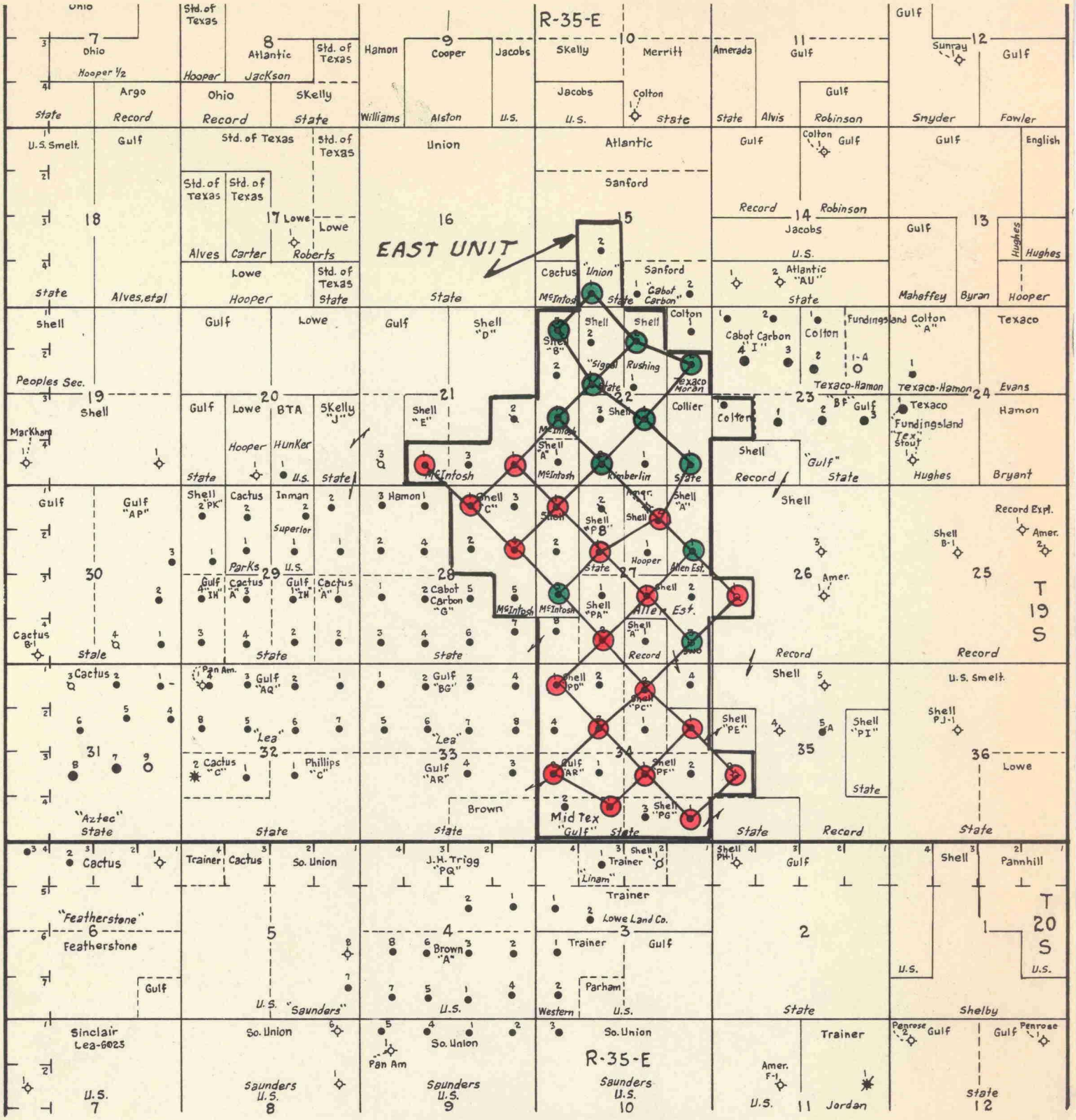


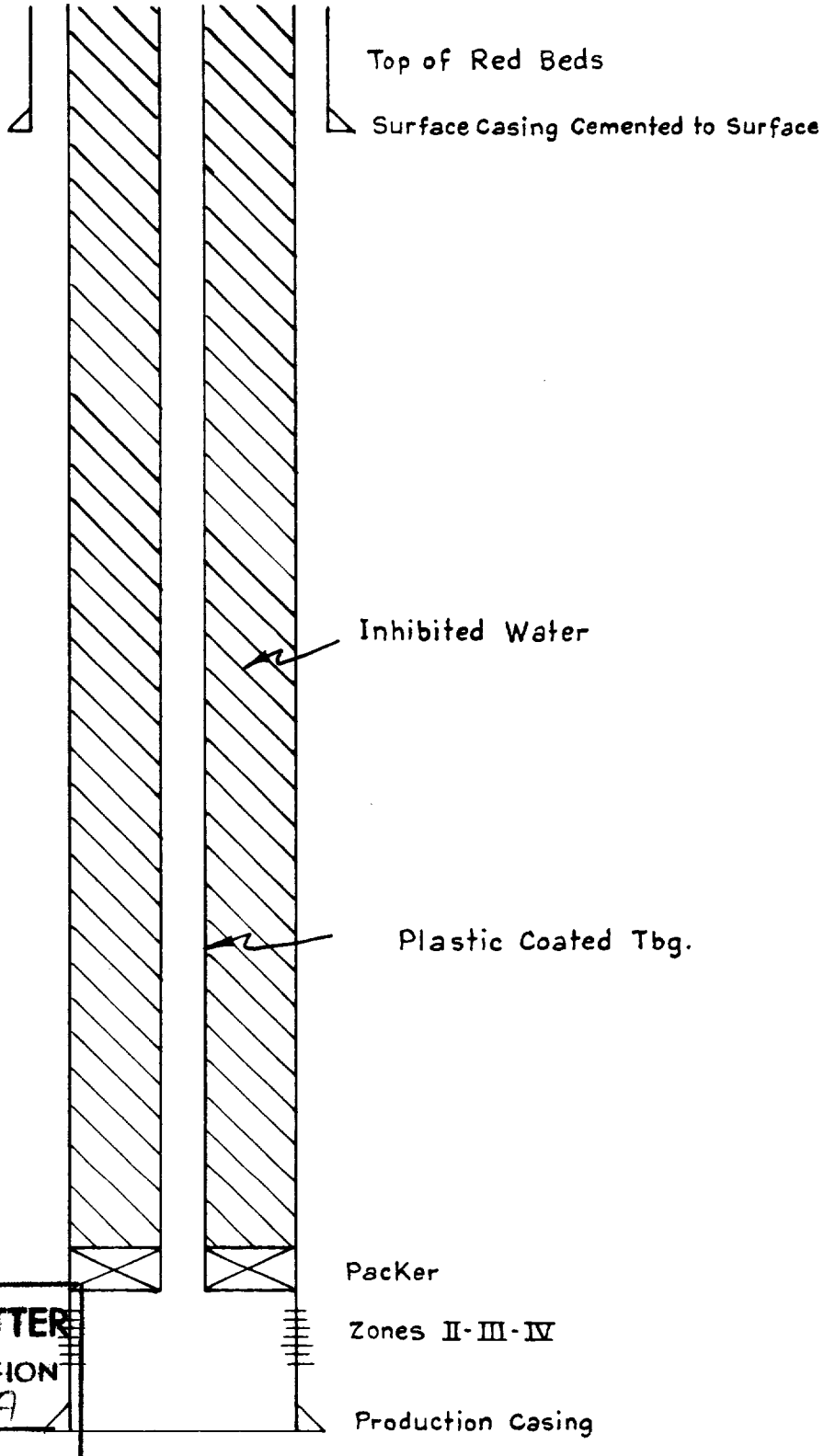
EAST PEARL QUEEN UNIT
LEA COUNTY, NEW MEXICO
Scale: 1" = 4000'

LEGEND

- Queen Producer
- A Atoka Producer
- Queen Gas Producer
- Injection Well—Dual
- Drilling Well
- Injection Well—Single

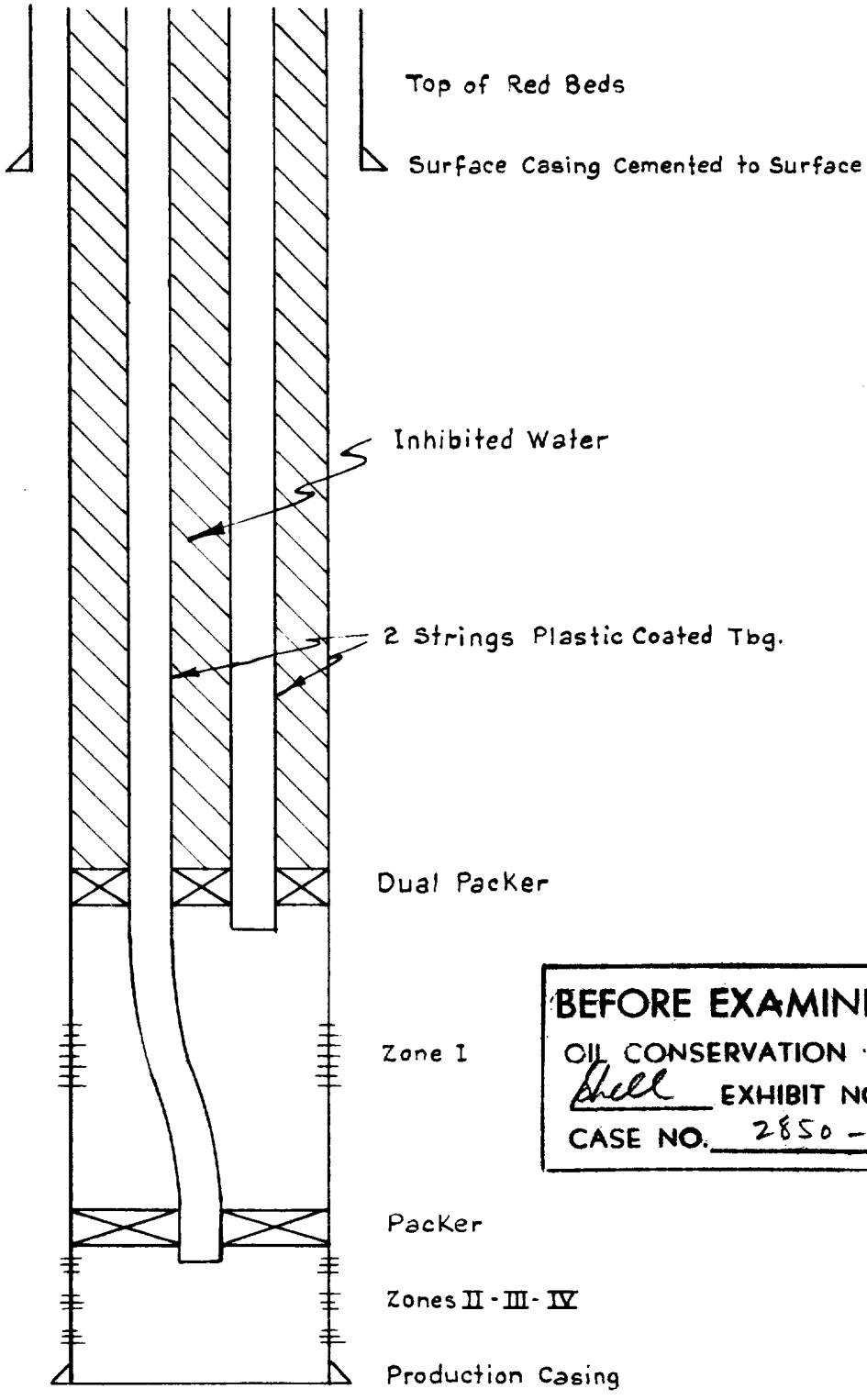
Ex #1

EAST PEARL QUEEN UNIT
Lea County, N. Mex.
DIAGRAMMATIC SKETCH OF SINGLE INJECTION WELL



BEFORE EXAMINER NUTTER
OIL CONSERVATION COMMISSION
Shell EXHIBIT NO. 4 A
CASE NO. 2850-2851

EAST PEARL QUEEN UNIT
Lea County, N. Mex.
DIAGRAMMATIC SKETCH OF DUAL INJECTION WELL



BEFORE EXAMINER NUTTER
OIL CONSERVATION COMMISSION
Shell EXHIBIT NO. 4-B
CASE NO. 2850 - 2851

EAST PEARL QUEEN UNIT
LEA COUNTY, NEW MEXICO
CASING AND CEMENTING DETAIL IN PROPOSED INJECTION WELLS

Injection Well	Surface Casing Size In.	Depth Ft.	Cement Sx.	Top Cement Ft.	Production Casing Size In.	Depth Ft.	Cement Sx.	Top Cement Ft.	Approximate Depth Inj. Interval Top Ft.
Sanford-Union State 1	8 5/8	178	175	Surface (E)	5 1/2	5012	150	4150 (E)	4862
Shell-McIntosh B-1	8 5/8	296	300	Surface (V)	5 1/2	4880	700	Surface (V)	4757
Shell-McIntosh B-3	8 5/8	106	85	Surface (V)	2 7/8	4947	200	4100 (E)	4844
Shell-Signal State 1	8 5/8	102	42	Surface (E)	4 1/2	4918	200	3760 (E)	4804
Shell-Rushing 2	8 5/8	100	85	Surface (E)	4 1/2	4920	150	4050 (E)	4808
Colton-Texaco Moran 2	8 5/8	192	100	Surface (E)	4 1/2	5087	150	4220 (E)	4833
Collier-State 1	10 3/4	344	250	Surface (E)	5 1/2	4850	1200	Surface (E)	4818
Shell-Kimberlin 2	9 5/8	301	300	Surface (V)	5 1/2	4904	700	860 (E)	4652
Shell-Kimberlin 4	8 5/8	98	80	Surface (V)	5 1/2	4906	200	3750 (E)	4652
Shell-McIntosh D-1	8 5/8	309	350	Surface (V)	5 1/2	4922	700	Surface (V)	4661
Shell-McIntosh E-1	9 5/8	306	300	Surface (V)	5 1/2	4962	700	Surface (V)	4742
Shell-McIntosh C-1	8 5/8	298	300	Surface (V)	5 1/2	4949	700	Surface (V)	4698
Shell-McIntosh C-4	8 5/8	172	150	Surface (V)	5 1/2	4960	200	3800 (E)	4689
Shell-McIntosh 1	8 5/8	306	300	Surface (V)	5 1/2	4885	700	Surface (V)	4656
Shell-McIntosh 3	8 5/8	113	100	Surface (V)	5 1/2	5065	200	3910 (E)	4704
Shell-State PB-1	9 5/8	304	300	Surface (V)	5 1/2	4878	800	2725 (S)	4689
Shell-Hooper 2	8 5/8	312	300	Surface (V)	5 1/2	4895	700	Surface (V)	4676
Shell-Allen Est. A-1	9 5/8	309	300	Surface (V)	5 1/2	4940	700	900 (E)	4720
Shell-Record 1	8 5/8	325	300	Surface (V)	5 1/2	4918	700	880 (E)	4686
Shell-Allen Est. 1	8 5/8	380	350	Surface (V)	5 1/2	4916	900	Surface (V)	4712
Shell-Allen Est. 3	8 5/8	96	100	Surface (V)	5 1/2	4900	400	2580 (E)	4862
Shell-State PA-2	8 5/8	110	100	Surface (V)	5 1/2	5024	200	3860 (E)	4737
Shell-State PD-1	8 5/8	230	125	Surface (E)	5 1/2	5034	200	3870 (E)	4748
Shell-State PD-3	8 5/8	141	100	Surface (V)	5 1/2	5046	200	3890 (E)	4760
Shell-State PC-2	8 5/8	110	85	Surface (V)	5 1/2	4998	200	3840 (E)	4750
Shell-State PE-1	8 5/8	108	85	Surface (V)	5 1/2	4985	200	3830 (E)	4736
Shell-State PE-2	8 5/8	94	85	Surface (V)	5 1/2	4987	250	3550 (E)	4734
Shell-State PF-1	9 5/8	106	85	Surface (V)	5 1/2	5037	200	3880 (E)	4743
Gulf-State AR-2	8 5/8	136	100	Surface (E)	4 1/2	5051	275	3060 (E)	4781
Mid-Tex - Gulf State 1	8 5/8	241	125	Surface (E)	5 1/2	5000	300	3270 (E)	4744
Shell-State PG-1	8 5/8	108	85	Surface (V)	5 1/2	5019	200	3860 (E)	4750

(E) Estimated
(V) Visual
(S) Survey

EAST PEARL QUEEN UNIT
LEA COUNTY, NEW MEXICO
INJECTION WELL DETAIL
PART I
CASING AND CEMENT

Injection Well	Surface Casing				Production Casing			
	Size In.	Depth Ft.	Cement Sx.	Top Cement Ft.	Size In.	Depth Ft.	Cement Sx.	Top Cement Ft.
Sanford-Union State 1	8 5/8	178	175	Surface (E)	5 1/2	5012	150	4150 (E)
Shell-McIntosh B-1	8 5/8	296	300	Surface (V)	5 1/2	4880	700	Surface (V)
Shell-McIntosh B-3	8 5/8	106	85	Surface (V)	2 7/8	4947	200	4100 (E)
Shell-Signal State 1	8 5/8	102	42	Surface (E)	4 1/2	4918	200	3760 (E)
Shell-Rushing 2	8 5/8	100	85	Surface (E)	4 1/2	4920	150	4050 (E)
Colton-Texaco Moran 2	8 5/8	192	100	Surface (E)	4 1/2	5087	150	4220 (E)
Collier-State 1	10 3/4	344	250	Surface (E)	5 1/2	4850	1200	Surface (E)
Shell-Kimberlin 2	9 5/8	301	300	Surface (V)	5 1/2	4904	700	860 (E)
Shell-Kimberlin 4	8 5/8	98	80	Surface (V)	5 1/2	4906	200	3750 (E)
Shell-McIntosh D-1	8 5/8	309	350	Surface (V)	5 1/2	4922	700	Surface (V)
Shell-McIntosh E-1	9 5/8	306	300	Surface (V)	5 1/2	4962	700	Surface (V)
Shell-McIntosh C-1	8 5/8	298	300	Surface (V)	5 1/2	4949	700	Surface (V)
Shell-McIntosh C-4	8 5/8	172	150	Surface (V)	5 1/2	4960	200	3800 (E)
Shell-McIntosh 1	8 5/8	306	300	Surface (V)	5 1/2	4885	700	Surface (V)
Shell-McIntosh 3	8 5/8	113	100	Surface (V)	5 1/2	5065	200	3910 (E)
Shell-State PB-1	9 5/8	304	300	Surface (V)	5 1/2	4878	800	2725 (S)
Shell-Hooper 2	8 5/8	312	300	Surface (V)	5 1/2	4895	700	Surface (V)
Shell-Allen Est. A-1	9 5/8	309	300	Surface (V)	5 1/2	4940	700	900 (E)
Shell-Record 1	8 5/8	325	300	Surface (V)	5 1/2	4918	700	880 (E)
Shell-Allen Est. 1	8 5/8	380	350	Surface (V)	5 1/2	4916	900	Surface (V)
Shell-Allen Est. 3	8 5/8	96	100	Surface (V)	5 1/2	4900	400	2580 (E)
Shell-State PA-2	8 5/8	110	100	Surface (V)	5 1/2	5024	200	3860 (E)
Shell-State PD-1	8 5/8	230	125	Surface (E)	5 1/2	5034	200	3870 (E)
Shell-State PD-3	8 5/8	141	100	Surface (V)	5 1/2	5046	200	3890 (E)
Shell-State PC-2	8 5/8	110	85	Surface (V)	5 1/2	4998	200	3840 (E)
Shell-State PE-1	8 5/8	108	85	Surface (V)	5 1/2	4985	200	3830 (E)
Shell-State PE-2	8 5/8	94	85	Surface (V)	5 1/2	4987	250	3550 (E)
Shell- State PF-1	9 5/8	106	85	Surface (V)	5 1/2	5037	200	3880 (E)
Gulf-State AR-2	8 5/8	136	100	Surface (E)	4 1/2	5051	275	3060 (E)
Mid-Tex - Gulf State 1	8 5/8	241	125	Surface (E)	5 1/2	5000	300	3270 (E)
Shell-State PG-1	8 5/8	108	85	Surface (V)	5 1/2	5019	200	3860 (E)

