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WILLIAMS HOLDING LEASE
STEAMFLOOD DEMONSTRATION PROJECT
CAT CANYON OIL FIELD

Third Progress Report for July 1978—November 1979

Date Published—June 1980

Work Performed for the Department of Energy
Under Contract DE-AC03-76ET12058

Getty Oil Company
Ventura, California

U. S. DEPARTMENT OF ENERGY

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STEAMFLOOD DEMONSTRATION PROJECT
CAT CANYON OIL FIELD

Third Progress Report
for the Period
July 1978–November 1979

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Table of Contents

THIRD PROGRESS REPORT TO USDOE

WILLIAMS HOLDING STEAMFLOOD PILOT CONTRACT NO. DE-AC03-76ET12058

Period: July 1, 1978 to December 1, 1979

	<u>PAGE</u>
I. SUMMARY	1
II. INTRODUCTION	2
III. PROJECT PROGRESS	7
Operations	7
Steam Generator Operations	10
Sulfur Dioxide Removal	13
Well Workovers	17
Production	19
Thermal Observation Wells	26
IV. PROJECT ECONOMICS	29
V. PERFORMANCE ANALYSIS	31
Introduction	31
Williams Holding 205 Cyclic Steam	
Stimulation History Match	32
Displacement Phase History Match	34
Pilot Performance Projection	46
VI. - FUTURE OPERATIONS	50
VII. REFERENCES	51
APPENDIX A - Production Performance, Williams Holding Steamflood Pilot and Individual Wells	52
APPENDIX B - Flowline Temperature Gauges Williams Holding Steamflood Pilot Individual Wells	63
APPENDIX C - Temperature Profiles Williams Holding Steamflood Pilot Individual Wells	73

Table of Contents

	<u>PAGE</u>
APPENDIX D - Drilling Histories, Logs, And Core Data For Thermal Observation Wells	78
APPENDIX E - Temperature Profiles For Thermal Observation Wells	127
APPENDIX F - Reservoir Data For Computer Thermal Simulation	132

LIST OF FIGURES

		<u>PAGE</u>
Figure 1	Location of Cat Canyon Field	3
Figure 2	Location of Williams Holding Steamflood Pilot	4
Figure 3	Steamflood Pilot Configuration	5
Figure 4	Displacement Steam Generator Performance	11
Figure 5	Schematic of Sulfur Dioxide Removal System	15
Figure 6	Williams Holding Steamflood Pilot Production Performance	20
Figure 7	Williams Holding 205-25 Production Performance	21
Figure 8	Williams Holding 205-25 Flow-line Temperature Gauges	22
Figure 9	Total Project Cumulative Steam-Oil Ratio	23
Figure 10	Williams Holding 205 Cumulative Steam-Oil Ratio	24
Figure 11	History Matching of WH 205-25	33
Figure 12	Cartesian Configuration of Thermal Reservoir Simulator	35
Figure 13	5-Layer and 3-Layer Models of Thermal Reservoir Simulator	36
Figure 14	Effect of Water Sand - History Matching	38
Figure 15	Simulation for Channeling	40
Figure 16	Effect of Channeling - History Match	42

LIST OF FIGURES (con't)

	<u>PAGE</u>
Figure 17 Effect of Steam Injection Rate - History Matching	44
Figure 18 Effect of Steam Quality - History Matching	45
Figure 19 Effect of Steam Injection Rate - Performance Predictions	47
Figure 20 Effect of Steam Quality - Performance Predictions	49
Figure 21 Effect of Blocking of Channel at Producer - Performance Predictions	49
Figure A-1 Williams Holding Steam Displace- ment Pilot Production Per- formance	53
Figure A-2 WH 25-25 Performance	54
Figure A-3 WH 26-25 Performance	55
Figure A-4 WH 35-25 Performance	56
Figure A-5 WH 36-25 Performance	57
Figure A-6 WH 105-25 Performance	58
Figure A-7 WH 205-25 Performance	59
Figure A-8 WH 206-25 Performance	60
Figure A-9 WH 305-25 Performance	61
Figure A-10 WH/RF 204-25 Performance	62
Figure B-1 WH 25-25 Flowline Temperature Gauges	64
Figure B-2 WH 26-25 Flowline Temperature Gauges	65
Figure B-3 WH 35-25 Flowline Temperature Gauges	66
Figure B-4 WH 36-25 Flowline Temperature Gauges	67

LIST OF FIGURES (con't)

	<u>PAGE</u>
Figure B-5 WH 105-25 Flowline Temperature Gauges	68
Figure B-6 WH 205-25 Flowline Temperature Gauges	69
Figure B-7 WH 206-25 Flowline Temperature Gauges	70
Figure B-8 WH 305-25 Flowline Temperature Gauges	71
Figure B-9 WH/RF 204-25 Flowline Temperature Gauges	72
Figure C-1 WH 25 Temperature Profile	74
Figure C-2 WH 26 Temperature Profile	75
Figure C-3 WH 205 Temperature Profile	76
Figure C-4 WH/RF 204 Temperature Profile	77
Figure D-1 TO 1 Dual Induction-SFL Log	80
Figure D-2 TO 1 Compensated Neutron-Formation Density Log	81
Figure D-3 TO 1 Computer Processed Log	82
Figure D-4 TO 2 Dual Induction-SFL Log	95
Figure D-5 TO 2 Compensated Neutron-Formation Density Log	96
Figure D-6 TO 2 Computer Processed Log	97
Figure D-7 TO 3 Dual Induction-SFL Log	107
Figure D-8 TO 3 Compensated Neutron-Formation Density Log	108
Figure D-9 TO 3 Computer Processed Log	109
Figure D-10 TO 4 Dual Induction-SFL Log	117
Figure D-11 TO 4 Compensated Neutron-Formation Density Log	118
Figure D-12 TO 4 Computer Processed Log	119
Figure E-1 TO 1 Temperature Profiles	128

LIST OF FIGURES (con't)

	<u>PAGE</u>
Figure E-2 TO 2 Temperature Profiles	129
Figure E-3 TO 3 Temperature Profiles	130
Figure E-4 TO 4 Temperature Profiles	131

LIST OF TABLES

	<u>PAGE</u>
Table 1 Cyclic Steam Stimulation Summary	8
Table 2 Displacement Steam Generator Performance	12
Table 3 Scrubber Performance	16
Table 4 Summary of Actual Operating Costs	30
Table D-1 TO 1 Core Analysis	83
Table D-2 TO 1 Core Descriptions	89
Table D-3 TO 2 Core Analysis	98
Table D-4 TO 2 Core Descriptions	100
Table D-5 TO 3 Core Analysis	110
Table D-6 TO 3 Core Descriptions	112
Table D-7 TO 4 Core Analysis	120
Table D-8 TO 4 Core Descriptions	122

I. SUMMARY

On June 25, 1976 Getty Oil Company was awarded a cost-sharing contract from the USDOE to conduct a joint steamflood pilot on the Williams Holding Lease of Cat Canyon Field in the Santa Maria Basin. The objective of this pilot program is to evaluate the efficiency and economics of the steam displacement process for future full-scale development in the Cat Canyon Sl-B reservoir and in similar heavy crude oil reservoirs.

Precontract activities of Getty Oil Company are reported in the Topical Report I - Project Design and Development. Pre-displacement activities, such as cyclic steam stimulation of the pilot producers and acquisition of steam generator permits, as well as preliminary displacement phase results are discussed in The First Annual Report, June 25, 1976 - June 1, 1977. Pilot response and operations during the first year of steam displacement are summarized in the Second Annual Report, June 1, 1977 - June 30, 1978. The report also presents performance of the displacement steam generator, sulfur dioxide scrubbing system and pilot producers as well as the results of extensive computer thermal simulation studies.

This Third Progress Report discusses pilot operations and results during the reporting period of July 1, 1978 to December 1, 1979. The performance of the displacement steam generator, the status of the sulfur dioxide scrubbing system, well workovers and the results of drilling four thermal observation wells are examined. Additional computer thermal simulation studies are discussed in detail and a new production performance projection is made. Finally, project economics and future operations are summarized.

II. INTRODUCTION

On June 25, 1976, Getty Oil Company was awarded a cost-sharing contract by the Energy Research and Development Administration (now Department of Energy) to conduct a steamflood pilot on the Williams Holding Lease of Cat Canyon Field, Santa Barbara County, California. The objective of the pilot program is to evaluate the efficiency and economics of the steam displacement process for future full-scale development in the Cat Canyon Sl-B reservoir and in other similar very heavy oil reservoirs.

Precontract activities of Getty Oil Company are reported in the Topical Report I - Project Design and Development¹. These activities include site selection and preparation, and drilling of the production and injection wells. Figures 1 and 2 show the location of the Cat Canyon Field and the steamflood pilot, respectively. Pilot configuration, shown in Figure 3, was selected on the basis of steamflood experience in the Kern River Field and projections resulting from preliminary computer thermal simulation studies conducted by Getty Oil Company.

Project progress from signing the contract to June 1, 1977 is discussed in the First Annual Report, Williams Holding Lease Steamflood Demonstration Project². Pre-displacement activities are summarized, including cyclic steam stimulation of the pilot producers and the acquisition of steam generator permits. Results of further computer simulation studies conducted under more restrictive assumptions for field operating conditions expected during the pilot project are also presented. Finally, a discussion of the preliminary results of the displacement phase of the project, which started in April, 1977, is included.

The reporting period of the First Annual Report included only the first two months of the steam displacement phase. Briefly summarized, this initial period was beset by repeated failures of the thermal packers in the steam injection wells. Operation of the 50MM BTU/Hr. displacement steam generator was straightforward and uncomplicated by major problems. Generator

Figure 1

LOCATION OF CAT CANYON FIELD
SANTA BARBARA COUNTY

Figure 2

LOCATION OF WILLIAMS HOLDING STEAMFLOOD PILOT
CAT CANYON FIELD

Figure 3

WILLIAMS HOLDING
STEAMFLOOD PILOT CONFIGURATION

downtime was predominantly due to replacement of thermal packers.

Initial pilot response and operations during the period June 1, 1977 to July 1, 1978 are discussed in the Second Annual Report, Williams Holding Lease Steamflood Demonstration Project.³ Pilot operations including the displacement steam generator performance, the status of sulfur dioxide scrubbing system, and major well workovers during this period are summarized. Oil production and heat distribution within the pilot patterns are also reviewed. The results of extensive computer thermal simulation studies are discussed and a summary of the project economics as of June 30, 1978 is presented.

During the reporting period of the Second Annual Report, definite displacement heat response was noted in four of the producing wells. The high gross production rates accompanying the heat response exceeded artificial lift capacity in the four responding wells. Efforts were directed toward achieving heat response in the remaining five producing wells in order to balance fluid withdrawal rates in the project.

Pilot response and operations during the period July 1, 1978 to December 1, 1979 are discussed in detail in this Third Progress Report. The performance of the displacement steam generator, sulfur dioxide scrubbing system and results of drilling four thermal observation wells during this period are reported. Production and heat response of individual pilot producers is discussed and operating economics to date are presented. Also presented are the results of a new computer simulation study which indicate the cause of the high water/oil ratios observed in the pilot. The future operating strategies for the pilot, based on the results of the computer study and analysis of field data are outlined.

III. PROJECT PROGRESS

Operations

Initial pilot response to continuous steam injection was adversely affected by repeated failures of thermal packers in the steam injection wells. After over two months of difficulties, thermal packers were removed from three of the injectors. A packer was maintained in Williams Holding 935 to protect cement-squeezed perforations in the casing, which were made necessary by problems encountered during the primary cementing operations. Sand control was lost in the four injection wells and two of the producers in late 1977. This required shutting down the steam generator twice for long periods while these wells were recompleted with new liners and gravel packs. A revised completion technique using a thicker gravel pack was used for the injectors which eliminated the sand control problems. This technique is described in detail in the Second Annual Report - Williams Holding Lease Steamflood Demonstration Project.⁴ Additionally, a protective tubing string was cemented in place in Williams Holding 935.

By March, 1978, the packer and liner failure problems were solved and continuous steam injection was again established. Cyclic steam stimulations of the pilot producers, excluding WH 205 and WH/RF 204, were performed from May through July, 1978 to promote uniform heat advance in the pilot area. The two excluded producers were showing significant heat and fluid responses and did not require steam stimulation. Table 1 presents a summary of steam stimulations performed on pilot wells.

From mid-June, 1978 through January, 1979, WH/RF 204 was idled in an attempt to divert steam towards nearby pilot producers WH 25 and WH 35. By October, 1978 WH 25 was showing an increasing temperature response to the displacement phase and a higher fluid production rate. WH/RF 204 was placed back on production during February and March, 1979 when injection well WH 825 was shut in to test for communication with surrounding producers, WH 25, WH 35, WH 205 and WH/RF 204. Indication of communications was evident in WH 25 and WH/RF 204 and was characterized by a drop in

TABLE 1 - CYCLIC STEAM STIMULATION SUMMARY

Well	Injection Dates		Barrels Injected	Average Steam Quality (%)	Average Temp. (°F)	Average Pres. (psig)	Cycle Oil Produced* (Bbls)
	Start	Finish					
WH 25**	12-03-76	12-17-76	10,982	66	530	1,060	5,487
	10-19-77	10-28-77	7,168	74	533	1,075	4,836
	6-06-78	6-13-78	6,055	74	565	1,030	3,560
WH 26**	12-29-76	1-09-77	10,089	91	555	1,407	8,147
	12-02-77	12-10-77	6,532	63	562	1,456	3,239
	5-08-78	5-15-78	6,080	75	600	1,290	4,136
WH 35	2-06-77	2-19-77	10,925	83	565	1,455	5,352
	11-26-77	12-02-77	6,470	75	550	1,400	8,391
	7-04-78	7-11-78	6,208	74	590	1,275	7,021
	4-02-79	4-09-79	6,117	53	525	900	4,370
WH 36	1-26-77	2-06-77	10,201	87	550	1,395	1,377
	10-12-77	10-19-77	5,905	59	503	1,034	1,104
	6-14-78	6-20-78	6,203	72	610	1,490	7,609
	3-22-79	3-30-79	6,498	67	610	1,280	2,688
WH 105	1-09-77	1-26-77	10,567	79	570	1,440	5,724
	11-09-77	11-15-77	6,107	77	545	1,353	3,331
	5-15-78	5-26-78	10,040	78	600	1,320	5,379
	4-01-79	4-10-79	10,010	80	610	1,380	2,429
WH 205**	3-31-77	4-13-77	10,650	75	550	1,330	24,919
WH 206	12-17-76	12-23-76	10,336	88	560	1,430	5,983
	10-27-77	11-03-77	6,056	74	583	1,590	3,145
	4-28-78	5-03-78	10,029	68	595	1,295	7,155
	3-04-79	3-13-79	9,840	80	645	1,390	4,625
WH 305	2-22-77	3-07-77	10,707	84	550	1,345	1,966
	11-03-77	11-09-77	6,556	76	550	1,400	6,678
	5-28-78	6-03-78	6,105	75	600	1,310	9,330
	3-22-79	4-02-79	4,984	43	555	1,170	3,839
WH/RF 204**	4-13-77	4-24-77	10,012	80	560	1,355	12,078

* Cycle oil produced is given as oil produced during the cycle immediately following the steam stimulation. The number of barrels given for the last cycle of each well is the oil produced from the steam stimulation date to December 1, 1979.

** WH 205 and WH/RF 204 were showing good temperature response and high fluid levels in November, 1977 and therefore were not steamed. WH 25, 26, 205 and WH/RF 204 were showing good temperature response and high fluid levels in March, 1979 and therefore were not steamed.

fluid production and heat response.

In March and April, 1979 five of the nine producers were cyclicly steam stimulated. WH 25, WH 26, WH 205 and WH/RF 204 were not stimulated since all were showing steam displacement response. Instead, these four producers were idled in early April, 1979 in hopes of diverting steam to the remaining pilot producers.

To investigate fluid movement and sweep efficiency of the pilot, as of June, 1979, Williams Holding Thermal Observation Well 1 (TO 1) was drilled and cored between central producer WH 205 and northernmost injector WH 825. The results obtained from TO 1 are discussed in detail in the section, Thermal Observation Wells.

WH/RF 204 was placed back on production for a 2-week period in June, 1979 to determine the severity of a sanding problem noted during the WH 825 communication test. The well was re-idled after the test and is scheduled to have its liner and gravel pack replaced before being returned to production in early December, 1979.

Sand control in WH 105 was lost in September, 1979 and the well remained idle until mid-November, 1979. During its recompletion in November an additional 15 feet of Sl-B sand was opened for production in hopes of encouraging future steam breakthrough. The Well Workovers section discusses this further.

During the first half of October, 1979 three additional thermal observation wells, TO 2, TO 3, and TO 4, were drilled between central producer WH 205, and the three other injection wells (see Figure 3 for well locations). The information obtained from these wells is discussed in detail in the section, Thermal Observation Wells.

Sand control was also lost in WH 206 in October, 1979 and the well was idled, awaiting replacement of its liner and gravel pack. This work is scheduled for mid-December, 1979.

Following completion of the thermal observation wells, continuous steam injection was again established in early November, 1979. On November 19, 1979 the 50MM BTU/Hr. steam generator

was idled and replaced by the 22MM BTU/Hr. steam generator with stack gas scrubber. This was made necessary when the design injection rate was lowered to below the minimum rate of the 50MM BTU/Hr. steam generator.

