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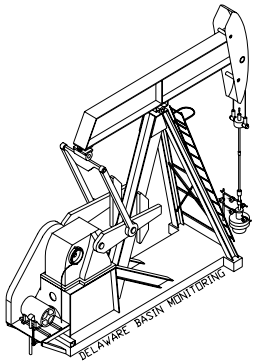
Delaware Basin Monitoring Annual Report

September 1999

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 1998 through September 1999

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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.

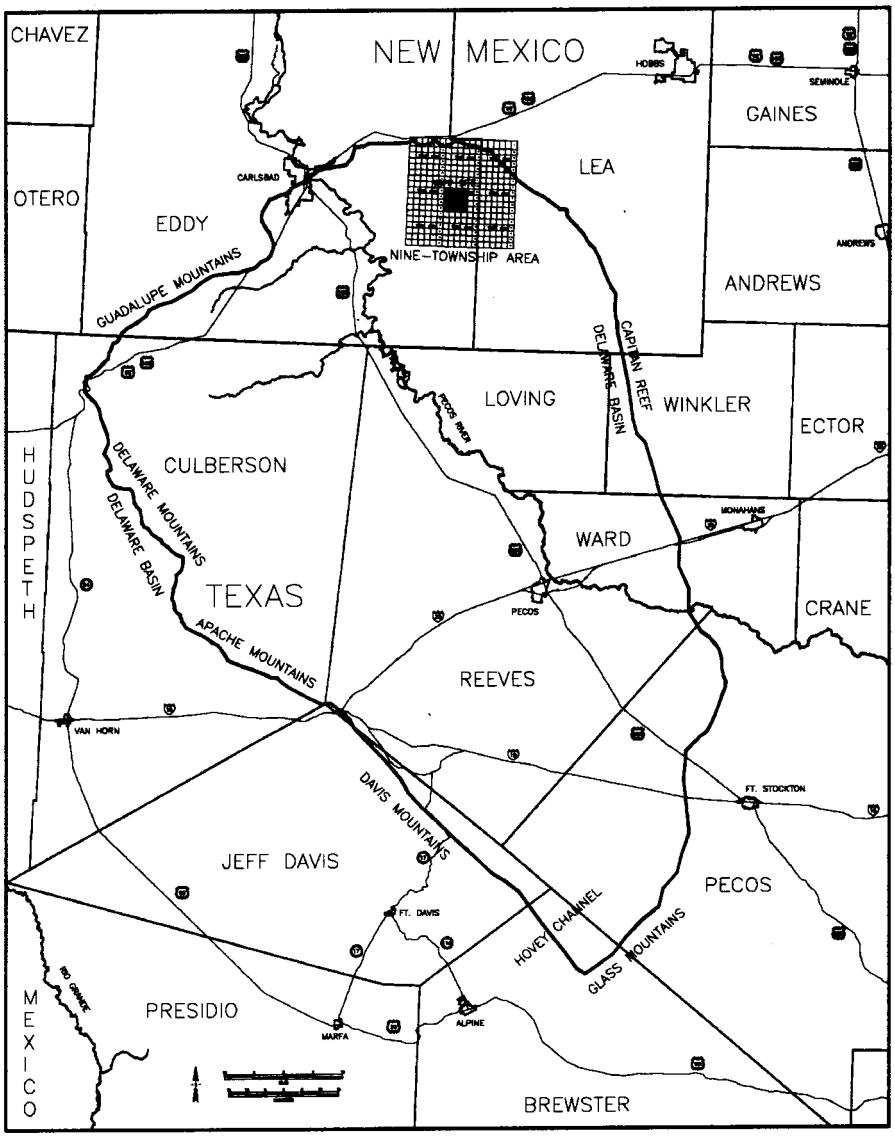

Figure 1
WIPP Site, Delaware Basin, and Surrounding Area

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

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 1999 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 38 wells spudded, not necessarily completed, from July 1, 1998 through June 31, 1999. The rotary drilling rig was used in the drilling of all 38 wells. All were conventionally drilled utilizing mud as a medium for circulation. Sixteen of these wells were in the nine-township area and completed as oil wells. The depths of the wells range from 8,129 feet to 9,000 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 38 new wells drilled in the New Mexico portion of the Delaware Basin, three were directionally drilled with one completed as a horizontal well. All three wells are located outside of the nine-township area.