(E) Estimated
(V) Visual
(S) Survey

BEFORE EXAMINER NUTTER
OIL CONSERVATION COMMISSION
EXHIBIT NO. 5-A
CASE NO. 2858-2859

EAST PEARL QUEEN UNIT
LEA COUNTY, NEW MEXICO
INJECTION WELL DETAIL
PART II
INJECTION TUBING, PACKERS, AND PERFORATIONS

BEFORE EXAMINER NUTTER
OIL CONSERVATION COMMISSION
Shell EXHIBIT NO. 5-B
CASE NO. 2850 - 2851

	Type Injection Well	Upper Injection Interval				Lower Injection Interval			
		Gross Perforated Interval	Tubing Size* - Depth	Packer Type	Packer Depth	Gross Perforated Interval	Tubing Size* - Depth	Packer Type	Packer Depth
Sanford-Union State 1	Single	Injection into lower interval only.				4862-4870	2.375 - 4800	RS w/HH	4800
Shell-McIntosh B-1	Single	Injection into lower interval only.				4762-4851	2.375 - 4700	RS w/HH	4700
Shell-McIntosh B-3	Single	Injection into lower interval only.				4853-4887	1.9 - 4800	Permanent	4800
Shell-Signal State 1	Single	Injection into lower interval only.				4804-4844	2.375 - 4750	RS w/HH	4750
Shell-Rushing 2	Single	Injection into lower interval only.				4810-4842	2.375 - 4750	RS w/HH	4750
Colton-Texaco Moran 2	Single	Injection into lower interval only.				4838-4842	2.375 - 4800	RS w/HH	4800
Collier-State 1	Single	Injection into lower interval only.				4774-4861	2.375 - 4750	RS w/HH	4750
Shell-Kimberlin 2	Single	4658-4860	2.375 - 4600	RS w/HH	4600	4808-4856	Commingled Injection		
Shell-Kimberlin 4	Single	4657-4658	2.375 - 4600	RS w/HH	4600	4772-4846	Commingled Injection		
Shell-McIntosh D-1	Dual	4661-4671	1.90 - 4600	RD w/HH	4600	4776-4873	1.90 - 4700	Permanent	4700
Shell-McIntosh E-1	Dual	4743-4749	1.315 - 4700	RD w/HH	4700	4914-4920	2.375 - 4800	Permanent	4800
Shell-McIntosh C-1	Dual	4700-4704	1.315 - 4650	RD w/HH	4650	4810-4877	2.375 - 4750	Permanent	4750
Shell-McIntosh C-4	Dual	4691-4703	1.9 - 4650	RD w/HH	4650	4804-4889	1.9 - 4750	Permanent	4750
Shell-McIntosh 1	Dual	4656-4670	1.9 - 4600	RD w/HH	4600	4856-4870	1.9 - 4800	Permanent	4800
Shell-McIntosh 3	Single	4708-4716	2.375 - 4650	RS w/HH	4650	Injection into upper interval only.			
Shell-State PB-1	Dual	4688-4700	2.375 - 4650	RD w/HH	4650	4799-4856	1.315 - 4750	Permanent	4750
Shell-Hooper 2	Dual	4677-4684	1.315 - 4650	RD w/HH	4650	4781-4874	2.375 - 4750	Permanent	4750
Shell-Allen Estate A-1	Single	4701-4706	2.375 - 4650	RS w/HH	4650	4810-4870	Commingled Injection		
Shell-Record 1	Dual	4687-4696	1.315 - 4650	RD w/HH	4650	4815-4849	2.375 - 4750	Permanent	4750
Shell-Allen Estate 1	Dual	4712-4724	1.9 - 4650	RD w/HH	4650	4819-4890	1.9 - 4750	Permanent	4750
Shell-Allen Estate 3	Single	Injection into lower interval only.				4880-4885	2.875 - 4870	Tension Set	Hookwall
Shell-State PA-2	Dual	4742	2.375 - 4700	RD w/HH	4700	4859-4915	1.315 - 4800	Permanent	4800
Shell-State PD-1	Dual	4750-4756	1.9 - 4700	RD w/HH	4700	4879-4965	1.9 - 4800	Permanent	4800
Shell-State PD-3	Dual	4762-4768	1.9 - 4700	RD w/HH	4700	4888-4975	1.9 - 4850	Permanent	4850
Shell-State PC-2	Dual	4754-4758	1.9 - 4700	RD w/HH	4700	4872-4953	1.9 - 4850	Permanent	4850
Shell-State PE-1	Dual	4738-4745	1.9 - 4700	RD w/HH	4700	4879-4944	1.9 - 4850	Permanent	4850
Shell-State PE-2	Dual	4735-4742	1.315 - 4700	RD w/HH	4700	4869-4893	2.375 - 4800	Permanent	4800
Shell-State PF-1	Dual	4744-4750	1.9 - 4700	RD w/HH	4700	4896-4958	1.9 - 4800	Permanent	4850
Gulf-State AR-2	Dual	4786-4788	1.315 - 4750	RD w/HH	4750	4912-4984	1.9 - 4850	Permanent	4850
Mid-Tex - Gulf State 1	Dual	4745-4752	1.9 - 4700	RD w/HH	4700	4954-4967	1.9 - 4800	Permanent	4900
Shell-State PG-1	Dual	4753-4760	1.9 - 4700	RD w/HH	4700	4900-4962	1.9 - 4800	Permanent	4850

*Tubing outside diameter.
RD w/HH - Retrievable dual with hydraulic holddown similar to Baker Model K.
RS w/HH - Retrievable single with hydraulic holddown similar to Baker Model R.
Permanent - Drillable packer similar to Baker Model D.

EAST PEARL QUEEN UNIT

WATERFLOOD STUDY

PEARL QUEEN FIELD
LEA COUNTY, NEW MEXICO

NOVEMBER 1962

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INTRODUCTION

The Pearl Queen Field is located 20 miles southwest of Hobbs in central Lea County, New Mexico. Presently the field encompasses an areal extent of some 5,600 acres with the production being from a series of Queen sands at an average depth of approximately 4,800 feet.

The field was discovered in December 1956 with the completion of the Shell-Hooper No. 1. Development has continued to the present with a total of 144 completions effected by the end of August 1962. Current drilling activity is confined to the northeast section of the field where production has been established from a new lower Queen sand interval not found to be productive in the main portion of the Pearl Queen Field.

In June 1962 a meeting of all the Pearl Queen Field Operators was held in Roswell, New Mexico, to discuss plans for initiating a waterflood project. It was agreed that in view of the field's advanced stage of depletion an engineering study should be conducted to determine the feasibility of a waterflood project. The field operators also recommended that the field be subdivided into three units (East, West, and South) in order to facilitate the engineering study and subsequent operations. Figure 1 is a map of the Pearl Queen Field showing the proposed unit subdivisions of the field.

The engineering study herein contained was limited to the area comprising the East Pearl Queen Unit. Some core and well control data from wells outside the East Unit were utilized to complete this study.

CONCLUSIONS

1. A waterflood of the main Queen sand interval in the East Pearl Queen Unit should provide an economically attractive secondary recovery project.
2. Primary recovery in the East Unit will amount to 2,192,000 stock tank barrels, or 10.16 per cent of the original oil in place.
3. Ultimate recovery after waterflood should be approximately 6,780,000 stock tank barrels, or 31.44 per cent of the original oil in place.
4. The waterflood project in the East Unit should recover an additional 4,588,000 barrels of oil with a profit of $7,300,000 or 802 per cent of a $910,000 capital investment.

RECOMMENDATIONS

1. Take necessary steps to unitize the main Queen sand section in the east half of the Pearl Queen Field as delineated in Figure 1.
2. Initiate a cooperative 5-spot pattern waterflood with the West Unit as soon as unitization is completed.
3. Should unitization of the East Unit precede that of the West Unit, consider initiating a Zone IV flood using the same 5-spot pattern and enlarge to a full-scale flood when a field-wide project can be commenced.
4. Conduct a joint study with the West Unit to find an adequate water supply for flood operations.

DISCUSSION

Geology

Production in the Pearl Queen Field is from a series of sands in the Queen (Middle Whitehorse) member, Guadalupe series of the upper Permian. The Queen sand interval which is productive throughout the main part of the Pearl Field comprises approximately 200 feet of gross section. This interval can be divided into four distinct sands or groups of sands which have been designated as Zones I through IV. Zones II and III have been further subdivided into A and B sands. These four zones are considered the main Queen sand interval.

Lithologically, the productive interval is a series of fine-grained, gray, dolomitic and anhydritic sandstones interbedded with tan anhydritic dolomite and anhydrite. Although the various sand zones are correlative over the entire Pearl Queen Field, porosity development is quite erratic with rapid changes noted from one well to the next. Deterioration of porosity is primarily due to cementation.

The main oil accumulation in the Queen sands is controlled by a combination stratigraphic-structural trap. Trapping is afforded by porosity deterioration on the north or up-dip edge of a relatively gentle southwesterly sloping feature. Water levels provide the down-dip productive limits. Laterally, the field is bounded by porosity deterioration to the east and by water levels to the south and west where the productive sands are structurally low.

The structure of the four main Queen sand zones within the East Unit are depicted by Figures 2 through 5. The indicated water levels in Zones I and IV were determined from log analyses and production test data. A water level of 1064

feet subsea provides the down-dip productive limits of Zone I. The Zone IV water level is indicated at 1125 feet subsea, which, as can be seen, confines the productive limits of this zone to within the boundaries of the East Unit. The water levels in Zones II and III are not shown as they do not occur within the boundaries of the East Unit.

The correlative nature of the main Queen sands is shown by two east-west cross-sections, A-A' and B-B', Figures 14 and 15, and one north-south cross-section, C-C', Figure 16. The index to these cross-sections is shown in Figure 13.

As previously mentioned, current development is confined to the northeast section of the field which is to the east of the proposed waterflood unit. In this area a lower Queen sand (designated Zone V) has been proven productive while the main Queen sand interval is not of reservoir quality. Zone V is found approximately 80-100 feet below Zone IV, which is the lowest Queen zone found to be productive in the main part of the Pearl Queen Field. Within the boundaries of the East Unit eight wells have penetrated Zone V. Only the Colton-Texaco Moran No. 2 has found Zone V to be productive; however, the Colton-Gulf State No. 1 has good porosity development indicated by log analysis. The other six wells have either condemned Zone V by production test or log analysis. Cross-section A-A', Figure 14, depicts the Zone V correlation in respect to the main Queen sand interval (Zones I through IV).

Reservoir Characteristics

The four sand zones comprising the main pay interval are considered separate reservoirs and each is producing under solution gas drive and fluid expansion.

The average reservoir porosity, as determined from log analyses, is 15.1 per cent. A cut-off porosity of ten per cent was utilized in determining net pay. This cut-off porosity was based on an analysis of the statistical capillary

pressure and average core permeability data presented in Graph 1, Figure 19, and well completion experience which has indicated conclusively that sands with less than ten per cent log porosity are non-productive. The indicated average permeability of a 15.1 per cent porosity rock is 12 md. with the range of average permeabilities in ten per cent porosity rock and greater being 1 to 140 md.

Core analysis data used in this report were from 14 wells. Capillary pressure measurements were run on three of these cores. The capillary pressure data presented in Graph 1, Figure 19, are considered to be a valid representation of the average capillary properties of the main Queen sand interval.

The average water saturation from log analysis versus porosity is presented in Graph 2, Figure 19. The connate water saturation of a 15.1 per cent porosity rock is indicated to be 35 per cent. This value was used in subsequent volumetric calculations. The corresponding irreducible water saturation as indicated by the 62 atm. curve is 21 per cent. This may account for the free water production in areas of the field considerably above oil-water contacts.

The mobile oil factor, expressed as a per cent of the total oil in place, is presented in Graph 3, Figure 19. The mobile oil factor represents that portion of the total void space occupied by hydrocarbons that actively contributes to production. The mobile oil factors at various porosity values were obtained by dividing the percentage of 0-5 atm. pores (recoverable oil) by the corresponding oil saturations expressed as a per cent. The oil saturations (1 - water saturation) were determined from the water saturation versus porosity plot presented in Graph 2, Figure 19. It was thus determined that 68 per cent of the total oil saturation contained in the average reservoir rock (15.1% porosity) is mobile oil and therefore considered recoverable. The mobile oil saturation would be 44 per cent with the resulting residual oil saturation after waterflood being 21 per cent. This residual oil saturation appears to be in agreement with the range of residual oil

saturations measured in the core analyses. A sample calculation of the residual oil saturation after waterflood is present in Table VII.

Available bottom hole pressure data in the Pearl Queen Field are limited to surveys run by Shell Oil Company in wells located predominately in the north-half of the proposed East Unit. The lack of field-wide pressure data is attributed to the fact that most wells were pumping completions with the remaining wells experiencing only a short flowing life. Shell has run build-up pressure surveys in 15 wells with six of these wells equipped with offset well heads to enable the taking of bottom hole pressure measurements without pulling rods and pump. Routine pressure surveys have been conducted in these six wells throughout their producing life. An analysis of the available pressure data indicated that the original reservoir pressure was 1776 psi with the bubble point pressure being approximately 1400 psi at the reservoir temperature of 100° F. The predicted reservoir pressure performance of the East Unit, shown in Figure 17, was based on this analysis utilizing the estimated primary ultimate recovery as indicated from the production performance history, Figure 20.

A recombined P.V.T. analysis was performed using samples of separator liquid and vapor collected from the Shell-State PF No. 1 in January 1961. The separator products were recombined so that the resulting mixture would have a bubble point pressure of 1400 psi at 100° F. Differential liberation of the recombined sample indicated a formation volume factor of 1.176 at the original reservoir pressure of 1776 psi and 1.180 at the saturation or bubble point pressure of 1400 psi. Figure 18 presents the formation volume factors as determined from the P.V.T. analysis.

Determination of Original Oil in Place

The determination of original oil in place was based on volumetric data obtained from the quality isopachous maps presented in Figures 6 through 11. Individual quality isopachous maps were constructed for each of the sand zones. These maps were contoured on the factor of per cent porosity multiplied by net feet of pay as determined from log analyses.

The reservoir pore volume expressed in acre-porosity-feet of net pay was determined by planimetering each of the six quality isopachous maps. Tables II, III, and IV are tabulations by operator, lease, and zone of the acre-porosity-feet of net pay presently open to production, not open to production but considered productive in the well bore, and not productive in well bore but considered productive within lease boundary, respectively. Table V is a summary tabulation of total productive acre-porosity-feet of net pay by operator and lease. Table VI is a summary tabulation of acre-porosity-feet by zone.

The total productive reservoir pore volume was determined to be 5,028.99 acre-porosity-feet. Based on the average water saturation of 35 per cent and a formation volume factor at original conditions of 1.176, the original oil in place was found to be 21,565,000 stock tank barrels. Table VII presents the volumetric calculation of the original oil in place.

Determination of Ultimate Primary Recovery

The ultimate primary recovery of the East Unit is estimated to be 2,192,000 barrels of oil or 10.16 per cent of the original oil in place. This estimate was based on an exponential or constant percentage decline of future production to an economic limit of 3,300 barrels of oil per month (55 wells x 60 barrels per month). Oil production history, including predicted performance by primary depletion, is presented by Graph 20.

Waterflood Pattern and Injection Plans

A five-spot flood pattern, as illustrated in Figure 12, is recommended for this project. As can be seen from the quality isopachous maps, Figures 6 through 11, there is considerable variation in the sand quality within the individual zones. Also, the sand zones are not all productive throughout the unit area with Zone IV being limited to the north area and Zones II B and III B being limited primarily to the south area. For these reasons the five-spot is considered the best pattern to obtain adequate areal sweep in all sand zones.

The effective injection of water into more than one sand zone through a common injection well is considered somewhat of a problem. Due to the relatively small separations (3-10 feet) between Zones II A through IV, the completion fracture stimulations may not have effectively treated all perforated zones. Initially the bulk of the injected water will preferentially enter those zones which were effectively treated at completion; however, after fill up it is anticipated that the per zone injectivity will more nearly approach original permeability-capacity relationships.

Dual injection equipment has been provided for 22 of the 31 injection wells in order to segregate Zone I from the lower sand zones. Zone I is the most uniform and continuous sand in the main Queen sand section. Stratigraphically, it is separated from the lower zones by approximately 100 feet of section comprised primarily of dense anhydrite and anhydritic dolomite. Zone I contains 38.46 per cent of the total productive acre-porosity-feet in the East Unit. This zone by itself would be an attractive flood prospect and will probably contribute more than 40 per cent of the total oil recovered by waterflood. Controlled injection into Zone I should provide added assurance of a successful flood.

Prediction of Waterflood Performance

An empirical method of predicting waterflood performance has been used in this study. Several analytical methods were considered; however, all involved the basic assumption that a series of homogeneous layers of different permeability, derived from a grouping of core analysis data, would represent the average injection well. Due to the plan of segregated injection and the variations in the productive areas of the various sand zones, it would be difficult if not impossible to approximate an average injection well by this method. It was therefore concluded that an empirical method, based on the average known performance of many waterfloods, would yield the most satisfactory performance prediction.

