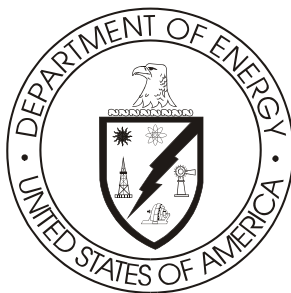


# **Delaware Basin Monitoring Annual Report**

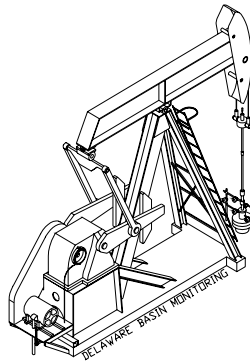


September 2000

**United States Department of Energy  
Waste Isolation Pilot Plant**

**Carlsbad Area Office  
Carlsbad, New Mexico**

***DELAWARE BASIN DRILLING SURVEILLANCE PROGRAM  
ANNUAL REPORT***



***WASTE ISOLATION PILOT PLANT***

***ENVIRONMENT, SAFETY, AND HEALTH  
LONG-TERM REGULATORY COMPLIANCE***

**October 1999 through September 2000**

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### **1.0 Delaware Basin Drilling Surveillance Program**

The Delaware Basin Drilling Surveillance Program (DBDSP) is designed to monitor drilling activities in the vicinity of the Waste Isolation Pilot Plant (WIPP). This program is based on Environmental Protection Agency (EPA) requirements. The EPA environmental standards for the management and disposal of Transuranic (TRU) radioactive waste are codified in 40 CFR Part 191 (EPA 1993). Subparts B and C of the standard address the disposal of radioactive waste. The standard requires the Department of Energy (DOE) to demonstrate the expected performance of the disposal system using a probabilistic risk assessment or performance assessment (PA). This PA must show that the expected repository performance will not release radioactive material above limits set by the EPA's standard. This assessment must include the consideration of inadvertent drilling into the repository at some future time.

The EPA provided criteria in 40 CFR § 194.33 to address the consideration of future deep and shallow drilling in PA. These criteria led to the formulation of conceptual models that incorporate the effects of these activities. These conceptual models use parameter values drawn from the databases in Appendix DEL of the Compliance Certification Application (CCA). Examples of information of interest include the drilling rate of deep and shallow boreholes and data relating to the physical properties of drill holes such as diameter.

The EPA defined in 40 CFR Part 194.2 the area to be used for the historical rate of drilling for resources. It reads in part:

Delaware Basin means those surface and subsurface features which lie inside the boundary formed to the north, east and west of the [WIPP] disposal system, by the innermost edge of the Capitan Reef, and formed, to the south, by a straight line drawn from the southeastern point of the Davis Mountains to the most southwestern point of the Glass Mountains.

The Delaware Basin, depicted in Figure 1, includes all or part of Brewster, Culberson, Jeff Davis, Loving, Pecos, Reeves, Ward, and Winkler Counties in West Texas, and portions of Eddy and Lea Counties in southeastern New Mexico.

In accordance with these criteria, the DOE used the historical rate of drilling for resources in the Delaware Basin to calculate a future drilling rate. In particular, in calculating the frequency of future deep drilling, 40 CFR § 194.33(b)(3)(i) (EPA 1996) provided the following guidance to the DOE:

Identify deep drilling that has occurred for each resource in the Delaware Basin over the past 100 years prior to the time at which a compliance application is prepared.

The DOE used the historical record of deep drilling for resources below 2,150 feet that has occurred over the past 100 years in the Delaware Basin. This was chosen because it is the depth

of the repository, and the repository is not directly breached by boreholes less than this depth. In the past 100 years, deep drilling occurred for oil, gas, potash, and sulfur. These drilling events were used in calculating a rate for deep drilling for PA as discussed in Appendix DEL of the CCA. Historical drilling for purposes other than resource exploration and recovery (such as WIPP Site investigation) were excluded from the calculation in accordance with guidance provided in 40 CFR 194.33.

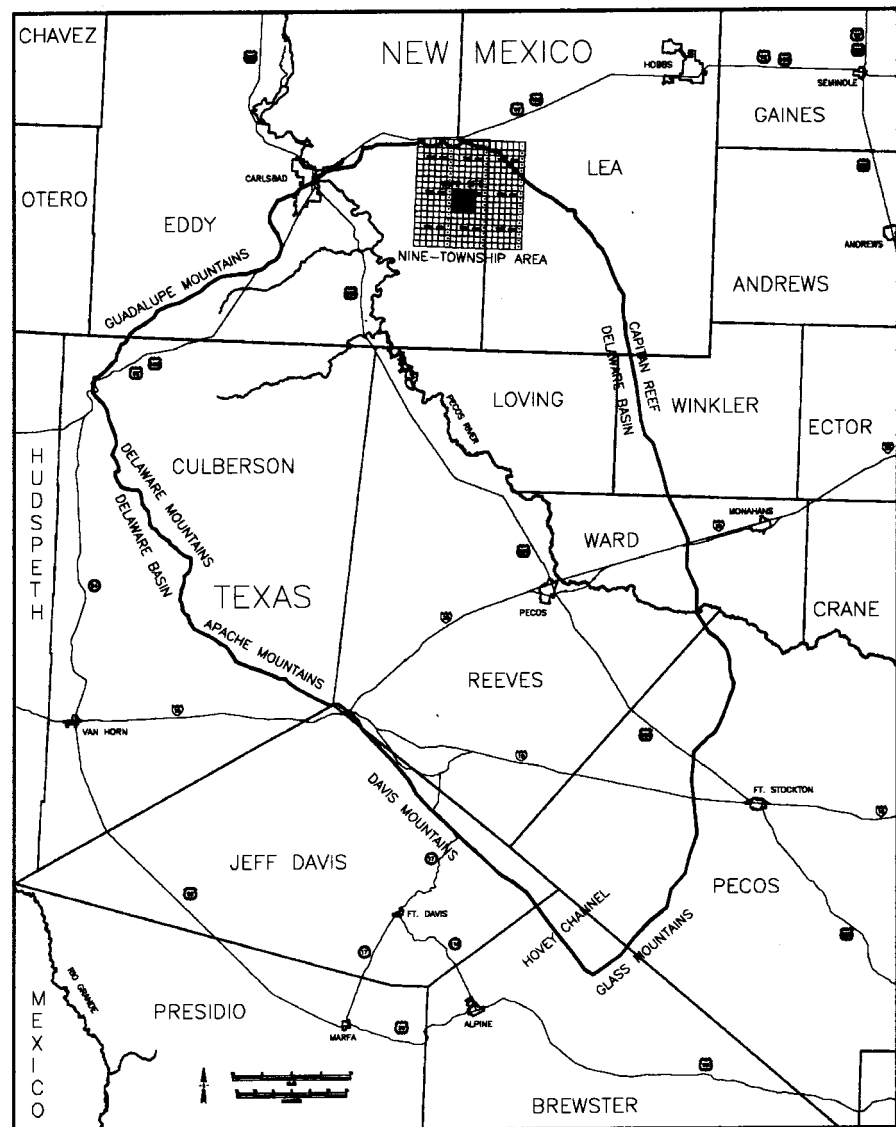
In calculating the frequency of future shallow drilling, 40 CFR § 194.33(b)(4)(i) states that the DOE should:

Identify shallow drilling that has occurred for each resource in the Delaware Basin over the past 100 years prior to the time at which a compliance application is prepared.

Additional criterion for calculation of future shallow drilling rates is provided in 40 CFR § 194.33(b)(4)(iii):

in considering the historical rate of all shallow drilling, the Department may, if justified, consider only the historical rate of shallow drilling for resources of similar type and quality to those in the controlled area.

The only resources present at shallow depths (less than 2,150 feet below the surface) within the controlled area are water and potash. Thus, consistent with 40 CFR § 194.33(b)(4), the DOE used the historical record of shallow drilling associated with water and potash extraction in the Delaware Basin to calculate the rate of shallow drilling within the controlled area. The controlled



**Figure 1**  
**WIPP Site, Delaware Basin, and Surrounding Area**

area is the 16 sections of land (16 square miles) within the WIPP Site boundary.

The EPA provides further criteria concerning the analysis of the consequences of future drilling events in performance assessments in 40 CFR § 194.33(c)(EPA 1996). Consistent with these criteria, the following parameters regarding drilling were considered in the performance assessment as documented in Appendix DEL of the CCA:

- types of drilling fluids
- amounts of drilling fluids
- borehole depths
- borehole diameters
- borehole plugs
- fraction of each borehole that is plugged
- natural processes that will degrade borehole plugs
- instances of encountering pressurized brine in the Castile Formation

The DOE continues to provide surveillance of the drilling activity in the Delaware Basin in accordance with the criteria established in 40 CFR 194 during the operational phase and will continue until the DOE and the EPA agree no further benefit can be gained from continued surveillance. The results of this surveillance activity will be used to determine if a significant change has occurred that would be detrimental to the performance of the disposal system.

The Delaware Basin Drilling Surveillance Plan (WP 02-PC.02) places specific emphasis on the nine-township area that includes the WIPP Site and provides data to build on the data presented in Appendix DEL.

Surveillance of drilling activities within the Delaware Basin will continue after closure for 100 years or until the DOE can demonstrate to the EPA there are no significant concerns to be addressed by further surveillance (Section 7.1.4, DOE 1996b).

## **2.0 2000 Updates**

PA is required by regulation to consider disturbed case scenarios that include intrusions into the repository by inadvertent and intermittent drilling for resources. The probability of these intrusions is based on a future drilling rate of 46.8 boreholes per square kilometer per 10,000 years. This rate is based on consideration of the past record of drilling events in the Delaware

Basin. The DOE models multiple types of human intrusion scenarios in the PA. These include both single intrusion events and combinations of multiple boreholes. Two different types of boreholes are considered: (1) those that penetrate a pressurized brine reservoir in the underlying Castile Formation and (2) those that do not. While the presence of pressurized brine under the repository is speculative, it cannot be completely ruled out based on available information. The primary consequence of contacting pressurized brine is the introduction of an additional source of brine beyond that which is normally found in the repository in the Salado Formation. The human intrusion scenario models are based on extensive field data sets collected by the DOE. The Delaware Basin Drilling Surveillance Program collects the drilling related data to be used for future PA calculations. The data collected from the time of the 1996 submittal of the CCA to the present and on specific wells drilled during the last year in the New Mexico portion of the Delaware Basin, specifically that of the nine-township area immediately surrounding the WIPP Site, are summarized in the following sections.

## **2.1 Drilling Techniques**

The drilling techniques reported in Appendix DEL of the CCA are still being implemented by area drillers. There were a total of 95 wells spudded, not necessarily completed, in the New Mexico portion of the Delaware Basin from August 1, 1999 through August 15, 2000. The rotary drilling rig was used in the drilling of all 95 wells. Some have been completed as oil wells, others as gas wells, while the rest are still in the process of being completed. All were conventionally drilled utilizing mud as a medium for circulation. Fifty-four of these wells were in the nine-township area. The depths of the completed wells in the nine-township area range from 4,250 feet to 11,460 feet. Outside of the nine-township area the depths of the completed wells range from 3,136 feet to 17,675 feet.

A technique used by operators to increase production is to drill a well directionally or horizontally. As reported in Appendix DEL, this technique is not often used in this area because of the increased costs. Of the 95 new wells spudded or completed in the last year in the New Mexico portion of the Delaware Basin, one was directionally drilled but has yet to be completed. This well is located in the nine-township area immediately surrounding the WIPP Site.