All four idle producers (WH 25, 26, 204, 205) will be returned to production by mid-December, 1979, thus bringing the pilot back to full operation.

Steam Generator Operations

The operation of the 50MM BTU/Hr. displacement steam generator has been straightforward and uncomplicated by major problems. Table 2 summarizes the steam generator performance for the period July 1, 1978 through November 19, 1979. Steam generator performance from the beginning of steam displacement through June 30, 1978 is available in the Second Annual Report - Williams Holding Lease Steamflood Demonstration Project.⁵

Figure 4 shows the steam generator performance since initiation of steam displacement. The generator was down the entire month of September, 1977 waiting on completion of well work for WH 935. From mid-December, 1977 through February, 1978 liners and gravel packs in WH 205 and WH 36 were replaced and three injectors WH 825, WH 826 and WH 925 were recompleted.

A dramatic improvement in steam quality was achieved in late 1977 when the use of thermal packers was discontinued. Starting in October, 1977 the steam generator did not need to be shut down every few days to replace a thermal packer. Consequently, steam generator operations improved significantly.

The design injection rate was lowered to 1600 BSPD in January, 1979 when one injection well was shut in to test for communication with the surrounding producers. The total injection rate remained at 1600 BSPD after the well was returned to injection on March 16, 1979, because four of the nine producers were shut in due to high fluid levels that could not be pumped off. During the period of May 9, 1979 through June 19, 1979, the generator

Figure 4
DISPLACEMENT STEAM GENERATOR PERFORMANCE
WILLIAMS HOLDING STEAMFLOOD PILOT

TABLE 2

PERFORMANCE SUMMARY OF THE
DISPLACEMENT STEAM GENERATOR **

Periods (Dates)	Average Injection Rate (ESPD) *	Average Steam Quality (%)	Average Discharge Temp. (°F)	Average Discharge Pressure (psig)	Average Wellhead Pressure (psig)
July 1-31, 1978	2,016	75	650	2,120	1,060
August 1-31	1,822	82	655	1,980	1,050
Sept. 1-30	2,077	70	660	2,150	1,000
Oct. 1-31	1,596	77	650	2,030	930
Nov. 1-30	1,910	73	645	2,020	920
Dec. 1-31	2,042	78	650	2,100	890
Jan. 1-31, 1979	1,972	78	640	2,030	860
Feb. 1-28	1,433	71	640	1,950	790
March 1-31	1,561	72	630	1,770	780
April 1-30	1,425	73	615	1,600	780
May 1-8	1,601	73	620	1,615	840
May 9 - June 19	-	-	-	-	-
June 19-30	1,760	78	630	1,870	850
July 1-31	1,256	77	645	1,800	920
August 1-10	1,670	74	615	1,890	940
August 11-31	-	-	-	-	-
Sept. 1-11	1,335	75	635	1,890	930
Sept. 12- Oct. 31	-	-	-	-	-
Nov. 1-30, 1979	1,353	76	615	1,760	813

* BSPD = equivalent barrels of water as steam per day

** 22MM BTU/Hr steam generator substituted for 50MM BTU/Hr steam generator
on November 19, 1979

was down while a temperature survey was being run in WH 205 and while TO 1 was being drilled, cored and surveyed. A fuel shortage in mid-August, 1979 caused the steam generator to be shut down for the remainder of that month. During the period of September 12, 1979 to November 3, 1979 the generator was down while TO 2, TO 3 and TO 4 were drilled.

In late October, 1979, 1200 feet of 2 inch schedule 80 injection line was run from the discharge of the 22MM BTU/Hr. steam generator to the displacement header. The pipe was buried in a 3 foot trench and surrounded by 6 inches of vermiculite insulation to reduce heat losses. On November 19, 1979, the 50MM BTU/Hr. steam generator was idled and replaced by the 22MM BTU/Hr. generator with stack gas scrubber. The 22MM BTU/Hr. steam generator was substituted because of the reduced (1200 BSPD) design rate as discussed in the section, PERFORMANCE ANALYSIS. Also, since the 22MM BTU/Hr. steam generator is capable of burning lower priced crude oil, both the economics and experience to be gained from using the SO₂ scrubber justified using it for displacement.

Since the installation of critical flow chokes in the four steam injection wells in April, 1978, WH 925 and WH 935 have in critical flow about 85% of the time, while WH 826 has been in critical flow approximately 60% of the time. Maintenance of critical flow allows for proper monitoring of the steam mass flow rates into each injector.

Sulfur Dioxide Removal

Getty Oil Company is testing a stack gas scrubber for the removal of sulfur dioxide from emissions resulting from burning high sulfur (4.5%) crude oil as steam generator fuel in a 22MM BTU/Hr. generator. The original scrubber design was a disc-and-doughnut type with three sets of gas-liquid contact surfaces, using a soda ash (sodium carbonate, Na₂CO₃) solution as the reactant.

Testing of the initial scrubber design was significantly delayed due to the unsuitability of some components. During the

first firing of the steam generator-flue gas scrubbing system, the demister pad was blown out the top of the scrubbing vessel, which required that a new demister pad be ordered and installed. Testing was then further delayed by heavy rain damage to the scrubber site in February and March, 1978.

In April, 1978, the generator was test fired again. The replacement demister pad plugged in 1-1/2 hours with fly-ash and sulfate, and was subsequently replaced with a multiple chevron mist eliminator. The generator was fired again in July, 1978, and a cyclic steam stimulation was performed on a non-pilot thermal well. Preliminary sulfur dioxide removal tests showed that the chemical efficiency of the soda ash-SO₂ reaction was not as great as predicted for the desired pH range of 6.7-7.0. A pH of approximately 9 was necessary to achieve the required 89% of SO₂ removal efficiency. Such a high pH would cause a scaling problem. To avoid this, the soda ash was replaced with caustic soda (sodium hydroxide, NaOH) solution. The caustic solution proved to be no more efficient than the soda ash. This dictated a major redesign of the scrubbers to improve gas-liquid contact. The disc-and-doughnut cascade contactor was replaced with a fluted media contact surface. A schematic of the revised scrubbing system is shown in Figure 5.

In March, 1979 a series of certification tests were performed for the EPA and Santa Barbara County Air Pollution Control District. The revised internal design of the scrubber vessel greatly improved the efficiency of the system and it was able to meet the emissions limits while operating in the desired pH range of 6.8-7.0 using caustic soda. Table 3 summarizes the results of the emissions testing.

The primary pollutant to be controlled is sulfur dioxide. Burning lease crude, which has a 4.5% sulfur content, the raw flue gas contained between 49 and 80 lbs/hr. of sulfur dioxide, depending on firing rate. The emissions from the scrubber outlet ranged for 1.2 to 10.3 lbs./hr compared to the permit limit of 11.0 lbs/hr. These results are equivalent to 83-97% reductions in emissions. The 97% reduction in SO₂ was achieved on a single test in which the pH of the scrubbing liquor was purposely

Figure 5

SCHEMATIC OF SULFUR DIOXIDE REMOVAL SYSTEM

TABLE 3

SCRUBBER PERFORMANCE

<u>Pollutant</u>	<u>Permit Limit</u>	<u>Emissions</u>		<u>Percent Reduction</u>
		<u>Scrubber Inlet</u>	<u>Scrubber Outlet</u>	
SO ₂ (lb/hr)	11.0	49.4-79.7	1.2-10.3	83-97
NO ₂ (lb/hr)	11.2	6.0-7.7	5.5-7.4	2-7
Particulates (gr/scf)	0.3	0.27-6.4	0.07-0.10	73-86

allowed to increase beyond the desired operating range. Average emission reductions were approximately 92%.

The nitrous oxides content of the raw flue gas were equivalent to emissions of 6.0-7.0 lb/hr, comfortably within the permit limit of 11.2 lb/hr. The scrubber is not intended to provide any control for this pollutant. However, a very small (2-7%) reduction was noted.

Particulates are the third pollutant regulated. The scrubber removed 73-86% of the particulates during testing. The final emissions level of 0.07-0.1 gr/scf was well within the permit limit of 0.3 gr/scf.

In August, 1979 Santa Barbara County APCD notified Getty Oil Company that no operating permits would be issued unless continuous SO₂ monitoring of the stack gases was applied. Since reliable technology for continuously monitoring SO₂ emission in an oilfield environment is not available it was negotiated, under protest, that the generator and scrubber be allowed to operate from mid-November, 1979 to mid-January, 1980. During this period the pH of the scrubbing liquor must be continuously monitored. SO₂ emissions will be continuously monitored for a selected one-week period. Following analysis of these tests, it is hoped that the Santa Barbara County APCD will concur that pH monitoring is an acceptable and reliable method of continuous monitoring for this scrubbing system.

Well Workovers

The steam injection wells were originally completed with a 3-1/2", 30-mesh wire-wrapped screen landed inside selectively perforated 7" casing. The annulus between the casing and liner was then pressure gravel packed with 10-18 gravel. In late 1977, sand control was lost in the four injectors. A revised completion technique using a thicker gravel pack and gravel containing a high percentage of quartz was instituted and the sand control problem in the injection wells was solved. This technique is described in detail in the Second Annual Report - Williams Holding Lease Steamflood Demonstration Project.⁶

All pilot producing wells were originally completed with

5-1/2" liners, pre-cut with 30-mesh or 40-mesh slots, landed in twelve or fourteen-inch open hole and flow-packed with 10-16 or 10-18 gravel. In mid-December, 1977 sand control was lost in WH 36 and WH 205. Both wells were recompleted using 25-mesh slotted liner pressure packed with 16-20 gravel which had been re-screened on a 20-mesh screen. To date, these recompletions have been effective in keeping sand under control in both wells. The recompletions of both wells are described further in the Second Annual Report - Williams Holding Lease Steamflood Demonstration Project.⁷

Loss of sand control was confirmed in WH/RF 204 during a two-week production test in June, 1979. The well was subsequently re-idled. WH/RF 204 is scheduled for replacement of the liner and gravel pack in early December, 1979, before it is returned to production.

Sand control was also lost in WH 105 in September, 1979 and in WH 206 in October, 1979. A liner and gravel pack replacement for WH 206 is scheduled for mid-December, 1979.

WH 105 was originally completed with the older open-hole flow gravel packing technique. Field wide performance has shown significant reduction of liner failures using a pressure packing technique. The original completion of WH 105 was with a 5-1/2", 40-mesh slotted liner, flow-packed with 10-16 gravel in 12" open hole. On November 19, 1979, WH 105 was recompleted with a 5", 25-mesh slotted liner, pressure-packed in 14" open hole with 16-20 gravel containing a high percentage of quartz, which had been re-screened on a 20-mesh screen. To investigate the possibility of fluid movement below the original completion interval, WH 105 was deepended 58' to a new T.D. of 2650' during the work-over. The new interval was logged but no conclusive evidence of fluid movement was observed. WH 105 was plugged back to 2608' and completed with an additional 15' of SI-B sand opened for production. The additional 15' increased the production interval in common between WH 105 and injection well WH 925. This is felt to be a positive step towards encouraging steam breakthrough into WH 105, thus helping more equally distribute the steam within the pilot.

Production

Initial pilot response to continuous steam injection was delayed by repeated thermal packer failures and sand control problems in the steam injection wells. Gross fluid production and heat response has paralleled the periods of continuous steam injection after the initial packer and sand control problems were solved.

Production performances for the total pilot area and for the confined, central producer, Williams Holding 205, are shown in Figures 6 and 7, respectively. The effect of steam displacement is shown in both figures by an increasing gross production beginning in late 1977. These effects can also be seen in the temperature response of WH 205, as shown by Figure 8. The initial temperature response occurred in November, 1977, when the flowline temperature reached 200°F. Almost immediately afterwards, in December, 1977, sand control was lost. When continuous steam injection resumed in March, 1978, flowline temperatures in WH 205 increased very rapidly before stabilizing between 320°F and 350°F in July, 1978. Temperatures remained at this level until WH 205 was shut-in in April, 1979. Production and temperature response for all of the pilot wells are shown in Appendices A and B, respectively.

Cumulative monthly steam-oil ratios for the total project and for WH 205 are shown in the Figures 9 and 10, respectively. The cumulative steam injected for the project includes the steam used for stimulating the producers as well as the displacement steam injected. Similarly, the WH 205 cumulative steam injected includes stimulation steam, while the displacement steam is prorated as one-fourth of the total pilot displacement steam injected.

Williams Holding/Recruit Fee 204 showed response to steam injection as early as October, 1977. By May, 1978 the flowline temperature exceeded 300°F and the fluid level had risen to 2,000 feet over the pump. WH/RF 204 was then idled in June, 1978 to help induce steam breakthrough to nearby producers WH 25 and WH 35.

In October, 1978, the fluid level and flowline temperature in WH 25 began to increase, indicating response to the steam

Figure 6

"WILLIAMS HOLDING" STEAM DISPLACEMENT PILOT PRODUCTION PERFORMANCE

Figure 7

WILLIAMS HOLDING 205-25 PERFORMANCE

Figure 8
WILLIAMS HOLDING 205-25 FLOWLINE TEMPERATURE GAUGES

Figure 9
TOTAL PROJECT CUMULATIVE STEAM OIL RATIO
WILLIAMS HOLDING STEAMFLOOD PILOT

Figure 10
WH 205 CUMULATIVE STEAM OIL RATIO

displacement. By January, 1979, the fluid level had increased to 1900 feet over the pump. In late January, 1979, WH/RF 204 was returned to production and nearby injector, WH 825, was shut in to determine its effect on the surrounding production wells. Flowline temperatures in WH 25 soon peaked at over 300°F, then declined sharply, as did gross fluid production and the fluid level. Similarly, gross fluid production and flowline temperatures in WH/RF 204 declined during the period injector WH 825 was shut in, indicating that WH/RF 204 was also responding to injection from WH 825. WH 825 was returned to injection in March, 1979 after completion of the test.

Response to steam injection was first evident in WH 26 in August, 1978. Flowline temperatures began rising steadily along with gross fluid production and the fluid level. By January, 1979, flowline temperature exceeded 300°F.

Unfortunately, total pilot oil production response did not match the gross production response to steam displacement. Oil production declined from 291 BOPD in August, 1978 to 106 BOPD in March, 1979. This was due to the fact that production response was seen in only four of the producing wells (WH 25, WH 26, WH 205, and WH/RF 204) and it became impossible to keep these wells pumped off. The difficulty in pumping the wells off was increased by the high fluid temperatures which cause very poor pump efficiency.

Previous studies and field experience have shown the importance of maintaining low fluid levels in the production wells of this steamflood pilot. The central producer, WH 205, and northernmost producer WH/RF 204 have both shown oil production increases with lower fluid levels.

Because artificial lift capacity in the four responding wells (WH 25, WH 26, WH 205 and WH/204) was exceeded, efforts were directed toward encouraging heat response in the remaining five producers. To achieve this, the responding producers were shut-in in April, 1979. Two benefits were anticipated if fluid and heat response could have been spread evenly to all nine producing wells. First, better steam sweep efficiency would have resulted. Second, by spreading fluid production to more wells, lower fluid

levels would have been easier to maintain.

Temperature surveys were run in the four responding producers during the month of May, 1979. Results from these surveys are presented in Appendix C. Two wells, WH 26 and WH/RF 204, showed similar temperature profiles, with peak temperatures occurring near the middle of the Sl-B Zone (above the displacement interval). However, temperature profiles in WH 25 and WH 205 showed peak temperatures near the bottom of the Sl-B Zone, within the injection interval. The results of these surveys, showing dissimilar flow paths, along with the unevenly distributed heat response and overwhelming gross production, indicated that some type of channeling was probable. This theory is further supported by recent modeling results, as is explained in the section, PERFORMANCE ANALYSIS.

Recent simulation studies indicate that the maximum production response occurs when the total production rate exceeds the injection rate. Thus, these four wells will be returned to production in early December, 1979. This is explained further in a later section, PERFORMANCE ANALYSIS.

Since shutting in the four responding producers in April, 1979, oil production in the remaining five producers has increased from 50 BOPD in April, 1979 to an average of 89 BOPD for the next four months. However, oil production dropped to a low of 47 BOPD in September, 1979 with the loss of sand control in WH 105. The well was subsequently idled until late-November when the liner and gravel pack were replaced. Oil production recovered somewhat in October, 1979 to 75 BOPD with only four pilot wells producing.

Thermal Observation Wells

Four thermal observation wells were drilled within the pilot to monitor areal and vertical response to steam displacement. Each thermal observation well was located between one of the four injectors and the central producer, WH 205 (see Figure 3). Thermal observation Well 1 (TO 1) was drilled and completed in June, 1979. Wells TO 2, TO 3, and TO 4 were drilled and completed in October, 1979. Drilling histories, logs, and core data are provided in

Appendix D.

TO 1 was cored throughout the producing interval and showed near-virgin oil saturations of 60-65%. Logs run before completing the well show good agreement with the core data. Temperature surveys run in June, July, and October, 1979 indicated very little response to steam injection in this area of the reservoir (see Appendix E for temperature profiles). A maximum temperature of 133°F was recorded in the July survey. Subsequent cooling shown in the October survey can be explained by extended downtimes of the generator prior to that survey.

