CAMPBELL, CARR, BERGE
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November 26, 1991

HAND-DELIVERED

Case 10428

William J. LeMay, Director
Oil Conservation Division
New Mexico Department of Energy,
Minerals and Natural Resources
State Land Office Building
Santa Fe, New Mexico 87503

Re: In the Matter of the Application of Enron Oil & Gas Company for Designation of a Tight Formation, Lea County, New Mexico

Dear Mr. LeMay:

Enclosed in triplicate is the Application of Enron Oil & Gas Company in the above-referenced case. Enron Oil & Gas Company respectfully requests that this matter be placed on the docket for the December 19, 1991 Examiner hearings.

Very truly yours,

WILLIAM F. CARR

WFC:mlh
Enclosures
cc w/enclosures: Mr. Patrick Tower
Enron Oil & Gas Company
Post Office Box 2267
Midland, Texas 79702

BEFORE THE

OIL CONSERVATION DIVISION

NEW MEXICO DEPARTMENT OF ENERGY, MINERALS AND NATURAL RESOURCES

IN THE MATTER OF THE APPLICATION
OF ENRON OIL & GAS COMPANY FOR
DESIGNATION OF A TIGHT FORMATION,
LEA COUNTY, NEW MEXICO. CASE NO. 10428

APPLICATION

COMES NOW ENRON OIL & GAS COMPANY, through its undersigned attorneys, and as provided in the Oil Conservation Division's Special Rules and Procedures for Tight Formation Designation under Section 107 of the Natural Gas Policy Act of 1978 promulgated by Oil Conservation Division Order No. R-6388 on June 30, 1980, hereby makes application for an order designating certain portions of the Morrow formation, Red Hills-Morrow Gas Pool, Pitchfork Ranch-Morrow Gas Pool and Vaca Draw-Morrow Gas Pool, as a tight formation under Section 107 of the Natural Gas Policy Act of 1978 and in support of its application would show the Division:

1. Applicant is the owner and operator of certain interests in the Morrow formation, in certain pools, underlying the following described lands situated in Lea County, New Mexico:

Township 25 South, Range 33 East, N.M.P.M.

Sections 1 through 14: All
Section 15: S/2
Sections 16 through 20: All
Section 21: N/2
Sections 22 through 36: All

Township 25 South, Range 34 East, N.M.P.M.

Sections 6 and 7: All
Section 8: S/2
Sections 17 through 20: All
Sections 29 through 32: All

containing a total of 29,120 acres, more or less of federal, state and fee lands.

2. The Morrow formation is expected to have an estimated average in situ gas permeability throughout the pay section of less than 0.1 millidarcy.

3. The average depth of the top of the Morrow formation is 14,700 feet, and the stabilized production rate, against atmospheric pressure, of wells completed for production in said formations without stimulation, is not expected to exceed 2,557 mcf of gas per day.

4. No well drilled into the Morrow formation in the above-described area is expected to produce, without stimulation, more than five barrels of crude oil per day.

5. Approval of these tight formations is necessary to provide reasonable incentive for production of this natural gas from the formation due to the extraordinary risks or costs associated with such production.

WHEREFORE, Enron Oil & Gas Company requests that this application be set for hearing before a duly appointed Examiner of the Oil Conservation Division on December 19, 1991, and that, after notice and hearing as required by law, the Division enter its order recommending to the Federal Energy Regulatory Commission that pursuant to 18 CFR, Section 271.701 - 705 that the Morrow formation underlying the above-described land be designated as a tight formation, and making such other and further provisions as may be proper in the premises.

Respectfully submitted,

CAMPBELL, CARR, BERGE & SHERIDAN, P.A.

By: _____

WILLIAM F. CARR
Post Office Box 2208
Santa Fe, New Mexico 87504
Telephone: (505) 988-4421

ATTORNEYS FOR ENRON OIL
& GAS COMPANY

CAMPBELL, CARR, BERGE
& SHERIDAN, P.A.
LAWYERS

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December 3, 1991

Case 10428

HAND-DELIVERED

William J. LeMay, Director
Oil Conservation Division
New Mexico Department of Energy,
Minerals and Natural Resources
State Land Office Building
Santa Fe, New Mexico 87503

Re: In the Matter of the Amended Application of Enron Oil & Gas Company for Designation of a Tight Formation, Lea County, New Mexico

Dear Mr. LeMay:

Enclosed in triplicate is the Amended Application of Enron Oil & Gas Company in the above-referenced case. Enron Oil & Gas Company respectfully requests that this matter be placed on the docket for the December 19, 1991 Examiner hearings.

Very truly yours,

WILLIAM F. CARR

WFC:mlh
Enclosures
cc w/enclosures: Mr. Patrick Tower
Enron Oil & Gas Company
Post Office Box 2267
Midland, Texas 79702

BEFORE THE

OIL CONSERVATION DIVISION

NEW MEXICO DEPARTMENT OF ENERGY, MINERALS AND NATURAL RESOURCES

RECEIVED

1991

OIL CONSERVATION DIVISION

IN THE MATTER OF THE APPLICATION OF ENRON OIL & GAS COMPANY FOR DESIGNATION OF A TIGHT FORMATION, LEA COUNTY, NEW MEXICO.

CASE NO. 10425

AMENDED
APPLICATION

COMES NOW ENRON OIL & GAS COMPANY, through its undersigned attorneys, and as provided in the Oil Conservation Division's Special Rules and Procedures for Tight Formation Designation under Section 107 of the Natural Gas Policy Act of 1978 promulgated by Oil Conservation Division Order No. R-6388 on June 30, 1980, hereby makes application for an order designating certain portions of the Morrow formation, Red Hills-Morrow Gas Pool, Pitchfork Ranch-Morrow Gas Pool and Vaca Draw-Morrow Gas Pool, as a tight formation under Section 107 of the Natural Gas Policy Act of 1978 and in support of its application would show the Division:

1. Applicant is the owner and operator of certain interests in the Morrow formation, in certain pools, underlying the following described lands situated in Lea County, New Mexico:

Township 25 South, Range 33 East, N.M.P.M.

Sections 1 through 14: All
Section 15: W/2
Sections 16 through 20: All
Section 21: N/2
Sections 22 through 36: All

Township 25 South, Range 34 East, N.M.P.M.

Sections 6 and 7: All
Section 8: S/2
Sections 17 through 20: All
Sections 29 through 32: All

containing a total of 29,120 acres, more or less of federal, state and fee lands.

2. The Morrow formation is expected to have an estimated average in situ gas permeability throughout the pay section of less than 0.1 millidarcy.

3. The average depth of the top of the Morrow formation is 14,700 feet, and the stabilized production rate, against atmospheric pressure, of wells completed for production in said formations without stimulation, is not expected to exceed 2,557 mcf of gas per day.

4. No well drilled into the Morrow formation in the above-described area is expected to produce, without stimulation, more than five barrels of crude oil per day.

5. Approval of these tight formations is necessary to provide reasonable incentive for production of this natural gas from the formation due to the extraordinary risks or costs associated with such production.

WHEREFORE, Enron Oil & Gas Company requests that this application be set for hearing before a duly appointed Examiner of the Oil Conservation Division on December 19, 1991, and that, after notice and hearing as required by law, the Division enter its order recommending to the Federal Energy Regulatory Commission that pursuant to 18 CFR, Section 271.701 - 705 that the Morrow formation underlying the above-described land be designated as a tight formation, and making such other and further provisions as may be proper in the premises.

Respectfully submitted,

CAMPBELL, CARR, BERGE & SHERIDAN, P.A.

By: _____

WILLIAM F. CARR
Post Office Box 2208
Santa Fe, New Mexico 87504
Telephone: (505) 988-4421

ATTORNEYS FOR ENRON OIL
& GAS COMPANY

Case 10428

APPLICATION OF ENRON OIL & GAS COMPANY FOR DESIGNATION OF THE MORROW AS A TIGHT FORMATION IN THE VACA DRAW / PITCHFORK RANCH AREA IN LEA COUNTY, NEW MEXICO

DISCUSSION OF APPLICATION PURPOSE, PERMEABILITY CALCULATIONS AND VALIDITY; STABILIZED FLOW RATES AND EXHIBITS

Enron Oil & Gas Company requests that the subject lands be designated as a Tight Gas Formation for the Morrow sands that occur at 14,700'. The application area borders on lands currently designated TGF. The wells within the application area have a calculated average permeability of 0.07587 MD and stabilized flow rates of 1,271 MCFPD. The primary method of permeability calculation was from Holditch and Lee. This method used actual test flow rates and pressures and derives a permeability by iteration. Several bottom hole pressure build up analyses were used and the data agreed very closely to the Holditch & Lee method. Holditch and Lee was used to calculate all stabilized flow rates.

The tight formation characteristics are supported by the geologic description of the formation in the application area. These sands are found off the main Pitchfork Ranch Field and have become thinner and limy with an increase in calcareous and siliceous cement compared to the Pitchfork producers. Permeability drops from 6.1 MD to 0.022 MD in one mile on the southwestern edge of the field.

Two wells in the application area were excluded from the average permeability calculations due to their indicated high permeability but very limited reservoir extent. Enron recommends that the TGF area exclude 320 acres around the two wells as approved windows.

In the alternative, if the authority body wishes to keep the anomalous wells in the calculations, Enron would request approval be granted due to the extraordinary costs and risks associated with the drilling, completion, and enhanced production techniques and that the tax credit associated with the TGF designation will provide the necessary incentive for the development of the gas reserves within the application area.

GEOGRAPHICAL AND GEOLOGICAL DISCUSSION OF THE AREA OF APPLICATION

The area of application for designation as a Tight Gas Formation (TGF) in the Morrow is located in southwestern Lea County, New Mexico, approximately 45 miles southwest of the city of Hobbs and 6 miles north of the New Mexico/Texas state line. Figure 1, a regional map whose scale is one inch equals approximately 12 miles, illustrates the geographical location of the area. Superimposed on this map are regionally recognized geological provinces in this portion of southeastern New Mexico identified as the Northwest Shelf, the Delaware Basin and the Central Basin Platform. The area of application is found in the Delaware Basin adjacent to the Pitchfork Ranch (Atoka/Morrow) Field which was discovered by Enron Oil & Gas Company (HNG) in 1982.

The Morrow formation is lower Pennsylvanian in age and lies above the Mississippian shale and below the Pennsylvania Atoka formation. This relationship is illustrated in Figure 2, a compensated density-neutron log with gamma ray from the BTA Oil Producers No. 1 Rojo 7811 JV-P well (Section 27-15S-33E), which is presented as a type log for the Morrow. Figure 2 also illustrates the three correlative units (lower, middle and upper) making up the Morrow formation. The BTA well log was chosen for a type log because it is one of only three wells in the area of application that penetrated the entire Morrow section. The well log is also the number six well on stratigraphic cross-section B-B'. The top and base of the Morrow on the log are at 14,728' and 16,600' respectively, making the Morrow formation 1,872' thick at the BTA well location in Section 27-25S-33E. The measured vertical depth to the top of Morrow increases from the northeast to southwest and east to west across the area of application with the average depth placed at 14,700'.

Although the Superior Oil Company No. 1 Ochoa Federal did not penetrate the total Morrow section its well log is presented as the second type log because it is common to both stratigraphic cross-sections A-A' (well log number 3) and B-B' (well log number 4) as it is located near the center of the area of application in Section 15-25S-33E. Figure 3, a compensated density-neutron log with gamma ray from Superior's well

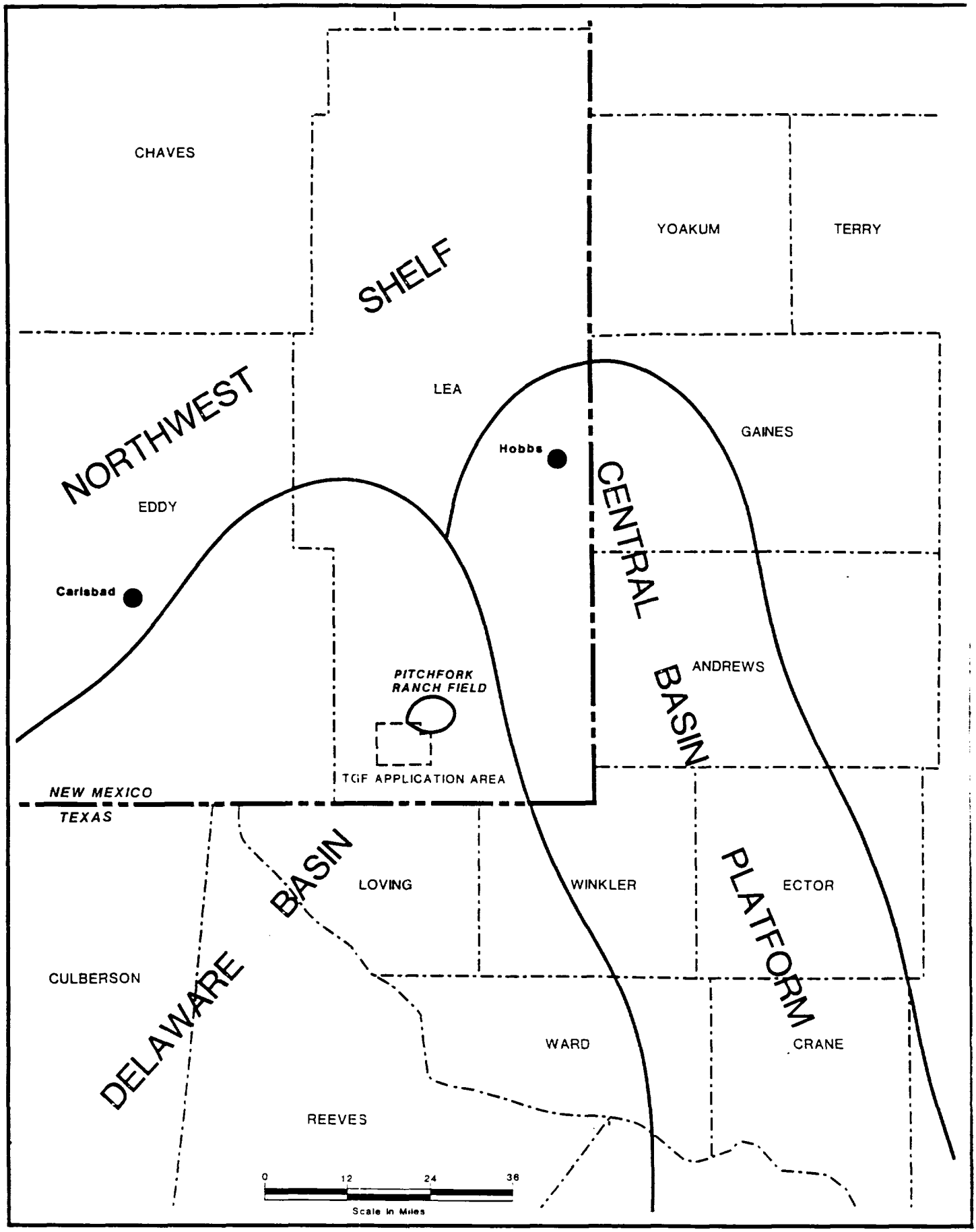

Figure 1 - Regional geographical and geologic province map. Area of application is outlined.