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 bigger 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 8.4 to 10 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 10 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 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. As was presented in the testimony 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 all 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 was therefore not 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 (Figure 2). Commercial sources and visits to the New Mexico Oil Conservation Division (NMOCD) 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 68 new wells added to the different databases. All 68 wells were drilled for hydrocarbon extraction and all were deep drilling events. Sixteen of these new wells were in the nine-township area immediately surrounding the WIPP Site.

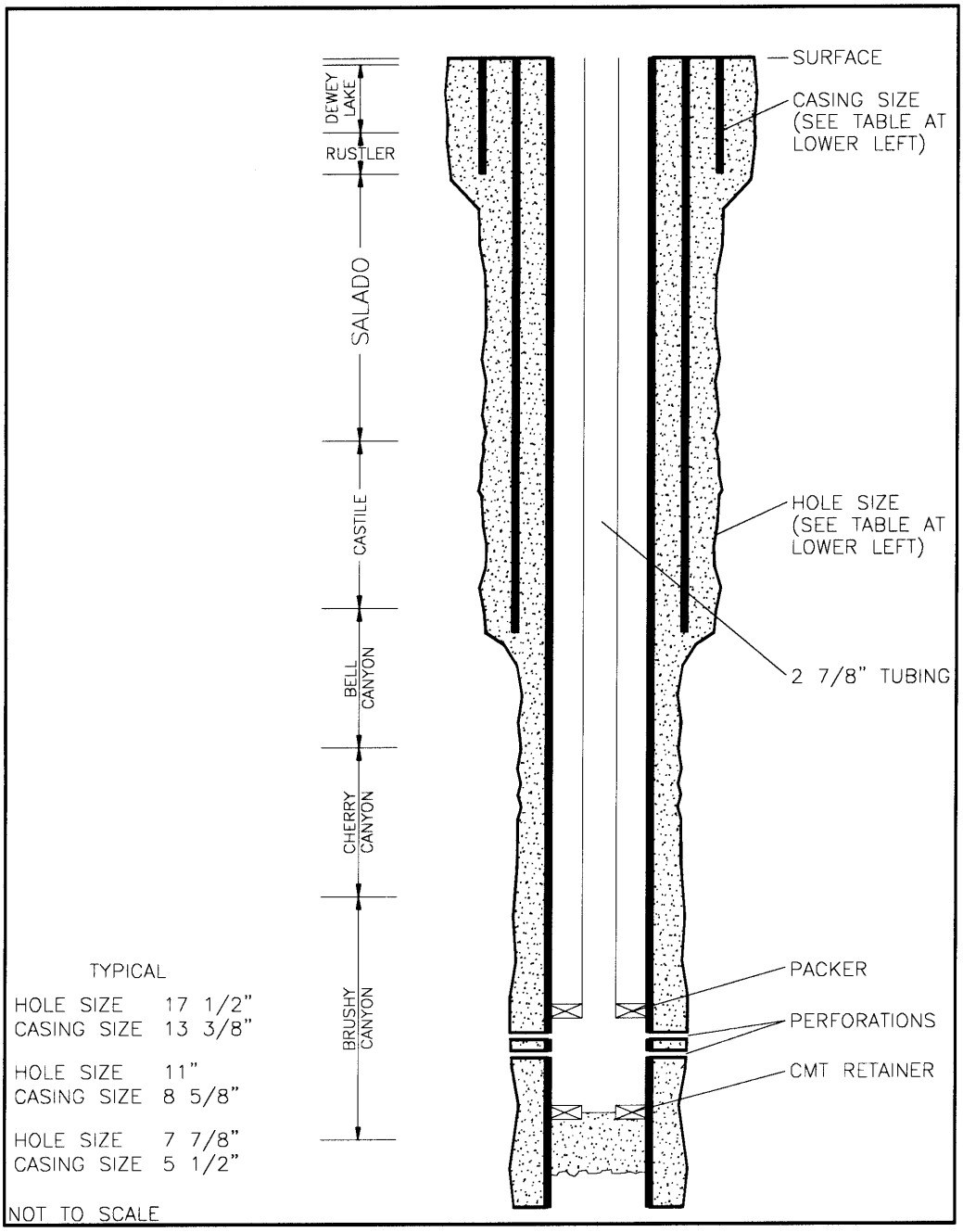

Figure 2
Typical Well Structure & General Stratigraphy Near the WIPP Site

2.4 Current Drilling Rate

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 divided by 100 years (1896-1996, the year the CCA was submitted). This formula was used to calculate both shallow and deep drilling rates for each resource. Since shallow drilling events are of no consequence, only deep drilling events will be 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.