Sidewall samples from TO 2 showed oil saturations of less than 30%, compared to normal virgin oil saturations of 60 to 65%. This reduction, confirmed by log analysis, was more evident in the upper portion of the producing interval. A temperature survey run in October, 1979 showed good response to steam injection with temperatures in excess of 300°F. The maximum temperature was observed in the area of greatest oil saturation reduction. The reduced oil saturations may be explained by the high temperatures having lowered the viscosity of the crude sufficiently to cause wellbore flushing during drilling operations. However, it is believed that steam sweep in the area is the primary cause of the reduced oil saturations.

Sidewall samples of TO 3 showed oil saturations of less than 40% within the producing interval. Log analysis showed a somewhat smaller reduction, concentrated in the upper portion of the zone. A temperature survey run in October, 1979 confirmed good heat response with temperatures of 300°F near the area of greatest oil saturation reduction. Again, the high temperatures may have caused a greater wellbore flushing during drilling operations, but steam sweep is believed to be the primary cause of the reduced oil saturations.

Sidewall samples from TO 4 showed oil saturations of less than 45%. Log analysis, however, indicated little reduction from virgin oil saturations except in the upper portion of the producing interval. The reduced oil saturations seen in the sidewall cores may have been due to wellbore flushing during drilling operations.

A temperature survey run in October, 1979 showed only moderate heat response with temperatures reaching 173°F near the area of greatest oil saturation reduction. Results of all temperature surveys run in the Thermal Observation wells are given in Appendix E.

IV. PROJECT ECONOMICS

Operating costs per barrel of oil produced have been very high. Initially, high operating costs were a result of repeated thermal packer failures and the loss of sand control in six wells due to liner failures. More recently however, the project economics have been adversely affected by declining oil production and inflation. In particular, the cost of low sulfur fuel oil burned in the steam generator has risen sharply from an initial cost of \$14.31/bbl. to a cost of \$31.08/bbl. in November, 1979.

Table 4 itemizes the operating costs of the pilot from the effective date of the contract to December 1, 1979. The costs are given in terms of dollars per barrel of oil produced. Total operating costs to date are \$13.93/bbl. Of this amount, \$1.28/bbl. was due to major well workovers caused by the six liner failures in late 1977 and early 1978. Cost figures for the three liner replacements in November and December, 1979 are not yet available.

In future steamflood operations, improved well completion techniques should reduce the high workover costs encountered in this pilot. It is anticipated that future oil production will increase, particularly when all producing wells are returned to production. This should help lower the operating costs per barrel of oil produced. In addition, project economics will improve with higher crude oil prices. The price received for Cat Canyon 13°API blended crude (includes diluent) has increased from \$8.68/bbl. in April, 1977 to \$15.33/bbl. in November, 1979.* Finally, the conversion to Cat Canyon crude as the generator fuel (replacing more expensive low sulfur fuel oil that has been burned) should substantially lower displacement fuel costs.

*Crude oil prices for 13°API Cat Canyon blended crude increased sharply to \$22/bbl. as of December 21, 1979. However, the "Windfall Profits" excise tax will lower the effective price to about \$20/bbl.

TABLE 4

WILLIAMS HOLDING STEAMFLOOD PILOT
SUMMARY OF ACTUAL OPERATING COSTS TO DATE
(\$/BBL OIL PRODUCED)
Period: June 25, 1976 to December 1, 1979

<u>Item</u>	<u>Cost</u>
Displacement Generator (excluding fuel)	\$ 1.28
Displacement Fuel	5.51
Contract Services	2.49
Company Services	0.71
Materials and Supplies	1.17
Utilities	0.46
Central Plants	0.50
Cyclic Stimulation	0.82
Engineering and Supervision	0.45
Computer and Deliverables	0.08
General and Administrative	0.46
Total Operating Costs	<u>\$13.93</u>
Major Well Workovers ¹	<u>(1.28)</u>
Operating Costs Excluding Major Well Workovers	\$12.65

1

The major well workover costs only include the liner replacements that were required on WH 205, WH 36, and the four pilot steam injection wells.

V. PERFORMANCE ANALYSIS

Introduction

The results of the Computer Simulation study reported in the Second Annual Report⁸ were based on history matching the stimulation history of Williams Holding 205-25, the central producer of the pilot. This study did a good job of modeling near-wellbore conditions around WH 205 but proved to be inadequate in describing the reservoir conditions that existed between WH 205 and the surrounding injectors. This possibility was recognized at the time of this study. Since that time, sufficient steam displacement data has become available to permit an attempt to obtain a good displacement history match. Also, improved laboratory techniques resulted in the availability of better relative permeability data. The poor production performance of the steamflood pilot necessitated a project review. Consequently, a new computer simulation study was undertaken which history matched both the stimulation and displacement production history of WH 205. Based on this history match and additional simulation runs, modifications have been made in the operation of the pilot and a new performance projection made.

The first phase of the study consisted of matching the stimulation response of WH 205. Unlike the previous study, the rectilinear gridblock configuration of the model was used to achieve a reasonable history match of oil and water production. This was economically feasible due to the fact that enough previous work had been done to allow an easy history match to be achieved.

The second phase of the study consisted of matching the displacement history of WH 205. This was the most difficult phase of this study. Many modifications to the reservoir model were made in an attempt to match the high water cut history of WH 205. The results are detailed later in this section.

The third phase of the study was the performance projection of various operating conditions. The main objective at this phase of the study was to determine what changes in the operation of the steamflood pilot were necessary to reverse the poor per-

formance seen to date. These results are also detailed later in this section.

Williams Holding 205 Cyclic Steam Stimulation History Match

Williams Holding 205 was completed on February 5, 1975. Before the steam displacement phase of this project began in April, 1977, WH 205 was steam stimulated for two cycles. The first steam stimulation was performed in May, 1975. The well was stimulated with 5,898 barrels of water converted to 69% quality steam with an average temperature of 538°F and an average injection pressure of 1380 psig. The cycle lasted 13-1/2 months during which 11.0M barrels of oil and 14.3M barrels of water were produced. The second steam stimulation was performed from July 8, 1976 to July 19, 1976. During this time, the well was simulated with 11,335 barrels of water converted to 67% quality steam with an average temperature of 574°F and an average injection pressure of 1470 psig. The second cycle lasted for 9-1/2 months during which the well produced 12.7M barrels of oil and 22.6M barrels of water. A third steam stimulation was done in April, 1977, just prior to the beginning of steam displacement. However, this stimulation was included in the displacement phase of the study since the production from this cycle could not be separated from the effects of steam displacement.

Figure 11 compares the actual production for oil and gross fluid to the simulator history match, including the displacement phase which will be discussed later. Reservoir data used to obtain the match are given in Appendix F. These data were taken from WH 205 logs, core analysis, and oil viscosity measurements. Other data and correlations used are also indicated in Appendix F. It should be noted that different high temperature relative permeability data were used in this study than in previous studies. The new data were measured by Getty Oil Company's Exploration and Production Research Center⁹ using improved equipment and experimental techniques. A lower initial oil saturation was used in this study (52.2% vs. 65% in the previous

Figure 11. HISTORY MATCHING OF WH 205-25

study) in order to match one of the measured relative permeability curves. This lower oil saturation will have some effect on the ultimate recovery predictions but does not affect the basic conclusions of the study.

This computer simulation study was conducted using thermal simulation model jointly developed by Getty Oil Company and Intercomp Resource Development and Engineering, Inc. The Thermal Model is a three-dimensional non-isothermal reservoir simulator that calculates flow behavior of steam and hot water injection processes. This model is described in greater detail in the Second Annual Report¹⁰. Symmetry conditions in the five-spot pilot pattern allowed simulation of only 1/8th of a five-spot as shown in Figure 12.

Displacement Phase History Match

Once the cyclic stimulation history match was achieved for WH 205, displacement steam injection was simulated with the computer model. History matching this phase of the steamflood pilot operations was difficult due to the pilot's high producing water/oil ratios. One theory proposed for the exceedingly high water/oil ratios was that an underlying water sand discovered during the drilling of TO-1 could serve as a channel for steam flow and thus cause the high water/oil ratio.

To test this theory, a 5-layered model, shown in Figure 13(a), was used for simulation. A 12 foot thick water sand was modeled to lie 20 feet below the completion interval of the oil sand. The permeability of this water sand was one-half that of the oil sand. The extent to which the water sand can affect the performance of the steamflood depends on the communicability between the water sand and the oil sand. A modeling factor called FTZ is used to indicate this communicability. The water sand is fully communicable with the oil sand if $FTZ = 1$. The water sand is only slightly communicable with the oil sand if this factor is very low. This latter case can be interpreted as the existence of a flow barrier between the bottom water sand and the oil sand above it.

Figure 14 shows the effect of the water sand on the reservoir performance during the first two stimulation cycles. In Figure

Figure 12

PLAN VIEW OF CARTESIAN CONFIGURATION FOR SIMULATION OF 1/8 5-SPOT PATTERN

Figure 13. 5-LAYER AND 3-LAYER MODELS.

(a) 5-Layer Model

(b) 3-Layer Model

14(a), an FTZ factor of one is used and the water sand is assumed to be fully communicable with the oil sand. In the Fall of 1975, the simulated gross fluid and oil rates were 125 and 4 BPD, respectively. The simulated water/oil ratio was therefore 30. This means that the water/oil ratio would be very high at the outset if the water sand were fully communicable with the oil sand. This high water/oil ratio was not borne out by the field data since the actual water/oil ratio was only 2.5 in the Fall of 1975. In Figure 14(b) an FTZ factor of 0.0002 is assumed, indicating that the water sand is only slightly communicable with the oil sand. An excellent match was obtained for the oil rate whereas the simulated gross fluid rate was somewhat higher than that of the field data in the first stimulation cycle. One can conclude, then, that the water sand, although existing, is not significantly communicable with the oil sand and will not affect the reservoir performance during steam stimulation or steamflood. One simulation run was carried through the steamflood phase of the pilot performance using the 5-layer model with a communicating water sand. The history match was as poor during the steamflood phase as during the first two stimulation cycles given in Figure 14.

A 3-layer model, shown in Figure 13(b), was therefore used in all subsequent simulations. In this model, the water sand was not included. Furthermore, the 20 foot thick layer of oil sand underneath the completion interval was also ignored. This was justified by the excellent history match of the stimulation performance in the first two cycles which was attainable only by using three layers (Figure 11). The inclusion of a fourth layer for the oil sand was thus deemed unnecessary. This 3-layer model was used in all subsequent simulations.

After determining that a bottom water sand was not the cause of the high water/oil ratios, the following factors were studied to determine their effects on steamflood performance:

1. Top water sand
2. Areas external to the pilot
3. 8 degree dip
4. Rock compressibility
5. Permeability variation

Figure 14. EFFECT OF WATER SAND-HISTORY MATCHING.

(a) Water Sand Fully Communicable

(b) Water Sand Slightly Communicable

FTZ = 1.0 Between
Water Sand and
Oil Sand

FTZ = 0.0002 Between
Water Sand and
Oil Sand

6. Water-oil relative permeability
7. Oil viscosity
8. Steam quality
9. Unequal split of the liquid portion in quality steam
10. Fluid level over the pump
11. Pump capacity
12. Number of layers representing the reservoir

The top water sand was ruled out because of the same reason as the bottom water sand. Some of the other factors enumerated above showed some effect on the water/oil ratio. None, however, gave a water/oil ratio as high as the 100/1 ratio experienced in the pilot.

After a series of unfruitful attempts, an excellent history match of both the stimulation and displacement performance of WH 205 was finally reached, as shown in Figure 11. In the simulated results, the gross fluid rate was 1330 BPD and the oil rate was 16 BPD at the end of 1978. This means that the water/oil ratio was 82 to 1, close to the field results. To achieve this exceedingly high water/oil ratio, the following assumptions were made for the period starting February 5, 1978:

1. A channel exists which directly connects the injector and the producer.
2. Over-injection. The gross fluid/steam ratio is less than unity for WH 205.
3. The steam quality at the sand face is equal to or close to zero.

The channeling between the injector and the producer was simulated by using the model shown in Figure 15. This triangular area represents 1/8 of a 5-spot pattern. The shaded strip shows the region where the channeling is assumed to occur. To signify the extent of channeling, a multiplying factor called FTX is applied to the normal value of x-direction transmissibility in the shaded area, in the lower 1/3 of the completion interval of the oil sand. When the factor FTX is one, the transmissibility assumes its normal value. This means no channeling. However, if FTX is greater than one, channeling does occur to the extent specified by the value of FTX.

Figure 15. SIMULATION FOR CHANNELING

Region where the x-direction transmissibility is FTX times the normal value in the lower third of the completion interval of the oil sand.

If channeling did not occur, then WH 205 would receive $1/4$ of the injected steam from each of the four injectors. This means that the total amount of steam received by the pattern surrounding WH 205 would be exactly the amount of steam injected into one injector. If channeling did occur, then the amount of steam coming toward WH 205, originating from some injectors, would be much more than $1/4$ of the steam injected into these injectors. Thus, the total amount of steam coming into the pattern surrounding WH 205 could be much more than the steam injected into one of the injectors. This uneven distribution of steam within the reservoir is the main cause for over-injection seen by WH 205. It is the amount of steam actually coming into the WH 205 pattern which is used in defining the gross fluid/steam ratio used in this study.

It has been asserted that three factors (channeling, over-injection and low quality) are essential for history matching the performance of WH 205 after February 5, 1978. It remains to be shown that it is not these three individual factors per se but the concomitance of these factors which lead to the high water-cut production in the Cat Canyon Field Steamflood Pilot. In the following paragraph, the effect of each of the three factors on steamflood performance will be presented by varying one factor at a time while leaving the other two factors constant.

Figure 16(a) is a reproduction of the part of Figure 11 after February 5, 1978. Here, an FTX equal to 100 was assumed. This means that channeling exists to such a great extent that the transmissibility within the "channel" portion of the reservoir model is 100 times its normal value. The excellent match between the simulated results and field data is obvious. In Figure 16(c), an FTX of one was assumed indicating no channeling. Although the simulated gross fluid rate matched the field data, the simulated oil rate differed from the field data to a great extent. The most striking difference is that the peak in oil production occurred about six months later than the actual data. Figure 16(b) presents an intermediate case where FTX equals ten. In this case, the peak in oil production occurs about three months later than the field data although an excellent match in oil rate is achieved

Figure 16. EFFECT OF CHANNELING - HISTORY MATCHING.

(Over-injection and zero quality are assumed for all 3 cases.)

later. A comparison of these three sets of curves leads to the inevitable conclusion that channeling is occurring, between the injectors and the producer. This is not an unexpected conclusion. However, the ability to mathematically model this phenomenon allows analysis of the significance of variations in controllable operating parameters.

Figure 17(a) again reproduces the right part of the history matching shown in Figure 11. Here, a variable rate of steam injection is assumed. During the whole period between February 1978 and March 1979, the gross fluid/steam ratio remains under unity. In Figure 17(b), a constant injection rate of 1200 BPD is assumed. This is lower than any of the rates specified in Figure 17(a). The gross fluid-steam ratio crosses the threshold of one in October, 1978. About the same time, the simulated oil rate starts to rise so that the exceedingly high water/oil ratio experienced in the pilot is not achieved. In Figure 17(c), the assumed steam rate is further reduced to 800 BPD. The gross fluid/steam ratio crosses the threshold of one much earlier, in May, 1978. Concurrently, the simulated oil rate rises and peaks at more than 300 barrels a day in January, 1979. This, of course, was not experienced in the field. Figures 17(a)-(c) show that the exceedingly high water/oil ratio cannot be simulated if the gross fluid/steam ratio crosses the threshold of unity, even with the existence of channeling and with the use of low-quality steam. This shows the remedial action to be taken to improve the oil recovery and reduce the water/oil ratio. That is, the gross fluid/steam ratio seen by an individual well should be maintained above unity at all times.

Figure 18(a) again is a reproduction of the right part of Figure 11. Here zero-quality steam at the sand face is assumed. In Figure 18(b), the assumed quality is increased to 10%. The simulated oil rate increases after the end of November, 1978. However, the simulated oil rate has a good match with the field data as far as it goes. In Figure 18(c), the quality is further increased to 30%. The simulated oil rate starts to increase at the end of August, 1978 and later deviates considerably from the field data. This figure shows that the steam quality at the

Figure 17. EFFECT OF STEAM INJECTION RATE - HISTORY MATCHING.

(Channeling and zero quality are assumed for all 3 cases.)

(a) Variable Rate, (b) 1200 BPD
 BPD (Mo) =
 1328(5) 1248(2)
 1360(3) 1600(3)

(c) 800 BPD

Figure 18. EFFECT OF STEAM QUALITY - HISTORY MATCHING
(Channeling and over-injection are assumed for all 3 cases.)

sand face has probably been equal or close to zero because, otherwise, the exceedingly high water/oil ratio experienced in the pilot would not be reproduced.

The above results indicate strongly that the high water/oil ratio production of the Williams Holding Steamflood Pilot has been caused by the concomitance of the three factors, namely, channeling, over-injection and low-quality steam.

Pilot Performance Projection

It has been concluded from history matching the performance of WH 205 that the high water/oil ratio was caused by concomitance of channeling, over-injection and low-quality steam. This means that the oil rate would increase and the water/oil ratio would decrease if one or more of these three conditions were not present. It is impossible to eliminate the channeling if channels already exist in the reservoir. However, it is possible to eliminate over-injection and improve the steam quality. In addition, it is conceivably possible to block the channel at the wellbore of the producer if the channel could be pinpointed.