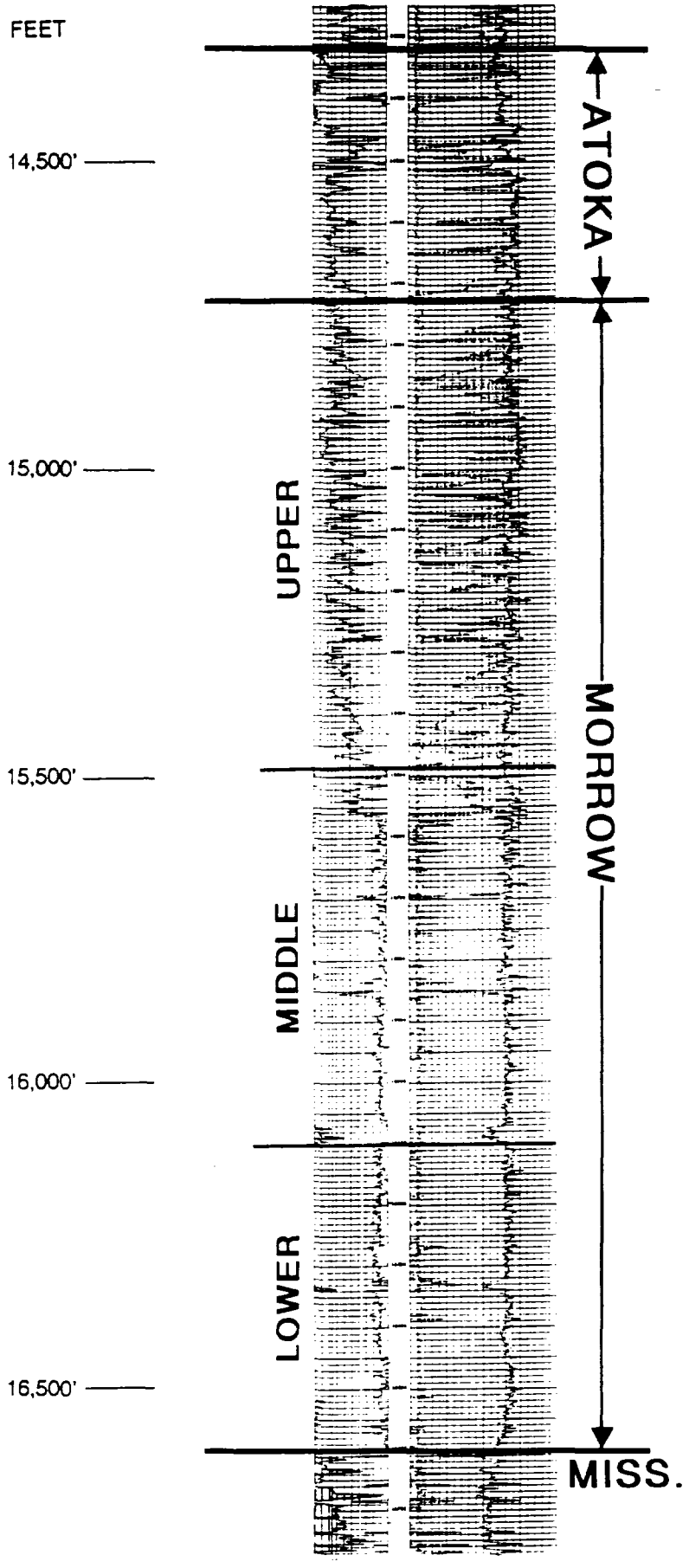

Figure 2 - Type Log: Compensated density-neutron log from BTA Oil Producers No. 1 Rojo 7811 JV-P.

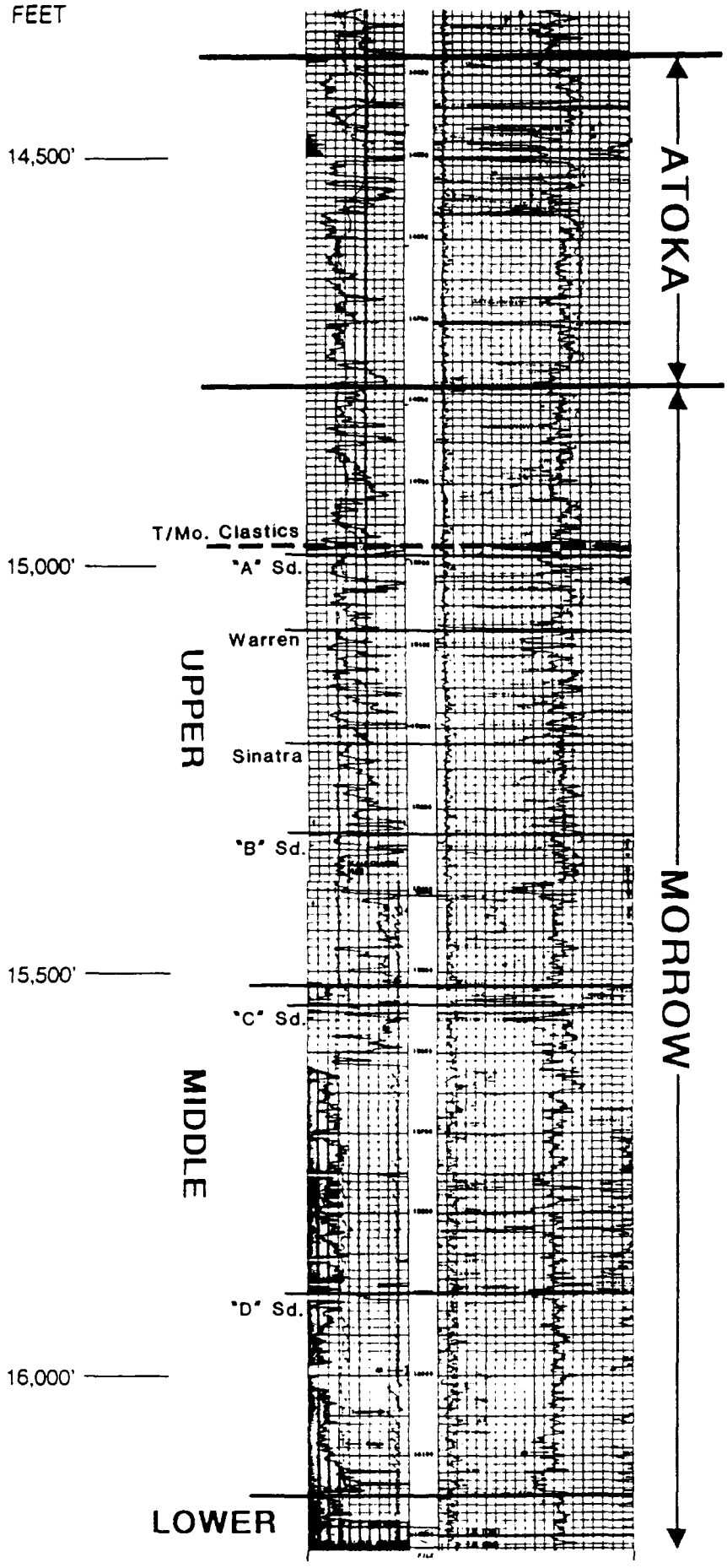

Figure 3 - Type Log: Compensated density-neutron log from The Superior Oil Company No. 1 Ochoa Federal

indicates only the middle and upper Morrow sediments were completely penetrated. Local nomenclature taken from the Pitchfork Ranch Field located immediately northeast of the area is used to identify the various clastic units found on the type log in Figure 3.

The Morrow TGF area of application appears on the Morrow "C" sand structure map as the black hatchered outline, while the shaded area represents a previously designated Morrow TGF area. Enron Oil & Gas Company's acreage is in yellow. This map, whose scale is one inch equals 4,000', has a contour interval of 50'. Present day regional dip of the Morrow "C" sand in the area is south to southwest. The observed fault patterns are based primarily on seismic data but is supported somewhat by well control and production. Well logs that have been designated as type logs for the Morrow are indicated on the map. The traces for the two stratigraphic cross-sections are also shown on the map. Located within the application boundary are two areas designated windows on the structure map. These two areas are being excluded from the area of application due to localized Morrow reservoirs with high permeability and limited areal extent. Each window represents a 320 acre proration unit.

The same Morrow nomenclature used on the type log in Figure 3 is also used on stratigraphic cross-sections A-A' and B-B'. Each cross-section datum is the top of the Morrow clastics, a good stratigraphic marker common to all the wells in the area. Vertical scales are one inch equals 40' with horizontal scales of one inch equals 2,000'. Cross-sections A-A' runs east to west across the area of application while cross-section B-B' has a northeast to southwest trace through the area. These cross-sections show the disposition of the middle and upper Morrow within and around the area of application. Well completion information is also documented on the cross-sections.

During lower Morrow time the sediments deposited over the area of application were basinal shales. Middle Morrow deposition was characterized by an increase in clastic material sourced from the Central Basin Platform which created packages of lenticular sands within the deep water shales. Upper Morrow sediments

contain alternating sequences of limestones, shales and sands. This is probably indicative of a regressive Morrow sea and shallower water conditions.

The clastic deposits in the middle and upper Morrow are the dominate reservoir rocks of the Morrow formation in the Pitchfork Ranch Field and have been considered the primary targets in the area of application. For these reasons the majority of Morrow tests did not drill below the middle Morrow section. The middle and upper Morrow clastics become poorly developed in a southwest direction away from the Pitchfork Ranch Field across the area of application. Mud logs were available on many wells in the area and this data indicates the sands are more limy and less homogeneous with greater amounts of calcareous and siliceous cement. These lithologic changes have resulted in tighter rock which is supported by production data, log calculations and permeability calculations.

lh118bzw

STATE OF NEW MEXICO
ENERGY, MINERALS AND NATURAL RESOURCES DEPARTMENT
OIL CONSERVATION DIVISION

BRUCE KING
GOVERNOR

POST OFFICE BOX 2088
STATE LAND OFFICE BUILDING
SANTA FE, NEW MEXICO 87504
(505) 827-5800

February 4, 1992

Federal Energy Regulatory Commission
U.S. Department of Energy
825 North Capitol Street, N.E.
Washington, D.C. 20426

Attn: Marilyn Rand, Director
Division of Producer Regulations

RE: Division Case No. 10428. Application of Enron Oil & Gas Company for Designation of a Tight Formation, Lea County, New Mexico.

Dear Ms. Rand:

Pursuant to FERC Rule 271.703(c)(3), please find enclosed two copies of Division Order No. R-9632, issued in said Case No. 10428 and dated February 3, 1992, recommending to the Federal Energy Regulatory Commission that the Morrow formation underlying the proposed Pitchfork Ranch Tight Formation Area in Lea County, New Mexico, be designated as a "tight formation" under Section 107 of the Natural Gas Policy Act of 1978.

Enclosed, also find copies of the hearing transcript and Exhibits presented by the applicant at the December 20, 1991 public hearing.

Please note concurrence of the U.S. Department of the Interior, Bureau of Land Management with our recommendation for said area by letter dated January 31, 1992 from Allan F. Buckingham, Manager of the NGPA Section, Albuquerque District Office.

Should you have any questions or require additional information, please contact me.

Sincerely,

Michael E. Stogner
Chief Hearing Examiner/Engineer

MES/jc

cc: Case File: 10428
William F. Carr - Santa Fe
U.S. BLM - Albuquerque, Allan Buckingham
NMOCD - Hobbs

UNITED STATES OF AMERICA
BEFORE THE
FEDERAL ENERGY REGULATORY COMMISSION

NGPA SECTION 107 TIGHT FORMATION RECOMMENDATION	)	Docket No. _____
STATE OF NEW MEXICO OIL CONSERVATION DIVISION OF THE ENERGY, MINERALS AND NATURAL RESOURCES DEPARTMENT	)	

RECOMMENDATION FOR TIGHT FORMATION DESIGNATION UNDER SECTION 107 OF THE NGPA.

Enron Oil and Gas Company, pursuant to Section 107 of the Natural Gas Policy Act, 18 CFR §271.703 of the FERC regulations and the New Mexico Oil Conservation Division's Special Rules and Procedures for Tight Formation Designations under Section 107 of the Natural Gas Policy Act of 1978, as promulgated by Order No. R-6388-A, petitioned the New Mexico Oil Conservation Division for tight formation designation of the Morrow formation underlying the proposed Pitchfork Ranch Tight Formation Area in Lea County, New Mexico.

After notice and hearing on the Application of Enron Oil and Gas Company, the New Mexico Oil Conservation Division hereby recommends that portion of the Morrow formation as described on pages 4 and 5 of Exhibit "A", being New Mexico Oil Conservation Division Order No. R-9632 attached hereto and incorporated by reference, be designated a tight formation. Additionally, the Oil Conservation Division submits herewith Exhibit "B", a copy of the transcript and exhibits presented to the Division in Case 10428, and Exhibit "C", a copy of a letter of the Bureau of Land Management, dated January 31, 1992, attached hereto and incorporated herein by reference, which are supporting data required under 18 CFR §271.703(c)(3) of the FERC regulations, respectively.

Respectively submitted this 4th day of February, 1992.

Michael E. Stogner
Chief Hearing Officer/Engineer

STATE OF NEW MEXICO
ENERGY, MINERALS AND NATURAL RESOURCES DEPARTMENT
OIL CONSERVATION DIVISION

IN THE MATTER OF THE HEARING
CALLED BY THE OIL CONSERVATION
DIVISION FOR THE PURPOSE OF
CONSIDERING:

Case No. 10428
Order No. R-9632

APPLICATION OF ENRON OIL & GAS COMPANY FOR DESIGNATION OF A TIGHT FORMATION, LEA COUNTY, NEW MEXICO.

ORDER OF THE DIVISION

BY THE DIVISION:

This cause came on for hearing at 9:00 a.m. on December 20, 1991, at Albuquerque, New Mexico, before Examiner Michael E. Stogner.

NOW, on this 3rd day of February, 1992, the Division Director, having considered the testimony, the record, and the recommendations of the Examiner, and being fully advised in the premises,

FINDS THAT:

(1) Due public notice having been given as required by law, the Division has jurisdiction of this cause and the subject matter thereof.

