New File
Well Spacing

07 43B

1967

SUBMISSION TO MANITOBA
DEPT. MINES and NATURAL RESOURCES
Re: 160 ACRE SPACING
NORTH PIERSON AREA, MANITOBA

PETROLEUM DIVISION

OAKLAND PETROLEUMS LIMITED
THUNDERBIRD PETROLEUMS LIMITED
THUNDERBIRD EXPLORATION LTD.
TACOMA PETROLEUMS LIMITED
CAMPBELL PETROLEUMS LIMITED
P. N. R. MORRISON

902 LANCASTER BUILDING,
CALGARY, ALBERTA

October 10, 1967

Mr. M. J. Gobert,
Assistant Deputy Minister,
Manitoba Department of Mines and Natural Resources,
Norquay Building,
Winnipeg, Manitoba.

Dear Sir:

RE: Spacing Application North Pierson Area

Further to our letter of September 29, 1967 we have calculated the allowable for our 2-24 well to be 128.28 barrels. This calculation was made on the basis of a formula used in the Province of Saskatchewan and in that regard we are enclosing a copy of our calculations prepared on a Saskatchewan form. As a result of these calculations we feel that a maximum permissible rate of production per well in the North Pierson area of 120 barrels per day as mentioned in our letter of September 29, 1967 is reasonable.

Relative to the spacing application itself, we understand that if a government re-spacing order is granted as requested, such order will apply to all drilled and un-drilled spacing units in the area under application.

Yours very truly,

TACOMA PETROLEUMS LIMITED

P. N. R. Morrison

P. N. R. Morrison
President

PNRM/h
Encl.

c. c. to: Mr. Stuart Anderson,
Chairman.

Mr. M. J. Gobert,
Member.

Mr. [illegible] Daniel,
President,
[illegible] Consultants (1965) Ltd.

Mr. [illegible] Boylan,
Departmental Solicitor,
Department of Attorney-General.

Mr. F. [illegible] [illegible]ey,
Reservoir Engineer.

APPLICATION FOR MPR—OIL

GOVERNMENT OF SASKATCHEWAN

DEPARTMENT OF MINERAL RESOURCES

Petroleum & Natural Gas Branch

REGINA . SASKATCHEWAN . CANADA

FOR DEPARTMENT USE	DATE YR. MO. DA.	
U		1

	SS X	QUAD XX	LSD XX	SEC XX	TWP XXX	RGE XX	MER WX	IDEN XX	YM		WELL NAME	OPERATOR CODE	BATTERY CODE
01	1									N	Tacoma North Pierson 2-24-3-29	C	B

02		P	POOL CODE	HORIZON CODE	APPLIED FOR MPR	AUTHORIZED MPR
			.	– .	A .	+ .

(See example and explanation on reverse side of this form)

Field: Pierson

Pool:

Pay Interval: 3247 – 63

Perforations: 3247 – 58

FACTORS	REFERENCE WELL	Applicant's Calculations: VALUES USED	SOURCE OF VALUES
Av. Pay Thickness	T	16	Logs
Av. Porosity	F=10	12	Logs
Av. Interstitial Water	C=25	32	Log calculation
Av. Shrinkage Factor	S=75	90	Pierson field data
Recovery Factor	R=20	30	Assumed water drive for this well.
Expected Uniform Rate Life	L=10	10	Submission
Assigned Acreage	A=40	160	

Reference well values shall be used, unless revisions are substantiated

Porosity Shrinkage Factor (F_{PS}): $\left(\frac{12}{10}\right)\left(\frac{90}{75}\right)\left(\frac{68}{75}\right)$ = 1.31

Recovery Life Factor (F_{RL}): $\frac{(30)}{20}\frac{10}{(10)}$ = 1.50

Acreage Factor (F_A): $\frac{(160)(1.0188)}{40}$ = 4.08

Formula: MPR = (T) (F_{PS}) (F_{RL}) (F_A)

MPR = (16)(4.08)(1.31)(1.50) = 128.28

(FOR DEPARTMENT USE ONLY)

Pay Interval:

Factors & Calculations:

Reservoir Engineering Division

Signature of Authorized Company Representative .... Date: ....

Name of Company Representative (Typed) .... Company ....

Title .... Company Address ....

AUTHORIZED MPR: .... B/D Economic Allowance: .... B/D Effective Date ....

Field: .... Pool: ....

Remarks:

Date Issued: .... Recommended: .... Approved: ....

Director of Petroleum & Natural Gas Branch

Deputy Minister of Mineral Resources

The completed form must be in the office of the Petroleum & Natural Gas Branch, Department of Mineral Resources Canada, not later than five (5) days from date of first production. (Submit in QUADRUPLICATE).

