PETRO LEWIS CORPORATION

Oil and Gas Producers

Petro-Lewis Tower
717 17th Street, P.O. Box 2250
Denver, Colorado 80201-2250
303/620-1000

February 24, 1982

Division Director
New Mexico Oil Conservation Commission
State Land Office Building
Santa Fe, NM 87501

Dear Sir:

Petro-Lewis Corporation requests administrative approval for downhole commingling in its L. G. Warlick #1. We wish to commingle oil produced from Blinebry perforations at 5585' - 5737' and Penrose Skelly Grayburg perforations at 3736' - 3839'.

As shown on the attached well bore schematic the two zones are now separated by a packer. We are pumping the Blinebry zone below the packer and the Penrose Skelly is not producing. The last production date for the Penrose Skelly was November 1979. It was uneconomical to continue pumping that zone for 1 BOPD, so it was shut in.

If granted approval of this application, we intend to remove the packer and pump both zones through a single string of tubing. This will improve pumping efficiency as well as allowing recovery of reserves from the very marginal Penrose Skelly Graybrug zone which by itself is uneconomical to produce.

The information required by Rule 303-C is attached. We have notified all offset operators by copy of this application. Insofar as we have complied with the requirements of Rule 303-C we respectfully request your approval.

Sincerely,

Michael G. Handren

Michael G. Handren
Senior Staff Engineer

MGH/pp

attachments

PETRO LEWIS CORPORATION

Oil and Gas Producers

Petro-Lewis Tower
717 17th Street, P.O. Box 2250
Denver, Colorado 80201-2250
303/620-1000

February 24, 1982

Secretary - Director
NMOCC
State Land Office Building
Santa Fe, NM 87501

RE: Application for
Downhole Commingling
L. G. Warlick #1

Dear Sir:

In accordance with Statewide Rule 303-C, I am submitting the following information in application for a downhole commingling permit.

a) Operator: Petro-Lewis Corporation
P. O. Box 2250
Denver, CO 80201

b) Lease & Well: L. G. Warlick Lease
Well Number 1
Unit A, Sec. 19, T 21 S, R37E
Lea County, NM

c) Completed Pools: Blinebry - Perfs @5585' - 5737'
Penrose Skelly Grayburg - Perfs @3736' - 3859'
This dual completion was authorized by order MC-1599 on February 18, 1965.

d) Current Production Test on from C-116.
A current test (within 30 days) is attached for the Blinebry zone. We do not have a current test (within 30 days) for the Penrose Skelly zone since that zone has not produced since November 1979. The last producing rate at that time was 1.6 BOPD, 10 BWPD, 60 MCFGPD on pump. This test is attached on from C-116.

e) A Production Decline Curve for each zone is attached.

f) Estimated Bottom Hole Pressure for each atrifically lifted zone.
Blinebry - ~~250 psi~~ 855
Penrose Skelly Grayburg - ~~150 psi~~ 878

Please show how these pressures were determined
Thank you
Michael Stogner

g) A Description of the Fluid Characterisitcs:
Blinebry Oil - 34.4° API gravity, sour crude
Penrose Skelly Oil - 37.5° API gravity, sour crude

h) The value of the crude will not be reduced. These same zones are commingled downhole in other wells and also in surface facilities on Petro-Lewis' Warlick, Warlick A, Warlick B, and State DC Leases.

i) All offset operators have been notified by certified mail of the proposed commingling. Copies of the receipts are attached.

j) The ownership of both zones is common as to working interest, royalties, and overrides.