(2) The applicant, Enron Oil & Gas Company (Enron), requests that the Division recommend to the Federal Energy Regulatory Commission (FERC) that the Morrow formation underlying the following lands be designated as a "tight formation" in accordance with Section 107 of the Natural Gas Policy Act, FERC Regulations in Title 18 CFR Section 271.703 and Oil Conservation Division Order No. R-6388-A:

Township 25 South, Range 33 East, NMPM
Sections 1 through 14: All
Section 15: W/2
Sections 16 through 20: All
Section 21: N/2
Sections 22 through 36: All

Township 25 South, Range 34 East, NMPM
Sections 6 and 7: All
Section 8: S/2
Sections 17 through 20: All
Sections 29 through 32: All

(3) The proposed "tight formation" area contains 29,120 acres (81% Federal, 16% State and 3% Fee), more or less, and includes portions of the Pitchfork Ranch-Morrow Gas Pool, Red Hills-Morrow Gas Pool, and Vaca Draw-Morrow Gas Pool. The applicant proposes to designate the area as the "Pitchfork Ranch Tight Formation Area" (Pitchfork Ranch Area).

(4) The type log presented by the applicant to represent the Morrow formation in the Pitchfork Ranch Area is the Compensated Density-Neutron Log run in the BTA Oil Producers Rojo 7811 JV-P Well No. 1 located 660 feet from the North and West lines (Unit D) of Section 27, Township 25 South, Range 33 East, NMPM, Lea County, New Mexico. The vertical limits of the Morrow formation in the Pitchfork Ranch Area should include the entire Morrow interval of the Lower Pennsylvanian System found to occur from the base of the Atoka formation at 14,728 feet to the top of the Mississippian shale at 16,600 feet on this type log.

(5) Enron included a geological description of the Morrow formation in its application and a witness reviewed the geological description at the hearing. A summary of the geological information is as follows:

> The Morrow formation in the Pitchfork Ranch Area is divided into three correlative units (lower, middle and upper) consisting of limestones, shales and sands with a gross thickness of approximately 1,872 feet. The measured vertical depth to the top of the Morrow increases from the Northeast to the Southwest and also East to West across the Pitchfork Ranch Area with an average depth to the top of the Morrow formation of 14,700 feet.
>
> During lower Morrow time the sediments deposited over the area of application were basinal shales. Middle Morrow deposition was characterized by an increase in clastic material sourced from the Central Basin Platform which created packages of lenticular sands within the deep water shales. Upper Morrow sediments contain alternating

sequences of limestones, shales and sands, which is indicative of a regressive Morrow sea and shallower water conditions.

The clastic deposits in the middle and upper Morrow are the dominate reservoir rocks of the Morrow formation in the Pitchfork Ranch Field. The middle and upper Morrow clastics become poorly developed in a Southwest direction away from the Pitchfork Ranch Field across the area of application. Data indicates the sands are more limy and less homogeneous with greater amounts of calcareous and siliceous cement. These lithologic changes have resulted in tighter rock which is supported by production data, log calculations and permeability calculations.

(6) Applicant's data shows that there are sixteen wells that penetrated the Morrow formation in the Pitchfork Ranch Area.

(7) Applicant's witnesses testified that average in situ gas permeability for the Pitchfork Ranch Area is less than 0.1 millidarcys (md) and presented testimony in exhibits concerning two methods for determining average in situ permeability. Calculated permeability was the primary source of permeability data. Calculations based on well performance, bottomhole pressure measurements and reservoir data were used. Measured permeabilities from pressure build up analyses was used on three wells and confirmed the calculated permeabilities on the others.

(8) Permeability data from the Morrow sands was obtained from eleven wells which are well distributed over the Pitchfork Ranch Area. Calculated and measured permeabilities from the pay sections from the eleven wells established that the average in-situ permeability was 0.07585 md. or less.

(9) Applicant submitted testimony and exhibits to explain Pitchfork Ranch Area permeability calculations using the Holditch and Lee method. Applicant compared the measured permeability from four build-ups in the Pitchfork Ranch Area and in three of four cases the calculated permeability was slightly higher than the measured permeabilities, thereby confirming applicant's calculation method.

(10) To show that unstimulated producing rates for Pitchfork Ranch Area wells are not expected to exceed FERC "tight formation" limits of 5 BOPD and 2557 MCFPD, the applicant used actual flow test data from eleven wells in the Pitchfork Ranch Area, using the Holditch and Lee method, the average pre stimulation stabilized production rate at atmospheric pressure, or calculated against atmospheric pressure, in the Pitchfork Ranch Area was determined to be 1,339 MCFPD.

(11) Applicant's witness testified that wells in the Pitchfork Ranch Area produced dry gas with very little condensate and that no well in the area is expected to produce without stimulation more than 5 BOPD.

(12) No fresh water sands are known to occur in the area. However, existing State and Federal regulations relating to drilling, casing, and cementing wells and disposal of produced water, will apply to all wells in the Pitchfork Ranch Area and will provide for the protection for fresh water aquifers if any are found to exist in the area.

(13) A review of the rules for pools within the Pitchfork Ranch Area shows that Special Pool Rules have not been adopted to authorize infill drilling in the various pools.

(14) Based on evidence and testimony submitted by the applicant, the Morrow formation within the vertical intervals described in Finding Paragraph Nos. (4) and (5), underlying the area described in Finding Paragraph No. (2), meet the criteria set forth in FERC Regulations in Title 18 CFR, Section 271.703 and should therefore be recommended for designation as a "tight formation".

IT IS THEREFORE ORDERED THAT:

(1) A recommendation to the Federal Energy Regulatory Commission is hereby submitted pursuant to Section 107 of the Natural Gas Policy Act of 1978 and FERC Regulations in Title 18 CFR, Section 271.703, and that the Morrow formation within the vertical limits described in Finding Paragraph Nos. (4) and (5) of this order, underlying the following described lands in Lea County, New Mexico, be designated as a "tight formation".

Township 25 South, Range 33 East, NMPM
Sections 1 through 14: All
Section 15: W/2
Sections 16 through 20: All
Section 21: N/2
Sections 22 through 36: All

Township 25 South, Range 34 East, NMPM
Sections 6 and 7: All
Section 8: S/2
Section 17 through 20: All
Sections 29 through 32: All

The above lands contain 29,120 acres (81% Federal, 16% State and 3% Fee), more or less, and are to be designated the Pitchfork Ranch Tight Formation Area.

(2) Jurisdiction is hereby retained for the entry of such further orders as the Division may deem necessary.

DONE at Santa Fe, New Mexico, on the day and year hereinabove designated.

STATE OF NEW MEXICO
OIL CONSERVATION DIVISION

WILLIAM J. LeMAY
Director

S E A L

CAMPBELL, CARR, BERGE
& SHERIDAN, P.A.
LAWYERS

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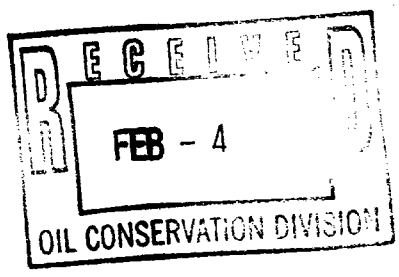
February 4, 1992

HAND-DELIVERED



Mr. Michael E. Stogner
Hearing Officer
New Mexico Oil Conservation Division
Department of Energy, Minerals
and Natural Resources
State Land Office Building
Santa Fe, New Mexico 87503

Re: Case No. 10428
Application of Enron Oil & Gas Company for Designation of a Tight Formation, Lea County, New Mexico

Dear Mr. Stogner:

Pursuant to your request, enclosed are copies of Enron Oil & Gas Company's Exhibits 1, 4, 5, 6 and 7 in the above-referenced case.

If you need anything further from Enron concerning this matter, please advise.

Very truly yours,

WILLIAM F. CARR
WFC:mlh
Enclosures
cc w/o enc: Mr. Patrick J. Tower
Enron Oil & Gas Company
Post Office Box 2267
Midland, Texas 79702

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!

BRUCE KING
GOVERNOR

ANITA LOCKWOOD
CABINET SECRETARY

MATTHEW BACA
DEPUTY SECRETARY

February 3, 1992

CAMBELL & BLACK
Attorneys at Law
P. O. Box 2208
Santa Fe, New Mexico 87504

RE: CASE NO. 10428
ORDER NO. R-9632

Dear Sir:

Enclosed herewith are two copies of the above-referenced Division order recently entered in the subject case.

Sincerely,

Florene Davidson

Florene Davidson
OC Staff Specialist

FD/sl

cc: BLM Carlsbad Office
Paul Burchell

VILLAGRA BUILDING - 408 Galisteo
Forestry and Resources Conservation Division
P.O. Box 1948 87504-1948
827-5830

Park and Recreation Division
P.O. Box 1147 87504-1147
827-7465

2040 South Pacheco
Office of the Secretary
827-5950

Administrative Services
827-5925

Energy Conservation & Management
827-5900

Mining and Minerals
827-5970

LAND OFFICE BUILDING - 310 Old Santa Fe Trail
Oil Conservation Division
P.O. Box 2088 87504-2088
827-5800

CASE 10430: **Application of Harvey E. Yates Company for compulsory pooling, Lea County, New Mexico.** Applicant, in the above-styled cause, seeks an order pooling all mineral interests from the surface to the base of the Grayburg formation underlying the NW/4 NE/4 (Unit B) of Section 32, Township 18 South, Range 33 East, forming a standard 40-acre oil spacing and proration unit for any and all formations and/or pools developed on 40-acre oil spacing within said vertical extent which presently includes but not necessarily limited to the Undesignated Buffalo-Yates Pool and Undesignated Buffalo-Queen Pool. Said unit is to be dedicated to a well to be drilled at a standard oil well location thereon. Also to be considered will be the cost of drilling and completing said well and the allocation of the cost thereof as well as actual operating costs and charges for supervision, designation of applicant as operator of the well and a charge for risk involved in drilling said well. Said unit is located approximately 9 miles west by south of the Old Hobbs Army Air Corps Auxiliary Airfield No. 4.

CASE 10431: **Application of Texaco Exploration and Producing Inc. for special pool rules, Lea County, New Mexico.** Applicant, in the above-styled cause, seeks an order promulgating special rules and regulations for the East Weir-Blinebry Pool including a provision for a gas-oil ratio limitation of 10,000 cubic feet of gas per barrel of oil. Said pool is located in portions of Sections 1, 11, 12 and 13, Township 20 South, Range 37 East, which is approximately 5.5 miles southwest-west of Nadine, New Mexico.

CASE 10370: **(Continued from November 21, 1991, Examiner Hearing.)**

Application of Coleman Oil and Gas, Inc. for salt water disposal, San Juan County, New Mexico. Applicant, in the above-styled cause, seeks authority to dispose of produced salt water into the Point Lookout interval of the Blanco-Mesaverde Pool in the perforated interval from approximately 4380 feet to 4480 feet in its Sunco Disposal Well No. 1 to be drilled 1595 feet from the North line and 1005 feet from the West line (Unit E) of Section 2, Township 29 North, Range 12 West. Said location is approximately 2.5 miles south by east of Flora Vista, New Mexico.

The above cases will be considered and called on Thursday at which time a recess will be taken and the remaining four cases will be called when the hearing reconvenes at 9:00 A.M. at the Albuquerque District Office of the U. S. Department of the Interior's Bureau of Land Management located in Albuquerque, New Mexico at 435 Montano Road Northeast.

CASE 10425: **Application of Conoco, Inc. for designation of a tight formation, San Juan County, New Mexico.** Applicant, in the above-styled cause, seeks the designation of the Pictured Cliffs formation underlying portions of Townships 30, 31 and 32 North, Ranges 9 and 10 West, containing 76,800 acres, more or less, as a "Tight Formation" pursuant to Section 107 of the Natural Gas Policy Act of 1978 and 18 C.F.R. Section 271.701-705. Said area extends south for 12 miles from the Colorado/New Mexico stateline between Mile Corners 261.5 and 252.

CASE 10428: **Application of ENRON Oil & Gas Company for designation of a tight formation, Lea County, New Mexico.** Applicant, in the above-styled cause, seeks the designation of the Morrow formation underlying portions of Township 24 South, Ranges 33 and 34 East, containing 17,280 acres, more or less, as a "Tight Formation" pursuant to Section 107 of the Natural Gas Policy Act of 1978 and 18 C.F.R. Section 271.701-705. Said area is located approximately 19 miles west northwest of Jal, New Mexico.

CASE 10420: **(Continued from December 5, 1991, Examiner Hearing.)**

Application of Union Oil Company of California d/b/a UNOCAL, for designation of a tight formation, Rio Arriba County, New Mexico. Applicant, in the above-styled cause, seeks the designation of the Basin-Dakota Pool underlying portions of Townships 26 and 27 North, Ranges 6 and 7 West, containing 20,642.7 acres, more or less, as a "Tight Formation" pursuant to Section 107 of the Natural Gas Policy Act of 1978 and 18 C.F.R. Section 271.701-705. Said area is located 22 miles southeast by east of Blanco, New Mexico.

CASE 10421: **(Continued from December 5, 1991, Examiner Hearing.)**

— Application of Union Oil Company of California d/b/a UNOCAL for designation of a tight formation, Rio Arriba County, New Mexico. Applicant, in the above-styled cause, seeks the designation of the Blanco-Mesaverde Pool underlying portions of Townships 26 and 27 North, Ranges 6 and 7 West, containing 20,642.7 acres, more or less, as a "Tight Formation" pursuant to Section 107 of the Natural Gas Policy Act of 1978 and 18 C.F.R. Section 271.701-705. Said area is located 22 miles southeast by east of Blanco, New Mexico.

United States Department of the Interior
BUREAU OF LAND MANAGEMENT
ALBUQUERQUE DISTRICT OFFICE
435 MONTANO N.E.
ALBUQUERQUE, NEW MEXICO 87107

TAKE PRIDE IN AMERICA

3160 (013)

January 31, 1992

Marilyn L. Rand, Director
Division of Producer Regulation
Federal Energy Regulatory Commission
825 North Capitol Street NE
Washington, DC 20426

Michael E. Stogner
Chief Hearing Officer
New Mexico Oil Conservation Division
P. O. Box 2088
Santa Fe, NM 87504-2088

Dear Ms. Rand and Mr. Stogner:

This letter is to be included with the submission to the FERC of the New Mexico Oil Conservation Division (NMOCD) Case No. 10428, Order No. R-9632, which designates a tight formation in New Mexico. The formation referred to is the Morrow formation designated as the Pitchfork Ranch Tight Formation Area consisting of 29,120 acres.

A copy of the BLM geologic review and engineering report is enclosed.

This jurisdictional agency concurs with the NMOCD designation and hereby designates the area in NMOCD Case No. 10428, Order No. R-9632, and BLM Docket No. NM-561-91 as a tight formation.