Performance predictions have been made to indicate the effect of steam injection rate, steam quality and the blocking of the channels at the producer. In these runs, it is assumed that, after the conclusion of the history-matching period, a period of three months elapsed during which there was neither injection nor production. Injection and production resumed after this three-month hiatus. The two-year time period shown on these curves will approximately correspond with the 1980-81 calendar years.

To produce the exceedingly high water/oil ratio, it was found to be essential to keep the ratio of gross fluid production to steam injection less than unity. Conversely, keeping the gross fluid/steam ratio above unity increases the model projection of oil rate and reduces the water/oil ratio. In Figure 19(a), a constant effective injection rate of 800 BPD is assumed. The gross fluid/steam ratio is maintained around 1.7 for about fifteen months. After that, the gross fluid rate decreases because of

Figure 19. EFFECT OF STEAM INJECTION RATE - PERFORMANCE PREDICTIONS.

declining pressure. Since the gross fluid/steam ratio is constantly maintained above unity the oil rate increases after re-starting the injection and production. The rate increases to above 100 BOPD after about three months. When the projected oil rate peaks at about 280 BOPD, the water/oil ratio is only four. Figure 19(b) shows a case where the effective injection rate is further reduced to 400 BPD. The gross fluid/steam ratio is as high as 3.4 for a period of about six months, after which this ratio declines to around one, again because of the depletion of reservoir pressure. The projected oil rate is seen to rise above 100 BOPD around the end of the second month. The peak oil rate reaches 480 BOPD. At this time, the water/oil ratio is around 1.9. These two figures indicate the importance of maintaining the gross fluid/steam ratio above unity. It should be reiterated that the so-called steam injection rate used here is the rate of steam coming into the pattern surrounding WH 205, not the rate of steam entering any one of the injectors.

In Figure 20, the case for a steam quality of zero is the same as in Figure 19(a). A second case is shown in Figure 20 in which the assumed steam quality is 30%. A comparison of these two cases shows that an increase in steam quality would improve the oil production to some extent.

In Figure 21, the base case where the channel at the producer is not blocked is the same as that given in Figure 19(a). In comparison, another case was included in which the channel at the producer was blocked. This Figure indicates that, even if the channel at the producer could be located and blocked, the blocking would have only slight effect on the oil production.

Figure 20. EFFECT OF STEAM QUALITY - PERFORMANCE PREDICTIONS.

21. EFFECT OF BLOCKING OF CHANNEL AT PRODUCER - PERFORMANCE PREDICTIONS.

VI. FUTURE OPERATIONS

The Williams Holding Steamflood has experienced extremely high producing water/oil ratios but reservoir simulation studies have shown methods which should alleviate this problem. Future steam injection rates will be kept low enough to guarantee that the gross fluid production/steam injection ratio is kept above unity. Efforts will be made to produce the wells in the pilot at the maximum possible rate, which will also keep the production/injection ratio high. Studies will also be made to determine economical methods of improving steam quality.

It is anticipated that production response will be first seen in about three months and that peak production response should occur in about one year. If necessary, additional computer simulation runs will be conducted to determine the effects of possible alternate operating strategies which may be considered as the project progresses.

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APPENDIX A
PRODUCTION PERFORMANCE
WILLIAMS HOLDING STEAMFLOOD PILOT
AND INDIVIDUAL WELLS

Figure A-1

"WILLIAMS HOLDING" STEAM DISPLACEMENT PILOT PRODUCTION PERFORMANCE

Figure A-2

"WILLIAMS HOLDING" 25-25 PERFORMANCE

Figure A-3

"WILLIAMS HOLDING" 26-25 PERFORMANCE

Figure A-4

"WILLIAMS HOLDING" 35-25 PERFORMANCE

Figure A-5

"WILLIAMS HOLDING" 36-25 PERFORMANCE

Figure A-6

"WILLIAMS HOLDING" 105-25 PERFORMANCE

Figure A-7

WILLIAMS HOLDING 205-25 PERFORMANCE

Figure A-8

"WILLIAMS HOLDING" 206-25 PERFORMANCE

Figure A-9

"WILLIAMS HOLDING" 305-25 PERFORMANCE

Figure A-10

"WILLIAMS HOLDING/RECRUIT FEE" 204-25 PERFORMANCE

APPENDIX B

FLOWLINE TEMPERATURE GAUGES
WILLIAMS HOLDING STEAMFLOOD PILOT
INDIVIDUAL WELLS

Figure B-1
 WILLIAMS HOLDING 25-25 FLOWLINE TEMPERATURE GAUGES

Figure B-2
 WILLIAMS HOLDING 26-25 FLOWLINE TEMPERATURE GAUGES

Figure B-3
WILLIAMS HOLDING 35-25 FLOWLINE TEMPERATURE GAUGES

Figure B-4

WILLIAMS HOLDING 36-25 FLOWLINE TEMPERATURE GAUGES

Figure B-5

WILLIAMS HOLDING 105-25 FLOWLINE TEMPERATURE GAUGES

Figure B-6
 WILLIAMS HOLDING 205-25 FLOWLINE TEMPERATURE GAUGES

Figure B-7
WILLIAMS HOLDING 206-25 FLOWLINE TEMPERATURE GAUGES

Figure B-8

WILLIAMS HOLDING 305-25 FLOWLINE TEMPERATURE GAUGES

Figure B-9

**WILLIAMS HOLDING/RECRUIT FEE 204-25
FLOWLINE TEMPERATURE GAUGES**

APPENDIX C
TEMPERATURE PROFILES
WILLIAMS HOLDING STEAMFLOOD PILOT
INDIVIDUAL WELLS

Figure C-1

WH 25
TEMPERATURE PROFILE
MAY 14, 1979

Figure C-2

WH 26
TEMPERATURE PROFILE
MAY 31, 1979

Figure C-3

WH 205 TEMPERATURE PROFILES

Figure C-4

WH / RF 204
TEMPERATURE PROFILE
MAY 31, 1979

APPENDIX D
DRILLING HISTORIES, LOGS
AND CORE DATA FOR THERMAL
OBSERVATION WELLS

WILLIAMS HOLDING THERMAL OBSERVATION WELL #1

DRILLING HISTORY

WH TO 1-25 was spudded on May 30, 1979. A 9-7/8" hole was directionally drilled to 2565'. The Sl-B Zone was cored from 2564-2742' (178') using conventional coring equipment and water based mud. A 9-7/8" hole was then drilled from 2742-2800' (T.D.). On June 6, a dual induction-SFL log, compensated neutron-formation density log, and computer processed log were run. Seven inch casing was then run and cemented at 2800'. The casing was stressed with 280,000# for 27" of elongation. The float and cement were drilled out to 2790' and the rig released on June 7, 1979.

FIGURE D-1

TO 1 DUAL INDUCTION-SFL LOG

FIGURE D-2
TO 1 COMPENSATED NEUTRON-FORMATION
DENSITY LOG

TO 1 COMPUTER PROCESSED LOG

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PAGE 1

GETTY OIL COMPANY
"WILLIAMS HOLDING" #T0-1-25
CAT CANYON
SANTA BARBARA, CALIFORNIA

DATE : 08-JUN-79
FORMATION :
DRLG. FLUID: WB
LOCATION : SEC 25-T9N/R33W

FILE NO : BP-1-8289
LABORATORY: BAKERSFIELD
ANALYSTS : DLK
ELEVATION : 918'KB

DEAN-STARK CORE ANALYSIS

SMP NO	DEPTH	HORIZ PERM	HELI POR %	OIL % P.V.	WTR % P.V.	TOTAL FLUID	O/W RATIO	DESCRIPTION
DEAN-STARK CORE ANALYSIS/SAMPLES MOUNTED IN SLEEVES/A TRI-AXIAL PRESSURE EQUAL TO THE DEPTH MINUS 100 Psig., TO A MAXIMUM OF 700 Psig.								
1	2564.0-65.0	3.65	33.2	0.0	74.3	74.4	0.00	SH;GY,NO STN,NO FLU
2	2565.0-66.0	4.61	31.4	0.0	91.0	91.0	0.00	SAME
3	2566.0-67.0	2.33	32.6	0.0	94.6	94.6	0.00	SAME
4	2572.0-73.0	1.68	28.3	0.0	91.3	91.3	0.00	SAME
5	2573.0-74.0	558.	26.9	5.3	45.6	50.9	0.12	SD;GY-BRN,F-MGR,LT STN
6	2574.0-75.0	633.	35.3	8.8	52.3	61.1	0.17	SAME
7	2575.0-76.0	1144.	35.6	11.2	62.7	73.9	0.18	SAME
8	2576.0-77.0	2284.	38.6	17.8	58.2	76.0	0.31	SAME
9	2577.0-78.0	2337.	36.2	25.2	58.8	84.0	0.43	SAME
10	2578.0-79.0	3235.	36.9	25.6	54.5	80.1	0.47	SAME
11	2579.0-80.0	6092.	37.6	40.5	31.3	71.8	1.29	SD;BRN,F-MGR,DK STN
12	2580.0-81.0	5659.	37.7	55.3	23.0	78.4	2.40	SAME
13	2581.0-82.0	5748.	39.9	59.8	15.8	75.7	3.78	SAME
14	2582.0-83.0	6001.	39.3	53.4	22.9	76.3	2.33	SAME
15	2583.0-84.0	5609.	38.5	60.0	16.1	76.1	3.73	SAME
16	2584.0-85.0	5801.	38.3	55.1	20.8	75.9	2.65	SAME
17	2585.0-86.0	5395.	37.6	53.2	23.6	81.8	2.47	SAME
18	2586.0-87.0	5034.	37.3	54.5	31.4	86.0	1.73	SAME
19	2587.0-88.0	5899.	37.1	56.8	24.7	81.4	2.30	SAME
20	2588.0-89.0	5360.	38.3	57.6	19.9	77.5	2.90	SAME
21	2589.0-90.0	4964.	38.4	60.1	28.7	88.8	2.09	SAME
22	2590.0-91.0	4840.	36.7	54.7	26.3	80.9	2.08	SAME
23	2591.0-92.0	4966.	37.5	54.3	23.4	77.7	2.33	SAME
24	2592.0-93.0	5096.	38.0	58.6	23.3	81.9	2.51	SAME
25	2593.0-94.0	5899.	38.7	55.5	21.3	76.8	2.61	SAME
26	2594.0-95.0	4087.	38.8	52.9	24.6	77.5	2.15	SAME

TABLE D-1
T0 1 Core Analysis

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Petroleum Reservoir Engineering
DALLAS, TEXAS

PAGE 2

GETTY OIL COMPANY
"WILLIAMS HOLDING" #T0-1-25

DATE : 03-JUN-79
FORMATION :

FILE NO : BP-1-8289
LABORATORY: BAKERSFIELD

DEAN-STARK CORE ANALYSIS

SMP NO	DEPTH	HORIZ PERM	HELI POR %	OIL % P.V.	WTR % P.V.	TOTAL FLUID	O/W RATIO	DESCRIPTION
27	2595.0-96.0	4206.	38.8	53.2	27.1	80.2	1.96	SAME
28	2596.0-97.0	1528.	37.0	40.1	46.3	86.4	0.86	SAME
29	2597.0-98.0	2877.	38.0	54.4	26.1	80.5	2.08	SAME
30	2598.0-99.0	4864.	38.4	46.7	29.6	76.2	1.58	SAME
31	2599.0-00.0	3212.	37.2	46.9	34.7	81.6	1.35	SAME
32	2600.0-01.0	1331.	34.3	33.6	52.3	85.9	0.64	SAME
33	2601.0-02.0	5355.	36.3	48.6	26.2	74.8	1.85	SAME
34	2602.0-03.0	4793.	35.5	56.0	20.7	76.7	2.70	SAME
35	2603.0-04.0	5104.	36.0	43.4	37.3	80.7	1.16	SAME
36	2604.0-05.0	4318.	36.5	44.4	31.6	76.0	1.40	SAME
37	2605.0-06.0	5038.	34.6	54.3	34.4	88.7	1.58	SAME
38	2606.0-07.0	3055.	36.3	39.6	43.3	83.0	0.91	SD; BRN, F-MGR/F CLY INCLS, DK STN
39	2607.0-08.0	4822.	38.5	42.2	30.0	72.2	1.41	SAME
40	2608.0-09.0	2785.	35.7	39.0	42.0	81.0	0.93	SAME
41	2609.0-10.0	3297.	35.0	41.9	43.3	85.2	0.97	SAME
42	2610.0-11.0	5193.	36.4	46.1	31.2	77.3	1.48	SD; BRN, F-MGR, DK STN
43	2611.0-12.0	4341.	36.6	45.7	32.1	77.8	1.42	SAME
44	2612.0-13.0	4595.	37.6	38.6	33.3	72.0	1.16	SAME
45	2613.0-14.0	3245.	37.1	55.6	24.0	79.6	2.31	SAME
46	2614.0-15.0	3578.	37.5	49.2	24.3	73.6	2.02	SAME
47	2616.0-17.0	4112.	37.8	46.6	29.2	75.9	1.59	SAME
48	2617.0-18.0	4256.	37.1	47.5	30.4	77.9	1.56	SAME
49	2618.0-19.0	4782.	37.0	52.1	25.4	77.5	2.05	SAME
50	2619.0-20.0	3442.	36.8	49.8	32.7	82.7	1.51	SAME
51	2620.0-21.0	4641.	37.0	52.5	30.4	82.9	1.73	SAME
52	2621.0-22.0	3927.	37.9	44.2	39.1	83.4	1.13	SAME
53	2622.0-23.0	3870.	38.5	43.5	33.8	77.2	1.29	SAME
54	2623.0-24.0	5038.	38.8	50.3	27.7	78.0	1.82	SAME
55	2624.0-25.0	4316.	39.1	50.9	23.9	74.8	2.13	SAME
56	2625.0-26.0	4264.	38.1	41.4	36.9	78.3	1.12	SAME

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Petroleum Reservoir Engineering
DALLAS, TEXAS

PAGE 3

GETTY OIL COMPANY
"WILLIAMS HOLDING" #T0-1-25

DATE : 08-JUN-79
FORMATION :

FILE NO : BP-1-8289
LABORATORY: BAKERSFIELD

DEAN-STARK CORE ANALYSIS

SMP NO	DEPTH	HORIZ PERM	HELI POR %	OIL % P.V.	WTR % P.V.	TOTAL FLUID	O/W RATIO	DESCRIPTION
57	2626.0-27.0	3068.	37.9	40.5	38.9	79.4	1.04	SAME
58	2627.0-28.0	4603.	37.9	40.4	37.3	77.6	1.08	SAME
59	2628.0-29.0	4131.	38.2	36.1	41.3	77.4	0.88	SAME
60	2629.0-30.0	1909.	36.8	40.0	41.8	81.7	0.96	SAME
61	2630.0-31.0	4523.	38.6	42.8	34.4	77.1	1.24	SAME
62	2631.0-32.0	3768.	38.0	48.4	27.9	76.3	1.74	SAME
63	2632.0-33.0	5766.	38.9	36.4	38.9	75.2	0.93	SAME
64	2633.0-34.0	635.	28.4	14.8	53.0	67.7	0.28	SAME/SH LAM
65	2634.0-35.0	2153.	37.0	38.3	36.3	74.6	1.05	SAME
66	2635.0-36.0	4997.	37.5	54.2	24.6	78.8	2.21	SAME
67	2636.0-37.0	3782.	37.9	52.5	23.1	75.6	2.28	SAME
68	2637.0-38.0	4938.	39.5	46.0	29.6	75.6	1.55	SAME
69	2638.0-39.0	4383.	36.6	55.6	26.1	81.7	2.13	SAME
70	2639.0-40.0	5073.	38.2	47.7	30.7	78.5	1.55	SAME
71	2640.0-41.0	4849.	37.9	51.5	25.0	76.4	2.06	SAME
72	2641.0-42.0	4158.	37.3	46.1	32.4	78.4	1.42	SAME
73	2642.0-43.0	5313.	39.0	45.2	25.2	70.4	1.79	SAME
74	2643.0-44.0	4439.	37.1	52.3	29.4	81.7	1.78	SAME
75	2644.0-45.0	5009.	38.0	48.0	30.7	78.7	1.56	SAME
76	2645.0-46.0	5856.	36.6	49.4	25.8	75.2	1.91	SAME
77	2646.0-47.0	4466.	38.0	41.8	36.0	77.8	1.16	SAME
78	2647.0-48.0	3632.	38.5	36.7	42.9	79.6	0.85	SAME
79	2648.0-49.0	4193.	38.0	36.9	38.1	75.0	0.97	SAME
80	2649.0-50.0	4558.	38.0	46.8	34.4	81.2	1.36	SAME
81	2650.0-51.0	4022.	38.1	46.2	30.8	76.9	1.50	SAME
82	2651.0-51.5	4758.	38.7	52.7	30.2	82.9	1.75	SAME
83	2652.0-53.0	3777.	38.1	46.9	37.1	84.0	1.26	SAME
84	2653.0-54.0	1055.	36.8	52.1	23.3	75.4	2.24	SAME
85	2654.0-55.0	4081.	37.7	55.3	26.1	81.4	2.12	SAME
86	2655.0-56.0	4861.	38.0	54.0	24.9	78.9	2.17	SAME

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Petroleum Reservoir Engineering
 DALLAS, TEXAS

PAGE 4

GETTY OIL COMPANY
 "WILLIAMS HOLDING" #T0-1-25

DATE : 08-JUN-79
 FORMATION :