Sincerely,

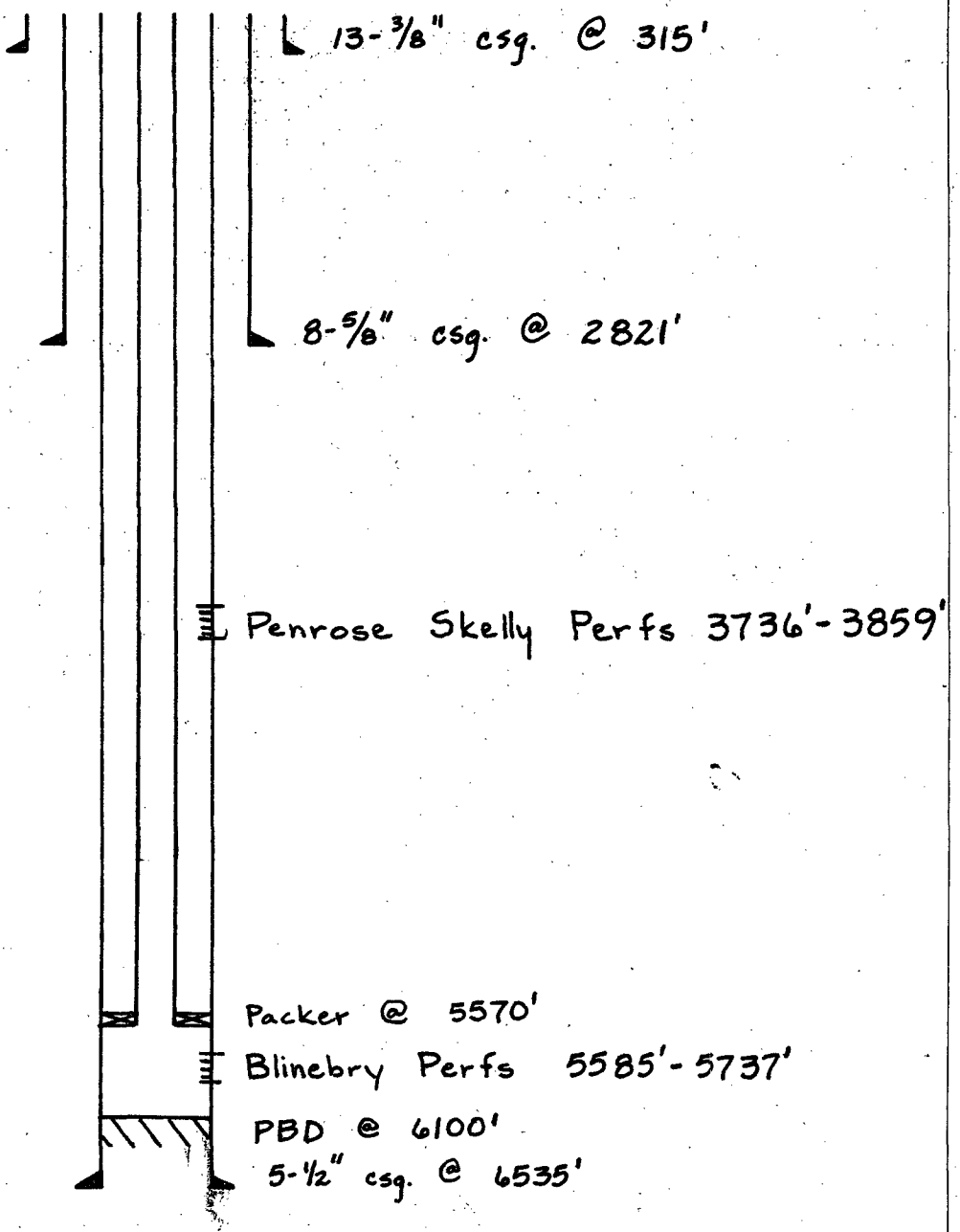
Michael G. Handren

Michael G. Handren
Senior Staff Engineer

MGH/pp

attachments

Petro Lewis Corporation
L. G. Warlick No. 1
Unit A, Sec. 19, T-21-S, R-37-E
Lea County, N.M.



42-381 50 SHEETS 5 SQUARE
42-382 100 SHEETS 5 SQUARE
42-389 200 SHEETS 5 SQUARE
NATIONAL

STATE OF NEW MEXICO
ENERGY AND MINERALS DEPARTMENT

P. O. BOX 2088
SANTA FE, NEW MEXICO 87501

Form C-116
Revised 10-1-78

GAS – OIL RATIO TESTS

Operator	Pool	County
Petro-Lewis Corporation	Blinebry	Lea

Address	TYPE OF TEST – (X)	Scheduled ☐	Completion ☐	Special ☒
P. O. Box 2250, Denver, CO 80201				

LEASE NAME	WELL NO.	LOCATION U	S	T	R	DATE OF TEST	STATUS	CHOKE SIZE	TBG. PRESS.	DAILY ALLOWABLE	LENGTH OF TEST HOURS	PROD. DURING TEST WATER BBLS.	GRAV. OIL	OIL BBLS.	GAS M.C.F.	GAS – OIL RATIO CU.FT/BBL
L. G. Warlick	1	A	19	21S	37E	1-30-82	P	None	25	10	24	15	34.4	4	8.3	2075

No well will be assigned an allowable greater than the amount of oil produced on the official test.

During gas-oil ratio test, each well shall be produced at a rate not exceeding the top unit allowable for the pool in which well is located by more than 25 percent. Operator is encouraged to take advantage of this 25 percent tolerance in order that well can be assigned increased allowables when authorized by the Division.

Gas volumes must be reported in MCF measured at a pressure base of 15.025 psia and a temperature of 60° F. Specific gravity base will be 0.60.

Report casing pressure in lieu of tubing pressure for any well producing through casing.

Mail original and one copy of this report to the district office of the New Mexico Oil Conservation Division in accordance with Rule 301 and appropriate pool rules.

I hereby certify that the above information is true and complete to the best of my knowledge and belief.

Michael G. Harden
(Signature)

Senior Staff Engineer
(Title)

STATE OF NEW MEXICO
ENERGY AND MINERALS DEPARTMENT

P. O. BOX 2088
SANTA FE, NEW MEXICO 87501

Form C-116
Revised 10-1-78

GAS – OIL RATIO TESTS

Operator: Petro-Lewis Corporation
Pool: Penrose Skelly Grayburg
County: Lea
Address: P. O. Box 2250, Denver, CO 80201
TYPE OF TEST – (X): Scheduled [ ] Completion [ ] Special [X]

LEASE NAME	WELL NO.	LOCATION U	S	T	R	DATE OF TEST	STATUS	CHOKE SIZE	TBG. PRESS.	DAILY ALLOWABLE	LENGTH OF TEST HOURS	PROD. DURING TEST WATER BBLS.	GRAV. OIL	OIL BBLS.	GAS M.C.F.	GAS – OIL RATIO CU.FT/BBL
L. G. Warlick	1	A	19	21S	37E	10-17-79	P	None	25	–	24	10	37.5	1.6	60	37,500

No well will be assigned an allowable greater than the amount of oil produced on the official test.

During gas-oil ratio test, each well shall be produced at a rate not exceeding the top unit allowable for the pool in which well is located by more than 25 percent. Operator is encouraged to take advantage of this 25 percent tolerance in order that well can be assigned increased allowables when authorized by the Division.

Gas volumes must be reported in MCF measured at a pressure base of 15.025 psia and a temperature of 60° F. Specific gravity base will be 0.60.