MR 66

Z

REQUEST FOR 160 ACRE SPACING, NORTH PIERSON AREA, MANITOBA

A Submission on behalf of
Tacoma Petroleums Ltd.,
902 Lancaster Building,
Calgary, Alberta

by

Andrichuk and Edie
Consulting Geologists,
300 MacLean Building,
Calgary, Alberta

CONTENTS

FIGURES AND TABLES

PHONE 269-6084

ANDRICHUK AND EDIE
Consulting Geologists

300 MacLEAN BLDG.
CALGARY, ALBERTA

September 21, 1967

Mr. M. J. Gobert,
Assistant Deputy Minister,
Manitoba Department of Mines
and Natural Resources,
Norquay Building,
Winnipeg, Manitoba.

Dear Sir:

Re: Request for 160 acre well spacing,
MC-3 Limestone
North Pierson Area, Manitoba

With respect to Clause (e) of subsection (1) of Section 58 (and Clause 8 (b) of Section 59) of the Mines Act, we hereby apply (on behalf of Tacoma Petroleums Limited, 902 Lancaster Building, Calgary, Alberta) for 160 acre spacing in the North Pierson area as shown on the accompanying map (Figure 1).

HISTORY

The Tacoma North Pierson 2-24 well (2-24-3-29-W1) was drilled during August, 1967. The well was perforated in the MC-3 limestone (basal Alida Beds) in the interval 3247-58 on August 17, 1967 and placed on production as a flowing oil well on the same day. The initial production rate was 32 bbls. of clean oil per day but as of September 3, 1967, the production rate declined to 12 B.O.P.D. Although no water has been produced to date, the decline in production rate could be due to a build-up of salt-water in the lower part of the tubing and annulus. In any case it is obvious that the well will have to be placed on pump for commercial rate of production. However, because of the possible absence of an anhydrite floor seal at this location, it is recommended that high pumping rates be avoided initially because of the risk of severe water coning and attendant water disposal problems.

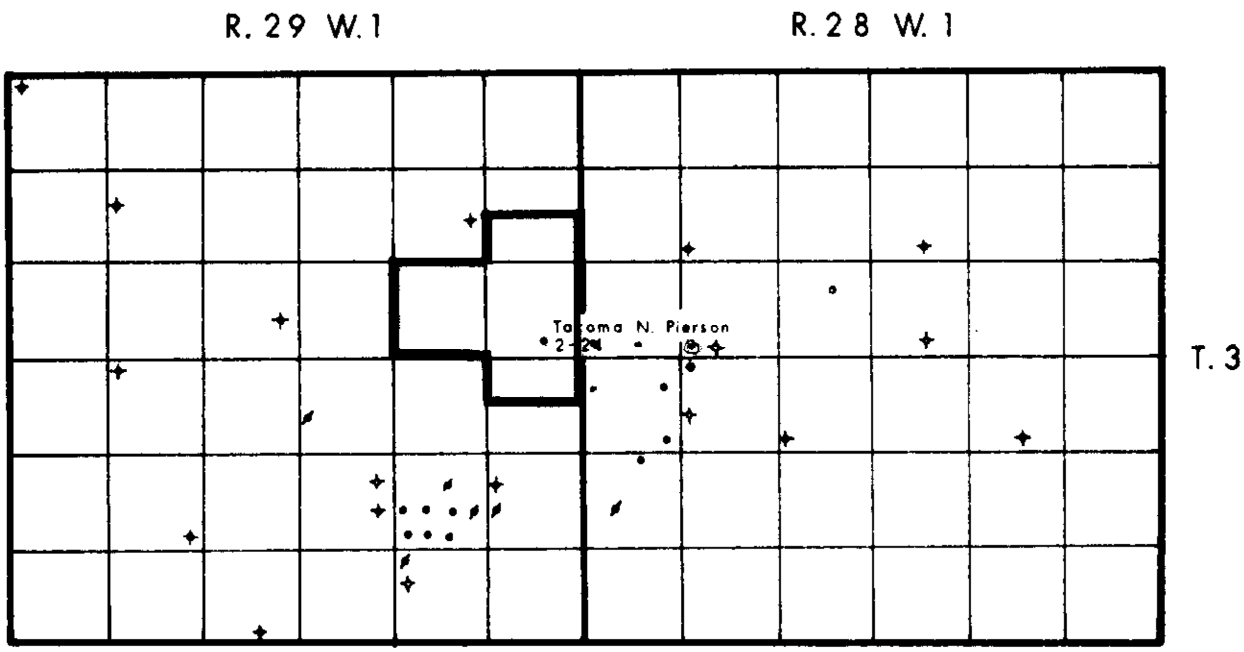


FIGURE 1.

PIERSON AREA, MANITOBA.

REQUESTED 160 ACRE SPACING AREA

- Location
- Oil Well
- Abandoned oil well
- Dry and abandoned

To accompany submission
by Andrichuk and Edie,
Consulting Geologists,
SEPTEMBER 21, 1967.