FILE NO : BF-1-8289
 LABORATORY: BAKERSFIELD

DEAN-STARK CORE ANALYSIS

SMP NO	DEPTH	HORIZ PERM	HELL FOR %	OIL % P.V.	WTR % P.V.	TOTAL FLUID	O/W RATIO	DESCRIPTION
87	2656.0-57.0	4466.	38.5	55.2	20.4	75.6	2.70	SAME
88	2657.0-58.0	4410.	37.4	48.6	28.7	77.3	1.70	SAME
89	2658.0-59.0	4344.	38.0	52.6	25.4	78.1	2.07	SAME
90	2659.0-60.0	3957.	37.9	41.4	34.5	75.8	1.20	SAME
91	2660.0-61.0	2663.	37.3	44.1	43.7	87.7	1.01	SAME
92	2661.0-62.0	2369.	37.4	62.9	24.2	87.1	2.60	SAME
93	2662.0-63.0	2485.	36.4	40.5	45.8	86.3	0.88	SAME
94	2663.0-64.0	1626.	36.7	36.8	53.0	89.8	0.69	SAME
95	2664.0-65.0	3183.	38.0	44.1	38.9	82.9	1.13	SAME
96	2665.0-66.0	3094.	36.8	44.1	35.5	79.6	1.24	SAME
97	2666.0-67.0	3704.	38.5	49.1	30.3	79.4	1.62	SAME
98	2667.0-68.0	1531.	36.9	36.3	54.5	90.8	0.67	SAME
99	2668.0-69.0	2110.	36.7	30.5	40.3	70.9	0.76	SAME
100	2669.0-70.0	4986.	36.2	36.3	40.2	76.9	0.92	SAME
101	2670.0-71.0	2468.	37.5	34.3	49.2	84.0	0.71	SAME
102	2671.0-72.0	2124.	36.0	39.6	44.1	83.7	0.90	SAME
103	2672.0-73.0	2230.	36.3	33.0	37.3	70.4	0.89	SAME
104	2673.0-74.0	2965.	36.5	34.8	37.9	72.7	0.92	SAME
105	2674.0-75.0	1984.	35.2	30.5	47.2	77.7	0.65	SAME
106	2675.0-76.0	1683.	35.7	36.8	37.2	74.0	0.99	SAME
107	2676.0-77.0	2535.	36.7	35.2	33.7	68.8	1.04	SAME
108	2677.0-78.0	2734.	36.2	10.4	59.1	69.5	0.18	SD;GY-BRN,F-MGR/F CLY INCLS,DK SP STN
109	2678.0-79.0	1756.	35.1	3.0	68.9	71.9	0.04	SAME
110	2679.0-80.0	2311.	36.6	4.0	64.3	68.3	0.06	SAME
111	2680.0-81.0	2315.	35.1	0.3	69.2	69.5	0.00	SD;GY,F-MGR,CLY,NO STN
112	2681.0-82.0	2402.	35.0	1.4	64.8	66.2	0.02	SAME
113	2682.0-83.0	2547.	35.7	0.0	76.7	76.7	0.00	SAME
114	2683.0-84.0	2198.	35.0	0.0	74.8	74.8	0.00	SAME
115	2684.0-85.0	1794.	34.4	0.0	76.2	76.2	0.00	SAME
116	2685.0-86.0	1406.	34.8	0.0	78.3	78.3	0.00	SAME

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Petroleum Reservoir Engineering
DALLAS, TEXAS

PAGE 5

GETTY OIL COMPANY
"WILLIAMS HOLDING" #T0-1-25

DATE : 08-JUN-79
FORMATION :

FILE NO : BP-1-8289
LABORATORY: BAKERSFIELD

DEAN-STARK CORE ANALYSIS

SMP NO	DEPTH	HORIZ PERM	HELI POR %	OIL % P.V.	WTR % P.V.	TOTAL FLUID	O/W RATIO	DESCRIPTION
117	2686.0-87.0	1475.	33.5	0.0	72.2	72.2	0.00	SAME
118	2688.0-89.0	755.	29.5	0.0	76.0	76.0	0.00	SAME
119	2692.0-93.0	6118.	37.7	30.0	36.5	66.5	0.82	SD; BRN, F-MGR, DSTN
120	2693.0-94.0	4785.	37.2	34.0	34.0	68.0	1.00	SAME
121	2694.0-95.0	4707.	36.6	31.8	36.3	68.1	0.88	SAME
122	2695.0-96.0	5501.	37.6	26.2	39.5	65.7	0.66	SAME
123	2696.0-97.0	5298.	36.2	42.9	26.6	69.5	1.61	SAME
124	2698.0-99.0	4348.	36.9	32.8	38.3	71.1	0.86	SAME
125	2699.0-00.0	5886.	36.0	40.3	35.3	75.6	1.14	SAME
126	2700.0-01.0	6132.	36.4	41.4	33.3	74.6	1.24	SAME
127	2701.0-02.0	6923.	37.8	36.0	30.9	66.9	1.17	SAME
128	2702.0-03.0	5378.	37.3	33.3	35.7	69.0	0.93	SAME
129	2703.0-04.0	6599.	37.9	41.2	24.6	65.8	1.68	SAME
130	2704.0-05.0	6134.	37.7	34.9	28.7	63.6	1.21	SAME
131	2705.0-06.0	5773.	37.0	37.4	30.7	68.1	1.22	SAME
132	2706.0-07.0	4938.	37.5	29.1	35.6	64.7	0.82	SAME
133	2707.0-08.0	4862.	36.7	32.6	33.0	65.6	0.99	SAME
134	2708.0-09.0	4878.	35.4	31.6	38.9	70.5	0.81	SAME
135	2709.0-10.0	3758.	36.2	34.6	38.8	73.4	0.89	SAME
136	2710.0-11.0	5661.	37.4	38.4	27.1	65.5	1.42	SAME
137	2711.0-12.0	4800.	34.2	41.1	32.4	73.5	1.27	SAME
138	2712.0-13.0	6809.	37.7	43.7	25.9	69.6	1.68	SAME
139	2713.0-14.0	5520.	35.9	40.9	30.1	71.0	1.36	SAME
140	2714.0-15.0	3384.	34.4	41.7	33.8	75.4	1.23	SAME
141	2715.0-16.0	4217.	36.1	29.6	32.6	62.2	0.91	SAME
142	2716.0-17.0	5207.	36.5	38.8	30.5	69.3	1.27	SAME
143	2717.0-18.0	4516.	35.3	31.0	38.9	69.9	0.80	SAME
144	2718.0-19.0	4760.	37.4	33.3	29.4	62.8	1.13	SAME
145	2719.0-20.0	4089.	36.0	40.0	31.9	71.9	1.26	SAME
146	2720.0-21.0	2796.	30.9	21.7	42.4	64.1	0.51	SD; GY-BRN, F-MGR, CLY INCLS, SLTY, DK SF STN

-87-

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Petroleum Reservoir Engineering
 DALLAS, TEXAS

PAGE 6

GETTY OIL COMPANY
 "WILLIAMS HOLDING" #T0-1-25

DATE : 08-JUN-79
 FORMATION :

FILE NO : BP-1-8289
 LABORATORY: BAKERSFIELD

DEAN-STARK CORE ANALYSIS

SMP NO	DEPTH	HORIZ PERM	HELI POR %	OIL % P.V.	WTR % P.V.	TOTAL FLUID	O/W RATIO	DESCRIPTION
147	2721.0-22.0	2372.	31.5	13.0	44.5	57.5	0.29	SAME
148	2722.0-23.0	6957.	35.5	33.9	42.8	76.7	0.79	SD;BRN,F-MGR,DK STN
149	2723.0-24.0	5308.	35.3	37.8	36.2	74.0	1.04	SAME
150	2724.0-25.0	4004.	35.4	35.8	38.0	73.8	0.94	SAME
151	2725.0-26.0	4559.	36.5	49.4	41.2	90.6	1.20	SAME
152	2726.0-27.0	5546.	34.8	34.2	39.8	73.9	0.86	SAME
153	2727.0-28.0	5529.	35.5	30.9	44.7	75.6	0.69	SAME
154	2728.0-29.0	6052.	34.7	40.1	33.5	73.6	1.19	SAME
155	2729.0-30.0	5139.	33.4	25.3	36.9	62.2	0.69	SAME
156	2730.0-31.0	7527.	34.8	36.1	30.6	66.7	1.18	SAME
157	2731.0-32.0	4571.	35.2	36.8	38.5	75.3	0.95	SAME
158	2732.0-33.0	5156.	36.3	44.2	28.8	73.1	1.53	SAME
159	2733.0-34.0	3734.	31.9	39.2	33.1	72.3	1.19	SAME
160	2734.0-35.0	6698.	33.4	47.7	25.6	73.3	1.87	SAME
161	2735.0-36.0	7432.	33.8	36.5	24.4	60.9	1.49	SAME
162	2736.0-37.0	6017.	33.4	27.3	33.0	60.3	0.83	SAME
163	2737.0-38.0	501.	28.7	3.2	57.3	60.5	0.06	SD;GY-BRN,F-MGR,CLY INCLS,SLTY,DK SP STN
164	2738.0-39.0	2911.	28.4	12.4	50.8	63.2	0.24	SAME
165	2739.0-40.0	2477.	30.0	29.6	33.4	63.0	0.89	SAME
166	2740.0-41.0	4317.	32.8	20.3	40.5	60.8	0.50	SAME
167	2741.0-42.0	1340.	29.0	12.8	49.5	62.3	0.26	SAME

1001

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TABLE D-2

TO 1 Core Descriptions

Cat Canyon Field

Getty Oil Company

Williams Holding #TO-1

Surface Location: 3234'S & 1398'W from N/4 corner, Sec. 25, T9N,R33W

Subsurface Location: 3173'S & 1373'W from N/4 corner, Sec. 25, T9N,R33W

Elevation: 918' K.B.

Date cored: 6/3/79 - 6/6/79

Logged by: D. K. Willis

R. J. McCarthy

J. A. Grover

R. A. Haworth

CORE DESCRIPTIONS

Core #1 2564'-2574', Cut 10', Recovered 3', Time 125 min.

2564'-2567' = 3'

Claystone, greenish-gray, trace sand, very silty, firm to hard, no P&P, few fossil imprints.

2567'-2574' = 7'

Lost core.

Core #2 2574'-2576', Cut 2', Recovered 4', Time 4 min.

Recovered 2' from Core #1. Take back to 2572'

2572'-2573.25' = 1.25'

Claystone, gray to dark greenish-gray, very silty, trace fine sand, hard, fissile, no P&P, fossiliferous.

2573.25-2576' = 2.75'

Oil stained sand, gray to dark brown, mottled, silty, evenly calcareous, slightly firm to friable, very fine to fine grain, subangular to sub-rounded, poor P&P, good odor, uneven saturation, dark brown cut, good sorting, So 25%.

Core #3 2576'-2596', Cut 20', Recovered 20', Time 16 min.

2576'-2580' = 4'

Oil sand, dark brown and greenish-gray mottled, very silty and clayey, very friable, very fine grain, subangular, fair P&P, fair odor, fair mottled saturation, dark brown cut, fair sorting, So 30%.

2580'-2596' = 16'

Oil sand, dark brown, silt with very few blebs of greenish-gray clay, very friable, very fine to fine grain, subangular, good to very good P&P, good odor, very good saturation, black cut, fair sorting, So 60%.

Core #4 2596'-2616', Cut 20', Recovered 19', Time 20 min.

2596'-2599.5' = 3.5' Oil sand, dark brown, silty, mottled and spotty, very friable, very fine to fine grain, subangular, good to very good P&P, good odor, good even tarry saturation with patches clear of oil corresponding to silty spots, black cut, fair to good sorting, So 50%.

2599.5'-2600.5' = 1' Oil sand, dark brown, calcareous, silty, friable, very fine grain, subangular, fair to poor P&P, fair odor, fair to poor saturation, black cut, fair sorting, So 40%. 2" calcareous hard sand (shell) at 2600'.

2600.5'-2615' = 14.5' Oil sand, dark brown, silty, calcareous, mottled and spotty with silt and clay, heavy greenish clay patch at 2608', very friable, very fine to fine grain, subangular, good P&P, good odor, good even tarry saturation around silty spots, black cut, fair to good sorting, So 50%.

2615'-2616' = 1' Lost core.

Core #5 2616'-2632', Cut 16', Recovered 15.5', Time 15 min.

2616'-2631.5' = 15.5' Oil sand, dark brown, silty, locally calcareous, very friable, fine grain, subangular to subrounded, very good P&P, very good odor, very good even saturation, good sorting, So 60%.

2631.5'-2632' = 0.5' Lost core.

Core #6 2632'-2652', Cut 20', Recovered 19.5', Time 25 min.

2632'-2651.5' = 19.5' Oil sand, dark brown, slightly silty, very friable, fine grain, subrounded, good P&P, very good odor, good even saturation, black cut, good sorting, So 55%. Gas bubbles uniform throughout core.

Core #7 2652'-2672', Cut 20', Recovered 20', Time 25 min.

- 2652'-2656' = 4' Oil sand, black, silty, slightly mottled with greenish-gray clay-silt, very friable, fine grain, subangular, good P&P, good odor, good even saturation, black cut, good sorting, So 55%.
- 2656'-2664' = 8' Oil sand, dark brown to black, silty, mottled with greenish-gray silt-clay, very friable, very fine to fine grain, subangular, good to fair P&P, good odor, good even saturation, black cut, fair to good sorting, So 50%.
- 2664'-2672' = 8' Oil sand, dark brown, mottled with greenish-gray silt-clay, silty, friable, very fine grain, subangular, fair to good P&P, good odor, fair to good even saturation around mottled silt-clay, black cut, fair sorting, So 45%.

Core #8 2672'-2692', Cut 20', Recovered 17', Time 20 min.

- 2672'-2677' = 5' Oil sand, dark brown, mottled with greenish silt-clay, silty, slightly firm, very fine grain, subangular, fair P&P, fair to good odor, fair even saturation around mottled clay, dark brown cut, fair sorting, So 40%.
- 2677'-2680.5' = 3.5' Oil stained sand, dark brown, very silty, heavily mottled with greenish silt-clay, slightly firm, very fine grain to silty, subangular, poor P&P, poor odor, fair to poor uneven saturation, dark brown cut, fair to poor sorting, So 25%.
- Oil Sand/Siltstone contact at 2680.5'
- 2680.5'-2682.5' = 2' Siltstone, greenish-gray, rare patches of oil stained sand with 1-2" patches at 2680.5' and 2682', slightly calcareous, silty, subangular, very poor P&P, no odor, very poor saturation dark brown cut, fair sorting, So 10%.
- 2682.5'-2686' = 3.5' Siltstone, greenish-gray, calcareous, silt-size grains, subangular, firm, no show.

Page #4
Cat Canyon Field
Williams Holding #TO-1

2686'-2689' = 3' Siltstone, greenish-gray, very calcareous, silt-size grains, sub-angular, very firm, no show, abundant fossil molds - mostly clams and other bivalves.

2689'-2692' = 3' Lost core.

Core #9 2692'-2702', Cut 10', Recovered 4.5', Time 30 min.

2692'-2692.25' = 0.25' Siltstone, greenish-gray, silty, calcareous, firm, silt-size to very fine grain, angular to subangular, no show.

Siltstone/Oil sand contact at 2692.25

2692.25'-2696.5' = 4.25' Oil sand, gray-black, silty, friable, fine grain, subangular, good P&P, good odor, good saturation, black cut, fair to good sorting, So 40%.

2696.5'-2702' = 5.5' Lost core.

Core #10 2702'-2722', Cut 20', Recovered 24', Time 26 min.
Recovered 4' from Core #9. Take back to 2698'.

2698'-2716' = 18' Oil sand, dark brown, silty, very friable, very fine to fine grained, subangular to subrounded, good P&P, fair odor, good even tarry saturation with occasional unsaturated clay patches, black cut, good sorting, So 45%. 2" shell at 2704.5'.

2716'-2720' = 4' Oil sand, dark brown, silty, very friable, very fine to fine grain, subangular to subrounded, poor to fair permeability, fair to good porosity, fair odor, fair to good somewhat uneven tarry saturation, many greenish-gray unsaturated patches (carbonate cement), black cut, fair sorting, So 30%.

Page #5
Cat Canyon Field
Williams Holding #TO-1

2720'-2722' = 2'

Oil sand and shells interbedded, dark brown oil sand and greenish gray sandstone shell, hard shell at 2721', silty, very friable to firm, very fine to fine grained, subangular to subrounded, poor to fair permeability, poor to good porosity, fair odor, fair uneven tarry saturation, black cut in oil sand sections, fair sorting, So 0-30%.

Core #12 2722'-2742', Cut 20', Recovered 20', Time 90 min.

2722'-2737' = 15'

Oil sand, dark brown to black, silty, clayey, patches of firm calcareous gray, silty sand (1-3" patches at 2722.5', 2723.5', 2726.5', 2730.5', 2733.0', 2737.0' and other minor patches throughout), friable, very fine to fine grain, subangular, good P&P, fair to good odor, fair saturation, black cut, fair to good sorting, So 50%.

2737'-2740' = 3'

Oil sand, dark brown to black, silty, mottled with calcareous firm gray-silty clay patches, very fine to fine grained, subangular, fair to good P&P, fair to good odor, fair saturation, black cut, fair sorting, So 40%.

