/ Betsy Perner
LEGAL ADVERTISEMENT REPRESENTATIVE

Subscribed and sworn to before me on this 15th day of MAY A.D., 1996

OK
MA
5-17-96

OFFICIAL SEAL
Candace C. Ruiz
NOTARY PUBLIC - STATE OF NEW MEXICO
My Commission Expires: 9/29/99

Candace C. Ruiz

202 East Marcy Street • P.O. Box 2048 • Santa Fe, New Mexico 87501
505~983~3303 • (FAX) 505~984~1785

NOTICE OF PUBLICATION

STATE OF NEW MEXICO

ENERGY, MINERALS AND NATURAL RESOURCES DEPARTMENT

OIL CONSERVATION DIVISION

Notice is hereby given that a public meeting will be held to solicit input regarding the following discharge plan applications, for disposal of oil field waste into the Salado Formation, that have been submitted to the Director of the Oil Conservation Division, 2040 South Pacheco, Santa Fe, New Mexico 87505, Telephone (505) 827-7131:

(GW-226) - Permian Brine Sales, A. L. Hickerson, 6067 W. Tenth, Odessa, Texas 79763, has submitted a discharge plan application for disposal of non-hazardous semi-solid oil field waste in abandoned salt caverns located in the SE/4 SE/4 of Section 34, Township 19 South, Range 36 East, NMPM, Lea County, New Mexico. Approximately 5,000 barrels per day of non-hazardous oil field waste slurry will be injected down the tubing of the abandoned Climax Chemical Company Foster No. 1 to the bottom of the salt cavern, approximately 2,500 feet, and brine will be produced up the annulus for sale. Ground water most likely to be affected in the event of an accidental discharge is at a depth of approximately 35 to 60 feet with a total dissolved solids concentration ranging from 500 to 3000 mg/L. The discharge plan addresses construction, operation and monitoring of the well and associated surface facilities and how spills, leaks, and other accidental discharges to the surface will be managed.

(UIC-CL1-006) - P. & S. Brine Sales, Paul Prather, P.O. Box 1768, Eunice, New Mexico, 88231 has submitted a discharge plan application for disposal of non-hazardous oil field waste in salt caverns located in Section 16, Township 25 South, Range 37 East, NMPM, Lea County, New Mexico. Currently, under discharge plan BW-007, fresh water is injected through the casing of the Arnott Ramsey State No.4 into the Salado Formation at an approximate depth of 1,260 feet and brine is extracted through the tubing. The average total dissolved solids concentration of the brine is approximately 290,000 mg/l. The discharge plan application proposes to reenter the previously plugged Arnott Ramsey State No. 5 brine well to allow for the injection of approximately 2,500 barrels per day on non-hazardous oil field waste slurry. Injection will be through the tubing into the existing salt cavern to approximately 1,582 feet. The Arnott Ramsey State No. 4 will be used for brine returns through the tubing. Ground water most likely to be affected by any accidental discharge is at a depth of approximately 400 feet with a total dissolved solids concentration of approximately 1,025 mg/l. Pockets of ground water may exist in the area at depth as shallow as 50 feet, with higher or lower total dissolved solids concentrations. The discharge plan addresses construction, operation and monitoring of the well and associated surface facilities and provides a contingency plan in the event of accidental spills, leaks, and other accidental discharges to the ground surface.

The public meeting will be held at the New Mexico Junior College, Bob Moran Multi-Purpose meeting room, on May 28, 1996 at 3:00 PM. Any interested person may attend to present comments. Written requests may be submitted to the Director of the Oil Conservation Division at the address given above.

Legal #59651
Pub. May 15, 1996

Oil Conservation Division
2040 S. Pacheco
Santa Fe, New Mexico 87505

May 10, 1996

Hobbs Daily News Sun
P. O. Box 860
Hobbs, New Mexico 88240

RE: NOTICE OF PUBLICATION

ATTN: ADVERTISING MANAGER

Dear Sir/Madam:

Please publish the attached notice one time immediately on receipt of this request. Please proofread carefully, as any error in a land description or in a key word or phrase can invalidate the entire notice.

Immediately upon completion of publication, please send the following to this office:

1. ***Publisher's affidavit in duplicate.***
2. ***Statement of cost (also in duplicate.)***
3. ***CERTIFIED invoices for prompt payment.***

We should have these immediately after publication in order that the legal notice will be available for the hearing which it advertises, and also so that there will be no delay in your receiving payment.

Please publish the notice no later than May 17, 1996.

Sincerely,

Sally Martinez

Sally E. Martinez
Administrative Secretary

Attachment

Z 765 962 229

UNITED STATES POSTAL SERVICE

Receipt for Certified Mail
No Insurance Coverage Provided
Do not use for International Mail
(See Reverse)

Sent to	Hobbs Daily
Street and No.	News Sun
P.O., State and ZIP Code	
Postage	$
Certified Fee	
Special Delivery Fee	
Restricted Delivery Fee	
Return Receipt Showing to Whom & Date Delivered	
Return Receipt Showing to Whom, Date, and Addressee's Address	
TOTAL Postage & Fees	$
Postmark or Date	Mande

PS Form 3800, March 1993

NEW MEXICO ENERGY, MINERALS
& NATURAL RESOURCES DEPARTMENT

OIL CONSERVATION DIVISION
2040 South Pacheco Street
Santa Fe, New Mexico 87505
(505) 827-7131

May 10, 1996

LOVINGTON DAILY LEADER
P. O. Box 1717
Lovington, New Mexico 88260

RE: NOTICE OF PUBLICATION

ATTN: ADVERTISING MANAGER

Dear Sir/Madam:

Please publish the attached notice one time immediately on receipt of this request. Please proofread carefully, as any error in a land description or in a key word or phrase can invalidate the entire notice.

Immediately upon completion of publication, please send the following to this office:

1. ***Publisher's affidavit in duplicate.***
2. ***Statement of cost (also in duplicate.)***
3. ***CERTIFIED invoices for prompt payment.***

We should have these immediately after publication in order that the legal notice will be available for the hearing which it advertises, and also so that there will be no delay in your receiving payment.

Please publish the notice no later than May 17, *, 1996.*

Sincerely,

Sally Martinez

Sally E. Martinez
Administrative Secretary

Attachment

Z 765 963 250

Receipt for Certified Mail
No Insurance Coverage Provided
Do not use for International Mail
(See Reverse)

UNITED STATES POSTAL SERVICE

Sent to	Lovington Daily Leader
Street & No.	P.O. Box 1717
P.O., State and ZIP Code	Lovington, NM 88260
Postage	$
Certified Fee	
Special Delivery Fee	
Restricted Delivery Fee	
Return Receipt Showing to Whom & Date Delivered	
Return Receipt Showing to Whom, Date, and Addressee's Address	
TOTAL Postage & Fees	$
Postmark or Date	

PS Form **3800**, March 1993

NEW MEXICO ENERGY, MINERALS
& NATURAL RESOURCES DEPARTMENT

OIL CONSERVATION DIVISION
2040 South Pacheco Street
Santa Fe, New Mexico 87505
(505) 827-7131

May 10, 1996

THE NEW MEXICAN
202 E. Marcy
Santa Fe, New Mexico 87501

RE: NOTICE OF PUBLICATION

PO #96-199-002997

ATTN: Betsy Perner

Dear Sir/Madam:

Please publish the attached notice one time immediately on receipt of this request. Please proofread carefully, as any error in a land description or in a key word or phrase can invalidate the entire notice.

Immediately upon completion of publication, please send the following to this office:

1. *Publisher's affidavit.*
2. *Invoices for prompt payment.*

We should have these immediately after publication in order that the legal notice will be available for the hearing which it advertises, and also so that there will be no delay in your receiving payment.

Please publish the notice on Wednesday, May 15 *, 1996.*

Sincerely,

Sally Martinez

Sally E. Martinez
Administrative Secretary

Attachment

PUBLIC NOTICE
STATE OF NEW MEXICO
ENERGY, MINERALS AND NATURAL RESOURCES DEPARTMENT
OIL CONSERVATION DIVISION

Notice is hereby given that a public meeting will be held to solicit input regarding the following discharge plan applications, for disposal of oil field waste into the Salado Formation, that have been submitted to the Director of the Oil Conservation Division, 2040 South Pacheco, Santa Fe, New Mexico 87505, Telephone (505) 827-7131:

(GW-226) - Permian Brine Sales, A. L. Hickerson, 6067 W Tenth, Odessa, Texas 79763, has submitted a discharge plan application for disposal of non-hazardous semi-solid oil field waste in abandoned salt caverns located in the SE/4 SE/4 of Section 34, Township 19 South, Range 36 East, NMPM, Lea County, New Mexico. Approximately 5,000 barrels per day of non-hazardous oil field waste slurry will be injected down the tubing of the abandoned Climax Chemical Company Foster No. 1 to the bottom of the salt cavern, approximately 2,500 feet, and brine will be produced up the annulus for sale. Ground water most likely to be affected in the event of an accidental discharge is at a depth of approximately 35 to 60 feet with a total dissolved solids concentration ranging from 500 to 3000 mg/l. The discharge plan addresses construction, operation and monitoring of the well and associated surface facilities and how spills, leaks, and other accidental discharges to the surface will be managed.

(UIC-CL1-006) - P. & S. Brine Sales, Paul Prather, P.O. Box 1768, Eunice, New Mexico, 88231 has submitted a discharge plan application for disposal of non-hazardous oil field waste in salt caverns located in Section 16, Township 25 South, Range 37 East, NMPM, Lea County, New Mexico. Currently, under discharge plan BW-007, fresh water is injected through the casing of the Arnott Ramsey State No.4 into the Salado Formation at an approximate depth of 1,260 feet and brine is extracted through the tubing. The average total dissolved solids concentration of the brine is approximately 290,000 mg/l. The discharge plan application proposes to reenter the previously plugged Arnott Ramsey State No. 5 brine well to allow for the injection of approximately 2,500 barrels per day of non-hazardous oil field waste slurry. Injection will be through the tubing into the existing salt cavern to approximately 1,582 feet. The Arnott Ramsey State No. 4 will be used for brine returns through the tubing. Ground water most likely to be affected by any accidental discharge is at a depth of approximately 400 feet with a total dissolved solids concentration of approximately 1,025 mg/l. Pockets of ground water may exist in the area at depths as shallow as 50 feet, with higher or lower total dissolved solids concentrations. The discharge plan addresses construction, operation and monitoring of the well and associated surface facilities and provides a contingency plan in the event of accidental spills, leaks and other accidental discharges to the ground surface.

The public meeting will be held at the New Mexico Junior College, Bob Moran Multi-Purpose meeting room, on May 28, 1996 at 3:00 PM. Any interested person may attend to present comments. Written requests may be submitted to the Director of the Oil Conservation Division at the address given above.

PUBLIC NOTICE
STATE OF NEW MEXICO
ENERGY, MINERALS AND NATURAL RESOURCES DEPARTMENT
OIL CONSERVATION DIVISION

Notice is hereby given that a public meeting will be held to solicit input regarding the following discharge plan applications, for disposal of oil field waste into the Salado Formation, that have been submitted to the Director of the Oil Conservation Division, 2040 South Pacheco, Santa Fe, New Mexico 87505, Telephone (505) 827-7131:

(GW-226) - Permian Brine Sales, A. L. Hickerson, 6067 W Tenth, Odessa, Texas 79763, has submitted a discharge plan application for disposal of non-hazardous semi-solid oil field waste in abandoned salt caverns located in the SE/4 SE/4 of Section 34, Township 19 South, Range 36 East, NMPM, Lea County, New Mexico. Approximately 5,000 barrels per day of non-hazardous oil field waste slurry will be injected down the tubing of the abandoned Climax Chemical Company Foster No. 1 to the bottom of the salt cavern, approximately 2,500 feet, and brine will be produced up the annulus for sale. Ground water most likely to be affected in the event of an accidental discharge is at a depth of approximately 35 to 60 feet with a total dissolved solids concentration ranging from 500 to 3000 mg/l. The discharge plan addresses construction, operation and monitoring of the well and associated surface facilities and how spills, leaks, and other accidental discharges to the surface will be managed.

(UIC-CL1-006) - P. & S. Brine Sales, Paul Prather, P.O. Box 1768, Eunice, New Mexico, 88231 has submitted a discharge plan application for disposal of non-hazardous oil field waste in salt caverns located in Section 16, Township 25 South, Range 37 East, NMPM, Lea County, New Mexico. Currently, under discharge plan BW-007, fresh water is injected through the casing of the Arnott Ramsey State No.4 into the Salado Formation at an approximate depth of 1,260 feet and brine is extracted through the tubing. The average total dissolved solids concentration of the brine is approximately 290,000 mg/l. The discharge plan application proposes to reenter the previously plugged Arnott Ramsey State No. 5 brine well to allow for the injection of approximately 2,500 barrels per day of non-hazardous oil field waste slurry. Injection will be through the tubing into the existing salt cavern to approximately 1,582 feet. The Arnott Ramsey State No. 4 will be used for brine returns through the tubing. Ground water most likely to be affected by any accidental discharge is at a depth of approximately 400 feet with a total dissolved solids concentration of approximately 1,025 mg/l. Pockets of ground water may exist in the area at depths as shallow as 50 feet, with higher or lower total dissolved solids concentrations. The discharge plan addresses construction, operation and monitoring of the well and associated surface facilities and provides a contingency plan in the event of accidental spills, leaks and other accidental discharges to the ground surface.

The public meeting will be held at the New Mexico Junior College, Bob Moran Multi-Purpose meeting room, on May 28, 1996 at 3:00 PM. Any interested person may attend to present comments. Written requests may be submitted to the Director of the Oil Conservation Division at the address given above.

'96 APR 8 AM 8 52

The Santa Fe New Mexican

Since 1849. We Read You.

NEW MEXICO OIL CONSERVATION
ATTN: SALLY MARTINEZ
2040 S. PACHECO
SANTA FE, N.M. 87505

AD NUMBER: 481405 ACCOUNT: 56689

LEGAL NO: 59318 P.O. # 96199002997

216 LINES twice at $ 86.40

Affidavits: 5.25

Tax: 5.73

Total: $ 97.38

AFFIDAVIT OF PUBLICATION

STATE OF NEW MEXICO
COUNTY OF SANTA FE

I, BETSY PERNER being first duly sworn declare and say that I am Legal Advertising Representative of THE SANTA FE NEW MEXICAN, a daily news paper published in the English language, and having a general circulation in the Counties of Santa Fe and Los Alamos, State of New Mexico and being a Newspaper duly qualified to publish legal notices and advertisements under the provisions of Chapter 167 on Session Laws of 1937; that the publication # 59318 a copy of which is hereto attached was published in said newspaper once each week for two consecutive week(s) and that the notice was published in the newspaper proper and not in any supplement; the first publication being on the 22nd day of MARCH 1996 and that the undersigned has personal knowledge of the matter and things set forth in this affidavit.

/S/ Betsy Perner
LEGAL ADVERTISEMENT REPRESENTATIVE

Subscribed and sworn to before me on this 3rd day of APRIL A.D., 1996

OK MA
4-9-96

OFFICIAL SEAL
Candace C. Ruiz
NOTARY PUBLIC - STATE OF NEW MEXICO
My Commission Expires: 9/24/97

Candace C Ruiz

NOTICE OF PUBLICATION

STATE OF NEW MEXICO

Energy, Minerals and Natural Resources Department Oil Conservation Division

Notice is hereby given that pursuant to New Mexico Water Quality Control Commission Regulations, the following discharge plan application has been submitted to the Director of the Oil Conservation Division, 2040 South Pacheco, Santa Fe, New Mexico, 87505, Telephone (505) 827-7131:

(GW-226) - Permian Brine Sales, A. L. Hickerson, 6067 W. Tenth, Odessa, Texas 79763, has submitted a discharge plan application for disposal of non-hazardous semi-solid oil field waste in abandoned salt caverns located in the SE/4 SE/4 of Section 34, Township 19 South, Range 36 East, NMPM, Lea County, New Mexico. Approximately 5,000 barrels per day of non-hazardous oil field waste slurry will be injected down the tubing of the abandoned Climax Chemical Company Foster No. 1 to the bottom of the salt cavern, approximately 2,500 feet, and brine will be produced up the annulus for sale. Ground water most likely to be affected in the event of an accidental discharge is at a depth of approximately 35 to 60 feet with a total dissolved solids concentration ranging from 500 to 3000 mg/l. The discharge plan addresses construction, operation and monitoring of the well and associated surface facilities and how spills, leaks, and other accidental discharges to the surface will be managed.

(GW-240) - Diamond Rental, Inc., Harry Teague, (505) 392-6498, 3400 Industrial, Hobbs, New Mexico 88240, has submitted a Discharge Plan Application for the Diamond Rental, Inc. Facility located in the NW/4 NW/4 of Section 21, Township 18 South, Range 38 East, NMPM, Lea County, New Mexico. Approximately 16 gallons per day of waste water is stored in bermed above ground closed top steel tanks. All wastes are disposed of at an OCD permitted offsite Class II injection well. Groundwater most likely to be affected by a spill, leak, or accidental discharge to the surface is at a depth of approximately 50 feet with a total dissolved solids concentration of approximately 750 mg/L. The discharge plan addresses how spills, leaks, and other accidental discharges to the surface will be managed.

Any interested person may obtain further information from the Oil Conservation Division and may submit written comments to the Director of the Oil Conservation Division at the address given above. The discharge plan application may be viewed at the above address between 8:00 a.m. and 4:00 p.m., Monday thru Friday. Prior to ruling on any proposed discharge plan or its modification, the Director of the Oil Conservation Division shall allow at least thirty (30) days after the date of publication of this notice during which comments may be submitted to him and a public hearing may be requested by any interested person. Requests for a public hearing shall set forth the reasons why a hearing shall be held. A hearing will be held if the Director determines there is significant public interest.

If no hearing is held, the Director will approve or disapprove the plan based on the information available. If a public hearing is held, the director will approve the plan based on information in the discharge plan application and information submitted at the hearing.

GIVEN under the Seal of New Mexico Oil Conservation Commission at Santa Fe, New Mexico, on this 15th day of March, 1996.

STATE OF NEW MEXICO
OIL CONSERVATION DIVISION
WILLIAM J. LEMAY,
Director

Legal #59318

The Santa Fe New Mexican
Since 1849. We Read You.

NEW MEXICO OIL CONSERVATION

AD NUMBER: 481405 ACCOUNT: 56689

LEGAL NO: 59318 P.O. # 96199002997

216 LINES once at $ 86.40

Affidavits: 5.25

Tax: 5.73

Total: $ 97.38

50' with a TDS of approximately 750 mg/l.

AFFIDAVIT OF PUBLICATION

STATE OF NEW MEXICO
COUNTY OF SANTA FE

I, BETSY PERNER being first duly sworn declare and say that I am Legal Advertising Representative of THE SANTA FE NEW MEXICAN, a daily news paper published in the English language, and having a general circulation in the Counties of Santa Fe and Los Alamos, State of New Mexico and being a Newspaper duly qualified to publish legal notices and advertisements under the provisions of Chapter 167 on Session Laws of 1937; that the publication #59318 a copy of which is hereto attached was published in said newspaper once each week for one consecutive week(s) and that the notice was published in the newspaper proper and not in any supplement; the first publication being on the 22nd day of MARCH 1996 and that the undersigned has personal knowledge of the matter and things set forth in this affidavit.

/S/ Betsy Perner
LEGAL ADVERTISEMENT REPRESENTATIVE

Subscribed and sworn to before me on this 22nd day of MARCH A.D., 1996

MISTAKES WILL BE CORRECTED & REPUBLISHED ON 4-3-96
MA 3-29-96

OFFICIAL SEAL
Candace C. Ruiz
NOTARY PUBLIC - STATE OF NEW MEXICO
My Commission Expires: 9/29/99

Candace C Ruiz

NOTICE OF PUBLICATION

STATE OF NEW MEXICO
Energy, Minerals and Natural Resources Department
Oil Conservation Division

Notice is hereby given that pursuant to New Mexico Water Quality Control Commission Regulations, the following discharge plan application has been submitted to the Director of the Oil Conservation Division, 2040 South Pacheco, Santa Fe, New Mexico, 87505, Telephone (505) 827-7131:

(GW-226) - Permian Brine Sales, A. L. Hickerson, 6067 W. Tenth, Odessa, Texas 79763, has submitted a discharge plan application for disposal of non-hazardous semi-solid oil field waste in abandoned salt caverns located in the SE/4 SE/4 of Section 34, Township 19 South, Range 36 East, NMPM, Lea County, New Mexico. Approximately 5,000 barrels per day of non-hazardous oil field waste slurry will be injected down the tubing of the abandoned Climax Chemical Company Foster No. 1 to the bottom of the salt cavern, approximately 2,500 feet, and brine will be produced up the annulus for sale. Ground water most likely to be affected in the event of an accidental discharge is at a depth of approximately 35 to 60 feet with a total dissolved solids concentration ranging from 500 to 3000 mg/l. The discharge plan addresses construction, operation and monitoring of the well and associated surface facilities and how spills, leaks, and other accidental discharges to the surface will be managed.

(GW-240) - Diamond Rental, Inc., Harry Teague, (505) 392-6498, 3400 Industrial, Hobbs, New Mexico 88240, has submitted a Discharge Plan Application for the Diamond Rental, Inc. Facility located in the NW/4 NW/4 of Section 21, Township 18 South, Range 38 East, NMPM, Lea County, New Mexico. Approximately 16 gallons per day of waste water is stored in bermed above ground closed top steel tanks. All wastes are disposed of at an OCD permitted offsite Class II injection well. Groundwater most likely to be affected by a spill, leak, or accidental discharge to the surface is at a depth of approximately 750 mg/L. The discharge plan addresses how spills, leaks, and other accidental discharges to the surface will be managed.

Any interested person may obtain further information from the Oil Conservation Division and may submit written comments to the Director of the Oil Conservation Division at the address given above. The discharge plan application may be viewed at the above address between 8:00 a.m. and 4:00 p.m., Monday thru Friday. Prior to ruling on any proposed discharge plan or its modification, the Director of the Oil Conservation Division shall allow at least thirty (30) days after the date of publication of this notice during which comments may be submitted to him and a public hearing may be requested by any interested person. Requests for a public hearing shall set forth the reasons why a hearing shall be held. A hearing will be held if the Director determines there is significant public interest.

If no hearing is held, the Director will approve or disapprove the plan based on the information available. If a public hearing is held, the director will approve the plan based on information in the discharge plan application and information submitted at the hearing.

GIVEN under the Seal of New Mexico Oil Conservation Commission at Santa Fe, New Mexico, on this 15th day of March, 1996.

STATE OF NEW MEXICO
OIL CONSERVATION DIVISION
WILLIAM J. LEMAY, Director
Legal #59318
Pub. March 22, 1996

CRI
CONTROLLED RECOVERY INC.
P.O. BOX 369, HOBBS, NM 88241 (505) 393-1079

April 26, 1996

MR. WILLIAM J. LEMAY
State of New Mexico
Energy, Minerals and Natural
Resources Department
Oil Conservation Division
2040 South Pacheco
Santa Fe, New Mexico 87505

Re: (GW-226) Permian Brine Sales
(UIC-CL1-006) P & S Brine Sales

Dear Mr. LeMay:

I am enclosing a copy of Petition for Judicial Review filed by the State of Texas vs. United States Environmental Protection Agency which outlines in general terms the same concerns I have expressed in previous correspondence requesting denial of referenced permit applications. Specifically, the overwhelming risks associated with salt cavern waste storage/disposal located proximate to water aquifiers is imminent.

Hopefully, this information will aid in your evaluation of the Permian and P & S applications.

Sincerely,

Gail Power

Gail Power

GP/jh

Enclosure

xc: Mr. Jerry Sexton

IN THE UNITED STATES COURT OF APPEALS
FOR THE
DISTRICT OF COLUMBIA CIRCUIT

STATE OF TEXAS,	§	
	§	
Petitioner,	§	
	§	
vs.	§	No. 96-1109
	§	
U.S. ENVIRONMENTAL PROTECTION AGENCY,	§	
	§	
and	§	
	§	
CAROL M. BROWNER, ADMINISTRATOR,	§	
U.S. ENVIRONMENTAL PROTECTION AGENCY,	§	
	§	
Respondents.	§	

PETITION FOR JUDICIAL REVIEW OF AGENCY REGULATION

PRELIMINARY STATEMENT

PETITIONER, the State of Texas ("Texas"), by its Attorney General, Dan Morales, seeks judicial review pursuant to 28 U.S.C. § 2344, 5 U.S.C. §§ 701-06, and § 18 of the Waste Isolation Pilot Plant Land Withdrawal Act, Pub, L. 102-579 (the "WIPP Act"), of the "Criteria for the Certification and Recertification of the Waste Isolation Pilot Plant's Compliance with the 40 C.F.R. Part 191 Disposal Regulations," 61 Fed Reg. 5224 (Feb. 9, 1996)(the "Compliance Criteria"), issued by the United States Environmental Protection Agency ("EPA").

JURISDICTION AND VENUE

1. This case arises under the WIPP Act, § 18; the Hobbs Act, 28 U.S.C. § 2342(4); and the judicial review provisions of the Administrative Procedure Act, 5 U.S.C. §§ 701-06.

PARTIES

2. Petitioner, the State of Texas, is represented by its Attorney General, Dan Morales. The Attorney General of Texas is authorized to sue on behalf of Texas as a governmental entity and on behalf of the interests of the people of Texas in recreation, their natural resources, and their environment.

3. Respondent EPA is an executive agency of the United States. Respondent Carol M. Browner is the Administrator of the EPA. Pursuant to § 8(c) of the WIPP Act the Administrator of the EPA is charged with the responsibility of issuing criteria for the determination of compliance by the Waste Isolation Pilot Plant ("WIPP") with the radioactive waste disposal regulations, 40 C.F.R. Part 191, Subpart B (the "Disposal Regulations").

STANDING

4. Texas and its citizens are vitally interested in the lawful and scientifically correct determination of WIPP's compliance with the Disposal Regulations and, therefore, in the issuance of Compliance Criteria which lawfully and correctly carry out the purpose of the Disposal Regulations as to WIPP. The Compliance Criteria issued by EPA, however, are invalid and ineffective in carrying out the purpose of the Disposal Regulations. Following such criteria, EPA may certify that WIPP complies with the Disposal Regulations when it would not otherwise do so or may fail to impose terms and conditions of certification which it would otherwise impose. In such circumstances:

(a) The WIPP site would continue to be withdrawn from public use pursuant to §§ 3 and 8(d)(2)(B) of the WIPP Act.

(b) The operation of WIPP may result in the escape of nonnatural radiation.

5. WIPP is located in southeast New Mexico. The WIPP site is only 15 miles from the Texas border and 30 miles from the Pecos River, which flows from New Mexico into Texas. Pursuant to Texas law, Texas owns the water in the Pecos River once that water enters Texas. TEX. WATER CODE ANN. § 11.021 (Vernon 1988). Texas therefore has an interest in protecting its state property.

6. The Pecos River is a major source of irrigation for Pecos, Reeves, Loving, and Ward Counties in west Texas. Texas has a significant economic interest in protecting the quality of Pecos River water.

7. Furthermore, there are several water-bearing formations that overlie and underlie the WIPP repository horizon. These water-bearing formations exist both in Texas and New Mexico. Groundwater from one of these formations, the Rustler, is currently used in Texas for oil and gas activities. There is the potential that this groundwater will be used more extensively in the future. Any contamination of these formations could result in a corresponding contamination of Texas groundwater.

8. Because of Texas's close proximity to the WIPP site, a release of radiation and/or hazardous substance from the WIPP site would have a detrimental impact on Texas's air, land, and water. The impact of such a release could be devastating to the State of Texas, Texas's citizens, its natural resources, and its economy, particularly the agricultural industry located just miles from the WIPP site.

9. Two of the major routes that the U.S. Department or Energy ("DOE") has proposed for the transportation of waste to WIPP cross Texas. Interstate 20 passes through Dallas, Ft.

Worth, Abilene, Midland, and Odessa. Interstate 40 passes through Amarillo. The transportation of these wastes to WIPP through Texas poses a risk to the citizens of Texas because of the possibility of releases of radioactive and hazardous materials to land, air, or water.

10. Texas has monitored WIPP since the plant's inception. Interests of Texas are within the zone of interests of the statute involved in this action.

NATURE OF THE CLAIMS

11. DOE has constructed WIPP and plans to operate it as the world's first geologic repository for radioactive waste. However, WIPP has not been found to be in compliance with the Disposal Regulations, nor is it authorized to receive radioactive waste.

12. The WIPP Act places EPA over DOE as independent regulator at WIPP. EPA is charged therein with:

(a) issuing final Disposal Regulations;

(b) issuing the Compliance Criteria containing WIPP-specific standards for application of the Disposal Regulations; and

(c) ultimately determining whether WIPP will comply with the Disposal Regulations and the Compliance Criteria.

13. Texas is compelled to seek this Court's review of the Compliance Criteria by EPA's multiple violation of the principles of notice-and-comment rulemaking, including the following:

(a) after the public comment period, and after EPA had decided on the terms of a final rule, EPA engaged in closed-door discussions with the Office of Management and Budget ("OMB"), DOE, and DOE's outside contractors. Based on those discussions, and relying upon data and information supplied to EPA in those discussions, EPA made major changes in the final rule. OMB, DOE, and the DOE contractors are not authorized by law to have such a role in the issuance of the Compliance Criteria. The data and information which convinced EPA to make such major changes were not available for comment during the public comment period and have never been put in the public record;

(b) EPA prevented public participation in the Compliance Criteria rulemaking by failing to give the required public notice and to disclose the bases for the proposed rule. Thus, the final rule contains provisions which were not even suggested by the proposed rule, EPA in the final rule has changed both the underlying rationale and the substance of other provisions, and EPA has withheld critical technical studies until long after the public comment period;

(c) several of the Compliance Criteria provisions conflict with the mandate of the WIPP Act, which directs EPA to issue "criteria for the Administrator's certification of compliance with the final disposal regulations" (§ 8 (c) (2)), in that they do not contain criteria, or the criteria they contain conflict with the Disposal Regulations; and

(d) several of the Compliance Criteria provisions are arbitrary and capricious under the standards consistently applied by this Court on review of administrative regulations (*e.g.*, in that they contain terms which are at odds with the EPA' s stated rationale or have no rational basis at all).

14. The actions by EPA complained of herein have no remedy in any court except this Court of Appeals. The Compliance Criteria is reviewable in this Court. Texas has suffered legal wrong and is adversely affected and aggrieved by the action complained of herein.

RELIEF REQUESTED

Petitioner requests that the Court find that the Compliance Criteria, as issued, are arbitrary, capricious, and contrary to law; vacate them; and remand them to EPA for further rulemaking in compliance with law.

Respectfully submitted,

DAN MORALES
Attorney General or Texas

JORGE VEGA
First Assistant Attorney General

SAM GOODHOPE
Special Assistant Attorney General

Nancy E. Olinger
NANCY E. OLINGER
Assistant Attorney General

P. O. BOX 12548
Austin, TX 78711-2548
(512) 463-2012

Attorneys for the State of Texas

CERTIFICATE OF SERVICE

I, Nancy E. Olinger, do hereby certify that on this 8 th day of April, 1996, caused a copy of the foregoing Petition to be served by first class mail on:

U.S. Environmental Protection Agency
401 M Street, S.W.
Washington, D.C. 20460

Carol M. Browner, Administrator
U.S. Environmental Protection Agency
401 M Street, SW
Washington, D.C. 20460

Such service conforms to the requirements of Circuit Rule 27(a)(1) and Appellate Rule 2E

Nancy E. Olinger
Nancy E. Olinger

OIL CONSERVATION DIVISION
RECEIVED

'96 APR 25 AM 8 52

Lea County, New Mexico

Courthouse Box 4-C • Lovington, New Mexico 88260-4030
BUS: (505) 396-8521 • BUS: (505) 393-7816 • FAX: (505) 396-5684

Env. MTJ

April 17, 1996

Mr. Jerry Sexton
P.O. Box 1980
Hobbs, NM 88241

Dear Mr. Sexton:

The Lea County Board of Commissioners recently received some comments from the public with regard to the two proposed disposal sites to be located in nearby salt caverns.

At the County Commission meeting on April 4, 1996, the Commissioners voted to request that the Oil Conservation Commission hold a public hearing so that Lea County residents have the opportunity to voice their concerns.

Sincerely,

Dennis M. Holmberg
Lea County Manager

DMH:lde

To: Bill LeMay
Roger Anderson

PERMIAN BRINE SALES, INC.
BRINE — FRESHWATER — WATER DISPOSAL — SOLIDS DISPOSAL
6067 W. TENTH • ODESSA, TEXAS 79763
(915) 381-0531 (915) 530-0664 FAX (915) 381-9316

RECEIVED
'96 APR 12 AM 8 52

April 9, 1996

Mr. William J. LeMay
State of New Mexico
Energy, Minerals and Natural Resources Department
Oil Conservation Division
2040 South Pacheco
Santa Fe, NM 87505

RE: (GW-226) Our request for brine well permit and for non-hazardous oil field waste disposal permit in abandoned Climax salt cavern wells in S/2 of S/2 of Section 34, T-19-S, R-36-E in Lea County.

Dear Mr. LeMay:

It is our understanding that there have been several requests that our permit be denied. We therefore look forward to being able to present our proposal at a hearing.

This utilization of idle caverns in the rock salt underlying the Permian Basin presents the oil industry with an excellent opportunity to safely dispose of their semi-solid wastes in a place far below all fresh water aquifers, where it will safely remain throughout eternity.

One of our competitors (CRI, Inc.) has requested the Lea County Commissioners to join in a protest against the approval of our permit. Obviously because CRI is not a legally concerned party - except as a competitor. The County Commissioners naturally are interested and have agreed to let us tell them about what we are doing in our Texas caverns and what our plans are at Monument at their next meeting on April 17th in Lovington.

We appreciate this opportunity. I have invited your Mr. Jerry Sexton at Hobbs to visit our disposal cavern facility at Andrews, Texas and to attend the County Commissioners meeting. We would also like to invite interested people in your Santa Fe staff to visit our facility before the hearing on our application. We believe that you will agree with the Hart's Oil and Gas World magazine's committee in awarding us the *Best Environmental Project in the Permian Basin* in 1995.

I believe that I am more familiar with salt caverns than anyone! Please see the attached copy of my resume. There are 102 LPG storage caverns and 73 brine well caverns in the Permian Basin. (See attached map.) I appreciate your attention. If you or your staff need additional information, just let us know.

Very truly yours,
PERMIAN BRINE SALES, INC.

A. L. Hickerson

A.L. Hickerson
CEO

ALH/rdw
Attachments

A.L. HICKERSON

Professional Engineer - Texas #1183OK
6067 WEST 10th STREET • ODESSA, TX 79763 • Telephone: (915)381-0531

EDUCATION

Oklahoma State University
B.S. in Chemical Engineering - 1939

Sales Analysis Institute - Chicago Illinois

EXPERIENCE

Permian Brine Sales, Inc.
CEO-Owner-Manager - (1958 - Present)

Phillips Petroleum Company
Various Supervisory Engineering and Operating Positions - 14 Years

Phillips Petroleum Company
Process and Design Engineer - 6 Years

SALT CAVERN EXPERIENCE

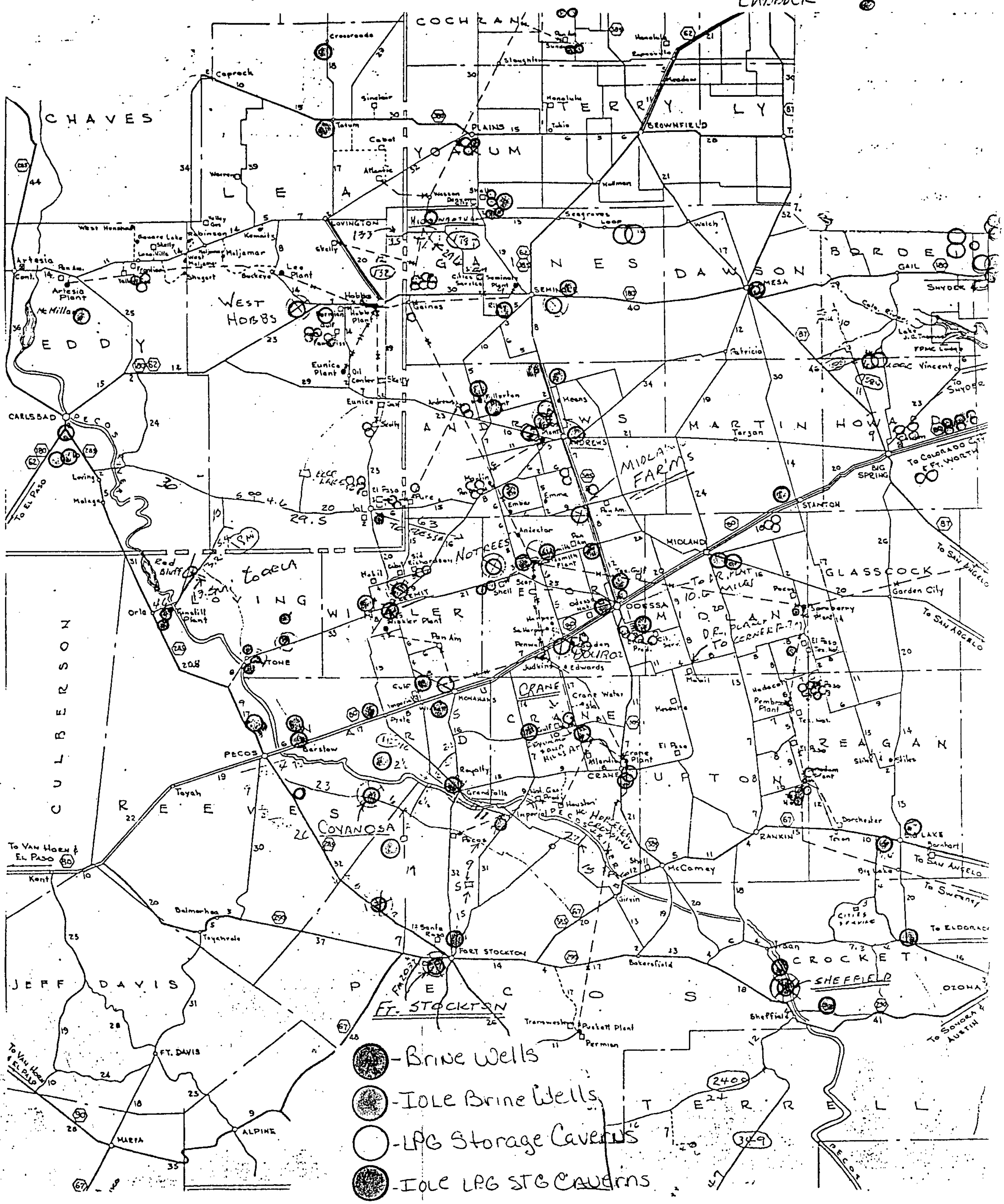
- Project Engineer on installation of 5 LPG storage caverns at Borger, Texas for Phillips Petroleum Company in 1951.
- Project Engineer on cavern at Goldsmith, Texas for Phillips Petroleum Company.
- Consultant on Hydrocarbon storage caverns as follows:
  - Texas Gulf at Odessa, Texas
  - Chevron Pipeline at Wink, Texas
  - Amarillo Oil Company at Pampa, Texas
  - Diamond Shamrock at Sunray, Texas
  - Santa Fe Pipeline at Andrews, Texas
  - Three Bar Underground Storage at Andrews, Texas
  - Edmonson LPG at Edmonson, Texas
  - United Gas at Levelland, Texas
  - HYDRO GAS Juarez at Goldsmith, Texas
  - Sid Richardson at Kermit, Texas

  Installed and operated propane cavern for Chevron at Kermit, Texas
  Installed, owned and operated thirty-five caverns in West Texas, New Mexico, and Oklahoma for production and sale of brine

CONSULTANT ON OTHER BRINE WELLS

- Basin H_2O, Inc. in Andrews, Texas
- Petro-Thermo Corporation in Hobbs, New Mexico
- Chief Well in Monahans, Texas
- D.B.I., Inc. in Seminole, Texas

CAVERNS IN PERMIAN BASIN



PAM HOWARD
3813 TREVINO
HOBBS, NM 88240

OIL CONSERVATION DIVISION
RECEIVED
'96 APR 8 AM 8 52

April 3, 1996

Mr. William J. LeMay
State of New Mexico
Oil Conservation Division
2040 South Pacheco
Santa Fe, NM 87505

RE: (GW-226) Permian Brine Sales
(UIC-CL1-006) P & S Brine Sales

Dear Mr. LeMay:

Please register my name as an opponent of the above mentioned applications. I am of the opinion that the risks of this method of disposal far exceed the possible benefits.

If the applicants are unable to absolutely guarantee that no leaks of waste will occur and possibly contaminate the underground water, then the wise choice would be to deny these requests.

I have been a resident and rancher in Lea County all of my life. My children are fifth generation Lea Countians. My predecessors and myself have been ranchers and landowners in Lea County since the early 1900's.

I am presently president of the Lea County Chapter of the New Mexico Cattle Grower's Association.

I urge you to deny these applications.

Sincerely,

Pam Howard

Pam Howard

BRUCE A. CARLIN
P.O. BOX 61
HOBBS, NEW MEXICO 88241
APRIL 3, 1996

OIL CONSERVATION DIVISION
RECEIVED
'96 APR 8 AM 8 52

Mr. William J. LeMay
State of New Mexico
Oil Conservation Division
2040 South Pacheco
Sante Fe, NM 87505

RE: (GW-226) Permian Brine Sales
(UIC-CLl-006) P & S Brine Sales

Dear Mr. LeMay:

I am opposed to referenced permit applications. The salt caverns could collapse or develop leaks which would cause damage to our precious and irreplaceable water aquifer. The risk to the environment and related public safety and health hazards are over whelming.

My family settled in Lea County in 1906 and we have been residents and ranchers in Lea County since that time.

I urge you to deny these applications.

Yours truly,

Bruce A Carlin

Bruce A. Carlin

SIMS FARMS & RANCHES

TELEPHONE (505) 393-3024 119 NORTH DALMONT

HOBBS, NEW MEXICO 88240

OIL CONSER... ON DIVISION
REC..ED
'96 APR 1 AM 8 52

March 29, 1996

Mr. William J. LeMay
State of New Mexico
Energy, Minerals, and
Natural Resources Department
Oil Conservation Division
2040 South Pacheco
Santa Fe, NM 87505

Re: (GW-226) Permian Brine Sales

Dear Mr. LeMay:

Please enter my name as an opponent of referred application. The indicated risks of this method of disposal far exceed any possible benefit.

If the applicants cannot absolutely guarantee no leaks of waste will occur and possibly contaminate underground water, then the wise and prudent indication is to deny this request.

My family and myself are ranchers in Lea County, New Mexico, with land near the proposed site. I was born in Lea County seventy-four (74) years ago and have maintained a permanent residence for this time.

I sincerely believe the best decision in this case is to deny the application.

Thank you,

Leo Sims

Leo Sims

CLYDE "RED" ARSBON
219 WEST ST. ANNE PLACE
HOBBS, NEW MEXICO 88240

OIL CONSERVATION DIVISION
RECEIVED
'96 AP 1 AM 8 52

March 29, 1996

Mr. William J. LeMay
State of New Mexico
Energy, Minerals, and
Natural Resources Division
2040 South Pacheco
Santa Fe, NM 87505

Re: (GW-226) Permian Brine Sales
(UIC-CL1-006) P & S Brine Sales

Dear Mr. LeMay:

I am opposed to the issuance of referred permits.

The salt cavern disposal method has too many risks associated with possible leaks of liquid waste into the water aquifer. If a break in the salt did occur, the waste would be irretrievable.

I have been a resident of Lea County, New Mexico for more than fifty years. I am a rancher and own land in Lea County and am also in the oil business. I have previously served two terms as Chairman of the Lea County Commission.

To issue these permits would not be prudent to the people of Lea County. The possible damage to the environment and related risk to public safety is infinite.

Thank you for your consideration,

Clyde "Red" Arsbon

JIMMIE T. COOPER

P. O. Box 55

Monument, New Mexico 88265

OIL CONSERVATION DIVISION RECEIVED

'96 MAR 28 AM 8 52

March 15, 1996

MR. WILLIAM J. LEMAY
State of New Mexico
Energy, Minerals and Natural
Resources Department
Oil Conservation Division
2040 South Pacheco
Santa Fe, New Mexico 87505

Re: (GW-226) Permian Brine Sales

Dear Mr. LeMay:

I respectfully request referenced permit application be denied. As a land owner with property adjacent to referenced site in Section 34, Township 19 South Range 36 East, NMPM Lea County, New Mexico, I am very concerned the disposal of various waste into a salt cavern would have an adverse impact on my property. Specifically, the salt cavern could collapse or develop a leak which possibly would allow migration of waste into the underground water aquifer and cause irreversible damage to the environment and would detrimentally effect the health and safety of area residents and workers.

In the event this permit application is not denied and the Oil Conservation Commission decides to conduct a public hearing, I wish to register as a protestant with the opportunity to appear before the Oil Conservation Commission to submit documentation to support my very strong opposition to the request submitted by Permian Sales.

Sincerely,

Jimmie T. Cooper

Jimmie T. Cooper

NEW MEXICO ENERGY, MINERALS AND NATURAL RESOURCES DEPARTMENT

March 19, 1996

NEW MEXICAN
202 E. Marcy
Santa Fe, New Mexico 87501

RE: NOTICE OF PUBLICATION

PO #96-199-002997

ATTN: BETSY PERNER

Dear Sir/Madam:

Please publish the attached notice(s) one time. Please proofread carefully, as any error in a land description or in a key word or phrase can invalidate the entire notice.

Immediately upon completion of publication, please send the following to this office:

1. Publisher's affidavit.
2. Invoices for prompt payment.

We should have these immediately after publication in order that the legal notice will be available for the hearing which it advertises, and also so that there will be no delay in your receiving payment.

Please publish the notice on Friday, March 22, ~~1995.~~ 1996

Sincerely,

Sally Martinez
Sally E. Martinez
Administrative Secretary

Attachment

OFFICE OF THE SECRETARY - P. O. BOX 6429 - SANTA FE, NM 87505-6429 - (505) 827-5950
ADMINISTRATIVE SERVICES DIVISION - P. O. BOX 6429 - SANTA FE, NM 87505-6429 - (505) 827-5925
ENERGY CONSERVATION AND MANAGEMENT DIVISION - P. O. BOX 6429 - SANTA FE, NM 87505-6429 - (505) 827-5900
FORESTRY AND RESOURCES CONSERVATION DIVISION - P. O. BOX 1948 - SANTA FE, NM 87504-1948 - (505) 827-5830
MINING AND MINERALS DIVISION - P. O. BOX 6429 - SANTA FE, NM 87505-6429 - (505) 827-5970
OIL CONSERVATION DIVISION - P. O. BOX 6429 - SANTA FE, NM 87505-6429 - (505) 827-7131
PARK AND RECREATION DIVISION - P. O. BOX 1147 - SANTA FE, NM 87504-1147 - (505) 827-7465

Santa Fe, New Mexico 87505

DRUG

March 22, 1996

LOVINGTON DAILY LEADER
P. O. Box 1717
Lovington, New Mexico 88260

RE: NOTICE OF PUBLICATION

ATTN: ADVERTISING MANAGER

Der· Sir/Madam:

Please publish the attached notice one time immediately on receipt of this request. Plea proofread carefully, as any error in a land description or in a key word or phrase can invalida the entire notice.

Immediately upon completion of publication, please send the following to this office:

1. ***Publisher's affidavit in duplicate.***
2. ***Statement of cost (also in duplicate.)***
3. ***CERTIFIED invoices for prompt payment.***

We should have these immediately after publication in order that the legal notice will l available for the hearing which it advertises, and also so that there will be no delay in yo receiving payment.

Please publish the notice no later than March 29, 1996. ~~1995~~

Sincerely,

Sally E. Martinez
Administrative Secretary

Attachment

Z 765 962 266

Receipt for Certified Mail

UNITED STATES POSTAL SERVICE

No Insurance Coverage Provided
Do not use for International Mail
(See Reverse)

Sent to Lovington Daily Leader	
Street and No. P.O. Box 1717	
P.O., State and ZIP Code Lovington, NM 88260	
Postage	$
Certified Fee	
Special Delivery Fee	
Restricted Delivery Fee	
Return Receipt Showing to Whom & Date Delivered	
Return Receipt Showing to Whom, Date, and Addressee's Address	
TOTAL Postage & Fees	$
Postmark or Date	

PS Form 3800, March 1993

NOTICE OF PUBLICATION
STATE OF NEW MEXICO
ENERGY, MINERALS AND NATURAL RESOURCES DEPARTMENT
OIL CONSERVATION DIVISION

Notice is hereby given that pursuant to the New Mexico Water Quality Control Commission Regulations, the following discharge plan applications have been submitted to the Director of the Oil Conservation Division, 2040 South Pacheco, Santa Fe, New Mexico 87505, Telephone (505) 827-7131:

(GW-226) - Permian Brine Sales, A. L. Hickerson, 6067 W Tenth, Odessa, Texas 79763, has submitted a discharge plan application for disposal of non-hazardous semi-solid oil field waste in abandoned salt caverns located in the SE/4 SE/4 of Section 34, Township 19 South, Range 36 East, NMPM, Lea County, New Mexico. Approximately 5,000 barrels per day of non-hazardous oil field waste slurry will be injected down the tubing of the abandoned Climax Chemical Company Foster No. 1 to the bottom of the salt cavern, approximately 2,500 feet, and brine will be produced up the annulus for sale. Ground water most likely to be affected in the event of an accidental discharge is at a depth of approximately 35 to 60 feet with a total dissolved solids concentration ranging from 500 to 3000 mg/l. The discharge plan addresses construction, operation and monitoring of the well and associated surface facilities and how spills, leaks, and other accidental discharges to the surface will be managed.

(GW-240) - Diamond Rental, Inc., Harry Teague, (505) 392-6498, 3400 Industrial, Hobbs, New Mexico 88240, has submitted a Discharge Plan Application for the Diamond Rental, Inc. Facility located in the NW/4 NW/4 of Section 21, Township 18 South, Range 38 East, NMPM, Lea County, New Mexico. Approximately 16 gallons per day of waste water is stored in bermed above ground closed top steel tanks. All wastes are disposed of at an OCD permitted offsite Class II injection well. Groundwater most likely to be affected by a spill, leak, or accidental discharge to the surface is at a depth of approximately 50 feet with a total dissolved solids concentration of approximately 750 mg/L. The discharge plan addresses how spills, leaks, and other accidental discharges to the surface will be managed.

Any interested person may obtain further information from the Oil Conservation Division and may submit written comments to the Director of the Oil Conservation Division at the address given above. The discharge plan applications may be viewed at the above address between 8:00 a.m. and 4:00 p.m., Monday thru Friday. Prior to ruling on any proposed discharge plan or its modification, the Director of the Oil Conservation Division shall allow at least thirty (30) days after the date of publication of this notice during which comments may be submitted to him and a public hearing may be requested by any interested person. Requests for a public hearing shall

set forth the reasons why a hearing shall be held. A hearing will be held if the director determines that there is significant public interest.

If no hearing is held, the Director will approve or disapprove the plan based on the information available. If a public hearing is held, the Director will approve the plan based on the information in the discharge plan application and information presented at the hearing.

GIVEN under the Seal of New Mexico Oil Conservation Commission at Santa Fe, New Mexico, on this 15th day of March, 1996.

STATE OF NEW MEXICO
OIL CONSERVATION DIVISION

SEAL

WILLIAM J. LEMAY, Director

NOTICE OF PUBLICATION
STATE OF NEW MEXICO
ENERGY, MINERALS AND NATURAL RESOURCES DEPARTMENT
OIL CONSERVATION DIVISION

Notice is hereby given that pursuant to the New Mexico Water Quality Control Commission Regulations, the following discharge plan applications have been submitted to the Director of the Oil Conservation Division, 2040 South Pacheco, Santa Fe, New Mexico 87505, Telephone (505) 827-7131:

(GW-226) - Permian Brine Sales, A. L. Hickerson, 6067 W Tenth, Odessa, Texas 79763, has submitted a discharge plan application for disposal of non-hazardous semi-solid oil field waste in abandoned salt caverns located in the SE/4 SE/4 of Section 34, Township 19 South, Range 36 East, NMPM, Lea County, New Mexico. Approximately 5,000 barrels per day of non-hazardous oil field waste slurry will be injected down the tubing of the abandoned Climax Chemical Company Foster No. 1 to the bottom of the salt cavern, approximately 2,500 feet, and brine will be produced up the annulus for sale. Ground water most likely to be affected in the event of an accidental discharge is at a depth of approximately 35 to 60 feet with a total dissolved solids concentration ranging from 500 to 3000 mg/l. The discharge plan addresses construction, operation and monitoring of the well and associated surface facilities and how spills, leaks, and other accidental discharges to the surface will be managed.

(GW-240) - Diamond Rental, Inc., Harry Teague, (505) 392-6498, 3400 Industrial, Hobbs, New Mexico 88240, has submitted a Discharge Plan Application for the Diamond Rental, Inc. Facility located in the NW/4 NW/4 of Section 21, Township 18 South, Range 38 East, NMPM, Lea County, New Mexico. Approximately 16 gallons per day of waste water is stored in bermed above ground closed top steel tanks. All wastes are disposed of at an OCD permitted offsite Class II injection well. Groundwater most likely to be affected by a spill, leak, or accidental discharge to the surface is at a depth of approximately 50 feet with a total dissolved solids concentration of approximately 750 mg/L. The discharge plan addresses how spills, leaks, and other accidental discharges to the surface will be managed.

Any interested person may obtain further information from the Oil Conservation Division and may submit written comments to the Director of the Oil Conservation Division at the address given above. The discharge plan applications may be viewed at the above address between 8:00 a.m. and 4:00 p.m., Monday thru Friday. Prior to ruling on any proposed discharge plan or its modification, the Director of the Oil Conservation Division shall allow at least thirty (30) days after the date of publication of this notice during which comments may be submitted to him and a public hearing may be requested by any interested person. Requests for a public hearing shall

set forth the reasons why a hearing shall be held. A hearing will be held if the director determines that there is significant public interest.

If no hearing is held, the Director will approve or disapprove the plan based on the information available. If a public hearing is held, the Director will approve the plan based on the information in the discharge plan application and information presented at the hearing.

GIVEN under the Seal of New Mexico Oil Conservation Commission at Santa Fe, New Mexico, on this 15th day of March, 1996.

STATE OF NEW MEXICO
OIL CONSERVATION DIVISION

WILLIAM J. LEMAY, Director

SEAL

NO EFFECT FINDING

The described action will have no effect on listed species, wetlands, or other important wildlife resources.

Date April 18, 1996

Consultation # GWOCD96-1

Approved by

U.S. FISH and WILDLIFE SERVICE
NEW MEXICO ECOLOGICAL SERVICES FIELD OFFICE
ALBUQUERQUE, NEW MEXICO

NOTICE OF PUBLICATION
STATE OF NEW MEXICO
ENERGY, MINERALS AND NATURAL RESOURCES DEPARTMENT
OIL CONSERVATION DIVISION

Notice is hereby given that pursuant to the New Mexico Water Quality Control Commission Regulations, the following discharge plan applications have been submitted to the Director of the Oil Conservation Division, 2040 South Pacheco, Santa Fe, New Mexico 87505, Telephone (505) 827-7131:

(GW-226) - Permian Brine Sales, A. L. Hickerson, 6067 W Tenth, Odessa, Texas 79763, has submitted a discharge plan application for disposal of non-hazardous semi-solid oil field waste in abandoned salt caverns located in the SE/4 SE/4 of Section 34, Township 19 South, Range 36 East, NMPM, Lea County, New Mexico. Approximately 5,000 barrels per day of non-hazardous oil field waste slurry will be injected down the tubing of the abandoned Climax Chemical Company Foster No. 1 to the bottom of the salt cavern, approximately 2,500 feet, and brine will be produced up the annulus for sale. Ground water most likely to be affected in the event of an accidental discharge is at a depth of approximately 35 to 60 feet with a total dissolved solids concentration ranging from 500 to 3000 mg/l. The discharge plan addresses construction, operation and monitoring of the well and associated surface facilities and how spills, leaks, and other accidental discharges to the surface will be managed.

(GW-240) - Diamond Rental, Inc., Harry Teague, (505) 392-6498, 3400 Industrial, Hobbs, New Mexico 88240, has submitted a Discharge Plan Application for the Diamond Rental, Inc. Facility located in the NW/4 NW/4 of Section 21, Township 18 South, Range 38 East, NMPM, Lea County, New Mexico. Approximately 16 gallons per day of waste water is stored in bermed above ground closed top steel tanks. All wastes are disposed of at an OCD permitted offsite Class II injection well. Groundwater most likely to be affected by a spill, leak, or accidental discharge to the surface is at a depth of approximately 50 feet with a total dissolved solids concentration of approximately 750 mg/L. The discharge plan addresses how spills, leaks, and other accidental discharges to the surface will be managed.

Any interested person may obtain further information from the Oil Conservation Division and may submit written comments to the Director of the Oil Conservation Division at the address given above. The discharge plan applications may be viewed at the above address between 8:00 a.m. and 4:00 p.m., Monday thru Friday. Prior to ruling on any proposed discharge plan or its modification, the Director of the Oil Conservation Division shall allow at least thirty (30) days after the date of publication of this notice during which comments may be submitted to him and a public hearing may be requested by any interested person. Requests for a public hearing shall

set forth the reasons why a hearing shall be held. A hearing will be held if the director determines that there is significant public interest.

If no hearing is held, the Director will approve or disapprove the plan based on the information available. If a public hearing is held, the Director will approve the plan based on the information in the discharge plan application and information presented at the hearing.

GIVEN under the Seal of New Mexico Oil Conservation Commission at Santa Fe, New Mexico, on this 15th day of March, 1996.

STATE OF NEW MEXICO
OIL CONSERVATION DIVISION

WILLIAM J. LEMAY, Director

SEAL

United States Department of the Interior

FISH AND WILDLIFE SERVICE
New Mexico Ecological Services Field Office
2105 Osuna NE
Albuquerque, New Mexico 87113
Phone: (505) 761-4525 Fax: (505) 761-4542

October 18, 1995

William J. Lemay, Director
Oil Conservation Division
State Land Office Building
P.O. Box 2088
Santa Fe, New Mexico 87504-2088

Dear Mr. Lemay:

This responds to your agency's public notice dated September 22, 1995, regarding the State of New Mexico Energy, Minerals and Natural Resources Department's proposal to approve the discharge plan for the applicant listed below.

> **(GW-226) - Permian Brine Sales.** A. L. Hickerson has submitted a discharge plan application for the disposal of semi-solid oil field waste in abandoned salt caverns located in the SE/4 SE/4 of section 34, T. 19 S., R. 36 E. Lea County, New Mexico. Approximately 5000 barrels of solid waste per day will be injected down tubing to the bottom of a salt cavern.

On October 16, 1995, we learned from your staff (R. Anderson, pers. comm.), that the abandoned salt caverns were artificially created through prior brine removal. No adverse effects to wildlife, threatened or endangered species, or wetlands are anticipated.

Thank you for the opportunity to review and comment on this discharge plan application. If you have any questions, please contact Joel D. Lusk at (505) 761-4525.

Sincerely,

Jennifer Fowler-Propst
Field Supervisor

cc:
Director, New Mexico Department of Game and Fish, Santa Fe, New Mexico

NOTICE OF PUBLICATION
STATE OF NEW MEXICO
ENERGY, MINERALS AND
NATURAL RESOURCES
DEPARTMENT
OIL CONSERVATION
DIVISION

Notice is hereby given that pursuant to the New Mexico Water Quality Control Commission Regulations, the following discharge plan application has been submitted to the Director of the Oil Conservation Division, 2040 South Pacheco, Santa Fe, New mexico 87505, Telephone (505) 827-7131:

(GW-226) - Permian Brine Sales, A. L. Hickerson, 6067 W. Tenth, Odessa, Texas 79763, has submitted a discharge plan application for disposal of non-hazardous semi-solid oil field waste in abandoned salt caverns located in the SE/4 SE/4 of Section 34, Township 19 South, Range 36 East, NMPM, Lea County, New Mexico. Approximately 5,000 barrels per day of solid waste slurry will be injected down the tubing of the abandoned Climax Chemical Company Foster No. 1 to the bottom of the salt cavern, approximately 2,500 feet, and brine will be produced up the annulus for sale. Ground water most likely to be affected in the event of an accidental discharge is at a depth of approximately 35 to 60 feet with a total dissolved solids concentration ranging from 500 to 3000 mg/l. The discharge plan addresses how spills, leaks, and other accidental discharges to the surface will be managed.

Any interested person may obtain further information from the Oil Conservation Division and may submit written comments to the Director of the Oil Conservation Division at the address given above. The discharge plan applications may be viewed at the above address between 8:00 a.m. and 4:00 p.m., Monday thru Friday. prior to ruling on any proposed discharge plan or its modification, the Director of the Oil Conservation Division shall allow at least thirty (30) days after the date of publication of this notice during which comments may be submitted to him and public hearing may be requested by any interested person. Request for public hearing shall set forth the reasons why a hearing shall be held. A hearing will be held if the director determines that there is significant public interest.

If no hearing is held, the Director will approve or disapprove the plan based on the information available. If a public hearing is held, the Director will approve the plan based on the information in the plan and information presented at the hearing.

GIVEN under the Seal of New Mexico Oil Conservation Commission at Santa Fe, New Mexico, on this 22nd day of September, 1995.

STATE OF NEW MEXICO
OIL CONSERVATION DIVISION
s/WILLIAM J. LEMAY, Director

Journal: September 30, 1995.

RECEIVED
OCT - 6 1995
Oil Conservation Division

STATE OF NEW MEXICO
County of Bernalillo SS

Bill Tafoya being duly sworn declares and says that he is Classified Advertising manager of **The Albuquerque Journal**, and that this newspaper is duly qualified to publish legal notices or advertisements within the meaning of Section 3, Chapter 167, Session Laws of 1937, and that payment therefore has been made of assessed as court cost; that the notice, copy of which is hereto attached, was published in said paper in the regular daily edition, for one times, the first publication being of the 30 day of Sept, 1995, and the subsequent consecutive publications on ______, 1995 Bill Tafoya

OFFICIAL SEAL
Corrina Duncan
NOTARY PUBLIC
STATE OF NEW MEXICO
My Commission Expires: 12-8-99

Corrina Duncan

Sworn and subscribed to before me, a notary Public in and for the County of Bernalillo and State of New Mexico, this 4 day of Oct 1995

PRICE 37.35

Statement to come at end of month.

CLA-22-A (R-1/93) ACCOUNT NUMBER 1308387

Affidavit of Publication

STATE OF NEW MEXICO)
) ss.
COUNTY OF LEA)

Joyce Clemens being first duly sworn on oath deposes and says that he is Adv. Director of THE LOVINGTON DAILY LEADER, a daily newspaper of general paid circulation published in the English language at Lovington, Lea County, New Mexico; that said newspaper has been so published in such county continuously and uninterruptedly for a period in excess of Twenty-six (26) consecutive weeks next prior to the first publication of the notice hereto attached as hereinafter shown; and that said newspaper is in all things duly qualified to publish legal notices within the meaning of Chapter 167 of the 1937 Session Laws of the State of New Mexico.

That the notice which is hereto attached, entitled

Notice Of Publication

~~and numbered~~ .... ~~in the~~

.... ~~Court of Lea~~

~~County, New Mexico~~ was published in a regular and entire issue of THE LOVINGTON DAILY LEADER and not in any supplement thereof, ~~once each week on the~~

~~same day of the week~~, for one (1) day

~~consecutive weeks~~ beginning with the issue of

October 3, 1995

and ending with the issue of

October 3, 1995

And that the cost of publishing said notice is the sum of $44.80

which sum has been (Paid) ~~(Assessed)~~ as Court Costs

Joyce Clemens

Subscribed and sworn to before me this 11th

day of October, 1995

Jean Sevier

Notary Public, Lea County, New Mexico

My Commission Expires Sept. 28, 1998

LEGAL NOTICE

NOTICE OF PUBLICATION

STATE OF NEW MEXICO
ENERGY, MINERALS AND
NATURAL RESOURCES DEPARTMENT
OIL CONSERVATION DIVISION

Notice is hereby given that pursuant to New Mexico Water Quality Control Commission Regulations, the following discharge plan application have been submitted to the Director of the Oil Conservation Division, 2040 South Pacheco, Santa Fe, New Mexico 87505, Telephone (505)827-7131:

(GW-226) - Permian Brine Sales, A.L. Hickerson, 6067 W. Tenth, Odessa, Texas 79763, has submitted a discharge plan application for disposal of non-hazardous semi-solid oil field waste in abandoned salt caverns located in the SE/4 SE/4 of Section 34, Township 19 South, Range 36 East, NMPM, Lea County, New Mexico. Approximately 5,000 barrels per day of solid waste slurry will be injected down the tubing of the abandoned Climax Chemical Company Foster No. 1 to the bottom of the salt cavern, approximately 2,500 feet, and brine will be produced up the annulus for sale. Ground water most likely to be affected in the event of an accidental discharge is at a depth of approximately 35 to 60 feet with a total dissolved solids concentration ranging from 500 to 3000 mg/l. The discharge plan addresses how spills, leaks, and other accidental discharges to the surface will be managed.