GEOLOGY OF THE TACOMA NORTH PIERSON 2-24 WELL

The following geological tops and rock descriptions from the Tacoma Pierson 2-24 well are summarized from detailed microscopic sample descriptions by John M. Andrichuk (co-author of this report) who was the well-site geologist.

Top of eroded MC_3 anhydritized caprock	3224
Top of MC-3 limestone porosity	3247
Top of MC-2 argillaceous dolomite	3263
Total Depth	3267

A 2 hour drillstem test of the interval 3235 to 3267 yielded gas to surface in 8 minutes, with gas blow continuing throughout the test. The recovery was 2585 feet of fluid consisting of 2465 feet of clean gassy oil and 120 feet of oil and water cut mud.

Except for an approximately 6 inch thick poorly permeable microcrystalline dolomite bed at a depth of 3240 feet (which accounts for the shape of the SP curve), the anhydritized cap-rock (interval 3224-47) is dense and does not exhibit any porosity or oil staining. The porous MC-3 limestone (interval 3247-63) consists of well sorted medium grained oolites (exhibiting good intergranular porosity and estimated horizontal permeability of 50 millidarcies) with interbedded chalky poorly permeable limestone. The permeability of the chalky limestone layers is estimated at less than one millidarcy. The chalky limestone is only slightly to moderately oil stained compared with the highly oil stained oolitic limestone. Based on detailed microscopic examination of 2-foot samples and correlation with the Gamma Ray - Sonic log, only 11 feet of the 16 feet thick porous MC-3 limestone is considered to have sufficient permeability for an effective reservoir. The presence of chalky limestone within the porous MC-3 limestone section is also confirmed by the high porosity (17%), low resistivity and high water saturation (50%) in the interval 3247-50 (see point 1, Sonic vs Resistivity plot attached to the Gamma Ray - Sonic log).

The MC-2 interval penetrated consists of earthy argillaceous dolomite in part containing lenses of anhydrite. As the Tacoma Pierson 2-24 well is located near the depositional edge of the MC_2 anhydrite, it was anticipated that the MC-2 anhydrite would be either thin or absent at this location. In any case, no massive anhydrite was encountered within the MC-2 interval penetrated (3263-67) so that it is not known whether an effective floor-seal is present at this location.

ANTICIPATED NET PAY THICKNESS IN DEVELOPMENT OF THE NORTH PIERSON MC-3 RESERVOIR

Examination of cores (by R.W. Edie at Winnipeg, Manitoba in 1964) from dry holes at (4-29-3-28-W1) and (8-26-3-29 W1) shows that the MC-3 limestone is progressively eroded and wedges out toward the north and northeast. Thus, it is anticipated that the net pay thickness will decrease northward from the Tacoma North Pierson 2-24 well, but provided that a satisfactory drillstem test is obtained, Tacoma Petroleums Limited is prepared to complete wells with as little as three feet of net pay.

In offset wells to the south and southwest (down-dip direction), some bottom water will likely be encountered as the Tacoma Pierson 2-24 well is located close to the oil-water contact as determined from drillstem test and production data at the King Resources wells on strike to the southeast. Thus, because of this anticipated bottom water, net pay thickness is not expected to increase southward. (The old Pierson field drilled on 40 acre spacing, mainly in the south half of Section 11, Township 3, Range 29 W1 appears to be a separate oil accumulation occurring in stratigraphically higher MC-3 limestone beds on an ancient hill on the Mississippian erosion surface).

Thus, for the aforementioned reasons, the average net pay thickness of the North Pierson pool is expected to be somewhat less than the 11 feet encountered at the Tacoma 2-24 well and for purposes of oil reserve calculations is assumed to be 8 feet.

ANTICIPATED PRIMARY RECOVERY FACTOR

Examination of cores from dry holes north of the Tacoma North Pierson 2-24 well reveals the presence of two massive anhydrite beds with cumulative thickness of 14 feet within the MC-2 interval at Texaco McColl Graham Creek 4-29 (4-29-3-28-W1) and one anhydrite bed 6 feet thick within the same stratigraphic interval at Imperial Canadian Superior Pierson 8-26 (8-26-3-29-W1). Furthermore, the absence of significant structure on the MC-2 unit in addition to the previously mentioned truncation of the MC-3 limestone to the north and northeast indicates that the Tacoma North Pierson 2-24 well intersected a stratigraphic trap oil pool representing a northwest extension of the MC_3 oil accumulation encountered in the King Resources wells approximately 1 1/2 miles to the southeast. As bottom water is definitely present in some of the King Resources wells, the geological conditions are similar to some of the narrower parts of the Carnduff, Glen Ewen and Alameda fields of the Midale trend, Saskatchewan (where bottom water is present within the truncated belt of Midale limestone) and the Willmar field to the north. However, unless an unexpected topographic "high" occurs on the Mississippian erosion surface, the net pay thickness of the North Pierson oil pool and width of the productive belt are likely to be less than the aforementioned fields in Saskatchewan.