### **2.1.1 Drilling Fluids**

Employing a rotary rig for drilling involves the use of drilling fluids. Typically, an area driller will use fresh water and additives to drill the surface section of the hole which ends at the top of the Salado Formation. A change in drilling practices would necessitate a change in the application of drilling fluids. Within the Known Potash Lease Area (KPLA) of southeastern New Mexico, drillers are required under Title 19, Chapter 15, Order R-111-P of the New Mexico Administrative Code (NMAC) to use a saturated brine to drill through the salt formation which is usually called the intermediate section. This requirement is to keep the salt from washing out and making the hole larger than necessary and to protect the potash reserves that occur in this formation. Once this section has been drilled and cased, the driller again changes to fresh water and additives to finish drilling the hole to depth. All the operators of new wells completed in the



New Mexico portion of the Delaware Basin during the last year reported mud weights of 8.3 to 9.9 pounds per gallon while drilling the intermediate portion of the wellbore. The operators completing wells in the nine-township area reported mud weights to be a 8.6 pound per gallon saturated brine for drilling the intermediate section of the well through the salt formation.

### **2.1.2 Air Drilling**

A method of hydrocarbon drilling not emphasized in Appendix DEL is air drilling. The definition of air drilling by the oil industry is a method of rotary drilling using compressed air as the circulation medium. The conventional method of removing cuttings from the wellbore is to use a flow of water or drilling mud. In some cases, compressed air removes the cuttings with equal or greater efficiency. The rate of penetration is usually increased considerably when air drilling is used; however, a fundamental problem in air drilling is the penetration of formations containing water, since the entry of water into the system reduces the ability of the air to remove cuttings.

Critics noted the air drilling scenario was not included by DOE in the CCA and raised several issues which were (1) air drilling technology is currently successfully used in the Delaware Basin, (2) air drilling is thought to be a viable drilling technology under the hydrological and geological conditions at the WIPP Site, and (3) air drilling could result in releases of radionuclides that are substantially greater than those considered by the DOE in the CCA. Much research on the issue of air drilling in the Delaware Basin has been done. It has been shown that although air drilling is a common method of drilling wells it is not practiced in the vicinity of the WIPP Site because (1) it is against R-111-P regulations to drill with anything but saturated brine through the salt formation in the KPLA, (2) it is not economical to drill with air when a driller has to use saturated brine for the intermediate section, and (3) water is encountered prior to and after drilling the salt formation causing the driller to convert to a conventional system of drilling.

Additional information was provided to Docket No. A-93-02, IV-G-7. In this information, the following was provided:

The well record search has continued and now includes information from the entire New Mexico portion of the Delaware Basin. Within the nine-townships surrounding the WIPP, the records showed no evidence of air drilling. One possible exception to this may be the Lincoln Federal #1. This well is said to have been air drilled due to a loss of circulation at a depth of 1290 feet, but this has not been verified. The records associated with the Lincoln Federal #1 do not contain any evidence of air drilling. Rather, this information is based on verbal communications with the operating and drilling companies involved with the well. Nonetheless, the Lincoln Federal #1 may have been drilled with air, although it was not a systematic use of the technology. Air drilling at this well was used from 2984' to 4725' merely as a mitigative attempt to continue drilling to the next casing transition depth. After this casing transition, mud drilling was used for the remainder of the hole.

The area of the expanded search contains 3,756 boreholes. Of these, 407 well files were unavailable for viewing (in process), therefore, 3,349 well files constitute the database. Among these wells, 11 instances of air drilling were found in which any portion of the borehole was drilled with air. Only 7 of these were drilled through the Salado Formation at the depth of the repository. This results in a frequency of 7/3349, or 0.0021. This value is conservative in that it includes the Lincoln Federal #1, and four other wells which

were proposed to be drilled with air, but no subsequent verification of actual drilling exists in the records.

During the summer of 1999, another search of these same records was conducted as a follow up to the original research. This search of the records was performed by an independent third party and was used as a quality assurance check of the original search. The database consisted of 3,810 boreholes with only 12 records unavailable for viewing. This search added five more wells with indications of some portion of the hole being drilled with air. None were air drilled through the Salado Formation or were located in the nine-township area. Of the five wells added to the count, one had the first 358 feet air drilled while the other four had the conductor pipe drilled with air which consists of the first 40 feet of the borehole and is not usually reported in the drilling process. The conductor casing is typically drilled, set in place, and cemented prior to setting up the rotary drilling rig that will eventually drill the well.

The records on the new wells spudded during the last year (August-99 thru August 15-00) are being checked as they become available at the New Mexico Oil Conservation Division (NMOCD) for instances of air drilling. The records submitted to the NMOCD offices can be as long as two years after the well has been drilled. The record review is an ongoing process that is conducted on a continuous basis. None of the records reviewed so far have indicated any instances of air drilling. As was presented in the testimony (public hearings conducted by the EPA on WIPP certification) and continues to show with ongoing research, air drilling is not a common practice in the vicinity of the WIPP Site.

## **2.2 Shallow Drilling Events**

One of the requirements of 40 CFR Part 194 is that the CCA must adequately and accurately characterize the frequency of shallow drilling within the Delaware Basin, as well as, support the assumptions and determinations, particularly those that limit consideration of shallow drilling events based on the presence of resources of similar type and quantity found in the controlled area. The DOE concluded in Appendix SCR that shallow drilling could be removed from PA consideration based on low consequence. As a result, the DOE did not include shallow drilling in its PA drilling rate calculations, and did not include any reduction in shallow drilling rates during the active and passive institutional control periods. In CARD (Compliance Application Review Document) 32, the EPA accepted the DOE's finding that shallow drilling would not be of consequence to repository performance and need not be included in the PA.

Although the EPA has agreed shallow drilling can be eliminated from PA and need not be tracked, the Delaware Basin Drilling Surveillance Program collects data on all wells drilled within the boundaries of the Delaware Basin. The program makes no distinctions between shallow and deep drilling events except when calculating the intrusion rate for deep drilling. Information on all wells drilled is vital for trending future activities.