2740'-2742' = 2'

Oil sand, dark brown, heavily mottled with greenish gray hard calcareous, silty sand, very firm, very fine to poor P&P, fair to poor odor, poor saturation, dark brown cut, fair sorting, So 30%.

Drill 2742'-2800' T.D.

WILLIAMS HOLDING THERMAL OBSERVATION WELL #2

DRILLING HISTORY

WH TO 2-25 was spudded on October 10, 1979. A 7-7/8" hole was directionally drilled to 2804' using conventional water-base mud. On October 10, a dual induction-SFL log, compensated neutron-formation density log, and computer processed log were run. Sidewall samples were taken between 2554-2773'. A 7-7/8" hole was then drilled from 2804-2824' (T.D.). Four and one-half inch casing was run and cemented at 2824'. The rig was released on October 11, 1979.

FIGURE D-4

TO 2 DUAL INDUCTION-SFL LOG

TO 2 COMPENSATED NEUTRON-FORMATION DENSITY LOG

FIGURE D-6

TO 2 COMPUTER PROCESSED LOG

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PAGE 1

GETTY OIL COMPANY
 "WILLIAMS HOLDING" TO-2-25
 CAT CANYON FIELD
 SANTA BARBARA COUNTY, CA

DATE : 19-OCT-79
 FORMATION :
 DRLG. FLUID: WB
 LOCATION : SEC.25-T9N/R25W

FILE NO : BF-1-8536
 LABORATORY: BAKERSFIELD
 ANALYSTS : DLK
 ELEVATION : 917'KB

DEAN-STARK CORE ANALYSIS

SMP NO	DEPTH	HORIZ PERM	HELI POR %	OIL % P.V.	WTR % P.V.	TOTAL FLUID	O/W RATIO	DESCRIPTION
DEAN-STARK CORE ANALYSIS/SAMPLES MOUNTED IN SLEEVES/A TRI-AXIAL PRESSURE EQUAL TO THE DEPTH MINUS 100 PSIS., TO A MAXIMUM OF 700 PSIS.								
1	2554.0	694.	34.6	7.8	79.1	86.9	0.10	SD;BRN,VF-FGR,DK STN
2	2557.0	387.	33.1	5.6	78.5	84.0	0.07	SAME
3	2560.0	550.	34.1	6.7	66.0	72.6	0.10	SAME
4	2563.0	496.	32.2	20.9	57.2	78.1	0.37	SAME
5	2566.0	1004.	33.9	24.4	55.5	79.9	0.44	SAME
6	2569.0	1073.	33.5	30.8	48.6	79.4	0.64	SAME
7	2572.0	959.	34.0	28.2	49.7	78.0	0.57	SAME
8	2575.0	187.	29.1	12.3	63.5	75.8	0.19	SD;BRN,F-MGR,GY INCL,DK STN
9	2578.0	402.	30.7	15.3	64.8	80.1	0.24	SAME
10	2581.0	900.	32.6	14.1	62.5	76.6	0.23	SD;BRN,F-MGR,DK STN
11	2584.0	609.	30.6	22.0	61.5	83.5	0.36	SAME
12	2587.0	384.	29.9	11.6	69.6	81.5	0.17	SD;BRN,VF-FGR,SLTY,DK STN
13	2590.0	402.	31.3	28.9	58.9	87.8	0.49	SAME
14	2595.0	166.	29.1	25.8	52.7	78.4	0.49	SAME
15	2600.0	451.	32.9	27.7	51.9	79.6	0.53	SAME
16	2624.0	209.	23.7	23.1	59.9	83.0	0.39	SAME
17	2628.0	904.	35.7	29.7	49.0	78.7	0.60	SD;BRN,VF-MGR,SLTY,DK STN
18	2631.0	993.	32.4	37.0	50.0	87.0	0.74	SAME
19	2635.0	428.	29.7	32.2	57.6	89.8	0.56	SAME
20	2640.0	577.	30.2	28.1	56.8	84.9	0.49	SAME
21	2645.0	409.	31.8	33.1	50.6	83.7	0.66	SAME,CLY
22	2650.0	287.	29.0	26.6	62.1	88.7	0.43	SD;BRN,VF-FGR,SLTY,DK STN
23	2655.0	154.	29.4	21.6	63.5	85.0	0.34	SAME
24	2660.0	155.	29.4	14.5	72.3	86.8	0.20	SD;GY-BRN,VF-MGR,DK SP STN
25	2663.0	115.	27.3	4.9	76.7	81.6	0.06	SAME
26	2666.0	1167.	32.3	38.0	44.5	82.5	0.85	SD;BRN,F-MGR,DK STN

TABLE D-3
 TO 2 Core Analysis

-98-

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Petroleum Reservoir Engineering
 DALLAS, TEXAS

PAGE 2

GETTY OIL COMPANY
 "WILLIAMS HOLDING" TO-2-25

DATE : 19-OCT-79
 FORMATION :

FILE NO : BP-1-8536
 LABORATORY: BAKERSFIELD

DEAN-STARK CORE ANALYSIS

SNF NO	DEPTH	HORIZ PERM	HELI POR %	OIL % P.V.	WTR % P.V.	TOTAL FLUID	O/W RATIO	DESCRIPTION
27	2670.0	1343.	32.5	35.9	39.0	74.9	0.92	SAME
28	2675.0	1033.	32.1	39.7	39.2	78.9	1.01	SAME
29	2680.0	1148.	32.1	45.2	31.9	77.1	1.41	SAME
30	2685.0	695.	31.3	28.3	43.0	71.3	0.66	SAME
31	2695.0	2488.	32.6	53.0	34.4	87.3	1.54	SD;BRN-GY,VF-MGR,DK STN
32	2700.0	2738.	33.2	56.2	24.4	80.6	2.30	SAME
33	2705.0	951.	32.6	36.2	36.8	73.0	0.98	SAME,SLTY
34	2710.0	1135.	31.8	34.7	36.3	71.0	0.96	SAME
35	2715.0	1808.	26.3	35.7	38.9	74.6	0.92	SAME
36	2720.0	734.	30.3	27.4	45.1	72.5	0.61	SAME,SLTY
37	2730.0	158.	32.1	2.2	66.9	69.1	0.03	SD;GY-BRN,VF-FGR,VSLTY,DK STN
38	2736.0	182.	31.0	3.4	63.3	66.7	0.05	SD;GY,VF-FGR,MSP STN
39	2739.0	1644.	31.6	37.3	33.5	70.8	1.11	SD;BRN,F-MGR,MICA,DK STN
40	2742.0	2342.	35.2	40.7	29.9	70.6	1.36	SAME
41	2745.0	1859.	30.7	36.5	33.8	70.2	1.08	SAME
42	2748.0	865.	30.2	7.6	77.3	84.9	0.10	SD;BRN,-GY,VF-MGR,MSTN
43	2751.0	1131.	33.4	7.6	72.0	79.6	0.11	SAME
44	2753.0	471.	32.4	2.7	81.5	84.2	0.03	SAME
45	2758.0	475.	33.9	0.0	74.9	74.9	0.00	SD;GY,F-MGR,ND STN
46	2764.0	488.	33.8	0.0	95.8	95.8	0.00	SAME
47	2769.0	142.	31.0	0.0	97.9	97.9	0.00	SAME
48	2773.0	82.	28.4	0.0	93.7	93.7	0.00	SAME

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TABLE D-4

TO 2 Core Descriptions

Cat Canyon Field
Getty Oil Company

Williams Holding TO. #2-25

Surface Location: 3,373.45'S and 1,296.82'W, From N1/4 corner

Section 25, T9N, R33W

Subsurface Location: 3,305'S and 1,208'W (Proposed) From N1/4 corner

Section 25, T9N, R33W

Elevation: 917' 1" Diameter Schlumberger side-wall cores

Date Cored: 10/10/79 T.D. = 28-24'

<u>Depth</u>	<u>Recovery</u>	<u>Description</u>
2554	2"	Oil sand, medium dark grey with mottled light blueish grey clay streaks (15%), silty, friable, fine-grained, subrounded, fair P&P, fair odor, uneven saturation, , light yellow cut, fair sorting, $S_o = 35\%$.
2557	2"	Oil sand, light-medium grey with mottled light blueish grey streaks (10%), silty, friable, fine-grained, subrounded, fair P&P, fair odor, uneven saturation, straw cut, fair sorting, $S_o = 20\%$.
2560	1 1/4"	Oil sand, medium grey, silty, friable, fine-grained, subrounded, fair P&P, fair odor, even saturation, fair sorting, $S_o = 40\%$.
2563	1 1/4"	Oil sand, medium-dark grey, silty, friable, fine-grained, subrounded-subangular, fair P&P, fair odor, fair saturation, fair sorting, $S_o = 35-40\%$.
2566	1 1/4"	Oil sand, dark grey, silty, friable, fine-grained, subrounded, fair P&P, fair odor, good saturation, fair sorting, $S_o = 40-45\%$.
2569	1 3/4"	Oil sand, medium-dark grey, silty, friable, fine-grained, subrounded, fair P&P, fair odor, fair saturation, fair sorting, $S_o = 35\%$.
2572	1 1/2	Oil sand, medium grey, silty, friable, fine-grained, subrounded, fair P&P, fair odor, fair saturation, fair sorting, $S_o = 30\%$.
2575	2"	Oil sand, dark grey mottled with light blueish grey (25%), silty, friable, fine-grained, subrounded-subangular, fair P&P, fair odor, uneven saturation, fair sorting, $S_o = 35\%$.

<u>Depth</u>	<u>Recovery</u>	<u>Description</u>
2578	2"	Oil sand, dark grey, silty, friable, fine-grained, subrounded, fair P&P, fair odor, poor saturation, fair sorting, $S_o = 20\%$.
2581	1 3/4"	Oil sand, dark grey with mottled blueish grey patches (10%), silty, friable, fine-grained, subrounded, fair P&P, good-fair odor, uneven saturation, fair sorting, $S_o = 30\%$.
2584	1 3/4"	Oil sand, dark grey, silty, friable, fine-grained, subrounded, fair P&P, good odor, good saturation, fair sorting, $S_o = 40\%$.
2587	1 1/2"	Oil sand, dark grey, silty, friable, fine-grained, subrounded, fair P&P, good odor, fair saturation, fair sorting, $S_o = 30\%$.
2590	1 1/2"	Oil sand, dark grey, silty, friable, fine-grained, subrounded, fair P&P, good odor, fair saturation, fair sorting, $S_o = 30\%$.
2595	1 1/4"	Oil sand, dark grey, silty, friable, fine-grained, subrounded-subangular, fair P&P, good odor, fair saturation, fair sorting, $S_o = 40\%$.
2600	1 1/4"	Oil sand, dark grey, silty, friable, fine-grained, subangular-subrounded, fair P&P, poor odor, fair saturation, fair sorting, $S_o = 30\%$.
2612	Core destroyed during removal from barrel.	Oil sand dark grey, silty, friable, fine-grained, subrounded, fair P&P, good odor, fair saturation, fair sorting, $S_o = 35\%$.
2604	Cores could not be shot due to poor hole condition. Schlumberger felt they might lose their gun if these shots were attempted.	
2608		
2611		
2616		
2620		
2624	1 3/4"	Oil sand, blackish grey, silty, friable, fine-grained, subrounded-subangular, fair P&P, very good odor, good saturation, fair sorting, $S_o = 50\%$.

<u>Depth</u>	<u>Recovery</u>	<u>Description</u>
2628	1 1/2"	Oil sand, blackish grey, silty, friable, fine-grained, subrounded-subangular, fair P&P, fair odor, fair saturation, fair sorting, $S_o = 40-45\%$.
2631	2"	Oil sand, blackish grey, silty, friable, fine-grained, subrounded-subangular, fair P&P, fair odor, fair sorting, fair saturation, $S_o = 55\%$.
2635	2"	Oil sand, blackish grey mottled with light blue-grey, firm, fine-grained, subrounded-subangular, fair P&P, fair odor, fair saturation, fair sorting, $S_o = 40\%$.
2640	2"	Oil sand, blackish grey, silty, friable, fine-grained, subrounded-subangular, fair P&P, good odor, good saturation, fair sorting, $S_o = 50-55\%$.
2645	2"	Oil sand, dark grey, mottled, silty, firm, fine-grained, subrounded-subangular, fair P&P, fair odor, fair saturation, fair sorting, $S_o = 35\%$.
2650	2"	Oil sand, blackish grey mottled with grey, silty, firm, fine-grained, subrounded, fair P&P, fair odor, good saturation, fair sorting, $S_o = 45\%$.
2655	1 1/2"	Oil sand, blackish grey mottled with streaks of medium grey, silty, firm, fine-grained, subrounded-subangular, fair P&P, fair odor, fair saturation, fair sorting, $S_o = 45\%$.
2660	2"	Oil sand, dark grey, silty, mottled oil staining, firm, fine-grained, subrounded-subangular, fair P&P, fair odor, uneven saturation, fair sorting, $S_o = 20\%$.
2663	1 1/4"	Oil sand, medium grey, silty and clayey, firm, fine-grained, subrounded-subangular, fair P&P, faint odor, very poor saturation, fair sorting, $S_o = 5-10\%$.

<u>Depth</u>	<u>Recovery</u>	<u>Description</u>
2666	2"	Oil sand, blackish grey, "salt and pepper" texture, silty, friable, fine-grained, subrounded-subangular, fair P&P, good odor, good saturation, fair sorting, $S_o = 50\%$.
2670	1 1/2"	Oil sand, blackish grey, silty, friable, fine-grained, subrounded-subangular, fair P&P, good odor, good saturation, fair sorting, $S_o = 45\%$.
2675	1 1/2"	Oil sand, blackish grey, silty, friable, fine-grained, subrounded-subangular, fair P&P, good odor, good saturation, fair sorting, $S_o = 60\%$.
2680	1 1/2"	Oil sand, blackish grey, silty, friable, fine-grained, subrounded-subangular, fair P&P, good odor, good saturation, fair sorting, $S_o = 50-55\%$.
2685	1"	Oil sand, dark grey, silty, friable, fine-grained, subrounded-subangular, fair P&P, good odor, fair saturation, fair sorting, $S_o = 45\%$.
2690	1/4"	Oil sand, light blueish grey mottled with dark grey, silty, friable, fine-grained, subrounded-subangular, fair P&P, fair odor, uneven saturation, fair sorting, $S_o = 25\%$.
2695	2"	Oil sand, blackish grey, silty, friable, fine-grained, subrounded-subangular, fair P&P, good odor, good saturation, fair sorting, $S_o = 55\%$.
2700	1 3/4"	Oil sand, blackish grey, silty, friable, fine-grained, subrounded-subangular, fair P&P, good odor, good saturation, fair sorting, $S_o = 55\%$.
2705	1 1/4"	Oil sand, blackish grey, silty, friable, fine-grained, subrounded-subangular, fair P&P, good odor, good saturation, fair sorting, $S_o = 55\%$.
2710	1 1/4"	Oil sand, dark grey, "salt and pepper" texture, silty, friable, fine-medium-grained, subrounded-subangular, fair P&P, good odor, good saturation, fair sorting, $S_o = 50\%$.
2715	1"	Oil sand, blackish grey, silty, fine-grained, subrounded-subangular, fair-good P&P, good odor, good saturation, fair sorting $S_o = 55\%$.
20	1"	Oil sand, dark grey, "salt and pepper" texture, silty, fine-grained, subrounded-subangular, fair P&P, fair odor, fair saturation, fair sorting, $S_o = 35\%$.

<u>Depth</u>	<u>Recovery</u>	<u>Description</u>
2725	1/2"	Oil sand, light grey, silty, friable, fine-grained, subrounded, fair-poor P&P, faint odor, very uneven saturation, fair sorting $S_o = 25\%$.
2730	3/4"	Oil sand, light grey, silty, friable, fine-grained, subrounded-subangular, fair-poor P&P, faint odor, very uneven saturation, fair sorting, $S_o = 10\%$.
2733	1/2"	Oil sand, light grey, silty, friable, fine-grained, subrounded-subangular, fair-poor P&P, faint odor, very uneven saturation, fair sorting, $S_o = 10\%$.
2736	1"	Oil sand, light grey, silty, friable, fine-grained, subrounded-subangular, fair-poor P&P, fair odor, very uneven saturation, fair sorting, $S_o = 10\%$.
2739	1 1/4"	Oil sand, blackish grey, "salt and pepper" texture, silty, friable, fine-grained, subrounded-subangular, fair P&P, good odor, good saturation, fair sorting, $S_o = 45\%$.
2742	1 1/4"	Oil sand, blackish grey, "salt and pepper" texture, silty, friable, fine-grained, subangular - subrounded, fair P&P, good odor, good saturation, fair sorting, $S_o = 45\%$.
2745	1 1/4"	Oil sand, blackish-grey, silty, friable, fine-grained, subrounded-subangular, fair P&P, good odor, good saturation, fair sorting, $S_o = 40\%$.
2748	2"	Oil sand, blackish grey, silty, friable, fine-grained, subrounded-subangular, fair P&P, fair odor, fair saturation, coffee cut, fair sorting, $S_o = 30\%$.
2751	1 3/4"	Oil sand, dark grey, silty, friable, fine-grained, subrounded-subangular, fair P&P, fair odor, uneven (streaked) saturation, amber cut, fair sorting, $S_o = 15\%$.
2753	1 3/4"	Sand, grey, silty, firm, fine-grained, subrounded, fair P&P, slight odor, no cut, dry, fair sorting, $S_o = 0\%$.