Based on a study of performance of wells from similar stratigraphic trap oil fields in Saskatchewan over the past 12 to 14 years, it is believed that the recovery mechanism will be mainly solution gas drive with added partial water drive. In addition, the presence of an excellent carrier bed at the Tacoma Pierson 2-24 well suggests that good drainage can be expected on both 80 acre and 160 acre spacing. Thus, the average primary recovery factor for the North Pierson pool is estimated as follows:

80 acre spacing	160 acre spacing
18%	16%

DEVELOPMENT DRY HOLES

Because of variations in thickness of anhydritized cap-rock in the Pierson area, the possible presence of pre-Jurassic erosion channels at the top of the Mississippian and possible unexpected structural warping, we anticipate drilling one dry hole for each 5 producing oil wells on initial 80 acre or 160 acre spacing. Thus, in calculating capital costs, each producing oil well bears 1/5 of the cost of an associated development dry hole.

USE OF ACID IN COMPLETIONS

Strain (1962) reported that a geological study of limestone cores from 195 wells in Steelman oil field, Saskatchewan revealed near vertical fractures in all but two wells. This essentially universal presence of vertical fractures in carbonate rocks is also confirmed by hundreds of core studies by the authors from various carbonate rock formations throughout western Canada.

In limestone reservoirs where bottom water directly underlies an oil column, acidization commonly increases the "water-cut" and many Mississippian wells in southeastern Saskatchewan have been ruined by acid in completion. The reason for this phenomenon is undoubtedly related to vertical fracturing. A possible explanation is that the tendency of carbon dioxide gas (formed by reaction of hydrochloric acid and limestone) to rise to the top of the reservoir may have the effect of displacing the partly spent acid downward and this process may be particularly critical when the acid under pressure follows near vertical fractures outward from the bore hole. Thus, originally fairly tight near vertical fractures extending down into water laden beds below may be considerably widened resulting in excessive water coning.

Because of early recognition of this problem of vertical fracturing, our firm, together with P. N. R. Morrison, president of Tacoma Petroleums Limited, pioneered in acid-free completions of permeable Mississippian limestones in southeastern Saskatchewan and this practice is now commonly accepted by industry.

Furthermore, our experience along the Midale trend of southeastern Saskatchewan shows that where a well has drilled through the Frobisher anhydrite (floor-seal), despite all precautions now used by industry, including use of centralizers and scratchers and reciprocating action of the "long string" prior to cementation, approximately one cement job in 4 is a failure. In such cases, most of the acid intended to stimulate the Midale limestone reservoir follows channels in the partly cement-filled annulus and opens up water laden Frobisher-Alida Beds below. Unfortunately, in most cases, repeated and expensive squeeze cement jobs fail to shut off the water so that the well has to be abandoned or produces at a rate much below capacity. Thus, unless structural evidence suggests the presence of a closed anticlinal structure (with possible dual zone production), it is our policy to avoid whenever possible puncturing of a natural floor-seal.

In the North Pierson area, the MC-2 anhydrite is expected to be approximately 6 feet thick throughout much of the requested 160 acre spacing area (Figure 1) but could be very thin or absent in the southern and southwestern part of this requested area. Because of the thinness of this anhydrite unit, special precautions are necessary to avoid drilling through this unit and for this reason, the Tacoma

North Pierson 2-24 well was bottomed within the MC-2 unit. Furthermore, because of the possible absence of MC-2 anhydrite at this location, acid was not used to clean out perforations for fear of opening up possible near vertical fractures extending downward into water laden MC-1 (Tilston Beds).

CORING

Although our firm has consistently recommended coring in the search for reefs in western Canada and also for the purpose of obtaining reliable geological data from wildcat wells drilled through bedded limestone sequences, in development drilling of stratigraphic traps where it is important not to puncture a thin natural floor-seal we do not recommend coring of the reservoir unit. The problem with coring under such circumstances is that we lose precision on stratigraphic penetration because coring times (minutes per foot) are not nearly as diagnostic of the presence of porosity as drilling times. This is particularly true of a new diamond bit (where very little of the diamond surfaces are exposed above the matrix metal) or an old diamond bit where the diamond fragments (although well exposed by differential wear of the diamonds and matrix metal) are polished to a smooth surface. Thus, near the erosional edge of the MC-3 limestone, because of partial or complete anhydritization of the MC-3 section, the first break on coring times may not be reached until the porous MC-1 limestone (beneath the thin MC-2 anhydrite unit) has been penetrated.

Furthermore, even a thin fairly highly anhydritized MC-3 section, if characterized by an open and connected fracture system may be completed as a commercial oil well. Thus, we recommend drillstem testing all MC-3 sections even if microscopic examination of samples does not reveal any intergranular, intercrystalline or vuggy porosity. Thus, in the area north of the Tacoma Pierson 2-24 well, special precautions should be taken not to puncture the MC-2 anhydrite floor-seal so that if necessary a large amount of acid can be injected without fear of cement failure.