Any interested person may obtain further information from the Oil Conservation Division and may submit written comments to the Director of the Oil Conservation Division at the address given above. The discharge plan application may be viewed at the above address between 8:00 a.m. and 4:00 p.m., Monday through Friday. Prior to ruling on any proposed discharge plan or its modification, the Director of the Oil Conservation Division shall allow at least thirty (30) days after the date of publication of this notice during which comments may be submitted to him and public hearing may be requested by any interested person. Requests for public hearing shall set forth the reasons why a hearing should be held. A hearing will be held if the Director determines there is significant public interest.

If no public hearing is held, the Director will approve or disapprove the proposed plan based on information available. If a public hearing is held, the director will approve or disapprove the proposed plan based on information in the plan and information submitted at the hearing.

GIVEN under the Seal of the State of New Mexico Oil Conservation Commission at Santa Fe, New Mexico, on this 22nd day of September, 1995.

STATE OF NEW MEXICO
OIL CONSERVATION DIVISION
WILLIAM J. LEMAY, Director

SEAL

Published in the Lovington Daily Leader October 3, 1995.

ENERGY, MINERALS and NATURAL RESOURCES DEPARTMENT
Santa Fe, New Mexico 87505

New Mexico DRUG FREE It's a State of Mind!

September 26, 1996

ALBUQUERQUE JOURNAL
P. O. Drawer J-T
Albuquerque, New Mexico 87103

RE: NOTICE OF PUBLICATION

ATTN: ADVERTISING MANAGER

Dear Sir/Madam:

Please publish the attached notice one time immediately on receipt of this request. Please proofread carefully, as any error in a land description or in a key word or phrase can invalidate the entire notice.

Immediately upon completion of publication, please send the following to this office:

1. Publisher's affidavit in duplicate.
2. Statement of cost (also in duplicate.)
2. CERTIFIED invoices for prompt payment.

We should have these immediately after publication in order that the legal notice will be available for the hearing which it advertises, and also so that there will be no delay in your receiving payment.

Please publish the notice no later than October 3, 1995.

Sincerely,

Sally Martinez

Sally E. Martinez
Administrative Secretary

Attachment

P 614 928 250

US Postal Service

Receipt for Certified Mail

No Insurance Coverage Provided.
Do not use for International Mail *(See reverse)*

Sent to Alby - Journal	
Street & Number	
Post Office, State, & ZIP Code	
Postage	$
Certified Fee	
Special Delivery Fee	
Restricted Delivery Fee	
Return Receipt Showing to Whom & Date Delivered	
Return Receipt Showing to Whom, Date, & Addressee's Address	
TOTAL Postage & Fees	$
Postmark or Date	

PS Form **3800**, April 1995

State of New Mexico
ENERGY, MINERALS and NATURAL RESOURCES DEPARTMENT
Santa Fe, New Mexico 87505

New Mexico DRUG FREE It's a State of Mind!

September 26, 1995

LOVINGTON DAILY LEADER
P. O. Box 1717
Lovington, New Mexico 88260

RE: NOTICE OF PUBLICATION

ATTN: ADVERTISING MANAGER

Dear Sir/Madam:

Please publish the attached notice one time immediately on receipt of this request. Please proofread carefully, as any error in a land description or in a key word or phrase can invalidate the entire notice.

Immediately upon completion of publication, please send the following to this office:

1. ***Publisher's affidavit in duplicate.***
2. ***Statement of cost (also in duplicate.)***
3. ***CERTIFIED invoices for prompt payment.***

We should have these immediately after publication in order that the legal notice will be available for the hearing which it advertises, and also so that there will be no delay in your receiving payment.

Please publish the notice no later than October 3, *1995.*

Sincerely,

Sally E. Martinez
Administrative Secretary

Attachment

P 614 928 448

US Postal Service
Receipt for Certified Mail
No Insurance Coverage Provided.
Do not use for International Mail *(See reverse)*

Sent to Lovington Daily Leader	
Street & Number P.O. Box 1717	
Post Office, State, & ZIP Code Lovington, NM 88260	
Postage	$
Certified Fee	
Special Delivery Fee	
Restricted Delivery Fee	
Return Receipt Showing to Whom & Date Delivered	
Return Receipt Showing to Whom, Date, & Addressee's Address	
TOTAL Postage & Fees	$
Postmark or Date	

PS Form **3800**, April 1995

State of New Mexico
Energy, Minerals and Natural Resources Department
OIL CONSERVATION DIVISION
P.O. Box 2088
Santa Fe, NM 87501

DISCHARGE PLAN APPLICATION FOR BRINE EXTRACTION FACILITIES

(Refer to OCD Guidelines for assistance in completing the application.)

I. FACILITY NAME: Monument Station

II. OPERATOR: PERMIAN BRINE SALES, INC

ADDRESS: 6067 West 10th Street Odessa, Texas 79763

CONTACT PERSON: A.L. Hickerson PHONE: (915)381-0531

III. LOCATION: SE /4 SE /4 Section 34 Township 19 South Range 36 East

Submit large scale topographic map showing exact location.

IV. Attach the name and address of the landowner of the facility site and landowners of record within one-half mile of the site.

Enclosed

V. Attach a description of the sources and quantities of fluids at the facility.

Enclosed

VI. Attach a description of all fluid transferring and handling facilities.

Enclosed

VII. Attach a description of underground facilities.

Enclosed

VIII. Attach a contingency plan for reporting and clean-up of spills or releases.

Enclosed

IX. Attach geological/hydrological evidence demonstrating that disposal of oil field wastes will not adversely impact fresh water. Enclosed

X. Attach such other information as is necessary to demonstrate compliance with any other OCD rules, regulations and/or orders.

Enclosed

XI. CERTIFICATION

I hereby certify that the information submitted with this application is true and correct to the best of my knowledge and belief.

Name: A.L. Hickerson Title: C.E.O.

Signature: A.L. Hickerson Date: 9/11/95

DISTRIBUTION: Original and one copy to Santa Fe with one copy to appropriate Division District Office.

BRINE WELL APPLICATION
FOR PERMIAN BRINE SALES, INC. MONUMENT STATION

Item IV. Names and addresses of landowners within one-half mile of site. A section map is enclosed.

Sec 34 T-19-S R-36-E

James W. Foster - 160 acres
Landowner at well site
1901 West Avenue J
Lovington, New Mexico 88260

Betty T. Cooper - 320 acres
PO Box 55
Monument, New Mexico 88265

G.T. Sims - 160 acres
PO Box 1046
Eunice, New Mexico 88231

Sec 35 T-19-S R-36-E

Climax Chemical - 560 acres
PO Box 1595
Hobbs, New Mexico 88241

Jimmy T. Cooper Trust - 40 acres
Betty T. Cooper Trust
Star Route A, Box 55
Monument, New Mexico 88265

State Land - 40 acres

Sec 3 T-20-S R-36-E

Federal Land
Lessee E.H. Lkein Estate
PO Box 1503
Hobbs, New Mexico 88241

Sec 2 T-20-S R-36-E

NW/4 Lot 1	40.16 acres	- State Land leased to Climax
Lot 2	40.21 acres	- State Land Leased to Climax
Lot 3	40.25 acres	- State Land leased to Climax
Lot 4	4.31 acres	- Owned by Climax

Rest of section is state land leased to James F. Byrd.

Item V. Description, source and quantity of fluid at the facility.

Source - produced water, drilling mud, tank bottoms, work overs fluids, and other oil and gas wastes that contian solids from wells in the area.
Quantity - Estimated 5000 BPD.
Storage - 1-500 steel pit (slurry tank).
Brine Water - from brine well. Stored in three (3) 1000 barrel tanks for subsequent hauling to drilling sites for use as a drilling and completion fluid.
Brine water - from shallow water wells on site.

Item VI. Description of fluid transferring and handling facilities.

Well Head
Piping
3-1000 bbl brine tanks
1-1000 bbl rinse water tank
Structural Pipe (wash racks, fences, sheds)
Steel (walkways, ladders, splash guards)
Portable Buildings (office, storage, shed, bathroom)
Sump Pump
#1 Positive Displacement Pump (5x10 Duplex)
#2 Positive Displacement Pump (5x8 Duplex)
Steel Pit with Agitators (slurry tank)
Pipe and pipe fittings for mud system (hoses, wash rack, blending, strainers)
Electric Panel, Conduit, switches, lights (8 starters, main disconnect, etc.
Concrete - 110' x 170' (truck unloading area)
Concrete blocks - 50
Dirt work
300' caliche pad and dikes
Fencing - Gate
Trees, landscaping
Pick-up truck
Mobil Home (septic, gas, electric, parking, fence)
Front end loader
2 skim oil tanks

Item VII. Description of underground facilities.

Casing and cementing records are enclosed for wells No 1 and No 2 along with plat showing locations.

Item VIII. Contingency plan for reporting and clean-up of spills or releases.

The fluid handling area will be surrounded by and earthen dike. The unloading area and sump will be concrete - draining to a sump with sump pumps - for pumping back into storage. Operator will be on site so that any major spills can be reported.

Item IX. Geological and hydrological data as prepared by Ken Davis for Climax Chemical enclosed.

Item X. Enclosed are plats, sketches, and forms C-101 and C-102.

Pressure integrity tests will be performed on each well to insure proper cementing before any operation is performed. Also enclosed are the records of all wells within one-half mile of well No. 1.

Climax well No.1 was washed down the tubing and out the casing from 1962 until January, 1970. Then, due to ledge sloughing problems and inability to make saturated brine by continuing to wash down the tubing, the flow was reversed, with fresh water going down the casing and up the tubing which was hanging at 1469 feet, so they could make saturated brine.

This resulted in the "clover leaf" shape at the top of the cavern, which I have shown in my sketch of the wells. This also happened on No. 2 well.

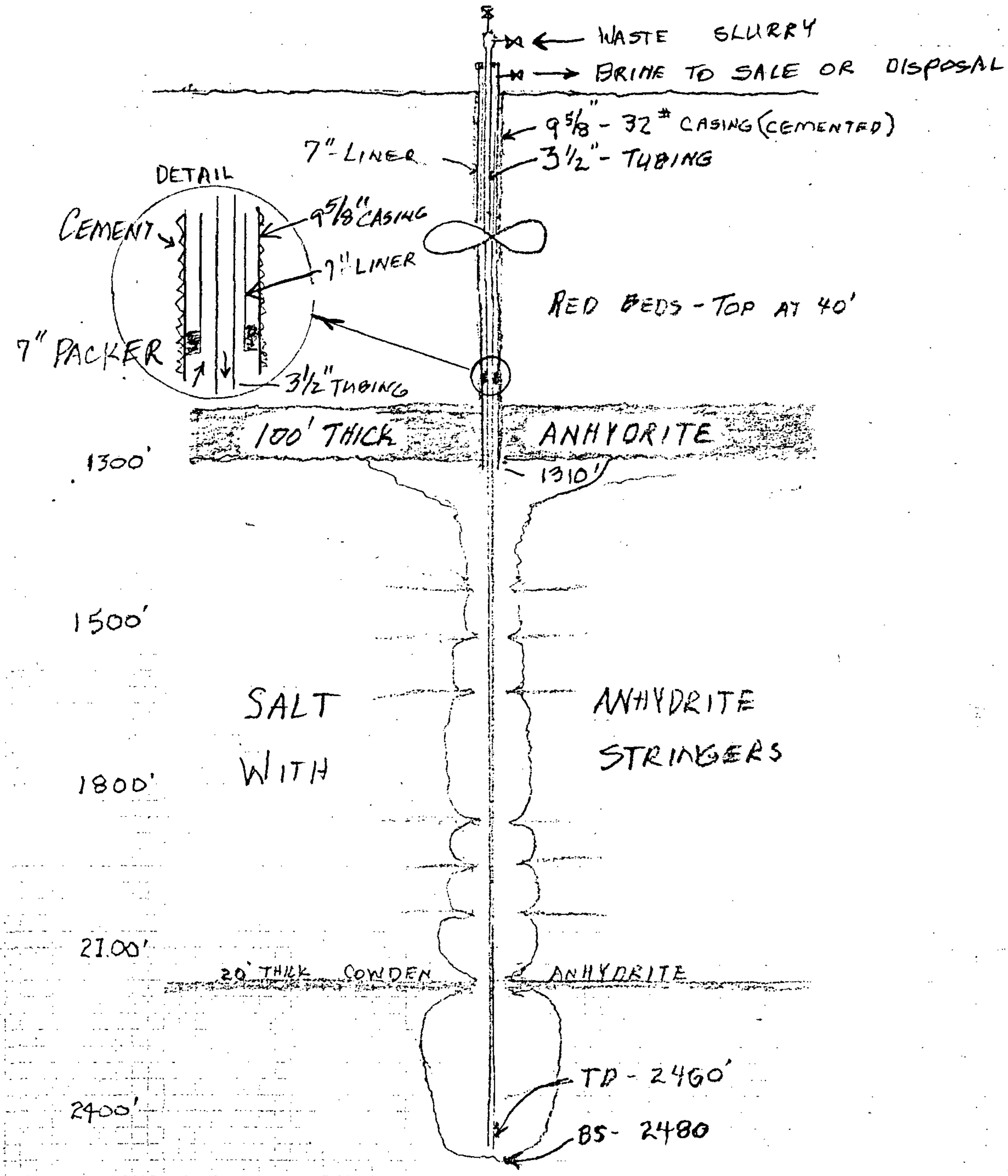
We are requesting a permit for two wells, just in case we can not get clean brine for sale out of No.1 well at the same time we are injecting waste into the bottom of the cavern, we can re-enter No.2 and make brine for sale.

We propose to hang a 7" liner inside the 9 casing on a packer. The 3 1/2 inch tubing for injection of the solid waste=slurry will be made through the inside of the 3 1/2" tubing to the bottom of hte cavern. Solids will settle into the cavern bottom and clean brine will return to the surface through the 7"-3 1/2" annulus. The hanging of the 7" lener will prevent the brine from coming into contact with the outer cemnted 9 " casing.

We have not filed any public notice and will not do so until we hear from you.

Plan for plugging and abandonment:

In order to plug and abandon the well, the tubing will be pulled from the well, a cast iron bridge plug will be set in the casing within 100 feet of the casing shoe. The casing will then be filled with cement and a steel cap welded on the casing. An identification marker will then be welded on the casing, according to New Mexico's requirements.

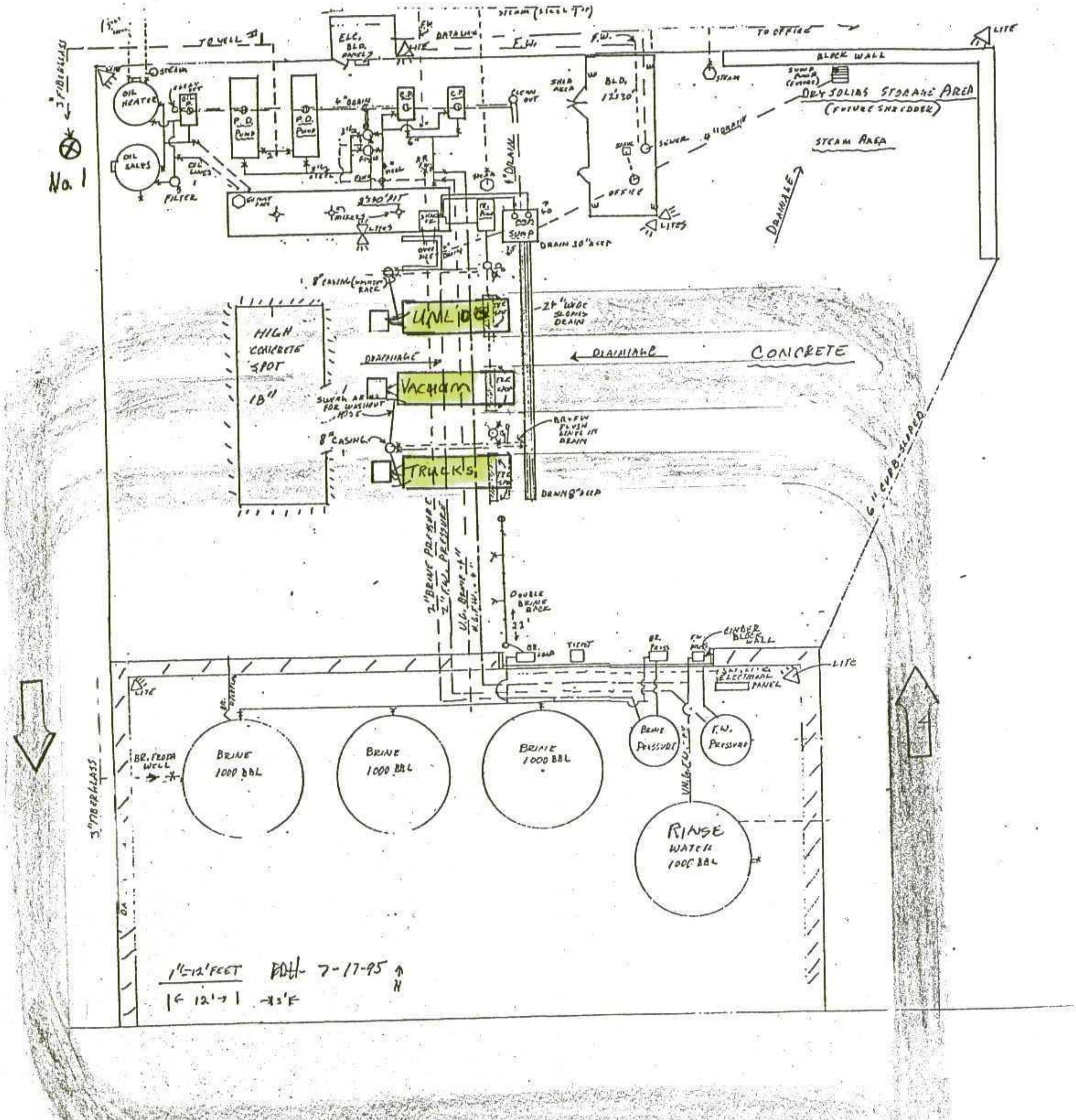


PERMIAN BRINE SALES, INC.
ODESSA, TEXAS

MONUMENT NO. 1

OLD CLIMAX FOSTER NO. 1 (1962)
SEC. 34 T-19-S R-36-E
990' FSL 1155' FEL
SCALE - 1" = 300 ft.

DATE:	BY:	DRAWING NO.:
9-6-95	ALH	1



WASTE DISPOSAL LAYOUT

PERMIAN BRINE SALES, INC.

BRINE — FRESHWATER — WATER DISPOSAL — SOLIDS DISPOSAL

6067 W. TENTH • ODESSA, TEXAS 79763
(915) 381-0531 (915) 530-0664 FAX (915) 381-9316

September 18, 1995

-2 copies GW-226

Mr Roger Anderson
Oil Conservation Division
2040 South Pacheco
Santa Fe, New Mexico 87505

RE: Request for brine well permit and for non-hazardous oil field waste disposal permit in abandoned Climax wells in S/2 of S/2 of Section 34 T-19-S, R-36-E in Lea County.

Dear Sir;

Permission is requested to re-enter two of the subject wells and for a permit to dispose of non-hazardous semi-solid oil field waste, as well as to sell brine from the wells.

Enclosed is the application cover page, description of items I through XI, forms C 101 and C 102, records of wells within 1/2 mile, sketch of well casing plan, and a detail plot plan of the proposed facility.

Your approval will be appreciated.

As you requested, I am sending this to you. If you have any questions, or if additional information is needed, please let us know.

Sincerely,

PERMIAN BRINE SALES, INC.

A.L. Hickerson

A.L. Hickerson
CEO

ALH/lji

Enclosures

C. Jerry Sexton
NMOCD office - Hobbs
1000 West Broadway
Hobbs, New Mexico 88241

PERMIAN BRINE SALES, INC.

BRINE — FRESHWATER — WATER DISPOSAL — SOLIDS DISPOSAL

6067 W. TENTH • ODESSA, TEXAS 79763
(915) 381-0531 (915) 530-0664 FAX (915) 381-9316

September 18, 1995

Mr Roger Anderson
Oil Conservation Division
2040 South Pacheco
Santa Fe, New Mexico 87505

RE: Request for brine well permit and for non-hazardous oil field waste disposal permit in abandoned Climax wells in S/2 of S/2 of Section 34 T-19-S, R-36-E in Lea County.

Dear Sir;

Permission is requested to re-enter two of the subject wells and for a permit to dispose of non-hazardous semi-solid oil field waste, as well as to sell brine from the wells.

Enclosed is the application cover page, description of items I through XI, forms C 101 and C 102, records of wells within 1/2 mile, sketch of well casing plan, and a detail plot plan of the proposed facility.

Your approval will be appreciated.

As you requested, I am sending this to you. If you have any questions, or if additional information is needed, please let us know.

Sincerely,

PERMIAN BRINE SALES, INC.

A.L. Hickerson
CEO

ALH/lji

Enclosures

C. Jerry Sexton
NMOCD office - Hobbs
1000 West Broadway
Hobbs, New Mexico 88241

State of New Mexico
Energy, Minerals and Natural Resources Department
OIL CONSERVATION DIVISION
P.O. Box 2088
Santa Fe, NM 87501

DISCHARGE PLAN APPLICATION FOR BRINE EXTRACTION FACILITIES

(Refer to OCD Guidelines for assistance in completing the application.)

✓ I. FACILITY NAME: Monument Station

✓ II. OPERATOR: PERMIAN BRINE SALES, INC

ADDRESS: 6067 West 10th Street Odessa, Texas 79763

CONTACT PERSON: A.L. Hickerson PHONE: (915)381-0531

✓ III. LOCATION: SE /4 SE /4 Section 34 Township 19 South Range 36 East

Submit large scale topographic map showing exact location.

✓ IV. Attach the name and address of the landowner of the facility site and landowners of record within one-half mile of the site.

Enclosed

✓ V. Attach a description of the sources and quantities of fluids at the facility.

Enclosed

? VI. Attach a description of all fluid transferring and handling facilities.

Enclosed

? VII. Attach a description of underground facilities.

Enclosed

? VIII. Attach a contingency plan for reporting and clean-up of spills or releases.

Enclosed

IX. Attach geological/hydrological evidence demonstrating that disposal of oil field wastes will not adversely impact fresh water. Enclosed

X. Attach such other information as is necessary to demonstrate compliance with any other OCD rules, regulations and/or orders.

Enclosed

XI. CERTIFICATION

I hereby certify that the information submitted with this application is true and correct to the best of my knowledge and belief.

Name: A.L. Hickerson Title: C.E.O.

Signature: A.L. Hickerson Date: 9/11/95

DISTRIBUTION: Original and one copy to Santa Fe with one copy to appropriate Division District Office.

BRINE WELL APPLICATION
FOR PERMIAN BRINE SALES, INC. MONUMENT STATION

Item IV. Names and addresses of landowners within one-half mile of site. A section map is enclosed.

Sec 34 T-19-S R-36-E

James W. Foster - 160 acres
Landowner at well site
1901 West Avenue J
Lovington, New Mexico 88260

Betty T. Cooper - 320 acres
PO Box 55
Monument, New Mexico 88265

G.T. Sims - 160 acres
PO Box 1046
Eunice, New Mexico 88231

Sec 35 T-19-S R-36-E

Climax Chemical - 560 acres
PO Box 1595
Hobbs, New Mexico 88241

Jimmy T. Cooper Trust - 40 acres
Betty T. Cooper Trust
Star Route A, Box 55
Monument, New Mexico 88265

State Land - 40 acres

Sec 3 T-20-S R-36-E

Federal Land
Lessee E.H. Lkein Estate
PO Box 1503
Hobbs, New Mexico 88241

Sec 2 T-20-S R-36-E

NW/4	Lot 1	40.16 acres	- State Land leased to Climax
	Lot 2	40.21 acres	- State Land Leased to Climax
	Lot 3	40.25 acres	- State Land leased to Climax
	Lot 4	4.31 acres	- Owned by Climax

Rest of section is state land leased to James F. Byrd.

Item V. Description, source and quantity of fluid at the facility.

Source - produced water, drilling mud, tank bottoms, work overs fluids, and other oil and gas wastes that contian solids from wells in the area.
Quantity - Estimated 5000 BPD.
Storage - 1-500 steel pit (slurry tank).
Brine Water - from brine well. Stored in three (3) 1000 barrel tanks for subsequent hauling to drilling sites for use as a drilling and completion fluid.
Brine water - from shallow water wells on site.

Item VI. Description of fluid transferring and handling facilities.

Well Head
Piping
3-1000 bbl brine tanks
1-1000 bbl rinse water tank
Structural Pipe (wash racks, fences, sheds)
Steel (walkways, ladders, splash guards)
Portable Buildings (office, storage, shed, bathroom)
Sump Pump
#1 Positive Displacement Pump (5x10 Duplex)
#2 Positive Displacement Pump (5x8 Duplex)
Steel Pit with Agitators (slurry tank)
Pipe and pipe fittings for mud system (hoses, wash rack, blending, strainers)
Electric Panel, Conduit, switches, lights (8 starters, main disconnect, etc.
Concrete - 110' x 170' (truck unloading area)
Concrete blocks - 50
Dirt work
    300' caliche pad and dikes
Fencing - Gate
Trees, landscaping
Pick-up truck
Mobil Home (septic, gas, electric, parking, fence)
Front end loader
2 skim oil tanks

Item VII. Description of underground facilities.

Casing and cementing records are enclosed for wells No 1 and No 2 along with plat showing locations.

Item VIII. Contingency plan for reporting and clean-up of spills or releases.

The fluid handling area will be surrounded by and earthen dike. The unloading area and sump will be concrete - draining to a sump with sump pumps - for pumping back into storage. Operator will be on site so that any major spills can be reported.

[illegible]
contained
VI.A.

Item IX. Geological and hydrological data as prepared by Ken Davis for Climax Chemical enclosed.

Item X. Enclosed are plats, sketches, and forms C-101 and C-102.

Pressure integrity tests will be performed on each well to insure proper cementing before any operation is performed. Also enclosed are the records of all wells within one-half mile of well No. 1.

Climax well No.1 was washed down the tubing and out the casing from 1962 until January, 1970. Then, due to ledge sloughing problems and inability to make saturated brine by continuing to wash down the tubing, the flow was reversed, with fresh water going down the casing and up the tubing which was hanging at 1469 feet, so they could make saturated brine.

This resulted in the "clover leaf" shape at the top of the cavern, which I have shown in my sketch of the wells. This also happened on No. 2 well.

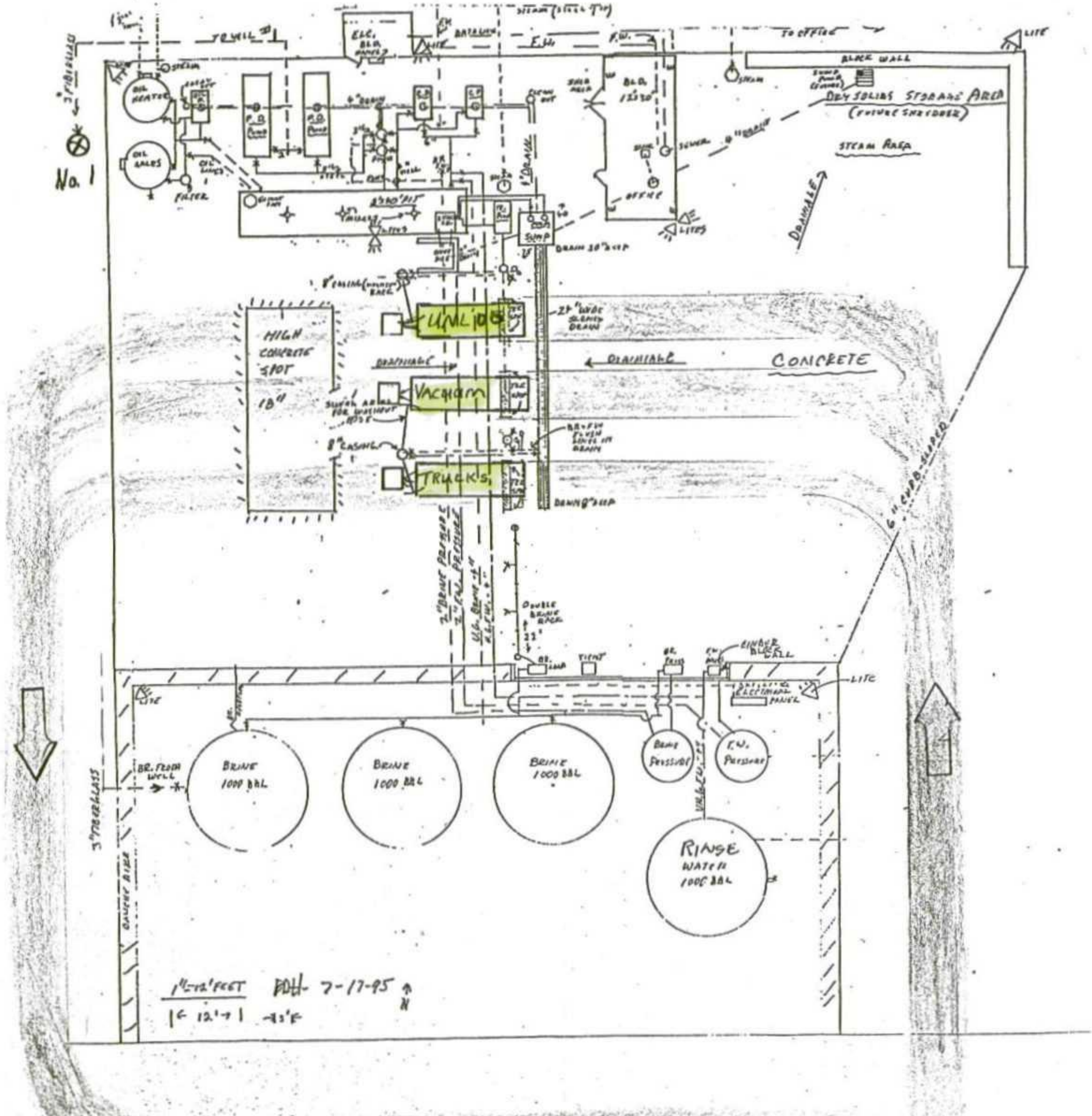
We are requesting a permit for two wells, just in case we can not get clean brine for sale out of No.1 well at the same time we are injecting waste into the bottom of the cavern, we can re-enter No.2 and make brine for sale.

We propose to hang a 7" liner inside the 9 casing on a packer. The 3 1/2 inch tubing for injection of the solid waste=slurry will be made through the inside of the 3 1/2" tubing to the bottom of hte cavern. Solids will settle into the cavern bottom and clean brine will return to the surface through the 7"-3 1/2" annulus. The hanging of the 7" lener will prevent the brine from coming into contact with the outer cemnted 9 " casing.

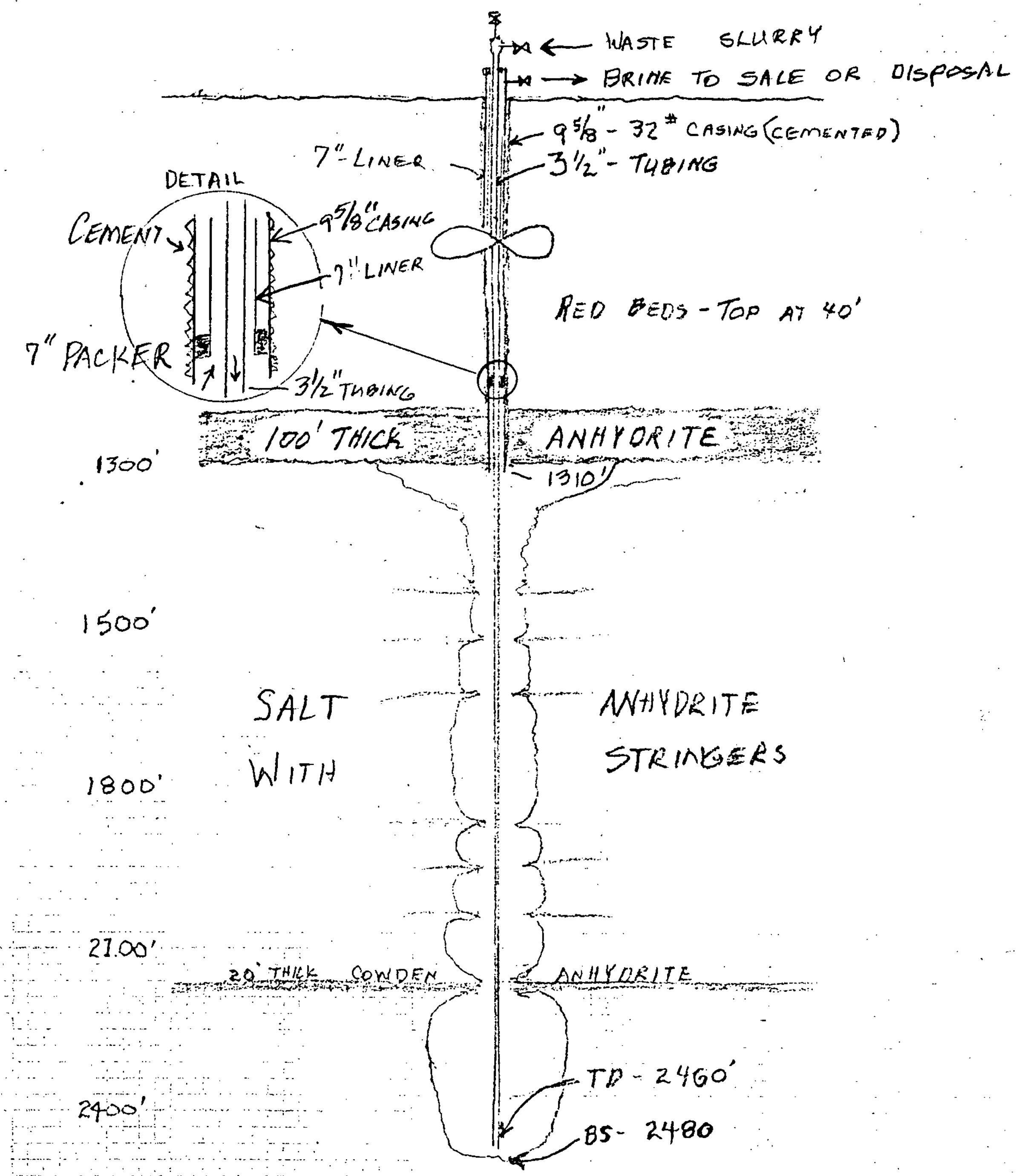
We have not filed any public notice and will not do so until we hear from you.

Plan for plugging and abandonment:

In order to plug and abandon the well, the tubing will be pulled from the well, a cast iron bridge plug will be set in the casing within 100 feet of the casing shoe. The casing will then be filled with cement and a steel cap welded on the casing. An identification marker will then be welded on the casing, according to New Mexico's requirements.



WASTE DISPOSAL LAYOUT



PERMIAN BRINE SALES, INC.
ODESSA, TEXAS

MONUMENT NO. 1

OLD CLIMAX FOSTER NO. 1 (1962)
SEC. 34 T-19-S R-36-E
990' FSL 1155' FEL
SCALE - 1" = 300 ft.

DATE:	BY:	DRAWING NO.:
9-6-95	ALH	1

District I
PO Box 1980, Hobbs, NM 88241-1980
District II
PO Drawer DD, Artesia, NM 88211-0719
District III
1000 Rio Brazos Rd., Aztec, NM 87410
District IV
PO Box 2088, Santa Fe, NM 87504-2088

State of New Mexico
Energy, Minerals & Natural Resources Department

OIL CONSERVATION DIVISION
PO Box 2088
Santa Fe, NM 87504-2088

Form C-101
Revised February 10, 1994
Instructions on back
Submit to Appropriate District Office
State Lease - 6 Copies
Fee Lease - 5 Copies

☐ AMENDED REPORT

APPLICATION FOR PERMIT TO DRILL, RE-ENTER, DEEPEN, PLUGBACK, OR ADD A ZONE

[1] Operator Name and Address.	[2] OGRID Number
PERMIAN BRINE SALES, INC. 6067 West 10th Street Odessa, Texas 79763	[3] API Number 30 - 0

[4] Property Code	[5] Property Name	[6] Well No.
	Formerly Climax Chemical Saline Well No.1 Foster	1

[7] Surface Location

UL or lot no.	Section	Township	Range	Lot Idn	Feet from the	~~North~~/South line	Feet from the	East/~~West~~ line	County
	34	19-S	36-E			990 ft.		1155 ft	Lea

[8] Proposed Bottom Hole Location If Different From Surface

UL or lot no.	Section	Township	Range	Lot Idn	Feet from the	North/South line	Feet from the	East/West line	County

[9] Proposed Pool 1	[10] Proposed Pool 2

[11] Work Type Code	[12] Well Type Code	[13] Cable/Rotary	[14] Lease Type Code	[15] Ground Level Elevation
E	Brine - I	Rotary	P	3618
[16] Multiple	**[17] Proposed Depth**	**[18] Formation**	**[19] Contractor**	**[20] Spud Date**
No	2480 ft.	Salado		

[21] Proposed Casing and Cement Program

Hole Size	Casing Size	Casing weight/foot	Setting Depth	Sacks of Cement	Estimated TOC
12¼	9 5/8	32.3	~~1287~~ 1310	440	Circ

[22] Describe the proposed program. If this application is to DEEPEN or PLUG BACK give the data on the present productive zone and proposed new productive zone. Describe the blowout prevention program, if any. Use additional sheets if necessary.

Re-entry, drill out cement and bridge plug
Hang 3½ tubing to T.D.

[23] I hereby certify that the information given above is true and complete to the best of my knowledge and belief.	OIL CONSERVATION DIVISION
Signature: A.L. Hickerson	Approved by:
Printed name: A.L. Hickerson	Title:
Title: C.E.O,	Approval Date: / Expiration Date:
Date: 9-11-95 / Phone: (915)381-0531	Conditions of Approval: Attached ☐

C-101 Instructions

Measurements and dimensions are to be in feet/inches. We[illegible] ocations will refer to the New Mexico Principal Meridian.

IF THIS IS AN AMENDED REPORT CHECK THE BOX LABLED "AMENDED REPORT" AT THE TOP OF THIS DOCUMENT.

1 Operator's OGRID number. If you do not have one it will be assigned and filled in by the District office.

2 Operator's name and address

3 API number of this well. If this is a new drill the OCD will assign the number and fill this in.

4 Property code. If this is a new property the OCD will assign the number and fill it in.

5 Property name that used to be called 'well name'

6 The number of this well on the property.

7 The surveyed location of this well New Mexico Principal Meridian NOTE: If the United States government survey designates a Lot Number for this location use that number in the 'UL or lot no.' box. Otherwise use the OCD Unit Letter.

8 The proposed bottom hole location of this well at TD

9 and 10 The proposed pool(s) to which this well is beeing drilled.

11 Work type code from the following table:

N	New well
E	Re-entry
D	Drill deeper
P	Plugback
A	Add a zone

12 Well type code from the following table:

O	Single oil completion
G	Single gas completion
M	Mutiple completion
I	Injection well
S	SWD well
W	Water supply well
C	Carbon dioxide well

13 Cable or rotary drilling code

C	Propose to cable tool drill
R	Propose to rotary drill

14 Lease type code from the following table:

F	Federal
S	State
P	Private
N	Navajo
J	Jicarilla
U	Ute
I	Other Indian tribe

15 Ground level elevation above sea level

16 Intend to mutiple complete? Yes or No

17 Proposed total depth of this well

18 Geologic formation at TD

19 Name of the intended drilling company if known.

20 Anticipated spud date.

21 Proposed hole size ID inches, proposed casing OD inches, casing weight in pounds per foot, setting depth of the casing or depth and top of liner, proposed cementing volume, and estimated top of cement

22 Brief description of the proposed drilling program and BOP program. Attach additional sheets if necessary.

23 The signature, printed name, and title of the person authorized to make this report. The date this report was signed and the telephone number to call for questions about this report.

FORM C-128
Revised 5/1/57

102

NEW MEXICO OIL CONSERVATION COMMISSION

WELL LOCATION AND ACREAGE DEDICATION PLAT

SEE INSTRUCTIONS FOR COMPLETING THIS FORM ON THE REVERSE SIDE

SECTION A

Operator	Lease	Well No.
CLIMAX CHEMICAL CORP.	Fatton SALINE WATER WELL	1

Unit Letter	Section	Township	Range	County
P	34	19 SOUTH	36 EAST	LEA

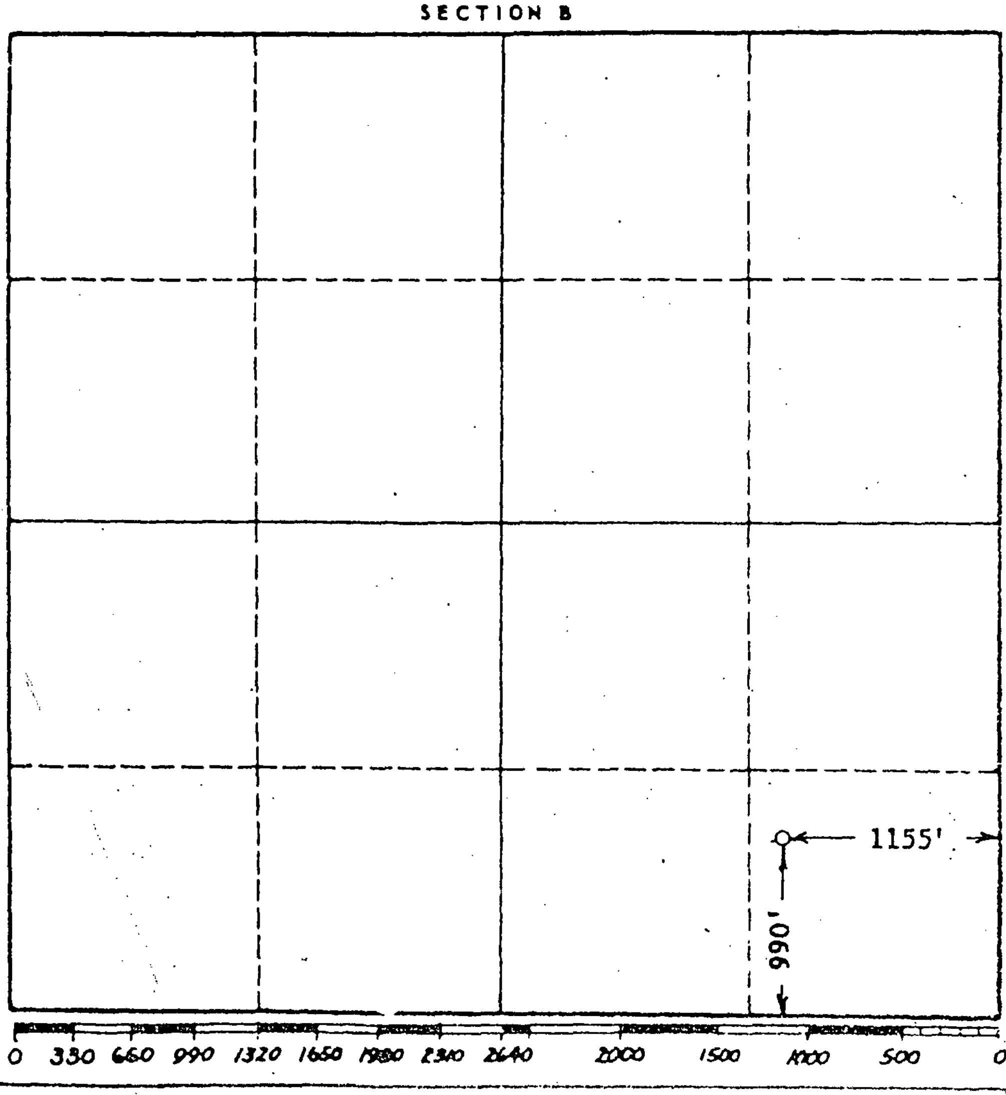
Actual Footage Location of Well:
990 feet from the SOUTH line and 1155 feet from the EAST line

Ground Level Elev.	Producing Formation	Pool	Dedicated Acreage:
			Acres

1. Is the Operator the only owner in the dedicated acreage outlined on the plat below? YES ______ NO ______ . *("Owner" means the person who has the right to drill into and to produce from any pool and to appropriate the production either for himself or for himself and another. (65-3-29 (e) NMSA 1935 Comp.)*
2. If the answer to question one is "no," have the interests of all the owners been consolidated by communitization agreement or otherwise? YES______ NO ______ . If answer is "yes," Type of Consolidation ______________________
3. If the answer to question two is "no," list all the owners and their respective interests below:

Owner	Land Description

SECTION B



CERTIFICATION

I hereby certify that the information in *SECTION A* above is true and complete to the best of my knowledge and belief.

E. D. Smith
Name

Mech. Supt.
Position

Climax Chemical Co
Company

Date
1-4-62

I hereby certify that the well location shown on the plat in *SECTION B* was plotted from field notes of actual surveys made by me or under my supervision, and that the same is true and correct to the best of my knowledge and belief.

REG. PROF. ENGINEER & LAND SURVEYOR
STATE OF NEW MEXICO
676
JOHN W. WEST

Date Surveyed
12-26-1961

Registered Professional Engineer and/or Land Surveyor, JOHN W. WEST

John W. West

Certificate No.
N. M. - P.E. & L.S. NO. 676

NEW M CO OIL CONSERVATION COMMI N
Santa Fe, New Mexico

Form C-101
Revised (12/1/55)

NOTICE OF INTENTION TO DRILL IN 1962

Notice must be given to the District Office of the Oil Conservation Commission and approval obtained before drilling or recompletion begins. If changes in the proposed plan are considered advisable, a copy of this notice showing such changes will be returned to the sender. Submit this notice in QUINTUPLICATE. One copy will be returned following approval. See additional instructions in Rules and Regulations of the Commission. If State Land submit 6 Copies Attach Form C- 128 in triplicate to first 3 copies of form C-101

Hobbs, New Mexico (Place) January 16, 1962 (Date)

OIL CONSERVATION COMMISSION
SANTA FE, NEW MEXICO

Gentlemen:

You are hereby notified that it is our intention to commence the Drilling of a well to be known as CLIMAX CHEMICAL COMPANY (Company or Operator)

Foster (Lease), Well No. 1, in P (Unit). The well is located 990 feet from the South line and 1155 feet from the East line of Section 34, T. 19 S, R. 36 E, NMPM.

(GIVE LOCATION FROM SECTION LINE) Undesignated Pool, Lea County

D	C	B	A
E	F	G	H
L	K	J	I
M	N	O	o P

If State Land the Oil and Gas Lease is No.

If patented land the owner is J. W. Foster

Address

We propose to drill well with drilling equipment as follows: Rotary tools from surfac to bottom Rustler Anhydrite. Cable tools Base Anhy. to Base Sal

The status of plugging bond is $5,000 bond approved

Drilling Contractor Not determined at this date

We intend to complete this well in the Base of the Salt section at depth of formation at an approximate depth of approximately 2520 feet feet.

CASING PROGRAM

We propose to use the following strings of Casing and to cement them as indicated:

Size of Hole	Size of Casing	Weight per Foot	New or Second Hand	Depth	Sacks Cement
12-1/4"	9-5/8"	32	New	1310'	Circulate to su
8-3/4"	5-1/2"	15.5	New	Will hang inside 9-5/8" casing	
and use as input for fresh water to wash Salt section and return Brine water.					

If changes in the above plans become advisable we will notify you immediately.

ADDITIONAL INFORMATION (If recompletion give full details of proposed plan of work.)

Approved ...., 19......
Except as follows:

OIL CONSERVATION COMMISSION

By

Sincerely yours,

Climax Chemical Company (Company or Operator)

By Charles P. Heller

Position Agent

Send Communications regarding well to

Name W. H. Kolins

Box 1595 Hobbs, New Mexico

NEW MEXICO OIL CONSERVATION COMMISSION

FORM C-103
(Rev 3-55)

MISCELLANEOUS REPORTS ON WELLS

(Submit to appropriate District Office as per Commission Rule 1106)

Name of Company	Address
Climax Chemical Company	Hobbs, New Mexico

Lease	Well No.	Unit Letter	Section	Township	Range
(Foster) Saline Water Well	1	P	34	19 South	36 East

Date Work Performed	Pool	County
January 30,31 1962	Undesignated	Lea

THIS IS A REPORT OF: *(Check appropriate block)*

- [ ] Beginning Drilling Operations
- [x] Casing Test and Cement Job
- [ ] Other *(Explain)*:
- [ ] Plugging
- [ ] Remedial Work

Detailed account of work done, nature and quantity of materials used, and results obtained.

Spudded 12-1/4" hole with Rotary tools January 26, 1962. Drilled to depth of 1300 feet. Ran 42 joints H-40 32.3# 3.3, 9 5/8" casing with Halliburton Float shoe. Tagged bottom of hole then picked casing up one foot and cemented same with 145 sax Incor cement, 145 sax Diamax A 6% jel, 100 sax regular cement. Plug pumped down at 2:45 P.M. January 30, 1962. Cement did not circulate. At 3:00 P.M. January 31, 1962 ran 1" tubing down annulus between hole and casing and found firm cement forty feet below ground level. Pumped water into hole and circulated to pits to lighten mud load in annulus. Thenpumped 50 sacks Regular cement to bottom of uncemented hole and circulated cement to surface. Estimated to have circulated about 25 sax cement back to pits. Bailed hole dry to top of plug at 1260 feet. Allowed hole to stand one hour and ran bailer again. Found no increase in fluid. Drilled plug and shoe, then allowed hole to stand one hour. Hole remained dry after bailing test. Drilling new hole below casing with Cable tools.

Cement allowed to set on 9-5/8" casing from 2:45 P.M., January 30, 1962 until 3:00 A.M. February 1, 1962 before plug was drilled.

Witnessed by	Position	Company
Charles P. Miller	Agent	Climax Chemical Company

FILL IN BELOW FOR REMEDIAL WORK REPORTS *ONLY*

ORIGINAL WELL DATA

D F Elev.	T D	PBTD	Producing Interval	Completion Date

Tubing Diameter	Tubing Depth	Oil String Diameter	Oil String Depth

Perforated Interval(s)

Open Hole Interval	Producing Formation(s)

RESULTS OF WORKOVER

Test	Date of Test	Oil Production BPD	Gas Production MCFPD	Water Production BPD	GOR Cubic feet/Bbl	Gas Well Potential MCFPD
Before Workover						
After Workover						

OIL CONSERVATION COMMISSION	I hereby certify that the information given above is true and complete to the best of my knowledge.
Approved by	Name Charles P. Miller
Title	Position Agent
Date	Company

RECORD OF DRILL-STEM AND SPECIAL TESTS

If drill-stem or other special tests or deviation surveys were made, submit report on separate sheet and attach hereto.

TOOLS USED

Rotary tools were used from 0 feet to 1300 feet, and from .... feet to .... feet.

Cable tools were used from 1300 feet to 2482 feet, and from .... feet to .... feet.

PRODUCTION

Put to Producing ...., 19........ Saline water well. No test for oil or gas.

OIL WELL: The production during the first 24 hours was .... barrels of liquid of which ....% was oil; ....% was emulsion; ....% water; and ....% was sediment. A.P.I. Gravity........

GAS WELL: The production during the first 24 hours was .... M.C.F. plus .... barrels of liquid Hydrocarbon. Shut in Pressure........lbs.

Length of Time Shut in........

PLEASE INDICATE BELOW FORMATION TOPS (IN CONFORMANCE WITH GEOGRAPHICAL SECTION OF STATE):

Southeastern New Mexico		Northwestern New Mexico
T. Anhy 1196	T. Devonian	T. Ojo Alamo
T. Salt 1297	T. Silurian	T. Kirtland-Fruitland
B. Salt 2480	T. Montoya	T. Farmington
T. Yates	T. Simpson	T. Pictured Cliffs
T. 7 Rivers	T. McKee	T. Menefee
T. Queen	T. Ellenburger	T. Point Lookout
T. Grayburg	T. Gr. Wash	T. Mancos
T. San Andres	T. Granite	T. Dakota
T. Glorieta	T.	T. Morrison
T. Drinkard	T.	T. Penn
T. Tubbs	T.	T.
T. Abo	T.	T.
T. Penn	T.	T.
T. Miss	T.	T.

FORMATION RECORD

From	To	Thickness in Feet	Formation	From	To	Thickness in Feet	Formation
0	95	95	Sand	1865	1880	15	Salt & polyhalite
95	565	470	Red beds	1880	1905	25	Salt
565	635	70	Red beds and sand	1905	1965	60	Salt & polyhalite
635	875	240	Red beds, sand, shale	1965	1995	30	Salt
875	1065	190	Red beds	1995	2005	10	Anhydrite & polyhalite
1065	1200	135	Red beds & sdy. red shale	2005	2123	118	Salt
1200	1297	97	Anhydrite & shells	2123	2143	20	Salt & polyhalite
1297	1335	38	Salt	2143	2175	32	Anhydrite & salt
1335	1370	35	Anhydrite & shale	2175	2275	100	Salt
1370	1380	10	Anhydrite	2275	2315	40	Salt & polyhalite
1380	1415	35	Shale & salt	2315	2480	165	Salt
1415	1440	25	Red shells	2480	2482	2	Anhydrite
1440	1480	40	Shell & salt				
1480	1535	55	Salt & shale				
1535	1610	75	Salt				
1610	1640	30	Salt & anhy. streaks				
1640	1655	15	Salt				
1655	1675	20	Anhydrite				
1675	1865	190	Salt				

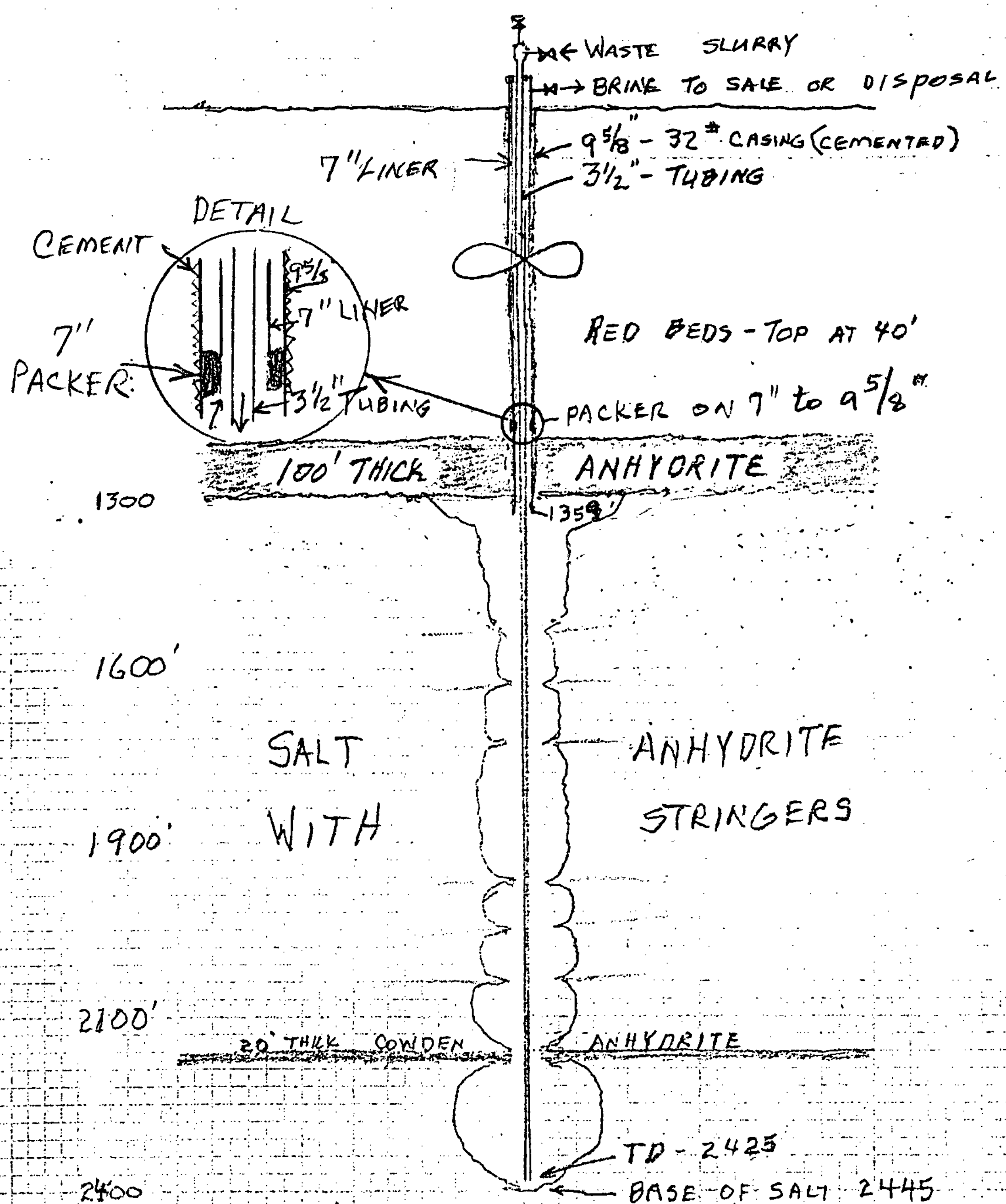
ATTACH SEPARATE SHEET IF ADDITIONAL SPACE IS NEEDED

I hereby swear or affirm that the information given herewith is a complete and correct record of the well and all work done on it so far as can be determined from available records.

March 19, 1962
(Date)

Company or Operator Climax Chemical Company   Address Hobbs, New Mexico

Name Charles P. Miller   Position or Title Agent



PERMIAN BRINE SALES, INC.
ODESSA, TEXAS

MONUMENT NO. 2

OLD CLIMAX FOSTER No 2 (1969)
SEC. 34 T-19-S R-36-E
1020' FSL 300' FEL
SCALE - 1" = 300 ft.

DATE:	BY:	DRAWING NO.:
9-/-95	ALH	2

District I
PO Box 1980, Hobbs, NM 88241-1980
District II
PO Drawer DD, Artesia, NM 88211-0719
District III
1000 Rio Brazos Rd., Aztec, NM 87410
District IV
PO Box 2088, Santa Fe, NM 87504-2088

State of New Mexico
Energy, Minerals & Natural Resources Department

OIL CONSERVATION DIVISION
PO Box 2088
Santa Fe, NM 87504-2088

Form C-101
Revised February 10, 1994
Instructions on back
Submit to Appropriate District Office
State Lease - 6 Copies
Fee Lease - 5 Copies

☐ AMENDED REPORT

APPLICATION FOR PERMIT TO DRILL, RE-ENTER, DEEPEN, PLUGBACK, OR ADD A ZONE

[1] Operator Name and Address.	[2] OGRID Number	[3] API Number
PERMIAN BRINE SALES, INC 6067 West 10th Street Odessa, Texas 79763		30 - 0

[4] Property Code	[5] Property Name	[6] Well No.
	Formerly Climax Saline Well No.2 Foster	2

[7] Surface Location

UL or lot no.	Section	Township	Range	Lot Idn	Feet from the	North/South line	Feet from the	East/West line	County
	34	19-S	36-E			1020 ft		300 ft	Lea

[8] Proposed Bottom Hole Location If Different From Surface

UL or lot no.	Section	Township	Range	Lot Idn	Feet from the	North/South line	Feet from the	East/West line	County

[9] Proposed Pool 1	[10] Proposed Pool 2

[11] Work Type Code	[12] Well Type Code	[13] Cable/Rotary	[14] Lease Type Code	[15] Ground Level Elevation
E	Brine - I	Rotary	P	3618
[16] Multiple	**[17] Proposed Depth**	**[18] Formation**	**[19] Contractor**	**[20] Spud Date**
No	2449	Salado		

[21] Proposed Casing and Cement Program

Hole Size	Casing Size	Casing weight/foot	Setting Depth	Sacks of Cement	Estimated TOC
12¼	9 5/8	32.3	1359	500	Circ

[22] Describe the proposed program. If this application is to DEEPEN or PLUG BACK give the data on the present productive zone and proposed new productive zone. Describe the blowout prevention program, if any. Use additional sheets if necessary.

Re- entry, drill out cement and bridge plug
Hang 3½ tubing to T.D.

[23] I hereby certify that the information given above is true and complete to the best of my knowledge and belief.

Signature: A.L. Hickerson
Printed name: A.L. Hickerson
Title: C.E.O.
Date: 9-11-95
Phone: (915)381-0531

OIL CONSERVATION DIVISION
Approved by:
Title:
Approval Date:
Expiration Date:
Conditions of Approval :
Attached ☐

C-101 Instructions

Measurements and dimensions are to be in feet/inches. We ocations will refer to the New Mexico Principal Meridian.

IF THIS IS AN AMENDED REPORT CHECK THE BOX LABLED "AMENDED REPORT" AT THE TOP OF THIS DOCUMENT.

1 Operator's OGRID number. If you do not have one it will be assigned and filled in by the District office.

2 Operator's name and address

3 API number of this well. If this is a new drill the OCD will assign the number and fill this in.

4 Property code. If this is a new property the OCD will assign the number and fill it in.

5 Property name that used to be called 'well name'

6 The number of this well on the property.

7 The surveyed location of this well New Mexico Principal Meridian NOTE: If the United States government survey designates a Lot Number for this location use that number in the 'UL or lot no.' box. Otherwise use the OCD Unit Letter.

8 The proposed bottom hole location of this well at TD

9 and 10 The proposed pool(s) to which this well is beeing drilled.

11 Work type code from the following table:

N	New well
E	Re-entry
D	Drill deeper
P	Plugback
A	Add a zone

12 Well type code from the following table:

O	Single oil completion
G	Single gas completion
M	Mutiple completion
I	Injection well
S	SWD well
W	Water supply well
C	Carbon dioxide well

13 Cable or rotary drilling code

C	Propose to cable tool drill
R	Propose to rotary drill

14 Lease type code from the following table:

F	Federal
S	State
P	Private
N	Navajo
J	Jicarilla
U	Ute
I	Other Indian tribe

15 Ground level elevation above sea level

16 Intend to mutiple complete? Yes or No

17 Proposed total depth of this well

18 Geologic formation at TD

19 Name of the intended drilling company if known.

20 Anticipated spud date.

21 Proposed hole size ID inches, proposed casing OD inches, casing weight in pounds per foot, setting depth of the casing or depth and top of liner, proposed cementing volume, and estimated top of cement

22 Brief description of the proposed drilling program and BOP program. Attach additional sheets if necessary.

23 The signature, printed name, and title of the person authorized to make this report. The date this report was signed and the telephone number to call for questions about this report.

NO. OF COPIES RECEIVED		
DISTRIBUTION		
SANTA FE		
FILE		
U.S.G.S.		
LAND OFFICE		
OPERATOR		

NEW MEXICO OIL CONSERVATION COMMISSION

Form C-103
Supersedes Old
C-102 and C-103
Effective 1-1-65

5a. Indicate Type of Lease
State [ ] Fee [X]

5. State Oil & Gas Lease No.
Patented Land

SUNDRY NOTICES AND REPORTS ON WELLS

(DO NOT USE THIS FORM FOR PROPOSALS TO DRILL OR TO DEEPEN OR PLUG BACK TO A DIFFERENT RESERVOIR. USE "APPLICATION FOR PERMIT -" (FORM C-101) FOR SUCH PROPOSALS.)

1. OIL WELL [ ] GAS WELL [ ] OTHER- Saline Water Well #2

7. Unit Agreement Name
None

2. Name of Operator
CLIMAX CHEMICAL COMPANY

8. Farm or Lease Name
~~Foster~~ Saline Wa[illegible]

3. Address of Operator
Box 1595 - Hobbs, New Mexico 88240

9. Well No.
2

4. Location of Well
UNIT LETTER none , 300' FEET FROM THE East LINE AND ~~[illegible]~~ 1020 FEET FROM THE ~~North~~ South LINE, SECTION 34 TOWNSHIP 19 RANGE 36E NMPM.

10. Field and Pool, or Wildcat
Monument

15. Elevation (*Show whether DF, RT, GR, etc.*)
3618 G. R.

12. County
Lea

16. Check Appropriate Box To Indicate Nature of Notice, Report or Other Data

NOTICE OF INTENTION TO:

PERFORM REMEDIAL WORK [ ]
TEMPORARILY ABANDON [ ]
PULL OR ALTER CASING [ ]
PLUG AND ABANDON [ ]
CHANGE PLANS [ ]
OTHER Drill New Well [ ]

SUBSEQUENT REPORT OF:

REMEDIAL WORK [ ]
COMMENCE DRILLING OPNS. [ ]
CASING TEST AND CEMENT JOB [ ]
ALTERING CASING [ ]
PLUG AND ABANDONMENT [ ]
OTHER [ ]

17. Describe Proposed or Completed Operations (*Clearly state all pertinent details, and give pertinent dates, including estimated date of starting any proposed work*) SEE RULE 1103.