<u>Depth</u>	<u>Recovery</u>	<u>Description</u>
2758	1 3/4"	Sand, grey, silty and clayey, firm, fine-grained, subrounded-subangular, fair P&P; slight odor, no cut, dry, fair sorting, $S_o = 0\%$.
2764	2"	Sand, grey, silty and clayey, firm, fine-grained, subrounded, fair P&P, slight odor, dry, fair sorting, $S_o = 0\%$.
2769	2"	Sand, grey, silty and clayey, firm, fine-grained, subrounded, fair - poor P&P, slight odor, dry, fair sorting, $S_o = 0\%$.
2773	1 3/4"	Siltstone, medium grey, clayey, hard, very fine-fine-grained, subrounded, fair-poor P&P, no odor, dry, poor sorting, $S_o = 0\%$.

Described by: W. P. Ziemianski
October 10, 1979

WILLIAMS HOLDING THERMAL OBSERVATION WELL #3

DRILLING HISTORY

WH TO 3-25 was spudded on October 11, 1979. A 7-7/8" hole was directionally drilled to 2814' using conventional water-base mud. On October 14, a dual induction-SFL log, compensated neutron-formation density log, and computer processed log were run. Sidewall samples were taken between 2560-2803'. A 7-7/8" hole was then drilled from 2814-2820' (T.D.). Four and one-half inch casing was run and cemented at 2820'. The rig was released on October 15, 1979.

FIGURE D-7
TO 3 DUAL INDUCTION-SFL LOG

FIGURE D-8

TO 3 COMPENSATED NEUTRON-FORMATION DENSITY LOG

CORE LABORATORIES, INC.
Petroleum Reservoir Engineering
DALLAS, TEXAS

PAGE 1

GETTY OIL CO.
"WILLIAMS HOLDING" T.G. 3-25
CAT CANYON
SANTA BARBARA COUNTY, CA.

DATE : 30-OCT-79
FORMATION :
DRLG. FLUID: WB
LOCATION :

FILE NO : DK BB
LABORATORY: BAKERSFIELD
ANALYSTS : DK BB
ELEVATION :

DEAN-STARK CORE ANALYSIS

SMP NO	DEPTH	HORIZ PERM	HELI POR %	OIL % P.V.	WTR % P.V.	TOTAL FLUID	O/W RATIO	DESCRIPTION
DEAN-STARK CORE ANALYSIS/SAMPLES MOUNTED IN SLEEVES/A TRI-AXIAL PRESSURE EQUAL TO THE DEPTH MINUS 100 Psis., TO A MAXIMUM OF 700 Psis.								
1	2560.0	60.	30.0	0.0	88.4	88.4	0.00	SLTSTN;GY,NO STN
2	2562.0	48.	27.9	0.0	72.2	72.2	0.00	SAME
3	2567.0	366.	32.6	9.9	73.8	83.7	0.13	SD;BRN,VF-FGR,SLTY,MSTN
4	2581.0	847.	32.8	30.6	46.6	77.2	0.66	SD;BRN,FGR,SLTY,DK STN
5	2584.0	739.	32.9	29.4	48.8	78.2	0.60	SAME
6	2588.0	395.	31.8	13.6	61.2	74.8	0.22	SD;BRN,VF-FGR,SLTY,DK STN
7	2593.0	684.	30.8	25.0	55.7	80.7	0.45	SD;BRN,VF-FGR,DK STN
8	2598.0	1023.	31.6	25.4	49.2	74.6	0.52	SAME
9	2604.0	561.	33.1	23.4	56.4	79.9	0.42	SAME
10	2520.0	832.	29.7	40.7	57.4	98.1	0.71	SAME
11	2640.0	1558.	32.6	32.9	52.8	85.7	0.62	SAME
12	2660.0	1335.	33.9	39.3	38.1	77.4	1.03	SAME
13	2667.0	308.	30.0	33.5	56.0	89.5	0.60	SD;BRN,VFGR,SLTY,DK STN
14	2672.0	439.	28.9	24.6	71.1	95.7	0.35	SAME
15	2675.0	269.	27.3	11.7	83.5	95.2	0.14	SD;GY-BRN,VFGR,SLTY,HSP STN
16	2680.0	99.	28.3	0.0	88.7	88.7	0.00	SD;GY,VF-FGR,SLTY,NO STN
17	2684.0	28.	22.2	0.0	94.1	94.1	0.00	SAME
18	2703.0	1137.	30.0	32.3	51.4	83.6	0.63	SD;BRN,FGR,MSTN
19	2713.0	654.	26.9	31.0	58.8	89.8	0.53	SD;BRN,FGR,SLTY,DK STN
20	2747.0	857.	29.9	41.0	33.7	74.7	1.22	SAME
21	2754.0	172.	30.5	0.0	77.1	77.2	0.00	SD;GY,VFGR,SLTY,NO STN
22	2763.0	1542.	32.9	51.3	27.6	78.9	1.86	DS;BRN,FGR,MSTN
23	2767.0	130.	28.7	0.0	89.6	89.6	0.00	SD;GY,VF-FGR,SLTY,NO STN
24	2769.0	372.	30.2	0.0	79.7	79.7	0.00	SAME
25*	2773.0	310.	27.3	23.4	47.5	70.9	0.49	SD;GY-BRN,VF-FGR,SLTY,DSF STN
26	2773.5	208.	30.5	0.0	84.9	84.9	0.00	SD;GY,VF-FGR,SLTY,NO STN

TABLE D-5
TO 3 Core Analysis

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Petroleum Reservoir Engineering
DALLAS, TEXAS

PAGE 2

GETTY OIL CO.
"WILLIAMS HOLDING" T.O. 3-25

DATE : 30-OCT-79
FORMATION :

FILE NO : DK BB
LABORATORY: BAKERSFIELD

DEAN-STARK CORE ANALYSIS

SNP NO	DEPTH	HORIZ PERM	HELI POR %	GIL % P.V.	WTR % P.V.	TOTAL FLUID	O/W RATIO	DESCRIPTION
27	2776.0	397.	32.6	0.0	95.3	95.3	0.00	SAME
28	2779.0	275.	31.7	0.0	88.2	88.2	0.00	SAME
29	2781.0	1372.	31.7	40.1	39.7	79.8	1.01	SD;BRN,VF-MGR,DK STN
30	2784.0	177.	28.9	0.0	83.8	83.8	0.00	SD;GY,FGR,SLTY,NO STN
31	2786.0	328.	32.4	0.0	89.3	89.3	0.00	SD;GY,VF-FGR,SLTY,NO STN
32	2790.0	229.	32.1	0.0	88.0	88.0	0.00	SAME
33*	2793.0	103.	25.4	0.0	77.4	77.4		SAME
34	2795.0	39.	24.0	0.0	87.4	87.4	0.00	SD;GY,VFGR,SLTY,NO STN
35	2797.0	26.	30.7	0.0	89.7	89.7	0.00	SAME
36	2803.0	21.	33.2	0.0	75.6	75.6	0.00	SAME

* INSUFFICIENT SAMPLE TO MOUNT IN SLEEVE.
POROSITY AND FLUIDS WERE DETERMINED BY SUMMATION OF FLUIDS METHOD.

-111-

TABLE D-6

TO 3 Core Descriptions

Cat Canyon Field

Getty Oil Company

Williams Holding T.O.#3-25

Surface Location: 3,389.38'S. and 1,295.41'W. from N.1/4 corner
Section 25 - T9N, R33Subsurface Location: 3,458'S. and 1,325'W. from N1/4 corner
Section 25 - (TD 2820)Elevation: K.B. 917.24' - 1" Schlumberger Sidewall Cores -
Run 1* and Run 2

Date Cored: 10/14/79

<u>Depth</u>	<u>Recovery</u>	<u>Description</u>
2560'	1 3/4"	Oil silt, Brownish-grey, sandy, firm, very poor P&P and saturation, faint odor, light yellow cut, $S_o = 5\%$.
2562	1 1/4"	Oil sand with light grey sand, silty, firm, mottled, dark, very fine grained, poor P&P, fair odor, yellow cut, $S_o = 10\%$.
2567	1 1/2"	Sand, grey, oil stained, silty, soft, fine grained, fair P&P, uneven saturation, good odor, straw cut, $S_o = 10\%$.
2581	1 1/4"	Oil sand, dark brownish-grey, silty, friable, fine grained, subrounded, good P&P and saturation, good odor, amber cut, $S_o = 35\%$.
2584	1 1/2"	Oil sand, dark grey, silty, friable, fine grained, subrounded to subangular, fair P&P and saturation, coffee cut, fair odor, $S_o = 30\%$.
2588	1 3/4"	Oil sand, brownish grey, silty, friable, fine to medium grained, subrounded to subangular, fair P&P & saturation, light amber cut, fair odor, $S_o = 35\%$.
2593	1 1/4"	Oil sand, dark grey, silty, friable, fine to medium grained, subrounded to subangular, fair P&P and saturation, good odor, amber cut.
2598	1 1/4	Oil sand, brownish grey, very silty, fine grained, subrounded to subangular, fair P&P and saturation, fair-good odor, dark amber cut, $S_o = 30\%$.
2604	1 1/4	Oil sand, dark brownish grey, silty, soft, fine-medium grained, subrounded to subangular, good P&P and saturation, good odor, coffee cut, $S_o = 40\%$.
2620	1 1/4	Oil sand, dark brownish grey, silty, soft, fine-medium grained, subrounded to subangular, good P&P and saturation, good odor, black cut, $S_o = 45\%$.

<u>Depth</u>	<u>Recovery</u>	<u>Description</u>
2640	1 1/4"	Oil sand, dark brownish grey, silty, soft, fine-medium grained, subrounded to subangular, good P&P and saturation, good odor, black cut, $S_o = 45\%$.
2660	1 1/2"	Oil sand, dark brownish grey, silty, soft, fine - medium grained, subrounded to subangular, good P&P and saturation, fair-good odor, black cut, $S_o = 35\%$.
2667	1 3/4"	Oil sand, dark grey, very silty, friable, very fine grained, poor P&P, fair saturation, fair odor, amber cut, $S_o = 20\%$.
* Note: From 2667 to 2767 - in Run 1 - 6 samples taken at indefinite depths due to gun malfunction.		
2672 (Run 2)	1 1/2"	Oil sand and grey sand, silty, clayey, mottled, friable, fine grained, fair P&P, uneven saturation, fair odor, amber cut, $S_o = 30\%$.
2675	2"	Oil sand, light and dark grey, mottled, silty, friable, fine grained, fair P&P, uneven saturation, good-fair odor, amber cut, $S_o = 25\%$.
2680	1 1/2"	Sand, medium grey, silty, friable, fine grained, fair P&P, fair odor, no to faint cut, $S_o = 3\%$.
2684	1"	Sand, medium grey, silty, friable, very fine grained, poor P&P, faint odor, light straw cut, $S_o = \sim 1\%$.
2695	No Recovery	
2703	1 1/2"	Oil sand, dark grey, clayey, in streaks, soft, fine grained, fair P&P, fair to black cut, good odor, $S_o = 35\%$.
2713	1"	Oil sand, dark grey, silty, friable, fine grained, "salt and pepper" texture, subrounded, fair P&P, fair to good odor, black cut, $S_o = 35\%$.
2730	No Recovery	
2747	3/4"	Oil sand, light and dark grey, mottled, silty, friable, fine grained, fair P&P, uneven saturation, fair odor, amber cut.
2754	1 1/4"	Sand, light grey, silty, soft, fine grained, with mud or clay inclusion, fair P&P, very faint odor, no cut.

<u>Depth</u>	<u>Recovery</u>	<u>Description</u>
2763	1 1/2"	Oil sand, dark grey silty, soft fine grained, subrounded, fair P&P, faint odor, dark amber cut, $S_o = 25\%$.
2767	1 3/4"	Sand, medium-grey silty, soft, fine-medium grained, subrounded, fair P&P, vary faint odor no cut, $S_o = 0\%$.
*Note: 2767 to 2667 - 6 samples taken at indefinite depths on Run 1 - not described.		
2769	2"	Sand, light to medium grey, friable, fine grained, poor P&P, faint odor, no cut.
2773 ⁺	3/4"	Oil sand, light and medium grey, silty soft, mottled, fine to medium grains, subangular to subrounded, poor sorting, fair P&P, faint odor, amber cut, $S_o = 15\%$.
2773 1/2	1 1/2"	Sand, medium grey, silty, friable, fine-medium grained, fair P&P, faint odor, no cut.
2776 (Run 2)	1"	Sand, light grey, silty soft, even, "salt and pepper" texture, fine-medium grained, subangular to subrounded, fair P&P, fair-poor sort, faint odor, no cut.
2776 " (Run 1)	2"	Sand, dark grey, silty, friable, fine-medium grained, fair P&P, fair odor, faint cut.
2779	2"	Sand, medium grey, silty, friable, fine-medium grained, fair P&P, faint odor, faint cut.
2781	1 1/4"	Oil sand, brownish grey to light grey, soft, fine medium grained, subangular to subrounded, good P&P, poor sort, faint odor, coffee cut, $S_o = 35\%$.
2784	1 1/2"	Sand, light brownish grey, silty, soft, fine grained, subrounded, fair P&P, even sorting, faint odor, no cut.
2786*	2"	Sand, dark grey, silty, friable, fine grained, fair P&P, fair odor, no cut.
2790	2"	Sand, grey, friable, very silty, fine grained, poor P&P, faint odor, no cut.

<u>Depth</u>	<u>Recovery</u>	<u>Description</u>
2793	1"	Sand, light grey, silty, friable to firm, fine grained, very poor P&P, faint odor, no cut.
2797	1 3/4"	Sand, medium grey, very silty, firm, fine grained, very poor P&P, no odor, no cut.
2803	1 1/2"	Sand, grey, firm very silty, firm, fine grained, very poor P&P, no odor, no cut.
2805	No Recovery	Misfire.

Described by: A.C.Hanson
G.J.Cavette
October 14, 1979

WILLIAMS HOLDING THERMAL OBSERVATION WELL #4

DRILLING HISTORY

WH TO 4-25 was spudded on October 1, 1979. A 7-7/8" hole was directionally drilled to 2847' using conventional water-base mud. On October 4, a dual induction-SFL log, compensated neutron-formation density log, and computer processed log were run. Sidewall samples were taken from 2605-2840'. A 7-7/8" hole was then drilled from 2847-2867' (T.D.). Four and one-half inch casing was run and cemented at 2867'. The rig was released on October 6, 1979.

FIGURE D-10
TO 4 DUAL INDUCTION-SFL LOG

FIGURE D-11

TO 4 COMPENSATED NEUTRON-FORMATION DENSITY LOG

FIGURE D-12

TO 4 COMPUTER PROCESSED LOG

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Petroleum Reservoir Engineering
DALLAS, TEXAS

PAGE 1

GETTY OIL COMPANY
"WILLIAMS HOLDING" TO-4-25
CAT CANYON FIELD
SANTA BARBARA COUNTY, CA

DATE : 17-OCT-79
FORMATION :
DRLG. FLUID: WB
LOCATION : SEC.25-T9N-R33W

FILE NO : BP-1-8532
LABORATORY: BAKERSFIELD
ANALYSTS : DLK
ELEVATION : 916' KB

DEAN-STARK CORE ANALYSIS

SMP NO	DEPTH	HORIZ PERM	HELI POR %	OIL % P.V.	WTR % P.V.	TOTAL FLUID	O/W RATIO	DESCRIPTION
DEAN-STARK CORE ANALYSIS/SAMPLES MOUNTED IN SLEEVES/A TRI-AXIAL PRESSURE EQUAL TO THE DEPTH MINUS 100 PSIS., TO A MAXIMUM OF 700 PSIS.								
1	2605.0	104.	30.9	9.1	60.9	70.0	0.15	SD;GY-BRN,VF-FGR,SLTY,DK SPT STN
2	2608.0	1217.	33.7	26.6	47.3	74.1	0.57	SD;BRN,VF-FGR,DK STN
3	2611.0	218.	30.4	27.7	59.9	87.6	0.46	SAME
4	2614.0	644.	32.4	28.3	59.6	87.9	0.47	SAME
5	2618.0	1356.	34.4	22.8	57.4	80.3	0.40	SAME
6	2620.0	1301.	33.4	27.7	50.7	78.4	0.55	SAME
7	2623.0	1320.	33.8	31.6	43.6	75.2	0.72	SAME
8	2627.0	996.	32.8	29.9	55.7	85.6	0.54	SAME
9	2630.0	830.	37.0	26.5	42.0	68.5	0.63	SAME
10	2640.0	1257.	32.5	30.4	50.5	80.9	0.60	SAME
11	2650.0	1259.	31.3	41.8	48.3	90.1	0.87	SAME
12	2660.0	774.	32.9	40.3	46.6	86.9	0.86	SAME
13	2670.0	1612.	34.9	43.6	43.7	87.3	1.00	SAME
14	2680.0	1619.	33.7	43.7	40.5	84.2	1.08	SAME
15	2690.0	1220.	35.8	34.2	39.0	73.2	0.88	SAME
16	2695.0	1337.	32.8	44.4	41.2	85.6	1.08	SAME
17	2704.0	250.	28.7	28.7	57.9	86.6	0.50	SAME/CLY INC.
18	2707.0	289.	31.6	6.0	76.1	82.0	0.08	SD;GY-BRN,VF-FGR,SLTY,DK SPT STN
19	2710.0	116.	28.3	0.0	92.5	92.5		SD;GY,VF-FGR,SLTY,NO STN
20	2714.0	350.	30.0	6.7	79.6	86.4	0.08	SD;GY-BRN,VF-FGR,DK SPT STN
21	2716.0	72.	26.5	0.0	89.4	89.4		SD;GY,VF-FGR,SLTY,NO STN
22	2722.0	51.	25.7	0.0	75.2	75.2		SAME
23	2726.0	1622.	32.2	41.6	34.0	75.8	1.23	SD;BRN,VF-FGR,SLTY,DK STN
24	2731.0	2059.	32.2	49.8	35.3	85.1	1.41	SAME
25	2736.0	1496.	32.3	46.5	41.1	87.4	1.13	SAME
26	2740.0	1039.	30.8	48.0	41.7	89.7	1.15	SAME