In our opinion, permeability measurements of cores of limestone reservoirs for predicting reservoir performance are greatly overrated because owing to the presence of near vertical fractures, the cores are too small to be truly representative of the reservoir. The important factor in reservoir performance where an oil column is directly underlain by bottom water is the ratio of bulk horizontal permeability to bulk vertical permeability (including fractures). Because a 3 1/2 inch diameter core may have just missed an open near vertical fracture, the limitations of laboratory permeability measurements of cores are obvious.

On the other hand, a well trained geologist, from microscopic measurements of intergranular and/or intercrystalline pore size and presence or absence of vugs, can readily determine the approximate horizontal permeability and stratigraphic position of a carrier bed within the pay section. This horizontal permeability can be confirmed in part by drillstem test (including the amount of fluid recovery, the presence and time of gas to surface and the pressure draw-down during the test), which in our opinion is far more important in predicting performance of oil reservoirs than laboratory measurements of permeability to air from cores.

In addition, porosity measurements from velocity logs (where detailed lithology is known) are now considered superior to laboratory core measurements. However, it remains for the well site geologist on the basis of microscopic measurement of pore size of samples combined with visual amount of oil staining (from freshly caught samples) and log calculations (on porosity and water saturation) to differentiate between chalky highly porous (non-reservoir) limestones from true reservoir limestones exhibiting effective interparticulate or vuggy porosity (or both). Fracture porosity, although extremely important in determining paths of fluid flow in limestone reservoirs normally does not exceed 1% of the rock volume and can readily be recognized on drillstem test of dense limestone sections. If the fractures are open and connected, considerable amounts of oil may be recovered on drillstem test of such dense limestones (provided they are underlain by an impermeable floor-seal) with very little pressure draw-down during the test. In contrast, open fractures near the well bore which are not connected with an overall open fracture network may result in similar drillstem test recoveries but are characterized by drastic decline in reservoir pressure at the bore hole (extremely slow pressure build-up after final closing of the tool).

IMPORTANCE OF QUALITY OF SAMPLES

In the absence of coring, it is imperative that top quality samples be obtained for the well-site geologist to evaluate the reservoir. In recent years, quality of samples in the oil industry in western Canada has greatly deteriorated to the point where in many cases they are not only useless but misleading. In order to obtain top quality samples through the reservoir section, and where it is important not to puncture a natural anhydrite or shaly floor-seal, our firm recommends the following procedure:

(1) insistence on high viscosity drilling mud prior to and during drilling of the pay section

(2) "stop and start" drilling of the pay section in two-foot intervals with circulation to surface and careful collection of individual 2-foot samples before resuming drilling the next two feet.

This procedure was carried out at the Tacoma North Pierson 2-24 well and although considerable additional costs are incurred because of increased rig time, the method assures top quality samples for determination of net pay thickness and precision control on depth of stratigraphic penetration.

RECOMMENDED COMPLETION TECHNIQUES IN NORTH PIERSON AREA, MANITOBA

1. Bottom the well within the MC-2 unit

2. Run Induction Electric log (including spontaneous potential curve) and Gamma Ray - Sonic log

3. If bottom water is suspected from microscopic sample examination and log calculations, drillstem test the entire MC-3 limestone section to determine how serious water invasion is likely to be. If the water bearing section is chalky limestone, there is likely no remedy to prevent at least some water coning along fractures from the chalky section. In this case, after cementation of 4 1/2 inch casing, multiple perforations in the most permeable carrier bed within the oil zone are recommended i.e. attempt completion without acid.

   However, if on the basis of microscopic examination of samples, a one or two feet thick highly permeable bed occurs within the water bearing basal MC-3 section (preferably just below the oil-water contact) the following procedure* is recommended after cementing 4 1/2 inch casing through the MC-3 limestone) :

   (a) after the cement is well set**, spot approximately 1 barrel of 15% hydrochloric acid at the bottom of the hole and perforate (the highly permeable bed) in acid. The recommended perforating tool is Schlumberger's Hyperjet Perforator*** which simultaneously fires 4 radial shots in a horizontal plane (at 90 degrees to each other). The tool should then be raised one foot and a similar additional 4 shots fired in a plane (on the same trip) thus resulting in 8 shots per foot.

---

* The procedure outline has been recommended by the authors for the past three years and recently several wells have been successfully completed in southeastern Saskatchewan using this technique.

** Cement should be well set and of high strength to minimize deformation of steel casing and prevent disruption of the cement-steel bond above and below perforations.