Started drilling 12-30-69. Drilled 1359.53 12 1/4" hole. Set 9 5/8" H-40-32.30# casing cemented with 500 sacks incor with 2% calcium chloride and 200 neet sacks. Circulated 150 sacks cement into pits. Bumped insert float (set 1 joint off bottom of string) with plug and pressured casing to 1500# PSI. Casing held pressure O.K. 9 5/8" casing cemented at 1359.53 from rotary bushing 12' above ground.

After cement set drilled plug and drilled to 2449' base of salt 2445. Set 5 1/2" J-55-15.5# tubing to 2425' using Braden Head to support tubing. Well completed 1-9-70 and put in service

18. I hereby certify that the information above is true and complete to the best of my knowledge and belief.

SIGNED E. D. Smith TITLE Mechanical Superintendent DATE 7-15-70

APPROVED BY [signature] TITLE SUPERVISOR DISTRICT DATE AUG 17 1970

CONDITIONS OF APPROVAL, IF ANY:

NEW MEXICO OIL CONSERVATION COMMISSION
WELL LOCATION AND ACREAGE DEDICATION PLAT

Form C-102
Supersedes C-128
Effective 1-1-65

HOBBS OFFICE O. C. C.
JAN 7 3 40 PM '70

All distances must be from the outer boundaries of the Section.

Operator		Lease	Well No.
CLIMAX CHEMICAL CORP.		SALINE WATER WELL	2

Unit Letter	Section	Township	Range	County
P	34	19 SOUTH	36 EAST	LEA

Actual Footage Location of Well:
1020 feet from the SOUTH line and 300 feet from the EAST line

Ground Level Elev.	Producing Formation	Pool	Dedicated Acreage:
			Acres

1. Outline the acreage dedicated to the subject well by colored pencil or hachure marks on the plat below.

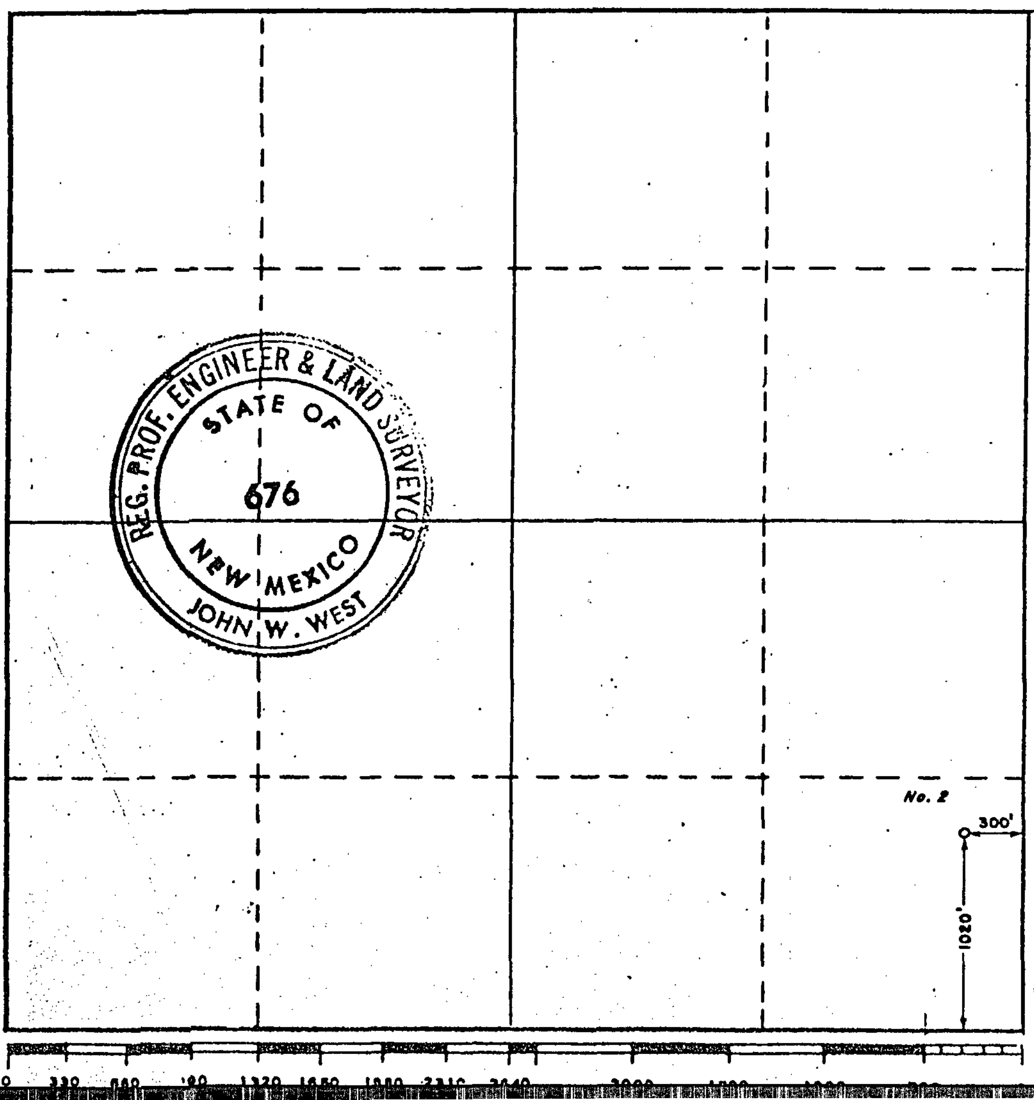
2. If more than one lease is dedicated to the well, outline each and identify the ownership thereof (both as to working interest and royalty).

3. If more than one lease of different ownership is dedicated to the well, have the interests of all owners been consolidated by communitization, unitization, force-pooling. etc?

[ ] Yes [ ] No If answer is "yes," type of consolidation ____________

If answer is "no," list the owners and tract descriptions which have actually been consolidated. (Use reverse side of this form if necessary.)____________

No allowable will be assigned to the well until all interests have been consolidated (by communitization, unitization, forced-pooling, or otherwise) or until a non-standard unit, eliminating such interests, has been approved by the Commission.



CERTIFICATION

I hereby certify that the information contained herein is true and complete to the best of my knowledge and belief.

Name: W H Kolms
Position: Vice-President
Company: Climax Chemical Company
Date: December 30, 1969

I hereby certify that the well location shown on this plat was plotted from field notes of actual surveys made by me or under my supervision, and that the same is true and correct to the best of my knowledge and belief.

Date Surveyed: 12-27-69

Registered Professional Engineer and/or Land Surveyor
John W West

Certificate No. 676

NO. OF COPIES RECEIVED		
DISTRIBUTION		
SANTA FE		
FILE		
U.S.G.S.		
LAND OFFICE		
OPERATOR		

NEW MEXICO OIL CONSERVATION COMMISSION

JAN 1970 3 10 PM '70

Form C-101
Revised 1-1-65

5A. Indicate Type of Lease: STATE [ ] FEE [X]

5. State Oil & Gas Lease No.

APPLICATION FOR PERMIT TO DRILL, DEEPEN, OR PLUG BACK

1a. Type of Work: DRILL [ ] DEEPEN [ ] PLUG BACK [ ]

b. Type of Well: OIL WELL [ ] GAS WELL [ ] OTHER Saline water well SINGLE ZONE [ ] MULTIPLE ZONE [ ]

7. Unit Agreement Name

8. Farm or Lease Name: Saline water well

2. Name of Operator: Climax Chemical Company

9. Well No.: 2

3. Address of Operator

10. Field and Pool, or Wildcat: ---

4. Location of Well: UNIT LETTER P LOCATED 1020 FEET FROM THE S LINE AND 300 FEET FROM THE E LINE OF SEC. 34 TWP. 19S RGE. 36E NMPM

12. County: Lea

19. Proposed Depth: 2480

19A. Formation: Salt

20. Rotary or C.T.: R

21. Elevations (Show whether DF, RT, etc.)

21A. Kind & Status Plug. Bond

21B. Drilling Contractor: Lohmann Well Service

22. Approx. Date Work will start: 12/30/69

23.

PROPOSED CASING AND CEMENT PROGRAM

SIZE OF HOLE	SIZE OF CASING	WEIGHT PER FOOT	SETTING DEPTH	SACKS OF CEMENT	EST. TOP
0-1353-12¼"	9 5/8"	32.30	1353'	700	Surface
1353'-Bottom-8 3/4"	5 1/2"	15.50	0-Bottom	Cement from Surface to Bottom	

IN ABOVE SPACE DESCRIBE PROPOSED PROGRAM: IF PROPOSAL IS TO DEEPEN OR PLUG BACK, GIVE DATA ON PRESENT PRODUCTIVE ZONE AND PROPOSED NEW PRODUCTIVE ZONE. GIVE BLOWOUT PREVENTER PROGRAM, IF ANY.

I hereby certify that the information above is true and complete to the best of my knowledge and belief.

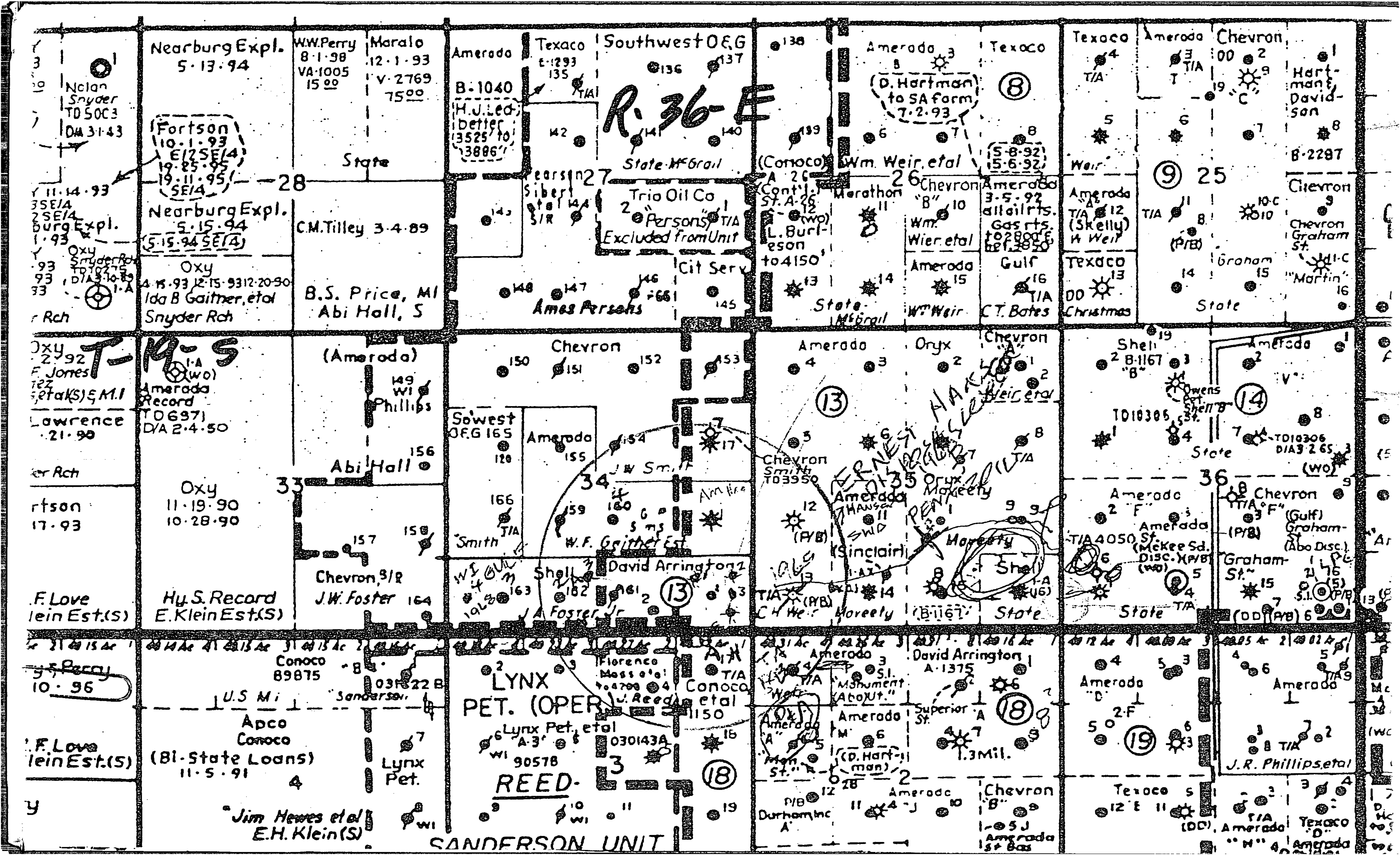
Climax Chemical Company

Signed [signature] Title Vice-President Date December 30, 196

(This space for State Use)

APPROVED BY [signature] TITLE SUPERVISOR DISTRICT I DATE AUG 17 1970

CONDITIONS OF APPROVAL, IF ANY:



R. 36-E
T-14-S
Nearburg Expl. 5-13-94
Fortson 10-1-93 E/2SE/4
Nearburg Expl. 5-15-94
W.W.Perry 8-1-98 VA-1005
Maralo 12-1-93 V-2769
State
28
C.M.Tilley 3-4-89
Oxy
Ida B Gaitner, etal
Snyder Rch
B.S. Price, MI
Abi Hall, S
Amerada
B-1040
Texaco
Southwest O&G
State McGrail
27
Trio Oil Co
Persons
Excluded from Unit
Cit Serv
Ames Persons
(Conoco)
L. Burleson to 4150
State McGrail
D. Hartman to SA form 7-2-93
Wm. Weir, etal
26
Marathon
Chevron "B"
Wm. Wier etal
Amerada
Wm Weir
Gulf
C.T. Bates
Texaco
Christmas
Chevron
Hartman-Davidson
B-2287
9
25
Chevron Graham St.
Graham
"Martin"
State
Weir
(Skelly) W Weir
Nolan Snyder
(Amerada)
Phillips
Abi Hall
Amerada Record
Lawrence
33
Oxy 11-19-90 10-28-90
Chevron
Chevron, S/R
J.W. Foster
Hy S. Record
E.Klein Est.(S)
F. Love
Klein Est.(S)
Sowest O&G 165
Amerada
34
J W Smith
W.F. Gaither Est.
Smith
Shell
David Arrington
13
J A Foster Jr
Amerada
Onyx
Chevron "A"
Weir etal
13
Chevron Smith
35
Sinclair
Moreely
State
Shell
Shell B-1167 "B"
Amerada
"V"
14
State
36
Chevron
Amerada "F"
Graham St.
State
Conoco 89875
U.S Mi
Sanderson
Apco
Conoco
(81-State Loans) 11-5-91
4
Jim Hewes etal
E.H. Klein (S)
Lynx Pet.
LYNX
PET. (OPER)
Lynx Pet. etal
REED
3
SANDERSON UNIT
Florence Moss etal
J. Reed
Conoco etal
18
Amerada
Monument (Abo Ut.)
Amerada "M"
D. Hartman
2
Durham Inc
Chevron "B"
David Arrington A-1375
Superior St.
18
Amerada "D"
19
Texaco
Amerada "N"
J.R. Phillips etal
Texaco "D"

Wells
within
1/2 miles

HOBBS

Form 9-331 a
(March 1942)

COPY TO O. C. C.

(*SUBMIT IN TRIPLICATE*)

Budget Bureau No. 42-R358.
Approval expires 11-30-46.

Land Office Las Cruces

Lease No. 030143-a

Unit B

UNITED STATES
DEPARTMENT OF THE INTERIOR
GEOLOGICAL SURVEY

SUNDRY NOTICES AND REPORTS ON WELLS

NOTICE OF INTENTION TO DRILL	X	SUBSEQUENT REPORT OF WATER SHUT-OFF	
NOTICE OF INTENTION TO CHANGE PLANS		SUBSEQUENT REPORT OF SHOOTING OR ACIDIZING	
NOTICE OF INTENTION TO TEST WATER SHUT-OFF		SUBSEQUENT REPORT OF ALTERING CASING	
NOTICE OF INTENTION TO RE-DRILL OR REPAIR WELL		SUBSEQUENT REPORT OF REDRILLING OR REPAIR	
NOTICE OF INTENTION TO SHOOT OR ACIDIZE		SUBSEQUENT REPORT OF ABANDONMENT	
NOTICE OF INTENTION TO PULL OR ALTER CASING		SUPPLEMENTARY WELL HISTORY	
NOTICE OF INTENTION TO ABANDON WELL			

(INDICATE ABOVE BY CHECK MARK NATURE OF REPORT, NOTICE, OR OTHER DATA)

February 1, 1953

Well No. 1 is located 1002.5 ft. from [N] line and 1652.5 ft. from [E] line of sec. 3

NW¼ NE¼ Sec. 3 (¼ Sec. and Sec. No.) 20S (Twp.) 36E (Range) N.M.P.M. (Meridian)

Monument (Field) Lea (County or Subdivision) New Mexico (State or Territory)

The elevation of the derrick floor above sea level is ______ ft.

DETAILS OF WORK

(State names of and expected depths to objective sands; show sizes, weights, and lengths of proposed casings; indicate mudding jobs, cementing points, and all other important proposed work)

We propose to drill this test with Rotary tools to a total depth of approximately 3900'. We will set and cement 10-3/4" 32# casing at a depth of about 300 feet and cement same with sufficient cement to circulate back into cellar. We will cut an 8-3/4" hole below surface casing to a depth of approximately 3800 feet and cement casing with a two-stage job, using 300 sacks on the bottom job and 250 sacks through two-stage tool at 1275 feet.

We propose to diamond core the hole from shoe of pay string to total depth.

I understand that this plan of work must receive approval in writing by the Geological Survey before operations may be commenced.

Company H. S. Moss

Address 1503 First Nat'l. Bank Bld'g.

Dallas, Texas.

By Charles P. Miller

Title Agent

(Form C-110)
(Revised 7/1/52)

NEW MEXICO OIL CONSERVATION COMMISSION
Santa Fe, New Mexico

HOBBS OFFICE OCC
1955 APR 2 AM 9:51

necessary that Form C-104 be approved before this form can be approved an an *initial* allowable be assigned to any completed Oil or Gas well. Submit this form in QUADRUPLICATE.

CERTIFICATE OF COMPLIANCE AND AUTHORIZATION TO TRANSPORT OIL AND NATURAL GAS

npany or Operator H. S. Moss Lease J. L. Reed

lress 1503 First National BankBuilding (Local or Field Office) Dallas, Texas (Principal Place of Business)

it B, Well(s) No. 1, Sec. 3, T. 20S, R. 36E, Pool Monument

unty Lea Kind of Lease: Federal Lease

Oil well Location of Tanks Approx 175' FSL 450' FEL of Lot 2

ithorized Transporter Warren Petroleum Corporation Address of Transporter

Monument, New Mexico (Local or Field Office), Tulsa, Oklahoma (Principal Place of Business)

r cent of Oil or Natural Gas to be Transported 100 Other Transporters authorized to transport Oil or Natural Gas

om this unit are Texas-New Mexico Pipe Line Co.

%

REASON FOR FILING: (Please check proper box)

NEW WELL ☐ CHANGE IN OWNERSHIP ☐

CHANGE IN TRANSPORTER ☐ OTHER (Explain under Remarks) ☒

REMARKS:

Filed for casinghead gas

The undersigned certifies that the Rules and Regulations of the Oil Conservation Commission have been complied with.

Executed this the 1st day of April 1955

H. S. MOSS

By [signature]

Title Agent

Approved APR 12 1955, 19

OIL CONSERVATION COMMISSION

By M L Armstrong

Title

(See Instructions on Reverse Side)

(Form C-110)
(Revised 7/1/52)

DUPLICATE

NEW MEXICO OIL CONSERVATION COMMISSION
Santa Fe, New Mexico

It is necessary that Form C-104 be approved before this form can be approved an an *initial* allowable be assigned to any completed Oil or Gas well. Submit this form in QUADRUPLICATE.

RECEIVED
MAR 9 1953
OIL CONSERVATION COMMISSION
HOBBS OFFICE

CERTIFICATE OF COMPLIANCE AND AUTHORIZATION TO TRANSPORT OIL AND NATURAL GAS

Company or Operator H. S. Moss Lease J. L. Reed

Address Hobbs, New Mexico (Local or Field Office) Dallas, Texas (Principal Place of Business)

Unit B, Well(s) No. 1, Sec. 3, T. 20S, R. 36E, Pool Monument

County Lea Kind of Lease: Federal land

If Oil well Location of Tanks Approx. 175' fr. SL & 450' fr. EL of Lot 2, section 3

Authorized Transporter Texas New Mexico Pipeline Company Address of Transporter

Eunice, New Mexico (Local or Field Office), Houston, Texas. (Principal Place of Business)

Per cent of Oil or Natural Gas to be Transported 100 Other Transporters authorized to transport Oil or Natural Gas from this unit are None

%

REASON FOR FILING: (Please check proper box)

NEW WELL	X	CHANGE IN OWNERSHIP	☐
CHANGE IN TRANSPORTER	☐	OTHER (Explain under Remarks)	☐

REMARKS:

The undersigned certifies that the Rules and Regulations of the Oil Conservation Commission have been complied with.

Executed this the 2nd day of March, 1953.

H. S. Moss

By Charles P. Miller

Title Agent

Approved 3 - 9, 1953

OIL CONSERVATION COMMISSION

By Roy O Yarbrough

Title Gas Inspector

Submit 5 Copies
Appropriate District Office
DISTRICT I
P.O. Box 1980, Hobbs, NM 88240

DISTRICT II
P.O. Drawer DD, Artesia, NM 88210

DISTRICT III
1000 Rio Brazos Rd., Aztec, NM 87410

State of New Mexico
Energy, Minerals and Natural Resources Department

Form C-104
Revised 1-1-89
See Instructions at Bottom of Page

OIL CONSERVATION DIVISION

P.O. Box 2088
Santa Fe, New Mexico 87504-2088

REQUEST FOR ALLOWABLE AND AUTHORIZATION TO TRANSPORT OIL AND NATURAL GAS

I.

Operator	Well API No.
Lynx Petroleum Consultants, Inc.	

Address: P. O. Box 1979, Hobbs, NM 88241

Reason(s) for Filing (Check proper box): ☐ Other (Please explain)

New Well ☐ — Change in Transporter of:
Recompletion ☐ — Oil ☐ Dry Gas ☐
Change in Operator ☒ — Casinghead Gas ☐ Condensate ☐

If change of operator give name and address of previous operator: Conoco Inc. 10 Desta Drive, Suite 100 W, Midland, TX 79705

II. DESCRIPTION OF WELL AND LEASE

Lease Name	Well No.	Pool Name, Including Formation	Kind of Lease State, Federal or Fee	Lease No.
Reed Sanderson Unit	4	Eumont-Yates-7 Rivers-Queen	Federal	LC-030143A

Location
Unit Letter B : 1002 Feet From The North Line and 1652 Feet From The East Line
Section 3 Township 20S Range 36E, NMPM, Lea County

III. DESIGNATION OF TRANSPORTER OF OIL AND NATURAL GAS

Name of Authorized Transporter of Oil ☒ or Condensate ☐	Address (Give address to which approved copy of this form is to be sent)
ARCO Pipe Line Company	200 ARCO Place, Independence, KS 67301
Name of Authorized Transporter of Casinghead Gas ☒ or Dry Gas ☐	**Address (Give address to which approved copy of this form is to be sent)**
Warren Petroleum Company	Box 1589, Tulsa, OK 74102

If well produces oil or liquids, give location of tanks.	Unit	Sec.	Twp.	Rge.	Is gas actually connected?	When ?

If this production is commingled with that from any other lease or pool, give commingling order number:

IV. COMPLETION DATA

Designate Type of Completion - (X)	Oil Well	Gas Well	New Well	Workover	Deepen	Plug Back	Same Res'v	Diff Res'v

Date Spudded	Date Compl. Ready to Prod.	Total Depth	P.B.T.D.
Elevations (DF, RKB, RT, GR, etc.)	**Name of Producing Formation**	**Top Oil/Gas Pay**	**Tubing Depth**
Perforations			**Depth Casing Shoe**

TUBING, CASING AND CEMENTING RECORD

HOLE SIZE	CASING & TUBING SIZE	DEPTH SET	SACKS CEMENT

V. TEST DATA AND REQUEST FOR ALLOWABLE

OIL WELL (Test must be after recovery of total volume of load oil and must be equal to or exceed top allowable for this depth or be for full 24 hours.)

Date First New Oil Run To Tank	Date of Test	Producing Method (Flow, pump, gas lift, etc.)	
Length of Test	**Tubing Pressure**	**Casing Pressure**	**Choke Size**
Actual Prod. During Test	**Oil - Bbls.**	**Water - Bbls.**	**Gas- MCF**

GAS WELL

Actual Prod. Test - MCF/D	Length of Test	Bbls. Condensate/MMCF	Gravity of Condensate
Testing Method (pitot, back pr.)	**Tubing Pressure (Shut-in)**	**Casing Pressure (Shut-in)**	**Choke Size**

VI. OPERATOR CERTIFICATE OF COMPLIANCE

I hereby certify that the rules and regulations of the Oil Conservation Division have been complied with and that the information given above is true and complete to the best of my knowledge and belief.

Gary W Fonay
Signature
Gary W. Fonay — Vice-President
Printed Name — Title
7-13-92 — 392-6950
Date — Telephone No.

OIL CONSERVATION DIVISION

Date Approved JUL 17 '92

By ORIGINAL SIGNED BY JERRY SEXTON
DISTRICT I SUPERVISOR

Title

INSTRUCTIONS: This form is to be filed in compliance with Rule 1104

1) Request for allowable for newly drilled or deepened well must be accompanied by tabulation of deviation tests taken in accordance with Rule 111.
2) All sections of this form must be filled out for allowable on new and recompleted wells.
3) Fill out only Sections I, II, III, and VI for changes of operator, well name or number, transporter, or other such changes.
4) Separate Form C-104 must be filed for each pool in multiply completed wells.

Form 9–331
Dec. 1973

Form Approved.
Budget Bureau No. 42–R1424

UNITED STATES
DEPARTMENT OF THE INTERIOR
GEOLOGICAL SURVEY

SUNDRY NOTICES AND REPORTS ON WELLS

(Do not use this form for proposals to drill or to deepen or plug back to a different reservoir. Use Form 9–331–C for such proposals.)

1. oil well ☑ gas well ☐ other
2. NAME OF OPERATOR
CONOCO INC.
3. ADDRESS OF OPERATOR
P. O. Box 460, Hobbs, N.M. 88240
4. LOCATION OF WELL (REPORT LOCATION CLEARLY. See space 17 below.)
AT SURFACE: 1002' FNL + 1652' FEL
AT TOP PROD. INTERVAL:
AT TOTAL DEPTH:

5. LEASE LC-030143 (A)
6. IF INDIAN, ALLOTTEE OR TRIBE NAME
7. UNIT AGREEMENT NAME NMFU
8. FARM OR LEASE NAME Reed Sanderson Unit
9. WELL NO. 4
10. FIELD OR WILDCAT NAME Eumont Yates 7 Rvrs. Qn.
11. SEC., T., R., M., OR BLK. AND SURVEY OR AREA Sec. 3, T-20S, R-36E
12. COUNTY OR PARISH Lea
13. STATE NM
14. API NO.
15. ELEVATIONS (SHOW DF, KDB, AND WD)

16. CHECK APPROPRIATE BOX TO INDICATE NATURE OF NOTICE, REPORT, OR OTHER DATA

	REQUEST FOR APPROVAL TO:	SUBSEQUENT REPORT OF:
TEST WATER SHUT-OFF	☐	☐
FRACTURE TREAT	☐	☑
SHOOT OR ACIDIZE	☐	☑
REPAIR WELL	☐	☑
PULL OR ALTER CASING	☐	☐
MULTIPLE COMPLETE	☐	☐
CHANGE ZONES	☐	☐
ABANDON*	☐	☐
(other) Chemically Inhibit		✓

(NOTE: Report results of multiple completion or zone change on Form 9–330.)

BUREAU OF LAND MANAGEMENT
RECEIVED
NOV 16 1983
DIST. 6 N. M.
ROSWELL, NEW MEXICO

17. DESCRIBE PROPOSED OR COMPLETED OPERATIONS (Clearly state all pertinent details, and give pertinent dates, including estimated date of starting any proposed work. If well is directionally drilled, give subsurface locations and measured and true vertical depths for all markers and zones pertinent to this work.)*

MIRU 7/11/83. Reamed hole to 3875'. Set RBP @ 2000'. Tested csg for leaks. Reset RBP @ 980'. Set pkr @ 288'. Squeezed 415'-724' w/ 300 sxs Class "C". Rel pkr. DO cmt 435'-672'. Rel RBP. CO to 3897'. Set pkr @ 3790'. Acidized OH 3809'-3897' w/60 bbls 15% HCL-NE-FE, 4 bbls 10 ppg brine w/ guar gum + rocksalt. Flushed w/ 22 bbls TFW. Swbd. Inhibited OH w/ 2 drums chemical. Flushed w/100 bbls TFW. Rel pkr. Set RBP @ 3790'. Spotted 7 bbls 15% acid 3600'-3790'. Perf w/1 JSPF @ 3630', 35', 40', 45', 67', 72', 77', 82', 87', 92', 97', 3702', 07', 12', 37', 40', 43', 46', 66', + 3780'. Set pkr @ 3558'. Acidized perfs w/40 bbls 15% acid. (Attachment)

Subsurface Safety Valve: Manu. and Type ______ Set @ ______ Ft.

18. I hereby certify that the foregoing is true and correct

SIGNED Wm A. Butterfield TITLE Administrative Supervisor DATE 11/15/83

(This space for Federal or State office use)

ACCEPTED FOR RECORD
PETER W. CHESTER
MAR 1 1984

APPROVED BY ______ TITLE ______ DATE ______
CONDITIONS OF APPROVAL, IF ANY:

*See Instructions on Reverse Side

REED SANDERSON UNIT No. 4

FLUSHED W/34 BBLS TFW. FRAC'D W/408 BBLS FRAC FLUID + 26,300 LBS 20/40 SAND. SWBD. REL PKR. CO TO 3785'. REL RBP. CO TO 3900'. RAN PRODUCTION EQUIPMENT. PUMPED 8 BO, 36 BW, + 274 MCF IN 24 HRS 9/29/83.

Submit 3 Copies to Appropriate District Office

State of New Mexico
Energy, Minerals and Natural Resources Department

Form C-103
Revised 1-1-89

DISTRICT I
P.O. Box 1980, Hobbs, NM 88240

DISTRICT II
P.O. Drawer DD, Artesia, NM 88210

DISTRICT III
1000 Rio Brazos Rd., Aztec, NM 87410

OIL CONSERVATION DIVISION

P.O. Box 2088
Santa Fe, New Mexico 87504-2088

WELL API NO. 30-025-04162

5. Indicate Type of Lease STATE [ ] FEE [X]

6. State Oil & Gas Lease No.

SUNDRY NOTICES AND REPORTS ON WELLS

(DO NOT USE THIS FORM FOR PROPOSALS TO DRILL OR TO DEEPEN OR PLUG BACK TO A DIFFERENT RESERVOIR. USE "APPLICATION FOR PERMIT" (FORM C-101) FOR SUCH PROPOSALS.)

7. Lease Name or Unit Agreement Name
NORTH MONUMENT G/SA UNIT
BLK. 18

1. Type of Well: OIL WELL [X] GAS WELL [ ] OTHER

2. Name of Operator
AMERADA HESS CORPORATION

8. Well No.
4

3. Address of Operator
POST OFFICE DRAWER D, MONUMENT, NEW MEXICO 88265

9. Pool name or Wildcat
EUNICE MONUMENT G/SA

4. Well Location
Unit Letter D : 660 Feet From The NORTH Line and 660 Feet From The WEST Line

Section 2 Township 20S Range 36E NMPM LEA County

10. Elevation (*Show whether DF, RKB, RT, GR, etc.*)

11. Check Appropriate Box to Indicate Nature of Notice, Report, or Other Data

NOTICE OF INTENTION TO:		SUBSEQUENT REPORT OF:	
PERFORM REMEDIAL WORK [ ]	PLUG AND ABANDON [ ]	REMEDIAL WORK [ ]	ALTERING CASING [ ]
TEMPORARILY ABANDON [ ]	CHANGE PLANS [ ]	COMMENCE DRILLING OPNS. [ ]	PLUG AND ABANDONMENT [ ]
PULL OR ALTER CASING [ ]		CASING TEST AND CEMENT JOB [ ]	
OTHER: ____ [ ]		OTHER: Casing Test. Temporary Abandon [X]	

12. Describe Proposed or Completed Operations (*Clearly state all pertinent details, and give pertinent dates, including estimated date of starting any proposed work*) SEE RULE 1103.

07-05-93 Thru 07-16-93 NMGSAU #1804

X-Pert Well Service rigged up pulling unit. Received 133 jts. 2-7/8" and 8 jts. 2-3/8" tbg. as work string. Flowed gas from casing and removed 6" 600 tubinghead flange. Installe a 6" 600 manual BOP. TIH with a 3-7/8" drill bit, bit sub, 8 jts. 2-3/8" 10V tbg. and 125 jts. 2-7/8" 10V tbg. Tagged liner top at 3,742' and top of fill at 3,927', for 1' of fill in 4-1/2" liner. TOH with 125 jts. 2-7/8" 10V tbg., 8 jts. 2-3/8" 10V tbg., bit sub and drill bit. TIH with a 4-1/2" Elder Cast Iron Bridge Plug, setting tool and SN on 8 jts. 2-3/8" tbg. and 122 jts. 2-7/8" tbg. Set CIBP at 3,850', pulled setting tool to 3,841' and circulated casing with 120 bbls. fresh water. Pressure tested 6-5/8" casing from 0' to 3,739' and 4-1/2" liner from 3,739' to 3,929'. Pressure decreased from 560 psi to 540 psi in 30 mins. Checked surface-intermediate and intermediate-production casing annuli and found no pressure or flow. Circulated casing with 120 bbls. packer fluid and TOH laying

(Continued On Back)

I hereby certify that the information above is true and complete to the best of my knowledge and belief.

SIGNATURE Terry L. Harvey TITLE Staff Assistant DATE 07-16-93

TYPE OR PRINT NAME Terry L. Harvey TELEPHONE NO. 393-2144

(This space for State Use)

ORIGINAL SIGNED BY JERRY SEXTON
DISTRICT I SUPERVISOR

AUG 13 1993

APPROVED BY ____ TITLE ____ DATE ____

CONDITIONS OF APPROVAL, IF ANY:

This Approval of Temporary Abandonment Expires 8-1-98

N.

NEW MEXICO OIL CONSERVATION COMMISSION

Santa Fe, New Mexico

WELL RECORD

Mail to Oil Conservation Commission, Santa Fe, New Mexico, or its proper agent not more than twenty days after completion of well. Follow instructions in the Rules and Regulations of the Commission. Indicate questionable data by following it with (?). SUBMIT IN TRIPLICATE.

AREA 640 ACRES
LOCATE WELL CORRECTLY

Amerada Petroleum Corporation — Company or Operator — Well No. 2 — Lease, NW¼ NW¼ of Sec. 2, T. 20

R. 36, N. M. P. M., Monument Field, Lea County.

Well is 660 feet south of the North line and 4620 feet west of the East line of 2-20-36

If State land the oil and gas lease is No. ________ Assignment No. ________

If patented land the owner is ________, Address ________

If Government land the permittee is ________, Address ________

The Lessee is Amerada Petroleum Corproation, Address Tulsa, Oklahoma

Drilling commenced February 19, 1936 19__ Drilling was completed April 1, 1936 19__

Name of drilling contractor H.W. Bass, Address Dallas, Texas

Elevation above sea level at top of casing 3606 feet.

The information given is to be kept confidential until ________ 19__

OIL SANDS OR ZONES

No. 1, from 3800 to 3839 No. 4, from ________ to ________

No. 2, from 3850 to 3893 No. 5, from ________ to ________

No. 3, from 3904 to 3930 No. 6, from ________ to ________

IMPORTANT WATER SANDS

Include data on rate of water inflow and elevation to which water rose in hole.

No. 1, from None to ________ feet.

No. 2, from ________ to ________ feet.

No. 2, from ________ to ________ feet.

No. 4, from ________ to ________ feet.

CASING RECORD

SIZE	WEIGHT PER FOOT	THREADS PER INCH	MAKE	AMOUNT	KIND OF SHOE	CUT & FILLED FROM	PERFORATED FROM	PERFORATED TO	PURPOSE
12½	40	8	L.Weld	203' 8"					
8-5/8"	28	8	L.Weld	2411' 9"					
6-5/8"	20	10	L.Weld	3813' 10"					

MUDDING AND CEMENTING RECORD

SIZE OF HOLE	SIZE OF CASING	WHERE SET	NO. SACKS OF CEMENT	METHOD USED	MUD GRAVITY	AMOUNT OF MUD USED
17½"	12½"	216'	150	Halliburton		
11"	8-5/8"	2406'	500	Halliburton		
7-7/8"	6-5/8"	3800'	100	Halliburton		

PLUGS AND ADAPTERS

Heaving plug—Material ________ Length ________ Depth Set ________

Adapters—Material ________ Size ________

RECORD OF SHOOTING OR CHEMICAL TREATMENT

SIZE	SHELL USED	EXPLOSIVE OR CHEMICAL USED	QUANTITY	DATE	DEPTH SHOT OR TREATED	DEPTH CLEANED OUT

DUPLICATE

(Form C-102)
(Revised 7/1/52)

NEW MEXICO OIL CONSERVATION COMMISSION

Santa Fe, New Mexico

HOBBS OFFICE OCC

MISCELLANEOUS NOTICES

1954 MAY 7 AM 8:00

Submit this notice in TRIPLICATE to the District Office, Oil Conservation Commission, before the work specified is to begin. A copy will be returned to the sender on which will be given the approval, with any modifications considered advisable, or the rejection by the Commission or agent, of the plan submitted. The plan as approved should be followed, and work should not begin until approval is obtained. See additional instructions in the Rules and Regulations of the Commission.

Indicate Nature of Notice by Checking Below

NOTICE OF INTENTION TO CHANGE PLANS		NOTICE OF INTENTION TO TEMPORARILY ABANDON WELL		NOTICE OF INTENTION TO DRILL DEEPER	
NOTICE OF INTENTION TO PLUG WELL		NOTICE OF INTENTION TO PLUG BACK		NOTICE OF INTENTION TO SET LINER	
NOTICE OF INTENTION TO SQUEEZE		NOTICE OF INTENTION TO ACIDIZE		NOTICE OF INTENTION TO SHOOT (Nitro)	
NOTICE OF INTENTION TO GUN PERFORATE		NOTICE OF INTENTION (OTHER)		NOTICE OF INTENTION (OTHER) Dual Complete	X

OIL CONSERVATION COMMISSION
SANTA FE, NEW MEXICO

Monument, New Mexico (Place) — April 15, 1954 (Date)

Gentlemen:

Following is a Notice of Intention to do certain work as described below at the M.E. Gaither

Amerada Petroleum Corporation (Company or Operator) Well No. 1 in I (Unit)

NE ¼ SE ¼ (40-acre Subdivision) of Sec. 34, T. 19-S, R. 36-E, NMPM., Eumont - Gas / Monument - Oil Pool

Lea County.

FULL DETAILS OF PROPOSED PLAN OF WORK
(FOLLOW INSTRUCTIONS IN THE RULES AND REGULATIONS)

3950' T.D. - 6-5/8" OD Csg. set @ 3819' and cemented w/100 sacks cement and 5" liner set from 3780' to 3950' and cemented w/50 sacks cement. Oil is being produced from the perforated interval of 3932' to 3948' from Monument Pool. It is our intention to dual complete well by perf. 6-5/8" OD Csg. from 3425' to 3820' in the Seven-Rivers Queen Formation, Eumont Gas Pool and produce gas through csg. We will continue to produce oil through the tubing from the Monument Pool.

Approved MAY 24 1954, 19
Except as follows:

Approved
OIL CONSERVATION COMMISSION

By [signature] Stanley

Title Engineer District 1

Amerada Petroleum Corporation
Company or Operator

By [signature]

Position Foreman

Send Communications regarding well to:

Name Amerada Petroleum Corporation

Address Drawer D, Monument, New Mexico

FORM C-105

N.

NEW MEXICO OIL CONSERVATION COMMISSION

Santa Fe, New Mexico

WELL RECORD

Mail to Oil Conservation Commission, Santa Fe, New Mexico, or its proper agent not more than twenty days after completion of well. Follow instructions in the Rules and Regulations of the Commission. Indicate questionable data by following it with (?). SUBMIT IN TRIPLICATE.

AREA 640 ACRES
LOCATE WELL CORRECTLY

Amerada Petroleum Corporation — Company or Operator; Gaither — Lease

Well No. 1 in NE¼ NE¼ of Sec. 34, 19

R. 36, N. M. P. M., Monument Field, Lea County.

Well is 1980 feet ~~south~~ of the North line and 660 feet ~~west~~ of the East line of 34-19-36

If State land the oil and gas lease is No. ____ Assignment No. ____

If patented land the owner is ____, Address ____

If Government land the permittee is ____, Address ____

The Lessee is Amerada Petroleum Corporation, Address Tulsa, Oklahoma.

Drilling commenced June 15, 1936, Drilling was completed July 13, 1936

Name of drilling contractor Rowan Drilling Company, Address Trinity Life Bldg. Fort Worth, Texas

Elevation above sea level at top of casing ____ feet.

The information given is to be kept confidential until ____ 19__

OIL SANDS OR ZONES

No. 1, from ____ to ____ No. 4, from ____ to ____

No. 2, from ____ to ____ No. 5, from ____ to ____

No. 3, from ____ to ____ No. 6, from ____ to ____

IMPORTANT WATER SANDS

Include data on rate of water inflow and elevation to which water rose in hole.

No. 1, from ____ to ____ feet.

No. 2, from ____ to ____ feet.

No. 2, from ____ to ____ feet.

No. 4, from ____ to ____ feet.

CASING RECORD

SIZE	WEIGHT PER FOOT	THREADS PER INCH	MAKE	AMOUNT	KIND OF SHOE	CUT & FILLED FROM	PERFORATED FROM	PERFORATED TO	PURPOSE
12½"	40#	8 thd.	L.Weld	222'3"	Texas Pattern				
8 5/8"	32#	8 thd.	Smls.	2551'6"	Halliburton				
6 5/8	20#	10 thd.	Smls.	3834'0"	Halliburton				

MUDDING AND CEMENTING RECORD

SIZE OF HOLE	SIZE OF CASING	WHERE SET	NO. SACKS OF CEMENT	METHOD USED	MUD GRAVITY	AMOUNT OF MUD USED
17½"	12½"	222'	150	Halliburton		
11"	8-5/8	2540'	500	Halliburton		
7-7/8"	6-5/8"	3819'	100	Halliburton		

PLUGS AND ADAPTERS

Heaving plug—Material ____ Length ____ Depth Set ____

Adapters—Material ____ Size ____

RECORD OF SHOOTING OR CHEMICAL TREATMENT

SIZE	SHELL USED	EXPLOSIVE OR CHEMICAL USED	QUANTITY	DATE	DEPTH SHOT OR TREATED	DEPTH CLEANED OUT
		Dowell XX	2000	[illegible]		

Submit 3 Copies to Appropriate District Office

State of New Mexico
Energy Minerals and Natural Resources Department

Form C-103
Revised 1-1-89

DISTRICT I
P.O. Box 1980, Hobbs, NM 88240

DISTRICT II
P.O. Drawer DD, Artesia, NM 88210

DISTRICT III
1000 Rio Brazos Rd., Aztec, NM 87410

OIL CONSERVATION DIVISION
P.O. Box 2088
Santa Fe, New Mexico 87504-2088

WELL API NO.
30-025-31982

5. Indicate Type of Lease
STATE [ ] FEE [X]

6. State Oil & Gas Lease No.

SUNDRY NOTICES AND REPORTS ON WELLS
(DO NOT USE THIS FORM FOR PROPOSALS TO DRILL OR TO DEEPEN OR PLUG BACK TO A DIFFERENT RESERVOIR. USE "APPLICATION FOR PERMIT" (FORM C-101) FOR SUCH PROPOSALS.)

7. Lease Name or Unit Agreement Name
J.A. FOSTER

1. Type of Well:
OIL WELL [XX] GAS WELL [ ] OTHER

2. Name of Operator
DAVID H. ARRINGTON OIL & GAS, INC.

8. Well No.
#3

3. Address of Operator
P.O. BOX 2071, MIDLAND, TEXAS 79702

9. Pool name or Wildcat
MONUMENT ABO

4. Well Location
Unit Letter P : 660 Feet From The SOUTH Line and 330 Feet From The EAST Line

Section 34 Township 19-S Range 36-E NMPM Lea County

10. Elevation (*Show whether DF, RKB, RT, GR, etc.*)
3614' GR, 3627' KB

11. Check Appropriate Box to Indicate Nature of Notice, Report, or Other Data

NOTICE OF INTENTION TO:				SUBSEQUENT REPORT OF:			
PERFORM REMEDIAL WORK	[ ]	PLUG AND ABANDON	[ ]	REMEDIAL WORK	[ ]	ALTERING CASING	[ ]
TEMPORARILY ABANDON	[ ]	CHANGE PLANS	[ ]	COMMENCE DRILLING OPNS.	[XX]	PLUG AND ABANDONMENT	[ ]
PULL OR ALTER CASING	[ ]			CASING TEST AND CEMENT JOB	[XX]		
OTHER:	[ ]			OTHER: COMPLETE DRILLING OPERATIONS	[X]		

12. Describe Proposed or Completed Operations (*Clearly state all pertinent details, and give pertinent dates, including estimated date of starting any proposed work*) SEE RULE 1103.

0/06/93 - SPUDDED @ 4:00 pm 10/5/93. DRILLED 17 1/2" HOLE TO 300', SET 13 3/8" CASING @300' WITH 400 SXS CLASS C. CIRC 200 SXS. WOC 12 HRS. TESTING CASING TO 800 PSI, OK.

0/11/93 - DRILLING 12 1/4" HOLE TO 2613'. SET 8 5/8" CSG. @ 2613'. CEMENT WITH 1200 sxs HALIBURTON LT & 200 SXS PREMIUM PLUS. TOC @ 1240' BY TEMP SURVEY. TEST CSG TO 1000 PSI, OK.

0/25/93 - DRILLED TO TD 8050'. RAN LOGS.

0/27/93 - RAN 5 1/2" CSG. TO 8035'. DV TOOL @ 4984'. CMT 1St. STAGE W/250 SXS HALIBURTON LT & 560 SXS CL H. CIRC 105 SX CEMENT OUT FROM DV TOOL. CEMENTED 2ND STAGE W/200 SXS HALIBURTOH LT + 650 SXS CL C. DID NOT CIRCULATE TO SURFACE. RELEASE RIG @ 6:00 am 10/27/93.

I hereby certify that the information above is true and complete to the best of my knowledge and belief.

SIGNATURE [signature] TITLE President DATE 12/15/93

TYPE OR PRINT NAME TELEPHONE NO.

(This space for State Use)

ORIGINAL SIGNED BY JERRY SEXTON
DISTRICT I SUPERVISOR

APPROVED BY TITLE DATE DEC 20 1993

CONDITIONS OF APPROVAL, IF ANY:

Submit 5 Copies
Appropriate District Office
DISTRICT I
P.O. Box 1980, Hobbs, NM 88240

DISTRICT II
P.O. Drawer DD, Artesia, NM 88210

DISTRICT III
1000 Rio Brazos Rd., Aztec, NM 87410

State of New Mexico
Energy, Minerals and Natural Resources Department

OIL CONSERVATION DIVISION

P.O. Box 2088
Santa Fe, New Mexico 87504-2088

Form C-104
Revised 1-1-89
See Instructions at Bottom of Page

REQUEST FOR ALLOWABLE AND AUTHORIZATION TO TRANSPORT OIL AND NATURAL GAS

I.

Operator	Well API No.
DAVID H. ARRINGTON OIL & GAS, INC.	30-025-31982

Address: P.O. BOX 2071, MIDLAND, TEXAS 79702

Reason(s) for Filing (Check proper box)

- New Well [XX]
- Recompletion [ ]
- Change in Operator [ ]

Change in Transporter of: Oil [ ] Dry Gas [ ] Casinghead Gas [ ] Condensate [ ]

Other (Please explain) [ ]

If change of operator give name and address of previous operator

II. DESCRIPTION OF WELL AND LEASE

Lease Name	Well No.	Pool Name, Including Formation	Kind of Lease State, Federal or Fee	Lease No.
J.A. Foster	3	Monument Abo R-10091 4/1/94	Fee	

Location

Unit Letter P : 660 Feet From The South Line and 330 Feet From The East Line

Section 34 Township 19-S Range 36-E , NMPM, Lea County

III. DESIGNATION OF TRANSPORTER OF OIL AND NATURAL GAS

Name of Authorized Transporter of Oil [XX] or Condensate [ ]	Address (Give address to which approved copy of this form is to be sent)
Kelly McClasky Oilfield Serv. Inc.	P.O. Box 580 Hobbs, NM 88241
Name of Authorized Transporter of Casinghead Gas [XX] or Dry Gas [ ]	**Address (Give address to which approved copy of this form is to be sent)**
Warren Petroleum Corp.	P.O. Box 67, Monument, NM 88265

If well produces oil or liquids, give location of tanks.	Unit	Sec.	Twp.	Rge.	Is gas actually connected?	When ?
	P	34	19-S	36-E	Yes	11/20/93

If this production is commingled with that from any other lease or pool, give commingling order number:

IV. COMPLETION DATA

	Oil Well	Gas Well	New Well	Workover	Deepen	Plug Back	Same Res'v	Diff Res'v
Designate Type of Completion - (X)	X		X					

Date Spudded	Date Compl. Ready to Prod.	Total Depth	P.B.T.D.
10/6/93	11/20/93	8050	7987
Elevations (DF, RKB, RT, GR, etc.)	**Name of Producing Formation**	**Top Oil/Gas Pay**	**Tubing Depth**
3614' GR, 3627 KB	Abo	7323	7182
Perforations			**Depth Casing Shoe**
7323'-7428' (30 Holes)			8035'

TUBING, CASING AND CEMENTING RECORD

HOLE SIZE	CASING & TUBING SIZE	DEPTH SET	SACKS CEMENT
17 1/2	13 3/8	300'	400 sxs C
12 1/4	8 5/8	2613'	1200 sx Lt + 200 sx C
7 7/8	5 1/2	8035'	450 sx Lt & 560 H
	2 3/8	7182	650 Cl C

V. TEST DATA AND REQUEST FOR ALLOWABLE

OIL WELL (Test must be after recovery of total volume of load oil and must be equal to or exceed top allowable for this depth or be for full 24 hours.)

Date First New Oil Run To Tank	Date of Test	Producing Method (Flow, pump, gas lift, etc.)	
11/20/93	11/23/93	Pump	
Length of Test	**Tubing Pressure**	**Casing Pressure**	**Choke Size**
24			
Actual Prod. During Test	**Oil - Bbls.**	**Water - Bbls.**	**Gas- MCF**
	22	230	35

GAS WELL

Actual Prod. Test - MCF/D	Length of Test	Bbls. Condensate/MMCF	Gravity of Condensate
Testing Method (pitot, back pr.)	**Tubing Pressure (Shut-in)**	**Casing Pressure (Shut-in)**	**Choke Size**

VI. OPERATOR CERTIFICATE OF COMPLIANCE

I hereby certify that the rules and regulations of the Oil Conservation Division have been complied with and that the information given above is true and complete to the best of my knowledge and belief.

Signature: [signature]

David H. Arrington /President
Printed Name — Title

12/15/93 — 915-682-6685
Date — Telephone No.

OIL CONSERVATION DIVISION

Date Approved DEC 20 1993

By ORIGINAL SIGNED BY JERRY SEXTON
DISTRICT I SUPERVISOR

Title

INSTRUCTIONS: This form is to be filed in compliance with Rule 1104

1) Request for allowable for newly drilled or deepened well must be accompanied by tabulation of deviation tests taken in accordance with Rule 111.
2) All sections of this form must be filled out for allowable on new and recompleted wells.
3) Fill out only Sections I, II, III, and VI for changes of operator, well name or number, transporter, or other such changes.
4) Separate Form C-104 must be filed for each pool in multiply completed wells.

NUMBER OF COPIES RECEIVED		
DISTRIBUTION		
SANTA FE		
FILE		
U.S.G.S.		
LAND OFFICE		
TRANSPORTER	OIL	
	GAS	
PRORATION OFFICE		
OPERATOR		

NEW MEXICO OIL CONSERVATION COMMISSION
SANTA FE, NEW MEXICO

CERTIFICATE OF COMPLIANCE AND AUTHORIZATION TO TRANSPORT OIL AND NATURAL GAS

FORM C-110 (Rev. 7-60)

O. C. C. MAR 31 ... '64

FILE THE ORIGINAL AND 4 COPIES WITH THE APPROPRIATE OFFICE

Company or Operator				Lease	Well No.
Gulf Oil Corporation				Northwest Eumont Unit 34	~~34~~-14
Unit Letter: N	Section: 34	Township: 19-S	Range: 36-E	County: Lea	
Pool: Eumont				Kind of Lease (State, Fed, Fee): Fee	

If well produces oil or condensate give location of tanks	Unit Letter	Section	Township	Range
	0	34	19-S	36-E

Authorized transporter of oil ☒ or condensate ☐	Address (give address to which approved copy of this form is to be sent)
Texas-New Mexico Pipeline Co.	Box 1510, Midland, Texas

Is Gas Actually Connected? Yes XX No ____

Authorized transporter of casing head gas ☒ or dry gas ☐	Date Connected	Address (give address to which approved copy of this form is to be sent)
Warren Pet. Corp.	Unk	Box 1589, Tulsa, Oklahoma

If gas is not being sold, give reasons and also explain its present disposition:

REASON(S) FOR FILING *(please check proper box)*

- New Well ☐
- Change in Transporter *(check one)*
  - Oil ☐
  - Dry Gas ☐
  - Casing head gas ☐
  - Condensate ☐
- Change in Ownership ☐
- Other *(explain below)*

To change the name of operator, lease and well number.

Remarks

This well was formerly known as Shell Oil Corporation's J. A. Foster No. 3. The Northwest Eumont Unit has been formed, effective 4-1-64 with Gulf as operator. Permission is hereby requested to change the name of the operator to Gulf and change the name of the lease and well No. to Northwest Eumont Unit, Well No. 34-14.

The undersigned certifies that the Rules and Regulations of the Oil Conservation Commission have been complied with.

Executed this the 30th day of March, 1964.

OIL CONSERVATION COMMISSION	
Approved by	By: ORIGINAL SIGNED BY C. D. BORLAND
Title: Engineer District 1	Title: Area Production Manager
	Company: Gulf Oil Corporation
Date	Address: Box 670, Hobbs, New Mexico

(Revised 7/1/52)
(Form C-105)

N.

36-E

Section 34

T 19 S

X

AREA 640 ACRES
LOCATE WELL CORRECTLY

NEW MEXICO OIL CONSERVATION COMMISSION

Santa Fe, New Mexico

DEC 13 AM 2:34

WELL RECORD

Mail to District Office, Oil Conservation Commission, to which Form C-101 was sent not later than twenty days after completion of well. Follow instructions in Rules and Regulations of the Commission. Submit in QUINTUPLICATE.

Shell Oil Company (Company or Operator) Foster (Lease)

Well No. 3, in SE ¼ of SW ¼, of Sec. 34, T. 19-S, R. 36-E, NMPM.

Eumont Pool, Lea County.

Well is 660 feet from south line and 1980 feet from west line

of Section 34. If State Land the Oil and Gas Lease No. is -

Drilling Commenced November 22, 19 54 Drilling was Completed December 4, 19 54

Name of Drilling Contractor Velma Petroleum Corporation

Address Hobbs, New Mexico

Elevation above sea level at Top of Tubing Head 3621 The information given is to be kept confidential until Not confidential, 19

OIL SANDS OR ZONES

No. 1, from to No. 4, from to

No. 2, from to No. 5, from to

No. 3, from to No. 6, from to

IMPORTANT WATER SANDS

Include data on rate of water inflow and elevation to which water rose in hole.

No. 1, from to feet.

No. 2, from to feet.

No. 3, from to feet.

No. 4, from to feet.

CASING RECORD

SIZE	WEIGHT PER FOOT	NEW OR USED	AMOUNT	KIND OF SHOE	CUT AND PULLED FROM	PERFORATIONS	PURPOSE
8-5/8"	32#	New	288.63	-		-	Surface string
5-1/2"	15.5#	New	3937.85	Larkin		3910'-3935'	Oil string

MUDDING AND CEMENTING RECORD

SIZE OF HOLE	SIZE OF CASING	WHERE SET	NO. SACKS OF CEMENT	METHOD USED	MUD GRAVITY	AMOUNT OF MUD USED
11"	8-5/8"	310'	250	Pump & Plug	Cemented	to surface
7-7/8	5-1/2"	3950'	750	Pump & Plug		

RECORD OF PRODUCTION AND STIMULATION

(Record the Process used, No. of Qts. or Gals. used, interval treated or shot.)

Treated formation thru casing perforations 3910' - 3935' with 10,000 gallons Sandfrac (Dowell) containing 1-1/2 # sand/gallon.

Result of Production Stimulation On OPT flowed at the rate of 247.2 BOPD (based on 46.31 barrels in 4.5 hours) thru 16/64" choke. FTP 450 psi. GOR 143.

Depth Cleaned Out

NUMBER OF COPIES RECEIVED		
DISTRIBUTION		
SANTA FE		
FILE		
U.S.G.S.		
LAND OFFICE		
TRANSPORTER	OIL	
	GAS	
PRORATION OFFICE		
OPERATOR		

NEW MEXICO OIL CONSERVATION COMMISSION

FORM C-103
(Rev 3-55)

MISCELLANEOUS REPORTS ON WELLS

(Submit to appropriate District Office as per Commission Rule 1106)

Name of Company					Address	
Amerada Petroleum Corporation					P. O. Box 668 - Hobbs, New Mexico	
Lease M. E. Gaither	**Well No.** 4	**Unit Letter** J	**Section** 34	**Township** 19S	**Range** 36E	
Date Work Performed 5-27-63 to 5-31-63	**Pool** Eumont				**County** Lea	

THIS IS A REPORT OF: *(Check appropriate block)*

- [ ] Beginning Drilling Operations
- [ ] Casing Test and Cement Job
- [ ] Other *(Explain)*:
- [ ] Plugging
- [X] Remedial Work

Detailed account of work done, nature and quantity of materials used, and results obtained.

Pulled rods, pump and tubing. Made 2 runs with string shot in 7-7/8" open hole from 3870' to 3933'. Run #1 - 400 grains per ft. pf pay and Run #2 - 400 grains per ft. of pay. Cleaned out open hole from 3933' to 3940'. Ran tubing and packer. Acidized open hole from 3870' to 3940' with 500 gals. 15% N.E. acid. Pulled tubing. Reran tubing, pump and rods. Resumed production

Witnessed by	Position	Company
A. J. Troop	Asst. Dist. Supt.	Amerada Petroleum Corporation

FILL IN BELOW FOR REMEDIAL WORK REPORTS *ONLY*

ORIGINAL WELL DATA

D F Elev.	T D	PBTD	Producing Interval	Completion Date
3636'	3940'		3870' to 3940'	6-6-56

Tubing Diameter	Tubing Depth	Oil String Diameter	Oil String Depth
2-3/8"	3921'	5-1/2"	3870'

Perforated Interval(s)

Open Hole Interval	Producing Formation(s)
3870' to 3940'	Stuart

RESULTS OF WORKOVER

Test	Date of Test	Oil Production BPD	Gas Production MCFPD	Water Production BPD	GOR Cubic feet/Bbl	Gas Well Potential MCFPD
Before Workover	5-25-63	8.28	132	2.76	15,960	
After Workover	6-1-63	40	245	7	6,116	

OIL CONSERVATION COMMISSION

Approved by

Title

Date

I hereby certify that the information given above is true and complete to the best of my knowledge.

Name A. J. Troop

Position Asst. District Superintendent

Company Amerada Petroleum Corporation

(Revised 7/1/52)
(Form C-105)

DUPLICATE

NEW MEXICO OIL CONSERVATION COMMISSION
Santa Fe, New Mexico

1956 JUN 11

WELL RECORD

Sec. 34
#4
T 19 S

AREA 640 ACRES
LOCATE WELL CORRECTLY

Mail to District Office, Oil Conservation Commission, to which Form C-101 was sent not later than twenty days after completion of well. Follow instructions in Rules and Regulations of the Commission. Submit in QUINTUPLICATE. If State Land submit 6 Copies

Amerada Petroleum Corporation (Company or Operator) M. E. Gaither (Lease)

Well No. 4, in NW ¼ of SE ¼, of Sec. 34, T. 19-S, R. 36-E, NMPM.

Eumont Pool, Lea County.

Well is 1980 feet from South line and 2310 feet from East line of Section 34. If State Land the Oil and Gas Lease No. is

Drilling Commenced May 26, 1956 Drilling was Completed June 4, 1956

Name of Drilling Contractor McQueen & Stout Drilling Company

Address 1601 West Texas, Midland, Texas

Elevation above sea level at Top of Tubing Head Not Determined The information given is to be kept confidential until Not Confidential, 19

OIL SANDS OR ZONES

No. 1, from 3870' to 3940' No. 4, from to

No. 2, from to No. 5, from to

No. 3, from to No. 6, from to

IMPORTANT WATER SANDS

Include data on rate of water inflow and elevation to which water rose in hole.

No. 1, from None to feet.

No. 2, from to feet.

No. 3, from to feet.

No. 4, from to feet.

CASING RECORD

SIZE	WEIGHT PER FOOT	NEW OR USED	AMOUNT	KIND OF SHOE	CUT AND PULLED FROM	PERFORATIONS	PURPOSE
8-5/8"	24#	New	1314'	Guide			
5-1/2"	15.5#	New	3870'	Float			

MUDDING AND CEMENTING RECORD

SIZE OF HOLE	SIZE OF CASING	WHERE SET	NO. SACKS OF CEMENT	METHOD USED	MUD GRAVITY	AMOUNT OF MUD USED
12¼"	8-5/8"	1314'	800	Halliburton		
7-7/8"	5-1/2"	3870'	400	Halliburton		

RECORD OF PRODUCTION AND STIMULATION

(Record the Process used, No. of Qts. or Gals. used, interval treated or shot.)

Sand-Oil open hole from 3870' to 3940' down tubing and casing with 20,000 gallons Famariss 24 gravity refined oil and 20,000# Sand. Maximum pressure 2600#, minimum pressure 2200#, final pressure 1600#, injection rate 20 bbls. per minute. Flushed with 190 bbls. oil.

Result of Production Stimulation Swabbed in. After Flowing load oil. Flowed 75.76 bbls. oil and no water in 2 hrs. on 1/2" choke, tubing pressure 320#, casing pressure 700#, gas volume 790,050 cu. ft. per day, GOR 869, gravity 34.5 corrected.

Depth Cleaned Out

FORM C-101

NEW MEXICO OIL CONSERVATION COMMISSION

Santa Fe, New Mexico

NOTICE OF INTENTION TO DRILL

Notice must be given to the Oil Conservation Commission or its proper agent and approval obtained before drilling begins. If changes in the proposed plan are considered advisable, a copy of this notice showing such changes will be returned to the sender. Submit this notice in triplicate. One copy will be returned following approval. See additional instructions in Rules and Regulations of the Commission.

Hobbs, New Mex. (Place) 4-19-36 (Date)

OIL CONSERVATION COMMISSION,
Santa Fe, New Mexico

Gentlemen:

You are hereby notified that it is our intention to commence the drilling of a well to be known as Shell Petroleum Corporation (Company or Operator) Foster (Lease) Well No. 1 in SE 1/4 of SE 1/4 of Sec. 34, T. 19-S, R. 36-E, N. M. P. M., Monument Field, Lea County.

N.

The well is 660' feet [N.] [S.] of the S line and 660' feet [E.] [W.] of the E line of Sec 34

(Give location from section or other legal subdivision lines. Cross out wrong directions.)

If state land the oil and gas lease is No. ______ Assignment No. ______

If patented land the owner is J. H. Foster

Address Hobbs, N M

If government land the permittee is ______

Address ______

The lessee is Shell Petroleum Corporation

Address Houston Texas

AREA 640 ACRES
LOCATE WELL CORRECTLY

We propose to drill well with drilling equipment as follows: Rotary Tools

The status of a bond for this well in conformance with Rule 39 of the General Rules and Regulations of the Commission is as follows: ______

We propose to use the following strings of casing and to land or cement them as indicated:

Size of Hole	Size of Casing	Weight Per Foot	New or Second Hand	Depth	Landed or Cemented	Sacks Cement
17½	12½	50	SH	250	Cem	150
12	9-5/8	36	New	1200	"	450
8-3/4	7"	24	"	3725	"	250

If changes in the above plan become advisable we will notify you before cementing or landing casing. We estimate that the first productive oil or gas sand should occur at a depth of about 3800 feet.