## **2.3 Deep Drilling Events**

In the Delaware Basin, deep drilling events are usually associated with oil and gas drilling.

Commercial sources and visits to the New Mexico Oil Conservation Division offices are used to identify these events. As stated previously, the Delaware Basin Drilling Surveillance Program collects data on all drilled wells within the Delaware Basin, making no distinction between resources. Two separate databases are maintained on hydrocarbon wells, one for Texas and one for New Mexico. As information on wells is acquired, it is entered into the individual databases. The Texas database contains information only on the current status of the well, when it was drilled, its location, who the operator is, and the total depth of the well. The Texas portion of the Delaware Basin is used only for calculating the drilling rate. The database for the New Mexico portion of the Delaware Basin contains the same basic information as Texas plus all the information required for PA related drilling events.

The DBDSP continues to monitor all hydrocarbon drilling activity and any new potash, sulfur, water, or monitoring wells for deep drilling events. Information from the drilling of these wells is added to the databases maintained for these separate resources. During the last year, there were 137 new wells added to the different databases. All 137 wells were drilled for hydrocarbon extraction and all but three were deep drilling events. Fifty-four of these new wells were in the nine-township area immediately surrounding the WIPP Site.

## 2.4 Past Drilling Rates

The EPA provided a formula for calculating the current drilling rate or intrusion rate when 40 CFR Part 194 was promulgated. The formula is as follows: number of holes times 10,000 years divided by the area of the Delaware Basin (23, 102.1 Sq. Km.) divided by 100 years (1896-1996, the year the CCA was submitted). This formula is used to calculate both shallow and deep drilling rates for each resource. Since shallow drilling events are of no consequence, only deep drilling events is applied to the formula. The DBDSP uses all deep drilling events of any resource (potash, oil, gas, water, etc.) to calculate the drilling or intrusion rate. Including resources other than hydrocarbon will not affect the product of the formula due to the high number of deep drilling events recorded over the last 100 years in the Delaware Basin.

Figure 2 shows the past drilling rates since the submittal of the CCA in 1996. The large increase between 1996 and 1997 is the result of updating the databases with information from June 1995 through August 1997. Also, the 100-year window is considered a sliding window, that is, 100 years worth of data will

be used in the calculation. As each new year's data is added, an old year's data will be dropped. For example, the drilling rate was calculated in 1999 by using the data from 1899 through 1999.

<b>YEAR</b>	<b>NO. OF DEEP HOLES</b>	<b>DRILLING RATE</b>
1996	10,804 Holes Deeper Than 2,150 Ft.	46.8
1997	11,444 Holes Deeper Than 2,150 Ft.	49.5
1998	11,616 Holes Deeper Than 2,150 Ft.	50.3
1999	11,684 Holes Deeper Than 2,150 Ft.	50.6

**Figure 2**  
*Past Drilling Rates for the Delaware Basin*

## 2.5 Current Drilling Rate

Figure 3 shows the calculated intrusion or drilling rate for 2000. There were 17,647 resource holes within the Delaware Basin. Of those, 11,828 were deeper than 2,150 feet. Applying the formula results in the following: 11,828 boreholes x 10,000 years / 23,102.1 square kilometers / 100 years. This results in a drilling or intrusion rate of 51.2 boreholes per square kilometer over 10,000 years.

Although the intrusion rate has risen from 46.8 holes per square kilometer to 51.2 holes per square kilometer since 1996, the drilling rate is actually decreasing. The current drilling rate will continue to climb because of the way it is calculated. Since the first well drilled in the area occurred in 1911 it will be 2011 before one well is dropped and 2014 before the second well is dropped from the count. In the meantime, numerous wells will have been added thus driving up the count. Figure 4 depicts the true state of the drilling rate. Petroleum exploration activity is directly related to the price of crude oil and gas. This figure (4) shows the number of wells drilled per year for the last 21 years in the Delaware Basin and the average price per barrel of

*Intrusion Rate for the Delaware Basin through 08/18/2000*

Hydrocarbon Holes			
Well Type	Texas	N.M.	Totals
Dry Hole	2,433	992	3,425
Oil Well	3,954	1,702	5,656
Gas Well	824	569	1,389
Oil/Gas Well	16	5	21
Drilling or Waiting on Paperwork	162	31	193
Injection Well	152	62	214
Plugged Oil Well	487	267	754
Plugged Gas Well	155	122	277
Plugged Injection Well	0	20	20
Plugged Oil & Gas Well	0	0	0
Salt Water Disposal Well	3	96	99
Plugged Salt Water Disposal Well	0	9	9
Junked & Abandoned Hole	111	42	153
Service Well	107	4	111
	8,404	3,921	12,325

Other Resource Holes			
Well Type	Texas	N.M.	Totals
Sulfur Boreholes	597	0	597
Potash Boreholes	0	1,005	1,005
WIPP Boreholes	0	198	198
Stratigraphic Test Holes	1,210	2	1,212
Water Wells	1,706	590	2,296
Salt Wells	8	3	11
Core Holes	1	2	3
	3,522	1,800	5,322
Total Resource Holes in the Basin	11,926	5,721	17,647

Additional Information			
Well Type			Totals
Hydrocarbon Holes >2,150 Feet Deep			11,654
Hydrocarbon Holes<2,150 Feet Deep			671
Sulfur Boreholes >2,150 Feet Deep			89
Potash Boreholes > 2,150 Feet Deep			19
WIPP Boreholes > 2,150 Feet Deep			10
Stratigraphic Test Holes > 2,150 Feet Deep			56
Water Wells >2,150 Feet Deep			0
Total Resource Holes >2,150 Feet Deep			11,828
Total Resource Holes < 2,150 Feet Deep			5,819
Total Resource Holes Within the Delaware Basin			17,647

Area Information			
Location	Acres	Sq. Miles	Sq. Kilometers
Delaware Basin	5,708,682.50	8,919.76	23,102.1

### *Intrusion Rate*

The intrusion rate is calculated as follows: (number of holes) x 10,000 years / area / 100 years. The intrusion rate is 51.2 boreholes per square kilometer over 10,000 years.