The recoverable oil by waterflood was determined from a volumetric calculation assuming that 40 per cent of the mobile oil in place at the time of flood initiation would be recovered. As shown in Table VII, the estimated recoverable oil by waterflood is 4,952,000 stock tank barrels. This represents an increase in recovery due to waterflood operations of 4,588,000 stock tank barrels or approximately 2.1 times the primary ultimate. The recovery after waterflood will be 31.44 per cent of the original oil in place compared with a 10.16 per cent primary recovery efficiency.

The cumulative water injected at the project economic limit is estimated to be approximately 50 million barrels or 1.27 pore volumes assuming the injection of ten barrels of water per barrel of oil produced under waterflood operation. An injection rate of 300 barrels of water per day per injection well is anticipated based on the injection history of the Shell-Allen Estate No. 3 Salt Water Disposal Well. This well is currently disposing of approximately 300 barrels of water per day into a lower water-bearing Queen sand zone at surface injection pressures of 1,800 to 1,900 psi. The total make-up water required for this project is estimated to be 15 million barrels or 30 per cent of the total injected water assuming the recycling of produced water.

Figure 20 illustrates the predicted performance of the East Unit waterflood project. It is estimated that fill-up will require 12 months of injection predicated on an average injection rate of 283,000 barrels of water per month and an initial gas saturation of 8.7 per cent. The first oil response should occur seven months after the start of injection or at 60 per cent fill-up. The top unit allowable oil production rate will be 71,500 barrels per month with a basic waterflood allowable of 42 barrels per day per well. The total project life of 15 years is based on maintaining an injection rate of 283,000 barrels of water per month except after fill-up when injection rates will be reduced for an estimated one-year period in order to balance injected and produced fluids.

Water Sources and Requirements

The initial daily water requirement for the East Unit will be 9,300 barrels based on a water injection rate of 300 barrels per day per well and a total of 31 injection wells. Combined water requirements for the East and West Units, which by necessity will have to be operated on a cooperative basis, are estimated to be approximately 19,000 barrels per day. During the life of the project the reinjection of produced water will reduce the make-up requirements necessary to maintain constant injection rates.

Since the development of a common source or sources of water for both units should have certain economic advantages, it is felt that a combined effort by the East and West Unit operators should be made to find and develop an adequate water source for flood operations in both units.

A cursory evaluation of water sources in the Pearl area indicates the following possibilities:

1. Shallow Water Sands - The Ogallala (100-200 feet) has been found to be productive of fresh water in the volumes required for drilling activity, but

it is doubtful that the sustained capacity of these sands could provide any more than a fraction of the total water requirement. The Santa Rosa (900-1300 feet) has not been tested; however, log evaluation indicates approximately 200 feet of sand with a porosity of 6-10 per cent and a water salinity of 2000-3000 ppm. Since both C. W. Trainer and Gulf Oil Corporation hold water leases in this area, it is felt that the Santa Rosa source merits further investigation.

2. Disposal Water From the Vacuum South Devonian Field - The field operators are presently considering SWD facilities. It is estimated that approximately 10,000 barrels per day will ultimately be available from the field. Since this amount would represent only one-half of the total water requirements, it would have to be supplemented from some other source. The pipe line cost to transport this water is estimated to be $60,000.

3. Eunice-Monument-Eumont SWD System - Total flood water requirements could be obtained from this SWD system. Present and anticipated future water disposal in this field is in excess of the estimated requirements. At this time the Eunice-Monument-Eumont SWD System appears to be the only adequate source of water available in the Pearl area. The estimated cost to provide a gathering line and a pump station to transport 19,000 barrels per day is $220,000. This source has been used in the economic analysis of waterflooding with the East Unit's share being approximately 50 per cent or $110,000.

Development Cost

The ultimate waterflood development cost for the East Unit is estimated to be $910,000. A capital investment of $731,000 will be required to initiate this project with a subsequent investment of $179,000 providing high capacity lifting equipment during the second and third years. A summary of the estimated development costs using disposal water from the Eunice-Monument-Eumont SWD system is as follows:

Item	Amount
Convert 31 wells to injection status	$269,000
Additional perforating and stimulation (producers & injectors)	70,000
Provide high capacity pumping equipment	179,000
Water Injection Plant	85,000
Water distribution system	102,000
Tank batteries, gathering and test facilities, LACT	64,000
Water supply line and pump station	110,000
Contingencies	31,000
Total Investment	$910,000

Economics

The economics of the East Unit waterflood are summarized in Table VIII. Tables IX and X present profitability analyses for continued primary depletion and waterflood operation, respectively. The total capital investment for the waterflood project is estimated to be $910,000 with an initial investment of $731,000. An additional 4,588,000 barrels of oil should be recovered by waterflood operations. The net increase in profit is $7,300,000 or 802% of the total capital investment. Payout is estimated to be 1.2 years.

Unitization

Unitization of the area included within the boundaries of the proposed East Unit shown in Figure 1 will provide the initial step toward field-wide unitization and the subsequent initiation of full scale waterflood operations. The unitized interval should include the Queen formation down to the top of Zone V. Since this zone is currently being developed outside the proposed unit boundary and isn't considered floodable within the unit, the exclusion of Zone V should facilitate unitization. At the time of unitization those wells producing from Zone V which are to be included within the East Unit can be given primary credit for any anticipated loss in production.

Table XI is a tabulation of potential unitization parameters. Ultimate recovery and remaining primary reserves by lease have not been included as possible parameters due to the lack of sufficient data to accurately predict these values. Acre-porosity-feet was included as a potential unitization parameter since this value should represent the relative secondary potential of each lease within the unit. It was originally thought that this parameter could also be used in determining the magnitude of the primary ultimate recovery from each lease; however, a comparison of the relative current capacity, cumulative production, and acre-porosity-feet by lease indicates that in some cases offset drainage has apparently taken place. Therefore, the use of the acre-porosity-feet parameter should be limited to the secondary phase of unitization if a split formula is used.

TABLE I
BASIC DATA
EAST PEARL QUEEN UNIT

Average Porosity (%)	15.1
Average Connate Water Saturation (%)	35
Range of Average Permeabilities in Productive Zones (md.)	1-140
Average Permeability (md.)	12
Original Formation Volume Factor	1.176
Estimated Formation Volume Factor at Start of Water Injection (1-1-64)	1.114
Acre-Porosity-Feet of Net Pay	5,028.99
Original Oil-in-Place (MMSTB)	21.565
Mobile Oil Saturation (%)	44
Oil Saturation After Primary (%)	54
Oil Saturation After Waterflood (%)	21
Ultimate Primary Recovery (MMSTB)	2.192
Primary Recovery Efficiency (%)	10.16
Estimated Cumulative Production at Start of Water Injection (MMSTB)	1.828
Waterflood Efficiency (%)	40
Combined Ultimate Recovery - Primary and Secondary (MMSTB)	6.780
Increased Recovery Due to Waterflood (MMSTB)	4.588
Recovery Efficiency After Waterflood (%)	31.44

TABLE II
TABULATION OF ACRE-POROSITY-FEET OF NET PAY PRESENTLY OPEN TO PRODUCTION EAST PEARL QUEEN UNIT

Operator	Lease	Acre-Porosity-Feet of Net Pay by Zone						
		I	II A	II B	III A	III B	IV	Totals
Cabot	State G	82.40	37.51	0	0	0	0	119.91
Collier	State	0	0	0	8.81	0	0	8.81
Colton	Gulf State	0	0	0	0	0	5.39	5.39
	Texaco-Moran	0	0	0	0	0	18.55	18.55
	Subtotal	0	0	0	0	0	23.94	23.94
Gulf	State AR	34.95	119.58	0	99.55	0	0	254.08
Mid-Tex	Gulf-State	0	0	0	57.30	6.65	0	63.95
Sanford	Union-State	0	0	0	11.29	0	55.58	66.87
Trainer	Rushing	0	0	0	22.79	0	55.58	78.37
	Signal-State	0	0	0	0	0	127.09	127.09
	Subtotal	0	0	0	22.79	0	182.67	205.46
Shell	Allen Estate	123.25	12.00	0	101.84	0	0	237.09
	Allen Estate A	13.58	1.69	0	41.72	0	0	56.99
	Hooper	67.51	42.52	0	24.70	0	0	134.73
	Kimberlin	16.19	51.40	0	59.78	4.01	164.47	295.85
	McIntosh	240.61	4.08	0	0	0	52.83	297.52
	McIntosh A	36.07	0	0	21.87	0	78.51	136.45
	McIntosh B	0	6.00	0	37.75	0	119.45	163.20
	McIntosh C	314.81	53.71	0	46.50	0	0	415.02
	McIntosh D	59.26	0	0	33.25	0	61.97	154.48
	McIntosh E	16.79	0	0	18.29	0	0	35.08
	Record	0	0	0	0	0	0	0
	Record A	21.21	3.53	0	43.59	0	0	68.33
	State PA	118.93	2.95	2.45	0	0	0	124.33
	State PB	69.17	10.05	0	34.78	0	31.70	145.70
	State PC	130.88	30.16	0.84	14.78	13.37	0	190.03
	State PD	154.84	142.20	8.00	165.02	0	0	470.06
	State PE	66.72	0	0	0	21.27	0	87.99
	State PF	104.21	12.00	10.00	31.47	0	0	157.68
	State PG	97.49	0	0	0	0	0	97.49
	Subtotal	1,651.52	372.29	21.29	675.34	38.65	508.93	3,268.02
Unit Totals		1,768.87	529.38	21.29	875.08	45.30	771.12	4,011.04

TABLE III
TABULATION OF ACRE-POROSITY-FEET OF NET PAY NOT OPEN TO PRODUCTION BUT CONSIDERED PRODUCTIVE IN WELL BORE
EAST PEARL QUEEN UNIT

Operator	Lease	Acre-Porosity-Feet of Net Pay by Zone						
		I	II A	II B	III A	III B	IV	Totals
Cabot	State G	0	0	0	0	0	0	0
Collier	State	0	0	0	0	0	0	0
Colton	Gulf State	0	0	0	0	0	0	0
	Texaco-Moran	0	0	0	0	0	0	0
	Subtotal	0	0	0	0	0	0	0
Gulf	State AR	0	0	33.27	0	0	0	33.27
Mid-Tex	Gulf-State	55.82	27.77	8.74	0	5.74	0	98.07
Sanford	Union-State	0	0	0	0	1.17	0	1.17
Trainer	Rushing	0	0	0	25.61	0	0	25.61
	Signal-State	17.11	0	0	33.91	19.49	0	70.51
	Subtotal	17.11	0	0	59.52	19.49	0	96.12
Shell	Allen Estate	0	12.00	0	0	7.73	0	19.73
	Allen Est. (DH)	0	0	0	0	0	0	0
	Allen Est. A	0	0	0	0	0	0	0
	Hooper	0	0	0	46.68	0	0	46.68
	Kimberlin	12.23	0	0	19.83	7.11	0	39.17
	McIntosh	0	0	0	0	0	0	0
	McIntosh A	0	4.53	0	0	0	0	4.53
	McIntosh B	3.94	0	0	7.32	0	0	11.26
	McIntosh C	0	14.84	0	26.04	23.36	0	64.24
	McIntosh D	0	4.97	0	25.18	4.78	0	34.93
	McIntosh E	0	0	0	0	0	0	0
	Record (DH)	18.58	4.39	0	13.13	0	0	36.10
	Record A	0	0	0	0	0	0	0
	State PA	0	10.20	0	21.90	0	0	32.10
	State PB	0	0	0	0	0	0	0
	State PC	0	0	4.16	18.88	19.28	0	42.32
	State PD	0	37.46	19.81	14.80	24.65	0	96.72
	State PE	0	7.73	0	7.44	0	0	15.17
	State PE (DH)	17.60	12.00	3.12	0	0	0	32.72
	State PF	0	12.00	3.60	11.17	15.23	0	42.00
	State PG	0	12.00	3.37	22.81	15.13	0	53.31
	Subtotal	52.35	132.12	34.06	235.18	117.27	0	570.98
Unit Totals		125.28	159.89	76.07	294.70	143.67	0	799.61

DH - 40-Acre Dry Hole Unit

TABLE IV
TABULATION OF ACRE-POROSITY-FEET OF NET PAY NOT PRODUCTIVE IN WELL BORE BUT CONSIDERED PRODUCTIVE WITHIN LEASE BOUNDARY

EAST PEARL QUEEN UNIT

Operator	Lease	Acre-Porosity-Feet of Net Pay by Zone						
		I	II A	II B	III A	III B	IV	Totals
Cabot	State G	0	0	2.18	0.59	0	0	2.77
Collier	State	1.60	7.47	0	0	0.02	0	9.09
	State (UD)	0.26	0.93	0	3.84	0.01	13.54	18.58
	Subtotal	1.86	8.40	0	3.84	0.03	13.54	27.67
Colton	Gulf-State	0	0	0	0	0	0	0
	Texaco-Moran	0	0	0	3.71	0	0	3.71
	Subtotal	0	0	0	3.71	0	0	3.71
Gulf	State AR	0	0	15.12	0	2.82	0	17.94
Mid-Tex	Gulf-State	0	3.11	2.19	0	0	0	5.30
Sanford	Union-State	0	0	0	7.76	1.50	0	9.26
Trainer	Rushing	0	0	0	0	0.38	0	0.38
	Signal-State	0	0.16	0	0	0	0	0.16
	Subtotal	0	0.16	0	0	0.38	0	0.54
Shell	Allen Est.	0	3.56	0	0	0	0	3.56
	Allen Est. (DH)	10.55	0.26	0	9.97	0	0	20.78
	Allen Estate A	0	0	0	0	0	0	0
	Allen Est. A (UD)	4.62	1.53	0	6.35	0	0	12.50
	Hooper	0	0	0	0	0	3.30	3.30
	Kimberlin	1.49	13.40	0	0	0.80	0	15.69
	McIntosh	0	4.71	0.11	7.29	1.83	0	13.94
	McIntosh A	0	0	0	0	1.40	0	1.40
	McIntosh B	5.15	0.66	0	0	3.33	0	9.14
	McIntosh C	0	0	0	0	2.00	10.58	12.58
	McIntosh D	4.41	1.77	0	0	0.01	2.35	8.54
	McIntosh E	0	1.28	0	0	0	0	1.28
	Record (DH)	0	0	0	0	0	0	0
	Record A	0	0	0	0	0.30	0	0.30
	State PA	0	0	2.20	3.32	0.13	0	5.65
	State PB	0	10.73	0	0	0	0	10.73
	State PC	0	0	0	0	0	0	0
	State PD	11.81	0	0	0	9.45	0	21.26
	State PE	0	0	0.06	0	0	0	0.06
	State PE (DH)	0	0	0	1.81	2.99	0	4.80
	State PF	0	0	0	0	0	0	0
	State PG	0	3.46	2.18	0	0	0	5.64
	Subtotal	38.03	41.36	4.55	28.74	22.24	16.23	151.15
Unit Totals		39.89	53.03	24.04	44.64	26.97	29.77	218.34

DH - 40-Acre Dry Hole Unit
UD - 40-Acre Undrilled Unit

TABLE V
SUMMARY TABULATION OF
PRODUCTIVE ACRE-POROSITY-FEET
OF NET PAY BY OPERATOR AND LEASE
EAST PEARL QUEEN UNIT

Operator	Lease	Acre-Porosity-Feet of Net Pay: Open to Production	Not Open to Production	Not Present In Well Bore	Totals
Cabot	State G	119.91	0	2.77	122.68
Collier	State	8.81	0	9.09	17.90
	State (UD)	0	0	18.58	18.58
	Subtotal	8.81	0	27.67	36.48
Colton	Gulf-State	5.39	0	0	5.39
	Texaco-Moran	18.55	0	3.71	22.26
	Subtotal	23.94	0	3.71	27.65
Gulf	State AR	254.08	33.27	17.94	305.29
Mid-Tex	Gulf-State	63.95	98.07	5.30	167.32
Sanford	Union-State	66.87	1.17	9.26	77.30
Trainer	Rushing	78.37	25.61	0.38	104.36
	Signal-State	127.09	70.51	0.16	197.76
	Subtotal	205.46	96.12	0.54	302.12
Shell	Allen Est.	237.09	19.73	3.56	260.38
	Allen Est. (DH)	0	0	20.78	20.78
	Allen Est. A	56.99	0	0	56.99
	Allen Est. A (UD)	0	0	12.50	12.50
	Hooper	134.73	46.68	3.30	184.71
	Kimberlin	295.85	39.17	15.69	350.71
	McIntosh	297.52	0	13.94	311.46
	McIntosh A	136.45	4.53	1.40	142.38
	McIntosh B	163.20	11.26	9.14	183.60
	McIntosh C	415.02	64.24	12.58	491.84
	McIntosh D	154.48	34.93	8.54	197.95
	McIntosh E	35.08	0	1.28	36.36
	Record (DH)	0	36.10	0	36.10
	Record A	68.33	0	0.30	68.63
	State PA	124.33	32.10	5.65	162.08
	State PB	145.70	0	10.73	156.43
	State PC	190.03	42.32	0	232.35
	State PD	470.06	96.72	21.26	588.04
	State PE	87.99	15.17	0.06	103.22
	State PE (DH)	0	32.72	4.80	37.52
	State PF	157.68	42.00	0	199.68
	State PG	97.49	53.31	5.64	156.44
	Subtotal	3,268.02	570.98	151.15	3,990.15
Unit Totals		4,011.04	799.61	218.34	5,028.99

DH - 40-Acre Dry Hole Unit
UD - 40-Acre Undrilled Unit

TABLE VI
SUMMARY TABULATION OF PRODUCTIVE
ACRE-POROSITY-FEET OF NET PAY BY ZONE
EAST PEARL QUEEN UNIT

Zone	Acre-Porosity-Feet of Net Pay				% of Total Unit Acre-Porosity-Feet
	Open to Production	Not Open to Production	Not Present In Well Bore	Zone Totals	
I	1,768.87	125.28	39.89	1,934.04	38.46
II A	529.38	159.89	53.03	742.30	14.76
II B	21.29	76.07	24.04	121.40	2.41
III A	875.08	294.70	44.64	1,214.42	24.15
III B	45.30	143.67	26.97	215.94	4.29
IV	771.12	0	29.77	800.89	15.93
Unit Totals	4,011.04	799.61	218.34	5,028.99	100.00

TABLE VII
SAMPLE CALCULATIONS
EAST PEARL QUEEN UNIT

Residual Oil After Waterflood:

At 15.1 per cent porosity:

Mobile Oil Saturation = Mobile Oil Factor (from Graph 3, Fig. 19)
x Original Oil Saturation (from Graph 2, Fig. 19)
= 0.68 x (1-0.35) = 0.44

Residual Oil Saturation After Waterflood = Original Oil Saturation
- Mobile Oil Saturation = (1-0.35) - 0.44 = 0.21

Original Oil In Place:

$$OOIP\ (STB) = \frac{7758\ Ac\ \phi\ Ft\ (1-S_w)}{Boi} = \frac{7758 \times 5028.99\ (1-0.35)}{1.176} = 21,565,000\ STB$$

Oil Saturations:

At Primary Depletion:

$$S_o = B_o\left(\frac{1-S_w}{Boi} - \frac{N_p}{7758\ Ac\ \phi\ Ft}\right) = 1.088\left(\frac{1-0.35}{1.176} - \frac{2.192 \times 10^6}{7758 \times 5028.99}\right) = 0.540$$

At Start of Water Injection:

$$S_o = B_o\left(\frac{1-S_w}{Boi} - \frac{N_p}{7758\ Ac\ \phi\ Ft}\right) = 1.114\left(\frac{1-0.35}{1.176} - \frac{1.828 \times 10^6}{7758 \times 5028.99}\right) = 0.563$$

Recoverable Oil by Waterflood:

$$N_{wf} = \text{Waterflood Efficiency}\ [7758\ Ac\ \phi\ Ft\left(\frac{1-S_w}{Boi} - \frac{S_{or}}{Bo}\right) - N_p]$$

$$N_{wf} = 0.40\ [7758 \times 5028.99\left(\frac{1-0.35}{1.176} - \frac{0.21}{1.114}\right) - 1.828 \times 10^6] = 4,952,000\ STB$$

TABLE VIII
SUMMARY TABULATION OF
WATERFLOOD ECONOMICS
EAST PEARL QUEEN UNIT

Profitability Item	Continued Primary	Waterflood Project	Net Increase Due to Water-flood Operation
Gross Oil Production, (M) Bbls.	364	4,952	4,588
Value of Net Production, (M) $	930	12,301	11,371
Operating Costs, (M) $	433	2,668	2,235
Taxes & Insurance, (M) $	74	1,000	926
Capital Investment, (M) $	0	910	910
Total Expenditures, (M) $	507	4,578	4,071
Net Profit, (M) $	423	7,723	7,300
Per Cent Profit	-	-	802
Present Value Profit (@ 6%), (M) $	393	6,095	5,702
Per Cent Deferred Profit	-	-	641
Project Life, Yrs.	4	15	11
Pay Out Time, Yrs.	-	-	1.2

TABLE IX
PROFITABILITY ANALYSIS OF
CONTINUED PRIMARY DEPLETION
EAST PEARL QUEEN UNIT

Year	Gross Oil Production (M) Bbls.	Value of Net Prod.(1) (M) $	Expenditures (M) $				Net Profit (3) (M) $	Present Value of Net Profit Discounted at 6% (M) $
			Operating Costs	Taxes (2) & Insurance	Capital Investments	Total		
1964	140	358	110	28		138	220	212
1965	103	263	109	21		130	133	121
1966	70	179	108	14		122	57	49
1967	51	130	106	11	-	117	13	11
Totals	364	930	433	74	0	507	423	393

(1) Basic Royalty 12.5 Per Cent
(2) State and Local taxes
(3) Before Federal Income Tax

TABLE X
PROFITABILITY ANALYSIS OF
WATERFLOOD PROJECT
EAST PEARL QUEEN UNIT

Year	Gross Oil Production (M) Bbls.	Value of Net Prod.(1) (M) $	Expenditures (M) $				Net Profit(3) (M) $	Present Value of Net Profit Discounted at 6% (M) $
			Operating Costs	Taxes(2) & Insurance	Capital Investments	Total		
1964	415	1031	129	84	731	944	87	56
1965	858	2131	165	173	60	398	1733	1573
1966	858	2131	185	173	119	477	1654	1416
1967	706	1754	199	143		342	1412	1141
1968	468	1162	191	95		286	876	668
1969	311	773	185	63		248	525	378
1970	238	591	183	48		231	360	244
1971	208	517	181	42		223	294	188
1972	183	455	181	37		218	237	143
1973	162	402	180	33		213	189	108
1974	138	343	179	28		207	136	73
1975	123	305	178	25		203	102	52
1976	107	266	178	22		200	66	32
1977	93	231	177	17		194	37	17
1978	84	209	177	17		194	15	6
Totals	4,952	12,301	2,668	1,000	910	4,578	7,723	6,095

(1) Basic Royalty 12.5 Per Cent
(2) State and Local Taxes
(3) Before Federal Income Tax

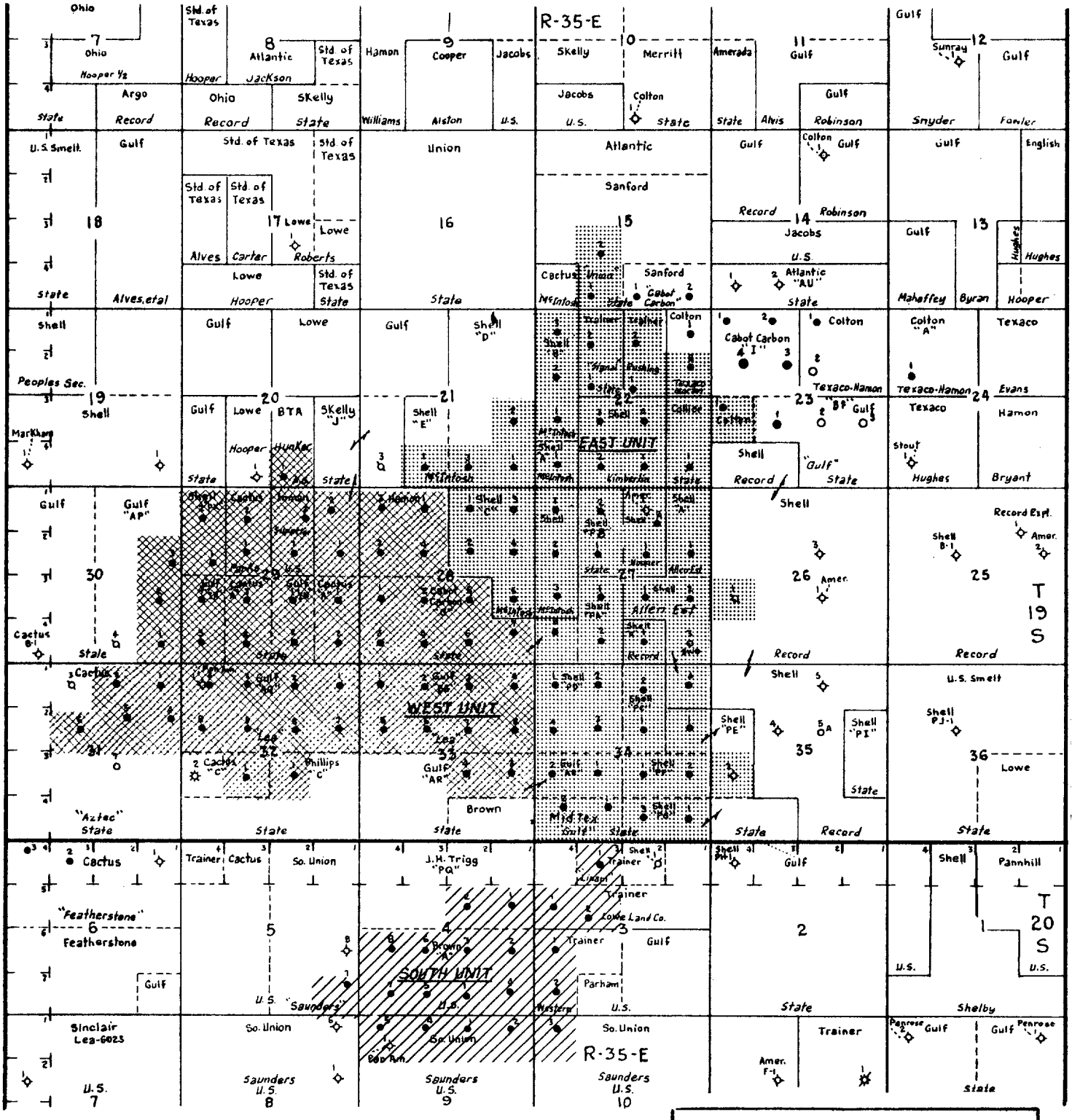
TABLE XI
POTENTIAL UNITIZATION PARAMETERS
EAST PEARL QUEEN UNIT

Operator & Lease	Statistics: Useable Wells	Statistics: Production June-Aug. 1962	Statistics: Cumulative Production (9-1-62)	Statistics: Total Acre-Porosity-Feet	Percentages: Useable Wells	Percentages: Production June-Aug. 1962	Percentages: Cumulative Production (9-1-62)	Percentages: Total Acre-Porosity-Feet
Cabot								
State "G"	1	1,335	36,646	122.68	1.7241	1.9519	2.3642	2.4395
Collier								
State	1	471	5,358	36.48	1.7241	0.6887	0.3457	0.7254
Colton								
Gulf-State	1	1,908	8,828	5.39	1.7242	2.7897	0.5696	0.1072
Texaco-Moran	1	2,278*	7,031*	22.26	1.7241	3.3307*	0.4536*	0.4426
Company Total	2	4,186*	15,859*	27.65	3.4483	6.1204*	1.0232*	0.5498
Gulf								
State "AR"	2	4,763	35,540	305.29	3.4483	6.9641	2.2929	6.0706
Mid-Tex								
Gulf-State	2	2,335	32,151	167.32	3.4483	3.4140	2.0742	3.3271
Sanford								
Union-State	2	1,196	19,315	77.30	3.4483	1.7487	1.2461	1.5371
Trainer								
Rushing	2	2,090	33,522	104.36	3.4483	3.0558	2.1627	2.0752
Signal-State	2	3,315	59,876	197.76	3.4483	4.8469	3.8629	3.9324
Company Total	4	5,405	93,398	302.12	6.8966	7.9027	6.0256	6.0076

*Production from Zone V is included in these values.

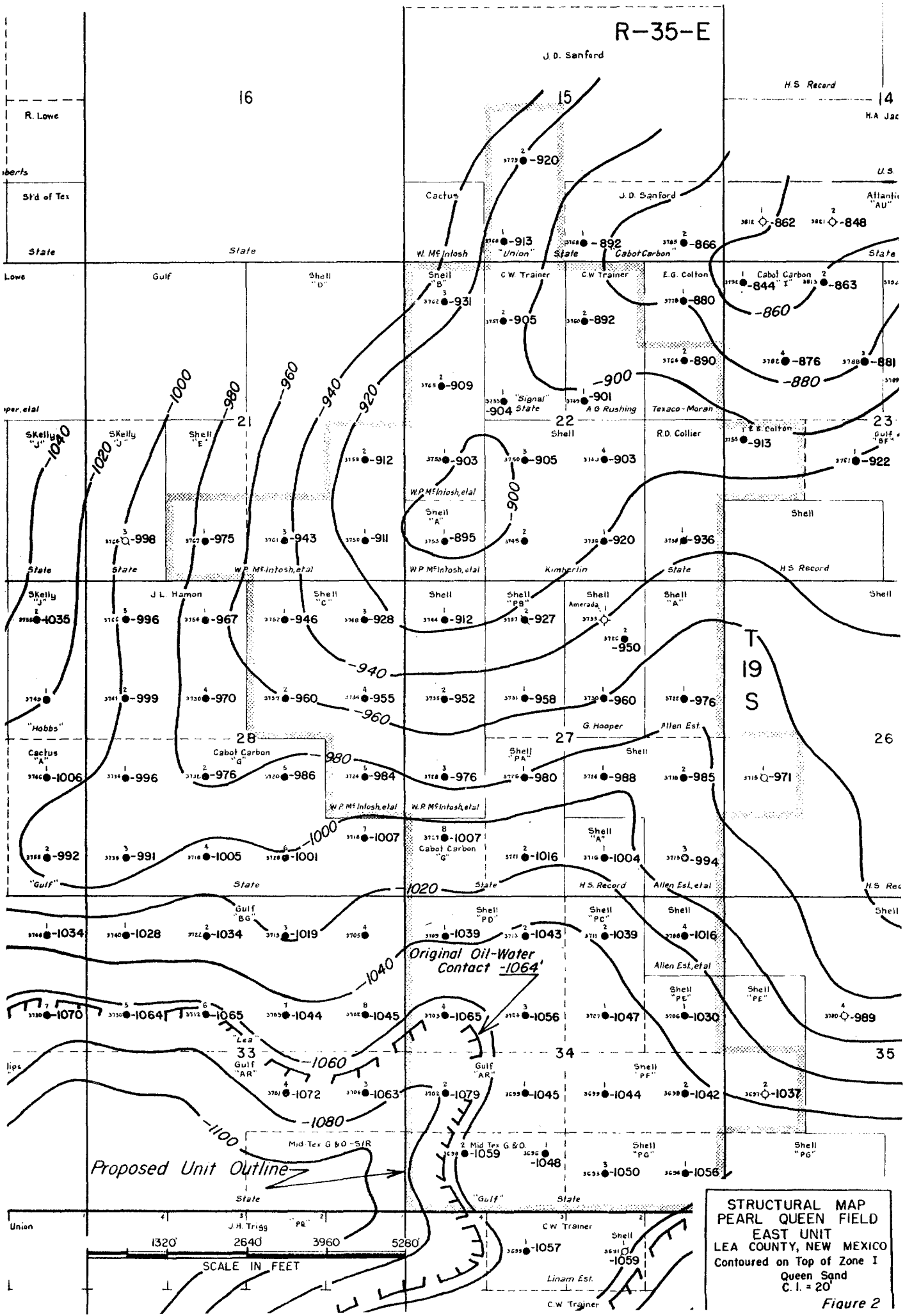
TABLE XI (CONTINUED)
POTENTIAL UNITIZATION PARAMETERS
EAST PEARL QUEEN UNIT

Operator & Lease	Statistics: Useable Wells	Statistics: Production June-Aug. 1962	Statistics: Cumulative Production (9-1-62)	Statistics: Total Acre-Porosity-Feet	Percentages: Useable Wells	Percentages: Production June-Aug. 1962	Percentages: Cumulative Production (9-1-62)	Percentages: Total Acre-Porosity-Feet
Shell								
Allen Estate	4	5,521	137,715	281.16	6.8966	8.0723	8.8848	5.5908
Allen Estate "A"	1	1,567	48,110	69.49	1.7241	2.2911	3.1039	1.3818
Hooper	2	377	42,264	184.71	3.4483	0.5512	2.7267	3.6729
Kimberlin	4	1,912	124,574	350.71	6.8966	2.7956	8.0370	6.9738
McIntosh	3	1,910	108,768	311.46	5.1724	2.7926	7.0172	6.1933
McIntosh "A"	1	1,029	47,365	142.38	1.7241	1.5045	3.0558	2.8312
McIntosh "B"	3	1,552	77,066	183.60	5.1724	2.2692	4.9720	3.6508
McIntosh "C"	5	4,308	161,820	491.84	8.6207	6.2988	10.4399	9.7801
McIntosh "D"	3	888	50,631	197.95	5.1724	1.2984	3.2665	3.9362
McIntosh "E"	1	283	13,927	36.36	1.7241	0.4138	0.8985	0.7230
Record	1	-	-	36.10	1.7241	-	-	0.7178
Record "A"	1	1,445	50,388	68.63	1.7241	2.1128	3.2508	1.3647
State "PA"	2	1,324	69,703	162.08	3.4483	1.9358	4.4969	3.2229
State "PB"	2	359	50,902	156.43	3.4483	0.5249	3.2840	3.1106
State "PC"	2	4,312	57,190	232.35	3.4483	6.3047	3.6897	4.6202
State "PD"	4	10,224	134,848	588.04	6.8966	14.9487	8.6998	11.6930
State "PE"	1	2,834	30,517	140.74	1.7241	4.1436	1.9688	2.7986
State "PF"	2	4,763	53,964	199.68	3.4483	6.9641	3.4815	3.9706
State "PG"	2	4,095	51,992	156.44	3.4482	5.9874	3.3543	3.1107
Company Total	44	48,703	1,311,744	3,990.15	75.8620	71.2095	84.6281	79.3430
Unit Totals	58	68,394	1,550,011	5,028.99	100.0000	100.0000	100.0000	100.0000



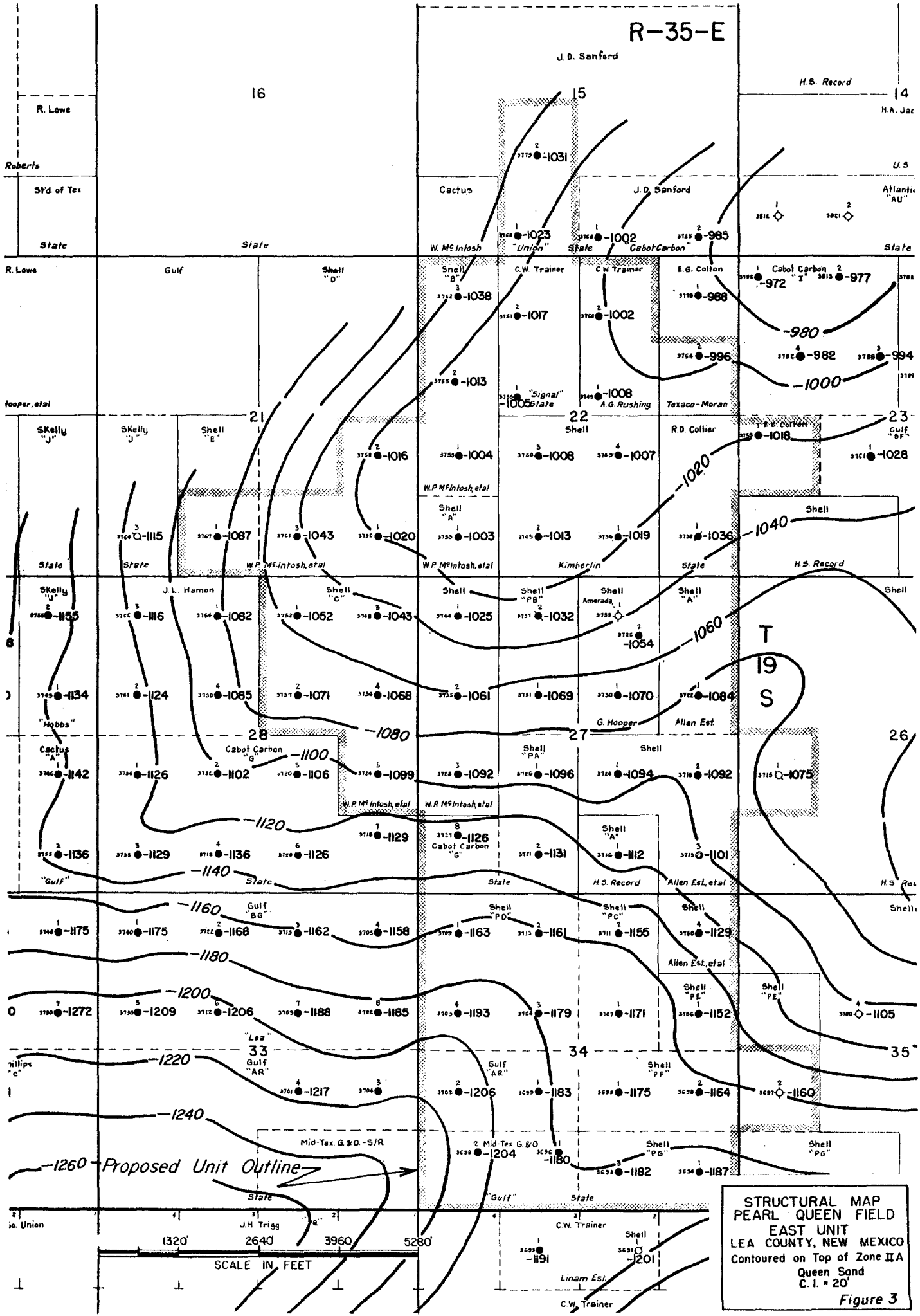
Pearl Queen Field
Lea County, New Mexico
Proposed Unit Subdivisions
Scale: 1" = 4000'

