DOE/BC/14982--3

QUARTERLY TECHNICAL PROGRESS REPORT NO. 3

"AN INTEGRATED STUDY OF THE GRAYBURG/SAN ANDRES RESERVOIR, FOSTER AND SOUTH COWDEN FIELDS, ECTOR COUNTY, TEXAS"

NO. DE-FC22-94BC14982

LAGUNA PETROLEUM CORPORATION

DATE SUBMITTED:

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ANTICIPATED COMPLETION DATE: Phase I, October 1, 1995
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GOVERNMENT AWARD FOR CURRENT YEAR: $71,200

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REPORTING PERIOD: February 1, 1995 through April 30, 1995

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Objectives

The objective of this study is to demonstrate a methodology for reservoir characterization of shallow shelf carbonate reservoirs which is feasible for the independent operator. Furthermore, it will provide one of the first public demonstrations of the enhancement of reservoir characterization using high resolution 3-D seismic data. This particular project will evaluate the Grayburg and San Andres reservoirs in the Foster and South Cowden Fields of Ector County, Texas. We intend to showcase a multi-disciplinary approach to waterflood design and implementation, along with the addition of reserves by selective infill drilling. We believe this approach in reservoir development will be applicable to a wide range of shallow shelf carbonate reservoirs throughout the United States. Technology transfer will take place through all phases of the project.

Geological

1. Reviewed offset wells. Looked for and at old scout tickets, looking for cable tool information on gas caps, oil/water contacts, porosity increases. There appears to be a secondary gas cap developed in the section to the west (Sec. 35) and the SW/4 of Section 36.

2. Reviewed samples for Brock #10. The core has been lost, but core chips were retained. Unfortunately, the chips were not labeled as to depth and therefore unusable.

3. Reviewed core for Sun #6 Witcher. Core is available from the Queen (3,850-3,860'), Grayburg (3,860-4,025') and San Andres (4,260-4,315'). A detailed core description was completed and 31 thin section blanks taken. Thin sections are presently being made.

4. Evaluation and integration of the information from the core was undertaken. Identification of subareal exposure surfaces along with the identification of a series of shallowing upward sequences and environment of deposition were completed. The best reservoir quality facies are in shallow subtidal grainstones and packstones with good interparticle porosity. This information will be integrated into the log evaluation.

Reservoir Engineering

The work performed for this quarter was directed toward obtaining annual production histories for each well in the study area. This was a formidable task inasmuch as operators' records for early years was sparse, and in some cases non-existent. However, production reported to the Texas Railroad Commission for each of the five leases (Witcher, Brock, Foster, Foster-Pegues, and Maurice) were available from Petroleum Information beginning with the year 1970. These were made available on computer print-

outs. Pre-1970 lease production values, also compiled by the TRC, are maintained by the Midland Public Library. For these early production data, manual retrieval was necessary.

Allocation of lease production to individual wells leading to the lease battery was performed by incorporating well test results, and well status history gleaned from the well files. Considerable effort was directed toward obtaining these data employing the services of a competent technician. The allocation process for estimating individual well production for the entire 54 year history period was time consuming. The average daily production rate for each well was determined as required as input data by the reservoir simulator (WORKBENCH). The annual production by lease is calculated which conforms with published data. (Production for the years 1934 through 1939 for brevity). The annual production history for each of the five leases, and combined area total are presented in Table 1. A summary of the total recovery by lease follows:

Lease	Number of Producers	Cumulative Production
Witcher	10	1,909,420 (STB)
Brock	10	1,809,399
Foster	10	651,373
Foster-Pegues	8	1,447,360
Maurice	7	1,358,765
Combined	45	7,176,317

Plots of the production data are given in Figs. 1 through 5 for the same five leases, respectively. These graphs include annual production and cumulative production. Figure 6 represents the Study Area total of both annual and cumulative production.

It is interesting to observe that three peaks in annual production are reflected in the 55 year history of this unit's production. (See for example the Witcher and Foster leases). These peaks reflect distinct changes in operations identified as follows: a) the mid-40's when proration was relaxed in order to supply more oil required for World War II then in progress, b) the mid-50's when an extensive frac program on wells was undertaken throughout the study area, and c) the early 70's when infill drilling was initiated, as well as responses to staggered water-flood efforts.