Additional information:

DUPLICATE

Approved ______, 19____
except as follows:

OIL CONSERVATION COMMISSION,

By ______

Title ______

Sincerely yours,

SHELL PETROLUEM CORPORATION
Company or Operator

By ______

Position District Engineer

Send communication regarding well to

Name Shell Petroleum Corporation

Address Box p Hobbs N M

Submit 3 Copies
Appropriate
District Office

State of New Mexico
Energy, Minerals and Natural Resources Department

Form C-103
Revised 1-1-89

DISTRICT I
P.O. Box 1980, Hobbs, NM 88240

DISTRICT II
P.O. Drawer DD, Artesia, NM 88210

DISTRICT III
1000 Rio Brazos Rd., Aztec, NM 87410

OIL CONSERVATION DIVISION

P.O. Box 2088
Santa Fe, New Mexico 87504-2088

WELL API NO. 30-025-04112

5. Indicate Type of Lease STATE [ ] FEE [X]

6. State Oil & Gas Lease No.

SUNDRY NOTICES AND REPORTS ON WELLS

(DO NOT USE THIS FORM FOR PROPOSALS TO DRILL OR TO DEEPEN OR PLUG BACK TO A DIFFERENT RESERVOIR. USE "APPLICATION FOR PERMIT" (FORM C-101) FOR SUCH PROPOSALS.)

7. Lease Name or Unit Agreement Name
NORTH MONUMENT G/SA UNIT
BLOCK 13

1. Type of Well: OIL WELL [X] GAS WELL [ ] OTHER

2. Name of Operator
AMERADA HESS CORPORATION

8. Well No.
18

3. Address of Operator
DRAWER D, MONUMENT, NM 88265

9. Pool name or Wildcat
EUNICE MONUMENT G/SA

4. Well Location
Unit Letter P : 660 Feet From The SOUTH Line and 660 Feet From The EAST Line
Section 34 Township 19S Range 36E NMPM LEA County

10. Elevation (Show whether DF, RKB, RT, GR, etc.)

11. Check Appropriate Box to Indicate Nature of Notice, Report, or Other Data

NOTICE OF INTENTION TO:				SUBSEQUENT REPORT OF:			
PERFORM REMEDIAL WORK	[ ]	PLUG AND ABANDON	[ ]	REMEDIAL WORK	[ ]	ALTERING CASING	[ ]
TEMPORARILY ABANDON	[ ]	CHANGE PLANS	[ ]	COMMENCE DRILLING OPNS.	[ ]	PLUG AND ABANDONMENT	[ ]
PULL OR ALTER CASING	[ ]			CASING TEST AND CEMENT JOB	[ ]		
OTHER:			[ ]	OTHER: TESTED CASING			[X]

12. Describe Proposed or Completed Operations (Clearly state all pertinent details, and give pertinent dates, including estimated date of starting any proposed work) SEE RULE 1103.

6-24 THRU 6-28-93

MIRU DA&S WELL SER. PULLING UNIT & TOH WITH A 1-1/4" X 22'. POLISHED ROD WITH A 1-1/2" X 12' LINER AND FOUND PUMP STUCK. BACKED OFF RODS & RECOVERED 2 3/4" X 8' PONY RODS AND 45 3/4" SUCKER RODS. REMOVED 9-5/8" HINDERLITER TUBINGHEAD PACKING AND SLIP ASSEMBLY AND INSTALLED A 9-5/8" ADAPTER FLANGE AND A 6" 900 MANUAL BOP. STRIPPED OUT RODS AND TUBING. TIH WITH 4-1/4" DRILL BIT, TAGGED TOP OF LINER AT 3,664' & PBD AT 3,967'. TOH WITH BIT. TIH WITH A 5" ELDER LOK-SET RETRIEVABLE BRIDGE PLUG. SET AT 3,855', CIRC. CASING WITH 130 BBLS. FRESH WATER & PRESS. TESTED CASING FROM 0' TO 3,855'. PRESS. DECREASED FROM 580 PSI TO 535 PSI IN 30 MINS. CHECKED INTERMEDIATE-PRODUCTION CASING ANNULUS AND FOUND NO PRESSURE OR FLOW. RELEASED RBP AT 3,855' & TOH. SCHLUMBERGER RIH WITH GR-CCL-CNL TOOLS. SCHLUMBERGER FOUND TOP OF 5" LINER AT 3,662' & TD AT 3,935'. LOGGED FROM 3,932' TO 2,865'. FOUND GR READINGS
(CONT)

I hereby certify that the information above is true and complete to the best of my knowledge and belief.

SIGNATURE R L Wheeler Jr TITLE SUPV. ADMIN. SER. DATE 7-12-93

TYPE OR PRINT NAME ROY L. WHEELER, JR. TELEPHONE NO. 393-2144

(This space for State Use)

Orig. Signed by
Paul Kautz
Geologist

APPROVED BY ______ TITLE ______ DATE JUL 16 1993

CONDITIONS OF APPROVAL, IF ANY:

COPY TO O. C. C.

Form 9-330 (Rev. 5-63)

UNITED STATES
DEPARTMENT OF THE INTERIOR
GEOLOGICAL SURVEY

SUBMIT IN DUPLICATE (See other instructions on reverse side)

Form approved. Budget Bureau No. 42-R355.5.

WELL COMPLETION OR RECOMPLETION REPORT AND LOG *

1a. TYPE OF WELL: OIL WELL [X] GAS WELL [ ] DRY [ ] Other

b. TYPE OF COMPLETION: NEW WELL [X] WORK OVER [ ] DEEP-EN [ ] PLUG BACK [ ] DIFF. RESVR. [ ] Other

14 AM '65

2. NAME OF OPERATOR: Ernest A. Hanson

3. ADDRESS OF OPERATOR: P. O. Box 1515, Roswell, New Mexico

4. LOCATION OF WELL (*Report location clearly and in accordance with any State requirements*)*
At surface: 1980' FSL & 990' FWL
Sec. 35, T-19-S, R-34-E, N.M.P.M.
At top prod. interval reported below: Lea County, New Mexico
At total depth

5. LEASE DESIGNATION AND SERIAL NO.: NM 052

6. IF INDIAN, ALLOTTEE OR TRIBE NAME:

7. UNIT AGREEMENT NAME: Mescalero Ridge

8. FARM OR LEASE NAME: Mescalero Ridge Unit "35"

9. WELL NO.: 13

10. FIELD AND POOL, OR WILDCAT: Pearl Queen

11. SEC., T., R., M., OR BLOCK AND SURVEY OR AREA: Sec. 35, T-19-S, R-34-E

14. PERMIT NO.: DATE ISSUED:

12. COUNTY OR PARISH: Lea

13. STATE: New Mexico

15. DATE SPUDDED	16. DATE T.D. REACHED	17. DATE COMPL. (*Ready to prod.*)	18. ELEVATIONS (DF, RKB, RT, GR, ETC.)*	19. ELEV. CASINGHEAD
8/16/65	9/7/65	9/20/65	3711' KB	3701'

20. TOTAL DEPTH, MD & TVD	21. PLUG, BACK T.D., MD & TVD	22. IF MULTIPLE COMPL., HOW MANY*	23. INTERVALS DRILLED BY	ROTARY TOOLS	CABLE TOOLS
5200'	5189'		→	210 - 5200'	0 - 210'

24. PRODUCING INTERVAL(S), OF THIS COMPLETION—TOP, BOTTOM, NAME (MD AND TVD)*: 4576' - 5036' Queen Formation

25. WAS DIRECTIONAL SURVEY MADE: No

26. TYPE ELECTRIC AND OTHER LOGS RUN: Gamma-Ray/Density/Caliper

27. WAS WELL CORED: Yes

28. CASING RECORD (*Report all strings set in well*)

CASING SIZE	WEIGHT, LB./FT.	DEPTH SET (MD)	HOLE SIZE	CEMENTING RECORD	AMOUNT PULLED
8-5/8"	23#	202'	12"	125 sx. circ. to surf.	None
5-1/2"	15½#	5192'	7-7/8"	350 sx.	None

29. LINER RECORD

SIZE	TOP (MD)	BOTTOM (MD)	SACKS CEMENT*	SCREEN (MD)

30. TUBING RECORD

SIZE	DEPTH SET (MD)	PACKER SET (MD)
2-3/8"	4575'	None

31. PERFORATION RECORD (*Interval, size and number*)

1 - 0.50" jet/ft. @ 4576', 4595', 4597', 4605', 4617', 4619', 4745', 4881', 4885', 4929', 4931', 5024' & 5036'.

32. ACID, SHOT, FRACTURE, CEMENT SQUEEZE, ETC.

DEPTH INTERVAL (MD)	AMOUNT AND KIND OF MATERIAL USED
4576 - 4619'	1500 acid, 20,000 gals. lease oil & 20,000 lbs. sand.
4745 - 5036'	1500 acid, 20,000 gals. lease oil & 16,000 lbs. sand.

33.* PRODUCTION

DATE FIRST PRODUCTION	PRODUCTION METHOD (*Flowing, gas lift, pumping—size and type of pump*)	WELL STATUS (*Producing or shut-in*)
9/20/65	Pumping w/1-25/32" tubing pump.	Producing

DATE OF TEST	HOURS TESTED	CHOKE SIZE	PROD'N. FOR TEST PERIOD	OIL—BBL.	GAS—MCF.	WATER—BBL.	GAS-OIL RATIO
9/20/65	24	2"	→	47		3	

FLOW. TUBING PRESS.	CASING PRESSURE	CALCULATED 24-HOUR RATE	OIL—BBL.	GAS—MCF.	WATER—BBL.	OIL GRAVITY-API (CORR.)
		→	47		3	36°

34. DISPOSITION OF GAS (*Sold, used for fuel, vented, etc.*): Sold

TEST WITNESSED BY: Schram

35. LIST OF ATTACHMENTS: 2 - Gamma-Ray/Density/Caliper

36. I hereby certify that the foregoing and attached information is complete and correct as determined from all available records

SIGNED Ernest A. Hanson TITLE Operator DATE 9/20/65

*(See Instructions and Spaces for Additional Data on Reverse Side)

DISTRIBUTION		
SANTA FE		
FILE		
U.S.G.S.		
LAND OFFICE		
TRANSPORTER	OIL	
	GAS	
OPERATOR		
PRORATION OFFICE		

NEW MEXICO OIL CONSERVATION COMMISSION

REQUEST FOR ALLOWABLE
AND
AUTHORIZATION TO TRANSPORT OIL AND NATURAL GAS

Form C-104
Supersedes Old C-104 and C-110
Effective 1-1-65

AUG 24 11 44 AM '65

I.

Operator
Ernest A. Hanson

Address
P. O. Box 1515, Roswell, New Mexico

Reason(s) for filing *(Check proper box)*

New Well	[X]	Change in Transporter of:			
Recompletion	[ ]	Oil	[ ]	Dry Gas	[ ]
Change in Ownership	[ ]	Casinghead Gas	[ ]	Condensate	[ ]

Other *(Please explain)*

If change of ownership give name and address of previous owner

II. DESCRIPTION OF WELL AND LEASE

Lease Name	Well No.	Pool Name, Including Formation	Kind of Lease State, Federal or Fee
Mescalero Ridge Unit "35"	12	Pearl Queen	Federal

Location
Unit Letter E ; 1980 Feet From The North Line and 990' Feet From The West
Line of Section 35 , Township 19-S Range 34-E , NMPM, Lea County

III. DESIGNATION OF TRANSPORTER OF OIL AND NATURAL GAS

Name of Authorized Transporter of Oil [X] or Condensate [ ]	Address *(Give address to which approved copy of this form is to be sent)*
Shell Pipe Line Corp.	Box 1598, Hobbs, New Mexico

Name of Authorized Transporter of Casinghead Gas [ ] or Dry Gas [ ]	Address *(Give address to which approved copy of this form is to be sent)*
Phillips Petroleum Co.	Bartlesville, Okla.

If well produces oil or liquids, give location of tanks.	Unit	Sec.	Twp.	Rge.	Is gas actually connected?	When
	F	35	19-S	34-E	Yes	Aug. 15, 1965

If this production is commingled with that from any other lease or pool, give commingling order number:

IV. COMPLETION DATA

Designate Type of Completion – (X)	Oil Well	Gas Well	New Well	Workover	Deepen	Plug Back	Same Res'v.	Diff. Res'v.
	X							

Date Spudded	Date Compl. Ready to Prod.	Total Depth	P.B.T.D.
July 25, 1965	August 15, 1965	5200' dolo.	5116'
Pool	**Name of Producing Formation**	**Top Oil/Gas Pay**	**Tubing Depth**
Pearl Queen	Queen Fm.	4568'	4565'

Perforations
1 SPF @ 4568, 4588, 4602, 4615, 4624, 4629, 4875, 4877, 4879, 5012, 5014 & 5016

Depth Casing Shoe
5126'

TUBING, CASING, AND CEMENTING RECORD

HOLE SIZE	CASING & TUBING SIZE	DEPTH SET	SACKS CEMENT
11"	8-5/8"	246'	125 sx. circulated
7-7/8"	5-1/2"	5126'	350 sx.

V. TEST DATA AND REQUEST FOR ALLOWABLE

(Test must be after recovery of total volume of load oil and must be equal to or exceed top allowable for this depth or be for full 24 hours)

OIL WELL

Date First New Oil Run To Tanks	Date of Test	Producing Method *(Flow, pump, gas lift, etc.)*	
August 15, 1965	August 15, 1965	Pumping	
Length of Test	**Tubing Pressure**	**Casing Pressure**	**Choke Size**
24 hours			2"
Actual Prod. During Test	**Oil-Bbls.**	**Water-Bbls.**	**Gas-MCF**
	52	8	

GAS WELL

Actual Prod. Test-MCF/D	Length of Test	Bbls. Condensate/MMCF	Gravity of Condensate
Testing Method *(pitot, back pr.)*	**Tubing Pressure**	**Casing Pressure**	**Choke Size**

VI. CERTIFICATE OF COMPLIANCE

I hereby certify that the rules and regulations of the Oil Conservation Commission have been complied with and that the information given above is true and complete to the best of my knowledge and belief.

Ernest A. Hanson
(Signature)

Operator
(Title)

August 18, 1965
(Date)

OIL CONSERVATION COMMISSION

APPROVED AUG 25 1965 , 19

BY

TITLE Engineer District I

This form is to be filed in compliance with RULE 1104.

If this is a request for allowable for a newly drilled or deepened well, this form must be accompanied by a tabulation of the deviation tests taken on the well in accordance with RULE 111.

All sections of this form must be filled out completely for allowable on new and recompleted wells.

Fill out Sections I, II, III, and VI only for changes of owner, well name or number, or transporter, or other such change of condition.

Separate Forms C-104 must be filed for each pool in multiply completed wells.

R-36-E

(Revised 7/1/52)
(Form C-105)

	Section 34						

T 19 S

AREA 640 ACRES
LOCATE WELL CORRECTLY

NEW MEXICO OIL CONSERVATION COMMISSION

Santa Fe, New Mexico

HOBBS OFFICE OCC
1957 JAN 28 AM 7:19

WELL RECORD

Mail to District Office, Oil Conservation Commission, to which Form C-101 was sent not later than twenty days after completion of well. Follow instructions in Rules and Regulations of the Commission. Submit in QUINTUPLICATE.

Shell Oil Company (Company or Operator) Foster (Lease)

Well No. 2-A, in SW 1/4 of SE 1/4, of Sec. 34, T. 19-S, R. 36-E, NMPM.

Eunont Pool, Lea County.

Well is 660 feet from south line and 2310 feet from east line of Section 34. If State Land the Oil and Gas Lease No. is -

Drilling Commenced January 2, 19 57 Drilling was Completed January 16, 19 57

Name of Drilling Contractor O'Neal Drilling Company

Address R R 1 Box 2, Midland, Texas

Elevation above sea level at Top of Tubing Head 3621 The information given is to be kept confidential until not confidential, 19

OIL SANDS OR ZONES

No. 1, from 3866 to 3961 No. 4, from to

No. 2, from to No. 5, from to

No. 3, from to No. 6, from to

IMPORTANT WATER SANDS

Include data on rate of water inflow and elevation to which water rose in hole.

No. 1, from to feet.

No. 2, from to feet.

No. 3, from to feet.

No. 4, from to feet.

CASING RECORD

SIZE	WEIGHT PER FOOT	NEW OR USED	AMOUNT	KIND OF SHOE	CUT AND PULLED FROM	PERFORATIONS	PURPOSE
8 5/8"	32#	new	295'				Surface String
5 1/2"	15.5#	new	3856'				Oil String

MUDDING AND CEMENTING RECORD

SIZE OF HOLE	SIZE OF CASING	WHERE SET	NO. SACKS OF CEMENT	METHOD USED	MUD GRAVITY	AMOUNT OF MUD USED
12 1/4"	8 5/8"	304	300	Pump & Plug	Cemented to surface	
7 7/8"	5 1/2"	3866	750	Pump & Plug		

RECORD OF PRODUCTION AND STIMULATION

(Record the Process used, No. of Qts. or Gals. used, interval treated or shot.)

Treated down tubing & casing w/20,000 gallons Control-frac w/1#/gallon sand & fluid-loss additive.

Result of Production Stimulation On OPT flowed 141 BOPD + 5 BW thru 14/64" choke. FTP 400 psi. FCP 1000 psi. GOR 821

Depth Cleaned Out 3961

Submit 3 Copies to Appropriate District Office

State of New Mexico
Energy, Minerals and Natural Resources Department

Form C-103
Revised 1-1-89

DISTRICT I
P.O. Box 1980, Hobbs, NM 88240

DISTRICT II
P.O. Drawer DD, Artesia, NM 88210

DISTRICT III
1000 Rio Brazos Rd., Aztec, NM 87410

OIL CONSERVATION DIVISION

P.O. Box 2088
Santa Fe, New Mexico 87504-2088

WELL API NO. 30-025-04164

5. Indicate Type of Lease STATE [X] FEE [ ]

6. State Oil & Gas Lease No. B-1543-1

SUNDRY NOTICES AND REPORTS ON WELLS

(DO NOT USE THIS FORM FOR PROPOSALS TO DRILL OR TO DEEPEN OR PLUG BACK TO A DIFFERENT RESERVOIR. USE "APPLICATION FOR PERMIT" (FORM C-101) FOR SUCH PROPOSALS.)

7. Lease Name or Unit Agreement Name
NORTH MONUMENT G/SA UNIT
BLK. 18

1. Type of Well: OIL WELL [X] GAS WELL [ ] OTHER

2. Name of Operator
AMERADA HESS CORPORATION

8. Well No.
9

3. Address of Operator
DRAWER D, MONUMENT, NEW MEXICO 88265

9. Pool name or Wildcat
EUNICE MONUMENT G/SA

4. Well Location
Unit Letter I : 1980 Feet From The SOUTH Line and 660 Feet From The EAST Line

Section 2 Township 20S Range 36E NMPM LEA County

10. Elevation (Show whether DF, RKB, RT, GR, etc.)

11. Check Appropriate Box to Indicate Nature of Notice, Report, or Other Data

NOTICE OF INTENTION TO:		SUBSEQUENT REPORT OF:	
PERFORM REMEDIAL WORK [ ]	PLUG AND ABANDON [ ]	REMEDIAL WORK [ ]	ALTERING CASING [ ]
TEMPORARILY ABANDON [ ]	CHANGE PLANS [ ]	COMMENCE DRILLING OPNS. [ ]	PLUG AND ABANDONMENT [ ]
PULL OR ALTER CASING [ ]		CASING TEST AND CEMENT JOB [ ]	
OTHER: [ ]		OTHER: Casing Test. [X]	

12. Describe Proposed or Completed Operations *(Clearly state all pertinent details, and give pertinent dates, including estimated date of starting any proposed work)* SEE RULE 1103.

03-24-93 Through 04-01-93
MIRU Ram Well Ser. & TOH w/rods & pump. Removed wellhead, installed BOP & TOH w/tbg. TIH w/6-1/8" bit to 3,793' & TOH. TIH w/7" RBP & set at 3,675'. Circ. hole w/fresh water. Press. tested 7" csg. to 500# for 30 min. Held OK. Chart attached. Pulled up hole & re-set RBP at 634'. Circ. hole clean. Removed BOP & Hinderliter tbg. head. Found top of 7" csg. lipped in. Re-installed BOP & re-set RBP at 3,634'. Spotted 4 sks. 12/20 sand on top RBP. Beveled out inside 7" csg. Cut off & removed 9-5/8" Hinderliter csg. head. Installed & tested 11" 3000# x 9-5/8" National csg. head & 7-1/16" 3000# x 11" 3000# National tbg. head. Set slips in csg. head w/90,000# tension. TIH w/retrieving head, cir sand off RBP, latched onto RBP & TOH. TIH w/6-1/8" bit & tagged up at 3,793'. Drld. & bailed out to 3,855'. Lowered bit to PBD at 3,911'. TOH w/bit. TIH w/7" TAC on 2-3/8" t Removed BOP & set TAC at 3,611' w/15,000# tension & SN at 3,893'. TIH w/pump & rods. RDPU cleaned lcoation & resumed prod. well.
Test of 04-07-93? Prod. 40 BO, 80 BW, & 7 MCFGPD in 24 hours.

I hereby certify that the information above is true and complete to the best of my knowledge and belief.

SIGNATURE R L Wheeler Jr TITLE SUPV. ADMIN. SERV. DATE 04-13-93

TYPE OR PRINT NAME Roy L. Wheeler, Jr. TELEPHONE NO. 393-2144

(This space for State Use)

Orig. Signed by
Paul Kautz
Geologist

APPROVED BY ______ TITLE ______ DATE APR 16 199

CONDITIONS OF APPROVAL, IF ANY:

C-105

N.

NEW MEXICO OIL CONSERVATION COMMISSION

Santa Fe, New Mexico

WELL RECORD

Mail to Oil Conservation Commission, Santa Fe, New Mexico, or its proper agent not more than twenty days after completion of well. Follow instructions in the Rules and Regulations of the Commission. Indicate questionable data by following it with (?). SUBMIT IN TRIPLICATE.

AREA 640 ACRES
LOCATE WELL CORRECTLY

Gulf Oil Corporation — Graham State
Company or Operator — Lease

2 Well No. 2 in NE SE of Sec. 2, T. 20S

R. 36E, N. M. P. M., Monument Field, Lea County.

Well is 660 feet south of the North line and 660 feet west of the East line of NE SE

If State land the oil and gas lease is No. A-1548 Assignment No.

If patented land the owner is -, Address

If Government land the permittee is, Address

The Lessee is Gulf Oil Corporation, Address Tulsa, Oklahoma

Drilling commenced Jan. 11, 1936 Drilling was completed Feb. 24, 1936

Name of drilling contractor Loffland Bros., Address Tulsa, Oklahoma

Elevation above sea level at top of casing 3585 feet.

The information given is to be kept confidential until ? 19

OIL SANDS OR ZONES

No. 1, from 3800' to 3915' No. 4, from to

No. 2, from to No. 5, from to

No. 3, from to No. 6, from to

IMPORTANT WATER SANDS

Include data on rate of water inflow and elevation to which water rose in hole.

No. 1, from Rotary hole to feet.

No. 2, from to feet.

No. 2, from to feet.

No. 4, from to feet.

CASING RECORD

SIZE	WEIGHT PER FOOT	THREADS PER INCH	MAKE	AMOUNT	KIND OF SHOE	CUT & FILLED FROM	PERFORATED FROM	PERFORATED TO	PURPOSE
13"OD	40	8	SS	306'	?				
9-5/8"OD	36	8	LW	1065'	?				
7" OD	24	10	SS	3724'	?				

MUDDING AND CEMENTING RECORD

SIZE OF HOLE	SIZE OF CASING	WHERE SET	NO. SACKS OF CEMENT	METHOD USED	MUD GRAVITY	AMOUNT OF MUD USED
17½"	13"OD	306'	250	Halliburton		
12½"	9-5/8"	1065'	350	"		
8-5/8"	7"	3724'	525	"		

PLUGS AND ADAPTERS

Heaving plug—Material Length Depth Set

Adapters—Material Size

RECORD OF SHOOTING OR CHEMICAL TREATMENT

SIZE	SHELL USED	EXPLOSIVE OR CHEMICAL USED	QUANTITY	DATE	DEPTH SHOT OR TREATED	DEPTH CLEANED OUT
		Hydrochloric Acid	2000 Gal.	2-24-36		

Form 3160-5
(June 1990)

UNITED STATES
DEPARTMENT OF THE INTERIOR
BUREAU OF LAND MANAGEMENT

FORM APPROVED
Budget Bureau No. 1004-0135
Expires: March 31, 1993

SUNDRY NOTICES AND REPORTS ON WELLS

Do not use this form for proposals to drill or to deepen or reentry to a different reservoir.
Use "APPLICATION FOR PERMIT—" for such proposals

SUBMIT IN TRIPLICATE

5. Lease Designation and Serial No.
NM-1150

6. If Indian, Allottee or Tribe Name

7. If Unit or CA, Agreement Designation
BLK. 18
N. Monument G/SA Unit

1. Type of Well
☐ Oil Well ☐ Gas Well ☐ Other TA'd

2. Name of Operator
Amerada Hess Corporation

3. Address and Telephone No.
Drawer D, Monument, New Mexico 88265 (505) 393-2144

4. Location of Well (Footage, Sec., T., R., M., or Survey Description)
660' FNL & 660' FEL, Sec. 3, T20S, R36E

8. Well Name and No.
17

9. API Well No.
30-025-0417400

10. Field and Pool, or Exploratory Area
Eunice Monument G/SA

11. County or Parish, State
Lea County, NM

12. CHECK APPROPRIATE BOX(s) TO INDICATE NATURE OF NOTICE, REPORT, OR OTHER DATA

TYPE OF SUBMISSION	TYPE OF ACTION	
☐ Notice of Intent	☐ Abandonment	☐ Change of Plans
☒ Subsequent Report	☐ Recompletion	☐ New Construction
☐ Final Abandonment Notice	☐ Plugging Back	☐ Non-Routine Fracturing
	☐ Casing Repair	☐ Water Shut-Off
	☐ Altering Casing	☐ Conversion to Injection
	☒ Other Press. Test csg. & check Bradenhead.	☐ Dispose Water
		(Note: Report results of multiple completion on Well Completion or Recompletion Report and Log form.)

13. Describe Proposed or Completed Operations (Clearly state all pertinent details, and give pertinent dates, including estimated date of starting any proposed work. If well is directionally drilled, give subsurface locations and measured and true vertical depths for all markers and zones pertinent to this work.)*

NMGSAU #1817 05-16-95

Rowland Trucking moved in and rigged up. Opened surface and intermediate casing valves. No pressure. Note: 10-3/4" x 7-5/8" annulus and 7-5/8" x 5-1/2" annulus both have cement to surface. Pressure tested 5-1/2" and 4-1/2" liner, CIBP at 3,830', to 540# and charted 30 min. casing integrity test. Well lost 20# to 520#. Test witnessed by Steve Caffey w/Bureau Of Land Management. Released casing pressure. Rowland Trucking rigged down and moved out. Closed in. Well TA'd for future NMGSAU use.

14. I hereby certify that the foregoing is true and correct

Signed Bill Hearne Title Sr. Production Foreman Date 05-18-95

(This space for Federal or State office use)

Approved by ______ Title ______ Date ______
Conditions of approval, if any:

Title 18 U.S.C. Section 1001, makes it a crime for any person knowingly and willfully to make to any department or agency of the United States any false, fictitious or fraudulent statements or representations as to any matter within its jurisdiction.

*See Instruction on Reverse Side

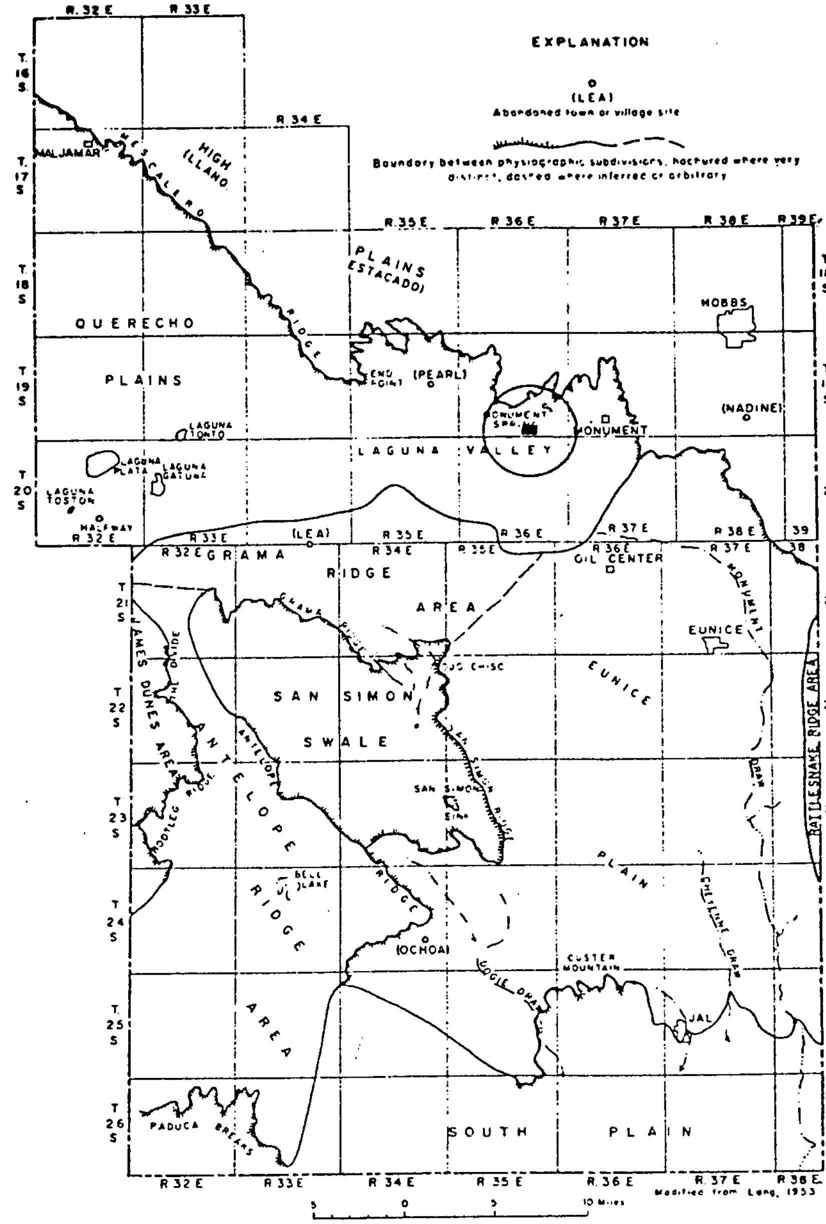
GEOLOGY

PHYSIOGRAPHY

The Climax Chemical plant is located near Monument, Lea County, New Mexico, approximately 20 miles west of the Texas - New Mexico border (Plate 1). The nearest populated area is Hobbs, located ten miles northeast of Monument. The climate of the area ranges from dry subhumid to arid, and is characterized by low annual precipitation, low humidity and high average annual temperature. Mean annual precipitation ranges from 15.68 to 12.63 inches per year and the mean annual temperature is about 62°F (Nicholson and Clebsch, 1961). Due to the low precipitation and rapid infiltration into the surficial sediments, flood potential is extremely low.

Lea County is divided into two physiographic subdivisions of the Great Plains physiographic province, the Pecos Valley section and the High Plains section. As illustrated in Figure 3.1, the proposed well location is in the Pesos Valley section which is divided into the Querecho Plains, Laguna Valley, Grama Ridge Area, Eunice Plains, San Simon Swale, Antelope Ridge Area and the South Plain (Nicholson and Clebsch, 1961).

To the north of Climax Chemical, the southern extent of the High Plains section is marked by the Mescalero Ridge of the Llano Estacado. An abrupt change in topography is the primary contrast between the Llano Estacado and the Pecos Valley. The Llano Estacado is an almost uniform depositional surface of low relief sloping southeastward. In contrast, the Pecos Valley is a very irregular erosional surface



PHYSIOGRAPHIC SUBDIVISIONS OF SOUTHERN LEA COUNTY, N. MEX.

AFTER GROUND WATER REPORT 6, STATE BUREAU OF MINES AND MINERAL RESOURCES

KEN E. DAVIS ASSOCIATES
BATON ROUGE LA HOUSTON TX

FIGURE 3.1
PHYSIOGRAPHIC MAP OF SOUTHERN LEA COUNTY
CLIMAX CHEMICAL
HOBBS, NEW MEXICO

DATE 6-14-83	CHECKED BY MDJ	JOB NO 83-261
DRAWN BY PJE	APPROVED BY MDJ	DWG NO

C & D REPROGRAPHICS 53555-1

sloping toward the Pecos River (westward). Total relief of the area is about 1,300', having altitudes ranging from 4,000' mean sea level (MSL) to 2,900' MSL. A geologic map depicting the physiographic subdivisions of southern Lea County is included as Plate 2 and a brief description of the divisions follow:

Mescalero Ridge and High Plains

Mescalero Ridge is the most prominent topographic feature in southern Lea County and as previously stated, marks the southern limit of the High Plains section. The ridge is a nearly perpendicular cliff capped by a thick layer of resistant caliche, locally called caprock.

The High Plains is a uniformly flat surface sloping about 17' per mile southeast. The only significant relief features are small sand dunes and shallow depressions called buffalo wallows. These depressions range in size from a few feet to more than a quarter of a mile and can be up to 20' deep. Buffalo wallows collect rainfall and contain it until removed by evaporation or seepage.

Querecho Plains and Laguna Valley

Immediately southwest and south of Mescalero Ridge is a vast sand dune area of approximately 400 square miles called Querecho Plains (to the west) and Laguna Valley (to the east). As shown on Figure 3.1, the Climax Chemical plant is located in Laguna Valley. The Querecho Plains - Laguna Valley area is almost entirely covered by dune sand which is stable or semi-stable over most of the area. The sand is generally underlain by Recent alluvium and may be underlain by caliche in places. Drillers logs indicate surface sand underlain by caliche is found to depths of about 35'.

The most significant feature in the area is a group of four playas or dry lakes. These playas are irregularly shaped, flat-bottomed, and are underlain by fine sediments with some pebble gravel and precipitated salt and gypsum.

Grama Ridge Area

The Grama Ridge Area is directly south of the Querecho Plains-Laguna Valley area and is topographically higher, indicating it may be an outlier, or detached portion of the High Plains. It is characterized by a hard caliche surface with a texture and composition indicating it was once part of the Llano Estacado. The surface of the Grama Ridge Area has many shallow depressions which do not have integrated drainage.

Eunice Plain

The area east of Laguna Valley and Grama Ridge is referred to as the Eunice Plain. It is bounded on the north by the Llano Estacado and on the southwest by San Simon Ridge and Antelope Ridge. The westward extension of the Eunice Plain is the Grama Ridge area. Dune sands almost entirely cover the Eunice Plain and it is usually underlain by a hard caliche surface. In some places; however, it is underlain by alluvial sediments. A sand cover is generally 2' to 5' thick, but may be 20' to 30' thick locally.

Rattlesnake Ridge

Toward the east, the Eunice Plain rises into a north-trending topographic high called Rattlesnake Ridge. It parallels the state line for most of its length and is regarded as the drainage divide between the Pecos Basin and the Colorado River Basin, Texas.

San Simon Swale

To the west of Eunice Plain is San Simon Swale, a large depression covering about 100 square miles. Most of San Simon Swale is covered by stabilized dune sand and shows no apparent drainage pattern. The deepest point of the swale is San Simon Sink, being 100' deep and a half mile across. Calcareous silt and fine sand are the predominant fill material in the sink.

Antelope Ridge Area

The area to the west and southwest of Antelope Ridge has been called the Antelope Ridge Area, located in southwestern Lea County. The area is relatively flat, sand-covered surface similar to the Eunice Plain and it is also partially underlain by caliche. Towards the south, the area appears to be underlain by Quaternary fill and loamy soil similar to the San Simon Swale. Because the Antelope Ridge is an anomalous geographic feature similar to the High Plains, it is thought to be an outlying remnant of the High Plains.

3.2 HISTORICAL GEOLOGY

The Precambrian history of Southern Lea County is a complex history of mountain building, metamorphism and erosion. Active deposition was taking place in the area during most of the Paleozoic Era. In later Paleozoic time, the south-central United States was a region of crustal unrest with the most significant activity in the West Texas-New Mexico area taking place in Pennsylvanian time. During this time and earlier in the the Paleozoic, a geosyncline (the Llanoria geosyncline) formed across West Texas and adjacent states. (A geosyncline is a linear trough which has subsided throughout time accumulating large volumes of clastic sediment). Strong compressional forces from the southeast caused the geosynclinal area to be raised into mountain ranges which some refer to as the Marathon folded belt. Although much of the folded belt was eroded, it remained high during most of Permian time. During the Pennsylvanian Period, what is now the Central Basin Platform was also emergent in the form of mountain ranges and the area was subject to erosion.

At the close of the Pennsylvanian, the major features of the Permian Basin formed as the whole area subsided. The Central Basin Platform subsided more slowly than the Delaware and Midland Basins and received fewer sediments under different depositional conditions. The basins were areas of accumulation of large amounts of sediment. Limestone tended to form in higher areas, such as the Central Basin Platform, while the formation of evaporites took place at the fringes of the sea. At the very edge of the seas, redbeds were formed by the deposition of sediments from nearby land masses.

During Wolfcamp time (early Permian), seas spread over the region and later became restricted causing deposition of (redbeds,) evaporites and limestones. The final event of the Permian was the retreat of evaporite-depositing waters from the West Texas region which caused the deposition of a thin layer of redbeds known as the Ochoan Series.

The end of the Permian, and therefore the end of the Paleozoic Era, marks a major time break in the geologic column. During most of the Triassic (except late Triassic) and Jurassic, most of southern Lea County was emergent and undergoing erosion.

During early to middle Cretaceous time, Southeastern New Mexico was covered by a large shallow sea which deposited a thick sequence of Cretaceous rocks. In the late Cretaceous, during the uplift of the Rocky Mountains, seas retreated from the Lea County area and intense erosion took place removing almost all Cretaceous rocks.

In the Pliocene Age, the Ogallala Formation was evenly deposited across the High Plains area, effectively removing the irregular surface formed by previous episodes of erosion. An erosional cycle again began during the Quaternary, removing much of the Ogallala Formation and eroding Triassic rocks for the third time at some locations. Accordingly, erosion by the major rivers of New Mexico and Texas caused the isolation of a large remnant of the Ogallala Formation, the Llano

Estacado. The climate of the region became more arid in the late Quaternary, and detrital material was reworked by wind creating the large sand dune deposits in the area.

3.3 STRATIGRAPHY

The Climax Chemical plant is located in the Central Basin Platform of the Permian Basin. According to the work of Nicholson and Clebsch (1961), approximately 8,000' of geologic strata overlie the Precambrian basement rocks in the Central Basin Platform. Only strata of middle Permian age and younger are pertinent to this study. Included as Figure 3.2 is a generalized stratigraphic column for Southeastern New Mexico and a regional cross-section is shown in Plate 3 . In addition, a colored stratigraphic column based on driller's logs near the site is depicted in Figures 3.3 and 3.4. Following in ascending order is a brief description of the stratigraphy beneath the proposed well site.

Guadalupian Series (Middle Permian)

The Guadalupian Series in the Central Basin Platform consists of the San Andres Formation and the Whitehorse Group. The Whitehouse Group consist of a fine-grained sandstone with thin layers of black shale and argillaceous limestone and, according to King (1942), can also be referred to as the Artesia or Chalk Bluff Group. The Whitehorse Group of the Central Basin Platform is correlative to the Delaware Mountain Group of the Delaware Basin. In the Monument area, it

TABLE 3.1

GEOLOGIC CROSS SECTION AT CLIMAX PLANT SITE
SECTION 35, TOWNSHIP 19S, RANGE 36W
MONUMENT, NEW MEXICO
ELEVATION -3595'

FROM	TO	THICKNESS IN FEET	FORMATION	TDS RANGE IN MG/L
0 -	2	2	Soil	
2 -	22	20	Calichi	
22 -	45	23	Ogallala	600->3250
45 -	1008	963	Red Beds	
	(Top of Anhydrite @ 1008')			
1008 -	1160	152	Dockum Group	
1160 -	2303	1143	Salt	
2303 -	2423	120	Tansill	
2423 -	2853	430	Yates	
2853 -	3225	372	7-Rivers	
3225 -	3570	345	Queen	
	(Top of Penrose @ 3380')			13-19,000
3570 -	3800	230	Grayburg	15 - 34,000
3800 -	5150	1350	San Andres	15,000+
	(Top of Oil/Water contact - 3995')			
	(Disposal Zone 4300'-5150'±)			

Revised 2/13/84

KEN E. DAVIS ASSOCIATES

Ochoan Series (Upper Permian)

The lowermost formation of the Ochoan Series is the "Salt" Formation, consisting of anhydrite and some halite. It rests unconformably on the Whitehorse Group in the Central Basin Platform but does not extend beyond the basin margins. Total thickness of the anhydrite and halite at the plant site is approximately 1200'. Halite was mined by Climax Chemical Company in the subsurface interval between 1400' to 2616'.* Three brine wells previously used to leach salt have been plugged and abandoned by Climax. The base of mineable salt was found to be at a depth of approximately 2610'.

The "Salt" Formation is unconformable in places with the overlying Rustler Formation. The top of the Rustler is considered to be the top of the first continuous anhydrite bed penetrated by oil and gas wells in southeastern New Mexico and occurs at a depth of 1008' in the Climax area. The Rustler is characterized as dolomitic limestone with some sandstone and chert pebble conglomerates at the base. Eastward, in the area of Monument, the limestone is overlain by anhydrite, redbeds and halite which is considered an upper member. In Lea County, the Rustler is between 90' to 360' thick and appears to be 100'$\pm$ thick at the proposed well site.

The "Salt" Formation and Rustler Formation together compose the Salado Group or Ochoan Series as shown in Figure 3.2.

Upper Permian or Triassic

Above the Rustler Formation are the undifferentiated redbeds of Permian or Triassic age. They consist of micaceous red siltstone, sandstone, shale and are cemented with gypsum. They are thought to retard the movement of water between the rocks of the Permian and the overlying aquifers (Nicholson and Clebsch, 1961). The Middle and Upper Triassic consists of a sequence of redbeds, the Dockum Group, which rest unconformably on the lower undifferentiated redbeds. The Dockum can usually be differentiated into the Santa Rosa Formation and the uppermost Chinle Formation. The Santa Rosa is a fine-to-coarse-grained sandstone containing minor shale layers and ranging in thickness from 140' to 300'. The Santa Rosa and the Chinle are similar lithologically and in some places have been mapped as the Dockum Group, undifferentiated.

The Chinle Formation consists of red and green claystone which is interbedded with fine-grained sandstone and siltstone. The Chinle has been eroded in the west; however, it reaches a thickness of 1,270' near the Monument area. About 2 miles southeast of Monument, the Chinle grades into a micaceous red clay (Nicholson and Clebsch, 1961).

Both the Dockum Group and the undifferential redbeds are estimated to be 888' thick at the plant site with the top at approximately 120' below the surface.

Cretaceous

The rocks of Cretaceous age, although once present in Lea County, have been almost entirely removed by erosion. The only known exposure of Cretaceous rocks in Lea County are found in a gravel pit of the Lea County Concrete Company about seven miles south of Hobbs. At the site, the limestone is white, light gray or buff and highly fossiliferous. There are no known deposits of Jurassic rocks in Lea County.

Tertiary

Beneath the surficial deposits, at the proposed location, are rocks of the Tertiary System represented by the Ogallala Formation of Pliocene age. It is a heterogeneous complex of terrestrial sediments, consisting chiefly of a calcareous, unconsolidated sand containing clay, silt, and gravel. Conditions of deposition varied rapidly during Ogallala time causing well-sorted sediments to be interbedded with poorly sorted sediments. The Ogallala Formation ranges from a few feet to as much as 300' thick and is a major aquifer where it has sufficient thickness.

Quaternary System

In the Monument area, sediments of the Quaternary System exist in the form of alluvial deposits of Pleistocene and Recent age and dune sands of Recent age. The older alluvium is exposed locally in small duneless patches, or in pits and it underlies the areas of Querecho Plains, Laguna Valley, San Simon Swale and several smaller areas. The alluvium ranges in thickness from a few inches to more than 400' in San Simon Sink.

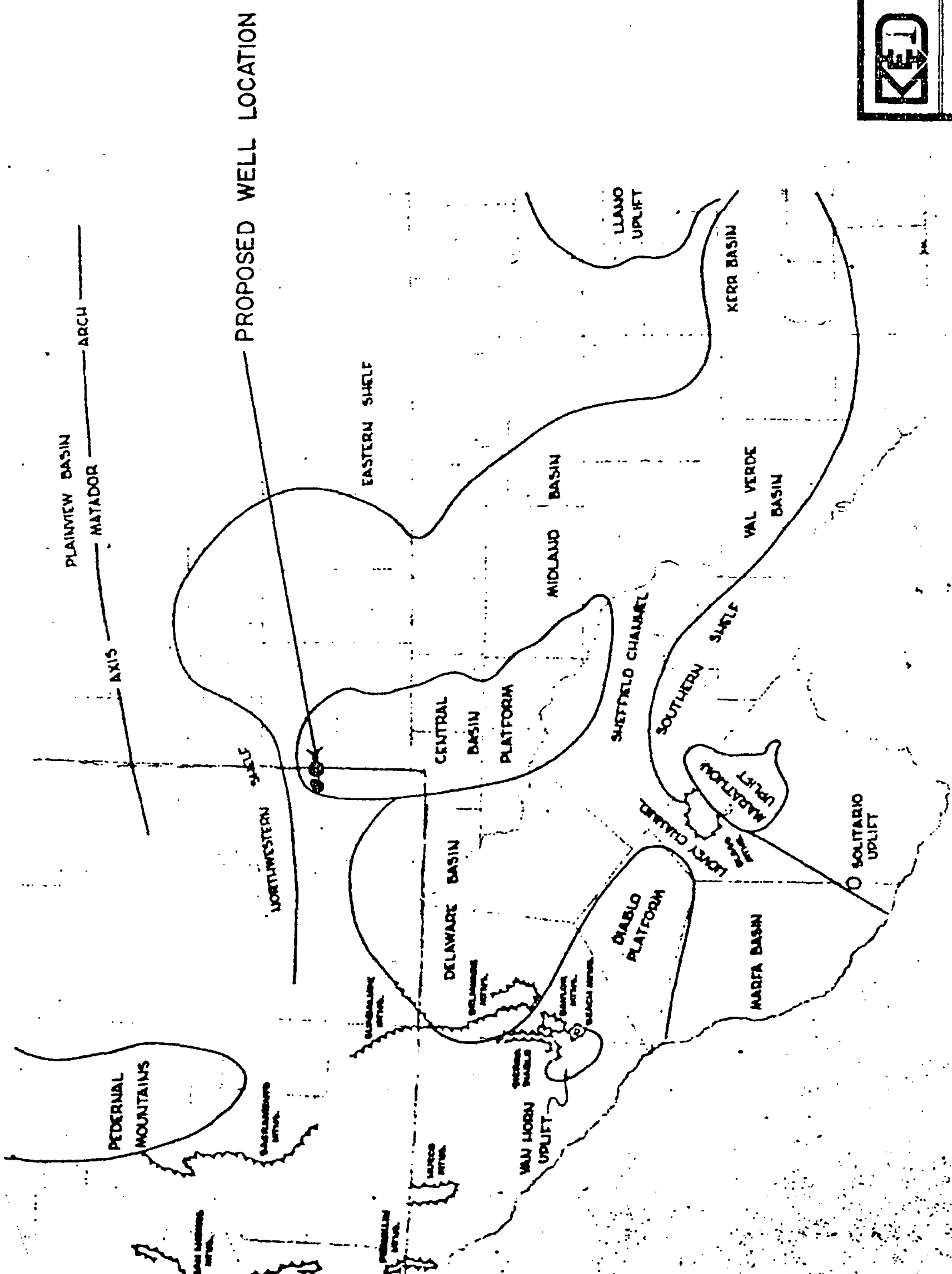
The most extensive Quaternary unit is the cover of red dune sand called the Mescalero Sands. This fine-to-medium grained, reddish-brown sand, which covers 80% of Lea County, parts of Eddy County, and West Texas, was probably derived from the Permian and Triassic rocks of the Pecos Valley. In the vicinity of Climax, the alluvial deposits consist of unconsolidated fine to coarse sand and gravel with stringers of silt and clay, and Eaolian sands cover the surface. (Geohydrology Associates, 1982).

3.4 STRUCTURAL GEOLOGY

Regional Structure

West Texas and half of Southern New Mexico is part of a large subsurface structural feature known as the Permian Basin, which is subdivided into several smaller areas. As previously mentioned, Climax Chemical Plant is located on the Central Basin Platform (See Figure 3.5) and is bounded by the Northwestern Shelf on the North, the Delaware Basin on the West, the Sheffield Channel and Southern Shelf on the south and the Midland Basin on the East. Basins are depressed areas that may vary in size and shape and are formed by subsidence of an area or uplift of the surrounding regions. In most cases, basins probably result from both subsidence and uplift (Huffington, et al 1951).

Jones, T. S. (1953), Stratigraphy of the Permian Basin of West Texas, West Texas Geological Society, Page 3.



AFTER JONES, 1953

KEN E. DAVIS ASSOCIATES
BATON ROUGE LA HOUSTON TX

FIGURE 3.5

PERMIAN BASIN STRUCTURE

CLIMAX CHEMICAL
HOBBS, NEW MEXICO

DATE 6-14-83	CHECKED BY SEO	JOB NO 83-281
DRAWN BY PJE	APPROVED BY SEO	DWG NO

OFFICE PHONE EX 3-2961
RES. PHONE EX 3-2062

905 NORTH DALMONT

MILLER ENGINEERING & GEOLOGICAL CO.
POST OFFICE BOX 417
ZIP CODE 88240
HOBBS, NEW MEXICO

E-8-8
~~Fed #4~~
~~Potter~~
Fell #4 Brine well

July 28, 1978

Climax Chemical Company Attn: Mr. Ed Smith
P. O. Box 1595
Hobbs, New Mexico 88240

Dear Ed:

The enclosed tabulation of Casing records and total depths drilled on wells located in sections 34 and 35 of township 19 South, range 36 E; and sections 3 and 4 of township 20 South, range 36 E, of the Monument Field may be of some informative value.

This data was compiled, to a large extent, from Oil Scout reports and to a limited from personal investigation of the Oil Conservation records. It is somewhat of a reconnaissance survey and if we find the need to go into more detail, the Oil Conservation records should be consulted.

Yours very truly,

Charles P. Miller

Charles P. Miller

cpm

T 19 S, R 36 E

COMPANY & LSE	SEC.	UNIT	SURF CSG (DEPTH SX)	INTERMEDIATE	PAY CSG (DEPTH SX)	T.D.	ELEV	COMPL. DATE
Amerada Gaither 1	34	I	12½-227-150	8-5/8 2540-500	6-5/8-3814-100	3950	3632	7/13/36
" " 2	34	F	9-5/8-310-300	- - - - - - - -	7"- 3996- 800	3996	3652	10/11/54
" " 3	34	K	9-5/8-317-300	- - - - - - - -	7"-3800- 700	3940	3638	11/7/64
" " 4	34	J	8-5/8-1314-800	- - - - - - - - -	5½-3870-400	3940		6/7/56
Climax Chem 3	34	K						
" " 4	34	P						
Gulf Oil Smith 1	34	H	10-3/4-228-200	7-5/8-1281-300	5½-3800-300	3970	3642	6/11/36
" " " 2	34	A	12½-285-250	9-5/8-1240-375	7 -3843-200	3975	3657	5/11/37
" " " 3	34	C	9-5/8-311-275	- - - - - - - -	7- 3832-1650	4000	3677	1/28/55
" " " 4	34	D	9-5/8-338-275	- - - - - - - -	7- 3860-1750	4000	3681	5/26/55
" " " 5	34	B	9-5/8-1377-900	- - - - - - - -	7- 3980-600	3980	3685	3/16/56
" " " 6	34	G	8-5/8-1378-850	- - - - - - - -	5½-3950-600	3950	3651	4/9/56
Resler & Sheldon Smith 1	34	E	8-5/8-234-100	- - - - - - - -	5½-4000-400	4000	3654	8/9/54
" " 2	34	L	8-5/8-285-150	- - - - - - - -	5½- 3903-400	3980	3642	9/30/54
Shell Foster 1	34	P	12½-248-125	9-5/8-1201-350	7 -3707-250	3957	3632	6/11/36
" " 2	34	O	8-5/8-1265-500,	- - - - - - - -	5½-3702-125	3953	3627	3/13/39
" " 2A	34	O	8-5/8-304- 300	- - - - - - - -	5½-3866-750	3961		1/22/57
" " 3	34	N	8-5/8-301- 250	- - - - - - - -	5½-3950-750	3950	3633	12/2/54
" " 4	34	M	8-5/8-306-300	- - - - - - - -	5½-3971-660 ,,	3972	3638	12/30/54
Amerada Weir 1	35	M	12½-205-100	9-5/8-2435-500	7 -3815-100	3945	3621	2/5/36
" " 3	35	L	12½-219-150	8-5/8-2455-500	6-5/8-3815-100	3945	3626	4/19/36
" " 4	35	F	12½-217-150.	8-5/8-2425-500	6-5/8-3815-100	3945	3627	4/22/16
" " 5	35	E	12½-222-50	8-5/8-2479-500	6-5/8-3819-100,	3955	3636	7/6/36
" " 6	35	C	12½-188-180	8-5/8-2492-500	6-5/8-3828-100	3975	3652	8/22/36
" " 8	35	D	12½-191-200,	8-5/8-2539-600	6-5/8-3845-100	3960	3653	4/15/37
Gulf Oil Weir 1	35	A	10-3/4-279-250	7-5/8-1181-250	5½- 3866-300	3978	3633	3/5/36

COMPANY & LSE	SEC	UNIT	SURF. CSG (DEPTH SX)	INTERMEDIATE	PAY CSG. (DEPTH SX)	T.D.	ELEV	COMPL DATE
Shell State 1	35	P	12½-174-150	9-5/8-2450-450	7-3800-135	3929	3594	6/22/35
Republic Prod.								
Selby-Maveety 1	35	N	12½-253-100	9-5/8-2375-400	7-3975-200	3940?	3975	11/9/35
" " " 2	35	K	12½-313-200	9-5/8-2400-400	7-3815-232	3927	3610	2/5/36
" " " 1A	35	K	7 - 308-300	Excessive deviation @ 2310"	P @ A			
Sinclair,Selby1AX	35	N				3950	3653	11/19/59
Sun Maveety 1	35	P		7"-2532-400	4-3/4-3790-200	3935	3591	7/16/35
" " 2	35	O	12½-162-100	9-5/8-2340-400	7-3776-200	3936	3607	9/3/35
" " 3	35	H	12½-258-250	9-5/8-2395-400	7-3774-215	3945	3604	10/27/35
" " 4	35	J	13¼-249-400	9-5/8-2397-400	7-3777-200	3939	3610	2/7/36
" " 5	35	G	12½-305-125	9-5/8-2476-400	7-3825-200	3940	3609	5/8/36
" " 6	35	B	12½-297-125	9-5/8-2481-400	7-3824-200	3972	3647	6/21/36
" " 7	35	G	8-5/8-342-200	- - - - - - -	4½-4100-454	4100	3611	12/3/66 Few Holes in csg 503-1075
Sun Oil Weir 1	35	I	12½-158-100	9-5/8-2334-390	7-3795-200	3935	3601	7/20/35

T 20 S, R 36 E

COMPANY & LSE	SEC	UNIT	SURF. CSG	INTERMEDIATE	PAY CSG.	T.D.	ELEV	COMPL DATE
Amerada St. J 1	2	O	12½-220-150	9-5/8-2376-500	7-3789-200	3921	3591	1/20/36
" " " 2	2	J	12½-197-150	8-5/8-2334-500	7-3784-125	3900	3597	1/20/36
" " " 3	2	K	13/58-162-	8-5/8-2346-500	6-5/8-3810-100	3930	3612	4/13/36
" " " 4	2	K	8-5/8 383-350	- - - - - - - -	4½-3499-1150	3500	3598	6/12/76
Amerada St. M 1	2	F	12½-225-150	8-5/8-2386-500	7-3805-160	3920	3605	3/18/36
" St. S 1	2	N	12½-239-150	8-5/8-2372-500	6-5/8-3811-100	3915	3604	5/25/36
" " " 2	2	M	12½-224-150	8-5/8-2435-500	6-5/8-3756-100	3920	3605	7/19/36
" Weir 1	2	C	12½-216-150	8-5/8-2408-500	6-5/8-3800-100	3930	3614	4/1/36
" " 2	2	D	12½-216-150	8-5/8-2412-500	7-3800-100	3930	3614	4/1/36
Anderson-Prich.								
State 1	2	E	12½-265-250	9-5/8-2541-600	7-3795- 50	3910	3614	6/11/36
Gulf Graham St								
"B"1	2	P	13-255-250	9-5/8-2353-800	7-3696-125	3903	3579	11/22/35
" " 2	2	I	13-311-300	9-5/8-1065-350	7-3724-525	3915	3583	2/28/36

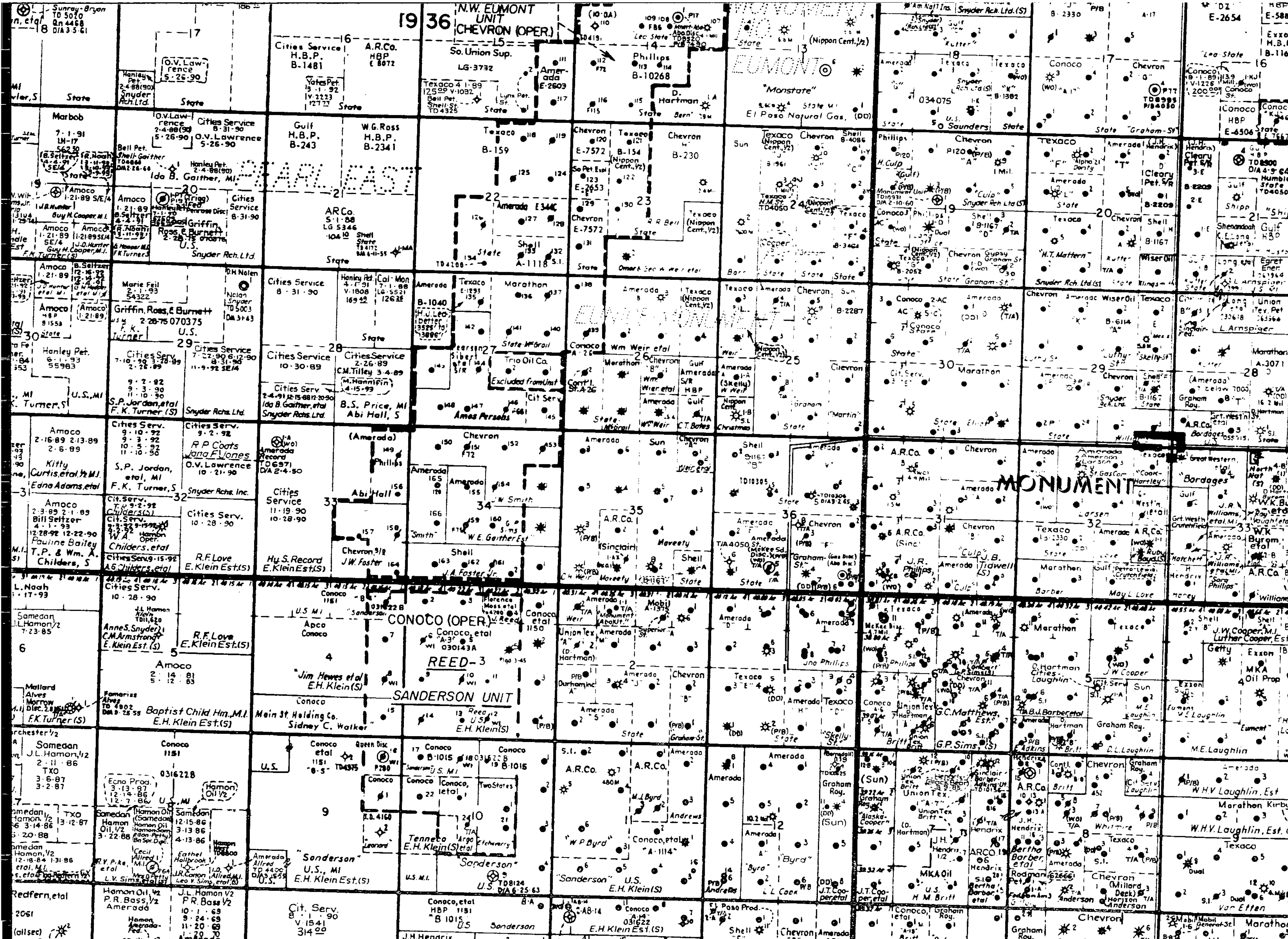
T 20 S, R 36 E

COMPANY & LSE		SEC.	UNIT	SURF CSG. Depth Sx	INTEEMEDIATE	PAY CSG. Depth Sx	T.D.	ELEV.	COMPL DATE	
Superior St A	1	2	A	13-3/8- 170-110	9-5/8-2344-450	7-3791-75	3945	3596	7/10/35	
" "	2	2	B	12½-265-100	9-5/8-2385-500	7-3785-45	3935	3603	10/30/35	
" "	3	2	H	13-3/8-255-200	9-5/8-2441-500	7-3791-45	3923	3592	12/14/35	
" "	4	2	G	13-3/8-166-110	9-5/8-2383-500	7-3815-165	3912	3594	1/27/36	
" "	6	2	A		9-5/8-340 -250	7-4000-300	4000	3597	9/8/54	
Turner St,A	1	2	K	12½-255-200,	9-5/8-1210-500 ,,	7-3773-200	3899	3604	6/8/36	
Union Tex. Pet. Corp.(St.A	2	2	E	8-5/8-370-170	- - - - - - - -	5½-4050-1800	4050	3610	10/3/63	(2 wells on this unit. Easterly test. Plugged
Cont'l Oil Co. Reed A-3	1	3	A	10-3/4-254-200	7-5/8-2628-900	5½-3787-150	3896	3628	4/17/36	Temp. Abnd
"	2	3	H	10-3/4-250-250	7-5/8-1221-400	5½-3812-400	3930	3616	6/27/36	Gas well
"	3	3	I	10-3/4-245-200	7-5/8-1235-400	5½-3817-400	3930	3616	6/27/36	Gas well
"	4	3	P	10-3/4-272-225	7-5/8-1278-425	5½-3768-425	3851	3611	10/19/36	Temp S.I.
"	5	3	G	10-3/4-274-250	7-5/8-1301-425	5½-3925-425	3925	3622	12/9/36	P & A
"	6	3	D	8-5/8-1404-600		5½-4001-1095	4003	3632	4/19/55	Injec.Well
"	7	3	C	8-5/8-1339-650		5½-3950-1203	3950	3627	4/20/55	Injec Well
"	8	3	F	9-5/8-1369-70		5½-3949-1360	3950	3626	6/3/55	
"	9	3	E	8-5/8-1372-650		5½-4009-1402	4010	3631	6/30/55	
"	10	3	K	8-5/8-1324-650		5½-3949-1045	3950	3626	8/3/55	Injec Well
"	11	3	L	8-5/8-1399-650		5½-3995-888	3996	3630	8/30/55	
"	12	3	N	8-5/8-325- 250		5½-3949-1390	3950	3621	9/9/55	
"	13	3	M	8-5/8-334-215		5½-3999-1530	4000	3626	10/9/55	Injec Well
"	14	3	O	8-5/8-318-250		5½-4006-348	4000	3619	8/12/57	
"	15	3	J	8-5/8-314-250		5½-3999-1675	4000	3622	5/1/58	
H.S. Moss (Cont'l Oil) Reed	1	3	G	10-3/4-295-225		7"3804-200	3913	3625	2/20/53	

See Next Page For Additional Data Contl. Reed #6, #7, #10, #13, #14, etc

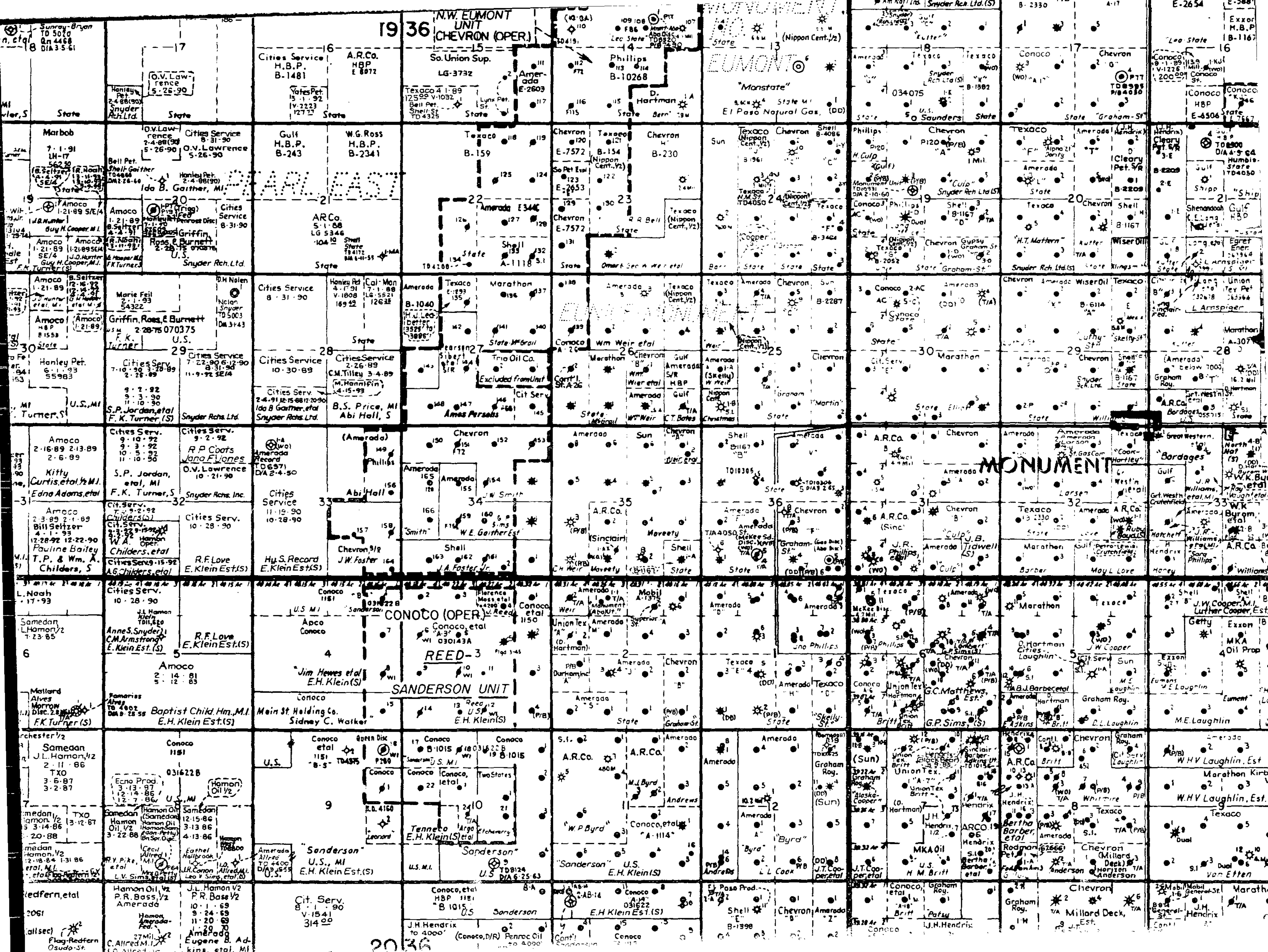
T 20 S, R 36 E

Continental	Reed A-3	#1	Temporarily Abandoned
"	"	#2	Recpmpleted as a gas well
"	"	#3	Recompleted as a gas well
"	"	#4	Temporarily shut in
"	"	#5	Plugged and abandoned
"	"	#6	Converted to water injection well. Packer on tbg. @ 3689
"	"	#7	Converted to water injection well. Packer on tbg. @ 3910
"	"	#10	Converted to water injection well. Packer on tbg. @ 3865
"	"	#13	Converted to water injection well. Packer on tbg. @ 3678
" "	"	#14	Converted to water injection well. Packer on tbg. @ 3698



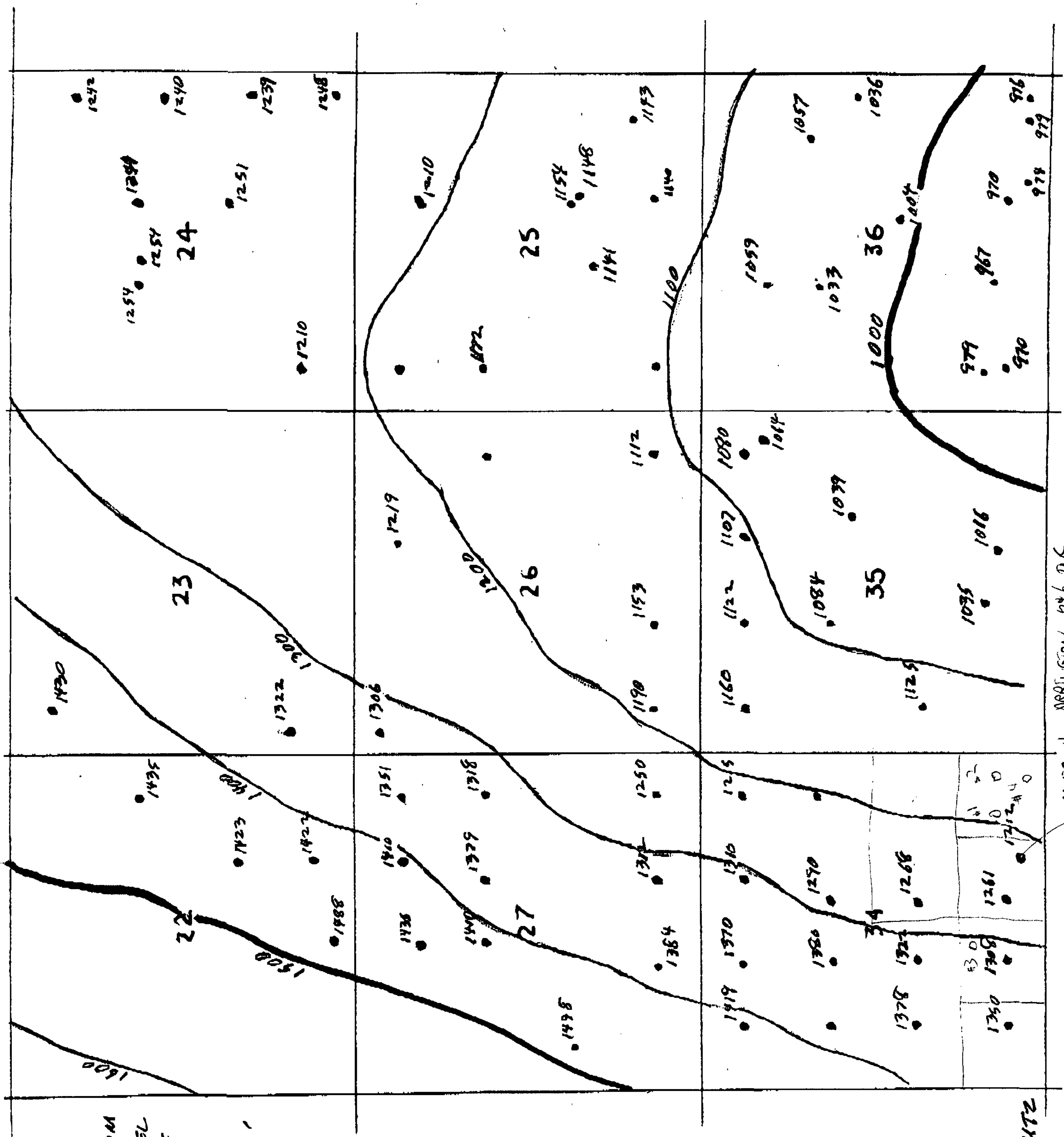
N.W. EUMONT UNIT CHEVRON (OPER.)
EUMONT
MONUMENT
CONOCO (OPER.)
REED-3
SANDERSON UNIT
Ames Persons
Excluded from Unit

6-9-88



N.W. EUMONT UNIT CHEVRON (OPER.)
EUMONT
MONUMENT
CONOCO (OPER.)
REED-3
SANDERSON UNIT
So. Union Sup.
Cities Service
Snyder Rch. Ltd.
Griffin, Ross, & Burnett
Excluded from Unit
Baptist Child. Hm., M.I.
E.H. Klein Est. (S)
Mein St. Holding Co.
Sidney C. Walker
El Paso Natural Gas
"Monstate"
Ida B. Gaither, MI
Ames Persels
W.E. Gaither Est.
J.A. Foster, Jr.
G.C. Matthews, Est.
G.P. Sims (S)
W.H.V. Laughlin, Est.
Millard Deck, Est.