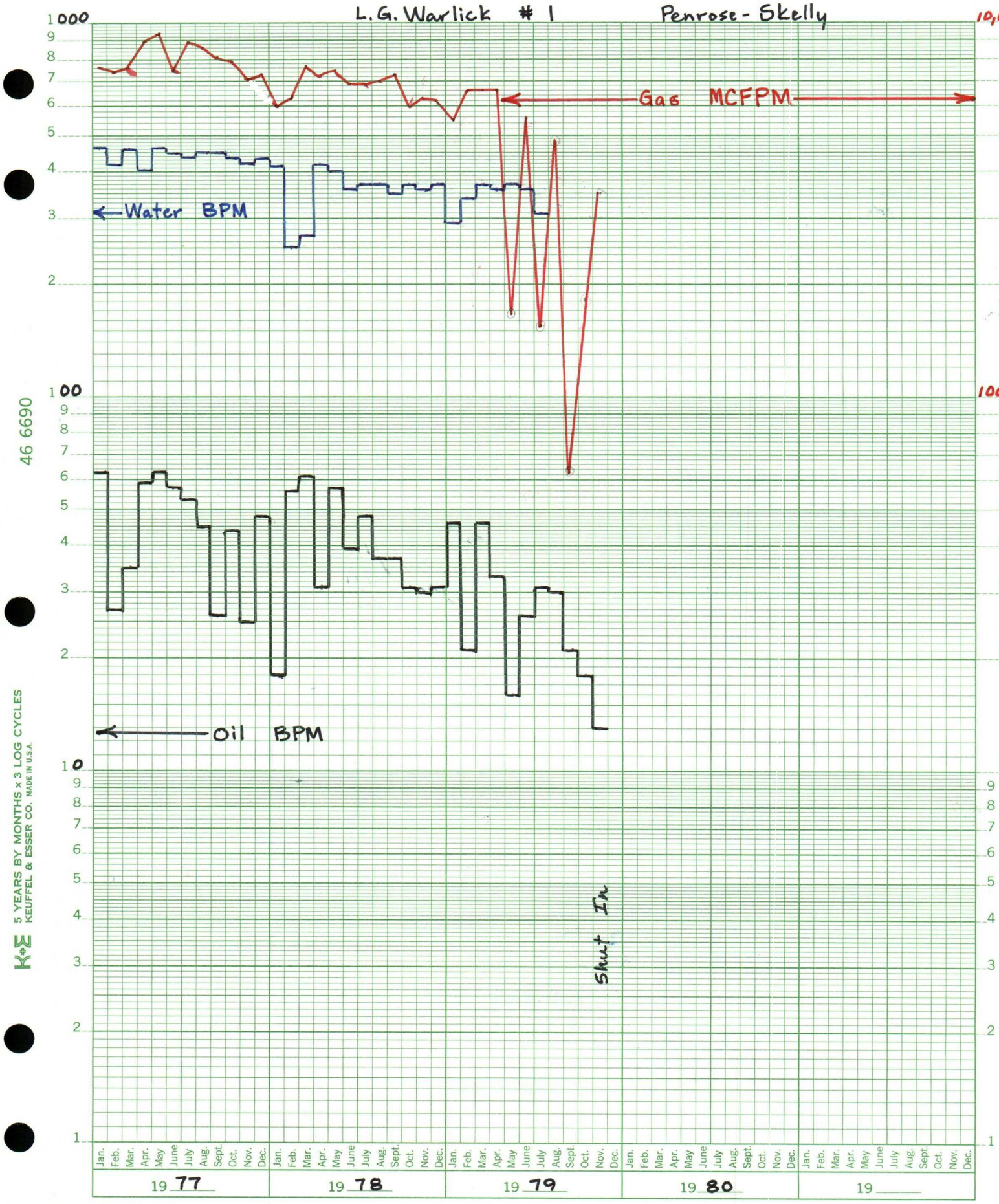
Report casing pressure in lieu of tubing pressure for any well producing through casing.

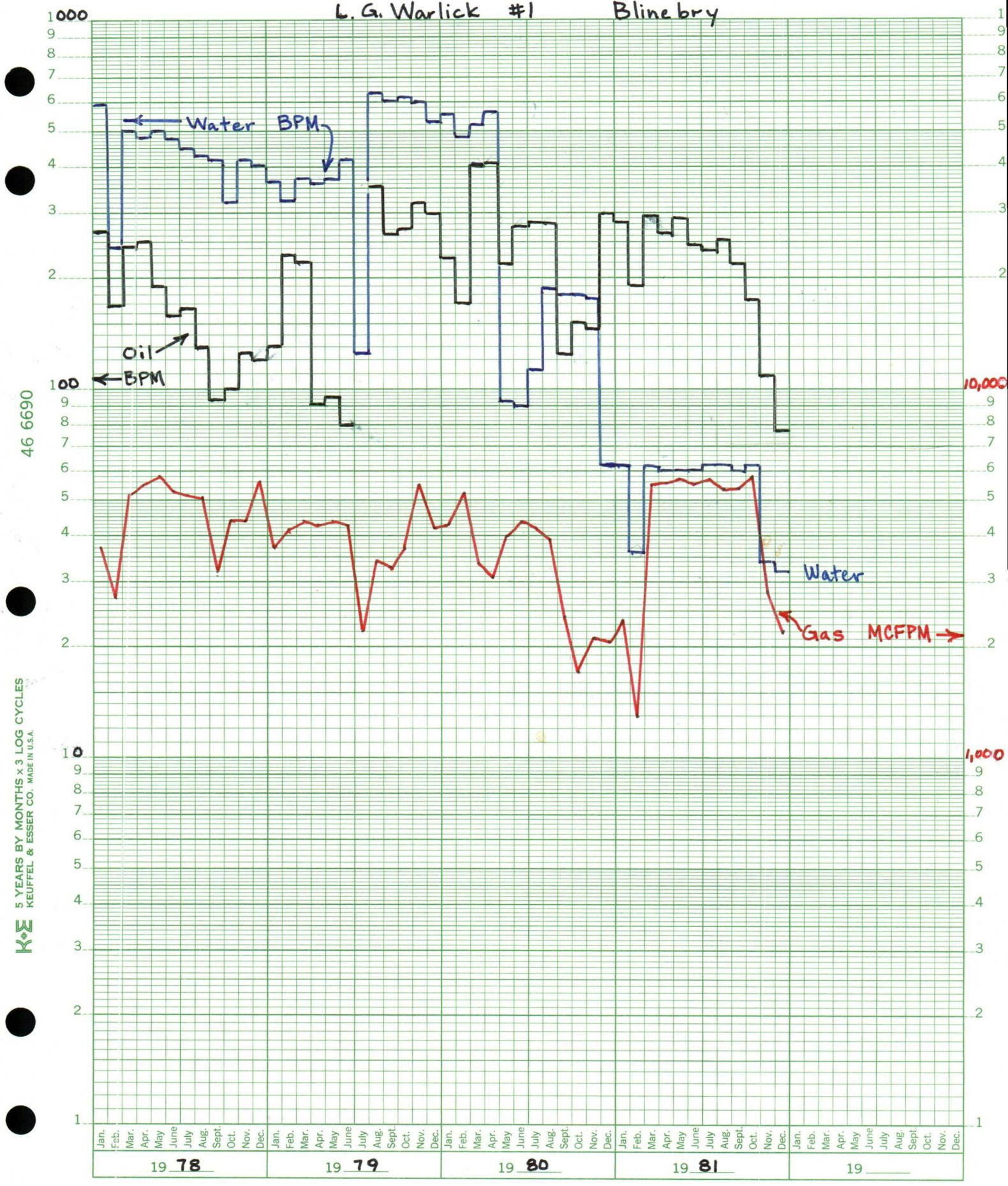
Mail original and one copy of this report to the district office of the New Mexico Oil Conservation Division in accordance with Rule 301 and appropriate pool rules.