*** The Hyperjet Perforator makes a 0.43 inch hole and although it uses less powder than Schlumberger's older type Radial Jet Perforator, because of improved design of the shaped charge, greater penetration is obtained. In addition, use of the Hyperjet Perforator results in a cleaner hole due to removal of powdered steel, concrete and limestone by the jet action of hot gases.

(b) squeeze acid through perforations and follow with water. Measure feed rate of water and start mixing cement. (The amount of cement that should be mixed will depend on the feed rate of the water and may vary from 100 to 600 sacks. Field experience indicates that if a feed rate of 4 barrels of water per minute can be injected into the formation, then 250 sacks of cement can be readily injected through the perforations).

(c) squeeze a pancake of low viscosity cement into the permeable water laden bed in an attempt to prevent water-coning near the well bore

(d) perforate the most permeable oil bearing section (carrier bed) and if the horizontal permeability resulting from interparticulate pores or vugs is of the order of 50 millidarcies or more (as estimated from pore size under the microscope and confirmed by drillstem test data) attempt completion without acid.

(e) place well on pump but refrain from pumping too hard to minimize pressure draw-down near the well bore and prevent serious water coning

(f) if the well fails to produce at commercial rates, a minimum amount of acid should be used to open perforations and attempt to increase horizontal permeability close to the well bore

4. In the area north of the Tacoma North Pierson 2-24 well, the MC-3 pay zone (if present) is expected to be very thin and/or anhydritized. In this area, only oil cut mud or a small amount of oil may be recovered on drillstem test of the MC-3 unit, without trace of salt water. Under such circumstances, provided the well is bottomed in the upper part of the MC-2 anhydrite unit and the MC-3 unit appears to have good reservoir continuity (for example, if gas arrives at surface within two hours and encouraging rate of pressure buildup during the final shut in pressure period occurs), we would recommend completion with 4 1/2 inch casing, multiple perforation of the MC-3 unit and injection of 2000 gallons of 15 percent hydrochloric acid.

Table I: Estimated per well primary recoverable reserves, North Pierson Area, Manitoba

Estimated average net pay thickness in requested area for 160 acre spacing	8 feet
Estimated average effective porosity	12%
Estimated average connate water	35%
Estimated Shrinkage factor*	0.84

80 acre spacing

Estimated average primary recovery factor	18%
Estimated average primary recoverable reserves = 91.5 bbl. per acre foot	
Estimated average primary recoverable reserves per spacing unit =	58,600 bbl.

160 acre spacing

Estimated average primary recovery factor	16%
Estimated average primary recoverable reserves = 81 bbl. per acre foot	
Estimated average primary recoverable reserves per spacing unit =	103,700 bbl.

---

* The commonly accepted shrinkage factor for Pierson Field crude (37° API) is 0.90. However, our experience in Saskatchewan shows that in stratigraphic traps with an anhydrite floor-seal, the initial gas-oil ratio increases toward the pinchout edge of the reservoir unit, and based on an average depth of 3200 feet, we calculate the average shrinkage factor to be 0.84 for this type of crude.

TABLE II: Estimated per Well Completion and Operating Costs, North Pierson Area, Manitoba prepared by D. M. Campbell, B. Comm., C. A., Secretary-Treasurer, Tacoma Petroleums, Calgary, Alberta

	80 acre Spacing	160 acre Spacing
Land	$ 500	$ 1,000
Completion*	48,600	49,400
Share of development dry holes**	4,800	4,800
Office overhead	400	400
Total investment	54,300	55,600

Price per bbl. of oil	$2.67
Trucking cost of oil to Cromer, Man. per bbl.	.42
Wellhead price per bbl.	2.25

Salt water disposal cost per bbl. 26 cents

Annual operating costs per well (including office overhead) = $4,400 initially with estimated escalation shown in Table IV

Average royalty burden = 23%

Operators share of recoverable oil 77%

---

* Completion cost comprises all field costs of placing an individual MC_3 oil well on production including drilling, logging, testing, casing, cementation, perforation, acidization, installation of pump, share of battery, line pipe and wellsite consultant fees.

** Individual dry holes cost $24,000 (see report heading 'Development Dry Holes')

TABLE III: Estimated future oil and salt water production from average MC-3 wells, North Pierson Area, Manitoba (based on well production history of geologically similar oil pools in southeastern Saskatchewan) bbls.