**Figure 3**  
**Intrusion Rate for 2000**

domestic crude oil.

### 2.5.1 Nine-Township Area Drilling Activities

From Aug 1, 1999 through Aug 15, 2000, there were 54 new wells spudded in the nine-township area immediately surrounding the WIPP Site. Most of the drilling activity occurred south of the WIPP Site and began declining in March 2000. Fifteen of these 54 wells were located within the one-mile buffer area of the WIPP Site. Thirteen of the fifteen wells were located in the three sections immediately to the southwest of the WIPP Site, the other two in the southeast corner. One well, spudded in July 2000, located in T22S-R30E-Sec 36, is being directionally drilled under the WIPP Site into Sec 31. The leases on Sec 31 start at 6,000 feet below the surface and are held by several different oil companies. This is the second well to be drilled into this section of land, the other well was drilled in the 1970s and is currently a gas producing well. Figure 5 shows the status of all known hydrocarbon wells drilled within the one-mile buffer area of the WIPP Site.

YEAR	No. of New Wells in NM <sup>1</sup>	No. of New Wells in Texas <sup>1</sup>	Total No. of New Wells	Domestic Price of Crude Oil <sup>2</sup>
1980	99	232	331	\$21.59
1981	133	327	460	\$31.77
1982	149	295	444	\$28.52
1983	99	235	334	\$26.19
1984	101	268	369	\$25.88
1985	127	231	358	\$24.09
1986	81	223	304	\$12.51
1987	50	143	193	\$15.40
1988	42	179	221	\$12.58
1989	29	103	132	\$15.86
1990	79	166	245	\$20.03
1991	112	139	251	\$16.54
1992	125	75	200	\$15.99
1993	199	67	266	\$14.25
1994	192	58	250	\$13.19
1995	193	54	247	\$14.62
1996	149	75	224	\$18.46
1997	181	121	302	\$17.23
1998	118	54	172	\$10.87
1999	38	30	68	\$15.56
2000	95	42	137	\$24.77

1 Retrieved from Delaware Basin Drilling Surveillance Program Database

2 Price per barrel from the DOE-Energy Information Administration

3 Price for current year is average of the first six months-does not reflect the entire year

### 2.6 Pressurized Brine Encounters

*Figure 4  
Drilling Rates in Relationship to the Cost of Crude Oil Since 1980*

WIPP PA included the assumption that a borehole results in the establishment of a flow path between the repository and a pressurized brine pocket that might be located beneath the repository in the Castile Formation. Research was performed in an attempt to verify this assumption. Studies recorded a total of 27 encounters with pressurized brine in the Castile

Formation. Of these, 25 were hydrocarbon wells scattered over a wide area in the vicinity of the WIPP Site. Two wells, ERDA 6 and WIPP 12, were drilled in support of WIPP Site characterization.

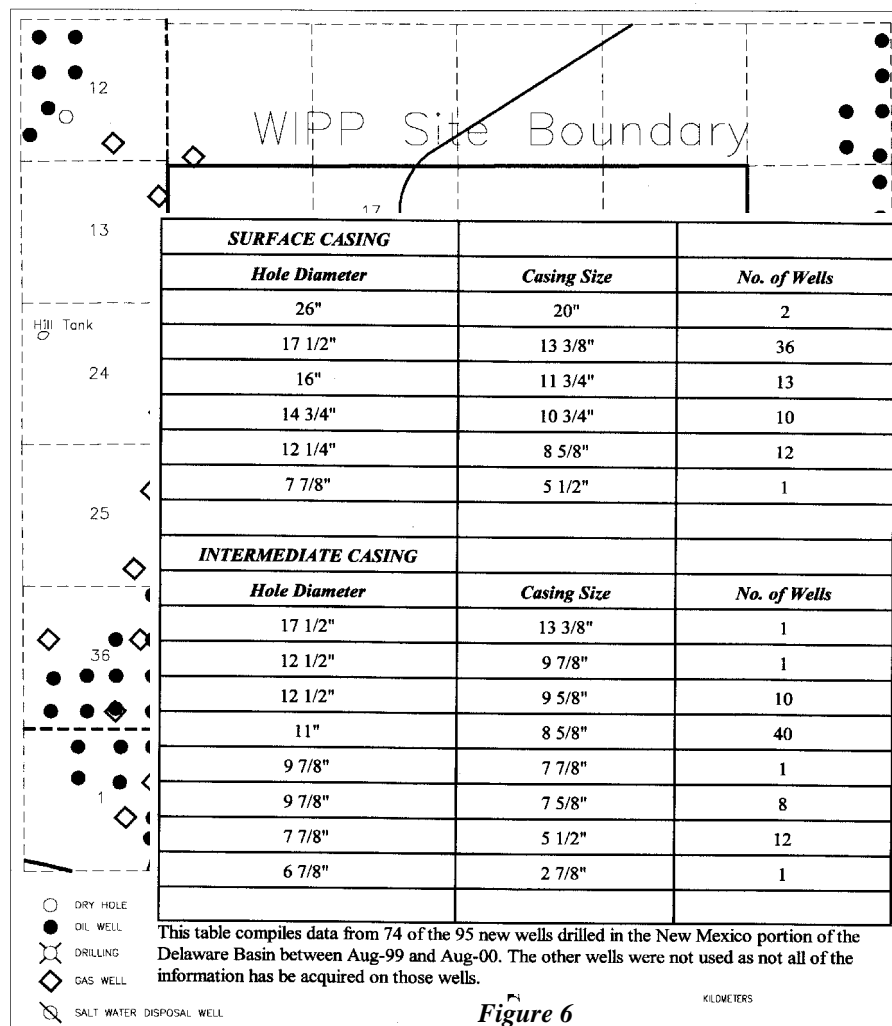
As indicated earlier, the independent search of the records performed in 1999 for instances of air drilling also looked for instances of pressurized brine. Although the search of the records noted a number of instances of encounters with sulfur water and brine water, none but the original 27 were found to have been pressurized brine encounters in the Castile Formation.