I hereby certify that the above information is true and complete to the best of my knowledge and belief.

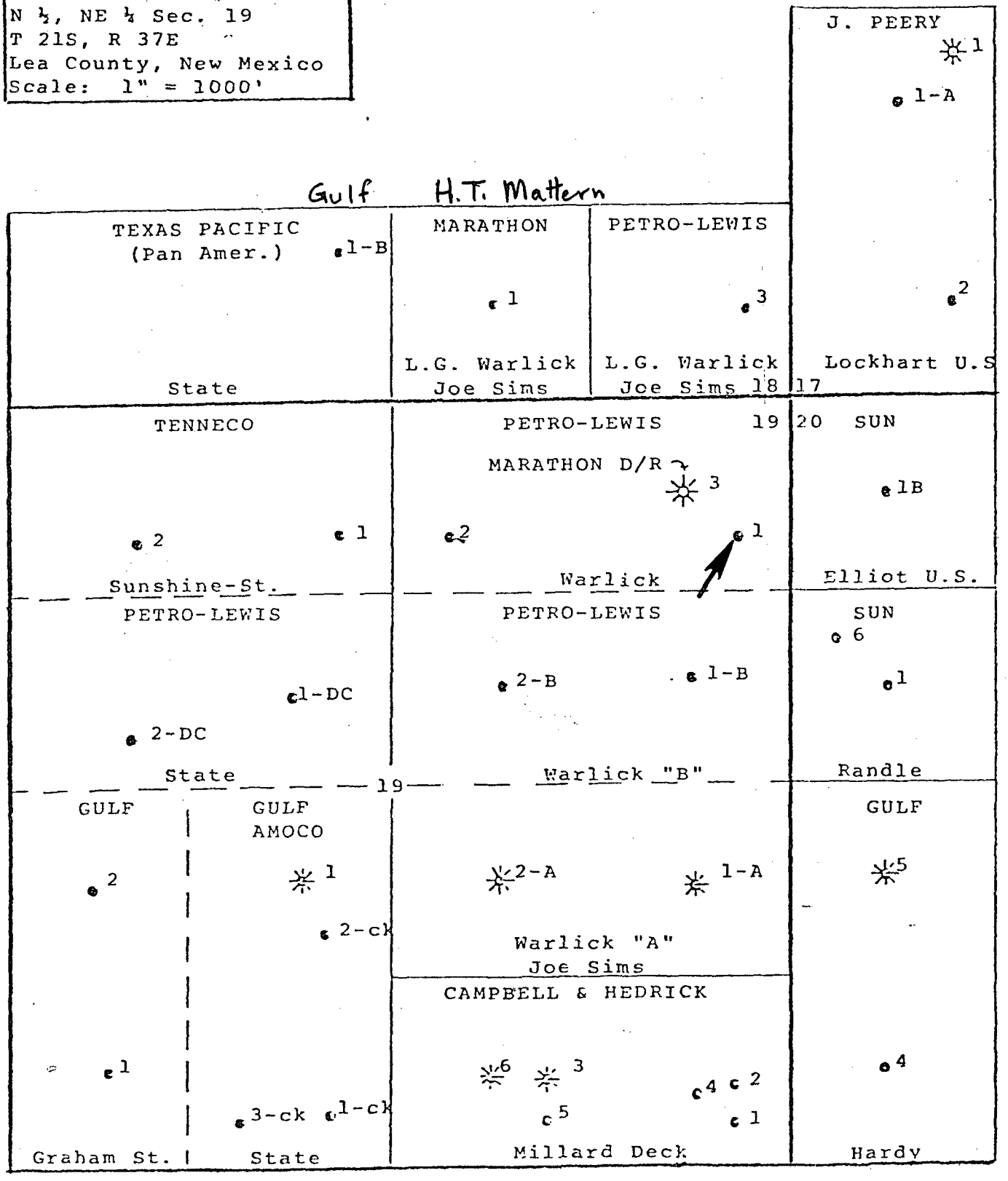
Michael G. Harden
(Signature)

Senior Staff Engineer
(Title)


L. G. Warlick # 1
Penrose - Skelly
Gas MCFPM
Water BPM
Oil BPM
Shut In
1000
100
10
10,000
1000
46 6690
K&E 5 YEARS BY MONTHS x 3 LOG CYCLES
KEUFFEL & ESSER CO. MADE IN U.S.A.
Jan. Feb. Mar. Apr. May June July Aug. Sept. Oct. Nov. Dec.
19 77
19 78
19 79
19 80
19


L. G. Warlick #1
Blinebry
Water BPM
Oil BPM
Water
Gas MCFPM
1000
100
10
10,000
1,000
Jan. Feb. Mar. Apr. May June July Aug. Sept. Oct. Nov. Dec.
19 78
19 79
19 80
19 81
19
46 6690
K+E 5 YEARS BY MONTHS x 3 LOG CYCLES
KEUFFEL & ESSER CO. MADE IN U.S.A.