6-9-88



DEPTH FROM GROUND LEVEL TO TOP OF ANHYDRITE

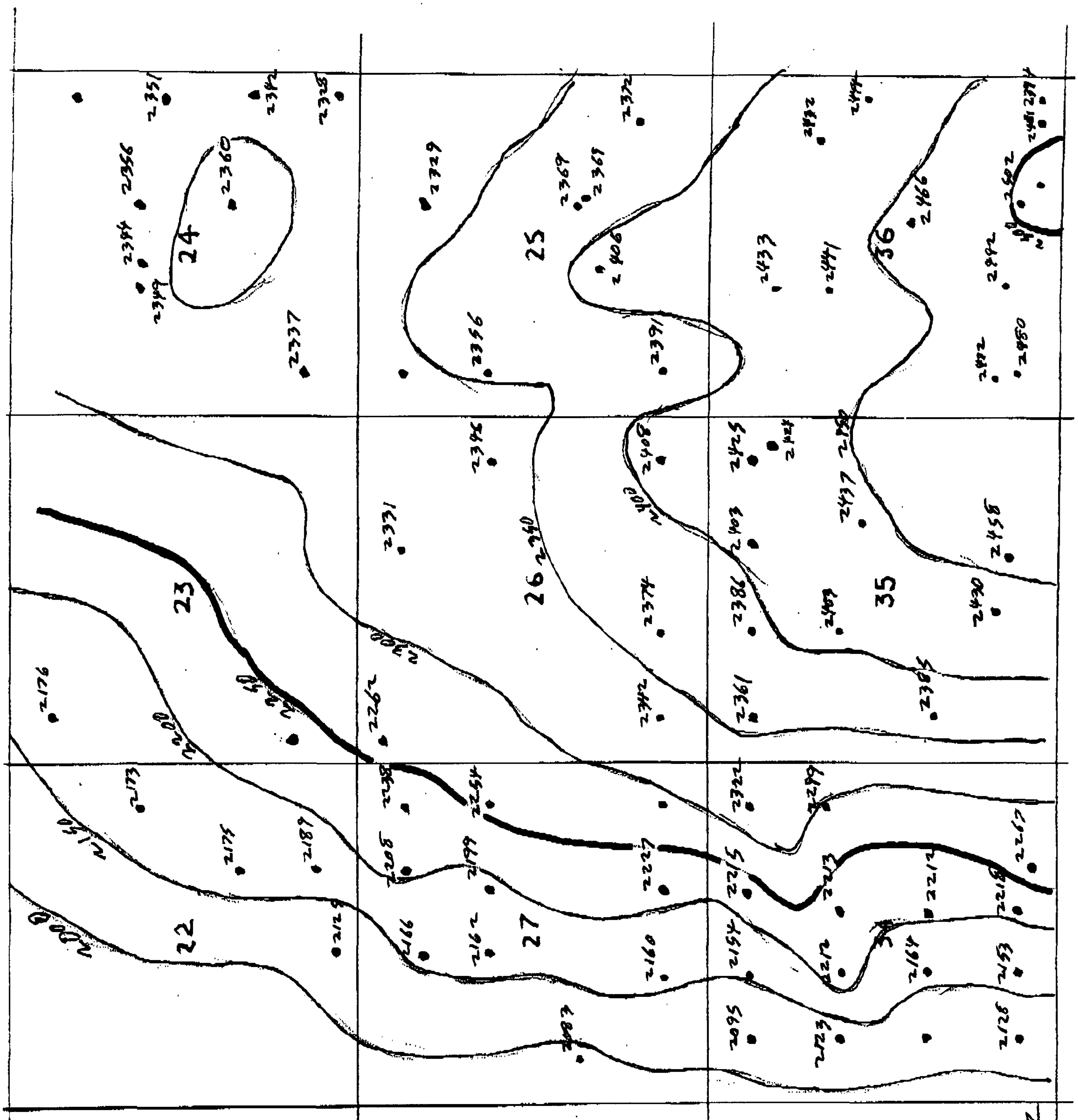
CI = 100'

P. F. KAUTZ

34-19-36

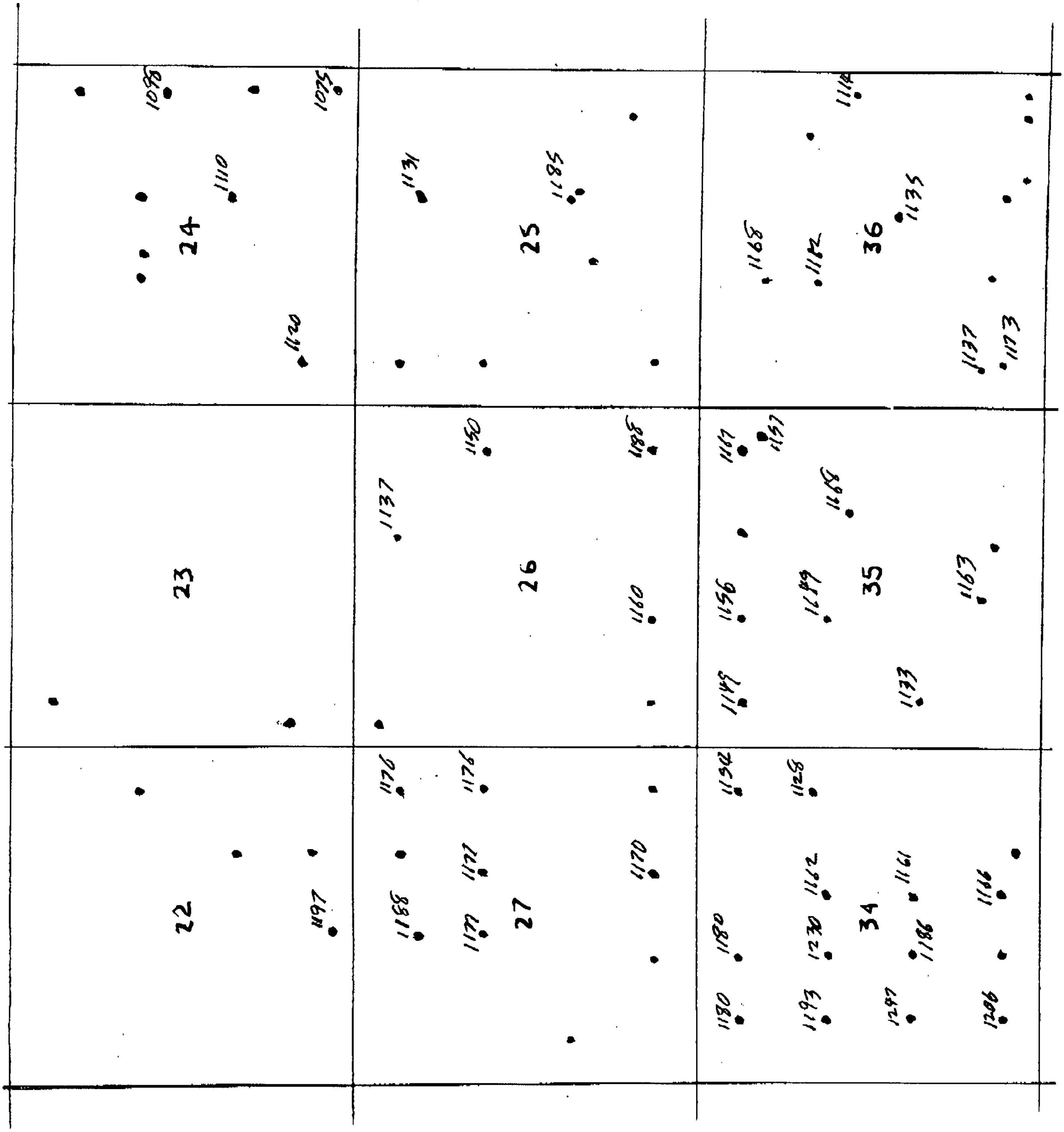
WELLS S/2 SE/4

LOC. ~~S/2 S/2~~



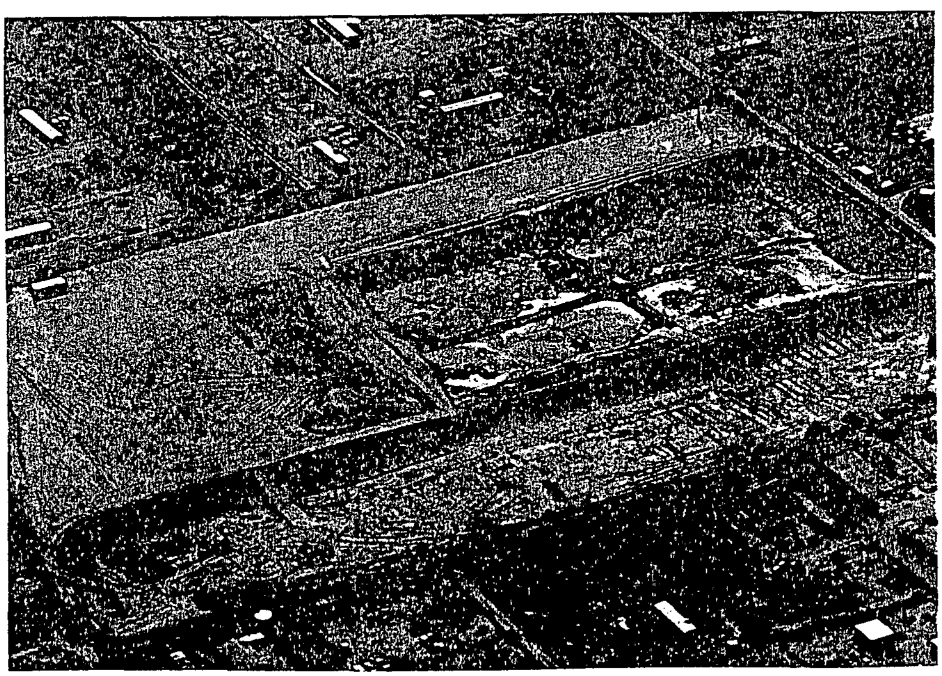
STRUCTURE MAP ON TOP SALT
CI = 50'

P.F. KAUTZ

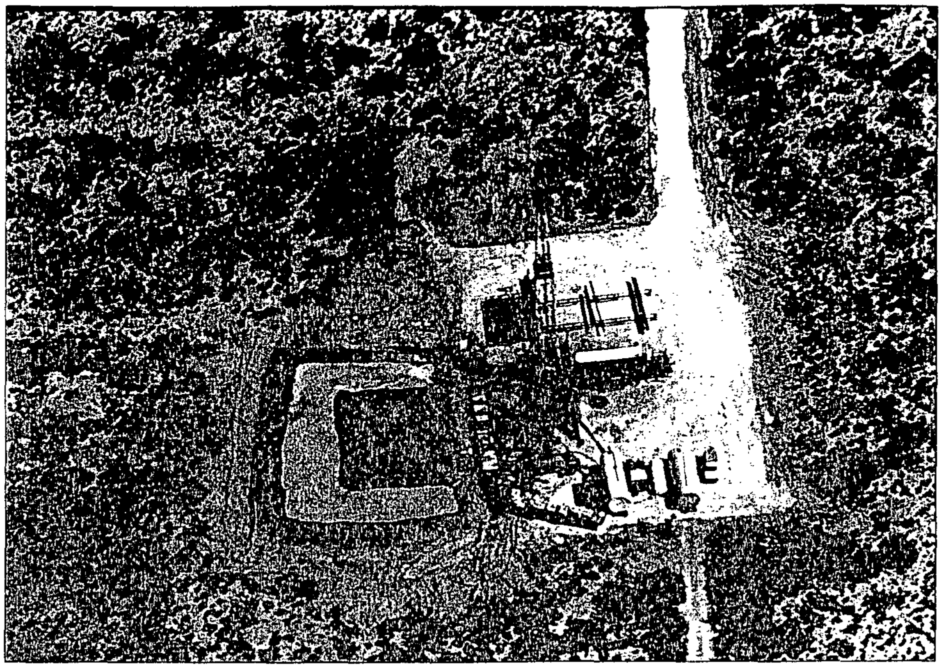


150 PAC
ON
SALT

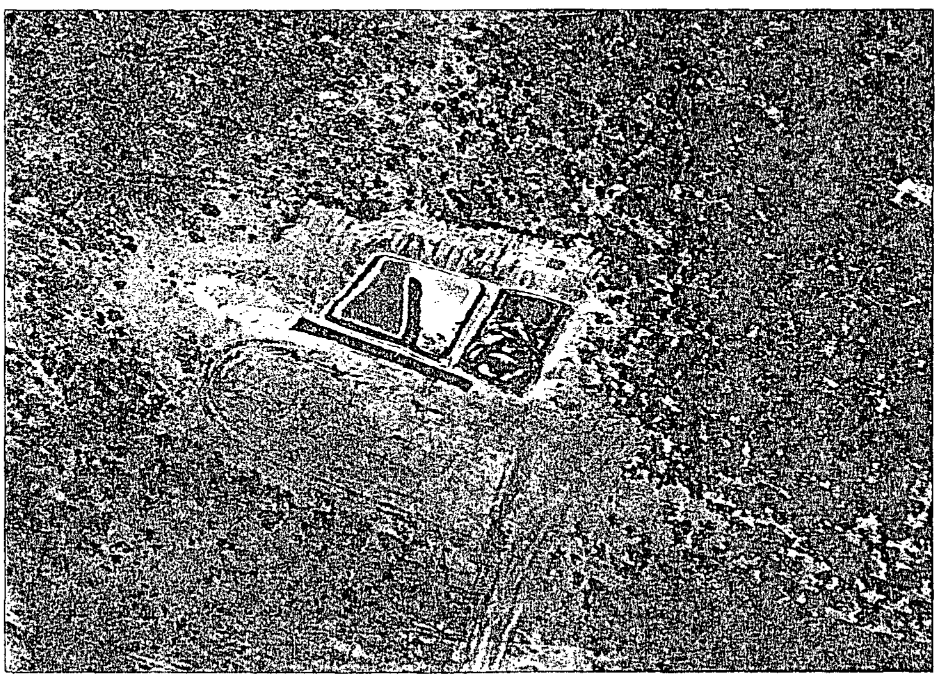
SURFACE SOLIDS DISPOSAL PITS
Ector, County



SURFACE SOLIDS DISPOSAL PITS IN RESIDENTIAL AREA
SINGLE LINER - NO LEAK DETECTION SYSTEM

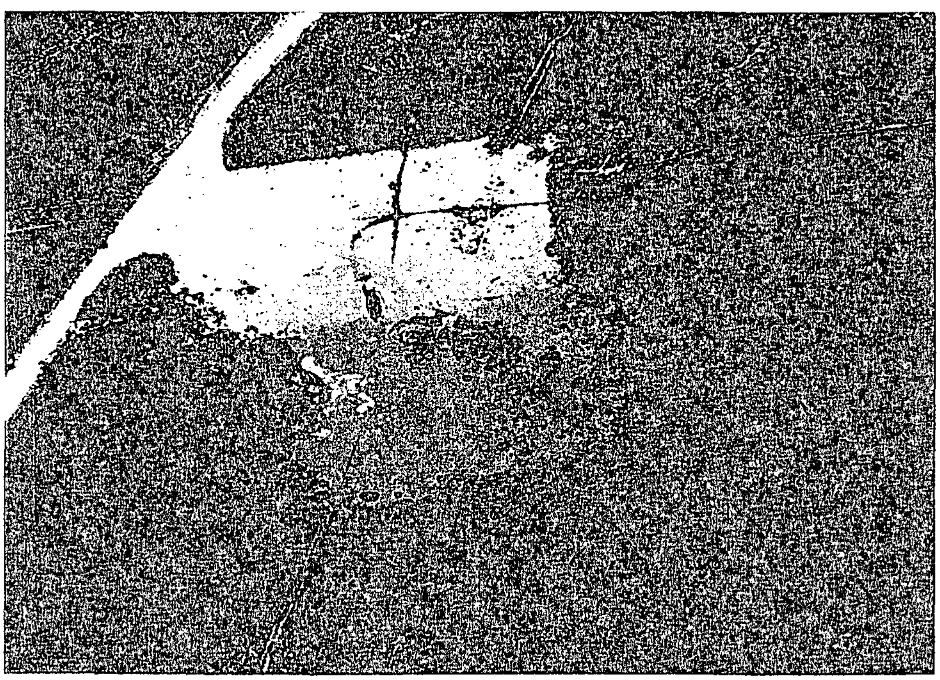


DRILLING RIG WITH EARTHEN PIT

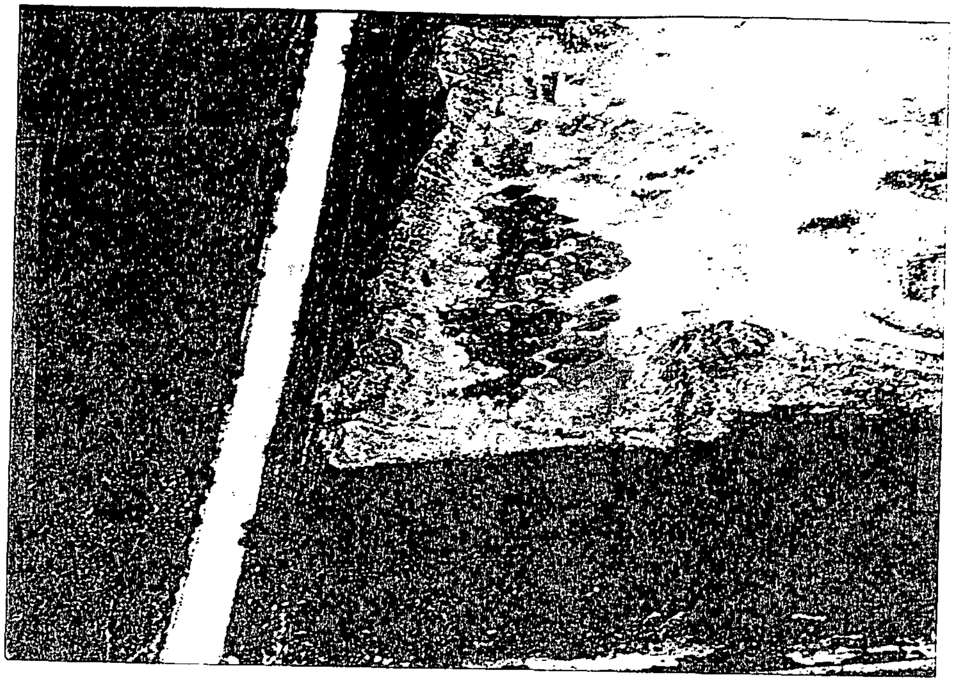


DRILLING RIG PITS DRYING UP

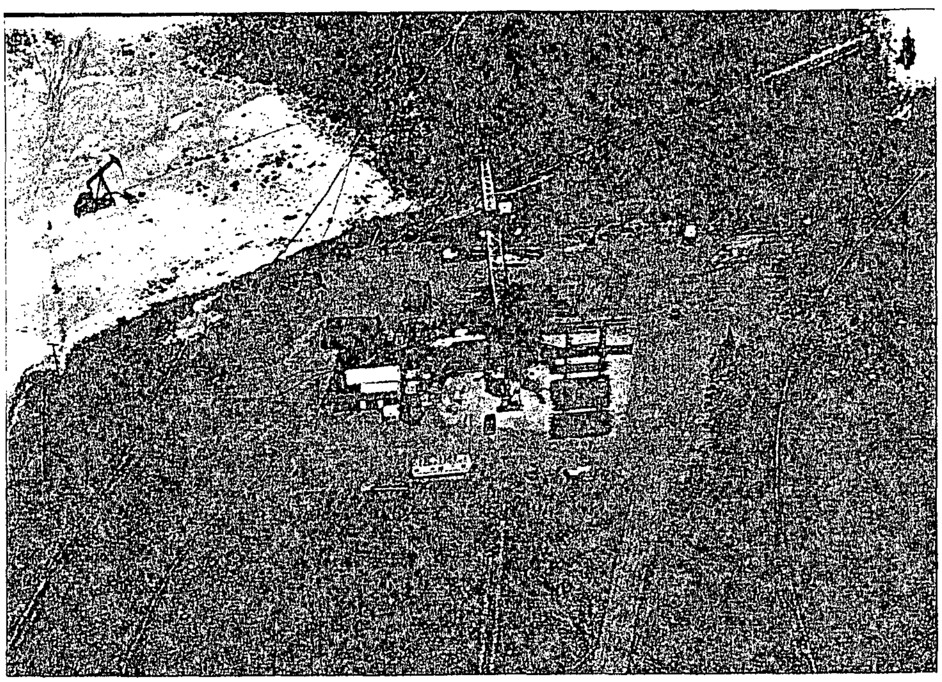
OIL SPILL



OLD DRILLING PITS WITH SALT SHOWING



ILLEGAL DUMPING OF SALTY AND OILY WASTE



DRILLING RIG USING ROLL OFF BOXES AND
CLOSED LOOP SYSTEM (NO EARTHEN PITS)

NOTE SALTY OLD COVERED PIT IN TOP LEFT OF PHOTO

OIL & GAS REVIEW
ODESSA AMERICAN ● Sunday, June 25, 1995

BEST IN THE BASIN

The Odessa American: Larry Beckner

Al Hickerson, CEO of Permian Brine Sales Inc., holds a copy of Hart's Oil and Gas World magazine, which awarded his company the Best Environmental Project for its innovative use of salt caverns for disposal of non-hazardous oil field wastes.

Publication recognizes five companies

By George Van Dam
Odessa American

Five companies with ties to the Permian Basin have been singled out by a major oil and gas publication as being the best in the Permian Basin region.

Odessa's Permian Brine Sales Inc. and Marathon Oil Co., and Union Royalty Inc., Midland Resources Inc. and Conoco Inc., all of Midland, were recognized in the June 1995 issue of Hart's Oil and Gas World for outstanding performance in the Permian Basin.

Permian Brine Sales Inc. of Odessa won the Best Environmental Project award for its innovative use of salt caverns for disposal of non-hazardous oil field wastes.

"The judges appreciated the more efficient, cost-effective way Permian Brine Sales dispo... field wastes," said Don Lyle, editor of Hart's.

A 400,000-barrel cavern, created from washing out an underground salt bed, is located on property leased by Permian Brine Sales, eight miles east of Big Springs, Lyle said.

The cavern is used to dispose of non-hazardous oil field wastes that are safely stored well below the water table, he added.

Lyle said the cost-effectiveness of this method of disposing of wastes extends the life of marginal wells by reducing lease operating costs.

E.L Hickerson, CEO for Permian Brine Sales, said he is pleased with his company's recognition by Hart's, and is optimistic about the future use of salt caverns in disposing of wastes.

"I believe the oil industry continues to endeavor to operate in an environmentally safe manner," Hickerson said. "And the use and di... safe place to put a lot of waste."

Hickerson predicted that other industries, not just oil and gas, will soon use salt caverns to contain non-hazardous and hazardous wastes.

"And it'll help make the world more environmentally clean," Hickerson said.

Permian Brine Sales was also recognized as a challenger in the Best New Technology category for using salt caverns to dispose of non-hazardous oil field wastes, but Marathon Oil Co.'s operations in Midland took the honors, Lyle said.

Marathon developed a technique using its own coiled tubing instead of traditional pulling units for its low-pressure marginal gas wells, Lyle said.

The technique prevents formation damage, puts wells on line faster and reduces costs, he added.

Marathon used a system that allows wells to flow throughout the ...

B. Quick, Inc.
Application for Permit
Class I Non-hazardous Salt Cavern Disposal Wells
for Oilfield and Non-hazardous Waste

Lea County, New Mexico

Safety & Environmental Solutions, Inc.
703 E. Clinton Suite 103
Hobbs, New Mexico 88240
(505) 397-0510

P.O. Box 1613
703 E. Clinton Suite 103
Hobbs, New Mexico 88240
505/397-0510
fax 505/393-4388

Safety & Environmental Solutions, Inc.

August 13, 1999

Mr. Wayne Price
New Mexico Oil Conservation Division
2040 South Pacheo Street
Santa Fe, New Mexico 87508

Dear Wayne:

After further consideration of the request to amend our application for a Class I Disposal permit submitted to you on behalf of B. Quick, Inc. to include disposal of Naturally Occurring Radioactive Material (NORM), we have decided to withdraw this request at this time

If you should require additional information, please contact me.

Sincerely,

Bob Allen

Bob Allen REM, CET, CES
President

BA/jra

~~enclosures~~

P.O. Box 1613
703 E. Clinton Suite 103
Hobbs, New Mexico 88240
505/397-0510
fax 505/393-4388

Safety & Environmental Solutions, Inc.

August 9, 1999

Mr. Wayne Price
New Mexico Oil Conservation Division
2040 South Pacheo Street
Santa Fe, New Mexico 87508

RECEIVED
AUG 1 0 1999
Environmental Bureau
Oil Conservation Division

Dear Wayne:

Please amend the application for a Class I Disposal permit submitted to you on behalf of B. Quick, Inc. to include disposal of Naturally Occurring Radioactive Material (NORM). I believe that the Salt Cavern method of disposal is a safe and economically sound alternative to conventional NORM disposal methods.

I have enclosed, for your information, copies of three (3) studies, conducted by different agencies, which focus on NORM disposal, salt caverns, and risk analysis of salt caverns.

Please contact me prior to your next trip to Lea County and I will set up a tour of the Salt Cavern Disposal facility located in Andrew, Texas. I feel the tour would be of great benefit to you and any members of the approval committee.

I your should require additional information, please contact me.

Sincerely,

Bob Allen

Bob Allen REM, CET, CES
President

BA/jra

enclosures

OIL CONSERVATION DIVISION
2040 South Pacheco Street
Santa Fe, New Mexico 87505
(505) 827-7131

Price, Wayne

From: Price, Wayne
Sent: Friday, August 13, 1999 2:14 PM
To: 'ballen@sesi-nm.com'
Subject: FW: B-Quick Class I cavern Disposal well(S)

Also!

All submittals must be in duplicate to OCD Santa Fe and a copy to Hobbs!
We only received one copy!

From: Price, Wayne
Sent: Friday, August 13, 1999 1:58 PM
To: 'ballen@sesi-nm.com'
Subject: B-Quick Class I cavern Disposal well(S)

Dear Bob:

Please note the application submitted is referencing the old P&S UIC-CLI-006 number. This is incorrect! This number has been retired! It was withdrawn and will remain with the old system. Please do not use this reference #.

The NMOCD will assign a new number!

OIL CONSERVATION DIVISION
2040 South Pacheco Street
Santa Fe, New Mexico 87505
(505) 827-7131

Price, Wayne

Sent: Friday, August 13, 1999 1:06 PM

----IMA12d5d52.37b4/mail.SESI-NM.COM
Content-Type: text/plain; charset=us-ascii

Message delivered successfully to ballen@mail.SESI-NM.COM

----IMA12d5d52.37b4/mail.SESI-NM.COM
Content-Type: message/delivery-status

Reporting-MTA: mail.SESI-NM.COM
Final-Recipient: rfc8222;ballen@mail.SESI-NM.COM
Action: delivered
Status: 2.0.0

----IMA12d5d52.37b4/mail.SESI-NM.COM
Content-Type: message/rfc822

Received: from xconn.state.nm.us [164.64.5.16] by mail.SESI-NM.COM with ESMTP
(SMTPD32-5.01) id AD4E258020E; Fri, 13 Aug 1999 14:00:46 EST
Received: by xconn.state.nm.us with Internet Mail Service (5.5.2448.0)
id <QZRRVDMP>; Fri, 13 Aug 1999 11:54:40 -0600
Message-ID: <1D079F6056F3D211BC0F00A0C9EA33FC06FBC6@NMEMNRDDEPT>
From: "Price, Wayne" <WPrice@state.nm.us>
To: "'ballen@sesi-nm.com'" <ballen@sesi-nm.com>
Subject: B-Quick Class I Cavern Disposal
Date: Fri, 13 Aug 1999 11:48:29 -0600
Return-Receipt-To: "Price, Wayne" <WPrice@state.nm.us>
MIME-Version: 1.0
X-Mailer: Internet Mail Service (5.5.2448.0)
Content-Type: multipart/mixed;
boundary="----_=_NextPart_000_01BEE5B4.EA4674B4"

----IMA12d5d52.37b4/mail.SESI-NM.COM--

OIL CONSERVATION DIVISION
2040 South Pacheco Street
Santa Fe, New Mexico 87505
(505) 827-7131

Price, Wayne

From: Price, Wayne
Sent: Friday, August 13, 1999 11:48 AM
To: 'ballen@sesi-nm.com'
Subject: B-Quick Class I Cavern Disposal

In order for OCD to issue public notice we must know specifics about the system! The permit application cannot be approved on probable information! The way the application was issued to OCD we cannot continue the review process! Also pursuant to our telephone conversation your ideal of having a meeting in Santa Fe is most welcomed!

Please find attached a public notice that was issued sometime ago! Please Provide the correct information required under 20 NMAC 6.2 3108.C.

Example:

Pubnot.wpd

EMAIL BALLEN@SESI-NM.COM

P.O. Box 1613
703 E. Clinton Suite 103
Hobbs, New Mexico 88240
505/397-0510
fax 505/393-4388

SM CAPS

Safety & Environmental Solutions, Inc.

RECEIVED
JUL 9 1999
OIL CONSERVATION DIVISION

July 8, 1999

Mr. Mark Ashley
Geologist
New Mexico Oil Conservation Division
2040 South Pacheco
Santa Fe, New Mexico 87505

Dear Mark:

Enclosed please find the response to your letter of June 11, 1998 to Mr. Bill Quick in which you requested additional information in order to complete his application for Class I Non-hazardous Salt Cavern Disposal Wells in Lea County, New Mexico.

This information is to be considered an application for the Class I designation for the following wells located in Letter P, Section 34, T19S, R36E, Lea County, New Mexico:

Climax Chemical Saline Water Well # 1
Climax Chemical Saline Water Well # 2
Climax Chemical Saline Water Well # 3
Climax Chemical Saline Water Well # 4

The original drilling and casing records are included for you reference in Figure 1 of the application document.

B. Quick, Inc. feels that salt caverns are an ideal final resting place for oilfield and other OCD approved non-hazardous waste. Several studies have been conducted which conclude that salt caverns are a safe, economical and environmentally friendly method of disposal for certain classes of waste. I have enclosed and made part of this application the study of oil field waste disposal in salt caverns prepared by Argonne National Laboratory in Washington, DC for the U.S. Department of Energy under Contract W-31-109-ENG-38. As I am sure you are aware, this study addresses operations similar to the facility that we plan to operate in Monument.

I believe this project has a great deal of merit and Mr. Quick intends to continue his efforts to permit this operation. I remain ready and available to work with your office in order to facilitate this permitting process.

Thank you for your time to review this application. If you should require additional information or if I may be of further service, please contact me.

Sincerely,

Bob Allen

Bob Allen REM, CET, CES
President

BA/jra

cc: Bill Quick
3340 Quail View Dr.
Nashville, Tn 37214

PERMIAN BRINE SALES, INC.

BRINE — FRESHWATER — WATER DISPOSAL — SOLIDS DISPOSAL

6067 W. TENTH • ODESSA, TEXAS 79763

(915) 381-0531 (915) 530-0664 FAX (915) 381-9316

OIL CONSERV... N DIVISION RECEIVED

'95 JUL 24 AM 8 52

July 21, 1995

Mr. Roger Anderson
Environmental Bureau Chief
2040 So. Pacheco St
Santa Fe, New Mexico 87505

Dear Sir:

We propose to re-enter the old plugged and abandoned Climax brine wells near Monument, New Mexico and install facilities for disposing of non-hazardous oil field solid waste into the abandoned caverns. Salt was mined in the brine form from 1962 until 1982.

Enclosed is a discussion of the process, along with sketches and personal and company data.

We would like to come to Santa Fe and meet with you (and any other interested parties) to get acquainted and answer questions and to discuss with you the proper procedures for getting required New Mexico Permits. The facility will operate very much the same as a brine well except that we will be pumping a solid waste slurry into the cavern instead of fresh water. When a barrel of slurry is pumped into the cavern, we will, of course, have a barrel of clear brine return. This brine may be sold for drilling fluid, or to a nearby waterflood for use as a make-up water. Surplus brine will then go to a regular disposal well.

I met with Mr. Jerry Sexton (whom I have known for a number of years) last week in Hobbs and he suggested I work with you. We have previously had brine wells in New Mexico, but have none at the present.

After you have read this, please give me a call and we can schedule a mutually satisfactory time for a meeting.

Very truly yours,

PERMIAN BRINE SALES, INC.

A.L. Hickerson

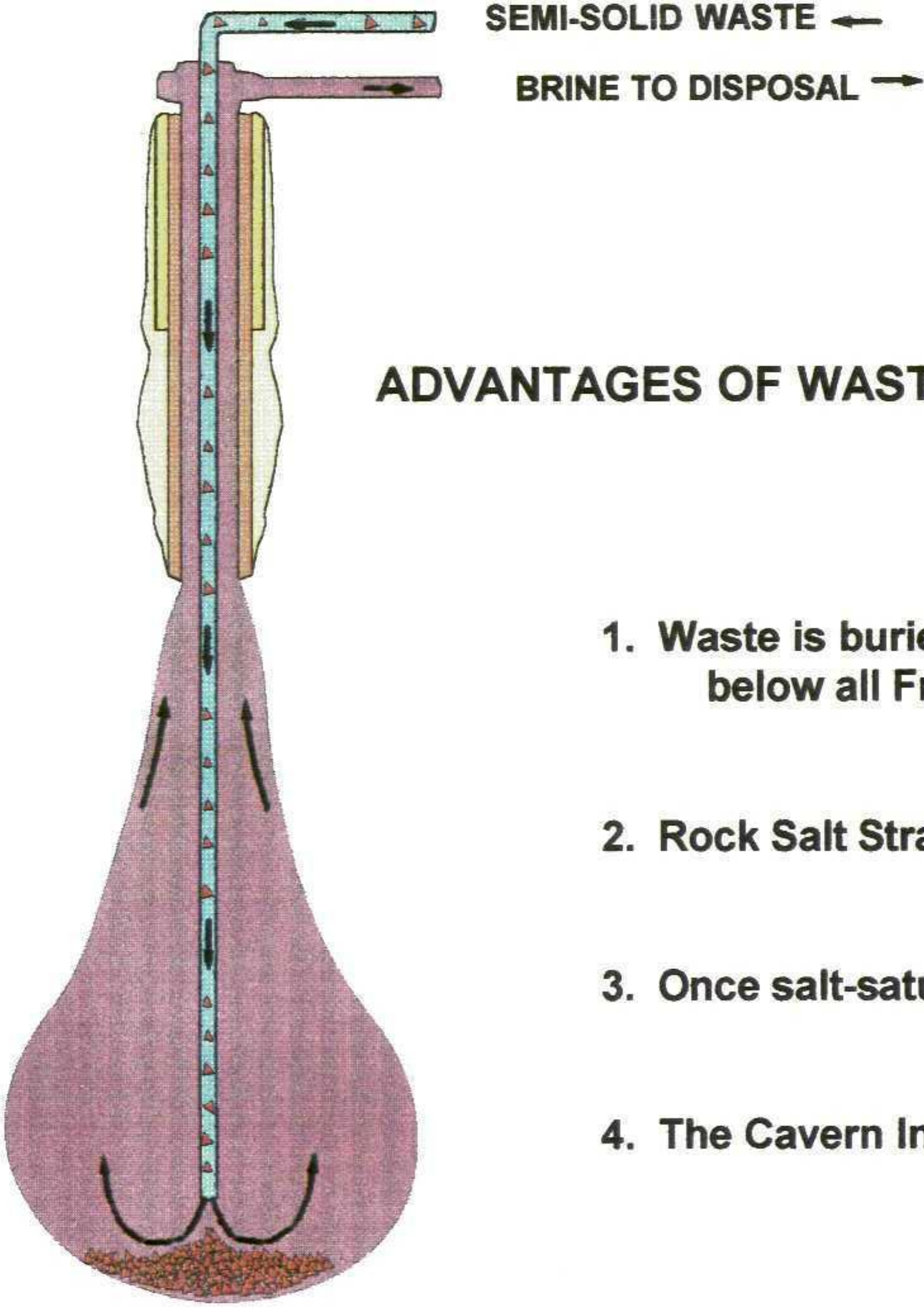
A.L. Hickerson
CEO

ALH/rdw

CAVERN SOLIDS WASTE DISPOSAL

PERMIAN BRINE SALES INC.

JULY 1995



ADVANTAGES OF WASTE DISPOSAL INTO A SALT CAVERN

1. Waste is buried safely and permanently below all Fresh-Water Zones

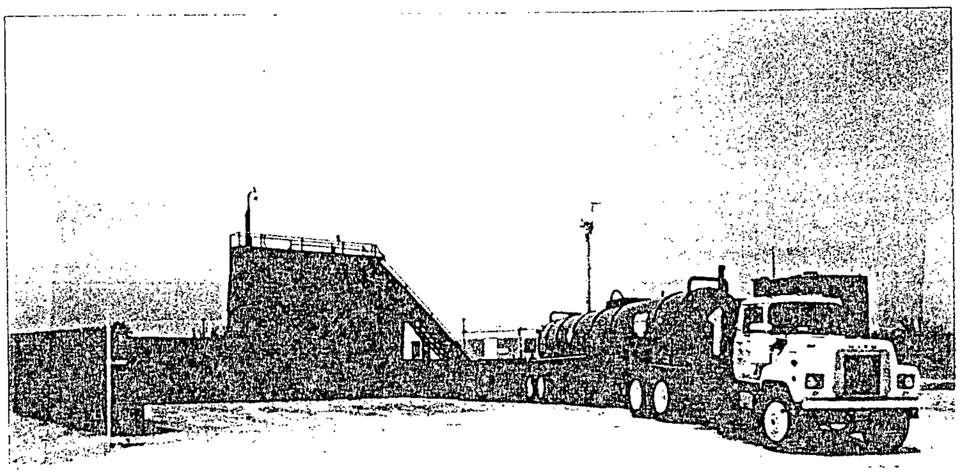
2. Rock Salt Strata is stable and self-healing

3. Once salt-saturated, the Waste remains inert

4. The Cavern Integrity is monitored daily

SOLIDS INJECTION WELL HEAD

@ Big spring Tx



CONCRETE UNLOADING RAMP AT SOLIDS DISPOSAL CAVERN FACILITY

at Big spring

CAVERN SOLIDS WASTES DISPOSAL

PERMIAN BRINE SALES, INC.

July 1995

I. AN OVERVIEW OF FIELD OPERATIONS OF "CAVERN SOLID WASTE DISPOSAL"

A. Solids Waste is generally hauled to cavern disposals in vacuum trucks, dump trucks, or roll off boxes. Vacuum trucks function by connecting the lower portion of the tank truck by hose with the fluid to be transported (from a tank, a pit, or from the ground). An air vacuum pump then withdraws air from the upper portion of the tank truck, thus pulling fluid into the tank through the hose. Vacuum trucks are well known for sucking up everything near the hose (fluid, as well as solids in the form of dirt, rocks, gloves, grass, bolts, nuts, rust, sludge, scale, pocket combs, etc.). Vacuum trucks are the preferred method of transporting wastes that contain solids.

Ordinary oilfield transport trucks function by actually pumping the fluid they handle. Their pumps have great difficulty pumping fluid out of pits or off the ground because doing so requires the pump to pull a vacuum (which they do not do very well) and the solids plug up and tear up the pump.

Roll off boxes are similar to portable trash bins that are seen around construction sites. When the roll off box is full, it is exchanged for an empty one and the full one hauled to a solids disposal system.

The advent of roll off boxes and solids disposal sites makes it possible to drill oil and gas wells without digging large drilling pits. These types of earthen pits are lined with thin plastic and when drilling operations are completed, the free water is removed and the rest is allowed to dry up and soak in and then covered "on site".

The solids waste we handle is common to all oilfield operations. It is essentially the same as oilfield waste fluids, except it is un-injectable due to it viscosity or solids content. This waste stream will "plug up" a conventional oilfield injection well in just a few hours.

The old policy of "out of site, out of mind" and just burying the solids laden waste near the surface has sometimes proven disastrous in the oilfield and other industrial enterprises.

The underground injection of waste, far below the environment we live in and below underground sources of drinking water is an effective method of waste management.

The 53,000 injection wells in Texas dispose of about 10,000,000,000 (ten billion) barrels of waste water annually. This method of oilfield produced water disposal works very well but these type wells cannot handle solids or semi-solids wastes.

Clearly, deep underground semi-solid waste injection is effective, workable, and far better than near surface disposal from an environmental and land use perspective.

From an economic perspective, the use of existing caverns for solids disposal is all but unparalleled in the oil industry.

Existing caverns are widespread, available, and have **proven** track records of mechanical integrity.

The caverns will provide the oil and gas industry a cost effective method of "keeping their house clean." Other methods of disposal are available (plastic lined pits, incineration, treatment, land farming, etc.) that will be a part of the waste handling picture, but most are generally more expensive and riskier than cavern disposal.

Permian Brine's current rates for disposal in the Permian Basin are usually the lowest available, thus enabling the oil and gas industry to continue to operate their wells economically and in an environmentally sound manner.

II. FORMS OF WASTE HAULED TO SOLIDS DISPOSAL CAVERNS

A. Waste received at a solids disposal facility

1. **Roll off boxes and dump trucks.**
   Roll off boxes and dump trucks transport dry solids waste, sand, salt, scale, drill cuttings, filter media, etc. The waste is blended with brine that returns from the disposal cavern. The resulting slurry is injected into the bottom of the cavern. This method only fills the cavern and does not leach any salt.

2. **Vacuum trucks from oilfield spills**
   An oil or disposal water spill is usually discovered in the field by oil company personnel. In the past the salvageable oil was sucked up by a vacuum truck and returned to the oil stock tanks. The dirty oil as well as the salty disposal water was left to dry or covered with dirt. Now, if a solids disposal facility is available nearby, the salvageable oil is recovered and the salty water and contaminated dirt is sucked up or

scraped up and transported to the solids disposal cavern in vacuum trucks, roll off boxes, and/or dump trucks.

3. **Vacuum trucks from workover pits**
At wells that are being repaired, cleaned out, re-cemented, deepened, fractured, acidized, etc., small shallow pits are commonly dug and lined with thin plastic to temporarily contain any waste fluids generated at the site. This waste would be mostly fluids, but would contain rust, scale, excess cement slurries, frac sand, acids, traces of xylene and toluene, produced sand and other contaminates used on the well or blown out of the well after the remedial operation. If solids render the fluid un-injectable, the solids and fluids mixture is hauled to a solids disposal facility. Previous to solids disposal systems, free water was removed and the rest covered up on site. If the solids disposal facility employs plastic lined pits, the powerful solvents in the waste may attack the plastic liners and dramatically reduce the liners integrity. If the solids waste facility is a salt cavern type, this types of waste solvents will have no effect on the long term isolation of the waste. The fluid from these pits is not always salt saturated and may leach some salt.

4. **Vacuum trucks from drilling rigs with earthen pits**
During the course of drilling an ordinary well (oil or gas) the drill cuttings, drilling mud, drilling additives, excess cement slurries, etc. are circulated through the mud system and pits. When drilling is complete, most operators remove the free water and allow the pit to dry up and cover the entire pit system with dirt. Hauling the salty drilling mud and other contaminants to a solids disposal facility that employs plastic lined pits is seldom done because it is expensive and most operators recognize the folly of hauling waste from one plastic lined surface pit to another plastic lined surface pit.

   When such waste is received at a cavern disposal facility, it is nearly always fully saturated with salt and only serves to fill the cavern with solids and does not leach any more salt.

5. **Roll off boxes from closed loop drilling system.**
Some operators use a closed loop drilling system that "filters" the drilling mud mechanically (no earthen pits are required). The cuttings and solids waste are directed into a roll off box at the well site and hauled to a disposal system. At a cavern disposal, the waste is blended with brine and only serves to fill the cavern and does not leach any more salt.

6. **Vacuum trucks from washdown pits.**
In the past oilfield trucks and equipment (pumps, pulling units, etc.) were cleaned off in the back of contractors service yards or at well sites. This practice led to many contaminated sites. Now most oilfield contractors have permitted pits or catch basins where they wash trucks and equipment that have accumulated sand, oil, rust, dirt, sludge, etc. from oilfield operations. The waste in these pits is un-injectable into normal water disposal wells. These pits are periodically sucked out with a vacuum truck and must be taken to a solids waste disposal facility. The fluid in these loads is not saturated and does leach some salt. However, to minimize disposal and trucking costs, the loads from these pits have a very high solids content. Typically a truck load from such a clean out is 75% solids, and only 25% fluid.

Permian Brine has a truck washout system at Big Spring. Return brine from the disposal cavern is used and therefore does not leach any salt. The truckers in the area appreciate having a safe, efficient place to rinse out their tank trailers.

7. **Solids waste from tank clean outs**

Some oil producing formations produce sand mixed in the oil. Over time (months or years) sand as well as rust, scale, and heavy asphalt like sludge settles to the bottom of the oil production tanks. When this "sludge mixture" interferes with oil production or the tank is to be moved, patched, or taken out of service, the sludge must be removed. In the past, and sometimes now, this horrible, stinking, cruddy muck was physically cleaned out of the tank and buried on site. No plastic liner or treatment at all is involved.

If a solids waste disposal facility is near by, this sludge **can now** be sucked up in a vacuum truck and transported to the facility. It is blended with return brine from the disposal cavern and injected. After blending, the fluid in this waste is near saturated and does not leach appreciable salt.

III. CAVERN DISPOSAL SURFACE OPERATIONS

The wastes are received at the cavern disposal site, and off loaded into a 10 ft x 10 ft x 6 ft concrete pit. Brine is jetted into the pit and a mechanical mixer blends the fluid into a more or less uniform slurry. Loads that contain measurable oil can be skimmed and the oil reclaimed. The slurry is then pumped into a steel tank that is constantly re-circulated by pump. Finally the slurry is injected down the tubing of the well to the bottom of the cavern with a mud pump. Injection pressure is between 160# and 200#, depending on the viscosity and specific gravity of the fluid.

IV. **INJECTED HYDROCARBONS**

Minute traces of oil, or other hydrocarbon based fluids that are carried into the cavern will migrate upward.

It is known that in moderate sized hydrocarbon storage caverns in bedded salt (50,000 barrels to 150,000 barrels), about 10% of the hydrocarbons are trapped under the ledges. We are thus sure that the small amounts of hydrocarbons in the injected waste will also be trapped under ledges as the well fills with solids.

Like oil blankets that are intentionally floated in caverns during washing to protect the cavern roof, this residual oil will serve the same purpose. The oil film under each ledge and the cavern roof will prevent or reduce uncontrolled upward leaching.

This tiny amount of oil in a solids disposal cavern will have no effect on cavern integrity.

V. **RE-USE OF RETURN BRINE**

Saturated brine is used in the oilfield for drilling, completions, well workovers, fracing, and pressure control. The brine does not damage producing formations, and drills a better well.

The freshwater that brine is made from is produced from nearby water wells, thus, normal day to day oilfield operations (just like nearly all human endeavors) depletes valuable fresh water resources.

The use of surplus return brine from a disposal cavern for oilfield operations will conserve large quantities of Texas ground water.

Untreated, ordinary produced water when used for some well workovers or treating, poses virtually no environmental risk and is a form of recycling. The use of return brine in the oilfield is beneficial and is also a form of recycling. Attached is: 1) an article "Congress Moves to Revamp U.S. Laws on Environmental" (Oil and Gas Journal - July, 1995) that mentions the recycling of water based drilling muds as a "voluntary environmental action." 2) part of a newspaper article outlining the water problems of West

Texas, and 3) a page from "Waste Minimization in the Oil Field" published by the Texas Railroad Commission that encourages recycling.

The re-use of the return brine from a cavern disposal facility is beneficial.

We do not re-use the brine at Big Spring because it is only 85% salt saturated.

VI. FINAL CAVERN FILL

When the cavern becomes full of solids, it will be immediately detected at the surface. Slurry will be pumped in and a slurry will return. No damaging or catastrophic events will occur.

At that point the cavern should be left open for 3 to 6 months until residual leaching ceases and the well reaches equilibrium.

Then by properly plugging the well bore with cement the waste will be **permanently** and safely isolated from the environment.

The cavern itself, just like any excavation that has been filled up, will be stable and not subject to collapse or subsidence.

VII. SOLIDS WASTE DISPOSAL

A. Cavern Operations

Salt cavern stability has **never** been a problem in man made caverns leached in bedded salt in West Texas. Caverns have been leached to enormous size (millions of barrels) with no stability problems.

In a bedded salt cavern, regardless of size or shape, so long as the cavern is 1) stable 2) overlaid and interbedded with anhydrite or other impervious, hard rock, the filling of the cavern with solids will render the cavern **more stable** than the cavern was before solids were injected.

Water, whether it is produced along with oil or whether it is fresh water or brine, when used for a drilling fluid in West Texas will virtually always become salty. The Salado salt formation is a layer of rock salt that extends throughout West Texas, Eastern New Mexico, Oklahoma, and much of Kansas. All oil or gas wells must drill through this layer of salt, hence their drilling pits become full of salty fluid when they drill through the rock salt layer, even if they were originally drilling with fresh water. The enclosed caliper survey of the salt layer from adjacent wells, drilled near Goldsmith, Texas (one drilled with fresh water and one drilled with brine) vividly shows the amount of salt washed out when drilled with fresh water. Thus the drilling fluid becomes salty while drilling through the salt layer.

VIII. CALCULATION OF RATE OF CAVERN FILL DURING SOLIDS INJECTION BASED ON STATISTICS OF GENERAL OPERATION

At Big Spring (Permit No. 09812) to date through May 1995, 230,000 barrels of waste has been received.

Average:

salt saturation of injected slurry	45%
solids content	15%
salt saturation of return brine	85%

Therefore, for each 100 barrel load of incoming slurry:
Each 100 barrel load is 85% water of 45% salt saturated fluid and has 15% solids - thus 15 barrels of solids.

85 barrels of 45% salt saturated water will dissolve the equivalent to 34 barrels of fresh water, assuming the return brine is 85% salt saturated.

Each barrel of brine contains 111 pounds of salt.

Therefore, each 100 barrel load of waste slurry is equivalent to injecting 34 barrels of freshwater:

34 barrels x 111 lbs = 3,774 lbs of salt removed per 100 barrels of waste injected

3,777 ÷ 140 (lbs per cu.ft. of salt) = 34 cu. ft. of cavern made

34 ÷ 5.61 (cu. ft. per barrel) = 6.06 barrels of cavern made by each average load of slurry injected.

Each 100 barrel load contain 15 barrels of solids, therefore, each load results in a **net cavern fill up of 8.94 barrels.**

Please note that this calculation is based on brine return being only 85% salt saturated, as it is at Big Spring.

This happens because the Big Spring cavern is a relatively "short" cavern and the rock salt face is about 62 feet from the injection tubing. This saturation will gradually decrease as the cavern fills up with solids. Caverns that are taller will dissolve salt primarily in about 200 feet just above the injection point. **When the cavern is filled to the top, very little salt dissolution will occur during the final 100 feet of cavern filling because the**

injected fluid will "short circuit" back out the casing and not dissolve additional salt.

The Big Spring cavern had an originally calculated size of 400,000 barrels - based on salt removed. The cavern had a vertical dimension of 219 feet. This calculates to be an average diameter of:

400,000 x 5.61 (cu, ft. per barrel) = 2,244,000 cu. ft.
2,244,000 ÷ 219 (vertical dimension of cavern) = 10,246 sq. ft. area in cavern cross section.
10,246 ÷ 3.1416(π) = 3,261 for the radius squared
$\sqrt{3261}$ = 57.1 ft radius of cavern
57.1 x 2 = 114.2 ft. cavern diameter

The salt in West Texas is about 15% insolubles, this increases the horizontal dimension to approximately 124 ft.(10 feet more), an inconsequential amount.

2,244,000 cu. ft. ÷ 186 (219-15%) = 12,064
12,064 ÷ 3.1416 = 3,840
$\sqrt{3849}$ = 62' radius
62 ft. X 2 = 124 ft. cavern diameter

Assuming the angle of repose for the solids being deposited to be 45 degrees, you therefore have an available space of 1,951,517 cu. ft. or 347,864 barrels for receipt of solids.

To fill 347,864 barrels of cavern with solids, an additional approximately 150,000 barrels of cavern will be leached. This figure is based on present leaching rates until the cavern has less than 100 feet between the waste and the casing shoe, and only nominal leaching thereafter.

The "solids filled" cavern diameter will then be approximately 150 feet in the top 100 feet of the "solids filled" cavern.

Waste fluid is injected into porous formations in about 53,000 disposal wells in Texas (10,000,000 barrels per year). The fluid injected is isolated from the environment vertically, just like caverns, by impervious horizontal layers of rock and clay. Horizontally, fluid travel is only estimated. Fluid injected into these porous formations travels for **thousands** of feet laterally from the well bore. This practice is safe and effective in isolating waste fluid from the environment and underground sources of drinking water.

Solids waste in caverns can be isolated vertically and horizontally <u>AS WELL AS OR BETTER THAN</u> traditional fluid injection.

IX. DISCUSSION OF SOLUTION MINING OF SALT IN WEST TEXAS

The rock salt underlying West Texas was "laid down" when the Permian Sea evaporated about 225,000,000 years ago. This and similar salt formations have been successfully used for the storage of oil, propane, butane, high pressure natural gas, and an array of other hydrocarbons. Salt has also been used as a disposal zone for hazardous waste in other countries. The Waste Isolation Pilot Plant (WIPP) near Carlsbad, New Mexico is still on track (scheduled to open in 1998) to dispose of low level nuclear waste in the Salado salt.

The salt lies in layers interspersed with layers of anhydrite. Anhydrite is an impervious, marble like rock.

Each oil or gas well that is drilled in West Texas must drill through the salt section. To prevent washing out a large hole in the salt, the wells are drilled, using a saturated brine solution as a drilling fluid.

Permian Brine Sales put in the first brine well to make saturated brine for drilling, in 1958. Before that companies used sack salt added to their drilling mud to prevent excessive leaching of the rock salt while drilling through it.

We have learned a great deal about leaching out the salt in order to make saturated brine from over 50 brine wells that we have operated through the years.

We know it is better to pump the fresh water into the bottom of the well in order to make a better brine well. Direct circulation wells plug up with solids and salt less often. Attached sketch 1, shows the difference in cavern formation, between bottom injection and top injection of the fresh water. Permian Brine's disposal caverns have been leached by direct circulation.

When injecting water into the bottom, you leach out a series of lenses. We know from experience that when washing at our normal rate of 60 to 100 gallons per minute, that the water will become 100% saturated with salt when about 200 feet of salt is exposed. Therefore we know that most of the cavern will be created in the lower part of a tall cavern. However, as each lens of the cavern becomes larger, some of the fresh water tends to "short circuit" to the top of each lens and thus gradually washes out a cavern towards the top of the salt. This "short circuit" occurs because fresh water has a specific gravity of 1.0, while brine has a specific gravity of 1.2. Fresh water, being lighter, immediately starts to the top, and as the distance to the rock salt face becomes greater more unsaturated brine moves upward to the next "lens".

Sketch 2 was made by Neal E. Van Fossan, with Texas Brine, for a article written for the Symposium on Salt. His conception of the size and shape of caverns formed in "layered" salt agrees with ours.

Several years ago, while filling a layered cavern with propane we very carefully measured the volumes of propane injected into the cavern, with the change in static pressure at the surface and by knowing the specific gravity of the propane column and the brine column, we were able to calculate the diameter of the cavern after each 5,000 barrel injection of propane.

Sketch 3 shows the configuration and shape of that cavern. You will note that these caverns were washed by alternating bottom and intermediate injection of fresh water in order to get the desired dimensions. If this cavern had been washed entirely from the bottom, the lower lens would be somewhat larger.

Warren Petroleum Company checked the size and shape of their LPG cavern located south of Big Spring by using the same method. Other operators have used this same, accurate method for years.

X. CONCLUSION

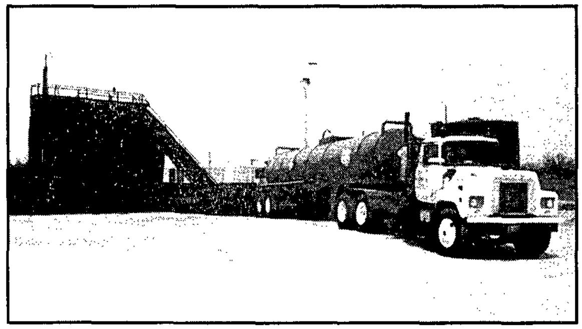
Many years of experience by the oil and propane storage industry and by our operations in cavern formation gives us complete confidence in the shape of caverns and that underground disposal of waste is safe and effective.

The use of existing caverns for disposal of oil and gas solids waste will help protect the environment, make beneficial use of an existing resource, conserve water, and reduce operating costs for oil and gas operators. Clearly a winning situation!