Finally, a three-layer simulation model was constructed using the DOE program called BOAST. Values for net pay, porosity, and water saturation used in this simulation were the same as published by Sun Oil over ten years ago. One very significant result revealed in this early simulation effort was that insufficient oil was present to allow the simulation to run the entire 54-year life of the project. It was obvious that in order to produce the 1.9 million barrels recorded history, the initial volume of OOIP had to be increased substantially.

Geophysics:

Systems Administration-

Early in February, training courses on Scientific Software Intercomp WorkBench (1 week) and Schlumberger GeoQuest IESX (1 week) were attended to become familiar with application software used in the study. Afterwards, the software packages WorkBench, GX Technology GXII and 3-D AIMS; and the upgrade for IESX 8.25 to 9.0 A were installed. A script was designed in UNIX to back up on 8 mm magnetic tape both hard disks (total of ~3 Gb) for the computer workstation. It is the responsibility of each consultant in the technical team to purchase 8 mm magnetic tapes and backup their work on the workstation. To further protect the computer system, an electrical surge protector and stand alone battery driven power supply were purchased. These devices protect the system from possible spurious voltages from the local power company and power outages. Other devices recently configured to the workstation include a Summagraphics digitizer for digitizing logs and a Digital VT420 computer terminal for system administrative tasks.

Ms. Olaya Covarrubias, our geological technician, recently took employment with Mobil Oil Corporation. To find a replacement, interviews were conducted with a couple of graduate students at UTPB. Mr. Paul Laverty ($8/hr) was selected as our new technician who is very familiar with PC computer systems. Mr. Laverty is rapidly learning the UNIX operating system and hopefully will free up much time by becoming the project systems administrator. He will also be able to perform a number of clerical tasks such as organization of project data, reports, and files in the project office.

Reservoir Description-

Shortly after returning from the software training classes in mid-February, a preliminary analysis of the seismic phase of the wavelet in our 3-D seismic volume was completed. The velocity survey in the Blair & French - El Paso Production Company No. 1 Moss Well was tied into the seismic data at the Yates, Grayburg, and San Andres intervals. Synthetic seismograms computed from sonic logs in the John L. Cox #1 William Moss, Atlantic Foster #3-X, and Atlantic Brock #5 wells were character tied to 0, 90, 180, and 270 degree phased rotated seismic sections. The best tie was obtained with the 90 degree phase rotated section. A more careful phase analysis is planned using the IESX tools on the computer workstation.

The following data has been loaded in the computer workstation, both 3-D seismic volumes (final migrations/with and without DMO); digital basemaps containing block and section lines, streams, and roads; well locations; and digital well logs. Structural time maps and seismic amplitude maps have been made on the near top of Yates, Grayburg, Lower Grayburg, and San Andres.

The next step to be completed for the reservoir characterization using the 3-D seismic data is the detailed integration of all digital well log data to the 3-D seismic volume. However, completion of this task requires completion and/or on-going effort in picking all tops in the digital well logs, including Yates, Queen, Grayburg, San Andres, and Glorieta Formations and the high frequency sequence boundaries in the Grayburg/San Andres reservoir. This task can be completed properly using the reservoir description module in the WorkBench software. The best approach would be for the project geologist and geophysicist to work both the logs and the 3-D seismic together.

In the ideal case, all sonic logs found in the 3-D seismic volume should be digitized. Approximately 26 wells in the 3-D seismic volume have sonic logs of which about 11 have been partially digitized. It was recommended that all wells that penetrate the Grayburg/San Andres reservoir in the 3-D seismic volume should be digitized between the top of Yates and Glorieta. Several days were spent reviewing the Synthetics and Synview application modules in IESX which will be used to tie sonic and pseudo-sonic logs to the 3-D seismic volume.

In accordance to the multi-disciplinary approach in our project, work is being closely performed with our project engineer in developing a generic reservoir simulation model in the WorkBench software. Working closely with our project geologist, his core descriptions from the Sun Witcher #6 well were reviewed and interesting features in the 3-D seismic volume were noted. Along with our project manager, a 2-D seismic model was developed through the study area to investigate the effects of reservoir properties on seismic attributes.