PETRO-LEWIS CORPORATION
L.G. WARLICK LEASE
N ½, NE ¼ Sec. 19
T 21S, R 37E
Lea County, New Mexico
Scale: 1" = 1000'



ADDRESS LIST
(Alphabetical Order)

OFFSET OPERATORS*

Amoco Production Company
P. O. Box 3092
Houston, Texas 77001

Attn: Mr. George Simmons
Division Geologist, NM & TX
(713) 652-5222

Gulf Oil Company - U.S.
P. O. Box 670
Hobbs, NM 88240

Attn: Mr. R. C. Anderson
Production Manager
(505) 393-4121

Peery, J. W., Estate
P. O. Box 401
Midland, TX 79701

(915) 684-4651

Sun Oil Company
P. O. Box 1861
Midland, TX 79701

Attn: Mr. R. K. Beggs
District Manager
(915) 685-0300

Tenneco Oil Company
Ciudad Bldg. - Suite 139
3000 United Founders Blvd.
Oklahoma City, OK 73112

Attn: Mr. Don Wright
(405) 848-8551

Texas Pacific Oil Co., Inc.
P. O. Box 4067
Midland, TX 79701

Attn: Mr. R. J. Womack
Regional Manager
(915) 684-5584

*Offset Operators to Petro-Lewis Corporation's L. G. Warlick No. 1 located in Unit A, Section 19, T21S, R37#, Lea County, New Mexico.

PETRO LEWIS CORPORATION

Oil and Gas Producers

Petro-Lewis Tower
717 17th Street, P.O. Box 2250
Denver, Colorado 80201-2250
303/620-1000

February 24, 1982

Amoco Production Company
P. O. Box 3092
Houston, TX 77001

Attn: Mr. George Simmons
Division Geologist

Gentlemen:

Attached for your information is a commingling request for the L. G. Warlick #1. We solicit your waiver of objection to this request. Please designate your decision below and return one copy to the undersigned in the enclosed envelope.

We will appreciate your most immediate reply.

Sincerely,

Michael G. Handren
Senior Staff Engineer

We do ( )/do not ( ) object to the downhole commingling of production in Petro-Lewis Corporation's L. G. Warlick #1.

Signed _____

Date _____

Company _____

MGH/pp

PETRO LEWIS CORPORATION

Oil and Gas Producers

Petro-Lewis Tower
717 17th Street, P.O. Box 2250
Denver, Colorado 80201-2250
303/620-1000

February 24, 1982

Gulf Oil Co. - U.S.
P. O. Box 670
Hobbs, NM 88240

Attn: Mr. R. C. Anderson
Production Manager

Gentlemen:

Attached for your information is a commingling request for the L. G. Warlick #1. We solicit your waiver of objection to this request. Please designate your decision below and return one copy to the undersigned in the enclosed envelope.

We will appreciate your most immediate reply.

Sincerely,

Michael G. Handren
Senior Staff Engineer

We do ( )/do not ( ) object to the downhole commingling of production in Petro-Lewis Corporation's L. G. Warlick #1.

Signed _____

Date _____

Company _____

MGH/pp

PETRO LEWIS CORPORATION

Oil and Gas Producers

Petro-Lewis Tower
717 17th Street, P.O. Box 2250
Denver, Colorado 80201-2250
303/620-1000

February 24, 1982

Peery, J. W., Estate
P. O. Box 401
Midland, TX 79701

Gentlemen:

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We will appreciate your most immediate reply.

Sincerely,

Michael G. Handren
Senior Staff Engineer

We do ( )/do not ( ) object to the downhole commingling of production in Petro-Lewis Corporation's L. G. Warlick #1.

Signed _____

Date _____

Company _____

MGH/pp

PETRO LEWIS CORPORATION

Oil and Gas Producers

Petro-Lewis Tower
717 17th Street, P.O. Box 2250
Denver, Colorado 80201-2250
303/620-1000

February 24, 1982

Sun Oil Company
P. O. Box 1861
Midland, TX 79701

Attn: Mr. R. K. Beggs
District Manager

Gentlemen:

Attached for your information is a commingling request for the L. G. Warlick #1. We solicit your waiver of objection to this request. Please designate your decision below and return one copy to the undersigned in the enclosed envelope.

We will appreciate your most immediate reply.

Sincerely,

Michael G. Handren
Senior Staff Engineer

We do ( )/do not ( ) object to the downhole commingling of production in Petro-Lewis Corporation's L. G. Warlick #1.

Signed _____

Date _____

Company _____

MGH/pp

PETRO LEWIS CORPORATION

Oil and Gas Producers

Petro-Lewis Tower
717 17th Street, P.O. Box 2250
Denver, Colorado 80201-2250
303/620-1000

February 24, 1982

Tenneco Oil Company
Ciudad Bldg. - Suite 139
3000 United Founders Blvd.
Oklahoma City, OK 73112

Attn: Mr. Don Wright

Gentlemen:

Attached for your information is a commingling request for the L. G. Warlick #1. We solicit your waiver of objection to this request. Please designate your decision below and return one copy to the undersigned in the enclosed envelope.

We will appreciate your most immediate reply.

Sincerely,

Michael G. Handren
Senior Staff Engineer

We do ( )/do not ( ) object to the downhole commingling of production in Petro-Lewis Corporation's L. G. Warlick #1.