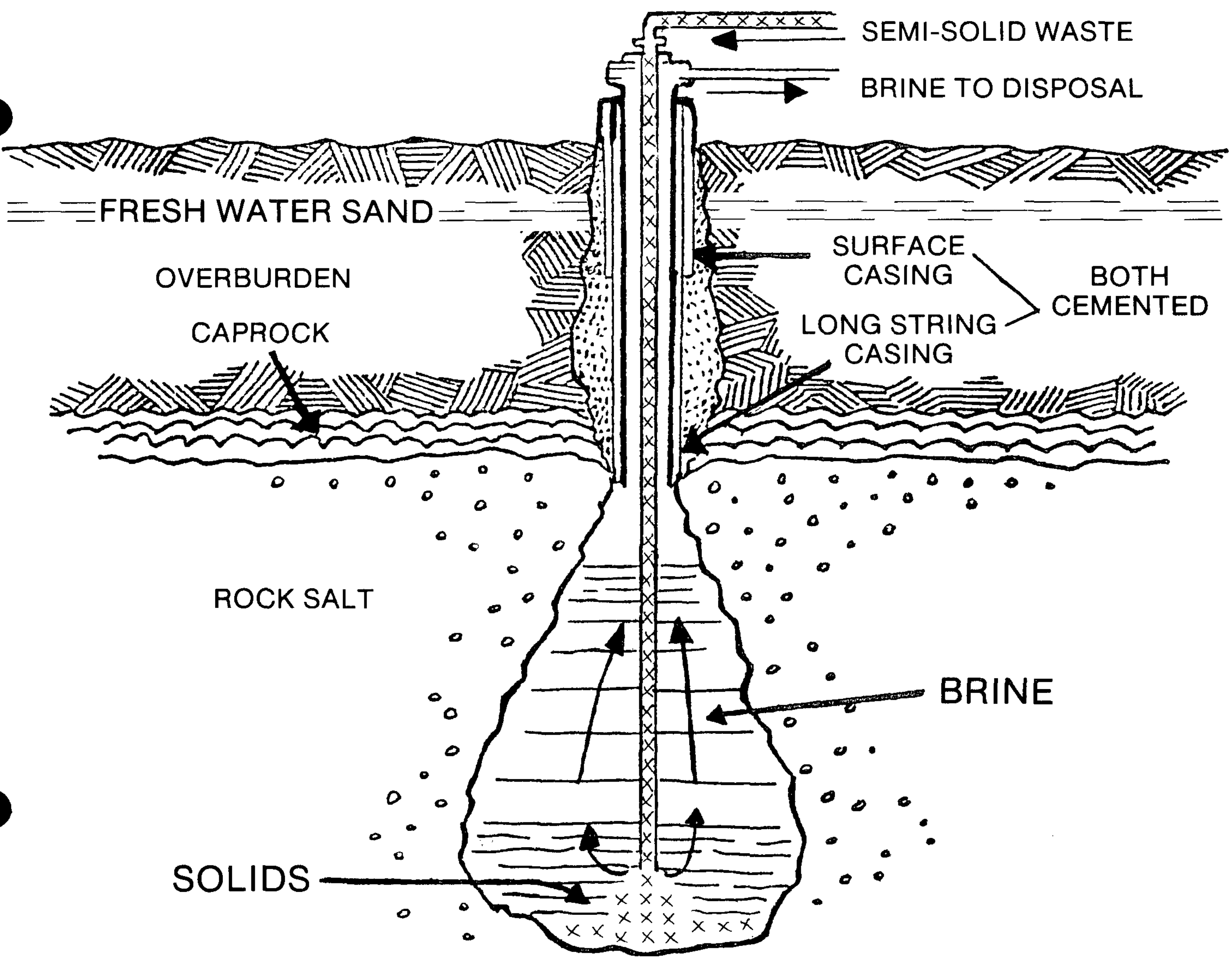
PERMIAN BRINE SALES, INC.

24-HOUR SERVICE/TEXAS - OKLAHOMA BRINE - FRESHWATER - DISPOSAL

6067 W. TENTH ST. • ODESSA, TEXAS 79763
(915) 381-0531 (915) 563-4730 FAX (915) 381-9316



Non-Hazardous Oilfield Solids Waste Disposed Into Cavern In Rock Salt Strata Below All Freshwater Sands



ADVANTAGES OF DISPOSING OF NON-HAZARDOUS OIL AND GAS WASTES INTO A CAVERN LEACHED OUT OF A ROCK SALT LAYER.

- AFTER BECOMING SALT SATURATED, THE WASTE IS INERT.
- THE WASTE IS FOREVER BURIED SAFELY BELOW ALL FRESH WATER ZONES.
- THE ROCK SALT STRATA IS STABLE AND SELF-HEALING.
- THE CAVERN IS MONITORED DAILY.

ACCEPTABLE NON-HAZARDOUS WASTES:

DRILLING MUD
DRILL CUTTINGS
RIG WASH
WORKOVER WASTES
PIT SLUDGES
PRODUCED SANDS
WASTE CRUDE
BLOW DOWN FLUIDS
BASIC SEDIMENT
PACKING FLUIDS
PIPELINE PIGGING WASTES

— Truck Washout Available —

Permian Brine Sales, Inc. employees have over 100 years of combined experience in working with salt caverns.

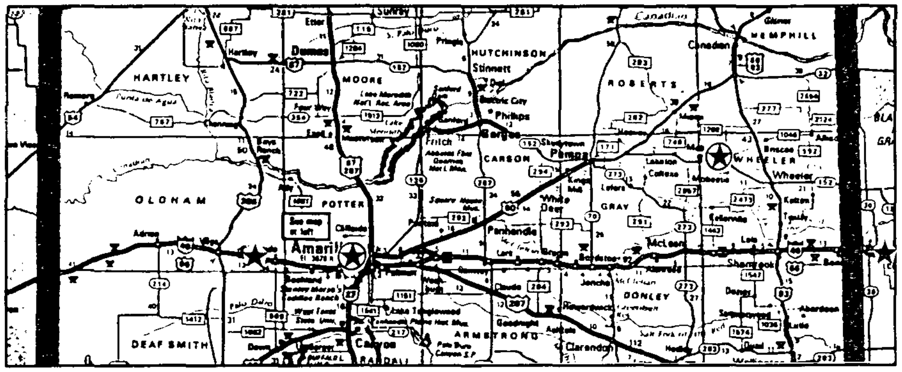
CALL 915-381-0531 FOR MORE INFORMATION.

LOCATIONS

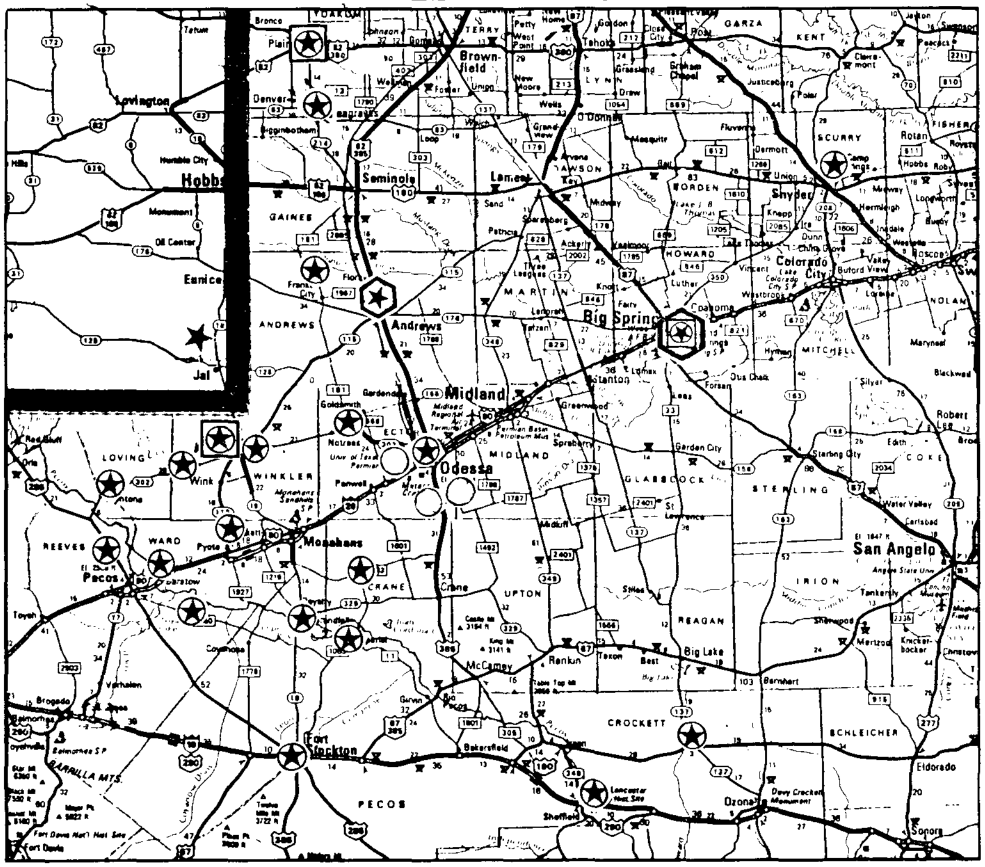
Big Spring, Texas

N.E. Corner of I.H. 20 and Salem Rd.
8 Miles East of Big Spring
Permit #09812
915-393-5965

TEXAS PANHANDLE



WEST TEXAS



★ *INDICATES BRINE SERVICE POINTS*

○ *INDICATES FRESHWATER SERVICE POINTS*

□ *INDICATES DISPOSAL SERVICE POINTS*

⬡ *INDICATES SOLIDS DISPOSAL*

BRINE DATA — For Brine At 60° F.

1 bbl. (42 gals.) saturated brine contains 111.174 lbs. of salt, 309.960 lbs. water, making a total weight of 421.134 lbs.

Bbls. saturated brine x .0556 equals tons saturated salt. Dry salt lbs. x .377 equals gals. saturated brine.

Salometer Degrees 60°F.	Wt. of a Gallon of Brine Lbs.	Specific Gravity 60°F.	Baume Degrees 60°F.	Per cent Sodium Chloride By Wt.	Pounds per Gallon of Brine NaCl	Pounds per Gallon of Brine Water
2	8.362	1.004	0.6	5.28	.044	8.318
4	8.386	1.007	1.1	1.056	.089	8.297
6	8.420	1.011	1.6	1.584	.133	8.287
8	8.453	1.015	2.1	2.112	.178	8.275
10	8.486	1.019	2.7	2.640	.224	8.262
12	8.520	1.023	3.3	3.167	.270	8.250
14	8.545	1.026	3.7	3.695	.316	8.229
16	8.578	1.030	4.2	4.223	.362	8.216
18	8.611	1.034	4.8	4.751	.409	8.202
20	8.644	1.038	5.3	5.279	.456	8.188
22	8.678	1.042	5.8	5.807	.503	8.175
24	8.711	1.046	6.4	6.335	.552	8.159
26	8.744	1.050	6.9	6.863	.600	8.144
28	8.778	1.054	7.4	7.391	.649	8.129
30	8.811	1.058	7.9	7.919	.698	8.113
32	8.844	1.062	8.5	8.446	.747	8.097
34	8.878	1.066	9.0	8.974	.797	8.081
36	8.911	1.070	9.5	8.502	.847	8.064
38	8.944	1.074	10.0	10.030	.897	8.047
40	8.978	1.078	10.5	10.558	.948	8.030
42	9.011	1.082	11.0	11.086	.999	8.012
44	9.044	1.086	11.5	11.614	1.050	7.994
46	9.078	1.090	12.0	12.142	1.102	7.976
48	9.111	1.094	12.5	12.670	1.154	7.957
50	9.144	1.098	12.9	13.198	1.207	7.937
52	9.178	1.102	13.4	13.725	1.260	7.918
54	9.211	1.106	13.9	14.253	1.313	7.898
56	9.244	1.110	14.4	14.781	1.366	7.878
58	9.278	1.114	14.8	15.309	1.420	7.858
60	9.311	1.118	15.3	15.837	1.475	7.836
62	9.344	1.112	15.8	16.865	1.529	7.815
64	9.378	1.126	16.2	16.893	1.584	7.794
66	9.411	1.130	16.7	17.421	1.639	7.772
68	9.452	1.135	17.2	17.949	1.697	7.755
70	9.486	1.139	17.7	18.477	1.753	7.733
72	9.519	1.143	18.1	19.004	1.809	7.710
74	9.552	1.147	18.6	19.532	1.866	7.686
76	9.594	1.152	19.1	20.060	1.925	7.669
78	9.627	1.156	19.6	20.588	1.982	7.645
80	9.660	1.160	20.0	21.116	2.040	7.620
82	9.694	1.164	20.4	21.644	2.098	7.596
84	9.735	1.169	21.0	22.172	2.158	7.577
86	9.769	1.173	21.4	22.700	2.218	7.551
88	9.810	1.178	21.9	23.228	2.279	7.531
90	9.844	1.182	22.3	23.755	2.338	7.506
92	9.877	1.186	22.7	24.283	2.398	7.479
94	9.919	1.191	23.3	24.811	2.459	7.460
96	9.952	1.195	23.7	25.339	2.522	7.430
98	9.994	1.200	24.2	25.867	2.585	7.409
100	10.027	1.204	24.6	26.395	2.647	7.380

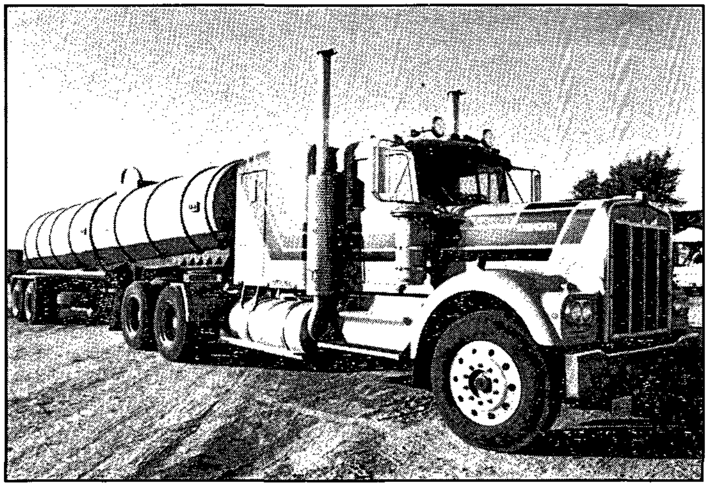
Permian Brine Sales, Inc.

915-381-0531 ODESSA, TX 79763

FOR WEIGHTING UP FRESH WATER WITH 10# BRINE

SIZE OF TRANSPORT LOAD

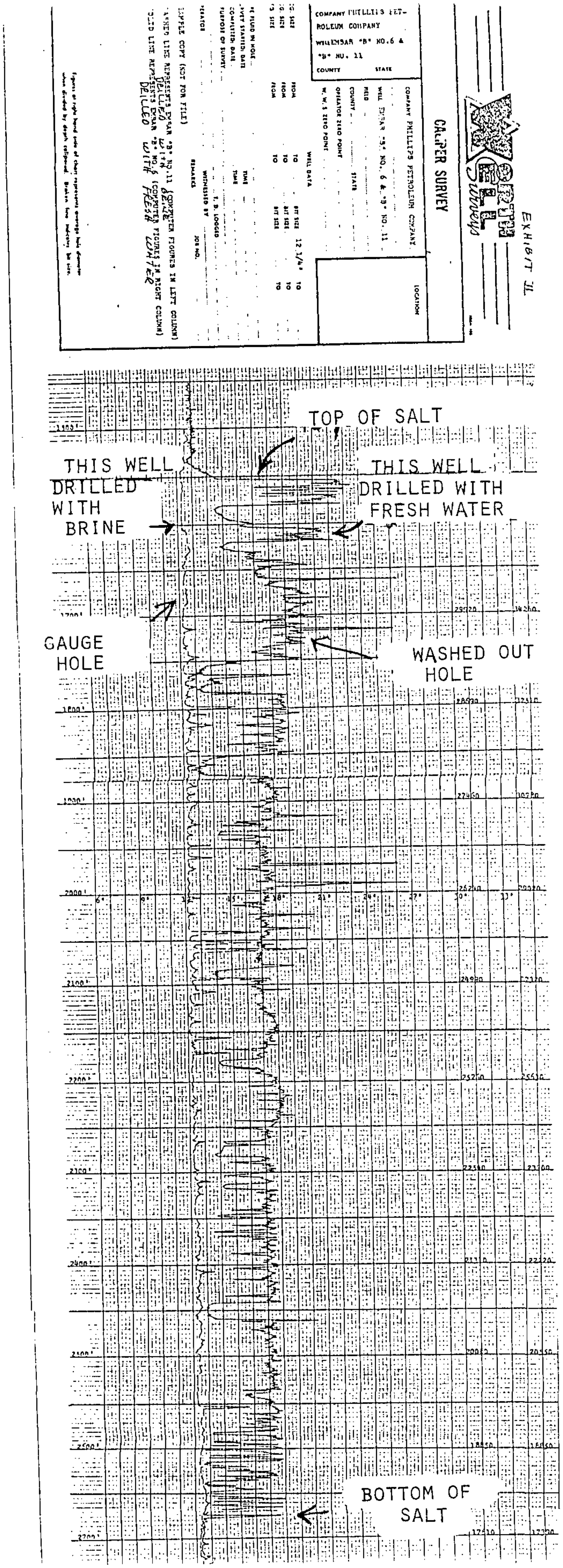
Final Desired Weight Pounds Per Gallon	Hydrostatic Pressure PSI Per 100 Feet	Degrees Salometer	100 BARRELS		110 BARRELS		120 BARRELS		130 BARRELS		135 BARRELS		140 BARRELS	
			BRINE	WATER	BRINE	WATER	BRINE	WATER	BRINE	WATER	BRINE	WATER	BRINE	WATER
8.33	43.3	0	0	100	0	110	0	120	0	130	0	135	0	140
8.5	44.2	11	10	90	11	99	12	108	13	117	14	121	14	126
8.6	44.7	18	16	84	18	92	19	101	21	109	22	113	22	118
8.7	45.3	24	22	78	24	86	26	94	29	101	30	105	31	109
8.8	45.8	30	28	72	31	79	34	86	36	94	38	97	39	101
8.9	46.3	36	34	66	37	73	41	79	44	86	46	89	48	92
9.0	46.8	42	40	60	44	66	48	72	52	78	54	81	56	84
9.1	47.4	48	46	54	51	59	55	65	60	70	62	73	64	76
9.2	47.9	54	52	48	57	53	62	58	68	62	70	65	73	67
9.3	48.4	60	58	42	64	46	70	50	75	55	78	57	81	59
9.4	48.9	66	64	36	70	40	77	43	83	47	86	49	90	50
9.5	49.4	71	70	30	77	33	84	36	91	39	95	40	98	42
9.6	49.9	77	76	24	84	26	91	29	99	31	103	32	106	34
9.7	50.5	83	82	18	90	20	98	22	107	23	111	24	115	25
9.8	51.0	88	88	12	97	13	106	14	114	16	119	16	123	17
9.9	51.5	94	94	6	103	7	113	7	122	8	127	8	132	8
10.0	52.0	99	100	0	110	0	120	0	130	0	135	0	140	0



ZEOLITE BRINE DELIVERY TRUCK

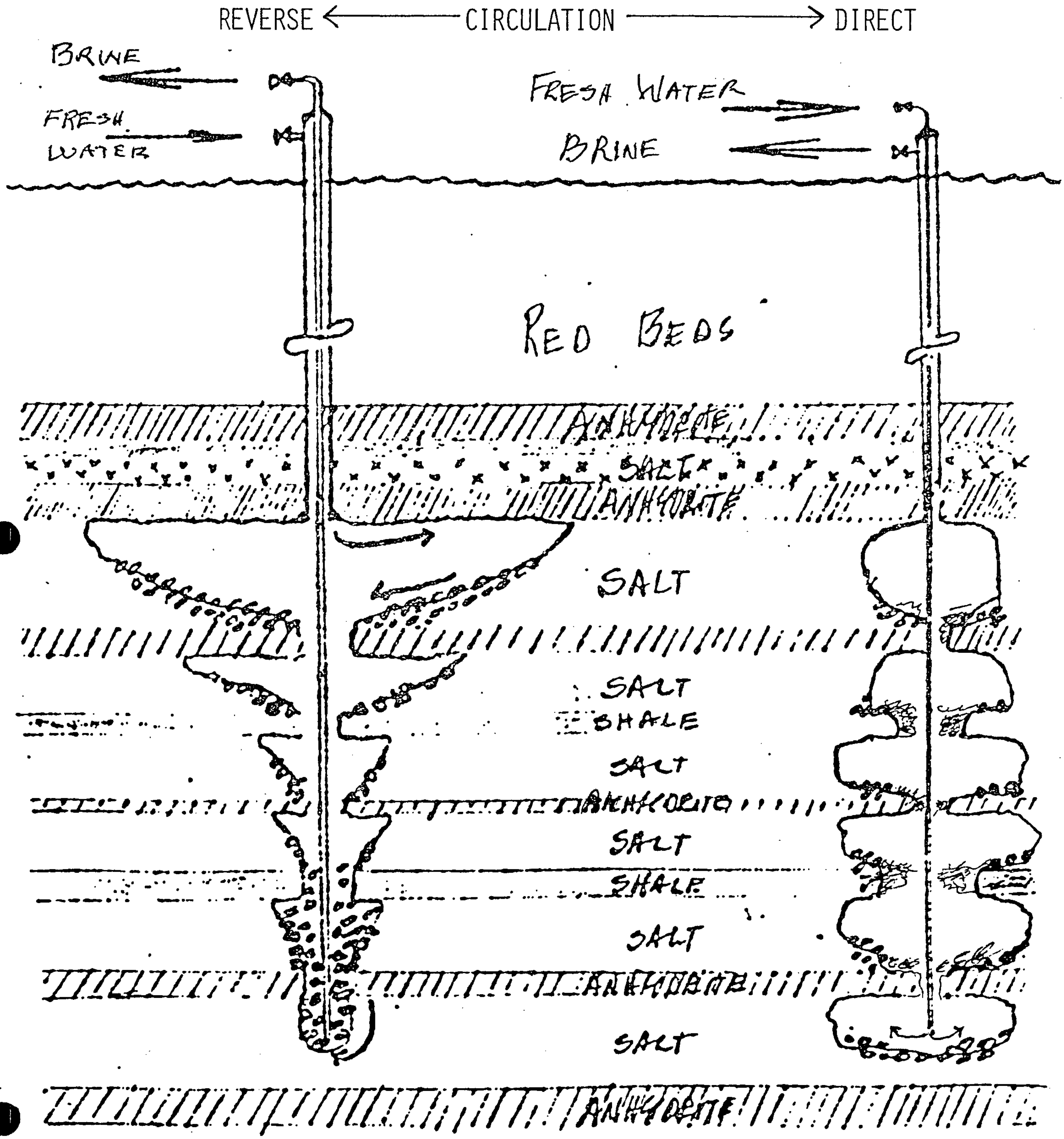
CALIPER SURVEY OF OFFSET WELLS

NEAR GOLDSMITH, TEXAS

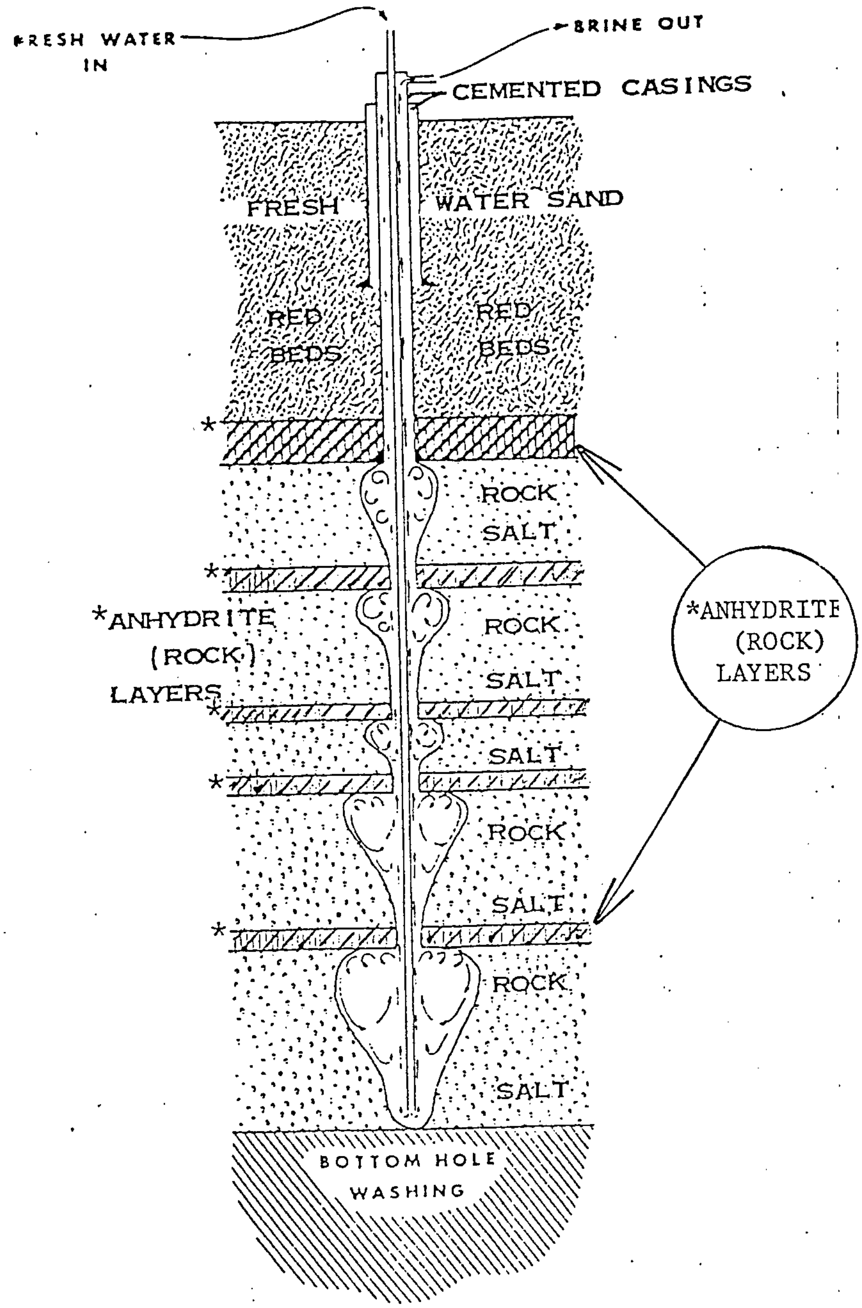


TYPICAL BRINE WELL CONFIGURATION

IN BEDDED SALT



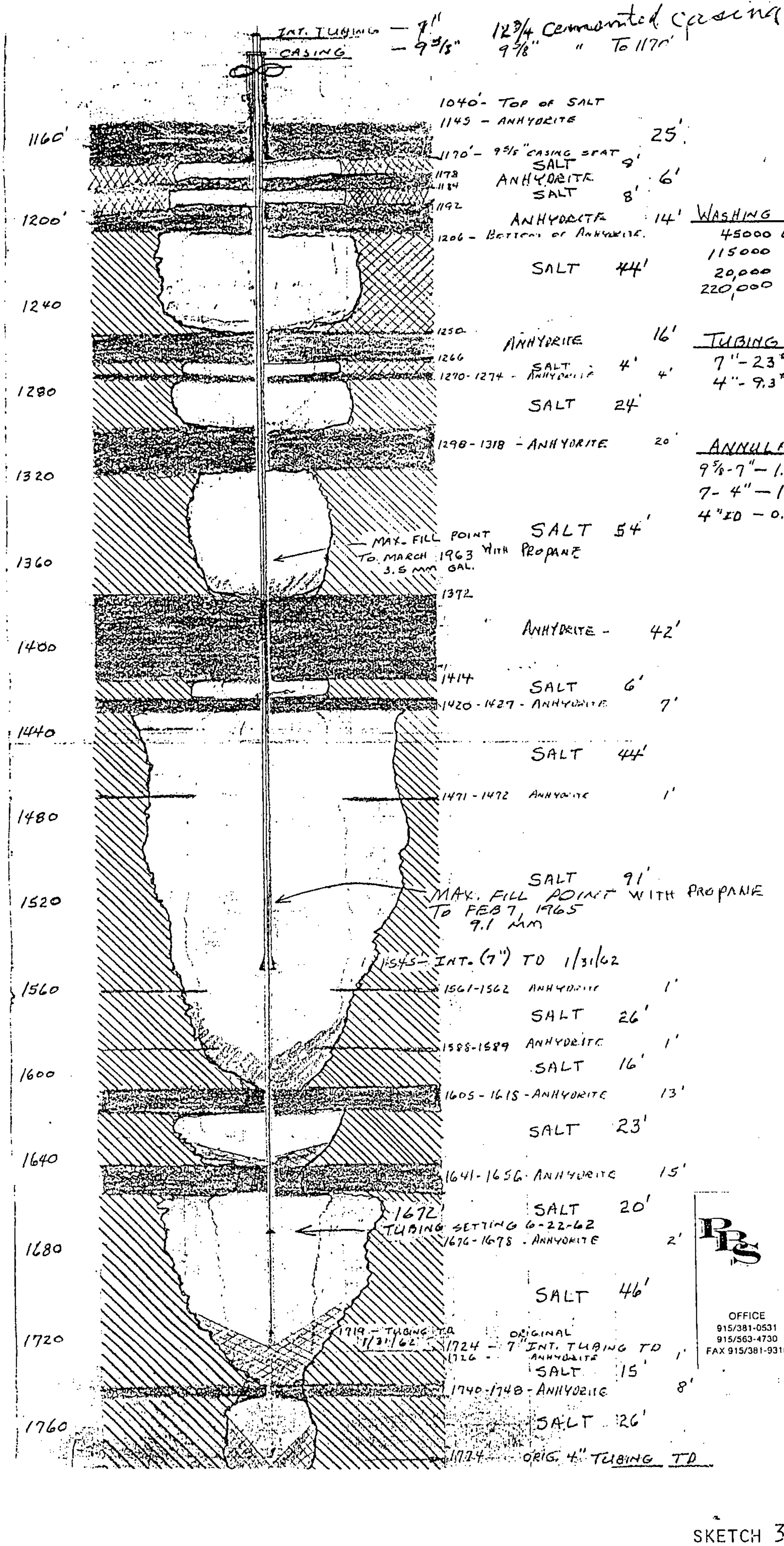
SKETCH 1



Salt bed woshing

Sketch by Neal E. Van Fossan
in article in Symposium On Salt

SKETCH 2



WASHING HISTORY

45000 BBLS IN 4" OUT 9 5/8"
115000 " IN 9 5/8" OUT 4"
20,000 " IN 7" OUT 4"
220,000 " " " "

TUBING STRINGS

7" - 23# = 35,600#
4" - 9.3# = 15,950#

ANNULAR CAPACITIES

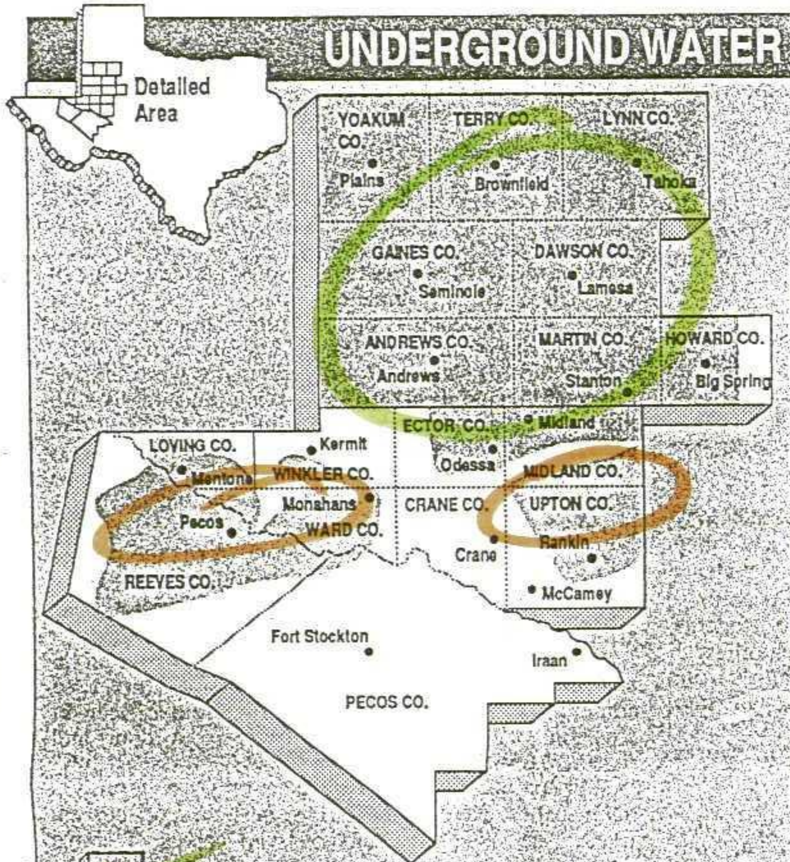
9 5/8 - 7" - 1.245 g/FT = 1460 gal
7 - 4" - 1.0 g/ft = 1545 gal
4" ID - 0.5 g/ft = 859.5 gal

PBS
A. L. HICKERSON
C. E. O.
Prof. Engr. 11830-K
PERMIAN BRINE SALES, IN
6067 W. Tenth St.
Odessa, Texas 79763
OFFICE
915/381-0531
915/563-4730
FAX 915/381-9316
RESIDENCE
915/362-4814
3216 Bainbridge
Odessa, Texas 79

SKETCH 3

ODESSA AMERICAN FEBRUARY 10, 1991

UNDERGROUND WATER PROBLEMS



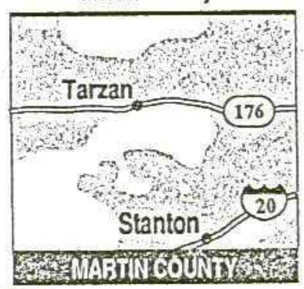
Counties included in a new study by the Texas Water Commission to determine whether the area should be designated as a critical area to protect and conserve its ground water.

Other West Texas areas designated by the TWC and Texas Water Development Board as possibly having future groundwater problems.

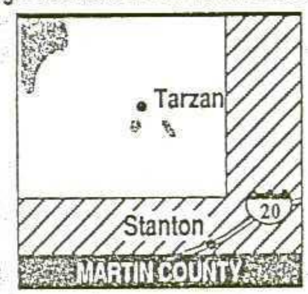
Source: Texas Water Commission

The American: Debra Simpson

Preliminary studies show developing water problems in Martin County.



Area of declining underground water levels 1988 to 1990.



Chloride levels in ground water

1,000 parts per million

500 parts per million

Area of Martin County not included in study.

Source: Martin County Underground Water Conservation District

State begins ground water supply study

By Mike Wheeler
The American

No one will predict how long West Texas will have an available water supply. But experts agree that ground water problems exist in several West Texas areas.

The Texas Water Commission and Texas Water Development Board have begun a study to pinpoint the problems — including shortages, land subsidence and water quality degradation — and how severe those problems could be in the Permian Basin during the next 20 years.

TWC spokesman Bill Colbert said last week that the agency and the TWDB will begin a "critical-area ground water" study that will include all of Yoakum, Terry, Lynn, Gaines, Dawson, Andrews and Martin counties, and portions of Ector, Midland and Howard counties.

"Such a study is used to determine whether a region's water needs special protection," Colbert said. The study should be completed by mid-to late summer, he said.

Mark Hoelscher, manager of the Martin County Underground Water Conservation District, said several preliminary studies there already have shown problems with declining water levels, high concentrations of chlorides and some pesticide and herbicide pollutants.

"We looked at the levels of ground water during the last 10 years and found there is a decline," Hoelscher said. "But the district is only 3 years old and we had to use available data for the remaining period. The quantity doesn't seem to be a big problem now, but we plan to watch levels over the next three to five years to get a more precise

Please see WATER/2B

NOTICE OF PUBLICATION
STATE OF NEW MEXICO
ENERGY, MINERALS AND NATURAL RESOURCES DEPARTMENT
OIL CONSERVATION DIVISION

Notice is hereby given that pursuant to the New Mexico Water Quality Control Commission Regulations, the following discharge plan application has been submitted to the Director of the Oil Conservation Division, 2040 South Pacheco, Santa Fe, New Mexico 87505, Telephone (505) 827-7131:

> **(GW-226) - Permian Brine Sales, A. L. Hickerson, 6067 W Tenth, Odessa, Texas 79763, has submitted a discharge plan application for disposal of non-hazardous semi-solid oil field waste in abandoned salt caverns located in the SE/4 SE/4 of Section 34, Township 19 South, Range 36 East, NMPM, Lea County, New Mexico. Approximately 5,000 barrels per day of solid waste slurry will be injected down the tubing of the abandoned Climax Chemical Company Foster No. 1 to the bottom of the salt cavern, approximately 2,500 feet, and brine will be produced up the annulus for sale. Ground water most likely to be affected in the event of an accidental discharge is at a depth of approximately 35 to 60 feet with a total dissolved solids concentration ranging from 500 to 3000 mg/l. The discharge plan addresses how spills, leaks, and other accidental discharges to the surface will be managed.**

Any interested person may obtain further information from the Oil Conservation Division and may submit written comments to the Director of the Oil Conservation Division at the address given above. The discharge plan applications may be viewed at the above address between 8:00 a.m. and 4:00 p.m., Monday thru Friday. Prior to ruling on any proposed discharge plan or its modification, the Director of the Oil Conservation Division shall allow at least thirty (30) days after the date of publication of this notice during which comments may be submitted to him and public hearing may be requested by any interested person. Request for public hearing shall set forth the reasons why a hearing shall be held. A hearing will be held if the director determines that there is significant public interest.

If no hearing is held, the Director will approve or disapprove the plan based on the information available. If a public hearing is held, the Director will approve the plan based on the information in the plan and information presented at the hearing.

GIVEN under the Seal of New Mexico Oil Conservation Commission at Santa Fe, New Mexico, on this 22nd day of September, 1995.

STATE OF NEW MEXICO
OIL CONSERVATION DIVISION

by [signature] Deputy Director

SEAL

WILLIAM J. LEMAY, Director

NOTICE OF PUBLICATION
STATE OF NEW MEXICO
ENERGY, MINERALS AND NATURAL RESOURCES DEPARTMENT
OIL CONSERVATION DIVISION

Notice is hereby given that pursuant to the New Mexico Water Quality Control Commission Regulations, the following discharge plan application has been submitted to the Director of the Oil Conservation Division, 2040 South Pacheco, Santa Fe, New Mexico 87505, Telephone (505) 827-7131:

> **(GW-226) - Permian Brine Sales, A. L. Hickerson, 6067 W Tenth, Odessa, Texas 79763, has submitted a discharge plan application for disposal of non-hazardous semi-solid oil field waste in abandoned salt caverns located in the SE/4 SE/4 of Section 34, Township 19 South, Range 36 East, NMPM, Lea County, New Mexico. Approximately 5,000 barrels per day of solid waste slurry will be injected down the tubing of the abandoned Climax Chemical Company Foster No. 1 to the bottom of the salt cavern, approximately 2,500 feet, and brine will be produced up the annulus for sale. Ground water most likely to be affected in the event of an accidental discharge is at a depth of approximately 35 to 60 feet with a total dissolved solids concentration ranging from 500 to 3000 mg/l. The discharge plan addresses how spills, leaks, and other accidental discharges to the surface will be managed.**

Any interested person may obtain further information from the Oil Conservation Division and may submit written comments to the Director of the Oil Conservation Division at the address given above. The discharge plan applications may be viewed at the above address between 8:00 a.m. and 4:00 p.m., Monday thru Friday. Prior to ruling on any proposed discharge plan or its modification, the Director of the Oil Conservation Division shall allow at least thirty (30) days after the date of publication of this notice during which comments may be submitted to him and public hearing may be requested by any interested person. Request for public hearing shall set forth the reasons why a hearing shall be held. A hearing will be held if the director determines that there is significant public interest.

If no hearing is held, the Director will approve or disapprove the plan based on the information available. If a public hearing is held, the Director will approve the plan based on the information in the plan and information presented at the hearing.

GIVEN under the Seal of New Mexico Oil Conservation Commission at Santa Fe, New Mexico, on this 22nd day of September, 1995.

STATE OF NEW MEXICO
OIL CONSERVATION DIVISION

by [signature] Deputy Director

SEAL

WILLIAM J. LEMAY, Director

FORM C-101

NEW MEXICO OIL CONSERVATION COMMISSION

Santa Fe, New Mexico

NOTICE OF INTENTION TO DRILL

Notice must be given to the Oil Conservation Commission or its proper agent and approval obtained before drilling begins. If changes in the proposed plan are considered advisable, a copy of this notice showing such changes will be returned to the sender. Submit this notice in triplicate. One copy will be returned following approval. See additional instructions in Rules and Regulations of the Commission.

Hobbs, New Mex. (Place) 4-19-36 (Date)

OIL CONSERVATION COMMISSION,
Santa Fe, New Mexico

Gentlemen:

You are hereby notified that it is our intention to commence the drilling of a well to be known as Shell Petroleum Corporation (Company or Operator) Foster (Lease) Well No. 1 in SE ¼ of SE ¼ of Sec. 34, T. 19-S, R. 36-E, N. M. P. M., Monument Field, Lea County.

N.

AREA 640 ACRES
LOCATE WELL CORRECTLY

The well is 660' feet [N.] [~~S~~] of the S line and 660' feet [~~E~~] [W.] of the E line of Sec 34

(Give location from section or other legal subdivision lines. Cross out wrong directions.)

If state land the oil and gas lease is No. ____ Assignment No. ____

If patented land the owner is J. H. Foster

Address Hobbs, N M

If government land the permittee is ____

Address ____

The lessee is Shell Petroleum Corporation

Address Houston Texas

We propose to drill well with drilling equipment as follows: Rotary Tools

The status of a bond for this well in conformance with Rule 39 of the General Rules and Regulations of the Commission is as follows: ____

We propose to use the following strings of casing and to land or cement them as indicated:

Size of Hole	Size of Casing	Weight Per Foot	New or Second Hand	Depth	Landed or Cemented	Sacks Cement
17½	12½	50	SH	250	Cem	150
12	9-5/8	36	New	1200	"	450
8-3/4	7"	24	"	3725	"	250

If changes in the above plan become advisable we will notify you before cementing or landing casing. We estimate that the first productive oil or gas sand should occur at a depth of about 3800 feet.

Additional information:

Approved ____, 19____
except as follows:

OIL CONSERVATION COMMISSION,
By F. J. Vesely
Title ____

Sincerely yours,

SHELL PETROLUEM CORPORATION
Company or Operator
By [signature]
Position District Engineer

Send communication regarding well to
Name Shell Petrolaum Corporation
Address [illegible] Hobbs N M

Submit 3 Copies
Appropriate
District Office

State of New Mexico
Energy, Minerals and Natural Resources Department

Form C-103
Revised 1-1-89

DISTRICT I
P.O. Box 1980, Hobbs, NM 88240

DISTRICT II
P.O. Drawer DD, Artesia, NM 88210

DISTRICT III
1000 Rio Brazos Rd., Aztec, NM 87410

OIL CONSERVATION DIVISION
P.O. Box 2088
Santa Fe, New Mexico 87504-2088

WELL API NO.
30-025-04112

5. Indicate Type of Lease STATE ☐ FEE ☒

6. State Oil & Gas Lease No.

SUNDRY NOTICES AND REPORTS ON WELLS
(DO NOT USE THIS FORM FOR PROPOSALS TO DRILL OR TO DEEPEN OR PLUG BACK TO A DIFFERENT RESERVOIR. USE "APPLICATION FOR PERMIT" (FORM C-101) FOR SUCH PROPOSALS.)

7. Lease Name or Unit Agreement Name
NORTH MONUMENT G/SA UNIT
BLOCK 13

1. Type of Well:
OIL WELL ☒ GAS WELL ☐ OTHER

2. Name of Operator
AMERADA HESS CORPORATION

8. Well No.
18

3. Address of Operator
DRAWER D, MONUMENT, NM 88265

9. Pool name or Wildcat
EUNICE MONUMENT G/SA

4. Well Location
Unit Letter P : 660 Feet From The SOUTH Line and 660 Feet From The EAST Line

Section 34 Township 19S Range 36E NMPM LEA County

10. Elevation (Show whether DF, RKB, RT, GR, etc.)

11. Check Appropriate Box to Indicate Nature of Notice, Report, or Other Data

NOTICE OF INTENTION TO:				SUBSEQUENT REPORT OF:			
PERFORM REMEDIAL WORK	☐	PLUG AND ABANDON	☐	REMEDIAL WORK	☐	ALTERING CASING	☐
TEMPORARILY ABANDON	☐	CHANGE PLANS	☐	COMMENCE DRILLING OPNS.	☐	PLUG AND ABANDONMENT	☐
PULL OR ALTER CASING	☐			CASING TEST AND CEMENT JOB	☐		
OTHER:	☐			OTHER: TESTED CASING			☒

12. Describe Proposed or Completed Operations (*Clearly state all pertinent details, and give pertinent dates, including estimated date of starting any proposed work*) SEE RULE 1103.

6-24 THRU 6-28-93

MIRU DA&S WELL SER. PULLING UNIT & TOH WITH A 1-1/4" X 22' POLISHED ROD WITH A 1-1/2" X 12' LINER AND FOUND PUMP STUCK. BACKED OFF RODS & RECOVERED 2 3/4" X 8' PONY RODS AND 45 3/4" SUCKER RODS. REMOVED 9-5/8" HINDERLITER TUBINGHEAD PACKING AND SLIP ASSEMBLY AND INSTALLED A 9-5/8" ADAPTER FLANGE AND A 6" 900 MANUAL BOP. STRIPPED OUT RODS AND TUBING. TIH WITH 4-1/4" DRILL BIT, TAGGED TOP OF LINER AT 3,664' & PBD AT 3,967'. TOH WITH BIT. TIH WITH A 5" ELDER LOK-SET RETRIEVABLE BRIDGE PLUG. SET AT 3,855', CIRC. CASING WITH 130 BBLS. FRESH WATER & PRESS. TESTED CASING FROM 0' TO 3,855'. PRESS. DECREASED FROM 580 PSI TO 535 PSI IN 30 MINS. CHECKED INTERMEDIATE-PRODUCTION CASING ANNULUS AND FOUND NO PRESSURE OR FLOW. RELEASED RBP AT 3,855' & TOH. SCHLUMBERGER RIH WITH GR-CCL-CNL TOOLS. SCHLUMBERGER FOUND TOP OF 5" LINER AT 3,662' & TD AT 3,935'. LOGGED FROM 3,932' TO 2,865'. FOUND GR READINGS
(CONT)

I hereby certify that the information above is true and complete to the best of my knowledge and belief.

SIGNATURE R L Wheeler Jr TITLE SUPV. ADMIN. SER. DATE 7-12-93

TYPE OR PRINT NAME ROY L. WHEELER, JR. TELEPHONE NO. 393-2144

(This space for State Use)

APPROVED BY Orig. Signed by Paul Kautz TITLE Geologist DATE JUL 16 1993

CONDITIONS OF APPROVAL, IF ANY:

District I
PO Box 1980, Hobbs, NM 88241-1980
District II
PO Drawer DD, Artesia, NM 88211-0719
District III
1000 Rio Brazos Rd., Aztec, NM 87410
District IV
PO Box 2088, Santa Fe, NM 87504-2088

State of New Mexico
Energy, Minerals & Natural Resources Department

OIL CONSERVATION DIVISION
PO Box 2088
Santa Fe, NM 87504-2088

Form C-101
Revised February 10, 1994
Instructions on back
Submit to Appropriate District Office
State Lease - 6 Copies
Fee Lease - 5 Copies

☐ AMENDED REPORT

APPLICATION FOR PERMIT TO DRILL, RE-ENTER, DEEPEN, PLUGBACK, OR ADD A ZONE

1 Operator Name and Address.	2 OGRID Number
PERMIAN BRINE SALES, INC. 6067 West 10th Street Odessa, Texas 79763	
	3 API Number 30 - 0

4 Property Code	5 Property Name	6 Well No.
	Formerly Climax Chemical Saline Well No.1 Foster	1

7 Surface Location

UL or lot no.	Section	Township	Range	Lot Idn	Feet from the	~~North~~/South line	Feet from the	East/~~West~~ line	County
	34	19-S	36-E			990 ft.		1155 ft	Lea

8 Proposed Bottom Hole Location If Different From Surface

UL or lot no.	Section	Township	Range	Lot Idn	Feet from the	North/South line	Feet from the	East/West line	County

9 Proposed Pool 1	10 Proposed Pool 2

11 Work Type Code	12 Well Type Code	13 Cable/Rotary	14 Lease Type Code	15 Ground Level Elevation
E	Brine - I	Rotary	P	3618
16 Multiple	17 Proposed Depth	18 Formation	19 Contractor	20 Spud Date
No	2480 ft.	Salado		

21 Proposed Casing and Cement Program

Hole Size	Casing Size	Casing weight/foot	Setting Depth	Sacks of Cement	Estimated TOC
12¼	9 5/8	32.3	~~1297~~ 1310	440	Circ

22 Describe the proposed program. If this application is to DEEPEN or PLUG BACK give the data on the present productive zone and proposed new productive zone. Describe the blowout prevention program, if any. Use additional sheets if necessary.

Re-entry, drill out cement and bridge plug
Hang 3½ tubing to T.D.

23 I hereby certify that the information given above is true and complete to the best of my knowledge and belief.		OIL CONSERVATION DIVISION	
Signature: A.L. Hickerson		Approved by:	
Printed name: A.L. Hickerson		Title:	
Title: C.E.O,		Approval Date:	Expiration Date:
Date: 9-11-95	Phone: (915)381-0531	Conditions of Approval : Attached ☐	

C-101 Instructions

Measurements and dimensions are to be in feet/inches. We‹ ›ocations will refer to the New Mexico Principal Meridian.

IF THIS IS AN AMENDED REPORT CHECK THE BOX LABLED "AMENDED REPORT" AT THE TOP OF THIS DOCUMENT.

1 Operator's OGRID number. If you do not have one it will be assigned and filled in by the District office.

2 Operator's name and address

3 API number of this well. If this is a new drill the OCD will assign the number and fill this in.

4 Property code. If this is a new property the OCD will assign the number and fill it in.

5 Property name that used to be called 'well name'

6 The number of this well on the property.

7 The surveyed location of this well New Mexico Principal Meridian NOTE: If the United States government survey designates a Lot Number for this location use that number in the 'UL or lot no.' box. Otherwise use the OCD Unit Letter.

8 The proposed bottom hole location of this well at TD

9 and 10 The proposed pool(s) to which this well is beeing drilled.

11 Work type code from the following table:

N	New well
E	Re-entry
D	Drill deeper
P	Plugback
A	Add a zone

12 Well type code from the following table:

O	Single oil completion
G	Single gas completion
M	Mutiple completion
I	Injection well
S	SWD well
W	Water supply well
C	Carbon dioxide well

13 Cable or rotary drilling code

C	Propose to cable tool drill
R	Propose to rotary drill

14 Lease type code from the following table:

F	Federal
S	State
P	Private
N	Navajo
J	Jicarilla
U	Ute
I	Other Indian tribe

15 Ground level elevation above sea level

16 Intend to mutiple complete? Yes or No

17 Proposed total depth of this well

18 Geologic formation at TD

19 Name of the intended drilling company if known.

20 Anticipated spud date.

21 Proposed hole size ID inches, proposed casing OD inches, casing weight in pounds per foot, setting depth of the casing or depth and top of liner, proposed cementing volume, and estimated top of cement

22 Brief description of the proposed drilling program and BOP program. Attach additional sheets if necessary.

23 The signature, printed name, and title of the person authorized to make this report. The date this report was signed and the telephone number to call for questions about this report.

FORM C-128
Revised 5/1/57

NEW MEXICO OIL CONSERVATION COMMISSION
WELL LOCATION AND ACREAGE DEDICATION PLAT

SEE INSTRUCTIONS FOR COMPLETING THIS FORM ON THE REVERSE SIDE

SECTION A

Operator	Lease	Well No.
CLIMAX CHEMICAL CORP.	SALINE WATER WELL	1

Unit Letter	Section	Township	Range	County
P	34	19 SOUTH	36 EAST	LEA

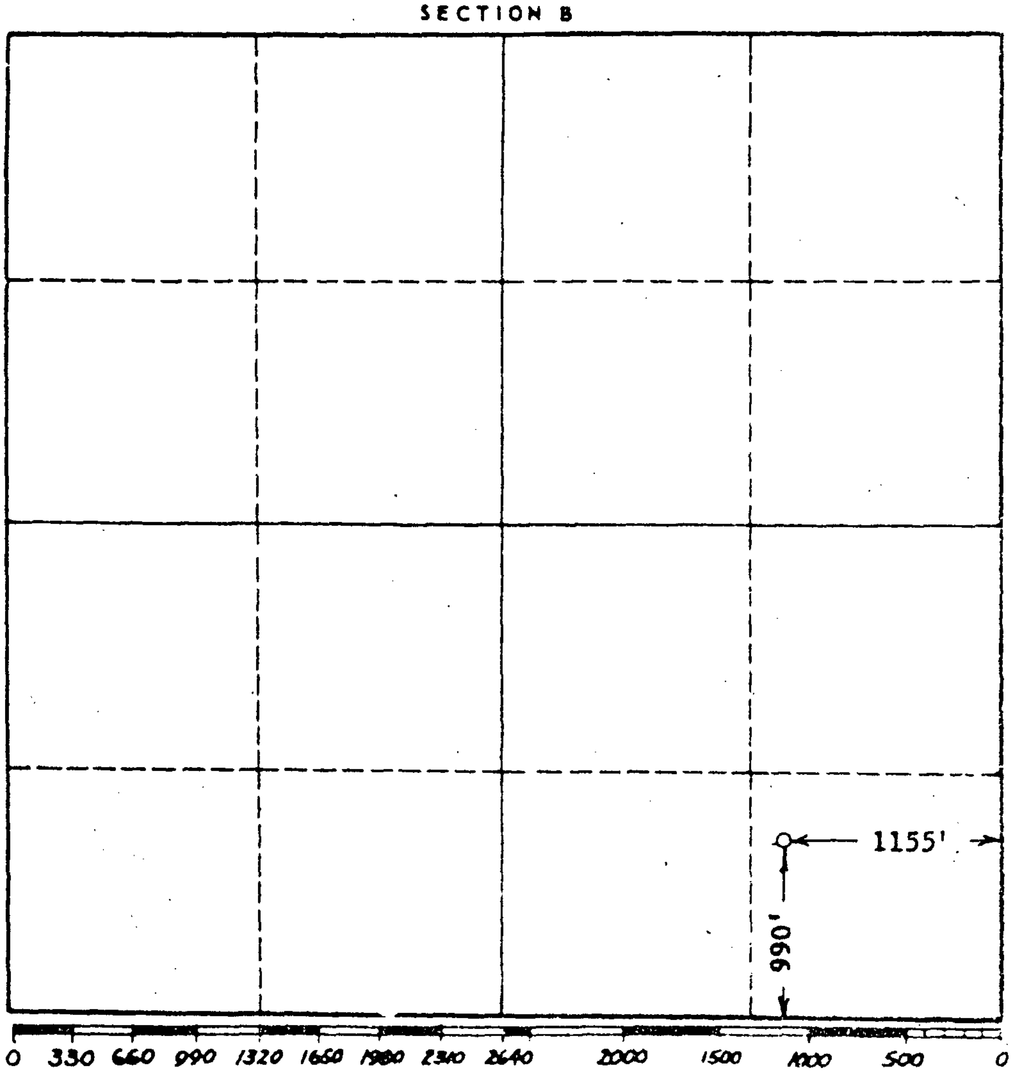
Actual Footage Location of Well: 990 feet from the SOUTH line and 1155 feet from the EAST line

Ground Level Elev.	Producing Formation	Pool	Dedicated Acreage:
			Acres

1. Is the Operator the only owner in the dedicated acreage outlined on the plat below? YES ______ NO ______ . (*"Owner" means the person who has the right to drill into and to produce from any pool and to appropriate the production either for himself or for himself and another.* (65-3-29 (e) NMSA 1935 Comp.)
2. If the answer to question one is "no," have the interests of all the owners been consolidated by communitization agreement or otherwise? YES ______ NO ______ . If answer is "yes," Type of Consolidation ______
3. If the answer to question two is "no," list all the owners and their respective interests below:

Owner	Land Description

SECTION B



CERTIFICATION

I hereby certify that the information in *SECTION A* above is true and complete to the best of my knowledge and belief.

E. D. Smith
Name

Mech. Supt.
Position

Climax Chemical Co
Company

Date 1-4-62

I hereby certify that the well location shown on the plat in *SECTION B* was plotted from field notes of actual surveys made by me or under my supervision, and that the same is true and correct to the best of my knowledge and belief.

REG. PRO. ENGINEER & LAND SURVEYOR STATE OF NEW MEXICO 676 JOHN W. WEST

Date Surveyed
12-26-1961

Registered Professional Engineer and/or Land Surveyor, JOHN W. WEST

John W. West

Certificate No.
N. M. P.E. & L.S. NO. 676

NEW M   CO OIL CONSERVATION COMM   N

Santa Fe, New Mexico

Form C-101
Revised (12/1/55)

NOTICE OF INTENTION TO DRILL IN 1962

Notice must be given to the District Office of the Oil Conservation Commission and approval obtained before drilling or recompletion begins. If changes in the proposed plan are considered advisable, a copy of this notice showing such changes will be returned to the sender. Submit this notice in QUINTUPLICATE. One copy will be returned following approval. See additional instructions in Rules and Regulations of the Commission. If State Land submit 6 Copies Attach Form C- 128 in triplicate to first 3 copies of form C-101

Hobbs, New Mexico (Place) January 16, 1962 (Date)

OIL CONSERVATION COMMISSION
SANTA FE, NEW MEXICO

Gentlemen:

You are hereby notified that it is our intention to commence the Drilling of a well to be known as CLIMAX CHEMICAL COMPANY (Company or Operator) Foster (Lease), Well No. 1, in P (Unit) The well is located 990 feet from the South line and 1155 feet from the East line of Section 34, T. 19 S, R. 36 E, NMPM.

(GIVE LOCATION FROM SECTION LINE) Undesignated Pool, Lea County

D	C	B	A
E	F	G	H
L	K	J	I
M	N	O	o P

If State Land the Oil and Gas Lease is No.

If patented land the owner is J. W. Foster

Address

We propose to drill well with drilling equipment as follows: Rotary tools from surfac to bottom Rustler Anhydrite. Cable tools Base Anhy. to Base Sal

The status of plugging bond is $5,000 bond approved

Drilling Contractor Not determined at this date

We intend to complete this well in the Base of the Salt section at depth of formation at an approximate depth of approximately 2520 feet feet.

CASING PROGRAM

We propose to use the following strings of Casing and to cement them as indicated:

Size of Hole	Size of Casing	Weight per Foot	New or Second Hand	Depth	Sacks Cement
12-1/4"	9-5/8"	32	New	1310'	Circulate to su
8-3/4"	5-1/2"	15.5	New	Will hang inside 9-5/8" casing	

and use as input for fresh water to wash Salt section and return Brine water.

If changes in the above plans become advisable we will notify you immediately.

ADDITIONAL INFORMATION (If recompletion give full details of proposed plan of work.)

Approved ...., 19........
Except as follows:

OIL CONSERVATION COMMISSION

By ....

Sincerely yours,

Climax Chemical Company
(Company or Operator)

By Charles P. Weller

Position Agent

Send Communications regarding well to

Name W. H. Kolins

Address Box 1595, Hobbs, New Mexico

NEW MEXICO OIL CONSERVATION COMMISSION

FORM C-103 (Rev 3-55)

MISCELLANEOUS REPORTS ON WELLS

(Submit to appropriate District Office as per Commission Rule 1106)

Name of Company					Address	
Climax Chemical Company					Hobbs, New Mexico	
Lease	Well No.	Unit Letter	Section	Township		Range
(Foster) Saline Water Well	1	P	34	19 South		36 East
Date Work Performed	Pool			County		
January 30,31 1962	Undesignated			Lea		

THIS IS A REPORT OF: *(Check appropriate block)*

- [ ] Beginning Drilling Operations
- [x] Casing Test and Cement Job
- [ ] Other *(Explain)*:
- [ ] Plugging
- [ ] Remedial Work

Detailed account of work done, nature and quantity of materials used, and results obtained.

Spudded 12-1/4" hole with Rotary tools January 26, 1962. Drilled to depth of 1300 feet. Ran 42 joints H-40 32.3# 3.3 9 5/8" casing with Halliburton Float shoe. Tagged bottom of hole then picked casing up one foot and cemented same with 145 sax Incor cement, 145 sax Diamax A 6% jel, 100 sax regular cement. Plug pumped down at 2:45 P.M. January 30, 1962. Cement did not circulate. At 3:00 P.M. January 31, 1962 ran 1" tubing down annulus between hole and casing and found firm cement forty feet below ground level. Pumped water into hole and circulated to pits to lighten mud load in annulus. Thenpumped 50 sacks Regular cement to bottom of uncemented hole and circulated cement to surface. Estimated to have circulated about 25 sax cement back to pits. Bailed hole dry to top of plug at 1260 feet. Allowed hole to stand one hour and ran bailer again. Found no increase in fluid. Drilled plug and shoe, then allowed hole to stand one hour. Hole remained dry after bailing test. Drilling new hole below casing with Cable tools.

Cement allowed to set on 9-5/8" casing from 2:45 P.M., January 30, 1962 until 3:00 A.M. February 1, 1962 before plug was drilled.

Witnessed by	Position	Company
Charles P. Miller	Agent	Climax Chemical Company

FILL IN BELOW FOR REMEDIAL WORK REPORTS *ONLY*

ORIGINAL WELL DATA

D F Elev.	T D	P B T D	Producing Interval	Completion Date

Tubing Diameter	Tubing Depth	Oil String Diameter	Oil String Depth

Perforated Interval(s)

Open Hole Interval	Producing Formation(s)

RESULTS OF WORKOVER

Test	Date of Test	Oil Production BPD	Gas Production MCFPD	Water Production BPD	GOR Cubic feet/Bbl	Gas Well Potential MCFPD
Before Workover						
After Workover						

OIL CONSERVATION COMMISSION	I hereby certify that the information given above is true and complete to the best of my knowledge.
Approved by	Name Charles P. Miller
Title	Position Agent
Date	Company Climax Chemical Company

RECORD OF DRILL-STEM AND SPECIAL TESTS

If drill-stem or other special tests or deviation surveys were made, submit report on separate sheet and attach hereto.

TOOLS USED

Rotary tools were used from 0 feet to 1300 feet, and from .... feet to .... feet.
Cable tools were used from 1300 feet to 2482 feet, and from .... feet to .... feet.

PRODUCTION

Put to Producing ...., 19........ **Saline water well. No test for oil or gas.**

OIL WELL: The production during the first 24 hours was .... barrels of liquid of which ....% was was oil; ....% was emulsion; ....% water; and ....% was sediment. A.P.I. Gravity ....

GAS WELL: The production during the first 24 hours was .... M.C.F. plus .... barrels of liquid Hydrocarbon. Shut in Pressure .... lbs.

Length of Time Shut in ....

PLEASE INDICATE BELOW FORMATION TOPS (IN CONFORMANCE WITH GEOGRAPHICAL SECTION OF STATE):

Southeastern New Mexico		Northwestern New Mexico
T. Anhy. 1196	T. Devonian	T. Ojo Alamo
T. Salt 1297	T. Silurian	T. Kirtland-Fruitland
B. Salt 2480	T. Montoya	T. Farmington
T. Yates	T. Simpson	T. Pictured Cliffs
T. 7 Rivers	T. McKee	T. Menefee
T. Queen	T. Ellenburger	T. Point Lookout
T. Grayburg	T. Gr. Wash	T. Mancos
T. San Andres	T. Granite	T. Dakota
T. Glorieta	T.	T. Morrison
T. Drinkard	T.	T. Penn
T. Tubbs	T.	T.
T. Abo	T.	T.
T. Penn	T.	T.
T. Miss	T.	T.