Technology Transfer

This quarter, presentations and progress reports were co-authored to be presented to the following technical and scientific organization:

Southwest Petroleum Short Course
GX Technology L. P. User's Conference

Field trips were taken to visit outcrops that are similar to our Grayburg/San Andres reservoir in the Guadalupe Mountains of Texas and New Mexico, including:

SEPM McKitrick Canyon Field Trip
WTGS Field Trip/Guadalupe Mountains

Agreements with Hampson and Russell in Calgary, Canada, are in place to use their seismic inversion and geostatistics software. This software will be used to determine interpolation functions to evaluate reservoir properties between wells using seismic attributes.

In our first quarterly report, the possibility of doing some crosswell seismic work for our project with Providence Technology was mentioned. Since that time, Providence Technology has recommended to GRI our project as one of three possible sites for funding for crosswell seismic research.

Recommendations

Completion of Phase I of our study is contingent on a comprehensive reservoir description using the well control and 3-D seismic data. To complete this task, both the well control and seismic data must be interpreted together. Reservoir simulation studies cannot be completed before reservoir description and model development.

It is recommended purchasing a 486 PC based graphics terminal (about $2,500) to interface into the Sun workstation. This would allow both the project geologist and geophysicist to use the WorkBench and IESX software at the same time on the Sun workstation. We have a two seat license for the WorkBench software which would also allow both the project geologist and engineer to work at the same time. Likewise, interpretation and modelling work could be done during system administrative and data management tasks. The 486 PC would also be available to the technical team for work processing and management tasks so that most if not all work could be done in the project office and not at home.

Also recommended is using Paul Laverty ($8/hr) as much as necessary for data input/management and system administration.