Signed _____

Date _____

Company _____

MGH/pp

PETRO LEWIS CORPORATION

Oil and Gas Producers

Petro-Lewis Tower
717 17th Street, P.O. Box 2250
Denver, Colorado 80201-2250
303/620-1000

February 24, 1982

Texas Pacific Oil Co., Inc.
P. O. Box 4067
Midland, TX 79701

Attn: Mr. R. J. Womack
Regional Manager

Gentlemen:

Attached for your information is a commingling request for the L. G. Warlick #1. We solicit your waiver of objection to this request. Please designate your decision below and return one copy to the undersigned in the enclosed envelope.

We will appreciate your most immediate reply.

Sincerely,

Michael G. Handren
Senior Staff Engineer

We do ( )/do not ( ) object to the downhole commingling of production in Petro-Lewis Corporation's L. G. Warlick #1.

Signed _____

Date _____

Company _____

MGH/pp

Amoco Production Company (USA)

Houston Region–West
500 Jefferson Building
Post Office Box 3092
Houston, Texas 77001

R. G. Smith
Regional Engineering
Manager-West

August 13, 1982

File: JCA-986.51-1568

Re: Downhole Commingling
L. G. Warlick A #1
Drinkard and Penrose Skelly Formations
Lea County, New Mexico

New Mexico Oil Conservation Commission
P. O. Box 2088
Santa Fe, NM 87501

Gentlemen:

Petro-Lewis Corporation has filed an application for permission to commingle production downhole in their L. G. Warlick A well No. 1. They propose to commingle oil producted from the Drinkard and Penrose Shelly Grayburg formations.

As an offset operator, Amoco Production Company has no objection to Petro-Lewis' application to downhole commingle production through the subject well.

Yours very truly,

R. G. Smith
MLC

MLC/dc
5/026

cc: Petro-Lewis Corporation
P. O. Box 16200
Lubbock, TX 79490

RECEIVED
AUG 19 1982
OIL CONS. DIVISION
SANTA FE

Amoco Production Company (USA)
500 Jefferson Building
P.O. Box 3092
Houston, Texas 77001

March 11, 1982

File: JCA-986.511-060

Re: Downhole Commingling
L. G. Warlick Well No. 1
Unit A Sec. 19, T-21-S, R-37-E
Lea County, New Mexico

State of New Mexico
Oil Conservation Division
P. O. Box 2088
Santa Fe, New Mexico 87501

Gentlemen:

Petro-Lewis Corporation has filed an application for a downhole commingling permit for their L.G. Warlick Well No. 1 located in Unit A, Sec. 19, T-21-S, R-37-E Lea County, New Mexico.

An offset operator Amoco has no objection to Petro-Lewis application to commingle production downhole in the subject well completed in the Blinebry and Penrose Skelly Grayburg Pools.

Yours very truly,

R. G. Smith

R. G. Smith
Regional Engineer Manager - West

MLC/fp

cc: Petro-Lewis Corporation
P.O. Box 2250
Denver, Colorado 80201-2250

PETRO LEWIS CORPORATION

Oil and Gas Producers

Petro-Lewis Tower
717 17th Street, P.O. Box 2250
Denver, Colorado 80201-2250
303/620-1000

RECEIVED
MAR 04 '82
HOBBS AREA

February 24, 1982

Gulf Oil Co. - U.S.
P. O. Box 670
Hobbs, NM 88240

Attn: Mr. R. C. Anderson
Production Manager

Gentlemen:

Attached for your information is a commingling request for the L. G. Warlick #1. We solicit your waiver of objection to this request. Please designate your decision below and return one copy to the undersigned in the enclosed envelope. *

We will appreciate your most immediate reply.

Sincerely,

Michael G. Handren

Michael G. Handren
Senior Staff Engineer

We do ( )/do not (X) object to the downhole commingling of production in Petro-Lewis Corporation's L. G. Warlick #1.

Signed C. F. Kalteyer
Chief Proration Engineer
Date March 11, 1982

Company Gulf Oil Corporation

MGH/pp

*Location: 990' FNL & 330' FEL of Unit A, Section 19, T21S, R37E
Lea County, NM

MAR 5 1982

PETRO LEWIS CORPORATION

Oil and Gas Producers

Petro-Lewis Tower
717 17th Street, P.O. Box 2250
Denver, Colorado 80201-2250
303/620-1000

February 24, 1982

Peery, J. W., Estate
P. O. Box 401
Midland, TX 79701

Gentlemen:

Attached for your information is a commingling request for the L. G. Warlick #1. We solicit your waiver of objection to this request. Please designate your decision below and return one copy to the undersigned in the enclosed envelope.

We will appreciate your most immediate reply.

Sincerely,

Michael G. Handren

Michael G. Handren
Senior Staff Engineer

We do ( )/do not (✓) object to the downhole commingling of production in Petro-Lewis Corporation's, L. G. Warlick #1.

Signed J F Hedrick

Date 3/10/82

Company Campbell & Hedrick

MGH/pp

MAR 8 1982

P

PETRO LEWIS CORPORATION

Oil and Gas Producers

Petro-Lewis Tower
717 17th Street, P.O. Box 2250
Denver, Colorado 80201-2250
303/620-1000

February 24, 1982

Sun Oil Company
P. O. Box 1861
Midland, TX 79701

Attn: Mr. R. K. Beggs
District Manager

Gentlemen:

Attached for your information is a commingling request for the L. G. Warlick #1. We solicit your waiver of objection to this request. Please designate your decision below and return one copy to the undersigned in the enclosed envelope.

We will appreciate your most immediate reply.

Sincerely,

Michael G. Handren

Michael G. Handren
Senior Staff Engineer

We do ( )/do not (X) object to the downhole commingling of production in Petro-Lewis Corporation's L. G. Warlick #1.

Signed J. L. Power

Date 3-12-82

Company SUN EXPLORATION & PRODUCTION CO.