It is requested that FERC give this area designation priority consideration to enable the applicant to begin their drilling program as soon as possible. If applicable, a FERC notice of intent to take no action and let the 45-day review period expire would be most helpful in expediting the commencement of drilling. A copy of Enron Oil & Gas Company's request is enclosed.

Any persons objecting to this determination may file a protest directly with the Federal Energy Regulatory Commission, in accordance with 18 CFR Part 275.203 and 275.204, within 20 days after the notice is published in the Federal Register by the FERC.

If you have any questions contact Allen F. Buckingham at FTS 479-8765 or (505) 761-8765.

Sincerely yours,

for Assistant District Manager
Mineral Resources

Enclosures

cc:
FERC Advance Cy (Marilyn Rand)
William F. Carr, Attorney
Patrick J. Tower, ENRON O&G Co
WO-610 (Donnie Shaw)
NM-922 (Joe Chesser)

NGPA 107 Tight Formation Application
Lea Co. NM, Morrow Formation
NMOCD Case # 10428
Enron O&G Co., Midland, TX

Geologic Review:

On December 20, 1991, Enron came before the NMOCD in application for the designation of Tight Formation classification of the Morrow Formation in the Vaca Draw / Pitchfork Ranch Area.

In support of their application, Enron submitted numerous exhibits which are identified below. Following the exhibit title is a brief explanation of it's significance to the application. In summary, examination of the geologic data shows the application is complete and accurate.

Exhibit No. 1 - Land Plat: shows the boundaries for Pitchfork Ranch Field, the application area, and the existing designated tight gas area.

Exhibit No. 4 - Structure Map of Morrow 'C' Sand: generated from seismic data. Individual well points are clearly identified and support the seismic interpretation

Exhibits No. 5 and 6 - Stratigraphic Cross Sections A-A'and B-B', respectively: provide an east-west and north-south oriented perspective across the area. The number of wells, log scale, marker horizon and completion annotations show four major groups of sands (A-D) occur throughout the area and that completion practices adequately represent the various zones.

Exhibit No. 7 -

Geographical and Geological Discussion of the Area;
Figure 1- Regional Geographical and Geologic Province Map;
Figures 2 and 3- Type logs of the Morrow:
provides the geologic and structural nature of the area along with the nomenclature specific to the discussion of the Morrow in the application area.

Individual Well Data: provide the well names, locations, depth to Morrow, completion interval, surface elevation and reservoir values for porosity, water saturation, and thickness.

No core data was available. Permeabilities were calculated using drill stem tests, pressure build-up data, or the Holditch & Lee method. The engineering review will give a more detailed analysis of the methodologies used in these calculations. The average permeability for the area including the S/2 section 6, T. 25 S., R. 34 E. is .076 MD. Not including this 320 acre spacing unit which contain the Half 6 Fed. No. 1 well, the average drops

to .050 MD. It should be noted that a cautious approach was practiced by Enron in this application. The average "perms" for the area did not include two wells which were non productive and indicated 0 permeabilities. Also, input variables selected (eg. skin) for the Holditch & Lee equations resulted in higher "perms" than evidenced by the pressure build up tests. Due to this margin of safety incorporated in their calculations, the original application area requested, including the S/2 of section 6 is believed to qualify for tight formation designation.

Recommendation: Approve application including S/2 section 6, T. 25 S., R. 34 E..

Jane Clancy
12/30/91

Engineering Report: Application of Enron Oil and Gas Company for designation of the Morrow Formation in the Vaca Draw/Pitchfork Ranch area in Lea county, New Mexico as a Tight Gas Formation

Enron has applied for an area in T.25 N., R.33,34 E., Lea county, New Mexico, containing 29,120 acres, to be designated as a tight formation. The formation requested in the application is the Morrow and the area covers part of the Pitchfork Ranch, Red Hills, and Vaca Draw gas pools.

In the proposed area 16 wells were drilled in the Morrow formation. Data was presented on 11 of them and is presented in the exhibit labeled Summary of Permeability and Stabilized Rates. This table presents the permeabilities and stabilized flow rates for the 11 wells. Permeabilities were calculated from pressure build up tests, drill stem tests, or by iteration using a method developed by Holditch & Lee. Three of the wells had actual test data and this data was used to validate the use of the Holditch & Lee model. All of the stabilized flow rates were calculated using the Holditch & Lee method.

The data sheets attached to the application show that with reasonable assumptions, the Holditch & Lee method gave reasonable and consistent results. This determination was made by comparing the iterative results to those obtained using actual data. The results of Enron's analysis and calculations show that the average in situ permeability is .07587 md and the average stabilized flow rate is 1397 mcfgpd. A review of Enron's analysis indicates that the values and methods used were on the high side. That is to say that the final values obtained could be alittle high and the actual permeability and flow rates may be slightly lower than indicated. Therefore, Enron's values are acceptable.

Two windows are included in the application. They are the E/2 Section 15 and the S/2 Section 21, T.25 S., R.33 E. The wells involved are the Ochoa Federal No.1 and Brinninstool 21 Federal No.1 respectively. These wells show a high permeability and flow rates, but the reservoir appears to be of limited areal extent. These "Sweet Spots" have been eliminated from the proposed area.

There are three wells in the proposed area which are not included in the data presented in the application. The Gila 4 Deep Com in section 4 was completed in the Morrow, swabbed water, was plugged back and completed in the Atoka. No cores or tests were done in the Morrow. This information was obtained from a scout ticket. The Flagler Federal No.1 in section 8 was drilled to the Morrow and P&A'd. According to the records, the well was perforated in the Morrow and tested only water. The well was plugged back and perforated in the Atoka. The Atoka tested dry and the well was P&A'd. No information was available on the Rojo No.1 in section 27.

Based on the information presented in the application, this area appears to meet the requirements for designation of a Tight Gas Formation area under the FERC standards for in situ permeability, pre-stimulation stabilized flow rate, and oil production.

Robert Kent
21 Jan 92

ENRON
Oil & Gas Company

P. O. Box 2267 Midland, Texas 79702 (915) 686-3600

January 8, 1992

State of New Mexico Oil Conservation Division
P. O. Box 2088
Santa Fe, New Mexico 87504
Attn: Michael E. Stogner

Bureau of Land Management
Minerals Division/NGPA
Albuquerque District Office
435 Montano Road NE
Albuquerque, New Mexico 87107
Attn: Allen F. Buckingham

RE: Tight Gas (Morrow) Formation Application
Lea County, New Mexico

Gentlemen:

With regard to Enron Oil & Gas Company's current application for designation of a tight formation in Lea County, New Mexico (OCD Case #10428), Enron would request that its application be given priority status. Enron makes this request in order that it might begin the scheduling of wells. As the time is fast approaching for the end of the tax credit, it is critical that the designation be in place in order to support the proper drilling program. Noting the average depth in the targeted area is 14,700', this area will require more drilling time than many of the applications currently before FERC.

Any assistance towards expediting the application is sincerely appreciated.

Sincerely,

ENRON OIL & GAS COMPANY

Patrick J. Tower
Project Landman

PJT/cl
cc: Bill Carr (w/o encls.)

NGPA DETERMINATIONS
BLM, Albuquerque, NM
JAN 13 1992
ALLEN BUCKINGHAM

STATE OF NEW MEXICO
ENERGY, MINERALS AND NATURAL RESOURCES DEPARTMENT
OIL CONSERVATION DIVISION

IN THE MATTER OF THE HEARING
CALLED BY THE OIL CONSERVATION
DIVISION FOR THE PURPOSE OF
CONSIDERING:

Case No. 10428
Order No. R-9632

APPLICATION OF ENRON OIL & GAS COMPANY FOR DESIGNATION OF A TIGHT FORMATION, LEA COUNTY, NEW MEXICO.

ORDER OF THE DIVISION

BY THE DIVISION:

This cause came on for hearing at 9:00 a.m. on December 20, 1991, at Albuquerque, New Mexico, before Examiner Michael E. Stogner.

NOW, on this 3rd day of February, 1992, the Division Director, having considered the testimony, the record, and the recommendations of the Examiner, and being fully advised in the premises,

FINDS THAT:

(1) Due public notice having been given as required by law, the Division has jurisdiction of this cause and the subject matter thereof.

(2) The applicant, Enron Oil & Gas Company (Enron), requests that the Division recommend to the Federal Energy Regulatory Commission (FERC) that the Morrow formation underlying the following lands be designated as a "tight formation" in accordance with Section 107 of the Natural Gas Policy Act, FERC Regulations in Title 18 CFR Section 271.703 and Oil Conservation Division Order No. R-6388-A:

Township 25 South, Range 33 East, NMPM
Sections 1 through 14: All
Section 15: W/2
Sections 16 through 20: All
Section 21: N/2
Sections 22 through 36: All

Township 25 South, Range 34 East, NMPM
Sections 6 and 7: All
Section 8: S/2
Sections 17 through 20: All
Sections 29 through 32: All

(3) The proposed "tight formation" area contains 29,120 acres (81% Federal, 16% State and 3% Fee), more or less, and includes portions of the Pitchfork Ranch-Morrow Gas Pool, Red Hills-Morrow Gas Pool, and Vaca Draw-Morrow Gas Pool. The applicant proposes to designate the area as the "Pitchfork Ranch Tight Formation Area" (Pitchfork Ranch Area).

(4) The type log presented by the applicant to represent the Morrow formation in the Pitchfork Ranch Area is the Compensated Density-Neutron Log run in the BTA Oil Producers Rojo 7811 JV-P Well No. 1 located 660 feet from the North and West lines (Unit D) of Section 27, Township 25 South, Range 33 East, NMPM, Lea County, New Mexico. The vertical limits of the Morrow formation in the Pitchfork Ranch Area should include the entire Morrow interval of the Lower Pennsylvanian System found to occur from the base of the Atoka formation at 14,728 feet to the top of the Mississippian shale at 16,600 feet on this type log.

(5) Enron included a geological description of the Morrow formation in its application and a witness reviewed the geological description at the hearing. A summary of the geological information is as follows:

> The Morrow formation in the Pitchfork Ranch Area is divided into three correlative units (lower, middle and upper) consisting of limestones, shales and sands with a gross thickness of approximately 1,872 feet. The measured vertical depth to the top of the Morrow increases from the Northeast to the Southwest and also East to West across the Pitchfork Ranch Area with an average depth to the top of the Morrow formation of 14,700 feet.
>
> During lower Morrow time the sediments deposited over the area of application were basinal shales. Middle Morrow deposition was characterized by an increase in clastic material sourced from the Central Basin Platform which created packages of lenticular sands within the deep water shales. Upper Morrow sediments contain alternating

sequences of limestones, shales and sands, which is indicative of a regressive Morrow sea and shallower water conditions.

The clastic deposits in the middle and upper Morrow are the dominate reservoir rocks of the Morrow formation in the Pitchfork Ranch Field. The middle and upper Morrow clastics become poorly developed in a Southwest direction away from the Pitchfork Ranch Field across the area of application. Data indicates the sands are more limy and less homogeneous with greater amounts of calcareous and siliceous cement. These lithologic changes have resulted in tighter rock which is supported by production data, log calculations and permeability calculations.

(6) Applicant's data shows that there are sixteen wells that penetrated the Morrow formation in the Pitchfork Ranch Area.

(7) Applicant's witnesses testified that average in situ gas permeability for the Pitchfork Ranch Area is less than 0.1 millidarcys (md) and presented testimony in exhibits concerning two methods for determining average in situ permeability. Calculated permeability was the primary source of permeability data. Calculations based on well performance, bottomhole pressure measurements and reservoir data were used. Measured permeabilities from pressure build up analyses was used on three wells and confirmed the calculated permeabilities on the others.

(8) Permeability data from the Morrow sands was obtained from eleven wells which are well distributed over the Pitchfork Ranch Area. Calculated and measured permeabilities from the pay sections from the eleven wells established that the average in-situ permeability was 0.07585 md. or less.

(9) Applicant submitted testimony and exhibits to explain Pitchfork Ranch Area permeability calculations using the Holditch and Lee method. Applicant compared the measured permeability from four build-ups in the Pitchfork Ranch Area and in three of four cases the calculated permeability was slightly higher than the measured permeabilities, thereby confirming applicant's calculation method.

(10) To show that unstimulated producing rates for Pitchfork Ranch Area wells are not expected to exceed FERC "tight formation" limits of 5 BOPD and 2557 MCFPD, the applicant used actual flow test data from eleven wells in the Pitchfork Ranch Area, using the Holditch and Lee method, the average pre stimulation stabilized production rate at atmospheric pressure, or calculated against atmospheric pressure, in the Pitchfork Ranch Area was determined to be 1,339 MCFPD.

(11) Applicant's witness testified that wells in the Pitchfork Ranch Area produced dry gas with very little condensate and that no well in the area is expected to produce without stimulation more than 5 BOPD.

(12) No fresh water sands are known to occur in the area. However, existing State and Federal regulations relating to drilling, casing, and cementing wells and disposal of produced water, will apply to all wells in the Pitchfork Ranch Area and will provide for the protection for fresh water aquifers if any are found to exist in the area.

(13) A review of the rules for pools within the Pitchfork Ranch Area shows that Special Pool Rules have not been adopted to authorize infill drilling in the various pools.

(14) Based on evidence and testimony submitted by the applicant, the Morrow formation within the vertical intervals described in Finding Paragraph Nos. (4) and (5), underlying the area described in Finding Paragraph No. (2), meet the criteria set forth in FERC Regulations in Title 18 CFR, Section 271.703 and should therefore be recommended for designation as a "tight formation".

IT IS THEREFORE ORDERED THAT:

(1) A recommendation to the Federal Energy Regulatory Commission is hereby submitted pursuant to Section 107 of the Natural Gas Policy Act of 1978 and FERC Regulations in Title 18 CFR, Section 271.703, and that the Morrow formation within the vertical limits described in Finding Paragraph Nos. (4) and (5) of this order, underlying the following described lands in Lea County, New Mexico, be designated as a "tight formation".

Township 25 South, Range 33 East, NMPM
Sections 1 through 14: All
Section 15: W/2
Sections 16 through 20: All
Section 21: N/2
Sections 22 through 36: All

Township 25 South, Range 34 East, NMPM
Sections 6 and 7: All
Section 8: S/2
Section 17 through 20: All
Sections 29 through 32: All

The above lands contain 29,120 acres (81% Federal, 16% State and 3% Fee), more or less, and are to be designated the Pitchfork Ranch Tight Formation Area.

(2) Jurisdiction is hereby retained for the entry of such further orders as the Division may deem necessary.

DONE at Santa Fe, New Mexico, on the day and year hereinabove designated.