Table 1: Production History for Combined Leases - Foster Field Study

prod.wk2

	Witcher Lease		Brock Lease		Foster Lease		Foster-Pegues Lease		Maurice Lease		Combined Leases	
Year	Annual	Cumulative	Annual	Cumulative	Annual	Cumulative	Annual	Cumulative	Annual	Cumulative	Annual	Cumulative
1939	0	0	28,195	28,195	0	0	0	0	0	0	28,195	28,195
1940	15,839	15,839	8,314	36,509	0	0	11,481	11,481	5,098	5,098	40,732	68,927
1941	55,808	71,647	53,048	89,557	32,466	32,466	56,730	68,211	51,228	56,326	249,280	318,207
1942	29,319	100,966	28,690	118,247	21,815	54,281	30,181	98,392	27,066	83,392	137,071	455,278
1943	46,585	147,551	44,905	163,152	24,630	78,911	47,590	145,982	30,615	114,007	194,325	649,603
1944	96,952	244,503	96,528	259,680	25,390	104,301	85,521	231,503	35,462	149,469	339,853	989,456
1945	86,934	331,437	83,948	343,628	18,829	123,130	48,689	280,192	32,005	181,474	270,405	1,259,861
1946	65,999	397,436	61,169	404,797	15,344	138,474	31,425	311,617	29,809	211,283	203,746	1,463,607
1947	51,722	449,158	40,631	445,428	14,489	152,963	26,053	337,670	28,394	239,677	161,289	1,624,896
1948	43,011	492,169	27,158	472,586	12,085	165,048	21,451	359,121	23,839	263,516	127,544	1,752,440
1949	28,889	521,058	19,388	491,974	8,670	173,718	14,698	373,819	18,524	282,040	90,169	1,842,609
1950	29,621	550,679	16,702	508,676	10,111	183,829	14,816	388,635	20,956	302,996	92,206	1,934,815
1951	25,082	575,761	13,943	522,619	6,524	190,353	15,862	404,497	17,034	320,030	78,445	2,013,260
1952	22,958	598,719	13,479	536,098	6,107	196,460	22,138	426,635	16,574	336,604	81,256	2,094,516
1953	17,182	615,901	12,609	548,707	5,353	201,813	14,128	440,763	16,931	353,535	66,203	2,160,719
1954	18,252	634,153	13,327	562,034	6,921	208,734	12,268	453,031	41,093	394,628	91,861	2,252,580
1955	57,523	691,676	47,140	609,174	31,248	239,982	33,638	486,669	68,575	463,203	238,124	2,490,704
1956	45,740	737,416	22,529	631,703	11,977	251,959	29,229	515,898	45,649	508,852	155,124	2,645,828
1957	28,419	765,835	14,580	646,283	8,378	260,337	18,393	534,291	38,646	547,498	108,416	2,754,244
1958	20,346	786,181	11,572	657,855	6,450	266,787	13,738	548,029	30,888	578,386	82,994	2,837,238
1959	18,331	804,512	8,901	666,756	3,867	270,654	10,414	558,443	26,939	605,325	68,452	2,905,690
1960	16,736	821,248	6,930	673,686	3,959	274,613	8,950	567,393	22,888	628,213	59,463	2,965,153
1961	12,544	833,792	5,148	678,834	2,996	277,609	10,717	578,110	22,317	650,530	53,722	3,018,875
1962	7,998	841,790	3,280	682,114	2,929	280,538	19,065	597,175	20,460	670,990	53,732	3,072,607
1963	6,909	848,699	3,433	685,547	12,478	293,016	11,641	608,816	18,208	689,198	52,669	3,125,276
1964	12,009	860,708	3,000	688,547	11,642	304,658	10,269	619,085	17,534	706,732	54,454	3,179,730
1965	13,923	874,631	3,045	691,592	7,129	311,787	9,971	629,056	16,109	722,841	50,177	3,229,907
1966	10,722	885,353	3,280	694,872	6,944	318,731	23,315	652,371	17,467	740,308	61,728	3,291,635