The DBDSP researches the well files of all new wells drilled in the New Mexico portion of the Delaware Basin each year looking for instances of encounters with pressurized brine. The program also sends out an annual

survey to operators of new wells asking if they encountered pressurized brine during the drilling process. As of this report, none of the records reviewed or any of the returned surveys indicated encounters with pressurized brine during the drilling process on new wells spudded in the New Mexico portion of the Delaware Basin between August 99 and August 2000.

## 2.7 Borehole Permeability Assessment - Plugging Practices

The hydrocarbon well plugging practices used for the borehole permeability assessment remain valid. The regulations in place during the submittal of the CCA have not changed. The assessment will not change unless the regulations change to allow a different method of plugging. Regulations require the well be plugged in a manner that will permanently confine all



oil, gas, and water in the separate strata in which they were originally found. These regulations require a notice of intent to plug from the operator. This notice includes a diagram of the well bore and the placement of the plugs. A 24-hour notice to the NMOCD or to the Bureau of Land Management (BLM) is required before plugging may commence. Most of the wells in the vicinity of the WIPP Site are in the KPLA. Under R-111-P regulations, the operator is required to run a solid cement plug through the entire salt section and water bearing zones in addition to installing a bridge plug above the perforations. Installing a solid cement plug through the salt provides additional assurance no fluids or gases escape through the casing into potash mining areas or fresh water formations.

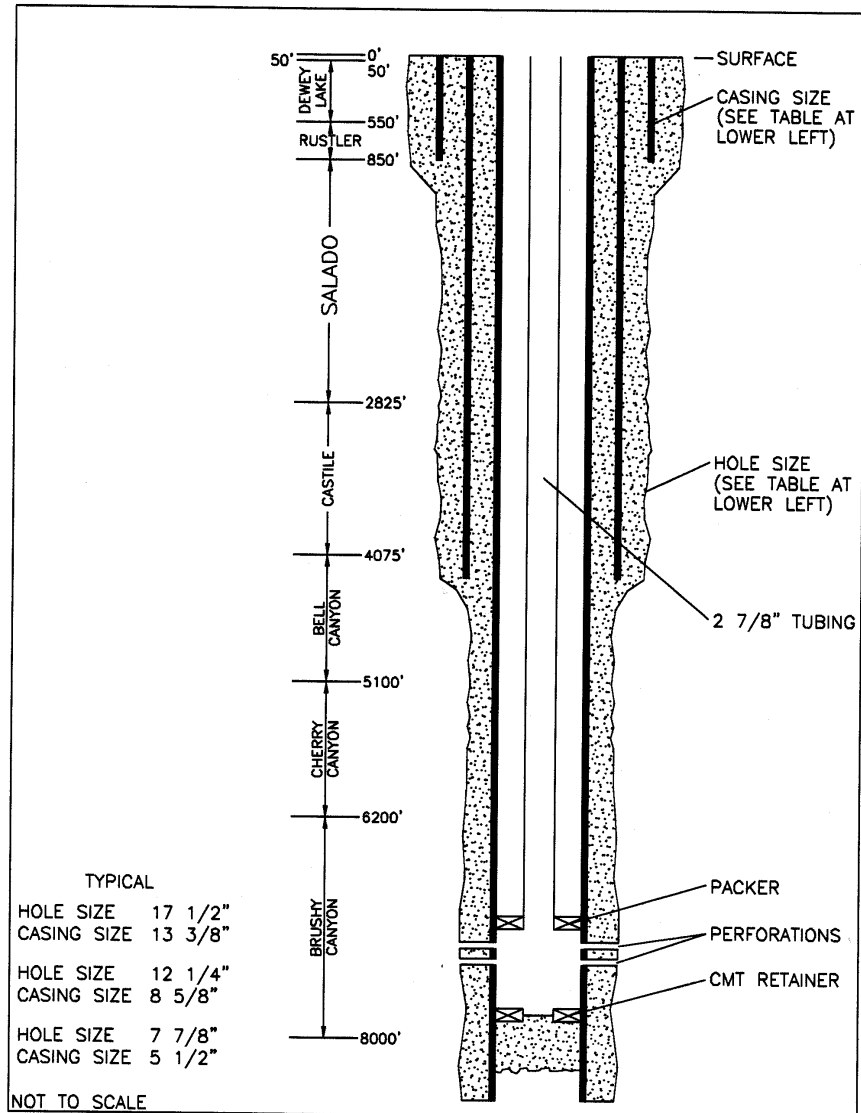
In the New Mexico portion of the Delaware Basin, the DBDSP retrieves a copy of the plugging report from the appropriate NMOCD office when a well has been plugged and abandoned. This information will be added to the records maintained on each well drilled within the Delaware Basin. By maintaining records in such a fashion, should the regulations change and the plugging methods differ from what is now occurring, a trend would be noticed and the borehole permeability assessment revisited.

## **2.8 Borehole Depths and Diameters**

The DBDSP tracks borehole depths for all wells drilled in the Delaware Basin (Figure 6). Borehole depths tracked by the DBDSP range from 19 feet to 25,201 feet. The 19 foot hole is a PZ monitoring well located on the WIPP Site, and the 25,201 foot hole is a gas well located in Texas. Borehole depths in the immediate vicinity of the WIPP Site typically range from 8,000 to 9,000 feet for oil wells and 13,000 to 16,000 feet for gas wells.