STATE OF NEW MEXICO
OIL CONSERVATION DIVISION

WILLIAM J. LeMAY
Director

S E A L

STATE OF NEW MEXICO

ENERGY, MINERALS AND NATURAL RESOURCES DEPARTMENT

OIL CONSERVATION DIVISION

BRUCE KING
GOVERNOR

POST OFFICE BOX 2088
STATE LAND OFFICE BUILDING
SANTA FE, NEW MEXICO 87504
(505) 827-5800

January 28, 1992

US Bureau of Land Management
Albuquerque District Office
435 Montaño Road
Albuquerque, NM 87107

Attention: Allen Buckingham

RE: Division Case No. 10428. Application of Enron Oil and Gas Company for Designation of a Tight Formation, Lea County, New Mexico.

Dear Mr. Buckingham:

Enclosed please find a copy of Division Order No. R-9632 to be issued in Case No. 10428 recommending to the Federal Energy Regulatory Commission that the Morrow formation underlying the Pitchfork Ranch Tight Formation Area in Lea County, New Mexico, be designated as a "tight formation" under Section 107 of the Natural Gas Policy Act of 1978.

Enclosed for your files is also a copy of the December 20, 1991 hearing transcript of this matter.

Should you require additional information, please contact me at (505) 827-5811.

Sincerely,

Michael E. Stogner
Chief Hearing Officer/Engineer

MES/ag

cc: Case File 10428
William F. Carr - Santa Fe

STATE OF NEW MEXICO
ENERGY, MINERALS AND NATURAL RESOURCES DEPARTMENT
OIL CONSERVATION DIVISION

IN THE MATTER OF THE HEARING
CALLED BY THE OIL CONSERVATION
DIVISION FOR THE PURPOSE OF
CONSIDERING:

Case No. 10428
Order No. R-9632

APPLICATION OF ENRON OIL & GAS COMPANY FOR DESIGNATION OF A TIGHT FORMATION, LEA COUNTY, NEW MEXICO.

ORDER OF THE DIVISION

BY THE DIVISION:

This cause came on for hearing at 9:00 a.m. on December 20, 1991, at Albuquerque, New Mexico, before Examiner Michael E. Stogner.

NOW, on this _____ day of January, 1992, the Division Director, having considered the testimony, the record, and the recommendations of the Examiner, and being fully advised in the premises,

FINDS THAT:

(1) Due public notice having been given as required by law, the Division has jurisdiction of this cause and the subject matter thereof.

(2) The applicant, Enron Oil & Gas Company (Enron), requests that the Division recommend to the Federal Energy Regulatory Commission (FERC) that the Morrow formation underlying the following lands be designated as a "tight formation" in accordance with Section 107 of the Natural Gas Policy Act, FERC Regulations in Title 18 CFR Section 271.703 and Oil Conservation Division Order No. R-6388-A:

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Sections 1 through 14: All
Section 15: W/2
Sections 16 through 20: All
Section 21: N/2
Sections 22 through 36: All

Township 25 South, Range 34 East, NMPM
Sections 6 and 7: All
Section 8: S/2
Sections 17 through 20: All
Sections 29 through 32: All

(3) The proposed "tight formation" area contains 29,120 acres (81% Federal, 16% State and 3% Fee), more or less, and includes portions of the Pitchfork Ranch-Morrow Gas Pool, Red Hills-Morrow Gas Pool, and Vaca Draw-Morrow Gas Pool. The applicant proposes to designate the area as the "Pitchfork Ranch Tight Formation Area" (Pitchfork Ranch Area).

(4) The type log presented by the applicant to represent the Morrow formation in the Pitchfork Ranch Area is the Compensated Density-Neutron Log run in the BTA Oil Producers Rojo 7811 JV-P Well No. 1 located 660 feet from the North and West lines (Unit D) of Section 27, Township 25 South, Range 33 East, NMPM, Lea County, New Mexico. The vertical limits of the Morrow formation in the Pitchfork Ranch Area should include the entire Morrow interval of the Lower Pennsylvanian System found to occur from the base of the Atoka formation at 14,728 feet to the top of the Mississippian shale at 16,600 feet on this type log.

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>
> During lower Morrow time the sediments deposited over the area of application were basinal shales. Middle Morrow deposition was characterized by an increase in clastic material

sourced from the Central Basin Platform which created packages of lenticular sands within the deep water shales. Upper Morrow sediments contain alternating sequences of limestones, shales and sands, which is indicative of a regressive Morrow sea and shallower water conditions.

The clastic deposits in the middle and upper Morrow are the dominate reservoir rocks of the Morrow formation in the Pitchfork Ranch Field. The middle and upper Morrow clastics become poorly developed in a Southwest direction away from the Pitchfork Ranch Field across the area of application. Data indicates the sands are more limy and less homogeneous with greater amounts of calcareous and siliceous cement. These lithologic changes have resulted in tighter rock which is supported by production data, log calculations and permeability calculations.

(6) Applicant's data shows that there are sixteen wells that penetrated the Morrow formation in the Pitchfork Ranch Area.

(7) Applicant's witnesses testified that average in situ gas permeability for the Pitchfork Ranch Area is less than 0.1 millidarcys (md) and presented testimony in exhibits concerning two methods for determining average in situ permeability. Calculated permeability was the primary source of permeability data. Calculations based on well performance, bottomhole pressure measurements and reservoir data were used. Measured permeabilities from pressure build up analyses was used on three wells and confirmed the calculated permeabilities on the others.

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(9) Applicant submitted testimony and exhibits to explain Pitchfork Ranch Area permeability calculations using the Holditch and Lee method. Applicant compared the measured permeability from four build-ups in the Pitchfork Ranch Area and in three of four cases the calculated permeability was slightly higher than the measured permeabilities, thereby confirming applicant's calculation method.

(10) To show that unstimulated producing rates for Pitchfork Ranch Area wells are not expected to exceed FERC "tight formation" limits of 5 BOPD and 2557 MCFPD, the applicant used actual flow test data from eleven wells in the Pitchfork Ranch Area, using the Holditch and Lee method, the average pre stimulation stabilized production rate at atmospheric pressure, or calculated against atmospheric pressure, in the Pitchfork Ranch Area was determined to be 1,339 MCFPD.

(11) Applicant's witness testified that wells in the Pitchfork Ranch Area produced dry gas with very little condensate and that no well in the area is expected to produce without stimulation more than 5 BOPD.

(12) No fresh water sands are known to occur in the area. However, existing State and Federal regulations relating to drilling, casing, and cementing wells and disposal of produced water, will apply to all wells in the Pitchfork Ranch Area and will provide for the protection for fresh water aquifers if any are found to exist in the area.

(13) A review of the rules for pools within the Pitchfork Ranch Area shows that Special Pool Rules have not been adopted to authorize infill drilling in the various pools.

(14) Based on evidence and testimony submitted by the applicant, the Morrow formation within the vertical intervals described in Finding Paragraph Nos. (4) and (5), underlying the area described in Finding Paragraph No. (2), meet the criteria set forth in FERC Regulations in Title 18 CFR, Section 271.703 and should therefore be recommended for designation as a "tight formation".

IT IS THEREFORE ORDERED THAT:

(1) A recommendation to the Federal Energy Regulatory Commission is hereby submitted pursuant to Section 107 of the Natural Gas Policy Act of 1978 and FERC Regulations in Title 18 CFR, Section 271.703, and that the Morrow formation within the vertical limits described in Finding Paragraph Nos. (4) and (5) of this order, underlying the following described lands in Lea County, New Mexico, be designated as a "tight formation".

Township 25 South, Range 33 East, NMPM

Sections 1 through 14: All
Section 15: W/2
Sections 16 through 20: All
Section 21: N/2
Sections 22 through 36: All

Township 25 South, Range 34 East, NMPM
Sections 6 and 7: All
Section 8: S/2
Section 17 through 20: All
Sections 29 through 32: All

The above lands contain 29,120 acres (81% Federal, 16% State and 3% Fee), more or less, and are to be designated the Pitchfork Ranch Tight Formation Area.

(2) Jurisdiction is hereby retained for the entry of such further orders as the Division may deem necessary.

DONE at Santa Fe, New Mexico, on the day and year hereinabove designated.

STATE OF NEW MEXICO
OIL CONSERVATION DIVISION

Original Signed by William J. LeMay

WILLIAM J. LeMAY
Director

S E A L

CAMPBELL, CARR, BERGE
& SHERIDAN, P.A.
LAWYERS

MICHAEL B. CAMPBELL
WILLIAM F. CARR
BRADFORD C. BERGE
MARK F. SHERIDAN
WILLIAM P. SLATTERY

PATRICIA A. MATTHEWS
MICHAEL H. FELDEWERT

JACK M. CAMPBELL
OF COUNSEL

JEFFERSON PLACE
SUITE 1 - 110 NORTH GUADALUPE
POST OFFICE BOX 2208
SANTA FE, NEW MEXICO 87504-2208
TELEPHONE: (505) 988-4421
TELECOPIER: (505) 983-6043

January 10, 1992

HAND-DELIVERED

Mr. Michael E. Stogner
Hearing Officer
New Mexico Oil Conservation Division
Department of Energy, Minerals
and Natural Resources
State Land Office Building
Santa Fe, New Mexico 87503

Re: Case No. 10428
Application of Enron Oil & Gas Company for Designation of a Tight Formation, Lea County, New Mexico

Dear Mr. Stogner:

Pursuant to your request at the December 20, 1991 Examiner hearing in the above-referenced case, I am enclosing Enron Oil & Gas Company's proposed Order granting this application.

I am also providing a copy of this proposed Order to Mr. Allen F. Buckingham at the Bureau of Land Management in Albuquerque.

If you need anything further from Enron to proceed with your consideration of this matter, please advise.

Very truly yours,

WILLIAM F. CARR
WFC:mlh
Enclosure
cc w/enc: Mr. Patrick J. Tower
Enron Oil & Gas Company
Post Office Box 2267
Midland, Texas 79702

ENRON
Oil & Gas Company

P. O. Box 2267 Midland, Texas 79702 (915) 686-3600

January 8, 1992

State of New Mexico Oil Conservation Division
P. O. Box 2088
Santa Fe, New Mexico 87504
Attn: Michael E. Stogner

Bureau of Land Management
Minerals Division/NGPA
Albuquerque District Office
435 Montano Road NE
Albuquerque, New Mexico 87107
Attn: Allen F. Buckingham

RE: Tight Gas (Morrow) Formation Application
Lea County, New Mexico

Gentlemen:

With regard to Enron Oil & Gas Company's current application for designation of a tight formation in Lea County, New Mexico (OCD Case #10428), Enron would request that its application be given priority status. Enron makes this request in order that it might begin the scheduling of wells. As the time is fast approaching for the end of the tax credit, it is critical that the designation be in place in order to support the proper drilling program. Noting the average depth in the targeted area is 14,700', this area will require more drilling time than many of the applications currently before FERC.

Any assistance towards expediting the application is sincerely appreciated.

Sincerely,

ENRON OIL & GAS COMPANY

Patrick J. Tower
Project Landman

PJT/cl
cc: Bill Carr (w/o encls.)

CASE 10428

Received
12/2/91

VACA DRAW/PITCHFORK AREA TGF DESIGNATION - MORROW SANDS

PERMEABILITY AND STABILIZED FLOW RATES

ENRON OIL AND GAS COMPANY

ENRON OIL AND GAS COMPANY
VACA DRAW/PITCHFORK RANCH AREA TGF DESIGNATION
SUMMARY OF PERMEABILITY AND STABILIZED RATES

WELL NAME	INTERVAL	PRE-STIM K (MD)	POST-STIM K (MD)	K USED	CALCULATED STABILIZED FLOW RATE (MCFPD)
Andrikopoulos No. 1	15,554 - 64'	0.0	0.0	0.0	0.0
	15,301 - 55'	0.0 D	0.0	0.0 D	0.0
	14,986 - 15,209'	0.0146	0.1081 BU	0.1081 BU	979
Average				0.0321	979
Bell Lake 2 St. No. 1	15,380 - 458'	0.004	0.0542 BU	-	-
	15,159 - 458'	-	0.0098 BU	0.0098 BU	1,618
	14,819 - 92'	0.0015	0.0217	0.0015	306
Average				0.0074	1,618
Bell Lake 11 No. 1	15,447 - 82'	-	-	-	-
	15,210 - 20'	0.0	0.0	0.0	-
	14,883 - 977'	-	0.2352	0.2352	2,617
Average				0.1176	2,617
Diamond 6 Federal No. 1	14,897 - 15,556'	0.045	0.7871	0.045	1,445
Half 6' Federal No. 1	15,288 - 360'	0.3099	0.3099	0.3099	2,370
Javelina Basin Unit 1	15,159 - 920'	-	0.1859	-	1,653
	19,594 - 604'	-	0.0367	-	76
Average				-	1,653
Longway Draw No. 1	15,605 - 10'	0.0145	0.0145	0.0145	97
	15,047 - 289'	0.0	0.0249	0.0249	351
	14,829 - 15,289'	0.0	0.024 BU	0.024 BU	933
Average				0.0222	933
Red Hills Unit No. 1	15,442 - 530'	-	-	-	-
	15,034 - 138	0.0	0.0	0.0	0.0
	14,840 - 64'	0.247	0.4881	0.247	1,028
Average				0.1647	1,028
Vaca Draw Unit 1	15,291 - 15,330'	0.0009	-	-	-
	14,954 - 15,710'	0.0092	0.0020	0.0092	261
Vaca Draw 13 Federal No. 1	15,493 - 546'	0.0	0.0	0.0	0.0
	15,264 - 88'	0.006	0.0451	0.0451	271
	15,014 - 53'	0.0	0.086	0.086	1,073
Average				0.0506	1,073
Vaca Draw 16 St. 1	15,058 - 718'	0.0	0.0	0.0	0.0

All permeabilities calculated by Holditch & Lee method unless denoted by BU - Build-up test or D - DST
All stabilized flow rates calculated by Holditch & Lee method

Average Permeability = 0.7587/10 wells = 0.07587 MD
Average Stabilized Flow Rate @ 1 ATM = 13,977/11 wells = 1,271 MCFPD