1967	8,687	894,040	3,857	698,729	4,130	322,861	20,149	672,520	14,146	754,454	50,969	3,342,604
1968	10,861	904,901	8,020	706,749	5,490	328,351	14,598	687,118	13,025	767,479	51,994	3,394,598
1969	11,305	916,206	13,792	720,541	5,239	333,590	9,223	696,341	13,986	781,465	53,545	3,448,143
1970	64,883	981,089	22,078	742,619	3,845	337,435	6,810	703,151	11,007	792,472	108,623	3,556,766
1971	103,117	1,084,206	29,807	772,426	3,655	341,090	7,395	710,546	10,135	802,607	154,109	3,710,875
1972	65,905	1,150,111	31,515	803,941	4,439	345,529	39,122	749,668	13,494	816,101	154,475	3,865,350
1973	55,099	1,205,210	40,177	844,118	12,414	357,943	44,365	794,033	18,913	835,014	170,968	4,036,318
1974	68,376	1,273,586	39,750	883,868	16,044	373,987	32,138	826,171	21,174	856,188	177,482	4,213,800
1975	60,081	1,333,667	40,618	924,486	11,701	385,688	32,794	858,965	22,111	878,299	167,305	4,381,105
1976	52,875	1,386,542	44,443	968,929	14,329	400,017	34,501	893,466	26,516	904,815	172,664	4,553,769
1977	47,775	1,434,317	65,541	1,034,470	16,792	416,809	37,063	930,529	26,375	931,190	193,546	4,747,315
1978	39,040	1,473,357	64,963	1,099,433	14,247	431,056	33,969	964,498	23,479	954,669	175,698	4,923,013
1979	35,271	1,508,628	66,898	1,166,331	10,105	441,161	48,864	1,013,362	19,594	974,263	180,732	5,103,745
1980	31,066	1,539,694	59,978	1,226,309	5,096	446,257	45,966	1,059,328	42,436	1,016,699	184,542	5,288,287
1981	33,587	1,573,281	66,329	1,292,638	17,516	463,773	62,586	1,121,914	38,481	1,055,180	218,499	5,506,786
1982	27,352	1,600,633	60,669	1,353,307	26,024	489,797	41,820	1,163,734	28,664	1,083,844	184,529	5,691,315
1983	24,593	1,625,226	61,029	1,414,336	22,143	511,940	35,171	1,198,905	29,337	1,113,181	172,273	5,863,588
1984	21,778	1,647,004	57,666	1,472,002	23,338	535,278	33,606	1,232,511	33,446	1,146,627	169,834	6,033,422
1985	27,818	1,674,822	49,509	1,521,511	26,593	561,871	28,112	1,260,623	28,856	1,175,483	160,888	6,194,310
1986	28,368	1,703,190	44,560	1,566,071	21,458	583,329	24,587	1,285,210	22,406	1,197,889	141,379	6,335,689
1987	21,694	1,724,884	39,316	1,605,387	13,393	596,722	28,987	1,314,197	20,326	1,218,215	123,716	6,459,405
1988	23,127	1,748,011	34,746	1,640,133	9,504	606,226	27,898	1,342,095	25,131	1,243,346	120,406	6,579,811
1989	26,485	1,774,496	26,638	1,666,771	12,299	618,525	21,988	1,364,083	18,393	1,261,739	105,803	6,685,614
1990	28,818	1,803,314	34,013	1,700,784	9,332	627,857	20,913	1,384,996	19,937	1,281,676	113,013	6,798,627
1991	32,986	1,836,300	25,258	1,726,042	5,613	633,470	18,954	1,403,950	20,261	1,301,937	103,072	6,901,699
1992	28,930	1,865,230	25,490	1,751,532	6,518	639,988	17,028	1,420,978	20,652	1,322,589	98,618	7,000,317
1993	22,882	1,888,112	26,936	1,778,468	6,175	646,163	14,254	1,435,232	19,457	1,342,046	89,704	7,090,021
1994	21,308	1,909,420	30,931	1,809,399	5,210	651,373	12,128	1,447,360	16,719	1,358,765	86,296	7,176,317