Figure 1



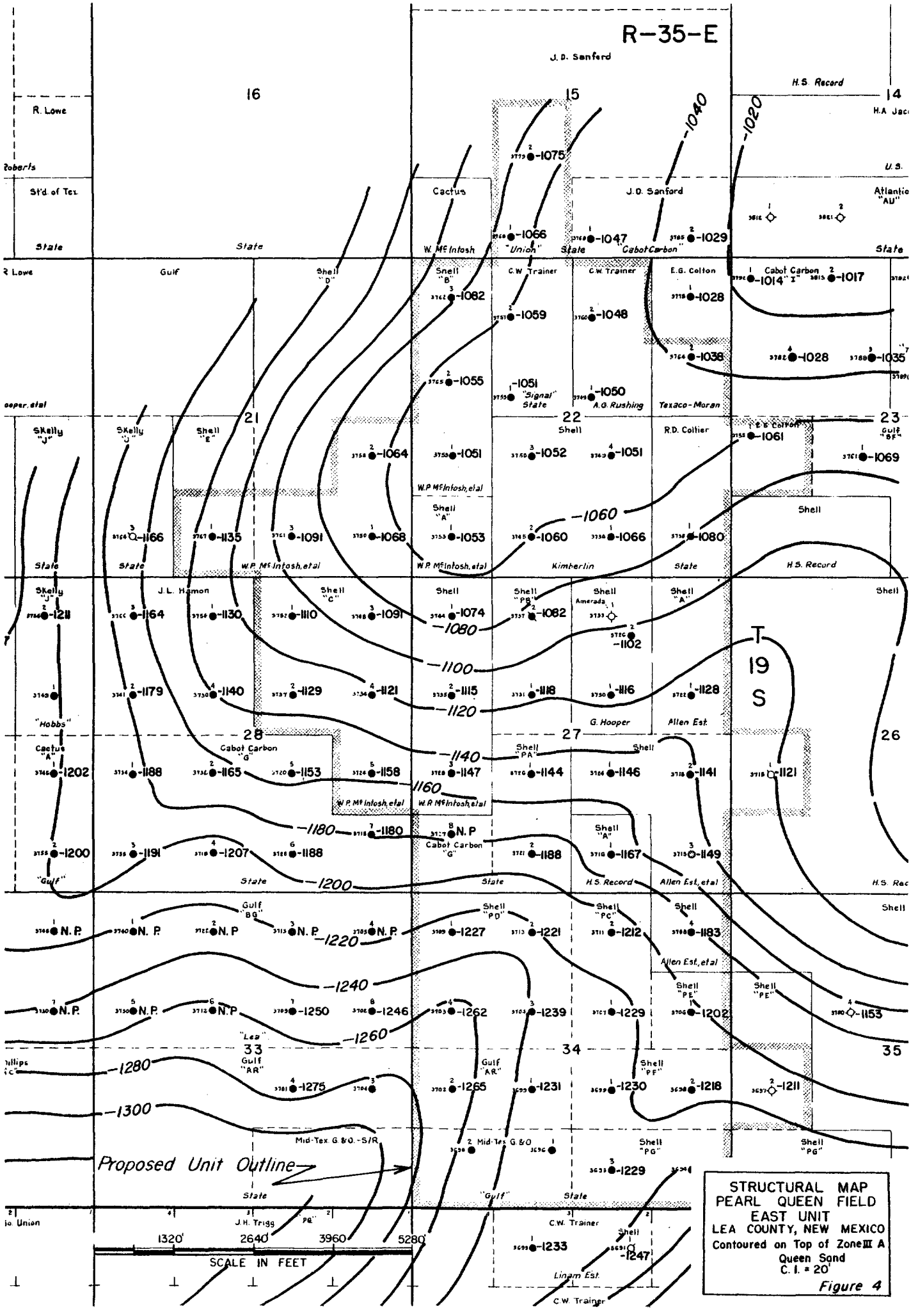
STRUCTURAL MAP
PEARL QUEEN FIELD
EAST UNIT
LEA COUNTY, NEW MEXICO
Contoured on Top of Zone I
Queen Sand
C.I. = 20'

Figure 2



STRUCTURAL MAP
PEARL QUEEN FIELD
EAST UNIT
LEA COUNTY, NEW MEXICO
Contoured on Top of Zone IIA
Queen Sand
C.I. = 20'

Figure 3


R-35-E
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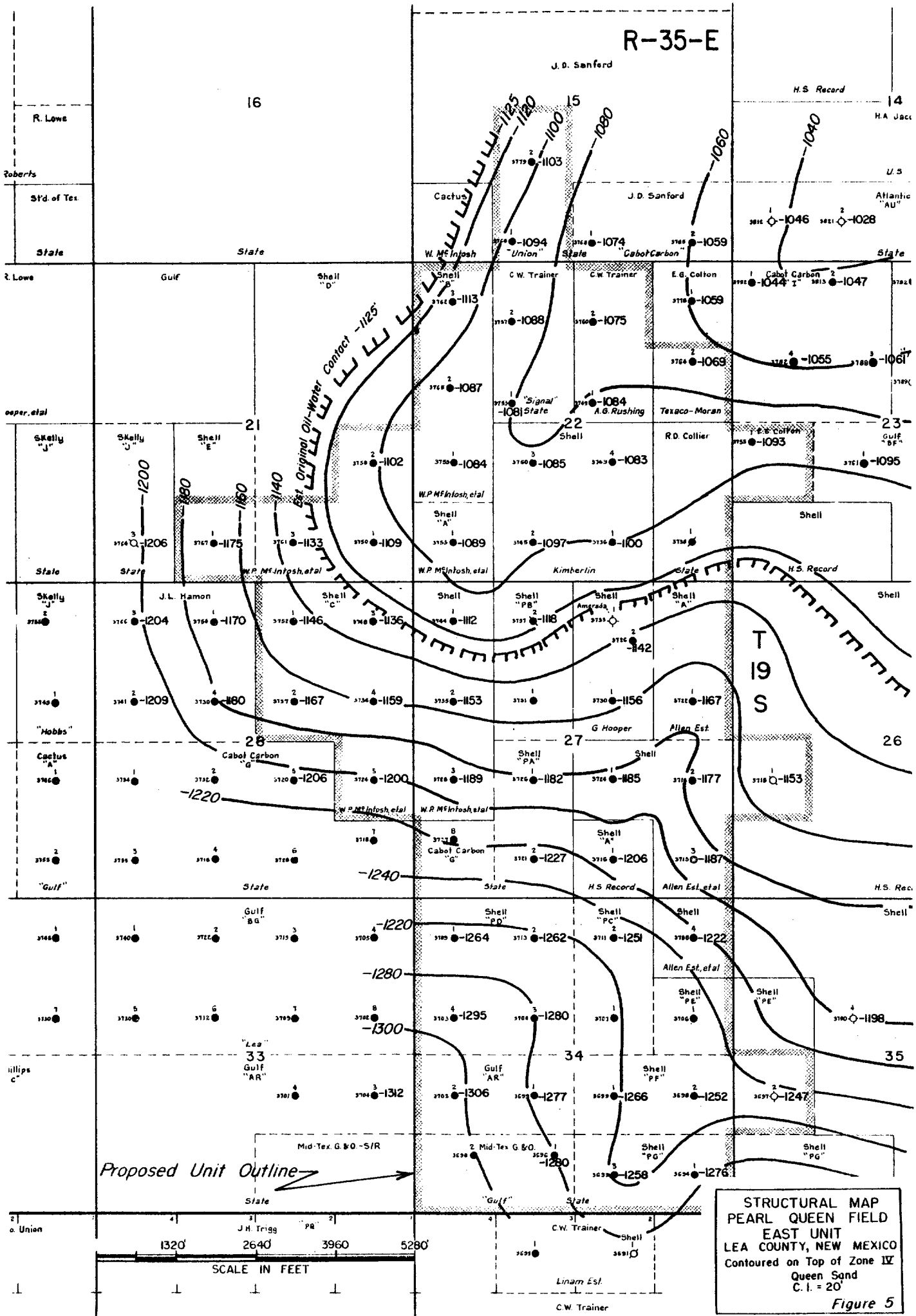
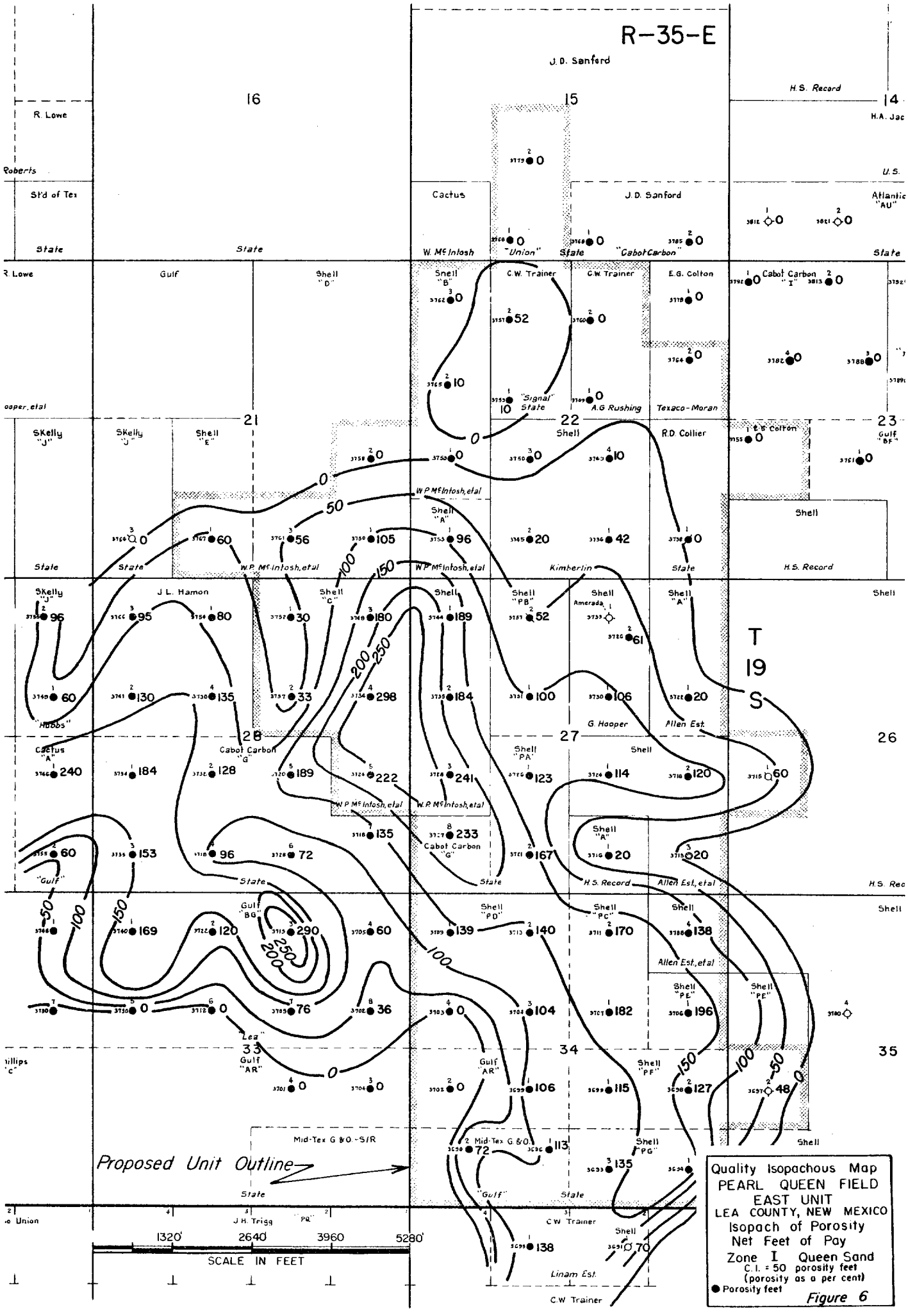
35
J. D. Sanford
H.S. Record
R. Lowe
Roberts
St'd. of Tex.
State
Cactus
W. McIntosh
"Union"
Cabot Carbon
Atlantic "AU"
U.S.
Gulf
Shell "D"
Shell "B"
C.W. Trainer
E.G. Colton
Cabot Carbon "I"
Skelly "J"
Skelly "O"
Shell "E"
"Signal" State
A.G. Rushing
Texaco-Moran
R.D. Collier
Gulf "BF"
W.P. McIntosh, et al
Shell "A"
Kimberlin
J.L. Hamon
Shell "C"
Shell "PB"
Amerada
Shell "PA"
G. Hooper
Allen Est
"Hobbs"
Cactus "A"
Cabot Carbon "G"
Shell "PC"
Shell "PD"
Gulf "BQ"
Allen Est, et al
Shell "PE"
"Lea"
Gulf "AR"
Shell "PF"
Shell "PG"
Mid-Tex. G. & O. - S/R
Linam Est.
Proposed Unit Outline
1320'
2640'
3960'
5280'
SCALE IN FEET
STRUCTURAL MAP
PEARL QUEEN FIELD
EAST UNIT
LEA COUNTY, NEW MEXICO
Contoured on Top of Zone III A
Queen Sand
C. I. = 20'
Figure 4



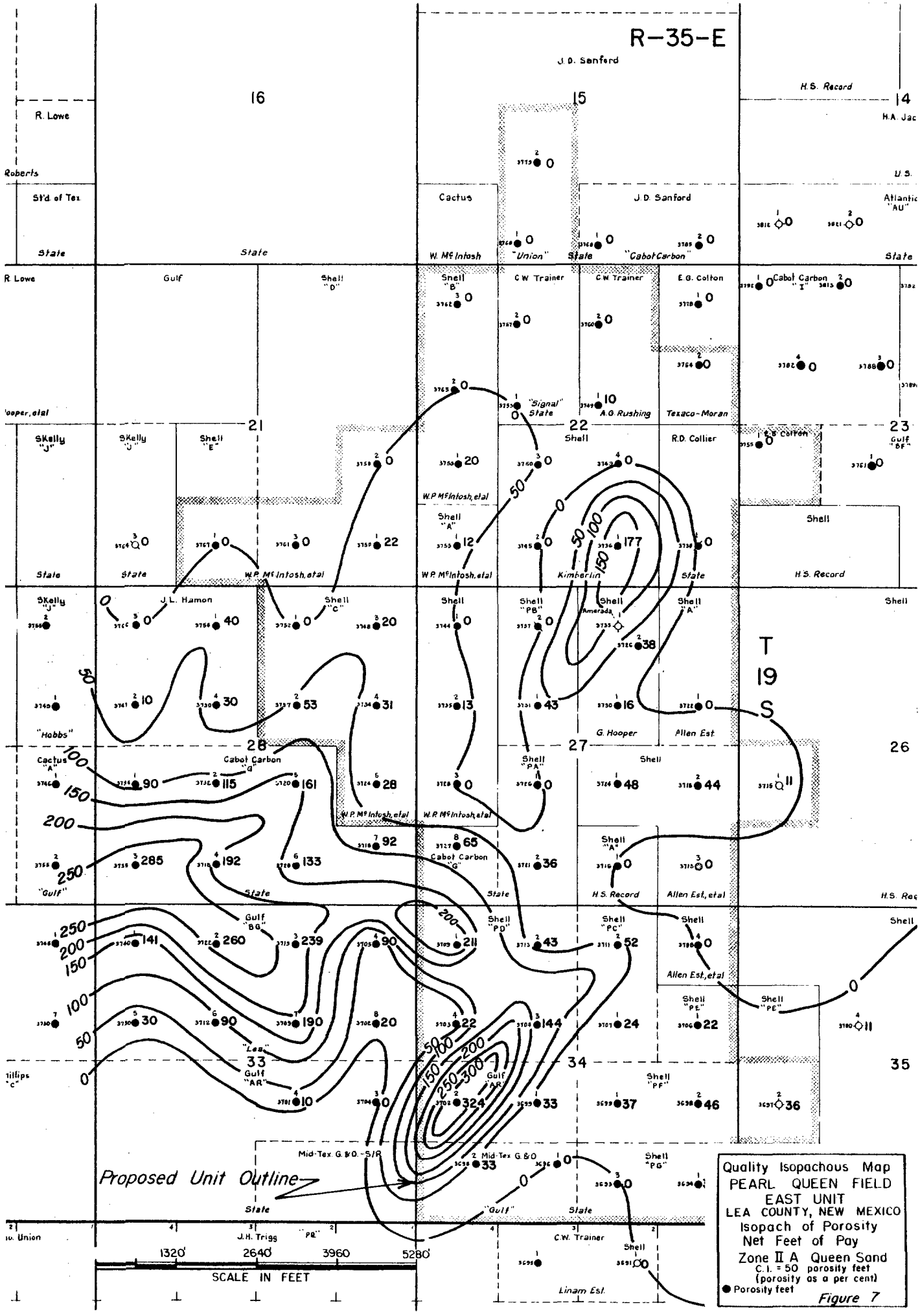
STRUCTURAL MAP
PEARL QUEEN FIELD
EAST UNIT
LEA COUNTY, NEW MEXICO
Contoured on Top of Zone IV
Queen Sand
C. I. = 20'