VACA DRAW/PITCHFORK AREA
MORROW FORMATION

INDIVIDUAL WELL DATA

ENRON OIL AND GAS COMPANY

INDIVIDUAL WELL DATA

MORROW FORMATION

VACA DRAW / PITCHFORK RANCH AREA

Lea County, New Mexico

lh117bzl
11/27/91

WELL NAME	OPERATOR	DEPTH OF MORROW	SPUD DATE	COMPLETION DATE	MORROW PERFORATIONS	PAY THICKNESS	POROSITY	WATER SATURATION	STATUS	CUM PRODUCTION MMCFG
Andrikopoulos Fed. No. 1	Enron Oil & Gas	14,755'	8/79	4/80	"A" Sd 14,986'-995'	10'	3%	20%	Producing	
Sec. 24-25S-33E	(Amoco)				Warren/					
KB Elev. 3,354'					Sinatra 15,096'-209'	9'	6.5%	21%	Producing	1,256
					"B" Sd 15,314'-356' (1)	29'	6%	24%	Non-Productive	
					"C" Sd 15,554'-564' (2)	16'	4%	(3)	Non-Productive	
Bell Lake "2" State No. 1	Hallwood (HNG)	14,598'	12/80	9/84	"A" Sd 14,819'-842'	27'	12%	17%	Producing	819
Sec. 2-25S-33E				5/81	"B" Sd 15,159'-176'	16'	6%	15%	Abandoned	
KB Elev. 3,486'					15,184'-188'	8'	9%	44%	Abandoned	
					15,194'-198'	8'	9%	30%	Abandoned	
					"C" Sd 15,380'-386'	8'	6%	24%	Abandoned	
					15,423'-458'	28'	6%	41%	Abandoned	453
Bell Lake "11" Fed. No. 1	Hallwood (HNG)	14,638'	4/80	8/80	"A" Sd/					
Sec. 11-25S-33E					Warren 14,883'-977'	20'	8%	(3)	Abandoned	2
KB Elev. 3,429'					"B" Sd 15,210'-220'	20'	5.5%	(3)	Non-Productive	
					"C" Sd 15,447'-482'	26'	6.5%	(3)	Non-Productive	
Brinninstool "21" Fed. No. 1	Enron Oil & Gas	14,793'	10/87	1/88	Warren 15,170'-176'	6'	4%	57%	Producing	
Sec. 21-25S-33E					"B" Sd 15,349'-383'	28'	6%	47%	Producing	
KB Elev. 3,391'					"D" Sd 15,759'-765'	7'	9%	39%	Producing	1,028
Diamond "6" Fed. No. 1	Enron Oil & Gas	14,450'	9/82	11/82	"B" Sd 14,897'-15,017'	21'	6%	23%	Producing	
Sec. 6-25S-34E					"C" Sd 15,234'-249'	4'	7%	8%	Producing	
KB Elev. 3,462'					"C" Sd/					
					"D" Sd 15,285'-556'	26'	7.5%	26%	Producing	4,190
Flagler Fed. No. 1	Exxon	14,766'	6/89	11/89	"C" Sd 15,529'-575'	50'	(4)	(4)	Non-Productive	
Sec. 8-25S-33E										
KB Elev. 3,482'										
Gila "4" Deep Com. No. 1	Oryx Energy	14,764'	5/90	9/90	"C" Sd 15,490'-594'	56'	(5)	(5)	Non-Productive	
Sec. 4-25S-33E										
KB Elev. 3,436'										

INDIVIDUAL WELL DATA

MORROW FORMATION

VACA DRAW / PITCHFORK RANCH AREA

Lea County, New Mexico

lh117bzl
11/27/91

WELL NAME	OPERATOR	DEPTH OF MORROW	SPUD DATE	COMPLETION DATE	MORROW PERFORATIONS	PAY THICKNESS	POROSITY	WATER SATURATION	STATUS	CUM PRODUCTION MMCFG
Half "6" Fed. Com. No. 1	Enron Oil & Gas	14,445'	9/90	12/90	"C" Sd 15,288'-300'	12'	8.5%	9%	Producing	
Sec. 6-25S-34E					15,340'-360'	24'	8.5%	31%	Producing	1,148
KB Elev. 3,465'										
Javelina Basin Ut. No. 1	Stone Petroleum	14,592'	11/82	8/85	U. Morr. 14,594'-604'	4'	11%	30%	Abandoned	39
Sec. 17-25S-34E				2/83	"B" Sd 15,154'-178'	8'	4.5%	56%	Abandoned	
KB Elev. 3,361'					"C" Sd 15,389'-420'	10'	6.5%	43%	Abandoned	93
					"D" Sd 15,695'-712'	15'	6%	58%	Non-Productive	
Longway Draw Fed. Com. No. 1	Martin Yates Co.	14,485'	12/83	8/90	Warren 14,829'-865'	11'	5%	18%	Producing	
Sec. 8-25S-34E				7/84	"B" Sd 15,047'-078'	8'	6%	28%	Producing	
KB Elev. 3,377'					"C" Sd 15,283'-289'	11'	4%	34%	Producing	173
					"C" Sd 15,331'-336'	9'	6%	87%	Non-Productive	
					"D" Sd 15,605'-610'	14'	4.5%	56%	Non-Productive	
Ochoa Fed. No. 1	Enron Oil & Gas	14,776'	11/81	7/82	Warren 15,082'-106'	18'	10%	25%	Abandoned	
Sec. 15-25S-33E	(Superior)				15,115'-124'	3'	5%	38%	Abandoned	
KB Elev. 3,400'					Sinatra 15,222'-236'	5'	5%	42%	Abandoned	40
					"C" Sd 15,594'-622'	14'	5%	30%	Non-Productive	
					"D" Sd 15,898'-908'	4'	8%	9%	Non-Productive	
Red Hills Ut. No. 1	Union Oil (Pure)	14,826'	2/63	12/64	U. Morr. 14,840'-864'	10'	3%	45%	Abandoned	236
Sec. 32-25S-33E					"A" Sd/					
KB Elev. 3,382'					Warren 15,034'-138'	5'	11%	43%	Non-Productive	
					"B" Sd 15,442'-530'	7'	9%	58%	Non-Productive	
Vaca Draw Ut. No. 1	American Quasar	14,740'	10/71	12/72	"A" Sd 14,954'-970'	15'	6%	71%	Non-Productive	
Sec. 21-25S-33E					"B" Sd/					
KB Elev. 3,392'					Sinatra 15,183'-330'	36'	4%	66%	Non-Productive	
					"C" Sd/					
					"D" Sd 15,512'-716'	11'	8%	29%	Non-Productive	

INDIVIDUAL WELL DATA

MORROW FORMATION

VACA DRAW / PITCHFORK RANCH AREA

Lea County, New Mexico

lh117bzl
11/27/91

WELL NAME	OPERATOR	DEPTH OF MORROW	SPUD DATE	COMPLETION DATE	MORROW PERFORATIONS	PAY THICKNESS	POROSITY	WATER SATURATION	STATUS	CUM PRODUCTION MMCFG
Vaca "13" Fed. No. 1	Enron Oil & Gas	14,700'	8/83	12/83	Warren 15,014'-053'	22'	6%	42%	Non-Productive	
Sec. 13-25S-33E					"B" Sd 15,264'-288'	13'	6.5%	40%	Non-Productive	
KB Elev. 3,387'					"C" Sd 15,493'-546'	14'	5%	33%	Non-Productive	
Vaca Draw "16" St. No. 1	Hallwood (EOG)	14,889'	2/81	9/81	U. Morr./					
Sec. 16-25S-33E					Warren 15,058'-209'	13'	7%	37%	Non-Productive	
KB Elev. 3,443'					Sinatra 15,327'-331'	4'	8%	29%	Non-Productive	
					"B" Sd 15,457'-502'	26'	7%	35%	Non-Productive	
					"C" Sd 15,660'-718'	29'	6%	69%	Non-Productive	

(1) DST Only
(2) DST/Perforated
(3) No Resistivity Log
(4) No Porosity Log
(5) No Openhole Logs

VACA DRAW/PITCHFORK AREA
TGF DESIGNATION - MORROW SANDS

SUMMARY OF WELL COMPLETION DATA
AND BOTTOM HOLE PRESSURES

ENRON OIL AND GAS COMPANY

VACA DRAW / PITCHFORK AREA TGF DESIGNATION MORROW SANDS

27-Nov-91

SUMMARY OF WELL COMPLETION DATA AND BOTTOM HOLE PRESSURES

LH117RCL

WELL	INTERVAL	PRE-STIM FLOW TEST @ FTP	BREAKDOWN	STIM FLUID and AMOUNTS	MAX IP AIP #	AIR BPM	POST-STIM FLOW TEST @ FTP	INITIAL RESERVOIR PRESSURE SIBHP (PSIA) M, C or EST		IF C OR EST SITP
Andrikopoulos No. 1	15,554'-64'	No flow	Natural	2,000 gal 7-1/2% Acid w/ 1 MCF N2/bbl	8,200# 6,500#	3.8 BPM	No flow	-	-	6,100 #
	14,986'-15,209'	240 MCFD @ 25#		5,000 gal 7-1/2% Acid w/ 1 MCF N2/bbl	8,150# 7,600# 7,600#	5.2 BPM	1,080 MCFD @ 630#	11,421#	M	9,100#
	15,301'-355'	DST No flow								
Bell Lake 2 St No. 1	15,380'-458'	500 MCFD @ 30#	Spot acid	3,000 gal 7-1/2% Acid	9,000# 8,000#	6 BPM	680 MCFD @ 4,325#	9,335#	M	
	15,159'-458'	No test	-	5,000 gal 7-1/2% Acid	10,000# 7,140#	4.5 BPM	1,100 MCFD @ 1,250#	8,996#	M	6,443#
	14,819'-92'	5' Flare 0# 50 MCFD EST	Natural	3,500 gal 7-1/2% Acid	8,600# 8,500#	3.5 BPM	356 MCFD @ 825#	9,745#	C	7,114#
Bell Lake 11 No. 1	15,447'-82'	Gas, Mud, H2O		Cement Squeeze						
	15,210'-20'	No Flow	750 gal spot	2,500 gal 7-1/2% Acid w/ .5 MCF N2/bbl	7,300#	3.1 BPM	No flow set CIBP	-		7,511#
	14,883'-977'	No test	-	3,000 gal 7-1/2% Acid w/ .5 MCF N2/bbl	7,500# 7,100#	3 BPM	1,350 MCFD @ 2,050#	10,391#	M	8,229#
Brinninstool 21 Fed No. 1	15,759'-66'	2,574 MCFD @ 3,900#	20 bbl spot acid	-	-	-	-	10,734#	M	
	15,170'-383'	1,600 MCFD @ 4,900#	Natural	-	-	-	-	8,500#	EST	6,200#
Diamond "6" Fed. No. 1	15,234'-556' 14,897'-15,017'	2,000 MCFD @ 764#	200 gal	5,000 gal 7-1/2% Acid	7,400# 6,500#	5.9 BPM	5,300 MCFD @ 6,464	9,824#	M	
Diamond "36" SM No. 1	15,217'-98'	No flow	N2 Breakdown	3,500 gal 7-1/2% Acid w/ .50 MCF N2/bbl	6,000# 6,200#	5.3 BPM	1,500 MCFD @ 2,450#	8,500#	EST	5,900#
	14,994'-15,028'	No flow	Natural	1,500 gal 7-1/2% Acid 4,000 gal Alcogel w/ .74 MCF N2/bbl	9,100# 8,200#	10 BPM	760 MCFD @320#	8,500#	EST	6,800#
	14,892'-900'	No flow	Natural	2,000 gal 7-1/2% Acid w/ 1 MCF N2/bbl	9,200# 8,000#	4 BPM	136 MCFD @ 860#	8,966#	C	7,200#
	14,674'-698'	866 MCFD @ 410#	500 gal spot	1,000 gal 7-1/2% Acid	8,000# 6,995#	4.5 BPM	1,155 MCFD @ 1,250#	7,711#	M	-

VACA DRAW / PITCHFORK AREA TGF DESIGNATION MORROW SANDS

27-Nov-91

SUMMARY OF WELL COMPLETION DATA AND BOTTOM HOLE PRESSURES

LH117RCL

WELL	INTERVAL	PRE-STIM FLOW TEST @ FTP	BREAKDOWN	STIM FLUID and AMOUNTS	MAX IP AIP #	AIR BPM	POST-STIM FLOW TEST @ FTP	INITIAL RESERVOIR PRESSURE SIBHP (PSIA) M, C or EST		IF C OR EST SITP
Flagler Fed. No. 1	15,529'-75'	Swab H2O Not enough data to make calculations								
Gila "4" Deep Com. No. 1	15,490'-594'	Swab H2O Not enough data to make calculations								
Half 6 Fed No. 1	15,288'-360'	1,700 MCFD @ 1,250#	Natural	2,000 gal 7-1/2% Acid +4,000 gal Alcogel w/ .75 MCF N2/bbl Sand Frac w/ 42 M gal 60 quality CO2/Alco foam w/ 35 M# sand	9,200# 8,800# 11,238# 8,807#	11 BPM 18 BPM	1,700 MCFD @ 1,250# 6,521 MCFD @ 2,220#	4,574#	C	3,279#
Javelina Basin Unit No. 1	15,154'-420'	No report	-	5,000 gal 7-1/2% Acid w/ 1 MCF N2/bbl	8,900#	6.3 BPM	1,231 MCFD @ 3,365#	9,014#	C	7,094#
	14,594'-604'	No report	-	2,500 gal 7-1/2% Acid	-	-	101 MCFD @ 950#	9,210#	C	7,400#
Longway Draw No. 1	15,605'-10'	141 MCFD @ 96#	250 gal	2,000 gal 7-1/2% Acid w/ 2,000 gal CO2	10,000# 9,400#	4 BPM	141 MCFD @ 89#	8,500#	EST	6,500#
	15,047'-289'	No flow	Natural	5,000 gal 7-1/2% Acid w/ 29 tons CO2	14,800# 13,005#	5 BPM	504 MCFD @ 455#	9,039#	M	
	14,829'-865'	No flow	Natural							
	14,829'-15,289'	-	-	2,000 gal 7-1/2% Acid w/ 1 MCF N2/bbl	7,600#	3 BPM	550 MCFD @ 713 psia BH	9,986#	M	7,250#
Ochoa Fed. No. 1	15,898'-908'	285 MCFD @ 500#	40 BBL Methanol/H2O	None				9,311#	EST	6,715#
	15,594'-908'	450 MCFD @ 770#	110 BBL Methanol/H2O	None				9,311#	EST	
	15,082'-236'	2,400 MCFD @ 5,600#	Natural	None				9,311#	EST	6,014#