Intrusion Rate for the Delaware Basin through 08/01/1998

Hydrocarbon Holes

Well Type	**Texas**	**N.M.**	**Totals**
Dry Hole	2,425	1,006	3,431
Oil Well	3,707	1,775	5,482
Gas Well	782	584	1,366
Oil/Gas Well	126	4	130
Drilling or Waiting on Paperwork	15	46	61
Injection Well	302	9	311
Plugged Oil Well	518	157	675
Plugged Gas Well	164	76	240
Plugged Injection Well	0	8	8
Plugged Oil & Gas Well	56	0	56
Salt Water Disposal Well	1	37	38
Plugged Salt Water Disposal Well	0	4	4
Junked & Abandoned Hole	111	41	152
Service Well	105	17	122
	8,312	3,764	12,076

Other Resource Holes

Well Type	**Texas**	**N.M.**	**Totals**
Sulfur Boreholes	584	0	584
Potash Boreholes	0	1,005	1,005
WIPP Boreholes	0	198	198
Stratigraphic Test Holes	1,222	2	1,224
Water Wells	1,706	590	2,296
Salt Wells	8	4	12
Core Holes	45	2	47
	3,565	1,801	5,366
Total Resource Holes in the Basin	11,877	5,565	17,442

Additional Information

Well Type	**Totals**
Hydrocarbon Holes >2,150 Feet Deep	11,442
Hydrocarbon Holes<2,150 Feet Deep	634
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	11,616
Total Resource Holes < 2,150 Feet Deep	5,826
Total Resource Holes Within the Delaware Basin	17,442

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 50.3 boreholes per square kilometer over 10,000 years.

Figure 3
Intrusion Rate for 1998

Figure 3 shows the calculated intrusion or drilling rate for 1998. There were 17,442 resource holes within the Delaware Basin. Of those, 11,616 were deeper than 2,150 feet. Applying the formula results in the following: 11,616 x 10,000 years / 23,102.1 / 100 years. This resulted in a

drilling or intrusion rate of 50.3 boreholes per square kilometer over 10,000 years. The result in 1996 was 46.8 boreholes per square kilometer over 10,000 years. This increase was the result of updating the databases with information from June of 1995 through August of 1998, three years worth of data.

From August of 1998 through August of 1999 (Figure 4), there were 68 new wells added to the total count of resource holes for the Delaware Basin. All 68 were classified as deep drilling events. The intrusion rate was calculated as follows: 11,684 x 10,000 / 23,102.1 / 100 and resulted in 50.6 boreholes per square kilometer over 10,000 years.

Intrusion Rate for the Delaware Basin through 08/01/1999

Hydrocarbon Holes

Well Type	**Texas**	**N.M.**	**Totals**
Dry Hole	2,436	997	3,433
Oil Well	3,992	1,711	5,703
Gas Well	820	558	1,378
Oil/Gas Well	12	5	17
Drilling or Waiting on Paperwork	184	16	200
Injection Well	108	31	139
Plugged Oil Well	480	253	733
Plugged Gas Well	148	119	267
Plugged Injection Well	0	20	20
Plugged Oil & Gas Well	0	0	0
Salt Water Disposal Well	2	53	55
Plugged Salt Water Disposal Well	0	6	6
Junked & Abandoned Hole	112	41	153
Service Well	106	10	116
	8,400	3,820	12,220

Other Resource Holes

Well Type	**Texas**	**N.M.**	**Totals**
Sulfur Boreholes	563	0	563
Potash Boreholes	0	1,005	1,005
WIPP Boreholes	0	198	198
Stratigraphic Test Holes	1,211	2	1,213
Water Wells	1,706	590	2,296
Salt Wells	8	4	12
Core Holes	1	2	3
	3,489	1,801	5,290
Total Resource Holes in the Basin	11,889	5,621	17,510

Additional Information

Well Type	**Totals**
Hydrocarbon Holes >2,150 Feet Deep	11,510
Hydrocarbon Holes<2,150 Feet Deep	710
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	11,684
Total Resource Holes < 2,150 Feet Deep	5,826
Total Resource Holes Within the Delaware Basin	17,510

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 50.6 boreholes per square kilometer over 10,000 years.

Figure 4
Intrusion Rate for 1999

Although the intrusion rate has risen from 46.8 holes per square kilometer to 50.6 holes per square kilometer since 1996 the drilling rate is actually decreasing. Petroleum exploration activity is directly related to the price of crude oil and gas. Figure 5 shows the number of wells drilled per year for the last 20 years in the Delaware Basin and the average price per barrel of domestic crude oil.