The diameter of each well bore is more difficult to ascertain. The DBDSP tracks the casing size and depth for each section of the hole. Drill bit size is not a reportable element although hole

sizes are sometimes reported on sundry notices maintained by the NMOCD. The casing size or hole size is used to determine the size of the bit used to drill that particular section of the well. Currently, the most common bit sizes being used are 17 1/2" for the surface section, 11" for the intermediate section, and 7 7/8" for the production section of the hole. In the early days of well drilling, the 12 1/4" bit was popular with rotary drill operators for the surface section of the hole. In those days, the wells were much shallower and did not require the larger sections of casing. Most holes drilled at that time were a two-string hole versus the three- and four-strings commonly used now. In the area of the WIPP Site, regulations require a three-string hole making the larger bit sizes more popular. Figure 7 shows the typical hole and casing sizes for a three-string well in the vicinity of the WIPP Site.



**Figure 7**  
*Typical Well Structure and General Stratigraphy Near the WIPP Site*

## 2.9 Secondary and Tertiary Recovery

Secondary recovery is defined by the oil industry as the first improved recovery method of any type applied to a reservoir to produce oil not recoverable by primary recovery methods. Water flooding is one such method. This method involves pumping water through the existing perforations in a well in which production has decreased sufficiently to merit stimulation. As the water is pumped into a formation, it stimulates production of oil or gas in other nearby wells. This is a proven method of recovering hydrocarbons that otherwise would be economically



unrecoverable. Water flooding has been a popular form of secondary recovery for over 40 years. Water flooding can be accomplished by one injection well or several injection wells in the immediate vicinity of other producing wells.

In the New Mexico portion of the Delaware Basin, there are three major water flood projects and several one and two injection well operations. One of the major waterflood projects in the area is the El Mar, located in T26S-R32E, on the Texas border. At one time, this project (currently operated by Quay Valley Inc.) had 31 permitted injection wells. Currently, there are only two wells actively injecting water. The remaining wells are either shut-in (not being used) or plugged and abandoned. The operation for this facility has not changed since last year. The Paduca water flood project, located in T25S-R32E, has 19 permitted injection wells with seven (down from eight this time last year) injecting water into the formation. The third major water flood project (Indian Draw) in this area, located in T22S-R28E, is currently not injecting into the ten permitted wells.

Tertiary recovery is defined by the oil industry as the use of any improved recovery method to remove additional oil after secondary recovery. One method of tertiary recovery practiced in the industry, where conditions permit, is the injection of carbon dioxide into the formation. This consists of injecting a prescribed amount of CO<sub>2</sub> into the reservoir followed by an injection of water and a subsequent injection of CO<sub>2</sub>. Although CO<sub>2</sub> can be injected continuously, it is not cost effective to implement this process. At the time of this report, there are no known CO<sub>2</sub> injection wells or tertiary recovery projects being operated in the vicinity of the WIPP Site, although several are being operated by oil companies in the Texas portion of the Delaware Basin.

### **2.9.1 Nine-Township Injection Wells**

Secondary recovery projects occurring in the nine-township area are on a small scale. There are three injection wells located in the nine-township area surrounding the WIPP Site. Phillips Petroleum operates two injection wells, James "A" #3 and #12, located in section 2-T22S-R30E, northwest of the site. Both are active and injecting near the maximum permitted pressure of 945 psi for #3 and 1,120 psi for #12. Both first injected water in the early 1990s. The other injection well, the Neff Federal #3, is operated by Pogo Producing Co. and is located in section 25-T22S-R31E. It went online in 1995 and has injected approximately 1,318,396 barrels of water at a maximum permitted pressure of 1,410 psi. All three wells are injecting into the Brushy Canyon Formation of the Delaware Mountain Group at approximately 7,200 feet.

### **2.9.2 Nine-Township Salt Water Disposal Wells**

The most common type of injection well is for the disposal of brine water coming from the producing formation in oil and gas wells. Most producing oil and gas wells produce water along with oil or gas. Salt Water Disposal (SWD) wells have become necessary as a result of the EPA's ruling that formation water may no longer be disposed of on the surface. This water is now disposed of by injecting it into approved salt water disposal wells.

There are currently 31 salt water disposal wells, an increase of one over the last year, operated by 14 companies (12 companies in 1999) located in the nine-township area surrounding the WIPP Site. Three operators, Devon Energy, Pogo Producing, and Yates Petroleum have four or more salt water disposal wells. Injection depths range from 3,800 to 8,200 feet. During the last year, all operated within their maximum permitted injection pressure. The volume of disposed brine water depends on the number of producing wells maintained by the operator in the immediate vicinity of the SWD well.

## **2.10 Pipeline Activity**

Pipeline activity is monitored in the nine-township area, specifically within a five mile radius of the WIPP Site. Only pipelines of permanent construction, such as buried rigid metal pipelines, are of concern to the DBDSP. Many oil, gas, and SWD wells are connected to tank batteries by gathering systems constructed of poly flowlines (flexible plastic pipe) that may or may not be buried. These flowlines are semi-permanent, that is, when they are no longer needed they are removed for use elsewhere. This type of pipeline activity is not monitored by the DBDSP. Only natural gas and water pipelines are located within the immediate vicinity of the WIPP Site. The natural gas pipelines are owned and operated by three companies, El Paso Natural Gas Company, Natural Gas Pipeline Company of America, and Transwestern Pipeline Company.

One type of pipeline activity of major concern to the DBDSP is CO<sub>2</sub> pipelines. A form of tertiary recovery of oil discussed previously involves the use of CO<sub>2</sub>. An indicator of this form of recovery would be the construction of a CO<sub>2</sub> pipeline in the area. Currently, there are no CO<sub>2</sub> pipelines within the New Mexico portion of the Delaware Basin. The nearest CO<sub>2</sub> pipeline is located south of the WIPP Site in the Texas portion of the Delaware Basin.