Figure 5



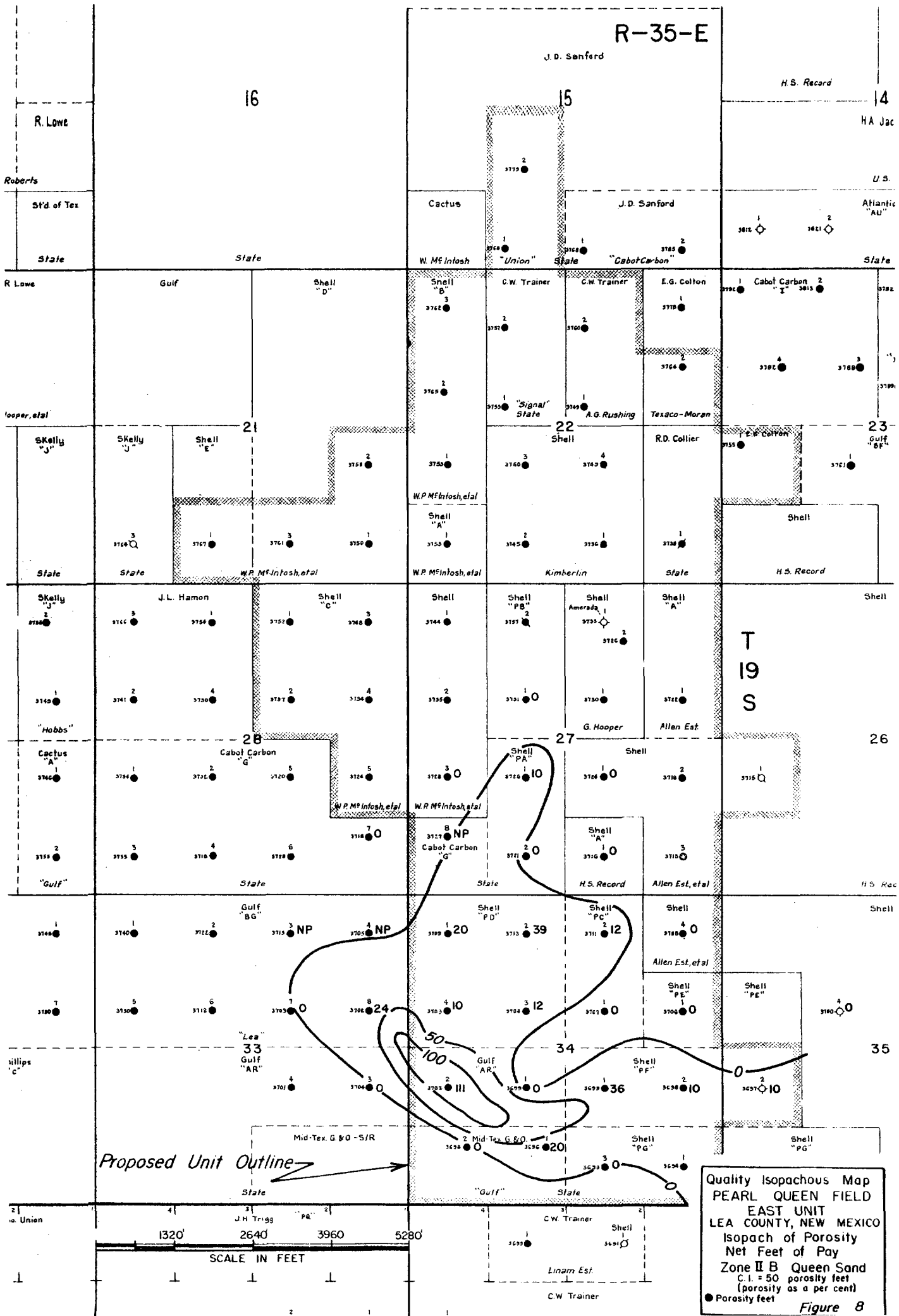
Quality Isopachous Map
PEARL QUEEN FIELD
EAST UNIT
LEA COUNTY, NEW MEXICO
Isopach of Porosity
Net Feet of Pay
Zone I Queen Sand
C.I. = 50 porosity feet
(porosity as a per cent)
● Porosity feet

Figure 6



Quality Isopachous Map
PEARL QUEEN FIELD
EAST UNIT
LEA COUNTY, NEW MEXICO
Isopach of Porosity
Net Feet of Pay
Zone II A Queen Sand
C.I. = 50 porosity feet
(porosity as a per cent)
● Porosity feet

Figure 7


R-35-E
T 19 S
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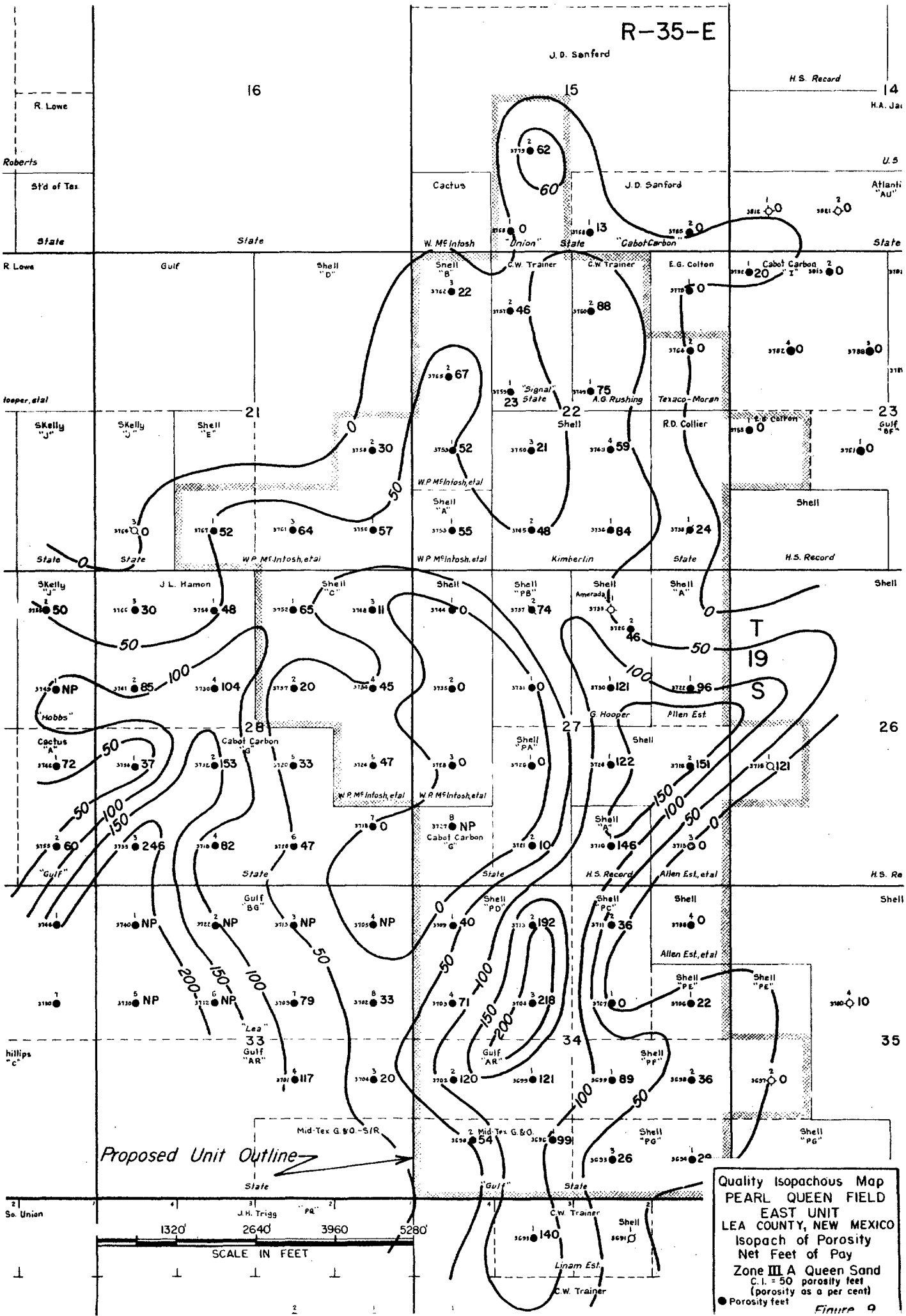
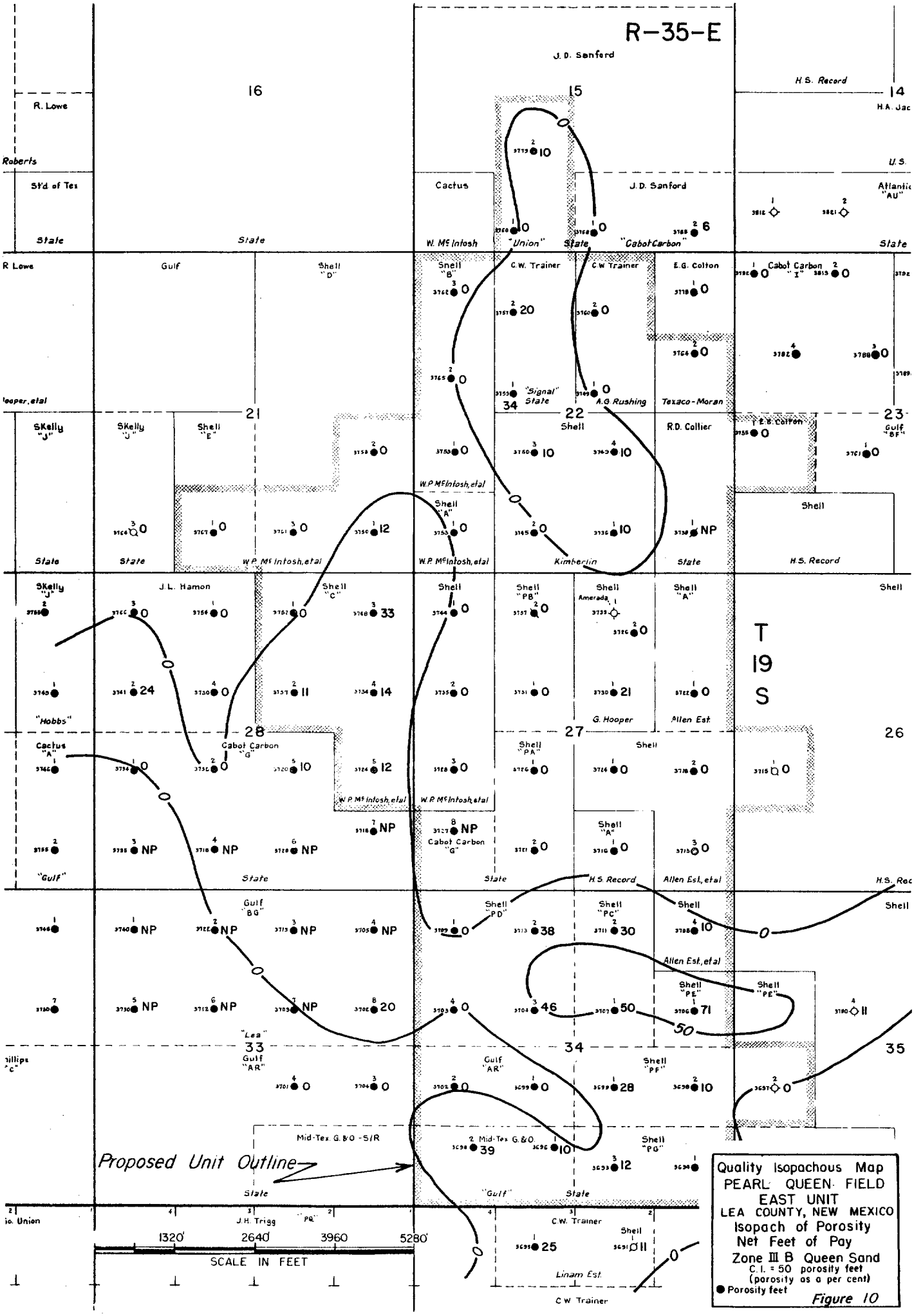
23
26
27
28
33
34
35
J.D. Sanford
H.S. Record
R. Lowe
Roberts
Std. of Tex.
Cactus
J.D. Sanford
Atlantic "AU"
U.S.
State
W. McIntosh
"Union"
"Cabot Carbon"
Gulf
Shell "D"
Shell "B"
C.W. Trainer
E.G. Colton
Cabot Carbon "I"
"Signal" State
A.G. Rushing
Texaco-Moran
Skelly "J"
Shell "E"
Shell
R.D. Collier
Gulf "BF"
W.P. McIntosh, etal
Shell "A"
Kimberlin
J.L. Hamon
Shell "C"
Shell "PB"
Amerada
Shell "A"
"Hobbs"
G. Hooper
Allen Est.
Cactus "A"
Cabot Carbon "G"
Shell "PA"
"Gulf"
Shell "A"
Gulf "BG"
Shell "PD"
Shell "PC"
Allen Est, etal
Shell "PE"
"Lea"
Gulf "AR"
Shell "PF"
Mid-Tex. G. & O. - S/R
Shell "PG"
Proposed Unit Outline
J.H. Trigg
C.W. Trainer
Linam Est.
1320'
2640'
3960
5280'
SCALE IN FEET
50
100
0
Quality Isopachous Map
PEARL QUEEN FIELD
EAST UNIT
LEA COUNTY, NEW MEXICO
Isopach of Porosity
Net Feet of Pay
Zone II B Queen Sand
C.I. = 50 porosity feet
(porosity as a per cent)
● Porosity feet
Figure 8



Quality Isopachous Map
PEARL QUEEN FIELD
EAST UNIT
LEA COUNTY, NEW MEXICO
Isopach of Porosity
Net Feet of Pay
Zone III A Queen Sand
C.I. = 50 porosity feet
(porosity as a per cent)
● Porosity feet

Figure 9


R-35-E
T 19 S
16
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14
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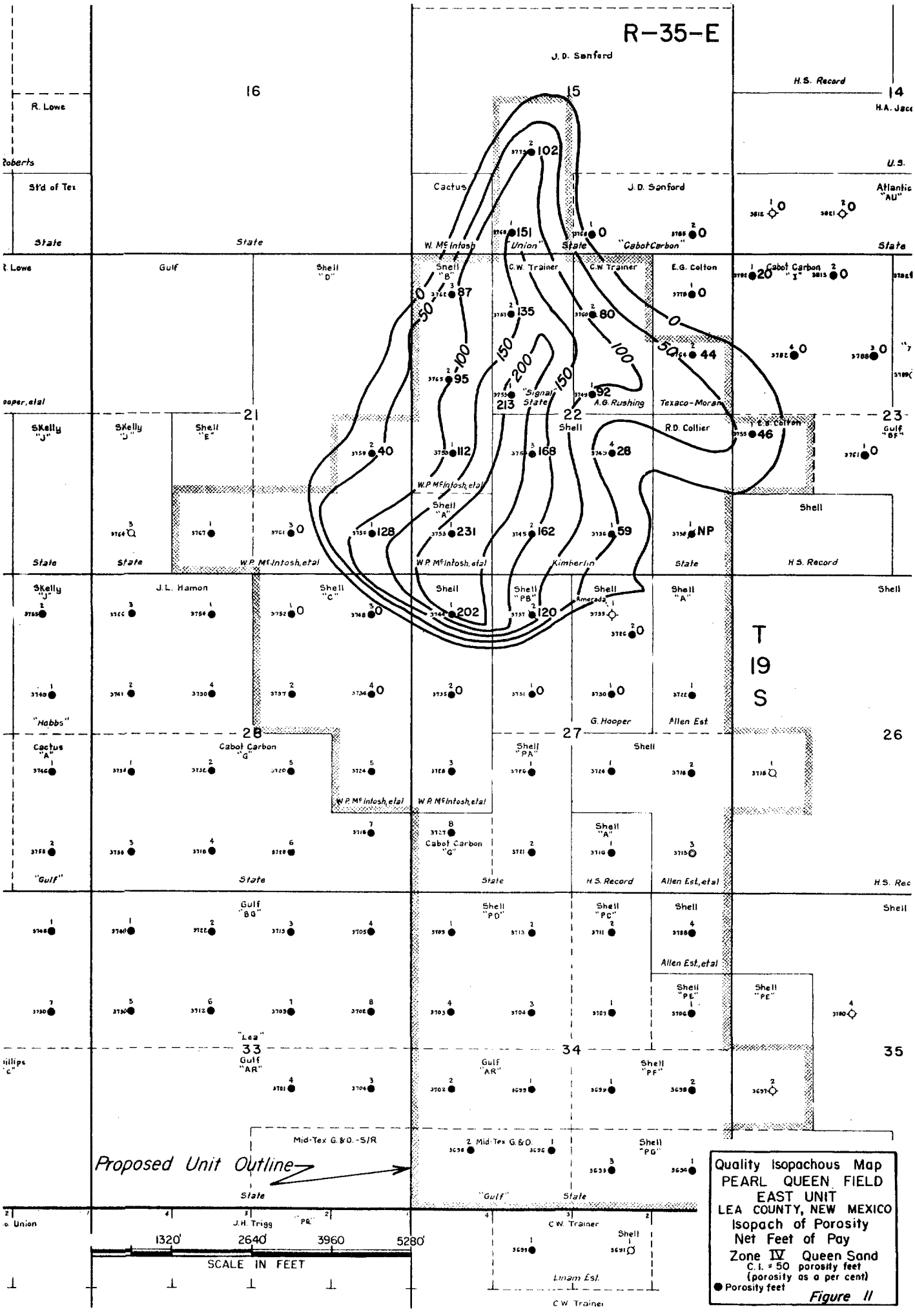
26
33
34
35
J. D. Sanford
R. Lowe
Roberts
Std. of Tex
Cactus
J. D. Sanford
H.S. Record
H.A. Jac
U.S.
Atlantic "AU"
State
W. McIntosh
"Union"
"Cabot-Carbon"
Gulf
Shell "D"
Shell "B"
C.W. Trainer
E.G. Colton
Cabot Carbon "I"
"Signal" State
A.G. Rushing
Texaco-Moran
SKelly "J"
Shell "E"
R.D. Collier
T.E.B. Colton
Gulf "BF"
W.P. McIntosh, etal
Shell "A"
Kimberlin
J.L. Hamon
Shell "C"
Shell "PB"
Amerada
G. Hooper
Allen Est
"Hobbs"
Cactus "A"
Cabot Carbon "G"
Shell "PA"
Shell "A"
"Gulf"
Gulf "BG"
Shell "PD"
Shell "PC"
Allen Est, etal
Shell "PE"
"Lea"
Gulf "AR"
Shell "PF"
Mid-Tex G.&O. -S/R
Shell "PG"
Proposed Unit Outline
J.H. Trigg
C.W. Trainer
Linam Est.
1320'
2640'
3960
5280'
SCALE IN FEET
Quality Isopachous Map
PEARL QUEEN FIELD
EAST UNIT
LEA COUNTY, NEW MEXICO
Isopach of Porosity
Net Feet of Pay
Zone III B Queen Sand
C.I. = 50 porosity feet
(porosity as a per cent)
Porosity feet
Figure 10