MGH/pp

PETRO LEWIS CORPORATION

Oil and Gas Producers

Petro-Lewis Tower
717 17th Street, P.O. Box 2250
Denver, Colorado 80201-2250
303/620-1000

February 24, 1982

Tenneco Oil Company
Ciudad Bldg. - Suite 139
3000 United Founders Blvd.
Oklahoma City, OK 73112

Attn: Mr. ~~Don Wright~~ Vernon

Gentlemen:

Attached for your information is a commingling request for the L. G. Warlick #1. We solicit your waiver of objection to this request. Please designate your decision below and return one copy to the undersigned in the enclosed envelope.

We will appreciate your most immediate reply.

Sincerely,

Michael G. Handren

Michael G. Handren
Senior Staff Engineer

We do ( )/do not (✓) object to the downhole commingling of production in Petro-Lewis Corporation's L. G. Warlick #1.

Signed ~~Hugh Wilbanks~~

Date 3-22-82

Company Tenneco Oil Company

MGH/pp

PETRO LEWIS CORPORATION

Oil and Gas Producers

Petro-Lewis Tower
717 17th Street, P.O. Box 2250
Denver, Colorado 80201-2250
303/620-1000

February 24, 1982

* Texas Pacific Oil Co., Inc.
P. O. Box 4067
Midland, TX 79701

Attn: Mr. R. J. Womack
Regional Manager

Gentlemen:

Attached for your information is a commingling request for the L. G. Warlick #1. We solicit your waiver of objection to this request. Please designate your decision below and return one copy to the undersigned in the enclosed envelope.

We will appreciate your most immediate reply.

Sincerely,

Michael G. Handren

Michael G. Handren
Senior Staff Engineer

We do ( )/do not (X) object to the downhole commingling of production in Petro-Lewis Corporation's L. G. Warlick #1.

Signed J. J. Power

Date 3-12-82

* NOW Company SUN EXPLORATION & PRODUCTION CO.

MGH/pp

PETRO LEWIS CORPORATION

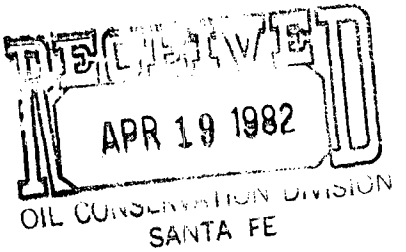
Oil and Gas Producers

Petro-Lewis Tower
717 17th Street, P.O. Box 2250
Denver, Colorado 80201-2250
303/620-1000

April 14, 1982

New Mexico Oil Conservation Commission
State Land Office Building
P.O. Box 2088
Santa Fe, NM 87501

attn. Michael Stagner



RE: L.G. Warlick #1
Lea County, NM

Dear Mr. Stagner:

You wish to know how I estimated the BHP of the two zones in the L.G. Warlick #1 in Lea County, New Mexico. These values were estimated from BHPs in other wells. However, after further consideration prompted by your question, I feel the pressures reported in the commingling application were wrong.

I have calculated approximate BHPs for each zone based on instantaneous shut in pressures after a recent acid job which was done on December 3, 1981. The new calculated BHP for the Blinebry zone is 855 psi and for the Penrose-Skelly Grayburg is 878 psi. These were calculated using equations from SPE Monograph 6, Acidizing Fundamentals. The calculations are attached.

In addition to the BHP information, I am also attaching copies of signed waivers from all offset operators.

I hope this information will be sufficient.

Sincerely,

M G Handren

Michael G. Handren
Sr. Staff Engineer

MGH/ag

att.

Calculation of BHP from ISIP

Equation 7.1 from SPE Monograph 6

$$g_f = \frac{ISIP + HH}{depth}$$

Equation 7.2 from SPE Monograph 6

$$g_f = \alpha + (g_o - \alpha)\left(\frac{\text{Reservoir Pressure}}{\text{depth}}\right)$$

g_o = overburden gradient
g_f = fracture gradient
α = constant (.33 to .5)
HH = hydrostatic head
ISIP = instantaneous shut in pressure

for these calculations: $\alpha = .4$, $g_o = 1$

Blinebry Zone

ISIP = 300 psig
HH = (.4334)(5700) = 2470 psi
depth = 5700 ft.
α = .4
g_o = 1

substituting into Eq. 7.1:

$$g_f = \frac{300 \text{ psi} + 2470 \text{ psi}}{5700 \text{ ft.}} = .49 \text{ psi/ft.}$$

substituting into Eq. 7.2:

$$.49 = .4 + (1 - .4)\left(\frac{\text{Reservoir Pressure}}{5700}\right)$$

$$.09 = (.6)\frac{\text{Reservoir Pressure}}{5700}$$

855 psi = Reservoir Pressure

Penrose-Skelly Grayburg Zone

ISIP = 400 psig
HH = (.4334) (3800) = 1647 psi
depth = 3800 ft.
α = .4
g_o = 1

Eq. 7.1:

$$g_f = \frac{400 + 1647}{3800} = .54 \text{ psi/ft.}$$

Eq. 7.2:

$$.54 = .4\ (1 - .4)\ \left(\frac{\text{Reservoir Pressure}}{3800}\right)$$

$$.14 = \frac{(.6)\ \text{Reservoir Pressure}}{3800}$$

$$878 = \text{Reservoir Pressure}$$

determined relative permeability curves, when available. When relative permeability data are not available, a rule of thumb we often use is to divide the absolute permeability by 1.5 for oil-based fracturing fluids and by 5 for water-based fracturing fluids.

Formation Porosity

Use the average porosity of the reservoir determined from log or core analysis; porosity normally is not a critical parameter in treatment design.

Formation Depth

Use the distance from ground level to the middle of the formation, expressed in feet.