## **2.11 Mining**

Resources found in the Delaware Basin that can be mined are potash, sulfur, caliche, gypsum, and halite. Potash and sulfur are present in quantities large enough to be mined profitably. Of the other resources available, only caliche is economically extracted from the earth in conventional mining methods. Caliche is mainly used in the construction of pads for oil and gas well drilling rigs.

### **2.11.1 Potash Mining**

Potash mining in the immediate vicinity of the WIPP Site continues as reported in Appendix DEL of the CCA. There have been several changes to the companies that operate in the area, most notably, only two potash mining companies remain in operation. No plans have been promulgated by either company to sink new shafts or encroach upon the potash reserves identified in Appendix DEL. Currently, these reserves are not economically recoverable, and it does not appear they will be in the foreseeable future.

Mississippi Potash, a subsidiary of Mississippi Chemical Corporation, purchased in August of

1996 all the assets of New Mexico Potash Corporation and Eddy Potash, Inc. These plants were renamed Mississippi East and Mississippi North, respectively. December 1997 saw the Mississippi North plant, the old Eddy Potash mine, shut down because it could no longer be economically operated. Mississippi Potash continues to produce potash fertilizer from both the east and west plant mines and refineries.

The other potash producer in the area, IMC Kalium Potash, is a wholly owned subsidiary of IMC Global. Western Ag-Minerals was purchased by IMC Global in September 1997. This acquisition doubled the potash reserves for IMC Kalium and increased their other reserves by 30 percent. IMC Global merged with Freeport-McMoRan, a major world potash producer, in December 1997 with IMC Global as the surviving entity in the transaction.

### **2.11.2 Sulfur Extraction**

The only viable sulfur mining activity within the Delaware Basin was being conducted by Freeport-McMoRan Sulphur Inc., a wholly owned subsidiary of McMoRan Exploration Company. The mine is located in Culberson County, Texas. The mine was recovering sulfur utilizing the Frasch process which consists of a hole drilled into the sulfur bearing formation and then cased. Then, three concentric pipes are placed with the protective casing to facilitate pumping superheated water down the hole melting the sulfur and recovering the molten sulfur to the surface. In June 1998, it was announced the mine would cease production in September 1998 because it was no longer economically feasible to operate. Because of problems at other facilities, the Culberson mine was operated until it permanently ceased production on June 30, 1999. Abandonment and salvage operations continued until the early summer of 2000.

Recently, a number of sulfur exploration coreholes were found in the BLM records. These coreholes were drilled in the late 1960s through the early 1980s in the Yeso Hills near Washington Ranch in the far southwest corner of the New Mexico portion of the Delaware Basin. These coreholes have yet to be added to the databases. All were shallow (less than 2,150 feet) drilling events that were conducted for various small-time operators. There have been no reports on whether any of the holes encountered sufficient quantities of mineable sulfur. Estimating from the amount of activity in the area since the holes were drilled, it can be assumed there were not sufficient quantities of mineable sulfur.

### **2.12 New Drilling Technology**

New drilling methods are being researched by the DBDSP for impacts to the drilling methods currently used in the area. So far, no new methods of drilling have been identified or implemented in the vicinity of the WIPP Site.

## **3.0 Survey of Well Operators for Drilling Information**

Periodically a survey of local well operators is performed to acquire information on drilling practices normally not available on the sundry notices supplied to the local state and federal offices by the operator or through commercial sources maintained by the DBDSP. There are no regulatory requirements to provide the information. This survey requests information on other items of interest to the WIPP such as H<sub>2</sub>S encounters, Castile Brine encounters, or if any section of the well was drilled with air. DBDSP personnel review the records on all new wells drilled to look for the above data. The survey provides an additional source for acquiring information on drilling activities in the New Mexico portion of the Delaware Basin.

The first such survey of area operators was performed during July 1999 to acquire information on drilling practices not available from the state and federal offices or commercial sources. Drilling information was requested on the 16 wells drilled in the nine-township area of the New Mexico portion of the Delaware Basin. In July 2000, 45 surveys were sent out to nine different operators on wells their companies drilled in the nine-township area during the last year. As of this report date twelve surveys had been returned. A summary of the data collected from the survey wells in the nine-township area is provided in Figure 8.

<i>Drilling Information - Annual Survey</i>			
<i>Parameter</i>	<i>Surface</i>	<i>Intermediate</i>	<i>Production</i>
Drill Bit Diameter	17 1/2"	11"	7 7/8"
Drill Collar Diameter	8" & 6"	8" & 6"	6"
Drill Collar Number or Length (usually 31 ft)	25	25	26
Surface Casing Diameter	13 3/8"		
Drill Pipe Diameter	4 1/2"	4 1/2"	4 1/2"
Drill String Angular Velocity		115 RPM	
Penetration Rate thru the Salado Formation		28'/Hr.	
Drilling Mud Density		8.6#	
Drilling Mud Viscosity		33	
Drilling Mud Yield Stress Point		No Report	
Air Drilled (list any portion)	No	No	No
H <sub>2</sub> S Encounters (depth & PPM)	No	No	No
Any Pressurized Brine Encounter (flow rate, etc.)	No	No	No
Castile Formation Brine Encounter	No	No	No
Castile Brine Reservoir Pressure	No	No	No
Castile Brine Reservoir Volume	No	No	No
Typical Time till shut-in (Castile Brine)	No	No	No
Longest Time till shut-in (Castile Brine)	No	No	No

Information on this table is averaged from the replies received during the Annual Survey. The above information is on wells drilled during the last year in the Nine Township area immediately surrounding the WIPP Site.

**Figure 8**  
**Summary of Nine-Township Survey Information**

#### **4.0 Summary - 2000 Delaware Basin Drilling Surveillance Program**

Very little has changed since 1996 when the CCA was submitted to the EPA. Drilling practices continue to be the same as do the methods for mineral extraction. The drilling rate is in a decline from previous years although the price of oil is at its highest price in twenty years. The potash mining activity declined from five companies to two companies actively pursuing mining although during this time only one mine actually ceased production.

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