FORMATION RECORD

From	To	Thickness in Feet	Formation	From	To	Thickness in Feet	Formation
0	95	95	Sand	1865	1880	15	Salt & polyhalite
95	565	470	Red beds	1880	1905	25	Salt
565	635	70	Red beds and sand	1905	1965	60	Salt & polyhalite
635	875	240	Red beds, sand, shale	1965	1995	30	Salt
875	1065	190	Red beds	1995	2005	10	Anhydrite & polyhalite
1065	1200	135	Red beds & sdy. red shale	2005	2123	118	Salt
1200	1297	97	Anhydrite & shells	2123	2143	20	Salt & polyhalite
1297	1335	38	Salt	2143	2175	32	Anhydrite & salt
1335	1370	35	Anhydrite & shale	2175	2275	100	Salt
1370	1380	10	Anhydrite	2275	2315	40	Salt & polyhalite
1380	1415	35	Shale & salt	2315	2480	165	Salt
1415	1440	25	Red shells	2480	2482	2	Anhydrite
1440	1480	40	Shell & salt				
1480	1535	55	Salt & shale				
1535	1610	75	Salt				
1610	1640	30	Salt & anhy. streaks				
1640	1655	15	Salt				
1655	1675	20	Anhydrite				
1675	1865	190	Salt				

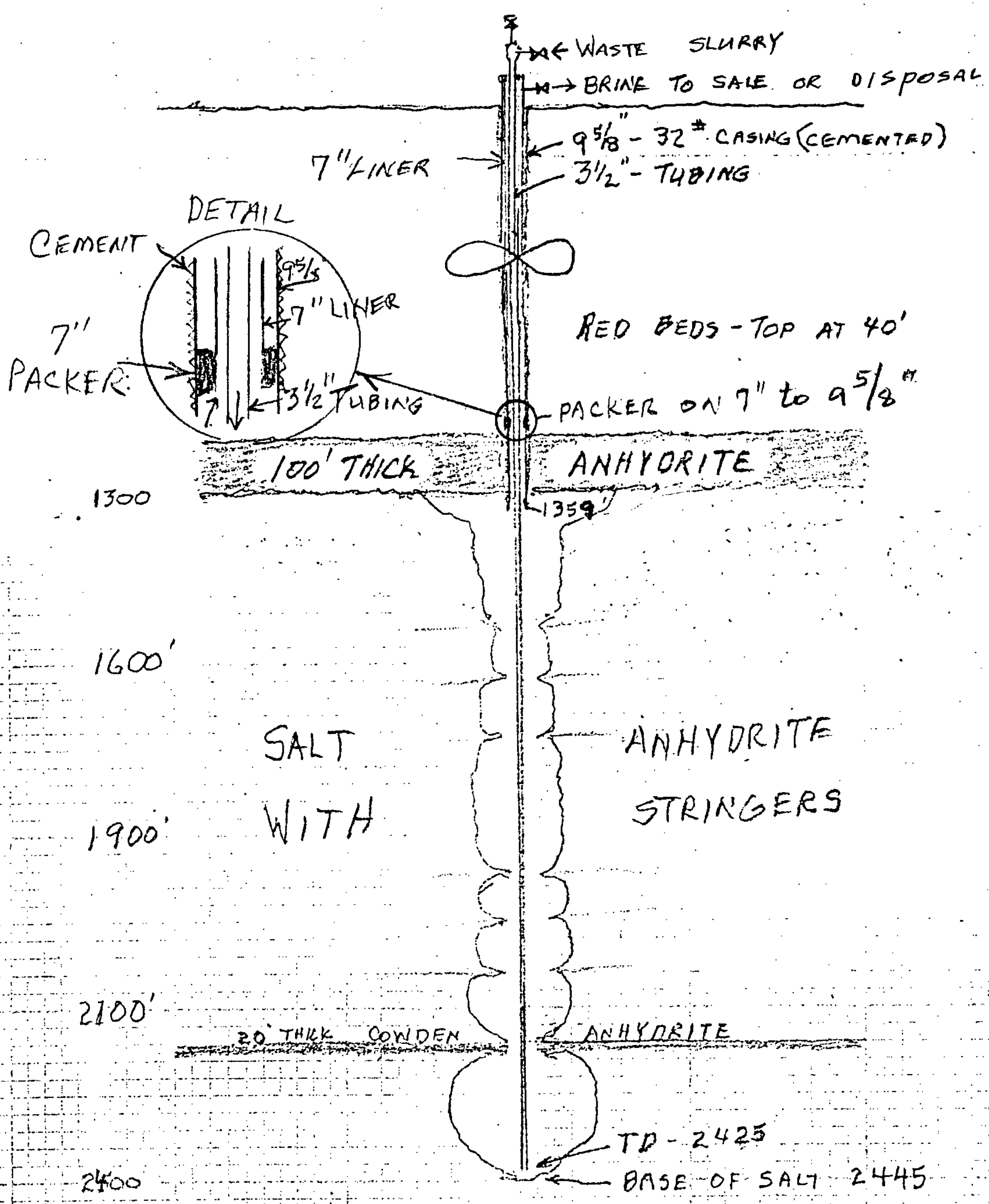
ATTACH SEPARATE SHEET IF ADDITIONAL SPACE IS NEEDED

I hereby swear or affirm that the information given herewith is a complete and correct record of the well and all work done on it so far as can be determined from available records.

March 19, 1962
(Date)

Company or Operator Climax Chemical Company — Address Hobbs, New Mexico

Name Charles P. Miller — Position or Title Agent



PERMIAN BRINE SALES, INC.
ODESSA, TEXAS

MONUMENT NO. 2

OLD CLIMAX FOSTER No 2 (1969)
SEC. 34 T-19-S R-36-E
1020' FSL 300' FEL
SCALE - 1" = 300 ft.

DATE:	BY:	DRAWING NO.:

District I PO Box 1980, Hobbs, NM 88241-1980 District II PO Drawer DD, Artesia, NM 88211-0719 District III 1000 Rio Brazos Rd., Aztec, NM 87410 District IV PO Box 2088, Santa Fe, NM 87504-2088	State of New Mexico Energy, Minerals & Natural Resources Department OIL CONSERVATION DIVISION PO Box 2088 Santa Fe, NM 87504-2088	Form C-101 Revised February 10, 1994 Instructions on back Submit to Appropriate District Office State Lease - 6 Copies Fee Lease - 5 Copies ☐ AMENDED REPORT

APPLICATION FOR PERMIT TO DRILL, RE-ENTER, DEEPEN, PLUGBACK, OR ADD A ZONE

[1] Operator Name and Address.	[2] OGRID Number
PERMIAN BRINE SALES, INC 6067 West 10th Street Odessa, Texas 79763	[3] API Number 30 - 0

[4] Property Code	[5] Property Name	[6] Well No.
	Formerly Climax Saline Well No.2 Foster	2

[7] Surface Location

UL or lot no.	Section	Township	Range	Lot Idn	Feet from the	North/South line	Feet from the	East/West line	County
	34	19-S	36-E			1020 ft		300 ft	Lea

[8] Proposed Bottom Hole Location If Different From Surface

UL or lot no.	Section	Township	Range	Lot Idn	Feet from the	North/South line	Feet from the	East/West line	County

[9] Proposed Pool 1	[10] Proposed Pool 2

[11] Work Type Code	[12] Well Type Code	[13] Cable/Rotary	[14] Lease Type Code	[15] Ground Level Elevation
E	Brine - I	Rotary	P	3618
[16] Multiple	[17] Proposed Depth	[18] Formation	[19] Contractor	[20] Spud Date
No	2449	Salado		

[21] Proposed Casing and Cement Program

Hole Size	Casing Size	Casing weight/foot	Setting Depth	Sacks of Cement	Estimated TOC
12¼	9 5/8	32.3	1359	500	Circ

[22] Describe the proposed program. If this application is to DEEPEN or PLUG BACK give the data on the present productive zone and proposed new productive zone. Describe the blowout prevention program, if any. Use additional sheets if necessary.

Re- entry, drill out cement and bridge plug
Hang 3½ tubing to T.D.

[23] I hereby certify that the information given above is true and complete to the best of my knowledge and belief.	OIL CONSERVATION DIVISION
Signature: A. L. Hickerson	Approved by:
Printed name: A.L. Hickerson	Title:
Title: C.E.O.	Approval Date: / Expiration Date:
Date: 9-11-95 / Phone: (915)381-0531	Conditions of Approval: Attached ☐

C-101 Instructions

Measurements and dimensions are to be in feet/inches. We·· ocations will refer to the New Mexico Principal Meridian.

IF THIS IS AN AMENDED REPORT CHECK THE BOX LABLED "AMENDED REPORT" AT THE TOP OF THIS DOCUMENT.

1 Operator's OGRID number. If you do not have one it will be assigned and filled in by the District office.

2 Operator's name and address

3 API number of this well. If this is a new drill the OCD will assign the number and fill this in.

4 Property code. If this is a new property the OCD will assign the number and fill it in.

5 Property name that used to be called 'well name'

6 The number of this well on the property.

7 The surveyed location of this well New Mexico Principal Meridian NOTE: If the United States government survey designates a Lot Number for this location use that number in the 'UL or lot no.' box. Otherwise use the OCD Unit Letter.

8 The proposed bottom hole location of this well at TD

9 and 10 The proposed pool(s) to which this well is beeing drilled.

11 Work type code from the following table:

N	New well
E	Re-entry
D	Drill deeper
P	Plugback
A	Add a zone

12 Well type code from the following table:

O	Single oil completion
G	Single gas completion
M	Mutiple completion
I	Injection well
S	SWD well
W	Water supply well
C	Carbon dioxide well

13 Cable or rotary drilling code

C	Propose to cable tool drill
R	Propose to rotary drill

14 Lease type code from the following table:

F	Federal
S	State
P	Private
N	Navajo
J	Jicarilla
U	Ute
I	Other Indian tribe

15 Ground level elevation above sea level

16 Intend to mutiple complete? Yes or No

17 Proposed total depth of this well

18 Geologic formation at TD

19 Name of the intended drilling company if known.

20 Anticipated spud date.

21 Proposed hole size ID inches, proposed casing OD inches, casing weight in pounds per foot, setting depth of the casing or depth and top of liner, proposed cementing volume, and estimated top of cement

22 Brief description of the proposed drilling program and BOP program. Attach additional sheets if necessary.

23 The signature, printed name, and title of the person authorized to make this report. The date this report was signed and the telephone number to call for questions about this report.

NO. OF COPIES RECEIVED		
DISTRIBUTION		
SANTA FE		
FILE		
U.S.G.S.		
LAND OFFICE		
OPERATOR		

NEW MEXICO OIL CONSERVATION COMMISSION

JAN '70 3 PM

Form C-101
Revised 1-1-65

5A. Indicate Type of Lease
STATE ☐ FEE ☒

5. State Oil & Gas Lease No.

APPLICATION FOR PERMIT TO DRILL, DEEPEN, OR PLUG BACK

1a. Type of Work
DRILL ☐ DEEPEN ☐ PLUG BACK ☐

b. Type of Well
OIL WELL ☐ GAS WELL ☐ OTHER Saline water well SINGLE ZONE ☐ MULTIPLE ZONE ☐

7. Unit Agreement Name

8. Farm or Lease Name
Saline water well

2. Name of Operator
Climax Chemical Company

9. Well No.
2

3. Address of Operator

10. Field and Pool, or Wildcat
---

4. Location of Well UNIT LETTER P LOCATED 1020 FEET FROM THE S LINE AND 300 FEET FROM THE E LINE OF SEC. 34 TWP. 19S RGE. 36E NMPM

12. County
Lea

19. Proposed Depth
2480

19A. Formation
Salt

20. Rotary or C.T.
R

21. Elevations (Show whether DF, RT, etc.)

21A. Kind & Status Plug. Bond

21B. Drilling Contractor
Lohmann Well Service

22. Approx. Date Work will start
12/30/69

23.

PROPOSED CASING AND CEMENT PROGRAM

SIZE OF HOLE	SIZE OF CASING	WEIGHT PER FOOT	SETTING DEPTH	SACKS OF CEMENT	EST. TOP
0-1353'-12¼"	9 5/8"	32.30	1353'	700	Surface
1353'-Bottom-8 3/4"	5 1/2"	15.50	0-Bottom	Cement from Surface to Bottom	

IN ABOVE SPACE DESCRIBE PROPOSED PROGRAM: IF PROPOSAL IS TO DEEPEN OR PLUG BACK, GIVE DATA ON PRESENT PRODUCTIVE ZONE AND PROPOSED NEW PRODUCTIVE ZONE. GIVE BLOWOUT PREVENTER PROGRAM, IF ANY.

I hereby certify that the information above is true and complete to the best of my knowledge and belief.

Signed Climax Chemical Company Title Vice-President Date December 30, 196

(This space for State Use)

APPROVED BY ________ TITLE SUPERVISOR DISTRICT I DATE JUN 17 1970

CONDITIONS OF APPROVAL, IF ANY:

NO. OF COPIES RECEIVED		
DISTRIBUTION		
SANTA FE		
FILE		
U.S.G.S.		
LAND OFFICE		
OPERATOR		

NEW MEXICO OIL CONSERVATION COMMISSION

Form C-103
Supersedes Old
C-102 and C-103
Effective 1-1-65

5a. Indicate Type of Lease
State [ ] Fee [X]

5. State Oil & Gas Lease No.
Patented Land

SUNDRY NOTICES AND REPORTS ON WELLS

(DO NOT USE THIS FORM FOR PROPOSALS TO DRILL OR TO DEEPEN OR PLUG BACK TO A DIFFERENT RESERVOIR. USE "APPLICATION FOR PERMIT –" (FORM C-101) FOR SUCH PROPOSALS.)

1. OIL WELL [ ] GAS WELL [ ] OTHER- Saline Water Well #2

7. Unit Agreement Name
None

2. Name of Operator
CLIMAX CHEMICAL COMPANY

8. Farm or Lease Name
~~Foster~~ Saline Wa[illegible]

3. Address of Operator
Box 1595 - Hobbs, New Mexico 88240

9. Well No.
2

4. Location of Well
UNIT LETTER none , 300' FEET FROM THE East LINE AND ~~[illegible]~~ 1020 FEET FROM THE ~~North~~ South LINE, SECTION 34 TOWNSHIP 19 RANGE 36E NMPM.

10. Field and Pool, or Wildcat
Monument

15. Elevation (Show whether DF, RT, GR, etc.)
3618 G. R.

12. County
Lea

16. Check Appropriate Box To Indicate Nature of Notice, Report or Other Data

NOTICE OF INTENTION TO:

PERFORM REMEDIAL WORK [ ] PLUG AND ABANDON [ ]
TEMPORARILY ABANDON [ ]
PULL OR ALTER CASING [ ] CHANGE PLANS [ ]
OTHER Drill New Well [ ]

SUBSEQUENT REPORT OF:

REMEDIAL WORK [ ] ALTERING CASING [ ]
COMMENCE DRILLING OPNS. [ ] PLUG AND ABANDONMENT [ ]
CASING TEST AND CEMENT JOB [ ]
OTHER [ ]

17. Describe Proposed or Completed Operations *(Clearly state all pertinent details, and give pertinent dates, including estimated date of starting any proposed work)* SEE RULE 1103.

Started drilling 12-30-69. Drilled 1359.53 12 1/4" hole. Set 9 5/8" H-40-32.30# casing cemented with 500 sacks incor with 2% calcium chloride and 200 neet sacks. Circulated 150 sacks cement into pits. Bumped insert float (set 1 joint off bottom of string) with plug and pressured casing to 1500# PSI. Casing held pressure O.K. 9 5/8" casing cemented at 1359.53 from rotary bushing 12' above ground.

After cement set drilled plug and drilled to 2449' base of salt 2445. Set 5 1/2" J-55-15.5# tubing to 2425' using Braden Head to support tubing. Well completed 1-9-70 and put in service

18. I hereby certify that the information above is true and complete to the best of my knowledge and belief.

SIGNED E. D. Smith TITLE Mechanical Superintendent DATE 7-15-70

APPROVED BY [illegible] TITLE SUPERVISOR DISTRICT DATE AUG 17 1970

CONDITIONS OF APPROVAL, IF ANY:

Form C-102
Supersedes C-128
Effective 1-1-65

NEW MEXICO OIL CONSERVATION COMMISSION
WELL LOCATION AND ACREAGE DEDICATION PLAT

HOBBS OFFICE O. C. C.

All distances must be from the outer boundaries of the Section.

JAN 7 3 40 PM '70

Operator	Lease	Well No.
CLIMAX CHEMICAL CORP.	SALINE WATER WELL	2

Unit Letter	Section	Township	Range	County
P	34	19 SOUTH	36 EAST	LEA

Actual Footage Location of Well:
1020 feet from the SOUTH line and 300 feet from the EAST line

Ground Level Elev.	Producing Formation	Pool	Dedicated Acreage:
			Acres

1. Outline the acreage dedicated to the subject well by colored pencil or hachure marks on the plat below.

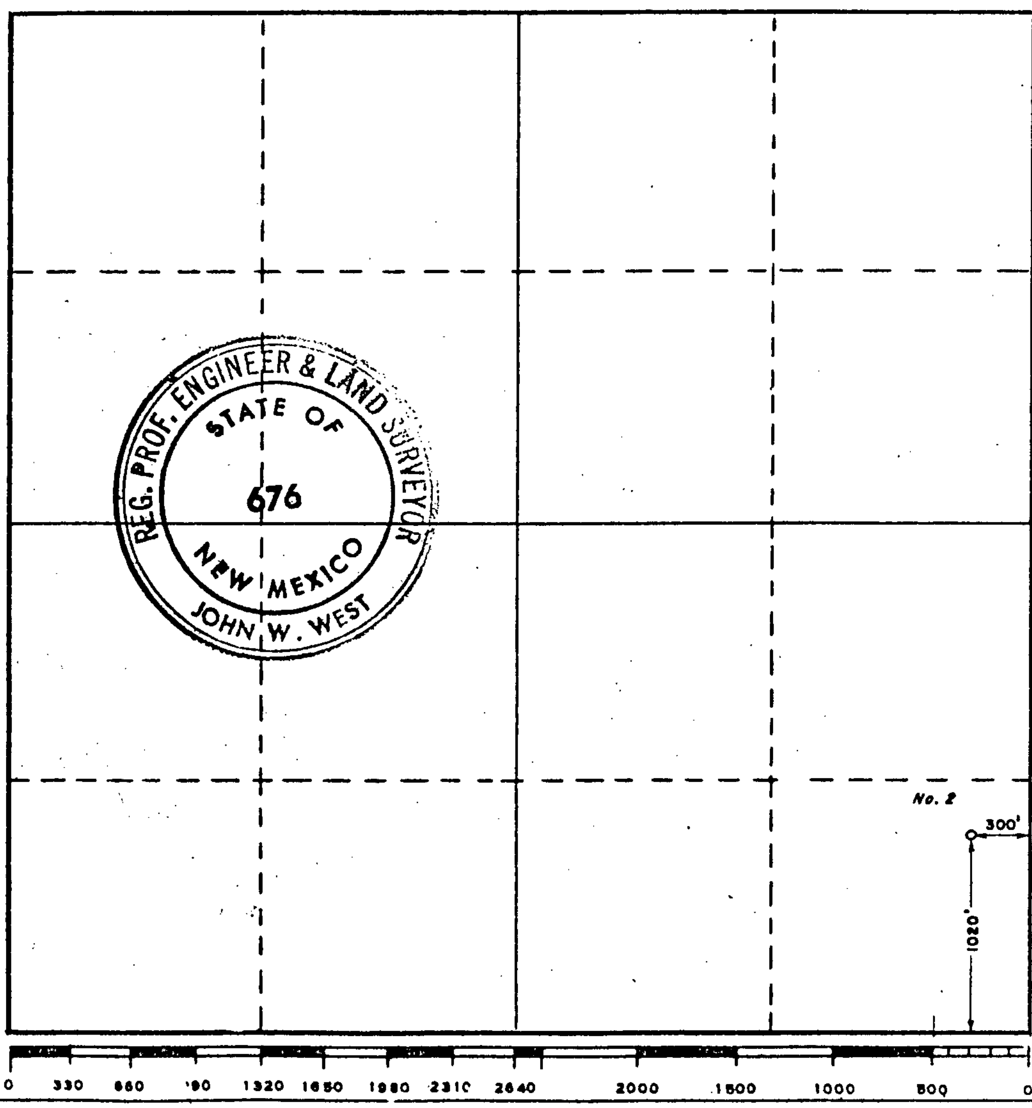
2. If more than one lease is dedicated to the well, outline each and identify the ownership thereof (both as to working interest and royalty).

3. If more than one lease of different ownership is dedicated to the well, have the interests of all owners been consolidated by communitization, unitization, force-pooling. etc?

☐ Yes ☐ No If answer is "yes," type of consolidation ______

If answer is "no," list the owners and tract descriptions which have actually been consolidated. (Use reverse side of this form if necessary.)______

No allowable will be assigned to the well until all interests have been consolidated (by communitization, unitization, forced-pooling, or otherwise) or until a non-standard unit, eliminating such interests, has been approved by the Commission.



CERTIFICATION

I hereby certify that the information contained herein is true and complete to the best of my knowledge and belief.

Name [signature]

Position
Vice-President

Company
Climax Chemical Company

Date
December 30, 1969

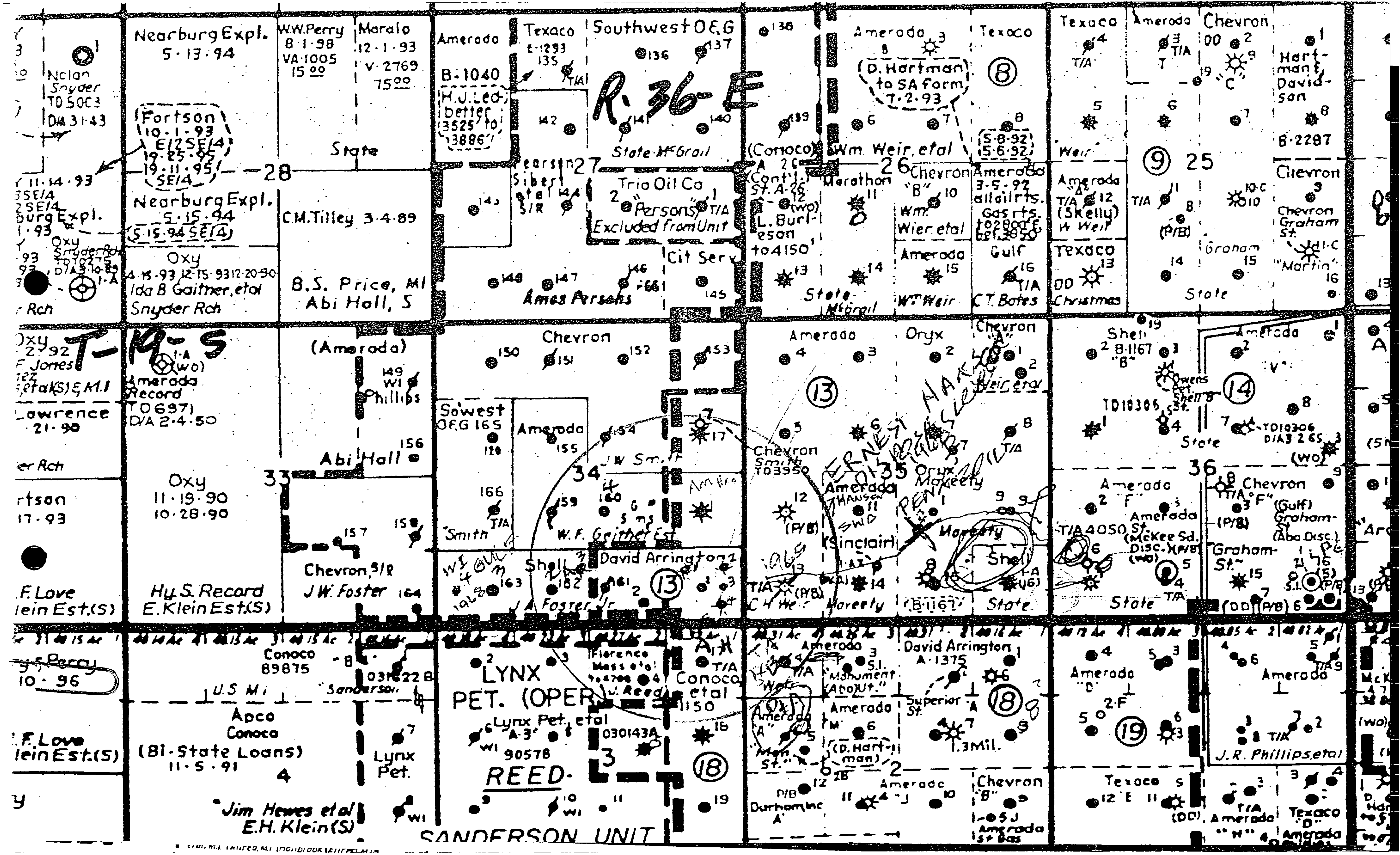
I hereby certify that the well location shown on this plat was plotted from field notes of actual surveys made by me or under my supervision, and that the same is true and correct to the best of my knowledge and belief.

Date Surveyed 12-27-69

Registered Professional Engineer and/or Land Surveyor

John W West

Certificate No. 676



R-36-E
T-19-S
Nearburg Expl.
5-13-94
W.W. Perry
8-1-98
VA-1005
Maralo
12-1-93
V-2769
Amerado
B-1040
H.J. Ledbetter
Texaco
Southwest O&G
Fortson
Nearburg Expl.
5-15-94
C.M. Tilley 3-4-89
State
State McGrail
Trio Oil Co
Excluded from Unit
Cit Serv
Oxy
Ida B Gaitner, et al
Snyder Rch
B.S. Price, MI
Abi Hall, S
Ames Persons
D. Hartman to SA form 7-2-93
Wm Weir, et al
Chevron
Marathon
Gulf
C.T. Bates
Christmas
Texaco
Amerada
Chevron
Nolan Snyder
Amerada Record
Lawrence
Abi Hall
Sowest O&G 165
Amerada
Oryx
Shell
Owens Pet
Oxy
11-19-90
10-28-90
J.W. Smith
W.F. Gaither Est.
Smith
Chevron Smith TD3950
Sinclair
Moreety
Chevron
Graham St.
F. Love
Klein Est. (S)
Hy S. Record
E. Klein Est. (S)
Chevron
J.W. Foster
David Arrington
J.A. Foster Jr
Conoco
89875
U.S. MI
Apco
Conoco
(81-State Loans)
11-5-91
Lynx Pet.
LYNX
PET. (OPER)
Lynx Pet. etal
90578
REED
Florence Moss et al
Conoco etal
Jim Hewes et al
E.H. Klein (S)
SANDERSON UNIT
David Arrington
A-1375
Superior St.
Durham Inc
Chevron
Amerada
Texaco
J.R. Phillips etal

wells
within
1/2 mile

Form 9-331 a
(March 1942)

COPY TO O. C. C.

HOBBS

Budget Bureau No. 42-R358.
Approval expires 11-30-46.

(*SUBMIT IN TRIPLICATE*)

UNITED STATES
DEPARTMENT OF THE INTERIOR
GEOLOGICAL SURVEY

Land Office Las Cruces
Lease No. 030143-a
Unit B

SUNDRY NOTICES AND REPORTS ON WELLS

NOTICE OF INTENTION TO DRILL	X	SUBSEQUENT REPORT OF WATER SHUT-OFF	
NOTICE OF INTENTION TO CHANGE PLANS		SUBSEQUENT REPORT OF SHOOTING OR ACIDIZING	
NOTICE OF INTENTION TO TEST WATER SHUT-OFF		SUBSEQUENT REPORT OF ALTERING CASING	
NOTICE OF INTENTION TO RE-DRILL OR REPAIR WELL		SUBSEQUENT REPORT OF REDRILLING OR REPAIR	
NOTICE OF INTENTION TO SHOOT OR ACIDIZE		SUBSEQUENT REPORT OF ABANDONMENT	
NOTICE OF INTENTION TO PULL OR ALTER CASING		SUPPLEMENTARY WELL HISTORY	
NOTICE OF INTENTION TO ABANDON WELL			

(INDICATE ABOVE BY CHECK MARK NATURE OF REPORT, NOTICE, OR OTHER DATA)

February 1, 1953

Well No. 1 is located 1002.5 ft. from [N] line and 1652.5 ft. from [E] line of sec. 3

NW¼ NE¼ Sec. 3 (¼ Sec. and Sec. No.) — 20S (Twp.) — 36E (Range) — N.M.P.M. (Meridian)

Monument (Field) — Lea (County or Subdivision) — New Mexico (State or Territory)

The elevation of the derrick floor above sea level is .... ft.

DETAILS OF WORK

(State names of and expected depths to objective sands; show sizes, weights, and lengths of proposed casings; indicate mudding jobs, cementing points, and all other important proposed work)

We propose to drill this test with Rotary tools to a total depth of approximately 3900'. We will set and cement 10-3/4" 32# casing at a depth of about 300 feet and cement same with sufficient cement to circulate back into cellar. We will cut an 8-3/4" hole below surface casing to a depth of approximately 3800 feet and cement casing with a two-stage job, using 300 sacks on the bottom job and 250 sacks through two-stage tool at 1275 feet.

We propose to diamond core the hole from shoe of pay string to total depth.

I understand that this plan of work must receive approval in writing by the Geological Survey before operations may be commenced.

Company H. S. Moss

Address 1503 First Nat'l. Bank Bld'g.

Dallas, Texas.

By Charles P. Miller

Title Agent

(Form C-110)
(Revised 7/1/52)

NEW MEXICO OIL CONSERVATION COMMISSION
Santa Fe, New Mexico

HOBBS OFFICE OCC

1955 APR 2 AM 9:51

necessary that Form C-104 be approved before this form can be approved an an *initial* allowable be assigned to any completed Oil or Gas well. Submit this form in QUADRUPLICATE.

CERTIFICATE OF COMPLIANCE AND AUTHORIZATION TO TRANSPORT OIL AND NATURAL GAS

npany or Operator H. S. Moss Lease J. L. Reed

lress 1503 First National BankBuilding (Local or Field Office) Dallas, Texas (Principal Place of Business)

it B, Well(s) No. 1, Sec. 3, T. 20S, R. 36E, Pool Monument

unty Lea Kind of Lease: Federal Lease

Oil well Location of Tanks Approx 175' FSL 450' FEL of Lot 2

ithorized Transporter Warren Petroleum Corporation Address of Transporter

Monument, New Mexico (Local or Field Office), Tulsa, Oklahoma (Principal Place of Business)

r cent of Oil or Natural Gas to be Transported 100 Other Transporters authorized to transport Oil or Natural Gas

om this unit are Texas-New Mexico Pipe Line Co.

%

REASON FOR FILING: (Please check proper box)

NEW WELL ☐ CHANGE IN OWNERSHIP ☐

CHANGE IN TRANSPORTER ☐ OTHER (Explain under Remarks) ☒

REMARKS:

Filed for casinghead gas

The undersigned certifies that the Rules and Regulations of the Oil Conservation Commission have been complied with.

Executed this the 1st day of April 1955

H. S. MOSS

APR 1 1955

Approved , 19

By [signature]

OIL CONSERVATION COMMISSION

Title Agent

By [signature] M L Armstrong

Title

(See Instructions on Reverse Side)

(Form C-110)
(Revised 7/1/52)

DUPLICATE

NEW MEXICO OIL CONSERVATION COMMISSION

Santa Fe, New Mexico

It is necessary that Form C-104 be approved before this form can be approved an an *initial* allowable be assigned to any completed Oil or Gas well. Submit this form in QUADRUPLICATE.

RECEIVED
MAR 9 1953
OIL CONSERVATION COMMISSION
HOBBS OFFICE

CERTIFICATE OF COMPLIANCE AND AUTHORIZATION TO TRANSPORT OIL AND NATURAL GAS

Company or Operator H. S. Moss Lease J. L. Reed

Address Hobbs, New Mexico (Local or Field Office) Dallas, Texas (Principal Place of Business)

Unit B, Well(s) No. 1, Sec. 3, T. 20S, R. 36E, Pool Monument

County Lea Kind of Lease: Federal land

If Oil well Location of Tanks Approx. 175' fr. SL & 450' fr. EL of Lot 2, section 3

Authorized Transporter Texas New Mexico Pipeline Company Address of Transporter

Eunice, New Mexico (Local or Field Office), Houston, Texas. (Principal Place of Business)

Per cent of Oil or Natural Gas to be Transported 100 Other Transporters authorized to transport Oil or Natural Gas from this unit are None

%

REASON FOR FILING: (Please check proper box)

NEW WELL ☒ CHANGE IN OWNERSHIP ☐

CHANGE IN TRANSPORTER ☐ OTHER (Explain under Remarks) ☐

REMARKS:

The undersigned certifies that the Rules and Regulations of the Oil Conservation Commission have been complied with.

Executed this the 2nd day of March, 19 53.

Approved 3 – 9, 19 53

OIL CONSERVATION COMMISSION

By Roy O Yarbrough

Title Gas Inspector

H. S. Moss

By Charles P. Miller

Title Agent

Submit 5 Copies
Appropriate District Office
DISTRICT I
P.O. Box 1980, Hobbs, NM 88240

DISTRICT II
P.O. Drawer DD, Artesia, NM 88210

DISTRICT III
1000 Rio Brazos Rd., Aztec, NM 87410

State of New Mexico
Energy, Minerals and Natural Resources Department

OIL CONSERVATION DIVISION

P.O. Box 2088
Santa Fe, New Mexico 87504-2088

Form C-104
Revised 1-1-89
See Instructions at Bottom of Page

REQUEST FOR ALLOWABLE AND AUTHORIZATION TO TRANSPORT OIL AND NATURAL GAS

I.

Operator: Lynx Petroleum Consultants, Inc.	Well API No.
Address: P. O. Box 1979, Hobbs, NM 88241	

Reason(s) for Filing (Check proper box) — Other (Please explain) ☐

New Well ☐ — Change in Transporter of:
Recompletion ☐ — Oil ☐ Dry Gas ☐
Change in Operator ☒ — Casinghead Gas ☐ Condensate ☐

If change of operator give name and address of previous operator: Conoco Inc. 10 Desta Drive, Suite 100 W, Midland, TX 79705

II. DESCRIPTION OF WELL AND LEASE

Lease Name	Well No.	Pool Name, Including Formation	Kind of Lease	Lease No.
Reed Sanderson Unit	4	Eumont-Yates-7 Rivers-Queen	~~State~~, Federal ~~or Fee~~	LC-030143A

Location
Unit Letter B : 1002 Feet From The North Line and 1652 Feet From The East Line
Section 3 Township 20S Range 36E , NMPM, Lea County

III. DESIGNATION OF TRANSPORTER OF OIL AND NATURAL GAS

Name of Authorized Transporter of Oil ☒ or Condensate ☐: ARCO Pipe Line Company	Address (Give address to which approved copy of this form is to be sent): 200 ARCO Place, Independence, KS 67301
Name of Authorized Transporter of Casinghead Gas ☒ or Dry Gas ☐: Warren Petroleum Company	Address (Give address to which approved copy of this form is to be sent): Box 1589, Tulsa, OK 74102

If well produces oil or liquids, give location of tanks.	Unit	Sec.	Twp.	Rge.	Is gas actually connected?	When ?

If this production is commingled with that from any other lease or pool, give commingling order number:

IV. COMPLETION DATA

Designate Type of Completion - (X)	Oil Well	Gas Well	New Well	Workover	Deepen	Plug Back	Same Res'v	Diff Res'v

Date Spudded	Date Compl. Ready to Prod.	Total Depth	P.B.T.D.
Elevations (DF, RKB, RT, GR, etc.)	Name of Producing Formation	Top Oil/Gas Pay	Tubing Depth
Perforations			Depth Casing Shoe

TUBING, CASING AND CEMENTING RECORD

HOLE SIZE	CASING & TUBING SIZE	DEPTH SET	SACKS CEMENT

V. TEST DATA AND REQUEST FOR ALLOWABLE

OIL WELL (Test must be after recovery of total volume of load oil and must be equal to or exceed top allowable for this depth or be for full 24 hours.)

Date First New Oil Run To Tank	Date of Test	Producing Method (Flow, pump, gas lift, etc.)	
Length of Test	Tubing Pressure	Casing Pressure	Choke Size
Actual Prod. During Test	Oil - Bbls.	Water - Bbls.	Gas- MCF

GAS WELL

Actual Prod. Test - MCF/D	Length of Test	Bbls. Condensate/MMCF	Gravity of Condensate
Testing Method (pitot, back pr.)	Tubing Pressure (Shut-in)	Casing Pressure (Shut-in)	Choke Size

VI. OPERATOR CERTIFICATE OF COMPLIANCE

I hereby certify that the rules and regulations of the Oil Conservation Division have been complied with and that the information given above is true and complete to the best of my knowledge and belief.

Gary W. Fonay
Signature
Gary W. Fonay — Vice-President
Printed Name — Title
7-13-92 — 392-6950
Date — Telephone No.

OIL CONSERVATION DIVISION
Date Approved JUL 17 '92
By ORIGINAL SIGNED BY JERRY SEXTON
DISTRICT I SUPERVISOR
Title

INSTRUCTIONS: This form is to be filed in compliance with Rule 1104
1) Request for allowable for newly drilled or deepened well must be accompanied by tabulation of deviation tests taken in accordance with Rule 111.
2) All sections of this form must be filled out for allowable on new and recompleted wells.
3) Fill out only Sections I, II, III, and VI for changes of operator, well name or number, transporter, or other such changes.
4) Separate Form C-104 must be filed for each pool in multiply completed wells.

Form 9-331
Dec. 1973

Form Approved.
Budget Bureau No. 42-R1424

UNITED STATES
DEPARTMENT OF THE INTERIOR
GEOLOGICAL SURVEY

SUNDRY NOTICES AND REPORTS ON WELLS

(Do not use this form for proposals to drill or to deepen or plug back to a different reservoir. Use Form 9-331-C for such proposals.)

1. oil well ☑ gas well ☐ other
2. NAME OF OPERATOR
   CONOCO INC.
3. ADDRESS OF OPERATOR
   P. O. Box 460, Hobbs, N.M. 88240
4. LOCATION OF WELL (REPORT LOCATION CLEARLY. See space 17 below.)
   AT SURFACE: 1002' FNL + 1652' FEL
   AT TOP PROD. INTERVAL:
   AT TOTAL DEPTH:

5. LEASE LC-030143 (A)
6. IF INDIAN, ALLOTTEE OR TRIBE NAME
7. UNIT AGREEMENT NAME NMFU
8. FARM OR LEASE NAME Reed Sanderson Unit
9. WELL NO. 4
10. FIELD OR WILDCAT NAME Eumont Yates 7 Rvrs. Qn.
11. SEC., T., R., M., OR BLK. AND SURVEY OR AREA Sec. 3, T-20S, R-36E
12. COUNTY OR PARISH Lea
13. STATE NM
14. API NO.
15. ELEVATIONS (SHOW DF, KDB, AND WD)

16. CHECK APPROPRIATE BOX TO INDICATE NATURE OF NOTICE, REPORT, OR OTHER DATA

	REQUEST FOR APPROVAL TO:	SUBSEQUENT REPORT OF:
TEST WATER SHUT-OFF	☐	☐
FRACTURE TREAT	☐	☑
SHOOT OR ACIDIZE	☐	☑
REPAIR WELL	☐	☑
PULL OR ALTER CASING	☐	☐
MULTIPLE COMPLETE	☐	☐
CHANGE ZONES	☐	☐
ABANDON*	☐	☐
(other) Chemically Inhibit		✓

(NOTE: Report results of multiple completion or zone change on Form 9-330.)

BUREAU OF LAND MANAGEMENT
RECEIVED
NOV 16 1983
DIST. 6 N. M.
ROSWELL, NEW MEXICO

17. DESCRIBE PROPOSED OR COMPLETED OPERATIONS (Clearly state all pertinent details, and give pertinent dates, including estimated date of starting any proposed work. If well is directionally drilled, give subsurface locations and measured and true vertical depths for all markers and zones pertinent to this work.)*

MIRU 7/11/83. Reamed hole to 3875'. Set RBP @ 2000'. Tested csg for leaks. Reset RBP @ 980'. Set pkr @ 288'. Squeezed 415'-724' w/ 300 sxs Class "C". Rel pkr. DO cmt 435'-672'. Rel RBP. CO to 3897'. Set pkr @ 3790'. Acidized OH 3809'-3897' w/60 bbls 15% HCL-NE-FE, 4 bbls 10 ppg brine w/ guar gum + rocksalt. Flushed w/ 22 bbls TFW. Swbd. Inhibited OH w/ 2 drums chemical. Flushed w/100 bbls TFW. Rel pkr. Set RBP @ 3790'. Spotted 7 bbls 15% acid 3600'-3790'. Perf w/1 JSPF @ 3630', 35', 40', 45', 67', 72', 77', 82', 87', 92', 97', 3702', 07', 12', 37', 40', 43', 46', 66', + 3780'. Set pkr @ 3568'. Acidized perfs w/ 40 bbls 15% acid. (Attachment)

Subsurface Safety Valve: Manu. and Type ________ Set @ ________ Ft.

18. I hereby certify that the foregoing is true and correct

SIGNED Wm A. Butterfield TITLE Administrative Supervisor DATE 11/15/83

(This space for Federal or State office use)

ACCEPTED FOR RECORD
PETER W. CHESTER
MAR 1 1984

APPROVED BY ________ TITLE ________ DATE ________
CONDITIONS OF APPROVAL, IF ANY:

*See Instructions on Reverse Side

REED SANDERSON UNIT No. 4

FLUSHED W/34 BBLS TFW. FRAC'D W/408 BBLS FRAC FLUID + 26,300 LBS 20/40 SAND. SWBD. REL PKR. CO TO 3785'. REL RBP. CO TO 3900'. RAN PRODUCTION EQUIPMENT. PUMPED 8 BO, 36 BW, + 274 MCF IN 24 HRS 9/29/83.

Submit 3 Copies to Appropriate District Office

State of New Mexico
Energy, Minerals and Natural Resources Department

Form C-103
Revised 1-1-89

DISTRICT I
P.O. Box 1980, Hobbs, NM 88240

DISTRICT II
P.O. Drawer DD, Artesia, NM 88210

DISTRICT III
1000 Rio Brazos Rd., Aztec, NM 87410

OIL CONSERVATION DIVISION

P.O. Box 2088
Santa Fe, New Mexico 87504-2088

WELL API NO. 30-025-04162

5. Indicate Type of Lease STATE [ ] FEE [X]

6. State Oil & Gas Lease No.

SUNDRY NOTICES AND REPORTS ON WELLS

(DO NOT USE THIS FORM FOR PROPOSALS TO DRILL OR TO DEEPEN OR PLUG BACK TO A DIFFERENT RESERVOIR. USE "APPLICATION FOR PERMIT" (FORM C-101) FOR SUCH PROPOSALS.)

7. Lease Name or Unit Agreement Name
NORTH MONUMENT G/SA UNIT
BLK. 18

1. Type of Well: OIL WELL [X] GAS WELL [ ] OTHER

2. Name of Operator
AMERADA HESS CORPORATION

8. Well No.
4

3. Address of Operator
POST OFFICE DRAWER D, MONUMENT, NEW MEXICO 88265

9. Pool name or Wildcat
EUNICE MONUMENT G/SA

4. Well Location
Unit Letter D : 660 Feet From The NORTH Line and 660 Feet From The WEST Line
Section 2 Township 20S Range 36E NMPM LEA County

10. Elevation (*Show whether DF, RKB, RT, GR, etc.*)

11. Check Appropriate Box to Indicate Nature of Notice, Report, or Other Data

NOTICE OF INTENTION TO:				SUBSEQUENT REPORT OF:			
PERFORM REMEDIAL WORK	[ ]	PLUG AND ABANDON	[ ]	REMEDIAL WORK	[ ]	ALTERING CASING	[ ]
TEMPORARILY ABANDON	[ ]	CHANGE PLANS	[ ]	COMMENCE DRILLING OPNS.	[ ]	PLUG AND ABANDONMENT	[ ]
PULL OR ALTER CASING	[ ]			CASING TEST AND CEMENT JOB	[ ]		
OTHER:	[ ]			OTHER: Casing Test. Temporary Abandon	[X]		

12. Describe Proposed or Completed Operations (*Clearly state all pertinent details, and give pertinent dates, including estimated date of starting any proposed work*) SEE RULE 1103.

07-05-93 Thru 07-16-93 NMGSAU #1804

X-Pert Well Service rigged up pulling unit. Received 133 jts. 2-7/8" and 8 jts. 2-3/8" tbg. as work string. Flowed gas from casing and removed 6" 600 tubinghead flange. Installe a 6" 600 manual BOP. TIH with a 3-7/8" drill bit, bit sub, 8 jts. 2-3/8" 10V tbg. and 125 jts. 2-7/8" 10V tbg. Tagged liner top at 3,742' and top of fill at 3,927', for 1' of fill in 4-1/2" liner. TOH with 125 jts. 2-7/8" 10V tbg., 8 jts. 2-3/8" 10V tbg., bit sub and drill bit. TIH with a 4-1/2" Elder Cast Iron Bridge Plug, setting tool and SN on 8 jts. 2-3/8" tbg. and 122 jts. 2-7/8" tbg. Set CIBP at 3,850', pulled setting tool to 3,841' and circulated casing with 120 bbls. fresh water. Pressure tested 6-5/8" casing from 0' to 3,739' and 4-1/2" liner from 3,739' to 3,929'. Pressure decreased from 560 psi to 540 psi in 30 mins. Checked surface-intermediate and intermediate-production casing annuli and found no pressure or flow. Circulated casing with 120 bbls. packer fluid and TOH laying

(Continued On Back)

I hereby certify that the information above is true and complete to the best of my knowledge and belief.

SIGNATURE Terry L. Harvey TITLE Staff Assistant DATE 07-16-93

TYPE OR PRINT NAME Terry L. Harvey TELEPHONE NO. 393-2144

(This space for State Use)

ORIGINAL SIGNED BY JERRY SEXTON
DISTRICT I SUPERVISOR

APPROVED BY ____ TITLE ____ DATE AUG 13 1993

CONDITIONS OF APPROVAL, IF ANY:

This Approval of Temporary Abandonment Expires 8-1-98

N.

NEW MEXICO OIL CONSERVATION COMMISSION

Santa Fe, New Mexico

DUPLICATE

WELL RECORD

AREA 640 ACRES
LOCATE WELL CORRECTLY

Mail to Oil Conservation Commission, Santa Fe, New Mexico, or its proper agent not more than twenty days after completion of well. Follow instructions in the Rules and Regulations of the Commission. Indicate questionable data by following it with (?). SUBMIT IN TRIPLICATE.

Amerada Petroleum Corporation
Company or Operator

Weir #2 Lease

Well No. 2 in NW¼ NW¼ of Sec. 2, T. 20

R. 36, N. M. P. M., Monument Field, Lea County.

Well is 660 feet south of the North line and 4620 feet west of the East line of 2-20-36

If State land the oil and gas lease is No. ______ Assignment No. ______

If patented land the owner is ______, Address ______

If Government land the permittee is ______, Address ______

The Lessee is Amerada Petroleum Corproation, Address Tulsa, Oklahoma

Drilling commenced February 19, 1936 19__ Drilling was completed April 1, 1936 19__

Name of drilling contractor H.W. Bass, Address Dallas, Texas

Elevation above sea level at top of casing 3606 feet.

The information given is to be kept confidential until ______ 19__

OIL SANDS OR ZONES

No. 1, from 3800 to 3839 No. 4, from ______ to ______

No. 2, from 3850 to 3893 No. 5, from ______ to ______

No. 3, from 3904 to 3930 No. 6, from ______ to ______

IMPORTANT WATER SANDS

Include data on rate of water inflow and elevation to which water rose in hole.

No. 1, from None to ______ feet.

No. 2, from ______ to ______ feet.

No. 2, from ______ to ______ feet.

No. 4, from ______ to ______ feet.

CASING RECORD

SIZE	WEIGHT PER FOOT	THREADS PER INCH	MAKE	AMOUNT	KIND OF SHOE	CUT & FILLED FROM	PERFORATED FROM	PERFORATED TO	PURPOSE
12½	40	8	L.Weld	203' 8"					
8-5/8"	28	8	L.Weld	2411' 9"					
6-5/8"	20	10	L.Weld	3813' 10"					

MUDDING AND CEMENTING RECORD

SIZE OF HOLE	SIZE OF CASING	WHERE SET	NO. SACKS OF CEMENT	METHOD USED	MUD GRAVITY	AMOUNT OF MUD USED
17½"	12½"	216'	150	Halliburton		
11"	8-5/8"	2406'	500	Halliburton		
7-7/8"	6-5/8"	3800'	100	Halliburton		

PLUGS AND ADAPTERS

Heaving plug—Material ______ Length ______ Depth Set ______

Adapters—Material ______ Size ______

RECORD OF SHOOTING OR CHEMICAL TREATMENT

SIZE	SHELL USED	EXPLOSIVE OR CHEMICAL USED	QUANTITY	DATE	DEPTH SHOT OR TREATED	DEPTH CLEANED OUT

(Form C-102)
(Revised 7/1/52)

DUPLICATE

NEW MEXICO OIL CONSERVATION COMMISSION

Santa Fe, New Mexico

HOBBS OFFICE OCC

MISCELLANEOUS NOTICES

1954 MAY 7 AM 8:00

Submit this notice in TRIPLICATE to the District Office, Oil Conservation Commission, before the work specified is to begin. A copy will be returned to the sender on which will be given the approval, with any modifications considered advisable, or the rejection by the Commission or agent, of the plan submitted. The plan as approved should be followed, and work should not begin until approval is obtained. See additional instructions in the Rules and Regulations of the Commission.

Indicate Nature of Notice by Checking Below

Notice of Intention to Change Plans		Notice of Intention to Temporarily Abandon Well		Notice of Intention to Drill Deeper	
Notice of Intention to Plug Well		Notice of Intention to Plug Back		Notice of Intention to Set Liner	
Notice of Intention to Squeeze		Notice of Intention to Acidize		Notice of Intention to Shoot (Nitro)	
Notice of Intention to Gun Perforate		Notice of Intention (Other)		Notice of Intention (Other) Dual Complete	X

OIL CONSERVATION COMMISSION
SANTA FE, NEW MEXICO

Monument, New Mexico (Place) April 15, 1954 (Date)

Gentlemen:

Following is a Notice of Intention to do certain work as described below at the M.E. Gaither

Amerada Petroleum Corporation (Company or Operator) Well No. 1 in I (Unit)

NE ¼ SE ¼ of Sec. 34, T. 19-S, R. 36-E, NMPM., Eumont - Gas / Monument - Oil Pool

(40-acre Subdivision)

Lea County.

FULL DETAILS OF PROPOSED PLAN OF WORK
(FOLLOW INSTRUCTIONS IN THE RULES AND REGULATIONS)

3950' T.D. - 6-5/8" OD Csg. set @ 3819' and cemented w/100 sacks cement and 5" liner set from 3780' to 3950' and cemented w/50 sacks cement. Oil is being produced from the perforated interval of 3932' to 3948' from Monument Pool. It is our intention to dual complete well by perf. 6-5/8" OD Csg. from 3425' to 3820' in the Seven-Rivers Queen Formation, Eumont Gas Pool and produce gas through csg. We will continue to produce oil through the tubing from the Monument Pool.

Approved MAY 24 1954, 19......
Except as follows:

Amerada Petroleum Corporation
Company or Operator
By [signature]

Position Foreman

Send Communications regarding well to:

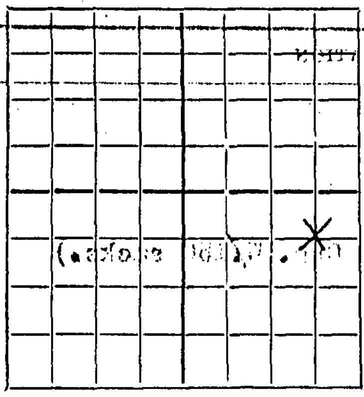
Name Amerada Petroleum Corporation

Address Drawer D. Monument, New Mexico

Approved
OIL CONSERVATION COMMISSION
By [signature] Stanley
Title Engineer District 1

FORM C-105

N.



AREA 640 ACRES
LOCATE WELL CORRECTLY

NEW MEXICO OIL CONSERVATION COMMISSION

Santa Fe, New Mexico

WELL RECORD

Mail to Oil Conservation Commission, Santa Fe, New Mexico, or its proper agent not more than twenty days after completion of well. Follow instructions in the Rules and Regulations of the Commission. Indicate questionable data by following it with (?). SUBMIT IN TRIPLICATE.

Amerada Petroleum Corporation — Gaither
Company or Operator — Lease

Well No. 1 in NE¼ SE¼ of Sec. 34 T. 19

R. 36, N. M. P. M., Monument Field, Lea County.

Well is 1980 feet ~~south~~ of the North line and 660 feet ~~west~~ of the East line of 34 - 19 - 36

If State land the oil and gas lease is No. ______ Assignment No. ______

If patented land the owner is ______, Address ______

If Government land the permittee is ______, Address ______

The Lessee is Amerada Petroleum Corporation, Address Tulsa, Oklahoma.

Drilling commenced June 15, 1936. Drilling was completed July 13, 1936

Name of drilling contractor Rowan Drilling Company, Address Trinity Life Bldg. Fort Worth, Texas

Elevation above sea level at top of casing ______ feet.

The information given is to be kept confidential until ______ 19___

OIL SANDS OR ZONES

No. 1, from ______ to ______ No. 4, from ______ to ______

No. 2, from ______ to ______ No. 5, from ______ to ______

No. 3, from ______ to ______ No. 6, from ______ to ______

IMPORTANT WATER SANDS

Include data on rate of water inflow and elevation to which water rose in hole.

No. 1, from ______ to ______ feet.

No. 2, from ______ to ______ feet.

No. 2, from ______ to ______ feet.

No. 4, from ______ to ______ feet.

CASING RECORD

SIZE	WEIGHT PER FOOT	THREADS PER INCH	MAKE	AMOUNT	KIND OF SHOE	CUT & FILLED FROM	PERFORATED FROM	PERFORATED TO	PURPOSE
12½"	40#	8 thd.	L.Weld	222'3"	Texas Pattern				
8 5/8"	32#	8 thd.	Smls.	2551'6"	Halliburton				
6 5/8	20#	10 thd.	Smls.	3834'0"	Halliburton				

MUDDING AND CEMENTING RECORD

SIZE OF HOLE	SIZE OF CASING	WHERE SET	NO. SACKS OF CEMENT	METHOD USED	MUD GRAVITY	AMOUNT OF MUD USED
17½"	12½"	222'	150	Halliburton		
11"	8-5/8	2540'	500	Halliburton		
7-7/8"	6-5/8"	3819'	100	Halliburton		

PLUGS AND ADAPTERS

Heaving plug—Material ______ Length ______ Depth Set ______

Adapters—Material ______ Size ______

RECORD OF SHOOTING OR CHEMICAL TREATMENT

SIZE	SHELL USED	EXPLOSIVE OR CHEMICAL USED	QUANTITY	DATE	DEPTH SHOT OR TREATED	DEPTH CLEANED OUT
		Dowell XX	2000	7/15/36		

Submit 3 Copies to Appropriate District Office

State of New Mexico
Energy, Minerals and Natural Resources Department

Form C-103
Revised 1-1-89

DISTRICT I
P.O. Box 1980, Hobbs, NM 88240

DISTRICT II
P.O. Drawer DD, Artesia, NM 88210

DISTRICT III
1000 Rio Brazos Rd., Aztec, NM 87410

OIL CONSERVATION DIVISION
P.O. Box 2088
Santa Fe, New Mexico 87504-2088

WELL API NO.
30-025-31982

5. Indicate Type of Lease STATE [ ] FEE [X]

6. State Oil & Gas Lease No.

SUNDRY NOTICES AND REPORTS ON WELLS
(DO NOT USE THIS FORM FOR PROPOSALS TO DRILL OR TO DEEPEN OR PLUG BACK TO A DIFFERENT RESERVOIR. USE "APPLICATION FOR PERMIT" (FORM C-101) FOR SUCH PROPOSALS.)

7. Lease Name or Unit Agreement Name
J.A. FOSTER

1. Type of Well: OIL WELL [XX] GAS WELL [ ] OTHER

2. Name of Operator
DAVID H. ARRINGTON OIL & GAS, INC.

8. Well No.
#3

3. Address of Operator
P.O. BOX 2071, MIDLAND, TEXAS 79702

9. Pool name or Wildcat
MONUMENT ABO

4. Well Location
Unit Letter P : 660 Feet From The SOUTH Line and 330 Feet From The EAST Line

Section 34 Township 19-S Range 36-E NMPM Lea County

10. Elevation (Show whether DF, RKB, RT, GR, etc.)
3614' GR, 3627' KB

11. Check Appropriate Box to Indicate Nature of Notice, Report, or Other Data

NOTICE OF INTENTION TO:		SUBSEQUENT REPORT OF:	
PERFORM REMEDIAL WORK [ ]	PLUG AND ABANDON [ ]	REMEDIAL WORK [ ]	ALTERING CASING [ ]
TEMPORARILY ABANDON [ ]	CHANGE PLANS [ ]	COMMENCE DRILLING OPNS. [XX]	PLUG AND ABANDONMENT [ ]
PULL OR ALTER CASING [ ]		CASING TEST AND CEMENT JOB [XX]	
OTHER: [ ]		OTHER: COMPLETE DRILLING OPERATIONS [X]	

12. Describe Proposed or Completed Operations (*Clearly state all pertinent details, and give pertinent dates, including estimated date of starting any proposed work*) SEE RULE 1103.

0/06/93 - SPUDDED @ 4:00 pm 10/5/93. DRILLED 17 1/2" HOLE TO 300', SET 13 3/8" CASING @300' WITH 400 SXS CLASS C. CIRC 200 SXS. WOC 12 HRS. TESTING CASING TO 800 PSI, OK.

0/11/93 - DRILLING 12 1/4" HOLE TO 2613'. SET 8 5/8" CSG. @ 2613'. CEMENT WITH 1200 sxs HALIBURTON LT & 200 SXS PREMIUM PLUS. TOC @ 1240' BY TEMP SURVEY. TEST CSG TO 1000 PSI, OK.

0/25/93 - DRILLED TO TD 8050'. RAN LOGS.

0/27/93 - RAN 5 1/2" CSG. TO 8035'. DV TOOL @ 4984'. CMT 1St. STAGE W/250 SXS HALIBURTON LT & 560 SXS CL H. CIRC 105 SX CEMENT OUT FROM DV TOOL. CEMENTED 2ND STAGE W/200 SXS HALIBURTOH LT + 650 SXS CL C. DID NOT CIRCULATE TO SURFACE. RELEASE RIG @ 6:00 am 10/27/93.

I hereby certify that the information above is true and complete to the best of my knowledge and belief.

SIGNATURE ______ TITLE President DATE 12/15/93

TYPE OR PRINT NAME TELEPHONE NO.

(This space for State Use) ORIGINAL SIGNED BY JERRY SEXTON
DISTRICT I SUPERVISOR

DEC 20 1993

APPROVED BY ______ TITLE ______ DATE ______

CONDITIONS OF APPROVAL, IF ANY:

Submit to Appropriate District Office
DISTRICT I
P.O. Box 1980, Hobbs, NM 88240

DISTRICT II
P.O. Drawer DD, Artesia, NM 88210

DISTRICT III
1000 Rio Brazos Rd., Aztec, NM 87410

State of New Mexico
Energy, Minerals and Natural Resources Department

Form C-104
Revised 1-1-89
See Instructions at Bottom of Page

OIL CONSERVATION DIVISION
P.O. Box 2088
Santa Fe, New Mexico 87504-2088

REQUEST FOR ALLOWABLE AND AUTHORIZATION TO TRANSPORT OIL AND NATURAL GAS

I.

Operator	Well API No.
DAVID H. ARRINGTON OIL & GAS, INC.	30-025-31982

Address: P.O. BOX 2071, MIDLAND, TEXAS 79702

Reason(s) for Filing (Check proper box): New Well XX; Recompletion ☐; Change in Operator ☐; Change in Transporter of: Oil ☐, Casinghead Gas ☐, Dry Gas ☐, Condensate ☐; Other (Please explain) ☐

If change of operator give name and address of previous operator

II. DESCRIPTION OF WELL AND LEASE

Lease Name	Well No.	Pool Name, Including Formation	Kind of Lease	Lease No.
J.A. Foster	3	Monument Abo 4/1/94 R-11091	State, Federal or Fee	

Location
Unit Letter P : 660 Feet From The South Line and 330 Feet From The East Line
Section 34 Township 19-S Range 36-E, NMPM, Lea County

III. DESIGNATION OF TRANSPORTER OF OIL AND NATURAL GAS

Name of Authorized Transporter of Oil XX or Condensate ☐	Address (Give address to which approved copy of this form is to be sent)
Kelly McClasky (Oilfield Serv. Inc.)	P.O. Box 580 Hobbs, NM 88241
Name of Authorized Transporter of Casinghead Gas XX or Dry Gas ☐	**Address (Give address to which approved copy of this form is to be sent)**
Warren Petroleum Corp.	P.O. Box 67, Monument, NM 88265

If well produces oil or liquids, give location of tanks.	Unit	Sec.	Twp.	Rge.	Is gas actually connected?	When ?
	P	34	19-S	36-E	Yes	11/20/93

If this production is commingled with that from any other lease or pool, give commingling order number:

IV. COMPLETION DATA

	Oil Well	Gas Well	New Well	Workover	Deepen	Plug Back	Same Res'v	Diff Res'v
Designate Type of Completion - (X)	X		X					

Date Spudded	Date Compl. Ready to Prod.	Total Depth	P.B.T.D.
10/6/93	11/20/93	8050	7987
Elevations (DF, RKB, RT, GR, etc.)	**Name of Producing Formation**	**Top Oil/Gas Pay**	**Tubing Depth**
3614' GR, 3627 KB	Abo	7323	7182
Perforations			**Depth Casing Shoe**
7323'-7428' (30 Holes)			8035'

TUBING, CASING AND CEMENTING RECORD

HOLE SIZE	CASING & TUBING SIZE	DEPTH SET	SACKS CEMENT
17 1/2	13 3/8	300'	400 sxs C
12 1/4	8 5/8	2613'	1200 sx Lt + 200 sx C
7 7/8	5 1/2	8035'	450 sx Lt & 560 H
	2 3/8	7182	650 Cl C

V. TEST DATA AND REQUEST FOR ALLOWABLE

OIL WELL (Test must be after recovery of total volume of load oil and must be equal to or exceed top allowable for this depth or be for full 24 hours.)

Date First New Oil Run To Tank	Date of Test	Producing Method (Flow, pump, gas lift, etc.)	
11/20/93	11/23/93	Pump	
Length of Test	**Tubing Pressure**	**Casing Pressure**	**Choke Size**
24			
Actual Prod. During Test	**Oil - Bbls.**	**Water - Bbls.**	**Gas- MCF**
	22	230	35

GAS WELL

Actual Prod. Test - MCF/D	Length of Test	Bbls. Condensate/MMCF	Gravity of Condensate
Testing Method (pitot, back pr.)	**Tubing Pressure (Shut-in)**	**Casing Pressure (Shut-in)**	**Choke Size**

VI. OPERATOR CERTIFICATE OF COMPLIANCE

I hereby certify that the rules and regulations of the Oil Conservation Division have been complied with and that the information given above is true and complete to the best of my knowledge and belief.

Signature
David H. Arrington /President
Printed Name — Title
12/15/93 — 915-682-6685
Date — Telephone No.

OIL CONSERVATION DIVISION
Date Approved DEC 20 1993
By ORIGINAL SIGNED BY JERRY SEXTON DISTRICT I SUPERVISOR
Title

INSTRUCTIONS: This form is to be filed in compliance with Rule 1104
1) Request for allowable for newly drilled or deepened well must be accompanied by tabulation of deviation tests taken in accordance with Rule 111.
2) All sections of this form must be filled out for allowable on new and recompleted wells.
3) Fill out only Sections I, II, III, and VI for changes of operator, well name or number, transporter, or other such changes.
4) Separate Form C-104 must be filed for each pool in multiply completed wells.

NUMBER OF COPIES RECEIVED		
DISTRIBUTION		
SANTA FE		
FILE		
U.S.G.S.		
LAND OFFICE		
TRANSPORTER	OIL	
	GAS	
PRORATION OFFICE		
OPERATOR		

NEW MEXICO OIL CONSERVATION COMMISSION
SANTA FE, NEW MEXICO

FORM C-110
(Rev. 7-60)

CERTIFICATE OF COMPLIANCE AND AUTHORIZATION TO TRANSPORT OIL AND NATURAL GAS

O. C. C.

MAR 31 ... '64

FILE THE ORIGINAL AND 4 COPIES WITH THE APPROPRIATE OFFICE

Company or Operator			Lease	Well No.
Gulf Oil Corporation			Northwest Eumont Unit 34	34-14

Unit Letter	Section	Township	Range	County
N	34	19-S	36-E	Lea

Pool	Kind of Lease (State, Fed, Fee)
Eumont	Fee

If well produces oil or condensate give location of tanks	Unit Letter	Section	Township	Range
	O	34	19-S	36-E

Authorized transporter of oil XX or condensate ☐	Address (give address to which approved copy of this form is to be sent)
Texas-New Mexico Pipeline Co.	Box 1510, Midland, Texas

Is Gas Actually Connected? Yes XX No ____

Authorized transporter of casing head gas XX or dry gas ☐	Date Connected	Address (give address to which approved copy of this form is to be sent)
Warren Pet. Corp.	Unk	Box 1589, Tulsa, Oklahoma

If gas is not being sold, give reasons and also explain its present disposition:

REASON(S) FOR FILING (please check proper box)

New Well ☐
Change in Transporter (check one)
Oil ☐ Dry Gas ☐
Casing head gas ☐ Condensate ☐
Change in Ownership ☐
Other (explain below)

To change the name of operator, lease and well number.