Formation Fracturing Gradient

Use the pressure, expressed as the gradient (psi per foot of depth), required to hold open the fracture just as the fracture walls are about to close. This is not the pressure required to initiate a fracture, often called the breakdown pressure. The breakdown pressure will normally exceed the fracture propagation pressure as measured by the fracturing gradient defined below.

The fracture gradient is estimated by adding the surface pressure observed instantaneously after shut-in of the fracturing pumps to the hydrostatic head of the fluid in the wellbore, and dividing by formation depth.

$$g_f = \frac{\text{instantaneous shut-in pressure} + \text{hydrostatic head}}{\text{depth}} \quad \ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots (7.1)$$

The fracture gradient for a reservoir is not constant, but changes as reservoir pressure is changed. Two example surface-pressure records for fracture treatments in the same reservoir are presented in Fig. 7.4 to illustrate this effect. The first treatment was in a newly developed field with an initial reservoir pressure of 2,000 psi; the fracture gradient was 0.7 psi/ft. At the time of the second treatment, reservoir pressure had been depleted to 1,000 psi; the fracture gradient was 0.6 psi/ft. From this example, it is apparent that a method is needed to predict changes in fracture gradient with reservoir pressure, to estimate the fracture gradient for deep, high-pressure reservoirs, and to predict the gradient for newly developed fields.

A simple, approximate method that can be used to estimate the fracture gradient is to assume it is proportional to the overburden and reservoir pressure gradients:

$$g_f = \alpha + (\text{overburden gradient} - \alpha)\frac{\text{reservoir pressure}}{\text{depth}}, \quad \ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots (7.2)$$

where α = constant (0.33 to 0.5) and the overburden gradient is about 1.0 psi/ft at depths less than 10,000 ft and 1.0 to 1.2 psi/ft at depths greater than 10,000 ft. To extrapolate to a reduced reservoir pressure from a fracture gradient obtained at initial reservoir pressure, substitute the old fracture gradient and reservoir pressure into Eq. 7.2 and calculate α. Then, for the new reservoir pressure and the computed value of α, estimate the revised fracturing gradient. More rigorous theories for predicting the fracture gradient as a function of changes in overburden stress, pore pressure, rock tensile strength, etc. exist. We seldom have sufficient data to use these theories, however, and the simple relationship given in Eq. 7.2, although not exact, is usually adequate.

In a new field, the fracture gradient can be approximated using Eq. 7.2 with $\alpha = 0.5$. *Remember, this is an approximate equation* and that the proper value of α should be verified from field data.

Poisson's Ratio

The fracture geometry predicted for a given formation will vary only slightly as Poisson's ratio for the rock varies. Therefore, it is sufficient to select values for Poisson's ratio based upon the general rock type. Typical values are listed below.

Rock Type	Poisson's Ratio
Hard carbonate	0.25
Medium-hard carbonate	0.27
Soft carbonate	0.30

Mean Sonic Travel Time

The mean sonic travel time can be used to calculate the modulus of elasticity of the formation (Young's modulus). It is best to use travel times from sonic logs taken in the well to be treated. Since Young's modulus, which is an important parameter in the prediction of fracture geometry, is normally evaluated from the sonic travel time, the travel time must be measured as accurately as possible. If in doubt, select the

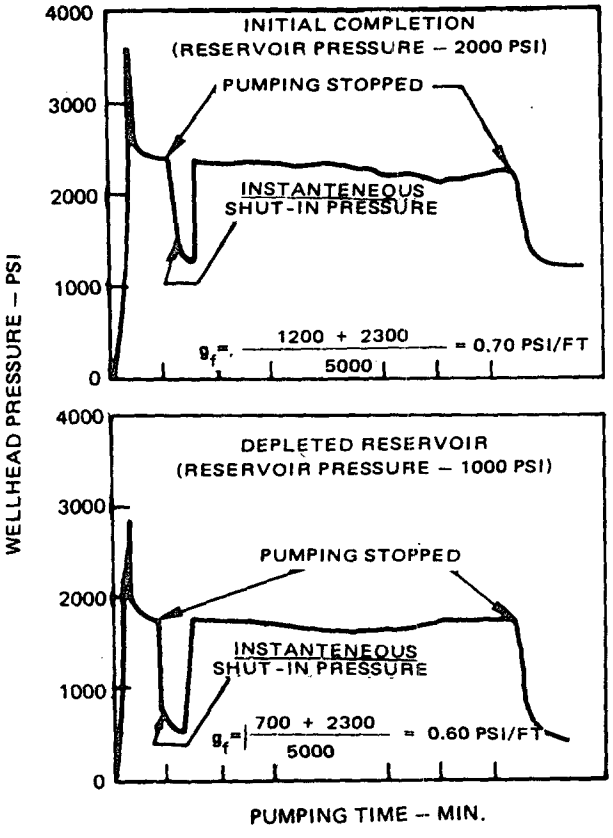


Fig. 7.4—Typical fracture pressure recordings.

OIL CONSERVATION DIVISION
DISTRICT I

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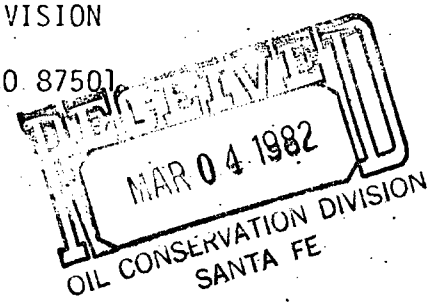
SANTA FE, NEW MEXICO 87501



DATE March 2, 1982

RE: Proposed MC _____
Proposed DHC X
Proposed NSL _____
Proposed NSP _____
Proposed SWD _____
Proposed WFX _____
Proposed PMX _____

Gentlemen:

I have examined the application for the:

Petro-Lewis Corp.	L. G. Warlick	No. 1-A	19-21-37
Operator	Lease and Well No.		Unit, S - T - R

and my recommendations are as follows:

O.K.----J.S.

Yours very truly,

/mc