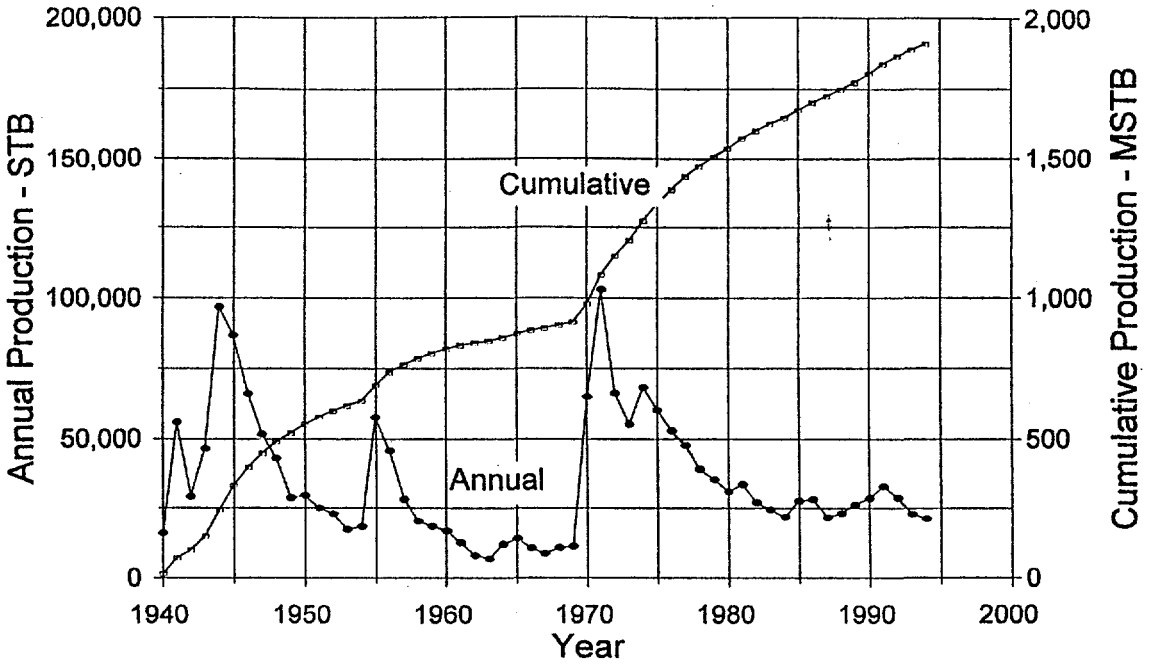

Fig. 1: Production History for Witcher Lease - Foster Field Study

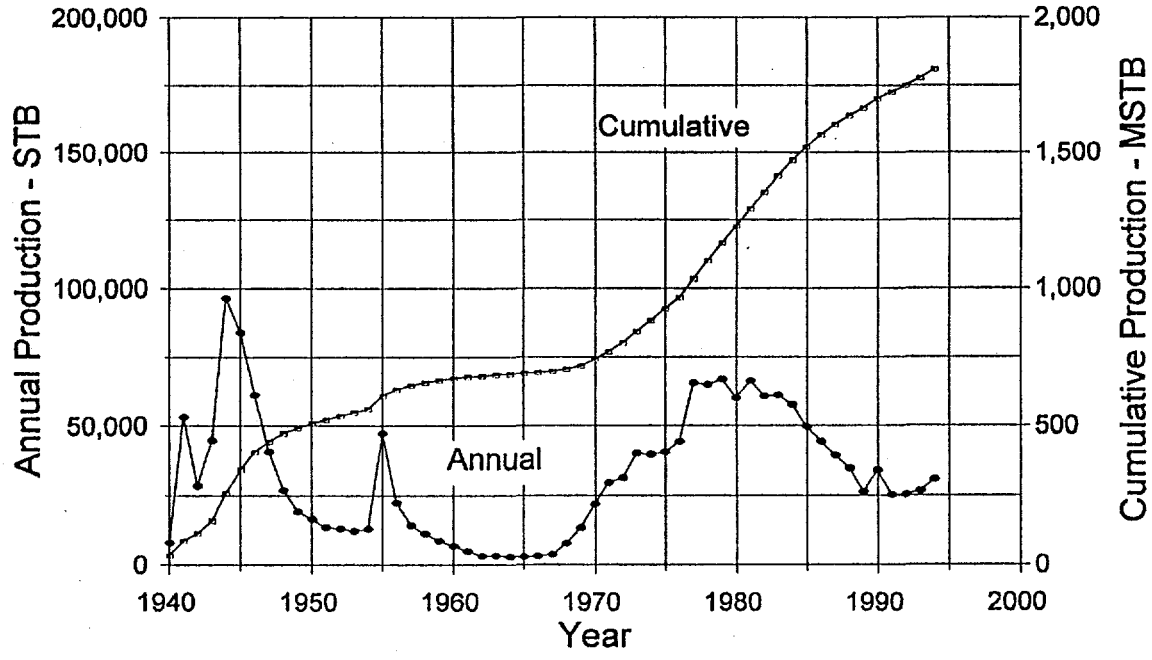

Fig. 2: Production History for Brock Lease - Foster Field Study