TABLE D-7
TO 4 Core Analysis

--120--

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Petroleum Reservoir Engineering
DALLAS, TEXAS

PAGE 2

GETTY OIL COMPANY
"WILLIAMS HOLDING" TO-4-25

DATE : 17-OCT-79
FORMATION :

FILE NO : BP-1-8532
LABORATORY: BAKERSFIELD

DEAN-STARK CORE ANALYSIS

SNP NO	DEPTH	HORIZ PERM	HELI FOR %	OIL % P.V.	WTR % P.V.	TOTAL FLUID	O/W RATIO	DESCRIPTION
27	2744.0	1367.	32.9	41.3	38.7	80.1	1.07	SAME
28	2749.0	120.	31.8	36.9	43.2	80.1	0.86	SAME/SLTY
29	2754.0	1318.	30.3	47.3	39.2	86.7	1.21	SAME
30	2760.0	837.	31.2	36.0	44.2	80.2	0.82	SAME
31	2765.0	529.	31.1	13.4	54.9	71.2	0.30	SD;GY-BRN,VF-FGR,SLTY,DK SPT STN
32	2770.0	689.	29.5	35.5	48.0	83.5	0.74	SAME
33*	2773.0	3141.	28.0	25.6	51.3	76.9	0.50	SAME
34	2780.0	725.	31.1	46.6	39.0	85.8	1.20	SD;BRN,VF-FGR,DK STN
35	2786.0	1961.	31.5	56.5	31.7	88.2	1.78	SAME
36	2792.0	2392.	33.1	55.8	29.2	85.0	1.91	SAME
37*	2798.0	2953.	28.5	13.0	63.9	76.9	0.24	SAME
38*	2801.0	2703.	23.0	26.0	42.9	71.4	0.67	SAME
39	2804.0	1835.	35.4	50.8	25.2	75.9	2.02	SD;BRN,VF-FGR,DK STN
40	2808.0	2620.	34.8	46.1	27.5	73.6	1.68	SAME
41	2812.0	349.	32.1	2.2	67.3	71.5	0.03	SD;GY-BRN,VF-FGR,DK SPT STN
42	2815.0	410.	32.4	0.0	86.3	86.3		SD;GY,VF-FGR,SLTY,NO STN
43	2820.0	554.	33.7	0.0	83.7	83.7		SAME
44	2824.0	664.	35.6	0.0	79.2	79.2		SAME
45	2828.0	411.	32.6	0.0	83.2	83.2		SAME
46	2833.0	66.	28.5	0.0	85.2	85.2		SAME
47	2837.0	31.	27.9	0.0	84.1	84.1		SAME
48	2840.0	45.	30.7	0.0	78.5	78.5		SAME/LAM

* INSUFFICIENT SAMPLE TO MOUNT IN SLEEVE.
POROSITY AND FLUIDS WERE DETERMINED BY SUMMATION OF FLUIDS METHOD.

These analyses, opinions or interpretations are based on observations and materials supplied by the client to whom, and for whose exclusive and confidential use, this report is made. The interpretations or opinions expressed represent the best judgment of Core Laboratories, Inc. (all errors and omissions excepted); but Core Laboratories, Inc. and its officers and employees, assume no responsibility and make no warranty or representations, as to the productivity, proper operations, or profitability of any oil, gas or other mineral well or sand in connection with which such report is used or relied upon.

TABLE D-8

TO 4 Core Descriptions

Cat Canyon Field
 Getty Oil Company
 Williams Holding TO. #4-25
 Surface Location: 3245.6'S and 1403.71'W, N1/4 corner
 Section 25, T9N, R33W
 Subsurface Location (T.D.): 3283'S and 1532'W of N1/4 corner
 (T.D. 2867)
 Elevation: 918' 1" Diameter Schlumberger Side-wall Cores
 Date Cored: 10/4/79

<u>Depth</u>	<u>Recovery</u>	<u>Description</u>
2601	No Recovery	-
2603	No Recovery	-
2605	3/4"	Oil siltstone, blue-grey, clayey with mottled oil stains, friable, very fine grained, subrounded subangular, poor P&P, poor odor, uneven saturation, poor sorting, $S_O = 25\%$.
2608	1"	Oil sand, dark blueish-grey, silty, mottled with clay streaks, friable, fine-grained, subrounded- subangular, poor P&P, fair - poor odor, uneven saturation, fair - poor sorting, $S_O = 20\% - 25\%$.
2611	2"	Oil sand, dark blueish-grey, silty, mottled with clay streaks, friable, fine-grained, subrounded to subangular, poor P&P, fair odor, uneven saturation, fair - poor sorting, $S_O = 25\% - 30\%$.
2614	1 3/4"	Oil sand, dark blueish-grey, silty, mottled with clay streaks, friable, fine-grained, subrounded-subangular, fair-poor P&P, fair odor, uneven saturation, fair sorting, $S_O = 30\%$.
2618	1"	Oil sand, dark grey, silty, mottled, friable, fine-grained, subangular - subrounded, fair P&P, fair odor, uneven saturation, fair sorting, $S_O = 35\%$.
2620	1"	Oil sand, dark grey, silty, friable, fine-grained, subangular - subrounded, good - fair P&P, good odor, even saturation, fair sorting, $S_O = 45\%$.
2623	1 1/4"	Oil sand, blackish grey, silty, friable, fine-grained, subangular - subrounded, good - fair P&P, good odor, good saturation, fair sorting, $S_O = 50\%$.

<u>Depth</u>	<u>Recovery</u>	<u>Description</u>
2627	1 1/2"	Oil sand, blackish grey, silty, friable, fine grained, subangular - subrounded, good - fair P&P, good odor, good saturation, fair sorting, $S_O = 55\% - 60\%$.
2630	1 1/4"	Oil sand, dark grey, silty, friable, fine-grained, subrounded - subangular, fair P&P, fair odor, good saturation, fair sorting, $S_O = 45\% - 50\%$.
2640	1 1/2"	Oil sand, blackish grey, silty, friable, fine-grained, sub-rounded - subangular, fair P&P, good odor, good saturation, fair sorting, $S_O = 55\% - 60\%$.
2650	1 3/4"	Oil sand, blackish grey, silty, friable, fine-grained, subrounded - subangular, fair P&P, good odor, good saturation, fair sorting, $S_O = 55\% - 60\%$.
2660	1 3/4"	Oil sand, blackish-grey, silty, friable, fine-grained, subrounded -subangular, fair P&P, good odor, good saturation, fair sorting, $S_O = 50\% - 55\%$.
2670	2"	Oil sand, blackish grey, silty, friable, fine-grained, subrounded -subangular, fair P&P, good odor, good saturation, fair sorting, $S_O = 50\% - 55\%$.
2680	1 1/2"	Oil sand, blackish-grey, silty, friable, fine-grained, subrounded - subangular, fair P&P, good odor, good saturation, fair sorting, $S_O = 45\% - 50\%$.
2690	1 1/2"	Oil sand, grey-black, silty, friable, fine-grained, subrounded - subangular, fair P&P, good odor, fair saturation, fair sorting, $S_O = 45\%$.
2695	1"	Oil sand, grey-black, silty, friable, fine-grained, subangular - subrounded, good - fair P&P, fair to good odor, good saturation fair sorting, $S_O = 50\% - 60\%$.

<u>Depth</u>	<u>Recovery</u>	<u>Description</u>
2700	No Recovery	-
2704	1 1/2"	Oil sand, dark grey-black, silty, friable, fine-grained, subangular - subrounded, good-fair P&P, fair odor, fair sorting, good saturation, $S_O = 45\% - 50\%$.
2707	2"	Oil sand, dark grey, silty, very friable, fine grained, subangular - subrounded, good-fair P&P, poor odor, fair to uneven saturation, fair sorting, $S_O = 30\%$.
2710	1 1/2"	Sand, light grey, silty, soft, fine grained, subrounded, good P&P, faint odor, no cut, fair sorting, $S_O = 0\%$.
2714	1 3/4"	Sand, light to medium grey, silty, soft, fine grained, subrounded, mottled, good P&P, poor odor, light amber cut, $S_O = 12\%$.
2718	1 1/2"	Sand, medium grey, silty, fine grain, subrounded, good P&P, poor odor, slight cut, fair sorting, $S_O = 5\%$.
2722	1"	Sand, light grey, silty, firm, subrounded, poor P&P, no odor or cut, poor sorting, $S_O = 0\%$.
2726	1"	Oil sand, dark grey, silty, friable, fine - medium grain, fair P&P, fair odor, amber cut, poor sorting, $S_O = 35\%$.
2731	1 1/4"	Oil sand, dark grey, silty, friable, fine to medium grain, good P&P, fair odor, amber cut, poor sorting, $S_O = 37\%$.
2736	1 1/4"	Oil sand, dark grey, silty, friable, fine to medium grained, subrounded, good P&P, good odor and cut, fair sorting, $S_O = 35\%$.
2740	1 1/2"	Oil sand, dark grey, silty, friable, fine to medium grained, subrounded to subangular, good, P&P, salt and pepper texture, good odor, fair sorting, $S_O = 40\%$.

<u>Depth</u>	<u>Recovery</u>	<u>Description</u>
2744	1 1/4"	Oil sand, dark grey, silty, friable, fine to medium grain, subrounded - subangular, good P&P, "salt and pepper" texture, excellent odor, fair to poor sorting, $S_O = 45\%$.
2749	1 1/4"	Oil sand, grey, silty, with 3/8", "wedge" of light grey, fine-grained sand, poor P&P, fair odor, fair sorting, $S_O = 0\% - 30\%$.
2754	1 1/4"	Oil sand, dark grey, silty, friable, fine grained, subrounded, fair P&P, "salt and pepper" texture, fair odor, good sorting, $S_O = 40\%$.
2760	1 1/4"	Oil sand, dark grey, silty, friable, fine to medium grain, subrounded, fair P&P, "salt and pepper" texture, good odor, fair sorting, $S_O = 35\%$.
2765	1"	Oil sand (60%), and light grey sand (40%) in streaks, mottled, silty, friable, fair P&P, good odor, poor sorting, $S_O = 5\% - 30\%$.
2770	1"	Oil sand, dark grey with mottled light grey streaks, silty, friable, fair P&P, fair odor, poor sorting, $S_O = 25\%$.
2775	3/4"	Sand, light grey, with few mottled oil streaks, silty, soft, good P&P, poor odor, faint cut, $S_O = 5\%$.
2780	1 1/4"	Oil sand, dark grey, silty, friable, fine to medium grained, subrounded, good P&P, good odor, poor sorting, $S_O = 52\%$, "salt and pepper" texture.
2786	1 1/2"	Oil sand, dark grey, silty, friable, fine to medium grain, subrounded to subangular, good P&P, good odor, poor sorting, $S_O = 50\%$.
2792	1 1/4"	Oil sand, dark grey, silty, friable, fine to medium grain, subrounded, good P&P, excellent odor and cut, poor sorting, "salt and pepper" texture, $S_O = 55\%$.
2798	3/4"	Sand, grey, silty, very friable, fine-grained, subrounded to subangular, poor P&P, no odor, very uneven saturation, poor sorting, $S_O = 5\%$.

<u>Depth</u>	<u>Recovery</u>	<u>Description</u>
2801	3/4"	Oil sand, dark grey, silty, mottled, friable, fine grained, subrounded - subangular, poor P&P, slight odor, uneven saturation, poor sorting, $S_O = 5\%$.
2804	1"	Oil sand, dark grey-black, silty, friable, fine-grained, subrounded to subangular, fair P&P, fair odor, even saturation, fair sorting, $S_O = 35\%$.
2808	1"	Oil sand, dark oil stained grey, silty, friable, fine-grained, subrounded - subangular, fair P&P, fair odor, even saturation, coffee cut, fair sorting, $S_O = 35\%$.
2812	1 1/4"	Oil sand, dark grey with mottled texture, silty, friable, fine - medium grained, subangular to subrounded, fair - good P&P, faint odor, uneven saturation, fair sorting, amber cut $S_O = 10\%$.
2815	1 1/4"	Sand, grey, silty, fine grained, subangular to subrounded, fair P&P, faint odor, dry, fair sorting, $S_O = 0\%$, no cut.
2820	2"	Sand, grey, silty, fine-grained, subangular to subrounded, poor - fair P&P, slight odor, dry, no cut, fair sorting, $S_O = 0\%$.
2824	1 1/4"	Sand, grey, silty, fine-grained, subangular - subrounded, poor to fair P&P, slight odor, dry, no cut, fair sorting, $S_O = 0\%$.
2823	2"	Sand, grey, silty, very friable, fine grained, subrounded - subangular, poor to fair P&P, no odor, poor sorting, $S_O = 0\%$.
2833	2"	Sand, grey, silty, firm, very fine to fine-grained, subrounded - subangular, poor - fair P&P, no odor, dry, fair sorting, $S_O = 0\%$.
2837	1 1/2"	Sand, grey, silty, firm, very fine grained, subrounded - subangular, poor - fair P&P, no odor, dry, fair sorting, $S_O = 0\%$.
2840	1 1/2"	Siltstone, grey, clayey, hard. very, very fine, subrounded-subangular, fair-poor P&P, no odor, dry, fair-poor sorting, $S_O = 0\%$.

Described by: W. Ziemianski
October 4, 1979

APPENDIX E
TEMPERATURE PROFILES
FOR
THERMAL OBSERVATION WELLS

Figure E-1

TO I
TEMPERATURE PROFILES

Figure E-2

TO 2
TEMPERATURE PROFILES

Figure E-3

TO 3
TEMPERATURE PROFILES

Figure E-4

TO 4
TEMPERATURE PROFILES

APPENDIX F
RESERVOIR DATA
FOR
COMPUTER THERMAL SIMULATION

RESERVOIR DATA

<u>Data</u>	<u>Source</u>	<u>Symbol</u>	<u>Value</u>
Water compressibility, psi^{-1}	1	CW	3×10^{-6}
Oil compressibility, psi^{-1}	2	CO	5×10^{-6}
Rock compressibility, psi^{-1}	3	CR	3×10^{-4}
Oil thermal expansion factor, $^{\circ}\text{F}^{-1}$	4	CTO	4×10^{-4}
Oil specific heat, $\text{Btu/lb/}^{\circ}\text{F}$	5	CP	.5
Rock heat capacity, $\text{Btu/ft}^3/^{\circ}\text{F}$	16	CPR	35
Water density at TO, PINIT, lbs/ft^3	6	DWB	61.8
Initial reservoir temperature, $^{\circ}\text{F}$	7	TO	110
Stock tank oil density, lbs/ft^3	8	DOB	61.6
Oil formation volume factor at TO, PINIT, RB/STB	2	BORES	1.00
Solution gas/oil ratio at TO, PINIT, SCF/STB	9	RS	0
Reservoir thermal conductivity, $\text{BTU/ft/day}^{\circ}\text{F}$	5	KTX, KTY, KTZ	38.4
Thermal conductivity of ORF and underburden, $\text{BTU/ft/day}^{\circ}\text{F}$	5	KOB, KUB	38.4
Heat capacity of over and under burden, $\text{BTU/ft}^3/^{\circ}\text{F}$	5	CPOB, CPVB	35
Initial water saturation, fraction		SWI	.478
Permeability, md.	11,12	KX, KY, KZ	2790
Porosity, fraction	11	PHI	.30
Initial reservoir pressure, psia	13	PINIT	1000
Sand thickness, ft.	14	TH	70

OIL VISCOSITY VS. TEMPERATURE DATA 8,9

<u>TEMP. (°F)</u>	<u>VISCOSITY (cp) *</u>
110	28,000
250	105
400	17
700	10.0

* Live oil viscosity

RELATIVE PERMEABILITY ¹⁵

<u>S_{wc}</u>	<u>K_{rw}</u>	<u>K_{ro}</u>	<u>S_l</u>	<u>K_{rg}</u>	<u>K_{ro}</u>
.478	0.0000	1.0000	.779	.1165	0.0000
.513	.0061	.8321	.789	.0795	.0100
.550	.0135	.5800	.805	.0467	.0200
.600	.0240	.2700	.836	.0207	.0420
.622	.0295	.1896	.866	.0127	.0672
.654	.0380	.0920	.906	.0077	.1229
.677	.0455	.0412	.920	.0061	.1498
.700	.0540	.0129	.943	.0040	.2318
.726	.0619	.0000	1.000	.0000	1.0000

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