R-35-E
T 19 S
J. D. Sanford
H.S. Record
R. Lowe
Roberts
U.S.
Atlantic "AU"
Cactus
J. D. Sanford
State
W. McIntosh
"Union"
"Cabot Carbon"
Gulf
Shell "D"
Shell "B"
C.W. Trainer
E.G. Colton
Cabot Carbon "I"
Cooper, etal
SKelly "J"
SKelly "D"
Shell "E"
"Signal" State
A.G. Rushing
Texaco-Moran
R.D. Collier
E.S. Colton
Gulf "BF"
W.P. McIntosh, etal
Shell "A"
Kimberlin
J.L. Hamon
Shell "C"
Shell "PB"
Amerada
Shell "A"
"Habbs"
G. Hooper
Allen Est.
Cactus "A"
Cabot Carbon "G"
Shell "PA"
"Gulf"
Allen Est, etal
Gulf "BQ"
Shell "PD"
Shell "PC"
Shell "PE"
"Lea"
Gulf "AR"
Shell "PF"
Shell "PG"
Mid-Tex G.&O.-S/R
Proposed Unit Outline
Mid-Tex G.&O.
J.H. Trigg
C.W. Trainer
Linam Est.
1320' 2640' 3960' 5280'
SCALE IN FEET
Quality Isopachous Map
PEARL QUEEN FIELD
EAST UNIT
LEA COUNTY, NEW MEXICO
Isopach of Porosity
Net Feet of Pay
Zone IV Queen Sand
C.I. = 50 porosity feet
(porosity as a per cent)
Porosity feet
Figure 11

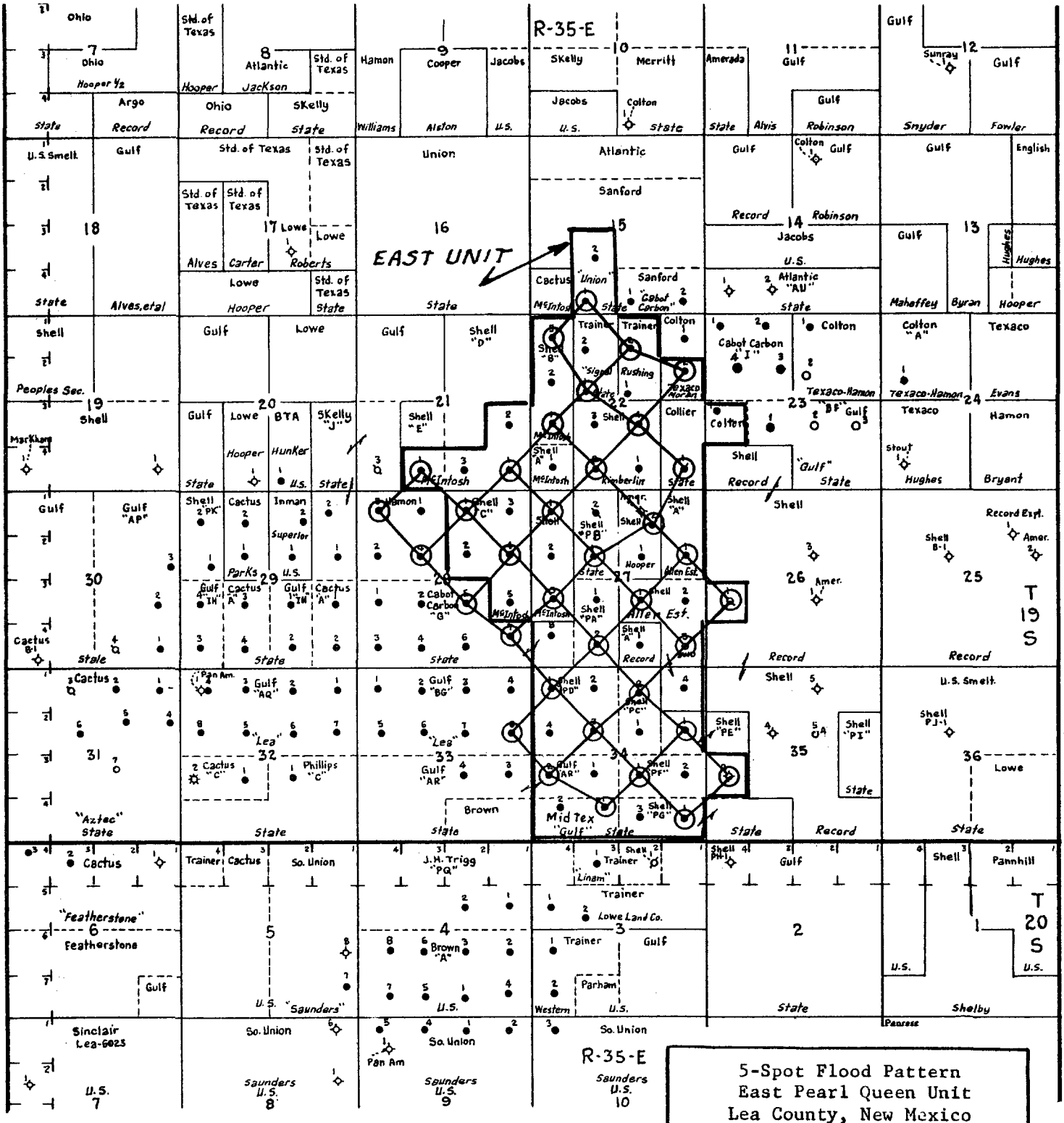
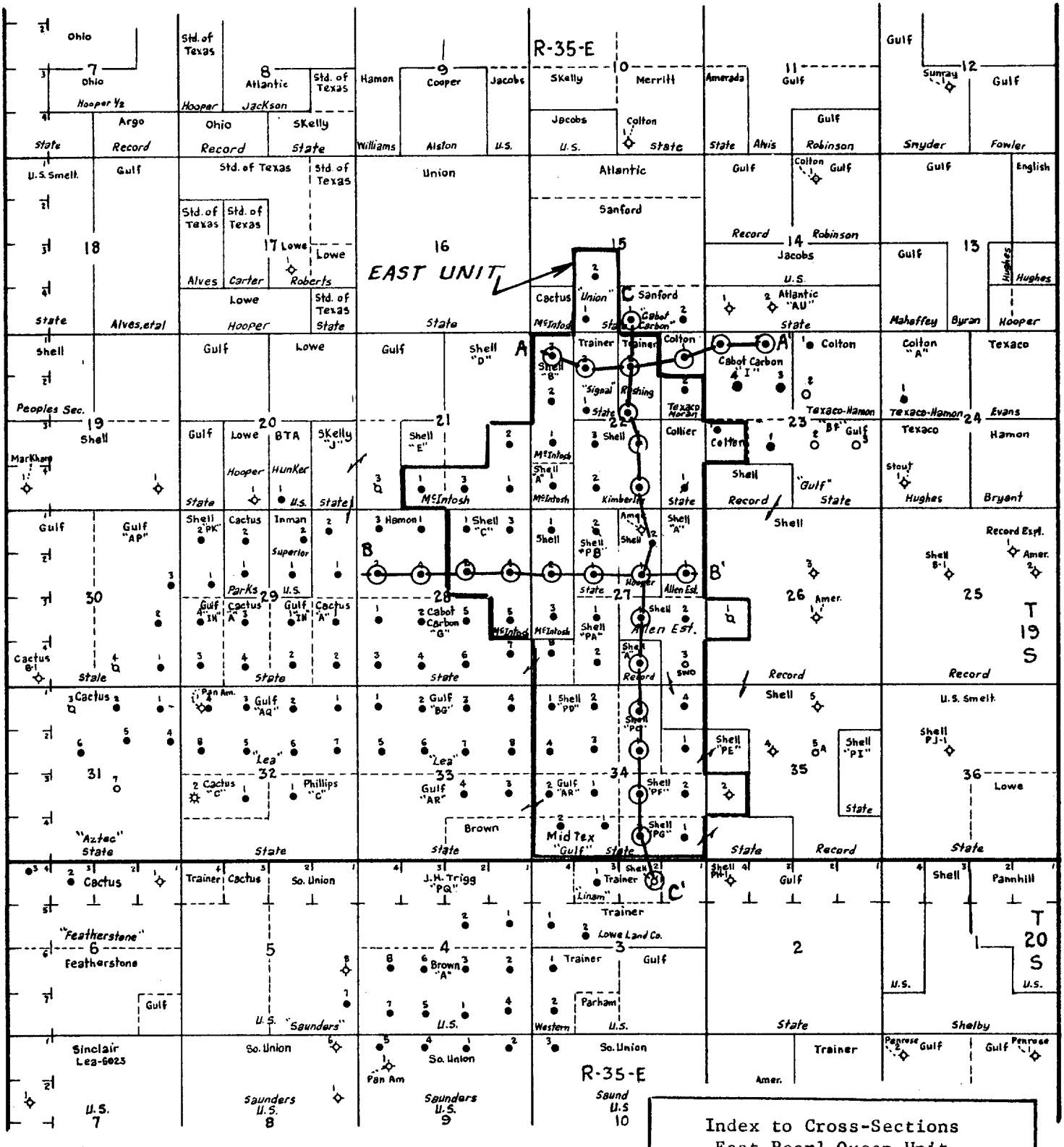
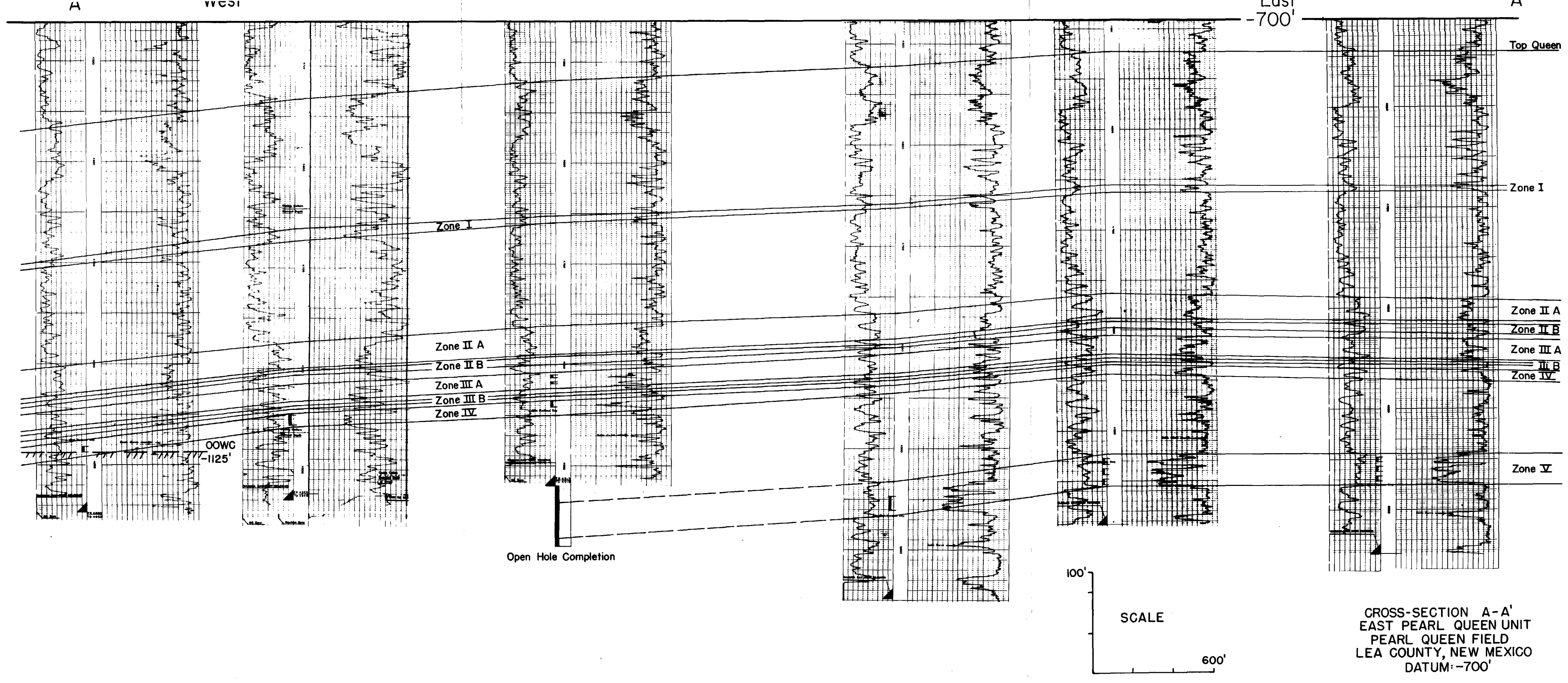

EAST UNIT
R-35-E
T 19 S
T 20 S
5-Spot Flood Pattern
East Pearl Queen Unit
Lea County, New Mexico
Scale: 1" = 4000'
Producing Well
Water Injection Well

Figure 12

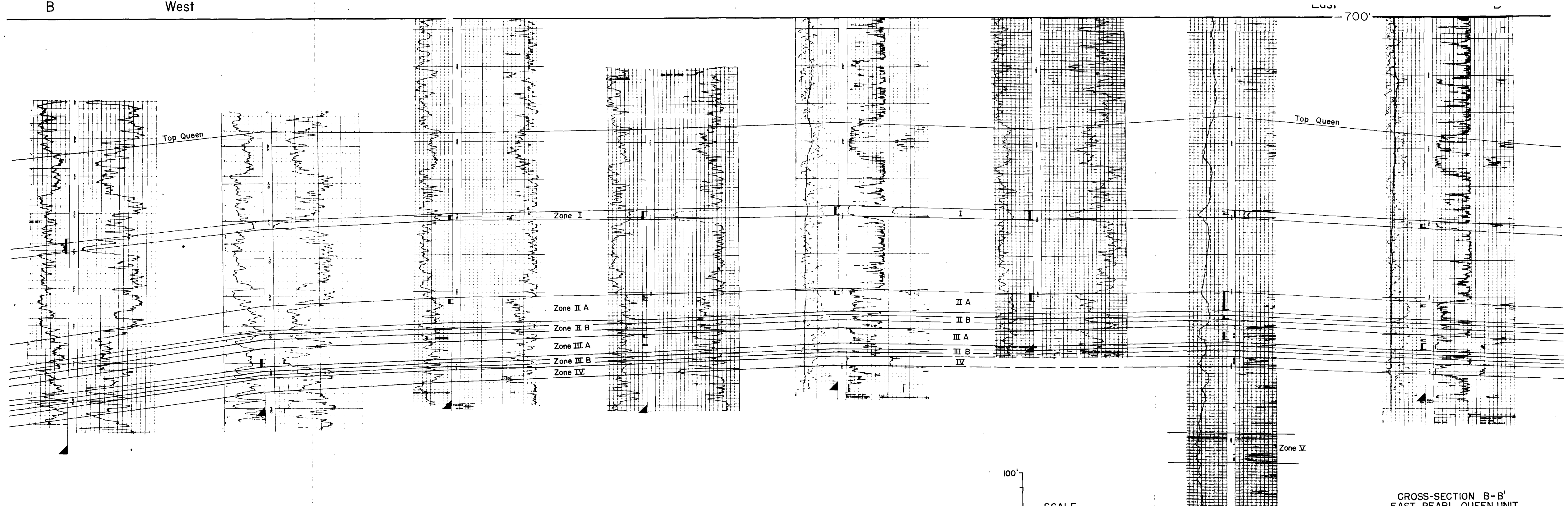


Index to Cross-Sections
East Pearl Queen Unit
Lea County, New Mexico
Scale: 1" = 4000'
◉ Wells on Cross Sections