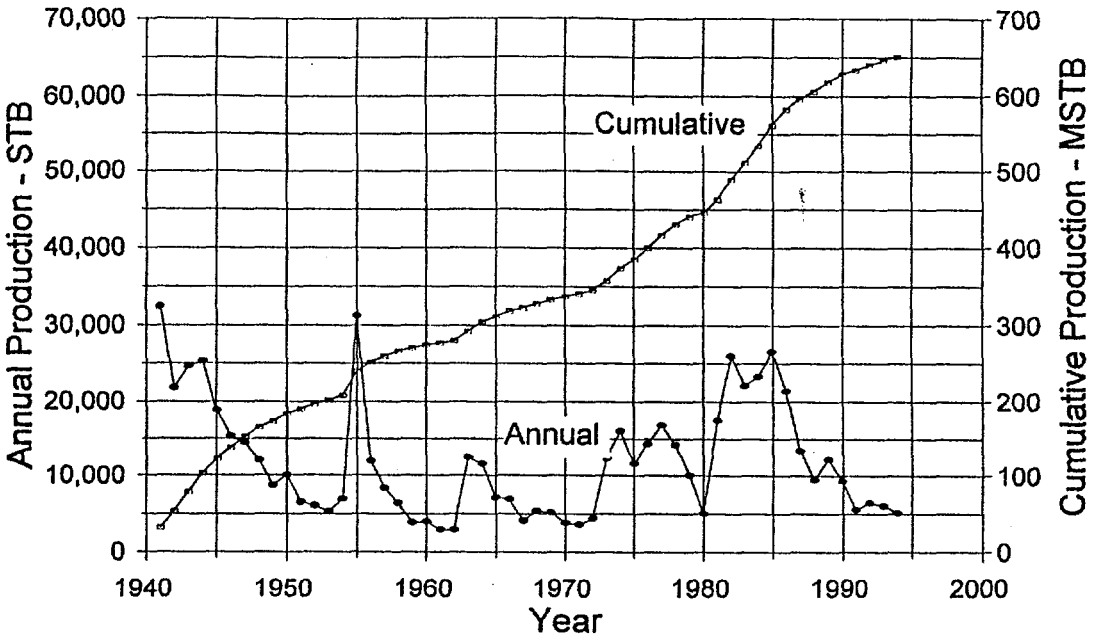

Fig. 3: Production History for Foster Lease - Foster Field Study

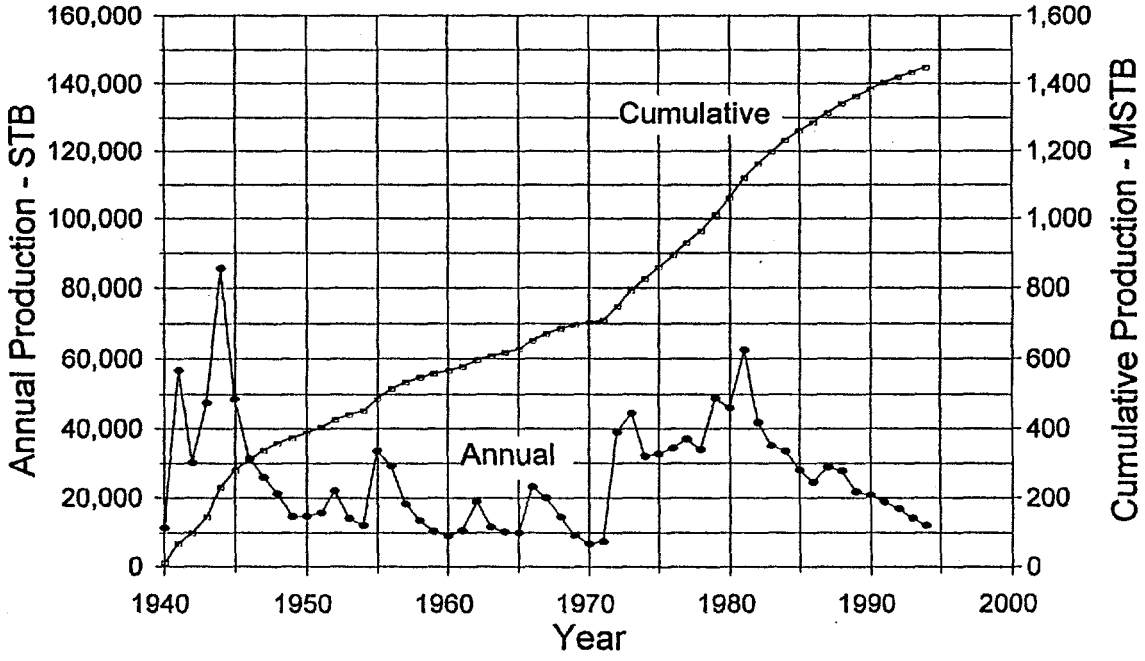

Fig. 4: Production History for Foster-Pegues Lease - Foster Field Study