YEAR	No. of New Wells in NM[1]	No. of New Wells in Texas[1]	Total No. of New Wells	Domestic Price of Crude Oil[2]
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	$10.88
1999	38	30	68	$10.92

1 Retrieved from Delaware Basin Drilling Surveillance Program Database
2 Price per barrel from the DOE-Energy Information Administration

Figure 5
Drilling Rates in the Delaware Basin for the Last 20 Years

2.5 Pressurized Brine Encounters

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 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.

2.6 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. The 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 intent shows a diagram of the well bore and the placement of the plugs. A 24-hour notice 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 will retrieve 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 may be revisited.

2.7 Borehole Depths and Diameters

The DBDSP tracks borehole depths for all wells drilled in the Delaware Basin. 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 (Figure 6). 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 ½” 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.

Number of Wells	3	19	5	10	1	38
Hole Diameter	26"	17 1/2"	16"	14 3/4"	12 1/4"	
Surface Casing	20"	13 3/8"	11 3/4"	10 3/4"	8 5/8"	
Total Hole Depth	13,600 13,450 13,380	13,910 13,800 13,767 13,750 13,678 13,309 12,440 10,657 10,000 9,000 8,959 8,450 8,450 8,450 8,450 8,450 8,450 8,124 8,050	13,915 13,886 13,870 13,868 13,000	13,772 8,950 8,700 8,450 8,403 8,150 8,150 8,150 6,885 5,400	5,220	
Number of Wells	9	19	9	1		38
Hole Diameter	12 1/2"	11"	9 7/8"	7 7/8"		
Intermediate Casing	9 5/8"	8 5/8"	7 5/8"	5 1/2"		

Figure 6
Casing & Hole Sizes for New Wells Drilled Last Year in the New Mexico Portion of the Delaware Basin

2.8 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. Waterflooding 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 unretrievable. Waterflooding has been a popular form of secondary recovery for over 40 years. Waterflooding 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 waterflood 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 Paduca waterflood project, located in T25S-R32E, has 19 permitted injection wells with eight injecting water into the formation. The third major waterflood project in this area, located inT22S-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_2 into the reservoir followed by an injection of water and a subsequent injection of CO_2. Although CO_2 can be injected continuously, it is not cost effective to implement this process. At the time of this report, there are no known CO_2 injection wells or tertiary recovery projects being operated in the vicinity of the WIPP Site.

2.8.1 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 approximately 43,000 barrels per month at a 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 683,000 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.

2.8.2 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 30 salt water disposal wells operated by 12 companies 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. Of the thirty SWD wells, 26 are currently disposing of produced brine water. Four wells are shut-in and not being used at this time. Injection depths range from 3,800 to 8,200 feet. Injection pressures range from 20 psi to 900 psi. During the last year, all operated within their maximum permitted injection pressure. Volumes of disposed brine water ranged from 496 barrels per month to 83,000 barrels per month. 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.

2.9 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_2 pipelines. A form of tertiary recovery of oil discussed previously involves the use of CO_2. An indicator of this form of recovery would be the construction of a CO_2 pipeline in the area. Currently, there are no CO_2 pipelines within the New Mexico portion of the Delaware Basin. The nearest CO_2 pipeline is located south of the WIPP Site in the Texas portion of the Delaware Basin.

2.10 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.

2.10.1 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 of 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 of 1997. The close proximity of the two mining operations allowed for a more efficient operation. This acquisition doubled the muriate of 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 of 1997 with IMC Global as the surviving entity in the transaction.

2.10.2 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 of 1998, it was announced the mine would cease production in September of 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 are underway and are anticipated to be completed by the end of 1999.

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.

2.11 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 such as H_2S 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 new wells drilled in the nine-township area of the New Mexico portion of the Delaware Basin during the last year. A summary of the data collected from the survey wells in the nine-township area is provided in Figure 7.

DRILLING INFORMATION			
Parameter	***Surface***	***Intermediate***	***Production***
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)	9	23	26
Surface Casing Diameter	13 3/8"		
Drill Pipe Diameter	4 1/2"	4 1/2"	4 1/2"
Drill String Angular Velocity		110 RPM	
Penetration Rate thru the Salado Formation		No Report	
Drilling Mud Density		10#	
Drilling Mud Viscosity		29	
Drilling Mud Yield Stress Point		No Report	
Air Drilled (list any portion)	No	No	No
H_2S 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

Figure 7
Summary of Nine-Township Survey Information

4.0 Summary - 1999 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 due to the low prices for oil which resulted in less exploration. 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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