	OIL		SALT WATER	
	80 acres	160 acres	80 acres	160 acres
1st year	14,500	14,500	1500	1500
2nd year	12,000	12,500	2000	1900
3rd year	10,000	11,000	2600	2300
4th year	8,500	10,000	3300	2700
5th year	7,500	9,500	4100	3100
6th year	5,500	9,000	5300	3500
7th year		8,500		3900
8th year		8,000		4300
9th year		7,500		4700
10th year		7,000		5100
11th year		5,500		5500

TABLE IV: Estimated Operators Net Income per Well (before Taxes), North Pierson Area, Manitoba

80 acre Spacing

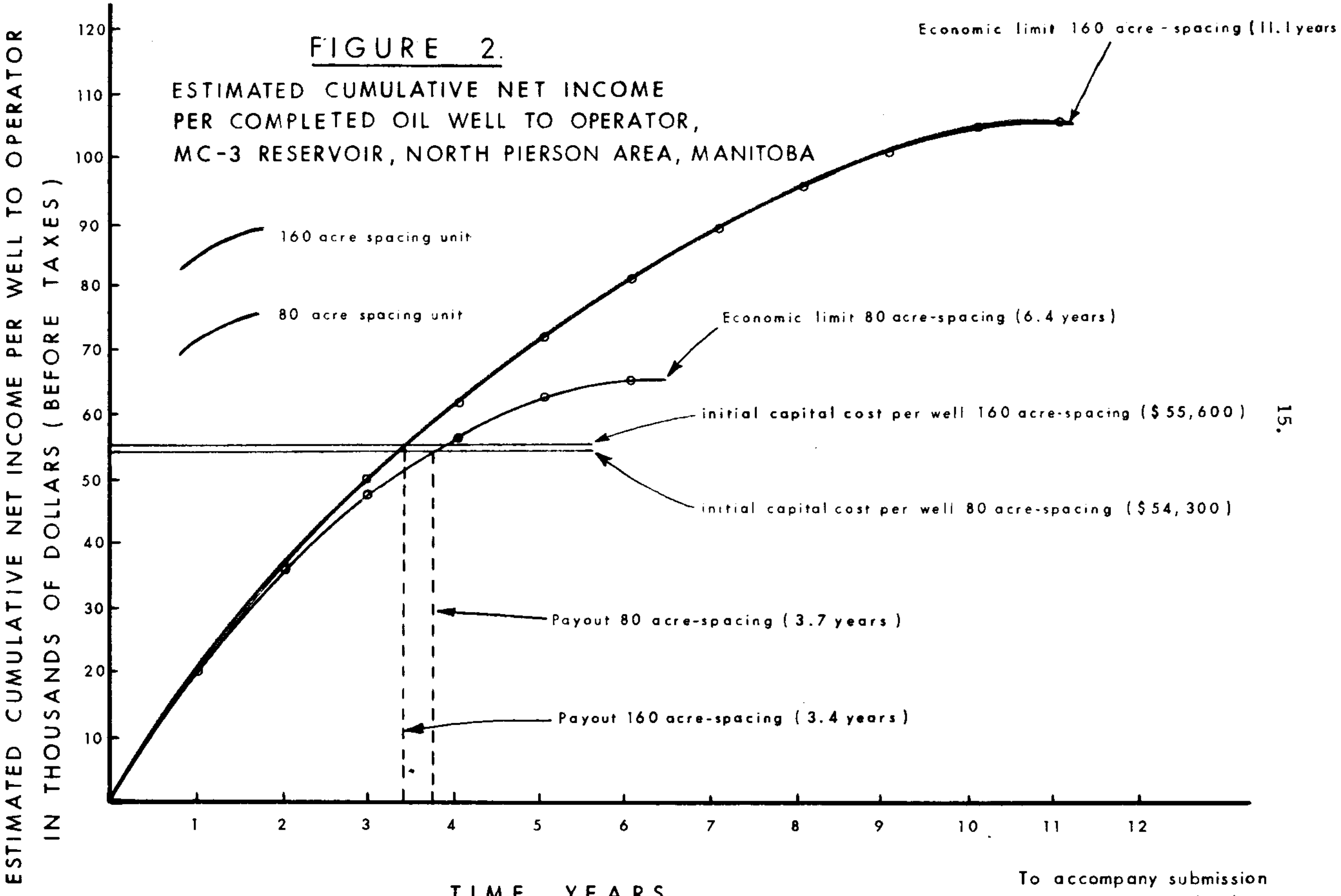
	Wellhead Gross	Gross to Operator after Royalties	Salt Water Disposal	Operating Cost	Net to Operator	Cumulative Net to Operator
1st year	$32,600	$25,100	$ 400	$ 4,400	$20,300	$20,300
2nd year	27,000	20,800	500	4,600	15,700	36,000
3rd year	22,500	17,300	700	4,800	11,800	47,800
4th year	19,100	14,700	900	5,000	8,800	56,600
5th year	16,900	13,000	1,100	5,300	6,600	63,200
6th year	12,400	9,600	1,400	5,900	2,300	65,500

160 acre Spacing

	Wellhead Gross	Gross to Operator after Royalties	Salt Water Disposal	Operating Cost	Net to Operator	Cumulative Net to Operator
1st year	$32,600	$25,100	$ 400	$ 4,400	$20,300	$20,300
2nd year	28,100	21,600	500	4,600	16,500	36,800
3rd year	24,800	19,100	600	4,800	13,700	50,500
4th year	22,500	17,300	700	5,000	11,600	62,100
5th year	21,400	16,500	800	5,300	10,400	72,500
6th year	20,200	15,600	900	5,600	9,100	81,600
7th year	19,100	14,700	1,000	5,900	7,800	89,400
8th year	18,000	13,900	1,100	6,200	6,600	96,000
9th year	16,900	13,000	1,200	6,500	5,300	101,300
10th year	15,700	12,100	1,300	6,900	3,900	105,200
11th year	12,400	9,600	1,400	7,600	600	105,800

FIGURE 2.