VACA DRAW / PITCHFORK AREA TGF DESIGNATION MORROW SANDS

27-Nov-91

SUMMARY OF WELL COMPLETION DATA AND BOTTOM HOLE PRESSURES

LH117RCL

WELL	INTERVAL	PRE-STIM FLOW TEST @ FTP	BREAKDOWN	STIM FLUID and AMOUNTS	MAX IP AIP #	AIR BPM	POST-STIM FLOW TEST @ FTP	INITIAL RESERVOIR PRESSURE SIBHP (PSIA) M, C or EST		IF C OR EST SITP
Red Hills Unit No. 1	15,442'-530'	No flow	Failed Hole in tubing	None						
	15,034'-138'	No flow	26 bbl Acid	None Cement squeeze						
	14,840'-64'	1,360 MCFD @ 420#	48 bbl Acid	5,000 gal Acid	-	-	2,300 MCFD @ 600#	7,405#	M	5,794#
Vaca Draw Unit 1	15,291'-322'	30 MCFD @ 0#	240 bbl H2O	365 bbl gelled H2O Myti-Frac	-	-	500 - 1,500 MCFD No psi reported	8,500#	EST	
	14,954'-15,330'	400 MCFD @ 60#	No report	6,000 gal Acid	-	-	90 MCFD @ 250#	8,500#	EST	
Vaca Draw 13 Fed No. 1	15,493'-546'	No flow	5 bbl spot acid	4,500 gal 7-1/2% Acid w/ .5 MCF N2/bbl	8,000#	3 BPM	No flow			
	15,264'-88'	50 MCFD @ 0#	Natural	4,000 gal 7-1/2% Acid w/ .5 MCF N2/bbl	9,200# 8,200#	5.3 BPM	350 MCFD @ 360#	9,063#	C	7,214#
	15,014'-53'	No flow	H2O	4,000 gal 7-1/2% Acid w/ .5 MCF N2/bbl	9,200# 7,700#	4.9 BPM	850 MCFD @ 3,650#	10,814#	C	8,800#
Vaca Draw 16 St 1	15,058'-718'	No measurable flow	750 gal spot	3,500 gal 7-1/2% Acid w/ .5 MCF N2/bbl	8,200# 8,000#	5.8 BPM	No flow			

VACA DRAW/PITCHFORK AREA
TGF DESIGNATION - MORROW SANDS

HIGH COST RECOMPLETIONS AND PRODUCTION ENHANCEMENT TECHNIQUES USED IN PITCHFORK RANCH FIELD

ENRON OIL AND GAS COMPANY

ENRON OIL & GAS COMPANY

VACA DRAW / PITCHFORK RANCH AREA

TGF Designation – Morrow Sands

High Cost Recompletions and Production Enhancement Techniques Used in Pitchfork Ranch Field

11/27/91

lh122rcl

WELL NAME	DESCRIPTION OF WORK DONE	WORKOVER RESPONSE	COST INCURRED
Diamond "31" Fed. No. 1	In 1989, acidized with 5,000 gal. and fracture treated with 46,000 gal. Alcofoam and 30,000 lbs. sand.	From 30 MCFPD to 800 MCFPD	$137,000
Diamond SM-36 No. 1	Starting in November 1990, fracture treated the "C" sand with 42,000 gal. Alcofoam and 35,000 lbs. sand. Had to re-perf and mine frac before main job would go.	From 300 MCFPD to 1,500 MCFPD	$231,000
	Set sand plug across "C" sand, perforated "B" sand, acidized and minifrac.	From 0 MCFPD to 760 MCFPD	$54,000
	Set sand plug across "B" sand, perfed Sinatra sand, re-perfed Sinatra. Zone has bridged off, wireline tools blew out of hole when bridge broke. Left some tools and debris in hole. Fishing and milling job failed. Left a mill and debris in hole. Job took 43 days.	From 0 MCFPD to 136 MCFPD	$354,000
	Set sand plug across Sinatra Morrow; perfed "A" sand; attempted acid job but could not pump in; re-perf "A" sand, perf gun got stuck in hole, attempted fish job for gun and mill for 40 days. Set CIBP @ 14,839', re-perf "A" sand, Breakdown with 500 gal acid, pump 1,000 gal. acid and 3,530 gal. flush.	From 0 MCFPD to 1,155 MCFPD	$417,000
	Will fracture treat "A" sand with 40,000 gal. Alcofoam and 35,000 lbs. sand.	Estimate 2,000 MCFPD increase	$130,000 Total Well $1,186,000
Half "5" Fed. Com. No. 1	In November 1989 thru April 1990, perfed additional "B" sand and fracture treated well with 48,000 gal. Alcofoam and 35,300 lbs. sand.	From 2,000 MCFPD to 4,500 MCFPD	$132,000
Half "6" Fed Com. No. 1	During completion operations in January 1991, acidized with 2,000 gal. acid and fracture treated with 42,000 gal. CO2/Alcofoam and 35,000 lbs. sand.	From 1,700 MCFPD to 5,000 MCFPD	$129,000
Madera "29" Fed. Com. No. 1	In April 1990, fracture treated "C" sand with 48,000 gal. Alcofoam and 35,300 lbs. sand.	From 800 MCFPD to 2,000 MCFPD	$135,000

ENRON OIL & GAS COMPANY

VACA DRAW / PITCHFORK RANCH AREA

TGF Designation – Morrow Sands

High Cost Recompletions and Production Enhancement Techniques Used in Pitchfork Ranch Field

11/27/91

lh122rcl

WELL NAME	DESCRIPTION OF WORK DONE	WORKOVER RESPONSE	COST INCURRED
Madera "33" Fed. No. 1	During drilling operations in 1983, drill pipe was stuck at 15,000'. Fishing job took 28 days. Could not recover fish.	-	$410,000
	Sidetrack operations were done twice for 42 days.	-	$520,000
	Lost returns while cementing 4-1/2" csing. Squeezed four times.	-	$200,000
	In 1989, the well started flowing rocks and mud. Cement broke down. Squeezed liner 3 times isolated "A" and "C" sands. Re-perf "A" & "C" sands. Fracture treated "C" sand with 46,000 gal. Alcofoam and 28,000 lbs. sand.	"A" sand same as before workover "C" sand 600 MCFPD after frac, now dead	$1,113,000 Total Well $2,653,000
Madera "33" Fed. No. 2	In August 1989, acidized existing "C" sand with 5,500 gal. 7-1/2% acid. Fracture treated with 24,000 gal. Alcofoam and 17,000 lbs. sand. Well screened out prior to flush.	From 950 MCFPD to 2,100 MCFPD	$85,000
Marshall "29" Fed. No. 1	In December 1990, fracture treated the Morrow "C" sand with 43,000 gal. Alcofoam and 35,000 lbs. sand	From dead to 800 MCFPD	$145,000

ITERATIVE METHOD OF ESTIMATING FORMATION PERMEABILITY AND STABILIZED FLOW RATE FROM TRANSIENT FLOW DATA

(S.A. Holditch and W.J. Lee)

Formation permeability and stabilized flow rate can be estimated from short-term, pre-stimulation flow tests in tight gas reservoirs. These formation and well properties are rarely measured directly; accordingly, there is a need to calculate them from the types of measurements that are made. The calculated properties can then be used to assist regulatory agencies in determining when specific formations qualify for special price incentives.

Permeability and stabilized rate estimation procedures proposed in this report are based on flow equations firmly grounded in recent research in gas flow in porous media. Application of the equations is straightforward, as examples in the report illustrate.

2.0 INTRODUCTION

The purpose of this report is to present and illustrate calculation techniques to (1) estimate formation permeability from transient flow data in low permeability gas wells and (2) to estimate stabilized flow rate in an unstimulated gas well from data obtained during the transient flow period.

The need to estimate formation permeability arises because coring and core analysis at insitu formation conditions are infrequent in most reservoirs. The need to calculate (rather than measure) stabilized flow rates in low permeability wells arises because it can require months or years for rates to stabilize, making measurements impractical. In fact, most of these wells must be stimulated before they can produce at economic rates; accordingly, pre-stimulation tests of significant duration are rare. Despite scarcity of data, however, knowledge of formation permeability and stabilized flow rate may be required for a reservoir to be classified as a "tight gas reservoir" and thus qualify for special regulatory treatment, such as price incentives.

The calculation techniques are stated and illustrated in the following sections of this report. The theoretical basis for the techniques is summarized in the Appendix.

Formation permeability can be estimated from transient (unsteady-state) flow test data obtained from a low permeability gas well prior to stimulation. In the Appendix, we show that flow in a gas well at pressures greater than about 3000 psia can be modeled adequately by*

$$\frac{q_g}{\bar{p} - p_{wf}} = \frac{kh}{141.2\, B_{gi}\mu_i \left[\ln\left(\frac{r_d}{r_w}\right) - 0.75 + s'\right]}$$

where

$$r_d = \left(\frac{kt}{376\phi\mu_i c_{ti}}\right)^{\frac{1}{2}}, \quad t \leq 948\, \phi\mu_i c_{ti} r_e^2/k$$

and

$$r_d = r_e, \quad t > 948\, \phi\mu_i c_{ti} r_e^2/k$$

Strictly speaking, this equation is valid only for tests conducted at constant rate; however, it is an acceptable approximation when rate declines smoothly (rather than abruptly), as in production through a fixed choke[4]. For lower reservoir pressures, a similar equation written in terms of a difference in pressures squared is a better model; this equation is also discussed in the Appendix.

* A table of nonmenclature is provided at the end of this report.

Permeability can be estimated using an iterative technique based on a simple rearrangement of the basic equation:

$$k = \frac{141.2\ q_g\ B_{gi}\ \mu_i}{h\ (p_i - p_{wf})}\ \left[\ln\left(\frac{rd}{r_w}\right) - 0.75 + s'\right]$$

Application of this equation for permeability estimation is illustrated in the following example.

Example: An unstimulated well in the Cotton Valley formation flowed at 100 MCF/D. The rate was measured at 6 hour flow time; flowing bottom hole pressure was estimated to be 3000 psia at this time.

Other formation and completion properties are assumed to be:

$\gamma_g = 0.65$

$T = 265°\ F$

$p_i = 5200$ psia

$\phi_g = 0.045$

$r_w = 0.333$ ft

$h = 50$ ft

$Z_i = 0.983$

$c_{gi} = 1 \times 10^{-4}\ psi^{-1}$

$\mu_{gi} = 0.0328$ cp

Spacing = 320 acres

$B_{gi} = 0.691$ RB/Mscf

Estimate formation permeability from these data.

Solution: Our method will be (1) to assume a value of k and calculate a transient radius of drainage, r_d, from

$$r_d = \left(\frac{kt}{376\ \phi \mu_i c_{ti}}\right)^{\frac{1}{2}} \qquad \text{or,}\ r_d = \left(\frac{Kt}{376\ \phi g\ ui\ Cgi}\right)^{1/2}$$

(2) to calculate k from

$$K = \frac{141.2\ q_g B_{gi} \mu_i}{h(p_i - p_{wf})} \left[\ln \left(\frac{r_d}{r_w}\right) - 0.75 + s'\right] ;$$

(3) to repeat steps (1) and (2) until assumed and calculated values of k agree;

(4) to verify that flow is transient at 6 hour flow time by checking the inequality

$$t \leq 948\ \phi \mu_i c_{ti} r_e^2/k \qquad \text{or, } T = 948\ \phi g\ ui\ Cgi\ r_e^2/k$$

Additional assumptions will be required in this case before a permeability estimate is possible.

(1) $s' = 0$ for this well (negligible damage or stimulation).

(2) $\phi c_{ti} \equiv \phi_g c_{gi}$ (almost always an adequate assumption in a well producing only gas).

(3) Effective drainage radius, r_e, found from $\pi r_e^2 = (43{,}560)(320)$ or $r_e = 2106$ ft.

Trial 1: Assume k = 0.01 md.

$$r_d = \left[\frac{(0.01)(6)}{(376)(0.045)(0.0328)(1\times10^{-4})}\right]^{\frac{1}{2}} = 32.9 \text{ ft}$$

$$k = \frac{(141.2)(100)(0.69)(0.0328)}{(50)(5200-3000)} \left[\ln\left(\frac{32.9}{0.333}\right) - 0.75 + 0\right] = 0.0112 \text{ md}$$

Calculated k is slightly greater than assumed k; at least one more trial will be required.

Trial 2: Assume k = 0.0112 md.

$$r_d = (32.9)\left(\frac{0.0112}{0.01}\right)^{\frac{1}{2}} = 34.8 \text{ ft}$$

$$k = (0.00291)\left[\ln\left(\frac{34.8}{0.333}\right) - 0.75\right] = 0.0113 \text{ md}$$

Convergence is adequate; k = 0.0113 md. We can verify that flow is unsteady state by noting that

$$6 \text{ hr} < 948\,\phi\mu_i c_{ti} r_e^2/k = (948)(0.045)(0.0328)(1\times10^{-4})(2106)^2/0.0113$$
$$= 5.49 \times 10^4 \text{ hr}$$

Flow is transient, and will remain so for 5.49×10^4 hr (6.3 yr) -- which illustrates vividly why stabilized flow conditions are not likely to be obtained in the typical tight gas reservoir flow tests.

Note: The iterative procedure used in this example would best be applied in practice using a programmable calculator or computer.

4.0 STABILIZED FLOW RATE CALCULATION FROM TRANSIENT TEST DATA

Stabilized flow rate at a given pressure drawdown can be estimated from flow rate measured during transient conditions by taking the ratio of $q/(\bar{p} - p_{wf})$ from the transient and pseudo-steady-state equations. The result is

$$\frac{q_{gs}}{q_g(t)} = \frac{\ln\left(\frac{r_d}{r_w}\right) - 0.75 + s'}{\ln\left(\frac{r_e}{r_w}\right) - 0.75 + s'}$$

where

$$r_d = (kt/376\ \phi\mu_i c_{ti})^{\frac{1}{2}} \cong (kt/376\ \phi_g\mu_i c_{gi})^{\frac{1}{2}}$$

Application of this equation is illustrated by the following example.

Example: Estimate the stabilized rate at which the well described in the previous example could deliver gas with a drawdown in bottom hole pressure of 2200 psi.

Solution: The first step in the calculation procedure is to determine formation permeability, k, so that the transient radius of drainage, r_d, can be estimated. In this example, permeability has been determined by the iterative procedure to be 0.0113 md, and r_d is 35.0 feet.