Figure 13

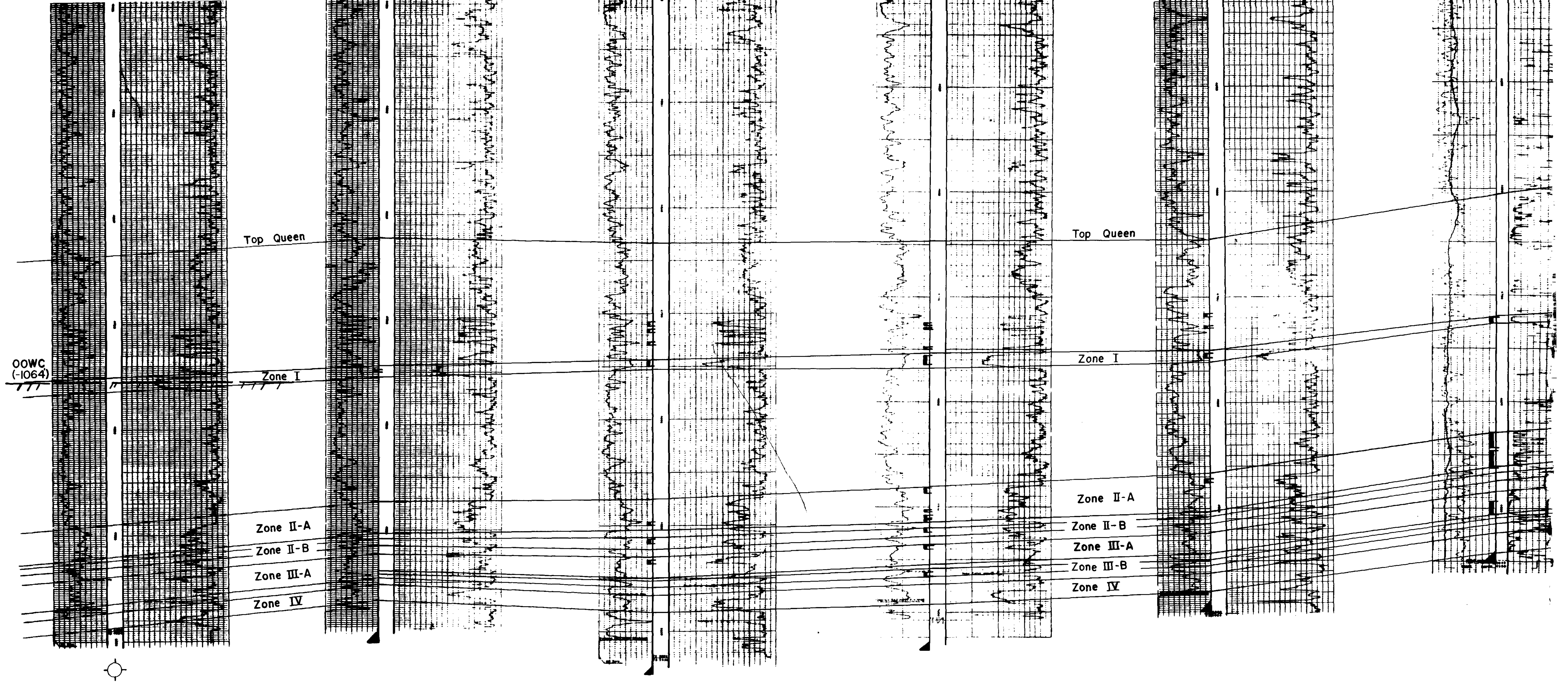


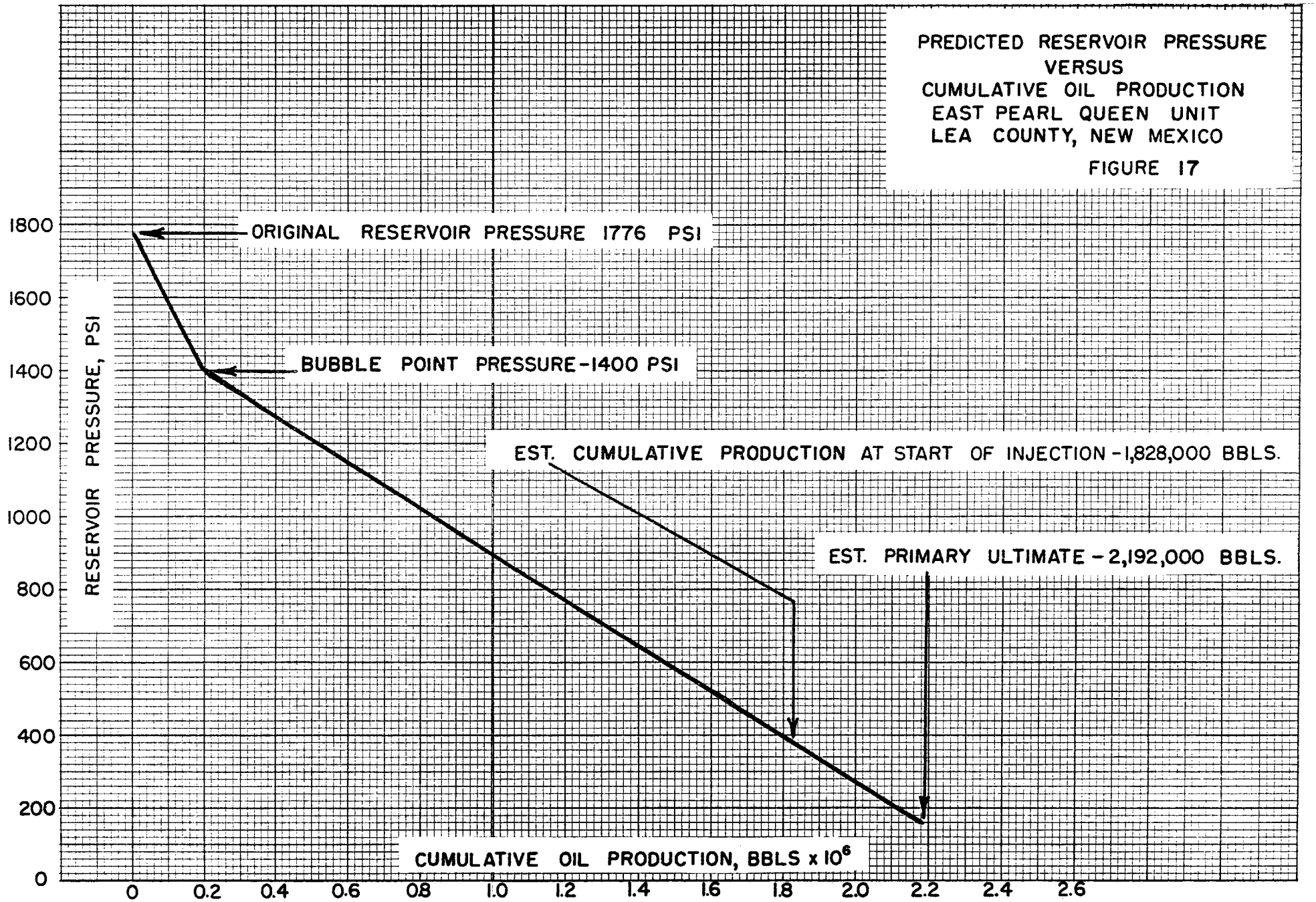
CROSS-SECTION A-A'
EAST PEARL QUEEN UNIT
PEARL QUEEN FIELD
LEA COUNTY, NEW MEXICO
DATUM: -700'

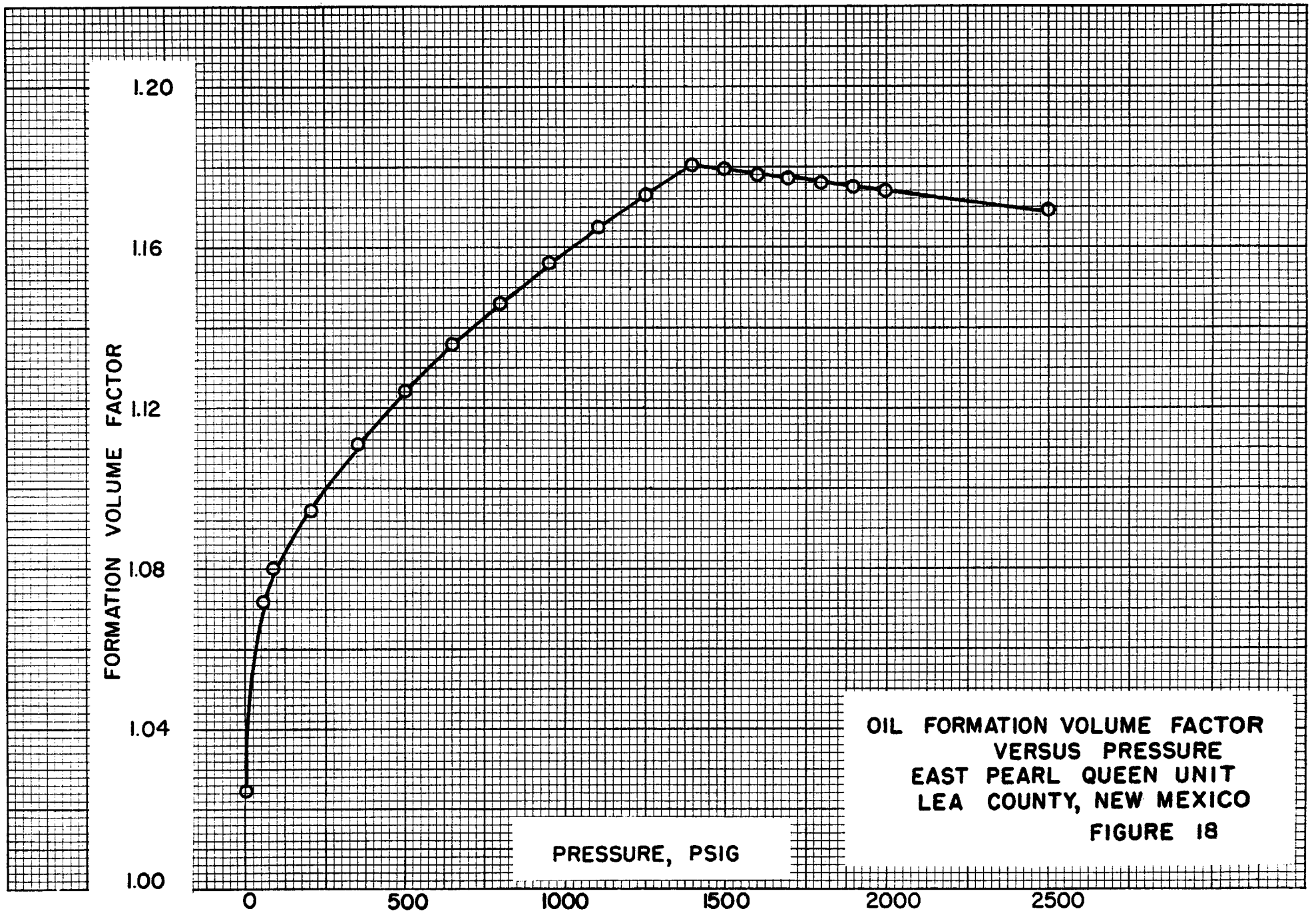


CROSS-SECTION B-B'
EAST PEARL QUEEN UNIT


-700'
Top Queen
Zone I
Zone II-A
Zone II-B
Zone III-A
Zone III-B
Zone IV
Zone V
I
II-A
II-B
III-A
III-B
IV
?
Open Hole Completion
SCALE
100'
600'
CROSS SECTION C-C'


Top Queen
OOWC
(-1064)
Zone I
Zone II-A
Zone II-B
Zone III-A
Zone IV
Top Queen
Zone I
Zone II-A
Zone II-B
Zone III-A
Zone III-B
Zone IV


PREDICTED RESERVOIR PRESSURE
VERSUS
CUMULATIVE OIL PRODUCTION
EAST PEARL QUEEN UNIT
LEA COUNTY, NEW MEXICO
FIGURE 17
ORIGINAL RESERVOIR PRESSURE 1776 PSI
BUBBLE POINT PRESSURE-1400 PSI
EST. CUMULATIVE PRODUCTION AT START OF INJECTION - 1,828,000 BBLS.
EST. PRIMARY ULTIMATE - 2,192,000 BBLS.
RESERVOIR PRESSURE, PSI
CUMULATIVE OIL PRODUCTION, BBLS x 10^6
0
200
400
600
800
1000
1200
1400
1600
1800
0
0.2
0.4
0.6
0.8
1.0
1.2
1.4
1.6
1.8
2.0
2.2
2.4
2.6



OIL FORMATION VOLUME FACTOR
VERSUS PRESSURE
EAST PEARL QUEEN UNIT
LEA COUNTY, NEW MEXICO

FIGURE 18

GRAPHICAL PRESENTATION OF CAPILLARY PRESSURE
AND LOG ANALYSIS DATA WITH A MOBILE OIL DETERMINATION
EAST PEARL QUEEN UNIT

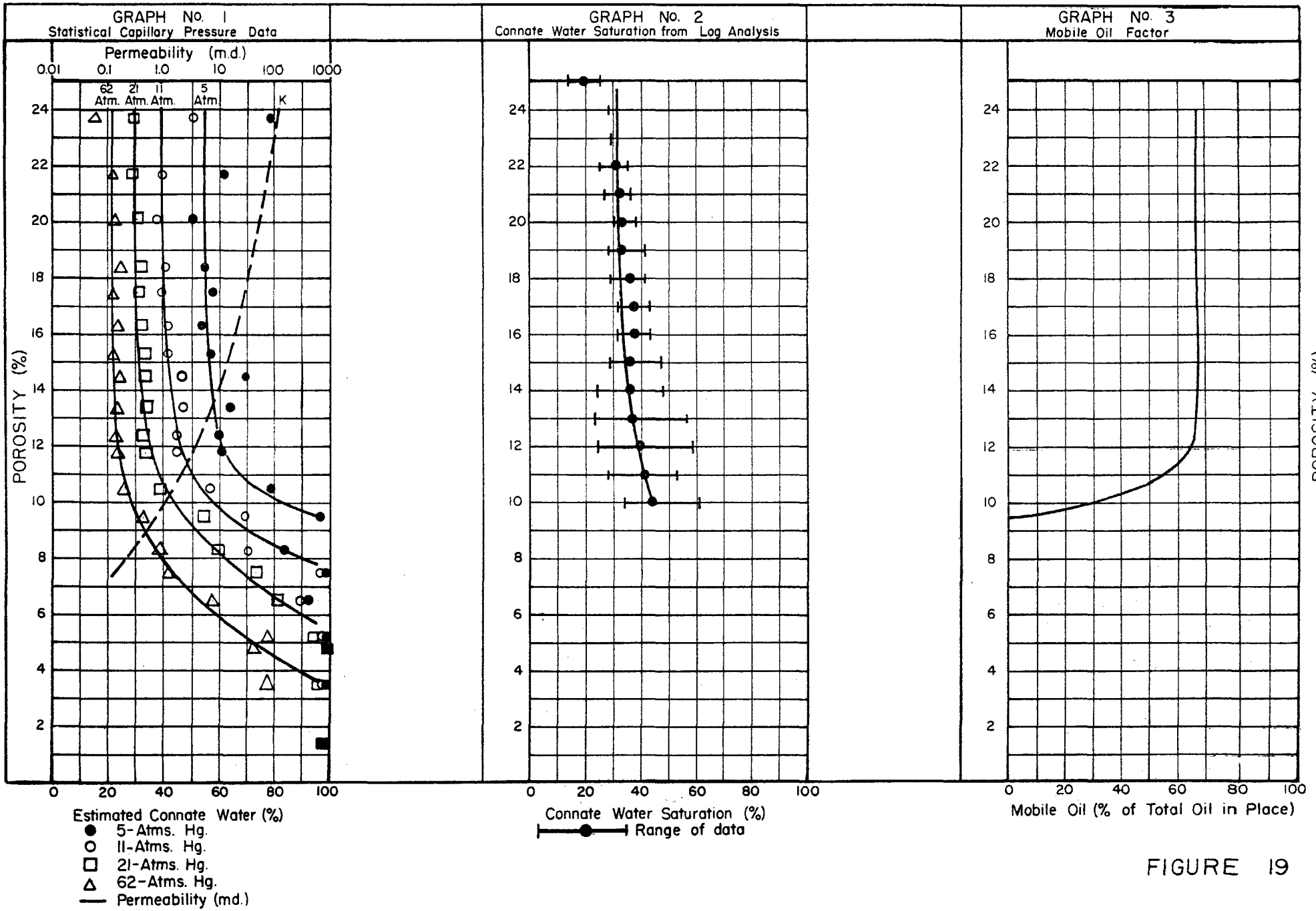
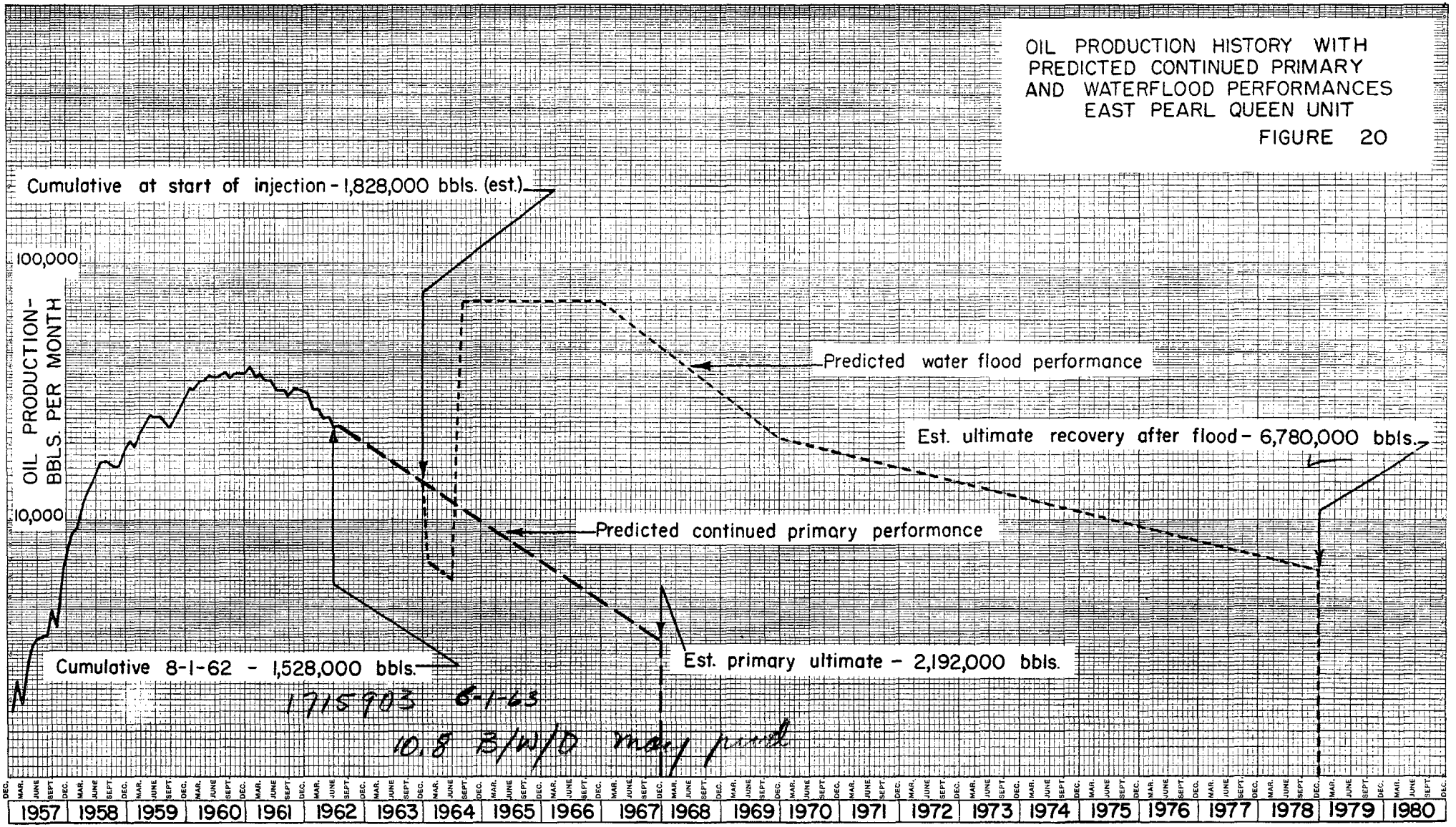


FIGURE 19

OIL PRODUCTION HISTORY WITH
PREDICTED CONTINUED PRIMARY
AND WATERFLOOD PERFORMANCES
EAST PEARL QUEEN UNIT

FIGURE 20



4,588,000 add recov. / 2,192,000 / secondary
6780000 tot. /.