ESTIMATED CUMULATIVE NET INCOME PER COMPLETED OIL WELL TO OPERATOR, MC-3 RESERVOIR, NORTH PIERSON AREA, MANITOBA



To accompany submission
by Andrichuk and Edie,
Consulting Geologists,
SEPTEMBER 21, 1967.

ECONOMICS

The estimated per well completion and operating costs in the North Pierson area by D. M. Campbell (Table II) are based on actual completion costs of the Tacoma North Pierson 2-24 well in addition to present day costs of operation by Tacoma Petroleums (and associated companies) in southeastern Saskatchewan.

The four King Resources oil wells, approximately 1 1/2 miles southeast of the Tacoma North Pierson 2-24 well, have had a very poor performance record and individual wells (on the average) are at present producing only 22 barrels of oil per day (and 26 barrels of salt water per day). However, with improved completion procedures and improvement in reservoir quality at the Tacoma North Pierson 2-24 well, we anticipate an average initial production rate for the first year of approximately 40 B. O. P. D. for each well (14, 500 barrels of oil per year) with rate of decline shown in Table III. Salt water production is estimated at approximately 10% of total fluid produced initially increasing to approximately 50% of total fluid produced at the economic limit.

As shown in Table IV and Figure 2, it is anticipated that drilling on 80 acre spacing will result in a definitely marginal operation. In contrast, it is believed that 160 acre spacing will yield a reasonably good return on invested capital considering the risks involved.

CONSERVATION

From a purely conservation point of view, close spacing resulting in maximum primary oil recovery per acre, would appear to be a desirable objective. However, if an operator cannot show a reasonable profit on primary oil production, he is not likely to be convinced of the merits of investing an additional $20,000 per well in a secondary water-flood operation. Thus, under 80 acre spacing, producing oil wells in the North Pierson area are likely to be abandoned at their economic limit with estimated recovery of 18% (Table I).

However, if production rates are maintained on 160 acre spacing as shown in Table III, it is likely that secondary recovery operations would be undertaken. On the basis of successful water-flood operations of geologically similar stratigraphic trap oil fields along the Midale trend of Saskatchewan (where water-flooding is expected to double the primary recovery), water-flooding of the MC-3 reservoir in the North Pierson area may increase recovery on 160 acre spacing from 16% (Table I) to possibly 24 to 30%. Thus, we firmly believe that 160 acre spacing offers the prospect of not only increasing the profitability of the operation but may substantially increase ultimate recovery with resultant benefits to all concerned.

SUMMARY AND CONCLUSIONS

The reasons for 160 acre spacing in the North Pierson area are as follows:

(1) the anticipated thin net pay thickness as shown by data from the Tacoma North Pierson 2-24 well

(2) the presence of an excellent carrier bed within the MC-3 reservoir at the Tacoma North Pierson 2-24 well indicates the probability that 160 acre spacing will drain almost as much primary oil as 80 acre spacing

(3) with 80 acre spacing, the operator is faced with the prospect of barely getting his money back so that producing wells are likely to be abandoned at the economic limit (without secondary recovery)

(4) with 160 acre spacing, profitability on primary oil recovery is likely to be such as to encourage the further investment in secondary water-flooding operations with greatly enhanced ultimate recovery and increased benefits to all concerned.

Respectfully submitted,

Ralph W. Edie

Ralph W. Edie

John M. Andrichuk

John M. Andrichuk

September 21, 1967

REFERENCES

EDIE, R. W., 1958, "Mississippian Sedimentation and Oil Fields in Southeastern Saskatchewan", Bull. Amer. Assoc. Petrol. Geol., Vol. 42, pp. 94-126.

EDIE, R. W., 1963, "Distribution and Behavior of Oil and Water in Mississippian Limestone Reservoirs", Southeastern Saskatchewan", Jour. Can. Petrol. Technology, Vol. 2, No. 3, pp. 122-132.

McCABE, H. R., 1959, "Mississippian Stratigraphy of Manitoba", Province of Manitoba, Dept. of Mines and Natural Resources, Publication 58-1.

McCABE, H. R., 1963, "Mississippian Oil Fields of Southwestern Manitoba", ibid, Publication 60-5.

STRAIN, H. J., 1962, "Well-Bore Notching and Hydraulic Fracturing", Jour. Can. Pet. Technology, Vol. 1, pp. 153-161.