The next step is to calculate the stabilized gas flow rate, q_{gs}, from the equation

NOMENCLATURE

Symbol	Definitions
B_{gi}	$5.04\ TZ_i/p_i$ = Gas formation volume factor evaluated at initial reservoir pressure, RB/Mcf.
$\bar{B}_g$	$5.04\ T\bar{Z}/\bar{p}$ = Gas formation volume factor evaluated at average reservoir pressure, RB/Mcf.
c_{gi}	Gas compressibility evaluated at initial reservoir pressure, psi^{-1}.
c_{ti}	Total system compressibility evaluated at initial reservoir pressure, psi^{-1}.
D	Turbulance or non-Darcy flow coefficient, D/Mcf
h	Net formation thickness, ft
k	Formation permeability, md
p_D	Dimensionless pressure
p_i	Initial formation pressure, psi
p_{sc}	Standard-condition pressure (14.7 psi)
p_{wf}	Flowing bottom hole pressure, psi
q_g	Gas flow rate, Mcf/D
q_{gs}	Stabilized gas flow rate, Mcf/D
$q_g(t$	Transient gas flow rate, Mcf/D
r_d	$(kt/376\ \phi\mu_i c_{ti})^{\frac{1}{2}}$ = Transient radius of drainage, ft
r_e	Radius of drainage, ft
r_w	Wellbore radius, ft
s	Skin factor, dimensionless
s'	$s + D\lvert q_g \rvert$ = Apparent skin factor, dimensionless
t	Elapsed time, hr
T	Formation temperature, °R
T_{sc}	Standard-condition temperature (520° R)
Z_i	Gas law deviation factor elevated at initial reservoir pressure, dimensionless
γ_g	Gas gravity (air = 1.0)
μ_i	Gas viscosity evaluated at initial reservoir pressure, cp
ϕ	Formation porosity, fraction
ϕ_g	Gas porosity, fraction

$$q_{gs} = q_g\,(t)\,\frac{[\ln (rd/r_w) - 0.75 + s']}{[\ln (r_e/r_w) - 0.75 + s']}$$

In this case,

$$q_{gs} = \frac{100\,[\ln (35.0/0.333) - 0.75 + 0]}{[\ln (2106/0.333) - 0.75 + 0]} = 48.8 \text{ Mcf/D}$$

Thus, with the same drawdown (2200 psi) observed in the 6 hour test, the stabilized rate would be approximately 48.8 Mcf/D. Approximately 6.3 years would be required to achieve this rate, as calculated in the previous example.

Once stabilized rate is known at the pressure drawdown imposed in the transient flow test, stabilized rate at other drawdowns can be estimated from the relationship

$$q_{gs,2} = q_{gs,1}\,\frac{(\bar{p}-p_{wf})_2}{(\bar{p}-p_{wf})_1}$$

This relationship is approximately correct when the apparent skin factor, s', is negligible or when its dependence on rate is negligible.

REFERENCES

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4. Winestock, A. G. and Colpitts, G. P.: "Advances in Estimating Gas Well Deliverability", J. Cdn. Pet. Tech. (July-Sept. 1965) 111-119.

APPENDIX

The purpose of this Appendix is to present derivations of equations used to estimate permeability and stabilized flow rate in low permeability, high pressure gas reservoirs. These equations include a transient flow equation, an equation for transient radius of drainage, and a pseudo-steady-state flow equation.

Transient Flow Equation

Recent research[1,2] has shown that, for reservoir pressures above 3000 psia, gas flow in a reservoir is adequately modeled by the equation

$$p_{wf} = p_i - 50{,}300 \frac{Z_i \mu_i}{2p_i} \frac{p_{sc}}{T_{sc}} \frac{q_g T}{kh} [p_D + s + D|q_g|] \qquad (1)$$

For transient flow (i.e., flow in which the pressure drawdown has not yet been influenced by reservoir boundaries),

$$p_D = \tfrac{1}{2} \ln \left(\frac{kt}{1688\ \phi \mu_i c_{ti} r_w^2}\right) \qquad (2)$$

Thus, for transient flow at high pressures,

$$p_{wf} = p_i - 50{,}300 \frac{Z_i \mu_i}{2p_i} \frac{p_{sc}}{T_{sc}} \frac{q_g T}{kh} \left[\tfrac{1}{2} \ln \left(\frac{kt}{1688\ \phi \mu_i c_{ti} r_w^2}\right) + s + D|q_g|\right] \qquad (3)$$

This equation can be simplied with the following substitutions:

$$s' = s + D|q_g| \tag{4}$$

$$\frac{T_{zi}}{p_i} = B_{gi}/5.039 \tag{5}$$

The result, for T_{sc} = 520° R and p_{sc} = 14.7 psia

$$p_{wf} = p_i - \frac{141.2\ q_g B_{gi} \mu_i}{kh} \left[\tfrac{1}{2} \ln \left(\frac{kt}{1688\ \phi \mu_i c_{ti} r_w^2}\right) + s'\right] \tag{6}$$

It is convenient to define a transient radius of drainage, r_d, as[1]

$$r_d^2 = \frac{kt}{376\ \phi \mu_i c_{ti}} \tag{7}$$

In terms of this radius of drainage,

$$p_{wf} = p_i - \frac{141.2\ q_g B_{gi} \mu_i}{kh} \left[\ln \left(r_d/r_w\right) - 0.75 + s'\right] \tag{8}$$

For reservoir pressures below 2000 psia, gas flow in a reservoir is better modeled by the equation

$$p_{wf}^2 = p_i^2 - 50{,}300\ \ Z_i \mu_i\ \ \frac{p_{sc}}{T_{sc}}\ \ \frac{q_g T}{kh}\ \ \left[\ p_D + s'\right] \tag{9}$$

For transient flow, equation (2) still relates p_D to time; thus, for T_{sc} = 520° R and p_{sc} = 14.7 psia,

$$p_{wf}^2 = p_i^2 - 1422\ \frac{q_g T \mu_i Z_i}{kh}\ \ \left[\tfrac{1}{2} \ln \left(\frac{kt}{1688\ \phi \mu_i c_{ti} r_w^2}\right) + s'\right] \tag{10}$$

which can also be written

$$p_{wf}^2 = p_i^2 - \frac{1422\, q_g T \mu_i Z_i}{kh} \left[\ln\left(\frac{r_d}{r_w}\right) - 0.75 + s'\right] \qquad (11)$$

For pressures between 2000 and 3000 psia, both equations (8) and (11) are somewhat inaccurate; traditionally, an equation in the "p^2" form similar to equation (11) has been used. At all pressure levels, flow is transient for $t \leq 948\, \phi \mu_i c_{ti} r_e^2/k$. Finally, we note that for brief-duration transient flow in a "new" (previously unproduced) portion of a reservoir, $\bar{p} \equiv p_i$; thus, $\bar{p}$ can replace p_i in equations (8) and (11).

Pseudo-Steady-State Equation

For pseudo-steady-state flow (i.e., flow in which the pressure drawdown has reached the drainage radius of the well) in a cylindrical reservoir (well centered)[3],

$$p_D = \frac{0.0005274\, kt}{\phi \mu_i c_{ti} r_e^2} + \ln\left(\frac{r_e}{r_w}\right) - 0.75 \qquad (12)$$

For higher-pressure reservoirs, then, substituting into equation (11) and application of simplifications (4) and (5) gives

$$p_{wf} = p_i - \frac{0.07447\, q_g B_{gi} t}{\phi h r_e^2 c_{ti}} - \frac{141.2\, q_g B_{gi} \mu_i}{kh} \left[\ln\left(\frac{r_e}{r_w}\right) - 0.75 + s'\right] \qquad (13)$$

Average drainage area pressure, $\bar{p}$, can be related to original reservoir pressure, p_i, with a material balance

$$p_i - \bar{p} = \frac{0.07447\, q_c \bar{B}_g t}{\phi h r_e^2 c_t} \cong \frac{0.07447\, q_g B_{gi} t}{\phi h r_e^2 c_{ti}} \qquad (14)$$

Thus, the pseudo-steady-state equation can be written in the simplified form

$$p_{wf} = \bar{p} - \frac{141.2\, q_g B_{gi} \mu_i}{kh} \left[\ln \left(\frac{r_e}{r_w}\right) - 0.75 + s'\right] \qquad (15)$$

For lower pressure reservoirs better described by the "p^2" equation, substiiution of equation (12) into equation (9) gives

$$p_{wf}^2 = p_i^2 - \frac{0.750\, q_g T Z_i t}{\phi h r_e^2 c_{ti}} - \frac{1422\, q_g T \mu_i Z_i}{kh} \left[\ln \left(\frac{r_e}{r_w}\right) - 0.75 + s'\right] \qquad (16$$

Now the material balance can be written

$$p_i - \bar{p} = \frac{0.07447\, q_g \bar{B}_g t}{\phi h r_e^2 c_t} \cong \frac{0.375\, q_g T Z_i t}{\phi h r_e^2 c_{ti} (\bar{p}+p_i)/2} \qquad (17)$$

or

$$p_i^2 - \bar{p}^2 \cong \frac{0.750\, q_g T Z_i t}{\phi h r_e^2 c_{ti}} \qquad (18)$$

Then, as an approximation,

$$p_{wf}^2 = \bar{p}^2 - \frac{1422\, q_g T \mu_i Z_i}{kh} \left[\ln \left(\frac{r_e}{r_w}\right) - 0.75 + s'\right] \qquad (19)$$

Equations (15) and (19) are applicable for $t > 948\, \phi \mu_i c_{ti} r_e^2/k$.

Summary of Working Equations

The equations useful in applications for a gas well with $p > 3000$ psi are:

$$p_{wf} = \bar{p} - \frac{141.2\, q_g\, B_{gi}\, \mu_i}{kh} \left[\ln\left(\frac{r_d}{r_w}\right) - 0.75 + s'\right]$$

where

$$r_d = \left(\frac{kt}{376\, \phi \mu_i c_{ti}}\right)^{\frac{1}{2}}, \quad t \leq 948\, \phi \mu_i\, c_{ti}\, r_e^2/k$$

and

$$r_d = r_e, \quad t > 948\, \phi \mu_i c_{ti} r_e^2/k$$

For a gas well with $p < 2000$ psi, the working equations are

$$p_{wf}^2 = \bar{p}^2 - \frac{1422\, q_g\, T\, \mu_i Z_i}{kh} \left[\ln\left(\frac{r_d}{r_w}\right) - 0.75 + s'\right]$$

where r_d has the same definition as above:

$$r_d = \left(\frac{kt}{376\, \phi \mu_i c_{ti}}\right)^{\frac{1}{2}}, \quad t \leq 948\, \phi \mu_i c_{ti} r_e^2/k$$

and

$$r_d = r_e, \quad t > 948 \phi \mu_i c_{ti} r_e^2/k$$

VACA DRAW/PITCHFORK RANCH AREA
TGS DESIGNATION

EXAMPLE CALCULATIONS
USING THE DIAMOND "6" FEDERAL NO. 1
PRE-STIMULATION FLOW DATA

Cgi = Gas compressibility evaluated at initial reservoir pressure, psi^{-1}

Pc = 675 psia T_c = 346° R (from 4-pt Form C-122)

Pr = 9,824 psia/675 psia = 14.6

Tr = $\frac{460 + 222}{346}$ = 1.97

Cgi = .034/675 = 5.04×10^{-5} spi^{-1} (From Fiq 6.10; Applied Petroleum Reservoir Engineering, Craft and Hawkins)

Bgi = Gas formation volume factor evaluated at initial reservior pressure, RB/Mcf

Bgi = $5.04\ TZ/P_i$

= (5.04)(682)(1.376)/9,824
= .482 RB/Mcf

kl813rcw

EXAMPLE : DIAMOND 6' FED No. 1

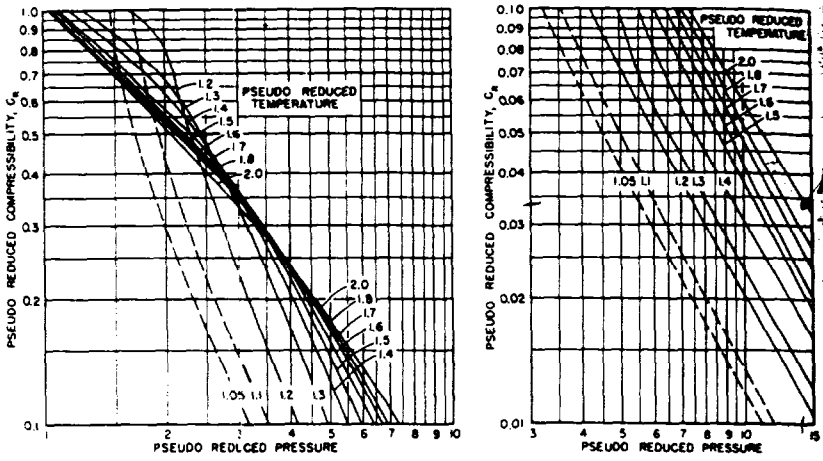

Fig. 6.10. The pseudoreduced compressibility of hydrocarbon gases as functions of their pseudoreduced temperatures and pressures. (*After* Trube,[5] *Trans.* AIME.)

pseudoreduced compressibility of a gas as a function of its pseudoreduced temperature and pressure. The actual compressibility is obtained by dividing the pseudoreduced compressibility by the pseudocritical pressure. Example 6.5 shows the use of Trube's curves.

Example 6.5. To find the compressibility of a 0.90 specific gravity gas condensate fluid at 150°F and 4500 psia using Fig. 6.10.

SOLUTION: From Fig. 1.2 find $p_c = 650$ psia and $T_c = 427$°R. Then

$$p_r = \frac{4500}{650} = 6.92 \text{ and } T_r = \frac{610}{427} = 1.43$$

From Fig. 6.10 find the pseudoreduced compressibility of 0.065 for $p_r = 6.92$ and $T_r = 1.43$. Then, since $p_c = 650$ psia,

$$c_g = \frac{0.065}{650} = 100 \times 10^{-6}\text{psi}^{-1}$$

(Compare with Example 6.4.)

In the study of transient flow in reservoirs the diffusivity constant $k/\mu c\phi$ enters the equations. So long as there is only one fluid present and rock compressibility is neglected, the compressibility is simply the compressibility of the fluid and the porosity is simply the *total* effective porosity. Where gas, oil, and water are present in the pore space, but only one of these three phases is mobile, the permeability is the *effective* permeability to that mobile phase and the viscosity is the viscosity of the mobile phase. In this case the product $(c\phi)$ may be either (a) the product of the *average*

SEC. 3

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Example
$(c\phi)$.

Given:

$\phi = 0.$

$S_g = 0.$

$c_f = 7.$

$c_g = 1$

SOLUTION:

c_a

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-- Gas Viscosity --

Well Name	DIAMOND 6 FED 1	21-Nov-91
Field Name	PITCHFORK	

Pressure	9,824	psia	Z factor	1.376
Reservoir Temp	222	'F	Pressure/Z	7,141
Gas Gravity	0.580		Gas Viscosity	0.03224
Condensate (yes=1)	0			
% N2	0.41	%		
% CO2	0.64	%		
% H2S	0.00	%		

-- BHP or Pwf Calculation --

Well Name:	DIAMOND 6 FED 1			
Gas Gravity:	0.58	% N2	0.41	
Condensate (yes=1):	0	% CO2	0.64	%
Reservoir Temp:	222 'F	% H2S	0.00	%
Surface Temp:	60 'F	Pc =	675.11	%
Depth of Zone:	15,250 feet	Tc =	350.67	
Tubing Diameter:	2.350 inches			

FTP psia	Rate Mcfd	Pwf psia	Z	Pwf/Z psia
764	2,000	1,087	0.947	1,149
14	1,444	246	0.985	249
14	40,000	6,712	1.141	5,880