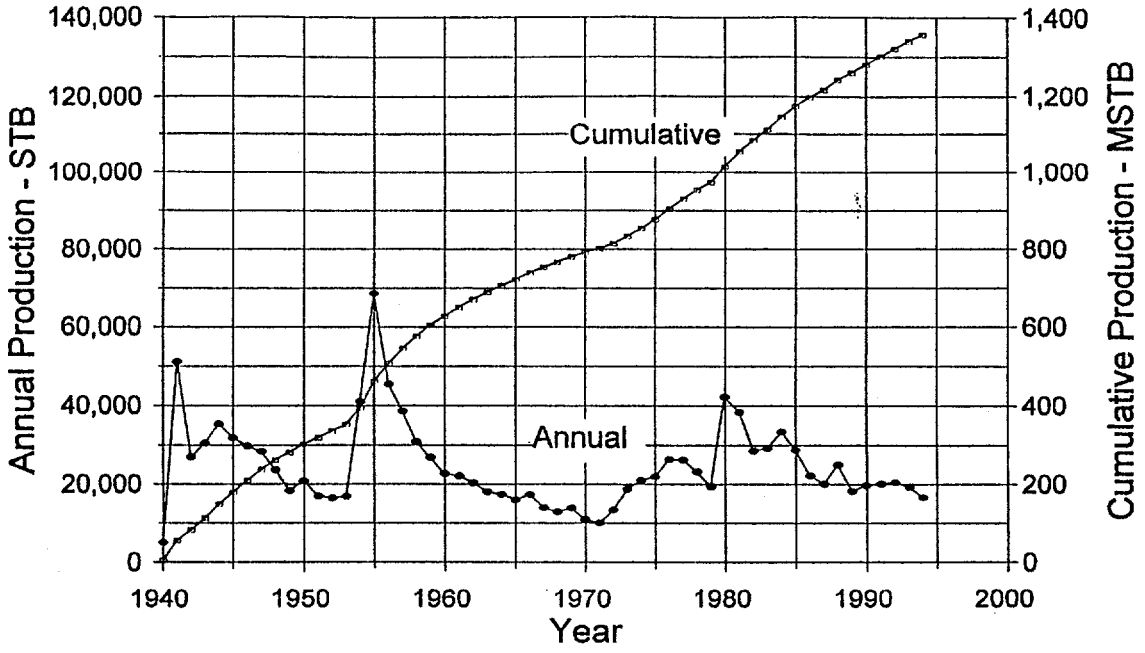

Fig. 5: Production History for Maurice Lease - Foster Field Study

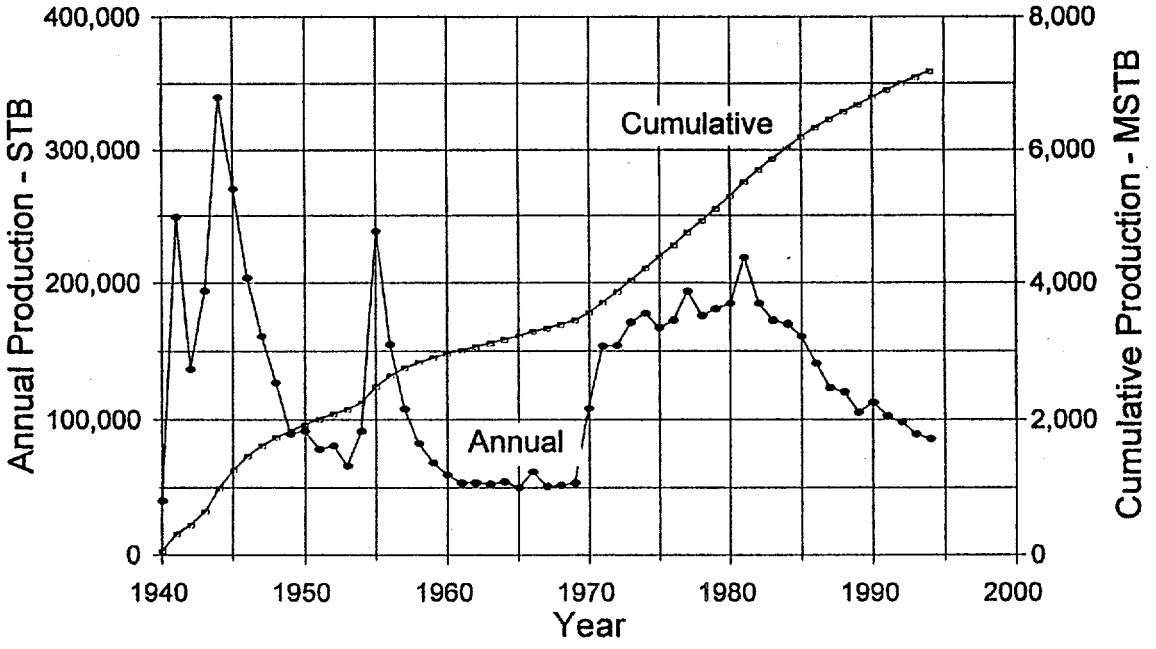

Fig. 6: Production History for Combined Leases - Foster Field Study