Remarks

This well was formerly known as Shell Oil Corporation's J. A. Foster No. 3. The Northwest Eumont Unit has been formed, effective 4-1-64 with Gulf as operator. Permission is hereby requested to change the name of the operator to Gulf and change the name of the lease and well No. to Northwest Eumont Unit,, Well No. 34-14.

The undersigned certifies that the Rules and Regulations of the Oil Conservation Commission have been complied with.

Executed this the 30th day of March, 1964.

OIL CONSERVATION COMMISSION	By ORIGINAL SIGNED BY C. D. BORLAND
Approved by	Title: Area Production Mangger
Title: Engineer District 1	Company: Gulf Oil Corporation
Date: ... 1964	Address: Box 670, Hobbs, New Mexico

(Revised 7/1/52)
(Form C-105)

N.

Section 34

T 19 S

AREA 640 ACRES
LOCATE WELL CORRECTLY

NEW MEXICO OIL CONSERVATION COMMISSION

Santa Fe, New Mexico

WELL RECORD

Mail to District Office, Oil Conservation Commission, to which Form C-101 was sent not later than twenty days after completion of well. Follow instructions in Rules and Regulations of the Commission. Submit in QUINTUPLICATE.

Shell Oil Company (Company or Operator) Foster (Lease)

Well No. 3, in SE ¼ of SW ¼, of Sec. 34, T. 19-S, R. 36-E, NMPM.

Eumont Pool, Lea County.

Well is 660 feet from south line and 1980 feet from west line of Section 34. If State Land the Oil and Gas Lease No. is -

Drilling Commenced November 22, 19 54 Drilling was Completed December 4, 19 54

Name of Drilling Contractor Velma Petroleum Corporation

Address Hobbs, New Mexico

Elevation above sea level at Top of Tubing Head 3621 The information given is to be kept confidential until Not confidential, 19

OIL SANDS OR ZONES

No. 1, from .... to .... No. 4, from .... to ....

No. 2, from .... to .... No. 5, from .... to ....

No. 3, from .... to .... No. 6, from .... to ....

IMPORTANT WATER SANDS

Include data on rate of water inflow and elevation to which water rose in hole.

No. 1, from .... to .... feet.

No. 2, from .... to .... feet.

No. 3, from .... to .... feet.

No. 4, from .... to .... feet.

CASING RECORD

SIZE	WEIGHT PER FOOT	NEW OR USED	AMOUNT	KIND OF SHOE	CUT AND PULLED FROM	PERFORATIONS	PURPOSE
8-5/8"	32#	New	288.63	-		-	Surface string
5-1/2"	15.5#	New	3937.85	Larkin		3910'-3935'	Oil string

MUDDING AND CEMENTING RECORD

SIZE OF HOLE	SIZE OF CASING	WHERE SET	NO. SACKS OF CEMENT	METHOD USED	MUD GRAVITY	AMOUNT OF MUD USED
11"	8-5/8"	310'	250	Pump & Plug	Cemented	to surface
7-7/8	5-1/2"	3950'	750	Pump & Plug		

RECORD OF PRODUCTION AND STIMULATION

(Record the Process used, No. of Qts. or Gals. used, interval treated or shot.)

Treated formation thru casing perforations 3910' - 3935' with 10,000 gallons Sandfrac (Dowell) containing 1-1/2 # sand/gallon.

Result of Production Stimulation On OPT flowed at the rate of 247.2 BOPD (based on 46.31 barrels in 4.5 hours) thru 16/64" choke. FTP 450 psi. GOR 143.

Depth Cleaned Out

NUMBER OF COPIES RECEIVED		
DISTRIBUTION		
SANTA FE		
FILE		
U.S.G.S.		
LAND OFFICE		
TRANSPORTER	OIL	
	GAS	
PRORATION OFFICE		
OPERATOR		

NEW MEXICO OIL CONSERVATION COMMISSION

FORM C-103
(Rev 3-55)

MISCELLANEOUS REPORTS ON WELLS

(Submit to appropriate District Office as per Commission Rule 1106)

Name of Company	Address
Amerada Petroleum Corporation	P. O. Box 668 - Hobbs, New Mexico

Lease	Well No.	Unit Letter	Section	Township	Range
M. E. Gaither	4	J	34	19S	36E

Date Work Performed	Pool	County
5-27-63 to 5-31-63	Eumont	Lea

THIS IS A REPORT OF: *(Check appropriate block)*

- [ ] Beginning Drilling Operations
- [ ] Casing Test and Cement Job
- [ ] Other *(Explain)*:
- [ ] Plugging
- [X] Remedial Work

Detailed account of work done, nature and quantity of materials used, and results obtained.

Pulled rods, pump and tubing. Made 2 runs with string shot in 7-7/8" open hole from 3870' to 3933'. Run #1 - 400 grains per ft. pf pay and Run #2 - 400 grains per ft. of pay. Cleaned out open hole from 3933' to 3940'. Ran tubing and packer. Acidized open hole from 3870' to 3940' with 500 gals. 15% N.E. acid. Pulled tubing. Reran tubing, pump and rods. Resumed production

Witnessed by	Position	Company
A. J. Troop	Asst. Dist. Supt.	Amerada Petroleum Corporation

FILL IN BELOW FOR REMEDIAL WORK REPORTS *ONLY*

ORIGINAL WELL DATA

D F Elev.	T D	PBTD	Producing Interval	Completion Date
3636'	3940'		3870' to 3940'	6-6-56

Tubing Diameter	Tubing Depth	Oil String Diameter	Oil String Depth
2-3/8"	3921'	5-1/2"	3870'

Perforated Interval(s)

Open Hole Interval	Producing Formation(s)
3870' to 3940'	Stuart

RESULTS OF WORKOVER

Test	Date of Test	Oil Production BPD	Gas Production MCFPD	Water Production BPD	GOR Cubic feet/Bbl	Gas Well Potential MCFPD
Before Workover	5-25-63	8.28	132	2.76	15,960	
After Workover	6-1-63	40	245	7	6,116	

OIL CONSERVATION COMMISSION	I hereby certify that the information given above is true and complete to the best of my knowledge.
Approved by	Name A J Troop
Title	Position Asst. District Superintendent
Date	Company Amerada Petroleum Corporation

E-36-E

(Revised 7/1/52)
(Form C-105)

DUPLICATE

NEW MEXICO OIL CONSERVATION COMMISSION
Santa Fe, New Mexico

1956 JUN 11

WELL RECORD

			Sec. 34				
			#4				

T 19 S

AREA 640 ACRES
LOCATE WELL CORRECTLY

Mail to District Office, Oil Conservation Commission, to which Form C-101 was sent not later than twenty days after completion of well. Follow instructions in Rules and Regulations of the Commission. Submit in QUINTUPLICATE. If State Land submit 6 Copies

Amerada Petroleum Corporation (Company or Operator) M.E. Gaither (Lease)

Well No. 4, in NW ¼ of SE ¼, of Sec. 34, T. 19-S, R. 36-E, NMPM.

Eumont Pool, Lea County.

Well is 1980 feet from South line and 2310 feet from East line

of Section 34. If State Land the Oil and Gas Lease No. is

Drilling Commenced May 26, 1956 Drilling was Completed June 4, 1956

Name of Drilling Contractor McQueen & Stout Drilling Company

Address 1601 West Texas, Midland, Texas

Elevation above sea level at Top of Tubing Head Not Determined The information given is to be kept confidential until Not Confidential, 19

OIL SANDS OR ZONES

No. 1, from 3870' to 3940' No. 4, from to

No. 2, from to No. 5, from to

No. 3, from to No. 6, from to

IMPORTANT WATER SANDS

Include data on rate of water inflow and elevation to which water rose in hole.

No. 1, from None to feet.

No. 2, from to feet.

No. 3, from to feet.

No. 4, from to feet.

CASING RECORD

SIZE	WEIGHT PER FOOT	NEW OR USED	AMOUNT	KIND OF SHOE	CUT AND PULLED FROM	PERFORATIONS	PURPOSE
8-5/8"	24#	New	1314'	Guide			
5-1/2"	15.5#	New	3870'	Float			

MUDDING AND CEMENTING RECORD

SIZE OF HOLE	SIZE OF CASING	WHERE SET	NO. SACKS OF CEMENT	METHOD USED	MUD GRAVITY	AMOUNT OF MUD USED
12¼"	8-5/8"	1314'	800	Halliburton		
7-7/8"	5-1/2"	3870'	400	Halliburton		

RECORD OF PRODUCTION AND STIMULATION

(Record the Process used, No. of Qts. or Gals. used, interval treated or shot.)

Sand-Oil open hole from 3870' to 3940' down tubing and casing with 20,000 gallons Famariss 24 gravity refined oil and 20,000# Sand. Maximum pressure 2600#, minimum pressure 2200#, final pressure 1600#, injection rate 20 bbls. per minute. Flushed with 190 bbls. oil.

Result of Production Stimulation Swabbed in. After Flowing load oil. Flowed 75.76 bbls. oil and no water in 2 hrs. on 1/2" choke, tubing pressure 320#, casing pressure 700#, gas volume 790,050 cu. ft. per day, GOR 869, gravity 34.5 corrected.

Depth Cleaned Out

COPY TO O. C. C.

Form 9-330
(Rev. 5-63)

UNITED STATES
DEPARTMENT OF THE INTERIOR
GEOLOGICAL SURVEY

SUBMIT IN DUPLICATE*
(See other instructions on reverse side)

Form approved.
Budget Bureau No. 42-R355.5.

WELL COMPLETION OR RECOMPLETION REPORT AND LOG*

1a. TYPE OF WELL: OIL WELL [X] GAS WELL [ ] DRY [ ] Other

SEP 20 ... 14 AM '65

b. TYPE OF COMPLETION: NEW WELL [X] WORK OVER [ ] DEEP-EN [ ] PLUG BACK [ ] DIFF. RESVR. [ ] Other

2. NAME OF OPERATOR
Ernest A. Hanson

3. ADDRESS OF OPERATOR
P. O. Box 1515, Roswell, New Mexico

4. LOCATION OF WELL (*Report location clearly and in accordance with any State requirements*)*
At surface 1980' FSL & 990' FWL
At top prod. interval reported below Sec. 35, T-19-S, R-34-E, N.M.P.M.
Lea County, New Mexico
At total depth

14. PERMIT NO.
DATE ISSUED

5. LEASE DESIGNATION AND SERIAL NO.
NM 052

6. IF INDIAN, ALLOTTEE OR TRIBE NAME

7. UNIT AGREEMENT NAME
Mescalero Ridge

8. FARM OR LEASE NAME
Mescalero Ridge Unit "35"

9. WELL NO.
13

10. FIELD AND POOL, OR WILDCAT
Pearl Queen

11. SEC., T., R., M., OR BLOCK AND SURVEY OR AREA
Sec. 35, T-19-S, R-34-E

12. COUNTY OR PARISH
Lea

13. STATE
New Mexico

15. DATE SPUDDED	16. DATE T.D. REACHED	17. DATE COMPL. (*Ready to prod.*)	18. ELEVATIONS (DF, RKB, RT, GR, ETC.)*	19. ELEV. CASINGHEAD
8/16/65	9/7/65	9/20/65	3711' KB	3701'

20. TOTAL DEPTH, MD & TVD	21. PLUG, BACK T.D., MD & TVD	22. IF MULTIPLE COMPL., HOW MANY*	23. INTERVALS DRILLED BY →	ROTARY TOOLS	CABLE TOOLS
5200'	5189'			210 - 5200'	0 - 210'

24. PRODUCING INTERVAL(S), OF THIS COMPLETION—TOP, BOTTOM, NAME (MD AND TVD)*
4576' - 5036' Queen Formation

25. WAS DIRECTIONAL SURVEY MADE
No

26. TYPE ELECTRIC AND OTHER LOGS RUN
Gamma-Ray/Density/Caliper

27. WAS WELL CORED
Yes

28. CASING RECORD (*Report all strings set in well*)

CASING SIZE	WEIGHT, LB./FT.	DEPTH SET (MD)	HOLE SIZE	CEMENTING RECORD	AMOUNT PULLED
8-5/8"	23#	202'	12"	125 sx. circ. to surf.	None
5-1/2"	15½#	5192'	7-7/8"	350 sx.	None

29. LINER RECORD

SIZE	TOP (MD)	BOTTOM (MD)	SACKS CEMENT*	SCREEN (MD)

30. TUBING RECORD

SIZE	DEPTH SET (MD)	PACKER SET (MD)
2-3/8"	4575'	None

31. PERFORATION RECORD (*Interval, size and number*)
1 - 0.50" jet/ft. @ 4576', 4595', 4597', 4605', 4617', 4619', 4745', 4881', 4885', 4929', 4931', 5024' & 5036'.

32. ACID, SHOT, FRACTURE, CEMENT SQUEEZE, ETC.

DEPTH INTERVAL (MD)	AMOUNT AND KIND OF MATERIAL USED
4576 - 4619'	1500 acid, 20,000 gals. lease oil & 20,000 lbs. sand.
4745 - 5036'	1500 acid, 20,000 gals. lease oil & 16,000 lbs. sand.

33.* PRODUCTION

DATE FIRST PRODUCTION	PRODUCTION METHOD (*Flowing, gas lift, pumping—size and type of pump*)	WELL STATUS (*Producing or shut-in*)
9/20/65	Pumping w/1-25/32" tubing pump.	Producing

DATE OF TEST	HOURS TESTED	CHOKE SIZE	PROD'N. FOR TEST PERIOD →	OIL—BBL.	GAS—MCF.	WATER—BBL.	GAS-OIL RATIO
9/20/65	24	2"		47		3	

FLOW. TUBING PRESS.	CASING PRESSURE	CALCULATED 24-HOUR RATE →	OIL—BBL.	GAS—MCF.	WATER—BBL.	OIL GRAVITY-API (CORR.)
			47		3	36°

34. DISPOSITION OF GAS (*Sold, used for fuel, vented, etc.*)
Sold

TEST WITNESSED BY
Schram

35. LIST OF ATTACHMENTS
2 - Gamma-Ray/Density/Caliper

36. I hereby certify that the foregoing and attached information is complete and correct as determined from all available records

SIGNED Ernest A. Hanson TITLE Operator DATE 9/20/65

*(See Instructions and Spaces for Additional Data on Reverse Side)

R-36-E

(Revised 7/1/52)
(Form C-105)

Section 34 | T 19 S

AREA 640 ACRES
LOCATE WELL CORRECTLY

NEW MEXICO OIL CONSERVATION COMMISSION

Santa Fe, New Mexico

HOBBS OFFICE OCC
1957 JAN 28 AM 7:19

WELL RECORD

Mail to District Office, Oil Conservation Commission, to which Form C-101 was sent not later than twenty days after completion of well. Follow instructions in Rules and Regulations of the Commission. Submit in QUINTUPLICATE.

Shell Oil Company (Company or Operator) Foster (Lease)

Well No. 2-A, in SW 1/4 of SE 1/4, of Sec. 34, T. 19-S, R. 36-E, NMPM.

Eunont Pool, Lea County.

Well is 660 feet from south line and 2310 feet from east line of Section 34. If State Land the Oil and Gas Lease No. is -

Drilling Commenced January 2, 1957 Drilling was Completed January 16, 1957

Name of Drilling Contractor O'Neal Drilling Company

Address R R 1 Box 2, Midland, Texas

Elevation above sea level at Top of Tubing Head 3621 The information given is to be kept confidential until not confidential, 19

OIL SANDS OR ZONES

No. 1, from 3866 to 3961 No. 4, from to

No. 2, from to No. 5, from to

No. 3, from to No. 6, from to

IMPORTANT WATER SANDS

Include data on rate of water inflow and elevation to which water rose in hole.

No. 1, from to feet.

No. 2, from to feet.

No. 3, from to feet.

No. 4, from to feet.

CASING RECORD

SIZE	WEIGHT PER FOOT	NEW OR USED	AMOUNT	KIND OF SHOE	CUT AND PULLED FROM	PERFORATIONS	PURPOSE
8 5/8"	32#	new	295'				Surface String
5 1/2"	15.5#	new	3856'				Oil String

MUDDING AND CEMENTING RECORD

SIZE OF HOLE	SIZE OF CASING	WHERE SET	NO. SACKS OF CEMENT	METHOD USED	MUD GRAVITY	AMOUNT OF MUD USED
12 1/4"	8 5/8"	304	300	Pump & Plug	Cemented to surface	
7 7/8"	5 1/2"	3866	750	Pump & Plug		

RECORD OF PRODUCTION AND STIMULATION

(Record the Process used, No. of Qts. or Gals. used, interval treated or shot.)

Treated down tubing & casing w/20,000 gallons Control-frac w/1#/gallon sand & fluid-loss additive.

Result of Production Stimulation On OPT flowed 141 BOPD + 5 BW thru 14/64" choke. FTP 400 psi. FCP 1000 psi. GOR 821

Depth Cleaned Out 3961

COPIES RECEIVED		
DISTRIBUTION		
SANTA FE		
FILE		
U.S.G.S.		
LAND OFFICE		
TRANSPORTER OIL		
TRANSPORTER GAS		
OPERATOR		
PRORATION OFFICE		

NEW MEXICO OIL CONSERVATION COMMISSION
REQUEST FOR ALLOWABLE AND AUTHORIZATION TO TRANSPORT OIL AND NATURAL GAS

Form C-104
Supersedes Old C-104 and C-110
Effective 1-1-65

AUG 24 11 44 AM '65

I.

Operator: Ernest A. Hanson

Address: P. O. Box 1515, Roswell, New Mexico

Reason(s) for filing *(Check proper box)*
- New Well [X]
- Recompletion [ ]
- Change in Ownership [ ]
- Change in Transporter of: Oil [ ] Dry Gas [ ] Casinghead Gas [ ] Condensate [ ]

Other *(Please explain)*

If change of ownership give name and address of previous owner

II. DESCRIPTION OF WELL AND LEASE

Lease Name	Well No.	Pool Name, Including Formation	Kind of Lease State, Federal or Fee
Mescalero Ridge Unit "35"	12	Pearl Queen	Federal

Location

Unit Letter E ; 1980 Feet From The North Line and 990' Feet From The West

Line of Section 35 , Township 19-S Range 34-E , NMPM, Lea County

III. DESIGNATION OF TRANSPORTER OF OIL AND NATURAL GAS

Name of Authorized Transporter of Oil [X] or Condensate [ ]	Address *(Give address to which approved copy of this form is to be sent)*
Shell Pipe Line Corp.	Box 1598, Hobbs, New Mexico
Name of Authorized Transporter of Casinghead Gas [ ] or Dry Gas [ ]	Address *(Give address to which approved copy of this form is to be sent).*
Phillips Petroleum Co.	Bartlesville, Okla.

If well produces oil or liquids, give location of tanks.	Unit	Sec.	Twp.	Rge.	Is gas actually connected?	When
	F	35	19-S	34-E	Yes	Aug. 15, 1965

If this production is commingled with that from any other lease or pool, give commingling order number:

IV. COMPLETION DATA

Designate Type of Completion – (X)	Oil Well	Gas Well	New Well	Workover	Deepen	Plug Back	Same Res'v.	Diff. Res'v.
	X							

Date Spudded	Date Compl. Ready to Prod.	Total Depth	P.B.T.D.
July 25, 1965	August 15, 1965	5200' dolo.	5116'
Pool	**Name of Producing Formation**	**Top Oil/Gas Pay**	**Tubing Depth**
Pearl Queen	Queen Fm.	4568'	4565'
Perforations			**Depth Casing Shoe**
1 SPF @ 4568, 4588, 4602, 4615, 4624, 4629, 4875, 4877, 4879, 5012, 5014 & 5016			5126'

TUBING, CASING, AND CEMENTING RECORD

HOLE SIZE	CASING & TUBING SIZE	DEPTH SET	SACKS CEMENT
11"	8-5/8"	246'	125 sx. circulated
7-7/8"	5-1/2"	5126'	350 sx.

V. TEST DATA AND REQUEST FOR ALLOWABLE
(Test must be after recovery of total volume of load oil and must be equal to or exceed top allowable for this depth or be for full 24 hours)

OIL WELL

Date First New Oil Run To Tanks	Date of Test	Producing Method *(Flow, pump, gas lift, etc.)*	
August 15, 1965	August 15, 1965	Pumping	
Length of Test	**Tubing Pressure**	**Casing Pressure**	**Choke Size**
24 hours			2"
Actual Prod. During Test	**Oil-Bbls.**	**Water-Bbls.**	**Gas-MCF**
	52	8	

GAS WELL

Actual Prod. Test-MCF/D	Length of Test	Bbls. Condensate/MMCF	Gravity of Condensate
Testing Method *(pitot, back pr.)*	**Tubing Pressure**	**Casing Pressure**	**Choke Size**

VI. CERTIFICATE OF COMPLIANCE

I hereby certify that the rules and regulations of the Oil Conservation Commission have been complied with and that the information given above is true and complete to the best of my knowledge and belief.

Ernest A. Hanson
(Signature)

Operator
(Title)

August 18, 1965
(Date)

OIL CONSERVATION COMMISSION

APPROVED AUG 24 1965, 19

BY

TITLE Engineer District

This form is to be filed in compliance with RULE 1104.

If this is a request for allowable for a newly drilled or deepened well, this form must be accompanied by a tabulation of the deviation tests taken on the well in accordance with RULE 111.

All sections of this form must be filled out completely for allowable on new and recompleted wells.

Fill out Sections I, II, III, and VI only for changes of owner, well name or number, or transporter, or other such change of condition.

Separate Forms C-104 must be filed for each pool in multiply completed wells.

Submit 3 Copies to Appropriate District Office

State of New Mexico
Energy, Minerals and Natural Resources Department

Form C-103
Revised 1-1-89

DISTRICT I
P.O. Box 1980, Hobbs, NM 88240
DISTRICT II
P.O. Drawer DD, Artesia, NM 88210
DISTRICT III
1000 Rio Brazos Rd., Aztec, NM 87410

OIL CONSERVATION DIVISION

P.O. Box 2088
Santa Fe, New Mexico 87504-2088

WELL API NO.
30-025-04164 ✓

5. Indicate Type of Lease STATE [X] FEE [ ]

6. State Oil & Gas Lease No. B-1543-1

SUNDRY NOTICES AND REPORTS ON WELLS

(DO NOT USE THIS FORM FOR PROPOSALS TO DRILL OR TO DEEPEN OR PLUG BACK TO A DIFFERENT RESERVOIR. USE "APPLICATION FOR PERMIT" (FORM C-101) FOR SUCH PROPOSALS.)

7. Lease Name or Unit Agreement Name
NORTH MONUMENT G/SA UNIT
BLK. 18

1. Type of Well: OIL WELL [X] GAS WELL [ ] OTHER

2. Name of Operator
AMERADA HESS CORPORATION

8. Well No.
9

3. Address of Operator
DRAWER D, MONUMENT, NEW MEXICO 88265

9. Pool name or Wildcat
EUNICE MONUMENT G/SA

4. Well Location
Unit Letter I : 1980 Feet From The SOUTH Line and 660 Feet From The EAST Line
Section 2 Township 20S Range 36E NMPM LEA County

10. Elevation (Show whether DF, RKB, RT, GR, etc.)

11. Check Appropriate Box to Indicate Nature of Notice, Report, or Other Data

NOTICE OF INTENTION TO:		SUBSEQUENT REPORT OF:	
PERFORM REMEDIAL WORK [ ]	PLUG AND ABANDON [ ]	REMEDIAL WORK [ ]	ALTERING CASING [ ]
TEMPORARILY ABANDON [ ]	CHANGE PLANS [ ]	COMMENCE DRILLING OPNS. [ ]	PLUG AND ABANDONMENT [ ]
PULL OR ALTER CASING [ ]		CASING TEST AND CEMENT JOB [ ]	
OTHER: [ ]		OTHER: Casing Test. [X]	

12. Describe Proposed or Completed Operations (*Clearly state all pertinent details, and give pertinent dates, including estimated date of starting any proposed work*) SEE RULE 1103.

03-24-93 Through 04-01-93
MIRU Ram Well Ser. & TOH w/rods & pump. Removed wellhead, installed BOP & TOH w/tbg. TIH w/6-1/8" bit to 3,793' & TOH. TIH w/7" RBP & set at 3,675'. Circ. hole w/fresh water. Press. tested 7" csg. to 500# for 30 min. Held OK. Chart attached. Pulled up hole & re-set RBP at 634'. Circ. hole clean. Removed BOP & Hinderliter tbg. head. Found top of 7" csg. lipped in. Re-installed BOP & re-set RBP at 3,634'. Spotted 4 sks. 12/20 sand on top RBP. Beveled out inside 7" csg. Cut off & removed 9-5/8" Hinderliter csg. head. Installed & tested 11" 3000# x 9-5/8" National csg. head & 7-1/16" 3000# x 11" 3000# National tbg. head. Set slips in csg. head w/90,000# tension. TIH w/retrieving head, cir sand off RBP, latched onto RBP & TOH. TIH w/6-1/8" bit & tagged up at 3,793'. Drld. & bailed out to 3,855'. Lowered bit to PBD at 3,911'. TOH w/bit. TIH w/7" TAC on 2-3/8" t Removed BOP & set TAC at 3,611' w/15,000# tension & SN at 3,893'. TIH w/pump & rods. RDPU cleaned lcoation & resumed prod. well.
Test of 04-07-93: Prod. 40 BO, 80 BW, & 7 MCFGPD in 24 hours.

I hereby certify that the information above is true and complete to the best of my knowledge and belief.

SIGNATURE R L Wheeler Jr TITLE SUPV. ADMIN. SERV. DATE 04-13-93

TYPE OR PRINT NAME Roy L. Wheeler, Jr. TELEPHONE NO. 393-2144

(This space for State Use)

Orig. Signed by
Paul Kautz
Geologist

APPROVED BY ____ TITLE ____ DATE APR 16 1993

CONDITIONS OF APPROVAL, IF ANY:

C-105

N.

AREA 640 ACRES
LOCATE WELL CORRECTLY

NEW MEXICO OIL CONSERVATION COMMISSION

Santa Fe, New Mexico

WELL RECORD

Mail to Oil Conservation Commission, Santa Fe, New Mexico, or its proper agent not more than twenty days after completion of well. Follow instructions in the Rules and Regulations of the Commission. Indicate questionable data by following it with (?). SUBMIT IN TRIPLICATE.

Gulf Oil Corporation — Company or Operator; Graham State — Lease

Well No. 2 in NE SE of Sec. 2, T. 20S, R. 36E, N. M. P. M., Monument Field, Lea County.

Well is 660 feet south of the North line and 660 feet west of the East line of NE SE

If State land the oil and gas lease is No. A-1543 Assignment No.

If patented land the owner is -, Address

If Government land the permittee is, Address

The Lessee is Gulf Oil Corporation, Address Tulsa, Oklahoma

Drilling commenced Jan. 11, 1956 Drilling was completed Feb. 24, 1956

Name of drilling contractor Loffland Bros., Address Tulsa, Oklahoma

Elevation above sea level at top of casing 3585 feet.

The information given is to be kept confidential until ? 19

OIL SANDS OR ZONES

No. 1, from 3800' to 3915' No. 4, from to

No. 2, from to No. 5, from to

No. 3, from to No. 6, from to

IMPORTANT WATER SANDS

Include data on rate of water inflow and elevation to which water rose in hole.

No. 1, from Rotary hole to feet.

No. 2, from to feet.

No. 2, from to feet.

No. 4, from to feet.

CASING RECORD

SIZE	WEIGHT PER FOOT	THREADS PER INCH	MAKE	AMOUNT	KIND OF SHOE	CUT & FILLED FROM	PERFORATED FROM	PERFORATED TO	PURPOSE
13"OD	40	8	SS	306'	?				
9-5/8"OD	36	8	LW	1065'	?				
7" OD	24	10	SS	3724'	?				

MUDDING AND CEMENTING RECORD

SIZE OF HOLE	SIZE OF CASING	WHERE SET	NO. SACKS OF CEMENT	METHOD USED	MUD GRAVITY	AMOUNT OF MUD USED
17½"	13"OD	306'	250	Halliburton		
12¼"	9-5/8"	1065'	350	"		
8-5/8"	7"	3724'	525	"		

PLUGS AND ADAPTERS

Heaving plug—Material Length Depth Set

Adapters—Material Size

RECORD OF SHOOTING OR CHEMICAL TREATMENT

SIZE	SHELL USED	EXPLOSIVE OR CHEMICAL USED	QUANTITY	DATE	DEPTH SHOT OR TREATED	DEPTH CLEANED OUT
		Hydrochloric Acid	2000 Gal.	2-24-56		

Form 3160-5
(June 1990)

UNITED STATES
DEPARTMENT OF THE INTERIOR
BUREAU OF LAND MANAGEMENT

FORM APPROVED
Budget Bureau No. 1004-0135
Expires: March 31, 1993

SUNDRY NOTICES AND REPORTS ON WELLS

Do not use this form for proposals to drill or to deepen or reentry to a different reservoir.
Use "APPLICATION FOR PERMIT—" for such proposals

SUBMIT IN TRIPLICATE

1. Type of Well
☐ Oil Well ☐ Gas Well ☐ Other TA'd

2. Name of Operator
Amerada Hess Corporation

3. Address and Telephone No.
Drawer D, Monument, New Mexico 88265 (505) 393-2144

4. Location of Well (Footage, Sec., T., R., M., or Survey Description)
660' FNL & 660' FEL, Sec. 3, T20S, R36E

5. Lease Designation and Serial No.
NM-1150

6. If Indian, Allottee or Tribe Name

7. If Unit or CA, Agreement Designation
BLK. 18
N. Monument G/SA Unit

8. Well Name and No.
17

9. API Well No.
30-025-0417400

10. Field and Pool, or Exploratory Area
Eunice Monument G/SA

11. County or Parish, State
Lea County, NM

12. CHECK APPROPRIATE BOX(s) TO INDICATE NATURE OF NOTICE, REPORT, OR OTHER DATA

TYPE OF SUBMISSION	TYPE OF ACTION	
☐ Notice of Intent	☐ Abandonment	☐ Change of Plans
☒ Subsequent Report	☐ Recompletion	☐ New Construction
☐ Final Abandonment Notice	☐ Plugging Back	☐ Non-Routine Fracturing
	☐ Casing Repair	☐ Water Shut-Off
	☐ Altering Casing	☐ Conversion to Injection
	☒ Other Press. Test csg. & check Bradenhead.	☐ Dispose Water
		(Note: Report results of multiple completion on Well Completion or Recompletion Report and Log form.)

13. Describe Proposed or Completed Operations (Clearly state all pertinent details, and give pertinent dates, including estimated date of starting any proposed work. If well is directionally drilled, give subsurface locations and measured and true vertical depths for all markers and zones pertinent to this work.)*

NMGSAU #1817 05-16-95

Rowland Trucking moved in and rigged up. Opened surface and intermediate casing valves. No pressure. Note: 10-3/4" x 7-5/8" annulus and 7-5/8" x 5-1/2" annulus both have cement to surface. Pressure tested 5-1/2" and 4-1/2" liner, CIBP at 3,830', to 540# and charted 30 min. casing integrity test. Well lost 20# to 520#. Test witnessed by Steve Caffey w/Bureau Of Land Management. Released casing pressure. Rowland Trucking rigged down and moved out. Closed in. Well TA'd for future NMGSAU use.

14. I hereby certify that the foregoing is true and correct

Signed Bill Hearne Title Sr. Production Foreman Date 05-18-95

(This space for Federal or State office use)

Approved by ______ Title ______ Date ______
Conditions of approval, if any:

Title 18 U.S.C. Section 1001, makes it a crime for any person knowingly and willfully to make to any department or agency of the United States any false, fictitious or fraudulent statements or representations as to any matter within its jurisdiction.

*See Instruction on Reverse Side

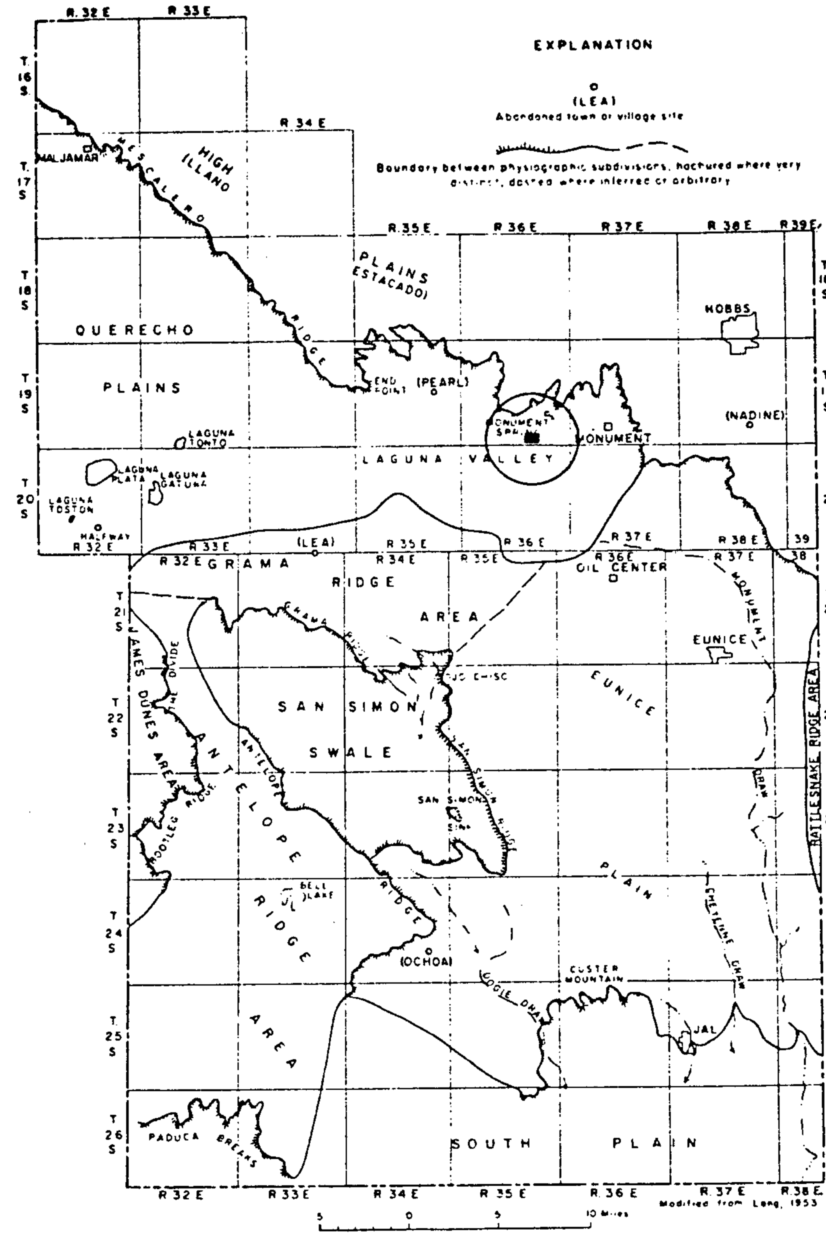
GEOLOGY

PHYSIOGRAPHY

The Climax Chemical plant is located near Monument, Lea County, New Mexico, approximately 20 miles west of the Texas - New Mexico border (Plate 1). The nearest populated area is Hobbs, located ten miles northeast of Monument. The climate of the area ranges from dry subhumid to arid, and is characterized by low annual precipitation, low humidity and high average annual temperature. Mean annual precipitation ranges from 15.68 to 12.63 inches per year and the mean annual temperature is about 62°F (Nicholson and Clebsch, 1961). Due to the low precipitation and rapid infiltration into the surficial sediments, flood potential is extremely low.

Lea County is divided into two physiographic subdivisions of the Great Plains physiographic province, the Pecos Valley section and the High Plains section. As illustrated in Figure 3.1, the proposed well location is in the Pesos Valley section which is divided into the Querecho Plains, Laguna Valley, Grama Ridge Area, Eunice Plains, San Simon Swale, Antelope Ridge Area and the South Plain (Nicholson and Clebsch, 1961).

To the north of Climax Chemical, the southern extent of the High Plains section is marked by the Mescalero Ridge of the Llano Estacado. An abrupt change in topography is the primary contrast between the Llano Estacado and the Pecos Valley. The Llano Estacado is an almost uniform depositional surface of low relief sloping southeastward. In contrast, the Pecos Valley is a very irregular erosional surface



PHYSIOGRAPHIC SUBDIVISIONS OF SOUTHERN LEA COUNTY, N. MEX.

AFTER GROUND WATER REPORT 6, STATE BUREAU OF MINES AND MINERAL RESOURCES

KEN E. DAVIS ASSOCIATES

BATON ROUGE LA HOUSTON TX

FIGURE 3.1

PHYSIOGRAPHIC MAP OF SOUTHERN LEA COUNTY

CLIMAX CHEMICAL
HOBBS, NEW MEXICO

DATE 6-14-83	CHECKED BY MDJ	JOB NO 83-261
DRAWN BY PJE	APPROVED BY MDJ	DWG NO

sloping toward the Pecos River (westward). Total relief of the area is about 1,300', having altitudes ranging from 4,000' mean sea level (MSL) to 2,900' MSL. A geologic map depicting the physiographic subdivisions of southern Lea County is included as Plate 2 and a brief description of the divisions follow:

Mescalero Ridge and High Plains

Mescalero Ridge is the most prominent topographic feature in southern Lea County and as previously stated, marks the southern limit of the High Plains section. The ridge is a nearly perpendicular cliff capped by a thick layer of resistant caliche, locally called caprock.

The High Plains is a uniformly flat surface sloping about 17' per mile southeast. The only significant relief features are small sand dunes and shallow depressions called buffalo wallows. These depressions range in size from a few feet to more than a quarter of a mile and can be up to 20' deep. Buffalo wallows collect rainfall and contain it until removed by evaporation or seepage.

Querecho Plains and Laguna Valley

Immediately southwest and south of Mescalero Ridge is a vast sand dune area of approximately 400 square miles called Querecho Plains (to the west) and Laguna Valley (to the east). As shown on Figure 3.1, the Climax Chemical plant is located in Laguna Valley. The Querecho Plains - Laguna Valley area is almost entirely covered by dune sand which is stable or semi-stable over most of the area. The sand is generally underlain by Recent alluvium and may be underlain by caliche in places. Drillers logs indicate surface sand underlain by caliche is found to depths of about 35'.

The most significant feature in the area is a group of four playas or dry lakes. These playas are irregularly shaped, flat-bottomed, and are underlain by fine sediments with some pebble gravel and precipitated salt and gypsum.

Grama Ridge Area

The Grama Ridge Area is directly south of the Querecho Plains-Laguna Valley area and is topographically higher, indicating it may be an outlier, or detached portion of the High Plains. It is characterized by a hard caliche surface with a texture and composition indicating it was once part of the Llano Estacado. The surface of the Grama Ridge Area has many shallow depressions which do not have integrated drainage.

Eunice Plain

The area east of Laguna Valley and Grama Ridge is referred to as the Eunice Plain. It is bounded on the north by the Llano Estacado and on the southwest by San Simon Ridge and Antelope Ridge. The westward extension of the Eunice Plain is the Grama Ridge area. Dune sands almost entirely cover the Eunice Plain and it is usually underlain by a hard caliche surface. In some places; however, it is underlain by alluvial sediments. A sand cover is generally 2' to 5' thick, but may be 20' to 30' thick locally.

Rattlesnake Ridge

Toward the east, the Eunice Plain rises into a north-trending topographic high called Rattlesnake Ridge. It parallels the state line for most of its length and is regarded as the drainage divide between the Pecos Basin and the Colorado River Basin, Texas.

San Simon Swale

To the west of Eunice Plain is San Simon Swale, a large depression covering about 100 square miles. Most of San Simon Swale is covered by stabilized dune sand and shows no apparent drainage pattern. The deepest point of the swale is San Simon Sink, being 100' deep and a half mile across. Calcareous silt and fine sand are the predominant fill material in the sink.

Antelope Ridge Area

The area to the west and southwest of Antelope Ridge has been called the Antelope Ridge Area, located in southwestern Lea County. The area is relatively flat, sand-covered surface similar to the Eunice Plain and it is also partially underlain by caliche. Towards the south, the area appears to be underlain by Quaternary fill and loamy soil similar to the San Simon Swale. Because the Antelope Ridge is an anomalous geographic feature similar to the High Plains, it is thought to be an outlying remnant of the High Plains.

3.2 HISTORICAL GEOLOGY

The Precambrian history of Southern Lea County is a complex history of mountain building, metamorphism and erosion. Active deposition was taking place in the area during most of the Paleozoic Era. In later Paleozoic time, the south-central United States was a region of crustal unrest with the most significant activity in the West Texas-New Mexico area taking place in Pennsylvanian time. During this time and earlier in the the Paleozoic, a geosyncline (the Llanoria geosyncline) formed across West Texas and adjacent states. (A geosyncline is a linear trough which has subsided throughout time accumulating large volumes of clastic sediment). Strong compressional forces from the southeast caused the geosynclinal area to be raised into mountain ranges which some refer to as the Marathon folded belt. Although much of the folded belt was eroded, it remained high during most of Permian time. During the Pennsylvanian Period, what is now the Central Basin Platform was also emergent in the form of mountain ranges and the area was subject to erosion.

At the close of the Pennsylvanian, the major features of the Permian Basin formed as the whole area subsided. The Central Basin Platform subsided more slowly than the Delaware and Midland Basins and received fewer sediments under different depositional conditions. The basins were areas of accumulation of large amounts of sediment. Limestone tended to form in higher areas, such as the Central Basin Platform, while the formation of evaporites took place at the fringes of the sea. At the very edge of the seas, redbeds were formed by the deposition of sediments from nearby land masses.

During Wolfcamp time (early Permian), seas spread over the region and later became restricted causing deposition of redbeds, evaporites and limestones. The final event of the Permian was the retreat of evaporite-depositing waters from the West Texas region which caused the deposition of a thin layer of redbeds known as the Ochoan Series.

The end of the Permian, and therefore the end of the Paleozoic Era, marks a major time break in the geologic column. During most of the Triassic (except late Triassic) and Jurassic, most of southern Lea County was emergent and undergoing erosion.

During early to middle Cretaceous time, Southeastern New Mexico was covered by a large shallow sea which deposited a thick sequence of Cretaceous rocks. In the late Cretaceous, during the uplift of the Rocky Mountains, seas retreated from the Lea County area and intense erosion took place removing almost all Cretaceous rocks.

In the Pliocene Age, the Ogallala Formation was evenly deposited across the High Plains area, effectively removing the irregular surface formed by previous episodes of erosion. An erosional cycle again began during the Quaternary, removing much of the Ogallala Formation and eroding Triassic rocks for the third time at some locations. Accordingly, erosion by the major rivers of New Mexico and Texas caused the isolation of a large remnant of the Ogallala Formation, the Llano

Estacado. The climate of the region became more arid in the late Quaternary, and detrital material was reworked by wind creating the large sand dune deposits in the area.

3.3 STRATIGRAPHY

The Climax Chemical plant is located in the Central Basin Platform of the Permian Basin. According to the work of Nicholson and Clebsch (1961), approximately 8,000' of geologic strata overlie the Precambrian basement rocks in the Central Basin Platform. Only strata of middle Permian age and younger are pertinent to this study. Included as Figure 3.2 is a generalized stratigraphic column for Southeastern New Mexico and a regional cross-section is shown in Plate 3 . In addition, a colored stratigraphic column based on driller's logs near the site is depicted in Figures 3.3 and 3.4. Following in ascending order is a brief description of the stratigraphy beneath the proposed well site.

<u>Guadalupian Series (Middle Permian)</u>

The Guadalupian Series in the Central Basin Platform consists of the San Andres Formation and the Whitehorse Group. The Whitehouse Group consist of a fine-grained sandstone with thin layers of black shale and argillaceous limestone and, according to King (1942), can also be referred to as the Artesia or Chalk Bluff Group. The Whitehorse Group of the Central Basin Platform is correlative to the Delaware Mountain Group of the Delaware Basin. In the Monument area, it

TABLE 3.1

GEOLOGIC CROSS SECTION AT CLIMAX PLANT SITE
SECTION 35, TOWNSHIP 19S, RANGE 36W
MONUMENT, NEW MEXICO
ELEVATION -3595'

FROM	TO	THICKNESS IN FEET	FORMATION	TDS RANGE IN MG/L
0 -	2	2	Soil	
2 -	22	20	Calichi	
22 -	45	23	Ogallala	600->3250
45 -	1008	963	Red Beds	
	(Top of Anhydrite @ 1008')			
1008 -	1160	152	Dockum Group	
1160 -	2303	1143	Salt	
2303 -	2423	120	Tansill	
2423 -	2853	430	Yates	
2853 -	3225	372	7-Rivers	
3225 -	3570	345	Queen	
	(Top of Penrose @ 3380')			13-19,000
3570 -	3800	230	Grayburg	15 - 34,000
3800 -	5150	1350	San Andres	15,000+

(Top of Oil/Water contact - 3995')
(Disposal Zone 4300'-5150'±)

Revised 2/13/84

KEN E. DAVIS ASSOCIATES

Ochoan Series (Upper Permian)

The lowermost formation of the Ochoan Series is the "Salt" Formation, consisting of anhydrite and some halite. It rests unconformably on the Whitehorse Group in the Central Basin Platform but does not extend beyond the basin margins. Total thickness of the anhydrite and halite at the plant site is approximately 1200'. Halite was mined by Climax Chemical Company in the subsurface interval between 1400' to 2616'.* Three brine wells previously used to leach salt have been plugged and abandoned by Climax. The base of mineable salt was found to be at a depth of approximately 2610'.

The "Salt" Formation is unconformable in places with the overlying Rustler Formation. The top of the Rustler is considered to be the top of the first continuous anhydrite bed penetrated by oil and gas wells in southeastern New Mexico and occurs at a depth of 1008' in the Climax area. The Rustler is characterized as dolomitic limestone with some sandstone and chert pebble conglomerates at the base. Eastward, in the area of Monument, the limestone is overlain by anhydrite, redbeds and halite which is considered an upper member. In Lea County, the Rustler is between 90' to 360' thick and appears to be 100'± thick at the proposed well site.

The "Salt" Formation and Rustler Formation together compose the Salado Group or Ochoan Series as shown in Figure 3.2.

Upper Permian or Triassic

Above the Rustler Formation are the undifferentiated redbeds of Permian or Triassic age. They consist of micaceous red siltstone, sandstone, shale and are cemented with gypsum. They are thought to retard the movement of water between the rocks of the Permian and the overlying aquifers (Nicholson and Clebsch, 1961). The Middle and Upper Triassic consists of a sequence of redbeds, the Dockum Group, which rest unconformably on the lower undifferentiated redbeds. The Dockum can usually be differentiated into the Santa Rosa Formation and the uppermost Chinle Formation. The Santa Rosa is a fine-to-coarse-grained sandstone containing minor shale layers and ranging in thickness from 140' to 300'. The Santa Rosa and the Chinle are similar lithologically and in some places have been mapped as the Dockum Group, undifferentiated.

The Chinle Formation consists of red and green claystone which is interbedded with fine-grained sandstone and siltstone. The Chinle has been eroded in the west; however, it reaches a thickness of 1,270' near the Monument area. About 2 miles southeast of Monument, the Chinle grades into a micaceous red clay (Nicholson and Clebsch, 1961).

Both the Dockum Group and the undifferential redbeds are estimated to be 888' thick at the plant site with the top at approximately 120' below the surface.

Cretaceous

The rocks of Cretaceous age, although once present in Lea County, have been almost entirely removed by erosion. The only known exposure of Cretaceous rocks in Lea County are found in a gravel pit of the Lea County Concrete Company about seven miles south of Hobbs. At the site, the limestone is white, light gray or buff and highly fossiliferous. There are no known deposits of Jurassic rocks in Lea County.

Tertiary

Beneath the surficial deposits, at the proposed location, are rocks of the Tertiary System represented by the Ogallala Formation of Pliocene age. It is a heterogeneous complex of terrestrial sediments, consisting chiefly of a calcareous, unconsolidated sand containing clay, silt, and gravel. Conditions of deposition varied rapidly during Ogallala time causing well-sorted sediments to be interbedded with poorly sorted sediments. The Ogallala Formation ranges from a few feet to as much as 300' thick and is a major aquifer where it has sufficient thickness.

Quaternary System

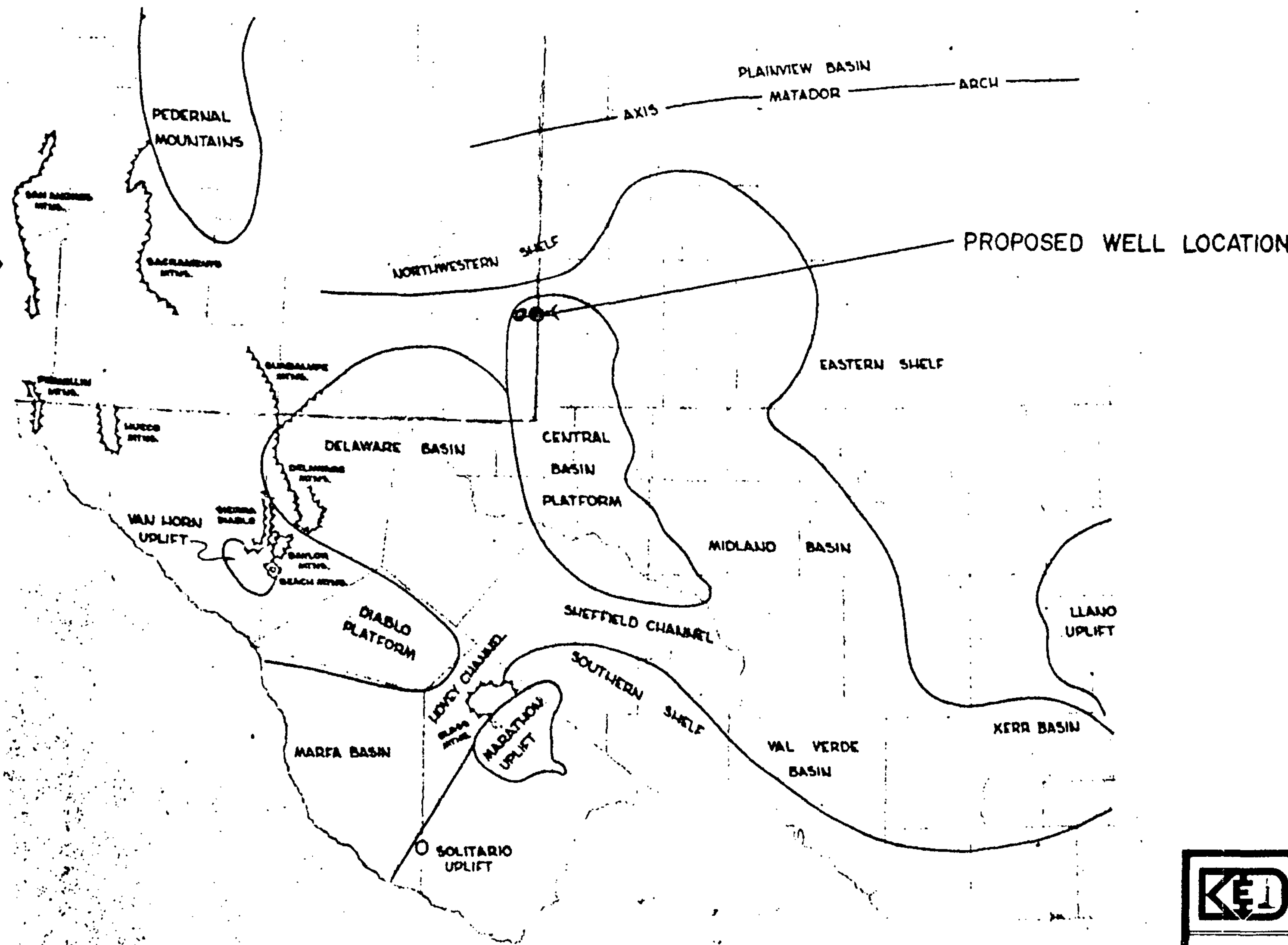
In the Monument area, sediments of the Quaternary System exist in the form of alluvial deposits of Pleistocene and Recent age and dune sands of Recent age. The older alluvium is exposed locally in small duneless patches, or in pits and it underlies the areas of Querecho Plains, Laguna Valley, San Simon Swale and several smaller areas. The alluvium ranges in thickness from a few inches to more than 400' in San Simon Sink.

The most extensive Quaternary unit is the cover of red dune sand called the Mescalero Sands. This fine-to-medium grained, reddish-brown sand, which covers 80% of Lea County, parts of Eddy County, and West Texas, was probably derived from the Permian and Triassic rocks of the Pecos Valley. In the vicinity of Climax, the alluvial deposits consist of unconsolidated fine to coarse sand and gravel with stringers of silt and clay, and Eaolian sands cover the surface. (Geohydrology Associates, 1982).

3.4 STRUCTURAL GEOLOGY

Regional Structure

West Texas and half of Southern New Mexico is part of a large subsurface structural feature known as the Permian Basin, which is subdivided into several smaller areas. As previously mentioned, Climax Chemical Plant is located on the Central Basin Platform (See Figure 3.5) and is bounded by the Northwestern Shelf on the North, the Delaware Basin on the West, the Sheffield Channel and Southern Shelf on the south and the Midland Basin on the East. Basins are depressed areas that may vary in size and shape and are formed by subsidence of an area or uplift of the surrounding regions. In most cases, basins probably result from both subsidence and uplift (Huffington, et al 1951).



AFTER JONES, 1953

Jones, T. S. (1953), Stratigraphy of the Permian Basin of West Texas, West Texas Geological Society, Page 3.

KEN E. DAVIS ASSOCIATES
BATON ROUGE LA   HOUSTON TX

FIGURE 3.5

PERMIAN BASIN STRUCTURE

CLIMAX CHEMICAL
HOBBS, NEW MEXICO

DATE 6-14-83	CHECKED BY SEO	JOB NO 83-261
DRAWN BY PJE	APPROVED BY SEO	DWG NO

OFFICE PHONE EX 3-2961
RES. PHONE EX 3-2062

905 NORTH DALMONT

MILLER ENGINEERING & GEOLOGICAL CO.
POST OFFICE BOX 417
ZIP CODE 88240
HOBBS, NEW MEXICO

E-S-S
Fell #4 Brine well

July 28, 1978

Climax Chemical Company
P. O. Box 1595
Hobbs, New Mexico 88240

Attn: Mr. Ed Smith

Dear Ed:

The enclosed tabulation of Casing records and total depths drilled on wells located in sections 34 and 35 of township 19 South, range 36 E; and sections 3 and 4 of township 20 South, range 36 E, of the Monument Field may be of some informative value.

This data was compiled, to a large extent, from Oil Scout reports and to a limited from personal investigation of the Oil Conservation records. It is somewhat of a reconnaissance survey and if we find the need to go into more detail, the Oil Conservation records should be consulted.

Yours very truly,

Charles P. Miller

Charles P. Miller

cpm

T 19 S, R 36 E

COMPANY & LSE	SEC.	UNIT	SURF CSG (DEPTH SX)	INTERMEDIATE	PAY CSG (DEPTH SX)	T.D.	ELEV	COMPL. DATE
Amerada Gaither 1	34	I	12½-227-150	8-5/8 2540-500	6-5/8-3814-100	3950	3632	7/13/36
" " 2	34	F	9-5/8-310-300	- - - - - - - -	7"- 3996- 800	3996	3652	10/11/54
" " 3	34	K	9-5/8-317-300	- - - - - - - -	7"-3800- 700	3940	3638	11/7/64
" " 4	34	J	8-5/8-1314-800	- - - - - - - - -	5½-3870-400	3940		6/7/56
Climax Chem 3	34	K						
" " 4	34	P						
Gulf Oil Smith 1	34	H	10-3/4-228-200	7-5/8-1281-300	5½-3800-300	3970	3642	6/11/36
" " " 2	34	A	12½-285-250	9-5/8-1240-375	7 -3843-200	3975	3657	5/11/37
" " " 3	34	C	9-5/8-311-275	- - - - - - - -	7- 3832-1650	4000	3677	1/28/55
" " " 4	34	D	9-5/8-338-275	- - - - - - - -	7- 3860-1750	4000	3681	5/26/55
" " " 5	34	B	9-5/8-1377-900	- - - - - - - -	7- 3980-600	3980	3685	3/16/56
" " " 6	34	G	8-5/8-1378-850	- - - - - - - -	5½-3950-600	3950	3651	4/9/56
Resler & Sheldon Smith 1	34	E	8-5/8-234-100	- - - - - - - -	5½-4000-400	4000	3654	8/9/54
" " 2	34	L	8-5/8-285-150	- - - - - - - -	5½- 3903-400	3980	3642	9/30/54
Shell Foster 1	34	P	12½-248-125	9-5/8-1201-350	7 -3707-250	3957	3632	6/11/36
" " 2	34	O	8-5/8-1265-500,	- - - - - - - -	5½-3702-125	3953	3627	3/13/39
" " 2A	34	O	8-5/8-304- 300	- - - - - - - -	5½-3866-750	3961		1/22/57
" " 3	34	N	8-5/8-301- 250	- - - - - - - -	5½-3950-750	3950	3633	12/2/54
" " 4	34	M	8-5/8-306-300	- - - - - - - -	5½-3971-660 ,,	3972	3638	12/30/54
Amerada Weir 1	35	M	12½-205-100	9-5/8-2435-500	7 -3815-100	3945	3621	2/5/36
" " 3	35	L	12½-219-150	8-5/8-2455-500	6-5/8-3815-100	3945	3626	4/19/36
" " 4	35	F	12½-217-150.	8-5/8-2425-500	6-5/8-3815-100	3945	3627	4/22/16
" " 5	35	E	12½-222-50	8-5/8-2479-500	6-5/8-3819-100,	3955	3636	7/6/36
" " 6	35	C	12½-188-180	8-5/8-2492-500	6-5/8-3828-100	3975	3652	8/22/36
" " 8	35	D	12½-191-200,	8-5/8-2539-600	6-5/8-3845-100	3960	3653	4/15/37
Gulf Oil Weir 1	35	A	10-3/4-279-250	7-5/8-1181-250	5½- 3866-300	3978	3633	3/5/36

COMPANY & LSE	SEC	UNIT	SURF. CSG DEPTH SX	INTERMEDIATE	PAY CSG. DEPTH SX	T.D.	ELEV	COMPL DATE
Shell State 1	35	P	12½-174-150	9-5/8-2450-450	7-3800-135	3929	3594	6/22/35
Republic Prod.								
Selby-Maveety 1	35	N	12½-253-100	9-5/8-2375-100	7-3975-200	3940?	3975	11/9/35
" " " 2	35	K	12½-313-200	9-5/8-2400-400	7-3815-232	3927	3610	2/5/36
" " " 1A	35	K	7 - 308-300	Excessive deviation @ 2310"	P @ A			
Sinclair, Selby1AX	35	N				3950	3653	11/19/59
Sun Maveety 1	35	P		7"-2532-400	4-3/4-3790-200	3935	3591	7/16/35
" " 2	35	O	12½-162-100	9-5/8-2340-400	7-3776-200	3936	3607	9/3/35
" " 3	35	H	12½-258-250	9-5/8-2395-400	7-3774-215	3945	3604	10/27/35
" " 4	35	J	13¼-249-400	9-5/8-2397-400	7-3777-200	3939	3610	2/7/36
" " 5	35	G	12½-305-125	9-5/8-2476-400	7-3825-200	3940	3609	5/8/36
" " 6	35	B	12½-297-125	9-5/8-2481-400	7-3824-200	3972	3647	6/24/36 Few
" " 7	35	G	8-5/8-342-200	- - - - - - - -	4½-4100-454	4100	3611	12/3/66 {Holes in csg 503-1015
Sun Oil Weir 1	35	I	12½-158-100	9-5/8-2334-390	7-3795-200	3935	3601	7/20/35

T 20 S, R 36 E

COMPANY & LSE	SEC	UNIT	SURF. CSG	INTERMEDIATE	PAY CSG.	T.D.	ELEV	COMPL DATE
Amerada St. J 1	2	O	12½-220-150	9-5/8-2376-500	7-3789-200	3921	3591	1/20/36
" " " 2	2	J	12½-197-150	8-5/8-2334-500	7-3784-125	3900	3597	1/20/36
" " " 3	2	K	13/58-162-	8-5/8-2346-500	6-5/8-3810-100	3930	3612	4/13/36
" " " 4	2	K	8-5/8 383-350	- - - - - - - - -	4½-3499-1150	3500	3598	6/12/76
Amerada St. M 1	2	F	12½-225-150	8-5/8-2386-500	7-3805-160	3920	3605	3/18/36
" St. S 1	2	N	12½-239-150	8-5/8-2372-500	6-5/8-3811-100	3915	3604	5/25/36
" " " 2	2	M	12½-224-150	8-5/8-2435-500	6-5/8-3756-100	3920	3605	7/19/36
" Weir 1	2	C	12½-216-150	8-5/8-2408-500	6-5/8-3800-100	3930	3614	4/1/36
" " 2	2	D	12½-216-150	8-5/8-2412-500	7-3800-100	3930	3614	4/1/36
Anderson-Prich.								
State 1	2	E	12½-265-250	9-5/8-2541-600	7-3795- 50	3910	3614	6/11/36
Gulf Graham St								
"B"1	2	P	13-255-250	9-5/8-2353-800	7-3696-125	3903	3579	11/22/35
" " 2	2	I	13-311-300	9-5/8-1065-350	7-3724-525	3915	3583	2/28/36

T 20 S, R 36 E

COMPANY & LSE		SEC.	UNIT	SURF CSG. Depth Sx	INTEEMEDIATE	PAY CSG. Depth Sx	T.D.	ELEV.	COMPL DATE	
Superior St A	1	2	A	13-3/8- 170-110	9-5/8-2344-450	7-3791-75	3945	3596	7/10/35	
" "	2	2	B	12½-265-100	9-5/8-2385-500	7-3785-45	3935	3603	10/30/35	
" "	3	2	H	13-3/8-255-200	9-5/8-2441-500	7-3791-45	3923	3592	12/14/35	
" "	4	2	G	13-3/8-166-110	9-5/8-2383-500	7-3815-165	3912	3594	1/27/36	
" "	6	2	A		9-5/8-340 -250	7-4000-300	4000	3597	9/8/54	
Turner St,A	1	2	K	12½-255-200,	9-5/8-1210-500 ,,	7-3773-200	3899	3604	6/8/36	
Union Tex. Pet. Corp.(St.A	2	2	E	8-5/8-370-170	- - - - - - - -	5½-4050-1800	4050	3610	10/3/63	(2 wells on this unit. Easterly test. Plugged
Cont'l Oil Co. Reed A-3	1	3	A	10-3/4-254-200	7-5/8-2628-900	5½-3787-150	3896	3628	4/17/36	Temp. Abnd
"	2	3	H	10-3/4-250-250	7-5/8-1221-400	5½-3812-400	3930	3616	6/27/36	Gas well
"	3	3	I	10-3/4-245-200	7-5/8-1235-400	5½-3817-400	3930	3616	6/24/36	Gas well
"	4	3	P	10-3/4-272-225	7-5/8-1278-425	5½-3768-425	3851	3611	10/19/36	Temp S.I.
"	5	3	G	10-3/4-274-250	7-5/8-1301-425	5½-3925-425	3925	3622	12/9/36	P & A
"	6	3	D	8-5/8-1404-600		5½-4001-1095	4003	3632	4/19/55	Injec.Well
"	7	3	C	8-5/8-1339-650		5½-3950-1203	3950	3627	4/20/55	Injec Well
"	8	3	F	9-5/8-1369-70		5½-3949-1360	3950	3626	6/3/55	
"	9	3	E	8-5/8-1372-650		5½-4009-1402	4010	3631	6/30/55	
"	10	3	K	8-5/8-1324-650		5½-3949-1045	3950	3626	8/3/55	Injec Well
"	11	3	L	8-5/8-1399-650		5½-3995-888	3996	3630	8/30/55	
"	12	3	N	8-5/8-325- 250		5½-3949-1390	3950	3621	9/9/55	
"	13	3	M	8-5/8-334-215		5½-3999-1530	4000	3626	10/9/55	Injec Well
"	14	3	O	8-5/8-318-250		5½-4006-348	4000	3619	8/12/57	
"	15	3	J	8-5/8-314-250		5½-3999-1675	4000	3622	5/1/58	
H.S. Moss (Cont'l Oil) Reed	1	3	G	10-3/4-295-225		7"3804-200	3913	3625	2/20/53	

See Next Page For Additional Data Cont'l. Reed #6, #7, #10, #13, #14, etc

T 20 S, R 36 E

Continental	Reed A-3	#1	Temporarily Abandoned
"	"	#2	Recpmpleted as a gas well
"	"	#3	Recompleted as a gas well
"	"	#4	Temporarily shut in
"	"	#5	Plugged and abandoned
"	"	#6	Converted to water injection well. Packer on tbg. @ 3689
"	"	#7	Converted to water injection well. Packer on tbg. @ 3910
"	"	#10	Converted to water injection well. Packer on tbg. @ 3865
"	"	#13	Convérted to water injection well. Packer on tbg. @ 3678
"	"	#14	Converted to water injection well. Packer on tbg. @ 3698